The Racket Reference

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This manual defines the core Racket language and describes its most prominent libraries. The companion manual *The Racket Guide* provides a friendlier (though less precise and less complete) overview of the language.

The source of this manual is available on GitHub.

```
#lang racket/base      package: base
 #lang racket
```

Unless otherwise noted, the bindings defined in this manual are exported by the racket/base and racket languages.

The racket/base library is much smaller than the racket library and will typically load faster.
The racket library combines racket/base, racket/bool, racket/bytes, racket/class, racket/cmdline, racket/contract, racket/dict, racket/file, racket/format, racket/function, racket/future, racket/include, racket/list, racket/local, racket/match, racket/math, racket/path, racket/place, racket/port, racket/pretty, racket/promise, racket/sequence, racket/set, racket/shared, racket/stream, racket/string, racket/system, racket/tcp, racket/udp, racket/unit, and racket/vector. In addition, it

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1 Language Model

1.1 Evaluation Model

Racket evaluation can be viewed as the simplification of expressions to obtain values. For example, just as an elementary-school student simplifies

```
1 + 1 = 2
```

Racket evaluation simplifies

```
(+ 1 1) → 2
```

The arrow → replaces the more traditional = to emphasize that evaluation proceeds in a particular direction toward simpler expressions. In particular, a *value*, such as the number `2`, is an expression that evaluation simplifies no further.

1.1.1 Sub-expression Evaluation and Continuations

Some simplifications require more than one step. For example:

```
(- 4 (+ 1 1)) → (- 4 2) → 2
```

An expression that is not a value can always be partitioned into two parts: a *redex* ("reducible expression"), which is the part that can change in a single-step simplification (highlighted), and the *continuation*, which is the evaluation context surrounding the redex. In `(- 4 (+ 1 1))`, the redex is `(+ 1 1)`, and the continuation is `(- 4 [])`, where [] takes the place of the redex as it is reduced. That is, the continuation says how to "continue" after the redex is reduced to a value.

Before some expressions can be evaluated, some or all of their sub-expressions must be evaluated. For example, in the application `(- 4 (+ 1 1))`, the application of `-` cannot be reduced until the sub-expression `(+ 1 1)` is reduced. Thus, the specification of each syntactic form specifies how (some of) its sub-expressions are evaluated and then how the results are combined to reduce the form away.

The *dynamic extent* of an expression is the sequence of evaluation steps during which the expression contains the redex.

1.1.2 Tail Position

An expression *`expr1`* is in *tail position* with respect to an enclosing expression *`expr2`* if, whenever *`expr1`* becomes a redex, its continuation is the same as was the enclosing *`expr2`*'s continuation.

For example, the `(+ 1 1)` expression is *not* in tail position with respect to `(- 4 (+ 1 1))`. To illustrate, we use the notation `C[expr]` to mean the expression that is produced by substituting `expr` in place of `[]` in some continuation `C`:

```
C[(- 4 (+ 1 1))] → C[(- 4 2)]
```

In this case, the continuation for reducing `(+ 1 1)` is `C[(- 4 [])]`, not just `C`. The requirement specified in the first paragraph above is not met.

In contrast, `(+ 1 1)` is in tail position with respect to `(if (zero? 0) (+ 1 1) 3)` because, for any continuation `C`,

```
C[(if (zero? 0) (+ 1 1) 3)] → C[(if #t (+ 1 1) 3)] → C[(+ 1 1)]
```

The requirement specified in the first paragraph is met. The steps in this reduction sequence are driven by the definition of `if`, and they do not depend on the continuation `C`. The "then" branch of an `if` form is always in tail position with respect to the `if` form. Due to a similar reduction rule for `if` and `#f`, the "else" branch of an `if` form is also in tail position.

Tail-position specifications provide a guarantee about the asymptotic space consumption of a computation. In general, the specification of tail positions accompanies the description of each syntactic form, such as `if`.

1.1.3 Multiple Return Values

A Racket expression can evaluate to *multiple values*, to provide symmetry with the fact that a procedure can accept multiple arguments.

Most continuations expect a certain number of result values, although some continuations can accept an arbitrary number. Indeed, most continuations, such as `(+ [] 1)`, expect a single value. The continuation `(let-values ([(x y) []]) expr)` expects two result values; the first result replaces `x` in the body `expr`, and the second replaces `y` in `expr`. The continuation `(begin [] (+ 1 2))` accepts any number of result values, because it ignores the result(s).

In general, the specification of a syntactic form indicates the number of values that it produces and the number that it expects from each of its sub-expressions. In addition, some procedures (notably `values`) produce multiple values, and some procedures (notably `call-with-values`) create continuations internally that accept a certain number of values.

1.1.4 Top-Level Variables

Given

```
x = 10
```

then an algebra student simplifies `x + 1` as follows:

```
x + 1 = 10 + 1 = 11
```

Racket works much the same way, in that a set of top-level variables (see also §1.1.8 "Variables and Locations") are available for substitutions on demand during evaluation. For example, given

```
(define x 10)
```

then

```
(+ x 1) → (+ 10 1) → 11
```

In Racket, the way definitions are created is just as important as the way they are used. Racket evaluation thus keeps track of both definitions and the current expression, and it extends the set of definitions in response to evaluating forms such as `define`.

Each evaluation step, then, transforms the current set of definitions and program into a new set of definitions and program. Before a `define` can be moved into the set of definitions, its expression (i.e., its right-hand side) must be reduced to a value. (The left-hand side is not an expression position, and so it is not evaluated.)

```
  defined:
  evaluate: (begin (define x (+ 9 1)) (+ x 1))
→ defined:
  evaluate: (begin (define x 10) (+ x 1))
→ defined:  (define x 10)
  evaluate: (begin (void) (+ x 1))
→ defined:  (define x 10)
  evaluate: (+ x 1)
→ defined:  (define x 10)
  evaluate: (+ 10 1)
→ defined:  (define x 10)
  evaluate: 11
```

Using `set!`, a program can change the value associated with an existing top-level variable:

```
  defined:  (define x 10)
  evaluate: (begin (set! x 8) x)
```

```
→ defined:  (define x 8)
  evaluate: (begin (void) x)
→ defined:  (define x 8)
  evaluate: x
→ defined:  (define x 8)
  evaluate: 8
```

1.1.5 Objects and Imperative Update

In addition to `set!` for imperative update of top-level variables, various procedures enable the modification of elements within a compound data structure. For example, `vector-set!` modifies the content of a vector.

To explain such modifications to data, we must distinguish between values, which are the results of expressions, and *objects*, which actually hold data.

A few kinds of objects can serve directly as values, including booleans, `(void)`, and small exact integers. More generally, however, a value is a reference to an object stored somewhere else. For example, a value can refer to a particular vector that currently holds the value `10` in its first slot. If an object is modified via one value, then the modification is visible through all the values that reference the object.

In the evaluation model, a set of objects must be carried along with each step in evaluation, just like the definition set. Operations that create objects, such as `vector`, add to the set of objects:

```
  objects:
  defined:
  evaluate: (begin (define x (vector 10 20))
                   (define y x)
                   (vector-set! x 0 11)
                   (vector-ref y 0))
→ objects:  (define <o1> (vector 10 20))
  defined:
  evaluate: (begin (define x <o1>)
                   (define y x)
                   (vector-set! x 0 11)
                   (vector-ref y 0))
→ objects:  (define <o1> (vector 10 20))
  defined:  (define x <o1>)
  evaluate: (begin (void)
                   (define y x)
                   (vector-set! x 0 11)
                   (vector-ref y 0))
```

```
→ objects:  (define <o1> (vector 10 20))
  defined:  (define x <o1>)
  evaluate: (begin (define y x)
                   (vector-set! x 0 11)
                   (vector-ref y 0))
→ objects:  (define <o1> (vector 10 20))
  defined:  (define x <o1>)
  evaluate: (begin (define y <o1>)
                   (vector-set! x 0 11)
                   (vector-ref y 0))
→ objects:  (define <o1> (vector 10 20))
  defined:  (define x <o1>)
            (define y <o1>)
  evaluate: (begin (void)
                   (vector-set! x 0 11)
                   (vector-ref y 0))
→ objects:  (define <o1> (vector 10 20))
  defined:  (define x <o1>)
            (define y <o1>)
  evaluate: (begin (vector-set! x 0 11)
                   (vector-ref y 0))
→ objects:  (define <o1> (vector 10 20))
  defined:  (define x <o1>)
            (define y <o1>)
  evaluate: (begin (vector-set! <o1> 0 11)
                   (vector-ref y 0))
→ objects:  (define <o1> (vector 11 20))
  defined:  (define x <o1>)
            (define y <o1>)
  evaluate: (begin (void)
                   (vector-ref y 0))
→ objects:  (define <o1> (vector 11 20))
  defined:  (define x <o1>)
            (define y <o1>)
  evaluate: (vector-ref y 0)
→ objects:  (define <o1> (vector 11 20))
  defined:  (define x <o1>)
            (define y <o1>)
  evaluate: (vector-ref <o1> 0)
→ objects:  (define <o1> (vector 11 20))
  defined:  (define x <o1>)
            (define y <o1>)
  evaluate: 11
```

The distinction between a top-level variable and an object reference is crucial. A top-level variable is not a value, so it must be evaluated. Each time a variable expression is evaluated, the value of the variable is extracted from the current set of definitions. An object reference, in contrast, is a value and therefore needs no further evaluation. The evaluation steps above use angle-bracketed `<o1>` for an object reference to distinguish it from a variable name.

An object reference can never appear directly in a text-based source program. A program representation created with `datum->syntax`, however, can embed direct references to existing objects.

1.1.6 Garbage Collection

See §16 "Memory Management" for functions related to garbage collection.

In the program state

```
objects: (define <o1> (vector 10 20))
         (define <o2> (vector 0))
defined: (define x <o1>)
evaluate: (+ 1 x)
```

evaluation cannot depend on `<o2>`, because it is not part of the program to evaluate, and it is not referenced by any definition that is accessible by the program. The object is said to not be *reachable*. The object `<o2>` may therefore be removed from the program state by *garbage collection*.

A few special compound datatypes hold *weak references* to objects. Such weak references are treated specially by the garbage collector in determining which objects are reachable for the remainder of the computation. If an object is reachable *only* via a weak reference, then the object can be reclaimed, and the weak reference is replaced by a different value (typically `#f`).

As a special case, a fixnum is always considered reachable by the garbage collector. Many other values are always reachable due to the way they are implemented and used: A character in the Latin-1 range is always reachable, because `equal?` Latin-1 characters are always `eq?`, and all of the Latin-1 characters are referenced by an internal module. Similarly, `null`, `#t`, `#f`, `eof`, and `#<void>` are always reachable. Values produced by `quote` remain reachable when the `quote` expression itself is reachable.

1.1.7 Procedure Applications and Local Variables

Given

```
f(x) = x + 10
```

an algebra student simplifies `f(7)` as follows:

```
f(7) = 7 + 10 = 17
```

The key step in this simplification is to take the body of the defined function `f` and replace each `x` with the actual value `7`.

Racket procedure application works much the same way. A procedure is an object, so evaluating `(f 7)` starts with a variable lookup:

```
  objects:  (define <p1> (lambda (x) (+ x 10)))
  defined:  (define f <p1>)
  evaluate: (f 7)
→ objects:  (define <p1> (lambda (x) (+ x 10)))
  defined:  (define f <p1>)
  evaluate: (<p1> 7)
```

Unlike in algebra, however, the value associated with a procedure argument variable can be changed in the body of a procedure by using `set!`, as in the example `(lambda (x) (begin (set! x 3) x))`. Since the value associated with argument variable `x` should be able to change, we cannot just substitute the value in for `x` when we first apply the procedure.

We do not use the term "parameter variable" to refer to the argument variable names declared with a function. This choice avoids confusion with parameters.

Instead, a new *location* is created for each variable on each application. The argument value is placed in the location, and each instance of the variable in the procedure body is replaced with the new location:

```
  objects:  (define <p1> (lambda (x) (+ x 10)))
  defined:  (define f <p1>)
  evaluate: (<p1> 7)
→ objects:  (define <p1> (lambda (x) (+ x 10)))
  defined:  (define f <p1>)
            (define xloc 7)
  evaluate: (+ xloc 10)
→ objects:  (define <p1> (lambda (x) (+ x 10)))
  defined:  (define f <p1>)
            (define xloc 7)
  evaluate: (+ 7 10)
→ objects:  (define <p1> (lambda (x) (+ x 10)))
  defined:  (define f <p1>)
            (define xloc 7)
  evaluate: 17
```

A location is the same as a top-level variable, but when a location is generated, it (conceptually) uses a name that has not been used before and that cannot be generated again or accessed directly.

Generating a location in this way means that `set!` evaluates for local variables, including argument variables, in the same way as for top-level variables, because the local variable is always replaced with a location by the time the `set!` form is evaluated:

```
  objects: (define <p1> (lambda (x) (begin (set! x 3) x)))
  defined: (define f <p1>)
  evaluate: (f 7)
→ objects: (define <p1> (lambda (x) (begin (set! x 3) x)))
  defined: (define f <p1>)
  evaluate: (<p1> 7)
→ objects: (define <p1> (lambda (x) (begin (set! x 3) x)))
  defined: (define f <p1>)
           (define xloc 7)
  evaluate: (begin (set! xloc 3) xloc)
→ objects: (define <p1> (lambda (x) (begin (set! x 3) x)))
  defined: (define f <p1>)
           (define xloc 3)
  evaluate: (begin (void) xloc)
→ objects: (define <p1> (lambda (x) (begin (set! x 3) x)))
  defined: (define f <p1>)
           (define xloc 3)
  evaluate: xloc
→ objects: (define <p1> (lambda (x) (begin (set! x 3) x)))
  defined: (define f <p1>)
           (define xloc 3)
  evaluate: 3
```

The location-generation and substitution step of procedure application requires that the argument is a value. Therefore, in `((lambda (x) (+ x 10)) (+ 1 2))`, the `(+ 1 2)` subexpression must be simplified to the value `3`, and then `3` can be placed into a location for `x`. In other words, Racket is a *call-by-value* language.

Evaluation of a local-variable form, such as `(let ([x (+ 1 2)]) expr)`, is the same as for a procedure call. After `(+ 1 2)` produces a value, it is stored in a fresh location that replaces every instance of `x` in `expr`.

1.1.8 Variables and Locations

A *variable* is a placeholder for a value, and expressions in an initial program refer to variables. A *top-level variable* is both a variable and a location. Any other variable is always replaced by a location at run-time; thus, evaluation of expressions involves only locations. A single *local variable* (i.e., a non-top-level, non-module-level variable), such as an argument variable, can correspond to different locations during different applications.

For example, in the program

```
(define y (+ (let ([x 5]) x) 6))
```

both `y` and `x` are variables. The `y` variable is a top-level variable, and the `x` is a local variable. When this code is evaluated, a location is created for `x` to hold the value `5`, and a location is also created for `y` to hold the value `11`.

The replacement of a variable with a location during evaluation implements Racket's *lexical scoping*. For example, when an argument variable `x` is replaced by the location `xloc`, it is replaced *throughout* the body of the procedure, including any nested `lambda` forms. As a result, future references to the variable always access the same location.

For the purposes of substituting `xloc` for `x`, all variable bindings must use distinct names, so no `x` that is really a different variable will get replaced. Ensuring that distinction is one of the jobs of the macro expander; see §1.2 “Syntax Model”.

1.1.9 Modules and Module-Level Variables

See §3.1 “Modules: `module`, `module*`, ...” for the syntax of modules.

Most definitions in Racket are in *modules*. In terms of evaluation, a module is essentially a prefix on a defined name, so that different modules can define the same name. That is, a *module-level variable* is like a top-level variable from the perspective of evaluation.

One difference between a module and a top-level definition is that a module can be *declared* without instantiating its module-level definitions. Evaluation of a `require` *instantiates* (i.e., triggers the *instantiation* of) the declared module, which creates variables that correspond to its module-level definitions.

For example, given the module declaration

```
(module m racket
  (define x 10))
```

the evaluation of `(require 'm)` creates the variable `x` and installs `10` as its value. This `x` is unrelated to any top-level definition of `x` (as if it were given a unique, module-specific prefix).

Phases

See also §16.2.6 “General Phase Levels” in *The Racket Guide*.

The purpose of *phases* is to address the necessary separation of names defined at execution time versus names defined at expansion time.

A module can be instantiated in multiple phases. A phase is an integer that, like a module name, is effectively a prefix on the names of module-level definitions. Phase 0 is the execution-time phase.

A top-level `require` instantiates a module at phase 0, if the module is not already instantiated at phase 0. A top-level `(require (for-syntax ....))` instantiates a module at phase 1 (if it is not already instantiated at that phase); `for-syntax` also has a different binding effect on further program parsing, as described in §1.2.3.4 “Introducing Bindings”.

Within a module, some definitions are already shifted by a phase: the `begin-for-syntax` form is similar to `begin`, but it shifts expressions and definitions by a relative phase +1.

Likewise, the `define-for-syntax` form is similar to `define`, but shifts the definition by +1. Thus, if the module is instantiated at phase 1, the variables defined with `begin-for-syntax` are created at phase 2, and so on. Moreover, this relative phase acts as another layer of prefixing, so that `x` defined with `define` and `x` defined with `define-for-syntax` can co-exist in a module without colliding. A `begin-for-syntax` form can be nested within a `begin-for-syntax` form, in which case the inner definitions and expressions are in relative phase +2, and so on. Higher phases are mainly related to program parsing instead of normal evaluation.

If a module instantiated at phase *n* `requires` another module, then the `required` module is first instantiated at phase *n*, and so on transitively. (Module `requires` cannot form cycles.) If a module instantiated at phase *n* `requires` another module *`M`* `for-syntax`, then *`M`* becomes *available* at phase *n*+1, and it later may be instantiated at phase *n*+1. If a module that is available at phase *n* (for *n*>0) `requires` another module *`M`* `for-template`, then *`M`* becomes available at phase *n*-1, and so on. Instantiations of available modules above phase 0 are triggered on demand as described in §1.2.3.9 "Module Expansion, Phases, and Visits".

A final distinction among module instantiations is that multiple instantiations may exist at phase 1 and higher. These instantiations are created by the parsing of module forms (see §1.2.3.9 "Module Expansion, Phases, and Visits"), and are, again, conceptually distinguished by prefixes.

Top-level variables can exist in multiple phases in the same way as within modules. For example, `define` within `begin-for-syntax` creates a phase 1 variable. Furthermore, reflective operations like `make-base-namespace` and `eval` provide access to top-level variables in higher phases, while module instantiations (triggered by `require`) relative to such top-levels are in correspondingly higher phases.

The Separate Compilation Guarantee

When a module is compiled, its phase 1 is instantiated. This can, in turn, trigger the transitive instantiation of many other modules at other phases, including phase 1. Racket provides a guarantee about this instantiation called "The Separate Compilation Guarantee":

> Any effects of the instantiation of the module's phase 1 due to compilation on the Racket runtime system are discarded.

The guarantee concerns *effects*. There are two different kinds of effects: internal and external.

Internal effects are exemplified by mutation. Mutation is the action of a function such as `set-box!`, which changes the value contained in the box. The modified box is not observable outside Racket, so the effect is said to be "internal." By definition, internal effects are not detectable outside the Racket program.

External effects are exemplified by input/output (I/O). I/O is the action of a function such as tcp-connect, which communicates with the operating system to send network packets outside the machine running Racket. The transmission of these packets is observable outside Racket, in particular by the receiving computer or any routers in between. External effects exist to be detectable outside the Racket program and are often detectable using physical processes.

An effect is *discarded* when it is no longer detectable. For instance, the mutation of a box from 3 to 4 is discarded when it ceases to be detectable that it was ever changed and thus would still contain 3. Because external effects are intrinsically observable outside Racket, they are irreversible and cannot be discarded.

Thus, the Separate Compilation Guarantee only concerns effects like mutation, because they are exclusively effects “on the Racket runtime system” and not “on the physical universe.”

Whenever a Racket program calls an unsafe function, the Racket runtime system makes no promises about its effects. For instance, all foreign calls use ffi/unsafe, so all foreign calls are unsafe and their effects cannot be discarded by Racket.

Finally, The Separate Compilation Guarantee only concerns instantiations at phase 1 during compilation and not all phase 1 instantiations generally, such as when its phase 1 is required and used for effects via reflective mechanisms.

The practical consequence of this guarantee is that because effects are not visible, no module can detect whether a module it requires is already compiled. Thus, it cannot change the compilation of one module to have already compiled a different module. In particular, if module A is shared by the phase 1 portion of modules X and Y, then any internal effects while X is compiled are not visible during the compilation of Y, regardless of whether X and Y are compiled during the same execution of Racket’s runtime system and regardless of the order of compilation.

The following set of modules demonstrate this guarantee. First, we define a module with the ability to observe effects via a box:

```
(module box racket/base
  (provide (all-defined-out))
  (define b (box 0)))
```

Next, we define two syntax transformers that use and mutate this box:

```
(module transformers racket/base
  (provide (all-defined-out))
  (require (for-syntax racket/base 'box))
  (define-syntax (sett stx)
    (set-box! b 2)
    #'(void))
  (define-syntax (gett stx)
    #`#,(unbox b)))
```

Next, we define a module that uses these transformers:

```
(module user racket/base
  (provide (all-defined-out))
  (require 'transformers)
  (sett)
  (define gott (gett)))
```

Finally, we define a second module that uses these transformers and the `user` module:

```
(module test racket/base
  (require 'box 'transformers 'user)
  (displayln gott)
  (displayln (gett))

  (sett)
  (displayln (gett))

  (displayln (unbox b)))
```

This module displays:

- `2`, because the `(gett)` in module `user` expanded to `2`.
- `0`, because the effects of compiling `user` were discarded.
- `2`, because the effect of `(sett)` inside `test` has not yet been discarded.
- `0`, because the effects of `sett` at phase 1 are irrelevant to the phase 0 use of `b` in `(unbox b)`.

Furthermore, this display will never change, regardless of which order these modules are compiled in or whether they are compiled at the same time or separately.

In contrast, if these modules were changed to store the value of `b` in a file on the filesystem, then the program would only display `2`.

The Separate Compilation Guarantee is described in more detail in the papers "Composable and Compilable Macros" [Flatt02] and "Submodules in Racket" [Flatt13], including informative examples. The paper "Advanced Macrology and the implementation of Typed Scheme" [Culpepper07] also contains an extended example of why it is important and how to design effectful syntactic extensions in its presence.

Cross-Phase Persistent Modules

Module declarations that fit a highly constrained form—including a (#%declare #:cross-phase-persistent) form in the module body—create *cross-phase persistent* modules. A cross-phase persistent module's instantiations across all phases share the variables produced by the first instantiation of the module. Additionally, cross-phase persistent module instantiations persist across module registries when they share a common module declaration.

Examples:

```
> (module cross '#%kernel
    (#%declare #:cross-phase-persistent)
    (#%provide x)
    (define-values (x) (gensym)))
> (module noncross '#%kernel
    (#%provide x)
    (define-values (x) (gensym)))
> (define ns (current-namespace))
> (define (same-instance? mod)
    (namespace-require mod)
    (define a
      (parameterize ([current-namespace (make-base-namespace)])
        (namespace-attach-module-declaration ns mod)
        (namespace-require mod)
        (namespace-variable-value 'x)))
    (define b
      (parameterize ([current-namespace (make-base-namespace)])
        (namespace-attach-module-declaration ns mod)
        (namespace-require mod)
        (namespace-variable-value 'x)))
    (eq? a b))
> (same-instance? ''noncross)
#f
> (same-instance? ''cross)
#t
```

The intent of a cross-phase persistent module is to support values that are recognizable after phase crossings. For example, when a macro transformer running in phase 1 raises a syntax error as represented by an exn:fail:syntax instance, the instance is recognizable by a phase-0 exception handler wrapping a call to eval or expand that triggered the syntax error, because the exn:fail:syntax structure type is defined by a cross-phase persistent module.

A cross-phase persistent module imports only other cross-phase persistent modules, and it contains only definitions that bind variables to functions, structure types and related functions, or structure-type properties and related functions. A cross-phase persistent module never includes syntax literals (via quote-syntax) or variable references (via #%variable-reference). See §1.2.7 "Cross-Phase Persistent Module Declarations" for the syntactic specification of a cross-phase persistent module declaration.

A documented module should be assumed non–cross-phase persistent unless it is specified as cross-phase persistent (such as `racket/kernel`).

Module Redeclarations

When a module is declared using a name with which a module is already declared, the new declaration's definitions replace and extend the old declarations. If a variable in the old declaration has no counterpart in the new declaration, the old variable continues to exist, but its binding is not included in the lexical information for the module body. If a new variable definition has a counterpart in the old declaration, it effectively assigns to the old variable.

If a module is instantiated in the current namespace's base phase before the module is redeclared, the redeclaration of the module is immediately instantiated in that phase.

If the current inspector does not manage a module's declaration inspector (see §14.10 "Code Inspectors"), then the module cannot be redeclared. Similarly, a cross-phase persistent module cannot be redeclared. Even if redeclaration succeeds, instantiation of a module that is previously instantiated may fail if instantiation for the redeclaration attempts to modify variables that are constant (see `compile-enforce-module-constants`).

Submodules

A `module` or `module*` form within a top-level `module` form declares a *submodule*. A submodule is accessed relative to its enclosing module, usually with a `submod` path. Submodules can be nested to any depth.

Although a submodule is lexically nested within a module, it cannot necessarily access the bindings of its enclosing module directly. More specifically, a submodule declared with `module` cannot `require` from its enclosing module, but the enclosing module can `require` the submodule. In contrast, a submodule declared with `module*` conceptually follows its enclosing module, so can `require` from its enclosing module, but the enclosing module cannot `require` the submodule. Unless a submodule imports from its enclosing module or vice versa, then visits or instantiations of the two modules are independent, and their implementations may even be loaded from bytecode sources at different times.

A submodule declared with `module` can import any preceding submodule declared with `module`. A submodule declared with `module*` can import any preceding module declared with `module*` and any submodule declared with `module`.

When a submodule declaration has the form `(module* name #f ....)`, then all of the bindings of the enclosing module's bodies are visible in the submodule's body, and the submodule implicitly imports the enclosing module. The submodule can `provide` any bindings that it inherits from its enclosing module.

1.1.10 Continuation Frames and Marks

See §10.5 "Continuation Marks" for continuation-mark forms and functions.

Every continuation C can be partitioned into *continuation frames* C_1, C_2, ..., C_n such that $C = C_1[C_2[...[C_n]]]$, and no frame C_i can be itself partitioned into smaller continuations. Evaluation steps add frames to and remove frames from the current continuation, typically one at a time.

Each frame is conceptually annotated with a set of *continuation marks*. A mark consists of a key and its value. The key is an arbitrary value, and each frame includes at most one mark for any given key. Various operations set and extract marks from continuations, so that marks can be used to attach information to a dynamic extent. For example, marks can be used to record information for a "stack trace" to be presented when an exception is raised, or to implement dynamic scope.

1.1.11 Prompts, Delimited Continuations, and Barriers

See §10.4 "Continuations" for continuation and prompt functions.

A *prompt* is a special kind of continuation frame that is annotated with a specific *prompt tag* (essentially a continuation mark). Various operations allow the capture of frames in the continuation from the redex position out to the nearest enclosing prompt with a particular prompt tag; such a continuation is sometimes called a *delimited continuation*. Other operations allow the current continuation to be extended with a captured continuation (specifically, a *composable continuation*). Yet other operations abort the computation to the nearest enclosing prompt with a particular tag, or replace the continuation to the nearest enclosing prompt with another one. When a delimited continuation is captured, the marks associated with the relevant frames are also captured.

A *continuation barrier* is another kind of continuation frame that prohibits certain replacements of the current continuation with another. Specifically, a continuation can be replaced by another only when the replacement does not introduce any continuation barriers. A continuation barrier thus prevents "downward jumps" into a continuation that is protected by a barrier. Certain operations install barriers automatically; in particular, when an exception handler is called, a continuation barrier prohibits the continuation of the handler from capturing the continuation past the exception point.

An *escape continuation* is essentially a derived concept. It combines a prompt for escape purposes with a continuation for mark-gathering purposes. As the name implies, escape continuations are used only to abort to the point of capture.

1.1.12 Threads

See §11 "Concurrency and Parallelism" for thread and synchronization functions.

Racket supports multiple *threads* of evaluation. Threads run concurrently, in the sense that one thread can preempt another without its cooperation. By default, however, a thread is a *coroutine thread* that runs on the same processor (i.e., the same underlying operating-system process and thread) as other coroutine threads, at least within the same place.

Threads are created explicitly by functions such as `thread`. In terms of the evaluation model, each step in evaluation actually deals with multiple concurrent expressions, up to one per thread, rather than a single expression. The expressions all share the same objects and top-level variables, so that they can communicate through shared state, and *sequential consistency* [Lamport79] is guaranteed among coroutine threads (i.e., the result is consistent with some global sequence imposed on all evaluation steps across threads). Most evaluation steps involve a single step in a single thread, but certain synchronization primitives require multiple threads to progress together in one step; for example, an exchange of a value through a channel progresses in two threads simultaneously.

Unless otherwise noted, all constant-time procedures and operations provided by Racket are thread-safe in the sense that they are *atomic*: they happen as a single evaluation step. For example, `set!` assigns to a variable as an atomic action with respect to all threads, so that no thread can see a "half-assigned" variable. Similarly, `vector-set!` assigns to a vector atomically. Note that the evaluation of a `set!` expression with its subexpression is not necessarily atomic, because evaluating the subexpression involves a separate step of evaluation. Only the assignment action itself (which takes after the subexpression is evaluated to obtain a value) is atomic. Similarly, a procedure application can involve multiple steps that are not atomic, even if the procedure itself performs an atomic action.

The `hash-set!` procedure is not atomic, but the table is protected by a lock; see §4.15 "Hash Tables" for more information. Port operations are generally not atomic, but they are thread-safe in the sense that a byte consumed by one thread from an input port will not be returned also to another thread, and procedures like `port-commit-peeked` and `write-bytes-avail` offer specific concurrency guarantees.

In addition to the state that is shared among all threads, each thread has its own private state that is accessed through *thread cells*. A thread cell is similar to a normal mutable object, but a change to the value inside a thread cell is seen only when extracting a value from that cell in the same thread. A thread cell can be *preserved*; when a new thread is created, the creating thread's value for a preserved thread cell serves as the initial value for the cell in the created thread. For a non-preserved thread cell, a new thread sees the same initial value (specified when the thread cell is created) as all other threads.

A *parallel thread* is like a coroutine thread, but it can run on a different processor (i.e., a different underlying operating-system thread). A parallel thread can be created by calling `thread` with a `#:pool` argument whose value is `'own` or a parallel-thread pool. Operations provided by Racket remain thread-safe with parallel threads, but sequential consistency is not guaranteed across operations and threads. If two parallel threads share state, each read or write operation to shared state corresponds to a read or write operation at the virtual-memory level; Racket does not enforce additional guarantees about reordering that might be performed at the virtual-memory level or below, except in the case of operations that specify such guarantees explicitly (e.g., `box-cas!`). That is, the host machine's memory model can be exposed by observations across parallel threads.

The possibility of shared state imposes a cost on some operations, particularly in the case of sharing among parallel threads, and using parallel threads can easily make a computation slower than using coroutine threads when the underlying primitives resort to a more pessimistic mode. Futures and places are alternatives to parallel threads that provide different trade-offs in sharing constraints and performance. Futures sometimes achieve better performance by limiting operations that run in parallel; as a result, they can be created and complete more cheaply, and they can fall back more consistently to coroutine performance in cases where parallel threads would become slow. Places can sometimes achieve better performance by limiting sharing (somewhat like separate processes at the operating-system level), so that operations can proceed more optimistically. A place has its own set of coroutine threads that it schedules with sequential consistency, but the can run in parallel to coroutine threads in other places. Both futures and places include the possibly of shared state, and they have the same kind of weak ordering on operations as parallel threads.

1.1.13 Parameters

See §11.3.2 "Parameters" for parameter forms and functions.

Parameters are essentially a derived concept in Racket; they are defined in terms of continuation marks and thread cells. However, parameters are also "built in," due to the fact that some primitive procedures consult parameter values. For example, the default output stream for primitive output operations is specified by a parameter.

A parameter is a setting that is both thread-specific and continuation-specific. In the empty continuation, each parameter corresponds to a preserved thread cell; a corresponding *parameter procedure* accesses and sets the thread cell's value for the current thread.

In a non-empty continuation, a parameter's value is determined through a *parameterization* that is associated with the nearest enclosing continuation frame via a continuation mark (whose key is not directly accessible). A parameterization maps each parameter to a preserved thread cell, and the combination of the thread cell and the current thread yields the parameter's value. A parameter procedure sets or accesses the relevant thread cell for its parameter.

Various operations, such as `parameterize` or `call-with-parameterization`, install a parameterization into the current continuation's frame.

1.1.14 Exceptions

See §10.2 "Exceptions" for exception forms, functions, and types.

Exceptions are essentially a derived concept in Racket; they are defined in terms of continuations, prompts, and continuation marks. However, exceptions are also "built in," due to the fact that primitive forms and procedures may raise exceptions.

An *exception handler* to *catch* exceptions can be associated with a continuation frame though a continuation mark (whose key is not directly accessible). When an exception is raised, the current continuation's marks determine a chain of exception handler procedures that are consulted to handle the exception. A handler for uncaught exceptions is designated through a built-in parameter.

One potential action of an exception handler is to abort the current continuation up to an enclosing prompt with a particular prompt tag. The default handler for uncaught exceptions, in particular, aborts to a particular tag for which a prompt is always present, because the prompt is installed in the outermost frame of the continuation for any new thread.

1.1.15 Custodians

See §14.7 "Custodians" for custodian functions.

A *custodian* manages a collection of threads, file-stream ports, TCP ports, TCP listeners, UDP sockets, byte converters, and places. Whenever a thread, etc., is created, it is placed under the management of the *current custodian* as determined by the `current-custodian` parameter.

Custodians also manage eventspaces from `racket/gui/base`.

Except for the root custodian, every custodian itself is managed by a custodian, so that custodians form a hierarchy. Every object managed by a subordinate custodian is also managed by the custodian's owner.

When a custodian is shut down via `custodian-shutdown-all`, it forcibly and immediately closes the ports, TCP connections, etc., that it manages, as well as terminating (or suspending) its threads. A custodian that has been shut down cannot manage new objects. After the current custodian is shut down, if a procedure is called that attempts to create a managed resource (e.g., `open-input-file`, `thread`), then the `exn:fail:contract` exception is raised.

A thread can have multiple managing custodians, and a suspended thread created with `thread/suspend-to-kill` can have zero custodians. Extra custodians become associated with a thread through `thread-resume` (see §11.1.2 "Suspending, Resuming, and Killing Threads"). When a thread has multiple custodians, it is not necessarily killed by a `custodian-shutdown-all`. Instead, shut-down custodians are removed from the thread's managing custodian set, and the thread is killed when its managing set becomes empty.

The values managed by a custodian are semi-weakly held by the custodian: a will can be executed for a value that is managed by a custodian; in addition, weak references via weak hash tables, ephemerons, or weak boxes can be dropped on the BC implementation of Racket, but not on the CS implementation. For all variants, a custodian only weakly references its subordinate custodians; if a subordinate custodian is unreferenced but has its own subordinates, then the custodian may be garbage collected, at which point its subordinates become immediately subordinate to the collected custodian's superordinate (owner) custodian.

In addition to the other entities managed by a custodian, a *custodian box* created with `make-custodian-box` strongly holds onto a value placed in the box until the box's custodian is shut down. However, the custodian only weakly retains the box itself, so the box and its content can be collected if there are no other references to them.

When Racket is compiled with support for per-custodian memory accounting (see `custodian-memory-accounting-available?`), the `current-memory-use` procedure can report a custodian-specific result. This result determines how much memory is occupied by objects that are reachable from the custodian's managed values, especially its threads, and including its sub-custodians' managed values. If an object is reachable from two custodians where neither is an ancestor of the other, an object is arbitrarily charged to one or the other, and the choice can change after each collection; objects reachable from both a custodian and its descendant, however, are reliably charged to the custodian and not to the descendants, unless the custodian can reach the objects only through a descendant custodian or a descendant's thread. Reachability for per-custodian accounting does not include weak references, references to threads managed by other custodians, references to other custodians, or references to custodian boxes for other custodians.

1.2 Syntax Model

The syntax of a Racket program is defined by

- a *read* pass that processes a character stream into a syntax object; and
- an *expand* pass that processes a syntax object to produce one that is fully parsed.

For details on the read pass, see §1.3 "The Reader". Source code is normally read in `read-syntax` mode, which produces a syntax object.

The expand pass recursively processes a syntax object to produce a complete parse of the program. Binding information in a syntax object drives the expansion process, and when the expansion process encounters a binding form, it extends syntax objects for sub-expressions with new binding information.

1.2.1 Identifiers, Binding, and Scopes

§4.2 "Identifiers and Binding" in *The Racket Guide* introduces binding.

An *identifier* is a source-program entity. Parsing (i.e., expanding) a Racket program reveals that some identifiers correspond to variables, some refer to syntactic forms (such as `lambda`, which is the syntactic form for functions), some refer to transformers for macro expansion, and some are quoted to produce symbols or syntax objects. An identifier *binds* another (i.e., it is a *binding*) when the former is parsed as a variable or syntactic form and the latter is parsed as a *reference* to the former; the latter is *bound*.

For example, as a fragment of source, the text

```
(let ([x 5]) x)
```

includes two identifiers: `let` and `x` (which appears twice). When this source is parsed in a context where `let` has its usual meaning, the first `x` binds the second `x`.

Bindings and references are determined through scope sets. A *scope* corresponds to a region of the program that is either in part of the source or synthesized through elaboration of the source. Nested binding contexts (such as nested functions) create nested scopes, while macro expansion creates scopes that overlap in more complex ways. Conceptually, each scope is represented by a unique token, but the token is not directly accessible. Instead, each scope is represented by a value that is internal to the representation of a program.

A *form* is a fragment of a program, such as an identifier or a function call. A form is represented as a syntax object, and each syntax object has an associated set of scopes (i.e., a *scope set*). In the above example, the representations of the `x`s include the scope that corresponds to the `let` form.

When a form parses as the binding of a particular identifier, parsing updates a global table that maps a combination of an identifier's symbol and scope set to its meaning: a variable, a syntactic form, or a transformer. An identifier refers to a particular binding when the reference's symbol and the identifier's symbol are the same, and when the reference's scope set is a superset of the binding's scope set. For a given identifier, multiple bindings may have scope sets that are subsets of the identifier's; in that case, the identifier refers to the binding whose set is a superset of all others; if no such binding exists, the reference is ambiguous (and triggers a syntax error if it is parsed as an expression). A binding *shadows* any binding (i.e., it is *shadowing* any binding) with the same symbol but a subset of scopes.

For example, in

```
(let ([x 5]) x)
```

in a context where `let` corresponds to the usual syntactic form, the parsing of `let` introduces a new scope for the binding of `x`. Since the second `x` receives that scope as part of the `let` body, the first `x` binds the second `x`. In the more complex case

```
(let ([x 5])
  (let ([x 6])
    x))
```

the inner `let` creates a second scope for the second `x`, so its scope set is a superset of the first `x`'s scope set—which means that the binding for the second `x` shadows the one for the first `x`, and the third `x` refers to the binding created by the second one.

A *top-level binding* is a binding from a definition at the top-level; a *module binding* is a binding from a definition in a module; all other bindings are *local bindings*. Within a module, references to top-level bindings are disallowed. An identifier without a binding is *unbound*.

Throughout the documentation, identifiers are typeset to suggest the way that they are parsed.

A hyperlinked identifier like `lambda` indicates a reference to a syntactic form or variable. A plain identifier like `x` is a variable or a reference to an unspecified top-level variable.

Every binding has a *phase level* in which it can be referenced, where a phase level normally corresponds to an integer (but the special label phase level does not correspond to an integer). Phase level 0 corresponds to the run time of the enclosing module (or the run time of top-level expressions). Bindings in phase level 0 constitute the *base environment*. Phase level 1 corresponds to the time during which the enclosing module (or top-level expression) is expanded; bindings in phase level 1 constitute the *transformer environment*. Phase level -1 corresponds to the run time of a different module for which the enclosing module is imported for use at phase level 1 (relative to the importing module); bindings in phase level -1 constitute the *template environment*. The *label phase level* does not correspond to any execution time; it is used to track bindings (e.g., to identifiers within documentation) without implying an execution dependency.

An identifier can have different bindings in different phase levels. More precisely, the scope set associated with a form can be different at different phase levels; a top-level or module context implies a distinct scope at every phase level, while scopes from macro expansion or other syntactic forms are added to a form's scope sets at all phases. The context of each binding and reference determines the phase level whose scope set is relevant.

A *binding space* is a convention that distinguishes bindings by having a specific scope for the space; an identifier is "bound in a space" if its binding includes the space's scope in its scope set. A space's scope is accessed indirectly by using `make-interned-syntax-introducer`; that is, a space is just the set of bindings with a scope that is interned with that space's name, where the *default binding space* corresponds to having no interned scopes. The `require` and `provide` forms include support for bindings spaces through subforms like `for-space` and `only-space-in`. No other forms provided by the `racket` module bind or reference identifier in a specified space; such forms are intended to be implemented by new macros. By convention, when an identifier is bound in a space, a corresponding identifier also should be bound in the default binding space; that convention helps avoid mismatches between imports or mismatches due to local bindings that shadow only in some spaces.

Changed in version 6.3 of package `base`: Changed local bindings to have a specific phase level, like top-level and module bindings.
Changed in version 8.2.0.3: Added binding spaces.

1.2.2 Syntax Objects

§16.2.1 "Syntax Objects" in *The Racket Guide* introduces the use of syntax objects.

A *syntax object* combines a simpler Racket value, such as a symbol or pair, with lexical information, source-location information, syntax properties, and whether the syntax object is tainted. The *lexical information* of a syntax object comprises a set of scope sets, one for each phase level. In particular, an identifier is represented as a syntax object containing a symbol, and its lexical information can be combined with the global table of bindings to determine its binding (if any) at each phase level.

For example, a `car` identifier might have lexical information that designates it as the `car` from the `racket/base` language (i.e., the built-in `car`). Similarly, a `lambda` identifier's lexical information may indicate that it represents a procedure form. Some other identifier's lexical information may indicate that it references a top-level variable.

When a syntax object represents a more complex expression than an identifier or simple constant, its internal components can be extracted. Even for extracted identifiers, detailed information about binding is available mostly indirectly; two identifiers can be compared to determine whether they refer to the same binding (i.e., `free-identifier=?`), or whether the identifiers have the same scope set so that each identifier would bind the other if one were in a binding position and the other in an expression position (i.e., `bound-identifier=?`).

For example, when the program written as

```
(let ([x 5]) (+ x 6))
```

is represented as a syntax object, then two syntax objects can be extracted for the two `x`s. Both the `free-identifier=?` and `bound-identifier=?` predicates will indicate that the `x`s are the same. In contrast, the `let` identifier is not `free-identifier=?` or `bound-identifier=?` to either `x`.

The lexical information in a syntax object is independent of the rest of the syntax object, and it can be copied to a new syntax object in combination with an arbitrary other Racket value. Thus, identifier-binding information in a syntax object is predicated on the symbolic name of the identifier as well as the identifier's lexical information; the same question with the same lexical information but different base value can produce a different answer.

For example, combining the lexical information from `let` in the program above to `'x` would not produce an identifier that is `free-identifier=?` to either `x`, since it does not appear in the scope of the `x` binding. Combining the lexical context of the `6` with `'x`, in contrast, would produce an identifier that is `bound-identifier=?` to both `x`s.

The `quote-syntax` form bridges the evaluation of a program and the representation of a program. Specifically, `(quote-syntax datum #:local)` produces a syntax object that preserves all of the lexical information that *`datum`* had when it was parsed as part of the `quote-syntax` form. Note that the `(quote-syntax datum)` form is similar, but it removes certain scopes from the *`datum`*'s scope sets; see `quote-syntax` for more information.

1.2.3 Expansion (Parsing)

Expansion recursively processes a syntax object in a particular phase level, starting with phase level 0. Bindings from the syntax object's lexical information drive the expansion process, and cause new bindings to be introduced for the lexical information of sub-expressions.

In some cases, a sub-expression is expanded in a phase deeper (having a bigger phase level number) than the enclosing expression.

Fully Expanded Programs

A complete expansion produces a syntax object matching the following grammar:

Beware that the symbolic names of identifiers in a fully expanded program may not match the symbolic names in the grammar. Only the binding (according to `free-identifier=?`) matters.

```
     top-level-form = general-top-level-form
                    | (#%expression expr)
                    | (module id module-path
                        (#%plain-module-begin
                         module-level-form ...))
                    | (begin top-level-form ...)
                    | (begin-for-syntax top-level-form ...)

  module-level-form = general-top-level-form
                    | (#%provide raw-provide-spec ...)
                    | (begin-for-syntax module-level-form ...)
                    | submodule-form
                    | (#%declare declaration-keyword ...)

     submodule-form = (module id module-path
                        (#%plain-module-begin
                         module-level-form ...))
                    | (module* id module-path
                        (#%plain-module-begin
                         module-level-form ...))
                    | (module* id #f
                        (#%plain-module-begin
                         module-level-form ...))

general-top-level-form = expr
                    | (define-values (id ...) expr)
                    | (define-syntaxes (id ...) expr)
                    | (#%require raw-require-spec ...)

               expr = id
                    | (#%plain-lambda formals expr ...+)
                    | (case-lambda (formals expr ...+) ...)
                    | (if expr expr expr)
                    | (begin expr ...+)
                    | (begin0 expr expr ...)
                    | (let-values ([(id ...) expr] ...)
                        expr ...+)
                    | (letrec-values ([(id ...) expr] ...)
                        expr ...+)
```

```
                   | (set! id expr)
                   | (quote datum)
                   | (quote-syntax datum)
                   | (quote-syntax datum #:local)
                   | (with-continuation-mark expr expr expr)
                   | (#%plain-app expr ...+)
                   | (#%top . id)
                   | (#%variable-reference id)
                   | (#%variable-reference (#%top . id))
                   | (#%variable-reference)

         formals = (id ...)
                   | (id ...+ . id)
                   | id
```

A *fully-expanded* syntax object corresponds to a *parse* of a program (i.e., a *parsed* program), and lexical information on its identifiers indicates the parse.

More specifically, the typesetting of identifiers in the above grammar is significant. For example, the second case for `expr` is a syntax-object list whose first element is an identifier, where the identifier's lexical information specifies a binding to the `#%plain-lambda` of the `racket/base` language (i.e., the identifier is `free-identifier=?` to one whose binding is `#%plain-lambda`). In all cases, identifiers above typeset as syntactic-form names refer to the bindings defined in §3 "Syntactic Forms".

In a fully expanded program for a namespace whose base phase is 0, the relevant phase level for a binding in the program is *N* if the binding has *N* surrounding `begin-for-syntax` and/or `define-syntaxes` forms—not counting any `begin-for-syntax` forms that wrap a `module` or `module*` form for the body of the `module` or `module*`, unless a `module*` form has `#f` in place of a `module-path` after the `id`. The `datum` in a `quote-syntax` form preserves its information for all phase levels.

A reference to a local binding in a fully expanded program has a scope set that matches its binding identifier exactly. Additional scopes, if any, are removed. As a result, `bound-identifier=?` can be used to correlate local binding identifiers with reference identifiers, while `free-identifier=?` must be used to relate references to module bindings or top-level bindings.

In addition to the grammar above, `#%expression` can appear in a fully local-expanded expression position. For example, `#%expression` can appear in the result from `local-expand` when the stop list is empty. Reference-identifier scope sets are reduced in local-expanded expressions only when the `local-expand` stop list is empty.

Changed in version 6.3 of package `base`: Added the `#:local` variant of `quote-syntax`; removed `letrec-syntaxes+values` from possibly appearing in a fully local-expanded form.

Expansion Steps

In a recursive expansion, each single step in expanding a syntax object at a particular phase level depends on the immediate shape of the syntax object being expanded:

- If it is an identifier (i.e., a syntax-object symbol), then a binding is determined by the identifier's lexical information. If the identifier has a binding, that binding is used to continue. If the identifier is unbound, a new syntax-object symbol `'#%top` is created using the lexical information of the identifier with implicit-made-explicit properties; if this `#%top` identifier has no binding, then parsing fails with an `exn:fail:syntax` exception. Otherwise, the new identifier is combined with the original identifier in a new syntax-object pair (also using the same lexical information as the original identifier), and the `#%top` binding is used to continue.

  Changed in version 6.3 of package `base`: Changed the introduction of `#%top` in a top-level context to unbound identifiers only.

- If it is a syntax-object pair whose first element is an identifier, and if the identifier has a binding other than as a top-level variable, then the identifier's binding is used to continue.

- If it is a syntax-object pair of any other form, then a new syntax-object symbol `'#%app` is created using the lexical information of the pair with implicit-made-explicit properties. If the resulting `#%app` identifier has no binding, parsing fails with an `exn:fail:syntax` exception. Otherwise, the new identifier is combined with the original pair to form a new syntax-object pair (also using the same lexical information as the original pair), and the `#%app` binding is used to continue.

- If it is any other syntax object, then a new syntax-object symbol `'#%datum` is created using the lexical information of the original syntax object with implicit-made-explicit properties. If the resulting `#%datum` identifier has no binding, parsing fails with an `exn:fail:syntax` exception. Otherwise, the new identifier is combined with the original syntax object in a new syntax-object pair (using the same lexical information as the original pair), and the `#%datum` binding is used to continue.

Thus, the possibilities that do not fail lead to an identifier with a particular binding. This binding refers to one of three things:

- A *transformer*, such as introduced by `define-syntax` or `let-syntax`. If the associated value is a procedure of one argument, the procedure is called as a syntax transformer (described below), and parsing starts again with the syntax-object result. If the transformer binding is to any other kind of value, parsing fails with an `exn:fail:syntax` exception. The call to the syntax transformer is `parameterized` to set `current-namespace` to a namespace that shares bindings and variables with the namespace being used to expand, except that its base phase is one greater.

- A variable binding, such as introduced by a module-level `define` or by `let`. In this case, if the form being parsed is just an identifier, then it is parsed as a reference to the corresponding variable. If the form being parsed is a syntax-object pair, then an `#%app` is added to the front of the syntax-object pair in the same way as when the first item in the syntax-object pair is not an identifier (third case in the previous enumeration), and parsing continues.

- A core *syntactic form* (often abbreviated as *core form*), which is parsed as described for each form in §3 "Syntactic Forms". Parsing a core syntactic form typically involves recursive parsing of sub-forms, and may introduce bindings that determine the parsing of sub-forms.

When a `#%top`, `#%app`, or `#%datum` identifier is added by the expander, it is given *implicit-made-explicit properties*: an `'implicit-made-explicit` syntax property whose value is `#t`, and a hidden property to indicate that the implicit identifier is original in the sense of `syntax-original?` if the syntax object that gives the identifier its lexical information has that property.

Changed in version 7.9.0.13 of package `base`: Added implicit-made-explicit properties.

Expansion Context

Each expansion step occurs in a particular *context*, and transformers and core syntactic forms may expand differently for different contexts. For example, a `module` form is allowed only in a top-level context or module context, and it fails in other contexts. The possible contexts are as follows:

- *top-level context* : outside of any module, definition, or expression, except that sub-expressions of a top-level `begin` form are also expanded as top-level forms.
- *module-begin context* : inside the body of a module, as the only form within the module.
- *module context* : in the body of a module (inside the module-begin layer).
- *internal-definition context* : in a nested context that allows both definitions and expressions.
- *expression context* : in a context where only expressions are allowed.

Different core syntactic forms parse sub-forms using different contexts. For example, a `let` form always parses the right-hand expressions of a binding in an expression context, but it starts parsing the body in an internal-definition context.

Introducing Bindings

Bindings are introduced during expansion when certain core syntactic forms are encountered:

- When a `require` form is encountered at the top level or module level, each symbol specified by the form is paired with the scope set of the specification to introduce new bindings. If not otherwise indicated in the `require` form, bindings are introduced at the phase levels specified by the exporting modules: phase level 0 for each normal `provide`, phase level 1 for each `for-syntax provide`, and so on. The `for-meta provide` form allows exports at an arbitrary phase level (as long as a binding exists within the module at the phase level).

  A `for-syntax` sub-form within `require` imports similarly, but the resulting bindings have a phase level that is one more than the exported phase levels, when exports for the label phase level are still imported at the label phase level. More generally, a `for-meta` sub-form within `require` imports with the specified phase level shift; if the specified shift is `#f`, or if `for-label` is used to import, then all bindings are imported into the label phase level.

- When a `define`, `define-values`, `define-syntax`, or `define-syntaxes` form is encountered at the top level or module level, a binding is added to phase level 0 (i.e., the base environment is extended) for each defined identifier.

- When a `begin-for-syntax` form is encountered at the top level or module level, bindings are introduced as for `define-values` and `define-syntaxes`, but at phase level 1 (i.e., the transformer environment is extended). More generally, `begin-for-syntax` forms can be nested, and each `begin-for-syntax` shifts its body by one phase level.

- When a `let-values` form is encountered, the body of the `let-values` form is extended (by creating new syntax objects) with a fresh scope. The scope is added to the identifiers themselves, so that the identifiers in binding position are `bound-identifier=?` to uses in the fully expanded form, and so they are not `bound-identifier=?` to other identifiers. The new bindings are at the phase level at which the `let-values` form is expanded.

- When a `letrec-values` or `letrec-syntaxes+values` form is encountered, bindings are added as for `let-values`, except that the right-hand-side expressions are also extended with the new scope.

- Definitions in internal-definition contexts introduce new scopes and bindings as described in §1.2.3.8 “Internal Definitions”.

For example, in

```
(let-values ([(x) 10]) (+ x y))
```

the binding introduced for `x` applies to the `x` in the body, because a fresh scope is created and added to both the binding `x` and reference `x`. The same scope is added to the `y`, but since it has a different symbol than the binding `x`, it does not refer to the new binding. Any `x` outside of this `let-values` form does not receive the fresh scope and therefore does not refer to the new binding.

Transformer Bindings

In a top-level context or module context, when the expander encounters a `define-syntaxes` form, the binding that it introduces for the defined identifiers is a transformer binding. The value of the binding exists at expansion time, rather than run time (though the two times can overlap), though the binding itself is introduced with phase level 0 (i.e., in the base environment).

The value for the binding is obtained by evaluating the expression in the `define-syntaxes` form. This expression must be expanded (i.e., parsed) before it can be evaluated, and it is expanded at phase level 1 (i.e., in the transformer environment) instead of phase level 0.

If the resulting value is a procedure of one argument or the result of `make-set!-transformer` on a procedure, then it is used as a *syntax transformer* (a.k.a. *macro*). The procedure is expected to accept a syntax object and return a syntax object. A use of the binding (at phase level 0) triggers a call of the syntax transformer by the expander; see §1.2.3.2 "Expansion Steps".

Before the expander passes a syntax object to a transformer, the syntax object is extended with a fresh *macro-introduction scope* (that applies to all sub-syntax objects) to distinguish syntax objects at the macro's use site from syntax objects that are introduced by the macro; in the result of the transformer the presence of the scope is flipped, so that introduced syntax objects retain the scope, and use-site syntax objects do not have it. In addition, if the use of a transformer is in the same definition context as its binding, the use-site syntax object is extended with an additional fresh *use-site scope* that is not flipped in the transformer's result, so that only use-site syntax objects have the use-site scope.

The scope-introduction process for macro expansion helps keep binding in an expanded program consistent with the lexical structure of the source program. For example, the expanded form of the program

```
(define x 12)
(define-syntax m
  (syntax-rules ()
    [(_ id) (let ([x 10]) id)]))
(m x)
```

is

```
(define x 12)
(define-syntax m ....)
(let ([x 10]) x)
```

However, the result of the last expression is `12`, not `10`. The reason is that the transformer bound to `m` introduces the binding `x`, but the referencing `x` is present in the argument to the transformer. The introduced `x` is left with one fresh scope, while the reference `x` has a different fresh scope, so the binding `x` is not `bound-identifier=?` to the body `x`.

A use-site scope on a binding identifier is ignored when the definition is in the same context where the use-site scope was introduced. This special treatment of use-site scopes allows a macro to expand to a visible definition. For example, the expanded form of the program

```
(define-syntax m
  (syntax-rules ()
    [(_ id) (define id 5)]))
(m x)
x
```

is

```
(define-syntax m ....)
(define x 5)
x
```

where the `x` in the `define` form has a use-site scope that is not present on the final `x`. The final `x` nevertheless refers to the definition, because the use-site scope is effectively removed before installing the definition's binding. In contrast, the expansion of

```
(define-syntax m
  (syntax-rules ()
    [(_ id) (let ([x 4])
              (let ([id 5])
                x))]))
(m x)
```

is

```
(define-syntax m ....)
(let ([x 4])
  (let ([x 5])
    x))
```

where the second `x` has a use-site scope that prevents it from binding the final `x`. The use-site scope is not ignored in this case, because the binding is not part of the definition context where `(m x)` was expanded.

The `set!` form works with the `make-set!-transformer` and `prop:set!-transformer` property to support *assignment transformers* that transform `set!` expressions. An assignment transformer contains a procedure that is applied by `set!` in the same way as a normal transformer by the expander.

The `make-rename-transformer` procedure or `prop:rename-transformer` property creates a value that is also handled specially by the expander and by `set!` as a transformer binding's value. When *id* is bound to a *rename transformer* produced by make-rename-transformer, it is replaced with the target identifier passed to make-rename-transformer. In addition, as long as the target identifier does not have a true value for the 'not-free-identifier=? syntax property, the binding table is extended to indicate that *id* is an alias for the identifier in the rename transformer. The free-identifier=? function follows aliasing chains to determine equality of bindings, the identifier-binding function similarly follows aliasing chains, and the provide form exports *id* as the target identifier. Finally, the syntax-local-value function follows rename transformer chains even when binding aliases are not installed.

In addition to using scopes to track introduced identifiers, the expander tracks the expansion history of a form through syntax properties such as 'origin. See §12.7 "Syntax Object Properties" for more information.

The expander's handling of letrec-syntaxes+values is similar to its handling of define-syntaxes. A letrec-syntaxes+values can be expanded in an arbitrary phase level *n* (not just 0), in which case the expression for the transformer binding is expanded at phase level *n*+1.

The expressions in a begin-for-syntax form are expanded and evaluated in the same way as for define-syntaxes. However, any introduced bindings from definition within begin-for-syntax are at phase level 1 (not a transformer binding at phase level 0).

Local Binding Context

Although the binding of an identifier can be uniquely determined from the combination of its lexical information and the global binding table, the expander also maintains a *local binding context* that records additional information about local bindings to ensure they are not used outside of the lexical region in which they are bound.

Due to the way local binding forms like let add a fresh scope to both bound identifiers and body forms, it isn't ordinarily possible for an identifier to reference a local binding without appearing in the body of the let. However, if macros use compile-time state to stash bound identifiers, or use local-expand to extract identifiers from an expanded binding form, they can violate this constraint. For example, the following stash-id and unstash-id macros cooperate to move a reference to a locally-bound x identifier outside of the lexical region in which it is bound:

```
> (begin-for-syntax
    (define stashed-id #f))
> (define-syntax (stash-id stx)
    (syntax-case stx ()
      [(_ id)
       (begin
         (set! stashed-id #'id)
         #'(void))]))
> (define-syntax (unstash-id stx)
```

```
    stashed-id)
> (let ([x 42])
    (stash-id x)
    (unstash-id))
42
> (unstash-id)
eval:5:0: x: identifier used out of context
  in: x
```

In general, an identifier's lexical information is not sufficient to know whether or not its binding is available in the enclosing context, since the scope set for the identifier stored in `stashed-id` unambiguously refers to a binding in the global binding table. This can be observed by the fact that `identifier-binding` produces `'lexical`, not `#f`:

```
> (define-syntax (stashed-id-binding stx)
    #`'#,(identifier-binding stashed-id))
> (stashed-id-binding)
'lexical
```

However, the reference produced by `(unstash-id)` in the above program is still illegal, even if it isn't technically unbound. To record the fact that `x`'s binding is in scope only within the body of its corresponding `let` form, the expander adds `x`'s binding to the local binding context while expanding the `let` body. More generally, the expander adds all local variable bindings to the local binding context while expanding expressions in which a reference to the variable would be legal. When the expander encounters an identifier bound to a local variable, and the associated binding is not in the current local binding context, it raises a syntax error.

The local binding context also tracks local transformer bindings (i.e. bindings bound by forms like `let-syntax`) in a similar way, except that the context also stores the compile-time value associated with the transformer. When an identifier that is locally bound as a transformer is used in application position as a syntax transformer, or its compile-time value is looked up using `syntax-local-value`, the local binding context is consulted to retrieve the value. If the binding is in scope, its associated compile-time value is used; otherwise, the expander raises a syntax error.

Examples:

```
> (define-syntax (stashed-id-local-value stx)
    #`'#,(syntax-local-value stashed-id))
> (let-syntax ([y 42])
    (stash-id y)
    (stashed-id-local-value))
42
> (stashed-id-local-value)
syntax-local-value: identifier is not bound to syntax:
```

#<syntax:eval:11:0 y>

Partial Expansion

In certain contexts, such as an internal-definition context or module context, *partial expansion* is used to determine whether forms represent definitions, expressions, or other declaration forms. Partial expansion works by cutting off the normal recursive expansion when the relevant binding is for a primitive syntactic form.

As a special case, when expansion would otherwise add an `#%app`, `#%datum`, or `#%top` identifier to an expression, and when the binding turns out to be the primitive `#%app`, `#%datum`, or `#%top` form, then expansion stops without adding the identifier.

Internal Definitions

An internal-definition context supports local definitions mixed with expressions. Forms that allow internal definitions document such positions using the *`body`* meta-variable. Definitions in an internal-definition context are equivalent to local binding via `letrec-syntaxes+values`; macro expansion converts internal definitions to a `letrec-syntaxes+values` form.

Expansion relies on partial expansion of each *`body`* in an internal-definition sequence. Partial expansion of each *`body`* produces a form matching one of the following cases:

- A `define-values` form: The binding table is immediately enriched with bindings for the `define-values` form. Further expansion of the definition is deferred, and partial expansion continues with the rest of the body.
- A `define-syntaxes` form: The right-hand side is expanded and evaluated (as for a `letrec-syntaxes+values` form), and a transformer binding is installed for the body sequence before partial expansion continues with the rest of the body.
- A primitive expression form other than `begin`: Further expansion of the expression is deferred, and partial expansion continues with the rest of the body.
- A `begin` form: The sub-forms of the `begin` are spliced into the internal-definition sequence, and partial expansion continues with the first of the newly-spliced forms (or the next form, if the `begin` had no sub-forms).

After all body forms are partially expanded, if no definitions were encountered, then the expressions are collected into a `begin` form as the internal-definition context's expansion. Otherwise, at least one expression must appear after the last definition, and any *`expr`* that appears between definitions is converted to `(define-values () (begin expr (values)))`; the definitions are then converted to bindings in a `letrec-syntaxes+values` form, and all expressions after the last definition become the body of the `letrec-syntaxes+values` form.

Before partial expansion begins, expansion of an internal-definition context begins with the introduction of a fresh *outside-edge scope* on the content of the internal-definition context. This outside-edge scope effectively identifies syntax objects that are present in the original form. An *inside-edge scope* is also created and added to the original content; furthermore, the inside-edge scope is added to the result of any partial expansion. This inside-edge scope ensures that all bindings introduced by the internal-definition context have a particular scope in common.

Module Expansion, Phases, and Visits

Expansion of a `module` form proceeds in a similar way to expansion of an internal-definition context: an outside-edge scope is created for the original module content, and an inside-edge scope is added to both the original module and any form that appears during a partial expansion of the module's top-level forms to uncover definitions and imports.

A `require` form not only introduces bindings at expansion time, but also *visits* the referenced module when it is encountered by the expander. That is, the expander instantiates any variables defined in the module within `begin-for-syntax`, and it also evaluates all expressions for `define-syntaxes` transformer bindings.

Module visits propagate through `requires` in the same way as module instantiation. Moreover, when a module is visited at phase 0, any module that it `requires` `for-syntax` is instantiated at phase 1, while further `requires` `for-template` leading back to phase 0 causes the required module to be visited at phase 0 (i.e., not instantiated).

During compilation, the top-level of module context is itself implicitly visited. Thus, when the expander encounters `(require (for-syntax ....))`, it immediately instantiates the required module at phase 1, in addition to adding bindings at phase level 1 (i.e., the transformer environment). Similarly, the expander immediately evaluates any form that it encounters within `begin-for-syntax`.

Phases beyond 0 are visited on demand. For example, when the right-hand side of a phase-0 `let-syntax` is to be expanded, then modules that are available at phase 1 are visited. More generally, initiating expansion at phase n visits modules at phase n, which in turn instantiates modules at phase n+1. These visits and instantiations apply to available modules in the enclosing namespace's module registry; a per-registry lock prevents multiple threads from concurrently instantiating and visiting available modules. On-demand instantiation of available modules uses the same reentrant lock as `namespace-call-with-registry-lock`.

When the expander encounters `require` and `(require (for-syntax ....))` within a module context, the resulting visits and instantiations are specific to the expansion of the enclosing module, and are kept separate from visits and instantiations triggered from a top-level context or from the expansion of a different module. Along the same lines, when a module is attached to a namespace through `namespace-attach-module`, modules that it `requires` are transitively attached, but instances are attached only at phases at or below the namespace's base phase.

When a module is instantiated at a phase other than 0, any syntax literals in the module are shifted by the instantiation phase. When a module is imported with `for-label`, then provided bindings from multiple phases are all mapped to the label phase level, and they are unaffected by further phase shifting of a syntax object with those bindings. When a syntax object is shifted into the label phase level, however, only bindings in phase level 0 become bindings in the label phase level, and further phase shifting can adjust which of the original phase levels is shifted into the label phase; see `syntax-shift-phase-level`.

Macro-Introduced Bindings

When a top-level definition binds an identifier that originates from a macro expansion, the definition captures only uses of the identifier that are generated by the same expansion due to the fresh scope that is generated for the expansion.

Examples:

```
> (define-syntax def-and-use-of-x
    (syntax-rules ()
      [(def-and-use-of-x val)
       ; x below originates from this macro:
       (begin (define x val) x)]))
> (define x 1)
> x
1
> (def-and-use-of-x 2)
2
> x
1
> (define-syntax def-and-use
    (syntax-rules ()
      [(def-and-use x val)
       ; "x" below was provided by the macro use:
       (begin (define x val) x)]))
> (def-and-use x 3)
3
> x
3
```

For a top-level definition (outside of a module), the order of evaluation affects the binding of a generated definition for a generated identifier use. If the use precedes the definition, then the use is resolved with the bindings that are in place at that point, which will not include the binding from the subsequently macro-generated definition. (No such dependency on order occurs within a module, since a module binding covers the entire module body.) To support the declaration of an identifier before its use, the `define-syntaxes` form avoids binding an identifier if the body of the `define-syntaxes` declaration produces zero results.

Examples:

```
> (define bucket-1 0)
> (define bucket-2 0)
> (define-syntax def-and-set!-use-of-x
    (syntax-rules ()
      [(def-and-set!-use-of-x val)
       (begin (set! bucket-1 x) (define x val) (set! bucket-
2 x))]))
> (define x 1)
> (def-and-set!-use-of-x 2)
> x
1
> bucket-1
1
> bucket-2
2
> (define-syntax defs-and-uses/fail
    (syntax-rules ()
      [(def-and-use)
       (begin
         ; Initial reference to even precedes definition:
         (define (odd x) (if (zero? x) #f (even (sub1 x))))
         (define (even x) (if (zero? x) #t (odd (sub1 x))))
         (odd 17))]))
> (defs-and-uses/fail)
even: undefined;
 cannot reference an identifier before its definition
  in module: top-level
> (define-syntax defs-and-uses
    (syntax-rules ()
      [(def-and-use)
       (begin
         ; Declare before definition via no-values define-
syntaxes:
         (define-syntaxes (odd even) (values))
         (define (odd x) (if (zero? x) #f (even (sub1 x))))
         (define (even x) (if (zero? x) #t (odd (sub1 x))))
         (odd 17))]))
> (defs-and-uses)
#t
```

Macro-generated `require` and `provide` clauses also introduce and reference generation-specific bindings (due to the added scope) with the same ordering effects as for definitions. The bindings depend on the scope set attached to specific parts of the form:

- In `require`, for a *`require-spec`* of the form `(rename-in [`*`orig-id bind-id`*`])` or (`only-in .... [`*`orig-id bind-id`*`]`), the *`bind-id`* supplies the scope set for the binding. In `require` for other *`require-spec`*s, the generator of the *`require-spec`* determines the scope set.

- In `provide`, for a *`provide-spec`* of the form *`id`*, the exported identifier is the one that binds *`id`*, but the external name is the plain, symbolic part of *`id`*. The exceptions for `all-except-out` are similarly determined, as is the *`orig-id`* binding of a `rename-out` form, and plain symbols are used for the external names. For `all-defined-out`, only identifiers with definitions having only the scopes of `(all-defined-out)` form are exported; the external name is the plain symbol from the definition.

1.2.4 Compilation

Before expanded code is evaluated, it is first *compiled*. A compiled form has essentially the same information as the corresponding expanded form, though the internal representation naturally dispenses with identifiers for syntactic forms and local bindings. One significant difference is that a compiled form is almost entirely opaque, so the information that it contains cannot be accessed directly (which is why some identifiers can be dropped). At the same time, a compiled form can be marshaled to and from a byte string, so it is suitable for saving and re-loading code.

Although individual read, expand, compile, and evaluate operations are available, the operations are often combined automatically. For example, the `eval` procedure takes a syntax object and expands it, compiles it, and evaluates it.

1.2.5 Namespaces

See §14.1 "Namespaces" for functions that manipulate namespaces.

A *namespace* is both a starting point for parsing and a starting point for running compiled code. A namespace also has a *module registry* that maps module names to module declarations (see §1.1.9 "Modules and Module-Level Variables"). This registry is shared by all phase levels, and it applies both to parsing and to running compiled code.

As a starting point for parsing, a namespace provides scopes (one per phase level, plus one that spans all phase levels). Operations such as `namespace-require` create initial bindings using the namespace's scopes, and the further expansion and evaluation in the namespace can create additional bindings. Evaluation of a form with a namespace always adds the namespace's phase-specific scopes to the form and to the result of expanding a top-level form; as a consequence, every binding identifier has at least one scope. The namespace's additional scope is added only on request (e.g., by using `eval` as opposed to `eval-syntax`); if requested, the additional scope is added at all phase levels. Except for namespaces generated by a module (see `module->namespace`), every namespace uses the same scope as the one added to all phase levels, while the scopes specific to a phase level are always distinct.

As a starting point for evaluating compiled code, each namespace encapsulates a distinct set of top-level variables at various phases, as well as a potentially distinct set of module instances in each phase. That is, even though module declarations are shared for all phase levels, module instances are distinct for each phase. Each namespace has a *base phase*, which corresponds to the phase used by reflective operations such as `eval` and `dynamic-require`. In particular, using `eval` on a `require` form instantiates a module in the namespace's base phase.

After a namespace is created, module instances from existing namespaces can be attached to the new namespace. In terms of the evaluation model, top-level variables from different namespaces essentially correspond to definitions with different prefixes, but attaching a module uses the same prefix for the module's definitions in namespaces where it is attached. The first step in evaluating any compiled expression is to link its top-level variable and module-level variable references to specific variables in the namespace.

At all times during evaluation, some namespace is designated as the *current namespace*. The current namespace has no particular relationship, however, with the namespace that was used to expand the code that is executing, or with the namespace that was used to link the compiled form of the currently evaluating code. In particular, changing the current namespace during evaluation does not change the variables to which executing expressions refer. The current namespace only determines the behavior of reflective operations to expand code and to start evaluating expanded/compiled code.

Examples:

```
> (define x 'orig) ; define in the original namespace
; The following let expression is compiled in the original
; namespace, so direct references to x see 'orig.
> (let ([n (make-base-namespace)]) ; make new namespace
    (parameterize ([current-namespace n])
      (eval '(define x 'new)) ; evals in the new namespace
      (display x) ; displays 'orig
      (display (eval 'x)))) ; displays 'new
orignew
```

If an identifier is bound to syntax or to an import, then defining the identifier as a variable shadows the syntax or import in future uses of the environment. Similarly, if an identifier is bound to a top-level variable, then binding the identifier to syntax or an import shadows the variable; the variable's value remains unchanged, however, and may be accessible through previously evaluated expressions.

Examples:

```
> (define x 5)
> (define (f) x)
> x
5
```

```
> (f)
5
> (define-syntax x (syntax-id-rules () [_ 10]))
> x
10
> (f)
5
> (define x 7)
> x
7
> (f)
7
> (module m racket (define x 8) (provide x))
> (require 'm)
> x
8
> (f)
7
```

Like a top-level namespace, each `module` form has an associated scope to span all phase levels of the module's content, plus a scope at each phase level. The latter is added to every form, original or appearing through partial macro expansion, within the module's immediate body. Those same scopes are propagated to a namespace created by `module->namespace` for the module. Meanwhile, parsing of a `module` form begins by removing the all scopes that correspond to the enclosing top-level or (in the case of submodules) `module` and `module*` forms.

1.2.6 Inferred Value Names

To improve error reporting, names are inferred at compile-time for certain kinds of values, such as procedures. For example, evaluating the following expression:

```
(let ([f (lambda () 0)]) (f 1 2 3))
```

produces an error message because too many arguments are provided to the procedure. The error message is able to report `f` as the name of the procedure. In this case, Racket decides, at compile-time, to name as `'f` all procedures created by the `let`-bound `lambda`.

See `procedure-rename` to override a procedure's inferred name at runtime.

Names are inferred whenever possible for procedures. Names closer to an expression take precedence. For example, in

```
(define my-f
  (let ([f (lambda () 0)]) f))
```

the procedure bound to `my-f` will have the inferred name `'f`.

When an `'inferred-name` property is attached to a syntax object for an expression (see §12.7 "Syntax Object Properties"), the property value is used for naming the expression, and it overrides any name that was inferred from the expression's context. Normally, the property value should be a symbol. A `'inferred-name` property value of `#<void>` hides a name that would otherwise be inferred from context (perhaps to avoid exposing an identifier from an automatically generated binding).

To support the propagation and merging of consistent properties during expansions, the value of the `'inferred-name` property can be a tree formed with `cons` where all of the leaves are the same. For example, `(cons 'name 'name)` is equivalent to `'name`, and `(cons (void) (void))` is equivalent to `#<void>`.

When an inferred name is not available, but a source location is available, a name is constructed using the source location information. Inferred and property-assigned names are also available to syntax transformers, via `syntax-local-name`.

1.2.7 Cross-Phase Persistent Module Declarations

A module is cross-phase persistent only if it fits the following grammar, which uses non-terminals from §1.2.3.1 "Fully Expanded Programs", only if it includes `(#%declare #:cross-phase-persistent)`, only it includes no uses of `quote-syntax` or `#%variable-reference`, and only if no module-level binding is `set!`ed.

```
cross-module = (module id module-path
                 (#%plain-module-begin
                   cross-form ...))

  cross-form = (#%declare #:cross-phase-persistent)
             | (begin cross-form ...)
             | (#%provide raw-provide-spec ...)
             | submodule-form
             | (define-values (id ...) cross-expr)
             | (#%require raw-require-spec ...)

  cross-expr = id
             | (quote cross-datum)
             | (#%plain-lambda formals expr ...+)
             | (case-lambda (formals expr ...+) ...)
             | (#%plain-app cons cross-expr ...+)
             | (#%plain-app list cross-expr ...+)
             | (#%plain-app hasheq cross-expr ...+)
             | (#%plain-app make-struct-type cross-expr ...+)
```

```
                | (#%plain-app make-struct-type-property
                                cross-expr ...+)
                | (#%plain-app make-parameter cross-expr ...+)
                | (#%plain-app gensym)
                | (#%plain-app gensym string)
                | (#%plain-app string->uninterned-symbol string)
                | (#%plain-app variable-reference-from-unsafe?
                                (#%variable-reference))

   cross-datum = number
                | boolean
                | identifier
                | string
                | bytes
                | ()
```

This grammar applies after expansion, but because a cross-phase persistent module imports only from other cross-phase persistent modules, the only relevant expansion steps are the implicit introduction of `#%plain-module-begin`, implicit introduction of `#%plain-app`, and implicit introduction and/or expansion of `#%datum`.

Changed in version 7.5.0.12 of package `base`: Allow `(#%plain-app variable-reference-from-unsafe? (#%variable-reference))`.
Changed in version 8.15.0.4: Allow `(#%plain-app hasheq cross-expr ...+)` and `(#%plain-app make-parameter cross-expr ...+)`.

1.3 The Reader

Racket's reader is a recursive-descent parser that can be configured through a readtable and various other parameters. This section describes the reader's parsing when using the default readtable.

Reading from a stream produces one *datum*. If the result datum is a compound value, then reading the datum typically requires the reader to call itself recursively to read the component data.

The reader can be invoked in either of two modes: `read` mode, or `read-syntax` mode. In `read-syntax` mode, the result is always a syntax object that includes source-location and (initially empty) lexical information wrapped around the sort of datum that `read` mode would produce. In the case of pairs, vectors, and boxes, the content is also wrapped recursively as a syntax object. Unless specified otherwise, this section describes the reader's behavior in `read` mode, and `read-syntax` mode does the same modulo wrapping of the final result.

Reading is defined in terms of Unicode characters; see §13.1 "Ports" for information on how a byte stream is converted to a character stream.

Symbols, keywords, strings, byte strings, regexps, characters, and numbers produced by the reader in `read-syntax` mode are *interned*, which means that such values in the result of `read-syntax` are always `eq?` when they are `equal?` (whether from the same call or different calls to `read-syntax`). Symbols and keywords are interned in both `read` and `read-syntax` mode. When a quoted value is in compiled code that written and then read back in (see §1.4.16 "Printing Compiled Code"), only strings and byte strings are interned when reading the code. Sending an interned value across a place channel does not necessarily produce an interned value at the receiving place. See also `datum-intern-literal` and `datum->syntax`.

Note that interned values are only weakly held by the reader's internal table, so they may be garbage collected if they are no longer otherwise reachable. This weakness can never affect the result of an `eq?`, `eqv?`, or `equal?` test, but an interned value may disappear when placed into a weak box (see §16.1 "Weak Boxes"), used as the key in a weak hash table (see §4.15 "Hash Tables"), or used as an ephemeron key (see §16.2 "Ephemerons").

1.3.1 Delimiters and Dispatch

Along with whitespace and a BOM character, the following characters are *delimiters*:

`(` `)` `[` `]` `{` `}` `"` `,` `'` `` ` `` `;`

A delimited sequence that starts with any other character is typically parsed as either a symbol, number, or extflonum, but a few non-delimiter characters play special roles:

- `#` has a special meaning as an initial character in a delimited sequence; its meaning depends on the characters that follow; see below.
- `|` starts a subsequence of characters to be included verbatim in the delimited sequence (i.e., they are never treated as delimiters, and they are not case-folded when case-insensitivity is enabled); the subsequence is terminated by another `|`, and neither the initial nor terminating `|` is part of the subsequence.
- `\` outside of a `|` pair causes the following character to be included verbatim in a delimited sequence.

More precisely, after skipping whitespace and `#\uFEFF` BOM characters, the reader dispatches based on the next character or characters in the input stream as follows:

`(` starts a pair or list; see §1.3.6 "Reading Pairs and Lists"
`[` starts a pair or list; see §1.3.6 "Reading Pairs and Lists"
`{` starts a pair or list; see §1.3.6 "Reading Pairs and Lists"
`)` matches `(` or raises `exn:fail:read`

`]` matches `[` or raises `exn:fail:read`
`}` matches `{` or raises `exn:fail:read`
`"` starts a string; see §1.3.7 “Reading Strings”
`'` starts a quote; see §1.3.8 “Reading Quotes”
`` ` `` starts a quasiquote; see §1.3.8 “Reading Quotes”
`,` starts a [splicing] unquote; see §1.3.8 “Reading Quotes”
`;` starts a line comment; see §1.3.9 “Reading Comments”
`#t` or `#T` true; see §1.3.5 “Reading Booleans”
`#f` or `#F` false; see §1.3.5 “Reading Booleans”
`#(` starts a vector; see §1.3.10 “Reading Vectors”
`#[` starts a vector; see §1.3.10 “Reading Vectors”
`#{` starts a vector; see §1.3.10 “Reading Vectors”
`#fl(` or `#Fl(` starts a flvector; see §1.3.10 “Reading Vectors”
`#fl[` or `#Fl[` starts a flvector; see §1.3.10 “Reading Vectors”
`#fl{` or `#Fl{` starts a flvector; see §1.3.10 “Reading Vectors”
`#fx(` or `#Fx(` starts a fxvector; see §1.3.10 “Reading Vectors”
`#fx[` or `#Fx[` starts a fxvector; see §1.3.10 “Reading Vectors”
`#fx{` or `#Fx{` starts a fxvector; see §1.3.10 “Reading Vectors”
`#s(` starts a structure literal; see §1.3.11 “Reading Structures”
`#s[` starts a structure literal; see §1.3.11 “Reading Structures”
`#s{` starts a structure literal; see §1.3.11 “Reading Structures”
`#\` starts a character; see §1.3.14 “Reading Characters”
`#"` starts a byte string; see §1.3.7 “Reading Strings”
`#%` starts a symbol; see §1.3.2 “Reading Symbols”
`#:` starts a keyword; see §1.3.15 “Reading Keywords”
`#&` starts a box; see §1.3.13 “Reading Boxes”
`#|` starts a block comment; see §1.3.9 “Reading Comments”
`#;` starts an S-expression comment; see §1.3.9 “Reading Comments”
`#'` starts a syntax quote; see §1.3.8 “Reading Quotes”
`#! ` starts a line comment; see §1.3.9 “Reading Comments”
`#!/` starts a line comment; see §1.3.9 “Reading Comments”
`#!` may start a reader extension; see §1.3.18 “Reading via an Extension”
``#` `` starts a syntax quasiquote; see §1.3.8 “Reading Quotes”
`#,` starts a syntax [splicing] unquote; see §1.3.8 “Reading Quotes”
`#~` starts compiled code; see §1.4.16 “Printing Compiled Code”
`#i` or `#I` starts a number; see §1.3.3 “Reading Numbers”
`#e` or `#E` starts a number; see §1.3.3 “Reading Numbers”
`#x` or `#X` starts a number or extflonum; see §1.3.3 “Reading Numbers”
`#o` or `#O` starts a number or extflonum; see §1.3.3 “Reading Numbers”
`#d` or `#D` starts a number or extflonum; see §1.3.3 “Reading Numbers”
`#b` or `#B` starts a number or extflonum; see §1.3.3 “Reading Numbers”
`#<<` starts a string; see §1.3.7 “Reading Strings”
`#rx` starts a regular expression; see §1.3.16 “Reading Regular Expressions”
`#px` starts a regular expression; see §1.3.16 “Reading Regular Expressions”
`#ci`, `#cI`, `#Ci`, or `#CI` switches case sensitivity; see §1.3.2 “Reading Symbols”
`#cs`, `#cS`, `#Cs`, or `#CS` switches case sensitivity; see §1.3.2 “Reading Symbols”

`#hash`	starts a hash table; see §1.3.12 "Reading Hash Tables"
`#reader`	starts a reader extension use; see §1.3.18 "Reading via an Extension"
`#lang`	starts a reader extension use; see §1.3.18 "Reading via an Extension"
`#`⟨*digit10*⟩+`(`	starts a vector; see §1.3.10 "Reading Vectors"
`#`⟨*digit10*⟩+`[`	starts a vector; see §1.3.10 "Reading Vectors"
`#`⟨*digit10*⟩+`{`	starts a vector; see §1.3.10 "Reading Vectors"
`#fl`⟨*digit10*⟩+`(`	starts a flvector; see §1.3.10 "Reading Vectors"
`#fl`⟨*digit10*⟩+`[`	starts a flvector; see §1.3.10 "Reading Vectors"
`#fl`⟨*digit10*⟩+`{`	starts a flvector; see §1.3.10 "Reading Vectors"
`#Fl`⟨*digit10*⟩+`(`	starts a flvector; see §1.3.10 "Reading Vectors"
`#Fl`⟨*digit10*⟩+`[`	starts a flvector; see §1.3.10 "Reading Vectors"
`#Fl`⟨*digit10*⟩+`{`	starts a flvector; see §1.3.10 "Reading Vectors"
`#fx`⟨*digit10*⟩+`(`	starts a fxvector; see §1.3.10 "Reading Vectors"
`#fx`⟨*digit10*⟩+`[`	starts a fxvector; see §1.3.10 "Reading Vectors"
`#fx`⟨*digit10*⟩+`{`	starts a fxvector; see §1.3.10 "Reading Vectors"
`#Fx`⟨*digit10*⟩+`(`	starts a fxvector; see §1.3.10 "Reading Vectors"
`#Fx`⟨*digit10*⟩+`[`	starts a fxvector; see §1.3.10 "Reading Vectors"
`#Fx`⟨*digit10*⟩+`{`	starts a fxvector; see §1.3.10 "Reading Vectors"
`#`⟨*digit10*⟩{1,8}`=`	binds a graph tag; see §1.3.17 "Reading Graph Structure"
`#`⟨*digit10*⟩{1,8}`#`	uses a graph tag; see §1.3.17 "Reading Graph Structure"
otherwise	starts a symbol; see §1.3.2 "Reading Symbols"

Changed in version 7.8.0.9 of package `base`: Changed treatment of the BOM character so that it is treated like whitespace in the same places that comments are allowed.

1.3.2 Reading Symbols

§3.6 "Symbols" in *The Racket Guide* introduces the syntax of symbols.

A sequence that does not start with a delimiter or `#` is parsed as either a symbol, a number (see §1.3.3 "Reading Numbers"), or a extflonum (see §1.3.4 "Reading Extflonums"), except that `.` by itself is never parsed as a symbol or number (unless the `read-accept-dot` parameter is set to `#f`). A successful number or extflonum parse takes precedence over a symbol parse. A `#%` also starts a symbol. The resulting symbol is interned. See the start of §1.3.1 "Delimiters and Dispatch" for information about `|` and `\` in parsing symbols.

When the `read-case-sensitive` parameter is set to `#f`, characters in the sequence that are not quoted by `|` or `\` are first case-normalized. If the reader encounters `#ci`, `#CI`, `#Ci`, or `#cI`, then it recursively reads the following datum in case-insensitive mode. If the reader encounters `#cs`, `#CS`, `#Cs`, or `#cS`, then it recursively reads the following datum in case-sensitive mode.

Examples:

`Apple`	reads equal to `(string->symbol "Apple")`
`Ap#ple`	reads equal to `(string->symbol "Ap#ple")`
`Ap ple`	reads equal to `(string->symbol "Ap")`
`Ap| |ple`	reads equal to `(string->symbol "Ap ple")`

`Ap\ ple`	reads equal to	`(string->symbol "Ap ple")`
`#ci Apple`	reads equal to	`(string->symbol "apple")`
`#ci |A|pple`	reads equal to	`(string->symbol "Apple")`
`#ci \Apple`	reads equal to	`(string->symbol "Apple")`
`#ci#cs Apple`	reads equal to	`(string->symbol "Apple")`
`#%Apple`	reads equal to	`(string->symbol "#%Apple")`

1.3.3 Reading Numbers

§3.2 "Numbers" in *The Racket Guide* introduces the syntax of numbers.

A sequence that does not start with a delimiter is parsed as a number when it matches the following grammar case-insensitively for ⟨*number*$_{10}$⟩ (decimal), where *n* is a meta-meta-variable in the grammar. The resulting number is interned in `read-syntax` mode.

A number is optionally prefixed by an exactness specifier, `#e` (exact) or `#i` (inexact), which specifies its parsing as an exact or inexact number; see §4.3 "Numbers" for information on number exactness. As the non-terminal names suggest, a number that has no exactness specifier and matches only ⟨*inexact-number*$_n$⟩ is normally parsed as an inexact number, otherwise it is parsed as an exact number. If the `read-decimal-as-inexact` parameter is set to `#f`, then all numbers without an exactness specifier are instead parsed as exact.

If the reader encounters `#b` (binary), `#o` (octal), `#d` (decimal), or `#x` (hexadecimal), it must be followed by a sequence that is terminated by a delimiter or end-of-file, and that is either an extflonum (see §1.3.4 "Reading Extflonums") or matches the ⟨*general-number*$_2$⟩, ⟨*general-number*$_8$⟩, ⟨*general-number*$_{10}$⟩, or ⟨*general-number*$_{16}$⟩ grammar, respectively.

A `#e` or `#i` followed immediately by `#b`, `#o`, `#d`, or `#x` is treated the same as the reverse order: `#b`, `#o`, `#d`, or `#x` followed by `#e` or `#i`.

An ⟨*exponent-mark*$_n$⟩ in an inexact number serves both to specify an exponent and to specify a numerical precision. If single-flonums are supported (see §4.3 "Numbers") and the `read-single-flonum` parameter is set to `#t`, the marks `f` and `s` specify single-flonums. If `read-single-flonum` is set to `#f`, or with any other mark, a double-precision flonum is produced. If single-flonums are not supported and `read-single-flonum` is set to `#t`, then the `exn:fail:unsupported` exception is raised when a single-flonum would otherwise be produced. Special infinity and not-a-number flonums and single-flonums are distinct; specials with the `.0` suffix, like `+nan.0`, are double-precision flonums, while specials with the `.f` suffix, like `+nan.f`, are single-flonums if enabled though `read-single-flonum`.

A `#` in an ⟨*inexact*$_n$⟩ number is the same as `0`, but `#` can be used to suggest that the digit's actual value is unknown.

All letters in a number representation are parsed case-insensitively, independent of the `read-case-sensitive` parameter. For example, `#I#D+InF.F+3I` is parsed the same as `#i#d+inf.f+3i`. In the grammar below, each literal lowercase letter stands for both itself and its uppercase form.

⟨*number*$_n$⟩	::=	⟨*exact*$_n$⟩ | ⟨*inexact*$_n$⟩
⟨*exact*$_n$⟩	::=	⟨*exact-rational*$_n$⟩ | ⟨*exact-complex*$_n$⟩
⟨*exact-rational*$_n$⟩	::=	[⟨*sign*⟩] ⟨*unsigned-rational*$_n$⟩
⟨*unsigned-rational*$_n$⟩	::=	⟨*unsigned-integer*$_n$⟩
	|	⟨*unsigned-integer*$_n$⟩ `/` ⟨*unsigned-integer*$_n$⟩
⟨*exact-integer*$_n$⟩	::=	[⟨*sign*⟩] ⟨*unsigned-integer*$_n$⟩
⟨*unsigned-integer*$_n$⟩	::=	⟨*digit*$_n$⟩$^+$
⟨*exact-complex*$_n$⟩	::=	[⟨*exact-rational*$_n$⟩] ⟨*sign*⟩ [⟨*unsigned-rational*$_n$⟩] `i`
⟨*inexact*$_n$⟩	::=	⟨*inexact-real*$_n$⟩ | ⟨*inexact-complex*$_n$⟩
⟨*inexact-real*$_n$⟩	::=	[⟨*sign*⟩] ⟨*inexact-normal*$_n$⟩
	|	⟨*sign*⟩ ⟨*inexact-special*$_n$⟩
⟨*inexact-unsigned*$_n$⟩	::=	⟨*inexact-normal*$_n$⟩ | ⟨*inexact-special*$_n$⟩
⟨*inexact-normal*$_n$⟩	::=	⟨*inexact-simple*$_n$⟩ [⟨*exp-mark*$_n$⟩ ⟨*exact-integer*$_n$⟩]
⟨*inexact-simple*$_n$⟩	::=	⟨*digits#*$_n$⟩ [`.`] `#*`
	|	[⟨*unsigned-integer*$_n$⟩] `.` ⟨*digits#*$_n$⟩
	|	⟨*digits#*$_n$⟩ `/` ⟨*digits#*$_n$⟩
⟨*inexact-special*$_n$⟩	::=	`inf.0` | `nan.0` | `inf.f` | `nan.f`
⟨*digits#*$_n$⟩	::=	⟨*digit*$_n$⟩$^+$ `#*`
⟨*inexact-complex*$_n$⟩	::=	[⟨*inexact-real*$_n$⟩] ⟨*sign*⟩ [⟨*inexact-unsigned*$_n$⟩] `i`
	|	⟨*inexact-real*$_n$⟩ `@` ⟨*inexact-real*$_n$⟩
⟨*sign*⟩	::=	`+` | `-`
⟨*digit*$_{16}$⟩	::=	⟨*digit*$_{10}$⟩ | `a` | `b` | `c` | `d` | `e` | `f`
⟨*digit*$_{10}$⟩	::=	⟨*digit*$_8$⟩ | `8` | `9`
⟨*digit*$_8$⟩	::=	⟨*digit*$_2$⟩ | `2` | `3` | `4` | `5` | `6` | `7`
⟨*digit*$_2$⟩	::=	`0` | `1`
⟨*exp-mark*$_{16}$⟩	::=	`s` | `l`
⟨*exp-mark*$_{10}$⟩	::=	⟨*exp-mark*$_{16}$⟩ | `d` | `e` | `f`
⟨*exp-mark*$_8$⟩	::=	⟨*exp-mark*$_{10}$⟩
⟨*exp-mark*$_2$⟩	::=	⟨*exp-mark*$_{10}$⟩
⟨*general-number*$_n$⟩	::=	[⟨*exactness*⟩] ⟨*number*$_n$⟩
⟨*exactness*⟩	::=	`#e` | `#i`

Examples:

`-1`	reads equal to	`-1`
`1/2`	reads equal to	`(/ 1 2)`
`1.0`	reads equal to	`(exact->inexact 1)`
`1+2i`	reads equal to	`(make-rectangular 1 2)`
`1/2+3/4i`	reads equal to	`(make-rectangular (/ 1 2) (/ 3 4))`
`1.0+3.0e7i`	reads equal to	`(exact->inexact (make-rectangular 1 30000000))`
`2e5`	reads equal to	`(exact->inexact 200000)`
`#i5`	reads equal to	`(exact->inexact 5)`
`#e2e5`	reads equal to	`200000`
`#x2e5`	reads equal to	`741`
`#b101`	reads equal to	`5`

1.3.4 Reading Extflonums

An extflonum has the same syntax as an ⟨*inexact-real*$_n$⟩ that includes an ⟨*exp-mark*$_n$⟩, but with `t` or `T` in place of the ⟨*exp-mark*$_n$⟩. In addition, `+inf.t`, `-inf.t`, `+nan.t`, `-nan.t` are extflonums. A `#b` (binary), `#o` (octal), `#d` (decimal), or `#x` (hexadecimal) radix specification can prefix an extflonum, but `#i` or `#e` cannot, and a extflonum cannot be used to form a complex number. The `read-decimal-as-inexact` parameter has no effect on extflonum reading.

1.3.5 Reading Booleans

A `#true`, `#t`, `#T` followed by a delimiter is the input syntax for the boolean constant "true," and `#false`, `#f`, or `#F` followed by a delimiter is the complete input syntax for the boolean constant "false."

1.3.6 Reading Pairs and Lists

When the reader encounters a `(`, `[`, or `{`, it starts parsing a pair or list; see §4.10 "Pairs and Lists" for information on pairs and lists.

To parse the pair or list, the reader recursively reads data until a matching `)`, `]`, or `}` (respectively) is found, and it specially handles a `.` surrounded by delimiters. Pairs `()`, `[]`, and `{}` are treated the same way, so the remainder of this section simply uses "parentheses" to mean any of these pair.

If the reader finds no delimited `.` among the elements between parentheses, then it produces a list containing the results of the recursive reads.

If the reader finds two data between the matching parentheses that are separated by a delimited `.`, then it creates a pair. More generally, if it finds two or more data where the last datum is preceded by a delimited `.`, then it constructs nested pairs: the next-to-last element is paired with the last, then the third-to-last datum is paired with that pair, and so on.

If the reader finds three or more data between the matching parentheses, and if a pair of delimited `.`s surrounds any other than the first and last elements, the result is a list containing the element surrounded by `.`s as the first element, followed by the others in the read order. This convention supports a kind of infix notation at the reader level.

In `read-syntax` mode, the recursive reads for the pair/list elements are themselves in `read-syntax` mode, so that the result is a list or pair of syntax objects that is itself wrapped as a syntax object. If the reader constructs nested pairs because the input included a single delimited `.`, then only the innermost pair and outermost pair are wrapped as syntax objects.

Whether wrapping a pair or list, if the pair or list was formed with `[` and `]`, then a `'paren-shape` property is attached to the result with the value `#\[`. If the `read-square-bracket-with-tag` parameter is set to `#t`, then the resulting pair or list is wrapped by the equivalent of `(cons '#%brackets pair-or-list)`.

Similarly, if the list or pair was formed with `{` and `}`, then a `'paren-shape` property is attached to the result with the value `#\{`. If the `read-curly-brace-with-tag` parameter is set to `#t`, then the resulting pair or list is wrapped by the equivalent of `(cons '#%braces pair-or-list)`.

If a delimited `.` appears in any other configuration, then the `exn:fail:read` exception is raised. Similarly, if the reader encounters a `)`, `]`, or `}` that does not end a list being parsed, then the `exn:fail:read` exception is raised.

Examples:

`()`	reads equal to	`(list)`
`(1 2 3)`	reads equal to	`(list 1 2 3)`
`{1 2 3}`	reads equal to	`(list 1 2 3)`
`[1 2 3]`	reads equal to	`(list 1 2 3)`
`(1 (2) 3)`	reads equal to	`(list 1 (list 2) 3)`
`(1 . 3)`	reads equal to	`(cons 1 3)`
`(1 . (3))`	reads equal to	`(list 1 3)`
`(1 . 2 . 3)`	reads equal to	`(list 2 1 3)`

If the `read-square-bracket-as-paren` and `read-square-bracket-with-tag` parameters are set to `#f`, then when the reader encounters `[` and `]`, the `exn:fail:read` exception is raised. Similarly, if the `read-curly-brace-as-paren` and `read-curly-brace-with-tag` parameters are set to `#f`, then when the reader encounters `{` and `}`, the `exn:fail:read` exception is raised.

If the `read-accept-dot` parameter is set to `#f`, then a delimited `.` triggers an `exn:fail:read` exception. If the `read-accept-infix-dot` parameter is set to `#f`, then multiple delimited `.`s trigger an `exn:fail:read` exception, instead of the infix conversion.

1.3.7 Reading Strings

§3.4 "Strings (Unicode)" in *The Racket Guide* introduces the syntax of strings.

When the reader encounters `"`, it begins parsing characters to form a string. The string continues until it is terminated by another `"` (that is not escaped by `\`). The resulting string is interned in `read-syntax` mode.

Within a string sequence, the following escape sequences are recognized:

- `\a`: alarm (ASCII 7)
- `\b`: backspace (ASCII 8)

- `\t`: tab (ASCII 9)
- `\n`: linefeed (ASCII 10)
- `\v`: vertical tab (ASCII 11)
- `\f`: formfeed (ASCII 12)
- `\r`: return (ASCII 13)
- `\e`: escape (ASCII 27)
- `\"`: double-quotes (without terminating the string)
- `\'`: quote (i.e., the backslash has no effect)
- `\\`: backslash (i.e., the second is not an escaping backslash)
- `\`$\langle$*digit$_8$*$\rangle^{\{1,3\}}$: Unicode for the octal number specified by digit$_8$$^{\{1,3\}}$ (i.e., 1 to 3 $\langle$*digit$_8$*$\rangle$s), where each $\langle$*digit$_8$*$\rangle$ is `0`, `1`, `2`, `3`, `4`, `5`, `6`, or `7`. A longer form takes precedence over a shorter form, and the resulting octal number must be between 0 and 255 decimal, otherwise the `exn:fail:read` exception is raised.
- `\x`$\langle$*digit$_{16}$*$\rangle^{\{1,2\}}$: Unicode for the hexadecimal number specified by $\langle$*digit$_{16}$*$\rangle^{\{1,2\}}$, where each $\langle$*digit$_{16}$*$\rangle$ is `0`, `1`, `2`, `3`, `4`, `5`, `6`, `7`, `8`, `9`, `a`, `b`, `c`, `d`, `e`, or `f` (case-insensitive). The longer form takes precedence over the shorter form.
- `\u`$\langle$*digit$_{16}$*$\rangle^{\{1,4\}}$: like `\x`, but with up to four hexadecimal digits (longer sequences take precedence). The resulting hexadecimal number must be a valid argument to `integer->char`, otherwise the `exn:fail:read` exception is raised—unless the encoding continues with another `\u` to form a surrogate-style encoding.
- `\u`$\langle$*digit$_{16}$*$\rangle^{\{4,4\}}$`\u`$\langle$*digit$_{16}$*$\rangle^{\{4,4\}}$: like `\u`, but for two hexadecimal numbers, where the first is in the range `#xD800` to `#xDBFF` and the second is in the range `#xDC00` to `#xDFFF`; the resulting character is the one represented by the numbers as a UTF-16 surrogate pair.
- `\U`$\langle$*digit$_{16}$*$\rangle^{\{1,8\}}$: like `\x`, but with up to eight hexadecimal digits (longer sequences take precedence). The resulting hexadecimal number must be a valid argument to `integer->char`, otherwise the `exn:fail:read` exception is raised.
- `\`$\langle$*newline*$\rangle$: elided, where $\langle$*newline*$\rangle$ is either a linefeed, carriage return, or carriage return–linefeed combination. This convention allows single-line strings to span multiple lines in the source.

If the reader encounters any other use of a backslash in a string constant, the `exn:fail:read` exception is raised.

§3.5 "Bytes and Byte Strings" in *The Racket Guide* introduces the syntax of byte strings.

A string constant preceded by `#` is parsed as a byte string. (That is, `#"` starts a byte-string literal.) See §4.5 "Byte Strings" for information on byte strings. The resulting byte string is interned in `read-syntax` mode. Byte-string constants support the same escape sequences as character strings, except `\u` and `\U`. Otherwise, each character within the byte-string quotes must have a Unicode code-point number in the range 0 to 255, which is used as the corresponding byte's value; if a character is not in that range, the `exn:fail:read` exception is raised.

When the reader encounters `#<<`, it starts parsing a *here string*. The characters following `#<<` until a newline character define a terminator for the string. The content of the string includes all characters between the `#<<` line and a line whose only content is the specified terminator. More precisely, the content of the string starts after a newline following `#<<`, and it ends before a newline that is followed by the terminator, where the terminator is itself followed by either a newline or end-of-file. No escape sequences are recognized between the starting and terminating lines; all characters are included in the string (and terminator) literally. A return character is not treated as a line separator in this context. If no characters appear between `#<<` and a newline or end-of-file, or if an end-of-file is encountered before a terminating line, the `exn:fail:read` exception is raised.

Examples:

`"Apple"`	reads equal to	`"Apple"`
`"\x41pple"`	reads equal to	`"Apple"`
`"\"Apple\""`	reads equal to	`"\x22Apple\x22"`
`"\\"`	reads equal to	`"\x5C"`
`#"Apple"`	reads equal to	`(bytes 65 112 112 108 101)`

1.3.8 Reading Quotes

When the reader encounters `'`, it recursively reads one datum and forms a new list containing the symbol `'quote` and the following datum. This convention is mainly useful for reading Racket code, where `'s` can be used as a shorthand for `(quote s)`.

Several other sequences are recognized and transformed in a similar way. Longer prefixes take precedence over short ones:

`'`	adds	`quote`
`` ` ``	adds	`quasiquote`
`,`	adds	`unquote`
`,@`	adds	`unquote-splicing`
`#'`	adds	`syntax`
``#` ``	adds	`quasisyntax`
`#,`	adds	`unsyntax`
`#,@`	adds	`unsyntax-splicing`

Examples:

`'apple`	reads equal to	`(list 'quote 'apple)`
`` `(1 ,2) ``	reads equal to	`(list 'quasiquote (list 1 (list 'unquote 2)))`

The `` ` ``, `,`, and `,@` forms are disabled when the `read-accept-quasiquote` parameter is set to `#f`, in which case the `exn:fail:read` exception is raised instead.

1.3.9 Reading Comments

A `;` starts a line comment. When the reader encounters `;`, it skips past all characters until the next linefeed (ASCII 10), carriage return (ASCII 13), next-line (Unicode 133), line-separator (Unicode 8232), or paragraph-separator (Unicode 8233) character.

A `#|` starts a nestable block comment. When the reader encounters `#|`, it skips past all characters until a closing `|#`. Pairs of matching `#|` and `|#` can be nested.

A `#;` starts an S-expression comment. When the reader encounters `#;`, it recursively reads one datum, and then discards it (continuing on to the next datum for the read result).

A `#! ` (which is `#!` followed by a space) or `#!/` starts a line comment that can be continued to the next line by ending a line with `\`. This form of comment normally appears at the beginning of a Unix script file.

Examples:

`; comment`	reads equal to *nothing*
`#| a |# 1`	reads equal to `1`
`#| #| a |# 1 |# 2`	reads equal to `2`
`#;1 2`	reads equal to `2`
`#!/bin/sh`	reads equal to *nothing*
`#! /bin/sh`	reads equal to *nothing*

1.3.10 Reading Vectors

When the reader encounters a `#(`, `#[`, or `#{`, it starts parsing a vector; see §4.12 "Vectors" for information on vectors. A `#fl` in place of `#` starts an flvector, but is not allowed in `read-syntax` mode; see §4.3.3.2 "Flonum Vectors" for information on flvectors. A `#fx` in place of `#` starts an fxvector, but is not allowed in `read-syntax` mode; see §4.3.4.2 "Fixnum Vectors" for information on fxvectors. The `#[`, `#{`, `#fl[`, `#fl{`, `#fx[`, and `#fx{` forms can be disabled through the `read-square-bracket-as-paren` and `read-curly-brace-as-paren` parameters.

The elements of the vector are recursively read until a matching `)`, `]`, or `}` is found, just as for lists (see §1.3.6 "Reading Pairs and Lists"). A delimited `.` is not allowed among the vector elements. In the case of flvectors, the recursive read for element is implicitly prefixed with `#i` and must produce a flonum. In the case of fxvectors, the recursive read for element is implicitly prefixed with `#e` and must produce a fixnum.

An optional vector length can be specified between `#`, `#fl`, `#fx` and `(`, `[`, or `{`. The size is specified using a sequence of decimal digits, and the number of elements provided for the vector must be no more than the specified size. If fewer elements are provided, the last provided element is used for the remaining vector slots; if no elements are provided, then `0` is used for all slots.

In `read-syntax` mode, each recursive read for vector elements is also in `read-syntax` mode, so that the wrapped vector's elements are also wrapped as syntax objects, and the vector is immutable.

Examples:

`#(1 apple 3)`	reads equal to	`(vector 1 'apple 3)`
`#3("apple" "banana")`	reads equal to	`(vector "apple" "banana" "banana")`
`#3()`	reads equal to	`(vector 0 0 0)`

1.3.11 Reading Structures

When the reader encounters a `#s(`, `#s[`, or `#s{`, it starts parsing an instance of a prefab structure type; see §5 "Structures" for information on structure types. The `#s[` and `#s{` forms can be disabled through the `read-square-bracket-as-paren` and `read-curly-brace-as-paren` parameters.

The elements of the structure are recursively read until a matching `)`, `]`, or `}` is found, just as for lists (see §1.3.6 "Reading Pairs and Lists"). A single delimited `.` is not allowed among the elements, but two `.`s can be used as in a list for an infix conversion.

The first element is used as the structure descriptor, and it must have the form (when quoted) of a possible argument to `make-prefab-struct`; in the simplest case, it can be a symbol. The remaining elements correspond to field values within the structure.

In `read-syntax` mode, the structure type must not have any mutable fields. The structure's elements are read in `read-syntax` mode, so that the wrapped structure's elements are also wrapped as syntax objects.

If the first structure element is not a valid prefab structure type key, or if the number of provided fields is inconsistent with the indicated prefab structure type, the `exn:fail:read` exception is raised.

1.3.12 Reading Hash Tables

A `#hash` starts an immutable hash-table constant with key matching based on `equal?`. The characters after `hash` must parse as a list of pairs (see §1.3.6 "Reading Pairs and Lists") with a specific use of delimited `.`: it must appear between the elements of each pair in the list and nowhere in the sequence of list elements. The first element of each pair is used as the key for a table entry, and the second element of each pair is the associated value.

A `#hashalw` starts a hash table like `#hash`, except that it constructs a hash table based on `equal-always?` instead of `equal?`.

A `#hasheq` starts a hash table like `#hash`, except that it constructs a hash table based on `eq?` instead of `equal?`.

A `#hasheqv` starts a hash table like `#hash`, except that it constructs a hash table based on `eqv?` instead of `equal?`.

In all cases, the table is constructed by adding each mapping to the hash table from left to right, so later mappings can hide earlier mappings if the keys are equivalent.

Examples, where `make-...` stands for `make-immutable-hash`:

`#hash()`	reads equal to	`(make-... '())`
`#hasheq()`	reads equal to	`(make-...eq '())`
`#hash(("a" . 5))`	reads equal to	`(make-... '(("a" . 5)))`
`#hasheq((a . 5) (b . 7))`	reads equal to	`(make-...eq '((b . 7) (a . 5)))`
`#hasheq((a . 5) (a . 7))`	reads equal to	`(make-...eq '((a . 7)))`

1.3.13 Reading Boxes

When the reader encounters a `#&`, it starts parsing a box; see §4.14 "Boxes" for information on boxes. The content of the box is determined by recursively reading the next datum.

In `read-syntax` mode, the recursive read for the box content is also in `read-syntax` mode, so that the wrapped box's content is also wrapped as a syntax object, and the box is immutable.

Examples:
`#&17` reads equal to `(box 17)`

1.3.14 Reading Characters

§3.3 "Characters" in *The Racket Guide* introduces the syntax of characters.

A `#\` starts a character constant, which has one of the following forms:

- `#\nul` or `#\null`: NUL (ASCII 0); the next character must not be alphabetic.
- `#\backspace`: backspace (ASCII 8); the next character must not be alphabetic.
- `#\tab`: tab (ASCII 9); the next character must not be alphabetic.
- `#\newline` or `#\linefeed`: linefeed (ASCII 10); the next character must not be alphabetic.
- `#\vtab`: vertical tab (ASCII 11); the next character must not be alphabetic.

- `#\page`: page break (ASCII 12); the next character must not be alphabetic.
- `#\return`: carriage return (ASCII 13); the next character must not be alphabetic.
- `#\space`: space (ASCII 32); the next character must not be alphabetic.
- `#\rubout`: delete (ASCII 127); the next character must not be alphabetic.
- `#\`$\langle digit_8 \rangle^{\{3,3\}}$: Unicode for the octal number specified by three octal digits—as in string escapes (see §1.3.7 "Reading Strings"), but constrained to exactly three digits.
- `#\u`$\langle digit_{16} \rangle^{\{1,4\}}$: Unicode for the hexadecimal number specified by $\langle digit_{16} \rangle^{\{1,4\}}$, as in string escapes (see §1.3.7 "Reading Strings").
- `#\U`$\langle digit_{16} \rangle^{\{1,8\}}$: like `#\u`, but with up to eight hexadecimal digits (although only six digits are actually useful).
- `#\`$\langle c \rangle$: the character $\langle c \rangle$, as long as `#\`$\langle c \rangle$ and the characters following it do not match any of the previous cases, as long as $\langle c \rangle$ or the character after $\langle c \rangle$ is not alphabetic, and as long as $\langle c \rangle$ is not an octal digit or is not followed by an octal digit (i.e., two octal digits commit to a third).

Examples:

`#\newline`	reads equal to	`(integer->char 10)`
`#\n`	reads equal to	`(integer->char 110)`
`#\u3BB`	reads equal to	`(integer->char 955)`
`#\λ`	reads equal to	`(integer->char 955)`

1.3.15 Reading Keywords

A `#:` starts a keyword. The parsing of a keyword after the `#:` is the same as for a symbol, including case-folding in case-insensitive mode, except that the part after `#:` is never parsed as a number. The resulting keyword is interned.

Examples:

`#:Apple`	reads equal to	`(string->keyword "Apple")`
`#:1`	reads equal to	`(string->keyword "1")`

1.3.16 Reading Regular Expressions

A `#rx` or `#px` starts a regular expression. The characters immediately after `#rx` or `#px` must parse as a string or byte string (see §1.3.7 "Reading Strings"). A `#rx` prefix starts a regular expression as would be constructed by `regexp`, `#px` as constructed by `pregexp`, `#rx#` as constructed by `byte-regexp`, and `#px#` as constructed by `byte-pregexp`. The resulting regular expression is interned in `read-syntax` mode.

Examples:

`#rx".*"`	reads equal to	`(regexp ".*")`
`#px"[\\s]*"`	reads equal to	`(pregexp "[\\s]*")`
`#rx#".*"`	reads equal to	`(byte-regexp #".*")`
`#px#"[\\s]*"`	reads equal to	`(byte-pregexp #"[\\s]*")`

1.3.17 Reading Graph Structure

A `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`=` tags the following datum for reference via `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`#`, which allows the reader to produce a datum that has graph structure.

In `read` mode, for a specific ⟨*digit₁₀*⟩$^{\{1,8\}}$ in a single read result, each `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`#` reference is replaced by the datum read for the corresponding `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`=`; the definition `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`=` also produces just the datum after it. A `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`=` definition can appear at most once, and a `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`=` definition must appear before a `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`#` reference appears, otherwise the `exn:fail:read` exception is raised. If the `read-accept-graph` parameter is set to `#f`, then `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`=` or `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`#` triggers a `exn:fail:read` exception.

In `read-syntax` mode, graph structure is parsed the same way as in `read` mode. However, since syntax objects made from plain S-expressions may not contain cycles, each `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`=` definition and `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`#` reference is replaced with a placeholder in the result that contains the referenced value. Since such syntax objects are not directly useful (they cannot be marshaled to compiled code and are therefore rejected by the default compilation handler), parsing of graph structure in `read-syntax` mode is controlled by the separate `read-syntax-accept-graph` parameter, which is initially set to `#f`.

Although a comment parsed via `#;` discards the datum afterward, `#`⟨*digit₁₀*⟩$^{\{1,8\}}$`=` definitions in the discarded datum still can be referenced by other parts of the reader input, as long as both the comment and the reference are grouped together by some other form (i.e., some recursive read); a top-level `#;` comment neither defines nor uses graph tags for other top-level forms.

Examples:

`(#1=100 #1# #1#)` reads equal to `(list 100 100 100)`

`#0=(1 . #0#)` reads equal to

```
(let* ([ph (make-placeholder #f)]
       [v (cons 1 ph)])
  (placeholder-set! ph v)
  (make-reader-graph v))
```

Changed in version 8.4.0.8 of package `base`: Added support for reading graph structure in `read-syntax` mode if enabled by `read-syntax-accept-graph`.

1.3.18 Reading via an Extension

§17.2 "Reader Extensions" in *The Racket Guide* introduces reader extension.

When the reader encounters `#reader`, it loads an external reader procedure and applies it to the current input stream.

The reader recursively reads the next datum after `#reader`, and passes it to the procedure that is the value of the `current-reader-guard` parameter; the result is used as a module path. The module path is passed to `dynamic-require` with either `'read` or `'read-syntax` (depending on whether the reader is in `read` or `read-syntax` mode) while holding the registry lock via `namespace-call-with-registry-lock`. The module is loaded in a root namespace of the current namespace.

The arity of the resulting procedure determines whether it accepts extra source-location information: a `read` procedure accepts either one argument (an input port) or five, and a `read-syntax` procedure accepts either two arguments (a name value and an input port) or six. In either case, the four optional arguments are the reader's module path (as a syntax object in `read-syntax` mode) followed by the line (positive exact integer or `#f`), column (non-negative exact integer or `#f`), and position (positive exact integer or `#f`) of the start of the `#reader` form. The input port is the one whose stream contained `#reader`, where the stream position is immediately after the recursively read module path.

The procedure should produce a datum result. If the result is a syntax object in `read` mode, then it is converted to a datum using `syntax->datum`; if the result is not a syntax object in `read-syntax` mode, then it is converted to one using `datum->syntax`. See also §13.7.2 "Reader-Extension Procedures" for information on the procedure's results.

If the `read-accept-reader` parameter is set to `#f`, then if the reader encounters `#reader`, the `exn:fail:read` exception is raised.

§6.2.2 "The `#lang` Shorthand" in *The Racket Guide* introduces `#lang`.

The `#lang` reader form is similar to `#reader`, but more constrained: the `#lang` must be followed by a single space (ASCII 32), and then a non-empty sequence of alphanumeric ASCII, `+`, `-`, `_`, and/or `/` characters terminated by whitespace or an end-of-file. The sequence must not start or end with `/`. A sequence `#lang` ⟨*name*⟩ is equivalent to either `#reader (submod` ⟨*name*⟩ `reader)` or `#reader` ⟨*name*⟩`/lang/reader`, where the former is tried first guarded by a `module-declared?` check (but after filtering by `current-reader-guard`, so both are passed to the value of `current-reader-guard` if the latter is used). Note that the terminating whitespace (if any) is not consumed before the external reading procedure is called.

§17.3 "Defining new `#lang` Languages" in *The Racket Guide* introduces the creation languages for `#lang`.

The `syntax/module-reader` library provides a domain-specific language for writing language readers.

Finally, `#!` is an alias for `#lang` followed by a space when `#!` is followed by alphanumeric ASCII, `+`, `-`, or `_`. Use of this alias is discouraged except as needed to construct programs that conform to certain grammars, such as that of R^{6}RS [Sperber07].

By convention, `#lang` normally appears at the beginning of a file, possibly after comment forms, to specify the syntax of a module.

If the `read-accept-reader` or `read-accept-lang` parameter is set to `#f`, then if the reader encounters `#lang` or equivalent `#!`, the `exn:fail:read` exception is raised.

Changed in version 8.2.0.2 of package `base`: Changed reader-module loading for `#reader` and `#lang` to hold the current namespace registry's lock.

1.3.19 Reading with C-style Infix-Dot Notation

When the `read-cdot` parameter is set to `#t`, then a variety of changes occur in the reader.

First, symbols can no longer include the character `.`, unless the `.` is quoted with `|` or `\`.

Second, numbers can no longer include the character `.`, unless the number is prefixed with `#e`, `#i`, `#b`, `#o`, `#d`, `#x`, or an equivalent prefix as discussed in §1.3.3 "Reading Numbers". If these numbers are followed by a `.` intended to be read as a C-style infix dot, then a delimiter must precede the `.`.

Finally, after reading any datum *x*, the reader will consume whitespace, BOM characters, and comments to look for zero or more sequences of a `.` followed by another datum *y*. It will then group *x* and *y* with `'#%dot` so that `x.y` reads equal to reading `(#%dot x y)`.

If `x.y` has another `.` after it, the reader will accumulate more `.`-separated datums, grouping them from left-to-right. For example, `x.y.z` reads equal to reading `(#%dot (#%dot x y) z)`.

In `read-syntax` mode, the `'#%dot` symbol has the source location information of the `.` character and the entire list has the source location information spanning from the start of *x* to the end of *y*.

S-Expression Reader Language

`#lang s-exp`   package: `base`

§17.1.2 "Using `#lang s-exp`" in *The Racket Guide* introduces the `s-exp` meta-language.

The `s-exp` "language" is a kind of meta-language. It `read`s the S-expression that follows `#lang s-exp` and uses it as the language of a `module` form. It also reads all remaining S-expressions until an end-of-file, using them for the body of the generated `module`.

That is,

```
#lang s-exp module-path
form ...
```

is equivalent to

```
(module name-id module-path
  form ...)
```

where *name-id* is derived from the source input port's name: if the port name is a filename path, the filename without its directory path and extension is used for *name-id*, otherwise *name-id* is anonymous-module.

Chaining Reader Language

#lang reader   package: base

§17.3.2 "Using #lang reader" in *The Racket Guide* introduces the reader meta-language.

The reader "language" is a kind of meta-language. It reads the S-expression that follows #lang reader and uses it as a module path (relative to the module being read) that effectively takes the place of reader. In other words, the reader meta-language generalizes the syntax of the module specified after #lang to be a module path, and without the implicit addition of /lang/reader to the path.

1.4 The Printer

The Racket printer supports three modes:

- write mode prints core datatypes in such a way that using read on the output produces a value that is equal? to the printed value;
- display mode prints core datatypes in a more "end-user" style rather than "programmer" style; for example, a string displays as its content characters without surrounding "s or escapes;
- print mode by default—when print-as-expression is #t—prints most datatypes in such a way that evaluating the output as an expression produces a value that is equal? to the printed value; when print-as-expression is set to #f, then print mode is like write mode.

In print mode when print-as-expression is #t (as is the default), a value prints at a *quoting depth* of either 0 (unquoted) or 1 (quoted). The initial quoting depth is accepted as an optional argument by print, and printing of some compound datatypes adjusts the print depth for component values. For example, when a list is printed at quoting depth 0 and all of its elements are *quotable*, the list is printed with a ' prefix, and the list's elements are printed at quoting depth 1.

When the print-graph parameter is set to #t, then the printer first scans an object to detect cycles. The scan traverses the components of pairs, mutable pairs, vectors, boxes (when print-box is #t), hash tables (when print-hash-table is #t and when key are held strongly), fields of structures exposed by struct->vector (when print-struct is #t), and fields of structures exposed by printing when the structure's type has the prop:custom-write property. If print-graph is #t, then this information is used to print sharing through graph definitions and references (see §1.3.17 "Reading Graph Structure"). If a cycle is detected in the initial scan, then print-graph is effectively set to #t automatically.

With the exception of displaying byte strings, printing is defined in terms of Unicode characters; see §13.1 “Ports” for information on how a character stream is written to a port’s underlying byte stream.

1.4.1 Printing Symbols

Symbols containing spaces or special characters `write` using escaping `\` and quoting `|`s. When the `read-case-sensitive` parameter is set to `#f`, then symbols containing uppercase characters also use escaping `\` and quoting `|`s. In addition, symbols are quoted with `|`s or leading `\` when they would otherwise print the same as a numerical constant or as a delimited `.` (when `read-accept-dot` is `#t`).

When `read-accept-bar-quote` is `#t`, `|`s are used in printing when one `|` at the beginning and one `|` at the end suffice to correctly print the symbol. Otherwise, `\`s are always used to escape special characters, instead of quoting them with `|`s.

When `read-accept-bar-quote` is `#f`, then `|` is not treated as a special character. The following are always special characters:

```
( ) [ ] { } " , ' ` ; \
```

In addition, `#` is a special character when it appears at the beginning of the symbol, and when it is not followed by `%`.

Symbols `display` without escaping or quoting special characters. That is, the display form of a symbol is the same as the display form of `symbol->string` applied to the symbol.

Symbols `print` the same as they `write`, unless `print-as-expression` is set to `#t` (as is the default) and the current quoting depth is `0`. In that case, the symbol’s `print`ed form is prefixed with `'`. For the purposes of printing enclosing datatypes, a symbol is quotable.

1.4.2 Printing Numbers

A number prints the same way in `write`, `display`, and `print` modes. For the purposes of printing enclosing datatypes, a number is quotable.

A complex number that is not a real number always prints as ⟨*m*⟩`+`⟨*n*⟩`i` or ⟨*m*⟩`-`⟨*n*⟩`i`, where ⟨*m*⟩ and ⟨*n*⟩ (for a non-negative imaginary part) or `-`⟨*n*⟩ (for a negative imaginary part) are the printed forms of its real and imaginary parts, respectively.

An exact `0` prints as `0`. A positive, exact integer prints as a sequence of digits that does not start with `0`. A positive, exact, real, non-integer number prints as ⟨*m*⟩`/`⟨*n*⟩, where ⟨*m*⟩ and ⟨*n*⟩ are the printed forms of the number’s numerator and denominator (as determined by `numerator` and `denominator`). A negative exact number prints with a `-` prefix on the printed form of the number's exact negation. When printing a number as hexadecimal (e.g., via `number->string`), digits `a` though `f` are printed in lowercase. A `#e` or radix marker such as `#d` *does not* prefix the number.

A double-precision inexact number (i.e., a flonum) that is a rational number prints with either a `.` decimal point, an `e` exponent marker and non-zero exponent, or both. The form is selected to keep the output short, with the constraint that reading the printed form back in produces an `equal?` number. A `#i` *does not* prefix the number, and `#` is never used in place of a digit. A `+` does not prefix a positive number, but a `+` or `-` is printed before the exponent if `e` is present. Positive infinity prints as `+inf.0`, negative infinity prints as `-inf.0`, and not-a-number prints as `+nan.0`.

A single-precision inexact number that is a rational number prints like a double-precision number, but always with an exponent, using `f` in place of `e` to indicate the number's precision; if the number would otherwise print without an exponent, `0` (with no `+`) is printed as the exponent part. Single-precision positive infinity prints as `+inf.f`, negative infinity prints as `-inf.f`, and not-a-number prints as `+nan.f`.

1.4.3 Printing Extflonums

An extflonum prints the same way in `write`, `display`, and `print` modes. For the purposes of printing enclosing datatypes, an extflonum is quotable.

An extflonum prints in the same way a single-precision inexact number (see §1.4.2 "Printing Numbers"), but always with a `t` or `T` exponent marker or as a suffix for `+inf.t`, `-inf.t`, or `+nan.t`. When extflonum operations are supported, printing always uses lowercase `t`; when extflonum operations are not supported, an extflonum prints the same as its reader (see §1.3 "The Reader") source, since reading is the only way to produce an extflonum.

1.4.4 Printing Booleans

The boolean constant `#t` prints as `#true` or `#t` in all modes (`display`, `write`, and `print`), depending on the value of `print-boolean-long-form`, and the constant `#f` prints as `#false` or `#f`. For the purposes of printing enclosing datatypes, a symbol is quotable.

1.4.5 Printing Pairs and Lists

In `write` and `display` modes, an empty list prints as `()`. A pair normally prints starting with `(` followed by the printed form of its `car`. The rest of the printed form depends on the `cdr`:

- If the `cdr` is a pair or the empty list, then the printed form of the pair completes with the printed form of the `cdr`, except that the leading `(` in the `cdr`'s printed form is omitted.

- Otherwise, the printed for of the pair continues with a space, `.`, another space, the printed form of the `cdr`, and a `)`.

If `print-reader-abbreviations` is set to `#t`, then pair printing in `write` mode is adjusted in the case of a pair that starts a two-element list whose first element is `'quote`, `'quasiquote`, `'unquote`, `'unquote-splicing`, `'syntax`, `'quasisyntax`, `'unsyntax`, or `'unsyntax-splicing`. In that case, the pair is printed with the corresponding reader syntax: `'`, `` ` ``, `,`, `,@`, `#'`, `` #` ``, `#,`, or `#,@`, respectively. After the reader syntax, the second element of the list is printed. When the list is a tail of an enclosing list, the tail is printed after a `.` in the enclosing list (after which the reader abbreviations work), instead of including the tail as two elements of the enclosing list. If the reader syntax `,` or `#,` is followed by a symbol that prints with a leading `@`, then the printer adds an extra space before the `@`.

The printed form of a pair is the same in both `write` and `display` modes, except as the printed form of the pair's `car` and `cdr` vary with the mode. The `print` form is also the same if `print-as-expression` is `#f` or the quoting depth is `1`.

For `print` mode when `print-as-expression` is `#t` and the quoting depth is `0`, then the empty list prints as `'()`. For a pair whose `car` and `cdr` are quotable, the pair prints in `write` mode but with a `'` prefix; the pair's content is printed with quoting depth `1`. Otherwise, when the `car` or `cdr` is not quotable, then pair prints with either `cons` (when the `cdr` is not a pair), `list` (when the pair is a list), or `list*` (otherwise) after the opening `(`, any `.` that would otherwise be printed is suppressed, and the pair content is printed at quoting depth `0`. In all cases, when `print-as-expression` is `#t` for `print` mode, then the value of `print-reader-abbreviations` is ignored and reader abbreviations are always used for lists printed at quoting depth `1`.

By default, mutable pairs (as created with `mcons`) print the same as pairs for `write` and `display`, except that `{` and `}` are used instead of `(` and `)`. Note that the reader treats `{...}` and `(...)` equivalently on input, creating immutable pairs in both cases. Mutable pairs in `print` mode with `print-as-expression` as `#f` or a quoting depth of `1` also use `{` and `}`. In `print` mode with `print-as-expression` as `#t` and a quoting depth of `0`, a mutable pair prints as `(mcons `, the `mcar` and `mcdr` printed at quoting depth `0` and separated by a space, and a closing `)`.

If the `print-pair-curly-braces` parameter is set to `#t`, then pairs print using `{` and `}` when not using `print` mode with `print-as-expression` as `#t` and a quoting depth of `0`. If the `print-mpair-curly-braces` parameter is set to `#f`, then mutable pairs print using `(` and `)` in that mode.

For the purposes of printing enclosing datatypes, an empty list is always quotable, a pair is quotable when its `car` and `cdr` are quotable, and a mutable list is never quotable.

Changed in version 6.9.0.6 of package `base`: Added a space when printing `,` or `#,` followed by a symbol that prints with a leading `@`.

1.4.6 Printing Strings

All strings `display` as their literal character sequences.

The `write` or `print` form of a string starts with `"` and ends with another `"`. Between the `"`s, each character is represented. Each graphic or blank character (according to `char-graphic?` and `char-blank?`) is represented as itself, with two exceptions: `"` is printed as `\"`, and `\` is printed as `\\`. A non-graphic, non-blank character that is part of a grapheme sequence that starts with a graphic character is also represented as itself. Each other non-graphic, non-blank character is printed using the escape sequences described in §1.3.7 "Reading Strings", using `\a`, `\b`, `\t`, `\n`, `\v`, `\f`, `\r`, or `\e` if possible, otherwise using `\u` with four hexadecimal digits or `\U` with eight hexadecimal digits (using the latter only if the character value does not fit into four digits).

All byte strings `display` as their literal byte sequence; this byte sequence may not be a valid UTF-8 encoding, so it may not correspond to a sequence of characters.

The `write` or `print` form of a byte string starts with `#"` and ends with a `"`. Between the `"`s, each byte is written using the corresponding ASCII decoding if the byte is between 0 and 127 and the character is graphic or blank (according to `char-graphic?` and `char-blank?`). Otherwise, the byte is written using `\a`, `\b`, `\t`, `\n`, `\v`, `\f`, `\r`, or `\e` if possible, otherwise using `\` followed by one to three octal digits (only as many as necessary).

For the purposes of printing enclosing datatypes, a string or a byte string is quotable.

1.4.7 Printing Vectors

In `display` mode, the printed form of a vector is `#` followed by the printed form of `vector->list` applied to the vector. In `write` mode, the printed form is the same, except that when the `print-vector-length` parameter is `#t`, a decimal integer is printed after the `#`, and a repeated last element is printed only once.

Vectors `print` the same as they `write`, unless `print-as-expression` is set to `#t` and the current quoting depth is `0`. In that case, if all of the vector's elements are quotable, then the vector's `print`ed form is prefixed with `'` and its elements printed with quoting depth `1`. If its elements are not all quotable, then the vector `print`s as `(vector `, the elements at quoting depth `0`, and a closing `)`. A vector is quotable when all of its elements are quotable.

In `write` or `display` mode, a flvector prints like a vector, but with a `#fl` prefix instead of `#`. A fxvector similarly prints with a `#fx` prefix instead of `#`. The `print-vector-length` parameter affects flvector and fxvector printing the same as vector printing. In `print` mode, flvectors and fxvectors are not quotable, and they print like a vector at quoting depth 0 using a `(flvector` or `(fxvector` prefix, respectively.

1.4.8 Printing Structures

When the `print-struct` parameter is set to `#t`, then the way that structures print depends on details of the structure type for which the structure is an instance:

- If the structure type is a prefab structure type, then it prints in `write` or `display` mode using `#s(` followed by the prefab structure type key, then the printed form of each field in the structure, and then `)`.

  In `print` mode when `print-as-expression` is set to `#t` and the current quoting depth is `0`, if the structure's content is all quotable, then the structure's `print`ed form is prefixed with `'` and its content is printed with quoting depth `1`. If any of its content is not quotable, then the structure type prints the same as a non-prefab structure type.

  An instance of a prefab structure type is quotable when all of its content is quotable.

- If the structure has a `prop:custom-write` property value, then the associated procedure is used to print the structure, unless the `print-unreadable` parameter is set to `#f`.

  For `print` mode, an instance of a structure type with a `prop:custom-write` property is treated as quotable if it has the `prop:custom-print-quotable` property with a value of `'always`. If it has `'maybe` as the property value, then the structure is treated as quotable if its content is quotable, where the content is determined by the values recursively printed by the structure's `prop:custom-write` procedure. Finally, if the structure has `'self` as the property value, then it is treated as quotable.

  In `print` mode when `print-as-expression` is `#t`, the structure's `prop:custom-write` procedure is called with either `0` or `1` as the quoting depth, normally depending on the structure's `prop:custom-print-quotable` property value. If the property value is `'always`, the quoting depth is normally `1`. If the property value is `'maybe`, then the quoting depth is `1` if the structure is quotable, or normally `0` otherwise. If the property value is `'self`, then the quoting depth may be `0` or `1`; it is normally `0` if the structure is not printed as a part of an enclosing quotable value, even though the structure is treated as quotable. Finally, if the property value is `'never`, then the quoting depth is normally `0`. The quoting depth can vary from its normal value if the structure is printed with an explicit quoting depth of `1`.

- If the structure's type is transparent or if any ancestor is transparent (i.e., `struct?` on the instance produces `#t`), then the structure prints as the vector produced by `struct->vector` in `display` mode, in `write` mode, or in `print` mode when `print-as-expression` is set to `#f` or when the quoting depth is `0`.

  In `print` mode with `print-as-expression` as `#t` and a quoting depth of `0`, the structure content is printed with a `(` followed by the structure's type name (as determined by `object-name`) in `write` mode; the remaining elements are `print`ed at quoting depth `0` and separated by a space, and finally a closing `)`.

A transparent structure type that is not a prefab structure type is never quotable.

- For any other structure type, the structure prints as an unreadable value; see §1.4.15 "Printing Unreadable Values" for more information.

If the print-struct parameter is set to #f, then all structures without a prop:custom-write property print as unreadable values (see §1.4.15 "Printing Unreadable Values") and count as quotable.

1.4.9 Printing Hash Tables

When the print-hash-table parameter is set to #t, in write and display modes, a hash table prints starting with #hash(, #hasheqv(, or #hasheq(for a table using equal?, eqv?, or eq? key comparisons, respectively, as long as the hash table retains keys strongly. After the prefix, each key–value mapping is shown as (, the printed form of a key, a space, ., a space, the printed form the corresponding value, and), with an additional space if the key–value pair is not the last to be printed. After all key–value pairs, the printed form completes with).

In print mode when print-as-expression is #f or the quoting depth is 1, the printed form is the same as for write. Otherwise, if the hash table's keys and values are all quotable, the table prints with a ' prefix, and the table's key and values are printed at quoting depth 1. If some key or value is not quotable, the hash table prints as (hash , (hasheqv , or (hasheq followed by alternating keys and values printed at quoting depth 1 and separated by spaces, and finally a closing). A hash table is quotable when all of its keys and values are quotable.

When the print-hash-table parameter is set to #f or when a hash table retains its keys weakly, a hash table prints as #<hash> and counts as quotable.

1.4.10 Printing Boxes

When the print-box parameter is set to #t, a box prints as #& followed by the printed form of its content in write, display, or print mode when print-as-expression is #f or the quoting depth is 1.

In print mode when print-as-expression is #t and the quoting depth is 0, a box prints with a ' prefix and its value is printed at quoting depth 1 when its content is quotable, otherwise the box prints a (box followed by the content at quoting depth 0 and a closing). A box is quotable when its content is quotable.

When the print-box parameter is set to #f, a box prints as #<box> and counts as quotable.

1.4.11 Printing Characters

Characters with the special names described in §1.3.14 "Reading Characters" `write` and `print` using the same name. (Some characters have multiple names; the `#\newline` and `#\nul` names are used instead of `#\linefeed` and `#\null`.) Other graphic characters (according to `char-graphic?`) `write` as `#\` followed by the single character, and all others characters are written in `#\u` notation with four digits or `#\U` notation with eight digits (using the latter only if the character value does not fit in four digits).

All characters `display` directly as themselves (i.e., a single character).

For the purposes of printing enclosing datatypes, a character is quotable.

1.4.12 Printing Keywords

Keywords `write`, `print`, and `display` the same as symbols (see §1.4.1 "Printing Symbols") except with a leading `#:` (after any `'` prefix added in `print` mode), and without special handling for an initial `#` or when the printed form would match a number or a delimited `.` (since `#:` distinguishes the keyword).

For the purposes of printing enclosing datatypes, a keyword is quotable.

1.4.13 Printing Regular Expressions

Regexp values `write`, `display`, and `print` starting with `#px` (for `pregexp`-based regexps) or `#rx` (for `regexp`-based regexps) followed by the `write` form of the regexp's source string or byte string.

For the purposes of printing enclosing datatypes, a regexp value is quotable.

1.4.14 Printing Paths

Paths `write` and `print` as `#<path:....>`. A path `display`s the same as the string produced by `path->string`. For the purposes of printing enclosing datatypes, a path counts as quotable.

Although a path can be converted to a string with `path->string` or to a byte string with `path->bytes`, neither is clearly the right choice for printing a path and reading it back. If the path value is meant to be moved among platforms, then a string is probably the right choice, despite the potential for losing information when converting a path to a string. For a path that is intended to be re-read on the same platform, a byte string is probably the right choice, since it preserves information in an unportable way. Paths do not print in a readable way so that programmers are not misled into thinking that either choice is always appropriate.

1.4.15 Printing Unreadable Values

For any value with no other printing specification, assuming that the `print-unreadable` parameter is set to `#t`, the output form is `#<`⟨*something*⟩`>`, where ⟨*something*⟩ is specific to the type of the value and sometimes to the value itself. If `print-unreadable` is set to `#f`, then attempting to print an unreadable value raises `exn:fail`.

For the purposes of printing enclosing datatypes, a value that prints unreadably nevertheless counts as quotable.

1.4.16 Printing Compiled Code

Compiled code as produced by `compile` prints using `#~`. Compiled code printed with `#~` is essentially assembly code for Racket, and reading such a form produces a compiled form when the `read-accept-compiled` parameter is set to `#t`.

Compiled code parsed from `#~` is marked as non-runnable if the current code inspector (see `current-code-inspector`) is not the original code inspector; on attempting to evaluate or reoptimize non-runnable bytecode, `exn:fail` exception is raised. Otherwise, compiled code parsed from `#~` may contain references to unexported or protected bindings from a module. Conceptually, the references in bytecode are associated with the current code inspector, where the code will only execute if that inspector controls the relevant module invocation (see §14.10 “Code Inspectors”)—but the original code inspector controls all other inspectors, anyway.

A compiled-form object may contain uninterned symbols (see §4.7 “Symbols”) that were created by `gensym` or `string->uninterned-symbol`. When the compiled object is read via `#~`, each uninterned symbol in the original form is mapped to a new uninterned symbol, where multiple instances of a single symbol are consistently mapped to the same new symbol. The original and new symbols have the same printed representation. Unreadable symbols, which are typically generated indirectly during expansion and compilation, are saved and restored consistently through `#~`.

The dynamic nature of uninterned symbols and their localization within `#~` can cause problems when `gensym` or `string->uninterned-symbol` is used to construct an identifier for a top-level or module binding (depending on how the identifier and its references are compiled). To avoid problems, generate distinct identifiers either with `generate-temporaries` or by applying the result of `make-syntax-introducer` to an existing identifier; those functions lead to top-level and module variables with unreadable symbolic names, and the names are deterministic as long as expansion is otherwise deterministic.

When a compiled-form object has string and byte string literals, they are interned using `datum-intern-literal` when the compiled-object for is read back in. Numbers and other values that `read-syntax` would intern, however, are not interned when read back as quoted literals in a compiled object.

A compiled form may contain path literals. Although paths are not normally printed in a way that can be read back in, path literals can be written and read as part of compiled code. The `current-write-relative-directory` parameter is used to convert the path to a relative path as is it written, and then `current-load-relative-directory` parameter (falling back to `current-directory`) is used to convert any relative path back as it is read.

For a path in a syntax object's source, if the `current-write-relative-directory` parameter is not set or the path is not relative to the value of the `current-write-relative-directory` parameter, then the path is coerced to a string that preserves only part of the path (an in effort to make it less tied to the build-time filesystem, which can be different than the run-time filesystem).

Finally, a compiled form may contain `srcloc` structures if the source field of the structure is a path for some system, a string, a byte string, a symbol, or `#f`. For a path value (matching the current platform's convention), if the path cannot be recorded as a relative path based on `current-write-relative-directory`, then it is converted to a string with at most two path elements; if the path contains more than two elements, then the string contains `.../`, the next-to-last element, `/` and the last element. The intent of the constraints on `srcloc` values and the conversion of the source field is to preserve some source information but not expose or record a path that makes no sense on a different filesystem or platform.

For internal testing purposes in the BC implementation of Racket, when the `PLT_VALIDATE_LOAD` environment variable is set, the reader runs a validator on bytecode parsed from `#~`. The validator may catch miscompilations or bytecode-file corruption. The validator may run lazily, such as checking a procedure only when the procedure is called.

Changed in version 6.90.0.21 of package `base`: Adjusted the effect of changing the code inspector on parsed bytecode, causing the reader to mark the loaded code as generally unrunnable instead of rejecting at read time references to unsafe operations.
Changed in version 7.0: Allowed some `srcloc` values embedded in compiled code.

1.5 Implementations

The definition of Racket aims for determinism and independence from its implementation. Nevertheless, some details inevitably vary with the implementation. Racket currently has two main implementations:

- The *CS* implementation is the default implementation as of Racket version 8.0. This variant is called "CS" because it uses Chez Scheme as its core compiler and runtime system.

The CS implementation typically provides the best performance for Racket programs. Compiled Racket CS code in a ".zo" file normally contains machine code that is specific to an operating system and architecture.

- The *BC* implementation was the default implementation up until version 7.9. The "BC" label stands for "before Chez" or "bytecode."

  Compiled Racket BC code in a ".zo" file normally contains platform-independent bytecode that is further compiled to machine code "just in time" as the code is loaded.

  Racket BC has two variants: *3m* and *CGC*. The difference is the garbage collection implementation, where 3m uses a garbage collector that moves objects in memory (an effect that is visible to foreign libraries, for example) and keeps precise track of allocated objects, while CGC uses a "conservative" collector that requires less cooperation from an embedding foreign environment. The 3m subvariant tends to perform much better than CGC, and it became the default variant in version 370 (which would be v3.7 in the current versioning convention).

Most Racket programs run the same in all implementation variants, but some Racket features are available only on some implementation variants, and the interaction of Racket and foreign functions is significantly different across the variants. Use `system-type` to get information about the current running implementation.

2 Notation for Documentation

This chapter introduces essential terminology and notation that is used throughout Racket documentation.

2.1 Notation for Module Documentation

Since Racket programs are organized into modules, documentation reflects that organization with an annotation at the beginning of a section or subsection that describes the bindings that a particular module provides.

For example, the section that describes the functionality provided by `racket/list` starts

```
(require racket/list)        package: base
```

Instead of `require`, some modules are introduced with `#lang`:

```
#lang racket/base        package: base
```

Using `#lang` means that the module is normally used as the language of a whole module—that is, by a module that starts `#lang` followed by the language—instead of imported with `require`. Unless otherwise specified, however, a module name documented with `#lang` can also be used with `require` to obtain the language's bindings.

The module annotation also shows the package that the module belongs to on the right-hand side. For more details about packages, see *Package Management in Racket*.

Sometimes, a module specification appears at the beginning of a document or at the start of a section that contains many subsections. The document's section or section's subsections are meant to "inherit" the module declaration of the enclosing document or section. Thus, bindings documented in *The Racket Reference* are available from `racket` and `racket/base` unless otherwise specified in a section or subsection.

2.2 Notation for Syntactic Form Documentation

§4.1 "Notation" in *The Racket Guide* introduces this notation for syntactic forms.

Syntactic forms are specified with a grammar. Typically, the grammar starts with an open parenthesis followed by the syntactic form's name, as in the grammar for `if`:

```
(if test-expr then-expr else-expr)
```

Since every form is expressed in terms of syntax objects, parentheses in a grammar specification indicate a syntax object wrapping a list, and the leading `if` is an identifier that starts the list whose binding is the `if` binding of the module being documented—in this case, `racket/base`. Square brackets in the grammar indicate a syntax-object list in the same way as parentheses, but in places square brackets are normally used by convention in a program's source.

Italic identifiers in the grammar are *metavariables* that correspond to other grammar productions. Certain metavariable names have implicit grammar productions:

- A metavariable that ends in *`id`* stands for an identifier.
- A metavariable that ends in *`keyword`* stands for a syntax-object keyword.
- A metavariable that ends with *`expr`* stands for any form, and the form will be parsed as an expression.
- A metavariable that ends with *`body`* stands for any form; the form will be parsed as either a local definition or an expression. A *`body`* can parse as a definition only if it is not preceded by any expression, and the last *`body`* must be an expression; see also §1.2.3.8 "Internal Definitions".
- A metavariable that ends with *`datum`* stands for any form, and the form is normally uninterpreted (e.g., `quoted`).
- A metavariable that ends with *`number`* or *`boolean`* stands for any syntax-object (i.e., literal) number or boolean, respectively.

In a grammar, *`form`* `...` stands for any number of forms (possibly zero) matching *`form`*, while *`form`* `...+` stands for one or more forms matching *`form`*.

Metavariables without an implicit grammar are defined by productions alongside the syntactic form's overall grammar. For example, in

```
(lambda formals body ...+)

formals = id
        | (id ...)
        | (id ...+ . rest-id)
```

the *`formals`* metavariable stands for either an identifier, zero or more identifiers in a syntax-object list, or a syntax object corresponding to a chain of one or more pairs where the chain ends in an identifier instead of an empty list.

Some syntactic forms have multiple top-level grammars, in which case the documentation of the syntactic forms shows multiple grammars. For example,

```
(init-rest id)
(init-rest)
```

indicates that `init-rest` can either be alone in its syntax-object list or followed by a single identifier.

Finally, a grammar specification that includes *expr* metavariables may be augmented with run-time contracts on some of the metavariables, which indicate a predicate that the result of the expression must satisfy at run time. For example,

```
(parameterize ([parameter-expr value-expr] ...)
  body ...+)

  parameter-expr : parameter?
```

indicates that the result of each *parameter-expr* must be a value *v* for which `(parameter? v)` returns true.

2.3 Notation for Function Documentation

Procedures and other values are described using a notation based on contracts. In essence, these contracts describe the interfaces of the documented library using Racket predicates and expressions.

For example, the following is the header of the definition of a typical procedure:

```
(char->integer char) → exact-integer?
  char : char?
```

The function being defined, `char->integer`, is typeset as if it were being applied. The metavariables that come after the function name stand in for arguments. The white text in the corner identifies the kind of value that is being documented.

Each metavariable is described with a contract. In the preceding example, the metavariable *char* has the contract `char?`. This contract specifies that any argument *char* that answers true to the `char?` predicate is valid. The documented function may or may not actually check this property, but the contract signals the intent of the implementer.

The contract on the right of the arrow, `exact-integer?` in this case, specifies the expected result that is produced by the function.

Contract specifications can be more expressive than just names of predicates. Consider the following header for `argmax`:

```
(argmax proc lst) → any
  proc : (-> any/c real?)
  lst : (and/c pair? list?)
```

The contract `(-> any/c real?)` denotes a function contract specifying that `proc`'s argument can be any single value and the result should be a real number. The contract `(and/c pair? list?)` for `lst` specifies that `lst` should pass both `pair?` and `list?` (i.e., that it is a non-empty list).

Both `->` and `and/c` are examples of contract combinators. Contract combinators such as `or/c`, `cons/c`, `listof`, and others are used throughout the documentation. Clicking on the hyperlinked combinator name will provide more information on its meaning.

A Racket function may be documented as having one or more optional arguments. The `read` function is an example of such a function:

```
(read [in]) → any
  in : input-port? = (current-input-port)
```

The brackets surrounding the `in` argument in the application syntax indicates that it is an optional argument.

The header for `read` specifies a contract for the parameter `in` as usual. To the right of the contract, it also specifies a default value `(current-input-port)` that is used if `read` is called with no arguments.

Functions may also be documented as accepting mandatory or optional keyword-based arguments. For example, the `sort` function has two optional, keyword-based arguments:

```
(sort  lst
       less-than?
      [#:key extract-key
       #:cache-keys? cache-keys?]) → list?
  lst : list?
  less-than? : (any/c any/c . -> . any/c)
  extract-key : (any/c . -> . any/c) = (lambda (x) x)
  cache-keys? : boolean? = #f
```

The brackets around the `extract-key` and `cache-keys?` arguments indicate that they are optional as before. The contract section of the header shows the default values that are provided for these keyword arguments.

2.4 Notation for Structure Type Documentation

A structure type is also documented using contract notation:

```
(struct color (red green blue alpha))
  red : (and/c natural-number/c (<=/c 255))
  green : (and/c natural-number/c (<=/c 255))
  blue : (and/c natural-number/c (<=/c 255))
  alpha : (and/c natural-number/c (<=/c 255))
```

The structure type is typeset as it were declared in the source code of a program using the `struct` form. Each field of the structure is documented with a corresponding contract that specifies the values that are accepted for that field.

In the example above, the structure type *`color`* has four fields: *`red`*, *`green`*, *`blue`*, and *`alpha`*. The constructor for the structure type accepts field values that satisfy `(and/c natural-number/c (<=/c 255))`, i.e., non-negative exact integers up to 255.

Additional keywords may appear after the field names in the documentation for a structure type:

```
(struct data-source (connector args extensions)
    #:mutable)
  connector : (or/c 'postgresql 'mysql 'sqlite3 'odbc)
  args : list?
  extensions : (listof (list/c symbol? any/c))
```

Here, the `#:mutable` keyword indicates that the fields of instances of the *`data-source`* structure type can be mutated with their respective setter functions.

2.5 Notation for Parameter Documentation

A parameter is documented the same way as a function:

```
(current-command-line-arguments) → (vectorof string?)
(current-command-line-arguments argv) → void?
  argv : (vectorof (and/c string? immutable?))
```

Since parameters can be referenced or set, there are two entries in the header above. Calling `current-command-line-arguments` with no arguments accesses the parameter's value, which must be a vector whose elements pass both `string?` and `immutable?`. Calling `current-command-line-arguments` with a single argument sets the parameter's value, where the value must be a vector whose elements pass `string?` (and a guard on the parameter coerces the strings to immutable form, if necessary).

2.6 Notation for Other Documentation

Some libraries provide bindings to constant values. These values are documented with a separate header:

```
object% : class?
```

The `racket/class` library provides the `object%` value, which is the root of the class hierarchy in Racket. Its documentation header just indicates that it is a value that satisfies the predicate `class?`.

3 Syntactic Forms

This section describes the core syntax forms that appear in a fully expanded expression, plus many closely related non-core forms. See §1.2.3.1 "Fully Expanded Programs" for the core grammar.

3.1 Modules: `module`, `module*`, ...

§6.2.1 "The `module` Form" in *The Racket Guide* introduces `module`.

```
(module id module-path form ...)
```

Declares a top-level module or a submodule. For a top-level module, if the `current-module-declare-name` parameter is set, the parameter value is used for the module name and *`id`* is ignored, otherwise `(quote id)` is the name of the declared module. For a submodule, *`id`* is the name of the submodule to be used as an element within a `submod` module path. A `module` form is not allowed in an expression context or internal-definition context.

For a `module`-like form that works in definition contexts other than the top level or a module body, there's `define-package`, but using a separate module or submodule is usually better.

The *`module-path`* form must be as for `require`, and it supplies the initial bindings for the body *`form`*s. That is, it is treated like a `(require module-path)` prefix before the *`form`*s, except that the bindings introduced by *`module-path`* can be shadowed by definitions and `require`s in the module body *`form`*s.

If a single *`form`* is provided, then it is partially expanded in a module-begin context. If the expansion leads to `#%plain-module-begin`, then the body of the `#%plain-module-begin` is the body of the module. If partial expansion leads to any other primitive form, then the form is wrapped with `#%module-begin` using the lexical context of the module body; this identifier must be bound by the initial *`module-path`* import, and its expansion must produce a `#%plain-module-begin` to supply the module body. If partial expansion produces a compiled module in the sense of `compiled-module-expression?`, that compiled module is used for the enclosing module (skipping all other expansion and compilation steps), but such a result is allowed only in a compilation mode where `syntax-local-compiling-module?` produces true and when the current code inspector is the initial one. Finally, if multiple *`form`*s are provided, they are wrapped with `#%module-begin`, as in the case where a single *`form`* does not expand to `#%plain-module-begin`.

After such wrapping, if any, and before any expansion, an `'enclosing-module-name` property is attached to the `#%module-begin` syntax object (see §12.7 "Syntax Object Properties"); the property's value is a symbol corresponding to *`id`*.

Each *`form`* is partially expanded (see §1.2.3.7 "Partial Expansion") in a module context. Further action depends on the shape of the form:

- If it is a `begin` form, the sub-forms are flattened out into the module's body and immediately processed in place of the `begin`.

- If it is a define-syntaxes form, then the right-hand side is evaluated (in phase 1), and the binding is immediately installed for further partial expansion within the module. Evaluation of the right-hand side is parameterized to set current-namespace as in let-syntax.
- If it is a begin-for-syntax form, then the body is expanded (in phase 1) and evaluated. Expansion within a begin-for-syntax form proceeds with the same partial-expansion process as for a module body, but in a higher phase, and saving all #%provide forms for all phases until the end of the module's expansion. Evaluation of the body is parameterized to set current-namespace as in let-syntax.
- If the form is a #%require form, bindings are introduced immediately, and the imported modules are instantiated or visited as appropriate.
- If the form is a #%provide form, then it is recorded for processing after the rest of the body.
- If the form is a define-values form, then the binding is installed immediately, but the right-hand expression is not expanded further.
- If the form is a module form, then it is immediately expanded and declared for the extent of the current top-level enclosing module's expansion.
- If the form is a module* form, then it is not expanded further.
- Similarly, if the form is an expression, it is not expanded further.

After all *form*s have been partially expanded this way, then the remaining expression forms (including those on the right-hand side of a definition) are expanded in an expression context. After all expression forms, #%provide forms are processed in the order in which they appear (independent of phase) in the expanded module. Finally, all module* forms are expanded in order, so that each becomes available for use by subsequent module* forms; the enclosing module itself is also available for use by module* submodules.

The scope of all imported identifiers covers the entire module body, except for nested module and module* forms (assuming a non-#f *module-path* in the latter case). The scope of any identifier defined within the module body similarly covers the entire module body except for such nested module and module* forms. The ordering of syntax definitions does not affect the scope of the syntax names; a transformer for A can produce expressions containing B, while the transformer for B produces expressions containing A, regardless of the order of declarations for A and B. However, a syntactic form that produces syntax definitions must be defined before it is used.

No identifier can be imported or defined more than once at any phase level within a single module, except that a definition via define-values or define-syntaxes can shadow an import via #%require—as long as no preceding #%declare form includes #:require=defined. Every exported identifier must be imported or defined. No expression can refer to a top-level variable. A module* form in which the enclosing module's bindings are visible (i.e., a nested module* with #f instead of a *module-path*) can define or import bindings that shadow the enclosing module's bindings.

The evaluation of a module form does not evaluate the expressions in the body of the module (except sometimes for redeclarations; see §1.1.9.4 "Module Redeclarations"). Evaluation merely declares a module, whose full name depends both on *id* or (current-module-declare-name).

A module body is executed only when the module is explicitly instantiated via require or dynamic-require. On invocation, imported modules are instantiated in the order in which they are required into the module (although earlier instantiations or transitive requires can trigger the instantiation of a module before its order within a given module). Then, expressions and definitions are evaluated in order as they appear within the module. Each evaluation of an expression or definition is wrapped with a continuation prompt (see call-with-continuation-prompt) for the default prompt tag and using a prompt handler that re-aborts and propagates its argument to the next enclosing prompt. Each evaluation of a definition is followed, outside of the prompt, by a check that each of the definition's variables has a value; if the portion of the prompt-delimited continuation that installs values is skipped, then the exn:fail:contract:variable? exception is raised.

Portions of a module body at higher phase levels are delimited similarly to run-time portions. For example, portions of a module within begin-for-syntax are delimited by a continuation prompt both as the module is expanded and when it is visited. The evaluation of a define-syntaxes form is delimited, but unlike define-values, there is no check that the syntax definition completed.

Accessing a module-level variable before it is defined signals a run-time error, just like accessing an undefined global variable. If a module (in its fully expanded form) does not contain a set! for an identifier that defined within the module, then the identifier is a *constant* after it is defined; its value cannot be changed afterward, not even through reflective mechanisms. The compile-enforce-module-constants parameter, however, can be used to disable enforcement of constants.

When a syntax object representing a module form has a 'module-language syntax property attached, and when the property value is a vector of three elements where the first is a module path (in the sense of module-path?) and the second is a symbol, then the property value is preserved in the corresponding compiled and/or declared module. The third component of the vector should be printable and readable, so that it can be preserved in marshaled bytecode. The racket/base and racket languages attach '#(racket/language-info get-info #f) to a module form. See also module-compiled-language-info, module->language-info, and racket/language-info.

See also §1.1.9 "Modules and Module-Level Variables", §1.2.3.9 "Module Expansion, Phases, and Visits", and §12.9.1 "Information on Expanded Modules".

Example:

```
> (module duck racket/base
    (provide num-eggs quack)
    (define num-eggs 2)
    (define (quack n)
      (unless (zero? n)
        (printf "quack\n")
        (quack (sub1 n)))))
```

Changed in version 6.3 of package base: Changed define-syntaxes and define-values to shadow any preceding import, and dropped the use of 'submodule syntax property values on nested module or module* forms.

```
(module* id module-path form ...)
(module* id #f form ...)
```

§6.2.3 "Submodules" in *The Racket Guide* introduces module*.

Like module, but only for declaring a submodule within a module, and for submodules that may require the enclosing module.

Instead of a *module-path* after *id*, #f indicates that all bindings from the enclosing module are visible in the submodule. In that case, begin-for-syntax forms that wrap the module* form shift the phase level of the enclosing module's bindings relative to the submodule. The macro expander handles such nesting by shifting the phase level of the module* form so that its body starts at phase level 0, expanding, and then reverting the phase level shift; beware that this process can leave syntax objects as 'origin syntax property values out-of-sync with the expanded module.

When a module* form has a *module-path*, the submodule expansion starts by removing the scopes of the enclosing module, the same as the module form. No shifting compensates for any begin-for-syntax forms that may wrap the submodule.

```
(module+ id form ...)
```

§6.2.4 "Main and Test Submodules" in *The Racket Guide* introduces module+.

Declares and/or adds to a submodule named *id*.

Each addition for *id* is combined in order to form the entire submodule using (module* *id* #f ....) at the end of the enclosing module. If there is only one module+ for a given *id*, then (module+ *id* *form* ...) is equivalent to (module* *id* #f *form* ...), but still moved to the end of the enclosing module.

A syntax property on the module* form with the key 'origin-form-srcloc records the srcloc for every contributing module+ form.

When a module contains multiple submodules declared with module+, then the relative order of the initial module+ declarations for each submodule determines the relative order of the module* declarations at the end of the enclosing module.

A submodule must not be defined using module+ *and* module or module*. That is, if a submodule is made of module+ pieces, then it must be made *only* of module+ pieces.

Changed in version 8.9.0.1 of package base: Added 'origin-form-srcloc syntax property.

```
(#%module-begin form ...)
```

Legal only in a module begin context, and handled by the module and module* forms.

The #%module-begin form of racket/base wraps every top-level expression to print non-#<void> results using the print handler as determined by current-print, and it also returns the values after printing. This printing is added as part of the #%module-begin expansion, so the prompt that module itself adds is outside the printing wrapper—and it potentially makes the values returned after printing relevant, because a continuation could be captured and then invoked in a different context.

The #%module-begin form of racket/base also declares a configure-runtime submodule (before any other *form*), unless some *form* is either an immediate module or module* form with the name configure-runtime. If a configure-runtime submodule is added, the submodule calls the configure function of racket/runtime-config.

```
(#%printing-module-begin form ...)
```

Legal only in a module begin context.

Like #%module-begin, but without adding a configure-runtime submodule.

```
(#%plain-module-begin form ...)
```

Legal only in a module begin context, and handled by the module and module* forms.

```
(#%declare declaration-keyword ...)

declaration-keyword = #:cross-phase-persistent
                    | #:empty-namespace
                    | #:require=define
                    | #:flatten-requires
                    | #:unlimited-compile
                    | #:unsafe
                    | #:realm identifier
```

Declarations that affect run-time or reflective properties of the module:

- #:cross-phase-persistent — declares the module as cross-phase persistent, and reports a syntax error if the module does not meet the import or syntactic constraints of a cross-phase persistent module.
- #:empty-namespace — declares that module->namespace for this module should produce a namespace with no bindings; limiting namespace support in this way can reduce the lexical information that otherwise must be preserved for the module.

- `#:require=define` — declares that no subsequent definition immediately with the module body is allowed to shadow a `#%require` (or `require`) binding. This declaration does not affect shadowing of a module's initial imports (i.e., the module's language).

- `#:flatten-requires` — declares the performance hint that a compiled form of the module should gather transitive imports into a single, flattened list, which can improve performance when the module is instantiated or when it is attached via `namespace-attach-module` or `namespace-attach-module-declaration`. Flattening imports can be counterproductive, however, when it is applied to multiple modules that are both use by another and that have overlapping transitive-import subtrees.

- `#:unlimited-compile` — declares that compilation should not fall back to interpreted mode for an especially large module body. Otherwise, a compilation mode is selected based on the size of the module body (as converted to a linklet) and the `PLT_CS_COMPILE_LIMIT` environment variable (see §18.7.1.2 "CS Compilation Modes").

- `#:unsafe` — declares that the module can be compiled without checks that could trigger `exn:fail:contract`, and the resulting behavior is unspecified for an evaluation where `exn:fail:contract` should have been raised; see also §17 "Unsafe Operations". For example, a use of `car` can be compiled as a use of `unsafe-car`, and the behavior is unspecified is `unsafe-car` is applied to a non-pair. The `#:unsafe` declaration keyword is allowed only when the current code inspector is the initial one. Macros can generate conditionally unsafe code, depending on the expansion context, by expanding to a use of `(variable-reference-from-unsafe? (#%variable-reference))`.

- `#:realm` *`identifier`* — declares that the module and any procedures within the module are given a realm that is the symbol form of *`identifier`*, effectively overriding the value of `current-compile-realm`.

A `#%declare` form must appear in a module context or a module-begin context. Each *`declaration-keyword`* can be declared at most once within a `module` body.

Changed in version 6.3 of package `base`: Added `#:empty-namespace`.
Changed in version 7.9.0.5: Added `#:unsafe`.
Changed in version 8.4.0.2: Added `#:realm`.
Changed in version 8.6.0.9: Added `#:require=define`.
Changed in version 8.13.0.4: Added `#:flatten-requires`.
Changed in version 8.13.0.9: Added `#:unlimited-compile`.

3.2 Importing and Exporting: `require` and `provide`

§6.4 "Imports: `require`" in *The Racket Guide* introduces `require`.

```
(require require-spec ...)
```

```
       require-spec = module-path
                    | (only-in require-spec id-maybe-renamed ...)
                    | (except-in require-spec id ...)
                    | (prefix-in prefix-id require-spec)
                    | (rename-in require-spec [orig-id bind-id] ...)
                    | (combine-in require-spec ...)
                    | (relative-in module-path require-spec ...)
                    | (only-meta-in phase-level require-spec ...)
                    | (only-space-in space require-spec ...)
                    | (for-syntax require-spec ...)
                    | (for-template require-spec ...)
                    | (for-label require-spec ...)
                    | (for-meta phase-level require-spec ...)
                    | (for-space space require-spec ...)
                    | derived-require-spec

        module-path = root-module-path
                    | (submod root-module-path submod-path-element ...)
                    | (submod "." submod-path-element ...)
                    | (submod ".." submod-path-element ...)

   root-module-path = (quote id)
                    | rel-string
                    | (lib rel-string ...+)
                    | id
                    | (file string)
                    | (planet id)
                    | (planet string)
                    | (planet rel-string
                              (user-string pkg-string vers)
                              rel-string ...)

submod-path-element = id
                    | ".."

   id-maybe-renamed = id
                    | [orig-id bind-id]

        phase-level = exact-integer
                    | #f

              space = id
                    | #f

               vers =
                    | nat
                    | nat minor-vers

         minor-vers = nat
                    | (nat nat)
                    | (= nat)
                    | (+ nat)
                    | (- nat)
```

In a top-level context, `require` instantiates modules (see §1.1.9 "Modules and Module-Level Variables"). In a top-level context or module context, expansion of `require` visits modules (see §1.2.3.9 "Module Expansion, Phases, and Visits"). In both contexts and both evaluation and expansion, `require` introduces bindings into a namespace or a module (see §1.2.3.4 "Introducing Bindings"). A `require` form in a expression context or internal-definition context is a syntax error.

A *`require-spec`* designates a particular set of identifiers to be bound in the importing context. Each identifier is mapped to a particular export of a particular module; the identifier to bind may be different from the symbolic name of the originally exported identifier. Each identifier also binds at a particular phase level and in a binding space.

No identifier can be bound multiple times in a given combination of phase level and binding space by an import, unless all of the bindings refer to the same original definition in the same module. In a module context, an identifier can be either imported or defined for a given phase level and binding space, but not both.

The syntax of *`require-spec`* can be extended via `define-require-syntax`, and when multiple *`require-spec`*s are specified in a `require`, the bindings of each *`require-spec`* are visible for expanding later *`require-spec`*s. The pre-defined forms (as exported by `racket/base`) are as follows:

```
module-path
```

Imports all exported bindings from the named module, using the export name for the local identifiers. (See below for information on *`module-path`*.) The lexical context of the *`module-path`* form determines the context of the introduced identifiers, adding a space scope for exports in a particular binding space, and in each export's phase level.

If any identifier provided by *`module-path`* has a symbol form that is uninterned, the identifier is not imported (i.e., it is impossible to import a binding for an uninterned symbol). This restriction is intended to avoid compilation differences depending on whether a module has been saved to a file or not (see §1.4.16 "Printing Compiled Code").

```
(only-in require-spec id-maybe-renamed ...)
```

Like *`require-spec`*, but constrained to those exports for which the identifiers to bind match *`id-maybe-renamed`*: as *`id`* or as *`orig-id`* in `[`*`orig-id bind-id`*`]`. When a *`id-maybe-renamed`* has a *`bind-id`*, the lexical context of *`bind-id`* is used for the binding. If the *`id`* or *`orig-id`* of any *`id-maybe-renamed`* is not in the set that *`require-spec`* describes, a syntax error is reported.

Examples:

```
> (require (only-in racket/tcp
                    tcp-listen
                    [tcp-accept my-accept]))
> tcp-listen
#<procedure:tcp-listen>
> my-accept
#<procedure:tcp-accept>
> tcp-accept
tcp-accept: undefined;
 cannot reference an identifier before its definition
  in module: top-level
```

```
(except-in require-spec id ...)
```

Like *require-spec*, but omitting those imports for which *id*s are the identifiers to bind; if any *id* is not in the set that *require-spec* describes, a syntax error is reported.

Examples:

```
> (require (except-in racket/tcp
                      tcp-listen))
> tcp-accept
#<procedure:tcp-accept>
> tcp-listen
tcp-listen: undefined;
 cannot reference an identifier before its definition
  in module: top-level
```

```
(prefix-in prefix-id require-spec)
```

Like *require-spec*, but adjusting each identifier to be bound by prefixing it with *prefix-id*. The lexical context of the *prefix-id* is ignored, and instead preserved from the identifiers before prefixing.

Examples:

```
> (require (prefix-in tcp: racket/tcp))
> tcp:tcp-accept
#<procedure:tcp-accept>
> tcp:tcp-listen
#<procedure:tcp-listen>
```

A syntax property with the key `'import-or-export-prefix-ranges` is added to the local identifier in the expanded form of `require`.

Changed in version 8.9.0.5 of package `base`: Added the `'import-or-export-prefix-ranges` syntax property.

```
(rename-in require-spec [orig-id bind-id] ...)
```

Like *require-spec*, but replacing the identifier to bind *orig-id* with *bind-id*. The lexical context of *bind-id* is used for the binding. If any *orig-id* is not in the set that *require-spec* describes, a syntax error is reported.

Examples:

```
> (require (rename-in racket/tcp
                      (tcp-accept accept)
                      (tcp-listen listen)))
> accept
#<procedure:tcp-accept>
> listen
#<procedure:tcp-listen>
```

```
(combine-in require-spec ...)
```

The union of the *require-spec*s. If two or more imports from the *require-spec*s have the same identifier name but they do not refer to the same original binding, a syntax error is reported.

Examples:

```
> (require (combine-in (only-in racket/tcp tcp-accept)
                       (only-in racket/tcp tcp-listen)))
> tcp-accept
#<procedure:tcp-accept>
> tcp-listen
#<procedure:tcp-listen>
```

```
(relative-in module-path require-spec ...)
```

Like the union of the *require-spec*s, but each relative module path in a *require-spec* is treated as relative to *module-path* instead of the enclosing context.

The require transformer that implements `relative-in` sets `current-require-module-path` to adjust module paths in the *require-spec*s.

```
(only-meta-in phase-level require-spec ...)
```

Like the combination of *require-spec*s, but removing any binding that is not for *phase-level*, where `#f` for *phase-level* corresponds to the label phase level.

The following example imports bindings only at phase level 1, the transform phase:

```
> (module nest racket
    (provide (for-syntax meta-eggs)
             (for-meta 1 meta-chicks)
             num-eggs)
    (define-for-syntax meta-eggs 2)
    (define-for-syntax meta-chicks 3)
    (define num-eggs 2))
> (require (only-meta-in 1 'nest))
> (define-syntax (desc stx)
    (printf "~s ~s\n" meta-eggs meta-chicks)
    #'(void))
> (desc)
2 3
> num-eggs
num-eggs: undefined;
 cannot reference an identifier before its definition
  in module: top-level
```

The following example imports only bindings at phase level 0, the normal phase.

```
> (require (only-meta-in 0 'nest))
> num-eggs
2
```

```
(only-space-in space require-spec ...)
```

Like the combination of *require-spec*s, but removing any binding that is not provided for the binding space identifier by *space*—which is normally an identifier, but `#f` for *space* corresponds to the default binding space.

Added in version 8.2.0.3 of package `base`.

```
(for-meta phase-level require-spec ...)
```

Like the combination of *require-spec*s, but the bindings specified by each *require-spec* are shifted by *phase-level*. The label phase level corresponds to `#f`, and a shifting combination that involves `#f` produces `#f`.

Examples:

```
> (module nest racket
    (provide num-eggs)
    (define num-eggs 2))
> (require (for-meta 0 'nest))
> num-eggs
2
> (require (for-meta 1 'nest))
```

```
> (define-syntax (roost stx)
    (datum->syntax stx num-eggs))
> (roost)
2
```

`(for-syntax require-spec ...)`

Same as `(for-meta 1 require-spec ...)`.

`(for-template require-spec ...)`

Same as `(for-meta -1 require-spec ...)`.

`(for-label require-spec ...)`

Same as `(for-meta #f require-spec ...)`. If an identifier in any of the *require-spec*s is bound at more than one phase level, a syntax error is reported.

`(for-space space require-spec ...)`

Like the combination of *require-spec*s, but the bindings specified by each *require-spec* are moved to the binding space specified by *space*—which is normally an identifier, but `#f` for *space* corresponds to the default binding space.

A binding is moved to the new space by removing the scope for the space originally implied by *require-spec*, if any, and adding the scope for *space*, if any.

Added in version 8.2.0.3 of package `base`.

derived-require-spec

See `define-require-syntax` for information on expanding the set of *require-spec* forms.

§6.3 "Module Paths" in *The Racket Guide* introduces module paths.

A *module-path* identifies a module, either a root module or a submodule that is declared lexically within another module. A root module is identified either through a concrete name in the form of an identifier, or through an indirect name that can trigger automatic loading of the module declaration. Except for the `(quote id)` case below, the actual resolution of a root module path is up to the current module name resolver (see `current-module-name-resolver`), and the description below corresponds to the default module name resolver.

```
(quote id)
```

Refers to a submodule previously declared with the name *id* or a module previously declared interactively with the name *id*. When *id* refers to a submodule, `(quote id)` is equivalent to `(submod "." id)`.

Examples:

```
; a module declared interactively as test:
> (require 'test)
```

```
rel-string
```

A path relative to the containing source (as determined by `current-load-relative-directory` or `current-directory`). Regardless of the current platform, *rel-string* is always parsed as a Unix-format relative path: `/` is the path delimiter (multiple adjacent `/`s are not allowed), `..` accesses the parent directory, and `.` accesses the current directory. The path cannot be empty or contain a leading or trailing slash, path elements before than the last one cannot include a file suffix (i.e., a `.` in an element other than `.` or `..`), and the only allowed characters are ASCII letters, ASCII digits, `-`, `+`, `_`, `.`, `/`, and `%`. Furthermore, a `%` is allowed only when followed by two lowercase hexadecimal digits, and the digits must form a number that is not the ASCII value of a letter, digit, `-`, `+`, or `_`.

The `%` provision is intended to support a one-to-one encoding of arbitrary strings as path elements (after UTF-8 encoding). Such encodings are not decoded to arrive at a filename, but instead preserved in the file access.

If *rel-string* ends with a `".ss"` suffix, it is converted to a `".rkt"` suffix. The compiled-load handler may reverse that conversion if a `".rkt"` file does not exist and a `".ss"` exists.

Examples:

```
; a module named "x.rkt" in the same
; directory as the enclosing module's file:
> (require "x.rkt")
; a module named "x.rkt" in the parent directory
; of the enclosing module file's directory:
> (require "../x.rkt")
```

```
(lib rel-string ...+)
```

A path to a module installed into a collection (see §18.2 "Libraries and Collections"). The *rel-string*s in `lib` are constrained similar to the plain *rel-string* case, with the additional constraint that a *rel-string* cannot contain `.` or `..` directory indicators.

The specific interpretation of the path depends on the number and shape of the *rel-string*s:

- If a single *rel-string* is provided, and if it consists of a single element (i.e., no `/`) with no file suffix (i.e., no `.`), then *rel-string* names a collection, and `"main.rkt"` is the library file name.

  Examples:

  ```
  ; the main swindle library:
  > (require (lib "swindle"))
  ; the same:
  > (require (lib "swindle/main.rkt"))
  ```

- If a single *rel-string* is provided, and if it consists of multiple `/`-separated elements, then each element up to the last names a collection, subcollection, etc., and the last element names a file. If the last element has no file suffix, `".rkt"` is added, while a `".ss"` suffix is converted to `".rkt"`.

  Examples:

  ```
  ; "turbo.rkt" from the "swindle" collection:
  > (require (lib "swindle/turbo"))
  ; the same:
  > (require (lib "swindle/turbo.rkt"))
  ; the same:
  > (require (lib "swindle/turbo.ss"))
  ```

- If a single *rel-string* is provided, and if it consists of a single element *with* a file suffix (i.e, with a `.`), then *rel-string* names a file within the `"mzlib"` collection. A `".ss"` suffix is converted to `".rkt"`. (This convention is for compatibility with older version of Racket.)

  Examples:

  ```
  ; "tar.rkt" module from the "mzlib" collection:
  > (require (lib "tar.ss"))
  ```

- Otherwise, when multiple *rel-string*s are provided, the first *rel-string* is effectively moved after the others, and all *rel-string*s are appended with `/` separators. The resulting path names a collection, then subcollection, etc., ending with a file name. No suffix is added automatically, but a `".ss"` suffix is converted to `".rkt"`. (This convention is for compatibility with older version of Racket.)

  Examples:

  ```
  ; "tar.rkt" module from the "mzlib" collection:
  > (require (lib "tar.ss" "mzlib"))
  ```

id

A shorthand for a `lib` form with a single *rel-string* whose characters are the same as in the symbolic form of *id*. In addition to the constraints of a `lib` *rel-string*, *id* must not contain `.`.

Example:

```
> (require racket/tcp)
```

```
(file string)
```

Similar to the plain *rel-string* case, but *string* is a path—possibly absolute—using the current platform's path conventions and `expand-user-path`. A `".ss"` suffix is converted to `".rkt"`.

Example:

```
> (require (file "~/tmp/x.rkt"))
```

```
(planet id)
(planet string)
(planet rel-string (user-string pkg-string vers)
        rel-string ...)
```

Specifies a library available via the PLaneT server.

The first form is a shorthand for the last one, where the *id*'s character sequence must match the following ⟨*spec*⟩ grammar:

```
⟨spec⟩    ::= ⟨owner⟩ / ⟨pkg⟩ ⟨lib⟩
⟨owner⟩   ::= ⟨elem⟩
⟨pkg⟩     ::= ⟨elem⟩  |  ⟨elem⟩ : ⟨version⟩
⟨version⟩ ::= ⟨int⟩  |  ⟨int⟩ : ⟨minor⟩
⟨minor⟩   ::= ⟨int⟩  |  <= ⟨int⟩  |  >= ⟨int⟩  |  = ⟨int⟩
            |  ⟨int⟩ - ⟨int⟩
⟨lib⟩     ::= ⟨empty⟩  |  / ⟨path⟩
⟨path⟩    ::= ⟨elem⟩  |  ⟨elem⟩ / ⟨path⟩
```

and where an ⟨*elem*⟩ is a non-empty sequence of characters that are ASCII letters, ASCII digits, `-`, `+`, `_`, or `%` followed by lowercase hexadecimal digits (that do not encode one of the other allowed characters), and an ⟨*int*⟩ is a non-empty sequence of ASCII digits. As this shorthand is expended, a `".plt"` extension is added to ⟨*pkg*⟩, and a `".rkt"` extension is added to ⟨*path*⟩; if no ⟨*path*⟩ is included, `"main.rkt"` is used in the expansion.

A `(planet string)` form is like a `(planet id)` form with the identifier converted to a string, except that the *string* can optionally end with a file extension (i.e., a `.`) for a ⟨*path*⟩. A `".ss"` file extension is converted to `".rkt"`.

In the more general last form of a `planet` module path, the *rel-string*s are similar to the `lib` form, except that the `(user-string pkg-string vers)` names a PLaneT-based package instead of a collection. A version specification can include an optional major and minor version, where the minor version can be a specific number or a constraint: `(nat nat)` specifies an inclusive range, `(= nat)` specifies an exact match, `(+ nat)` specifies a minimum version and is equivalent to just `nat`, and `(- nat)` specifies a maximum version. The `=`, `+`, and `-` identifiers in a minor-version constraint are recognized symbolically.

Examples:

```
; "main.rkt" in package "farm" by "mcdonald":
> (require (planet mcdonald/farm))
; "main.rkt" in version >= 2.0 of "farm" by "mcdonald":
> (require (planet mcdonald/farm:2))
; "main.rkt" in version >= 2.5 of "farm" by "mcdonald":
> (require (planet mcdonald/farm:2:5))
; "duck.rkt" in version >= 2.5 of "farm" by "mcdonald":
> (require (planet mcdonald/farm:2:5/duck))
```

```
(submod root-module-path submod-path-element ...)
(submod "." submod-path-element ...)
(submod ".." submod-path-element ...)
```

Identifies a submodule within the module specified by *root-module-path* or relative to the current module in the case of `(submod "." ....)`, where `(submod ".." submod-path-element ...)` is equivalent to `(submod "." ".." submod-path-element ...)`. Submodules have symbolic names, and a sequence of identifiers as *submod-path-element*s determine a path of successively nested submodules with the given names. A `".."` as a *submod-path-element* names the enclosing module of a submodule, and it's intended for use in `(submod "." ....)` and `(submod ".." ....)` forms.

As `require` prepares to handle a sequence of *require-spec*s, it logs a "prefetch" message to the current logger at the `'info` level, using the name `'module-prefetch`, and including message data that is a list of two elements: a list of module paths that appear to be imported, and a directory path to use for relative module paths. The logged list of module paths may be incomplete, but a compilation manager can use approximate prefetch information to start on compilations in parallel.

Changed in version 6.0.1.10 of package `base`: Added prefetch logging.

```
(local-require require-spec ...)
```

Like `require`, but for use in a internal-definition context to import just into the local context. Only bindings from phase level 0 are imported.

Examples:

```
> (let ()
    (local-require racket/control)
    fcontrol)
#<procedure:fcontrol>
> fcontrol
fcontrol: undefined;
 cannot reference an identifier before its definition
  in module: top-level
```

§6.5 "Exports: provide" in *The Racket Guide* introduces provide.

```
(provide provide-spec ...)

provide-spec = id
             | (all-defined-out)
             | (all-from-out module-path ...)
             | (rename-out [orig-id export-id] ...)
             | (except-out provide-spec provide-spec ...)
             | (prefix-out prefix-id provide-spec)
             | (struct-out id)
             | (combine-out provide-spec ...)
             | (protect-out provide-spec ...)
             | (for-meta phase-level provide-spec ...)
             | (for-syntax provide-spec ...)
             | (for-template provide-spec ...)
             | (for-label provide-spec ...)
             | (for-space space provide-spec ...)
             | derived-provide-spec

 phase-level = exact-integer
             | #f

       space = id
             | #f
```

Declares exports from a module. A `provide` form must appear in a module context or a module-begin context.

A *`provide-spec`* indicates one or more bindings to provide. For each exported binding, the external name is a symbol that can be different from the symbolic form of the identifier that is bound within the module. Also, each export is drawn from a particular phase level and exported at the same phase level; by default, the relevant phase level is the number of `begin-for-syntax` forms that enclose the `provide` form. Finally, each export is drawn from a binding space and exported at the same binding space.

The syntax of *`provide-spec`* can be extended by bindings to provide transformers or provide pre-transformers, such as via `define-provide-syntax`, but the pre-defined forms are as follows.

id

Exports *id*, which must be bound within the module (i.e., either defined or imported) at the relevant phase level and binding space. The symbolic form of *id* is used as the external name, and the symbolic form of the defined or imported identifier must match (otherwise, the external name could be ambiguous).

Examples:

```
> (module nest racket
    (provide num-eggs)
    (define num-eggs 2))
> (require 'nest)
> num-eggs
2
```

If *id* has a transformer binding to a rename transformer, then the transformer affects the exported binding. See `make-rename-transformer` for more information.

`(all-defined-out)`

Exports all identifiers that are defined at the relevant phase level within the exporting module, and that have the same lexical context as the `(all-defined-out)` form, excluding bindings to rename transformers where the target identifier has the `'not-provide-all-defined` syntax property. The external name for each identifier is the symbolic form of the identifier. Only identifiers accessible from the lexical context of the `(all-defined-out)` form are included; that is, macro-introduced imports are not re-exported, unless the `(all-defined-out)` form was introduced at the same time.

Examples:

```
> (module nest racket
    (provide (all-defined-out))
    (define num-eggs 2))
> (require 'nest)
> num-eggs
2
```

`(all-from-out module-path ...)`

Exports all identifiers that are imported into the exporting module using a `require-spec` built on each *`module-path`* (see §3.2 "Importing and Exporting: `require` and `provide`") with no phase-level shift. The symbolic name for export is derived from the name that is bound within the module, as opposed to the symbolic name of the export from each *`module-path`*. Only identifiers accessible from the lexical context of the *`module-path`* are included; that is, macro-introduced imports are not re-exported, unless the *`module-path`* was introduced at the same time.

Examples:

```
> (module nest racket
    (provide num-eggs)
    (define num-eggs 2))
> (module hen-house racket
    (require 'nest)
    (provide (all-from-out 'nest)))
> (require 'hen-house)
> num-eggs
2
```

```
(rename-out [orig-id export-id] ...)
```

Exports each *`orig-id`*, which must be bound within the module at the relevant phase level and binding space. The symbolic name for each export is *`export-id`* instead of *`orig-id`*.

Examples:

```
> (module nest racket
    (provide (rename-out [count num-eggs]))
    (define count 2))
> (require 'nest)
> num-eggs
2
> count
count: undefined;
 cannot reference an identifier before its definition
  in module: top-level
```

```
(except-out provide-spec provide-spec ...)
```

Like the first *`provide-spec`*, but omitting the bindings listed in each subsequent *`provide-spec`*. If one of the latter bindings is not included in the initial *`provide-spec`*, a syntax error is reported. The symbolic export name information in the latter *`provide-spec`*s is ignored; only the bindings are used.

Examples:

```
> (module nest racket
    (provide (except-out (all-defined-out)
                         num-chicks))
    (define num-eggs 2)
    (define num-chicks 3))
> (require 'nest)
> num-eggs
2
> num-chicks
num-chicks: undefined;
 cannot reference an identifier before its definition
  in module: top-level
```

```
(prefix-out prefix-id provide-spec)
```

Like *provide-spec*, but with each symbolic export name from *provide-spec* prefixed with *prefix-id*.

Examples:

```
> (module nest racket
    (provide (prefix-out chicken: num-eggs))
    (define num-eggs 2))
> (require 'nest)
> chicken:num-eggs
2
```

A syntax property with the key `'import-or-export-prefix-ranges` is added to the exported identifier in the expanded form of `provide`.

Changed in version 8.9.0.5 of package `base`: Added the `'import-or-export-prefix-ranges` syntax property.

```
(struct-out id)
```

Exports the bindings associated with a structure type *id*. Typically, *id* is bound with `(struct id ....)`; more generally, *id* must have a transformer binding of structure-type information at the relevant phase level; see §5.7 "Structure Type Transformer Binding". Furthermore, for each identifier mentioned in the structure-type information, the enclosing module must define or import one identifier that is `free-identifier=?`. If the structure-type information includes a super-type identifier, and if the identifier has a transformer binding of structure-type information, the accessor and mutator bindings of the super-type are *not* included by `struct-out` for export.

Examples:

```
> (module nest racket
    (provide (struct-out egg))
    (struct egg (color wt)))
> (require 'nest)
> (egg-color (egg 'blue 10))
'blue
```

```
(combine-out provide-spec ...)
```

The union of the *provide-spec*s.

Examples:

```
> (module nest racket
    (provide (combine-out num-eggs num-chicks))
    (define num-eggs 2)
    (define num-chicks 1))
> (require 'nest)
> num-eggs
2
> num-chicks
1
```

```
(protect-out provide-spec ...)
```

Like the union of the *provide-spec*s, except that the exports are protected: requiring modules may refer to these bindings, but may not extract these bindings from macro expansions or access them via `eval` without access privileges. For more details, see §14.10 "Code Inspectors". The *provide-spec* must specify only bindings that are defined within the exporting module.

Examples:

```
> (module nest racket
    (provide num-eggs (protect-out num-chicks))
    (define num-eggs 2)
    (define num-chicks 3))
> (define weak-inspector (make-inspector (current-code-
inspector)))
> (define (weak-eval x)
    (parameterize ([current-code-inspector weak-
inspector])
      (define weak-ns (make-base-namespace))
      (namespace-attach-module (current-namespace)
                               ''nest
```

```
                                  weak-ns)
      (parameterize ([current-namespace weak-ns])
        (namespace-require ''nest)
        (eval x))))
> (require 'nest)
> (list num-eggs num-chicks)
'(2 3)
> (weak-eval 'num-eggs)
2
> (weak-eval 'num-chicks)
?: access disallowed by code inspector to protected variable
  from module: 'nest
  at: num-chicks
```

See also §15.4 "Code Inspectors for Trusted and Untrusted Code".

```
(for-meta phase-level provide-spec ...)
```

Like the union of the *provide-spec*s, but adjusted to apply to the phase level specified by *phase-level* relative to the current phase level (where `#f` corresponds to the label phase level). In particular, an *id* or `rename-out` form as a *provide-spec* refers to a binding at *phase-level* relative to the current level, an `all-defined-out` exports only definitions at *phase-level* relative to the current phase level, and an `all-from-out` exports bindings imported with a shift by *phase-level*.

Examples:

```
> (module nest racket
    (begin-for-syntax
     (define eggs 2))
    (define chickens 3)
    (provide (for-syntax eggs)
             chickens))
> (require 'nest)
> (define-syntax (test-eggs stx)
    (printf "Eggs are ~a\n" eggs)
    #'0)
> (test-eggs)
Eggs are 2
0
> chickens
3
> (module broken-nest racket
    (define eggs 2)
```

```
    (define chickens 3)
    (provide (for-syntax eggs)
             chickens))
```

eval:7:0: provide: provided identifier is not defined or required
at: eggs
in: (provide (for-syntax eggs) chickens)

```
> (module nest2 racket
    (begin-for-syntax
     (define eggs 2))
    (provide (for-syntax eggs)))
> (require (for-meta 2 racket/base)
           (for-syntax 'nest2))
> (define-syntax (test stx)
    (define-syntax (show-eggs stx)
      (printf "Eggs are ~a\n" eggs)
      #'0)
    (begin
      (show-eggs)
      #'0))
Eggs are 2
> (test)
0
```

`(for-syntax provide-spec ...)`

Same as `(for-meta 1 provide-spec ...)`.

`(for-template provide-spec ...)`

Same as `(for-meta -1 provide-spec ...)`.

`(for-label provide-spec ...)`

Same as `(for-meta #f provide-spec ...)`.

`(for-space space provide-spec ...)`

Like the union of the *provide-spec*s, but adjusted to apply to the binding space specified by *space*—where *space* is either an identifier or `#f` for the default binding space. In particular, an *id* or rename-out form as a *provide-spec* refers to a binding in *space*, an all-defined-out exports only definitions in *space*, and an all-from-out exports bindings imported into *space*.

When providing a binding for a non-default binding space, normally a module should also provide a binding for the default binding space, where the default-space binding represents the intended meaning of the identifier. When a module later imports the same name in different spaces from modules that adhere to this convention, then if the two modules also (re)export the same binding for the name in the default space, the imports are likely consistent. If the two modules export different bindings for the name in the default space, then attempting to import both modules will trigger an error about conflicting imports, and a programmer can explicitly resolve the mismatch.

Added in version 8.2.0.3 of package base.

```
derived-provide-spec
```

See define-provide-syntax for information on expanding the set of *provide-spec* forms.

Each export specified within a module must have a distinct symbolic export name, though the same binding can be specified with the multiple symbolic names.

```
(for-meta phase-level require-spec ...)
```

See require and provide.

```
(for-syntax require-spec ...)
```

See require and provide.

```
(for-template require-spec ...)
```

See require and provide.

```
(for-label require-spec ...)
```

See require and provide.

```
(for-space space require-spec ...)
```

See require and provide.

```
(#%require raw-require-spec ...)

    raw-require-spec = phaseless-spec
                     | (for-meta phase-level raw-require-spec ...)
                     | (for-syntax raw-require-spec ...)
                     | (for-template raw-require-spec ...)
                     | (for-label raw-require-spec ...)
                     | (just-meta phase-level raw-require-spec ...)
                     | (portal portal-id content)

         phase-level = exact-integer
                     | #f

      phaseless-spec = spaceless-spec
                     | (for-space space phaseless-spec ...)
                     | (just-space space spaceless-spec ...)

               space = id
                     | #f

      spaceless-spec = raw-module-path
                     | (only raw-module-path id ...)
                     | (prefix prefix-id raw-module-path)
                     | (all-except raw-module-path id ...)
                     | (prefix-all-except prefix-id
                                          raw-module-path id ...)
                     | (rename raw-module-path local-id exported-id)

     raw-module-path = raw-root-module-path
                     | (submod raw-root-module-path id ...+)
                     | (submod "." id ...+)

raw-root-module-path = (quote id)
                     | rel-string
                     | (lib rel-string ...)
                     | id
                     | (file string)
                     | (planet rel-string
                               (user-string pkg-string vers ...))
                     | literal-path
```

The primitive import form, to which require expands. A *raw-require-spec* is similar to a *require-spec* in a require form, except that the syntax is more constrained, not composable, and not extensible. Also, sub-form names like for-syntax and lib are recognized symbolically, instead of via bindings. Some nested constraints are not formalized in the grammar above:

- a `just-meta` form cannot appear within a `just-meta` form;
- a `for-meta`, `for-syntax`, `for-template`, or `for-label` form cannot appear within a `for-meta`, `for-syntax`, `for-template`, or `for-label` form; and
- a `for-space` form cannot appear within a `for-space` form.
- a `portal` form cannot appear within a `just-meta` form.

Except for the `portal` form, each *`raw-require-spec`* corresponds to the obvious *`require-spec`*, but the `rename` sub-form has the identifiers in reverse order compared to `rename-in`.

For most *`raw-require-spec`*s, the lexical context of the *`raw-require-spec`* determines the context of introduced identifiers. The exception is the `rename` sub-form, where the lexical context of the *`local-id`* is preserved.

A *`literal-path`* as a *`raw-root-module-path`* corresponds to a path in the sense of `path?`. Since path values are never produced by `read-syntax`, they appear only in programmatically constructed expressions. They also appear naturally as arguments to functions such as `namespace-require`, with otherwise take a quoted `raw-module-spec`.

The `portal` form provides a way to define portal syntax at any phase level. A `(portal` *`portal-id content`*`)`, defines *`portal-id`* to portal syntax with *`content`* effectively quoted to serve as its content.

Changed in version 8.2.0.3 of package `base`: Added `for-space` and `just-space`.
Changed in version 8.3.0.8: Added `portal`.

```
(#%provide raw-provide-spec ...)
```

```
raw-provide-spec = phaseless-spec
                 | (for-meta phase-level phaseless-spec ...)
                 | (for-syntax phaseless-spec ...)
                 | (for-label phaseless-spec ...)
                 | (protect raw-provide-spec ...)

     phase-level = exact-integer
                 | #f

  phaseless-spec = spaceless-spec
                 | (for-space space spaceless-spec ...)
                 | (protect phaseless-spec ...)

           space = id
                 | #f

  spaceless-spec = id
                 | (rename local-id export-id)
                 | (struct struct-id (field-id ...))
                 | (all-from raw-module-path)
                 | (all-from-except raw-module-path id ...)
                 | (all-defined)
                 | (all-defined-except id ...)
                 | (prefix-all-defined prefix-id)
                 | (prefix-all-defined-except prefix-id id ...)
                 | (protect spaceless-spec ...)
                 | (expand (id . datum))
                 | (expand (id . datum) orig-form)
```

The primitive export form, to which `provide` expands. A *`raw-module-path`* is as for `#%require`. A `protect` sub-form cannot appear within a `protect` sub-form.

Like `#%require`, the sub-form keywords for `#%provide` are recognized symbolically, and nearly every *`raw-provide-spec`* has an obvious equivalent *`provide-spec`* via `provide`, with the exception of the `struct` and `expand` sub-forms.

A `(struct struct-id (field-id ...))` sub-form expands to *`struct-id`*, `make-`*`struct-id`*, `struct:`*`struct-id`*, *`struct-id`*`?`, *`struct-id`*`-`*`field-id`* for each *`field-id`*, and `set-`*`struct-id`*`-`*`field-id`*`!` for each *`field-id`*. The lexical context of the *`struct-id`* is used for all generated identifiers.

Unlike `#%require`, the `#%provide` form is macro-extensible via an explicit `expand` sub-form; the `(id . datum)` part is locally expanded as an expression (even though it is not actually an expression), stopping when a `begin` form is produced; if the expansion result is `(begin raw-provide-spec ...)`, it is spliced in place of the `expand` form, otherwise a syntax error is reported. If an *`orig-form`* part is provided, then it is used instead of the

#%provide form when raising syntax errors, such as a "provide identifier is not defined" error. The expand sub-form is not normally used directly; it provides a hook for implementing provide and provide transformers.

The all-from and all-from-except forms re-export only identifiers that are accessible in lexical context of the all-from or all-from-except form itself. That is, macro-introduced imports are not re-exported, unless the all-from or all-from-except form was introduced at the same time. Similarly, all-defined and its variants export only definitions accessible from the lexical context of the *spaceless-spec* form.

Changed in version 8.2.0.3 of package base: Added for-space.
Changed in version 8.2.0.5: Added *orig-form* support to expand.

3.2.1 Additional require Forms

```
(require racket/require)
```
package: base

The bindings documented in this section are provided by the racket/require library, not racket/base or racket.

The following forms support more complex selection and manipulation of sets of imported identifiers.

```
(matching-identifiers-in regexp require-spec)
```

Like *require-spec*, but including only imports whose names match *regexp*. The *regexp* must be a literal regular expression (see §4.8 "Regular Expressions").

Examples:

```
> (module zoo racket/base
    (provide tunafish swordfish blowfish
             monkey lizard ant)
    (define tunafish 1)
    (define swordfish 2)
    (define blowfish 3)
    (define monkey 4)
    (define lizard 5)
    (define ant 6))
> (require racket/require)
> (require (matching-identifiers-in #rx"\\w*fish" 'zoo))
> tunafish
1
> swordfish
2
> blowfish
```

```
3
> monkey
```

monkey: undefined;
cannot reference an identifier before its definition
in module: top-level

```
(subtract-in require-spec subtracted-spec ...)
```

Like *require-spec*, but omitting those imports that would be imported by one of the *subtracted-spec*s.

Examples:

```
> (module earth racket
    (provide land sea air)
    (define land 1)
    (define sea 2)
    (define air 3))
> (module mars racket
    (provide aliens)
    (define aliens 4))
> (module solar-system racket
    (require 'earth 'mars)
    (provide (all-from-out 'earth)
             (all-from-out 'mars)))
> (require racket/require)
> (require (subtract-in 'solar-system 'earth))
> land
```

land: undefined;
cannot reference an identifier before its definition
in module: top-level

```
> aliens
4
```

```
(filtered-in proc-expr require-spec)
```

Applies an arbitrary transformation on the import names (as strings) of *require-spec*. The *proc-expr* must evaluate at expansion time to a single-argument procedure, which is applied on each of the names from *require-spec*. For each name, the procedure must return either a string for the import's new name or `#f` to exclude the import.

The second part of `filtered-in` is expand-time code evaluated in the scope of the enclosing module. Accordingly, most uses need `(require (for-syntax racket/base))` if `racket/base` is not already imported `for-syntax`. For example, `#lang racket` establishes this import automatically, while

For example,

```
(require (filtered-in
          (lambda (name)
```

```
             (and (regexp-match? #rx"^[a-z-]+$" name)
                  (regexp-replace #rx"-" (string-
titlecase name) "")))
           racket/base))
```

imports only bindings from `racket/base` that match the pattern `#rx"^[a-z-]+$"`, and it converts the names to "camel case."

```
(path-up rel-string ...)
```

Specifies paths to modules named by the *rel-string*s similar to using the *rel-string*s directly, except that if a required module file is not found relative to the enclosing source, it is searched for in the parent directory, and then in the grand-parent directory, etc., all the way to the root directory. The discovered path relative to the enclosing source becomes part of the expanded form.

This form is useful in setting up a "project environment." For example, using the following `"config.rkt"` file in the root directory of your project:

```
#lang racket/base
(require racket/require-syntax
         (for-syntax "utils/in-here.rkt"))

(provide utils-in)
(define-require-syntax utils-in in-here-transformer)
```

and using `"utils/in-here.rkt"` under the same root directory:

```
#lang racket/base
(require racket/runtime-path)
(provide in-here-transformer)
(define-runtime-path here ".")
(define (in-here-transformer stx)
  (syntax-case stx ()
    [(_ sym)
     (identifier? #'sym)
     (let ([path (build-path here (format "~a.rkt" (syntax-
e #'sym)))])
       (datum->syntax stx `(file ,(path->string path)) stx))]))
```

then `path-up` works for any other module under the project directory to find `"config.rkt"`:

```
(require racket/require
         (path-up "config.rkt")
         (utils-in foo))
```

Note that the order of requires in the example is important, as each of the first two bind the identifier used in the following.

An alternative in this scenario is to use `path-up` directly to find the utility module:

```
(require racket/require
         (path-up "utils/foo.rkt"))
```

but then sub-directories that are called `"utils"` override the one in the project's root. In other words, the previous method requires only a single unique name.

```
(multi-in subs ...+)

    subs = sub-path
         | (sub-path ...)

sub-path = rel-string
         | id
```

Specifies multiple files to be required from a hierarchy of directories or collections. The set of required module paths is computed as the Cartesian product of the *subs* groups, where each *sub-path* is combined with other *sub-path*s in order using a `/` separator. A *sub-path* as a *subs* is equivalent to `(sub-path)`. All *sub-path*s in a given `multi-in` form must be either strings or identifiers.

Examples:

```
(require (multi-in racket (dict list)))
```

is equivalent to `(require racket/dict racket/list)`

```
(require (multi-in "math" "matrix" "utils.rkt"))
```

is equivalent to `(require "math/matrix/utils.rkt")`

```
(require (multi-in "utils" ("math.rkt" "matrix.rkt")))
```

is equivalent to `(require "utils/math.rkt" "utils/matrix.rkt")`

```
(require (multi-in ("math" "matrix") "utils.rkt"))
```

is equivalent to `(require "math/utils.rkt" "matrix/utils.rkt")`

```
(require (multi-in ("math" "matrix") ("utils.rkt" "helpers.rkt")))
```

is equivalent to

```
(require "math/utils.rkt" "math/helpers.rkt"
         "matrix/utils.rkt" "matrix/helpers.rkt")
```

3.2.2 Additional provide Forms

```
(require racket/provide)
```
package: base

The bindings documented in this section are provided by the racket/provide library, not racket/base or racket.

```
(matching-identifiers-out regexp provide-spec)
```

Like *provide-spec*, but including only exports of bindings with an external name that matches *regexp*. The *regexp* must be a literal regular expression (see §4.8 "Regular Expressions").

```
(filtered-out proc-expr provide-spec)
```

Analogous to filtered-in, but for filtering and renaming exports.

See the documentation of filtered-in for use with #lang racket/base.

For example,

```
(provide (filtered-out
          (lambda (name)
            (and (regexp-match? #rx"^[a-z-]+$" name)
                 (regexp-replace
                  #rx"-" (string-titlecase name) "")))
          (all-defined-out)))
```

exports only bindings that match the pattern #rx"^[a-z-]+$", and it converts the names to "camel case."

3.3 Literals: quote and #%datum

Many forms are implicitly quoted (via #%datum) as literals. See §1.2.3.2 "Expansion Steps" for more information.

§4.10 "Quoting: quote and '" in *The Racket Guide* introduces quote.

```
(quote datum)
```

Produces a constant value corresponding to *datum* (i.e., the representation of the program fragment) without its lexical information, source location, etc. Quoted pairs, vectors, and boxes are immutable.

Examples:

```
> (quote x)
'x
```

```
> (quote (+ 1 2))
'(+ 1 2)
> (+ 1 2)
3
```

```
(#%datum . datum)
```

Expands to `(quote datum)`, as long as `datum` is not a keyword. If `datum` is a keyword, a syntax error is reported.

See also §1.2.3.2 "Expansion Steps" for information on how the expander introduces `#%datum` identifiers.

Examples:

```
> (#%datum . 10)
10
> (#%datum . x)
'x
> (#%datum . #:x)
eval:6:0: #%datum: keyword misused as an expression
  at: #:x
```

3.4 Expression Wrapper: `#%expression`

```
(#%expression expr)
```

Produces the same result as `expr`. Using `#%expression` forces the parsing of a form as an expression.

Examples:

```
> (#%expression (+ 1 2))
3
> (#%expression (define x 10))
eval:8:0: define: not allowed in an expression context
  in: (define x 10)
```

The `#%expression` form is helpful in recursive definition contexts where expanding a subsequent definition can provide compile-time information for the current expression. For example, consider a `define-sym-case` macro that simply records some symbols at compile-time in a given identifier.

```
(define-syntax (define-sym-case stx)
  (syntax-case stx ()
    [(_ id sym ...)
     (andmap identifier? (syntax->list #'(sym ...)))
     #'(define-syntax id
         '(sym ...))]))
```

and then a variant of case that checks to make sure the symbols used in the expression match those given in the earlier definition:

```
(define-syntax (sym-case stx)
  (syntax-case stx ()
    [(_ id val-expr [(sym) expr] ...)
     (let ()
       (define expected-ids
         (syntax-local-value
          #'id
          (λ ()
            (raise-syntax-error
             'sym-case
             "expected an identifier bound via define-sym-case"
             stx
             #'id))))
       (define actual-ids (syntax->datum #'(sym ...)))
       (unless (equal? expected-ids actual-ids)
         (raise-syntax-error
          'sym-case
          (format "expected the symbols ~s"
                  expected-ids)
          stx))
       #'(case val-expr [(sym) expr] ...))]))
```

If the definition follows the use like this, then the `define-sym-case` macro does not have a chance to bind `id` and the `sym-case` macro signals an error:

```
> (let ()
    (sym-case land-creatures 'bear
              [(bear) 1]
              [(fox) 2])
    (define-sym-case land-creatures bear fox))
```
eval:11:0: sym-case: expected an identifier bound via define-sym-case
at: land-creatures
in: (sym-case land-creatures (quote bear) ((bear) 1) ((fox) 2))

But if the `sym-case` is wrapped in an `#%expression`, then the expander does not need to expand it to know it is an expression and it moves on to the `define-sym-case` expression.

```
> (let ()
    (#%expression (sym-case sea-creatures 'whale
                            [(whale) 1]
                            [(squid) 2]))
    (define-sym-case sea-creatures whale squid)
    'more...)
'more...
```

Of course, a macro like `sym-case` should not require its clients to add `#%expression`; instead it should check the basic shape of its arguments and then expand to `#%expression` wrapped around a helper macro that calls `syntax-local-value` and finishes the expansion.

3.5 Variable References and `#%top`

```
id
```

Refers to a top-level, module-level, or local binding, when *`id`* is not bound as a transformer (see §1.2.3 "Expansion"). At run-time, the reference evaluates to the value in the location associated with the binding.

When the expander encounters an *`id`* that is not bound by a module-level or local binding, it converts the expression to `(#%top . id)` giving `#%top` the lexical context of the *`id`*; typically, that context refers to `#%top`. See also §1.2.3.2 "Expansion Steps".

Examples:

```
> (define x 10)
> x
10
> (let ([x 5]) x)
5
> ((lambda (x) x) 2)
2
```

```
(#%top . id)
```

Equivalent to *`id`* when *`id`* is bound to a module-level or top-level variable. In a top-level context, `(#%top . id)` always refers to a top-level variable, even if *`id`* is unbound or bound to syntax, as long as *`id`* does not have a local binding. In all contexts, `(#%top . id)` is a syntax error if *`id`* has a local binding.

Within a `module` form, `(#%top . id)` expands to just `id` as long as `id` is defined within the module and has no local binding in its context. At phase level 0, `(#%top . id)` is an immediate syntax error if `id` is not bound. At phase level 1 and higher, a syntax error is reported if `id` is not defined at the corresponding phase by the end of `module`-body partial expansion.

See also §1.2.3.2 "Expansion Steps" for information on how the expander introduces `#%top` identifiers.

Examples:

```
> (define x 12)
> (#%top . x)
12
```

Changed in version 6.3 of package `base`: Changed the introduction of `#%top` in a top-level context to unbound identifiers only.
Changed in version 8.2.0.7: Changed treatment of locally bound `id` to always report a syntax error, even outside of a module.

3.6 Locations: `#%variable-reference`

```
(#%variable-reference id)
(#%variable-reference (#%top . id))
(#%variable-reference)
```

Produces an opaque *variable reference* value representing the location of `id`, which must be bound as a variable. If no `id` is supplied, the resulting value refers to an "anonymous" variable defined within the enclosing context (i.e., within the enclosing module, or at the top level if the form is not inside a module).

When `(#%top . id)` is used, then the variable reference refers to the same variable as `(#%top . id)`. Note that `(#%top . id)` is not allowed if `id` is locally bound or within a module if `id` is bound as a transformer.

A variable reference can be used with `variable-reference->empty-namespace`, `variable-reference->resolved-module-path`, and `variable-reference->namespace`, but facilities like `define-namespace-anchor` and `namespace-anchor->namespace` wrap those to provide a clearer interface. A variable reference is also useful to low-level extensions; see *Inside: Racket C API*.

Changed in version 8.2.0.7 of package `base`: Changed `#%top` treatment to be consistent with `#%top` by itself.

3.7 Procedure Applications and #%app

§4.3 "Function Calls" in *The Racket Guide* introduces procedure applications.

```
(proc-expr arg ...)
```

Applies a procedure, when *proc-expr* is not an identifier that has a transformer binding (see §1.2.3 "Expansion").

More precisely, the expander converts this form to `(#%app proc-expr arg ...)`, giving `#%app` the lexical context that is associated with the original form (i.e., the pair that combines *proc-expr* and its arguments). Typically, the lexical context of the pair indicates the procedure-application #%app that is described next. See also §1.2.3.2 "Expansion Steps".

Examples:

```
> (+ 1 2)
3
> ((lambda (x #:arg y) (list y x)) #:arg 2 1)
'(2 1)
```

```
(#%app proc-expr arg ...)
```

Applies a procedure. Each *arg* is one of the following:

```
arg-expr
```

> The resulting value is a non-keyword argument.

```
keyword arg-expr
```

> The resulting value is a keyword argument using *keyword*. Each *keyword* in the application must be distinct.

The *proc-expr* and *arg-expr*s are evaluated in order, left to right. If the result of *proc-expr* is a procedure that accepts as many arguments as non-*keyword* *arg-expr*s, if it accepts arguments for all of the *keyword*s in the application, and if all required keyword-based arguments are represented among the *keyword*s in the application, then the procedure is called with the values of the arg-exprs. Otherwise, the `exn:fail:contract` exception is raised.

The continuation of the procedure call is the same as the continuation of the application expression, so the results of the procedure are the results of the application expression.

The relative order of *keyword*-based arguments matters only for the order of *arg-expr* evaluations; the arguments are associated with argument variables in the applied procedure based on the *keyword*s, and not their positions. The other *arg-expr* values, in contrast, are associated with variables according to their order in the application form.

See also §1.2.3.2 "Expansion Steps" for information on how the expander introduces `#%app` identifiers.

Examples:

```
> (#%app + 1 2)
3
> (#%app (lambda (x #:arg y) (list y x)) #:arg 2 1)
'(2 1)
> (#%app cons)
cons: arity mismatch;
 the expected number of arguments does not match the given
number
  expected: 2
  given: 0
```

```
(#%plain-app proc-expr arg-expr ...)
(#%plain-app)
```

Like #%app, but without support for keyword arguments. As a special case, `(#%plain-app)` produces `'()`.

3.8 Procedure Expressions: `lambda` and `case-lambda`

§4.4 "Functions: `lambda`" in *The Racket Guide* introduces procedure expressions.

```
(lambda kw-formals body ...+)
(λ kw-formals body ...+)

kw-formals = (arg ...)
           | (arg ...+ . rest-id)
           | rest-id

       arg = id
           | [id default-expr]
           | keyword id
           | keyword [id default-expr]
```

Produces a procedure. The *kw-formals* determines the number of arguments and which keyword arguments that the procedure accepts.

Considering only the first `arg` case, a simple `kw-formals` has one of the following three forms:

`(id ...)`

> The procedure accepts as many non-keyword argument values as the number of `id`s. Each `id` is associated with an argument value by position.

`(id ...+ . rest-id)`

> The procedure accepts any number of non-keyword arguments greater or equal to the number of `id`s. When the procedure is applied, the `id`s are associated with argument values by position, and all leftover arguments are placed into a list that is associated to `rest-id`.

`rest-id`

> The procedure accepts any number of non-keyword arguments. All arguments are placed into a list that is associated with `rest-id`.

More generally, an `arg` can include a keyword and/or default value. Thus, the first two cases above are more completely specified as follows:

`(arg ...)`

> Each `arg` has the following four forms:

`id`

> Adds one to both the minimum and maximum number of non-keyword arguments accepted by the procedure. The `id` is associated with an actual argument by position.

`[id default-expr]`

> Adds one to the maximum number of non-keyword arguments accepted by the procedure. The `id` is associated with an actual argument by position, and if no such argument is provided, the `default-expr` is evaluated to produce a value associated with `id`. No `arg` with a `default-expr` can appear before an `id` without a `default-expr` and without a `keyword`.

keyword id

The procedure requires a keyword-based argument using *keyword*. The *id* is associated with a keyword-based actual argument using *keyword*.

keyword [*id default-expr*]

The procedure accepts a keyword-based argument using *keyword*. The *id* is associated with a keyword-based actual argument using *keyword*, if supplied in an application; otherwise, the *default-expr* is evaluated to obtain a value to associate with *id*.

The position of a *keyword arg* in *kw-formals* does not matter, but each specified *keyword* must be distinct.

(*arg* ...+ . *rest-id*)

Like the previous case, but the procedure accepts any number of non-keyword arguments beyond its minimum number of arguments. When more arguments are provided than non-*keyword* arguments among the *arg*s, the extra arguments are placed into a list that is associated to *rest-id*.

The *kw-formals* identifiers are bound in the *body*s. When the procedure is applied, a new location is created for each identifier, and the location is filled with the associated argument value. The locations are created and filled in order, with *default-expr*s evaluated as needed to fill locations.

In other words, argument bindings with default-value expressions are evaluated analogous to `let*`.

If any identifier appears in the *body*s that is not one of the identifiers in *kw-formals*, then it refers to the same location that it would if it appeared in place of the `lambda` expression. (In other words, variable reference is lexically scoped.)

When multiple identifiers appear in a *kw-formals*, they must be distinct according to `bound-identifier=?`.

If the procedure produced by `lambda` is applied to fewer or more by-position or by-keyword arguments than it accepts, to by-keyword arguments that it does not accept, or without required by-keyword arguments, then the `exn:fail:contract` exception is raised.

The last *body* expression is in tail position with respect to the procedure body.

Examples:

```
> ((lambda (x) x) 10)
10
```

```
> ((lambda (x y) (list y x)) 1 2)
'(2 1)
> ((lambda (x [y 5]) (list y x)) 1 2)
'(2 1)
> (let ([f (lambda (x #:arg y) (list y x))])
    (list (f 1 #:arg 2)
          (f #:arg 2 1)))
'((2 1) (2 1))
```

When compiling a `lambda` or `case-lambda` expression, Racket looks for a `'method-arity-error` property attached to the expression (see §12.7 "Syntax Object Properties"). If it is present with a true value, and if no case of the procedure accepts zero arguments, then the procedure is marked so that an `exn:fail:contract:arity` exception involving the procedure will hide the first argument, if one was provided. (Hiding the first argument is useful when the procedure implements a method, where the first argument is implicit in the original source). The property affects only the format of `exn:fail:contract:arity` exceptions, not the result of `procedure-arity`.

Along similar lines, Racket looks for a `'body-as-unsafe` property when compiling a `lambda` or `case-lambda` expression. If it is present with a true value, then the procedure body may be compiled in unsafe mode in same sense as `(#%declare #:unsafe)`. The `'body-as-unsafe` property is allowed only when the current code inspector is the initial one at compile time.

When a keyword-accepting procedure is bound to an identifier in certain ways, and when the identifier is used in the function position of an application form, then the application form may be expanded in such a way that the original binding is obscured as the target of the application. To help expose the connection between the function application and function declaration, an identifier in the expansion of the function application is tagged with a syntax property accessible via `syntax-procedure-alias-property` if it is effectively an alias for the original identifier. An identifier in the expansion is tagged with a syntax property accessible via `syntax-procedure-converted-arguments-property` if it is like the original identifier except that the arguments are converted to a flattened form: keyword arguments, required by-position arguments, by-position optional arguments, and rest arguments—all as required, by-position arguments; the keyword arguments are sorted by keyword name, each optional keyword argument is followed by a boolean to indicate whether a value is provided, and `#f` is used for an optional keyword argument whose value is not provided; optional by-position arguments include `#f` for each non-provided argument, and then the sequence of optional-argument values is followed by a parallel sequence of booleans to indicate whether each optional-argument value was provided.

Changed in version 8.13.0.5 of package `base`: Adjusted binding so that `(free-identifier=? #'λ #'lambda)` produces `#t`.
Changed in version 8.15.0.12: Added the `'body-as-unsafe` property.

```
(case-lambda [formals body ...+] ...)
```

```
(case-λ [formals body ...+] ...)

formals = (id ...)
        | (id ...+ . rest-id)
        | rest-id
```

Produces a procedure. Each `[formals body ...+]` clause is analogous to a single `lambda` procedure; applying the `case-lambda`-generated procedure is the same as applying a procedure that corresponds to one of the clauses—the first procedure that accepts the given number of arguments. If no corresponding procedure accepts the given number of arguments, the `exn:fail:contract` exception is raised.

Note that a `case-lambda` clause supports only *`formals`*, not the more general *`kw-formals`* of `lambda`. That is, `case-lambda` does not directly support keyword and optional arguments.

Example:

```
> (let ([f (case-lambda
             [() 10]
             [(x) x]
             [(x y) (list y x)]
             [r r])])
    (list (f)
          (f 1)
          (f 1 2)
          (f 1 2 3)))
'(10 1 (2 1) (1 2 3))
```

Changed in version 8.13.0.5 of package `base`: Added `case-λ`.

```
(#%plain-lambda formals body ...+)
```

Like `lambda`, but without support for keyword or optional arguments.

3.9 Local Binding: `let`, `let*`, `letrec`, ...

§4.6 "Local Binding" in *The Racket Guide* introduces local binding.

```
(let ([id val-expr] ...) body ...+)
(let proc-id ([id init-expr] ...) body ...+)
```

The first form evaluates the *`val-expr`*s left-to-right, creates a new location for each *`id`*, and places the values into the locations. It then evaluates the *`body`*s, in which the *`id`*s are bound. The last *`body`* expression is in tail position with respect to the `let` form. The *`id`*s must be distinct according to `bound-identifier=?`.

Examples:

```
> (let ([x 5]) x)
5
> (let ([x 5])
    (let ([x 2]
          [y x])
      (list y x)))
'(5 2)
```

The second form, usually known as *named* `let`, evaluates the *`init-expr`*s; the resulting values become arguments in an application of a procedure `(lambda (id ...) body ...+)`, where *`proc-id`* is bound within the *`body`*s to the procedure itself.

Example:

```
> (let fac ([n 10])
    (if (zero? n)
        1
        (* n (fac (sub1 n)))))
3628800
```

```
(let* ([id val-expr] ...) body ...+)
```

Like `let`, but evaluates the *`val-expr`*s one by one, creating a location for each *`id`* as soon as the value is available. The *`id`*s are bound in the remaining *`val-expr`*s as well as the *`body`*s, and the *`id`*s need not be distinct; later bindings shadow earlier bindings.

Example:

```
> (let* ([x 1]
         [y (+ x 1)])
    (list y x))
'(2 1)
```

```
(letrec ([id val-expr] ...) body ...+)
```

Like `let`, including left-to-right evaluation of the *`val-expr`*s, but the locations for all *`id`*s are created first, all *`id`*s are bound in all *`val-expr`*s as well as the *`body`*s, and each *`id`* is initialized immediately after the corresponding *`val-expr`* is evaluated. The *`id`*s must be distinct according to `bound-identifier=?`.

Referencing or assigning to an *`id`* before its initialization raises `exn:fail:contract:variable`. If an *`id`* (i.e., the binding instance or *`id`*) has an 'undefined-error-name syntax property whose value is a symbol, the symbol is used as the name of the variable for error reporting, instead of the symbolic form of *id*.

Example:

```
> (letrec ([is-even? (lambda (n)
                       (or (zero? n)
                           (is-odd? (sub1 n))))]
           [is-odd? (lambda (n)
                      (and (not (zero? n))
                           (is-even? (sub1 n))))])
    (is-odd? 11))
#t
```

Changed in version 6.0.1.2 of package `base`: Changed reference or assignment of an uninitialized *id* to an error.

```
(let-values ([(id ...) val-expr] ...) body ...+)
```

Like `let`, except that each *val-expr* must produce as many values as corresponding *id*s, otherwise the `exn:fail:contract` exception is raised. A separate location is created for each *id*, all of which are bound in the *body*s.

Example:

```
> (let-values ([(x y) (quotient/remainder 10 3)])
    (list y x))
'(1 3)
```

```
(let*-values ([(id ...) val-expr] ...) body ...+)
```

Like `let*`, except that each *val-expr* must produce as many values as corresponding *id*s. A separate location is created for each *id*, all of which are bound in the later *val-expr*s and in the *body*s.

Example:

```
> (let*-values ([(x y) (quotient/remainder 10 3)]
                [(z) (list y x)])
    z)
'(1 3)
```

```
(letrec-values ([(id ...) val-expr] ...) body ...+)
```

Like `letrec`, except that each *val-expr* must produce as many values as corresponding *id*s. A separate location is created for each *id*, all of which are bound in all *val-expr*s and in the *body*s.

Example:

```
> (letrec-values ([(is-even? is-odd?)
                   (values
                     (lambda (n)
                       (or (zero? n)
                           (is-odd? (sub1 n))))
                     (lambda (n)
                       (or (= n 1)
                           (is-even? (sub1 n)))))])
    (is-odd? 11))
#t
```

```
(let-syntax ([id trans-expr] ...) body ...+)
```

See also `splicing-let-syntax`.

Creates a transformer binding (see §1.2.3.5 "Transformer Bindings") of each *`id`* with the value of *`trans-expr`*, which is an expression at phase level 1 relative to the surrounding context. (See §1.2.1 "Identifiers, Binding, and Scopes" for information on phase levels.)

The evaluation of each *`trans-expr`* is `parameterize`d to set `current-namespace` to a namespace that shares bindings and variables with the namespace being used to expand the `let-syntax` form, except that its base phase is one greater.

Each *`id`* is bound in the *`body`*s, and not in other *`trans-expr`*s.

```
(letrec-syntax ([id trans-expr] ...) body ...+)
```

See also `splicing-letrec-syntax`.

Like `let-syntax`, except that each *`id`* is also bound within all *`trans-expr`*s.

```
(let-syntaxes ([(id ...) trans-expr] ...) body ...+)
```

See also `splicing-let-syntaxes`.

Like `let-syntax`, but each *`trans-expr`* must produce as many values as corresponding *`id`*s, each of which is bound to the corresponding value.

```
(letrec-syntaxes ([(id ...) trans-expr] ...) body ...+)
```

See also `splicing-letrec-syntaxes`.

Like `let-syntax`, except that each *`id`* is also bound within all *`trans-expr`*s.

```
(letrec-syntaxes+values ([(trans-id ...) trans-expr] ...)
                        ([(val-id ...) val-expr] ...)
   body ...+)
```

Combines `letrec-syntaxes` with a variant of `letrec-values`: each *`trans-id`* and *`val-id`* is bound in all *`trans-expr`*s and *`val-expr`*s.

The `letrec-syntaxes+values` form is the core form for local compile-time bindings, since forms like `letrec-syntax` and internal-definition contexts expand to it. In a fully expanded expression (see §1.2.3.1 "Fully Expanded Programs"), the *trans-id* bindings are discarded and the form reduces to a combination of `letrec-values` or `let-values`.

For variables bound by `letrec-syntaxes+values`, the location-creation rules differ slightly from `letrec-values`. The `[(val-id ...) val-expr]` binding clauses are partitioned into minimal sets of clauses that satisfy the following rule: if a clause has a *val-id* binding that is referenced (in a full expansion) by the *val-expr* of an earlier clause, the two clauses and all in between are in the same set. If a set consists of a single clause whose *val-expr* does not refer to any of the clause's *val-id*s, then locations for the *val-id*s are created *after* the *val-expr* is evaluated. Otherwise, locations for all *val-id*s in a set are created just before the first *val-expr* in the set is evaluated. For the purposes of forming sets, a `(quote-syntax datum #:local)` form counts as a reference to all bindings in the `letrec-syntaxes+values` form

The end result of the location-creation rules is that scoping and evaluation order are the same as for `letrec-values`, but the compiler has more freedom to optimize away location creation. The rules also correspond to a nesting of `let-values` and `letrec-values`, which is how `letrec-syntaxes+values` for a fully-expanded expression.

See also `local`, which supports local bindings with `define`, `define-syntax`, and more.

3.10 Local Definitions: `local`

```
(require racket/local)
```
package: `base`

The bindings documented in this section are provided by the `racket/local` and `racket` libraries, but not `racket/base`.

```
(local [definition ...] body ...+)
```

Like `letrec-syntaxes+values`, except that the bindings are expressed in the same way as in the top-level or in a module body: using `define`, `define-values`, `define-syntax`, `struct`, etc. Definitions are distinguished from non-definitions by partially expanding *definition* forms (see §1.2.3.7 "Partial Expansion"). As in the top-level or in a module body, a `begin`-wrapped sequence is spliced into the sequence of *definition*s.

3.11 Constructing Graphs: `shared`

```
(require racket/shared)
```
package: `base`

The bindings documented in this section are provided by the `racket/shared` and `racket` libraries, but not `racket/base`.

```
(shared ([id expr] ...) body ...+)
```

Binds *id*s with shared structure according to *expr*s and then evaluates the *body*s, returning the result of the last expression.

The `shared` form is similar to `letrec`, except that special forms of *expr* are recognized (after partial macro expansion) to construct graph-structured data, where the corresponding `letrec` would instead produce a use-before-initialization error.

Each *expr* (after partial expansion) is matched against the following *shared-expr* grammar, where earlier variants in a production take precedence over later variants:

```
        shared-expr = shell-expr
                    | plain-expr

         shell-expr = (cons in-immutable-expr in-immutable-expr)
                    | (list in-immutable-expr ...)
                    | (list* in-immutable-expr ...)
                    | (append early-expr ... in-immutable-expr)
                    | (vector-immutable in-immutable-expr ...)
                    | (box-immutable in-immutable-expr)
                    | (mcons patchable-expr patchable-expr)
                    | (vector patchable-expr ...)
                    | (box patchable-expr)
                    | (prefix:make-id patchable-expr ...)

  in-immutable-expr = shell-id
                    | shell-expr
                    | early-expr

           shell-id = id

     patchable-expr = expr

         early-expr = expr

         plain-expr = expr
```

The *prefix*`:make-`*id* identifier above matches three kinds of references. The first kind is any binding whose name has `make-` in the middle, and where *prefix*`:`*id* has a transformer binding to structure information with a full set of mutator bindings; see §5.7 "Structure Type Transformer Binding". The second kind is an identifier that itself has a transformer binding to structure information. The third kind is an identifier that has a `'constructor-for` syntax property whose value is an identifier with a transformer binding to structure information. A *shell-id*, meanwhile, must be one of the *id*s bound by the `shared` form to a *shell-expr*.

When the *expr*s of the `shared` form are parsed as *shared-expr* (taking into account the order of the variants for parsing precedence), the sub-expressions that were parsed via *early-expr* will be evaluated first when the `shared` form is evaluated. Among such expressions, they are evaluated in the order as they appear within the `shared` form. However, any reference to an *id* bound by `shared` produces a use-before-initialization errror, even if the binding for the *id* appears before the corresponding *early-expr* within the `shared` form.

The *shell-id*s and *shell-expr*s (not counting *patchable-expr* and *early-expr* sub-expressions) are effectively evaluated next:

- A *shell-id* reference produces the same value as the corresponding *id* will produce within the *body*s, assuming that *id* is never mutated with `set!`. This special handling of a *shell-id* reference is one way in which `shared` supports the creation of cyclic data, including immutable cyclic data.
- A *shell-expr* of the form `(mcons patchable-expr patchable-expr)`, `(vector patchable-expr ...)`, `(box patchable-expr)`, or `(prefix:make-id patchable-expr ...)` produces a mutable value whose content positions are initialized to `undefined`. Each content position is *patched* (i.e., updated) after the corresponding *patchable-expr* expression is later evaluated.

Next, the *plain-expr*s are evaluated as for `letrec`, where a reference to an *id* raises `exn:fail:contract:variable` if it is evaluated before the right-hand side of the *id* binding.

Finally, the *patchable-expr*s are evaluated and their values replace `undefined`s in the results of *shell-expr*s. At this point, all *id*s are bound, so *patchable-expr*s can create data cycles (but only with cycles that can be created via mutation).

Examples:

```
> (shared ([a (cons 1 a)])
    a)
#0='(1 . #0#)
> (shared ([a (cons 1 b)]
           [b (cons 2 a)])
    a)
#0='(1 2 . #0#)
> (shared ([a (cons 1 b)]
           [b 7])
    a)
'(1 . 7)
> (shared ([a a]) ; no indirection...
    a)
a: undefined;
 cannot use before initialization
> (shared ([a (cons 1 b)] ; b is early...
```

```
               [b a])
       a)
a: undefined;
 cannot use before initialization
> (shared ([a (mcons 1 b)] ; b is patchable...
               [b a])
       a)
#0=(mcons 1 #0#)
> (shared ([a (vector b b b)]
               [b (box 1)])
       (set-box! b 5)
       a)
'#(#&5 #&5 #&5)
> (shared ([a (box b)]
               [b (vector (unbox a)    ; unbox after a is patched
                          (unbox c))] ; unbox before c is patched
               [c (box b)])
       b)
#0='#(#0# #<undefined>)
```

3.12 Conditionals: if, cond, and, and or

§4.7 "Conditionals" in *The Racket Guide* introduces conditionals.

```
(if test-expr then-expr else-expr)
```

Evaluates *test-expr*. If it produces any value other than #f, then *then-expr* is evaluated, and its results are the result for the if form. Otherwise, *else-expr* is evaluated, and its results are the result for the if form. The *then-expr* and *else-expr* are in tail position with respect to the if form.

Examples:

```
> (if (positive? -5) (error "doesn't get here") 2)
2
> (if (positive? 5) 1 (error "doesn't get here"))
1
> (if 'we-have-no-bananas "yes" "no")
"yes"
```

```
(cond cond-clause ...)

cond-clause = [test-expr then-body ...+]
            | [else then-body ...+]
            | [test-expr => proc-expr]
            | [test-expr]
```

§4.7.3 "Chaining Tests: cond" in *The Racket Guide* introduces cond.

A *cond-clause* that starts with else must be the last *cond-clause*.

If no *cond-clause*s are present, the result is #<void>.

If only a [else *then-body* ...+] is present, then the *then-body*s are evaluated. The results from all but the last *then-body* are ignored. The results of the last *then-body*, which is in tail position with respect to the cond form, are the results for the whole cond form.

Otherwise, the first *test-expr* is evaluated. If it produces #f, then the result is the same as a cond form with the remaining *cond-clause*s, in tail position with respect to the original cond form. Otherwise, evaluation depends on the form of the *cond-clause*:

[*test-expr* *then-body* ...+]

The *then-body*s are evaluated in order, and the results from all but the last *then-body* are ignored. The results of the last *then-body*, which is in tail position with respect to the cond form, provides the result for the whole cond form.

[*test-expr* => *proc-expr*]

The *proc-expr* is evaluated, and it must produce a procedure that accepts one argument, otherwise the exn:fail:contract exception is raised. The procedure is applied to the result of *test-expr* in tail position with respect to the cond expression.

[*test-expr*]

The result of the *test-expr* is returned as the result of the cond form. The *test-expr* is not in tail position.

Examples:

```
> (cond)
> (cond
    [else 5])
5
> (cond
   [(positive? -5) (error "doesn't get here")]
   [(zero? -5) (error "doesn't get here, either")]
   [(positive? 5) 'here])
```

```
'here
> (cond
   [(member 2 '(1 2 3)) => (lambda (l) (map - l))])
'(-2 -3)
> (cond
   [(member 2 '(1 2 3))])
'(2 3)
```

```
else
```

Recognized specially within forms like `cond`. An `else` form as an expression is a syntax error.

```
=>
```

Recognized specially within forms like `cond`. A `=>` form as an expression is a syntax error.

```
(and expr ...)
```

§4.7.2 "Combining Tests: `and` and `or`" in *The Racket Guide* introduces `and`.

If no *expr*s are provided, then result is `#t`.

If a single *expr* is provided, then it is in tail position, so the results of the `and` expression are the results of the *expr*.

Otherwise, the first *expr* is evaluated. If it produces `#f`, the result of the `and` expression is `#f`. Otherwise, the result is the same as an `and` expression with the remaining *expr*s in tail position with respect to the original `and` form.

Examples:

```
> (and)
#t
> (and 1)
1
> (and (values 1 2))
1
2
> (and #f (error "doesn't get here"))
#f
> (and #t 5)
5
```

```
(or expr ...)
```

§4.7.2 "Combining Tests: `and` and `or`" in *The Racket Guide* introduces `or`.

If no *expr*s are provided, then result is `#f`.

If a single *expr* is provided, then it is in tail position, so the results of the `or` expression are the results of the *expr*.

Otherwise, the first *expr* is evaluated. If it produces a value other than `#f`, that result is the result of the `or` expression. Otherwise, the result is the same as an `or` expression with the remaining *expr*s in tail position with respect to the original `or` form.

Examples:

```
> (or)
#f
> (or 1)
1
> (or (values 1 2))
1
2
> (or 5 (error "doesn't get here"))
5
> (or #f 5)
5
```

3.13 Dispatch: `case`

```
(case val-expr case-clause ...)

case-clause = [(datum ...) then-body ...+]
            | [else then-body ...+]
```

Evaluates *val-expr* and uses the result to select a *case-clause*. The selected clause is the first one with a *datum* whose `quote`d form is `equal?` to the result of *val-expr*. If no such *datum* is present, the `else` *case-clause* is selected; if no `else` *case-clause* is present, either, then the result of the `case` form is `#<void>`.

The `case` form of `racket` differs from that of R6RS or R5RS by being based on `equal?` instead of `eqv?` (in addition to allowing internal definitions).

For the selected *case-clause*, the results of the last *then-body*, which is in tail position with respect to the `case` form, are the results for the whole `case` form.

A *case-clause* that starts with `else` must be the last *case-clause*.

The `case` form can dispatch to a matching *case-clause* in $O(log\ N)$ time for N *datum*s.

Examples:

```
> (case (+ 7 5)
   [(1 2 3) 'small]
   [(10 11 12) 'big])
'big
```

```
> (case (- 7 5)
    [(1 2 3) 'small]
    [(10 11 12) 'big])
'small
> (case (string-append "do" "g")
    [("cat" "dog" "mouse") "animal"]
    [else "mineral or vegetable"])
"animal"
> (case (list 'y 'x)
    [((a b) (x y)) 'forwards]
    [((b a) (y x)) 'backwards])
'backwards
> (case 'x
    [(x) "ex"]
    [('x) "quoted ex"])
"ex"
> (case (list 'quote 'x)
    [(x) "ex"]
    [('x) "quoted ex"])
"quoted ex"
```

```
(define (classify c)
  (case (char-general-category c)
   [(ll lu lt ln lo) "letter"]
   [(nd nl no) "number"]
   [else "other"]))
```

```
> (classify #\A)
"letter"
> (classify #\1)
"number"
> (classify #\!)
"other"
```

3.13.1 Variants of case

```
(require racket/case)
```
package: base

The bindings documented in this section are provided by the racket/case library, not racket/base or racket.

Added in version 8.11.1.8 of package base.

```
(case/equal val-expr case-clause ...)
(case/equal-always val-expr case-clause ...)
```

```
(case/eq val-expr case-clause ...)
(case/eqv val-expr case-clause ...)
```

Like `case`, but using `equal?`, `equal-always?`, `eq?`, or `eqv?` for comparing the result of *`val-expr`* to the literals in the *`case-clause`*s. The `case/equal` form is equivalent to `case`.

3.14 Definitions: `define`, `define-syntax`, ...

§4.5 "Definitions: `define`" in *The Racket Guide* introduces definitions.

```
(define id expr)
(define (head args) body ...+)

head = id
     | (head args)

args = arg ...
     | arg ... . rest-id

 arg = arg-id
     | [arg-id default-expr]
     | keyword arg-id
     | keyword [arg-id default-expr]
```

The first form binds *`id`* to the result of *`expr`*, and the second form binds *`id`* to a procedure. In the second case, the generated procedure is `(CVT (head args) body ...+)`, using the `CVT` meta-function defined as follows:

```
(CVT (id . kw-formals) . datum)   = (lambda kw-formals . datum)
(CVT (head . kw-formals) . datum) = (lambda kw-formals expr)
                                    if (CVT head . datum) = expr
```

In an internal-definition context, a `define` form introduces a local binding; see §1.2.3.8 "Internal Definitions". At the top level, the top-level binding for *`id`* is created after evaluating *`expr`*, if it does not exist already, and the top-level mapping of *`id`* (in the namespace linked with the compiled definition) is set to the binding at the same time.

In a context that allows liberal expansion of `define`, *`id`* is bound as syntax if *`expr`* is an immediate `lambda` form with keyword arguments or *`args`* include keyword arguments.

Examples:

```
(define x 10)
```

```
> x
10

(define (f x)
  (+ x 1))

> (f 10)
11

(define ((f x) [y 20])
  (+ x y))

> ((f 10) 30)
40
> ((f 10))
30
```

```
(define-values (id ...) expr)
```

Evaluates the *expr*, and binds the results to the *id*s, in order, if the number of results matches the number of *id*s; if *expr* produces a different number of results, the `exn:fail:contract` exception is raised.

In an internal-definition context (see §1.2.3.8 "Internal Definitions"), a `define-values` form introduces local bindings. At the top level, the top-level binding for each *id* is created after evaluating *expr*, if it does not exist already, and the top-level mapping of each *id* (in the namespace linked with the compiled definition) is set to the binding at the same time.

Examples:

```
> (define-values () (values))
> (define-values (x y z) (values 1 2 3))
> z
3
```

If a `define-values` form for a function definition in a module body has a `'compiler-hint:cross-module-inline` syntax property with a true value, then the Racket treats the property as a performance hint. See §19.5 "Function-Call Optimizations" in *The Racket Guide* for more information, and see also `begin-encourage-inline`.

```
(define-syntax id expr)
(define-syntax (head args) body ...+)
```

The first form creates a transformer binding (see §1.2.3.5 "Transformer Bindings") of *id* with the value of *expr*, which is an expression at phase level 1 relative to the surrounding context. (See §1.2.1 "Identifiers, Binding, and Scopes" for information on phase levels.) Evaluation of *expr* side is parameterized to set current-namespace as in let-syntax.

The second form is a shorthand the same as for define; it expands to a definition of the first form where the *expr* is a lambda form.

In an internal-definition context (see §1.2.3.8 "Internal Definitions"), a define-syntax form introduces a local binding.

Examples:

```
> (define-syntax foo
    (syntax-rules ()
      ((_ a ...)
       (printf "~a\n" (list a ...)))))
> (foo 1 2 3 4)
(1 2 3 4)
> (define-syntax (bar syntax-object)
    (syntax-case syntax-object ()
      ((_ a ...)
       #'(printf "~a\n" (list a ...)))))
> (bar 1 2 3 4)
(1 2 3 4)
```

```
(define-syntaxes (id ...) expr)
```

Like define-syntax, but creates a transformer binding for each *id*. The *expr* should produce as many values as *id*s, and each value is bound to the corresponding *id*.

When *expr* produces zero values for a top-level define-syntaxes (i.e., not in a module or internal-definition position), then the *id*s are effectively declared without binding; see §1.2.3.10 "Macro-Introduced Bindings".

In an internal-definition context (see §1.2.3.8 "Internal Definitions"), a define-syntaxes form introduces local bindings.

Examples:

```
> (define-syntaxes (foo1 foo2 foo3)
    (let ([transformer1 (lambda (syntax-object)
                          (syntax-case syntax-object ()
                            [(_) #'1]))]
          [transformer2 (lambda (syntax-object)
                          (syntax-case syntax-object ()
                            [(_) #'2]))]
          [transformer3 (lambda (syntax-object)
```

```
                              (syntax-case syntax-object ()
                                [(_) #'3]))])
        (values transformer1
                transformer2
                transformer3)))
> (foo1)
1
> (foo2)
2
> (foo3)
3
```

```
(define-for-syntax id expr)
(define-for-syntax (head args) body ...+)
```

Like `define`, except that the binding is at phase level 1 instead of phase level 0 relative to its context. The expression for the binding is also at phase level 1. (See §1.2.1 "Identifiers, Binding, and Scopes" for information on phase levels.) The form is a shorthand for `(begin-for-syntax (define id expr))` or `(begin-for-syntax (define (head args) body ...+))`.

Within a module, bindings introduced by `define-for-syntax` must appear before their uses or in the same `define-for-syntax` form (i.e., the `define-for-syntax` form must be expanded before the use is expanded). In particular, mutually recursive functions bound by `define-for-syntax` must be defined by the same `define-for-syntax` form.

Examples:

```
> (define-for-syntax helper 2)
> (define-syntax (make-two syntax-object)
    (printf "helper is ~a\n" helper)
    #'2)
> (make-two)
helper is 2
2
; 'helper' is not bound in the runtime phase
> helper
helper: undefined;
 cannot reference an identifier before its definition
  in module: top-level
> (define-for-syntax (filter-ids ids)
    (filter identifier? ids))
> (define-syntax (show-variables syntax-object)
    (syntax-case syntax-object ()
      [(_ expr ...)
       (with-syntax ([(only-ids ...)
```

```
                        (filter-ids (syntax->list #'(expr ...)))])
            #'(list only-ids ...))]))
> (let ([a 1] [b 2] [c 3])
    (show-variables a 5 2 b c))
'(1 2 3)
```

```
(define-values-for-syntax (id ...) expr)
```

Like `define-for-syntax`, but *`expr`* must produce as many values as supplied *`id`*s, and all of the *`id`*s are bound (at phase level 1).

Examples:

```
> (define-values-for-syntax (foo1 foo2) (values 1 2))
> (define-syntax (bar syntax-object)
    (printf "foo1 is ~a foo2 is ~a\n" foo1 foo2)
    #'2)
> (bar)
foo1 is 1 foo2 is 2
2
```

3.14.1 `require` Macros

```
(require racket/require-syntax)      package: base
```

The bindings documented in this section are provided by the `racket/require-syntax` library, not `racket/base` or `racket`.

```
(define-require-syntax id proc-expr)
(define-require-syntax (id args ...) body ...+)
```

The first form is like `define-syntax`, but for a `require` sub-form. The *`proc-expr`* must produce a procedure that accepts and returns a syntax object representing a `require` sub-form.

This form expands to `define-syntax` with a use of `make-require-transformer` (see §12.4.1 "`require` Transformers" for more information).

The second form is a shorthand the same as for `define-syntax`; it expands to a definition of the first form where the *`proc-expr`* is a `lambda` form.

```
(syntax-local-require-introduce stx) → syntax?
  stx : syntax?
```

For backward compatibility only; equivalent to `syntax-local-introduce`.

Changed in version 6.90.0.29 of package `base`: Made equivalent to `syntax-local-introduce`.

3.14.2 `provide` Macros

```
(require racket/provide-syntax)        package: base
```

The bindings documented in this section are provided by the `racket/provide-syntax` library, not `racket/base` or `racket`.

```
(define-provide-syntax id proc-expr)
(define-provide-syntax (id args ...) body ...+)
```

The first form is like `define-syntax`, but for a `provide` sub-form. The *`proc-expr`* must produce a procedure that accepts and returns a syntax object representing a `provide` sub-form.

This form expands to `define-syntax` with a use of `make-provide-transformer` (see §12.4.2 “`provide` Transformers” for more information).

The second form is a shorthand the same as for `define-syntax`; it expands to a definition of the first form where the `expr` is a `lambda` form.

```
(syntax-local-provide-introduce stx) → syntax?
  stx : syntax?
```

For backward compatibility only; equivalent to `syntax-local-introduce`.

Changed in version 6.90.0.29 of package `base`: Made equivalent to `syntax-local-introduce`.

3.15 Sequencing: `begin`, `begin0`, and `begin-for-syntax`

§4.8 “Sequencing” in *The Racket Guide* introduces `begin` and `begin0`.

```
(begin form ...)
(begin expr ...+)
```

The first form applies when `begin` appears at the top level, at module level, or in an internal-definition position. In that case, the `begin` form is equivalent to splicing the *`form`*s into the enclosing context.

The second form applies for `begin` in an expression position. In that case, the *`expr`*s are evaluated in order, and the results are ignored for all but the last *`expr`*. The last *`expr`* is in tail position with respect to the `begin` form.

Examples:

```
> (begin
    (define x 10)
    x)
10
```

```
> (+ 1 (begin
         (printf "hi\n")
         2))
hi
3
> (let-values ([(x y) (begin
                        (values 1 2 3)
                        (values 1 2))])
   (list x y))
'(1 2)
```

```
(begin0 expr ...+)
```

Evaluates the first *expr*, then evaluates the other `exprs`s in order, ignoring their results. The results of the first *expr* are the results of the `begin0` form; the first *expr* is in tail position only if no other *expr*s are present.

Example:

```
> (begin0
    (values 1 2)
    (printf "hi\n"))
hi
1
2
```

```
(begin-for-syntax form ...)
```

Allowed only in a top-level context or module context, shifts the phase level of each *form* by one:

- expressions reference bindings at a phase level one greater than in the context of the `begin-for-syntax` form;
- `define`, `define-values`, `define-syntax`, and `define-syntaxes` forms bind at a phase level one greater than in the context of the `begin-for-syntax` form;
- in `require` and `provide` forms, the default phase level is greater, which is roughly like wrapping the content of the `require` form with `for-syntax`;
- expression form *expr*: converted to `(define-values-for-syntax () (begin expr (values)))`, which effectively evaluates the expression at expansion time and, in the case of a module context, preserves the expression for future visits of the module.

See also `module` for information about expansion order and partial expansion for `begin-for-syntax` within a module context. Evaluation of an `expr` within `begin-for-syntax` is parameterized to set `current-namespace` as in `let-syntax`.

3.16 Guarded Evaluation: `when` and `unless`

§4.8.3 "Effects If...: `when` and `unless`" in *The Racket Guide* introduces `when` and `unless`.

```
(when test-expr body ...+)
```

Evaluates *test-expr*. If the result is `#f`, then the result of the `when` expression is `#<void>`. Otherwise, the *body*s are evaluated, and the last *body* is in tail position with respect to the `when` form.

Examples:

```
> (when (positive? -5)
    (display "hi"))
> (when (positive? 5)
    (display "hi")
    (display " there"))
hi there
```

```
(unless test-expr body ...+)
```

Equivalent to `(when (not test-expr) body ...+)`.

Examples:

```
> (unless (positive? 5)
    (display "hi"))
> (unless (positive? -5)
    (display "hi")
    (display " there"))
hi there
```

3.17 Assignment: `set!` and `set!-values`

§4.9 "Assignment: `set!`" in *The Racket Guide* introduces `set!`.

```
(set! id expr)
```

If *id* has a transformer binding to an assignment transformer, as produced by `make-set!-transformer` or as an instance of a structure type with the `prop:set!-transformer` property, then this form is expanded by calling the assignment transformer with the full expressions. If *id* has a transformer binding to a rename transformer as produced by `make-rename-transformer` or as an instance of a structure type with the `prop:rename-transformer` property, then this form is expanded by replacing *id* with the target identifier (e.g., the one provided to `make-rename-transformer`). If a transformer binding has both `prop:set!-transformer` and `prop:rename-transformer` properties, the latter takes precedence.

Otherwise, evaluates *expr* and installs the result into the location for *id*, which must be bound as a local variable or defined as a top-level variable or module-level variable. If *id* refers to an imported binding, a syntax error is reported. If *id* refers to a top-level variable that has not been defined, the `exn:fail:contract` exception is raised.

See also `compile-allow-set!-undefined`.

Examples:

```
> (define x 12)
> (set! x (add1 x))
> x
13
> (let ([x 5])
    (set! x (add1 x))
    x)
6
> (set! i-am-not-defined 10)
set!: assignment disallowed;
 cannot set variable before its definition
  variable: i-am-not-defined
  in module: top-level
```

```
(set!-values (id ...) expr)
```

Assuming that all *id*s refer to variables, this form evaluates *expr*, which must produce as many values as supplied *id*s. The location of each *id* is filled with the corresponding value from *expr* in the same way as for `set!`.

Example:

```
> (let ([a 1]
        [b 2])
    (set!-values (a b) (values b a))
    (list a b))
'(2 1)
```

More generally, the `set!-values` form is expanded to

```
(let-values ([(tmp-id ...) expr])
  (set! id tmp-id) ...)
```

which triggers further expansion if any *id* has a transformer binding to an assignment transformer.

3.18 Iterations and Comprehensions: for, for/list, ...

§11 "Iterations and Comprehensions" in *The Racket Guide* introduces iterations and comprehensions.

The for iteration forms are based on SRFI-42 [SRFI-42].

3.18.1 Iteration and Comprehension Forms

```
(for (for-clause ...) body-or-break ... body)

   for-clause = [id seq-expr]
              | [(id ...) seq-expr]
              | #:when guard-expr
              | #:unless guard-expr
              | #:do [do-body ...]
              | break-clause
              | #:splice (splicing-id . form)
              | #:on-length-mismatch mismatch-expr

 break-clause = #:break guard-expr
              | #:final guard-expr

body-or-break = body
              | break-clause

  seq-expr : sequence?
```

Iteratively evaluates *body*s. The *for-clause*s introduce bindings whose scope includes *body* and that determine the number of times that *body* is evaluated. A *break-clause* either among the *for-clause*s or *body*s stops further iteration.

In the simple case, each *for-clause* has one of its first two forms, where `[id seq-expr]` is a shorthand for `[(id) seq-expr]`. In this simple case, the *seq-expr*s are evaluated left-to-right, and each must produce a sequence value (see §4.17.1 "Sequences").

The `for` form iterates by drawing an element from each sequence; if any sequence is empty, then the iteration stops (but see `#:on-length-mistmatch` below), and `#<void>` is the result of the `for` expression. Otherwise, a location is created for each *id* to hold the values of each element; the sequence produced by a *seq-expr* must return as many values for each iteration as corresponding *id*s.

The *id*s are then bound in the *body*, which is evaluated, and whose results are ignored. Iteration continues with the next element in each sequence and with fresh locations for each *id*.

A `for` form with zero *for-clause*s is equivalent to a single *for-clause* that binds an unreferenced *id* to a sequence containing a single element. All of the *id*s must be distinct according to bound-identifier=?.

If any *for-clause* has the form #:when *guard-expr*, then only the preceding clauses (containing no #:when, #:unless, or #:do) determine iteration as above, and the *body* is effectively wrapped as

```
(when guard-expr
  (for (for-clause ...) body ...+))
```

using the remaining *for-clause*s. A *for-clause* of the form #:unless *guard-expr* corresponds to the same transformation with unless in place of when. A *for-clause* of the form #:do [*do-body* ...] similarly creates nesting and corresponds to

```
(let ()
  do-body ...
  (for (for-clause ...) body ...+))
```

where the *do-body* forms may introduce definitions that are visible in the remaining *for-clause*s.

A #:break *guard-expr* clause is similar to a #:unless *guard-expr* clause, but when #:break avoids evaluation of the *body*s, it also effectively ends all sequences within the for form. A #:final *guard-expr* clause is similar to #:break *guard-expr*, but instead of immediately ending sequences and skipping the *body*s, it allows at most one more element from each later sequence and at most one more evaluation of the following *body*s. Among the *body*s, besides stopping the iteration and preventing later *body* evaluations, a #:break *guard-expr* or #:final *guard-expr* clause starts a new internal-definition context.

A #:splice (*splicing-id* . *form*) clause is replaced by the sequence of forms that are produced by expanding (*splicing-id* . *form*), where *splicing-id* is bound using define-splicing-for-clause-syntax. The binding context of that expansion includes previous binding from any clause preceding both the #:splice form and a #:when, #:unless, #:do, #:break, or #:final form. The result of a #:splice expansion can include more #:splice forms to further interleave clause binding and expansion. Support for #:splice clauses is intended less for direct use in source for forms than for building new forms that expand to for.

An #:on-length-mismatch *mismatch-expr* clause is similar to #:when #t, but if one of the sequences in the immediately preceding clauses ends before the others, then *mismatch-expr* is evaluated for its effect (such as throwing an exception). If *mismatch-expr* produces a value, it is ignored, and the iteration layer terminates. When #:on-length-mismatch is present, all sequences in a group are checked for termination in a potential iteration, even if a mismatch is found earlier.

In the case of list and stream sequences, the for form itself does not keep each element reachable. If a list or stream produced by a *seq-expr* is otherwise unreachable, and if the `for` body can no longer reference an *id* for a list element, then the element is subject to garbage collection. The `make-do-sequence` sequence constructor supports additional sequences that behave like lists and streams in this way.

If a *seq-expr* is a quoted literal list, vector, exact integer, string, byte string, immutable hash, or expands to such a literal, then it may be treated as if a sequence transformer such as `in-list` was used, unless the *seq-expr* has a true value for the `'for:no-implicit-optimization` syntax property; in most cases this improves performance.

Examples:

```
> (for ([i '(1 2 3)]
        [j "abc"]
        #:when (odd? i)
        [k #(#t #f)])
    (display (list i j k)))
(1 a #t)(1 a #f)(3 c #t)(3 c #f)
> (for ([i '(1 2 3)]
        #:do [(define neg-i (* i -1))]
        [j (list neg-i 0 i)])
    (display (list j)))
(-1)(0)(1)(-2)(0)(2)(-3)(0)(3)
> (for ([(i j) #hash(("a" . 1) ("b" . 20))])
    (display (list i j)))
(a 1)(b 20)
> (for ([i '(1 2 3)]
        [j "abc"]
        #:break (not (odd? i))
        [k #(#t #f)])
    (display (list i j k)))
(1 a #t)(1 a #f)
> (for ([i '(1 2 3)]
        [j "abc"]
        #:final (not (odd? i))
        [k #(#t #f)])
    (display (list i j k)))
(1 a #t)(1 a #f)(2 b #t)
> (for ([i '(1 2 3)]
        [j "abc"]
        [k #(#t #f)])
    #:break (not (or (odd? i) k))
    (display (list i j k)))
(1 a #t)
> (for ()
    (display "here"))
here
```

```
> (for ([i '()])
    (error "doesn't get here"))
> (for ([i (in-range 2)]
        [j (in-range 3)])
    (display i))
01
> (for ([i (in-range 2)]
        [j (in-range 3)]
        #:on-length-mismatch (error "different"))
    (display i))
01
```

different

Changed in version 6.7.0.4 of package `base`: Added support for the optional second result.
Changed in version 7.8.0.11: Added support for implicit optimization.
Changed in version 8.4.0.2: Added `#:do`.
Changed in version 8.4.0.3: Added `#:splice`.
Changed in version 9.0.0.2: Added `#:on-length-mismatch`.

```
(for/list (for-clause ...) body-or-break ... body)
```

Iterates like `for`, but that the last expression in the *`body`*s must produce a single value, and the result of the `for/list` expression is a list of the results in order. When evaluation of a *`body`* is skipped due to a `#:when` or `#:unless` clause, the result list includes no corresponding element.

Examples:

```
> (for/list ([i '(1 2 3)]
             [j "abc"]
             #:when (odd? i)
             [k #(#t #f)])
    (list i j k))
'((1 #\a #t) (1 #\a #f) (3 #\c #t) (3 #\c #f))
> (for/list ([i '(1 2 3)]
             [j "abc"]
             #:break (not (odd? i))
             [k #(#t #f)])
    (list i j k))
'((1 #\a #t) (1 #\a #f))
> (for/list () 'any)
'(any)
> (for/list ([i '()])
    (error "doesn't get here"))
'()
```

```
(for/vector maybe-length (for-clause ...) body-or-break ... body)

maybe-length =
             | #:length length-expr
             | #:length length-expr #:fill fill-expr

  length-expr : exact-nonnegative-integer?
```

Iterates like `for/list`, but results are accumulated into a vector instead of a list.

If the optional `#:length` clause is specified, the result of *`length-expr`* determines the length of the result vector. In that case, the iteration can be performed more efficiently, and it terminates when the vector is full or the requested number of iterations have been performed, whichever comes first. If *`length-expr`* specifies a length longer than the number of iterations, then the remaining slots of the vector are initialized to the value of *`fill-expr`*, which defaults to `0` (i.e., the default argument of `make-vector`).

Examples:

```
> (for/vector ([i '(1 2 3)]) (number->string i))
'#("1" "2" "3")
> (for/vector #:length 2 ([i '(1 2 3)]) (number->string i))
'#("1" "2")
> (for/vector #:length 4 ([i '(1 2 3)]) (number->string i))
'#("1" "2" "3" 0)
> (for/vector #:length 4 #:fill "?" ([i '(1 2 3)]) (number-
>string i))
'#("1" "2" "3" "?")
```

The `for/vector` form may allocate a vector and mutate it after each iteration of *`body`*, which means that capturing a continuation during *`body`* and applying it multiple times may mutate a shared vector.

```
(for/hash (for-clause ...) body-or-break ... body)
(for/hasheq (for-clause ...) body-or-break ... body)
(for/hasheqv (for-clause ...) body-or-break ... body)
(for/hashalw (for-clause ...) body-or-break ... body)
```

Like `for/list`, but the result is an immutable hash table; `for/hash` creates a table using `equal?` to distinguish keys, `for/hasheq` produces a table using `eq?`, `for/hasheqv` produces a table using `eqv?`, and `for/hashalw` produces a table using `equal-always?`. The last expression in the *`body`*s must return two values: a key and a value to extend the hash table accumulated by the iteration.

Example:

```
> (for/hash ([i '(1 2 3)])
    (values i (number->string i)))
'#hash((1 . "1") (2 . "2") (3 . "3"))
```

Changed in version 8.5.0.3 of package `base`: Added the `for/hashalw` form.

```
(for/and (for-clause ...) body-or-break ... body)
```

Iterates like `for`, but when last expression of *body* produces `#f`, then iteration terminates, and the result of the `for/and` expression is `#f`. If the *body* is never evaluated, then the result of the `for/and` expression is `#t`. Otherwise, the result is the (single) result from the last evaluation of *body*.

Examples:

```
> (for/and ([i '(1 2 3 "x")])
    (i . < . 3))
#f
> (for/and ([i '(1 2 3 4)])
    i)
4
> (for/and ([i '(1 2 3 4)])
    #:break (= i 3)
    i)
2
> (for/and ([i '()])
    (error "doesn't get here"))
#t
```

```
(for/or (for-clause ...) body-or-break ... body)
```

Iterates like `for`, but when last expression of *body* produces a value other than `#f`, then iteration terminates, and the result of the `for/or` expression is the same (single) value. If the *body* is never evaluated, then the result of the `for/or` expression is `#f`. Otherwise, the result is `#f`.

Examples:

```
> (for/or ([i '(1 2 3 "x")])
    (i . < . 3))
#t
> (for/or ([i '(1 2 3 4)])
    i)
1
> (for/or ([i '()])
    (error "doesn't get here"))
```

```
#f
```

```
(for/sum (for-clause ...) body-or-break ... body)
```

Iterates like `for`, but each result of the last *body* is accumulated into a result with `+`.

Example:

```
> (for/sum ([i '(1 2 3 4)]) i)
10
```

```
(for/product (for-clause ...) body-or-break ... body)
```

Iterates like `for`, but each result of the last *body* is accumulated into a result with `*`.

Example:

```
> (for/product ([i '(1 2 3 4)]) i)
24
```

```
(for/lists (id ... maybe-result)
           (for-clause ...)
  body-or-break ... body)

maybe-result =
             | #:result result-expr
```

Similar to `for/list`, but the last *body* expression should produce as many values as given *id*s. The *id*s are bound to the reversed lists accumulated so far in the *for-clause*s and *body*s.

If a *result-expr* is provided, it is used as with `for/fold` when iteration terminates; otherwise, the result is as many lists as supplied *id*s.

The scope of *id* bindings is the same as for accumulator identifiers in `for/fold`. Mutating a *id* affects the accumulated lists, and mutating it in a way that produces a non-list can cause a final `reverse` for each *id* to fail.

Examples:

```
> (for/lists (l1 l2 l3)
             ([i '(1 2 3)]
              [j "abc"]
              #:when (odd? i)
              [k #(#t #f)])
    (values i j k))
```

```
'(1 1 3 3)
'(#\a #\a #\c #\c)
'(#t #f #t #f)
> (for/lists (acc)
             ([x '(tvp tofu seitan tvp tofu)]
              #:unless (member x acc))
    x)
'(tvp tofu seitan)
> (for/lists (firsts seconds #:result (list firsts seconds))
             ([pr '((1 . 2) (3 . 4) (5 . 6))])
    (values (car pr) (cdr pr)))
'((1 3 5) (2 4 6))
```

Changed in version 7.1.0.2 of package `base`: Added the `#:result` form.

```
(for/first (for-clause ...) body-or-break ... body)
```

Iterates like `for`, but after *body* is evaluated the first time, then the iteration terminates, and the `for/first` result is the (single) result of *body*. If the *body* is never evaluated, then the result of the `for/first` expression is `#f`.

Examples:

```
> (for/first ([i '(1 2 3 "x")]
              #:when (even? i))
     (number->string i))
"2"
> (for/first ([i '()])
    (error "doesn't get here"))
#f
```

```
(for/last (for-clause ...) body-or-break ... body)
```

Iterates like `for`, but the `for/last` result is the (single) result of the last evaluation of *body*. If the *body* is never evaluated, then the result of the `for/last` expression is `#f`.

Examples:

```
> (for/last ([i '(1 2 3 4 5)]
              #:when (even? i))
     (number->string i))
"4"
> (for/last ([i '()])
    (error "doesn't get here"))
#f
```

```
(for/fold ([accum-id init-expr] ... maybe-result) (for-clause ...)
  body-or-break ... body)

maybe-result =
             | #:result result-expr
```

Iterates like `for`. Before iteration starts, the *`init-expr`*s are evaluated to produce initial accumulator values. At the start of each iteration, a location is generated for each *`accum-id`*, and the corresponding current accumulator value is placed into the location. The last expression in *`body`* must produce as many values as *`accum-id`*s, and those values become the current accumulator values. When iteration terminates, if a *`result-expr`* is provided then the result of the `for/fold` is the result of evaluating *`result-expr`* (with *`accum-id`*s in scope and bound to their final values), otherwise the results of the `for/fold` expression are the accumulator values.

Examples:

```
> (for/fold ([sum 0]
             [rev-roots null])
            ([i '(1 2 3 4)])
    (values (+ sum i) (cons (sqrt i) rev-roots)))
10
'(2 1.7320508075688772 1.4142135623730951 1)
> (for/fold ([acc '()]
             [seen (hash)]
             #:result (reverse acc))
            ([x (in-list '(0 1 1 2 3 4 4 4))])
    (cond
      [(hash-ref seen x #f)
       (values acc seen)]
      [else (values (cons x acc)
                    (hash-set seen x #t))]))
'(0 1 2 3 4)
```

The binding and evaluation order of *`accum-id`*s and *`init-expr`*s follow the textual, left-to-right order relative to the *`for-clause`*s, except that (for historical reasons) *`accum-id`*s are not available in the *`for-clause`*s for the outermost iteration. The lifetimes of variables are not quite the same as the lexical nesting, however: the variable referenced by a *`accum-id`* has a fresh location in each iteration.

Changed in version 6.11.0.1 of package `base`: Added the `#:result` form.

Changed in version 8.11.1.3: Changed evaluation order to match textual left-to-right order, including evaluating *`init-expr`*s before the first *`for-clause`*'s right-hand side and fixing shadowing of *`accum-id`*.

```
(for/foldr ([accum-id init-expr] ... accum-option ...)
           (for-clause ...)
  body-or-break ... body)

accum-option = #:result result-expr
             | #:delay
             | #:delay-as delayed-id
             | #:delay-with delayer-id
```

Like `for/fold`, but analogous to `foldr` rather than `foldl`: the given sequences are still iterated in the same order, but the loop body is evaluated in reverse order. Evaluation of a `for/foldr` expression uses space proportional to the number of iterations it performs, and all elements produced by the given sequences are retained until backwards evaluation of the loop body begins (assuming the element is, in fact, referenced in the body).

Examples:

```
> (define (in-printing seq)
    (sequence-map (lambda (v) (println v) v) seq))
> (for/foldr ([acc '()])
             ([v (in-printing (in-range 1 4))])
    (println v)
    (cons v acc))
1
2
3
3
2
1
'(1 2 3)
```

Furthermore, unlike `for/fold`, the *accum-id*s are not bound within *guard-expr*s or *body-or-break* forms that appear before a *break-clause*.

While the aforementioned limitations make `for/foldr` less generally useful than `for/fold`, `for/foldr` provides the additional capability to iterate lazily via the `#:delay`, `#:delay-as`, and `#:delay-with` options, which can mitigate many of `for/foldr`'s disadvantages. If at least one such option is specified, the loop body is given explicit control over when iteration continues: by default, each *accum-id* is bound to a promise that, when forced, produces the *accum-id*'s current value.

In this mode, iteration does not continue until one such promise is forced, which triggers any additional iteration necessary to produce a value. If the loop body is lazy in its *accum-id*s—that is, it returns a value without forcing any of them—then the loop (or any of its iterations) will produce a value before iteration has completely finished. If a reference to at least one such promise is retained, then forcing it will resume iteration from the point at which it was suspended, even if control has left the dynamic extent of the loop body.

Examples:

```
> (for/foldr ([acc '()] #:delay)
             ([v (in-range 1 4)])
    (printf "--> ~v\n" v)
    (begin0
      (cons v (force acc))
      (printf "<-- ~v\n" v)))
--> 1
--> 2
--> 3
<-- 3
<-- 2
<-- 1
'(1 2 3)
> (define resume
    (for/foldr ([acc '()] #:delay)
               ([v (in-range 1 5)])
      (printf "--> ~v\n" v)
      (begin0
        (cond
          [(= v 1) (force acc)]
          [(= v 2) acc]
          [else    (cons v (force acc))])
        (printf "<-- ~v\n" v))))
--> 1
--> 2
<-- 2
<-- 1
> (force resume)
--> 3
--> 4
<-- 4
<-- 3
'(3 4)
```

This extra control over iteration order allows `for/foldr` to both consume and construct infinite sequences, so long as it is at least sometimes lazy in its accumulators.

See also `for/stream` for a more convenient (albeit less flexible) way to lazily transform infinite sequences. (Internally, `for/stream` is defined in terms of `for/foldr`.)

Examples:

```
> (define squares (for/foldr ([s empty-stream] #:delay)
                             ([n (in-naturals)])
```

```
                      (stream-cons (* n n) (force s))))
> (stream->list (stream-take squares 10))
'(0 1 4 9 16 25 36 49 64 81)
```

The suspension introduced by the `#:delay` option does not ordinarily affect the loop's eventual return value, but if `#:delay` and `#:result` are combined, the *`accum-id`*s will be delayed in the scope of the *`result-expr`* in the same way they are delayed within the loop body. This can be used to introduce an additional layer of suspension around the evaluation of the entire loop, if desired.

Examples:

```
> (define evaluated-yet? #f)
> (for/foldr ([acc (set! evaluated-yet? #t)] #:delay) ()
    (force acc))
> evaluated-yet?
#t
```

```
> (define evaluated-yet? #f)
> (define start
    (for/foldr ([acc (set! evaluated-yet? #t)] #:delay #:result acc) ()
      (force acc)))
> evaluated-yet?
#f
> (force start)
> evaluated-yet?
#t
```

If the `#:delay-as` option is provided, then *`delayed-id`* is bound to an additional promise that returns the values of all *`accum-id`*s at once. When multiple *`accum-id`*s are provided, forcing this promise can be slightly more efficient than forcing the promises bound to the *`accum-id`*s individually.

If the `#:delay-with` option is provided, the given *`delayer-id`* is used to suspend nested iterations (instead of the default, `delay`). A form of the shape `(`*`delayer-id recur-expr`*`)` is constructed and placed in expression position, where *`recur-expr`* is an expression that, when evaluated, will perform the next iteration and return its result (or results). Sensible choices for *`delayer-id`* include `lazy`, `delay/sync`, `delay/thread`, or any of the other promise constructors from `racket/promise`, as well as `thunk` from `racket/function`. However, beware that choices such as `thunk` or `delay/name` may evaluate their subexpression multiple times, which can lead to nonsensical results for sequences that have state, as the state will be shared between all evaluations of the *`recur-expr`*.

If multiple *`accum-id`*s are given, the `#:delay-with` option is provided, and *`delayer-id`* is not bound to one of `delay`, `lazy`, `delay/strict`, `delay/sync`, `delay/thread`, or delay/idle, the *accum-id*s will not be bound at all, even within the loop body. Instead, the #:delay-as option must be specified to access the accumulator values via *delayed-id*.

Added in version 7.3.0.3 of package base.

```
(for* (for-clause ...) body-or-break ... body)
```

Like for, but with an implicit #:when #t between each pair of for-clauses, so that all sequence iterations are nested.

Example:

```
> (for* ([i '(1 2)]
         [j "ab"])
    (display (list i j)))
(1 a)(1 b)(2 a)(2 b)
```

```
(for*/list (for-clause ...) body-or-break ... body)
(for*/lists (id ... maybe-result) (for-clause ...)
  body-or-break ... body)
(for*/vector maybe-length (for-clause ...) body-or-break ... body)
(for*/hash (for-clause ...) body-or-break ... body)
(for*/hasheq (for-clause ...) body-or-break ... body)
(for*/hasheqv (for-clause ...) body-or-break ... body)
(for*/hashalw (for-clause ...) body-or-break ... body)
(for*/and (for-clause ...) body-or-break ... body)
(for*/or (for-clause ...) body-or-break ... body)
(for*/sum (for-clause ...) body-or-break ... body)
(for*/product (for-clause ...) body-or-break ... body)
(for*/first (for-clause ...) body-or-break ... body)
(for*/last (for-clause ...) body-or-break ... body)
(for*/fold ([accum-id init-expr] ... maybe-result) (for-clause ...)
  body-or-break ... body)
(for*/foldr ([accum-id init-expr] ... accum-option ...)
            (for-clause ...)
  body-or-break ... body)
```

Like for/list, etc., but with the implicit nesting of for*.

Example:

```
> (for*/list ([i '(1 2)]
              [j "ab"])
    (list i j))
'((1 #\a) (1 #\b) (2 #\a) (2 #\b))
```

Changed in version 7.3.0.3 of package `base`: Added the `for*/foldr` form.
Changed in version 8.5.0.3: Added the `for*/hashalw` form.

3.18.2 Deriving New Iteration Forms

```
(for/fold/derived orig-datum
  ([accum-id init-expr] ... maybe-result) (for-clause ...)
  body-or-break ... body)
```

Like `for/fold`, but the extra *`orig-datum`* is used as the source for all syntax errors.

A macro that expands to `for/fold/derived` should typically use `split-for-body` to handle the possibility of macros and other definitions mixed with keywords like `#:break`.

Examples:

```
> (require (for-syntax syntax/for-body)
           syntax/parse/define)
> (define-syntax-parse-rule (for/digits clauses body ... tail-
expr)
    #:with original this-syntax
    #:with ((pre-body ...) (post-body ...)) (split-for-body this-
syntax #'(body ... tail-expr))
    (for/fold/derived original ([n 0] [k 1] #:result n)
      clauses
      pre-body ...
      (values (+ n (* (let () post-body ...) k)) (* k 10))))
; If we misuse for/digits, we can get good error reporting
; because the use of orig-datum allows for source correlation:
> (for/digits
      [a (in-list '(1 2 3))]
      [b (in-list '(4 5 6))]
    (+ a b))
eval:4:0: for/digits: bad sequence binding clause
  at: a
  in: (for/digits (a (in-list (quote (1 2 3)))) (b (in-list
(quote (4 5 6)))) (+ a b))
> (for/digits
      ([a (in-list '(1 2 3))]
       [b (in-list '(2 4 6))])
    (+ a b))
963
; Another example: compute the max during iteration:
> (define-syntax-parse-rule (for/max clauses body ... tail-expr)
    #:with original this-syntax
```

```
    #:with ((pre-body ...) (post-body ...)) (split-for-body this-
syntax #'(body ... tail-expr))
    (for/fold/derived original
      ([current-max -inf.0])
      clauses
      pre-body ...
      (define maybe-new-max (let () post-body ...))
      (if (> maybe-new-max current-max)
          maybe-new-max
          current-max)))
> (for/max ([n '(3.14159 2.71828 1.61803)]
            [s '(-1      1       1)])
    (* n s))
2.71828
```

Changed in version 6.11.0.1 of package base: Added the `#:result` form.

```
(for*/fold/derived orig-datum
  ([accum-id init-expr] ... maybe-result) (for-clause ...)
  body-or-break ... body)
```

Like `for*/fold`, but the extra *`orig-datum`* is used as the source for all syntax errors.

Examples:

```
> (require (for-syntax syntax/for-body)
           syntax/parse/define)
> (define-syntax-parse-rule (for*/digits clauses body ... tail-
expr)
    #:with original this-syntax
    #:with ((pre-body ...) (post-body ...)) (split-for-body this-
syntax #'(body ... tail-expr))
    (for*/fold/derived original ([n 0] [k 1] #:result n)
      clauses
      pre-body ...
      (values (+ n (* (let () post-body ...) k)) (* k 10))))
> (for*/digits
      [ds (in-list '((8 3) (1 1)))]
      [d (in-list ds)]
    d)
eval:10:0: for*/digits: bad sequence binding clause
  at: ds
  in: (for*/digits (ds (in-list (quote ((8 3) (1 1))))) (d
(in-list ds)) d)
> (for*/digits
      ([ds (in-list '((8 3) (1 1)))]
```

```
        [d (in-list ds)])
    d)
1138
```

Changed in version 6.11.0.1 of package base: Added the #:result form.

```
(for/foldr/derived orig-datum
  ([accum-id init-expr] ... accum-option ...) (for-clause ...)
  body-or-break ... body)
(for*/foldr/derived orig-datum
  ([accum-id init-expr] ... accum-option ...) (for-clause ...)
  body-or-break ... body)
```

Like for/foldr and for*/foldr, but the extra *orig-datum* is used as the source for all syntax errors as in for/fold/derived and for*/fold/derived.

Added in version 7.3.0.3 of package base.

```
(define-sequence-syntax id
  expr-transform-expr
  clause-transform-expr)

  expr-transform-expr : (or/c (-> identifier?)
                              (syntax? . -> . syntax?))
  clause-transform-expr : (syntax? . -> . syntax?)
```

Defines *id* as syntax. An (*id* . *rest*) form is treated specially when used to generate a sequence in a *for-clause* of for (or one of its variants). In that case, the procedure result of *clause-transform-expr* is called to transform the clause.

When *id* is used in any other expression position, the result of *expr-transform-expr* is used. If it is a procedure of zero arguments, then the result must be an identifier *other-id*, and any use of *id* is converted to a use of *other-id*. Otherwise, *expr-transform-expr* must produce a procedure (of one argument) that is used as a macro transformer.

When the *clause-transform-expr* transformer is used, it is given a *for-clause* as an argument, where the clause's form is normalized so that the left-hand side is a parenthesized sequence of identifiers. The right-hand side is of the form (*id* . *rest*). The result can be either #f, to indicate that the forms should not be treated specially (perhaps because the number of bound identifiers is inconsistent with the (*id* . *rest*) form), or a new *for-clause* to replace the given one. The new clause might use :do-in. To protect identifiers in the result of *clause-transform-expr*, use for-clause-syntax-protect instead of syntax-protect.

Examples:

```
> (define (check-nat n)
    (unless (exact-nonnegative-integer? n)
      (raise-argument-error 'in-digits "exact-nonnegative-
integer?" n)))
> (define-sequence-syntax in-digits
    (lambda () #'in-digits/proc)
    (lambda (stx)
      (syntax-case stx ()
        [[(d) (_ nat)]
         #'[(d)
            (:do-in
              ([(n) nat])
              (check-nat n)
              ([i n])
              (not (zero? i))
              ([(j d) (quotient/remainder i 10)])
              #t
              #t
              [j])]]
        [_ #f])))
> (define (in-digits/proc n)
    (for/list ([d (in-digits n)]) d))
> (for/list ([d (in-digits 1138)]) d)
'(8 3 1 1)
> (map in-digits (list 137 216))
'((7 3 1) (6 1 2))
```

```
(:do-in ([(outer-id ...) outer-expr] ...)
        outer-defn-or-expr
        ([loop-id loop-expr] ...)
        pos-guard
        ([(inner-id ...) inner-expr] ...)
        maybe-inner-defn-or-expr
        pre-guard
        post-guard
        (loop-arg ...))

maybe-inner-defn/expr =
                      | inner-defn-or-expr
```

A form that can only be used as a *seq-expr* in a *for-clause* of `for` (or one of its variants).

Within a `for`, the pieces of the `:do-in` form are spliced into the iteration essentially as follows:

```
(let-values ([(outer-id ...) outer-expr] ...)
```

```
outer-defn-or-expr
(let loop ([loop-id loop-expr] ...)
  (if pos-guard
      (let-values ([(inner-id ...) inner-expr] ...)
        inner-defn-or-expr
        (if pre-guard
            (let body-bindings
                 (if post-guard
                     (loop loop-arg ...)
                     done-expr))
            done-expr))
       done-expr)))
```

where *body-bindings* and *done-expr* are from the context of the `:do-in` use. The identifiers bound by the `for` clause are typically part of the `([(inner-id ...) inner-expr] ...)` section. When *inner-defn-or-expr* is not provided `(begin)` is used in its place.

Beware that *body-bindings* and *done-expr* can contain arbitrary expressions, potentially including `set!` on *outer-id* or *inner-id* identifiers if they are visible in the original `for` form, so beware of depending on such identifiers in *post-guard* and *loop-arg*.

The actual `loop` binding and call has additional loop arguments to support iterations in parallel with the `:do-in` form, and the other pieces are similarly accompanied by pieces from parallel iterations.

For an example of `:do-in`, see `define-sequence-syntax`.

Changed in version 8.10.0.3 of package `base`: Added support for non-empty *maybe-inner-defn-or-expr*.

```
(for-clause-syntax-protect stx) → syntax?
  stx : syntax?
```

Provided `for-syntax`: Like `syntax-protect`, just returns its argument.

Changed in version 8.2.0.4 of package `base`: Changed to just return *stx* instead of returning “armed” syntax.

```
(define-splicing-for-clause-syntax id proc-expr)
```

Binds *id* for reference via a `#:splice` clause in a `for` form. The *proc-expr* expression is evaluated in phase level 1, and it must produce a procedure that accepts a syntax object and returns a syntax object.

The procedure’s input is a syntax object that appears after `#:splice`. The result syntax object must be a parenthesized sequence of forms, and the forms are spliced in place of the `#:splice` clause in the enclosing `for` form.

Examples:

```
> (define-splicing-for-clause-syntax cross3
    (lambda (stx)
      (syntax-case stx ()
        [(_ n m) #'([n (in-range 3)]
                    #:when #t
                    [m (in-range 3)])])))
> (for (#:splice (cross3 n m))
    (println (list n m)))
'(0 0)
'(0 1)
'(0 2)
'(1 0)
'(1 1)
'(1 2)
'(2 0)
'(2 1)
'(2 2)
```

Added in version 8.4.0.3 of package `base`.

3.18.3 Iteration Expansion

```
(require racket/for-clause)        package: base
```

The bindings documented in this section are provided by the `racket/for-clause` library, not `racket/base` or `racket`.

```
(syntax-local-splicing-for-clause-introduce stx) → syntax?
  stx : syntax?
```

Equivalent to `syntax-local-introduce`, intended for use in an expander bound with `define-splicing-for-clause-syntax`.

Added in version 8.11.1.4 of package `base`.
Changed in version 9.0.0.2: Changed to be equivalent to `syntax-local-introduce`.

3.18.4 Do Loops

```
(do ([id init-expr step-expr-maybe] ...)
    (stop?-expr finish-expr ...)
  expr ...)

step-expr-maybe =
                | step-expr
```

Iteratively evaluates the *expr*s for as long as *stop?-expr* returns `#f`.

To initialize the loop, the *init-expr*s are evaluated in order and bound to the corresponding *id*s. The *id*s are bound in all expressions within the form other than the *init-expr*s.

After the *id*s have been bound, the *stop?-expr* is evaluated. If it produces `#f`, each *expr* is evaluated for its side-effect. The *id*s are then effectively updated with the values of the *step-expr*s, where the default *step-expr* for *id* is just *id*; more precisely, iteration continues with fresh locations for the *id*s that are initialized with the values of the corresponding *step-expr*s.

When *stop?-expr* produces a true value, then the *finish-expr*s are evaluated in order, and the last one is evaluated in tail position to produce the overall value for the `do` form. If no *finish-expr* is provided, the value of the `do` form is `#<void>`.

3.19 Continuation Marks: `with-continuation-mark`

```
(with-continuation-mark key-expr val-expr result-expr)
```

The *key-expr*, *val-expr*, and *result-expr* expressions are evaluated in order. After *key-expr* is evaluated to obtain a key and *val-expr* is evaluated to obtain a value, the key is mapped to the value as a continuation mark in the current continuation's initial continuation frame. If the frame already has a mark for the key, the mark is replaced. Finally, the *result-expr* is evaluated; the continuation for evaluating *result-expr* is the continuation of the `with-continuation-mark` expression (so the result of the *result-expr* is the result of the `with-continuation-mark` expression, and *result-expr* is in tail position for the `with-continuation-mark` expression).

§10.5 "Continuation Marks" provides more information on continuation marks.

3.20 Quasiquoting: `quasiquote`, `unquote`, and `unquote-splicing`

§4.11 "Quasiquoting: `quasiquote` and `‘`" in *The Racket Guide* introduces `quasiquote`.

```
(quasiquote datum)
```

The same as `'datum` if *datum* does not include `(unquote expr)` or `(unquote-splicing expr)`. An `(unquote expr)` form escapes from the quote, however, and the result of the *expr* takes the place of the `(unquote expr)` form in the `quasiquote` result. An `(unquote-splicing expr)` similarly escapes, but the *expr* produces a list whose elements are spliced as multiple values place of the `(unquote-splicing expr)`.

An `unquote` or `unquote-splicing` form is recognized in any of the following escaping positions within *datum*: in a pair, in a vector, in a box, in a prefab structure field after the name position, and in hash table value position (but not in a hash table key position). Such escaping positions can be nested to an arbitrary depth.

An `unquote-splicing` form must appear as the `car` of a quoted pair, as an element of a quoted vector, or as an element of a quoted prefab structure. In the case of a pair, if the `cdr` of the relevant quoted pair is empty, then *`expr`* need not produce a list, and its result is used directly in place of the quoted pair (in the same way that `append` accepts a non-list final argument).

If `unquote` or `unquote-splicing` appears within `quasiquote` in an escaping position but in a way other than as `(unquote expr)` or `(unquote-splicing expr)`, a syntax error is reported.

Examples:

```
> (quasiquote (0 1 2))
'(0 1 2)
> (quasiquote (0 (unquote (+ 1 2)) 4))
'(0 3 4)
> (quasiquote (0 (unquote-splicing (list 1 2)) 4))
'(0 1 2 4)
> (quasiquote (0 (unquote-splicing 1) 4))
unquote-splicing: contract violation
  expected: list?
  given: 1
> (quasiquote (0 (unquote-splicing 1)))
'(0 . 1)
```

A `quasiquote`, `unquote`, or `unquote-splicing` form is typically abbreviated with `` ` ``, `,`, or `,@`, respectively. See also §1.3.8 "Reading Quotes".

Examples:

```
> `(0 1 2)
'(0 1 2)
> `(1 ,(+ 1 2) 4)
'(1 3 4)
> `#s(stuff 1 ,(+ 1 2) 4)
'#s(stuff 1 3 4)
> `#hash(("a" . ,(+ 1 2)))
'#hash(("a" . 3))
> `#hash((,(+ 1 2) . "a"))
'#hash((,(+ 1 2) . "a"))
> `(1 ,@(list 1 2) 4)
'(1 1 2 4)
> `#(1 ,@(list 1 2) 4)
'#(1 1 2 4)
```

A `quasiquote` form within the original *`datum`* increments the level of quasiquotation: within the `quasiquote` form, each `unquote` or `unquote-splicing` is preserved, but a further nested unquote or unquote-splicing escapes. Multiple nestings of quasiquote require multiple nestings of unquote or unquote-splicing to escape.

Examples:

```
> `(1 `,(+ 1 ,(+ 2 3)) 4)
'(1 `,(+ 1 5) 4)
> `(1 ```,,@,,@(list (+ 1 2)) 4)
'(1 ```,,@,3 4)
```

The quasiquote form allocates only as many fresh cons cells, vectors, and boxes as are needed without analyzing unquote and unquote-splicing expressions. For example, in

```
`(,1 2 3)
```

a single tail '(2 3) is used for every evaluation of the quasiquote expression. When allocating fresh data, the quasiquote form allocates mutable vectors, mutable boxes and immutable hashes.

Examples:

```
> (immutable? `#(,0))
#f
> (immutable? `#hash((a . ,0)))
#t
```

unquote

See quasiquote, where unquote is recognized as an escape. An unquote form as an expression is a syntax error.

unquote-splicing

See quasiquote, where unquote-splicing is recognized as an escape. An unquote-splicing form as an expression is a syntax error.

3.21 Syntax Quoting: quote-syntax

```
(quote-syntax datum)
(quote-syntax datum #:local)
```

Similar to quote, but produces a syntax object that preserves the lexical information and source-location information attached to *datum* at expansion time.

When `#:local` is specified, then all scopes in the syntax object's lexical information are preserved. When `#:local` is omitted, then the scope sets within *`datum`* are pruned to omit the scope for any binding form that appears between the `quote-syntax` form and the enclosing top-level context, module body, or phase level crossing, whichever is closer.

Unlike `syntax` (`#'`), `quote-syntax` does not substitute pattern variables bound by `with-syntax`, `syntax-parse`, or `syntax-case`.

Examples:

```
> (syntax? (quote-syntax x))
#t
> (quote-syntax (1 2 3))
#<syntax:eval:78:0 (1 2 3)>
> (with-syntax ([a #'5])
    (quote-syntax (a b c)))
#<syntax:eval:79:0 (a b c)>
> (free-identifier=? (let ([x 1]) (quote-syntax x))
                     (quote-syntax x))
#t
> (free-identifier=? (let ([x 1]) (quote-syntax x #:local))
                     (quote-syntax x))
#f
```

Changed in version 6.3 of package `base`: Added scope pruning and support for `#:local`.

3.22 Interaction Wrapper: `#%top-interaction`

```
(#%top-interaction . form)
```

Expands to simply *`form`*. The `#%top-interaction` form is similar to `#%app` and `#%module-begin`, in that it provides a hook to control interactive evaluation through `load` (more precisely, the default load handler) or `read-eval-print-loop`.

3.23 Blocks: `block`

```
(require racket/block)
```
package: `base`

The bindings documented in this section are provided by the `racket/block` library, not `racket/base` or `racket`.

```
(block defn-or-expr ...)
```

Supports a mixture of expressions and mutually recursive definitions, as in a `module` body. Unlike an internal-definition context, the last *defn-or-expr* need not be an expression.

The result of the `block` form is the result of the last *defn-or-expr* if it is an expression, `#<void>` otherwise. If no *defn-or-expr* is provided (after flattening `begin` forms), the result is `#<void>`.

The final *defn-or-expr* is executed in tail position, if it is an expression.

Examples:

```
> (define (f x)
    (block
      (define y (add1 x))
      (displayln y)
      (define z (* 2 y))
      (+ 3 z)))
> (f 12)
13
29
```

3.24 Internal-Definition Limiting: `#%stratified-body`

```
(#%stratified-body defn-or-expr ...)
```

Like `(let () defn-or-expr ...)` for an internal-definition context sequence, except that an expression is not allowed to precede a definition, and all definitions are treated as referring to all other definitions (i.e., locations for variables are all allocated first, like `letrec` and unlike `letrec-syntaxes+values`).

The `#%stratified-body` form is useful for implementing syntactic forms or languages that supply a more limited kind of internal-definition context.

3.25 Performance Hints: `begin-encourage-inline`

```
(require racket/performance-hint)
```
package: `base`

The bindings documented in this section are provided by the `racket/performance-hint` library, not `racket/base` or `racket`.

```
(begin-encourage-inline form ...)
```

Attaches a `'compiler-hint:cross-module-inline` syntax property to each *form*, which is useful when a *form* is a function definition. See `define-values`.

The begin-encourage-inline form is also provided by the (submod racket/performance-hint begin-encourage-inline) module, which has fewer dependencies than racket/performance-hint.

Changed in version 6.2 of package base: Added the (submod racket/performance-hint begin-encourage-inline) submodule.

```
(define-inline id expr)
(define-inline (head args) body ...+)

head = id
     | (head args)

args = arg ...
     | arg ... . rest-id

 arg = arg-id
     | [arg-id default-expr]
     | keyword arg-id
     | keyword [arg-id default-expr]
```

Like define, but ensures that the definition will be inlined at its call sites. Recursive calls are not inlined, to avoid infinite inlining. Higher-order uses are supported, but also not inlined. Misapplication (by supplying the wrong number of arguments or incorrect keyword arguments) is also not inlined and left as a run-time error.

The define-inline form may interfere with the Racket compiler's own inlining heuristics, and should only be used when other inlining attempts (such as begin-encourage-inline) fail.

Changed in version 8.1.0.5 of package base: Changed to treat misapplication as a run-time error.

3.26 Importing Modules Lazily: lazy-require

```
(require racket/lazy-require)
```
package: base

The bindings documented in this section are provided by the racket/lazy-require library, not racket/base or racket.

```
(lazy-require [module-path (fun-import ...)] ...)

fun-import = fun-id
           | (orig-fun-id fun-id)
```

Defines each *fun-id* as a function that, when called, dynamically requires the export named *orig-fun-id* from the module specified by *module-path* and calls it with the same arguments. If *orig-fun-id* is not given, it defaults to *fun-id*.

If the enclosing relative phase level is not 0, then *module-path* is also placed in a submodule (with a use of `define-runtime-module-path-index` at phase level 0 within the submodule). Introduced submodules have the names `lazy-require-aux`*n*`-`*m*, where *n* is a phase-level number and *m* is a number.

When the use of a lazily-required function triggers module loading, it also triggers a use of `register-external-module` to declare an indirect compilation dependency (in case the function is used in the process of compiling a module).

Examples:

```
> (lazy-require
    [racket/list (partition)])
> (partition even? '(1 2 3 4 5))
'(2 4)
'(1 3 5)
> (module hello racket/base
    (provide hello)
    (printf "starting hello server\n")
    (define (hello) (printf "hello!\n")))
> (lazy-require
    ['hello ([hello greet])])
> (greet)
starting hello server
hello!
```

```
(lazy-require-syntax [module-path (macro-import ...)] ...)

macro-import = macro-id
             | (orig-macro-id macro-id)
```

Like `lazy-require` but for macros. That is, it defines each *macro-id* as a macro that, when used, dynamically loads the macro's implementation from the given *module-path*. If *orig-macro-id* is not given, it defaults to *macro-id*.

Use `lazy-require-syntax` in the *implementation* of a library with large, complicated macros to avoid a dependence from clients of the library on the macro "compilers." Note that only macros with exceptionally large compile-time components (such as Typed Racket, which includes a type checker and optimizer) benefit from `lazy-require-syntax`; typical macros do not.

Warning: `lazy-require-syntax` breaks the invariants that Racket's module loader and linker rely on; these invariants normally ensure that the references in code produced by a macro are loaded before the code runs. Safe use of `lazy-require-syntax` requires a particular structure in the macro implementation. (In particular, `lazy-require-syntax` cannot simply be introduced in the client code.) The macro implementation must follow these rules:

1. the interface module must `require` the runtime-support module
2. the compiler module must `require` the runtime-support module via an *absolute* module path rather than a *relative* path

To explain the concepts of "interface, compiler, and runtime-support modules", here is an example module that exports a macro:

```
(module original racket/base
  (define (ntimes-proc n thunk)
    (for ([i (in-range n)]) (thunk)))
  (define-syntax-rule (ntimes n expr)
    (ntimes-proc n (lambda () expr)))
  (provide ntimes))
```

Suppose we want to use `lazy-require-syntax` to lazily load the implementation of the `ntimes` macro transformer. The original module must be split into three parts:

```
(module runtime-support racket/base
  (define (ntimes-proc n thunk)
    (for ([i (in-range n)]) (thunk)))
  (provide ntimes-proc))
(module compiler racket/base
  (require 'runtime-support)
  (define-syntax-rule (ntimes n expr)
    (ntimes-proc n (lambda () expr)))
  (provide ntimes))
(module interface racket/base
  (require racket/lazy-require)
  (require 'runtime-support)
  (lazy-require-syntax ['compiler (ntimes)])
  (provide ntimes))
```

The runtime support module contains the function and value definitions that the macro refers to. The compiler module contains the macro definition(s) themselves—the part of the code that "disappears" after compile time. The interface module lazily loads the macro transformer, but it makes sure the runtime support module is defined at run time by requiring it normally. In a larger example, of course, the runtime support and compiler may both consist of multiple modules.

Here what happens when we don't separate the runtime support into a separate module:

```
> (module bad-no-runtime racket/base
    (define (ntimes-proc n thunk)
      (for ([i (in-range n)]) (thunk)))
    (define-syntax-rule (ntimes n expr)
      (ntimes-proc n (lambda () expr)))
    (provide ntimes))
> (module bad-client racket/base
    (require racket/lazy-require)
    (lazy-require-syntax ['bad-no-runtime (ntimes)])
    (ntimes 3 (printf "hello?\n")))
> (require 'bad-client)
require: namespace mismatch;
 reference to a module that is not instantiated
  module: 'bad-no-runtime
  phase: 0
```

A similar error occurs when the interface module doesn't introduce a dependency on the runtime support module.

4 Datatypes

Each pre-defined datatype comes with a set of procedures for manipulating instances of the datatype.

§3 "Built-In Datatypes" in *The Racket Guide* introduces Datatypes.

4.1 Equality

Equality is the concept of whether two values are "the same." Racket supports a few different kinds of equality by default, although `equal?` is preferred for most uses.

```
(equal? v1 v2) → boolean?
  v1 : any/c
  v2 : any/c
```

Two values are `equal?` if and only if they are `eqv?`, unless otherwise specified for a particular datatype.

Datatypes with further specification of `equal?` include strings, byte strings, pairs, mutable pairs, vectors, boxes, hash tables, and inspectable structures. In the last six cases, equality is recursively defined; if both *v1* and *v2* contain reference cycles, they are equal when the infinite unfoldings of the values would be equal. See also `gen:equal+hash` and `prop:impersonator-of`.

Examples:

```
> (equal? 'yes 'yes)
#t
> (equal? 'yes 'no)
#f
> (equal? (* 6 7) 42)
#t
> (equal? (expt 2 100) (expt 2 100))
#t
> (equal? 2 2.0)
#f
> (let ([v (mcons 1 2)]) (equal? v v))
#t
> (equal? (mcons 1 2) (mcons 1 2))
#t
> (equal? (integer->char 955) (integer->char 955))
#t
> (equal? (make-string 3 #\z) (make-string 3 #\z))
#t
> (equal? #t #t)
```

```
#t
```

```
(equal-always? v1 v2) → boolean?
  v1 : any/c
  v2 : any/c
```

Indicates whether `v1` and `v2` are equal and will always stay equal independent of *mutations*. Generally, for two values to be equal-always, corresponding immutable values within `v1` and `v2` must be `equal?`, while corresponding mutable values within them must be `eq?`.

Precedents for this operator in other languages include `egal` [Baker93].

Two values `v1` and `v2` are `equal-always?` if and only if there exists a third value `v3` such that `v1` and `v2` are both chaperones of `v3`, meaning `(chaperone-of? v1 v3)` and `(chaperone-of? v2 v3)` are both true.

For values that include no chaperones or other impersonators, `v1` and `v2` can be considered equal-always if they are `equal?`, except that corresponding mutable vectors, boxes, hash tables, strings, byte strings, mutable pairs, and mutable structures within `v1` and `v2` must be `eq?`, and equality on structures can be specialized for `equal-always?` through `gen:equal-mode+hash`.

Examples:

```
> (equal-always? 'yes 'yes)
#t
> (equal-always? 'yes 'no)
#f
> (equal-always? (* 6 7) 42)
#t
> (equal-always? (expt 2 100) (expt 2 100))
#t
> (equal-always? 2 2.0)
#f
> (equal-always? (list 1 2) (list 1 2))
#t
> (let ([v (mcons 1 2)]) (equal-always? v v))
#t
> (equal-always? (mcons 1 2) (mcons 1 2))
#f
> (equal-always? (integer->char 955) (integer->char 955))
#t
> (equal-always? (make-string 3 #\z) (make-string 3 #\z))
#f
> (equal-always? (string->immutable-string (make-string 3 #\z))
                 (string->immutable-string (make-string 3 #\z)))
#t
> (equal-always? #t #t)
```

```
#t
```

Added in version 8.5.0.3 of package `base`.

```
(eqv? v1 v2) → boolean?
  v1 : any/c
  v2 : any/c
```

Two values are `eqv?` if and only if they are `eq?`, unless otherwise specified for a particular datatype.

The number and character datatypes are the only ones for which `eqv?` differs from `eq?`. Two numbers are `eqv?` when they have the same exactness, precision, and are both equal and non-zero, both `+0.0`, both `+0.0f0`, both `-0.0`, both `-0.0f0`, both `+nan.0`, or both `+nan.f`—considering real and imaginary components separately in the case of complex numbers. Two characters are `eqv?` when their `char->integer` results are equal.

Generally, `eqv?` is identical to `equal?` except that the former cannot recursively compare the contents of compound data types (such as lists and structs) and cannot be customized by user-defined data types. The use of `eqv?` is lightly discouraged in favor of `equal?`.

Examples:

```
> (eqv? 'yes 'yes)
#t
> (eqv? 'yes 'no)
#f
> (eqv? (* 6 7) 42)
#t
> (eqv? (expt 2 100) (expt 2 100))
#t
> (eqv? 2 2.0)
#f
> (let ([v (mcons 1 2)]) (eqv? v v))
#t
> (eqv? (mcons 1 2) (mcons 1 2))
#f
> (eqv? (integer->char 955) (integer->char 955))
#t
> (eqv? (make-string 3 #\z) (make-string 3 #\z))
#f
> (eqv? #t #t)
#t
```

```
(eq? v1 v2) → boolean?
  v1 : any/c
  v2 : any/c
```

Return `#t` if *v1* and *v2* refer to the same object, `#f` otherwise. As a special case among numbers, two fixnums that are `=` are also the same according to `eq?`. See also §4.1.1 "Object Identity and Comparisons".

Examples:

```
> (eq? 'yes 'yes)
#t
> (eq? 'yes 'no)
#f
> (eq? (* 6 7) 42)
#t
> (eq? (expt 2 100) (expt 2 100))
#f
> (eq? 2 2.0)
#f
> (let ([v (mcons 1 2)]) (eq? v v))
#t
> (eq? (mcons 1 2) (mcons 1 2))
#f
> (eq? (integer->char 955) (integer->char 955))
#t
> (eq? (make-string 3 #\z) (make-string 3 #\z))
#f
> (eq? #t #t)
#t
```

```
(equal?/recur v1 v2 recur-proc) → boolean?
  v1 : any/c
  v2 : any/c
  recur-proc : (any/c any/c . -> . any/c)
```

Like `equal?`, but using *recur-proc* for recursive comparisons (which means that reference cycles are not handled automatically). Non-`#f` results from *recur-proc* are converted to `#t` before being returned by `equal?/recur`.

Examples:

```
> (equal?/recur 1 1 (lambda (a b) #f))
#t
> (equal?/recur '(1) '(1) (lambda (a b) #f))
#f
> (equal?/recur '#(1 1 1) '#(1 1.2 3/4)
                (lambda (a b) (<= (abs (- a b)) 0.25)))
#t
```

```
(equal-always?/recur v1 v2 recur-proc) → boolean?
  v1 : any/c
  v2 : any/c
  recur-proc : (any/c any/c . -> . any/c)
```

Like `equal-always?`, but using *`recur-proc`* for recursive comparisons (which means that reference cycles are not handled automatically). Non-`#f` results from *`recur-proc`* are converted to `#t` before being returned by `equal-always?/recur`.

Examples:

```
> (equal-always?/recur 1 1 (lambda (a b) #f))
#t
> (equal-always?/recur '(1) '(1) (lambda (a b) #f))
#f
> (equal-always?/recur (vector-immutable 1 1 1) (vector-
immutable 1 1.2 3/4)
                       (lambda (a b) (<= (abs (- a b)) 0.25)))
#t
```

4.1.1 Object Identity and Comparisons

The `eq?` operator compares two values, returning `#t` when the values refer to the same object. This form of equality is suitable for comparing objects that support imperative update (e.g., to determine that the effect of modifying an object through one reference is visible through another reference). Also, an `eq?` test evaluates quickly, and `eq?`-based hashing is more lightweight than `equal?`-based hashing in hash tables.

In some cases, however, `eq?` is unsuitable as a comparison operator, because the generation of objects is not clearly defined. In particular, two applications of `+` to the same two exact integers may or may not produce results that are `eq?`, although the results are always `equal?`. Similarly, evaluation of a `lambda` form typically generates a new procedure object, but it may re-use a procedure object previously generated by the same source `lambda` form.

The behavior of a datatype with respect to `eq?` is generally specified with the datatype and its associated procedures.

4.1.2 Equality and Hashing

All comparable values have at least one *hash code* — an arbitrary integer (more specifically a fixnum) computed by applying a hash function to the value. The defining property of these hash codes is that **equal values have equal hash codes**. Note that the reverse is not true: two unequal values can still have equal hash codes. Hash codes are useful for various indexing and comparison operations, especially in the implementation of hash tables. See §4.15 "Hash Tables" for more information.

```
(equal-hash-code v) → fixnum?
  v : any/c
```

Returns a hash code consistent with `equal?`. For any two calls with `equal?` values, the returned number is the same. A hash code is computed even when *v* contains a cycle through pairs, vectors, boxes, and/or inspectable structure fields. Additionally, user-defined data types can customize how this hash code is computed by implementing `gen:equal+hash` or `gen:equal-mode+hash`.

For any *v* that could be produced by `read`, if `v2` is produced by `read` for the same input characters, the `(equal-hash-code v)` is the same as `(equal-hash-code v2)` — even if *v* and `v2` do not exist at the same time (and therefore could not be compared by calling `equal?`).

Changed in version 6.4.0.12 of package `base`: Strengthened guarantee for `read`able values.

```
(equal-hash-code/recur v recur-proc) → fixnum?
  v : any/c
  recur-proc : (-> any/c exact-integer?)
```

Like `equal-hash-code`, but using *recur-proc* for recursive hashing within *v*.

Examples:

```
> (define (rational-hash x)
    (cond
      [(rational? x) (equal-hash-code (inexact->exact x))]
      [else (equal-hash-code/recur x rational-hash)]))
> (= (rational-hash 0.0) (rational-hash -0.0))
#t
> (= (rational-hash 1.0) (rational-hash -1.0))
#f
> (= (rational-hash (list (list (list 4.0 0.0) 9.0) 6.0))
     (rational-hash (list (list (list 4 0) 9) 6)))
#t
```

Added in version 8.8.0.9 of package `base`.

```
(equal-secondary-hash-code v) → fixnum?
  v : any/c
```

Like `equal-hash-code`, but computes a secondary hash code suitable for use in double hashing.

```
(equal-always-hash-code v) → fixnum?
  v : any/c
```

Returns a hash code consistent with `equal-always?`. For any two calls with `equal-always?` values, the returned number is the same.

As `equal-always-hash-code` traverses *v*, immutable values within *v* are hashed with `equal-hash-code`, while mutable values within *v* are hashed with `eq-hash-code`.

```
(equal-always-hash-code/recur v recur-proc) → fixnum?
  v : any/c
  recur-proc : (-> any/c exact-integer?)
```

Like `equal-always-hash-code`, but using *recur-proc* for recursive hashing within *v*.

Added in version 8.8.0.9 of package `base`.

```
(equal-always-secondary-hash-code v) → fixnum?
  v : any/c
```

Like `equal-always-hash-code`, but computes a secondary hash code suitable for use in double hashing.

```
(eq-hash-code v) → fixnum?
  v : any/c
```

Returns a hash code consistent with `eq?`. For any two calls with `eq?` values, the returned number is the same.

Equal fixnums are always `eq?`.

```
(eqv-hash-code v) → fixnum?
  v : any/c
```

Returns a hash code consistent with `eqv?`. For any two calls with `eqv?` values, the returned number is the same.

4.1.3 Implementing Equality for Custom Types

```
gen:equal+hash : any/c
```

A generic interface (see §5.4 "Generic Interfaces") for types that can be compared for equality using `equal?`. The following methods must be implemented:

- `equal-proc : (-> any/c any/c (-> any/c any/c boolean?) any/c)` — tests whether the first two arguments are equal, where both values are instances of the structure type to which the generic interface is associated (or a subtype of the structure type).

  The third argument is an `equal?` predicate to use for recursive equality checks; use the given predicate instead of `equal?` to ensure that data cycles are handled properly and to work with `equal?/recur` (but beware that an arbitrary function can be provided to `equal?/recur` for recursive checks, which means that arguments provided to the predicate might be exposed to arbitrary code).

  The `equal-proc` is called for a pair of structures only when they are not `eq?`, and only when they both have a `gen:equal+hash` value inherited from the same structure type. With this strategy, the order in which `equal?` receives two structures does not matter. It also means that, by default, a structure sub-type inherits the equality predicate of its parent, if any.

- `hash-proc : (-> any/c (-> any/c exact-integer?) exact-integer?)` — computes a hash code for the given structure, like `equal-hash-code`. The first argument is an instance of the structure type (or one of its subtypes) to which the generic interface is associated.

  The second argument is an `equal-hash-code`-like procedure to use for recursive hash-code computation; use the given procedure instead of `equal-hash-code` to ensure that data cycles are handled properly.

  Although the result of `hash-proc` can be any exact integer, it will be truncated for most purposes to a fixnum (e.g., for the result of `equal-hash-code`). Roughly, truncation uses `bitwise-and` to take the lower bits of the number. Thus, variation in the hash-code computation should be reflected in the fixnum-compatible bits of `hash-proc`'s result. Consumers of a hash code are expected to use variation within the fixnum range appropriately, and producers are *not* responsible to reflect variation in hash codes across the full range of bits that fit within a fixnum.

- `hash2-proc : (-> any/c (-> any/c exact-integer?) exact-integer?)` — computes a secondary hash code for the given structure. This procedure is like `hash-proc`, but analogous to `equal-secondary-hash-code`.

Take care to ensure that `hash-proc` and `hash2-proc` are consistent with `equal-proc`. Specifically, `hash-proc` and `hash2-proc` should produce the same value for any two structures for which `equal-proc` produces a true value.

The `equal-proc` is not only used for `equal?`, it is also used for `equal?/recur`, and `impersonator-of?`. Furthermore, if the structure type has no mutable fields, `equal-proc` is used for `equal-always?`, and `chaperone-of?`. Likewise `hash-proc` and `hash2-proc` are used for `equal-always-hash-code` and `equal-always-secondary-hash-code`, respectively, when the structure type has no mutable fields. Instances of these methods should follow the guidelines in §4.1.4 "Honest Custom Equality" to implement all of these operations reasonably. In particular, these methods should not access mutable data unless the struct is declared mutable.

When a structure type has no `gen:equal+hash` or `gen:equal-mode+hash` implementation, then transparent structures (i.e., structures with an inspector that is controlled by the current inspector) are `equal?` when they are instances of the same structure type (not counting sub-types), and when they have `equal?` field values. For transparent structures, `equal-hash-code` and `equal-secondary-hash-code` (in the case of no mutable fields) derive hash code using the field values. For a transparent structure type with at least one mutable field, `equal-always?` is the same as `eq?`, and an `equal-secondary-hash-code` result is based only on `eq-hash-code`. For opaque structure types, `equal?` is the same as `eq?`, and `equal-hash-code` and `equal-secondary-hash-code` results are based only on `eq-hash-code`. If a structure has a `prop:impersonator-of` property, then the `prop:impersonator-of` property takes precedence over `gen:equal+hash` if the property value's procedure returns a non-`#f` value when applied to the structure.

Examples:

```
(define (farm=? farm1 farm2 recursive-equal?)
  (and (= (farm-apples farm1)
          (farm-apples farm2))
       (= (farm-oranges farm1)
          (farm-oranges farm2))
       (= (farm-sheep farm1)
          (farm-sheep farm2))))

(define (farm-hash-code farm recursive-equal-hash)
  (+ (* 10000 (farm-apples farm))
     (* 100 (farm-oranges farm))
     (* 1 (farm-sheep farm))))

(define (farm-secondary-hash-code farm recursive-equal-hash)
  (+ (* 10000 (farm-sheep farm))
     (* 100 (farm-apples farm))
     (* 1 (farm-oranges farm))))

(struct farm (apples oranges sheep)
  #:methods gen:equal+hash
  [(define equal-proc farm=?)
   (define hash-proc  farm-hash-code)
   (define hash2-proc farm-secondary-hash-code)])

(define eastern-farm (farm 5 2 20))
(define western-farm (farm 18 6 14))
(define northern-farm (farm 5 20 20))
(define southern-farm (farm 18 6 14))

> (equal? eastern-farm western-farm)
#f
```

```
> (equal? eastern-farm northern-farm)
#f
> (equal? western-farm southern-farm)
#t
```

Changed in version 8.7.0.5 of package `base`: Added a check so that omitting any of *equal-proc*, *hash-proc*, and *hash2-proc* is now a syntax error.

```
gen:equal-mode+hash : any/c
```

A generic interface (see §5.4 "Generic Interfaces") for types that may specify differences between `equal?` and `equal-always?`. The following methods must be implemented:

- `equal-mode-proc : (-> any/c any/c (-> any/c any/c boolean?) boolean? any/c)` — the first two arguments are the values to compare, the third argument is an equality function to use for recursive comparisons, and the last argument is the mode: `#t` for an `equal?` or `impersonator-of?` comparison or `#f` for an `equal-always?` or `chaperone-of?` comparison.
- `hash-mode-proc : (-> any/c (-> any/c exact-integer?) boolean? exact-integer?)` — the first argument is the value to compute a hash code for, the second argument is a hashing function to use for recursive hashing, and the last argument is the mode: `#t` for `equal?` hashing or `#f` for `equal-always?` hashing.

The *hash-mode-proc* implementation is used both for a primary hash code and secondary hash code.

When implementing these methods, follow the guidelines in §4.1.4 "Honest Custom Equality". In particular, these methods should only access mutable data if the "mode" argument is true to indicate `equal?` or `impersonator-of?`.

Implementing `gen:equal-mode+hash` is most useful for types that specify differences between `equal?` and `equal-always?`, such as a structure type that wraps mutable data with getter and setter procedures:

Examples:

```
> (define (get gs) ((getset-getter gs)))
> (define (set gs new) ((getset-setter gs) new))
> (struct getset (getter setter)
    #:methods gen:equal-mode+hash
    [(define (equal-mode-proc self other rec mode)
       (and mode (rec (get self) (get other))))
     (define (hash-mode-proc self rec mode)
       (if mode (rec (get self)) (eq-hash-code self)))])
```

```
> (define x 1)
> (define y 2)
> (define gsx (getset (lambda () x) (lambda (new) (set! x new))))
> (define gsy (getset (lambda () y) (lambda (new) (set! y new))))
> (equal? gsx gsy)
#f
> (equal-always? gsx gsy)
#f
> (set gsx 3)
> (set gsy 3)
> (equal? gsx gsy)
#t
> (equal-always? gsx gsy)
#f
> (equal-always? gsx gsx)
#t
```

Added in version 8.5.0.3 of package `base`.
Changed in version 8.7.0.5: Added a check so that omitting either *`equal-mode-proc`* or *`hash-mode-proc`* is now a syntax error.

`prop:equal+hash : struct-type-property?`

A structure type property (see §5.3 "Structure Type Properties") that supplies an equality predicate and hashing functions for a structure type. Using the `prop:equal+hash` property is an alternative to using the `gen:equal+hash` or `gen:equal-mode+hash` generic interface.

A `prop:equal+hash` property value is a list of either three procedures `(list equal-proc hash-proc hash2-proc)` or two procedures `(list equal-mode-proc hash-mode-proc)`:

- The three-procedure case corresponds to the procedures of `gen:equal-hash`:
  - `equal-proc : (-> any/c any/c (-> any/c any/c boolean?) any/c)`
  - `hash-proc : (-> any/c (-> any/c exact-integer?) exact-integer?)`
  - `hash2-proc : (-> any/c (-> any/c exact-integer?) exact-integer?)`
- The two-procedure case corresponds to the procedures of `gen:equal-mode-hash`:
  - `equal-mode-proc : (-> any/c any/c (-> any/c any/c boolean?) boolean? any/c)`

– *hash-mode-proc* : (-> any/c (-> any/c exact-integer?) boolean? exact-integer?)

When implementing these methods, follow the guidelines in §4.1.4 "Honest Custom Equality". In particular, these methods should only access mutable data if the struct is declared mutable or the mode is true.

Changed in version 8.5.0.3 of package `base`: Added support for two-procedure values to customize `equal-always?`.

4.1.4 Honest Custom Equality

Since the *equal-proc* or *equal-mode-proc* is used for more than just `equal?`, instances of them should follow certain guidelines to make sure that they work correctly for `equal-always?`, `chaperone-of?`, and `impersonator-of?`.

Due to the differences between these operations, avoid calling `equal?` within them. Instead, use the third argument to "recur" on the pieces, which allows `equal?/recur` to work properly, lets the other operations behave in their own distinct ways on the pieces, and enables some cycle detection.

good

```
(define (equal-proc self other rec)
  (rec (fish-size self) (fish-size other)))
```

bad

```
(define (equal-proc self other rec)
  (equal? (fish-size self) (fish-size other)))
```

Don't use the third argument to "recur" on counts of elements. When a data structure cares about discrete numbers, it can use `=` on those, not `equal?` or "recur". Using "recur" on counts is bad when a "recur" argument from `equal?/recur` is too tolerant on numbers within some range of each other.

good

```
(define (equal-proc self other rec)
  (and (= (tuple-length self) (tuple-length other))
       (for/and ([i (in-range (tuple-length self))])
         (rec ((tuple-getter self) i)
              ((tuple-getter other) i)))))
```

bad

```
(define (equal-proc self other rec)
  (and (rec (tuple-length self) (tuple-length other))
       (for/and ([i (in-range (tuple-length self))])
         (rec ((tuple-getter self) i)
              ((tuple-getter other) i)))))
```

The operations `equal?` and `equal-always?` should be symmetric, so *equal-proc* instances should not change their answer when the arguments swap:

good

```
(define (equal-proc self other rec)
  (rec (fish-size self) (fish-size other)))
```

bad

```
(define (equal-proc self other rec)
  (<= (fish-size self) (fish-size other)))
```

However, the operations chaperone-of? and impersonator-of? are *not* symmetric, so when calling the third argument to "recur" on pieces, pass the pieces in the same order they came in:

good

```
(define (equal-proc self other rec)
  (rec (fish-size self) (fish-size other)))
```

bad

```
(define (equal-proc self other rec)
  (rec (fish-size other) (fish-size self)))
```

The operations equal-always? and chaperone-of? shouldn't change on mutation, so *equal-proc* instances should not access potentially-mutable data. This includes avoiding string=?, since strings can be mutable. Type-specific equality functions for immutable types, such as symbol=?, are fine.

fine

```
(define (equal-proc self other rec)
  ; symbols are immutable: no problem
  (symbol=? (thing-name self) (thing-name other)))
```

bad

```
(define (equal-proc self other rec)
  ; strings can be mutable: accesses mutable data
  (string=? (thing-name self) (thing-name other)))
```

Declaring a struct as mutable makes equal-always? and chaperone-of? avoid using *equal-proc*, so *equal-proc* instances are free to access mutable data if the struct is declared mutable:

good

```
(struct mcell (value) #:mutable
  #:methods gen:equal+hash
  [(define (equal-proc self other rec)
     (rec (mcell-value self)
          (mcell-value other)))
   (define (hash-proc self rec)
     (+ (eq-hash-code struct:mcell)
        (rec (mcell-value self))))
   (define (hash2-proc self rec)
     (+ (eq-hash-code struct:mcell)
        (rec (mcell-value self))))])
```

bad

```
(struct mcell (box)
  ; not declared mutable,
  ; but represents mutable data anyway
  #:methods gen:equal+hash
  [(define (equal-proc self other rec)
     (rec (unbox (mcell-box self))
          (unbox (mcell-box other))))
   (define (hash-proc self rec)
     (+ (eq-hash-code struct:mcell)
        (rec (unbox (mcell-value self)))))
   (define (hash2-proc self rec)
     (+ (eq-hash-code struct:mcell)
        (rec (unbox (mcell-value self)))))])
```

Another way for a struct to control access to mutable data is by implementing gen:equal-mode+hash instead of gen:equal+hash. When the mode is true, *equal-mode-proc* instances are free to access mutable data, and when the mode is false, they shouldn't:

also good

```
(struct mcell (value) #:mutable
  ; only accesses mutable data when mode is true
  #:methods gen:equal-mode+hash
  [(define (equal-mode-proc self other rec mode)
     (and mode
          (rec (mcell-value self)
               (mcell-value other))))
   (define (hash-mode-proc self rec mode)
     (if mode
         (+ (eq-hash-code struct:mcell)
            (rec (mcell-value self)))
         (eq-hash-code self)))])
```

still bad

```
(struct mcell (value) #:mutable
  ; accesses mutable data ignoring mode
  #:methods gen:equal-mode+hash
  [(define (equal-mode-proc self other rec mode)
     (rec (mcell-value self)
          (mcell-value other)))
   (define (hash-mode-proc self rec mode)
     (+ (eq-hash-code struct:mcell)
        (rec (mcell-value self))))])
```

4.1.5 Combining Hash Codes

```
(require racket/hash-code)
```
package: base

The bindings documented in this section are provided by the `racket/hash-code` library, not `racket/base` or `racket`.

Added in version 8.8.0.5 of package base.

```
(hash-code-combine hc ...) → fixnum?
  hc : exact-integer?
```

Combines the *hc*s into a hash code that depends on the order of the inputs. Useful for combining the hash codes of different fields in a structure.

Examples:

```
> (require racket/hash-code)
> (struct ordered-triple (fst snd thd)
    #:methods gen:equal+hash
    [(define (equal-proc self other rec)
       (and (rec (ordered-triple-fst self) (ordered-triple-
fst other))
            (rec (ordered-triple-snd self) (ordered-triple-
snd other))
            (rec (ordered-triple-thd self) (ordered-triple-
thd other))))
     (define (hash-proc self rec)
       (hash-code-combine (eq-hash-code struct:ordered-triple)
                          (rec (ordered-triple-fst self))
                          (rec (ordered-triple-snd self))
```

```
                           (rec (ordered-triple-thd self))))
     (define (hash2-proc self rec)
       (hash-code-combine (eq-hash-code struct:ordered-triple)
                          (rec (ordered-triple-fst self))
                          (rec (ordered-triple-snd self))
                          (rec (ordered-triple-thd self))))])
> (equal? (ordered-triple 'A 'B 'C) (ordered-triple 'A 'B 'C))
#t
> (= (equal-hash-code (ordered-triple 'A 'B 'C))
     (equal-hash-code (ordered-triple 'A 'B 'C)))
#t
> (equal? (ordered-triple 'A 'B 'C) (ordered-triple 'C 'B 'A))
#f
> (= (equal-hash-code (ordered-triple 'A 'B 'C))
     (equal-hash-code (ordered-triple 'C 'B 'A)))
#f
> (equal? (ordered-triple 'A 'B 'C) (ordered-triple 'C 'A 'B))
#f
> (= (equal-hash-code (ordered-triple 'A 'B 'C))
     (equal-hash-code (ordered-triple 'C 'A 'B)))
#f
```

With one argument, `(hash-code-combine hc)` mixes the hash code so that it isn't just *hc*.

Examples:

```
> (require racket/hash-code)
> (struct wrap (value)
    #:methods gen:equal+hash
    [(define (equal-proc self other rec)
       (rec (wrap-value self) (wrap-value other)))
     (define (hash-proc self rec)
       ; demonstrates `hash-code-combine` with only one argument
       ; but it's good to combine `(eq-hash-code struct:wrap)` too
       (hash-code-combine (rec (wrap-value self))))
     (define (hash2-proc self rec)
       (hash-code-combine (rec (wrap-value self))))])
> (equal? (wrap 'A) (wrap 'A))
#t
> (= (equal-hash-code (wrap 'A))
     (equal-hash-code (wrap 'A)))
#t
> (equal? (wrap 'A) 'A)
#f
> (= (equal-hash-code (wrap 'A))
```

```
      (equal-hash-code 'A))
#f
```

```
(hash-code-combine-unordered hc ...) → fixnum?
  hc : exact-integer?
```

Combines the *hc*s into a hash code that *does not* depend on the order of the inputs. Useful for combining the hash codes of elements of an unordered set.

Examples:

```
> (require racket/hash-code)
> (struct flip-triple (left mid right)
    #:methods gen:equal+hash
    [(define (equal-proc self other rec)
       (and (rec (flip-triple-mid self) (flip-triple-mid other))
            (or
             (and (rec (flip-triple-left self) (flip-triple-
left other))
                  (rec (flip-triple-right self) (flip-triple-
right other)))
             (and (rec (flip-triple-left self) (flip-triple-
right other))
                  (rec (flip-triple-right self) (flip-triple-
left other))))))
     (define (hash-proc self rec)
       (hash-code-combine (eq-hash-code struct:flip-triple)
                          (rec (flip-triple-mid self))
                          (hash-code-combine-unordered
                           (rec (flip-triple-left self))
                           (rec (flip-triple-right self)))))
     (define (hash2-proc self rec)
       (hash-code-combine (eq-hash-code struct:flip-triple)
                          (rec (flip-triple-mid self))
                          (hash-code-combine-unordered
                           (rec (flip-triple-left self))
                           (rec (flip-triple-right self)))))])
> (equal? (flip-triple 'A 'B 'C) (flip-triple 'A 'B 'C))
#t
> (= (equal-hash-code (flip-triple 'A 'B 'C))
     (equal-hash-code (flip-triple 'A 'B 'C)))
#t
> (equal? (flip-triple 'A 'B 'C) (flip-triple 'C 'B 'A))
#t
> (= (equal-hash-code (flip-triple 'A 'B 'C))
     (equal-hash-code (flip-triple 'C 'B 'A)))
```

```
#t
> (equal? (flip-triple 'A 'B 'C) (flip-triple 'C 'A 'B))
#f
> (= (equal-hash-code (flip-triple 'A 'B 'C))
     (equal-hash-code (flip-triple 'C 'A 'B)))
#f
> (struct rotate-triple (rock paper scissors)
    #:methods gen:equal+hash
    [(define (equal-proc self other rec)
       (or
        (and (rec (rotate-triple-rock self) (rotate-triple-
rock other))
             (rec (rotate-triple-paper self) (rotate-triple-
paper other))
             (rec (rotate-triple-scissors self) (rotate-triple-
scissors other)))
        (and (rec (rotate-triple-rock self) (rotate-triple-
paper other))
             (rec (rotate-triple-paper self) (rotate-triple-
scissors other))
             (rec (rotate-triple-scissors self) (rotate-triple-
rock other)))
        (and (rec (rotate-triple-rock self) (rotate-triple-
scissors other))
             (rec (rotate-triple-paper self) (rotate-triple-
rock other))
             (rec (rotate-triple-scissors self) (rotate-triple-
paper other)))))
     (define (hash-proc self rec)
       (define r (rec (rotate-triple-rock self)))
       (define p (rec (rotate-triple-paper self)))
       (define s (rec (rotate-triple-scissors self)))
       (hash-code-combine
        (eq-hash-code struct:rotate-triple)
        (hash-code-combine-unordered
         (hash-code-combine r p)
         (hash-code-combine p s)
         (hash-code-combine s r))))
     (define (hash2-proc self rec)
       (define r (rec (rotate-triple-rock self)))
       (define p (rec (rotate-triple-paper self)))
       (define s (rec (rotate-triple-scissors self)))
       (hash-code-combine
        (eq-hash-code struct:rotate-triple)
        (hash-code-combine-unordered
         (hash-code-combine r p)
```

```
          (hash-code-combine p s)
          (hash-code-combine s r))))])
> (equal? (rotate-triple 'A 'B 'C) (rotate-triple 'A 'B 'C))
#t
> (= (equal-hash-code (rotate-triple 'A 'B 'C))
     (equal-hash-code (rotate-triple 'A 'B 'C)))
#t
> (equal? (rotate-triple 'A 'B 'C) (rotate-triple 'C 'B 'A))
#f
> (= (equal-hash-code (rotate-triple 'A 'B 'C))
     (equal-hash-code (rotate-triple 'C 'B 'A)))
#f
> (equal? (rotate-triple 'A 'B 'C) (rotate-triple 'C 'A 'B))
#t
> (= (equal-hash-code (rotate-triple 'A 'B 'C))
     (equal-hash-code (rotate-triple 'C 'A 'B)))
#t
```

```
(hash-code-combine* hc ... hcs) → fixnum?
  hc : exact-integer?
  hcs : (listof exact-integer?)
```

Like `hash-code-combine`, but the last argument is used as a list of arguments for `hash-code-combine`, so `(hash-code-combine* hc ... hcs)` is the same as `(apply hash-code-combine hc ... hcs)`. In other words, the relationship between `hash-code-combine` and `hash-code-combine*` is similar to the one between `list` and `list*`.

```
(hash-code-combine-unordered* hc ... hcs) → fixnum?
  hc : exact-integer?
  hcs : (listof exact-integer?)
```

Like `hash-code-combine-unordered`, but the last argument is used as a list of arguments for `hash-code-combine-unordered`, so `(hash-code-combine-unordered* hc ... hcs)` is the same as `(apply hash-code-combine-unordered hc ... hcs)`. In other words, the relationship between `hash-code-combine-unordered` and `hash-code-combine-unordered*` is similar to the one between `list` and `list*`.

4.2 Booleans

True and false *booleans* are represented by the values `#t` and `#f`, respectively, though operations that depend on a boolean value typically treat anything other than `#f` as true. The `#t` value is always `eq?` to itself, and `#f` is always `eq?` to itself.

See §1.3.5 “Reading Booleans” for information on `read`ing booleans and §1.4.4 “Printing Booleans” for information on `print`ing booleans.

See also `and`, `or`, `andmap`, and `ormap`.

```
(boolean? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is `#t` or `#f`, `#f` otherwise.

Examples:

```
> (boolean? #f)
#t
> (boolean? #t)
#t
> (boolean? 'true)
#f
```

```
(not v) → boolean?
  v : any/c
```

Returns `#t` if *v* is `#f`, `#f` otherwise.

Examples:

```
> (not #f)
#t
> (not #t)
#f
> (not 'we-have-no-bananas)
#f
```

```
(immutable? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is an immutable string, byte string, vector, hash table, or box, `#f` otherwise.

Note that `immutable?` is not a general predicate for immutability (despite its name). It works only for a handful of datatypes for which a single predicate—`string?`, `vector?`, etc.—recognizes both mutable and immutable variants of the datatype. In particular, `immutable?` produces `#f` for a pair, even though pairs are immutable, since `pair?` implies immutability.

See also `immutable-string?`, `mutable-string?`, etc.

Examples:

```
> (immutable? 'hello)
#f
> (immutable? "a string")
#t
> (immutable? (box 5))
#f
> (immutable? #(0 1 2 3))
#t
> (immutable? (make-hash))
#f
> (immutable? (make-immutable-hash '([a b])))
#t
> (immutable? #t)
#f
```

4.2.1 Boolean Aliases

```
(require racket/bool)        package: base
```

The bindings documented in this section are provided by the `racket/bool` and `racket` libraries, but not `racket/base`.

```
true : boolean?
```

An alias for `#t`.

```
false : boolean?
```

An alias for `#f`.

```
(symbol=? a b) → boolean?
  a : symbol?
  b : symbol?
```

Returns `(equal? a b)` (if `a` and `b` are symbols).

```
(boolean=? a b) → boolean?
  a : boolean?
  b : boolean?
```

Returns `(equal? a b)` (if `a` and `b` are booleans).

```
(false? v) → boolean?
  v : any/c
```

Returns `(not v)`.

```
(nand expr ...)
```

Same as `(not (and expr ...))`.

Examples:

```
> (nand #f #t)
#t
> (nand #f (error 'ack "we don't get here"))
#t
```

```
(nor expr ...)
```

Same as `(not (or expr ...))`.

In the two argument case, returns `#t` if neither of the arguments is a true value.

Examples:

```
> (nor #f #t)
#f
> (nor #t (error 'ack "we don't get here"))
#f
```

```
(implies expr1 expr2)
```

Checks to be sure that the first expression implies the second.

Same as `(if expr1 expr2 #t)`.

Examples:

```
> (implies #f #t)
#t
> (implies #f #f)
#t
> (implies #t #f)
#f
> (implies #f (error 'ack "we don't get here"))
#t
```

```
(xor b1 b2) → any
  b1 : any/c
  b2 : any/c
```

Returns the exclusive or of *b1* and *b2*.

If exactly one of *b1* and *b2* is not `#f`, then return it. Otherwise, returns `#f`.

Examples:

```
> (xor 11 #f)
11
> (xor #f 22)
22
> (xor 11 22)
#f
> (xor #f #f)
#f
```

4.2.2 Mutability Predicates

```
(require racket/mutability)
```
package: `base`

The bindings documented in this section are provided by the `racket/mutability` library, not `racket/base` or `racket`.

Added in version 8.9.0.3 of package `base`.

```
(mutable-string? v) → boolean?
  v : any/c
(immutable-string? v) → boolean?
  v : any/c
(mutable-bytes? v) → boolean?
  v : any/c
(immutable-bytes? v) → boolean?
  v : any/c
(mutable-vector? v) → boolean?
  v : any/c
(immutable-vector? v) → boolean?
  v : any/c
(mutable-box? v) → boolean?
  v : any/c
(immutable-box? v) → boolean?
  v : any/c
(mutable-hash? v) → boolean?
  v : any/c
(immutable-hash? v) → boolean?
  v : any/c
```

Predicates that combine `string?`, `bytes?`, `vector?`, `box?`, and `hash?` with `immutable?`

or its inverse. The predicates are potentially faster than using `immutable?` and other predicates separately.

4.3 Numbers

§3.2 "Numbers" in *The Racket Guide* introduces numbers.

All *numbers* are *complex numbers*. Some of them are *real numbers*, and all of the real numbers that can be represented are also *rational numbers*, except for `+inf.0` (positive infinity), `+inf.f` (single-precision variant, when enabled via `read-single-flonum`), `-inf.0` (negative infinity), `-inf.f` (single-precision variant, when enabled), `+nan.0` (not-a-number), and `+nan.f` (single-precision variant, when enabled). Among the rational numbers, some are *integers*, because `round` applied to the number produces the same number.

See §1.3.3 "Reading Numbers" for information on the syntax of number literals.

Orthogonal to those categories, each number is also either an *exact number* or an *inexact number*. Unless otherwise specified, computations that involve an inexact number produce inexact results. Certain operations on inexact numbers, however, produce an exact number, such as multiplying an inexact number with an exact `0`. Operations that mathematically produce irrational numbers for some rational arguments (e.g., `sqrt`) may produce inexact results even for exact arguments.

In the case of complex numbers, either the real and imaginary parts are both exact or inexact with the same precision, or the number has an exact zero real part and an inexact imaginary part; a complex number with an exact zero imaginary part is a real number.

Inexact real numbers are implemented as double-precision IEEE floating-point numbers, also known as *flonums*, or as single-precision IEEE floating-point numbers, also known as *single-flonums*. Single-flonums are supported only when `(single-flonum-available?)` reports `#t`. Although we write `+inf.f`, `-inf.f`, and `+nan.f` to mean single-flonums, those forms read as double-precision flonums by default, since `read-single-flonum` is `#f` by default. When single-flonums are supported, inexact numbers are still represented as flonums by default, and single precision is used only when a computation starts with single-flonums.

Inexact numbers can be coerced to exact form, except for the inexact numbers `+inf.0`, `+inf.f`, `-inf.0`, `-inf.f`, `+nan.0`, and `+nan.f`, which have no exact form. Dividing a number by exact zero raises an exception; dividing a non-zero number other than `+nan.0` or `+nan.f` by an inexact zero returns `+inf.0`, `+inf.f`, `-inf.0` or `-inf.f`, depending on the sign and precision of the dividend. The `+nan.0` value is not `=` to itself, but `+nan.0` is `eqv?` to itself, and `+nan.f` is similarly `eqv?` but not `=` to itself. Conversely, `(= 0.0 -0.0)` is `#t`, but `(eqv? 0.0 -0.0)` is `#f`, and the same for `0.0f0` and `-0.0f0` (which are single-precision variants). The datum `-nan.0` refers to the same constant as `+nan.0`, and `-nan.f` is the same as `+nan.f`.

Calculations with infinities produce results consistent with IEEE double- or single-precision floating point where IEEE specifies the result; in cases where IEEE provides no specification, the result corresponds to the limit approaching infinity, or `+nan.0` or `+nan.f` if no such limit exists.

The precision and size of exact numbers is limited only by available memory (and the precision of operations that can produce irrational numbers). In particular, adding, multiplying, subtracting, and dividing exact numbers always produces an exact result.

A *fixnum* is an exact integer whose two's complement representation fits into 30 or 31 bits (depending on the Racket variant) on a 32-bit platform or 61 or 63 bits (depending on the Racket variant) on a 64-bit platform. No allocation is required when computing with fixnums. See also the `racket/fixnum` module, below.

Two fixnums that are `=` are also the same according to `eq?`. Otherwise, the result of `eq?` applied to two numbers is undefined, except that numbers produced by the default reader in `read-syntax` mode are interned and therefore `eq?` when they are `eqv?`.

Two real numbers are `eqv?` when they are both inexact with the same precision or both exact, and when they are `=` (except for `+nan.0`, `+nan.f`, `0.0`, `+0.0f0`, `-0.0`, and `-0.0f0`, as noted above). Two complex numbers are `eqv?` when their real and imaginary parts are `eqv?`. Two numbers are `equal?` when they are `eqv?`.

See §1.3.3 "Reading Numbers" for information on `read`ing numbers and §1.4.2 "Printing Numbers" for information on `print`ing numbers.

4.3.1 Number Types

```
(number? v) → boolean?
  v : any/c
```

Returns `#t` if `v` is a number, `#f` otherwise.

Examples:

```
> (number? 1)
#t
> (number? 2+3i)
#t
> (number? "hello")
#f
> (number? +nan.0)
#t
```

```
(complex? v) → boolean?
  v : any/c
```

Returns `(number? v)`, because all numbers are complex numbers.

```
(real? v) → boolean?
  v : any/c
```

Returns #t if *v* is a real number, #f otherwise.

Examples:

```
> (real? 1)
#t
> (real? +inf.0)
#t
> (real? 2+3i)
#f
> (real? 2.0+0.0i)
#f
> (real? "hello")
#f
```

```
(rational? v) → boolean?
  v : any/c
```

Returns #t if *v* is a rational number, #f otherwise.

Examples:

```
> (rational? 1)
#t
> (rational? +inf.0)
#f
> (rational? "hello")
#f
```

```
(integer? v) → boolean?
  v : any/c
```

Returns #t if *v* is a number that is an integer, #f otherwise.

Examples:

```
> (integer? 1)
#t
> (integer? 2.3)
#f
> (integer? 4.0)
#t
> (integer? +inf.0)
#f
> (integer? 2+3i)
```

```
#f
> (integer? "hello")
#f
```

```
(exact-integer? v) → boolean?
  v : any/c
```

Returns `(and (integer? v) (exact? v))`.

Examples:

```
> (exact-integer? 1)
#t
> (exact-integer? 4.0)
#f
```

```
(exact-nonnegative-integer? v) → boolean?
  v : any/c
```

Returns `(and (exact-integer? v) (not (negative? v)))`.

Examples:

```
> (exact-nonnegative-integer? 0)
#t
> (exact-nonnegative-integer? -1)
#f
```

```
(exact-positive-integer? v) → boolean?
  v : any/c
```

Returns `(and (exact-integer? v) (positive? v))`.

Examples:

```
> (exact-positive-integer? 1)
#t
> (exact-positive-integer? 0)
#f
```

```
(inexact-real? v) → boolean?
  v : any/c
```

Returns `(and (real? v) (inexact? v))`.

```
(fixnum? v) → boolean?
  v : any/c
```

Return `#t` if *v* is a fixnum, `#f` otherwise.

Note: the result of this function is platform-dependent, so using it in syntax transformers can lead to platform-dependent bytecode files. See also `fixnum-for-every-system?`.

```
(flonum? v) → boolean?
  v : any/c
```

Return `#t` if *v* is a flonum, `#f` otherwise.

```
(double-flonum? v) → boolean?
  v : any/c
```

Identical to `flonum?`.

```
(single-flonum? v) → boolean?
  v : any/c
```

Return `#t` if *v* is a single-flonum (i.e., a single-precision floating-point number), `#f` otherwise.

```
(single-flonum-available?) → boolean?
```

Returns `#t` if single-flonums are supported on the current platform, `#f` otherwise.

Currently, `single-flonum-available?` produces `#t` when `(system-type 'vm)` produces `'racket`, and `single-flonum-available?` produces `#f` otherwise.

If the result is `#f`, then `single-flonum?` also produces `#f` for all arguments.

Added in version 7.3.0.5 of package `base`.

```
(zero? z) → boolean?
  z : number?
```

Returns `(= 0 z)`.

Examples:

```
> (zero? 0)
#t
> (zero? -0.0)
#t
```

```
(positive? x) → boolean?
  x : real?
```

Returns `(> x 0)`.

Examples:

```
> (positive? 10)
#t
> (positive? -10)
#f
> (positive? 0.0)
#f
```

```
(negative? x) → boolean?
  x : real?
```

Returns `(< x 0)`.

Examples:

```
> (negative? 10)
#f
> (negative? -10)
#t
> (negative? -0.0)
#f
```

```
(even? n) → boolean?
  n : integer?
```

Returns `(zero? (modulo n 2))`.

Examples:

```
> (even? 10.0)
#t
> (even? 11)
#f
> (even? +inf.0)
even?: contract violation
  expected: integer?
  given: +inf.0
```

```
(odd? n) → boolean?
  n : integer?
```

Returns `(not (even? n))`.

Examples:

```
> (odd? 10.0)
#f
> (odd? 11)
#t
> (odd? +inf.0)
odd?: contract violation
  expected: integer?
  given: +inf.0
```

```
(exact? z) → boolean?
  z : number?
```

Returns `#t` if *z* is an exact number, `#f` otherwise.

Examples:

```
> (exact? 1)
#t
> (exact? 1.0)
#f
```

```
(inexact? z) → boolean?
  z : number?
```

Returns `#t` if *z* is an inexact number, `#f` otherwise.

Examples:

```
> (inexact? 1)
#f
> (inexact? 1.0)
#t
```

```
(inexact->exact z) → exact?
  z : number?
```

Coerces `z` to an exact number. If `z` is already exact, it is returned. If `z` is `+inf.0`, `-inf.0`, `+nan.0`, `+inf.f`, `-inf.f`, or `+nan.f`, then the `exn:fail:contract` exception is raised.

Examples:

```
> (inexact->exact 1)
1
> (inexact->exact 1.0)
1
```

```
(exact->inexact z) → inexact?
  z : number?
```

Coerces `z` to an inexact number. If `z` is already inexact, it is returned.

Examples:

```
> (exact->inexact 1)
1.0
> (exact->inexact 1.0)
1.0
```

```
(real->single-flonum x) → single-flonum?
  x : real?
```

Coerces `x` to a single-precision floating-point number. If `x` is already a single-precision floating-point number, it is returned.

```
(real->double-flonum x) → flonum?
  x : real?
```

Coerces `x` to a double-precision floating-point number. If `x` is already a double-precision floating-point number, it is returned.

4.3.2 Generic Numerics

Most Racket numeric operations work on any kind of number.

Arithmetic

```
(+ z ...) → number?
  z : number?
```

Returns the sum of the *z*s, adding pairwise from left to right. If no arguments are provided, the result is `0`.

Examples:

```
> (+ 1 2)
3
> (+ 1.0 2+3i 5)
8.0+3.0i
> (+)
0
```

```
(- z) → number?
  z : number?
(- z w ...+) → number?
  z : number?
  w : number?
```

When no *w*s are supplied, returns `(- 0 z)`. Otherwise, returns the subtraction of the *w*s from *z* working pairwise from left to right.

Examples:

```
> (- 5 3.0)
2.0
> (- 1)
-1
> (- 2+7i 1 3)
-2+7i
```

```
(* z ...) → number?
  z : number?
```

Returns the product of the *z*s, multiplying pairwise from left to right. If no arguments are provided, the result is `1`. Multiplying any number by exact `0` produces exact `0`.

Examples:

```
> (* 2 3)
6
> (* 8.0 9)
72.0
> (* 1+2i 3+4i)
-5+10i
```

```
(/ z) → number?
  z : number?
(/ z w ...+) → number?
  z : number?
  w : number?
```

When no `w`s are supplied, returns `(/ 1 z)`. Otherwise, returns the division of `z` by the `w`s working pairwise from left to right.

If `z` is exact `0` and no `w` is exact `0`, then the result is exact `0`. If any `w` is exact `0`, the `exn:fail:contract:divide-by-zero` exception is raised.

Examples:

```
> (/ 3 4)
3/4
> (/ 81 3 3)
9
> (/ 10.0)
0.1
> (/ 1+2i 3+4i)
11/25+2/25i
```

```
(quotient n m) → integer?
  n : integer?
  m : integer?
```

Returns `(truncate (/ n m))`.

Examples:

```
> (quotient 10 3)
3
> (quotient -10.0 3)
-3.0
> (quotient +inf.0 3)
quotient: contract violation
  expected: integer?
  given: +inf.0
```

```
(remainder n m) → integer?
  n : integer?
  m : integer?
```

Returns `q` with the same sign as `n` such that

- `(abs q)` is between `0` (inclusive) and `(abs m)` (exclusive), and
- `(+ q (* m (quotient n m)))` equals *n*.

If *m* is exact `0`, the `exn:fail:contract:divide-by-zero` exception is raised.

Examples:

```
> (remainder 10 3)
1
> (remainder -10.0 3)
-1.0
> (remainder 10.0 -3)
1.0
> (remainder -10 -3)
-1
> (remainder +inf.0 3)
remainder: contract violation
  expected: integer?
  given: +inf.0
```

```
(quotient/remainder n m) → integer? integer?
  n : integer?
  m : integer?
```

Returns `(values (quotient n m) (remainder n m))`, but the combination may be computed more efficiently than separate calls to `quotient` and `remainder`.

Example:

```
> (quotient/remainder 10 3)
3
1
```

```
(modulo n m) → integer?
  n : integer?
  m : integer?
```

Returns *q* with the same sign as *m* where

- `(abs q)` is between `0` (inclusive) and `(abs m)` (exclusive), and
- the difference between *q* and `(- n (* m (quotient n m)))` is a multiple of *m*.

If *m* is exact `0`, the `exn:fail:contract:divide-by-zero` exception is raised.

Examples:

```
> (modulo 10 3)
1
> (modulo -10.0 3)
2.0
> (modulo 10.0 -3)
-2.0
> (modulo -10 -3)
-1
> (modulo +inf.0 3)
modulo: contract violation
  expected: integer?
  given: +inf.0
```

```
(add1 z) → number?
  z : number?
```

Returns `(+ z 1)`.

```
(sub1 z) → number?
  z : number?
```

Returns `(- z 1)`.

```
(abs x) → number?
  x : real?
```

Returns the absolute value of *x*.

Examples:

```
> (abs 1.0)
1.0
> (abs -1)
1
```

```
(max x ...+) → real?
  x : real?
```

Returns the largest of the *x*s, or `+nan.0` if any *x* is `+nan.0`. If any *x* is inexact, the result is coerced to inexact. See also `argmax`.

Examples:

```
> (max 1 3 2)
3
> (max 1 3 2.0)
3.0
```

```
(min x ...+) → real?
  x : real?
```

Returns the smallest of the `x`s, or `+nan.0` if any `x` is `+nan.0`. If any `x` is inexact, the result is coerced to inexact. See also `argmin`.

Examples:

```
> (min 1 3 2)
1
> (min 1 3 2.0)
1.0
```

```
(gcd n ...) → rational?
  n : rational?
```

Returns the greatest common divisor (a non-negative number) of the `n`s; for non-integer `n`s, the result is the `gcd` of the numerators divided by the `lcm` of the denominators. If no arguments are provided, the result is `0`. If all arguments are zero, the result is zero.

Examples:

```
> (gcd 10)
10
> (gcd 12 81.0)
3.0
> (gcd 1/2 1/3)
1/6
```

```
(lcm n ...) → (or/c rational? +inf.0)
  n : rational?
```

Returns the least common multiple (a non-negative number) of the `n`s. For two non-integer `n`s, the result is the absolute value of the product divided by the `gcd`. If no arguments are provided, the result is `1`. If any argument is zero, the result is zero; furthermore, if any argument is exact `0`, the result is exact `0`.

Examples:

```
> (lcm 10)
10
> (lcm 3 4.0)
12.0
> (lcm 1/2 2/3)
2
```

```
(round x) → (or/c integer? +inf.0 -inf.0 +nan.0)
  x : real?
```

Returns the integer closest to `x`, resolving ties in favor of an even number, but `+inf.0`, `-inf.0`, and `+nan.0` round to themselves.

Examples:

```
> (round 17/4)
4
> (round -17/4)
-4
> (round 2.5)
2.0
> (round -2.5)
-2.0
> (round +inf.0)
+inf.0
```

```
(floor x) → (or/c integer? +inf.0 -inf.0 +nan.0)
  x : real?
```

Returns the largest integer that is no more than `x`, but `+inf.0`, `-inf.0`, and `+nan.0` floor to themselves.

Examples:

```
> (floor 17/4)
4
> (floor -17/4)
-5
> (floor 2.5)
2.0
> (floor -2.5)
-3.0
> (floor +inf.0)
+inf.0
```

```
(ceiling x) → (or/c integer? +inf.0 -inf.0 +nan.0)
  x : real?
```

Returns the smallest integer that is at least as large as `x`, but `+inf.0`, `-inf.0`, and `+nan.0` ceiling to themselves.

Examples:

```
> (ceiling 17/4)
5
> (ceiling -17/4)
-4
> (ceiling 2.5)
3.0
> (ceiling -2.5)
-2.0
> (ceiling +inf.0)
+inf.0
```

```
(truncate x) → (or/c integer? +inf.0 -inf.0 +nan.0)
  x : real?
```

Returns the integer farthest from `0` that is not farther from `0` than `x`, but `+inf.0`, `-inf.0`, and `+nan.0` truncate to themselves.

Examples:

```
> (truncate 17/4)
4
> (truncate -17/4)
-4
> (truncate 2.5)
2.0
> (truncate -2.5)
-2.0
> (truncate +inf.0)
+inf.0
```

```
(numerator q) → integer?
  q : rational?
```

Coerces `q` to an exact number, finds the numerator of the number expressed in its simplest fractional form, and returns this number coerced to the exactness of `q`.

Examples:

```
> (numerator 5)
5
> (numerator 17/4)
17
> (numerator 2.3)
2589569785738035.0
```

```
(denominator q) → (and/c integer? positive?)
  q : rational?
```

Coerces *q* to an exact number, finds the denominator of the number expressed in its simplest fractional form, and returns this number coerced to the exactness of *q*.

Examples:

```
> (denominator 5)
1
> (denominator 17/4)
4
> (denominator 2.3)
1125899906842624.0
```

```
(rationalize x tolerance) → real?
  x : real?
  tolerance : real?
```

Among the real numbers within `(abs tolerance)` of *x*, returns the one corresponding to an exact number whose `denominator` is the smallest. If multiple integers are within *tolerance* of *x*, the one closest to `0` is used.

Examples:

```
> (rationalize 1/4 1/10)
1/3
> (rationalize -1/4 1/10)
-1/3
> (rationalize 1/4 1/4)
0
> (rationalize 11/40 1/4)
1/2
```

Number Comparison

```
(= z w ...) → boolean?
  z : number?
  w : number?
```

Returns #t if all of the arguments are numerically equal, #f otherwise. An inexact number is numerically equal to an exact number when the exact coercion of the inexact number is the exact number. Also, 0.0 and -0.0 are numerically equal, but +nan.0 is not numerically equal to itself.

Examples:

```
> (= 1 1.0)
#t
> (= 1 2)
#f
> (= 2+3i 2+3i 2+3i)
#t
> (= 1)
#t
```

Changed in version 7.0.0.13 of package base: Allow one argument, in addition to allowing two or more.

```
(< x y ...) → boolean?
  x : real?
  y : real?
```

Returns #t if the arguments in the given order are strictly increasing, #f otherwise.

Examples:

```
> (< 1 1)
#f
> (< 1 2 3)
#t
> (< 1)
#t
> (< 1 +inf.0)
#t
> (< 1 +nan.0)
#f
```

Changed in version 7.0.0.13 of package base: Allow one argument, in addition to allowing two or more.

```
(<= x y ...) → boolean?
  x : real?
  y : real?
```

Returns #t if the arguments in the given order are non-decreasing, #f otherwise.

Examples:

```
> (<= 1 1)
#t
> (<= 1 2 1)
#f
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(> x y ...) → boolean?
  x : real?
  y : real?
```

Returns `#t` if the arguments in the given order are strictly decreasing, `#f` otherwise.

Examples:

```
> (> 1 1)
#f
> (> 3 2 1)
#t
> (> +inf.0 1)
#t
> (> +nan.0 1)
#f
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(>= x y ...) → boolean?
  x : real?
  y : real?
```

Returns `#t` if the arguments in the given order are non-increasing, `#f` otherwise.

Examples:

```
> (>= 1 1)
#t
> (>= 1 2 1)
#f
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

Powers and Roots

```
(sqrt z) → number?
  z : number?
```

Returns the principal square root of `z`. The result is exact if `z` is exact and `z`'s square root is rational. See also `integer-sqrt`.

Examples:

```
> (sqrt 4/9)
2/3
> (sqrt 2)
1.4142135623730951
> (sqrt -1)
0+1i
```

```
(integer-sqrt n) → complex?
  n : integer?
```

Returns `(floor (sqrt n))` for positive `n`. The result is exact if `n` is exact. For negative `n`, the result is `(* (integer-sqrt (- n)) 0+1i)`.

Examples:

```
> (integer-sqrt 4.0)
2.0
> (integer-sqrt 5)
2
> (integer-sqrt -4.0)
0.0+2.0i
> (integer-sqrt -4)
0+2i
```

```
(integer-sqrt/remainder n) → complex? integer?
  n : integer?
```

Returns `(integer-sqrt n)` and `(- n (expt (integer-sqrt n) 2))`.

Examples:

```
> (integer-sqrt/remainder 4.0)
2.0
0.0
> (integer-sqrt/remainder 5)
2
1
```

```
(expt z w) → number?
  z : number?
  w : number?
```

Returns `z` raised to the power of `w`.

If `w` is exact `0`, the result is exact `1`. If `w` is `0.0` or `-0.0` and `z` is a real number other than exact `1` or `0`, the result is `1.0` (even if `z` is `+nan.0`).

If `z` is exact `1`, the result is exact `1`. If `z` is `1.0` and `w` is a real number, the result is `1.0` (even if `w` is `+nan.0`).

If `z` is exact `0`, the result is as follows:

- `w` is exact `0` — result is `1`
- `w` is `0.0` or `-0.0` — result is `1.0`
- real part of `w` is negative — the `exn:fail:contract:divide-by-zero` exception is raised
- `w` is nonreal with a nonpositive real part — the `exn:fail:contract:divide-by-zero` exception is raised
- `w` is `+nan.0` — result is `+nan.0`
- otherwise — result is `0`

If `w` is exact `1/2`, the result is the same as `(sqrt z)`, which can be exact. Other fractional powers are not treated specially in this manner:

Examples:

```
> (expt 9 1/2)
3
> (expt 9 0.5)
3.0
> (expt 16 1/4)
2.0
> (expt 16 0.25)
2.0
```

Further special cases when `w` is a real number:

These special cases correspond to `pow` in C99 [C99], except when `z` is negative and `w` is a not an integer.

- `(expt 0.0 w)`:
  - `w` is negative — result is `+inf.0`
  - `w` is positive — result is `0.0`

- `(expt -0.0 w)`:
  - *w* is negative:
    - *w* is an odd integer — result is `-inf.0`
    - *w* otherwise rational — result is `+inf.0`
  - *w* is positive:
    - *w* is an odd integer — result is `-0.0`
    - *w* otherwise rational — result is `0.0`
- `(expt z -inf.0)` for positive *z*:
  - *z* is less than `1.0` — result is `+inf.0`
  - *z* is greater than `1.0` — result is `0.0`
- `(expt z +inf.0)` for positive *z*:
  - *z* is less than `1.0` — result is `0.0`
  - *z* is greater than `1.0` — result is `+inf.0`
- `(expt -inf.0 w)` for integer *w*:
  - *w* is negative:
    - *w* is odd — result is `-0.0`
    - *w* is even — result is `0.0`
  - *w* is positive:
    - *w* is odd — result is `-inf.0`
    - *w* is even — result is `+inf.0`
- `(expt +inf.0 w)`:
  - *w* is negative — result is `0.0`
  - *w* is positive — result is `+inf.0`

Examples:

```
> (expt 2 3)
8
> (expt 4 0.5)
2.0
> (expt +inf.0 0)
1
```

```
(exp z) → number?
  z : number?
```

Returns Euler's number raised to the power of `z`. The result is normally inexact, but it is exact `1` when `z` is an exact `0`. See also `expt`.

Examples:

```
> (exp 1)
2.718281828459045
> (exp 2+3i)
-7.315110094901103+1.0427436562359045i
> (exp 0)
1
```

```
(log z [b]) → number?
  z : number?
  b : number? = (exp 1)
```

Returns the natural logarithm of `z`. The result is normally inexact, but it is exact `0` when `z` is an exact `1`. When `z` is exact `0`, `exn:fail:contract:divide-by-zero` exception is raised.

If `b` is provided, it serves as an alternative base. It is equivalent to `(/ (log z) (log b))`, but can potentially run faster. If `b` is exact `1`, `exn:fail:contract:divide-by-zero` exception is raised.

Consider using `fllogb` from `math/flonum` instead when accuracy is important.

Examples:

```
> (log (exp 1))
1.0
> (log 2+3i)
1.2824746787307684+0.982793723247329i
> (log 1)
0
> (log 100 10)
2.0
> (log 8 2)
3.0
> (log 5 5)
1.0
```

Changed in version 6.9.0.1 of package `base`: Added second argument for arbitrary bases.

Trigonometric Functions

```
(sin z) → number?
  z : number?
```

Returns the sine of *z*, where *z* is in radians. The result is normally inexact, but it is exact `0` if *z* is exact `0`.

Examples:

```
> (sin 3.14159)
2.65358979335273e-6
> (sin 1.0+5.0i)
62.44551846769654+40.0921657779984i
```

```
(cos z) → number?
  z : number?
```

Returns the cosine of *z*, where *z* is in radians.

Examples:

```
> (cos 3.14159)
-0.9999999999964793
> (cos 1.0+5.0i)
40.09580630629883-62.43984868079963i
```

```
(tan z) → number?
  z : number?
```

Returns the tangent of *z*, where *z* is in radians. The result is normally inexact, but it is exact `0` if *z* is exact `0`.

Examples:

```
> (tan 0.7854)
1.0000036732118494
> (tan 1.0+5.0i)
8.2567198342296e-5+1.0000377833796008i
```

```
(asin z) → number?
  z : number?
```

Returns the arcsine in radians of *z*. The result is normally inexact, but it is exact `0` if *z* is exact `0`.

Examples:

```
> (asin 0.25)
0.25268025514207865
> (asin 1.0+5.0i)
0.1937931365549322+2.3309746530493123i
```

```
(acos z) → number?
  z : number?
```

Returns the arccosine in radians of *z*.

Examples:

```
> (acos 0.25)
1.318116071652818
> (acos 1.0+5.0i)
1.3770031902399644-2.3309746530493123i
```

```
(atan z) → number?
  z : number?
(atan y x) → number?
  y : real?
  x : real?
```

In the one-argument case, returns the arctangent of the inexact approximation of *z*, except that the result is an exact `0` for *z* as `0`, and the `exn:fail:contract:divide-by-zero` exception is raised for *z* as exact `0+1i` or exact `0-1i`.

In the two-argument case, the result is roughly the same as `(atan (/ (exact->inexact y)) (exact->inexact x))`, but the signs of *y* and *x* determine the quadrant of the result. Moreover, a suitable angle is returned when *y* divided by *x* produces `+nan.0` in the case that neither *y* nor *x* is `+nan.0`. Finally, if *y* is exact `0` and *x* is a positive number, the result is exact `0`. If both *x* and *y* are exact `0`, the `exn:fail:contract:divide-by-zero` exception is raised.

Examples:

```
> (atan 0.5)
0.4636476090008061
> (atan 2 1)
1.1071487177940904
> (atan -2 -1)
-2.0344439357957027
> (atan 1.0+5.0i)
1.530881333938778+0.19442614214700213i
> (atan +inf.0 -inf.0)
2.356194490192345
```

Changed in version 7.2.0.2 of package `base`: Changed to raise `exn:fail:contract:divide-by-zero` for `0+1i` and `0-1i` and to produce exact `0` for any positive *x* (not just exact values) when *y* is `0`.

Complex Numbers

```
(make-rectangular x y) → number?
  x : real?
  y : real?
```

Creates a complex number with *x* as the real part and *y* as the imaginary part. That is, returns `(+ x (* y 0+1i))`.

Example:

```
> (make-rectangular 3 4.0)
3.0+4.0i
```

```
(make-polar magnitude angle) → number?
  magnitude : real?
  angle : real?
```

Creates a complex number which, if thought of as a point, is *magnitude* away from the origin and is rotated *angle* radians counter clockwise from the positive x-axis. That is, returns `(+ (* magnitude (cos angle)) (* magnitude (sin angle) 0+1i))`.

Examples:

```
> (make-polar 10 (* pi 1/2))
6.123233995736766e-16+10.0i
> (make-polar 10 (* pi 1/4))
7.0710678118654755+7.071067811865475i
```

```
(real-part z) → real?
  z : number?
```

Returns the real part of the complex number *z* in rectangle coordinates.

Examples:

```
> (real-part 3+4i)
3
> (real-part 5.0)
5.0
```

```
(imag-part z) → real?
  z : number?
```

Returns the imaginary part of the complex number *z* in rectangle coordinates.

Examples:

```
> (imag-part 3+4i)
4
> (imag-part 5.0)
0
> (imag-part 5.0+0.0i)
0.0
```

```
(magnitude z) → (and/c real? (not/c negative?))
  z : number?
```

Returns the magnitude of the complex number *z* in polar coordinates. A complex number with `+inf.0` or `-inf.0` as a component has magnitude `+inf.0`, even if the other component is `+nan.0`.

Examples:

```
> (magnitude -3)
3
> (magnitude 3.0)
3.0
> (magnitude 3+4i)
5
```

Changed in version 7.2.0.2 of package `base`: Changed to always return `+inf.0` for a complex number with a `+inf.0` or `-inf.0` component.

```
(angle z) → real?
  z : number?
```

Returns the angle of the complex number *z* in polar coordinates.

The result is guaranteed to be between `(- pi)` and `pi`, possibly equal to `pi` (but never equal to `(- pi)`).

Examples:

```
> (angle -3)
3.141592653589793
> (angle 3.0)
0
> (angle 3+4i)
```

```
0.9272952180016122
> (angle +inf.0+inf.0i)
0.7853981633974483
> (angle -1)
3.141592653589793
```

Bitwise Operations

```
(bitwise-ior n ...) → exact-integer?
  n : exact-integer?
```

Returns the bitwise "inclusive or" of the *n*s in their (semi-infinite) two's complement representation. If no arguments are provided, the result is `0`.

Examples:

```
> (bitwise-ior 1 2)
3
> (bitwise-ior -32 1)
-31
```

```
(bitwise-and n ...) → exact-integer?
  n : exact-integer?
```

Returns the bitwise "and" of the *n*s in their (semi-infinite) two's complement representation. If no arguments are provided, the result is `-1`.

Examples:

```
> (bitwise-and 1 2)
0
> (bitwise-and -32 -1)
-32
```

```
(bitwise-xor n ...) → exact-integer?
  n : exact-integer?
```

Returns the bitwise "exclusive or" of the *n*s in their (semi-infinite) two's complement representation. If no arguments are provided, the result is `0`.

Examples:

```
> (bitwise-xor 1 5)
4
> (bitwise-xor -32 -1)
31
```

```
(bitwise-not n) → exact-integer?
  n : exact-integer?
```

Returns the bitwise “not” of `n` in its (semi-infinite) two’s complement representation.

Examples:

```
> (bitwise-not 5)
-6
> (bitwise-not -1)
0
```

```
(bitwise-bit-set? n m) → boolean?
  n : exact-integer?
  m : exact-nonnegative-integer?
```

Returns `#t` when the `m`th bit of `n` is set in `n`’s (semi-infinite) two’s complement representation.

This operation is equivalent to `(not (zero? (bitwise-and n (arithmetic-shift 1 m))))`, but it is faster and runs in constant time when `n` is positive.

Examples:

```
> (bitwise-bit-set? 5 0)
#t
> (bitwise-bit-set? 5 2)
#t
> (bitwise-bit-set? -5 (expt 2 700))
#t
```

```
(bitwise-first-bit-set n) → exact-integer?
  n : exact-integer?
```

Returns `-1` if `n` is `0`, otherwise returns the smallest `m` for which `(bitwise-bit-set? n m)` produces `#t`.

Example:

```
> (bitwise-first-bit-set 128)
7
```

Added in version 8.16.0.4 of package `base`.

```
(bitwise-bit-field n start end) → exact-integer?
  n : exact-integer?
  start : exact-nonnegative-integer?
  end : (and/c exact-nonnegative-integer?
               (>=/c start))
```

Extracts the bits between position `start` and `(- end 1)` (inclusive) from `n` and shifts them down to the least significant portion of the number.

This operation is equivalent to the computation

```
(bitwise-and (sub1 (arithmetic-shift 1 (- end start)))
             (arithmetic-shift n (- start)))
```

but it runs in constant time when `n` is positive, `start` and `end` are fixnums, and `(- end start)` is no more than the maximum width of a fixnum.

Each pair of examples below uses the same numbers, showing the result both in binary and as integers.

Examples:

```
> (format "~b" (bitwise-bit-field (string->number "1101" 2) 1 1))
"0"
> (bitwise-bit-field 13 1 1)
0
> (format "~b" (bitwise-bit-field (string->number "1101" 2) 1 3))
"10"
> (bitwise-bit-field 13 1 3)
2
> (format "~b" (bitwise-bit-field (string->number "1101" 2) 1 4))
"110"
> (bitwise-bit-field 13 1 4)
6
```

```
(arithmetic-shift n m) → exact-integer?
  n : exact-integer?
  m : exact-integer?
```

Returns the bitwise "shift" of `n` in its (semi-infinite) two's complement representation. If `m` is non-negative, the integer `n` is shifted left by `m` bits; i.e., `m` new zeros are introduced as rightmost digits. If `m` is negative, `n` is shifted right by `(- m)` bits; i.e., the rightmost `m` digits are dropped.

Examples:

```
> (arithmetic-shift 1 10)
1024
> (arithmetic-shift 255 -3)
31
```

```
(integer-length n) → exact-integer?
  n : exact-integer?
```

Returns the number of bits in the (semi-infinite) two's complement representation of *n* after removing all leading zeros (for non-negative *n*) or ones (for negative *n*).

Examples:

```
> (integer-length 8)
4
> (integer-length -8)
3
```

Random Numbers

```
(random k [rand-gen]) → exact-nonnegative-integer?
  k : (integer-in 1 4294967087)
  rand-gen : pseudo-random-generator?
           = (current-pseudo-random-generator)
(random min max [rand-gen]) → exact-integer?
  min : exact-integer?
  max : (integer-in (+ 1 min) (+ 4294967087 min))
  rand-gen : pseudo-random-generator?
           = (current-pseudo-random-generator)
(random [rand-gen]) → (and/c real? inexact? (>/c 0) (</c 1))
  rand-gen : pseudo-random-generator?
           = (current-pseudo-random-generator)
```

When called with an integer argument *k*, returns a random exact integer in the range `0` to *k*-1.

When called with two integer arguments *min* and *max*, returns a random exact integer in the range *min* to *max*-1.

When called with zero arguments, returns a random inexact number between `0` and `1`, exclusive.

In each case, the number is provided by the given pseudo-random number generator (which defaults to the current one, as produced by `current-pseudo-random-generator`). The generator maintains an internal state for generating numbers. The random number generator uses L'Ecuyer's MRG32k3a algorithm [L'Ecuyer02] that has a state space of practically 192 bits.

When security is a concern, use `crypto-random-bytes` instead of `random`.

The `math/base` library provides additional functions for random number generation without the limit of `4294967087`.

Changed in version 6.4 of package `base`: Added support for ranges.

```
(random-seed k) → void?
  k : (integer-in 0 (sub1 (expt 2 31)))
```

Seeds the current pseudo-random number generator with `k`. Seeding a generator sets its internal state deterministically; that is, seeding a generator with a particular number forces it to produce a sequence of pseudo-random numbers that is the same across runs and across platforms.

The `random-seed` function is convenient for some purposes, but note that the space of states for a pseudo-random number generator is much larger that the space of allowed values for `k`. Use `vector->pseudo-random-generator!` to set a pseudo-random number generator to any of its possible states.

```
(make-pseudo-random-generator) → pseudo-random-generator?
```

Returns a new pseudo-random number generator. The new generator is seeded with a number derived from `(current-milliseconds)`.

```
(pseudo-random-generator? v) → boolean?
  v : any/c
```

Returns `#t` if `v` is a pseudo-random number generator, `#f` otherwise.

```
(current-pseudo-random-generator) → pseudo-random-generator?
(current-pseudo-random-generator rand-gen) → void?
  rand-gen : pseudo-random-generator?
```

A parameter that determines the pseudo-random number generator used by `random`.

```
(pseudo-random-generator->vector rand-gen)
 → pseudo-random-generator-vector?
  rand-gen : pseudo-random-generator?
```

Produces a vector that represents the complete internal state of `rand-gen`. The vector is suitable as an argument to `vector->pseudo-random-generator` to recreate the generator in its current state (across runs and across platforms).

```
(vector->pseudo-random-generator vec)
 → pseudo-random-generator?
  vec : pseudo-random-generator-vector?
```

Produces a pseudo-random number generator whose internal state corresponds to `vec`.

```
(vector->pseudo-random-generator! rand-gen
                                  vec)     → void?
  rand-gen : pseudo-random-generator?
  vec : pseudo-random-generator-vector?
```

Like `vector->pseudo-random-generator`, but changes `rand-gen` to the given state, instead of creating a new generator.

```
(pseudo-random-generator-vector? v) → boolean?
  v : any/c
```

Returns `#t` if `v` is a vector of six exact integers, where the first three integers are in the range `0` to `4294967086`, inclusive; the last three integers are in the range `0` to `4294944442`, inclusive; at least one of the first three integers is non-zero; and at least one of the last three integers is non-zero. Otherwise, the result is `#f`.

Other Randomness Utilities

```
(require racket/random)      package: base
```

```
(crypto-random-bytes n) → bytes?
  n : exact-positive-integer?
```

Provides an interface to randomness from the underlying operating system. Use `crypto-random-bytes` instead of `random` wherever security is a concern.

Returns `n` random bytes. On Unix systems, the bytes are obtained from `"/dev/urandom"`, while Windows uses the `RtlGenRand` system function.

Example:

```
> (crypto-random-bytes 14)
#"\0\1\1\2\3\5\b\r\25\"7Y\220\351"
```

Added in version 6.3 of package `base`.

```
(random-ref seq [rand-gen]) → any/c
  seq : sequence?
  rand-gen : pseudo-random-generator?
           = (current-pseudo-random-generator)
```

Returns a random element of the sequence. Like `sequence-length`, does not terminate on infinite sequences, and evaluates the entire sequence.

Added in version 6.4 of package `base`.

```
(random-sample  seq
                n
               [rand-gen
                #:replacement? replacement?]) → (listof any/c)
  seq : sequence?
  n : exact-positive-integer?
  rand-gen : pseudo-random-generator?
           = (current-pseudo-random-generator)
  replacement? : any/c = #t
```

Returns a list of *n* elements of *seq*, picked at random, listed in any order. If *replacement?* is non-false, elements are drawn with replacement, which allows for duplicates.

Like `sequence-length`, does not terminate on infinite sequences, and evaluates the entire sequence.

Added in version 6.4 of package `base`.

Number–String Conversions

```
(number->string z [radix]) → string?
  z : number?
  radix : (or/c 2 8 10 16) = 10
```

Returns a string that is the printed form of *z* (see §1.4.2 "Printing Numbers") in the base specified by *radix*. If *z* is inexact, *radix* must be `10`, otherwise the `exn:fail:contract` exception is raised.

Examples:

```
> (number->string 3.0)
"3.0"
> (number->string 255 8)
"377"
```

```
(string->number  s
                [radix
                 convert-mode
                 decimal-mode
                 single-mode])
 → (or/c number? #f string? extflonum?)
```

```
s : string?
radix : (integer-in 2 16) = 10
convert-mode : (or/c 'number-or-false 'read)
             = 'number-or-false
decimal-mode : (or/c 'decimal-as-inexact 'decimal-as-exact)
             = (if (read-decimal-as-inexact)
                   'decimal-as-inexact
                   'decimal-as-exact)
single-mode : (or/c 'single 'double)
            = (if (read-single-flonum)
                  'single
                  'double)
```

Reads and returns a number datum from *s* (see §1.3.3 "Reading Numbers"). The optional *radix* argument specifies the default base for the number, which can be overridden by `#b`, `#o`, `#d`, or `#x` in the string.

If *convert-mode* is `'number-or-false`, the result is `#f` if *s* does not parse exactly as a number datum (with no whitespace). If *convert-mode* is `'read`, the result can be an extflonum, and it can be a string that contains an error message if `read` of *s* would report a reader exception (but the result can still be `#f` if `read` would report a symbol).

The *decimal-mode* argument controls number parsing the same way that the `read-decimal-as-inexact` parameter affects `read`.

The *single-mode* argument controls number parsing the same way that the `read-single-flonum` parameter affects `read`.

Examples:

```
> (string->number "3.0+2.5i")
3.0+2.5i
> (string->number "hello")
#f
> (string->number "111" 7)
57
> (string->number "#b111" 7)
7
> (string->number "#e+inf.0" 10 'read)
"no exact representation for +inf.0"
> (string->number "10.3" 10 'read 'decimal-as-exact)
103/10
```

Changed in version 6.8.0.2 of package `base`: Added the *convert-mode* and *decimal-mode* arguments.
Changed in version 7.3.0.5: Added the *single-mode* argument.

```
(real->decimal-string n [decimal-digits]) → string?
  n : rational?
  decimal-digits : exact-nonnegative-integer? = 2
```

Prints `n` into a string and returns the string. The printed form of `n` shows exactly `decimal-digits` digits after the decimal point. The printed form uses a minus sign if `n` is negative, and it does not use a plus sign if `n` is positive.

Before printing, `n` is converted to an exact number, multiplied by `(expt 10 decimal-digits)`, rounded, and then divided again by `(expt 10 decimal-digits)`. The result of this process is an exact number whose decimal representation has no more than `decimal-digits` digits after the decimal (and it is padded with trailing zeros if necessary).

If `n` is a real number with no decimal representation (e.g. `+nan.0`, `+inf.0`), then the `exn:fail:contract` exception is raised. (Any real number that is convertible to decimal notation is rational, so `n` must be `rational?`, despite the name of the function.)

Examples:

```
> (real->decimal-string pi)
"3.14"
> (real->decimal-string pi 5)
"3.14159"
```

```
(integer-bytes->integer  bstr
                         signed?
                        [big-endian?
                         start
                         end])        → exact-integer?
  bstr : bytes?
  signed? : any/c
  big-endian? : any/c = (system-big-endian?)
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (bytes-length bstr)
```

Converts the machine-format number encoded in `bstr` to an exact integer. The `start` and `end` arguments specify the substring to decode, where `(- end start)` must be `1`, `2`, `4`, or `8`. If `signed?` is true, then the bytes are decoded as a two's-complement number, otherwise it is decoded as an unsigned integer. If `big-endian?` is true, then the first byte's value provides the most significant eight bits of the number, otherwise the first byte provides the least-significant eight bits, and so on.

Changed in version 6.10.0.1 of package `base`: Added support for decoding a 1-byte string.

```
(integer->integer-bytes  n
                         size-n
                         signed?
                        [big-endian?
                         dest-bstr
                         start])      → bytes?
  n : exact-integer?
  size-n : (or/c 1 2 4 8)
  signed? : any/c
  big-endian? : any/c = (system-big-endian?)
  dest-bstr :  (and/c bytes? (not/c immutable?))
            = (make-bytes size-n)
  start : exact-nonnegative-integer? = 0
```

Converts the exact integer *n* to a machine-format number encoded in a byte string of length *size-n*, which must be 1, 2, 4, or 8. If *signed?* is true, then the number is encoded as two's complement, otherwise it is encoded as an unsigned bit stream. If *big-endian?* is true, then the most significant eight bits of the number are encoded in the first byte of the resulting byte string, otherwise the least-significant bits are encoded in the first byte, and so on.

The *dest-bstr* argument must be a mutable byte string of length *size-n*. The encoding of *n* is written into *dest-bstr* starting at offset *start*, and *dest-bstr* is returned as the result.

If *n* cannot be encoded in a byte string of the requested size and format, the `exn:fail:contract` exception is raised. If *dest-bstr* is not of length *size-n*, the `exn:fail:contract` exception is raised.

Changed in version 6.10.0.1 of package `base`: Added support for encoding a 1-byte value.

```
(floating-point-bytes->real  bstr
                            [big-endian?
                             start
                             end])       → flonum?
  bstr : bytes?
  big-endian? : any/c = (system-big-endian?)
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (bytes-length bstr)
```

Converts the IEEE floating-point number encoded in *bstr* from position *start* (inclusive) to *end* (exclusive) to an inexact real number. The difference between *start* an *end* must be either 4 or 8 bytes. If *big-endian?* is true, then the first byte's ASCII value provides the most significant eight bits of the IEEE representation, otherwise the first byte provides the least-significant eight bits, and so on.

```
(real->floating-point-bytes  x
                             size-n
                            [big-endian?
                             dest-bstr
                             start])      → bytes?
  x : real?
  size-n : (or/c 4 8)
  big-endian? : any/c = (system-big-endian?)
  dest-bstr : (and/c bytes? (not/c immutable?))
            = (make-bytes size-n)
  start : exact-nonnegative-integer? = 0
```

Converts the real number *x* to its IEEE representation in a byte string of length *size-n*, which must be 4 or 8. If *big-endian?* is true, then the most significant eight bits of the number are encoded in the first byte of the resulting byte string, otherwise the least-significant bits are encoded in the first character, and so on.

The *dest-bstr* argument must be a mutable byte string of length *size-n*. The encoding of n is written into *dest-bstr* starting with byte *start*, and *dest-bstr* is returned as the result.

If *dest-bstr* is provided and it has less than *start* plus *size-n* bytes, the `exn:fail:contract` exception is raised.

```
(system-big-endian?) → boolean?
```

Returns `#t` if the native encoding of numbers is big-endian for the machine running Racket, `#f` if the native encoding is little-endian.

Extra Constants and Functions

```
(require racket/math)        package: base
```

The bindings documented in this section are provided by the `racket/math` and `racket` libraries, but not `racket/base`.

```
pi : flonum?
```

An approximation of π, the ratio of a circle's circumference to its diameter.

Examples:

```
> pi
3.141592653589793
> (cos pi)
-1.0
```

```
pi.f : (or/c single-flonum? flonum?)
```

The same value as `pi`, but as a single-precision floating-point number if the current platform supports it.

Changed in version 7.3.0.5 of package `base`: Allow value to be a double-precision flonum.

```
(degrees->radians x) → real?
  x : real?
```

Converts an *x*-degree angle to radians.

Examples:

```
> (degrees->radians 180)
3.141592653589793
> (sin (degrees->radians 45))
0.7071067811865475
```

```
(radians->degrees x) → real?
  x : real?
```

Converts *x* radians to degrees.

Examples:

```
> (radians->degrees pi)
180.0
> (radians->degrees (* 1/4 pi))
45.0
```

```
(sqr z) → number?
  z : number?
```

Returns `(* z z)`.

```
(sgn x) → (or/c (=/c -1) (=/c 0) (=/c 1) +nan.0 +nan.f)
  x : real?
```

Returns the sign of *x* as either -1, 0 (or a signed-zero variant, when inexact), 1, or not-a-number.

Examples:

```
> (sgn 10)
1
> (sgn -10.0)
-1.0
> (sgn 0)
0
> (sgn -0.0)
-0.0
> (sgn 0.0)
0.0
> (sgn +nan.0)
+nan.0
> (sgn +inf.0)
1.0
> (sgn -inf.0)
-1.0
```

```
(conjugate z) → number?
  z : number?
```

Returns the complex conjugate of *z*.

Examples:

```
> (conjugate 1)
1
> (conjugate 3+4i)
3-4i
```

```
(sinh z) → number?
  z : number?
```

Returns the hyperbolic sine of *z*.

```
(cosh z) → number?
  z : number?
```

Returns the hyperbolic cosine of *z*.

```
(tanh z) → number?
  z : number?
```

Returns the hyperbolic tangent of *z*.

```
(exact-round x) → exact-integer?
  x : rational?
```

Equivalent to `(inexact->exact (round x))`.

```
(exact-floor x) → exact-integer?
  x : rational?
```

Equivalent to `(inexact->exact (floor x))`.

```
(exact-ceiling x) → exact-integer?
  x : rational?
```

Equivalent to `(inexact->exact (ceiling x))`.

```
(exact-truncate x) → exact-integer?
  x : rational?
```

Equivalent to `(inexact->exact (truncate x))`.

```
(order-of-magnitude r) → (and/c exact? integer?)
  r : (and/c real? positive?)
```

Computes the greatest exact integer `m` such that:

```
(<= (expt 10 m)
    (inexact->exact r))
```

Hence also:

```
(< (inexact->exact r)
   (expt 10 (add1 m)))
```

Examples:

```
> (order-of-magnitude 999)
2
> (order-of-magnitude 1000)
3
> (order-of-magnitude 1/100)
-2
> (order-of-magnitude 1/101)
-3
```

```
(nan? x) → boolean?
  x : real?
```

Returns `#t` if `x` is `eqv?` to `+nan.0` or `+nan.f`; otherwise `#f`.

```
(infinite? x) → boolean?
  x : real?
```

Returns `#t` if `x` is `+inf.0`, `-inf.0`, `+inf.f`, `-inf.f`; otherwise `#f`.

```
(positive-integer? x) → boolean?
  x : any/c
```

Like `exact-positive-integer?`, but also returns `#t` for positive `inexact?` integers.

Added in version 6.8.0.2 of package `base`.

```
(negative-integer? x) → boolean?
  x : any/c
```

The same as `(and (integer? x) (negative? x))`.

Added in version 6.8.0.2 of package `base`.

```
(nonpositive-integer? x) → boolean?
  x : any/c
```

The same as `(and (integer? x) (not (positive? x)))`.

Added in version 6.8.0.2 of package `base`.

```
(nonnegative-integer? x) → boolean?
  x : any/c
```

Like `exact-nonnegative-integer?`, but also returns `#t` for non-negative `inexact?` integers.

Added in version 6.8.0.2 of package `base`.

```
(natural? x) → boolean?
  x : any/c
```

An alias for `exact-nonnegative-integer?`.

Added in version 6.8.0.2 of package `base`.

4.3.3 Flonums

```
(require racket/flonum)
```
package: base

The racket/flonum library provides operations like fl+ that consume and produce only flonums. Flonum-specific operations can provide better performance when used consistently, and they are as safe as generic operations like +.

See also §19.8 "Fixnum and Flonum Optimizations" in *The Racket Guide*.

Flonum Arithmetic

```
(fl+ a ...) → flonum?
  a : flonum?
(fl- a b ...) → flonum?
  a : flonum?
  b : flonum?
(fl* a ...) → flonum?
  a : flonum?
(fl/ a b ...) → flonum?
  a : flonum?
  b : flonum?
(flabs a) → flonum?
  a : flonum?
```

Like +, -, *, /, and abs, but constrained to consume flonums. The result is always a flonum.

Changed in version 7.0.0.13 of package base: Allow zero or more arguments for fl+ and fl* and one or more arguments for fl- and fl/.

```
(fl= a b ...) → boolean?
  a : flonum?
  b : flonum?
(fl< a b ...) → boolean?
  a : flonum?
  b : flonum?
(fl> a b ...) → boolean?
  a : flonum?
  b : flonum?
(fl<= a b ...) → boolean?
  a : flonum?
  b : flonum?
(fl>= a b ...) → boolean?
  a : flonum?
  b : flonum?
(flmin a b ...) → flonum?
  a : flonum?
  b : flonum?
```

```
(flmax a b ...) → flonum?
  a : flonum?
  b : flonum?
```

Like `=`, `<`, `>`, `<=`, `>=`, `min`, and `max`, but constrained to consume flonums.

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(flround a) → flonum?
  a : flonum?
(flfloor a) → flonum?
  a : flonum?
(flceiling a) → flonum?
  a : flonum?
(fltruncate a) → flonum?
  a : flonum?
```

Like `round`, `floor`, `ceiling`, and `truncate`, but constrained to consume flonums.

```
(flsingle a) → flonum?
  a : flonum?
```

Returns a value like `a`, but potentially discards precision and range so that the result can be represented as a single-precision IEEE floating-point number (even if single-flonums are not supported).

Using `flsingle` on the arguments and results of `fl+`, `fl-`, `fl*`, `fl/`, and `flsqrt`—that is, performing double-precision operations on values representable in single precision and then rounding the result to single precision—is always the same as performing the corresponding single-precision operation [Roux14]. (For other operations, the IEEE floating-point specification does not make enough guarantees to say more about the interaction with `flsingle`.)

Added in version 7.8.0.7 of package `base`.

```
(flbit-field a start end) → exact-nonnegative-integer?
  a : flonum?
  start : (integer-in 0 64)
  end : (integer-in 0 64)
```

Extracts a range of bits from the 64-bit IEEE representation of `a`, returning the non-negative integer that has the same bits set in its (semi-infinite) two's complement representation.

Examples:

```
> (flbit-field -0.0 63 64)
1
> (format "~x" (flbit-field 3.141579e+132 16 48))
"b43544f2"
```

Added in version 8.15.0.3 of package `base`.

```
(flsin a) → flonum?
  a : flonum?
(flcos a) → flonum?
  a : flonum?
(fltan a) → flonum?
  a : flonum?
(flasin a) → flonum?
  a : flonum?
(flacos a) → flonum?
  a : flonum?
(flatan a) → flonum?
  a : flonum?
(fllog a) → flonum?
  a : flonum?
(flexp a) → flonum?
  a : flonum?
(flsqrt a) → flonum?
  a : flonum?
```

Like `sin`, `cos`, `tan`, `asin`, `acos`, `atan`, `log`, `exp`, and `sqrt`, but constrained to consume and produce flonums. The result is `+nan.0` when a number outside the range `-1.0` to `1.0` is given to `flasin` or `flacos`, or when a negative number is given to `fllog` or `flsqrt`.

```
(flexpt a b) → flonum?
  a : flonum?
  b : flonum?
```

Like `expt`, but constrained to consume and produce flonums.

Due to the result constraint, the results compared to `expt` differ in the following cases:

These special cases correspond to `pow` in C99 [C99].

- `(flexpt -1.0 +inf.0)` — `1.0`
- `(flexpt a +inf.0)` where `a` is negative — `(expt (abs a) +inf.0)`
- `(flexpt a -inf.0)` where `a` is negative — `(expt (abs a) -inf.0)`
- `(expt -inf.0 b)` where `b` is a non-integer:
  - `b` is negative — `0.0`
  - `b` is positive — `+inf.0`
- `(flexpt a b)` where `a` is negative and `b` is not an integer — `+nan.0`

```
(->fl a) → flonum?
  a : exact-integer?
```

Like `exact->inexact`, but constrained to consume exact integers, so the result is always a flonum.

```
(fl->exact-integer a) → exact-integer?
  a : flonum?
```

Like `inexact->exact`, but constrained to consume an integer flonum, so the result is always an exact integer.

```
(make-flrectangular a b)
 → (and/c complex?
          (lambda (c) (flonum? (real-part c)))
          (lambda (c) (flonum? (imag-part c))))
  a : flonum?
  b : flonum?
(flreal-part a) → flonum?
  a : (and/c complex?
             (lambda (c) (flonum? (real-part c)))
             (lambda (c) (flonum? (imag-part c))))
(flimag-part a) → flonum?
  a : (and/c complex?
             (lambda (c) (flonum? (real-part c)))
             (lambda (c) (flonum? (imag-part c))))
```

Like `make-rectangular`, `real-part`, and `imag-part`, but both parts of the complex number must be inexact.

```
(flrandom rand-gen) → (and flonum? (>/c 0) (</c 1))
  rand-gen : pseudo-random-generator?
```

Equivalent to `(random rand-gen)`.

Flonum Vectors

A *flvector* is like a vector, but it holds only inexact real numbers. This representation can be more compact, and unsafe operations on flvectors (see `racket/unsafe/ops`) can execute more efficiently than unsafe operations on vectors of inexact reals.

An f64vector as provided by `ffi/vector` stores the same kinds of values as a flvector, but with extra indirections that make f64vectors more convenient for working with foreign libraries. The lack of indirections makes unsafe flvector access more efficient.

Two flvectors are `equal?` if they have the same length, and if the values in corresponding slots of the flvectors are `equal?`.

A printed flvector starts with `#fl(`, optionally with a number between the `#fl` and `(`. See §1.3.10 "Reading Vectors" for information on `read`ing flvectors and §1.4.7 "Printing Vectors" for information on `print`ing flvectors.

```
(flvector? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a flvector, `#f` otherwise.

```
(flvector x ...) → flvector?
  x : flonum?
```

Creates a flvector containing the given inexact real numbers.

Example:

```
> (flvector 2.0 3.0 4.0 5.0)
(flvector 2.0 3.0 4.0 5.0)
```

```
(make-flvector size [x]) → flvector?
  size : exact-nonnegative-integer?
  x : flonum? = 0.0
```

Creates a flvector with *size* elements, where every slot in the flvector is filled with *x*.

Example:

```
> (make-flvector 4 3.0)
(flvector 3.0 3.0 3.0 3.0)
```

```
(flvector-length vec) → exact-nonnegative-integer?
  vec : flvector?
```

Returns the length of *vec* (i.e., the number of slots in the flvector).

```
(flvector-ref vec pos) → flonum?
  vec : flvector?
  pos : exact-nonnegative-integer?
```

Returns the inexact real number in slot *pos* of *vec*. The first slot is position `0`, and the last slot is one less than `(flvector-length vec)`.

```
(flvector-set! vec pos x) → flonum?
  vec : flvector?
  pos : exact-nonnegative-integer?
  x : flonum?
```

Sets the inexact real number in slot *pos* of *vec*. The first slot is position `0`, and the last slot is one less than `(flvector-length vec)`.

```
(flvector-copy vec [start end]) → flvector?
  vec : flvector?
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (vector-length v)
```

Creates a fresh flvector of size `(- end start)`, with all of the elements of *vec* from *start* (inclusive) to *end* (exclusive).

```
(in-flvector vec [start stop step]) → sequence?
  vec : flvector?
  start : exact-nonnegative-integer? = 0
  stop : (or/c exact-integer? #f) = #f
  step : (and/c exact-integer? (not/c zero?)) = 1
```

Returns a sequence equivalent to *vec* when no optional arguments are supplied.

The optional arguments *start*, *stop*, and *step* are as in `in-vector`.

A `in-flvector` application can provide better performance for flvector iteration when it appears directly in a `for` clause.

```
(for/flvector maybe-length (for-clause ...) body ...)
(for*/flvector maybe-length (for-clause ...) body ...)

maybe-length =
             | #:length length-expr
             | #:length length-expr #:fill fill-expr

  length-expr : exact-nonnegative-integer?
  fill-expr : flonum?
```

Like `for/vector` or `for*/vector`, but for flvectors. The default *fill-expr* produces `0.0`.

```
(shared-flvector x ...) → flvector?
  x : flonum?
```

Creates a flvector containing the given inexact real numbers. For communication among places, the new flvector is allocated in the shared memory space.

Example:

```
> (shared-flvector 2.0 3.0 4.0 5.0)
(flvector 2.0 3.0 4.0 5.0)
```

```
(make-shared-flvector size [x]) → flvector?
  size : exact-nonnegative-integer?
  x : flonum? = 0.0
```

Creates a flvector with `size` elements, where every slot in the flvector is filled with `x`. For communication among places, the new flvector is allocated in the shared memory space.

Example:

```
> (make-shared-flvector 4 3.0)
(flvector 3.0 3.0 3.0 3.0)
```

4.3.4 Fixnums

```
(require racket/fixnum)
```
package: `base`

The `racket/fixnum` library provides operations like `fx+` that consume and produce only fixnums. The operations in this library are meant to be safe versions of unsafe operations like `unsafe-fx+`. These safe operations are generally no faster than using generic primitives like `+`.

The expected use of the `racket/fixnum` library is for code where the `require` of `racket/fixnum` is replaced with

See the documentation of `filtered-in` for use with `#lang racket/base`.

```
(require (filtered-in
          (λ (name)
            (and (regexp-match #rx"^unsafe-fx" name)
                 (regexp-replace #rx"unsafe-" name "")))
          racket/unsafe/ops))
```

to drop in unsafe versions of the library. Alternately, when encountering crashes with code that uses unsafe fixnum operations, use the `racket/fixnum` library to help debug the problems.

Fixnum Arithmetic

```
(fx+ a ...) → fixnum?
  a : fixnum?
```

```
(fx- a b ...) → fixnum?
  a : fixnum?
  b : fixnum?
(fx* a ...) → fixnum?
  a : fixnum?
(fxquotient a b) → fixnum?
  a : fixnum?
  b : fixnum?
(fxremainder a b) → fixnum?
  a : fixnum?
  b : fixnum?
(fxmodulo a b) → fixnum?
  a : fixnum?
  b : fixnum?
(fxabs a) → fixnum?
  a : fixnum?
```

Safe versions of `unsafe-fx+`, `unsafe-fx-`, `unsafe-fx*`, `unsafe-fxquotient`, `unsafe-fxremainder`, `unsafe-fxmodulo`, and `unsafe-fxabs`. The `exn:fail:contract:non-fixnum-result` exception is raised if the arithmetic result would not be a fixnum.

Changed in version 7.0.0.13 of package `base`: Allow zero or more arguments for `fx+` and `fx*` and one or more arguments for `fx-`.

```
(fxand a ...) → fixnum?
  a : fixnum?
(fxior a ...) → fixnum?
  a : fixnum?
(fxxor a ...) → fixnum?
  a : fixnum?
(fxnot a) → fixnum?
  a : fixnum?
(fxlshift a b) → fixnum?
  a : fixnum?
  b : fixnum?
(fxrshift a b) → fixnum?
  a : fixnum?
  b : fixnum?
```

Like `bitwise-and`, `bitwise-ior`, `bitwise-xor`, `bitwise-not`, and `arithmetic-shift`, but constrained to consume fixnums; the result is always a fixnum. The `unsafe-fxlshift` and `unsafe-fxrshift` operations correspond to `arithmetic-shift`, but require non-negative arguments; `unsafe-fxlshift` is a positive (i.e., left) shift, and `unsafe-fxrshift` is a negative (i.e., right) shift, where the number of bits to shift must be no more than the number of bits used to represent a fixnum. The `exn:fail:contract:non-fixnum-result` exception is raised if the arithmetic result would not be a fixnum.

Changed in version 7.0.0.13 of package `base`: Allow any number of arguments for `fxand`, `fxior`, and `fxxor`.

```
(fxpopcount a) → fixnum?
  a : (and/c fixnum? (not/c negative?))
(fxpopcount32 a) → fixnum?
  a : (and/c fixnum? (integer-in 0 #xFFFFFFFF))
(fxpopcount16 a) → fixnum?
  a : (and/c fixnum? (integer-in 0 #xFFFF))
```

Counts the number of bits in the two's complement representation of `a`. Depending on the platform, the `fxpopcount32` and `fxpopcount16` operations can be faster when the result is known to be no more than 32 or 16, respectively.

Added in version 8.5.0.7 of package `base`.

```
(fx+/wraparound a b) → fixnum?
  a : fixnum?
  b : fixnum?
(fx-/wraparound [a] b) → fixnum?
  a : fixnum? = 0
  b : fixnum?
(fx*/wraparound a b) → fixnum?
  a : fixnum?
  b : fixnum?
(fxlshift/wraparound a b) → fixnum?
  a : fixnum?
  b : fixnum?
```

Like `fx+`, `fx-`, `fx*`, and `fxlshift`, but a fixnum result is produced for any allowed arguments (i.e., for any fixnum argument, except that the second `fxlshift/wraparound` argument must be between 0 and the number of bits in a fixnum, inclusive). The result is produced by simply discarding bits that do not fit in a fixnum representation. The result is negative if the highest of the retained bits is set—even, for example, if the value was produced by adding two positive fixnums.

Added in version 7.9.0.6 of package `base`.
Changed in version 8.15.0.12: Changed `fx-/wraparound` to accept a single argument.

```
(fxrshift/logical a b) → fixnum?
  a : fixnum?
  b : fixnum?
```

Shifts the bits in `a` to the right by `b`, filling in with zeros. With the sign bit treated as just another bit, a logical right-shift of a negative-signed fixnum can produce a large positive fixnum. For example, `(fxrshift/logical -1 1)` produces `(most-positive-fixnum)`, illustrating that logical right-shift results are platform-dependent.

Examples:

```
> (fxrshift/logical 128 2)
32
> (fxrshift/logical 255 4)
15
> (= (fxrshift/logical -1 1) (most-positive-fixnum))
#t
```

Added in version 8.8.0.5 of package `base`.

```
(fx= a b ...) → boolean?
  a : fixnum?
  b : fixnum?
(fx< a b ...) → boolean?
  a : fixnum?
  b : fixnum?
(fx> a b ...) → boolean?
  a : fixnum?
  b : fixnum?
(fx<= a b ...) → boolean?
  a : fixnum?
  b : fixnum?
(fx>= a b ...) → boolean?
  a : fixnum?
  b : fixnum?
(fxmin a b ...) → fixnum?
  a : fixnum?
  b : fixnum?
(fxmax a b ...) → fixnum?
  a : fixnum?
  b : fixnum?
```

Like `=`, `<`, `>`, `<=`, `>=`, `min`, and `max`, but constrained to consume fixnums.

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(fx->fl a) → flonum?
  a : fixnum?
(fl->fx fl) → fixnum?
  fl : flonum?
```

Conversion between fixnums and flonums with truncation in the case of converting a flonum to a fixnum.

The `fx->fl` function is the same as `exact->inexact` or `->fl` constrained to a fixnum argument.

The `fl->fx` function is the same as `truncate` followed by `inexact->exact` or `fl->exact-integer` constrained to returning a fixnum. If the truncated flonum does not fit into a fixnum, the `exn:fail:contract` exception is raised.

Changed in version 7.7.0.8 of package `base`: Changed `fl->fx` to truncate.

```
(fixnum-for-every-system? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a fixnum and is represented by fixnum by every Racket implementation, `#f` otherwise.

Added in version 7.3.0.11 of package `base`.

Fixnum Vectors

A *fxvector* is like a vector, but it holds only fixnums. The only advantage of a fxvector over a vector is that a shared version can be created with functions like `shared-fxvector`.

Two fxvectors are `equal?` if they have the same length, and if the values in corresponding slots of the fxvectors are `equal?`.

A printed fxvector starts with `#fx(`, optionally with a number between the `#fx` and `(`. See §1.3.10 “Reading Vectors” for information on `read`ing fxvectors and §1.4.7 “Printing Vectors” for information on `print`ing fxvectors.

```
(fxvector? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a fxvector, `#f` otherwise.

```
(fxvector x ...) → fxvector?
  x : fixnum?
```

Creates a fxvector containing the given fixnums.

Example:

```
> (fxvector 2 3 4 5)
(fxvector 2 3 4 5)
```

```
(make-fxvector size [x]) → fxvector?
  size : exact-nonnegative-integer?
  x : fixnum? = 0
```

Creates a fxvector with *size* elements, where every slot in the fxvector is filled with *x*.

Example:

```
> (make-fxvector 4 3)
(fxvector 3 3 3 3)
```

```
(fxvector-length vec) → exact-nonnegative-integer?
  vec : fxvector?
```

Returns the length of `vec` (i.e., the number of slots in the fxvector).

```
(fxvector-ref vec pos) → fixnum?
  vec : fxvector?
  pos : exact-nonnegative-integer?
```

Returns the fixnum in slot `pos` of `vec`. The first slot is position `0`, and the last slot is one less than `(fxvector-length vec)`.

```
(fxvector-set! vec pos x) → fixnum?
  vec : fxvector?
  pos : exact-nonnegative-integer?
  x : fixnum?
```

Sets the fixnum in slot `pos` of `vec`. The first slot is position `0`, and the last slot is one less than `(fxvector-length vec)`.

```
(fxvector-copy vec [start end]) → fxvector?
  vec : fxvector?
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (vector-length v)
```

Creates a fresh fxvector of size `(- end start)`, with all of the elements of `vec` from `start` (inclusive) to `end` (exclusive).

```
(in-fxvector vec [start stop step]) → sequence?
  vec : fxvector?
  start : exact-nonnegative-integer? = 0
  stop : (or/c exact-integer? #f) = #f
  step : (and/c exact-integer? (not/c zero?)) = 1
```

Returns a sequence equivalent to `vec` when no optional arguments are supplied.

The optional arguments `start`, `stop`, and `step` are as in `in-vector`.

An `in-fxvector` application can provide better performance for fxvector iteration when it appears directly in a `for` clause.

```
(for/fxvector maybe-length (for-clause ...) body ...)
(for*/fxvector maybe-length (for-clause ...) body ...)

maybe-length =
             | #:length length-expr
             | #:length length-expr #:fill fill-expr

  length-expr : exact-nonnegative-integer?
  fill-expr : fixnum?
```

Like `for/vector` or `for*/vector`, but for fxvectors. The default *`fill-expr`* produces `0`.

```
(shared-fxvector x ...) → fxvector?
  x : fixnum?
```

Creates a fxvector containing the given fixnums. For communication among places, the new fxvector is allocated in the shared memory space.

Example:

```
> (shared-fxvector 2 3 4 5)
(fxvector 2 3 4 5)
```

```
(make-shared-fxvector size [x]) → fxvector?
  size : exact-nonnegative-integer?
  x : fixnum? = 0
```

Creates a fxvector with *`size`* elements, where every slot in the fxvector is filled with *`x`*. For communication among places, the new fxvector is allocated in the shared memory space.

Example:

```
> (make-shared-fxvector 4 3)
(fxvector 3 3 3 3)
```

Fixnum Range

```
(most-positive-fixnum) → fixnum?
(most-negative-fixnum) → fixnum?
```

Returns the largest-magnitude positive and negative fixnums. The values of `(most-positive-fixnum)` and `(most-negative-fixnum)` depend on the platform and virtual machine, but all fixnums are in the range `(most-negative-fixnum)` to `(most-positive-fixnum)` inclusive, and all exact integers in that range are fixnums.

Added in version 8.1.0.7 of package `base`.

4.3.5 Extflonums

```
(require racket/extflonum)
```
package: base

An *extflonum* is an extended-precision (80-bit) floating-point number. Extflonum arithmetic is supported on platforms with extended-precision hardware and where the extflonum implementation does not conflict with normal double-precision arithmetic (i.e., on x86 and x86_64 platforms when Racket is compiled to use SSE instructions for floating-point operations, and on Windows when `"longdouble.dll"` is available).

A extflonum is **not** a number in the sense of `number?`. Only extflonum-specific operations such as `extfl+` perform extflonum arithmetic.

A literal extflonum is written like an inexact number, but using an explicit `t` or `T` exponent marker (see §1.3.4 "Reading Extflonums"). For example, `3.5t0` is an extflonum. The extflonum values for infinity are `+inf.t` and `-inf.t`. The extflonum value for not-a-number is `+nan.t` or `-nan.t`.

If `(extflonum-available?)` produces `#f`, then all operations exported by `racket/extflonum` raise `exn:fail:unsupported`, except for `extflonum?`, `extflonum-available?`, and `extflvector?` (which always work). The reader (see §1.3 "The Reader") always accepts extflonum input; when extflonum operations are not supported, printing an extflonum from the reader uses its source notation (as opposed to normalizing the format).

Two extflonums are `equal?` along the same lines as flonums: when they are `extfl=` and have the same sign (which matters for `-0.0t0` and `+0.0t0`), or when they are both `+nan.t`. If extflonums are not supported on a platform, extflonums are `equal?` only if they are `eq?`.

```
(extflonum? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is an extflonum, `#f` otherwise.

```
(extflonum-available?) → boolean?
```

Returns `#t` if extflonum operations are supported on the current platform, `#f` otherwise.

Extflonum Arithmetic

```
(extfl+ a b) → extflonum?
  a : extflonum?
  b : extflonum?
(extfl- a b) → extflonum?
  a : extflonum?
  b : extflonum?
```

```
(extfl* a b) → extflonum?
  a : extflonum?
  b : extflonum?
(extfl/ a b) → extflonum?
  a : extflonum?
  b : extflonum?
(extflabs a) → extflonum?
  a : extflonum?
```

Like `fl+`, `fl-`, `fl*`, `fl/`, and `flabs`, but for extflonums.

```
(extfl= a b) → boolean?
  a : extflonum?
  b : extflonum?
(extfl< a b) → boolean?
  a : extflonum?
  b : extflonum?
(extfl> a b) → boolean?
  a : extflonum?
  b : extflonum?
(extfl<= a b) → boolean?
  a : extflonum?
  b : extflonum?
(extfl>= a b) → boolean?
  a : extflonum?
  b : extflonum?
(extflmin a b) → extflonum?
  a : extflonum?
  b : extflonum?
(extflmax a b) → extflonum?
  a : extflonum?
  b : extflonum?
```

Like `fl=`, `fl<`, `fl>`, `fl<=`, `fl>=`, `flmin`, and `flmax`, but for extflonums.

```
(extflround a) → extflonum?
  a : extflonum?
(extflfloor a) → extflonum?
  a : extflonum?
(extflceiling a) → extflonum?
  a : extflonum?
(extfltruncate a) → extflonum?
  a : extflonum?
```

Like `flround`, `flfloor`, `flceiling`, and `fltruncate`, but for extflonums.

```
(extflsin a) → extflonum?
  a : extflonum?
(extflcos a) → extflonum?
  a : extflonum?
(extfltan a) → extflonum?
  a : extflonum?
(extflasin a) → extflonum?
  a : extflonum?
(extflacos a) → extflonum?
  a : extflonum?
(extflatan a) → extflonum?
  a : extflonum?
(extfllog a) → extflonum?
  a : extflonum?
(extflexp a) → extflonum?
  a : extflonum?
(extflsqrt a) → extflonum?
  a : extflonum?
(extflexpt a b) → extflonum?
  a : extflonum?
  b : extflonum?
```

Like `flsin`, `flcos`, `fltan`, `flasin`, `flacos`, `flatan`, `fllog`, `flexp`, and `flsqrt`, and `flexpt`, but for extflonums.

```
(->extfl a) → extflonum?
  a : exact-integer?
(extfl->exact-integer a) → exact-integer?
  a : extflonum?
(real->extfl a) → extflonum?
  a : real?
(extfl->exact a) → (and/c real? exact?)
  a : extflonum?
(extfl->fx a) → fixnum?
  a : extflonum?
(fx->extfl a) → extflonum?
  a : fixnum?
(extfl->inexact a) → flonum?
  a : extflonum?
```

The first six are like `->fl`, `fl->exact-integer`, `real->double-flonum`, `inexact->exact`, `fl->fx`, and `fx->fl`, but for extflonums. The `extfl->inexact` function converts a extflonum to its closest flonum approximation.

Changed in version 7.7.0.8 of package `base`: Changed `extfl->fx` to truncate.

Extflonum Constants

```
pi.t : extflonum?
```

Like `pi`, but with 80 bits precision.

Extflonum Vectors

An *extflvector* is like an flvector, but it holds only extflonums. See also §17.4 "Unsafe Extflonum Operations".

Two extflvectors are `equal?` if they have the same length, and if the values in corresponding slots of the extflvectors are `equal?`.

```
(extflvector? v) → boolean?
  v : any/c
(extflvector x ...) → extflvector?
  x : extflonum?
(make-extflvector size [x]) → extflvector?
  size : exact-nonnegative-integer?
  x : extflonum? = 0.0t0
(extflvector-length vec) → exact-nonnegative-integer?
  vec : extflvector?
(extflvector-ref vec pos) → extflonum?
  vec : extflvector?
  pos : exact-nonnegative-integer?
(extflvector-set! vec pos x) → extflonum?
  vec : extflvector?
  pos : exact-nonnegative-integer?
  x : extflonum?
(extflvector-copy vec [start end]) → extflvector?
  vec : extflvector?
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (vector-length v)
```

Like `flvector?`, `flvector`, `make-flvector`, `flvector-length`, `flvector-ref`, `flvector-set`, and `flvector-copy`, but for extflvectors.

```
(in-extflvector vec [start stop step]) → sequence?
  vec : extflvector?
  start : exact-nonnegative-integer? = 0
  stop : (or/c exact-integer? #f) = #f
  step : (and/c exact-integer? (not/c zero?)) = 1
(for/extflvector maybe-length (for-clause ...) body ...)
```

```
(for*/extflvector maybe-length (for-clause ...) body ...)

maybe-length =
             | #:length length-expr
             | #:length length-expr #:fill fill-expr

  length-expr : exact-nonnegative-integer?
  fill-expr : extflonum?
```

Like `in-flvector`, `for/flvector`, and `for*/flvector`, but for extflvectors.

```
(shared-extflvector x ...) → extflvector?
  x : extflonum?
(make-shared-extflvector size [x]) → extflvector?
  size : exact-nonnegative-integer?
  x : extflonum? = 0.0t0
```

Like `shared-flvector` and `make-shared-flvector`, but for extflvectors.

Extflonum Byte Strings

```
(floating-point-bytes->extfl  bstr
                             [big-endian?
                              start
                              end])        → extflonum?
  bstr : bytes?
  big-endian? : any/c = (system-big-endian?)
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `floating-point-bytes->real`, but for extflonums: Converts the extended-precision floating-point number encoded in *bstr* from position *start* (inclusive) to *end* (exclusive) to an extflonum. The difference between *start* an *end* must be 10 bytes.

```
(extfl->floating-point-bytes  x
                             [big-endian?
                              dest-bstr
                              start])      → bytes?
  x : extflonum?
  big-endian? : any/c = (system-big-endian?)
  dest-bstr :  (and/c bytes? (not/c immutable?))
            = (make-bytes 10)
  start : exact-nonnegative-integer? = 0
```

Like `real->floating-point-bytes`, but for extflonums: Converts *x* to its representation in a byte string of length 10.

4.4 Strings

§3.4 "Strings (Unicode)" in *The Racket Guide* introduces strings.

A *string* is a fixed-length array of characters.

A string can be *mutable* or *immutable*. When an immutable string is provided to a procedure like `string-set!`, the `exn:fail:contract` exception is raised. String constants generated by the default reader (see §1.3.7 "Reading Strings") are immutable, and they are interned in `read-syntax` mode. Use `immutable?` to check whether a string is immutable.

Two strings are `equal?` when they have the same length and contain the same sequence of characters.

A string can be used as a single-valued sequence (see §4.17.1 "Sequences"). The characters of the string serve as elements of the sequence. See also `in-string`.

See §1.3.7 "Reading Strings" for information on `read`ing strings and §1.4.6 "Printing Strings" for information on `print`ing strings.

See also: `immutable?`, `symbol->string`, `bytes->string/utf-8`.

4.4.1 String Constructors, Selectors, and Mutators

```
(string? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a string, `#f` otherwise.

See also `immutable-string?` and `mutable-string?`.

Examples:

```
> (string? "Apple")
#t
> (string? 'apple)
#f
```

```
(make-string k [char]) → string?
  k : exact-nonnegative-integer?
  char : char? = #\nul
```

Returns a new mutable string of length *k* where each position in the string is initialized with the character *char*.

Example:

```
> (make-string 5 #\z)
"zzzzz"
```

```
(string char ...) → string?
  char : char?
```

Returns a new mutable string whose length is the number of provided *char*s, and whose positions are initialized with the given *char*s.

Example:

```
> (string #\A #\p #\p #\l #\e)
"Apple"
```

```
(string->immutable-string str) → (and/c string? immutable?)
  str : string?
```

Returns an immutable string with the same content as *str*, returning *str* itself if *str* is immutable.

Examples:

```
> (immutable? (string #\H #\e #\l #\l #\o))
#f
> (immutable? (string->immutable-string (string #\H #\e #\l #\l #\o)))
#t
```

```
(string-length str) → exact-nonnegative-integer?
  str : string?
```

Returns the length of *str*.

Example:

```
> (string-length "Apple")
5
```

```
(string-ref str k) → char?
  str : string?
  k : exact-nonnegative-integer?
```

Returns the character at position *k* in *str*. The first position in the string corresponds to `0`, so the position *k* must be less than the length of the string, otherwise the `exn:fail:contract` exception is raised.

Example:

```
> (string-ref "Apple" 0)
#\A
```

```
(string-set! str k char) → void?
  str : (and/c string? (not/c immutable?))
  k : exact-nonnegative-integer?
  char : char?
```

Changes the character position `k` in `str` to `char`. The first position in the string corresponds to `0`, so the position `k` must be less than the length of the string, otherwise the `exn:fail:contract` exception is raised.

Examples:

```
> (define s (string #\A #\p #\p #\l #\e))
> (string-set! s 4 #\y)
> s
"Apply"
```

```
(substring str start [end]) → string?
  str : string?
  start : exact-nonnegative-integer?
  end : exact-nonnegative-integer? = (string-length str)
```

Returns a new mutable string that is `(- end start)` characters long, and that contains the same characters as `str` from `start` inclusive to `end` exclusive. The first position in a string corresponds to `0`, so the `start` and `end` arguments must be less than or equal to the length of `str`, and `end` must be greater than or equal to `start`, otherwise the `exn:fail:contract` exception is raised.

Examples:

```
> (substring "Apple" 1 3)
"pp"
> (substring "Apple" 1)
"pple"
```

```
(string-copy str) → string?
  str : string?
```

Returns `(substring str 0)`.

Examples:

```
> (define s1 "Yui")
> (define pilot (string-copy s1))
> (list s1 pilot)
'("Yui" "Yui")
> (for ([i (in-naturals)] [ch '(#\R #\e #\i)])
    (string-set! pilot i ch))
> (list s1 pilot)
'("Yui" "Rei")
```

```
(string-copy! dest
              dest-start
              src
             [src-start
              src-end])  → void?
  dest : (and/c string? (not/c immutable?))
  dest-start : exact-nonnegative-integer?
  src : string?
  src-start : exact-nonnegative-integer? = 0
  src-end : exact-nonnegative-integer? = (string-length src)
```

Changes the characters of *dest* starting at position *dest-start* to match the characters in *src* from *src-start* (inclusive) to *src-end* (exclusive), where the first position in a string corresponds to 0. The strings *dest* and *src* can be the same string, and in that case the destination region can overlap with the source region; the destination characters after the copy match the source characters from before the copy. If any of *dest-start*, *src-start*, or *src-end* are out of range (taking into account the sizes of the strings and the source and destination regions), the `exn:fail:contract` exception is raised.

Examples:

```
> (define s (string #\A #\p #\p #\l #\e))
> (string-copy! s 4 "y")
> (string-copy! s 0 s 3 4)
> s
"lpply"
```

```
(string-fill! dest char) → void?
  dest : (and/c string? (not/c immutable?))
  char : char?
```

Changes *dest* so that every position in the string is filled with *char*.

Examples:

```
> (define s (string #\A #\p #\p #\l #\e))
```

```
> (string-fill! s #\q)
> s
"qqqqq"
```

```
(string-append str ...) → string?
  str : string?
```

Returns a new mutable string that is as long as the sum of the given *str*s' lengths, and that contains the concatenated characters of the given *str*s. If no *str*s are provided, the result is a zero-length string.

Example:

```
> (string-append "Apple" "Banana")
"AppleBanana"
```

```
(string-append-immutable str ...) → (and/c string? immutable?)
  str : string?
```

The same as `string-append`, but the result is an immutable string.

Examples:

```
> (string-append-immutable "Apple" "Banana")
"AppleBanana"
> (immutable? (string-append-immutable "A" "B"))
#t
```

Added in version 7.5.0.14 of package `base`.

```
(string->list str) → (listof char?)
  str : string?
```

Returns a new list of characters corresponding to the content of *str*. That is, the length of the list is `(string-length str)`, and the sequence of characters in *str* is the same sequence in the result list.

Example:

```
> (string->list "Apple")
'(#\A #\p #\p #\l #\e)
```

```
(list->string lst) → string?
  lst : (listof char?)
```

Returns a new mutable string whose content is the list of characters in `lst`. That is, the length of the string is `(length lst)`, and the sequence of characters in `lst` is the same sequence in the result string.

Example:

```
> (list->string (list #\A #\p #\p #\l #\e))
"Apple"
```

```
(build-string n proc) → string?
  n : exact-nonnegative-integer?
  proc : (exact-nonnegative-integer? . -> . char?)
```

Creates a string of `n` characters by applying `proc` to the integers from `0` to `(sub1 n)` in order. If `str` is the resulting string, then `(string-ref str i)` is the character produced by `(proc i)`.

Example:

```
> (build-string 5 (lambda (i) (integer->char (+ i 97))))
"abcde"
```

4.4.2 String Comparisons

```
(string=? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Returns `#t` if all of the arguments are `equal?`.

Examples:

```
> (string=? "Apple" "apple")
#f
> (string=? "a" "as" "a")
#f
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string<? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Returns `#t` if the arguments are lexicographically sorted increasing, where individual characters are ordered by `char<?`, `#f` otherwise.

Examples:

```
> (string<? "Apple" "apple")
#t
> (string<? "apple" "Apple")
#f
> (string<? "a" "b" "c")
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string<=? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string<?`, but checks whether the arguments are nondecreasing.

Examples:

```
> (string<=? "Apple" "apple")
#t
> (string<=? "apple" "Apple")
#f
> (string<=? "a" "b" "b")
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string>? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string<?`, but checks whether the arguments are decreasing.

Examples:

```
> (string>? "Apple" "apple")
#f
> (string>? "apple" "Apple")
#t
> (string>? "c" "b" "a")
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string>=? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string<?`, but checks whether the arguments are nonincreasing.

Examples:

```
> (string>=? "Apple" "apple")
#f
> (string>=? "apple" "Apple")
#t
> (string>=? "c" "b" "b")
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string-ci=? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Returns `#t` if all of the arguments are `equal?` after locale-insensitive case-folding via `string-foldcase`.

Examples:

```
> (string-ci=? "Apple" "apple")
#t
> (string-ci=? "a" "a" "a")
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string-ci<? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string<?`, but checks whether the arguments would be in increasing order if each was first case-folded using `string-foldcase` (which is locale-insensitive).

Examples:

```
> (string-ci<? "Apple" "apple")
```

```
#f
> (string-ci<? "apple" "banana")
#t
> (string-ci<? "a" "b" "c")
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string-ci<=? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string-ci<?`, but checks whether the arguments would be nondecreasing after case-folding.

Examples:

```
> (string-ci<=? "Apple" "apple")
#t
> (string-ci<=? "apple" "Apple")
#t
> (string-ci<=? "a" "b" "b")
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string-ci>? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string-ci<?`, but checks whether the arguments would be decreasing after case-folding.

Examples:

```
> (string-ci>? "Apple" "apple")
#f
> (string-ci>? "banana" "Apple")
#t
> (string-ci>? "c" "b" "a")
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string-ci>=? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string-ci<?`, but checks whether the arguments would be nonincreasing after case-folding.

Examples:

```
> (string-ci>=? "Apple" "apple")
#t
> (string-ci>=? "apple" "Apple")
#t
> (string-ci>=? "c" "b" "b")
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

4.4.3 String Conversions

```
(string-upcase str) → string?
  str : string?
```

Returns a string whose characters are the upcase conversion of the characters in *str*. The conversion uses Unicode's locale-independent conversion rules that map code-point sequences to code-point sequences (instead of simply mapping a 1-to-1 function on code points over the string), so the string produced by the conversion can be longer than the input string.

Examples:

```
> (string-upcase "abc!")
"ABC!"
> (string-upcase "Straße")
"STRASSE"
```

```
(string-downcase string) → string?
  string : string?
```

Like `string-upcase`, but the downcase conversion.

Examples:

```
> (string-downcase "aBC!")
"abc!"
> (string-downcase "Straße")
"straße"
> (string-downcase "ΚΑΟΣ")
"καος"
> (string-downcase "Σ")
"σ"
```

```
(string-titlecase string) → string?
  string : string?
```

Like `string-upcase`, but the titlecase conversion only for the first character in each sequence of cased characters in `str` (ignoring case-ignorable characters).

Examples:

```
> (string-titlecase "aBC  twO")
"Abc  Two"
> (string-titlecase "y2k")
"Y2k"
> (string-titlecase "main straße")
"Main Straße"
> (string-titlecase "stra ße")
"Stra Sse"
```

```
(string-foldcase string) → string?
  string : string?
```

Like `string-upcase`, but the case-folding conversion.

Examples:

```
> (string-foldcase "aBC!")
"abc!"
> (string-foldcase "Straße")
"strasse"
> (string-foldcase "ΚΑΟΣ")
"καοσ"
```

```
(string-normalize-nfd string) → string?
  string : string?
```

Returns a string that is the Unicode normalized form D of *string*. If the given string is already in the corresponding Unicode normal form, the string may be returned directly as the result (instead of a newly allocated string).

Example:

```
> (equal? (string-normalize-nfd "Ç") "Ç")
#t
```

```
(string-normalize-nfkd string) → string?
  string : string?
```

Like `string-normalize-nfd`, but for normalized form KD.

Example:

```
> (equal? (string-normalize-nfkd "ℌ") "H")
#t
```

```
(string-normalize-nfc string) → string?
  string : string?
```

Like `string-normalize-nfd`, but for normalized form C.

Example:

```
> (equal? (string-normalize-nfc "Ç") "Ç")
#t
```

```
(string-normalize-nfkc string) → string?
  string : string?
```

Like `string-normalize-nfd`, but for normalized form KC.

Example:

```
> (equal? (string-normalize-nfkc "ℋ̧") "Ḩ")
#t
```

4.4.4 Locale-Specific String Operations

```
(string-locale=? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string=?`, but the strings are compared in a locale-specific way, based on the value of `current-locale`. See §13.1.1 “Encodings and Locales” for more information on locales.

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string-locale<? str1 str2 ...+) → boolean?
  str1 : string?
  str2 : string?
```

Like `string<?`, but the sort order compares strings in a locale-specific way, based on the value of `current-locale`. In particular, the sort order may not be simply a lexicographic extension of character ordering.

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string-locale>? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string>?`, but locale-specific like `string-locale<?`.

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string-locale-ci=? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string-locale=?`, but strings are compared using rules that are both locale-specific and case-insensitive (depending on what "case-insensitive" means for the current locale).

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string-locale-ci<? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string<?`, but both locale-sensitive and case-insensitive like `string-locale-ci=?`.

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string-locale-ci>? str1 str2 ...) → boolean?
  str1 : string?
  str2 : string?
```

Like `string>?`, but both locale-sensitive and case-insensitive like `string-locale-ci=?`.

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(string-locale-upcase string) → string?
  string : string?
```

Like `string-upcase`, but using locale-specific case-conversion rules based on the value of `current-locale`.

```
(string-locale-downcase string) → string?
  string : string?
```

Like `string-downcase`, but using locale-specific case-conversion rules based on the value of `current-locale`.

4.4.5 String Grapheme Clusters

```
(string-grapheme-span str start [end]) → exact-nonnegative-integer?
  str : string?
  start : exact-nonnegative-integer?
  end : exact-nonnegative-integer? = (string-length str)
```

Returns the number of characters (i.e., code points) in the string that form a Unicode grapheme cluster starting at `start`, assuming that `start` is the start of a grapheme cluster and extending no further than the character before `end`. The result is `0` if `start` equals `end`.

The `start` and `end` arguments must be valid indices as for `substring`, otherwise the `exn:fail:contract` exception is raised.

See also `char-grapheme-cluster-step`.

Examples:

```
> (string-grapheme-span "" 0)
0
> (string-grapheme-span "a" 0)
1
> (string-grapheme-span "ab" 0)
1
> (string-grapheme-span "\r\n" 0)
2
> (string-grapheme-span "\r\nx" 0)
2
> (string-grapheme-span "\r\nx" 2)
1
> (string-grapheme-span "\r\nx" 0 1)
1
```

Added in version 8.6.0.2 of package `base`.

```
(string-grapheme-count str start [end])
 → exact-nonnegative-integer?
  str : string?
  start : exact-nonnegative-integer?
  end : exact-nonnegative-integer? = (string-length str)
```

Returns the number of grapheme clusters in `(substring str start end)`.

The `start` and `end` arguments must be valid indices as for `substring`, otherwise the `exn:fail:contract` exception is raised.

Examples:

```
> (string-grapheme-count "")
0
> (string-grapheme-count "a")
1
> (string-grapheme-count "ab")
2
> (string-grapheme-count "ab" 0 2)
2
> (string-grapheme-count "ab" 0 1)
1
> (string-grapheme-count "\r\n")
1
> (string-grapheme-count "a\r\nb")
3
```

Added in version 8.6.0.2 of package base.

4.4.6 Additional String Functions

```
(require racket/string)        package: base
```

The bindings documented in this section are provided by the `racket/string` and `racket` libraries, but not `racket/base`.

```
(string-append* str ... strs) → string?
  str : string?
  strs : (listof string?)
```

Like `string-append`, but the last argument is used as a list of arguments for `string-append`, so `(string-append* str ... strs)` is the same as `(apply string-append str ... strs)`. In other words, the relationship between `string-append` and `string-append*` is similar to the one between `list` and `list*`.

Examples:

```
> (string-append* "a" "b" '("c" "d"))
"abcd"
> (string-append* (cdr (append* (map (lambda (x) (list ", " x))
                                     '("Alpha" "Beta" "Gamma")))))
"Alpha, Beta, Gamma"
```

```
(string-join strs
            [sep
             #:before-first before-first
             #:before-last before-last
             #:after-last after-last])   → string?
```

```
strs : (listof string?)
sep : string? = " "
before-first : string? = ""
before-last : string? = sep
after-last : string? = ""
```

Appends the strings in `strs`, inserting `sep` between each pair of strings in `strs`. `before-last`, `before-first`, and `after-last` are analogous to the inputs of `add-between`: they specify an alternate separator between the last two strings, a prefix string, and a suffix string respectively.

Examples:

```
> (string-join '("one" "two" "three" "four"))
"one two three four"
> (string-join '("one" "two" "three" "four") ", ")
"one, two, three, four"
> (string-join '("one" "two" "three" "four") " potato ")
"one potato two potato three potato four"
> (string-join '("x" "y" "z") ", "
               #:before-first "Todo: "
               #:before-last " and "
               #:after-last ".")
"Todo: x, y and z."
```

```
(string-normalize-spaces  str
                         [sep
                          space
                          #:trim? trim?
                          #:repeat? repeat?]) → string?
  str : string?
  sep : (or/c string? regexp?) = #px"\\s+"
  space : string? = " "
  trim? : any/c = #t
  repeat? : any/c = #f
```

Normalizes spaces in the input `str` by trimming it (using `string-trim` and `sep`) and replacing all whitespace sequences in the result with `space`, which defaults to a single space.

Example:

```
> (string-normalize-spaces "  foo bar  baz \r\n\t")
"foo bar baz"
```

The result of `(string-normalize-spaces str sep space)` is the same as `(string-join (string-split str sep ....) space)`.

```
(string-replace str from to [#:all? all?]) → string?
  str : string?
  from : (or/c string? regexp?)
  to : string?
  all? : any/c = #t
```

Returns *str* with all occurrences of *from* replaced with by *to*. If *from* is a string, it is matched literally (as opposed to being used as a regular expression).

By default, all occurrences are replaced, but only the first match is replaced if *all?* is `#f`.

Example:

```
> (string-replace "foo bar baz" "bar" "blah")
"foo blah baz"
```

```
(string-split  str
              [sep
               #:trim? trim?
               #:repeat? repeat?]) → (listof string?)
  str : string?
  sep : (or/c string? regexp?) = #px"\\s+"
  trim? : any/c = #t
  repeat? : any/c = #f
```

Splits the input *str* on *sep*, returning a list of substrings of *str* that are separated by *sep*, defaulting to splitting the input on whitespaces. The input is first trimmed using *sep* (see `string-trim`), unless *trim?* is `#f`. Empty matches are handled in the same way as for `regexp-split`. As a special case, if *str* is the empty string after trimming, the result is `'()` instead of `'("")`.

Like `string-trim`, provide *sep* to use a different separator, and *repeat?* controls matching repeated sequences.

Examples:

```
> (string-split "  foo bar  baz \r\n\t")
'("foo" "bar" "baz")
> (string-split "  ")
'()
> (string-split "  " #:trim? #f)
'("" "")
```

```
(string-trim str
             [sep
              #:left? left?
              #:right? right?
              #:repeat? repeat?]) → string?
  str : string?
  sep : (or/c string? regexp?) = #px"\\s+"
  left? : any/c = #t
  right? : any/c = #t
  repeat? : any/c = #f
```

Trims the input *str* by removing prefix and suffix *sep*, which defaults to whitespace. A string *sep* is matched literally (as opposed to being used as a regular expression).

Use `#:left? #f` or `#:right? #f` to suppress trimming the corresponding side. When *repeat?* is `#f` (the default), only one match is removed from each side; when *repeat?* is true, all initial or trailing matches are trimmed (which is an alternative to using a regular expression *sep* that contains `+`).

Examples:

```
> (string-trim "  foo bar  baz \r\n\t")
"foo bar  baz"
> (string-trim "  foo bar  baz \r\n\t" " " #:repeat? #t)
"foo bar  baz \r\n\t"
> (string-trim "aaaxaayaa" "aa")
"axaay"
```

```
(non-empty-string? x) → boolean?
  x : any/c
```

Returns `#t` if *x* is a string and is not empty; returns `#f` otherwise.

Added in version 6.3 of package `base`.

```
(string-find s contained) → (or/c exact-nonnegative-integer? #f)
  s : string?
  contained : string?
(string-contains? s contained) → boolean?
  s : string?
  contained : string?
(string-prefix? s prefix) → boolean?
  s : string?
  prefix : string?
(string-suffix? s suffix) → boolean?
  s : string?
  suffix : string?
```

Checks whether *s* includes at any location, starts with, or ends with the second argument, respectively. The `string-find` function returns the first position within *s* where *contained* is found, if any, while `string-contains?` reports only whether it was found.

Examples:

```
> (string-prefix? "Racket" "R")
#t
> (string-prefix? "Jacket" "R")
#f
> (string-suffix? "Racket" "et")
#t
> (string-find "Racket" "ack")
1
> (string-contains? "Racket" "ack")
#t
```

Added in version 6.3 of package `base`.
Changed in version 8.15.0.7: Added `string-find`.

4.4.7 Converting Values to Strings

```
(require racket/format)      package: base
```

The bindings documented in this section are provided by the `racket/format` and `racket` libraries, but not `racket/base`.

The `racket/format` library provides functions for converting Racket values to strings. In addition to features like padding and numeric formatting, the functions have the virtue of being shorter than `format` (with format string), `number->string`, or `string-append`.

```
(~a v
    ...
   [#:separator separator
    #:width width
    #:max-width max-width
    #:min-width min-width
    #:limit-marker limit-marker
    #:limit-prefix? limit-prefix?
    #:align align
    #:pad-string pad-string
    #:left-pad-string left-pad-string
    #:right-pad-string right-pad-string]) → string?
  v : any/c
  separator : string? = ""
```

```
width : (or/c exact-nonnegative-integer? #f) = #f
max-width : (or/c exact-nonnegative-integer? +inf.0)
          = (or width +inf.0)
min-width : exact-nonnegative-integer? = (or width 0)
limit-marker : string? = ""
limit-prefix? : boolean? = #f
align : (or/c 'left 'center 'right) = 'left
pad-string : non-empty-string? = " "
left-pad-string : non-empty-string? = pad-string
right-pad-string : non-empty-string? = pad-string
```

Converts each *v* to a string in `display` mode—that is, like `(format "~a" v)`—then concatenates the results with *separator* between consecutive items, and then pads or truncates the string to be at least *min-width* characters and at most *max-width* characters.

Examples:

```
> (~a "north")
"north"
> (~a 'south)
"south"
> (~a #"east")
"east"
> (~a #\w "e" 'st)
"west"
> (~a (list "red" 'green #"blue"))
"(red green blue)"
> (~a 17)
"17"
> (~a #e1e20)
"100000000000000000000"
> (~a pi)
"3.141592653589793"
> (~a (expt 6.1 87))
"2.1071509386211452e+68"
```

The `~a` function is primarily useful for strings, numbers, and other atomic data. The `~v` and `~s` functions are better suited to compound data.

Let *s* be the concatenated string forms of the *v*s plus separators. If *s* is longer than *max-width* characters, it is truncated to exactly *max-width* characters. If *s* is shorter than *min-width* characters, it is padded to exactly *min-width* characters. Otherwise *s* is returned unchanged. If *min-width* is greater than *max-width*, an exception is raised.

If *s* is longer than *max-width* characters, it is truncated and the end of the string is replaced with *limit-marker*. If *limit-marker* is longer than *max-width*, an exception is raised.

If *limit-prefix?* is `#t`, the beginning of the string is truncated instead of the end.

Examples:

```
> (~a "abcde" #:max-width 5)
"abcde"
> (~a "abcde" #:max-width 4)
"abcd"
> (~a "abcde" #:max-width 4 #:limit-marker "*")
"abc*"
> (~a "abcde" #:max-width 4 #:limit-marker "...")
"a..."
> (~a "The quick brown fox" #:max-width 15 #:limit-marker "")
"The quick brown"
> (~a "The quick brown fox" #:max-width 15 #:limit-marker "...")
"The quick br..."
> (~a "The quick brown fox" #:max-width 15 #:limit-
marker "..." #:limit-prefix? #f)
"The quick br..."
```

If *s* is shorter than *min-width*, it is padded to at least *min-width* characters. If *align* is `'left`, then only right padding is added; if *align* is `'right`, then only left padding is added; and if *align* is `'center`, then roughly equal amounts of left padding and right padding are added.

Padding is specified as a non-empty string. Left padding consists of *left-pad-string* repeated in its entirety as many times as possible followed by a *prefix* of *left-pad-string* to fill the remaining space. In contrast, right padding consists of a *suffix* of *right-pad-string* followed by a number of copies of *right-pad-string* in its entirety. Thus left padding starts with the start of *left-pad-string* and right padding ends with the end of *right-pad-string*.

Examples:

```
> (~a "apple" #:min-width 20 #:align 'left)
"apple               "
> (~a "pear" #:min-width 20 #:align 'left #:right-pad-string " .")
"pear . . . . . . . ."
> (~a "plum" #:min-width 20 #:align 'right #:left-pad-string ". ")
". . . . . . . . plum"
> (~a "orange" #:min-width 20 #:align 'center
                #:left-pad-string "- " #:right-pad-string " -")
"- - - -orange- - - -"
```

Use *width* to set both *max-width* and *min-width* simultaneously, ensuring that the resulting string is exactly *width* characters long:

```
> (~a "terse" #:width 6)
"terse "
> (~a "loquacious" #:width 6)
"loquac"
```

```
(~v v
    ...
   [#:separator separator
    #:width width
    #:max-width max-width
    #:min-width min-width
    #:limit-marker limit-marker
    #:limit-prefix? limit-prefix?
    #:align align
    #:pad-string pad-string
    #:left-pad-string left-pad-string
    #:right-pad-string right-pad-string]) → string?
  v : any/c
  separator : string? = " "
  width : (or/c exact-nonnegative-integer? #f) = #f
  max-width : (or/c exact-nonnegative-integer? +inf.0)
            = (or width +inf.0)
  min-width : exact-nonnegative-integer? = (or width 0)
  limit-marker : string? = "..."
  limit-prefix? : boolean? = #f
  align : (or/c 'left 'center 'right) = 'left
  pad-string : non-empty-string? = " "
  left-pad-string : non-empty-string? = pad-string
  right-pad-string : non-empty-string? = pad-string
```

Like `~a`, but each value is converted like `(format "~v" v)`, the default separator is `" "`, and the default limit marker is `"..."`.

Examples:

```
> (~v "north")
"\"north\""
> (~v 'south)
"'south"
> (~v #"east")
"#\"east\""
> (~v #\w)
"#\\w"
> (~v (list "red" 'green #"blue"))
"'(\"red\" green #\"blue\")"
```

Use `~v` to produce text that talks about Racket values.

Example:

```
> (let ([nums (for/list ([i 10]) i)])
    (~a "The even numbers in " (~v nums)
        " are " (~v (filter even? nums)) "."))
"The even numbers in '(0 1 2 3 4 5 6 7 8 9) are '(0 2 4 6 8)."
```

```
(~s  v
     ...
    [#:separator separator
     #:width width
     #:max-width max-width
     #:min-width min-width
     #:limit-marker limit-marker
     #:limit-prefix? limit-prefix?
     #:align align
     #:pad-string pad-string
     #:left-pad-string left-pad-string
     #:right-pad-string right-pad-string]) → string?
  v : any/c
  separator : string? = " "
  width : (or/c exact-nonnegative-integer? #f) = #f
  max-width :  (or/c exact-nonnegative-integer? +inf.0)
            = (or width +inf.0)
  min-width : exact-nonnegative-integer? = (or width 0)
  limit-marker : string? = "..."
  limit-prefix? : boolean? = #f
  align : (or/c 'left 'center 'right) = 'left
  pad-string : non-empty-string? = " "
  left-pad-string : non-empty-string? = pad-string
  right-pad-string : non-empty-string? = pad-string
```

Like `~a`, but each value is converted like `(format "~s" v)`, the default separator is `" "`, and the default limit marker is `"..."`.

Examples:

```
> (~s "north")
"\"north\""
> (~s 'south)
"south"
> (~s #"east")
"#\"east\""
> (~s #\w)
```

```
"#\\w"
> (~s (list "red" 'green #"blue"))
"(\"red\" green #\"blue\")"
```

```
(~e  v
     ...
    [#:separator separator
     #:width width
     #:max-width max-width
     #:min-width min-width
     #:limit-marker limit-marker
     #:limit-prefix? limit-prefix?
     #:align align
     #:pad-string pad-string
     #:left-pad-string left-pad-string
     #:right-pad-string right-pad-string]) → string?
  v : any/c
  separator : string? = " "
  width : (or/c exact-nonnegative-integer? #f) = #f
  max-width : (or/c exact-nonnegative-integer? +inf.0)
            = (or width +inf.0)
  min-width : exact-nonnegative-integer? = (or width 0)
  limit-marker : string? = "..."
  limit-prefix? : boolean? = #f
  align : (or/c 'left 'center 'right) = 'left
  pad-string : non-empty-string? = " "
  left-pad-string : non-empty-string? = pad-string
  right-pad-string : non-empty-string? = pad-string
```

Like `~a`, but each value is converted like `(format "~e" v)`, the default separator is `" "`, and the default limit marker is `"..."`.

Examples:

```
> (~e "north")
"\"north\""
> (~e 'south)
"'south"
> (~e #"east")
"#\"east\""
> (~e #\w)
"#\\w"
> (~e (list "red" 'green #"blue"))
"'(\"red\" green #\"blue\")"
```

```
(~r x
   [#:sign sign
    #:base base
    #:precision precision
    #:notation notation
    #:format-exponent format-exponent
    #:min-width min-width
    #:pad-string pad-string
    #:groups groups
    #:group-sep group-sep
    #:decimal-sep decimal-sep])        → string?
  x : rational?
  sign : (or/c #f '+ '++ 'parens
               (let ([ind (or/c string? (list/c string? string?))])
                 (list/c ind ind ind)))
       = #f
  base : (or/c (integer-in 2 36) (list/c 'up (integer-in 2 36)))
       = 10
  precision : (or/c exact-nonnegative-integer?              = 6
                    (list/c '= exact-nonnegative-integer?))
  notation : (or/c 'positional 'exponential
                   (-> rational? (or/c 'positional 'exponential)))
           = 'positional
  format-exponent : (or/c #f string? (-> exact-integer? string?))
                  = #f
  min-width : exact-positive-integer? = 1
  pad-string : non-empty-string? = " "
  groups : (non-empty-listof exact-positive-integer?) = '(3)
  group-sep : string? = ""
  decimal-sep : string? = "."
```

Converts the rational number *x* to a string in either positional or exponential notation, depending on *notation*. The exactness or inexactness of *x* does not affect its formatting.

The optional arguments control number formatting:

- *notation* — determines whether the number is printed in positional or exponential notation. If *notation* is a function, it is applied to *x* to get the notation to be used.

  Examples:

  ```
  > (~r 12345)
  "12345"
  > (~r 12345 #:notation 'exponential)
  "1.2345e+04"
  ```

```
> (let ([pick-notation
         (lambda (x)
           (if (or (< (abs x) 0.001) (> (abs x) 1000))
               'exponential
               'positional))])
    (for/list ([i (in-range 1 5)])
      (~r (expt 17 i) #:notation pick-notation)))
'("17" "289" "4.913e+03" "8.3521e+04")
```

- *precision* — controls the number of digits after the decimal point (or more accurately, the radix point). When *x* is formatted in exponential form, *precision* applies to the significand.

  If *precision* is a natural number, then up to *precision* digits are displayed, but trailing zeroes are dropped, and if all digits after the decimal point are dropped the decimal point is also dropped. If *precision* is `(list '= digits)`, then exactly *digits* digits after the decimal point are used, and the decimal point is never dropped.

  Examples:

  ```
  > (~r pi)
  "3.141593"
  > (~r pi #:precision 4)
  "3.1416"
  > (~r pi #:precision 0)
  "3"
  > (~r 1.5 #:precision 4)
  "1.5"
  > (~r 1.5 #:precision '(= 4))
  "1.5000"
  > (~r 50 #:precision 2)
  "50"
  > (~r 50 #:precision '(= 2))
  "50.00"
  > (~r 50 #:precision '(= 0))
  "50."
  ```

- *decimal-sep* specifies what decimal separator is printed.

  Examples:

  ```
  > (~r 123.456)
  "123.456"
  > (~r 123.456 #:decimal-sep ",")
  "123,456"
  ```

- *groups* controls how digits of the integral part of the number are separated into groups. Rightmost numbers of *groups* are used to group rightmost digits of the integral part. The leftmost number of *groups* is used repeatedly to group leftmost digits. The *group-sep* argument specifies which separator to use between digit groups.

Examples:

```
> (~r 1234567890 #:groups '(3) #:group-sep ",")
"1,234,567,890"
> (~r 1234567890 #:groups '(3 2) #:group-sep ",")
"12,345,678,90"
> (~r 1234567890 #:groups '(1 3 2) #:group-sep "_")
"1_2_3_4_5_678_90"
```

- *min-width* — if *x* would normally be printed with fewer than *min-width* digits (including the decimal point but not including the sign indicator), the digits are left-padded using *pad-string*.

  Examples:

```
> (~r 17)
"17"
> (~r 17 #:min-width 4)
"  17"
> (~r -42 #:min-width 4)
"-  42"
> (~r 1.5 #:min-width 4)
" 1.5"
> (~r 1.5 #:precision 4 #:min-width 10)
"       1.5"
> (~r 1.5 #:precision '(= 4) #:min-width 10)
"    1.5000"
> (~r #e1e10 #:min-width 6)
"10000000000"
```

- *pad-string* — specifies the string used to pad the number to at least *min-width* characters (not including the sign indicator). The padding is placed between the sign and the normal digits of *x*.

  Examples:

```
> (~r 17 #:min-width 4 #:pad-string "0")
"0017"
> (~r -42 #:min-width 4 #:pad-string "0")
"-0042"
```

- *sign* — controls how the sign of the number is indicated:

  - If *sign* is #f (the default), no sign output is generated if *x* is either positive or zero, and a minus sign is prefixed if *x* is negative.

    Example:

```
> (for/list ([x '(17 0 -42)]) (~r x))
'("17" "0" "-42")
```

- If *sign* is `'+`, no sign output is generated if *x* is zero, a plus sign is prefixed if *x* is positive, and a minus sign is prefixed if *x* is negative.

  Example:

  ```
  > (for/list ([x '(17 0 -42)]) (~r x #:sign '+))
  '("+17" "0" "-42")
  ```

- If *sign* is `'++`, a plus sign is prefixed if *x* is zero or positive, and a minus sign is prefixed if *x* is negative.

  Example:

  ```
  > (for/list ([x '(17 0 -42)]) (~r x #:sign '++))
  '("+17" "+0" "-42")
  ```

- If *sign* is `'parens`, no sign output is generated if *x* is zero or positive, and the number is enclosed in parentheses if *x* is negative.

  Example:

  ```
  > (for/list ([x '(17 0 -42)]) (~r x #:sign 'parens))
  '("17" "0" "(42)")
  ```

- If *sign* is `(list pos-ind zero-ind neg-ind)`, then *pos-ind*, *zero-ind*, and *neg-ind* are used to indicate positive, zero, and negative numbers, respectively. Each indicator is either a string to be used as a prefix or a list containing two strings: a prefix and a suffix.

  Example:

  ```
  > (let ([sign-table '(("" " up") "an even " ("" "
  down"))])
      (for/list ([x '(17 0 -42)]) (~r x #:sign sign-
  table)))
  '("17 up" "an even 0" "42 down")
  ```

  The default behavior is equivalent to `'("" "" "-")`; the `'parens` mode is equivalent to `'("" "" ("(" ")"))`.

- *base* — controls the base that *x* is formatted in. If *base* is a number greater than `10`, then lower-case letters are used. If *base* is `(list 'up base*)` and *base** is greater than `10`, then upper-case letters are used.

  Examples:

  ```
  > (~r 100 #:base 7)
  "202"
  > (~r 4.5 #:base 2)
  "100.1"
  > (~r 3735928559 #:base 16)
  ```

```
"deadbeef"
> (~r 3735928559 #:base '(up 16))
"DEADBEEF"
> (~r 3735928559 #:base '(up 16) #:notation 'exponential)
"D.EADBEF*16^+07"
```

- *format-exponent* — determines how the exponent is displayed.

  If *format-exponent* is a string, the exponent is displayed with an explicit sign (as with a *sign* of '++) and at least two digits, separated from the significand by the "exponent marker" *format-exponent*:

  ```
  > (~r 1234 #:notation 'exponential #:format-exponent "E")
  "1.234E+03"
  ```

  If *format-exponent* is #f, the "exponent marker" is "e" if *base* is 10 and a string involving *base* otherwise:

  ```
  > (~r 1234 #:notation 'exponential)
  "1.234e+03"
  > (~r 1234 #:notation 'exponential #:base 8)
  "2.322*8^+03"
  ```

  If *format-exponent* is a procedure, it is applied to the exponent and the resulting string is appended to the significand:

  ```
  > (~r 1234 #:notation 'exponential
            #:format-exponent (lambda (e) (format "E~a" e)))
  "1.234E3"
  ```

Changed in version 8.5.0.5 of package base: Added #:groups, #:group-sep and #:decimal-sep.

```
(~.a v
     ...
    [#:separator separator
     #:width width
     #:max-width max-width
     #:min-width min-width
     #:limit-marker limit-marker
     #:limit-prefix? limit-prefix?
     #:align align
     #:pad-string pad-string
     #:left-pad-string left-pad-string
     #:right-pad-string right-pad-string]) → string?
  v : any/c
  separator : string? = ""
  width : (or/c exact-nonnegative-integer? #f) = #f
  max-width : (or/c exact-nonnegative-integer? +inf.0)
            = (or width +inf.0)
  min-width : exact-nonnegative-integer? = (or width 0)
  limit-marker : string? = ""
  limit-prefix? : boolean? = #f
  align : (or/c 'left 'center 'right) = 'left
  pad-string : non-empty-string? = " "
  left-pad-string : non-empty-string? = pad-string
  right-pad-string : non-empty-string? = pad-string
```

```
(~.v  v
      ...
     [#:separator separator
      #:width width
      #:max-width max-width
      #:min-width min-width
      #:limit-marker limit-marker
      #:limit-prefix? limit-prefix?
      #:align align
      #:pad-string pad-string
      #:left-pad-string left-pad-string
      #:right-pad-string right-pad-string]) → string?
  v : any/c
  separator : string? = " "
  width : (or/c exact-nonnegative-integer? #f) = #f
  max-width : (or/c exact-nonnegative-integer? +inf.0)
            = (or width +inf.0)
  min-width : exact-nonnegative-integer? = (or width 0)
  limit-marker : string? = "..."
  limit-prefix? : boolean? = #f
  align : (or/c 'left 'center 'right) = 'left
  pad-string : non-empty-string? = " "
  left-pad-string : non-empty-string? = pad-string
  right-pad-string : non-empty-string? = pad-string
```

```
(~.s v
     ...
    [#:separator separator
     #:width width
     #:max-width max-width
     #:min-width min-width
     #:limit-marker limit-marker
     #:limit-prefix? limit-prefix?
     #:align align
     #:pad-string pad-string
     #:left-pad-string left-pad-string
     #:right-pad-string right-pad-string]) → string?
  v : any/c
  separator : string? = " "
  width : (or/c exact-nonnegative-integer? #f) = #f
  max-width : (or/c exact-nonnegative-integer? +inf.0)
            = (or width +inf.0)
  min-width : exact-nonnegative-integer? = (or width 0)
  limit-marker : string? = "..."
  limit-prefix? : boolean? = #f
  align : (or/c 'left 'center 'right) = 'left
  pad-string : non-empty-string? = " "
  left-pad-string : non-empty-string? = pad-string
  right-pad-string : non-empty-string? = pad-string
```

Like `~a`, `~v`, and `~s`, but each *v* is formatted like `(format "~.a" v)`, `(format "~.v" v)`, and `(format "~.s" v)`, respectively.

4.5 Byte Strings

§3.5 "Bytes and Byte Strings" in *The Racket Guide* introduces byte strings.

A *byte string* is a fixed-length array of bytes. A *byte* is an exact integer between `0` and `255` inclusive.

A byte string can be *mutable* or *immutable*. When an immutable byte string is provided to a procedure like `bytes-set!`, the `exn:fail:contract` exception is raised. Byte-string constants generated by the default reader (see §1.3.7 "Reading Strings") are immutable, and they are interned in `read-syntax` mode. Use `immutable?` to check whether a byte string is immutable.

Two byte strings are `equal?` when they have the same length and contain the same sequence of bytes.

A byte string can be used as a single-valued sequence (see §4.17.1 "Sequences"). The bytes of the string serve as elements of the sequence. See also `in-bytes`.

See §1.3.7 "Reading Strings" for information on reading byte strings and §1.4.6 "Printing Strings" for information on printing byte strings.

See also: `immutable?`.

4.5.1 Byte String Constructors, Selectors, and Mutators

```
(bytes? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a byte string, `#f` otherwise.

See also `immutable-bytes?` and `mutable-bytes?`.

Examples:

```
> (bytes? #"Apple")
#t
> (bytes? "Apple")
#f
```

```
(make-bytes k [b]) → bytes?
  k : exact-nonnegative-integer?
  b : byte? = 0
```

Returns a new mutable byte string of length *k* where each position in the byte string is initialized with the byte *b*.

Example:

```
> (make-bytes 5 65)
#"AAAAA"
```

```
(bytes b ...) → bytes?
  b : byte?
```

Returns a new mutable byte string whose length is the number of provided *b*s, and whose positions are initialized with the given *b*s.

Example:

```
> (bytes 65 112 112 108 101)
#"Apple"
```

```
(bytes->immutable-bytes bstr) → (and/c bytes? immutable?)
  bstr : bytes?
```

Returns an immutable byte string with the same content as *bstr*, returning *bstr* itself if *bstr* is immutable.

Examples:

```
> (bytes->immutable-bytes (bytes 65 65 65))
#"AAA"
> (define b (bytes->immutable-bytes (make-bytes 5 65)))
> (bytes->immutable-bytes b)
#"AAAAA"
> (eq? (bytes->immutable-bytes b) b)
#t
```

```
(byte? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a byte (i.e., an exact integer between `0` and `255` inclusive), `#f` otherwise.

Examples:

```
> (byte? 65)
#t
> (byte? 0)
#t
> (byte? 256)
#f
> (byte? -1)
#f
```

```
(bytes-length bstr) → exact-nonnegative-integer?
  bstr : bytes?
```

Returns the length of *bstr*.

Example:

```
> (bytes-length #"Apple")
5
```

```
(bytes-ref bstr k) → byte?
  bstr : bytes?
  k : exact-nonnegative-integer?
```

Returns the byte at position *k* in *bstr*. The first position in the bytes corresponds to 0, so the position *k* must be less than the length of the bytes, otherwise the `exn:fail:contract` exception is raised.

Example:

```
> (bytes-ref #"Apple" 0)
65
```

```
(bytes-set! bstr k b) → void?
  bstr : (and/c bytes? (not/c immutable?))
  k : exact-nonnegative-integer?
  b : byte?
```

Changes the byte at position *k* in *bstr* to *b*. The first position in the byte string corresponds to 0, so the position *k* must be less than the length of the bytes, otherwise the `exn:fail:contract` exception is raised.

Examples:

```
> (define s (bytes 65 112 112 108 101))
> (bytes-set! s 4 121)
> s
#"Apply"
```

```
(subbytes bstr start [end]) → bytes?
  bstr : bytes?
  start : exact-nonnegative-integer?
  end : exact-nonnegative-integer? = (bytes-length str)
```

Returns a new mutable byte string that is `(- end start)` bytes long, and that contains the same bytes as *bstr* from *start* inclusive to *end* exclusive. The *start* and *end* arguments must be less than or equal to the length of *bstr*, and *end* must be greater than or equal to *start*, otherwise the `exn:fail:contract` exception is raised.

Examples:

```
> (subbytes #"Apple" 1 3)
#"pp"
> (subbytes #"Apple" 1)
#"pple"
```

```
(bytes-copy bstr) → bytes?
  bstr : bytes?
```

Returns `(subbytes bstr 0)`.

```
(bytes-copy! dest
             dest-start
             src
            [src-start
             src-end])   → void?
  dest : (and/c bytes? (not/c immutable?))
  dest-start : exact-nonnegative-integer?
  src : bytes?
  src-start : exact-nonnegative-integer? = 0
  src-end : exact-nonnegative-integer? = (bytes-length src)
```

Changes the bytes of *dest* starting at position *dest-start* to match the bytes in *src* from *src-start* (inclusive) to *src-end* (exclusive). The byte strings *dest* and *src* can be the same byte string, and in that case the destination region can overlap with the source region; the destination bytes after the copy match the source bytes from before the copy. If any of *dest-start*, *src-start*, or *src-end* are out of range (taking into account the sizes of the byte strings and the source and destination regions), the `exn:fail:contract` exception is raised.

Examples:

```
> (define s (bytes 65 112 112 108 101))
> (bytes-copy! s 4 #"y")
> (bytes-copy! s 0 s 3 4)
> s
#"lpply"
```

```
(bytes-fill! dest b) → void?
  dest : (and/c bytes? (not/c immutable?))
  b : byte?
```

Changes *dest* so that every position in the bytes is filled with *b*.

Examples:

```
> (define s (bytes 65 112 112 108 101))
> (bytes-fill! s 113)
> s
#"qqqqq"
```

```
(bytes-append bstr ...) → bytes?
  bstr : bytes?
```

Returns a new mutable byte string that is as long as the sum of the given *bstr*s' lengths, and that contains the concatenated bytes of the given *bstr*s. If no *bstr*s are provided, the result is a zero-length byte string.

Example:

```
> (bytes-append #"Apple" #"Banana")
#"AppleBanana"
```

```
(bytes->list bstr) → (listof byte?)
  bstr : bytes?
```

Returns a new list of bytes corresponding to the content of *bstr*. That is, the length of the list is `(bytes-length bstr)`, and the sequence of bytes in *bstr* is the same sequence in the result list.

Example:

```
> (bytes->list #"Apple")
'(65 112 112 108 101)
```

```
(list->bytes lst) → bytes?
  lst : (listof byte?)
```

Returns a new mutable byte string whose content is the list of bytes in *lst*. That is, the length of the byte string is `(length lst)`, and the sequence of bytes in *lst* is the same sequence in the result byte string.

Example:

```
> (list->bytes (list 65 112 112 108 101))
#"Apple"
```

```
(make-shared-bytes k [b]) → bytes?
  k : exact-nonnegative-integer?
  b : byte? = 0
```

Returns a new mutable byte string of length *k* where each position in the byte string is initialized with the byte *b*. For communication among places, the new byte string is allocated in the shared memory space.

Example:

```
> (make-shared-bytes 5 65)
#"AAAAA"
```

```
(shared-bytes b ...) → bytes?
  b : byte?
```

Returns a new mutable byte string whose length is the number of provided `b`s, and whose positions are initialized with the given `b`s. For communication among places, the new byte string is allocated in the shared memory space.

Example:

```
> (shared-bytes 65 112 112 108 101)
#"Apple"
```

4.5.2 Byte String Comparisons

```
(bytes=? bstr1 bstr2 ...) → boolean?
  bstr1 : bytes?
  bstr2 : bytes?
```

Returns `#t` if all of the arguments are `eqv?`.

Examples:

```
> (bytes=? #"Apple" #"apple")
#f
> (bytes=? #"a" #"as" #"a")
#f
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(bytes<? bstr1 bstr2 ...) → boolean?
  bstr1 : bytes?
  bstr2 : bytes?
```

Returns `#t` if the arguments are lexicographically sorted increasing, where individual bytes are ordered by `<`, `#f` otherwise.

Examples:

```
> (bytes<? #"Apple" #"apple")
#t
> (bytes<? #"apple" #"Apple")
#f
> (bytes<? #"a" #"b" #"c")
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(bytes>? bstr1 bstr2 ...) → boolean?
  bstr1 : bytes?
  bstr2 : bytes?
```

Like `bytes<?`, but checks whether the arguments are decreasing.

Examples:

```
> (bytes>? #"Apple" #"apple")
#f
> (bytes>? #"apple" #"Apple")
#t
> (bytes>? #"c" #"b" #"a")
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

4.5.3 Bytes to/from Characters, Decoding and Encoding

```
(bytes->string/utf-8 bstr [err-char start end]) → string?
  bstr : bytes?
  err-char : (or/c #f char?) = #f
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (bytes-length bstr)
```

Produces a string by decoding the *start* to *end* substring of *bstr* as a UTF-8 encoding of Unicode code points. If *err-char* is not `#f`, then it is used for bytes that fall in the range `128` to `255` but are not part of a valid encoding sequence. (This rule is consistent with reading characters from a port; see §13.1.1 "Encodings and Locales" for more details.) If *err-char* is `#f`, and if the *start* to *end* substring of *bstr* is not a valid UTF-8 encoding overall, then the `exn:fail:contract` exception is raised.

Example:

```
> (bytes->string/utf-8 (bytes 195 167 195 176 195 182 194 163))
"çðö£"
```

```
(bytes->string/locale  bstr
                      [err-char
                       start
                       end])     → string?
```

```
bstr : bytes?
err-char : (or/c #f char?) = #f
start : exact-nonnegative-integer? = 0
end : exact-nonnegative-integer? = (bytes-length bstr)
```

Produces a string by decoding the *start* to *end* substring of *bstr* using the current locale's encoding (see also §13.1.1 "Encodings and Locales"). If *err-char* is not `#f`, it is used for each byte in *bstr* that is not part of a valid encoding; if *err-char* is `#f`, and if the *start* to *end* substring of *bstr* is not a valid encoding overall, then the `exn:fail:contract` exception is raised.

```
(bytes->string/latin-1  bstr
                       [err-char
                        start
                        end])     → string?
  bstr : bytes?
  err-char : (or/c #f char?) = #f
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (bytes-length bstr)
```

Produces a string by decoding the *start* to *end* substring of *bstr* as a Latin-1 encoding of Unicode code points; i.e., each byte is translated directly to a character using `integer->char`, so the decoding always succeeds. The *err-char* argument is ignored, but present for consistency with the other operations.

Example:

```
> (bytes->string/latin-1 (bytes 254 211 209 165))
"þÓÑ¥"
```

```
(string->bytes/utf-8 str [err-byte start end]) → bytes?
  str : string?
  err-byte : (or/c #f byte?) = #f
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (string-length str)
```

Produces a byte string by encoding the *start* to *end* substring of *str* via UTF-8 (always succeeding). The *err-byte* argument is ignored, but included for consistency with the other operations.

Examples:

```
> (define b
    (bytes->string/utf-8
     (bytes 195 167 195 176 195 182 194 163)))
```

```
> (string->bytes/utf-8 b)
#"\303\247\303\260\303\266\302\243"
> (bytes->string/utf-8 (string->bytes/utf-8 b))
"çðö£"
```

```
(string->bytes/locale str [err-byte start end]) → bytes?
  str : string?
  err-byte : (or/c #f byte?) = #f
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (string-length str)
```

Produces a string by encoding the *start* to *end* substring of *str* using the current locale's encoding (see also §13.1.1 "Encodings and Locales"). If *err-byte* is not #f, it is used for each character in *str* that cannot be encoded for the current locale; if *err-byte* is #f, and if the *start* to *end* substring of *str* cannot be encoded, then the exn:fail:contract exception is raised.

```
(string->bytes/latin-1 str
                      [err-byte
                       start
                       end])    → bytes?
  str : string?
  err-byte : (or/c #f byte?) = #f
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (string-length str)
```

Produces a string by encoding the *start* to *end* substring of *str* using Latin-1; i.e., each character is translated directly to a byte using char->integer. If *err-byte* is not #f, it is used for each character in *str* whose value is greater than 255. If *err-byte* is #f, and if the *start* to *end* substring of *str* has a character with a value greater than 255, then the exn:fail:contract exception is raised.

Examples:

```
> (define b
    (bytes->string/latin-1 (bytes 254 211 209 165)))
> (string->bytes/latin-1 b)
#"\376\323\321\245"
> (bytes->string/latin-1 (string->bytes/latin-1 b))
"þÓÑ¥"
```

```
(string-utf-8-length str [start end]) → exact-nonnegative-integer?
  str : string?
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (string-length str)
```

Returns the length in bytes of the UTF-8 encoding of *str*'s substring from *start* to *end*, but without actually generating the encoded bytes.

Examples:

```
> (string-utf-8-length
    (bytes->string/utf-8 (bytes 195 167 195 176 195 182 194 163)))
8
> (string-utf-8-length "hello")
5
```

```
(bytes-utf-8-length bstr [err-char start end])
 → (or/c exact-nonnegative-integer? #f)
  bstr : bytes?
  err-char : (or/c #f char?) = #f
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (bytes-length bstr)
```

Returns the length in characters of the UTF-8 decoding of *bstr*'s substring from *start* to *end*, but without actually generating the decoded characters. If *err-char* is `#f` and the substring is not a UTF-8 encoding overall, the result is `#f`. Otherwise, *err-char* is used to resolve decoding errors as in `bytes->string/utf-8`.

Examples:

```
> (bytes-utf-8-length (bytes 195 167 195 176 195 182 194 163))
4
> (bytes-utf-8-length (make-bytes 5 65))
5
```

```
(bytes-utf-8-ref bstr [skip err-char start end]) → (or/c char? #f)
  bstr : bytes?
  skip : exact-nonnegative-integer? = 0
  err-char : (or/c #f char?) = #f
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (bytes-length bstr)
```

Returns the *skip*th character in the UTF-8 decoding of *bstr*'s substring from *start* to *end*, but without actually generating the other decoded characters. If the substring is not a UTF-8 encoding up to the *skip*th character (when *err-char* is `#f`), or if the substring decoding produces fewer than *skip* characters, the result is `#f`. If *err-char* is not `#f`, it is used to resolve decoding errors as in `bytes->string/utf-8`.

Examples:

```
> (bytes-utf-8-ref (bytes 195 167 195 176 195 182 194 163) 0)
#\ç
> (bytes-utf-8-ref (bytes 195 167 195 176 195 182 194 163) 1)
#\ð
> (bytes-utf-8-ref (bytes 195 167 195 176 195 182 194 163) 2)
#\ö
> (bytes-utf-8-ref (bytes 65 66 67 68) 0)
#\A
> (bytes-utf-8-ref (bytes 65 66 67 68) 1)
#\B
> (bytes-utf-8-ref (bytes 65 66 67 68) 2)
#\C
```

```
(bytes-utf-8-index  bstr
                    skip
                   [err-char
                    start
                    end])
 → (or/c exact-nonnegative-integer? #f)
  bstr : bytes?
  skip : exact-nonnegative-integer?
  err-char : (or/c #f char?) = #f
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (bytes-length bstr)
```

Returns the offset in bytes into `bstr` at which the `skip`th character's encoding starts in the UTF-8 decoding of `bstr`'s substring from `start` to `end` (but without actually generating the other decoded characters). The result is relative to the start of `bstr`, not to `start`. If the substring is not a UTF-8 encoding up to the `skip`th character (when `err-char` is `#f`), or if the substring decoding produces fewer than `skip` characters, the result is `#f`. If `err-char` is not `#f`, it is used to resolve decoding errors as in `bytes->string/utf-8`.

Examples:

```
> (bytes-utf-8-index (bytes 195 167 195 176 195 182 194 163) 0)
0
> (bytes-utf-8-index (bytes 195 167 195 176 195 182 194 163) 1)
2
> (bytes-utf-8-index (bytes 195 167 195 176 195 182 194 163) 2)
4
> (bytes-utf-8-index (bytes 65 66 67 68) 0)
0
> (bytes-utf-8-index (bytes 65 66 67 68) 1)
1
> (bytes-utf-8-index (bytes 65 66 67 68) 2)
2
```

4.5.4 Bytes to Bytes Encoding Conversion

```
(bytes-open-converter from-name to-name)
 → (or/c bytes-converter? #f)
  from-name : string?
  to-name : string?
```

Produces a *byte converter* to go from the encoding named by `from-name` to the encoding named by `to-name`. If the requested conversion pair is not available, `#f` is returned instead of a converter.

Certain encoding combinations are always available:

- `(bytes-open-converter "UTF-8" "UTF-8")` — the identity conversion, except that encoding errors in the input lead to a decoding failure.
- `(bytes-open-converter "UTF-8-permissive" "UTF-8")` — the identity conversion, except that any input byte that is not part of a valid encoding sequence is effectively replaced by the UTF-8 encoding sequence for `#\uFFFD`. (This handling of invalid sequences is consistent with the interpretation of port bytes streams into characters; see §13.1 "Ports".)
- `(bytes-open-converter "" "UTF-8")` — converts from the current locale's default encoding (see §13.1.1 "Encodings and Locales") to UTF-8.
- `(bytes-open-converter "UTF-8" "")` — converts from UTF-8 to the current locale's default encoding (see §13.1.1 "Encodings and Locales").
- `(bytes-open-converter "platform-UTF-8" "platform-UTF-16")` — converts UTF-8 to UTF-16 on Unix and Mac OS, where each UTF-16 code unit is a sequence of two bytes ordered by the current platform's endianness. On Windows, the conversion is the same as `(bytes-open-converter "WTF-8" "WTF-16")` to support unpaired surrogate code units.
- `(bytes-open-converter "platform-UTF-8-permissive" "platform-UTF-16")` — like `(bytes-open-converter "platform-UTF-8" "platform-UTF-16")`, but an input byte that is not part of a valid UTF-8 encoding sequence (or valid for the unpaired-surrogate extension on Windows) is effectively replaced with `#\uFFFD`.
- `(bytes-open-converter "platform-UTF-16" "platform-UTF-8")` — converts UTF-16 (bytes ordered by the current platform's endianness) to UTF-8 on Unix and Mac OS. On Windows, the conversion is the same as `(bytes-open-converter "WTF-16" "WTF-8")` to support unpaired surrogates. On Unix and Mac OS, surrogates are assumed to be paired: a pair of bytes with the bits `#xD800` starts a surrogate pair, and the `#x03FF` bits are used from the pair and following pair (independent of the value of the `#xDC00` bits). On all platforms, performance may be poor when decoding from an odd offset within an input byte string.

- `(bytes-open-converter "WTF-8" "WTF-16")` — converts the WTF-8 [Sapin18] superset of UTF-8 to a superset of UTF-16 to support unpaired surrogate code units, where each UTF-16 code unit is a sequence of two bytes ordered by the current platform's endianness.

- `(bytes-open-converter "WTF-8-permissive" "WTF-16")` — like `(bytes-open-converter "WTF-8" "WTF-16")`, but an input byte that is not part of a valid WTF-8 encoding sequence is effectively replaced with `#\uFFFD`.

- `(bytes-open-converter "WTF-16" "WTF-8")` — converts the WTF-16 [Sapin18] superset of UTF-16 to the WTF-8 superset of UTF-8. The input can include UTF-16 code units that are unpaired surrogates, and the corresponding output includes an encoding of each surrogate in a natural extension of UTF-8.

A newly opened byte converter is registered with the current custodian (see §14.7 "Custodians"), so that the converter is closed when the custodian is shut down. A converter is not registered with a custodian (and does not need to be closed) if it is one of the guaranteed combinations not involving `""` on Unix, or if it is any of the guaranteed combinations (including `""`) on Windows and Mac OS.

In the Racket software distributions for Windows, a suitable `"iconv.dll"` is included with `"libmzsch`*VERS*`.dll"`.

The set of available encodings and combinations varies by platform, depending on the `iconv` library that is installed; the *`from-name`* and *`to-name`* arguments are passed on to `iconv_open`. On Windows, `"iconv.dll"` or `"libiconv.dll"` must be in the same directory as `"libmzsch`*VERS*`.dll"` (where *VERS* is a version number), in the user's path, in the system directory, or in the current executable's directory at run time, and the DLL must either supply `_errno` or link to `"msvcrt.dll"` for `_errno`; otherwise, only the guaranteed combinations are available.

Use `bytes-convert` with the result to convert byte strings.

Changed in version 7.9.0.17 of package `base`: Added built-in converters for `"WTF-8"`, `"WTF-8-permissive"`, and `"WTF-16"`.

```
(bytes-close-converter converter) → void
  converter : bytes-converter?
```

Closes the given converter, so that it can no longer be used with `bytes-convert` or `bytes-convert-end`.

```
(bytes-convert  converter
                src-bstr
               [src-start-pos
                src-end-pos
                dest-bstr
                dest-start-pos
                dest-end-pos])
```

```
→ (or/c bytes? exact-nonnegative-integer?)
  exact-nonnegative-integer?
  (or/c 'complete 'continues 'aborts 'error)
 converter : bytes-converter?
 src-bstr : bytes?
 src-start-pos : exact-nonnegative-integer? = 0
 src-end-pos : exact-nonnegative-integer?
             = (bytes-length src-bstr)
 dest-bstr : (or/c bytes? #f) = #f
 dest-start-pos : exact-nonnegative-integer? = 0
 dest-end-pos : (or/c exact-nonnegative-integer? #f)
              = (and dest-bstr
                     (bytes-length dest-bstr))
```

Converts the bytes from `src-start-pos` to `src-end-pos` in `src-bstr`.

If `dest-bstr` is not `#f`, the converted bytes are written into `dest-bstr` from `dest-start-pos` to `dest-end-pos`. If `dest-bstr` is `#f`, then a newly allocated byte string holds the conversion results, and if `dest-end-pos` is not `#f`, the size of the result byte string is no more than `(- dest-end-pos dest-start-pos)`.

The result of `bytes-convert` is three values:

- `result-bstr` or `dest-wrote-amt` — a byte string if `dest-bstr` is `#f` or not provided, or the number of bytes written into `dest-bstr` otherwise.
- `src-read-amt` — the number of bytes successfully converted from `src-bstr`.
- `'complete`, `'continues`, `'aborts`, or `'error` — indicates how conversion terminated:
  - `'complete`: The entire input was processed, and `src-read-amt` will be equal to `(- src-end-pos src-start-pos)`.
  - `'continues`: Conversion stopped due to the limit on the result size or the space in `dest-bstr`; in this case, fewer than `(- dest-end-pos dest-start-pos)` bytes may be returned if more space is needed to process the next complete encoding sequence in `src-bstr`.
  - `'aborts`: The input stopped part-way through an encoding sequence, and more input bytes are necessary to continue. For example, if the last byte of input is `195` for a `"UTF-8-permissive"` decoding, the result is `'aborts`, because another byte is needed to determine how to use the `195` byte.
  - `'error`: The bytes starting at `(+ src-start-pos src-read-amt)` bytes in `src-bstr` do not form a legal encoding sequence. This result is never produced for some encodings, where all byte sequences are valid encodings. For example, since `"UTF-8-permissive"` handles an invalid UTF-8 sequence by dropping characters or generating "?," every byte sequence is effectively valid.

Applying a converter accumulates state in the converter (even when the third result of `bytes-convert` is `'complete`). This state can affect both further processing of input and further generation of output, but only for conversions that involve "shift sequences" to change modes within a stream. To terminate an input sequence and reset the converter, use `bytes-convert-end`.

Examples:

```
> (define convert (bytes-open-converter "UTF-8" "UTF-16"))
> (bytes-convert convert (bytes 65 66 67 68))
#"\376\377\0A\0B\0C\0D"
4
'complete
> (bytes 195 167 195 176 195 182 194 163)
#"\303\247\303\260\303\266\302\243"
> (bytes-convert convert (bytes 195 167 195 176 195 182 194 163))
#"\0\347\0\360\0\366\0\243"
8
'complete
> (bytes-close-converter convert)
```

```
(bytes-convert-end  converter
                   [dest-bstr
                    dest-start-pos
                    dest-end-pos])
 → (or/c bytes? exact-nonnegative-integer?)
   (or/c 'complete 'continues)
  converter : bytes-converter?
  dest-bstr : (or/c bytes? #f) = #f
  dest-start-pos : exact-nonnegative-integer? = 0
  dest-end-pos :  (or/c exact-nonnegative-integer? #f)
               = (and dest-bstr
                      (bytes-length dest-bstr))
```

Like `bytes-convert`, but instead of converting bytes, this procedure generates an ending sequence for the conversion (sometimes called a "shift sequence"), if any. Few encodings use shift sequences, so this function will succeed with no output for most encodings. In any case, successful output of a (possibly empty) shift sequence resets the converter to its initial state.

The result of `bytes-convert-end` is two values:

- *result-bstr* or *dest-wrote-amt* — a byte string if *dest-bstr* is `#f` or not provided, or the number of bytes written into *dest-bstr* otherwise.

- 'complete or 'continues — indicates whether conversion completed. If 'complete, then an entire ending sequence was produced. If 'continues, then the conversion could not complete due to the limit on the result size or the space in *dest-bstr*, and the first result is either an empty byte string or 0.

```
(bytes-converter? v) → boolean?
  v : any/c
```

Returns #t if *v* is a byte converter produced by bytes-open-converter, #f otherwise.

Examples:

```
> (bytes-converter? (bytes-open-converter "UTF-8" "UTF-16"))
#t
> (bytes-converter? (bytes-open-converter "whacky" "not likely"))
#f
> (define b (bytes-open-converter "UTF-8" "UTF-16"))
> (bytes-close-converter b)
> (bytes-converter? b)
#t
```

```
(locale-string-encoding) → any
```

Returns a string for the current locale's encoding (i.e., the encoding normally identified by ""). See also system-language+country.

4.5.5 Additional Byte String Functions

```
(require racket/bytes)        package: base
```

The bindings documented in this section are provided by the racket/bytes and racket libraries, but not racket/base.

```
(bytes-append* str ... strs) → bytes?
  str : bytes?
  strs : (listof bytes?)
```

Like bytes-append, but the last argument is used as a list of arguments for bytes-append, so (bytes-append* *str* ... *strs*) is the same as (apply bytes-append *str* ... *strs*). In other words, the relationship between bytes-append and bytes-append* is similar to the one between list and list*.

Examples:

```
> (bytes-append* #"a" #"b" '(#"c" #"d"))
#"abcd"
> (bytes-append* (cdr (append* (map (lambda (x) (list #", " x))
                                    '(#"Alpha" #"Beta" #"Gamma")))))
#"Alpha, Beta, Gamma"
```

```
(bytes-join strs sep) → bytes?
  strs : (listof bytes?)
  sep : bytes?
```

Appends the byte strings in *strs*, inserting *sep* between each pair of bytes in *strs*. A new mutable byte string is returned.

Example:

```
> (bytes-join '(#"one" #"two" #"three" #"four") #" potato ")
#"one potato two potato three potato four"
```

4.6 Characters

§3.3 "Characters" in *The Racket Guide* introduces characters.

Characters range over Unicode scalar values, which includes characters whose values range from `#x0` to `#x10FFFF`, but not including `#xD800` to `#xDFFF`. The scalar values are a subset of the Unicode code points.

Two characters are `eqv?` if they correspond to the same scalar value. For each scalar value less than 256, character values that are `eqv?` are also `eq?`. Characters produced by the default reader are interned in `read-syntax` mode.

See §1.3.14 "Reading Characters" for information on `read`ing characters and §1.4.11 "Printing Characters" for information on `print`ing characters.

Changed in version 6.1.1.8 of package `base`: Updated from Unicode 5.0.1 to Unicode 7.0.0.

4.6.1 Characters and Scalar Values

```
(char? v) → boolean?
  v : any/c
```

Return `#t` if *v* is a character, `#f` otherwise.

```
(char->integer char) → exact-integer?
  char : char?
```

Returns a character's code-point number.

Example:

```
> (char->integer #\A)
65
```

```
(integer->char k) → char?
  k : (and/c exact-integer?
             (or/c (integer-in 0 #xD7FF)
                   (integer-in #xE000 #x10FFFF)))
```

Return the character whose code-point number is `k`. For `k` less than `256`, the result is the same object for the same `k`.

Example:

```
> (integer->char 65)
#\A
```

```
(char-utf-8-length char) → (integer-in 1 6)
  char : char?
```

Produces the same result as `(bytes-length (string->bytes/utf-8 (string char)))`.

4.6.2 Character Comparisons

```
(char=? char1 char2 ...) → boolean?
  char1 : char?
  char2 : char?
```

Returns `#t` if all of the arguments are `eqv?`.

Examples:

```
> (char=? #\a #\a)
#t
> (char=? #\a #\A #\a)
#f
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(char<? char1 char2 ...) → boolean?
  char1 : char?
  char2 : char?
```

Returns `#t` if the arguments are sorted increasing, where two characters are ordered by their scalar values, `#f` otherwise.

Examples:

```
> (char<? #\A #\a)
#t
> (char<? #\a #\A)
#f
> (char<? #\a #\b #\c)
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(char<=? char1 char2 ...) → boolean?
  char1 : char?
  char2 : char?
```

Like `char<?`, but checks whether the arguments are nondecreasing.

Examples:

```
> (char<=? #\A #\a)
#t
> (char<=? #\a #\A)
#f
> (char<=? #\a #\b #\b)
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(char>? char1 char2 ...) → boolean?
  char1 : char?
  char2 : char?
```

Like `char<?`, but checks whether the arguments are decreasing.

Examples:

```
> (char>? #\A #\a)
```

```
#f
> (char>? #\a #\A)
#t
> (char>? #\c #\b #\a)
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(char>=? char1 char2 ...) → boolean?
  char1 : char?
  char2 : char?
```

Like `char<?`, but checks whether the arguments are nonincreasing.

Examples:

```
> (char>=? #\A #\a)
#f
> (char>=? #\a #\A)
#t
> (char>=? #\c #\b #\b)
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(char-ci=? char1 char2 ...) → boolean?
  char1 : char?
  char2 : char?
```

Returns `#t` if all of the arguments are `eqv?` after locale-insensitive case-folding via `char-foldcase`.

Examples:

```
> (char-ci=? #\A #\a)
#t
> (char-ci=? #\a #\a #\a)
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(char-ci<? char1 char2 ...) → boolean?
  char1 : char?
  char2 : char?
```

Like `char<?`, but checks whether the arguments would be in increasing order if each was first case-folded using `char-foldcase` (which is locale-insensitive).

Examples:

```
> (char-ci<? #\A #\a)
#f
> (char-ci<? #\a #\b)
#t
> (char-ci<? #\a #\b #\c)
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(char-ci<=? char1 char2 ...) → boolean?
  char1 : char?
  char2 : char?
```

Like `char-ci<?`, but checks whether the arguments would be nondecreasing after case-folding.

Examples:

```
> (char-ci<=? #\A #\a)
#t
> (char-ci<=? #\a #\A)
#t
> (char-ci<=? #\a #\b #\b)
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(char-ci>? char1 char2 ...) → boolean?
  char1 : char?
  char2 : char?
```

Like `char-ci<?`, but checks whether the arguments would be decreasing after case-folding.

Examples:

```
> (char-ci>? #\A #\a)
#f
> (char-ci>? #\b #\A)
#t
> (char-ci>? #\c #\b #\a)
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

```
(char-ci>=? char1 char2 ...) → boolean?
  char1 : char?
  char2 : char?
```

Like `char-ci<?`, but checks whether the arguments would be nonincreasing after case-folding.

Examples:

```
> (char-ci>=? #\A #\a)
#t
> (char-ci>=? #\a #\A)
#t
> (char-ci>=? #\c #\b #\b)
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

4.6.3 Classifications

```
(char-alphabetic? char) → boolean?
  char : char?
```

Returns `#t` if *char* has the Unicode "Alphabetic" property.

```
(char-lower-case? char) → boolean?
  char : char?
```

Returns `#t` if *char* has the Unicode "Lowercase" property.

```
(char-upper-case? char) → boolean?
  char : char?
```

Returns `#t` if *char* has the Unicode "Uppercase" property.

```
(char-title-case? char) → boolean?
  char : char?
```

Returns `#t` if *char*'s Unicode general category is Lt, `#f` otherwise.

```
(char-numeric? char) → boolean?
  char : char?
```

Returns `#t` if *char* has a Unicode "Numeric_Type" property value that is not `None`.

```
(char-symbolic? char) → boolean?
  char : char?
```

Returns `#t` if *char*'s Unicode general category is Sm, Sc, Sk, or So, `#f` otherwise.

```
(char-punctuation? char) → boolean?
  char : char?
```

Returns `#t` if *char*'s Unicode general category is Pc, Pd, Ps, Pe, Pi, Pf, or Po, `#f` otherwise.

```
(char-graphic? char) → boolean?
  char : char?
```

Returns `#t` if *char*'s Unicode general category is Ll, Lm, Lo, Lt, Lu, Nd, Nl, No, Mn, Mc, or Me, or if one of the following produces `#t` when applied to *char*: `char-alphabetic?`, `char-numeric?`, `char-symbolic?`, or `char-punctuation?`.

```
(char-whitespace? char) → boolean?
  char : char?
```

Returns `#t` if *char* has the Unicode "White_Space" property.

```
(char-blank? char) → boolean?
  char : char?
```

Returns `#t` if *char*'s Unicode general category is Zs or if *char* is `#\tab`. (These correspond to horizontal whitespace.)

```
(char-iso-control? char) → boolean?
  char : char?
```

Return `#t` if *char* is between `#\nul` and `#\u001F` inclusive or `#\rubout` and `#\u009F` inclusive.

```
(char-extended-pictographic? char) → boolean?
  char : char?
```

Returns `#t` if *char* has the Unicode "Extended_Pictographic" property.

Added in version 8.6.0.1 of package `base`.

```
(char-general-category char) → symbol?
  char : char?
```

Returns a symbol representing the character's Unicode general category, which is 'lu, 'll, 'lt, 'lm, 'lo, 'mn, 'mc, 'me, 'nd, 'nl, 'no, 'ps, 'pe, 'pi, 'pf, 'pd, 'pc, 'po, 'sc, 'sm, 'sk, 'so, 'zs, 'zp, 'zl, 'cc, 'cf, 'cs, 'co, or 'cn.

```
(char-grapheme-break-property char) → ?
  char : char?
```

Returns the Unicode graheme-break property for *char*, which is 'Other, 'CR, 'LF, 'Control, 'Extend, 'ZWJ, 'Regional_Indicator, 'Prepend, 'SpacingMark, 'L, 'V, 'T, 'LV, or 'LVT.

Added in version 8.6.0.1 of package base.

```
(make-known-char-range-list)
 → (listof (list/c exact-nonnegative-integer?
                   exact-nonnegative-integer?
                   boolean?))
```

Produces a list of three-element lists, where each three-element list represents a set of consecutive code points for which the Unicode standard specifies character properties. Each three-element list contains two integers and a boolean; the first integer is a starting code-point value (inclusive), the second integer is an ending code-point value (inclusive), and the boolean is #t when all characters in the code-point range have identical results for all of the character predicates above, have analogous transformations (shifting by the same amount, if any, in code-point space) for char-downcase, char-upcase, and char-titlecase, and have the same decomposition–normalization behavior. The three-element lists are ordered in the overall result list such that later lists represent larger code-point values, and all three-element lists are separated from every other by at least one code-point value that is not specified by Unicode.

4.6.4 Character Conversions

```
(char-upcase char) → char?
  char : char?
```

Produces a character consistent with the 1-to-1 code point mapping defined by Unicode. If *char* has no upcase mapping, char-upcase produces *char*.

String procedures, such as string-upcase, handle the case where Unicode defines a locale-independent mapping from the code point to a code-point sequence (in addition to the 1-1 mapping on scalar values).

Examples:

```
> (char-upcase #\a)
#\A
> (char-upcase #\λ)
#\Λ
> (char-upcase #\space)
#\space
```

```
(char-downcase char) → char?
  char : char?
```

Like `char-upcase`, but for the Unicode downcase mapping.

Examples:

```
> (char-downcase #\A)
#\a
> (char-downcase #\Λ)
#\λ
> (char-downcase #\space)
#\space
```

```
(char-titlecase char) → char?
  char : char?
```

Like `char-upcase`, but for the Unicode titlecase mapping.

Examples:

```
> (char-upcase #\a)
#\A
> (char-upcase #\λ)
#\Λ
> (char-upcase #\space)
#\space
```

```
(char-foldcase char) → char?
  char : char?
```

Like `char-upcase`, but for the Unicode case-folding mapping.

Examples:

```
> (char-foldcase #\A)
#\a
> (char-foldcase #\Σ)
#\σ
> (char-foldcase #\ς)
#\σ
> (char-foldcase #\space)
#\space
```

4.6.5 Character Grapheme-Cluster Streaming

```
(char-grapheme-step char state) → boolean? fixnum?
  char : char?
  state : fixnum?
```

Encodes a state machine for Unicode's grapheme-cluster specification on a sequence of code points. It accepts a character for the next code point in a sequence, and it returns two values: whether a (single) grapheme cluster has terminated since the most recently reported termination (or the start of the stream), and a new state to be used with `char-grapheme-step` and the next character.

A value of `0` for *`state`* represents the initial state or a state where no characters are pending toward a new boundary. Thus, if a sequence of characters is exhausted and accumulated *`state`* is not `0`, then the end of the stream creates one last grapheme-cluster boundary. When `char-grapheme-step` produces a true value as its first result and a non-`0` value as its second result, then the given *`char`* must be the only character pending toward the next grapheme cluster (by the rules of Unicode grapheme clustering).

The `char-grapheme-step` procedure will produce a result for any fixnum *`state`*, but the meaning of a non-`0` *`state`* is specified only in that providing such a state produced by `char-grapheme-step` in another call to `char-grapheme-step` continues detecting grapheme-cluster boundaries in the sequence.

See also `string-grapheme-span` and `string-grapheme-count`.

Examples:

```
> (char-grapheme-step #\a 0)
#f
1
> (let*-values ([(consumed? state) (char-grapheme-step #\a 0)]
                [(consumed? state) (char-grapheme-
step #\b state)])
    (values consumed? state))
#t
1
> (let*-values ([(consumed? state) (char-grapheme-
step #\return 0)]
                [(consumed? state) (char-grapheme-
step #\newline state)])
    (values consumed? state))
#t
0
> (let*-values ([(consumed? state) (char-grapheme-step #\a 0)]
                [(consumed? state) (char-grapheme-
step #\u300 state)])
```

```
    (values consumed? state))
#f
5
```

Added in version 8.6.0.2 of package base.

4.7 Symbols

§3.6 "Symbols" in *The Racket Guide* introduces symbols.

A *symbol* is like an immutable string, but symbols are normally interned, so that two symbols with the same character content are normally eq?. All symbols produced by the default reader (see §1.3.2 "Reading Symbols") are interned.

The two procedures string->uninterned-symbol and gensym generate *uninterned* symbols, i.e., symbols that are not eq?, eqv?, or equal? to any other symbol, although they may print the same as other symbols.

The procedure string->unreadable-symbol returns an *unreadable symbol* that is partially interned. The default reader (see §1.3.2 "Reading Symbols") never produces an unreadable symbol, but two calls to string->unreadable-symbol with equal? strings produce eq? results. An unreadable symbol can print the same as an interned or uninterned symbol. Unreadable symbols are useful in expansion and compilation to avoid collisions with symbols that appear in the source; they are usually not generated directly, but they can appear in the result of functions like identifier-binding.

Interned and unreadable symbols are only weakly held by the internal symbol table. This weakness can never affect the result of an eq?, eqv?, or equal? test, but a symbol may disappear when placed into a weak box (see §16.1 "Weak Boxes"), used as the key in a weak hash table (see §4.15 "Hash Tables"), or used as an ephemeron key (see §16.2 "Ephemerons").

See §1.3.2 "Reading Symbols" for information on reading symbols and §1.4.1 "Printing Symbols" for information on printing symbols.

```
(symbol? v) → boolean?
  v : any/c
```

Returns #t if *v* is a symbol, #f otherwise.

Examples:

```
> (symbol? 'Apple)
#t
> (symbol? 10)
#f
```

```
(symbol-interned? sym) → boolean?
  sym : symbol?
```

Returns `#t` if *`sym`* is interned, `#f` otherwise.

Examples:

```
> (symbol-interned? 'Apple)
#t
> (symbol-interned? (gensym))
#f
> (symbol-interned? (string->unreadable-symbol "Apple"))
#f
```

```
(symbol-unreadable? sym) → boolean?
  sym : symbol?
```

Returns `#t` if *`sym`* is an unreadable symbol, `#f` otherwise.

Examples:

```
> (symbol-unreadable? 'Apple)
#f
> (symbol-unreadable? (gensym))
#f
> (symbol-unreadable? (string->unreadable-symbol "Apple"))
#t
```

```
(symbol->string sym) → string?
  sym : symbol?
```

Returns a freshly allocated mutable string whose characters are the same as in *`sym`*.

See also `symbol->immutable-string` from `racket/symbol`.

Example:

```
> (symbol->string 'Apple)
"Apple"
```

```
(string->symbol str) → symbol?
  str : string?
```

Returns an interned symbol whose characters are the same as in *str*.

Examples:

```
> (string->symbol "Apple")
'Apple
> (string->symbol "1")
'|1|
```

```
(string->uninterned-symbol str) → symbol?
  str : string?
```

Like `(string->symbol str)`, but the resulting symbol is a new uninterned symbol. Calling `string->uninterned-symbol` twice with the same *str* returns two distinct symbols.

Examples:

```
> (string->uninterned-symbol "Apple")
'Apple
> (eq? 'a (string->uninterned-symbol "a"))
#f
> (eq? (string->uninterned-symbol "a")
       (string->uninterned-symbol "a"))
#f
```

```
(string->unreadable-symbol str) → symbol?
  str : string?
```

Like `(string->symbol str)`, but the resulting symbol is a new unreadable symbol. Calling `string->unreadable-symbol` twice with equivalent *str*s returns the same symbol, but `read` never produces the symbol.

Examples:

```
> (string->unreadable-symbol "Apple")
'Apple
> (eq? 'a (string->unreadable-symbol "a"))
#f
> (eq? (string->unreadable-symbol "a")
       (string->unreadable-symbol "a"))
#t
```

```
(gensym [base]) → symbol?
  base : (or/c string? symbol?) = "g"
```

Returns a new uninterned symbol with an automatically-generated name. The optional `base` argument is a prefix symbol or string.

Example:

```
> (gensym "apple")
'apple2177701
```

```
(symbol<? a-sym b-sym ...) → boolean?
  a-sym : symbol?
  b-sym : symbol?
```

Returns `#t` if the arguments are sorted, where the comparison for each pair of symbols is the same as using `symbol->string` with `string->bytes/utf-8` and `bytes<?`.

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

4.7.1 Additional Symbol Functions

```
(require racket/symbol)        package: base
```

The bindings documented in this section are provided by the `racket/symbol` library, not `racket/base` or `racket`.

Added in version 7.6 of package `base`.

```
(symbol->immutable-string sym) → (and/c string? immutable?)
  sym : symbol?
```

Like `symbol->string`, but the result is an immutable string, not necessarily freshly allocated.

Examples:

```
> (symbol->immutable-string 'Apple)
"Apple"
> (immutable? (symbol->immutable-string 'Apple))
#t
```

Added in version 7.6 of package `base`.

4.8 Regular Expressions

§9 "Regular Expressions" in *The Racket Guide* introduces regular expressions.

Regular expressions are specified as strings or byte strings, using the same pattern language as either the Unix utility `egrep` or Perl. A string-specified pattern produces a character regexp matcher, and a byte-string pattern produces a byte regexp matcher. If a character regexp is used with a byte string or input port, it matches UTF-8 encodings (see §13.1.1 "Encodings and Locales") of matching character streams; if a byte regexp is used with a character string, it matches bytes in the UTF-8 encoding of the string.

A regular expression that is represented as a string or byte string can be compiled to a *regexp value*, which can be used more efficiently by functions such as `regexp-match` compared to the string or byte string form. The `regexp` and `byte-regexp` procedures convert a string or byte string (respectively) into a regexp value using a syntax of regular expressions that is most compatible to `egrep`. The `pregexp` and `byte-pregexp` procedures produce a regexp value using a slightly different syntax of regular expressions that is more compatible with Perl.

Two regexp values are `equal?` if they have the same source, use the same pattern language, and are both character regexps or both byte regexps.

A literal or printed regexp value starts with `#rx` or `#px`. See §1.3.16 "Reading Regular Expressions" for information on `read`ing regular expressions and §1.4.13 "Printing Regular Expressions" for information on `print`ing regular expressions. Regexp values produced by the default reader are interned in `read-syntax` mode.

On the BC variant of Racket, the internal size of a regexp value is limited to 32 kilobytes; this limit roughly corresponds to a source string with 32,000 literal characters or 5,000 operators.

4.8.1 Regexp Syntax

The following syntax specifications describe the content of a string that represents a regular expression. The syntax of the corresponding string may involve extra escape characters. For example, the regular expression `(.*)\1` can be represented with the string `"(.*)\\1"` or the regexp constant `#rx"(.*)\\1"`; the `\` in the regular expression must be escaped to include it in a string or regexp constant.

The `regexp` and `pregexp` syntaxes share a common core:

⟨*regexp*⟩	::=	⟨*pces*⟩	Match ⟨*pces*⟩	
	|	⟨*regexp*⟩`|`⟨*regexp*⟩	Match either ⟨*regexp*⟩, try left first	ex1
⟨*pces*⟩	::=		Match empty	
	|	⟨*pce*⟩⟨*pces*⟩	Match ⟨*pce*⟩ followed by ⟨*pces*⟩	
⟨*pce*⟩	::=	⟨*repeat*⟩	Match ⟨*repeat*⟩, longest possible	ex3
	|	⟨*repeat*⟩`?`	Match ⟨*repeat*⟩, shortest possible	ex6
	|	⟨*atom*⟩	Match ⟨*atom*⟩ exactly once	
⟨*repeat*⟩	::=	⟨*atom*⟩`*`	Match ⟨*atom*⟩ 0 or more times	ex3
	|	⟨*atom*⟩`+`	Match ⟨*atom*⟩ 1 or more times	ex4
	|	⟨*atom*⟩`?`	Match ⟨*atom*⟩ 0 or 1 times	ex5
⟨*atom*⟩	::=	`(`⟨*regexp*⟩`)`	Match sub-expression ⟨*regexp*⟩ and report	ex11

<table>
<tr><td></td><td>|</td><td>[⟨rng⟩]</td><td>Match any character in ⟨rng⟩</td><td>ex2</td></tr>
<tr><td></td><td>|</td><td>[^⟨crng⟩]</td><td>Match any character not in ⟨crng⟩</td><td>ex12</td></tr>
<tr><td></td><td>|</td><td>.</td><td>Match any (except newline in multi mode)</td><td>ex13</td></tr>
<tr><td></td><td>|</td><td>^</td><td>Match start (or after newline in multi mode)</td><td>ex14</td></tr>
<tr><td></td><td>|</td><td>$</td><td>Match end (or before newline in multi mode)</td><td>ex15</td></tr>
<tr><td></td><td>|</td><td>⟨literal⟩</td><td>Match a single literal character</td><td>ex1</td></tr>
<tr><td></td><td>|</td><td>(?⟨mode⟩:⟨regexp⟩)</td><td>Match ⟨regexp⟩ using ⟨mode⟩</td><td>ex35</td></tr>
<tr><td></td><td>|</td><td>(?>⟨regexp⟩)</td><td>Match ⟨regexp⟩, only first possible</td><td></td></tr>
<tr><td></td><td>|</td><td>⟨look⟩</td><td>Match empty if ⟨look⟩ matches</td><td></td></tr>
<tr><td></td><td>|</td><td>(?⟨tst⟩⟨pces⟩|⟨pces⟩)</td><td>Match 1st ⟨pces⟩ if ⟨tst⟩, else 2nd ⟨pces⟩</td><td>ex36</td></tr>
<tr><td></td><td>|</td><td>(?⟨tst⟩⟨pces⟩)</td><td>Match ⟨pces⟩ if ⟨tst⟩, empty if not ⟨tst⟩</td><td></td></tr>
<tr><td></td><td>|</td><td>\ at end of pattern</td><td>Match the nul character (ASCII 0)</td><td></td></tr>
<tr><td>⟨crng⟩</td><td>::=</td><td>⟨rng⟩</td><td>⟨crng⟩ contains everything in ⟨rng⟩</td><td></td></tr>
<tr><td></td><td>|</td><td>^⟨crng⟩</td><td>⟨crng⟩ contains ^ and everything in ⟨crng⟩</td><td>ex37</td></tr>
<tr><td>⟨rng⟩</td><td>::=</td><td>]</td><td>⟨rng⟩ contains] only</td><td>ex27</td></tr>
<tr><td></td><td>|</td><td>-</td><td>⟨rng⟩ contains - only</td><td>ex28</td></tr>
<tr><td></td><td>|</td><td>⟨mrng⟩</td><td>⟨rng⟩ contains everything in ⟨mrng⟩</td><td></td></tr>
<tr><td></td><td>|</td><td>⟨mrng⟩-</td><td>⟨rng⟩ contains - and everything in ⟨mrng⟩</td><td></td></tr>
<tr><td>⟨mrng⟩</td><td>::=</td><td>]⟨lrng⟩</td><td>⟨mrng⟩ contains] and everything in ⟨lrng⟩</td><td>ex29</td></tr>
<tr><td></td><td>|</td><td>-⟨lrng⟩</td><td>⟨mrng⟩ contains - and everything in ⟨lrng⟩</td><td>ex29</td></tr>
<tr><td></td><td>|</td><td>⟨lirng⟩</td><td>⟨mrng⟩ contains everything in ⟨lirng⟩</td><td></td></tr>
<tr><td>⟨lirng⟩</td><td>::=</td><td>⟨riliteral⟩</td><td>⟨lirng⟩ contains a literal character</td><td></td></tr>
<tr><td></td><td>|</td><td>⟨riliteral⟩-⟨rliteral⟩</td><td>⟨lirng⟩ contains Unicode range inclusive</td><td>ex22</td></tr>
<tr><td></td><td>|</td><td>⟨lirng⟩⟨lrng⟩</td><td>⟨lirng⟩ contains everything in both</td><td></td></tr>
<tr><td>⟨lrng⟩</td><td>::=</td><td>^</td><td>⟨lrng⟩ contains ^</td><td>ex30</td></tr>
<tr><td></td><td>|</td><td>⟨rliteral⟩-⟨rliteral⟩</td><td>⟨lrng⟩ contains Unicode range inclusive</td><td></td></tr>
<tr><td></td><td>|</td><td>^⟨lrng⟩</td><td>⟨lrng⟩ contains ^ and more</td><td></td></tr>
<tr><td></td><td>|</td><td>⟨lirng⟩</td><td>⟨lrng⟩ contains everything in ⟨lirng⟩</td><td></td></tr>
<tr><td>⟨look⟩</td><td>::=</td><td>(?=⟨regexp⟩)</td><td>Match if ⟨regexp⟩ matches</td><td>ex31</td></tr>
<tr><td></td><td>|</td><td>(?!⟨regexp⟩)</td><td>Match if ⟨regexp⟩ doesn’t match</td><td>ex32</td></tr>
<tr><td></td><td>|</td><td>(?<=⟨<i>regexp</i>⟩)</td><td>Match if ⟨<i>regexp</i>⟩ matches preceding</td><td>ex33</td></tr>
<tr><td></td><td>|</td><td>(?<!⟨<i>regexp</i>⟩)</td><td>Match if ⟨<i>regexp</i>⟩ doesn’t match preceding</td><td>ex34</td></tr>
<tr><td>⟨tst⟩</td><td>::=</td><td>(⟨n⟩)</td><td>True if ⟨n⟩th (has a match</td><td></td></tr>
<tr><td></td><td>|</td><td>⟨look⟩</td><td>True if ⟨look⟩ matches</td><td>ex36</td></tr>
<tr><td>⟨mode⟩</td><td>::=</td><td></td><td>Like the enclosing mode</td><td></td></tr>
<tr><td></td><td>|</td><td>⟨mode⟩i</td><td>Like ⟨mode⟩, but case-insensitive</td><td>ex35</td></tr>
<tr><td></td><td>|</td><td>⟨mode⟩-i</td><td>Like ⟨mode⟩, but sensitive</td><td></td></tr>
<tr><td></td><td>|</td><td>⟨mode⟩s</td><td>Like ⟨mode⟩, but not in multi mode</td><td></td></tr>
<tr><td></td><td>|</td><td>⟨mode⟩-s</td><td>Like ⟨mode⟩, but in multi mode</td><td></td></tr>
<tr><td></td><td>|</td><td>⟨mode⟩m</td><td>Like ⟨mode⟩, but in multi mode</td><td></td></tr>
<tr><td></td><td>|</td><td>⟨mode⟩-m</td><td>Like ⟨mode⟩, but not in multi mode</td><td></td></tr>
</table>

The following completes the grammar for `regexp`, which treats { and } as literals, \ as a literal within ranges, and \ as a literal producer outside of ranges.

⟨*literal*⟩ ::= Any character except (,), *, +, ?, [, ., ^, \, or |

	|	`\`⟨*aliteral*⟩	Match ⟨*aliteral*⟩	ex21
⟨*aliteral*⟩	::=	Any character		
⟨*riliteral*⟩	::=	Any character except `]`, `-`, or `^`		
⟨*rliteral*⟩	::=	Any character except `]` or `-`		

The following completes the grammar for `pregexp`, which uses `{` and `}` bounded repetition and uses `\` for meta-characters both inside and outside of ranges.

⟨*repeat*⟩	::=	...	...	
	|	⟨*atom*⟩`{`⟨*n*⟩`}`	Match ⟨*atom*⟩ exactly ⟨*n*⟩ times	ex7
	|	⟨*atom*⟩`{`⟨*n*⟩`,}`	Match ⟨*atom*⟩ ⟨*n*⟩ or more times	ex8
	|	⟨*atom*⟩`{,`⟨*m*⟩`}`	Match ⟨*atom*⟩ between 0 and ⟨*m*⟩ times	ex9
	|	⟨*atom*⟩`{`⟨*n*⟩`,`⟨*m*⟩`}`	Match ⟨*atom*⟩ between ⟨*n*⟩ and ⟨*m*⟩ times	ex10
	|	⟨*atom*⟩`{}`	Match ⟨*atom*⟩ 0 or more times	
⟨*atom*⟩	::=	...	...	
	|	`\`⟨*n*⟩	Match latest reported match for ⟨*n*⟩th `(`	ex16
	|	⟨*class*⟩	Match any character in ⟨*class*⟩	
	|	`\b`	Match `\w*` boundary	ex17
	|	`\B`	Match where `\b` does not	ex18
	|	`\p{`⟨*property*⟩`}`	Match (UTF-8 encoded) in ⟨*property*⟩	ex19
	|	`\P{`⟨*property*⟩`}`	Match (UTF-8 encoded) not in ⟨*property*⟩	ex20
	|	`\X`	Match (UTF-8 encoded) grapheme cluster	
⟨*literal*⟩	::=	Any character except `(`, `)`, `*`, `+`, `?`, `[`, `]`, `{`, `}`, `.`, `^`, `\`, or `|`		
	|	`\`⟨*aliteral*⟩	Match ⟨*aliteral*⟩	ex21
⟨*aliteral*⟩	::=	Any character except `a`-`z`, `A`-`Z`, `0`-`9`		
⟨*lirng*⟩	::=	...	...	
	|	⟨*class*⟩	⟨*lirng*⟩ contains all characters in ⟨*class*⟩	
	|	⟨*posix*⟩	⟨*lirng*⟩ contains all characters in ⟨*posix*⟩	ex26
	|	`\`⟨*eliteral*⟩	⟨*lirng*⟩ contains ⟨*eliteral*⟩	
⟨*riliteral*⟩	::=	Any character except `]`, `\`, `-`, or `^`		
⟨*rliteral*⟩	::=	Any character except `]`, `\`, or `-`		
⟨*eliteral*⟩	::=	Any character except `a`-`z`, `A`-`Z`		
⟨*class*⟩	::=	`\d`	Contains `0`-`9`	ex23
	|	`\D`	Contains characters not in `\d`	
	|	`\w`	Contains `a`-`z`, `A`-`Z`, `0`-`9`, `_`	ex24
	|	`\W`	Contains characters not in `\w`	
	|	`\s`	Contains space, tab, newline, formfeed, return	ex25
	|	`\S`	Contains characters not in `\s`	
⟨*posix*⟩	::=	`[:alpha:]`	Contains `a`-`z`, `A`-`Z`	
	|	`[:upper:]`	Contains `A`-`Z`	
	|	`[:lower:]`	Contains `a`-`z`	ex26
	|	`[:digit:]`	Contains `0`-`9`	
	|	`[:xdigit:]`	Contains `0`-`9`, `a`-`f`, `A`-`F`	
	|	`[:alnum:]`	Contains `a`-`z`, `A`-`Z`, `0`-`9`	
	|	`[:word:]`	Contains `a`-`z`, `A`-`Z`, `0`-`9`, `_`	
	|	`[:blank:]`	Contains space and tab	

	|	`[:space:]`	Contains space, tab, newline, formfeed, return
	|	`[:graph:]`	Contains all ASCII characters that use ink
	|	`[:print:]`	Contains space, tab, and ASCII ink users
	|	`[:cntrl:]`	Contains all characters with scalar value < 32
	|	`[:ascii:]`	Contains all ASCII characters
⟨*property*⟩	`::=`	⟨*category*⟩	Includes all characters in ⟨*category*⟩
	|	`^`⟨*category*⟩	Includes all characters not in ⟨*category*⟩

In case-insensitive mode, a backreference of the form `\`⟨*n*⟩ matches case-insensitively only with respect to ASCII characters.

The Unicode categories follow.

⟨*category*⟩	`::=`	`Ll`	Letter, lowercase	ex19
	|	`Lu`	Letter, uppercase	
	|	`Lt`	Letter, titlecase	
	|	`Lm`	Letter, modifier	
	|	`L&`	Union of `Ll`, `Lu`, `Lt`, and `Lm`	
	|	`Lo`	Letter, other	
	|	`L`	Union of `L&` and `Lo`	
	|	`Nd`	Number, decimal digit	
	|	`Nl`	Number, letter	
	|	`No`	Number, other	
	|	`N`	Union of `Nd`, `Nl`, and `No`	
	|	`Ps`	Punctuation, open	
	|	`Pe`	Punctuation, close	
	|	`Pi`	Punctuation, initial quote	
	|	`Pf`	Punctuation, final quote	
	|	`Pc`	Punctuation, connector	
	|	`Pd`	Punctuation, dash	
	|	`Po`	Punctuation, other	
	|	`P`	Union of `Ps`, `Pe`, `Pi`, `Pf`, `Pc`, `Pd`, and `Po`	
	|	`Mn`	Mark, non-spacing	
	|	`Mc`	Mark, spacing combining	
	|	`Me`	Mark, enclosing	
	|	`M`	Union of `Mn`, `Mc`, and `Me`	
	|	`Sc`	Symbol, currency	
	|	`Sk`	Symbol, modifier	
	|	`Sm`	Symbol, math	
	|	`So`	Symbol, other	
	|	`S`	Union of `Sc`, `Sk`, `Sm`, and `So`	
	|	`Zl`	Separator, line	
	|	`Zp`	Separator, paragraph	
	|	`Zs`	Separator, space	
	|	`Z`	Union of `Zl`, `Zp`, and `Zs`	
	|	`Cc`	Other, control	

|	`Cf`	Other, format
|	`Cs`	Other, surrogate
|	`Cn`	Other, not assigned
|	`Co`	Other, private use
|	`C`	Union of `Cc`, `Cf`, `Cs`, `Cn`, and `Co`
|	`.`	Union of all Unicode categories

When a character regexp with `.` is used with a byte string or input port, the `.` matches only a valid UTF-8 encoding in the input. A `.` in a byte regexp matches any byte (except a newline in multi mode). A property specified with `\P` or `\p` matches only a valid UTF-8 encoding, whether it is written in a character regexp or byte regexp. Similarly, `\X` matches only valid UTF-8 encoding sequences, and it will not match a prefix of a sequence (even if matching only a prefix would allow the rest of the pattern to match remaining input), but a grapheme-cluster sequence can be terminated by an invalid UTF-8 encoding.

Examples:

```
> (regexp-match #rx"a|b" "cat") ; ex1
'("a")
> (regexp-match #rx"[at]" "cat") ; ex2
'("a")
> (regexp-match #rx"ca*[at]" "caaat") ; ex3
'("caaat")
> (regexp-match #rx"ca+[at]" "caaat") ; ex4
'("caaat")
> (regexp-match #rx"ca?t?" "ct") ; ex5
'("ct")
> (regexp-match #rx"ca*?[at]" "caaat") ; ex6
'("ca")
> (regexp-match #px"ca{2}" "caaat") ; ex7, uses #px
'("caa")
> (regexp-match #px"ca{2,}t" "catcaat") ; ex8, uses #px
'("caat")
> (regexp-match #px"ca{,2}t" "caaatcat") ; ex9, uses #px
'("cat")
> (regexp-match #px"ca{1,2}t" "caaatcat") ; ex10, uses #px
'("cat")
> (regexp-match #rx"(c<*)(a*)" "caat") ; ex11
'("caa" "c" "aa")
> (regexp-match #rx"[^ca]" "caat") ; ex12
'("t")
> (regexp-match #rx".(.)." "cat") ; ex13
'("cat" "a")
> (regexp-match #rx"^a|^c" "cat") ; ex14
'("c")
> (regexp-match #rx"a$|t$" "cat") ; ex15
```

```
'("t")
> (regexp-match #px"c(.)\\1t" "caat") ; ex16, uses #px
'("caat" "a")
> (regexp-match #px".\\b." "cat in hat") ; ex17, uses #px
'("t ")
> (regexp-match #px".\\B." "cat in hat") ; ex18, uses #px
'("ca")
> (regexp-match #px"\\p{Ll}" "Cat") ; ex19, uses #px
'("a")
> (regexp-match #px"\\P{Ll}" "cat!") ; ex20, uses #px
'("!")
> (regexp-match #rx"\\|" "c|t") ; ex21
'("|")
> (regexp-match #rx"[a-f]*" "cat") ; ex22
'("ca")
> (regexp-match #px"[a-f\\d]*" "1cat") ; ex23, uses #px
'("1ca")
> (regexp-match #px" [\\w]" "cat hat") ; ex24, uses #px
'(" h")
> (regexp-match #px"t[\\s]" "cat\nhat") ; ex25, uses #px
'("t\n")
> (regexp-match #px"[[:lower:]]+" "Cat") ; ex26, uses #px
'("at")
> (regexp-match #rx"[]]" "c]t") ; ex27
'("]")
> (regexp-match #rx"[-]" "c-t") ; ex28
'("-")
> (regexp-match #rx"[]a[]+" "c[a]t") ; ex29
'("[a]")
> (regexp-match #rx"[a^]+" "ca^t") ; ex30
'("a^")
> (regexp-match #rx".a(?=p)" "cat nap") ; ex31
'("na")
> (regexp-match #rx".a(?!t)" "cat nap") ; ex32
'("na")
> (regexp-match #rx"(?<=n)a." "cat nap") ; ex33
'("ap")
> (regexp-match #rx"(?<!c)a." "cat nap") ; ex34
'("ap")
> (regexp-match #rx"(?i:a)[tp]" "cAT nAp") ; ex35
'("Ap")
> (regexp-match #rx"(?(?<=c)a|b)+" "cabal") ; ex36
'("ab")
> (regexp-match #rx"[^^]+" "^cat^") ; ex37
'("cat")
```

Changed in version 8.15.0.8 of package `base`: Added `\X` grapheme cluster pattern.

4.8.2 Additional Syntactic Constraints

In addition to matching a grammar, regular expressions must meet two syntactic restrictions:

- In a ⟨*repeat*⟩ other than ⟨*atom*⟩`?`, the ⟨*atom*⟩ must not match an empty sequence.
- In a `(?<=`⟨*regexp*⟩`)` or `(?<!`⟨*regexp*⟩`)`, the ⟨*regexp*⟩ must match a bounded sequence only.

These constraints are checked syntactically by the following type system. A type $[n, m]$ corresponds to an expression that matches between n and m characters. In the rule for `(`⟨*regexp*⟩`)`, ⟨*n*⟩ means the number such that the opening parenthesis is the ⟨*n*⟩th opening parenthesis for collecting match reports. Non-emptiness is inferred for a backreference pattern, `\`⟨*n*⟩, so that a backreference can be used for repetition patterns; in the case of mutual dependencies among backreferences, the inference chooses the fixpoint that maximizes non-emptiness. Finiteness is not inferred for backreferences (i.e., a backreference is assumed to match an arbitrarily large sequence). No syntactic constraint prohibits a backreference within the group that it references, although such self references might create a pattern with no possible matches (as in the case of `(.\1)`, although `(^.|\1){2}` matches an input that starts with the same two characters).

$$\frac{\langle regexp\rangle_1 \;:\; [n_1, m_1] \qquad \langle regexp\rangle_2 \;:\; [n_2, m_2]}{\langle regexp\rangle_1\texttt{|}\langle regexp\rangle_2 \;:\; [\min(n_1, n_2), \max(m_1, m_2)]}$$

$$\frac{\langle pce\rangle \;:\; [n_1, m_1] \qquad \langle pces\rangle \;:\; [n_2, m_2]}{\langle pce\rangle\langle pces\rangle \;:\; [n_1{+}n_2, m_1{+}m_2]}$$

$$\frac{\langle repeat\rangle \;:\; [n, m]}{\langle repeat\rangle\texttt{?} \;:\; [0, m]} \qquad \frac{\langle atom\rangle \;:\; [n, m] \qquad n > 0}{\langle atom\rangle\texttt{*} \;:\; [0, \infty]}$$

$$\frac{\langle atom\rangle \;:\; [n, m] \qquad n > 0}{\langle atom\rangle\texttt{+} \;:\; [1, \infty]} \qquad \frac{\langle atom\rangle \;:\; [n, m]}{\langle atom\rangle\texttt{?} \;:\; [0, m]}$$

$$\frac{\langle atom\rangle \;:\; [n, m] \qquad n > 0}{\langle atom\rangle\texttt{\{}\langle n\rangle\texttt{\}} \;:\; [n*\langle n\rangle, m*\langle n\rangle]}$$

$$\frac{\langle atom\rangle \;:\; [n, m] \qquad n > 0}{\langle atom\rangle\texttt{\{}\langle n\rangle\texttt{,\}} \;:\; [n*\langle n\rangle, \infty]}$$

$$\frac{\langle atom\rangle \;:\; [n, m] \qquad n > 0}{\langle atom\rangle\texttt{\{,}\langle m\rangle\texttt{\}} \;:\; [0, m*\langle m\rangle]}$$

$$\frac{\langle atom\rangle \;:\; [n, m] \qquad n > 0}{\langle atom\rangle\texttt{\{}\langle n\rangle\texttt{,}\langle m\rangle\texttt{\}} \;:\; [n{*}\langle n\rangle, m{*}\langle m\rangle]}$$

$$\frac{\langle regexp\rangle \;:\; [n, m]}{\texttt{(}\langle regexp\rangle\texttt{)} \;:\; [n, m] \qquad \alpha_{\langle n\rangle}{=}n}$$

$$\frac{\langle regexp\rangle \;:\; [n, m]}{\texttt{(?}\langle mode\rangle\texttt{:}\langle regexp\rangle\texttt{)} \;:\; [n, m]}$$

$$\frac{\langle regexp\rangle \;:\; [n, m]}{\texttt{(?=}\langle regexp\rangle\texttt{)} \;:\; [0, 0]} \qquad \frac{\langle regexp\rangle \;:\; [n, m]}{\texttt{(?!}\langle regexp\rangle\texttt{)} \;:\; [0, 0]}$$

$$\frac{\langle regexp\rangle \;:\; [n, m] \qquad m < \infty}{\texttt{(?<=}\langle regexp\rangle\texttt{)} \;:\; [0, 0]} \qquad \frac{\langle regexp\rangle \;:\; [n, m] \qquad m < \infty}{\texttt{(?<!}\langle regexp\rangle\texttt{)} \;:\; [0, 0]}$$

$$\frac{\langle regexp\rangle \;:\; [n, m]}{\texttt{(?>}\langle regexp\rangle\texttt{)} \;:\; [n, m]}$$

$$\frac{\langle tst\rangle \;:\; [n_0, m_0] \qquad \langle pces\rangle_1 \;:\; [n_1, m_1] \qquad \langle pces\rangle_2 \;:\; [n_2, m_2]}{\texttt{(?}\langle tst\rangle\langle pces\rangle_1\texttt{|}\langle pces\rangle_2\texttt{)} \;:\; [\min(n_1, n_2), \max(m_1, m_2)]}$$

$$\frac{\langle tst\rangle \;:\; [n_0, m_0] \qquad \langle pces\rangle \;:\; [n_1, m_1]}{\texttt{(?}\langle tst\rangle\langle pces\rangle\texttt{)} \;:\; [0, m_1]}$$

$$\texttt{(}\langle n\rangle\texttt{)} \;:\; [\alpha_{\langle n\rangle}, \infty] \qquad \texttt{[}\langle rng\rangle\texttt{]} \;:\; [1, 1] \qquad \texttt{[\^{}}\langle rng\rangle\texttt{]} \;:\; [1, 1]$$

$$\texttt{.} \;:\; [1, 1] \qquad \texttt{\^{}} \;:\; [0, 0] \qquad \texttt{\$} \;:\; [0, 0]$$

$$\langle literal\rangle \;:\; [1, 1] \qquad \texttt{\textbackslash}\langle n\rangle \;:\; [\alpha_{\langle n\rangle}, \infty] \qquad \langle class\rangle \;:\; [1, 1]$$

$$\texttt{\textbackslash b} \;:\; [0, 0] \qquad \texttt{\textbackslash B} \;:\; [0, 0]$$

$$\texttt{\textbackslash p\{}\langle property\rangle\texttt{\}} \;:\; [1, 6] \qquad \texttt{\textbackslash P\{}\langle property\rangle\texttt{\}} \;:\; [1, 6]$$

$$\texttt{\textbackslash X} \;:\; [1, \infty]$$

4.8.3 Regexp Constructors

```
(regexp? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a regexp value created by `regexp` or `pregexp`, `#f` otherwise.

```
(pregexp? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a regexp value created by `pregexp` (not `regexp`), `#f` otherwise.

```
(byte-regexp? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a regexp value created by `byte-regexp` or `byte-pregexp`, `#f` otherwise.

```
(byte-pregexp? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a regexp value created by `byte-pregexp` (not `byte-regexp`), `#f` otherwise.

```
(regexp str) → regexp?
  str : string?
(regexp str handler) → any
  str : string?
  handler : (or/c #f (string? . -> . any))
```

Takes a string representation of a regular expression (using the syntax in §4.8.1 "Regexp Syntax") and compiles it into a regexp value. Other regular expression procedures accept either a string or a regexp value as the matching pattern. If a regular expression string is used multiple times, it is faster to compile the string once to a regexp value and use it for repeated matches instead of using the string each time.

If *handler* is provided and not `#f`, it is called and its result is returned when *str* is not a valid representation of a regular expression; the argument to *handler* is a string that describes the problem with *str*. If *handler* is `#f` or not provided, then `exn:fail:contract` exception is raised.

The `object-name` procedure returns the source string for a regexp value.

Examples:

```
> (regexp "ap*le")
#rx"ap*le"
> (object-name #rx"ap*le")
"ap*le"
> (regexp "+" (λ (s) (list s)))
'("`+` follows nothing in pattern")
```

Changed in version 6.5.0.1 of package `base`: Added the *handler* argument.

```
(pregexp str) → pregexp?
  str : string?
(pregexp str handler) → any
  str : string?
  handler : (or/c #f (string? . -> . any))
```

Like regexp, except that it uses a slightly different syntax (see §4.8.1 "Regexp Syntax"). The result can be used with regexp-match, etc., just like the result from regexp.

Examples:

```
> (pregexp "ap*le")
#px"ap*le"
> (regexp? #px"ap*le")
#t
> (pregexp "+" (λ (s) (vector s)))
'#("`+` follows nothing in pattern")
```

Changed in version 6.5.0.1 of package base: Added the *handler* argument.

```
(byte-regexp bstr) → byte-regexp?
  bstr : bytes?
(byte-regexp bstr handler) → any
  bstr : bytes?
  handler : (or/c #f (bytes? . -> . any))
```

Takes a byte-string representation of a regular expression (using the syntax in §4.8.1 "Regexp Syntax") and compiles it into a byte-regexp value.

If *handler* is provided, it is called and its result is returned if *bstr* is not a valid representation of a regular expression.

The object-name procedure returns the source byte string for a regexp value.

Examples:

```
> (byte-regexp #"ap*le")
#rx#"ap*le"
> (object-name #rx#"ap*le")
#"ap*le"
> (byte-regexp "ap*le")
byte-regexp: contract violation
  expected: bytes?
  given: "ap*le"
> (byte-regexp #"+" (λ (s) (list s)))
'("`+` follows nothing in pattern")
```

Changed in version 6.5.0.1 of package base: Added the *handler* argument.

```
(byte-pregexp bstr) → byte-pregexp?
  bstr : bytes?
(byte-pregexp bstr handler) → any
```

```
bstr : bytes?
handler : (or/c #f (bytes? . -> . any))
```

Like `byte-regexp`, except that it uses a slightly different syntax (see §4.8.1 "Regexp Syntax"). The result can be used with `regexp-match`, etc., just like the result from `byte-regexp`.

Examples:

```
> (byte-pregexp #"ap*le")
#px#"ap*le"
> (byte-pregexp #"+" (λ (s) (vector s)))
'#("`+` follows nothing in pattern")
```

Changed in version 6.5.0.1 of package `base`: Added the *`handler`* argument.

```
(regexp-quote str [case-sensitive?]) → string?
  str : string?
  case-sensitive? : any/c = #t
(regexp-quote bstr [case-sensitive?]) → bytes?
  bstr : bytes?
  case-sensitive? : any/c = #t
```

Produces a string or byte string suitable for use with `regexp` to match the literal sequence of characters in *`str`* or sequence of bytes in *`bstr`*. If *`case-sensitive?`* is true (the default), the resulting regexp matches letters in *`str`* or *`bstr`* case-sensitively, otherwise it matches case-insensitively.

Examples:

```
> (regexp-match "." "apple.scm")
'("a")
> (regexp-match (regexp-quote ".") "apple.scm")
'(".")
```

```
(pregexp-quote str [case-sensitive?]) → string?
  str : string?
  case-sensitive? : any/c = #t
(pregexp-quote bstr [case-sensitive?]) → bytes?
  bstr : bytes?
  case-sensitive? : any/c = #t
```

Like `regexp-quote`, but intended for use with `pregexp`. Escapes all non-alphanumeric, non-underscore characters in the input.

Added in version 8.11.1.9 of package `base`.

```
(regexp-max-lookbehind pattern) → exact-nonnegative-integer?
  pattern : (or/c regexp? byte-regexp?)
```

Returns the maximum number of bytes that *pattern* may consult before the starting position of a match to determine the match. For example, the pattern `(?<=abc)d` consults three bytes preceding a matching `d`, while `e(?<=a..)d` consults two bytes before a matching `ed`. A `^` pattern may consult a preceding byte to determine whether the current position is the start of the input or of a line.

Examples:

```
> (regexp-max-lookbehind #rx#"(?<=abc)d")
3
> (regexp-max-lookbehind #rx#"e(?<=a..)d")
2
> (regexp-max-lookbehind #rx"^")
1
```

```
(regexp-capture-group-count pattern)
 → exact-nonnegative-integer?
  pattern : (or/c regexp? byte-regexp?)
```

Returns the number of capture groups that are in *pattern*, which corresponds to one less than the length of the list returned by `regexp-match` for a successful match to *pattern*.

Examples:

```
> (regexp-capture-group-count #rx"abcd")
0
> (regexp-capture-group-count #rx"a(b*c)(d*)")
2
> (regexp-capture-group-count #rx"a(?:bc)*d")
0
```

Added in version 8.15.0.8 of package `base`.

4.8.4 Regexp Matching

```
(regexp-match pattern
              input
             [start-pos
              end-pos
              output-port
              input-prefix])
```

```
→ (if (and (or (string? pattern) (regexp? pattern))
           (or (string? input) (path? input)))
      (or/c #f (cons/c string? (listof (or/c string? #f))))
      (or/c #f (cons/c bytes?  (listof (or/c bytes?  #f)))))
 pattern : (or/c regexp? byte-regexp? string? bytes?)
 input : (or/c string? bytes? path? input-port?)
 start-pos : exact-nonnegative-integer? = 0
 end-pos : (or/c exact-nonnegative-integer? #f) = #f
 output-port : (or/c output-port? #f) = #f
 input-prefix : bytes? = #""
```

Attempts to match `pattern` (a string, byte string, regexp value, or byte-regexp value) once to a portion of `input`. The matcher finds a portion of `input` that matches and is closest to the start of the input (after `start-pos`).

If `input` is a path, it is converted to a byte string with `path->bytes` if `pattern` is a byte string or a byte-based regexp. Otherwise, `input` is converted to a string with `path->string`.

The optional `start-pos` and `end-pos` arguments select a portion of `input` for matching; the default is the entire string or the stream up to an end-of-file. When `input` is a string, `start-pos` is a character position; when `input` is a byte string, then `start-pos` is a byte position; and when `input` is an input port, `start-pos` is the number of bytes to skip before starting to match. The `end-pos` argument can be `#f`, which corresponds to the end of the string or an end-of-file in the stream; otherwise, it is a character or byte position, like `start-pos`. If `input` is an input port, and if an end-of-file is reached before `start-pos` bytes are skipped, then the match fails.

In `pattern`, a start-of-string `^` refers to the first position of `input` after `start-pos`, assuming that `input-prefix` is `#""`. The end-of-input `$` refers to the `end-pos`th position or (in the case of an input port) an end-of-file, whichever comes first.

The `input-prefix` specifies bytes that effectively precede `input` for the purposes of `^` and other look-behind matching. For example, a `#""` prefix means that `^` matches at the beginning of the stream, while a `#"\n"` `input-prefix` means that a start-of-line `^` can match the beginning of the input, while a start-of-file `^` cannot.

If the match fails, `#f` is returned. If the match succeeds, a list containing strings or byte string, and possibly `#f`, is returned. The list contains strings only if `input` is a string and `pattern` is not a byte regexp. Otherwise, the list contains byte strings (substrings of the UTF-8 encoding of `input`, if `input` is a string).

The first (byte) string in a result list is the portion of `input` that matched `pattern`. If two portions of `input` can match `pattern`, then the match that starts earliest is found.

Additional (byte) strings are returned in the list if `pattern` contains parenthesized sub-expressions (but not when the opening parenthesis is followed by `?`). Matches for the sub-expressions are provided in the order of the opening parentheses in *pattern*. When sub-expressions occur in branches of an `|` "or" pattern, in a `*` "zero or more" pattern, or other places where the overall pattern can succeed without a match for the sub-expression, then a `#f` is returned for the sub-expression if it did not contribute to the final match. When a single sub-expression occurs within a `*` "zero or more" pattern or other multiple-match positions, then the rightmost match associated with the sub-expression is returned in the list.

If the optional *output-port* is provided as an output port, the part of *input* from its beginning (not *start-pos*) that precedes the match is written to the port. All of *input* up to *end-pos* is written to the port if no match is found. This functionality is most useful when *input* is an input port.

When matching an input port, a match failure reads up to *end-pos* bytes (or end-of-file), even if *pattern* begins with a start-of-string `^`; see also `regexp-try-match`. On success, all bytes up to and including the match are eventually read from the port, but matching proceeds by first peeking bytes from the port (using `peek-bytes-avail!`), and then (re-)reading matching bytes to discard them after the match result is determined. Non-matching bytes may be read and discarded before the match is determined. The matcher peeks in blocking mode only as far as necessary to determine a match, but it may peek extra bytes to fill an internal buffer if immediately available (i.e., without blocking). Greedy repeat operators in *pattern*, such as `*` or `+`, tend to force reading the entire content of the port (up to *end-pos*) to determine a match.

If the input port is read simultaneously by another thread, or if the port is a custom port with inconsistent reading and peeking procedures (see §13.1.9 "Custom Ports"), then the bytes that are peeked and used for matching may be different than the bytes read and discarded after the match completes; the matcher inspects only the peeked bytes. To avoid such interleaving, use `regexp-match-peek` (with a *progress* argument) followed by `port-commit-peeked`.

Examples:

```
> (regexp-match #rx"x." "12x4x6")
'("x4")
> (regexp-match #rx"y." "12x4x6")
#f
> (regexp-match #rx"x." "12x4x6" 3)
'("x6")
> (regexp-match #rx"x." "12x4x6" 3 4)
#f
> (regexp-match #rx#"x." "12x4x6")
'(#"x4")
> (regexp-match #rx"x." "12x4x6" 0 #f (current-output-port))
12
'("x4")
> (regexp-match #rx"(-[0-9]*)+" "a-12--345b")
'("-12--345" "-345")
```

```
(regexp-match* pattern
               input
              [start-pos
               end-pos
               input-prefix
               #:match-select match-select
               #:gap-select? gap-select])
 → (if (and (or (string? pattern) (regexp? pattern))
            (or (string? input) (path? input)))
       (listof (or/c string? (listof (or/c #f string?))))
       (listof (or/c bytes? (listof (or/c #f bytes?)))))
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : (or/c string? bytes? path? input-port?)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  input-prefix : bytes? = #""
  match-select : (or/c (list? . -> . (or/c any/c list?)) = car
                       #f)
  gap-select : any/c = #f
```

Like `regexp-match`, but the result is a list of strings or byte strings corresponding to a sequence of matches of *pattern* in *input*.

The *pattern* is used in order to find matches, where each match attempt starts at the end of the last match, and `^` is allowed to match the beginning of the input (if *input-prefix* is `#""`) only for the first match. Empty matches are handled like other matches, returning a zero-length string or byte sequence (they are more useful in making this a complement of `regexp-split`), but *pattern* is restricted from matching an empty sequence immediately after an empty match.

If *input* contains no matches (in the range *start-pos* to *end-pos*), `null` is returned. Otherwise, each item in the resulting list is a distinct substring or byte sequence from *input* that matches *pattern*. The *end-pos* argument can be `#f` to match to the end of *input* (which corresponds to an end-of-file if *input* is an input port).

Examples:

```
> (regexp-match* #rx"x." "12x4x6")
'("x4" "x6")
> (regexp-match* #rx"x*" "12x4x6")
'("" "" "x" "" "x" "" "")
```

The *match-select* function specifies the collected results. The default of `car` means that the result is the list of matches without returning parenthesized sub-patterns. It can be given as a “selector” function which chooses an item from a list, or it can choose a list of items.

For example, you can use `cdr` to get a list of lists of parenthesized sub-patterns matches, or `values` (as an identity function) to get the full matches as well. (Note that the selector must choose an element of its input list or a list of elements, but it must not inspect its input as they can be either a list of strings or a list of position pairs. Furthermore, the selector must be consistent in its choice(s).)

Examples:

```
> (regexp-match* #rx"x(.)" "12x4x6" #:match-select cadr)
'("4" "6")
> (regexp-match* #rx"x(.)" "12x4x6" #:match-select values)
'(("x4" "4") ("x6" "6"))
```

In addition, specifying *gap-select* as a non-`#f` value will make the result an interleaved list of the matches as well as the separators between them matches, starting and ending with a separator. In this case, *match-select* can be given as `#f` to return *only* the separators, making such uses equivalent to `regexp-split`.

Examples:

```
> (regexp-match* #rx"x(.)" "12x4x6" #:match-select cadr #:gap-
select? #t)
'("12" "4" "" "6" "")
> (regexp-match* #rx"x(.)" "12x4x6" #:match-select #f #:gap-
select? #t)
'("12" "" "")
```

```
(regexp-try-match  pattern
                   input
                  [start-pos
                   end-pos
                   output-port
                   input-prefix])
 → (or/c #f (cons/c bytes? (listof (or/c bytes? #f))))
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : input-port?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  output-port : (or/c output-port? #f) = #f
  input-prefix : bytes? = #""
```

Like `regexp-match` on input ports, except that if the match fails, no characters are read and discarded from `in`.

This procedure is especially useful with a *pattern* that begins with a start-of-string `^` or with a non-`#f` *end-pos*, since each limits the amount of peeking into the port. Otherwise, beware that a large portion of the stream may be peeked (and therefore pulled into memory) before the match succeeds or fails.

```
(regexp-match-positions  pattern
                         input
                        [start-pos
                         end-pos
                         output-port
                         input-prefix])
 → (or/c (cons/c (cons/c exact-nonnegative-integer?
                         exact-nonnegative-integer?)
                 (listof (or/c (cons/c exact-integer?
                                       exact-integer?)
                               #f)))
         #f)
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : (or/c string? bytes? path? input-port?)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  output-port : (or/c output-port? #f) = #f
  input-prefix : bytes? = #""
```

Like `regexp-match`, but returns a list of number pairs (and `#f`) instead of a list of strings. Each pair of numbers refers to a range of characters or bytes in *input*. If the result for the same arguments with `regexp-match` would be a list of byte strings, the resulting ranges correspond to byte ranges; in that case, if *input* is a character string, the byte ranges correspond to bytes in the UTF-8 encoding of the string.

Range results are returned in a `substring`- and `subbytes`-compatible manner, independent of *start-pos*. In the case of an input port, the returned positions indicate the number of bytes that were read, including *start-pos*, before the first matching byte.

Examples:

```
> (regexp-match-positions #rx"x." "12x4x6")
'((2 . 4))
> (regexp-match-positions #rx"x." "12x4x6" 3)
'((4 . 6))
> (regexp-match-positions #rx"(-[0-9]*)+" "a-12--345b")
'((1 . 9) (5 . 9))
```

Range results after the first one can include negative numbers if *input-prefix* is non-empty and if *pattern* includes a lookbehind pattern. Such ranges start in the *input-prefix* instead of *input*. More generally, when *start-pos* is positive, then range results that are less than *start-pos* start in *input-prefix*.

Examples:

```
> (regexp-match-positions #rx"(?<=(.))." "a" 0 #f #f #"x")
'((0 . 1) (-1 . 0))
> (regexp-match-positions #rx"(?<=(..))." "a" 0 #f #f #"x")
#f
> (regexp-match-positions #rx"(?<=(..))." "_a" 1 #f #f #"x")
#f
```

Although *input-prefix* is always a byte string, when the returned positions are string indices and they refer to a portion of *input-prefix*, then they correspond to a UTF-8 decoding of a tail of *input-prefix*.

Examples:

```
> (bytes-length (string->bytes/utf-8 "λ"))
2
> (regexp-match-positions #rx"(?<=(.))." "a" 0 #f #f (string-
>bytes/utf-8 "λ"))
'((0 . 1) (-1 . 0))
```

```
(regexp-match-positions*  pattern
                          input
                         [start-pos
                          end-pos
                          input-prefix
                          #:match-select match-select])
 → (or/c (listof (cons/c exact-nonnegative-integer?
                         exact-nonnegative-integer?))
         (listof (listof (or/c #f (cons/c exact-nonnegative-integer?
                                          exact-nonnegative-integer?)))))
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : (or/c string? bytes? path? input-port?)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  input-prefix : bytes? = #""
  match-select : (list? . -> . (or/c any/c list?)) = car
```

Like `regexp-match-positions`, but returns multiple matches like `regexp-match*`.

Examples:

```
> (regexp-match-positions* #rx"x." "12x4x6")
'((2 . 4) (4 . 6))
> (regexp-match-positions* #rx"x(.)" "12x4x6" #:match-select cadr)
'((3 . 4) (5 . 6))
```

Note that unlike `regexp-match*`, there is no `#:gap-select?` input keyword, as this information can be easily inferred from the resulting matches.

```
(regexp-match? pattern
               input
              [start-pos
               end-pos
               output-port
               input-prefix]) → boolean?
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : (or/c string? bytes? path? input-port?)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  output-port : (or/c output-port? #f) = #f
  input-prefix : bytes? = #""
```

Like `regexp-match`, but returns merely `#t` when the match succeeds, `#f` otherwise.

Examples:

```
> (regexp-match? #rx"x." "12x4x6")
#t
> (regexp-match? #rx"y." "12x4x6")
#f
```

```
(regexp-match-exact? pattern input) → boolean?
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : (or/c string? bytes? path?)
```

Like `regexp-match?`, but `#t` is only returned when the first found match is to the entire content of *`input`*.

Examples:

```
> (regexp-match-exact? #rx"x." "12x4x6")
#f
> (regexp-match-exact? #rx"1.*x." "12x4x6")
#t
```

Beware that `regexp-match-exact?` can return `#f` if *`pattern`* generates a partial match for *`input`* first, even if *`pattern`* could also generate a complete match. To check if there is any match of *`pattern`* that covers all of *`input`*, use `regexp-match?` with `^(?:pattern)$` instead.

Examples:

```
> (regexp-match-exact? #rx"a|ab" "ab")
#f
> (regexp-match? #rx"^(?:a|ab)$" "ab")
#t
```

The `(?:)` grouping is necessary because concatenation has lower precedence than alternation; the regular expression without it, `^a|ab$`, matches any input that either starts with `a` or ends with `ab`.

Example:

```
> (regexp-match? #rx"^a|ab$" "123ab")
#t
```

```
(regexp-match-peek  pattern
                    input
                   [start-pos
                    end-pos
                    progress
                    input-prefix])
 → (or/c (cons/c bytes? (listof (or/c bytes? #f)))
         #f)
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : input-port?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  progress : (or/c progress-evt? #f) = #f
  input-prefix : bytes? = #""
```

Like `regexp-match` on input ports, but only peeks bytes from *`input`* instead of reading them. Furthermore, instead of an output port, the optional *`progress`* argument is a progress event for *`input`* (see `port-progress-evt`). If *`progress`* becomes ready, then the match stops peeking from *`input`* and returns `#f`. The *`progress`* argument can be `#f`, in which case the peek may continue with inconsistent information if another process meanwhile reads from *`input`*.

Examples:

```
> (define p (open-input-string "a abcd"))
> (regexp-match-peek ".*bc" p)
'(#"a abc")
> (regexp-match-peek ".*bc" p 2)
'(#"abc")
> (regexp-match ".*bc" p 2)
'(#"abc")
```

```
> (peek-char p)
#\d
> (regexp-match ".*bc" p)
#f
> (peek-char p)
#<eof>
```

```
(regexp-match-peek-positions  pattern
                              input
                             [start-pos
                              end-pos
                              progress
                              input-prefix])
 → (or/c (cons/c (cons/c exact-nonnegative-integer?
                         exact-nonnegative-integer?)
                 (listof (or/c (cons/c exact-nonnegative-integer?
                                       exact-nonnegative-integer?)
                               #f)))
         #f)
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : input-port?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  progress : (or/c progress-evt? #f) = #f
  input-prefix : bytes? = #""
```

Like `regexp-match-positions` on input ports, but only peeks bytes from *input* instead of reading them, and with a *progress* argument like `regexp-match-peek`.

```
(regexp-match-peek-immediate  pattern
                              input
                             [start-pos
                              end-pos
                              progress
                              input-prefix])
 → (or/c (cons/c bytes? (listof (or/c bytes? #f)))
         #f)
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : input-port?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  progress : (or/c progress-evt? #f) = #f
  input-prefix : bytes? = #""
```

Like `regexp-match-peek`, but it attempts to match only bytes that are available from *input* without blocking. The match fails if not-yet-available characters might be used to match *pattern*.

```
(regexp-match-peek-positions-immediate  pattern
                                        input
                                       [start-pos
                                        end-pos
                                        progress
                                        input-prefix])
 → (or/c (cons/c (cons/c exact-nonnegative-integer?
                         exact-nonnegative-integer?)
                 (listof (or/c (cons/c exact-nonnegative-integer?
                                       exact-nonnegative-integer?)
                               #f)))
         #f)
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : input-port?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  progress : (or/c progress-evt? #f) = #f
  input-prefix : bytes? = #""
```

Like `regexp-match-peek-positions`, but it attempts to match only bytes that are available from *input* without blocking. The match fails if not-yet-available characters might be used to match *pattern*.

```
(regexp-match-peek-positions*  pattern
                               input
                              [start-pos
                               end-pos
                               input-prefix
                               #:match-select match-select])
 → (or/c (listof (cons/c exact-nonnegative-integer?
                         exact-nonnegative-integer?))
         (listof (listof (or/c #f (cons/c exact-nonnegative-integer?
                                          exact-nonnegative-integer?)))))
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : input-port?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  input-prefix : bytes? = #""
  match-select : (list? . -> . (or/c any/c list?)) = car
```

Like `regexp-match-peek-positions`, but returns multiple matches like `regexp-match-positions*`.

```
(regexp-match/end pattern
                  input
                 [start-pos
                  end-pos
                  output-port
                  input-prefix
                  count])
   (if (and (or (string? pattern) (regexp? pattern))
            (or/c (string? input) (path? input)))
 →      (or/c #f (cons/c string? (listof (or/c string? #f))))
        (or/c #f (cons/c bytes?  (listof (or/c bytes?  #f)))))
   (or/c #f bytes?)
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : (or/c string? bytes? path? input-port?)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  output-port : (or/c output-port? #f) = #f
  input-prefix : bytes? = #""
  count : exact-nonnegative-integer? = 1
```

Like `regexp-match`, but with a second result: a byte string of up to *count* bytes that correspond to the input (possibly including the *input-prefix*) leading to the end of the match; the second result is `#f` if no match is found.

The second result can be useful as an *input-prefix* for attempting a second match on *input* starting from the end of the first match. In that case, use `regexp-max-lookbehind` to determine an appropriate value for *count*.

```
(regexp-match-positions/end pattern
                            input
                           [start-pos
                            end-pos
                            input-prefix
                            count])
   (listof (cons/c exact-nonnegative-integer?
 →                 exact-nonnegative-integer?))
   (or/c #f bytes?)
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : (or/c string? bytes? path? input-port?)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  input-prefix : bytes? = #""
  count : exact-nonnegative-integer? = 1
```

```
(regexp-match-peek-positions/end  pattern
                                  input
                                 [start-pos
                                  end-pos
                                  progress
                                  input-prefix
                                  count])
   (or/c (cons/c (cons/c exact-nonnegative-integer?
                         exact-nonnegative-integer?)
 →                (listof (or/c (cons/c exact-nonnegative-integer?
                                        exact-nonnegative-integer?)
                                #f)))
         #f)
   (or/c #f bytes?)
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : input-port?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  progress : (or/c progress-evt? #f) = #f
  input-prefix : bytes? = #""
  count : exact-nonnegative-integer? = 1
(regexp-match-peek-positions-immediate/end  pattern
                                            input
                                           [start-pos
                                            end-pos
                                            progress
                                            input-prefix
                                            count])
   (or/c (cons/c (cons/c exact-nonnegative-integer?
                         exact-nonnegative-integer?)
 →                (listof (or/c (cons/c exact-nonnegative-integer?
                                        exact-nonnegative-integer?)
                                #f)))
         #f)
   (or/c #f bytes?)
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : input-port?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  progress : (or/c progress-evt? #f) = #f
  input-prefix : bytes? = #""
  count : exact-nonnegative-integer? = 1
```

Like `regexp-match-positions`, etc., but with a second result like `regexp-match/end`.

4.8.5 Regexp Splitting

```
(regexp-split  pattern
               input
              [start-pos
               end-pos
               input-prefix])
 → (if (and (or (string? pattern) (regexp? pattern))
            (string? input))
       (cons/c string? (listof string?))
       (cons/c bytes? (listof bytes?)))
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : (or/c string? bytes? input-port?)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  input-prefix : bytes? = #""
```

The complement of `regexp-match*`: the result is a list of strings (if *pattern* is a string or character regexp and *input* is a string) or byte strings (otherwise) from *input* that are separated by matches to *pattern*. Adjacent matches are separated with `""` or `#""`. Zero-length matches are treated the same as for `regexp-match*`.

If *input* contains no matches (in the range *start-pos* to *end-pos*), the result is a list containing *input*'s content (from *start-pos* to *end-pos*) as a single element. If a match occurs at the beginning of *input* (at *start-pos*), the resulting list will start with an empty string or byte string, and if a match occurs at the end (at *end-pos*), the list will end with an empty string or byte string. The *end-pos* argument can be `#f`, in which case splitting goes to the end of *input* (which corresponds to an end-of-file if *input* is an input port).

Examples:

```
> (regexp-split #rx" +" "12  34")
'("12" "34")
> (regexp-split #rx"." "12  34")
'("" "" "" "" "" "" "")
> (regexp-split #rx"" "12  34")
'("" "1" "2" " " " " "3" "4" "")
> (regexp-split #rx" *" "12  34")
'("" "1" "2" "" "3" "4" "")
> (regexp-split #px"\\b" "12, 13 and 14.")
'("" "12" ", " "13" " " "and" " " "14" ".")
> (regexp-split #rx" +" "")
'("")
```

4.8.6 Regexp Substitution

```
(regexp-replace pattern
                input
                insert
               [input-prefix])
 → (if (and (or (string? pattern) (regexp? pattern))
            (string? input))
       string?
       bytes?)
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : (or/c string? bytes?)
  insert : (or/c string? bytes?
                 (string? string? ... . -> . string?)
                 (bytes? bytes? ... . -> . bytes?))
  input-prefix : bytes? = #""
```

Performs a match using *pattern* on *input*, and then returns a string or byte string in which the matching portion of *input* is replaced with *insert*. If *pattern* matches no part of *input*, then *input* is returned unmodified.

The *insert* argument can be either a (byte) string, or a function that returns a (byte) string. In the latter case, the function is applied on the list of values that `regexp-match` would return (i.e., the first argument is the complete match, and then one argument for each parenthesized sub-expression) to obtain a replacement (byte) string.

If *pattern* is a string or character regexp and *input* is a string, then *insert* must be a string or a procedure that accept strings, and the result is a string. If *pattern* is a byte string or byte regexp, or if *input* is a byte string, then *insert* as a string is converted to a byte string, *insert* as a procedure is called with a byte string, and the result is a byte string.

If *insert* contains `&`, then `&` is replaced with the matching portion of *input* before it is substituted into the match's place. If *insert* contains `\`⟨*n*⟩ for some integer ⟨*n*⟩, then it is replaced with the ⟨*n*⟩th matching sub-expression from *input*. A `&` and `\0` are aliases. If the ⟨*n*⟩th sub-expression was not used in the match, or if ⟨*n*⟩ is greater than the number of sub-expressions in *pattern*, then `\`⟨*n*⟩ is replaced with the empty string.

To substitute a literal `&` or `\`, use `\&` and `\\`, respectively, in *insert*. A `\$` in *insert* is equivalent to an empty sequence; this can be used to terminate a number ⟨*n*⟩ following `\`. If a `\` in *insert* is followed by anything other than a digit, `&`, `\`, or `$`, then the `\` by itself is treated as `\0`.

Note that the `\` described in the previous paragraphs is a character or byte of *insert*. To write such an *insert* as a Racket string literal, an escaping `\` is needed before the `\`. For example, the Racket constant `"\\1"` is `\1`.

Examples:

```
> (regexp-replace #rx"mi" "mi casa" "su")
"su casa"
> (regexp-replace #rx"mi" "mi casa" string-upcase)
"MI casa"
> (regexp-replace #rx"([Mm])i ([a-zA-Z]*)" "Mi Casa" "\\1y \\2")
"My Casa"
> (regexp-replace #rx"([Mm])i ([a-zA-Z]*)" "mi cerveza Mi Mi Mi"
                  "\\1y \\2")
"my cerveza Mi Mi Mi"
> (regexp-replace #rx"x" "12x4x6" "\\\\")
"12\\4x6"
> (display (regexp-replace #rx"x" "12x4x6" "\\\\"))
12\4x6
```

```
(regexp-replace* pattern
                 input
                 insert
                [start-pos
                 end-pos
                 input-prefix]) → (or/c string? bytes?)
  pattern : (or/c regexp? byte-regexp? string? bytes?)
  input : (or/c string? bytes?)
  insert : (or/c string? bytes?
                (string? string? ... . -> . string?)
                (bytes? bytes? ... . -> . bytes?))
  start-pos : exact-nonnegative-integer? = 0
  end-pos : (or/c exact-nonnegative-integer? #f) = #f
  input-prefix : bytes? = #""
```

Like `regexp-replace`, except that every instance of *pattern* in *input* is replaced with *insert*, instead of just the first match. The result is *input* only if there are no matches, *start-pos* is `0`, and *end-pos* is `#f` or the length of *input*. Only non-overlapping instances of *pattern* in *input* are replaced, so instances of *pattern* within inserted strings are *not* replaced recursively. Zero-length matches are treated the same as in `regexp-match*`.

The optional *start-pos* and *end-pos* arguments select a portion of *input* for matching; the default is the entire string or the stream up to an end-of-file.

Examples:

```
> (regexp-replace* #rx"([Mm])i ([a-zA-Z]*)" "mi cerveza Mi Mi Mi"
                   "\\1y \\2")
"my cerveza My Mi Mi"
```

```
> (regexp-replace* #rx"([Mm])i ([a-zA-Z]*)" "mi cerveza Mi Mi Mi"
                   (lambda (all one two)
                     (string-append (string-downcase one) "y"
                                    (string-upcase two))))
"myCERVEZA myMI Mi"
> (regexp-replace* #px"\\w" "hello world" string-upcase 0 5)
"HELLO world"
> (display (regexp-replace* #rx"x" "12x4x6" "\\\\"))
12\4\6
```

Changed in version 8.1.0.7 of package base: Changed to return *input* when no replacements are performed.

```
(regexp-replaces input replacements) → (or/c string? bytes?)
  input : (or/c string? bytes?)
  replacements : (listof
                  (list/c (or/c regexp? byte-regexp? string? bytes?)
                          (or/c string? bytes?
                                (string? string? ... . -> . string?)
                                (bytes? bytes? ... . -> . bytes?))))
```

Performs a chain of `regexp-replace*` operations, where each element in *replacements* specifies a replacement as a `(list pattern insert)`. The replacements are done in order, so later replacements can apply to previous insertions.

Examples:

```
> (regexp-replaces "zero-or-more?"
                   '([#rx"-" "_"] [#rx"(.*)\\?$" "is_\\1"]))
"is_zero_or_more"
> (regexp-replaces "zero-or-more?"
                   '([#rx"e" "o"] [#rx"o" "oo"]))
"zooroo-oor-mooroo?"
```

```
(regexp-replace-quote str) → string?
  str : string?
(regexp-replace-quote bstr) → bytes?
  bstr : bytes?
```

Produces a string suitable for use as the third argument to `regexp-replace` to insert the literal sequence of characters in *str* or bytes in *bstr* as a replacement. Concretely, every `\` and `&` in *str* or *bstr* is protected by a quoting `\`.

Examples:

```
> (regexp-replace #rx"UT" "Go UT!" "A&M")
"Go AUTM!"
> (regexp-replace #rx"UT" "Go UT!" (regexp-replace-quote "A&M"))
"Go A&M!"
```

4.9 Keywords

§3.7 "Keywords" in *The Racket Guide* introduces keywords.

A *keyword* is like an interned symbol, but its printed form starts with `#:`, and a keyword cannot be used as an identifier. Furthermore, a keyword by itself is not a valid expression, though a keyword can be `quote`d to form an expression that produces the symbol.

Two keywords are `eq?` if and only if they print the same (i.e., keywords are always interned).

Like symbols, keywords are only weakly held by the internal keyword table; see §4.7 "Symbols" for more information.

See §1.3.15 "Reading Keywords" for information on `read`ing keywords and §1.4.12 "Printing Keywords" for information on `print`ing keywords.

```
(keyword? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a keyword, `#f` otherwise.

Examples:

```
> (keyword? '#:apple)
#t
> (keyword? 'define)
#f
> (keyword? '#:define)
#t
```

```
(keyword->string keyword) → string?
  keyword : keyword?
```

Returns a string for the `display`ed form of *keyword*, not including the leading `#:`.

See also `keyword->immutable-string` from `racket/keyword`.

Example:

```
> (keyword->string '#:apple)
"apple"
```

```
(string->keyword str) → keyword?
  str : string?
```

Returns a keyword whose `display`ed form is the same as that of *str*, but with a leading `#:`.

Example:

```
> (string->keyword "apple")
'#:apple
```

```
(keyword<? a-keyword b-keyword ...) → boolean?
  a-keyword : keyword?
  b-keyword : keyword?
```

Returns `#t` if the arguments are sorted, where the comparison for each pair of keywords is the same as using `keyword->string` with `string->bytes/utf-8` and `bytes<?`.

Example:

```
> (keyword<? '#:apple '#:banana)
#t
```

Changed in version 7.0.0.13 of package `base`: Allow one argument, in addition to allowing two or more.

4.9.1 Additional Keyword Functions

```
(require racket/keyword)        package: base
```

The bindings documented in this section are provided by the `racket/keyword` library, not `racket/base` or `racket`.

Added in version 7.6 of package `base`.

```
(keyword->immutable-string sym) → (and/c string? immutable?)
  sym : keyword?
```

Like `keyword->string`, but the result is an immutable string, not necessarily freshly allocated.

Examples:

```
> (keyword->immutable-string '#:apple)
"apple"
> (immutable? (keyword->immutable-string '#:apple))
#t
```

Added in version 7.6 of package `base`.

4.10 Pairs and Lists

§3.8 "Pairs and Lists" in *The Racket Guide* introduces pairs and lists.

A *pair* combines exactly two values. The first value is accessed with the `car` procedure, and the second value is accessed with the `cdr` procedure. Pairs are not mutable (but see §4.11 "Mutable Pairs and Lists").

A *list* is recursively defined: it is either the constant `null`, or it is a pair whose second value is a list.

A list can be used as a single-valued sequence (see §4.17.1 "Sequences"). The elements of the list serve as elements of the sequence. See also `in-list`.

Cyclic data structures can be created using only immutable pairs via `read` or `make-reader-graph`. If starting with a pair and using some number of `cdr`s returns to the starting pair, then the pair is not a list.

See §1.3.6 "Reading Pairs and Lists" for information on `read`ing pairs and lists and §1.4.5 "Printing Pairs and Lists" for information on `print`ing pairs and lists.

4.10.1 Pair Constructors and Selectors

```
(pair? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a pair, `#f` otherwise.

Examples:

```
> (pair? 1)
#f
> (pair? (cons 1 2))
#t
> (pair? (list 1 2))
#t
> (pair? '(1 2))
#t
> (pair? '())
#f
```

```
(null? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is the empty list, `#f` otherwise.

Examples:

```
> (null? 1)
#f
> (null? '(1 2))
#f
> (null? '())
#t
> (null? (cdr (list 1)))
#t
```

```
(cons a d) → list?
  a : any/c
  d : list?
(cons a d) → pair?
  a : any/c
  d : any/c
```

Returns a newly allocated pair whose first element is `a` and second element is `d`. When `d` is a list, the allocated pair is also a list.

Examples:

```
> (cons 1 2)
'(1 . 2)
> (cons 1 '())
'(1)
```

```
(car p) → any/c
  p : pair?
```

Returns the first element of the pair `p`.

Examples:

```
> (car '(1 2))
1
> (car '(2 . 3))
2
```

```
(cdr p) → any/c
  p : pair?
```

Returns the second element of the pair `p`.

Examples:

```
> (cdr '(1 2))
'(2)
> (cdr '(2 . 3))
3
```

```
null : null?
```

The empty list.

Examples:

```
> null
'()
> '()
'()
> (eq? '() null)
#t
```

```
(list? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a list: either the empty list, or a pair whose second element is a list. This procedure effectively takes constant time due to internal caching (so that any necessary traversals of pairs can in principle count as an extra cost of allocating the pairs).

Examples:

```
> (list? '(1 2))
#t
> (list? (cons 1 (cons 2 '())))
#t
> (list? (cons 1 2))
#f
```

```
(list v ...) → list?
  v : any/c
```

Returns a newly allocated list containing the *v*s as its elements.

Examples:

```
> (list 1 2 3 4)
'(1 2 3 4)
> (list (list 1 2) (list 3 4))
'((1 2) (3 4))
```

```
(list* v ... tail) → list?
  v : any/c
  tail : list?
(list* v ... tail) → any/c
  v : any/c
  tail : any/c
```

Like `list`, but the last argument is used as the tail of the result, instead of the final element. The result is a list only if the last argument is a list.

Examples:

```
> (list* 1 2 3)
'(1 2 . 3)
> (list* 1 2 (list 3 4))
'(1 2 3 4)
```

```
(build-list n proc) → list?
  n : exact-nonnegative-integer?
  proc : (exact-nonnegative-integer? . -> . any/c)
```

Creates a list of *n* elements by applying *proc* to the integers from `0` to `(sub1 n)` in order. If *lst* is the resulting list, then `(list-ref lst i)` is the value produced by `(proc i)`.

Examples:

```
> (build-list 10 values)
'(0 1 2 3 4 5 6 7 8 9)
> (build-list 5 (lambda (x) (* x x)))
'(0 1 4 9 16)
```

4.10.2 List Operations

```
(length lst) → exact-nonnegative-integer?
  lst : list?
```

Returns the number of elements in *lst*. This function takes time proportional to that length.

Examples:

```
> (length (list 1 2 3 4))
4
> (length '())
0
```

```
(list-ref lst pos) → any/c
  lst : list?
  pos : exact-nonnegative-integer?
(list-ref lst pos) → any/c
  lst : pair?
  pos : exact-nonnegative-integer?
```

Returns the element of `lst` at position `pos`, where the list's first element is position `0`. If the list has `pos` or fewer elements, then the `exn:fail:contract` exception is raised.

The `lst` argument need not actually be a list; `lst` must merely start with a chain of at least `(add1 pos)` pairs.

This function takes time proportional to `pos`.

Examples:

```
> (list-ref (list 'a 'b 'c) 0)
'a
> (list-ref (list 'a 'b 'c) 1)
'b
> (list-ref (list 'a 'b 'c) 2)
'c
> (list-ref (cons 1 2) 0)
1
> (list-ref (cons 1 2) 1)
list-ref: index reaches a non-pair
  index: 1
  in: '(1 . 2)
```

```
(list-tail lst pos) → list?
  lst : list?
  pos : exact-nonnegative-integer?
(list-tail lst pos) → any/c
  lst : any/c
  pos : exact-nonnegative-integer?
```

Returns the list after the first `pos` elements of `lst`. If the list has fewer than `pos` elements, then the `exn:fail:contract` exception is raised.

The `lst` argument need not actually be a list; `lst` must merely start with a chain of at least `pos` pairs.

This function takes time proportional to `pos`.

Examples:

```
> (list-tail (list 1 2 3 4 5) 2)
'(3 4 5)
> (list-tail (cons 1 2) 1)
2
> (list-tail (cons 1 2) 2)
list-tail: index reaches a non-pair
  index: 2
  in: '(1 . 2)
> (list-tail 'not-a-pair 0)
'not-a-pair
```

```
(append lst ...) → list?
  lst : list?
(append lst ... v) → any/c
  lst : list?
  v : any/c
```

When given all list arguments, the result is a list that contains all of the elements of the given lists in order. The last argument is used directly in the tail of the result.

The last argument need not be a list, in which case the result is an "improper list."

This function takes time proportional to the length of all arguments (added together) except the last argument.

Examples:

```
> (append (list 1 2) (list 3 4))
'(1 2 3 4)
> (append (list 1 2) (list 3 4) (list 5 6) (list 7 8))
'(1 2 3 4 5 6 7 8)
```

```
(reverse lst) → list?
  lst : list?
```

Returns a list that has the same elements as `lst`, but in reverse order.

This function takes time proportional to the length of `lst`.

Example:

```
> (reverse (list 1 2 3 4))
'(4 3 2 1)
```

4.10.3 List Iteration

```
(map proc lst ...+) → list?
  proc : procedure?
  lst : list?
```

Applies *proc* to the elements of the *lst*s from the first elements to the last. The *proc* argument must accept the same number of arguments as the number of supplied *lst*s, and all *lst*s must have the same number of elements. The result is a list containing each result of *proc* in order.

Examples:

```
> (map (lambda (number)
         (+ 1 number))
       '(1 2 3 4))
'(2 3 4 5)
> (map (lambda (number1 number2)
         (+ number1 number2))
       '(1 2 3 4)
       '(10 100 1000 10000))
'(11 102 1003 10004)
```

```
(andmap proc lst ...+) → any
  proc : procedure?
  lst : list?
```

Similar to `map` in the sense that *proc* is applied to each element of *lst*, but

- the result is `#f` if any application of *proc* produces `#f`, in which case *proc* is not applied to later elements of the *lst*s; and
- the result is that of *proc* applied to the last elements of the *lst*s; more specifically, the application of *proc* to the last elements in the *lst*s is in tail position with respect to the `andmap` call.

The `andmap` function is actually closer to `foldl` than `map`, since `andmap` doesn't produce a list. Still, `(andmap f (list x y z))` is equivalent to `(and (f x) (f y) (f z))` in the same way that `(map f (list x y z))` is equivalent to `(list (f x) (f y) (f z))`.

If the *lst*s are empty, then `#t` is returned.

Examples:

```
> (andmap positive? '(1 2 3))
#t
> (andmap positive? '(1 2 a))
positive?: contract violation
```

expected: real?
given: 'a

```
> (andmap positive? '(1 -2 a))
#f
> (andmap + '(1 2 3) '(4 5 6))
9
```

```
(ormap proc lst ...+) → any
  proc : procedure?
  lst : list?
```

Similar to `map` in the sense that *`proc`* is applied to each element of *`lst`*, but

To continue the `andmap` note above, `(ormap f (list x y z))` is equivalent to `(or (f x) (f y) (f z))`.

- the result is `#f` if every application of *`proc`* produces `#f`; and
- the result is that of the first application of *`proc`* producing a value other than `#f`, in which case *`proc`* is not applied to later elements of the *`lst`*s; the application of *`proc`* to the last elements of the *`lst`*s is in tail position with respect to the `ormap` call.

If the *`lst`*s are empty, then `#f` is returned.

Examples:

```
> (ormap eq? '(a b c) '(a b c))
#t
> (ormap positive? '(1 2 a))
#t
> (ormap + '(1 2 3) '(4 5 6))
5
```

```
(for-each proc lst ...+) → void?
  proc : procedure?
  lst : list?
```

Similar to `map`, but *`proc`* is called only for its effect, and its result (which can be any number of values) is ignored.

Example:

```
> (for-each (lambda (arg)
              (printf "Got ~a\n" arg)
              23)
            '(1 2 3 4))
```

```
Got 1
Got 2
Got 3
Got 4
```

```
(foldl proc init lst ...+) → any/c
  proc : procedure?
  init : any/c
  lst : list?
```

Like `map`, `foldl` applies a procedure to the elements of one or more lists. Whereas `map` combines the return values into a list, `foldl` combines the return values in an arbitrary way that is determined by *`proc`*.

If `foldl` is called with n lists, then *`proc`* must take n+1 arguments. The extra argument is the combined return values so far. The *`proc`* is initially invoked with the first item of each list, and the final argument is *`init`*. In subsequent invocations of *`proc`*, the last argument is the return value from the previous invocation of *`proc`*. The input *`lst`*s are traversed from left to right, and the result of the whole `foldl` application is the result of the last application of *`proc`*. If the *`lst`*s are empty, the result is *`init`*.

Unlike `foldr`, `foldl` processes the *`lst`*s in constant space (plus the space for each call to *`proc`*).

Examples:

```
> (foldl cons '() '(1 2 3 4))
'(4 3 2 1)
> (foldl + 0 '(1 2 3 4))
10
> (foldl (lambda (a b result)
           (* result (- a b)))
         1
         '(1 2 3)
         '(4 5 6))
-27
```

```
(foldr proc init lst ...+) → any/c
  proc : procedure?
  init : any/c
  lst : list?
```

Like `foldl`, but the lists are traversed from right to left. Unlike `foldl`, `foldr` processes the *`lst`*s in space proportional to the length of *`lst`*s (plus the space for each call to *`proc`*).

Examples:

```
> (foldr cons '() '(1 2 3 4))
'(1 2 3 4)
> (foldr (lambda (v l) (cons (add1 v) l)) '() '(1 2 3 4))
'(2 3 4 5)
```

4.10.4 More List Iteration

```
(require racket/list/iteration)
        package: sequence-tools-lib
```

The bindings documented in this section are provided by the `racket/list/iteration` library, not `racket/base` or `racket`.

The bindings in this section are provided by the `sequence-tools-lib` package, which acts as an extension to the base sequence libraries.

```
(running-foldl proc init lst ...+) → list?
  proc : procedure?
  init : any/c
  lst : list?
```

Like `foldl`, but produces a list containing all the results of applying *proc* as well as the initial accumulator.

Examples:

```
> (running-foldl + 0 '(1 2 3))
'(0 1 3 6)
> (running-foldl + 0 '())
'(0)
> (running-foldl (lambda (a b acc)
                   (* acc (+ a b)))
                 1
                 '(1 2)
                 '(3 4))
'(1 4 24)
```

```
(running-foldr proc init lst ...+) → list?
  proc : procedure?
  init : any/c
  lst : list?
```

Like `running-foldl`, but produces the intermediate results from the right like `foldr`.

Examples:

```
> (running-foldr + 0 '(1 2 3))
'(6 5 3 0)
> (running-foldr + 0 '())
'(0)
> (running-foldr (lambda (a b acc)
                   (* acc (+ a b)))
                 1
                 '(1 2)
                 '(3 4))
'(24 6 1)
```

4.10.5 List Filtering

```
(filter pred lst) → list?
  pred : procedure?
  lst : list?
```

Returns a list with the elements of *lst* for which *pred* produces a true value. The *pred* procedure is applied to each element from first to last.

Example:

```
> (filter positive? '(1 -2 3 4 -5))
'(1 3 4)
```

```
(remove v lst [proc]) → list?
  v : any/c
  lst : list?
  proc : procedure? = equal?
```

Returns a list that is like *lst*, omitting the first element of *lst* that is equal to *v* using the comparison procedure *proc* (which must accept two arguments), with *v* as the first argument and an element in *lst* as the second argument. If no element in *lst* is equal to *v* (according to *proc*), *lst* is returned unchanged.

Examples:

```
> (remove 2 (list 1 2 3 2 4))
'(1 3 2 4)
> (remove '(2) (list '(1) '(2) '(3)))
'((1) (3))
> (remove "2" (list "1" "2" "3"))
'("1" "3")
> (remove #\c (list #\a #\b #\c))
```

```
'(#\a #\b)
> (remove "B" (list "a" "A" "b" "B") string-ci=?)
'("a" "A" "B")
> (remove 5 (list 1 2 3 2 4))
'(1 2 3 2 4)
```

Changed in version 8.2.0.2 of package `base`: Guaranteed that the output is `eq?` to *`lst`* if no removal occurs.

```
(remq v lst) → list?
  v : any/c
  lst : list?
```

Returns `(remove v lst eq?)`.

Examples:

```
> (remq 2 (list 1 2 3 4 5))
'(1 3 4 5)
> (remq '(2) (list '(1) '(2) '(3)))
'((1) (2) (3))
> (remq "2" (list "1" "2" "3"))
'("1" "3")
> (remq #\c (list #\a #\b #\c))
'(#\a #\b)
```

```
(remv v lst) → list?
  v : any/c
  lst : list?
```

Returns `(remove v lst eqv?)`.

Examples:

```
> (remv 2 (list 1 2 3 4 5))
'(1 3 4 5)
> (remv '(2) (list '(1) '(2) '(3)))
'((1) (2) (3))
> (remv "2" (list "1" "2" "3"))
'("1" "3")
> (remv #\c (list #\a #\b #\c))
'(#\a #\b)
```

```
(remw v lst) → list?
  v : any/c
  lst : list?
```

Returns (remove v lst equal-always?).

Examples:

```
> (remw 2 (list 1 2 3 4 5))
'(1 3 4 5)
> (remw '(2) (list '(1) '(2) '(3)))
'((1) (3))
> (remw "2" (list "1" "2" "3"))
'("1" "3")
> (remw #\c (list #\a #\b #\c))
'(#\a #\b)
> (define b1 (box 5))
> (define b2 (box 5))
> (remw b2 (list 0 b1 1 b2 2))
'(0 #&5 1 2)
```

Added in version 8.5.0.3 of package base.

```
(remove* v-lst lst [proc]) → list?
  v-lst : list?
  lst : list?
  proc : procedure? = equal?
```

Like remove, but removes from lst every instance of every element of v-lst.

Example:

```
> (remove* (list 1 2) (list 1 2 3 2 4 5 2))
'(3 4 5)
```

Changed in version 8.2.0.2 of package base: Guaranteed that the output is eq? to lst if no removal occurs.

```
(remq* v-lst lst) → list?
  v-lst : list?
  lst : list?
```

Returns (remove* v-lst lst eq?).

Example:

```
> (remq* (list 1 2) (list 1 2 3 2 4 5 2))
'(3 4 5)
```

```
(remv* v-lst lst) → list?
  v-lst : list?
  lst : list?
```

Returns (remove* *v-lst* *lst* eqv?).

Example:

```
> (remv* (list 1 2) (list 1 2 3 2 4 5 2))
'(3 4 5)
```

```
(remw* v-lst lst) → list?
  v-lst : list?
  lst : list?
```

Returns (remove* *v-lst* *lst* equal-always?).

Examples:

```
> (remw* (list 1 2) (list 1 2 3 2 4 5 2))
'(3 4 5)
> (define b1 (box 5))
> (define b2 (box 5))
> (remw* (list b2) (list 0 b1 1 b2 2 b2 3))
'(0 #&5 1 2 3)
```

Added in version 8.5.0.3 of package base.

```
(sort  lst
       less-than?
      [#:key extract-key
       #:cache-keys? cache-keys?]) → list?
  lst : list?
  less-than? : (any/c any/c . -> . any/c)
  extract-key : (or/c #f (any/c . -> . any/c)) = #f
  cache-keys? : boolean? = #f
```

Returns a list sorted according to the *less-than?* procedure, which takes two elements of *lst* and returns a true value if the first is less (i.e., should be sorted earlier) than the second.

The sort is stable; if two elements of *lst* are "equal" (i.e., *less-than?* does not return a true value when given the pair in either order), then the elements preserve their relative order from *lst* in the output list. To preserve this guarantee, use sort with a strict comparison functions (e.g., < or string<?; not <= or string<=?).

Because of the peculiar fact that the IEEE-754 number system specifies that +nan.0 is neither greater nor less than nor equal to any other number, sorting lists containing this value may produce a surprising result.

The #:key argument *extract-key* is used to extract a key value for comparison from each list element, where #f is replaced by (lambda (x) x) That is, the full comparison procedure is essentially

```
(lambda (x y)
  (less-than? (extract-key x) (extract-key y)))
```

By default, *extract-key* is applied to two list elements for every comparison, but if *cache-keys?* is true, then the *extract-key* function is used exactly once for each list item. Supply a true value for *cache-keys?* when *extract-key* is an expensive operation; for example, if `file-or-directory-modify-seconds` is used to extract a timestamp for every file in a list, then *cache-keys?* should be `#t` to minimize file-system calls, but if *extract-key* is `car`, then *cache-keys?* should be `#f`. As another example, providing *extract-key* as `(lambda (x) (random))` and `#t` for *cache-keys?* effectively shuffles the list.

Examples:

```
> (sort '(1 3 4 2) <)
'(1 2 3 4)
> (sort '("aardvark" "dingo" "cow" "bear") string<?)
'("aardvark" "bear" "cow" "dingo")
> (sort '(("aardvark") ("dingo") ("cow") ("bear"))
        #:key car string<?)
'(("aardvark") ("bear") ("cow") ("dingo"))
```

4.10.6 List Searching

```
(member v lst [is-equal?]) → (or/c #f list?)
  v : any/c
  lst : list?
  is-equal? : (any/c any/c . -> . any/c) = equal?
(member v lst [is-equal?]) → any/c
  v : any/c
  lst : any/c
  is-equal? : (any/c any/c . -> . any/c) = equal?
```

Locates the first element of *lst* that is equal to *v* according to *is-equal?*. If such an element exists, the tail of *lst* starting with that element is returned. Otherwise, the result is `#f`.

The *lst* argument need not actually be a list; *lst* must merely start with a chain of pairs until a matching element is found. If no matching element is found, then *lst* must be a list (and not a cyclic list). The result can be a non-list in the case that an element is found and the returned tail of *lst* is a non-list.

Examples:

```
> (member 2 (list 1 2 3 4))
'(2 3 4)
> (member 9 (list 1 2 3 4))
#f
```

```
> (member #'x (list #'x #'y) free-identifier=?)
'(#<syntax:eval:576:0 x> #<syntax:eval:576:0 y>)
> (member #'a (list #'x #'y) free-identifier=?)
#f
> (member 'b '(a b . etc))
'(b . etc)
> (member 'c '(a b . etc))
member: not a proper list
  in: '(a b . etc)
```

```
(memw v lst) → (or/c #f list?)
  v : any/c
  lst : list?
(memw v lst) → any/c
  v : any/c
  lst : any/c
```

Like `member`, but finds an element using `equal-always?`.

Examples:

```
> (memw 2 (list 1 2 3 4))
'(2 3 4)
> (memw 9 (list 1 2 3 4))
#f
> (define b1 (box 5))
> (define b2 (box 5))
> (memw b2 (list 0 b1 1 b2 2))
'(#&5 2)
```

Added in version 8.5.0.3 of package `base`.

```
(memv v lst) → (or/c #f list?)
  v : any/c
  lst : list?
(memv v lst) → any/c
  v : any/c
  lst : any/c
```

Like `member`, but finds an element using `eqv?`.

Examples:

```
> (memv 2 (list 1 2 3 4))
'(2 3 4)
> (memv 9 (list 1 2 3 4))
#f
```

```
(memq v lst) → (or/c #f list?)
  v : any/c
  lst : list?
(memq v lst) → any/c
  v : any/c
  lst : any/c
```

Like `member`, but finds an element using `eq?`.

Examples:

```
> (memq 2 (list 1 2 3 4))
'(2 3 4)
> (memq 9 (list 1 2 3 4))
#f
```

```
(memf proc lst) → (or/c #f list?)
  proc : procedure?
  lst : list?
(memf proc lst) → any/c
  proc : procedure?
  lst : any/c
```

Like `member`, but finds an element using the predicate *`proc`*; an element is found when *`proc`* applied to the element returns a true value.

Example:

```
> (memf (lambda (arg)
          (> arg 9))
        '(7 8 9 10 11))
'(10 11)
```

```
(findf proc lst) → (or/c #f any/c)
  proc : procedure?
  lst : list?
(findf proc lst) → any/c
  proc : procedure?
  lst : any/c
```

Like `memf`, but returns the element or `#f` instead of a tail of *`lst`* or `#f`.

Notably, if `#f` is an element of *`lst`*, then the result of `#f` is ambiguous: it may indicate that no element satisfies *`proc`*, or may indicate that the element `#f` satisfies *`proc`*.

Example:

```
> (findf (lambda (arg)
           (> arg 9))
         '(7 8 9 10 11))
10
```

```
(assoc v lst [is-equal?]) → (or/c pair? #f)
  v : any/c
  lst : (listof pair?)
  is-equal? : (any/c any/c . -> . any/c) = equal?
(assoc v lst [is-equal?]) → pair?
  v : any/c
  lst : (list*of pair? (not/c '()))
  is-equal? : (any/c any/c . -> . any/c) = equal?
```

Locates the first element of `lst` whose `car` is equal to `v` according to `is-equal?`. If such an element exists, the pair (i.e., an element of `lst`) is returned. Otherwise, the result is `#f`.

The `lst` argument need not actually be a list of pairs; `lst` must merely start with a chain of pairs contains pairs until a matching element is found. If no matching element is found, then `lst` must be a list of pairs (and not a cyclic list).

Examples:

```
> (assoc 3 (list (list 1 2) (list 3 4) (list 5 6)))
'(3 4)
> (assoc 9 (list (list 1 2) (list 3 4) (list 5 6)))
#f
> (assoc 3.5
         (list (list 1 2) (list 3 4) (list 5 6))
         (lambda (a b) (< (abs (- a b)) 1)))
'(3 4)
```

```
(assw v lst) → (or/c pair? #f)
  v : any/c
  lst : (listof pair?)
(assw v lst) → pair?
  v : any/c
  lst : (list*of pair? (not/c '()))
```

Like `assoc`, but finds an element using `equal-always?`.

Examples:

```
> (assw 3 (list (list 1 2) (list 3 4) (list 5 6)))
'(3 4)
```

```
> (define b1 (box 0))
> (define b2 (box 0))
> (assw b2 (list (cons b1 1) (cons b2 2)))
'(#&0 . 2)
```

Added in version 8.5.0.3 of package `base`.

```
(assv v lst) → (or/c pair? #f)
  v : any/c
  lst : (listof pair?)
(assv v lst) → pair?
  v : any/c
  lst : (list*of pair? (not/c '()))
```

Like `assoc`, but finds an element using `eqv?`.

Example:

```
> (assv 3 (list (list 1 2) (list 3 4) (list 5 6)))
'(3 4)
```

```
(assq v lst) → (or/c pair? #f)
  v : any/c
  lst : (listof pair?)
(assq v lst) → pair?
  v : any/c
  lst : (list*of pair? (not/c '()))
```

Like `assoc`, but finds an element using `eq?`.

Example:

```
> (assq 'c (list (list 'a 'b) (list 'c 'd) (list 'e 'f)))
'(c d)
```

```
(assf proc lst) → (or/c pair? #f)
  proc : procedure?
  lst : (listof pair?)
(assf proc lst) → pair?
  proc : procedure?
  lst : (list*of pair? (not/c '()))
```

Like `assoc`, but finds an element using the predicate *`proc`*; an element is found when *`proc`* applied to the `car` of an *`lst`* element returns a true value.

Example:

```
> (assf (lambda (arg)
          (> arg 2))
        (list (list 1 2) (list 3 4) (list 5 6)))
'(3 4)
```

4.10.7 Pair Accessor Shorthands

```
(caar v) → any/c
  v : (cons/c pair? any/c)
```

Returns `(car (car v))`.

Example:

```
> (caar '((1 2) 3 4))
1
```

```
(cadr v) → any/c
  v : (cons/c any/c pair?)
```

Returns `(car (cdr v))`.

Example:

```
> (cadr '((1 2) 3 4))
3
```

```
(cdar v) → any/c
  v : (cons/c pair? any/c)
```

Returns `(cdr (car v))`.

Example:

```
> (cdar '((7 6 5 4 3 2 1) 8 9))
'(6 5 4 3 2 1)
```

```
(cddr v) → any/c
  v : (cons/c any/c pair?)
```

Returns `(cdr (cdr v))`.

Example:

```
> (cddr '(2 1))
'()
```

```
(caaar v) → any/c
  v : (cons/c (cons/c pair? any/c) any/c)
```

Returns `(car (car (car v)))`.

Example:

```
> (caaar '(((6 5 4 3 2 1) 7) 8 9))
6
```

```
(caadr v) → any/c
  v : (cons/c any/c (cons/c pair? any/c))
```

Returns `(car (car (cdr v)))`.

Example:

```
> (caadr '(9 (7 6 5 4 3 2 1) 8))
7
```

```
(cadar v) → any/c
  v : (cons/c (cons/c any/c pair?) any/c)
```

Returns `(car (cdr (car v)))`.

Example:

```
> (cadar '((7 6 5 4 3 2 1) 8 9))
6
```

```
(caddr v) → any/c
  v : (cons/c any/c (cons/c any/c pair?))
```

Returns `(car (cdr (cdr v)))`.

Example:

```
> (caddr '(3 2 1))
1
```

```
(cdaar v) → any/c
  v : (cons/c (cons/c pair? any/c) any/c)
```

Returns `(cdr (car (car v)))`.

Example:

```
> (cdaar '(((6 5 4 3 2 1) 7) 8 9))
'(5 4 3 2 1)
```

```
(cdadr v) → any/c
  v : (cons/c any/c (cons/c pair? any/c))
```

Returns `(cdr (car (cdr v)))`.

Example:

```
> (cdadr '(9 (7 6 5 4 3 2 1) 8))
'(6 5 4 3 2 1)
```

```
(cddar v) → any/c
  v : (cons/c (cons/c any/c pair?) any/c)
```

Returns `(cdr (cdr (car v)))`.

Example:

```
> (cddar '((7 6 5 4 3 2 1) 8 9))
'(5 4 3 2 1)
```

```
(cdddr v) → any/c
  v : (cons/c any/c (cons/c any/c pair?))
```

Returns `(cdr (cdr (cdr v)))`.

Example:

```
> (cdddr '(3 2 1))
'()
```

```
(caaaar v) → any/c
  v : (cons/c (cons/c (cons/c pair? any/c) any/c) any/c)
```

Returns `(car (car (car (car v))))`.

Example:

```
> (caaaar '(((((5 4 3 2 1) 6) 7) 8 9))
5
```

```
(caaadr v) → any/c
  v : (cons/c any/c (cons/c (cons/c pair? any/c) any/c))
```

Returns `(car (car (car (cdr v))))`.

Example:

```
> (caaadr '(9 ((6 5 4 3 2 1) 7) 8))
6
```

```
(caadar v) → any/c
  v : (cons/c (cons/c any/c (cons/c pair? any/c)) any/c)
```

Returns `(car (car (cdr (car v))))`.

Example:

```
> (caadar '((7 (5 4 3 2 1) 6) 8 9))
5
```

```
(caaddr v) → any/c
  v : (cons/c any/c (cons/c any/c (cons/c pair? any/c)))
```

Returns `(car (car (cdr (cdr v))))`.

Example:

```
> (caaddr '(9 8 (6 5 4 3 2 1) 7))
6
```

```
(cadaar v) → any/c
  v : (cons/c (cons/c (cons/c any/c pair?) any/c) any/c)
```

Returns `(car (cdr (car (car v))))`.

Example:

```
> (cadaar '(((6 5 4 3 2 1) 7) 8 9))
5
```

```
(cadadr v) → any/c
  v : (cons/c any/c (cons/c (cons/c any/c pair?) any/c))
```

Returns `(car (cdr (car (cdr v))))`.

Example:

```
> (cadadr '(9 (7 6 5 4 3 2 1) 8))
6
```

```
(caddar v) → any/c
  v : (cons/c (cons/c any/c (cons/c any/c pair?)) any/c)
```

Returns `(car (cdr (cdr (car v))))`.

Example:

```
> (caddar '((7 6 5 4 3 2 1) 8 9))
5
```

```
(cadddr v) → any/c
  v : (cons/c any/c (cons/c any/c (cons/c any/c pair?)))
```

Returns `(car (cdr (cdr (cdr v))))`.

Example:

```
> (cadddr '(4 3 2 1))
1
```

```
(cdaaar v) → any/c
  v : (cons/c (cons/c (cons/c pair? any/c) any/c) any/c)
```

Returns `(cdr (car (car (car v))))`.

Example:

```
> (cdaaar '((((5 4 3 2 1) 6) 7) 8 9))
'(4 3 2 1)
```

```
(cdaadr v) → any/c
  v : (cons/c any/c (cons/c (cons/c pair? any/c) any/c))
```

Returns `(cdr (car (car (cdr v))))`.

Example:

```
> (cdaadr '(9 ((6 5 4 3 2 1) 7) 8))
'(5 4 3 2 1)
```

```
(cdadar v) → any/c
  v : (cons/c (cons/c any/c (cons/c pair? any/c)) any/c)
```

Returns `(cdr (car (cdr (car v))))`.

Example:

```
> (cdadar '((7 (5 4 3 2 1) 6) 8 9))
'(4 3 2 1)
```

```
(cdaddr v) → any/c
  v : (cons/c any/c (cons/c any/c (cons/c pair? any/c)))
```

Returns `(cdr (car (cdr (cdr v))))`.

Example:

```
> (cdaddr '(9 8 (6 5 4 3 2 1) 7))
'(5 4 3 2 1)
```

```
(cddaar v) → any/c
  v : (cons/c (cons/c (cons/c any/c pair?) any/c) any/c)
```

Returns `(cdr (cdr (car (car v))))`.

Example:

```
> (cddaar '(((6 5 4 3 2 1) 7) 8 9))
'(4 3 2 1)
```

```
(cddadr v) → any/c
  v : (cons/c any/c (cons/c (cons/c any/c pair?) any/c))
```

Returns `(cdr (cdr (car (cdr v))))`.

Example:

```
> (cddadr '(9 (7 6 5 4 3 2 1) 8))
'(5 4 3 2 1)
```

```
(cdddar v) → any/c
  v : (cons/c (cons/c any/c (cons/c any/c pair?)) any/c)
```

Returns `(cdr (cdr (cdr (car v))))`.

Example:

```
> (cdddar '((7 6 5 4 3 2 1) 8 9))
'(4 3 2 1)
```

```
(cddddr v) → any/c
  v : (cons/c any/c (cons/c any/c (cons/c any/c pair?)))
```

Returns `(cdr (cdr (cdr (cdr v))))`.

Example:

```
> (cddddr '(4 3 2 1))
'()
```

4.10.8 Additional List Functions and Synonyms

```
(require racket/list)
```
package: base

The bindings documented in this section are provided by the `racket/list` and `racket` libraries, but not `racket/base`.

```
empty : null?
```

The empty list.

Examples:

```
> empty
'()
> (eq? empty null)
#t
```

```
(cons? v) → boolean?
  v : any/c
```

The same as `(pair? v)`.

Example:

```
> (cons? '(1 2))
#t
```

```
(empty? v) → boolean?
  v : any/c
```

The same as `(null? v)`.

Examples:

```
> (empty? '(1 2))
#f
> (empty? '())
#t
```

```
(first lst) → any/c
  lst : list?
```

The same as `(car lst)`, but only for lists (that are not empty).

Example:

```
> (first '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
1
```

```
(rest lst) → list?
  lst : list?
```

The same as `(cdr lst)`, but only for lists (that are not empty).

Example:

```
> (rest '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
'(2 3 4 5 6 7 8 9 10 11 12 13 14 15)
```

```
(second lst) → any/c
  lst : list?
```

Returns the second element of the list.

Example:

```
> (second '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
2
```

```
(third lst) → any/c
  lst : list?
```

Returns the third element of the list.

Example:

```
> (third '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
3
```

```
(fourth lst) → any/c
  lst : list?
```

Returns the fourth element of the list.

Example:

```
> (fourth '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
4
```

```
(fifth lst) → any/c
  lst : list?
```

Returns the fifth element of the list.

Example:

```
> (fifth '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
5
```

```
(sixth lst) → any/c
  lst : list?
```

Returns the sixth element of the list.

Example:

```
> (sixth '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
6
```

```
(seventh lst) → any/c
  lst : list?
```

Returns the seventh element of the list.

Example:

```
> (seventh '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
7
```

```
(eighth lst) → any/c
  lst : list?
```

Returns the eighth element of the list.

Example:

```
> (eighth '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
8
```

```
(ninth lst) → any/c
  lst : list?
```

Returns the ninth element of the list.

Example:

```
> (ninth '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
9
```

```
(tenth lst) → any/c
  lst : list?
```

Returns the tenth element of the list.

Example:

```
> (tenth '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
10
```

```
(eleventh lst) → any/c
  lst : list?
```

Returns the eleventh element of the list.

Example:

```
> (eleventh '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
11
```

Added in version 8.15.0.3 of package `base`.

```
(twelfth lst) → any/c
  lst : list?
```

Returns the twelfth element of the list.

Example:

```
> (twelfth '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
12
```

Added in version 8.15.0.3 of package `base`.

```
(thirteenth lst) → any/c
  lst : list?
```

Returns the thirteenth element of the list.

Example:

```
> (thirteenth '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
13
```

Added in version 8.15.0.3 of package `base`.

```
(fourteenth lst) → any/c
  lst : list?
```

Returns the fourteenth element of the list.

Example:

```
> (fourteenth '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
14
```

Added in version 8.15.0.3 of package `base`.

```
(fifteenth lst) → any/c
  lst : list?
```

Returns the fifteenth element of the list.

Example:

```
> (fifteenth '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
15
```

Added in version 8.15.0.3 of package `base`.

```
(last lst) → any/c
  lst : list?
```

Returns the last element of the list.

This function takes time proportional to the length of *lst*.

Example:

```
> (last '(1 2 3 4 5 6 7 8 9 10 11 12 13 14 15))
15
```

```
(last-pair p) → pair?
  p : pair?
```

Returns the last pair of a (possibly improper) list.

This function takes time proportional to the “length” of `p`.

Example:

```
> (last-pair '(1 2 3 4))
'(4)
```

```
(make-list k v) → list?
  k : exact-nonnegative-integer?
  v : any/c
```

Returns a newly constructed list of length `k`, holding `v` in all positions.

Example:

```
> (make-list 7 'foo)
'(foo foo foo foo foo foo foo)
```

```
(list-update lst pos updater) → list?
  lst : list?
  pos : (and/c (>=/c 0) (</c (length lst)))
  updater : (-> any/c any/c)
```

Returns a list that is the same as `lst` except at the specified index. The element at the specified index is `(updater (list-ref lst pos))`.

This function takes time proportional to `pos`.

Example:

```
> (list-update '(zero one two) 1 symbol->string)
'(zero "one" two)
```

Added in version 6.3 of package `base`.

```
(list-set lst pos value) → list?
  lst : list?
  pos : (and/c (>=/c 0) (</c (length lst)))
  value : any/c
```

Returns a list that is the same as *lst* except at the specified index. The element at the specified index is *value*.

This function takes time proportional to *pos*.

Example:

```
> (list-set '(zero one two) 2 "two")
'(zero one "two")
```

Added in version 6.3 of package `base`.

```
(index-of lst v [is-equal?]) → (or/c exact-nonnegative-integer? #f)
  lst : list?
  v : any/c
  is-equal? : (any/c any/c . -> . any/c) = equal?
```

Like `member`, but returns the index of the first element found instead of the tail of the list.

Example:

```
> (index-of '(1 2 3 4) 3)
2
```

Added in version 6.7.0.3 of package `base`.

```
(index-where lst proc) → (or/c exact-nonnegative-integer? #f)
  lst : list?
  proc : (any/c . -> . any/c)
```

Like `index-of` but with the predicate-searching behavior of `memf`.

Example:

```
> (index-where '(1 2 3 4) even?)
1
```

Added in version 6.7.0.3 of package `base`.

```
(indexes-of lst v [is-equal?])
 → (listof exact-nonnegative-integer?)
  lst : list?
  v : any/c
  is-equal? : (any/c any/c . -> . any/c) = equal?
```

Like `index-of`, but returns the a list of all the indexes where the element occurs in the list instead of just the first one.

Example:

```
> (indexes-of '(1 2 1 2 1) 2)
'(1 3)
```

Added in version 6.7.0.3 of package `base`.

```
(indexes-where lst proc) → (listof exact-nonnegative-integer?)
  lst : list?
  proc : (any/c . -> . any/c)
```

Like `indexes-of` but with the predicate-searching behavior of `index-where`.

Example:

```
> (indexes-where '(1 2 3 4) even?)
'(1 3)
```

Added in version 6.7.0.3 of package `base`.

```
(take lst pos) → list?
  lst : list?
  pos : exact-nonnegative-integer?
(take lst pos) → list?
  lst : any/c
  pos : exact-nonnegative-integer?
```

Returns a fresh list whose elements are the first *pos* elements of *lst*. If *lst* has fewer than *pos* elements, the `exn:fail:contract` exception is raised.

The *lst* argument need not actually be a list; *lst* must merely start with a chain of at least *pos* pairs.

This function takes time proportional to *pos*.

Examples:

```
> (take '(1 2 3 4 5) 2)
'(1 2)
> (take 'non-list 0)
'()
```

```
(drop lst pos) → list?
  lst : list?
  pos : exact-nonnegative-integer?
(drop lst pos) → any/c
  lst : any/c
  pos : exact-nonnegative-integer?
```

Just like `list-tail`.

```
(split-at lst pos) → list? list?
  lst : list?
  pos : exact-nonnegative-integer?
(split-at lst pos) → list? any/c
  lst : any/c
  pos : exact-nonnegative-integer?
```

Returns the same result as

```
(values (take lst pos) (drop lst pos))
```

except that it can be faster, but it will still take time proportional to *pos*.

```
(takef lst pred) → list?
  lst : list?
  pred : procedure?
(takef lst pred) → list?
  lst : any/c
  pred : procedure?
```

Returns a fresh list whose elements are taken successively from *lst* as long as they satisfy *pred*. The returned list includes up to, but not including, the first element in *lst* for which *pred* returns `#f`.

The *lst* argument need not actually be a list; the chain of pairs in *lst* will be traversed until a non-pair is encountered.

Examples:

```
> (takef '(2 4 5 8) even?)
'(2 4)
> (takef '(2 4 6 8) odd?)
'()
> (takef '(2 4 . 6) even?)
'(2 4)
```

```
(dropf lst pred) → list?
  lst : list?
  pred : procedure?
(dropf lst pred) → any/c
  lst : any/c
  pred : procedure?
```

Drops elements from the front of *lst* as long as they satisfy *pred*.

Examples:

```
> (dropf '(2 4 5 8) even?)
'(5 8)
> (dropf '(2 4 6 8) odd?)
'(2 4 6 8)
```

```
(splitf-at lst pred) → list? list?
  lst : list?
  pred : procedure?
(splitf-at lst pred) → list? any/c
  lst : any/c
  pred : procedure?
```

Returns the same result as

```
(values (takef lst pred) (dropf lst pred))
```

except that it can be faster.

```
(take-right lst pos) → list?
  lst : list?
  pos : exact-nonnegative-integer?
(take-right lst pos) → any/c
  lst : any/c
  pos : exact-nonnegative-integer?
```

Returns the `list`'s *pos*-length tail. If *lst* has fewer than *pos* elements, then the `exn:fail:contract` exception is raised.

The *lst* argument need not actually be a list; *lst* must merely end with a chain of at least *pos* pairs.

This function takes time proportional to the length of *lst*.

Examples:

```
> (take-right '(1 2 3 4 5) 2)
'(4 5)
> (take-right 'non-list 0)
'non-list
```

```
(drop-right lst pos) → list?
  lst : list?
  pos : exact-nonnegative-integer?
(drop-right lst pos) → list?
  lst : any/c
  pos : exact-nonnegative-integer?
```

Returns a fresh list whose elements are the prefix of `lst`, dropping its `pos`-length tail. If `lst` has fewer than `pos` elements, then the `exn:fail:contract` exception is raised.

The `lst` argument need not actually be a list; `lst` must merely end with a chain of at least `pos` pairs.

This function takes time proportional to the length of `lst`.

Examples:

```
> (drop-right '(1 2 3 4 5) 2)
'(1 2 3)
> (drop-right 'non-list 0)
'()
```

```
(split-at-right lst pos) → list? list?
  lst : list?
  pos : exact-nonnegative-integer?
(split-at-right lst pos) → list? any/c
  lst : any/c
  pos : exact-nonnegative-integer?
```

Returns the same result as

```
(values (drop-right lst pos) (take-right lst pos))
```

except that it can be faster, but it will still take time proportional to the length of `lst`.

Examples:

```
> (split-at-right '(1 2 3 4 5 . 6) 4)
'(1)
'(2 3 4 5 . 6)
```

```
> (split-at-right '(1 2 3 4 5 6) 4)
'(1 2)
'(3 4 5 6)
```

```
(takef-right lst pred) → list?
  lst : list?
  pred : procedure?
(takef-right lst pred) → any/c
  lst : any/c
  pred : procedure?
(dropf-right lst pred) → list?
  lst : list?
  pred : procedure?
(dropf-right lst pred) → list?
  lst : any/c
  pred : procedure?
(splitf-at-right lst pred) → list? list?
  lst : list?
  pred : procedure?
(splitf-at-right lst pred) → list? any/c
  lst : any/c
  pred : procedure?
```

Like `takef`, `dropf`, and `splitf-at`, but combined with the from-right functionality of `take-right`, `drop-right`, and `split-at-right`.

```
(list-prefix? l r [same?]) → boolean?
  l : list?
  r : list?
  same? : (any/c any/c . -> . any/c) = equal?
```

True if *l* is a prefix of *r*.

Example:

```
> (list-prefix? '(1 2) '(1 2 3 4 5))
#t
```

Added in version 6.3 of package `base`.

```
(take-common-prefix l r [same?]) → list?
  l : list?
  r : list?
  same? : (any/c any/c . -> . any/c) = equal?
```

Returns the longest common prefix of *l* and *r*.

Example:

```
> (take-common-prefix '(a b c d) '(a b x y z))
'(a b)
```

Added in version 6.3 of package base.

```
(drop-common-prefix l r [same?]) → list? list?
  l : list?
  r : list?
  same? : (any/c any/c . -> . any/c) = equal?
```

Returns the tails of *l* and *r* with the common prefix removed.

Example:

```
> (drop-common-prefix '(a b c d) '(a b x y z))
'(c d)
'(x y z)
```

Added in version 6.3 of package base.

```
(split-common-prefix l r [same?]) → list? list? list?
  l : list?
  r : list?
  same? : (any/c any/c . -> . any/c) = equal?
```

Returns the longest common prefix together with the tails of *l* and *r* with the common prefix removed.

Example:

```
> (split-common-prefix '(a b c d) '(a b x y z))
'(a b)
'(c d)
'(x y z)
```

Added in version 6.3 of package base.

```
(add-between  lst
              v
             [#:before-first before-first
              #:before-last before-last
              #:after-last after-last
              #:splice? splice?])          → list?
```

```
lst : list?
v : any/c
before-first : list? = '()
before-last : any/c = v
after-last : list? = '()
splice? : any/c = #f
```

Returns a list with the same elements as `lst`, but with `v` between each pair of elements in `lst`; the last pair of elements will have `before-last` between them, instead of `v` (but `before-last` defaults to `v`).

If `splice?` is true, then `v` and `before-last` should be lists, and the list elements are spliced into the result. In addition, when `splice?` is true, `before-first` and `after-last` are inserted before the first element and after the last element respectively.

Examples:

```
> (add-between '(x y z) 'and)
'(x and y and z)
> (add-between '(x) 'and)
'(x)
> (add-between '("a" "b" "c" "d") "," #:before-last "and")
'("a" "," "b" "," "c" "and" "d")
> (add-between '(x y z) '(-) #:before-last '(- -)
               #:before-first '(begin) #:after-last '(end LF)
               #:splice? #t)
'(begin x - y - - z end LF)
```

```
(append* lst ... lsts) → list?
  lst : list?
  lsts : (listof list?)
(append* lst ... lsts) → any/c
  lst : list?
  lsts : list?
```

Like `append`, but the last argument is used as a list of arguments for `append`, so `(append* lst ... lsts)` is the same as `(apply append lst ... lsts)`. In other words, the relationship between `append` and `append*` is similar to the one between `list` and `list*`.

Examples:

```
> (append* '(a) '(b) '((c) (d)))
'(a b c d)
> (cdr (append* (map (lambda (x) (list ", " x))
                     '("Alpha" "Beta" "Gamma"))))
```

```
'("Alpha" ", " "Beta" ", " "Gamma")
```

```
(flatten v) → list?
  v : any/c
```

Flattens an arbitrary S-expression structure of pairs into a list. More precisely, *v* is treated as a binary tree where pairs are interior nodes, and the resulting list contains all of the non-`null` leaves of the tree in the same order as an inorder traversal.

Examples:

```
> (flatten '((a) b (c (d) . e) ()))
'(a b c d e)
> (flatten 'a)
'(a)
```

```
(check-duplicates  lst
                  [same?
                   #:key extract-key
                   #:default failure-result]) → any
  lst : list?
  same? : (any/c any/c . -> . any/c) = equal?
  extract-key : (-> any/c any/c) = (lambda (x) x)
  failure-result : failure-result/c = (lambda () #f)
```

Returns the first duplicate item in *lst*. More precisely, it returns the first *x* such that there was a previous *y* where `(same? (extract-key x) (extract-key y))`.

If no duplicate is found, then *failure-result* determines the result:

- If *failure-result* is a procedure, it is called (through a tail call) with no arguments to produce the result.
- Otherwise, *failure-result* is returned as the result.

The *same?* argument should be an equivalence predicate such as `equal?` or `eqv?`. The procedures `equal?`, `eqv?`, `eq?`, and `equal-always?` automatically use a dictionary for speed.

Examples:

```
> (check-duplicates '(1 2 3 4))
#f
> (check-duplicates '(1 2 3 2 1))
2
> (check-duplicates '((a 1) (b 2) (a 3)) #:key car)
'(a 3)
```

```
> (check-duplicates '(1 2 3 4 5 6)
                    (lambda (x y) (equal? (modulo x 3) (modulo y 3))))
4
> (check-duplicates '(1 2 3 4) #:default "no duplicates")
"no duplicates"
```

Added in version 6.3 of package base.
Changed in version 6.11.0.2: Added the `#:default` optional argument.

```
(remove-duplicates  lst
                   [same?
                    #:key extract-key]) → list?
  lst : list?
  same? : (any/c any/c . -> . any/c) = equal?
  extract-key : (any/c . -> . any/c) = (lambda (x) x)
```

Returns a list that has all items in `lst`, but without duplicate items, where `same?` determines whether two elements of the list are equivalent. The resulting list is in the same order as `lst`, and for any item that occurs multiple times, the first one is kept.

The `#:key` argument `extract-key` is used to extract a key value from each list element, so two items are considered equal if `(same? (extract-key x) (extract-key y))` is true.

Like `check-duplicates`, if the `same?` argument is one of `equal?`, `eqv?`, `eq?`, and `equal-always?`, the operation can be specialized to improve performance.

Examples:

```
> (remove-duplicates '(a b b a))
'(a b)
> (remove-duplicates '(1 2 1.0 0))
'(1 2 1.0 0)
> (remove-duplicates '(1 2 1.0 0) =)
'(1 2 0)
```

```
(filter-map proc lst ...+) → list?
  proc : procedure?
  lst : list?
```

Like `(map proc lst ...)`, except that, if `proc` returns `#false`, that element is omitted from the resulting list. In other words, `filter-map` is equivalent to `(filter (lambda (x) x) (map proc lst ...))`, but more efficient, because `filter-map` avoids building the intermediate list.

Example:

```
> (filter-map (lambda (x) (and (negative? x) (abs x))) '(1 2 -3 -4 8))
'(3 4)
```

```
(count proc lst ...+) → exact-nonnegative-integer?
  proc : procedure?
  lst : list?
```

Returns `(length (filter-map proc lst ...))`, but without building the intermediate list.

Example:

```
> (count positive? '(1 -1 2 3 -2 5))
4
```

```
(partition pred lst) → list? list?
  pred : procedure?
  lst : list?
```

Similar to `filter`, except that two values are returned: the items for which *pred* returns a true value, and the items for which *pred* returns `#f`.

The result is the same as

```
(values (filter pred lst) (filter (negate pred) lst))
```

but *pred* is applied to each item in *lst* only once.

Example:

```
> (partition even? '(1 2 3 4 5 6))
'(2 4 6)
'(1 3 5)
```

```
(range end) → list?
  end : real?
(range start end [step]) → list?
  start : real?
  end : real?
  step : real? = 1
```

Similar to `in-range`, but returns lists.

The resulting list holds numbers starting at *start* and whose successive elements are computed by adding *step* to their predecessor until *end* (excluded) is reached. If no starting point is provided, `0` is used. If no *step* argument is provided, `1` is used.

Like `in-range`, a `range` application can provide better performance when it appears directly in a `for` clause.

Examples:

```
> (range 10)
'(0 1 2 3 4 5 6 7 8 9)
> (range 10 20)
'(10 11 12 13 14 15 16 17 18 19)
> (range 20 40 2)
'(20 22 24 26 28 30 32 34 36 38)
> (range 20 10 -1)
'(20 19 18 17 16 15 14 13 12 11)
> (range 10 15 1.5)
'(10 11.5 13.0 14.5)
```

Changed in version 6.7.0.4 of package `base`: Adjusted to cooperate with `for` in the same way that `in-range` does.

```
(inclusive-range start end [step]) → list?
  start : real?
  end : real?
  step : real? = 1
```

Similar to `in-inclusive-range`, but returns lists.

The resulting list holds numbers starting at *start* and whose successive elements are computed by adding *step* to their predecessor until *end* (included) is reached. If no *step* argument is provided, `1` is used.

Like `in-inclusive-range`, an `inclusive-range` application can provide better performance when it appears directly in a `for` clause.

Examples:

```
> (inclusive-range 10 20)
'(10 11 12 13 14 15 16 17 18 19 20)
> (inclusive-range 20 40 2)
'(20 22 24 26 28 30 32 34 36 38 40)
> (inclusive-range 20 10 -1)
'(20 19 18 17 16 15 14 13 12 11 10)
> (inclusive-range 10 15 1.5)
'(10 11.5 13.0 14.5)
```

Added in version 8.0.0.13 of package `base`.

```
(append-map proc lst ...+) → list?
  proc : procedure?
  lst : list?
```

Returns `(append* (map proc lst ...))`.

Example:

```
> (append-map vector->list '(#(1) #(2 3) #(4)))
'(1 2 3 4)
```

```
(filter-not pred lst) → list?
  pred : (any/c . -> . any/c)
  lst : list?
```

Like `filter`, but the meaning of the *pred* predicate is reversed: the result is a list of all items for which *pred* returns `#f`.

Example:

```
> (filter-not even? '(1 2 3 4 5 6))
'(1 3 5)
```

```
(shuffle lst) → list?
  lst : list?
```

Returns a list with all elements from *lst*, randomly shuffled.

Examples:

```
> (shuffle '(1 2 3 4 5 6))
'(4 6 1 5 2 3)
> (shuffle '(1 2 3 4 5 6))
'(3 1 4 6 5 2)
> (shuffle '(1 2 3 4 5 6))
'(4 5 6 1 2 3)
```

```
(combinations lst) → list?
  lst : list?
(combinations lst size) → list?
  lst : list?
  size : exact-nonnegative-integer?
```

Wikipedia combinations

Return a list of all combinations of elements in the input list (a.k.a. the powerset of *lst*). If *size* is given, limit results to combinations of *size* elements.

Examples:

```
> (combinations '(1 2 3))
'(() (1) (2) (1 2) (3) (1 3) (2 3) (1 2 3))
> (combinations '(1 2 3) 2)
'((1 2) (1 3) (2 3))
```

```
(in-combinations lst) → sequence?
  lst : list?
(in-combinations lst size) → sequence?
  lst : list?
  size : exact-nonnegative-integer?
```

Returns a sequence of all combinations of elements in the input list, or all combinations of length *size* if *size* is given. Builds combinations one-by-one instead of all at once.

Examples:

```
> (time (begin (combinations (range 15)) (void)))
cpu time: 7 real time: 2 gc time: 0
> (time (begin (in-combinations (range 15)) (void)))
cpu time: 0 real time: 0 gc time: 0
```

```
(permutations lst) → list?
  lst : list?
```

Returns a list of all permutations of the input list. Note that this function works without inspecting the elements, and therefore it ignores repeated elements (which will result in repeated permutations). Raises an error if the input list contains more than 256 elements.

Examples:

```
> (permutations '(1 2 3))
'((1 2 3) (2 1 3) (1 3 2) (3 1 2) (2 3 1) (3 2 1))
> (permutations '(x x))
'((x x) (x x))
```

```
(in-permutations lst) → sequence?
  lst : list?
```

Returns a sequence of all permutations of the input list. It is equivalent to `(in-list (permutations l))` but much faster since it builds the permutations one-by-one on each iteration. Raises an error if the input list contains more than 256 elements.

```
(argmin proc lst) → any/c
  proc : (-> any/c real?)
  lst : (and/c pair? list?)
```

Returns the first element in the list *lst* that minimizes the result of *proc*. Signals an error on an empty list. See also `min`.

Examples:

```
> (argmin car '((3 pears) (1 banana) (2 apples)))
'(1 banana)
> (argmin car '((1 banana) (1 orange)))
'(1 banana)
```

```
(argmax proc lst) → any/c
  proc : (-> any/c real?)
  lst : (and/c pair? list?)
```

Returns the first element in the list *lst* that maximizes the result of *proc*. Signals an error on an empty list. See also `max`.

Examples:

```
> (argmax car '((3 pears) (1 banana) (2 apples)))
'(3 pears)
> (argmax car '((3 pears) (3 oranges)))
'(3 pears)
```

```
(group-by key lst [same?]) → (listof list?)
  key : (-> any/c any/c)
  lst : list?
  same? : (any/c any/c . -> . any/c) = equal?
```

Groups the given list into equivalence classes, with equivalence being determined by *same?*. Within each equivalence class, `group-by` preserves the ordering of the original list. Equivalence classes themselves are in order of first appearance in the input.

Example:

```
> (group-by (lambda (x) (modulo x 3)) '(1 2 1 2 54 2 5 43 7 2 643 1 2 0))
'((1 1 43 7 643 1) (2 2 2 5 2 2) (54 0))
```

Added in version 6.3 of package `base`.

```
(cartesian-product lst ...) → (listof list?)
  lst : list?
```

Computes the n-ary cartesian product of the given lists.

Examples:

```
> (cartesian-product '(1 2 3) '(a b c))
'((1 a) (1 b) (1 c) (2 a) (2 b) (2 c) (3 a) (3 b) (3 c))
> (cartesian-product '(4 5 6) '(d e f) '(#t #f))
'((4 d #t)
  (4 d #f)
  (4 e #t)
  (4 e #f)
  (4 f #t)
  (4 f #f)
  (5 d #t)
  (5 d #f)
  (5 e #t)
  (5 e #f)
  (5 f #t)
  (5 f #f)
  (6 d #t)
  (6 d #f)
  (6 e #t)
  (6 e #f)
  (6 f #t)
  (6 f #f))
```

Added in version 6.3 of package `base`.

```
(remf pred lst) → list?
  pred : procedure?
  lst : list?
```

Returns a list that is like *lst*, omitting the first element of *lst* for which *pred* produces a true value.

Example:

```
> (remf negative? '(1 -2 3 4 -5))
'(1 3 4 -5)
```

Added in version 6.3 of package `base`.

```
(remf* pred lst) → list?
  pred : procedure?
  lst : list?
```

Like `remf`, but removes all the elements for which *pred* produces a true value.

Example:

```
> (remf* negative? '(1 -2 3 4 -5))
'(1 3 4)
```

Added in version 6.3 of package `base`.

4.10.9 More List Grouping

```
(require racket/list/grouping)        package: sequence-tools-lib
```

The bindings documented in this section are provided by the `racket/list/grouping` library, not `racket/base` or `racket`.

The bindings in this section are provided by the `sequence-tools-lib` package, which acts as an extension to the base sequence libraries.

```
(windows size step lst) → (listof list?)
  size : exact-positive-integer?
  step : exact-positive-integer?
  lst : list?
```

Returns a list of sliding windows such that each window contains *size* elements with the window sliding *step* positions on each iteration. If the number of remaining elements is less than *size*, then those elements are dropped.

Examples:

```
> (windows 3 1 '(1 2 3 4))
'((1 2 3) (2 3 4))
> (windows 2 3 '(1 2 3))
'((1 2))
> (windows 1 2 '(1 2 3 4))
'((1) (3))
```

```
(slice-by proc lst) → (listof list?)
  proc : (-> any/c any/c any/c)
  lst : list?
```

Returns a list such that each element is a sublist (slice) that is constructed from comparing each pair of adjacent elements. All pairs of elements that satisfy *proc* will be grouped together into a slice, otherwise the element will start a new slice.

Examples:

```
> (slice-by eq? '(1 1 2 1 3 3))
'((1 1) (2) (1) (3 3))
> (slice-by < '(1 2 3 3 4))
'((1 2 3) (3 4))
```

4.10.10 Immutable Cyclic Data

```
(make-reader-graph v) → any/c
  v : any/c
```

Returns a value like *v*, with *placeholders* created by `make-placeholder` replaced with the values that they contain, and with *hash placeholders* created by `make-hash-placeholder` with an immutable hash table. No part of *v* is mutated; instead, parts of *v* are copied as necessary to construct the resulting graph, where at most one copy is created for any given value.

Since the copied values can be immutable, and since the copy is also immutable, `make-reader-graph` can create cycles involving only immutable pairs, vectors, boxes, and hash tables.

Only the following kinds of values are copied and traversed to detect placeholders:

- pairs
- vectors, both mutable and immutable
- boxes, both mutable and immutable
- hash tables, both mutable and immutable
- instances of a prefab structure type
- placeholders created by `make-placeholder` and `make-hash-placeholder`

Due to these restrictions, `make-reader-graph` creates exactly the same sort of cyclic values as `read`.

Example:

```
> (let* ([ph (make-placeholder #f)]
         [x (cons 1 ph)])
    (placeholder-set! ph x)
    (make-reader-graph x))
#0='(1 . #0#)
```

```
(placeholder? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a placeholder created by `make-placeholder`, `#f` otherwise.

```
(make-placeholder v) → placeholder?
  v : any/c
```

Returns a placeholder for use with `placeholder-set!` and `make-reader-graph`. The *v* argument supplies the initial value for the placeholder.

```
(placeholder-set! ph datum) → void?
  ph : placeholder?
  datum : any/c
```

Changes the value of *ph* to `v`.

```
(placeholder-get ph) → any/c
  ph : placeholder?
```

Returns the value of *ph*.

```
(hash-placeholder? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a hash placeholder created by `make-hash-placeholder`, `#f` otherwise.

```
(make-hash-placeholder assocs) → hash-placeholder?
  assocs : (listof pair?)
```

Like `make-immutable-hash`, but produces a hash placeholder for use with `make-reader-graph`.

```
(make-hasheq-placeholder assocs) → hash-placeholder?
  assocs : (listof pair?)
```

Like `make-immutable-hasheq`, but produces a hash placeholder for use with `make-reader-graph`.

```
(make-hasheqv-placeholder assocs) → hash-placeholder?
  assocs : (listof pair?)
```

Like `make-immutable-hasheqv`, but produces a hash placeholder for use with `make-reader-graph`.

```
(make-hashalw-placeholder assocs) → hash-placeholder?
  assocs : (listof pair?)
```

Like `make-immutable-hashalw`, but produces a hash placeholder for use with `make-reader-graph`.

Added in version 8.5.0.3 of package `base`.

4.11 Mutable Pairs and Lists

A *mutable pair* is like a pair created by `cons`, but it supports `set-mcar!` and `set-mcdr!` mutation operations to change the parts of the mutable pair (like traditional Lisp and Scheme pairs).

A *mutable list* is analogous to a list created with pairs, but instead created with mutable pairs.

A mutable pair is not a pair; they are completely separate datatypes. Similarly, a mutable list is not a list, except that the empty list is also the empty mutable list. Instead of programming with mutable pairs and mutable lists, data structures such as pairs, lists, and hash tables are practically always better choices.

A mutable list can be used as a single-valued sequence (see §4.17.1 "Sequences"). The elements of the mutable list serve as elements of the sequence. See also `in-mlist`.

4.11.1 Mutable Pair Constructors and Selectors

```
(mpair? v) → boolean?
  v : any/c
```

Returns `#t` if `v` is a mutable pair, `#f` otherwise.

```
(mcons a d) → mpair?
  a : any/c
  d : any/c
```

Returns a newly allocated mutable pair whose first element is `a` and second element is `d`.

```
(mcar p) → any/c
  p : mpair?
```

Returns the first element of the mutable pair `p`.

```
(mcdr p) → any/c
  p : mpair?
```

Returns the second element of the mutable pair `p`.

```
(set-mcar! p v) → void?
  p : mpair?
  v : any/c
```

Changes the mutable pair `p` so that its first element is `v`.

```
(set-mcdr! p v) → void?
  p : mpair?
  v : any/c
```

Changes the mutable pair `p` so that its second element is `v`.

4.12 Vectors

§3.9 "Vectors" in *The Racket Guide* introduces vectors.

A *vector* is a fixed-length array with constant-time access and update of the vector slots, which are numbered from `0` to one less than the number of slots in the vector.

Two vectors are `equal?` if they have the same length, and if the values in corresponding slots of the vectors are `equal?`.

A vector can be *mutable* or *immutable*. When an immutable vector is provided to a procedure like `vector-set!`, the `exn:fail:contract` exception is raised. Vectors generated by the default reader (see §1.3.7 "Reading Strings") are immutable. Use `immutable?` to check whether a vector is immutable.

A vector can be used as a single-valued sequence (see §4.17.1 "Sequences"). The elements of the vector serve as elements of the sequence. See also `in-vector`.

A literal or printed vector starts with `#(`, optionally with a number between the `#` and `(`. See §1.3.10 "Reading Vectors" for information on `read`ing vectors and §1.4.7 "Printing Vectors" for information on `print`ing vectors.

```
(vector? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a vector, `#f` otherwise.

See also `immutable-vector?` and `mutable-vector?`.

```
(make-vector size [v]) → vector?
  size : exact-nonnegative-integer?
  v : any/c = 0
```

Returns a mutable vector with *size* slots, where all slots are initialized to contain *v*. Note that *v* is shared for all elements, so for mutable data, mutating an element will affect other elements.

Examples:

```
> (make-vector 3 2)
'#(2 2 2)
> (define v (make-vector 5 (box 3)))
> v
'#(#&3 #&3 #&3 #&3 #&3)
> (set-box! (vector-ref v 0) 7)
> v
'#(#&7 #&7 #&7 #&7 #&7)
```

This function takes time proportional to *size*.

A common mistake is using `make-vector` to create nested vectors. The fact that *v* is shared for all elements means that `(make-vector 3 (make-vector 4))` would not be a good way of representing a mutable 3x4 matrix, for example, since just one mutable vector would be shared three times. Using `for/vector` as follows more likely produces the intended result, since it evaluates `(make-vector 4)` separately for each iteration:

Example:

```
> (for/vector ([i (in-range 3)])
    (make-vector 4))
'#(#(0 0 0 0) #(0 0 0 0) #(0 0 0 0))
```

```
(vector v ...) → vector?
  v : any/c
```

Returns a newly allocated mutable vector with as many slots as provided *v*s, where the slots are initialized to contain the given *v*s in order.

```
(vector-immutable v ...) → (and/c vector?
                                  immutable?)
  v : any/c
```

Returns a newly allocated immutable vector with as many slots as provided `v`s, where the slots contain the given `v`s in order.

```
(vector-length vec) → exact-nonnegative-integer?
  vec : vector?
```

Returns the length of `vec` (i.e., the number of slots in the vector).

This function takes constant time.

```
(vector-ref vec pos) → any/c
  vec : vector?
  pos : exact-nonnegative-integer?
```

Returns the element in slot `pos` of `vec`. The first slot is position `0`, and the last slot is one less than `(vector-length vec)`.

This function takes constant time.

```
(vector-set! vec pos v) → void?
  vec : (and/c vector? (not/c immutable?))
  pos : exact-nonnegative-integer?
  v : any/c
```

Updates the slot `pos` of `vec` to contain `v`.

This function takes constant time.

```
(vector*-length vec) → exact-nonnegative-integer?
  vec : (and/c vector? (not/c impersonator?))
(vector*-ref vec pos) → any/c
  vec : (and/c vector? (not/c impersonator?))
  pos : exact-nonnegative-integer?
(vector*-set! vec pos v) → void?
  vec : (and/c vector? (not/c immutable?) (not/c impersonator?))
  pos : exact-nonnegative-integer?
  v : any/c
```

Like `vector-length`, `vector-ref`, and `vector-set!`, but constrained to work on vectors that are not impersonators.

Added in version 6.90.0.15 of package `base`.

```
(vector-cas! vec pos old-v new-v) → boolean?
  vec : (and/c vector? (not/c immutable?) (not/c impersonator?))
  pos : exact-nonnegative-integer?
  old-v : any/c
  new-v : any/c
```

Compare and set operation for vectors. See `box-cas!`.

Added in version 6.11.0.2 of package `base`.

```
(vector->list vec) → list?
  vec : vector?
```

Returns a list with the same length and elements as *vec*.

This function takes time proportional to the size of *vec*.

```
(list->vector lst) → vector?
  lst : list?
```

Returns a mutable vector with the same length and elements as *lst*.

This function takes time proportional to the length of *lst*.

```
(vector->immutable-vector vec) → (and/c vector? immutable?)
  vec : vector?
```

Returns an immutable vector with the same length and elements as *vec*. If *vec* is itself immutable, then it is returned as the result.

This function takes time proportional to the size of *vec* when *vec* is mutable.

```
(vector-fill! vec v) → void?
  vec : (and/c vector? (not/c immutable?))
  v : any/c
```

Changes all slots of *vec* to contain *v*.

This function takes time proportional to the size of *vec*.

```
(vector-copy! dest
              dest-start
              src
             [src-start
              src-end])   → void?
  dest : (and/c vector? (not/c immutable?))
  dest-start : exact-nonnegative-integer?
  src : vector?
  src-start : exact-nonnegative-integer? = 0
  src-end : exact-nonnegative-integer? = (vector-length src)
```

Changes the elements of *dest* starting at position *dest-start* to match the elements in *src* from *src-start* (inclusive) to *src-end* (exclusive). The vectors *dest* and *src* can be the same vector, and in that case the destination region can overlap with the source region; the destination elements after the copy match the source elements from before the copy. If any of `dest-start`, `src-start`, or `src-end` are out of range (taking into account the sizes of the vectors and the source and destination regions), the `exn:fail:contract` exception is raised.

This function takes time proportional to `(- src-end src-start)`.

Examples:

```
> (define v (vector 'A 'p 'p 'l 'e))
> (vector-copy! v 4 #(y))
> (vector-copy! v 0 v 3 4)
> v
'#(l p p l y)
```

```
(vector->values vec [start-pos end-pos]) → any
  vec : vector?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (vector-length vec)
```

Returns `end-pos` - `start-pos` values, which are the elements of `vec` from `start-pos` (inclusive) to `end-pos` (exclusive). If `start-pos` or `end-pos` are greater than `(vector-length vec)`, or if `end-pos` is less than `start-pos`, the `exn:fail:contract` exception is raised.

This function takes time proportional to the size of `vec`.

```
(build-vector n proc) → vector?
  n : exact-nonnegative-integer?
  proc : (exact-nonnegative-integer? . -> . any/c)
```

Creates a vector of `n` elements by applying `proc` to the integers from `0` to `(sub1 n)` in order. If `vec` is the resulting vector, then `(vector-ref vec i)` is the value produced by `(proc i)`.

Example:

```
> (build-vector 5 add1)
'#(1 2 3 4 5)
```

4.12.1 Additional Vector Functions

```
(require racket/vector)        package: base
```

The bindings documented in this section are provided by the racket/vector and racket libraries, but not racket/base.

```
(vector-empty? v) → boolean?
  v : vector?
```

Returns #t if *v* is empty (i.e. its length is 0), #f otherwise.

Added in version 7.4.0.4 of package base.

```
(vector-set*! vec pos v ... ...) → void?
  vec : (and/c vector? (not/c immutable?))
  pos : exact-nonnegative-integer?
  v : any/c
```

Updates each slot *pos* of *vec* to contain each *v*. The update takes place from the left so later updates overwrite earlier updates.

```
(vector-map proc vec ...+) → vector?
  proc : procedure?
  vec : vector?
```

Applies *proc* to the elements of the *vec*s from the first elements to the last. The *proc* argument must accept the same number of arguments as the number of supplied *vec*s, and all *vec*s must have the same number of elements. The result is a fresh vector containing each result of *proc* in order.

Example:

```
> (vector-map + #(1 2) #(3 4))
'#(4 6)
```

```
(vector-map! proc vec ...+) → vector?
  proc : procedure?
  vec : (and/c vector? (not/c immutable?))
```

Like vector-map, but result of *proc* is inserted into the first *vec* at the index that the arguments to *proc* were taken from. The result is the first *vec*.

Examples:

```
> (define v (vector 1 2 3 4))
> (vector-map! add1 v)
'#(2 3 4 5)
> v
'#(2 3 4 5)
```

```
(vector-append vec ...) → vector?
  vec : vector?
```

Creates a fresh vector that contains all of the elements of the given vectors in order.

Example:

```
> (vector-append #(1 2) #(3 4))
'#(1 2 3 4)
```

```
(vector-take vec pos) → vector?
  vec : vector?
  pos : exact-nonnegative-integer?
```

Returns a fresh vector whose elements are the first *pos* elements of `vec`. If `vec` has fewer than *pos* elements, then the `exn:fail:contract` exception is raised.

Example:

```
> (vector-take #(1 2 3 4) 2)
'#(1 2)
```

```
(vector-take-right vec pos) → vector?
  vec : vector?
  pos : exact-nonnegative-integer?
```

Returns a fresh vector whose elements are the last *pos* elements of `vec`. If `vec` has fewer than *pos* elements, then the `exn:fail:contract` exception is raised.

Example:

```
> (vector-take-right #(1 2 3 4) 2)
'#(3 4)
```

```
(vector-drop vec pos) → vector?
  vec : vector?
  pos : exact-nonnegative-integer?
```

Returns a fresh vector whose elements are the elements of `vec` after the first *pos* elements. If `vec` has fewer than *pos* elements, then the `exn:fail:contract` exception is raised.

Example:

```
> (vector-drop #(1 2 3 4) 2)
'#(3 4)
```

```
(vector-drop-right vec pos) → vector?
  vec : vector?
  pos : exact-nonnegative-integer?
```

Returns a fresh vector whose elements are the prefix of *vec*, dropping its *pos*-length tail. If *vec* has fewer than *pos* elements, then the `exn:fail:contract` exception is raised.

Examples:

```
> (vector-drop-right #(1 2 3 4) 1)
'#(1 2 3)
> (vector-drop-right #(1 2 3 4) 3)
'#(1)
```

```
(vector-split-at vec pos) → vector? vector?
  vec : vector?
  pos : exact-nonnegative-integer?
```

Returns the same result as

```
(values (vector-take vec pos) (vector-drop vec pos))
```

except that it can be faster.

Example:

```
> (vector-split-at #(1 2 3 4 5) 2)
'#(1 2)
'#(3 4 5)
```

```
(vector-split-at-right vec pos) → vector? vector?
  vec : vector?
  pos : exact-nonnegative-integer?
```

Returns the same result as

```
(values (vector-take-right vec pos) (vector-drop-right vec pos))
```

except that it can be faster.

Example:

```
> (vector-split-at-right #(1 2 3 4 5) 2)
'#(1 2 3)
'#(4 5)
```

```
(vector-copy vec [start end]) → vector?
  vec : vector?
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (vector-length v)
```

Creates a fresh vector of size `(- end start)`, with all of the elements of `vec` from `start` (inclusive) to `end` (exclusive).

Examples:

```
> (vector-copy #(1 2 3 4))
'#(1 2 3 4)
> (vector-copy #(1 2 3 4) 3)
'#(4)
> (vector-copy #(1 2 3 4) 2 3)
'#(3)
```

```
(vector-set/copy vec pos val) → vector?
  vec : vector?
  pos : exact-nonnegative-integer?
  val : any/c
```

Creates a fresh vector with the same content as `vec`, except that `val` is the element at index `pos`.

Examples:

```
> (vector-set/copy #(1 2 3) 0 'x)
'#(x 2 3)
> (vector-set/copy #(1 2 3) 2 'x)
'#(1 2 x)
```

Added in version 8.11.1.10 of package `base`.

```
(vector-extend vec new-size [val]) → vector?
  vec : vector?
  new-size : (and/c exact-nonnegative-integer? (>=/c (vector-length vec)))
  val : any/c = 0
```

Creates a fresh vector of length `new-size` where the prefix is filled with the elements of `vec` and the remainder with `val`.

Examples:

```
> (vector-extend #(1 2 3) 10)
'#(1 2 3 0 0 0 0 0 0 0)
> (vector-extend #(1 2 3) 10 #f)
'#(1 2 3 #f #f #f #f #f #f #f)
> (vector-extend #(1 2 3) 3 #f)
'#(1 2 3)
```

Added in version 8.12.0.10 of package `base`.

```
(vector-filter pred vec) → vector?
  pred : procedure?
  vec : vector?
```

Returns a fresh vector with the elements of *vec* for which *pred* produces a true value. The *pred* procedure is applied to each element from first to last.

Example:

```
> (vector-filter even? #(1 2 3 4 5 6))
'#(2 4 6)
```

```
(vector-filter-not pred vec) → vector?
  pred : procedure?
  vec : vector?
```

Like `vector-filter`, but the meaning of the *pred* predicate is reversed: the result is a vector of all items for which *pred* returns `#f`.

Example:

```
> (vector-filter-not even? #(1 2 3 4 5 6))
'#(1 3 5)
```

```
(vector-count proc vec ...+) → exact-nonnegative-integer?
  proc : procedure?
  vec : vector?
```

Returns the number of elements of the *vec* ... (taken in parallel) on which *proc* does not evaluate to `#f`.

Examples:

```
> (vector-count even? #(1 2 3 4 5))
2
> (vector-count = #(1 2 3 4 5) #(5 4 3 2 1))
1
```

```
(vector-argmin proc vec) → any/c
  proc : (-> any/c real?)
  vec : vector?
```

This returns the first element in the non-empty vector `vec` that minimizes the result of `proc`.

Examples:

```
> (vector-argmin car #((3 pears) (1 banana) (2 apples)))
'(1 banana)
> (vector-argmin car #((1 banana) (1 orange)))
'(1 banana)
```

```
(vector-argmax proc vec) → any/c
  proc : (-> any/c real?)
  vec : vector?
```

This returns the first element in the non-empty vector `vec` that maximizes the result of `proc`.

Examples:

```
> (vector-argmax car #((3 pears) (1 banana) (2 apples)))
'(3 pears)
> (vector-argmax car #((3 pears) (3 oranges)))
'(3 pears)
```

```
(vector-member v vec [is-equal?]) → (or/c natural-number/c #f)
  v : any/c
  vec : vector?
  is-equal? : (-> any/c any/c any/c) = equal?
```

Locates the first element of `vec` that is equal to `v` according to `is-equal?`. If such an element exists, the index of that element in `vec` is returned. Otherwise, the result is `#f`.

Examples:

```
> (vector-member 2 (vector 1 2 3 4))
1
> (vector-member 9 (vector 1 2 3 4))
#f
> (vector-member 1.0 (vector 1 2 3 4) =)
0
```

Changed in version 8.15.0.1 of package `base`: Added the `is-equal?` argument.

```
(vector-memv v vec) → (or/c natural-number/c #f)
  v : any/c
  vec : vector?
```

Like `vector-member`, but finds an element using `eqv?`.

Examples:

```
> (vector-memv 2 (vector 1 2 3 4))
1
> (vector-memv 9 (vector 1 2 3 4))
#f
```

```
(vector-memq v vec) → (or/c natural-number/c #f)
  v : any/c
  vec : vector?
```

Like `vector-member`, but finds an element using `eq?`.

Examples:

```
> (vector-memq 2 (vector 1 2 3 4))
1
> (vector-memq 9 (vector 1 2 3 4))
#f
```

```
(vector-sort  vec
              less-than?
             [start
              end
              #:key key
              #:cache-keys? cache-keys?]) → vector?
  vec : vector?
  less-than? : (any/c any/c . -> . any/c)
  start : exact-nonnegative-integer? = 0
  end : (or/c #f exact-nonnegative-integer?) = #f
  key : (or/c #f (any/c . -> . any/c)) = #f
  cache-keys? : boolean? = #f
```

Like `sort`, but operates on vectors; a *fresh* vector of length `(- end start)` is returned containing the elements from indices `start` (inclusive) through `end` (exclusive) of `vec`, but in sorted order (i.e., `vec` is not modified). This sort is stable (i.e., the order of "equal" elements is preserved).

If *end* is #f, it is replaced with (vector-length *vec*).

Examples:

```
> (define v1 (vector 4 3 2 1))
> v1
'#(4 3 2 1)
> (vector-sort v1 <)
'#(1 2 3 4)
> v1
'#(4 3 2 1)
> (vector-sort v1 < 2 #f #:key #f)
'#(1 2)
> v1
'#(4 3 2 1)
> (define v2 (vector '(4) '(3) '(2) '(1)))
> v2
'#((4) (3) (2) (1))
> (vector-sort v2 < 1 3 #:key car)
'#((2) (3))
> v2
'#((4) (3) (2) (1))
```

Added in version 6.6.0.5 of package base.

```
(vector-sort! vec
              less-than?
             [start
              end
              #:key key
              #:cache-keys? cache-keys?]) → void?
  vec : (and/c vector? (not/c immutable?))
  less-than? : (any/c any/c . -> . any/c)
  start : exact-nonnegative-integer? = 0
  end : (or/c #f exact-nonnegative-integer?) = #f
  key : (or/c #f (any/c . -> . any/c)) = #f
  cache-keys? : boolean? = #f
```

Like vector-sort, but *updates* indices *start* (inclusive) through *end* (exclusive) of *vec* by sorting them according to the *less-than?* procedure.

Examples:

```
> (define v1 (vector 4 3 2 1))
> v1
'#(4 3 2 1)
```

```
> (vector-sort! v1 <)
> v1
'#(1 2 3 4)
> (define v2 (vector 4 3 2 1))
> v2
'#(4 3 2 1)
> (vector-sort! v2 < 2 #f #:key #f)
> v2
'#(4 3 1 2)
> (define v3 (vector '(4) '(3) '(2) '(1)))
> v3
'#((4) (3) (2) (1))
> (vector-sort! v3 < 1 3 #:key car)
> v3
'#((4) (2) (3) (1))
```

Added in version 6.6.0.5 of package `base`.

```
(vector*-copy vec [start end]) → vector?
  vec : (and/c vector? (not/c impersonator?))
  start : exact-nonnegative-integer? = 0
  end : exact-nonnegative-integer? = (vector-length v)
(vector*-append vec ...) → vector?
  vec : (and/c vector? (not/c impersonator?))
(vector*-set/copy vec pos val) → vector?
  vec : (and/c vector? (not/c impersonator?))
  pos : exact-nonnegative-integer?
  val : any/c
(vector*-extend vec pos [val]) → vector?
  vec : (and/c vector? (not/c impersonator?))
  pos : exact-nonnegative-integer?
  val : any/c = 0
```

Like `vector-copy`, `vector-append`, `vector-set/copy`, and `vector-extend` but constrained to work on vectors that are not impersonators.

Added in version 8.11.1.10 of package `base`.
Changed in version 8.12.0.10: Added `vector*-extend`.

4.13 Stencil Vectors

A *stencil vector* is like a vector, but it has an associated mask fixnum where the number of bits set in the mask determines the length of the vector. A stencil vector is useful for implementing some data structures [Torosyan21], such as a hash array mapped trie (HAMT).

Conceptually, a stencil vector's mask indicates which virtual elements of a full-sized stencil vector are present, but mask bits have no effect on access or mutation via `stencil-vector-ref` and `stencil-vector-set!`. For example, such a stencil vector has a mask `25`, which could also be written `#b11001`; reading from low bit to high, that mask represents values present at the virtual slots 0, 3, and 4. If that stencil vector's elements are `'a`, `'b`, and `'c`, then `'a` is at virtual slot 0 and accessed with index `0`, `'b` is at virtual slot 3 and accessed with index `1`, and `'c` is at virtual slot 4 and accessed with index `2`.

The relative order of bits in a mask *is* relevant for a functional-update operation with `stencil-vector-update`. Elements to remove are specified with a removal mask, and elements to add are ordered relative to remaining elements through an addition mask. For example, starting with the stencil vector whose mask is `#b11001` with elements `'a`, `'b`, and `'c`, adding new elements `'d` and `'e` using the addition mask `#b100100` produces a stencil vector whose mask is `#b111101` and whose elements in order are `'a`, `'d`, `'b`, `'c`, and `'e`.

The maximum size of a stencil vector is 58 elements on a 64-bit platform and 26 elements on a 32-bit platform. This limited size enables a compact internal representation and ensures that update operations are relatively simple. Stencil vectors are mutable, although they are intended primarily for use without mutation to implement a persistent data structure.

Two stencil vectors are `equal?` if they have the same mask, and if the values in corresponding slots of the stencil vectors are `equal?`.

A printed vector starts with `#<stencil ...>`, and this printed form cannot be parsed by `read`. The `s-exp->fasl` and `serialize` functions do not support stencil vectors, in part because a stencil vector on a 64-bit platform might not be representable on a 32-bit platform. The intent is that stencil vectors are used as an in-memory representation for a datatype implementation.

Added in version 8.5.0.7 of package `base`.

```
(stencil-vector? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a stencil vector, `#f` otherwise.

Examples:

```
> (stencil-vector #b10010 'a 'b)
#<stencil 18: a b>
> (stencil-vector #b111 'a 'b 'c)
#<stencil 7: a b c>
```

Added in version 8.5.0.7 of package `base`.

```
(stencil-vector-mask-width) → exact-nonnegative-integer?
```

Returns the maximum number of elements allowed in a stencil vector on the current platform. The result is 58 on a 64-bit platform or 26 on a 32-bit platform.

```
(stencil-vector mask v ...) → stencil-vector?
  mask : (integer-in 0 (sub1 (expt 2 (stencil-vector-mask-width))))
  v : any/c
```

Returns a stencil vector combining *mask* with elements *v*. The number of supplied *v*s must match the number of bits set in *mask*'s two's complement representation.

Added in version 8.5.0.7 of package base.

```
(stencil-vector-mask vec)
 → (integer-in 0 (sub1 (expt 2 (stencil-vector-mask-width))))
  vec : stencil-vector?
```

Returns the mask of *vec*. Note that the mask of a stencil vector is determined at creation time and cannot be changed later.

Example:

```
> (stencil-vector-mask (stencil-vector #b10010 'a 'b))
18
```

Added in version 8.5.0.7 of package base.

```
(stencil-vector-length vec)
 → (integer-in 0 (sub1 (stencil-vector-mask-width)))
  vec : stencil-vector?
```

Returns the length of *vec* (i.e., the number of slots in the vector). The result is the same as `(fxpopcount (stencil-vector-mask vec))`.

Example:

```
> (stencil-vector-length (stencil-vector #b10010 'a 'b))
2
```

Added in version 8.5.0.7 of package base.

```
(stencil-vector-ref vec pos) → any/c
  vec : stencil-vector?
  pos : exact-nonnegative-integer?
```

Returns the element in slot *pos* of *vec*. The first slot is position 0, and the last slot is one less than `(stencil-vector-length vec)`.

Examples:

```
> (stencil-vector-ref (stencil-vector #b10010 'a 'b) 1)
'b
> (stencil-vector-ref (stencil-vector #b111 'a 'b 'c) 1)
'b
```

Added in version 8.5.0.7 of package `base`.

```
(stencil-vector-set! vec pos v) → void?
  vec : stencil-vector?
  pos : exact-nonnegative-integer?
  v : any/c
```

Updates the slot *pos* of *vec* to contain *v*.

Examples:

```
> (define st-vec (stencil-vector #b101 'a 'b))
> st-vec
#<stencil 5: a b>
> (stencil-vector-set! st-vec 1 'c)
> st-vec
#<stencil 5: a c>
```

Added in version 8.5.0.7 of package `base`.

```
(stencil-vector-update vec
                       remove-mask
                       add-mask
                       v ...)      → stencil-vector?
  vec : stencil-vector?
  remove-mask : (integer-in 0 (sub1 (expt 2 (stencil-vector-mask-width))))
  add-mask : (integer-in 0 (sub1 (expt 2 (stencil-vector-mask-width))))
  v : any/c
```

Returns a stencil vector that is like *vec*, but with elements corresponding to *remove-mask* removed, and with the given *v*s added at positions relative to existing (unremoved) elements determined by *add-mask*.

Examples:

```
> (define st-vec (stencil-vector #b101 'a 'b))
> (stencil-vector-update st-vec #b0 #b10 'c)
#<stencil 7: a c b>
> (stencil-vector-update st-vec #b0 #b1000 'c)
#<stencil 13: a b c>
```

```
> st-vec ; unchanged by updates
#<stencil 5: a b>
> (stencil-vector-update st-vec #b1 #b1 'c)
#<stencil 5: c b>
> (stencil-vector-update st-vec #b100 #b100 'c)
#<stencil 5: a c>
> (stencil-vector-update st-vec #b100 #b0)
#<stencil 1: a>
```

Added in version 8.5.0.7 of package `base`.

4.14 Boxes

§3.11 "Boxes" in *The Racket Guide* introduces boxes.

A *box* is like a single-element vector, normally used as minimal mutable storage.

A box can be *mutable* or *immutable*. When an immutable box is provided to a procedure like `set-box!`, the `exn:fail:contract` exception is raised. Box constants generated by the default reader (see §1.3.7 "Reading Strings") are immutable. Use `immutable?` to check whether a box is immutable.

A literal or printed box starts with `#&`. See §1.3.13 "Reading Boxes" for information on `read`ing boxes and §1.4.10 "Printing Boxes" for information on `print`ing boxes.

```
(box? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a box, `#f` otherwise.

See also `immutable-box?` and `mutable-box?`.

```
(box v) → box?
  v : any/c
```

Returns a new mutable box that contains *v*.

```
(box-immutable v) → (and/c box? immutable?)
  v : any/c
```

Returns a new immutable box that contains *v*.

```
(unbox box) → any/c
  box : box?
```

Returns the content of *box*.

For any `v`, `(unbox (box v))` and `(unbox (box-immutable v))` returns `v`.

```
(set-box! box v) → void?
  box : (and/c box? (not/c immutable?))
  v : any/c
```

Sets the content of `box` to `v`.

```
(unbox* box) → any/c
  box : (and box? (not/c impersonator?))
(set-box*! box v) → void?
  box : (and/c box? (not/c immutable?) (not/c impersonator?))
  v : any/c
```

Like `unbox` and `set-box!`, but constrained to work on boxes that are not impersonators.

Added in version 6.90.0.15 of package `base`.

```
(box-cas! box old new) → boolean?
  box : (and/c box? (not/c immutable?) (not/c impersonator?))
  old : any/c
  new : any/c
```

Atomically updates the contents of `box` to `new`, provided that `box` currently contains a value that is `eq?` to `old`, and returns `#t` in that case. If `box` does not contain `old`, then the result is `#f`.

If no other threads or futures attempt to access `box`, the operation is equivalent to

```
(and (eq? old (unbox box)) (set-box! box new) #t)
```

except that `box-cas!` can spuriously fail on some platforms. That is, with low probability, the result can be `#f` with the value in `box` left unchanged, even if `box` contains `old`.

When Racket is compiled with support for futures, `box-cas!` is guaranteed to use a hardware *compare and set* operation. Uses of `box-cas!` can be performed safely in a future (i.e., allowing the future thunk to continue in parallel). See also §11.7 “Machine Memory Order”.

4.15 Hash Tables

§3.10 “Hash Tables” in *The Racket Guide* introduces hash tables.

A *hash table* (or simply *hash*) maps each of its keys to a single value. For a given hash table, keys are equivalent via `equal?`, `equal-always?`, `eqv?`, or `eq?`, and keys are retained either strongly, weakly (see §16.1 “Weak Boxes”), or like ephemerons. A hash table is also either mutable or immutable. Immutable hash tables support effectively constant-time access and update, just like mutable hash tables; the constant on immutable operations is usually larger, but the functional nature of immutable hash tables can pay off in certain algorithms. Use immutable? to check whether a hash table is immutable.

Immutable hash tables actually provide *O*(*log N*) access and update. Since *N* is limited by the address space so that *log N* is limited to less than 30 or 62 (depending on the platform), *log N* can be treated reasonably as a constant.

For equal?-based hashing, the built-in hash functions on strings, pairs, lists, vectors, prefab or transparent structures, etc., take time proportional to the size of the value. The hash code for a compound data structure, such as a list or vector, depends on hashing each item of the container, but the depth of such recursive hashing is limited (to avoid potential problems with cyclic data). For a non-list pair, both car and cdr hashing is treated as a deeper hash, but the cdr of a list is treated as having the same hashing depth as the list.

A hash table can be used as a two-valued sequence (see §4.17.1 "Sequences"). The keys and values of the hash table serve as elements of the sequence (i.e., each element is a key and its associated value). If a mapping is added to or removed from a mutable hash table during iteration, then an iteration step may fail with exn:fail:contract, or the iteration may skip or duplicate keys and values. See also in-hash, in-hash-keys, in-hash-values, and in-hash-pairs.

Two hash tables cannot be equal? unless they have the same mutability, use the same key-comparison procedure (equal?, equal-always?, eqv?, or eq?), both hold keys strongly, weakly, or like ephemerons. Empty immutable hash tables are eq? when they are equal?.

Changed in version 7.2.0.9 of package base: Made empty immutable hash tables eq? when they are equal?.

Caveats concerning concurrent modification: A mutable hash table can be manipulated with hash-ref, hash-set!, and hash-remove! concurrently by multiple threads, and the operations are protected by a table-specific semaphore as needed. Several caveats apply, however:

- If a thread is terminated while applying hash-ref, hash-ref-key, hash-set!, hash-remove!, hash-ref!, hash-update!, or hash-clear! to a hash table that uses equal?, equal-always?, or eqv? key comparisons, all current and future operations on the hash table may block indefinitely.
- The hash-map, hash-for-each, and hash-clear! procedures do not use the table's semaphore to guard the traversal as a whole (if a traversal is needed, in the case of hash-clear!). Changes by one thread to a hash table can affect the keys and values seen by another thread part-way through its traversal of the same hash table.
- The hash-update! and hash-ref! functions use a table's semaphore independently for the hash-ref and hash-set! parts of their functionality, which means that the update as a whole is not "atomic."
- Adding a mutable hash table as a key in itself is trouble on the grounds that the key is being mutated (see the caveat below), but it is also a kind of concurrent use of the hash table: computing a hash table's hash code may require waiting on the table's semaphore, but the semaphore is already held for modifying the hash table, so the hash-table addition can block indefinitely.

Caveat concerning mutable keys: If a key in an `equal?`-based hash table is mutated (e.g., a key string is modified with `string-set!`), then the hash table's behavior for insertion and lookup operations becomes unpredictable.

A literal or printed hash table starts with `#hash`, `#hashalw`, `#hasheqv`, or `#hasheq`. See §1.3.12 "Reading Hash Tables" for information on `read`ing hash tables and §1.4.9 "Printing Hash Tables" for information on `print`ing hash tables.

```
(hash? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a hash table, `#f` otherwise.

See also `immutable-hash?` and `mutable-hash?`.

```
(hash-equal? ht) → boolean?
  ht : hash?
```

Returns `#t` if *ht* compares keys with `equal?`, `#f` if it compares with `eq?`, `eqv?`, or `equal-always?`.

```
(hash-equal-always? ht) → boolean?
  ht : hash?
```

Returns `#t` if *ht* compares keys with `equal-always?`, `#f` if it compares with `eq?`, `eqv?`, or `equal?`.

Added in version 8.5.0.3 of package `base`.

```
(hash-eqv? ht) → boolean?
  ht : hash?
```

Returns `#t` if *ht* compares keys with `eqv?`, `#f` if it compares with `equal?`, `equal-always?`, or `eq?`.

```
(hash-eq? ht) → boolean?
  ht : hash?
```

Returns `#t` if *ht* compares keys with `eq?`, `#f` if it compares with `equal?`, `equal-always?`, or `eqv?`.

```
(hash-strong? ht) → boolean?
  ht : hash?
```

Returns `#t` if *ht* retains its keys strongly, `#f` if it retains keys weakly or like ephemerons.

Added in version 8.0.0.10 of package `base`.

```
(hash-weak? ht) → boolean?
  ht : hash?
```

Returns `#t` if *`ht`* retains its keys weakly, `#f` if it retains keys strongly or like ephemerons.

```
(hash-ephemeron? ht) → boolean?
  ht : hash?
```

Returns `#t` if *`ht`* retains its keys like ephemerons, `#f` if it retains keys strongly or merely weakly.

Added in version 8.0.0.10 of package `base`.

```
(hash key val ... ...)
 → (and/c hash? hash-equal? immutable? hash-strong?)
  key : any/c
  val : any/c
(hashalw key val ... ...)
 → (and/c hash? hash-equal-always? immutable? hash-strong?)
  key : any/c
  val : any/c
(hasheq key val ... ...)
 → (and/c hash? hash-eq? immutable? hash-strong?)
  key : any/c
  val : any/c
(hasheqv key val ... ...)
 → (and/c hash? hash-eqv? immutable? hash-strong?)
  key : any/c
  val : any/c
```

Creates an immutable hash table with each given *`key`* mapped to the following *`val`*; each *`key`* must have a *`val`*, so the total number of arguments to `hash` must be even.

The `hash` procedure creates a table where keys are compared with `equal?`, `hashalw` creates a table where keys are compared with `equal-always?`, `hasheq` procedure creates a table where keys are compared with `eq?`, `hasheqv` procedure creates a table where keys are compared with `eqv?`.

The *`key`* to *`val`* mappings are added to the table in the order that they appear in the argument list, so later mappings can hide earlier mappings if the *`key`*s are equal.

Changed in version 8.5.0.3 of package `base`: Added `hashalw`.

```
(make-hash [assocs])
 → (and/c hash? hash-equal? (not/c immutable?) hash-strong?)
  assocs : (listof pair?) = null
```

```
(make-hashalw [assocs])
 → (and/c hash? hash-equal-always? (not/c immutable?) hash-strong?)
  assocs : (listof pair?) = null
(make-hasheqv [assocs])
 → (and/c hash? hash-eqv? (not/c immutable?) hash-strong?)
  assocs : (listof pair?) = null
(make-hasheq [assocs])
 → (and/c hash? hash-eq? (not/c immutable?) hash-strong?)
  assocs : (listof pair?) = null
```

Creates a mutable hash table that holds keys strongly.

The `make-hash` procedure creates a table where keys are compared with `equal?`, `make-hasheq` procedure creates a table where keys are compared with `eq?`, `make-hasheqv` procedure creates a table where keys are compared with `eqv?`, and `make-hashalw` creates a table where keys are compared with `equal-always?`.

The table is initialized with the content of *assocs*. In each element of *assocs*, the `car` is a key, and the `cdr` is the corresponding value. The mappings are added to the table in the order that they appear in *assocs*, so later mappings can hide earlier mappings.

See also `make-custom-hash`.

Examples:

```
> (make-hash)
'#hash()
> (make-hash '([0 . 1] [42 . "meaning of life"] [2 . 3]))
'#hash((0 . 1) (2 . 3) (42 . "meaning of life"))
> (make-hash '([0 . 1] [1 . 2] [0 . 3]))
'#hash((0 . 3) (1 . 2))
> (make-hash (list (cons 0 1) (cons 'apple 'orange) (cons #t #f)))
'#hash((#t . #f) (0 . 1) (apple . orange))
> (make-hash '((0 1) (1 2) (2 3)))
'#hash((0 . (1)) (1 . (2)) (2 . (3)))
> (make-hash (list (cons + -)))
'#hash((#<procedure:+> . #<procedure:->))
```

Changed in version 8.5.0.3 of package `base`: Added `make-hashalw`.

```
(make-weak-hash [assocs])
 → (and/c hash? hash-equal? (not/c immutable?) hash-weak?)
  assocs : (listof pair?) = null
(make-weak-hashalw [assocs])
 → (and/c hash? hash-equal-always? (not/c immutable?) hash-weak?)
  assocs : (listof pair?) = null
```

```
(make-weak-hasheqv [assocs])
 → (and/c hash? hash-eqv? (not/c immutable?) hash-weak?)
  assocs : (listof pair?) = null
(make-weak-hasheq [assocs])
 → (and/c hash? hash-eq? (not/c immutable?) hash-weak?)
  assocs : (listof pair?) = null
```

Like `make-hash`, `make-hasheq`, `make-hasheqv`, and `make-hashalw`, but creates a mutable hash table that holds keys weakly.

Beware that values in a weak hash table are retained normally. If a value in the table refers back to its key, then the table will retain the value and therefore the key; the mapping will never be removed from the table even if the key becomes otherwise inaccessible. To avoid that problem, use an ephemeron hash table as created by `make-ephemeron-hash`, `make-ephemeron-hashalw`, `make-ephemeron-hasheqv`, or `make-ephemeron-hasheq`. For values that do not refer to keys, there is a modest extra cost to using an ephemeron hash table instead of a weak hash table, but prefer an ephemeron hash table when in doubt.

Changed in version 8.5.0.3 of package `base`: Added `make-weak-hashalw`.

```
(make-ephemeron-hash [assocs])
 → (and/c hash? hash-equal? (not/c immutable?) hash-ephemeron?)
  assocs : (listof pair?) = null
(make-ephemeron-hashalw [assocs])
 → (and/c hash? hash-equal-always? (not/c immutable?) hash-ephemeron?)
  assocs : (listof pair?) = null
(make-ephemeron-hasheqv [assocs])
 → (and/c hash? hash-eqv? (not/c immutable?) hash-ephemeron?)
  assocs : (listof pair?) = null
(make-ephemeron-hasheq [assocs])
 → (and/c hash? hash-eq? (not/c immutable?) hash-ephemeron?)
  assocs : (listof pair?) = null
```

Like `make-hash`, `make-hasheq`, `make-hasheqv`, and `make-hashalw`, but creates a mutable hash table that holds key-value combinations in the same way as an ephemeron.

Using an ephemeron hash table is like using a weak hash table and mapping each key to a ephemeron that pairs the key and value. An advantage of an ephemeron hash table is that the value need not be extracted with `ephemeron-value` from the result of functions like `hash-ref`. An ephemeron hash table might also be represented more compactly than a weak hash table with explicit ephemeron values.

Added in version 8.0.0.10 of package `base`.
Changed in version 8.5.0.3: Added `make-ephemeron-hashalw`.

```
(make-immutable-hash [assocs])
 → (and/c hash? hash-equal? immutable? hash-strong?)
  assocs : (listof pair?) = null
(make-immutable-hashalw [assocs])
 → (and/c hash? hash-equal-always? immutable? hash-strong?)
  assocs : (listof pair?) = null
(make-immutable-hasheqv [assocs])
 → (and/c hash? hash-eqv? immutable? hash-strong?)
  assocs : (listof pair?) = null
(make-immutable-hasheq [assocs])
 → (and/c hash? hash-eq? immutable? hash-strong?)
  assocs : (listof pair?) = null
```

Like `hash`, `hashalw`, `hasheq`, and `hasheqv`, but accepts the key–value mapping in association-list form like `make-hash`, `make-hashalw`, `make-hasheq`, and `make-hasheqv`.

Changed in version 8.5.0.3 of package `base`: Added `make-immutable-hashalw`.

```
(hash-set! ht key v) → void?
  ht : (and/c hash? (not/c immutable?))
  key : any/c
  v : any/c
```

Maps *key* to *v* in *ht*, overwriting any existing mapping for *key*.

See also the caveats concerning concurrent modification and the caveat concerning mutable keys above.

```
(hash-set*! ht key v ... ...) → void?
  ht : (and/c hash? (not/c immutable?))
  key : any/c
  v : any/c
```

Maps each *key* to each *v* in *ht*, overwriting any existing mapping for each *key*. Mappings are added from the left, so later mappings overwrite earlier mappings.

See also the caveats concerning concurrent modification and the caveat concerning mutable keys above.

```
(hash-set ht key v) → (and/c hash? immutable?)
  ht : (and/c hash? immutable?)
  key : any/c
  v : any/c
```

Functionally extends *ht* by mapping *key* to *v*, overwriting any existing mapping for *key*, and returning the extended hash table.

See also the caveat concerning mutable keys above.

```
(hash-set* ht key v ... ...) → (and/c hash? immutable?)
  ht : (and/c hash? immutable?)
  key : any/c
  v : any/c
```

Functionally extends `ht` by mapping each `key` to `v`, overwriting any existing mapping for each `key`, and returning the extended hash table. Mappings are added from the left, so later mappings overwrite earlier mappings.

See also the caveat concerning mutable keys above.

```
(hash-ref ht key [failure-result]) → any
  ht : hash?
  key : any/c
  failure-result : failure-result/c
                 = (lambda ()
                     (raise (make-exn:fail:contract ....)))
```

Returns the value for `key` in `ht`. If no value is found for `key`, then `failure-result` determines the result:

- If `failure-result` is a procedure, it is called (through a tail call) with no arguments to produce the result.
- Otherwise, `failure-result` is returned as the result.

Examples:

```
> (hash-ref (hash) "hi")
hash-ref: no value found for key
  key: "hi"
> (hash-ref (hash) "hi" 5)
5
> (hash-ref (hash) "hi" (lambda () "flab"))
"flab"
> (hash-ref (hash "hi" "bye") "hi")
"bye"
> (hash-ref (hash "hi" "bye") "no")
hash-ref: no value found for key
  key: "no"
```

See also the caveats concerning concurrent modification and the caveat concerning mutable keys above.

```
(hash-ref-key ht key [failure-result]) → any
  ht : hash?
  key : any/c
  failure-result : failure-result/c
                 = (lambda ()
                     (raise (make-exn:fail:contract ....)))
```

Returns the key held by *ht* that is equivalent to *key* according to *ht*'s key-comparison function. If no key is found, then *failure-result* is used as in `hash-ref` to determine the result.

If *ht* is not an impersonator, then the returned key, assuming it is found, will be `eq?`-equivalent to the one actually retained by *ht*:

Examples:

```
> (define original-key "hello")
> (define key-copy (string-copy original-key))
> (equal? original-key key-copy)
#t
> (eq? original-key key-copy)
#f
> (define table (make-hash))
> (hash-set! table original-key 'value)
> (eq? (hash-ref-key table "hello") original-key)
#t
> (eq? (hash-ref-key table "hello") key-copy)
#f
```

If a mutable hash is updated multiple times using keys that are not `eq?`-equivalent but are equivalent according to the hash's key-comparison procedure, the hash retains the first one:

Examples:

```
> (define original-key "hello")
> (define key-copy (string-copy original-key))
> (define table (make-hash))
> (hash-set! table original-key 'one)
> (hash-set! table key-copy 'two)
> (eq? (hash-ref-key table "hello") original-key)
#t
> (eq? (hash-ref-key table "hello") key-copy)
#f
```

Conversely, an immutable hash retains the key that was most-recently used to update it:

Examples:

```
> (define original-key "hello")
> (define key-copy (string-copy original-key))
> (define table0 (hash))
> (define table1 (hash-set table0 original-key 'one))
> (define table2 (hash-set table1 key-copy 'two))
> (eq? (hash-ref-key table2 "hello") original-key)
#f
> (eq? (hash-ref-key table2 "hello") key-copy)
#t
```

If *ht* is an impersonator, then the returned key will be determined as described in the documentation to `impersonate-hash`.

See also the caveats concerning concurrent modification and the caveat concerning mutable keys above.

Added in version 7.4.0.3 of package `base`.

```
(hash-ref! ht key to-set) → any
  ht : hash?
  key : any/c
  to-set : failure-result/c
```

Returns the value for *key* in *ht*. If no value is found for *key*, then *to-set* determines the result as in `hash-ref` (i.e., it is either a thunk that computes a value or a plain value), and this result is stored in *ht* for the *key*. (Note that if *to-set* is a thunk, it is not invoked in tail position.)

See also the caveats concerning concurrent modification and the caveat concerning mutable keys above.

```
(hash-has-key? ht key) → boolean?
  ht : hash?
  key : any/c
```

Returns `#t` if *ht* contains a value for the given *key*, `#f` otherwise.

```
(hash-update! ht key updater [failure-result]) → void?
  ht : (and/c hash? (not/c immutable?))
  key : any/c
  updater : (any/c . -> . any/c)
  failure-result : failure-result/c
                 = (lambda ()
                     (raise (make-exn:fail:contract ....)))
```

Updates the value mapped by *key* in *ht* by applying *updater* to the value. The value returned by *updater* becomes the new mapping for *key*, overwriting the original value in *ht*.

Examples:

```
(define h (make-hash))
(hash-set! h 'a 5)

> (hash-update! h 'a add1)
> h
'#hash((a . 6))
```

The optional *failure-result* argument is used when no mapping exists for *key* already, in the same manner as in `hash-ref`.

Examples:

```
(define h (make-hash))

> (hash-update! h 'b add1)
hash-update!: no value found for key: 'b
> (hash-update! h 'b add1 0)
> h
'#hash((b . 1))
```

See also the caveats concerning concurrent modification and the caveat concerning mutable keys above.

```
(hash-update ht key updater [failure-result])
 → (and/c hash? immutable?)
  ht : (and/c hash? immutable?)
  key : any/c
  updater : (any/c . -> . any/c)
  failure-result : failure-result/c
                 = (lambda ()
                     (raise (make-exn:fail:contract ....)))
```

Functionally updates the value mapped by *key* in *ht* by applying *updater* to the value and returning a new hash table. The value returned by *updater* becomes the new mapping for *key* in the returned hash table.

Examples:

```
(define h (hash 'a 5))
```

```
> (hash-update h 'a add1)
'#hash((a . 6))
```

The optional *failure-result* argument is used when no mapping exists for *key* already, in the same manner as in `hash-ref`.

Examples:

```
(define h (hash))

> (hash-update h 'b add1)
hash-update: no value found for key: 'b
> (hash-update h 'b add1 0)
'#hash((b . 1))
```

See also the caveat concerning mutable keys above.

```
(hash-remove! ht key) → void?
  ht : (and/c hash? (not/c immutable?))
  key : any/c
```

Removes any existing mapping for *key* in *ht*.

See also the caveats concerning concurrent modification and the caveat concerning mutable keys above.

```
(hash-remove ht key) → (and/c hash? immutable?)
  ht : (and/c hash? immutable?)
  key : any/c
```

Functionally removes any existing mapping for *key* in *ht*, returning *ht* (i.e., a result `eq?` to *ht*) if *key* is not present in *ht*.

See also the caveat concerning mutable keys above.

```
(hash-clear! ht) → void?
  ht : (and/c hash? (not/c immutable?))
```

Removes all mappings from *ht*.

If *ht* is not an impersonator, then all mappings are removed in constant time. If *ht* is an impersonator, then each key is removed one-by-one using `hash-remove!`.

See also the caveats concerning concurrent modification and the caveat concerning mutable keys above.

```
(hash-clear ht) → (and/c hash? immutable?)
  ht : (and/c hash? immutable?)
```

Functionally removes all mappings from *ht*.

If *ht* is not a chaperone, then clearing is equivalent to creating a new hash table, and the operation is performed in constant time. If *ht* is a chaperone, then each key is removed one-by-one using `hash-remove`.

```
(hash-copy-clear ht [#:kind kind]) → hash?
  ht : hash?
  kind : (or/c #f 'immutable 'mutable 'weak 'ephemeron) = #f
```

Produces an empty hash table with the same key-comparison procedure as *ht*, with either the given *kind* or the same kind as the given *ht*.

If *kind* is not supplied or `#f`, produces a hash table of the same kind and mutability as the given *ht*. If *kind* is `'immutable`, `'mutable`, `'weak`, or `'ephemeron`, produces a table that's immutable, mutable with strongly-held keys, mutable with weakly-held keys, or mutable with ephemeron-held keys respectively.

Changed in version 8.5.0.2 of package `base`: Added the *kind* argument.

```
(hash-map ht proc [try-order?]) → (listof any/c)
  ht : hash?
  proc : (any/c any/c . -> . any/c)
  try-order? : any/c = #f
```

Applies the procedure *proc* to each element in *ht* in an unspecified order, accumulating the results into a list. The procedure *proc* is called each time with a key and its value, and the procedure's individual results appear in order in the result list.

If a hash table is extended with new keys (either through *proc* or by another thread) while a `hash-map` or `hash-for-each` traversal is in process, arbitrary key–value pairs can be dropped or duplicated in the traversal. Key mappings can be deleted or remapped (by any thread) with no adverse affects; the change does not affect a traversal if the key has been seen already, otherwise the traversal skips a deleted key or uses the remapped key's new value.

See also the caveats concerning concurrent modification above.

If *try-order?* is true, then the order of keys and values passed to *proc* is normalized under certain circumstances—including when every key is one of the following and with the following order (earlier bullets before later):

- booleans sorted `#f` before `#t`;

- characters sorted by `char<?`;
- real numbers sorted by `<`;
- symbols sorted with uninterned symbols before unreadable symbols before interned symbols, then sorted by `symbol<?`;
- keywords sorted by `keyword<?`;
- strings sorted by `string<?`;
- byte strings sorted by `bytes<?`;
- `null`;
- `#<void>`; and
- `eof`.

Changed in version 6.3 of package `base`: Added the *`try-order?`* argument.
Changed in version 7.1.0.7: Added guarantees for *`try-order?`*.

Examples:

```
> (hash-map (make-hash '([0 . 1] [1 . 2] [2 . 3])) (λ (k v) k))
'(0 1 2)
> (hash-map (make-hash '([0 . 1] [1 . 2] [2 . 3])) (λ (k v) v))
'(1 2 3)
```

```
(hash-map/copy ht proc [#:kind kind]) → hash?
  ht : hash?
  proc : (any/c any/c . -> . (values any/c any/c))
  kind : (or/c #f 'immutable 'mutable 'weak 'ephemeron) = #f
```

Applies the procedure *`proc`* to each element in *`ht`* in an unspecified order, accumulating the results into a new hash with the same key-comparison procedure as *`ht`*, with either the given *`kind`* or the same kind as the given *`ht`*.

If *`kind`* is not supplied or `#f`, produces a hash table of the same kind and mutability as the given *`ht`*. If *`kind`* is `'immutable`, `'mutable`, `'weak`, or `'ephemeron`, produces a table that's immutable, mutable with strongly-held keys, mutable with weakly-held keys, or mutable with ephemeron-held keys respectively.

Examples:

```
> (hash-map/copy #hash((a . "apple") (b . "banana"))
                 (lambda (k v) (values k (string-upcase v))))
'#hash((a . "APPLE") (b . "BANANA"))
```

```
> (define frozen-capital
    (hash-map/copy (make-hash '((a . "apple") (b . "banana")))
                   (lambda (k v) (values k (string-upcase v)))
                   #:kind 'immutable))
> frozen-capital
'#hash((a . "APPLE") (b . "BANANA"))
> (immutable? frozen-capital)
#t
```

Added in version 8.5.0.2 of package `base`.

```
(hash-keys ht [try-order?]) → (listof any/c)
  ht : hash?
  try-order? : any/c = #f
```

Returns a list of the keys of *ht* in an unspecified order.

If *try-order?* is true, then the order of keys is normalized under certain circumstances. See `hash-map` for further explanations on *try-order?* and on information about modifying *ht* during `hash-keys`.

See also the caveats concerning concurrent modification above.

Changed in version 8.3.0.11 of package `base`: Added the *try-order?* argument.

```
(hash-values ht [try-order?]) → (listof any/c)
  ht : hash?
  try-order? : any/c = #f
```

Returns a list of the values of *ht* in an unspecified order.

If *try-order?* is true, then the order of values is normalized under certain circumstances, based on the ordering of the associated keys. See `hash-map` for further explanations on *try-order?* and on information about modifying *ht* during `hash-values`.

See also the caveats concerning concurrent modification above.

Changed in version 8.3.0.11 of package `base`: Added the *try-order?* argument.

```
(hash->list ht [try-order?]) → (listof (cons/c any/c any/c))
  ht : hash?
  try-order? : any/c = #f
```

Returns a list of the key–value pairs of *ht* in an unspecified order.

If *try-order?* is true, then the order of keys and values is normalized under certain circumstances. See `hash-map` for further explanations on *try-order?* and on information about modifying *ht* during `hash->list`.

See also the caveats concerning concurrent modification above.

Changed in version 8.3.0.11 of package `base`: Added the *`try-order?`* argument.

```
(hash-keys-subset? ht1 ht2) → boolean?
  ht1 : hash?
  ht2 : hash?
```

Returns `#t` if the keys of *`ht1`* are a subset of or the same as the keys of *`ht2`*. The hash tables must both use the same key-comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`), otherwise the `exn:fail:contract` exception is raised.

Using `hash-keys-subset?` on immutable hash tables can be much faster than iterating through the keys of *`ht1`* to make sure that each is in *`ht2`*.

Added in version 6.5.0.8 of package `base`.

```
(hash-for-each ht proc [try-order?]) → void?
  ht : hash?
  proc : (any/c any/c . -> . any)
  try-order? : any/c = #f
```

Applies *`proc`* to each element in *`ht`* (for the side-effects of *`proc`*) in an unspecified order. The procedure *`proc`* is called each time with a key and its value.

See `hash-map` for information about *`try-order?`* and about modifying *`ht`* within *`proc`*.

See also the caveats concerning concurrent modification above.

Changed in version 6.3 of package `base`: Added the *`try-order?`* argument.
Changed in version 7.1.0.7: Added guarantees for *`try-order?`*.

```
(hash-count ht) → exact-nonnegative-integer?
  ht : hash?
```

Returns the number of keys mapped by *`ht`*.

For the CS implementation of Racket, the result is always computed in constant time and atomically. For the BC implementation of Racket, the result is computed in constant time and atomically only if *`ht`* does not retain keys weakly or like an ephemeron, otherwise, a traversal is required to count the keys.

```
(hash-empty? ht) → boolean?
  ht : hash?
```

Equivalent to `(zero? (hash-count ht))`.

```
(hash-iterate-first ht) → (or/c #f exact-nonnegative-integer?)
  ht : hash?
```

Returns `#f` if *ht* contains no elements, otherwise it returns an integer that is an index to the first element in the hash table; "first" refers to an unspecified ordering of the table elements, and the index values are not necessarily consecutive integers.

For a mutable *ht*, this index is guaranteed to refer to the first item only as long as no items are added to or removed from *ht*. More generally, an index is guaranteed to be a *valid hash index* for a given hash table only as long it comes from `hash-iterate-first` or `hash-iterate-next`, and only as long as the hash table is not modified. In the case of a hash table with weakly held keys or keys held like ephemerons, the hash table can be implicitly modified by the garbage collector (see §1.1.6 "Garbage Collection") when it discovers that the key is not reachable.

```
(hash-iterate-next ht pos)
 → (or/c #f exact-nonnegative-integer?)
  ht : hash?
  pos : exact-nonnegative-integer?
```

Returns either an integer that is an index to the element in *ht* after the element indexed by *pos* (which is not necessarily one more than *pos*) or `#f` if *pos* refers to the last element in *ht*.

If *pos* is not a valid hash index of *ht*, then the result may be `#f` or it may be the next later index that remains valid. The latter result is guaranteed if a hash table has been modified only by the removal of keys.

Changed in version 7.0.0.10 of package `base`: Handle an invalid index by returning `#f` instead of raising `exn:fail:contract`.

```
(hash-iterate-key ht pos) → any/c
  ht : hash?
  pos : exact-nonnegative-integer?
(hash-iterate-key ht pos bad-index-v) → any/c
  ht : hash?
  pos : exact-nonnegative-integer?
  bad-index-v : any/c
```

Returns the key for the element in *ht* at index *pos*.

If *pos* is not a valid hash index for *ht*, the result is *bad-index-v* if provided, otherwise the `exn:fail:contract` exception is raised.

Changed in version 7.0.0.10 of package `base`: Added the optional *bad-index-v* argument.

```
(hash-iterate-value ht pos) → any/c
  ht : hash?
  pos : exact-nonnegative-integer?
(hash-iterate-value ht pos bad-index-v) → any/c
  ht : hash?
  pos : exact-nonnegative-integer?
  bad-index-v : any/c
```

Returns the value for the element in *ht* at index *pos*.

If *pos* is not a valid hash index for *ht*, the result is *bad-index-v* if provided, otherwise the `exn:fail:contract` exception is raised.

Changed in version 7.0.0.10 of package `base`: Added the optional *bad-index-v* argument.

```
(hash-iterate-pair ht pos) → (cons/c any/c any/c)
  ht : hash?
  pos : exact-nonnegative-integer?
(hash-iterate-pair ht pos bad-index-v) → (cons/c any/c any/c)
  ht : hash?
  pos : exact-nonnegative-integer?
  bad-index-v : any/c
```

Returns a pair containing the key and value for the element in *ht* at index *pos*.

If *pos* is not a valid hash index for *ht*, the result is `(cons bad-index-v bad-index-v)` if *bad-index-v* is provided, otherwise the `exn:fail:contract` exception is raised.

Added in version 6.4.0.5 of package `base`.
Changed in version 7.0.0.10: Added the optional *bad-index-v* argument.

```
(hash-iterate-key+value ht pos) → any/c any/c
  ht : hash?
  pos : exact-nonnegative-integer?
(hash-iterate-key+value ht pos bad-index-v) → any/c any/c
  ht : hash?
  pos : exact-nonnegative-integer?
  bad-index-v : any/c
```

Returns the key and value for the element in *ht* at index *pos*.

If *pos* is not a valid hash index for *ht*, the result is `(values bad-index-v bad-index-v)` if *bad-index-v* is provided, otherwise the `exn:fail:contract` exception is raised.

Added in version 6.4.0.5 of package `base`.
Changed in version 7.0.0.10: Added the optional *bad-index-v* argument.

```
(hash-copy ht) → (and/c hash? (not/c immutable?))
  ht : hash?
```

Returns a mutable hash table with the same mappings, same key-comparison mode, and same key-holding strength as `ht`.

4.15.1 Additional Hash Table Functions

```
(require racket/hash)        package: base
```

The bindings documented in this section are provided by the `racket/hash` library, not `racket/base` or `racket`.

```
(hash-union  ht0
             ht ...
            [#:combine combine
             #:combine/key combine/key])
 → (and/c hash? immutable?)
  ht0 : (and/c hash? immutable?)
  ht : hash?
  combine : (-> any/c any/c any/c)
          = (lambda _ (error 'hash-union ....))
  combine/key : (-> any/c any/c any/c any/c)
              = (lambda (k a b) (combine a b))
```

Computes the union of `ht0` with each hash table `ht` by functional update, adding each element of each `ht` to `ht0` in turn. For each key `k` and value `v`, if a mapping from `k` to some value `v0` already exists, it is replaced with a mapping from `k` to `(combine/key k v0 v)`.

Examples:

```
> (hash-union (make-immutable-hash '([1 . one]))
              (make-immutable-hash '([2 . two]))
              (make-immutable-hash '([3 . three])))
'#hash((1 . one) (2 . two) (3 . three))
> (hash-union (make-immutable-hash '([1    one uno]  [2    two dos]))
              (make-immutable-hash '([1    eins un]  [2    zwei deux]))
              #:combine/key (lambda (k v1 v2) (append v1 v2)))
'#hash((1 . (one uno eins un)) (2 . (two dos zwei deux)))
```

```
(hash-union!  ht0
              ht ...
             [#:combine combine
              #:combine/key combine/key]) → void?
```

```
ht0 : (and/c hash? (not/c immutable?))
ht : hash?
combine : (-> any/c any/c any/c)
        = (lambda _ (error 'hash-union ....))
combine/key : (-> any/c any/c any/c any/c)
            = (lambda (k a b) (combine a b))
```

Computes the union of `ht0` with each hash table `ht` by mutable update, adding each element of each `ht` to `ht0` in turn. For each key `k` and value `v`, if a mapping from `k` to some value `v0` already exists, it is replaced with a mapping from `k` to `(combine/key k v0 v)`.

Examples:

```
> (define h (make-hash))
> h
'#hash()
> (hash-union! h (make-immutable-hash '([1    one uno]  [2    two dos])))
> h
'#hash((1 . (one uno)) (2 . (two dos)))
> (hash-union! h
               (make-immutable-hash '([1    eins un]  [2    zwei deux]))
               #:combine/key (lambda (k v1 v2) (append v1 v2)))
> h
'#hash((1 . (one uno eins un)) (2 . (two dos zwei deux)))
```

```
(hash-intersect  ht0
                 ht ...
                [#:combine combine
                 #:combine/key combine/key])
 → (and/c hash? immutable?)
  ht0 : (and/c hash? immutable?)
  ht : hash?
  combine : (-> any/c any/c any/c)
          = (lambda _ (error 'hash-intersect ...))
  combine/key : (-> any/c any/c any/c any/c)
              = (lambda (k a b) (combine a b))
```

Constructs the hash table which is the intersection of `ht0` with every hash table `ht`. In the resulting hash table, a key `k` is mapped to a combination of the values to which `k` is mapped in each of the hash tables. The final values are computed by stepwise combination of the values appearing in each of the hash tables by applying `(combine/key k v vi)`, where `vi` is the value to which `k` is mapped in the *i*-th hash table `ht`, and `v` is the accumulation of the values from the previous steps. The comparison predicate of the first argument (`eq?`, `eqv?`, `equal-always?`, `equal?`) determines the one for the result.

Examples:

```
> (hash-intersect (make-immutable-hash '((a . 1) (b . 2) (c . 3)))
                  (make-immutable-hash '((a . 4) (b . 5)))
                  #:combine +)
'#hash((a . 5) (b . 7))
> (hash-intersect (make-immutable-hash '((a . 1) (b . 2) (c . 3)))
                  (make-immutable-hash '((a . 4) (b . 5)))
                  #:combine/key
                  (lambda (k v1 v2) (if (eq? k 'a) (+ v1 v2) (- v1 v2))))
'#hash((a . 5) (b . -3))
```

Added in version 7.9.0.1 of package base.

```
(hash-filter ht pred) → hash?
  ht : hash?
  pred : (-> any/c any/c boolean?)
```

Filters the `hash?` *ht* based on a predicate *pred* applied to both its keys and values. This function constructs a new hash table that includes only those key-value pairs from the input *ht* for which the predicate *pred* returns true when applied simultaneously to the keys and values of *ht*. The output hash table retains the mutability and the key comparison predicate (e.g., `eqv?`, `equal-always?`, `equal?`) of the input hash table *ht*, ensuring that the structural and operational properties of the original hash are preserved in the output.

Examples:

```
> (hash-filter (for/hash ([num '(1 2 3 4 5)]) (values num (* num 2)))
               (λ (k v) (and (< k 3) (even? v))))
'#hash((1 . 2) (2 . 4))
> (hash-filter (make-hash) (λ (k v) (< k 3)))
'#hash()
> (hash-filter (make-hasheq '([#f . "false"] [#t . "true"]))
               (λ (k v) (and (eq? k #t) (string=? v "true"))))
'#hasheq((#t . "true"))
> (hash-filter (hash (list 1 2) 'pair (vector 3 4) 'vector)
               (λ (k v) (and (list? k) (symbol? v))))
'#hash(((1 2) . pair))
> (hash-filter (hash "one" 1 2 "two" "three" 3)
               (λ (k v) (and (not (number? k)) (number? v) (> v 1))))
'#hash(("three" . 3))
```

Added in version 8.13.0.4 of package base.

```
(hash-filter-keys ht pred) → hash?
  ht : hash?
  pred : procedure?
```

Filters the hash? *ht* based on a predicate *pred* applied to its keys. This function constructs a new hash table that includes only those key-value pairs from the input *ht* for which the predicate *pred* returns true when applied to the keys. Similar to hash-filter-values, the output hash table maintains the mutability and key comparator of the input hash table, ensuring that the structural and operational properties of the original hash are retained.

Examples:

```
> (hash-filter-keys (for/hash ([num '(1 2 3 4 5)]) (values num 0)) (λ (k) (< k 3)))
'#hash((1 . 0) (2 . 0))
> (hash-filter-keys (make-hash) (λ (k) (< k 3)))
'#hash()
> (hash-filter-keys (make-hasheq '([#f . "false"] [#t .
"true"])) (λ (k) (eq? k #t)))
'#hasheq((#t . "true"))
> (hash-filter-keys (hash (list 1 2) 'pair (vector 3 4) 'vector) list?)
'#hash(((1 2) . pair))
> (hash-filter-keys (hash "one" 1 2 "two" "three" 3) (lambda (k) (number? k)))
'#hash((2 . "two"))
> (hash-filter-keys (hash 'apple "fruit" 'carrot "vegetable" "banana" "fruit")
                    (lambda (k) (symbol? k)))
'#hash((apple . "fruit") (carrot . "vegetable"))
```

Added in version 8.12.0.9 of package base.

```
(hash-filter-values ht pred) → hash?
  ht : hash?
  pred : procedure?
```

Filters the hash? *ht* based on a predicate *pred* applied to its values. This function returns a new hash table containing only the key-value pairs for which the predicate *pred* returns true when applied to the values of *ht*. The resulting hash table retains the mutability and the key comparison predicate (e.g., eq?, eqv?, equal-always?, equal?) of the input hash table *ht*.

Examples:

```
> (hash-filter-values (for/hash ([num '(1 2 3 4 5)]) (values num num)) (λ (v) (< v 3)))
'#hash((1 . 1) (2 . 2))
> (hash-filter-values (make-hash) (λ (v) (< v 3)))
'#hash()
> (hash-filter-values (make-hasheqv '([1 . "one"] [2 .
"two"])) (λ (v) (eqv? v "two")))
'#hasheqv((2 . "two"))
> (hash-filter-values (hash 'one "1" 'two 2 'three "3") (lambda (v) (string? v)))
'#hash((one . "1") (three . "3"))
```

```
> (hash-filter-values (hash 'list (list 1 2 3) 'vector #(4 5 6) 'string "hello")
                      (lambda (v) (vector? v)))
'#hash((vector . #(4 5 6)))
> (hash-filter-values (hash 'nested-hash (hash 'a 1 'b 2) 'nested-
list (list 'x 'y 'z))
                      (lambda (v) (hash? v)))
'#hash((nested-hash . #hash((a . 1) (b . 2))))
```

Added in version 8.12.0.9 of package `base`.

4.16 Treelists

A *treelist* represents a sequence of elements in a way that supports many operations in $O(log\ N)$ time: accessing an element of the list by index, adding to the front of the list, adding to the end of the list, removing an element by index, replacing an element by index, appending lists, dropping elements from the start or end of the list, and extracting a sublist. More generally, unless otherwise specified, operations on a treelist of length N take $O(log\ N)$ time. The base for the *log* in $O(log\ N)$ is large enough that it's effectively constant-time for many purposes. Treelists are currently implemented as RRB trees [Stucki15].

Treelists are primarily intended to be used in immutable form via `racket/treelist`, where an operation such as adding to the treelist produces a new treelist while the old one remains intact. A mutable variant of treelists is provided by `racket/mutable-treelist`, where a mutable treelist can be a convenient alternative to putting an immutable treelist into a box. Mutable treelist operations take the same time as immutable treelist operations, unless otherwise specified. Where the term "treelist" is used by itself, it refers to an immutable treelist.

An immutable or mutable treelist can be used as a single-valued sequence (see §4.17.1 "Sequences"). The elements of the list serve as elements of the sequence. See also `in-treelist` and `in-mutable-treelist`. An immutable treelist can also be used as a stream.

Changed in version 8.15.0.3 of package `base`: Made treelists serializable.

4.16.1 Immutable Treelists

```
(require racket/treelist)        package: base
```

The bindings documented in this section are provided by the `racket/treelist` library, not `racket/base` or `racket`.

Added in version 8.12.0.7 of package `base`.

```
(treelist? v) → boolean?
```

```
v : any/c
```

Returns #t if *v* is a treelist, #f otherwise.

```
(treelist v ...) → treelist?
  v : any/c
```

Returns a treelist with *v*s as its elements in order.

This operation takes *O*(*N log N*) time to construct a treelist of *N* elements.

Example:

```
> (treelist 1 "a" 'apple)
(treelist 1 "a" 'apple)
```

```
(make-treelist size v) → treelist?
  size : exact-nonnegative-integer?
  v : any/c
```

Returns a treelist with size *size*, where every element is *v*. This operation takes *O*(*log N*) time to construct a treelist of *N* elements.

Examples:

```
> (make-treelist 0 'pear)
(treelist)
> (make-treelist 3 'pear)
(treelist 'pear 'pear 'pear)
```

Added in version 8.12.0.11 of package base.

```
(treelist-empty? tl) → boolean?
  tl : treelist?
empty-treelist : (and/c treelist? treelist-empty?)
```

A predicate and constant for a treelist of length 0.

Although every empty treelist is equal? to empty-treelist, since a treelist can be chaperoned via chaperone-treelist, not every empty treelist is eq? to empty-treelist.

```
(treelist-length tl) → exact-nonnegative-integer?
  tl : treelist?
```

Returns the number of elements in *tl*. This operation takes $O(1)$ time.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-length items)
3
```

```
(treelist-ref tl pos) → any/c
  tl : treelist?
  pos : exact-nonnegative-integer?
```

Returns the *pos*th element of *tl*. The first element is position `0`, and the last position is one less than `(treelist-length tl)`.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-ref items 0)
1
> (treelist-ref items 2)
'apple
> (treelist-ref items 3)
treelist-ref: index is out of range
  index: 3
  valid range: [0, 2]
  treelist: (treelist 1 "a" 'apple)
```

```
(treelist-first tl) → any/c
  tl : treelist?
(treelist-last tl) → any/c
  tl : treelist?
```

Shorthands for using `treelist-ref` to access the first or last element of a treelist.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-first items)
1
> (treelist-last items)
'apple
```

```
(treelist-insert tl pos v) → treelist?
  tl : treelist?
  pos : exact-nonnegative-integer?
  v : any/c
```

Produces a treelist like *tl*, except that *v* is inserted as an element before the element at *pos*. If *pos* is `(treelist-length tl)`, then *v* is added to the end of the treelist.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-insert items 1 "alpha")
(treelist 1 "alpha" "a" 'apple)
> (treelist-insert items 3 "alpha")
(treelist 1 "a" 'apple "alpha")
```

```
(treelist-add tl v) → treelist?
  tl : treelist?
  v : any/c
(treelist-cons tl v) → treelist?
  tl : treelist?
  v : any/c
```

Shorthands for using `treelist-insert` to insert at the end or beginning of a treelist.

Although the main operation to extend a pair list is `cons` to add to the front, treelists are intended to be extended by adding to the end with `treelist-add`, and `treelist-add` tends to be faster than `treelist-cons`.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-add items "alpha")
(treelist 1 "a" 'apple "alpha")
> (treelist-cons items "alpha")
(treelist "alpha" 1 "a" 'apple)
```

```
(treelist-delete tl pos) → treelist?
  tl : treelist?
  pos : exact-nonnegative-integer?
```

Produces a treelist like *tl*, except that the element at *pos* is removed.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-delete items 1)
(treelist 1 'apple)
> (treelist-delete items 3)
treelist-delete: index is out of range
```

index: 3
valid range: [0, 2]
treelist: (treelist 1 "a" 'apple)

```
(treelist-set tl pos v) → treelist?
  tl : treelist?
  pos : exact-nonnegative-integer?
  v : any/c
```

Produces a treelist like `tl`, except that the element at `pos` is replaced with `v`. The result is equivalent to `(treelist-insert (treelist-delete tl pos) pos v)`.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-set items 1 "b")
(treelist 1 "b" 'apple)
```

```
(treelist-append tl ...) → treelist?
  tl : treelist?
```

Appends the elements of the given `tl`s into a single treelist. If *M* treelists are given and the resulting treelist's length is *N*, then appending takes *O*(*M log N*) time.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-append items items)
(treelist 1 "a" 'apple 1 "a" 'apple)
> (treelist-append items (treelist "middle") items)
(treelist 1 "a" 'apple "middle" 1 "a" 'apple)
```

```
(treelist-take tl n) → treelist?
  tl : treelist?
  n : exact-nonnegative-integer?
(treelist-drop tl n) → treelist?
  tl : treelist?
  n : exact-nonnegative-integer?
(treelist-take-right tl n) → treelist?
  tl : treelist?
  n : exact-nonnegative-integer?
(treelist-drop-right tl n) → treelist?
  tl : treelist?
  n : exact-nonnegative-integer?
```

Produces a treelist like *tl* but with only the first *n* elements, without the first *n* elements, with only the last *n* elements, or without the last *n* elements, respectively.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-take items 2)
(treelist 1 "a")
> (treelist-drop items 2)
(treelist 'apple)
> (treelist-take-right items 2)
(treelist "a" 'apple)
> (treelist-drop-right items 2)
(treelist 1)
```

```
(treelist-sublist tl n m) → treelist?
  tl : treelist?
  n : exact-nonnegative-integer?
  m : exact-nonnegative-integer?
```

Produces a treelist like *tl* but with only elements at position *n* (inclusive) through position *m* (exclusive).

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-sublist items 1 3)
(treelist "a" 'apple)
```

```
(treelist-reverse tl) → treelist?
  tl : treelist?
```

Produces a treelist like *tl* but with its elements reversed, equivalent to using `treelist-take` to keep `0` elements (but also any chaperone on the treelist) and then adding each element back in reverse order. Reversing takes $O(N \log N)$ time.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-reverse items)
(treelist 'apple "a" 1)
```

```
(treelist-rest tl) → treelist?
  tl : treelist?
```

A shorthand for using `treelist-drop` to drop the first element of a treelist.

The `treelist-rest` operation is efficient, but not as fast as `rest` or `cdr`. For iterating through a treelist, consider using `treelist-ref` or a `for` form with `in-treelist`, instead.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-rest items)
(treelist "a" 'apple)
```

```
(treelist->vector tl) → vector?
  tl : treelist?
(treelist->list tl) → list?
  tl : treelist?
(vector->treelist vec) → treelist?
  vec : vector?
(list->treelist lst) → treelist?
  lst : list?
```

Convenience functions for converting between treelists, lists, and vectors. Each conversion takes $O(N)$ time.

Examples:

```
> (define items (list->treelist '(1 "a" 'apple)))
> (treelist->vector items)
'#(1 "a" 'apple)
```

```
(treelist-map tl proc) → treelist?
  tl : treelist?
  proc : (any/c . -> . any/c)
```

Produces a treelist by applying *proc* to each element of *tl* and gathering the results into a new treelist. For a constant-time *proc*, this operation takes $O(N)$ time.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-map items box)
(treelist '#&1 '#&"a" '#&apple)
```

```
(treelist-for-each tl proc) → void?
  tl : treelist?
  proc : (any/c . -> . any)
```

Applies *proc* to each element of *tl*, ignoring the results. For a constant-time *proc*, this operation takes $O(N)$ time.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-for-each items println)
1
"a"
'apple
```

```
(treelist-filter keep tl) → treelist?
  keep : (any/c . -> . any/c)
  tl : treelist?
```

Produces a treelist with only members of *tl* that satisfy *keep*.

Examples:

```
> (treelist-filter even? (treelist 1 2 3 2 4 5 2))
(treelist 2 2 4 2)
> (treelist-filter odd? (treelist 1 2 3 2 4 5 2))
(treelist 1 3 5)
> (treelist-filter (λ (x) (not (even? x))) (treelist 1 2 3 2 4 5 2))
(treelist 1 3 5)
> (treelist-filter (λ (x) (not (odd? x))) (treelist 1 2 3 2 4 5 2))
(treelist 2 2 4 2)
```

Added in version 8.15.0.6 of package `base`.

```
(treelist-member? tl v [eql?]) → boolean?
  tl : treelist?
  v : any/c
  eql? : (any/c any/c . -> . any/c) = equal?
```

Checks each element of *tl* with *eql?* and *v* (with *v* the second argument) until the result is a true value, and then returns `#t`. If no such element is found, the result is `#f`. For a constant-time *eql?*, this operation takes $O(N)$ time.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-member? items "a")
#t
> (treelist-member? items 1.0 =)
```

```
#t
> (treelist-member? items 2.0 =)
=: contract violation
  expected: number?
  given: "a"
```

```
(treelist-find tl pred) → any/c
  tl : treelist?
  pred : (any/c . -> . any/c)
```

Checks each element of `tl` with `pred` until the result is a true value, and then returns that element. If no such element is found, the result is `#f`. For a constant-time `pred`, this operation takes $O(N)$ time.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-find items string?)
"a"
> (treelist-find items symbol?)
'apple
> (treelist-find items number->string)
1
```

```
(treelist-index-of tl v [eql?])
 → (or/c exact-nonnegative-integer? #f)
  tl : treelist?
  v : any/c
  eql? : (any/c any/c . -> . any/c) = equal?
```

Returns the index of the first element in `tl` that is `eql?` to `v`. If no such element is found, the result is `#f`.

Examples:

```
> (define items (treelist 1 "a" 'apple))
> (treelist-index-of items 1)
0
> (treelist-index-of items "a")
1
> (treelist-index-of items 'apple)
2
> (treelist-index-of items 'unicorn)
#f
```

Added in version 8.15.0.6 of package `base`.

```
(treelist-flatten v) → treelist?
  v : any/c
```

Flattens a tree of nested treelists into a single treelist.

Examples:

```
> (treelist-flatten
   (treelist (treelist "a") "b" (treelist "c" (treelist "d") "e") (treelist)))
(treelist "a" "b" "c" "d" "e")
> (treelist-flatten "a")
(treelist "a")
```

Added in version 8.15.0.6 of package `base`.

```
(treelist-append* tlotl) → treelist?
  tlotl : (treelist/c treelist?)
```

Appends elements of a treelist of treelists together into one treelist, leaving any further nested treelists alone.

Example:

```
> (treelist-append*
   (treelist (treelist "a" "b") (treelist "c" (treelist "d") "e") (treelist)))
(treelist "a" "b" "c" (treelist "d") "e")
```

Added in version 8.15.0.6 of package `base`.

```
(treelist-sort  tl
                less-than?
               [#:key key
                #:cache-keys? cache-keys?]) → treelist?
  tl : treelist?
  less-than? : (any/c any/c . -> . any/c)
  key : (or/c #f (any/c . -> . any/c)) = #f
  cache-keys? : boolean? = #f
```

Like `sort`, but operates on a treelist to produce a sorted treelist. Sorting takes $O(N \log N)$ time.

Examples:

```
> (define items (treelist "x" "a" "q"))
> (treelist-sort items string<?)
(treelist "a" "q" "x")
```

```
(in-treelist tl) → sequence?
  tl : treelist?
```

Returns a sequence equivalent to `tl`.

An `in-treelist` application can provide better performance for treelist iteration when it appears directly in a `for` clause.

Examples:

```
> (define items (treelist "x" "a" "q"))
> (for/list ([e (in-treelist items)])
    (string-append e "!"))
'("x!" "a!" "q!")
```

```
(sequence->treelist s) → treelist?
  s : sequence?
```

Returns a treelist whose elements are the elements of `s`, each of which must be a single value. If `s` is infinite, this function does not terminate.

Examples:

```
> (sequence->treelist (list 1 "a" 'apple))
(treelist 1 "a" 'apple)
> (sequence->treelist (vector 1 "a" 'apple))
(treelist 1 "a" 'apple)
> (sequence->treelist (stream 1 "a" 'apple))
(treelist 1 "a" 'apple)
> (sequence->treelist (open-input-bytes (bytes 1 2 3 4 5)))
(treelist 1 2 3 4 5)
> (sequence->treelist (in-range 0 10))
(treelist 0 1 2 3 4 5 6 7 8 9)
```

Added in version 8.15.0.6 of package `base`.

```
(for/treelist (for-clause ...) body-or-break ... body)
(for*/treelist (for-clause ...) body-or-break ... body)
```

Like `for/list` and `for*/list`, but generating treelists.

Example:

```
> (for/treelist ([i (in-range 10)])
    i)
(treelist 0 1 2 3 4 5 6 7 8 9)
```

```
(chaperone-treelist  tl
                     #:state state
                    [#:state-key state-key]
                     #:ref ref-proc
                     #:set set-proc
                     #:insert insert-proc
                     #:delete delete-proc
                     #:take take-proc
                     #:drop drop-proc
                     #:append append-proc
                     #:prepend prepend-proc
                    [#:append2 append2-proc]
                     prop
                     prop-val ...
                     ...)
 → (and/c treelist? chaperone?)
  tl : treelist?
  state : any/c
  state-key : any/c = (list 'fresh)
  ref-proc : (treelist? exact-nonnegative-integer? any/c any/c
             . -> . any/c)
  set-proc : (treelist? exact-nonnegative-integer? any/c any/c
             . -> . (values any/c any/c))
  insert-proc : (treelist? exact-nonnegative-integer? any/c any/c
                . -> . (values any/c any/c))
  delete-proc : (treelist? exact-nonnegative-integer? any/c
                . -> . any/c)
  take-proc : (treelist? exact-nonnegative-integer? any/c
              . -> . any/c)
  drop-proc : (treelist? exact-nonnegative-integer? any/c
              . -> . any/c)
  append-proc : (treelist? treelist? any/c
                . -> . (values treelist? any/c))
  prepend-proc : (treelist? treelist? any/c
                 . -> . (values treelist? any/c))
  append2-proc :  (or/c #f (treelist? treelist? any/c any/c
                           . -> . (values treelist? any/c any/c)))
               = #f
  prop : impersonator-property?
  prop-val : any/c
```

Analogous to `chaperone-vector`, returns a chaperone of *tl*, which redirects the `treelist-ref`, `treelist-set`, `treelist-insert`, `treelist-append`, `treelist-delete`, `treelist-take`, and `treelist-drop` operations, as well as operations derived from those. The *`state`* argument is an initial state, where a state value is passed to each procedure that redirects an operation, and except for *`ref-proc`* (which corresponds to the one operation that does not update a treelist), a new state is returned to be associated with the updated treelist. When *`state-key`* is provided, it can be used with `treelist-chaperone-state` to extract the state from the original treelist or an updated treelist.

The *`ref-proc`* procedure must accept *`tl`*, an index passed to `treelist-ref`, the value that `treelist-ref` on *`tl`* produces for the given index, and the current chaperone state; it must produce a chaperone replacement for the value, which is the result of `treelist-ref` on the chaperone.

The *`set-proc`* procedure must accept *`tl`*, an index passed to `treelist-set`, the value provided to `treelist-set`, and the current chaperone state; it must produce two values: a chaperone replacement for the value, which is used in the result of `treelist-set` on the chaperone, and an updated state. The result of `treelist-set` is chaperoned with the same procedures and properties as *`tl`*, but with the updated state.

The *`insert-proc`* procedure is like *`set-proc`*, but for inserting via `treelist-insert`.

The *`delete-proc`*, *`take-proc`*, and *`drop-proc`* procedures must accept *`tl`*, the index or count for deleting, taking or dropping, and the current chaperone state; they must produce an updated state. The result of `treelist-delete`, `treelist-take`, or `treelist-drop` is chaperoned with the same procedures and properties as *`tl`*, but with the updated state.

The *`append-proc`* procedure must accept *`tl`*, a treelist to append onto *`tl`*, and the current chaperone state; it must produce a chaperone replacement for the second treelist, which is appended for the result of `treelist-append` on the chaperone, and an updated state. The result of `treelist-append` is chaperoned with the same procedures and properties as *`tl`*, but with the updated state.

The *`prepend-proc`* procedure must accept a treelist being append with *`tl`*, *`tl`*, and the current chaperone state; it must produce a chaperone replacement for the first treelist, which is prepended for the result of `treelist-append` on the chaperone, and an updated state. The result of `treelist-append` is chaperoned with the same procedures and properties as *`tl`*, but with the updated state.

The *`append2-proc`* procedure is optional and similar to *`append-proc`*, but when it is non-`#f`, *`append2-proc`* is used instead of *`append-proc`* when a second argument to `treelist-append` is chaperoned with the same *`state-key`*. In that case, the second argument to *`append2-proc`* is the second argument with a *`state-key`* chaperone wrapper removed, and with that chaperone's state as the last argument to *`append2-proc`*.

When two chaperoned treelists are given to `treelist-append` and *`append2-proc`* is not used, then the *`append-proc`* of the first treelist is used, and the result of *`append-proc`* will still be a chaperone whose *`prepend-proc`* is used. If the result of *`prepend-proc`* is a chaperone, then that chaperone's *append-proc* is used, and so on. If *prepend-proc* and *append-proc* keep returning chaperones, it is possible that no progress will be made.

Example:

```
> (chaperone-treelist
   (treelist 1 "a" 'apple)
   #:state 'ignored-state
   #:ref (λ (tl pos v state)
           v)
   #:set (λ (tl pos v state)
           (values v state))
   #:insert (λ (tl pos v state)
              (values v state))
   #:delete (λ (tl pos state)
              state)
   #:take (λ (tl pos state)
            state)
   #:drop (λ (tl pos state)
            state)
   #:append2 (λ (tl other state other-state) ; or #f
               (values other state))
   #:append (λ (tl other state)
              (values other state))
   #:prepend (λ (other tl state)
               (values other state)))
(treelist 1 "a" 'apple)
```

```
(treelist-chaperone-state tl
                          state-key
                         [fail-k])  → any/c
  tl : treelist?
  state-key : any/c
  fail-k : (procedure-arity-includes/c 0) = key-error
```

Extracts state associated with a treelist chaperone where *state-key* (compared using `eq?`) was provided along with the initial state to `chaperone-treelist`. If *tl* is not a chaperone with state keyed by *state-key*, then *fail-k* is called, and the default *fail-k* raises `exn:fail:contract`.

4.16.2 Mutable Treelists

```
(require racket/mutable-treelist)      package: base
```

The bindings documented in this section are provided by the `racket/mutable-treelist` library, not `racket/base` or `racket`.

A *mutable treelist* is like an immutable treelist in a box, where operations that change the mutable treelist replace the treelist in the box. As a special case, `mutable-treelist-set!` on an unimpersonated mutable treelist modifies the treelist representation within the boxed value. This model of a mutable treelist explains its behavior in the case of concurrent modification: concurrent `mutable-treelist-set!` operations for different positions will not interefere, but races with other operations or on impersonated mutable treelists will sometimes negate one of the modifications. Concurrent modification is thus somewhat unpredictable but still safe, and it is not managed by a lock.

A mutable treelist is not a treelist in the sense of `treelist?`, which recognizes only immutable treelists. Operations on a mutable treelist have the same time complexity as corresponding operations on an immutable treelist unless otherwise noted.

Added in version 8.12.0.7 of package `base`.

```
(mutable-treelist? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a mutable treelist, `#f` otherwise.

```
(mutable-treelist v ...) → mutable-treelist?
  v : any/c
```

Returns a mutable treelist with *v*s as its elements in order.

Example:

```
> (mutable-treelist 1 "a" 'apple)
(mutable-treelist 1 "a" 'apple)
```

```
(make-mutable-treelist n [v]) → mutable-treelist?
  n : exact-nonnegative-integer?
  v : any/c = #f
```

Creates a mutable treelist that contains *n* elements, each initialized as *v*. Creating the mutable treelist takes $O(N)$ time for N elements.

Example:

```
> (make-mutable-treelist 3 "a")
(mutable-treelist "a" "a" "a")
```

```
(treelist-copy tl) → mutable-treelist?
  tl : treelist?
(mutable-treelist-copy tl) → mutable-treelist?
  tl : mutable-treelist?
```

Creates a mutable treelist that contains the same elements as `tl`. Creating the mutable treelist takes $O(N)$ time for N elements.

Examples:

```
> (treelist-copy (treelist 3 "a"))
(mutable-treelist 3 "a")
> (mutable-treelist-copy (mutable-treelist 3 "a"))
(mutable-treelist 3 "a")
```

```
(mutable-treelist-snapshot tl [n m]) → treelist?
  tl : mutable-treelist?
  n : exact-nonnegative-integer? = 0
  m : (or/c #f exact-nonnegative-integer?) = #f
```

Produces an immutable treelist that has the same elements as `tl` at position `n` (inclusive) through position `m` (exclusive). If `m` is `#f`, then the length of `tl` is used, instead. Creating the immutable treelist takes $O(N)$ time for N elements of the resulting treelist, on top of the cost of `treelist-sublist` if the result is a sublist.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (define snap (mutable-treelist-snapshot items))
> snap
(treelist 1 "a" 'apple)
> (mutable-treelist-snapshot items 1)
(treelist "a" 'apple)
> (mutable-treelist-snapshot items 1 2)
(treelist "a")
> (mutable-treelist-drop! items 2)
> items
(mutable-treelist 'apple)
> snap
(treelist 1 "a" 'apple)
```

```
(mutable-treelist-empty? tl) → boolean?
  tl : mutable-treelist?
```

Returns `#t` for mutable treelist that is currently of length 0, `#f` otherwise.

```
(mutable-treelist-length tl) → exact-nonnegative-integer?
  tl : mutable-treelist?
```

Returns the number of elements currently in `tl`.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-length items)
3
> (mutable-treelist-add! items 'extra)
> (mutable-treelist-length items)
4
```

```
(mutable-treelist-ref tl pos) → any/c
  tl : mutable-treelist?
  pos : exact-nonnegative-integer?
```

Returns the `pos`th element of `tl`. The first element is position `0`, and the last position is one less than `(mutable-treelist-length tl)`.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-ref items 0)
1
> (mutable-treelist-ref items 2)
'apple
> (mutable-treelist-ref items 3)
mutable-treelist-ref: index is out of range
  index: 3
  valid range: [0, 2]
  mutable treelist: (mutable-treelist 1 "a" 'apple)
```

```
(mutable-treelist-first tl) → any/c
  tl : mutable-treelist?
(mutable-treelist-last tl) → any/c
  tl : mutable-treelist?
```

Shorthands for using `mutable-treelist-ref` to access the first or last element of a treelist.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
```

```
> (mutable-treelist-first items)
1
> (mutable-treelist-last items)
'apple
```

```
(mutable-treelist-insert! tl pos v) → void?
  tl : mutable-treelist?
  pos : exact-nonnegative-integer?
  v : any/c
```

Modifies *tl* to insert *v* into the list before position *pos*. If *pos* is `(mutable-treelist-length tl)`, then *v* is added to the end of the treelist.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-insert! items 1 "alpha")
> items
(mutable-treelist 1 "alpha" "a" 'apple)
```

```
(mutable-treelist-cons! tl v) → void?
  tl : mutable-treelist?
  v : any/c
(mutable-treelist-add! tl v) → void?
  tl : mutable-treelist?
  v : any/c
```

Shorthands for using `mutable-treelist-insert!` to insert at the beginning or end of a treelist.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-cons! items "before")
> (mutable-treelist-add! items "after")
> items
(mutable-treelist "before" 1 "a" 'apple "after")
```

```
(mutable-treelist-delete! tl pos) → void?
  tl : mutable-treelist?
  pos : exact-nonnegative-integer?
```

Modifies *tl* to remove the element at *pos*.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-delete! items 1)
> items
(mutable-treelist 1 'apple)
```

```
(mutable-treelist-set! tl pos v) → void?
  tl : mutable-treelist?
  pos : exact-nonnegative-integer?
  v : any/c
```

Modifies `tl` to change the element at `pos` to `v`.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-set! items 1 "b")
> items
(mutable-treelist 1 "b" 'apple)
```

```
(mutable-treelist-append! tl other-tl) → void?
  tl : mutable-treelist?
  other-tl : (or/c treelist? mutable-treelist?)
(mutable-treelist-prepend! tl other-tl) → void?
  tl : mutable-treelist?
  other-tl : (or/c treelist? mutable-treelist?)
```

Modifies `tl` by appending or prepending all of the elements of `other-tl`. If `other-tl` is a mutable treelist, it is first converted to an immutable treelist with `mutable-treelist-snapshot`, which takes $O(N)$ time if `other-tl` has N elements. If `other-tl` is an immutable treelist but chaperoned, then appending or prepending takes $O(N)$ time for N elements.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-append! items (treelist 'more 'things))
> items
(mutable-treelist 1 "a" 'apple 'more 'things)
> (mutable-treelist-prepend! items (treelist 0 "b" 'banana))
> items
(mutable-treelist 0 "b" 'banana 1 "a" 'apple 'more 'things)
> (mutable-treelist-append! items items)
> items
(mutable-treelist
 0
```

```
  "b"
  'banana
  1
  "a"
  'apple
  'more
  'things
  0
  "b"
  'banana
  1
  "a"
  'apple
  'more
  'things)
```

Changed in version 8.15.0.11 of package `base`: Added `mutable-treelist-prepend!`.

```
(mutable-treelist-take! tl n) → void?
  tl : mutable-treelist?
  n : exact-nonnegative-integer?
(mutable-treelist-drop! tl n) → void?
  tl : mutable-treelist?
  n : exact-nonnegative-integer?
(mutable-treelist-take-right! tl n) → void?
  tl : mutable-treelist?
  n : exact-nonnegative-integer?
(mutable-treelist-drop-right! tl n) → void?
  tl : mutable-treelist?
  n : exact-nonnegative-integer?
```

Modifies *tl* to remove all but the first *n* elements, to remove the first *n* elements, to remove all but the last *n* elements, or to remove the last *n* elements, respectively.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-take! items 2)
> items
(mutable-treelist 1 "a")
> (mutable-treelist-drop-right! items 1)
> items
(mutable-treelist 1)
```

```
(mutable-treelist-sublist! tl n m) → void?
```

```
tl : mutable-treelist?
n : exact-nonnegative-integer?
m : exact-nonnegative-integer?
```

Modifies `tl` to remove elements other than elements at position `n` (inclusive) through position `m` (exclusive).

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple 'pie))
> (mutable-treelist-sublist! items 1 3)
> items
(mutable-treelist "a" 'apple)
```

```
(mutable-treelist-reverse! tl) → void?
  tl : mutable-treelist?
```

Modifies `tl` to reverse all of its elements.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple 'pie))
> (mutable-treelist-reverse! items)
> items
(mutable-treelist 'pie 'apple "a" 1)
```

```
(mutable-treelist->vector tl) → vector?
  tl : mutable-treelist?
(mutable-treelist->list tl) → list?
  tl : mutable-treelist?
(vector->mutable-treelist vec) → mutable-treelist?
  vec : vector?
(list->mutable-treelist lst) → mutable-treelist?
  lst : list?
```

Convenience functions for converting between mutable treelists, lists, and vectors. Each conversion takes $O(N)$ time.

Examples:

```
> (define items (list->mutable-treelist '(1 "a" 'apple)))
> (mutable-treelist->vector items)
'#(1 "a" 'apple)
```

```
(mutable-treelist-map! tl proc) → void?
  tl : mutable-treelist?
  proc : (any/c . -> . any/c)
```

Modifies *tl* by applying *proc* to each element of *tl* and installing the result in place of the element.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-map! items box)
> items
(mutable-treelist '#&1 '#&"a" '#&apple)
```

```
(mutable-treelist-for-each tl proc) → void?
  tl : mutable-treelist?
  proc : (any/c . -> . any)
```

Like `treelist-for-each`, but for a mutable treelist.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-for-each items println)
1
"a"
'apple
```

```
(mutable-treelist-member? tl v [eql?]) → boolean?
  tl : mutable-treelist?
  v : any/c
  eql? : (any/c any/c . -> . any/c) = equal?
```

Like `treelist-member?`, but for a mutable treelist.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-member? items "a")
#t
> (mutable-treelist-member? items 1.0 =)
#t
```

```
(mutable-treelist-find tl pred) → any/c
  tl : mutable-treelist?
  pred : (any/c . -> . any/c)
```

Like `treelist-find`, but for a mutable treelist.

Examples:

```
> (define items (mutable-treelist 1 "a" 'apple))
> (mutable-treelist-find items string?)
"a"
> (mutable-treelist-find items symbol?)
'apple
```

```
(mutable-treelist-sort! tl
                        less-than?
                       [#:key key
                        #:cache-keys? cache-keys?]) → void?
  tl : mutable-treelist?
  less-than? : (any/c any/c . -> . any/c)
  key : (or/c #f (any/c . -> . any/c)) = #f
  cache-keys? : boolean? = #f
```

Like `vector-sort!`, but operates on a mutable treelist.

Examples:

```
> (define items (mutable-treelist "x" "a" "q"))
> (mutable-treelist-sort! items string<?)
> items
(mutable-treelist "a" "q" "x")
```

```
(in-mutable-treelist tl) → sequence?
  tl : mutable-treelist?
```

Returns a sequence equivalent to *tl*.

An `in-mutable-treelist` application can provide better performance for mutable treelist iteration when it appears directly in a `for` clause.

Examples:

```
> (define items (mutable-treelist "x" "a" "q"))
```

```
> (for/list ([e (in-mutable-treelist items)])
    (string-append e "!"))
'("x!" "a!" "q!")
```

```
(for/mutable-treelist maybe-length (for-clause ...) body-or-
break ... body)
(for*/mutable-treelist maybe-length (for-clause ...) body-or-
break ... body)
```

Like `for/vector` and `for*/vector`, but generating mutable treelists.

Examples:

```
> (for/mutable-treelist ([i (in-range 10)]) i)
(mutable-treelist 0 1 2 3 4 5 6 7 8 9)
> (for/mutable-treelist #:length 15 ([i (in-range 10)]) i)
(mutable-treelist 0 1 2 3 4 5 6 7 8 9 0 0 0 0 0)
> (for/mutable-treelist #:length 15 #:fill 'a ([i (in-
range 10)]) i)
(mutable-treelist 0 1 2 3 4 5 6 7 8 9 'a 'a 'a 'a 'a)
```

```
(chaperone-mutable-treelist  tl
                             #:ref ref-proc
                             #:set set-proc
                             #:insert insert-proc
                             #:append append-proc
                            [#:prepend prepend-proc]
                             prop
                             prop-val ...
                             ...)
 → (and/c mutable-treelist? chaperone?)
  tl : mutable-treelist?
  ref-proc : (mutable-treelist? exact-nonnegative-integer? any/c
             . -> . any/c)
  set-proc : (mutable-treelist? exact-nonnegative-integer? any/c
             . -> . any/c)
  insert-proc : (mutable-treelist? exact-nonnegative-integer? any/c
                . -> . any/c)
  append-proc : (mutable-treelist? treelist?
                . -> . treelist?)
  prepend-proc :  (treelist? mutable-treelist?
                  . -> . treelist?)
               = (λ (o t) (append-proc t o))
  prop : impersonator-property?
  prop-val : any/c
```

Similar to chaperone-treelist, but for mutable treelists. For example, the given *set-proc* is used for mutable-treelist-set!, and the resulting value is installed into the mutable treelist instead of the one provided to *set-proc*. Mutable treelist chaperones do not have state separate from the treelist itself, and procedures like *set-proc* do not consume or return a state.

```
(impersonate-mutable-treelist  tl
                               #:ref ref-proc
                               #:set set-proc
                               #:insert insert-proc
                               #:append append-proc
                              [#:prepend prepend-proc]
                               prop
                               prop-val ...
                               ...)
 → (and/c mutable-treelist? impersonator?)
  tl : mutable-treelist?
  ref-proc : (mutable-treelist? exact-nonnegative-integer? any/c
             . -> . any/c)
  set-proc : (mutable-treelist? exact-nonnegative-integer? any/c
             . -> . any/c)
  insert-proc : (mutable-treelist? exact-nonnegative-integer? any/c
                . -> . any/c)
  append-proc : (mutable-treelist? treelist?
                . -> . treelist?)
  prepend-proc :  (treelist? mutable-treelist?
                  . -> . treelist?)
               = (λ (o t) (append-proc t o))
  prop : impersonator-property?
  prop-val : any/c
```

Like chaperone-mutable-treelist, but *ref-proc*, *set-proc*, *insert-proc*, and *append-proc* are not obligated to produce chaperones.

4.17 Sequences and Streams

Sequences and streams abstract over iteration of elements in a collection. Sequences allow iteration with for macros or with sequence operations such as sequence-map. Streams are functional sequences that can be used either in a generic way or a stream-specific way. Generators are closely related stateful objects that can be converted to a sequence and vice-versa.

4.17.1 Sequences

§11.1 "Sequence Constructors" in *The Racket Guide* introduces sequences.

A *sequence* encapsulates an ordered collection of values. The elements of a sequence can be extracted with one of the `for` syntactic forms, with the procedures returned by `sequence-generate`, or by converting the sequence into a stream.

The sequence datatype overlaps with many other datatypes. Among built-in datatypes, the sequence datatype includes the following:

- exact nonnegative integers (see below)
- strings (see §4.4 "Strings")
- byte strings (see §4.5 "Byte Strings")
- lists (see §4.10 "Pairs and Lists")
- mutable lists (see §4.11 "Mutable Pairs and Lists")
- vectors (see §4.12 "Vectors")
- flvectors (see §4.3.3.2 "Flonum Vectors")
- fxvectors (see §4.3.4.2 "Fixnum Vectors")
- hash tables (see §4.15 "Hash Tables")
- dictionaries (see §4.18 "Dictionaries")
- sets (see §4.19 "Sets")
- input ports (see §13.1 "Ports")
- streams (see §4.17.2 "Streams")

An exact number *k* that is a non-negative integer acts as a sequence similar to `(in-range k)`, except that *k* by itself is not a stream.

Custom sequences can be defined using structure type properties. The easiest method to define a custom sequence is to use the `gen:stream` generic interface. Streams are a suitable abstraction for data structures that are directly iterable. For example, a list is directly iterable with `first` and `rest`. On the other hand, vectors are not directly iterable: iteration has to go through an index. For data structures that are not directly iterable, the *iterator* for the data structure can be defined to be a stream (e.g., a structure containing the index of a vector).

For example, unrolled linked lists (represented as a list of vectors) themselves do not fit the stream abstraction, but have index-based iterators that can be represented as streams:

Examples:

```
> (struct unrolled-list-iterator (idx lst)
    #:methods gen:stream
    [(define (stream-empty? iter)
       (define lst (unrolled-list-iterator-lst iter))
       (or (null? lst)
           (and (>= (unrolled-list-iterator-idx iter)
                    (vector-length (first lst)))
                (null? (rest lst)))))
     (define (stream-first iter)
       (vector-ref (first (unrolled-list-iterator-lst iter))
                   (unrolled-list-iterator-idx iter)))
     (define (stream-rest iter)
       (define idx (unrolled-list-iterator-idx iter))
       (define lst (unrolled-list-iterator-lst iter))
       (if (>= idx (sub1 (vector-length (first lst))))
           (unrolled-list-iterator 0 (rest lst))
           (unrolled-list-iterator (add1 idx) lst)))])
> (define (make-unrolled-list-iterator ul)
    (unrolled-list-iterator 0 (unrolled-list-lov ul)))
> (struct unrolled-list (lov)
    #:property prop:sequence
    make-unrolled-list-iterator)
> (define ul1 (unrolled-list '(#(cracker biscuit) #(cookie scone))))
> (for/list ([x ul1]) x)
'(cracker biscuit cookie scone)
```

The prop:sequence property provides more flexibility in specifying iteration, such as when a pre-processing step is needed to prepare the data for iteration. The make-do-sequence function creates a sequence given a thunk that returns procedures to implement a sequence, and the prop:sequence property can be associated with a structure type to implement its implicit conversion to a sequence.

For most sequence types, extracting elements from a sequence has no side-effect on the original sequence value; for example, extracting the sequence of elements from a list does not change the list. For other sequence types, each extraction implies a side effect; for example, extracting the sequence of bytes from a port causes the bytes to be read from the port. A sequence's state may either span all uses of the sequence, as for a port, or it may be confined to each distinct time that a sequence is *initiated* by a for form, sequence->stream, sequence-generate, or sequence-generate*. Concretely, the thunk passed to make-do-sequence is called to initiate the sequence each time the sequence is used. Accordingly, different sequences behave differently when they are initiated multiple times.

```
> (define (double-initiate s1)
    ; initiate the sequence twice
    (define-values (more?.1 next.1) (sequence-generate s1))
    (define-values (more?.2 next.2) (sequence-generate s1))
```

```
     ; alternate fetching from sequence via the two initiations
     (list (next.1) (next.2) (next.1) (next.2)))
> (double-initiate (open-input-string "abcdef"))
'(97 98 99 100)
> (double-initiate (list 97 98 99 100))
'(97 97 98 98)
> (double-initiate (in-naturals 97))
'(97 97 98 98)
```

Also, subsequent elements in a sequence may be "consumed" just by calling the first result of `sequence-generate`, even if the second result is never called.

```
> (define (double-initiate-and-use-more? s1)
     ; initiate the sequence twice
     (define-values (more?.1 next.1) (sequence-generate s1))
     (define-values (more?.2 next.2) (sequence-generate s1))
     ; alternate fetching from sequence via the two initiations
     ; but this time call `more?` in between
     (list (next.1) (more?.1) (next.2) (more?.2)
           (next.1) (more?.1) (next.2) (more?.2)))
> (double-initiate-and-use-more? (open-input-string "abcdef"))
'(97 #t 99 #t 98 #t 100 #t)
```

In this example, the state embedded in the first call to `sequence-generate` "takes" the `98` just by virtue of the invocation of *more?.1*.

Individual elements of a sequence typically correspond to single values, but an element may also correspond to multiple values. For example, a hash table generates two values—a key and its value—for each element in the sequence.

Sequence Predicate and Constructors

```
(sequence? v) → boolean?
  v : any/c
```

Returns `#t` if *v* can be used as a sequence, `#f` otherwise.

Examples:

```
> (sequence? 42)
#t
> (sequence? '(a b c))
#t
> (sequence? "word")
#t
> (sequence? #\x)
#f
```

```
(in-range end) → stream?
  end : real?
(in-range start end [step]) → stream?
  start : real?
  end : real?
  step : real? = 1
```

Returns a sequence (that is also a stream) whose elements are numbers. The single-argument case `(in-range end)` is equivalent to `(in-range 0 end 1)`. The first number in the sequence is *start*, and each successive element is generated by adding *step* to the previous element. The sequence stops before an element that would be greater or equal to *end* if *step* is non-negative, or less or equal to *end* if *step* is negative.

An `in-range` application can provide better performance for number iteration when it appears directly in a `for` clause.

Example: gaussian sum

```
> (for/sum ([x (in-range 10)]) x)
45
```

Example: sum of even numbers

```
> (for/sum ([x (in-range 0 100 2)]) x)
2450
```

When given zero as *step*, `in-range` returns an infinite sequence. It may also return infinite sequences when *step* is a very small number, and either *step* or the sequence elements are floating-point numbers.

```
(in-inclusive-range start end [step]) → stream?
  start : real?
  end : real?
  step : real? = 1
```

Similar to `in-range`, but the sequence stopping condition is changed so that the last element is allowed to be equal to *end*.

An `in-inclusive-range` application can provide better performance for number iteration when it appears directly in a `for` clause.

Examples:

```
> (sequence->list (in-inclusive-range 7 11))
```

```
'(7 8 9 10 11)
> (sequence->list (in-inclusive-range 7 11 2))
'(7 9 11)
> (sequence->list (in-inclusive-range 7 10 2))
'(7 9)
```

Added in version 8.0.0.13 of package `base`.

```
(in-naturals [start]) → stream?
  start : exact-nonnegative-integer? = 0
```

Returns an infinite sequence (that is also a stream) of exact integers starting with *start*, where each element is one more than the preceding element.

An `in-naturals` application can provide better performance for integer iteration when it appears directly in a `for` clause.

Example:

```
> (for/list ([k (in-naturals)]
             [x (in-range 10)])
    (list k x))
'((0 0) (1 1) (2 2) (3 3) (4 4) (5 5) (6 6) (7 7) (8 8) (9 9))
```

```
(in-list lst) → stream?
  lst : list?
```

Returns a sequence (that is also a stream) that is equivalent to using *lst* directly as a sequence.

See §4.10 "Pairs and Lists" for information on using lists as sequences.

An `in-list` application can provide better performance for list iteration when it appears directly in a `for` clause.

See `for` for information on the reachability of list elements during an iteration.

Example:

```
> (for/list ([x (in-list '(3 1 4))])
    `(,x ,(* x x)))
'((3 9) (1 1) (4 16))
```

Changed in version 6.7.0.4 of package `base`: Improved element-reachability guarantee for lists in `for`.

```
(in-mlist mlst) → sequence?
  mlst : mlist?
```

Returns a sequence equivalent to *mlst*. Although the expectation is that *mlst* is mutable list, `in-mlist` initially checks only whether *mlst* is a mutable pair or `null`, since it could change during iteration.

See §4.11 "Mutable Pairs and Lists" for information on using mutable lists as sequences.

An `in-mlist` application can provide better performance for mutable list iteration when it appears directly in a `for` clause.

Example:

```
> (for/list ([x (in-mlist (mcons "RACKET" (mcons "LANG" '())))])
    (string-length x))
'(6 4)
```

```
(in-vector vec [start stop step]) → sequence?
  vec : vector?
  start : exact-nonnegative-integer? = 0
  stop : (or/c exact-integer? #f) = #f
  step : (and/c exact-integer? (not/c zero?)) = 1
```

Returns a sequence equivalent to *vec* when no optional arguments are supplied.

See §4.12 "Vectors" for information on using vectors as sequences.

The optional arguments *start*, *stop*, and *step* are analogous to `in-range`, except that a `#f` value for *stop* is equivalent to `(vector-length vec)`. That is, the first element in the sequence is `(vector-ref vec start)`, and each successive element is generated by adding *step* to index of the previous element. The sequence stops before an index that would be greater or equal to `end` if *step* is non-negative, or less or equal to `end` if *step* is negative.

If *start* is not a valid index, then the `exn:fail:contract` exception is raised, except when *start*, *stop*, and `(vector-length vec)` are equal, in which case the result is an empty sequence.

Examples:

```
> (for ([x (in-vector (vector 1) 1)]) x)
> (for ([x (in-vector (vector 1) 2)]) x)
in-vector: starting index is out of range
  starting index: 2
  valid range: [0, 0]
  vector: '#(1)
> (for ([x (in-vector (vector) 0 0)]) x)
> (for ([x (in-vector (vector 1) 1 1)]) x)
```

If *stop* is not in [-1, `(vector-length vec)`], then the `exn:fail:contract` exception is raised.

If *start* is less than *stop* and *step* is negative, then the `exn:fail:contract` exception is raised. Similarly, if *start* is more than *stop* and *step* is positive, then the `exn:fail:contract` exception is raised.

An `in-vector` application can provide better performance for vector iteration when it appears directly in a `for` clause.

Examples:

```
> (define (histogram vector-of-words)
    (define a-hash (make-hash))
    (for ([word (in-vector vector-of-words)])
      (hash-set! a-hash word (add1 (hash-ref a-hash word 0))))
    a-hash)
> (histogram #("hello" "world" "hello" "sunshine"))
'#hash(("hello" . 2) ("sunshine" . 1) ("world" . 1))
```

```
(in-string str [start stop step]) → sequence?
  str : string?
  start : exact-nonnegative-integer? = 0
  stop : (or/c exact-integer? #f) = #f
  step : (and/c exact-integer? (not/c zero?)) = 1
```

Returns a sequence equivalent to *str* when no optional arguments are supplied.

See §4.4 "Strings" for information on using strings as sequences.

The optional arguments *start*, *stop*, and *step* are as in `in-vector`.

An `in-string` application can provide better performance for string iteration when it appears directly in a `for` clause.

Examples:

```
> (define (line-count str)
    (for/sum ([ch (in-string str)])
      (if (char=? #\newline ch) 1 0)))
> (line-count "this string\nhas\nthree \nnewlines")
3
```

```
(in-bytes bstr [start stop step]) → sequence?
  bstr : bytes?
  start : exact-nonnegative-integer? = 0
  stop : (or/c exact-integer? #f) = #f
  step : (and/c exact-integer? (not/c zero?)) = 1
```

Returns a sequence equivalent to *bstr* when no optional arguments are supplied.

See §4.5 "Byte Strings" for information on using byte strings as sequences.

The optional arguments *start*, *stop*, and *step* are as in `in-vector`.

An `in-bytes` application can provide better performance for byte string iteration when it appears directly in a `for` clause.

Examples:

```
> (define (has-eof? bs)
    (for/or ([ch (in-bytes bs)])
      (= ch 0)))
> (has-eof? #"this byte string has an \0embedded zero byte")
#t
> (has-eof? #"this byte string does not")
#f
```

```
(in-port [r in]) → sequence?
  r : (input-port? . -> . any/c) = read
  in : input-port? = (current-input-port)
```

Returns a sequence whose elements are produced by calling *r* on *in* until it produces `eof`.

```
(in-input-port-bytes in) → sequence?
  in : input-port?
```

Returns a sequence equivalent to `(in-port read-byte in)`.

```
(in-input-port-chars in) → sequence?
  in : input-port?
```

Returns a sequence whose elements are read as characters from *in* (equivalent to `(in-port read-char in)`).

```
(in-lines [in mode]) → sequence?
  in : input-port? = (current-input-port)
  mode : (or/c 'linefeed 'return 'return-linefeed 'any 'any-one)
       = 'any
```

Returns a sequence equivalent to `(in-port (lambda (p) (read-line p mode)) in)`. Note that the default mode is `'any`, whereas the default mode of `read-line` is `'linefeed`.

```
(in-bytes-lines [in mode]) → sequence?
  in : input-port? = (current-input-port)
  mode : (or/c 'linefeed 'return 'return-linefeed 'any 'any-one)
       = 'any
```

Returns a sequence equivalent to `(in-port (lambda (p) (read-bytes-line p mode)) in)`. Note that the default mode is `'any`, whereas the default mode of `read-bytes-line` is `'linefeed`.

```
(in-hash hash) → sequence?
  hash : hash?
(in-hash hash bad-index-v) → sequence?
  hash : hash?
  bad-index-v : any/c
```

Returns a sequence equivalent to *hash*, except when *bad-index-v* is supplied.

Like `hash-map`, iteration via `in-hash` can adapt to certain modifications to a mutable hash table while a traversal is in progress. Keys removes or remapped by the traversing thread have no immediate adverse affects; the change does not affect a traversal if the key has been seen already, otherwise the traversal skips a deleted key or uses the remapped key's new value.

Other concurrent modifications, including key removal by a different thread, can lead to skipped entries or an exception if an expected entry key was removed before its key or value could be fetched. If *bad-index-v* is supplied, then *bad-index-v* is returned as both the key and the value in the case that the *hash* is modified concurrently so that iteration does not have a valid hash index. Providing *bad-index-v* is particularly useful when iterating through a hash table with weakly held keys, since entries can be removed asynchronously (i.e., after `in-hash` has committed to another iteration, but before it can access the entry for the next iteration).

Examples:

```
> (define table (hash 'a 1 'b 2))
> (for ([(key value) (in-hash table)])
    (printf "key: ~a value: ~a\n" key value))
key: b value: 2
key: a value: 1
```

See §4.15 "Hash Tables" for information on using hash tables as sequences.

Changed in version 7.0.0.10 of package `base`: Added the optional *bad-index-v* argument.
Changed in version 8.18.0.11: Strengthened the guarantees about traversal with same-thread modifications to a mutable hash table.

```
(in-hash-keys hash) → sequence?
  hash : hash?
(in-hash-keys hash bad-index-v) → sequence?
  hash : hash?
  bad-index-v : any/c
```

Returns a sequence whose elements are the keys of *hash*, using *bad-index-v* in the same way as in-hash, and with concurrent-modification guarantees analogous to those of in-hash.

Examples:

```
> (define table (hash 'a 1 'b 2))
> (for ([key (in-hash-keys table)])
    (printf "key: ~a\n" key))
key: b
key: a
```

Changed in version 7.0.0.10 of package base: Added the optional *bad-index-v* argument.
Changed in version 8.18.0.11: Strengthened the guarantees about traversal with same-thread modifications to a mutable hash table.

```
(in-hash-values hash) → sequence?
  hash : hash?
(in-hash-values hash bad-index-v) → sequence?
  hash : hash?
  bad-index-v : any/c
```

Returns a sequence whose elements are the values of *hash*, using *bad-index-v* in the same way as in-hash, and with concurrent-modification guarantees analogous to those of in-hash.

Examples:

```
> (define table (hash 'a 1 'b 2))
> (for ([value (in-hash-values table)])
    (printf "value: ~a\n" value))
value: 2
value: 1
```

Changed in version 7.0.0.10 of package base: Added the optional *bad-index-v* argument.
Changed in version 8.18.0.11: Strengthened the guarantees about traversal with same-thread modifications to a mutable hash table.

```
(in-hash-pairs hash) → sequence?
  hash : hash?
(in-hash-pairs hash bad-index-v) → sequence?
  hash : hash?
  bad-index-v : any/c
```

Returns a sequence whose elements are pairs, each containing a key and its value from *hash* (as opposed to using *hash* directly as a sequence to get the key and value as separate values for each element).

The *bad-index-v* argument, if supplied, is used in the same way as by in-hash. When an invalid index is encountered, the pair in the sequence with have *bad-index-v* as both its car and cdr. The concurrent-modification guarantees for in-hash-pairs are analogous to those of in-hash.

Examples:

```
> (define table (hash 'a 1 'b 2))
> (for ([key+value (in-hash-pairs table)])
    (printf "key and value: ~a\n" key+value))
key and value: (b . 2)
key and value: (a . 1)
```

Changed in version 7.0.0.10 of package base: Added the optional *bad-index-v* argument.
Changed in version 8.18.0.11: Strengthened the guarantees about traversal with same-thread modifications to a mutable hash table.

```
(in-mutable-hash hash) → sequence?
  hash : (and/c hash? (not/c immutable?) hash-strong?)
(in-mutable-hash hash bad-index-v) → sequence?
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  bad-index-v : any/c
(in-mutable-hash-keys hash) → sequence?
  hash : (and/c hash? (not/c immutable?) hash-strong?)
(in-mutable-hash-keys hash bad-index-v) → sequence?
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  bad-index-v : any/c
(in-mutable-hash-values hash) → sequence?
  hash : (and/c hash? (not/c immutable?) hash-strong?)
(in-mutable-hash-values hash bad-index-v) → sequence?
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  bad-index-v : any/c
(in-mutable-hash-pairs hash) → sequence?
  hash : (and/c hash? (not/c immutable?) hash-strong?)
(in-mutable-hash-pairs hash bad-index-v) → sequence?
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  bad-index-v : any/c
(in-immutable-hash hash) → sequence?
  hash : (and/c hash? immutable?)
(in-immutable-hash hash bad-index-v) → sequence?
  hash : (and/c hash? immutable?)
  bad-index-v : any/c
(in-immutable-hash-keys hash) → sequence?
  hash : (and/c hash? immutable?)
(in-immutable-hash-keys hash bad-index-v) → sequence?
  hash : (and/c hash? immutable?)
  bad-index-v : any/c
```

```
(in-immutable-hash-values hash) → sequence?
  hash : (and/c hash? immutable?)
(in-immutable-hash-values hash bad-index-v) → sequence?
  hash : (and/c hash? immutable?)
  bad-index-v : any/c
(in-immutable-hash-pairs hash) → sequence?
  hash : (and/c hash? immutable?)
(in-immutable-hash-pairs hash bad-index-v) → sequence?
  hash : (and/c hash? immutable?)
  bad-index-v : any/c
(in-weak-hash hash) → sequence?
  hash : (and/c hash? hash-weak?)
(in-weak-hash hash bad-index-v) → sequence?
  hash : (and/c hash? hash-weak?)
  bad-index-v : any/c
(in-weak-hash-keys hash) → sequence?
  hash : (and/c hash? hash-weak?)
(in-weak-hash-keys hash bad-index-v) → sequence?
  hash : (and/c hash? hash-weak?)
  bad-index-v : any/c
(in-weak-hash-values hash) → sequence?
  hash : (and/c hash? hash-weak?)
(in-weak-hash-keys hash bad-index-v) → sequence?
  hash : (and/c hash? hash-weak?)
  bad-index-v : any/c
(in-weak-hash-pairs hash) → sequence?
  hash : (and/c hash? hash-weak?)
(in-weak-hash-pairs hash bad-index-v) → sequence?
  hash : (and/c hash? hash-weak?)
  bad-index-v : any/c
(in-ephemeron-hash hash) → sequence?
  hash : (and/c hash? hash-ephemeron?)
(in-ephemeron-hash hash bad-index-v) → sequence?
  hash : (and/c hash? hash-ephemeron?)
  bad-index-v : any/c
(in-ephemeron-hash-keys hash) → sequence?
  hash : (and/c hash? hash-ephemeron?)
(in-ephemeron-hash-keys hash bad-index-v) → sequence?
  hash : (and/c hash? hash-ephemeron?)
  bad-index-v : any/c
(in-ephemeron-hash-values hash) → sequence?
  hash : (and/c hash? hash-ephemeron?)
(in-ephemeron-hash-keys hash bad-index-v) → sequence?
  hash : (and/c hash? hash-ephemeron?)
  bad-index-v : any/c
```

```
(in-ephemeron-hash-pairs hash) → sequence?
  hash : (and/c hash? hash-ephemeron?)
(in-ephemeron-hash-pairs hash bad-index-v) → sequence?
  hash : (and/c hash? hash-ephemeron?)
  bad-index-v : any/c
```

Sequence constructors for specific kinds of hash tables. These may perform better than the analogous `in-hash` forms.

Added in version 6.4.0.6 of package `base`.
Changed in version 7.0.0.10: Added the optional *`bad-index-v`* argument.
Changed in version 8.0.0.10: Added `ephemeron` variants.

```
(in-directory [dir use-dir?]) → (sequence/c path?)
  dir : (or/c #f path-string?) = #f
  use-dir? : ((and/c path? complete-path?) . -> . any/c)
           = (lambda (dir-path) #t)
```

Returns a sequence that produces all of the paths for files, directories, and links within *`dir`*, except for the contents of any directory for which *`use-dir?`* returns `#f`. If *`dir`* is not `#f`, then every produced path starts with *`dir`* as its prefix. If *`dir`* is `#f`, then paths in and relative to the current directory are produced.

An `in-directory` sequence traverses nested subdirectories recursively (filtered by *`use-dir?`*). To generate a sequence that includes only the immediate content of a directory, use the result of `directory-list` as a sequence.

The immediate content of each directory is reported as sorted by `path<?`, and the content of a subdirectory is reported before subsequent paths within the directory.

Examples:

```
> (current-directory (path-only (collection-file-
path "main.rkt" "info")))
> (for/list ([f (in-directory)])
     f)
'(#<path:compiled>
  #<path:compiled/main_rkt.dep>
  #<path:compiled/main_rkt.zo>
  #<path:main.rkt>)
> (for/list ([f (in-directory "compiled")])
    f)
'(#<path:compiled/main_rkt.dep> #<path:compiled/main_rkt.zo>)
> (for/list ([f (in-directory #f (lambda (p)
                                   (not (regexp-
match? #rx"compiled" p))))])
     f)
```

```
'(#<path:compiled> #<path:main.rkt>)
```

Changed in version 6.0.0.1 of package base: Added *use-dir?* argument.
Changed in version 6.6.0.4: Added guarantee of sorted results.

```
(in-producer producer) → sequence?
  producer : procedure?
(in-producer producer stop arg ...) → sequence?
  producer : procedure?
  stop : any/c
  arg : any/c
```

Returns a sequence that contains values from sequential calls to *producer*, which would usually use some state to do its work.

If a *stop* value is not given, the sequence goes on infinitely, and therefore it is common to use it with a finite sequence or using `#:break` etc. If a *stop* value is given, it is used to identify a value that marks the end of the sequence (and the *stop* value is not included in the sequence); *stop* can be a predicate that is applied to the results of *producer*, or it can be a value that is tested against the result of with `eq?`. (The *stop* argument must be a predicate if the stop value is itself a function or if *producer* returns multiple values.)

If additional *arg*s are specified, they are passed to every call to *producer*.

Examples:

```
> (define (counter)
    (define n 0)
    (lambda ([d 1]) (set! n (+ d n)) n))
> (for/list ([x (in-producer (counter))] [y (in-range 4)]) x)
'(1 2 3 4)
> (for/list ([x (in-producer (counter))] #:break (= x 5)) x)
'(1 2 3 4)
> (for/list ([x (in-producer (counter) 5)]) x)
'(1 2 3 4)
> (for/list ([x (in-producer (counter) 5 1/2)]) x)
'(1/2 1 3/2 2 5/2 3 7/2 4 9/2)
> (for/list ([x (in-producer read eof (open-input-string "1 2
3"))]) x)
'(1 2 3)
```

```
(in-value v) → sequence?
  v : any/c
```

Returns a sequence that produces a single value: *v*.

This form is mostly useful for `let`-like bindings in forms such as `for*/list`—but a `#:do` clause form, added more recently, covers many of the same uses.

```
(in-indexed seq) → sequence?
  seq : sequence?
```

Returns a sequence where each element has two values: the value produced by *seq*, and a non-negative exact integer starting with `0`. The elements of *seq* must be single-valued.

Example:

```
> (for ([(ch i) (in-indexed "hello")])
    (printf "The char at position ~a is: ~a\n" i ch))
The char at position 0 is: h
The char at position 1 is: e
The char at position 2 is: l
The char at position 3 is: l
The char at position 4 is: o
```

```
(in-sequences seq ...) → sequence?
  seq : sequence?
```

Returns a sequence that is made of all input sequences, one after the other. Each *seq* is initiated only after the preceding *seq* is exhausted. If a single *seq* is provided, then *seq* is returned; otherwise, the elements of each *seq* must all have the same number of values.

```
(in-cycle seq ...) → sequence?
  seq : sequence?
```

Similar to `in-sequences`, but the sequences are repeated in an infinite cycle, where each *seq* is initiated afresh in each iteration. Beware that if no *seq*s are provided or if all *seq*s become empty, then the sequence produced by `in-cycle` never returns when an element is demanded—or even when the sequence is initiated, if all *seq*s are initially empty.

```
(in-parallel seq ...) → sequence?
  seq : sequence?
```

Returns a sequence where each element has as many values as the number of supplied *seq*s; the values are, in order, the value of each *seq*. The elements of each *seq* must be single-valued.

```
(in-parallel-values n seq ... ...) → sequence?
  n : exact-nonnegative-integer?
  seq : sequence?
```

Returns a sequence where each element has as many values as the sum of the number of values produced by the supplied *seq*s, where each *seq* is preceded by the number of values *n* that it produces (so, the resulting number of values is the sum of the *n*s). The values of the new sequence are, in order, the values of each *seq*.

Added in version 9.0.0.2 of package `base`.

```
(in-values-sequence seq) → sequence?
  seq : sequence?
```

Returns a sequence that is like *seq*, but it combines multiple values for each element from *seq* as a list of elements.

```
(in-values*-sequence seq) → sequence?
  seq : sequence?
```

Returns a sequence that is like *seq*, but when an element of *seq* has multiple values or a single list value, then the values are combined in a list. In other words, `in-values*-sequence` is like `in-values-sequence`, except that non-list, single-valued elements are not wrapped in a list.

```
(stop-before seq pred) → sequence?
  seq : sequence?
  pred : (any/c . -> . any)
```

Returns a sequence that contains the elements of *seq* (which must be single-valued), but only until the last element for which applying *pred* to the element produces `#t`, after which the sequence ends.

```
(stop-after seq pred) → sequence?
  seq : sequence?
  pred : (any/c . -> . any)
```

Returns a sequence that contains the elements of *seq* (which must be single-valued), but only until the element (inclusive) for which applying *pred* to the element produces `#t`, after which the sequence ends.

```
(make-do-sequence thunk) → sequence?
```

```
thunk : (or/c (-> (values (any/c . -> . any)
                          (any/c . -> . any/c)
                          any/c
                          (or/c (any/c . -> . any/c) #f)
                          (or/c (any/c ... . -> . any/c) #f)
                          (or/c (any/c any/c ... . -> . any/c) #f)))
              (-> (values (any/c . -> . any)
                          (or/c (any/c . -> . any/c) #f)
                          (any/c . -> . any/c)
                          any/c
                          (or/c (any/c . -> . any/c) #f)
                          (or/c (any/c ... . -> . any/c) #f)
                          (or/c (any/c any/c ... . -> . any/c) #f))))
```

Returns a sequence whose elements are generated according to *thunk*.

The sequence is initiated when *thunk* is called. The initiated sequence is defined in terms of a *position*, which is initialized to *init-pos*, and the *element*, which may consist of multiple values.

The *thunk* procedure must return either six or seven values. However, use `initiate-sequence` to return these multiple values, as opposed to listing the values directly.

If *thunk* returns six values:

- The first result is a *pos->element* procedure that takes the current position and returns the value(s) for the current element.
- The second result is a *next-pos* procedure that takes the current position and returns the next position.
- The third result is a *init-pos* value, which is the initial position.
- The fourth result is a *continue-with-pos?* function that takes the current position and returns a true result if the sequence includes the value(s) for the current position, and false if the sequence should end instead of including the value(s). Alternatively, *continue-with-pos?* can be `#f` to indicate that the sequence should always include the current value(s). This function is checked on each position before *pos->element* is used.
- The fifth result is a *continue-with-val?* function that is like *continue-with-pos?*, but it takes the current element value(s) as arguments instead of the current position. Alternatively, *continue-with-val?* can be `#f` to indicate that the sequence should always include the value(s) at the current position.
- The sixth result is a *continue-after-pos+val?* procedure that takes both the current position and the current element value(s) and determines whether the sequence

ends after the current element is already included in the sequence. Alternatively, *continue-after-pos+val?* can be #f to indicate that the sequence can always continue after the current value(s).

If *thunk* returns seven values, the first result is still the *pos->element* procedure. However, the second result is now an *early-next-pos* procedure that is described further below. Alternatively, *early-next-pos* can be #f, which is equivalent to the identity function. Other results' positions are shifted by one, so the third result is now *next-pos*, and the fourth result is now *init-pos*, etc.

The *early-next-pos* procedure takes the current position and returns an updated position. This updated position is used for *next-pos* and *continue-after-pos+val?*, but not with *continue-with-pos?* (which uses the original current position). The intent of *early-next-pos* is to support a sequence where the position must be incremented to avoid keeping a value reachable while a loop processes the sequence value, so *early-next-pos* is applied just after *pos->element*. The *continue-after-pos+val?* function needs to be #f to avoid retaining values to supply to that function.

Each of the procedures listed above is called only once per position. Among the procedures *continue-with-pos?*, *continue-with-val?*, and *continue-after-pos+val?*, as soon as one of the procedures returns #f, the sequence ends, and none are called again. Typically, one of the functions determines the end condition, and #f is used in place of the other two functions.

Changed in version 6.7.0.4 of package base: Added support for the optional second result.

```
prop:sequence : struct-type-property?
```

Associates a procedure to a structure type that takes an instance of the structure and returns a sequence. If v is an instance of a structure type with this property, then (sequence? v) produces #t.

Using a pre-existing sequence:

Examples:

```
> (struct my-set (table)
    #:property prop:sequence
    (lambda (s)
      (in-hash-keys (my-set-table s))))
> (define (make-set . xs)
    (my-set (for/hash ([x (in-list xs)])
              (values x #t))))
> (for/list ([c (make-set 'celeriac 'carrot 'potato)])
    c)
'(potato celeriac carrot)
```

Using make-do-sequence:

Examples:

```
> (require racket/sequence)
> (struct train (car next)
    #:property prop:sequence
    (lambda (t)
      (make-do-sequence
       (lambda ()
         (initiate-sequence
          #:pos->element train-car
          #:next-pos train-next
          #:init-pos t
          #:continue-with-pos? (lambda (t) t))))))
> (for/list ([c (train 'engine
                       (train 'boxcar
                              (train 'caboose
                                     #f)))])
    c)
'(engine boxcar caboose)
```

Sequence Conversion

```
(sequence->stream seq) → stream?
  seq : sequence?
```

Converts a sequence to a stream, which supports the stream-first and stream-rest operations. Creation of the stream eagerly initiates the sequence, but the stream lazily draws elements from the sequence, caching each element so that stream-first produces the same result each time is applied to a stream.

If extracting an element from *seq* involves a side-effect, then the effect is performed each time that either stream-first or stream-rest is first used to access or skip an element.

Note that a sequence itself can have state, so multiple calls to sequence->stream on the same *seq* are not necessarily independent.

Examples:

```
> (define inport (open-input-bytes (bytes 1 2 3 4 5)))
> (define strm (sequence->stream inport))
> (stream-first strm)
1
> (stream-first (stream-rest strm))
2
```

```
> (stream-first strm)
1
> (define strm2 (sequence->stream inport))
> (stream-first strm2)
3
> (stream-first (stream-rest strm2))
4
```

```
(sequence-generate seq) → (-> boolean?) (-> any)
  seq : sequence?
```

Initiates a sequence and returns two thunks to extract elements from the sequence. The first returns `#t` if more values are available for the sequence. The second returns the next element (which may be multiple values) from the sequence; if no more elements are available, the `exn:fail:contract` exception is raised.

Note that a sequence itself can have state, so multiple calls to `sequence-generate` on the same *seq* are not necessarily independent.

Examples:

```
> (define inport (open-input-bytes (bytes 1 2 3 4 5)))
> (define-values (more? get) (sequence-generate inport))
> (more?)
#t
> (get)
1
> (get)
2
> (define-values (more2? get2) (sequence-generate inport))
> (list (get2) (get2) (get2))
'(3 4 5)
> (more2?)
#f
```

```
(sequence-generate* seq)
 → (or/c list? #f)
   (-> (values (or/c list? #f) procedure?))
  seq : sequence?
```

Like `sequence-generate`, but avoids state (aside from any inherent in the sequence) by returning a list of values for the sequence's first element—or `#f` if the sequence is empty—and a thunk to continue with the sequence; the result of the thunk is the same as the result of `sequence-generate*`, but for the second element of the sequence, and so on. If the thunk is called when the element result is `#f` (indicating no further values in the sequence), the `exn:fail:contract` exception is raised.

Additional Sequence Operations

```
(require racket/sequence)        package: base
```

The bindings documented in this section are provided by the `racket/sequence` and `racket` libraries, but not `racket/base`.

```
empty-sequence : sequence?
```

A sequence with no elements.

```
(sequence->list s) → list?
  s : sequence?
```

Returns a list whose elements are the elements of *s*, each of which must be a single value. If *s* is infinite, this function does not terminate.

```
(sequence-length s) → exact-nonnegative-integer?
  s : sequence?
```

Returns the number of elements of *s* by extracting and discarding all of them. If *s* is infinite, this function does not terminate.

```
(sequence-ref s i) → any
  s : sequence?
  i : exact-nonnegative-integer?
```

Returns the *i*th element of *s* (which may be multiple values).

```
(sequence-tail s i) → sequence?
  s : sequence?
  i : exact-nonnegative-integer?
```

Returns a sequence equivalent to *s*, except that the first *i* elements are omitted.

In case initiating *s* involves a side effect, the sequence *s* is not initiated until the resulting sequence is initiated, at which point the first *i* elements are extracted from the sequence.

```
(sequence-append s ...) → sequence?
  s : sequence?
```

Returns a sequence that contains all elements of each sequence in the order they appear in the original sequences. The new sequence is constructed lazily.

If all given *s*s are streams, the result is also a stream.

```
(sequence-map f s) → sequence?
  f : procedure?
  s : sequence?
```

Returns a sequence that contains *f* applied to each element of *s*. The new sequence is constructed lazily.

If *s* is a stream, then the result is also a stream.

```
(sequence-andmap f s) → boolean?
  f : (-> any/c ... boolean?)
  s : sequence?
```

Returns `#t` if *f* returns a true result on every element of *s*. If *s* is infinite and *f* never returns a false result, this function does not terminate.

```
(sequence-ormap f s) → boolean?
  f : (-> any/c ... boolean?)
  s : sequence?
```

Returns `#t` if *f* returns a true result on some element of *s*. If *s* is infinite and *f* never returns a true result, this function does not terminate.

```
(sequence-for-each f s) → void?
  f : (-> any/c ... any)
  s : sequence?
```

Applies *f* to each element of *s*. If *s* is infinite, this function does not terminate.

```
(sequence-fold f i s) → any/c
  f : (-> any/c any/c ... any/c)
  i : any/c
  s : sequence?
```

Folds *f* over each element of *s* with *i* as the initial accumulator. If *s* is infinite, this function does not terminate. The *f* function takes the accumulator as its first argument and the next sequence element as its second.

```
(sequence-count f s) → exact-nonnegative-integer?
  f : procedure?
  s : sequence?
```

Returns the number of elements in *s* for which *f* returns a true result. If *s* is infinite, this function does not terminate.

```
(sequence-filter f s) → sequence?
  f : (-> any/c ... boolean?)
  s : sequence?
```

Returns a sequence whose elements are the elements of `s` for which `f` returns a true result. Although the new sequence is constructed lazily, if `s` has an infinite number of elements where `f` returns a false result in between two elements where `f` returns a true result, then operations on this sequence will not terminate during the infinite sub-sequence.

If `s` is a stream, then the result is also a stream.

```
(sequence-add-between s e) → sequence?
  s : sequence?
  e : any/c
```

Returns a sequence whose elements are the elements of `s`, but with `e` between each pair of elements in `s`. The new sequence is constructed lazily.

If `s` is a stream, then the result is also a stream.

Examples:

```
> (let* ([all-reds (in-cycle '("red"))]
         [red-and-blues (sequence-add-between all-reds "blue")])
    (for/list ([n (in-range 10)]
               [elt red-and-blues])
      elt))
'("red" "blue" "red" "blue" "red" "blue" "red" "blue" "red"
"blue")
> (for ([text (sequence-add-between '("veni" "vidi" "duci") ",
")])
    (display text))
veni, vidi, duci
```

```
(sequence/c [#:min-count min-count]
             elem/c ...)            → contract?
  min-count : (or/c #f exact-nonnegative-integer?) = #f
  elem/c : contract?
```

Wraps a sequence, obligating it to produce elements with as many values as there are `elem/c` contracts, and obligating each value to satisfy the corresponding `elem/c`. The result is not guaranteed to be the same kind of sequence as the original value; for instance, a wrapped list is not guaranteed to satisfy `list?`.

If `min-count` is a number, the stream is required to have at least that many elements in it.

Examples:

```
> (define/contract predicates
    (sequence/c (-> any/c boolean?))
    (in-list (list integer?
                   string->symbol)))
> (for ([P predicates])
    (printf "~s\n" (P "cat")))
#f
predicates: broke its own contract
  promised: boolean?
  produced: 'cat
  in: an element of
      (sequence/c (-> any/c boolean?))
  contract from: (definition predicates)
  blaming: (definition predicates)
   (assuming the contract is correct)
  at: eval:55:0
> (define/contract numbers&strings
    (sequence/c number? string?)
    (in-dict (list (cons 1 "one")
                   (cons 2 "two")
                   (cons 3 'three))))
> (for ([(N S) numbers&strings])
    (printf "~s: ~a\n" N S))
1: one
2: two
numbers&strings: broke its own contract
  promised: string?
  produced: 'three
  in: an element of
      (sequence/c number? string?)
  contract from: (definition numbers&strings)
  blaming: (definition numbers&strings)
   (assuming the contract is correct)
  at: eval:57:0
> (define/contract a-sequence
    (sequence/c #:min-count 2 char?)
    "x")
> (for ([x a-sequence]
        [i (in-naturals)])
    (printf "~a is ~a\n" i x))
0 is x
a-sequence: broke its own contract
  promised: a sequence that contains at least 2 values
  produced: "x"
```

in: (sequence/c #:min-count 2 char?)
contract from: (definition a-sequence)
blaming: (definition a-sequence)
(assuming the contract is correct)
at: eval:59:0

Additional Sequence Constructors and Functions

```
(in-syntax stx) → sequence?
  stx : syntax?
```

Produces a sequence whose elements are the successive subparts of *stx*. Equivalent to `(stx->list lst)`.

An `in-syntax` application can provide better performance for syntax iteration when it appears directly in a `for` clause.

Example:

```
> (for/list ([x (in-syntax #'(1 2 3))])
    x)
'(#<syntax:eval:61:0 1> #<syntax:eval:61:0 2> #<syntax:eval:61:0
3>)
```

Added in version 6.3 of package `base`.

```
(in-slice length seq) → sequence?
  length : exact-positive-integer?
  seq : sequence?
```

Returns a sequence whose elements are lists with the first *length* elements of *seq*, then the next *length* and so on.

Example:

```
> (for/list ([e (in-slice 3 (in-range 8))]) e)
'((0 1 2) (3 4 5) (6 7))
```

Added in version 6.3 of package `base`.

```
(initiate-sequence
  #:pos->element pos->element
 [#:early-next-pos early-next-pos]
  #:next-pos next-pos
  #:init-pos init-pos
 [#:continue-with-pos? continue-with-pos?
  #:continue-with-val? continue-with-val?
  #:continue-after-pos+val? continue-after-pos+val?])
```

```
→ (any/c . -> . any)
  (or/c (any/c . -> . any) #f)
  (any/c . -> . any/c)
  any/c
  (or/c (any/c . -> . any/c) #f)
  (or/c (any/c ... . -> . any/c) #f)
  (or/c (any/c any/c ... . -> . any/c) #f)
 pos->element : (any/c . -> . any)
 early-next-pos : (or/c (any/c . -> . any) #f) = #f
 next-pos : (any/c . -> . any/c)
 init-pos : any/c
 continue-with-pos? : (or/c (any/c . -> . any/c) #f) = #f
 continue-with-val? : (or/c (any/c ... . -> . any/c) #f) = #f
 continue-after-pos+val? : (or/c (any/c any/c ... . -> . any/c) #f)
                         = #f
```

Returns values suitable for the thunk argument in `make-do-sequence`. See `make-do-sequence` for the meaning of each argument.

Examples:

```
> (define (in-alt-list xs)
    (make-do-sequence
     (λ ()
       (initiate-sequence
        #:pos->element car
        #:next-pos (λ (xs) (cdr (cdr xs)))
        #:init-pos xs
        #:continue-with-pos? pair?
        #:continue-after-pos+val? (λ (xs _) (pair? (cdr xs)))))))
> (sequence->list (in-alt-list '(1 2 3 4 5 6)))
'(1 3 5)
> (sequence->list (in-alt-list '(1 2 3 4 5 6 7)))
'(1 3 5 7)
```

Added in version 8.10.0.5 of package `base`.

4.17.2 Streams

A *stream* is a kind of sequence that supports functional iteration via `stream-first` and `stream-rest`. The `stream-cons` form constructs a lazy stream, but plain lists can be used as streams, and functions such as `in-range` and `in-naturals` also create streams.

`(require racket/stream)` package: `base`

The bindings documented in this section are provided by the `racket/stream` and `racket` libraries, but not `racket/base`.

```
(stream? v) → boolean?
  v : any/c
```

Returns `#t` if *v* can be used as a stream, `#f` otherwise.

```
(stream-empty? s) → boolean?
  s : stream?
```

Returns `#t` if *s* has no elements, `#f` otherwise.

```
(stream-first s) → any
  s : (and/c stream? (not/c stream-empty?))
```

Returns the value(s) of the first element in *s*.

```
(stream-rest s) → stream?
  s : (and/c stream? (not/c stream-empty?))
```

Returns a stream that is equivalent to *s* without its first element.

```
(stream-cons first-expr rest-expr)
(stream-cons #:eager first-expr rest-expr)
(stream-cons first-expr #:eager rest-expr)
(stream-cons #:eager first-expr #:eager rest-expr)
```

Produces a stream whose first element is determined by *first-expr* and whose rest is determined by *rest-expr*.

If *first-expr* is not preceded by `#:eager`, then *first-expr* is not evaluated immediately. Instead, `stream-first` on the result stream forces the evaluation of *first-expr* (once) to produce the first element of the stream. If evaluating *first-expr* raises an exception or tries to force itself, then an `exn:fail:contract` exception is raised, and future attempts to force evaluation will trigger another exception.

If *rest-expr* is not preceded by `#:eager`, then *rest-expr* is not evaluated immediately. Instead, `stream-rest` on the result stream produces another stream that is like the one produced by `(stream-lazy rest-expr)`.

The first element of the stream as produced by *first-expr* can be multiple values. The *rest-expr* must produce a stream when it is evaluated, otherwise the `exn:fail:contract?` exception is raised.

Changed in version 8.0.0.12 of package `base`: Added `#:eager` options.
Changed in version 8.8.0.7: Changed to allow multiple values.

```
(stream-lazy stream-expr)
(stream-lazy #:who who-expr stream-expr)
```

Similar to `(delay stream-expr)`, but the result is a stream instead of a promise, and *stream-expr* must produce a stream when it is eventually forced. The stream produced by `stream-lazy` has the same content as the stream produced by *stream-expr*; that is, operations like `stream-first` on the result stream will force *stream-expr* and retry on its result.

If evaluating *stream-expr* raises an exception or tries to force itself, then an `exn:fail:contract` exception is raised, and future attempts to force evaluation will trigger another exception.

If *who-expr* is provided, it is evaluated when constructing the delayed stream. If *stream-expr* later produces a value that is not a stream, and if *who-expr* produced a symbol value, then the symbol is used for the error message.

Added in version 8.0.0.12 of package `base`.

```
(stream-force s) → stream?
  s : stream?
```

Forces the evaluation of a delayed stream from `stream-lazy`, from the `stream-rest` of a `stream-cons`, etc., returning the forced stream. If *s* is not a delayed stream, then *s* is returned.

Normally, `stream-force` is not needed, because operations like `stream-first`, `stream-rest`, and `stream-empty?` force a delayed stream as needed. In rare cases, `stream-force` can be useful to reveal the underlying implementation of a stream (e.g., a stream that is an instance of a structure type that has the `prop:stream` property).

Added in version 8.0.0.12 of package `base`.

```
(stream elem-expr ...)

elem-expr = (values single-expr ...)
          | single-expr
```

A shorthand for nested `stream-cons`es ending with `empty-stream`. As a match pattern, `stream` matches a stream with as many elements as *elem-expr*s, and each element must match the corresponding *elem-expr* pattern. The pattern *elem-expr* can be `(values single-expr ...)`, which matches against multiple valued elements in the stream.

Changed in version 8.8.0.7 of package `base`: Changed to allow multiple values.

```
(stream* elem-expr ... tail-expr)
```

A shorthand for nested stream-conses, but the *tail-expr* must produce a stream when it is forced, and that stream is used as the rest of the stream instead of empty-stream. Similar to list* but for streams. As a match pattern, stream* is similar to a stream pattern, but the *tail-expr* pattern matches the "rest" of the stream after the last *elem-expr*.

Added in version 6.3 of package base.
Changed in version 8.0.0.12: Changed to delay rest-expr even if zero exprs are provided.
Changed in version 8.8.0.7: Changed to allow multiple values.

```
(in-stream s) → sequence?
  s : stream?
```

Returns a sequence that is equivalent to *s*.

An in-stream application can provide better performance for streams iteration when it appears directly in a for clause.

See for for information on the reachability of stream elements during an iteration.

Changed in version 6.7.0.4 of package base: Improved element-reachability guarantee for streams in for.

```
empty-stream : stream?
```

A stream with no elements.

```
(stream->list s) → list?
  s : stream?
```

Returns a list whose elements are the elements of *s*, each of which must be a single value. If *s* is infinite, this function does not terminate.

```
(stream-length s) → exact-nonnegative-integer?
  s : stream?
```

Returns the number of elements of *s*. If *s* is infinite, this function does not terminate.

In the case of lazy streams, this function forces evaluation only of the sub-streams, and not the stream's elements.

```
(stream-ref s i) → any
  s : stream?
  i : exact-nonnegative-integer?
```

Returns the *i*th element of *s* (which may be multiple values).

```
(stream-tail s i) → stream?
  s : stream?
  i : exact-nonnegative-integer?
```

Returns a stream equivalent to *s*, except that the first *i* elements are omitted.

In case extracting elements from *s* involves a side effect, they will not be extracted until the first element is extracted from the resulting stream.

```
(stream-take s i) → stream?
  s : stream?
  i : exact-nonnegative-integer?
```

Returns a stream of the first *i* elements of *s*.

```
(stream-append s ...) → stream?
  s : stream?
```

Returns a stream that contains all elements of each stream in the order they appear in the original streams. The new stream is constructed lazily, while the last given stream is used in the tail of the result.

```
(stream-map f s) → stream?
  f : procedure?
  s : stream?
```

Returns a stream that contains *f* applied to each element of *s*. The new stream is constructed lazily.

```
(stream-andmap f s) → boolean?
  f : (-> any/c ... boolean?)
  s : stream?
```

Returns `#t` if *f* returns a true result on every element of *s*. If *s* is infinite and *f* never returns a false result, this function does not terminate.

```
(stream-ormap f s) → boolean?
  f : (-> any/c ... boolean?)
  s : stream?
```

Returns `#t` if *f* returns a true result on some element of *s*. If *s* is infinite and *f* never returns a true result, this function does not terminate.

```
(stream-for-each f s) → void?
  f : (-> any/c ... any)
  s : stream?
```

Applies *f* to each element of *s*. If *s* is infinite, this function does not terminate.

```
(stream-fold f i s) → any/c
  f : (-> any/c any/c ... any/c)
  i : any/c
  s : stream?
```

Folds *f* over each element of *s* with *i* as the initial accumulator. If *s* is infinite, this function does not terminate. The *f* function takes the accumulator as its first argument and the next stream element as its second.

```
(stream-count f s) → exact-nonnegative-integer?
  f : procedure?
  s : stream?
```

Returns the number of elements in *s* for which *f* returns a true result. If *s* is infinite, this function does not terminate.

```
(stream-filter f s) → stream?
  f : (-> any/c ... boolean?)
  s : stream?
```

Returns a stream whose elements are the elements of *s* for which *f* returns a true result. Although the new stream is constructed lazily, if *s* has an infinite number of elements where *f* returns a false result, then operations on this stream will not terminate during the infinite sub-stream.

```
(stream-add-between s e) → stream?
  s : stream?
  e : any/c
```

Returns a stream whose elements are the elements of *s*, but with *e* between each pair of elements in *s*. The new stream is constructed lazily.

```
(for/stream (for-clause ...) body-or-break ... body)
(for*/stream (for-clause ...) body-or-break ... body)
```

Iterates like `for/list` and `for*/list`, respectively, but the results are lazily collected into a stream instead of a list.

Unlike most `for` forms, these forms are evaluated lazily, so each *body* will not be evaluated until the resulting stream is forced. This allows `for/stream` and `for*/stream` to iterate over infinite sequences, unlike their finite counterparts.

Examples:

```
> (for/stream ([i '(1 2 3)]) (* i i))
#<stream>
> (stream->list (for/stream ([i '(1 2 3)]) (* i i)))
'(1 4 9)
> (stream-ref (for/stream ([i '(1 2 3)]) (displayln i) (* i i)) 1)
2
4
> (stream-ref (for/stream ([i (in-naturals)]) (* i i)) 25)
625
> (stream-ref (for/stream ([i (in-naturals)]) (values i (add1 i))) 10)
10
11
```

Added in version 6.3.0.9 of package `base`.
Changed in version 8.8.0.7: Changed to allow multiple values.

`gen:stream : any/c`

Associates three methods to a structure type to implement the generic interface (see §5.4 "Generic Interfaces") for streams.

To supply method implementations, the `#:methods` keyword should be used in a structure type definition. The following three methods must be implemented:

- *`stream-empty?`* : accepts one argument
- *`stream-first`* : accepts one argument
- *`stream-rest`* : accepts one argument

Examples:

```
> (struct list-stream (v)
    #:methods gen:stream
    [(define (stream-empty? stream)
       (empty? (list-stream-v stream)))
     (define (stream-first stream)
       (first (list-stream-v stream)))
     (define (stream-rest stream)
       (list-stream (rest (list-stream-v stream))))])
> (define l1 (list-stream '(1 2)))
> (stream? l1)
#t
> (stream-first l1)
1
```

Changed in version 8.7.0.5 of package `base`: Added a check so that omitting any of *`stream-empty?`*, *`stream-first`*, and *`stream-rest`* is now a syntax error.

```
prop:stream : struct-type-property?
```

A structure type property used to define custom extensions to the stream API. Using the `prop:stream` property is discouraged; use the `gen:stream` generic interface instead. Accepts a vector of three procedures taking the same arguments as the methods in `gen:stream`.

```
(stream/c c) → contract?
  c : contract?
```

Returns a contract that recognizes streams. All elements of the stream must match *`c`*.

If the *`c`* argument is a flat contract or a chaperone contract, then the result will be a chaperone contract. Otherwise, the result will be an impersonator contract.

When an `stream/c` contract is applied to a stream, the result is not `eq?` to the input. The result will be either a chaperone or impersonator of the input depending on the type of contract.

Contracts on streams are evaluated lazily by necessity (since streams may be infinite). Contract violations will not be raised until the value in violation is retrieved from the stream. As an exception to this rule, streams that are lists are checked immediately, as if *`c`* had been used with `listof`.

If a contract is applied to a stream, and that stream is subsequently used as the tail of another stream (as the second parameter to `stream-cons`), the new elements will not be checked with the contract, but the tail's elements will still be enforced.

Added in version 6.1.1.8 of package `base`.

4.17.3 Generators

A *generator* is a procedure that returns a sequence of values, incrementing the sequence each time that the generator is called. In particular, the `generator` form implements a generator by evaluating a body that calls `yield` to return values from the generator.

```
(require racket/generator)
```
package: `base`

```
(generator? v) → boolean?
  v : any/c
```

Return `#t` if *`v`* is a generator, `#f` otherwise.

```
(generator formals body ...+)

formals = (id ...)
        | (id ...+ . rest-id)
        | rest-id
```

Creates a generator, where *formals* specify the arguments. Keyword and optional arguments are not supported. This is the same as the *formals* of a single `case-lambda` clause.

For the first call to a generator, the arguments are bound to the *formals* and evaluation of *body* starts. During the dynamic extent of *body*, the generator can return immediately using the `yield` function. A second call to the generator resumes at the `yield` call, producing the arguments of the second call as the results of the `yield`, and so on. The eventual results of *body* are supplied to an implicit final `yield`; after that final `yield`, calling the generator again returns the same values, but all such calls must provide 0 arguments to the generator.

Examples:

```
> (define g (generator ()
              (let loop ([x '(a b c)])
                (if (null? x)
                    0
                    (begin
                      (yield (car x))
                      (loop (cdr x)))))))
> (g)
'a
> (g)
'b
> (g)
'c
> (g)
0
> (g)
0
```

```
(yield v ...) → any
  v : any/c
```

Returns *v*s from a generator, saving the point of execution inside a generator (i.e., within the dynamic extent of a `generator` body) to be resumed by the next call to the generator. The results of `yield` are the arguments that are provided to the next call of the generator.

When not in the dynamic extent of a `generator`, `infinite-generator`, or `in-generator` body, `yield` raises `exn:fail:contract`.

Examples:

```
> (define my-generator (generator () (yield 1) (yield 2 3 4)))
> (my-generator)
1
> (my-generator)
2
3
4
```

Examples:

```
> (define pass-values-generator
    (generator ()
      (let* ([from-user (yield 2)]
             [from-user-again (yield (add1 from-user))])
        (yield from-user-again))))
> (pass-values-generator)
2
> (pass-values-generator 5)
6
> (pass-values-generator 12)
12
```

```
(infinite-generator body ...+)
```

Like `generator`, but repeats evaluation of the *body*s when the last *body* completes without implicitly `yield`ing.

Examples:

```
> (define welcome
    (infinite-generator
      (yield 'hello)
      (yield 'goodbye)))
> (welcome)
'hello
> (welcome)
'goodbye
> (welcome)
'hello
> (welcome)
'goodbye
```

```
(in-generator maybe-arity body ...+)
```

```
maybe-arity =
            | #:arity arity-k
```

Produces a sequence that encapsulates the generator formed by `(generator () body ...)`. The values produced by the generator form the elements of the sequence, except for the last value produced by the generator (i.e., the values produced by returning).

Example:

```
> (for/list ([i (in-generator
                  (let loop ([x '(a b c)])
                    (when (not (null? x))
                      (yield (car x))
                      (loop (cdr x)))))])
    i)
'(a b c)
```

If `in-generator` is used immediately with a `for` (or `for/list`, etc.) binding's right-hand side, then its result arity (i.e., the number of values in each element of the sequence) can be inferred. Otherwise, if the generator produces multiple values for each element, its arity should be declared with an `#:arity arity-k` clause; the `arity-k` must be a literal, exact, non-negative integer.

Examples:

```
> (let ([g (in-generator
            (let loop ([n 3])
              (unless (zero? n) (yield n (add1 n)) (loop (sub1 n)))))])
    (let-values ([(not-empty? next) (sequence-generate g)])
      (let loop () (when (not-empty?) (next) (loop))) 'done))
stop?: arity mismatch;
 the expected number of arguments does not match the given
number
   expected: 1
   given: 2
> (let ([g (in-generator #:arity 2
            (let loop ([n 3])
              (unless (zero? n) (yield n (add1 n)) (loop (sub1 n)))))])
    (let-values ([(not-empty? next) (sequence-generate g)])
      (let loop () (when (not-empty?) (next) (loop))) 'done))
'done
```

To use an existing generator as a sequence, use `in-producer` with a stop-value known for the generator:

```
> (define abc-generator (generator ()
                          (for ([x '(a b c)])
                            (yield x))))
> (for/list ([i (in-producer abc-generator (void))])
    i)
'(a b c)
> (define my-stop-value (gensym))
> (define my-generator (generator ()
                         (let loop ([x (list 'a (void) 'c)])
                           (if (null? x)
                               my-stop-value
                               (begin
                                 (yield (car x))
                                 (loop (cdr x)))))))
> (for/list ([i (in-producer my-generator my-stop-value)])
    i)
'(a #<void> c)
```

```
(generator-state g) → symbol?
  g : generator?
```

Returns a symbol that describes the state of the generator.

- `'fresh` — The generator has been freshly created and has not been called yet.
- `'suspended` — Control within the generator has been suspended due to a call to `yield`. The generator can be called.
- `'running` — The generator is currently executing.
- `'done` — The generator has executed its entire body and will continue to produce the same result as from the last call.

Examples:

```
> (define my-generator (generator () (yield 1) (yield 2)))
> (generator-state my-generator)
'fresh
> (my-generator)
1
> (generator-state my-generator)
'suspended
> (my-generator)
2
> (generator-state my-generator)
```

```
'suspended
> (my-generator)
> (generator-state my-generator)
'done
> (define introspective-generator (generator () ((yield 1))))
> (introspective-generator)
1
> (introspective-generator
   (lambda () (generator-state introspective-generator)))
'running
> (generator-state introspective-generator)
'done
> (introspective-generator)
'running
```

```
(sequence->generator s) → (-> any)
  s : sequence?
```

Converts a sequence to a generator. The generator returns the next element of the sequence each time the generator is invoked, where each element of the sequence must be a single value. When the sequence ends, the generator returns `#<void>` as its final result.

```
(sequence->repeated-generator s) → (-> any)
  s : sequence?
```

Like `sequence->generator`, but when `s` has no further values, the generator starts the sequence again (so that the generator never stops producing values).

4.18 Dictionaries

A *dictionary* is an instance of a datatype that maps keys to values. The following datatypes are all dictionaries:

- hash tables;
- vectors (using only exact integers as keys);
- lists of pairs as an *association list* using `equal?` to compare keys, which must be distinct; and
- structures whose types implement the `gen:dict` generic interface.

When list of pairs is used as association list but does not have distinct keys (so it's not an association list), operations like `dict-ref` and `dict-remove` operate on the first instance of the key, while operations like dict-map and dict-keys produce an element for every instance of the key.

```
(require racket/dict)        package: base
```

The bindings documented in this section are provided by the racket/dict and racket libraries, but not racket/base.

4.18.1 Dictionary Predicates and Contracts

```
(dict? v) → boolean?
  v : any/c
```

Returns #t if *v* is a dictionary, #f otherwise.

Beware that dict? is not a constant-time test on pairs, since checking that *v* is an association list may require traversing the list.

Examples:

```
> (dict? #hash((a . "apple")))
#t
> (dict? '#("apple" "banana"))
#t
> (dict? '("apple" "banana"))
#f
> (dict? '((a . "apple") (b . "banana")))
#t
```

```
(dict-implements? d sym ...) → boolean?
  d : dict?
  sym : symbol?
```

Returns #t if *d* implements all of the methods from gen:dict named by the *sym*s; returns #f otherwise. Fallback implementations do not affect the result; *d* may support the given methods via fallback implementations yet produce #f.

Examples:

```
> (dict-implements? (hash 'a "apple") 'dict-set!)
#f
> (dict-implements? (make-hash '((a . "apple") (b . "ba-
nana"))) 'dict-set!)
#t
```

```
> (dict-implements? (make-hash '((b . "banana") (a . "ap-
ple"))) 'dict-remove!)
#t
> (dict-implements? (vector "apple" "banana") 'dict-set!)
#t
> (dict-implements? (vector 'a 'b) 'dict-remove!)
#f
> (dict-implements? (vector 'a "apple") 'dict-set! 'dict-remove!)
#f
```

```
(dict-implements/c sym ...) → flat-contract?
  sym : symbol?
```

Recognizes dictionaries that support all of the methods from `gen:dict` named by the *sym*s. Note that the generated contract is not similar to `hash/c`, but closer to `dict-implements?`.

Examples:

```
> (struct deformed-dict ()
    #:methods gen:dict [])
> (define/contract good-dict
    (dict-implements/c)
    (deformed-dict))
> (define/contract bad-dict
    (dict-implements/c 'dict-ref)
    (deformed-dict))
bad-dict: broke its own contract
  promised: (dict-implements/c dict-ref)
  produced: #<deformed-dict>
  in: (dict-implements/c dict-ref)
  contract from: (definition bad-dict)
  blaming: (definition bad-dict)
   (assuming the contract is correct)
  at: eval:14:0
```

```
(dict-mutable? d) → boolean?
  d : dict?
```

Returns `#t` if *d* is mutable via `dict-set!`, `#f` otherwise.

Equivalent to `(dict-implements? d 'dict-set!)`.

Examples:

```
> (dict-mutable? #hash((a . "apple")))
```

```
#f
> (dict-mutable? (make-hash))
#t
> (dict-mutable? '#("apple" "banana"))
#f
> (dict-mutable? (vector "apple" "banana"))
#t
> (dict-mutable? '((a . "apple") (b . "banana")))
#f
```

```
(dict-can-remove-keys? d) → boolean?
  d : dict?
```

Returns `#t` if *d* supports removing mappings via `dict-remove!` and/or `dict-remove`, `#f` otherwise.

Equivalent to `(or (dict-implements? d 'dict-remove!) (dict-implements? d 'dict-remove))`.

Examples:

```
> (dict-can-remove-keys? #hash((a . "apple")))
#t
> (dict-can-remove-keys? '#("apple" "banana"))
#f
> (dict-can-remove-keys? '((a . "apple") (b . "banana")))
#t
```

```
(dict-can-functional-set? d) → boolean?
  d : dict?
```

Returns `#t` if *d* supports functional update via `dict-set`, `#f` otherwise.

Equivalent to `(dict-implements? d 'dict-set)`.

Examples:

```
> (dict-can-functional-set? #hash((a . "apple")))
#t
> (dict-can-functional-set? (make-hash))
#f
> (dict-can-functional-set? '#("apple" "banana"))
#f
> (dict-can-functional-set? '((a . "apple") (b . "banana")))
#t
```

4.18.2 Generic Dictionary Interface

```
gen:dict
```

A generic interface (see §5.4 "Generic Interfaces") that supplies dictionary method implementations for a structure type via the `#:methods` option of `struct` definitions. This interface can be used to implement any of the methods documented as §4.18.2.1 "Primitive Dictionary Methods" and §4.18.2.2 "Derived Dictionary Methods".

Examples:

```
> (struct alist (v)
    #:methods gen:dict
    [(define (dict-ref dict key
                       [default (lambda () (error "key not
found" key))])
       (cond [(assoc key (alist-v dict)) => cdr]
             [else (if (procedure? default) (default) default)]))
     (define (dict-set dict key val)
       (alist (cons (cons key val) (alist-v dict))))
     (define (dict-remove dict key)
       (define al (alist-v dict))
       (alist (remove* (filter (λ (p) (equal? (car p) key)) al) al)))
     (define (dict-count dict)
       (length (remove-duplicates (alist-v dict) #:key car)))])
; etc. other methods
> (define d1 (alist '((1 . a) (2 . b))))
> (dict? d1)
#t
> (dict-ref d1 1)
'a
> (dict-remove d1 1)
#<alist>
```

```
prop:dict : struct-type-property?
```

A structure type property used to define custom extensions to the dictionary API. Using the `prop:dict` property is discouraged; use the `gen:dict` generic interface instead. Accepts a vector of 10 method implementations:

- `dict-ref`
- `dict-set!`, or `#f` if unsupported
- `dict-set`, or `#f` if unsupported

- dict-remove!, or #f if unsupported
- dict-remove, or #f if unsupported
- dict-count
- dict-iterate-first
- dict-iterate-next
- dict-iterate-key
- dict-iterate-value

Primitive Dictionary Methods

These methods of gen:dict have no fallback implementations; they are only supported for dictionary types that directly implement them.

```
(dict-ref dict key [failure-result]) → any
  dict : dict?
  key : any/c
  failure-result : failure-result/c
                 = (lambda () (raise (make-exn:fail ....)))
```

Returns the value for *key* in *dict*. If no value is found for *key*, then *failure-result* determines the result:

- If *failure-result* is a procedure, it is called (through a tail call) with no arguments to produce the result.
- Otherwise, *failure-result* is returned as the result.

Examples:

```
> (dict-ref #hash((a . "apple") (b . "beer")) 'a)
"apple"
> (dict-ref #hash((a . "apple") (b . "beer")) 'c)
hash-ref: no value found for key
  key: 'c
> (dict-ref #hash((a . "apple") (b . "beer")) 'c #f)
#f
> (dict-ref '((a . "apple") (b . "banana")) 'b)
"banana"
> (dict-ref #("apple" "banana") 1)
"banana"
> (dict-ref #("apple" "banana") 3 #f)
```

```
#f
> (dict-ref #("apple" "banana") -3 #f)
dict-ref: contract violation
  expected: natural?
  given: -3
  in: the k argument of
      (->i
       ((d dict?) (k (d) (dict-key-contract d)))
       ((default any/c))
       any)
  contract from: <collects>/racket/dict.rkt
  blaming: top-level
   (assuming the contract is correct)
  at: <collects>/racket/dict.rkt:182:2
```

```
(dict-set! dict key v) → void?
  dict : (and/c dict? (not/c immutable?))
  key : any/c
  v : any/c
```

Maps *key* to *v* in *dict*, overwriting any existing mapping for *key*. The update can fail with a `exn:fail:contract` exception if *dict* is not mutable or if *key* is not an allowed key for the dictionary (e.g., not an exact integer in the appropriate range when *dict* is a vector).

Examples:

```
> (define h (make-hash))
> (dict-set! h 'a "apple")
> h
'#hash((a . "apple"))
> (define v (vector #f #f #f))
> (dict-set! v 0 "apple")
> v
'#("apple" #f #f)
```

```
(dict-set dict key v) → (and/c dict? immutable?)
  dict : (and/c dict? immutable?)
  key : any/c
  v : any/c
```

Functionally extends *dict* by mapping *key* to *v*, overwriting any existing mapping for *key*, and returning an extended dictionary. The update can fail with a `exn:fail:contract` exception if *dict* does not support functional extension or if *key* is not an allowed key for the dictionary.

Examples:

```
> (dict-set #hash() 'a "apple")
'#hash((a . "apple"))
> (dict-set #hash((a . "apple") (b . "beer")) 'b "banana")
'#hash((a . "apple") (b . "banana"))
> (dict-set '() 'a "apple")
'((a . "apple"))
> (dict-set '((a . "apple") (b . "beer")) 'b "banana")
'((a . "apple") (b . "banana"))
```

```
(dict-remove! dict key) → void?
  dict : (and/c dict? (not/c immutable?))
  key : any/c
```

Removes any existing mapping for *key* in *dict*. The update can fail if *dict* is not mutable or does not support removing keys (as is the case for vectors, for example).

Examples:

```
> (define h (make-hash))
> (dict-set! h 'a "apple")
> h
'#hash((a . "apple"))
> (dict-remove! h 'a)
> h
'#hash()
```

```
(dict-remove dict key) → (and/c dict? immutable?)
  dict : (and/c dict? immutable?)
  key : any/c
```

Functionally removes any existing mapping for *key* in *dict*, returning the fresh dictionary. The update can fail if *dict* does not support functional update or does not support removing keys.

Examples:

```
> (define h #hash())
> (define h (dict-set h 'a "apple"))
> h
'#hash((a . "apple"))
> (dict-remove h 'a)
'#hash()
> h
'#hash((a . "apple"))
> (dict-remove h 'z)
```

```
'#hash((a . "apple"))
> (dict-remove '((a . "apple") (b . "banana")) 'a)
'((b . "banana"))
```

```
(dict-iterate-first dict) → any/c
  dict : dict?
```

Returns `#f` if *dict* contains no elements, otherwise it returns a non-`#f` value that is an index to the first element in the dict table; “first” refers to an unspecified ordering of the dictionary elements. For a mutable *dict*, this index is guaranteed to refer to the first item only as long as no mappings are added to or removed from *dict*.

Examples:

```
> (dict-iterate-first #hash((a . "apple") (b . "banana")))
0
> (dict-iterate-first #hash())
#f
> (dict-iterate-first #("apple" "banana"))
0
> (dict-iterate-first '((a . "apple") (b . "banana")))
#<assoc-iter>
```

```
(dict-iterate-next dict pos) → any/c
  dict : dict?
  pos : any/c
```

Returns either a non-`#f` that is an index to the element in *dict* after the element indexed by *pos* or `#f` if *pos* refers to the last element in *dict*. If *pos* is not a valid index, then the `exn:fail:contract` exception is raised. For a mutable *dict*, the result index is guaranteed to refer to its item only as long as no items are added to or removed from *dict*. The `dict-iterate-next` operation should take constant time.

Examples:

```
> (define h #hash((a . "apple") (b . "banana")))
> (define i (dict-iterate-first h))
> i
0
> (dict-iterate-next h i)
1
> (dict-iterate-next h (dict-iterate-next h i))
#f
```

```
(dict-iterate-key dict pos) → any
  dict : dict?
  pos : any/c
```

Returns the key for the element in `dict` at index `pos`. If `pos` is not a valid index for `dict`, the `exn:fail:contract` exception is raised. The `dict-iterate-key` operation should take constant time.

Examples:

```
> (define h '((a . "apple") (b . "banana")))
> (define i (dict-iterate-first h))
> (dict-iterate-key h i)
'a
> (dict-iterate-key h (dict-iterate-next h i))
'b
```

```
(dict-iterate-value dict pos) → any
  dict : dict?
  pos : any/c
```

Returns the value for the element in `dict` at index `pos`. If `pos` is not a valid index for `dict`, the `exn:fail:contract` exception is raised. The `dict-iterate-key` operation should take constant time.

Examples:

```
> (define h '((a . "apple") (b . "banana")))
> (define i (dict-iterate-first h))
> (dict-iterate-value h i)
"apple"
> (dict-iterate-value h (dict-iterate-next h i))
"banana"
```

Derived Dictionary Methods

These methods of `gen:dict` have fallback implementations in terms of the other methods; they may be supported even by dictionary types that do not directly implement them.

```
(dict-has-key? dict key) → boolean?
  dict : dict?
  key : any/c
```

Returns `#t` if `dict` contains a value for the given `key`, `#f` otherwise.

Supported for any *dict* that implements `dict-ref`.

Examples:

```
> (dict-has-key? #hash((a . "apple") (b . "beer")) 'a)
#t
> (dict-has-key? #hash((a . "apple") (b . "beer")) 'c)
#f
> (dict-has-key? '((a . "apple") (b . "banana")) 'b)
#t
> (dict-has-key? #("apple" "banana") 1)
#t
> (dict-has-key? #("apple" "banana") 3)
#f
> (dict-has-key? #("apple" "banana") -3)
#f
```

```
(dict-set*! dict key v ... ...) → void?
  dict : (and/c dict? (not/c immutable?))
  key : any/c
  v : any/c
```

Maps each *key* to each *v* in *dict*, overwriting any existing mapping for each *key*. The update can fail with a `exn:fail:contract` exception if *dict* is not mutable or if any *key* is not an allowed key for the dictionary (e.g., not an exact integer in the appropriate range when *dict* is a vector). The update takes place from the left, so later mappings overwrite earlier mappings.

Supported for any *dict* that implements `dict-set!`.

Examples:

```
> (define h (make-hash))
> (dict-set*! h 'a "apple" 'b "banana")
> h
'#hash((a . "apple") (b . "banana"))
> (define v1 (vector #f #f #f))
> (dict-set*! v1 0 "apple" 1 "banana")
> v1
'#("apple" "banana" #f)
> (define v2 (vector #f #f #f))
> (dict-set*! v2 0 "apple" 0 "banana")
> v2
'#("banana" #f #f)
```

```
(dict-set* dict key v ... ...) → (and/c dict? immutable?)
  dict : (and/c dict? immutable?)
  key : any/c
  v : any/c
```

Functionally extends *dict* by mapping each *key* to each *v*, overwriting any existing mapping for each *key*, and returning an extended dictionary. The update can fail with a `exn:fail:contract` exception if *dict* does not support functional extension or if any *key* is not an allowed key for the dictionary. The update takes place from the left, so later mappings overwrite earlier mappings.

Supported for any *dict* that implements `dict-set`.

Examples:

```
> (dict-set* #hash() 'a "apple" 'b "beer")
'#hash((a . "apple") (b . "beer"))
> (dict-set* #hash((a . "apple") (b . "beer")) 'b "banana" 'a "anchor")
'#hash((a . "anchor") (b . "banana"))
> (dict-set* '() 'a "apple" 'b "beer")
'((a . "apple") (b . "beer"))
> (dict-set* '((a . "apple") (b . "beer")) 'b "banana" 'a "anchor")
'((a . "anchor") (b . "banana"))
> (dict-set* '((a . "apple") (b . "beer")) 'b "banana" 'b "ballistic")
'((a . "apple") (b . "ballistic"))
```

```
(dict-ref! dict key to-set) → any
  dict : dict?
  key : any/c
  to-set : any/c
```

Returns the value for *key* in *dict*. If no value is found for *key*, then *to-set* determines the result as in `dict-ref` (i.e., it is either a thunk that computes a value or a plain value), and this result is stored in *dict* for the *key*. (Note that if *to-set* is a thunk, it is not invoked in tail position.)

Supported for any *dict* that implements `dict-ref` and `dict-set!`.

Examples:

```
> (dict-ref! (make-hasheq '((a . "apple") (b . "beer"))) 'a #f)
"apple"
> (dict-ref! (make-hasheq '((a . "apple") (b .
"beer"))) 'c 'cabbage)
'cabbage
```

```
> (define h (make-hasheq '((a . "apple") (b . "beer"))))
> (dict-ref h 'c)
hash-ref: no value found for key
  key: 'c
> (dict-ref! h 'c (λ () 'cabbage))
'cabbage
> (dict-ref h 'c)
'cabbage
```

```
(dict-update! dict
              key
              updater
             [failure-result]) → void?
  dict : (and/c dict? (not/c immutable?))
  key : any/c
  updater : (any/c . -> . any/c)
  failure-result : failure-result/c
                 = (lambda () (raise (make-exn:fail ....)))
```

Composes `dict-ref` and `dict-set!` to update an existing mapping in *dict*, where the optional *failure-result* argument is used as in `dict-ref` when no mapping exists for *key* already.

Supported for any *dict* that implements `dict-ref` and `dict-set!`.

Examples:

```
> (define h (make-hash))
> (dict-update! h 'a add1)
hash-update!: no value found for key: 'a
> (dict-update! h 'a add1 0)
> h
'#hash((a . 1))
> (define v (vector #f #f #f))
> (dict-update! v 0 not)
> v
'#(#t #f #f)
```

```
(dict-update dict key updater [failure-result])
 → (and/c dict? immutable?)
  dict : dict?
  key : any/c
  updater : (any/c . -> . any/c)
  failure-result : failure-result/c
                 = (lambda () (raise (make-exn:fail ....)))
```

Composes `dict-ref` and `dict-set` to functionally update an existing mapping in *dict*, where the optional *failure-result* argument is used as in `dict-ref` when no mapping exists for *key* already.

Supported for any *dict* that implements `dict-ref` and `dict-set`.

Examples:

```
> (dict-update #hash() 'a add1)
hash-update: no value found for key: 'a
> (dict-update #hash() 'a add1 0)
'#hash((a . 1))
> (dict-update #hash((a . "apple") (b . "beer")) 'b string-length)
'#hash((a . "apple") (b . 4))
```

```
(dict-map dict proc) → (listof any/c)
  dict : dict?
  proc : (any/c any/c . -> . any/c)
```

Applies the procedure *proc* to each element in *dict* in an unspecified order, accumulating the results into a list. The procedure *proc* is called each time with a key and its value.

Supported for any *dict* that implements `dict-iterate-first`, `dict-iterate-next`, `dict-iterate-key`, and `dict-iterate-value`.

Example:

```
> (dict-map #hash((a . "apple") (b . "banana")) vector)
'(#(b "banana") #(a "apple"))
```

```
(dict-map/copy dict proc) → dict?
  dict : dict?
  proc : (any/c any/c . -> . (values any/c any/c))
```

Applies the procedure *proc* to each element in *dict* in an unspecified order, accumulating the results into a dict of the same kind. The procedure *proc* is called each time with a key and its value, and must return a corresponding key and value.

Supported for any *dict* that implements `dict-iterate-first`, `dict-iterate-next`, `dict-iterate-key`, and `dict-iterate-value`, and either `dict-set` and `dict-clear`, or `dict-set!`, `dict-copy`, and `dict-clear!`.

Example:

```
> (dict-map/copy #hash((a . "apple") (b . "ba-
nana")) (lambda (k v) (values k (string-upcase v))))
'#hash((a . "APPLE") (b . "BANANA"))
```

Added in version 8.5.0.2 of package base.

```
(dict-for-each dict proc) → void?
  dict : dict?
  proc : (any/c any/c . -> . any)
```

Applies *proc* to each element in *dict* (for the side-effects of *proc*) in an unspecified order. The procedure *proc* is called each time with a key and its value.

Supported for any *dict* that implements `dict-iterate-first`, `dict-iterate-next`, `dict-iterate-key`, and `dict-iterate-value`.

Example:

```
> (dict-for-each #hash((a . "apple") (b . "banana"))
                 (lambda (k v)
                   (printf "~a = ~s\n" k v)))
b = "banana"
a = "apple"
```

```
(dict-empty? dict) → boolean?
  dict : dict?
```

Reports whether *dict* is empty.

Supported for any *dict* that implements `dict-iterate-first`.

Examples:

```
> (dict-empty? #hash((a . "apple") (b . "banana")))
#f
> (dict-empty? (vector))
#t
```

```
(dict-count dict) → exact-nonnegative-integer?
  dict : dict?
```

Returns the number of keys mapped by *dict*, usually in constant time.

Supported for any *dict* that implements `dict-iterate-first` and `dict-iterate-next`.

Examples:

```
> (dict-count #hash((a . "apple") (b . "banana")))
2
> (dict-count #("apple" "banana"))
2
```

```
(dict-copy dict) → dict?
  dict : dict?
```

Produces a new, mutable dictionary of the same type as *dict* and with the same key/value associations.

Supported for any *dict* that implements `dict-clear`, `dict-set!`, `dict-iterate-first`, `dict-iterate-next`, `dict-iterate-key`, and `dict-iterate-value`.

Examples:

```
> (define original (vector "apple" "banana"))
> (define copy (dict-copy original))
> original
'#("apple" "banana")
> copy
'#("apple" "banana")
> (dict-set! copy 1 "carrot")
> original
'#("apple" "banana")
> copy
'#("apple" "carrot")
```

```
(dict-clear dict) → dict?
  dict : dict?
```

Produces an empty dictionary of the same type as *dict*. If *dict* is mutable, the result must be a new dictionary.

Supported for any *dict* that supports `dict-remove`, `dict-iterate-first`, `dict-iterate-next`, and `dict-iterate-key`.

Examples:

```
> (dict-clear #hash((a . "apple") ("banana" . b)))
'#hash()
> (dict-clear '((1 . two) (three . "four")))
'()
```

```
(dict-clear! dict) → void?
  dict : dict?
```

Removes all of the key/value associations in *dict*.

Supported for any *dict* that supports dict-remove!, dict-iterate-first, and dict-iterate-key.

Examples:

```
> (define table (make-hash))
> (dict-set! table 'a "apple")
> (dict-set! table "banana" 'b)
> table
'#hash((a . "apple") ("banana" . b))
> (dict-clear! table)
> table
'#hash()
```

```
(dict-keys dict) → list?
  dict : dict?
```

Returns a list of the keys from *dict* in an unspecified order.

Supported for any *dict* that implements dict-iterate-first, dict-iterate-next, and dict-iterate-key.

Examples:

```
> (define h #hash((a . "apple") (b . "banana")))
> (dict-keys h)
'(b a)
```

```
(dict-values dict) → list?
  dict : dict?
```

Returns a list of the values from *dict* in an unspecified order.

Supported for any *dict* that implements dict-iterate-first, dict-iterate-next, and dict-iterate-value.

Examples:

```
> (define h #hash((a . "apple") (b . "banana")))
> (dict-values h)
'("banana" "apple")
```

```
(dict->list dict) → list?
  dict : dict?
```

Returns a list of the associations from *dict* in an unspecified order.

Supported for any *dict* that implements `dict-iterate-first`, `dict-iterate-next`, `dict-iterate-key`, and `dict-iterate-value`.

Examples:

```
> (define h #hash((a . "apple") (b . "banana")))
> (dict->list h)
'((b . "banana") (a . "apple"))
```

4.18.3 Dictionary Sequences

```
(in-dict dict) → sequence?
  dict : dict?
```

Returns a sequence whose each element is two values: a key and corresponding value from *dict*.

Supported for any *dict* that implements `dict-iterate-first`, `dict-iterate-next`, `dict-iterate-key`, and `dict-iterate-value`.

Examples:

```
> (define h #hash((a . "apple") (b . "banana")))
> (for/list ([(k v) (in-dict h)])
    (format "~a = ~s" k v))
'("b = \"banana\"" "a = \"apple\"")
```

```
(in-dict-keys dict) → sequence?
  dict : dict?
```

Returns a sequence whose elements are the keys of *dict*.

Supported for any *dict* that implements `dict-iterate-first`, `dict-iterate-next`, and `dict-iterate-key`.

Examples:

```
> (define h #hash((a . "apple") (b . "banana")))
> (for/list ([k (in-dict-keys h)])
    k)
'(b a)
```

```
(in-dict-values dict) → sequence?
  dict : dict?
```

Returns a sequence whose elements are the values of `dict`.

Supported for any `dict` that implements `dict-iterate-first`, `dict-iterate-next`, and `dict-iterate-value`.

Examples:

```
> (define h #hash((a . "apple") (b . "banana")))
> (for/list ([v (in-dict-values h)])
    v)
'("banana" "apple")
```

```
(in-dict-pairs dict) → sequence?
  dict : dict?
```

Returns a sequence whose elements are pairs, each containing a key and its value from `dict` (as opposed to using `in-dict`, which gets the key and value as separate values for each element).

Supported for any `dict` that implements `dict-iterate-first`, `dict-iterate-next`, `dict-iterate-key`, and `dict-iterate-value`.

Examples:

```
> (define h #hash((a . "apple") (b . "banana")))
> (for/list ([p (in-dict-pairs h)])
    p)
'((b . "banana") (a . "apple"))
```

4.18.4 Contracted Dictionaries

```
prop:dict/contract : struct-type-property?
```

A structure type property for defining dictionaries with contracts. The value associated with `prop:dict/contract` must be a list of two immutable vectors:

```
(list dict-vector
      (vector type-key-contract
              type-value-contract
              type-iter-contract
```

```
                 instance-key-contract
                 instance-value-contract
                 instance-iter-contract))
```

The first vector must be a vector of 10 procedures which match the `gen:dict` generic interface (in addition, it must be an immutable vector). The second vector must contain six elements; each of the first three is a contract for the dictionary type's keys, values, and positions, respectively. Each of the second three is either `#f` or a procedure used to extract the contract from a dictionary instance.

```
(dict-key-contract d) → contract?
  d : dict?
(dict-value-contract d) → contract?
  d : dict?
(dict-iter-contract d) → contract?
  d : dict?
```

Returns the contract that *d* imposes on its keys, values, or iterators, respectively, if *d* implements the `prop:dict/contract` interface.

4.18.5 Custom Hash Tables

```
(define-custom-hash-types name
                          optional-predicate
                          comparison-expr
                          optional-hash-functions)

     optional-predicate =
                        | #:key? predicate-expr

optional-hash-functions =
                        | hash1-expr
                        | hash1-expr hash2-expr
```

Creates a new dictionary type based on the given comparison *comparison-expr*, hash functions *hash1-expr* and *hash2-expr*, and key predicate *predicate-expr*; the interfaces for these functions are the same as in `make-custom-hash-types`. The new dictionary type has three variants: immutable, mutable with strongly-held keys, and mutable with weakly-held keys.

Defines seven names:

- *name?* recognizes instances of the new type,

- `immutable-name?` recognizes immutable instances of the new type,
- `mutable-name?` recognizes mutable instances of the new type with strongly-held keys,
- `weak-name?` recognizes mutable instances of the new type with weakly-held keys,
- `make-immutable-name` constructs immutable instances of the new type,
- `make-mutable-name` constructs mutable instances of the new type with strongly-held keys, and
- `make-weak-name` constructs mutable instances of the new type with weakly-held keys.

The constructors all accept a dictionary as an optional argument, providing initial key/value pairs.

Examples:

```
> (define-custom-hash-types string-hash
                            #:key? string?
                            string=?
                            string-length)
> (define imm
    (make-immutable-string-hash
     '(("apple" . a) ("banana" . b))))
> (define mut
    (make-mutable-string-hash
     '(("apple" . a) ("banana" . b))))
> (dict? imm)
#t
> (dict? mut)
#t
> (string-hash? imm)
#t
> (string-hash? mut)
#t
> (immutable-string-hash? imm)
#t
> (immutable-string-hash? mut)
#f
> (dict-ref imm "apple")
'a
> (dict-ref mut "banana")
'b
> (dict-set! mut "banana" 'berry)
```

```
> (dict-ref mut "banana")
'berry
> (equal? imm mut)
#f
> (equal? (dict-remove (dict-remove imm "apple") "banana")
          (make-immutable-string-hash))
#t
```

```
(make-custom-hash-types  eql?
                        [hash1
                         hash2
                         #:key? key?
                         #:name name
                         #:for who]) → (any/c . -> . boolean?)
                                       (any/c . -> . boolean?)
                                       (any/c . -> . boolean?)
                                       (any/c . -> . boolean?)
                                       (->* [] [dict?] dict?)
                                       (->* [] [dict?] dict?)
                                       (->* [] [dict?] dict?)
  eql? : (or/c (any/c any/c . -> . any/c)
               (any/c any/c (any/c any/c . -> . any/c) . -> . any/c))
  hash1 : (or/c (any/c . -> . exact-integer?)
                (any/c (any/c . -> . exact-integer?) . -> . exact-integer?))
        = (const 1)
  hash2 : (or/c (any/c . -> . exact-integer?)
                (any/c (any/c . -> . exact-integer?) . -> . exact-integer?))
        = (const 1)
  key? : (any/c . -> . boolean?) = (const #true)
  name : symbol? = 'custom-hash
  who : symbol? = 'make-custom-hash-types
```

Creates a new dictionary type based on the given comparison function `eql?`, hash functions `hash1` and `hash2`, and predicate `key?`. The new dictionary type has variants that are immutable, mutable with strongly-held keys, and mutable with weakly-held keys. The given `name` is used when printing instances of the new dictionary type, and the symbol `who` is used for reporting errors.

The comparison function `eql?` may accept 2 or 3 arguments. If it accepts 2 arguments, it given two keys to compare them. If it accepts 3 arguments and does not accept 2 arguments, it is also given a recursive comparison function that handles data cycles when comparing sub-parts of the keys.

The hash functions `hash1` and `hash2` may accept 1 or 2 arguments. If either hash function accepts 1 argument, it is applied to a key to compute the corresponding hash value. If either hash function accepts 2 arguments and does not accept 1 argument, it is also given a recursive hash function that handles data cycles when computing hash values of sub-parts of the keys.

The predicate *key?* must accept 1 argument and is used to recognize valid keys for the new dictionary type.

Produces seven values:

- a predicate recognizing all instances of the new dictionary type,
- a predicate recognizing immutable instances,
- a predicate recognizing mutable instances,
- a predicate recognizing weak instances,
- a constructor for immutable instances,
- a constructor for mutable instances, and
- a constructor for weak instances.

See `define-custom-hash-types` for an example.

```
(make-custom-hash  eql?
                  [hash1
                   hash2
                   #:key? key?]) → dict?
  eql? : (or/c (any/c any/c . -> . any/c)
               (any/c any/c (any/c any/c . -> . any/c) . -> . any/c))
  hash1 :  (or/c (any/c . -> . exact-integer?)
                 (any/c (any/c . -> . exact-integer?) . -> . exact-integer?))
        = (const 1)
  hash2 :  (or/c (any/c . -> . exact-integer?)
                 (any/c (any/c . -> . exact-integer?) . -> . exact-integer?))
        = (const 1)
  key? : (any/c . -> . boolean?) = (λ (x) #true)
```

```
(make-weak-custom-hash  eql?
                       [hash1
                        hash2
                        #:key? key?]) → dict?
  eql? : (or/c (any/c any/c . -> . any/c)
               (any/c any/c (any/c any/c . -> . any/c) . -> . any/c))
  hash1 :  (or/c (any/c . -> . exact-integer?)
                 (any/c (any/c . -> . exact-integer?) . -> . exact-integer?))
        = (const 1)
  hash2 :  (or/c (any/c . -> . exact-integer?)
                 (any/c (any/c . -> . exact-integer?) . -> . exact-integer?))
        = (const 1)
  key? : (any/c . -> . boolean?) = (λ (x) #true)
(make-immutable-custom-hash  eql?
                            [hash1
                             hash2
                             #:key? key?]) → dict?
  eql? : (or/c (any/c any/c . -> . any/c)
               (any/c any/c (any/c any/c . -> . any/c) . -> . any/c))
  hash1 :  (or/c (any/c . -> . exact-integer?)
                 (any/c (any/c . -> . exact-integer?) . -> . exact-integer?))
        = (const 1)
  hash2 :  (or/c (any/c . -> . exact-integer?)
                 (any/c (any/c . -> . exact-integer?) . -> . exact-integer?))
        = (const 1)
  key? : (any/c . -> . boolean?) = (λ (x) #true)
```

Creates an instance of a new dictionary type, implemented in terms of a hash table where keys are compared with *eql?*, hashed with *hash1* and *hash2*, and where the key predicate is *key?*. See `gen:equal-mode+hash` and `gen:equal+hash` for information on suitable equality and hashing functions.

The `make-custom-hash` and `make-weak-custom-hash` functions create a mutable dictionary that does not support functional update, while `make-immutable-custom-hash` creates an immutable dictionary that supports functional update. The dictionary created by `make-weak-custom-hash` retains its keys weakly, like the result of `make-weak-hash`.

Dictionaries created by `make-custom-hash` and company are `equal?` when they have the same mutability and key strength, the associated procedures are `equal?`, and the key–value mappings are the same when keys and values are compared with `equal?`.

See also `define-custom-hash-types`.

Examples:

```
> (define h (make-custom-hash (lambda (a b)
                                (string=? (format "~a" a)
```

```
                                         (format "~a" b)))
                                  (lambda (a)
                                    (equal-hash-code
                                     (format "~a" a)))))
> (dict-set! h 1 'one)
> (dict-ref h "1")
'one
```

4.18.6 Passing Keyword Arguments in Dictionaries

```
(keyword-apply/dict proc
                    kw-dict
                    pos-arg ...
                    pos-args
                    #:<kw> kw-arg ...) → any
  proc : procedure?
  kw-dict : dict?
  pos-arg : any/c
  pos-args : (listof any/c)
  kw-arg : any/c
```

Applies the *proc* using the positional arguments from `(list* pos-arg ... pos-args)`, and the keyword arguments from *kw-dict* in addition to the directly supplied keyword arguments in the `#:<kw> kw-arg` sequence.

All the keys in *kw-dict* must be keywords. The keywords in the *kw-dict* do not have to be sorted. However, the keywords in *kw-dict* and the directly supplied `#:<kw>` keywords must not overlap. The given *proc* must accept all of the keywords in *kw-dict* plus the `#:<kw>`s.

Examples:

```
> (define (sundae #:ice-cream [ice-cream '("vanilla")]
                  #:toppings [toppings '("brownie-bits")]
                  #:sprinkles [sprinkles "chocolate"]
                  #:syrup [syrup "caramel"])
    (format "A sundae with ~a ice cream, ~a, ~a sprinkles, and ~a
syrup."
            (string-join ice-cream #:before-last " and ")
            (string-join toppings #:before-last " and ")
            sprinkles
            syrup))
> (keyword-apply/dict sundae '((#:ice-cream   "chocolate"))  '())
"A sundae with chocolate ice cream, brownie-bits, chocolate sprin-
kles, and caramel syrup."
```

```
> (keyword-apply/dict sundae
                      (hash '#:toppings '("cookie-dough")
                            '#:sprinkles "rainbow"
                            '#:syrup "chocolate")
                      '())
"A sundae with vanilla ice cream, cookie-dough, rainbow sprinkles,
and chocolate syrup."
> (keyword-apply/dict sundae
                      #:sprinkles "rainbow"
                      (hash '#:toppings '("cookie-dough")
                            '#:syrup "chocolate")
                      '())
"A sundae with vanilla ice cream, cookie-dough, rainbow sprinkles,
and chocolate syrup."
```

Added in version 7.9 of package `base`.

4.19 Sets

A *set* represents a collection of distinct elements. The following datatypes are all sets:

- hash sets;
- lists using `equal?` to compare elements; and
- structures whose types implement the `gen:set` generic interface.

```
(require racket/set)
```
package: `base`

The bindings documented in this section are provided by the `racket/set` and `racket` libraries, but not `racket/base`.

4.19.1 Hash Sets

A *hash set* is a set whose elements are compared via `equal?`, `equal-always?`, `eqv?`, or `eq?` and partitioned via `equal-hash-code`, `equal-always-hash-code`, `eqv-hash-code`, or `eq-hash-code`. A hash set is either immutable or mutable; mutable hash sets retain their elements either strongly or weakly.

Like operations on immutable hash tables, "constant time" hash set operations actually require $O(log\ N)$ time for a set of size N.

A hash set can be used as a stream (see §4.17.2 "Streams") and thus as a single-valued sequence (see §4.17.1 "Sequences"). The elements of the set serve as elements of the stream or sequence. If an element is added to or removed from the hash set during iteration, then an iteration step may fail with exn:fail:contract, or the iteration may skip or duplicate elements. See also in-set.

Two hash sets are equal? when they use the same element-comparison procedure (equal?, equal-always?, eqv?, or eq?), both hold elements strongly or weakly, have the same mutability, and have equivalent elements. Immutable hash sets support effectively constant-time access and update, just like mutable hash sets; the constant on immutable operations is usually larger, but the functional nature of immutable hash sets can pay off in certain algorithms.

All hash sets implement set->stream, set-empty?, set-member?, set-count, subset?, proper-subset?, set-map, set-for-each, set-copy, set-copy-clear, set->list, and set-first. Immutable hash sets in addition implement set-add, set-remove, set-clear, set-union, set-intersect, set-subtract, and set-symmetric-difference. Mutable hash sets in addition implement set-add!, set-remove!, set-clear!, set-union!, set-intersect!, set-subtract!, and set-symmetric-difference!.

Operations on sets that contain elements that are mutated are unpredictable in much the same way that hash table operations are unpredictable when keys are mutated.

```
(set-equal? x) → boolean?
  x : any/c
(set-equal-always? x) → boolean?
  x : any/c
(set-eqv? x) → boolean?
  x : any/c
(set-eq? x) → boolean?
  x : any/c
```

Returns #t if *x* is a hash set that compares elements with equal?, equal-always?, eqv?, or eq?, respectively; returns #f otherwise.

Changed in version 8.5.0.3 of package base: Added set-equal-always?.

```
(set? x) → boolean?
  x : any/c
(set-mutable? x) → boolean?
  x : any/c
(set-weak? x) → boolean?
  x : any/c
```

Returns #t if *x* is a hash set that is respectively immutable, mutable with strongly-held keys, or mutable with weakly-held keys; returns #f otherwise.

```
(set v ...) → (and/c generic-set? set-equal? set?)
  v : any/c
```

```
(setalw v ...) → (and/c generic-set? set-equal-always? set?)
  v : any/c
(seteqv v ...) → (and/c generic-set? set-eqv? set?)
  v : any/c
(seteq v ...) → (and/c generic-set? set-eq? set?)
  v : any/c
(mutable-set v ...)
 → (and/c generic-set? set-equal? set-mutable?)
  v : any/c
(mutable-setalw v ...)
 → (and/c generic-set? set-equal-always? set-mutable?)
  v : any/c
(mutable-seteqv v ...)
 → (and/c generic-set? set-eqv? set-mutable?)
  v : any/c
(mutable-seteq v ...)
 → (and/c generic-set? set-eq? set-mutable?)
  v : any/c
(weak-set v ...) → (and/c generic-set? set-equal? set-weak?)
  v : any/c
(weak-setalw v ...)
 → (and/c generic-set? set-equal-always? set-weak?)
  v : any/c
(weak-seteqv v ...) → (and/c generic-set? set-eqv? set-weak?)
  v : any/c
(weak-seteq v ...) → (and/c generic-set? set-eq? set-weak?)
  v : any/c
```

Creates a hash set with the given `v`s as elements. The elements are added in the order that they appear as arguments, so in the case of sets that use `equal?`, `equal-always?`, or `eqv?`, an earlier element may be replaced by a later element that is `equal?`, `equal-always?`, or `eqv?`, but not `eq?`.

Changed in version 8.5.0.3 of package `base`: Added `setalw`, `mutable-setalw`, and `weak-setalw`.

```
(list->set lst) → (and/c generic-set? set-equal? set?)
  lst : list?
(list->setalw lst)
 → (and/c generic-set? set-equal-always? set?)
  lst : list?
(list->seteqv lst) → (and/c generic-set? set-eqv? set?)
  lst : list?
(list->seteq lst) → (and/c generic-set? set-eq? set?)
  lst : list?
```

```
(list->mutable-set lst)
 → (and/c generic-set? set-equal? set-mutable?)
  lst : list?
(list->mutable-setalw lst)
 → (and/c generic-set? set-equal-always? set-mutable?)
  lst : list?
(list->mutable-seteqv lst)
 → (and/c generic-set? set-eqv? set-mutable?)
  lst : list?
(list->mutable-seteq lst)
 → (and/c generic-set? set-eq? set-mutable?)
  lst : list?
(list->weak-set lst)
 → (and/c generic-set? set-equal? set-weak?)
  lst : list?
(list->weak-setalw lst)
 → (and/c generic-set? set-equal-always? set-weak?)
  lst : list?
(list->weak-seteqv lst)
 → (and/c generic-set? set-eqv? set-weak?)
  lst : list?
(list->weak-seteq lst) → (and/c generic-set? set-eq? set-weak?)
  lst : list?
```

Creates a hash set with the elements of the given `lst` as the elements of the set. Equivalent to `(apply set lst)`, `(apply setalw lst)`, `(apply seteqv lst)`, `(apply seteq lst)`, and so on, respectively.

Changed in version 8.5.0.3 of package `base`: Added `list->setalw`, `list->mutable-setalw`, and `list->weak-setalw`.

```
(for/set (for-clause ...) body ...+)
(for/seteq (for-clause ...) body ...+)
(for/seteqv (for-clause ...) body ...+)
(for/setalw (for-clause ...) body ...+)
(for*/set (for-clause ...) body ...+)
(for*/seteq (for-clause ...) body ...+)
(for*/seteqv (for-clause ...) body ...+)
(for*/setalw (for-clause ...) body ...+)
(for/mutable-set (for-clause ...) body ...+)
(for/mutable-seteq (for-clause ...) body ...+)
(for/mutable-seteqv (for-clause ...) body ...+)
(for/mutable-setalw (for-clause ...) body ...+)
(for*/mutable-set (for-clause ...) body ...+)
(for*/mutable-seteq (for-clause ...) body ...+)
(for*/mutable-seteqv (for-clause ...) body ...+)
```

```
(for*/mutable-setalw (for-clause ...) body ...+)
(for/weak-set (for-clause ...) body ...+)
(for/weak-seteq (for-clause ...) body ...+)
(for/weak-seteqv (for-clause ...) body ...+)
(for/weak-setalw (for-clause ...) body ...+)
(for*/weak-set (for-clause ...) body ...+)
(for*/weak-seteq (for-clause ...) body ...+)
(for*/weak-seteqv (for-clause ...) body ...+)
(for*/weak-setalw (for-clause ...) body ...+)
```

Analogous to `for/list` and `for*/list`, but to construct a hash set instead of a list.

Changed in version 8.5.0.3 of package `base`: Added `for/setalw`, `for/mutable-setalw`, and `for/weak-setalw`.

```
(in-immutable-set st) → sequence?
  st : set?
(in-mutable-set st) → sequence?
  st : set-mutable?
(in-weak-set st) → sequence?
  st : set-weak?
```

Explicitly converts a specific kind of hash set to a sequence for use with `for` forms.

As with `in-list` and some other sequence constructors, `in-immutable-set` performs better when it appears directly in a `for` clause.

These sequence constructors are compatible with §4.19.4 “Custom Hash Sets”.

Added in version 6.4.0.7 of package `base`.

4.19.2 Set Predicates and Contracts

```
(generic-set? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a set; returns `#f` otherwise.

Examples:

```
> (generic-set? (list 1 2 3))
#t
> (generic-set? (set 1 2 3))
#t
```

```
> (generic-set? (mutable-seteq 1 2 3))
#t
> (generic-set? (vector 1 2 3))
#f
```

```
(set-implements? st sym ...) → boolean?
  st : generic-set?
  sym : symbol?
```

Returns `#t` if *st* implements all of the methods from `gen:set` named by the *sym*s; returns `#f` otherwise. Fallback implementations do not affect the result; *st* may support the given methods via fallback implementations yet produce `#f`.

Examples:

```
> (set-implements? (list 1 2 3) 'set-add)
#t
> (set-implements? (list 1 2 3) 'set-add!)
#f
> (set-implements? (set 1 2 3) 'set-add)
#t
> (set-implements? (set 1 2 3) 'set-add!)
#t
> (set-implements? (mutable-seteq 1 2 3) 'set-add)
#t
> (set-implements? (mutable-seteq 1 2 3) 'set-add!)
#t
> (set-implements? (weak-seteqv 1 2 3) 'set-remove 'set-remove!)
#t
```

```
(set-implements/c sym ...) → flat-contract?
  sym : symbol?
```

Recognizes sets that support all of the methods from `gen:set` named by the *sym*s.

```
(set/c  elem/c
       [#:cmp cmp
        #:kind kind
        #:lazy? lazy?
        #:equal-key/c equal-key/c]) → contract?
  elem/c : chaperone-contract?
  cmp : (or/c 'dont-care 'equal 'equal-always 'eqv 'eq)
      = 'dont-care
  kind : (or/c 'dont-care 'immutable 'mutable 'weak 'mutable-or-weak)
       = 'immutable
```

```
lazy? : any/c = (not (and (equal? kind 'immutable)
                          (flat-contract? elem/c)))
equal-key/c : contract? = any/c
```

Constructs a contract that recognizes sets whose elements match *elem/c*.

If *kind* is 'immutable, 'mutable, or 'weak, the resulting contract accepts only hash sets that are respectively immutable, mutable with strongly-held keys, or mutable with weakly-held keys. If *kind* is 'mutable-or-weak, the resulting contract accepts any mutable hash sets, regardless of key-holding strength.

If *cmp* is 'equal, 'equal-always, 'eqv, or 'eq, the resulting contract accepts only hash sets that compare elements using equal?, equal-always?, eqv?, or eq?, respectively.

If *cmp* is 'eqv or 'eq, then *elem/c* must be a flat contract.

If *cmp* and *kind* are both 'dont-care, then the resulting contract will accept any kind of set, not just hash sets.

If *lazy?* is not #f, then the elements of the set are not checked immediately by the contract and only the set itself is checked (according to the *cmp* and *kind* arguments). If *lazy?* is #f, then the elements are checked immediately by the contract. The *lazy?* argument is ignored when the set contract accepts generic sets (i.e., when *cmp* and *kind* are both 'dont-care); in that case, the value being checked in that case is a list?, then the contract is not lazy otherwise the contract is lazy.

If *kind* allows mutable sets (i.e., is 'dont-care, 'mutable, 'weak, or 'mutable-or-weak) and *lazy?* is #f, then the elements are checked both immediately and when they are accessed from the set.

The *equal-key/c* contract is used when values are passed to the comparison and hashing functions used internally.

The result contract will be a flat contract when *elem/c* and *equal-key/c* are both flat contracts, *lazy?* is #f, and *kind* is 'immutable. The result will be a chaperone contract when *elem/c* is a chaperone contract.

Changed in version 8.3.0.9 of package base: Added support for random generation.
Changed in version 8.5.0.3: Added 'equal-always support for *cmp*.

4.19.3 Generic Set Interface

```
gen:set
```

A generic interface (see §5.4 “Generic Interfaces”) that supplies set method implementations for a structure type via the #:methods option of struct definitions. This interface can be used to implement any of the methods documented as §4.19.3.1 “Set Methods”.

A set should also be a sequence, but gen:set by itself does not by itself imply prop:sequence. A use of gen:set typically should be combined with a use of prop:sequence with in-set or a more specific sequence constructor. Note that in-set requires supporting set->stream (e.g., by implementing set->stream or another supporting combination, such as set-first, set-remove, and set-empty?).

Examples:

```
> (struct binary-set [integer]
    #:transparent
    #:methods gen:set
    [(define (set-member? st i)
       (bitwise-bit-set? (binary-set-integer st) i))
     (define (set-add st i)
       (binary-set (bitwise-ior (binary-set-integer st)
                                (arithmetic-shift 1 i))))
     (define (set-remove st i)
       (binary-set (bitwise-and (binary-set-integer st)
                                (bitwise-not (arithmetic-
shift 1 i)))))
     (define (set-first st)
       (sub1 (integer-length (binary-set-integer st))))
     (define (set-empty? st)
       (= (binary-set-integer st) 0))]
    #:property prop:sequence in-set)
> (define bset (binary-set 5))
> bset
(binary-set 5)
> (generic-set? bset)
#t
> (set-member? bset 0)
#t
> (set-member? bset 1)
#f
> (set-member? bset 2)
#t
> (set-add bset 4)
(binary-set 21)
> (set-remove bset 2)
(binary-set 1)
> (set-first bset)
2
> (require racket/sequence)
```

```
> (sequence->list bset)
'(2 0)
```

Set Methods

The methods of `gen:set` can be classified into three categories, as determined by their fallback implementations:

1. methods with no fallbacks,
2. methods whose fallbacks depend on other, non-fallback methods,
3. and methods whose fallbacks can depend on either fallback or non-fallback methods.

As an example, implementing the following methods would guarantee that all the methods in `gen:set` would at least have a fallback method:

- `set-member?`
- `set-add`
- `set-add!`
- `set-remove`
- `set-remove!`
- `set-first`
- `set-empty?`
- `set-copy-clear`

There may be other such subsets of methods that would guarantee at least a fallback for every method.

```
(set-member? st v) → boolean?
  st : generic-set?
  v : any/c
```

Returns `#t` if *v* is in *st*, `#f` otherwise. Has no fallback.

```
(set-add st v) → generic-set?
  st : generic-set?
  v : any/c
```

Produces a set that includes *v* plus all elements of *st*. This operation runs in constant time for hash sets. Has no fallback.

```
(set-add! st v) → void?
  st : generic-set?
  v : any/c
```

Adds the element *v* to *st*. This operation runs in constant time for hash sets. Has no fallback.

For hash sets, see also the caveats concerning concurrent modification for hash tables, which applies to hash sets.

```
(set-remove st v) → generic-set?
  st : generic-set?
  v : any/c
```

Produces a set that includes all elements of *st* except *v*. This operation runs in constant time for hash sets. Has no fallback.

```
(set-remove! st v) → void?
  st : generic-set?
  v : any/c
```

Removes the element *v* from *st*. This operation runs in constant time for hash sets. Has no fallback.

For hash sets, see also the caveats concerning concurrent modification for hash tables, which applies to hash sets.

```
(set-empty? st) → boolean?
  st : generic-set?
```

Returns `#t` if *st* has no members; returns `#f` otherwise.

Supported for any *st* that implements `set->stream` or `set-count`.

```
(set-count st) → exact-nonnegative-integer?
  st : generic-set?
```

Returns the number of elements in *st*.

Supported for any *st* that supports `set->stream`.

```
(set-first st) → any/c
  st : (and/c generic-set? (not/c set-empty?))
```

Produces an unspecified element of `st`. Multiple uses of `set-first` on `st` produce the same result.

Supported for any `st` that implements `set->stream`.

```
(set-rest st) → generic-set?
  st : (and/c generic-set? (not/c set-empty?))
```

Produces a set that includes all elements of `st` except `(set-first st)`.

Supported for any `st` that implements `set-remove` and either `set-first` or `set->stream`.

```
(set->stream st) → stream?
  st : generic-set?
```

Produces a stream containing the elements of `st`.

Supported for any `st` that implements:

- `set->list`
- `in-set`
- `set-empty?`, `set-first`, `set-rest`
- `set-empty?`, `set-first`, `set-remove`
- `set-count`, `set-first`, `set-rest`
- `set-count`, `set-first`, `set-remove`

```
(set-copy st) → generic-set?
  st : generic-set?
```

Produces a new, mutable set of the same type and with the same elements as `st`.

Supported for any `st` that supports `set->stream` and implements `set-copy-clear` and `set-add!`.

```
(set-copy-clear st) → (and/c generic-set? set-empty?)
  st : generic-set?
```

Produces a new, empty set of the same type, mutability, and key strength as `st`.

A difference between `set-copy-clear` and `set-clear` is that the latter conceptually iterates `set-remove` on the given set, and so it preserves any contract on the given set. The `set-copy-clear` function produces a new set without any contracts.

The `set-copy-clear` function must call concrete set constructors and thus has no generic fallback.

```
(set-clear st) → (and/c generic-set? set-empty?)
  st : generic-set?
```

Produces a set like *st* but with all elements removed.

Supported for any *st* that implements `set-remove` and supports `set->stream`.

```
(set-clear! st) → void?
  st : generic-set?
```

Removes all elements from *st*.

Supported for any *st* that implements `set-remove!` and either supports `set->stream` or implements `set-first` and either `set-count` or `set-empty?`.

For hash sets, see also the caveats concerning concurrent modification for hash tables, which applies to hash sets.

```
(set-union st0 st ...) → generic-set?
  st0 : generic-set?
  st : generic-set?
```

Produces a set of the same type as *st0* that includes the elements from *st0* and all of the *st*s.

If *st0* is a list, each *st* must also be a list. This operation runs on lists in time proportional to the total size of the *st*s times the size of the result.

If *st0* is a hash set, each *st* must also be a hash set that uses the same comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`). The mutability and key strength of the hash sets may differ. This operation runs on hash sets in time proportional to the total size of all of the sets except the largest immutable set.

At least one set must be provided to `set-union` to determine the type of the resulting set (list, hash set, etc.). If there is a case where `set-union` may be applied to zero arguments, instead pass an empty set of the intended type as the first argument.

Supported for any *st* that implements `set-add` and supports `set->stream`.

Examples:

```
> (set-union (set))
(set)
> (set-union (seteq))
(seteq)
> (set-union (set 1 2) (set 2 3))
(set 1 2 3)
> (set-union (list 1 2) (list 2 3))
'(3 1 2)
> (set-union (set 1 2) (seteq 2 3))
set-union: set arguments have incompatible equivalence
predicates
   first set: (set 1 2)
   incompatible set: (seteq 2 3)
; Sets of different types cannot be unioned
```

```
(set-union! st0 st ...) → void?
  st0 : generic-set?
  st : generic-set?
```

Adds the elements from all of the `st`s to `st0`.

If `st0` is a hash set, each `st` must also be a hash set that uses the same comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`). The mutability and key strength of the hash sets may differ. This operation runs on hash sets in time proportional to the total size of the `st`s.

Supported for any `st` that implements `set-add!` and supports `set->stream`.

For hash sets, see also the caveats concerning concurrent modification for hash tables, which applies to hash sets.

```
(set-intersect st0 st ...) → generic-set?
  st0 : generic-set?
  st : generic-set?
```

Produces a set of the same type as `st0` that includes the elements from `st0` that are also contained by all of the `st`s.

If `st0` is a list, each `st` must also be a list. This operation runs on lists in time proportional to the total size of the `st`s times the size of `st0`.

If `st0` is a hash set, each `st` must also be a hash set that uses the same comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`). The mutability and key strength of the hash sets may differ. This operation runs on hash sets in time proportional to the size of the smallest immutable set.

Supported for any `st` that implements either `set-remove` or both `set-clear` and `set-add`, and supports `set->stream`.

```
(set-intersect! st0 st ...) → void?
  st0 : generic-set?
  st : generic-set?
```

Removes every element from `st0` that is not contained by all of the `st`s.

If `st0` is a hash set, each `st` must also be a hash set that uses the same comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`). The mutability and key strength of the hash sets may differ. This operation runs on hash sets in time proportional to the size of `st0`.

Supported for any `st` that implements `set-remove!` and supports `set->stream`.

For hash sets, see also the caveats concerning concurrent modification for hash tables, which applies to hash sets.

```
(set-subtract st0 st ...) → generic-set?
  st0 : generic-set?
  st : generic-set?
```

Produces a set of the same type as `st0` that includes the elements from `st0` that are not contained by any of the `st`s.

If `st0` is a list, each `st` must also be a list. This operation runs on lists in time proportional to the total size of the `st`s times the size of `st0`.

If `st0` is a hash set, each `st` must also be a hash set that uses the same comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`). The mutability and key strength of the hash sets may differ. This operation runs on hash sets in time proportional to the size of `st0`.

Supported for any `st` that implements either `set-remove` or both `set-clear` and `set-add`, and supports `set->stream`.

```
(set-subtract! st0 st ...) → void?
  st0 : generic-set?
  st : generic-set?
```

Removes every element from `st0` that is contained by any of the `st`s.

If `st0` is a hash set, each `st` must also be a hash set that uses the same comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`). The mutability and key strength of the hash sets may differ. This operation runs on hash sets in time proportional to the size of `st0`.

Supported for any `st` that implements `set-remove!` and supports `set->stream`.

For hash sets, see also the caveats concerning concurrent modification for hash tables, which applies to hash sets.

```
(set-symmetric-difference st0 st ...) → generic-set?
  st0 : generic-set?
  st : generic-set?
```

Produces a set of the same type as `st0` that includes all of the elements contained an odd number of times in `st0` and the `st`s.

If `st0` is a list, each `st` must also be a list. This operation runs on lists in time proportional to the total size of the `st`s times the size of `st0`.

If `st0` is a hash set, each `st` must also be a hash set that uses the same comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`). The mutability and key strength of the hash sets may differ. This operation runs on hash sets in time proportional to the total size of all of the sets except the largest immutable set.

Supported for any `st` that implements `set-remove` or both `set-clear` and `set-add`, and supports `set->stream`.

Example:

```
> (set-symmetric-difference (set 1) (set 1 2) (set 1 2 3))
(set 1 3)
```

```
(set-symmetric-difference! st0 st ...) → void?
  st0 : generic-set?
  st : generic-set?
```

Adds and removes elements of `st0` so that it includes all of the elements contained an odd number of times in the `st`s and the original contents of `st0`.

If `st0` is a hash set, each `st` must also be a hash set that uses the same comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`). The mutability and key strength of the hash sets may differ. This operation runs on hash sets in time proportional to the total size of the `st`s.

Supported for any `st` that implements `set-remove!` and supports `set->stream`.

For hash sets, see also the caveats concerning concurrent modification for hash tables, which applies to hash sets.

```
(set=? st st2) → boolean?
  st : generic-set?
  st2 : generic-set?
```

Returns `#t` if `st` and `st2` contain the same members; returns `#f` otherwise.

If *st* is a list, then *st2* must also be a list. This operation runs on lists in time proportional to the size of *st* times the size of *st2*.

If *st* is a hash set, then *st2* must also be a hash set that uses the same comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`). The mutability and key strength of the hash sets may differ. This operation runs on hash sets in time proportional to the size of *st* plus the size of *st2*.

Supported for any *st* and *st2* that both support `subset?`; also supported for any if *st2* that implements `set=?` regardless of *st*.

Examples:

```
> (set=? (list 1 2) (list 2 1))
#t
> (set=? (set 1) (set 1 2 3))
#f
> (set=? (set 1 2 3) (set 1))
#f
> (set=? (set 1 2 3) (set 1 2 3))
#t
> (set=? (seteq 1 2) (mutable-seteq 2 1))
#t
> (set=? (seteq 1 2) (seteqv 1 2))
set=?: set arguments have incompatible equivalence
predicates
  first set: (seteq 1 2)
  incompatible set: (seteqv 1 2)
; Sets of different types cannot be compared
```

```
(subset? st st2) → boolean?
  st : generic-set?
  st2 : generic-set?
```

Returns `#t` if *st2* contains every member of *st*; returns `#f` otherwise.

If *st* is a list, then *st2* must also be a list. This operation runs on lists in time proportional to the size of *st* times the size of *st2*.

If *st* is a hash set, then *st2* must also be a hash set that uses the same comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`). The mutability and key strength of the hash sets may differ. This operation runs on hash sets in time proportional to the size of *st*.

Supported for any *st* that supports `set->stream`.

Examples:

```
> (subset? (set 1) (set 1 2 3))
#t
> (subset? (set 1 2 3) (set 1))
#f
> (subset? (set 1 2 3) (set 1 2 3))
#t
```

```
(proper-subset? st st2) → boolean?
  st : generic-set?
  st2 : generic-set?
```

Returns `#t` if `st2` contains every member of `st` and at least one additional element; returns `#f` otherwise.

If `st` is a list, then `st2` must also be a list. This operation runs on lists in time proportional to the size of `st` times the size of `st2`.

If `st` is a hash set, then `st2` must also be a hash set that uses the same comparison function (`equal?`, `equal-always?`, `eqv?`, or `eq?`). The mutability and key strength of the hash sets may differ. This operation runs on hash sets in time proportional to the size of `st` plus the size of `st2`.

Supported for any `st` and `st2` that both support `subset?`.

Examples:

```
> (proper-subset? (set 1) (set 1 2 3))
#t
> (proper-subset? (set 1 2 3) (set 1))
#f
> (proper-subset? (set 1 2 3) (set 1 2 3))
#f
```

```
(set->list st) → list?
  st : generic-set?
```

Produces a list containing the elements of `st`.

Supported for any `st` that supports `set->stream`.

```
(set-map st proc) → (listof any/c)
  st : generic-set?
  proc : (any/c . -> . any/c)
```

Applies the procedure `proc` to each element in `st` in an unspecified order, accumulating the results into a list.

Supported for any *st* that supports `set->stream`.

```
(set-for-each st proc) → void?
  st : generic-set?
  proc : (any/c . -> . any)
```

Applies *proc* to each element in *st* (for the side-effects of *proc*) in an unspecified order.

Supported for any *st* that supports `set->stream`.

```
(in-set st) → sequence?
  st : generic-set?
```

Explicitly converts a set to a sequence for use with `for` and other forms.

Supported for any *st* that supports `set->stream`.

```
(impersonate-hash-set  st
                       inject-proc
                       add-proc
                       shrink-proc
                       extract-proc
                      [clear-proc
                       equal-key-proc]
                       prop
                       prop-val ...
                       ...)
 → (and/c (or/c set-mutable? set-weak?) impersonator?)
  st : (or/c set-mutable? set-weak?)
  inject-proc : (or/c #f (-> set? any/c any/c))
  add-proc : (or/c #f (-> set? any/c any/c))
  shrink-proc : (or/c #f (-> set? any/c any/c))
  extract-proc : (or/c #f (-> set? any/c any/c))
  clear-proc : (or/c #f (-> set? any)) = #f
  equal-key-proc : (or/c #f (-> set? any/c any/c)) = #f
  prop : impersonator-property?
  prop-val : any/c
```

Impersonates *st*, redirecting various set operations via the given procedures.

The *inject-proc* procedure is called whenever an element is temporarily put into the set for the purposes of comparing it with other elements that may already be in the set. For example, when evaluating `(set-member? s e)`, `e` will be passed to the *inject-proc* before comparing it with other elements of `s`.

The *add-proc* procedure is called when adding an element to a set, e.g., via `set-add` or `set-add!`. The result of the *add-proc* is stored in the set.

The *shrink-proc* procedure is called when building a new set with one fewer element. For example, when evaluating `(set-remove s e)` or `(set-remove! s e)`, an element is removed from a set, e.g., via `set-remove` or `set-remove!`. The result of the *shrink-proc* is the element actually removed from the set.

The *extract-proc* procedure is called when an element is pulled out of a set, e.g., by `set-first`. The result of the *extract-proc* is the element actually produced by from the set.

The *clear-proc* is called by `set-clear` and `set-clear!` and if it returns (as opposed to escaping, perhaps via raising an exception), the clearing operation is permitted. Its result is ignored. If *clear-proc* is `#f`, then clearing is done element by element (via calls into the other supplied procedures).

The *equal-key-proc* is called when an element's hash code is needed of when an element is supplied to the underlying equality in the set. The result of *equal-key-proc* is used when computing the hash or comparing for equality.

If any of the *inject-proc*, *add-proc*, *shrink-proc*, or *extract-proc* arguments are `#f`, then they all must be `#f`, the *clear-proc* and *equal-key-proc* must also be `#f`, and there must be at least one property supplied.

Pairs of *prop* and *prop-val* (the number of arguments to `impersonate-hash-set` must be odd) add impersonator properties or override impersonator property values of *st*.

```
(chaperone-hash-set  st
                     inject-proc
                     add-proc
                     shrink-proc
                     extract-proc
                    [clear-proc
                     equal-key-proc]
                     prop
                     prop-val ...
                     ...)
 → (and/c (or/c set? set-mutable? set-weak?) chaperone?)
  st : (or/c set? set-mutable? set-weak?)
  inject-proc : (or/c #f (-> set? any/c any/c))
  add-proc : (or/c #f (-> set? any/c any/c))
  shrink-proc : (or/c #f (-> set? any/c any/c))
  extract-proc : (or/c #f (-> set? any/c any/c))
  clear-proc : (or/c #f (-> set? any)) = #f
  equal-key-proc : (or/c #f (-> set? any/c any/c)) = #f
  prop : impersonator-property?
  prop-val : any/c
```

Chaperones *st*. Like `impersonate-hash-set` but with the constraints that the results of the *inject-proc*, *add-proc*, *shrink-proc*, *extract-proc*, and *equal-key-proc* must be chaperone-of? their second arguments. Also, the input may be an immutable? set.

4.19.4 Custom Hash Sets

```
(define-custom-set-types name
                         optional-predicate
                         comparison-expr
                         optional-hash-functions)

     optional-predicate =
                        | #:elem? predicate-expr

optional-hash-functions =
                        | hash1-expr
                        | hash1-expr hash2-expr
```

Creates a new hash set type based on the given comparison *comparison-expr*, hash functions *hash1-expr* and *hash2-expr*, and element predicate *predicate-expr*; the interfaces for these functions are the same as in make-custom-set-types. The new set type has three variants: immutable, mutable with strongly-held elements, and mutable with weakly-held elements.

Defines seven names:

- *name*? recognizes instances of the new type,
- immutable-*name*? recognizes immutable instances of the new type,
- mutable-*name*? recognizes mutable instances of the new type with strongly-held elements,
- weak-*name*? recognizes mutable instances of the new type with weakly-held elements,
- make-immutable-*name* constructs immutable instances of the new type,
- make-mutable-*name* constructs mutable instances of the new type with strongly-held elements, and
- make-weak-*name* constructs mutable instances of the new type with weakly-held elements.

The constructors all accept a stream as an optional argument, providing initial elements.

Examples:

```
> (define-custom-set-types string-set
                           #:elem? string?
                           string=?
                           string-length)
> (define imm
    (make-immutable-string-set '("apple" "banana")))
> (define mut
    (make-mutable-string-set '("apple" "banana")))
> (generic-set? imm)
#t
> (generic-set? mut)
#t
> (set? imm)
#t
> (generic-set? imm)
#t
> (string-set? imm)
#t
> (string-set? mut)
#t
> (immutable-string-set? imm)
#t
> (immutable-string-set? mut)
#f
> (set-member? imm "apple")
#t
> (set-member? mut "banana")
#t
> (equal? imm mut)
#f
> (set=? imm mut)
#t
> (set-remove! mut "banana")
> (set-member? mut "banana")
#f
> (equal? (set-remove (set-remove imm "apple") "banana")
          (make-immutable-string-set))
#t
```

```
(make-custom-set-types  eql?
                       [hash1
                        hash2
                        #:elem? elem?
                        #:name name
                        #:for who])
```

```
→ (any/c . -> . boolean?)
  (any/c . -> . boolean?)
  (any/c . -> . boolean?)
  (any/c . -> . boolean?)
  (->* [] [stream?] generic-set?)
  (->* [] [stream?] generic-set?)
  (->* [] [stream?] generic-set?)
 eql? : (or/c (any/c any/c . -> . any/c)
              (any/c any/c (any/c any/c . -> . any/c) . -> . any/c))
 hash1 : (or/c (any/c . -> . exact-integer?)
               (any/c (any/c . -> . exact-integer?) . -> . exact-integer?))
       = (const 1)
 hash2 : (or/c (any/c . -> . exact-integer?)
               (any/c (any/c . -> . exact-integer?) . -> . exact-integer?))
       = (const 1)
 elem? : (any/c . -> . boolean?) = (const #true)
 name : symbol? = 'custom-set
 who : symbol? = 'make-custom-set-types
```

Creates a new set type based on the given comparison function *eql?*, hash functions *hash1* and *hash2*, and predicate *elem?*. The new set type has variants that are immutable, mutable with strongly-held elements, and mutable with weakly-held elements. The given *name* is used when printing instances of the new set type, and the symbol *who* is used for reporting errors.

The comparison function *eql?* may accept 2 or 3 arguments. If it accepts 2 arguments, it given two elements to compare them. If it accepts 3 arguments and does not accept 2 arguments, it is also given a recursive comparison function that handles data cycles when comparing sub-parts of the elements.

The hash functions *hash1* and *hash2* may accept 1 or 2 arguments. If either hash function accepts 1 argument, it is applied to a element to compute the corresponding hash value. If either hash function accepts 2 arguments and does not accept 1 argument, it is also given a recursive hash function that handles data cycles when computing hash values of sub-parts of the elements.

The predicate *elem?* must accept 1 argument and is used to recognize valid elements for the new set type.

Produces seven values:

- a predicate recognizing all instances of the new set type,
- a predicate recognizing weak instances,
- a predicate recognizing mutable instances,

- a predicate recognizing immutable instances,
- a constructor for weak instances,
- a constructor for mutable instances, and
- a constructor for immutable instances.

See `define-custom-set-types` for an example.

4.20 Procedures

```
(procedure? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a procedure, `#f` otherwise.

```
(apply proc v ... lst #:<kw> kw-arg ...) → any
  proc : procedure?
  v : any/c
  lst : list?
  kw-arg : any/c
```

§4.3.3 "The `apply` Function" in *The Racket Guide* introduces `apply`.

Applies *proc* using the content of `(list* v ... lst)` as the (by-position) arguments. The `#:<kw> kw-arg` sequence is also supplied as keyword arguments to *proc*, where `#:<kw>` stands for any keyword.

The given *proc* must accept as many arguments as the number of *v*s plus length of *lst*, it must accept the supplied keyword arguments, and it must not require any other keyword arguments; otherwise, the `exn:fail:contract` exception is raised. The given *proc* is called in tail position with respect to the `apply` call.

Examples:

```
> (apply + '(1 2 3))
6
> (apply + 1 2 '(3))
6
> (apply + '())
0
> (apply sort (list (list '(2) '(1)) <) #:key car)
'((1) (2))
```

```
(compose proc ...) → procedure?
  proc : procedure?
(compose1 proc ...) → procedure?
  proc : procedure?
```

Returns a procedure that composes the given functions, applying the last *proc* first and the first *proc* last. The `compose` function allows the given functions to consume and produce any number of values, as long as each function produces as many values as the preceding function consumes, while `compose1` restricts the internal value passing to a single value. In both cases, the input arity of the last function and the output arity of the first are unrestricted, and they become the corresponding arity of the resulting composition (including keyword arguments for the input side).

When no *proc* arguments are given, the result is `values`. When exactly one is given, it is returned.

Examples:

```
> ((compose1 - sqrt) 10)
-3.1622776601683795
> ((compose1 sqrt -) 10)
0.0+3.1622776601683795i
> ((compose list split-path) (bytes->path #"/a" 'unix))
'(#<path:/> #<path:a> #f)
```

Note that in many cases, `compose1` is preferred. For example, using `compose` with two library functions may lead to problems when one function is extended to return two values, and the preceding one has an optional input with different semantics. In addition, `compose1` may create faster compositions.

```
(procedure-rename proc name [realm]) → procedure?
  proc : procedure?
  name : symbol?
  realm : symbol? = 'racket
```

Returns a procedure that is like *proc*, except that its name as returned by `object-name` (and as printed for debugging) is *name* and its realm (potentially used for adjusting error messages) is *realm*.

The given *name* and *realm* are used for printing and adjusting an error message if the resulting procedure is applied to the wrong number of arguments. In addition, if *proc* is an accessor or mutator produced by `struct`, `make-struct-field-accessor`, or `make-struct-field-mutator`, the resulting procedure also uses *name* when its (first) argument has the wrong type. More typically, however, *name* is not used for reporting errors, since the procedure name is typically hard-wired into an internal check.

Changed in version 8.4.0.2 of package base: Added the *realm* argument.

```
(procedure-realm proc) → symbol?
  proc : procedure?
```

Reports the realm of a procedure, which can depend on the module where the procedure was created, the current-compile-realm value when the procedure's code was compiled, or a realm explicitly assigned through a function like procedure-rename.

Added in version 8.4.0.2 of package base.

```
(procedure->method proc) → procedure?
  proc : procedure?
```

Returns a procedure that is like *proc* except that, when applied to the wrong number of arguments, the resulting error hides the first argument as if the procedure had been compiled with the 'method-arity-error syntax property.

```
(procedure-closure-contents-eq? proc1
                                proc2) → boolean?
  proc1 : procedure?
  proc2 : procedure?
```

Compares the contents of the closures of *proc1* and *proc2* for equality by comparing closure elements pointwise using eq?

4.20.1 Keywords and Arity

```
(keyword-apply proc
               kw-lst
               kw-val-lst
               v ...
               lst
               #:<kw> kw-arg ...) → any
  proc : procedure?
  kw-lst : (listof keyword?)
  kw-val-lst : list?
  v : any/c
  lst : list?
  kw-arg : any/c
```

§4.3.3 "The apply Function" in *The Racket Guide* introduces keyword-apply.

Like apply, but *kw-lst* and *kw-val-lst* supply by-keyword arguments in addition to the by-position arguments of the *v*s and *lst*, and in addition to the directly supplied keyword arguments in the #:<kw> *kw-arg* sequence, where #:<kw> stands for any keyword.

The given *kw-lst* must be sorted using `keyword<?`. No keyword can appear twice in *kw-lst* or both in *kw-lst* and as a `#:<kw>`, otherwise, the `exn:fail:contract` exception is raised. The given *kw-val-lst* must have the same length as *kw-lst*, otherwise, the `exn:fail:contract` exception is raised. The given *proc* must accept all of the keywords in *kw-lst* plus the `#:<kw>`s, it must not require any other keywords, and it must accept as many by-position arguments as supplied via the *v*s and *lst*; otherwise, the `exn:fail:contract` exception is raised.

Examples:

```
(define (f x #:y y #:z [z 10])
  (list x y z))

> (keyword-apply f '(#:y) '(2) '(1))
'(1 2 10)
> (keyword-apply f '(#:y #:z) '(2 3) '(1))
'(1 2 3)
> (keyword-apply f #:z 7 '(#:y) '(2) '(1))
'(1 2 7)
```

```
(procedure-arity proc) → normalized-arity?
  proc : procedure?
```

Returns information about the number of by-position arguments accepted by *proc*. See also `procedure-arity?`, `normalized-arity?`, and `procedure-arity-mask`.

```
(procedure-arity? v) → boolean?
  v : any/c
```

A valid arity `a` is one of the following:

- An exact non-negative integer, which means that the procedure accepts `a` arguments, only.
- A `arity-at-least` instance, which means that the procedure accepts `(arity-at-least-value a)` or more arguments.
- A list containing integers and `arity-at-least` instances, which means that the procedure accepts any number of arguments that can match one of the elements of `a`.

The result of `procedure-arity` is always normalized in the sense of `normalized-arity?`.

Examples:

```
> (procedure-arity cons)
```

```
2
> (procedure-arity list)
(arity-at-least 0)
> (arity-at-least? (procedure-arity list))
#t
> (arity-at-least-value (procedure-arity list))
0
> (arity-at-least-value (procedure-arity (lambda (x . y) x)))
1
> (procedure-arity (case-lambda [(x) 0] [(x y) 1]))
'(1 2)
```

```
(procedure-arity-mask proc) → exact-integer?
  proc : procedure?
```

Returns the same information as `procedure-arity`, but encoded differently. The arity is encoded as an exact integer *mask* where `(bitwise-bit-set? mask n)` returns true if *proc* accepts *n* arguments.

The mask encoding of an arity is often easier to test and manipulate, and `procedure-arity-mask` is sometimes faster than `procedure-arity` while always being at least as fast.

Added in version 7.0.0.11 of package `base`.

```
(procedure-arity-includes? proc k [kws-ok?]) → boolean?
  proc : procedure?
  k : exact-nonnegative-integer?
  kws-ok? : any/c = #f
```

Returns `#t` if the procedure can accept *k* by-position arguments, `#f` otherwise. If *kws-ok?* is `#f`, the result is `#t` only if *proc* has no required keyword arguments.

Examples:

```
> (procedure-arity-includes? cons 2)
#t
> (procedure-arity-includes? display 3)
#f
> (procedure-arity-includes? (lambda (x #:y y) x) 1)
#f
> (procedure-arity-includes? (lambda (x #:y y) x) 1 #t)
#t
```

```
(procedure-reduce-arity proc
                        arity
                       [name
                        realm]) → procedure?
  proc : procedure?
  arity : procedure-arity?
  name : (or/c symbol? #f) = #f
  realm : symbol? = 'racket
```

Returns a procedure that is the same as *proc* (including the same name returned by `object-name`), but that accepts only arguments consistent with *arity*. In particular, when `procedure-arity` is applied to the generated procedure, it returns a value that is `equal?` to the normalized form of *arity*.

If the *arity* specification allows arguments that are not in `(procedure-arity proc)`, the `exn:fail:contract` exception is raised. If *proc* accepts keyword argument, either the keyword arguments must be all optional (and they are not accepted in by the arity-reduced procedure) or *arity* must be the empty list (which makes a procedure that cannot be called); otherwise, the `exn:fail:contract` exception is raised.

If *name* is not `#f`, then `object-name` of the result procedure produces *name*, and `procedure-realm` of the result produced produces *realm*. Otherwise, `object-name` and `procedure-realm` of the result procedure produce the same result as for *proc*.

Examples:

```
> (define my+ (procedure-reduce-arity + 2))
> (my+ 1 2)
3
> (my+ 1 2 3)
+: arity mismatch;
 the expected number of arguments does not match the given
number
  expected: 2
  given: 3
> (define also-my+ (procedure-reduce-arity + 2 'also-my+))
> (also-my+ 1 2 3)
also-my+: arity mismatch;
 the expected number of arguments does not match the given
number
  expected: 2
  given: 3
```

Changed in version 7.0.0.11 of package `base`: Added the optional *name* argument.
Changed in version 8.4.0.2: Added the *realm* argument.

```
(procedure-reduce-arity-mask  proc
                              mask
                             [name
                              realm]) → procedure?
  proc : procedure?
  mask : exact-integer?
  name : (or/c symbol? #f) = #f
  realm : symbol? = 'racket
```

The same as `procedure-reduce-arity`, but using the representation of arity described with `procedure-arity-mask`.

The mask encoding of an arity is often easier to test and manipulate, and `procedure-reduce-arity-mask` is sometimes faster than `procedure-reduce-arity` while always being at least as fast.

Added in version 7.0.0.11 of package `base`.
Changed in version 8.4.0.2: Added the *`realm`* argument.

```
(procedure-keywords proc) → (listof keyword?)
                            (or/c (listof keyword?) #f)
  proc : procedure?
```

Returns information about the keyword arguments required and accepted by a procedure. The first result is a list of distinct keywords (sorted by `keyword<?`) that are required when applying *`proc`*. The second result is a list of distinct accepted keywords (sorted by `keyword<?`), or `#f` to mean that any keyword is accepted. When the second result is a list, every element in the first list is also in the second list.

Examples:

```
> (procedure-keywords +)
'()
'()
> (procedure-keywords (lambda (#:tag t #:mode m) t))
'(#:mode #:tag)
'(#:mode #:tag)
> (procedure-keywords (lambda (#:tag t #:mode [m #f]) t))
'(#:tag)
'(#:mode #:tag)
```

```
(procedure-result-arity proc) → (or/c #f procedure-arity?)
  proc : procedure?
```

Returns the arity of the result of the procedure *`proc`* or `#f` if the number of results are not known, perhaps due to shortcomings in the implementation of `procedure-result-arity` or because *`proc`*'s behavior is not sufficiently simple.

Examples:

```
> (procedure-result-arity car)
1
> (procedure-result-arity values)
#f
> (procedure-result-arity
   (λ (x)
     (apply
      values
      (let loop ()
        (cond
          [(zero? (random 10)) '()]
          [else (cons 1 (loop))])))))
#f
```

Added in version 6.4.0.3 of package `base`.

```
(make-keyword-procedure proc [plain-proc]) → procedure?
  proc : ((listof keyword?) list? any/c ... . -> . any)
  plain-proc : procedure?
             = (lambda args (apply proc null null args))
```

Returns a procedure that accepts all keyword arguments (without requiring any keyword arguments).

When the procedure returned by `make-keyword-procedure` is called with keyword arguments, then *proc* is called; the first argument is a list of distinct keywords sorted by `keyword<?`, the second argument is a parallel list containing a value for each keyword, and the remaining arguments are the by-position arguments.

When the procedure returned by `make-keyword-procedure` is called without keyword arguments, then *plain-proc* is called—possibly more efficiently than dispatching through *proc*. Normally, *plain-proc* should have the same behavior as calling *proc* with empty lists as the first two arguments, but that correspondence is in no way enforced.

The result of `procedure-arity` and `object-name` on the new procedure is the same as for *plain-proc*, if *plain-proc* is provided. Otherwise, the result of `object-name` is the same as for *proc*, but the result of `procedure-arity` is derived from that of *proc* by reducing its arity by 2 (i.e., without the two prefix arguments that handle keyword arguments). See also `procedure-reduce-keyword-arity` and `procedure-rename`.

Examples:

```
(define show
  (make-keyword-procedure (lambda (kws kw-args . rest)
```

```
                              (list kws kw-args rest))))
```

```
> (show 1)
'(() () (1))
> (show #:init 0 1 2 3 #:extra 4)
'((#:extra #:init) (4 0) (1 2 3))
```

```
(define show2
  (make-keyword-procedure (lambda (kws kw-args . rest)
                            (list kws kw-args rest))
                          (lambda args
                            (list->vector args))))
```

```
> (show2 1)
'#(1)
> (show2 #:init 0 1 2 3 #:extra 4)
'((#:extra #:init) (4 0) (1 2 3))
```

```
(procedure-reduce-keyword-arity  proc
                                 arity
                                 required-kws
                                 allowed-kws
                                [name
                                 realm])      → procedure?
  proc : procedure?
  arity : procedure-arity?
  required-kws : (listof keyword?)
  allowed-kws : (or/c (listof keyword?)
                      #f)
  name : (or/c symbol? #f) = #f
  realm : symbol? = 'racket
```

Like `procedure-reduce-arity`, but constrains the keyword arguments according to *`required-kws`* and *`allowed-kws`*, which must be sorted using `keyword<?` and contain no duplicates. If *`allowed-kws`* is `#f`, then the resulting procedure still accepts any keyword, otherwise the keywords in *`required-kws`* must be a subset of those in *`allowed-kws`*. The original *`proc`* must require no more keywords than the ones listed in *`required-kws`*, and it must allow at least the keywords in *`allowed-kws`* (or it must allow all keywords if *`allowed-kws`* is `#f`).

Examples:

```
(define orig-show
  (make-keyword-procedure (lambda (kws kw-args . rest)
                            (list kws kw-args rest))))
```

```
(define show (procedure-reduce-keyword-arity
              orig-show 3 '(#:init) '(#:extra #:init)))
```

```
> (show #:init 0 1 2 3 #:extra 4)
'((#:extra #:init) (4 0) (1 2 3))
> (show 1)
arity mismatch;
 the expected number of arguments does not match the given
number
  expected: 3 plus an argument with keyword #:init plus an
optional argument with keyword #:extra
  given: 1
  arguments...:
   1
> (show #:init 0 1 2 3 #:extra 4 #:more 7)
application: procedure does not expect an argument with
given keyword
  procedure: #<procedure>
  given keyword: #:more
  arguments...:
   1
   2
   3
   #:extra 4
   #:init 0
   #:more 7
```

Changed in version 8.4.0.2 of package `base`: Added the *realm* argument.

```
(procedure-reduce-keyword-arity-mask proc
                                     mask
                                     required-kws
                                     allowed-kws
                                    [name
                                     realm])      → procedure?
  proc : procedure?
  mask : exact-integer?
  required-kws : (listof keyword?)
  allowed-kws : (or/c (listof keyword?)
                      #f)
  name : (or/c symbol? #f) = #f
  realm : symbol? = 'racket
```

The same as `procedure-reduce-keyword-arity`, but using the representation of arity described with `procedure-arity-mask`.

Added in version 7.0.0.11 of package base.
Changed in version 8.4.0.2: Added the *realm* argument.

```
(struct arity-at-least (value)
    #:extra-constructor-name make-arity-at-least)
  value : exact-nonnegative-integer?
```

A structure type used for the result of `procedure-arity`. See also `procedure-arity?`.

```
prop:procedure : struct-type-property?
```

A structure type property to identify structure types whose instances can be applied as procedures. In particular, when `procedure?` is applied to the instance, the result will be `#t`, and when an instance is used in the function position of an application expression, a procedure is extracted from the instance and used to complete the procedure call.

If the `prop:procedure` property value is an exact non-negative integer, it designates a field within the structure that should contain a procedure. The integer must be between `0` (inclusive) and the number of non-automatic fields in the structure type (exclusive, not counting supertype fields). The designated field must also be specified as immutable, so that after an instance of the structure is created, its procedure cannot be changed. (Otherwise, the arity and name of the instance could change, and such mutations are generally not allowed for procedures.) When the instance is used as the procedure in an application expression, the value of the designated field in the instance is used to complete the procedure call. (This procedure can be another structure that acts as a procedure; the immutability of procedure fields disallows cycles in the procedure graph, so that the procedure call will eventually continue with a non-structure procedure.) That procedure receives all of the arguments from the application expression. The procedure's name (see `object-name`), arity (see `procedure-arity`), and keyword protocol (see `procedure-keywords`) are also used for the name, arity, and keyword protocol of the structure. If the value in the designated field is not a procedure, then the instance behaves like `(case-lambda)` (i.e., a procedure which does not accept any number of arguments). See also `procedure-extract-target`.

Providing an integer `proc-spec` argument to `make-struct-type` is the same as both supplying the value with the `prop:procedure` property and designating the field as immutable (so that a property binding or immutable designation is redundant and disallowed).

Examples:

```
> (struct annotated-proc (base note)
    #:property prop:procedure
               (struct-field-index base))
> (define plus1 (annotated-proc
                  (lambda (x) (+ x 1))
                  "adds 1 to its argument"))
> (procedure? plus1)
```

```
#t
> (annotated-proc? plus1)
#t
> (plus1 10)
11
> (annotated-proc-note plus1)
"adds 1 to its argument"
```

When the prop:procedure value is a procedure, it should accept at least one non-keyword argument. When an instance of the structure is used in an application expression, the property-value procedure is called with the instance as the first argument. The remaining arguments to the property-value procedure are the arguments from the application expression (including keyword arguments). Thus, if the application expression provides five non-keyword arguments, the property-value procedure is called with six non-keyword arguments. The name of the instance (see object-name) and its keyword protocol (see procedure-keywords) are unaffected by the property-value procedure, but the instance's arity is determined by subtracting one from every possible non-keyword argument count of the property-value procedure. If the property-value procedure cannot accept at least one argument, then the instance behaves like (case-lambda).

Providing a procedure proc-spec argument to make-struct-type is the same as supplying the value with the prop:procedure property (so that a specific property binding is disallowed).

Examples:

```
> (struct fish (weight color)
    #:mutable
    #:property
    prop:procedure
    (lambda (f n)
      (let ([w (fish-weight f)])
        (set-fish-weight! f (+ n w)))))
> (define wanda (fish 12 'red))
> (fish? wanda)
#t
> (procedure? wanda)
#t
> (fish-weight wanda)
12
> (for-each wanda '(1 2 3))
> (fish-weight wanda)
18
```

If the value supplied for the prop:procedure property is not an exact non-negative integer or a procedure, the exn:fail:contract exception is raised.

```
(procedure-struct-type? type) → boolean?
  type : struct-type?
```

Returns #t if instances of the structure type represented by *type* are procedures (according to procedure?), #f otherwise.

```
(procedure-extract-target proc) → (or/c #f procedure?)
  proc : procedure?
```

If *proc* is an instance of a structure type with property prop:procedure, and if the property value indicates a field of the structure, and if the field value is a procedure, then procedure-extract-target returns the field value. Otherwise, the result is #f.

When a prop:procedure property value is a procedure, the procedure is *not* returned by procedure-extract-target. Such a procedure is different from one accessed through a structure field, because it consumes an extra argument, which is always the structure that was applied as a procedure. Keeping the procedure private ensures that is it always called with a suitable first argument.

```
prop:arity-string : struct-type-property?
```

A structure type property that is used for reporting arity-mismatch errors when a structure type with the prop:procedure property is applied to the wrong number of arguments. The value of the prop:arity-string property must be a procedure that takes a single argument, which is the misapplied structure, and returns a string. The result string is used after the word “expects,” and it is followed in the error message by the number of actual arguments.

Arity-mismatch reporting automatically uses procedure-extract-target when the prop:arity-string property is not associated with a procedure structure type.

Examples:

```
> (struct evens (proc)
    #:property prop:procedure (struct-field-index proc)
    #:property prop:arity-string
    (lambda (p)
      "an even number of arguments"))
> (define pairs
    (evens
     (case-lambda
      [() null]
      [(a b . more)
       (cons (cons a b)
             (apply pairs more))])))
```

```
> (pairs 1 2 3 4)
'((1 . 2) (3 . 4))
> (pairs 5)
arity mismatch;
 the expected number of arguments does not match the given
number
   expected: an even number of arguments
   given: 1
   arguments...:
    5
```

```
prop:checked-procedure : struct-type-property?
```

A structure type property that is used with `checked-procedure-check-and-extract`, which is a hook to allow the compiler to improve the performance of keyword arguments. The property can only be attached to a structure type without a supertype and with at least two fields.

```
(checked-procedure-check-and-extract type
                                     v
                                     proc
                                     v1
                                     v2)  → any/c
  type : struct-type?
  v : any/c
  proc : (any/c any/c any/c . -> . any/c)
  v1 : any/c
  v2 : any/c
```

Extracts a value from *v* if it is an instance of *type*, which must have the property `prop:checked-procedure`. If *v* is such an instance, then the first field of *v* is extracted and applied to *v1* and *v2*; if the result is a true value, the result is the value of the second field of *v*.

If *v* is not an instance of *type*, or if the first field of *v* applied to *v1* and *v2* produces `#f`, then *proc* is applied to *v*, *v1*, and *v2*, and its result is returned by `checked-procedure-check-and-extract`.

```
(procedure-specialize proc) → procedure?
  proc : procedure?
```

Returns *proc* or its equivalent, but provides a hint to the run-time system that it should spend extra time and memory to specialize the implementation of *proc*.

The hint is currently used when *proc* is the value of a `lambda` or `case-lambda` form that references variables bound outside of the `lambda` or `case-lambda`, and when *proc* has not been previously applied.

Added in version 6.3.0.10 of package `base`.

4.20.2 Reflecting on Primitives

A *primitive procedure* is a built-in procedure that may be implemented in a lower-level language. Not all procedures of `racket/base` are primitives, but many are. The distinction between primitives and other procedures may be useful to other low-level code.

```
(primitive? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a primitive procedure, `#f` otherwise.

```
(primitive-closure? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is internally implemented as a primitive closure rather than a simple primitive procedure, `#f` otherwise.

```
(primitive-result-arity prim) → procedure-arity?
  prim : primitive?
```

Returns the arity of the result of the primitive procedure *prim* (as opposed to the procedure's input arity as returned by `procedure-arity`). For most primitives, this procedure returns `1`, since most primitives return a single value when applied.

4.20.3 Additional Higher-Order Functions

```
(require racket/function)        package: base
```

The bindings documented in this section are provided by the `racket/function` and `racket` libraries, but not `racket/base`.

```
(identity v) → any/c
  v : any/c
```

Returns *v*.

```
(const v) → procedure?
  v : any/c
```

Returns a procedure that accepts any arguments (including keyword arguments) and returns *v*.

Examples:

```
> ((const 'foo))
'foo
> ((const 'foo) 1 2 3)
'foo
> ((const 'foo) 'a 'b #:c 'c)
'foo
```

```
(const* v ...) → procedure?
  v : any/c
```

Similar to `const`, except it returns *v*s.

Examples:

```
> ((const*))
> ((const*) 1 2 3)
> ((const*) 'a 'b #:c 'c)
> ((const* 'foo))
'foo
> ((const* 'foo) 1 2 3)
'foo
> ((const* 'foo) 'a 'b #:c 'c)
'foo
> ((const* 'foo 'foo))
'foo
'foo
> ((const* 'foo 'foo) 1 2 3)
'foo
'foo
> ((const* 'foo 'foo) 'a 'b #:c 'c)
'foo
'foo
```

Added in version 8.7.0.5 of package `base`.

```
(thunk  body ...+)
(thunk* body ...+)
```

The `thunk` form creates a nullary function that evaluates the given body. The `thunk*` form is similar, except that the resulting function accepts any arguments (including keyword arguments).

Examples:

```
(define th1 (thunk (define x 1) (printf "~a\n" x)))
```

```
> (th1)
1
> (th1 'x)
th1: arity mismatch;
 the expected number of arguments does not match the given
number
  expected: 0
  given: 1
> (th1 #:y 'z)
application: procedure does not accept keyword arguments
  procedure: th1
  arguments...:
   #:y 'z
```

```
(define th2 (thunk* (define x 1) (printf "~a\n" x)))
```

```
> (th2)
1
> (th2 'x)
1
> (th2 #:y 'z)
1
```

```
(negate proc) → procedure?
  proc : procedure?
```

Returns a procedure that is just like `proc`, except that it returns the `not` of `proc`'s result.

Examples:

```
> (filter (negate symbol?) '(1 a 2 b 3 c))
'(1 2 3)
> (map (negate =) '(1 2 3) '(1 1 1))
'(#f #t #t)
```

```
((conjoin f ...) x ...) → any
  f : procedure?
  x : any/c
```

Combines calls to each function with and. Equivalent to `(and (f x ...) ...)`

Examples:

```
(define f (conjoin exact? integer?))
```

```
> (f 1)
#t
> (f 1.0)
#f
> (f 1/2)
#f
> (f 0.5)
#f
> ((conjoin (λ (x) (values 1 2))) 0)
1
2
```

```
((disjoin f ...) x ...) → any
  f : procedure?
  x : any/c
```

Combines calls to each function with `or`. Equivalent to `(or (f x ...) ...)`

Examples:

```
(define f (disjoin exact? integer?))
```

```
> (f 1)
#t
> (f 1.0)
#t
> (f 1/2)
#t
> (f 0.5)
#f
> ((disjoin (λ (x) (values 1 2))) 0)
1
2
```

```
(curry proc) → procedure?
  proc : procedure?
(curry proc v ...+) → any
  proc : procedure?
  v : any/c
```

The result of `(curry proc)` is a procedure that is a curried version of *proc*. When the resulting procedure is first applied, unless it is given the maximum number of arguments that it can accept according to `(procedure-arity proc)`, the result is a procedure to accept additional arguments.

Examples:

```
> ((curry list) 1 2)
#<procedure:curried:list>
> ((curry cons) 1)
#<procedure:curried:cons>
> ((curry cons) 1 2)
'(1 . 2)
```

After the first application of the result of `(curry proc)`, each further application accumulates arguments until an acceptable number of arguments according to `(procedure-arity proc)` have been accumulated, at which point the original *proc* is called.

Examples:

```
> (((curry list) 1 2) 3)
'(1 2 3)
> (((curry list) 1) 3)
'(1 3)
> ((((curry foldl) +) 0) '(1 2 3))
6
> (define foo (curry (lambda (x y z) (list x y z))))
> (foo 1 2 3)
'(1 2 3)
> (((((foo) 1) 2)) 3)
'(1 2 3)
```

A function call `(curry proc v ...)` is equivalent to `((curry proc) v ...)`. In other words, `curry` itself is curried.

Examples:

```
> (map ((curry +) 10) '(1 2 3))
'(11 12 13)
> (map (curry + 10) '(1 2 3))
'(11 12 13)
> (map (compose (curry * 2) (curry + 10)) '(1 2 3))
'(22 24 26)
```

The `curry` function also supports functions with keyword arguments: keyword arguments will be accumulated in the same way as positional arguments until all required keyword arguments according to `(procedure-keywords proc)` have been supplied.

Examples:

```
(define (f #:a a #:b b #:c c)
```

```
    (list a b c))

> ((((curry f) #:a 1) #:b 2) #:c 3)
'(1 2 3)
> ((((curry f) #:b 1) #:c 2) #:a 3)
'(3 1 2)
> ((curry f #:a 1 #:c 2) #:b 3)
'(1 3 2)
```

Changed in version 7.0.0.7 of package `base`: Added support for keyword arguments.

```
(curryr proc) → procedure?
  proc : procedure?
(curryr proc v ...+) → any
  proc : procedure?
  v : any/c
```

Like `curry`, except that the arguments are collected in the opposite direction: the first step collects the rightmost group of arguments, and following steps add arguments to the left of these.

Example:

```
> (map (curryr list 'foo) '(1 2 3))
'((1 foo) (2 foo) (3 foo))
```

```
(normalized-arity? arity) → boolean?
  arity : any/c
```

A normalized arity has one of the following forms:

- the empty list;
- an exact non-negative integer;
- an `arity-at-least` instance;
- a list of two or more strictly increasing, exact non-negative integers; or
- a list of one or more strictly increasing, exact non-negative integers followed by a single `arity-at-least` instance whose value is greater than the preceding integer by at least 2.

Every normalized arity is a valid procedure arity and satisfies `procedure-arity?`. Any two normalized arity values that are `arity=?` must also be `equal?`.

Examples:

```
> (normalized-arity? (arity-at-least 1))
#t
> (normalized-arity? (list (arity-at-least 1)))
#f
> (normalized-arity? (list 0 (arity-at-least 2)))
#t
> (normalized-arity? (list (arity-at-least 2) 0))
#f
> (normalized-arity? (list 0 2 (arity-at-least 3)))
#f
```

```
(normalize-arity arity)
 → (and/c normalized-arity? (lambda (x) (arity=? x arity)))
  arity : procedure-arity?
```

Produces a normalized form of `arity`. See also `normalized-arity?` and `arity=?`.

Examples:

```
> (normalize-arity 1)
1
> (normalize-arity (list 1))
1
> (normalize-arity (arity-at-least 2))
(arity-at-least 2)
> (normalize-arity (list (arity-at-least 2)))
(arity-at-least 2)
> (normalize-arity (list 1 (arity-at-least 2)))
(arity-at-least 1)
> (normalize-arity (list (arity-at-least 2) 1))
(arity-at-least 1)
> (normalize-arity (list (arity-at-least 2) 3))
(arity-at-least 2)
> (normalize-arity (list 3 (arity-at-least 2)))
(arity-at-least 2)
> (normalize-arity (list (arity-at-least 6) 0 2 (arity-at-
least 4)))
(list 0 2 (arity-at-least 4))
```

```
(arity=? a b) → boolean?
  a : procedure-arity?
  b : procedure-arity?
```

Returns `#true` if procedures with arity `a` and `b` accept the same numbers of arguments, and `#false` otherwise. Equivalent to both `(and (arity-includes? a b) (arity-includes? b a))` and `(equal? (normalize-arity a) (normalize-arity b))`.

Examples:

```
> (arity=? 1 1)
#t
> (arity=? (list 1) 1)
#t
> (arity=? 1 (list 1))
#t
> (arity=? 1 (arity-at-least 1))
#f
> (arity=? (arity-at-least 1) 1)
#f
> (arity=? (arity-at-least 1) (list 1 (arity-at-least 2)))
#t
> (arity=? (list 1 (arity-at-least 2)) (arity-at-least 1))
#t
> (arity=? (arity-at-least 1) (list 1 (arity-at-least 3)))
#f
> (arity=? (list 1 (arity-at-least 3)) (arity-at-least 1))
#f
> (arity=? (list 0 1 2 (arity-at-least 3)) (list (arity-at-
least 0)))
#t
> (arity=? (list (arity-at-least 0)) (list 0 1 2 (arity-at-
least 3)))
#t
> (arity=? (list 0 2 (arity-at-least 3)) (list (arity-at-
least 0)))
#f
> (arity=? (list (arity-at-least 0)) (list 0 2 (arity-at-
least 3)))
#f
```

```
(arity-includes? a b) → boolean?
  a : procedure-arity?
  b : procedure-arity?
```

Returns `#true` if procedures with arity `a` accept any number of arguments that procedures with arity `b` accept.

Examples:

```
> (arity-includes? 1 1)
#t
> (arity-includes? (list 1) 1)
#t
```

```
> (arity-includes? 1 (list 1))
#t
> (arity-includes? 1 (arity-at-least 1))
#f
> (arity-includes? (arity-at-least 1) 1)
#t
> (arity-includes? (arity-at-least 1) (list 1 (arity-at-least 2)))
#t
> (arity-includes? (list 1 (arity-at-least 2)) (arity-at-least 1))
#t
> (arity-includes? (arity-at-least 1) (list 1 (arity-at-least 3)))
#t
> (arity-includes? (list 1 (arity-at-least 3)) (arity-at-least 1))
#f
> (arity-includes? (list 0 1 2 (arity-at-least 3)) (list (arity-
at-least 0)))
#t
> (arity-includes? (list (arity-at-least 0)) (list 0 1 2 (arity-
at-least 3)))
#t
> (arity-includes? (list 0 2 (arity-at-least 3)) (list (arity-at-
least 0)))
#f
> (arity-includes? (list (arity-at-least 0)) (list 0 2 (arity-at-
least 3)))
#t
```

4.21 Void

The constant `#<void>` is returned by most forms and procedures that have a side-effect and no useful result.

The `#<void>` value is always `eq?` to itself.

```
(void? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is the constant `#<void>`, `#f` otherwise.

```
(void v ...) → void?
  v : any/c
```

Returns the constant `#<void>`. Each *v* argument is ignored.

4.22 Undefined

```
(require racket/undefined)
```
package: base

The bindings documented in this section are provided by the `racket/undefined` library, not `racket/base` or `racket`.

The constant `undefined` can be used as a placeholder value for a value to be installed later, especially for cases where premature access of the value is either difficult or impossible to detect or prevent.

The `undefined` value is always `eq?` to itself.

Added in version 6.0.0.6 of package `base`.

```
undefined : any/c
```

The "undefined" constant.

5 Structures

§5 "Programmer-Defined Datatypes" in *The Racket Guide* introduces structure types via `struct`.

A *structure type* is a record datatype composing a number of *fields*. A *structure*, an instance of a structure type, is a first-class value that contains a value for each field of the structure type. A structure instance is created with a type-specific constructor procedure, and its field values are accessed and changed with type-specific accessor and mutator procedures. In addition, each structure type has a predicate procedure that answers `#t` for instances of the structure type and `#f` for any other value.

A structure type's fields are essentially unnamed, though names are supported for error-reporting purposes. The constructor procedure takes one value for each field of the structure type, except that some of the fields of a structure type can be *automatic fields*; the automatic fields are initialized to a constant that is associated with the structure type, and the corresponding arguments are omitted from the constructor procedure. All automatic fields in a structure type follow the non-automatic fields.

A structure type can be created as a *structure subtype* of an existing base structure type. An instance of a structure subtype can always be used as an instance of the base structure type, but the subtype gets its own predicate procedure, and it may have its own fields in addition to the fields of the base type.

A structure subtype "inherits" the fields of its base type. If the base type has m fields, and if n fields are specified for the new structure subtype, then the resulting structure type has $m+n$ fields. The value for automatic fields can be different in a subtype than in its base type.

If m' of the original m fields are non-automatic (where $m'<m$), and n' of the new fields are non-automatic (where $n'<n$), then $m'+n'$ field values must be provided to the subtype's constructor procedure. Values for the first m fields of a subtype instance are accessed with selector procedures for the original base type (or its supertypes), and the last n are accessed with subtype-specific selectors. Subtype-specific accessors and mutators for the first m fields do not exist.

The `struct` form and `make-struct-type` procedure typically create a new structure type, but they can also access *prefab* (i.e., previously fabricated) structure types that are globally shared, and whose instances can be parsed and written by the default reader (see §1.3 "The Reader") and printer (see §1.4 "The Printer"). Prefab structure types can inherit only from other prefab structure types, and they cannot have guards (see §5.2 "Creating Structure Types") or properties (see §5.3 "Structure Type Properties"). Exactly one prefab structure type exists for each combination of name, supertype, field count, automatic field count, automatic field value (when there is at least one automatic field), and field mutability.

§13.9 "Serialization" also provides information on reading and writing structures.

Two structure values are `eqv?` if and only if they are `eq?`. Two structure values are `equal?` if they are `eq?`. By default, two structure values are also `equal?` if they are instances of the same structure type, no fields are opaque, and the results of applying `struct->vector` to the structs are `equal?`. (Consequently, `equal?` testing for structures may depend on the current inspector.) A structure type can override the default `equal?` definition through the gen:equal+hash or gen:equal-mode+hash generic interface.

5.1 Defining Structure Types: struct

§5 "Programmer-Defined Datatypes" in *The Racket Guide* introduces struct.

```
(struct id maybe-super (field ...)
        struct-option ...)

  maybe-super =
              | super-id

        field = field-id
              | [field-id field-option ...]

struct-option = #:mutable
              | #:super super-expr
              | #:inspector inspector-expr
              | #:auto-value auto-expr
              | #:guard guard-expr
              | #:property prop-expr val-expr
              | #:properties prop-list-expr
              | #:transparent
              | #:prefab
              | #:sealed
              | #:authentic
              | #:name name-id
              | #:extra-name name-id
              | #:constructor-name constructor-id
              | #:extra-constructor-name constructor-id
              | #:reflection-name symbol-expr
              | #:methods gen:name-id method-defs
              | #:omit-define-syntaxes
              | #:omit-define-values

 field-option = #:mutable
              | #:auto

  method-defs = (definition ...)
```

Creates a new structure type (or uses a pre-existing structure type if #:prefab is specified), and binds transformers and variables related to the structure type.

A struct form with *n* fields defines up to 4+2*n* names:

- struct:id, a *structure type descriptor* value that represents the structure type.

- *constructor-id* (which defaults to *id*), a *constructor* procedure that takes *m* arguments and returns a new instance of the structure type, where *m* is the number of *field*s that do not include an #:auto option.
- *name-id* (which defaults to *id*), a transformer binding that encapsulates information about the structure type declaration. This binding is used to define subtypes, and it also works with the shared and match forms. For detailed information about the binding of *name-id*, see §5.7 "Structure Type Transformer Binding".

  The *constructor-id* and *name-id* can be the same, in which case *name-id* performs both roles. In that case, the expansion of *name-id* as an expression produces an otherwise inaccessible identifier that is bound to the constructor procedure; the expanded identifier has a 'constructor-for property whose value is an identifier that is free-identifier=? to *name-id* as well as a syntax property accessible via syntax-procedure-alias-property with an identifier that is free-identifier=? to *name-id*.
- *id?*, a *predicate* procedure that returns #t for instances of the structure type (constructed by *constructor-id* or the constructor for a subtype) and #f for any other value.
- *id-field-id*, for each *field*; an *accessor* procedure that takes an instance of the structure type and extracts the value for the corresponding field.
- set-*id-field-id*!, for each *field* that includes a #:mutable option, or when the #:mutable option is specified as a *struct-option*; a *mutator* procedure that takes an instance of the structure type and a new field value. The structure is destructively updated with the new value, and #<void> is returned.

If *super-id* is provided, it must have a transformer binding of the same sort bound to *name-id* (see §5.7 "Structure Type Transformer Binding"), and it specifies a supertype for the structure type. Alternately, the #:super option can be used to specify an expression that must produce a structure type descriptor. See §5 "Structures" for more information on structure subtypes and supertypes. If both *super-id* and #:super are provided, a syntax error is reported.

Examples:

```
> (struct document (author title content))
> (struct book document (publisher))
> (struct paper (journal) #:super struct:document)
```

If the #:mutable option is specified for an individual field, then the field can be mutated in instances of the structure type, and a mutator procedure is bound. Supplying #:mutable as a *struct-option* is the same as supplying it for all *field*s. If #:mutable is specified as both a *field-option* and *struct-option*, a syntax error is reported.

Examples:

```
> (struct cell ([content #:mutable]) #:transparent)
> (define a-cell (cell 0))
> (set-cell-content! a-cell 1)
```

The #:inspector, #:auto-value, and #:guard options specify an inspector, value for automatic fields, and guard procedure, respectively. See make-struct-type for more information on these attributes of a structure type. The #:property option, which can be supplied multiple times, attaches a property value to the structure type; see §5.3 “Structure Type Properties” for more information on properties. The #:properties option, which can be supplied multiple times, accepts multiple properties and their values as an association list. The #:transparent option is a shorthand for #:inspector #f.

Examples:

```
> (struct point (x y) #:inspector #f)
> (point 3 5)
(point 3 5)
> (struct celsius (temp)
    #:guard (λ (temp name)
              (unless (and (real? temp) (>= temp -273.15))
                (error "not a valid temperature"))
              temp))
> (celsius -275)
not a valid temperature
```

Use the prop:procedure property to implement an applicable structure, use prop:evt to create a structure type whose instances are synchronizable events, and so on. By convention, property names start with prop:.

The #:prefab option obtains a prefab (pre-defined, globally shared) structure type, as opposed to creating a new structure type. Such a structure type is inherently transparent and non-sealed, and it cannot have a guard or properties, so using #:prefab with #:transparent, #:inspector, #:guard, #:property, #:sealed, #:authentic, or #:methods is a syntax error. If a supertype is specified, it must also be a prefab structure type.

Examples:

```
> (struct prefab-point (x y) #:prefab)
> (prefab-point 1 2)
'#s(prefab-point 1 2)
> (prefab-point? #s(prefab-point 1 2))
#t
```

The #:sealed option is a shorthand for #:property prop:sealed #t, which prevents the structure type from being used as the supertype of another structure type. See prop:sealed for more information.

The #:authentic option is a shorthand for #:property prop:authentic #t, which prevents instances of the structure type from being impersonated (see impersonate-struct), chaperoned (see chaperone-struct), or acquiring a non-flat contract (see struct/c). See prop:authentic for more information. If a supertype is specified, it must also have the prop:authentic property.

If *name-id* is supplied via #:extra-name and it is not *id*, then both *name-id* and *id* are bound to information about the structure type. Only one of #:extra-name and #:name can be provided within a struct form, and #:extra-name cannot be combined with #:omit-define-syntaxes.

Examples:

```
> (struct ghost (color name) #:prefab #:extra-name GHOST)
> (match (ghost 'red 'blinky)
    [(GHOST c n) c])
'red
```

If *constructor-id* is supplied, then the transformer binding of *name-id* records *constructor-id* as the constructor binding; as a result, for example, struct-out includes *constructor-id* as an export. If *constructor-id* is supplied via #:extra-constructor-name and it is not *id*, applying object-name on the constructor produces the symbolic form of *id* rather than *constructor-id*. If *constructor-id* is supplied via #:constructor-name and it is not the same as *name-id*, then *name-id* does not serve as a constructor, and object-name on the constructor produces the symbolic form of *constructor-id*. Only one of #:extra-constructor-name and #:constructor-name can be provided within a struct form.

Examples:

```
> (struct color (r g b) #:constructor-name -color)
> (struct rectangle (w h color) #:extra-constructor-name rect)
> (rectangle 13 50 (-color 192 157 235))
#<rectangle>
> (rect 50 37 (-color 35 183 252))
#<rectangle>
```

If #:reflection-name *symbol-expr* is provided, then *symbol-expr* must produce a symbol that is used to identify the structure type in reflective operations such as struct-type-info. It corresponds to the first argument of make-struct-type. Structure printing uses the reflective name, as do the various procedures that are bound by struct.

Examples:

```
> (struct circle (radius) #:reflection-name '<circle>)
> (circle 15)
#<<circle>>
> (circle-radius "bad")
```

```
<circle>-radius: contract violation
  expected: <circle>?
  given: "bad"
```

If #:methods *gen:name-id method-defs* is provided (potentially multiple times), then *gen:name-id* must be a transformer binding for the static information about a generic interface produced by define-generics. The *method-defs* define the methods of the *gen:name-id* interface. A define/generic form or auxiliary definitions and expressions may also appear in *method-defs*.

Examples:

```
> (struct constant-stream (val)
    #:methods gen:stream
    [(define (stream-empty? stream) #f)
     (define (stream-first stream)
       (constant-stream-val stream))
     (define (stream-rest stream) stream)])
> (stream-ref (constant-stream 'forever) 0)
'forever
> (stream-ref (constant-stream 'forever) 50)
'forever
```

If the #:omit-define-syntaxes option is supplied, then *name-id* (and *id*, if #:extra-name is specified) is not bound as a transformer. If the #:omit-define-values option is supplied, then none of the usual variables are bound, but *id* is bound. If both are supplied, then the struct form is equivalent to (begin).

Examples:

```
> (struct square (side) #:omit-define-syntaxes)
> (match (square 5)
    ; fails to match because syntax is omitted
    [(struct square x) x])
eval:28:0: match: square does not refer to a structure
definition
  at: square
  in: (struct square x)
> (struct ellipse (width height) #:omit-define-values)
> ellipse-width
ellipse-width: undefined;
 cannot reference an identifier before its definition
  in module: top-level
```

If #:auto is supplied as a *field-option*, then the constructor procedure for the structure type does not accept an argument corresponding to the field. Instead, the structure type's

Expressions supplied to #:auto-value are evaluated once and shared between every instance of the structure type. In particular, updates to a mutable #:auto-value affect all current and future instances.

automatic value is used for the field, as specified by the `#:auto-value` option, or as defaults to `#f` when `#:auto-value` is not supplied. The field is mutable (e.g., through reflective operations), but a mutator procedure is bound only if `#:mutable` is specified.

If a *`field`* includes the `#:auto` option, then all fields after it must also include `#:auto`, otherwise a syntax error is reported. If any *`field-option`* or *`struct-option`* keyword is repeated, other than `#:property`, a syntax error is reported.

Examples:

```
(struct posn (x y [z #:auto #:mutable])
  #:auto-value 0
  #:transparent)

> (posn 1 2)
(posn 1 2 0)
> (posn? (posn 1 2))
#t
> (posn-y (posn 1 2))
2
> (posn-z (posn 1 2))
0

(struct color-posn posn (hue) #:mutable)
(define cp (color-posn 1 2 "blue"))

> (color-posn-hue cp)
"blue"
> cp
(color-posn 1 2 0 ...)
> (set-posn-z! cp 3)
```

For serialization, see `define-serializable-struct`.

Changed in version 6.9.0.4 of package `base`: Added `#:authentic`.
Changed in version 8.0.0.7: Added `#:sealed`.
Changed in version 8.17.0.4: Added `#:properties`.

```
(struct-field-index field-id)
```

This form can only appear as an expression within a `struct` form; normally, it is used with `#:property`, especially for a property like `prop:procedure`. The result of a `struct-field-index` expression is an exact, non-negative integer that corresponds to the position within the structure declaration of the field named by *`field-id`*.

Examples:

```
(struct mood-procedure (base rating)
  #:property prop:procedure (struct-field-index base))
(define happy+ (mood-procedure add1 10))
```

```
> (happy+ 2)
3
> (mood-procedure-rating happy+)
10
```

```
(define-struct id-maybe-super (field ...)
               struct-option ...)

id-maybe-super = id
               | (id super-id)
```

Like `struct`, except that the syntax for supplying a *`super-id`* is different, and a *`constructor-id`* that has a `make-` prefix on *`id`* is implicitly supplied via `#:extra-constructor-name` if neither `#:extra-constructor-name` nor `#:constructor-name` is provided.

This form is provided for backwards compatibility; `struct` is preferred.

Examples:

```
(define-struct posn (x y [z #:auto])
   #:auto-value 0
   #:transparent)
```

```
> (make-posn 1 2)
(posn 1 2 0)
> (posn? (make-posn 1 2))
#t
> (posn-y (make-posn 1 2))
2
```

```
(struct/derived (id . rest-form)
id (field ...) struct-option ...)
(struct/derived (id . rest-form)
id super-id (field ...) struct-option ...)
```

The same as `struct`, but with an extra `(id . rest-form)` sub-form that is treated as the overall form for syntax-error reporting and otherwise ignored. The only constraint on the sub-form for error reporting is that it starts with *`id`*. The `struct/derived` form is intended for use by macros that expand to `struct`.

Examples:

```
(define-syntax (fruit-struct stx)
  (syntax-case stx ()
   [(ds name . rest)
    (with-syntax ([orig stx])
      #'(struct/derived orig name (seeds color) . rest))]))

> (fruit-struct apple)
> (apple-seeds (apple 12 "red"))
12
> (fruit-struct apple #:mutable)
> (set-apple-seeds! (apple 12 "red") 8)
; this next line will cause an error due to a bad keyword
> (fruit-struct apple #:bad-option)
eval:54:0: fruit-struct: unrecognized struct-specification
keyword
  at: #:bad-option
  in: (fruit-struct apple #:bad-option)
```

Added in version 7.5.0.16 of package base.

```
(define-struct/derived (id . rest-form)
  id-maybe-super (field ...) struct-option ...)
```

Like `struct/derived`, except that the syntax for supplying a `super-id` is different, and a *`constructor-id`* that has a `make-` prefix on *`id`* is implicitly supplied via `#:extra-constructor-name` if neither `#:extra-constructor-name` nor `#:constructor-name` is provided. The `define-struct/derived` form is intended for use by macros that expand to `define-struct`.

Examples:

```
(define-syntax (define-xy-struct stx)
  (syntax-case stx ()
   [(ds name . rest)
    (with-syntax ([orig stx])
      #'(define-struct/derived orig name (x y) . rest))]))

> (define-xy-struct posn)
> (posn-x (make-posn 1 2))
1
> (define-xy-struct posn #:mutable)
> (set-posn-x! (make-posn 1 2) 0)
; this next line will cause an error due to a bad keyword
> (define-xy-struct posn #:bad-option)
eval:60:0: define-xy-struct: unrecognized
struct-specification keyword
```

at: #:bad-option
in: (define-xy-struct posn #:bad-option)

Changed in version 7.5.0.16 of package `base`: Moved main description to `struct/derived` and replaced with differences.

5.2 Creating Structure Types

```
(make-struct-type  name
                   super-type
                   init-field-cnt
                   auto-field-cnt
                  [auto-v
                   props
                   inspector
                   proc-spec
                   immutables
                   guard
                   constructor-name])
 → struct-type?
   struct-constructor-procedure?
   struct-predicate-procedure?
   struct-accessor-procedure?
   struct-mutator-procedure?
  name : symbol?
  super-type : (or/c struct-type? #f)
  init-field-cnt : exact-nonnegative-integer?
  auto-field-cnt : exact-nonnegative-integer?
  auto-v : any/c = #f
  props : (listof (cons/c struct-type-property? = null
                          any/c))
  inspector : (or/c inspector? #f 'prefab) = (current-inspector)
  proc-spec : (or/c procedure?                  = #f
                    exact-nonnegative-integer?
                    #f)
  immutables : (listof exact-nonnegative-integer?) = null
  guard : (or/c procedure? #f) = #f
  constructor-name : (or/c symbol? #f) = #f
```

Creates a new structure type, unless *inspector* is `'prefab`, in which case `make-struct-type` accesses a prefab structure type. The *name* argument is used as the type name. If *super-type* is not `#f`, the resulting type is a subtype of the corresponding structure type.

The resulting structure type has *init-field-cnt*+*auto-field-cnt* fields (in addition to any fields from *super-type*), but only *init-field-cnt* constructor arguments (in addition to any constructor arguments from *super-type*). The remaining fields are initialized with *auto-v*. The total field count (including *super-type* fields) must be no more than 32768.

The *props* argument is a list of pairs, where the `car` of each pair is a structure type property descriptor, and the `cdr` is an arbitrary value. A property can be specified multiple times in *props* (including properties that are automatically added by properties that are directly included in *props*) only if the associated values are `eq?`, otherwise the `exn:fail:contract` exception is raised. See §5.3 "Structure Type Properties" for more information about properties. When *inspector* is `'prefab`, then *props* must be `null`.

The *inspector* argument normally controls access to reflective information about the structure type and its instances; see §14.9 "Structure Inspectors" for more information. If *inspector* is `'prefab`, then the resulting prefab structure type and its instances are always transparent. If *inspector* is `#f`, then the structure type's instances are transparent.

If *proc-spec* is an integer or procedure, instances of the structure type act as procedures. See `prop:procedure` for further information. Providing a non-`#f` value for *proc-spec* is the same as pairing the value with `prop:procedure` at the end of *props*, plus including *proc-spec* in *immutables* when *proc-spec* is an integer.

The *immutables* argument provides a list of field positions. Each element in the list must be unique, otherwise `exn:fail:contract` exception is raised. Each element must also fall in the range `0` (inclusive) to *init-field-cnt* (exclusive), otherwise `exn:fail:contract` exception is raised.

The *guard* argument is either a procedure of n+1 arguments or `#f`, where n is the number of arguments for the new structure type's constructor (i.e., *init-field-cnt* plus constructor arguments implied by *super-type*, if any). If *guard* is a procedure, then the procedure is called whenever an instance of the type is constructed, or whenever an instance of a subtype is created. The arguments to *guard* are the values provided for the structure's first n fields, followed by the name of the instantiated structure type (which is *name*, unless a subtype is instantiated). The *guard* result must be n values, which become the actual values for the structure's fields. The *guard* can raise an exception to prevent creation of a structure with the given field values. If a structure subtype has its own guard, the subtype guard is applied first, and the first n values produced by the subtype's guard procedure become the first n arguments to *guard*. When *inspector* is `'prefab`, then *guard* must be `#f`.

If *constructor-name* is not `#f`, it is used as the name of the generated constructor procedure as returned by `object-name` or in the printed form of the constructor value.

The result of `make-struct-type` is five values:

- a structure type descriptor,
- a constructor procedure,

- a predicate procedure,
- an accessor procedure, which consumes a structure and a field index between 0 (inclusive) and *init-field-cnt*+*auto-field-cnt* (exclusive), and
- a mutator procedure, which consumes a structure, a field index, and a field value.

Examples:

```
(define-values (struct:a make-a a? a-ref a-set!)
  (make-struct-type 'a #f 2 1 'uninitialized))
(define an-a (make-a 'x 'y))

> (a-ref an-a 1)
'y
> (a-ref an-a 2)
'uninitialized
> (define a-first (make-struct-field-accessor a-ref 0))
> (a-first an-a)
'x

(define-values (struct:b make-b b? b-ref b-set!)
  (make-struct-type 'b struct:a 1 2 'b-uninitialized))
(define a-b (make-b 'x 'y 'z))

> (a-ref a-b 1)
'y
> (a-ref a-b 2)
'uninitialized
> (b-ref a-b 0)
'z
> (b-ref a-b 1)
'b-uninitialized
> (b-ref a-b 2)
'b-uninitialized

(define-values (struct:c make-c c? c-ref c-set!)
  (make-struct-type
   'c struct:b 0 0 #f null (make-inspector) #f null
   ; guard checks for a number, and makes it inexact
   (lambda (a1 a2 b1 name)
     (unless (number? a2)
       (error (string->symbol (format "make-~a" name))
              "second field must be a number"))
     (values a1 (exact->inexact a2) b1))))
```

```
> (make-c 'x 'y 'z)
make-c: second field must be a number
> (define a-c (make-c 'x 2 'z))
> (a-ref a-c 1)
2.0

(define p1 #s(p a b c))
(define-values (struct:p make-p p? p-ref p-set!)
  (make-struct-type 'p #f 3 0 #f null 'prefab #f '(0 1 2)))

> (p? p1)
#t
> (p-ref p1 0)
'a
> (make-p 'x 'y 'z)
'#s(p x y z)
```

```
(make-struct-field-accessor  accessor-proc
                             field-pos
                            [field/proc-name
                             arg-contract-str
                             realm])          → procedure?
  accessor-proc : struct-accessor-procedure?
  field-pos : exact-nonnegative-integer?
  field/proc-name : (or/c symbol? #f)
                  = (symbol->string (format "field~a" field-pos))
  arg-contract-str : (or/c string? symbol? #f) = #f
  realm : symbol? = 'racket
```

Returns a field accessor that is equivalent to `(lambda (s) (accessor-proc s field-pos))`. The `accessor-proc` must be an accessor returned by `make-struct-type`.

The `field/proc-name` argument determines the name of the resulting procedure for error reporting and debugging purposes. If `field/proc-name` is a symbol and `arg-contract-str` is not `#f`, then `field/proc-name` is used as the procedure name. If `field/proc-name` is a symbol and `arg-contract-str` is `#f`, then `field/proc-name` is combined with the name of `accessor-proc`'s structure type to form the procedure name. If `field/proc-name` is `#f`, then `'accessor` is used as the procedure name.

The `arg-contract-str` argument determines how the accessor procedure reports an error when it is applied to a value that is not an instance of the `accessor-proc`'s structure type. If it is a string or symbol, the text of the string or symbol is used as a contract for error reporting. Otherwise, contract text is synthesized from the name of `accessor-proc`'s structure type.

The `realm` argument is also used for error reporting. It specifies a realm that an error-message adjuster may use to determine how to adjust an error message. The `realm` argument also determines the result of procedure-realm for the accessor procedure.

For examples, see make-struct-type.

Changed in version 8.4.0.2 of package base: Added the *arg-contract-str* and *realm* arguments.

```
(make-struct-field-mutator  mutator-proc
                            field-pos
                           [field/proc-name
                            arg-contract-str
                            realm])          → procedure?
  mutator-proc : struct-mutator-procedure?
  field-pos : exact-nonnegative-integer?
  field/proc-name : (or/c symbol? #f)
                  = (symbol->string (format "field~a" field-pos))
  arg-contract-str : (or/c string? symbol? #f) = #f
  realm : symbol? = 'racket
```

Returns a field mutator that is equivalent to `(lambda (s v) (mutator-proc s field-pos v))`. The *mutator-proc* must be a mutator returned by make-struct-type.

The field-name, *arg-contract-str*, and *realm* arguments are used for error and debugging purposes analogous to the same arguments to make-struct-field-accessor.

For examples, see make-struct-type.

Changed in version 8.4.0.2 of package base: Added the *arg-contract-str* and *realm* arguments.

```
prop:sealed : struct-type-property?
```

A structure type property that declares a structure type as *sealed*. The value associated with the property is ignored; the presence of the property itself makes the structure type sealed.

A sealed structure type cannot be used as the supertype of another structure type. Declaring a structure type as sealed is typically just a performance hint, since checking for an instance of a sealed structure type can be slightly faster than checking for an instance of a structure type that might have subtypes.

Added in version 8.0.0.7 of package base.

5.3 Structure Type Properties

§5.4 "Generic Interfaces" provide a high-level API on top of structure type properties.

A *structure type property* allows per-type information to be associated with a structure type (as opposed to per-instance information associated with a structure value). A property value is associated with a structure type through the make-struct-type procedure (see §5.2

"Creating Structure Types") or through the `#:property` option of `struct`. Subtypes inherit the property values of their parent types, and subtypes can override an inherited property value with a new value.

```
(make-struct-type-property  name
                           [guard
                            supers
                            can-impersonate?
                            accessor-name
                            contract-str
                            realm])
 → struct-type-property?
   (any/c . -> . boolean?)
   procedure?
  name : symbol?
  guard : (or/c procedure? #f 'can-impersonate) = #f
  supers : (listof (cons/c struct-type-property?  = null
                           (any/c . -> . any/c)))
  can-impersonate? : any/c = #f
  accessor-name : (or/c symbol? #f) = #f
  contract-str : (or/c string? symbol? #f) = #f
  realm : symbol? = 'racket
```

Creates a new structure type property and returns three values:

- a *structure type property descriptor*, for use with `make-struct-type` and `struct`;
- a *property predicate* procedure, which takes an arbitrary value and returns `#t` if the value is a descriptor or instance of a structure type that has a value for the property, `#f` otherwise;
- a *property accessor* procedure, which returns the value associated with the structure type given its descriptor or one of its instances; if the structure type does not have a value for the property, or if any other kind of value is provided, the `exn:fail:contract` exception is raised unless a second argument, *`failure-result`*, is supplied to the procedure. In that case, if *`failure-result`* is a procedure, it is called (through a tail call) with no arguments to produce the result of the property accessor procedure; otherwise, *`failure-result`* is itself returned as the result.

If the optional *`guard`* is supplied as a procedure, it is called by `make-struct-type` before attaching the property to a new structure type. The *`guard`* must accept two arguments: a value for the property supplied to `make-struct-type`, and a list containing information about the new structure type. The list contains the values that `struct-type-info` would return for the new structure type if it skipped the current-inspector control checks.

The result of calling *guard* is associated with the property in the target structure type, instead of the value supplied to `make-struct-type`. To reject a property association (e.g., because the value supplied to `make-struct-type` is inappropriate for the property), the *guard* can raise an exception. Such an exception prevents `make-struct-type` from returning a structure type descriptor.

If *guard* is `'can-impersonate`, then the property's accessor can be redirected through `impersonate-struct`. This option is identical to supplying `#t` as the *can-impersonate?* argument and is provided for backwards compatibility.

The optional *supers* argument is a list of properties that are automatically associated with some structure type when the newly created property is associated to the structure type. Each property in *supers* is paired with a procedure that receives the value supplied for the new property (after it is processed by *guard*) and returns a value for the associated property (which is then sent to that property's guard, of any).

The optional *can-impersonate?* argument determines if the structure type property can be redirected through `impersonate-struct`. If the argument is `#f`, then redirection is not allowed. Otherwise, the property accessor may be redirected by a struct impersonator.

The optional *accessor-name* argument supplies a name (in the sense of `object-name`) to use for the returned accessor function. If *accessor-name* is `#f`, a name is created by adding `-accessor` to the end of *name*.

The optional *contract-str* argument supplies a contract that is included in an error message with the returned accessor is applied to a value that is not an instance of the property (and where a *failure-result* argument is not supplied to the accessor). If *contract-str* is `#f`, a contract is created by adding `?` to the end of *name*.

The optional *realm* argument supplies a realm (in the sense of `procedure-realm`) to associate with the returned accessor.

Examples:

```
> (define-values (prop:p p? p-ref) (make-struct-type-property 'p))
> (define-values (struct:a make-a a? a-ref a-set!)
    (make-struct-type 'a #f 2 1 'uninitialized
                      (list (cons prop:p 8))))
> (p? struct:a)
#t
> (p? 13)
#f
> (define an-a (make-a 'x 'y))
> (p? an-a)
#t
> (p-ref an-a)
8
```

```
> (define-values (struct:b make-b b? b-ref b-set!)
    (make-struct-type 'b #f 0 0 #f))
> (p? struct:b)
#f
> (define-values (prop:q q? q-ref) (make-struct-type-property
                                     'q (lambda (v si) (add1 v))
                                     (list (cons prop:p sqrt))))
> (define-values (struct:c make-c c? c-ref c-set!)
    (make-struct-type 'c #f 0 0 'uninit
                      (list (cons prop:q 8))))
> (q-ref struct:c)
9
> (p-ref struct:c)
3
```

Changed in version 7.0 of package `base`: The CS implementation of Racket skips the inspector check for exposing an ancestor structure type, if any, in information provided to a guard procedure.
Changed in version 8.4.0.2: Added the *accessor-name*, *contract-str*, and *realm* arguments.
Changed in version 8.5.0.2: Changed the BC implementation of Racket to skip the inspector check, the same as the CS implementation, for ancestor information provided to a guard procedure.

```
(struct-type-property? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a structure type property descriptor value, `#f` otherwise.

```
(struct-type-property-accessor-procedure? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is an accessor procedure produced by `make-struct-type-property`, `#f` otherwise.

```
(struct-type-property-predicate-procedure? v
                                           [prop]) → boolean?
  v : any/c
  prop : (or/c struct-type-property? #f) = #f
```

Returns `#t` if *v* is a predicate procedure produced by `make-struct-type-property` and either *prop* is `#f` or it was produced by the same call to `make-struct-type-property`, `#f` otherwise.

Added in version 7.5.0.11 of package `base`.

5.4 Generic Interfaces

```
(require racket/generic)      package: base
```

A *generic interface* allows per-type methods to be associated with generic functions. Generic functions are defined using a `define-generics` form. Method implementations for a structure type are defined using the `#:methods` keyword (see §5.1 "Defining Structure Types: `struct`").

```
(define-generics id
  generics-opt ...
  [method-id . kw-formals*] ...
  generics-opt ...)

generics-opt = #:defaults ([default-pred? default-impl ...] ...)
             | #:fast-defaults ([fast-pred? fast-impl ...] ...)
             | #:fallbacks [fallback-impl ...]
             | #:defined-predicate defined-pred-id
             | #:defined-table defined-table-id
             | #:derive-property prop-expr prop-value-expr
             | #:requires [required-method-id ...]

 kw-formals* = (arg* ...)
             | (arg* ...+ . rest-id)
             | rest-id

        arg* = arg-id
             | [arg-id]
             | keyword arg-id
             | keyword [arg-id]
```

Defines the following names, plus any specified by keyword options.

- `gen:id` as a transformer binding for the static information about a new generic interface;
- `id?` as a predicate identifying instances of structure types that implement this generic group; and
- each `method-id` as a *generic method* that calls the corresponding method on values where `id?` is true. Each `method-id`'s `kw-formals*` must include a required by-position argument that is `free-identifier=?` to `id`. That argument is used in the generic definition to locate the specialization.
- `id/c` as a contract combinator that recognizes instances of structure types which implement the `gen:id` generic interface. The combinator takes pairs of `method-id`s and contracts. The contracts will be applied to each of the corresponding method implementations. The `id/c` combinator is intended to be used to contract the range of a constructor procedure for a struct type that implements the generic interface.

The `#:defaults` option may be provided at most once. When it is provided, each generic function uses *`default-pred?`*s to dispatch to the given *default method* implementations, *`default-impl`*s, if dispatching to the generic method table fails. The syntax of the *`default-impl`*s is the same as the methods provided for the `#:methods` keyword for `struct`.

The `#:fast-defaults` option may be provided at most once. It works the same as `#:defaults`, except the *`fast-pred?`*s are checked before dispatching to the generic method table. This option is intended to provide a fast path for dispatching to built-in datatypes, such as lists and vectors, that do not overlap with structures implementing `gen:`*`id`*.

The `#:fallbacks` option may be provided at most once. When it is provided, the *`fallback-impl`*s define *fallback method* implementations that are used for any instance of the generic interface that does not supply a specific implementation. The syntax of the *`fallback-impl`*s is the same as the methods provided for the `#:methods` keyword for `struct`.

The `#:defined-predicate` option may be provided at most once. When it is provided, *`defined-pred-id`* is defined as a procedure that reports whether a specific instance of the generic interface implements a given set of methods. Specifically, `(`*`defined-pred-id`*` v 'name ...)` produces `#t` if `v` has implementations for each method `name`, not counting `#:fallbacks` implementations, and produces `#f` otherwise. This procedure is intended for use by higher-level APIs to adapt their behavior depending on method availability.

The `#:defined-table` option may be provided at most once. When it is provided, *`defined-table-id`* is defined as a procedure that takes an instance of the generic interface and returns an immutable hash table that maps symbols corresponding to method names to booleans representing whether or not that method is implemented by the instance. This option is deprecated; use `#:defined-predicate` instead.

The `#:derive-property` option may be provided any number of times. Each time it is provided, it specifies a structure type property via *`prop-expr`* and a value for the property via *`prop-value-expr`*. All structures implementing the generic interface via `#:methods` automatically implement this structure type property using the provided values. When *`prop-value-expr`* is executed, each *`method-id`* is bound to its specific implementation for the structure type.

The `#:requires` option may be provided at most once. When it is provided, any instance of the generic interface *must* supply an implementation of the specified *`required-method-id`*s. Otherwise, a compile-time error is raised.

If a value `v` satisfies *`id`*`?`, then `v` is a *generic instance* of `gen:`*`id`*.

If a generic instance `v` has a corresponding implementation for some *`method-id`* provided via `#:methods` in `struct` or via `#:defaults` or `#:fast-defaults` in `define-generics`, then *`method-id`* is an *implemented generic method* of `v`.

If *method-id* is not an implemented generic method of a generic instance `v`, and *method-id* has a fallback implementation that does not raise an `exn:fail:support` exception when given `v`, then *method-id* is a *supported generic method* of `v`.

Changed in version 8.7.0.5 of package `base`: Added the `#:requires` option.

```
(raise-support-error name v) → none/c
  name : symbol?
  v : any/c
```

Raises an `exn:fail:support` exception for a generic method called *name* that does not support the generic instance *v*.

Example:

```
> (raise-support-error 'some-method-name '("arbitrary" "instance" "value"))
some-method-name: not implemented for '("arbitrary"
"instance" "value")
```

```
(struct exn:fail:support exn:fail ()
    #:transparent)
```

Raised for generic methods that do not support the given generic instance.

```
(define/generic local-id method-id)
```

When used inside the method definitions associated with the `#:methods`, `#:fallbacks`, `#:defaults` or `#:fast-defaults` keywords, binds *local-id* to the generic for *method-id*. This form is useful for method specializations to use generic methods (as opposed to the local specialization) on other values.

The `define/generic` form is only allowed inside:

- a `#:methods` specification in `struct` (or `define-struct`)
- the specification of `#:fallbacks`, `#:defaults` or `#:fast-defaults` in `define-generics`

Using `define/generic` elsewhere is a syntax error.

Examples:

```
> (define-generics printable
    (gen-print printable [port])
```

```
    (gen-port-print port printable)
    (gen-print* printable [port] #:width width #:height [height])
    #:defaults ([string?
                 (define/generic super-print gen-print)
                 (define (gen-print s [port (current-output-
port)])
                   (fprintf port "String: ~a" s))
                 (define (gen-port-print port s)
                   ; we can call gen-print alternatively
                   (super-print s port))
                 (define (gen-print* s [port (current-output-
port)]
                                     #:width w #:height [h 0])
                   (fprintf port "String (~ax~a): ~a" w h s))]))
> (struct num (v)
    #:methods gen:printable
    [(define (gen-print n [port (current-output-port)])
       (fprintf port "Num: ~a" (num-v n)))
     (define (gen-port-print port n)
       (gen-print n port))
     (define (gen-print* n [port (current-output-port)]
                         #:width w #:height [h 0])
       (fprintf port "Num (~ax~a): ~a" w h (num-v n)))])
> (struct string+num (v n)
    #:methods gen:printable
    [(define/generic super-print gen-print)
     (define/generic super-print* gen-print*)
     (define (gen-print b [port (current-output-port)])
       (super-print (string+num-v b) port)
       (fprintf port " ")
       (super-print (string+num-n b) port))
     (define (gen-port-print port b)
       (gen-print b port))
     (define (gen-print* b [port (current-output-port)]
                         #:width w #:height [h 0])
       (super-print* (string+num-v b) #:width w #:height h)
       (fprintf port " ")
       (super-print* (string+num-n b) #:width w #:height h))])
> (define x (num 10))
> (gen-print x)
Num: 10
> (gen-port-print (current-output-port) x)
Num: 10
> (gen-print* x #:width 100 #:height 90)
Num (100x90): 10
> (define str "Strings are printable too!")
```

```
> (gen-print str)
String: Strings are printable too!
> (define y (string+num str x))
> (gen-print y)
String: Strings are printable too! Num: 10
> (gen-port-print (current-output-port) y)
String: Strings are printable too! Num: 10
> (gen-print* y #:width 100 #:height 90)
String (100x90): Strings are printable too! Num (100x90): 10
> (define/contract make-num-contracted
    (-> number?
        (printable/c
          [gen-print (->* (printable?) (output-port?) void?)]
          [gen-port-print (-> output-port? printable? void?)]
          [gen-print* (->* (printable? #:width exact-nonnegative-
integer?)
                           (output-port? #:height exact-
nonnegative-integer?)
                           void?)]))
     num)
> (define z (make-num-contracted 10))
> (gen-print* z #:width "not a number" #:height 5)
make-num-contracted: contract violation
  expected: natural?
  given: "not a number"
  in: the #:width argument of
      method gen-print*
      the range of
      (->
       number?
       (printable/c
        (gen-print
         (->* (printable?) (output-port?) void?))
        (gen-port-print
         (-> output-port? printable? void?))
        (gen-print*
         (->*
          (printable? #:width natural?)
          (output-port? #:height natural?)
          void?))))
  contract from:
      (definition make-num-contracted)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:16:0
```

```
(generic-instance/c gen-id [method-id method-ctc] ...)

  method-ctc : contract?
```

Creates a contract that recognizes structures that implement the generic interface *gen-id*, and constrains their implementations of the specified *method-id*s with the corresponding *method-ctc*s.

```
(impersonate-generics gen-id val-expr
  [method-id method-proc-expr] ...
  maybe-properties)

maybe-properties =
                 | #:properties props-expr

  method-proc-expr : (any/c . -> . any/c)
  props-expr : (list/c impersonator-property? any/c ... ...)
```

Creates an impersonator of *val-expr*, which must be a structure that implements the generic interface *gen-id*. The impersonator applies the results of the *method-proc-expr*s to the structure's implementation of the corresponding *method-id*s, and replaces the method implementation with the result.

A *props-expr* can provide properties to attach to the impersonator. The result of *props-expr* must be a list with an even number of elements, where the first element of the list is an impersonator property, the second element is its value, and so on.

Changed in version 6.1.1.8 of package `base`: Added `#:properties`.

```
(chaperone-generics gen-id val-expr
  [method-id method-proc-expr] ...
  maybe-properties)
```

Like `impersonate-generics`, but creates a chaperone of *val-expr*, which must be a structure that implements the generic interface *gen-id*. The chaperone applies the specified `method-procs` to the structure's implementation of the corresponding *method-id*s, and replaces the method implementation with the result, which must be a chaperone of the original.

```
(redirect-generics mode gen-id val-expr
   [method-id method-proc-expr] ...
   maybe-properties)
```

Like `impersonate-generics`, but creates an impersonator of *val-expr* if *mode* evaluates to `#f`, or creates a chaperone of *val-expr* otherwise.

```
(make-struct-type-property/generic
  name-expr
  maybe-guard-expr
  maybe-supers-expr
  maybe-can-impersonate?-expr
  property-option
  ...)

          maybe-guard-expr =
                           | guard-expr

          maybe-supers-expr =
                           | supers-expr

maybe-can-impersonate?-expr =
                           | can-impersonate?-expr

           property-option = #:property prop-expr val-expr
                           | #:methods gen:name-id method-defs

               method-defs = (definition ...)

  name-expr : symbol?
  guard-expr : (or/c procedure? #f 'can-impersonate)
  supers-expr : (listof (cons/c struct-type-property? (-> any/c any/c)))
  can-impersonate?-expr : any/c
  prop-expr : struct-type-property?
  val-expr : any/c
```

Creates a new structure type property and returns three values, just like `make-struct-type-property` would:

- a structure type property descriptor
- a property predicate procedure
- a property accessor procedure

Any struct that implements this property will also implement the properties and generic interfaces given in the `#:property` and `#:methods` declarations. The property *val-expr*s and *method-def*s are evaluated eagerly when the property is created, not when it is attached to a structure type.

```
(make-generic-struct-type-property
   gen:name-id
   method-def
   ...)
```

Creates a new structure type property and returns the structure type property descriptor.

Any struct that implements this property will also implement the generic interface given by *gen:name-id* with the given *method-def*s. The *method-def*s are evaluated eagerly when the property is created, not when it is attached to a structure type.

5.5 Copying and Updating Structures

```
(struct-copy id struct-expr fld-id ...)

fld-id = [field-id expr]
       | [field-id #:parent parent-id expr]
```

Creates a new instance of the structure type *id* (which is defined via a structure type defining form such as `struct`) with the same field values as the structure produced by *struct-expr*, except that the value of each supplied *field-id* is instead determined by the corresponding *expr*. If `#:parent` is specified, the *parent-id* must be bound to a parent structure type of *id*.

The *id* must have a transformer binding that encapsulates information about a structure type (i.e., like the initial identifier bound by `struct`), and the binding must supply a constructor, a predicate, and all field accessors.

Each *field-id* must correspond to a *field-id* in the structure type defining forms of *id* (or *parent-id*, if present). The accessor bindings determined by different *field-id*s under the same *id* (or *parent-id*, if present) must be distinct. The order of the *field-id*s need not match the order of the corresponding fields in the structure type.

The *struct-expr* is evaluated first. The result must be an instance of the *id* structure type, otherwise the `exn:fail:contract` exception is raised. Next, the field *expr*s are evaluated in order (even if the fields that correspond to the *field-id*s are in a different order). Finally, the new structure instance is created.

The result of *struct-expr* can be an instance of a sub-type of *id*, but the resulting copy is an immediate instance of *id* (not the sub-type).

Examples:

```
> (struct fish (color weight) #:transparent)
> (define marlin (fish 'orange-and-white 11))
```

```
> (define dory (struct-copy fish marlin
                             [color 'blue]))
> dory
(fish 'blue 11)
> (struct shark fish (weeks-since-eating-fish) #:transparent)
> (define bruce (shark 'grey 110 3))
> (define chum (struct-copy shark bruce
                             [weight #:parent fish 90]
                             [weeks-since-eating-fish 0]))
> chum
(shark 'grey 90 0)
; subtypes can be copied as if they were supertypes,
; but the result is an instance of the supertype
> (define not-really-chum
    (struct-copy fish bruce
                 [weight 90]))
> not-really-chum
(fish 'grey 90)
```

5.6 Structure Utilities

```
(struct->vector v [opaque-v]) → vector?
  v : any/c
  opaque-v : any/c = '...
```

Creates a vector representing *v*. The first slot of the result vector contains a symbol whose printed name has the form `struct:id`. Each remaining slot contains either the value of a field in *v*, if it is accessible via the current inspector, or *opaque-v* for a field that is not accessible. A single *opaque-v* value is used in the vector for contiguous inaccessible fields. (Consequently, the size of the vector does not match the size of the `struct` if more than one field is inaccessible.)

```
(struct? v) → any
  v : any/c
```

Returns `#t` if `struct-info` exposes any structure types of *v* with the current inspector, `#f` otherwise.

Typically, when `(struct? v)` is true, then `(struct->vector v)` exposes at least one field value. It is possible, however, for the only visible types of *v* to contribute zero fields.

```
(struct-type? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a structure type descriptor value, `#f` otherwise.

```
(struct-constructor-procedure? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a constructor procedure generated by `struct` or `make-struct-type`, `#f` otherwise.

```
(struct-predicate-procedure? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a predicate procedure generated by `struct` or `make-struct-type`, `#f` otherwise.

```
(struct-accessor-procedure? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is an accessor procedure generated by `struct`, `make-struct-type`, or `make-struct-field-accessor`, `#f` otherwise.

```
(struct-mutator-procedure? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a mutator procedure generated by `struct`, `make-struct-type`, or `make-struct-field-mutator`, `#f` otherwise.

```
(prefab-struct-key v) → (or/c #f symbol? list?)
  v : any/c
```

Returns `#f` if *v* is not an instance of a prefab structure type. Otherwise, the result is the shorted key that could be used with `make-prefab-struct` to create an instance of the structure type.

Examples:

```
> (prefab-struct-key #s(cat "Garfield"))
'cat
> (struct cat (name) #:prefab)
> (struct cute-cat cat (shipping-dest) #:prefab)
> (cute-cat "Nermel" "Abu Dhabi")
'#s((cute-cat cat 1) "Nermel" "Abu Dhabi")
> (prefab-struct-key (cute-cat "Nermel" "Abu Dhabi"))
'(cute-cat cat 1)
```

```
(make-prefab-struct key v ...) → struct?
  key : prefab-key?
  v : any/c
```

Creates an instance of a prefab structure type, using the *v*s as field values. The *key* and the number of *v*s determine the prefab structure type.

A *key* identifies a structure type based on a list with the following items:

- A symbol for the structure type's name.
- An exact, nonnegative integer representing the number of non-automatic fields in the structure type, not counting fields from the supertype (if any).
- A list of two items, where the first is an exact, nonnegative integer for the number of automatic fields in the structure type that are not from the supertype (if any), and the second element is an arbitrary value that is the value for the automatic fields.
- A vector of exact, nonnegative integers that indicate mutable non-automatic fields in the structure type, counting from `0` and not including fields from the supertype (if any).
- Nothing else, if the structure type has no supertype. Otherwise, the rest of the list is the key for the supertype.

An empty vector and an auto-field list that starts with `0` can be omitted. Furthermore, the first integer (which indicates the number of non-automatic fields) can be omitted, since it can be inferred from the number of supplied *v*s. Finally, a single symbol can be used instead of a list that contains only a symbol (in the case that the structure type has no supertype, no automatic fields, and no mutable fields).

The total field count must be no more than 32768. If the number of fields indicated by *key* is inconsistent with the number of supplied *v*s, the `exn:fail:contract` exception is raised.

Examples:

```
> (make-prefab-struct 'clown "Binky" "pie")
'#s(clown "Binky" "pie")
> (make-prefab-struct '(clown 2) "Binky" "pie")
'#s(clown "Binky" "pie")
> (make-prefab-struct '(clown 2 (0 #f) #()) "Binky" "pie")
'#s(clown "Binky" "pie")
> (make-prefab-struct '(clown 1 (1 #f) #()) "Binky" "pie")
'#s((clown (1 #f)) "Binky" "pie")
> (make-prefab-struct '(clown 1 (1 #f) #(0)) "Binky" "pie")
'#s((clown (1 #f) #(0)) "Binky" "pie")
```

```
(prefab-struct-type-key+field-count type)
 → (or/c #f (cons/c prefab-key? (integer-in 0 32768)))
  type : struct-type?
```

Returns a pair containing the prefab key and field count for the structure type descriptor *type* if it represents a prefab structure type, `#f` otherwise.

Added in version 8.5.0.8 of package `base`.

```
(prefab-key->struct-type key field-count) → struct-type?
  key : prefab-key?
  field-count : (integer-in 0 32768)
```

Returns a structure type descriptor for the prefab structure type specified by the combination of *key* and *field-count*.

If the number of fields indicated by *key* is inconsistent with *field-count*, the `exn:fail:contract` exception is raised.

```
(prefab-key? v) → boolean?
  v : any/c
```

Return `#t` if *v* can be a prefab structure type key, `#f` otherwise.

See `make-prefab-struct` for a description of valid key shapes.

5.6.1 Additional Structure Utilities

```
(require racket/struct)      package: base
```

The bindings documented in this section are provided by the `racket/struct` library, not `racket/base` or `racket`.

```
(make-constructor-style-printer get-constructor
                                get-contents)
 → (-> any/c output-port? (or/c #t #f 0 1) void?)
  get-constructor : (-> any/c (or/c symbol? string?))
  get-contents : (-> any/c sequence?)
```

Produces a function suitable as a value for `gen:custom-write` or `prop:custom-write`. The function prints values in "constructor style." When the value is `print`ed as an expression, it is shown as an application of the constructor (as returned by *get-constructor*) to the contents (as returned by *get-contents*). When given to `write`, it is shown as an unreadable value with the constructor separated from the contents by a colon.

Examples:

```
> (struct point (x y)
    #:methods gen:custom-write
```

```
    [(define write-proc
       (make-constructor-style-printer
        (lambda (obj) 'point)
        (lambda (obj) (list (point-x obj) (point-y obj)))))])
> (print (point 1 2))
(point 1 2)
> (write (point 1 2))
#<point: 1 2>
```

The function also cooperates with pretty-print:

```
> (parameterize ((pretty-print-columns 10))
    (pretty-print (point 3000000 4000000)))
(point
 3000000
 4000000)
> (parameterize ((pretty-print-columns 10))
    (pretty-write (point 3000000 4000000)))
#<point:
 3000000
 4000000>
```

Note that the printer uses a separate property, prop:custom-print-quotable, to determine whether a struct instance is quotable. If so, the printer may print it in write mode it in certain contexts, such as within a list. For example:

```
> (print (list (point 1 2) (point 3 4)))
'(#<point: 1 2> #<point: 3 4>)
```

Use #:property prop:custom-print-quotable 'never to prevent a struct instance from being considered quotable. For example:

```
> (struct point2 (x y)
    #:property prop:custom-print-quotable 'never
    #:methods gen:custom-write
    [(define write-proc
       (make-constructor-style-printer
        (lambda (obj) 'point)
        (lambda (obj) (list (point2-x obj) (point2-y obj)))))])
> (print (list (point2 1 2) (point2 3 4)))
(list (point 1 2) (point 3 4))
```

Keyword arguments can be simulated with unquoted-printing-string:

```
; Private implementation
```

```
> (struct kwpoint-impl (x y)
    #:methods gen:custom-write
    [(define write-proc
       (make-constructor-style-printer
        (lambda (obj) 'kwpoint)
        (lambda (obj)
          (list (unquoted-printing-string "#:x")
                (kwpoint-impl-x obj)
                (unquoted-printing-string "#:y")
                (kwpoint-impl-y obj)))))])
; Public ``constructor''
> (define (kwpoint #:x x #:y y)
    (kwpoint-impl x y))
; Example use
> (print (kwpoint #:x 1 #:y 2))
(kwpoint #:x 1 #:y 2)
> (write (kwpoint #:x 3 #:y 4))
#<kwpoint: #:x 3 #:y 4>
```

Added in version 6.3 of package `base`.

```
(struct->list v [#:on-opaque on-opaque]) → (or/c list? #f)
  v : any/c
  on-opaque : (or/c 'error 'return-false 'skip) = 'error
```

Returns a list containing the struct instance *v*'s fields. Unlike `struct->vector`, the struct name itself is not included.

If any fields of *v* are inaccessible via the current inspector the behavior of `struct->list` is determined by *on-opaque*. If *on-opaque* is `'error` (the default), an error is raised. If it is `'return-false`, `struct->list` returns `#f`. If it is `'skip`, the inaccessible fields are omitted from the list.

Examples:

```
> (struct open (u v) #:transparent)
> (struct->list (open 'a 'b))
'(a b)
> (struct->list #s(pre 1 2 3))
'(1 2 3)
> (struct secret open (x y))
> (struct->list (secret 0 1 17 22))
struct->list: expected argument of type <non-opaque struct>;
given: (secret 0 1 ...)
> (struct->list (secret 0 1 17 22) #:on-opaque 'return-false)
#f
```

```
> (struct->list (secret 0 1 17 22) #:on-opaque 'skip)
'(0 1)
> (struct->list 'not-a-struct #:on-opaque 'return-false)
#f
> (struct->list 'not-a-struct #:on-opaque 'skip)
'()
```

Added in version 6.3 of package `base`.

5.7 Structure Type Transformer Binding

The `struct` form binds the name of a structure type as a transformer binding that records the other identifiers bound to the structure type, the constructor procedure, the predicate procedure, and the field accessor and mutator procedures. This information can be used during the expansion of other expressions via `syntax-local-value`.

For example, the `struct` variant for subtypes uses the base type name `t` to find the variable `struct:t` containing the base type's descriptor; it also folds the field accessor and mutator information for the base type into the information for the subtype. As another example, the `match` form uses a type name to find the predicates and field accessors for the structure type. The `struct` form in an imported signature for `unit` causes the `unit` transformer to generate information about imported structure types, so that `match` and subtyping `struct` forms work within the unit.

The expansion-time information for a structure type can be represented directly as a list of six elements (of the same sort that the encapsulated procedure must return):

- an identifier that is bound to the structure type's descriptor, or `#f` if none is known;
- an identifier that is bound to the structure type's constructor, or `#f` if none is known;
- an identifier that is bound to the structure type's predicate, or `#f` if none is known;
- a list of identifiers bound to the field accessors of the structure type, optionally with `#f` as the list's last element. A `#f` as the last element indicates that the structure type may have additional fields, otherwise the list is a reliable indicator of the number of fields in the structure type. Furthermore, the accessors are listed in reverse order for the corresponding constructor arguments. (The reverse order enables sharing in the lists for a subtype and its base type.)
- a list of identifiers bound to the field mutators of the structure type, or `#f` for each field that has no known mutator, and optionally with an extra `#f` as the list's last element (if the accessor list has such a `#f`). The list's order and the meaning of a final `#f` are the same as for the accessor identifiers, and the length of the mutator list is the same as the accessor list's length.

- an identifier that determines a super-type for the structure type, `#f` if the super-type (if any) is unknown, or `#t` if there is no super-type. If a super-type is specified, the identifier is also bound to structure-type expansion-time information.

Instead of this direct representation, the representation can be a structure created by `make-struct-info` (or an instance of a subtype of `struct:struct-info`), which encapsulates a procedure that takes no arguments and returns a list of six elements. Alternately, the representation can be a structure whose type has the `prop:struct-info` structure type property. Finally, the representation can be an instance of a structure type derived from `struct:struct-info` or with the `prop:struct-info` property that also implements `prop:procedure`, and where the instance is further is wrapped by `make-set!-transformer`. In addition, the representation may implement the `prop:struct-auto-info` and `prop:struct-field-info` properties.

Use `struct-info?` to recognize all allowed forms of the information, and use `extract-struct-info` to obtain a list from any representation.

The implementor of a syntactic form can expect users of the form to know what kind of information is available about a structure type. For example, the `match` implementation works with structure information containing an incomplete set of accessor bindings, because the user is assumed to know what information is available in the context of the `match` expression. In particular, the `match` expression can appear in a `unit` form with an imported structure type, in which case the user is expected to know the set of fields that are listed in the signature for the structure type.

```
(require racket/struct-info)        package: base
```

The bindings documented in this section are provided by the `racket/struct-info` library, not `racket/base` or `racket`.

```
(struct-info? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is either a six-element list with the correct shape for representing structure-type information, a procedure encapsulated by `make-struct-info`, a structure with the `prop:struct-info` property, or a structure type derived from `struct:struct-info` or with `prop:struct-info` and wrapped with `make-set!-transformer`.

```
(checked-struct-info? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a procedure encapsulated by `make-struct-info` and produced by `struct`, but only when no parent type is specified or the parent type is also specified through a transformer binding to such a value.

```
(make-struct-info thunk) → struct-info?
  thunk : (-> (and/c struct-info? list?))
```

Encapsulates a thunk that returns structure-type information in list form. Note that accessors are listed in reverse order, as mentioned in §5.7 "Structure Type Transformer Binding". Note that the field names are not well-defined for struct-type informations that are created with this method, so it is likely not going to work well with forms like `struct-copy` and `struct*`.

Examples:

```
> (define (new-pair? x) (displayln "new pair?") (pair? x))
> (define (new-car x) (displayln "new car") (car x))
> (define (new-cdr x) (displayln "new cdr") (cdr x))
> (define-syntax new-list
    (make-struct-info
     (λ () (list #f
                 #'cons
                 #'new-pair?
                 (list #'new-cdr #'new-car)
                 (list #f #f)
                 #t))))
> (match (list 1 2 3)
    [(new-list hd tl) (append tl (list hd))])
new pair?
new car
new cdr
'(2 3 1)
```

Examples:

```
> (struct A (x y))
> (define (new-A-x a) (displayln "A-x") (A-x a))
> (define (new-A-y a) (displayln "A-y") (A-y a))
> (define (new-A? a) (displayln "A?") (A? a))
> (define-syntax A-info
    (make-struct-info
     (λ () (list #'A
                 #'A
                 #'new-A?
                 (list #'new-A-y #'new-A-x)
                 (list #f #f)
                 #t))))
> (define-match-expander B
    (syntax-rules () [(_ x ...) (A-info x ...)]))
> (match (A 10 20)
    [(B x y) (list y x)])
A?
A-x
A-y
```

```
'(20 10)
```

```
(extract-struct-info v) → (and/c struct-info? list?)
  v : struct-info?
```

Extracts the list form of the structure type information represented by `v`.

```
struct:struct-info : struct-type?
```

The structure type descriptor for the structure type returned by `make-struct-info`. This structure type descriptor is mostly useful for creating structure subtypes. The structure type includes a guard that checks an instance's first field in the same way as `make-struct-info`.

```
prop:struct-info : struct-type-property?
```

The structure type property for creating new structure types like `struct:struct-info`. The property value must be a procedure of one argument that takes an instance structure and returns structure-type information in list form.

```
prop:struct-auto-info : struct-type-property?
(struct-auto-info? v) → boolean?
  v : any/c
(struct-auto-info-lists sai)
 → (list/c (listof identifier?) (listof identifier?))
  sai : struct-auto-info?
```

The `prop:struct-auto-info` property is implemented to provide static information about which of the accessor and mutator identifiers for a structure type correspond to `#:auto` fields (so that they have no corresponding argument in the constructor). The property value must be a procedure that accepts an instance structure to which the property is given, and the result must be two lists of identifiers suitable as a result from `struct-auto-info-lists`.

The `struct-auto-info?` predicate recognizes values that implement the `prop:struct-auto-info` property.

The `struct-auto-info-lists` function extracts two lists of identifiers from a value that implements the `prop:struct-auto-info` property. The first list should be a subset of the accessor identifiers for the structure type described by `sai`, and the second list should be a subset of the mutator identifiers. The two subsets correspond to `#:auto` fields.

```
prop:struct-field-info : struct-type-property?
(struct-field-info? v) → boolean?
  v : any/c
(struct-field-info-list sfi) → (listof symbol?)
  sfi : struct-field-info?
```

The `prop:struct-field-info` property is implemented to provide static information about field names in a structure type. The property value must be a procedure that accepts an instance structure to which the property is given, and the result must be a list of symbols suitable as a result from `struct-field-info-list`.

The `struct-field-info?` predicate recognizes values that implement the `prop:struct-field-info` property.

The `struct-field-info-list` function extracts a list of symbols from a value that implements the `prop:struct-field-info` property. The list should contain every immediate field name (that is, not including fields from its super struct type) in the reverse order.

Examples:

```
> (struct foo (x))
> (struct bar foo (y z))
> (define-syntax (get-bar-field-names stx)
    #`'#,(struct-field-info-list (syntax-local-value #'bar)))
> (get-bar-field-names)
'(z y)
```

Added in version 7.7.0.9 of package `base`.

6 Classes and Objects

(require racket/class) package: base

§13 "Classes and Objects" in *The Racket Guide* introduces classes and objects.

The bindings documented in this section are provided by the racket/class and racket libraries, but not racket/base.

A *class* specifies

- a collection of fields;
- a collection of methods;
- initial value expressions for the fields; and
- initialization variables that are bound to initialization arguments.

In the context of the class system, an *object* is a collection of bindings for fields that are instantiated according to a class description.

The class system allows a program to define a new class (a *derived class*) in terms of an existing class (the *superclass*) using inheritance, overriding, and augmenting:

- *inheritance*: An object of a derived class supports methods and instantiates fields declared by the derived class's superclass, as well as methods and fields declared in the derived class expression.
- *overriding*: Some methods declared in a superclass can be replaced in the derived class. References to the overridden method in the superclass use the implementation in the derived class.
- *augmenting*: Some methods declared in a superclass can be merely extended in the derived class. The superclass method specifically delegates to the augmenting method in the derived class.

An *interface* is a collection of method names to be implemented by a class, potentially with default implementations some methods, combined with a *derivation requirement*. A class *implements* an interface when it

- declares (or inherits) a public method for each method in the interface (that does not have an implementation in the interface);
- is derived from the class required by the interface, if any; and
- specifically declares its intention to implement the interface.

A class can implement any number of interfaces. A derived class automatically implements any interface that its superclass implements. Each class also implements an implicitly-defined interface that is associated with the class. The implicitly-defined interface contains all of the class's public method names, and it requires that all other implementations of the interface are derived from the class. When a class implements an interface but does not explicitly declare an implementation of a method that has a default implementation in the interface, then the default implementation is used for the class.

A new interface can *extend* one or more interfaces with additional method names; each class that implements the extended interface also implements the original interfaces. The derivation requirements of the original interface must be consistent, and the extended interface inherits the most specific derivation requirement from the original interfaces.

Classes, objects, and interfaces are all values. However, a class or interface is not an object (i.e., there are no "meta-classes" or "meta-interfaces").

6.1 Creating Interfaces

§13 "Classes and Objects" in *The Racket Guide* introduces classes, objects, and interfaces.

```
(interface (super-interface-expr ...) name-clause ...)

name-clause = id
            | (id contract-expr)
            | (id #:public default-expr)
            | (id #:override default-expr)
            | (id contract-expr #:public impl-expr)
            | (id contract-expr #:override impl-expr)
```

Produces an interface. The `id`s must be mutually distinct.

Each `super-interface-expr` is evaluated (in order) when the `interface` expression is evaluated. The result of each `super-interface-expr` must be an interface value, otherwise the `exn:fail:object` exception is raised. The interfaces returned by the `super-interface-expr`s are the new interface's superinterfaces, which are all extended by the new interface. Any class that implements the new interface also implements all of the superinterfaces.

The result of an `interface` expression is an interface that includes all of the specified `id`s, plus all identifiers from the superinterfaces. A given `id` may be paired with a corresponding `contract-expr`, and it may have a `impl-expr`, which supplies an implementation of `id` to be inherited or overridden in an implementing class. Each `impl-expr` must be a `method-procedure`; see §6.2.3.1 "Method Definitions". Duplicate identifier names among the superinterfaces are ignored, as long as no more than one of them provides a default implementation for each identifier that originated in a different interface.

An interface can provide an implementation of a method using `#:public` if no superinterface has an implementation of the method, or using `#:override` otherwise. If multiple superinterfaces provide implementations of a method that originate from different ancestor interfaces, then the method must be overridden. The `super` form is not supported within an interface method implementation.

If no *super-interface-expr*s are provided, then the derivation requirement of the resulting interface is trivial: any class that implements the interface must be derived from `object%`. Otherwise, the implementation requirement of the resulting interface is the most specific requirement from its superinterfaces. If the superinterfaces specify inconsistent derivation requirements, then `exn:fail:object` exception is raised is raised.

Examples:

```
(define file-interface<%>
  (interface ()
    open close read-byte write-byte
    [append-line
     #:public
     (λ (bts)
       (send this open 'append)
       (for ([b (in-bytes bts)])
         (send this write-byte b))
       (send this close))]))
(define directory-interface<%>
  (interface (file-interface<%>)
    [file-list (->m (listof (is-a?/c file-interface<%>)))]
    parent-directory))
```

Changed in version 8.17.0.4 of package `base`: Added support for `#:public` and `#:override` method implementations.

```
(interface* (super-interface-expr ...)
            ([property-expr val-expr] ...)
  name-clause ...)

name-clause = id
            | (id contract-expr)
            | (id #:public default-expr)
            | (id #:override default-expr)
            | (id contract-expr #:public default-expr)
            | (id contract-expr #:override default-expr)
```

Like `interface`, but also associates to the interface the structure-type properties produced by the *property-expr*s with the corresponding *val-expr*s.

Whenever the resulting interface (or a sub-interface derived from it) is explicitly implemented by a class through the `class*` form, each property is attached with its value to a structure type that instantiated by instances of the class. Specifically, the property is attached to a structure type with zero immediate fields, which is extended to produce the internal structure type for instances of the class (so that no information about fields is accessible to the structure type property's guard, if any).

Example:

```
(define i<%> (interface* () ([prop:custom-write
                               (lambda (obj port mode) (void))])
               method1 method2 method3))
```

Changed in version 8.17.0.4 of package `base`: Added support for `#:public` and `#:override` method implementations.

6.2 Creating Classes

§13 "Classes and Objects" in *The Racket Guide* introduces classes and objects.

```
object% : class?
```

A built-in class that has no methods fields, implements only its own interface `(class->interface object%)`, and is transparent (i.e,. its inspector is `#f`, so all immediate instances are `equal?`). All other classes are derived from `object%`.

```
(class* superclass-expr (interface-expr ...)
  class-clause
  ...)
```

```
     class-clause = (inspect inspector-expr)
                  | (init init-decl ...)
                  | (init-field init-decl ...)
                  | (field field-decl ...)
                  | (inherit-field maybe-renamed ...)
                  | (init-rest id)
                  | (init-rest)
                  | (public maybe-renamed ...)
                  | (pubment maybe-renamed ...)
                  | (public-final maybe-renamed ...)
                  | (override maybe-renamed ...)
                  | (overment maybe-renamed ...)
                  | (override-final maybe-renamed ...)
                  | (augment maybe-renamed ...)
                  | (augride maybe-renamed ...)
                  | (augment-final maybe-renamed ...)
                  | (private id ...)
                  | (abstract id ...)
                  | (inherit maybe-renamed ...)
                  | (inherit/super maybe-renamed ...)
                  | (inherit/inner maybe-renamed ...)
                  | (rename-super renamed ...)
                  | (rename-inner renamed ...)
                  | method-definition
                  | definition
                  | expr
                  | (begin class-clause ...)

        init-decl = id
                  | (renamed)
                  | (maybe-renamed default-value-expr)

       field-decl = (maybe-renamed default-value-expr)

    maybe-renamed = id
                  | renamed

          renamed = (internal-id external-id)

method-definition = (define-values (id) method-procedure)

 method-procedure = (lambda kw-formals expr ...+)
                  | (case-lambda (formals expr ...+) ...)
                  | (#%plain-lambda formals expr ...+)
                  | (let-values ([(id) method-procedure] ...)
                      method-procedure)
                  | (letrec-values ([(id) method-procedure] ...)
                      method-procedure)
                  | (let-values ([(id) method-procedure] ...+)
                      id)
                  | (letrec-values ([(id) method-procedure] ...+)
                      id)
                  | (chaperone-procedure method-procedure wrapper-proc
                                         other-arg-expr ...)
```

Produces a class value.

The *superclass-expr* expression is evaluated when the `class*` expression is evaluated. The result must be a class value (possibly `object%`), otherwise the `exn:fail:object` exception is raised. The result of the *superclass-expr* expression is the new class's superclass.

The *interface-expr* expressions are also evaluated when the `class*` expression is evaluated, after *superclass-expr* is evaluated. The result of each *interface-expr* must be an interface value, otherwise the `exn:fail:object` exception is raised. The interfaces returned by the *interface-expr*s are all implemented by the class. For each identifier in each interface, the class (or one of its ancestors) must declare a public method with the same name, otherwise the `exn:fail:object` exception is raised. The class's superclass must satisfy the implementation requirement of each interface, otherwise the `exn:fail:object` exception is raised.

An `inspect` *class-clause* selects an inspector (see §14.9 "Structure Inspectors") for the class extension. The *inspector-expr* must evaluate to an inspector or `#f` when the `class*` form is evaluated. Just as for structure types, an inspector controls access to the class's fields, including private fields, and also affects comparisons using `equal?`. If no `inspect` clause is provided, access to the class is controlled by the parent of the current inspector (see §14.9 "Structure Inspectors"). A syntax error is reported if more than one `inspect` clause is specified.

The other *class-clause*s define initialization arguments, public and private fields, and public and private methods. For each *id* or *maybe-renamed* in a `public`, `override`, `augment`, `pubment`, `overment`, `augride`, `public-final`, `override-final`, `augment-final`, or `private` clause, there must be one *method-definition*. All other definition *class-clause*s create private fields. All remaining *expr*s are initialization expressions to be evaluated when the class is instantiated (see §6.3 "Creating Objects").

The result of a `class*` expression is a new class, derived from the specified superclass and implementing the specified interfaces. Instances of the class are created with the `instantiate` form or `make-object` procedure, as described in §6.3 "Creating Objects".

Each *class-clause* is (partially) macro-expanded to reveal its shapes. If a *class-clause* is a `begin` expression, its sub-expressions are lifted out of the `begin` and treated as *class-clause*s, in the same way that `begin` is flattened for top-level and embedded definitions. Each *class-clause* has the syntax property `'class-body` set to true before expansion.

Within a `class*` form for instances of the new class, `this` is bound to the object itself; `this%` is bound to the class of the object; `super-instantiate`, `super-make-object`, and `super-new` are bound to forms to initialize fields in the superclass (see §6.3 "Creating Objects"); `super` is available for calling superclass methods (see §6.2.3.1 "Method Definitions"); and `inner` is available for calling subclass augmentations of methods (see §6.2.3.1 "Method Definitions").

Changed in version 8.8.0.10 of package `base`: Added the `'class-body` syntax property to class body forms.

```
(class superclass-expr class-clause ...)
```

Like `class*`, but omits the *`interface-expr`*s, for the case that none are needed.

Example:

```
(define book-class%
  (class object%
    (field (pages 5))
    (define/public (letters)
      (* pages 500))
    (super-new)))
```

```
this
```

Within a `class*` form, `this` refers to the current object (i.e., the object being initialized or whose method was called). Use outside the body of a `class*` form is a syntax error.

Examples:

```
(define (describe obj)
  (printf "Hello ~a\n" obj))
(define table%
  (class object%
    (define/public (describe-self)
      (describe this))
    (super-new)))

> (send (new table%) describe-self)
Hello #(struct:object:table% ...)
```

```
this%
```

Within a `class*` form, `this%` refers to the class of the current object (i.e., the object being initialized or whose method was called). Use outside the body of a `class*` form is a syntax error.

Examples:

```
(define account%
  (class object%
    (super-new)
    (init-field balance)
```

```
    (define/public (add n)
      (new this% [balance (+ n balance)]))))
(define savings%
  (class account%
    (super-new)
    (inherit-field balance)
    (define interest 0.04)
    (define/public (add-interest)
      (send this add (* interest balance)))))
```

```
> (let* ([acct (new savings% [balance 500])]
         [acct (send acct add 500)]
         [acct (send acct add-interest)])
    (printf "Current balance: ~a\n" (get-field balance acct)))
Current balance: 1040.0
```

```
(inspect inspector-expr)
```

See `class*`; use outside the body of a `class*` form is a syntax error.

```
(init init-decl ...)
```

See `class*` and §6.2.1 “Initialization Variables”; use outside the body of a `class*` form is a syntax error.

Example:

```
> (class object%
    (super-new)
    (init turnip
          [(internal-potato potato)]
          [carrot 'good]
          [(internal-rutabaga rutabaga) 'okay]))
#<class:eval:10:0>
```

```
(init-field init-decl ...)
```

See `class*`, §6.2.1 “Initialization Variables”, and §6.2.2 “Fields”; use outside the body of a `class*` form is a syntax error.

Example:

```
> (class object%
```

```
    (super-new)
    (init-field turkey
                [(internal-ostrich ostrich)]
                [chicken 7]
                [(internal-emu emu) 13]))
#<class:eval:11:0>
```

```
(field field-decl ...)
```

See `class*` and §6.2.2 "Fields"; use outside the body of a `class*` form is a syntax error.

Example:

```
> (class object%
    (super-new)
    (field [minestrone 'ready]
           [(internal-coq-au-vin coq-au-vin) 'stewing]))
#<class:eval:12:0>
```

```
(inherit-field maybe-renamed ...)
```

See `class*` and §6.2.2 "Fields"; use outside the body of a `class*` form is a syntax error.

Examples:

```
(define cookbook%
  (class object%
    (super-new)
    (field [recipes '(caldo-verde oyakodon eggs-benedict)]
           [pages 389])))

> (class cookbook%
    (super-new)
    (inherit-field recipes
                   [internal-pages pages]))
#<class:eval:14:0>
```

```
(init-rest id)
(init-rest)
```

See `class*` and §6.2.1 "Initialization Variables"; use outside the body of a `class*` form is a syntax error.

Examples:

```
(define fruit-basket%
  (class object%
    (super-new)
    (init-rest fruits)
    (displayln fruits)))
```

```
> (make-object fruit-basket% 'kiwi 'lychee 'melon)
(kiwi lychee melon)
(object:fruit-basket% ...)
```

```
(public maybe-renamed ...)
```

See `class*` and §6.2.3.1 "Method Definitions"; use outside the body of a `class*` form is a syntax error.

Examples:

```
(define jumper%
  (class object%
    (super-new)
    (define (skip) 'skip)
    (define (hop) 'hop)
    (public skip [hop jump])))
```

```
> (send (new jumper%) skip)
'skip
> (send (new jumper%) jump)
'hop
```

```
(pubment maybe-renamed ...)
```

See `class*` and §6.2.3.1 "Method Definitions"; use outside the body of a `class*` form is a syntax error.

Examples:

```
(define runner%
  (class object%
    (super-new)
    (define (run) 'run)
    (define (trot) 'trot)
    (pubment run [trot jog])))
```

```
> (send (new runner%) run)
'run
> (send (new runner%) jog)
'trot
```

```
(public-final maybe-renamed ...)
```

See class* and §6.2.3.1 “Method Definitions”; use outside the body of a class* form is a syntax error.

Examples:

```
(define point%
  (class object%
    (super-new)
    (init-field [x 0] [y 0])
     (define (get-x) x)
    (define (do-get-y) y)
    (public-final get-x [do-get-y get-y])))

> (send (new point% [x 1] [y 3]) get-y)
3
> (class point%
    (super-new)
    (define (get-x) 3.14)
    (override get-x))
class*: cannot override or augment final method
  method name: get-x
  class name: eval:25:0
```

```
(override maybe-renamed ...)
```

See class* and §6.2.3.1 “Method Definitions”; use outside the body of a class* form is a syntax error.

Examples:

```
(define sheep%
  (class object%
    (super-new)
    (define/public (bleat)
      (displayln "baaaaaaaaah"))))
```

```
(define confused-sheep%
  (class sheep%
    (super-new)
    (define (bleat)
      (super bleat)
      (displayln "???"))
    (override bleat)))
```

```
> (send (new sheep%) bleat)
baaaaaaaaah
> (send (new confused-sheep%) bleat)
baaaaaaaaah
???
```

```
(overment maybe-renamed ...)
```

See `class*` and §6.2.3.1 "Method Definitions"; use outside the body of a `class*` form is a syntax error.

Examples:

```
(define turkey%
  (class object%
    (super-new)
    (define/public (gobble)
      (displayln "gobble gobble"))))

(define extra-turkey%
  (class turkey%
    (super-new)
    (define (gobble)
      (super gobble)
      (displayln "gobble gobble gobble")
      (inner (void) gobble))
    (overment gobble)))

(define cyborg-turkey%
  (class extra-turkey%
    (super-new)
    (define/augment (gobble)
      (displayln "110011111011111100010110001011011001100101"))))
```

```
> (send (new extra-turkey%) gobble)
gobble gobble
gobble gobble gobble
```

```
> (send (new cyborg-turkey%) gobble)
gobble gobble
gobble gobble gobble
1100111110111111000101100010110110011001 01
```

```
(override-final maybe-renamed ...)
```

See `class*` and §6.2.3.1 "Method Definitions"; use outside the body of a `class*` form is a syntax error.

Examples:

```
(define meeper%
  (class object%
    (super-new)
    (define/public (meep)
      (displayln "meep"))))

(define final-meeper%
  (class meeper%
    (super-new)
    (define (meep)
      (super meep)
      (displayln "This meeping ends with me"))
    (override-final meep)))

> (send (new meeper%) meep)
meep
> (send (new final-meeper%) meep)
meep
This meeping ends with me
```

```
(augment maybe-renamed ...)
```

See `class*` and §6.2.3.1 "Method Definitions"; use outside the body of a `class*` form is a syntax error.

Examples:

```
(define buzzer%
  (class object%
    (super-new)
    (define/pubment (buzz)
```

```
      (displayln "bzzzt")
      (inner (void) buzz))))

(define loud-buzzer%
  (class buzzer%
    (super-new)
    (define (buzz)
      (displayln "BZZZZZZZZZT"))
    (augment buzz)))

> (send (new buzzer%) buzz)
bzzzt
> (send (new loud-buzzer%) buzz)
bzzzt
BZZZZZZZZZT
```

```
(augride maybe-renamed ...)
```

See `class*` and §6.2.3.1 "Method Definitions"; use outside the body of a `class*` form is a syntax error.

```
(augment-final maybe-renamed ...)
```

See `class*` and §6.2.3.1 "Method Definitions"; use outside the body of a `class*` form is a syntax error.

```
(private id ...)
```

See `class*` and §6.2.3.1 "Method Definitions"; use outside the body of a `class*` form is a syntax error.

Examples:

```
(define light%
  (class object%
    (super-new)
    (define on? #t)
    (define (toggle) (set! on? (not on?)))
    (private toggle)
    (define (flick) (toggle))
    (public flick)))
```

```
> (send (new light%) toggle)
send: no such method
  method name: toggle
  class name: light%
> (send (new light%) flick)
```

```
(abstract id ...)
```

See `class*` and §6.2.3.1 "Method Definitions"; use outside the body of a `class*` form is a syntax error.

Examples:

```
(define train%
  (class object%
    (super-new)
    (abstract get-speed)
    (init-field [position 0])
    (define/public (move)
      (new this% [position (+ position (get-speed))]))))

(define acela%
  (class train%
    (super-new)
    (define/override (get-speed) 241)))

(define talgo-350%
  (class train%
    (super-new)
    (define/override (get-speed) 330)))

> (new train%)
instantiate: cannot instantiate class with abstract methods
  class: #<class:train%>
  abstract methods:
   get-speed
> (send (new acela%) move)
(object:acela% ...)
```

```
(inherit maybe-renamed ...)
```

See `class*` and §6.2.3.2 "Inherited and Superclass Methods"; use outside the body of a `class*` form is a syntax error.

Examples:

```
(define alarm%
  (class object%
    (super-new)
    (define/public (alarm)
      (displayln "beeeeeeeep"))))

(define car-alarm%
  (class alarm%
    (super-new)
    (init-field proximity)
    (inherit alarm)
    (when (< proximity 10)
      (alarm))))

> (new car-alarm% [proximity 5])
beeeeeeeep
(object:car-alarm% ...)
```

```
(inherit/super maybe-renamed ...)
```

See `class*` and §6.2.3.2 "Inherited and Superclass Methods"; use outside the body of a `class*` form is a syntax error.

```
(inherit/inner maybe-renamed ...)
```

See `class*` and §6.2.3.2 "Inherited and Superclass Methods"; use outside the body of a `class*` form is a syntax error.

```
(rename-super renamed ...)
```

See `class*` and §6.2.3.2 "Inherited and Superclass Methods"; use outside the body of a `class*` form is a syntax error.

```
(rename-inner renamed ...)
```

See `class*` and §6.2.3.2 "Inherited and Superclass Methods"; use outside the body of a `class*` form is a syntax error.

```
(public* (id expr) ...)
```

Shorthand for `(begin (public id) ... (define id expr) ...)`.

`(pubment* (id expr) ...)`

Shorthand for `(begin (pubment id) ... (define id expr) ...)`.

`(public-final* (id expr) ...)`

Shorthand for `(begin (public-final id) ... (define id expr) ...)`.

`(override* (id expr) ...)`

Shorthand for `(begin (override id) ... (define id expr) ...)`.

`(overment* (id expr) ...)`

Shorthand for `(begin (overment id) ... (define id expr) ...)`.

`(override-final* (id expr) ...)`

Shorthand for `(begin (override-final id) ... (define id expr) ...)`.

`(augment* (id expr) ...)`

Shorthand for `(begin (augment id) ... (define id expr) ...)`.

`(augride* (id expr) ...)`

Shorthand for `(begin (augride id) ... (define id expr) ...)`.

`(augment-final* (id expr) ...)`

Shorthand for `(begin (augment-final id) ... (define id expr) ...)`.

`(private* (id expr) ...)`

Shorthand for `(begin (private id) ... (define id expr) ...)`.

```
(define/public id expr)
(define/public (id . formals) body ...+)
```

Shorthand for `(begin (public id) (define id expr))` or `(begin (public id) (define (id . formals) body ...+))`

```
(define/pubment id expr)
(define/pubment (id . formals) body ...+)
```

Shorthand for `(begin (pubment id) (define id expr))` or `(begin (pubment id) (define (id . formals) body ...+))`

```
(define/public-final id expr)
(define/public-final (id . formals) body ...+)
```

Shorthand for `(begin (public-final id) (define id expr))` or `(begin (public-final id) (define (id . formals) body ...+))`

```
(define/override id expr)
(define/override (id . formals) body ...+)
```

Shorthand for `(begin (override id) (define id expr))` or `(begin (override id) (define (id . formals) body ...+))`

```
(define/overment id expr)
(define/overment (id . formals) body ...+)
```

Shorthand for `(begin (overment id) (define id expr))` or `(begin (overment id) (define (id . formals) body ...+))`

```
(define/override-final id expr)
(define/override-final (id . formals) body ...+)
```

Shorthand for `(begin (override-final id) (define id expr))` or `(begin (override-final id) (define (id . formals) body ...+))`

```
(define/augment id expr)
(define/augment (id . formals) body ...+)
```

Shorthand for `(begin (augment id) (define id expr))` or `(begin (augment id) (define (id . formals) body ...+))`

```
(define/augride id expr)
(define/augride (id . formals) body ...+)
```

Shorthand for `(begin (augride id) (define id expr))` or `(begin (augride id) (define (id . formals) body ...+))`

```
(define/augment-final id expr)
(define/augment-final (id . formals) body ...+)
```

Shorthand for `(begin (augment-final id) (define id expr))` or `(begin (augment-final id) (define (id . formals) body ...+))`

```
(define/private id expr)
(define/private (id . formals) body ...+)
```

Shorthand for `(begin (private id) (define id expr))` or `(begin (private id) (define (id . formals) body ...+))`

```
(class/derived original-datum
  (name-id super-expr (interface-expr ...) deserialize-id-expr)
  class-clause
  ...)
```

Like `class*`, but includes a sub-expression to be used as the source for all syntax errors within the class definition. For example, `define-serializable-class` expands to `class/derived` so that errors in the body of the class are reported in terms of `define-serializable-class` instead of `class`.

The *`original-datum`* is the original expression to use for reporting errors.

The *`name-id`* is used to name the resulting class; if it is `#f`, the class name is inferred.

The *`super-expr`*, *`interface-expr`*s, and *`class-clause`*s are as for `class*`.

If the *`deserialize-id-expr`* is not literally `#f`, then a serializable class is generated, and the result is two values instead of one: the class and a deserialize-info structure produced by `make-deserialize-info`. The *`deserialize-id-expr`* should produce a value suitable as the second argument to `make-serialize-info`, and it should refer to an export whose value is the deserialize-info structure.

Future optional forms may be added to the sequence that currently ends with *`deserialize-id-expr`*.

6.2.1 Initialization Variables

A class's initialization variables, declared with `init`, `init-field`, and `init-rest`, are instantiated for each object of a class. Initialization variables can be used in the initial value expressions of fields, default value expressions for initialization arguments, and in initialization expressions. Only initialization variables declared with `init-field` can be accessed from methods; accessing any other initialization variable from a method is a syntax error.

The values bound to initialization variables are

- the arguments provided with `instantiate` or passed to `make-object`, if the object is created as a direct instance of the class; or,
- the arguments passed to the superclass initialization form or procedure, if the object is created as an instance of a derived class.

If an initialization argument is not provided for an initialization variable that has an associated *`default-value-expr`*, then the *`default-value-expr`* expression is evaluated to obtain a value for the variable. A *`default-value-expr`* is only evaluated when an argument is not provided for its variable. The environment of *`default-value-expr`* includes all of the initialization variables, all of the fields, and all of the methods of the class. If multiple *`default-value-expr`*s are evaluated, they are evaluated from left to right. Object creation and field initialization are described in detail in §6.3 "Creating Objects".

If an initialization variable has no *`default-value-expr`*, then the object creation or superclass initialization call must supply an argument for the variable, otherwise the `exn:fail:object` exception is raised.

Initialization arguments can be provided by name or by position. The external name of an initialization variable can be used with `instantiate` or with the superclass initialization form. Those forms also accept by-position arguments. The `make-object` procedure and the superclass initialization procedure accept only by-position arguments.

Arguments provided by position are converted into by-name arguments using the order of `init` and `init-field` clauses and the order of variables within each clause. When an `instantiate` form provides both by-position and by-name arguments, the converted arguments are placed before by-name arguments. (The order can be significant; see also §6.3 "Creating Objects".)

Unless a class contains an `init-rest` clause, when the number of by-position arguments exceeds the number of declared initialization variables, the order of variables in the superclass (and so on, up the superclass chain) determines the by-name conversion.

If a class expression contains an `init-rest` clause, there must be only one, and it must be last. If it declares a variable, then the variable receives extra by-position initialization arguments as a list (similar to a dotted "rest argument" in a procedure). An `init-rest` variable can receive by-position initialization arguments that are left over from a by-name conversion for a derived class. When a derived class's superclass initialization provides even more by-position arguments, they are prefixed onto the by-position arguments accumulated so far.

If too few or too many by-position initialization arguments are provided to an object creation or superclass initialization, then the `exn:fail:object` exception is raised. Similarly, if extra by-position arguments are provided to a class with an `init-rest` clause, the `exn:fail:object` exception is raised.

Unused (by-name) arguments are to be propagated to the superclass, as described in §6.3 "Creating Objects". Multiple initialization arguments can use the same name if the class derivation contains multiple declarations (in different classes) of initialization variables with the name. See §6.3 "Creating Objects" for further details.

See also §6.2.3.3 "Internal and External Names" for information about internal and external names.

6.2.2 Fields

Each `field`, `init-field`, and non-method `define-values` clause in a class declares one or more new fields for the class. Fields declared with `field` or `init-field` are public. Public fields can be accessed and mutated by subclasses using `inherit-field`. Public fields are also accessible outside the class via `class-field-accessor` and mutable via `class-field-mutator` (see §6.4 "Field and Method Access"). Fields declared with `define-values` are accessible only within the class.

A field declared with `init-field` is both a public field and an initialization variable. See §6.2.1 "Initialization Variables" for information about initialization variables.

An `inherit-field` declaration makes a public field defined by a superclass directly accessible in the class expression. If the indicated field is not defined in the superclass, the `exn:fail:object` exception is raised when the class expression is evaluated. Every field in a superclass is present in a derived class, even if it is not declared with `inherit-field` in the derived class. The `inherit-field` clause does not control inheritance, but merely controls lexical scope within a class expression.

When an object is first created, all of its fields have the #<undefined> value (see §4.21 "Void"). The fields of a class are initialized at the same time that the class's initialization expressions are evaluated; see §6.3 "Creating Objects" for more information.

See also §6.2.3.3 "Internal and External Names" for information about internal and external names.

6.2.3 Methods

Method Definitions

Each `public`, `override`, `augment`, `pubment`, `overment`, `augride`, `public-final`, `override-final`, `augment-final`, and `private` clause in a class declares one or more method names. Each method name must have a corresponding *`method-definition`*. The order of `public`, etc., clauses and their corresponding definitions (among themselves, and with respect to other clauses in the class) does not matter.

As shown in the grammar for `class*`, a method definition is syntactically restricted to certain procedure forms, as defined by the grammar for *`method-procedure`*; in the last two forms of *`method-procedure`*, the body `id` must be one of the `id`s bound by `let-values` or `letrec-values`. A *`method-procedure`* expression is not evaluated directly. Instead, for each method, a class-specific method procedure is created; it takes an initial object argument, in addition to the arguments the procedure would accept if the *`method-procedure`* expression were evaluated directly. The body of the procedure is transformed to access methods and fields through the object argument.

A method declared with `public`, `pubment`, or `public-final` introduces a new method into a class. The method must not be present already in the superclass or have an implementation in any superinterface, otherwise the `exn:fail:object` exception is raised when the class expression is evaluated. A method declared with `public` can be overridden in a subclass that uses `override`, `overment`, or `override-final`. A method declared with `pubment` can be augmented in a subclass that uses `augment`, `augride`, or `augment-final`. A method declared with `public-final` cannot be overridden or augmented in a subclass.

A method declared with `override`, `overment`, or `override-final` overrides a definition already present in the superclass or a superinterface. If the method is not already present, the `exn:fail:object` exception is raised when the class expression is evaluated. A method declared with `override` can be overridden again in a subclass that uses `override`, `overment`, or `override-final`. A method declared with `overment` can be augmented in a subclass that uses `augment`, `augride`, or `augment-final`. A method declared with `override-final` cannot be overridden further or augmented in a subclass.

A method declared with `augment`, `augride`, or `augment-final` augments a definition already present in the superclass. If the method is not already present, the `exn:fail:object` exception is raised when the class expression is evaluated. A method declared with `augment` can be augmented further in a subclass that uses `augment`, `augride`, or `augment-final`. A method declared with `augride` can be overridden in a subclass that uses `override`, `overment`, or `override-final`. (Such an override merely replaces the augmentation, not the method that is augmented.) A method declared with `augment-final` cannot be overridden or augmented further in a subclass.

A method declared with `private` is not accessible outside the class expression, cannot be overridden, and never overrides a method in the superclass.

When a method is declared with `override`, `overment`, or `override-final`, then the superclass or superinterface implementation of the method can be called using `super` form. If multiple superinterfaces provide an implementation of the overridden method, then `super` raises `exn:fail:object` when it is evaluated.

When a method is declared with `pubment`, `augment`, or `overment`, then a subclass augmenting method can be called using the `inner` form. The only difference between `public-final` and `pubment` without a corresponding `inner` is that `public-final` prevents the declaration of augmenting methods that would be ignored.

A method declared with `abstract` must be declared without an implementation. Subclasses may implement abstract methods via the `override`, `overment`, or `override-final` forms. Any class that contains or inherits any abstract methods is considered abstract and cannot be instantiated.

```
(super id arg ...)
(super id arg ... . arg-list-expr)
```

Always accesses the superclass method or a superinterface method, independent of whether the method is overridden again in subclasses. Using the `super` form outside of `class*` is a syntax error. Each *`arg`* is as for #%app: either *`arg-expr`* or *`keyword arg-expr`*.

The second form is analogous to using `apply` with a procedure; the *`arg-list-expr`* must not be a parenthesized expression.

```
(inner default-expr id arg ...)
(inner default-expr id arg ... . arg-list-expr)
```

If the object's class does not supply an augmenting method, then *`default-expr`* is evaluated, and the *`arg`* expressions are not evaluated. Otherwise, the augmenting method is called with the *`arg`* results as arguments, and *`default-expr`* is not evaluated. If no `inner` call is evaluated for a particular method, then augmenting methods supplied by subclasses are never used. Using the `inner` form outside of `class*` is an syntax error.

The second form is analogous to using `apply` with a procedure; the *`arg-list-expr`* must not be a parenthesized expression.

Inherited and Superclass Methods

Each `inherit`, `inherit/super`, `inherit/inner`, `rename-super`, and `rename-inner` clause declares one or more methods that are defined in the class, but must be present in the superclass. The `rename-super` and `rename-inner` declarations are rarely used, since `inherit/super` and `inherit/inner` provide the same access. Also, superclass and augmenting methods are typically accessed through `super` and `inner` in a class that also declares the methods, instead of through `inherit/super`, `inherit/inner`, `rename-super`, or `rename-inner`.

Method names declared with inherit, inherit/super, or inherit/inner access overriding declarations, if any, at run time. Method names declared with inherit/super can also be used with the super form to access the superclass implementation, and method names declared with inherit/inner can also be used with the inner form to access an augmenting method, if any.

Method names declared with rename-super always access the superclass's implementation at run-time. Methods declared with rename-inner access a subclass's augmenting method, if any, and must be called with the form

```
(id (lambda () default-expr) arg ...)
```

so that a default-expr is available to evaluate when no augmenting method is available. In such a form, lambda is a literal identifier to separate the default-expr from the arg. When an augmenting method is available, it receives the results of the arg expressions as arguments.

Methods that are present in the superclass but not declared with inherit, inherit/super, or inherit/inner or rename-super are not directly accessible in the class (though they can be called with send). Every public method in a superclass is present in a derived class, even if it is not declared with inherit in the derived class; the inherit clause does not control inheritance, but merely controls lexical scope within a class expression.

If a method declared with inherit, inherit/super, inherit/inner, rename-super, or rename-inner is not present in the superclass, the exn:fail:object exception is raised when the class expression is evaluated.

Internal and External Names

Each method declared with public, override, augment, pubment, overment, augride, public-final, override-final, augment-final, inherit, inherit/super, inherit/inner, rename-super, and rename-inner can have separate internal and external names when (internal-id external-id) is used for declaring the method. The internal name is used to access the method directly within the class expression (including within super or inner forms), while the external name is used with send and generic (see §6.4 "Field and Method Access"). If a single id is provided for a method declaration, the identifier is used for both the internal and external names.

Method inheritance, overriding, and augmentation are based on external names only. Separate internal and external names are required for rename-super and rename-inner (for historical reasons, mainly).

Each init, init-field, field, or inherit-field variable similarly has an internal and an external name. The internal name is used within the class to access the variable, while the external name is used outside the class when providing initialization arguments (e.g., to instantiate), inheriting a field, or accessing a field externally (e.g., with class-field-accessor). As for methods, when inheriting a field with inherit-field, the external name is matched to an external field name in the superclass, while the internal name is bound in the `class` expression.

A single identifier can be used as an internal identifier and an external identifier, and it is possible to use the same identifier as internal and external identifiers for different bindings. Furthermore, within a single class, a single name can be used as an external method name, an external field name, and an external initialization argument name. Overall, each internal identifier must be distinct from all other internal identifiers, each external method name must be distinct from all other method names, each external field name must be distinct from all other field names, and each initialization argument name must be distinct from all other initialization argument names.

By default, external names have no lexical scope, which means, for example, that an external method name matches the same syntactic symbol in all uses of `send`. The `define-local-member-name` and `define-member-name` forms introduce scoped external names.

When a `class` expression is compiled, identifiers used in place of external names must be symbolically distinct (when the corresponding external names are required to be distinct), otherwise a syntax error is reported. When no external name is bound by `define-member-name`, then the actual external names are guaranteed to be distinct when `class` expression is evaluated. When any external name is bound by `define-member-name`, the `exn:fail:object` exception is raised by `class` if the actual external names are not distinct.

```
(define-local-member-name id ...)
```

Unless it appears as the top-level definition, binds each *id* so that, within the scope of the definition, each use of each *id* as an external name is resolved to a hidden name generated by the `define-local-member-name` declaration. Thus, methods, fields, and initialization arguments declared with such external-name *id*s are accessible only in the scope of the `define-local-member-name` declaration. As a top-level definition, `define-local-member-name` binds *id* to its symbolic form.

The binding introduced by `define-local-member-name` is a syntax binding that can be exported and imported with `module`s. Each evaluation of a `define-local-member-name` declaration generates a distinct hidden name (except as a top-level definition). The `interface->method-names` procedure does not expose hidden names.

Examples:

```
(define-values (r o)
  (let ()
    (define-local-member-name m)
    (define c% (class object%
                 (define/public (m) 10)
                 (super-new)))
    (define o (new c%))
```

```
    (values (send o m)
            o)))
```

```
> r
10
> (send o m)
send: no such method
  method name: m
  class name: c%
```

```
(define-member-name id key-expr)
```

Maps a single external name to an external name that is determined by an expression. The value of *key-expr* must be the result of either a `member-name-key` expression or a `generate-member-key` call.

```
(member-name-key identifier)
```

Produces a representation of the external name for `id` in the environment of the `member-name-key` expression.

```
(generate-member-key) → member-name-key?
```

Produces a hidden name, just like the binding for `define-local-member-name`.

```
(member-name-key? v) → boolean?
  v : any/c
```

Returns `#t` for values produced by `member-name-key` and `generate-member-key`, `#f` otherwise.

```
(member-name-key=? a-key b-key) → boolean?
  a-key : member-name-key?
  b-key : member-name-key?
```

Produces `#t` if member-name keys *a-key* and *b-key* represent the same external name, `#f` otherwise.

```
(member-name-key-hash-code a-key) → integer?
  a-key : member-name-key?
```

Produces an integer hash code consistent with `member-name-key=?` comparisons, analogous to `equal-hash-code`.

Examples:

```
(define (make-c% key)
  (define-member-name m key)
  (class object%
    (define/public (m) 10)
    (super-new)))

> (send (new (make-c% (member-name-key m))) m)
10
> (send (new (make-c% (member-name-key p))) m)
send: no such method
  method name: m
  class name: eval:57:0
> (send (new (make-c% (member-name-key p))) p)
10

(define (fresh-c%)
  (let ([key (generate-member-key)])
    (values (make-c% key) key)))

(define-values (fc% key) (fresh-c%))

> (send (new fc%) m)
send: no such method
  method name: m
  class name: eval:57:0
> (let ()
    (define-member-name p key)
    (send (new fc%) p))
10
```

6.3 Creating Objects

The `make-object` procedure creates a new object with by-position initialization arguments, the `new` form creates a new object with by-name initialization arguments, and the `instantiate` form creates a new object with both by-position and by-name initialization arguments.

All fields in the newly created object are initially bound to the special `#<undefined>` value (see §4.21 "Void"). Initialization variables with default value expressions (and no provided value) are also initialized to `#<undefined>`. After argument values are assigned to initialization variables, expressions in `field` clauses, `init-field` clauses with no provided argument, `init` clauses with no provided argument, private field definitions, and other expressions are evaluated. Those expressions are evaluated as they appear in the class expression, from left to right.

Sometime during the evaluation of the expressions, superclass-declared initializations must be evaluated once by using the `super-make-object` procedure, `super-new` form, or `super-instantiate` form.

By-name initialization arguments to a class that have no matching initialization variable are implicitly added as by-name arguments to a `super-make-object`, `super-new`, or `super-instantiate` invocation, after the explicit arguments. If multiple initialization arguments are provided for the same name, the first (if any) is used, and the unused arguments are propagated to the superclass. (Note that converted by-position arguments are always placed before explicit by-name arguments.) The initialization procedure for the `object%` class accepts zero initialization arguments; if it receives any by-name initialization arguments, then `exn:fail:object` exception is raised.

If the end of initialization is reached for any class in the hierarchy without invoking the superclass's initialization, the `exn:fail:object` exception is raised. Also, if superclass initialization is invoked more than once, the `exn:fail:object` exception is raised.

Fields inherited from a superclass are not initialized until the superclass's initialization procedure is invoked. In contrast, all methods are available for an object as soon as the object is created; the overriding of methods is not affected by initialization (unlike objects in C++).

```
(make-object class init-v ...) → object?
  class : class?
  init-v : any/c
```

Creates an instance of *class*. The *init-v*s are passed as initialization arguments, bound to the initialization variables of *class* for the newly created object as described in §6.2.1 "Initialization Variables". If *class* is not a class, the `exn:fail:contract` exception is raised.

```
(new class-expr (id by-name-expr) ...)
```

Creates an instance of the value of *class-expr* (which must be a class), and the value of each *by-name-expr* is provided as a by-name argument for the corresponding *id*.

```
(instantiate class-expr (by-pos-expr ...) (id by-name-expr) ...)
```

Creates an instance of the value of *class-expr* (which must be a class), and the values of the *by-pos-expr*s are provided as by-position initialization arguments. In addition, the value of each *by-name-expr* is provided as a by-name argument for the corresponding *id*.

```
(dynamic-instantiate cls pos-vs named-vs) → object?
  cls : class?
  pos-vs : list?
  named-vs : (listof (cons/c symbol? any/c))
```

Like `(apply make-object cls pos-vs)`, but *named-vs* supplies named arguments in addition to the by-position arguments supplied by *pos-vs*.

Examples:

```
> (define point% (class object%
                   (super-new)
                   (init-field x y)))
> (define p (dynamic-instantiate point% '(1) '([y . 2])))
> (get-field x p)
1
> (get-field y p)
2
```

Added in version 8.8.0.1 of package `base`.

```
super-make-object
```

Produces a procedure that takes by-position arguments an invokes superclass initialization. See §6.3 "Creating Objects" for more information.

```
(super-instantiate (by-pos-expr ...) (id by-expr ...) ...)
```

Invokes superclass initialization with the specified by-position and by-name arguments. See §6.3 "Creating Objects" for more information.

```
(super-new (id by-name-expr ...) ...)
```

Invokes superclass initialization with the specified by-name arguments. See §6.3 "Creating Objects" for more information.

6.4 Field and Method Access

In expressions within a class definition, the initialization variables, fields, and methods of the class are all part of the environment. Within a method body, only the fields and other methods of the class can be referenced; a reference to any other class-introduced identifier is a syntax error. Elsewhere within the class, all class-introduced identifiers are available, and fields and initialization variables can be mutated with `set!`.

6.4.1 Methods

Method names used within a class can only be used in the procedure position of an application expression; any other use is a syntax error.

To allow methods to be applied to lists of arguments, a method application can have the following form:

```
(method-id arg ... . arg-list-expr)
```

This form calls the method in a way analogous to `(apply method-id arg ... arg-list-expr)`. The `arg-list-expr` must not be a parenthesized expression.

Methods are called from outside a class with the `send`, `send/apply`, and `send/keyword-apply` forms.

```
(send obj-expr method-id arg ...)
(send obj-expr method-id arg ... . arg-list-expr)
```

Evaluates *obj-expr* to obtain an object, and calls the method with (external) name *method-id* on the object, providing the *arg* results as arguments. Each *arg* is as for `#%app`: either *arg-expr* or *keyword arg-expr*. In the second form, *arg-list-expr* cannot be a parenthesized expression.

If *obj-expr* does not produce an object, the `exn:fail:contract` exception is raised. If the object has no public method named *method-id*, the `exn:fail:object` exception is raised.

```
(send/apply obj-expr method-id arg ... arg-list-expr)
```

Like the dotted form of `send`, but *arg-list-expr* can be any expression.

```
(send/keyword-apply obj-expr method-id
                    keyword-list-expr value-list-expr
                    arg ... arg-list-expr)
```

Like `send/apply`, but with expressions for keyword and argument lists like `keyword-apply`.

```
(dynamic-send obj
              method-name
              v ...
              #:<kw> kw-arg ...) → any
  obj : object?
  method-name : symbol?
  v : any/c
  kw-arg : any/c
```

Calls the method on *obj* whose name matches *method-name*, passing along all given *v*s and *kw-arg*s.

```
(send* obj-expr msg ...+)

msg = (method-id arg ...)
    | (method-id arg ... . arg-list-expr)
```

Calls multiple methods (in order) of the same object. Each *msg* corresponds to a use of `send`.

For example,

```
(send* edit (begin-edit-sequence)
            (insert "Hello")
            (insert #\newline)
            (end-edit-sequence))
```

is the same as

```
(let ([o edit])
  (send o begin-edit-sequence)
  (send o insert "Hello")
  (send o insert #\newline)
  (send o end-edit-sequence))
```

```
(send+ obj-expr msg ...)

msg = (method-id arg ...)
    | (method-id arg ... . arg-list-expr)
```

Calls methods (in order) starting with the object produced by *obj-expr*. Each method call will be invoked on the result of the last method call, which is expected to be an object. Each *msg* corresponds to a use of `send`.

This is the functional analogue of `send*`.

Examples:

```
(define point%
  (class object%
    (super-new)
    (init-field [x 0] [y 0])
    (define/public (move-x dx)
      (new this% [x (+ x dx)] [y y]))
    (define/public (move-y dy)
      (new this% [y (+ y dy)] [x x]))
```

```
    (define/public (get-pair)
      (cons x y))))

> (send+ (new point%)
         (move-x 5)
         (move-y 7)
         (move-x 12)
         (get-pair))
'(17 . 7)
```

```
(with-method ([id (obj-expr method-id)] ...)
  body ...+)
```

Extracts methods from an object and binds a local name that can be applied directly (in the same way as declared methods within a class) for each method. Each *obj-expr* must produce an object, which must have a public method named by the corresponding *method-id*. The corresponding *id* is bound so that it can be applied directly (see §6.4.1 "Methods").

Example:

```
(let ([s (new stack%)])
  (with-method ([push (s push!)]
                [pop (s pop!)])
    (push 10)
    (push 9)
    (pop)))
```

is the same as

```
(let ([s (new stack%)])
  (send s push! 10)
  (send s push! 9)
  (send s pop!))
```

6.4.2 Fields

```
(get-field id obj-expr)
```

Extracts the field with (external) name *id* from the value of *obj-expr*.

If *obj-expr* does not produce an object, the `exn:fail:contract` exception is raised. If the object has no *id* field, the `exn:fail:object` exception is raised.

```
(dynamic-get-field field-name obj) → any/c
  field-name : symbol?
  obj : object?
```

Extracts the field from `obj` with the (external) name that matches `field-name`. If the object has no field matching `field-name`, the `exn:fail:object` exception is raised.

```
(set-field! id obj-expr expr)
```

Sets the field with (external) name `id` from the value of `obj-expr` to the value of `expr`.

If `obj-expr` does not produce an object, the `exn:fail:contract` exception is raised. If the object has no `id` field, the `exn:fail:object` exception is raised.

```
(dynamic-set-field! field-name obj v) → void?
  field-name : symbol?
  obj : object?
  v : any/c
```

Sets the field from `obj` with the (external) name that matches `field-name` to `v`. If the object has no field matching `field-name`, the `exn:fail:object` exception is raised.

```
(field-bound? id obj-expr)
```

Produces `#t` if the object result of `obj-expr` has a field with (external) name `id`, `#f` otherwise.

If `obj-expr` does not produce an object, the `exn:fail:contract` exception is raised.

```
(class-field-accessor class-expr field-id)
```

Returns an accessor procedure that takes an instance of the class produced by `class-expr` and returns the value of the object's field with (external) name `field-id`.

If `class-expr` does not produce a class, the `exn:fail:contract` exception is raised. If the class has no `field-id` field, the `exn:fail:object` exception is raised.

```
(class-field-mutator class-expr field-id)
```

Returns a mutator procedure that takes an instance of the class produced by `class-expr` and a value, and sets the value of the object's field with (external) name `field-id` to the given value. The result is `#<void>`.

If `class-expr` does not produce a class, the `exn:fail:contract` exception is raised. If the class has no `field-id` field, the `exn:fail:object` exception is raised.

6.4.3 Generics

A *generic* can be used instead of a method name to avoid the cost of relocating a method by name within a class.

```
(generic class-or-interface-expr id)
```

Produces a generic that works on instances of the class or interface produced by `class-or-interface-expr` (or an instance of a class/interface derived from `class-or-interface`) to call the method with (external) name `id`.

If `class-or-interface-expr` does not produce a class or interface, the `exn:fail:contract` exception is raised. If the resulting class or interface does not contain a method named `id`, the `exn:fail:object` exception is raised.

```
(send-generic obj-expr generic-expr arg ...)
(send-generic obj-expr generic-expr arg ... . arg-list-expr)
```

Calls a method of the object produced by `obj-expr` as indicated by the generic produced by `generic-expr`. Each `arg` is as for `#%app`: either `arg-expr` or `keyword arg-expr`. The second form is analogous to calling a procedure with `apply`, where `arg-list-expr` is not a parenthesized expression.

If `obj-expr` does not produce an object, or if `generic-expr` does not produce a generic, the `exn:fail:contract` exception is raised. If the result of `obj-expr` is not an instance of the class or interface encapsulated by the result of `generic-expr`, the `exn:fail:object` exception is raised.

```
(make-generic type method-name) → generic?
  type : (or/c class? interface?)
  method-name : symbol?
```

Like the `generic` form, but as a procedure that accepts a symbolic method name.

6.5 Mixins

```
(mixin (interface-expr ...) (interface-expr ...)
  class-clause ...)
```

Produces a *mixin*, which is a procedure that encapsulates a class extension, leaving the superclass unspecified. Each time that a mixin is applied to a specific superclass, it produces a new derived class using the encapsulated extension.

The given class must implement interfaces produced by the first set of `interface-expr`s. The result of the procedure is a subclass of the given class that implements the interfaces produced by the second set of *interface-expr*s. The *class-clause*s are as for `class*`, to define the class extension encapsulated by the mixin.

Evaluation of a `mixin` form checks that the *class-clause*s are consistent with both sets of *interface-expr*s.

6.6 Traits

```
(require racket/trait)
```
package: `base`

The bindings documented in this section are provided by the `racket/trait` library, not `racket/base` or `racket`.

A *trait* is a collection of methods that can be converted to a mixin and then applied to a class. Before a trait is converted to a mixin, the methods of a trait can be individually renamed, and multiple traits can be merged to form a new trait.

```
(trait trait-clause ...)

trait-clause = (public maybe-renamed ...)
             | (pubment maybe-renamed ...)
             | (public-final maybe-renamed ...)
             | (override maybe-renamed ...)
             | (overment maybe-renamed ...)
             | (override-final maybe-renamed ...)
             | (augment maybe-renamed ...)
             | (augride maybe-renamed ...)
             | (augment-final maybe-renamed ...)
             | (inherit maybe-renamed ...)
             | (inherit/super maybe-renamed ...)
             | (inherit/inner maybe-renamed ...)
             | method-definition
             | (field field-declaration ...)
             | (inherit-field maybe-renamed ...)
```

Creates a trait. The body of a `trait` form is similar to the body of a `class*` form, but restricted to non-private method definitions. In particular, the grammar of *maybe-renamed*, *method-definition*, and *field-declaration* are the same as for `class*`, and every *method-definition* must have a corresponding declaration (one of `public`, `override`, etc.). As in `class`, uses of method names in direct calls, `super` calls, and `inner` calls depend on bringing method names into scope via `inherit`, `inherit/super`, `inherit/inner`, and other method declarations in the same trait; an exception, compared to `class` is that `overment` binds a method name only in the corresponding method, and not in other methods of the same trait. Finally, macros such as `public*` and `define/public` work in `trait` as in `class`.

External identifiers in `trait`, `trait-exclude`, `trait-exclude-field`, `trait-alias`, `trait-rename`, and `trait-rename-field` forms are subject to binding via `define-member-name` and `define-local-member-name`. Although `private` methods or fields are not allowed in a `trait` form, they can be simulated by using a `public` or `field` declaration and a name whose scope is limited to the `trait` form.

```
(trait? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a trait, `#f` otherwise.

```
(trait->mixin tr) → (class? . -> . class?)
  tr : trait?
```

Converts a trait to a mixin, which can be applied to a class to produce a new class. An expression of the form

```
(trait->mixin
 (trait
   trait-clause ...))
```

is equivalent to

```
(lambda (%)
  (class %
    trait-clause ...
    (super-new)))
```

Normally, however, a trait's methods are changed and combined with other traits before converting to a mixin.

```
(trait-sum tr ...+) → trait?
  tr : trait?
```

Produces a trait that combines all of the methods of the given *tr*s. For example,

```
(define t1
  (trait
    (define/public (m1) 1)))
(define t2
  (trait
    (define/public (m2) 2)))
(define t3 (trait-sum t1 t2))
```

creates a trait `t3` that is equivalent to

```
(trait
  (define/public (m1) 1)
  (define/public (m2) 2))
```

but `t1` and `t2` can still be used individually or combined with other traits.

When traits are combined with `trait-sum`, the combination drops `inherit`, `inherit/super`, `inherit/inner`, and `inherit-field` declarations when a definition is supplied for the same method or field name by another trait. The `trait-sum` operation fails (the `exn:fail:contract` exception is raised) if any of the traits to combine define a method or field with the same name, or if an `inherit/super` or `inherit/inner` declaration to be dropped is inconsistent with the supplied definition. In other words, declaring a method with `inherit`, `inherit/super`, or `inherit/inner`, does not count as defining the method; at the same time, for example, a trait that contains an `inherit/super` declaration for a method `m` cannot be combined with a trait that defines `m` as `augment`, since no class could satisfy the requirements of both `augment` and `inherit/super` when the trait is later converted to a mixin and applied to a class.

```
(trait-exclude trait-expr id)
```

Produces a new trait that is like the trait result of *`trait-expr`*, but with the definition of a method named by *`id`* removed; as the method definition is removed, either an `inherit`, `inherit/super`, or `inherit/inner` declaration is added:

- A method declared with `public`, `pubment`, or `public-final` is replaced with an `inherit` declaration.
- A method declared with `override` or `override-final` is replaced with an `inherit/super` declaration.
- A method declared with `augment`, `augride`, or `augment-final` is replaced with an `inherit/inner` declaration.
- A method declared with `overment` is not replaced with any `inherit` declaration.

If the trait produced by *`trait-expr`* has no method definition for *`id`*, the `exn:fail:contract` exception is raised.

```
(trait-exclude-field trait-expr id)
```

Produces a new trait that is like the trait result of *`trait-expr`*, but with the definition of a field named by *`id`* removed; as the field definition is removed, an `inherit-field` declaration is added.

```
(trait-alias trait-expr id new-id)
```

Produces a new trait that is like the trait result of *trait-expr*, but the definition and declaration of the method named by *id* is duplicated with the name *new-id*. The consistency requirements for the resulting trait are the same as for `trait-sum`, otherwise the `exn:fail:contract` exception is raised. This operation does not rename any other use of *id*, such as in method calls (even method calls to `identifier` in the cloned definition for *new-id*).

```
(trait-rename trait-expr id new-id)
```

Produces a new trait that is like the trait result of *trait-expr*, but all definitions and references to methods named *id* are replaced by definitions and references to methods named by *new-id*. The consistency requirements for the resulting trait are the same as for `trait-sum`, otherwise the `exn:fail:contract` exception is raised.

```
(trait-rename-field trait-expr id new-id)
```

Produces a new trait that is like the trait result of *trait-expr*, but all definitions and references to fields named *id* are replaced by definitions and references to fields named by *new-id*. The consistency requirements for the resulting trait are the same as for `trait-sum`, otherwise the `exn:fail:contract` exception is raised.

6.7 Object and Class Contracts

```
(class/c maybe-opaque member-spec ...)
```

```
maybe-opaque =
             | #:opaque
             | #:opaque #:ignore-local-member-names

 member-spec = method-spec
             | (field field-spec ...)
             | (init field-spec ...)
             | (init-field field-spec ...)
             | (inherit method-spec ...)
             | (inherit-field field-spec ...)
             | (super method-spec ...)
             | (inner method-spec ...)
             | (override method-spec ...)
             | (augment method-spec ...)
             | (augride method-spec ...)
             | (absent absent-spec ...)

 method-spec = method-id
             | (method-id method-contract-expr)

  field-spec = field-id
             | (field-id contract-expr)

 absent-spec = method-id
             | (field field-id ...)
```

Produces a contract for a class.

There are two major categories of contracts listed in a `class/c` form: external and internal contracts. External contracts govern behavior when an object is instantiated from a class or when methods or fields are accessed via an object of that class. Internal contracts govern behavior when method or fields are accessed within the class hierarchy. This separation allows for stronger contracts for class clients and weaker contracts for subclasses.

Method contracts must contain an additional initial argument which corresponds to the implicit `this` parameter of the method. This allows for contracts which discuss the state of the object when the method is called (or, for dependent contracts, in other parts of the contract). Alternative contract forms, such as `->m`, are provided as a shorthand for writing method contracts.

Methods and fields listed in an `absent` clause must *not* be present in the class.

A class contract can be specified to be *opaque* with the `#:opaque` keyword. An opaque class contract will only accept a class that defines exactly the external methods and fields specified by the contract. A contract error is raised if the contracted class contains any methods or fields that are not specified. Methods or fields with local member names (i.e., defined with define-local-member-name) are ignored for this check if #:ignore-local-member-names is provided.

The external contracts are as follows:

- An external method contract without a tag describes the behavior of the implementation of *method-id* on method sends to an object of the contracted class. This contract will continue to be checked in subclasses until the contracted class's implementation is no longer the entry point for dynamic dispatch.

  If only the field name is present, this is equivalent to insisting only that the method is present in the class.

  Examples:

  ```
  (define woody%
    (class object%
      (define/public (draw who)
        (format "reach for the sky, ~a" who))
      (super-new)))

  (define/contract woody+c%
    (class/c [draw (->m symbol? string?)])
    woody%)

  > (send (new woody%) draw #f)
  "reach for the sky, #f"
  > (send (new woody+c%) draw 'zurg)
  "reach for the sky, zurg"
  > (send (new woody+c%) draw #f)
  draw: contract violation
    expected: symbol?
    given: #f
    in: the 1st argument of
        the draw method in
        (class/c (draw (->m symbol? string?)))
    contract from: (definition woody+c%)
    contract on: woody+c%
    blaming: top-level
     (assuming the contract is correct)
    at: eval:74:0
  ```

- An external field contract, tagged with field, describes the behavior of the value contained in that field when accessed from outside the class. Since fields may be mutated, these contracts are checked on any external access (via get-field) and external mutations (via set-field!) of the field.

  If only the field name is present, this is equivalent to using the contract any/c (but it is checked more efficiently).

Examples:

```
(define woody/hat%
  (class woody%
    (field [hat-location 'uninitialized])
    (define/public (lose-hat) (set! hat-location 'lost))
    (define/public (find-hat) (set! hat-location 'on-head))
    (super-new)))
(define/contract woody/hat+c%
  (class/c [draw (->m symbol? string?)]
           [lose-hat (->m void?)]
           [find-hat (->m void?)]
           (field [hat-location (or/c 'on-head 'lost)]))
  woody/hat%)

> (get-field hat-location (new woody/hat%))
'uninitialized
> (let ([woody (new woody/hat+c%)])
    (send woody lose-hat)
    (get-field hat-location woody))
'lost
> (get-field hat-location (new woody/hat+c%))
woody/hat+c%: broke its own contract
  promised: (or/c (quote on-head) (quote lost))
  produced: 'uninitialized
  in: the hat-location field in
      (class/c
       (draw (->m symbol? string?))
       (lose-hat (->m void?))
       (find-hat (->m void?))
       (field (hat-location
               (or/c 'on-head 'lost))))
  contract from: (definition woody/hat+c%)
  blaming: (definition woody/hat+c%)
   (assuming the contract is correct)
  at: eval:79:0
> (let ([woody (new woody/hat+c%)])
    (set-field! hat-location woody 'under-the-dresser))
woody/hat+c%: contract violation
  expected: (or/c (quote on-head) (quote lost))
  given: 'under-the-dresser
  in: the hat-location field in
      (class/c
       (draw (->m symbol? string?))
       (lose-hat (->m void?))
       (find-hat (->m void?))
```

```
          (field (hat-location
                   (or/c 'on-head 'lost))))
  contract from: (definition woody/hat+c%)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:79:0
```

- An initialization argument contract, tagged with `init`, describes the expected behavior of the value paired with that name during class instantiation. The same name can be provided more than once, in which case the first such contract in the `class/c` form is applied to the first value tagged with that name in the list of initialization arguments, and so on.

  If only the initialization argument name is present, this is equivalent to using the contract `any/c` (but it is checked more efficiently).

  Examples:

```
(define woody/init-hat%
  (class woody%
    (init init-hat-location)
    (field [hat-location init-hat-location])
    (define/public (lose-hat) (set! hat-location 'lost))
    (define/public (find-hat) (set! hat-location 'on-head))
    (super-new)))
(define/contract woody/init-hat+c%
  (class/c [draw (->m symbol? string?)]
           [lose-hat (->m void?)]
           [find-hat (->m void?)]
           (init [init-hat-location (or/c 'on-head 'lost)])
           (field [hat-location (or/c 'on-head 'lost)]))
  woody/init-hat%)

> (get-field hat-location
             (new woody/init-hat+c%
                  [init-hat-location 'lost]))
'lost
> (get-field hat-location
             (new woody/init-hat+c%
                  [init-hat-location 'slinkys-mouth]))
woody/init-hat+c%: contract violation
  expected: (or/c (quote on-head) (quote lost))
  given: 'slinkys-mouth
  in: the init-hat-location init argument in
      (class/c
       (draw (->m symbol? string?))
       (lose-hat (->m void?))
```

```
        (find-hat (->m void?))
        (init (init-hat-location
               (or/c 'on-head 'lost)))
        (field (hat-location
                (or/c 'on-head 'lost))))
  contract from:
      (definition woody/init-hat+c%)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:85:0
```

- The contracts listed in an `init-field` section are treated as if each contract appeared in an `init` section and a `field` section.

The internal contracts restrict the behavior of method calls made between classes and their subclasses; such calls are not controlled by the class contracts described above.

As with the external contracts, when a method or field name is specified but no contract appears, the contract is satisfied merely with the presence of the corresponding field or method.

- A method contract tagged with `inherit` describes the behavior of the method when invoked directly (i.e., via `inherit`) in any subclass of the contracted class. This contract, like external method contracts, applies until the contracted class's method implementation is no longer the entry point for dynamic dispatch.

  Examples:

```
> (new (class woody+c%
         (inherit draw)
         (super-new)
         (printf "woody sez: “~a”\n" (draw "evil dr pork-
chop"))))
woody sez: “reach for the sky, evil dr porkchop”
(object:eval:88:0 ...)

(define/contract woody+c-inherit%
  (class/c (inherit [draw (->m symbol? string?)]))
  woody+c%)

> (new (class woody+c-inherit%
         (inherit draw)
         (printf "woody sez: ~a\n" (draw "evil dr pork-
chop"))))
draw: contract violation
  expected: symbol?
  given: "evil dr porkchop"
```

```
in: the 1st argument of
      the draw method in
      (class/c
        (inherit (draw (->m symbol? string?))))
contract from: (definition woody+c-inherit%)
contract on: woody+c-inherit%
blaming: top-level
  (assuming the contract is correct)
at: eval:89:0
```

- A method contract tagged with `super` describes the behavior of *`method-id`* when called by the `super` form in a subclass. This contract only affects `super` calls in subclasses which call the contract class's implementation of *`method-id`*.

  This example shows how to extend the `draw` method so that if it is passed two arguments, it combines two calls to the original `draw` method, but with a contract the controls how the `super` methods must be invoked.

  Examples:

```
(define/contract woody%+s
  (class/c (super [draw (->m symbol? string?)]))
  (class object%
    (define/public (draw who)
      (format "reach for the sky, ~a" who))
    (super-new)))

(define woody2+c%
  (class woody%+s
    (define/override draw
      (case-lambda
        [(a) (super draw a)]
        [(a b) (string-append (super draw a)
                              " and "
                              (super draw b))]))
    (super-new)))

> (send (new woody2+c%) draw 'evil-dr-porkchop  'zurg)
"reach for the sky, evil-dr-porkchop and reach for the sky,
zurg"
> (send (new woody2+c%) draw "evil dr porkchop" "zurg")
draw: contract violation
  expected: symbol?
  given: "evil dr porkchop"
  in: the 1st argument of
        the draw method in
        (class/c
```

```
      (super (draw (->m symbol? string?))))
  contract from: (definition woody%+s)
  contract on: woody%+s
  blaming: top-level
   (assuming the contract is correct)
  at: eval:91:0
```

The last call signals an error blaming `woody2%+c` because there is no contract checking the initial `draw` call and the super-call violates its contract.

- A method contract tagged with `inner` describes the behavior the class expects of an augmenting method in a subclass. This contract affects any implementations of *`method-id`* in subclasses which can be called via `inner` from the contracted class. This means a subclass which implements *`method-id`* via `augment` or `overment` stop future subclasses from being affected by the contract, since further extension cannot be reached via the contracted class.
- A method contract tagged with `override` describes the behavior expected by the contracted class for *`method-id`* when called directly (i.e. by the application `(`*`method-id`* `...)`). This form can only be used if overriding the method in subclasses will change the entry point to the dynamic dispatch chain (i.e., the method has never been augmentable).

  This time, instead of overriding `draw` to support two arguments, we can make a new method, `draw2` that takes the two arguments and calls `draw`. We also add a contract to make sure that overriding `draw` doesn't break `draw2`.

  Examples:

```
(define/contract woody2+override/c%
  (class/c (override [draw (->m symbol? string?)]))
  (class woody+c%
    (inherit draw)
    (define/public (draw2 a b)
      (string-append (draw a)
                     " and "
                     (draw b)))
    (super-new)))

(define woody2+broken-draw
  (class woody2+override/c%
    (define/override (draw x)
      'not-a-string)
    (super-new)))

> (send (new woody2+broken-draw) draw2
        'evil-dr-porkchop
        'zurg)
```

```
draw: contract violation
  expected: string?
  given: 'not-a-string
  in: the range of
      the draw method in
      (class/c
       (override (draw (->m symbol? string?))))
  contract from:
      (definition woody2+override/c%)
  contract on: woody2+override/c%
  blaming: top-level
   (assuming the contract is correct)
  at: eval:95:0
```

- A method contract tagged with either `augment` or `augride` describes the behavior provided by the contracted class for *`method-id`* when called directly from subclasses. These forms can only be used if the method has previously been augmentable, which means that no augmenting or overriding implementation will change the entry point to the dynamic dispatch chain. `augment` is used when subclasses can augment the method, and `augride` is used when subclasses can override the current augmentation.
- A field contract tagged with `inherit-field` describes the behavior of the value contained in that field when accessed directly (i.e., via `inherit-field`) in any subclass of the contracted class. Since fields may be mutated, these contracts are checked on any access and/or mutation of the field that occurs in such subclasses.
- Changed in version 6.1.1.8 of package `base`: Opaque class/c now optionally ignores local member names if an additional keyword is supplied.

```
(absent absent-spec ...)
```

See `class/c`; use outside of a `class/c` form is a syntax error.

```
(->m dom ... range)
```

Similar to `->`, except that the domain of the resulting contract contains one more element than the stated domain, where the first (implicit) argument is contracted with `any/c`. This contract is useful for writing simpler method contracts when no properties of `this` need to be checked.

```
(->*m (mandatory-dom ...) (optional-dom ...) rest range)
```

Similar to `->*`, except that the mandatory domain of the resulting contract contains one more element than the stated domain, where the first (implicit) argument is contracted with `any/c`. This contract is useful for writing simpler method contracts when no properties of `this` need to be checked.

```
(case->m (-> dom ... rest range) ...)
```

Similar to `case->`, except that the mandatory domain of each case of the resulting contract contains one more element than the stated domain, where the first (implicit) argument is contracted with `any/c`. This contract is useful for writing simpler method contracts when no properties of `this` need to be checked.

```
(->dm (mandatory-dependent-dom ...)
      (optional-dependent-dom ...)
      dependent-rest
      pre-cond
      dep-range)
```

Similar to `->d`, except that the mandatory domain of the resulting contract contains one more element than the stated domain, where the first (implicit) argument is contracted with `any/c`. In addition, `this` is appropriately bound in the body of the contract. This contract is useful for writing simpler method contracts when no properties of `this` need to be checked.

```
(object/c member-spec ...)

member-spec = method-spec
            | (field field-spec ...)

method-spec = method-id
            | (method-id method-contract)

 field-spec = field-id
            | (field-id contract-expr)
```

Produces a contract for an object.

Unlike the older form `object-contract`, but like `class/c`, arbitrary contract expressions are allowed. Also, method contracts for `object/c` follow those for `class/c`. An object wrapped with `object/c` behaves as if its class had been wrapped with the equivalent `class/c` contract.

```
(instanceof/c class-contract) → contract?
  class-contract : contract?
```

Produces a contract for an object, where the object is an instance of a class that conforms to *class-contract*.

```
(dynamic-object/c method-names
                  method-contracts
                  field-names
                  field-contracts) → contract?
```

```
method-names : (listof symbol?)
method-contracts : (listof contract?)
field-names : (listof symbol?)
field-contracts : (listof contract?)
```

Produces a contract for an object, similar to `object/c` but where the names and contracts for both methods and fields can be computed dynamically. The list of names and contracts for both methods and field respectively must have the same lengths.

```
(object-contract member-spec ...)
```

```
         member-spec = (method-id method-contract)
                     | (field field-id contract-expr)

     method-contract = (-> dom ... range)
                     | (->* (mandatory-dom ...)
                            (optional-dom ...)
                            rest
                            range)
                     | (->d (mandatory-dependent-dom ...)
                            (optional-dependent-dom ...)
                            dependent-rest
                            pre-cond
                            dep-range)

                 dom = dom-expr
                     | keyword dom-expr

               range = range-expr
                     | (values range-expr ...)
                     | any

       mandatory-dom = dom-expr
                     | keyword dom-expr

        optional-dom = dom-expr
                     | keyword dom-expr

                rest =
                     | #:rest rest-expr

mandatory-dependent-dom = [id dom-expr]
                     | keyword [id dom-expr]

 optional-dependent-dom = [id dom-expr]
                     | keyword [id dom-expr]

      dependent-rest =
                     | #:rest id rest-expr

            pre-cond =
                     | #:pre-cond boolean-expr

           dep-range = any
                     | [id range-expr] post-cond
                     | (values [id range-expr] ...) post-cond

           post-cond =
                     | #:post-cond boolean-expr
```

Produces a contract for an object.

Each of the contracts for a method has the same semantics as the corresponding function contract, but the syntax of the method contract must be written directly in the body of the object-contract—much like the way that methods in class definitions use the same syntax as regular function definitions, but cannot be arbitrary procedures. Unlike the method contracts for `class/c`, the implicit `this` argument is not part of the contract. To allow for the use of `this` in dependent contracts, `->d` contracts implicitly bind `this` to the object itself.

```
mixin-contract : contract?
```

A function contract that recognizes mixins. It guarantees that the input to the function is a class and the result of the function is a subclass of the input.

```
(make-mixin-contract type ...) → contract?
  type : (or/c class? interface?)
```

Produces a function contract that guarantees the input to the function is a class that implements/subclasses each *type*, and that the result of the function is a subclass of the input.

```
(is-a?/c type) → flat-contract?
  type : (or/c class? interface?)
```

Accepts a class or interface and returns a flat contract that recognizes objects that instantiate the class/interface.

See `is-a?`.

```
(implementation?/c interface) → flat-contract?
  interface : interface?
```

Returns a flat contract that recognizes classes that implement *interface*.

See `implementation?`.

```
(subclass?/c class) → flat-contract?
  class : class?
```

Returns a flat contract that recognizes classes that are subclasses of *class*.

See `subclass?`.

6.8 Object Equality and Hashing

By default, objects that are instances of different classes or that are instances of a non-transparent class are `equal?` only if they are `eq?`. Like transparent structures, two objects that are instances of the same transparent class (i.e., every superclass of the class has #f as its inspector) are equal? when their field values are equal?.

To customize the way that a class instance is compared to other instances by equal?, implement the equal<%> interface.

```
equal<%> : interface?
```

The equal<%> interface includes three methods, which are analogous to the functions provided for a structure type with prop:equal+hash:

- equal-to? — Takes two arguments. The first argument is an object that is an instance of the same class (or a subclass that does not re-declare its implementation of equal<%>) and that is being compared to the target object. The second argument is an equal?-like procedure of two arguments that should be used for recursive equality testing. The result should be a true value if the object and the first argument of the method are equal, #f otherwise.
- equal-hash-code-of — Takes one argument, which is a procedure of one argument that should be used for recursive hash-code computation. The result should be an exact integer representing the target object's hash code.
- equal-secondary-hash-code-of — Takes one argument, which is a procedure of one argument that should be used for recursive hash-code computation. The result should be an exact integer representing the target object's secondary hash code.

The equal<%> interface is unusual in that declaring the implementation of the interface is different from inheriting the interface. Two objects can be equal only if they are instances of classes whose most specific ancestor to explicitly implement equal<%> is the same ancestor.

See prop:equal+hash for more information on equality comparisons and hash codes. The equal<%> interface is implemented with interface* and prop:equal+hash.

Example:

```
#lang racket

;; Case insensitive words:
(define ci-word%
  (class* object% (equal<%>)

    ;; Initialization
```

```
    (init-field word)
    (super-new)

    ;; We define equality to ignore case:
    (define/public (equal-to? other recur)
      (string-ci=? word (get-field word other)))

    ;; The hash codes need to be insensitive to casing as well.
    ;; We'll just downcase the word and get its hash code.
    (define/public (equal-hash-code-of hash-code)
      (hash-code (string-downcase word)))

    (define/public (equal-secondary-hash-code-of hash-code)
      (hash-code (string-downcase word)))))

;; We can create a hash with a single word:
(define h (make-hash))
(hash-set! h (new ci-word% [word "inconceivable!"]) 'value)

;; Lookup into the hash should be case-insensitive, so that
;; both of these should return 'value.
(hash-ref h (new ci-word% [word "inconceivable!"]))
(hash-ref h (new ci-word% [word "INCONCEIVABLE!"]))

;; Comparison fails if we use a non-ci-word%:
(hash-ref h "inconceivable!" 'i-dont-think-it-means-what-you-
think-it-means)
```

6.9 Object Serialization

```
(define-serializable-class* class-id superclass-expr
                                     (interface-expr ...)
  class-clause ...)
```

Binds *class-id* to a class, where *superclass-expr*, the *interface-expr*s, and the *class-clause*s are as in `class*`.

This form can only be used at the top level, either within a module or outside. The *class-id* identifier is bound to the new class, and `deserialize-info:`*class-id* is also defined; if the definition is within a module, then the latter is provided from a `deserialize-info` submodule via `module+`.

Serialization for the class works in one of two ways:

- If the class implements the built-in interface externalizable<%>, then an object is serialized by calling its externalize method; the result can be anything that is serializable (but, obviously, should not be the object itself). Deserialization creates an instance of the class with no initialization arguments, and then calls the object's internalize method with the result of externalize (or, more precisely, a deserialized version of the serialized result of a previous call).

  To support this form of serialization, the class must be instantiable with no initialization arguments. Furthermore, cycles involving only instances of the class (and other such classes) cannot be serialized.

- If the class does not implement externalizable<%>, then every superclass of the class must be either serializable or transparent (i.e,. have #f as its inspector). Serialization and deserialization are fully automatic, and may involve cycles of instances.

  To support cycles of instances, deserialization may create an instance of the call with all fields as the undefined value, and then mutate the object to set the field values. Serialization support does not otherwise make an object's fields mutable.

In the second case, a serializable subclass can implement externalizable<%>, in which case the externalize method is responsible for all serialization (i.e., automatic serialization is lost for instances of the subclass). In the first case, all serializable subclasses implement externalizable<%>, since a subclass implements all of the interfaces of its parent class.

In either case, if an object is an immediate instance of a subclass (that is not itself serializable), the object is serialized as if it was an immediate instance of the serializable class. In particular, overriding declarations of the externalize method are ignored for instances of non-serializable subclasses.

```
(define-serializable-class class-id superclass-expr
  class-clause ...)
```

Like define-serializable-class*, but without interface expressions (analogous to class).

```
externalizable<%> : interface?
```

The externalizable<%> interface includes only the externalize and internalize methods. See define-serializable-class* for more information.

6.10 Object Printing

To customize the way that a class instance is printed by print, write and display, implement the printable<%> interface.

```
printable<%> : interface?
```

The printable<%> interface includes only the custom-print, custom-write, and custom-display methods. The custom-print method accepts two arguments: the destination port and the current quasiquote depth as an exact nonnegative integer. The custom-write and custom-display methods each accepts a single argument, which is the destination port to write or display the object.

Calls to the custom-print, custom-write, or custom-display methods are like calls to a procedure attached to a structure type through the prop:custom-write property. In particular, recursive printing can trigger an escape from the call.

See prop:custom-write for more information. The printable<%> interface is implemented with interface* and prop:custom-write.

```
writable<%> : interface?
```

Like printable<%>, but includes only the custom-write and custom-display methods. A print request is directed to custom-write.

6.11 Object, Class, and Interface Utilities

```
(object? v) → boolean?
  v : any/c
```

Returns #t if *v* is an object, #f otherwise.

Examples:

```
> (object? (new object%))
#t
> (object? object%)
#f
> (object? "clam chowder")
#f
```

```
(class? v) → boolean?
  v : any/c
```

Returns #t if *v* is a class, #f otherwise.

Examples:

```
> (class? object%)
#t
> (class? (class object% (super-new)))
#t
> (class? (new object%))
#f
> (class? "corn chowder")
#f
```

```
(interface? v) → boolean?
  v : any/c
```

Returns #t if *v* is an interface, #f otherwise.

Examples:

```
> (interface? (interface () empty cons first rest))
#t
> (interface? object%)
#f
> (interface? "gazpacho")
#f
```

```
(generic? v) → boolean?
  v : any/c
```

Returns #t if *v* is a generic, #f otherwise.

Examples:

```
> (define c%
    (class object%
      (super-new)
      (define/public (m x)
        (+ 3.14 x))))
> (generic? (generic c% m))
#t
> (generic? c%)
#f
> (generic? "borscht")
#f
```

```
(object=? a b) → boolean?
  a : object?
  b : object?
```

Determines whether `a` and `b` were returned from the same call to `new` or not. If the two objects have fields, this procedure determines whether mutating a field of one would change that field in the other.

This procedure is similar in spirit to `eq?` but also works properly with contracts (and has a stronger guarantee).

Examples:

```
> (define obj-1 (new object%))
> (define obj-2 (new object%))
> (define/contract obj-3 (object/c) obj-1)
> (object=? obj-1 obj-1)
#t
> (object=? obj-1 obj-2)
#f
> (object=? obj-1 obj-3)
#t
> (eq? obj-1 obj-1)
#t
> (eq? obj-1 obj-2)
#f
> (eq? obj-1 obj-3)
#f
```

```
(object-or-false=? a b) → boolean?
  a : (or/c object? #f)
  b : (or/c object? #f)
```

Like `object=?`, but accepts `#f` for either argument and returns `#t` if both arguments are `#f`.

Examples:

```
> (object-or-false=? #f (new object%))
#f
> (object-or-false=? (new object%) #f)
#f
> (object-or-false=? #f #f)
#t
```

Added in version 6.1.1.8 of package `base`.

```
(object=-hash-code o) → fixnum?
  o : object?
```

Returns the hash code for *o* that corresponds to the equality relation `object=?`.

Added in version 7.1.0.6 of package `base`.

```
(object->vector object [opaque-v]) → vector?
  object : object?
  opaque-v : any/c = #f
```

Returns a vector representing *object* that shows its inspectable fields, analogous to `struct->vector`.

Examples:

```
> (object->vector (new object%))
'#(object:object% ...)
> (object->vector (new (class object%
                         (super-new)
                         (field [x 5] [y 10]))))
'#(object:eval:113:0 ...)
```

```
(class->interface class) → interface?
  class : class?
```

Returns the interface implicitly defined by *class*.

Example:

```
> (class->interface object%)
#<interface:object%>
```

```
(object-interface object) → interface?
  object : object?
```

Returns the interface implicitly defined by the class of *object*.

Example:

```
> (object-interface (new object%))
#<interface:object%>
```

```
(is-a? v type) → boolean?
  v : any/c
  type : (or/c interface? class?)
```

Returns `#t` if *v* is an instance of a class *type* or a class that implements an interface *type*, `#f` otherwise.

Examples:

```
> (define point<%> (interface () get-x get-y))
> (define 2d-point%
    (class* object% (point<%>)
      (super-new)
      (field [x 0] [y 0])
      (define/public (get-x) x)
      (define/public (get-y) y)))
> (is-a? (new 2d-point%) 2d-point%)
#t
> (is-a? (new 2d-point%) point<%>)
#t
> (is-a? (new object%) 2d-point%)
#f
> (is-a? (new object%) point<%>)
#f
```

```
(subclass? v cls) → boolean?
  v : any/c
  cls : class?
```

Returns `#t` if *v* is a class derived from (or equal to) *cls*, `#f` otherwise.

Examples:

```
> (subclass? (class object% (super-new)) object%)
#t
> (subclass? object% (class object% (super-new)))
#f
> (subclass? object% object%)
#t
```

```
(implementation? v intf) → boolean?
  v : any/c
  intf : interface?
```

Returns #t if *v* is a class that implements *intf*, #f otherwise.

Examples:

```
> (define i<%> (interface () go))
> (define c%
    (class* object% (i<%>)
      (super-new)
      (define/public (go) 'go)))
> (implementation? c% i<%>)
#t
> (implementation? object% i<%>)
#f
```

```
(interface-extension? v intf) → boolean?
  v : any/c
  intf : interface?
```

Returns #t if *v* is an interface that extends *intf*, #f otherwise.

Examples:

```
> (define point<%> (interface () get-x get-y))
> (define colored-point<%> (interface (point<%>) color))
> (interface-extension? colored-point<%> point<%>)
#t
> (interface-extension? point<%> colored-point<%>)
#f
> (interface-extension? (interface () get-x get-y get-z) point<%>)
#f
```

```
(method-in-interface? sym intf) → boolean?
  sym : symbol?
  intf : interface?
```

Returns #t if *intf* (or any of its ancestor interfaces) includes a member with the name *sym*, #f otherwise.

Examples:

```
> (define i<%> (interface () get-x get-y))
> (method-in-interface? 'get-x i<%>)
#t
> (method-in-interface? 'get-z i<%>)
#f
```

```
(interface->method-names intf) → (listof symbol?)
  intf : interface?
```

Returns a list of symbols for the method names in *intf*, including methods inherited from superinterfaces, but not including methods whose names are local (i.e., declared with `define-local-member-name`).

Examples:

```
> (define i<%> (interface () get-x get-y))
> (interface->method-names i<%>)
'(get-x get-y)
```

```
(object-method-arity-includes? object
                               sym
                               cnt)    → boolean?
  object : object?
  sym : symbol?
  cnt : exact-nonnegative-integer?
```

Returns `#t` if *object* has a method named *sym* that accepts *cnt* arguments, `#f` otherwise.

Examples:

```
> (define c%
    (class object%
      (super-new)
      (define/public (m x [y 0])
        (+ x y))))
> (object-method-arity-includes? (new c%) 'm 1)
#t
> (object-method-arity-includes? (new c%) 'm 2)
#t
> (object-method-arity-includes? (new c%) 'm 3)
#f
> (object-method-arity-includes? (new c%) 'n 1)
#f
```

```
(field-names object) → (listof symbol?)
  object : object?
```

Returns a list of all of the names of the fields bound in *object*, including fields inherited from superinterfaces, but not including fields whose names are local (i.e., declared with `define-local-member-name`).

Examples:

```
> (field-names (new object%))
'()
> (field-names (new (class object% (super-
new) (field [x 0] [y 0]))))
'(x y)
```

```
(object-info object) → (or/c class? #f) boolean?
  object : object?
```

Returns two values, analogous to the return values of `struct-info`:

- *`class`*: a class or `#f`; the result is `#f` if the current inspector does not control any class for which the *`object`* is an instance.
- *`skipped?`*: `#f` if the first result corresponds to the most specific class of *`object`*, `#t` otherwise.

```
(class-info class)
 → symbol?
   exact-nonnegative-integer?
   (listof symbol?)
   (any/c exact-nonnegative-integer? . -> . any/c)
   (any/c exact-nonnegative-integer? any/c . -> . any/c)
   (or/c class? #f)
   boolean?
  class : class?
```

Returns seven values, analogous to the return values of `struct-type-info`:

- *`name`*: the class's name as a symbol;
- *`field-cnt`*: the number of fields (public and private) defined by the class;
- *`field-name-list`*: a list of symbols corresponding to the class's public fields; this list can be larger than *`field-cnt`* because it includes inherited fields;
- *`field-accessor`*: an accessor procedure for obtaining field values in instances of the class; the accessor takes an instance and a field index between `0` (inclusive) and *`field-cnt`* (exclusive);
- *`field-mutator`*: a mutator procedure for modifying field values in instances of the class; the mutator takes an instance, a field index between `0` (inclusive) and *`field-cnt`* (exclusive), and a new field value;

- *super-class*: a class for the most specific ancestor of the given class that is controlled by the current inspector, or `#f` if no ancestor is controlled by the current inspector;
- *skipped?*: `#f` if the sixth result is the most specific ancestor class, `#t` otherwise.

```
(struct exn:fail:object exn:fail ()
   #:extra-constructor-name make-exn:fail:object)
```

Raised for `class`-related failures, such as attempting to call a method that is not supplied by an object.

```
(class-seal class
            key
            unsealed-inits
            unsealed-fields
            unsealed-methods
            inst-proc
            member-proc)      → class?
  class : class?
  key : symbol?
  unsealed-inits : (listof symbol?)
  unsealed-fields : (listof symbol?)
  unsealed-methods : (listof symbol?)
  inst-proc : (-> class? any)
  member-proc : (-> class? (listof symbol?) any)
```

Adds a seal to a given class keyed with the symbol *key*. The given *unsealed-inits*, *unsealed-fields*, and *unsealed-methods* list corresponding class members that are unaffected by sealing.

When a class has any seals, the *inst-proc* procedure is called on instantiation (normally, this is used to raise an error on instantiation) and the *member-proc* function is called (again, this is normally used to raise an error) when a subclass attempts to add class members that are not listed in the unsealed lists.

The *inst-proc* is called with the class value on which an instantiation was attempted. The *member-proc* is called with the class value and the list of initialization argument, field, or method names.

```
(class-unseal class key wrong-key-proc) → class?
  class : class?
  key : symbol?
  wrong-key-proc : (-> class? any)
```

Removes a seal on a class that has been previously sealed with the `class-seal` function and the given *key*.

If the unseal removed all of the seals in the class, the class value can be instantiated or subclassed freely. If the given class value does not contain or any seals or does not contain any seals with the given key, the *wrong-key-proc* function is called with the class value.

6.12 Surrogates

```
(require racket/surrogate)        package: base
```

The bindings documented in this section are provided by the `racket/surrogate` library, not `racket/base` or `racket`.

The `racket/surrogate` library provides an abstraction for building an instance of the *proxy design pattern*. The pattern consists of two objects, a *host* and a *surrogate* object. The host object delegates method calls to its surrogate object. Each host has a dynamically assigned surrogate, so an object can completely change its behavior merely by changing the surrogate.

```
(surrogate use-wrapper-proc method-spec ...)

use-wrapper-proc = #:use-wrapper-proc
                 |

     method-spec = (augment default-expr method-id arg-spec ...)
                 | (override method-id arg-spec ...)

        arg-spec = (id ...)
                 | id
```

The `surrogate` form produces four values: a host mixin (a procedure that accepts and returns a class), a host interface, a surrogate class, and a surrogate interface.

If `#:use-wrapper-proc` does not appear, the host mixin adds a single private field to its argument. It also adds getter and setter methods `get-surrogate` and `set-surrogate` to get and set the value of the field. The `set-surrogate` method accepts instances of the class returned by the `surrogate` form or `#f`, and it updates the field with its argument; then, `set-surrogate` calls the `on-disable-surrogate` on the previous value of the field and `on-enable-surrogate` for the new value of the field. The `get-surrogate` method returns the current value of the field.

If `#:use-wrapper-proc` does appear, the host mixin adds a second private field and its getter and setter methods `get-surrogate-wrapper-proc` and `set-surrogate-wrapper-proc`. The additional field holds a wrapper procedure whose contract is `(-> (-> any) (-> any) any)`, so the procedure is invoked with two thunks. The first thunk is a fallback that invokes the original object's method, skipping the surrogate. The second thunk invokes the surrogate. The default wrapper procedure is

```
(λ (fallback-thunk surrogate-thunk)
```

```
  (surrogate-thunk))
```

That is, it simply defers to the method being invoked on the surrogate. Note that wrapper procedure can adjust the dynamic extent of calls to the surrogate by, for example, changing the values of parameters. The wrapper procedure is also invoked when calling the `on-disable-surrogate` and `on-enable-surrogate` methods of the surrogate.

The host mixin has a single overriding method for each *`method-id`* in the `surrogate` form (even the ones specified with `augment`). Each of these methods is defined with a `case-lambda` with one arm for each *`arg-spec`*. Each arm has the variables as arguments in the *`arg-spec`*. The body of each method tests the private surrogate field. If the field value is `#f`, the method just returns the result of invoking the super or inner method. If the field value is not `#f`, the corresponding method of the object in the field is invoked. This method receives the same arguments as the original method, plus two extras. The extra arguments come at the beginning of the argument list. The first is the original object. The second is a procedure that calls the super or inner method (i.e., the method of the class that is passed to the mixin or an extension, or the method in an overriding class), with the arguments that the procedure receives.

For example, the host-mixin for this surrogate:

```
(surrogate (override m (x y z)))
```

will override the `m` method and call the surrogate like this:

```
(define/override (m x y z)
  (if surrogate
      (send surrogate m
            this
            (λ (x y z) (super m x y z))
            x y z)
      (super m x y z)))
```

where *`surrogate`* is bound to the value most recently passed to the host mixin's `set-surrogate` method.

The host interface has the names `set-surrogate`, `get-surrogate`, and each of the *`method-id`*s in the original form.

The surrogate class has a single public method for each *`method-id`* in the `surrogate` form. These methods are invoked by classes constructed by the mixin. Each has a corresponding method signature, as described in the above paragraph. Each method just passes its argument along to the super procedure it receives.

In the example above, this is the *`m`* method in the surrogate class:

```
(define/public (m original-object original-super x y z)
  (original-super x y z))
```

If you derive a class from the surrogate class, do not both call the super argument and the super method of the surrogate class itself. Only call one or the other, since the default methods call the super argument.

Finally, the interface contains all of the names specified in surrogate's argument, plus on-enable-surrogate and on-disable-surrogate. The class returned by surrogate implements this interface.

7 Units

§14 "Units" in *The Racket Guide* introduces units.

Units organize a program into separately compilable and reusable components. The imports and exports of a unit are grouped into a *signature*, which can include "static" information (such as macros) in addition to placeholders for run-time values. Units with suitably matching signatures can be *linked* together to form a larger unit, and a unit with no imports can be *invoked* to execute its body.

```
(require racket/unit)       package: base
```

The bindings documented in this section are provided by the `racket/unit` and `racket` libraries, but not `racket/base`. The `racket/unit` module name can be used as a language name with `#lang`; see §7.10 "Single-Unit Modules".

7.1 Creating Units

```
(unit
  (import tagged-sig-spec ...)
  (export tagged-sig-spec ...)
  init-depends-decl
  unit-body-expr-or-defn
  ...)

  tagged-sig-spec = sig-spec
                  | (tag id sig-spec)

         sig-spec = sig-id
                  | (prefix id sig-spec)
                  | (rename sig-spec (id id) ...)
                  | (only sig-spec id ...)
                  | (except sig-spec id ...)

init-depends-decl =
                  | (init-depend tagged-sig-id ...)

    tagged-sig-id = sig-id
                  | (tag id sig-id)
```

Produces a unit that encapsulates its *unit-body-expr-or-defn*s. Expressions in the `unit` body can refer to identifiers bound by the *sig-spec*s of the `import` clause, and the body must include one definition for each identifier of a *sig-spec* in the `export` clause. An identifier that is exported cannot be `set!`ed in either the defining unit or importing units, although the implicit assignment to initialize the variable may be visible as a mutation.

Each import or export `sig-spec` ultimately refers to a `sig-id`, which is an identifier that is bound to a signature by `define-signature`. The lexical information of each identifier imported through a `sig-id` starts with the lexical information of the `sig-id`; see `define-signature` form more information.

In a specific import or export position, the set of identifiers bound or required by a particular `sig-id` can be adjusted in a few ways:

- `(prefix id sig-spec)` as an import binds the same as `sig-spec`, except that each binding is prefixed with `id`. As an export, this form causes definitions using the `id` prefix to satisfy the exports required by `sig-spec`.
- `(rename sig-spec (id id) ...)` as an import binds the same as `sig-spec`, except that the first `id` is used for the binding instead of the second `id` (where `sig-spec` by itself must imply a binding that is `bound-identifier=?` to second `id`). As an export, this form causes a definition for the first `id` to satisfy the export named by the second `id` in `sig-spec`.
- `(only sig-spec id ...)` as an import binds the same as `sig-spec`, but restricted to just the listed `id`s (where `sig-spec` by itself must imply a binding that is `bound-identifier=?` to each `id`). This form is not allowed for an export.
- `(except sig-spec id ...)` as an import binds the same as `sig-spec`, but excluding all listed `id`s (where `sig-spec` by itself must imply a binding that is `bound-identifier=?` to each `id`). This form is not allowed for an export.

As suggested by the grammar, these adjustments to a signature can be nested arbitrarily.

A unit's declared imports are matched with actual supplied imports by signature. That is, the order in which imports are supplied to a unit when linking is irrelevant; all that matters is the signature implemented by each supplied import. One actual import must be provided for each declared import. Similarly, when a unit implements multiple signatures, the order of the export signatures does not matter.

To support multiple imports or exports for the same signature, an import or export can be tagged using the form `(tag id sig-spec)`. When an import declaration of a unit is tagged, then one actual import must be given the same tag (with the same signature) when the unit is linked. Similarly, when an export declaration is tagged for a unit, then references to that particular export must explicitly use the tag.

A unit is prohibited syntactically from importing two signatures that are not distinct, unless they have different tags; two signatures are *distinct* only if they share no ancestor through `extends`. The same syntactic constraint applies to exported signatures. In addition, a unit is prohibited syntactically from importing the same identifier twice (after renaming and other transformations on a `sig-spec`), exporting the same identifier twice (again, after renaming), or exporting an identifier that is imported.

When units are linked, the bodies of the linked units are executed in an order that is specified at the linking site. An optional `(init-depend tagged-sig-id ...)` declaration constrains the allowed orders of linking by specifying that the current unit must be initialized after the unit that supplies the corresponding import. Each *tagged-sig-id* in an `init-depend` declaration must have a corresponding import in the `import` clause.

```
(define-signature sig-id extension-decl
  (sig-elem ...))

extension-decl =
               | extends sig-id

      sig-elem = id
               | (define-syntaxes (id ...) expr)
               | (define-values (id ...) expr)
               | (define-values-for-export (id ...) expr)
               | (contracted [id contract] ...)
               | (open sig-spec)
               | (struct id (field ...) struct-option ...)
               | (sig-form-id . datum)

         field = id
               | [id #:mutable]

 struct-option = #:mutable
               | #:constructor-name constructor-id
               | #:extra-constructor-name constructor-id
               | #:omit-constructor
               | #:omit-define-syntaxes
               | #:omit-define-values
```

Binds an identifier *sig-id* to a signature that specifies a group of bindings for import or export:

- Each *id* in a signature declaration means that a unit implementing the signature must supply a variable definition for the *id*. That is, *id* is available for use in units importing the signature, and *id* must be defined by units exporting the signature.
- Each `define-syntaxes` form in a signature declaration introduces a macro that is available for use in any unit that imports the signature. Free variables in the definition's *expr* refer to other identifiers in the signature first, or the context of the `define-signature` form if the signature does not include the identifier.
- Each `define-values` form in a signature declaration introduces code that effectively prefixes every unit that imports the signature. Free variables in the definition's *expr* are treated the same as for `define-syntaxes`.

- Each `define-values-for-export` form in a signature declaration introduces code that effectively suffixes every unit that exports the signature. Free variables in the definition's *expr* are treated the same as for `define-syntaxes`.
- Each `contracted` form in a signature declaration means that a unit exporting the signature must supply a variable definition for each *id* in that form. If the signature is imported, then uses of *id* inside the unit are protected by the appropriate contracts using the unit as the negative blame. If the signature is exported, then the exported values are protected by the appropriate contracts which use the unit as the positive blame, but internal uses of the exported identifiers are not protected. Variables in the *contract* expressions are treated the same as for `define-syntaxes`.
- Each `(open sig-spec)` adds to the signature everything specified by *sig-spec*.
- Each `(struct id (field ...) struct-option ...)` adds all of the identifiers that would be bound by the `struct` form, where the extra option `#:omit-constructor` omits the constructor identifier.
- Each `(sig-form-id . datum)` extends the signature in a way that is defined by *sig-form-id*, which must be bound by `define-signature-form`. One such binding is for `struct/ctc`.

When a `define-signature` form includes an `extends` clause, then the define signature automatically includes everything in the extended signature. Furthermore, any implementation of the new signature can be used as an implementation of the extended signature.

The lexical information of each *id* within a signature is compared to the lexical information of *sig-id*. The extra scopes of *id* relative to *sig-id* are recorded for the *id*. When the *sig-id* is used as a reference (e.g., in the `import` clause of `unit`), a variant of *id* is created for the referencing context by starting with the lexical information of the referencing *sig-id*, and then adding the extra scopes for *id*.

```
(open sig-spec)
```

Allowed only in a *sig-elem*; see `define-signature`.

```
(define-values-for-export (id ...) expr)
```

Allowed only in a *sig-elem*; see `define-signature`.

```
(contracted [id contract] ...)
```

Allowed only in a *sig-elem*; see `define-signature`.

```
(only sig-spec id ...)
```

Allowed only in a *sig-spec*; see `unit`.

```
(except sig-spec id ...)
```

Allowed only in a *sig-spec*; see `unit`.

```
(rename sig-spec (id id) ...)
```

Allowed only in a *sig-spec*; see `unit`.

```
(prefix id sig-spec)
```

Allowed only in a *sig-spec*; see `unit`.

```
(import tagged-sig-spec ...)
```

Allowed only in certain forms; see, for example, `unit`.

```
(export tagged-sig-spec ...)
```

Allowed only in certain forms; see, for example, `unit`.

```
(link linkage-decl ...)
```

Allowed only in certain forms; see, for example, `compound-unit`.

```
(tag id sig-spec)
(tag id sig-id)
```

Allowed only in certain forms; see, for example, `unit`.

```
(init-depend tagged-sig-id ...)
```

Allowed only in a *init-depend-decl*; see `unit`.

```
extends
```

Allowed only within `define-signature`.

7.2 Invoking Units

```
(invoke-unit unit-expr)
(invoke-unit unit-expr (import tagged-sig-spec ...))
```

Invokes the unit produced by `unit-expr`. For each of the unit's imports, the `invoke-unit` expression must contain a `tagged-sig-spec` in the `import` clause; see `unit` for the grammar of `tagged-sig-spec`. If the unit has no imports, the `import` clause can be omitted.

When no `tagged-sig-spec`s are provided, `unit-expr` must produce a unit that expects no imports. To invoke the unit, all bindings are first initialized to the `#<undefined>` value. Next, the unit's body definitions and expressions are evaluated in order; in the case of a definition, evaluation sets the value of the corresponding variable(s). Finally, the result of the last expression in the unit is the result of the `invoke-unit` expression.

Each supplied `tagged-sig-spec` takes bindings from the surrounding context and turns them into imports for the invoked unit. The unit need not declare an import for every provided `tagged-sig-spec`, but one `tagged-sig-spec` must be provided for each declared import of the unit. For each variable identifier in each provided `tagged-sig-spec`, the value of the identifier's binding in the surrounding context is used for the corresponding import in the invoked unit.

```
(define-values/invoke-unit unit-expr
  (import tagged-sig-spec ...)
  (export tagged-sig-spec ...)
  maybe-results-clause)

maybe-results-clause =
                     | (values result-id ...)
                     | (values result-id ... . rest-results-id)
```

Like `invoke-unit`, but the values of the unit's exports are copied to new bindings.

The unit produced by `unit-expr` is linked and invoked as for `invoke-unit`. In addition, the `export` clause is treated as a kind of import into the local definition context. That is, for every binding that would be available in a unit that used the `export` clause's `tagged-sig-spec` as an import, a definition is generated for the context of the `define-values/invoke-unit` form.

If no `maybe-results-clause` is provided, the unit body may return any number of values, all of which are ignored. Otherwise, the values returned from the unit body are bound to the given `result-id`s, in order. If no `rest-results-id` is provided, the body must return exactly as many values as there are `result-id`s, but if it is provided, the body may return arbitrarily many more, and `rest-results-id` is bound to a list containing the extra results.

Changed in version 8.8.0.7 of package `base`: Added `maybe-results-clause`.

7.3 Linking Units and Creating Compound Units

```
(compound-unit
  (import link-binding ...)
  (export tagged-link-id ...)
  (link linkage-decl ...))

  link-binding = (link-id : tagged-sig-id)

tagged-link-id = (tag id link-id)
               | link-id

  linkage-decl = ((link-binding ...) unit-expr tagged-link-id ...)
```

Links several units into one new compound unit without immediately invoking any of the linked units. The *unit-expr*s in the `link` clause determine the units to be linked in creating the compound unit. The *unit-expr*s are evaluated when the `compound-unit` form is evaluated.

The `import` clause determines the imports of the compound unit. Outside the compound unit, these imports behave as for a plain unit; inside the compound unit, they are propagated to some of the linked units. The `export` clause determines the exports of the compound unit. Again, outside the compound unit, these exports are treated the same as for a plain unit; inside the compound unit, they are drawn from the exports of the linked units. Finally, the left-hand and right-hand parts of each declaration in the `link` clause specify how the compound unit's imports and exports are propagated to the linked units.

Individual elements of an imported or exported signature are not available within the compound unit. Instead, imports and exports are connected at the level of whole signatures. Each specific import or export (i.e., an instance of some signature, possibly tagged) is given a *link-id* name. Specifically, a *link-id* is bound by the `import` clause or the left-hand part of a declaration in the `link` clause. A bound *link-id* is referenced in the right-hand part of a declaration in the `link` clause or by the `export` clause.

The left-hand side of a `link` declaration gives names to each expected export of the unit produced by the corresponding *unit-expr*. The actual unit may export additional signatures, and it may export an extension of a specific signature instead of just the specified one. If the unit does not export one of the specified signatures (with the specified tag, if any), the `exn:fail:contract` exception is raised when the `compound-unit` form is evaluated.

The right-hand side of a `link` declaration specifies the imports to be supplied to the unit produced by the corresponding *unit-expr*. The actual unit may import fewer signatures, and it may import a signature that is extended by the specified one. If the unit imports a signature (with a particular tag) that is not included in the supplied imports, the `exn:fail:contract` exception is raised when the `compound-unit` form is evaluated. Each *link-id* supplied as an import must be bound either in the `import` clause or in some declaration within the `link` clause.

The order of declarations in the `link` clause determines the order of invocation of the linked units. When the compound unit is invoked, the unit produced by the first *`unit-expr`* is invoked first, then the second, and so on. If the order specified in the `link` clause is inconsistent with `init-depend` declarations of the actual units, then the `exn:fail:contract` exception is raised when the `compound-unit` form is evaluated.

7.4 Inferred Linking

```
(define-unit unit-id
  (import tagged-sig-spec ...)
  (export tagged-sig-spec ...)
  init-depends-decl
  unit-body-expr-or-defn
  ...)
```

Binds *`unit-id`* to both a unit and static information about the unit.

Evaluating a reference to a *`unit-id`* bound by `define-unit` produces a unit, just like evaluating an *`id`* bound by `(define id (unit ...))`. In addition, however, *`unit-id`* can be used in `compound-unit/infer`. See `unit` for information on *`tagged-sig-spec`*, *`init-depends-decl`*, and *`unit-body-expr-or-defn`*.

```
(compound-unit/infer
  (import tagged-infer-link-import ...)
  (export tagged-infer-link-export ...)
  (link infer-linkage-decl ...))

tagged-infer-link-import = tagged-sig-id
                         | (link-id : tagged-sig-id)

tagged-infer-link-export = (tag id infer-link-export)
                         | infer-link-export

       infer-link-export = link-id
                         | sig-id

       infer-linkage-decl = ((link-binding ...) unit-id
                                             tagged-link-id ...)
                          | unit-id
```

Like `compound-unit`. Syntactically, the difference between `compound-unit` and `compound-unit/infer` is that the *`unit-expr`* for a linked unit is replaced with a *`unit-id`*, where a *`unit-id`* is bound by `define-unit` (or one of the other unit-binding forms that we introduce later in this section). Furthermore, an import can name just a *sig-id* without locally binding a *link-id*, and an export can be based on a *sig-id* instead of a *link-id*, and a declaration in the `link` clause can be simply a *unit-id* with no specified exports or imports.

The `compound-unit/infer` form expands to `compound-unit` by adding *sig-id*s as needed to the `import` clause, by replacing *sig-id*s in the `export` clause by *link-id*s, and by completing the declarations of the `link` clause. This completion is based on static information associated with each *unit-id*. Links and exports can be inferred when all signatures exported by the linked units are distinct from each other and from all imported signatures, and when all imported signatures are distinct. Two signatures are *distinct* only if they share no ancestor through `extends`.

The long form of a `link` declaration can be used to resolve ambiguity by giving names to some of a unit's exports and supplying specific bindings for some of a unit's imports. The long form need not name all of a unit's exports or supply all of a unit's imports if the remaining parts can be inferred.

When a unit declares initialization dependencies, `compound-unit/infer` checks that the `link` declaration is consistent with those dependencies, and it reports a syntax error if not.

Like `compound-unit`, the `compound-unit/infer` form produces a (compound) unit without statically binding information about the result unit's imports and exports. That is, `compound-unit/infer` consumes static information, but it does not generate it. Two additional forms, `define-compound-unit` and `define-compound-unit/infer`, generate static information (where the former does not consume static information).

Changed in version 6.1.1.8 of package `base`: Added static checking of the `link` clause with respect to declared initialization dependencies.

```
(define-compound-unit id
  (import link-binding ...)
  (export tagged-link-id ...)
  (link linkage-decl ...))
```

Like `compound-unit`, but binds static information about the compound unit like `define-unit`, including the propagation of initialization-dependency information (on remaining imports) from the linked units.

```
(define-compound-unit/infer id
  (import link-binding ...)
  (export tagged-infer-link-export ...)
  (link infer-linkage-decl ...))
```

Like `compound-unit/infer`, but binds static information about the compound unit like `define-compound-unit`.

```
(define-unit-binding unit-id
  unit-expr
  (import tagged-sig-spec ...+)
  (export tagged-sig-spec ...+)
  init-depends-decl)
```

Like `define-unit`, but the unit implementation is determined from an existing unit produced by *unit-expr*. The imports and exports of the unit produced by *unit-expr* must be consistent with the declared imports and exports, otherwise the `exn:fail:contract` exception is raised when the `define-unit-binding` form is evaluated.

```
(invoke-unit/infer unit-spec)

unit-spec = unit-id
          | (link link-unit-id ...)
```

Like `invoke-unit`, but uses static information associated with *unit-id* to infer which imports must be assembled from the current context. If given a link form containing multiple *link-unit-id*s, then the units are first linked via `define-compound-unit/infer`.

When assembling imports from the current context, the lexical information of a *unit-id* is used for constructing the lexical information of the signatures for the unit's imports (i.e., the lexical information that would normally be derived from the signature reference). See `define-signature` for more information.

```
(define-values/invoke-unit/infer
  unit-spec
  maybe-exports
  maybe-results-clause)
(define-values/invoke-unit/infer
  (export tagged-sig-spec ...)
  unit-spec)

           unit-spec = unit-id
                     | (link link-unit-id ...)

       maybe-exports =
                     | (export tagged-sig-spec ...)

maybe-results-clause =
                     | (values result-id ...)
                     | (values result-id ... . rest-results-id)
```

Like `define-values/invoke-unit`, but uses static information associated with *unit-id* to infer which imports must be assembled from the current context and, if no `export` clause is present, which exports should be bound by the definition. If given a link form containing multiple *link-unit-id*s, then the units are first linked via `define-compound-unit/infer`.

Similar to `invoke-unit/infer`, the lexical information of a *unit-id* is used for constructing the lexical information of the signatures for the unit's inferred imports and inferred exports (i.e., the lexical information that would normally be derived from a signature reference). See `define-signature` for more information.

If *maybe-results-clause* is provided, the values returned by the unit body are bound in the same way as `define-values/invoke-unit`.

For backwards compatibility, an `export` clause is allowed to appear before *unit-spec* (in which case no *maybe-results-clause* may be provided). New programs should provide *unit-spec* first (which is consistent with `define-values/invoke-unit`).

Changed in version 8.8.0.7 of package `base`: Allowed *unit-spec* to appear before *maybe-exports* for consistency with `define-values/invoke-unit` and added *maybe-results-clause*.

7.5 Generating A Unit from Context

```
(unit-from-context tagged-sig-spec)
```

Creates a unit that implements an interface using bindings in the enclosing environment. The generated unit is essentially the same as

```
(unit
  (import)
  (export tagged-sig-spec)
  (define id expr) ...)
```

for each *id* that must be defined to satisfy the exports, and each corresponding *expr* produces the value of *id* in the environment of the `unit-from-context` expression. (The unit cannot be written as above, however, since each *id* definition within the unit shadows the binding outside the `unit` form.)

See `unit` for the grammar of *tagged-sig-spec*.

```
(define-unit-from-context id tagged-sig-spec)
```

Like `unit-from-context`, in that a unit is constructed from the enclosing environment, and like `define-unit`, in that *id* is bound to static information to be used later with inference.

7.6 Structural Matching

```
(unit/new-import-export
  (import tagged-sig-spec ...)
  (export tagged-sig-spec ...)
  init-depends-decl
  ((tagged-sig-spec ...) unit-expr tagged-sig-spec))
```

Similar to `unit`, except the body of the unit is determined by an existing unit produced by *`unit-expr`*. The result is a unit whose implementation is *`unit-expr`*, but whose imports, exports, and initialization dependencies are as in the `unit/new-import-export` form (instead of as in the unit produced by *`unit-expr`*).

The final clause of the `unit/new-import-export` form determines the connection between the old and new imports and exports. The connection is similar to the way that `compound-unit` propagates imports and exports; the difference is that the connection between `import` and the right-hand side of the link clause is based on the names of elements in signatures, rather than the names of the signatures. That is, a *`tagged-sig-spec`* on the right-hand side of the link clause need not appear as a *`tagged-sig-spec`* in the `import` clause, but each of the bindings implied by the linking *`tagged-sig-spec`* must be implied by some *`tagged-sig-spec`* in the `import` clause. Similarly, each of the bindings implied by an `export` *`tagged-sig-spec`* must be implied by some left-hand-side *`tagged-sig-spec`* in the linking clause.

```
(define-unit/new-import-export unit-id
  (import tagged-sig-spec ...)
  (export tagged-sig-spec ...)
  init-depends-decl
  ((tagged-sig-spec ...) unit-expr tagged-sig-spec))
```

Like `unit/new-import-export`, but binds static information to *`unit-id`* like `define-unit`.

```
(unit/s
  (import tagged-sig-spec ...)
  (export tagged-sig-spec ...)
  init-depends-decl
  unit-id)
```

Like `unit/new-import-export`, but the linking clause is inferred, so *`unit-id`* must have the appropriate static information.

```
(define-unit/s name-id
  (import tagged-sig-spec ...)
  (export tagged-sig-spec ...)
  init-depends-decl
  unit-id)
```

Like unit/s, but binds static information to *name-id* like define-unit.

7.7 Extending the Syntax of Signatures

```
(define-signature-form sig-form-id expr)
(define-signature-form (sig-form-id id) body ...+)
(define-signature-form (sig-form-id id intro-id) body ...+)
```

Binds *sig-form-id* for use within a define-signature form.

In the first form, the result of *expr* must be a transformer procedure that accepts one argument. In the second form, *sig-form-id* is bound to a transformer procedure whose argument is *id* and whose body is the *body*s. The third form is like the second one, but *intro-id* is bound to a procedure that is analogous to syntax-local-introduce for the signature-form expansion.

The result of the transformer procedure must be a list of syntax objects, which are substituted for a use of *sig-form-id* in a define-signature expansion. (The result is a list so that the transformer can produce multiple declarations; define-signature has no splicing begin form.)

Changed in version 8.1.0.7 of package base: Added support for the form with a transformer *expr*.

```
(struct/ctc id ([field contract-expr] ...) struct-option ...)

        field = id
              | [id #:mutable]

struct-option = #:mutable
              | #:omit-constructor
              | #:omit-define-syntaxes
              | #:omit-define-values
```

For use with define-signature. The struct/ctc form works similarly to struct, but the constructor, predicate, field accessors, and field mutators are contracted appropriately.

7.8 Unit Utilities

```
(unit? v) → boolean?
  v : any/c
```

Returns #t if *v* is a unit, #f otherwise.

```
(provide-signature-elements sig-spec ...)
```

Expands to a provide of all identifiers implied by the *sig-spec*s. See unit for the grammar of *sig-spec*.

7.9 Unit Contracts

```
(unit/c
  (import sig-spec-block ...)
  (export sig-spec-block ...)
  init-depends-decl
  optional-body-ctc)

   sig-spec-block = (tagged-sig-spec [id contract] ...)
                  | tagged-sig-spec

init-depends-decl =
                  | (init-depend tagged-sig-id ...)

optional-body-ctc =
                  | contract
                  | (values contract ...)
```

A *unit contract* wraps a unit and checks both its imported and exported identifiers to ensure that they match the appropriate contracts. This allows the programmer to add contract checks to a single unit value without adding contracts to the imported and exported signatures.

The unit value must import a subset of the import signatures and export a superset of the export signatures listed in the unit contract. Additionally, the unit value must declare initialization dependencies that are a subset of those specified in the unit contract. Any identifier which is not listed for a given signature is left alone. Variables used in a given *contract* expression first refer to other variables in any of the listed signatures, and then to the context of the unit/c expression. If a body contract is specified then the result of invoking the unit value is wrapped with the given contract, otherwise the values are returned as-is.

Changed in version 8.8.0.7 of package base: Changed *sig-spec-block* to allow arbitrary *tagged-sig-spec*s instead of only allowing *tagged-sig-id*s. Made bindings from *all* signatures visible in the scope of each *contract* expression instead of only the bindings from the same signature. Additionally, contracts on signature bindings are enforced within *contract* expressions.

```
(define-unit/contract unit-id
  (import sig-spec-block ...)
  (export sig-spec-block ...)
  init-depends-decl
  optional-body-ctc
  unit-body-expr-or-defn
  ...)

   sig-spec-block = (tagged-sig-spec [id contract] ...)
                  | tagged-sig-spec

optional-body-ctc =
                  | #:invoke/contract contract
                  | #:invoke/contract (values contract ...)
```

The `define-unit/contract` form defines a unit compatible with link inference whose imports and exports are contracted with a unit contract. The unit name is used for the positive blame of the contract.

Changed in version 8.8.0.7 of package `base`: Made bindings from *all* signatures visible in the scope of each `contract` expression instead of only the bindings from the same signature. Additionally, contracts on signature bindings are enforced within `contract` expressions.

7.10 Single-Unit Modules

As a language name with `#lang`, `racket/unit` provides all bindings of `racket/unit` and `racket/base` except for `%#module-begin`, and the `racket/unit` module body is treated as a unit body. The body must match the following *`module-body`* grammar:

```
  module-body = require-decl ...
                (import tagged-sig-expr ...)
                (export tagged-sig-expr ...)
                init-depends-decl
                unit-body-expr-or-defn
                ...

 require-decl = (require require-spec ...)
              | (begin require-decl ...)
              | derived-require-form
```

After any number of *`require-decl`*s, the content of the module is the same as a `unit` body with access to `racket/base`.

The resulting unit is exported as *`base@`*, where *`base`* is derived from the enclosing module's name (i.e., its symbolic name, or its path without the directory and file suffix). If the module name ends in -unit, then *base* corresponds to the module name before -unit. Otherwise, the module name serves as *base*.

7.11 Single-Signature Modules

```
#lang racket/signature
```
package: base

The racket/signature language treats a module body as a unit signature in the same way that racket/unit treats a module body as unit body: it provides all bindings of racket/signature and racket/base except for %#module-begin.

The body must match the following *module-body* grammar:

```
module-body = (require require-spec ...) ... sig-elem ...
```

See define-signature for the grammar of *sig-elem*. Unlike the body of a racket/unit module, a require in a racket/signature module must be a literal use of require.

The resulting signature is exported as *base*^, where *base* is derived from the enclosing module's name (i.e., its symbolic name, or its path without the directory and file suffix). If the module name ends in -sig, then *base* corresponds to the module name before -sig. Otherwise, the module name serves as *base*.

A struct form as a *sig-elem* is consistent with the definitions introduced by define-struct, as opposed to definitions introduced by struct. (That behavior was originally a bug, but it is preserved for compatibility.)

7.12 Transformer Helpers

```
(require racket/unit-exptime)
```
package: base

The racket/unit-exptime library provides procedures that are intended for use by macro transformers. In particular, the library is typically imported using for-syntax into a module that defines macro with define-syntax.

```
(unit-static-signatures unit-identifier
                        err-syntax)
 → (list/c (cons/c (or/c symbol? #f)
                   identifier?))
   (list/c (cons/c (or/c symbol? #f)
                   identifier?))
  unit-identifier : identifier?
  err-syntax : syntax?
```

If *unit-identifier* is bound to static unit information via `define-unit` (or other such forms), the result is two values. The first value is for the unit's imports, and the second is for the unit's exports. Each result value is a list, where each list element pairs a symbol or `#f` with an identifier. The symbol or `#f` indicates the import's or export's tag (where `#f` indicates no tag), and the identifier indicates the binding of the corresponding signature.

If *unit-identifier* is not bound to static unit information, then the `exn:fail:syntax` exception is raised. In that case, the given *err-syntax* argument is used as the source of the error, where *unit-identifier* is used as the detail source location.

```
(signature-members sig-identifier
                   err-syntax)    → (or/c identifier? #f)
                                    (listof identifier?)
                                    (listof identifier?)
                                    (listof identifier?)
  sig-identifier : identifier?
  err-syntax : syntax?
```

If *sig-identifier* is bound to static unit information via `define-signature` (or other such forms), the result is four values:

- an identifier or `#f` indicating the signature (of any) that is extended by the *sig-identifier* binding;
- a list of identifiers representing the variables supplied/required by the signature;
- a list of identifiers for variable definitions in the signature (i.e., variable bindings that are provided on import, but not defined by units that implement the signature); and
- a list of identifiers with syntax definitions in the signature.

Each of the result identifiers is given lexical information that is based on *sig-identifier*, so the names are suitable for reference or binding in the context of *sig-identifier*. See `define-signature` for more information.

If *sig-identifier* is not bound to a signature, then the `exn:fail:syntax` exception is raised. In that case, the given *err-syntax* argument is used as the source of the error, where *sig-identifier* is used as the detail source location.

```
(unit-static-init-dependencies unit-identifier
                               err-syntax)
 → (list/c (cons/c (or/c symbol? #f)
                   identifier?))
  unit-identifier : identifier?
  err-syntax : syntax?
```

If *unit-identifier* is bound to static unit information via define-unit (or other such forms), the result is a list of pairs. Each pair combines a tag (or #f for no tag) and a signature name, indicating an initialization dependency of the unit on the specified import (i.e., the same tag and signature are included in the first result from unit-static-signatures).

If *unit-identifier* is not bound to static unit information, then the exn:fail:syntax exception is raised. In that case, the given *err-syntax* argument is used as the source of the error, where *unit-identifier* is used as the detail source location.

Added in version 6.1.1.8 of package base.

8 Contracts

§7 "Contracts" in *The Racket Guide* introduces contracts.

The contract system guards one part of a program from another. Programmers specify the behavior of a module's exports via `(provide (contract-out ....))` or `(require (contract-in ...))`, and the contract system enforces those constraints.

```
(require racket/contract)        package: base
```

The bindings documented in this section are provided by the `racket/contract` and `racket` libraries, but not `racket/base`.

Contracts come in two forms: those constructed by the various operations listed in this section of the manual, and various ordinary Racket values that double as contracts, including

- symbols, booleans, keywords, and `null`, which are treated as contracts that recognize themselves, using `eq?`,
- strings, byte strings, characters, `+nan.0`, and `+nan.f`, which are treated as contracts that recognize themselves using `equal?`,
- numbers (except `+nan.0` and `+nan.f`), which are treated as contracts that recognize themselves using `=`,
- regular expressions, which are treated as contracts that recognize byte strings and strings that match the regular expression, and
- predicates: any procedure of arity 1 is treated as a predicate. During contract checking, it is applied to the values that appear and should return `#f` to indicate that the contract failed, and anything else to indicate it passed.

Contract combinators are functions such as `->` and `listof` that take contracts and produce other contracts.

Contracts in Racket are subdivided into three different categories:

- *Flat contracts* can be fully checked immediately for a given value. These kinds of contracts are essentially predicate functions. Using `flat-contract-predicate`, you can extract the predicate from an arbitrary flat contract; some flat contracts can be applied like functions, in which case they accept a single argument and return `#t` or `#f` to indicate if the given value would be accepted by the contract. All of the flat contracts returned by functions in this library can be used directly as predicates, but ordinary Racket values that double as flat contracts (e.g., numbers or symbols) cannot.

  The function `flat-contract?` recognizes a flat contract.

- *Chaperone contracts* may wrap a value in such a way that it signals contract violations later, as the value is used, but are guaranteed to not otherwise change behavior. For example, a function contract wraps a function value and later checks inputs and outputs; any properties that the function value had before being wrapped by the contract are preserved by the contract wrapper.

  All flat contracts may be used where chaperone contracts are expected (but not vice-versa). The function `chaperone-contract?` recognizes a chaperone contract.

- *Impersonator contracts* may wrap values and do not provide any guarantees. Impersonator contracts may hide properties of values, or even make them completely opaque (e.g, `new-∀/c`).

  All contracts may be used where impersonator contracts are expected. The function `impersonator-contract?` recognizes an impersonator contract.

For more about this hierarchy, see the section "§14.5 "Impersonators and Chaperones"" as well as a research paper [Strickland12] on chaperones, impersonators, and how they can be used to implement contracts.

Changed in version 6.1.1.8 of package `base`: Changed `+nan.0` and `+nan.f` to be `equal?`-based contracts.

8.1 Data-structure Contracts

```
(flat-contract-with-explanation  get-explanation
                                [#:name name])
 → flat-contract?
  get-explanation : (-> any/c (or/c boolean? (-> blame? any)))
  name : any/c = (object-name get-explanation)
```

Provides a way to use flat contracts that, when a contract fails, provide more information about the failure.

If *get-explanation* returns a boolean, then that boolean value is treated as the predicate in a flat contract. If it returns a procedure, then it is treated similarly to returning `#f`, except the result procedure is called to actually signal the contract violation.

The *name* argument is used as the name of the contract; it defaults to the name of the *get-explanation* function.

```
(flat-contract-with-explanation
 (λ (val)
   (cond
     [(even? val) #t]
     [else
      (λ (blame)
```

```
        (define more-information ...do-some-complex-computation-
here...)
        (raise-blame-error blame val
                           '(expected: "an even num-
ber" given: "~e"
                                        "and, here is more help:
~s")
                           val more-information))])))
```

```
(flat-named-contract name
                     flat-contract
                    [generator])  → flat-contract?
  name : any/c
  flat-contract : flat-contract?
  generator : (or/c #f (-> exact-nonnegative-integer? (-> any/c)))
            = #f
```

Produces a flat contract like *flat-contract*, but with the name *name*.

For example,

```
(define/contract i
  (flat-named-contract
   'odd-integer
   (lambda (x) (and (integer? x) (odd? x))))
  2)
```

The generator argument adds a generator for the flat-named-contract. See contract-random-generate for more information.

```
any/c : flat-contract?
```

A flat contract that accepts any value.

When using this contract as the result portion of a function contract, consider using any instead; using any leads to better memory performance, but it also allows multiple results.

```
none/c : flat-contract?
```

A flat contract that accepts no values.

```
(or/c contract ...) → contract?
  contract : contract?
```

Takes any number of contracts and returns a contract that accepts any value that any one of the contracts accepts individually.

The `or/c` result tests any value by applying the contracts in order, from left to right, with the exception that it always moves the non-flat contracts (if any) to the end, checking them last. Thus, a contract such as `(or/c (not/c real?) positive?)` is guaranteed to only invoke the `positive?` predicate on real numbers.

If all of the arguments are procedures or flat contracts, the result is a flat contract. If only one of the arguments is a higher-order contract, the result is a contract that just checks the flat contracts and, if they don't pass, applies the higher-order contract.

If there are multiple higher-order contracts, `or/c` uses `contract-first-order-passes?` to distinguish between them. More precisely, when an `or/c` is checked, it first checks all of the flat contracts. If none of them pass, it calls `contract-first-order-passes?` with each of the higher-order contracts. If only one returns true, `or/c` uses that contract. If none of them return true, it signals a contract violation. If more than one returns true, it also signals a contract violation. For example, this contract

```
(or/c (-> number? number?)
      (-> string? string? string?))
```

does not accept a function like this one: `(lambda args ...)` since it cannot tell which of the two arrow contracts should be used with the function.

If all of its arguments are `list-contract?`s, then `or/c` returns a `list-contract?`.

```
(first-or/c contract ...) → contract?
  contract : contract?
```

Takes any number of contracts and returns a contract that accepts any value that any one of the contracts accepts individually.

The `first-or/c` result tests any value by applying the contracts in order from left to right. Thus, a contract such as `(first-or/c (not/c real?) positive?)` is guaranteed to only invoke the `positive?` predicate on real numbers.

If all of the arguments are procedures or flat contracts, the result is a flat contract and similarly if all of the arguments are chaperone contracts the result is too. Otherwise, the result is an impersonator contract.

If there are multiple higher-order contracts, `first-or/c` uses `contract-first-order-passes?` to distinguish between them. More precisely, when an `first-or/c` is checked, it checks the first order passes of the first contract against the value. If it succeeds, then it uses only that contract. If it fails, then it moves to the second contract, continuing until it finds one of the contracts where the first order check succeeds. If none of them do, a contract violation is signaled.

For example, this contract

```
(first-or/c (-> number? number?)
        (-> string? string? string?))
```

accepts the function `(λ args 0)`, applying the `(-> number? number?)` contract to the function because it comes first, even though `(-> string? string? string?)` also applies.

If all of its arguments are `list-contract?`s, then `first-or/c` returns a `list-contract?`.

```
(and/c contract ...) → contract?
  contract : contract?
```

Takes any number of contracts and returns a contract that accepts any value that satisfies all of the contracts simultaneously.

If all of the arguments are procedures or flat contracts, the result is a flat contract.

The contract produced by `and/c` tests any value by applying the contracts in order, from left to right.

This means that `and/c` can be used to guard predicates that are not total in contracts. For example, this contract is well-behaved, correctly blaming the definition of `whoops-not-a-number` for not being a number:

Example:

```
> (define/contract whoops-not-a-number
    (and/c real? even?)
    "four")
whoops-not-a-number: broke its own contract
  promised: real?
  produced: "four"
  in: an and/c case of
      (and/c real? even?)
  contract from:
      (definition whoops-not-a-number)
  blaming: (definition whoops-not-a-number)
   (assuming the contract is correct)
  at: eval:2:0
```

but if the arguments to `and/c` are reversed, then the contract itself raises an error:

Example:

```
> (define/contract whoops-not-a-number
    (and/c even? real?)
    "four")
even?: contract violation
  expected: integer?
  given: "four"
```

If more than one of the contracts are not flat contracts, then the order in which the higher-order parts of the contract are tested can be counter-intuitive. As an example, consider this function that uses and/c in a higher-order manner with contracts that always succeed, but that print when they are called, in order for us to see the order in which they are called.

Examples:

```
> (define ((show-me n) x)
    (printf "show-me ~a\n" n)
    #t)
> (define/contract identity-with-complex-printing-contract
    (and/c (-> (show-me 4) (show-me 5))
           (-> (show-me 3) (show-me 6))
           (-> (show-me 2) (show-me 7))
           (-> (show-me 1) (show-me 8)))
    (λ (x) x))
> (identity-with-complex-printing-contract 101)
show-me 1
show-me 2
show-me 3
show-me 4
show-me 5
show-me 6
show-me 7
show-me 8
101
```

The checking order is just like the usual ordering when a contract is double-wrapped. The contract that is first put on has its domain checked second but its range checked first and we see a similar pattern here in this example, because and/c simply applies the contracts in order.

```
(not/c flat-contract) → flat-contract?
  flat-contract : flat-contract?
```

Accepts a flat contract or a predicate and returns a flat contract that checks the inverse of the argument.

```
(=/c z) → flat-contract?
  z : real?
```

Returns a flat contract that requires the input to be a number and `=` to *z*.

```
(</c n) → flat-contract?
  n : real?
```

Returns a flat contract that requires the input to be a number and `<` than *n*.

```
(>/c n) → flat-contract?
  n : real?
```

Like `</c`, but for `>`.

```
(<=/c n) → flat-contract?
  n : real?
```

Like `</c`, but for `<=`.

```
(>=/c n) → flat-contract?
  n : real?
```

Like `</c`, but for `>=`.

```
(between/c n m) → flat-contract?
  n : real?
  m : real?
```

Returns a flat contract that requires the input to be a real number between *n* and *m* or equal to one of them.

```
(real-in n m) → flat-contract?
  n : real?
  m : real?
```

An alias for `between/c`.

```
(integer-in j k) → flat-contract?
  j : (or/c exact-integer? #f)
  k : (or/c exact-integer? #f)
```

Returns a flat contract that requires the input to be an exact integer between *j* and *k*, inclusive. If either *j* or *k* is `#f`, then the range is unbounded on that end.

Examples:

```
> (define/contract two-digit-number
    (integer-in 10 99)
    23)
> (define/contract not-a-two-digit-number
    (integer-in 10 99)
    124)
not-a-two-digit-number: broke its own contract
  promised: (integer-in 10 99)
  produced: 124
  in: (integer-in 10 99)
  contract from:
      (definition not-a-two-digit-number)
  blaming: (definition not-a-two-digit-number)
   (assuming the contract is correct)
  at: eval:3:0
> (define/contract negative-number
    (integer-in #f -1)
    -4)
> (define/contract not-a-negative-number
    (integer-in #f -1)
    4)
not-a-negative-number: broke its own contract
  promised: (integer-in #f -1)
  produced: 4
  in: (integer-in #f -1)
  contract from:
      (definition not-a-negative-number)
  blaming: (definition not-a-negative-number)
   (assuming the contract is correct)
  at: eval:5:0
```

Changed in version 6.8.0.2 of package `base`: Allow *j* and *k* to be `#f`

```
(complex/c real imag) → flat-contract?
  real : flat-contract?
  imag : flat-contract?
```

Returns a flat contract that accepts complex numbers whose real parts match *real* and whose imaginary parts match *imag*.

Examples:

```
> (define/contract can-be-converted-to-exact
    (complex/c rational? rational?)
    +inf.0)
can-be-converted-to-exact: broke its own contract
```

```
promised: a complex number with
real part: rational?
imaginary part: rational?
produced: +inf.0
in: (complex/c rational? rational?)
contract from:
      (definition can-be-converted-to-exact)
blaming: (definition can-be-converted-to-exact)
 (assuming the contract is correct)
at: eval:2:0
> (define/contract complex-integer
    (complex/c integer? integer?)
   1+2i)
```

Added in version 8.11.1.10 of package `base`.

```
(char-in a b) → flat-contract?
  a : char?
  b : char?
```

Returns a flat contract that requires the input to be a character whose code point number is between the code point numbers of `a` and `b`, inclusive.

```
natural-number/c : flat-contract?
```

A flat contract that requires the input to be an exact non-negative integer.

```
(string-len/c len) → flat-contract?
  len : real?
```

Returns a flat contract that recognizes strings that have fewer than `len` characters.

```
false/c : flat-contract?
```

An alias for `#f` for backwards compatibility.

```
printable/c : flat-contract?
```

A flat contract that recognizes values that can be written out and read back in with `write` and `read`.

```
(one-of/c v ...+) → flat-contract?
  v : any/c
```

Accepts any number of atomic values and returns a flat contract that recognizes those values, using `eqv?` as the comparison predicate. For the purposes of `one-of/c`, atomic values are defined to be: characters, symbols, booleans, `null`, keywords, numbers, `#<void>`, and `#<undefined>`.

This is a backwards compatibility contract constructor. If neither `#<void>` nor `#<undefined>` are arguments, it simply passes its arguments to `or/c`.

```
(symbols sym ...+) → flat-contract?
  sym : symbol?
```

Accepts any number of symbols and returns a flat contract that recognizes those symbols.

This is a backwards compatibility constructor; it merely passes its arguments to `or/c`.

```
(vectorof  c
          [#:immutable immutable
           #:flat? flat?
           #:eager eager])       → contract?
  c : contract?
  immutable : (or/c #t #f 'dont-care) = 'dont-care
  flat? : boolean? = #f
  eager : (or/c #t #f exact-nonnegative-integer?) = #t
```

Returns a contract that recognizes vectors. The elements of the vector must match *c*.

If the *flat?* argument is `#t`, then the resulting contract is a flat contract, and the *c* argument must also be a flat contract. Such flat contracts will be unsound if applied to mutable vectors, as they will not check future operations on the vector.

If the *immutable* argument is `#t` and the *c* argument is a flat contract and the *eager* argument is `#t`, the result will be a flat contract. If the *c* argument is a chaperone contract, then the result will be a chaperone contract.

If the *eager* argument is `#t`, then immutable vectors are checked eagerly when *c* is a flat contract. If the *eager* argument is a number `n`, then immutable vectors are checked eagerly when *c* is a flat contract and the length of the vector is less than or equal to `n`.

When a higher-order `vectorof` contract is applied to a vector, the result is not `eq?` to the input. The result will be a copy for immutable vectors and a chaperone or impersonator of the input for mutable vectors, unless the *c* argument is a flat contract and the vector is immutable, in which case the result is the original vector.

Changed in version 6.3.0.5 of package `base`: Changed flat vector contracts to not copy immutable vectors.
Changed in version 6.7.0.3: Added the `#:eager` option.

```
(vector-immutableof c) → contract?
  c : contract?
```

Returns the same contract as `(vectorof c #:immutable #t)`. This form exists for backwards compatibility.

```
(vector/c  c
           ...
          [#:immutable immutable
           #:flat? flat?])        → contract?
  c : contract?
  immutable : (or/c #t #f 'dont-care) = 'dont-care
  flat? : boolean? = #f
```

Returns a contract that recognizes vectors whose lengths match the number of contracts given. Each element of the vector must match its corresponding contract.

If the `flat?` argument is `#t`, then the resulting contract is a flat contract, and the `c` arguments must also be flat contracts. Such flat contracts will be unsound if applied to mutable vectors, as they will not check future operations on the vector.

If the `immutable` argument is `#t` and the `c` arguments are flat contracts, the result will be a flat contract. If the `c` arguments are chaperone contracts, then the result will be a chaperone contract.

When a higher-order `vector/c` contract is applied to a vector, the result is not `eq?` to the input. The result will be a copy for immutable vectors and a chaperone or impersonator of the input for mutable vectors.

```
(vector-immutable/c c ...) → contract?
  c : contract?
```

Returns the same contract as `(vector/c c ... #:immutable #t)`. This form exists for reasons of backwards compatibility.

```
(box/c  in-c
       [c
        #:immutable immutable
        #:flat? flat?])        → contract?
  in-c : contract?
  c : contract? = in-c
  immutable : (or/c #t #f 'dont-care) = 'dont-care
  flat? : boolean? = #f
```

Returns a contract that recognizes boxes. The content of the box must match `c`, and mutations on mutable boxes must match `in-c`.

If the `flat?` argument is `#t`, then the resulting contract is a flat contract, and the `out` argument must also be a flat contract. Such flat contracts will be unsound if applied to mutable boxes, as they will not check future operations on the box.

If the *immutable* argument is #t and the *c* argument is a flat contract, the result will be a flat contract. If the *c* argument is a chaperone contract, then the result will be a chaperone contract.

When a higher-order box/c contract is applied to a box, the result is not eq? to the input. The result will be a copy for immutable boxes and either a chaperone or impersonator of the input for mutable boxes.

```
(box-immutable/c c) → contract?
  c : contract?
```

Returns the same contract as (box/c c #:immutable #t). This form exists for reasons of backwards compatibility.

```
(listof c) → list-contract?
  c : contract?
```

Returns a contract that recognizes a list whose every element matches the contract *c*. Beware that when this contract is applied to a value, the result is not necessarily eq? to the input.

Examples:

```
> (define/contract some-numbers
    (listof number?)
    (list 1 2 3))
> (define/contract just-one-number
    (listof number?)
    11)
just-one-number: broke its own contract
  promised: list?
  produced: 11
  in: (listof number?)
  contract from: (definition just-one-number)
  blaming: (definition just-one-number)
   (assuming the contract is correct)
  at: eval:3:0
```

```
(non-empty-listof c) → list-contract?
  c : contract?
```

Returns a contract that recognizes non-empty lists whose elements match the contract *c*. Beware that when this contract is applied to a value, the result is not necessarily eq? to the input.

Examples:

```
> (define/contract some-numbers
    (non-empty-listof number?)
    (list 1 2 3))
> (define/contract not-enough-numbers
    (non-empty-listof number?)
    (list))
not-enough-numbers: broke its own contract
  promised: (and/c list? pair?)
  produced: '()
  in: (non-empty-listof number?)
  contract from:
      (definition not-enough-numbers)
  blaming: (definition not-enough-numbers)
   (assuming the contract is correct)
  at: eval:3:0
```

```
(list*of ele-c [last-c]) → contract?
  ele-c : contract?
  last-c : contract? = ele-c
```

Returns a contract that recognizes improper lists whose elements match the contract `ele-c` and whose last position matches `last-c`. If an improper list is created with `cons`, then its `car` position is expected to match `ele-c` and its `cdr` position is expected to be `(list*of ele-c list-c)`. Otherwise, it is expected to match `last-c`. Beware that when this contract is applied to a value, the result is not necessarily `eq?` to the input.

Examples:

```
> (define/contract improper-numbers
    (list*of number?)
    (cons 1 (cons 2 3)))
> (define/contract not-improper-numbers
    (list*of number?)
    (list 1 2 3))
not-improper-numbers: broke its own contract
  promised: number?
  produced: '()
  in: an element of
      (list*of number?)
  contract from:
      (definition not-improper-numbers)
  blaming: (definition not-improper-numbers)
   (assuming the contract is correct)
  at: eval:3:0
```

Added in version 6.1.1.1 of package `base`.

Changed in version 6.4.0.4: Added the *last-c* argument.

```
(cons/c car-c cdr-c) → contract?
  car-c : contract?
  cdr-c : contract?
```

Produces a contract that recognizes pairs whose first and second elements match *car-c* and *cdr-c*, respectively. Beware that when this contract is applied to a value, the result is not necessarily eq? to the input.

If the *cdr-c* contract is a list-contract?, then cons/c returns a list-contract?.

Examples:

```
> (define/contract a-pair-of-numbers
    (cons/c number? number?)
    (cons 1 2))
> (define/contract not-a-pair-of-numbers
    (cons/c number? number?)
    (cons #f #t))
not-a-pair-of-numbers: broke its own contract
  promised: number?
  produced: #f
  in: the car of
      (cons/c number? number?)
  contract from:
      (definition not-a-pair-of-numbers)
  blaming: (definition not-a-pair-of-numbers)
   (assuming the contract is correct)
  at: eval:3:0
```

Changed in version 6.0.1.13 of package base: Added the list-contract? propagating behavior.

```
(cons/dc [car-id contract-expr] [cdr-id (car-id) contract-
expr] cons/dc-option)
(cons/dc [car-id (cdr-id) contract-expr] [cdr-id contract-expr] cons/dc-option)

cons/dc-option =
               | #:flat
               | #:chaperone
               | #:impersonator
```

Produces a contract that recognizes pairs whose first and second elements match the expressions after *car-id* and *cdr-id*, respectively.

In the first case, the contract on the *cdr-id* portion of the contract may depend on the value in the *car-id* portion of the pair and in the second case, the reverse is true.

Examples:

```
> (define/contract an-ordered-pair-of-reals
    (cons/dc [hd real?] [tl (hd) (>=/c hd)])
    (cons 1 2))
> (define/contract not-an-ordered-pair-of-reals
    (cons/dc [hd real?] [tl (hd) (>=/c hd)])
    (cons 2 1))
not-an-ordered-pair-of-reals: broke its own contract
  promised: (>=/c 2)
  produced: 1
  in: the cdr of
      (cons/dc (hd real?) (tl (hd) (>=/c hd)))
  contract from:
      (definition not-an-ordered-pair-of-reals)
  blaming: (definition not-an-ordered-pair-of-reals)
   (assuming the contract is correct)
  at: eval:3:0
```

Added in version 6.1.1.6 of package `base`.

```
(list/c c ...) → list-contract?
  c : contract?
```

Produces a contract for a list. The number of elements in the list must match the number of arguments supplied to `list/c`, and each element of the list must match the corresponding contract. Beware that when this contract is applied to a value, the result is not necessarily `eq?` to the input.

```
(*list/c prefix suffix ...) → list-contract?
  prefix : contract?
  suffix : contract?
```

Produces a contract for a list. The number of elements in the list must be at least as long as the number of *`suffix`* contracts and the tail of the list must match those contracts, one for each element. The beginning portion of the list can be arbitrarily long, and each element must match *`prefix`*.

Beware that when this contract is applied to a value, the result is not necessarily `eq?` to the input.

Examples:

```
> (define/contract a-list-of-numbers-ending-with-two-integers
    (*list/c number? integer? integer?)
    (list 1/2 4/5 0+1i -11 322))
```

```
> (define/contract not-enough-integers-at-the-end
    (*list/c number? integer? integer? integer?)
    (list 1/2 4/5 1/2 321 322))
not-enough-integers-at-the-end: broke its own contract
  promised: integer?
  produced: 1/2
  in: the 3rd to the last element of
      (*list/c number? integer? integer? integer?)
  contract from:
      (definition not-enough-integers-at-the-end)
  blaming: (definition not-enough-integers-at-the-end)
   (assuming the contract is correct)
  at: eval:3:0
```

```
(treelist/c ctc [#:flat? flat? #:lazy? lazy?]) → contract?
  ctc : contract?
  flat? : any/c = (flat-contract? ctc)
  lazy? : any/c = #f
```

Produces a contract for treelists whose elements match `ctc`.

If `flat?` is a true value then `ctc` must be a flat contract. In that situation, the result of `treelist/c` will also be a flat contract.

If `lazy?` is a true value, then `ctc` must be a chaperone contract and the resulting contract will be a chaperone contract. In that situation, the contracts on the elements of the treelist are not checked until the values are accessed.

If both `flat?` and `lazy?` are `#f`, then the contract will copy the treelist as part of the process of checking the contract and the result will be a chaperone contract if `ctc` is a chaperone contract.

At least one of `flat?` and `lazy?` must be `#f`.

Examples:

```
> (define/contract natural-treelist
    (treelist/c natural?)
    (treelist 1 2 3))
> (define/contract unnatural-treelist
    (treelist/c natural?)
    (treelist -1 -2 -3))
unnatural-treelist: broke its own contract
  promised: natural?
  produced: -1
  in: the elements of
```

```
        (treelist/c natural?)
  contract from:
        (definition unnatural-treelist)
  blaming: (definition unnatural-treelist)
   (assuming the contract is correct)
  at: eval:3:0
```

Added in version 8.12.0.7 of package base.
Changed in version 8.15.0.2: Changed the default value of *lazy?* from `(and (chaperone-contract? ctc) (not (flat-contract? ctc)))` to `#f`.

```
(mutable-treelist/c ctc) → contract?
  ctc : contract?
```

Produces a contract for mutable treelists whose elements match *ctc*.

Examples:

```
> (define/contract natural-treelist
    (mutable-treelist/c natural?)
    (mutable-treelist 0 1 2 3))
> (mutable-treelist-ref natural-treelist 1)
1
> (define/contract unnatural-treelist
    (mutable-treelist/c natural?)
    (mutable-treelist -1 2 3))
> (mutable-treelist-ref unnatural-treelist 0)
unnatural-treelist: broke its own contract
  promised: natural?
  produced: -1
  in: the elements of
        (mutable-treelist/c natural?)
  contract from:
        (definition unnatural-treelist)
  blaming: (definition unnatural-treelist)
   (assuming the contract is correct)
  at: eval:4:0
> (mutable-treelist-set! unnatural-treelist 2 -3)
unnatural-treelist: contract violation
  expected: natural?
  given: -3
  in: the elements of
        (mutable-treelist/c natural?)
  contract from:
        (definition unnatural-treelist)
  blaming: top-level
```

(assuming the contract is correct)
at: eval:4:0

Added in version 8.12.0.11 of package `base`.

```
(syntax/c c) → flat-contract?
  c : flat-contract?
```

Produces a flat contract that recognizes syntax objects whose `syntax-e` content matches *c*.

```
(struct/c struct-id contract-expr ...)
```

Produces a contract that recognizes instances of the structure type named by *struct-id*, and whose field values match the contracts produced by the *contract-expr*s.

Contracts for immutable fields must be either flat or chaperone contracts. Contracts for mutable fields may be impersonator contracts. If all fields are immutable and the *contract-expr*s evaluate to flat contracts, a flat contract is produced. If all the *contract-expr*s are chaperone contracts, a chaperone contract is produced. Otherwise, an impersonator contract is produced.

```
(struct/dc struct-id field-spec ... maybe-inv)

         field-spec = [field-name maybe-lazy contract-expr]
                    | [field-name (dep-field-name ...)
                                  maybe-lazy
                                  maybe-contract-type
                                  maybe-dep-state
                                  contract-expr]

         field-name = field-id
                    | (#:selector selector-id)
                    | (field-id #:parent struct-id)

         maybe-lazy =
                    | #:lazy

maybe-contract-type =
                    | #:flat
                    | #:chaperone
                    | #:impersonator

    maybe-dep-state =
                    | #:depends-on-state

          maybe-inv =
                    | #:inv (dep-field-name ...) invariant-expr
```

Produces a contract that recognizes instances of the structure type named by *struct-id*, and whose field values match the contracts produced by the *field-spec*s.

If the *field-spec* lists the names of other fields, then the contract depends on values in those fields, and the *contract-expr* expression is evaluated each time a selector is applied, building a new contract for the fields based on the values of the *dep-field-name* fields (the *dep-field-name* syntax is the same as the *field-name* syntax). If the field is a dependent field and no contract-type annotation appears, then it is assumed that the contract is a chaperone, but not always a flat contract (and thus the entire struct/dc contract is not a flat contract). If this is not the case, and the contract is always flat then the field must be annotated with the #:flat, or the field must be annotated with #:impersonator (in which case, it must be a mutable field).

A *field-name* is either an identifier naming a field in the first case, an identifier naming a selector in the second case indicated by the #:selector keyword, or a field id for a struct that is a parent of *struct-id*, indicated by the #:parent keyword.

If the #:lazy keyword appears, then the contract on the field is checked lazily (only when a selector is applied); #:lazy contracts cannot be put on mutable fields.

If a dependent contract depends on some mutable state, then use the #:depends-on-state keyword argument (if a field's dependent contract depends on a mutable field, this keyword is automatically inferred). The presence of this keyword means that the contract expression is evaluated each time the corresponding field is accessed (or mutated, if it is a mutable field). Otherwise, the contract expression for a dependent field contract is evaluated when the contract is applied to a value.

If the #:inv clause appears, then the invariant expression is evaluated (and must return a non-#f value) when the contract is applied to a struct.

Contracts for immutable fields must be either flat or chaperone contracts. Contracts for mutable fields may be impersonator contracts. If all fields are immutable and the *contract-expr*s evaluate to flat contracts, a flat contract is produced. If all the *contract-expr*s are chaperone contracts, a chaperone contract is produced. Otherwise, an impersonator contract is produced.

As an example, the function bst/c below returns a contract for binary search trees whose values are all between lo and hi. The lazy annotations ensure that this contract does not change the running time of operations that do not inspect the entire tree.

Examples:

```
> (struct bt (val left right))
> (define (bst/c lo hi)
    (or/c #f
          (struct/dc bt
                     [val (between/c lo hi)]
```

```
                         [left (val) #:lazy (bst/c lo val)]
                         [right (val) #:lazy (bst/c val hi)])))
> (define/contract not-really-a-bst
    (bst/c -inf.0 +inf.0)
    (bt 5
        (bt 4
            (bt 2 #f #f)
            (bt 6 #f #f))
        #f))
> (bt-right not-really-a-bst)
#f
> (bt-val (bt-left (bt-left not-really-a-bst)))
2
> (bt-right (bt-left not-really-a-bst))
not-really-a-bst: broke its own contract
  promised: (between/c 4 5)
  produced: 6
  in: the val field of
        a part of the or/c of
        the right field of
        a part of the or/c of
        the left field of
        a part of the or/c of
        (or/c
         #f
         (struct/dc
          bt
          (val (between/c -inf.0 +inf.0))
          (left (val) #:lazy ...)
          (right (val) #:lazy ...)))
  contract from: (definition not-really-a-bst)
  blaming: (definition not-really-a-bst)
   (assuming the contract is correct)
  at: eval:4:0
```

Changed in version 6.0.1.6 of package `base`: Added `#:inv`.

```
(parameter/c  in
             [out
              #:impersonator? impersonator?]) → contract?
  in : contract?
  out : contract? = in
  impersonator? : any/c = #t
```

Produces a contract on parameters whose values must match *out*. When the value in the contracted parameter is set, it must match *in*.

If *impersonator?* is a true value, then `parameter/c` always returns an impersonator contract. If it is `#f`, then the result will be a chaperone contract when both *in* and *out* are chaperone contracts, and an impersonator contract otherwise.

Examples:

```
> (define/contract current-snack
    (parameter/c string?)
    (make-parameter "potato-chip"))
> (define baked/c
    (flat-named-contract 'baked/c (λ (s) (regexp-
match #rx"baked" s))))
> (define/contract current-dinner
    (parameter/c string? baked/c)
    (make-parameter "turkey" (λ (s) (string-append "roasted
" s))))
> (current-snack 'not-a-snack)
current-snack: contract violation
  expected: string?
  given: 'not-a-snack
  in: the parameter of
      (parameter/c string?)
  contract from: (definition current-snack)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:2:0
> (parameterize ([current-dinner "tofurkey"])
    (current-dinner))
current-dinner: broke its own contract
  promised: baked/c
  produced: "roasted tofurkey"
  in: the parameter of
      (parameter/c string? baked/c)
  contract from: (definition current-dinner)
  blaming: (definition current-dinner)
   (assuming the contract is correct)
  at: eval:4:0
```

```
(procedure-arity-includes/c n) → flat-contract?
  n : exact-nonnegative-integer?
```

Produces a contract for procedures that accept *n* argument (i.e,. the `procedure?` contract is implied).

```
(hash/c  key
         val
        [#:immutable immutable
         #:flat? flat?])         → contract?
  key : chaperone-contract?
  val : contract?
  immutable : (or/c #t #f 'dont-care) = 'dont-care
  flat? : boolean? = #f
```

Produces a contract that recognizes `hash` tables with keys and values as specified by the *key* and *val* arguments.

Examples:

```
> (define/contract good-hash
    (hash/c integer? boolean?)
    (hash 1 #t
          2 #f
          3 #t))
> (define/contract bad-hash
    (hash/c integer? boolean?)
    (hash 1 "elephant"
          2 "monkey"
          3 "manatee"))
bad-hash: broke its own contract
  promised: boolean?
  produced: "elephant"
  in: the values of
       (hash/c integer? boolean?)
  contract from: (definition bad-hash)
  blaming: (definition bad-hash)
   (assuming the contract is correct)
  at: eval:3:0
```

There are a number of technicalities that control how `hash/c` contracts behave.

- If the *flat?* argument is `#t`, then the resulting contract is a flat contract, and the *key* and *val* arguments must also be flat contracts.

  Examples:

  ```
  > (flat-contract? (hash/c integer? boolean?))
  #f
  > (flat-contract? (hash/c integer? boolean? #:flat? #t))
  #t
  ```

```
> (hash/c integer? (-> integer? integer?) #:flat? #t)
hash/c: contract violation
  expected: flat-contract?
  given: (-> integer? integer?)
```

Such flat contracts will be unsound if applied to mutable hash tables, as they will not check future mutations to the hash table.

Examples:

```
> (define original-h (make-hasheq))
> (define/contract ctc-h
    (hash/c integer? boolean? #:flat? #t)
    original-h)
> (hash-set! original-h 1 "not a boolean")
> (hash-ref ctc-h 1)
"not a boolean"
```

- If the *immutable* argument is `#t` and the *key* and *val* arguments are `flat-contract?`s, the result will be a `flat-contract?`.

  Example:

  ```
  > (flat-contract? (hash/c integer? boolean? #:immutable #t))
  #t
  ```

  If either the domain or the range is a `chaperone-contract?`, then the result will be a `chaperone-contract?`.

  Examples:

  ```
  > (flat-contract? (hash/c (-> integer? integer?) boolean?
                            #:immutable #t))
  #f
  > (chaperone-contract? (hash/c (-> integer? integer?) boolean?
                                 #:immutable #t))
  #t
  ```

- If the *key* argument is a `chaperone-contract?` but not a `flat-contract?`, then the resulting contract can be applied only to `equal?`-based hash tables.

  Example:

  ```
  > (define/contract h
      (hash/c (-> integer? integer?) any/c)
      (make-hasheq))
  h: broke its own contract;
   promised equal?-based hash table due to higher-order domain
  contract
  ```

```
produced: '#hasheq()
in: (hash/c (-> integer? integer?) any/c)
contract from: (definition h)
blaming: (definition h)
 (assuming the contract is correct)
at: eval:2:0
```

Also, when such a `hash/c` contract is applied to a hash table, the result is not `eq?` to the input. The result of applying the contract will be a copy for immutable hash tables, and either a chaperone or impersonator of the original hash table for mutable hash tables.

```
(hash/dc [key-id key-contract-expr] [value-id (key-id) value-contract-expr]
         hash/dc-option)

hash/dc-option =
               | #:immutable immutable?-expr hash/dc-option
               | #:kind kind-expr hash/dc-option
```

Creates a contract for `hash?` tables with keys matching `key-contract-expr` and where the contract on the values can depend on the key itself, since `key-id` will be bound to the corresponding key before evaluating the `values-contract-expr`.

If `immutable?-expr` is `#t`, then only `immutable?` hashes are accepted. If it is `#f` then `immutable?` hashes are always rejected. It defaults to `'dont-care`, in which case both mutable and immutable hashes are accepted.

If `kind-expr` evaluates to `'flat`, then `key-contract-expr` and `value-contract-expr` are expected to evaluate to `flat-contract?`s. If it is `'chaperone`, then they are expected to be `chaperone-contract?`s, and it may also be `'impersonator`, in which case they may be any `contract?`s. The default is `'chaperone`.

Examples:

```
> (define/contract h
    (hash/dc [k real?] [v (k) (>=/c k)])
    (hash 1 3
          2 4))
> (define/contract h
    (hash/dc [k real?] [v (k) (>=/c k)])
    (hash 3 1
          4 2))
h: broke its own contract
  promised: (>=/c 3)
  produced: 1
  in: the values of
```

```
    (hash/dc (k real?) (v (k) (>=/c k)))
  contract from: (definition h)
  blaming: (definition h)
   (assuming the contract is correct)
  at: eval:3:0
```

```
(channel/c val) → contract?
  val : contract?
```

Produces a contract that recognizes channels that communicate values as specified by the `val` argument.

If the `val` argument is a chaperone contract, then the resulting contract is a chaperone contract. Otherwise, the resulting contract is an impersonator contract. When a channel contract is applied to a channel, the resulting channel is not `eq?` to the input.

Examples:

```
> (define/contract chan
    (channel/c string?)
    (make-channel))
> (thread (λ () (channel-get chan)))
#<thread>
> (channel-put chan 'not-a-string)
chan: contract violation
  expected: string?
  given: 'not-a-string
  in: (channel/c string?)
  contract from: (definition chan)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:2:0
```

```
(prompt-tag/c contract ... maybe-call/cc)

maybe-call/cc =
               | #:call/cc contract
               | #:call/cc (values contract ...)

  contract : contract?
```

Takes any number of contracts and returns a contract that recognizes continuation prompt tags and will check any aborts or prompt handlers that use the contracted prompt tag.

Each `contract` will check the corresponding value passed to an `abort-current-continuation` and handled by the handler of a call to `call-with-continuation-prompt`.

If all of the *contracts* are chaperone contracts, the resulting contract will also be a chaperone contract. Otherwise, the contract is an impersonator contract.

If *maybe-call/cc* is provided, then the provided contracts are used to check the return values from a continuation captured with `call-with-current-continuation`.

Examples:

```
> (define/contract tag
    (prompt-tag/c (-> number? string?))
    (make-continuation-prompt-tag))
> (call-with-continuation-prompt
    (lambda ()
      (number->string
        (call-with-composable-continuation
          (lambda (k)
            (abort-current-continuation tag k)))))
    tag
    (lambda (k) (k "not a number")))
tag: contract violation
  expected: number?
  given: "not a number"
  in: the 1st argument of
      (prompt-tag/c
       (-> number? string?)
       #:call/cc)
  contract from: (definition tag)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:2:0
```

```
(continuation-mark-key/c contract) → contract?
  contract : contract?
```

Takes a single contract and returns a contract that recognizes continuation marks and will check any mappings of marks to values or any accesses of the mark value.

If the argument *contract* is a chaperone contract, the resulting contract will also be a chaperone contract. Otherwise, the contract is an impersonator contract.

Examples:

```
> (define/contract mark-key
    (continuation-mark-key/c (-> symbol? (listof symbol?)))
    (make-continuation-mark-key))
> (with-continuation-mark
```

```
    mark-key
    (lambda (s) (append s '(truffle fudge ganache)))
    (let ([mark-value (continuation-mark-set-first
                       (current-continuation-marks) mark-key)])
      (mark-value "chocolate-bar")))
```

mark-key: contract violation
expected: symbol?
given: "chocolate-bar"
in: the 1st argument of
(continuation-mark-key/c
(-> symbol? (listof symbol?)))
contract from: (definition mark-key)
blaming: top-level
(assuming the contract is correct)
at: eval:2:0

```
(evt/c contract ...) → chaperone-contract?
  contract : chaperone-contract?
```

Returns a contract that recognizes synchronizable events whose synchronization results are checked by the given *contract*s.

The resulting contract is always a chaperone contract and its arguments must all be chaperone contracts.

Examples:

```
> (define/contract my-evt
    (evt/c evt?)
    always-evt)
> (define/contract failing-evt
    (evt/c number? number?)
    (alarm-evt (+ (current-inexact-milliseconds) 50)))
> (sync my-evt)
#<always-evt>
> (sync failing-evt)
```

failing-evt: broke its own contract
promised: event that produces 2 values
produced: event that produces 1 values
in: (evt/c number? number?)
contract from: (definition failing-evt)
blaming: (definition failing-evt)
(assuming the contract is correct)
at: eval:3:0

```
(flat-rec-contract id flat-contract-expr ...)
```

Constructs a recursive flat contract. A *flat-contract-expr* can refer to *id* to refer recursively to the generated contract.

For example, the contract

```
(flat-rec-contract sexp
  (cons/c sexp sexp)
  number?
  symbol?)
```

is a flat contract that checks for (a limited form of) S-expressions. It says that a *sexp* is either two *sexp*s combined with `cons`, or a number, or a symbol.

Note that if the contract is applied to a circular value, contract checking will not terminate.

```
(flat-murec-contract ([id flat-contract-expr ...] ...) body ...+)
```

A generalization of `flat-rec-contract` for defining several mutually recursive flat contracts simultaneously. Each *id* is visible in the entire `flat-murec-contract` form, and the result of the final *body* is the result of the entire form.

```
any
```

Represents a contract that is always satisfied. In particular, it can accept multiple values. It can only be used in a result position of contracts like `->`. Using `any` elsewhere is a syntax error.

```
(promise/c c) → contract?
  c : contract?
```

Constructs a contract on a promise. The contract does not force the promise, but when the promise is forced, the contract checks that the result value meets the contract *c*.

```
(flat-contract predicate) → flat-contract?
  predicate : (-> any/c any/c)
```

Constructs a flat contract from *predicate*. A value satisfies the contract if the predicate returns a true value.

This function is a holdover from before predicates could be used directly as flat contracts. It exists today for backwards compatibility.

```
(flat-contract-predicate v) → (-> any/c any/c)
  v : flat-contract?
```

Extracts the predicate from a flat contract.

Note that most flat contracts can be used directly as predicates, but not all. This function can be used to build predicates for ordinary Racket values that double as contracts, such as numbers and symbols. When building a contract combinator that needs to explicitly convert ordinary racket values to flat contracts, consider using `coerce-flat-contract` instead of `flat-contract-predicate` so that the combinator can raise errors that use the combinator's name in the error message.

```
(property/c accessor ctc [#:name name]) → flat-contract?
  accessor : (-> any/c any/c)
  ctc : flat-contract?
  name : any/c = (object-name accessor)
```

Constructs a flat contract that checks that the first-order property accessed by *accessor* satisfies *ctc*. The resulting contract is equivalent to

```
(lambda (v) (ctc (accessor v)))
```

except that more information is included in error messages produced by violations of the contract. The *name* argument is used to describe the property being checked in error messages.

Examples:

```
> (define/contract (sum-triple lst)
    (-> (and/c (listof number?)
               (property/c length (=/c 3)))
        number?)
    (+ (first lst) (second lst) (third lst)))
> (sum-triple '(1 2 3))
6
> (sum-triple '(1 2))
sum-triple: contract violation
  expected: (=/c 3)
  given: 2
  in: the length of
      an and/c case of
      the 1st argument of
      (->
       (and/c
        (listof number?)
        (property/c length (=/c 3)))
       number?)
  contract from: (function sum-triple)
  blaming: top-level
```

```
    (assuming the contract is correct)
  at: eval:2:0
```

Added in version 7.3.0.11 of package `base`.

```
(suggest/c c field message) → contract?
  c : contract?
  field : string?
  message : string?
```

Returns a contract that behaves like *c*, except that it adds an extra line to the error message on a contract violation.

The *field* and *message* strings are added following the guidelines in §10.2.1 "Error Message Conventions".

Examples:

```
> (define allow-calls? #f)
> (define/contract (f)
    (suggest/c (->* () #:pre allow-calls? any)
               "suggestion" "maybe you should set! allow-calls? to
#t")
    5)
> (f)
f: contract violation
  #:pre condition
  suggestion: maybe you should set! allow-calls? to #t
  in: (->* () #:pre ... any)
  contract from: (function f)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:3:0
```

8.2 Function Contracts

A *function contract* wraps a procedure to delay checks for its arguments and results. There are three primary function contract combinators that have increasing amounts of expressiveness and increasing additional overheads. The first `->` is the cheapest. It generates wrapper functions that can call the original function directly. Contracts built with `->*` require packaging up arguments as lists in the wrapper function and then using either `keyword-apply` or `apply`. Finally, `->i` is the most expensive (along with `->d`), because it requires delaying the evaluation of the contract expressions for the domain and range until the function itself is called or returns.

The `case->` contract is a specialized contract, designed to match `case-lambda` and `unconstrained-domain->` allows range checking without requiring that the domain have any particular shape (see below for an example use).

```
(-> dom ... range)
(-> dom ... ellipsis dom-expr ... range)

     dom = dom-expr
         | keyword dom-expr

   range = range-expr
         | (values range-expr ...)
         | any

ellipsis = ...
```

Produces a contract for a function that accepts the argument specified by the *`dom-expr`* contracts and returns either a fixed number of results or completely unspecified results (the latter when `any` is specified).

Each *`dom-expr`* is a contract on an argument to a function, and each *`range-expr`* is a contract on a result of the function.

If the domain contain `...` then the function accepts as many arguments as the rest of the contracts in the domain portion specify, as well as arbitrarily many more that match the contract just before the `...`. Otherwise, the contract accepts exactly the argument specified.

Using a `->` between two whitespace-delimited `.`s is the same as putting the `->` right after the enclosing opening parenthesis. See §2.4.3 "Lists and Racket Syntax" or §1.3.6 "Reading Pairs and Lists" for more information.

For example,

```
(integer? boolean? . -> . integer?)
```

produces a contract on functions of two arguments. The first argument must be an integer, and the second argument must be a boolean. The function must produce an integer.

Examples:

```
> (define/contract (maybe-invert i b)
    (-> integer? boolean? integer?)
    (if b (- i) i))
> (maybe-invert 1 #t)
-1
> (maybe-invert #f 1)
maybe-invert: contract violation
  expected: integer?
  given: #f
  in: the 1st argument of
```

```
      (-> integer? boolean? integer?)
  contract from: (function maybe-invert)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:2:0
```

A domain specification may include a keyword. If so, the function must accept corresponding (mandatory) keyword arguments, and the values for the keyword arguments must match the corresponding contracts. For example:

```
(integer? #:invert? boolean? . -> . integer?)
```

is a contract on a function that accepts a by-position argument that is an integer and an `#:invert?` argument that is a boolean.

Examples:

```
> (define/contract (maybe-invert i #:invert? b)
    (-> integer? #:invert? boolean? integer?)
    (if b (- i) i))
> (maybe-invert 1 #:invert? #t)
-1
> (maybe-invert 1 #f)
maybe-invert: arity mismatch;
 the expected number of arguments does not match the given
number
  expected: 1 plus an argument with keyword #:invert?
  given: 2
  arguments...:
   1
   #f
```

As an example that uses an `...`, this contract:

```
(integer? string? ... integer? . -> . any)
```

on a function insists that the first and last arguments to the function must be integers (and there must be at least two arguments) and any other arguments must be strings.

Examples:

```
> (define/contract (string-length/between? lower-bound s1 . more-
args)
    (-> integer? string? ... integer? boolean?)
```

```
    (define all-but-first-arg-backwards (reverse (cons s1 more-
args)))
    (define upper-bound (first all-but-first-arg-backwards))
    (define strings (rest all-but-first-arg-backwards))
    (define strings-length
      (for/sum ([str (in-list strings)])
        (string-length str)))
    (<= lower-bound strings-length upper-bound))
> (string-length/between? 4 "farmer" "john" 40)
#t
> (string-length/between? 4 "farmer" 'john 40)
string-length/between?: contract violation
  expected: string?
  given: 'john
  in: the repeated argument of
       (-> integer? string? ... integer? boolean?)
  contract from:
       (function string-length/between?)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:2:0
> (string-length/between? 4 "farmer" "john" "fourty")
string-length/between?: contract violation
  expected: integer?
  given: "fourty"
  in: the last argument of
       (-> integer? string? ... integer? boolean?)
  contract from:
       (function string-length/between?)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:2:0
```

If `any` is used as the last sub-form for `->`, no contract checking is performed on the result of the function, and thus any number of values is legal (even different numbers on different invocations of the function).

Examples:

```
> (define/contract (multiple-xs n x)
    (-> natural? any/c any)
    (apply
     values
     (for/list ([_ (in-range n)])
       n)))
> (multiple-xs 4 "four")
```

```
4
4
4
4
```

If `(values range-expr ...)` is used as the last sub-form of `->`, the function must produce a result for each contract, and each value must match its respective contract.

Examples:

```
> (define/contract (multiple-xs n x)
    (-> natural? any/c (values any/c any/c any/c))
    (apply
     values
     (for/list ([_ (in-range n)])
       n)))
> (multiple-xs 3 "three")
3
3
3
> (multiple-xs 4 "four")
multiple-xs: broke its own contract;
 expected 3 values, returned 4 values
  in: the range of
      (->
       natural?
       any/c
       (values any/c any/c any/c))
  contract from: (function multiple-xs)
  blaming: (function multiple-xs)
   (assuming the contract is correct)
  at: eval:2:0
```

Changed in version 6.4.0.5 of package `base`: Added support for ellipses

```
(->* (mandatory-dom ...) optional-doms rest pre range post)
```

```
mandatory-dom = dom-expr
              | keyword dom-expr

optional-doms =
              | (optional-dom ...)

 optional-dom = dom-expr
              | keyword dom-expr

         rest =
              | #:rest rest-expr

          pre =
              | #:pre pre-cond-expr
              | #:pre/desc pre-cond-expr

        range = range-expr
              | (values range-expr ...)
              | any

         post =
              | #:post post-cond-expr
              | #:post/desc post-cond-expr
```

The `->*` contract combinator produces contracts for functions that accept optional arguments (either keyword or positional) and/or arbitrarily many arguments. The first clause of a `->*` contract describes the mandatory arguments, and is similar to the argument description of a `->` contract. The second clause describes the optional arguments. The range of description can either be `any` or a sequence of contracts, indicating that the function must return multiple values.

If present, the *`rest-expr`* contract governs the arguments in the rest parameter. Note that the *`rest-expr`* contract governs only the arguments in the rest parameter, not those in mandatory arguments. For example, this contract:

```
(->* () #:rest (cons/c integer? (listof integer?)) any)
```

does not match the function

```
(λ (x . rest) x)
```

because the contract insists that the function accept zero arguments (because there are no mandatory arguments listed in the contract). The `->*` contract does not know that the contract on the rest argument is going to end up disallowing empty argument lists.

The *pre-cond-expr* and *post-cond-expr* expressions are checked as the function is called and returns, respectively, and allow checking of the environment without an explicit connection to an argument (or a result). If the `#:pre` or `#:post` keywords are used, then a `#f` result is treated as a failure and any other result is treated as success. If the `#:pre/desc` or `#:post/desc` keyword is used, the result of the expression must be either a boolean, a string, or a list of strings, where `#t` means success and any of the other results mean failure. If the result is a string or a list of strings, the strings are expected to have at exactly one space after each newline and multiple are used as lines in the error message; the contract itself adds single space of indentation to each of the strings in that case. The formatting requirements are not checked but they match the recommendations in §10.2.1 "Error Message Conventions".

As an example, the contract

```
(->* () (boolean? #:x integer?) #:rest (listof symbol?) symbol?)
```

matches functions that optionally accept a boolean, an integer keyword argument `#:x` and arbitrarily more symbols, and that return a symbol.

```
(->i maybe-chaperone
     (mandatory-dependent-dom ...)
     dependent-rest
     pre-condition
     param-value
     dependent-range
     post-condition)
(->i maybe-chaperone
     (mandatory-dependent-dom ...)
     (optional-dependent-dom ...)
     dependent-rest
     pre-condition
     param-value
     dependent-range
     post-condition)
```

```
       maybe-chaperone = #:chaperone
                       |

mandatory-dependent-dom = id+ctc
                       | keyword id+ctc

 optional-dependent-dom = id+ctc
                       | keyword id+ctc

        dependent-rest =
                       | #:rest id+ctc

         pre-condition =
                       | #:pre (id ...)
                         boolean-expr pre-condition
                       | #:pre/desc (id ...)
                         expr pre-condition
                       | #:pre/name (id ...)
                         string boolean-expr pre-condition

           param-value =
                       | #:param (id ...)
                         param-expr val-expr param-value

       dependent-range = any
                       | id+ctc
                       | un+ctc
                       | (values id+ctc ...)
                       | (values un+ctc ...)

        post-condition =
                       | #:post (id ...)
                         boolean-expr post-condition
                       | #:post/desc (id ...)
                         expr post-condition
                       | #:post/name (id ...)
                         string boolean-expr post-condition

                id+ctc = [id contract-expr]
                       | [id (id ...) contract-expr]

                un+ctc = [_ contract-expr]
                       | [_ (id ...) contract-expr]
```

The `->i` contract combinator differs from the `->*` combinator in that each argument and result is named and these names can be used in the subcontracts and in the pre-/post-condition clauses. In other words, `->i` expresses dependencies among arguments and results.

The optional first keyword argument to `->i` indicates if the result contract will be a chaperone. If it is `#:chaperone`, all of the contract for the arguments and results must be chaperone contracts and the result of `->i` will be a chaperone contract. If it is not present, then the result contract will not be a chaperone contract.

The first sub-form of a `->i` contract covers the mandatory and the second sub-form covers the optional arguments. Following that is an optional rest-args contract, and an optional pre-condition. The pre-condition is introduced with the `#:pre` keyword followed by the list of names on which it depends. If the `#:pre/name` keyword is used, the string supplied is used as part of the error message; similarly with `#:post/name`. If `#:pre/desc` or `#:post/desc` is used, the result of the expression is treated the same way as `->*`.

Following the pre-condition is the optional *`param-value`* non-terminal that specifies parameters to be assigned to during the dynamic extent of the function. Each assignment is introduced with the `#:param` keyword followed by the list of names on which it depends, a *`param-expr`* that determines the parameter to set, and a *`val-expr`* that will be associated with the parameter.

The *`dependent-range`* non-terminal specifies the possible result contracts. If it is `any`, then any value is allowed. Otherwise, the result contract pairs a name and a contract or a multiple values return with names and contracts. In the last two cases, the range contract may be optionally followed by a post-condition; the post-condition expression is not allowed if the range contract is `any`. Like the pre-condition, the post-condition must specify the variables on which it depends.

Consider this sample contract:

```
(->i ([x number?]
      [y (x) (>=/c x)])
     [result (x y) (and/c number? (>=/c (+ x y)))])
```

It specifies a function of two arguments, both numbers. The contract on the second argument (`y`) demands that it is greater than the first argument. The result contract promises a number that is greater than the sum of the two arguments. While the dependency specification for `y` signals that the argument contract depends on the value of the first argument, the dependency sequence for `result` indicates that the contract depends on both argument values. Since the contract for `x` does not depend on anything else, it does not come with any dependency sequence, not even `()`.

In general, an empty sequence is (nearly) equivalent to not adding a sequence at all except that the former is more expensive than the latter.

This example is like the previous one, except the `x` and `y` arguments are now optional keyword arguments, instead of mandatory, by-position arguments:

```
(->i ()
     (#:x [x number?]
```

```
 #:y [y (x) (>=/c x)])
[result (x y)
 (and/c number?
        (if (and (number? x) (number? y))
            (>=/c (+ x y))
            any/c))])
```

The conditional in the range that tests *x* and *y* is necessary to cover the situation where *x* or *y* are not supplied by the calling context (meaning they might be bound to `the-unsupplied-arg`).

The contract expressions are not always evaluated in order. First, if there is no dependency for a given contract expression, the contract expression is evaluated at the time that the `->i` expression is evaluated rather than the time when the function is called or returns. These dependency-free contract expressions are evaluated in the order in which they are listed. Second, the dependent contract sub-expressions are evaluated when the contracted function is called or returns in some order that satisfies the dependencies. That is, if a contract for an argument depends on the value of some other contract, the former is evaluated first (so that the argument, with its contract checked, is available for the other). When there is no dependency between two arguments (or the result and an argument), then the contract that appears earlier in the source text is evaluated first.

If all of the identifier positions of a range contract with a dependency are `_`s (underscores), then the range contract expressions are evaluated when the function is called instead of when it returns. Otherwise, dependent range expressions are evaluated when the function returns.

If there are optional arguments that are not supplied, then the corresponding variables will be bound to a special value called `the-unsupplied-arg` value. For example, in this contract:

```
(->i ([x (y) (if (unsupplied-arg? y)
                 real?
                 (>=/c y))])
     ([y real?])
     any)
```

the contract on `x` depends on *y*, but *y* might not be supplied at the call site. In that case, the value of *y* in the contract on *x* is `the-unsupplied-arg` and the `->i` contract must check for it and tailor the contract on *x* to account for *y* not being supplied.

When the contract expressions for unsupplied arguments are dependent, and the argument is not supplied at the call site, the contract expressions are not evaluated at all. For example, in this contract, *y*'s contract expression is evaluated only when *y* is supplied:

```
(->i ()
     ([x real?]
      [y (x) (>=/c x)])
     any)
```

In contrast, *x*'s expression is always evaluated (indeed, it is evaluated when the `->i` expression is evaluated because it does not have any dependencies).

Changed in version 8.7.0.1 of package `base`: Added `#:param`.

```
(->d (mandatory-dependent-dom ...)
     dependent-rest
     pre-condition
     dependent-range
     post-condition)
(->d (mandatory-dependent-dom ...)
     (optional-dependent-dom ...)
     dependent-rest
     pre-condition
     dependent-range
     post-condition)

mandatory-dependent-dom = [id dom-expr]
                        | keyword [id dom-expr]

 optional-dependent-dom = [id dom-expr]
                        | keyword [id dom-expr]

         dependent-rest =
                        | #:rest id rest-expr

          pre-condition =
                        | #:pre boolean-expr
                        | #:pre-cond boolean-expr

        dependent-range = any
                        | [_ range-expr]
                        | (values [_ range-expr] ...)
                        | [id range-expr]
                        | (values [id range-expr] ...)

         post-condition =
                        | #:post-cond boolean-expr
```

This contract is here for backwards compatibility; any new code should use `->i` instead.

This contract is similar to `->i`, but is "lax", meaning that it does not enforce contracts internally. For example, using this contract

```
(->d ([f (-> integer? integer?)])
     #:pre
```

```
(zero? (f #f))
any)
```

will allow `f` to be called with `#f`, trigger whatever bad behavior the author of `f` was trying to prohibit by insisting that `f`'s contract accept only integers.

The `#:pre-cond` and `#:post-cond` keywords are aliases for `#:pre` and `#:post` and are provided for backwards compatibility.

```
(case-> (-> dom-expr ... rest range) ...)

 rest =
      | #:rest rest-expr

range = range-expr
      | (values range-expr ...)
      | any
```

This contract form is designed to match `case-lambda`. Each argument to `case->` is a contract that governs a clause in the `case-lambda`. If the `#:rest` keyword is present, the corresponding clause must accept an arbitrary number of arguments. The *range* specification is just like that for `->` and `->*`.

For example, this contract matches a function with two cases, one that accepts an integer, returning void, and one that accepts no arguments and returns an integer.

```
(case-> (-> integer? void?)
        (-> integer?))
```

Such a contract could be used to guard a function that controls access to a single shared integer.

```
(dynamic->*
 [#:mandatory-domain-contracts mandatory-domain-contracts
  #:optional-domain-contracts optional-domain-contracts
  #:mandatory-keywords mandatory-keywords
  #:mandatory-keyword-contracts mandatory-keyword-contracts
  #:optional-keywords optional-keywords
  #:optional-keyword-contracts optional-keyword-contracts
  #:rest-contract rest-contract]
  #:range-contracts range-contracts)
→ contract?
 mandatory-domain-contracts : (listof contract?) = '()
 optional-domain-contracts : (listof contract?) = '()
 mandatory-keywords : (listof keyword?) = '()
```

```
mandatory-keyword-contracts : (listof contract?) = '()
optional-keywords : (listof keyword?) = '()
optional-keyword-contracts : (listof contract?) = '()
rest-contract : (or/c #f contract?) = #f
range-contracts : (or/c #f (listof contract?))
```

Like `->*`, except the number of arguments and results can be computed at runtime, instead of being fixed at compile-time. Passing `#f` as the `#:range-contracts` argument produces a contract like one where `any` is used with `->` or `->*`.

For many uses, `dynamic->*`'s result is slower than `->*` (or `->`), but for some it has comparable speed. The name of the contract returned by `dynamic->*` uses the `->` or `->*` syntax.

```
(unconstrained-domain-> range-expr ...)
```

Constructs a contract that accepts a function, but makes no constraint on the function's domain. The *range-expr*s determine the number of results and the contract for each result.

Generally, this contract must be combined with another contract to ensure that the domain is actually known to be able to safely call the function itself.

For example, the contract

```
(provide
 (contract-out
  [f (->d ([size natural-number/c]
           [proc (and/c (unconstrained-domain-> number?)
                        (lambda (p)
                          (procedure-arity-includes? p size)))])
          ()
          [_ number?])]))
```

says that the function `f` accepts a natural number and a function. The domain of the function that `f` accepts must include a case for `size` arguments, meaning that `f` can safely supply `size` arguments to its input.

For example, the following is a definition of `f` that cannot be blamed using the above contract:

```
(define (f i g)
  (apply g (build-list i add1)))
```

```
predicate/c : contract?
```

Equivalent to `(-> any/c boolean?)`. Previously, this contract was necessary as it included an additional optimization that was not included in `->`. Now however, `->` performs the same optimization, so the contract should no longer be used. The contract is still provided for backward compatibility.

```
the-unsupplied-arg : unsupplied-arg?
```

Used by `->i` (and `->d`) to bind optional arguments that are not supplied by a call site.

```
(unsupplied-arg? v) → boolean?
  v : any/c
```

A predicate to determine whether *v* is `the-unsupplied-arg`.

8.3 Parametric Contracts

```
(require racket/contract/parametric)      package: base
```

The most convenient way to use parametric contract is to use `contract-out`'s `#:exists` keyword. The `racket/contract/parametric` provides a few more, general-purpose parametric contracts.

```
(parametric->/c (x ...) c)
```

Creates a contract for parametric polymorphic functions. Each function is protected by *c*, where each *x* is bound in *c* and refers to a polymorphic type that is instantiated each time the function is applied.

At each application of a function, the `parametric->/c` contract constructs a new opaque wrapper for each *x*; values flowing into the polymorphic function (i.e. values protected by some *x* in negative position with respect to `parametric->/c`) are wrapped in the corresponding opaque wrapper. Values flowing out of the polymorphic function (i.e. values protected by some *x* in positive position with respect to `parametric->/c`) are checked for the appropriate wrapper. If they have it, they are unwrapped; if they do not, a contract violation is signaled.

Examples:

```
> (define swap-ctc (parametric->/c [A B] (-> A B (values B A))))
> (define/contract (good-swap a b)
    swap-ctc
    (values b a))
> (good-swap 1 2)
2
1
> (define/contract (bad-swap a b)
    swap-ctc
    (values a b))
```

```
> (bad-swap 1 2)
bad-swap: broke its own contract
  promised: B
  produced: #<A>
  in: the range of
      (parametric->/c (A B) (-> A B (values B A)))
  contract from: (function bad-swap)
  blaming: (function bad-swap)
   (assuming the contract is correct)
  at: eval:5:0
> (define/contract (copy-first a b)
    swap-ctc
    (values a a))
> (let ((v 'same-symbol)) (copy-first v v))
copy-first: broke its own contract
  promised: B
  produced: #<A>
  in: the range of
      (parametric->/c (A B) (-> A B (values B A)))
  contract from: (function copy-first)
  blaming: (function copy-first)
   (assuming the contract is correct)
  at: eval:7:0
> (define/contract (inspect-first a b)
    swap-ctc
    (if (integer? a)
      (+ a b)
      (raise-user-error "an opaque wrapped value is not an inte-
ger")))
> (inspect-first 1 2)
an opaque wrapped value is not an integer
```

```
(new-∀/c [name]) → contract?
  name : (or/c symbol? #f) = #f
```

Constructs a new universal contract.

Universal contracts accept all values when in negative positions (e.g., function inputs) and wrap them in an opaque struct, hiding the precise value. In positive positions (e.g. function returns), a universal contract accepts only values that were previously accepted in negative positions (by checking for the wrappers).

The name is used to identify the contract in error messages and defaults to a name based on the lexical context of `new-∀/c`.

For example, this contract:

```
(let ([a (new-∀/c 'a)])
  (-> a a))
```

describes the identity function (or a non-terminating function). That is, the first use of the a appears in a negative position and thus inputs to that function are wrapped with an opaque struct. Then, when the function returns, it is checked to determine whether the result is wrapped, since the second a appears in a positive position.

The `new-∀/c` contract constructor is dual to `new-∃/c`.

```
(new-∃/c [name]) → contract?
  name : (or/c symbol? #f) = #f
```

Constructs a new existential contract.

Existential contracts accept all values when in positive positions (e.g., function returns) and wrap them in an opaque struct, hiding the precise value. In negative positions (e.g. function inputs), they accepts only values that were previously accepted in positive positions (by checking for the wrappers).

The name is used to identify the contract in error messages and defaults to a name based on the lexical context of `new-∀/c`.

For example, this contract:

```
(let ([a (new-∃/c 'a)])
  (-> (-> a a)
      any/c))
```

describes a function that accepts the identity function (or a non-terminating function) and returns an arbitrary value. That is, the first use of the a appears in a positive position and thus inputs to that function are wrapped with an opaque struct. Then, when the function returns, it is checked to see if the result is wrapped, since the second a appears in a negative position.

The `new-∃/c` construct constructor is dual to `new-∀/c`.

8.4 Lazy Data-structure Contracts

```
(contract-struct id (field-id ...))
```

> **NOTE:** This library is deprecated; use `struct`, instead. Lazy struct contracts no longer require a separate struct declaration; instead `struct/dc` and `struct/c` work directly with `struct` and `define-struct`.

Like `struct`, but with two differences: they do not define field mutators, and they define two contract constructors: *id*`/c` and *id*`/dc`. The first is a procedure that accepts as many arguments as there are fields and returns a contract for struct values whose fields match the arguments. The second is a syntactic form that also produces contracts on the structs, but the contracts on later fields may depend on the values of earlier fields.

The generated contract combinators are *lazy*: they only verify the contract holds for the portion of some data structure that is actually inspected. More precisely, a lazy data structure contract is not checked until a selector extracts a field of a struct.

```
(id/dc field-spec ...)

field-spec = [field-id contract-expr]
           | [field-id (field-id ...) contract-expr]
```

In each *field-spec* case, the first *field-id* specifies which field the contract applies to; the fields must be specified in the same order as the original `contract-struct`. The first case is for when the contract on the field does not depend on the value of any other field. The second case is for when the contract on the field does depend on some other fields, and the parenthesized *field-id*s indicate which fields it depends on; these dependencies can only be to earlier fields.

```
(define-contract-struct id (field-id ...))
```

NOTE: This library is deprecated; use `struct`, instead. Lazy struct contracts no longer require a separate struct declaration; instead `struct/dc` and `struct/c` work directly with `struct` and `define-struct`.

Like `contract-struct`, but where the constructor's name is `make-`*id*, much like `define-struct`.

8.5 Structure Type Property Contracts

```
(struct-type-property/c value-contract) → contract?
  value-contract : contract?
```

Produces a contract for a structure type property. When the contract is applied to a struct type property, it produces a wrapped struct type property that applies *value-contract* to the value associated with the property when it used to create a new struct type (via `struct`, `make-struct-type`, etc).

The struct type property's accessor function is not affected; if it is exported, it must be protected separately.

As an example, consider the following module. It creates a structure type property, `prop`, whose value should be a function mapping a structure instance to a numeric predicate. The module also exports `app-prop`, which extracts the predicate from a structure instance and applies it to a given value.

```
> (module propmod racket
    (require racket/contract)
    (define-values (prop prop? prop-ref)
      (make-struct-type-property 'prop))
    (define (app-prop x v)
      (((prop-ref x) x) v))
    (provide/contract
     [prop? (-> any/c boolean?)]
     [prop (struct-type-property/c
            (-> prop? (-> integer? boolean?)))]
     [app-prop (-> prop? integer? boolean?)])
    (provide prop-ref))
```

The `structmod` module creates a structure type named `s` with a single field; the value of `prop` is a function that extracts the field value from an instance. Thus the field ought to be an integer predicate, but notice that `structmod` places no contract on `s` enforcing that constraint.

```
> (module structmod racket
    (require 'propmod)
    (struct s (f) #:property prop (lambda (s) (s-f s)))
    (provide (struct-out s)))
> (require 'propmod 'structmod)
```

First we create an `s` instance with an integer predicate, so the constraint on `prop` is in fact satisfied. The first call to `app-prop` is correct; the second simply violates the contract of `app-prop`.

```
> (define s1 (s even?))
> (app-prop s1 5)
#f
> (app-prop s1 'apple)
app-prop: contract violation
  expected: integer?
  given: 'apple
  in: the 2nd argument of
        (-> prop? integer? boolean?)
  contract from: propmod
```

```
  blaming: top-level
   (assuming the contract is correct)
  at: eval:2:0
```

We are able to create `s` instances with values other than integer predicates, but applying `app-prop` on them blames `structmod`, because the function associated with `prop`—that is, `(lambda (s) (s-f s))`—does not always produce a value satisfying `(-> integer? boolean?)`.

```
> (define s2 (s "not a fun"))
> (app-prop s2 5)
prop: contract violation
  expected: a procedure
  given: "not a fun"
  in: the range of
      the struct property value of
      (struct-type-property/c
       (-> prop? (-> integer? boolean?)))
  contract from: propmod
  blaming: structmod
   (assuming the contract is correct)
  at: eval:2:0
> (define s3 (s list))
> (app-prop s3 5)
prop: contract violation
  expected: boolean?
  given: '(5)
  in: the range of
      the range of
      the struct property value of
      (struct-type-property/c
       (-> prop? (-> integer? boolean?)))
  contract from: propmod
  blaming: structmod
   (assuming the contract is correct)
  at: eval:2:0
```

The fix would be to propagate the obligation inherited from `prop` to `s`:

```
(provide (contract-out
          [struct s ([f (-> integer? boolean?)])]))
```

Finally, if we directly apply the property accessor, `prop-ref`, and then misuse the resulting function, the `propmod` module is blamed:

```
> ((prop-ref s3) 'apple)
prop: broke its own contract
   promised: prop?
   produced: 'apple
   in: the 1st argument of
         the struct property value of
         (struct-type-property/c
          (-> prop? (-> integer? boolean?)))
   contract from: propmod
   blaming: propmod
    (assuming the contract is correct)
   at: eval:2:0
```

The propmod module has an obligation to ensure a function associated with prop is applied only to values satisfying prop?. By directly providing prop-ref, it enables that constraint to be violated (and thus it is blamed), even though the bad application actually occurs elsewhere.

Generally there is no need to provide a structure type property accessor at all; it is typically only used by other functions within the module. But if it must be provided, it should be protected thus:

```
(provide (contract-out
           [prop-ref (-> prop? (-> prop? (-> integer? boolean?)))]))
```

8.6 Attaching Contracts to Values

```
(contract-in module-path in-out-item ...)
```

```
(contract-out unprotected-submodule in-out-item ...)

          in-out-item = [id contract-expr]
                      | (rename internal-id external-id contract-expr)
                      | (struct id/ignored ([id contract-expr] ...)
                          struct-option)
                      | #:∃ poly-variables
                      | #:exists poly-variables
                      | #:∀ poly-variables
                      | #:forall poly-variables

unprotected-submodule =
                      | #:unprotected-submodule submodule-name

       poly-variables = id
                      | (id ...)

           id/ignored = id
                      | (id ignored-id)

        struct-option =
                      | #:omit-constructor
```

Use `contract-in` in `require` and `contract-out` in `provide` (currently only for the same phase level as the `provide` form; for example, `contract-out` cannot be nested within `for-syntax`). Each identifier in `contract-out` is provided from the enclosing module and each one in `contract-in` is required from the named module. In addition, uses of the identifies must live up to the contract specified by *contract-expr* for each export.

The `contract-out` and `contract-in` forms treat modules as units of blame. The module that provides each identifier is expected to meet the positive (co-variant) positions of the contract. Each module that imports the provided variable must obey the negative (contra-variant) positions of the contract. Only uses of the contracted variable outside the module that provides them are checked. Inside the providing module, no contract checking occurs.

In a `contract-out` form, each *contract-expr* in a `contract-out` form is effectively moved to the end of the enclosing module, so a *contract-expr* can refer to variables that are defined later in the same module.

The `rename` form exports the first variable (the internal name) with the name specified by the second variable (the external name).

The `struct` form gives contracts to a structure-type definition *id*, and each field has a contract that dictates the contents of the fields. Unlike a `struct` definition, however, all of the fields (and their contracts) must be listed. The contract on the fields that the sub-struct shares with its parent are only used in the contract for the sub-struct's constructor, and the selector or mutators for the super-struct are not provided. The exported structure-type name always doubles as a constructor, even if the original structure-type name does not act as a constructor. If the `#:omit-constructor` option is present, the constructor is not provided. The second form of *id/ignored*, which has both *id* and *ignored-id*, is deprecated and allowed in the grammar only for backward compatibility, where *ignored-id* is ignored. The first form should be used instead.

Note that if the struct is created with `serializable-struct` or `define-serializable-struct`, `contract-out` does not protect struct instances that are created via `deserialize`. Consider using `struct-guard/c` instead.

The `#:∃`, `#:exists`, `#:∀`, and `#:forall` clauses define new abstract contracts. The variables are bound in the remainder of the `contract-out` form to new contracts that hide the values they accept and ensure that the exported functions are treated parametrically. See `new-∃/c` and `new-∀/c` for details on how the clauses hide the values.

If `#:unprotected-submodule` appears, the identifier that follows it is used as the name of a submodule that `contract-out` generates. The submodule exports all of the names in the `contract-out`, but without contracts. In particular, the original structure-type name is exported for each `struct` form, which means `#:omit-constructor` only omits the extra constructor, if any.

The implementation of `contract-out` uses `syntax-property` to attach properties to the code it generates that records the syntax of the contracts in the fully expanded program. Specifically, the symbol `'provide/contract-original-contract` is bound to vectors of two elements, the exported identifier and a syntax object for the expression that produces the contract controlling the export.

Examples:

```
> (module math-example racket/base
    (require racket/contract)
    ; Compute the reciprocal of a real number
    (define (recip x) (/ 1 x))
    (provide
     (contract-out
      [recip (-> (and/c real? (not/c zero?)) real?)])))
> (require 'math-example)
> (recip 3)
1/3
> (recip 1+2i)
recip: contract violation
  expected: real?
  given: 1+2i
  in: an and/c case of
      the 1st argument of
      (-> (and/c real? (not/c zero?)) real?)
```

```
contract from: math-example
blaming: top-level
 (assuming the contract is correct)
at: eval:2:0
```

Changed in version 7.3.0.3 of package `base`: Added `#:unprotected-submodule`.
Changed in version 7.7.0.9: Started ignoring *`ignored-id`*.
Changed in version 8.12.0.13: Added `contract-in`
Changed in version 8.13.0.1: Added `rename` and `struct` to `contract-in`

```
(recontract-out id ...)
```

A *`provide-spec`* for use in `provide` (currently, just like `contract-out`, only for the same phase level as the `provide` form).

It re-exports *`id`*, but with positive blame associated to the module containing `recontract-out` instead of the location of the original site of *`id`*.

This can be useful when a public module wants to export an identifier from a private module but where any contract violations should be reported in terms of the public module instead of the private one.

Examples:

```
> (module private-implementation racket/base
    (require racket/contract)
    (define (recip x) (/ 1 x))
    (define (non-zero? x) (not (= x 0)))
    (provide/contract [recip (-> (and/c real? non-zero?)
                                 (between/c -1 1))]))
> (module public racket/base
    (require racket/contract
             'private-implementation)
    (provide (recontract-out recip)))
> (require 'public)
> (recip +nan.0)
recip: broke its own contract
  promised: (between/c -1 1)
  produced: +nan.0
  in: the range of
      (->
       (and/c real? non-zero?)
       (between/c -1 1))
  contract from: public
  blaming: public
   (assuming the contract is correct)
  at: eval:3:0
```

Replacing the use of `recontract-out` with just `recip` would result in a contract violation blaming the private module.

```
(provide/contract unprotected-submodule in-out-item ...)
```

A legacy shorthand for `(provide (contract-out unprotected-submodule in-out-item ...))`, except that a *`contract-expr`* within `provide/contract` is evaluated at the position of the `provide/contract` form instead of at the end of the enclosing module.

```
(struct-guard/c contract-expr ...)
```

Returns a procedure suitable to be passed as the `#:guard` argument to `struct`, `serializable-struct` (and related forms). The guard procedure ensures that each contract protects the corresponding field values, as long as the struct is not mutated. Mutations are not protected.

Examples:

```
> (struct snake (weight hungry?)
    #:guard (struct-guard/c real? boolean?))
> (snake 1.5 "yep")
snake, field 2: contract violation
  expected: boolean?
  given: "yep"
  in: boolean?
  contract from: top-level
  blaming: top-level
   (assuming the contract is correct)
  at: eval:2:0
```

8.6.1 Nested Contract Boundaries

```
(require racket/contract/region)      package: base
```

```
(with-contract blame-id (wc-export ...) free-var-list ... body ...+)
(with-contract blame-id results-spec free-var-list ... body ...+)

    wc-export = (id contract-expr)

  result-spec = #:result contract-expr
              | #:results (contract-expr ...)

free-var-list =
              | #:freevar id contract-expr
              | #:freevars ([id contract-expr] ...)
```

Generates a local contract boundary.

The first `with-contract` form cannot appear in expression position. All names defined within the first `with-contract` form are visible externally, but those names listed in the *wc-export* list are protected with the corresponding contract. The *body* of the form allows definition/expression interleaving if its context does.

The second `with-contract` form must appear in expression position. The final *body* expression should return the same number of values as the number of contracts listed in the *result-spec*, and each returned value is contracted with its respective contract. The sequence of *body* forms is treated as for `let`.

The *blame-id* is used for the positive positions of contracts paired with exported *id*s. Contracts broken within the `with-contract` *body* will use the *blame-id* for their negative position.

If a *free-var-list* is given, then any uses of the free variables inside the *body* will be protected with contracts that blame the context of the `with-contract` form for the positive positions and the `with-contract` form for the negative ones.

```
(define/contract id contract-expr free-var-list init-value-expr)
(define/contract (head args) contract-expr free-var-list body ...+)
```

Works like `define`, except that the contract *contract-expr* is attached to the bound value. For the definition of *head* and *args*, see `define`. For the definition of *free-var-list*, see `with-contract`.

Examples:

```
> (define/contract distance (>=/c 0) 43.52)
> (define/contract (furlongs->feet fr)
    (-> real? real?)
    (* 660 fr))
; a contract violation expected here:
> (furlongs->feet "not a furlong")
furlongs->feet: contract violation
  expected: real?
  given: "not a furlong"
  in: the 1st argument of
      (-> real? real?)
  contract from: (function furlongs->feet)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:3:0
```

The `define/contract` form treats the individual definition as a contract region. The definition itself is responsible for positive (co-variant) positions of the contract, and references to *id* outside of the definition must meet the negative positions of the contract. Since the contract boundary is between the definition and the surrounding context, references to *id* inside the `define/contract` form are not checked.

Examples:

```
; an unsual predicate that prints when called
> (define (printing-int? x)
    (displayln "I was called")
    (exact-integer? x))
> (define/contract (fact n)
    (-> printing-int? printing-int?)
    (if (zero? n)
        1
        (* n (fact (sub1 n)))))
> (fact 5) ; only prints twice, not for each recursive call
I was called
I was called
120
```

If a free-var-list is given, then any uses of the free variables inside the *body* will be protected with contracts that blame the context of the `define/contract` form for the positive positions and the `define/contract` form for the negative ones.

Examples:

```
> (define (integer->binary-string n)
    (number->string n 2))
> (define/contract (numbers->strings lst)
    (-> (listof number?) (listof string?))
    #:freevar integer->binary-string (-> exact-integer? string?)
    ; mistake, lst might contain inexact numbers
    (map integer->binary-string lst))
> (numbers->strings '(4.0 3.3 5.8))
integer->binary-string: contract violation
  expected: exact-integer?
  given: 4.0
  in: the 1st argument of
      (-> exact-integer? string?)
  contract from: top-level
  blaming: (function numbers->strings)
   (assuming the contract is correct)
  at: eval:3:0
```

```
(struct/contract struct-id ([field contract-expr] ...)
                 struct-option ...)
```

```
(struct/contract struct-id super-struct-id
                 ([field contract-expr] ...)
                 struct-option ...)
```

Works like `struct`, except that the arguments to the constructor, accessors, and mutators are protected by contracts. For the definitions of *`field`* and *`struct-option`*, see `struct`.

The `struct/contract` form only allows a subset of the *`struct-option`* keywords: `#:mutable`, `#:transparent`, `#:auto-value`, `#:omit-define-syntaxes`, and `#:property`.

Examples:

```
> (struct/contract fruit ([seeds number?]))
> (fruit 60)
#<fruit>
> (fruit #f)
fruit: contract violation
  expected: number?
  given: #f
  in: the 1st argument of
      (-> number? symbol? any)
  contract from: (struct fruit)
  blaming: top-level
   (assuming the contract is correct)
> (struct/contract apple fruit ([type string?]))
> (apple 14 "golden delicious")
#<apple>
> (apple 5 30)
apple: contract violation
  expected: string?
  given: 30
  in: the 2nd argument of
      (-> any/c string? symbol? any)
  contract from: (struct apple)
  blaming: top-level
   (assuming the contract is correct)
> (apple #f "granny smith")
fruit: contract violation
  expected: number?
  given: #f
  in: the 1st argument of
      (-> number? symbol? any)
  contract from: (struct fruit)
  blaming: top-level
   (assuming the contract is correct)
```

```
(define-struct/contract struct-id ([field contract-expr] ...)
                        struct-option ...)
(define-struct/contract (struct-id super-struct-id)
                        ([field contract-expr] ...)
                        struct-option ...)
```

Works like `struct/contract`, except that the syntax for supplying a *super-struct-id* is different, and a *constructor-id* that has a `make-` prefix on *struct-id* is implicitly supplied. For the definitions of *field* and *struct-option*, see `define-struct`. Like `struct` versus `define-struct`, `struct/contract` is normally preferred to `define-struct/contract`.

The `define-struct/contract` form only allows a subset of the *struct-option* keywords: `#:mutable`, `#:transparent`, `#:auto-value`, `#:omit-define-syntaxes`, and `#:property`.

Examples:

```
> (define-struct/contract fish ([color number?]))
> (make-fish 5)
#<fish>
> (make-fish #f)
make-fish: contract violation
  expected: number?
  given: #f
  in: the 1st argument of
      (-> number? symbol? any)
  contract from: (struct fish)
  blaming: top-level
   (assuming the contract is correct)
> (define-struct/contract (salmon fish) ([ocean symbol?]))
> (make-salmon 5 'atlantic)
#<salmon>
> (make-salmon 5 #f)
make-salmon: contract violation
  expected: symbol?
  given: #f
  in: the 2nd argument of
      (-> any/c symbol? symbol? any)
  contract from: (struct salmon)
  blaming: top-level
   (assuming the contract is correct)
> (make-salmon #f 'pacific)
make-fish: contract violation
  expected: number?
```

```
given: #f
in: the 1st argument of
      (-> number? symbol? any)
contract from: (struct fish)
blaming: top-level
 (assuming the contract is correct)
```

```
(invariant-assertion invariant-expr expr)
```

Establishes an invariant of `expr`, determined by `invariant-expr`.

Unlike the specification of a contract, an `invariant-assertion` does not establish a boundary between two parties. Instead, it simply attaches a logical assertion to the value. Because the form uses contract machinery to check the assertion, the surrounding module is treated as the party to be blamed for any violations of the assertion.

This means, for example, that the assertion is checked on recursive calls, when an invariant is used on the right-hand side of a definition:

Examples:

```
> (define furlongss->feets
    (invariant-assertion
     (-> (listof real?) (listof real?))
     (λ (l)
       (cond
         [(empty? l) empty]
         [else
          (if (= 327 (car l))
              (furlongss->feets (list "wha?"))
              (cons (furlongs->feet (first l))
                    (furlongss->feets (rest l))))]))))
> (furlongss->feets (list 1 2 3))
'(660 1320 1980)
> (furlongss->feets (list 1 327 3))
furlongss->feets: assertion violation
  expected: real?
  given: "wha?"
  in: an element of
      the 1st argument of
      (-> (listof real?) (listof real?))
  contract from: invariant-assertion
  at: eval:5:0
```

Added in version 6.0.1.11 of package `base`.

```
current-contract-region
```

Bound by `define-syntax-parameter`, this contains information about the current contract region, used by the above forms to determine the candidates for blame assignment.

8.6.2 Low-level Contract Boundaries

```
(define-module-boundary-contract id
  orig-id
  contract-expr
  d-m-b-c-kwd-arg ...)

d-m-b-c-kwd-arg = #:name-for-contract name-for-contract-id
                | #:name-for-blame blame-id
                | #:srcloc srcloc-expr
                | #:pos-source pos-source-expr
                | #:context-limit limit-expr
                | #:lift-to-end? boolean
                | #:start-swapped? boolean
```

Defines *`id`* to be *`orig-id`*, but with the contract *`contract-expr`*.

The identifier *`id`* is defined as a macro transformer that consults the context of its use to determine the name for negative blame assignment (using the entire module where a reference appears as the negative party).

The name used in the error messages will be *`orig-id`*, unless `#:name-for-blame` is supplied, in which case the identifier following it is used as the name in the error messages.

The contract expression is wrapped in a `let` to give it a name which will be passed on to the name of the wrapped value in certain situations (e.g., if the contract is a function contract). If *`name-for-contract-id`* is supplied, the identifier that follows it is used to name the contract; otherwise *`orig-id`* is used.

The source location used in the blame error messages for the location of the place where the contract was put on the value defaults to the source location of the use of `define-module-boundary-contract`, but can be specified via the `#:srcloc` argument, in which case it can be any of the things that the third argument to `datum->syntax` can be.

The positive party defaults to the module containing the use of `define-module-boundary-contract`, but can be specified explicitly via the `#:pos-source` keyword.

If `#:context-limit` is supplied, it behaves the same as it does when supplied to `contract`.

If lift-to-end? is #t or is not supplied, then the contract expression is placed at the end of the enclosing module (using syntax-local-lift-module-end-declaration). If it is supplied and #f, the contract expression is placed where define-module-boundary-contract is placed.

If start-swapped? is #t, then the initial blame object is created in the "swapped?" state, and the pos-source is used as a negative source. This is helpful to get the "contract from:" line in contract violations correct in certain situations. If #:start-swapped? is not supplied, it is treated as if it was supplied as #f.

Examples:

```
> (module server racket/base
    (require racket/contract/base)
    (define (f x) #f)
    (define-module-boundary-contract g f (-> integer? integer?))
    (provide g))
> (module client racket/base
    (require 'server)
    (define (clients-fault) (g #f))
    (define (servers-fault) (g 1))
    (provide servers-fault clients-fault))
> (require 'client)
> (clients-fault)
g: contract violation
  expected: integer?
  given: #f
  in: the 1st argument of
      (-> integer? integer?)
  contract from: 'server
  blaming: client
   (assuming the contract is correct)
  at: eval:2:0
> (servers-fault)
g: broke its own contract
  promised: integer?
  produced: #f
  in: the range of
      (-> integer? integer?)
  contract from: 'server
  blaming: (quote server)
   (assuming the contract is correct)
  at: eval:2:0
```

Changed in version 6.7.0.4 of package base: Added the #:name-for-blame argument.
Changed in version 6.90.0.29: Added the #:context-limit argument.

Changed in version 8.13.0.1: Added the #:name-for-contract and #:start-swapped arguments.

```
(contract contract-expr to-protect-expr
          positive-blame-expr negative-blame-expr)
(contract contract-expr to-protect-expr
          positive-blame-expr negative-blame-expr
          #:context-limit limit-expr)
(contract contract-expr to-protect-expr
          positive-blame-expr negative-blame-expr
          value-name-expr source-location-expr)
```

The primitive mechanism for attaching a contract to a value. The purpose of `contract` is as a target for the expansion of some higher-level contract specifying form.

The `contract` expression adds the contract specified by *contract-expr* to the value produced by *to-protect-expr*. The result of a `contract` expression is the result of the *to-protect-expr* expression, but with the contract specified by *contract-expr* enforced on *to-protect-expr*.

The values of *positive-blame-expr* and *negative-blame-expr* indicate how to assign blame for positive and negative positions of the contract specified by *contract-expr*. They may be any value, and are formatted as by `display` for purposes of contract violation error messages.

If specified, *value-name-expr* indicates a name for the protected value to be used in error messages. If not supplied, or if *value-name-expr* produces `#f`, no name is printed. Otherwise, it is also formatted as by `display`. More precisely, the *value-name-expr* ends up in the `blame-value` field of the blame record, which is used as the first portion of the error message.

Examples:

```
> (contract integer? #f 'pos 'neg 'timothy #f)
timothy: broke its own contract
  promised: integer?
  produced: #f
  in: integer?
  contract from: pos
  blaming: pos
   (assuming the contract is correct)
> (contract integer? #f 'pos 'neg #f #f)
broke its own contract
  promised: integer?
  produced: #f
  in: integer?
  contract from: pos
  blaming: pos
```

(assuming the contract is correct)

If specified, *source-location-expr* indicates the source location reported by contract violations. The expression must produce a `srcloc` structure, syntax object, `#f`, or a list or vector in the format accepted by the third argument to `datum->syntax`.

If `#:context-limit` is supplied, the following expression must evaluate to either `#f` or a natural number. If the expression evaluates to an natural number, the number of layers of context information is limited to at most that many. For example, if the number is `0`, no context information is recorded and the error messages do not contain the section that starts with `in:`.

8.7 Building New Contract Combinators

```
(require racket/contract/combinator)        package: base
```

```
(make-contract
 [#:name name
  #:first-order first-order
  #:late-neg-projection late-neg-proj
  #:collapsible-late-neg-projection collapsible-late-neg-proj
  #:val-first-projection val-first-proj
  #:projection proj
  #:stronger stronger
  #:equivalent equivalent
  #:list-contract? is-list-contract?])
→ contract?
 name : any/c = 'anonymous-contract
 first-order : (-> any/c any/c) = (λ (x) #t)
 late-neg-proj : (or/c #f (-> blame? (-> any/c any/c any/c)))
               = #f
 collapsible-late-neg-proj : (or/c #f (-> blame? (values (-> any/c any/c any/c) collapsible-
                           = #f
 val-first-proj : (or/c #f (-> blame? (-> any/c (-> any/c any/c))))
                = #f
 proj : (-> blame? (-> any/c any/c))
      = (λ (b)
          (λ (x)
            (if (first-order x)
              x
              (raise-blame-error
               b x
               '(expected: "~a" given: "~e")
               name x))))
 stronger : (or/c #f (-> contract? contract? boolean?)) = #f
 equivalent : (or/c #f (-> contract? contract? boolean?)) = #f
 is-list-contract? : boolean? = #f
```

```
(make-chaperone-contract
 [#:name name
  #:first-order first-order
  #:late-neg-projection late-neg-proj
  #:collapsible-late-neg-projection collapsible-late-neg-proj
  #:val-first-projection val-first-proj
  #:projection proj
  #:stronger stronger
  #:equivalent equivalent
  #:list-contract? is-list-contract?])
→ chaperone-contract?
 name : any/c = 'anonymous-chaperone-contract
 first-order : (-> any/c any/c) = (λ (x) #t)
 late-neg-proj : (or/c #f (-> blame? (-> any/c any/c any/c)))
               = #f
 collapsible-late-neg-proj : (or/c #f (-> blame? (values (-> any/c any/c any/c) collapsible-
                           = #f
 val-first-proj : (or/c #f (-> blame? (-> any/c (-> any/c any/c))))
                = #f
 proj : (-> blame? (-> any/c any/c))
      = (λ (b)
          (λ (x)
            (if (first-order x)
              x
              (raise-blame-error
               b x
               '(expected: "~a" given: "~e")
               name x))))
 stronger : (or/c #f (-> contract? contract? boolean?)) = #f
 equivalent : (or/c #f (-> contract? contract? boolean?)) = #f
 is-list-contract? : boolean? = #f
```

```
(make-flat-contract
 [#:name name
  #:first-order first-order
  #:late-neg-projection late-neg-proj
  #:collapsible-late-neg-projection collapsible-late-neg-proj
  #:val-first-projection val-first-proj
  #:projection proj
  #:stronger stronger
  #:equivalent equivalent
  #:list-contract? is-list-contract?])
→ flat-contract?
 name : any/c = 'anonymous-flat-contract
 first-order : (-> any/c any/c) = (λ (x) #t)
 late-neg-proj : (or/c #f (-> blame? (-> any/c any/c any/c)))
               = #f
 collapsible-late-neg-proj : (or/c #f (-> blame? (values (-> any/c any/c any/c) collapsible-
                           = #f
 val-first-proj : (or/c #f (-> blame? (-> any/c (-> any/c any/c))))
                = #f
 proj : (-> blame? (-> any/c any/c))
      = (λ (b)
          (λ (x)
            (if (first-order x)
              x
              (raise-blame-error
               b x
               '(expected: "~a" given: "~e")
               name x))))
 stronger : (or/c #f (-> contract? contract? boolean?)) = #f
 equivalent : (or/c #f (-> contract? contract? boolean?)) = #f
 is-list-contract? : boolean? = #f
```

These functions build simple higher-order contracts, chaperone contracts, and flat contracts, respectively. They all take the same set of three optional arguments: a name, a first-order predicate, and a blame-tracking projection. For `make-flat-contract`, see also `flat-contract-with-explanation`.

The *name* argument is any value to be rendered using `display` to describe the contract when a violation occurs. The default name for simple higher-order contracts is `anonymous-contract`, for chaperone contracts is `anonymous-chaperone-contract`, and for flat contracts is `anonymous-flat-contract`.

The first-order predicate *first-order* is used to determine which values the contract applies to. This test is used by `contract-first-order-passes?`, and indirectly by `or/c` and `first-or/c` to determine which higher-order contract to wrap a value with when there are multiple higher-order contracts to choose from. The default value accepts any value, but it must match the behavior of the projection argument (see below for how). The predicate should be influenced by the value of (contract-first-order-okay-to-give-up?) (see it's documentation for more explanation).

The *late-neg-proj* argument defines the behavior of applying the contract via a *late neg projection*. If it is supplied, this argument accepts a blame object that is missing one party (see also blame-missing-party?). Then it must return a function that accepts both the value that is getting the contract and the name of the missing blame party, in that order. The result must either be the value (perhaps suitably wrapped with a chaperone or impersonator to enforce the contract), or signal a contract violation using raise-blame-error. The default is #f.

The *collapsible-late-neg-proj* argument takes the place of the *late-neg-proj* argument for contracts that support collapsing. If it is supplied, this argument accepts a blame object that is missing one party. It must return two values. The first value must be a function that accepts both the value that is getting the contract and the name of the missing blame party, in that order. The second value should be a collapsible representation of the contract.

The projection *proj* and *val-first-proj* are older mechanisms for defining the behavior of applying the contract. The *proj* argument is a curried function of two arguments: the first application accepts a blame object, and the second accepts a value to protect with the contract. The projection must either produce the value, suitably wrapped to enforce any higher-order aspects of the contract, or signal a contract violation using raise-blame-error. The default projection produces an error when the first-order test fails, and produces the value unchanged otherwise. The *val-first-proj* is like *late-neg-proj*, except with an extra layer of currying.

At least one of the *late-neg-proj*, *proj*, *val-first-proj*, or *first-order* must be non-#f.

The projection arguments (*late-neg-proj*, *proj*, and *val-first-proj*) must be in sync with the *first-order* argument. In particular, if the *first-order* argument returns #f for some value, then the projections must raise a blame error for that value and if the *first-order* argument returns #t for some value, then the projection must not signal any blame for this value, unless there are higher-order interactions later. In other words, for flat contracts, the *first-order* and projection arguments must check the same predicate. For convenience, the the default projection uses the *first-order* argument, signalling an error when it returns #f and never signalling one otherwise.

Projections for chaperone contracts must produce a value that passes chaperone-of? when compared with the original, uncontracted value. Projections for flat contracts must fail precisely when *first-order* does, and must produce the input value unchanged otherwise. Applying a flat contract may result in either an application of the predicate, or the projection, or both; therefore, the two must be consistent. The existence of a separate projection only serves to provide more specific error messages. Most flat contracts do not need to supply an explicit projection.

The *stronger* argument is used to implement `contract-stronger?`. The first argument is always the contract itself and the second argument is whatever was passed as the second argument to `contract-stronger?`. If no *stronger* argument is supplied, then a default that compares its arguments with `equal?` is used for flat contracts and chaperone contracts. For impersonator contracts constructed with `make-contract` that do not supply the *stronger* argument, `contract-stronger?` returns `#f`.

Similarly, the *equivalent* argument is used to implement `contract-equivalent?`. If it isn't supplied or `#false` is supplied, then `equal?` is used for chaperone and flat contracts, and `(λ (x y) #f)` is used otherwise.

The *is-list-contract?* argument is used by the `list-contract?` predicate to determine if this is a contract that accepts only `list?` values.

Examples:

```
> (define int/c
    (make-flat-contract #:name 'int/c #:first-order integer?))
> (contract int/c 1 'positive 'negative)
1
> (contract int/c "not one" 'positive 'negative)
eval:4:0: broke its own contract
  promised: int/c
  produced: "not one"
  in: int/c
  contract from: positive
  blaming: positive
   (assuming the contract is correct)
> (int/c 1)
#t
> (int/c "not one")
#f
> (define int->int/c
    (make-contract
     #:name 'int->int/c
     #:first-order
     (λ (x) (and (procedure? x) (procedure-arity-includes? x 1)))
     #:projection
     (λ (b)
       (let ([domain ((contract-projection int/c) (blame-swap b))]
             [range ((contract-projection int/c) b)])
         (λ (f)
           (if (and (procedure? f) (procedure-arity-
includes? f 1))
               (λ (x) (range (f (domain x))))
               (raise-blame-error
                b f
```

```
                 '(expected "a function of one argument" given: "~e")
                 f)))))))
> (contract int->int/c "not fun" 'positive 'negative)
eval:8:0: broke its own contract;
 promised a function of one argument
  produced: "not fun"
  in: int->int/c
  contract from: positive
  blaming: positive
   (assuming the contract is correct)
> (define halve
    (contract int->int/c (λ (x) (/ x 2)) 'positive 'negative))
> (halve 2)
1
> (halve 1/2)
halve: contract violation
  expected: int/c
  given: 1/2
  in: int->int/c
  contract from: positive
  blaming: negative
   (assuming the contract is correct)
> (halve 1)
halve: broke its own contract
  promised: int/c
  produced: 1/2
  in: int->int/c
  contract from: positive
  blaming: positive
   (assuming the contract is correct)
```

Changed in version 6.0.1.13 of package base: Added the `#:list-contract?` argument.
Changed in version 6.90.0.30: Added the `#:equivalent` argument.
Changed in version 7.1.0.10: Added the `#:collapsible-late-neg-projection` argument.

```
(build-compound-type-name c/s ...) → any
  c/s : any/c
```

Produces an S-expression to be used as a name for a contract. The arguments should be either contracts or symbols. It wraps parentheses around its arguments and extracts the names from any contracts it is supplied with.

```
(coerce-contract id v) → contract?
  id : symbol?
  v : any/c
```

Converts a regular Racket value into an instance of a contract struct, converting it according to the description of contracts.

If `v` is not one of the coercible values, `coerce-contract` signals an error, using the first argument in the error message.

```
(coerce-contracts id vs) → (listof contract?)
  id : symbol?
  vs : (listof any/c)
```

Coerces all of the arguments in `vs` into contracts (via `coerce-contract/f`) and signals an error if any of them are not contracts. The error messages assume that the function named by `id` got `vs` as its entire argument list.

```
(coerce-chaperone-contract id v) → chaperone-contract?
  id : symbol?
  v : any/c
```

Like `coerce-contract`, but requires the result to be a chaperone contract, not an arbitrary contract.

```
(coerce-chaperone-contracts id vs)
 → (listof chaperone-contract?)
  id : symbol?
  vs : (listof any/c)
```

Like `coerce-contracts`, but requires the results to be chaperone contracts, not arbitrary contracts.

```
(coerce-flat-contract id v) → flat-contract?
  id : symbol?
  v : any/c
```

Like `coerce-contract`, but requires the result to be a flat contract, not an arbitrary contract.

```
(coerce-flat-contracts id v) → (listof flat-contract?)
  id : symbol?
  v : (listof any/c)
```

Like `coerce-contracts`, but requires the results to be flat contracts, not arbitrary contracts.

```
(coerce-contract/f v) → (or/c contract? #f)
  v : any/c
```

Like `coerce-contract`, but returns `#f` if the value cannot be coerced to a contract.

```
(skip-projection-wrapper?) → boolean?
(skip-projection-wrapper? wrap?) → void?
  wrap? : boolean?
 = #f
```

The functions `make-chaperone-contract` and `build-chaperone-contract-property` wrap their arguments to ensure that the result of the projections are chaperones of the input. This layer of wrapping can, in some cases, introduce unwanted overhead into contract checking. If this parameter's value is `#t` during the dynamic extent of the call to either of those functions, the wrapping (and thus the checks) are skipped.

```
(with-contract-continuation-mark blame body ...)
(with-contract-continuation-mark blame+neg-party body ...)
```

Inserts a continuation mark that informs the contract profiler (see the contract profiling documentation) that contract checking is happening. For the costs from checking your new combinator to be included, you should wrap any deferred, higher-order checks with this form. First-order checks are recognized automatically and do not require this form.

If your combinator's projections operate on complete blame objects (i.e., no missing blame parties), the blame object should be the first argument to this form. Otherwise (e.g., in the case of *`late-neg`* projections), a pair of the blame object and the missing party should be used instead.

Added in version 6.4.0.4 of package `base`.

```
(contract-pos/neg-doubling e1 e2)
```

Some contract combinators need to build projections for subcontracts with both regular and `blame-swap`ed versions of the blame that they are given in order to check both access and mutations (e.g., `vector/c` and `vectorof`). In the case that such combinators are nested deeply inside each other, there is a potential for an exponential explosion of nested projections being built.

To avoid that explosion, wrap each of the calls to the blame-accepting portion of the combinator in `contract-pos/neg-doubling`. It returns three values. The first is a boolean, indicating how to interpret the other two results. If the boolean is `#t`, then the other two results are the values of *`e1`* and *`e2`* and we are not too deep in the nesting. If the boolean is `#f`, then we have passed a threshold and it is not safe to evaluate *`e1`* and *`e2`* yet, as we are in danger of running into the exponential slowdown. In that case, the last two results are thunks that, when invoked, compute the values of *`e1`* and *`e2`*.

As an example, `vectorof` uses `contract-pos/neg-doubling` wrapping its two calls to the blame-accepting part of the projection for its subcontract. When it receives a `#f` as that first boolean, it does not invoke the thunks right away, but waits until the interposition procedure that it attaches to the chaperoned vector is called. Then it invokes them (and caches the result). This delays the construction of the projections until they are actually needed, avoiding the exponential blowup.

Added in version 6.90.0.27 of package `base`.

8.7.1 Blame Objects

This section describes *blame objects* and operations on them.

```
(blame? v) → boolean?
  v : any/c
```

This predicate recognizes blame objects.

```
(raise-blame-error b
                   #:missing-party missing-party
                   v
                   fmt
                   v-fmt ...)                    → none/c
  b : blame?
  missing-party : #f
  v : any/c
  fmt : (or/c string?
              (listof (or/c string?
                            'given 'given:
                            'expected 'expected:)))
  v-fmt : any/c
```

Signals a contract violation. The first argument, `b`, records the current blame information, including positive and negative parties, the name of the contract, the name of the value, and the source location of the contract application. The `#:missing-party` argument supplies one of the blame parties. It should be non-`#f` when the `b` object was created without supplying a negative party. See `blame-add-missing-party` and the description of the *`late-neg-proj`* argument of `make-contract`.

The second positional argument, `v`, is the value that failed to satisfy the contract.

The remaining arguments are a format string, `fmt`, and its arguments, `v-fmt ...`, specifying an error message specific to the precise violation.

If `fmt` is a list, then the elements are concatenated together (with spaces added, unless there are already spaces at the ends of the strings), after first replacing symbols with either their string counterparts, or replacing `'given` with `"produced"` and `'expected` with "promised", depending on whether or not the *b* argument has been swapped or not (see blame-swap).

If *fmt* contains the symbols 'given: or 'expected:, they are replaced like 'given and 'expected are, but the replacements are prefixed with the string "\n " to conform to the error message guidelines in §10.2.1 "Error Message Conventions".

```
(blame-add-context  blame
                    context
                   [#:important important
                    #:swap? swap?])        → blame?
  blame : blame?
  context : (or/c string? #f)
  important : (or/c string? #f) = #f
  swap? : boolean? = #f
```

Adds some context information to blame error messages that explicates which portion of the contract failed (and that gets rendered by raise-blame-error).

The *context* argument describes one layer of the portion of the contract, typically of the form "the 1st argument of" (in the case of a function contract) or "a conjunct of" (in the case of an and/c contract).

For example, consider this contract violation:

```
> (define/contract f
    (list/c (-> integer? integer?))
    (list (λ (x) x)))
> ((car f) #f)
f: contract violation
  expected: integer?
  given: #f
  in: the 1st argument of
      the 1st element of
      (list/c (-> integer? integer?))
  contract from: (definition f)
  blaming: top-level
   (assuming the contract is correct)
  at: eval:2:0
```

It shows that the portion of the contract being violated is the first occurrence of integer?, because the -> and the list/c combinators each internally called blame-add-context to add the two lines following "in" in the error message.

The *important* argument is used to build the beginning part of the contract violation. The last *important* argument that gets added to a blame object is used. The class/c contract adds an important argument, as does the `->` contract (when `->` knows the name of the function getting the contract).

The *swap?* argument has the effect of calling `blame-swap` while adding the layer of context, but without creating an extra blame object.

Passing `#f` as the context string argument is no longer relevant. For backwards compatibility, `blame-add-context` returns `b` when *context* is `#f`.

Changed in version 6.90.0.29 of package `base`: The *context* argument being `#f` is no longer relevant.

```
(blame-context blame) → (listof string?)
  blame : blame?
```

Returns the context information that would be supplied in an error message, if *blame* is passed to `raise-blame-error`.

```
(blame-positive b) → any/c
  b : blame?
(blame-negative b) → any/c
  b : blame?
```

These functions produce printable descriptions of the current positive and negative parties of a blame object.

```
(blame-contract b) → any/c
  b : blame?
```

This function produces a description of the contract associated with a blame object (the result of `contract-name`).

```
(blame-value b) → any/c
  b : blame?
```

This function produces the name of the value to which the contract was applied, or `#f` if no name was provided.

```
(blame-source b) → srcloc?
  b : blame?
```

This function produces the source location associated with a contract. If no source location was provided, all fields of the structure will contain `#f`.

```
(blame-swap b) → blame?
  b : blame?
```

This function swaps the positive and negative parties of a blame object. (See also `blame-add-context`.)

```
(blame-original? b) → boolean?
  b : blame?
(blame-swapped? b) → boolean?
  b : blame?
```

These functions report whether the current blame of a given blame object is the same as in the original contract invocation (possibly of a compound contract containing the current one), or swapped, respectively. Each is the negation of the other; both are provided for convenience and clarity.

```
(blame-replace-negative b neg) → blame?
  b : blame?
  neg : any/c
```

Produces a `blame?` object just like *b* except that it uses *neg* instead of the negative position *b* has.

```
(blame-replaced-negative? b) → boolean?
  b : blame?
```

Returns `#t` if *b* is the result of calling `blame-replace-negative` (or the result of some other function whose input was the result of `blame-replace-negative`).

```
(blame-update b pos neg) → blame?
  b : blame?
  pos : any/c
  neg : any/c
```

Produces a `blame?` object just like *b* except that it adds *pos* and *neg* to the positive and negative parties of *b* respectively.

```
(blame-missing-party? b) → boolean?
  b : blame?
```

Returns `#t` when *b* does not have both parties.

```
(blame-add-missing-party b missing-party)
 → (and/c blame? (not/c blame-missing-party?))
  b : (and/c blame? blame-missing-party?)
  missing-party : any/c
```

Produces a new blame object like *b*, except that the missing party is replaced with *missing-party*.

```
(struct exn:fail:contract:blame exn:fail:contract (object)
    #:extra-constructor-name make-exn:fail:contract:blame)
  object : blame?
```

This exception is raised to signal a contract error. The `object` field contains a blame object associated with a contract violation.

```
(current-blame-format) → (-> blame? any/c string? string?)
(current-blame-format proc) → void?
  proc : (-> blame? any/c string? string?)
```

A parameter that is used when constructing a contract violation error. Its value is procedure that accepts three arguments:

- the blame object for the violation,
- the value that the contract applies to, and
- a message indicating the kind of violation.

The procedure then returns a string that is put into the contract error message. Note that the value is often already included in the message that indicates the violation.

Examples:

```
> (define (show-blame-error blame value message)
    (string-append
     "Contract Violation!\n"
     (format "Guilty Party: ~a\n" (blame-positive blame))
     (format "Innocent Party: ~a\n" (blame-negative blame))
     (format "Contracted Value Name: ~a\n" (blame-value blame))
     (format "Contract Location: ~s\n" (blame-source blame))
     (format "Contract Name: ~a\n" (blame-contract blame))
     (format "Offending Value: ~s\n" value)
     (format "Offense: ~a\n" message)))
> (current-blame-format show-blame-error)
> (define/contract (f x)
    (-> integer? integer?)
    (/ x 2))
> (f 2)
1
> (f 1)
Contract Violation!
Guilty Party: (function f)
```

Innocent Party: top-level
Contracted Value Name: f
Contract Location: #(struct:srcloc eval 4 0 4 1)
Contract Name: (-> integer? integer?)
Offending Value: 1/2
Offense: promised: integer?
produced: 1/2

```
> (f 1/2)
```

Contract Violation!
Guilty Party: top-level
Innocent Party: (function f)
Contracted Value Name: f
Contract Location: #(struct:srcloc eval 4 0 4 1)
Contract Name: (-> integer? integer?)
Offending Value: 1/2
Offense: expected: integer?
given: 1/2

8.7.2 Contracts as structs

The property `prop:contract` allows arbitrary structures to act as contracts. The property `prop:chaperone-contract` allows arbitrary structures to act as chaperone contracts; `prop:chaperone-contract` inherits `prop:contract`, so chaperone contract structures may also act as general contracts. The property `prop:flat-contract` allows arbitrary structures to act as flat contracts; `prop:flat-contract` inherits both `prop:chaperone-contract` and `prop:procedure`, so flat contract structures may also act as chaperone contracts, as general contracts, and as predicate procedures.

```
prop:contract : struct-type-property?
prop:chaperone-contract : struct-type-property?
prop:flat-contract : struct-type-property?
```

These properties declare structures to be contracts or flat contracts, respectively. The value for `prop:contract` must be a contract property constructed by `build-contract-property`; likewise, the value for `prop:chaperone-contract` must be a chaperone contract property constructed by `build-chaperone-contract-property` and the value for `prop:flat-contract` must be a flat contract property constructed by `build-flat-contract-property`.

```
prop:contracted : struct-type-property?
impersonator-prop:contracted : impersonator-property?
```

These properties attach a contract value to the protected structure, chaperone, or impersonator value. The function `has-contract?` returns `#t` for values that have one of these properties, and `value-contract` extracts the value from the property (which is expected to be the contract on the value).

```
prop:blame : struct-type-property?
impersonator-prop:blame : impersonator-property?
```

These properties attach a blame information to the protected structure, chaperone, or impersonator value. The function `has-blame?` returns `#t` for values that have one of these properties, and `value-blame` extracts the value from the property.

The value is expected to be the blame record for the contract on the value or a `cons`-pair of a blame record with a missing party and the missing party. The `value-blame` function reassembles the arguments of the pair into a complete blame record using `blame-add-missing-party`. If the value has one of the properties, but the value is not a blame object or a pair whose `car` position is a blame object, then `has-blame?` returns `#f` but `value-blame` returns `#f`.

```
(build-flat-contract-property
 [#:name get-name
  #:first-order get-first-order
  #:late-neg-projection late-neg-proj
  #:collapsible-late-neg-projection collapsible-late-neg-proj
  #:val-first-projection val-first-proj
  #:projection get-projection
  #:stronger stronger
  #:equivalent equivalent
  #:generate generate
  #:list-contract? is-list-contract?])
→ flat-contract-property?
 get-name : (or/c #f (-> contract? any/c))
          = (λ (c) 'anonymous-flat-contract)
 get-first-order : (-> contract? (-> any/c boolean?))
                 = (λ (c) (λ (x) #t))
 late-neg-proj : (or/c #f (-> contract? (-> blame? (-> any/c any/c any/c))))
               = #f
 collapsible-late-neg-proj : (or/c #f (-> contract? (-> blame? (values (-> any/c any/c any/
                           = #f
 val-first-proj : (or/c #f (-> contract? blame? (-> any/c (-> any/c any/c))))
                = #f
 get-projection : (-> contract? (-> blame? (-> any/c any/c)))
                = (λ (c)
                    (λ (b)
                      (λ (x)
                        (if ((get-first-order c) x)
                            x
                            (raise-blame-error
                             b x '(expected: "~a" given: "~e")
                             (get-name c) x)))))
 stronger : (or/c (-> contract? contract? boolean?) #f) = #f
 equivalent : (or/c #f (-> contract? contract? boolean?)) = #f
 generate : (->i ([c contract?])
                 [generator
                  (c)
                  (-> exact-nonnegative-integer?
                      (or/c (-> (or/c contract-random-generate-fail? c))
                            #f))])
          = (λ (c) (λ (fuel) #f))
 is-list-contract? : (-> contract? boolean?) = (λ (c) #f)
```

```
(build-chaperone-contract-property
 [#:name get-name
  #:first-order get-first-order
  #:late-neg-projection late-neg-proj
  #:collapsible-late-neg-projection collapsible-late-neg-proj
  #:val-first-projection val-first-proj
  #:projection get-projection
  #:stronger stronger
  #:equivalent equivalent
  #:generate generate
  #:exercise exercise
  #:list-contract? is-list-contract?])
→ chaperone-contract-property?
 get-name : (or/c #f (-> contract? any/c))
          = (λ (c) 'anonymous-chaperone-contract)
 get-first-order : (-> contract? (-> any/c boolean?))
                 = (λ (c) (λ (x) #t))
 late-neg-proj : (or/c #f (-> contract? (-> blame? (-> any/c any/c any/c))))
               = #f
 collapsible-late-neg-proj : (or/c #f (-> contract? (-> blame? (values (-> any/c any/c any/
                           = #f
 val-first-proj : (or/c #f (-> contract? blame? (-> any/c (-> any/c any/c))))
                = #f
 get-projection : (-> contract? (-> blame? (-> any/c any/c)))
                = (λ (c)
                    (λ (b)
                      (λ (x)
                        (if ((get-first-order c) x)
                            x
                            (raise-blame-error
                             b x '(expected: "~a" given: "~e")
                             (get-name c) x)))))
 stronger : (or/c (-> contract? contract? boolean?) #f) = #f
 equivalent : (or/c #f (-> contract? contract? boolean?)) = #f
 generate : (->i ([c contract?])
                 [generator
                  (c)
                  (-> exact-nonnegative-integer?
                      (or/c (-> (or/c contract-random-generate-fail? c))
                            #f))])
          = (λ (c) (λ (fuel) #f))
 exercise : (->i ([c contract?])
                 [result
                  (c)
                  (-> exact-nonnegative-integer?
                      (values
                       (-> c void?)
                       (listof contract?)))])
          = (λ (c) (λ (fuel) (values void '())))
 is-list-contract? : (-> contract? boolean?) = (λ (c) #f)
```

```
(build-contract-property
 [#:name get-name
  #:first-order get-first-order
  #:late-neg-projection late-neg-proj
  #:collapsible-late-neg-projection collapsible-late-neg-proj
  #:val-first-projection val-first-proj
  #:projection get-projection
  #:stronger stronger
  #:equivalent equivalent
  #:generate generate
  #:exercise exercise
  #:list-contract? is-list-contract?])
→ contract-property?
 get-name : (or/c #f (-> contract? any/c))
          = (λ (c) 'anonymous-contract)
 get-first-order : (-> contract? (-> any/c boolean?))
                 = (λ (c) (λ (x) #t))
 late-neg-proj : (or/c #f (-> contract? (-> blame? (-> any/c any/c any/c))))
               = #f
 collapsible-late-neg-proj : (or/c #f (-> contract? (-> blame? (values (-> any/c any/c any/
                           = #f
 val-first-proj : (or/c #f (-> contract? blame? (-> any/c (-> any/c any/c))))
                = #f
 get-projection : (-> contract? (-> blame? (-> any/c any/c)))
                = (λ (c)
                    (λ (b)
                      (λ (x)
                        (if ((get-first-order c) x)
                            x
                            (raise-blame-error
                             b x '(expected: "~a" given: "~e")
                             (get-name c) x)))))
 stronger : (or/c (-> contract? contract? boolean?) #f) = #f
 equivalent : (or/c #f (-> contract? contract? boolean?)) = #f
 generate : (->i ([c contract?])
                 [generator
                  (c)
                  (-> exact-nonnegative-integer?
                      (or/c (-> (or/c contract-random-generate-fail? c))
                            #f))])
          = (λ (c) (λ (fuel) #f))
 exercise : (->i ([c contract?])
                 [result
                  (c)
                  (-> exact-nonnegative-integer?
                      (values
                       (-> c void?)
                       (listof contract?)))])
          = (λ (c) (λ (fuel) (values void '())))
 is-list-contract? : (-> contract? boolean?) = (λ (c) #f)
```

These functions build the arguments for `prop:contract`, `prop:chaperone-contract`, and `prop:flat-contract`, respectively.

A *contract property* specifies the behavior of a structure when used as a contract. It is specified in terms of seven properties:

- *`get-name`* which produces a description to `write` as part of a contract violation and defaults to a function that always produces `'anonymous-contract`, `'anonymous-chaperone-contract`, or `'anonymous-flat-contract`;
- *`get-first-order`*, which produces a first-order predicate to be used by `contract-first-order-passes?`;
- *`late-neg-proj`*, which produces a blame-tracking projection defining the behavior of the contract (The *`get-projection`* and *`val-first-proj`* arguments also specify the projection, but using a different signature. They are here for backwards compatibility.);
- *`collapsible-late-neg-proj`*, similar to *`late-neg-proj`* which produces a blame-tracking projection defining the behavior of the contract, this function additionally specifies the collapsible behavior of the contract;
- *`stronger`*, a predicate that determines whether this contract (passed in the first argument) is stronger than some other contract (passed in the second argument) and whose default always returns `#f`;
- *`equivalent`*, a predicate that determines whether this contract (passed in the first argument) is equivalent to some other contract (passed in the second argument); the default for flat and chaperone contracts is `equal?` and for impersonator contracts returns `#f`;
- *`generate`*, which returns a thunk that generates random values matching the contract (using `contract-random-generate-fail`) to indicate failure) or `#f` to indicate that random generation for this contract isn't supported;
- *`exercise`*, which returns a function that exercises values matching the contract (e.g., if it is a function contract, it may call the function) and a list of contracts whose values will be generated by this process;
- and *`is-list-contract?`*, which is used by `flat-contract?` to determine if this contract accepts only `list?`s.

At least one of the *`late-neg-proj`*, *`collapsible-late-neg-proj`*, *`get-projection`*, *`val-first-proj`*, or *`get-first-order`* must be non-`#f`.

These accessors are passed as (optional) keyword arguments to `build-contract-property`, and are applied to instances of the appropriate structure type by the contract system. Their results are used analogously to the arguments of `make-contract`.

A *chaperone contract property* specifies the behavior of a structure when used as a chaperone contract. It is specified using `build-chaperone-contract-property`, and accepts exactly the same set of arguments as `build-contract-property`. The only difference is that the projection accessor must return a value that passes `chaperone-of?` when compared with the original, uncontracted value.

A *flat contract property* specifies the behavior of a structure when used as a flat contract. It is specified using `build-flat-contract-property`, and accepts similar arguments as `build-contract-property`. The differences are:

- the projection accessor is expected not to wrap its argument in a higher-order fashion, analogous to the constraint on projections in `make-flat-contract`;
- the `#:exercise` keyword argument is omitted because it is not relevant for flat contracts.

Changed in version 6.0.1.13 of package `base`: Added the `#:list-contract?` argument.
Changed in version 6.1.1.4: Allow *`generate`* to return `contract-random-generate-fail`.
Changed in version 6.90.0.30: Added the `#:equivalent` argument.
Changed in version 7.1.0.10: Added the `#:collapsible-late-neg-projection` argument.

```
(contract-property? v) → boolean?
  v : any/c
(chaperone-contract-property? v) → boolean?
  v : any/c
(flat-contract-property? v) → boolean?
  v : any/c
```

These predicates detect whether a value is a contract property, chaperone contract property, or a flat contract property, respectively.

8.7.3 Obligation Information in Check Syntax

Check Syntax in DrRacket shows obligation information for contracts according to `syntax-property`s that the contract combinators leave in the expanded form of the program. These properties indicate where contracts appear in the source and where the positive and negative positions of the contracts appear.

To make Check Syntax show obligation information for your new contract combinators, use the following properties (some helper macros and functions are below):

- `'racket/contract:contract : (vector/c symbol? (listof syntax?) (listof syntax?))`

This property should be attached to the result of a transformer that implements a contract combinator. It signals to Check Syntax that this is where a contract begins.

The first element in the vector should be a unique (in the sense of `eq?`) value that Check Syntax can use a tag to match up this contract with its subpieces (specified by the two following syntax properties).

The second and third elements of the vector are syntax objects from pieces of the contract, and Check Syntax will color them. The first list should contain subparts that are the responsibility of parties (typically modules) that provide implementations of the contract. The second list should contain subparts that are the responsibility of clients.

For example, in `(->* () #:pre #t any/c #:post #t)`, the `->*` and the `#:post` should be in the first list and `#:pre` in the second list.

- `'racket/contract:negative-position : symbol?`

  This property should be attached to sub-expressions of a contract combinator that are expected to be other contracts. The value of the property should be the key (the first element from the vector for the `'racket/contract:contract` property) indicating which contract this is.

  This property should be used when the expression's value is a contract that clients are responsible for.

- `'racket/contract:positive-position : symbol?`

  This form is just like `'racket/contract:negative-position`, except that it should be used when the expression's value is a contract that the original party should be responsible for.

- `'racket/contract:contract-on-boundary : symbol?`

  The presence of this property tells Check Syntax that it should start coloring from this point. It expects the expression to be a contract (and, thus, to have the `'racket/contract:contract` property); this property indicates that this contract is on a (module) boundary.

  (The value of the property is not used.)

- `'racket/contract:internal-contract : symbol?`

  Like `'racket/contract:contract-on-boundary`, the presence of this property triggers coloring, but this is meant for use when the party (module) containing the contract (regardless of whether or not this module exports anything matching the contract) can be blamed for violating the contract. This comes into play for `->i` contracts, since the contract itself has access to values under contract via the dependency.

```
(define/final-prop header body ...)

header = main-id
       | (main-id id ...)
       | (main-id id ... . id)
```

The same as (define *header* *body* ...), except that uses of *main-id* in the header are annotated with the 'racket/contract:contract property (as above).

```
(define/subexpression-pos-prop header body ...)

header = main-id
       | (main-id id ...)
       | (main-id id ... . id)
```

The same as (define *header* *body* ...), except that uses of *main-id* in the header are annotated with the 'racket/contract:contract property (as above) and arguments are annotated with the 'racket/contract:positive-position property.

8.7.4 Utilities for Building New Combinators

```
(contract-stronger? c1 c2) → boolean?
  c1 : contract?
  c2 : contract?
```

Returns #t if the contract *c1* accepts either fewer or the same set of values that *c2* does.

Chaperone contracts and flat contracts that are the same (i.e., where *c1* is equal? to *c2*) are considered to always be stronger than each other.

This function is conservative, so it may return #f when *c1* does, in fact, accept fewer values.

Examples:

```
> (contract-stronger? integer? integer?)
#t
> (contract-stronger? (between/c 25 75) (between/c 0 100))
#t
> (contract-stronger? (between/c 0 100) (between/c 25 75))
#f
> (contract-stronger? (between/c -10 0) (between/c 0 10))
#f
> (contract-stronger? (λ (x) (and (real? x) (<= x 0)))
                      (λ (x) (and (real? x) (<= x 100))))
#f
```

```
(contract-equivalent? c1 c2) → boolean?
  c1 : contract?
  c2 : contract?
```

Returns #t if the contract *c1* accepts the same set of values that *c2* does.

Chaperone contracts and flat contracts that are the same (i.e., where *c1* is equal? to *c2*) are considered to always be equivalent to each other.

This function is conservative, so it may return #f when *c1* does, in fact, accept the same set of values that *c2* does.

Examples:

```
> (contract-equivalent? integer? integer?)
#t
> (contract-equivalent? (non-empty-listof integer?)
                        (cons/c integer? (listof integer?)))
#t
> (contract-equivalent? (λ (x) (and (real? x) (and (number? x) (>= (sqr x) 0))))
                        (λ (x) (and (real? x) (real? x))))
#f
```

Added in version 6.90.0.30 of package base.

```
(contract-first-order-passes? contract v) → boolean?
  contract : contract?
  v : any/c
```

Returns a boolean indicating whether the first-order tests of *contract* pass for *v*.

If it returns #f, the contract is guaranteed not to hold for that value; if it returns #t, the contract may or may not hold. If the contract is a first-order contract, a result of #t guarantees that the contract holds.

See also contract-first-order-okay-to-give-up? and contract-first-order-try-less-hard.

```
(contract-first-order c) → (-> any/c boolean?)
  c : contract?
```

Produces the first-order test used by or/c to match values to higher-order contracts.

8.8 Contract Utilities

```
(contract? v) → boolean?
  v : any/c
```

Returns #t if its argument is a contract (i.e., constructed with one of the combinators described in this section or a value that can be used as a contract) and #f otherwise.

```
(chaperone-contract? v) → boolean?
  v : any/c
```

Returns `#t` if its argument is a chaperone contract, i.e., one that guarantees that it returns a value which passes `chaperone-of?` when compared to the original, uncontracted value.

```
(impersonator-contract? v) → boolean?
  v : any/c
```

Returns `#t` if its argument is an impersonator contract, i.e., a contract that is neither a chaperone contract nor a flat contract.

```
(flat-contract? v) → boolean?
  v : any/c
```

Returns `#t` when its argument is a contract that can be checked immediately (unlike, say, a function contract).

For example, `flat-contract` constructs flat contracts from predicates, and symbols, booleans, numbers, and other ordinary Racket values (that are defined as contracts) are also flat contracts.

```
(list-contract? v) → boolean?
  v : any/c
```

Recognizes certain `contract?` values that accept `list?`s.

A list contract is one that insists that its argument is a `list?`, meaning that the value cannot be cyclic and must either be the empty list or a pair constructed with `cons` and another list.

Added in version 6.0.1.13 of package `base`.

```
(contract-name c) → any/c
  c : contract?
```

Produces the name used to describe the contract in error messages.

```
(value-contract v) → (or/c contract? #f)
  v : has-contract?
```

Returns the contract attached to *v*, if recorded. Otherwise it returns `#f`.

To support `value-contract` and `value-contract` in your own contract combinators, use `prop:contracted` or `impersonator-prop:contracted`.

```
(has-contract? v) → boolean?
  v : any/c
```

Returns `#t` if `v` is a value that has a recorded contract attached to it.

```
(value-blame v) → (or/c blame? #f)
  v : has-blame?
```

Returns the blame object for the contract attached to `v`, if recorded. Otherwise it returns `#f`.

To support `value-contract` and `value-blame` in your own contract combinators, use `prop:blame` or `impersonator-prop:blame`.

Added in version 6.0.1.12 of package `base`.

```
(has-blame? v) → boolean?
  v : any/c
```

Returns `#t` if `v` is a value that has a contract with blame information attached to it.

Added in version 6.0.1.12 of package `base`.

```
(contract-late-neg-projection c)
 → (-> blame? (-> any/c (or/c #f any/c) any/c))
  c : contract?
```

Produces the projection defining a contract's behavior.

The first argument, `blame?` object encapsulates information about the contract checking, mostly used to create a meaningful error message if a contract violation is detected. The resulting function's first argument is the value that should have the contract and its second argument is a missing party for the blame object, to be passed to `raise-contract-error`.

If possible, use this function instead of `contract-val-first-projection` or `contract-projection`.

```
(contract-projection c) → (-> blame? (-> any/c any/c))
  c : contract?
```

Produces a projection defining a contract's behavior. This projection is a curried function of two arguments: the first application accepts a blame object, and the second accepts a value to protect with the contract.

If possible, use `contract-late-neg-projection` instead.

```
(contract-val-first-projection c)
 → (-> blame? (-> any/c (-> any/c any/c)))
  c : contract?
```

Produces a projection defining a contract's behavior. This projection is similar to the result of `contract-late-neg-projection` except with an extra layer of currying.

If possible, use `contract-late-neg-projection` instead.

```
(make-none/c sexp-name) → contract?
  sexp-name : any/c
```

Makes a contract that accepts no values, and reports the name *`sexp-name`* when signaling a contract violation.

```
(recursive-contract contract-expr recursive-contract-option ...)
(recursive-contract contract-expr type recursive-contract-option ...)

recursive-contract-option = #:list-contract?
                          | #:extra-delay

                     type = #:impersonator
                          | #:chaperone
                          | #:flat
```

Delays the evaluation of its argument until the contract is checked, making recursive contracts possible. If *`type`* is not given, an impersonator contract is created.

If the *`recursive-contract-option`* `#:list-contract?` is given, then the result is a `list-contract?` and the *`contract-expr`* must evaluate to a `list-contract?`.

If the *`recursive-contract-option`* `#:extra-delay` is given, then the *`contract-expr`* expression is evaluated only when the first value to be checked against the contract is supplied to the contract. Without it, the *`contract-expr`* is evaluated earlier. This option is supported only when *`type`* is `#:flat`.

Examples:

```
> (define even-length-list/c
    (or/c null?
          (cons/c any/c
                  (cons/c any/c
                          (recursive-contract even-length-
list/c #:flat)))))
> (even-length-list/c '(A B))
```

```
#t
> (even-length-list/c '(1 2 3))
#f
```

Changed in version 6.0.1.13 of package `base`: Added the `#:list-contract?` option.
Changed in version 6.7.0.3: Added the `#:extra-delay` option.

```
(opt/c contract-expr maybe-name)

maybe-name =
           | #:error-name id
```

This optimizes its argument contract expression by traversing its syntax and, for known contract combinators, fuses them into a single contract combinator that avoids as much allocation overhead as possible. The result is a contract that should behave identically to its argument, except faster.

If the `#:error-name` argument is present, and *`contract-expr`* evaluates to a non-contract expression, then `opt/c` raises an error using *`id`* as the name of the primitive, instead of using the name `opt/c`.

Examples:

```
> (define/contract (f x)
    (opt/c '(not-a-contract))
    x)
opt/c: contract violation
  expected: contract?
  given: '(not-a-contract)
> (define/contract (f x)
    (opt/c '(not-a-contract) #:error-name define/contract)
    x)
define/contract: contract violation
  expected: contract?
  given: '(not-a-contract)
```

```
(define-opt/c (id id ...) expr)
```

This defines a recursive contract and simultaneously optimizes it. As long as the defined function terminates, `define-opt/c` behaves just as if the `-opt/c` were not present, defining a function on contracts (except that the body expression must return a contract). But, it also optimizes that contract definition, avoiding extra allocation, much like `opt/c` does.

For example,

```
(define-contract-struct bt (val left right))

(define-opt/c (bst-between/c lo hi)
  (or/c null?
        (bt/c [val (real-in lo hi)]
              [left (val) (bst-between/c lo val)]
              [right (val) (bst-between/c val hi)])))

(define bst/c (bst-between/c -inf.0 +inf.0))
```

defines the `bst/c` contract that checks the binary search tree invariant. Removing the `-opt/c` also makes a binary search tree contract, but one that is (approximately) 20 times slower.

Note that in some cases, a call to a function defined by `define-opt/c` may terminate, even if the corresponding `define`-based function would not terminate. This is a shortcoming in `define-opt/c` that we hope to understand and fix at some point, but have no concrete plans currently.

```
contract-continuation-mark-key : continuation-mark-key?
```

Key used by continuation marks that are present during contract checking. The value of these marks are the blame objects that correspond to the contract currently being checked.

Added in version 6.4.0.4 of package `base`.

```
(contract-custom-write-property-proc c
                                     p
                                     mode) → void?
  c : contract?
  p : output-port?
  mode : (or/c #f #t 0 1)
```

Prints *c* to *p* using the contract's name.

Added in version 6.1.1.5 of package `base`.

```
(rename-contract contract name) → contract?
  contract : contract?
  name : any/c
```

Produces a contract that acts like *contract* but with the name *name*.

The resulting contract is a flat contract if *contract* is a flat contract.

Added in version 6.3 of package `base`.

```
(contract-first-order-okay-to-give-up?)
```

This form returns a boolean that controls the result of first-order contact checks. More specifically, if it returns `#t`, then a first-order check may return `#t` even when the entire first-order checks have not happened. If it returns `#f` then the first order checks must continue until a definitive answer is returned.

This will only return `#t` in the dynamic extent of `or/c` or `first-or/c`'s checking to determine which branch to use.

Added in version 6.3.0.9 of package `base`.

```
(contract-first-order-try-less-hard e)
```

Encourages first-order checks that happen in the dynamic-extent of `e` to be more likely to give up. That is, makes it more likely that `contract-first-order-okay-to-give-up?` might return `#t`.

If not in the dynamic-extent of `or/c`'s or `first-or/c`'s checking to determine the branch, then this form has no effect.

Added in version 6.3.0.9 of package `base`.

```
(if/c predicate then-contract else-contract) → contract?
  predicate : (-> any/c any/c)
  then-contract : contract?
  else-contract : contract?
```

Produces a contract that, when applied to a value, first tests the value with *`predicate`*; if *`predicate`* returns true, the *`then-contract`* is applied; otherwise, the *`else-contract`* is applied. The resulting contract is a flat contract if both *`then-contract`* and *`else-contract`* are flat contracts.

For example, the following contract enforces that if a value is a procedure, it is a thunk; otherwise it can be any (non-procedure) value:

```
(if/c procedure? (-> any) any/c)
```

Note that the following contract is **not** equivalent:

```
(or/c (-> any) any/c) ; wrong!
```

The last contract is the same as `any/c` because `or/c` tries flat contracts before higher-order contracts.

Added in version 6.3 of package `base`.

```
failure-result/c : contract?
```

A contract that describes the failure result arguments of procedures such as `hash-ref`.

Equivalent to `(if/c procedure? (-> any) any/c)`.

Added in version 6.3 of package `base`.

```
(get/build-val-first-projection c)
 → (-> blame? (-> any/c (-> any/c any/c)))
  c : contract?
```

Returns the *`val-first`* projection for *`c`*.

See `make-contract` for more details.

Added in version 6.1.1.5 of package `base`.

```
(get/build-late-neg-projection c)
 → (-> blame? (-> any/c any/c any/c))
  c : contract?
```

Returns the *`late-neg`* projection for *`c`*.

If *`c`* does not have a *`late-neg`* contract, then this function uses the original projection for it and logs a warning to the `'racket/contract` logger.

See `make-contract` for more details.

Added in version 6.2.900.11 of package `base`.

8.9 racket/contract/base

```
(require racket/contract/base)    package: base
```

The `racket/contract/base` module provides a subset of the exports of `racket/contract` module. In particular, it contains everything in the

- §8.1 “Data-structure Contracts”
- §8.2 “Function Contracts”
- §8.6 “Attaching Contracts to Values” and

- §8.8 “Contract Utilities” sections.

Unfortunately, using racket/contract/base does not yield a significantly smaller memory footprint than racket/contract, but it can still be useful to add contracts to libraries that racket/contract uses to implement some of the more sophisticated parts of the contract system.

8.10 Collapsible Contracts

```
(require racket/contract/collapsible)        package: base
```

Added in version 7.1.0.10 of package base.

Collapsible contracts are an optimization in the contract system designed to avoid a particular pathological build up of contract wrappers on higher-order values. The vectorof, vector/c, and -> contract combinators support collapsing for vector contracts and function contracts for functions returning a single value.

Intuitively, a collapsible contract is a tree structure. The tree nodes represent higher-order contracts (e.g., ->) and the tree leaves represent sequences of flat contracts. Two trees can collapse into one tree via the merge procedure, which removes unnecessary flat contracts from the leaves.

For more information on the motivation and design of collapsible contracts, see [Feltey18]. For the theoretical foundations, see [Greenberg15].

Warning: the features described in this section are experimental and may not be sufficient to implement new collapsible contracts. Implementing new collapsible contracts requires the use of unsafe chaperones and impersonators which are only supported for vector and procedure values. This documentation exists primarily to allow future maintenance of the racket/contract/collapsible library. **End Warning**

```
(get/build-collapsible-late-neg-projection c)
 → (-> blame? (values (-> any/c any/c any/c) collapsible-contract?))
  c : contract?
```

Returns the *collapsible-late-neg* projection for *c*.

If *c* does not have a *collapsible-late-neg* projection, then this function uses the original projection for it and constructs a leaf as its collapsible representation.

```
collapsible-contract-continuation-mark-key
 : continuation-mark-key?
```

Key used by continuation marks that are present during collapsible contract checking. The value of these marks are #t if the current contract is collapsible.

```
(with-collapsible-contract-continuation-mark body ...)
```

Inserts a continuation mark that informs the contract profiler that the current contract is collapsible.

```
prop:collapsible-contract : struct-type-property?
```

Structures implementing this property are usable as collapsible contracts. The value associated with this property should be constructed by calling `build-collapsible-contract-property`.

```
(collapsible-contract? v) → boolean?
  v : any/c
```

A predicate recognizing structures with the `prop:collapsible-contract` property.

```
(merge new-cc new-neg old-cc old-neg) → collapsible-contract?
  new-cc : collapsible-contract?
  new-neg : any/c
  old-cc : collapsible-contract?
  old-neg : any/c
```

Combine two collapsible contracts into a single collapsible contract. The *new-neg* and *old-neg* arguments are expected to be blame parties similar to those passed to a late neg projection.

```
(collapsible-guard cc val neg-party) → any/c
  cc : collapsible-contract?
  val : any/c
  neg-party : any/c
```

Similar to a late neg projection, this function guards the value *val* with the collapsible contract *cc*.

```
(collapsible-contract-property? v) → boolean?
  v : any/c
```

This predicate indicates that a value can be used as the property for `prop:collapsible-contract`.

```
(build-collapsible-contract-property
 [#:try-merge try-merge
  #:collapsible-guard collapsible-guard])
→ collapsible-contract-property?
```

```
try-merge : (or/c #f                                       = #f
                  (-> collapsible-contract?
                      any/c
                      collapsible-contract?
                      any/c
                      (or/c #f collapsible-contract?)))
collapsible-guard :  (-> collapsible-contract? any/c any/c any/c)
                  = (λ (cc v neg)
                      (error
                       "internal error: contract does not support `collapsible-guard`" cc))
```

Constructs a *collapsible contract property* from a merging function and a guard. The `try-merge` argument is similar to `merge`, but may return `#f` instead of a collapsible contract and may be specialized to a particular collapsible contract. The `collapsible-guard` argument should be specialized to the particular collapsible contract being implemented.

```
(struct collapsible-ho/c (latest-blame missing-party latest-ctc))
  latest-blame : blame?
  missing-party : any/c
  latest-ctc : contract?
```

A common parent structure for collapsible contracts for higher-order values. The `latest-blame` field holds the blame object for the most recent contract attached. Similarly, the `missing-party` field holds the latest missing party passed to the contract. The `latest-contract` field stores the most recent contract attached to the value.

```
(struct collapsible-leaf/c (proj-list
                            contract-list
                            blame-list
                            missing-party-list))
  proj-list : (listof (-> any/c any/c any/c))
  contract-list : (listof contract?)
  blame-list : (listof blame?)
  missing-party-list : (listof any/c)
```

A structure representing the leaf nodes of a collapsible contract. The `proj-list` field holds a list of partially applied late neg projections. The `contract-list`, `blame-list`, and `missing-party-list` fields hold a list of contracts, blame objects, and blame missing parties respectively.

```
impersonator-prop:collapsible : impersonator-property?
(has-impersonator-prop:collapsible? v) → boolean?
  v : any/c
(get-impersonator-prop:collapsible v) → collapsible-property?
  v : any/c
```

An impersonator property (and its accessors) that should be attached to chaperoned or impersonated values that are guarded with a collapsible contract.

```
(struct collapsible-property (c-c neg-party ref))
  c-c : collapsible-contract?
  neg-party : any/c
  ref : (or/c #f impersonator?)
```

The parent struct of properties that should be attached to chaperones or impersonators of values protected with a collapsible contract. The `c-c` field stores the collapsible contract that is or will in the future be attached to the value. The `neg-party` field stores the latest missing blame party passed to the contract on the value. The `ref` field is mutable and stores a reference to the chaperone or impersonator to which this property is attached. This is necessary to determine whether an unknown chaperone has been attached to a value after it has been protected by a collapsible contract.

```
(struct collapsible-count-property collapsible-property (count
                                                         prev))
  count : natural-number/c
  prev : (or/c collapsible-count-property? any/c)
```

This property is associated with the `impersonator-prop:collapsible` property before the value completely enters the collapsible mode. These properties keep track of the number of contracts on a value in the *count* field, and hold a reference to the previous *count property* in the `prev` field or the original value without a contract. This allows the contract system to traverse the chain of attached contracts and merge them into a single collapsible contract to protect the original value.

```
(struct collapsible-wrapper-property collapsible-property
        (checking-wrapper)
  checking-wrapper : impersonator?
```

This property is used when a value is guarded by a collapsible contract. The `checking-wrapper` field holds a chaperone or impersonator that dispatches to the collapsible contract stored in this property to perform any necessary contract checks. When the value receives another contract and merging happens, the checking wrapper will remain the same even though the specific collapsible contract attached to the value may change.

8.11 Legacy Contracts

```
(make-proj-contract name proj first-order) → contract?
  name : any/c
```

```
proj : (or/c (-> any/c
                 any/c
                 (list/c any/c any/c)
                 contact?
                 (-> any/c any/c))
             (-> any/c
                 any/c
                 (list/c any/c any/c)
                 contact?
                 boolean?
                 (-> any/c any/c)))
first-order : (-> any/c boolean?)
```

Builds a contract using an old interface.

Modulo errors, it is equivalent to:

```
(make-contract
 #:name name
 #:first-order first-order
 #:projection
 (cond
   [(procedure-arity-includes? proj 5)
    (lambda (blame)
      (proj (blame-positive blame)
            (blame-negative blame)
            (list (blame-source blame) (blame-value blame))
            (blame-contract blame)
            (not (blame-swapped? blame))))]
   [(procedure-arity-includes? proj 4)
    (lambda (blame)
      (proj (blame-positive blame)
            (blame-negative blame)
            (list (blame-source blame) (blame-value blame))
            (blame-contract blame)))]))
```

```
(raise-contract-error val
                      src
                      pos
                      name
                      fmt
                      arg ...) → any/c
  val : any/c
  src : any/c
  pos : any/c
  name : any/c
```

```
fmt : string?
arg : any/c
```

Calls `raise-blame-error` after building a `blame` struct from the *val*, *src*, *pos*, and *name* arguments. The *fmt* string and following arguments are passed to `format` and used as the string in the error message.

```
(contract-proc c)
 → (->* (symbol? symbol? (or/c syntax? (list/c any/c any/c)))
        (boolean?)
        (-> any/c any))
  c : contract?
```

Constructs an old-style projection from a contract.

The resulting function accepts the information that is in a `blame` struct and returns a projection function that checks the contract.

8.12 Random generation

```
(contract-random-generate ctc [fuel fail]) → any/c
  ctc : contract?
  fuel : 5 = exact-nonnegative-integer?
  fail : (or/c #f (-> any) (-> boolean? any)) = #f
```

Attempts to randomly generate a value which will match the contract. The *fuel* argument limits how hard the generator tries to generate a value matching the contract and is a rough limit of the size of the resulting value.

The generator may fail to generate a value, either because some contracts do not have corresponding generators (for example, not all predicates have generators) or because there is not enough fuel. In either case, the function *fail* is invoked. If *fail* accepts an argument, it is called with `#t` when there is no generator for *ctc* and called with `#f` when there is a generator, but the generator ended up returning `contract-random-generate-fail`.

Example:

```
> (for/list ([i (in-range 10)])
    (contract-random-generate (or/c integer? #f)))
'(197.0 #f #f 650117401 -65 163.0 1477030367.0 #f #f #f)
```

Changed in version 6.1.1.5 of package `base`: Allow *fail* to accept a boolean.

```
(contract-exercise [#:fuel fuel
                    #:shuffle? shuffle?]
                    val ...+)          → void?
  fuel : exact-nonnegative-integer? = 10
  shuffle? : any/c = #f
  val : any/c
```

Attempts to get the `val`s to break their contracts (if any).

Uses `value-contract` to determine if any of the `val`s have a contract and, for those that do, uses information about the contract's shape to poke and prod at the value. For example, if the value is function, it will use the contract to tell it what arguments to supply to the value.

The argument `fuel` determines how hard `contract-exercise` tries to break the values. It controls both the number of exercise iterations and the size of the intermediate values generated during the exercises.

The argument `shuffle?` controls whether `contract-exercise` randomizes the exercise order or not. If `shuffle?` is not `#f`, `contract-exercise` would shuffle the order of the contracts in each exercise iteration.

Examples:

```
> (define/contract (returns-false x)
    (-> integer? integer?)
    ; does not obey its contract
    #f)
> (contract-exercise returns-false)
returns-false: broke its own contract
  promised: integer?
  produced: #f
  in: the range of
      (-> integer? integer?)
  contract from: (function returns-false)
  blaming: (function returns-false)
   (assuming the contract is correct)
  at: eval:2:0
> (define/contract (calls-its-argument-with-eleven f)
    (-> (-> integer? integer?) boolean?)
    ; f returns an integer, but
    ; we're supposed to return a boolean
    (f 11))
> (contract-exercise calls-its-argument-with-eleven)
calls-its-argument-with-eleven: broke its own contract
  promised: boolean?
  produced: 11
```

in: the range of
(-> (-> integer? integer?) boolean?)
contract from:
(function calls-its-argument-with-eleven)
blaming: (function calls-its-argument-with-eleven)
(assuming the contract is correct)
at: eval:4:0

Changed in version 7.0.0.18 of package `base`: Added the *`shuffle?`* optional argument.

```
(contract-random-generate/choose c fuel) → (or/c #f (-> c))
  c : contract?
  fuel : exact-nonnegative-integer?
```

This function is like `contract-random-generate`, but it is intended to be used with combinators that generate values based on sub-contracts they have. It must be called when `contract-random-generate` (and `contract-exercise`) creates the generators. To be more precise, `contract-random-generate/choose` is available only for the *`generate`* and *`exercise`* arguments in `build-contract-property`, `build-chaperone-contract-property` or `build-flat-contract-property` and only during the dynamic extent of the call to *`generate`* (and *`exercise`*). That is, after it receives the *`c`* and *`fuel`* arguments and before it returns the thunk (or the exerciser).

`contract-random-generate/choose` will never fail, but it might escape back to an enclosing call or to the original call to `contract-random-generate`.

It chooses one of several possible generation strategies, and thus it may not actually use the generator associated with *`c`*, but might instead use a stashed value that matches *`c`* that it knows about via `contract-random-generate-stash`.

Added in version 6.1.1.5 of package `base`.

```
contract-random-generate-fail : contract-random-generate-fail?
```

An atomic value that is used to indicate that a generator failed to generate a value.

Added in version 6.1.1.5 of package `base`.

```
(contract-random-generate-fail? v) → boolean?
  v : any/c
```

A predicate to recognize `contract-random-generate-fail`.

Added in version 6.1.1.5 of package `base`.

```
(contract-random-generate-env? v) → boolean?
  v : any/c
```

Recognizes contract generation environments.

Added in version 6.1.1.5 of package base.

```
(contract-random-generate-stash env c v) → void?
  env : contract-random-generate-env?
  c : contract?
  v : c
```

This should be called with values that the program under test supplies during contract generation. For example, when `(-> (-> integer? integer?) integer?)` is generated, it may call its argument function. That argument function may return an integer and, if so, that integer should be saved by calling `contract-random-generate-stash`, so it can be used by other integer generators.

Added in version 6.1.1.5 of package base.

```
(contract-random-generate-get-current-environment)
 → contract-random-generate-env?
```

Returns the environment currently being used for generation. This function can be called only during the dynamic extent of contract generation. It is intended to be grabbed during the construction of a contract generator and then used with `contract-random-generate-stash` while generation is happening.

Added in version 6.1.1.5 of package base.

9 Pattern Matching

§12 "Pattern Matching" in *The Racket Guide* introduces pattern matching.

The `match` form and related forms support general pattern matching on Racket values. See also §4.8 "Regular Expressions" for information on regular-expression matching on strings, bytes, and streams.

```
(require racket/match)        package: base
```

The bindings documented in this section are provided by the `racket/match` and `racket` libraries, but not `racket/base`.

```
(match val-expr clause ...)

  clause = [pat option=> option ... body ...+]

option=> =
         | (=> id)

  option = #:when cond-expr
         | #:do [do-body ...]
```

Finds the first *pat* that matches the result of *val-expr*, and evaluates the corresponding *body*s with bindings introduced by *pat* (if any). Bindings introduced by *pat* are not available in other parts of *pat*. The last *body* in the matching clause is evaluated in tail position with respect to the `match` expression.

To find a match, the *clause*s are tried in order. If no *clause* matches, then the `exn:misc:match?` exception is raised.

An optional `#:when` *cond-expr* specifies that the pattern should only match if *cond-expr* produces a true value. *cond-expr* is in the scope of all of the variables bound in *pat*. *cond-expr* must not mutate the object being matched before calling the failure procedure, otherwise the behavior of matching is unpredictable. See also `failure-cont`, which is a lower-level mechanism achieving the same ends.

Examples:

```
> (define (m x)
    (match x
      [(list a b c)
       #:when (= 6 (+ a b c))
       'sum-is-six]
      [(list a b c) 'sum-is-not-six]))
> (m '(1 2 3))
'sum-is-six
> (m '(2 3 4))
'sum-is-not-six
```

An optional `#:do [do-body ...]` executes *do-body* forms. In particular, the forms may introduce definitions that are visible in the remaining options and the main clause body. Both `#:when` and `#:do` options may appear multiple times

Examples:

```
> (define (m x)
    (match x
      [(list a b c)
       #:do [(define sum (+ a b c))]
       #:when (> sum 6)
       (format "the sum, which is ~a, is greater than 6" sum)]
      [(list a b c) 'sum-is-not-greater-than-six]))
> (m '(1 2 3))
'sum-is-not-greater-than-six
> (m '(2 3 4))
"the sum, which is 9, is greater than 6"
```

An optional `(=> id)`, which must appear immediately after *pat*, is bound to a *failure procedure* of zero arguments. *id* is visible in all clause options and the clause body. If this procedure is invoked, it escapes back to the pattern matching expression, and resumes the matching process as if the pattern had failed to match. The *body*s must not mutate the object being matched before calling the failure procedure, otherwise the behavior of matching is unpredictable.

Examples:

```
> (define (m x)
    (match x
      [(list a b c)
       (=> exit)
       (f x exit)]
      [(list a b c) 'sum-is-not-six]))
> (define (f x exit)
    (if (= 6 (apply + x))
        'sum-is-six
        (exit)))
> (m '(1 2 3))
'sum-is-six
> (m '(2 3 4))
'sum-is-not-six
```

The grammar of *pat* is as follows, where non-italicized identifiers are recognized symbolically (i.e., not by binding).

pat	::= *id*	match anything, bind identifier

```
            | (var id)                                 match anything, bind identifier
            | _                                        match anything
            | literal                                  match literal
            | (quote datum)                            match equal? value
            | (list lvp ...)                           match sequence of lvps
            | (list-rest lvp ... pat)                  match lvps consed onto a pat
            | (list* lvp ... pat)                      match lvps consed onto a pat
            | (list-no-order pat ...)                  match pats in any order
            | (list-no-order pat ... lvp)              match pats in any order
            | (vector lvp ...)                         match vector of pats
            | (hash expr pat ... ... ht-opt)           match hash table
            | (hash* [expr pat kv-opt] ... ht-opt)     match hash table
            | (hash-table (pat pat) ...)               match hash table - deprecated
            | (hash-table (pat pat) ...+ ooo)          match hash table - deprecated
            | (cons pat pat)                           match pair of pats
            | (mcons pat pat)                          match mutable pair of pats
            | (box pat)                                match boxed pat
            | (struct-id pat ...)                      match struct-id instance
            | (struct struct-id (pat ...))             match struct-id instance
            | (regexp rx-expr)                         match string
            | (regexp rx-expr pat)                     match string, result with pat
            | (pregexp px-expr)                        match string
            | (pregexp px-expr pat)                    match string, result with pat
            | (and pat ...)                            match when all pats match
            | (or pat ...)                             match when any pat match
            | (not pat ...)                            match when no pat matches
            | (app expr pats ...)                      match (expr value) output values to pats
            | (? expr pat ...)                         match if (expr value) and pats
            | (quasiquote qp)                          match a quasipattern
            | derived-pattern                          match using extension
literal    ::= #t                                      match true
            | #f                                       match false
            | string                                   match equal? string
            | bytes                                    match equal? byte string
            | number                                   match equal? number
            | char                                     match equal? character
            | keyword                                  match equal? keyword
            | regexp                                   match equal? regexp literal
            | pregexp                                  match equal? pregexp literal
lvp        ::= pat ooo                                 greedily match pat instances
            | pat                                      match pat
qp         ::= literal                                 match literal
            | id                                       match symbol
            | (qp ...)                                 match sequences of qps
            | (qp ... . qp)                            match qps ending qp
            | (qp ooo . qp)                            match qps beginning with repeated qp
```

```
        | #(qp ...)                       match vector of qps
        | #&qp                            match boxed qp
        | #s(prefab-key qp ...)           match prefab struct with qp fields
        | ,pat                            match pat
        | ,@(list lvp ...)                match lvps, spliced
        | ,@(list-rest lvp ... pat)       match lvps plus pat, spliced
        | ,@'qp                           match list-matching qp, spliced
ooo    ::= ...                            zero or more; ... is literal
        | ___                             zero or more
        | ..k                             k or more
        | __k                             k or more
kv-opt ::=                                key must exist
        | #:default def-expr              key may not exist; match def-expr with the value patte
ht-opt ::=                                default mode
        | #:closed                        closed to extension mode
        | #:open                          open to extension mode
        | #:rest pat                      residue mode
```

In more detail, patterns match as follows:

- *id* (excluding the reserved names `_`, `...`, `___`, `..k`, and `__k` for non-negative integers *k*)

  Unlike in `cond` and `case`, `else` is not a keyword in `match`. Use the `_` pattern for the “else” clause.

  or `(var id)` — matches anything, and binds *id* to the matching values. If an *id* is used multiple times within a pattern, the corresponding matches must be the same according to `(match-equality-test)`, except that instances of an *id* in different `or` and `not` sub-patterns are independent. The binding for *id* is not available in other parts of the same pattern.

  Examples:

  ```
  > (match '(1 2 3)
      [(list a b a) (list a b)]
      [(list a b c) (list c b a)])
  '(3 2 1)
  > (match '(1 (x y z) 1)
      [(list a b a) (list a b)]
      [(list a b c) (list c b a)])
  '(1 (x y z))
  > (match #f
      [else
       (cond
         [#f 'not-evaluated]
         [else 'also-not-evaluated])])
  ```

- `_` — matches anything, without binding any identifiers.

  Example:

```
> (match '(1 2 3)
    [(list _ _ a) a])
3
```

- #t, #f, *string*, *bytes*, *number*, *char*, or (quote *datum*) — matches an equal? constant.

  Example:

  ```
  > (match "yes"
      ["no" #f]
      ["yes" #t])
  #t
  ```

- (list *lvp* ...) — matches a list of elements. In the case of (list *pat* ...), the pattern matches a list with as many elements as *pat*s, and each element must match the corresponding *pat*. In the more general case, each *lvp* corresponds to a "spliced" list of greedy matches.

  For spliced lists, ... and ___ are aliases for zero or more matches. The ..*k* and __*k* forms are also aliases, specifying *k* or more matches. Pattern variables that precede these splicing operators are bound to lists of matching forms.

  Examples:

  ```
  > (match '(1 2 3)
      [(list a b c) (list c b a)])
  '(3 2 1)
  > (match '(1 2 3)
      [(list 1 a ...) a])
  '(2 3)
  > (match '(1 2 3)
      [(list 1 a ..3) a]
      [_ 'else])
  'else
  > (match '(1 2 3 4)
      [(list 1 a ..3) a]
      [_ 'else])
  '(2 3 4)
  > (match '(1 2 3 4 5)
      [(list 1 a ..3 5) a]
      [_ 'else])
  '(2 3 4)
  > (match '(1 (2) (2) (2) 5)
      [(list 1 (list a) ..3 5) a]
      [_ 'else])
  '(2 2 2)
  ```

- `(list-rest lvp ... pat)` or `(list* lvp ... pat)` — similar to a `list` pattern, but the final `pat` matches the "rest" of the list after the last `lvp`. In fact, the matched value can be a non-list chain of pairs (i.e., an "improper list") if `pat` matches non-list values.

  Examples:

  ```
  > (match '(1 2 3 . 4)
      [(list-rest a b c d) d])
  4
  > (match '(1 2 3 . 4)
      [(list-rest a ... d) (list a d)])
  '((1 2 3) 4)
  ```

- `(list-no-order pat ...)` — similar to a `list` pattern, but the elements to match each `pat` can appear in the list in any order.

  Example:

  ```
  > (match '(1 2 3)
      [(list-no-order 3 2 x) x])
  1
  ```

- `(list-no-order pat ... lvp)` — generalizes `list-no-order` to allow a pattern that matches multiple list elements that are interspersed in any order with matches for the other patterns.

  Unlike other patterns, `list-no-order` doesn't allow duplicate identifiers between subpatterns. For example the patterns `(list-no-order x 1 x)` and `(list-no-order x 1 x ...)` both produce syntax errors.

  Example:

  ```
  > (match '(1 2 3 4 5 6)
      [(list-no-order 6 2 y ...) y])
  '(1 3 4 5)
  ```

- `(vector lvp ...)` — like a `list` pattern, but matching a vector.

  Example:

  ```
  > (match #(1 (2) (2) (2) 5)
      [(vector 1 (list a) ..3 5) a])
  '(2 2 2)
  ```

- `(hash expr pat ... ... ht-opt)` — matches against a hash table where `expr` matches a key and `pat` matches a corresponding value.

  Examples:

  ```
  > (match (hash "aa" 1 "b" 2)
      [(hash "b" b (string-append "a" "a") a)
       (list b a)])
  '(2 1)
  ```

```
> (match (hash "aa" 1 "b" 2)
    [(hash "b" _ "c" _) 'matched]
    [_ 'not-matched])
'not-matched
```

The key matchings use the key comparator of the matching hash table.

Examples:

```
> (let ([k (string-append "a" "b")])
    (match (hasheq "ab" 1)
      [(hash k v) 'matched]
      [_ 'not-matched]))
'not-matched
> (let ([k (string-append "a" "b")])
    (match (hasheq k 1)
      [(hash k v) 'matched]
      [_ 'not-matched]))
'matched
```

The behavior of residue key-value entries in the hash table value depends on *ht-opt*.

When *ht-opt* is not provided or when it is `#:closed`, all of the keys in the hash table value must be matched. I.e., the matching is closed to extension.

Example:

```
> (match (hash "a" 1 "b" 2)
    [(hash "b" _) 'matched]
    [_ 'not-matched])
'not-matched
```

When *ht-opt* is `#:open`, there can be keys in the hash table value that are not specified in the pattern. I.e., the matching is open to extension.

Example:

```
> (match (hash "a" 1 "b" 2)
    [(hash "b" _ #:open) 'matched]
    [_ 'not-matched])
'matched
```

When *ht-opt* is `#:rest` *pat*, *pat* is further matched against the residue hash table. If the matching hash table is immutable, this residue matching is efficient. Otherwise, the matching hash table will be copied, which could be expensive.

Example:

```
> (match (hash "a" 1 "b" 2)
    [(hash "b" _ #:rest (hash "a" a)) a]
    [_ #f])
1
```

Many key *expr*s could evaluate to the same value.

Example:

```
> (match (hash "a" 1 "b" 2)
    [(hash "b" _ "b" 2 "a" _) 'matched]
    [_ 'not-matched])
'matched
```

- `(hash* [expr pat kv-opt] ... ht-opt)` — similar to `hash`, but with the following differences:
  - The key-value pattern must be grouped syntactically.
  - If *ht-opt* is not specified, it behaves like `#:open` (as opposed to `#:closed`).
  - If *kv-opt* is specified with `#:default def-expr`, and the key does not exist in the hash table value, then the default value from *def-expr* will be matched against the value pattern, instead of immediately failing to match.

  Examples:

```
> (match (hash "a" 1 "b" 2)
    [(hash* ["b" b] ["a" a]) (list b a)])
'(2 1)
> (match (hash "a" 1 "b" 2)
    [(hash* ["b" b]) 'matched]
    [_ 'not-matched])
'matched
> (match (hash "a" 1 "b" 2)
    [(hash* ["a" a #:default 42] ["c" c #:default 100]) (list a c)]
    [_ #f])
'(1 100)
```

- `(hash-table (pat pat) ...)` — **This pattern is deprecated because it can be incorrect.** However, many programs rely on the incorrect behavior, so we still provide this pattern for backward compatibility reasons.

  Similar to `list-no-order`, but matching against hash table's key–value pairs.

  Example:

```
> (match #hash(("a" . 1) ("b" . 2))
    [(hash-table ("b" b) ("a" a)) (list b a)])
'(2 1)
```

- `(hash-table (pat pat) ...+ ooo)` — **This pattern is deprecated because it can be incorrect.** However, many programs rely on the incorrect behavior, so we still provide this pattern for backward compatibility reasons.

  Generalizes `hash-table` to support a final repeating pattern.

  Example:

```
> (match #hash(("a" . 1) ("b" . 2))
    [(hash-table (key val) ...) key])
'("b" "a")
```

- `(cons pat1 pat2)` — matches a pair value.

  Example:

  ```
  > (match (cons 1 2)
      [(cons a b) (+ a b)])
  3
  ```

- `(mcons pat1 pat2)` — matches a mutable pair value.

  Example:

  ```
  > (match (mcons 1 2)
      [(cons a b) 'immutable]
      [(mcons a b) 'mutable])
  'mutable
  ```

- `(box pat)` — matches a boxed value.

  Example:

  ```
  > (match #&1
      [(box a) a])
  1
  ```

- `(struct-id pat ...)` or `(struct struct-id (pat ...))` — matches an instance of a structure type named *struct-id*, where each field in the instance matches the corresponding *pat*. See also `struct*`.

  Usually, *struct-id* is defined with `struct`. More generally, *struct-id* must be bound to expansion-time information for a structure type (see §5.7 "Structure Type Transformer Binding"), where the information includes at least a predicate binding and field accessor bindings corresponding to the number of field *pat*s. In particular, a module import or a `unit` import with a signature containing a `struct` declaration can provide the structure type information.

  Examples:

  ```
  (struct tree (val left right))
  ```

  ```
  > (match (tree 0 (tree 1 #f #f) #f)
      [(tree a (tree b  _ _) _) (list a b)])
  '(0 1)
  ```

- `(struct struct-id _)` — matches any instance of *struct-id*, without regard to contents of the fields of the instance.

- (regexp *rx-expr*) — matches a string that matches the regexp pattern produced by *rx-expr*, where *rx-expr* can be either a regexp, a pregexp, a byte-regexp, a byte-pregexp, a string, or a byte string. A string and byte string value is converted to a pattern using regexp and byte-regexp respectively. See §4.8 “Regular Expressions” for more information about regexps.

  Examples:

  ```
  > (match "apple"
      [(regexp #rx"p+") 'yes]
      [_ 'no])
  'yes
  > (match "banana"
      [(regexp #px"(na){2}") 'yes]
      [_ 'no])
  'yes
  > (match "banana"
      [(regexp "(na){2}") 'yes]
      [_ 'no])
  'no
  > (match #"apple"
      [(regexp #rx#"p+") 'yes]
      [_ 'no])
  'yes
  > (match #"banana"
      [(regexp #px#"(na){2}") 'yes]
      [_ 'no])
  'yes
  > (match #"banana"
      [(regexp #"(na){2}") 'yes]
      [_ 'no])
  'no
  ```

- (regexp *rx-expr pat*) — extends the regexp form to further constrain the match where the result of regexp-match is matched against *pat*.

  Examples:

  ```
  > (match "apple"
      [(regexp #rx"p+(.)" (list _ "l")) 'yes]
      [_ 'no])
  'yes
  > (match "append"
      [(regexp #rx"p+(.)" (list _ "l")) 'yes]
      [_ 'no])
  'no
  ```

- (pregexp *rx-expr*) or (pregexp *rx-expr pat*) — like the regexp patterns, but *rx-expr* must be either a pregexp, a byte-pregexp, a string, or a byte string.

A string and byte string value is converted to a pattern using `pregexp` and `byte-pregexp` respectively.

- `(and pat ...)` — matches if all of the *pat*s match. This pattern is often used as `(and id pat)` to bind *id* to the entire value that matches *pat*. The *pat*s are matched in the order that they appear.

  Example:

  ```
  > (match '(1 (2 3) 4)
     [(list _ (and a (list _ ...)) _) a])
  '(2 3)
  ```

- `(or pat ...)` — matches if any of the *pat*s match. Each *pat* must bind the same set of identifiers.

  Example:

  ```
  > (match '(1 2)
     [(or (list a 1) (list a 2)) a])
  1
  ```

- `(not pat ...)` — matches when none of the *pat*s match, and binds no identifiers.

  Examples:

  ```
  > (match '(1 2 3)
     [(list (not 4) ...) 'yes]
     [_ 'no])
  'yes
  > (match '(1 4 3)
     [(list (not 4) ...) 'yes]
     [_ 'no])
  'no
  ```

- `(app expr pats ...)` — applies *expr* to the value to be matched; each result of the application is matched against one of the *pats*, respectively.

  Examples:

  ```
  > (match '(1 2)
     [(app length 2) 'yes])
  'yes
  > (match "3.14"
     [(app string->number (? number? pi))
      `(I got ,pi)])
  '(I got 3.14)
  > (match '(1 2)
     [(app (lambda (v) (split-at v 1)) '(1) '(2)) 'yes])
  ```

```
'yes
> (match '(1 2 3)
    [(app (λ (ls) (apply values ls)) x y (? odd? z))
     (list 'yes x y z)])
'(yes 1 2 3)
```

- `(? expr pat ...)` — applies *expr* to the value to be matched, and checks whether the result is a true value; the additional *pat*s must also match; i.e., `?` combines a predicate application and an `and` pattern. However, `?`, unlike `and`, guarantees that *expr* is matched before any of the *pat*s.

  The *expr* procedure may be called more than once on identical input (although this happens only rarely), and the order in which calls to *expr* are made should not be relied upon.

  Example:

  ```
  > (match '(1 3 5)
      [(list (? odd?) ...) 'yes])
  'yes
  ```

- `(quasiquote qp)` — introduces a quasipattern, in which identifiers match symbols. Like the `quasiquote` expression form, `unquote` and `unquote-splicing` escape back to normal patterns.

  Example:

  ```
  > (match '(1 2 3)
     [`(1 ,a ,(? odd? b)) (list a b)])
  '(2 3)
  ```

- *derived-pattern* — matches a pattern defined by a macro extension via `define-match-expander`.

Note that the matching process may destructure the input multiple times, and may evaluate expressions embedded in patterns such as `(app expr pat)` in arbitrary order, or multiple times. Therefore, such expressions must be safe to call multiple times, or in an order other than they appear in the original program.

Changed in version 8.9.0.5 of package `base`: Added a support for `#:do`.
Changed in version 8.11.1.10: Added the `hash` and `hash*` patterns.

9.1 Additional Matching Forms

```
(match* (val-expr ...+) clause* ...)

clause* = [(pat ...+) option=> option ... body ...+]
```

Matches a sequence of values against each clause in order, matching only when all patterns in a clause match. Each clause must have the same number of patterns as the number of *val-expr*s.

Examples:

```
> (match* (1 2 3)
    [(_ (? number?) x) (add1 x)])
4
> (match* (15 17)
    [((? number? a) (? number? b))
     #:when (= (+ a 2) b)
     'diff-by-two])
'diff-by-two
```

```
(match/values expr clause* clause* ...)
```

If *expr* evaluates to n values, then match all n values against the patterns in *clause* ...*. Each clause must contain exactly n patterns. At least one clause is required to determine how many values to expect from *expr*.

Example:

```
> (match/values (values 1 2 3)
    [(a (? number? b) (? odd? c)) (+ a b c)])
6
```

```
(define/match (head args)
  match*-clause ...)

        head = id
             | (head args)

        args = arg ...
             | arg ... . rest-id

         arg = arg-id
             | [arg-id default-expr]
             | keyword arg-id
             | keyword [arg-id default-expr]

match*-clause = [(pat ...+) option=> option ... body ...+]
```

Binds *id* to a procedure that is defined by pattern matching clauses using `match*`. Each clause takes a sequence of patterns that correspond to the arguments in the function header. The arguments are ordered as they appear in the function header for matching purposes.

Examples:

```
(define/match (fact n)
  [(0) 1]
  [(n) (* n (fact (sub1 n)))])

> (fact 5)
120
```

The function header may also contain optional or keyword arguments, may have curried arguments, and may also contain a rest argument.

Examples:

```
(define/match ((f x) #:y [y '(1 2 3)])
  [((regexp #rx"p+") `(,a 2 3)) a]
  [(_ _) #f])

> ((f "ape") #:y '(5 2 3))
5
> ((f "dog"))
#f

(define/match (g x y . rst)
  [(0 0 '()) #t]
  [(5 5 '(5 5)) #t]
  [(_ _ _) #f])

> (g 0 0)
#t
> (g 5 5 5 5)
#t
> (g 1 2)
#f
```

```
(match-lambda clause ...)
(match-λ clause ...)
```

Equivalent to `(lambda (id) (match id clause ...))`.

Changed in version 8.13.0.5 of package `base`: Added `match-λ`.

```
(match-lambda* clause ...)
(match-λ* clause ...)
```

Equivalent to `(lambda lst (match lst clause ...))`.

Changed in version 8.13.0.5 of package `base`: Added `match-λ*`.

```
(match-lambda** clause* ...)
(match-λ** clause* ...)
```

Equivalent to `(lambda (args ...) (match* (args ...) clause* ...))`, where the number of `args ...` is computed from the number of patterns appearing in each of the `clause*`.

Changed in version 8.13.0.5 of package `base`: Added `match-λ**`.

```
(match-let ([pat expr] ...) body ...+)
```

Generalizes `let` to support pattern bindings. Each `expr` is matched against its corresponding `pat` (the match must succeed), and the bindings that `pat` introduces are visible in the `body`s.

Example:

```
> (match-let ([(list a b) '(1 2)]
              [(vector x ...) #(1 2 3 4)])
    (list b a x))
'(2 1 (1 2 3 4))
```

```
(match-let* ([pat expr] ...) body ...+)
```

Like `match-let`, but generalizes `let*`, so that the bindings of each `pat` are available in each subsequent `expr`.

Example:

```
> (match-let* ([(list a b) '(#(1 2 3 4) 2)]
               [(vector x ...) a])
    x)
'(1 2 3 4)
```

```
(match-let-values ([(pat ...) expr] ...) body ...+)
```

Like `match-let`, but generalizes `let-values`.

```
(match-let*-values ([(pat ...) expr] ...) body ...+)
```

Like `match-let*`, but generalizes `let*-values`.

```
(match-letrec ([pat expr] ...) body ...+)
```

Like `match-let`, but generalizes `letrec`.

```
(match-letrec-values ([(pat ...) expr] ...) body ...+)
```

Like `match-let`, but generalizes `letrec-values`.

Added in version 6.1.1.8 of package `base`.

```
(match-define pat expr)
```

Defines the names bound by *pat* to the values produced by matching against the result of *expr*.

Examples:

```
> (match-define (list a b) '(1 2))
> b
2
```

```
(match-define-values (pat pats ...) expr)
```

Like `match-define` but for when expr produces multiple values. Like match/values, it requires at least one pattern to determine the number of values to expect.

Examples:

```
> (match-define-values (a b) (values 1 2))
> b
2
```

```
(exn:misc:match? v) → boolean?
  v : any/c
```

A predicate for the exception raised in the case of a match failure.

```
(failure-cont)
```

Continues matching as if the current pattern failed. Note that unlike use of the => form, this does *not* escape the current context, and thus should only be used in tail position with respect to the `match` form.

9.2 Extending `match`

```
(define-match-expander id proc-expr)
(define-match-expander id proc-expr proc-expr)
```

Binds *id* to a *match expander*.

The first *proc-expr* sub-expression must evaluate to a transformer that produces a *pat* for `match`. Whenever *id* appears as the beginning of a pattern, this transformer is given, at expansion time, a syntax object corresponding to the entire pattern (including *id*). The pattern is replaced with the result of the transformer.

A transformer produced by a second *proc-expr* sub-expression is used when *id* is used in an expression context. Using the second *proc-expr*, *id* can be given meaning both inside and outside patterns.

Match expanders are not invoked unless *id* appears in the first position in a sequence. Instead, identifiers bound by `define-match-expander` are used as binding identifiers (like any other identifier) when they appear anywhere except the first position in a sequence.

For example, to extend the pattern matcher and destructure syntax lists,

```
(define (syntax-list? x)
  (and (syntax? x)
       (list? (syntax->list x))))
(define-match-expander syntax-list
  (lambda (stx)
    (syntax-case stx ()
      [(_ elts ...)
       #'(? syntax-list?
            (app syntax->list (list elts ...)))])))
(define (make-keyword-predicate keyword)
  (lambda (stx)
    (and (identifier? stx)
         (free-identifier=? stx keyword))))
(define or-keyword? (make-keyword-predicate #'or))
(define and-keyword? (make-keyword-predicate #'and))

> (match #'(or 3 4)
    [(syntax-list (? or-keyword?) b c)
     (list "OOORRR!" b c)]
    [(syntax-list (? and-keyword?) b c)
     (list "AAANND!" b c)])
'("OOORRR!" #<syntax:eval:88:0 3> #<syntax:eval:88:0 4>)
> (match #'(and 5 6)
    [(syntax-list (? or-keyword?) b c)
     (list "OOORRR!" b c)]
    [(syntax-list (? and-keyword?) b c)
     (list "AAANND!" b c)])
'("AAANND!" #<syntax:eval:89:0 5> #<syntax:eval:89:0 6>)
```

And here is an example showing how `define-match-expander`-bound identifiers are *not* treated specially unless they appear in the first position of pattern sequence. Consider this (incorrect) definition of a length function:

```
(define-match-expander nil
  (λ (stx) #''())
  (λ (stx) #''()))
(define (len l)
  (match l
    [nil 0]
    [(cons hd tl) (+ 1 (len tl))]))
```

Because there are no parenthesis around `nil`, `match` treats the first case as an identifier (which matches everything) instead of a use of the match expander and `len` always returns `0`.

```
> (len nil)
0
> (len (cons 1 nil))
0
> (len (cons 1 (cons 2 nil)))
0
```

Match expanders accept any syntax pair whose first element is an `identifier?` bound to the expander. The following example shows a match expander which can be called with an improper syntax list of the form `(expander a b . rest)`.

```
(define-match-expander my-vector
  (λ (stx)
    (syntax-case stx ()
      [(_ pat ...)
       #'(vector pat ...)]
      [(_ pat ... . rest-pat)
       #'(app vector->list (list-rest pat ... rest-pat))])))

> (match #(1 2 3 4 5)
   [(my-vector a b . rest)
     (list->vector (append rest (list a b)))])
'#(3 4 5 1 2)
```

Changed in version 7.7.0.2 of package `base`: Match expanders now allowed any syntax pair whose first element is an `identifier?` bound to the expander. The example above did not work with previous versions.

`prop:match-expander : struct-type-property?`

A structure type property to identify structure types that act as match expanders like the ones created by `define-match-expander`.

The property value must be an exact non-negative integer or a procedure of one or two arguments. In the former case, the integer designates a field within the structure that should contain a procedure; the integer must be between 0 (inclusive) and the number of non-automatic fields in the structure type (exclusive, not counting supertype fields), and the designated field must also be specified as immutable.

If the property value is a procedure of one argument, then the procedure serves as the transformer for match expansion. If the property value is a procedure of two arguments, then the first argument is the structure whose type has `prop:match-expander` property, and the second argument is a syntax object as for a match expander..

If the property value is a assignment transformer, then the wrapped procedure is extracted with `set!-transformer-procedure` before it is called.

This binding is provided `for-syntax`.

```
prop:legacy-match-expander : struct-type-property?
```

Like `prop:match-expander`, but for the legacy match syntax.

This binding is provided `for-syntax`.

```
(match-expander? v) → boolean?
  v : any/c
(legacy-match-expander? v) → boolean?
  v : any/c
```

Predicates for values which implement the appropriate match expander properties.

```
(syntax-local-match-introduce stx) → syntax?
  stx : syntax?
```

For backward compatibility only; equivalent to `syntax-local-introduce`.

Changed in version 6.90.0.29 of package `base`: Made equivalent to `syntax-local-introduce`.

```
(match-equality-test) → (any/c any/c . -> . any)
(match-equality-test comp-proc) → void?
  comp-proc : (any/c any/c . -> . any)
```

A parameter that determines the comparison procedure used to check whether multiple uses of an identifier match the “same” value. The default is `equal?`.

```
(match/derived val-expr original-datum clause ...)
(match*/derived (val-expr ...) original-datum clause* ...)
```

Like `match` and `match*` respectively, but includes a sub-expression to be used as the source for all syntax errors within the form. For example, `match-lambda` expands to `match/derived` so that errors in the body of the form are reported in terms of `match-lambda` instead of `match`.

9.3 Library Extensions

```
(== val comparator)
(== val)
```

A match expander which checks if the matched value is the same as *val* when compared by *comparator*. If *comparator* is not provided, it defaults to `equal?`.

Examples:

```
> (match (list 1 2 3)
    [(== (list 1 2 3)) 'yes]
    [_ 'no])
'yes
> (match (list 1 2 3)
    [(== (list 1 2 3) eq?) 'yes]
    [_ 'no])
'no
> (match (list 1 2 3)
    [(list 1 2 (== 3 =)) 'yes]
    [_ 'no])
'yes
```

```
(struct* struct-id ([field pat] ...))
```

A `match` pattern form that matches an instance of a structure type named *struct-id*, where the field *field* in the instance matches the corresponding *pat*. The fields do not include those from super types.

Any field of *struct-id* may be omitted, and such fields can occur in any order.

Examples:

```
(struct tree (val left right))
(struct tree* tree (val))

> (match (tree 0 (tree 1 #f #f) #f)
    [(struct* tree ([val a]
                    [left (struct* tree ([right #f] [val b]))]))
     (list a b)])
```

```
'(0 1)
> (match (tree* 0 #f #f 42)
    [(and (struct* tree* ([val a]))
          (struct* tree ([val b])))
     (list a b)])
'(42 0)
```

10 Control Flow

10.1 Multiple Values

See §1.1.3 "Multiple Return Values" for general information about multiple result values. In addition to `call-with-values` (described in this section), the `let-values`, `let*-values`, `letrec-values`, and `define-values` forms (among others) create continuations that receive multiple values.

```
(values v ...) → any
  v : any/c
```

Returns the given *v*s. That is, `values` returns its provided arguments.

Examples:

```
> (values 1)
1
> (values 1 2 3)
1
2
3
> (values)
```

```
(call-with-values generator receiver) → any
  generator : (-> any)
  receiver : procedure?
```

Calls *generator*, and passes the values that *generator* produces as arguments to *receiver*. Thus, `call-with-values` creates a continuation that accepts any number of values that *receiver* can accept. The *receiver* procedure is called in tail position with respect to the `call-with-values` call.

Examples:

```
> (call-with-values (lambda () (values 1 2)) +)
3
> (call-with-values (lambda () 1) (lambda (x y) (+ x y)))
arity mismatch;
 the expected number of arguments does not match the given
number
  expected: 2
  given: 1
```

10.2 Exceptions

§10.1 "Exceptions" in *The Racket Guide* introduces exceptions.

See §1.1.14 "Exceptions" for information on the Racket exception model. It is based on a proposal by Friedman, Haynes, and Dybvig [Friedman95].

Whenever a primitive error occurs in Racket, an exception is raised. The value that is passed to the current exception handler for a primitive error is always an instance of the `exn` structure type. Every `exn` structure value has a `message` field that is a string, the primitive error message. The default exception handler recognizes exception values with the `exn?` predicate and passes the error message to the current error display handler (see `error-display-handler`).

Primitive procedures that accept a procedure argument with a particular required arity (e.g., `call-with-input-file`, `call/cc`) check the argument's arity immediately, raising `exn:fail:contract` if the arity is incorrect.

10.2.1 Error Message Conventions

Racket's *error message convention* is to produce error messages with the following shape:

```
⟨srcloc⟩: ⟨name⟩: ⟨message⟩;
 ⟨continued-message⟩ ...
  ⟨field⟩: ⟨detail⟩
  ...
```

The message starts with an optional source location, ⟨*srcloc*⟩, which is followed by a colon and space when present. The message continues with an optional ⟨*name*⟩ that usually identifies the complaining function, syntactic form, or other entity, but may also refer to an entity being complained about; the ⟨*name*⟩ is also followed by a colon and space when present.

The ⟨*message*⟩ should be relatively short, and it should be largely independent of specific values that triggered the error. More detailed explanation that requires multiple lines should continue with each line indented by a single space, in which case ⟨*message*⟩ should end in a semi-colon (but the semi-colon should be omitted if ⟨*continued-message*⟩ is not present). Message text should be lowercase—using semi-colons to separate sentences if needed, although long explanations may be better deferred to extra fields.

Specific values that triggered the error or other helpful information should appear in separate ⟨*field*⟩ lines, each of which is indented by two spaces. If a ⟨*detail*⟩ is especially long or takes multiple lines, it should start on its own line after the ⟨*field*⟩ label, and each of its lines should be indented by three spaces. Field names should be all lowercase.

A ⟨*field*⟩ name should end with `...` if the field provides relatively detailed information that might be distracting in common cases but useful in others. For example, when a contract failure is reported for a particular argument of a function, other arguments to the function might be shown in an "other arguments..." field. The intent is that fields whose names end in `...` might be hidden by default in an environment such as DrRacket.

Make ⟨*field*⟩ names as short as possible, relying on ⟨*message*⟩ or ⟨*continued message*⟩ text to clarify the meaning for a field. For example, prefer "given" to "given turtle" as a field name, where ⟨*message*⟩ is something like "given turtle is too sleepy" to clarify that "given" refers to a turtle.

10.2.2 Raising Exceptions

```
(raise v [barrier?]) → any
  v : any/c
  barrier? : any/c = #t
```

Raises an exception, where *v* represents the exception being raised. The *v* argument can be anything; it is passed to the current exception handler.

If *barrier?* is true, then the call to the exception handler is protected by a continuation barrier, so that multiple returns/escapes are impossible. All exceptions raised by `racket` functions effectively use `raise` with a `#t` value for *barrier?*.

Breaks are disabled from the time the exception is raised until the exception handler obtains control, and the handler itself is `parameterize-break`ed to disable breaks initially; see §10.6 "Breaks" for more information on breaks.

Examples:

```
> (with-handlers ([number? (lambda (n)
                             (+ n 5))])
    (raise 18 #t))
23
> (struct my-exception exn:fail:user ())
> (with-handlers ([my-exception? (lambda (e)
                                   #f)])
    (+ 5 (raise (my-exception
                 "failed"
                 (current-continuation-marks)))))
#f
> (raise 'failed #t)
uncaught exception: failed
```

```
(error message-sym) → any
  message-sym : symbol?
(error message-str v ...) → any
```

```
  message-str : string?
  v : any/c
(error who-sym format-str v ...) → any
  who-sym : symbol?
  format-str : string?
  v : any/c
```

Raises the exception `exn:fail`, which contains an error string. The different forms produce the error string in different ways:

- `(error message-sym)` creates a message string by concatenating `"error: "` with the string form of `message-sym`. Use this form sparingly.
- `(error message-str v ...)` creates a message string by concatenating `message-str` with string versions of the `v`s (as produced by the current error value conversion handler; see `error-value->string-handler`). A space is inserted before each `v`. Use this form sparingly, because it does not conform well to Racket's error message conventions; consider `raise-arguments-error`, instead.
- `(error who-sym format-str v ...)` creates a message string equivalent to the string created by

  ```
  (format (string-append "~s: " format-str) who-sym v ...)
  ```

  When possible, use functions such as `raise-argument-error`, instead, which construct messages that follow Racket's error message conventions.

In all cases, the constructed message string is passed to `make-exn:fail`, and the resulting exception is raised.

Examples:

```
> (error 'failed)
error: failed
> (error "failed" 23 'pizza (list 1 2 3))
failed 23 'pizza '(1 2 3)
> (error 'method-a "failed because ~a" "no argument supplied")
method-a: failed because no argument supplied
```

```
(raise-user-error message-sym) → any
  message-sym : symbol?
(raise-user-error message-str v ...) → any
  message-str : string?
  v : any/c
(raise-user-error who-sym format-str v ...) → any
```

```
who-sym : symbol?
format-str : string?
v : any/c
```

Like `error`, but constructs an exception with `make-exn:fail:user` instead of `make-exn:fail`. The default error display handler does not show a "stack trace" for `exn:fail:user` exceptions (see §10.5 "Continuation Marks"), so `raise-user-error` should be used for errors that are intended for end users.

```
(raise-argument-error name expected v) → any
  name : symbol?
  expected : string?
  v : any/c
(raise-argument-error name
                      expected
                      bad-pos
                      v ...)   → any
  name : symbol?
  expected : string?
  bad-pos : exact-nonnegative-integer?
  v : any/c
```

Creates an `exn:fail:contract` value and `raise`s it as an exception. The *name* argument is used as the source procedure's name in the error message. The *expected* argument is used as a description of the expected contract (i.e., as a string, but the string is intended to contain a contract expression).

In the first form, *v* is the value received by the procedure that does not have the expected type.

In the second form, the bad argument is indicated by an index *bad-pos* (counting from 0), and all of the original arguments *v* are provided (in order). The resulting error message names the bad argument and also lists the other arguments. If *bad-pos* is not less than the number of *v*s, the `exn:fail:contract` exception is raised.

The error message generated by `raise-argument-error` is adjusted via `error-contract->adjusted-string` and then `error-message->adjusted-string` using the default `'racket` realm.

Examples:

```
> (define (feed-machine bits)
    (unless (integer? bits)
      (raise-argument-error 'feed-machine "integer?" bits))
    "fed the machine")
> (feed-machine 'turkey)
```

```
feed-machine: contract violation
  expected: integer?
  given: 'turkey
> (define (feed-cow animal)
    (unless (eq? animal 'cow)
      (raise-argument-error 'feed-cow "'cow" animal))
    "fed the cow")
> (feed-cow 'turkey)
feed-cow: contract violation
  expected: 'cow
  given: 'turkey
> (define (feed-animals cow sheep goose cat)
    (unless (eq? goose 'goose)
      (raise-argument-error 'feed-animals "'goose" 2 cow sheep goose cat))
    "fed the animals")
> (feed-animals 'cow 'sheep 'dog 'cat)
feed-animals: contract violation
  expected: 'goose
  given: 'dog
  argument position: 3rd
  other arguments...:
   'cow
   'sheep
   'cat
```

```
(raise-argument-error* name realm expected v) → any
  name : symbol?
  realm : symbol?
  expected : string?
  v : any/c
(raise-argument-error* name
                       realm
                       expected
                       bad-pos
                       v ...)    → any
  name : symbol?
  realm : symbol?
  expected : string?
  bad-pos : exact-nonnegative-integer?
  v : any/c
```

Like `raise-argument-error`, but using the given *realm* for error-message adjustments.

Added in version 8.4.0.2 of package `base`.

```
(raise-result-error name expected v) → any
  name : symbol?
  expected : string?
  v : any/c
(raise-result-error name
                    expected
                    bad-pos
                    v ...)   → any
  name : symbol?
  expected : string?
  bad-pos : exact-nonnegative-integer?
  v : any/c
```

Like `raise-argument-error`, but the error message describe *v* as a “result” instead of an “argument.”

```
(raise-result-error* name realm expected v) → any
  name : symbol?
  realm : symbol?
  expected : string?
  v : any/c
(raise-result-error* name
                     realm
                     expected
                     bad-pos
                     v ...)   → any
  name : symbol?
  realm : symbol?
  expected : string?
  bad-pos : exact-nonnegative-integer?
  v : any/c
```

Like `raise-result-error`, but using the given *realm* for error-message adjustments.

Added in version 8.4.0.2 of package `base`.

```
(raise-arguments-error name
                       message
                       field
                       v ...
                       ...)    → any
  name : symbol?
  message : string?
  field : string?
  v : any/c
```

Creates an `exn:fail:contract` value and `raise`s it as an exception. The *name* is used as the source procedure's name in the error message. The *message* is the error message; if *message* contains newline characters, each extra line should be suitably indented (with one extra space at the start of each line), but it should not end with a newline character. Each *field* must have a corresponding *v*, and the two are rendered on their own line in the error message; each *v* is formatted using the error value conversion handler (see `error-value->string-handler`), unless *v* is a unquoted-printing string, in which case the string content is `display`ed without using the error value conversion handler. When a string produced by the error value conversion handler or in an unquoted-printing string contains a newline but does not start with a newline, then the string is started on its own line with extra spaces added before each line to indent the string content.

The error message generated by `raise-arguments-error` is adjusted via `error-message->adjusted-string` using the default `'racket` realm.

Examples:

```
> (raise-arguments-error 'eat
                         "fish is smaller than its given meal"
                         "fish" 12
                         "meal" 13)
eat: fish is smaller than its given meal
  fish: 12
  meal: 13
> (raise-arguments-error 'eat
                         "not edible"
                         "candidate" (unquoted-printing-string
                                      "a banana made\nof wax"))
eat: not edible
  candidate:
   a banana made
   of wax
```

Changed in version 8.15.0.2 of package `base`: Added indentation for *v* strings that contain newlines.

```
(raise-arguments-error* name
                        realm
                        message
                        field
                        v ...
                        ...)    → any
  name : symbol?
  realm : symbol?
  message : string?
  field : string?
  v : any/c
```

Like `raise-arguments-error`, but using the given *realm* for error-message adjustments.

Added in version 8.4.0.2 of package `base`.
Changed in version 8.15.0.2: Added indentation for *v* strings that contain newlines.

```
(raise-range-error  name
                    type-description
                    index-prefix
                    index
                    in-value
                    lower-bound
                    upper-bound
                   [alt-lower-bound]) → any
  name : symbol?
  type-description : string?
  index-prefix : string?
  index : exact-integer?
  in-value : any/c
  lower-bound : exact-integer?
  upper-bound : exact-integer?
  alt-lower-bound : (or/c #f exact-integer?) = #f
```

Creates an `exn:fail:contract` value and `raise`s it as an exception to report an out-of-range error. The *type-description* string describes the value for which the index is meant to select an element, and *index-prefix* is a prefix for the word "index." The *index* argument is the rejected index. The *in-value* argument is the value for which the index was meant. The *lower-bound* and *upper-bound* arguments specify the valid range of indices, inclusive; if *upper-bound* is below *lower-bound*, the value is characterized as "empty." If *alt-lower-bound* is not `#f`, and if *index* is between *alt-lower-bound* and *upper-bound*, then the error is report as *index* being less than the "starting" index *lower-bound*.

Since *upper-bound* is inclusive, a typical value is *one less than* the size of a collection—for example, `(sub1 (vector-length vec))`, `(sub1 (length lst))`, and so on.

The error message generated by `raise-range-error` is adjusted via `error-message->adjusted-string` using the default `'racket` realm.

Examples:

```
> (raise-range-error 'vector-ref "vector" "starting
" 5 #(1 2 3 4) 0 3)
vector-ref: starting index is out of range
  starting index: 5
  valid range: [0, 3]
  vector: '#(1 2 3 4)
```

```
> (raise-range-error 'vector-ref "vector" "ending
" 5 #(1 2 3 4) 0 3)
vector-ref: ending index is out of range
  ending index: 5
  valid range: [0, 3]
  vector: '#(1 2 3 4)
> (raise-range-error 'vector-ref "vector" "" 3 #() 0 -1)
vector-ref: index is out of range for empty vector
  index: 3
> (raise-range-error 'vector-ref "vector" "ending
" 1 #(1 2 3 4) 2 3 0)
vector-ref: ending index is smaller than starting index
  ending index: 1
  starting index: 2
  valid range: [0, 3]
  vector: '#(1 2 3 4)
```

```
(raise-range-error* name
                    realm
                    type-description
                    index-prefix
                    index
                    in-value
                    lower-bound
                    upper-bound
                   [alt-lower-bound]) → any
  name : symbol?
  realm : symbol?
  type-description : string?
  index-prefix : string?
  index : exact-integer?
  in-value : any/c
  lower-bound : exact-integer?
  upper-bound : exact-integer?
  alt-lower-bound : (or/c #f exact-integer?) = #f
```

Like `raise-range-error`, but using the given *realm* for error-message adjustments.

Added in version 8.4.0.2 of package `base`.

```
(raise-type-error name expected v) → any
  name : symbol?
  expected : string?
  v : any/c
(raise-type-error name expected bad-pos v ...) → any
  name : symbol?
```

```
expected : string?
bad-pos : exact-nonnegative-integer?
v : any/c
```

Like `raise-argument-error`, but with Racket's old formatting conventions, and where *`expected`* is used as a "type" description instead of a contract expression. Use `raise-argument-error` or `raise-result-error`, instead.

The error message generated by `raise-type-error` is adjusted via `error-message->adjusted-string` using the default `'racket` realm.

```
(raise-mismatch-error name
                      message
                      v ...+
                      ...+)   → any
  name : symbol?
  message : string?
  v : any/c
```

Similar to `raise-arguments-error`, but using Racket's old formatting conventions, with a required *`v`* immediately after the first *`message`* string, and with further *`message`* strings that are spliced into the message without line breaks or space. Use `raise-arguments-error`, instead.

The error message generated by `raise-mismatch-error` is adjusted via `error-message->adjusted-string` using the default `'racket` realm.

Changed in version 8.15.0.2 of package `base`: Added indentation for *`v`* strings that contain newlines.

```
(raise-arity-error name arity-v arg-v ...) → any
  name : (or/c symbol? procedure?)
  arity-v : (or/c exact-nonnegative-integer?
                  arity-at-least?
                  (listof
                   (or/c exact-nonnegative-integer?
                         arity-at-least?)))
  arg-v : any/c
```

Creates an `exn:fail:contract:arity` value and `raise`s it as an exception. The *`name`* is used for the source procedure's name in the error message.

The *`arity-v`* value must be a possible result from `procedure-arity`, except that it does not have to be normalized (see `procedure-arity?` for the details of normalized arities); `raise-arity-error` will normalize the arity and use the normalized form in the error message. If *`name`* is a procedure, its actual arity is ignored.

The *arg-v* arguments are the actual supplied arguments, which are shown in the error message (using the error value conversion handler; see `error-value->string-handler`); also, the number of supplied *arg-v*s is explicitly mentioned in the message.

The error message generated by `raise-arity-error` is adjusted via `error-message->adjusted-string` using the default `'racket` realm.

Example:

```
> (raise-arity-error 'unite (arity-at-least 13) "Virginia" "Maryland")
unite: arity mismatch;
 the expected number of arguments does not match the given
number
  expected: at least 13
  given: 2
  arguments...:
   "Virginia"
   "Maryland"
```

```
(raise-arity-error* name
                    realm
                    arity-v
                    arg-v ...) → any
  name : (or/c symbol? procedure?)
  realm : symbol?
  arity-v : (or/c exact-nonnegative-integer?
                  arity-at-least?
                  (listof
                   (or/c exact-nonnegative-integer?
                         arity-at-least?)))
  arg-v : any/c
```

Like `raise-arity-error`, but using the given *realm* for error-message adjustments.

Added in version 8.4.0.2 of package `base`.

```
(raise-arity-mask-error name mask arg-v ...) → any
  name : (or/c symbol? procedure?)
  mask : exact-integer?
  arg-v : any/c
```

The same as `raise-arity-error`, but using the arity representation described with `procedure-arity-mask`.

Added in version 7.0.0.11 of package `base`.

```
(raise-arity-mask-error* name
                         realm
                         mask
                         arg-v ...) → any
  name : (or/c symbol? procedure?)
  realm : symbol?
  mask : exact-integer?
  arg-v : any/c
```

Like `raise-arity-mask-error`, but using the given *`realm`* for error-message adjustments.

Added in version 8.4.0.2 of package `base`.

```
(raise-result-arity-error name
                          arity-v
                          detail-str
                          result-v ...) → any
  name : (or/c symbol? #f)
  arity-v : exact-nonnegative-integer?
  detail-str : (or/c string? #f)
  result-v : any/c
```

Like `raise-arity-error`, but reports a “result” mismatch instead of an “argument” mismatch. The *`name`* argument can be `#f` to omit an initial source for the error. The *`detail-str`* argument, if non-`#f`, should be a string that starts with a newline, since it is added near the end of the generated error message.

The error message generated by `raise-result-arity-error` is adjusted via `error-message->adjusted-string` using the default `'racket` realm.

Example:

```
> (raise-result-arity-error 'let-values 2 "\n  in: example" 'a 2.0 "three")
let-values: result arity mismatch;
 expected number of values not received
  expected: 2
  received: 3
  in: example
  arguments...:
   'a
   2.0
   "three"
```

Added in version 6.90.0.26 of package `base`.

```
(raise-result-arity-error* name
                           realm
                           arity-v
                           detail-str
                           result-v ...) → any
  name : (or/c symbol? #f)
  realm : symbol?
  arity-v : exact-nonnegative-integer?
  detail-str : (or/c string? #f)
  result-v : any/c
```

Like `raise-result-arity-error`, but using the given *realm* for error-message adjustments.

Added in version 8.4.0.2 of package `base`.

```
(raise-syntax-error  name
                     message
                    [expr
                     sub-expr
                     extra-sources
                     message-suffix
                     #:exn exn])    → any
  name : (or/c symbol? #f)
  message : string?
  expr : any/c = #f
  sub-expr : any/c = #f
  extra-sources : (listof syntax?) = null
  message-suffix : string? = ""
  exn : (-> string?                 = exn:fail:syntax
            continuation-mark-set?
            (listof syntax?)
            exn:fail:syntax?)
```

Creates an `exn:fail:syntax?` value and `raise`s it as an exception. Macros use this procedure to report syntax errors.

The *name* argument is usually `#f` when *expr* is provided; it is described in more detail below. The *message* is used as the main body of the error message; if *message* contains newline characters, each new line should be suitably indented (with one space at the start), and it should not end with a newline character.

The optional *expr* argument is the erroneous source syntax object or S-expression (but the expression `#f` cannot be represented by itself; it must be wrapped as a syntax object). The optional *sub-expr* argument is a syntax object or S-expression (again, `#f` cannot represent itself) within *expr* that more precisely locates the error. Both may appear in the generated error-message text if `error-print-source-location` is `#t`. Source location information in the error-message text is similarly extracted from *sub-expr* or *expr* when at least one is a syntax object and `error-print-source-location` is `#t`.

If *sub-expr* is provided and not `#f`, it is used (in syntax form) for the `exprs` field of the generated exception record, else the *expr* is used if provided and not `#f`. In either case, the syntax object is `cons`ed onto *extra-sources* to produce the `exprs` field, or *extra-sources* is used directly for `exprs` if neither *expr* nor *sub-expr* is provided and not `#f`. The *extra-sources* argument is also used directly for `exprs` in the unusual case that the *sub-expr* or *expr* that would be included in `exprs` cannot be converted to a syntax object (because it contains a cycle).

The form name used in the generated error message is determined through a combination of the *name*, *expr*, and *sub-expr* arguments:

- When *name* is `#f`, and when *expr* is either an identifier or a syntax pair containing an identifier as its first element, then the form name from the error message is the identifier's symbol.
- When *name* is `#f` and when *expr* is not an identifier or a syntax pair containing an identifier as its first element, then the form name in the error message is `"?"`.
- When *name* is a symbol, then the symbol is used as the form name in the generated error message.

The *message-suffix* string is appended to the end of the error message. If not `""`, it should normally start with a newline and two spaces to add extra fields to the message (see §10.2.1 "Error Message Conventions").

If specified, *exn* should be a constructor or function that has the same signature as the `exn:fail:syntax` constructor.

Examples:

```
> (raise-syntax-error #f "bad syntax" '(bad syntax))
?: bad syntax
  in: (bad syntax)
> (raise-syntax-error #f "unbound identifier" 'unbound-
id #:exn exn:fail:syntax:unbound)
?: unbound identifier
  in: unbound-id
```

Changed in version 6.90.0.18 of package `base`: Added the *message-suffix* optional argument.
Changed in version 8.4.0.6: Added the *exn* optional argument.

```
(unquoted-printing-string? v) → boolean?
  v : any/c
(unquoted-printing-string s) → unquoted-printing-string?
  s : string?
(unquoted-printing-string-value ups) → string?
  ups : unquoted-printing-string?
```

An *unquoted-printing string* wraps a string and `print`s, `write`s, and `display`s the same way that the string `display`s. An unquoted-printing string is especially useful with `raise-arguments-error` to serve as a field "value" that causes literal text to be printed as the field content.

The `unquoted-printing-string?` procedure returns `#t` if `v` is a unquoted-printing string, `#f` otherwise. The `unquoted-printing-string` creates a unquoted-printing string value that encapsulates the string `s`, and `unquoted-printing-string-value` returns the string within a unquoted-printing string.

Added in version 6.10.0.2 of package `base`.

10.2.3 Handling Exceptions

```
(call-with-exception-handler f thunk) → any
  f : (any/c . -> . any)
  thunk : (-> any)
```

Installs `f` as the exception handler for the dynamic extent of the call to `thunk`. If an exception is raised during the evaluation of `thunk` (in an extension of the current continuation that does not have its own exception handler), then `f` is applied to the `raise`d value in the continuation of the `raise` call (but the continuation is normally extended with a continuation barrier; see §1.1.11 "Prompts, Delimited Continuations, and Barriers" and `raise`).

Any procedure that takes one argument can be an exception handler. Normally, an exception handler escapes from the context of the `raise` call via `abort-current-continuation` or some other escape mechanism. To propagate an exception to the "previous" exception handler—that is, the exception handler associated with the rest of the continuation after the point where the called exception handler was associated with the continuation—an exception handler can simply return a result instead of escaping, in which case the `raise` call propagates the value to the previous exception handler (still in the dynamic extent of the call to `raise`, and under the same barrier, if any). If an exception handler returns a result and no previous handler is available, the uncaught-exception handler is used.

A call to an exception handler is `parameterize-breaked` to disable breaks, and it is wrapped with `call-with-exception-handler` to install an exception handler that reports both the original and newly raised exceptions via the error display handler and then escapes via the error escape handler.

```
(uncaught-exception-handler) → (any/c . -> . any)
(uncaught-exception-handler f) → void?
  f : (any/c . -> . any)
```

A parameter that determines an *uncaught-exception handler* used by `raise` when the relevant continuation has no exception handler installed with `call-with-exception-handler` or `with-handlers`. Unlike exception handlers installed with `call-with-exception-handler`, the uncaught-exception handler must not return a value when called by `raise`; if it returns, an exception is raised (to be handled by an exception handler that reports both the original and newly raised exception).

The default uncaught-exception handler prints an error message using the current error display handler (see `error-display-handler`), unless the argument to the handler is an instance of `exn:break:hang-up`. If the argument to the handler is an instance of `exn:break:hang-up` or `exn:break:terminate`, the default uncaught-exception handler then calls the exit handler with `1`, which normally exits or escapes. For any argument, the default uncaught-exception handler then escapes by calling the current error escape handler (see `error-escape-handler`). The call to each handler is `parameterize`d to set `error-display-handler` to the default error display handler, and it is `parameterize-break`ed to disable breaks. The call to the error escape handler is further parameterized to set `error-escape-handler` to the default error escape handler; if the error escape handler returns, then the default error escape handler is called.

When the current error display handler is the default handler, then the error-display call is parameterized to install an emergency error display handler that logs an error (see `log-error`) and never fails.

```
(with-handlers ([pred-expr handler-expr] ...)
  body ...+)
```

Evaluates each *`pred-expr`* and *`handler-expr`* in the order that they are specified, and then evaluates the *`body`*s with a new exception handler during its dynamic extent.

The new exception handler processes an exception only if one of the *`pred-expr`* procedures returns a true value when applied to the exception, otherwise the exception handler is invoked from the continuation of the `with-handlers` expression (by raising the exception again). If an exception is handled by one of the *`handler-expr`* procedures, the result of the entire `with-handlers` expression is the return value of the handler.

When an exception is raised during the evaluation of *`body`*s, each predicate procedure *`pred-expr`* is applied to the exception value; if a predicate returns a true value, the corresponding *`handler-expr`* procedure is invoked with the exception as an argument. The predicates are tried in the order that they are specified.

Before any predicate or handler procedure is invoked, the continuation of the entire `with-handlers` expression is restored, but also `parameterize-breaked` to disable breaks. Thus, breaks are disabled by default during the predicate and handler procedures (see §10.6 "Breaks"), and the exception handler is the one from the continuation of the `with-handlers` expression.

The `exn:fail?` procedure is useful as a handler predicate to catch all error exceptions. Avoid using `(lambda (x) #t)` as a predicate, because the `exn:break` exception typically should not be caught (unless it will be re-raised to cooperatively break). Beware, also, of catching and discarding exceptions, because discarding an error message can make debugging unnecessarily difficult; instead of discarding an error message, consider logging it via `log-error` or a logging form created by `define-logger`.

Examples:

```
> (with-handlers ([exn:fail:syntax?
                   (λ (e) (displayln "got a syntax error"))])
    (raise-syntax-error #f "a syntax error"))
got a syntax error
> (with-handlers ([exn:fail:syntax?
                   (λ (e) (displayln "got a syntax error"))]
                  [exn:fail?
                   (λ (e) (displayln "fallback clause"))])
    (raise-syntax-error #f "a syntax error"))
got a syntax error
```

```
(with-handlers* ([pred-expr handler-expr] ...)
  body ...+)
```

Like `with-handlers`, but if a *`handler-expr`* procedure is called, breaks are not explicitly disabled, and the handler call is in tail position with respect to the `with-handlers*` form.

10.2.4 Configuring Default Handling

```
(error-escape-handler) → (-> any)
(error-escape-handler proc) → void?
  proc : (-> any)
```

A parameter for the *error escape handler*, which takes no arguments and escapes from the dynamic context of an exception. The default error escape handler escapes using `(abort-current-continuation (default-continuation-prompt-tag) void)`.

The error escape handler is normally called directly by an exception handler, in a parameterization that sets the error display handler and error escape handler to the default handlers, and it is normally parameterize-breaked to disable breaks. To escape from a run-time error in a different context, use raise or error.

Due to a continuation barrier around exception-handling calls, an error escape handler cannot invoke a full continuation that was created prior to the exception, but it can abort to a prompt (see call-with-continuation-prompt) or invoke an escape continuation (see call-with-escape-continuation).

```
(error-display-handler) → (string? any/c . -> . any)
(error-display-handler proc) → void?
  proc : (string? any/c . -> . any)
```

A parameter for the *error display handler*, which is called by the default exception handler with an error message and the exception value. More generally, the handler's first argument is a string to print as an error message, and the second is a value representing a raised exception. An error display handler can print errors in different ways, but it should always print to the current error port.

The default error display handler displays its first argument to the current error port (determined by the current-error-port parameter) and extracts a stack trace (see continuation-mark-set->context) to display from the second argument if it is an exn value but not an exn:fail:user value.

The default error display handler in DrRacket also uses the second argument to highlight source locations.

To report a run-time error, use raise or procedures like error, instead of calling the error display handler directly.

```
(error-print-width) → (and/c exact-integer? (>=/c 3))
(error-print-width width) → void?
  width : (and/c exact-integer? (>=/c 3))
```

A parameter whose value is used as the maximum number of characters used to print a Racket value that is embedded in a primitive error message.

```
(error-print-context-length) → exact-nonnegative-integer?
(error-print-context-length cnt) → void?
  cnt : exact-nonnegative-integer?
```

A parameter whose value is used by the default error display handler as the maximum number of lines of context (or "stack trace") to print; a single "..." line is printed if more lines are available after the first *cnt* lines. A 0 value for *cnt* disables context printing entirely.

```
(error-print-source-location) → boolean?
(error-print-source-location include?) → void?
  include? : any/c
```

A parameter that controls whether read and syntax error messages include source information, such as the source line and column or the expression. This parameter also controls the error message when a module-defined variable is accessed before its definition is executed; the parameter determines whether the message includes a module name. Only the message field of an `exn:fail:read`, `exn:fail:syntax`, or `exn:fail:contract:variable` structure is affected by the parameter. The default is `#t`.

```
(error-value->string-handler)
 → (any/c exact-nonnegative-integer?
          . -> .
          string?)
(error-value->string-handler proc) → void?
  proc : (any/c exact-nonnegative-integer?
                . -> .
                string?)
```

A parameter that determines the *error value conversion handler*, which is used to print a Racket value that is embedded in a primitive error message.

The integer argument to the handler specifies the maximum number of characters that should be used to represent the value in the resulting string. The default error value conversion handler `print`s the value into a string (using the current global port print handler; see `global-port-print-handler`). If the printed form is too long, the printed form is truncated and the last three characters of the return string are set to "...".

When called by function like `error`, if the string returned by an error value conversion handler is longer than requested, the string is truncated to the requested length. If a byte string is returned instead of a string, it is converted using `bytes->string/utf-8`. If any other non-string value is returned, then the string `"..."` is used. If a primitive error string needs to be generated before the handler has returned, the default error value conversion handler is used.

Calls to an error value conversion handler are `parameterized` to re-install the default error value conversion handler, and to enable printing of unreadable values (see `print-unreadable`).

If the string produced by `error-value->string-handler` contains a newline but does not start with a newline, then a context that uses the string will add spaces or indentation after each newline as needed. For example, `raise-argument-error` adds a three-space indentation to the start of each line.

Changed in version 8.15.0.2 of package `base`: Added indentation convention for string results that contain newlines.

```
(error-syntax->string-handler)
 → (any/c (or/c exact-nonnegative-integer? #f)
         . -> .
         string?)
(error-syntax->string-handler proc) → void?
```

```
proc : (any/c (or/c exact-nonnegative-integer? #f)
             . -> .
             string?)
```

A parameter that determines the *error syntax conversion handler*, which is used to print a syntax form that is embedded in an error message, such as from `raise-syntax-error` when `error-print-source-location` is `#t`.

The arguments to the handler are analogous to the arguments for a error value conversion handler as configured with `error-value->string-handler`, except that `#f` can be provided instead of an integer for the length, meaning that the printed form should not be truncated. The first argument is normally a syntax object, but in the same way that `raise-syntax-error` accepts other S-expressions, the error syntax conversion handler must also handle representations that are not syntax objects.

Added in version 8.2.0.8 of package `base`.

```
(error-syntax->name-handler)
 → (syntax? . -> . (or/c symbol? #f))
(error-syntax->name-handler proc) → void?
  proc : (syntax? . -> . (or/c symbol? #f))
```

A parameter that determines the *error syntax name handler*, which is used to extract the name of a syntactic form when `raise-syntax-error` is called with `#f` as its first argument and a syntax object as its third argument.

The argument to the handler is a the syntax object provided to `raise-syntax-error` as its third argument. The result must be a symbol if a name can be extracted from the syntax object, `#f` otherwise.

Added in version 8.15.0.2 of package `base`.

```
(error-module-path->string-handler)
 → (any/c exact-nonnegative-integer?
          . -> .
          string?)
(error-module-path->string-handler proc) → void?
  proc : (any/c exact-nonnegative-integer?
               . -> .
               string?)
```

Similar to `error-value->string-handler`, but intended for a module path. The default `write`s the module path to a string.

Added in version 8.16.0.3 of package `base`.

10.2.5 Built-in Exception Types

```
(struct exn (message continuation-marks)
    #:extra-constructor-name make-exn
    #:transparent)
  message : string?
  continuation-marks : continuation-mark-set?
```

The base structure type for exceptions. The `message` field contains an error message, and the `continuation-marks` field contains the value produced by `(current-continuation-marks)` immediately before the exception was raised.

Exceptions raised by Racket form a hierarchy under `exn`:

```
exn
  exn:fail
    exn:fail:contract
      exn:fail:contract:arity
      exn:fail:contract:divide-by-zero
      exn:fail:contract:non-fixnum-result
      exn:fail:contract:continuation
      exn:fail:contract:variable
    exn:fail:syntax
      exn:fail:syntax:unbound
      exn:fail:syntax:missing-module
    exn:fail:read
      exn:fail:read:eof
      exn:fail:read:non-char
    exn:fail:filesystem
      exn:fail:filesystem:exists
      exn:fail:filesystem:version
      exn:fail:filesystem:errno
      exn:fail:filesystem:missing-module
    exn:fail:network
      exn:fail:network:errno
    exn:fail:out-of-memory
    exn:fail:unsupported
    exn:fail:user
  exn:break
    exn:break:hang-up
    exn:break:terminate
```

```
(struct exn:fail exn ()
    #:extra-constructor-name make-exn:fail
    #:transparent)
```

Raised for exceptions that represent errors, as opposed to `exn:break`.

```
(struct exn:fail:contract exn:fail ()
    #:extra-constructor-name make-exn:fail:contract
    #:transparent)
```

Raised for errors from the inappropriate run-time use of a function or syntactic form.

```
(struct exn:fail:contract:arity exn:fail:contract ()
    #:extra-constructor-name make-exn:fail:contract:arity
    #:transparent)
```

Raised when a procedure is applied to the wrong number of arguments.

```
(struct exn:fail:contract:divide-by-zero exn:fail:contract ()
    #:extra-constructor-name
    make-exn:fail:contract:divide-by-zero
    #:transparent)
```

Raised for division by exact zero.

```
(struct exn:fail:contract:non-fixnum-result exn:fail:contract ()
    #:extra-constructor-name
    make-exn:fail:contract:non-fixnum-result
    #:transparent)
```

Raised by functions like `fx+` when the result would not be a fixnum.

```
(struct exn:fail:contract:continuation exn:fail:contract ()
    #:extra-constructor-name make-exn:fail:contract:continuation
    #:transparent)
```

Raised when a continuation is applied where the jump would cross a continuation barrier.

```
(struct exn:fail:contract:variable exn:fail:contract (id)
    #:extra-constructor-name make-exn:fail:contract:variable
    #:transparent)
  id : symbol?
```

Raised for a reference to a not-yet-defined top-level variable or module-level variable.

```
(struct exn:fail:syntax exn:fail (exprs)
    #:extra-constructor-name make-exn:fail:syntax
    #:transparent)
  exprs : (listof syntax?)
```

Raised for a syntax error that is not a read error. The exprs indicate the relevant source expressions, least-specific to most-specific.

This structure type implements the prop:exn:srclocs property.

```
(struct exn:fail:syntax:unbound exn:fail:syntax ()
    #:extra-constructor-name make-exn:fail:syntax:unbound
    #:transparent)
```

Raised by #%top or set! for an unbound identifier within a module.

```
(struct exn:fail:syntax:missing-module exn:fail:syntax (path)
    #:extra-constructor-name make-exn:fail:syntax:missing-module
    #:transparent)
  path : module-path?
```

Raised by the default module name resolver or default load handler to report a module path—a reported in the path field—whose implementation file cannot be found.

The default module name resolver raises this exception only when it is given a syntax object as its second argument, and the default load handler raises this exception only when the value of current-module-path-for-load is a syntax object (in which case both the exprs field and the path field are determined by the syntax object).

This structure type implements the prop:exn:missing-module property.

```
(struct exn:fail:read exn:fail (srclocs)
    #:extra-constructor-name make-exn:fail:read
    #:transparent)
  srclocs : (listof srcloc?)
```

Raised for a read error. The srclocs indicate the relevant source expressions.

```
(struct exn:fail:read:eof exn:fail:read ()
    #:extra-constructor-name make-exn:fail:read:eof
    #:transparent)
```

Raised for a read error, specifically when the error is due to an unexpected end-of-file.

```
(struct exn:fail:read:non-char exn:fail:read ()
    #:extra-constructor-name make-exn:fail:read:non-char
    #:transparent)
```

Raised for a read error, specifically when the error is due to an unexpected non-character (i.e., “special”) element in the input stream.

```
(struct exn:fail:filesystem exn:fail ()
    #:extra-constructor-name make-exn:fail:filesystem
    #:transparent)
```

Raised for an error related to the filesystem (such as a file not found).

```
(struct exn:fail:filesystem:exists exn:fail:filesystem ()
    #:extra-constructor-name make-exn:fail:filesystem:exists
    #:transparent)
```

Raised for an error when attempting to create a file that exists already.

```
(struct exn:fail:filesystem:version exn:fail:filesystem ()
    #:extra-constructor-name make-exn:fail:filesystem:version
    #:transparent)
```

Raised for a version-mismatch error when loading an extension.

```
(struct exn:fail:filesystem:errno exn:fail:filesystem (errno)
    #:extra-constructor-name make-exn:fail:filesystem:errno
    #:transparent)
  errno : (cons/c exact-integer? (or/c 'posix 'windows 'gai))
```

Raised for a filesystem error for which a system error code is available. The symbol part of an `errno` field indicates the category of the error code: `'posix` indicates a C/Posix `errno` value, `'windows` indicates a Windows system error code (under Windows, only), and `'gai` indicates a `getaddrinfo` error code (which shows up only in `exn:fail:network:errno` exceptions for operations that resolve hostnames, but is allowed in `exn:fail:filesystem:errno` instances for consistency).

```
(struct exn:fail:filesystem:missing-module exn:fail:filesystem
        (path)
    #:extra-constructor-name
    make-exn:fail:filesystem:missing-module
    #:transparent)
  path : module-path?
```

Raised by the default module name resolver or default load handler to report a module path—a reported in the `path` field—whose implementation file cannot be found.

The default module name resolver raises this exception only when it is *not* given a syntax object as its second argument, and the default load handler raises this exception only when the value of `current-module-path-for-load` is *not* a syntax object.

This structure type implements the `prop:exn:missing-module` property.

```
(struct exn:fail:network exn:fail ()
    #:extra-constructor-name make-exn:fail:network
    #:transparent)
```

Raised for TCP and UDP errors.

```
(struct exn:fail:network:errno exn:fail:network (errno)
    #:extra-constructor-name make-exn:fail:network:errno
    #:transparent)
  errno : (cons/c exact-integer? (or/c 'posix 'windows 'gai))
```

Raised for a TCP or UDP error for which a system error code is available, where the `errno` field is as for `exn:fail:filesystem:errno`.

```
(struct exn:fail:out-of-memory exn:fail ()
    #:extra-constructor-name make-exn:fail:out-of-memory
    #:transparent)
```

Raised for an error due to insufficient memory, in cases where sufficient memory is at least available for raising the exception.

```
(struct exn:fail:unsupported exn:fail ()
    #:extra-constructor-name make-exn:fail:unsupported
    #:transparent)
```

Raised for an error due to an unsupported feature on the current platform or configuration.

```
(struct exn:fail:user exn:fail ()
    #:extra-constructor-name make-exn:fail:user
    #:transparent)
```

Raised for errors that are intended to be seen by end users. In particular, the default error printer does not show the program context when printing the error message.

```
(struct exn:break exn (continuation)
    #:extra-constructor-name make-exn:break
    #:transparent)
  continuation : continuation?
```

Raised asynchronously (when enabled) in response to a break request. The `continuation` field can be used to resume the interrupted computation in the uncaught-exception handler or `call-with-exception-handler` (but *not* `with-handlers` because it escapes from the exception context before evaluating any predicates or handlers).

```
(struct exn:break:hang-up exn:break ()
    #:extra-constructor-name make-exn:break:hang-up
    #:transparent)
```

Raised asynchronously for hang-up breaks. The default uncaught-exception handler reacts to this exception type by calling the exit handler.

```
(struct exn:break:terminate exn:break ()
    #:extra-constructor-name make-exn:break:terminate
    #:transparent)
```

Raised asynchronously for termination-request breaks. The default uncaught-exception handler reacts to this exception type by calling the exit handler.

```
prop:exn:srclocs : struct-type-property?
```

A property that identifies structure types that provide a list of `srcloc` values. The property is normally attached to structure types used to represent exception information.

The property value must be a procedure that accepts a single value—the structure type instance from which to extract source locations—and returns a list of `srcloc`s. Some error display handlers use only the first returned location.

As an example,

```
#lang racket

;; We create a structure that supports the
;; prop:exn:srcloc protocol.  It carries
;; with it the location of the syntax that
;; is guilty.
(struct exn:fail:he-who-shall-not-be-named exn:fail
  (a-srcloc)
  #:property prop:exn:srclocs
  (lambda (a-struct)
    (match a-struct
      [(exn:fail:he-who-shall-not-be-named msg marks a-srcloc)
       (list a-srcloc)])))

;; We can play with this by creating a form that
;; looks at identifiers, and only flags specific ones.
(define-syntax (skeeterize stx)
  (syntax-case stx ()
    [(_ expr)
     (cond
```

```
        [(and (identifier? #'expr)
              (eq? (syntax-e #'expr) 'voldemort))
         (quasisyntax/loc stx
           (raise (exn:fail:he-who-shall-not-be-named
                   "oh dear don't say his name"
                   (current-continuation-marks)
                   (srcloc '#,(syntax-source #'expr)
                           '#,(syntax-line #'expr)
                           '#,(syntax-column #'expr)
                           '#,(syntax-position #'expr)
                           '#,(syntax-span #'expr)))))]
        [else
         ;; Otherwise, leave the expression alone.
         #'expr])]))

(define (f x)
  (* (skeeterize x) x))

(define (g voldemort)
  (* (skeeterize voldemort) voldemort))

;; Examples:
(f 7)
(g 7)
;; The error should highlight the use
;; of voldemort in g.
```

```
(exn:srclocs? v) → boolean?
  v : any/c
```

Returns `#t` if *v* has the `prop:exn:srclocs` property, `#f` otherwise.

```
(exn:srclocs-accessor v)
 → (exn:srclocs? . -> . (listof srcloc))
  v : exn:srclocs?
```

Returns the `srcloc`-getting procedure associated with *v*.

```
(struct srcloc (source line column position span)
    #:extra-constructor-name make-srcloc
    #:transparent)
  source : any/c
  line : (or/c exact-positive-integer? #f)
  column : (or/c exact-nonnegative-integer? #f)
  position : (or/c exact-positive-integer? #f)
  span : (or/c exact-nonnegative-integer? #f)
```

A *source location* is most frequently represented by a `srcloc` structure. More generally, a source location has the same information as a `srcloc` structure, but potentially represented or accessed differently. For example, source-location information is accessed from a syntax object with functions like `syntax-source` and `syntax-line`, while `datum->syntax` accepts a source location as a list, vector, or another syntax object. For ports, a combination of `object-name` and `port-next-location` provides location information, especially in a port for which counting has been enabled through `port-count-lines!`.

The fields of a `srcloc` instance are as follows:

- `source` — An arbitrary value identifying the source, often a path (see §15.1 "Paths").
- `line` — The line number (counts from 1) or `#f` (unknown).
- `column` — The column number (counts from 0) or `#f` (unknown).
- `position` — The starting position (counts from 1) or `#f` (unknown).
- `span` — The number of covered positions (counts from 0) or `#f` (unknown).

See §1.4.16 "Printing Compiled Code" for information about the treatment of `srcloc` values that are embedded in compiled code.

```
(srcloc->string srcloc) → (or/c string? #f)
  srcloc : srcloc?
```

Formats *`srcloc`* as a string suitable for error reporting. A path source in *`srcloc`* is shown relative to the value of `current-directory-for-user`. The result is `#f` if *`srcloc`* does not contain enough information to format a string.

```
prop:exn:missing-module : struct-type-property?
```

A property that identifies structure types that provide a module path for a load that fails because a module is not found.

The property value must be a procedure that accepts a single value—the structure type instance from which to extract source locations—and returns a module path.

```
(exn:missing-module? v) → boolean?
  v : any/c
```

Returns `#t` if *`v`* has the `prop:exn:missing-module` property, `#f` otherwise.

```
(exn:missing-module-accessor v)
 → (exn:missing-module? . -> . module-path?)
  v : exn:srclocs?
```

Returns the module path-getting procedure associated with *`v`*.

10.2.6 Additional Exception Functions

```
(require racket/exn)        package: base
```

The bindings documented in this section are provided by the `racket/exn` library, not `racket/base` or `racket`.

Added in version 6.3 of package `base`.

```
(exn->string exn) → string?
  exn : (or/c exn? any/c)
```

Formats *exn* as a string. If *exn* is an `exn?`, collects and returns the output from the current `(error-display-handler)`; otherwise, simply converts *exn* to a string using `(format "~s\n" exn)`.

10.2.7 Realms and Error Message Adjusters

A *realm* identifies a convention for naming functions and specifying contracts for function arguments and results. Realms are intended to help improve layering and interoperability among languages that are implemented on top of Racket.

Realms primarily enable a language to recognize and rewrite error messages that are generated by lower layers of an implementation. For example, a language's implementation of "arrays" might use Racket vectors directly, but when an object-type or primitive bounds check fails for a vector, the generated error message mentions "vector" and possibly a contract like `vector?` and a function name like `vector-ref`. Since these error messages are identified as being from the `'racket/primitive` realm, a language implementation can look for `'racket/primitive` to detect and rewrite error messages with minimal danger of mangling error messages from other parts of an application (possibly implemented in the new language) that happen to use the word "vector."

Each procedure and each module also has a realm. A procedure's realm is relevant, for example, when it is applied to the wrong number of arguments; in that case, the arity-error message itself is from the `'racket/primitive` realm, but the error message also should include the name of the procedure, which can be from some different realm. Along similar lines, `continuation-mark-set->context` can report the realm associated with (the procedure for) each frame in a continuation, which might be useful to identify boundary crossings.

The construction of an error message must cooperate explicitly with error-message adjusting. The most basic may to cooperate is through functions like `error-message->adjusted-string` and `error-contract->adjusted-string`, which run error-message adjusters via the `current-error-message-adjuster` parameter and other adjusters associated with the current continuation using `error-message-adjuster-key` as a continuation-mark key.

Functions like `raise-argument-error` and `raise-arity-error` use `error-message->adjusted-string` and `error-contract->adjusted-string` with the default realm, `'racket`. Functions like `raise-argument-error*` and `raise-arity-error*` accept an explicit realm argument.

Not all error functions automatically cooperate with error-message adjusting. For example, the `raise-reader-error` and `raise-syntax-error` functions do not call adjusters, because they report errors that are intimately tied to syntax (and, along those lines, errors of a more static nature).

```
(error-message->adjusted-string name
                                name-realm
                                message
                                message-realm) → string?
  name : (or/c symbol? #f)
  name-realm : symbol?
  message : string?
  message-realm : symbol?
```

Combines *name* (if it is not `#f`) with `": "` and then *message* to generate an error-message string, but first giving error-message adjusters a chance to adjust *name* and/or *message*.

Any adjuster functions associated with the current continuation as a continuation mark with `error-message-adjuster-key` are run first; the adjusters are run in order from shallowest to deepest. Then, the adjuster value of `current-error-message-adjuster` is used.

Each adjuster is tried with the `'message` protocol, first. If the adjuster responds with `#f` for `'message`, then the `'name` protocol is tried. See `current-error-message-adjuster` for information on the protocols. An adjuster that responds with `#f` for both is skipped, as is any value associated as continuation mark using `error-message-adjuster-key` where the value is not a procedure that accepts one argument. In addition, the `'name` protocol is skipped if the (possibly adjusted) *name* is `#f`.

Added in version 8.4.0.2 of package `base`.

```
(error-contract->adjusted-string contract-str
                                 contract-realm) → string?
  contract-str : string?
  contract-realm : symbol?
```

Analogous to `error-message->adjusted-string`, but for just the contract part of an error message. The result string is typically incorporated into a larger error message that may then be adjusted further.

Adjustment of contract string uses the `'contract` protocol as described for `current-error-message-adjuster`.

Added in version 8.4.0.2 of package base.

```
(current-error-message-adjuster)
 → (symbol? . -> . (or/c procedure? #f))
(current-error-message-adjuster proc) → void?
  proc : (symbol? . -> . (or/c procedure? #f))
```

A parameter that determines an error-message adjuster that is applied after any adjusters associated to the current continuation via `error-message-adjuster-key`.

An adjuster procedure receives a symbol identifying a protocol, and it must return either `#f` or a procedure for performing adjustments through that protocol. The following protocols are currently defined, but more may be added in the future:

- `'name`: the procedure receives two arguments, a name symbol and a realm symbol; it returns an adjusted name symbol and an adjusted realm symbol.
- `'message`: the procedure receives four arguments: a name symbol or `#f` (which means that no name will be prefixed on the message), a name-realm symbol, an message string, and a message-realm symbol; it returns four adjusted values.
- `'contract`: the procedure receives two arguments, a contract string and a realm symbol; it returns an adjusted contract string and an adjusted realm symbol.

A new library or language can introduce additional mode symbols, too. To avoid conflicts, prefix the mode symbol with a collection or library name followed by `/`.

If an adjuster procedure returns `#f` for a protocol, it's the same as returning a function that performs no adjustment and returns its arguments. The default value of this parameter returns `#f` for any symbol argument except the protocols listed above, for which it returns a procedure that checks its arguments and returns them with no adjustment.

Added in version 8.4.0.2 of package base.

```
error-message-adjuster-key : symbol?
```

An uninterned symbol intended for use as a continuation mark key with an error-adjuster procedure value. An error adjuster associated with the key should follow the same protocol as a value of `current-error-message-adjuster`.

See `error-message->adjusted-string` for a description of how marks using this key are can adjust error messages.

Added in version 8.4.0.2 of package base.

10.3 Delayed Evaluation

```
(require racket/promise)        package: base
```

The bindings documented in this section are provided by the `racket/promise` and `racket` libraries, but not `racket/base`.

A *promise* encapsulates an expression to be evaluated on demand via `force`. After a promise has been `force`d, every later `force` of the promise produces the same result.

```
(promise? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a promise, `#f` otherwise.

```
(delay body ...+)
```

Creates a promise that, when `force`d, evaluates the *body*s to produce its value. The result is then cached, so further uses of `force` produce the cached value immediately. This includes multiple values and exceptions.

```
(lazy body ...+)
```

Like `delay`, if the last *body* produces a promise when forced, then this promise is `force`d, too, to obtain a value. In other words, this form creates a composable promise, where the computation of its body is "attached" to the computation of the following promise, and a single `force` iterates through the whole chain, tail-calling each step.

Note that the last *body* of this form must produce a single value, but the value can itself be a `delay` promise that returns multiple values.

The `lazy` form is useful for implementing lazy libraries and languages, where tail calls can be wrapped in a promise.

```
(force v) → any
  v : any/c
```

If *v* is a promise, then the promise is forced to obtain a value. If the promise has not been forced before, then the result is recorded in the promise so that future `force`s on the promise produce the same value (or values). If forcing the promise raises an exception, then the exception is similarly recorded so that forcing the promise will raise the same exception every time.

If *v* is `force`d again before the original call to `force` returns, then the `exn:fail` exception is raised.

If *v* is not a promise, then it is returned as the result.

```
(promise-forced? promise) → boolean?
  promise : promise?
```

Returns `#t` if *promise* has been forced.

```
(promise-running? promise) → boolean?
  promise : promise?
```

Returns `#t` if *promise* is currently being forced. (Note that a promise can be either running or forced but not both.)

10.3.1 Additional Promise Kinds

```
(delay/name body ...+)
```

Creates a “call-by-name” promise that is similar to `delay`-promises, except that the resulting value is not cached. This kind of promise is essentially a thunk that is wrapped in a way that `force` recognizes.

If a `delay/name` promise forces itself, no exception is raised, the promise is never considered “running” or “forced” in the sense of `promise-running?` and `promise-forced?`.

```
(promise/name? promise) → boolean?
  promise : any/c
```

Returns `#t` if *promise* is a promise created with `delay/name`.

Added in version 6.3 of package `base`.

```
(delay/strict body ...+)
```

Creates a “strict” promise: it is evaluated immediately, and the result is wrapped in a promise value. Note that the body can evaluate to multiple values, and forcing the resulting promise will return these values.

```
(delay/sync body ...+)
```

Produces a promise where an attempt to `force` the promise by a thread other than one currently running the promise causes the `force` to block until a result is available. This kind of promise is also a synchronizable event for use with `sync`; `sync`ing on the promise does not `force` it, but merely waits until a value is forced by another thread. The synchronization result is `#<void>`.

If a promise created by `delay/sync` is forced on a thread that is already running the promise, an exception is raised in the same way as for promises created with `delay`.

```
(delay/thread body/option ...+)

body/option = body
            | #:group thread-group-expr
```

Like `delay/sync`, but begins the computation immediately on a newly created thread. The thread is created under the thread group specified by *`thread-group-expr`*, which defaults to `(make-thread-group)`. A `#:group` specification can appear at most once.

Exceptions raised by the *`body`*s are caught as usual and raised only when the promise is `force`d. Unlike `delay/sync`, if the thread running *`body`* terminates without producing a result or exception, `force` of the promise raises an exception (instead of blocking).

```
(delay/idle body/option ...+)

body/option = body
            | #:wait-for wait-evt-expr
            | #:work-while while-evt-expr
            | #:tick tick-secs-expr
            | #:use use-ratio-expr
```

Like `delay/thread`, but with the following differences:

- the computation does not start until the event produced by *`wait-evt-expr`* is ready, where the default is `(system-idle-evt)`;
- the computation thread gets to work only when the process is otherwise idle as determined by *`while-evt-expr`*, which also defaults to `(system-idle-evt)`;
- the thread is allowed to run only periodically: out of every *`tick-secs-expr`* (defaults to `0.2`) seconds, the thread is allowed to run *`use-ratio-expr`* (defaults to `0.12`) of the time proportionally; i.e., the thread runs for `(* tick-secs-expr use-ratio-expr)` seconds.

If the promise is `forced` before the computation is done, it runs the rest of the computation immediately without waiting on events or periodically restricting evaluation.

A `#:wait-for`, `#:work-while`, `#:tick`, or `#:use` specification can appear at most once.

```
(for/list/concurrent maybe-group (for-clause ...)
  body-or-break ... body)

maybe-group =
            | #:group thread-group-expr

  thread-group-expr : thread-group?
```

Iterates like `for/list`, but the bodies (following any `#:break` or `#:final` clauses) are wrapped in `delay/thread`. Each promise is forced before the result list is returned.

Threads are created under *`thread-group-expr`*, which defaults to `(make-thread-group)`. An optional `#:group` clause may be provided, in which case the threads will be created under that thread group.

This form does not support returning multiple values.

Example:

```
> (time
   (for/list/concurrent ([i (in-range 5)])
     (define duration (/ 1.0 (random 50 100)))
     (sleep duration)
     (printf "thread ~a slept for ~a millisec-
onds~n" i (truncate (* duration 1000)))
     i))
thread 3 slept for 10.0 milliseconds
thread 4 slept for 12.0 milliseconds
thread 2 slept for 13.0 milliseconds
thread 1 slept for 13.0 milliseconds
thread 0 slept for 13.0 milliseconds
cpu time: 88 real time: 87 gc time: 5
'(0 1 2 3 4)
```

Added in version 8.6.0.4 of package `base`.

```
(for*/list/concurrent maybe-group (for-clause ...)
  body-or-break ... body)
```

Like `for/list/concurrent`, but with the implicit nesting of `for*/list`.

Added in version 8.6.0.4 of package `base`.

10.4 Continuations

§10.3 "Continuations" in *The Racket Guide* introduces continuations.

See §1.1.1 "Sub-expression Evaluation and Continuations" and §1.1.11 "Prompts, Delimited Continuations, and Barriers" for general information about continuations. Racket's support for prompts and composable continuations [Flatt07] closely resembles Sitaram's `%` and `fcontrol` operator [Sitaram93].

Racket installs a continuation barrier around evaluation in the following contexts, preventing full-continuation jumps into the evaluation context protected by the barrier:

- applying an exception handler, an error escape handler, or an error display handler (see §10.2 "Exceptions");
- applying a macro transformer (see §12.4 "Syntax Transformers"), evaluating a compile-time expression, or applying a module name resolver (see §14.4.1 "Resolving Module Names");
- applying a custom-port procedure (see §13.1.9 "Custom Ports"), an event guard procedure (see §11.2.1 "Events"), or a parameter guard procedure (see §11.3.2 "Parameters");
- applying a security-guard procedure (see §14.6 "Security Guards");
- applying a will procedure (see §16.3 "Wills and Executors"); or
- evaluating or loading code from the stand-alone Racket command line (see §18.1 "Running Racket or GRacket").

In addition, extensions of Racket may install barriers in additional contexts. Finally, `call-with-continuation-barrier` applies a thunk barrier between the application and the current continuation.

```
(call-with-continuation-prompt  proc
                               [prompt-tag
                                handler]
                                arg ...)    → any
  proc : procedure?
  prompt-tag : continuation-prompt-tag?
             = (default-continuation-prompt-tag)
  handler : (or/c procedure? #f) = #f
  arg : any/c
```

Applies *proc* to the given *arg*s with the current continuation extended by a prompt. The prompt is tagged by *prompt-tag*, which must be a result from either `default-continuation-prompt-tag` (the default) or `make-continuation-prompt-tag`. The call to `call-with-continuation-prompt` returns the result of *proc*.

The *handler* argument specifies a handler procedure to be called in tail position with respect to the `call-with-continuation-prompt` call when the installed prompt is the target of an `abort-current-continuation` call with *prompt-tag*; the remaining arguments of `abort-current-continuation` are supplied to the handler procedure. If *handler* is `#f`, the default handler accepts a single *abort-thunk* argument and calls `(call-with-continuation-prompt abort-thunk prompt-tag #f)`; that is, the default handler reinstalls the prompt and continues with a given thunk.

```
(abort-current-continuation prompt-tag
                            v ...)      → any
  prompt-tag : any/c
  v : any/c
```

Resets the current continuation to that of the nearest prompt tagged by *prompt-tag* in the current continuation; if no such prompt exists, the `exn:fail:contract:continuation` exception is raised. The *v*s are delivered as arguments to the target prompt's handler procedure.

The protocol for *v*s supplied to an abort is specific to the *prompt-tag*. When `abort-current-continuation` is used with `(default-continuation-prompt-tag)`, generally, a single thunk should be supplied that is suitable for use with the default prompt handler. Similarly, when `call-with-continuation-prompt` is used with `(default-continuation-prompt-tag)`, the associated handler should generally accept a single thunk argument.

Each thread's continuation starts with a prompt for `(default-continuation-prompt-tag)` that uses the default handler, which accepts a single thunk to apply (with the prompt intact).

```
(make-continuation-prompt-tag) → continuation-prompt-tag?
(make-continuation-prompt-tag name) → continuation-prompt-tag?
  name : symbol?
```

Creates a prompt tag that is not `equal?` to the result of any other value (including prior or future results from `make-continuation-prompt-tag`). The optional *name* argument, if supplied, specifies the name of the prompt tag for printing or `object-name`.

Changed in version 7.9.0.13 of package `base`: The *name* argument gives the name of the prompt tag.

```
(default-continuation-prompt-tag) → continuation-prompt-tag?
```

Returns a constant prompt tag for which a prompt is installed at the start of every thread's continuation; the handler for each thread's initial prompt accepts any number of values and returns. The result of `default-continuation-prompt-tag` is the default tag for any procedure that accepts a prompt tag.

```
(call-with-current-continuation proc
                                [prompt-tag]) → any
  proc : (continuation? . -> . any)
  prompt-tag : continuation-prompt-tag?
             = (default-continuation-prompt-tag)
```

Captures the current continuation up to the nearest prompt tagged by *prompt-tag*; if no such prompt exists, the `exn:fail:contract:continuation` exception is raised. The truncated continuation includes only continuation marks and `dynamic-wind` frames installed since the prompt.

The captured continuation is delivered to *proc*, which is called in tail position with respect to the `call-with-current-continuation` call.

If the continuation argument to *proc* is ever applied, then it removes the portion of the current continuation up to the nearest prompt tagged by *prompt-tag* (not including the prompt; if no such prompt exists, the `exn:fail:contract:continuation` exception is raised), or up to the nearest continuation frame (if any) shared by the current and captured continuations—whichever is first. While removing continuation frames, `dynamic-wind` *post-thunk*s are executed. Finally, the (unshared portion of the) captured continuation is appended to the remaining continuation, applying `dynamic-wind` *pre-thunk*s.

The arguments supplied to an applied procedure become the result values for the restored continuation. In particular, if multiple arguments are supplied, then the continuation receives multiple results.

If, at application time, a continuation barrier would be introduced by replacing the current continuation with the applied one, then the `exn:fail:contract:continuation` exception is raised.

A continuation can be invoked from the thread (see §11.1 "Threads") other than the one where it was captured.

```
(call/cc proc [prompt-tag]) → any
  proc : (continuation? . -> . any)
  prompt-tag : continuation-prompt-tag?
             = (default-continuation-prompt-tag)
```

The `call/cc` binding is an alias for `call-with-current-continuation`.

```
(call-with-composable-continuation  proc
                                    [prompt-tag]) → any
  proc : (continuation? . -> . any)
  prompt-tag : continuation-prompt-tag?
             = (default-continuation-prompt-tag)
```

Similar to `call-with-current-continuation`, but applying the resulting continuation procedure does not remove any portion of the current continuation. Instead, application always extends the current continuation with the captured continuation (without installing any prompts other than those captured in the continuation).

When `call-with-composable-continuation` is called, if a continuation barrier appears in the continuation before the closest prompt tagged by *prompt-tag*, the `exn:fail:contract:continuation` exception is raised (because attempting to apply the continuation would always fail).

```
(call-with-escape-continuation proc) → any
  proc : (continuation? . -> . any)
```

Like `call-with-current-continuation`, but *proc* is not called in tail position, and the continuation procedure supplied to *proc* can only be called during the dynamic extent of the `call-with-escape-continuation` call.

A continuation obtained from `call-with-escape-continuation` is actually a kind of prompt. Escape continuations are provided mainly for backwards compatibility, since they pre-date general prompts in Racket. In the BC implementation of Racket, `call-with-escape-continuation` is implemented more efficiently than `call-with-current-continuation`, so `call-with-escape-continuation` can sometimes replace `call-with-current-continuation` to improve performance in those older Racket variants.

```
(call/ec proc) → any
  proc : (continuation? . -> . any)
```

The `call/ec` binding is an alias for `call-with-escape-continuation`.

```
(call-in-continuation k proc) → any
  k : continuation?
  proc : (-> any)
```

Similar to applying the continuation *k*, but instead of delivering values to the continuation, *proc* is called with *k* as the continuation of the call (so the result of *proc* is returned to the continuation). If *k* is a composable continuation, the continuation of the call to *proc* is the current continuation extended with *k*.

Examples:

```
> (+ 1
     (call/cc (lambda (k)
                (call-in-continuation k (lambda () 4)))))
5
> (+ 1
     (call/cc (lambda (k)
                (let ([n 0])
                  (dynamic-wind
                   void
                   (lambda ()
                     ; n accessed after post thunk
                     (call-in-continuation k (lambda () n)))
                   (lambda ()
                     (set! n 4)))))))
5
> (+ 1
     (with-continuation-mark
      'n 4
       (call/cc (lambda (k)
                  (with-continuation-mark
                   'n 0
                   (call-in-continuation
                    k
```

```
                        (lambda ()
                          ; 'n mark accessed in continuation
                          (continuation-mark-set-first #f 'n))))))))
5
```

Added in version 7.6.0.17 of package `base`.

```
(let/cc k body ...+)
```

Equivalent to `(call/cc (lambda (k) body ...))`.

```
(let/ec k body ...+)
```

Equivalent to `(call/ec (lambda (k) body ...))`.

```
(call-with-continuation-barrier thunk) → any
  thunk : (-> any)
```

Applies *thunk* with a continuation barrier between the application and the current continuation. The results of *thunk* are the results of the `call-with-continuation-barrier` call.

```
(continuation-prompt-available? prompt-tag
                                [cont])     → any
  prompt-tag : continuation-prompt-tag?
  cont : continuation? = (call/cc values)
```

Returns `#t` if *cont*, which must be a continuation, includes a prompt tagged by *prompt-tag*, `#f` otherwise.

```
(continuation? v) → boolean?
  v : any/c
```

Return `#t` if *v* is a continuation as produced by `call-with-current-continuation`, `call-with-composable-continuation`, or `call-with-escape-continuation`, `#f` otherwise.

```
(continuation-prompt-tag? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a continuation prompt tag as produced by `default-continuation-prompt-tag` or `make-continuation-prompt-tag`.

```
(dynamic-wind pre-thunk
              value-thunk
              post-thunk) → any
  pre-thunk : (-> any)
  value-thunk : (-> any)
  post-thunk : (-> any)
```

Applies its three thunk arguments in order. The value of a `dynamic-wind` expression is the value returned by *`value-thunk`*. The *`pre-thunk`* procedure is invoked before calling *`value-thunk`* and *`post-thunk`* is invoked after *`value-thunk`* returns. The special properties of `dynamic-wind` are manifest when control jumps into or out of the *`value-thunk`* application (either due to a prompt abort or a continuation invocation): every time control jumps into the *`value-thunk`* application, *`pre-thunk`* is invoked, and every time control jumps out of *`value-thunk`*, *`post-thunk`* is invoked. (No special handling is performed for jumps into or out of the *`pre-thunk`* and *`post-thunk`* applications.)

When `dynamic-wind` calls *`pre-thunk`* for normal evaluation of *`value-thunk`*, the continuation of the *`pre-thunk`* application calls *`value-thunk`* (with `dynamic-wind`'s special jump handling) and then *`post-thunk`*. Similarly, the continuation of the *`post-thunk`* application returns the value of the preceding *`value-thunk`* application to the continuation of the entire `dynamic-wind` application.

When *`pre-thunk`* is called due to a continuation jump, the continuation of the call to *`pre-thunk`*

- jumps to a more deeply nested *`pre-thunk`*, if any, or jumps to the destination continuation; then
- continues the same as the enclosing `dynamic-wind` call in the destination continuation (i.e., matching the continuation of the original `dynamic-wind` call up to the enclosing prompt that delimited capture).

Normally, the second part of this continuation is never reached, due to a jump in the first part. However, the second part is relevant because it enables jumps to escape continuations that are contained in the continuation of the `dynamic-wind` call within the destination continuation. Furthermore, it means that the continuation marks (see §10.5 "Continuation Marks") and parameterization (see §11.3.2 "Parameters") for *`pre-thunk`* correspond to those of the enclosing `dynamic-wind` call. The *`pre-thunk`* call, however, is `parameterize-breaked` to disable breaks (see also §10.6 "Breaks").

Similarly, when *`post-thunk`* is called due to a continuation jump, the continuation of calling *`post-thunk`* jumps to a less deeply nested *`post-thunk`*, if any, or jumps to a *`pre-thunk`* protecting the destination, if any, or jumps to the destination continuation, then continues the same as the enclosing `dynamic-wind` call within the originating continuation for the jump. As for *pre-thunk*, the continuation marks and parameterization of the dynamic-wind call are in place for *post-thunk*, except that the call is further parameterize-breaked to disable breaks.

In both cases, the destination for a jump is recomputed after each *pre-thunk* or *post-thunk* completes. When a prompt-delimited continuation (see §1.1.11 "Prompts, Delimited Continuations, and Barriers") is captured in a *post-thunk*, it might be delimited and instantiated in such a way that the destination of a jump turns out to be different when the continuation is applied than when the continuation was captured. There may even be no appropriate destination, if a relevant prompt or escape continuation is not in the continuation after the restore; in that case, the first step in a *pre-thunk* or *post-thunk*'s continuation can raise an exception.

Examples:

```
> (let ([v (let/ec out
             (dynamic-wind
              (lambda () (display "in "))
              (lambda ()
                (display "pre ")
                (display (call/cc out))
                #f)
              (lambda () (display "out "))))])
    (when v (v "post ")))
in pre out in post out
> (let/ec k0
    (let/ec k1
      (dynamic-wind
       void
       (lambda () (k0 'cancel))
       (lambda () (k1 'cancel-canceled)))))
'cancel-canceled
> (let* ([x (make-parameter 0)]
         [l null]
         [add (lambda (a b)
                (set! l (append l (list (cons a b)))))])
    (let ([k (parameterize ([x 5])
               (dynamic-wind
                   (lambda () (add 1 (x)))
                   (lambda () (parameterize ([x 6])
                                (let ([k+e (let/cc k (cons k void))])
                                  (add 2 (x))
                                  ((cdr k+e))
                                  (car k+e))))
                   (lambda () (add 3 (x)))))])
      (parameterize ([x 7])
```

```
          (let/cc esc
            (k (cons void esc)))))
      l)
'((1 . 5) (2 . 6) (3 . 5) (1 . 5) (2 . 6) (3 . 5))
```

10.4.1 Additional Control Operators

```
(require racket/control)        package: base
```

The bindings documented in this section are provided by the `racket/control` library, not `racket/base` or `racket`.

The `racket/control` library provides various control operators from the research literature on higher-order control operators, plus a few extra convenience forms. These control operators are implemented in terms of `call-with-continuation-prompt`, `call-with-composable-continuation`, etc., and they generally work sensibly together. Many are redundant; for example, `reset` and `prompt` are interchangeable.

```
(call/prompt proc [prompt-tag handler] arg ...) → any
  proc : procedure?
  prompt-tag : continuation-prompt-tag?
             = (default-continuation-prompt-tag)
  handler : (or/c procedure? #f) = #f
  arg : any/c
```

The `call/prompt` binding is an alias for `call-with-continuation-prompt`.

```
(abort/cc prompt-tag v ...) → any
  prompt-tag : any/c
  v : any/c
```

The `abort/cc` binding is an alias for `abort-current-continuation`.

```
(call/comp proc [prompt-tag]) → any
  proc : (continuation? . -> . any)
  prompt-tag : continuation-prompt-tag?
             = (default-continuation-prompt-tag)
```

The `call/comp` binding is an alias for `call-with-composable-continuation`.

```
(abort v ...) → any
  v : any/c
```

Returns the *v*s to a prompt using the default continuation prompt tag and the default abort handler.

That is, `(abort v ...)` is equivalent to

```
(abort-current-continuation
 (default-continuation-prompt-tag)
 (lambda () (values v ...)))
```

Example:

```
> (prompt
    (printf "start here\n")
    (printf "answer is ~a\n" (+ 2 (abort 3))))
start here
3
```

```
(% expr)
(% expr handler-expr)
(% expr handler-expr #:tag tag-expr)
(fcontrol v #:tag prompt-tag) → any
  v : any/c
  prompt-tag : (default-continuation-prompt-tag)
```

Sitaram's operators [Sitaram93].

The essential reduction rules are:

```
(% val proc) => val
(% E[(fcontrol val)] proc) => (proc val (lambda (x) E[x]))
  ; where E has no %
```

When `handler-expr` is omitted, `%` is the same as `prompt`. If `prompt-tag` is provided, `%` uses specific prompt tags like `prompt-at`.

Examples:

```
> (% (+ 2 (fcontrol 5))
     (lambda (v k)
       (k v)))
7
> (% (+ 2 (fcontrol 5))
     (lambda (v k)
       v))
5
```

```
(prompt expr ...+)
(control id expr ...+)
```

Among the earliest operators for higher-order control [Felleisen88a, Felleisen88, Sitaram90].

The essential reduction rules are:

```
(prompt val) => val
(prompt E[(control k expr)]) => (prompt ((lambda (k) expr)
                                         (lambda (v) E[v])))
  ; where E has no prompt
```

Examples:

```
> (prompt
    (+ 2 (control k (k 5))))
7
> (prompt
    (+ 2 (control k 5)))
5
> (prompt
    (+ 2 (control k (+ 1 (control k1 (k1 6))))))
7
> (prompt
    (+ 2 (control k (+ 1 (control k1 (k 6))))))
8
> (prompt
    (+ 2 (control k (control k1 (control k2 (k2 6))))))
6
```

```
(prompt-at prompt-tag-expr expr ...+)
(control-at prompt-tag-expr id expr ...+)
```

Like `prompt` and `control`, but using specific prompt tags:

```
(prompt-at tag val) => val
(prompt-at tag E[(control-at tag k expr)]) => (prompt-at tag
                                               ((lambda (k) expr)
                                                (lambda (v) E[v])))
  ; where E has no prompt-at for tag
```

```
(reset expr ...+)
(shift id expr ...+)
```

Danvy and Filinski's operators [Danvy90].

The essential reduction rules are:

```
(reset val) => val
(reset E[(shift k expr)]) => (reset ((lambda (k) expr)
                                      (lambda (v) (reset E[v]))))
  ; where E has no reset
```

The `reset` and `prompt` forms are interchangeable.

```
(reset-at prompt-tag-expr expr ...+)
(shift-at prompt-tag-expr identifier expr ...+)
```

Like `reset` and `shift`, but using the specified prompt tags.

```
(prompt0 expr ...+)
(reset0 expr ...+)
(control0 id expr ...+)
(shift0 id expr ...+)
```

Generalizations of `prompt`, etc. [Shan04].

The essential reduction rules are:

```
(prompt0 val) => val
(prompt0 E[(control0 k expr)]) => ((lambda (k) expr)
                                   (lambda (v) E[v]))
(reset0 val) => val
(reset0 E[(shift0 k expr)]) => ((lambda (k) expr)
                                (lambda (v) (reset0 E[v])))
```

The `reset0` and `prompt0` forms are interchangeable. Furthermore, the following reductions apply:

```
(prompt E[(control0 k expr)]) => (prompt ((lambda (k) expr)
                                          (lambda (v) E[v])))
(reset E[(shift0 k expr)]) => (reset ((lambda (k) expr)
                                      (lambda (v) (reset0 E[v]))))
(prompt0 E[(control k expr)]) => (prompt0 ((lambda (k) expr)
                                           (lambda (v) E[v])))
(reset0 E[(shift k expr)]) => (reset0 ((lambda (k) expr)
                                       (lambda (v) (reset E[v]))))
```

That is, both the `prompt`/`reset` and `control`/`shift` sites must agree for `0`-like behavior, otherwise the non-`0` behavior applies.

```
(prompt0-at prompt-tag-expr expr ...+)
(reset0-at prompt-tag-expr expr ...+)
(control0-at prompt-tag-expr id expr ...+)
(shift0-at prompt-tag-expr id expr ...+)
```

Variants of prompt0, etc., that accept a prompt tag.

```
(spawn proc) → any
  proc : ((any/c . -> . any) . -> . any)
```

The operators of Hieb and Dybvig [Hieb90].

The essential reduction rules are:

```
(spawn proc)
  => (prompt/spawn tag
       (proc (lambda (proc) (abort/spawn tag proc))))
  ; where tag is a freshly generated prompt tag
(prompt/spawn tag val)
  => val
(prompt/spawn tag E[(abort/spawn tag proc)])
  => (proc (lambda (x) (prompt/spawn tag E[x])))
  ; where E has no prompt/spawn for tag
```

```
(splitter proc) → any
  proc : (((-> any) . -> . any)
          ((continuation? . -> . any) . -> . any)
          . -> . any)
```

The operator of Queinnec and Serpette [Queinnec91].

The essential reduction rules are:

```
(splitter proc)
  => (prompt/splitter tag
       (proc (lambda (thunk) (abort/splitter tag thunk))
             (lambda (proc) (control0/splitter tag k (proc k)))))
  ; where tag is a freshly generated prompt tag
(prompt/splitter tag val)
  => val
(prompt/splitter tag E[(abort/splitter tag thunk)])
  => (thunk)
  ; where E has no prompt/splitter for tag
(prompt/splitter tag E[(control0/splitter tag k expr)])
  => ((lambda (k) expr)
      (lambda (x) E[x]))
  ; where E has no prompt/splitter for tag
```

```
(new-prompt) → continuation-prompt-tag?
(new-prompt name) → continuation-prompt-tag?
  name : symbol?
```

```
(set prompt-expr expr ...+)
(cupto prompt-expr id expr ...+)
```

The operators of Gunter et al. [Gunter95].

In this library, `new-prompt` is an alias for `make-continuation-prompt-tag`, `set` is an alias for `prompt0-at`, and `cupto` is an alias for `control0-at`.

Changed in version 8.11.0.3 of package `base`: The `new-prompt` function is now really an alias for `make-continuation-prompt-tag`.

10.5 Continuation Marks

See §1.1.10 "Continuation Frames and Marks" and §1.1.11 "Prompts, Delimited Continuations, and Barriers" for general information about continuation marks.

The list of continuation marks for a key *k* and a continuation *C* that extends C_0 is defined as follows:

- If *C* is an empty continuation, then the mark list is `null`.
- If *C*'s first frame contains a mark *m* for *k*, then the mark list for *C* is `(cons m lst)`, where *lst* is the mark list for *k* in C_0.
- If *C*'s first frame does not contain a mark keyed by *k*, then the mark list for *C* is the mark list for C_0.

The `with-continuation-mark` form installs a mark on the first frame of the current continuation (see §3.19 "Continuation Marks: `with-continuation-mark`"). Procedures such as `current-continuation-marks` allow inspection of marks.

Whenever Racket creates an exception record for a primitive exception, it fills the `continuation-marks` field with the value of `(current-continuation-marks)`, thus providing a snapshot of the continuation marks at the time of the exception.

When a continuation procedure returned by `call-with-current-continuation` or `call-with-composable-continuation` is invoked, it restores the captured continuation, and also restores the marks in the continuation's frames to the marks that were present when `call-with-current-continuation` or `call-with-composable-continuation` was invoked.

```
(continuation-marks cont [prompt-tag]) → continuation-mark-set?
  cont : (or/c continuation? thread? #f)
  prompt-tag : continuation-prompt-tag?
             = (default-continuation-prompt-tag)
```

Returns an opaque value containing the set of continuation marks for all keys in the continuation *cont* (or the current continuation of *cont* if it is a thread) up to the prompt tagged by *prompt-tag*. If *cont* is #f, the resulting set of continuation marks is empty. If *cont* is an escape continuation (see §1.1.11 "Prompts, Delimited Continuations, and Barriers"), then the current continuation must extend *cont*, or the exn:fail:contract exception is raised. If *cont* was not captured with respect to *prompt-tag* and does not include a prompt for *prompt-tag*, the exn:fail:contract exception is raised. If *cont* is a dead thread, the result is an empty set of continuation marks.

```
(current-continuation-marks [prompt-tag])
 → continuation-mark-set?
  prompt-tag : continuation-prompt-tag?
             = (default-continuation-prompt-tag)
```

Returns an opaque value containing the set of continuation marks for all keys in the current continuation up to *prompt-tag*. In other words, it produces the same value as

```
(call-with-current-continuation
  (lambda (k)
    (continuation-marks k prompt-tag))
  prompt-tag)
```

```
(continuation-mark-set->list  mark-set
                              key-v
                             [prompt-tag]) → list?
  mark-set : (or/c continuation-mark-set? #f)
  key-v : any/c
  prompt-tag : continuation-prompt-tag?
             = (default-continuation-prompt-tag)
```

Returns a newly-created list containing the marks for *key-v* in *mark-set*, which is a set of marks returned by current-continuation-marks or #f as a shorthand for (current-continuation-marks *prompt-tag*). The result list is truncated at the first point, if any, where continuation frames were originally separated by a prompt tagged with *prompt-tag*. Producing the result takes time proportional to the size of the continuation reflected by *mark-set*.

Changed in version 8.0.0.1 of package base: Changed to allow *mark-set* as #f.

```
(continuation-mark-set->list*  mark-set
                               key-list
                              [none-v
                               prompt-tag]) → (listof vector?)
  mark-set : (or/c continuation-mark-set? #f)
  key-list : (listof any/c)
```

```
none-v : any/c = #f
prompt-tag : continuation-prompt-tag?
           = (default-continuation-prompt-tag)
```

Returns a newly-created list containing vectors of marks in *mark-set* for the keys in *key-list*, up to *prompt-tag*, where a #f value for *mark-set* is equivalent to (current-continuation-marks *prompt-tag*). The length of each vector in the result list is the same as the length of *key-list*, and a value in a particular vector position is the value for the corresponding key in *key-list*. Values for multiple keys appear in a single vector only when the marks are for the same continuation frame in *mark-set*. The *none-v* argument is used for vector elements to indicate the lack of a value. Producing the result takes time proportional to the size of the continuation reflected by *mark-set* times the length of *key-list*.

Changed in version 8.0.0.1 of package base: Changed to allow *mark-set* as #f.

```
(continuation-mark-set->iterator  mark-set
                                  key-list
                                 [none-v
                                  prompt-tag])
 → (-> (values (or/c vector? #f) procedure?))
  mark-set : (or/c continuation-mark-set? #f)
  key-list : (listof any/c)
  none-v : any/c = #f
  prompt-tag : continuation-prompt-tag?
             = (default-continuation-prompt-tag)
```

Like continuation-mark-set->list*, but instead of returning a list of values, returns a functional iterator in the form of a procedure that returns one element of the would-be list and a new iterator function for the rest of the would-be list. An iterator procedure returns #f instead of a vector when no more elements are available; in that case, the returned iterator procedure is like the called one, producing no further values. The time required for each step is proportional to the length of *key-list* times the size of the segment of the continuation reflected by *mark-set* between frames that have keys in *key-list*.

Added in version 7.5.0.7 of package base.
Changed in version 8.0.0.1: Changed to allow *mark-set* as #f.

```
(continuation-mark-set-first  mark-set
                              key-v
                             [none-v
                              prompt-tag]) → any
  mark-set : (or/c continuation-mark-set? #f)
  key-v : any/c
  none-v : any/c = #f
  prompt-tag : continuation-prompt-tag?
             = (default-continuation-prompt-tag)
```

Returns the first element of the list that would be returned by `(continuation-mark-set->list (or mark-set (current-continuation-marks prompt-tag)) key-v prompt-tag)`, or `none-v` if the result would be the empty list.

The result is produced in (amortized) constant time. Typically, this result can be computed more quickly using `continuation-mark-set-first` than using `continuation-mark-set->list` or by using `continuation-mark-set->iterator` and iterating just once.

Although `#f` and `(current-continuation-marks prompt-tag)` are equivalent for `mark-set`, providing `#f` as `mark-set` can enable shortcuts that make it even faster.

```
(call-with-immediate-continuation-mark  key-v
                                        proc
                                       [default-v]) → any
  key-v : any/c
  proc : (any/c . -> . any)
  default-v : any/c = #f
```

Calls `proc` with the value associated with `key-v` in the first frame of the current continuation (i.e., a value that would be replaced if the call to `call-with-immediate-continuation-mark` were replaced with a `with-continuation-mark` form using `key-v` as the key expression). If no such value exists in the first frame, `default-v` is passed to `proc`. The `proc` is called in tail position with respect to the `call-with-immediate-continuation-mark` call.

This function could be implemented with a combination of `with-continuation-mark`, `current-continuation-marks`, and `continuation-mark-set->list*`, as shown below, but `call-with-immediate-continuation-mark` is implemented more efficiently; it inspects only the first frame of the current continuation.

```
; Equivalent, but inefficient:
(define (call-with-immediate-continuation-mark key-
v proc [default-v #f])
  (define private-key (gensym))
  (with-continuation-mark
   private-key #t
   (let ([vecs (continuation-mark-set->list* (current-
continuation-marks)
                                              (list key-v private-
key)
                                              default-v)])
     (proc (vector-ref (car vecs) 0)))))
```

```
(make-continuation-mark-key) → continuation-mark-key?
(make-continuation-mark-key sym) → continuation-mark-key?
  sym : symbol?
```

Creates a continuation mark key that is not equal? to the result of any other value (including prior and future results from make-continuation-mark-key). The continuation mark key can be used as the key argument for with-continuation-mark or accessor procedures like continuation-mark-set-first. The mark key can be chaperoned or impersonated, unlike other values that are used as the mark key.

The optional *sym* argument, if provided, is used when printing the continuation mark.

```
(continuation-mark-key? v) → boolean?
  v : any/c
```

Returns #t if *v* is a mark key created by make-continuation-mark-key, #f otherwise.

```
(continuation-mark-set? v) → boolean?
  v : any/c
```

Returns #t if *v* is a mark set created by continuation-marks or current-continuation-marks, #f otherwise.

```
(continuation-mark-set->context  mark-set
                                [realms?]) → list?
  mark-set : continuation-mark-set?
  realms? : any/c = #f
```

Returns a list representing an approximate "stack trace" for *mark-set*'s continuation. The list contains pairs if *realms?* is #f, where the car of each pair contains either #f or a symbol for a procedure name, and the cdr of each pair contains either #f or a srcloc value for the procedure's source location (see §13.1.4 "Counting Positions, Lines, and Columns"); the car and cdr are never both #f. If *realms?* is true, the list contains 3-element vectors, where the first two elements are like the values for a pair, and the third element is a realm symbol.

Conceptually, the stack-trace list is the result of continuation-mark-set->list with *mark-set* and Racket's private key for procedure-call marks. The implementation may be different, however, and the results may merely approximate the correct answer. Thus, while the result may contain useful hints to humans about the context of an expression, it is not reliable enough for programmatic use.

A stack trace is extracted from an exception and displayed by the default error display handler (see error-display-handler) for exceptions other than exn:fail:user (see raise-user-error in §10.2.2 "Raising Exceptions").

Examples:

```
> (define (extract-current-continuation-marks key)
    (continuation-mark-set->list
     (current-continuation-marks)
     key))
```

```
> (with-continuation-mark 'key 'mark
    (extract-current-continuation-marks 'key))
'(mark)
> (with-continuation-mark 'key1 'mark1
    (with-continuation-mark 'key2 'mark2
      (list
       (extract-current-continuation-marks 'key1)
       (extract-current-continuation-marks 'key2))))
'((mark1) (mark2))
> (with-continuation-mark 'key 'mark1
    (with-continuation-mark 'key 'mark2 ; replaces previous mark
      (extract-current-continuation-marks 'key)))
'(mark2)
> (with-continuation-mark 'key 'mark1
    (list ; continuation extended to evaluate the argument
     (with-continuation-mark 'key 'mark2
        (extract-current-continuation-marks 'key))))
'((mark2 mark1))
> (let loop ([n 1000])
    (if (zero? n)
        (extract-current-continuation-marks 'key)
        (with-continuation-mark 'key n
          (loop (sub1 n)))))
'(1)
```

Changed in version 8.4.0.2 of package `base`: Added the *`realms?`* argument.

10.6 Breaks

A *break* is an asynchronous exception, usually triggered through an external source controlled by the user, or through the `break-thread` procedure. For example, the user may type Ctl-C in a terminal to trigger a break. On some platforms, the Racket process may receive `SIGINT`, `SIGHUP`, or `SIGTERM`; the latter two correspond to hang-up and terminate breaks as reflected by `exn:break:hang-up` and `exn:break:terminate`, respectively. Multiple breaks may be collapsed into a single exception, and multiple breaks of different kinds may be collapsed to a single "strongest" break, where a terminate break is stronger than a hang-up break which is stronger than an interrupt break.

A break exception can only occur in a thread while breaks are enabled. When a break is detected and enabled, the `exn:break` (or `exn:break:hang-up` or `exn:break:terminate`) exception is raised in the thread sometime afterward; if breaking is disabled when `break-thread` is called, the break is suspended until breaking is again enabled for the thread. While a thread has a suspended break, additional breaks are ignored.

Breaks are enabled through the break-enabled parameter-like procedure and through the parameterize-break form, which is analogous to parameterize. The break-enabled procedure does not represent a parameter to be used with parameterize, because changing the break-enabled state of a thread requires an explicit check for breaks, and this check is incompatible with the tail evaluation of a parameterize expression's body.

Certain procedures, such as semaphore-wait/enable-break, enable breaks temporarily while performing a blocking action. If breaks are enabled for a thread, and if a break is triggered for the thread but not yet delivered as an exn:break exception, then the break is guaranteed to be delivered before breaks can be disabled in the thread. The timing of exn:break exceptions is not guaranteed in any other way.

Before calling a with-handlers predicate or handler, an exception handler, an error display handler, an error escape handler, an error value conversion handler, or a pre-thunk or post-thunk for a dynamic-wind, the call is parameterize-breaked to disable breaks. Furthermore, breaks are disabled during the transitions among handlers related to exceptions, during the transitions between pre-thunks and post-thunks for dynamic-wind, and during other transitions for a continuation jump. For example, if breaks are disabled when a continuation is invoked, and if breaks are also disabled in the target continuation, then breaks will remain disabled from the time of the invocation until the target continuation executes unless a relevant dynamic-wind pre-thunk or post-thunk explicitly enables breaks.

If a break is triggered for a thread that is blocked on a nested thread (see call-in-nested-thread), and if breaks are enabled in the blocked thread, the break is implicitly handled by transferring it to the nested thread.

When breaks are enabled, they can occur at any point within execution, which makes certain implementation tasks subtle. For example, assuming breaks are enabled when the following code is executed,

```
(with-handlers ([exn:break? (lambda (x) (void))])
  (semaphore-wait s))
```

then it is *not* the case that a #<void> result means the semaphore was decremented or a break was received, exclusively. It is possible that *both* occur: the break may occur after the semaphore is successfully decremented but before a #<void> result is returned by semaphore-wait. A break exception will never damage a semaphore, or any other built-in construct, but many built-in procedures (including semaphore-wait) contain internal sub-expressions that can be interrupted by a break.

In general, it is impossible using only semaphore-wait to implement the guarantee that either the semaphore is decremented or an exception is raised, but not both. Racket therefore supplies semaphore-wait/enable-break (see §11.2.3 "Semaphores"), which does permit the implementation of such an exclusive guarantee:

```
(parameterize-break #f
```

```
(with-handlers ([exn:break? (lambda (x) (void))])
  (semaphore-wait/enable-break s)))
```

In the above expression, a break can occur at any point until breaks are disabled, in which case a break exception is propagated to the enclosing exception handler. Otherwise, the break can only occur within `semaphore-wait/enable-break`, which guarantees that if a break exception is raised, the semaphore will not have been decremented.

To allow similar implementation patterns over blocking port operations, Racket provides `read-bytes-avail!/enable-break`, `write-bytes-avail/enable-break`, and other procedures.

```
(break-enabled) → boolean?
(break-enabled on?) → void?
  on? : any/c
```

Gets or sets the break enabled state of the current thread. If *on?* is not supplied, the result is `#t` if breaks are currently enabled, `#f` otherwise. If *on?* is supplied as `#f`, breaks are disabled, and if *on?* is a true value, breaks are enabled.

```
(parameterize-break boolean-expr body ...+)
```

Evaluates *boolean-expr* to determine whether breaks are initially enabled while evaluating the *body*s in sequence. The result of the `parameterize-break` expression is the result of the last `expr`.

As with `parameterize`, a fresh thread cell is allocated to hold the break-enabled state of the continuation, and calls to `break-enabled` within the continuation access or modify the new cell. Unlike a parameter, a mutation to the break setting via `break-enabled` is not inherited by new threads (i.e., the thread cell is not preserved).

```
(current-break-parameterization) → break-parameterization?
```

Analogous to `(current-parameterization)` (see §11.3.2 “Parameters”); it returns a break parameterization (effectively, a thread cell) that holds the current continuation’s break-enable state.

```
(call-with-break-parameterization break-param
                                  thunk)      → any
  break-param : break-parameterization?
  thunk : (-> any)
```

Analogous to `(call-with-parameterization parameterization thunk)` (see §11.3.2 “Parameters”), calls *thunk* in a continuation whose break-enabled state is in *break-param*. The *thunk* is *not* called in tail position with respect to the `call-with-break-parameterization` call.

```
(break-parameterization? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a break parameterization as produced by `current-break-parameterization`, `#f` otherwise.

Added in version 6.1.1.8 of package `base`.

10.7 Exiting

```
(exit [v]) → any
  v : any/c = #t
```

Passes *v* to the current exit handler. If the exit handler does not escape or terminate the thread, `#<void>` is returned.

```
(exit-handler) → (any/c . -> . any)
(exit-handler proc) → void?
  proc : (any/c . -> . any)
```

A parameter that determines the current *exit handler*. The exit handler is called by `exit`.

The default exit handler in the Racket executable takes any argument, calls `plumber-flush-all` on the original plumber, and shuts down the OS-level Racket process. The argument is used as the OS-level exit code if it is an exact integer between `1` and `255` (which normally means "failure"); otherwise, the exit code is `0`, (which normally means "success").

```
(executable-yield-handler) → (byte? . -> . any)
(executable-yield-handler proc) → void?
  proc : (byte? . -> . any)
```

A parameter that determines a procedure to be called as the Racket process is about to exit normally. The procedure associated with this parameter is not called when `exit` (or, more precisely, the default exit handler) is used to exit early. The argument to the handler is the status code that is returned to the system on exit. The default executable-yield handler simply returns `#<void>`.

The `racket/gui/base` library sets this parameter to wait until all frames are closed, timers stopped, and queued events handled in the main eventspace. See `racket/gui/base` for more information.

10.8 Black-Box Procedure

As Racket programs are compiled (see §18.7 “Controlling and Inspecting Compilation”), the compiler may reorder or even remove *pure* computations that have no visible effect. For compilation purposes, the time needed to perform a computation is not considered a visible effect. The compiler takes into account memory used by a computation, including values that the computation keeps reachable, only to the degree that it will not increase the asymptotic memory use of a program, but it may remove or reorder computations in a way that reduces memory use. The black-box function inhibits many of these optimizations without adding additional overhead.

```
(black-box v) → any/c
  v : any/c
```

Returns *v*.

As far as the Racket compiler is concerned, black-box returns an unknown value, and it has a side effect involving *v*, which means that a call to black-box or its argument cannot be eliminated at compile time, and its evaluation cannot be reordered with respect to other side effects.

Examples:

```
> (let ([to-power 100])
    (let loop ([i 1000])
      (unless (zero? i)
        ; call to `expt` is optimized away entirely, since
        ; there's no effect and the result is unused:
        (expt 2 to-power)
        (loop (sub1 i)))))
> (let ([to-power 100])
    (let loop ([i 1000])
      (unless (zero? i)
        ; call to `expt` is optimized to just returning a folded
        ; constant, instead of calling `expt` each iteration:
        (black-box (expt 2 to-power))
        (loop (sub1 i)))))
> (let ([to-power (black-box 100)])
    (let loop ([i 1000])
      (unless (zero? i)
        ; in safe mode, calls `expt`, because `to-power` is not
        ; known to be a number; optimized away in unsafe mode:
        (expt 2 to-power)
        (loop (sub1 i)))))
> (let ([to-power (black-box 100)])
    (let loop ([i 1000])
```

```
(unless (zero? i)
  ; arithmetic really performed every iteration, since the
  ; `to-power` value is assumed unknown, and the `expt`
  ; result is assumed to be used, even in unsafe mode:
  (black-box (expt 2 to-power))
  (loop (sub1 i)))))
```

Added in version 8.18.0.17 of package `base`.

10.9 Unreachable Expressions

```
(assert-unreachable) → none/c
```

Reports an assertion failure by raising `exn:fail:contract`, which is useful as a safe counterpart to `unsafe-assert-unreachable`.

Added in version 8.0.0.11 of package `base`.

10.9.1 Customized Unreachable Reporting

```
(require racket/unreachable)
```
package: `base`

The bindings documented in this section are provided by the `racket/unreachable` library, not `racket/base` or `racket`.

Added in version 8.0.0.11 of package `base`.

```
(with-assert-unreachable
  body ...+)
```

Similar to `(assert-unreachable)`, asserts that the *body* forms should not be reached.

Unless the expression is part of a module that includes `(#%declare #:unsafe)`, then it is equivalent to `(let-values () body ...+)`. The intent is that the *body* forms will raise `exn:fail:contract`.

When a `with-assert-unreachable` expression is part of a module with `(#%declare #:unsafe)`, then it is equivalent to `(unsafe-assert-unreachable)`.

11 Concurrency and Parallelism

Racket supports multiple threads of control within a program, thread-local storage, some primitive synchronization mechanisms, and a framework for composing synchronization abstractions. In addition, the `racket/future` and `racket/place` libraries provide support for parallelism to improve performance.

11.1 Threads

§18 "Concurrency and Synchronization" in *The Racket Guide* introduces threads.

See §1.1.12 "Threads" for basic information on the Racket thread model. See also §11.4 "Futures" and §11.5 "Places".

When a thread is created, it is placed into the management of the current custodian and added to the current thread group. A thread can have any number of custodian managers added through `thread-resume`. The allocation made by a thread is accounted to the thread's custodian managers. See `custodian-limit-memory` for examples.

A thread that has not terminated can be garbage collected (see §1.1.6 "Garbage Collection") if it is unreachable and suspended or if it is unreachable and blocked on only unreachable events through functions such as `semaphore-wait`, `semaphore-wait/enable-break`, `channel-put`, `channel-get`, `sync`, `sync/enable-break`, or `thread-wait`. Beware, however, of a limitation on place-channel blocking; see the caveat in §11.5 "Places".

In GRacket, a handler thread for an eventspace is blocked on an internal semaphore when its event queue is empty. Thus, the handler thread is collectible when the eventspace is unreachable and contains no visible windows or running timers.

A thread can be used as a synchronizable event (see §11.2.1 "Events"). A thread is ready for synchronization when `thread-wait` would not block; the synchronization result of a thread is the thread itself.

11.1.1 Creating Threads

```
(thread thunk [#:pool pool #:keep keep]) → thread?
  thunk : (-> any)
  pool : (or/c #f 'own parallel-thread-pool?) = #f
  keep : (or/c #f 'results) = #f
```

Calls *thunk* with no arguments in a new thread of control. The `thread` procedure returns immediately with a *thread descriptor* value. When the invocation of *thunk* returns, the thread created to invoke *thunk* terminates.

The resulting thread is a coroutine thread if *pool* is `#f`. If *pool* is `'own`, then a new parallel thread pool is created, the thread is added to the pool, and the pool is closed (in the sense of `parallel-thread-pool-close`) to additional threads. If *pool* is a parallel thread pool, then the new thread is created in that pool, meaning that it shares processor resources with other threads in the same pool.

See §20.1 "Parallel Threads" for information about parallel threads and performance. Parallel threads do not run in parallel on the BC variant of Racket or when Racket is built without support for parallelism. For more information, If *keep* is `'results`, results are recorded with the thread so that they can be reported by `thread-wait`. Otherwise, then the results of *thunk* are ignored.

Changed in version 8.18.0.2 of package `base`: Added the `#:pool` and `#:keep` arguments.

```
(thread? v) → thread?
  v : any/c
```

Returns `#t` if *v* is a thread descriptor, `#f` otherwise.

```
(current-thread) → thread?
```

Returns the thread descriptor for the currently executing thread.

```
(thread/suspend-to-kill thunk) → thread?
  thunk : (-> any)
```

Like `thread`, except that "killing" the thread through `kill-thread` or `custodian-shutdown-all` merely suspends the thread instead of terminating it.

```
(call-in-nested-thread thunk [cust]) → any
  thunk : (-> any)
  cust : custodian? = (current-custodian)
```

Creates a nested thread managed by *cust* to execute *thunk*. (The nested thread's current custodian is inherited from the creating thread, independent of the *cust* argument.) The current thread blocks until *thunk* returns, and the result of the `call-in-nested-thread` call is the result returned by *thunk*.

The nested thread's exception handler is initialized to a procedure that jumps to the beginning of the thread and transfers the exception to the original thread. The handler thus terminates the nested thread and re-raises the exception in the original thread.

If the thread created by `call-in-nested-thread` dies before *thunk* returns, the `exn:fail` exception is raised in the original thread. If the original thread is killed before *thunk* returns, a break is queued for the nested thread.

If a break is queued for the original thread (with `break-thread`) while the nested thread is running, the break is redirected to the nested thread. If a break is already queued on the original thread when the nested thread is created, the break is moved to the nested thread. If a break remains queued on the nested thread when it completes, the break is moved to the original thread.

If the thread created by `call-in-nested-thread` dies while itself in a call to `call-in-nested-thread`, the outer call to `call-in-nested-thread` waits for the innermost nested thread to complete, and any breaks pending on the inner threads are moved to the original thread.

11.1.2 Suspending, Resuming, and Killing Threads

```
(thread-suspend thd) → void?
  thd : thread?
```

Immediately suspends the execution of *thd* if it is running. If the thread has terminated or is already suspended, `thread-suspend` has no effect. The thread remains suspended (i.e., it does not execute) until it is resumed with `thread-resume`. If the current custodian does not solely manage *thd* (i.e., some custodian of *thd* is not the current custodian or a subordinate), the `exn:fail:contract` exception is raised, and the thread is not suspended.

```
(thread-resume thd [benefactor]) → void?
  thd : thread?
  benefactor : (or/c thread? custodian? #f) = #f
```

Resumes the execution of *thd* if it is suspended and has at least one custodian (possibly added through *benefactor*, as described below). If the thread has terminated, or if the thread is already running and *benefactor* is not supplied, or if the thread has no custodian and *benefactor* is not supplied, then `thread-resume` has no effect. Otherwise, if *benefactor* is supplied, it triggers up to three additional actions:

- If *benefactor* is a thread, whenever it is resumed from a suspended state in the future, then *thd* is also resumed. (Resuming *thd* may trigger the resumption of other threads that were previously attached to *thd* through `thread-resume`.)
- New custodians may be added to *thd*'s set of managers. If *benefactor* is a thread, then all of the thread's custodians are added to *thd*. Otherwise, *benefactor* is a custodian, and it is added to *thd* (unless the custodian is already shut down). If *thd* becomes managed by both a custodian and one or more of its subordinates, the redundant subordinates are removed from *thd*. If *thd* is suspended and a custodian is added, then *thd* is resumed only after the addition.
- If *benefactor* is a thread, whenever it receives a new managing custodian in the future, then *thd* also receives the custodian. (Adding custodians to *thd* may trigger adding the custodians to other threads that were previously attached to *thd* through `thread-resume`.)

```
(kill-thread thd) → void?
  thd : thread?
```

Terminates the specified thread immediately, or suspends the thread if *thd* was created with `thread/suspend-to-kill`. Terminating the main thread exits the application. If *thd* has already terminated, `kill-thread` does nothing. If the current custodian does not solely manage *thd* (i.e., some custodian of *thd* is not the current custodian or a subordinate), the `exn:fail:contract` exception is raised, and the thread is not killed or suspended.

Unless otherwise noted, procedures provided by Racket (and GRacket) are kill-safe and suspend-safe; that is, killing or suspending a thread never interferes with the application of procedures in other threads. For example, if a thread is killed while extracting a character from an input port, the character is either completely consumed or not consumed, and other threads can safely use the port.

```
(break-thread thd [kind]) → void?
  thd : thread?
  kind : (or/c #f 'hang-up 'terminate) = #f
```

Registers a break with the specified thread. The optional *kind* value indicates the kind of break to register, where `#f`, `'hang-up`, and `'terminate` correspond to interrupt, hang-up, and terminate breaks respectively. If breaking is disabled in *thd*, the break will be ignored until breaks are re-enabled. See §10.6 "Breaks" for details.

```
(sleep [secs]) → void?
  secs : (>=/c 0) = 0
```

Causes the current thread to sleep until at least *secs* seconds have passed after it starts sleeping. A zero value for *secs* simply acts as a hint to allow other threads to execute. The value of *secs* can be a non-integer to request a sleep duration to any precision; the precision of the actual sleep time is unspecified.

```
(thread-running? thd) → any
  thd : thread?
```

Returns `#t` if *thd* has not terminated and is not suspended, `#f` otherwise.

```
(thread-dead? thd) → any
  thd : thread?
```

Returns `#t` if *thd* has terminated, `#f` otherwise.

11.1.3 Synchronizing Thread State

```
(thread-wait thd [fail-k]) → any
  thd : thread?
  fail-k : (procedure-arity-includes/c 0) = void
```

Blocks execution of the current thread until *thd* has terminated. If the thread's procedure raised an exception, otherwise aborted to the thread's initial prompt, or was terminated by being killed, then *fail-k* is called to produce the result of `thread-wait`. Otherwise, if the thread records its results (see `#:keep` in `thread`), those results are returned, while `#<void>` is return if the thread does not keep its results.

Note that `(thread-wait (current-thread))` deadlocks the current thread, but a break can end the deadlock if breaking is enabled and if the thread is the main thread or otherwise accessible; see §10.6 "Breaks".

Unless *thd* was created with `thread/suspend-to-kill`, a `(thread-wait thd)` may potentially continue even if *thd* is otherwise inaccessible, because a custodian shut down could terminate the thread. As a result, a thread blocking with `thread-wait` normally cannot be garbage collected (see §1.1.6 "Garbage Collection"). As a special case, however, `(thread-wait thd)` blocks without preventing garbage collection of the thread if *thd* is the current thread, since the thread could only continue if a break escapes from the wait.

Changed in version 8.18.0.2 of package `base`: Added support for threads with values and the *fail-k* argument.

```
(thread-dead-evt thd) → evt?
  thd : thread?
```

Returns a synchronizable event (see §11.2.1 "Events") that is ready for synchronization if and only if *thd* has terminated. Unlike using *thd* directly, however, retaining a reference to the event does not prevent *thd* from being garbage collected (see §1.1.6 "Garbage Collection"). The synchronization result of a thread-dead event is the thread-dead event itself.

A thread waiting on the result of `(thread-dead-evt thd)` normally cannot itself be garbage collected, unless *thd* was created with `thread/suspend-to-kill`, along the same lines as waiting via `thread-wait`. However, there is no special case for waiting on the result of `(thread-dead-evt thd)` where *thd* is the current thread.

For a given *thd*, `thread-dead-evt` always returns the same (i.e., `eq?`) result.

```
(thread-resume-evt thd) → evt?
  thd : thread?
```

Returns a synchronizable event (see §11.2.1 "Events") that becomes ready for synchronization when *thd* is running. (If *thd* has terminated, the event never becomes ready.) If *thd* runs and is then suspended after a call to `thread-resume-evt`, the result event remains ready; after each suspend of *thd* a fresh event is generated to be returned by `thread-resume-evt`. The result of the event is *thd*, but if *thd* is never resumed, then reference to the event does not prevent *thd* from being garbage collected (see §1.1.6 "Garbage Collection").

```
(thread-suspend-evt thd) → evt?
  thd : thread?
```

Returns a synchronizable event (see §11.2.1 "Events") that becomes ready for synchronization when *thd* is suspended. (If *thd* has terminated, the event will never unblock.) If *thd* is suspended and then resumes after a call to thread-suspend-evt, the result event remains ready; each resume of *thd* creates a fresh event to be returned by thread-suspend-evt. The result of the event is *thd*, but if *thd* was created with thread (as opposed to thread/suspend-to-kill) and is never resumed, then reference to the event does not prevent *thd* from being garbage collected (see §1.1.6 "Garbage Collection").

If *thd* was created with thread/suspend-to-kill, then waiting on (thread-suspend-evt *thd*) prevents garbage collection of the waiting thread in the same way as (thread-dead-evt *another-thd*) for a *another-thd* created via thread. Furthermore, since the event result is *thd*, waiting on (thread-suspend-evt *thd*) prevents garbage collection of *thd*.

11.1.4 Thread Mailboxes

Each thread has a *mailbox* through which it can receive arbitrary messages. In other words, each thread has a built-in asynchronous channel.

See also §11.2.4 "Buffered Asynchronous Channels".

```
(thread-send thd v [fail-thunk]) → any
  thd : thread?
  v : any/c
  fail-thunk : (or/c (-> any) #f)
             = (lambda () (raise-mismatch-error ....))
```

Queues *v* as a message to *thd* without blocking. If the message is queued, the result is #<void>. If *thd* stops running—as in thread-running?—before the message is queued, then *fail-thunk* is called (through a tail call) if it is a procedure to produce the result, or #f is returned if *fail-thunk* is #f.

```
(thread-receive) → any/c
```

Receives and dequeues a message queued for the current thread, if any. If no message is available, thread-receive blocks until one is available.

```
(thread-try-receive) → any/c
```

Receives and dequeues a message queued for the current thread, if any, or returns #f immediately if no message is available.

```
(thread-receive-evt) → evt?
```

Returns a constant synchronizable event (see §11.2.1 "Events") that becomes ready for synchronization when the synchronizing thread has a message to receive. The synchronization result of a thread-receive event is the thread-receive event itself.

```
(thread-rewind-receive lst) → void?
  lst : list?
```

Pushes the elements of `lst` back onto the front of the current thread's queue. The elements are pushed one by one, so that the first available message is the last element of `lst`.

11.1.5 Parallel Thread Pools

```
(parallel-thread-pool? v) → thread?
  v : any/c
```

Returns `#t` if `v` is a parallel thread pool, `#f` otherwise.

Added in version 8.18.0.2 of package `base`.

```
(make-parallel-thread-pool [n]) → parallel-thread-pool?
  n : exact-positive-integer? = (processor-count)
```

Creates a *parallel thread pool* that can be used to group a parallel thread with other parallel threads. The threads in a pool can use up to `n` processors to run. If more than `n` threads are in the pool, not all of them will run in parallel, but they will still all run concurrently.

The new thread pool is placed into the management of the current custodian. If the custodian is shut down, then the pool is closed in the same way as with `parallel-thread-pool-close`. Any threads already in the pool can continue to run and use the pool's resources (unless they are also shut down by the same custodian).

A parallel thread pool cannot run threads in parallel on the BC variant of Racket or when Racket is compiled without support for parallelism. In that case, parallel threads behave the same as coroutine threads. For the CS variant of Racket, the `futures-enabled?` predicate can be used to detect when parallel threads behave differently from coroutine threads.

Added in version 8.18.0.2 of package `base`.

```
(parallel-thread-pool-close p) → void?
  p : parallel-thread-pool?
```

Closes a parallel thread pool so that no threads can be added to the pool. Any existing threads in the pool are allowed to continue running, and they continue to share the pool's processor resources.

When no more threads are running within a closed thread pool, or when no threads are allowed to make progress because the pool's custodian has been shut down, then processor resources allocated to the pool can be returned to the operating system (i.e., operating-system threads allocated to the pool are terminated).

Added in version 8.18.0.2 of package `base`.

11.2 Synchronization

Racket's synchronization toolbox spans four layers:

- synchronizable events — a general framework for synchronization;
- channels — a primitive that can be used, in principle, to build most other kinds of synchronizable events (except the ones that compose events); and
- semaphores — a simple and especially cheap primitive for synchronization.
- future semaphores — a simple synchronization primitive for use with futures.

11.2.1 Events

A *synchronizable event* (or just *event* for short) works with the `sync` procedure to coordinate synchronization among threads. Certain kinds of objects double as events, including ports and threads. Other kinds of objects exist only for their use as events. Racket's event system is based on Concurrent ML [Reppy99].

At any point in time, an event is either *ready for synchronization*, or it is not; depending on the kind of event and how it is used by other threads, an event can switch from not ready to ready (or back), at any time. If a thread synchronizes on an event when it is ready, then the event produces a particular *synchronization result*.

Synchronizing an event may affect the state of the event. For example, when synchronizing a semaphore, then the semaphore's internal count is decremented, just as with `semaphore-wait`. For most kinds of events, however (such as a port), synchronizing does not modify the event's state.

Racket values that act as synchronizable events include asynchronous channels, channels, custodian boxes, log receivers, place channels, ports, semaphores, subprocesses, TCP listeners, threads, and will executors. Libraries can define new synchronizable events, especially though `prop:evt`.

```
(evt? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a synchronizable event, `#f` otherwise.

Examples:

```
> (evt? never-evt)
#t
> (evt? (make-channel))
#t
> (evt? 5)
#f
```

```
(sync evt ...) → any
  evt : evt?
```

Blocks as long as none of the synchronizable events *evt*s are ready, as defined above.

When at least one *evt* is ready, its synchronization result (often *evt* itself) is returned. If multiple *evt*s are ready, one of the *evt*s is chosen pseudo-randomly for the result; the `current-evt-pseudo-random-generator` parameter sets the random-number generator that controls this choice.

Examples:

```
> (define ch (make-channel))
> (thread (λ () (displayln (sync ch))))
#<thread>
> (channel-put ch 'hellooooo)
hellooooo
```

Changed in version 6.1.0.3 of package `base`: Allow 0 arguments instead of 1 or more.

```
(sync/timeout timeout evt ...) → any
  timeout : (or/c #f (and/c real? (not/c negative?)) (-> any))
  evt : evt?
```

Like `sync` if *timeout* is `#f`. If *timeout* is a real number, then the result is `#f` if *timeout* seconds pass without a successful synchronization. If *timeout* is a procedure, then it is called in tail position if polling the *evt*s discovers no ready events.

A zero value for *timeout* is equivalent to `(lambda () #f)`. In either case, each *evt* is checked at least once before returning `#f` or calling *timeout*.

See also `alarm-evt` for an alternative timeout mechanism.

Examples:

```
; times out before waking up
```

```
> (sync/timeout
   0.5
   (thread (λ () (sleep 1) (displayln "woke up!"))))
#f
> (sync/timeout
   (λ () (displayln "no ready events"))
   never-evt)
no ready events
```

Changed in version 6.1.0.3 of package base: Allow 1 argument instead of 2 or more.

```
(sync/enable-break evt ...) → any
  evt : evt?
```

Like sync, but breaking is enabled (see §10.6 "Breaks") while waiting on the *evt*s. If breaking is disabled when sync/enable-break is called, then either all *evt*s remain unchosen or the exn:break exception is raised, but not both.

```
(sync/timeout/enable-break timeout evt ...) → any
  timeout : (or/c #f (and/c real? (not/c negative?)) (-> any))
  evt : evt?
```

Like sync/enable-break, but with a timeout as for sync/timeout.

```
(choice-evt evt ...) → evt?
  evt : evt?
```

Creates and returns a single event that combines the *evt*s. Supplying the result to sync is the same as supplying each *evt* to the same call.

That is, an event returned by choice-evt is ready for synchronization when one or more of the *evt*s supplied to choice-evt are ready for synchronization. If the choice event is chosen, one of its ready *evt*s is chosen pseudo-randomly, and the synchronization result is the chosen *evt*'s synchronization result.

Examples:

```
> (define ch1 (make-channel))
> (define ch2 (make-channel))
> (define either-channel (choice-evt ch1 ch2))
> (thread (λ () (displayln (sync either-channel))))
#<thread>
> (channel-put
   (if (> (random) 0.5) ch1 ch2)
   'tuturuu)
```

```
tuturuu
```

```
(wrap-evt evt wrap) → evt?
  evt : evt?
  wrap : (any/c ... . -> . any)
```

Creates an event that is ready for synchronization when `evt` is ready for synchronization, but whose synchronization result is determined by applying `wrap` to the synchronization result of `evt`. The number of arguments accepted by `wrap` must match the number of values for the synchronization result of `evt`.

The call to `wrap` is `parameterize-break`ed to disable breaks initially.

Examples:

```
> (define ch (make-channel))
> (define evt (wrap-evt ch (λ (v) (format "you've got mail:
~a" v))))
> (thread (λ () (displayln (sync evt))))
#<thread>
> (channel-put ch "Dear Alice ...")
you've got mail: Dear Alice ...
```

```
(handle-evt evt handle) → handle-evt?
  evt : evt?
  handle : (any/c ... . -> . any)
```

Like `wrap-evt`, except that `handle` is called in tail position with respect to the synchronization request—and without breaks explicitly disabled—when it is not wrapped by `wrap-evt`, `chaperone-evt`, or another `handle-evt`.

Examples:

```
> (define msg-ch (make-channel))
> (define exit-ch (make-channel))
> (thread
   (λ ()
     (let loop ([val 0])
       (printf "val = ~a~n" val)
       (sync (handle-evt
              msg-ch
              (λ (val) (loop val)))
             (handle-evt
              exit-ch
              (λ (val) (displayln val)))))))
```

```
val = 0
#<thread>
> (channel-put msg-ch 5)
val = 5
> (channel-put msg-ch 7)
val = 7
> (channel-put exit-ch 'done)
done
```

```
(guard-evt maker) → evt?
  maker : (-> (or/c evt? any/c))
```

Creates a value that behaves as an event, but that is actually an event maker.

An event *guard* returned by `guard-evt` generates an event when *guard* is used with `sync` (or whenever it is part of a choice event used with `sync`, etc.), where the generated event is the result of calling *maker*. The *maker* procedure may be called by `sync` at most once for a given call to `sync`, but *maker* may not be called if a ready event is chosen before *guard* is even considered.

If *maker* returns a non-event, then *maker*'s result is replaced with an event that is ready for synchronization and whose synchronization result is *guard*.

```
(nack-guard-evt maker) → evt?
  maker : (evt? . -> . (or/c evt? any/c))
```

Like `guard-evt`, but when *maker* is called, it is given a NACK ("negative acknowledgment") event. After starting the call to *maker*, if the event from *maker* is not ultimately chosen as the ready event, then the NACK event supplied to *maker* becomes ready for synchronization with a `#<void>` value.

The NACK event becomes ready for synchronization when the event is abandoned when either some other event is chosen, the synchronizing thread is dead, or control escapes from the call to `sync` (even if *nack-guard*'s *maker* has not yet returned a value). If the event returned by *maker* is chosen, then the NACK event never becomes ready for synchronization.

```
(poll-guard-evt maker) → evt?
  maker : (boolean? . -> . (or/c evt? any/c))
```

Like `guard-evt`, but when *maker* is called, it is provided a boolean value that indicates whether the event will be used for a poll, `#t`, or for a blocking synchronization, `#f`.

If `#t` is supplied to *maker*, if breaks are disabled, if the polling thread is not terminated, and if polling the resulting event produces a synchronization result, then the event will certainly be chosen for its result.

```
(replace-evt evt maker) → evt?
  evt : evt?
  maker : (any/c ... . -> . (or/c evt? any/c))
```

Like `guard-evt`, but *`maker`* is called only after *`evt`* becomes ready for synchronization, and the synchronization result of *`evt`* is passed to *`maker`*.

The attempt to synchronize on *`evt`* proceeds concurrently as the attempt to synchronize on the result *`guard`* from `replace-evt`; despite that concurrency, if *`maker`* is called, it is called in the thread that is synchronizing on *`guard`*. Synchronization can succeed for both *`evt`* and another synchronized with *`guard`* at the same time; the single-choice guarantee of synchronization applies only to the result of *`maker`* and other events synchronized with *`guard`*.

If *`maker`* returns a non-event, then *`maker`*'s result is replaced with an event that is ready for synchronization and whose synchronization result is *`guard`*.

Added in version 6.1.0.3 of package `base`.

```
always-evt : evt?
```

A constant event that is always ready for synchronization, with itself as its synchronization result.

Example:

```
> (sync always-evt)
#<always-evt>
```

```
never-evt : evt?
```

A constant event that is never ready for synchronization.

Example:

```
> (sync/timeout 0.1 never-evt)
#f
```

```
(system-idle-evt) → evt?
```

Returns an event that is ready for synchronization when the system is otherwise idle: if the result event were replaced by `never-evt`, no thread in the system would be available to run. In other words, all threads must be suspended or blocked on events with timeouts that have not yet expired. The system-idle event's synchronization result is `#<void>`. The result of the `system-idle-evt` procedure is always the same event.

Examples:

```
> (define th (thread (λ () (let loop () (loop)))))
> (sync/timeout 0.1 (system-idle-evt))
#f
> (kill-thread th)
> (sync (system-idle-evt))
```

```
(alarm-evt msecs [monotonic?]) → evt?
  msecs : real?
  monotonic? : any/c = #f
```

Returns a synchronizable event that is not ready for synchronization when `(milliseconds)` would return a value that is less than `msecs`, and it is ready for synchronization when `(milliseconds)` would return a value that is more than `msecs`. The value of `milliseconds` is `current-inexact-milliseconds` when `monotonic?` is `#f`, or `current-inexact-monotonic-milliseconds` otherwise. The synchronization result of a alarm event is the alarm event itself.

Examples:

```
> (define alarm (alarm-evt (+ (current-inexact-
milliseconds) 100)))
> (sync alarm)
#<alarm-evt>
```

Changed in version 8.3.0.9 of package `base`: Added the `monotonic?` argument.

```
(handle-evt? evt) → boolean?
  evt : evt?
```

Returns `#t` if `evt` was created by `handle-evt` or by `choice-evt` applied to another event for which `handle-evt?` produces `#t`. For any other event, `handle-evt?` produces `#f`.

Examples:

```
> (handle-evt? never-evt)
#f
> (handle-evt? (handle-evt always-evt values))
#t
```

```
prop:evt : struct-type-property?
```

A structure type property that identifies structure types whose instances can serve as synchronizable events. The property value can be any of the following:

- An event *evt*: In this case, using the structure as an event is equivalent to using *evt*.
- A procedure *proc* of one argument: In this case, the structure is similar to an event generated by `guard-evt`, except that the would-be guard procedure *proc* receives the structure as an argument, instead of no arguments; also, a non-event result from *proc* is replaced with an event that is already ready for synchronization and whose synchronization result is the structure.
- An exact, non-negative integer between `0` (inclusive) and the number of non-automatic fields in the structure type (exclusive, not counting supertype fields): The integer identifies a field in the structure, and the field must be designated as immutable. If the field contains an object or an event-generating procedure of one argument, the event or procedure is used as above. Otherwise, the structure acts as an event that is never ready.

Instances of a structure type with the `prop:input-port` or `prop:output-port` property are also synchronizable events by virtue of being a port. If the structure type has more than one of `prop:evt`, `prop:input-port`, and `prop:output-port`, then the `prop:evt` value (if any) takes precedence for determining the instance's behavior as an event, and the `prop:input-port` property takes precedence over `prop:output-port` for synchronization.

For working with foreign libraries, a `prop:evt` value can also be a result of `unsafe-poller`, although that possibility is omitted from the safe contract of `prop:evt`.

Examples:

```
> (struct wt (base val)
    #:property prop:evt (struct-field-index base))
> (define sema (make-semaphore))
> (sync/timeout 0 (wt sema #f))
#f
> (semaphore-post sema)
> (sync/timeout 0 (wt sema #f))
#<semaphore>
> (semaphore-post sema)
> (sync/timeout 0 (wt (lambda (self) (wt-val self)) sema))
#<semaphore>
> (semaphore-post sema)
> (define my-wt (wt (lambda (self)
                      (wrap-evt
                       (wt-val self)
                       (lambda (x) self)))
                    sema))
> (sync/timeout 0 my-wt)
#<wt>
> (sync/timeout 0 my-wt)
#f
```

```
(current-evt-pseudo-random-generator)
 → pseudo-random-generator?
(current-evt-pseudo-random-generator generator) → void?
  generator : pseudo-random-generator?
```

A parameter that determines the pseudo-random number generator used by `sync` for events created by `choice-evt`.

11.2.2 Channels

A *channel* both synchronizes a pair of threads and passes a value from one to the other. Channels are synchronous; both the sender and the receiver must block until the (atomic) transaction is complete. Multiple senders and receivers can access a channel at once, but a single sender and receiver is selected for each transaction.

Channel synchronization is *fair*: if a thread is blocked on a channel and transaction opportunities for the channel occur infinitely often, then the thread eventually participates in a transaction.

In addition to its use with channel-specific procedures, a channel can be used as a synchronizable event (see §11.2.1 “Events”). A channel is ready for synchronization when `channel-get` would not block; the channel's synchronization result is the same as the `channel-get` result.

For buffered asynchronous channels, see §11.2.4 “Buffered Asynchronous Channels”.

```
(channel? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a channel, `#f` otherwise.

```
(make-channel) → channel?
```

Creates and returns a new channel. The channel can be used with `channel-get`, with `channel-try-get`, or as a synchronizable event (see §11.2.1 “Events”) to receive a value through the channel. The channel can be used with `channel-put` or through the result of `channel-put-evt` to send a value through the channel.

```
(channel-get ch) → any
  ch : channel?
```

Blocks until a sender is ready to provide a value through *ch*. The result is the sent value.

```
(channel-try-get ch) → any
  ch : channel?
```

Receives and returns a value from `ch` if a sender is immediately ready, otherwise returns `#f`.

```
(channel-put ch v) → void?
  ch : channel?
  v : any/c
```

Blocks until a receiver is ready to accept the value `v` through `ch`.

```
(channel-put-evt ch v) → channel-put-evt?
  ch : channel?
  v : any/c
```

Returns a fresh synchronizable event for use with `sync`. The event is ready for synchronization when `(channel-put ch v)` would not block, and the event's synchronization result is the event itself.

```
(channel-put-evt? v) → boolean?
  v : any/c
```

Returns `#t` if `v` is a channel-put event produced by `channel-put-evt`, `#f` otherwise.

11.2.3 Semaphores

A *semaphore* has an internal counter; when this counter is zero, the semaphore can block a thread's execution (through `semaphore-wait`) until another thread increments the counter (using `semaphore-post`). The maximum value for a semaphore's internal counter is platform-specific, but always at least `10000`.

A semaphore's counter is updated in a single-threaded manner, so that semaphores can be used for reliable synchronization. Semaphore waiting is *fair*: if a thread is blocked on a semaphore and the semaphore's internal value is non-zero infinitely often, then the thread is eventually unblocked.

In addition to its use with semaphore-specific procedures, a semaphore can be used as a synchronizable event (see §11.2.1 "Events"). A semaphore is ready for synchronization when `semaphore-wait` would not block. Upon synchronization, the semaphore's counter is decremented, and the synchronization result of a semaphore is the semaphore itself.

```
(semaphore? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a semaphore, `#f` otherwise.

```
(make-semaphore [init]) → semaphore?
  init : exact-nonnegative-integer? = 0
```

Creates and returns a new semaphore with the counter initially set to *init*. If *init* is larger than a semaphore's maximum internal counter value, the `exn:fail` exception is raised.

```
(semaphore-post sema) → void?
  sema : semaphore?
```

Increments the semaphore's internal counter and returns `#<void>`. If the semaphore's internal counter has already reached its maximum value, the `exn:fail` exception is raised.

```
(semaphore-wait sema) → void?
  sema : semaphore?
```

Blocks until the internal counter for semaphore *sema* is non-zero. When the counter is non-zero, it is decremented and `semaphore-wait` returns `#<void>`.

```
(semaphore-try-wait? sema) → boolean?
  sema : semaphore?
```

Like `semaphore-wait`, but `semaphore-try-wait?` never blocks execution. If *sema*'s internal counter is zero, `semaphore-try-wait?` returns `#f` immediately without decrementing the counter. If *sema*'s counter is positive, it is decremented and `#t` is returned.

```
(semaphore-wait/enable-break sema) → void?
  sema : semaphore?
```

Like `semaphore-wait`, but breaking is enabled (see §10.6 "Breaks") while waiting on *sema*. If breaking is disabled when `semaphore-wait/enable-break` is called, then either the semaphore's counter is decremented or the `exn:break` exception is raised, but not both.

```
(semaphore-peek-evt sema) → semaphore-peek-evt?
  sema : semaphore?
```

Creates and returns a new synchronizable event (for use with `sync`, for example) that is ready for synchronization when *sema* is ready, but synchronizing the event does not decrement *sema*'s internal count. The synchronization result of a semaphore-peek event is the semaphore-peek event itself.

```
(semaphore-peek-evt? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a semaphore wrapper produced by `semaphore-peek-evt`, `#f` otherwise.

```
(call-with-semaphore  sema
                      proc
                     [try-fail-thunk]
                      arg ...)          → any
  sema : semaphore?
  proc : procedure?
  try-fail-thunk : (or/c (-> any) #f) = #f
  arg : any/c
```

Waits on *sema* using `semaphore-wait`, calls *proc* with all *arg*s, and then posts to *sema*. A continuation barrier blocks full continuation jumps into or out of *proc* (see §1.1.11 "Prompts, Delimited Continuations, and Barriers"), but escape jumps are allowed, and *sema* is posted on escape. If *try-fail-thunk* is provided and is not `#f`, then `semaphore-try-wait?` is called on *sema* instead of `semaphore-wait`, and *try-fail-thunk* is called if the wait fails.

```
(call-with-semaphore/enable-break  sema
                                   proc
                                  [try-fail-thunk]
                                   arg ...)          → any
  sema : semaphore?
  proc : procedure?
  try-fail-thunk : (or/c (-> any) #f) = #f
  arg : any/c
```

Like `call-with-semaphore`, except that `semaphore-wait/enable-break` is used with *sema* in non-try mode. When *try-fail-thunk* is provided and not `#f`, then breaks are enabled around the use of `semaphore-try-wait?` on *sema*.

11.2.4 Buffered Asynchronous Channels

```
(require racket/async-channel)       package: base
```

The bindings documented in this section are provided by the `racket/async-channel` library, not `racket/base` or `racket`.

Creating and Using Asynchronous Channels

See also §11.1.4 "Thread Mailboxes".

An *asynchronous channel* is like a channel, but it buffers values so that a send operation does not wait on a receive operation.

In addition to its use with procedures that are specific to asynchronous channels, an asynchronous channel can be used as a synchronizable event (see §11.2.1 "Events"). An asynchronous channel is ready for synchronization when `async-channel-get` would not block;

the asynchronous channel's synchronization result is the same as the async-channel-get result.

```
(async-channel? v) → boolean?
  v : any/c
```

Returns #t if *v* is an asynchronous channel, #f otherwise.

```
(make-async-channel [limit]) → async-channel?
  limit : (or/c exact-positive-integer? #f) = #f
```

Returns an asynchronous channel with a buffer limit of *limit* items. A get operation blocks when the channel is empty, and a put operation blocks when the channel has *limit* items already. If *limit* is #f, the channel buffer has no limit (so a put never blocks).

```
(async-channel-get ach) → any/c
  ach : async-channel?
```

Blocks until at least one value is available in *ach*, and then returns the first of the values that were put into async-channel.

```
(async-channel-try-get ach) → any/c
  ach : async-channel?
```

If at least one value is immediately available in *ach*, returns the first of the values that were put into *ach*. If async-channel is empty, the result is #f.

```
(async-channel-put ach v) → void?
  ach : async-channel?
  v : any/c
```

Puts *v* into *ach*, blocking if *ach*'s buffer is full until space is available.

```
(async-channel-put-evt ach v) → evt?
  ach : async-channel?
  v : any/c
```

Returns a synchronizable event that is ready for synchronization when (async-channel-put *ach* *v*) would return a value (i.e., when the channel holds fewer values already than its limit); the synchronization result of a asynchronous channel-put event is the asynchronous channel-put event itself.

Examples:

```
(define (server input-channel output-channel)
  (thread (lambda ()
            (define (get)
              (async-channel-get input-channel))
            (define (put x)
              (async-channel-put output-channel x))
            (define (do-large-computation)
              (sqrt 9))
            (let loop ([data (get)])
              (case data
                [(quit) (void)]
                [(add) (begin
                         (put (+ 1 (get)))
                         (loop (get)))]
                [(long) (begin
                          (put (do-large-computation))
                          (loop (get)))])))))
(define to-server (make-async-channel))
(define from-server (make-async-channel))

> (server to-server from-server)
#<thread>
> (async-channel? to-server)
#t
> (printf "Adding 1 to 4\n")
Adding 1 to 4
> (async-channel-put to-server 'add)
> (async-channel-put to-server 4)
> (printf "Result is ~a\n" (async-channel-get from-server))
Result is 5
> (printf "Ask server to do a long computation\n")
Ask server to do a long computation
> (async-channel-put to-server 'long)
> (printf "I can do other stuff\n")
I can do other stuff
> (printf "Ok, computation from server is ~a\n"
          (async-channel-get from-server))
Ok, computation from server is 3
> (async-channel-put to-server 'quit)
```

Contracts and Impersonators on Asynchronous Channels

```
(async-channel/c c) → contract?
  c : contract?
```

Returns a contract that recognizes asynchronous channels. Values put into or retrieved from the channel must match *c*.

If the *c* argument is a flat contract or a chaperone contract, then the result will be a chaperone contract. Otherwise, the result will be an impersonator contract.

When an `async-channel/c` contract is applied to an asynchronous channel, the result is not `eq?` to the input. The result will be either a chaperone or impersonator of the input depending on the type of contract.

```
(impersonate-async-channel channel
                           get-proc
                           put-proc
                           prop
                           prop-val ...
                           ...)
 → (and/c async-channel? impersonator?)
  channel : async-channel?
  get-proc : (any/c . -> . any/c)
  put-proc : (any/c . -> . any/c)
  prop : impersonator-property?
  prop-val : any
```

Returns an impersonator of *channel*, which redirects the `async-channel-get` and `async-channel-put` operations.

The *get-proc* must accept the value that `async-channel-get` produces on *channel*; it must produce a replacement value, which is the result of the get operation on the impersonator.

The *put-proc* must accept the value passed to `async-channel-put` called on *channel*; it must produce a replacement value, which is the value passed to the put procedure called on the original channel.

The *get-proc* and *put-proc* procedures are called for all operations that get or put values from the channel, not just `async-channel-get` and `async-channel-put`.

Pairs of *prop* and *prop-val* (the number of arguments to `impersonate-async-channel` must be odd) add impersonator properties or override impersonator property values of *channel*.

```
(chaperone-async-channel channel
                         get-proc
                         put-proc
                         prop
                         prop-val ...
                         ...)
 → (and/c async-channel? chaperone?)
```

```
channel : async-channel?
get-proc : (any/c . -> . any/c)
put-proc : (any/c . -> . any/c)
prop : impersonator-property?
prop-val : any
```

Like `impersonate-async-channel`, but the *get-proc* procedure must produce the same value or a chaperone of the original value, and *put-proc* must produce the same value or a chaperone of the original value.

11.3 Thread-Local Storage

Thread cells provides primitive support for thread-local storage. Parameters combine thread cells and continuation marks to support thread-specific, continuation-specific binding.

11.3.1 Thread Cells

A *thread cell* contains a thread-specific value; that is, it contains a specific value for each thread, but it may contain different values for different threads. A thread cell is created with a default value that is used for all existing threads. When the cell's content is changed with `thread-cell-set!`, the cell's value changes only for the current thread. Similarly, `thread-cell-ref` obtains the value of the cell that is specific to the current thread.

A thread cell's value can be *preserved*, which means that when a new thread is created, the cell's initial value for the new thread is the same as the creating thread's current value. If a thread cell is non-preserved, then the cell's initial value for a newly created thread is the default value (which was supplied when the cell was created).

Within the current thread, the current values of all preserved threads cells can be captured through `current-preserved-thread-cell-values`. The captured set of values can be imperatively installed into the current thread through another call to `current-preserved-thread-cell-values`. The capturing and restoring threads can be different.

```
(thread-cell? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a thread cell, `#f` otherwise.

```
(make-thread-cell v [preserved?]) → thread-cell?
  v : any/c
  preserved? : any/c = #f
```

Creates and returns a new thread cell. Initially, *v* is the cell's value for all threads. If *preserved?* is true, then the cell's initial value for a newly created threads is the creating thread's value for the cell, otherwise the cell's value is initially *v* in all future threads.

```
(thread-cell-ref cell) → any
  cell : thread-cell?
```

Returns the current value of *cell* for the current thread.

```
(thread-cell-set! cell v) → any
  cell : thread-cell?
  v : any/c
```

Sets the value in *cell* to *v* for the current thread.

Examples:

```
> (define cnp (make-thread-cell '(nerve) #f))
> (define cp (make-thread-cell '(cancer) #t))
> (thread-cell-ref cnp)
'(nerve)
> (thread-cell-ref cp)
'(cancer)
> (thread-cell-set! cnp '(nerve nerve))
> (thread-cell-set! cp '(cancer cancer))
> (thread-cell-ref cnp)
'(nerve nerve)
> (thread-cell-ref cp)
'(cancer cancer)
> (define ch (make-channel))
> (thread (lambda ()
            (channel-put ch (thread-cell-ref cnp))
            (channel-put ch (thread-cell-ref cp))
            (channel-get ch)
            (channel-put ch (thread-cell-ref cp))))
#<thread>
> (channel-get ch)
'(nerve)
> (channel-get ch)
'(cancer cancer)
> (thread-cell-set! cp '(cancer cancer cancer))
> (thread-cell-ref cp)
'(cancer cancer cancer)
> (channel-put ch 'ok)
> (channel-get ch)
'(cancer cancer)
```

```
(current-preserved-thread-cell-values) → thread-cell-values?
(current-preserved-thread-cell-values thread-cell-vals) → void?
  thread-cell-vals : thread-cell-values?
```

When called with no arguments, this procedure produces a *thread-cell-vals* that represents the current values (in the current thread) for all preserved thread cells.

When called with a *thread-cell-vals* generated by a previous call to `current-preserved-thread-cell-values`, the values of all preserved thread cells (in the current thread) are set to the values captured in *thread-cell-vals*; if a preserved thread cell was created after *thread-cell-vals* was generated, then the thread cell's value for the current thread reverts to its initial value.

```
(thread-cell-values? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a set of thread cell values produced by `current-preserved-thread-cell-values`, `#f` otherwise.

11.3.2 Parameters

§4.13 "Dynamic Binding: `parameterize`" in *The Racket Guide* introduces parameters.

See §1.1.13 "Parameters" for basic information on the parameter model. Parameters correspond to *preserved thread fluids* in Scsh [Gasbichler02].

To parameterize code in a thread- and continuation-friendly manner, use `parameterize`. The `parameterize` form introduces a fresh thread cell for the dynamic extent of its body expressions.

When a new thread is created, the parameterization for the new thread's initial continuation is the parameterization of the creator thread. Since each parameter's thread cell is preserved, the new thread "inherits" the parameter values of its creating thread. When a continuation is moved from one thread to another, settings introduced with `parameterize` effectively move with the continuation.

In contrast, direct assignment to a parameter (by calling the parameter procedure with a value) changes the value in a thread cell, and therefore changes the setting only for the current thread. Consequently, as far as the memory manager is concerned, the value originally associated with a parameter through `parameterize` remains reachable as long the continuation is reachable, even if the parameter is mutated.

```
(make-parameter v [guard name realm]) → parameter?
  v : any/c
  guard : (or/c (any/c . -> . any) #f) = #f
  name : symbol? = 'parameter-procedure
  realm : symbol? = 'racket
```

Returns a new parameter procedure. The value of the parameter is initialized to *v* in all threads.

If *guard* is not #f, it is used as the parameter's guard procedure. A guard procedure takes one argument. Whenever the parameter procedure is applied to an argument, the argument is passed on to the guard procedure. The result returned by the guard procedure is used as the new parameter value. A guard procedure can raise an exception to reject a change to the parameter's value. The *guard* is not applied to the initial *v*.

The *name* argument is used as the parameter procedure's name as reported by object-name, and *realm* is used as the reported as reported by procedure-realm.

Changed in version 7.4.0.6 of package base: Added the *name* argument.
Changed in version 8.4.0.2: Added the *realm* argument.

```
(parameterize ([parameter-expr value-expr] ...)
  body ...+)

  parameter-expr : parameter?
```

§4.13 "Dynamic Binding: parameterize" in *The Racket Guide* introduces parameterize.

The result of a parameterize expression is the result of the last *body*. The *parameter-expr*s determine the parameters to set, and the *value-expr*s determine the corresponding values to install while evaluating the *body*s. The *parameter-expr*s and *value-expr*s are evaluated left-to-right (interleaved), and then the parameters are bound in the continuation to preserved thread cells that contain the values of the *value-expr*s; the result of each *parameter-expr* is checked with parameter? just before it is bound. The last *body* is in tail position with respect to the entire parameterize form.

Outside the dynamic extent of a parameterize expression, parameters remain bound to other thread cells. Effectively, therefore, old parameters settings are restored as control exits the parameterize expression.

If a continuation is captured during the evaluation of parameterize, invoking the continuation effectively re-introduces the parameterization, since a parameterization is associated to a continuation via a continuation mark (see §10.5 "Continuation Marks") using a private key.

Examples:

```
> (parameterize ([exit-handler (lambda (x) 'no-exit)])
    (exit))
> (define p1 (make-parameter 1))
> (define p2 (make-parameter 2))
> (parameterize ([p1 3]
                 [p2 (p1)])
    (cons (p1) (p2)))
'(3 . 1)
```

```
> (let ([k (let/cc out
             (parameterize ([p1 2])
               (p1 3)
               (cons (let/cc k
                       (out k))
                     (p1))))])
    (if (procedure? k)
        (k (p1))
        k))
'(1 . 3)
> (define ch (make-channel))
> (parameterize ([p1 0])
    (thread (lambda ()
              (channel-put ch (cons (p1) (p2))))))
#<thread>
> (channel-get ch)
'(0 . 2)
> (define k-ch (make-channel))
> (define (send-k)
    (parameterize ([p1 0])
      (thread (lambda ()
                (let/ec esc
                  (channel-put ch
                               ((let/cc k
                                  (channel-put k-ch k)
                                  (esc)))))))))
> (send-k)
#<thread>
> (thread (lambda () ((channel-get k-ch)
                      (let ([v (p1)])
                        (lambda () v)))))
#<thread>
> (channel-get ch)
1
> (send-k)
#<thread>
> (thread (lambda () ((channel-get k-ch) p1)))
#<thread>
> (channel-get ch)
0
```

```
(parameterize* ((parameter-expr value-expr) ...)
  body ...+)
```

Analogous to `let*` compared to `let`, `parameterize*` is the same as a nested series of single-parameter `parameterize` forms.

```
(make-derived-parameter  parameter
                         guard
                         wrap
                        [name
                         realm])    → parameter?
  parameter : parameter?
  guard : (any/c . -> . any)
  wrap : (any/c . -> . any)
  name : symbol? = (object-name parameter)
  realm : symbol? = (procedure-realm parameter)
```

Returns a parameter procedure that sets or retrieves the same value as *parameter*, but with:

- *guard* applied when setting the parameter (before any guard associated with *parameter*), and
- *wrap* applied when obtaining the parameter's value.

The *name* argument is used as the parameter procedure's name as reported by `object-name`, and *realm* is used as the reported as reported by `procedure-realm`. Supply `values` for *guard* and *wrap* if the goal is merely to replace the name or realm of *parameter*.

See also `chaperone-procedure`, which can also be used to guard parameter procedures.

Changed in version 8.15.0.4 of package `base`: Added the *name* and *realm* arguments.

```
(parameter? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a parameter procedure, `#f` otherwise.

```
(parameter-procedure=? a b) → boolean?
  a : parameter?
  b : parameter?
```

Returns `#t` if the parameter procedures *a* and *b* always modify the same parameter with the same guards (although possibly with different chaperones), `#f` otherwise.

```
(current-parameterization) → parameterization?
```

Returns the current continuation's parameterization.

```
(call-with-parameterization parameterization
                            thunk)           → any
  parameterization : parameterization?
  thunk : (-> any)
```

Calls *thunk* (via a tail call) with *parameterization* as the current parameterization.

```
(parameterization? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a parameterization returned by `current-parameterization`, `#f` otherwise.

11.4 Futures

```
(require racket/future)      package: base
```

§20.2 "Parallelism with Futures" in *The Racket Guide* introduces futures.

The bindings documented in this section are provided by the `racket/future` and `racket` libraries, but not `racket/base`.

Support for parallelism via `future` is normally enabled for all platforms in the CS implementation of Racket. In the BC implementation, support for parallelism is enabled by default for Windows, Linux x86/x86_64, and Mac OS x86/x86_64. To enable support for other platforms building Racket BC, use `--enable-futures` with `configure`.

The `future` and `touch` functions from `racket/future` provide access to parallelism as supported by the hardware and operating system. In contrast to `thread`, which provides concurrency for arbitrary computations without parallelism, `future` provides parallelism. A *future* executes its work in parallel (assuming that support for parallelism is available) until it detects an attempt to perform an operation that cannot run safely in parallel. Similarly, work in a future is suspended if it depends in some way on the current continuation, such as raising an exception. Operations that suspend a future are *blocking* operations. A suspended computation for a future is resumed when `touch` is applied to the future.

"Safe" parallel execution of a future means that all operations provided by the system must be able to enforce contracts and produce results as documented. "Safe" does not preclude concurrent access to mutable data that is visible in the program. For example, a computation in a future might use `set!` to modify a shared variable, in which case concurrent assignment to the variable can be visible in other futures and threads. Furthermore, guarantees about the visibility of effects and ordering are determined by the operating system and hardware—which rarely support, for example, the guarantee of sequential consistency that is provided for `thread`-based concurrency; see also §11.7 "Machine Memory Order". A system operation that seems obviously safe may have an internal implementation that cannot run in parallel; see §20.2 "Parallelism with Futures" in *The Racket Guide* for more discussion and an introduction to using `future-visualizer`) to understand the behavior of system operations.

A future never runs in parallel if all of the custodians that allow its creating thread to run are shut down. Such futures can execute through a call to `touch`, however.

11.4.1 Creating and Touching Futures

```
(future thunk) → future?
  thunk : (-> any)
```

```
(touch f) → any
  f : future?
```

The `future` procedure returns a future value that encapsulates *`thunk`*. The `touch` function forces the evaluation of the *`thunk`* inside the given future, returning the values produced by *`thunk`*. After `touch` forces the evaluation of a *`thunk`*, the resulting values are retained by the future in place of *`thunk`*, and additional `touch`es of the future return those values.

Between a call to `future` and `touch` for a given future, the given *`thunk`* may run speculatively in parallel to other computations, as described above.

Example:

```
> (let ([f (future (lambda () (+ 1 2)))])
    (list (+ 3 4) (touch f)))
'(7 3)
```

```
(futures-enabled?) → boolean?
```

Returns whether parallel support for futures is enabled in the current Racket configuration.

```
(current-future) → (or/c #f future?)
```

Returns the descriptor of the future whose thunk execution is the current continuation; that is, if a future descriptor `f` is returned, `(touch f)` will produce the result of the current continuation. If a future thunk itself uses `touch`, future-thunk executions can be nested, in which case the descriptor of the most immediately executing future is returned. If the current continuation does not return to the `touch` of any future, the result is `#f`.

```
(future? v) → boolean?
  v : any/c
```

Returns `#t` if *`v`* is a future value, `#f` otherwise.

```
(would-be-future thunk) → future?
  thunk : (-> any)
```

Returns a future that never runs in parallel, but that consistently logs all potentially "unsafe" operations during the execution of the future's thunk (i.e., operations that interfere with parallel execution).

With a normal future, certain circumstances might prevent the logging of unsafe operations. For example, when executed with debug-level logging,

```
(touch (future (lambda ()
                 (printf "hello1")
                 (printf "hello2")
                 (printf "hello3"))))
```

might log three messages, one for each `printf` invocation. However, if the `touch` is performed before the future has a chance to start running in parallel, the future thunk evaluates in the same manner as any ordinary thunk, and no unsafe operations are logged. Replacing `future` with `would-be-future` ensures the logging of all three calls to `printf`.

```
(processor-count) → exact-positive-integer?
```

Returns the number of parallel computation units (e.g., processors or cores) that are available on the current machine.

This is the same binding as available from `racket/place`.

```
(for/async (for-clause ...) body-or-break ... body)
(for*/async (for-clause ...) body-or-break ... body)
```

Like `for` and `for*`, but each iteration of the *body* is executed in a separate `future`, and the futures may be `touch`ed in any order.

11.4.2 Future Semaphores

```
(make-fsemaphore init) → fsemaphore?
  init : exact-nonnegative-integer?
```

Creates and returns a new *future semaphore* with the counter initially set to *init*.

A future semaphore is similar to a plain semaphore, but future-semaphore operations can be performed safely in parallel (to synchronize parallel computations). In contrast, operations on plain semaphores are not safe to perform in parallel, and they therefore prevent a computation from continuing in parallel.

Beware of trying to use an fsemaphore to implement a lock. A future may run concurrently and in parallel to other futures, but a future that is not demanded by a Racket thread can be suspended at any time—such as just after it takes a lock and before it releases the lock. If you must share mutable data among futures, lock-free data structures are generally a better fit.

```
(fsemaphore? v) → boolean?
  v : any/c
```

Returns #t if *v* is an future semaphore value, #f otherwise.

```
(fsemaphore-post fsema) → void?
  fsema : fsemaphore?
```

Increments the future semaphore's internal counter and returns #<void>.

```
(fsemaphore-wait fsema) → void?
  fsema : fsemaphore?
```

Blocks until the internal counter for *fsema* is non-zero. When the counter is non-zero, it is decremented and fsemaphore-wait returns #<void>.

```
(fsemaphore-try-wait? fsema) → boolean?
  fsema : fsemaphore?
```

Like fsemaphore-wait, but fsemaphore-try-wait? never blocks execution. If *fsema*'s internal counter is zero, fsemaphore-try-wait? returns #f immediately without decrementing the counter. If *fsema*'s counter is positive, it is decremented and #t is returned.

```
(fsemaphore-count fsema) → exact-nonnegative-integer?
  fsema : fsemaphore?
```

Returns *fsema*'s current internal counter value.

11.4.3 Future Performance Logging

Racket traces use logging (see §15.5 "Logging") extensively to report information about how futures are evaluated. Logging output is useful for debugging the performance of programs that use futures.

Though textual log output can be viewed directly (or retrieved in code via trace-futures), it is much easier to use the graphical profiler tool provided by future-visualizer.

Future events are logged with the topic 'future. In addition to its string message, each event logged for a future has a data value that is an instance of a future-event prefab structure:

```
(struct future-event (future-id proc-id action time prim-
name user-data)
  #:prefab)
```

The future-id field is an exact integer that identifies a future, or it is #f when action is 'missing. The future-id field is particularly useful for correlating logged events.

The `proc-id` fields is an exact, non-negative integer that identifies a parallel process. Process 0 is the main Racket process, where all expressions other than future thunks evaluate.

The `time` field is an inexact number that represents time in the same way as `current-inexact-milliseconds`.

The `action` field is a symbol:

- `'create`: a future was created.
- `'complete`: a future's thunk evaluated successfully, so that `touch` will produce a value for the future immediately.
- `'start-work` and `'end-work`: a particular process started and ended working on a particular future.
- `'start-0-work`: like `'start-work`, but for a future thunk that for some structural reason could not be started in a process other than 0 (e.g., the thunk requires too much local storage to start).
- `'start-overflow-work`: like `'start-work`, where the future thunk's work was previously stopped due to an internal stack overflow.
- `'sync`: blocking (processes other than 0) or initiation of handing (process 0) for an "unsafe" operation in a future thunk's evaluation; the operation must run in process 0.
- `'block`: like `'sync`, but for a part of evaluation that must be delayed until the future is `touch`ed, because the evaluation may depend on the current continuation.
- `'touch` (never in process 0): like `'sync` or `'block`, but for a `touch` operation within a future thunk.
- `'overflow` (never in process 0): like `'sync` or `'block`, but for the case that a process encountered an internal stack overflow while evaluating a future thunk.
- `'result` or `'abort`: waiting or handling for `'sync`, `'block`, or `'touch` ended with a value or an error, respectively.
- `'suspend` (never in process 0): a process blocked by `'sync`, `'block`, or `'touch` abandoned evaluation of a future; some other process may pick up the future later.
- `'touch-pause` and `'touch-resume` (in process 0, only): waiting in `touch` for a future whose thunk is being evaluated in another process.
- `'missing`: one or more events for the process were lost due to internal buffer limits before they could be reported, and the `time-id` field reports an upper limit on the time of the missing events; this kind of event is rare.

Assuming no 'missing events, then 'start-work, 'start-0-work, 'start-overflow-work is always paired with 'end-work; 'sync, 'block, and 'touch are always paired with 'result, 'abort, or 'suspend; and 'touch-pause is always paired with 'touch-resume.

In process 0, some event pairs can be nested within other event pairs: 'sync, 'block, or 'touch with 'result or 'abort; 'touch-pause with 'touch-resume; and 'start-work with 'end-work.

A 'block in process 0 is generated when an unsafe operation is handled. This type of event will contain a symbol in the unsafe-op-name field that is the name of the operation. In all other cases, this field contains #f.

The prim-name field will always be #f unless the event occurred on process 0 and its action is either 'block or 'sync. If these conditions are met, prim-name will contain the name of the Racket primitive which required the future to synchronize with the runtime thread (represented as a symbol).

The user-data field may take on a number of different values depending on both the action and prim-name fields:

- 'touch on process 0: contains the integer ID of the future being touched.
- 'sync and prim-name is '|allocate memory|: The size (in bytes) of the requested allocation.
- 'sync and prim-name is 'jit_on_demand: The runtime thread is performing a JIT compilation on behalf of the future future-id. The field contains the name of the function being JIT compiled (as a symbol).
- 'create: A new future was created. The field contains the integer ID of the newly created future.

11.5 Places

§20.3 "Parallelism with Places" in *The Racket Guide* introduces places.

```
(require racket/place)        package: base
 (require racket/place/dynamic)
```

The bindings documented in this section are provided by the racket/place, racket/place/dynamic, and racket libraries, but not racket/base.

Places enable the development of parallel programs that take advantage of machines with multiple processors, cores, or hardware threads.

Currently, parallel support for places is enabled on all platforms that support Racket CS, the default implementation of Racket. The 3m implementation also supports parallel execution of places by default on Windows, Linux x86/x86_64, and Mac OS x86/x86_64. To enable support for other platforms

A *place* is a parallel task that is effectively a separate instance of the Racket virtual machine, although all places run within a single operating-system process. Places communicate through *place channels*, which are endpoints for a two-way buffered communication.

To a first approximation, place channels support only immutable, transparent values as messages. In addition, place channels themselves can be sent across channels to establish new (possibly more direct) lines of communication in addition to any existing lines. Finally, mutable values produced by `shared-flvector`, `make-shared-flvector`, `shared-fxvector`, `make-shared-fxvector`, `shared-bytes`, and `make-shared-bytes` can be sent across place channels; mutation of such values is visible to all places that share the value, because they are allowed in a *shared memory space*. See `place-message-allowed?`.

A place channel can be used as a synchronizable event (see §11.2.1 "Events") to receive a value through the channel. A place channel is ready for synchronization when a message is available on the channel, and the place channel's synchronization result is the message (which is removed on synchronization). A place can also receive messages with `place-channel-get`, and messages can be sent with `place-channel-put`.

Two place channels are `equal?` if they are endpoints for the same underlying channels while both or neither is a place descriptor. Place channels can be `equal?` without being `eq?` after being sent messages through a place channel.

Constraints on messages across a place channel—and therefore on the kinds of data that places share—enable greater parallelism than `future`, even including separate garbage collection of separate places. At the same time, the setup and communication costs for places can be higher than for futures.

For example, the following expression launches two places, echoes a message to each, and then waits for the places to terminate:

```
(let ([pls (for/list ([i (in-range 2)])
              (dynamic-place "place-worker.rkt" 'place-main))])
   (for ([i (in-range 2)]
         [p pls])
      (place-channel-put p i)
      (printf "~a\n" (place-channel-get p)))
   (for-each place-wait pls))
```

The "place-worker.rkt" module (in a file that is separate from the above code) must export the `place-main` function that each place executes, where `place-main` must accept a single place channel argument:

"place-worker.rkt"

```
#lang racket
(provide place-main)

(define (place-main pch)
  (place-channel-put pch (format "Hello from place ~a"
                                  (place-channel-get pch))))
```

Place channels are subject to garbage collection, like other Racket values, and a thread that is blocked reading from a place channel can be garbage collected if place channel's writing end becomes unreachable. However, unlike normal channel blocking, if otherwise unreachable threads are mutually blocked on place channels that are reachable only from the same threads, the threads and place channels are all considered reachable, instead of unreachable.

When a place is created, its parameter values are generally set to the *initial* values of the parameters in the creating place, except that the *current* values of the following parameters are used: `current-library-collection-paths`, `current-library-collection-links`, and `current-compiled-file-roots`.

A newly created place is registered with the current custodian, so that the place is terminated when the custodian is shut down.

11.5.1 Using Places

```
(place-enabled?) → boolean?
```

Returns `#t` if Racket is configured so that `dynamic-place` and `place` create places that can run in parallel, `#f` if `dynamic-place` and `place` are simulated using `thread`.

```
(place? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a *place descriptor* value, `#f` otherwise. Every place descriptor is also a place channel.

```
(place-channel? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is place channel, `#f` otherwise.

```
(dynamic-place  module-path
                start-name
               [#:at location
                #:named named]) → place?
  module-path : (or/c module-path? path?)
  start-name : symbol?
  location : (or/c #f place-location?) = #f
  named : any/c = #f
```

Creates a place to run the procedure that is identified by *module-path* and *start-name*. The result is a place descriptor value that represents the new parallel task; the place descriptor is returned immediately. The place descriptor value is also a place channel that permits communication with the place.

The module indicated by *module-path* must export a function with the name *start-name*. The function must accept a single argument, which is a place channel that corresponds to the other end of communication for the place descriptor returned by `place`.

If *location* is provided, it must be a place location, such as a distributed places node produced by `create-place-node`.

When the place is created, the initial exit handler terminates the place, using the argument to the exit handler as the place's *completion value*. Use `(exit v)` to immediately terminate a place with the completion value *v*. Since a completion value is limited to an exact integer between `0` and `255`, any other value for `v` is converted to `0`.

If the function indicated by *module-path* and *start-name* returns, then the place terminates with the completion value `0`.

In the created place, the `current-input-port` parameter is set to an empty input port, while the values of the `current-output-port` and `current-error-port` parameters are connected to the current ports in the creating place. If the output ports in the creating place are file-stream ports, then the connected ports in the created place share the underlying streams, otherwise a thread in the creating place pumps bytes from the created place's ports to the current ports in the creating place.

Most parameters in the created place have their original initial values, but the created place inherits the creating place's values for the following parameters: `current-directory`, `current-library-collection-paths`, `current-library-collection-links`, and `current-compiled-file-roots`.

The *module-path* argument must not be a module path of the form `(quote sym)` unless the module is predefined (see `module-predefined?`).

The `dynamic-place` binding is protected in the sense of `protect-out`, so access to this operation can be prevented by adjusting the code inspector (see §14.10 "Code Inspectors").

Changed in version 8.2.0.7 of package `base`: Changed created place to inherit the creating place's `current-directory` value.

```
(dynamic-place* module-path
                start-name
               [#:in in
                #:out out
                #:err err]) → place?
                              (or/c output-port? #f)
                              (or/c input-port? #f)
                              (or/c input-port? #f)
  module-path : (or/c module-path? path?)
  start-name : symbol?
  in : (or/c input-port? #f) = #f
  out : (or/c output-port? #f) = (current-output-port)
```

```
err : (or/c output-port? #f) = (current-error-port)
```

Like `dynamic-place`, but accepts specific ports to the new place's ports, and returns a created port when `#f` is supplied for a port. The *in*, *out*, and *err* ports are connected to the `current-input-port`, `current-output-port`, and `current-error-port` ports, respectively, for the place. Any of the ports can be `#f`, in which case a file-stream port (for an operating-system pipe) is created and returned by `dynamic-place*`. The *err* argument can be `'stdout`, in which case the same file-stream port or that is supplied as standard output is also used for standard error. For each port or `'stdout` that is provided, no pipe is created and the corresponding returned value is `#f`.

The caller of `dynamic-place*` is responsible for closing all returned ports; none are closed automatically.

The `dynamic-place*` procedure returns four values:

- a place descriptor value representing the created place;
- an output port piped to the place's standard input, or `#f` if *in* was a port;
- an input port piped from the place's standard output, or `#f` if *out* was a port;
- an input port piped from the place's standard error, or `#f` if *err* was a port or `'stdout`.

The `dynamic-place*` binding is protected in the same way as `dynamic-place`.

```
(place-wait p) → exact-integer?
  p : place?
```

Returns the completion value of the place indicated by *p*, blocking until the place has terminated.

If any pumping threads were created to connect a non-file-stream port to the ports in the place for *p* (see `dynamic-place`), `place-wait` returns only when the pumping threads have completed.

```
(place-dead-evt p) → evt?
  p : place?
```

Returns a synchronizable event (see §11.2.1 "Events") that is ready for synchronization if and only if *p* has terminated. The synchronization result of a place-dead event is the place-dead event itself.

If any pumping threads were created to connect a non-file-stream port to the ports in the place for *p* (see `dynamic-place`), the event returned by `place-dead-evt` may become ready even if a pumping thread is still running.

```
(place-kill p) → void?
  p : place?
```

Immediately terminates the place, setting the place's completion value to `1` if the place does not have a completion value already.

```
(place-break p [kind]) → void?
  p : place?
  kind : (or/c #f 'hang-up 'terminate) = #f
```

Sends the main thread of place *p* a break; see §10.6 "Breaks".

```
(place-channel) → place-channel? place-channel?
```

Returns two place channels. Data sent through the first channel can be received through the second channel, and data sent through the second channel can be received from the first.

Typically, one place channel is used by the current place to send messages to a destination place; the other place channel is sent to the destination place (via an existing place channel).

```
(place-channel-put pch v) → void
  pch : place-channel?
  v : place-message-allowed?
```

Sends a message *v* on channel *pch*. Since place channels are asynchronous, `place-channel-put` calls are non-blocking.

See `place-message-allowed?` form information on automatic coercions in *v*, such as converting a mutable string to an immutable string.

```
(place-channel-get pch) → place-message-allowed?
  pch : place-channel?
```

Returns a message received on channel *pch*, blocking until a message is available.

```
(place-channel-put/get pch v) → any/c
  pch : place-channel?
  v : any/c
```

Sends an immutable message *v* on channel *pch* and then waits for a message (perhaps a reply) on the same channel.

```
(place-message-allowed? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is allowed as a message on a place channel, `#f` otherwise.

If `(place-enabled?)` returns `#f`, then the result is always `#t` and no conversions are performed on *v* as a message. Otherwise, the following kinds of data are allowed as messages:

- numbers, characters, booleans, keywords, and `#<void>`;
- symbols, where the `eq?`ness of uninterned symbols is preserved within a single message, but not across messages;
- strings and byte strings, where mutable strings and byte strings are automatically replaced by immutable variants;
- paths (for any platform);
- pairs, lists, boxes, vectors, and immutable prefab structures containing message-allowed values, where a mutable box is automatically replaced by an immutable box, a mutable vector is automatically replaced by an immutable vector and where impersonators of boxes, vectors and prefab structures are copied;
- hash tables where mutable hash tables are automatically replaced by immutable variants, and where a hash table impersonator is copied;
- place channels, where a place descriptor is automatically replaced by a plain place channel;
- file-stream ports and TCP ports, where the underlying representation (such as a file descriptor, socket, or handle) is duplicated in the sending place and attached to a fresh port in the receiving place;
- C pointers as created or accessed via `ffi/unsafe`; and
- values produced by `shared-flvector`, `make-shared-flvector`, `shared-fxvector`, `make-shared-fxvector`, `shared-bytes`, and `make-shared-bytes`.

Changed in version 8.4.0.7 of package `base`: Include boxes in allowed messages.

```
prop:place-location : struct-type-property?
(place-location? v) → boolean?
  v : any/c
```

A structure type property and associated predicate for implementations of *place locations*. The value of `prop:place-location` must be a procedure of four arguments: the place location itself, a module path, a symbol for the start function exported by the module, and a place name (which can be `#f` for an anonymous place).

A place location can be passed as the `#:at` argument to `dynamic-place`, which in turn simply calls the `prop:place-location` value of the place location.

A distributed places note created with `create-place-node` is an example of a place location.

11.5.2 Syntactic Support for Using Places

The bindings in this section are *not* provided by `racket/place/dynamic`.

```
(place id body ...+)
```

Creates a place that evaluates *body* expressions with *id* bound to a place channel. The *body*s close only over *id* plus the top-level bindings of the enclosing module, because the *body*s are lifted to a submodule. The result of `place` is a place descriptor, like the result of `dynamic-place`.

The generated submodule has the name `place-body-n` for an integer *n*, and the submodule exports a `main` function that takes a place channel for the new place. The submodule is not intended for use, however, except by the expansion of the `place` form.

The `place` binding is protected in the same way as `dynamic-place`.

```
(place* maybe-port ...
        id
        body ...+)

maybe-port =
           | #:in in-expr
           | #:out out-expr
           | #:err err-expr
```

Like `place`, but supports optional `#:in`, `#:out`, and `#:err` expressions (at most one of each) to specify ports in the same way and with the same defaults as `dynamic-place*`. The result of a `place*` form is also the same as for `dynamic-place*`.

The `place*` binding is protected in the same way as `dynamic-place`.

```
(place/context id body ...+)
```

Like `place`, but *body* `...` may have free lexical variables, which are automatically sent to the newly-created place. Note that these variables must have values accepted by `place-message-allowed?`, otherwise an `exn:fail:contract` exception is raised.

```
(processor-count) → exact-positive-integer?
```

Returns the number of parallel computation units (e.g., processors or cores) that are available on the current machine.

This is the same binding as available from `racket/future`.

11.5.3 Places Logging

Place events are reported to a logger named 'place. In addition to its string message, each event logged for a place has a data value that is an instance of a place-event prefab structure:

```
(struct place-event (place-id action value time)
  #:prefab)
```

The place-id field is an exact integer that identifies a place.

The time field is an inexact number that represents time in the same way as current-inexact-milliseconds.

The action field is a symbol:

- 'create: a place was created. This event is logged in the creating place, and the event's value field has the ID for the created place.
- 'reap: a place that was previously created in the current place has exited (and that fact has been detected, possibly via place-wait). The event's value field has the ID for the exited place.
- 'enter: a place has started, logged within the started place. The event's value field has #f.
- 'exit: a place is exiting, logged within the exiting place. The event's value field has #f.
- 'put: a place-channel message has been sent. The event's value field is a positive exact integer that approximates the message's size.
- 'get: a place-channel message has been received. The event's value field is a positive exact integer that approximates the message's size.

Changed in version 6.0.0.2 of package base: Added logging via 'place and place-event.

11.6 Engines

```
(require racket/engine)
```
package: base

The bindings documented in this section are provided by the racket/engine library, not racket/base or racket.

An *engine* is an abstraction that models processes that can be preempted by a timer or other external trigger. They are inspired by the work of Haynes and Friedman [Haynes84].

Engines log their behavior via a logger with the name 'racket/engine. The logger is created when the module is instantiated and uses the result of (current-logger) as its parent. The library logs a 'debug-level message: when engine-run is called, when the engine timeout expires, and when the engine is stopped (either because it terminated or it reached a safe point to stop). Each log message holds a value of the struct:

```
(struct engine-info (msec name) #:prefab)
```

where the *msec* field holds the result of (current-inexact-milliseconds) at the moment of logging, and the *name* field holds the name of the procedure passed to engine.

```
(engine proc) → engine?
  proc : ((any/c . -> . void?) . -> . any/c)
```

Returns an engine object to encapsulate a thread that runs only when allowed. The *proc* procedure should accept one argument, and *proc* is run in the engine thread when engine-run is called. If engine-run returns due to a timeout, then the engine thread is suspended until a future call to engine-run. Thus, *proc* only executes during the dynamic extent of a engine-run call.

The argument to *proc* is a procedure that takes a boolean, and it can be used to disable suspends (in case *proc* has critical regions where it should not be suspended). A true value passed to the procedure enables suspends, and #f disables suspends. Initially, suspends are allowed.

```
(engine? v) → any
  v : any/c
```

Returns #t if *v* is an engine produced by engine, #f otherwise.

```
(engine-run until engine) → boolean?
  until : (or/c evt? real?)
  engine : engine?
```

Allows the thread associated with *engine* to execute for up to as long as *until* milliseconds (if *until* is a real number) or *until* is ready (if *until* is an event). If *engine*'s procedure disables suspends, then the engine can run arbitrarily long until it re-enables suspends.

The engine-run procedure returns #t if *engine*'s procedure completes (or if it completed earlier), and the result is available via engine-result. The engine-run procedure returns #f if *engine*'s procedure does not complete before it is suspended. If *engine*'s procedure raises an exception, then it is re-raised by engine-run.

```
(engine-result engine) → any
  engine : engine?
```

Returns the result for *engine* if it has completed with a value (as opposed to an exception), #f otherwise.

```
(engine-kill engine) → void?
  engine : engine?
```

Forcibly terminates the thread associated with *engine* if it is still running, leaving the engine result unchanged.

11.7 Machine Memory Order

Parallel threads, futures and places can expose the underlying machine's memory model, including a weak memory ordering. For example, when a parallel thread writes to multiple slots in a mutable vector, it's possible on some platforms for another parallel thread to observe the writes in a different order or not at all, unless the threads are explicitly synchronized. Similarly, shared byte strings or fxvectors can expose the machine's memory model across places.

Racket ensures that a machine's memory model is not observed in a way that unsafely exposes the implementation of primitive datatypes. For example, it is not possible for one thread to see a partially constructed primitive value as a result of reading a vector that is mutated by another thread.

The `box-cas!`, `vector-cas!`, `unsafe-box*-cas!`, `unsafe-vector*-cas!`, and `unsafe-struct*-cas!` operations all provide a machine-level compare-and-set, so they can be used in ways that are specifically supported by the a machine's memory model. The `(memory-order-acquire)` and `(memory-order-release)` operations similarly constrain machine-level stores and loads. Synchronization operations such as semaphores, `sync`, place messages, future `touch`es, and future semaphores imply suitable machine-level acquire and release ordering.

```
(memory-order-acquire) → void?
(memory-order-release) → void?
```

Those operations implement a machine-level memory fence on platforms where one is needed for synchronization. The `memory-order-acquire` operation ensures at least a load–load and load–store fence at the machine level, and the `memory-order-release` operation ensures at least a store–store and store–load fence at the machine level.

Added in version 7.7.0.11 of package `base`.

12 Macros

§16 "Macros" in *The Racket Guide* introduces Macros.

See §1.2 "Syntax Model" for general information on how programs are parsed. In particular, the subsection §1.2.3.2 "Expansion Steps" describes how parsing triggers macros, and §1.2.3.5 "Transformer Bindings" describes how macro transformers are called.

12.1 Pattern-Based Syntax Matching

```
(syntax-case stx-expr (literal-id ...)
  clause ...)

      clause = [pattern result-expr]
             | [pattern fender-expr result-expr]

     pattern = np-pattern
             | (pattern ...)
             | (pattern ...+ . np-pattern)
             | (pattern ... pattern ellipsis pattern ... . np-pattern)

  np-pattern = _
             | id
             | #(pattern ...)
             | #(pattern ... pattern ellipsis pattern ...)
             | #&pattern
             | #s(key-datum pattern ...)
             | #s(key-datum pattern ... pattern ellipsis pattern ...)
             | (ellipsis stat-pattern)
             | const

stat-pattern = id
             | (stat-pattern ...)
             | (stat-pattern ...+ . stat-pattern)
             | #(stat-pattern ...)
             | #&stat-pattern
             | #s(key-datum stat-pattern ...)
             | const

    ellipsis = ...
```

Finds the first `pattern` that matches the syntax object produced by `stx-expr`, and for which the corresponding `fender-expr` (if any) produces a true value; the result is from the corresponding `result-expr`, which is in tail position for the `syntax-case` form. If no `clause` matches, then the `exn:fail:syntax` exception is raised; the exception is generated by calling `raise-syntax-error` with `#f` as the "name" argument, a string with a generic error message, and the result of *`stx-expr`*.

A syntax object matches a *`pattern`* as follows:

`_`

A `_` pattern (i.e., an identifier with the same binding as `_` and not among the *`literal-id`*s) matches any syntax object.

`id`

An *`id`* matches any syntax object when it is not bound to `...` or `_` and does not have the same binding as any *`literal-id`*. The *`id`* is further bound as *pattern variable* for the corresponding *`fender-expr`* (if any) and *`result-expr`*. A pattern-variable binding is a transformer binding; the pattern variable can be referenced only through forms like `syntax`. The binding's value is the syntax object that matched the pattern with a *depth marker* of 0.

With a *`stat-pattern`*, `...` is not treated specially. It either matches a *`literal-id`* or is bound as a pattern variable.

An *`id`* that has the same binding as a *`literal-id`* matches a syntax object that is an identifier with the same binding in the sense of `free-identifier=?`. The match does not introduce any pattern variables.

`(pattern ...)`

A `(pattern ...)` pattern matches a syntax object whose datum form (i.e., without lexical information) is a list with as many elements as sub-*`pattern`*s in the pattern, and where each syntax object that corresponds to an element of the list matches the corresponding sub-*`pattern`*.

Any pattern variables bound by the sub-*`pattern`*s are bound by the complete pattern; the bindings must all be distinct.

`(pattern ...+ . np-pattern)`

Like the previous kind of pattern, but matches syntax objects that are not necessarily lists; for *n* sub-*`pattern`*s before the final *`np-pattern`*, the syntax object's datum must be a pair such that *n*-1 `cdr`s produce pairs. The final *`np-pattern`* is matched against the syntax object corresponding to the *n*th `cdr` (or the `datum->syntax` coercion of the datum using the nearest enclosing syntax object's lexical context and source location).

`(pattern ... pattern ellipsis pattern ...)`

Like the `(pattern ...)` kind of pattern, but matching a syntax object with any number (zero or more) elements that match the sub-`pattern` followed by `ellipsis` in the corresponding position relative to other sub-`pattern`s.

For each pattern variable bound by the sub-`pattern` followed by `ellipsis`, the larger pattern binds the same pattern variable to a list of values, one for each element of the syntax object matched to the sub-`pattern`, with an incremented depth marker. (The sub-`pattern` itself may contain `ellipsis`, leading to a pattern variables bound to lists of lists of syntax objects with a depth marker of 2, and so on.)

All patterns forms with `ellipsis` apply only when `ellipsis` is not among the `literal-id`s.

`(pattern ... pattern ellipsis pattern ... . np-pattern)`

Like the previous kind of pattern, but with a final `np-pattern` as for `(pattern ...+ . np-pattern)`. The final `np-pattern` never matches a syntax object whose datum is a pair.

`#(pattern ...)`

Like a `(pattern ...)` pattern, but matching a vector syntax object whose elements match the corresponding sub-`pattern`s.

`#(pattern ... pattern ellipsis pattern ...)`

Like a `(pattern ... pattern ellipsis pattern ...)` pattern, but matching a vector syntax object whose elements match the corresponding sub-`pattern`s.

`#&pattern`

Matches a box syntax object whose content matches the `pattern`.

`#s(key-datum pattern ...)`

Like a `(pattern ...)` pattern, but matching a prefab structure syntax object whose fields match the corresponding sub-`pattern`s. The `key-datum` must correspond to a valid first argument to `make-prefab-struct`.

```
#s(key-datum pattern ... pattern ellipsis pattern ...)
```

Like a `(pattern ... pattern ellipsis pattern ...)` pattern, but matching a prefab structure syntax object whose elements match the corresponding sub-*patterns*.

```
(ellipsis stat-pattern)
```

Matches the same as *stat-pattern*, which is like a *pattern*, but identifiers with the binding `...` are treated the same as other *ids*.

```
const
```

A *const* is any datum that does not match one of the preceding forms; a syntax object matches a *const* pattern when its datum is `equal?` to the `quote`d *const*.

If *stx-expr* produces a non-syntax object, then its result is converted to a syntax object using `datum->syntax` and the lexical context and source location of the *stx-expr*.

If *stx-expr* produces a syntax object that is tainted, then any syntax object bound by a *pattern* are tainted.

Examples:

```
> (require (for-syntax racket/base))
> (define-syntax (swap stx)
    (syntax-case stx ()
      [(_ a b) #'(let ([t a])
                   (set! a b)
                   (set! b t))]))
> (let ([x 5] [y 10])
    (swap x y)
    (list x y))
'(10 5)
> (syntax-case #'(ops 1 2 3 => +) (=>)
    [(_ x ... => op) #'(op x ...)])
#<syntax:eval:687:0 (+ 1 2 3)>
> (syntax-case #'(let ([x 5] [y 9] [z 12])
                   (+ x y z))
               (let)
    [(let ([var expr] ...) body ...)
     (list #'(var ...)
           #'(expr ...))])
```

```
'(#<syntax:eval:688:0 (x y z)> #<syntax:eval:688:0 (5 9 12)>)
```

```
(syntax-case* stx-expr (literal-id ...) id-compare-expr
  clause ...)
```

Like syntax-case, but *id-compare-expr* must produce a procedure that accepts two arguments. A *literal-id* in a *pattern* matches an identifier for which the procedure returns true when given the identifier to match (as the first argument) and the identifier in the *pattern* (as the second argument).

In other words, syntax-case is like syntax-case* with an *id-compare-expr* that produces free-identifier=?.

```
(with-syntax ([pattern stx-expr] ...)
  body ...+)
```

Similar to syntax-case, in that it matches a *pattern* to a syntax object. Unlike syntax-case, all *pattern*s are matched, each to the result of a corresponding *stx-expr*, and the pattern variables from all matches (which must be distinct) are bound with a single *body* sequence. The result of the with-syntax form is the result of the last *body*, which is in tail position with respect to the with-syntax form.

If any *pattern* fails to match the corresponding *stx-expr*, the exn:fail:syntax exception is raised.

A with-syntax form is roughly equivalent to the following syntax-case form:

```
(syntax-case (list stx-expr ...) ()
  [(pattern ...) (let () body ...+)])
```

However, if any individual *stx-expr* produces a non-syntax object, then it is converted to one using datum->syntax and the lexical context and source location of the individual *stx-expr*.

Examples:

```
> (define-syntax (hello stx)
    (syntax-case stx ()
      [(_ name place)
       (with-syntax ([print-name #'(printf "~a\n" 'name)]
                     [print-place #'(printf "~a\n" 'place)])
         #'(begin
              (define (name times)
                (printf "Hello\n")
                (for ([i (in-range 0 times)])
```

```
                      print-name))
               (define (place times)
                 (printf "From\n")
                 (for ([i (in-range 0 times)])
                      print-place))))]))
> (hello jon utah)
> (jon 2)
Hello
jon
jon
> (utah 2)
From
utah
utah
> (define-syntax (math stx)
    (define (make+1 expression)
      (with-syntax ([e expression])
        #'(+ e 1)))
    (syntax-case stx ()
      [(_ numbers ...)
       (with-syntax ([(added ...)
                      (map make+1
                           (syntax->list #'(numbers ...)))])
         #'(begin
             (printf "got ~a\n" added)
             ...))]))
> (math 3 1 4 1 5 9)
got 4
got 2
got 5
got 2
got 6
got 10
```

```
(syntax template)
```

```
     template = id
              | (head-template ...)
              | (head-template ...+ . template)
              | #(head-template ...)
              | #&template
              | #s(key-datum head-template ...)
              | (~? template template)
              | (ellipsis stat-template)
              | const

head-template = template
              | head-template ellipsis ...+
              | (~@ . template)
              | (~? head-template head-template)
              | (~? head-template)

stat-template = like template, but without ..., ~?, and ~@

     ellipsis = ...
```

Constructs a syntax object based on a *template*, which can include pattern variables bound by `syntax-case` or `with-syntax`.

A *template* produces a single syntax object. A *head-template* produces a sequence of zero or more syntax objects. A *stat-template* is like a *template*, except that `...`, `~?`, and `~@` are interpreted as constants instead of template forms.

A *template* produces a syntax object as follows:

id

If *id* is bound as a pattern variable, then *id* as a template produces the pattern variable's match result. Unless the *id* is a sub-*template* that is replicated by *ellipsis* in a larger *template*, the pattern variable's value must be a syntax object with a depth marker of 0 (as opposed to a list of matches).

More generally, if the pattern variable's value has a depth marker n, then it can only appear within a template where it is replicated by at least n *ellipsis*es. In that case, the template will be replicated enough times to use each match result at least once.

If *id* is not bound as a pattern variable, then *id* as a template produces `(quote-syntax id)`.

`(head-template ...)`

Produces a syntax object whose datum is a list, and where the elements of the list correspond to syntax objects produced by the *head-template*s.

`(head-template ... . template)`

Like the previous form, but the result is not necessarily a list; instead, the place of the empty list in the resulting syntax object's datum is taken by the syntax object produced by *template*.

`#(head-template ...)`

Like the `(head-template ...)` form, but producing a syntax object whose datum is a vector instead of a list.

`#&template`

Produces a syntax object whose datum is a box holding the syntax object produced by *template*.

`#s(key-datum head-template ...)`

Like the `(head-template ...)` form, but producing a syntax object whose datum is a prefab structure instead of a list. The *key-datum* must correspond to a valid first argument of `make-prefab-struct`.

`(~? template1 template2)`

Produces the result of *template1* if *template1* has no pattern variables with "missing values"; otherwise, produces the result of *template2*.

A pattern variable bound by `syntax-case` never has a missing value, but pattern variables bound by `syntax-parse` (for example, `~or` or `~optional` patterns) can.

Examples:

```
> (syntax-parse #'(m 1 2 3)
    [(_ (~optional (~seq #:op op:expr)) arg:expr ...)
     #'((~? op +) arg ...)])
#<syntax:eval:3:0 (+ 1 2 3)>
```

```
> (syntax-parse #'(m #:op max 1 2 3)
    [(_ (~optional (~seq #:op op:expr)) arg:expr ...)
     #'((~? op +) arg ...)])
#<syntax:eval:4:0 (max 1 2 3)>
```

`(ellipsis stat-template)`

Produces the same result as *stat-template*, which is like a *template*, but `...`, `~?`, and `~@` are treated like an *id* (with no pattern binding).

`const`

A *const* template is any form that does not match the preceding cases, and it produces the result `(quote-syntax const)`.

A *head-template* produces a sequence of syntax objects; that sequence is "inlined" into the result of the enclosing *template*. The result of a *head-template* is defined as follows:

`template`

Produces one syntax object, according to the rules for *template* above.

`head-template ellipsis ...+`

Generates a sequence of syntax objects by "mapping" the *head-template* over the values of its pattern variables. The number of iterations depends on the values of the pattern variables referenced within the sub-template.

To be more precise: Let *outer* be *inner* followed by one ellipsis. A pattern variable is an *iteration pattern variable* for *outer* if occurs at a depth equal to its depth marker. There must be at least one; otherwise, an error is raised. If there are multiple iteration variables, then all of their values must be lists of the same length. The result for *outer* is produced by mapping the *inner* template over the iteration pattern variable values and decreasing their effective depth markers by 1 within *inner*. The *outer* result is formed by appending the *inner* results.

Consequently, if a pattern variable occurs at a depth greater than its depth marker, it is used as an iteration pattern variable for the innermost ellipses but not the outermost. A pattern variable must not occur at a depth less than its depth marker; otherwise, an error is raised.

```
(~@ . template)
```

Produces the sequence of elements in the syntax list produced by `template`. If `template` does not produce a proper syntax list, an exception is raised.

Examples:

```
> (with-syntax ([(key ...) #'('a 'b 'c)]
                [(val ...) #'(1 2 3)])
    #'(hash (~@ key val) ...))
#<syntax:eval:2:0 (hash (quote a) 1 (quote b) 2 (quote
c) 3)>
> (with-syntax ([xs #'(2 3 4)])
    #'(list 1 (~@ . xs) 5))
#<syntax:eval:3:0 (list 1 2 3 4 5)>
```

```
(~? head-template1 head-template2)
```

Produces the result of `head-template1` if none of its pattern variables have "missing values"; otherwise produces the result of `head-template2`.

```
(~? head-template)
```

Produces the result of `head-template` if none of its pattern variables have "missing values"; otherwise produces nothing.

Equivalent to `(~? head-template (~@))`.

A `(syntax template)` form is normally abbreviated as `#'template`; see also §1.3.8 "Reading Quotes". If `template` contains no pattern variables, then `#'template` is equivalent to `(quote-syntax template)`.

Changed in version 6.90.0.25 of package `base`: Added `~@` and `~?`.

```
(quasisyntax template)
```

Like `syntax`, but `(unsyntax expr)` and `(unsyntax-splicing expr)` escape to an expression within the `template`.

The `expr` must produce a syntax object (or syntax list) to be substituted in place of the `unsyntax` or `unsyntax-splicing` form within the quasiquoting template, just like `unquote` and `unquote-splicing` within `quasiquote`, except that a hash table value position is not an escape position for `quasisyntax`. (If the escaped expression does not generate a syntax object, it is converted to one in the same way as for the right-hand side of `with-syntax`.) Nested `quasisyntax`es introduce quasiquoting layers in the same way as nested `quasiquote`s.

Also analogous to `quasiquote`, the reader converts `` #` `` to `quasisyntax`, `#,` to `unsyntax`, and `#,@` to `unsyntax-splicing`. See also §1.3.8 "Reading Quotes".

```
(unsyntax expr)
```

Illegal as an expression form. The `unsyntax` form is for use only with a `quasisyntax` template.

```
(unsyntax-splicing expr)
```

Illegal as an expression form. The `unsyntax-splicing` form is for use only with a `quasisyntax` template.

```
(syntax/loc loc-expr template)

              (or/c #f srcloc? syntax?
                    (list/c any/c
                            (or/c exact-positive-integer? #f)
                            (or/c exact-nonnegative-integer? #f)
                            (or/c exact-positive-integer? #f)
  loc-expr :                (or/c exact-nonnegative-integer? #f))
                    (vector/c any/c
                              (or/c exact-positive-integer? #f)
                              (or/c exact-nonnegative-integer? #f)
                              (or/c exact-positive-integer? #f)
                              (or/c exact-nonnegative-integer? #f)))
```

Like `syntax`, except that the immediate resulting syntax object takes its source-location information from the result of *`loc-expr`*.

Only the source location of the immediate result—the "outermost" syntax object—is adjusted. The source location is *not* adjusted if both the source and position of *`loc-expr`* are `#f`. The source location is adjusted only if the resulting syntax object comes from the template itself rather than the value of a syntax pattern variable. For example, if *`x`* is a syntax pattern variable, then `(syntax/loc loc-expr x)` does not use the location of *`loc-expr`*.

Changed in version 6.90.0.25 of package `base`: Previously, `syntax/loc` did not enforce the contract on *`loc-expr`* if *`template`* was just a pattern variable.
Changed in version 8.2.0.6: Allows *`loc-expr`* to be any source location value that `datum->syntax` accepts.

```
(quasisyntax/loc loc-expr template)
```

```
             (or/c #f srcloc? syntax?
                   (list/c any/c
                           (or/c exact-positive-integer? #f)
                           (or/c exact-nonnegative-integer? #f)
                           (or/c exact-positive-integer? #f)
 loc-expr :                (or/c exact-nonnegative-integer? #f))
                   (vector/c any/c
                             (or/c exact-positive-integer? #f)
                             (or/c exact-nonnegative-integer? #f)
                             (or/c exact-positive-integer? #f)
                             (or/c exact-nonnegative-integer? #f)))
```

Like `quasisyntax`, but with source-location assignment like `syntax/loc`.

Changed in version 8.2.0.6 of package `base`: Allows *loc-expr* to be any source location value that `datum->syntax` accepts.

```
(quote-syntax/prune id)
```

Like `quote-syntax`, but the lexical context of *id* is pruned via `identifier-prune-lexical-context` to including binding only for the symbolic name of *id* and for `'#%top`. Use this form to quote an identifier when its lexical information will not be transferred to other syntax objects (except maybe to `'#%top` for a top-level binding).

```
(syntax-rules (literal-id ...)
  [(id . pattern) template] ...)
```

Equivalent to

```
(lambda (stx)
  (syntax-case stx (literal-id ...)
    [(generated-id . pattern) (syntax-protect #'template)]  ...))
```

where each *generated-id* binds no identifier in the corresponding *template*. This in particular means that the *id* positions are ignored. Conventionally, the *id* positions should be the identifier `_`.

Examples:

```
> (define-syntax my-let*
    (syntax-rules ()
      [(_ () body ...) (let () body ...)]
      [(_ ([x v] binding ...) body ...)
       (let ([x v])
         (my-let* (binding ...) body ...))]))
```

```
> (my-let* ([x 42]
            [x (+ x 1)])
    x)
43
```

```
(syntax-id-rules (literal-id ...)
  [pattern template] ...)
```

Equivalent to

```
(make-set!-transformer
 (lambda (stx)
   (syntax-case stx (literal-id ...)
     [pattern (syntax-protect #'template)]  ...)))
```

```
(define-syntax-rule (id . pattern) template)
```

Equivalent to

```
(define-syntax id
  (syntax-rules ()
   [(id . pattern) template]))
```

but with syntax errors potentially phrased in terms of *pattern*.

```
...
```

The `...` transformer binding prohibits `...` from being used as an expression. This binding is useful only in syntax patterns and templates (or other unrelated expression forms that treat it specially like `->`), where it indicates repetitions of a pattern or template. See `syntax-case` and `syntax`.

```
_
```

The `_` transformer binding prohibits `_` from being used as an expression. This binding is useful only in syntax patterns, where it indicates a pattern that matches any syntax object. See `syntax-case`.

```
~?
~@
```

The `~?` and `~@` transformer bindings prohibit these forms from being used as an expression. The bindings are useful only in syntax templates. See `syntax`.

Added in version 6.90.0.25 of package `base`.

```
(syntax-pattern-variable? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a value that, as a transformer-binding value, makes the bound variable as pattern variable in `syntax` and other forms. To check whether an identifier is a pattern variable, use `syntax-local-value` to get the identifier's transformer value, and then test the value with `syntax-pattern-variable?`.

The `syntax-pattern-variable?` procedure is provided `for-syntax` by `racket/base`.

12.2 Syntax Object Content

```
(syntax? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a syntax object, `#f` otherwise. See also §1.2.2 "Syntax Objects".

Examples:

```
> (syntax? #'quinoa)
#t
> (syntax? #'(spelt triticale buckwheat))
#t
> (syntax? (datum->syntax #f 'millet))
#t
> (syntax? "barley")
#f
```

```
(identifier? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a syntax object and `(syntax-e stx)` produces a symbol.

Examples:

```
> (identifier? #'linguine)
#t
> (identifier? #'(if wheat? udon soba))
#f
> (identifier? 'ramen)
#f
> (identifier? 15)
#f
```

```
(syntax-source stx) → any/c
  stx : syntax?
```

Returns the source component of the source location for the syntax object `stx`, or `#f` if none is known. The source is represented by an arbitrary value (e.g., one passed to `read-syntax`), but it is typically a file path string.

See also `syntax-srcloc` from `racket/syntax-srcloc`.

```
(syntax-line stx) → (or/c exact-positive-integer? #f)
  stx : syntax?
```

Returns the line number (positive exact integer) of the source location for the start of the syntax object in its source, or `#f` if the line number or source is unknown. See also §13.1.4 "Counting Positions, Lines, and Columns".

Changed in version 7.0 of package `base`: Dropped a guarantee that `syntax-line` and `syntax-column` both produce `#f` or both produce integers.

```
(syntax-column stx) → (or/c exact-nonnegative-integer? #f)
  stx : syntax?
```

Returns the column number (non-negative exact integer) of the source location for the start of the syntax object in its source, or `#f` if the source column is unknown. See also §13.1.4 "Counting Positions, Lines, and Columns".

Changed in version 7.0 of package `base`: Dropped a guarantee that `syntax-line` and `syntax-column` both produce `#f` or both produce integers.

```
(syntax-position stx) → (or/c exact-positive-integer? #f)
  stx : syntax?
```

Returns the position (positive exact integer) of the source location for the start of the syntax object in its source, or `#f` if the source position is unknown. The position is intended to be a character position, but reading from a port without line counting enabled will produce a position as a byte offset. See also §13.1.4 "Counting Positions, Lines, and Columns".

```
(syntax-span stx) → (or/c exact-nonnegative-integer? #f)
  stx : syntax?
```

Returns the span (non-negative exact integer) of the source location for syntax object in its source, or `#f` if the span is unknown. The span is intended to count in characters, but reading from a port without line counting enabled will produce a span in bytes. See also §13.1.4 "Counting Positions, Lines, and Columns".

```
(syntax-original? stx) → boolean?
  stx : syntax?
```

Returns `#t` if *stx* has the property that `read-syntax` attaches to the syntax objects that they generate (see §12.7 "Syntax Object Properties"), and if *stx*'s lexical information does not include any macro-introduction scopes (which indicate that the object was introduced by a syntax transformer; see §1.2.2 "Syntax Objects"). The result is `#f` otherwise.

This predicate can be used to distinguish syntax objects in an expanded expression that were directly present in the original expression, as opposed to syntax objects inserted by macros.

The (hidden) property to represent original syntax is dropped for a syntax object that is marshaled as part of compiled code; see also `current-compile`.

```
(syntax-source-module stx [source?])
 → (or/c module-path-index? symbol? path? resolved-module-path? #f)
  stx : syntax?
  source? : any/c = #f
```

Returns an indication of the module whose source contains *stx*, or `#f` if no source module for *stx* can be inferred from its lexical context. If *source?* is `#f`, then result is a module path index or symbol (see §14.4.2 "Compiled Modules and References") or a resolved module path; if *source?* is true, the result is a path or symbol corresponding to the loaded module's source in the sense of `current-module-declare-source`.

Note that `syntax-source-module` does *not* consult the source location of *stx*. The result is based on the lexical information of *stx*.

```
(syntax-e stx) → any/c
  stx : syntax?
```

Unwraps the immediate datum structure from a syntax object, leaving nested syntax structure (if any) in place. The result of `(syntax-e stx)` is one of the following:

- a symbol
- a syntax pair (described below)
- the empty list
- an immutable vector containing syntax objects
- an immutable box containing syntax objects
- an immutable hash table containing syntax object values (but not necessarily syntax object keys)

- an immutable prefab structure containing syntax objects
- some other kind of datum—usually a number, boolean, or string—that is interned when `datum-intern-literal` would convert the value

Examples:

```
> (syntax-e #'a)
'a
> (syntax-e #'(x . y))
'(#<syntax:eval:11:0 x> . #<syntax:eval:11:0 y>)
> (syntax-e #'#(1 2 (+ 3 4)))
'#(#<syntax:eval:12:0 1> #<syntax:eval:12:0 2> #<syntax:eval:12:0
(+ 3 4)>)
> (syntax-e #'#&"hello world")
'#&#<syntax:eval:13:0 "hello world">
> (syntax-e #'#hash((imperial . "yellow") (festival . "green")))
'#hash((festival . #<syntax:eval:14:0 "green">)
       (imperial . #<syntax:eval:14:0 "yellow">))
> (syntax-e #'#(point 3 4))
'#(#<syntax:eval:15:0 point> #<syntax:eval:15:0 3>
#<syntax:eval:15:0 4>)
> (syntax-e #'3)
3
> (syntax-e #'"three")
"three"
> (syntax-e #'#t)
#t
```

A *syntax pair* is a pair containing a syntax object as its first element, and either the empty list, a syntax pair, or a syntax object as its second element.

A syntax object that is the result of `read-syntax` reflects the use of delimited `.` in the input by creating a syntax object for every pair of parentheses in the source, and by creating a pair-valued syntax object *only* for parentheses in the source. See §1.3.6 "Reading Pairs and Lists" for more information.

If `stx` is tainted, then any syntax object in the result of `(syntax-e stx)` is tainted. The results from multiple calls to `syntax-e` of `stx` are `eq?`.

```
(syntax->list stx) → (or/c list? #f)
  stx : syntax?
```

Returns a list of syntax objects or `#f`. The result is a list of syntax objects when `(syntax->datum stx)` would produce a list. In other words, syntax pairs in `(syntax-e stx)` are flattened.

If `stx` is tainted, then any syntax object in the result of `(syntax->list stx)` is tainted.

Examples:

```
> (syntax->list #'())
'()
> (syntax->list #'(1 (+ 3 4) 5 6))
'(#<syntax:eval:20:0 1>
  #<syntax:eval:20:0 (+ 3 4)>
  #<syntax:eval:20:0 5>
  #<syntax:eval:20:0 6>)
> (syntax->list #'a)
#f
```

```
(syntax->datum stx) → any/c
  stx : syntax?
```

Returns a datum by stripping the lexical information, source-location information, properties, and tamper status from `stx`. Inside of pairs, (immutable) vectors, (immutable) boxes, immutable hash table values (not keys), and immutable prefab structures, syntax objects are recursively stripped.

The stripping operation does not mutate `stx`; it creates new pairs, vectors, boxes, hash tables, and prefab structures as needed to strip lexical and source-location information recursively.

Examples:

```
> (syntax->datum #'a)
'a
> (syntax->datum #'(x . y))
'(x . y)
> (syntax->datum #'#(1 2 (+ 3 4)))
'#(1 2 (+ 3 4))
> (syntax->datum #'#&"hello world")
'#&"hello world"
> (syntax->datum #'#hash((imperial . "yellow") (festival .
"green")))
'#hash((festival . "green") (imperial . "yellow"))
> (syntax->datum #'#(point 3 4))
'#(point 3 4)
> (syntax->datum #'3)
3
> (syntax->datum #'"three")
"three"
> (syntax->datum #'#t)
#t
```

```
(datum->syntax ctxt v [srcloc prop ignored]) → syntax?
  ctxt : (or/c syntax? #f)
  v : any/c
  srcloc : (or/c #f
                 syntax?
                 srcloc?
                 (list/c any/c
                         (or/c exact-positive-integer? #f)
                         (or/c exact-nonnegative-integer? #f)
                         (or/c exact-positive-integer? #f)
                         (or/c exact-nonnegative-integer? #f))
                 (vector/c any/c
                          (or/c exact-positive-integer? #f)
                          (or/c exact-nonnegative-integer? #f)
                          (or/c exact-positive-integer? #f)
                          (or/c exact-nonnegative-integer? #f)))
         = #f
  prop : (or/c syntax? #f) = #f
  ignored : (or/c syntax? #f) = #f
```

Converts the datum *v* to a syntax object. If *v* is already a syntax object, then there is no conversion, and *v* is returned unmodified. The contents of pairs, vectors, and boxes, the values of immutable hash tables, and the fields of immutable prefab structures are recursively converted. The keys of prefab structures and the keys of immutable hash tables are not converted. Mutable vectors and boxes are replaced by immutable vectors and boxes. For any kind of value other than a pair, vector, box, immutable hash table, immutable prefab structure, or syntax object, conversion means wrapping the value with lexical information, source-location information, and properties after the value is interned via `datum-intern-literal`.

Converted objects in *v* are given the lexical context information of *ctxt* and the source-location information of *srcloc*. The resulting immediate syntax object from conversion is given the properties (see §12.7 "Syntax Object Properties") of *prop* (even the hidden ones that would not be visible via `syntax-property-symbol-keys`); if *v* is a pair, vector, box, immutable hash table, or immutable prefab structure, recursively converted values are not given properties. If *ctxt* is tainted, then the resulting syntax object from `datum->syntax` is tainted. The code inspector of *ctxt*, if any, is compared to the code inspector of the module for the macro currently being transformed, if any; if both inspectors are available and if one is the same as or inferior to the other, then the result syntax has the same/inferior inspector, otherwise it has no code inspector.

Any of *ctxt*, *srcloc*, or *prop* can be `#f`, in which case the resulting syntax has no lexical context, source information, and/or new properties.

If *srcloc* is not `#f`, a `srcloc` instance, or a syntax object, it must be a list or vector of five elements that correspond to `srcloc` fields.

Graph structure is not preserved by the conversion of *v* to a syntax object. Instead, *v* is essentially unfolded into a tree. If *v* has a cycle through pairs, vectors, boxes, immutable hash tables, and immutable prefab structures, then the `exn:fail:contract` exception is raised.

The *ignored* argument is allowed for backward compatibility and has no effect on the returned syntax object.

Changed in version 8.2.0.5 of package `base`: Allow a `srcloc` value as a *srcloc* argument.

```
(syntax-binding-set? v) → boolean?
  v : any/c
(syntax-binding-set) → syntax-binding-set?
(syntax-binding-set->syntax binding-set
                            datum)      → syntax?
  binding-set : syntax-binding-set?
  datum : any/c
 (syntax-binding-set-extend
   binding-set
   symbol
   phase
   mpi
  [#:source-symbol source-symbol
   #:source-phase source-phase
   #:nominal-module nominal-mpi
   #:nominal-phase nominal-phase
   #:nominal-symbol nominal-symbol
   #:nominal-require-phase nominal-require-phase
   #:inspector inspector])
 → syntax-binding-set?
  binding-set : syntax-binding-set?
  symbol : symbol?
  phase : (or/c exact-integer? #f)
  mpi : module-path-index?
  source-symbol : symbol? = symbol
  source-phase : (or/c exact-integer? #f) = phase
  nominal-mpi : module-path-index? = mpi
  nominal-phase : (or/c exact-integer? #f) = source-phase
  nominal-symbol : symbol? = source-symbol
  nominal-require-phase : (or/c exact-integer? #f) = 0
  inspector : (or/c inspector? #f) = #f
```

A *syntax binding set* supports explicit construction of binding information for a syntax object. Start by creating an empty binding set with `syntax-binding-set`, add bindings with syntax-binding-set-extend, and create a syntax object that has the bindings as its lexical information using syntax-binding-set->syntax.

The first three arguments to syntax-binding-set-extend establish a binding of *symbol* at *phase* to an identifier that is defined in the module referenced by *mpi*. Supply *source-symbol* to make the binding of *symbol* refer to a different provided variable from *mpi*, and so on; the optional arguments correspond to the results of identifier-binding.

Added in version 7.0.0.12 of package base.

```
(datum-intern-literal v) → any/c
  v : any/c
```

Converts some values to be consistent with an interned result produced by the default reader in read-syntax mode.

If *v* is a number, character, string, byte string, or regular expression, then the result is a value that is equal? to *v* and eq? to a potential result of the default reader. (Note that mutable strings and byte strings are interned as immutable strings and byte strings.)

If *v* is an uninterned or an unreadable symbol, the result is still *v*, since an interned symbol would not be equal? to *v*.

The conversion process does not traverse compound values. For example, if *v* is a pair containing strings, then the strings within *v* are not interned.

If *v1* and *v2* are equal? but not eq?, then it is possible that (datum-intern-literal *v1*) will return *v1* and—sometime after *v1* becomes unreachable as determined by the garbage collector (see §1.1.6 “Garbage Collection”)—(datum-intern-literal *v2*) can still return *v2*. In other words, datum-intern-literal may adopt a given value as an interned representative, but if a former representative becomes otherwise unreachable, then datum-intern-literal may adopt a new representative.

```
(syntax-shift-phase-level stx shift) → syntax?
  stx : syntax?
  shift : (or/c exact-integer? #f)
```

Returns a syntax object that is like *stx*, but with all of its top-level and module bindings shifted by *shift* phase levels. If *shift* is #f, then only bindings at phase level 0 are shifted to the label phase level; shifting by an integer *shift* effectively shifts which phase has been moved into the label phase level. If *shift* is 0, then the result is *stx*.

Changed in version 9.0.0.1 of package base: Shifting by an integer phase level adjust which original phase is seen in the label phase level.

```
(generate-temporaries v) → (listof identifier?)
  v : stx-list?
```

Returns a list of identifiers that are distinct from all other identifiers. The list contains as many identifiers as *v* contains elements. The elements of *v* can be anything, but string, symbol, keyword (possibly wrapped as syntax), and identifier elements will be embedded in the corresponding generated name, which is useful for debugging purposes.

The generated identifiers are built with interned symbols (not `gensym`s); see also §1.4.16 "Printing Compiled Code".

Examples:

```
> (generate-temporaries '(a b c d))
'(#<syntax a1> #<syntax b2> #<syntax c3> #<syntax d4>)
> (generate-temporaries #'(1 2 3 4))
'(#<syntax temp5> #<syntax temp6> #<syntax temp7> #<syntax temp8>)
> (define-syntax (set!-values stx)
    (syntax-case stx ()
      [(_ (id ...) expr)
       (with-syntax ([(temp ...) (generate-
temporaries #'(id ...))])
         #'(let-values ([(temp ...) expr])
             (set! id temp) ... (void)))]))
```

```
(identifier-prune-lexical-context  id-stx
                                  [syms]) → identifier?
  id-stx : identifier?
  syms : (listof symbol?) = (list (syntax-e id-stx))
```

Returns an identifier with the same binding as *id-stx*, but without possibly lexical information from *id-stx* that does not apply to the symbols in *syms*, where even further extension of the lexical information drops information for other symbols. In particular, transferring the lexical context via `datum->syntax` from the result of this function to a symbol other than one in *syms* may produce an identifier with no binding.

Currently, the result is always *id-stx* exactly. Pruning was intended primarily as a kind of optimization in a previous version of Racket, but it is less useful and difficult to implement efficiently in the current macro expander.

See also `quote-syntax/prune`.

Changed in version 6.5 of package `base`: Always return *id-stx*.

```
(identifier-prune-to-source-module id-stx) → identifier?
  id-stx : identifier?
```

Returns an identifier with its lexical context minimized to that needed for `syntax-source-module`. The minimized lexical context does not include any bindings.

```
(syntax-recertify new-stx
                  old-stx
                  inspector
                  key)       → syntax?
  new-stx : syntax?
  old-stx : syntax?
  inspector : inspector?
  key : any/c
```

For backward compatibility only; returns `new-stx`.

```
(syntax-debug-info stx [phase all-bindings?]) → hash?
  stx : syntax?
  phase : (or/c exact-integer? #f) = (syntax-local-phase-level)
  all-bindings? : any/c = #f
```

Produces a hash table that describes the lexical information of `stx` (not counting components when `(syntax-e stx)` would return a compound value). The result can include—but is not limited to—the following keys:

- `'name` — the result of `(syntax-e stx)`, if it is a symbol.
- `'context` — a list of vectors, where each vector represents a scope attached to `stx`.

  Each vector starts with a number that is distinct for every scope. A symbol afterward provides a hint at the scope's origin: `'module` for a `module` scope, `'macro` for a macro-introduction scope, `'use-site` for a macro use-site scope, or `'local` for a local binding form. In the case of a `'module` scope that corresponds to the inside edge, the module's name and a phase (since an inside-edge scope is generated for each phase) are shown.
- `'bindings` — a list of bindings, each represented by a hash table. A binding table can include—but is not limited to—the following keys:
  - `'name` — the symbolic name for the binding.
  - `'context` — the scopes, as a list of vectors, for the binding.
  - `'local` — a symbol representing a local binding; when this key is present, `'module` is absent.
  - `'module` — an encoding of a import from another module; when this key is present, `'local` is absent.
  - `'free-identifier=?` — a hash table of debugging information from an identifier for which the binding is an alias.
- `'fallbacks` — a list of hash tables like the one produced by `syntax-debug-info` for cross-namespace binding fallbacks.

Added in version 6.3 of package `base`.

12.2.1 Syntax Object Source Locations

```
(require racket/syntax-srcloc)        package: base
```

The bindings documented in this section are provided by the `racket/syntax-srcloc` library, not `racket/base` or `racket`.

```
(syntax-srcloc stx) → (or/c #f srcloc?)
  stx : syntax?
```

Returns the source location for the syntax object *stx*, or `#f` if none is known.

Added in version 8.2.0.5 of package `base`.

12.3 Syntax Object Bindings

```
(bound-identifier=? a-id b-id [phase-level]) → boolean?
  a-id : syntax?
  b-id : syntax?
  phase-level : (or/c exact-integer? #f)
              = (syntax-local-phase-level)
```

Returns `#t` if the identifier *a-id* would bind *b-id* (or vice versa) if the identifiers were substituted in a suitable expression context at the phase level indicated by *phase-level*, `#f` otherwise. A `#f` value for *phase-level* corresponds to the label phase level.

Examples:

```
> (define-syntax (check stx)
    (syntax-case stx ()
      [(_ x y)
       (if (bound-identifier=? #'x #'y)
           #'(let ([y 'wrong]) (let ([x 'binds]) y))
           #'(let ([y 'no-binds]) (let ([x 'wrong]) y)))]))
> (check a a)
'binds
> (check a b)
'no-binds
> (define-syntax-rule (check-a x) (check a x))
> (check-a a)
'no-binds
```

```
(free-identifier=? a-id
                   b-id
                  [a-phase-level
                   b-phase-level]) → boolean?
  a-id : identifier?
  b-id : identifier?
  a-phase-level : (or/c exact-integer? #f)
                = (syntax-local-phase-level)
  b-phase-level : (or/c exact-integer? #f) = a-phase-level
```

Returns `#t` if *a-id* and *b-id* access the same local binding, module binding, or top-level binding—perhaps via rename transformers—at the phase levels indicated by *a-phase-level* and *b-phase-level*, respectively. A `#f` value for *a-phase-level* or *b-phase-level* corresponds to the label phase level.

"Same module binding" means that the identifiers refer to the same original definition site, and not necessarily to the same `require` or `provide` site. Due to renaming in `require` and `provide`, or due to a transformer binding to a rename transformer, the identifiers may return distinct results with `syntax-e`.

Examples:

```
> (define-syntax (check stx)
    (syntax-case stx ()
      [(_ x)
       (if (free-identifier=? #'car #'x)
           #'(list 'same: x)
           #'(list 'different: x))]))
> (check car)
'(same: #<procedure:car>)
> (check mcar)
'(different: #<procedure:mcar>)
> (let ([car list])
    (check car))
'(different: #<procedure:list>)
> (require (rename-in racket/base [car kar]))
> (check kar)
'(same: #<procedure:car>)
```

```
(free-transformer-identifier=? a-id b-id) → boolean?
  a-id : identifier?
  b-id : identifier?
```

Same as `(free-identifier=? a-id b-id (add1 (syntax-local-phase-level)))`.

```
(free-template-identifier=? a-id b-id) → boolean?
  a-id : identifier?
  b-id : identifier?
```

Same as `(free-identifier=? a-id b-id (sub1 (syntax-local-phase-level)))`.

```
(free-label-identifier=? a-id b-id) → boolean?
  a-id : identifier?
  b-id : identifier?
```

Same as `(free-identifier=? a-id b-id #f)`.

```
(check-duplicate-identifier ids) → (or/c identifier? #f)
  ids : (listof identifier?)
```

Compares each identifier in `ids` with every other identifier in the list with `bound-identifier=?`. If any comparison returns `#t`, one of the duplicate identifiers is returned (the first one in `ids` that is a duplicate), otherwise the result is `#f`.

```
(identifier-binding  id-stx
                    [phase-level
                     top-level-symbol?
                     exact-scopes?])
 → (or/c 'lexical
         #f
         (list/c module-path-index?
                 symbol?
                 module-path-index?
                 symbol?
                 exact-nonnegative-integer?
                 phase+space-shift?
                 phase+space?)
         (list/c symbol?))
  id-stx : identifier?
  phase-level : (or/c exact-integer? #f)
              = (syntax-local-phase-level)
  top-level-symbol? : any/c = #f
  exact-scopes? : any/c = #f
```

Returns one of three (if `top-level-symbol?` is `#f`) or four (if `top-level-symbol?` is true) kinds of values, depending on the binding of `id-stx` at the phase level indicated by `phase-level` (where a `#f` value for `phase-level` corresponds to the label phase level):

- The result is `'lexical` if `id-stx` has a local binding.

- The result is a list of seven items when *id-stx* has a module binding: `(list` *from-mod from-sym nominal-from-mod nominal-from-sym from-phase import-phase+space-shift nominal-export-phase*`)`.
  - *from-mod* is a module path index (see §14.4.2 "Compiled Modules and References") that indicates the defining module. It is the "self" module path index if the binding refers to a definition in the enclosing module of *id-stx*.
  - *from-sym* is a symbol for the identifier's name at its definition site in the originating module. This can be different from the local name returned by `syntax->datum` for several reasons: the identifier is renamed on import, it is renamed on export, or it is implicitly renamed because the binding site was generated by a macro invocation. In that last case, it may be an unreadable symbol, and it may be different from the result of `syntax->datum` on the identifier in the original source definition.
  - *nominal-from-mod* is a module path index (see §14.4.2 "Compiled Modules and References") that indicates the binding's module as it appears locally in the source around *id-stx*: it indicates a module `required` into the context of *id-stx* to provide its binding, or it is the same "self" as *from-mod* for a binding that refers to a definition in the enclosing module of *id-stx*. It can be different from *from-mod* due to a re-export in *nominal-from-mod* of some imported identifier. If the same binding is imported in multiple ways, an arbitrary representative is chosen.
  - *nominal-from-sym* is a symbol for the binding's identifier as it appears locally in the source around *id-stx*: it is the identifier's name as exported by *nominal-from-mod*, or it is the source identifier's symbol for a definition within the enclosing module of *id-stx*. It can be different from *from-sym* due to a renaming `provide`, even if *from-mod* and *nominal-from-mod* are the same, or due to a definition that was introduced by a macro expansion.
  - *from-phase* is an exact non-negative integer representing the originating phase. For example, it is `1` if the definition is for-syntax.
  - *import-phase+space-shift* is `0` if the binding import of *nominal-from-mode* is from a definition or a plain `require`, `1` if it is from a `for-syntax` import, a phase combined with a space name if it is from a `for-space` import, etc.
  - *nominal-export-phase+space* is the phase level and binding space of the export from *nominal-from-mod* for an imported binding, or it is the phase level of the definition for a binding from the enclosing module of *id-stx*.
- The result is `(list` *top-sym*`)` if *id-stx* has a top-level binding and *top-level-symbol?* is true. The *top-sym* can be different from the name returned by `syntax->datum` when the binding definition was generated by a macro invocation.
- The result is `#f` if *id-stx* has a top-level binding and *top-level-symbol?* is `#f` or if *id-stx* is unbound. An unbound identifier is typically treated the same as an identifier whose top-level binding is a variable.

If *id-stx* is bound to a rename-transformer, the result from `identifier-binding` is for the identifier in the transformer, so that `identifier-binding` is consistent with `free-identifier=?`.

If *exact-scopes?* is a true value, then the result is `#f` unless the binding for *id-stx* has exactly the scopes of *id-stx*. An exact-scopes check is useful for detecting whether an identifier is already bound in a specific definition context, for example.

Changed in version 6.6.0.4 of package `base`: Added the *top-level-symbol?* argument to report information on top-level bindings.
Changed in version 8.2.0.3: Generalized phase results to phase–space combinations.
Changed in version 8.6.0.9: Added the *exact-scopes?* argument.

```
(identifier-transformer-binding  id-stx
                                [rt-phase-level])
 → (or/c 'lexical
         #f
         (listof module-path-index?
                 symbol?
                 module-path-index?
                 symbol?
                 exact-nonnegative-integer?
                 phase+space-shift?
                 phase+space?))
  id-stx : identifier?
  rt-phase-level : (or/c exact-integer? #f)
                 = (syntax-local-phase-level)
```

Same as `(identifier-binding id-stx (and rt-phase-level (add1 rt-phase-level)))`.

Changed in version 8.2.0.3 of package `base`: Generalized phase results to phase–space combinations.

```
(identifier-template-binding id-stx)
 → (or/c 'lexical
         #f
         (listof module-path-index?
                 symbol?
                 module-path-index?
                 symbol?
                 phase+space?
                 phase+space-shift?
                 phase+space?))
  id-stx : identifier?
```

Same as `(identifier-binding id-stx (sub1 (syntax-local-phase-level)))`.

Changed in version 8.2.0.3 of package `base`: Generalized phase results to phase–space combinations.

```
(identifier-label-binding id-stx)
 → (or/c 'lexical
         #f
         (listof module-path-index?
                 symbol?
                 module-path-index?
                 symbol?
                 exact-nonnegative-integer?
                 phase+space-shift?
                 phase+space?))
  id-stx : identifier?
```

Same as `(identifier-binding id-stx #f)`.

Changed in version 8.2.0.3 of package `base`: Generalized phase results to phase–space combinations.

```
(identifier-distinct-binding  id-stx
                              wrt-id-stx
                             [phase-level
                              top-level-symbol?])
 → (or/c 'lexical
         #f
         (list/c module-path-index?
                 symbol?
                 module-path-index?
                 symbol?
                 exact-nonnegative-integer?
                 phase+space-shift?
                 phase+space?)
         (list/c symbol?))
  id-stx : identifier?
  wrt-id-stx : identifier?
  phase-level : (or/c exact-integer? #f)
              = (syntax-local-phase-level)
  top-level-symbol? : any/c = #f
```

Like `(identifier-binding id-stx phase-level top-level-symbol?)`, but the result is `#f` if the binding for *id-stx* has scopes that are a subset of the scopes for *wrt-id-stx*. That is, if *id-stx* and *wrt-id-stx* have the same symbolic name, a binding for *id-stx* is returned only if the binding does not also apply to *wrt-id-stx*.

Added in version 8.3.0.8 of package `base`.
Changed in version 8.8.0.2: Added the *top-level-symbol?* argument.

```
(identifier-binding-symbol  id-stx
                           [phase-level]) → symbol?
  id-stx : identifier?
  phase-level : (or/c exact-integer? #f)
              = (syntax-local-phase-level)
```

Like `identifier-binding`, but produces a symbol that corresponds to the binding. The symbol result is the same for any identifiers that are `free-identifier=?`, but the result may also be the same for identifiers that are not `free-identifier=?` (i.e., different symbols imply different bindings, but the same symbol does not imply the same binding).

When `identifier-binding` would produce a list, then the second element of that list is the result that `identifier-binding-symbol` produces.

```
(identifier-binding-portal-syntax  id-stx
                                   [phase-level])
 → (or/c #f syntax?)
  id-stx : identifier?
  phase-level : (or/c exact-integer? #f)
              = (syntax-local-phase-level)
```

If *id-stx* is bound at *phase-level* to portal syntax, either via `define-syntax` or `#%require`, then the portal syntax content is returned. The module that binds *id-stx* must be declared, but it need not be instantiated at the relevant phase, and `identifier-binding-portal-syntax` does not instantiate the module.

Added in version 8.3.0.8 of package `base`.

```
(syntax-bound-symbols  stx
                      [phase-level
                       exact-scopes?]) → (listof symbol?)
  stx : stx?
  phase-level : (or/c exact-integer? #f)
              = (syntax-local-phase-level)
  exact-scopes? : any/c = #f
```

Returns a list of all interned symbols for which `(identifier-binding (datum->syntax stx sym) phase-level #f exact-scopes?)` would produce a non-`#f` value. This procedure takes time proportional to the number of scopes on *stx* plus the length of the result list.

Added in version 8.6.0.6 of package `base`.
Changed in version 8.6.0.9: Added the *exact-scopes?* argument.

```
(syntax-bound-interned-scope-symbols  stx
                                     [phase-level
                                      exact-scopes?])
```

```
→ (listof symbol?)
  stx : stx?
  phase-level : (or/c exact-integer? #f)
              = (syntax-local-phase-level)
  exact-scopes? : any/c = #f
```

Returns a list of *sym* names of interned scopes for which `(identifier-binding ((make-interned-syntax-introducer sym) stx) phase-level #f exact-scopes?)` could produce a non-`#f` value. This procedure takes time proportional to the number of scopes on *stx* plus the length of the result list.

Added in version 8.13.0.8 of package `base`.

```
(syntax-bound-phases stx) → (listof (or/c exact-integer? #f))
  stx : stx?
```

Returns a list that includes all *phase-level*s for which `(syntax-bound-symbols stx phase-level)` might produce a non-empty list.

Examples:

```
> (syntax-bound-phases #'anything)
'(2 1 0)
> (require (for-meta 8 racket/base))
> (syntax-bound-phases #'anything)
'(9 8 2 1 0)
```

Added in version 8.6.0.8 of package `base`.

12.4 Syntax Transformers

```
(set!-transformer? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a value created by `make-set!-transformer` or an instance of a structure type with the `prop:set!-transformer` property, `#f` otherwise.

```
(make-set!-transformer proc) → set!-transformer?
  proc : (syntax? . -> . syntax?)
```

Creates an assignment transformer that cooperates with `set!`. If the result of `make-set!-transformer` is bound to *id* as a transformer binding, then *proc* is applied as a transformer when *id* is used in an expression position, or when it is used as the target of a `set!` assignment as `(set! id expr)`. When the identifier appears as a `set!` target, the entire `set!` expression is provided to the transformer.

Example:

```
> (let ([x 1]
        [y 2])
    (let-syntax ([x (make-set!-transformer
                      (lambda (stx)
                        (syntax-case stx (set!)
                          ; Redirect mutation of x to y
                          [(set! id v) #'(set! y v)]
                          ; Normal use of x really gets x
                          [id (identifier? #'id)  #'x])))])
      (begin
        (set! x 3)
        (list x y))))
'(1 3)
```

```
(set!-transformer-procedure transformer)
 → (syntax? . -> . syntax?)
  transformer : set!-transformer?
```

Returns the procedure that was passed to `make-set!-transformer` to create *transformer* or that is identified by the `prop:set!-transformer` property of *transformer*.

```
prop:set!-transformer : struct-type-property?
```

A structure type property to identify structure types that act as assignment transformers like the ones created by `make-set!-transformer`.

The property value must be an exact integer or procedure of one or two arguments. In the former case, the integer designates a field within the structure that should contain a procedure; the integer must be between `0` (inclusive) and the number of non-automatic fields in the structure type (exclusive, not counting supertype fields), and the designated field must also be specified as immutable.

If the property value is a procedure of one argument, then the procedure serves as a syntax transformer and for `set!` transformations. If the property value is a procedure of two arguments, then the first argument is the structure whose type has `prop:set!-transformer` property, and the second argument is a syntax object as for a syntax transformer and for `set!` transformations; `set!-transformer-procedure` applied to the structure produces a new function that accepts just the syntax object and calls the procedure associated through the property. Finally, if the property value is an integer, the target identifier is extracted from the structure instance; if the field value is not a procedure of one argument, then a procedure that always calls `raise-syntax-error` is used, instead.

If a value has both the `prop:set!-transformer` and `prop:rename-transformer` properties, then the latter takes precedence. If a structure type has the `prop:set!-transformer` and `prop:procedure` properties, then the former takes precedence for the purposes of macro expansion.

```
(rename-transformer? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a value created by `make-rename-transformer` or an instance of a structure type with the `prop:rename-transformer` property, `#f` otherwise.

Examples:

```
> (rename-transformer? (make-rename-transformer #'values))
#t
> (rename-transformer? 'not-a-rename-transformer)
#f
```

```
(make-rename-transformer id-stx) → rename-transformer?
  id-stx : syntax?
```

Creates a rename transformer that, when used as a transformer binding, acts as a transformer that inserts the identifier *id-stx* in place of whatever identifier binds the transformer, including in non-application positions, in `set!` expressions.

Such a transformer could be written manually, but the one created by `make-rename-transformer` triggers special cooperation with the parser and other syntactic forms when *id* is bound to the rename transformer:

- The parser installs a `free-identifier=?` and `identifier-binding` equivalence between *id* and *id-stx*, as long as *id-stx* does not have a true value for the `'not-free-identifier=?` syntax property.
- A `provide` of *id* provides the binding indicated by *id-stx* instead of *id*, as long as *id-stx* does not have a true value for the `'not-free-identifier=?` syntax property and as long as *id-stx* has a binding.
- If `provide` exports *id*, it uses a symbol-valued `'nominal-id` property of *id-stx* to specify the "nominal source identifier" of the binding as reported by `identifier-binding`.
- If *id-stx* has a true value for the `'not-provide-all-defined` syntax property, then *id* (or its target) is not exported by `all-defined-out`.

- The `syntax-local-value` function recognizes rename-transformer bindings and consult their targets.

Examples:

```
> (define-syntax my-or (make-rename-transformer #'or))
> (my-or #f #t)
#t
> (free-identifier=? #'my-or #'or)
#t
```

Changed in version 6.3 of package `base`: Removed an optional second argument.
Changed in version 7.4.0.10: Adjusted rename-transformer expansion to add a macro-introduction scope, the same as regular macro expansion.

```
(rename-transformer-target transformer) → identifier?
  transformer : rename-transformer?
```

Returns the identifier passed to `make-rename-transformer` to create *`transformer`* or as indicated by a `prop:rename-transformer` property on *`transformer`*.

Example:

```
> (rename-transformer-target (make-rename-transformer #'or))
#<syntax:eval:8:0 or>
```

```
prop:rename-transformer : struct-type-property?
```

A structure type property to identify structure types that act as rename transformers like the ones created by `make-rename-transformer`.

The property value must be an exact integer, an identifier syntax object, or a procedure that takes one argument. In the former case, the integer designates a field within the structure that should contain an identifier; the integer must be between `0` (inclusive) and the number of non-automatic fields in the structure type (exclusive, not counting supertype fields), and the designated field must also be specified as immutable.

If the property value is an identifier, the identifier serves as the target for renaming, just like the first argument to `make-rename-transformer`. If the property value is an integer, the target identifier is extracted from the structure instance; if the field value is not an identifier, then an identifier `?` with an empty context is used, instead.

If the property value is a procedure that takes one argument, then the procedure is called to obtain the identifier that the rename transformer will use as a target identifier. The returned identifier should probably have the `'not-free-identifier=?` syntax property. If the procedure returns any value that is not an identifier, the `exn:fail:contract` exception is raised.

Examples:

```
; Example of a procedure argument for prop:rename-transformer
> (define-syntax slv-1 'first-transformer-binding)
> (define-syntax slv-2 'second-transformer-binding)
> (begin-for-syntax
    (struct slv-cooperator (redirect-to-first?)
      #:property prop:rename-transformer
      (λ (inst)
        (if (slv-cooperator-redirect-to-first? inst)
            #'slv-1
            #'slv-2))))
> (define-syntax (slv-lookup stx)
    (syntax-case stx ()
      [(_ id)
       #`'#,(syntax-local-value #'id)]))
> (define-syntax slv-inst-1 (slv-cooperator #t))
> (define-syntax slv-inst-2 (slv-cooperator #f))
> (slv-lookup slv-inst-1)
'first-transformer-binding
> (slv-lookup slv-inst-2)
'second-transformer-binding
```

Changed in version 6.3 of package `base`: the property now accepts a procedure of one argument.

```
(local-expand  stx
               context-v
               stop-ids
              [intdef-ctx]) → syntax?
  stx : any/c
  context-v : (or/c 'expression 'top-level 'module 'module-begin list?)
  stop-ids : (or/c (listof identifier?) empty #f)
  intdef-ctx : (or/c internal-definition-context?          = #f
                     #f
                     (listof internal-definition-context?))
```

Expands *`stx`* in the lexical context of the expression currently being expanded. The *`context-v`* argument is used as the result of `syntax-local-context` for immediate expansions; a list indicates an internal-definition context, and more information on the form of the list is below. If *`stx`* is not already a syntax object, it is coerced with `(datum->syntax #f stx)` before expansion.

The *`stop-ids`* argument controls how far `local-expand` expands *`stx`*:

- If *stop-ids* is an empty list, then *stx* is recursively expanded (i.e. expansion proceeds to sub-expressions). The result is guaranteed to be a fully-expanded form, which can include the bindings listed in §1.2.3.1 "Fully Expanded Programs", plus `#%expression` in any expression position.
- If *stop-ids* is a list containing just `module*`, then expansion proceeds as if *stop-ids* were an empty list, except that expansion does not recur to submodules defined with `module*` (which are left unexpanded in the result).
- If *stop-ids* is any other list, then `begin`, `quote`, `set!`, `#%plain-lambda`, `case-lambda`, `let-values`, `letrec-values`, `if`, `begin0`, `with-continuation-mark`, `letrec-syntaxes+values`, `#%plain-app`, `#%expression`, `#%top`, and `#%variable-reference` are implicitly added to *stop-ids*. Expansion proceeds recursively, stopping when the expander encounters any of the forms in *stop-ids*, and the result is the partially-expanded form.

  When the expander would normally implicitly introduce a `#%app`, `#%datum`, or `#%top` identifier as described in §1.2.3.2 "Expansion Steps", it checks to see if an identifier with the same binding as the one to be introduced appears in *stop-ids*. If so, the identifier is *not* introduced; the result of expansion is the bare application, literal data expression, or unbound identifier rather than one wrapped in the respective explicit form.

  When `#%plain-module-begin` is not in *stop-ids*, the `#%plain-module-begin` transformer detects and expands sub-forms (such as `define-values`) regardless of the identifiers presence in *stop-ids*.

  Expansion does not replace the scopes in a local-variable reference to match the binding identifier.
- If *stop-ids* is `#f` instead of a list, then *stx* is expanded only as long as the outermost form of *stx* is a macro (i.e. expansion does *not* proceed to sub-expressions, and it does not replace the scopes in a local-variable reference to match the binding identifier). The `#%app`, `#%datum`, and `#%top` identifiers are never introduced.

Independent of *stop-ids*, when `local-expand` encounters an identifier that has a local binding but no binding in the current expansion context, the variable is left as-is (as opposed to triggering an "out of context" syntax error).

When *context-v* is `'module-begin`, and the result of expansion is a `#%plain-module-begin` form, then a `'submodule` syntax property is added to each enclosed `module` form (but not `module*` forms) in the same way as by `module` expansion.

If the *intdef-ctx* argument is an internal-definition context, its bindings and bindings from all parent internal-definition contexts are added to the local binding context during the dynamic extent of the call to `local-expand`. Additionally, unless `#f` was provided for the *add-scope?* argument to `syntax-local-make-definition-context` when the internal-definition context was created, its inside-edge scope (but *not* the scopes of any parent internal-definition contexts) is added to the lexical information for both *stx* prior to its expansion and the expansion result (because the expansion might introduce bindings or references to internal-definition bindings).

For backwards compatibility, when *intdef-ctx* is a list all bindings from all of the provided internal-definition contexts and their parents are added to the local binding context, and the inside-edge scope from each context for which *add-scope?* was not `#f` is added in the same way.

Expansion records use-site scopes for removal from definition bindings. When the *intdef-ctx* argument is an internal-definition context, use-site scopes are recorded with that context. When *intdef-ctx* is `#f` or (for backwards compatibility) a list, use-site scopes are recorded with the current expand context.

For a particular internal-definition context, generate a unique value and put it into a list for *context-v*. To allow liberal expansion of `define` forms, the generated value should be an instance of a structure with a true value for `prop:liberal-define-context`. If the internal-definition context is meant to be self-contained, the list for *context-v* should contain only the generated value; if the internal-definition context is meant to splice into an immediately enclosing context, then when `syntax-local-context` produces a list, `cons` the generated value onto that list.

When expressions are expanded via `local-expand` with an internal-definition context *intdef-ctx*, and when the expanded expressions are incorporated into an overall form *new-stx*, then typically `internal-definition-context-track` should be applied to *intdef-ctx* and *new-stx* to provide expansion history to external tools.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

Examples:

```
> (define-syntax-rule (do-print x ...)
    (printf x ...))
> (define-syntax-rule (hello x)
    (do-print "hello ~a" x))
> (define-syntax (show stx)
    (syntax-case stx ()
      [(_ x)
       (let ([partly (local-expand #'(hello x)
                                   'expression
                                   (list #'do-print))]
             [fully (local-expand #'(hello x)
                                  'expression
                                  #f)])
         (printf "partly expanded: ~s\n" (syntax->datum partly))
         (printf "fully expanded: ~s\n" (syntax->datum fully))
```

```
          fully)]))
> (show 1)
partly expanded: (do-print "hello ~a" 1)
fully expanded: (printf "hello ~a" 1)
hello 1
```

This procedure's binding is provided as protected in the sense of `protect-out`.

Changed in version 6.0.1.3 of package `base`: Changed treatment of `#%top` so that it is never introduced as an explicit wrapper.
Changed in version 6.0.90.27: Loosened the contract on the *`intdef-ctx`* argument to allow an empty list.
Changed in version 8.2.0.4: Changed binding to protected.

```
(syntax-local-expand-expression  stx
                                [opaque-only?])
 → (if opaque-only? #f syntax?) syntax?
  stx : any/c
  opaque-only? : any/c = #f
```

Like `local-expand` given `'expression` and an empty stop list, but with two results: a syntax object for the fully expanded expression, and a syntax object whose content is opaque.

The latter can be used in place of the former (perhaps in a larger expression produced by a macro transformer), and when the macro expander encounters the opaque object, it substitutes the fully expanded expression without re-expanding it; the `exn:fail:syntax` exception is raised if the expansion context includes scopes that were not present for the original expansion, in which case re-expansion might produce different results. Consistent use of `syntax-local-expand-expression` and the opaque object thus avoids quadratic expansion times when local expansions are nested.

If *`opaque-only?`* is true, then the first result is `#f` instead of the expanded expression. Obtaining only the second, opaque result can be more efficient in some expansion contexts.

Unlike `local-expand`, `syntax-local-expand-expression` normally produces an expanded expression that contains no `#%expression` forms. However, if `syntax-local-expand-expression` is used within an expansion that is triggered by an enclosing `local-expand` call, then the result of `syntax-local-expand-expression` can include `#%expression` forms.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

This procedure's binding is provided as protected in the sense of `protect-out`.

Changed in version 6.90.0.13 of package `base`: Added the *`opaque-only?`* argument.
Changed in version 8.2.0.4: Changed binding to protected.

```
(local-transformer-expand  stx
                           context-v
                           stop-ids
                          [intdef-ctx]) → syntax?
  stx : any/c
  context-v : (or/c 'expression 'top-level list?)
  stop-ids : (or/c (listof identifier?) #f)
  intdef-ctx : (or/c internal-definition-context?           = #f
                     #f
                     (listof internal-definition-context?))
```

Like `local-expand`, but *stx* is expanded as a transformer expression instead of a run-time expression.

Any lifted expressions—from calls to `syntax-local-lift-expression` during the expansion of *stx*—are captured in the result. If *context-v* is `'top-level`, then lifts are captured in a `begin` form, otherwise lifts are captured in `let-values` forms. If no expressions are lifted during expansion, then no `begin` or `let-values` wrapper is added.

This procedure's binding is provided as protected in the sense of `protect-out`.

Changed in version 6.5.0.3 of package `base`: Allowed and captured lifts in a `'top-level` context.
Changed in version 8.2.0.4: Changed binding to protected.

```
(local-expand/capture-lifts  stx
                             context-v
                             stop-ids
                            [intdef-ctx
                             lift-ctx]) → syntax?
  stx : any/c
  context-v : (or/c 'expression 'top-level 'module 'module-begin list?)
  stop-ids : (or/c (listof identifier?) #f)
  intdef-ctx : (or/c internal-definition-context?           = #f
                     #f
                     (listof internal-definition-context?))
  lift-ctx : any/c = (gensym 'lifts)
```

Like `local-expand`, but the result is a syntax object that represents a `begin` expression. Lifted expressions—from calls to `syntax-local-lift-expression` during the expansion of *stx*—appear with their identifiers in `define-values` forms, and the expansion of *stx* is the last expression in the `begin`. The *lift-ctx* value is reported by `syntax-local-lift-context` during local expansion. The lifted expressions are not expanded, but instead left as provided in the `begin` form.

If *context-v* is `'top-level` or `'module`, then `module` forms can appear in the result as added via `syntax-local-lift-module`. If *context-v* is `'module`, then `module*` forms can appear, too.

This procedure's binding is provided as protected in the sense of `protect-out`.

Changed in version 8.2.0.4 of package `base`: Changed binding to protected.

```
(local-transformer-expand/capture-lifts  stx
                                          context-v
                                          stop-ids
                                         [intdef-ctx
                                          lift-ctx])  → syntax?
  stx : any/c
  context-v : (or/c 'expression 'top-level list?)
  stop-ids : (or/c (listof identifier?) #f)
  intdef-ctx : (or/c internal-definition-context?           = #f
                     #f
                     (listof internal-definition-context?))
  lift-ctx : any/c = (gensym 'lifts)
```

Like `local-expand/capture-lifts`, but *stx* is expanded as a transformer expression instead of a run-time expression. Lifted expressions are reported as `define-values` forms (in the transformer environment).

This procedure's binding is provided as protected in the sense of `protect-out`.

Changed in version 8.2.0.4 of package `base`: Changed binding to protected.

```
(syntax-local-apply-transformer transformer
                                binding-id/insp
                                context-v
                                intdef-ctx
                                v ...)          → any
  transformer : procedure?
  binding-id/insp : (or/c #f identifier? inspector?
                          (list identifier? inspector?))
  context-v : (or/c 'expression 'top-level 'module 'module-begin list?)
  intdef-ctx : (or/c internal-definition-context? #f)
  v : any/c
```

Applies the procedure *transformer* to the *v*s in a new expansion context and local binding context. Adds and flips macro-introduction scopes and use-site scopes on the arguments and return values in the same manner as syntax transformer application. The arguments and returns may be any value; scopes are manipulated only for those that are syntax objects.

The *context-v* argument is as in `local-expand`, and the *intdef-ctx* is an internal-definition context value or `#f`.

The *binding-id/insp* argument encodes up to two additional arguments: *biding-id* as an identifier and *expander-insp* as an inspector. The *binding-id* part, if supplied, specifies a binding associated with the *transformer*, which the expander uses to determine whether to add use-site scopes and which code inspector to use during expansion. The *expander-insp* part specifies a code inspector for the expander itself, which defaults to the code inspector associated with the binding of the transformer currently in progress. The relevant inspector is the inferior (in the sense of `inspector-superior?`) of the one implied by *binding-id* and *expander-insp* if the inspector are comparable, or no inspector otherwise.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

Added in version 8.2.0.7 of package `base`.
Changed in version 8.18.0.15: Changed the *binding-id/insp* to allow an *expander-insp* component.

```
(internal-definition-context? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is an internal-definition context, `#f` otherwise.

```
(syntax-local-make-definition-context [parent-ctx
                                        add-scope?])
 → internal-definition-context?
  parent-ctx : (or/c internal-definition-context? #f) = #f
  add-scope? : any/c = #t
```

Creates an opaque internal-definition context value to be used with `local-expand` and other functions. A transformer should create one context for each set of internal definitions to be expanded.

Before expanding forms whose lexical context should include the definitions, the transformer should use `internal-definition-context-add-scopes` to apply the context's scopes to the syntax. Calls to procedures such as `local-expand` to expand the forms should provide the internal-definition context value as an argument.

After discovering an internal `define-values` or `define-syntaxes` form, use `syntax-local-bind-syntaxes` to add bindings to the context.

An internal-definition context internally creates an outside-edge scope and an inside-edge scope to represent the context. The inside-edge scope is added to any form that is expanded within the context or that appears as the result of a (partial) expansion within the context. For backward compatibility, providing `#f` for *add-scope?* disables this behavior.

If *parent-ctx* is not `#f`, then *parent-ctx* is made the *parent internal-definition context* for the new internal-definition context. Whenever the new context's bindings are added to the local binding context (e.g. by providing the context to local-expand, syntax-local-bind-syntaxes, or syntax-local-value), then the bindings from *parent-ctx* are also added as well. If *parent-ctx* was also created with a parent internal-definition context, bindings from its parent are also added, and so on recursively. Note that the scopes of parent contexts are *not* added implicitly, only the bindings, even when the inside-edge scope of the child context would be implicitly added. If the scopes of parent definition contexts should be added, the parent contexts must be provided explicitly.

Additionally, if the created definition context is intended to be spliced into a surrounding definition context, the surrounding context should always be provided for the *parent-ctx* argument to ensure the necessary use-site scopes are added to macros expanded in the context. Otherwise, expansion of nested definitions can be inconsistent with the expansion of definitions in the surrounding context.

An internal-definition context also tracks use-site scopes created during expansion within the definition context, so that they can be removed from bindings created in the context, at syntax-local-identifier-as-binding, and at internal-definition-context-splice-binding-identifier.

The scopes associated with a new definition context are pruned from quote-syntax forms only when it is created during the dynamic extent of a syntax transformer application or in a begin-for-syntax form (potentially nested) within a module being expanded.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see syntax-transforming?), otherwise the exn:fail:contract exception is raised.

Changed in version 6.3 of package base: Added the *add-scope?* argument, and made calling internal-definition-context-seal no longer necessary.
Changed in version 8.2.0.7: Added the outside-edge scope and use-site scope tracking behaviors.

```
(syntax-local-make-definition-context-introducer [name])
 → ((syntax?) ((or/c 'flip 'add 'remove)) . ->* . syntax?)
  name : (and/c symbol? (not/c 'macro)) = 'intdef
```

Like make-syntax-introducer, but the encapsulated scope is pruned from quote-syntax forms, much like the scopes associated with a new definition context (see syntax-local-make-definition-context). The *name* argument is used as the symbolic name, which serves as a debugging aid.

Typically, internal-definition-context-add-scopes and internal-definition-context-splice-binding-identifier are preferred, but this function can be useful when you are sure that you want a single scope that should be pruned from quote-syntax forms.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see syntax-transforming?), otherwise the exn:fail:contract exception is raised.

Added in version 8.12.0.8 of package base.

```
(internal-definition-context-add-scopes intdef-ctx
                                        stx)        → syntax?
  intdef-ctx : internal-definition-context?
  stx : syntax?
```

Adds the outside-edge scope and inside-edge scope for *intdef-ctx* to *stx*.

Use this function to apply the definition context scopes to syntax that originates within the definition context before expansion.

Added in version 8.2.0.7 of package base.

```
 (internal-definition-context-splice-binding-identifier
  intdef-ctx
  id)
 → syntax?
  intdef-ctx : internal-definition-context?
  id : identifier?
```

Removes scopes associated with the *intdef-ctx* from *id*: the outside-edge scope, the inside-edge scope, and use-site scopes created by expansions within the definition context.

Use when splicing a binding originating within the *intdef-ctx* into a surrounding context.

Added in version 8.2.0.7 of package base.

```
(syntax-local-bind-syntaxes  id-list
                             expr
                             intdef-ctx
                            [extra-intdef-ctxs])
 → (listof identifier?)
  id-list : (listof identifier?)
  expr : (or/c syntax? #f)
  intdef-ctx : internal-definition-context?
  extra-intdef-ctxs : (or/c internal-definition-context?
                            (listof internal-definition-context?))
                    = '()
```

Binds each identifier in *id-list* within the internal-definition context represented by *intdef-ctx*, where *intdef-ctx* is the result of syntax-local-make-definition-context. Returns identifiers with lexical information matching the new bindings.

For backwards compatibility, the lexical information of each element of *extra-intdef-ctxs* is also added to each identifier in *id-list* before binding.

Supply #f for *expr* when the identifiers correspond to `define-values` bindings, and supply a compile-time expression when the identifiers correspond to `define-syntaxes` bindings. In the latter case, the number of values produced by the expression should match the number of identifiers, otherwise the `exn:fail:contract:arity` exception is raised.

When *expr* is not #f, it is expanded in an expression context and evaluated in the current transformer environment. In this case, the bindings and lexical information from both *intdef-ctx* and *extra-intdef-ctxs* are used to enrich *expr*'s lexical information and extend the local binding context in the same way as the fourth argument to `local-expand`. If *expr* is #f, the value provided for *extra-intdef-ctxs* is ignored.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

Changed in version 6.90.0.27 of package `base`: Added the *extra-intdef-ctxs* argument.
Changed in version 8.2.0.7: Changed the return value from `#<void>` to the list of bound identifiers.

```
(internal-definition-context-binding-identifiers intdef-ctx)
 → (listof identifier?)
  intdef-ctx : internal-definition-context?
```

Returns a list of all binding identifiers registered for *intdef-ctx* through `syntax-local-bind-syntaxes`. Each identifier in the returned list includes the internal-definition context's scope.

Added in version 6.3.0.4 of package `base`.

```
(internal-definition-context-introduce  intdef-ctx
                                         stx
                                        [mode])      → syntax?
  intdef-ctx : internal-definition-context?
  stx : syntax?
  mode : (or/c 'flip 'add 'remove) = 'flip
```

Flips, adds, or removes (depending on *mode*) the scope for *intdef-ctx* for all parts of *stx*.

This function is provided for backwards compatibility; `internal-definition-context-add-scopes` and `internal-definition-context-splice-binding-identifier` are preferred. See also `syntax-local-make-definition-context-introducer` for encapsulating a single scope that should be pruned from `quote-syntax` forms.

Added in version 6.3 of package `base`.

```
(internal-definition-context-seal intdef-ctx) → void?
  intdef-ctx : internal-definition-context?
```

For backward compatibility only; has no effect.

```
(identifier-remove-from-definition-context id-stx
                                           intdef-ctx)
 → identifier?
  id-stx : identifier?
  intdef-ctx : (or/c internal-definition-context?
                     (listof internal-definition-context?))
```

Removes all of the scopes of *intdef-ctx* (or of each element in a list *intdef-ctx*) from *id-stx*.

The `identifier-remove-from-definition-context` function is provided for backward compatibility; the `internal-definition-context-splice-binding-identifier` function is preferred.

Changed in version 6.3 of package `base`: Simplified the operation to scope removal.

```
prop:expansion-contexts : struct-type-property?
```

A structure type property to constrain the use of macro transformers and rename transformers. The property's value must be a list of symbols, where the allowed symbols are `'expression`, `'top-level`, `'module`, `'module-begin`, and `'definition-context`. Each symbol corresponds to an expansion context in the same way as for `local-expand` or as reported by `syntax-local-context`, except that `'definition-context` is used (instead of a list) to represent an internal-definition context.

If an identifier is bound to a transformer whose list does not include a symbol for a particular use of the identifier, then the use is adjusted as follows:

- In a `'module-begin` context, then the use is wrapped in a `begin` form.
- In a `'module`, `'top-level`, `'internal-definition` or context, if `'expression` is present in the list, then the use is wrapped in an `#%expression` form.
- Otherwise, a syntax error is reported.

The `prop:expansion-contexts` property is most useful in combination with `prop:rename-transformer`, since a general transformer procedure can use `syntax-local-context`. Furthermore, a `prop:expansion-contexts` property makes the most sense when a rename transformer's identifier has the `'not-free-identifier=?` property, otherwise a definition of the binding creates a binding alias that effectively routes around the `prop:expansion-contexts` property.

Added in version 6.3 of package `base`.

```
(syntax-local-value  id-stx
                    [failure-thunk
                     intdef-ctx])   → any
  id-stx : identifier?
  failure-thunk : (or/c (-> any) #f) = #f
  intdef-ctx : (or/c internal-definition-context?           = #f
                     #f
                     (listof internal-definition-context?))
```

Returns the transformer binding value of the identifier *id-stx* in the context of the current expansion. If *intdef-ctx* is not `#f`, bindings from all provided definition contexts are also considered. Unlike the fourth argument to `local-expand`, the scopes associated with the provided definition contexts are *not* used to enrich *id-stx*'s lexical information.

If *id-stx* is bound to a rename transformer created with `make-rename-transformer`, `syntax-local-value` effectively calls itself with the target of the rename and returns that result, instead of the rename transformer.

If *id-stx* has no transformer binding (via `define-syntax`, `let-syntax`, etc.) in that environment, the result is obtained by applying *failure-thunk* if not `#f`. If *failure-thunk* is `false`, the `exn:fail:contract` exception is raised.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

Examples:

```
> (define-syntax swiss-cheeses? #t)
> (define-syntax (transformer stx)
    (if (syntax-local-value #'swiss-cheeses?)
        #''(gruyère emmental raclette)
        #''(roquefort camembert boursin)))
> (transformer)
'(gruyère emmental raclette)
```

Examples:

```
> (define-syntax (transformer-2 stx)
    (syntax-local-value #'something-else (λ () (error "no bind-
ing"))))
> (transformer-2)
no binding
```

Examples:

```
> (define-syntax nachos #'(printf "nachos~n"))
> (define-syntax chips (make-rename-transformer #'nachos))
> (define-syntax (transformer-3 stx)
    (syntax-local-value #'chips))
> (transformer-3)
nachos
```

This procedure's binding is provided as protected in the sense of `protect-out`.

Changed in version 6.90.0.27 of package `base`: Changed *`intdef-ctx`* to accept a list of internal-definition contexts in addition to a single internal-definition context or `#f`.
Changed in version 8.2.0.4: Changed binding to protected.

```
(syntax-local-value/immediate  id-stx
                              [failure-thunk
                               intdef-ctx])   → any
  id-stx : syntax?
  failure-thunk : (or/c (-> any) #f) = #f
  intdef-ctx : (or/c internal-definition-context?           = #f
                     #f
                     (listof internal-definition-context?))
```

Like `syntax-local-value`, but the result is normally two values. If *`id-stx`* is bound to a rename transformer, the results are the rename transformer and the identifier in the transformer. If *`id-stx`* is not bound to a rename transformer, then the results are the value that `syntax-local-value` would produce and `#f`.

Beware that `provide` on an *`id`* bound to a rename transformer may export the target of the rename instead of *`id`*. See `make-rename-transformer` for more information.

If *`id-stx`* has no transformer binding, then *`failure-thunk`* is called (and it can return any number of values), or an exception is raised if *`failure-thunk`* is `#f`.

Examples:

```
> (define-syntax agent-007 (make-rename-transformer #'james-bond))
> (define-syntax (show-secret-identity stx)
    (syntax-parse stx
      [(_ name:id)
       (define-values [_ orig-name] (syntax-local-
value/immediate #'name))
       #`'(name #,orig-name)]))
> (show-secret-identity agent-007)
'(agent-007 james-bond)
```

This procedure's binding is provided as protected in the sense of `protect-out`.

Changed in version 8.2.0.4 of package `base`: Changed binding to protected.

```
(syntax-local-lift-expression stx) → identifier?
  stx : syntax?
```

Returns a fresh identifier, and cooperates with the `module`, `letrec-syntaxes+values`, `define-syntaxes`, `begin-for-syntax`, and top-level expanders to bind the generated identifier to the expression *stx*.

A run-time expression within a module is lifted to the module's top level, just before the expression whose expansion requests the lift. Similarly, a run-time expression outside of a module is lifted to a top-level definition. A compile-time expression in a `letrec-syntaxes+values` or `define-syntaxes` binding is lifted to a `let` wrapper around the corresponding right-hand side of the binding. A compile-time expression within `begin-for-syntax` is lifted to a `define` declaration just before the requesting expression within the `begin-for-syntax`.

Other syntactic forms can capture lifts by using `local-expand/capture-lifts` or `local-transformer-expand/capture-lifts`.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

In addition, this procedure can be called only when a lift target is available, as indicated by `syntax-transforming-with-lifts?`.

```
(syntax-local-lift-values-expression n stx)
 → (listof identifier?)
  n : exact-nonnegative-integer?
  stx : syntax?
```

Like `syntax-local-lift-expression`, but binds the result to *n* identifiers, and returns a list of the *n* identifiers.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

```
(syntax-local-lift-context) → any/c
```

Returns a value that represents the target for expressions lifted via `syntax-local-lift-expression`. That is, for different transformer calls for which this procedure returns the same value (as determined by `eq?`), lifted expressions for the two transformer are moved to the same place. Thus, the result is useful for caching lift information to avoid redundant lifts.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

```
(syntax-local-lift-module stx) → void?
  stx : syntax?
```

Cooperates with the `module` form or top-level expansion to add *stx* as a module declaration in the enclosing module or top-level. The *stx* form must start with `module` or `module*`, where the latter is only allowed within the expansion of a module.

The module is not immediately declared when `syntax-local-lift-module` returns. Instead, the module declaration is recorded for processing when expansion returns to the enclosing module body or top-level sequence.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

If the current expression being transformed is not within a `module` form or within a top-level expansion, then the `exn:fail:contract` exception is raised. If *stx* form does not start with `module` or `module*`, or if it starts with `module*` in a top-level context, the `exn:fail:contract` exception is raised.

Added in version 6.3 of package `base`.

```
(syntax-local-lift-module-end-declaration stx) → void?
  stx : syntax?
```

Cooperates with the `module` form to insert *stx* as a top-level declaration at the end of the module currently being expanded. If the current expression being transformed is in phase level 0 and not in the module top-level, then *stx* is eventually expanded in an expression context. If the current expression being transformed is in a higher phase level (i.e., nested within some number of `begin-for-syntax`es within a module top-level), then the lifted declaration is placed at the very end of the module (under a suitable number of `begin-for-syntax`es), instead of merely the end of the enclosing `begin-for-syntax`.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

If the current expression being transformed is not within a `module` form (see `syntax-transforming-module-expression?`), then the `exn:fail:contract` exception is raised.

```
(syntax-local-lift-require  raw-require-spec
                            stx
                           [new-scope?])       → syntax?
```

```
raw-require-spec : any/c
stx : syntax?
new-scope? : any/c = #t
```

Lifts a `#%require` form corresponding to *raw-require-spec* (either as a syntax object or datum) to the top-level or to the top of the module currently being expanded or to an enclosing `begin-for-syntax`.

The resulting syntax object is the same as *stx*, except that a fresh scope is added if *new-scope?* is true. The same scope is added to the lifted `#%require` form, so that the `#%require` form can bind uses of imported identifiers in the resulting syntax object (assuming that the lexical information of *stx* includes the binding environment into which the `#%require` is lifted). If *new-scope?* is `#f`, then the result exactly *stx*, and no scope is added to the lifted `#%require` form; in that case, take care to ensure that the lifted require does not change the meaning of already-expanded identifiers in the module, otherwise re-expansion of the enclosing module will not produce the same result as the expanded module.

If *raw-require-spec* is part of the input to a transformer, then typically `syntax-local-introduce` should be applied before passing it to `syntax-local-lift-require`. Otherwise, marks added by the macro expander can prevent access to the new imports.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

Changed in version 6.90.0.27 of package `base`: Changed the scope added to inputs from a macro-introduction scope to one that does not affect whether or not the resulting syntax is considered original as reported by `syntax-original?`.
Changed in version 8.6.0.4: Added the *new-scope?* optional argument.

```
(syntax-local-lift-provide raw-provide-spec-stx) → void?
  raw-provide-spec-stx : syntax?
```

Lifts a `#%provide` form corresponding to *raw-provide-spec-stx* to the top of the module currently being expanded or to an enclosing `begin-for-syntax`.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

If the current expression being transformed is not within a `module` form (see `syntax-transforming-module-expression?`), then the `exn:fail:contract` exception is raised.

```
(syntax-local-name) → any/c
```

Returns an inferred name for the expression position being transformed, or `#f` if no such name is available. A name is normally a symbol or an identifier. See also §1.2.6 "Inferred Value Names".

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

```
(syntax-local-context)
 → (or/c 'expression 'top-level 'module 'module-begin list?)
```

Returns an indication of the context for expansion that triggered a syntax transformer call. See §1.2.3.3 "Expansion Context" for more information on contexts.

The symbol results indicate that the expression is being expanded for an expression context, a top-level context, a module context, or a module-begin context.

A list result indicates expansion in an internal-definition context. The identity of the list's first element (i.e., its `eq?`ness) reflects the identity of the internal-definition context; in particular two transformer expansions receive the same first value if and only if they are invoked for the same internal-definition context. Later values in the list similarly identify internal-definition contexts that are still being expanded, and that required the expansion of nested internal-definition contexts.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

```
(syntax-local-phase-level) → exact-integer?
```

During the dynamic extent of a syntax transformer application by the expander, the result is the phase level of the form being expanded. Otherwise, the result is `0`.

Examples:

```
; a macro bound at phase 0
> (define-syntax (print-phase-level stx)
    (printf "phase level: ~a~n" (syntax-local-phase-level))
    #'(void))
> (require (for-meta 2 racket/base))
> (begin-for-syntax
    ; a macro bound at phase 1
    (define-syntax (print-phase-level stx)
      (printf "phase level: ~a~n" (syntax-local-phase-level))
      #'(void)))
> (print-phase-level)
phase level: 0
```

```
> (begin-for-syntax (print-phase-level))
phase level: 1
```

```
(syntax-local-module-exports mod-path)
 → (listof (cons/c phase+space? (listof symbol?)))
  mod-path : (or/c module-path?
                   (syntax/c module-path?))
```

Returns an association list from phase level and binding space combinations to lists of symbols, where the symbols are the names of `provide`d bindings from *`mod-path`* at the corresponding phase level.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

Changed in version 8.2.0.3 of package `base`: Generalized result to phase–space combinations.

```
(syntax-local-submodules) → (listof symbol?)
```

Returns a list of submodule names that are declared via `module` (as opposed to `module*`) in the current expansion context.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

```
(syntax-local-module-interned-scope-symbols)
 → (listof symbol?)
```

Returns a list of distinct interned symbols corresponding to binding spaces that have been used, so far, for binding within the current expansion context's module or top-level namespace. The result is conservative in the sense that it may include additional symbols that have not been used in the current module or namespace.

The current implementation returns all symbols for reachable interned scopes, but that behavior may change in the future to return a less conservative list of symbols.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

Added in version 8.2.0.7 of package `base`.

```
(syntax-local-get-shadower  id-stx
                           [only-generated?]) → identifier?
  id-stx : identifier?
  only-generated? : any/c = #f
```

Adds scopes to *id-stx* so that it refers to bindings in the current expansion context or could bind any identifier obtained via (syntax-local-get-shadower *id-stx*) in more nested contexts. If *only-generated?* is true, the phase-spanning scope of the enclosing module or namespace is omitted from the added scopes, however, which limits the bindings that can be referenced (and therefore avoids certain ambiguous references).

This function is intended for the implementation of syntax-parameterize and local-require.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see syntax-transforming?), otherwise the exn:fail:contract exception is raised.

Changed in version 6.3 of package base: Simplified to the minimal functionality needed for syntax-parameterize and local-require.

```
(syntax-local-make-delta-introducer id-stx) → procedure?
  id-stx : identifier?
```

For (limited) backward compatibility only; raises exn:fail:unsupported.

Changed in version 6.3 of package base: changed to raise exn:fail:supported.

```
(syntax-local-certifier [active?])
 → ((syntax?) (any/c (or/c procedure? #f))
     . ->* . syntax?)
  active? : boolean? = #f
```

For backward compatibility only; returns a procedure that returns its first argument.

```
(syntax-transforming?) → boolean?
```

Returns #t during the dynamic extent of a syntax transformer application by the expander and while a module is being visited, #f otherwise.

```
(syntax-transforming-with-lifts?) → boolean?
```

Returns #t if (syntax-transforming?) produces #t and a target context is available for lifting expressions (via syntax-local-lift-expression), #f otherwise.

Currently, (syntax-transforming?) implies (syntax-transforming-with-lifts?).

Added in version 6.3.0.9 of package base.

```
(syntax-transforming-module-expression?) → boolean?
```

Returns #t during the dynamic extent of a syntax transformer application by the expander for an expression within a module form, #f otherwise.

```
(syntax-local-compiling-module?) → boolean?
```

Returns #t during the dynamic extent of a syntax transformer application by the expander in a module-begin context and when the expansion is part of a compilation process where a compiled module can be returned directly. See also module.

Added in version 8.13.0.7 of package base.

```
(syntax-local-identifier-as-binding id-stx
                                    [intdef-ctx]) → identifier?
  id-stx : identifier?
  intdef-ctx : (or/c internal-definition-context? #f) = #f
```

Returns an identifier like *id-stx*, but without use-site scopes that were previously added to the identifier as part of a macro expansion. When the *intdef-ctx* is an internal-definition context, the function removes use-site scopes created during expansion in that context. When it is #f (the default), it removes use-site scopes created during expansion in the current expansion context.

In a syntax transformer that runs in a non-expression context and forces the expansion of subforms with local-expand, use syntax-local-identifier-as-binding on an identifier from the expansion before moving it into a binding position or comparing it with bound-identifier=?. Otherwise, the results can be inconsistent with the way that define works in the same definition context.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see syntax-transforming?), otherwise the exn:fail:contract exception is raised.

Added in version 6.3 of package base.
Changed in version 8.2.0.7: Added the optional *intdef-ctx* argument.

```
(syntax-local-introduce stx) → syntax?
  stx : syntax?
```

Produces a syntax object that is like *stx*, except that the presence of scopes for the current expansion—both the macro-introduction scope and the use-site scope, if any—is flipped on all parts of the syntax object. See §1.2.3.5 "Transformer Bindings" for information on macro-introduction and use-site scopes.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see syntax-transforming?), otherwise the exn:fail:contract exception is raised.

Example:

```
> (module example racket
    (define-syntax (require-math stx)
      (syntax-local-introduce #'(require racket/math)))
    (require-math)
    pi)
```

```
(make-syntax-introducer [as-use-site?])
 → ((syntax?) ((or/c 'flip 'add 'remove)) . ->* . syntax?)
  as-use-site? : any/c = #f
```

Produces a procedure that encapsulates a fresh scope and flips, adds, or removes it in a given syntax object. By default, the fresh scope is a macro-introduction scope, but providing a true value for `as-use-site?` creates a scope that is like a use-site scope; the difference is in how the scopes are treated by `syntax-original?`.

The action of the generated procedure can be `'flip` (the default) to flip the presence of a scope in each part of a given syntax object, `'add` to add the scope to each regardless of whether it is present already, or `'remove` to remove the scope when it is currently present in any part.

Multiple applications of the same `make-syntax-introducer` result procedure use the same scope, and different result procedures use distinct scopes.

Changed in version 6.3 of package `base`: Added the optional `as-use-site?` argument, and added the optional operation argument in the result procedure.

```
(make-interned-syntax-introducer key)
 → ((syntax?) ((or/c 'flip 'add 'remove)) . ->* . syntax?)
  key : (and/c symbol? symbol-interned?)
```

Like `make-syntax-introducer`, but the encapsulated scope is an *interned scope*. Multiple calls to `make-interned-syntax-introducer` with the same `key` will produce procedures that flip, add, or remove the same scope, even across phases and module instantiations. Furthermore, the scope remains consistent even when embedded in compiled code, so a scope created with `make-interned-syntax-introducer` will retain its identity in syntax objects loaded from compiled code. (In this sense, the relationship between `make-syntax-introducer` and `make-interned-syntax-introducer` is analogous to the relationship between `gensym` and `quote`.)

This function is intended for the implementation of separate binding spaces within a single phase, for which the scope associated with each environment must be the same across modules.

Unlike `make-syntax-introducer`, the scope added by a procedure created with `make-interned-syntax-introducer` is always treated like a use-site scope, not a macro-introduction scope, so it does not affect originalness as reported by `syntax-original?`.

Added in version 6.90.0.28 of package `base`.
Changed in version 8.2.0.4: Added the constraint that *`key`* is interned.

```
(make-syntax-delta-introducer  ext-stx
                               base-stx
                              [phase-level])
 → ((syntax?) ((or/c 'flip 'add 'remove)) . ->* . syntax?)
  ext-stx : identifier?
  base-stx : (or/c syntax? #f)
  phase-level : (or/c #f exact-integer?)
              = (syntax-local-phase-level)
```

Produces a procedure that behaves like the result of `make-syntax-introducer`, but using a set of scopes from *`ext-stx`* and with a default action of `'add`.

- If the scopes of *`base-stx`* are a subset of the scopes of *`ext-stx`*, then the result of `make-syntax-delta-introducer` adds, removes, or flips scopes that are in the set for *`ext-stx`* and not in the set for *`base-stx`*.
- If the scopes of *`base-stx`* are not a subset of the scopes of *`ext-stx`*, but if it has a binding, then the set of scopes associated with the binding id subtracted from the set of scopes for *`ext-stx`*, and the result of `make-syntax-delta-introducer` adds, removes, or flips that difference.

A `#f` value for *`base-stx`* is equivalent to a syntax object with no scopes.

This procedure is potentially useful when some *`m-id`* has a transformer binding that records some *`orig-id`*, and a use of *`m-id`* introduces a binding of *`orig-id`*. In that case, the scopes one the use of *`m-id`* added since the binding of *`m-id`* should be transferred to the binding instance of *`orig-id`*, so that it captures uses with the same lexical context as the use of *`m-id`*.

If *`ext-stx`* is tainted, then an identifier result from the created procedure is tainted.

```
(syntax-local-transforming-module-provides?) → boolean?
```

Returns `#t` while a provide transformer is running (see `make-provide-transformer`) or while an `expand` sub-form of `#%provide` is expanded, `#f` otherwise.

```
(syntax-local-module-defined-identifiers)
 → (and/c hash? immutable?)
```

Can be called only while `syntax-local-transforming-module-provides?` returns `#t`.

It returns a hash table mapping a phase-level number (such as `0`) to a list of all definitions at that phase level within the module being expanded. This information is used for implementing `provide` sub-forms like `all-defined-out`.

Beware that the phase-level keys are absolute relative to the enclosing module, and not relative to the current transformer phase level as reported by `syntax-local-phase-level`.

```
(syntax-local-module-required-identifiers mod-path
                                          shift)
 → (or/c (listof (cons/c phase+space?
                         (listof identifier?)))
         #f)
  mod-path : (or/c module-path? #f)
  shift : (or/c #t phase+space-shift?)
```

Can be called only while `syntax-local-transforming-module-provides?` returns `#t`.

It returns an association list mapping phase level and binding space combinations to lists of identifiers. Each list of identifiers includes all bindings imported (into the module being expanded) using the module path *`mod-path`*, or all modules if *`mod-path`* is `#f`. The association list includes all identifiers imported with a phase level and binding space shift as represented by *`shift`*, or all shifts if *`shift`* is `#t`. If *`shift`* is not `#t`, the result can be `#f` if no identifiers are imported at that shift.

When an identifier is renamed on import, the result association list includes the identifier by its internal name. Use `identifier-binding` to obtain more information about the identifier.

Beware that the phase-level shifts are absolute relative to the enclosing module, and not relative to the current transformer phase level as reported by `syntax-local-phase-level`.

Changed in version 8.2.0.3 of package `base`: Generalized *`shift`* and result to phase–space combinations.

```
prop:liberal-define-context : struct-type-property?
(liberal-define-context? v) → boolean?
  v : any/c
```

An instance of a structure type with a true value for the `prop:liberal-define-context` property can be used as an element of an internal-definition context representation in the result of `syntax-local-context` or the second argument of `local-expand`. Such a value indicates that the context supports *liberal expansion* of `define` forms into potentially multiple `define-values` and `define-syntaxes` forms. The `'module` and `'module-body` contexts implicitly allow liberal expansion.

The `liberal-define-context?` predicate returns `#t` if *`v`* is an instance of a structure with a true value for the `prop:liberal-define-context` property, `#f` otherwise.

12.4.1 require Transformers

```
(require racket/require-transform)        package: base
```

The bindings documented in this section are provided by the racket/require-transform library, not racket/base or racket.

A transformer binding whose value is a structure with the prop:require-transformer property implements a derived *require-spec* for require as a *require transformer*.

A require transformer is called with the syntax object representing its use as a *require-spec* within a require form, and the result must be two lists: a list of imports and a list of import-sources.

If the derived form contains a sub-form that is a *require-spec*, then it can call expand-import to transform the sub-*require-spec* to lists of imports and import sources.

See also define-require-syntax, which supports macro-style require transformers.

```
(expand-import require-spec)
 → (listof import?) (listof import-source?)
  require-spec : syntax?
```

Expands the given *require-spec* to lists of imports and import sources. The latter specifies modules to be instantiated or visited, so the modules that it represents should be a superset of the modules represented in the former list (so that a module will be instantiated or visited even if all of imports are eventually filtered from the former list).

```
(make-require-transformer proc) → require-transformer?
  proc : (syntax? . -> . (values
                          (listof import?)
                          (listof import-source?)))
```

Creates a require transformer using the given procedure as the transformer. Often used in combination with expand-import.

Examples:

```
> (require (for-syntax racket/require-transform))
> (define-syntax printing
    (make-require-transformer
     (lambda (stx)
       (syntax-case stx ()
         [(_ path)
          (begin
            (printf "Importing: ~a~n" #'path)
            (expand-import #'path))]))))
```

```
> (require (printing racket/match))
Importing: #<syntax:eval:37:0 racket/match>
```

```
prop:require-transformer : struct-type-property?
```

A property to identify require transformers. The property value must be a procedure that takes the structure and returns a transformer procedure; the returned transformer procedure takes a syntax object and returns import and import-source lists.

```
(require-transformer? v) → boolean?
  v : any/c
```

Returns `#t` if `v` has the `prop:require-transformer` property, `#f` otherwise.

```
(struct import (local-id
                src-sym
                src-mod-path
                mode
                req-mode
                orig-mode
                orig-stx)
    #:extra-constructor-name make-import)
  local-id : identifier?
  src-sym : symbol?
  src-mod-path : (or/c module-path?
                       (syntax/c module-path?))
  mode : phase+space?
  req-mode : phase+space-shift?
  orig-mode : phase+space?
  orig-stx : syntax?
```

A structure representing a single imported identifier:

- `local-id` — the identifier to be bound within the importing module, but *without* any space-specific scope implied by `mode`.
- `src-sym` — the external name of the binding as exported from its source module.
- `src-mod-path` — a module path (relative to the importing module) for the source of the imported binding.
- `mode` — the phase level and binding space of the binding in the importing module, which must be the same as `(phase+space+ orig-mode req-mode)`.
- `req-mode` — the phase level shift and binding space shift of the import relative to the exporting module.

- orig-mode — the phase level and binding space of the binding as exported by the exporting module.
- orig-stx — a syntax object for the source of the import, used for error reporting.

Changed in version 8.2.0.3 of package base: Generalized modes to phase–space combinations.

```
(struct import-source (mod-path-stx mode)
    #:extra-constructor-name make-import-source)
  mod-path-stx : (syntax/c module-path?)
  mode : phase+space-shift?
```

A structure representing an imported module, which must be instantiated or visited even if no binding is imported into a module.

- mod-path-stx — a module path (relative to the importing module) for the source of the imported binding.
- mode — the phase level shift and binding space shift of the import.

Changed in version 8.2.0.3 of package base: Generalized mode to phase–space combinations.

```
(current-require-module-path) → (or/c #f module-path-index?)
(current-require-module-path module-path) → void?
  module-path : (or/c #f module-path-index?)
```

A parameter that determines how relative require-level module paths are expanded to #%require-level module paths by convert-relative-module-path (which is used implicitly by all built-in require sub-forms).

When the value of current-require-module-path is #f, relative module paths are left as-is, which means that the require context determines the resolution of the module path.

The require form parameterizes current-require-module-path as #f while invoking sub-form transformers, while relative-in parameterizes to a given module path.

```
(convert-relative-module-path module-path)
 → (or/c module-path?
         (syntax/c module-path?))
  module-path : (or/c module-path?
                      (syntax/c module-path?))
```

Converts *module-path* according to current-require-module-path.

If *module-path* is not relative or if the value of current-require-module-path is #f, then *module-path* is returned. Otherwise, *module-path* is converted to an absolute module path that is equivalent to *module-path* relative to the value of current-require-module-path.

```
(syntax-local-lift-require-top-level-form top-level-stx)
 → void?
  top-level-stx : syntax?
```

Lifts *top-level-stx* to the top-level of the enclosing module, immediately following the `require` that is being expanded.

This procedure must be called during the dynamic extent of a syntax transformer application by the expander or while a module is visited (see `syntax-transforming?`), otherwise the `exn:fail:contract` exception is raised.

In addition, this procedure may only be called while expanding a require transformer.

Added in version 8.12.0.13 of package `base`.

```
(syntax-local-require-certifier)
 → ((syntax?) (or/c #f (syntax? . -> . syntax?))
    . ->* . syntax?)
```

For backward compatibility only; returns a procedure that returns its first argument.

12.4.2 `provide` Transformers

`(require racket/provide-transform)`   package: `base`

The bindings documented in this section are provided by the `racket/provide-transform` library, not `racket/base` or `racket`.

A transformer binding whose value is a structure with the `prop:provide-transformer` property implements a derived *`provide-spec`* for `provide` as a *provide transformer*. A provide transformer is applied as part of the last phase of a module's expansion, after all other declarations and expressions within the module are expanded.

A transformer binding whose value is a structure with the `prop:provide-pre-transformer` property implements a derived *`provide-spec`* for `provide` as a *provide pre-transformer*. A provide pre-transformer is applied as part of the first phase of a module's expansion. Since it is used in the first phase, a provide pre-transformer can use functions such as `syntax-local-lift-expression` to introduce expressions and definitions in the enclosing module.

An identifier can have a transformer binding to a value that acts both as a provide transformer and provide pre-transformer. The result of a provide pre-transformer is *not* automatically re-expanded, so a provide pre-transformer can usefully expand to itself in that case.

A transformer is called with the syntax object representing its use as a *`provide-spec`* within a provide form and a list of symbols representing the export modes specified by enclosing *provide-spec*s. The result of a provide transformer must be a list of exports, while the result of a provide pre-transformer is a syntax object to be used as a *provide-spec* in the last phase of module expansion.

If a derived form contains a sub-form that is a *provide-spec*, then it can call expand-export or pre-expand-export to transform the sub-*provide-spec* sub-form.

See also define-provide-syntax, which supports macro-style provide transformers.

```
(expand-export provide-spec modes) → (listof export?)
  provide-spec : syntax?
  modes : (listof phase+space?)
```

Expands the given *provide-spec* to a list of exports. The *modes* list controls the expansion of sub-*provide-specs*; for example, an identifier refers to a binding in the phase level of the enclosing provide form, unless the *modes* list specifies otherwise. Normally, *modes* is either empty or contains a single element.

Changed in version 8.2.0.3 of package base: Generalized *modes* to phase–space combinations.

```
(pre-expand-export provide-spec modes) → syntax?
  provide-spec : syntax?
  modes : (listof phase+space?)
```

Expands the given *provide-spec* at the level of provide pre-transformers. The *modes* argument is the same as for expand-export.

Changed in version 8.2.0.3 of package base: Generalized *modes* to phase–space combinations.

```
(make-provide-transformer proc) → provide-transformer?
  proc : (syntax? (listof phase+space?)
          . -> . (listof export?))
(make-provide-transformer proc pre-proc)
 → (and/c provide-transformer? provide-pre-transformer?)
  proc : (syntax? (listof phase+space?)
          . -> . (listof export?))
  pre-proc : (syntax? (listof phase+space?)
              . -> . syntax?)
```

Creates a provide transformer (i.e., a structure with the prop:provide-transformer property) using the given procedure as the transformer. If a *pre-proc* is provided, then the result is also a provide pre-transformer. Often used in combination with expand-export and/or pre-expand-export.

```
(make-provide-pre-transformer pre-proc)
```

```
→ provide-pre-transformer?
  pre-proc : (syntax? (listof phase+space?)
              . -> . syntax?)
```

Like make-provide-transformer, but for a value that is a provide pre-transformer, only. Often used in combination with pre-expand-export.

Examples:

```
> (module m racket
    (require
      (for-syntax racket/provide-transform syntax/parse syntax/stx))

    (define-syntax wrapped-out
      (make-provide-pre-transformer
       (lambda (stx modes)
         (syntax-parse stx
           [(_ f ...)
            #:with (wrapped-f ...)
                   (stx-map
                    syntax-local-lift-expression
                    #'((lambda args
                         (printf "applying ~a, args:
~a\n" 'f args)
                         (apply f args)) ...))
            (pre-expand-export
             #'(rename-out [wrapped-f f] ...) modes)]))))

    (provide (wrapped-out + -)))
> (require 'm)
> (- 1 (+ 2 3))
applying +, args: (2 3)
applying -, args: (1 5)
-4
```

```
prop:provide-transformer : struct-type-property?
```

A property to identify provide transformers. The property value must be a procedure that takes the structure and returns a transformer procedure; the returned transformer procedure takes a syntax object and mode list and returns an export list.

```
prop:provide-pre-transformer : struct-type-property?
```

A property to identify provide pre-transformers. The property value must be a procedure that takes the structure and returns a transformer procedure; the returned transformer procedure takes a syntax object and mode list and returns a syntax object.

```
(provide-transformer? v) → boolean?
  v : any/c
```

Returns `#t` if *v* has the `prop:provide-transformer` property, `#f` otherwise.

```
(provide-pre-transformer? v) → boolean?
  v : any/c
```

Returns `#t` if *v* has the `prop:provide-pre-transformer` property, `#f` otherwise.

```
(struct export (local-id out-id mode protect? orig-stx)
    #:extra-constructor-name make-export)
  local-id : identifier?
  out-id : identifier?
  mode : phase+space?
  protect? : any/c
  orig-stx : syntax?
```

A structure representing a single exported identifier:

- `local-id` — the identifier that is bound within the exporting module.
- `out-id` — the external name of the binding.
- `mode` — the phase level and binding space of the export (which affects how it is imported).
- `protect?` — indicates whether the identifier should be protected (see §14.10 “Code Inspectors”).
- `orig-stx` — a syntax object for the source of the export, used for error reporting.

Changed in version 8.2.0.3 of package `base`: Generalized `mode` to phase–space combinations.

Changed in version 8.9.0.5 of package `base`: Changed the `out-sym` field to `out-id`. For backward compatibility, the `make-export` constructor also accepts a symbol, and a `export-out-sym` function returns the `syntax-e` value of the `out-id`.

```
(export-out-sym ex) → symbol?
  ex : export?
```

Composes `syntax-e` with `export-out-id`.

This function is intended for backward compatibility. Use `export-out-id` directly, instead.

Added in version 8.9.0.5 of package `base`.

```
(syntax-local-provide-certifier)
 → ((syntax?) (or/c #f (syntax? . -> . syntax?))
     . ->* . syntax?)
```

For backward compatibility only; returns a procedure that returns its first argument.

12.4.3 Keyword-Argument Conversion Introspection

```
(require racket/keyword-transform)
```
package: base

The bindings documented in this section are provided by the `racket/keyword-transform` library, not `racket/base` or `racket`.

```
(syntax-procedure-alias-property stx)
 → (or/c #f
         (letrec ([val? (recursive-contract
                         (or/c (cons/c identifier? identifier?)
                               (cons/c val? val?)))])
           val?))
  stx : syntax?
(syntax-procedure-converted-arguments-property stx)
 → (or/c #f
         (letrec ([val? (recursive-contract
                         (or/c (cons/c identifier? identifier?)
                               (cons/c val? val?)))])
           val?))
  stx : syntax?
```

Reports the value of a syntax property that can be attached to an identifier by the expansion of a keyword-application form. See `lambda` for more information about the property.

The property value is normally a pair consisting of the original identifier and an identifier that appears in the expansion. Property-value merging via `syntax-track-origin` can make the value a pair of such values, and so on.

12.4.4 Portal Syntax Bindings

An identifier bound to *portal syntax* value created by `make-portal-syntax` does not act as a transformer, but it encapsulates a syntax object that can be accessed and inspected even without instantiating the enclosing module. Portal syntax is also bound using the `portal` form of `#%require`.

```
(portal-syntax? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a value created by `make-portal-syntax`, `#f` otherwise.

Added in version 8.3.0.8 of package `base`.

```
(make-portal-syntax stx) → portal-syntax?
  stx : syntax?
```

Creates portal syntax with the content *stx*.

When `define-syntax` or `define-syntaxes` binds an identifier to portal syntax immediately in a module body, then in addition to being accessible via `syntax-local-value` while expanding, the portal syntax content is accessible via `identifier-binding-portal-syntax`.

Added in version 8.3.0.8 of package `base`.

```
(portal-syntax-content portal) → syntax?
  portal : portal-syntax?
```

Returns the content of portal syntax created with `make-portal-syntax`.

Added in version 8.3.0.8 of package `base`.

12.5 Syntax Parameters

```
(require racket/stxparam)
```
package: `base`

The bindings documented in this section are provided by the `racket/stxparam` library, not `racket/base` or `racket`.

```
(define-syntax-parameter id expr)
```

Binds *id* as syntax to a *syntax parameter*. The *expr* is an expression in the transformer environment that serves as the default value for the syntax parameter. The value is typically obtained by a transformer using `syntax-parameter-value`.

The *id* can be used with `syntax-parameterize` or `syntax-parameter-value` (in a transformer). If *expr* produces a procedure of one argument or a `make-set!-transformer` result, then *id* can be used as a macro. If *expr* produces a `make-rename-transformer` result, then *id* can be used as a macro that expands to a use of the target identifier, but `syntax-local-value` of *id* does not produce the target's value.

Examples:

```
> (define-syntax-parameter current-class #f)
> (define-syntax-parameter yield (make-rename-
transformer #'abort))
> (define-syntax-parameter define/public
    (λ (stx)
      (raise-syntax-error #f "use of a class keyword not in a
class" stx)))
> (begin-for-syntax (displayln (syntax-parameter-value #'current-
class)))
#f
> (yield 5)
5
```

```
(syntax-parameterize ([id expr] ...) body-expr ...+)
```

See also splicing-syntax-parameteriz

Each *id* must be bound to a syntax parameter using `define-syntax-parameter`. Each *expr* is an expression in the transformer environment. During the expansion of the *body-expr*s, the value of each *expr* is bound to the corresponding *id*.

If an *expr* produces a procedure of one argument or a `make-set!-transformer` result, then its *id* can be used as a macro during the expansion of the *body-expr*s. If *expr* produces a `make-rename-transformer` result, then *id* can be used as a macro that expands to a use of the target identifier, but `syntax-local-value` of *id* does not produce the target's value.

Examples:

```
> (define-syntax-parameter abort (syntax-rules ()))
> (define-syntax forever
    (syntax-rules ()
      [(forever body ...)
       (call/cc (lambda (abort-k)
         (syntax-parameterize
             ([abort (syntax-rules () [(_) (abort-k)])])
           (let loop () body ... (loop)))))]))
> (define-syntax-parameter it (syntax-rules ()))
> (define-syntax aif
    (syntax-rules ()
      [(aif test then else)
       (let ([t test])
         (syntax-parameterize ([it (syntax-id-rules () [_ t])])
           (if t then else)))]))
```

```
(define-rename-transformer-parameter id expr)
```

Binds *id* as syntax to a syntax parameter that must be bound to a make-rename-transformer result and, unlike define-syntax-parameter, syntax-local-value of *id* *does* produce the target's value, including inside of syntax-parameterize.

Examples:

```
> (define-syntax (test stx)
    (syntax-case stx ()
      [(_ t)
       #`#,(syntax-local-value #'t)]))
> (define-syntax one 1)
> (define-syntax two 2)
> (define-syntax-parameter not-num
    (make-rename-transformer #'one))
> (test not-num)
#<procedure:syntax-parameter>
> (define-rename-transformer-parameter num
    (make-rename-transformer #'one))
> (test num)
1
> (syntax-parameterize ([num (make-rename-transformer #'two)])
    (test num))
2
```

Added in version 6.3.0.14 of package base.

12.5.1 Syntax Parameter Inspection

```
(require racket/stxparam-exptime)        package: base
```

```
(syntax-parameter-value id-stx) → any
  id-stx : syntax?
```

This procedure is intended for use in a transformer environment, where *id-stx* is an identifier bound in the normal environment to a syntax parameter. The result is the current value of the syntax parameter, as adjusted by syntax-parameterize form.

This binding is provided for-syntax by racket/stxparam, since it is normally used in a transformer. It is provided normally by racket/stxparam-exptime.

```
(make-parameter-rename-transformer id-stx) → any
  id-stx : syntax?
```

This procedure is intended for use in a transformer, where *id-stx* is an identifier bound to a syntax parameter. The result is a transformer that behaves as *id-stx*, but that cannot be used with syntax-parameterize or syntax-parameter-value.

Using `make-parameter-rename-transformer` is analogous to defining a procedure that calls a parameter. Such a procedure can be exported to others to allow access to the parameter value, but not to change the parameter value. Similarly, `make-parameter-rename-transformer` allows a syntax parameter to be used as a macro, but not changed.

The result of `make-parameter-rename-transformer` is not treated specially by `syntax-local-value`, unlike the result of `make-rename-transformer`.

This binding is provided `for-syntax` by `racket/stxparam`, since it is normally used in a transformer. It is provided normally by `racket/stxparam-exptime`.

12.6 Local Binding with Splicing Body

```
(require racket/splicing)        package: base
```

The bindings documented in this section are provided by the `racket/splicing` library, not `racket/base` or `racket`.

```
splicing-let
splicing-letrec
splicing-let-values
splicing-letrec-values
splicing-let-syntax
splicing-letrec-syntax
splicing-let-syntaxes
splicing-letrec-syntaxes
splicing-letrec-syntaxes+values
splicing-local
splicing-parameterize
```

Like `let` (not named `let`), `letrec`, `let-values`, `letrec-values`, `let-syntax`, `letrec-syntax`, `let-syntaxes`, `letrec-syntaxes`, `letrec-syntaxes+values`, `local`, and `parameterize`, except that in a definition context, the body forms are spliced into the enclosing definition context (in the same way as for `begin`).

Examples:

```
> (splicing-let-syntax ([one (lambda (stx) #'1)])
    (define o one))
> o
1
> one
one: undefined;
 cannot reference an identifier before its definition
  in module: top-level
```

When a splicing binding form occurs in a top-level context or module context, its local bindings are treated similarly to definitions. In particular, syntax bindings are evaluated every time the module is visited, instead of only once during compilation as in `let-syntax`, etc.

Example:

```
> (splicing-letrec ([x bad]
                    [bad 1])
    x)
bad.1: undefined;
 cannot reference an identifier before its definition
  in module: top-level
```

If a definition within a splicing form is intended to be local to the splicing body, then the identifier should have a true value for the `'definition-intended-as-local` syntax property. For example, `splicing-let` itself adds the property to locally-bound identifiers as it expands to a sequence of definitions, so that nesting `splicing-let` within a splicing form works as expected (without any ambiguous bindings).

Changed in version 6.12.0.2 of package `base`: Added `splicing-parameterize`.

```
splicing-syntax-parameterize
```

Like `syntax-parameterize`, except that in a definition context, the body forms are spliced into the enclosing definition context (in the same way as for `begin`). In a definition context, the body of `splicing-syntax-parameterize` can be empty.

Note that require transformers and provide transformers are not affected by syntax parameterization. While all uses of `require` and `provide` will be spliced into the enclosing context, derived import or export specifications will expand as if they had not been inside of the `splicing-syntax-parameterize`.

Additionally, submodules defined with `module*` that specify `#f` in place of a module path *are* affected by syntax parameterization, but other submodules (those defined with `module` or `module*` with a module path) are *not*.

Examples:

```
> (define-syntax-parameter place (lambda (stx) #'"Kansas"))
> (define-syntax-rule (where) `(at ,(place)))
> (where)
'(at "Kansas")
> (splicing-syntax-parameterize ([place (lambda (stx) #'"Oz")])
    (define here (where)))
> here
'(at "Oz")
```

Changed in version 6.11.0.1 of package base: Modified to syntax parameterize module* submodules that specify #f in place of a module path.

12.7 Syntax Object Properties

Every syntax object has an associated *syntax property* list, which can be queried or extended with syntax-property. A property is set as *preserved* or not; a preserved property is maintained for a syntax object in a compiled form that is marshaled to a byte string or ".zo" file, and other properties are discarded when marshaling.

In read-syntax, the reader attaches a preserved 'paren-shape property to any pair or vector syntax object generated from parsing a pair [and] or { and }; the property value is #\[in the former case, and #\{ in the latter case. The syntax form copies any 'paren-shape property from the source of a template to corresponding generated syntax.

Both the syntax input to a transformer and the syntax result of a transformer may have associated properties. The two sets of properties are merged by the syntax expander: each property in the original and not present in the result is copied to the result, and the values of properties present in both are combined with cons (result value first, original value second) and the consed value is preserved if either of the values were preserved.

Before performing the merge, however, the syntax expander automatically adds a property to the original syntax object using the key 'origin. If the source syntax has no 'origin property, it is set to the empty list. Then, still before the merge, the identifier that triggered the macro expansion (as syntax) is consed onto the 'origin property so far. The 'origin property thus records (in reverse order) the sequence of macro expansions that produced an expanded expression. Usually, the 'origin value is a list of identifiers, but a transformer might return syntax that has already been expanded, in which case an 'origin list can contain other lists after a merge. The syntax-track-origin procedure implements this tracking. The 'origin property is added as non-preserved.

Besides 'origin tracking for general macro expansion, Racket adds properties to expanded syntax (often using syntax-track-origin) to record additional expansion details:

- When a begin form is spliced into a sequence with internal definitions (see §1.2.3.8 “Internal Definitions”), syntax-track-origin is applied to every spliced element from the begin body. The second argument to syntax-track-origin is the begin form, and the third argument is the begin keyword (extracted from the spliced form).
- When an internal define-values or define-syntaxes form is converted into a letrec-syntaxes+values form (see §1.2.3.8 “Internal Definitions”), syntax-track-origin is applied to each generated binding clause. The second argument to syntax-track-origin is the converted form, and the third argument is the define-values or define-syntaxes keyword form the converted form.

- When a `letrec-syntaxes+values` expression is fully expanded, syntax bindings disappear, and the result is either a `letrec-values` form (if the unexpanded form contained non-syntax bindings), or only the body of the `letrec-syntaxes+values` form (wrapped with `begin` if the body contained multiple expressions). To record the disappeared syntax bindings, a property is added to the expansion result: an immutable list of identifiers from the disappeared bindings, as a `'disappeared-binding` property.

- When a subtyping `struct` form is expanded, the identifier used to reference the base type does not appear in the expansion. Therefore, the `struct` transformer adds the identifier to the expansion result as a `'disappeared-use` property.

- When a rename transformer is used to replace a `set!` target, `syntax-track-origin` is used on the target identifier (the same as when the identifier is used as an expression).

- When a reference to an unexported or protected identifier from a module is discovered, the `'protected` property is added to the identifier with a `#t` value.

- When `read-syntax` generates a syntax object, it attaches a property to the object (using a private key) to mark the object as originating from a read. The `syntax-original?` predicate looks for the property to recognize such syntax objects. (See §12.2 "Syntax Object Content" for more information. The property is not transferred by the expander from a macro transformer input to its output or by `syntax-track-origin`.)

See also Check Syntax for one client of the `'disappeared-use` and `'disappeared-binding` properties.

See §12.9.1 "Information on Expanded Modules" for information about properties generated by the expansion of a module declaration. See `lambda` and §1.2.6 "Inferred Value Names" for information about properties recognized when compiling a procedure. See `current-compile` for information on properties and byte codes.

```
(syntax-property stx key v [preserved?]) → syntax?
  stx : syntax?
  key : (if preserved? (and/c symbol? symbol-interned?) any/c)
  v : any/c
  preserved? : any/c = (eq? key 'paren-shape)
(syntax-property stx key) → any
  stx : syntax?
  key : any/c
```

The three- or four-argument form extends *stx* by associating an arbitrary property value *v* with the key *key*; the result is a new syntax object with the association (while *stx* itself is unchanged). The property is added as preserved if *preserved?* is true, in which case *key* must be an interned symbol, and *v* should be a value as described below that can be saved in marshaled bytecode.

The two-argument form returns an arbitrary property value associated to *stx* with the key *key*, or `#f` if no value is associated to *stx* for *key*. If *stx* is tainted, then syntax objects with the result value are tainted.

To support marshaling to bytecode, a value for a preserved syntax property must be a non-cyclic value that is either

- a pair containing allowed preserved-property values;
- a vector (unmarshaled as immutable) containing allowed preserved-property values;
- a box (unmarshaled as immutable) containing allowed preserved-property values;
- an immutable prefab structure containing allowed preserved-property values;
- an immutable hash table whose keys and values are allowed preserved-property values;
- a syntax object; or
- an empty list, symbol, number, character, string, byte string, or regexp value.

Any other value for a preserved property triggers an exception at an attempt to marshal the owning syntax object to bytecode form.

Changed in version 6.4.0.14 of package `base`: Added the *preserved?* argument.

```
(syntax-property-remove stx key) → syntax?
  stx : syntax?
  key : any/c
```

Returns a syntax object like *stx*, but without a property (if any) for *key*.

Added in version 6.90.0.20 of package `base`.

```
(syntax-property-preserved? stx key) → boolean?
  stx : syntax?
  key : (and/c symbol? symbol-interned?)
```

Returns `#t` if *stx* has a preserved property value for *key*, `#f` otherwise.

Added in version 6.4.0.14 of package `base`.

```
(syntax-property-symbol-keys stx) → list?
  stx : syntax?
```

Returns a list of all symbols that as keys have associated properties in *stx*. Uninterned symbols (see §4.7 "Symbols") are not included in the result list.

```
(syntax-track-origin new-stx
                     orig-stx
                     id-stx)  → any
  new-stx : syntax?
  orig-stx : syntax?
  id-stx : identifier?
```

Adds properties to *new-stx* in the same way that macro expansion adds properties to a transformer result. In particular, it merges the properties of *orig-stx* into *new-stx*, first adding *id-stx* as an `'origin` property and removing the property recognized by `syntax-original?`, and it returns the property-extended syntax object. Use the `syntax-track-origin` procedure in a macro transformer that discards syntax (corresponding to *orig-stx* with a keyword *id-stx*) leaving some other syntax in its place (corresponding to *new-stx*).

For example, the expression

```
(or x y)
```

expands to

```
(let ([or-part x]) (if or-part or-part (or y)))
```

which, in turn, expands to

```
(let-values ([(or-part) x]) (if or-part or-part y))
```

The syntax object for the final expression will have an `'origin` property whose value is `(list (quote-syntax let) (quote-syntax or))`.

Changed in version 7.0 of package `base`: Included the `syntax-original?` property among the ones transferred to *new-stx*.
Changed in version 8.2.0.7: Corrected back to removing the `syntax-original?` property from the set transferred to *new-stx*.

12.8 Syntax Taints

§16.2.7 "Tainted Syntax" in *The Racket Guide* introduces syntax taints.

A *tainted* identifier is rejected by the macro expander for use as either a binding or expression. If a syntax object *stx* is tainted, then any syntax object in the result of `(syntax-e stx)` is tainted, and `datum->syntax` with *stx* as its first argument produces a tainted syntax object. Any syntax object in the result of `(syntax-property stx key)` is also tainted if it is in a position within the value that would be reached by `datum->syntax`'s conversion. Taints cannot be removed.

A syntax object is tainted when it is included in an exception by the macro expander or when it is produced by a function like `expand` using a code inspector that is not the original code inspector. The function `syntax-taint` also returns a tainted syntax object.

Previous versions of Racket included a notion of *arming* and *disarming* syntax to trigger taints or avoid taints. That indirection is no longer supported, and the operations `syntax-arm`, `syntax-disarm`, `syntax-rearm`, and `syntax-protect` now have no effect on their arguments. Along similar lines, the syntax properties (see §12.7 "Syntax Object Properties") `'taint-mode` and `'certify-mode` were formerly used to control syntax arming and are no longer specifically recognized by the macro expander.

```
(syntax-tainted? stx) → boolean?
  stx : syntax?
```

Returns `#t` if *stx* is tainted, `#f` otherwise.

```
(syntax-arm stx [inspector use-mode?]) → syntax?
  stx : syntax?
  inspector : (or/c inspector? #f) = #f
  use-mode? : any/c = #f
```

Returns *stx*.

Changed in version 8.2.0.4 of package `base`: Changed to just return *stx* instead of returning "armed" syntax.

```
(syntax-protect stx) → syntax?
  stx : syntax?
```

Returns *stx*.

Changed in version 8.2.0.4 of package `base`: Changed to just return *stx* instead of returning "armed" syntax.

```
(syntax-disarm stx inspector) → syntax?
  stx : syntax?
  inspector : (or/c inspector? #f)
```

Returns *stx*.

Changed in version 8.2.0.4 of package `base`: Changed to just return *stx* instead of potentially "disarming" syntax.

```
(syntax-rearm stx from-stx [use-mode?]) → syntax?
  stx : syntax?
  from-stx : syntax?
  use-mode? : any/c = #f
```

Returns *stx*.

Changed in version 8.2.0.4 of package `base`: Changed to just return *stx* instead of potentially "arming" syntax.

```
(syntax-taint stx) → syntax?
  stx : syntax?
```

Returns tainted version of *stx*, which is *stx* if it is already tainted.

12.9 Expanding Top-Level Forms

```
(expand top-level-form [insp]) → syntax?
  top-level-form : any/c
  insp : inspector? = (current-code-inspector)
```

Expands all non-primitive syntax in *top-level-form*, and returns a syntax object for the expanded form that contains only core forms, matching the grammar specified by §1.2.3.1 "Fully Expanded Programs".

Before *top-level-form* is expanded, its lexical context is enriched with `namespace-syntax-introduce`, just as for `eval`. Use `syntax->datum` to convert the returned syntax object into a printable datum.

If *insp* is not the original code inspector (i.e., the value of `(current-code-inspector)` when Racket starts), then the result syntax object is tainted.

Here's an example of using `expand` on a module:

```
(parameterize ([current-namespace (make-base-namespace)])
 (expand
  (datum->syntax
   #f
   '(module foo scheme
      (define a 3)
      (+ a 4)))))
```

Here's an example of using `expand` on a non-top-level form:

```
(define-namespace-anchor anchor)
(parameterize ([current-namespace
                (namespace-anchor->namespace anchor)])
 (expand
  (datum->syntax
   #f
   '(delay (+ 1 2)))))
```

Changed in version 8.2.0.4 of package base: Added the *insp* argument and tainting.

```
(expand-syntax stx [insp]) → syntax?
  stx : syntax?
  insp : inspector? = (current-code-inspector)
```

Like `(expand stx insp)`, except that the argument must be a syntax object, and its lexical context is not enriched before expansion.

Changed in version 8.2.0.4 of package base: Added the *insp* argument and tainting.

```
(expand-once top-level-form [insp]) → syntax?
  top-level-form : any/c
  insp : inspector? = (current-code-inspector)
```

Partially expands *top-level-form* and returns a syntax object for the partially-expanded expression. Due to limitations in the expansion mechanism, some context information may be lost. In particular, calling `expand-once` on the result may produce a result that is different from expansion via `expand`.

Before *top-level-form* is expanded, its lexical context is enriched with `namespace-syntax-introduce`, as for `eval`.

The *insp* argument determines whether the result is tainted, the same as for `expand`.

Changed in version 8.2.0.4 of package base: Added the *insp* argument and tainting.

```
(expand-syntax-once stx [insp]) → syntax?
  stx : syntax?
  insp : inspector? = (current-code-inspector)
```

Like `(expand-once stx)`, except that the argument must be a syntax object, and its lexical context is not enriched before expansion.

Changed in version 8.2.0.4 of package base: Added the *insp* argument and tainting.

```
(expand-to-top-form top-level-form [insp]) → syntax?
  top-level-form : any/c
  insp : inspector? = (current-code-inspector)
```

Partially expands *top-level-form* to reveal the outermost syntactic form. This partial expansion is mainly useful for detecting top-level uses of `begin`. Unlike the result of `expand-once`, expanding the result of `expand-to-top-form` with `expand` produces the same result as using `expand` on the original syntax.

Before `stx-or-sexpr` is expanded, its lexical context is enriched with `namespace-syntax-introduce`, as for `eval`.

The *insp* argument determines whether the result is tainted, the same as for `expand`.

Changed in version 8.2.0.4 of package `base`: Added the *insp* argument and tainting.

```
(expand-syntax-to-top-form stx [insp]) → syntax?
  stx : syntax?
  insp : inspector? = (current-code-inspector)
```

Like `(expand-to-top-form stx)`, except that the argument must be a syntax object, and its lexical context is not enriched before expansion.

Changed in version 8.2.0.4 of package `base`: Added the *insp* argument and tainting.

12.9.1 Information on Expanded Modules

Information for an expanded `module` declaration is stored in a set of syntax properties (see §12.7 "Syntax Object Properties") attached to the syntax object:

- `'module-body-context` — a syntax object whose lexical information corresponds to the inside of the module, so it includes the expansion's outside-edge scope and its inside-edge scope; that is, the syntax object simulates an identifier that is present in the original module body and inaccessible to manipulation by any macro, so that its lexical information includes bindings for the module's imports and definitions.

  Added in version 6.4.0.1 of package `base`.

- `'module-body-inside-context` — a syntax object whose lexical information corresponds to an identifier that starts with no lexical context and is moved into the macro, so that it includes only the expansions's inside-edge scope.

  Added in version 6.4.0.1 of package `base`.

- `'module-body-context-simple?` — a boolean, where `#t` indicates that the bindings of the module's body (as recorded in the lexical information of the value of the `'module-body-inside-context` property) can be directly reconstructed from modules directly imported into the module, including imported for-syntax, for-meta, and for-template.

  Added in version 6.4.0.1 of package `base`.

Changed in version 7.0 of package `base`: Removed `'module-variable-provides`, `'module-syntax-provides`, `'module-indirect-provides`, and `'module-indirect-for-meta-provides` properties.

12.10 Serializing Syntax

```
(syntax-serialize
  stx
  #:preserve-property-keys preserve-property-keys
 [#:provides-namespace provides-namespace
  #:base-module-path-index base-module-path-index])
→ any/c
 stx : syntax?
 preserve-property-keys : (listof symbol?)
 provides-namespace : (or/c namespace? #f)
                    = (current-namespace)
 base-module-path-index : (or/c module-path-index? #f) = #f
```

Converts *stx* to a serialized form that is suitable for use with `s-exp->fasl` or `serialize`. Although *stx* could be serialized with `(compile `(quote-syntax ,stx))` and then writing the compiled form, `syntax-serialize` provides more control over serialization:

- The *preserve-property-keys* lists syntax-property keys to whose values should be preserved in serialization, even if the property value was not added as preserved with `syntax-property` (so it would be discarded in compiled form). The values associated with the properties to preserve must be serializable in the sense required by `syntax-property` for a preserved property.

- The *provides-namespace* argument constrains how much the serialized syntax object can rely on *bulk bindings*, which are shared binding tables provided by exporting modules. If *provides-namespace* is `#f`, then complete binding information is recorded in the syntax object's serialized form, and no bulk bindings will be needed from the namespace at deserialization. Otherwise, bulk bindings will be used only for modules declared in *provides-namespace* (i.e., the deserialize-time namespace will have the same module declarations as *provides-namespace*); note that supplying a namespace with no module bindings is equivalent to supplying `#f`.

- The *base-module-path-index* argument specifies a module path index to which binding information in *stx* is relative. For example, if a syntax object originates from `quote-syntax` in the body of a module, then *base-module-path-index* could usefully be the enclosing module's module path index as produced by `(variable-reference->module-path-index (#%variable-reference))` within the module. On deserialization, a different module path index can be supplied to substitute in place of *base-module-path-index*, which shifts any binding that is relative to the serialize-time module's identity to be relative to the module identity supplied at deserialize time. If *base-module-path-index* is `#f`, then no shifting is supported at deserialize time, and any *base-module-path-index* supplied at that time is ignored.

A serialized syntax object is otherwise similar to compiled code: it is version-specific, and deserialization will require a sufficiently powerful code inspector.

Added in version 8.0.0.13 of package `base`.

```
(syntax-deserialize
  v
 [#:base-module-path-index base-module-path-index])
→ syntax?
 v : any/c
 base-module-path-index : (or/c module-path-index? #f) = #f
```

Converts the result of `syntax-serialize` back to a syntax object. See `syntax-serialize` for more information.

Added in version 8.0.0.13 of package `base`.

12.11 File Inclusion

```
(require racket/include)        package: base
```

The bindings documented in this section are provided by the `racket/include` and `racket` libraries, but not `racket/base`.

```
(include path-spec)

path-spec = string
          | (file string)
          | (lib string ...+)
```

Inlines the syntax in the file designated by *path-spec* in place of the `include` expression.

A *path-spec* resembles a subset of the *mod-path* forms for `require`, but it specifies a file whose content need not be a module. That is, *string* refers to a file using a platform-independent relative path, `(file string)` refers to a file using platform-specific notation, and `(lib string ...)` refers to a file within a collection.

If *path-spec* specifies a relative path, the path is resolved relative to the source for the `include` expression, if that source is a complete path string. If the source is not a complete path string, then *path-spec* is resolved relative to `(current-load-relative-directory)` if it is not `#f`, or relative to `(current-directory)` otherwise.

The included syntax is given the lexical context of the `include` expression, while the included syntax's source location refers to its actual source.

```
(include-at/relative-to context source path-spec)
```

Like `include`, except that the lexical context of *context* is used for the included syntax, and a relative *path-spec* is resolved with respect to the source of *source*. The *context* and *source* elements are otherwise discarded by expansion.

```
(include/reader path-spec reader-expr)
```

Like `include`, except that the procedure produced by the expression *reader-expr* is used to read the included file, instead of `read-syntax`.

The *reader-expr* is evaluated at expansion time in the transformer environment. Since it serves as a replacement for `read-syntax`, the expression's value should be a procedure that consumes two inputs—a string representing the source and an input port—and produces a syntax object or `eof`. The procedure will be called repeatedly until it produces `eof`.

The syntax objects returned by the procedure should have source location information, but usually no lexical context; any lexical context in the syntax objects will be ignored.

```
(include-at/relative-to/reader context source path-spec reader-expr)
```

Combines `include-at/relative-to` and `include/reader`.

12.12 Syntax Utilities

```
(require racket/syntax)    package: base
```

The bindings documented in this section are provided by the `racket/syntax` library, not `racket/base` or `racket`.

12.12.1 Creating formatted identifiers

```
(format-id  lctx
            fmt
            v ...
           [#:source src
            #:props props
            #:cert ignored
            #:subs? subs?
            #:subs-intro subs-introducer]) → identifier?
  lctx : (or/c syntax? #f)
  fmt : string?
  v : (or/c string? symbol? keyword? char? number?
            (syntax/c (or/c string? symbol? keyword? char? number?)))
  src : (or/c syntax? #f) = #f
```

```
props : (or/c syntax? #f) = #f
ignored : (or/c syntax? #f) = #f
subs? : boolean? = #f
subs-introducer : (-> syntax? syntax?)
                = (if (syntax-transforming?) syntax-local-introduce values)
```

Like `format`, but produces an identifier using *lctx* for the lexical context, *src* for the source location, and *props* for the properties. An argument supplied with `#:cert` is ignored. (See `datum->syntax`.)

The format string must use only `~a` placeholders. Syntax objects in the argument list are automatically unwrapped (e.g., identifiers will be automatically converted to symbols).

Examples:

```
> (define-syntax (make-pred stx)
    (syntax-case stx ()
      [(make-pred name)
       (format-id #'name "~a?" (syntax-e #'name))]))
> (make-pred pair)
#<procedure:pair?>
> (make-pred none-such)
none-such?: undefined;
 cannot reference an identifier before its definition
  in module: top-level
> (define-syntax (better-make-pred stx)
    (syntax-case stx ()
      [(better-make-pred name)
       (format-id #'name #:source #'name
                  "~a?" (syntax-e #'name))]))
> (better-make-pred none-such)
none-such?: undefined;
 cannot reference an identifier before its definition
  in module: top-level
```

(Scribble doesn't show it, but the DrRacket pinpoints the location of the second error but not of the first.)

If *subs?* is `#t`, then a `'sub-range-binders` syntax property is added to the result that records the position of each identifier in the *v*s. The `subs-intro` procedure is applied to each identifier, and its result is included in the sub-range binder record. This property value overrides a `'sub-range-binders` property copied from *props*.

Example:

```
> (syntax-property (format-id #'here "~a/~a-
~a" #'point 2 #'y #:subs? #t)
```

```
                     'sub-range-binders)
'(#(#<syntax point/2-y> 8 1 0.5 0.5 #<syntax:eval:8:0 y> 0 1 0.5
0.5)
  #(#<syntax point/2-y> 0 5 0.5 0.5 #<syntax:eval:8:0 point> 0 5
0.5 0.5))
```

Changed in version 7.4.0.5 of package `base`: Added the `#:subs?` and `#:subs-intro` arguments.
Changed in version 8.7.0.7: Allowed *v* to be a syntax object wrapping a string, a keyword, a character, or a number.

```
(format-symbol fmt v ...) → symbol?
  fmt : string?
  v : (or/c string? symbol? keyword? char? number?
            (syntax/c (or/c string? symbol? keyword? char? number?)))
```

Like `format`, but produces a symbol. The format string must use only `~a` placeholders. Syntax objects in the argument list are automatically unwrapped (e.g., identifiers will be automatically converted to symbols).

Example:

```
> (format-symbol "make-~a" 'triple)
'make-triple
```

Changed in version 8.7.0.7 of package `base`: Allowed *v* to be a syntax object wrapping a string, a keyword, a character, or a number.

12.12.2 Pattern variables

```
(define/with-syntax pattern stx-expr)

  stx-expr : syntax?
```

Definition form of `with-syntax`. That is, it matches the syntax object result of *stx-expr* against *pattern* and creates pattern variable definitions for the pattern variables of *pattern*.

Examples:

```
> (define/with-syntax (px ...) #'(a b c))
> (define/with-syntax (tmp ...) (generate-temporaries #'(px ...)))
> #'([tmp px] ...)
#<syntax:eval:12:0 ((a9 a) (b10 b) (c11 c))>
> (define/with-syntax name #'Alice)
> #'(hello name)
#<syntax:eval:14:0 (hello Alice)>
```

12.12.3 Error reporting

```
(current-syntax-context) → (or/c syntax? #f)
(current-syntax-context stx) → void?
  stx : (or/c syntax? #f)
```

The current contextual syntax object, defaulting to `#f`. It determines the special form name that prefixes syntax errors created by `wrong-syntax`.

```
(wrong-syntax stx format-string v ...) → any
  stx : syntax?
  format-string : string?
  v : any/c
```

Raises a syntax error using the result of `(current-syntax-context)` as the “major” syntax object and the provided *stx* as the specific syntax object. (The latter, *stx*, is usually the one highlighted by DrRacket.) The error message is constructed using the format string and arguments, and it is prefixed with the special form name as described under `current-syntax-context`.

Examples:

```
> (wrong-syntax #'here "expected ~s" 'there)
eval:15:0: ?: expected there
  at: here
> (parameterize ([current-syntax-context #'(look over here)])
    (wrong-syntax #'here "expected ~s" 'there))
eval:16:0: look: expected there
  at: here
  in: (look over here)
```

A macro using `wrong-syntax` might set the syntax context at the very beginning of its transformation as follows:

```
(define-syntax (my-macro stx)
  (parameterize ([current-syntax-context stx])
    (syntax-case stx ()
      __)))
```

Then any calls to `wrong-syntax` during the macro’s transformation will refer to `my-macro` (more precisely, the name that referred to `my-macro` where the macro was used, which may be different due to renaming, prefixing, etc).

12.12.4 Recording disappeared uses

```
(current-recorded-disappeared-uses)
 → (or/c (listof identifier?) #f)
(current-recorded-disappeared-uses ids) → void?
  ids : (or/c (listof identifier?) #f)
```

Parameter for tracking disappeared uses. Tracking is “enabled” when the parameter has a non-false value. This is done automatically by forms like `with-disappeared-uses`.

```
(with-disappeared-uses body-expr ... stx-expr)

  stx-expr : syntax?
```

Evaluates the *`body-expr`*s and *`stx-expr`*, catching identifiers looked up using `syntax-local-value/record`. Adds the caught identifiers to the `'disappeared-use` syntax property of the syntax object produced by *`stx-expr`*.

Changed in version 6.5.0.7 of package `base`: Added the option to include *`body-expr`*s.

```
(syntax-local-value/record id predicate) → any/c
  id : identifier?
  predicate : (-> any/c boolean?)
```

Looks up *`id`* in the syntactic environment (as `syntax-local-value`). If the lookup succeeds and returns a value satisfying the predicate, the value is returned and *`id`* is recorded as a disappeared use by calling `record-disappeared-uses`. If the lookup fails or if the value does not satisfy the predicate, `#f` is returned and the identifier is not recorded as a disappeared use.

```
(record-disappeared-uses id [intro?]) → void?
  id : (or/c identifier? (listof identifier?))
  intro? : boolean? = (syntax-transforming?)
```

Add *`id`* to `(current-recorded-disappeared-uses)`. If *`id`* is a list, perform the same operation on all the identifiers. If *`intro?`* is true, then `syntax-local-introduce` is first called on the identifiers.

If not used within the extent of a `with-disappeared-uses` form or similar, has no effect.

Changed in version 6.5.0.7 of package `base`: Added the option to pass a single identifier instead of requiring a list.
Changed in version 7.2.0.11: Added the *`intro?`* argument.

12.12.5 Miscellaneous utilities

```
(generate-temporary [name-base]) → identifier?
  name-base : any/c = 'g
```

Generates one fresh identifier. Singular form of `generate-temporaries`. If *name-base* is supplied, it is used as the basis for the identifier's name.

```
(internal-definition-context-apply intdef-ctx
                                   stx)      → syntax?
  intdef-ctx : internal-definition-context?
  stx : syntax?
```

Equivalent to `(internal-definition-context-introduce intdef-ctx stx 'add)`. The `internal-definition-context-apply` function is provided for backwards compatibility; the `internal-definition-context-add-scopes` function is preferred.

```
(syntax-local-eval stx [intdef-ctx]) → any
  stx : any/c
  intdef-ctx : (or/c internal-definition-context?
                     #f
                     (listof internal-definition-context?))
             = '()
```

Evaluates *stx* as an expression in the current transformer environment (that is, at phase level 1). If *intdef-ctx* is not `#f`, the value provided for *intdef-ctx* is used to enrich *stx*'s lexical information and extend the local binding context in the same way as the fourth argument to `local-expand`.

Examples:

```
> (define-syntax (show-me stx)
    (syntax-case stx ()
      [(show-me expr)
       (begin
         (printf "at compile time produces ~s\n"
                 (syntax-local-eval #'expr))
         #'(printf "at run time produces ~s\n"
                   expr))]))
> (show-me (+ 2 5))
at compile time produces 7
at run time produces 7
> (define-for-syntax fruit 'apple)
> (define fruit 'pear)
> (show-me fruit)
at compile time produces apple
at run time produces pear
```

Changed in version 6.90.0.27 of package base: Changed *intdef-ctx* to accept a list of internal-definition contexts in addition to a single internal-definition context or #f.

```
(with-syntax* ([pattern stx-expr] ...)
  body ...+)

  stx-expr : syntax?
```

Similar to `with-syntax`, but the pattern variables of each *pattern* are bound in the *stx-expr*s of subsequent clauses as well as the *body*s, and the *pattern*s need not bind distinct pattern variables; later bindings shadow earlier bindings.

Example:

```
> (with-syntax* ([(x y) (list #'val1 #'val2)]
                 [nest #'((x) (y))])
    #'nest)
#<syntax:eval:22:0 ((val1) (val2))>
```

12.13 Phase and Space Utilities

```
(require racket/phase+space)      package: base
```

The bindings documented in this section are provided by the `racket/phase+space` library, not `racket/base` or `racket`.

The `racket/phase+space` library provides functions for manipulating combined representations of phase levels and binding spaces, particularly as used for require transformers and provide transformers.

When `identifier-binding` (and related functions, like `identifier-transformer-binding`), `syntax-local-module-exports`, `syntax-local-module-required-identifiers`, `module-compiled-exports`, or `module->exports` produces a phase–space combination (or phase–space shift combination), then two such values that are `equal?` will be `eqv?`.

Added in version 8.2.0.3 of package base.

```
(phase? v) → boolean?
  v : any/c
```

Returns #t if *v* is a valid representation of a phase level, #f otherwise. A valid representation is either an exact integer representing a numbered phase level or #f representing the label phase level.

```
(space? v) → boolean?
  v : any/c
```

Returns #t if *v* is a valid representation of a binding space, #f otherwise. A valid representation is either an interned symbol representing the space whose scope is accessed via make-interned-syntax-introducer, or #f representing the default binding space.

```
(phase+space? v) → boolean?
  v : any/c
```

Returns #t if *v* is a valid representation of a phase level and binding space combination, #f otherwise. The possible representations are as follows:

- a phase (in the sense of phase?) by itself, which represents that phase plus the default binding space
- a pair whose car is a phase and whose cdr is a non-#f space (in the sense of space?)

```
(phase+space phase space) → phase+space?
  phase : phase?
  space : space?
```

Returns a value to represent the combination of *phase* and *space*.

```
(phase+space-phase p+s) → phase?
  p+s : phase+space?
(phase+space-space p+s) → phase?
  p+s : phase+space?
```

Extracts the phase level or binding space component from a combination.

```
(phase+space-shift? v) → boolean?
  v : any/c
```

Returns #t if *v* is a valid representation of a phase level shift and binding space shift combination, #f otherwise. A shift can be applied to a combination of a phase level and binding space using phase+shift+. The possible representations of a shift are as follows:

- exact integer — represents an amount to shift a phase level and no change to the binding space
- #f — represents a shift to the label phase level and no change to the binding space

- a pair whose `car` is an exact integer or `#f`, and whose `cdr` is a space (in the sense of `space?`) — represents a phase level shift in the `car` and a change to the binding space that is in the `cdr`

```
(phase+space+ p+s shift) → phase+space?
  p+s : phase+space?
  shift : phase+space-shift?
```

Applies *shift* to *p+s* to produce a new combination of phase level and binding space.

```
(phase+space-shift+ shift additional-shift) → phase+space-shift?
  shift : phase+space?
  additional-shift : phase+space-shift?
```

Composes *shift* and *additional-shift* to produce a new shift that behaves the same as applying *shift* followed by *additional-shift*.

13 Input and Output

13.1 Ports

§8 "Input and Output" in *The Racket Guide* introduces Ports and I/O.

Ports produce and/or consume bytes. An *input port* produces bytes, while an *output port* consumes bytes (and some ports are both input ports and output ports). When an input port is provided to a character-based operation, the bytes are decoded to a character, and character-based output operations similarly encode the character to bytes; see §13.1.1 "Encodings and Locales". In addition to bytes and characters encoded as bytes, some ports can produce and/or consume arbitrary values as *special* results.

When a port corresponds to a file, network connection, or some other system resource, it must be explicitly closed via `close-input-port` or `close-output-port` (or indirectly via `custodian-shutdown-all`) to release low-level resources associated with the port. For any kind of port, after it is closed, attempting to read from or write to the port raises `exn:fail`.

Data produced by a input port can be read or *peeked*. When data is read, it is considered consumed and removed from the port's stream. When data is peeked, it remains in the port's stream to be returned again by the next read or peek. Previously peeked data can be *committed*, which causes the data to be removed from the port as for a read in a way that can be synchronized with other attempts to peek or read through a synchronizable event. Both read and peek operations are normally blocking, in the sense that the read or peek operation does not complete until data is available from the port; non-blocking variants of read and peek operations are also available.

The global variable `eof` is bound to the end-of-file value, and `eof-object?` returns `#t` only when applied to this value. Reading from a port produces an end-of-file result when the port has no more data, but some ports may also return end-of-file mid-stream. For example, a port connected to a Unix terminal returns an end-of-file when the user types control-D; if the user provides more input, the port returns additional bytes after the end-of-file.

Every port has a name, as reported by `object-name`. The name can be any value, and it is used mostly for error-reporting purposes. The `read-syntax` procedure uses the name of an input port as the default source location for the syntax objects that it produces.

A port can be used as a synchronizable event. An input port is ready for synchronization when `read-byte` would not block, and an output port is ready for synchronization when `write-bytes-avail` would not block or when the port contains buffered characters and `write-bytes-avail*` can flush part of the buffer (although `write-bytes-avail` might block). A value that can act as both an input port and an output port acts as an input port for a synchronizable event. The synchronization result of a port is the port itself.

13.1.1 Encodings and Locales

When a port is provided to a character-based operation, such as read-char or read, the port's bytes are read and interpreted as a UTF-8 encoding of characters. Thus, reading a single character may require reading multiple bytes, and a procedure like char-ready? may need to peek several bytes into the stream to determine whether a character is available. In the case of a byte stream that does not correspond to a valid UTF-8 encoding, functions such as read-char may need to peek one byte ahead in the stream to discover that the stream is not a valid encoding.

When an input port produces a sequence of bytes that is not a valid UTF-8 encoding in a character-reading context, then bytes that constitute an invalid sequence are converted to the character #\uFFFD. Specifically, bytes 255 and 254 are always converted to #\uFFFD, bytes in the range 192 to 253 produce #\uFFFD when they are not followed by bytes that form a valid UTF-8 encoding, and bytes in the range 128 to 191 are converted to #\uFFFD when they are not part of a valid encoding that was started by a preceding byte in the range 192 to 253. To put it another way, when reading a sequence of bytes as characters, a minimal set of bytes are changed to the encoding of #\uFFFD so that the entire sequence of bytes is a valid UTF-8 encoding.

See §4.5 "Byte Strings" for procedures that facilitate conversions using UTF-8 or other encodings. See also reencode-input-port and reencode-output-port for obtaining a UTF-8-based port from one that uses a different encoding of characters.

A *locale* captures information about a user's language-specific interpretation of character sequences. In particular, a locale determines how strings are "alphabetized," how a lowercase character is converted to an uppercase character, and how strings are compared without regard to case. String operations such as string-ci=? are *not* sensitive to the current locale, but operations such as string-locale-ci=? (see §4.4 "Strings") produce results consistent with the current locale.

A locale also designates a particular encoding of code-point sequences into byte sequences. Racket generally ignores this aspect of the locale, with a few notable exceptions: command-line arguments passed to Racket as byte strings are converted to character strings using the locale's encoding; command-line strings passed as byte strings to other processes (through subprocess) are converted to byte strings using the locale's encoding; environment variables are converted to and from strings using the locale's encoding; filesystem paths are converted to and from strings (for display purposes) using the locale's encoding; and, finally, Racket provides functions such as string->bytes/locale to specifically invoke a locale-specific encoding.

A Unix user selects a locale by setting environment variables, such as LC_ALL. On Windows and Mac OS, the operating system provides other mechanisms for setting the locale. Within Racket, the current locale can be changed by setting the current-locale parameter. The locale name within Racket is a string, and the available locale names depend on the platform and its configuration, but the "" locale means the current user's default locale;

on Windows and Mac OS, the encoding for `""` is always UTF-8, and locale-sensitive operations use the operating system's native interface. (In particular, setting the `LC_ALL` and `LC_CTYPE` environment variables does not affect the locale `""` on Mac OS. Use `getenv` and `current-locale` to explicitly install the environment-specified locale, if desired.) Setting the current locale to `#f` makes locale-sensitive operations locale-insensitive, which means using the Unicode mapping for case operations and using UTF-8 for encoding.

```
(current-locale) → (or/c string? #f)
(current-locale locale) → void?
  locale : (or/c string? #f)
```

A parameter that determines the current locale for procedures such as `string-locale-ci=?`.

When locale sensitivity is disabled by setting the parameter to `#f`, strings are compared, etc., in a fully portable manner, which is the same as the standard procedures. Otherwise, strings are interpreted according to a locale setting (in the sense of the C library's `setlocale`). The `""` locale is always an alias for the current machine's default locale, and it is the default. The `"C"` locale is also always available; setting the locale to `"C"` is the same as disabling locale sensitivity with `#f` only when string operations are restricted to the first 128 characters. Other locale names are platform-specific.

String or character printing with `write` is not affected by the parameter, and neither are symbol case or regular expressions (see §4.8 "Regular Expressions").

13.1.2 Managing Ports

```
(input-port? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is an input port, `#f` otherwise.

```
(output-port? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is an output port, `#f` otherwise.

```
(port? v) → boolean?
  v : any/c
```

Returns `#t` if either `(input-port? v)` or `(output-port? v)` is `#t`, `#f` otherwise.

```
(close-input-port in) → void?
  in : input-port?
```

Closes the input port *in*. For some kinds of ports, closing the port releases lower-level resources, such as a file handle. If the port is already closed, `close-input-port` has no effect.

```
(close-output-port out) → void?
  out : output-port?
```

Closes the output port *out*. For some kinds of ports, closing the port releases lower-level resources, such as a file handle. Also, if the port is buffered, closing may first flush the port before closing it, and this flushing process can block. If the port is already closed, `close-output-port` has no effect.

```
(port-closed? port) → boolean?
  port : port?
```

Returns `#t` if the input or output port *port* is closed, `#f` otherwise.

```
(port-closed-evt port) → evt?
  port : port?
```

Return a synchronizable event that becomes ready for synchronization when *port* is closed. The synchronization result of a port-closed event is the port-closed event itself.

```
(current-input-port) → input-port?
(current-input-port in) → void?
  in : input-port?
```

A parameter that determines a default input port for many operations, such as `read`.

```
(current-output-port) → output-port?
(current-output-port out) → void?
  out : output-port?
```

A parameter that determines a default output port for many operations, such as `write`.

```
(current-error-port) → output-port?
(current-error-port out) → void?
  out : output-port?
```

A parameter that determines an output port that is typically used for errors and logging. For example, the default error display handler writes to this port.

```
(file-stream-port? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a file-stream port (see §13.1.5 "File Ports"), `#f` otherwise.

Changed in version 7.2.0.5 of package `base`: Extended `file-stream-port?` to any value, instead of resticting the domain to ports

```
(terminal-port? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a port that is attached to an interactive terminal, `#f` otherwise.

Changed in version 7.2.0.5 of package `base`: Extended `terminal-port?` to any value, instead of resticting the domain to ports

```
(port-waiting-peer? port) → boolean?
  port : port?
```

Returns `#t` if *port* is not ready for reading or writing because it is waiting for a peer process to complete a stream construction, `#f` otherwise.

On Unix and Mac OS, opening a fifo for output creates a peer-waiting port if no reader for the same fifo is already opened. In that case, the output port is not ready for writing until a reader is opened; that is, write opertaions will block. Use `sync` if necessary to wait until writing will not block—that is, until the read end of the fifo is opened.

Added in version 7.4.0.5 of package `base`.

```
eof : eof-object?
```

A value (distinct from all other values) that represents an end-of-file.

```
(eof-object? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is `eof`, `#f` otherwise.

13.1.3 Port Buffers and Positions

Some ports—especially those that read from and write to files—are internally buffered:

- An input port is typically block-buffered by default, which means that on any read, the buffer is filled with immediately-available bytes to speed up future reads. Thus, if a file is modified between a pair of reads to the file, the second read can produce stale data. Calling `file-position` to set an input port's file position flushes its buffer.

- An output port is typically block-buffered by default, though a terminal output port is line-buffered, and the initial error output port is unbuffered. An output buffer is filled with a sequence of written bytes to be committed as a group, either when the buffer is full (in block mode), when a newline is written (in line mode), when the port is closed via `close-output-port`, or when a flush is explicitly requested via a procedure like `flush-output`.

If a port supports buffering, its buffer mode can be changed via `file-stream-buffer-mode` (even if the port is not a file-stream port).

For an input port, peeking always places peeked bytes into the port's buffer, even when the port's buffer mode is `'none`; furthermore, on some platforms, testing the port for input (via `char-ready?` or `sync`) may be implemented with a peek. If an input port's buffer mode is `'none`, then at most one byte is read for `read-bytes-avail!*`, `read-bytes-avail!`, `peek-bytes-avail!*`, or `peek-bytes-avail!`; if any bytes are buffered in the port (e.g., to satisfy a previous peek), the procedures may access multiple buffered bytes, but no further bytes are read.

In addition, the initial current output and error ports are automatically flushed when they are terminal ports (see `terminal-port?`) and when `read`, `read-line`, `read-bytes`, `read-string`, etc., are performed on the initial standard input port. (More precisely, instead of `read`, flushing is performed by the default port read handler; see `port-read-handler`.)

```
(flush-output [out]) → void?
  out : output-port? = (current-output-port)
```

Forces all buffered data in the given output port to be physically written. Only file-stream ports, TCP ports, and custom ports (see §13.1.9 "Custom Ports") use buffers; when called on a port without a buffer, `flush-output` has no effect.

If flushing a file-stream port or TCP port encounters an error when writing, then all buffered bytes in the port are discarded. Consequently, a further attempt to flush or close the port will not fail.

Changed in version 7.4.0.10 of package `base`: Consistently, discard buffered bytes on error, including in a TCP output port.

```
(file-stream-buffer-mode port) → (or/c 'none 'line 'block #f)
  port : port?
(file-stream-buffer-mode port mode) → void?
  port : port?
  mode : (or/c 'none 'line 'block)
```

Gets or sets the buffer mode for *port*, if possible. File-stream ports support setting the buffer mode, TCP ports (see §15.3 "Networking") support setting and getting the buffer mode, and custom ports (see §13.1.9 "Custom Ports") may support getting and setting buffer modes.

If *mode* is provided, it must be one of 'none, 'line (output only), or 'block, and the port's buffering is set accordingly. If the port does not support setting the mode, the exn:fail exception is raised.

If *mode* is not provided, the current mode is returned, or #f is returned if the mode cannot be determined. If *port* is an input port and *mode* is 'line, the exn:fail:contract exception is raised.

```
(file-position port) → exact-nonnegative-integer?
  port : port?
(file-position port pos) → void?
  port : port?
  pos : (or/c exact-nonnegative-integer? eof-object?)
```

Returns or sets the current read/write position of *port*.

Calling file-position without a position on a port other than a file-stream port or string port returns the number of bytes that have been read from that port if the position is known (see §13.1.4 "Counting Positions, Lines, and Columns"), otherwise the exn:fail:filesystem exception is raised.

For file-stream ports and string ports, the position-setting variant sets the read/write position to *pos* relative to the beginning of the file or (byte) string if *pos* is a number, or to the current end of the file or (byte) string if *pos* is eof. In position-setting mode, file-position raises the exn:fail:contract exception for port kinds other than file-stream ports and string ports. Furthermore, not all file-stream ports support setting the position; if file-position is called with a position argument on such a file-stream port, the exn:fail:filesystem exception is raised.

When file-position sets the position *pos* beyond the current size of an output file or (byte) string, the file/string is enlarged to size *pos* and the new region is filled with 0 bytes; in the case of a file. In the case of a file output port, the file might not be enlarged until more data is written to the file; in that case, beware that writing to a file opened in 'append mode on Unix and Mac OS will reset the file pointer to the end of a file *before* each write, which defeats file enlargement via file-position. If *pos* is beyond the end of an input file or (byte) string, then reading thereafter returns eof without changing the port's position.

When changing the file position for an output port, the port is first flushed if its buffer is not empty. Similarly, setting the position for an input port clears the port's buffer (even if the new position is the same as the old position). However, although input and output ports produced by open-input-output-file share the file position, setting the position via one port does not flush the other port's buffer.

```
(file-position* port) → (or/c exact-nonnegative-integer? #f)
  port : port?
```

Like file-position on a single argument, but returns #f if the position is not known.

```
(file-truncate port size) → void?
  port : (and/c output-port? file-stream-port?)
  size : exact-nonnegative-integer?
```

Sets the size of the file written by *port* to *size*, assuming that the port is associated to a file whose size can be set.

The new file size can be either larger or smaller than its current size, but "truncate" in this function's name reflects that it is normally used to decrease the size of a file, since writing to a file or using `file-position` can extend a file's size.

13.1.4 Counting Positions, Lines, and Columns

By default, Racket keeps track of the *position* in a port as the number of bytes that have been read from or written to any port (independent of the read/write position, which is accessed or changed with `file-position`). Optionally, however, Racket can track the position in terms of characters (after UTF-8 decoding), instead of bytes, and it can track *line locations* and *column locations*; this optional tracking must be specifically enabled for a port via `port-count-lines!` or the `port-count-lines-enabled` parameter. Position, line, and column locations for a port are used by `read-syntax`. Position and line locations are numbered from 1; column locations are numbered from 0.

When counting lines, Racket treats linefeed, return, and return-linefeed combinations as a line terminator and as a single position (on all platforms). Each tab advances the column count to one before the next multiple of 8. When a sequence of bytes in the range 128 to 253 forms a UTF-8 encoding of a character, the position/column is incremented once for each byte, and then decremented appropriately when a complete encoding sequence is discovered. See also §13.1 "Ports" for more information on UTF-8 decoding for ports.

A position is known for any port as long as its value can be expressed as a fixnum (which is more than enough tracking for realistic applications in, say, syntax-error reporting). If the position for a port exceeds the value of the largest fixnum, then the position for the port becomes unknown, and line and column tacking is disabled. Return-linefeed combinations are treated as a single character position only when line and column counting is enabled.

Custom ports can define their own counting functions, which are not subject to the rules above, except that the counting functions are invoked only when tracking is specifically enabled with `port-count-lines!`.

```
(port-count-lines! port) → void?
  port : port?
```

Turns on line location and column location counting for a port. Counting can be turned on at any time, though generally it is turned on before any data is read from or written to a port. At the point that line counting is turned on, `port-next-location` typically starts reporting as its last result (one more than) the number of characters read since line counting was enabled, instead of (one more than) bytes read since the port was opened.

When a port is created, if the value of the `port-count-lines-enabled` parameter is true, then line counting is automatically enabled for the port. Line counting cannot be disabled for a port after it is enabled.

```
(port-counts-lines? port) → boolean?
  port : port?
```

Returns `#t` if line location and column location counting has been enabled for *port*, `#f` otherwise.

```
(port-next-location port)
 → (or/c exact-positive-integer? #f)
   (or/c exact-nonnegative-integer? #f)
   (or/c exact-positive-integer? #f)
  port : port?
```

Returns three values: an integer or `#f` for the line number of the next read/written item, an integer or `#f` for the next item's column, and an integer or `#f` for the next item's position. The next column and position normally increase as bytes are read from or written to the port, but if line/character counting is enabled for *port*, the column and position results can decrease after reading or writing a byte that ends a UTF-8 encoding sequence.

If line counting is not enabled for a port, than the first two results are `#f`, and the last result is one more than the number of bytes read so far. At the point when line counting is enabled, the first two results typically become non-`#f`, and last result starts reporting characters instead of bytes, typically starting from the point when line counting is enabled.

Even with line counting enabled, a port may return `#f` values if it somehow cannot keep track of lines, columns, or positions.

```
(set-port-next-location! port
                         line
                         column
                         position) → void?
  port : port?
  line : (or/c exact-positive-integer? #f)
  column : (or/c exact-nonnegative-integer? #f)
  position : (or/c exact-positive-integer? #f)
```

Sets the next line, column, and position for *port*. If line counting has not been enabled for *port* or if *port* is a custom port that defines its own counting function, then `set-port-next-location!` has no effect.

```
(port-count-lines-enabled) → boolean?
(port-count-lines-enabled on?) → void?
  on? : any/c
```

A parameter that determines whether line counting is enabled automatically for newly created ports. The default value is `#f`.

13.1.5 File Ports

A port created by `open-input-file`, `open-output-file`, `subprocess`, and related functions is a *file-stream port*. The initial input, output, and error ports in `racket` are also file-stream ports. The `file-stream-port?` predicate recognizes file-stream ports.

When an input or output file-stream port is created, it is placed into the management of the current custodian (see §14.7 “Custodians”). In the case of an output port, a flush callback is registered with the current plumber to flush the port.

```
(open-input-file  path
                 [#:mode mode-flag
                  #:for-module? for-module?]) → input-port?
  path : path-string?
  mode-flag : (or/c 'binary 'text) = 'binary
  for-module? : any/c = #f
```

Opens the file specified by *path* for input. The *mode-flag* argument specifies how the file's bytes are translated on input:

- `'binary` — bytes are returned from the port exactly as they are read from the file.
- `'text` — return and linefeed bytes (10 and 13) as read from the file are filtered by the port in a platform specific manner:
  - Unix and Mac OS: no filtering occurs.
  - Windows: a return-linefeed combination from a file is returned by the port as a single linefeed; no filtering occurs for return bytes that are not followed by a linefeed, or for a linefeed that is not preceded by a return.

On Windows, `'text` mode works only with regular files; attempting to use `'text` with other kinds of files triggers an `exn:fail:filesystem` exception.

Otherwise, the file specified by *path* need not be a regular file. It might be a device that is connected through the filesystem, such as `"aux"` on Windows or `"/dev/null"` on Unix. In all cases, the port is buffered by default.

The port produced by `open-input-file` should be explicitly closed, either though `close-input-port` or indirectly via `custodian-shutdown-all`, to release the OS-level file handle. The input port will not be closed automatically even if it is otherwise available for garbage collection (see §1.1.6 "Garbage Collection"); a will could be associated with an input port to close it more automatically (see §16.3 "Wills and Executors").

A path value that is the cleansed version of *path* is used as the name of the opened port.

On variants of Unix and MacOS that support `O_CLOEXEC`, the file is opened with `O_CLOEXEC` so that the underlying file descriptor is not shared with a subprocess created by `subprocess`. On Windows, the file is opened as a non-inherited handle.

If opening the file fails due to an error in the filesystem, then `exn:fail:filesystem:errno` exception is raised—as long as *for-module?* is `#f`, `current-module-path-for-load` has a non-`#f` value, or the filesystem error is not recognized as a file-not-found error. Otherwise, when *for-module?* is true, `current-module-path-for-load` has a non-`#f` value, and the filesystem error is recognized as a file-not-found error, then the raised exception is either `exn:fail:syntax:missing-module` (if the value of `current-module-path-for-load` is a syntax object) or `exn:fail:filesystem:missing-module` (otherwise).

Changed in version 6.0.1.6 of package `base`: Added `#:for-module?`.
Changed in version 8.11.1.6: Changed to use `O_CLOEXEC` where supported by the operating system.

Examples:

```
> (with-output-to-file some-file
    (lambda () (printf "hello world")))
> (define in (open-input-file some-file))
> (read-string 11 in)
"hello world"
> (close-input-port in)
```

```
(open-output-file  path
                  [#:mode mode-flag
                   #:exists exists-flag
                   #:permissions permissions
                   #:replace-permissions? replace-permissions?])
 → output-port?
  path : path-string?
  mode-flag : (or/c 'binary 'text) = 'binary
  exists-flag : (or/c 'error 'append 'update 'can-update
                      'replace 'truncate
                      'must-truncate 'truncate/replace)
              = 'error
  permissions : (integer-in 0 65535) = #o666
  replace-permissions? : any/c = #f
```

Opens the file specified by *path* for output. The *mode-flag* argument specifies how bytes written to the port are translated when written to the file:

- 'binary — bytes are written to the file exactly as written to the port.
- 'text — on Windows, a linefeed byte (10) written to the port is translated to a return-linefeed combination in the file; no filtering occurs for returns.

On Windows, 'text mode works only with regular files; attempting to use 'text with other kinds of files triggers an exn:fail:filesystem exception.

The *exists-flag* argument specifies how to handle/require files that already exist:

- 'error — raise exn:fail:filesystem if the file exists.
- 'replace — remove the old file, if it exists, and write a new one.
- 'truncate — remove all old data, if the file exists.
- 'must-truncate — remove all old data in an existing file; if the file does not exist, the exn:fail:filesystem exception is raised.
- 'truncate/replace — try 'truncate; if it fails (perhaps due to file permissions), try 'replace.
- 'update — open an existing file without truncating it; if the file does not exist, the exn:fail:filesystem exception is raised. Use file-position to change the current read/write position.
- 'can-update — open an existing file without truncating it, or create the file if it does not exist.
- 'append — append to the end of the file, whether it already exists or not; on Windows, 'append is equivalent to 'update, except that the file is not required to exist, and the file position is immediately set to the end of the file after opening it.

When the file specified by *path* is created, *permissions* specifies the permissions of the created file, where an integer representation of permissions is treated the same as for file-or-directory-permissions. On Unix and Mac OS, these permissions bits are combined with the process's umask. On Windows, the only relevant property of *permissions* is whether it has the #o2 bit set for write permission. Note that a read-only file can be created with open-output-file, in which case writing is prohibited only for later attempts to open the file. If *replace-permissions?* is a true value, then independent of whether the opened file is newly created, the value of *permissions* is applied to the opened file, and it is applied independent of the process's umask on Unix and Mac OS.

The file specified by *path* need not be a regular file. It might be a device that is connected through the filesystem, such as "aux" on Windows or "/dev/null" on Unix. The output port is block-buffered by default, unless the file corresponds to a terminal, in which case it is line-buffered by default. On Unix and Mac OS, if the file is a fifo, then the port will block for writing until a reader for the fifo is available; see also `port-waiting-peer?`.

The port produced by `open-output-file` should be explicitly closed, either though `close-output-port` or indirectly via `custodian-shutdown-all`, to release the OS-level file handle. The output port will not be closed automatically even if it is otherwise available for garbage collection (see §1.1.6 "Garbage Collection"); a will could be associated with an output port to close it more automatically (see §16.3 "Wills and Executors").

A path value that is the cleansed version of *path* is used as the name of the opened port.

On variants of Unix and MacOS that support `O_CLOEXEC`, the file is opened with `O_CLOEXEC` so that the underlying file descriptor is not shared with a subprocess created by `subprocess`. On Windows, the file is opened as a non-inherited handle.

If opening the file fails due to an error in the underlying filesystem then `exn:fail:filesystem:errno` exception is raised.

Examples:

```
> (define out (open-output-file some-file))
> (write "hello world" out)
> (close-output-port out)
```

Changed in version 6.9.0.6 of package `base`: On Unix and Mac OS, make `'truncate/replace` replace on a permission error. On Windows, make `'replace` always replace instead truncating like `'truncate/replace`.
Changed in version 7.4.0.5: Changed handling of a fifo on Unix and Mac OS to make the port block for output until the fifo has a reader.
Changed in version 8.1.0.3: Added the `#:permissions` argument.
Changed in version 8.7.0.10: Added the `#:replace-permissions?` argument.
Changed in version 8.11.1.6: Changed to use `O_CLOEXEC` where supported by the operating system.

```
(open-input-output-file
  path
 [#:mode mode-flag
  #:exists exists-flag
  #:permissions permissions
  #:replace-permissions? replace-permissions?])
→ input-port? output-port?
 path : path-string?
 mode-flag : (or/c 'binary 'text) = 'binary
 exists-flag : (or/c 'error 'append 'update 'can-update
                     'replace 'truncate
                     'must-truncate 'truncate/replace)
             = 'error
 permissions : (integer-in 0 65535) = #o666
```

```
replace-permissions? : any/c = #f
```

Like `open-output-file`, but producing two values: an input port and an output port. The two ports are connected in that they share the underlying file descriptor. This procedure is intended for use with special devices that can be opened by only one process, such as `"COM1"` in Windows. For regular files, sharing the file descriptor can be confusing. For example, using one port does not automatically flush the other port's buffer, and reading or writing in one port moves the file position (if any) for the other port. For regular files, use separate `open-input-file` and `open-output-file` calls to avoid confusion.

Changed in version 8.1.0.3 of package `base`: Added the `#:permissions` argument.
Changed in version 8.7.0.10: Added the `#:replace-permissions?` argument.

```
(call-with-input-file  path
                       proc
                      [#:mode mode-flag]) → any
  path : path-string?
  proc : (input-port? . -> . any)
  mode-flag : (or/c 'binary 'text) = 'binary
```

Calls `open-input-file` with the *`path`* and *`mode-flag`* arguments, and passes the resulting port to *`proc`*. The result of *`proc`* is the result of the `call-with-input-file` call, but the newly opened port is closed when *`proc`* returns.

Examples:

```
> (with-output-to-file some-file
    (lambda () (printf "text in a file")))
> (call-with-input-file some-file
    (lambda (in) (read-string 14 in)))
"text in a file"
```

```
(call-with-output-file
  path
  proc
 [#:mode mode-flag
  #:exists exists-flag
  #:permissions permissions
  #:replace-permissions? replace-permissions?])
→ any
  path : path-string?
  proc : (output-port? . -> . any)
  mode-flag : (or/c 'binary 'text) = 'binary
  exists-flag : (or/c 'error 'append 'update 'can-update
                      'replace 'truncate
                      'must-truncate 'truncate/replace)
              = 'error
```

```
permissions : (integer-in 0 65535) = #o666
replace-permissions? : any/c = #f
```

Analogous to `call-with-input-file`, but passing *path*, *mode-flag*, *exists-flag*, *permissions*, and *replace-permissions?* to `open-output-file`.

Examples:

```
> (call-with-output-file some-file
    (lambda (out)
      (write 'hello out)))
> (call-with-input-file some-file
    (lambda (in)
      (read-string 5 in)))
"hello"
```

Changed in version 8.1.0.3 of package `base`: Added the `#:permissions` argument.
Changed in version 8.7.0.10: Added the `#:replace-permissions?` argument.

```
(call-with-input-file*  path
                        proc
                       [#:mode mode-flag]) → any
  path : path-string?
  proc : (input-port? . -> . any)
  mode-flag : (or/c 'binary 'text) = 'binary
```

Like `call-with-input-file`, but the newly opened port is closed whenever control escapes the dynamic extent of the `call-with-input-file*` call, whether through *proc*'s return, a continuation application, or a prompt-based abort.

```
(call-with-output-file*
  path
  proc
 [#:mode mode-flag
  #:exists exists-flag
  #:permissions permissions
  #:replace-permissions? replace-permissions?])
→ any
  path : path-string?
  proc : (output-port? . -> . any)
  mode-flag : (or/c 'binary 'text) = 'binary
  exists-flag : (or/c 'error 'append 'update 'can-update
                      'replace 'truncate
                      'must-truncate 'truncate/replace)
              = 'error
```

```
permissions : (integer-in 0 65535) = #o666
replace-permissions? : any/c = #f
```

Like `call-with-output-file`, but the newly opened port is closed whenever control escapes the dynamic extent of the `call-with-output-file*` call, whether through *proc*'s return, a continuation application, or a prompt-based abort.

Changed in version 8.1.0.3 of package `base`: Added the `#:permissions` argument.
Changed in version 8.7.0.10: Added the `#:replace-permissions?` argument.

```
(with-input-from-file  path
                       thunk
                      [#:mode mode-flag]) → any
  path : path-string?
  thunk : (-> any)
  mode-flag : (or/c 'binary 'text) = 'binary
```

Like `call-with-input-file*`, but instead of passing the newly opened port to the given procedure argument, the port is installed as the current input port (see `current-input-port`) using `parameterize` around the call to *thunk*.

Examples:

```
> (with-output-to-file some-file
    (lambda () (printf "hello")))
> (with-input-from-file some-file
    (lambda () (read-string 5)))
"hello"
```

```
(with-output-to-file
  path
  thunk
 [#:mode mode-flag
  #:exists exists-flag
  #:permissions permissions
  #:replace-permissions? replace-permissions?])
→ any
  path : path-string?
  thunk : (-> any)
  mode-flag : (or/c 'binary 'text) = 'binary
  exists-flag :  (or/c 'error 'append 'update 'can-update
                       'replace 'truncate
                       'must-truncate 'truncate/replace)
              = 'error
  permissions : (integer-in 0 65535) = #o666
  replace-permissions? : any/c = #f
```

Like `call-with-output-file*`, but instead of passing the newly opened port to the given procedure argument, the port is installed as the current output port (see `current-output-port`) using `parameterize` around the call to *thunk*.

Examples:

```
> (with-output-to-file some-file
    (lambda () (printf "hello")))
> (with-input-from-file some-file
    (lambda () (read-string 5)))
"hello"
```

Changed in version 8.1.0.3 of package `base`: Added the `#:permissions` argument.
Changed in version 8.7.0.10: Added the `#:replace-permissions?` argument.

```
(port-try-file-lock? port mode) → boolean?
  port : file-stream-port?
  mode : (or/c 'shared 'exclusive)
```

Attempts to acquire a lock on the file using the current platform's facilities for file locking. Multiple processes can acquire a `'shared` lock on a file, but at most one process can hold an `'exclusive` lock, and `'shared` and `'exclusive` locks are mutually exclusive. When *mode* is `'shared`, then *port* must be an input port; when *mode* is `'exclusive`, then *port* must be an output port.

The result is `#t` if the requested lock is acquired, `#f` otherwise. When a lock is acquired, it is held until either it is released with `port-file-unlock` or the port is closed (perhaps because the process terminates).

Depending on the platform, locks may be merely advisory (i.e., locks affect only the ability of processes to acquire locks) or they may correspond to mandatory locks that prevent reads and writes to the locked file. Specifically, locks are mandatory on Windows and advisory on other platforms. Multiple tries for a `'shared` lock on a single port can succeed; on Unix and Mac OS, a single `port-file-unlock` release the lock, while on other Windows, a `port-file-unlock` is needed for each successful `port-try-file-lock?`. On Unix and Mac OS, multiple tries for a `'exclusive` lock can succeed and a single `port-file-unlock` releases the lock, while on Windows, a try for an `'exclusive` lock fails for a given port if the port already holds the lock.

A lock acquired for an input port from `open-input-output-file` can be released through `port-file-unlock` on the corresponding output port, and vice versa. If the output port from `open-input-output-file` holds an `'exclusive` lock, the corresponding input port can still acquire a `'shared` lock, even multiple times; on Windows, a `port-file-unlock` is needed for each successful lock try, while a single `port-file-unlock` balances the lock tries on Unix and Mac OS. A `'shared` lock on an input port can be upgraded to an `'exclusive` lock through the corresponding output port on Unix and Mac OS, in which case a single port-file-unlock (on either port) releases the lock, while such upgrades are not allowed on Windows.

Locking is normally supported only for file ports, and attempting to acquire a lock with other kinds of file-stream ports raises an exn:fail:filesystem exception.

```
(port-file-unlock port) → void?
  port : file-stream-port?
```

Releases a lock held by the current process on the file of *port*.

```
(port-file-identity port) → exact-positive-integer?
  port : file-stream-port?
```

Returns a number that represents the identity of the device and file read or written by *port*. For two ports whose open times overlap, the result of port-file-identity is the same for both ports if and only if the ports access the same device and file. For ports whose open times do not overlap, no guarantee can be provided for the port identities (even if the ports actually access the same file)—except as can be inferred through relationships with other ports. If *port* is closed, the exn:fail exception is raised. On Windows 95, 98, and Me, if *port* is connected to a pipe instead of a file, the exn:fail:filesystem exception is raised.

Examples:

```
> (define file1 (open-output-file some-file))
> (define file2 (open-output-file some-other-file))
> (port-file-identity file1)
1094449231445360656
> (port-file-identity file2)
1094449235740327952
> (close-output-port file1)
> (close-output-port file2)
```

```
(port-file-stat port) → (and/c (hash/c symbol? any/c) hash-eq?)
  port : file-stream-port?
```

Like file-or-directory-stat, but returns information for an open file represented by a port, instead using of the file's path.

Added in version 8.15.0.6 of package base.

13.1.6 String Ports

A *string port* reads or writes from a byte string. An input string port can be created from either a byte string or a string; in the latter case, the string is effectively converted to a byte string using `string->bytes/utf-8`. An output string port collects output into a byte string, but `get-output-string` conveniently converts the accumulated bytes to a string.

Input and output string ports do not need to be explicitly closed. The `file-position` procedure works for string ports in position-setting mode.

§4.5 “Byte Strings” also provides information on bytestrings.

```
(string-port? p) → boolean?
  p : port?
```

Returns `#t` if *p* is a string port, `#f` otherwise.

Added in version 6.0.1.6 of package `base`.

```
(open-input-bytes bstr [name]) → (and/c input-port? string-port?)
  bstr : bytes?
  name : any/c = 'string
```

Creates an input string port that reads characters from *bstr* (see §4.5 “Byte Strings”). Modifying *bstr* afterward does not affect the byte stream produced by the port. The optional *name* argument is used as the name for the returned port.

Examples:

```
> (define sp (open-input-bytes #"(apples 42 day)"))
> (define sexp1 (read sp))
> (first sexp1)
'apples
> (rest sexp1)
'(42 day)
> (read-line (open-input-bytes
              #"the cow jumped over the moon\nthe little dog\n"))
"the cow jumped over the moon"
```

§4.4 “Strings” also provides information on strings.

```
(open-input-string str [name]) → (and/c input-port? string-port?)
  str : string?
  name : any/c = 'string
```

Creates an input string port that reads bytes from the UTF-8 encoding (see §13.1.1 “Encodings and Locales”) of *str*. The optional *name* argument is used as the name for the returned port.

Examples:

```
> (define sp (open-input-string "(λ (x) x)"))
> (read sp)
```

```
'(λ (x) x)
> (define names (open-input-string "Günter Harder\nFrédéric
Paulin\n"))
> (read-line names)
"Günter Harder"
> (read-line names)
"Frédéric Paulin"
```

```
(open-output-bytes [name]) → (and/c output-port? string-port?)
  name : any/c = 'string
```

Creates an output string port that accumulates the output into a byte string. The optional `name` argument is used as the name for the returned port.

Examples:

```
> (define op1 (open-output-bytes))
> (write '((1 2 3) ("Tom" "Dick") ('a 'b 'c)) op1)
> (get-output-bytes op1)
#"((1 2 3) (\"Tom\" \"Dick\") ((quote a) (quote b) (quote c)))"
> (define op2 (open-output-bytes))
> (write "Hi " op2)
> (write "there" op2)
> (get-output-bytes op2)
#"\"Hi \"\"there\""
> (define op3 (open-output-bytes))
> (write-bytes #"Hi " op3)
3
> (write-bytes #"there" op3)
5
> (get-output-bytes op3)
#"Hi there"
```

```
(open-output-string [name]) → (and/c output-port? string-port?)
  name : any/c = 'string
```

The same as `open-output-bytes`.

Examples:

```
> (define op1 (open-output-string))
> (write '((1 2 3) ("Tom" "Dick") ('a 'b 'c)) op1)
> (get-output-string op1)
"((1 2 3) (\"Tom\" \"Dick\") ((quote a) (quote b) (quote c)))"
> (define op2 (open-output-string))
```

```
> (write "Hi " op2)
> (write "there" op2)
> (get-output-string op2)
"\"Hi \"\"there\""
> (define op3 (open-output-string))
> (write-string "Hi " op3)
3
> (write-string "there" op3)
5
> (get-output-string op3)
"Hi there"
```

```
(get-output-bytes out
                  [reset?
                   start-pos
                   end-pos]) → bytes?
  out : (and/c output-port? string-port?)
  reset? : any/c = #f
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = #f
```

Returns the bytes accumulated in the string port *out* so far in a freshly allocated byte string (including any bytes written after the port's current position, if any). The *out* port must be an output string port produced by `open-output-bytes` (or `open-output-string`) or a structure whose `prop:output-port` property refers to such an output port (transitively).

If *reset?* is true, then all bytes are removed from the port, and the port's position is reset to `0`; if *reset?* is `#f`, then all bytes remain in the port for further accumulation (so they are returned for later calls to `get-output-bytes` or `get-output-string`), and the port's position is unchanged.

The *start-pos* and *end-pos* arguments specify the range of bytes in the port to return; supplying *start-pos* and *end-pos* is the same as using `subbytes` on the result of `get-output-bytes`, but supplying them to `get-output-bytes` can avoid an allocation. The *end-pos* argument can be `#f`, which corresponds to not passing a second argument to `subbytes`.

Examples:

```
> (define op (open-output-bytes))
> (write '((1 2 3) ("Tom" "Dick") ('a 'b 'c)) op)
> (get-output-bytes op)
#"((1 2 3) (\"Tom\" \"Dick\") ((quote a) (quote b) (quote c)))"
> (get-output-bytes op #f 3 16)
#" 2 3) (\"Tom\" "
> (get-output-bytes op #t)
```

```
#"((1 2 3) (\"Tom\" \"Dick\") ((quote a) (quote b) (quote c)))"
> (get-output-bytes op)
#""
```

```
(get-output-string out) → string?
  out : (and/c output-port? string-port?)
```

Returns `(bytes->string/utf-8 (get-output-bytes out) #\uFFFD)`.

Examples:

```
> (define i (open-input-string "hello world"))
> (define o (open-output-string))
> (write (read i) o)
> (get-output-string o)
"hello"
```

13.1.7 Pipes

A Racket *pipe* is internal to Racket, and not related to OS-level pipes for communicating between different processes.

OS-level pipes may be created by `subprocess`, opening an existing named file on a Unix filesystem, or starting Racket with pipes for its original input, output, or error port. Such pipes are file-stream ports, unlike the pipes produced by `make-pipe`.

```
(pipe-port? p) → boolean?
  p : port?
```

Returns `#t` if *p* is either end of a pipe created by `make-pipe`, `#f` otherwise.

Added in version 8.15.0.9 of package `base`.

```
(make-pipe [limit input-name output-name])
 → (and/c input-port? pipe-port?)
   (and/c output-port? pipe-port?)
  limit : exact-positive-integer? = #f
  input-name : any/c = 'pipe
  output-name : any/c = 'pipe
```

Returns two port values: the first port is an input port and the second is an output port. Data written to the output port is read from the input port, with no intermediate buffering. Unlike some other kinds of ports, pipe ports do not need to be explicitly closed to be reclaimed by garbage collection.

If *limit* is `#f`, the new pipe holds an unlimited number of unread bytes (i.e., limited only by the available memory). If *limit* is a positive number, then the pipe will hold at most *limit* unread/unpeeked bytes; writing to the pipe's output port thereafter will block until a read or peek from the input port makes more space available. (Peeks effectively extend the port's capacity until the peeked bytes are read.)

The optional *input-name* and *output-name* are used as the names for the returned input and output ports, respectively.

```
(pipe-content-length pipe-port) → exact-nonnegative-integer?
  pipe-port : pipe-port?
```

Returns the number of bytes contained in a pipe, where *pipe-port* is either of the pipe's ports produced by `make-pipe`. The pipe's content length counts all bytes that have been written to the pipe and not yet read (though possibly peeked).

13.1.8 Structures as Ports

```
prop:input-port : struct-type-property?
```

```
prop:output-port : struct-type-property?
```

The `prop:input-port` and `prop:output-port` structure type properties identify structure types whose instances can serve as input and output ports, respectively.

Each property value can be either of the following:

- An input port (for `prop:input-port`) or output port (for `prop:output-port`): In this case, using the structure as port is equivalent to using the given input or output port.
- An exact, non-negative integer between `0` (inclusive) and the number of non-automatic fields in the structure type (exclusive, not counting supertype fields): The integer identifies a field in the structure, and the field must be designated as immutable. If the field contains an input port (for `prop:input-port`) or output port (for `prop:output-port`), the port is used. Otherwise, an empty string input port is used for `prop:input-port`, and a port that discards all data is used for `prop:output-port`.

Some procedures, such as `file-position`, work on both input and output ports. When given an instance of a structure type with both the `prop:input-port` and `prop:output-port` properties, the instance is used as an input port.

13.1.9 Custom Ports

The `make-input-port` and `make-output-port` procedures create *custom ports* with arbitrary control procedures (much like implementing a device driver). Custom ports are mainly useful to obtain fine control over the action of committing bytes as read or written.

```
(make-input-port  name
                  read-in
                  peek
                  close
                 [get-progress-evt
                  commit
                  get-location
                  count-lines!
                  init-position
                  buffer-mode])     → input-port?
  name : any/c
  read-in : (or/c
             (bytes?
              . -> . (or/c exact-nonnegative-integer?
                           eof-object?
                           procedure?
                           evt?))
             input-port?)
  peek : (or/c
          (bytes? exact-nonnegative-integer? (or/c evt? #f)
                  . -> . (or/c exact-nonnegative-integer?
                               eof-object?
                               procedure?
                               evt?
                               #f))
          input-port?
          #f)
  close : (-> any)
  get-progress-evt : (or/c (-> evt?) #f) = #f
  commit : (or/c (exact-positive-integer? evt? evt? . -> . any)
                 #f)
         = #f
  get-location : (or/c
                  (->
                   (values (or/c exact-positive-integer? #f)
                           (or/c exact-nonnegative-integer? #f)
                           (or/c exact-positive-integer? #f)))
                  #f)
               = #f
  count-lines! : (-> any) = void
```

```
init-position : (or/c exact-positive-integer?
                      port?
                      #f
                      (-> (or/c exact-positive-integer? #f)))
              = 1
buffer-mode : (or/c (case-> ((or/c 'block 'none) . -> . any)
                            (-> (or/c 'block 'none #f)))
                    #f)
            = #f
```

Creates an input port, which is immediately open for reading. If *close* procedure has no side effects, then the port need not be explicitly closed. See also make-input-port/read-to-peek.

The arguments implement the port as follows:

- *name* — the name for the input port.
- *read-in* — either an input port, in which case reads are redirected to the given port, or a procedure that takes a single argument: a mutable byte string to receive read bytes. The procedure's result is one of the following:
  - the number of bytes read, as an exact, non-negative integer;
  - eof;
  - a procedure of arity four (representing a "special" result, as discussed further below), but a procedure result is allowed only when *peek* is not #f;
  - a pipe input port that supplies bytes to be used as long as the pipe has content (see pipe-content-length) or until *read-in* or *peek* is called again; or
  - a synchronizable event (see §11.2.1 "Events") other than a pipe input port or procedure of arity four; the event becomes ready when the read is complete (roughly): the event's value can be one of the above four results or another event like itself; in the last case, a reading process loops with sync until it gets a non-event result.

  The *read-in* procedure must not block indefinitely. If no bytes are immediately available for reading, the *read-in* must return 0 or an event, and preferably an event (to avoid busy waits). The *read-in* should not return 0 (or an event whose value is 0) when data is available in the port, otherwise polling the port will behave incorrectly. An event result from an event can also break polling.

  If the result of a *read-in* call is not one of the above values, the exn:fail:contract exception is raised. If a returned integer is larger than the supplied byte string's length, the exn:fail:contract exception is raised. If *peek* is #f and a procedure for a special result is returned, the exn:fail:contract exception is raised.

The *read-in* procedure can report an error by raising an exception, but only if no bytes are read. Similarly, no bytes should be read if `eof`, an event, or a procedure is returned. In other words, no bytes should be lost due to spurious exceptions or non-byte data.

A port's reading procedure may be called in multiple threads simultaneously (if the port is accessible in multiple threads), and the port is responsible for its own internal synchronization. Note that improper implementation of such synchronization mechanisms might cause a non-blocking read procedure to block indefinitely.

If the result is a pipe input port, then previous *get-progress-evt* calls whose event is not yet ready must have been the pipe input port itself. Furthermore, *get-progress-evt* must continue to return the pipe as long as it contains data, or until the *read-in* or `peek-in` procedure is called again (instead of using the pipe, for whatever reason). If *read-in* or `peek-in` is called, any previously associated pipe (as returned by a previous call) is disassociated from the port and is not in use by any other thread as a result of the previous association.

If *peek*, *get-progress-evt*, and *commit* are all provided and non-`#f`, then the following is an acceptable implementation of *read-in*:

```
(lambda (bstr)
  (let* ([progress-evt (get-progress-evt)]
         [v (peek bstr 0 progress-evt)])
    (cond
     [(sync/timeout 0 progress-evt) 0] ; try again
     [(evt? v) (wrap-evt v (lambda (x) 0))] ; sync, try again
     [(and (number? v) (zero? v)) 0] ; try again
     [else
      (if (commit (if (number? v) v 1)
                  progress-evt
                  always-evt)
          v      ; got a result
          0)]))) ; try again
```

An implementor may choose not to implement the *peek*, *get-progress-evt*, and *commit* procedures, however, and even an implementor who does supply them may provide a different *read-in* that uses a fast path for non-blocking reads.

In an input port is provided for *read-in*, then an input port must also be provided for *peek*.

- *peek* — either `#f`, an input port (in which case peeks are redirected to the given port), or a procedure that takes three arguments:
  - a mutable byte string to receive peeked bytes;
  - a non-negative number of bytes (or specials) to skip before peeking; and
  - either `#f` or a progress event produced by *get-progress-evt*.

The results and conventions for *peek* are mostly the same as for *read-in*. The main difference is in the handling of the progress event, if it is not #f. If the given progress event becomes ready, the *peek* must abort any skip attempts and not peek any values. In particular, *peek* must not peek any values if the progress event is initially ready. If the port has been closed, the progress event should be ready, in which case *peek* should complete (instead of failing because the port is closed).

Unlike *read-in*, *peek* should produce #f (or an event whose value is #f) if no bytes were peeked because the progress event became ready. Like *read-in*, a 0 result indicates that another attempt is likely to succeed, so 0 is inappropriate when the progress event is ready. Also like *read-in*, *peek* must not block indefinitely. An event produced by *peek* is polled (in the sense of poll-guard-evt) by an option like byte-ready? or peek-bytes-avail*!.

The skip count provided to *peek* is a number of bytes (or specials) that must remain present in the port—in addition to the peek results—when the peek results are reported. If the skip count requests reading data that is past an eof, it should not, and instead produce eof (until the eof is consumed).

If a progress event is supplied, then the peek is effectively canceled when another process reads data before the given number can be skipped. If a progress event is not supplied and data is read, then the peek must effectively restart with the original skip count.

The system does not check that multiple peeks return consistent results, or that peeking and reading produce consistent results, although they must.

If *peek* is #f, then peeking for the port is implemented automatically in terms of reads, but with several limitations. First, the automatic implementation is not thread-safe. Second, the automatic implementation cannot handle special results (non-byte and non-eof), so *read-in* cannot return a procedure for a special when *peek* is #f. Finally, the automatic peek implementation is incompatible with progress events, so if *peek* is #f, then *get-progress-evt* and *commit* must be #f. See also make-input-port/read-to-peek, which implements peeking in terms of *read-in* without these constraints.

In an input port is provided for *peek*, then an input port must also be provided for *read-in*.

- *close* — a procedure of zero arguments that is called to close the port. The port is not considered closed until the closing procedure returns. The port's procedures will never be used again via the port after it is closed. However, the closing procedure can be called simultaneously in multiple threads (if the port is accessible in multiple threads), and it may be called during a call to the other procedures in another thread; in the latter case, any outstanding reads and peeks should be terminated with an error.

- *get-progress-evt* — either #f (the default), or a procedure that takes no arguments and returns an event. The event must become ready only after data is next read from the port or the port is closed. If the port is already closed, the event must be ready. After the event becomes ready, it must remain so. See the description of *read-in* for information about the allowed results of this function when *read-in* returns a pipe input port. See also `semaphore-peek-evt`, which is sometimes useful for implementing *`get-progress-evt`*.

If *`get-progress-evt`* is `#f`, then `port-provides-progress-evts?` applied to the port will produce `#f`, and the port will not be a valid argument to `port-progress-evt`.

The result event will not be exposed directly by `port-progress-evt`. Instead, it will be wrapped in an event for which `progress-evt?` returns true.

- *`commit`* — either `#f` (the default), or a procedure that takes three arguments:

  - an exact, positive integer k_r;
  - a progress event produced by *`get-progress-evt`*;
  - an event, *`done`*, that is either a channel-put event, channel, semaphore, semaphore-peek event, always event, or never event.

  A *commit* corresponds to removing data from the stream that was previously peeked, but only if no other process removed data first. (The removed data does not need to be reported, because it has been peeked already.) More precisely, assuming that k_p bytes, specials, and mid-stream `eof`s have been previously peeked or skipped at the start of the port's stream, *`commit`* must satisfy the following constraints:

  - It must return only when the commit is complete or when the given progress event becomes ready.
  - It must commit only if k_p is positive.
  - If it commits, then it must do so with either k_r items or k_p items, whichever is smaller, and only if k_p is positive.
  - It must never choose *`done`* in a synchronization after the given progress event is ready, or after *`done`* has been synchronized once.
  - It must not treat any data as read from the port unless *`done`* is chosen in a synchronization.
  - It must not block indefinitely if *`done`* is ready; it must return soon after the read completes or soon after the given progress event is ready, whichever is first.
  - It can report an error by raising an exception, but only if no data has been committed. In other words, no data should be lost due to an exception, including a break exception.
  - It must return a true value if data has been committed, `#f` otherwise. When it returns a value, the given progress event must be ready (perhaps because data has just been committed).
  - It should return a byte string as a true result when line counting is enabled and *`get-location`* is `#f` (so that line counting is implemented the default way); the result byte string represents the data that was committed for the purposes of character and line counting. If any other true result is returned when a byte string is expected, it is treated like a byte string where each byte corresponds to a non-newline character.

– It must raise an exception if no data (including `eof`) has been peeked from the beginning of the port's stream, or if it would have to block indefinitely to wait for the given progress event to become ready.

A call to *`commit`* is `parameterize-breaked` to disable breaks.

- *`get-location`* — either `#f` (the default), or a procedure that takes no arguments and returns three values: the line number for the next item in the port's stream (a positive number or `#f`), the column number for the next item in the port's stream (a non-negative number or `#f`), and the position for the next item in the port's stream (a positive number or `#f`). See also §13.1.4 "Counting Positions, Lines, and Columns".

  This procedure is called to implement `port-next-location`, but only if line counting is enabled for the port via `port-count-lines!` (in which case *`count-lines!`* is called). The `read` and `read-syntax` procedures assume that reading a non-whitespace character increments the column and position by one.

- *`count-lines!`* — a procedure of no arguments that is called if and when line counting is enabled for the port. The default procedure is `void`.

- *`init-position`* — normally an exact, positive integer that determines the position of the port's first item, which is used by `file-position` or when line counting is *not* enabled for the port. The default is `1`. If *`init-position`* is `#f`, the port is treated as having an unknown position. If *`init-position`* is a port, then the given port's position is always used for the new port's position. If *`init-position`* is a procedure, it is called as needed to obtain the port's position.

- *`buffer-mode`* — either `#f` (the default) or a procedure that accepts zero or one arguments. If *`buffer-mode`* is `#f`, then the resulting port does not support a buffer-mode setting. Otherwise, the procedure is called with one symbol argument (`'block` or `'none`) to set the buffer mode, and it is called with zero arguments to get the current buffer mode. In the latter case, the result must be `'block`, `'none`, or `#f` (unknown). See §13.1.3 "Port Buffers and Positions" for more information on buffer modes.

"Special" results: When *`read-in`* or *`peek`* (or an event produced by one of these) returns a procedure, the procedure is used to obtain a non-byte result. (This non-byte result is *not* intended to return a character or `eof`; in particular, `read-char` raises an exception if it encounters a special-result procedure, even if the procedure produces a byte.) A special-result procedure must accept four arguments that represent a source location. The first argument is `#f` when the special read is triggered by `read` or `read/recursive`.

The special-value procedure can return an arbitrary value, and it will be called zero or one times (not necessarily before further reads or peeks from the port). See §13.7.2 "Reader-Extension Procedures" for more details on the procedure's result.

If *`read-in`* or *`peek`* returns a special procedure when called by any reading procedure other than `read`, `read-syntax`, `read-char-or-special`, `peek-char-or-special`, `read-byte-or-special`, or `peek-byte-or-special`, then the `exn:fail:contract` exception is raised.

Examples:

```
; A port with no input...
; Easy: (open-input-bytes #"")
; Hard:
> (define /dev/null-in
    (make-input-port 'null
                     (lambda (s) eof)
                     (lambda (skip s progress-evt) eof)
                     void
                     (lambda () never-evt)
                     (lambda (k progress-evt done-evt)
                       (error "no successful peeks!"))))
> (read-char /dev/null-in)
#<eof>
> (peek-char /dev/null-in)
#<eof>
> (read-byte-or-special /dev/null-in)
#<eof>
> (peek-byte-or-special /dev/null-in 100)
#<eof>
; A port that produces a stream of 1s:
> (define infinite-ones
    (make-input-port
     'ones
     (lambda (s)
       (bytes-set! s 0 (char->integer #\1)) 1)
     #f
     void))
> (read-string 5 infinite-ones)
"11111"
; But we can't peek ahead arbitrarily far, because the
; automatic peek must record the skipped bytes, so
; we'd run out of memory.
; An infinite stream of 1s with a specific peek procedure:
> (define infinite-ones
    (let ([one! (lambda (s)
                  (bytes-set! s 0 (char->integer #\1)) 1)])
      (make-input-port
       'ones
       one!
       (lambda (s skip progress-evt) (one! s))
       void)))
> (read-string 5 infinite-ones)
"11111"
; Now we can peek ahead arbitrarily far:
```

```
> (peek-string 5 (expt 2 5000) infinite-ones)
"11111"
; The port doesn't supply procedures to implement progress events:
> (port-provides-progress-evts? infinite-ones)
#f
> (port-progress-evt infinite-ones)
port-progress-evt: port does not provide progress evts
  port: #<input-port:ones>
; Non-byte port results:
> (define infinite-voids
    (make-input-port
     'voids
     (lambda (s) (lambda args 'void))
     (lambda (skip s evt) (lambda args 'void))
     void))
> (read-char infinite-voids)
read-char: non-character in an unsupported context
  port: #<input-port:voids>
> (read-char-or-special infinite-voids)
'void
; This port produces 0, 1, 2, 0, 1, 2, etc., but it is not
; thread-safe, because multiple threads might read and change n.
> (define mod3-cycle/one-thread
    (let* ([n 2]
           [mod! (lambda (s delta)
                   (bytes-set! s 0 (+ 48 (modulo (+ n delta) 3)))
                   1)])
      (make-input-port
       'mod3-cycle/not-thread-safe
       (lambda (s)
         (set! n (modulo (add1 n) 3))
         (mod! s 0))
       (lambda (s skip evt)
         (mod! s skip))
       void)))
> (read-string 5 mod3-cycle/one-thread)
"01201"
> (peek-string 5 (expt 2 5000) mod3-cycle/one-thread)
"20120"
; Same thing, but thread-safe and kill-safe, and with progress
; events. Only the server thread touches the stateful part
; directly. (See the output port examples for a simpler thread-
safe
; example, but this one is more general.)
> (define (make-mod3-cycle)
    (define read-req-ch (make-channel))
```

```
(define peek-req-ch (make-channel))
(define progress-req-ch (make-channel))
(define commit-req-ch (make-channel))
(define close-req-ch (make-channel))
(define closed? #f)
(define n 0)
(define progress-sema #f)
(define (mod! s delta)
  (bytes-set! s 0 (+ 48 (modulo (+ n delta) 3)))
  1)
; ----------------------------
; The server has a list of outstanding commit requests,
;  and it also must service each port operation (read,
;  progress-evt, etc.)
(define (serve commit-reqs response-evts)
  (apply
   sync
   (handle-evt read-req-ch
               (handle-read commit-reqs response-evts))
   (handle-evt progress-req-ch
               (handle-progress commit-reqs response-evts))
   (handle-evt commit-req-ch
               (add-commit commit-reqs response-evts))
   (handle-evt close-req-ch
               (handle-close commit-reqs response-evts))
   (append
    (map (make-handle-response commit-reqs response-evts)
         response-evts)
    (map (make-handle-commit commit-reqs response-evts)
         commit-reqs))))
; Read/peek request: fill in the string and commit
(define ((handle-read commit-reqs response-evts) r)
  (let ([s (car r)]
        [skip (cadr r)]
        [ch (caddr r)]
        [nack (cadddr r)]
        [evt (car (cddddr r))]
        [peek? (cdr (cddddr r))])
    (let ([fail? (and evt
                      (sync/timeout 0 evt))])
      (unless (or closed? fail?)
        (mod! s skip)
        (unless peek?
          (commit! 1)))
      ; Add an event to respond:
      (serve commit-reqs
```

```
                  (cons (choice-evt
                         nack
                         (channel-put-evt ch (if closed?
                                                 0
                                                 (if fail? #f 1))))
                        response-evts)))))
    ; Progress request: send a peek evt for the current
    ;  progress-sema
    (define ((handle-progress commit-reqs response-evts) r)
      (let ([ch (car r)]
            [nack (cdr r)])
        (unless progress-sema
          (set! progress-sema (make-semaphore (if closed? 1 0))))
        ; Add an event to respond:
        (serve commit-reqs
               (cons (choice-evt
                      nack
                      (channel-put-evt
                       ch
                       (semaphore-peek-evt progress-sema)))
                     response-evts))))
    ; Commit request: add the request to the list
    (define ((add-commit commit-reqs response-evts) r)
      (serve (cons r commit-reqs) response-evts))
    ; Commit handling: watch out for progress, in which case
    ;  the response is a commit failure; otherwise, try
    ;  to sync for a commit. In either event, remove the
    ;  request from the list
    (define ((make-handle-commit commit-reqs response-evts) r)
      (let ([k (car r)]
            [progress-evt (cadr r)]
            [done-evt (caddr r)]
            [ch (cadddr r)]
            [nack (cddddr r)])
        ; Note: we don't check that k is <= the sum of
        ;  previous peeks, because the entire stream is actually
        ;  known, but we could send an exception in that case.
        (choice-evt
         (handle-evt progress-evt
                     (lambda (x)
                       (sync nack (channel-put-evt ch #f))
                       (serve (remq r commit-reqs) response-
evts)))
         ; Only create an event to satisfy done-evt if progress-
evt
         ;  isn't already ready.
```

```
    ; Afterward, if progress-evt becomes ready, then this
    ;  event-making function will be called again, because
    ;  the server controls all posts to progress-evt.
    (if (sync/timeout 0 progress-evt)
        never-evt
        (handle-evt done-evt
                    (lambda (v)
                      (commit! k)
                      (sync nack (channel-put-evt ch #t))
                      (serve (remq r commit-reqs)
                             response-evts)))))))
; Response handling: as soon as the respondee listens,
;  remove the response
(define ((make-handle-response commit-reqs response-evts) evt)
  (handle-evt evt
              (lambda (x)
                (serve commit-reqs
                       (remq evt response-evts)))))
; Close handling: post the progress sema, if any, and set
;   the closed? flag
(define ((handle-close commit-reqs response-evts) r)
  (let ([ch (car r)]
        [nack (cdr r)])
    (set! closed? #t)
    (when progress-sema
      (semaphore-post progress-sema))
    (serve commit-reqs
           (cons (choice-evt nack
                             (channel-put-evt ch (void)))
                 response-evts))))
; Helper for reads and post-peek commits:
(define (commit! k)
  (when progress-sema
    (semaphore-post progress-sema)
    (set! progress-sema #f))
  (set! n (+ n k)))
; Start the server thread:
(define server-thread (thread (lambda () (serve null null))))
; --------------------------
; Client-side helpers:
(define (req-evt f)
  (nack-guard-evt
   (lambda (nack)
     ; Be sure that the server thread is running:
     (thread-resume server-thread (current-thread))
     ; Create a channel to hold the reply:
```

```
        (let ([ch (make-channel)])
          (f ch nack)
          ch))))
    (define (read-or-peek-evt s skip evt peek?)
      (req-evt (lambda (ch nack)
                 (channel-put read-req-ch
                              (list* s skip ch nack evt peek?)))))
    ; Make the port:
    (make-input-port 'mod3-cycle
                     ; Each handler for the port just sends
                     ;  a request to the server
                     (lambda (s) (read-or-peek-evt s 0 #f #f))
                     (lambda (s skip evt)
                       (read-or-peek-evt s skip evt #t))
                     (lambda () ; close
                       (sync (req-evt
                              (lambda (ch nack)
                                (channel-put progress-req-ch
                                             (list* ch nack))))))
                     (lambda () ; progress-evt
                       (sync (req-evt
                              (lambda (ch nack)
                                (channel-put progress-req-ch
                                             (list* ch nack))))))
                     (lambda (k progress-evt done-evt)  ; commit
                       (sync (req-evt
                              (lambda (ch nack)
                                (channel-put
                                 commit-req-ch
                                 (list* k progress-evt done-evt ch
                                        nack))))))))
> (define mod3-cycle (make-mod3-cycle))
> (let ([result1 #f]
        [result2 #f])
    (let ([t1 (thread
               (lambda ()
                 (set! result1 (read-string 5 mod3-cycle))))]
          [t2 (thread
               (lambda ()
                 (set! result2 (read-string 5 mod3-cycle))))])
      (thread-wait t1)
      (thread-wait t2)
      (string-append result1 "," result2)))
"11120,02020"
> (define s (make-bytes 1))
> (define progress-evt (port-progress-evt mod3-cycle))
```

```
> (peek-bytes-avail! s 0 progress-evt mod3-cycle)
1
> s
#"1"
> (port-commit-peeked 1 progress-evt (make-semaphore 1)
                      mod3-cycle)
#t
> (sync/timeout 0 progress-evt)
#<progress-evt>
> (peek-bytes-avail! s 0 progress-evt mod3-cycle)
0
> (port-commit-peeked 1 progress-evt (make-semaphore 1)
                      mod3-cycle)
#f
> (close-input-port mod3-cycle)
```

```
(make-output-port  name
                   evt
                   write-out
                   close
                  [write-out-special
                   get-write-evt
                   get-write-special-evt
                   get-location
                   count-lines!
                   init-position
                   buffer-mode])          → output-port?
  name : any/c
  evt : evt?
  write-out : (or/c
              (bytes? exact-nonnegative-integer?
                      exact-nonnegative-integer?
                      boolean?
                      boolean?
                      . -> .
                      (or/c exact-nonnegative-integer?
                            #f
                            evt?))
              output-port?)
  close : (-> any)
```

```
write-out-special : (or/c (any/c boolean? boolean? = #f
                                . -> .
                                (or/c any/c
                                      #f
                                      evt?))
                          output-port?
                          #f)
get-write-evt : (or/c                                  = #f
                 (bytes? exact-nonnegative-integer?
                         exact-nonnegative-integer?
                         . -> .
                         evt?)
                 #f)
get-write-special-evt : (or/c                  = #f
                         (any/c . -> . evt?)
                         #f)
get-location : (or/c
                (->
                 (values (or/c exact-positive-integer? #f)
                         (or/c exact-nonnegative-integer? #f)
                         (or/c exact-positive-integer? #f)))
                #f)
             = #f
count-lines! : (-> any) = void
init-position : (or/c exact-positive-integer?
                      port?
                      #f
                      (-> (or/c exact-positive-integer? #f)))
              = 1
buffer-mode : (or/c (case->
                     ((or/c 'block 'line 'none) . -> . any)
                     (-> (or/c 'block 'line 'none #f)))
                    #f)
            = #f
```

Creates an output port, which is immediately open for writing. If *close* procedure has no side effects, then the port need not be explicitly closed. The port can buffer data within its *write-out* and *write-out-special* procedures.

- *name* — the name for the output port.
- *evt* — a synchronization event (see §11.2.1 "Events"; e.g., a semaphore or another port). The event is used in place of the output port when the port is supplied to synchronization procedures like `sync`. Thus, the event should be unblocked when the port is ready for writing at least one byte without blocking, or ready to make progress

in flushing an internal buffer without blocking. The event must not unblock unless the port is ready for writing; otherwise, the guarantees of `sync` will be broken for the output port. Use `always-evt` if writes to the port always succeed without blocking.

- *`write-out`* — either an output port, which indicates that writes should be redirected to the given port, or a procedure of five arguments:

  - an immutable byte string containing bytes to write;
  - a non-negative exact integer for a starting offset (inclusive) into the byte string;
  - a non-negative exact integer for an ending offset (exclusive) into the byte string;
  - a boolean; `#f` indicates that the port is allowed to keep the written bytes in a buffer, and that it is allowed to block indefinitely; `#t` indicates that the write should not block, and that the port should attempt to flush its buffer and completely write new bytes instead of buffering them;
  - a boolean; `#t` indicates that if the port blocks for a write, then it should enable breaks while blocking (e.g., using `sync/enable-break`); this argument is always `#f` if the fourth argument is `#t`.

  The procedure returns one of the following:

  - a non-negative exact integer representing the number of bytes written or buffered;
  - `#f` if no bytes could be written, perhaps because the internal buffer could not be completely flushed;
  - a pipe output port (when buffering is allowed and not when flushing) for buffering bytes as long as the pipe is not full and until *`write-out`* or *`write-out-special`* is called; or
  - a synchronizable event (see §11.2.1 "Events") other than a pipe output port that acts like the result of `write-bytes-avail-evt` to complete the write.

  Since *`write-out`* can produce an event, an acceptable implementation of *`write-out`* is to pass its first three arguments to the port's *`get-write-evt`*. Some port implementors, however, may choose not to provide *`get-write-evt`* (perhaps because writes cannot be made atomic), or may implement *`write-out`* to enable a fast path for non-blocking writes or to enable buffering.

  From a user's perspective, the difference between buffered and completely written data is (1) buffered data can be lost in the future due to a failed write, and (2) `flush-output` forces all buffered data to be completely written. Under no circumstances is buffering required.

  If the start and end indices are the same, then the fourth argument to *`write-out`* will be `#f`, and the write request is actually a flush request for the port's buffer (if any), and the result should be `0` for a successful flush (or if there is no buffer).

The result should never be `0` if the start and end indices are different, otherwise the `exn:fail:contract` exception is raised. Similarly, the `exn:fail:contract` exception is raised if *`write-out`* returns a pipe output port when buffering is disallowed or when it is called for flushing. If a returned integer is larger than the supplied byte-string range, the `exn:fail:contract` exception is raised.

The `#f` result should be avoided, unless the next write attempt is likely to work. Otherwise, if data cannot be written, return an event instead.

An event returned by *`write-out`* can return `#f` or another event like itself, in contrast to events produced by `write-bytes-avail-evt` or *`get-write-evt`*. A writing process loops with `sync` until it obtains a non-event result.

The *`write-out`* procedure is always called with breaks disabled, independent of whether breaks were enabled when the write was requested by a client of the port. If breaks were enabled for a blocking operation, then the fifth argument to *`write-out`* will be `#t`, which indicates that *`write-out`* should re-enable breaks while blocking.

If the writing procedure raises an exception, due to write or commit operations, it must not have committed any bytes (though it may have committed previously buffered bytes).

A port's writing procedure may be called in multiple threads simultaneously (if the port is accessible in multiple threads). The port is responsible for its own internal synchronization. Note that improper implementation of such synchronization mechanisms might cause a non-blocking write procedure to block.

- *`close`* — a procedure of zero arguments that is called to close the port. The port is not considered closed until the closing procedure returns. The port's procedures will never be used again via the port after it is closed. However, the closing procedure can be called simultaneously in multiple threads (if the port is accessible in multiple threads), and it may be called during a call to the other procedures in another thread; in the latter case, any outstanding writes or flushes should be terminated immediately with an error.

- *`write-out-special`* — either `#f` (the default), an output port (which indicates that special writes should be redirected to the given port), or a procedure to handle `write-special` calls for the port. If `#f`, then the port does not support special output, and `port-writes-special?` will return `#f` when applied to the port.

  If a procedure is supplied, it takes three arguments: the special value to write, a boolean that is `#f` if the procedure can buffer the special value and block indefinitely, and a boolean that is `#t` if the procedure should enable breaks while blocking. The result is one of the following:

  - a non-event true value, which indicates that the special is written;
  - `#f` if the special could not be written, perhaps because an internal buffer could not be completely flushed;
  - a synchronizable event (see §11.2.1 "Events") that acts like the result of *`get-write-special-evt`* to complete the write.

Since *write-out-special* can return an event, passing the first argument to an implementation of *get-write-special-evt* is acceptable as a *write-out-special*.

As for *write-out*, the #f result is discouraged, since it can lead to busy waiting. Also as for *write-out*, an event produced by *write-out-special* is allowed to produce #f or another event like itself. The *write-out-special* procedure is always called with breaks disabled, independent of whether breaks were enabled when the write was requested by a client of the port.

- *get-write-evt* — either #f (the default) or a procedure of three arguments:
  - an immutable byte string containing bytes to write;
  - a non-negative exact integer for a starting offset (inclusive) into the byte string; and
  - a non-negative exact integer for an ending offset (exclusive) into the byte string.

  The result is a synchronizable event (see §11.2.1 "Events") to act as the result of write-bytes-avail-evt for the port (i.e., to complete a write or flush), which becomes available only as data is committed to the port's underlying device, and whose result is the number of bytes written.

  If *get-write-evt* is #f, then port-writes-atomic? will produce #f when applied to the port, and the port will not be a valid argument to procedures such as write-bytes-avail-evt. Otherwise, an event returned by *get-write-evt* must not cause data to be written to the port unless the event is chosen in a synchronization, and it must write to the port if the event is chosen (i.e., the write must appear atomic with respect to the synchronization).

  If the event's result integer is larger than the supplied byte-string range, the exn:fail:contract exception is raised by a wrapper on the event. If the start and end indices are the same (i.e., no bytes are to be written), then the event should produce 0 when the buffer is completely flushed. (If the port has no buffer, then it is effectively always flushed.)

  If the event raises an exception, due to write or commit operations, it must not have committed any new bytes (though it may have committed previously buffered bytes).

  Naturally, a port's events may be used in multiple threads simultaneously (if the port is accessible in multiple threads). The port is responsible for its own internal synchronization.

- *get-write-special-evt* — either #f (the default), or a procedure to handle write-special-evt calls for the port. This argument must be #f if either *write-out-special* or *get-write-evt* is #f, and it must be a procedure if both of those arguments are procedures.

  If it is a procedure, it takes one argument: the special value to write. The resulting event (with its constraints) is analogous to the result of *get-write-evt*.

  If the event raises an exception, due to write or commit operations, it must not have committed the special value (though it may have committed previously buffered bytes and values).

- *get-location* — either #f (the default), or a procedure that takes no arguments and returns three values: the line number for the next item written to the port's stream (a positive number or #f), the column number for the next item written to port's stream (a non-negative number or #f), and the position for the next item written to port's stream (a positive number or #f). See also §13.1.4 "Counting Positions, Lines, and Columns".

  This procedure is called to implement port-next-location for the port, but only if line counting is enabled for the port via port-count-lines! (in which case *count-lines!* is called).

- *count-lines!* — a procedure of no arguments that is called if and when line counting is enabled for the port. The default procedure is void.

- *init-position* — normally an exact, positive integer that determines the position of the port's first item, which is used by file-position or when line counting is *not* enabled for the port. The default is 1. If *init-position* is #f, the port is treated as having an unknown position. If *init-position* is a port, then the given port's position is always used for the new port's position. If *init-position* is a procedure, it is called as needed to obtain the port's position.

- *buffer-mode* — either #f (the default) or a procedure that accepts zero or one arguments. If *buffer-mode* is #f, then the resulting port does not support a buffer-mode setting. Otherwise, the procedure is called with one symbol argument ('block, 'line, or 'none) to set the buffer mode, and it is called with zero arguments to get the current buffer mode. In the latter case, the result must be 'block, 'line, 'none, or #f (unknown). See §13.1.3 "Port Buffers and Positions" for more information on buffer modes.

Examples:

```
; A port that writes anything to nowhere:
> (define /dev/null-out
    (make-output-port
     'null
     always-evt
     (lambda (s start end non-block? breakable?) (- end start))
     void
     (lambda (special non-block? breakable?) #t)
     (lambda (s start end) (wrap-evt
                            always-evt
                            (lambda (x)
                              (- end start))))
     (lambda (special) always-evt)))
> (display "hello" /dev/null-out)
> (write-bytes-avail #"hello" /dev/null-out)
5
```

```
> (write-special 'hello /dev/null-out)
#t
> (sync (write-bytes-avail-evt #"hello" /dev/null-out))
5
; A port that accumulates bytes as characters in a list,
;  but not in a thread-safe way:
> (define accum-list null)
> (define accumulator/not-thread-safe
    (make-output-port
     'accum/not-thread-safe
     always-evt
     (lambda (s start end non-block? breakable?)
       (set! accum-list
             (append accum-list
                     (map integer->char
                          (bytes->list (subbytes s start end)))))
       (- end start))
     void))
> (display "hello" accumulator/not-thread-safe)
> accum-list
'(#\h #\e #\l #\l #\o)
; Same as before, but with simple thread-safety:
> (define accum-list null)
> (define accumulator
    (let* ([lock (make-semaphore 1)]
           [lock-peek-evt (semaphore-peek-evt lock)])
      (make-output-port
       'accum
       lock-peek-evt
       (lambda (s start end non-block? breakable?)
         (if (semaphore-try-wait? lock)
             (begin
               (set! accum-list
                     (append accum-list
                             (map integer->char
                                  (bytes->list
                                   (subbytes s start end)))))
               (semaphore-post lock)
               (- end start))
             ; Cheap strategy: block until the list is unlocked,
             ;   then return 0, so we get called again
             (wrap-evt
              lock-peek-evt
              (lambda (x) 0))))
       void)))
> (display "hello" accumulator)
```

```
> accum-list
'(#\h #\e #\l #\l #\o)
; A port that transforms data before sending it on
;  to another port. Atomic writes exploit the
;  underlying port's ability for atomic writes.
> (define (make-latin-1-capitalize port)
    (define (byte-upcase s start end)
      (list->bytes
       (map (lambda (b) (char->integer
                         (char-upcase
                          (integer->char b))))
            (bytes->list (subbytes s start end)))))
    (make-output-port
     'byte-upcase
     ; This port is ready when the original is ready:
     port
     ; Writing procedure:
     (lambda (s start end non-block? breakable?)
       (let ([s (byte-upcase s start end)])
         (if non-block?
             (write-bytes-avail* s port)
             (begin
               (display s port)
               (bytes-length s)))))
     ; Close procedure -- close original port:
     (lambda () (close-output-port port))
     #f
     ; Write event:
     (and (port-writes-atomic? port)
          (lambda (s start end)
            (write-bytes-avail-evt
             (byte-upcase s start end)
             port)))))
> (define orig-port (open-output-string))
> (define cap-port (make-latin-1-capitalize orig-port))
> (display "Hello" cap-port)
> (get-output-string orig-port)
"HELLO"
> (sync (write-bytes-avail-evt #"Bye" cap-port))
3
> (get-output-string orig-port)
"HELLOBYE"
```

13.1.10 More Port Constructors, Procedures, and Events

```
(require racket/port)        package: base
```

The bindings documented in this section are provided by the `racket/port` and `racket` libraries, but not `racket/base`.

Port String and List Conversions

```
(port->list [r in]) → (listof any/c)
  r : (input-port? . -> . any/c) = read
  in : input-port? = (current-input-port)
```

Returns a list whose elements are produced by calling *r* on *in* until it produces `eof`.

Examples:

```
> (define (read-number input-port)
    (define char (read-char input-port))
    (if (eof-object? char)
     char
     (string->number (string char))))
> (port->list read-number (open-input-string "12345"))
'(1 2 3 4 5)
```

```
(port->string [in #:close? close?]) → string?
  in : input-port? = (current-input-port)
  close? : any/c = #f
```

Reads all characters from *in* and returns them as a string. The input port is closed unless *close?* is `#f`.

Example:

```
> (port->string (open-input-string "hello world"))
"hello world"
```

Changed in version 6.8.0.2 of package `base`: Added the `#:close?` argument.

```
(port->bytes [in #:close? close?]) → bytes?
  in : input-port? = (current-input-port)
  close? : any/c = #f
```

Reads all bytes from *in* and returns them as a byte string. The input port is closed unless *close?* is `#f`.

Example:

```
> (port->bytes (open-input-string "hello world"))
#"hello world"
```

Changed in version 6.8.0.2 of package `base`: Added the `#:close?` argument.

```
(port->lines [in
              #:line-mode line-mode
              #:close? close?])      → (listof string?)
  in : input-port? = (current-input-port)
  line-mode : (or/c 'linefeed 'return 'return-linefeed 'any 'any-one)
            = 'any
  close? : any/c = #f
```

Read all characters from *in*, breaking them into lines. The *line-mode* argument is the same as the second argument to `read-line`, but the default is `'any` instead of `'linefeed`. The input port is closed unless *close?* is `#f`.

Example:

```
> (port->lines
    (open-input-string "line 1\nline 2\n  line 3\nline 4"))
'("line 1" "line 2" "  line 3" "line 4")
```

Changed in version 6.8.0.2 of package `base`: Added the `#:close?` argument.

```
(port->bytes-lines [in
                    #:line-mode line-mode
                    #:close? close?])      → (listof bytes?)
  in : input-port? = (current-input-port)
  line-mode : (or/c 'linefeed 'return 'return-linefeed 'any 'any-one)
            = 'any
  close? : any/c = #f
```

Like `port->lines`, but reading bytes and collecting them into lines like `read-bytes-line`. The input port is closed unless *close?* is `#f`.

Example:

```
> (port->bytes-lines
    (open-input-string "line 1\nline 2\n  line 3\nline 4"))
'(#"line 1" #"line 2" #"  line 3" #"line 4")
```

Changed in version 6.8.0.2 of package `base`: Added the `#:close?` argument.

```
(display-lines lst
               [out
                #:separator separator]) → void?
  lst : list?
  out : output-port? = (current-output-port)
  separator : any/c = #"\n"
```

Uses `display` on each element of *`lst`* to *`out`*, adding *`separator`* after each element.

```
(call-with-output-string proc) → string?
  proc : (output-port? . -> . any)
```

Calls *`proc`* with an output port that accumulates all output into a string, and returns the string.

The port passed to *`proc`* is like the one created by `open-output-string`, except that it is wrapped via `dup-output-port`, so that *`proc`* cannot access the port's content using `get-output-string`. If control jumps back into *`proc`*, the port continues to accumulate new data, and `call-with-output-string` returns both the old data and newly accumulated data.

```
(call-with-output-bytes proc) → bytes?
  proc : (output-port? . -> . any)
```

Like `call-with-output-string`, but returns the accumulated result in a byte string instead of a string. Furthermore, the port's content is emptied when `call-with-output-bytes` returns, so that if control jumps back into *`proc`* and returns a second time, only the newly accumulated bytes are returned.

```
(with-output-to-string proc) → string?
  proc : (-> any)
```

Equivalent to

```
(call-with-output-string
 (lambda (p) (parameterize ([current-output-port p])
               (proc))))
```

```
(with-output-to-bytes proc) → bytes?
  proc : (-> any)
```

Equivalent to

```
(call-with-output-bytes
 (lambda (p) (parameterize ([current-output-port p])
               (proc))))
```

```
(call-with-input-string str proc) → any
  str : string?
  proc : (input-port? . -> . any)
```

Equivalent to `(proc (open-input-string str))`.

```
(call-with-input-bytes bstr proc) → any
  bstr : bytes?
  proc : (input-port? . -> . any)
```

Equivalent to `(proc (open-input-bytes bstr))`.

```
(with-input-from-string str proc) → any
  str : string?
  proc : (-> any)
```

Equivalent to

```
(parameterize ([current-input-port (open-input-string str)])
  (proc))
```

```
(with-input-from-bytes bstr proc) → any
  bstr : bytes?
  proc : (-> any)
```

Equivalent to

```
(parameterize ([current-input-port (open-input-bytes str)])
  (proc))
```

Creating Ports

```
(input-port-append close-at-eof?
                   in ...
                  [#:name name]) → input-port?
  close-at-eof? : any/c
  in : input-port?
  name : any/c = (map object-name in)
```

Takes any number of input ports and returns an input port. Reading from the input port draws bytes (and special non-byte values) from the given input ports in order. If *close-at-eof?* is true, then each port is closed when an end-of-file is encountered from the port, or when the result input port is closed. Otherwise, data not read from the returned input port remains available for reading in its original input port.

The *name* argument determines the name as reported by `object-name` for the returned input port.

See also `merge-input`, which interleaves data from multiple input ports as it becomes available.

Changed in version 6.90.0.19 of package `base`: Added the *name* argument.

```
(make-input-port/read-to-peek  name
                               read-in
                               fast-peek
                               close
                              [get-location
                               count-lines!
                               init-position
                               buffer-mode
                               buffering?
                               on-consumed])  →  input-port?
  name : any/c
  read-in : (bytes?
             . -> . (or/c exact-nonnegative-integer?
                          eof-object?
                          procedure?
                          evt?))
  fast-peek : (or/c #f
                    (bytes? exact-nonnegative-integer?
                     (bytes? exact-nonnegative-integer?
                      . -> . (or/c exact-nonnegative-integer?
                                   eof-object?
                                   procedure?
                                   evt?
                                   #f))
                     . -> . (or/c exact-nonnegative-integer?
                                  eof-object?
                                  procedure?
                                  evt?
                                  #f)))
  close : (-> any)
```

```
get-location : (or/c                                    = #f
                (->
                 (values
                  (or/c exact-positive-integer? #f)
                  (or/c exact-nonnegative-integer? #f)
                  (or/c exact-positive-integer? #f)))
                #f)
count-lines! : (-> any) = void
init-position : exact-positive-integer? = 1
buffer-mode :  (or/c (case-> ((or/c 'block 'none) . -> . any)
                             (-> (or/c 'block 'none #f)))
                     #f)
             = #f
buffering? : any/c = #f
on-consumed :  (or/c ((or/c exact-nonnegative-integer? eof-object?
                            procedure? evt?)
                      . -> . any)
                     #f)
             = #f
```

Similar to `make-input-port`, but if the given *read-in* returns an event, the event's value must be `0`. The resulting port's peek operation is implemented automatically (in terms of *read-in*) in a way that can handle special non-byte values. The progress-event and commit operations are also implemented automatically. The resulting port is thread-safe, but not kill-safe (i.e., if a thread is terminated or suspended while using the port, the port may become damaged).

The *read-in*, *close*, *get-location*, *count-lines!*, *init-position*, and *buffer-mode* procedures are the same as for `make-input-port`.

The *fast-peek* argument can be either `#f` or a procedure of three arguments: a byte string to receive a peek, a skip count, and a procedure of two arguments. The *fast-peek* procedure can either implement the requested peek, or it can dispatch to its third argument to implement the peek. The *fast-peek* is not used when a peek request has an associated progress event.

The *buffering?* argument determines whether *read-in* can be called to read more characters than are immediately demanded by the user of the new port. If *buffer-mode* is not `#f`, then *buffering?* determines the initial buffer mode, and *buffering?* is enabled after a buffering change only if the new mode is `'block`.

If *on-consumed* is not `#f`, it is called when data is read (or committed) from the port, as opposed to merely peeked. The argument to *on-consumed* is the result value of the port's reading procedure, so it can be an integer or any result from *read-in*.

```
(make-limited-input-port in
                         limit
                        [close-orig?]) → input-port?
  in : input-port?
  limit : exact-nonnegative-integer?
  close-orig? : any/c = #t
```

Returns a port whose content is drawn from *in*, but where an end-of-file is reported after *limit* bytes (and non-byte special values) have been read. If *close-orig?* is true, then the original port is closed if the returned port is closed.

Bytes are consumed from *in* only when they are consumed from the returned port. In particular, peeking into the returned port peeks into the original port.

If *in* is used directly while the resulting port is also used, then the *limit* bytes provided by the port need not be contiguous parts of the original port's stream.

```
(make-pipe-with-specials [limit
                          in-name
                          out-name]) → input-port? output-port?
  limit : exact-nonnegative-integer? = #f
  in-name : any/c = 'pipe
  out-name : any/c = 'pipe
```

Returns two ports: an input port and an output port. The ports behave like those returned by `make-pipe`, except that the ports support non-byte values written with procedures such as `write-special` and read with procedures such as `get-byte-or-special`.

The *limit* argument determines the maximum capacity of the pipe in bytes, but this limit is disabled if special values are written to the pipe before *limit* is reached. The limit is re-enabled after the special value is read from the pipe.

The optional *in-name* and *out-name* arguments determine the names of the result ports.

```
(combine-output a-out b-out) → output-port?
  a-out : output-port?
  b-out : output-port?
```

Accepts two output ports and returns a new output port combining the original ports. When written to, the combined port first writes as many bytes as possible to *a-out*, and then tries to write the same number of bytes to *b-out*. If that doesn't succeed, what is left over is buffered and no further writes can go through until the ports are evened out. The port is ready (for the purposes of synchronization) when each port reports being ready. However, the first port may stop being ready while waiting on the second port to sync, so it cannot be guaranteed that both ports are ready at once. Closing the combined port is done after writing all remaining bytes to *b-out*.

Added in version 7.7.0.10 of package `base`.

```
(merge-input a-in b-in [buffer-limit]) → input-port?
  a-in : input-port?
  b-in : input-port?
  buffer-limit : (or/c exact-nonnegative-integer? #f) = 4096
```

Accepts two input ports and returns a new input port. The new port merges the data from two original ports, so data can be read from the new port whenever it is available from either of the two original ports. The data from the original ports are interleaved. When an end-of-file has been read from an original port, it no longer contributes characters to the new port. After an end-of-file has been read from both original ports, the new port returns end-of-file. Closing the merged port does not close the original ports.

The optional `buffer-limit` argument limits the number of bytes to be buffered from `a-in` and `b-in`, so that the merge process does not advance arbitrarily beyond the rate of consumption of the merged data. A `#f` value disables the limit. As for `make-pipe-with-specials`, `buffer-limit` does not apply when a special value is produced by one of the input ports before the limit is reached.

See also `input-port-append`, which concatenates input streams instead of interleaving them.

```
(open-output-nowhere [name special-ok?]) → output-port?
  name : any/c = 'nowhere
  special-ok? : any/c = #t
```

Creates and returns an output port that discards all output sent to it (without blocking). The `name` argument is used as the port's name. If the `special-ok?` argument is true, then the resulting port supports `write-special`, otherwise it does not.

```
(open-input-nowhere [name]) → input-port?
  name : any/c = 'nowhere
```

Creates and returns an input port that always returns `eof` (without blocking). The `name` argument is used as the port's name.

Added in version 8.15.0.2 of package `base`.

```
(peeking-input-port  in
                    [name
                     skip
                     #:init-position init-position])
 → input-port?
  in : input-port?
  name : any/c = (object-name in)
  skip : exact-nonnegative-integer? = 0
  init-position : exact-positive-integer? = 1
```

Returns an input port whose content is determined by peeking into *in*. In other words, the resulting port contains an internal skip count, and each read of the port peeks into *in* with the internal skip count, and then increments the skip count according to the amount of data successfully peeked.

The optional *name* argument is the name of the resulting port. The *skip* argument is the port initial skip count, and it defaults to `0`.

The resulting port's initial position (as reported by `file-position`) is `(- init-position 1)`, no matter the position of *in*.

The resulting port supports buffering, and a `'block` buffer mode allows the port to peek further into *in* than requested. The resulting port's initial buffer mode is `'block`, unless *in* supports buffer mode and its mode is initially `'none` (i.e., the initial buffer mode is taken from *in* when it supports buffering). If *in* supports buffering, adjusting the resulting port's buffer mode via `file-stream-buffer-mode` adjusts *in*'s buffer mode.

For example, when you read from a peeking port, you see the same answers as when you read from the original port:

Examples:

```
> (define an-original-port (open-input-string "123456789"))
> (define a-peeking-port (peeking-input-port an-original-port))
> (file-stream-buffer-mode a-peeking-port 'none)
> (read-string 3 a-peeking-port)
"123"
> (read-string 3 an-original-port)
"123"
```

Beware that the read from the original port is invisible to the peeking port, which keeps its own separate internal counter, and thus interleaving reads on the two ports can produce confusing results. Continuing the example before, if we read three more characters from the peeking port, we end up skipping over the `456` in the port (but only because we disabled buffering above):

Example:

```
> (read-string 3 a-peeking-port)
"789"
```

If we had left the buffer mode of `a-peeking-port` alone, that last `read-string` would have likely produced `"456"` as a result of buffering bytes from `an-original-port` earlier.

Changed in version 6.1.0.3 of package `base`: Enabled buffering and buffer-mode adjustments via `file-stream-buffer-mode`, and set the port's initial buffer mode to that of *in*.

```
(reencode-input-port  in
                      encoding
                     [error-bytes
                      close?
                      name
                      convert-newlines?
                      enc-error])       → input-port?
  in : input-port?
  encoding : string?
  error-bytes : (or/c #f bytes?) = #f
  close? : any/c = #f
  name : any/c = (object-name in)
  convert-newlines? : any/c = #f
  enc-error : (string? input-port? . -> . any)
           = (lambda (msg port) (error ...))
```

Produces an input port that draws bytes from *in*, but converts the byte stream using `(bytes-open-converter encoding-str "UTF-8")`. In addition, if *convert-newlines?* is true, then decoded sequences that correspond to UTF-8 encodings of `"\r\n"`, `"\r\u0085"`, `"\r"`, `"\u0085"`, and `"\u2028"` are all converted to the UTF-8 encoding of `"\n"`.

If *error-bytes* is provided and not `#f`, then the given byte sequence is used in place of bytes from *in* that trigger conversion errors. Otherwise, if a conversion is encountered, *enc-error* is called, which must raise an exception.

If *close?* is true, then closing the result input port also closes *in*. The *name* argument is used as the name of the result input port.

In non-buffered mode, the resulting input port attempts to draw bytes from *in* only as needed to satisfy requests. Toward that end, the input port assumes that at least *n* bytes must be read to satisfy a request for *n* bytes. (This is true even if the port has already drawn some bytes, as long as those bytes form an incomplete encoding sequence.)

```
(reencode-output-port  out
                       encoding
                      [error-bytes
                       close?
                       name
                       newline-bytes
                       enc-error])    → output-port?
  out : output-port?
  encoding : string?
  error-bytes : (or/c #f bytes?) = #f
  close? : any/c = #f
  name : any/c = (object-name out)
  newline-bytes : (or/c #f bytes?) = #f
```

```
enc-error : (string? output-port? . -> . any)
          = (lambda (msg port) (error ...))
```

Produces an output port that directs bytes to *out*, but converts its byte stream using `(bytes-open-converter "UTF-8" encoding-str)`. In addition, if *newline-bytes* is not `#f`, then bytes written to the port that are the UTF-8 encoding of `"\n"` are first converted to *newline-bytes* (before applying the convert from UTF-8 to `encoding-str`).

If *error-bytes* is provided and not `#f`, then the given byte sequence is used in place of bytes that have been sent to the output port and that trigger conversion errors. Otherwise, *enc-error* is called, which must raise an exception.

If *close?* is true, then closing the result output port also closes *out*. The *name* argument is used as the name of the result output port.

The resulting port supports buffering, and the initial buffer mode is `(or (file-stream-buffer-mode out) 'block)`. In `'block` mode, the port's buffer is flushed only when it is full or a flush is requested explicitly. In `'line` mode, the buffer is flushed whenever a newline or carriage-return byte is written to the port. In `'none` mode, the port's buffer is flushed after every write. Implicit flushes for `'line` or `'none` leave bytes in the buffer when they are part of an incomplete encoding sequence.

The resulting output port does not support atomic writes. An explicit flush or special-write to the output port can hang if the most recently written bytes form an incomplete encoding sequence.

When the port is buffered, a flush callback is registered with the current plumber to flush the buffer.

```
(dup-input-port in [close?]) → input-port?
  in : input-port?
  close? : any/c = #f
```

Returns an input port that draws directly from *in*. Closing the resulting port closes *in* only if *close?* is `#t`.

The new port is initialized with the port read handler of *in*, but setting the handler on the result port does not affect reading directly from *in*.

```
(dup-output-port out [close?]) → output-port?
  out : output-port?
  close? : any/c = #f
```

Returns an output port that propagates data directly to *out*. Closing the resulting port closes *out* only if *close?* is `#t`.

The new port is initialized with the port display handler and port write handler of *out*, but setting the handlers on the result port does not affect writing directly to *out*.

```
(relocate-input-port  in
                      line
                      column
                      position
                     [close?]
                      #:name name) → input-port?
  in : input-port?
  line : (or/c exact-positive-integer? #f)
  column : (or/c exact-nonnegative-integer? #f)
  position : exact-positive-integer?
  close? : any/c = #t
  name : (object-name in)
```

Produces an input port that is equivalent to *in* except in how it reports location information (and possibly its name). The resulting port's content starts with the remaining content of *in*, and it starts at the given line, column, and position. A `#f` for the line or column means that the line and column will always be reported as `#f`.

The *line* and *column* values are used only if line counting is enabled for *in* and for the resulting port, typically through `port-count-lines!`. The *column* value determines the column for the first line (i.e., the one numbered *line*), and later lines start at column `0`. The given *position* is used even if line counting is not enabled.

When line counting is on for the resulting port, reading from *in* instead of the resulting port increments location reports from the resulting port. Otherwise, the resulting port's position does not increment when data is read from *in*.

If *close?* is true, then closing the resulting port also closes *in*. If *close?* is `#f`, then closing the resulting port does not close *in*.

The *name* argument is used as the name for the resulting port; the default value keeps the same name as *in*.

```
(relocate-output-port  out
                       line
                       column
                       position
                      [close?]
                       #:name name) → output-port?
  out : output-port?
  line : (or/c exact-positive-integer? #f)
  column : (or/c exact-nonnegative-integer? #f)
  position : exact-positive-integer?
  close? : any/c = #t
  name : (object-name out)
```

Like relocate-input-port, but for output ports.

```
(transplant-input-port  in
                        get-location
                        init-pos
                       [close?
                        count-lines!]
                        #:name name)  → input-port?
  in : input-port?
  get-location : (or/c
                  (->
                   (values
                    (or/c exact-positive-integer? #f)
                    (or/c exact-nonnegative-integer? #f)
                    (or/c exact-positive-integer? #f)))
                  #f)
  init-pos : exact-positive-integer?
  close? : any/c = #t
  count-lines! : (-> any) = void
  name : (object-name in)
```

Like relocate-input-port, except that arbitrary position information can be produced (when line counting is enabled) via *get-location*, which is used as for make-input-port. If *get-location* is #f, then the port counts lines in the usual way starting from *init-pos*, independent of locations reported by *in*.

If *count-lines!* is supplied, it is called when line counting is enabled for the resulting port. The default is void.

```
(transplant-output-port  out
                         get-location
                         init-pos
                        [close?
                         count-lines!]
                         #:name name)  → output-port?
  out : output-port?
  get-location : (or/c
                  (->
                   (values
                    (or/c exact-positive-integer? #f)
                    (or/c exact-nonnegative-integer? #f)
                    (or/c exact-positive-integer? #f)))
                  #f)
  init-pos : exact-positive-integer?
  close? : any/c = #t
  count-lines! : (-> any) = void
  name : (object-name out)
```

Like transplant-input-port, but for output ports.

```
(filter-read-input-port in
                        read-wrap
                        peek-wrap
                       [close?])  → input-port?
  in : input-port?
  read-wrap : (bytes? (or/c exact-nonnegative-integer?
                            eof-object?
                            procedure?
                            evt?)
                      . -> .
                      (or/c exact-nonnegative-integer?
                            eof-object?
                            procedure?
                            evt?))
  peek-wrap : (bytes? exact-nonnegative-integer? (or/c evt? #f)
                      (or/c exact-nonnegative-integer?
                       eof-object?
                       procedure?
                       evt?
                       #f)
               . -> . (or/c exact-nonnegative-integer?
                       eof-object?
                       procedure?
                       evt?
                       #f))
  close? : any/c = #t
```

Creates a port that draws from *in*, but each result from the port's read and peek procedures (in the sense of make-input-port) is filtered by *read-wrap* and *peek-wrap*. The filtering procedures each receive both the arguments and results of the read and peek procedures on *in* for each call.

If *close?* is true, then closing the resulting port also closes *in*.

```
(special-filter-input-port in proc [close?]) → input-port?
  in : input-port?
  proc : (procedure? bytes? . -> . (or/c exact-nonnegative-integer?
                                         eof-object?
                                         procedure?
                                         evt?))
  close? : any/c = #t
```

Produces an input port that is equivalent to *in*, except that when *in* produces a procedure to access a special value, *proc* is applied to the procedure to allow the special value to be replaced with an alternative. The *proc* is called with the special-value procedure and the byte string that was given to the port's read or peek function (see make-input-port), and the result is used as the read or peek function's result. The *proc* can modify the byte string to substitute a byte for the special value, but the byte string is guaranteed only to hold at least one byte.

If *close?* is true, then closing the resulting input port also closes *in*.

Port Events

```
(eof-evt in) → evt?
  in : input-port?
```

Returns a synchronizable event that is ready when *in* produces an eof. If *in* produces a mid-stream eof, the eof is consumed by the event only if the event is chosen in a synchronization.

If attempting to read from *in* raises an exception during a synchronization attempt, then the exception may be reported during the synchronization attempt, but it will silently discarded if some another event in the same synchronization is selected or if some other event raises an exception first.

Changed in version 7.5.0.3 of package base: Changed handling of read errors so they are propagated to a synchronization attempt, instead of treated as unhandled errors in a background thread.

```
(read-bytes-evt k in) → evt?
  k : exact-nonnegative-integer?
  in : input-port?
```

Returns a synchronizable event that is ready when *k* bytes can be read from *in*, or when an end-of-file is encountered in *in*. If *k* is 0, then the event is ready immediately with "". For non-zero *k*, if no bytes are available before an end-of-file, the event's result is eof. Otherwise, the event's result is a byte string of up to *k* bytes, which contains as many bytes as are available (up to *k*) before an available end-of-file. (The result is a byte string of less than *k* bytes only when an end-of-file is encountered.)

Bytes are read from the port if and only if the event is chosen in a synchronization, and the returned bytes always represent contiguous bytes in the port's stream.

The event can be synchronized multiple times—even concurrently—and each synchronization corresponds to a distinct read request.

The *in* must support progress events, and it must not produce a special non-byte value during the read attempt.

Exceptions attempting to read from *in* are handled in the same way as by eof-evt.

```
(read-bytes!-evt bstr in) → evt?
  bstr : (and/c bytes? (not/c immutable?))
  in : input-port?
```

Like `read-bytes-evt`, except that the read bytes are placed into *bstr*, and the number of bytes to read corresponds to `(bytes-length bstr)`. The event's result is either `eof` or the number of read bytes.

The *bstr* may be mutated any time after the first synchronization attempt on the event and until either the event is selected, a non-`#f` `progress-evt` is ready, or the current custodian (at the time of synchronization) is shut down. Note that there is no time bound otherwise on when *bstr* might be mutated if the event is not selected by a synchronzation; nevertheless, multiple synchronization attempts can use the same result from `read-bytes!-evt` as long as there is no intervening read on *in* until one of the synchronization attempts selects the event.

Exceptions attempting to read from *in* are handled in the same way as by `eof-evt`.

```
(read-bytes-avail!-evt bstr in) → evt?
  bstr : (and/c bytes? (not/c immutable?))
  in : input-port?
```

Like `read-bytes!-evt`, except that the event reads only as many bytes as are immediately available, after at least one byte or one `eof` becomes available.

```
(read-string-evt k in) → evt?
  k : exact-nonnegative-integer?
  in : input-port?
```

Like `read-bytes-evt`, but for character strings instead of byte strings.

```
(read-string!-evt str in) → evt?
  str : (and/c string? (not/c immutable?))
  in : input-port?
```

Like `read-bytes!-evt`, but for a character string instead of a byte string.

```
(read-line-evt in [mode]) → evt?
  in : input-port?
  mode : (or/c 'linefeed 'return 'return-linefeed 'any 'any-one)
       = 'linefeed
```

Returns a synchronizable event that is ready when a line of characters or end-of-file can be read from *in*. The meaning of *mode* is the same as for `read-line`. The event result is the read line of characters (not including the line separator).

A line is read from the port if and only if the event is chosen in a synchronization, and the returned line always represents contiguous bytes in the port's stream.

Exceptions attempting to read from *in* are handled in the same way as by `eof-evt`.

```
(read-bytes-line-evt in [mode]) → evt?
  in : input-port?
  mode : (or/c 'linefeed 'return 'return-linefeed 'any 'any-one)
       = 'linefeed
```

Like `read-line-evt`, but returns a byte string instead of a string.

```
(peek-bytes-evt k skip progress-evt in) → evt?
  k : exact-nonnegative-integer?
  skip : exact-nonnegative-integer?
  progress-evt : (or/c progress-evt? #f)
  in : input-port?
(peek-bytes!-evt bstr skip progress-evt in) → evt?
  bstr : (and/c bytes? (not/c immutable?))
  skip : exact-nonnegative-integer?
  progress-evt : (or/c progress-evt? #f)
  in : input-port?
(peek-bytes-avail!-evt bstr
                       skip
                       progress-evt
                       in)          → evt?
  bstr : (and/c bytes? (not/c immutable?))
  skip : exact-nonnegative-integer?
  progress-evt : (or/c progress-evt? #f)
  in : input-port?
(peek-string-evt k skip progress-evt in) → evt?
  k : exact-nonnegative-integer?
  skip : exact-nonnegative-integer?
  progress-evt : (or/c progress-evt? #f)
  in : input-port?
(peek-string!-evt str skip progress-evt in) → evt?
  str : (and/c string? (not/c immutable?))
  skip : exact-nonnegative-integer?
  progress-evt : (or/c progress-evt? #f)
  in : input-port?
```

Like the `read-bytes-evt`, etc., functions, but for peeking. The *skip* argument indicates the number of bytes to skip, and *progress-evt* indicates an event that effectively cancels the peek (so that the event never becomes ready). The *progress-evt* argument can be `#f`, in which case the event is never canceled.

```
(regexp-match-evt pattern in) → any
  pattern : (or/c string? bytes? regexp? byte-regexp?)
  in : input-port?
```

Returns a synchronizable event that is ready when `pattern` matches the stream of bytes/characters from `in`; see also `regexp-match`. The event's value is the result of the match, in the same form as the result of `regexp-match`.

If `pattern` does not require a start-of-stream match, then bytes skipped to complete the match are read and discarded when the event is chosen in a synchronization.

Bytes are read from the port if and only if the event is chosen in a synchronization, and the returned match always represents contiguous bytes in the port's stream. If not-yet-available bytes from the port might contribute to the match, the event is not ready. Similarly, if `pattern` begins with a start-of-stream `^` and the `pattern` does not initially match, then the event cannot become ready until bytes have been read from the port.

The event can be synchronized multiple times—even concurrently—and each synchronization corresponds to a distinct match request.

The `in` port must support progress events. If `in` returns a special non-byte value during the match attempt, it is treated like `eof`.

Exceptions attempting to read from `in` are handled in the same way as by `eof-evt`.

Copying Streams

```
(convert-stream from-encoding
                in
                to-encoding
                out)          → void?
  from-encoding : string?
  in : input-port?
  to-encoding : string?
  out : output-port?
```

Reads data from `in`, converts it using `(bytes-open-converter from-encoding to-encoding)` and writes the converted bytes to `out`. The `convert-stream` procedure returns after reaching `eof` in `in`.

If opening the converter fails, the `exn:fail` exception is raised. Similarly, if a conversion error occurs at any point while reading from `in`, then `exn:fail` exception is raised.

```
(copy-port in out ...+) → void?
  in : input-port?
  out : output-port?
```

Reads data from *in* and writes it back out to *out*, returning when *in* produces `eof`. The copy is efficient, and it is without significant buffer delays (i.e., a byte that becomes available on *in* is immediately transferred to *out*, even if future reads on *in* must block). If *in* produces a special non-byte value, it is transferred to *out* using `write-special`.

This function is often called from a "background" thread to continuously pump data from one stream to another.

If multiple *out*s are provided, data from *in* is written to every *out*. The different *out*s block output to each other, because each block of data read from *in* is written completely to one *out* before moving to the next *out*. The *out*s are written in the provided order, so non-blocking ports (e.g., file output ports) should be placed first in the argument list.

13.2 Byte and String Input

```
(read-char [in]) → (or/c char? eof-object?)
  in : input-port? = (current-input-port)
```

Reads a single character from *in*—which may involve reading several bytes to UTF-8-decode them into a character (see §13.1 "Ports"); a minimal number of bytes are read/peeked to perform the decoding. If no bytes are available before an end-of-file, then `eof` is returned.

Examples:

```
> (let ([ip (open-input-string "S2")])
    (print (read-char ip))
    (newline)
    (print (read-char ip))
    (newline)
    (print (read-char ip)))
#\S
#\2
#<eof>
> (let ([ip (open-input-bytes #"\316\273")])
    ; The byte string contains UTF-8-encoded content:
    (print (read-char ip)))
#\λ
```

```
(read-byte [in]) → (or/c byte? eof-object?)
  in : input-port? = (current-input-port)
```

Reads a single byte from *in*. If no bytes are available before an end-of-file, then `eof` is returned.

Examples:

```
> (let ([ip (open-input-string "a")])
    ; The two values in the following list should be the same.
    (list (read-byte ip) (char->integer #\a)))
'(97 97)
> (let ([ip (open-input-string (string #\λ))])
    ; This string has a two byte-encoding.
    (list (read-byte ip) (read-byte ip) (read-byte ip)))
'(206 187 #<eof>)
```

```
(read-line [in mode]) → (or/c string? eof-object?)
  in : input-port? = (current-input-port)
  mode : (or/c 'linefeed 'return 'return-linefeed 'any 'any-one)
       = 'linefeed
```

Returns a string containing the next line of bytes from *in*.

Characters are read from *in* until a line separator or an end-of-file is read. The line separator is not included in the result string (but it is removed from the port's stream). If no characters are read before an end-of-file is encountered, `eof` is returned.

The *mode* argument determines the line separator(s). It must be one of the following symbols:

- `'linefeed` breaks lines on linefeed characters.
- `'return` breaks lines on return characters.
- `'return-linefeed` breaks lines on return-linefeed combinations. If a return character is not followed by a linefeed character, it is included in the result string; similarly, a linefeed that is not preceded by a return is included in the result string.
- `'any` breaks lines on any of a return character, linefeed character, or return-linefeed combination. If a return character is followed by a linefeed character, the two are treated as a combination.
- `'any-one` breaks lines on either a return or linefeed character, without recognizing return-linefeed combinations.

Return and linefeed characters are detected after the conversions that are automatically performed when reading a file in text mode. For example, reading a file in text mode on Windows automatically changes return-linefeed combinations to a linefeed. Thus, when a file is opened in text mode, `'linefeed` is usually the appropriate `read-line` mode.

Examples:

```
> (let ([ip (open-input-string "x\ny\n")])
    (read-line ip))
"x"
```

```
> (let ([ip (open-input-string "x\ny\n")])
    (read-line ip 'return))
"x\ny\n"
> (let ([ip (open-input-string "x\ry\r")])
    (read-line ip 'return))
"x"
> (let ([ip (open-input-string "x\r\ny\r\n")])
    (read-line ip 'return-linefeed))
"x"
> (let ([ip (open-input-string "x\r\ny\nz")])
    (list (read-line ip 'any) (read-line ip 'any)))
'("x" "y")
> (let ([ip (open-input-string "x\r\ny\nz")])
    (list (read-line ip 'any-one) (read-line ip 'any-one)))
'("x" "")
```

```
(read-bytes-line [in mode]) → (or/c bytes? eof-object?)
  in : input-port? = (current-input-port)
  mode : (or/c 'linefeed 'return 'return-linefeed 'any 'any-one)
       = 'linefeed
```

Like `read-line`, but reads bytes and produces a byte string.

```
(read-string amt [in]) → (or/c string? eof-object?)
  amt : exact-nonnegative-integer?
  in : input-port? = (current-input-port)
```

Returns a string containing the next *amt* characters from *in*.

To read an entire port as a string, use `port->string`.

If *amt* is `0`, then the empty string is returned. Otherwise, if fewer than *amt* characters are available before an end-of-file is encountered, then the returned string will contain only those characters before the end-of-file; that is, the returned string's length will be less than *amt*. (A temporary string of size *amt* is allocated while reading the input, even if the size of the result is less than *amt* characters.) If no characters are available before an end-of-file, then `eof` is returned.

If an error occurs during reading, some characters may be lost; that is, if `read-string` successfully reads some characters before encountering an error, the characters are dropped.

Example:

```
> (let ([ip (open-input-string "supercalifragilisticexpialidocious")])
    (read-string 5 ip))
"super"
```

```
(read-bytes amt [in]) → (or/c bytes? eof-object?)
  amt : exact-nonnegative-integer?
  in : input-port? = (current-input-port)
```

To read an entire port as bytes, use `port->bytes`.

Like `read-string`, but reads bytes and produces a byte string.

Example:

```
> (let ([ip (open-input-bytes
                      (bytes 6
                             115 101 99 114 101
                             116))])
    (define length (read-byte ip))
    (bytes->string/utf-8 (read-bytes length ip)))
"secret"
```

```
(read-string! str [in start-pos end-pos])
 → (or/c exact-nonnegative-integer? eof-object?)
  str : (and/c string? (not/c immutable?))
  in : input-port? = (current-input-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (string-length str)
```

Reads characters from *in* like `read-string`, but puts them into *str* starting from index *start-pos* (inclusive) up to *end-pos* (exclusive). Like `substring`, the `exn:fail:contract` exception is raised if *start-pos* or *end-pos* is out-of-range for *str*.

If the difference between *start-pos* and *end-pos* is `0`, then `0` is returned and *str* is not modified. If no bytes are available before an end-of-file, then `eof` is returned. Otherwise, the return value is the number of characters read. If m characters are read and m<*end-pos*-*start-pos*, then *str* is not modified at indices *start-pos*+m through *end-pos*.

Example:

```
> (let ([buffer (make-string 10 #\_)]
        [ip (open-input-string "cketRa")])
    (printf "~s\n" buffer)
    (read-string! buffer ip 2 6)
    (printf "~s\n" buffer)
    (read-string! buffer ip 0 2)
    (printf "~s\n" buffer))
"__________"
"__cket____"
"Racket____"
```

```
(read-bytes! bstr [in start-pos end-pos])
 → (or/c exact-nonnegative-integer? eof-object?)
  bstr : bytes?
  in : input-port? = (current-input-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `read-string!`, but reads bytes, puts them into a byte string, and returns the number of bytes read.

Example:

```
> (let ([buffer (make-bytes 10 (char->integer #\_))]
        [ip (open-input-string "cketRa")])
    (printf "~s\n" buffer)
    (read-bytes! buffer ip 2 6)
    (printf "~s\n" buffer)
    (read-bytes! buffer ip 0 2)
    (printf "~s\n" buffer))
#"__________"
#"__cket____"
#"Racket____"
```

```
(read-bytes-avail! bstr [in start-pos end-pos])
 → (or/c exact-nonnegative-integer? eof-object? procedure?)
  bstr : bytes?
  in : input-port? = (current-input-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `read-bytes!`, but returns without blocking after having read the immediately available bytes, and it may return a procedure for a "special" result. The `read-bytes-avail!` procedure blocks only if no bytes (or specials) are yet available. Also unlike `read-bytes!`, `read-bytes-avail!` never drops bytes; if `read-bytes-avail!` successfully reads some bytes and then encounters an error, it suppresses the error (treating it roughly like an end-of-file) and returns the read bytes. (The error will be triggered by future reads.) If an error is encountered before any bytes have been read, an exception is raised.

When *in* produces a special value, as described in §13.1.9 "Custom Ports", the result is a procedure of four arguments. The four arguments correspond to the location of the special value within the port, as described in §13.1.9 "Custom Ports". If the procedure is called more than once with valid arguments, the `exn:fail:contract` exception is raised. If `read-bytes-avail!` returns a special-producing procedure, then it does not place characters in *bstr*. Similarly, `read-bytes-avail!` places only as many bytes into *bstr* as are available before a special value in the port's stream.

```
(read-bytes-avail!* bstr
                   [in
                    start-pos
                    end-pos])
 → (or/c exact-nonnegative-integer? eof-object? procedure?)
  bstr : bytes?
  in : input-port? = (current-input-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `read-bytes-avail!`, but returns `0` immediately if no bytes (or specials) are available for reading and the end-of-file is not reached.

```
(read-bytes-avail!/enable-break bstr
                                [in
                                 start-pos
                                 end-pos])
 → (or/c exact-nonnegative-integer? eof-object? procedure?)
  bstr : bytes?
  in : input-port? = (current-input-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `read-bytes-avail!`, but breaks are enabled during the read (see also §10.6 "Breaks"). If breaking is disabled when `read-bytes-avail!/enable-break` is called, and if the `exn:break` exception is raised as a result of the call, then no bytes will have been read from *in*.

```
(peek-string amt skip-bytes-amt [in]) → (or/c string? eof-object?)
  amt : exact-nonnegative-integer?
  skip-bytes-amt : exact-nonnegative-integer?
  in : input-port? = (current-input-port)
```

Similar to `read-string`, except that the returned characters are peeked: preserved in the port for future reads and peeks. (More precisely, undecoded bytes are left for future reads and peeks.) The *skip-bytes-amt* argument indicates a number of bytes (*not* characters) in the input stream to skip before collecting characters to return; thus, in total, the next *skip-bytes-amt* bytes plus *amt* characters are inspected.

For most kinds of ports, inspecting *skip-bytes-amt* bytes and *amt* characters requires at least *skip-bytes-amt*+*amt* bytes of memory overhead associated with the port, at least until the bytes/characters are read. No such overhead is required when peeking into a string port (see §13.1.6 "String Ports"), a pipe port (see §13.1.7 "Pipes"), or a custom port with a specific peek procedure (depending on how the peek procedure is implemented; see §13.1.9 "Custom Ports").

If a port produces `eof` mid-stream, attempts to skip beyond the `eof` for a peek always produce `eof` until the `eof` is read.

```
(peek-bytes amt skip-bytes-amt [in]) → (or/c bytes? eof-object?)
  amt : exact-nonnegative-integer?
  skip-bytes-amt : exact-nonnegative-integer?
  in : input-port? = (current-input-port)
```

Like `peek-string`, but peeks bytes and produces a byte string.

```
(peek-string! str
              skip-bytes-amt
             [in
              start-pos
              end-pos])
 → (or/c exact-nonnegative-integer? eof-object?)
  str : (and/c string? (not/c immutable?))
  skip-bytes-amt : exact-nonnegative-integer?
  in : input-port? = (current-input-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (string-length str)
```

Like `read-string!`, but for peeking, and with a *skip-bytes-amt* argument like `peek-string`.

```
(peek-bytes! bstr
             skip-bytes-amt
            [in
             start-pos
             end-pos])
 → (or/c exact-nonnegative-integer? eof-object?)
  bstr : (and/c bytes? (not/c immutable?))
  skip-bytes-amt : exact-nonnegative-integer?
  in : input-port? = (current-input-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `peek-string!`, but peeks bytes, puts them into a byte string, and returns the number of bytes read.

```
(peek-bytes-avail! bstr
                   skip-bytes-amt
                  [progress
                   in
                   start-pos
                   end-pos])
```

```
 → (or/c exact-nonnegative-integer? eof-object? procedure?)
  bstr : (and/c bytes? (not/c immutable?))
  skip-bytes-amt : exact-nonnegative-integer?
  progress : (or/c progress-evt? #f) = #f
  in : input-port? = (current-input-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `read-bytes-avail!`, but for peeking, and with two extra arguments. The *skip-bytes-amt* argument is as in `peek-bytes`. The *progress* argument must be either `#f` or an event produced by `port-progress-evt` for *in*.

To peek, `peek-bytes-avail!` blocks until finding an end-of-file, at least one byte (or special) past the skipped bytes, or until a non-`#f` *progress* becomes ready. Furthermore, if *progress* is ready before bytes are peeked, no bytes are peeked or skipped, and *progress* may cut short the skipping process if it becomes available during the peek attempt. Furthermore, *progress* is checked even before determining whether the port is still open.

The result of `peek-bytes-avail!` is `0` only

- when *start-pos* is equal to *end-pos*, or
- when *progress* becomes ready before bytes are peeked.

```
(peek-bytes-avail!*  bstr
                     skip-bytes-amt
                    [progress
                     in
                     start-pos
                     end-pos])
 → (or/c exact-nonnegative-integer? eof-object? procedure?)
  bstr : (and/c bytes? (not/c immutable?))
  skip-bytes-amt : exact-nonnegative-integer?
  progress : (or/c progress-evt? #f) = #f
  in : input-port? = (current-input-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `read-bytes-avail!*`, but for peeking, and with *skip-bytes-amt* and *progress* arguments like `peek-bytes-avail!`. Since this procedure never blocks, it may return before even *skip-bytes-amt* bytes are available from the port.

```
(peek-bytes-avail!/enable-break  bstr
                                 skip-bytes-amt
                                [progress
                                 in
                                 start-pos
                                 end-pos])
 → (or/c exact-nonnegative-integer? eof-object? procedure?)
  bstr : (and/c bytes? (not/c immutable?))
  skip-bytes-amt : exact-nonnegative-integer?
  progress : (or/c progress-evt? #f) = #f
  in : input-port? = (current-input-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `read-bytes-avail!/enable-break`, but for peeking, and with *skip-bytes-amt* and *progress* arguments like `peek-bytes-avail!`.

```
(read-char-or-special [in
                       special-wrap
                       source-name])
 → (or/c char? eof-object? any/c)
  in : input-port? = (current-input-port)
  special-wrap : (or/c (any/c . -> . any/c) #f) = #f
  source-name : any/c = #f
```

Like `read-char`, but if the input port returns a special value (through a value-generating procedure in a custom port, where *source-name* is provided to the procedure; see §13.1.9 "Custom Ports" and §13.7.3 "Special Comments" for details), then the result of applying *special-wrap* to the special value is returned. A `#f` value for *special-wrap* is treated the same as the identity function.

Changed in version 6.8.0.2 of package `base`: Added the *special-wrap* and *source-name* arguments.

```
(read-byte-or-special [in
                       special-wrap
                       source-name])
 → (or/c byte? eof-object? any/c)
  in : input-port? = (current-input-port)
  special-wrap : (or/c (any/c . -> . any/c) #f) = #f
  source-name : any/c = #f
```

Like `read-char-or-special`, but reads and returns a byte instead of a character.

Changed in version 6.8.0.2 of package `base`: Added the *special-wrap* and *source-name* arguments.

```
(peek-char [in skip-bytes-amt]) → (or/c char? eof-object?)
  in : input-port? = (current-input-port)
  skip-bytes-amt : exact-nonnegative-integer? = 0
```

Like `read-char`, but peeks instead of reading, and skips *`skip-bytes-amt`* bytes (not characters) at the start of the port.

```
(peek-byte [in skip-bytes-amt]) → (or/c byte? eof-object?)
  in : input-port? = (current-input-port)
  skip-bytes-amt : exact-nonnegative-integer? = 0
```

Like `peek-char`, but peeks and returns a byte instead of a character.

```
(peek-char-or-special [in
                       skip-bytes-amt
                       special-wrap
                       source-name])
 → (or/c char? eof-object? any/c)
  in : input-port? = (current-input-port)
  skip-bytes-amt : exact-nonnegative-integer? = 0
  special-wrap : (or/c (any/c . -> . any/c) #f 'special) = #f
  source-name : any/c = #f
```

Like `peek-char`, but if the input port returns a non-byte value after *`skip-bytes-amt`* byte positions, then the result depends on *`special-wrap`*:

- If *`special-wrap`* is `#f`, then the special value is returned (as for `read-char-or-special`).
- If *`special-wrap`* is a procedure, then it is applied the special value to produce the result (as for `read-char-or-special`).
- If *`special-wrap`* is `'special`, then `'special` is returned in place of the special value—without calling the special-value procedure that is returned by the input-port implementation.

Changed in version 6.8.0.2 of package `base`: Added the *`special-wrap`* and *`source-name`* arguments.
Changed in version 6.90.0.16: Added `'special` as an option for *`special-wrap`*.

```
(peek-byte-or-special [in
                       skip-bytes-amt
                       progress
                       special-wrap
                       source-name])
 → (or/c byte? eof-object? any/c)
```

```
in : input-port? = (current-input-port)
skip-bytes-amt : exact-nonnegative-integer? = 0
progress : (or/c progress-evt? #f) = #f
special-wrap : (or/c (any/c . -> . any/c) #f 'special) = #f
source-name : any/c = #f
```

Like `peek-char-or-special`, but peeks and returns a byte instead of a character, and it supports a *progress* argument like `peek-bytes-avail!`.

Changed in version 6.8.0.2 of package `base`: Added the *special-wrap* and *source-name* arguments.
Changed in version 6.90.0.16: Added `'special` as an option for *special-wrap*.

```
(port-progress-evt [in]) → progress-evt?
  in : (and/c input-port? port-provides-progress-evts?)
     = (current-input-port)
```

Returns a synchronizable event (see §11.2.1 "Events") that becomes ready for synchronization after any subsequent read from *in* or after *in* is closed. After the event becomes ready, it remains ready. The synchronization result of a progress event is the progress event itself.

```
(port-provides-progress-evts? in) → boolean
  in : input-port?
```

Returns `#t` if `port-progress-evt` can return an event for *in*. All built-in kinds of ports support progress events, but ports created with `make-input-port` (see §13.1.9 "Custom Ports") may not.

```
(port-commit-peeked amt progress evt [in]) → boolean?
  amt : exact-nonnegative-integer?
  progress : progress-evt?
  evt : evt?
  in : input-port? = (current-input-port)
```

Attempts to commit as read the first *amt* previously peeked bytes, non-byte specials, and `eof`s from *in*, or the first `eof` or special value peeked from *in*. Mid-stream `eof`s can be committed, but an `eof` when the port is exhausted does not necessarily commit, since it does not correspond to data in the stream.

The read commits only if *progress* does not become ready first (i.e., if no other process reads from *in* first), and only if *evt* is chosen by a `sync` within `port-commit-peeked` (in which case the event result is ignored); the *evt* must be either a channel-put event, channel, semaphore, semaphore-peek event, always event, or never event. Suspending the thread that calls `port-commit-peeked` may or may not prevent the commit from proceeding.

The result from `port-commit-peeked` is `#t` if data has been committed, and `#f` otherwise.

If no data has been peeked from *in* and *progress* is not ready, then `exn:fail:contract` exception is raised. If fewer than *amt* items have been peeked at the current start of *in*'s stream, then only the peeked items are committed as read. If *in*'s stream currently starts at an `eof` or a non-byte special value, then only the `eof` or special value is committed as read.

If *progress* is not a result of `port-progress-evt` applied to *in*, then `exn:fail:contract` exception is raised.

```
(byte-ready? [in]) → boolean?
  in : input-port? = (current-input-port)
```

Returns `#t` if `(read-byte in)` would not block (at the time that `byte-ready?` was called, at least). Equivalent to `(and (sync/timeout 0 in) #t)`.

The `byte-ready?` and `char-ready?` functions are appropriate for relatively few applications, because ports are meant to support streaming data among concurrent producers and consumers; the fact that a byte or character is not ready in some instant does not necessarily mean that the producer is finished supplying data. (Also, if a port has multiple consumers, data might get consumed between the time that a given process uses `byte-ready?` to poll the port and the time that it reads data from the port.) Using `byte-ready?` makes sense if you are implementing your own scheduler or if you know that the port's implementation and use are particularly constrained.

```
(char-ready? [in]) → boolean?
  in : input-port? = (current-input-port)
```

Returns `#t` if `(read-char in)` would not block (at the time that `char-ready?` was called, at least). Depending on the initial bytes of the stream, multiple bytes may be needed to form a UTF-8 encoding.

See `byte-ready?` for a note on how `byte-ready?` and `char-ready?` are rarely the right choice.

```
(progress-evt? v) → boolean?
  v : any/c
(progress-evt? evt in) → boolean?
  evt : progress-evt?
  in : input-port?
```

With one argument, returns `#t` is *v* is a progress evt for some input port, `#f` otherwise.

With two arguments, returns `#t` if *evt* is a progress event for *in*, `#f` otherwise.

13.3 Byte and String Output

```
(write-char char [out]) → void?
  char : char?
  out : output-port? = (current-output-port)
```

Writes a single character to *out*; more precisely, the bytes that are the UTF-8 encoding of *char* are written to *out*.

```
(write-byte byte [out]) → void?
  byte : byte?
  out : output-port? = (current-output-port)
```

Writes a single byte to *out*.

```
(newline [out]) → void?
  out : output-port? = (current-output-port)
```

The same as `(write-char #\newline out)`.

```
(write-string str [out start-pos end-pos])
 → exact-nonnegative-integer?
  str : string?
  out : output-port? = (current-output-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (string-length str)
```

Writes characters to *out* from *str* starting from index *start-pos* (inclusive) up to *end-pos* (exclusive). Like `substring`, the `exn:fail:contract` exception is raised if *start-pos* or *end-pos* is out-of-range for *str*.

The result is the number of characters written to *out*, which is always `(- end-pos start-pos)`.

If *str* is mutable, mutations after `write-string` returns do not affect the characters written to *out*. (This independence from mutation is not a special property of `write-string`, but instead generally true of output functions.)

```
(write-bytes bstr [out start-pos end-pos])
 → exact-nonnegative-integer?
  bstr : bytes?
  out : output-port? = (current-output-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `write-string`, but writes bytes instead of characters.

```
(write-bytes-avail  bstr
                   [out
                    start-pos
                    end-pos])  → exact-nonnegative-integer?
  bstr : bytes?
  out : output-port? = (current-output-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `write-bytes`, but returns without blocking after writing as many bytes as it can immediately flush. It blocks only if no bytes can be flushed immediately. The result is the number of bytes written and flushed to *out*; if *start-pos* is the same as *end-pos*, then the result can be `0` (indicating a successful flush of any buffered data), otherwise the result is between `1` and `(- end-pos start-pos)`, inclusive.

The `write-bytes-avail` procedure never drops bytes; if `write-bytes-avail` successfully writes some bytes and then encounters an error, it suppresses the error and returns the number of written bytes. (The error will be triggered by future writes.) If an error is encountered before any bytes have been written, an exception is raised.

```
(write-bytes-avail*  bstr
                    [out
                     start-pos
                     end-pos])
 → (or/c exact-nonnegative-integer? #f)
  bstr : bytes?
  out : output-port? = (current-output-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `write-bytes-avail`, but never blocks, returns `#f` if the port contains buffered data that cannot be written immediately, and returns `0` if the port's internal buffer (if any) is flushed but no additional bytes can be written immediately.

```
(write-bytes-avail/enable-break  bstr
                                [out
                                 start-pos
                                 end-pos])
 → exact-nonnegative-integer?
  bstr : bytes?
  out : output-port? = (current-output-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `write-bytes-avail`, except that breaks are enabled during the write. The procedure provides a guarantee about the interaction of writing and breaks: if breaking is disabled when write-bytes-avail/enable-break is called, and if the exn:break exception is raised as a result of the call, then no bytes will have been written to *out*. See also §10.6 “Breaks”.

```
(write-special v [out]) → boolean?
  v : any/c
  out : output-port? = (current-output-port)
```

Writes *v* directly to *out* if the port supports special writes, or raises exn:fail:contract if the port does not support special write. The result is always #t, indicating that the write succeeded.

```
(write-special-avail* v [out]) → boolean?
  v : any/c
  out : output-port? = (current-output-port)
```

Like write-special, but without blocking. If *v* cannot be written immediately, the result is #f without writing *v*, otherwise the result is #t and *v* is written.

```
(write-bytes-avail-evt  bstr
                       [out
                        start-pos
                        end-pos]) → evt?
  bstr : bytes?
  out : output-port? = (current-output-port)
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Similar to write-bytes-avail, but instead of writing bytes immediately, it returns a synchronizable event (see §11.2.1 “Events”). The *out* must support atomic writes, as indicated by port-writes-atomic?.

Synchronizing on the object starts a write from *bstr*, and the event becomes ready when bytes are written (unbuffered) to the port. If *start-pos* and *end-pos* are the same, then the synchronization result is 0 when the port's internal buffer (if any) is flushed, otherwise the result is a positive exact integer. If the event is not selected in a synchronization, then no bytes will have been written to *out*.

```
(write-special-evt v [out]) → evt?
  v : any/c
  out : output-port? = (current-output-port)
```

Similar to write-special, but instead of writing the special value immediately, it returns a synchronizable event (see §11.2.1 “Events”). The *out* must support atomic writes, as indicated by port-writes-atomic?.

Synchronizing on the object starts a write of the special value, and the event becomes ready when the value is written (unbuffered) to the port. If the event is not selected in a synchronization, then no value will have been written to *out*.

```
(port-writes-atomic? out) → boolean?
  out : output-port?
```

Returns `#t` if `write-bytes-avail/enable-break` can provide an exclusive-or guarantee (break or write, but not both) for *out*, and if the port can be used with procedures like `write-bytes-avail-evt`. Racket's file-stream ports, pipes, string ports, and TCP ports all support atomic writes; ports created with `make-output-port` (see §13.1.9 "Custom Ports") may support atomic writes.

```
(port-writes-special? out) → boolean?
  out : output-port?
```

Returns `#t` if procedures like `write-special` can write arbitrary values to the port. Racket's file-stream ports, pipes, string ports, and TCP ports all reject special values, but ports created with `make-output-port` (see §13.1.9 "Custom Ports") may support them.

13.4 Reading

```
(read [in]) → any
  in : input-port? = (current-input-port)
```

Reads and returns a single datum from *in*. If *in* has a handler associated to it via `port-read-handler`, then the handler is called. Otherwise, the default reader is used, as parameterized by the `current-readtable` parameter, as well as many other parameters.

See §1.3 "The Reader" for information on the default reader and §1.3.18 "Reading via an Extension" for the protocol of `read`.

```
(read-syntax [source-name in]) → (or/c syntax? eof-object?)
  source-name : any/c = (object-name (current-input-port))
  in : input-port? = (current-input-port)
```

Like `read`, but produces a syntax object with source-location information. The *source-name* is used as the source field of the syntax object; it can be an arbitrary value, but it should generally be a path for the source file.

See §1.3 "The Reader" for information on the default reader in `read-syntax` mode and §1.3.18 "Reading via an Extension" for the protocol of `read-syntax`.

Typically, line counting should be enabled for *in* so that source locations in syntax objects are in characters, instead of bytes. See also §13.1.4 "Counting Positions, Lines, and Columns".

See also §16.2.1 "Syntax Objects" in *The Racket Guide*.

```
(read/recursive [in start readtable graph?]) → any
  in : input-port? = (current-input-port)
  start : (or/c char? #f) = #f
  readtable : (or/c readtable? #f) = (current-readtable)
  graph? : any/c = #t
```

Similar to calling `read`, but normally used during the dynamic extent of `read` within a reader-extension procedure (see §13.7.2 "Reader-Extension Procedures"). The main effect of using `read/recursive` instead of `read` is that graph-structure annotations (see §1.3.17 "Reading Graph Structure") in the nested read are considered part of the overall read, at least when the *graph?* argument is true; since the result is wrapped in a placeholder, however, it is not directly inspectable.

If *start* is provided and not `#f`, it is effectively prefixed to the beginning of *in*'s stream for the read. (To prefix multiple characters, use `input-port-append`.)

The *readtable* argument is used for top-level parsing to satisfy the read request, including various delimiters of a built-in top-level form (such as parentheses and `.` for reading a hash table); recursive parsing within the read (e.g., to read the elements of a list) instead uses the current readtable as determined by the `current-readtable` parameter. A reader macro might call `read/recursive` with a character and readtable to effectively invoke the readtable's behavior for the character. If *readtable* is `#f`, the default readtable is used for top-level parsing.

When *graph?* is `#f`, graph structure annotations in the read datum are local to the datum.

When called within the dynamic extent of `read`, the `read/recursive` procedure can produce a special-comment value (see §13.7.3 "Special Comments") when the input stream's first non-whitespace content parses as a comment.

See §13.7.1 "Readtables" for an extended example that uses `read/recursive`.

Changed in version 6.2 of package `base`: Adjusted use of *readtable* to more consistently apply to the delimiters of a built-in form.

```
(read-syntax/recursive [source-name
                        in
                        start
                        readtable
                        graph?])    → any
  source-name : any/c = (object-name in)
  in : input-port? = (current-input-port)
  start : (or/c char? #f) = #f
  readtable : (or/c readtable? #f) = (current-readtable)
  graph? : any/c = #t
```

Analogous to calling read/recursive, but the resulting value encapsulates S-expression structure with source-location information. As with read/recursive, when read-syntax/recursive is used within the dynamic extent of read-syntax, the result from read-syntax/recursive is either a special-comment value, end-of-file, or opaque graph-structure placeholder (not a syntax object). The placeholder can be embedded in an S-expression or syntax object returned by a reader macro, etc., and it will be replaced with the actual syntax object before the outermost read-syntax returns.

Using read/recursive within the dynamic extent of read-syntax does not allow graph structure for reading to be included in the outer read-syntax parsing, and neither does using read-syntax/recursive within the dynamic extent of read. In those cases, read/recursive and read-syntax/recursive produce results like read and read-syntax, except that a special-comment value is returned when the input stream starts with a comment (after whitespace).

See §13.7.1 "Readtables" for an extended example that uses read-syntax/recursive.

Changed in version 6.2 of package base: Adjusted use of *readtable* in the same way as for read/recursive.

```
(read-language [in fail-thunk])
 → (or/c (any/c any/c . -> . any) #f)
  in : input-port? = (current-input-port)
  fail-thunk : (-> any) = (lambda () (error ...))
```

Reads from *in* in the same way as read, but stopping as soon as a reader language (or its absence) is determined, and using the current namespace to load a reader module instead of its root namespace (if those are different).

A *reader language* is specified by #lang or #! (see §1.3.18 "Reading via an Extension") at the beginning of the input, though possibly after comment forms. The default readtable is used by read-language (instead of the value of current-readtable), and #reader forms (which might produce comments) are not allowed before #lang or #!.

See also §17.3.5 "Source-Handling Configuration" in *The Racket Guide*.

When it finds a #lang or #! specification, instead of dispatching to a read or read-syntax function as read and read-syntax do, read-language dispatches to the get-info function (if any) exported by the same module. The arguments to get-info are the same as for read as described in §1.3.18 "Reading via an Extension". The result of the get-info function is the result of read-language if it is a function of two arguments; if get-info produces any other kind of result, the exn:fail:contract exception is raised. If no get-info function is exported, read-language returns #f.

The function produced by get-info reflects information about the expected syntax of the input stream. The first argument to the function serves as a key on such information; acceptable keys and the interpretation of results is up to external tools, such as DrRacket (see the DrRacket documentation). If no information is available for a given key, the result should be the second argument.

Examples:

```
> (define scribble-manual-info
    (read-language (open-input-string "#lang scribble/manual")))
> (scribble-manual-info 'color-lexer #f)
#<procedure:scribble-inside-lexer>
> (scribble-manual-info 'something-else #f)
#f
```

The `get-info` function itself is applied to five arguments: the input port being read, the module path from which the `get-info` function was extracted, and the source line (positive exact integer or `#f`), column (non-negative exact integer or `#f`), and position (positive exact integer or `#f`) of the start of the `#lang` or `#!` form. The `get-info` function may further read from the given input port to determine its result, but it should read no further than necessary. The `get-info` function should not read from the port after returning a function.

If *in* starts with a reader language specification but the relevant module does not export `get-info` (but perhaps does export `read` and `read-syntax`), then the result of `read-language` is `#f`.

If *in* has a `#lang` or `#!` specification, but parsing and resolving the specification raises an exception, the exception is propagated by `read-language`. Having at least `#l` or `#!` (after comments and whitespace) counts as starting a `#lang` or `#!` specification.

If *in* does not specify a reader language with `#lang` or `#!`, then *fail-thunk* is called. The default *fail-thunk* raises `exn:fail:read` or `exn:fail:read:eof`.

```
(read-case-sensitive) → boolean?
(read-case-sensitive on?) → void?
  on? : any/c
```

A parameter that controls parsing and printing of symbols. When this parameter's value is `#f`, the reader case-folds symbols (e.g., producing `'hi` when the input is any one of `hi`, `Hi`, `HI`, or `hI`). The parameter also affects the way that `write` prints symbols containing uppercase characters; if the parameter's value is `#f`, then symbols are printed with uppercase characters quoted by a `\` or `|`. The parameter's value is overridden by quoting `\` or `|` vertical-bar quotes and the `#cs` and `#ci` prefixes; see §1.3.2 "Reading Symbols" for more information. While a module is loaded, the parameter is set to `#t` (see `current-load`).

```
(read-square-bracket-as-paren) → boolean?
(read-square-bracket-as-paren on?) → void?
  on? : any/c
```

A parameter that controls whether `[` and `]` are treated as parentheses. See §1.3.6 "Reading Pairs and Lists" for more information.

```
(read-curly-brace-as-paren) → boolean?
(read-curly-brace-as-paren on?) → void?
  on? : any/c
```

A parameter that controls whether `{` and `}` are treated as parentheses. See §1.3.6 "Reading Pairs and Lists" for more information.

```
(read-square-bracket-with-tag) → boolean?
(read-square-bracket-with-tag on?) → void?
  on? : any/c
```

A parameter that controls whether `[` and `]` are treated as parentheses, but the resulting list tagged with `#%brackets`. See §1.3.6 "Reading Pairs and Lists" for more information.

Added in version 6.3.0.5 of package `base`.

```
(read-curly-brace-with-tag) → boolean?
(read-curly-brace-with-tag on?) → void?
  on? : any/c
```

A parameter that controls whether `{` and `}` are treated as parentheses, but the resulting list tagged with `#%braces`. See §1.3.6 "Reading Pairs and Lists" for more information.

Added in version 6.3.0.5 of package `base`.

```
(read-accept-box) → boolean?
(read-accept-box on?) → void?
  on? : any/c
```

A parameter that controls parsing `#&` input. See §1.3.13 "Reading Boxes" for more information.

```
(read-accept-compiled) → boolean?
(read-accept-compiled on?) → void?
  on? : any/c
```

A parameter that controls parsing `#~` compiled input. See §1.3 "The Reader" and `current-compile` for more information.

```
(read-accept-bar-quote) → boolean?
(read-accept-bar-quote on?) → void?
  on? : any/c
```

A parameter that controls parsing and printing of `|` in symbols. See §1.3.2 "Reading Symbols" and §1.4 "The Printer" for more information.

```
(read-accept-graph) → boolean?
(read-accept-graph on?) → void?
  on? : any/c
```

A parameter value that controls parsing input with sharing in `read` mode. See §1.3.17 "Reading Graph Structure" for more information.

```
(read-syntax-accept-graph) → boolean?
(read-syntax-accept-graph on?) → void?
  on? : any/c
```

A parameter value that controls parsing input with sharing in `read-syntax` mode. See §1.3.17 "Reading Graph Structure" for more information.

Added in version 8.4.0.8 of package `base`.

```
(read-decimal-as-inexact) → boolean?
(read-decimal-as-inexact on?) → void?
  on? : any/c
```

A parameter that controls parsing input numbers with a decimal point or exponent (but no explicit exactness tag). See §1.3.3 "Reading Numbers" for more information.

```
(read-single-flonum) → boolean?
(read-single-flonum on?) → void?
  on? : any/c
```

A parameter that controls parsing input numbers that have a `f`, `F`, `s`, or `S` precision character. See §1.3.3 "Reading Numbers" for more information.

Added in version 7.3.0.5 of package `base`.

```
(read-accept-dot) → boolean?
(read-accept-dot on?) → void?
  on? : any/c
```

A parameter that controls parsing input with a dot, which is normally used for literal cons cells. See §1.3.6 "Reading Pairs and Lists" for more information.

```
(read-accept-infix-dot) → boolean?
(read-accept-infix-dot on?) → void?
  on? : any/c
```

A parameter that controls parsing input with two dots to trigger infix conversion. See §1.3.6 "Reading Pairs and Lists" for more information.

```
(read-cdot) → boolean?
(read-cdot on?) → void?
  on? : any/c
```

A parameter that controls parsing input with a dot, in a C structure accessor style. See §1.3.19 "Reading with C-style Infix-Dot Notation" for more information.

Added in version 6.3.0.5 of package base.

```
(read-accept-quasiquote) → boolean?
(read-accept-quasiquote on?) → void?
  on? : any/c
```

A parameter that controls parsing input with ` or , which is normally used for quasiquote, unquote, and unquote-splicing abbreviations. See §1.3.8 "Reading Quotes" for more information.

```
(read-accept-reader) → boolean?
(read-accept-reader on?) → void?
  on? : any/c
```

A parameter that controls whether #reader, #lang, or #! are allowed for selecting a parser. See §1.3.18 "Reading via an Extension" for more information.

```
(read-accept-lang) → boolean?
(read-accept-lang on?) → void?
  on? : any/c
```

A parameter that (along with read-accept-reader) controls whether #lang and #! are allowed for selecting a parser. See §1.3.18 "Reading via an Extension" for more information.

```
(current-readtable) → (or/c readtable? #f)
(current-readtable readtable) → void?
  readtable : (or/c readtable? #f)
```

A parameter whose value determines a readtable that adjusts the parsing of S-expression input, where #f implies the default behavior. See §13.7.1 "Readtables" for more information.

```
(call-with-default-reading-parameterization thunk) → any
  thunk : (-> any)
```

Calls *thunk* in tail position of a parameterize to set all reader parameters above to their default values.

Using the default parameter values ensures consistency, and it also provides safety when reading from untrusted sources, since the default values disable evaluation of arbitrary code via #lang or #reader.

```
(current-reader-guard) → (any/c . -> . any)
(current-reader-guard proc) → void?
  proc : (any/c . -> . any)
```

A parameter whose value converts or rejects (by raising an exception) a module-path datum following #reader. See §1.3.18 "Reading via an Extension" for more information.

```
(read-on-demand-source)
 → (or/c #f #t (and/c path? complete-path?))
(read-on-demand-source mode) → void?
  mode : (or/c #f #t (and/c path? complete-path?))
```

A parameter that enables lazy parsing of compiled code, so that closure bodies and syntax objects are extracted (and validated) from marshaled compiled code on demand. Normally, this parameter is set by the default load handler when load-on-demand-enabled is #t.

A #f value for read-on-demand-source disables lazy parsing of compiled code. A #t value enables lazy parsing. A path value furthers enable lazy retrieval from disk—instead of keeping unparsed compiled code in memory—when the PLT_DELAY_FROM_ZO environment variable is set (to any value) on start-up.

If the file at *mode* as a path changes before the delayed code is parsed when lazy retrieval from disk is enabled, then the on-demand parse most likely will encounter garbage, leading to an exception.

```
(port-read-handler in) → (case->
                           (input-port? . -> . any)
                           (input-port?  any/c . -> . any))
  in : input-port?
(port-read-handler in proc) → void?
  in : input-port?
  proc : (case->
          (input-port? . -> . any)
          (input-port? any/c . -> . any))
```

Gets or sets the *port read handler* for *in*. The handler called to read from the port when the built-in read or read-syntax procedure is applied to the port. (The port read handler is not used for read/recursive or read-syntax/recursive.)

A port read handler is applied to either one argument or two arguments:

- A single argument is supplied when the port is used with read; the argument is the port being read. The return value is the value that was read from the port (or end-of-file).

- Two arguments are supplied when the port is used with `read-syntax`; the first argument is the port being read, and the second argument is a value indicating the source. The return value is a syntax object that was read from the port (or end-of-file).

The default port read handler reads standard Racket expressions with Racket's built-in parser (see §1.3 "The Reader"). It handles a special result from a custom input port (see `make-input-port`) by treating it as a single expression, except that special-comment values (see §13.7.3 "Special Comments") are treated as whitespace.

The default port read handler itself can be customized through a readtable; see §13.7.1 "Readtables" for more information.

13.5 Writing

```
(write datum [out]) → void?
  datum : any/c
  out : output-port? = (current-output-port)
```

Writes *datum* to *out*, normally in such a way that instances of core datatypes can be read back in. If *out* has a handler associated to it via `port-write-handler`, then the handler is called. Otherwise, the default printer is used (in `write` mode), as configured by various parameters.

See §1.4 "The Printer" for more information about the default printer. In particular, note that `write` may require memory proportional to the depth of the value being printed, due to the initial cycle check.

Examples:

```
> (write 'hi)
hi
> (write (lambda (n) n))
#<procedure>
> (define o (open-output-string))
> (write "hello" o)
> (get-output-string o)
"\"hello\""
```

```
(display datum [out]) → void?
  datum : any/c
  out : output-port? = (current-output-port)
```

Displays *datum* to *out*, similar to `write`, but usually in such a way that byte- and character-based datatypes are written as raw bytes or characters. If *out* has a handler associated to it via `port-display-handler`, then the handler is called. Otherwise, the default printer is used (in `display` mode), as configured by various parameters.

See §1.4 "The Printer" for more information about the default printer. In particular, note that `display` may require memory proportional to the depth of the value being printed, due to the initial cycle check.

```
(print datum [out quote-depth]) → void?
  datum : any/c
  out : output-port? = (current-output-port)
  quote-depth : (or/c 0 1) = 0
```

Prints *datum* to *out*. If *out* has a handler associated to it via `port-print-handler`, then the handler is called. Otherwise, the handler specified by `global-port-print-handler` is called; the default handler uses the default printer in `print` mode.

The optional *quote-depth* argument adjusts printing when the `print-as-expression` parameter is set to `#t`. In that case, *quote-depth* specifies the starting quote depth for printing *datum*.

The rationale for providing `print` is that `display` and `write` both have specific output conventions, and those conventions restrict the ways that an environment can change the behavior of `display` and `write` procedures. No output conventions should be assumed for `print`, so that environments are free to modify the actual output generated by `print` in any way.

```
(writeln datum [out]) → void?
  datum : any/c
  out : output-port? = (current-output-port)
```

The same as `(write datum out)` followed by `(newline out)`.

Added in version 6.1.1.8 of package `base`.

```
(displayln datum [out]) → void?
  datum : any/c
  out : output-port? = (current-output-port)
```

The same as `(display datum out)` followed by `(newline out)`, which is similar to `println` in Pascal or Java.

```
(println datum [out quote-depth]) → void?
  datum : any/c
  out : output-port? = (current-output-port)
  quote-depth : (or/c 0 1) = 0
```

The same as `(print datum out quote-depth)` followed by `(newline out)`.

The `println` function is not equivalent to `println` in other languages, because `println` uses printing conventions that are closer to `write` than to `display`. For a closer analog to `println` in other languages, use `displayln`.

Added in version 6.1.1.8 of package `base`.

```
(fprintf out form v ...) → void?
  out : output-port?
  form : string?
  v : any/c
```

Prints formatted output to *out*, where *form* is a string that is printed directly, except for special formatting escapes:

- `~n` or `~%` prints a newline character (which is equivalent to `\n` in a literal format string)
- `~a` or `~A` `display`s the next argument among the *v*s
- `~s` or `~S` `write`s the next argument among the *v*s
- `~v` or `~V` `print`s the next argument among the *v*s
- `~.`⟨*c*⟩ where ⟨*c*⟩ is `a`, `A`, `s`, `S`, `v`, or `V`: truncates default-handler `display`, `write`, or `print` output to `(error-print-width)` characters, using `...` as the last three characters if the untruncated output would be longer
- `~e` or `~E` outputs the next argument among the *v*s using the current error value conversion handler (see `error-value->string-handler`) and current error printing width
- `~c` or `~C` `write-char`s the next argument in *v*s; if the next argument is not a character, the `exn:fail:contract` exception is raised
- `~b` or `~B` prints the next argument among the *v*s in binary; if the next argument is not an exact number, the `exn:fail:contract` exception is raised
- `~o` or `~O` prints the next argument among the *v*s in octal; if the next argument is not an exact number, the `exn:fail:contract` exception is raised
- `~x` or `~X` prints the next argument among the *v*s in hexadecimal; if the next argument is not an exact number, the `exn:fail:contract` exception is raised
- `~~` prints a tilde.
- `~`⟨*w*⟩, where ⟨*w*⟩ is a whitespace character (see `char-whitespace?`), skips characters in *form* until a non-whitespace character is encountered or until a second end-of-line is encountered (whichever happens first). On all platforms, an end-of-line can be `#\return`, `#\newline`, or `#\return` followed immediately by `#\newline`.

The *form* string must not contain any `~` that is not one of the above escapes, otherwise the `exn:fail:contract` exception is raised. When the format string requires more *v*s than are supplied, the `exn:fail:contract` exception is raised. Similarly, when more *v*s are supplied than are used by the format string, the `exn:fail:contract` exception is raised.

Example:

```
> (fprintf (current-output-port)
           "~a as a string is ~s.\n"
           '(3 4)
           "(3 4)")
(3 4) as a string is "(3 4)".
```

```
(printf form v ...) → void?
  form : string?
  v : any/c
```

The same as `(fprintf (current-output-port) form v ...)`.

```
(eprintf form v ...) → void?
  form : string?
  v : any/c
```

The same as `(fprintf (current-error-port) form v ...)`.

```
(format form v ...) → string?
  form : string?
  v : any/c
```

Formats to a string. The result is the same as

```
(let ([o (open-output-string)])
  (fprintf o form v ...)
  (get-output-string o))
```

Example:

```
> (format "~a as a string is ~s.\n" '(3 4) "(3 4)")
"(3 4) as a string is \"(3 4)\".\n"
```

```
(print-pair-curly-braces) → boolean?
(print-pair-curly-braces on?) → void?
  on? : any/c
```

A parameter that controls pair printing. If the value is true, then pairs print using `{` and `}` instead of `(` and `)`. The default is `#f`.

```
(print-mpair-curly-braces) → boolean?
(print-mpair-curly-braces on?) → void?
  on? : any/c
```

A parameter that controls pair printing. If the value is true, then mutable pairs print using `{` and `}` instead of `(` and `)`. The default is `#t`.

```
(print-unreadable) → boolean?
(print-unreadable on?) → void?
  on? : any/c
```

A parameter that enables or disables `print` and `write` of values that have no `read`able form (using the default reader), including structures that have a custom-write procedure (see `prop:custom-write`), but not including uninterned symbols and unreadable symbols (which print the same as interned symbols). If the parameter value is `#f`, an attempt to print an unreadable value raises `exn:fail`. The parameter value defaults to `#t`. See §1.4 "The Printer" for more information.

```
(print-graph) → boolean?
(print-graph on?) → void?
  on? : any/c
```

A parameter that controls printing data with sharing; defaults to `#f`. See §1.4 "The Printer" for more information.

```
(print-struct) → boolean?
(print-struct on?) → void?
  on? : any/c
```

A parameter that controls printing structure values in vector or prefab form; defaults to `#t`. See §1.4 "The Printer" for more information. This parameter has no effect on the printing of structures that have a custom-write procedure (see `prop:custom-write`).

```
(print-box) → boolean?
(print-box on?) → void?
  on? : any/c
```

A parameter that controls printing box values; defaults to `#t`. See §1.4.10 "Printing Boxes" for more information.

```
(print-vector-length) → boolean?
(print-vector-length on?) → void?
  on? : any/c
```

A parameter that controls printing vectors; defaults to `#f`. See §1.4.7 "Printing Vectors" for more information.

```
(print-hash-table) → boolean?
(print-hash-table on?) → void?
  on? : any/c
```

A parameter that controls printing hash tables; defaults to `#t`. See §1.4.9 "Printing Hash Tables" for more information.

```
(print-boolean-long-form) → boolean?
(print-boolean-long-form on?) → void?
  on? : any/c
```

A parameter that controls printing of booleans. When the parameter's value is true, `#t` and `#f` print as `#true` and `#false`, otherwise they print as `#t` and `#f`. The default is `#f`.

```
(print-reader-abbreviations) → boolean?
(print-reader-abbreviations on?) → void?
  on? : any/c
```

A parameter that controls printing of two-element lists that start with `quote`, `'quasiquote`, `'unquote`, `'unquote-splicing`, `'syntax`, `'quasisyntax`, `'unsyntax`, or `'unsyntax-splicing`; defaults to `#f`. See §1.4.5 "Printing Pairs and Lists" for more information.

```
(print-as-expression) → boolean?
(print-as-expression on?) → void?
  on? : any/c
```

A parameter that controls printing in `print` mode (as opposed to `write` or `display`); defaults to `#t`. See §1.4 "The Printer" for more information.

```
(print-syntax-width)
 → (or/c +inf.0 0 (and/c exact-integer? (>/c 3)))
(print-syntax-width width) → void?
  width : (or/c +inf.0 0 (and/c exact-integer? (>/c 3)))
```

A parameter that controls printing of syntax objects. Up to *width* characters are used to show the datum form of a syntax object within `#<syntax...>` (after the syntax object's source location, if any), where `...` is used as the last three characters if the printed form would otherwise be longer than *width* characters. A value of `0` for *width* means that the datum is not shown at all.

```
(print-value-columns)
 → (or/c +inf.0 (and/c exact-integer? (>/c 5)))
(print-value-columns columns) → void?
  columns : (or/c +inf.0 (and/c exact-integer? (>/c 5)))
```

A parameter that contains a recommendation for the number of columns that should be used for printing values via `print`. May or may not be respected by `print` - the current default handler for `print` does not. It is expected that REPLs that use some form of pretty-printing for values respect this parameter.

Added in version 8.0.0.13 of package `base`.

```
(current-write-relative-directory)
 → (or/c (and/c path? complete-path?)
         (cons/c (and/c path? complete-path?)
                 (and/c path? complete-path?))
         #f)
(current-write-relative-directory path) → void?
  path : (or/c (and/c path-string? complete-path?)
               (cons/c (and/c path-string? complete-path?)
                       (and/c path-string? complete-path?))
               #f)
```

A parameter that is used when writing compiled code (see §1.4.16 "Printing Compiled Code") that contains pathname literals, including source-location pathnames for procedure names. When the parameter's value is a *path*, paths that syntactically extend *path* are converted to relative paths; when the resulting compiled code is read, relative paths are converted back to complete paths using the `current-load-relative-directory` parameter (if it is not `#f`; otherwise, the path is left relative). When the parameter's value is `(cons rel-to-path base-path)`, then paths that syntactically extend *base-path* are converted as relative to *rel-to-path*; the *rel-to-path* must extend *base-path*, in which case `'up` path elements (in the sense of `build-path`) may be used to make a path relative to *rel-to-path*.

```
(port-write-handler out) → (any/c output-port? . -> . any)
  out : output-port?
(port-write-handler out proc) → void?
  out : output-port?
  proc : (any/c output-port? . -> . any)
(port-display-handler out) → (any/c output-port? . -> . any)
  out : output-port?
(port-display-handler out proc) → void?
  out : output-port?
  proc : (any/c output-port? . -> . any)
(port-print-handler out)
 → ((any/c output-port?) ((or/c 0 1)) . ->* . any)
  out : output-port?
(port-print-handler out proc) → void?
  out : output-port?
  proc : (any/c output-port? . -> . any)
```

Gets or sets the *port write handler*, *port display handler*, or *port print handler* for *out*. This handler is called to output to the port when `write`, `display`, or `print` (respectively) is applied to the port. Each handler must accept two arguments: the value to be printed and the destination port. The handler's return value is ignored.

A port print handler optionally accepts a third argument, which corresponds to the optional third argument to `print`; if a procedure given to `port-print-handler` does not accept a third argument, it is wrapped with a procedure that discards the optional third argument.

The default port display and write handlers print Racket expressions with Racket's built-in printer (see §1.4 "The Printer"). The default print handler calls the global port print handler (the value of the `global-port-print-handler` parameter); the default global port print handler is the same as the default write handler.

```
(global-port-print-handler)
 → (->* (any/c output-port?) ((or/c 0 1)) any)
(global-port-print-handler proc) → void?
  proc : (or/c (->* (any/c output-port?) ((or/c 0 1)) any)
               (any/c output-port? . -> . any))
```

A parameter that determines *global port print handler*, which is called by the default port print handler (see `port-print-handler`) to `print` values into a port. The default value is equivalent to `default-global-port-print-handler`.

A global port print handler optionally accepts a third argument, which corresponds to the optional third argument to `print`. If a procedure given to `global-port-print-handler` does not accept a third argument, it is wrapped with a procedure that discards the optional third argument.

```
(default-global-port-print-handler  v
                                    out
                                   [print-depth]) → void?
  v : any/c
  out : output-port?
  print-depth : (or/c 0 1) = 0
```

Prints *v* to *out* using the built-in printer (see §1.4 "The Printer") in `print` mode.

Added in version 8.8.0.6 of package `base`.

13.6 Pretty Printing

```
(require racket/pretty)      package: base
```

The bindings documented in this section are provided by the `racket/pretty` and `racket` libraries, but not `racket/base`.

```
(pretty-print  v
              [port
               quote-depth
               #:newline? newline?]) → void?
  v : any/c
  port : output-port? = (current-output-port)
  quote-depth : (or/c 0 1) = 0
  newline? : boolean? = #t
```

Pretty-prints the value *v* using the same printed form as the default `print` mode, but with newlines and whitespace inserted to avoid lines longer than `(pretty-print-columns)`, as controlled by `(pretty-print-current-style-table)`. The printed form ends in a newline by default, unless the *newline?* argument is supplied with false or the `pretty-print-columns` parameter is set to `'infinity`. When *port* has line counting enabled (see §13.1.4 "Counting Positions, Lines, and Columns"), then printing is sensitive to the column when printing starts—both for determining an initial line break and indenting subsequent lines.

In addition to the parameters defined in this section, `pretty-print` conforms to the `print-graph`, `print-struct`, `print-hash-table`, `print-vector-length`, `print-box`, and `print-as-expression` parameters.

The pretty printer detects structures that have the `prop:custom-write` property and calls the corresponding custom-write procedure. The custom-write procedure can check the parameter `pretty-printing` to cooperate with the pretty-printer. Recursive printing to the port automatically uses pretty printing, but if the structure has multiple recursively printed sub-expressions, a custom-write procedure may need to cooperate more to insert explicit newlines. Use `port-next-location` to determine the current output column, use `pretty-print-columns` to determine the target printing width, and use `pretty-print-newline` to insert a newline (so that the function in the `pretty-print-print-line` parameter can be called appropriately). Use `make-tentative-pretty-print-output-port` to obtain a port for tentative recursive prints (e.g., to check the length of the output).

If the *newline?* argument is omitted or supplied with true, the `pretty-print-print-line` callback is called with false as the first argument to print the last newline after the printed value. If it is supplied with false, the `pretty-print-print-line` callback is not called after the printed value.

Changed in version 6.6.0.3 of package `base`: Added *newline?* argument.

```
(pretty-write v [port #:newline? newline?]) → void?
  v : any/c
  port : output-port? = (current-output-port)
  newline? : boolean? = #t
```

Same as `pretty-print`, but *v* is printed like `write` instead of like `print`.

Changed in version 6.6.0.3 of package base: Added *newline?* argument.

```
(pretty-display v [port #:newline? newline?]) → void?
  v : any/c
  port : output-port? = (current-output-port)
  newline? : boolean? = #t
```

Same as `pretty-print`, but *v* is printed like `display` instead of like `print`.

Changed in version 6.6.0.3 of package base: Added *newline?* argument.

```
(pretty-format v [columns #:mode mode]) → string?
  v : any/c
  columns : exact-nonnegative-integer? = (pretty-print-columns)
  mode : (or/c 'print 'write 'display) = 'print
```

Like `pretty-print`, except that it returns a string containing the pretty-printed value, rather than sending the output to a port.

The optional argument *columns* argument is used to parameterize `pretty-print-columns`.

The keyword argument *mode* controls whether printing is done like either `pretty-print` (the default), `pretty-write` or `pretty-display`.

Changed in version 6.3 of package base: Added a *mode* argument.

```
(pretty-print-handler v) → void?
  v : any/c
```

Pretty-prints *v* if *v* is not `#<void>`, or prints nothing if *v* is `#<void>`. Pass this procedure to `current-print` to install the pretty printer into the REPL run by `read-eval-print-loop`.

13.6.1 Basic Pretty-Print Options

```
(pretty-print-columns)
 → (or/c exact-positive-integer? 'infinity)
(pretty-print-columns width) → void?
  width : (or/c exact-positive-integer? 'infinity)
```

A parameter that determines the default width for pretty printing.

If the display width is `'infinity`, then pretty-printed output is never broken into lines, and a newline is not added to the end of the output.

```
(pretty-print-depth) → (or/c exact-nonnegative-integer? #f)
(pretty-print-depth depth) → void?
  depth : (or/c exact-nonnegative-integer? #f)
```

Parameter that controls the default depth for recursive pretty printing. Printing to `depth` means that elements nested more deeply than `depth` are replaced with "..."; in particular, a depth of `0` indicates that only simple values are printed. A depth of `#f` (the default) allows printing to arbitrary depths.

```
(pretty-print-exact-as-decimal) → boolean?
(pretty-print-exact-as-decimal as-decimal?) → void?
  as-decimal? : any/c
```

A parameter that determines how exact non-integers are printed. If the parameter's value is `#t`, then an exact non-integer with a decimal representation is printed as a decimal number instead of a fraction. The initial value is `#f`.

```
(pretty-print-.-symbol-without-bars) → boolean?
(pretty-print-.-symbol-without-bars on?) → void?
  on? : any/c
```

A parameter that controls the printing of the symbol whose print name is just a period. If set to a true value, then such a symbol is printed as only the period. If set to a false value, it is printed as a period with vertical bars surrounding it.

```
(pretty-print-show-inexactness) → boolean?
(pretty-print-show-inexactness show?) → void?
  show? : any/c
```

A parameter that determines how inexact numbers are printed. If the parameter's value is `#t`, then inexact numbers are always printed with a leading `#i`. The initial value is `#f`.

13.6.2 Per-Symbol Special Printing

```
(pretty-print-abbreviate-read-macros) → boolean?
(pretty-print-abbreviate-read-macros abbrev?) → void?
  abbrev? : any/c
```

A parameter that controls whether or not `quote`, `unquote`, `unquote-splicing`, etc., are abbreviated with `'`, `,`, `,@`, etc. By default, the abbreviations are enabled.

See also `pretty-print-remap-stylable`.

```
(pretty-print-style-table? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a style table for use with `pretty-print-current-style-table`, `#f` otherwise.

```
(pretty-print-current-style-table) → pretty-print-style-table?
(pretty-print-current-style-table style-table) → void?
  style-table : pretty-print-style-table?
```

A parameter that holds a table of style mappings. See `pretty-print-extend-style-table`.

```
(pretty-print-extend-style-table style-table
                                 symbol-list
                                 like-symbol-list)
 → pretty-print-style-table?
  style-table : pretty-print-style-table?
  symbol-list : (listof symbol?)
  like-symbol-list : (listof symbol?)
```

Creates a new style table by extending an existing *style-table*, so that the style mapping for each symbol of *like-symbol-list* in the original table is used for the corresponding symbol of *symbol-list* in the new table. The *symbol-list* and *like-symbol-list* lists must have the same length. The *style-table* argument can be `#f`, in which case the default mappings are used from the original table (see below).

The style mapping for a symbol controls the way that whitespace is inserted when printing a list that starts with the symbol. In the absence of any mapping, when a list is broken across multiple lines, each element of the list is printed on its own line, each with the same indentation.

The default style mapping includes mappings for the following symbols, so that the output follows popular code-formatting rules:

```
'lambda 'λ 'case-lambda
'define 'define-macro 'define-syntax
'let 'letrec 'let*
'let-syntax 'letrec-syntax
'let-values 'letrec-values 'let*-values
'let-syntaxes 'letrec-syntaxes
'begin 'begin0 'do
'if 'set! 'set!-values
'unless 'when
'cond 'case 'and 'or
```

```
'module
'syntax-rules 'syntax-case 'letrec-syntaxes+values
'import 'export 'link
'require 'require-for-syntax 'require-for-template 'provide
'public 'private 'override 'rename 'inherit 'field 'init
'shared 'send 'class 'instantiate 'make-object
```

```
(pretty-print-remap-stylable)
 → (any/c . -> . (or/c symbol? #f))
(pretty-print-remap-stylable proc) → void?
  proc : (any/c . -> . (or/c symbol? #f))
```

A parameter that controls remapping for styles and for the determination of the reader shorthands.

This procedure is called with each sub-expression that appears as the first element in a sequence. If it returns a symbol, the style table is used, as if that symbol were at the head of the sequence. If it returns `#f`, the style table is treated normally. Similarly, when determining whether to abbreviate reader macros, this parameter is consulted.

13.6.3 Line-Output Hook

```
(pretty-print-newline port width) → void?
  port : output-port?
  width : exact-nonnegative-integer?
```

Calls the procedure associated with the `pretty-print-print-line` parameter to print a newline to *port*, if *port* is the output port that is redirected to the original output port for printing, otherwise a plain newline is printed to *port*. The *width* argument should be the target column width, typically obtained from `pretty-print-columns`.

```
(pretty-print-print-line)
 → ((or/c exact-nonnegative-integer? #f)
     output-port?
     exact-nonnegative-integer?
     (or/c exact-nonnegative-integer? 'infinity)
     . -> .
     exact-nonnegative-integer?)
(pretty-print-print-line proc) → void?
  proc : ((or/c exact-nonnegative-integer? #f)
          output-port?
          exact-nonnegative-integer?
          (or/c exact-nonnegative-integer? 'infinity)
          . -> .
          exact-nonnegative-integer?)
```

A parameter that determines a procedure for printing the newline separator between lines of a pretty-printed value. The procedure is called with four arguments: a new line number, an output port, the old line's length, and the number of destination columns. The return value from *proc* is the number of extra characters it printed at the beginning of the new line.

The *proc* procedure is called before any characters are printed with `0` as the line number and `0` as the old line length. Whenever the pretty-printer starts a new line, *proc* is called with the new line's number (where the first new line is numbered `1`) and the just-finished line's length. The destination-columns argument to *proc* is always the total width of the destination printing area, or `'infinity` if pretty-printed values are not broken into lines.

If the `#:newline?` argument was omitted or supplied with a true value, *proc* is also called after the last character of the value has been printed, with `#f` as the line number and with the length of the last line.

The default *proc* procedure prints a newline whenever the line number is not `0` and the column count is not `'infinity`, always returning `0`. A custom *proc* procedure can be used to print extra text before each line of pretty-printed output; the number of characters printed before each line should be returned by *proc* so that the next line break can be chosen correctly.

The destination port supplied to *proc* is generally not the port supplied to `pretty-print` or `pretty-display` (or the current output port), but output to this port is ultimately redirected to the port supplied to `pretty-print` or `pretty-display`.

13.6.4 Value Output Hook

```
(pretty-print-size-hook)
 → (any/c boolean? output-port?
     . -> .
     (or/c #f exact-nonnegative-integer?))
(pretty-print-size-hook proc) → void?
  proc : (any/c boolean? output-port?
          . -> .
          (or/c #f exact-nonnegative-integer?))
```

A parameter that determines a sizing hook for pretty-printing.

The sizing hook is applied to each value to be printed. If the hook returns `#f`, then printing is handled internally by the pretty-printer. Otherwise, the value should be an integer specifying the length of the printed value in characters; the print hook will be called to actually print the value (see `pretty-print-print-hook`).

The sizing hook receives three arguments. The first argument is the value to print. The second argument is a boolean: `#t` for printing like `display` and `#f` for printing like `write`.

The third argument is the destination port; the port is the one supplied to `pretty-print` or `pretty-display` (or the current output port). The sizing hook may be applied to a single value multiple times during pretty-printing.

```
(pretty-print-print-hook)
 → (any/c boolean? output-port? . -> . void?)
(pretty-print-print-hook proc) → void?
  proc : (any/c boolean? output-port? . -> . void?)
```

A parameter that determines a print hook for pretty-printing. The print-hook procedure is applied to a value for printing when the sizing hook (see `pretty-print-size-hook`) returns an integer size for the value.

The print hook receives three arguments. The first argument is the value to print. The second argument is a boolean: `#t` for printing like `display` and `#f` for printing like `write`. The third argument is the destination port; this port is generally not the port supplied to `pretty-print` or `pretty-display` (or the current output port), but output to this port is ultimately redirected to the port supplied to `pretty-print` or `pretty-display`.

```
(pretty-print-pre-print-hook)
 → (any/c output-port? . -> . void)
(pretty-print-pre-print-hook proc) → void?
  proc : (any/c output-port? . -> . void)
```

A parameter that determines a hook procedure to be called just before an object is printed. The hook receives two arguments: the object and the output port. The port is the one supplied to `pretty-print` or `pretty-display` (or the current output port).

```
(pretty-print-post-print-hook)
 → (any/c output-port? . -> . void)
(pretty-print-post-print-hook proc) → void?
  proc : (any/c output-port? . -> . void)
```

A parameter that determines a hook procedure to be called just after an object is printed. The hook receives two arguments: the object and the output port. The port is the one supplied to `pretty-print` or `pretty-display` (or the current output port).

13.6.5 Additional Custom-Output Support

```
(pretty-printing) → boolean?
(pretty-printing on?) → void?
  on? : any/c
```

A parameter that is set to `#t` when the pretty printer calls a custom-write procedure (see `prop:custom-write`) for output in a mode that supports line breaks. When pretty printer calls a custom-write procedure merely to detect cycles or to try to print on a single line, it sets this parameter to #f.

```
(make-tentative-pretty-print-output-port out
                                         width
                                         overflow-thunk)
 → output-port?
  out : output-port?
  width : exact-nonnegative-integer?
  overflow-thunk : (-> any)
```

Produces an output port that is suitable for recursive pretty printing without actually producing output. Use such a port to tentatively print when proper output depends on the size of recursive prints. After printing, determine the size of the tentative output using file-position.

The *out* argument should be a pretty-printing port, such as the one supplied to a custom-write procedure when pretty-printing is set to true, or another tentative output port. The *width* argument should be a target column width, usually obtained from pretty-print-columns, possibly decremented to leave room for a terminator. The *overflow-thunk* procedure is called if more than *width* items are printed to the port or if a newline is printed to the port via pretty-print-newline; it can escape from the recursive print through a continuation as a shortcut, but *overflow-thunk* can also return, in which case it is called every time afterward that additional output is written to the port.

After tentative printing, either accept the result with tentative-pretty-print-port-transfer or reject it with tentative-pretty-print-port-cancel. Failure to accept or cancel properly interferes with graph-structure printing, calls to hook procedures, etc. Explicitly cancel the tentative print even when *overflow-thunk* escapes from a recursive print.

```
(tentative-pretty-print-port-transfer tentative-out
                                      orig-out)     → void?
  tentative-out : output-port?
  orig-out : output-port?
```

Causes the data written to *tentative-out* to be transferred as if written to *orig-out*. The *tentative-out* argument should be a port produced by make-tentative-pretty-print-output-port, and *orig-out* should be either a pretty-printing port (provided to a custom-write procedure) or another tentative output port.

```
(tentative-pretty-print-port-cancel tentative-out) → void?
  tentative-out : output-port?
```

Cancels the content of *tentative-out*, which was produced by make-tentative-pretty-print-output-port. The main effect of canceling is that graph-reference definitions are undone, so that a future print of a graph-referenced object includes the defining `#`⟨*n*⟩`=`.

13.7 Reader Extension

Racket's reader can be extended in three ways: through a reader-macro procedure in a readtable (see §13.7.1 "Readtables"), through a `#reader` form (see §1.3.18 "Reading via an Extension"), or through a custom-port byte reader that returns a "special" result procedure (see §13.1.9 "Custom Ports"). All three kinds of *reader extension procedures* accept similar arguments, and their results are treated in the same way by `read` and `read-syntax` (or, more precisely, by the default read handler; see `port-read-handler`).

13.7.1 Readtables

The dispatch table in §1.3.1 "Delimiters and Dispatch" corresponds to the default *readtable*. By creating a new readtable and installing it via the `current-readtable` parameter, the reader's behavior can be extended.

A readtable is consulted at specific times by the reader:

- when looking for the start of a datum;
- when determining how to parse a datum that starts with `#`;
- when looking for a delimiter to terminate a symbol or number;
- when looking for an opener (such as `(`), closer (such as `)`), or `.` after the first character parsed as a sequence for a pair, list, vector, or hash table; or
- when looking for an opener after `#`⟨*n*⟩ in a vector of specified length ⟨*n*⟩.

The readtable is ignored at other times. In particular, after parsing a character that is mapped to the default behavior of `;`, the readtable is ignored until the comment's terminating newline is discovered. Similarly, the readtable does not affect string parsing until a closing double-quote is found. Meanwhile, if a character is mapped to the default behavior of `(`, then it starts a sequence that is closed by any character that is mapped to a closing parenthesis `)`. An apparent exception is that the default parsing of `|` quotes a symbol until a matching character is found, but the parser is simply using the character that started the quote; it does not consult the readtable.

For many contexts, `#f` identifies the default readtable. In particular, `#f` is the initial value for the `current-readtable` parameter, which causes the reader to behave as described in §1.3 "The Reader".

```
(readtable? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a readtable, `#f` otherwise.

```
(make-readtable readtable key mode action ...) → readtable?
  readtable : (or/c readtable? #f)
  key : (or/c char? #f)
  mode : (or/c 'terminating-macro
               'non-terminating-macro
               'dispatch-macro
               char?)
  action : (or/c procedure?
                 readtable?
                 #f)
```

Creates a new readtable that is like *readtable* (which can be `#f` to indicate the default readtable), except that the reader's behavior is modified for each *key* according to the given *mode* and *action*. The `...` for `make-readtable` applies to all three of *key*, *mode*, and *action*; in other words, the total number of arguments to `make-readtable` must be 1 modulo 3.

The possible combinations for *key*, *mode*, and *action* are as follows:

- *char* `'terminating-macro` *proc* — causes *char* to be parsed as a delimiter, and an unquoted/uncommented *char* in the input string triggers a call to the *reader macro* *proc*; the activity of *proc* is described further below. Conceptually, characters like `;`, `(`, and `)` are mapped to terminating reader macros in the default readtable.
- *char* `'non-terminating-macro` *proc* — like the `'terminating-macro` variant, but *char* is not treated as a delimiter, so it can be used in the middle of an identifier or number. Conceptually, `#` is mapped to a non-terminating macro in the default readtable.
- *char* `'dispatch-macro` *proc* — like the `'non-terminating-macro` variant, but for *char* only when it follows a `#` (or, more precisely, when the character follows one that has been mapped to the behavior of `#` in the default readtable).
- *char* *like-char* *readtable* — causes *char* to be parsed in the same way that *like-char* is parsed in *readtable*, where *readtable* can be `#f` to indicate the default readtable. (The mapping of *char* does not apply after `#`, which is configured separately via `'dispatch-macro`.) Mapping a character to the same actions as `|` in the default reader means that the character starts quoting for symbols, and the same character terminates the quote; in contrast, mapping a character to the same action as a `"` means that the character starts a string, but the string is still terminated with a

closing `"`. Finally, mapping a character to an action in the default readtable means that the character's behavior is sensitive to parameters that affect the original character; for example, mapping a character to the same action as a curly brace `{` in the default readtable means that the character is disallowed when the `read-curly-brace-as-paren` parameter is set to `#f`.

- `#f 'non-terminating-macro` *`proc`* — replaces the macro used to parse characters with no specific mapping: i.e., the characters (other than `#` or `|`) that can start a symbol or number with the default readtable.

If multiple `'dispatch-macro` mappings are provided for a single *`char`*, all but the last one are ignored. Similarly, if multiple non-`'dispatch-macro` mappings are provided for a single *`char`*, all but the last one are ignored.

A reader macro *`proc`* must accept six arguments, and it can optionally accept two arguments. The first two arguments are always the character that triggered the reader macro and the input port for reading. When the reader macro is triggered by `read-syntax` (or `read-syntax/recursive`), the procedure is passed four additional arguments that represent a source location for already-consumed character(s): the source name, a line number or `#f`, a column number or `#f`, and a position or `#f`. When the reader macro is triggered by `read` (or `read/recursive`), the procedure is passed only two arguments if it accepts two arguments, otherwise it is passed six arguments where the third is always `#f`. See §13.7.2 "Reader-Extension Procedures" for information on the procedure's results.

A reader macro normally reads characters from the given input port to produce a value to be used as the "reader macro-expansion" of the consumed characters. The reader macro might produce a special-comment value (see §13.7.3 "Special Comments") to cause the consumed character to be treated as whitespace, and it might use `read/recursive` or `read-syntax/recursive`.

```
(readtable-mapping readtable char)
   (or/c char?
→        'terminating-macro
         'non-terminating-macro)
   (or/c #f procedure?)
   (or/c #f procedure?)
  readtable : readtable?
  char : char?
```

Produces information about the mappings in *`readtable`* for *`char`*. The result is three values:

- either a character (mapping to the same behavior as the character in the default readtable), `'terminating-macro`, or `'non-terminating-macro`; this result reports the main (i.e., non-`'dispatch-macro`) mapping for *`char`*. When the result is a character, then *char* is mapped to the same behavior as the returned character in the default readtable.

- either #f or a reader-macro procedure; the result is a procedure when the first result is 'terminating-macro or 'non-terminating-macro.
- either #f or a reader-macro procedure; the result is a procedure when the character has a 'dispatch-macro mapping in *readtable* to override the default dispatch behavior.

Note that reader-macro procedures for the default readtable are not directly accessible. To invoke default behaviors, use read/recursive or read-syntax/recursive with a character and the #f readtable.

Examples:

```
; Provides raise-read-error and raise-read-eof-error
> (require syntax/readerr)
> (define (skip-whitespace port)
    ; Skips whitespace characters, sensitive to the current
    ; readtable's definition of whitespace
    (let ([ch (peek-char port)])
      (unless (eof-object? ch)
        ; Consult current readtable:
        (let-values ([(like-ch/sym proc dispatch-proc)
                      (readtable-mapping (current-readtable) ch)])
          ; If like-ch/sym is whitespace, then ch is whitespace
          (when (and (char? like-ch/sym)
                     (char-whitespace? like-ch/sym))
            (read-char port)
            (skip-whitespace port))))))
> (define (skip-comments read-one port src)
    ; Recursive read, but skip comments and detect EOF
    (let loop ()
      (let ([v (read-one)])
        (cond
         [(special-comment? v) (loop)]
         [(eof-object? v)
          (let-values ([(l c p) (port-next-location port)])
            (raise-read-eof-error
             "unexpected EOF in tuple" src l c p 1))]
         [else v]))))
> (define (parse port read-one src)
    ; First, check for empty tuple
    (skip-whitespace port)
    (if (eq? #\> (peek-char port))
        null
```

```
          (let ([elem (read-one)])
            (if (special-comment? elem)
                ; Found a comment, so look for > again
                (parse port read-one src)
                ; Non-empty tuple:
                (cons elem
                      (parse-nonempty port read-one src))))))
> (define (parse-nonempty port read-one src)
    ; Need a comma or closer
    (skip-whitespace port)
    (case (peek-char port)
      [(#\>) (read-char port)
       ; Done
       null]
      [(#\,) (read-char port)
       ; Read next element and recur
       (cons (skip-comments read-one port src)
             (parse-nonempty port read-one src))]
      [else
       ; Either a comment or an error; grab location (in case
       ; of error) and read recursively to detect comments
       (let-values ([(l c p) (port-next-location port)]
                    [(v) (read-one)])
         (cond
          [(special-comment? v)
           ; It was a comment, so try again
           (parse-nonempty port read-one src)]
          [else
           ; Wasn't a comment, comma, or closer; error
           ((if (eof-object? v)
                raise-read-eof-error
                raise-read-error)
            "expected `,` or `>`" src l c p 1)]))]))
> (define (make-delims-table)
    ; Table to use for recursive reads to disallow delimiters
    ;  (except those in sub-expressions)
    (letrec ([misplaced-delimiter
              (case-lambda
               [(ch port) (misplaced-delimiter ch port #f #f #f #f)]
               [(ch port src line col pos)
                (raise-read-error
                 (format "misplaced `~a` in tuple" ch)
                 src line col pos 1)])])
      (make-readtable (current-readtable)
                      #\, 'terminating-macro misplaced-delimiter
                      #\> 'terminating-macro misplaced-
```

```
delimiter)))
> (define (wrap l)
    `(make-tuple (list ,@l)))
> (define parse-open-tuple
    (case-lambda
     [(ch port)
      ; `read` mode
      (wrap (parse port
                   (lambda ()
                     (read/recursive port #f
                                     (make-delims-table)))
                   (object-name port)))]
     [(ch port src line col pos)
      ; `read-syntax` mode
      (datum->syntax
       #f
       (wrap (parse port
                    (lambda ()
                      (read-syntax/recursive src port #f
                                             (make-delims-table)))
                    src))
       (let-values ([(l c p) (port-next-location port)])
         (list src line col pos (and pos (- p pos)))))]))
> (define tuple-readtable
    (make-readtable #f #\< 'terminating-macro parse-open-tuple))
> (parameterize ([current-readtable tuple-readtable])
    (read (open-input-string "<1 , 2 , \"a\">")))
'(make-tuple (list 1 2 "a"))
> (parameterize ([current-readtable tuple-readtable])
    (read (open-input-string
           "< #||# 1 #||# , #||# 2 #||# , #||# \"a\" #||# >")))
'(make-tuple (list 1 2 "a"))
> (define tuple-readtable+
    (make-readtable tuple-readtable
                    #\* 'terminating-macro (lambda a
                                             (make-special-
comment #f))
                    #\_ #\space #f))
> (parameterize ([current-readtable tuple-readtable+])
    (read (open-input-string "< * 1 __,__  2 __,__ * \"a\" * >")))
'(make-tuple (list 1 2 "a"))
```

13.7.2 Reader-Extension Procedures

Calls to reader extension procedures can be triggered through `read`, `read/recursive`, or `read-syntax`. In addition, a special-read procedure can be triggered by calls to `read-char-or-special`, or by the context of `read-bytes-avail!`, `peek-bytes-avail!*`, `read-bytes-avail!`, and `peek-bytes-avail!*`.

Optional arities for reader-macro and special-result procedures allow them to distinguish reads via `read`, etc., from reads via `read-syntax`, etc. (where the source value is `#f` and no other location information is available).

When a reader-extension procedure is called in syntax-reading mode (via `read-syntax`, etc.), it should generally return a syntax object that has no lexical context (e.g., a syntax object created using `datum->syntax` with `#f` as the first argument and with the given location information as the third argument). Another possible result is a special-comment value (see §13.7.3 "Special Comments"). If the procedure's result is not a syntax object and not a special-comment value, it is converted to one using `datum->syntax`.

When a reader-extension procedure is called in non-syntax-reading modes, it should generally not return a syntax object. If a syntax object is returned, it is converted to a plain value using `syntax->datum`.

In either context, when the result from a reader-extension procedure is a special-comment value (see §13.7.3 "Special Comments"), then `read`, `read-syntax`, etc. treat the value as a delimiting comment and otherwise ignore it.

Also, in either context, the result may be copied to prevent mutation to vectors or boxes before the read result is completed, and to support the construction of graphs with cycles. Mutable boxes, vectors, and prefab structures are copied, along with any pairs, boxes, vectors, prefab structures that lead to such mutable values, to placeholders produced by a recursive read (see `read/recursive`), or to references of a shared value. Graph structure (including cycles) is preserved in the copy.

13.7.3 Special Comments

```
(make-special-comment v) → special-comment?
  v : any/c
```

Creates a special-comment value that encapsulates *v*. The `read`, `read-syntax`, etc., procedures treat values constructed with `make-special-comment` as delimiting whitespace when returned by a reader-extension procedure (see §13.7.2 "Reader-Extension Procedures").

```
(special-comment? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is the result of `make-special-comment`, `#f` otherwise.

```
(special-comment-value sc) → any
  sc : special-comment?
```

Returns the value encapsulated by the special-comment value *sc*. This value is never used directly by a reader, but it might be used by the context of a `read-char-or-special`, etc., call that detects a special comment.

13.8 Printer Extension

```
gen:custom-write : any/c
```

A generic interface (see §5.4 "Generic Interfaces") that supplies a method, `write-proc` used by the default printer to `display`, `write`, or `print` instances of the structure type.

A `write-proc` method takes three arguments: the structure to be printed, the target port, and an argument that is `#t` for `write` mode, `#f` for `display` mode, or `0` or `1` indicating the current quoting depth for `print` mode. The procedure should print the value to the given port using `write`, `display`, `print`, `fprintf`, `write-special`, etc.

The port write handler, port display handler, and print handler are specially configured for a port given to a custom-write procedure. Printing to the port through `display`, `write`, or `print` prints a value recursively with sharing annotations. To avoid a recursive print (i.e., to print without regard to sharing with a value currently being printed), print instead to a string or pipe and transfer the result to the target port using `write-string` or `write-special`. To print recursively to a port other than the one given to the custom-write procedure, copy the given port's write handler, display handler, and print handler to the other port.

The port given to `write-proc` is not necessarily the actual target port. In particular, to detect cycles, sharing, and quoting modes (in the case of `print`), the printer invokes a custom-write procedure with a port that records information about recursive prints, and does not retain any other output. This information-gathering phase needs the same objects (in the `eq?` sense) to be printed as later, so that the recorded information can be correlated with printed values.

Recursive print operations may trigger an escape from a call to `write-proc`. For example, printing may escape during pretty-printing where a tentative print attempt overflows the line, or it may escape while printing error output that is constrained to a limited width.

The following example definition of a `tuple` type includes a `write-proc` procedure that prints the tuple's list content using angle brackets in `write` and `print` mode and no brackets in `display` mode. Elements of the tuple are printed recursively, so that graph and cycle structure can be represented.

Examples:

```
(define (tuple-print tuple port mode)
  (when mode (write-string "<" port))
  (let ([l (tuple-ref tuple)]
        [recur (case mode
                 [(#t) write]
                 [(#f) display]
                 [else (lambda (p port) (print p port mode))])])
    (unless (zero? (vector-length l))
      (recur (vector-ref l 0) port)
      (for-each (lambda (e)
                  (write-string ", " port)
                  (recur e port))
                (cdr (vector->list l)))))
  (when mode (write-string ">" port)))

(struct tuple (ref)
        #:methods gen:custom-write
        [(define write-proc tuple-print)])

> (display (tuple #(1 2 "a")))
1, 2, a
> (print (tuple #(1 2 "a")))
<1, 2, "a">
> (let ([t (tuple (vector 1 2 "a"))])
    (vector-set! (tuple-ref t) 0 t)
    (write t))
#0=<#0#, 2, "a">
```

The make-constructor-style-printer function can help in the implementation of a write-proc, as in this example:

Examples:

```
(require racket/struct)

(struct point (x y)
  #:methods gen:custom-write
  [(define write-proc
     (make-constructor-style-printer
      (lambda (obj) 'point)
      (lambda (obj) (list (point-x obj) (point-y obj)))))])

> (print (point 1 2))
(point 1 2)
> (write (point 1 2))
#<point: 1 2>
```

Changed in version 8.7.0.5 of package base: Added a check so that omitting *write-proc* is now a syntax error.

```
prop:custom-write : struct-type-property?
```

A structure type property (see §5.3 "Structure Type Properties") that supplies a procedure that corresponds to `gen:custom-write`'s `write-proc`. Using the `prop:custom-write` property is discouraged; use the `gen:custom-write` generic interface instead.

```
(custom-write? v) → boolean?
  v : any/c
```

Returns `#t` if *v* has the `prop:custom-write` property, `#f` otherwise.

```
(custom-write-accessor v)
 → (custom-write? output-port? (or/c #t #f 0 1) . -> . any)
  v : custom-write?
```

Returns the custom-write procedure associated with *v*.

```
prop:custom-print-quotable : struct-type-property?
custom-print-quotable? : struct-type-property?
custom-print-quotable-accessor : struct-type-property?
```

A property and associated predicate and accessor. The property value is one of `'self`, `'never`, `'maybe`, or `'always`. When a structure has this property in addition to a `prop:custom-write` property value, then the property value affects printing in `print` mode; see §1.4 "The Printer". When a value does not have the `prop:custom-print-quotable`, it is equivalent to having the `'self` property value, which is suitable both for self-quoting forms and printed forms that are unreadable.

13.9 Serialization

```
(require racket/serialize)    package: base
```

The bindings documented in this section are provided by the `racket/serialize` library, not `racket/base` or `racket`.

```
(serializable? v) → boolean?
  v : any/c
```

Returns `#t` if *v* appears to be serializable, without checking the content of compound values, and `#f` otherwise. See `serialize` for an enumeration of serializable values.

```
(serialize
  v
 [#:relative-directory relative-to
  #:deserialize-relative-directory deserialize-relative-to])
→ any
 v : serializable?
 relative-to : (or/c (and/c path? complete-path?)          = #f
                     (cons/c (and/c path? complete-path?)
                             (and/c path? complete-path?))
                     #f)
 deserialize-relative-to : (or/c (and/c path? complete-path?)
                                 (cons/c (and/c path? complete-path?)
                                         (and/c path? complete-path?))
                                 #f)
                         = relative-to
```

Returns a value that encapsulates the value *v*. This value includes only readable values, so it can be written to a stream with `write` or `s-exp->fasl`, later read from a stream using `read` or `fasl->s-exp`, and then converted to a value like the original using `deserialize`. Serialization followed by deserialization produces a value with the same graph structure and mutability as the original value, but the serialized value is a plain tree (i.e., no sharing).

The following kinds of values are *serializable*:

- structures created through `serializable-struct` or `serializable-struct/versions`, or more generally structures with the `prop:serializable` property (see `prop:serializable` for more information);
- prefab structures;
- instances of classes defined with `define-serializable-class` or `define-serializable-class*`;
- booleans, numbers, characters, interned symbols, unreadable symbols, keywords, strings, byte strings, paths (for a specific convention), regexp values, `#<void>`, and the empty list;
- pairs, mutable pairs, vectors, flvectors, fxvectors, boxes, hash tables, sets, and treelists;
- `date`, `date*`, `arity-at-least` and `srcloc` structures; and
- module path index values.

Serialization succeeds for a compound value, such as a pair, only if all content of the value is serializable. If a value given to `serialize` is not completely serializable, the `exn:fail:contract` exception is raised.

If *v* contains a cycle (i.e., a collection of objects that are all reachable from each other), then *v* can be serialized only if the cycle includes a mutable value, where a prefab structure counts as mutable only if all of its fields are mutable.

If *relative-to* is not `#f`, then paths to serialize that extend the path in *relative-to* are recorded in relative and platform-independent form. The possible values and treatment of *relative-to* are the same as for `current-write-relative-directory`.

If *deserialize-relative-to* is not `#f`, then any paths to deserializers as extracted via `prop:serializable` are recorded in relative form. Note that *relative-to* and *deserialize-relative-to* are independent, but *deserialize-relative-to* defaults to *relative-to*.

See `deserialize` for information on the format of serialized data.

The `serialize` and `deserialize` functions currently do not handle certain cyclic values that `read` and `write` can handle, such as `'#0=(#0#)`.

Changed in version 6.5.0.4 of package `base`: Added keywords and regexp values as serializable.
Changed in version 7.0.0.6: Added the `#:relative-directory` and `#:deserialize-relative-directory` arguments.

```
(deserialize v) → any
  v : any/c
```

Given a value *v* that was produced by `serialize`, produces a value like the one given to `serialize`, including the same graph structure and mutability.

A serialized representation *v* is a list of six or seven elements:

- An optional list `'(1)`, `'(2)`, `'(3)`, or `'(4)` that represents the version of the serialization format. If the first element of a representation is not a list, then the version is `0`. Version 1 adds support for mutable pairs, version 2 adds support for unreadable symbols, version 3 adds support for `date*` structures, and version 4 adds support for paths that are meant to be relative to the deserialization directory.
- A non-negative exact integer *s-count* that represents the number of distinct structure types represented in the serialized data.
- A list *s-types* of length *s-count*, where each element represents a structure type. Each structure type is encoded as a pair. The `car` of the pair is `#f` for a structure whose deserialization information is defined at the top level, otherwise it is a quoted module path, a byte string (to be converted into a platform-specific path using `bytes->path`) for a module that exports the structure's deserialization information, or a relative path element list for a module to be resolved with respect to `current-load-relative-directory` or (as a fallback) `current-directory`; the list-of-relative-elements form is produced by `serialize` when the `#:deserialize-relative-directory` argument is not `#f`. The `cdr` of the pair is the name of a binding (at the top level or exported from a module) for deserialization information, either a symbol or a string representing an unreadable symbol. These two are used

with either `namespace-variable-binding` or `dynamic-require` to obtain deserialization information. See `make-deserialize-info` for more information on the binding's value. See also `deserialize-module-guard`.

- A non-negative exact integer, *g-count* that represents the number of graph points contained in the following list.
- A list *graph* of length *g-count*, where each element represents a serialized value to be referenced during the construction of other serialized values. Each list element is either a box or not:
  - A box represents a value that is part of a cycle, and for deserialization, it must be allocated with `#f` for each of its fields. The content of the box indicates the shape of the value:
    - a non-negative exact integer *i* for an instance of a structure type that is represented by the *i*th element of the *s-types* list;
    - `'c` for a pair, which fails on deserialization (since pairs are immutable; this case does not appear in output generated by `serialize`);
    - `'m` for a mutable pair;
    - `'b` for a box;
    - a pair whose `car` is `'v` and whose `cdr` is a non-negative exact integer *s* for a vector of length *s*;
    - a list whose first element is `'h` and whose remaining elements are symbols that determine the hash-table type:
      - `'equal` — `(make-hash)`
      - `'equal 'weak` — `(make-weak-hash)`
      - `'weak` — `(make-weak-hasheq)`
      - no symbols — `(make-hasheq)`
    - `'date*` for a `date*` structure, which fails on deserialization (since dates are immutable; this case does not appear in output generated by `serialize`);
    - `'date` for a `date` structure, which fails on deserialization (since dates are immutable; this case does not appear in output generated by `serialize`);
    - `'arity-at-least` for an `arity-at-least` structure, which fails on deserialization (since arity-at-least are immutable; this case does not appear in output generated by `serialize`); or
    - `'mpi` for a module path index, which fails on deserialization (since a module path index is immutable; this case does not appear in output generated by `serialize`).
    - `'srcloc` for a `srcloc` structure, which fails on deserialization (since srclocs are immutable; this case does not appear in output generated by `serialize`).

    The `#f`-filled value will be updated with content specified by the fifth element of the serialization list *v*.

– A non-box represents a *serial* value to be constructed immediately, and it is one of the following:

  * a boolean, number, character, interned symbol, or empty list, representing itself.
  * a string, representing an immutable string.
  * a byte string, representing an immutable byte string.
  * a pair whose car is '? and whose cdr is a non-negative exact integer *i*; it represents the value constructed for the *i*th element of *graph*, where *i* is less than the position of this element within *graph*.
  * a pair whose car is a number *i*; it represents an instance of a structure type that is described by the *i*th element of the *s-types* list. The cdr of the pair is a list of serials representing arguments to be provided to the structure type's deserializer.
  * a pair whose car is 'q and whose cdr is an immutable value; it represents the quoted value.
  * a pair whose car is 'f; it represents an instance of a prefab structure type. The cadr of the pair is a prefab structure type key, and the cddr is a list of serials representing the field values.
  * a pair whose car is 'void, representing #<void>.
  * a pair whose car is 'su and whose cdr is a character string; it represents an unreadable symbol.
  * a pair whose car is 'u and whose cdr is either a byte string or character string; it represents a mutable byte or character string.
  * a pair whose car is 'p and whose cdr is a byte string; it represents a path using the serializer's path convention (deprecated in favor of 'p+).
  * a pair whose car is 'p+, whose cadr is a byte string, and whose cddr is one of the possible symbol results of system-path-convention-type; it represents a path using the specified convention.
  * a pair whose car is 'p* and whose cdr is a list of byte strings represents a relative path; it will be converted by deserialization based on current-load-relative-directory, falling back to current-directory.
  * a pair whose car is 'c and whose cdr is a pair of serials; it represents an immutable pair.
  * a pair whose car is 'c! and whose cdr is a pair of serials; it represents a pair (but formerly represented a mutable pair), and does not appear in output generated by serialize.
  * a pair whose car is 'm and whose cdr is a pair of serials; it represents a mutable pair.
  * a pair whose car is 'v and whose cdr is a list of serials; it represents an immutable vector.
  * a pair whose car is 'v! and whose cdr is a list of serials; it represents a mutable vector.

* a pair whose `car` is `'vl` and whose `cdr` is a list of serials; it represents a flvector.
* a pair whose `car` is `'vx` and whose `cdr` is a list of serials; it represents a fxvector.
* a pair whose `car` is `'b` and whose `cdr` is a serial; it represents an immutable box.
* a pair whose `car` is `'b!` and whose `cdr` is a serial; it represents a mutable box.
* a pair whose `car` is `'h`, whose `cadr` is either `'!` or `'-` (mutable or immutable, respectively), whose `caddr` is a list of symbols (containing `'equal`, `'weak`, both, or neither) that determines the hash table type, and whose `cdddr` is a list of pairs, where the `car` of each pair is a serial for a hash-table key and the `cdr` is a serial for the corresponding value.
* a pair whose `car` is `'date*` and whose `cdr` is a list of serials; it represents a `date*` structure.
* a pair whose `car` is `'date` and whose `cdr` is a list of serials; it represents a `date` structure.
* a pair whose `car` is `'arity-at-least` and whose `cdr` is a serial; it represents an `arity-at-least` structure.
* a pair whose `car` is `'mpi` and whose `cdr` is a pair; it represents a module path index that joins the paired values.
* a pair whose `car` is `'srcloc` and whose `cdr` is a list of serials; it represents a `srcloc` structure.

- A list of pairs, where the `car` of each pair is a non-negative exact integer *i* and the `cdr` is a serial (as defined in the previous bullet). Each element represents an update to an *i*th element of *graph* that was specified as a box, and the serial describes how to construct a new value with the same shape as specified by the box. The content of this new value must be transferred into the value created for the box in *graph*.
- A final serial (as defined in the two bullets back) representing the result of `deserialize`.

The result of `deserialize` shares no mutable values with the argument to `deserialize`.

If a value provided to `serialize` is a simple tree (i.e., no sharing), then the fourth and fifth elements in the serialized representation will be empty.

```
(serialized=? v1 v2) → boolean?
  v1 : any/c
  v2 : any/c
```

Returns `#t` if *v1* and *v2* represent the same serialization information.

More precisely, it returns the same value that `(equal? (deserialize v1) (deserialize v2))` would return if

- all structure types whose deserializers are accessed with distinct module paths are actually distinct types;
- all structure types are transparent; and
- all structure instances contain only the constituent values recorded in each of *v1* and *v2*.

```
(deserialize-module-guard)
 → (-> module-path? symbol?
       (or/c void? (cons/c module-path? symbol?)))
(deserialize-module-guard guard) → void?
  guard : (-> module-path? symbol?
              (or/c void? (cons/c module-path? symbol?)))
```

A parameter whose value is called by `deserialize` before dynamically loading a module via `dynamic-require`. The two arguments provided to the procedure are the same as the arguments to be passed to `dynamic-require`. The procedure can raise an exception to disallow the `dynamic-require`.

The procedure can optionally return a pair containing a module-path and symbol. If returned, `deserialize` will use them as arguments to `dynamic-require` instead.

Changed in version 6.90.0.30 of package `base`: Adds optional return values for bindings.

```
(serializable-struct id maybe-super (field ...)
                     struct-option ...)
```

Like `struct`, but instances of the structure type are serializable with `serialize`. This form is allowed only at the top level or in a module's top level (so that deserialization information can be found later).

Serialization supports cycles involving the created structure type only when all fields are mutable (or when the cycle can be broken through some other mutable value).

In addition to the bindings generated by `struct`, `serializable-struct` binds `deserialize-info:id-v0` to deserialization information. Furthermore, in a module context, it automatically provides this binding in a `deserialize-info` submodule using `module+`.

The `serializable-struct` form enables the construction of structure instances from places where *id* is not accessible, since deserialization must construct instances. Furthermore, `serializable-struct` provides limited access to field mutation, but only for instances generated through the deserialization information bound to `deserialize-info:id-v0`. See `make-deserialize-info` for more information.

Beware that the previous paragraph means that if a serializable struct is exported via `contract-out`, for example, the contracts are not checked during deserialization. Consider using `struct-guard/c` instead.

The `-v0` suffix on the deserialization enables future versioning on the structure type through `serializable-struct/versions`.

When a supertype is supplied as *`maybe-super`*, compile-time information bound to the supertype identifier must include all of the supertype's field accessors. If any field mutator is missing, the structure type will be treated as immutable for the purposes of marshaling (so cycles involving only instances of the structure type cannot be handled by the deserializer).

Examples:

```
> (serializable-struct point (x y))
> (point-x (deserialize (serialize (point 1 2))))
1
```

```
(define-serializable-struct id-maybe-super (field ...)
                            struct-option ...)
```

Like `serializable-struct`, but with the supertype syntax and default constructor name of `define-struct`.

```
(serializable-struct/versions id maybe-super vers (field ...)
                              (other-version-clause ...)
                              struct-option ...)

other-version-clause = (other-vers make-proc-expr
                                   cycle-make-proc-expr)
```

Like `serializable-struct`, but the generated deserializer binding is `deserialize-info:`*`id`*`-v`*`vers`*. In addition, `deserialize-info:`*`id`*`-v`*`other-vers`* is bound for each *`other-vers`*. The *`vers`* and each *`other-vers`* must be a literal, exact, nonnegative integer.

Each *`make-proc-expr`* should produce a procedure, and the procedure should accept as many argument as fields in the corresponding version of the structure type, and it produces an instance of *`id`*. Each *`cycle-make-proc-expr`* should produce a procedure of no arguments; this procedure should return two values: an instance `x` of *`id`* (typically with `#f` for all fields) and a procedure that accepts another instance of *`id`* and copies its field values into `x`.

Examples:

```
> (serializable-struct point (x y) #:mutable #:transparent)
> (define ps (serialize (point 1 2)))
```

```
> (deserialize ps)
(point 1 2)
> (define x (point 1 10))
> (set-point-x! x x)
> (define xs (serialize x))
> (deserialize xs)
#0=(point #0# 10)
> (serializable-struct/versions point 1 (x y z)
    ([0
      ; Constructor for simple v0 instances:
      (lambda (x y) (point x y 0))
      ; Constructor for v0 instance in a cycle:
      (lambda ()
        (let ([p0 (point #f #f 0)])
          (values
            p0
            (lambda (p)
              (set-point-x! p0 (point-x p))
              (set-point-y! p0 (point-y p))))))])
    #:mutable #:transparent)
> (deserialize (serialize (point 4 5 6)))
(point 4 5 6)
> (deserialize ps)
(point 1 2 0)
> (deserialize xs)
#0=(point #0# 10 0)
```

```
(define-serializable-struct/versions id-maybe-super vers (field ...)
                                     (other-version-clause ...)
                                     struct-option ...)
```

Like `serializable-struct/versions`, but with the supertype syntax and default constructor name of `define-struct`.

```
(make-deserialize-info make cycle-make) → any
  make : procedure?
  cycle-make : (-> (values any/c procedure?))
```

Produces a deserialization information record to be used by `deserialize`. This information is normally tied to a particular structure because the structure has a `prop:serializable` property value that points to a top-level variable or module-exported variable that is bound to deserialization information.

The *`make`* procedure should accept as many arguments as the structure's serializer put into a vector; normally, this is the number of fields in the structure. It should return an instance of the structure.

The `cycle-make` procedure should accept no arguments, and it should return two values: a structure instance `x` (with dummy field values) and an update procedure. The update procedure takes another structure instance generated by the `make`, and it transfers the field values of this instance into `x`.

```
prop:serializable : struct-type-property?
```

This property identifies structures and structure types that are serializable. The property value should be constructed with `make-serialize-info`.

```
(make-serialize-info to-vector
                     deserialize-id
                     can-cycle?
                     dir)            → any
  to-vector : (any/c . -> . vector?)
  deserialize-id : (or identifier?
                       symbol?
                       (cons/c symbol?
                               module-path-index?)
                       (-> any/c))
  can-cycle? : any/c
  dir : path-string?
```

Produces a value to be associated with a structure type through the `prop:serializable` property. This value is used by `serialize`.

The `to-vector` procedure should accept a structure instance and produce a vector for the instance's content.

The `deserialize-id` value indicates a binding for deserialize information, to either a module export or a top-level definition. It must be one of the following:

- If `deserialize-id` is an identifier, and if `(identifier-binding deserialize-id)` produces a list, then the third element is used for the exporting module, otherwise the top-level is assumed. Before trying an exporting module directly, its `deserialize-info` submodule is tried; the module itself is tried if no `deserialize-info` submodule is available or if the export is not found. In either case, `syntax-e` is used to obtain the name of an exported identifier or top-level definition.
- If `deserialize-id` is a symbol, it indicates a top-level variable that is named by the symbol.
- If `deserialize-id` is a pair, the `car` must be a symbol to name an exported identifier, and the `cdr` must be a module path index to specify the exporting module.
- If `deserialize-id` is a procedure, then it is applied during serialization and its result is used for `deserialize-id`.

See make-deserialize-info and deserialize for more information.

The *can-cycle?* argument should be false if instances should not be serialized in such a way that deserialization requires creating a structure instance with dummy field values and then updating the instance later.

The *dir* argument should be a directory path that is used to resolve a module reference for the binding of *deserialize-id*. This directory path is used as a last resort when *deserialize-id* indicates a module that was loaded through a relative path with respect to the top level. Usually, it should be (or (current-load-relative-directory) (current-directory)).

Changed in version 7.0.0.6 of package base: Allow *deserialize-id* to be a procedure.

Examples:

```
> (struct pie (type)
    #:mutable
    #:property prop:serializable
    (make-serialize-info
     (λ (this)
       (vector (pie-type this)))
     'pie-beam
     #t
     (or (current-load-relative-directory) (current-directory))))
> (define pie-beam
    (make-deserialize-info
     (λ (type)
       (pie type))
     (λ ()
       (define pie-pattern (pie 'transporter-error))
       (values pie-pattern
               (λ (type)
                 (set-pie-type! pie-pattern type))))))
> (define original-pie
    (pie 'apple))
> original-pie
#<pie>
> (define pie-in-transit
    (serialize original-pie))
> pie-in-transit
'((3) 1 ((#f . pie-beam)) 0 () () (0 apple))
> (define beamed-up-pie
    (deserialize pie-in-transit))
> beamed-up-pie
#<pie>
> (pie-type beamed-up-pie)
```

```
'apple
> (equal? beamed-up-pie original-pie)
#f
```

13.9.1 Serialization Structures

```
(require racket/serialize-structs)
```
package: base

The `racket/serialize-structs` module provides only `prop:serializable`, `make-serialize-info`, `make-deserialize-info`, which is useful for minimizing dependencies with supporting serialization.

Added in version 8.15.0.3 of package base.

13.10 Fast-Load Serialization

```
(require racket/fasl)
```
package: base

The bindings documented in this section are provided by the `racket/fasl` library, not `racket/base` or `racket`.

```
(s-exp->fasl v
             [out
              #:keep-mutable? keep-mutable?
              #:handle-fail handle-fail
              #:external-lift? external-lift?
              #:skip-prefix? skip-prefix?])
 → (or/c (void) bytes?)
  v : any/c
  out : (or/c output-port? #f) = #f
  keep-mutable? : any/c = #f
  handle-fail : (or/c #f (any/c . -> . any/c)) = #f
  external-lift? : (or/c #f (any/c . -> . any/c)) = #f
  skip-prefix? : any/c = #f
(fasl->s-exp in
             [#:datum-intern? datum-intern?
              #:external-lifts external-lifts
              #:skip-prefix? skip-prefix?])  → any/c
  in : (or/c input-port? bytes?)
  datum-intern? : any/c = #t
  external-lifts : vector? = '#()
  skip-prefix? : any/c = #f
```

The `s-exp->fasl` function serializes *v* to a byte string, printing it directly to *out* if *out* is an output port or returning the byte string otherwise. The `fasl->s-exp` function decodes a value from a byte string (supplied either directly or as an input port) that was encoded with `s-exp->fasl`.

The *v* argument must be a value that could be `quote`d as a literal—that is, a value without syntax objects for which `(compile `',v)` would work and be `read`able after `write`—or it can include correlated objects mixed with those values. The byte string produced by `s-exp->fasl` does not use the same format as compiled code, however.

If a value within *v* is not valid as a `quote`d literal, and if *handle-fail* is not `#f`, then *handle-fail* is called on the nested value, and the result of *handle-fail* is written in that value's place. The *handle-fail* procedure might raise an exception instead of returning a replacement value. If *handle-fail* is `#f`, then the `exn:fail:contract` exception is raised when an invalid value is encountered.

If *external-lift?* is not `#f`, then it receives each value *v-sub* encountered in *v* by `s-exp->fasl`. If the result of *external-lift?* on *v-sub* is true, then *v-sub* is not encoded in the result, and it instead treated as *externally lifted*. A deserializing `fasl->s-exp` receives a *external-lifts* vector that has one value for each externally lifted value, in the same order as passed to *external-lift?* on serialization.

Like `(compile `',v)`, `s-exp->fasl` does not preserve graph structure, support cycles, or handle non-prefab structures. Compose `s-exp->fasl` with `serialize` to preserve graph structure, handle cyclic data, and encode serializable structures. The `s-exp->fasl` and `fasl->s-exp` functions consult `current-write-relative-directory` and `current-load-relative-directory` (falling back to `current-directory`), respectively, in the same way as bytecode saving and loading to store paths in relative form, and they similarly allow and convert constrained `srcloc` values (see §1.4.16 "Printing Compiled Code").

Unless *keep-mutable?* is provided as true to `s-exp->fasl`, then mutable values in *v* are replaced by immutable values when the result is decoded by `fasl->s-exp`. Unless *datum-intern?* is provided as `#f`, then any immutable value produced by `fasl->s-exp` is filtered by `datum-intern-literal`. The defaults make the composition of `s-exp->fasl` and `fasl->s-exp` behave like the composition of `write` and `read`.

If *skip-prefix?* is not `#f`, then a prefix that identifies the stream as a serialization is not written by `s-exp->fasl` or read by `fasl->s-exp`. Omitting a prefix can save a small amount of space, which can useful when serializing small values, but it gives up a sanity check on the `fasl->s-exp` that is often useful.

The byte-string encoding produced by `s-exp->fasl` is independent of the Racket version, except as future Racket versions introduce extensions that are not currently recognized. In particular, the result of `s-exp->fasl` will be valid as input to any future version of `fasl->s-exp` (as long as the *skip-prefix?* arguments are consistent).

Examples:

```
> (define fasl (s-exp->fasl (list #("speed") 'racer #\!)))
> fasl
#"racket/fasl:\0\24\34\3 \1\23\5speed\16\5racer\r!"
> (fasl->s-exp fasl)
'(#("speed") racer #\!)
```

Changed in version 6.90.0.21 of package `base`: Made `s-exp->fasl` format version-independent and added the `#:keep-mutable?` and `#:datum-intern?` arguments.
Changed in version 7.3.0.7: Added support for correlated objects.
Changed in version 7.5.0.3: Added the `#:handle-fail` argument.
Changed in version 7.5.0.9: Added the `#:external-lift?` and `#:external-lifts` arguments.
Changed in version 8.9.0.4: Added support for fxvectors and flvectors.

13.11 Cryptographic Hashing

```
(sha1-bytes in [start end]) → bytes?
  in : (or/c bytes? input-port?)
  start : exact-nonnegative-integer? = 0
  end : (or/c #f exact-nonnegative-integer?) = #f
(sha224-bytes in [start end]) → bytes?
  in : (or/c bytes? input-port?)
  start : exact-nonnegative-integer? = 0
  end : (or/c #f exact-nonnegative-integer?) = #f
(sha256-bytes in [start end]) → bytes?
  in : (or/c bytes? input-port?)
  start : exact-nonnegative-integer? = 0
  end : (or/c #f exact-nonnegative-integer?) = #f
```

Computes the SHA-1, SHA-224, or SHA-256 hash of a byte sequence and returns the hash as a byte string with 20 bytes, 28 bytes, or 32 bytes, respectively.

The *start* and *end* arguments determine the range of bytes of the input that are used to compute the hash. An *end* value of `#f` corresponds to the end of the byte string or an end-of-file position for an input port. When *in* is a byte string, the *start* and *end* values (when non `#f`) must be no greater than the length of the byte string, and *start* must be no greater than *end*. When *in* is an input port, *start* must be no greater than *end*; if *in* supplies less than *start* or *end* bytes before an end-of-file, then *start* and/or *end* is effectively changed to the number of supplied bytes (so that an empty or truncated byte sequence is hashed). When *in* is an input port and *end* is a number, then at most *end* bytes are read from the input port.

For security purposes, favor `sha224-bytes` and `sha256-bytes` (which are part of the SHA-2 family) over `sha1-bytes`.

Use bytes->hex-string from file/sha1 to convert a byte string hash to a human-readable string.

Examples:

```
> (sha1-bytes #"abc")
#"\251\231>6G\6\201j\272>%qxP\302l\234\320\330\235"
> (require file/sha1)
> (bytes->hex-string (sha1-bytes #"abc"))
"a9993e364706816aba3e25717850c26c9cd0d89d"
> (bytes->hex-string (sha224-bytes #"abc"))
"23097d223405d8228642a477bda255b32aadbce4bda0b3f7e36c9da7"
> (bytes->hex-string (sha224-bytes (open-input-
string "xabcy") 1 4))
"23097d223405d8228642a477bda255b32aadbce4bda0b3f7e36c9da7"
```

Added in version 7.0.0.5 of package base.

14 Reflection and Security

14.1 Namespaces

See §1.2.5 “Namespaces” for basic information on the namespace model.

A new namespace is created with procedures like `make-empty-namespace`, and `make-base-namespace`, which return a first-class namespace value. A namespace is used by setting the `current-namespace` parameter value, or by providing the namespace to procedures such as `eval` and `eval-syntax`.

```
(namespace? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a namespace value, `#f` otherwise.

```
(make-empty-namespace) → namespace?
```

Creates a new namespace that is empty, and whose module registry contains only mappings for some internal, predefined modules, such as `'#%kernel`. The namespace’s base phase is the same as the base phase of the current namespace. Attach modules from an existing namespace to the new one with `namespace-attach-module`.

The new namespace is associated with a new *root namespace*, which has the same module registry as the returned namespace and has a base phase of 0. The new root namespace is the same as the returned namespace if both have base phase 0.

```
(make-base-empty-namespace) → namespace?
```

Creates a new empty namespace like `make-empty-namespace`, but with `racket/base` attached. The namespace’s base phase is the same as the phase in which the `make-base-empty-namespace` function was created.

```
(make-base-namespace) → namespace?
```

Creates a new namespace like `make-empty-namespace`, but with `racket/base` attached and `required` into the top-level environment. The namespace’s base phase is the same as the phase in which the `make-base-namespace` function was created.

```
(define-namespace-anchor id)
```

Binds *id* to a namespace anchor that can be used with `namespace-anchor->empty-namespace` and `namespace-anchor->namespace`.

This form can be used only in a top-level context or in a module-context.

```
(namespace-anchor? v) → boolean?
  v : any/c
```

Returns #t if *v* is a namespace-anchor value, #f otherwise.

```
(namespace-anchor->empty-namespace a) → namespace?
  a : namespace-anchor?
```

Returns an empty namespace that shares a module registry and root namespace with the source of the anchor, and whose base phase is the phase in which the anchor was created.

If the anchor is from a `define-namespace-anchor` form in a module context, then the source is the namespace in which the containing module is instantiated. If the anchor is from a `define-namespace-anchor` form in a top-level content, then the source is the namespace in which the anchor definition was evaluated.

```
(namespace-anchor->namespace a) → namespace?
  a : namespace-anchor?
```

Returns a namespace corresponding to the source of the anchor.

If the anchor is from a `define-namespace-anchor` form in a module context, then the result is a namespace for the module's body in the anchor's phase. The result is the same as a namespace obtained via `module->namespace`, and the module is similarly made available if it is not available already.

If the anchor is from a `define-namespace-anchor` form in a top-level content, then the result is the namespace in which the anchor definition was evaluated.

```
(current-namespace) → namespace?
(current-namespace n) → void?
  n : namespace?
```

A parameter that determines the current namespace.

```
(namespace-symbol->identifier sym) → identifier?
  sym : symbol?
```

Similar to `datum->syntax` restricted to symbols. The lexical information of the resulting identifier corresponds to the top-level environment of the current namespace; the identifier has no source location or properties.

```
(namespace-base-phase [namespace]) → exact-integer?
  namespace : namespace? = (current-namespace)
```

Returns the base phase of *namespace*.

```
(namespace-module-identifier [where]) → identifier?
  where : (or/c namespace? exact-integer? #f)
        = (current-namespace)
```

Returns an identifier whose binding is `module` in the base phase of *where* if it is a namespace, or in the *where* phase level otherwise.

The lexical information of the identifier includes bindings (in the same phase level) for all syntactic forms that appear in fully expanded code (see §1.2.3.1 "Fully Expanded Programs"), but using the name reported by the second element of `identifier-binding` for the binding; the lexical information may also include other bindings.

```
(namespace-variable-value  sym
                          [use-mapping?
                           failure-thunk
                           namespace])   → any
  sym : symbol?
  use-mapping? : any/c = #t
  failure-thunk : (or/c (-> any) #f) = #f
  namespace : namespace? = (current-namespace)
```

Returns a value for *sym* in *namespace*, using *namespace*'s base phase. The returned value depends on *use-mapping?*:

- If *use-mapping?* is true (the default), and if *sym* maps to a top-level variable or an imported variable (see §1.2.5 "Namespaces"), then the result is the same as evaluating *sym* as an expression. If *sym* maps to syntax or imported syntax, then *failure-thunk* is called or the `exn:fail:syntax` exception is raised. If *sym* is mapped to an undefined variable or an uninitialized module variable, then *failure-thunk* is called or the `exn:fail:contract:variable` exception is raised.
- If *use-mapping?* is `#f`, the namespace's syntax and import mappings are ignored. Instead, the value of the top-level variable named *sym* in namespace is returned. If the variable is undefined, then *failure-thunk* is called or the `exn:fail:contract:variable` exception is raised.

If *failure-thunk* is not `#f`, `namespace-variable-value` calls *failure-thunk* to produce the return value in place of raising an `exn:fail:contract:variable` or `exn:fail:syntax` exception.

```
(namespace-set-variable-value!  sym
                                v
                               [map?
                                namespace
                                as-constant?]) → void?
```

```
sym : symbol?
v : any/c
map? : any/c = #f
namespace : namespace? = (current-namespace)
as-constant? : any/c = #f
```

Sets the value of *sym* in the top-level environment of *namespace* in the base phase, defining *sym* if it is not already defined.

If *map?* is supplied as true, then the namespace's identifier mapping is also adjusted (see §1.2.5 "Namespaces") in the phase level corresponding to the base phase, so that *sym* maps to the variable.

If *as-constant?* is true, then the variable is made a constant (so future assignments are rejected) after *v* is installed as the value.

Changed in version 6.90.0.14 of package `base`: Added the *as-constant?* argument.

```
(namespace-undefine-variable! sym
                              [namespace]) → void?
  sym : symbol?
  namespace : namespace? = (current-namespace)
```

Removes the *sym* variable, if any, in the top-level environment of *namespace* in its base phase. The namespace's identifier mapping (see §1.2.5 "Namespaces") is unaffected.

```
(namespace-mapped-symbols [namespace]) → (listof symbol?)
  namespace : namespace? = (current-namespace)
```

Returns a list of all symbols that are mapped to variables, syntax, and imports in *namespace* for the phase level corresponding to the namespace's base phase.

```
(namespace-require quoted-raw-require-spec
                   [namespace])            → void?
  quoted-raw-require-spec : any/c
  namespace : namespace? = (current-namespace)
```

Performs the import corresponding to *quoted-raw-require-spec* in the top-level environment of *namespace*, like a top-level `#%require`. The *quoted-raw-require-spec* argument must be either a datum that corresponds to a quoted *raw-require-spec* for `#%require`, which includes module paths, or it can be a resolved module path.

Module paths in *quoted-raw-require-spec* are resolved with respect to `current-load-relative-directory` or `current-directory` (if the former is `#f`), even if the current namespace corresponds to a module body.

Changed in version 6.90.0.16 of package `base`: Added the *namespace* optional argument.

```
(namespace-require/copy quoted-raw-require-spec
                        [namespace])          → void?
  quoted-raw-require-spec : any/c
  namespace : namespace? = (current-namespace)
```

Like `namespace-require` for syntax exported from the module, but exported variables at the namespace's base phase are treated differently: the export's current value is copied to a top-level variable in *namespace*.

Changed in version 6.90.0.16 of package `base`: Added the *namespace* optional argument.

```
(namespace-require/constant quoted-raw-require-spec
                            [namespace])          → void?
  quoted-raw-require-spec : any/c
  namespace : namespace? = (current-namespace)
```

Like `namespace-require`, but for each exported variable at the namespace's base phase, the export's value is copied to a corresponding top-level variable that is made immutable. Despite setting the top-level variable, the corresponding identifier is bound as imported.

Changed in version 6.90.0.16 of package `base`: Added the *namespace* optional argument.

```
(namespace-require/expansion-time quoted-raw-require-spec
                                  [namespace])
 → void?
  quoted-raw-require-spec : any/c
  namespace : namespace? = (current-namespace)
```

Like `namespace-require`, but only the transformer part of the module is executed relative to *namespace*'s base phase; that is, the module is merely visited, and not instantiated (see §1.2.3.9 "Module Expansion, Phases, and Visits"). If the required module has not been instantiated before, the module's variables remain undefined.

Changed in version 6.90.0.16 of package `base`: Added the *namespace* optional argument.

```
(namespace-attach-module src-namespace
                         modname
                        [dest-namespace]) → void?
  src-namespace : namespace?
  modname : (or module-path? resolved-module-path?)
  dest-namespace : namespace? = (current-namespace)
```

Attaches the instantiated module named by *modname* in *src-namespace* (at its base phase) to the module registry of *dest-namespace*.

In addition to *modname*, every module that it imports (directly or indirectly) is also recorded in the current namespace's module registry, and instances at the same phase are also attached to *dest-namespace* (while visits at the module's phase and instances at higher or lower phases are not attached, nor even made available for on-demand visits). The inspector of the module invocation in *dest-namespace* is the same as inspector of the invocation in *src-namespace*.

If *modname* is not a symbol, the current module name resolver is called to resolve the path, but no module is loaded; the resolved form of *modname* is used as the module name in *dest-namespace*.

If *modname* refers to a submodule or a module with submodules, unless the module was loaded from bytecode (i.e., a ".zo" file) independently from submodules within the same top-level module, then declarations for all submodules within the module's top-level module are also attached to *dest-namespace*.

If *modname* does not refer to an instantiated module in *src-namespace*, or if the name of any module to be attached already has a different declaration or same-phase instance in *dest-namespace*, then the exn:fail:contract exception is raised.

If *src-namespace* and *dest-namespace* do not have the same base phase, then the exn:fail:contract exception is raised.

Unlike namespace-require, namespace-attach-module does not instantiate the module, but copies the module instance from the source namespace to the target namespace.

Examples:

```
> (module food racket/base
    (provide apple)
    (define apple (list "pie")))
> (namespace-require ''food)
> (define ns (current-namespace))
> (parameterize ([current-namespace (make-base-namespace)])
    (namespace-require ''food))
require: unknown module
  module name: 'food
> (parameterize ([current-namespace (make-base-namespace)])
    (namespace-attach-module ns ''food)
    (namespace-require ''food)
    (eq? (eval 'apple) apple))
#t
> (parameterize ([current-namespace (make-base-namespace)])
    (namespace-attach-module-declaration ns ''food)
    (namespace-require ''food)
    (eq? (eval 'apple) apple))
#f
```

```
(namespace-attach-module-declaration src-namespace
                                     modname
                                    [dest-namespace]) → void?
  src-namespace : namespace?
  modname : module-path?
  dest-namespace : namespace? = (current-namespace)
```

Like `namespace-attach-module`, but the module specified by *modname* need only be declared (and not necessarily instantiated) in *src-namespace*, and the module is merely declared in *dest-namespace*.

```
(namespace-unprotect-module inspector
                            modname
                           [namespace]) → void?
  inspector : inspector?
  modname : module-path?
  namespace : namespace? = (current-namespace)
```

Changes the inspector for the instance of the module referenced by *modname* in *namespace*'s module registry so that it is controlled by the current code inspector. The given *inspector* must currently control the invocation of the module in *namespace*'s module registry, otherwise the inspector is not changed. See also §14.10 "Code Inspectors".

```
(namespace-module-registry namespace) → any
  namespace : namespace?
```

Returns the module registry of the given namespace. This value is useful only for identification via `eq?`.

```
(namespace-call-with-registry-lock namespace
                                   thunk)     → any
  namespace : namespace?
  thunk : (-> any)
```

Calls *thunk* while holding a reentrant lock for the namespace's module registry.

Namespace functions do not automatically use the registry lock, but it can be used via `namespace-call-with-registry-lock` among threads that load and instantiate modules to avoid internal race conditions. On-demand instantiation of available modules also takes the lock; see §1.2.3.9 "Module Expansion, Phases, and Visits".

Added in version 8.1.0.5 of package `base`.

```
(module->namespace mod [src-namespace]) → namespace?
```

```
mod : (or/c module-path?
            resolved-module-path?
            module-path-index?)
src-namespace : namespace? = (current-namespace)
```

Returns a namespace that corresponds to the body of an instantiated module in *src-namespace*'s module registry and in the *src-namespace*'s base phase, making the module available for on-demand visits at *src-namespace*'s base phase. The returned namespace has the same module registry as *src-namespace*. Modifying a binding in the resulting namespace changes the binding seen in modules that require the namespace's module.

Module paths in a top-level `require` expression are resolved with respect to the namespace's module. New `provide` declarations are not allowed.

If the current code inspector does not control the invocation of the module in *src-namespace*'s module registry, the `exn:fail:contract` exception is raised; see also §14.10 "Code Inspectors".

Bindings in the result namespace cannot be modified if the `compile-enforce-module-constants` parameter was true when the module was declared, unless the module declaration itself included assignments to the binding via `set!`.

Changed in version 6.90.0.16 of package `base`: Added the *src-namespace* optional argument.

```
(namespace-syntax-introduce stx [namespace]) → syntax?
  stx : syntax?
  namespace : namespace? = (current-namespace)
```

Returns a syntax object like *stx*, except that *namespace*'s bindings are included in the syntax object's lexical information (see §1.2.2 "Syntax Objects"). The additional context is overridden by any existing top-level bindings in the syntax object's lexical information, or by any existing or future module bindings in the lexical information.

Changed in version 6.90.0.16 of package `base`: Added the *namespace* optional argument.

```
(module-provide-protected? module-path-index
                           sym)              → boolean?
  module-path-index : (or/c symbol? module-path-index?)
  sym : symbol?
```

Returns `#f` if the module declaration for *module-path-index* defines *sym* and exports it unprotected, `#t` otherwise (which may mean that the symbol corresponds to an unexported definition, a protected export, or an identifier that is not defined at all within the module).

The *module-path-index* argument can be a symbol; see §14.4.2 "Compiled Modules and References" for more information on module path indices.

Typically, the arguments to `module-provide-protected?` correspond to the first two elements of a list produced by `identifier-binding`.

```
(variable-reference? v) → boolean?
  v : any/c
```

Return `#t` if *v* is a variable reference produced by `#%variable-reference`, `#f` otherwise.

```
(variable-reference-constant? varref) → boolean?
  varref : variable-reference?
```

Returns `#t` if the variable represented by *varref* will retain its current value (i.e., *varref* refers to a variable that cannot be further modified by `set!` or `define`), `#f` otherwise.

```
(variable-reference->empty-namespace varref) → namespace?
  varref : variable-reference?
```

Returns an empty namespace that shares module declarations and instances with the namespace in which *varref* is instantiated, and with the same phase as *varref*.

```
(variable-reference->namespace varref) → namespace?
  varref : variable-reference?
```

If *varref* refers to a module-level variable, then the result is a namespace for the module's body in the referenced variable's phase; the result is the same as a namespace obtained via `module->namespace`, and the module is similarly made available if it is not available already.

If *varref* refers to a top-level variable, then the result is the namespace in which the referenced variable is defined.

```
(variable-reference->resolved-module-path varref)
 → (or/c resolved-module-path? #f)
  varref : variable-reference?
```

If *varref* refers to a module-level variable, the result is a resolved module path naming the module.

If *varref* refers to a top-level variable, then the result is `#f`.

```
(variable-reference->module-path-index varref)
 → (or/c module-path-index? #f)
  varref : variable-reference?
```

If *varref* refers to a module-level variable, the result is a module path index naming the module.

If *varref* refers to a top-level variable, then the result is `#f`.

```
(variable-reference->module-source varref)
 → (or/c symbol? (and/c path? complete-path?) #f)
  varref : variable-reference?
```

If `varref` refers to a module-level variable, the result is a path or symbol naming the module's source (which is typically, but not always, the same as in the resolved module path). If the relevant module is a submodule, the result corresponds to the enclosing top-level module's source.

If `varref` refers to a top-level variable, then the result is `#f`.

```
(variable-reference->phase varref) → exact-nonnegative-integer?
  varref : variable-reference?
```

Returns the phase of the variable referenced by `varref`.

```
(variable-reference->module-base-phase varref) → exact-integer?
  varref : variable-reference?
```

Returns the phase in which the module is instantiated for the variable referenced by `varref`, or `0` if the variable for `varref` is not within a module.

For a variable with a module, the result is less than the result of `(variable-reference->phase varref)` by *n* when the variable is bound at phase level *n* within the module.

```
(variable-reference->module-declaration-inspector varref)
 → inspector?
  varref : variable-reference?
```

Returns the declaration inspector (see §14.10 "Code Inspectors") for the module of `varref`, where `varref` must refer to an anonymous module variable as produced by `(#%variable-reference)`.

```
(variable-reference-from-unsafe? varref) → boolean?
  varref : variable-reference?
```

Returns `#t` if the module of the variable reference itself (not necessarily a referenced variable) is compiled in unsafe mode, `#f` otherwise. Unsafe mode can be enabled through the linklet interface or enable for a module with `(#%declare #:unsafe)`.

The `variable-reference-from-unsafe?` procedure is intended for use as

```
(variable-reference-from-unsafe? (#%variable-reference))
```

which the compiler can optimize to a literal #t or #f (since the enclosing module is being compiled in unsafe mode or not).

Added in version 6.12.0.4 of package base.

14.2 Evaluation and Compilation

§15 "Reflection and Dynamic Evaluation" in *The Racket Guide* introduces dynamic evaluation.

Racket provides programmatic control over evaluation through eval and related functions. See §18.7 "Controlling and Inspecting Compilation" for information about extra-linguistic facilities related to the Racket compiler.

```
(current-eval) → (any/c . -> . any)
(current-eval proc) → void?
  proc : (any/c . -> . any)
```

A parameter that determines the current *evaluation handler*. The evaluation handler is a procedure that takes a top-level form and evaluates it, returning the resulting values. The evaluation handler is called by eval, eval-syntax, the default load handler, and read-eval-print-loop to evaluate a top-level form. The handler should evaluate its argument in tail position.

The *top-level-form* provided to the handler can be a syntax object, a compiled form, a compiled form wrapped as a syntax object, or an arbitrary datum.

The default handler converts an arbitrary datum to a syntax object using datum->syntax, and then enriches its lexical information in the same way as eval. (If *top-level-form* is a syntax object, then its lexical information is not enriched.) The default evaluation handler partially expands the form to splice the body of top-level begin forms into the top level (see expand-to-top-form), and then individually compiles and evaluates each spliced form before continuing to expand, compile, and evaluate later forms.

```
(eval top-level-form) → any
  top-level-form : any/c
(eval top-level-form namespace) → any
  top-level-form : any/c
  namespace : namespace?
```

See also §15.1.2 "Namespaces" in *The Racket Guide*.

Calls the current evaluation handler to evaluate *top-level-form*. The evaluation handler is called in tail position with respect to the eval call. An evaluation handler uses the current namespace; in the two-argument case of eval, the call to the evaluation handler is parameterized to set current-namespace to *namespace*.

If *top-level-form* is a syntax object whose datum is not a compiled form, then its lexical information is enriched before it is sent to the evaluation handler:

- If *top-level-form* is a pair whose car is a symbol or identifier, and if applying namespace-syntax-introduce to the (datum->syntax-converted) identifier produces an identifier bound to module in a phase level that corresponds to *namespace*'s base phase, then only that identifier is enriched.
- For any other *top-level-form*, namespace-syntax-introduce is applied to the entire syntax object.

For interactive evaluation in the style of read-eval-print-loop and load, wrap each expression with #%top-interaction, which is normally bound to #%top-interaction, before passing it to eval.

```
(eval-syntax stx) → any
  stx : syntax?
(eval-syntax stx namespace) → any
  stx : syntax?
  namespace : namespace?
```

Like eval, except that *stx* must be a syntax object, and its lexical context is not enriched before it is passed to the evaluation handler.

```
(current-load)
 → (path? (or/c #f
                symbol?
                (cons/c (or/c #f symbol?)
                        (non-empty-listof symbol?)))
         . -> .
         any)
(current-load proc) → void?
  proc : (path? (or/c #f
                      symbol?
                      (cons/c (or/c #f symbol?)
                              (non-empty-listof symbol?)))
               . -> .
               any)
```

A parameter that determines the current *load handler* to load top-level forms from a file. The load handler is called by load, load-relative, load/cd, and the default compiled-load handler.

A load handler takes two arguments: a path (see §15.1 "Paths") and an expected module name. The expected module name is a symbol or a list when the call is to load a module declaration in response to a require (in which case the file should contain a module declaration), or #f for any other load.

When loading a module from a stream that starts with a compiled module that contains submodules, the load handler should load only the requested module, where a symbol as the load handler's indicates the root module and a list indicates a submodule whose path relative to the root module is given by the `cdr` of the list. The list starts with `#f` when a submodule should be loaded *only* if it can be loaded independently (i.e., from compiled form—never from source); if the submodule cannot be loaded independently, the load handler should return without loading from a file. When the expected module name is a list that starts with a symbol, the root module and any other submodules can be loaded from the given file, which might be from source, and the load handler still should not complain if the expected submodule is not found. When loading modules from a nonexistent source file, the load handler may raise an exception regardless of whether submodules are requested or not.

The default load handler reads forms from the file in `read-syntax` mode with line-counting enabled for the file port, unless the path has a `".zo"` suffix. It also `parameterize`s each read to set `read-accept-compiled`, `read-accept-reader`, and `read-accept-lang` to `#t`. In addition, if `load-on-demand-enabled` is `#t`, then `read-on-demand-source` is set to the cleansed, absolute form of `path` during the `read-syntax` call. After reading a single form, the form is passed to the current evaluation handler, wrapping the evaluation in a continuation prompt (see `call-with-continuation-prompt`) for the default continuation prompt tag with handler that propagates the abort to the continuation of the `load` call.

If the second argument to the load handler is a symbol, then:

- The `read-syntax` from the file is additionally `parameterize`d as follows (to provide consistent reading of module source):

  ```
  (current-readtable #f)
  (read-case-sensitive #t)
  (read-square-bracket-as-paren #t)
  (read-curly-brace-as-paren #t)
  (read-accept-box #t)
  (read-accept-compiled #t)
  (read-accept-bar-quote #t)
  (read-accept-graph #t)
  (read-syntax-accept-graph #f)
  (read-decimal-as-inexact #t)
  (read-accept-dot #t)
  (read-accept-infix-dot #t)
  (read-accept-quasiquote #t)
  (read-accept-reader #t)
  (read-accept-lang #t)
  ```

- If the read result is not a `module` form, or if a second `read-syntax` does not produce an end-of-file, then the `exn:fail` exception is raised without evaluating the form that was read from the file. (In previous versions, the module declaration was checked to match the name given as the second argument to the load handler, but this check is no longer performed.)

- The lexical information of the initial `module` identifier is enriched with a binding for `module`, so that the form corresponds to a module declaration independent of the current namespace's bindings.

If the second argument to the load handler is `#f`, then each expression read from the file is wrapped with `#%top-interaction`, which is normally bound to `#%top-interaction`, before passing it to the evaluation handler.

The return value from the default load handler is the value of the last form from the loaded file, or `#<void>` if the file contains no forms. If the given path is a relative path, then it is resolved using the value of `current-directory`.

```
(load file) → any
  file : path-string?
```

See also §15.1.2 "Namespaces" in *The Racket Guide*.

Calls the current load handler in tail position. The call is `parameterized` to set `current-load-relative-directory` to the directory of *file*, which is resolved relative to the value of `current-directory`.

```
(load-relative file) → any
  file : path-string?
```

Like `load/use-compiled`, but when *file* is a relative path, it is resolved using the value of `current-load-relative-directory` instead of the value of `current-directory` if the former is not `#f`, otherwise `current-directory` is used.

```
(load/cd file) → any
  file : path-string?
```

Like `load`, but `load/cd` sets both `current-directory` and `current-load-relative-directory` before calling the load handler.

```
(current-load-extension)
 → (path? (or/c #f
                symbol?
                (cons/c (or/c #f symbol?)
                        (non-empty-listof symbol?)))
    . -> .
    any)
(current-load-extension proc) → void?
  proc : (path? (or/c #f
                      symbol?
                      (cons/c (or/c #f symbol?)
                              (non-empty-listof symbol?)))
          . -> .
          any)
```

A parameter that determines a *extension-load handler*, which is called by `load-extension` and the default compiled-load handler.

An extension-load handler takes the same arguments as a load handler, but the file should be a platform-specific *dynamic extension*, typically with the file suffix `".so"` (Unix), `".dll"` (Windows), or `".dylib"` (Mac OS). The file is loaded using internal, OS-specific primitives. See *Inside: Racket C API* for more information on dynamic extensions.

Extensions are supported only when `(system-type 'vm)` returns `'racket`.

```
(load-extension file) → any
  file : path-string?
```

Sets `current-load-relative-directory` like `load`, and calls the extension-load handler in tail position.

Extensions are supported only when `(system-type 'vm)` returns `'racket`.

```
(load-relative-extension file) → any
  file : path-string?
```

Like `load-extension`, but resolves *file* using `current-load-relative-directory` like `load-relative`.

Extensions are supported only when `(system-type 'vm)` returns `'racket`.

```
(current-load/use-compiled)
 → (path? (or/c #f
                symbol?
                (cons/c (or/c #f symbol?)
                        (non-empty-listof symbol?)))
          . -> . any)
(current-load/use-compiled proc) → void?
  proc : (path? (or/c #f
                      symbol?
                      (cons/c (or/c #f symbol?)
                              (non-empty-listof symbol?)))
                . -> . any)
```

A parameter that determines the current *compiled-load handler* to load from a file that may have a compiled form. The compiled-load handler is called by `load/use-compiled`.

The protocol for a compiled-load handler is the same as for the load handler (see `current-load`), except that a compiled-load handler is expected to set `current-load-relative-directory` itself. Additionally, the default compiled-load handler does the following:

- When the given path ends with ".rkt", no ".rkt" file exists, and when the handler's second argument is not #f, the default compiled-load handler checks for a ".ss" file.
- The default compiled-load handler checks for the opportunity to load from ".zo" (bytecode) files and, when (system-type 'vm) returns 'racket, for ".so" (native Unix), ".dll" (native Windows), or ".dylib" (native Mac OS) files.
- When the default compiled-load handler needs to load from the given path, the given path does not exist, and when the handler's second argument is not #f, the default compiled-load handler returns without raising an exception.

The check for a compiled file occurs whenever the given path *file* ends with any extension (e.g., ".rkt" or ".scrbl"), and the check consults the subdirectories indicated by the current-compiled-file-roots and use-compiled-file-paths parameters relative to *file*, where the former supplies "roots" for compiled files and the latter provides subdirectories. A "root" can be an absolute path, in which case *file*'s directory is combined with reroot-path and the root as the second argument; if the "root" is a relative path, then the relative path is instead suffixed onto the directory of *file*. The roots are tried in order, and the subdirectories are checked in order within each root. A ".zo" version of the file (whose name is formed by passing *file* and #".zo" to path-add-extension) is loaded if it exists directly in one of the indicated subdirectories, or when (system-type 'vm) returns 'racket, then a ".so"/".dll"/".dylib" version of the file is loaded if it exists within a "native" subdirectory of a use-compiled-file-paths directory, in an even deeper subdirectory as named by system-library-subpath. A compiled file is loaded only if it checks out according to (use-compiled-file-check); with the default parameter value of 'modify-seconds, a compiled file is used only if its modification date is not older than the date for *file*. If both ".zo" and ".so"/".dll"/".dylib" files are available when (system-type 'vm) returns 'racket, the ".so"/".dll"/".dylib" file is used. If *file* ends with ".rkt", no such file exists, the handler's second argument is a symbol, and a ".ss" file exists, then ".zo" and ".so"/".dll"/".dylib" files are used only with names based on *file* with its suffixed replaced by ".ss".

See also compiler/compilation-path.

While a ".zo", ".so", ".dll", or ".dylib" file is loaded, the current load-relative directory is set to the directory of the original *file*. If the file to be loaded has the suffix ".ss" while the requested file has the suffix ".rkt", then the current-module-declare-source parameter is set to the full path of the loaded file, otherwise the current-module-declare-source parameter is set to #f.

If the original *file* is loaded or a ".zo" variant is loaded, the load handler is called to load the file. If any other kind of file is loaded, the extension-load handler is called.

When the default compiled-load handler loads a module from a bytecode (i.e., ".zo") file, the handler records the bytecode file path in the current namespace's module registry. More specifically, the handler records the path for the top-level module of the loaded module, which is an enclosing module if the loaded module is a submodule. Thereafter, loads via the default compiled-load handler for modules within the same top-level module use the recorded file, independent of the file that otherwise would be selected by the compiled-load handler (e.g., even if the `use-compiled-file-paths` parameter value changes). The default module name resolver transfers bytecode-file information when a module declaration is attached to a new namespace. This protocol supports independent but consistent loading of submodules from bytecode files.

```
(load/use-compiled file) → any
  file : path-string?
```

Calls the current compiled-load handler in tail position.

```
(current-load-relative-directory)
 → (or/c (and/c path-string? complete-path?) #f)
(current-load-relative-directory path) → void?
  path : (or/c (and/c path-string? complete-path?) #f)
```

A parameter that is set by `load`, `load-relative`, `load-extension`, `load-relative-extension`, and the default compiled-load handler, and used by `load-relative`, `load-relative-extension`, and the default compiled-load handler.

When a new path or string is provided as the parameter's value, it is immediately expanded (see §15.1 "Paths") and converted to a path. (The directory need not exist.)

```
(use-compiled-file-paths)
 → (listof (and/c path? relative-path?))
(use-compiled-file-paths paths) → void?
  paths : (listof (and/c path-string? relative-path?))
```

A list of relative paths, which defaults to `(list (string->path "compiled"))`. It is used by the compiled-load handler (see `current-load/use-compiled`).

If the `PLT_ZO_PATH` environment variable is set on startup, it supplies a path instead of `"compiled"` to use for the initial parameter value.

Changed in version 7.7.0.9 of package `base`: Added `PLT_ZO_PATH`.

```
(current-compiled-file-roots) → (listof (or/c path? 'same))
(current-compiled-file-roots paths) → void?
  paths : (listof (or/c path-string? 'same))
```

A list of paths and `'same`s that is used by the default compiled-load handler (see `current-load/use-compiled`).

The parameter is normally initialized to `(list 'same)`, but the parameter's initial value can be adjusted by the installation configuration as reported by `(find-compiled-file-roots)`, and it can be further adjusted by the `PLTCOMPILEDROOTS` environment variable or the --compiled or -R command-line flag for racket. If the environment variable is defined and not overridden by a command-line flag, it is parsed by first replacing any @(version) with the result of (version), then using path-list-string->path-list with a path list produced by (find-compiled-file-roots) to arrive at the parameter's initial value.

```
(find-compiled-file-roots) → (listof (or/c path? 'same))
```

Produces a list of paths and 'same, which is normally used to initialize current-compiled-file-roots. The list is determined by consulting the "config.rtkd" file in the directory reported by (find-config-dir), and it defaults to (list 'same) if not configured there.

See also 'compiled-file-roots in §19 "Installation Configuration and Search Paths".

Added in version 8.0.0.9 of package base.

```
(use-compiled-file-check) → (or/c 'modify-seconds 'exists)
(use-compiled-file-check check) → void?
  check : (or/c 'modify-seconds 'exists)
```

A parameter that determines how a compiled file is checked against its source to enable use of the compiled file. By default, the file-check mode is 'modify-seconds, which uses a compiled file when its filesystem modification date is at least as new as the source file's. The 'exists mode causes a compiled file to be used in place of its source as long as the compiled file exists.

If the PLT_COMPILED_FILE_CHECK environment variable is set to modify-seconds or exists, then the environment variable's value configures the parameter when Racket starts.

Added in version 6.6.0.3 of package base.

```
(read-eval-print-loop) → any
```

Starts a new *REPL* using the current input, output, and error ports. The REPL wraps each expression to evaluate with #%top-interaction, which is normally bound to #%top-interaction, and it wraps each evaluation with a continuation prompt using the default continuation prompt tag and prompt handler (see call-with-continuation-prompt). The REPL also wraps the read and print operations with a prompt for the default tag whose handler ignores abort arguments and continues the loop. The read-eval-print-loop procedure does not return until eof is read, at which point it returns #<void>.

The read-eval-print-loop procedure can be configured through the current-prompt-read, current-eval, and current-print parameters.

```
(current-prompt-read) → (-> any)
(current-prompt-read proc) → void?
  proc : (-> any)
```

A parameter that determines a *prompt read handler*, which is a procedure that takes no arguments, displays a prompt string, and returns a top-level form to evaluate. The prompt read handler is called by `read-eval-print-loop`, and after printing a prompt, the handler typically should call the read interaction handler (as determined by the `current-read-interaction` parameter) with the port produced by the interaction port handler (as determined by the `current-get-interaction-input-port` parameter).

The default prompt read handler prints `>` and returns the result of

```
(let ([in ((current-get-interaction-input-port))])
  ((current-read-interaction) (object-name in) in))
```

If the input and output ports are both terminals (in the sense of `terminal-port?`) and if the output port appears to be counting lines (because `port-next-location` returns a non-`#f` line and column), then the output port's line is incremented and its column is reset to `0` via `set-port-next-location!` before returning the read result.

```
(current-get-interaction-input-port) → (-> input-port?)
(current-get-interaction-input-port proc) → void?
  proc : (-> input-port?)
```

A parameter that determines the *interaction port handler*, which returns a port to use for `read-eval-print-loop` inputs.

The default interaction port handler returns the current input port. In addition, if that port is the initial current input port, the initial current output and error ports are flushed.

The `racket/gui/base` library adjusts this parameter's value by extending the current value. The extension wraps the result port so that GUI events can be handled when reading from the port blocks.

```
(current-get-interaction-evt) → (-> evt?)
(current-get-interaction-evt proc) → void?
  proc : (-> evt?)
```

A parameter that determines the *interaction event handler*, which returns an synchronizable event that should be used in combination with blocking that is similar to `read-eval-print-loop` waiting for input—but where an input port is not read directly, so `current-get-interaction-input-port` does not apply.

When the interaction event handler returns an event that becomes ready, and when the event's ready value is a procedure, then the procedure is meant to be called with zero arguments blocking resumes. The default interaction event handler returns `never-evt`.

The `racket/gui/base` library adjusts this parameter's value by extending the current value. The extension combines the current value's result with `choice-evt` and an event that becomes ready when a GUI event is available, and the event's value is a procedure that yields to one or more available GUI events.

Added in version 8.3.0.3 of package base.

```
(current-read-interaction) → (any/c input-port? . -> . any)
(current-read-interaction proc) → void?
  proc : (any/c input-port? . -> . any)
```

A parameter that determines the current *read interaction handler*, which is procedure that takes an arbitrary value and an input port and returns an expression read from the input port.

The default read interaction handler accepts `src` and `in` and returns

```
(parameterize ([read-accept-reader #t]
               [read-accept-lang #f])
  (read-syntax src in))
```

```
(current-print) → (any/c . -> . any)
(current-print proc) → void?
  proc : (any/c . -> . any)
```

A parameter that determines the *print handler* that is called by `read-eval-print-loop` to print the result of an evaluation (and the result is ignored).

The default print handler `print`s the value to the current output port (as determined by the `current-output-port` parameter) and then outputs a newline, except that it prints nothing when the value is `#<void>`.

```
(current-compile)
 → (any/c boolean? . -> . compiled-expression?)
(current-compile proc) → void?
  proc : (any/c boolean? . -> . compiled-expression?)
```

A parameter that determines the current *compilation handler*. The compilation handler is a procedure that takes a top-level form and returns a compiled form; see §1.2.4 "Compilation" for more information on compilation.

The compilation handler is called by `compile`, and indirectly by the default evaluation handler and the default load handler.

The handler's second argument is `#t` if the compiled form will be used only for immediate evaluation, or `#f` if the compiled form may be saved for later use; the default compilation handler is optimized for the special case of immediate evaluation.

When a compiled form is written to an output port, the written form starts with `#~`. See §1.4.16 "Printing Compiled Code" for more information.

For internal testing purposes, when the `PLT_VALIDATE_COMPILE` environment variable is set, the default compilation handler runs a bytecode validator immediately on its own compilation results (instead of relying only on validation when compiled bytecode is loaded).

The `current-compile` binding is provided as protected in the sense of `protect-out`.

Changed in version 8.2.0.4 of package `base`: Changed binding to protected.

```
(compile top-level-form) → compiled-expression?
  top-level-form : any/c
```

Like `eval`, but calls the current compilation handler in tail position with *`top-level-form`*.

```
(compile-syntax stx) → compiled-expression?
  stx : syntax?
```

Like `eval-syntax`, but calls the current compilation handler in tail position with *`stx`*.

```
(compiled-expression-recompile ce) → compiled-expression?
  ce : compiled-expression?
```

Recompiles *`ce`*. If *`ce`* was compiled as machine-independent and `current-compile-target-machine` is not set to `#f`, then recompiling effectively converts to the current machine format. Otherwise, recompiling effectively re-runs optimization passes to produce an equivalent compiled form with potentially different performance characteristics.

Added in version 6.3 of package `base`.

```
(compiled-expression-add-target-machine ce
                                        other-ce)
 → compiled-expression?
  ce : compiled-expression?
  other-ce : (or/c compiled-expression? hash?)
```

Returns a compiled expression like *`ce`*, but augments or replaces cross-compilation information in *`ce`* with information from *`other-ce`*. The intent is that *`ce`* and *`other-ce`* have been compiled with different values for `current-compile-target-machine`, and *`ce`* will be used to run a module on the compiling machine, while information from *`other-ce`* is needed for cross-compiling imports of the module.

The *`other-ce`* argument can be a compiled module or a summary of a module's information as produced by `compiled-expression-summarize-target-machine`.

Added in version 8.12.0.3 of package `base`.
Changed in version 8.17.0.3: Added support for *`other-ce`* as a summary.

```
(compiled-expression-summarize-target-machine other-ce) → hash?
  other-ce : compiled-expression?
```

Returns a value that has the same information as *`other-ce`* for `compiled-expression-add-target-machine`, but in a form that can be portably serialized via `racket/fasl`.

Added in version 8.17.0.3 of package `base`.

```
(compiled-expression? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a compiled form, `#f` otherwise.

```
(compile-enforce-module-constants) → boolean?
(compile-enforce-module-constants on?) → void?
  on? : any/c
```

A parameter that determines how a module declaration is compiled.

When constants are enforced, and when the macro-expanded body of a module contains no `set!` assignment to a particular variable defined within the module, then the variable is marked as constant when the definition is evaluated. Afterward, the variable's value cannot be assigned or undefined through `module->namespace`, and it cannot be defined by redeclaring the module.

Enforcing constants allows the compiler to inline some variable values, and it allows the native-code just-in-time compiler to generate code that skips certain run-time checks.

```
(compile-allow-set!-undefined) → boolean?
(compile-allow-set!-undefined allow?) → void?
  allow? : any/c
```

A parameter that determines how a `set!` expression is compiled when it mutates a global variable. If the value of this parameter is a true value, `set!` expressions for global variables are compiled so that the global variable is set even if it was not previously defined. Otherwise, `set!` expressions for global variables are compiled to raise the `exn:fail:contract:variable` exception if the global variable is not defined at the time the `set!` is performed. Note that this parameter is used when an expression is *compiled*, not when it is *evaluated*.

```
(compile-context-preservation-enabled) → boolean?
(compile-context-preservation-enabled on?) → void?
  on? : any/c
```

A parameter that determines whether compilation should avoid function-call inlining and other optimizations that may cause information to be lost from stack traces (as reported by `continuation-mark-set->context`). The default is `#f`, which allows such optimizations.

```
(current-compile-target-machine)
 → (or/c #f (and/c symbol? compile-target-machine?))
(current-compile-target-machine target) → void?
  target : (or/c #f (and/c symbol? compile-target-machine?))
```

A parameter that determines the platform and/or virtual machine target for a newly compiled expression.

If the target is `#f`, the the compiled expression writes in a machine-independent format (usually in `".zo"` files). Machine-independent compiled code works for any platform and any Racket virtual machine. When the machine-independent compiled expression is read back in, it is subject to further compilation for the current platform and virtual machine, which can be considerably slower than reading a format that is fully compiled for a platform and virtual machine.

The default is something other than `#f`, unless machine-independent mode is enabled through the `-M`/`--compile-any` command-line flag to stand-alone Racket (or GRacket) or through the `PLT_COMPILE_ANY` environment variable (set to any value).

Added in version 7.1.0.6 of package `base`.

```
(compile-target-machine? sym) → boolean?
  sym : symbol?
```

Reports whether *sym* is a supported compilation target for the currently running Racket.

When `(system-type 'vm)` reports `'racket`, then the only target symbol is `'racket`. When `(system-type 'vm)` reports `'chez-scheme`, then a symbol corresponding to the current platform is a target, and other targets may also be supported. The `'target-machine` mode of `system-type` reports the running Racket's native target machine.

Added in version 7.1.0.6 of package `base`.

```
(current-compile-realm) → symbol?
(current-compile-realm realm) → void?
  realm : symbol?
```

Determines the realm that is assigned to modules and procedures when they are compiled.

Added in version 8.4.0.2 of package `base`.

```
(eval-jit-enabled) → boolean?
(eval-jit-enabled on?) → void?
  on? : any/c
```

See also §19.3 "Bytecode, Machine Code, and Just-in-Time (JIT) Compilers" in *The Racket Guide*.

A parameter that determines whether the native-code just-in-time compiler (*JIT*) is enabled for code (compiled or not) that is passed to the default evaluation handler. A true parameter value is effective only on platforms for which the JIT is supported and for Racket virtual machines that rely on a JIT.

The default is `#t`, unless the JIT is not supported by the current platform but is supported on the same virtual machine for other platforms, unless it is disabled through the `-j`/`--no-jit` command-line flag to stand-alone Racket (or GRacket), and unless it is disabled through the `PLTNOMZJIT` environment variable (set to any value).

```
(load-on-demand-enabled) → boolean?
(load-on-demand-enabled on?) → void?
  on? : any/c
```

A parameter that determines whether the default load handler sets `read-on-demand-source`. See `current-load` for more information. The default is `#t`, unless it is disabled through the `-d`/`--no-delay` command-line flag.

14.3 The `racket/load` Language

```
#lang racket/load      package: base
```

The `racket/load` language supports evaluation where each top-level form in the module body is separately passed to `eval` in the same way as for `load`.

The namespace for evaluation shares the module registry with the `racket/load` module instance, but it has a separate top-level environment, and it is initialized with the bindings of `racket`. A single namespace is created for each instance of the `racket/load` module (i.e., multiple modules using the `racket/load` language share a namespace). The `racket/load` library exports only `#%module-begin` and `#%top-interaction` forms that effectively swap in the evaluation namespace and call `eval`.

For example, the body of a module using `racket/load` can include `module` forms, so that running the following module prints `5`:

```
#lang racket/load

(module m racket/base
  (provide x)
  (define x 5))

(module n racket/base
  (require 'm)
  (display x))

(require 'n)
```

Definitions in a module using `racket/load` are evaluated in the current namespace, which means that `load` and `eval` can see the definitions. For example, running the following module prints `6`:

```
#lang racket/load
```

```
(define x 6)
(display (eval 'x))
```

Since all forms within a racket/load module are evaluated in the top level, bindings cannot be exported from the module using provide. Similarly, since evaluation of the module-body forms is inherently dynamic, compilation of the module provides essentially no benefit. For these reasons, use racket/load for interactive exploration of top-level forms only, and not for constructing larger programs.

14.4 Module Names and Loading

14.4.1 Resolving Module Names

The syntax/modresolve library provides additional operations for resolving and manipulating module names.

The name of a declared module is represented by a *resolved module path*, which encapsulates either a symbol or a complete filesystem path (see §15.1 "Paths"). A symbol normally refers to a predefined module or module declared through reflective evaluation (e.g., eval). A filesystem path normally refers to a module declaration that was loaded on demand via require or other forms.

A *module path* is a datum that matches the grammar for *module-path* for require. A module path is relative to another module.

```
(resolved-module-path? v) → boolean?
  v : any/c
```

Returns #t if *v* is a resolved module path, #f otherwise.

```
(make-resolved-module-path path) → resolved-module-path?
  path : (or/c symbol?
               (and/c path? complete-path?)
               (cons/c (or/c symbol?
                             (and/c path? complete-path?))
                       (non-empty-listof symbol?)))
```

Returns a resolved module path that encapsulates *path*, where a list *path* corresponds to a submodule path. If *path* is a path or starts with a path, the path normally should be cleansed (see cleanse-path) and simplified (see simplify-path, including consulting the file system).

A resolved module path is interned. That is, if two resolved module path values encapsulate paths that are equal?, then the resolved module path values are eq?.

```
(resolved-module-path-name module-path)
 → (or/c symbol?
         (and/c path? complete-path?)
         (cons/c (or/c symbol?
                       (and/c path? complete-path?))
                 (non-empty-listof symbol?)))
  module-path : resolved-module-path?
```

Returns the path or symbol encapsulated by a resolved module path. A list result corresponds to a submodule path.

```
(module-path? v) → boolean?
  v : any/c
```

Returns `#t` if *`v`* corresponds to a datum that matches the grammar for *`module-path`* for `require`, `#f` otherwise. Note that a path (in the sense of `path?`) is a module path.

```
(current-module-name-resolver)
 → (case->
     (resolved-module-path? (or/c #f namespace?) . -> . any)
     (module-path?
      (or/c #f resolved-module-path?)
      (or/c #f syntax?)
      boolean?
      . -> .
      resolved-module-path?))
(current-module-name-resolver proc) → void?
  proc : (case->
          (resolved-module-path? (or/c #f namespace?) . -> . any)
          (module-path?
           (or/c #f resolved-module-path?)
           (or/c #f syntax?)
           boolean?
           . -> .
           resolved-module-path?))
```

A parameter that determines the current *module name resolver*, which manages the conversion from other kinds of module references to a resolved module path. For example, when the expander encounters `(require module-path)` where *`module-path`* is not an identifier, then the expander passes `'module-path` to the module name resolver to obtain a symbol or resolved module path. When such a `require` appears within a module, the *module path resolver* is also given the name of the enclosing module, so that a relative reference can be converted to an absolute symbol or resolved module path.

The default module name resolver uses `collection-file-path` to convert `lib` and symbolic-shorthand module paths to filesystem paths. The `collection-file-path` function, in turn, uses the `current-library-collection-links` and `current-library-collection-paths` parameters.

A module name resolver takes two and four arguments:

- When given two arguments, the first is a name for a module that is now declared in the current namespace, and the second is optionally a namespace from which the declaration was copied. The module name resolver's result in this case is ignored.

  The current module name resolver is called with two arguments by `namespace-attach-module` or `namespace-attach-module-declaration` to notify the resolver that a module declaration was attached to the current namespace (and should not be loaded in the future for the namespace's module registry). Evaluation of a module declaration also calls the current module name resolver with two arguments, where the first is the declared module and the second is `#f`. No other Racket operation invokes the module name resolver with two arguments, but other tools (such as DrRacket) might call this resolver in this mode to avoid redundant module loads.

- When given four arguments, the first is a module path, equivalent to a quoted *`module-path`* for `require`. The second is name for the source module, if any, to which the path is relative; if the second argument is `#f`, the module path is relative to `(or (current-load-relative-directory) (current-directory))`. The third argument is a syntax object that can be used for error reporting, if it is not `#f`. If the last argument is `#t`, then the module declaration should be loaded (if it is not already), otherwise the module path should be simply resolved to a name. The result is the resolved name.

For the second case, the standard module name resolver keeps a table per module registry containing loaded module name. If a resolved module path is not in the table, and `#f` is not provided as the fourth argument to the module name resolver, then the name is put into the table and the corresponding file is loaded with a variant of `load/use-compiled` that passes the expected module name to the compiled-load handler.

While loading a file, the default module name resolver sets the `current-module-declare-name` parameter to the resolved module name (while the compiled-load handler sets `current-module-declare-source`). Also, the default module name resolver records in a private continuation mark the module being loaded, and it checks whether such a mark already exists; if such a continuation mark does exist in the current continuation, then the `exn:fail` exception is raised with a message about a dependency cycle.

The default module name resolver cooperates with the default compiled-load handler: on a module-attach notification, bytecode-file information recorded by the compiled-load handler for the source namespace's module registry is transferred to the target namespace's module registry.

The default module name resolver also maintains a small, module registry-specific cache that maps `lib` and symbolic module paths to their resolutions. This cache is consulted before checking parameters such as `current-library-collection-links` and `current-library-collection-paths`, so results may "stick" even if those parameter values change. An entry is added to the cache only when the fourth argument to the module name resolver is true (indicating that a module should be loaded) and only when loading succeeds.

Finally, the default module name resolver potentially treats a `submod` path specially. If the module path as the first element of the `submod` form refers to non-existent collection, then instead of raising an exception, the default module name resolver synthesizes an uninterned symbol module name for the resulting resolved module path. This special treatment of submodule paths is consistent with the special treatment of nonexistent submodules by the compiled-load handler, so that `module-declared?` can be used more readily to check for the existence of a submodule.

Module loading is suppressed (i.e., `#f` is supplied as a fourth argument to the module name resolver) when resolving module paths in syntax objects (see §1.2.2 "Syntax Objects"). When a syntax object is manipulated, the current namespace might not match the original namespace for the syntax object, and the module should not necessarily be loaded in the current namespace.

For historical reasons, the default module name resolver currently accepts three arguments, in addition to two and four. Three arguments are treated the same as four arguments with the fourth argument as `#t`, except that an error is also logged. Support for three arguments will be removed in a future version.

The `current-module-name-resolver` binding is provided as protected in the sense of `protect-out`.

Changed in version 6.0.1.12 of package `base`: Added error logging to the default module name resolver when called with three arguments.
Changed in version 7.0.0.17: Added special treatment of `submod` forms with a nonexistent collection by the default module name resolver.
Changed in version 8.2.0.4: Changed binding to protected.

```
(current-module-declare-name)
 → (or/c resolved-module-path? #f)
(current-module-declare-name name) → void?
  name : (or/c resolved-module-path? #f)
```

A parameter that determines a module name that is used when evaluating a `module` declaration (when the parameter value is not `#f`). In that case, the *`id`* from the `module` declaration is ignored, and the parameter's value is used as the name of the declared module.

When declaring submodules, `current-module-declare-name` determines the name used for the submodule's root module, while its submodule path relative to the root module is unaffected.

```
(current-module-declare-source)
 → (or/c symbol? (and/c path? complete-path?) #f)
(current-module-declare-source src) → void?
  src : (or/c symbol? (and/c path? complete-path?) #f)
```

A parameter that determines source information to be associated with a module when evaluating a `module` declaration. Source information is used in error messages and reflected by `variable-reference->module-source`. When the parameter value is `#f`, the module's name (as determined by `current-module-declare-name`) is used as the source name instead of the parameter value.

```
(current-module-path-for-load)
 → (or/c #f module-path?
          (and/c syntax?
                 (lambda (stx)
                   (module-path? (syntax->datum s)))))
(current-module-path-for-load path) → void?
  path : (or/c #f module-path?
               (and/c syntax?
                      (lambda (stx)
                        (module-path? (syntax->datum s)))))
```

A parameter that determines a module path used for `exn:fail:syntax:missing-module` and `exn:fail:filesystem:missing-module` exceptions as raised by the default load handler. The parameter is normally set by a module name resolver.

14.4.2 Compiled Modules and References

While expanding a `module` declaration, the expander resolves module paths for imports to load module declarations as necessary and to determine imported bindings, but the compiled form of a `module` declaration preserves the original module path. Consequently, a compiled module can be moved to another filesystem, where the module name resolver can resolve inter-module references among compiled code.

When a module reference is extracted from compiled form (see `module-compiled-imports`) or from syntax objects in macro expansion (see §12.2 "Syntax Object Content"), the module reference is reported in the form of a *module path index*. A module path index is a semi-interned (multiple references to the same relative module tend to use the same module path index value, but not always) opaque value that encodes a module path (see `module-path?`) and either a resolved module path or another module path index to which it is relative.

A module path index that uses both `#f` for its path and base module path index represents "self"—i.e., the module declaration that was the source of the module path index—and such a module path index can be used as the root for a chain of module path indexes at compile time. For example, when extracting information about an identifier's binding within a module, if the identifier is bound by a definition within the same module, the identifier's source module is reported using the "self" module path index. If the identifier is instead defined in a module that is imported via a module path (as opposed to a literal module name), then the identifier's source module will be reported using a module path index that contains the `required` module path and the "self" module path index. A "self" module path index has a submodule path when the module that it refers to is a submodule.

A module path index has state. When it is *resolved* to a resolved module path, then the resolved module path is stored with the module path index. In particular, when a module is loaded, its root module path index is resolved to match the module's declaration-time name. This resolved path is forgotten, however, in identifiers that the module contributes to the compiled and marshaled form of other modules. The transient nature of resolved names allows the module code to be loaded with a different resolved name than the name when it was compiled.

Two module path index values are `equal?` when they have `equal?` path and base values (even if they have different resolved values).

```
(module-path-index? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a module path index, `#f` otherwise.

```
(module-path-index-resolve  mpi
                           [load?
                            src-stx]) → resolved-module-path?
  mpi : module-path-index?
  load? : any/c = #f
  src-stx : (or/c syntax? #f) = #f
```

Returns a resolved module path for the resolved module name, computing the resolved name (and storing it in *mpi*) if it has not been computed before.

Resolving a module path index uses the current module name resolver (see `current-module-name-resolver`). Depending on the kind of module paths encapsulated by *mpi*, the computed resolved name can depend on the value of `current-load-relative-directory` or `current-directory`. The *load?* argument is propagated as the last argument to the module name resolver, while the *src-stx* argument is propagated as the next-to-last argument.

Beware that concurrent resolution in namespaces that share a module registry can create race conditions when loading modules. See also `namespace-call-with-registry-lock`.

If *mpi* represents a "self" (see above) module path that was not created by the expander as already resolved, then `module-path-index-resolve` raises `exn:fail:contract` without calling the module name resolver.

See also `resolve-module-path-index`.

Changed in version 6.90.0.16 of package `base`: Added the *`load?`* optional argument.
Changed in version 8.2: Added the *`src-stx`* optional argument.

```
(module-path-index-split mpi)
 → (or/c module-path? #f)
   (or/c module-path-index? resolved-module-path? #f)
  mpi : module-path-index?
```

Returns two values: a module path, and a base path—either a module path index, resolved module path, or `#f`—to which the first path is relative.

A `#f` second result means that the path is relative to an unspecified directory (i.e., its resolution depends on the value of `current-load-relative-directory` and/or `current-directory`).

A `#f` for the first result implies a `#f` for the second result, and means that *`mpi`* represents "self" (see above). Such a module path index may have a non-`#f` submodule path as reported by `module-path-index-submodule`.

```
(module-path-index-submodule mpi)
 → (or/c #f (non-empty-listof symbol?))
  mpi : module-path-index?
```

Returns a non-empty list of symbols if *`mpi`* is a "self" (see above) module path index that refers to a submodule. The result is always `#f` if either result of `(module-path-index-split mpi)` is non-`#f`.

```
(module-path-index-join path base [submod]) → module-path-index?
  path : (or/c module-path? #f)
  base : (or/c module-path-index? resolved-module-path? #f)
  submod : (or/c #f (non-empty-listof symbol?)) = #f
```

Combines *`path`*, *`base`*, and *`submod`* to create a new module path index. The *`path`* argument can be `#f` only if *`base`* is also `#f`. The *`submod`* argument can be a list only when *`path`* and *`base`* are both `#f`.

```
(compiled-module-expression? v) → boolean?
  v : any/c
```

Returns `#t` if *`v`* is a compiled `module` declaration, `#f` otherwise. See also `current-compile`.

```
(module-compiled-name compiled-module-code)
 → (or/c symbol? (cons/c symbol? (non-empty-listof symbol?)))
  compiled-module-code : compiled-module-expression?
(module-compiled-name compiled-module-code
                      name)
 → compiled-module-expression?
  compiled-module-code : compiled-module-expression?
  name : (or/c symbol? (cons/c symbol? (non-empty-listof symbol?)))
```

Takes a module declaration in compiled form and either gets the module's declared name (when *name* is not provided) or returns a revised module declaration with the given *name*.

The name is a symbol for a top-level module, or a symbol paired with a list of symbols where the list reflects the submodule path to the module starting with the top-level module's declared name.

```
(module-compiled-submodules compiled-module-code
                            non-star?)
 → (listof compiled-module-expression?)
  compiled-module-code : compiled-module-expression?
  non-star? : any/c
(module-compiled-submodules compiled-module-code
                            non-star?
                            submodules)
 → compiled-module-expression?
  compiled-module-code : compiled-module-expression?
  non-star? : any/c
  submodules : (listof compiled-module-expression?)
```

Takes a module declaration in compiled form and either gets the module's submodules (when *submodules* is not provided) or returns a revised module declaration with the given *submodules*. The *non-star?* argument determines whether the result or new submodule list corresponds to `module` declarations (when *non-star?* is true) or `module*` declarations (when *non-star?* is `#f`).

```
(module-compiled-imports compiled-module-code)
 → (listof (cons/c (or/c exact-integer? #f)
                   (listof module-path-index?)))
  compiled-module-code : compiled-module-expression?
```

Takes a module declaration in compiled form and returns an association list mapping phase level shifts (where `#f` corresponds to a shift into the label phase level) to module references for the module's explicit imports.

```
(module-compiled-exports  compiled-module-code
                          [verbosity])
 → (listof (cons/c phase+space? list?))
   (listof (cons/c phase+space? list?))
  compiled-module-code : compiled-module-expression?
  verbosity : (or/c #f 'defined-names) = #f
```

Returns two association lists mapping from a combination of phase level and binding space to exports at the corresponding phase and space. The first association list is for exported variables, and the second is for exported syntax. Beware however, that value bindings re-exported though a rename transformer are in the syntax list instead of the value list. See `phase+space?` for information on the phase-and-space representation.

Each associated list, which is represented by `list?` in the result contracts above, more precisely matches the contract

```
(listof (list/c symbol?
                (listof
                 (or/c module-path-index?
                       (list/c module-path-index?
                               phase+space?
                               symbol?
                               phase+space?)))
                ; only if verbosity is 'defined-names:
                symbol?))
```

For each element of the list, the leading symbol is the name of the export.

The second part—the list of module path index values, etc.—describes the origin of the exported identifier. If the origin list is `null`, then the exported identifier is defined in the module. If the exported identifier is re-exported, instead, then the origin list provides information on the import that was re-exported. The origin list has more than one element if the binding was imported multiple times from (possibly) different sources.

The last part, a symbol, is included only if *verbosity* is `'defined-names`. In that case, the included symbol is the name of the definition within its defining module (which may be different than the name that is exported).

For each origin, a module path index by itself means that the binding was imported with a phase level shift of `0` (i.e., a plain `require` without `for-meta`, `for-syntax`, etc.) into the default binding space (i.e., without `for-space`), and the imported identifier has the same name as the re-exported name. An origin represented with a list indicates explicitly the import, the phase level plus binding space where the imported identifier is bound (see `phase+space?` for more information on the representation), the symbolic name of the import as bound in the importing module, and the phase level plus binding space of the identifier from the exporting module.

Example:

```
> (module-compiled-exports
   (compile
    '(module banana racket/base
       (require (only-in racket/math pi)
                (for-syntax racket/base))
       (provide pi
                (rename-out [peel wrapper])
                bush
                cond
                (for-syntax compile-time))
       (define peel pi)
       (define bush (* 2 pi))
       (begin-for-syntax
         (define compile-time (current-seconds)))))
   'defined-names)
'((0
   (bush () bush)
   (pi (#<module-path-index:racket/math>) pi)
   (wrapper () peel))
  (1 (compile-time () compile-time)))
'((0 (cond (#<module-path-index:racket/base>) cond)))
```

Changed in version 7.5.0.6 of package `base`: Added the *verbosity* argument.
Changed in version 8.2.0.3: Generalized results to phase–space combinations.

```
(module-compiled-indirect-exports compiled-module-code)
 → (listof (cons/c exact-integer? (listof symbol?)))
  compiled-module-code : compiled-module-expression?
```

Returns an association list mapping phase level values to symbols that represent variables within the module. These definitions are not directly accessible from source, but they are accessible from bytecode, and the order of the symbols in each list corresponds to an order for bytecode access.

Added in version 6.5.0.5 of package `base`.

```
(module-compiled-language-info compiled-module-code)
 → (or/c #f (vector/c module-path? symbol? any/c))
  compiled-module-code : compiled-module-expression?
```

See also §17.3.6 “Module-Handling Configuration” in *The Racket Guide*.

Returns information intended to reflect the “language” of the module’s implementation as originally attached to the syntax of the module’s declaration though the `'module-language` syntax property. See also `module`.

If no information is available for the module, the result is `#f`. Otherwise, the result is `(vector mp name val)` such that `((dynamic-require mp name) val)` should return function that takes two arguments. The function's arguments are a key for reflected information and a default value. Acceptable keys and the interpretation of results is up to external tools, such as DrRacket. If no information is available for a given key, the result should be the given default value.

See also `module->language-info` and `racket/language-info`.

```
(module-compiled-cross-phase-persistent? compiled-module-code)
 → boolean?
  compiled-module-code : compiled-module-expression?
```

Returns `#t` if *`compiled-module-code`* represents a cross-phase persistent module, `#f` otherwise.

```
(module-compiled-realm compiled-module-code) → symbol?
  compiled-module-code : compiled-module-expression?
```

Returns the realm of the module represented by *`compiled-module-code`*.

Added in version 8.4.0.2 of package `base`.

14.4.3 Dynamic Module Access

```
(dynamic-require  mod
                  provided
                 [fail-thunk
                  syntax-thunk]) → (or/c void? any/c)
  mod : (or/c module-path?
              resolved-module-path?
              module-path-index?)
  provided : (or/c symbol? #f 0 void?)
  fail-thunk : (or/c 'error (-> any)) = 'error
  syntax-thunk : (or/c 'eval (-> any)) = 'eval
```

Dynamically instantiates the module specified by *`mod`* in the current namespace's registry at the namespace's base phase, if it is not yet instantiated. The current module name resolver may load a module declaration to resolve *`mod`* (see `current-module-name-resolver`); the path is resolved relative to `current-load-relative-directory` and/or `current-directory`. Beware that concurrent `dynamic-require`s in namespaces that share a module registry can create race conditions; see also `namespace-call-with-registry-lock`.

Because `dynamic-require` is a procedure, giving a plain S-expression for *`mod`* the same way as you would for a `require` expression likely won't give you expected results. What you need instead is something that evaluates to an S-expression; using `quote` is one way to do it.

If *`provided`* is `#f`, then the result is `#<void>`, and the module is not visited (see §1.2.3.9 "Module Expansion, Phases, and Visits") or even made available (for on-demand visits) in phases above the base phase.

Examples:

```
> (module a racket/base (displayln "hello"))
> (dynamic-require ''a #f)
hello
```

The double quoted `''a` evaluates to the *root-module-path* `'a` (see the grammar for `require`). Using `'a` for *mod* won't work, because that evaluates to *root-module-path* `a`, and the example is not a module installed in a collection. Using `a` won't work, because `a` is an undefined variable. Declaring `(module a ....)` within another module, instead of in the `read-eval-print` loop, would create a submodule. In that case, `(dynamic-require ''a #f)` would not access the module, because `''a` does not refer to a submodule.

When *provided* is a symbol, the value of the module's export with the given name is returned, and still the module is not visited or made available in higher phases.

Examples:

```
> (module b racket/base
    (provide dessert)
    (define dessert "gulab jamun"))
> (dynamic-require ''b 'dessert)
"gulab jamun"
```

If the module exports *provided* as syntax, then *syntax-thunk* is called if it is a procedure, and its result is the result of the `dynamic-require` call. If *syntax-thunk* is `'eval`, a use of the binding is expanded and evaluated in a fresh namespace to which the module is attached, which means that the module is visited in the fresh namespace. The expanded syntax must return a single value.

Examples:

```
> (module c racket/base
    (require (for-syntax racket/base))
    (provide dessert2)
    (define dessert "nanaimo bar")
    (define-syntax dessert2
      (make-rename-transformer #'dessert)))
> (dynamic-require ''c 'dessert2)
"nanaimo bar"
```

If the module has no such exported variable or syntax, then *fail-thunk* is called, or the `exn:fail:contract` exception is raised if *fail-thunk* is `'error`. If the variable named by *provided* is exported protected (see §14.10 "Code Inspectors"), then the `exn:fail:contract` exception is raised.

If *provided* is `0`, then the module is instantiated but not visited, the same as when *provided* is `#f`. With `0`, however, the module is made available in higher phases.

If *provided* is `#<void>`, then the module is visited but not instantiated (see §1.2.3.9 "Module Expansion, Phases, and Visits"), and the result is `#<void>`.

More examples using different `module-path` grammar expressions are given below:

Example:

```
> (dynamic-require 'racket/base #f)
```

Example:

```
> (dynamic-require (list 'lib "racket/base") #f)
```

Examples:

```
> (module a racket/base
    (module b racket/base
      (provide inner-dessert)
      (define inner-dessert "tiramisu")))
> (dynamic-require '(submod 'a b) 'inner-dessert)
"tiramisu"
```

The last line in the above example could instead have been written as

Example:

```
> (dynamic-require ((lambda () (list 'submod ''a 'b))) 'inner-
dessert)
"tiramisu"
```

which is equivalent.

Changed in version 8.16.0.3 of package `base`: Added the *`syntax-thunk`* argument and changed to allow `'error` for *`fail-thunk`*.

```
(dynamic-require-for-syntax  mod
                             provided
                            [fail-thunk
                             syntax-thunk]) → any
  mod : module-path?
  provided : (or/c symbol? #f)
  fail-thunk : (or/c 'error (-> any)) = 'error
  syntax-thunk : (or/c 'eval (-> any)) = 'eval
```

Like `dynamic-require`, but in a phase that is 1 more than the namespace's base phase.

Changed in version 8.16.0.3 of package `base`: Added the *`syntax-thunk`* argument and changed to allow `'error` for *`fail-thunk`*.

```
(module-declared? mod [load?]) → boolean?
  mod : (or/c module-path? module-path-index?
              resolved-module-path?)
  load? : any/c = #f
```

Returns `#t` if the module indicated by *mod* is declared (but not necessarily instantiated or visited) in the current namespace, `#f` otherwise.

If *load?* is `#t` and *mod* is not a resolved module path, the module is loaded in the process of resolving *mod* (as for `dynamic-require` and other functions). Checking for the declaration of a submodule does not trigger an exception if the submodule cannot be loaded because it does not exist, either within a root module that does exist or because the root module does not exist.

```
(module->language-info mod [load?])
 → (or/c #f (vector/c module-path? symbol? any/c))
  mod : (or/c module-path? module-path-index?
              resolved-module-path?)
  load? : any/c = #f
```

Returns information intended to reflect the "language" of the implementation of *mod*. If *mod* is a resolved module path or *load?* is `#f`, the module named by *mod* must be declared (but not necessarily instantiated or visited) in the current namespace; otherwise, *mod* may be loaded (as for `dynamic-require` and other functions). The information returned by `module->language-info` is the same as would have been returned by `module-compiled-language-info` applied to the module's implementation as compiled code.

A module can be declared by using `dynamic-require`.

Examples:

```
> (dynamic-require 'racket/dict (void))
> (module->language-info 'racket/dict)
#f
```

```
(module->imports mod)
 → (listof (cons/c (or/c exact-integer? #f)
                   (listof module-path-index?)))
  mod : (or/c module-path? module-path-index?
              resolved-module-path?)
```

Like `module-compiled-imports`, but produces the imports of *mod*, which must be declared (but not necessarily instantiated or visited) in the current namespace. See `module->language-info` for an example of declaring an existing module.

Examples:

```
> (module banana racket/base
    (require (only-in racket/math pi))
    (provide peel)
    (define peel pi))
```

```
    (define bush (* 2 pi)))
> (module->imports ''banana)
'((0 #<module-path-index:racket/base> #<module-path-
index:racket/math>))
```

```
(module->exports mod [verbosity])
 → (listof (cons/c phase+space? list?))
   (listof (cons/c phase+space? list?))
  mod : (or/c module-path? module-path-index?
              resolved-module-path?)
  verbosity : (or/c #f 'defined-names) = #f
```

Like `module-compiled-exports`, but produces the exports of *mod*, which must be declared (but not necessarily instantiated or visited) in the current namespace. See `module->language-info` for an example of declaring an existing module.

Examples:

```
> (module banana racket/base
    (require (only-in racket/math pi))
    (provide (rename-out [peel wrapper]))
    (define peel pi)
    (define bush (* 2 pi)))
> (module->exports ''banana)
'((0 (wrapper ())))
'()
```

Changed in version 7.5.0.6 of package `base`: Added the *verbosity* argument.
Changed in version 8.2.0.3: Generalized results to phase–space combinations.

```
(module->indirect-exports mod)
 → (listof (cons/c exact-integer? (listof symbol?)))
  mod : (or/c module-path? module-path-index?
              resolved-module-path?)
```

Like `module-compiled-indirect-exports`, but produces the indirect exports of *mod*, which must be declared (but not necessarily instantiated or visited) in the current namespace. See `module->language-info` for an example of declaring an existing module.

Examples:

```
> (module banana racket/base
    (require (only-in racket/math pi))
    (provide peel)
    (define peel pi)
```

```
    (define bush (* 2 pi)))
> (module->indirect-exports ''banana)
'((0 bush))
```

Added in version 6.5.0.5 of package `base`.

```
(module->realm mod) → symbol?
  mod : (or/c module-path? module-path-index?
              resolved-module-path?)
```

Like `module-compiled-realm`, but produces the realm of *`mod`*, which must be declared (but not necessarily instantiated or visited) in the current namespace.

Added in version 8.4.0.2 of package `base`.

```
(module-predefined? mod) → boolean?
  mod : (or/c module-path? module-path-index?
              resolved-module-path?)
```

Reports whether *`mod`* refers to a module that is predefined for the running Racket instance. Predefined modules always have a symbolic resolved module path, and they may be predefined always or specifically within a particular executable (such as one created by `raco exe` or `create-embedding-executable`).

14.4.4 Module Cache

The expander keeps a place-local module cache in order to save time while loading modules that have been previously declared.

```
(module-cache-clear!) → void?
```

Clears the place-local module cache.

Added in version 8.4.0.5 of package `base`.

14.5 Impersonators and Chaperones

An *impersonator* is a wrapper for a value where the wrapper redirects some of the value's operations. Impersonators apply only to procedures, structures for which an accessor or mutator is available, structure types, hash tables, vectors, boxes, channels, and prompt tags. An impersonator is `equal?` to the original value, but not `eq?` to the original value.

A *chaperone* is a kind of impersonator whose refinement of a value's operation is restricted to side effects (including, in particular, raising an exception) or chaperoning values supplied to or produced by the operation. For example, a vector chaperone can redirect `vector-ref` to raise an exception if the accessed vector slot contains a string, or it can cause the result of `vector-ref` to be a chaperoned variant of the value that is in the accessed vector slot, but it cannot redirect `vector-ref` to produce a value that is arbitrarily different from the value in the vector slot.

A non-chaperone impersonator, in contrast, can refine an operation to swap one value for any other. An impersonator cannot be applied to an immutable value or refine the access to an immutable field in an instance of a structure type, since arbitrary redirection of an operation amounts to mutation of the impersonated value.

Beware that each of the following operations can be redirected to an arbitrary procedure through an impersonator on the operation's argument—assuming that the operation is available to the creator of the impersonator:

- a structure-field accessor
- a structure-field mutator
- a structure type property accessor
- application of a procedure
- `unbox`
- `set-box!`
- `vector-ref`
- `vector-set!`
- `hash-ref`
- `hash-set`
- `hash-set!`
- `hash-remove`
- `hash-remove!`
- `channel-get`
- `channel-put`
- `call-with-continuation-prompt`
- `abort-current-continuation`

Derived operations, such as printing a value, can be redirected through impersonators due to their use of accessor functions. The `equal?`, `equal-hash-code`, and `equal-secondary-hash-code` operations, in contrast, may bypass impersonators (but they are not obliged to).

In addition to redirecting operations that work on a value, a impersonator can include *impersonator properties* for an impersonated value. An impersonator property is similar to a structure type property, but it applies to impersonators instead of structure types and their instances.

```
(impersonator? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is an impersonator created by procedures like `impersonate-procedure` or `impersonate-struct`, `#f` otherwise.

Programs and libraries generally should avoid `impersonator?` and treat impersonators the same as non-impersonator values. In rare cases, `impersonator?` may be needed to guard against redirection by an impersonator of an operation to an arbitrary procedure.

A limitation of `impersonator?` is that it does *not* recognize an impersonator that is created by instantiating a structure type with the `prop:impersonator-of` property. The limitation reflects how those impersonators cannot redirect structure access and mutation operations to arbitrary procedures.

```
(chaperone? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a chaperone, `#f` otherwise.

Programs and libraries generally should avoid `chaperone?` for the same reason that they should avoid `impersonator?`. A true value for `chaperone?` implies a true value of `impersonator?`.

```
(impersonator-of? v1 v2) → boolean?
  v1 : any/c
  v2 : any/c
```

Indicates whether *v1* can be considered equivalent modulo impersonators to *v2*.

Any two values that are `eq?` to one another are also `impersonator-of?`. For values that include no impersonators, *v1* and *v2* are considered impersonators of each other if they are `equal?`.

If at least one of *v1* or *v2* is an impersonator:

- If *v1* impersonates *v1** then `(impersonator-of? v1 v2)` is `#t` if and only if `(impersonator-of? v1* v2)` is `#t`.

- If *v2* is a non-interposing impersonator that impersonates *v2**, i.e., all of its interposition procedures are `#f`, then `(impersonator-of? v1 v2)` is `#t` if and only if `(impersonator-of? v1 v2*)` is `#t`.
- When *v2* is an impersonator constructed with at least one non-`#f` interposition procedure, but *v1* is not an impersonator then `(impersonator-of? v1 v2)` is `#f`.

Otherwise, if neither *v1* or *v2* is an impersonator, but either of them contains an impersonator as a subpart (e.g., *v1* is a list with an impersonator as one of its elements), then `(impersonator-of? v1 v2)` proceeds by comparing *v1* and *v2* recursively (as with `equal?`), returning true if all subparts are `impersonator-of?`.

Examples:

```
> (impersonator-of? (impersonate-procedure add1 (λ (x) x))
                    add1)
#t
> (impersonator-of? (impersonate-procedure add1 (λ (x) x))
                    sub1)
#f
> (impersonator-of? (impersonate-procedure
                      (impersonate-procedure add1 (λ (x) x)) (λ (x) x))
                    add1)
#t
> (impersonator-of? (impersonate-procedure add1 (λ (x) x))
                    (impersonate-procedure add1 #f))
#t
> (impersonator-of? (impersonate-procedure add1 (λ (x) x))
                    (impersonate-procedure add1 (λ (x) x)))
#f
> (impersonator-of? (list 1 2)
                    (list 1 2))
#t
> (impersonator-of? (list (impersonate-procedure add1 (λ (x) x)) sub1)
                    (list add1 sub1))
#t
```

```
(chaperone-of? v1 v2) → boolean?
  v1 : any/c
  v2 : any/c
```

Indicates whether *v1* can be considered equivalent modulo chaperones to *v2*.

For values that include no chaperones or other impersonators, *v1* and *v2* can be considered chaperones of each other if they are `equal-always?`, which requires that they are `equal?`

except that corresponding mutable vectors, boxes, hash tables, strings, byte strings, mutable pairs, and mutable structures within *v1* and *v2* must be `eq?`.

Otherwise, chaperones and other impersonators within *v2* must be intact within *v1* analogous to way that `impersonator-of?` requires that impersonators are preserved. Furthermore, *v1* must not have any non-chaperone impersonators whose corresponding value in *v2* is not the same impersonator. Note that `chaperone-of?` implies `impersonator-of?`, but not vice-versa.

```
(impersonator-ephemeron v) → ephemeron?
  v : any/c
```

Produces an ephemeron that can be used to connect the reachability of *v* (in the sense of garbage collection; see §1.1.6 "Garbage Collection") with the reachability of any value for which *v* is an impersonator. That is, the value *v* will be considered reachable as long as the result ephemeron is reachable in addition to any value that *v* impersonates (including itself).

In the terminology of ephemerons, *v* is the value of the ephemeron and all of the values that *v* impersonates are keys.

```
(procedure-impersonator*? v) → boolean?
  v : any/c
```

Returns `#t` for any procedure impersonator that either was produced by `impersonate-procedure*` or `chaperone-procedure*`, or is an impersonator/chaperone of a value that was created with `impersonate-procedure*` or `chaperone-procedure*` (possibly transitively).

14.5.1 Impersonator Constructors

```
(impersonate-procedure proc
                       wrapper-proc
                       prop
                       prop-val ...
                       ...)
 → (and/c procedure? impersonator?)
  proc : procedure?
  wrapper-proc : (or/c procedure? #f)
  prop : impersonator-property?
  prop-val : any/c
```

Returns an impersonator procedure that has the same arity, name, and other attributes as *proc*. When the impersonator procedure is applied, the arguments are first passed to *wrapper-proc* (when it is not `#f`), and then the results from *wrapper-proc* are passed to *proc*. The *wrapper-proc* can also supply a procedure that processes the results of *proc*.

The arity of *wrapper-proc* must include the arity of *proc*. The allowed keyword arguments of *wrapper-proc* must be a superset of the allowed keywords of *proc*. The required keyword arguments of *wrapper-proc* must be a subset of the required keywords of *proc*.

For applications without keywords, the result of *wrapper-proc* must be at least the same number of values as supplied to it. Additional results can be supplied—before the values that correspond to the supplied values—in the following pattern:

- An optional procedure, *result-wrapper-proc*, which will be applied to the results of *proc*; followed by
- any number of repetitions of `'mark` *key* *val* (i.e., three values), where the call *proc* is wrapped to install a continuation mark *key* and *val*.

If *result-wrapper-proc* is produced, it must be a procedure that accepts as many results as produced by *proc*; it must return the same number of results. If *result-wrapper-proc* is not supplied, then *proc* is called in tail position with respect to the call to the impersonator.

For applications that include keyword arguments, *wrapper-proc* must return an additional value before any other values but after *result-wrapper-proc* and `'mark` *key* *val* sequences (if any). The additional value must be a list of replacements for the keyword arguments that were supplied to the impersonator (i.e., not counting optional arguments that were not supplied). The arguments must be ordered according to the sorted order of the supplied arguments' keywords.

If *wrapper-proc* is `#f`, then applying the resulting impersonator is the same as applying *proc*. If *wrapper-proc* is `#f` and no *prop* is provided, then *proc* is returned and is not impersonated.

Pairs of *prop* and *prop-val* (the number of arguments to `impersonate-procedure` must be even) add impersonator properties or override impersonator-property values of *proc*.

If any *prop* is `impersonator-prop:application-mark` and if the associated *prop-val* is a pair, then the call to *proc* is wrapped with `with-continuation-mark` using `(car prop-val)` as the mark key and `(cdr prop-val)` as the mark value. In addition, if the immediate continuation frame of the call to the impersonated procedure includes a value for `(car prop-val)`—that is, if `call-with-immediate-continuation-mark` would produce a value for `(car prop-val)` in the call's continuation—then the value is also installed as an immediate value for `(car prop-val)` as a mark during the call to *wrapper-proc* (which allows tail-calls of impersonators with respect to wrapping impersonators to be detected within *wrapper-proc*).

Changed in version 6.3.0.5 of package `base`: Added support for `'mark` *key* *val* results from *wrapper-proc*.

Examples:

```
> (define (add15 x) (+ x 15))
> (define add15+print
    (impersonate-procedure add15
                           (λ (x)
                             (printf "called with ~s\n" x)
                             (values (λ (res)
                                        (printf "returned
~s\n" res)
                                        res)
                                      x))))
> (add15 27)
42
> (add15+print 27)
called with 27
returned 42
42
> (define-values (imp-prop:p1 imp-prop:p1? imp-prop:p1-get)
    (make-impersonator-property 'imp-prop:p1))
> (define-values (imp-prop:p2 imp-prop:p2? imp-prop:p2-get)
    (make-impersonator-property 'imp-prop:p2))
> (define add15.2 (impersonate-procedure add15 #f imp-prop:p1 11))
> (add15.2 2)
17
> (imp-prop:p1? add15.2)
#t
> (imp-prop:p1-get add15.2)
11
> (imp-prop:p2? add15.2)
#f
> (define add15.3 (impersonate-procedure add15.2 #f imp-
prop:p2 13))
> (add15.3 3)
18
> (imp-prop:p1? add15.3)
#t
> (imp-prop:p1-get add15.3)
11
> (imp-prop:p2? add15.3)
#t
> (imp-prop:p2-get add15.3)
13
> (define add15.4 (impersonate-procedure add15.3 #f imp-
prop:p1 101))
> (add15.4 4)
```

```
19
> (imp-prop:p1? add15.4)
#t
> (imp-prop:p1-get add15.4)
101
> (imp-prop:p2? add15.4)
#t
> (imp-prop:p2-get add15.4)
13
```

```
(impersonate-procedure* proc
                        wrapper-proc
                        prop
                        prop-val ...
                        ...)
 → (and/c procedure? impersonator?)
  proc : procedure?
  wrapper-proc : (or/c procedure? #f)
  prop : impersonator-property?
  prop-val : any/c
```

Like `impersonate-procedure`, except that *wrapper-proc* receives an additional argument before all other arguments. The additional argument is the procedure *orig-proc* that was originally applied.

If the result of `impersonate-procedure*` is applied directly, then *orig-proc* is that result. If the result is further impersonated before being applied, however, *orig-proc* is the further impersonator.

An *orig-proc* argument might be useful so that *wrapper-proc* can extract impersonator properties that are overridden by further impersonators, for example.

Added in version 6.1.1.5 of package `base`.

```
(impersonate-struct  v
                    [struct-type]
                     orig-proc
                     redirect-proc ...
                     ...
                     prop
                     prop-val ...
                     ...)              → any/c
  v : any/c
  struct-type : struct-type? = unspecified
  orig-proc : (or/c struct-accessor-procedure?
                    struct-mutator-procedure?
                    struct-type-property-accessor-procedure?)
```

```
redirect-proc : (or/c procedure? #f)
prop : impersonator-property?
prop-val : any/c
```

Returns an impersonator of *v*, which redirects certain operations on the impersonated value. The *orig-proc*s indicate the operations to redirect, and the corresponding *redirect-proc*s supply the redirections. The optional *struct-type* argument, when provided, acts as a witness for the representation of *v*, which must be an instance of *struct-type*.

The protocol for a *redirect-proc* depends on the corresponding *orig-proc*, where *self* refers to the value to which *orig-proc* is originally applied:

- A structure-field accessor: *redirect-proc* must accept two arguments, *self* and the value *field-v* that *orig-proc* produces for *v*; it must return a replacement for *field-v*. The corresponding field must not be immutable, and either the field's structure type must be accessible via the current inspector or one of the other *orig-proc*s must be a structure-field mutator for the same field.
- A structure-field mutator: *redirect-proc* must accept two arguments, *self* and the value *field-v* supplied to the mutator; it must return a replacement for *field-v* to be propagated to *orig-proc* and *v*.
- A property accessor: *redirect-proc* uses the same protocol as for a structure-field accessor. The accessor's property must have been created with `'can-impersonate` as the second argument to `make-struct-type-property`.

When a *redirect-proc* is `#f`, the corresponding *orig-proc* is unaffected. Supplying `#f` for a *redirect-proc* is useful to allow its *orig-proc* to act as a "witness" of *v*'s representation and enable the addition of *prop*s.

Pairs of *prop* and *prop-val* (the number of arguments to `impersonate-struct` must be even if *struct-type* is provided, odd otherwise) add impersonator properties or override impersonator-property values of *v*.

Each *orig-proc* must indicate a distinct operation. If no *struct-type* and no *orig-proc*s are supplied, then no *prop*s must be supplied. If *orig-proc*s are supplied only with `#f` *redirect-proc*s and no *prop*s are supplied, then *v* is returned and is not impersonated.

If any *orig-proc* is itself an impersonator, then a use of the accessor or mutator that *orig-proc* impersonates is redirected for the resulting impersonated structure to use *orig-proc* on *v* before *redirect-proc* (in the case of accessor) or after *redirect-proc* (in the case of a mutator).

Changed in version 6.1.1.2 of package `base`: Changed first argument to an accessor or mutator *redirect-proc* from *v* to *self*.
Changed in version 6.1.1.8: Added optional *struct-type* argument.

```
(impersonate-vector vec
                    ref-proc
                    set-proc
                    prop
                    prop-val ...
                    ...)
 → (and/c vector? impersonator?)
  vec : (and/c vector? (not/c immutable?))
  ref-proc : (or/c (vector? exact-nonnegative-integer? any/c . -> . any/c) #f)
  set-proc : (or/c (vector? exact-nonnegative-integer? any/c . -> . any/c) #f)
  prop : impersonator-property?
  prop-val : any/c
```

Returns an impersonator of *vec*, which redirects the `vector-ref` and `vector-set!` operations.

The *ref-proc* and *set-proc* arguments must either both be procedures or both be `#f`. If they are `#f` then `impersonate-vector` does not interpose on *vec*, but still allows attaching impersonator properties.

If *ref-proc* is a procedure it must accept *vec*, an index passed to `vector-ref`, and the value that `vector-ref` on *vec* produces for the given index; it must produce a replacement for the value, which is the result of `vector-ref` on the impersonator.

If *set-proc* is a procedure it must accept *vec*, an index passed to `vector-set!`, and the value passed to `vector-set!`; it must produce a replacement for the value, which is used with `vector-set!` on the original *vec* to install the value.

Pairs of *prop* and *prop-val* (the number of arguments to `impersonate-vector` must be odd) add impersonator properties or override impersonator-property values of *vec*.

Changed in version 6.9.0.2 of package `base`: Added non-interposing vector impersonators.

```
(impersonate-vector* vec
                     ref-proc
                     set-proc
                     prop
                     prop-val ...
                     ...)
 → (and/c vector? impersonator?)
  vec : (and/c vector? (not/c immutable?))
  ref-proc : (or/c (vector? vector? exact-nonnegative-integer? any/c . -> . any/c) #f)
  set-proc : (or/c (vector? vector? exact-nonnegative-integer? any/c . -> . any/c) #f)
  prop : impersonator-property?
  prop-val : any/c
```

Like `impersonate-vector`, except that *ref-proc* and *set-proc* each receive an additional vector as argument before other arguments. The additional argument is the original impersonated vector, access to which triggered interposition in the first place.

The additional vector argument might be useful so that *ref-proc* or *set-proc* can extract impersonator properties that are overridden by further impersonators, for example.

Added in version 6.9.0.2 of package `base`.

```
(impersonate-box box
                 unbox-proc
                 set-proc
                 prop
                 prop-val ...
                 ...)         → (and/c box? impersonator?)
  box : (and/c box? (not/c immutable?))
  unbox-proc : (box? any/c . -> . any/c)
  set-proc : (box? any/c . -> . any/c)
  prop : impersonator-property?
  prop-val : any/c
```

Returns an impersonator of *box*, which redirects the `unbox` and `set-box!` operations.

The *unbox-proc* must accept *box* and the value that `unbox` produces on *box*; it must produce a replacement value, which is the result of `unbox` on the impersonator.

The *set-proc* must accept *box* and the value passed to `set-box!`; it must produce a replacement value, which is used with `set-box!` on the original *box* to install the value.

Pairs of *prop* and *prop-val* (the number of arguments to `impersonate-box` must be odd) add impersonator properties or override impersonator-property values of *box*.

```
(impersonate-hash  hash
                   ref-proc
                   set-proc
                   remove-proc
                   key-proc
                  [clear-proc
                   equal-key-proc]
                   prop
                   prop-val ...
                   ...)         → (and/c hash? impersonator?)
  hash : (and/c hash? (not/c immutable?))
  ref-proc : (hash? any/c . -> . (values
                                  any/c
                                  (hash? any/c any/c . -> . any/c)))
  set-proc : (hash? any/c any/c . -> . (values any/c any/c))
```

```
remove-proc : (hash? any/c . -> . any/c)
key-proc : (hash? any/c . -> . any/c)
clear-proc : (or/c #f (hash? . -> . any)) = #f
equal-key-proc : (or/c #f (hash? any/c . -> . any/c)) = #f
prop : impersonator-property?
prop-val : any/c
```

Returns an impersonator of *hash*, which redirects the `hash-ref`, `hash-set!` or `hash-set` (as applicable), `hash-remove` or `hash-remove!` (as applicable), `hash-clear` or `hash-clear!` (as applicable and if *clear-proc* is not `#f`) operations. When `hash-set`, `hash-remove` or `hash-clear` is used on an impersonator of a hash table, the result is an impersonator with the same redirecting procedures. In addition, operations like `hash-iterate-key` or `hash-map`, which extract keys from the table, use *key-proc* to replace keys extracted from the table. Operations like `hash-iterate-value` or `hash-values` implicitly use `hash-ref` and therefore redirect through *ref-proc*. The `hash-ref-key` operation uses both *ref-proc* and *key-proc*, the former to lookup the requested key and the latter to extract it.

The *ref-proc* must accept *hash* and a key passed to `hash-ref`. It must return a replacement key as well as a procedure. The returned procedure is called only if the returned key is found in *hash* via `hash-ref`, in which case the procedure is called with *hash*, the previously returned key, and the found value. The returned procedure must itself return a replacement for the found value. The returned procedure is ignored by `hash-ref-key`.

The *set-proc* must accept *hash*, a key passed to `hash-set!` or `hash-set`, and the value passed to `hash-set!` or `hash-set`; it must produce two values: a replacement for the key and a replacement for the value. The returned key and value are used with `hash-set!` or `hash-set` on the original *hash* to install the value.

The *remove-proc* must accept *hash* and a key passed to `hash-remove!` or `hash-remove`; it must produce a replacement for the key, which is used with `hash-remove!` or `hash-remove` on the original *hash* to remove any mapping using the (impersonator-replaced) key.

The *key-proc* must accept *hash* and a key that has been extracted from *hash* (by `hash-ref-key`, `hash-iterate-key`, or other operations that use `hash-iterate-key` internally); it must produce a replacement for the key, which is then reported as a key extracted from the table.

If *clear-proc* is not `#f`, it must accept *hash* as an argument, and its result is ignored. The fact that *clear-proc* returns (as opposed to raising an exception or otherwise escaping) grants the capability to remove all keys from *hash*. If *clear-proc* is `#f`, then `hash-clear` or `hash-clear!` on the impersonator is implemented using `hash-iterate-key` and `hash-remove` or `hash-remove!`.

If *equal-key-proc* is not `#f`, it effectively interposes on calls to `equal?`, `equal-hash-code`, and `equal-secondary-hash-code` for the keys of *hash*. The *equal-key-proc* must accept as its arguments *hash* and a key that is either mapped by *hash* or passed to `hash-ref`, etc., where the latter has potentially been adjusted by the corresponding *ref-proc*, etc. The result is a value that is passed to `equal?`, `equal-hash-code`, and `equal-secondary-hash-code` as needed to hash and compare keys. In the case of `hash-set!` or `hash-set`, the key that is passed to *equal-key-proc* is the one stored in the hash table for future lookup.

The `hash-iterate-value`, `hash-map`, or `hash-for-each` functions use a combination of `hash-iterate-key` and `hash-ref`. If a key produced by *key-proc* does not yield a value through `hash-ref`, then the `exn:fail:contract` exception is raised.

Pairs of *prop* and *prop-val* add impersonator properties or override impersonator-property values of *hash*.

In the case of an immutable hash table, two impersonated hash tables count as "the same value" (for purposes of `impersonator-of?`) when their redirection procedures were originally attached to a hash table by the same call to `impersonate-hash` or `chaperone-hash` (and potentially propagated by `hash-set`, `hash-remove`, or `hash-clear`), as long as the content of the first hash table is `impersonator-of?` of the second hash table.

Changed in version 6.3.0.11 of package `base`: Added the *equal-key-proc* argument.

```
(impersonate-channel channel
                     get-proc
                     put-proc
                     prop
                     prop-val ...
                     ...)
 → (and/c channel? impersonator?)
  channel : channel?
  get-proc : (channel? . -> . (values channel? (any/c . -> . any/c)))
  put-proc : (channel? any/c . -> . any/c)
  prop : impersonator-property?
  prop-val : any/c
```

Returns an impersonator of *channel*, which redirects the `channel-get` and `channel-put` operations.

The *get-proc* generator is called on `channel-get` or any other operation that fetches results from the channel (such as a `sync` on the channel). The *get-proc* must return two values: a channel that is an impersonator of *channel*, and a procedure that is used to check the channel's contents.

The *put-proc* must accept *channel* and the value passed to `channel-put`; it must produce a replacement value, which is used with `channel-put` on the original *channel* to send the value over the channel.

Pairs of *prop* and *prop-val* (the number of arguments to `impersonate-channel` must be odd) add impersonator properties or override impersonator-property values of *channel*.

```
(impersonate-prompt-tag  prompt-tag
                         handle-proc
                         abort-proc
                        [cc-guard-proc
                         callcc-impersonate-proc]
                         prop
                         prop-val ...
                         ...)
 → (and/c continuation-prompt-tag? impersonator?)
  prompt-tag : continuation-prompt-tag?
  handle-proc : procedure?
  abort-proc : procedure?
  cc-guard-proc : procedure? = values
  callcc-impersonate-proc : (procedure? . -> . procedure?)
                          = (lambda (p) p)
  prop : impersonator-property?
  prop-val : any/c
```

Returns an impersonator of *prompt-tag*, which redirects the `call-with-continuation-prompt` and `abort-current-continuation` operations.

The *handle-proc* must accept the values that the handler of a continuation prompt would take and it must produce replacement values, which will be passed to the handler.

The *abort-proc* must accept the values passed to `abort-current-continuation`; it must produce replacement values, which are aborted to the appropriate prompt.

The *cc-guard-proc* must accept the values produced by `call-with-continuation-prompt` in the case that a non-composable continuation is applied to replace the continuation that is delimited by the prompt, but only if `abort-current-continuation` is not later used to abort the continuation delimited by the prompt (in which case *abort-proc* is used).

The *callcc-impersonate-proc* must accept a procedure that guards the result of a continuation captured by `call-with-current-continuation` with the impersonated prompt tag. The *callcc-impersonate-proc* is applied (under a continuation barrier) when the captured continuation is applied to refine a guard function (initially `values`) that is specific to the delimiting prompt; this prompt-specific guard is ultimately composed with any *cc-guard-proc* that is in effect at the delimiting prompt, and it is not used in the same case that a *cc-guard-proc* is not used (i.e., when `abort-current-continuation` is used to abort to the prompt). In the special case where the delimiting prompt at application time is a thread's built-in initial prompt, *callcc-impersonate-proc* is ignored (partly on the grounds that the initial prompt's result is ignored).

Pairs of *prop* and *prop-val* (the number of arguments to `impersonate-prompt-tag` must be odd) add impersonator properties or override impersonator-property values of *prompt-tag*.

Examples:

```
> (define tag
    (impersonate-prompt-tag
     (make-continuation-prompt-tag)
     (lambda (n) (* n 2))
     (lambda (n) (+ n 1))))
> (call-with-continuation-prompt
    (lambda ()
      (abort-current-continuation tag 5))
    tag
    (lambda (n) n))
12
```

```
(impersonate-continuation-mark-key key
                                   get-proc
                                   set-proc
                                   prop
                                   prop-val ...
                                   ...)
 → (and/c continuation-mark? impersonator?)
  key : continuation-mark-key?
  get-proc : procedure?
  set-proc : procedure?
  prop : impersonator-property?
  prop-val : any/c
```

Returns an impersonator of *key*, which redirects `with-continuation-mark` and continuation mark accessors such as `continuation-mark-set->list`.

The *get-proc* must accept the value attached to a continuation mark and it must produce a replacement value, which will be returned by the continuation mark accessor.

The *set-proc* must accept a value passed to `with-continuation-mark`; it must produce a replacement value, which is attached to the continuation frame.

Pairs of *prop* and *prop-val* (the number of arguments to `impersonate-continuation-mark-key` must be odd) add impersonator properties or override impersonator-property values of *key*.

Examples:

```
> (define mark-key
```

```
    (impersonate-continuation-mark-key
     (make-continuation-mark-key)
     (lambda (l) (map char-upcase l))
     (lambda (s) (string->list s))))
> (with-continuation-mark mark-key "quiche"
    (continuation-mark-set-first
     (current-continuation-marks)
     mark-key))
'(#\Q #\U #\I #\C #\H #\E)
```

`prop:impersonator-of : struct-type-property?`

A structure type property (see §5.3 "Structure Type Properties") that supplies a procedure for extracting an impersonated value from a structure that represents an impersonator. The property is used for `impersonator-of?` as well as `equal?`.

The property value must be a procedure of one argument, which is a structure whose structure type has the property. The result can be `#f` to indicate the structure does not represent an impersonator, otherwise the result is a value for which the original structure is an impersonator (so the original structure is an `impersonator-of?` and `equal?` to the result value). The result value must have the same `prop:impersonator-of` and `prop:equal+hash` property values as the original structure, if any, and the property values must be inherited from the same structure type (which ensures some consistency between `impersonator-of?` and `equal?`).

Impersonator property predicates and accessors applied to a structure with the `prop:impersonator-of` property first check for the property on the immediate structure, and if it is not found, the value produced by the `prop:impersonator-of` procedure is checked (recursively).

Changed in version 6.1.1.8 of package `base`: Made impersonator property predicates and accessors sensitive to `prop:impersonator-of`.

`prop:authentic : struct-type-property?`

A structure type property that declares a structure type as *authentic*. The value associated with the property is ignored; the presence of the property itself makes the structure type authentic.

Instances of an authentic structure type cannot be impersonated via `impersonate-struct` or chaperoned via `chaperone-struct`. As a consequence, an instance of an authentic structure type can be given a contract (see `struct/c`) only if it is a flat contract.

Declaring a structure type as authentic can prevent unwanted structure impersonation, but exposed structure types normally should support impersonators or chaperones to facilitate contracts. Declaring a structure type as authentic can also slightly improve the performance of structure predicates, selectors, and mutators, which can be appropriate for data structures that are private and frequently used within a library.

Added in version 6.9.0.4 of package `base`.

14.5.2 Chaperone Constructors

```
(chaperone-procedure proc
                     wrapper-proc
                     prop
                     prop-val ...
                     ...)
 → (and/c procedure? chaperone?)
  proc : procedure?
  wrapper-proc : (or/c procedure? #f)
  prop : impersonator-property?
  prop-val : any/c
```

Like `impersonate-procedure`, but for each value supplied to *`wrapper-proc`*, the corresponding result must be the same or a chaperone of (in the sense of `chaperone-of?`) the supplied value. The additional result, if any, that precedes the chaperoned values must be a procedure that accepts as many results as produced by *`proc`*; it must return the same number of results, each of which is the same or a chaperone of the corresponding original result.

For applications that include keyword arguments, *`wrapper-proc`* must return an additional value before any other values but after the result-chaperoning procedure (if any). The additional value must be a list of chaperones of the keyword arguments that were supplied to the chaperone procedure (i.e., not counting optional arguments that were not supplied). The arguments must be ordered according to the sorted order of the supplied arguments' keywords.

```
(chaperone-procedure* proc
                      wrapper-proc
                      prop
                      prop-val ...
                      ...)
 → (and/c procedure? chaperone?)
  proc : procedure?
  wrapper-proc : (or/c procedure? #f)
  prop : impersonator-property?
  prop-val : any/c
```

Like `chaperone-procedure`, but *`wrapper-proc`* receives an extra argument as with `impersonate-procedure*`.

Added in version 6.1.1.5 of package base.

```
(chaperone-struct  v
                  [struct-type]
                   orig-proc
                   redirect-proc ...
                   ...
                   prop
                   prop-val ...
                   ...)             → any/c
  v : any/c
  struct-type : struct-type? = unspecified
  orig-proc : (or/c struct-accessor-procedure?
                    struct-mutator-procedure?
                    struct-type-property-accessor-procedure?
                    (lambda (proc)
                      (eq? proc struct-info)))
  redirect-proc : (or/c procedure? #f)
  prop : impersonator-property?
  prop-val : any/c
```

Like `impersonate-struct`, but with the following refinements, where *self* refers to the value to which a *orig-proc* is originally applied:

- With a structure-field accessor as *orig-proc*, *redirect-proc* must accept two arguments, *self* and the value *field-v* that *orig-proc* produces for *v*; it must return a chaperone of *field-v*. The corresponding field may be immutable.
- With structure-field mutator as *orig-proc*, *redirect-proc* must accept two arguments, *self* and the value *field-v* supplied to the mutator; it must return a chaperone of *field-v* to be propagated to *orig-proc* and *v*.
- A property accessor can be supplied as *orig-proc*, and the property need not have been created with `'can-impersonate`. The corresponding *redirect-proc* uses the same protocol as for a structure-field accessor.
- With `struct-info` as *orig-proc*, the corresponding *redirect-proc* must accept two values, which are the results of `struct-info` on *v*; it must return each values or a chaperone of each value. The *redirect-proc* is not called if `struct-info` would return `#f` as its first argument. An *orig-proc* can be `struct-info` only if *struct-type* or some other *orig-proc* is supplied.
- Any accessor or mutator *orig-proc* that is an impersonator must be specifically a chaperone.

Supplying a property accessor for *orig-proc* enables *prop* arguments, the same as supplying an accessor, mutator, or structure type.

Changed in version 6.1.1.2 of package `base`: Changed first argument to an accessor or mutator *redirect-proc* from *v* to *self*.
Changed in version 6.1.1.8: Added optional *struct-type* argument.

```
(chaperone-vector vec
                  ref-proc
                  set-proc
                  prop
                  prop-val ...
                  ...)          → (and/c vector? chaperone?)
  vec : vector?
  ref-proc : (or/c (vector? exact-nonnegative-integer? any/c . -> . any/c) #f)
  set-proc : (or/c (vector? exact-nonnegative-integer? any/c . -> . any/c) #f)
  prop : impersonator-property?
  prop-val : any/c
```

Like `impersonate-vector`, but with support for immutable vectors. The *ref-proc* procedure must produce the same value or a chaperone of the original value, and *set-proc* must produce the value that is given or a chaperone of the value. The *set-proc* will not be used if *vec* is immutable.

```
(chaperone-vector* vec
                   ref-proc
                   set-proc
                   prop
                   prop-val ...
                   ...)          → (and/c vector? chaperone?)
  vec : vector?
  ref-proc : (or/c (vector? vector? exact-nonnegative-integer? any/c . -> . any/c) #f)
  set-proc : (or/c (vector? vector? exact-nonnegative-integer? any/c . -> . any/c) #f)
  prop : impersonator-property?
  prop-val : any/c
```

Like `chaperone-vector`, but *ref-proc* and *set-proc* receive an extra argument as with `impersonate-vector*`.

Added in version 6.9.0.2 of package `base`.

```
(chaperone-box box
               unbox-proc
               set-proc
               prop
               prop-val ...
               ...)          → (and/c box? chaperone?)
  box : box?
  unbox-proc : (box? any/c . -> . any/c)
```

```
set-proc : (box? any/c . -> . any/c)
prop : impersonator-property?
prop-val : any/c
```

Like `impersonate-box`, but with support for immutable boxes. The *`unbox-proc`* procedure must produce the same value or a chaperone of the original value, and *`set-proc`* must produce the same value or a chaperone of the value that it is given. The *`set-proc`* will not be used if *`box`* is immutable.

```
(chaperone-hash  hash
                 ref-proc
                 set-proc
                 remove-proc
                 key-proc
                [clear-proc
                 equal-key-proc]
                 prop
                 prop-val ...
                 ...)           → (and/c hash? chaperone?)
  hash : hash?
  ref-proc : (hash? any/c . -> . (values
                                   any/c
                                   (hash? any/c any/c . -> . any/c)))
  set-proc : (hash? any/c any/c . -> . (values any/c any/c))
  remove-proc : (hash? any/c . -> . any/c)
  key-proc : (hash? any/c . -> . any/c)
  clear-proc : (or/c #f (hash? . -> . any)) = #f
  equal-key-proc : (or/c #f (hash? any/c . -> . any/c)) = #f
  prop : impersonator-property?
  prop-val : any/c
```

Like `impersonate-hash`, but with constraints on the given functions and support for immutable hashes. The *`ref-proc`* procedure must return a found value or a chaperone of the value. The *`set-proc`* procedure must produce two values: the key that it is given or a chaperone of the key and the value that it is given or a chaperone of the value. The *`remove-proc`*, *`key-proc`*, and *`equal-key-proc`* procedures must produce the given key or a chaperone of the key.

Changed in version 6.3.0.11 of package `base`: Added the *`equal-key-proc`* argument.

```
(chaperone-struct-type struct-type
                       struct-info-proc
                       make-constructor-proc
                       guard-proc
                       prop
                       prop-val ...
                       ...)
```

```
 → (and/c struct-type? chaperone?)
  struct-type : struct-type?
  struct-info-proc : procedure?
  make-constructor-proc : (procedure? . -> . procedure?)
  guard-proc : procedure?
  prop : impersonator-property?
  prop-val : any/c
```

Returns a chaperoned value like `struct-type`, but with `struct-type-info` and `struct-type-make-constructor` operations on the chaperoned structure type redirected. In addition, when a new structure type is created as a subtype of the chaperoned structure type, `guard-proc` is interposed as an extra guard on creation of instances of the subtype.

The `struct-info-proc` must accept 8 arguments—the result of `struct-type-info` on `struct-type`. It must return 8 values, where each is the same or a chaperone of the corresponding argument. The 8 values are used as the results of `struct-type-info` for the chaperoned structure type.

The `make-constructor-proc` must accept a single procedure argument, which is a constructor produced by `struct-type-make-constructor` on `struct-type`. It must return the same or a chaperone of the procedure, which is used as the result of `struct-type-make-constructor` on the chaperoned structure type.

The `guard-proc` is like a `guard` argument to `make-struct-type`: it must accept one more argument than a constructor for `struct-type`, where the last argument is the name the name of the instantiated structure type. It must return the number of values needed by the constructor (i.e. one value for each argument but the last), and each returned value must be the same as or a chaperone of the corresponding argument. The `guard-proc` is added as a constructor guard when a subtype is created of the chaperoned structure type.

Pairs of `prop` and `prop-val` (the number of arguments to `chaperone-struct-type` must be even) add impersonator properties or override impersonator-property values of `struct-type`.

```
(chaperone-evt evt proc prop prop-val ... ...)
 → (and/c evt? chaperone?)
  evt : evt?
  proc : (evt? . -> . (values evt? (any/c . -> . any/c)))
  prop : impersonator-property?
  prop-val : any/c
```

Returns a chaperoned value like `evt`, but with `proc` as an event generator when the result is synchronized with functions like `sync`.

The `proc` generator is called on synchronization, much like the procedure passed to `guard-evt`, except that `proc` is given `evt`. The `proc` must return two values: a synchronizable event that is a chaperone of *evt*, and a procedure that is used to check the event's result if it is chosen in a selection. The latter procedure accepts the result of *evt*, and it must return a chaperone of that value.

Pairs of *prop* and *prop-val* (the number of arguments to `chaperone-evt` must be even) add impersonator properties or override impersonator-property values of *evt*.

The result is `chaperone-of?` the argument *evt*. However, if *evt* is a thread, semaphore, input port, output port, or will executor, the result is not recognized as such. For example, `thread?` applied to the result of `chaperone-evt` will always produce `#f`.

```
(chaperone-channel channel
                   get-proc
                   put-proc
                   prop
                   prop-val ...
                   ...)          → (and/c channel? chaperone?)
  channel : channel?
  get-proc : (channel? . -> . (values channel? (any/c . -> . any/c)))
  put-proc : (channel? any/c . -> . any/c)
  prop : impersonator-property?
  prop-val : any/c
```

Like `impersonate-channel`, but with restrictions on the *get-proc* and *put-proc* procedures.

The *get-proc* must return two values: a channel that is a chaperone of *channel*, and a procedure that is used to check the channel's contents. The latter procedure must return the original value or a chaperone of that value.

The *put-proc* must produce a replacement value that is either the original value communicated on the channel or a chaperone of that value.

Pairs of *prop* and *prop-val* (the number of arguments to `chaperone-channel` must be odd) add impersonator properties or override impersonator-property values of *channel*.

```
(chaperone-prompt-tag prompt-tag
                      handle-proc
                      abort-proc
                     [cc-guard-proc
                      callcc-chaperone-proc]
                      prop
                      prop-val ...
                      ...)
 → (and/c continuation-prompt-tag? chaperone?)
  prompt-tag : continuation-prompt-tag?
  handle-proc : procedure?
```

```
abort-proc : procedure?
cc-guard-proc : procedure? = values
callcc-chaperone-proc : (procedure? . -> . procedure?)
                      = (lambda (p) p)
prop : impersonator-property?
prop-val : any/c
```

Like `impersonate-prompt-tag`, but produces a chaperoned value. The *`handle-proc`* procedure must produce the same values or chaperones of the original values, *`abort-proc`* must produce the same values or chaperones of the values that it is given, and *`cc-guard-proc`* must produce the same values or chaperones of the original result values, and *`callcc-chaperone-proc`* must produce a procedure that is a chaperone or the same as the given procedure.

Examples:

```
> (define bad-chaperone
    (chaperone-prompt-tag
     (make-continuation-prompt-tag)
     (lambda (n) (* n 2))
     (lambda (n) (+ n 1))))
> (call-with-continuation-prompt
    (lambda ()
      (abort-current-continuation bad-chaperone 5))
    bad-chaperone
    (lambda (n) n))
abort-current-continuation: non-chaperone result; received a
prompt-abort argument that is not a chaperone of the
original prompt-abort argument
  original: 5
  received: 6
> (define good-chaperone
    (chaperone-prompt-tag
     (make-continuation-prompt-tag)
     (lambda (n) (if (even? n) n (error "not even")))
     (lambda (n) (if (even? n) n (error "not even")))))
> (call-with-continuation-prompt
    (lambda ()
      (abort-current-continuation good-chaperone 2))
    good-chaperone
    (lambda (n) n))
2
```

```
(chaperone-continuation-mark-key key
                                 get-proc
                                 set-proc
                                 prop
                                 prop-val ...
                                 ...)
 → (and/c continuation-mark-key? chaperone?)
  key : continuation-mark-key?
  get-proc : procedure?
  set-proc : procedure?
  prop : impersonator-property?
  prop-val : any/c
```

Like `impersonate-continuation-mark-key`, but produces a chaperoned value. The *get-proc* procedure must produce the same value or a chaperone of the original value, and *set-proc* must produce the same value or a chaperone of the value that it is given.

Examples:

```
> (define bad-chaperone
    (chaperone-continuation-mark-key
     (make-continuation-mark-key)
     (lambda (l) (map char-upcase l))
     string->list))
> (with-continuation-mark bad-chaperone "timballo"
    (continuation-mark-set-first
     (current-continuation-marks)
     bad-chaperone))
with-continuation-mark: non-chaperone result; received a
value that is not a chaperone of the original value
  original: "timballo"
  received: '(#\t #\i #\m #\b #\a #\l #\l #\o)
> (define (checker s)
    (if (> (string-length s) 5)
        s
        (error "expected string of length at least 5")))
> (define good-chaperone
    (chaperone-continuation-mark-key
     (make-continuation-mark-key)
     checker
     checker))
> (with-continuation-mark good-chaperone "zabaione"
    (continuation-mark-set-first
     (current-continuation-marks)
     good-chaperone))
"zabaione"
```

14.5.3 Impersonator Properties

```
(make-impersonator-property name)
 → impersonator-property?
   (-> any/c boolean?)
   (->* (impersonator?) (any/c) any)
  name : symbol?
```

Creates a new impersonator property and returns three values:

- an *impersonator property descriptor*, for use with `impersonate-procedure`, `chaperone-procedure`, and other impersonator constructors;
- an *impersonator property predicate* procedure, which takes an arbitrary value and returns `#t` if the value is an impersonator with a value for the property, `#f` otherwise;
- an *impersonator property accessor* procedure, which returns the value associated with an impersonator for the property; if a value given to the accessor is not an impersonator or does not have a value for the property (i.e. if the corresponding impersonator property predicate returns `#f`), then a second optional argument to the selector determines its response: the `exn:fail:contract` exception is raised if a second argument is not provided, the second argument is tail-called with zero arguments if it is a procedure, and the second argument is returned otherwise.

```
(impersonator-property? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a impersonator property descriptor value, `#f` otherwise.

```
(impersonator-property-accessor-procedure? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is an accessor procedure produced by `make-impersonator-property`, `#f` otherwise.

```
impersonator-prop:application-mark : impersonator-property?
```

An impersonator property that is recognized by `impersonate-procedure` and `chaperone-procedure`.

14.6 Security Guards

```
(security-guard? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a security guard value as created by `make-security-guard`, `#f` otherwise.

A *security guard* provides a set of access-checking procedures to be called when a thread initiates access of a file, directory, or network connection through a primitive procedure. For example, when a thread calls `open-input-file`, the thread's current security guard is consulted to check whether the thread is allowed read access to the file. If access is granted, the thread receives a port that it may use indefinitely, regardless of changes to the security guard (although the port's custodian could shut down the port; see §14.7 "Custodians").

A thread's current security guard is determined by the `current-security-guard` parameter. Every security guard has a parent, and a parent's access procedures are called whenever a child's access procedures are called. Thus, a thread cannot increase its own access arbitrarily by installing a new guard. The initial security guard enforces no access restrictions other than those enforced by the host platform.

```
(make-security-guard  parent
                      file-guard
                      network-guard
                     [link-guard])   → security-guard?
  parent : security-guard?
  file-guard : (symbol?
                (or/c path? #f)
                (listof symbol?)
                . -> . any)
  network-guard : (symbol?
                   (or/c (and/c string? immutable?) #f)
                   (or/c (integer-in 1 65535) #f)
                   (or/c 'server 'client)
                   . -> . any)
  link-guard : (or/c (symbol? path? path? . -> . any) #f) = #f
```

Creates a new security guard as child of *parent*.

The *file-guard* procedure must accept three arguments:

- a symbol for the primitive procedure that triggered the access check, which is useful for raising an exception to deny access.
- a path (see §15.1 "Paths") or `#f` for pathless queries, such as `(current-directory)`, `(filesystem-root-list)`, and `(find-system-path symbol)`. A path provided to *file-guard* is not expanded or otherwise normalized before checking access; it may be a relative path, for example.
- a list containing one or more of the following symbols:
  - `'read` — read a file or directory

- 'write — modify or create a file or directory
- 'execute — execute a file
- 'delete — delete a file or directory
- 'exists — determine whether a file or directory exists, or that a path string is well-formed

The 'exists symbol is never combined with other symbols in the last argument to *file-guard*, but any other combination is possible. When the second argument to *file-guard* is #f, the last argument always contains only 'exists.

The *network-guard* procedure must accept four arguments:

- a symbol for the primitive operation that triggered the access check, which is useful for raising an exception to deny access.
- an immutable string representing the target hostname for a client connection or the accepting hostname for a listening server; #f for a listening server or UDP socket that accepts connections at all of the host's address; or #f an unbound UDP socket.
- an exact integer between 1 and 65535 (inclusive) representing the port number, or #f for an unbound UDP socket. In the case of a client connection, the port number is the target port on the server. For a listening server, the port number is the local port number.
- a symbol, either 'client or 'server, indicating whether the check is for the creation of a client connection or a listening server. The opening of an unbound UDP socket is identified as a 'client connection; explicitly binding the socket is identified as a 'server action.

The *link-guard* argument can be #f or a procedure of three arguments:

- a symbol for the primitive procedure that triggered the access check, which is useful for raising an exception to deny access.
- a complete path (see §15.1 "Paths") representing the file to create as link.
- a path representing the content of the link, which may be relative the second-argument path; this path is not expanded or otherwise normalized before checking access.

If *link-guard* is #f, then a default procedure is used that always raises exn:fail.

The return value of *file-guard*, *network-guard*, or *link-guard* is ignored. To deny access, the procedure must raise an exception or otherwise escape from the context of the primitive call. If the procedure returns, the parent's corresponding procedure is called on the same inputs, and so on up the chain of security guards.

The *file-guard*, *network-guard*, and *link-guard* procedures are invoked in the thread that called the access-checked primitive. Breaks may or may not be enabled (see §10.6 "Breaks"). Full continuation jumps are blocked going into or out of the *file-guard* or *network-guard* call (see §1.1.11 "Prompts, Delimited Continuations, and Barriers").

```
(current-security-guard) → security-guard?
(current-security-guard guard) → void?
  guard : security-guard?
```

A parameter that determines the current security guard that controls access to the filesystem and network.

14.7 Custodians

See §1.1.15 "Custodians" for basic information on the Racket custodian model.

```
(custodian? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a custodian value, `#f` otherwise.

```
(make-custodian [cust]) → custodian?
  cust : (and/c custodian? (not/c custodian-shut-down?))
       = (current-custodian)
```

Creates a new custodian that is subordinate to *cust*. When *cust* is directed (via `custodian-shutdown-all`) to shut down all of its managed values, the new subordinate custodian is automatically directed to shut down its managed values as well.

```
(custodian-shutdown-all cust) → void?
  cust : custodian?
```

In `racket/gui/base`, eventspaces managed by *cust* are also shut down.

Closes all file-stream ports, TCP ports, TCP listeners, and UDP sockets that are managed by *cust* (and its subordinates), and empties all custodian boxes associated with *cust* (and its subordinates). It also removes *cust* (and its subordinates) as managers of all threads; when a thread has no managers, it is killed (or suspended; see `thread/suspend-to-kill`) If the current thread is to be killed, all other shut-down actions take place before killing the thread.

If *cust* is already shut down, then `custodian-shutdown-all` has no effect. When a custodian is shut down and it has subordinate custodians, the subordinates are not only shut down, they no longer count as subordinates.

```
(custodian-shut-down? cust) → boolean?
  cust : custodian?
```

Returns #t if *cust* has been shut down with custodian-shutdown-all or if it was a subordinate of a custodian that is shut down, #f otherwise.

Added in version 6.11.0.5 of package base.

```
(current-custodian) → custodian?
(current-custodian cust) → void?
  cust : custodian?
```

A parameter that determines a custodian that assumes responsibility for newly created threads, file-stream ports, TCP ports, TCP listeners, UDP sockets, and byte converters.

Custodians also manage eventspaces from racket/gui/base.

```
(custodian-managed-list cust super) → list?
  cust : custodian?
  super : custodian?
```

Returns a list of immediately managed objects (not including custodian boxes) and subordinate custodians for *cust*, where *cust* is itself subordinate to *super* (directly or indirectly). If *cust* is not strictly subordinate to *super*, the exn:fail:contract exception is raised.

If *cust* has been shut down, the result is '(). If *cust* was a subordinate of a custodian that was shut down, then it cannot be a subordinate of *super*.

```
(custodian-memory-accounting-available?) → boolean?
```

Returns #t if Racket is compiled with support for per-custodian memory accounting, #f otherwise.

Memory accounting is normally available, but not in the CGC implementation.

```
(custodian-require-memory limit-cust
                          need-amt
                          stop-cust) → void?
  limit-cust : custodian?
  need-amt : exact-nonnegative-integer?
  stop-cust : custodian?
```

Registers a required-memory check if Racket is compiled with support for per-custodian memory accounting, otherwise the exn:fail:unsupported exception is raised.

If a check is registered, and if Racket later reaches a state after garbage collection (see §1.1.6 “Garbage Collection”) where allocating *need-amt* bytes charged to *limit-cust* would fail or trigger some shutdown, then *stop-cust* is shut down.

The *stop-cust* must be a subordinate custodian of *limit-cust*.

```
(custodian-limit-memory limit-cust
                        limit-amt
                       [stop-cust]) → void?
```

```
limit-cust : custodian?
limit-amt : exact-nonnegative-integer?
stop-cust : custodian? = limit-cust
```

Registers a limited-memory check if Racket is compiled with support for per-custodian memory accounting, otherwise the `exn:fail:unsupported` exception is raised.

If a check is registered, and if Racket later reaches a state after garbage collection (see §1.1.6 "Garbage Collection") where *`limit-cust`* owns more than *`limit-amt`* bytes, then *`stop-cust`* is shut down.

A custodian's limit is checked only after a garbage collection, except that it may also be checked during certain large allocations that are individually larger than the custodian's limit. A single garbage collection may shut down multiple custodians, even if shutting down only one of the custodians would have reduced memory use for other custodians.

New memory allocation will be accounted to the running thread's managing custodian. In other words, a custodian's limit applies only to the allocation made by the threads that it manages. See also `call-in-nested-thread` for a simpler setup.

For reliable shutdown, *`limit-amt`* for `custodian-limit-memory` must be much lower than the total amount of memory available (minus the size of memory that is potentially used and not charged to *`limit-cust`*). Moreover, if individual allocations that are initially charged to *`limit-cust`* can be arbitrarily large, then *`stop-cust`* must be the same as *`limit-cust`*, so that excessively large immediate allocations can be rejected with an `exn:fail:out-of-memory` exception.

Examples:

```
> (require racket/async-channel)
> (define ch (make-async-channel))
> (parameterize ([current-custodian (make-custodian)])
    (thread-wait
     (thread
      (λ ()
        (with-handlers ([exn:fail:out-of-memory?
                         (λ (e) (async-channel-put ch e))])
          (custodian-limit-memory (current-
custodian) (* 1024 1024))
          (make-bytes (* 4 1024 1024))
          (async-channel-put ch "Not OK")))))
    (async-channel-get ch))
(exn:fail:out-of-memory "out of memory" #<continuation-mark-set>)
> (define cust (make-custodian))
> (with-handlers ([exn:fail:out-of-memory?
                   (λ (e) (error "Caught OOM exn"))])
    (call-in-nested-thread
     (λ ()
       (custodian-limit-memory cust (* 1024 1024))
       (make-bytes (* 4 1024 1024))
       "Not OK")
     cust))
Caught OOM exn
```

Non-examples:

```
> (parameterize ([current-custodian (make-custodian)])
    (custodian-limit-memory (current-custodian) (* 1024 1024))
    ; Allocation of make-bytes is charged to the current thread's
    ; managing custodian, not the new custodian.
    (make-bytes (* 4 1024 1024))
    "Not OK")
"Not OK"
```

```
(make-custodian-box cust v) → custodian-box?
  cust : custodian?
  v : any/c
```

Returns a custodian box that contains *v* as long as *cust* has not been shut down. If *cust* is already shut down, the custodian box's value is immediately removed.

A custodian box is a synchronizable event (see §11.2.1 "Events"). The custodian box becomes ready when its custodian is shut down; the synchronization result of a custodian box is the custodian box itself.

```
(custodian-box? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a custodian box produced by `make-custodian-box`, `#f` otherwise.

```
(custodian-box-value cb) → any
  cb : custodian-box?
```

Returns the value in the given custodian box, or `#f` if the value has been removed.

14.8 Thread Groups

A *thread group* is a collection of threads and other thread groups that have equal claim to the CPU. By nesting thread groups and by creating certain threads within certain groups, a programmer can control the amount of CPU allocated to a set of threads. Every thread belongs to a thread group, which is determined by the `current-thread-group` parameter when the thread is created. Thread groups and custodians (see §14.7 "Custodians") are independent.

The root thread group receives all of the CPU that the operating system gives Racket. Every thread or nested group in a particular thread group receives equal allocation of the CPU (a portion of the group's access), although a thread may relinquish part of its allocation by sleeping or synchronizing with other processes.

```
(make-thread-group [group]) → thread-group?
  group : thread-group? = (current-thread-group)
```

Creates a new thread group that belongs to *group*.

```
(thread-group? v) → boolean?
  v : any/c
```

Returns #t if *v* is a thread group value, #f otherwise.

```
(current-thread-group) → thread-group?
(current-thread-group group) → void?
  group : thread-group?
```

A parameter that determines the thread group for newly created threads.

14.9 Structure Inspectors

An *inspector* provides access to structure fields and structure type information without the normal field accessors and mutators. (Inspectors are also used to control access to module bindings; see §14.10 "Code Inspectors".) Inspectors are primarily intended for use by debuggers.

When a structure type is created, an inspector can be supplied. The given inspector is not the one that will control the new structure type; instead, the given inspector's parent will control the type. By using the parent of the given inspector, the structure type remains opaque to "peer" code that cannot access the parent inspector.

The current-inspector parameter determines a default inspector argument for new structure types. An alternate inspector can be provided though the #:inspector option of the struct form (see §5.1 "Defining Structure Types: struct"), or through an optional inspector argument to make-struct-type.

```
(inspector? v) → boolean?
  v : any/c
```

Returns #t if *v* is an inspector, #f otherwise.

```
(make-inspector [inspector]) → inspector?
  inspector : inspector? = (current-inspector)
```

Returns a new inspector that is a subinspector of *inspector*. Any structure type controlled by the new inspector is also controlled by its ancestor inspectors, but no other inspectors.

```
(make-sibling-inspector [inspector]) → inspector?
  inspector : inspector? = (current-inspector)
```

Returns a new inspector that is a subinspector of the same inspector as *inspector*. That is, *inspector* and the result inspector control mutually disjoint sets of structure types.

```
(inspector-superior? inspector
                     maybe-subinspector) → boolean?
  inspector : inspector?
  maybe-subinspector : inspector?
```

Returns `#t` if *inspector* is an ancestor of *maybe-subinspector* (and not equal to *maybe-subinspector*), `#f` otherwise.

Added in version 6.5.0.6 of package `base`.

```
(current-inspector) → inspector?
(current-inspector insp) → void?
  insp : inspector?
```

A parameter that determines the default inspector for newly created structure types.

```
(struct-info v) → (or/c struct-type? #f) boolean?
  v : any/c
```

Returns two values:

- *struct-type*: a structure type descriptor or `#f`; the result is a structure type descriptor of the most specific type for which *v* is an instance, and for which the current inspector has control, or the result is `#f` if the current inspector does not control any structure type for which the `struct` is an instance.
- *skipped?*: `#f` if the first result corresponds to the most specific structure type of *v*, `#t` otherwise.

```
(struct-type-info struct-type)
 → symbol?
   exact-nonnegative-integer?
   exact-nonnegative-integer?
   struct-accessor-procedure?
   struct-mutator-procedure?
   (listof exact-nonnegative-integer?)
   (or/c struct-type? #f)
   boolean?
  struct-type : struct-type?
```

Returns eight values that provide information about the structure type descriptor *struct-type*, assuming that the type is controlled by the current inspector:

- *name*: the structure type's name as a symbol;
- *init-field-cnt*: the number of fields defined by the structure type provided to the constructor procedure (not counting fields created by its ancestor types);
- *auto-field-cnt*: the number of fields defined by the structure type without a counterpart in the constructor procedure (not counting fields created by its ancestor types);
- *accessor-proc*: an accessor procedure for the structure type, like the one returned by `make-struct-type`;
- *mutator-proc*: a mutator procedure for the structure type, like the one returned by `make-struct-type`;
- *immutable-k-list*: an immutable list of exact non-negative integers that correspond to immutable fields for the structure type;
- *super-type*: a structure type descriptor for the most specific ancestor of the type that is controlled by the current inspector, or `#f` if no ancestor is controlled by the current inspector;
- *skipped?*: `#f` if the seventh result is the most specific ancestor type or if the type has no supertype, `#t` otherwise.

If the type for *struct-type* is not controlled by the current inspector, the `exn:fail:contract` exception is raised.

```
(struct-type-sealed? struct-type) → boolean?
  struct-type : struct-type?
```

Reports whether *struct-type* has the `prop:sealed` structure type property.

Added in version 8.0.0.7 of package `base`.

```
(struct-type-authentic? struct-type) → boolean?
  struct-type : struct-type?
```

Reports whether *struct-type* has the `prop:authentic` structure type property.

Added in version 8.0.0.7 of package `base`.

```
(struct-type-make-constructor  struct-type
                              [constructor-name])
 → struct-constructor-procedure?
  struct-type : struct-type?
  constructor-name : (or/c symbol? #f) = #f
```

Returns a constructor procedure to create instances of the type for *struct-type*. If *constructor-name* is not `#f`, it is used as the name of the generated constructor procedure. If the type for *struct-type* is not controlled by the current inspector, the `exn:fail:contract` exception is raised.

```
(struct-type-make-predicate struct-type) → any
  struct-type : any/c
```

Returns a predicate procedure to recognize instances of the type for *struct-type*. If the type for *struct-type* is not controlled by the current inspector, the `exn:fail:contract` exception is raised.

```
(object-name v) → any
  v : any/c
```

Returns a value for the name of *v* if *v* has a name, `#f` otherwise. The argument *v* can be any value, but only (some) procedures, structures, structure types, structure type properties, regexp values, ports, loggers, and prompt tags have names. See also §1.2.6 "Inferred Value Names".

If a structure's type implements the `prop:object-name` property, and the value of the `prop:object-name` property is an integer, then the corresponding field of the structure is the name of the structure. Otherwise, the property value must be a procedure, which is called with the structure as argument, and the result is the name of the structure. If a structure is a procedure as implemented by one of its fields (i.e., the `prop:procedure` property value for the structure's type is an integer), then its name is the implementing procedure's name. Otherwise, its name matches the name of the structure type that it instantiates.

The name (if any) of a procedure is a symbol, unless the procedure is also a structure whose type has the `prop:object-name` property, in which case `prop:object-name` takes precedence. The `procedure-rename` function creates a procedure with a specific name.

The name of a regexp value is a string or byte string. Passing the string or byte string to `regexp`, `byte-regexp`, `pregexp`, or `byte-pregexp` (depending on the kind of regexp whose name was extracted) produces a value that matches the same inputs.

The name of a port can be any value, but many tools use a path or string name as the port's for (to report source locations, for example).

The name of a logger is either a symbol or `#f`.

The name of a prompt tag is either the optional symbol given to `make-continuation-prompt-tag` or `#f`.

Changed in version 7.9.0.13 of package `base`: Recognize the name of continuation prompt tags.

```
prop:object-name : struct-type-property?
```

A structure type property that allows structure types to customize the result of `object-name` applied to their instances. The property value can be any of the following:

- A procedure *proc* of one argument: In this case, procedure *proc* receives the structure as an argument, and the result of *proc* is the `object-name` of the structure.
- An exact, non-negative integer between `0` (inclusive) and the number of non-automatic fields in the structure type (exclusive, not counting supertype fields): The integer identifies a field in the structure, and the field must be designated as immutable. The value of the field is used as the `object-name` of the structure.

Added in version 6.2 of package `base`.

14.10 Code Inspectors

In the same way that inspectors control access to structure fields (see §14.9 "Structure Inspectors"), inspectors also control access to module bindings. Inspectors used this way are *code inspectors*. The default code inspector for module bindings is determined by the `current-code-inspector` parameter, instead of the `current-inspector` parameter.

When a `module` declaration is evaluated, the value of the `current-code-inspector` parameter is associated with the module declaration. When the module is invoked via `require` or `dynamic-require`, a sub-inspector of the module's declaration-time inspector is created, and this sub-inspector is associated with the module invocation. Any inspector that controls the sub-inspector (including the declaration-time inspector and its superior) controls the module invocation. In particular, if the value of `current-code-inspector` never changes, then no control is lost for any module invocation, since the module's invocation is associated with a sub-inspector of `current-code-inspector`.

When an inspector that controls a module invocation is installed with `current-code-inspector`, it enables using `module->namespace` on the module, and it enables access to the module's *protected* exports (i.e., those identifiers exported from the module with `protect-out`) via `dynamic-require`. A module cannot `require` a module that has a weaker declaration-time code inspector.

When a `module` form is expanded or a namespace is created, the value of `current-code-inspector` is associated with the module or namespace's top-level lexical information. Syntax objects with that lexical information gain access to the protected and unexported bindings of any module that the inspector controls. In the case of a `module`, the inspector sticks with such syntax objects even the syntax object is used in the expansion of code in a less powerful context; furthermore, if the syntax object is an identifier that is compiled as a variable reference, the inspector sticks with the variable reference even if it appears in a module form that is evaluated (i.e., declared) with a weaker inspector. When a syntax object or variable reference is within compiled code that is printed (see §1.4.16 "Printing Compiled Code"), the associated inspector is not preserved.

When compiled code in printed form is `read` back in, no inspectors are associated with the code. When the code is `eval`uated, the instantiated syntax-object literals and module-variable references acquire value of `current-code-inspector` as their inspector.

When a module instantiation is attached to multiple namespaces, each with its own module registry, the inspector for the module invocation can be registry-specific. The invocation inspector in a particular module registry can be changed via `namespace-unprotect-module` (but changing the inspector requires control over the old one).

Changed in version 8.1.0.8 of package `base`: Added constraint against `require` of a module with a weaker code inspector.

```
(current-code-inspector) → inspector?
(current-code-inspector insp) → void?
  insp : inspector?
```

A parameter that determines an inspector to control access to module bindings and redefinitions.

If the code inspector is changed from its original value, then bytecode loaded by the default compiled-load handler is marked as non-runnable.

14.11 Plumbers

A *plumber* supports *flush callbacks*, which are normally triggered just before a Racket process or place exits. For example, a flush callback might flush an output port's buffer.

Flush callbacks are roughly analogous to the standard C library's `atexit`, but flush callback can also be used in other, similar scenarios.

There is no guarantee that a flush callback will be called before a process terminates—either because the plumber is not the original plumber that is flushed by the default exit handler, or because the process is terminated forcibly (e.g., through a custodian shutdown).

```
(plumber? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a plumber value, `#f` otherwise.

Added in version 6.0.1.8 of package `base`.

```
(make-plumber) → plumber?
```

Creates a new plumber.

Plumbers have no hierarchy (unlike custodians or inspectors), but a flush callback can be registered in one plumber to call `plumber-flush-all` with another plumber.

Added in version 6.0.1.8 of package `base`.

```
(current-plumber) → plumber?
(current-plumber plumber) → void?
  plumber : plumber?
```

A parameter that determines a *current plumber* for flush callbacks. For example, creating an output file stream port registers a flush callback with the current plumber to flush the port as long as the port is opened.

Added in version 6.0.1.8 of package `base`.

```
(plumber-flush-all plumber) → void?
  plumber : plumber?
```

Calls all flush callbacks that are registered with `plumber`.

The flush callbacks to call are collected from `plumber` before the first one is called. If a flush callback registers a new flush callback, the new one is *not* called. If a flush callback raises an exception or otherwise escapes, then the remaining flush callbacks are not called.

Added in version 6.0.1.8 of package `base`.

```
(plumber-flush-handle? v) → boolean?
  v : any/c
```

Returns `#t` if `v` is a *flush handle* represents the registration of a flush callback, `#f` otherwise.

Added in version 6.0.1.8 of package `base`.

```
(plumber-add-flush! plumber proc [weak?]) → plumber-flush-handle?
  plumber : plumber?
  proc : (plumber-flush-handle? . -> . any)
  weak? : any/c = #f
```

Registers `proc` as a flush callback with `plumber`, so that `proc` is called when `plumber-flush-all` is applied to `plumber`.

The result flush handle represents the registration of the callback, and it can be used with `plumber-flush-handle-remove!` to unregister the callback.

The given `proc` is reachable from the flush handle, but if `weak?` is true, then `plumber` retains only a weak reference to the result flush handle (and thus `proc`).

When `proc` is called as a flush callback, it is passed the same value that is returned by `plumber-add-flush!` so that `proc` can conveniently unregister itself. The call of `proc` is within a continuation barrier.

Added in version 6.0.1.8 of package `base`.

```
(plumber-flush-handle-remove! handle) → void?
  handle : plumber-flush-handle?
```

Unregisters the flush callback that was registered by the `plumber-add-flush!` call that produced *handle*.

If the registration represented by *handle* has been removed already, then `plumber-flush-handle-remove!` has no effect.

Added in version 6.0.1.8 of package `base`.

14.12 Sandboxed Evaluation

```
(require racket/sandbox)        package: sandbox-lib
```

The bindings documented in this section are provided by the `racket/sandbox` library, not `racket/base` or `racket`.

The `racket/sandbox` module provides utilities for creating "sandboxed" evaluators, which are configured in a particular way and can have restricted resources (memory and time), filesystem and network access, and much more. Sandboxed evaluators can be configured through numerous parameters — and the defaults are set for the common use case where sandboxes are very limited.

```
(make-evaluator
  language
  input-program ...
 [#:requires requires
  #:allow-for-require allow-for-require
  #:allow-for-load allow-for-load
  #:allow-read allow-read
  #:allow-syntactic-requires allow-syntactic-requires])
→ (any/c . -> . any)
 language : (or/c module-path?
                  (list/c 'special symbol?)
                  (cons/c 'begin list?))
 input-program : any/c
 requires : (listof (or/c module-path? path-string?
                          (cons/c 'for-syntax (listof module-path?))))
          = null
 allow-for-require : (listof (or/c module-path? path?)) = null
 allow-for-load : (listof path-string?) = null
 allow-read : (listof (or/c module-path? path-string?)) = null
 allow-syntactic-requires : (or/c #f (listof module-path?))
                          = #f
```

```
(make-module-evaluator
  module-decl
 [#:language lang
  #:readers readers
  #:allow-for-require allow-for-require
  #:allow-for-load allow-for-load
  #:allow-read allow-read
  #:allow-syntactic-requires allow-syntactic-requires])
→ (any/c . -> . any)
 module-decl : (or/c syntax? pair? path? input-port? string? bytes?)
 lang : (or/c #f module-path?) = #f
 readers : (or/c #f (listof module-path?))
         = (and lang (default-language-readers lang))
 allow-for-require : (listof (or/c module-path? path?)) = null
 allow-for-load : (listof path-string?) = null
 allow-read : (listof (or/c module-path? path-string?)) = null
 allow-syntactic-requires : (or/c #f (listof module-path?))
                          = #f
```

The `make-evaluator` function creates an evaluator with a *`language`* and *`requires`* specification, and starts evaluating the given *`input-program`*s. The `make-module-evaluator` function creates an evaluator that works in the context of a given module. The result in either case is a function for further evaluation.

The returned evaluator operates in an isolated and limited environment. In particular, filesystem access is restricted, which may interfere with using modules from the filesystem that are not in a collection. See below for information on the *`allow-for-require`*, *`allow-for-load`*, and *`allow-read`* arguments; collection-based module files typically do not need to be included in those lists. When *`language`* is a module path or when *`requires`* is provided, the indicated modules are implicitly included in the *`allow-for-require`* list. When *`allow-syntactic-requires`* is not `#f`, it constraints the set of modules that can be directly referenced in a module; see below for more information. (For backward compatibility, non-`module-path?` path strings are allowed in arguments like *`requires`*; they are implicitly converted to paths before addition to *`allow-for-require`*.)

Each *`input-program`* or *`module-decl`* argument provides a program in one of the following forms:

- an input port used to read the program;
- a string or a byte string holding the complete input;
- a path that names a file holding the input; or
- an S-expression or a syntax object, which is evaluated as with `eval` (see also `get-uncovered-expressions`).

In the first three cases above, the program is read using `sandbox-reader`, with line-counting enabled for sensible error messages, and with `'program` as the source (used for testing coverage). In the last case, the input is expected to be the complete program, and is converted to a syntax object (using `'program` as the source), unless it already is a syntax object.

The returned evaluator function accepts additional expressions (each time it is called) in essentially the same form: a string or byte string holding a sequence of expressions, a path for a file holding expressions, an S-expression, or a syntax object. If the evaluator receives an `eof` value, it is terminated and raises errors thereafter. See also `kill-evaluator`, which terminates the evaluator without raising an exception.

For `make-evaluator`, multiple *`input-program`*s are effectively concatenated to form a single program. The way that the *`input-program`*s are evaluated depends on the *`language`* argument:

- The *`language`* argument can be a module path (i.e., a datum that matches the grammar for *`module-path`* of `require`).

  In this case, the *`input-program`*s are automatically wrapped in a `module`, and the resulting evaluator works within the resulting module's namespace.

- The *`language`* argument can be a list starting with `'special`, which indicates a built-in language with special input configuration. The possible values are `'(special r5rs)` or a value indicating a teaching language: `'(special beginner)`, `'(special beginner-abbr)`, `'(special intermediate)`, `'(special intermediate-lambda)`, or `'(special advanced)`.

  In this case, the *`input-program`*s are automatically wrapped in a `module`, and the resulting evaluator works within the resulting module's namespace. In addition, certain parameters (such as such as `read-accept-infix-dot`) are set to customize reading programs from strings and ports.

  This option is provided mainly for older test systems. Using `make-module-evaluator` with input starting with `#lang` is generally better.

- Finally, *`language`* can be a list whose first element is `'begin`.

  In this case, a new namespace is created using `sandbox-namespace-specs`, which by default creates a new namespace using `sandbox-make-namespace` (which, in turn, uses `make-base-namespace` or `make-gui-namespace` depending on `sandbox-gui-available` and `gui-available?`).

  In the new namespace, *`language`* is evaluated as an expression to further initialize the namespace.

The *`requires`* list adds additional imports to the module or namespace for the *`input-program`*s, even in the case that `require` is not made available through the *`language`*. The *`allow-syntactic-requires`* argument, if non-`#f`, constrains `require` references expanded in the module when the *language* argument implies a `module` wrapper; more precisely, it constrains the module paths that can be resolved when a syntax object is provided to the module name resolver, which will include `require` forms that are created by macro expansion. A relative-submodule path using `submod` followed by either `"."` or `".."` is always allowed.

The following examples illustrate the difference between an evaluator that puts the program in a module and one that merely initializes a top-level namespace:

```
> (define base-module-eval
    ; a module cannot have free variables...
    (make-evaluator 'racket/base '(define (f) later)))
program:1:0: later: unbound identifier
  in: later
> (define base-module-eval
    (make-evaluator 'racket/base '(define (f) later)
                                 '(define later 5)))
> (base-module-eval '(f))
5
> (define base-top-eval
    ; non-module code can have free variables:
    (make-evaluator '(begin) '(define (f) later)))
> (base-top-eval '(+ 1 2))
3
> (base-top-eval '(define later 5))
> (base-top-eval '(f))
5
```

The `make-module-evaluator` function is essentially a restriction of `make-evaluator`, where the program must be a module, and all imports are part of the program. In some cases it is useful to restrict the program to be a module using a specific module in its language position; use the optional *lang* argument to specify such a restriction, where `#f` means that no restriction is enforced. The *readers* argument similarly constrains the paths that can follow `#lang` or `#reader` if it is not `#f`, and the default is based on *lang*. The *allow-syntactic-requires* argument is treated the same as for `make-evaluator` in the module-wrapper case.

When the program is specified as a path, then the path is implicitly added to the *allow-for-load* list.

```
(define base-module-eval2
  ; equivalent to base-module-eval:
  (make-module-evaluator '(module m racket/base
                            (define (f) later)
                            (define later 5))))
```

The `make-module-evaluator` function can be convenient for testing module files: pass in a path value for the file name, and you get back an evaluator in the module's context which you can use with your favorite test facility.

In all cases, the evaluator operates in an isolated and limited environment:

- It uses a new custodian and namespace. When gui-available? and sandbox-gui-available produce true, it is also runs in its own eventspace.
- The evaluator works under the sandbox-security-guard, which restricts file system and network access.
- The evaluator is contained in a memory-restricted environment, and each evaluation is wrapped in a call-with-limits (when memory accounting is available); see also sandbox-memory-limit, sandbox-eval-limits and set-eval-limits.

Note that these limits apply to the creation of the sandbox environment too — so, for example, if the memory that is required to create the sandbox is higher than the limit, then make-evaluator will fail with a memory limit exception.

The *allow-for-require* and *allow-for-load* arguments adjust filesystem permissions to extend the set of files that are usable by the evaluator. Modules that are in a collection are automatically accessible, but the *allow-for-require* argument lists additional modules that can be required along with their imports (transitively) through a filesystem path. The *allow-for-load* argument similarly lists files that can be loaded. (The precise permissions needed for require versus load can differ.) The *allow-read* argument is for backward compatibility, only; each module-path? element of *allow-read* is effectively moved to *allow-for-require*, while other elements are moved to *allow-for-load*.

The sandboxed environment is well isolated, and the evaluator function essentially sends it an expression and waits for a result. This form of communication makes it impossible to have nested (or concurrent) calls to a single evaluator. Usually this is not a problem, but in some cases you can get the evaluator function available inside the sandboxed code, for example:

```
> (let ([e (make-evaluator 'racket/base)])
    (e `(,e 1)))
evaluator: nested evaluator call with: 1
```

An error will be signaled in such cases.

If the value of sandbox-propagate-exceptions is true (the default) when the sandbox is created, then exceptions (both syntax and run-time) are propagated as usual to the caller of the evaluation function (i.e., catch them with with-handlers). See below for a caveat about using raised exceptions directly. If the value of sandbox-propagate-exceptions is #f when the sandbox is created, then uncaught exceptions in a sandbox evaluation cause the error to be printed to the sandbox's error port, and the caller of the evaluation receives `#<void>`.

Take care when using a value returned from a sandbox or raised as an exception by a sandbox. The value might by an impersonator, or it might be a structure whose structure type redirects equality comparisons or printing operations. To safely handle an unknown value produced by a sandbox, manipulate it within the sandbox, possibly using `call-in-sandbox-context`.

An evaluator can be used only by one thread at a time, and detected concurrent use triggers an exception. Beware of using an evaluator in a non-main thread, because the default value of `sandbox-make-plumber` registers a callback in the current plumber to flush the evaluator's plumber, and that means a flush of the current plumber (such as when the Racket process is about to exit) implies a use of the evaluator.

Changed in version 1.2 of package `sandbox-lib`: Added the `#:readers` and `#:allow-syntactic-require` arguments.

```
(exn:fail:sandbox-terminated? v) → boolean?
  v : any/c
(exn:fail:sandbox-terminated-reason exn) → symbol?
  exn : exn:fail:sandbox-terminated?
```

A predicate and accessor for exceptions that are raised when a sandbox is terminated. Once a sandbox raises such an exception, it will continue to raise it on further evaluation attempts.

14.12.1 Security Considerations

Although the sandbox is designed to provide a safe environment for executing Racket programs with restricted access to system resources, executing untrusted programs in a sandbox still carries some risk. Because a malicious program can exercise arbitrary functionality from the Racket runtime and installed collections, an attacker who identifies a vulnerability in Racket or an installed collection may be able to escape the sandbox.

To mitigate this risk, programs that use the sandbox should employ additional precautions when possible. Suggested measures include:

- Supplying a custom module language to `make-evaluator` or `make-module-evaluator` that gives untrusted code access to only the language constructs it absolutely requires.
- If untrusted code needs access to installed collections, installing only the collections required by your program.

- Using operating-system-level security features to provide defense-in-depth in case the process running the sandbox is compromised.
- Making sure your Racket installation and installed packages are up-to-date with the latest release.

14.12.2 Customizing Evaluators

The sandboxed evaluators that `make-evaluator` creates can be customized via many parameters. Most of the configuration parameters affect newly created evaluators; changing them has no effect on already-running evaluators.

The default configuration options are set for a very restricted sandboxed environment — one that is safe to make publicly available. Further customizations might be needed in case more privileges are needed, or if you want tighter restrictions. Another useful approach for customizing an evaluator is to begin with a relatively unrestricted configuration and add the desired restrictions. This approach is made possible by the `call-with-trusted-sandbox-configuration` function.

The sandbox environment uses two notions of restricting the time that evaluations takes: shallow time and deep time. *Shallow time* refers to the immediate execution of an expression. For example, a shallow time limit of five seconds would restrict `(sleep 6)` and other computations that take longer than five seconds. *Deep time* refers to the total execution of the expression and all threads and sub-processes that the expression creates. For example, a deep time limit of five seconds would restrict `(thread (λ () (sleep 6)))`, which shallow time would not, *as well as* all expressions that shallow time would restrict. By default, most sandboxes only restrict shallow time to facilitate expressions that use threads.

```
(call-with-trusted-sandbox-configuration thunk) → any
  thunk : (-> any)
```

Invokes the *thunk* in a context where sandbox configuration parameters are set for minimal restrictions. More specifically, there are no memory or time limits, and the existing existing inspectors, security guard, exit handler, logger, plumber, and environment variable set are used. (Note that the I/O ports settings are not included.)

```
(sandbox-init-hook) → (-> any)
(sandbox-init-hook thunk) → void?
  thunk : (-> any)
```

A parameter that determines a thunk to be called for initializing a new evaluator. The hook is called just before the program is evaluated in a newly-created evaluator context. It can be used to setup environment parameters related to reading, writing, evaluation, and so on. Certain languages (`'(special r5rs)` and the teaching languages) have initializations specific to the language; the hook is used after that initialization, so it can override settings.

```
(sandbox-reader) → (any/c . -> . any)
(sandbox-reader proc) → void?
  proc : (any/c . -> . any)
```

A parameter that specifies a function that reads all expressions from (current-input-port). The function is used to read program source for an evaluator when a string, byte string, or port is supplied. The reader function receives a value to be used as input source (i.e., the first argument to read-syntax), and it should return a list of syntax objects. The default reader calls read-syntax, accumulating results in a list until it receives eof.

Note that the reader function is usually called as is, but when it is used to read the program input for make-module-evaluator, read-accept-lang and read-accept-reader are set to #t.

```
(sandbox-input) → (or/c #f
                        string? bytes?
                        input-port?
                        'pipe
                        (-> input-port?))
(sandbox-input in) → void?
  in : (or/c #f
             string? bytes?
             input-port?
             'pipe
             (-> input-port?))
```

A parameter that determines the initial current-input-port setting for a newly created evaluator. It defaults to #f, which creates an empty port. The following other values are allowed:

- a string or byte string, which is converted to a port using open-input-string or open-input-bytes;
- an input port;
- the symbol 'pipe, which triggers the creation of a pipe, where put-input can return the output end of the pipe or write directly to it;
- a thunk, which is called to obtain a port (e.g., using current-input-port means that the evaluator input is the same as the calling context's input).

```
(sandbox-output) → (or/c #f
                         output-port?
                         'pipe
                         'bytes
                         'string
                         (-> output-port?))
```

```
(sandbox-output in) → void?
  in : (or/c #f
             output-port?
             'pipe
             'bytes
             'string
             (-> output-port?))
```

A parameter that determines the initial `current-output-port` setting for a newly created evaluator. It defaults to `#f`, which creates a port that discards all data. The following other values are allowed:

- an output port, which is used as-is;
- the symbol `'bytes`, which causes `get-output` to return the complete output as a byte string as long as the evaluator has not yet terminated (so that the size of the bytes can be charged to the evaluator);
- the symbol `'string`, which is similar to `'bytes`, but makes `get-output` produce a string;
- the symbol `'pipe`, which triggers the creation of a pipe, where `get-output` returns the input end of the pipe;
- a thunk, which is called to obtain a port (e.g., using `current-output-port` means that the evaluator output is not diverted).

```
(sandbox-error-output) → (or/c #f
                               output-port?
                               'pipe
                               'bytes
                               'string
                               (-> output-port?))
(sandbox-error-output in) → void?
  in : (or/c #f
             output-port?
             'pipe
             'bytes
             'string
             (-> output-port?))
```

Like `sandbox-output`, but for the initial `current-error-port` value. An evaluator's error output is set after its output, so using `current-output-port` (the parameter itself, not its value) for this parameter value means that the error port is the same as the evaluator's initial output port.

The default is (lambda () (dup-output-port (current-error-port))), which means that the error output of the generated evaluator goes to the calling context's error port.

```
(sandbox-coverage-enabled) → boolean?
(sandbox-coverage-enabled enabled?) → void?
  enabled? : any/c
```

A parameter that controls whether syntactic coverage information is collected by sandbox evaluators. Use get-uncovered-expressions to retrieve coverage information.

The default value is #f.

```
(sandbox-propagate-breaks) → boolean?
(sandbox-propagate-breaks propagate?) → void?
  propagate? : any/c
```

When both this boolean parameter and (break-enabled) are true, breaking while an evaluator is running propagates the break signal to the sandboxed context. This makes the sandboxed evaluator break, typically, but beware that sandboxed evaluation can capture and avoid the breaks (so if safe execution of code is your goal, make sure you use it with a time limit). Also, beware that a break may be received after the evaluator's result, in which case the evaluation result is lost. Finally, beware that a break may be propagated after an evaluator has produced a result, so that the break is visible on the next interaction with the evaluator (or the break is lost if the evaluator is not used further). The default is #t.

```
(sandbox-propagate-exceptions) → boolean?
(sandbox-propagate-exceptions propagate?) → void?
  propagate? : any/c
```

A parameter that controls how uncaught exceptions during a sandbox evaluation are treated. When the parameter value is #t, then the exception is propagated to the caller of sandbox. When the parameter value is #f, the exception message is printed to the sandbox's error port, and the caller of the sandbox receives #<void> for the evaluation. The default is #t.

```
(sandbox-namespace-specs) → (cons/c (-> namespace?)
                                    (listof module-path?))
(sandbox-namespace-specs spec) → void?
  spec : (cons/c (-> namespace?)
                 (listof module-path?))
```

A parameter that holds a list of values that specify how to create a namespace for evaluation in make-evaluator or make-module-evaluator. The first item in the list is a thunk that creates the namespace, and the rest are module paths for modules to be attached to the created namespace using namespace-attach-module.

The default is `(list sandbox-make-namespace)`.

The module paths are needed for sharing module instantiations between the sandbox and the caller. For example, sandbox code that returns `posn` values (from the `lang/posn` module) will not be recognized as such by your own code by default, since the sandbox will have its own instance of `lang/posn` and thus its own struct type for `posn`s. To be able to use such values, include `'lang/posn` in the list of module paths.

When testing code that uses a teaching language, the following piece of code can be helpful:

```
(sandbox-namespace-specs
 (let ([specs (sandbox-namespace-specs)])
   `(,(car specs)
     ,@(cdr specs)
     lang/posn
     ,@(if (gui-available?) '(mrlib/cache-image-snip) '()))))
```

```
(sandbox-make-namespace) → namespace?
```

Calls `make-gui-namespace` when `(sandbox-gui-available)` produces true, `make-base-namespace` otherwise.

```
(sandbox-gui-available) → boolean?
(sandbox-gui-available avail?) → void?
  avail? : any/c
```

Determines whether the `racket/gui` module can be used when a sandbox evaluator is created. If `gui-available?` produces `#f` during the creation of a sandbox evaluator, this parameter is forced to `#f` during initialization of the sandbox. The default value of the parameter is `#t`.

Various aspects of the library change when the GUI library is available, such as using a new eventspace for each evaluator.

```
(sandbox-override-collection-paths) → (listof path-string?)
(sandbox-override-collection-paths paths) → void?
  paths : (listof path-string?)
```

A parameter that determines a list of collection directories to prefix `current-library-collection-paths` in an evaluator. This parameter is useful for cases when you want to test code using an alternate, test-friendly version of a collection, for example, testing code that uses a GUI (like the `htdp/world` teachpack) can be done using a fake library that provides the same interface but no actual interaction. The default is `null`.

```
(sandbox-security-guard)
```

```
 → (or/c security-guard? (-> security-guard?))
(sandbox-security-guard guard) → void?
  guard : (or/c security-guard? (-> security-guard?))
```

A parameter that determines the initial (current-security-guard) for sandboxed evaluations. It can be either a security guard, or a function to construct one. The default is a function that restricts the access of the current security guard by forbidding all filesystem I/O except for specifications in sandbox-path-permissions, and it uses sandbox-network-guard for network connections.

```
(sandbox-path-permissions)
 → (listof (list/c (or/c 'execute 'write 'delete
                         'read-bytecode 'read 'exists)
                   (or/c byte-regexp? bytes? string? path?)))
(sandbox-path-permissions perms) → void?
  perms : (listof (list/c (or/c 'execute 'write 'delete
                                'read-bytecode 'read 'exists)
                          (or/c byte-regexp? bytes? string? path?)))
```

A parameter that configures the behavior of the default sandbox security guard by listing paths and access modes that are allowed for them. The contents of this parameter is a list of specifications, each is an access mode and a byte-regexp for paths that are granted this access.

The access mode symbol is one of: 'execute, 'write, 'delete, 'read, or 'exists. These symbols are in decreasing order: each implies access for the following modes too (e.g., 'read allows reading or checking for existence).

The path regexp is used to identify paths that are granted access. It can also be given as a path (or a string or a byte string), which is (made into a complete path, cleansed, simplified, and then) converted to a regexp that allows the path and sub-directories; e.g., "/foo/bar" applies to "/foo/bar/baz".

An additional mode symbol, 'read-bytecode, is not part of the linear order of these modes. Specifying this mode is similar to specifying 'read, but it is not implied by any other mode. (For example, even if you specify 'write for a certain path, you need to also specify 'read-bytecode to grant this permission.) The sandbox usually works in the context of a lower code inspector (see sandbox-make-code-inspector) which prevents loading of untrusted bytecode files — the sandbox is set-up to allow loading bytecode from files that are specified with 'read-bytecode. This specification is given by default to the Racket collection hierarchy (including user-specific libraries) and to libraries that are explicitly specified in an #:allow-read argument. (Note that this applies for loading bytecode files only, under a lower code inspector it is still impossible to use protected module bindings (see §14.10 "Code Inspectors").)

The default value is null, but when an evaluator is created, it is augmented by 'read-bytecode permissions that make it possible to use collection libraries (including sandbox-override-collection-paths). See make-evaluator for more information.

```
(sandbox-network-guard)
 → (symbol?
    (or/c (and/c string? immutable?) #f)
    (or/c (integer-in 1 65535) #f)
    (or/c 'server 'client)
    . -> . any)
(sandbox-network-guard proc) → void?
  proc : (symbol?
          (or/c (and/c string? immutable?) #f)
          (or/c (integer-in 1 65535) #f)
          (or/c 'server 'client)
          . -> . any)
```

A parameter that specifies a procedure to be used (as is) by the default sandbox-security-guard. The default forbids all network connection.

```
(sandbox-exit-handler) → (any/c . -> . any)
(sandbox-exit-handler handler) → void?
  handler : (any/c . -> . any)
```

A parameter that determines the initial (exit-handler) for sandboxed evaluations. The default kills the evaluator with an appropriate error message (see exn:fail:sandbox-terminated-reason).

```
(sandbox-memory-limit) → (or/c (>=/c 0) #f)
(sandbox-memory-limit limit) → void?
  limit : (or/c (>=/c 0) #f)
```

A parameter that determines the total memory limit on the sandbox in megabytes (it can hold a rational or a floating point number). When this limit is exceeded, the sandbox is terminated. This value is used when the sandbox is created and the limit cannot be changed afterwards. It defaults to 30mb. See sandbox-eval-limits for per-evaluation limits and a description of how the two limits work together.

Note that (when memory accounting is enabled) memory is attributed to the highest custodian that refers to it. This means that if you inspect a value that sandboxed evaluation returns outside of the sandbox, your own custodian will be charged for it. To ensure that it is charged back to the sandbox, you should remove references to such values when the code is done inspecting it.

This policy has an impact on how the sandbox memory limit interacts with the per-expression limit specified by sandbox-eval-limits: values that are reachable from the sandbox, as well as from the interaction will count against the sandbox limit. For example, in the last interaction of this code,

```
(define e (make-evaluator 'racket/base))
(e '(define a 1))
(e '(for ([i (in-range 20)]) (set! a (cons (make-
bytes 500000) a))))
```

the memory blocks are allocated within the interaction limit, but since they're chained to the defined variable, they're also reachable from the sandbox — so they will count against the sandbox memory limit but not against the interaction limit (more precisely, no more than one block counts against the interaction limit).

```
(sandbox-eval-limits) → (or/c (list/c (or/c (>=/c 0) #f)
                                      (or/c (>=/c 0) #f))
                              #f)
(sandbox-eval-limits limits) → void?
  limits : (or/c (list/c (or/c (>=/c 0) #f)
                         (or/c (>=/c 0) #f))
                 #f)
```

A parameter that determines the default limits on *each* use of a `make-evaluator` function, including the initial evaluation of the input program. Its value should be a list of two numbers; where the first is a shallow time value in seconds, and the second is a memory limit in megabytes (note that they don't have to be integers). Either one can be `#f` for disabling the corresponding limit; alternately, the parameter can be set to `#f` to disable all per-evaluation limits (useful in case more limit kinds are available in future versions). The default is `(list 30 20)`.

Note that these limits apply to the creation of the sandbox environment too — even `(make-evaluator 'racket/base)` can fail if the limits are strict enough. For example,

```
(parameterize ([sandbox-eval-limits '(0.25 5)])
  (make-evaluator 'racket/base '(sleep 2)))
```

will throw an error instead of creating an evaluator. Therefore, to avoid surprises you need to catch errors that happen when the sandbox is created.

When limits are set, `call-with-limits` (see below) is wrapped around each use of the evaluator, so consuming too much time or memory results in an exception. Change the limits of a running evaluator using `set-eval-limits`.

A custodian's limit is checked only after a garbage collection, except that it may also be checked during certain large allocations that are individually larger than the custodian's limit.

The memory limit that is specified by this parameter applies to each individual evaluation, but not to the whole sandbox — that limit is specified via `sandbox-memory-limit`. When the global limit is exceeded, the sandbox is terminated, but when the per-evaluation limit is exceeded, an exception recognizable by `exn:fail:resource?` is raised. For example, say that you evaluate an expression like

```
(for ([i (in-range 1000)])
```

```
(set! a (cons (make-bytes 1000000) a))
(collect-garbage))
```

then, assuming sufficiently small limits,

- if a global limit is set but no per-evaluation limit, the sandbox will eventually be terminated and no further evaluations possible;
- if there is a per-evaluation limit, but no global limit, the evaluation will abort with an error and it can be used again — specifically, a will still hold a number of blocks, and you can evaluate the same expression again which will add more blocks to it;
- if both limits are set, with the global one larger than the per-evaluation limit, then the evaluation will abort and you will be able to repeat it, but doing so several times will eventually terminate the sandbox (this will be indicated by the error message, and by the evaluator-alive? predicate).

```
(sandbox-eval-handlers)
 → (list/c (or/c #f ((-> any) . -> . any))
           (or/c #f ((-> any) . -> . any)))
(sandbox-eval-handlers handlers) → void?
  handlers : (list/c (or/c #f ((-> any) . -> . any))
                     (or/c #f ((-> any) . -> . any)))
```

A parameter that determines two (optional) handlers that wrap sandboxed evaluations. The first one is used when evaluating the initial program when the sandbox is being set-up, and the second is used for each interaction. Each of these handlers should expect a thunk as an argument, and they should execute these thunks — possibly imposing further restrictions. The default values are #f and call-with-custodian-shutdown, meaning no additional restrictions on initial sandbox code (e.g., it can start background threads), and a custodian-shutdown around each interaction that follows. Another useful function for this is call-with-killing-threads which kills all threads, but leaves other resources intact.

```
(sandbox-run-submodules) → (list/c symbol?)
(sandbox-run-submodules submod-syms) → void?
  submod-syms : (list/c symbol?)
```

A parameter that determines submodules to run when a sandbox is created by make-module-evaluator. The parameter's default value is the empty list.

```
(sandbox-make-inspector) → (-> inspector?)
(sandbox-make-inspector make) → void?
  make : (-> inspector?)
```

A parameter that determines the (nullary) procedure that is used to create the inspector for sandboxed evaluation. The procedure is called when initializing an evaluator. The default parameter value is `(lambda () (make-inspector (current-inspector)))`.

```
(sandbox-make-code-inspector) → (-> inspector?)
(sandbox-make-code-inspector make) → void?
  make : (-> inspector?)
```

A parameter that determines the (nullary) procedure that is used to create the code inspector for sandboxed evaluation. The procedure is called when initializing an evaluator. The default parameter value is `(lambda () (make-inspector (current-code-inspector)))`.

The `current-load/use-compiled` handler is setup to allow loading of bytecode files under the original code inspector when `sandbox-path-permissions` allows it through a `'read-bytecode` mode symbol, which makes loading libraries possible.

```
(sandbox-make-logger) → (-> logger?)
(sandbox-make-logger make) → void?
  make : (-> logger?)
```

A parameter that determines the procedure used to create the logger for sandboxed evaluation. The procedure is called when initializing an evaluator, and the default parameter value is `current-logger`. This means that it is not creating a new logger (this might change in the future).

```
(sandbox-make-plumber) → (or/c (-> plumber?) 'propagate)
(sandbox-make-plumber make) → void?
  make : (or/c (-> plumber?) 'propagate)
```

A parameter that determines the procedure used to create the plumber for sandboxed evaluation. The procedure is called when initializing an evaluator.

If the value is `'propagate` (the default), then a new plumber is created, and a flush callback is added to the current plumber to propagate the request to the new plumber within the created sandbox (if the sandbox has not already terminated).

Added in version 6.0.1.8 of package `sandbox-lib`.

```
(sandbox-make-environment-variables)
 → (-> environment-variables?)
(sandbox-make-environment-variables make) → void?
  make : (-> environment-variables?)
```

A parameter that determines the procedure used to create the environment variable set for sandboxed evaluation. The procedure is called when initializing an evaluator, and the default parameter value constructs a new environment variable set using `(environment-variables-copy (current-environment-variables))`.

```
(default-language-readers lang) → (listof module-path?)
  lang : module-path?
```

Creates a default list of readers that should be allowed to produce a module that uses `lang` as the language.

This default list includes the following (and more paths may be added in the future):

- `` `(submod ,lang reader) ``
- `'lang/lang/reader` if `lang` is a symbol
- the module path producing by adding the relative path `"lang/reader.rkt"` to `lang` if `lang` is not a symbol
- `'(submod at-exp reader)`
- `'at-exp/lang/reader`

Added in version 1.2 of package `sandbox-lib`.

14.12.3 Interacting with Evaluators

The following functions are used to interact with a sandboxed evaluator in addition to using it to evaluate code.

```
(evaluator-alive? evaluator) → boolean?
  evaluator : (any/c . -> . any)
```

Determines whether the evaluator is still alive.

```
(kill-evaluator evaluator) → void?
  evaluator : (any/c . -> . any)
```

Releases the resources that are held by `evaluator` by shutting down the evaluator's custodian. Attempting to use an evaluator after killing raises an exception, and attempts to kill a dead evaluator are ignored.

Killing an evaluator is similar to sending an `eof` value to the evaluator, except that an `eof` value will raise an error immediately.

```
(break-evaluator evaluator) → void?
  evaluator : (any/c . -> . any)
```

Sends a break to the running evaluator. The effect of this is as if Ctrl-C was typed when the evaluator is currently executing, which propagates the break to the evaluator's context.

```
(get-user-custodian evaluator) → void?
  evaluator : (any/c . -> . any)
```

Retrieves the *evaluator*'s toplevel custodian. This returns a value that is different from `(evaluator '(current-custodian))` or `(call-in-sandbox-context evaluator current-custodian)` — each sandbox interaction is wrapped in its own custodian, which is what these would return.

(One use for this custodian is with `current-memory-use`, where the per-interaction sub-custodians will not be charged with the memory for the whole sandbox.)

```
(set-eval-limits evaluator secs mb) → void?
  evaluator : (any/c . -> . any)
  secs : (or/c exact-nonnegative-integer? #f)
  mb : (or/c exact-nonnegative-integer? #f)
```

Changes the per-expression limits that *evaluator* uses to *secs* seconds of shallow time and *mb* megabytes (either one can be `#f`, indicating no limit).

This procedure should be used to modify an existing evaluator limits, because changing the `sandbox-eval-limits` parameter does not affect existing evaluators. See also `call-with-limits`.

```
(set-eval-handler evaluator handler) → void?
  evaluator : (any/c . -> . any)
  handler : (or/c #f ((-> any) . -> . any))
```

Changes the per-expression handler that the *evaluator* uses around each interaction. A `#f` value means no handler is used.

This procedure should be used to modify an existing evaluator handler, because changing the `sandbox-eval-handlers` parameter does not affect existing evaluators. See also `call-with-custodian-shutdown` and `call-with-killing-threads` for two useful handlers that are provided.

```
(call-with-custodian-shutdown thunk) → any
  thunk : (-> any)
(call-with-killing-threads thunk) → any
  thunk : (-> any)
```

These functions are useful for use as an evaluation handler. `call-with-custodian-shutdown` will execute the *thunk* in a fresh custodian, then shutdown that custodian, making sure that *thunk* could not have left behind any resources. `call-with-killing-threads` is similar, except that it kills threads that were left, but leaves other resources as is.

```
(put-input evaluator) → output-port?
  evaluator : (any/c . -> . any)
(put-input evaluator i/o) → void?
  evaluator : (any/c . -> . any)
  i/o : (or/c bytes? string? eof-object?)
```

If `(sandbox-input)` is `'pipe` when an evaluator is created, then this procedure can be used to retrieve the output port end of the pipe (when used with no arguments), or to add a string or a byte string into the pipe. It can also be used with `eof`, which closes the pipe.

```
(get-output evaluator) → (or/c #f input-port? bytes? string?)
  evaluator : (any/c . -> . any)
(get-error-output evaluator)
 → (or/c #f input-port? bytes? string?)
  evaluator : (any/c . -> . any)
```

Returns the output or error-output of the *evaluator*, in a way that depends on the setting of `(sandbox-output)` or `(sandbox-error-output)` when the evaluator was created:

- if it was `'pipe`, then `get-output` returns the input port end of the created pipe;
- if it was `'bytes` or `'string`, then the result is the accumulated output, and the output port is reset so each call returns a different piece of the evaluator's output (note that results are available only until the evaluator has terminated, and any allocations of the output are subject to the sandbox memory limit);
- otherwise, it returns `#f`.

```
(get-uncovered-expressions  evaluator
                           [prog?
                            src])      → (listof syntax?)
  evaluator : (any/c . -> . any)
  prog? : any/c = #t
  src : any/c = default-src
```

Retrieves uncovered expression from an evaluator, as longs as the `sandbox-coverage-enabled` parameter had a true value when the evaluator was created. Otherwise, an exception is raised to indicate that no coverage information is available.

The *prog?* argument specifies whether to obtain expressions that were uncovered after only the original input program was evaluated (`#t`) or after all later uses of the evaluator (`#f`).

Using `#t` retrieves a list that is saved after the input program is evaluated, and before the evaluator is used, so the result is always the same.

A `#t` value of *prog?* is useful for testing student programs to find out whether a submission has sufficient test coverage built in. A `#f` value is useful for writing test suites for a program to ensure that your tests cover the whole code.

The second optional argument, *src*, specifies that the result should be filtered to hold only syntax objects whose source matches *src*. The default is the source that was used in the program code, if there was one. Note that `'program` is used as the source value if the input program was given as S-expressions or as a string (and in these cases it will be the default for filtering). If given `#f`, the result is the unfiltered list of expressions.

The resulting list of syntax objects has at most one expression for each position and span. Thus, the contents may be unreliable, but the position information is reliable (i.e., it always indicates source code that would be painted red in DrRacket when coverage information is used).

Note that if the input program is a sequence of syntax values, either make sure that they have `'program` as the source field, or use the *src* argument. Using a sequence of S-expressions (not syntax objects) for an input program leads to unreliable coverage results, since each expression may be assigned a single source location.

```
(call-in-sandbox-context  evaluator
                          thunk
                         [unrestricted?]) → any
  evaluator : (any/c . -> . any)
  thunk : (-> any)
  unrestricted? : boolean? = #f
```

Calls the given *thunk* in the context of a sandboxed evaluator. The call is performed under the resource limits and evaluation handler that are used for evaluating expressions, unless *unrestricted?* is specified as true.

This process is usually similar to `(evaluator (list thunk))`, except that it does not rely on the common meaning of a sexpr-based syntax with list expressions as function application (which is not true in all languages). Note that this is more useful for meta-level operations such as namespace manipulation, it is not intended to be used as a safe-evaluation replacement (i.e., using the sandbox evaluator as usual).

In addition, you can avoid some of the sandboxed restrictions by using your own permissions, for example,

```
(let ([guard (current-security-guard)])
  (call-in-sandbox-context
    ev
    (lambda ()
```

```
    (parameterize ([current-security-guard guard])
      ; can access anything you want here
      (delete-file "/some/file")))))
```

14.12.4 Miscellaneous

```
gui? : boolean?
```

For backward compatibility, only: the result of `gui-available?` at the time that `racket/sandbox` was instantiated.

The value of `gui?` is no longer used by `racket/sandbox` itself. Instead, `gui-available?` and `sandbox-gui-available` are checked at the time that a sandbox evaluator is created.

```
(call-with-limits secs mb thunk) → any
  secs : (or/c exact-nonnegative-integer? #f)
  mb : (or/c exact-nonnegative-integer? #f)
  thunk : (-> any)
```

Executes the given *thunk* with memory and time restrictions: if execution consumes more than *mb* megabytes or more than *secs* shallow time seconds, then the computation is aborted and an exception recognizable by `exn:fail:resource?` is raised. Otherwise, the result of the thunk is returned as usual (a value, multiple values, or an exception). Each of the two limits can be `#f` to indicate the absence of a limit. See also `custodian-limit-memory` for information on memory limits.

To enforce limits, *thunk* is run in a new thread. As usual, the new thread starts with the same parameter values as the one that calls `call-with-limits`. *Not* as usual, parameter values from the thread used to run *thunk* are copied back to the thread that called `call-with-limits` when *thunk* completes.

Sandboxed evaluators use `call-with-limits`, according to the `sandbox-eval-limits` setting and uses of `set-eval-limits`: each expression evaluation is protected from time-outs and memory problems. Use `call-with-limits` directly only to limit a whole testing session, instead of each expression.

```
(with-limits sec-expr mb-expr body ...)
```

A macro version of `call-with-limits`.

```
(call-with-deep-time-limit secs thunk) → any
  secs : exact-nonnegative-integer?
  thunk : (-> any)
```

Executes the given *thunk* with deep time restrictions, and returns the values produced by *thunk*.

The given *thunk* is run in a new thread. If it errors or if the thread terminates returning a value, then (values) is returned.

Changed in version 1.1 of package sandbox-lib: Changed to return *thunk*'s result if it completes normally.

```
(with-deep-time-limit secs-expr body ...)
```

A macro version of call-with-deep-time-limit.

```
(exn:fail:resource? v) → boolean?
  v : any/c
(exn:fail:resource-resource exn)
 → (or/c 'time 'memory 'deep-time)
  exn : exn:fail:resource?
```

A predicate and accessor for exceptions that are raised by call-with-limits. The resource field holds a symbol, representing the resource that was expended. 'time is used for shallow time and 'deep-time is used for deep time.

14.13 The racket/repl Library

```
(require racket/repl)      package: base
```

The racket/repl provides the same read-eval-print-loop binding as racket/base, but with even fewer internal dependencies than racket/base. It is loaded in some situations on startup, as described in §18.1.1 "Initialization".

14.14 Linklets and the Core Compiler

```
(require racket/linklet)      package: base
```

A *linklet* is a primitive element of compilation, bytecode marshaling, and evaluation. Racket's implementations of modules, macros, and top-level evaluation are all built on linklets. Racket programmers generally do not encounter linklets directly, but the racket/linklet library provides access to linklet facilities.

A single Racket module (or collection of top-level forms) is typically implemented by multiple linklets. For example, each phase of evaluation that exists in a module is implemented in a separate linklet. A linklet is also used for metadata such as the module path indexes for a module's requires. These linklets, plus some other metadata, are combined to form a *linklet bundle*. Information in a linklet bundle is keyed by either a symbol or a fixnum. A linklet bundle containing linklets can be marshaled to and from a byte stream by `write` and (with `read-accept-compiled` is enabled) `read`. A compiled form in the sense of `compiled-expression?` (such as the result from `compile`) may be a linklet bundle.

When a Racket module has submodules, the linklet bundles for the module and the submodules are grouped together in a *linklet directory*. A linklet directory can have nested linklet directories. Information in a linklet directory is keyed by `#f` or a symbol, where `#f` must be mapped to a linklet bundle (if anything) and each symbol must be mapped to a linklet directory. A linklet directory can be equivalently viewed as a mapping from a lists of symbols to a linklet bundle. Like linklet bundles, a linklet directory can be marshaled to and from a byte stream by `write` and `read`; the marshaled form allows individual linklet bundles to be loaded independently. A compiled form in the sense of `compiled-expression?` (such as the result from `compile`) may be a linklet directory.

A linklet consists of a set of variable definitions and expressions, an exported subset of the defined variable names, a set of variables to export from the linklet despite having no corresponding definition, and a set of imports that provide other variables for the linklet to use. To run a linklet, it is instantiated as as *linklet instance* (or just *instance*, for short). When a linklet is instantiated, it receives other linklet instances for its imports, and it extracts a specified set of variables that are exported from each of the given instances. The newly created linklet instance provides its exported variables for use by other linklets or for direct access via `instance-variable-value`. A linklet instance can be synthesized directly with `make-instance`.

A linklet is created by compiling an enriched S-expression representation of its source. Since linklets exist below the layer of macros and syntax objects, linklet compilation does not use syntax objects. Instead, linklet compilation uses *correlated objects*, which are like syntax objects without lexical-context information and without the constraint that content is coerced to correlated objects. Using an S-expression or correlated object, the grammar of a linklet as recognized by `compile-linklet` is

```
(linklet [[imported-id/renamed ...] ...]
         [exported-id/renamed ...]
  defn-or-expr ...)

imported-id/renamed = imported-id
                    | (external-imported-id internal-imported-id)

exported-id/renamed = exported-id
                    | (internal-exported-id external-exported-id)
```

Each import set `[imported-id/renamed ...]` refers to a single imported instance, and each *`import-id/renamed`* corresponds to a variable from that instance. If separate *`external-imported-id`* and *`internal-imported-id`* are specified, then *`external-`*

imported-id is the name of the variable as exported by the instance, and *internal-imported-id* is the name used to refer to the variable in the *defn-or-expr*s. For exports, separate *internal-exported-id* and *external-exported-id* names corresponds to the variable name as exported as referenced in the *defn-or-expr*s, respectively.

The grammar of an *defn-or-expr* is similar to the expander's grammar of fully expanded expressions (see §1.2.3.1 "Fully Expanded Programs") with some exceptions: `quote-syntax` and `#%top` are not allowed; `#%plain-lambda` is spelled `lambda`; `#%plain-app` is omitted (i.e., application is implicit); `lambda`, `case-lambda`, `let-values`, and `letrec-values` can have only a single body expression; `begin-unsafe` is like `begin` in an expression position, but its body is compiled in unsafe mode; and numbers, booleans, strings, and byte strings are self-quoting. Primitives are accessed directly by name, and shadowing is not allowed within a `linklet` form for primitive names (see `linklet-body-reserved-symbol?`), imported variables, defined variables, or local variables.

When an *exported-id/renamed* has no corresponding definition among the *defn-or-expr*s, then the variable is effectively defined as uninitialized; referencing the variable will trigger `exn:fail:contract:variable`, the same as referencing a variable before it is defined. When a target instance is provided to `instantiate-linklet`, any existing variable with the same name will be left as-is, instead of set to undefined. This treatment of uninitialized variables provides core support for top-level evaluation where variables may be referenced and then defined in a separate element of compilation.

Added in version 6.90.0.1 of package `base`.

```
(linklet? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a linklet, `#f` otherwise.

```
(compile-linklet  form
                 [info
                  import-keys
                  get-import
                  options])    → linklet?
  form : (or/c correlated? any/c)
  info : (or/c hash? any/c) = #f
  import-keys : #f = #f
  get-import : #f = #f
  options : (listof (or/c 'serializable 'unsafe 'static 'quick
                          'use-prompt 'unlimited-compile
                          'uninterned-literal))
          = '(serializable)
```

```
(compile-linklet form
                 info
                 import-keys
                [get-import
                 options])   → linklet? vector?
  form : (or/c correlated? any/c)
  info : (or/c hash? any/c)
  import-keys : vector?
  get-import : (or/c #f (any/c . -> . (values (or/c linklet? instance? #f)
                                              (or/c vector? #f))))
             = #f
  options : (listof (or/c 'serializable 'unsafe 'static 'quick
                          'use-prompt 'unlimited-compile
                          'uninterned-literal))
          = '(serializable)
```

Takes an S-expression or correlated object for a `linklet` form and produces a linklet. As long as `'serializable` included in *`options`*, the resulting linklet can be marshaled to and from a byte stream when it is part of a linklet bundle (possibly in a linklet directory).

The optional *`info`* hash provides various debugging details about the linklet, such as the module name the linklet is part of, the linklet name, and the phase for body linklets. If a `'name` value is present in the hash, it is associated to the linklet for debugging purposes and as the default name of the linklet's instance. If *`info`* is not a hash, it is assumed to be a name value directly for backward compatibility.

The optional *`import-keys`* and *`get-import`* arguments support cross-linklet optimization. If *`import-keys`* is a vector, it must have as many elements as sets of imports in *`form`*. If the compiler becomes interested in optimizing a reference to an imported variable, it passes back to *`get-import`* (if non-`#f`) the element of *`import-keys`* that corresponds to the variable's import set. The *`get-import`* function can then return a linklet or instance that represents an instance to be provided to the compiled linklet when it is eventually instantiated; ensuring consistency between reported linklet or instance and the eventual instance is up to the caller of `compile-linklet`, but see also `linklet-add-target-machine-info`. If *`get-import`* returns `#f` as its first value, the compiler will be prevented from making any assumptions about the imported instance. The second result from *`get-import`* is an optional vector of keys to provide transitive information on a returned linklet's imports (and is not allowed for a returned instance); the returned vector must have the same number of elements as the linklet has imports. When vector elements are `eq?` and non-`#f`, the compiler can assume that they correspond to the same run-time instance. A `#f` value for *`get-import`* is equivalent to a function that always returns two `#f` results.

When *`import-keys`* is not `#f`, then the compiler is allowed to grow or shrink the set of imported instances for the linklet. The result vector specifies the keys of the imports for the returned linklet. Any key that is `#f` or a linklet instance must be preserved intact, however.

If 'unsafe is included in *options*, then the linklet is compiled in *unsafe mode*: uses of safe operations within the linklet can be converted to unsafe operations on the assumption that the relevant contracts are satisfied. For example, car is converted to unsafe-car. Some substituted unsafe operations may not have directly accessible names, such as the unsafe variant of in-list that can be substituted in unsafe mode. An unsafe operation is substituted only if its (unchecked) contract is subsumed by the safe operation's contract. The fact that the linklet is compiled in unsafe mode can be exposed through variable-reference-from-unsafe? using a variable reference produced by a #%variable-reference form within the module body. Within a linklet an individual expression can be compiled in unsafe mode by wrapping it in begin-unsafe; when a whole linklet is compiled in unsafe mode, begin-unsafe is redundant and ignored.

If 'static is included in *options*, then the linklet must be instantiated only once; if the linklet is serialized, then any individual instance read from the serialized form must be instantiated at most once. Compilation with 'static is intended to improve the performance of references within the linklet to defined and imported variables.

If 'quick is included in *options*, then linklet compilation may trade run-time performance for compile-time performance—that is, spend less time compiling the linklet, but the resulting linklet may run more slowly.

If 'use-prompt is included in *options*, then instantiating resulting linklet always wraps a prompt around each definition and immediate expression in the linklet. Otherwise, supplying #t as the *use-prompt?* argument to instantiate-linklet may only wrap a prompt around the entire instantiation.

If 'unlimited-compile is included in *options*, then compilation never falls back to interpreted mode for an especially large linklet. See also §18.7.1.2 "CS Compilation Modes".

If 'uninterned-literal is included in *options*, then literals in *form* will not necessarily be interned via datum-intern-literal when compiling or loading the linklet. Disabling the use of datum-intern-literal can be especially useful of the linklet includes a large string or byte string constant that is not meant to be shared.

The symbols in *options* must be distinct, otherwise exn:fail:contract exception is raised.

Changed in version 7.1.0.8 of package base: Added the 'use-prompt option.
Changed in version 7.1.0.10: Added the 'uninterned-literal option.
Changed in version 7.5.0.14: Added the 'quick option.
Changed in version 8.11.1.2: Changed *info* to a hash.
Changed in version 8.13.0.9: Added the 'unlimited-compile option.

```
(recompile-linklet  linklet
                   [info
                    import-keys
                    get-import
                    options])    → linklet?
```

```
  linklet : linklet?
  info : (or/c hash? any/c) = #f
  import-keys : #f = #f
  get-import : #f = #f
  options : (listof (or/c 'serializable 'unsafe 'static 'quick
                          'use-prompt 'uninterned-literal))
          = '(serializable)
(recompile-linklet  linklet
                    info
                    import-keys
                   [get-import
                    options])    → linklet? vector?
  linklet : linklet?
  info : (or/c hash? any/c)
  import-keys : vector?
  get-import : (or/c (any/c . -> . (values (or/c linklet? #f)
                                           (or/c vector? #f)))
                     #f)
             = (lambda (import-key) (values #f #f))
  options : (listof (or/c 'serializable 'unsafe 'static 'quick
                          'use-prompt 'uninterned-literal))
          = '(serializable)
```

Like `compile-linklet`, but takes an already-compiled linklet and potentially optimizes it further.

Changed in version 7.1.0.6 of package `base`: Added the *options* argument.
Changed in version 7.1.0.8: Added the `'use-prompt` option.
Changed in version 7.1.0.10: Added the `'uninterned-literal` option.
Changed in version 7.5.0.14: Added the `'quick` option.
Changed in version 8.11.1.2: Changed *info* to a hash.

```
(eval-linklet linklet) → linklet?
  linklet : linklet?
```

Returns a variant of a *linklet* that is prepared for JIT compilation such that every later use of the result linklet with `instantiate-linklet` shares the JIT-generated code. However, the result of `eval-linklet` cannot be marshaled to a byte stream as part of a linklet bundle, and it cannot be used with `recompile-linklet`.

```
(instantiate-linklet  linklet
                      import-instances
                     [target-instance?
                      use-prompt?])     → instance?
  linklet : linklet?
  import-instances : (listof instance?)
```

```
  target-instance? : #f = #f
  use-prompt? : any/c = #t
(instantiate-linklet  linklet
                      import-instances
                      target-instance
                     [use-prompt?])      → any
  linklet : linklet?
  import-instances : (listof instance?)
  target-instance : instance?
  use-prompt? : any/c = #t
```

Instantiates *linklet* by running its definitions and expressions, using the given *import-instances* for its imports. The number of instances in *import-instances* must match the number of import sets in *linklet*.

If *target-instance* is `#f` or not provided, the result is a fresh instance for the linklet. If *target-instance* is an instance, then the instance is used and modified for the linklet definitions and expressions, and the result is the value of the last expression in the linklet.

The linklet's exported variables are accessible in the result instance or in *target-instance* using the linklet's external name for each export. If *target-instance* is provided as non-`#f`, its existing variables remain intact if they are not modified by a linklet definition.

If *use-prompt?* is true, then a a prompt is wrapped around the linklet instantiation in same ways as an expression in a module body. If the linklet contains multiple definitions or immediate expressions, then a prompt may or may not be wrapped around each definition or expression; supply `'use-prompt` to `compile-linklet` to ensure that a prompt is used around each definition and expression.

```
(linklet-import-variables linklet) → (listof (listof symbol?))
  linklet : linklet?
```

Returns a description of a linklet's imports. Each element of the result list corresponds to an import set as satisfied by a single instance on instantiation, and each member of the set is a variable name that is used from the corresponding imported instance.

```
(linklet-export-variables linklet) → (listof symbol?)
  linklet : linklet?
```

Returns a description of a linklet's exports. Each element of the list corresponds to a variable that is made available by the linklet in its instance.

```
(linklet-add-target-machine-info linklet
                                 from-linklet) → linklet?
  linklet : linklet?
  from-linklet : (or linklet? hash?)
```

When `compile-linklet` or `recompile-linklet` requests a linklet via *`get-import`* for cross-module information, the linklet is expected to have information compatible with the current compilation target as determined by `current-compile-target-machine`. To simplify the management of linklets to both run and use for cross-compilation, a linklet implementation may support information for multiple target machines within a linklet, in which case `linklet-add-target-machine-info` returns a linklet like *`linklet`* but with target-specific information added from *`from-linklet`*. The two linklets must be from compatible sources, but `linklet-add-target-machine-info` might perform only a sanity check for compatibility.

The *`from-linklet`* can be a linklet or a summary of a linklet's information as produced by `linklet-summarize-target-machine-info`.

Added in version 8.12.0.3 of package `base`.
Changed in version 8.17.0.3: Added support for *`from-linklet`* as a summary.

```
(linklet-summarize-target-machine-info from-linklet) → hash?
  from-linklet : linklet?
```

Returns a value that has the same information as *`from-linklet`* for `linklet-add-target-machine-info`, but in a form that can be portably serialized via `racket/fasl`.

Added in version 8.17.0.3 of package `base`.

```
(decompile-linklet linklet) → (or/c #f correlated? any/c)
  linklet : linklet?
```

Attempts to recompile a linklet back into the S-expression form that `compile-linklet` expects. If the linklet cannot be decompiled, the result is `#f`. A linklet that is generated via `compile` with `current-compile-target-machine` set to `#f` (for machine-independent bytecode) always can be decompiled.

Added in version 8.18.0.19 of package `base`.

```
(linklet-directory? v) → boolean?
  v : any/c
```

Returns `#t` if *`v`* is a linklet directory, `#f` otherwise.

```
(hash->linklet-directory content) → linklet-directory?
  content : (and/c hash? hash-eq? immutable? (not/c impersonator?))
```

Constructs a linklet directory given mappings in the form of a hash table. Each key of *`content`* must be either a symbol or `#f`, each symbol must be mapped to a linklet directory, and `#f` must be mapped to a linklet bundle or not mapped.

```
(linklet-directory->hash linklet-directory)
 → (and/c hash? hash-eq? immutable? (not/c impersonator?))
  linklet-directory : linklet-directory?
```

Extracts the content of a linklet directory into a hash table.

```
(linklet-bundle? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a linklet bundle, `#f` otherwise.

```
(hash->linklet-bundle content) → linklet-bundle?
  content : (and/c hash? hash-eq? immutable? (not/c impersonator?))
```

Constructs a linklet bundle given mappings in the form of a hash table. Each key of *content* must be either a symbol or a fixnum. Values in the hash table are unconstrained, but the intent is that they are all linklets or values that can be recovered from `write` output by `read`.

```
(linklet-bundle->hash linklet-bundle)
 → (and/c hash? hash-eq? immutable? (not/c impersonator?))
  linklet-bundle : linklet-bundle?
```

Extracts the content of a linklet bundle into a hash table.

```
(linklet-body-reserved-symbol? sym) → boolean?
  sym : symbol?
```

Return `#t` if *sym* is a primitive name or other identifier that is not allowed as a binding within a linklet, `#f` otherwise.

Added in version 8.2.0.1 of package `base`.

```
(instance? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a linklet instance, `#f` otherwise.

```
(make-instance  name
               [data
                mode]
                variable-name
                variable-value ...
                ...)                → instance?
  name : any/c
```

```
data : any/c = #f
mode : (or/c #f 'constant 'consistent) = #f
variable-name : symbol?
variable-value : any/c
```

Constructs a linklet instance directly. Besides associating an arbitrary *name* and *data* value to the instance, the instance is populated with variables as specified by *variable-name* and *variable-value*.

The optional *data* and *mode* arguments must be provided if any *variable-name* and *variable-value* arguments are provided. The *mode* argument is used as in `instance-set-variable-value!` for every *variable-name*.

```
(instance-name instance) → any/c
  instance : instance?
```

Returns the value associated to *instance* as its name—either the first value provided to `make-instance` or the name of a linklet that was instantiated to create the instance.

```
(instance-data instance) → any/c
  instance : instance?
```

Returns the value associated to *instance* as its data—either the second value provided to `make-instance` or the default `#f`.

```
(instance-variable-names instance) → (list symbol?)
  instance : instance?
```

Returns a list of all names for all variables accessible from *instance*.

```
(instance-variable-value instance
                         name
                        [fail-k]) → any
  instance : instance?
  name : symbol?
  fail-k : any/c = (lambda () (error ....))
```

Returns the value of the variable exported as *name* from *instance*. If no such variable is exported, then *fail-k* is used in the same way as by `hash-ref`.

```
(instance-set-variable-value! instance
                              name
                              v
                             [mode])    → void?
  instance : instance?
  name : symbol?
  v : any/c
  mode : (or/c #f 'constant 'consistent) = #f
```

Sets or creates the variable exported as *name* in *instance* so that its value is *v*, as long as the variable does not exist already as constant. If a variable for *name* exists as constant, the `exn:fail:contract` exception is raised.

If *mode* is `'constant` or `'consistent`, then the variable is created or changed to be constant. Furthermore, when the instance is reported for a linklet's import though a *get-import* callback to `compile-linklet`, the compiler can assume that the variable will be constant in all future instances that are used to satisfy a linklet's imports.

If *mode* is `'consistent`, when the instance is reported though a callback to `compile-linklet`, the compiler can further assume that the variable's value will be the same for future instances. For compilation purposes, "the same" can mean that a procedure value will have the same arity and implementation details, a structure type value will have the same configuration, a marshalable constant will be `equal?` to the current value, and so on.

```
(instance-unset-variable! instance name) → void?
  instance : instance?
  name : symbol?
```

Changes *instance* so that it does not export a variable as *name*, as long as *name* does not exist as a constant variable. If a variable for *name* exists as constant, the `exn:fail:contract` exception is raised.

```
(instance-describe-variable! instance
                             name
                             desc-v)  → void?
  instance : instance?
  name : symbol?
  desc-v : any/c
```

Registers information about *name* in *instance* that may be useful for compiling linklets where the instance is returned via the *get-import* callback to `compile-linklet`. The *desc-v* description can be any value; the recognized descriptions depend on virtual machine, but may include the following:

- `` `(procedure ,arity-mask) `` — the value is always a procedure that is not impersonated and not a structure, and its arity in the style of `procedure-arity-mask` is `arity-mask`.
- `` `(procedure/succeeds ,arity-mask) `` — like `` `(procedure ,arity-mask) ``, but for a procedure that never raises an exception of otherwise captures or escapes the calling context.
- `` `(procedure/pure ,arity-mask) `` — like `` `(procedure/succeeds ,arity-mask) ``, but with no observable side effects, so a call to the procedure can be reordered.

Added in version 7.1.0.8 of package base.

```
(variable-reference->instance  varref
                               [ref-site?])
 → (if ref-site? (or/c instance? #f symbol?) instance?)
  varref : variable-reference?
  ref-site? : any/c = #f
```

Extracts the instance where the variable of *varref* is defined if *ref-site?* is #f, and returns the instance where *varref* itself resides if *ref-site?* is true. This notion of variable reference is the same as at the module level and can reflect the linklet instance that implements a particular phase of a module instance.

When *ref-site?* is #f, the result is #f when *varref* is from (#%variable-reference) with no identifier. The result is a symbol if *varref* refers to a primitive.

```
(correlated? v) → boolean?
  v : any/c
(correlated-source crlt) → any
  crlt : correlated?
(correlated-line crlt) → (or/c exact-positive-integer? #f)
  crlt : correlated?
(correlated-column crlt) → (or/c exact-nonnegative-integer? #f)
  crlt : correlated?
(correlated-position crlt) → (or/c exact-positive-integer? #f)
  crlt : correlated?
(correlated-span crlt) → (or/c exact-nonnegative-integer? #f)
  crlt : correlated?
(correlated-e crlt) → any
  crlt : correlated?
(correlated->datum crlt) → any
  crlt : (or/c correlated? any/c)
(datum->correlated v [srcloc prop]) → correlated?
  v : any/c
  srcloc : (or/c correlated? #f
                 (list/c any/c
                         (or/c exact-positive-integer? #f)
                         (or/c exact-nonnegative-integer? #f)
                         (or/c exact-positive-integer? #f)
                         (or/c exact-nonnegative-integer? #f))
                 (vector/c any/c
                          (or/c exact-positive-integer? #f)
                          (or/c exact-nonnegative-integer? #f)
                          (or/c exact-positive-integer? #f)
                          (or/c exact-nonnegative-integer? #f)))
         = #f
  prop : (or/c correlated? #f) = #f
```

```
(correlated-property crlt key val) → correlated?
  crlt : correlated?
  key : any/c
  val : any/c
(correlated-property crlt key) → any/c
  crlt : correlated?
  key : any/c
(correlated-property-symbol-keys crlt) → list?
  crlt : correlated?
```

Like `syntax?`, `syntax-source`, `syntax-line`, `syntax-column`, `syntax-position`, `syntax-span`, `syntax-e`, `syntax->datum`, `datum->syntax`, `syntax-property`, and `syntax-property-symbol-keys`, but for correlated objects.

Unlike `datum->syntax`, `datum->correlated` does not recur through the given S-expression and convert pieces to correlated objects. Instead, a correlated object is simply wrapped around the immediate value. In contrast, `correlated->datum` recurs through its argument (which is not necessarily a correlated object) to discover any correlated objects and convert them to plain S-expressions.

Changed in version 7.6.0.6 of package `base`: Added the *`prop`* argument to `datum->correlated`.

14.15 Deprecation

```
(require racket/deprecation)        package: base
```

The bindings documented in this section are provided by the `racket/deprecation` library, not `racket/base` or `racket`.

A *deprecated* function, macro, or other API element is one that's been formally declared obsolete, typically with an intended replacement that users should migrate to. The `racket/deprecation` library provides a standardized mechanism for declaring deprecations in a machine-processable manner. These declarations can allow tools such as `resyntax` to automate migrating code away from deprecated APIs. Note that a dependency on the `racket/deprecation` library does not imply a dependency on any such tools.

14.15.1 Deprecated Aliases

```
(define-deprecated-alias alias-id target-id)
```

Binds *`alias-id`* as an alias of *`target-id`* with the intent that users of *`alias-id`* should prefer to use *`target-id`* instead. The given *`alias-id`* is bound as a deprecated alias transformer, which is a kind of rename transformer. The given *`target-id`* may be bound to a function, macro, or any other kind of binding.

Note that although *alias-id* is an alias of *target-id*, it is *not* considered the same binding as *target-id* and is *not* free-identifier=?. This is because the alias binding must be inspectable at compile-time with deprecated-alias? and deprecated-alias-target, and it must remain inspectable even if the alias is provided by a module. This requires a module providing the alias and the target to provide them as two distinct bindings: one which is bound to a deprecated alias transformer and one which isn't.

Examples:

```
> (require racket/deprecation)
> (define a 42)
> (define-deprecated-alias legacy-a a)
> legacy-a
42
```

14.15.2 Deprecated Alias Transformers

```
(require racket/deprecation/transformer)
```
package: base

The racket/deprecation/transformer module provides compile-time supporting code for the racket/deprecation library, primarily for use in tools that wish to reflect on deprecated code.

A *deprecated alias transformer* is a kind of rename transformer which signals that the transformer binding is a deprecated alias of the target identifier. This signal is intended for consumption in tools such as editors (which may wish to display a warning when deprecated aliases are used) and automated refactoring systems (which may wish to replace deprecated aliases with their target identifiers automatically).

```
(deprecated-alias? v) → boolean?
  v : any/c
```

Returns true if *v* is a deprecated alias transformer and returns false otherwise. Implies rename-transformer?. To determine if an identifier is *bound* to a deprecated alias transformer, use syntax-local-value/immediate and then use deprecated-alias? on the transformer value.

Examples:

```
> (require (for-syntax racket/base
                       racket/deprecation/transformer)
           racket/deprecation
           syntax/parse/define)
> (define-syntax-parse-rule (is-deprecated? id:id)
    #:do [(define-values (transformer _)
```

```
          (syntax-local-value/immediate #'id (λ () (values #false #false))))]
     #:with result (deprecated-alias? transformer)
     'result)
> (define-deprecated-alias bad-list list)
> (is-deprecated? list)
#f
> (is-deprecated? bad-list)
#t
```

```
(deprecated-alias target) → deprecated-alias?
  target : identifier?
```

Constructs a deprecated alias transformer which expands to *target* when used. The returned alias is a rename transformer and is thus suitable for use with `define-syntax`. When expanding, the usage of *target* is annotated with the `'not-free-identifier=?` syntax property to ensure that the alias and the target are treated as distinct bindings, even when `provide`d by a module.

This constructor is not intended for direct use by users who just want to declare a deprecated alias. Such users should prefer the `define-deprecated-alias` form instead.

```
(deprecated-alias-target alias) → identifier?
  alias : deprecated-alias?
```

Returns the target identifier that *alias* expands to.

15 Operating System

15.1 Paths

When a Racket procedure takes a filesystem path as an argument, the path can be provided either as a string or as an instance of the *path* datatype. If a string is provided, it is converted to a path using `string->path`. Beware that some paths may not be representable as strings; see §15.1.3.1 "Unix Path Representation" and §15.1.4.1 "Windows Path Representation" for more information. A Racket procedure that generates a filesystem path always generates a path value.

By default, paths are created and manipulated for the current platform, but procedures that merely manipulate paths (without using the filesystem) can manipulate paths using conventions for other supported platforms. The `bytes->path` procedure accepts an optional argument that indicates the platform for the path, either `'unix` or `'windows`. For other functions, such as `build-path` or `simplify-path`, the behavior is sensitive to the kind of path that is supplied. Unless otherwise specified, a procedure that requires a path accepts only paths for the current platform.

Two path values are `equal?` when they use the same convention type and when their byte-string representations are `equal?`. A path string (or byte string) cannot be empty, and it cannot contain a nul character or byte. When an empty string or a string containing nul is provided as a path to any procedure except `absolute-path?`, `relative-path?`, or `complete-path?`, the `exn:fail:contract` exception is raised.

Most Racket primitives that accept paths first *cleanse* the path before using it. Procedures that build paths or merely check the form of a path do not cleanse paths, with the exceptions of `cleanse-path`, `expand-user-path`, and `simplify-path`. For more information about path cleansing and other platform-specific details, see §15.1.3 "Unix and Mac OS Paths" and §15.1.4 "Windows Paths".

15.1.1 Manipulating Paths

```
(path? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a path value for the current platform (not a string, and not a path for a different platform), `#f` otherwise.

```
(path-string? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is either a *path or string*: either a path for the current platform or a non-empty string without nul characters. Returns `#f` otherwise.

```
(path-for-some-system? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a path value for some platform (not a string), `#f` otherwise.

```
(string->path str) → path?
  str : string?
```

Produces a path whose byte-string encoding is `(string->bytes/locale str (char->integer #\?))` on Unix and Mac OS or `(string->bytes/utf-8 str)` on Windows.

Beware that the current locale might not encode every string, in which case `string->path` can produce the same path for different *str*s. See also `string->path-element`, which should be used instead of `string->path` when a string represents a single path element. For information on how strings and byte strings encode paths, see §15.1.3.1 "Unix Path Representation" and §15.1.4.1 "Windows Path Representation".

See also `string->some-system-path`, and see §15.1.3.1 "Unix Path Representation" and §15.1.4.1 "Windows Path Representation" for information on how strings encode paths.

Changed in version 6.1.1.1 of package `base`: Changed Windows conversion to always use UTF-8.

```
(bytes->path bstr [type]) → path?
  bstr : bytes?
  type : (or/c 'unix 'windows) = (system-path-convention-type)
```

Produces a path (for some platform) whose byte-string encoding is *bstr*, where *bstr* must not contain a nul byte. The optional *type* specifies the convention to use for the path.

For converting relative path elements from literals, use instead `bytes->path-element`, which applies a suitable encoding for individual elements.

For information on how byte strings encode paths, see §15.1.3.1 "Unix Path Representation" and §15.1.4.1 "Windows Path Representation".

```
(path->string path) → string?
  path : path?
```

Produces a string that represents *path* by decoding *path*'s byte-string encoding using the current locale on Unix and Mac OS and by using UTF-8 on Windows. In the former case, `?` is used in the result string where encoding fails, and if the encoding result is the empty string, then the result is `"?"`.

The resulting string is suitable for displaying to a user, string-ordering comparisons, etc., but it is not suitable for re-creating a path (possibly modified) via `string->path`, since decoding and re-encoding the path's byte string may lose information.

Furthermore, for display and sorting based on individual path elements (such as pathless file names), use `path-element->string`, instead, to avoid special encodings use to represent some relative paths. See §15.1.4 "Windows Paths" for specific information about the conversion of Windows paths.

See also `some-system-path->string`.

Changed in version 6.1.1.1 of package `base`: Changed Windows conversion to always use UTF-8.

```
(path->bytes path) → bytes?
  path : path-for-some-system?
```

Produces *path*'s byte-string representation. No information is lost in this translation, so that `(bytes->path (path->bytes path) (path-convention-type path))` always produces a path that is `equal?` to *path*. The *path* argument can be a path for any platform.

Conversion to and from byte values is useful for marshaling and unmarshaling paths, but manipulating the byte form of a path is generally a mistake. In particular, the byte string may start with a `\\?\REL` encoding for Windows paths. Instead of `path->bytes`, use `split-path` and `path-element->bytes` to manipulate individual path elements.

For information on how byte strings encode paths, see §15.1.3.1 "Unix Path Representation" and §15.1.4.1 "Windows Path Representation".

```
(string->path-element str
                      [false-on-non-element?])
 → (or/c (and/c path? path-element?) #f)
  str : string?
  false-on-non-element? : any/c = #f
```

Like `string->path`, except that *str* corresponds to a single relative element in a path, and it is encoded as necessary to convert it to a path. See §15.1.3 "Unix and Mac OS Paths" and §15.1.4 "Windows Paths" for more information on the conversion of paths.

If *str* does not correspond to any path element (e.g., it is an absolute path, or it can be split), or if it corresponds to an up-directory or same-directory indicator on Unix and Mac OS, then either `#f` is returned or `exn:fail:contract` exception is raised. A `#f` is returned only when *false-on-non-element?* is true.

Like `path->string`, information can be lost from *str* in the locale-specific conversion to a path.

Changed in version 8.1.0.6 of package `base`: Added the *false-on-non-element?* argument.

```
(bytes->path-element bstr
                     [type
                      false-on-non-element?])
```

```
 → (or/c path-element? #f)
  bstr : bytes?
  type : (or/c 'unix 'windows) = (system-path-convention-type)
  false-on-non-element? : any/c = #f
```

Like `bytes->path`, except that *bstr* corresponds to a single relative element in a path. In terms of conversions, restrictions on *bstr*, and the treatment of *false-on-non-element?*, `bytes->path-element` is like `string->path-element`.

The `bytes->path-element` procedure is generally the best choice for reconstructing a path based on another path (where the other path is deconstructed with `split-path` and `path-element->bytes`) when ASCII-level manipulation of path elements is necessary.

Changed in version 8.1.0.6 of package `base`: Added the *false-on-non-element?* argument.

```
(path-element->string path) → string?
  path : path-element?
```

Like `path->string`, except that trailing path separators are removed (as by `split-path`). On Windows, any `\\?\REL` encoding prefix is also removed; see §15.1.4 "Windows Paths" for more information.

The *path* argument must be such that `split-path` applied to *path* would return `'relative` as its first result and a path as its second result, otherwise the `exn:fail:contract` exception is raised.

The `path-element->string` procedure is generally the best choice for presenting a pathless file or directory name to a user.

```
(path-element->bytes path) → bytes?
  path : path-element?
```

Like `path->bytes`, except that any encoding prefix is removed, etc., as for `path-element->string`.

For any reasonable locale, consecutive ASCII characters in the printed form of *path* are mapped to consecutive byte values that match each character's code-point value, and a leading or trailing ASCII character is mapped to a leading or trailing byte, respectively. The *path* argument can be a path for any platform.

The `path-element->bytes` procedure is generally the right choice (in combination with `split-path`) for extracting the content of a path to manipulate it at the ASCII level (then reassembling the result with `bytes->path-element` and `build-path`).

```
(path<? a-path b-path ...) → boolean?
  a-path : path?
  b-path : path?
```

Returns #t if the arguments are sorted, where the comparison for each pair of paths is the same as using path->bytes and bytes<?.

Changed in version 7.0.0.13 of package base: Allow one argument, in addition to allowing two or more.

```
(path-convention-type path) → (or/c 'unix 'windows)
  path : path-for-some-system?
```

Accepts a path value (not a string) and returns its convention type.

```
(system-path-convention-type) → (or/c 'unix 'windows)
```

Returns the path convention type of the current platform: 'unix for Unix and Mac OS, 'windows for Windows.

```
(build-path base sub ...) → path-for-some-system?
  base : (or/c path-string? path-for-some-system? 'up 'same)
  sub : (or/c (and/c (or/c path-string? path-for-some-system?)
                     (not/c complete-path?))
              (or/c 'up 'same))
```

Creates a path given a base path and any number of sub-path extensions. If *base* is an absolute path, the result is an absolute path, otherwise the result is a relative path.

The *base* and each *sub* must be either a relative path, the symbol 'up (indicating the relative parent directory), or the symbol 'same (indicating the relative current directory). For Windows paths, if *base* is a drive specification (with or without a trailing slash) the first *sub* can be an absolute (driveless) path. For all platforms, the last *sub* can be a filename.

The *base* and *sub* arguments can be paths for any platform. The platform for the resulting path is inferred from the *base* and *sub* arguments, where string arguments imply a path for the current platform. If different arguments are for different platforms, the exn:fail:contract exception is raised. If no argument implies a platform (i.e., all are 'up or 'same), the generated path is for the current platform.

Each *sub* and *base* can optionally end in a directory separator. If the last *sub* ends in a separator, it is included in the resulting path.

If *base* or *sub* is an illegal path string (because it is empty or contains a nul character), the exn:fail:contract exception is raised.

The build-path procedure builds a path *without* checking the validity of the path or accessing the filesystem.

See §15.1.3 "Unix and Mac OS Paths" and §15.1.4 "Windows Paths" for more information on the construction of paths.

The following examples assume that the current directory is "/home/joeuser" for Unix examples and "C:\Joe's Files" for Windows examples.

```
(define p1 (build-path (current-directory) "src" "racket"))
 ; Unix: p1 is "/home/joeuser/src/racket"
 ; Windows: p1 is "C:\\Joe's Files\\src\\racket"
(define p2 (build-path 'up 'up "docs" "Racket"))
 ; Unix: p2 is "../../docs/Racket"
 ; Windows: p2 is "..\\..\\docs\\Racket"
(build-path p2 p1)
 ; Unix and Windows: raises exn:fail:contract; p1 is absolute
(build-path p1 p2)
 ; Unix: is "/home/joeuser/src/racket/../../docs/Racket"
 ; Windows: is "C:\\Joe's Files\\src\\racket\\..\\..\\docs\\Racket"
```

```
(build-path/convention-type type
                            base
                            sub ...) → path-for-some-system?
  type : (or/c 'unix 'windows)
  base : (or/c path-string? path-for-some-system? 'up 'same)
  sub : (or/c (and/c (or/c path-string? path-for-some-system?)
                     (not/c complete-path?))
              (or/c 'up 'same))
```

Like `build-path`, except a path convention type is specified explicitly.

Note that, just as with `build-path`, any string arguments for either *base* or *sub* will be implicitly converted into a path for the current platform before being combined with the others. For this reason, you cannot use this function to build paths from strings for any platform other than the current one; in such attempts, *type* does not match the inferred convention type for the strings and an `exn:fail:contract` exception is raised. (To create paths for foreign platforms, see `bytes->path`.)

The usefulness of `build-path/convention-type` over `build-path` is limited to cases where the sub-paths contain `'same` or `'up` elements.

```
(absolute-path? path) → boolean?
  path : (or/c path? string? path-for-some-system?)
```

Returns `#t` if *path* is an absolute path, `#f` otherwise. The *path* argument can be a path for any platform. If *path* is not a legal path string (e.g., it contains a nul character), `#f` is returned. This procedure does not access the filesystem.

```
(relative-path? path) → boolean?
  path : (or/c path? string? path-for-some-system?)
```

Returns #t if *path* is a relative path, #f otherwise. The *path* argument can be a path for any platform. If *path* is not a legal path string (e.g., it contains a nul character), #f is returned. This procedure does not access the filesystem.

```
(complete-path? path) → boolean?
  path : (or/c path? string? path-for-some-system?)
```

Returns #t if *path* is a *complete*ly determined path (*not* relative to a directory or drive), #f otherwise. The *path* argument can be a path for any platform. Note that for Windows paths, an absolute path can omit the drive specification, in which case the path is neither relative nor complete. If *path* is not a legal path string (e.g., it contains a nul character), #f is returned.

This procedure does not access the filesystem.

```
(path->complete-path path [base]) → path-for-some-system?
  path : (or/c path-string? path-for-some-system?)
  base : (or/c path-string? path-for-some-system?)
       = (current-directory)
```

Returns *path* as a complete path. If *path* is already a complete path, it is returned as the result. Otherwise, *path* is resolved with respect to the complete path *base*. If *base* is not a complete path, the exn:fail:contract exception is raised.

The *path* and *base* arguments can be paths for any platform; if they are for different platforms, the exn:fail:contract exception is raised.

This procedure does not access the filesystem.

```
(path->directory-path path) → path-for-some-system?
  path : (or/c path-string? path-for-some-system?)
```

Returns *path* if *path* syntactically refers to a directory and ends in a separator, otherwise it returns an extended version of *path* that specifies a directory and ends with a separator. For example, on Unix and Mac OS, the path "x/y/" syntactically refers to a directory and ends in a separator, but "x/y" would be extended to "x/y/", and "x/.." would be extended to "x/../". The *path* argument can be a path for any platform, and the result will be for the same platform.

This procedure does not access the filesystem.

```
(resolve-path path) → path?
  path : path-string?
```

Cleanses *path* and returns a path that references the same file or directory as *path*. If *path* is a soft link to another path, then the referenced path is returned (this may be a relative path with respect to the directory owning *path*), otherwise *path* is returned (after cleansing).

On Windows, the path for a link should be simplified syntactically, so that an up-directory indicator removes a preceding path element independent of whether the preceding element itself refers to a link. For relative-paths links, the path should be parsed specially; see §15.1.4 “Windows Paths” for more information.

Changed in version 6.0.1.12 of package `base`: Added support for links on Windows.

```
(cleanse-path path) → path-for-some-system?
  path : (or/c path-string? path-for-some-system?)
```

Cleanses *path* (as described at the beginning of this chapter) without consulting the filesystem.

Example:

```
> (let ([p (string->some-system-path "tiny//dancer" 'unix)])
    (cleanse-path p))
#<path:tiny/dancer>
```

```
(expand-user-path path) → path?
  path : path-string?
```

Cleanses *path*. In addition, on Unix and Mac OS, a leading `~` is treated as user's home directory and expanded; the username follows the `~` (before a `/` or the end of the path), where `~` by itself indicates the home directory of the current user.

```
(simplify-path path [use-filesystem?]) → path-for-some-system?
  path : (or/c path-string? path-for-some-system?)
  use-filesystem? : boolean? = #t
```

Eliminates redundant path separators (except for a single trailing separator), up-directory `..`, and same-directory `.` indicators in *path*, and changes `/` separators to `\` separators in Windows paths, such that the result accesses the same file or directory (if it exists) as *path*.

In general, the pathname is normalized as much as possible—without consulting the filesystem if *use-filesystem?* is `#f`, and (on Windows) without changing the case of letters within the path. If *path* syntactically refers to a directory, the result ends with a directory separator.

When *path* is simplified other than just converting slashes to backslashes and *use-filesystem?* is true (the default), a complete path is returned. If *path* is relative, it is resolved with respect to the current directory. On Unix and Mac OS, up-directory indicators are removed taking into account soft links (so that the resulting path refers to the same directory as before); on Windows, up-directory indicators are removed by deleting a preceding path element.

When *use-filesystem?* is `#f`, up-directory indicators are removed by deleting a preceding path element, and the result can be a relative path with up-directory indicators remaining at the beginning of the path; up-directory indicators are dropped when they refer to the parent of a root directory. Similarly, the result can be the same as `(build-path 'same)` (but with a trailing separator) if eliminating up-directory indicators leaves only same-directory indicators.

The *path* argument can be a path for any platform when *use-filesystem?* is `#f`, and the resulting path is for the same platform.

The filesystem might be accessed when *use-filesystem?* is true, but the source or simplified path might be a non-existent path. If *path* cannot be simplified due to a cycle of links, the `exn:fail:filesystem` exception is raised (but a successfully simplified path may still involve a cycle of links if the cycle did not inhibit the simplification).

See §15.1.3 “Unix and Mac OS Paths” and §15.1.4 “Windows Paths” for more information on simplifying paths.

Example:

```
> (let ([p (string->some-system-path "tiny//in/my/head/../../../dancer" 'unix)])
    (simplify-path p #f))
#<path:tiny/dancer>
```

```
(normal-case-path path) → path-for-some-system?
  path : (or/c path-string? path-for-some-system?)
```

Returns *path* with “normalized” case characters. For Unix and Mac OS paths, this procedure always returns the input path, because filesystems for these platforms can be case-sensitive. For Windows paths, if *path* does not start with `\\?\`, the resulting string uses only lowercase letters, based on the current locale. In addition, for Windows paths when the path does not start with `\\?\`, all `/`s are converted to `\`s, and trailing spaces and `.`s are removed.

The *path* argument can be a path for any platform, but beware that local-sensitive decoding and conversion of the path may be different on the current platform than for the path’s platform.

This procedure does not access the filesystem.

```
(split-path path) → (or/c path-for-some-system? 'relative #f)
                    (or/c path-for-some-system? 'up 'same)
                    boolean?
  path : (or/c path-string? path-for-some-system?)
```

Deconstructs *path* into a smaller path and an immediate directory or file name. Three values are returned:

- base is either
  - a path,
  - 'relative if *path* is an immediate relative directory or filename, or
  - #f if *path* is a root directory.
- name is either
  - a directory-name path,
  - a filename,
  - 'up if the last part of *path* specifies the parent directory of the preceding path (e.g., .. on Unix), or
  - 'same if the last part of *path* specifies the same directory as the preceding path (e.g., . on Unix).
- must-be-dir? is #t if *path* explicitly specifies a directory (e.g., with a trailing separator), #f otherwise. Note that must-be-dir? does not specify whether name is actually a directory or not, but whether *path* syntactically specifies a directory.

Compared to *path*, redundant separators (if any) are removed in the result base and name. If base is #f, then name cannot be 'up or 'same. The *path* argument can be a path for any platform, and resulting paths for the same platform.

This procedure does not access the filesystem.

See §15.1.3 "Unix and Mac OS Paths" and §15.1.4 "Windows Paths" for more information on splitting paths.

```
(explode-path path)
 → (listof (or/c path-for-some-system? 'up 'same))
  path : (or/c path-string? path-for-some-system?)
```

Returns the list of path elements that constitute *path*. If *path* is simplified in the sense of simple-form-path, then the result is always a list of paths, and the first element of the list is a root.

The explode-path function computes its result in time proportional to the length of *path* (unlike a loop that uses split-path, which must allocate intermediate paths).

```
(path-replace-extension path ext) → path-for-some-system?
  path : (or/c path-string? path-for-some-system?)
  ext : (or/c string? bytes?)
```

Returns a path that is the same as *path*, except that the extension for the last element of the path (including the extension separator) is changed to *ext*. If the last element of *path* has no extension, then *ext* is added to the path.

An extension is defined as a `.` that is not at the start of the path element followed by any number of non-`.` characters/bytes at the end of the path element, as long as the path element is not a directory indicator like `".."`.

The *path* argument can be a path for any platform, and the result is for the same platform. If *path* represents a root, the `exn:fail:contract` exception is raised. The given *ext* typically starts with `.`, but it is not required to start with an extension separator.

Examples:

```
> (path-replace-extension "x/y.ss" #".rkt")
#<path:x/y.rkt>
> (path-replace-extension "x/y.ss" #"")
#<path:x/y>
> (path-replace-extension "x/y" #".rkt")
#<path:x/y.rkt>
> (path-replace-extension "x/y.tar.gz" #".rkt")
#<path:x/y.tar.rkt>
> (path-replace-extension "x/.racketrc" #".rkt")
#<path:x/.racketrc.rkt>
```

Added in version 6.5.0.3 of package `base`.

```
(path-add-extension path ext [sep]) → path-for-some-system?
  path : (or/c path-string? path-for-some-system?)
  ext : (or/c string? bytes?)
  sep : (or/c string? bytes?) = #"_"
```

Similar to `path-replace-extension`, but any existing extension on *path* is preserved by replacing the `.` before the extension with *sep*, and then the *ext* is added to the end.

Examples:

```
> (path-add-extension "x/y.ss" #".rkt")
#<path:x/y_ss.rkt>
> (path-add-extension "x/y" #".rkt")
#<path:x/y.rkt>
> (path-add-extension "x/y.tar.gz" #".rkt")
#<path:x/y.tar_gz.rkt>
> (path-add-extension "x/y.tar.gz" #".rkt" #".")
#<path:x/y.tar.gz.rkt>
> (path-add-extension "x/.racketrc" #".rkt")
#<path:x/.racketrc.rkt>
```

Added in version 6.5.0.3 of package `base`.
Changed in version 6.8.0.2: Added the *sep* optional argument.

```
(path-replace-suffix path ext) → path-for-some-system?
  path : (or/c path-string? path-for-some-system?)
  ext : (or/c string? bytes?)
```

NOTE: This function is deprecated; use `path-replace-extension`, instead.

Like `path-replace-extension`, but treats a leading `.` in a path element as an extension separator.

```
(path-add-suffix path ext) → path-for-some-system?
  path : (or/c path-string? path-for-some-system?)
  ext : (or/c string? bytes?)
```

NOTE: This function is deprecated; use `path-add-extension`, instead.

Like `path-add-extension`, but treats a leading `.` in a path element as an extension separator.

```
(reroot-path path root-path) → path-for-some-system?
  path : (or/c path-string? path-for-some-system?)
  root-path : (or/c path-string? path-for-some-system?)
```

Produces a path that extends *root-path* based on the complete form of *path*.

If *path* is not already complete, is it completed via `path->complete-path`, in which case *path* must be a path for the current platform. The *path* argument is also cleansed and case-normalized via `normal-case-path`. The path is then appended to *root-path*; in the case of Windows paths, a root letter drive becomes a letter path element, while a root UNC path is prefixed with `"UNC"` as a path element and the machine and volume names become path elements.

Examples:

```
> (reroot-path (bytes->path #"/home/caprica/baltar" 'unix)
               (bytes->path #"/earth" 'unix))
#<path:/earth/home/caprica/baltar>
> (reroot-path (bytes->path #"c:\\usr\\adama" 'windows)
               (bytes->path #"\\\\earth\\africa\\" 'windows))
#<windows-path:\\earth\africa\c\usr\adama>
> (reroot-path (bytes->path #"\\\\galactica\\cac\\adama" 'windows)
               (bytes->path #"s:\\earth\\africa\\" 'windows))
#<windows-path:s:\earth\africa\UNC\galactica\cac\adama>
```

15.1.2 More Path Utilities

```
(require racket/path)        package: base
```

The bindings documented in this section are provided by the `racket/path` and `racket` libraries, but not `racket/base`.

```
(file-name-from-path path) → (or/c path-for-some-system? #f)
  path : (or/c path-string? path-for-some-system?)
```

Returns the last element of *path*. If *path* is syntactically a directory path (see `split-path`), then the result is `#f`.

```
(path-get-extension path) → (or/c bytes? #f)
  path : (or/c path-string? path-for-some-system?)
```

Returns a byte string that is the extension part of the filename in *path*, including the `.` separator. If the path has no extension, `#f` is returned.

See `path-replace-extension` for the definition of a filename extension.

Examples:

```
> (path-get-extension "x/y.rkt")
#".rkt"
> (path-get-extension "x/y")
#f
> (path-get-extension "x/y.tar.gz")
#".gz"
> (path-get-extension "x/.racketrc")
#f
```

Added in version 6.5.0.3 of package `base`.

```
(path-has-extension? path ext) → boolean?
  path : (or/c path-string? path-for-some-system?)
  ext : (or/c bytes? string?)
```

Determines whether the last element of *path* ends with *ext* but is not exactly the same as *ext*.

If *ext* is a byte string with the shape of an extension (i.e., starting with `.` and not including another `.`), this check is equivalent to checking whether `(path-get-extension path)` produces *ext*.

Examples:

```
> (path-has-extension? "x/y.rkt" #".rkt")
#t
> (path-has-extension? "x/y.ss" #".rkt")
#f
> (path-has-extension? "x/y" #".rkt")
#f
> (path-has-extension? "x/.racketrc" #".racketrc")
#f
> (path-has-extension? "x/compiled/y_rkt.zo" #"_rkt.zo")
#t
```

Added in version 6.5.0.3 of package `base`.

```
(filename-extension path) → (or/c bytes? #f)
  path : (or/c path-string? path-for-some-system?)
```

NOTE: This function is deprecated; use `path-get-extension`, instead.

Returns a byte string that is the extension part of the filename in *`path`* without the `.` separator. If *`path`* is syntactically a directory (see `split-path`) or if the path has no extension, `#f` is returned.

```
(find-relative-path  base
                     path
                    [#:more-than-root? more-than-root?
                     #:more-than-same? more-than-same?
                     #:normalize-case? normalize-case?])
 → (or/c path-for-some-system? path-string?)
  base : (or/c path-string? path-for-some-system?)
  path : (or/c path-string?  path-for-some-system?)
  more-than-root? : any/c = #f
  more-than-same? : any/c = #t
  normalize-case? : any/c = #t
```

Finds a relative pathname with respect to *`base`* that names the same file or directory as *`path`*. Both *`base`* and *`path`* must be simplified in the sense of `simple-form-path`. If *`path`* shares no subpath in common with *`base`*, *`path`* is returned.

If *`more-than-root?`* is true, if *`base`* and *`path`* share only a Unix root in common, and if neither *`base`* nor *`path`* is just a root path, then *`path`* is returned.

If *`path`* is the same as *`base`*, then `(build-path 'same)` is returned only if *`more-than-same?`* is `#f`. Otherwise, and by default, *`path`* is returned when *`path`* is the same as *`base`*.

If *normalize-case?* is true (the default), then pairs of path elements to be compared are first converted via `normal-case-path`, which means that path elements are compared case-insentively on Windows. If *normalize-case?* is `#f`, then path elements and the path roots match only if they have the same case.

The result is normally a path in the sense of `path?`. The result is a string only if *path* is provided a string and also returned as the result.

Changed in version 6.8.0.3 of package `base`: Made path elements case-normalized for comparison by default, and added the `#:normalize-case?` argument.
Changed in version 6.90.0.21: Added the `#:more-than-same?` argument.

```
(normalize-path path [wrt]) → path?
  path : path-string?
  wrt : (and/c path-string? complete-path?)
      = (current-directory)
```

Returns a complete version of *path* by making the path complete, expanding the complete path, and resolving all soft links (which requires consulting the filesystem). If *path* is relative, then *wrt* is used as the base path.

For most purposes, `simple-form-path` is the preferred mechanism to normalize a path, because it works for paths that include non-existent directory components, and it avoids unnecessarily expanding soft links.

Letter case is *not* normalized by `normalize-path`. For this and other reasons, such as whether the path is syntactically a directory, the result of `normalize-path` is not suitable for comparisons that determine whether two paths refer to the same file or directory (i.e., the comparison may produce false negatives).

An error is signaled by `normalize-path` if the input path contains an embedded path for a non-existent directory, or if an infinite cycle of soft links is detected.

Example:

```
> (equal? (current-directory) (normalize-path "."))
#t
```

```
(path-element? path) → boolean?
  path : any/c
```

Returns `#t` if *path* is a *path element*: a path value for some platform (see `path-for-some-system?`) such that `split-path` applied to *path* would return `'relative` as its first result and a path as its second result. Otherwise, the result is `#f`.

```
(path-only path) → (or/c #f path-for-some-system?)
  path : (or/c path-string? path-for-some-system?)
```

Returns *path* without its final path element in the case that *path* is not syntactically a directory; if *path* has only a single, non-directory path element, `#f` is returned. If *path* is syntactically a directory, then *path* is returned unchanged (but as a path, if it was a string).

Examples:

```
> (path-only (build-path "a" "b"))
#<path:a/>
> (path-only (build-path "a"))
#f
> (path-only (path->directory-path (build-path "a")))
#<path:a/>
> (path-only (build-path 'up 'up))
#<path:../..>
```

```
(simple-form-path path) → path?
  path : path-string?
```

Returns `(simplify-path (path->complete-path path))`, which ensures that the result is a complete path containing no up- or same-directory indicators.

```
(some-system-path->string path) → string?
  path : path-for-some-system?
```

Converts *path* to a string using a UTF-8 encoding of the path's bytes.

Use this function when working with paths for a different system (whose encoding of pathnames might be unrelated to the current locale's encoding) and when starting and ending with strings.

```
(string->some-system-path str kind) → path-for-some-system?
  str : string?
  kind : (or/c 'unix 'windows)
```

Converts *str* to a *kind* path using a UTF-8 encoding of the path's bytes.

Use this function when working with paths for a different system (whose encoding of pathnames might be unrelated to the current locale's encoding) and when starting and ending with strings.

```
(shrink-path-wrt pth other-pths) → (or/c #f path?)
  pth : path?
  other-pths : (listof path?)
```

Returns a suffix of *pth* that shares nothing in common with the suffixes of *other-pths*, or *pth*, if not possible (e.g. when *other-pths* is empty or contains only paths with the same elements as *pth*).

Examples:

```
> (shrink-path-wrt (build-path "racket" "list.rkt")
                   (list (build-path "racket" "list.rkt")
                         (build-path "racket" "base.rkt")))
#<path:list.rkt>
> (shrink-path-wrt (build-path "racket" "list.rkt")
                   (list (build-path "racket" "list.rkt")
                         (build-path "racket" "private" "list.rkt")
                         (build-path "racket" "base.rkt")))
#<path:racket/list.rkt>
```

15.1.3 Unix and Mac OS Paths

In a path on Unix and Mac OS, a `/` separates elements of the path, `.` as a path element always means the directory indicated by preceding path, and `..` as a path element always means the parent of the directory indicated by the preceding path. A leading `~` in a path is not treated specially, but `expand-user-path` can be used to convert a leading `~` element to a user-specific directory. No other character or byte has a special meaning within a path. Multiple adjacent `/` are equivalent to a single `/` (i.e., they act as a single path separator).

A path root is always `/`. A path starting with `/` is an absolute, complete path, and a path starting with any other character is a relative path.

Any pathname that ends with a `/` syntactically refers to a directory, as does any path whose last element is `.` or `..`.

A Unix and Mac OS path is cleansed by replacing multiple adjacent `/`s with a single `/`.

For `(bytes->path-element bstr)`, `bstr` must not contain any `/`, otherwise the `exn:fail:contract` exception is raised. The result of `(path-element->bytes path)` or `(path-element->string path)` is always the same as the result of `(path->bytes path)` and `(path->string path)`. Since that is not the case for other platforms, however, `path-element->bytes` and `path-element->string` should be used when converting individual path elements.

On Mac OS, Finder aliases are zero-length files.

Unix Path Representation

A path on Unix and Mac OS is natively a byte string. For presentation to users and for other string-based operations, a path is converted to/from a string using the current locale's encoding with `?` (encoding) or `#\uFFFD` (decoding) in place of errors. Beware that the encoding may not accommodate all possible paths as distinct strings.

15.1.4 Windows Paths

In general, a Windows pathname consists of an optional drive specifier and a drive-specific path. A Windows path can be *absolute* but still relative to the current drive; such paths start with a `/` or `\` separator and are not UNC paths or paths that start with `\\?\`.

A path that starts with a drive specification is *complete*. Roughly, a drive specification is either a Latin letter followed by a colon, a UNC path of the form `\\`⟨*machine*⟩`\`⟨*volume*⟩, or a `\\?\` form followed by something other than `REL\`⟨*element*⟩, or `RED\`⟨*element*⟩. (Variants of `\\?\` paths are described further below.)

Racket fails to implement the usual Windows path syntax in one way. Outside of Racket, a pathname `"C:rant.txt"` can be a drive-specific relative path. That is, it names a file `"rant.txt"` on drive `"C:"`, but the complete path to the file is determined by the current working directory for drive `"C:"`. Racket does not support drive-specific working directories (only a working directory across all drives, as reflected by the `current-directory` parameter). Consequently, Racket implicitly converts a path like `"C:rant.txt"` into `"C:\rant.txt"`.

- *Racket-specific:* Whenever a path starts with a drive specifier ⟨*letter*⟩`:` that is not followed by a `/` or `\`, a `\` is inserted as the path is cleansed.

Otherwise, Racket follows standard Windows path conventions, but also adds `\\?\REL` and `\\?\RED` conventions to deal with paths inexpressible in the standard convention, plus conventions to deal with excessive `\`s in `\\?\` paths.

In the following, ⟨*letter*⟩ stands for a Latin letter (case does not matter), ⟨*machine*⟩ stands for any sequence of characters that does not include `\` or `/` and is not `?`, ⟨*volume*⟩ stands for any sequence of characters that does not include `\` or `/` , and ⟨*element*⟩ stands for any sequence of characters that does not include `\`.

- Trailing spaces and `.` in a path element are ignored when the element is the last one in the path, unless the path starts with `\\?\` or the element consists of only spaces and `.`s.
- The following special "files", which access devices, exist in all directories, case-insensitively, and with all possible endings after a period or colon, except in pathnames that start with `\\?\`: `"NUL"`, `"CON"`, `"PRN"`, `"AUX"`, `"COM1"`, `"COM2"`, `"COM3"`, `"COM4"`, `"COM5"`, `"COM6"`, `"COM7"`, `"COM8"`, `"COM9"`, `"LPT1"`, `"LPT2"`, `"LPT3"`, `"LPT4"`, `"LPT5"`, `"LPT6"`, `"LPT7"`, `"LPT8"`, `"LPT9"`.
- Except for `\\?\` paths, `/`s are equivalent to `\`s. Except for `\\?\` paths and the start of UNC paths, multiple adjacent `/`s and `\`s count as a single `\`. In a path that starts `\\?\` paths, elements can be separated by either a single or double `\`.

- A directory can be accessed with or without a trailing separator. In the case of a non-`\\?\` path, the trailing separator can be any number of `/`s and `\`s; in the case of a `\\?\` path, a trailing separator must be a single `\`, except that two `\`s can follow `\\?\`⟨*letter*⟩`:`.

- Except for `\\?\` paths, a single `.` as a path element means "the current directory," and a `..` as a path element means "the parent directory." Up-directory path elements (i.e., `..`) immediately after a drive are ignored.

- A pathname that starts `\\`⟨*machine*⟩`\`⟨*volume*⟩ (where a `/` can replace any `\`) is a UNC path, and the starting `\\`⟨*machine*⟩`\`⟨*volume*⟩ counts as the drive specifier.

- Normally, a path element cannot contain a character in the range `#\x 0` to `#\x 1F` nor any of the following characters:

  `< > : " / \ | ? *`

  Except for `\`, path elements containing these characters can be accessed using a `\\?\` path (assuming that the underlying filesystem allows the characters).

- In a pathname that starts `\\?\`⟨*letter*⟩`:\`, the `\\?\`⟨*letter*⟩`:\` prefix counts as the path's drive, as long as the path does not both contain non-drive elements and end with two consecutive `\`s, and as long as the path contains no sequence of three or more `\`s. Two `\`s can appear in place of the `\` before ⟨*letter*⟩. A `/` cannot be used in place of a `\` (but `/`s can be used in element names, though the result typically does not name an actual directory or file).

- In a pathname that starts `\\?\UNC\`⟨*machine*⟩`\`⟨*volume*⟩, the `\\?\UNC\`⟨*machine*⟩`\`⟨*volume*⟩ prefix counts as the path's drive, as long as the path does not end with two consecutive `\`s, and as long as the path contains no sequence of three or more `\`s. Two `\`s can appear in place of the `\` before `UNC`, the `\`s after `UNC`, and/or the `\`s after⟨*machine*⟩. The letters in the `UNC` part can be uppercase or lowercase, and `/` cannot be used in place of `\`s (but `/` can be used in element names).

- *Racket-specific:* A pathname that starts `\\?\REL\`⟨*element*⟩ or `\\?\REL\\`⟨*element*⟩ is a relative path, as long as the path does not end with two consecutive `\`s, and as long as the path contains no sequence of three or more `\`s. This Racket-specific path form supports relative paths with elements that are not normally expressible in Windows paths (e.g., a final element that ends in a space). The `REL` part must be exactly the three uppercase letters, and `/`s cannot be used in place of `\`s. If the path starts `\\?\REL\..` then for as long as the path continues with repetitions of `\..`, each element counts as an up-directory element; a single `\` must be used to separate the up-directory elements. As soon as a second `\` is used to separate the elements, or as soon as a non-`..` element is encountered, the remaining elements are all literals (never up-directory elements). When a `\\?\REL` path value is converted to a string (or when the path value is written or displayed), the string does not contain the starting `\\?\REL` or the immediately following `\`s; converting a path value to a byte string preserves the `\\?\REL` prefix.

- *Racket-specific:* A pathname that starts `\\?\RED\`⟨*element*⟩ or `\\?\RED\\`⟨*element*⟩ is a drive-relative path, as long as the path does not end with two consecutive `\`s, and as long as the path contains no sequence of three or more `\`s. This Racket-specific path form supports drive-relative paths (i.e., absolute given a drive) with elements that are not normally expressible in Windows paths. The `RED` part must be exactly the three uppercase letters, and `/`s cannot be used in place of `\`s. Unlike `\\?\REL` paths, a `..` element is always a literal path element. When a `\\?\RED` path value is converted to a string (or when the path value is written or displayed), the string does not contain the starting `\\?\RED` and it contains a single starting `\`; converting a path value to a byte string preserves the `\\?\RED` prefix.

Three additional Racket-specific rules provide meanings to character sequences that are otherwise ill-formed as Windows paths:

- *Racket-specific:* In a pathname of the form `\\?\`⟨*any*⟩`\\` where ⟨*any*⟩ is any non-empty sequence of characters other than ⟨*letter*⟩`:` or `\`⟨*letter*⟩`:`, the entire path counts as the path's (non-existent) drive.
- *Racket-specific:* In a pathname of the form `\\?\`⟨*any*⟩`\\\`⟨*elements*⟩, where ⟨*any*⟩ is any non-empty sequence of characters and ⟨*elements*⟩ is any sequence that does not start with a `\`, does not end with two `\`s, and does not contain a sequence of three `\`s, then `\\?\`⟨*any*⟩`\\` counts as the path's (non-existent) drive.
- *Racket-specific:* In a pathname that starts `\\?\` and does not match any of the patterns from the preceding bullets, `\\?\` counts as the path's (non-existent) drive.

Outside of Racket, except for `\\?\` paths, pathnames are typically limited to 259 characters when used as a file path and 247 characters when used as a directory path. Racket internally converts pathnames longer than 247 characters to `\\?\` form to avoid the limits; in that case, the path is first simplified syntactically (in the sense of `simplify-path`). The operating system cannot access files through `\\?\` paths that are longer than 32,000 characters or so.

Where the above descriptions says "character," substitute "byte" for interpreting byte strings as paths. The encoding of Windows paths into bytes preserves ASCII characters, and all special characters mentioned above are ASCII, so all of the rules are the same.

Beware that the `\` path separator is an escape character in Racket strings. Thus, the path `\\?\REL\..\\..` as a string must be written `"\\\\?\\REL\\..\\\\.."`.

A path that ends with a directory separator syntactically refers to a directory. In addition, a path syntactically refers to a directory if its last element is a same-directory or up-directory indicator (not quoted by a `\\?\` form), or if it refers to a root.

Even on variants of Windows that support symbolic links, up-directory `..` indicators in a path are resolved syntactically, not sensitive to links. For example, if a path ends with `d\..\f` and `d` refers to a symbolic link that references a directory with a different parent than `d`, the path nevertheless refers to `f` in the same directory as `d`. A relative-path link is parsed as if prefixed with `\\?\REL` paths, except that `..` and `.` elements are allowed throughout the path, and any number of redundant `\` separators are allowed.

Windows paths are cleansed as follows: In paths that start `\\?\`, redundant `\`s are removed, an extra `\` is added in a `\\?\REL` if an extra one is not already present to separate up-directory indicators from literal path elements, and an extra `\` is similarly added after `\\?\RED` if an extra one is not already present. For other paths, multiple `/`s and `\`s are converted to single `/`s or `\` (except at the beginning of a shared folder name), and a `\` is inserted after the colon in a drive specification if it is missing.

For `(bytes->path-element bstr)`, `/`s, colons, trailing dots, trailing whitespace, and special device names (e.g., "aux") in *bstr* are encoded as a literal part of the path element by using a `\\?\REL` prefix. The `bstr` argument must not contain a `\`, otherwise the `exn:fail:contract` exception is raised.

For `(path-element->bytes path)` or `(path-element->string path)`, if the byte-string form of *path* starts with a `\\?\REL`, the prefix is not included in the result.

For `(build-path base-path sub-path ...)`, trailing spaces and periods are removed from the last element of *base-path* and all but the last *sub-path* (unless the element consists of only spaces and periods), except for those that start with `\\?\`. If *base-path* starts `\\?\`, then after each non-`\\?\REL\` and non-`\\?\RED\` *sub-path* is added, all `/`s in the addition are converted to `\`s, multiple consecutive `\`s are converted to a single `\`, added `.` elements are removed, and added `..` elements are removed along with the preceding element; these conversions are not performed on the original *base-path* part of the result or on any `\\?\REL\` or `\\?\RED\` or *sub-path*. If a `\\?\REL\` or `\\?\RED\` *sub-path* is added to a non-`\\?\` *base-path*, the *base-path* (with any additions up to the `\\?\REL\` or `\\?\RED\` *sub-path*) is simplified and converted to a `\\?\` path. In other cases, a `\` may be added or removed before combining paths to avoid changing the root meaning of the path (e.g., combining `//x` and `y` produces `/x/y`, because `//x/y` would be a UNC path instead of a drive-relative path).

For `(simplify-path path use-filesystem?)`, *path* is expanded, and if *path* does not start with `\\?\`, trailing spaces and periods are removed, a `/` is inserted after the colon in a drive specification if it is missing, and a `\` is inserted after `\\?\` as a root if there are elements and no extra `\` already. Otherwise, if no indicators or redundant separators are in *path*, then *path* is returned.

For `(split-path path)` producing *base*, *name*, and *must-be-dir?*, splitting a path that does not start with `\\?\` can produce parts that start with `\\?\`. For example, splitting `C:/x /aux/` twice produces `\\?\REL\\x ` and `\\?\REL\\aux`; the `\\?\` is needed in these cases to preserve a trailing space after `x` and to avoid referring to the AUX device instead of an `"aux"` file.

Windows Path Representation

A path on Windows is natively a sequence of UTF-16 code units, where the sequence can include unpaired surrogates. This sequence is encoded as a byte string through an extension of UTF-8, where unpaired surrogates in the UTF-16 code-unit sequence are converted as if they were non-surrogate values. The extended encodings are implemented on Windows as the `"platform-UTF-16"` and `"platform-UTF-8"` encodings for `bytes-open-converter`.

Racket's internal representation of a Windows path is a byte string, so that `path->bytes` and `bytes->path` are always inverses. When converting a path to a native UTF-16 code-unit sequence, `#\tab` is used in place of platform-UTF-8 decoding errors (on the grounds that tab is normally disallowed as a character in a Windows path, unlike `#\uFFFD`).

A Windows path is converted to a string by treating the platform-UTF-8 encoding as a UTF-8 encoding with `#\uFFFD` in place of decoding errors. Similarly, a string is converted to a path by UTF-8 encoding (in which case no errors are possible).

15.2 Filesystem

15.2.1 Locating Paths

```
(find-system-path kind) → path?
  kind : symbol?
```

Returns a machine-specific path for a standard type of path specified by *kind*, which must be one of the following:

- `'home-dir` — the current *user's home directory*.

  On all platforms, if the `PLTUSERHOME` environment variable is defined as a complete path, then the path is used as the user's home directory.

  On Unix and Mac OS, when `PLTUSERHOME` does not apply, the user's home directory is determined by expanding the path `"~"`, which is expanded by first checking for a `HOME` environment variable. If none is defined, the `USER` and `LOGNAME` environment variables are consulted (in that order) to find a user name, and then system files are consulted to locate the user's home directory.

  On Windows, when `PLTUSERHOME` does not apply, the user's home directory is the user-specific profile directory as determined by the Windows registry. If the registry cannot provide a directory for some reason, the value of the `USERPROFILE` environment variable is used instead, as long as it refers to a directory that exists. If `USERPROFILE` also fails, the directory is the one specified by the `HOMEDRIVE` and `HOMEPATH` environment variables. If those environment variables are not defined, or if the indicated directory still does not exist, the directory containing the current executable is used as the home directory.

- `'pref-dir` — the standard directory for storing the current user's preferences. The preferences directory might not exist.

  On Unix, the preferences directory is normally the `"racket"` subdirectory of the path specified by `XDG_CONFIG_HOME`, or `".config/racket"` in the user's home directory if `XDG_CONFIG_HOME` is not set to an absolute path or if `PLTUSERHOME` is set. Either way, if that directory does not exist but a `".racket"` directory exists in the user's home directory, then that directory is the preference directory, instead.

  On Windows, the preferences directory is `"Racket"` in the user's home directory if determined by `PLTUSERHOME`, otherwise in the user's application-data folder as specified by the Windows registry; the application-data folder is usually `"Application Data"` in the user's profile directory.

  On Mac OS, the preferences directory is `"Library/Preferences"` in the user's home directory.

- `'pref-file` — a file that contains a symbol-keyed association list of preference values. The file's directory path always matches the result returned for `'pref-dir`. The file name is `"racket-prefs.rktd"` on Unix and Windows, and it is `"org.racket-lang.prefs.rktd"` on Mac OS. The file's directory might not exist. See also `get-preference`.

- `'temp-dir` — the standard directory for storing temporary files. On Unix and Mac OS, this is the directory specified by the `TMPDIR` environment variable, if it is defined, otherwise it is the first path that exists among `"/var/tmp"`, `"/usr/tmp"`, and `"/tmp"`. On Windows, the result is the directory specified by the `TMP` or `TEMP` environment variable, if it is defined, otherwise it is the current directory.

- `'init-dir` — the directory containing the initialization file used by the Racket executable.

  On Unix, the initialization directory is the same as the result returned for `'pref-dir`—unless that directory does not exist and a `".racketrc"` file exists in the user's home directory, in which case the home directory is the initialization directory.

  On Windows, the initialization directory is the same as the user's home directory.

  On Mac OS, the initialization directory is `"Library/Racket"` in the user's home directory—unless no `"racketrc.rktl"` exists there and a `".racketrc"` file does exist in the home directory, in which case the home directory is the initialization directory.

- `'init-file` — the file loaded at start-up by the Racket executable. The directory part of the path is the same path as returned for `'init-dir`.

  On Windows, the file part of the name is `"racketrc.rktl"`.

  On Unix and Mac OS, the file part of the name is `"racketrc.rktl"`—unless the path returned for `'init-dir` is the user's home directory, in which case the file part of the name is `".racketrc"`.

- `'config-dir` — a directory for the installation's configuration. This directory is specified by the `PLTCONFIGDIR` environment variable, and it can be overridden by the `--config` or `-G` command-line flag. If no environment variable or flag is specified, or if the value is not a legal path name, then this directory defaults to an `"etc"` directory relative to the current executable. If the result of `(find-system-path 'config-dir)` is a relative path, it is relative to the current executable. The directory might not exist.

- `'host-config-dir` — like `'config-dir`, but when cross-platform build mode has been selected (through the `-C` or `--cross` argument to `racket`; see §18.1.4 "Command Line"), the result refers to a directory for the current system's installation, instead of for the target system.

- `'addon-dir` — a directory for user-specific Racket configuration, packages, and extension. This directory is specified by the `PLTADDONDIR` environment variable, and it can be overridden by the `--addon` or `-A` command-line flag. If no environment variable or flag is specified, or if the value is not a legal path name, then this directory defaults to a platform-specific locations. The directory might not exist.

  On Unix, the default is normally the `"racket"` subdirectory of the path specified by `XDG_DATA_HOME`, or `".local/share/racket"` in the user's home directory if `XDG_CONFIG_HOME` is not set to an absolute path or if `PLTUSERHOME` is set. If that directory does not exists but a `".racket"` directory exists in the user's home directory, that the `".racket"` directory path is the default, instead.

  On Windows, the default is the same as the `'pref-dir` directory.

  On Mac OS, the default is `"Library/Racket"` within the user's home directory.

- `'host-addon-dir` — like `'addon-dir`, but when cross-platform build mode has been selected (through the `-C` or `--cross` argument to `racket`; see §18.1.4 "Command Line"), the result refers to a directory for the current system's installation, instead of for the target system.

  Added in version 8.17.0.2 of package `base`.

- `'cache-dir` — a directory for storing user-specific caches. The directory might not exist.

  On Unix, the cache directory is normally the `"racket"` subdirectory of the path specified by `XDG_CACHE_HOME`, or `".cache/racket"` in the user's home directory if `XDG_CACHE_HOME` is not set to an absolute path or if `PLTUSERHOME` is set. If that directory does not exist but a `".racket"` directory exists in the home directory, then the `".racket"` directory is the cache directory, instead.

  On Windows, the cache directory is the same as the result returned for `'addon-dir`.

  On Mac OS, the cache directory is `"Library/Caches/Racket"` within the user's home directory.

- `'doc-dir` — the standard directory for storing the current user's documents. On Unix, it's the user's home directory. On Windows, it is the user's home directory if determined by PLTUSERHOME, otherwise it is the user's documents folder as specified by the Windows registry; the documents folder is usually "My Documents" in the user's home directory. On Mac OS, it's the "Documents" directory in the user's home directory.

- 'desk-dir — the directory for the current user's desktop. On Unix, it's the user's home directory. On Windows, it is the user's home directory if determined by PLTUSERHOME, otherwise it is the user's desktop folder as specified by the Windows registry; the desktop folder is usually "Desktop" in the user's home directory. On Mac OS, it is "Desktop" in the user's home directory
- 'sys-dir — the directory containing the operating system for Windows. On Unix and Mac OS, the result is "/".
- 'exec-file — the path of the Racket executable as provided by the operating system for the current invocation. For some operating systems, the path can be relative.

For GRacket, the executable path is the name of a GRacket executable.

- 'run-file — the path of the current executable; this may be different from result for 'exec-file because an alternate path was provided through a --name or -N command-line flag to the Racket (or GRacket) executable, or because an embedding executable installed an alternate path. In particular a "launcher" script created by make-racket-launcher sets this path to the script's path.
- 'collects-dir — a path to the main collection of libraries (see §18.2 "Libraries and Collections"). If this path is relative, then it is relative to the executable as reported by (find-system-path 'exec-file)—though the latter could be a soft-link or relative to the user's executable search path, so that the two results should be combined with find-executable-path. The 'collects-dir path is normally embedded in the Racket executable, but it can be overridden by the --collects or -X command-line flag.
- 'host-collects-dir — like 'collects-dir, but when cross-platform build mode has been selected (through the -C or --cross argument to racket; see §18.1.4 "Command Line"), the result refers to a directory for the current system's installation, instead of for the target system. In cross-platform build mode, collection files are normally read from the target system's installation, but some tasks require current-system directories (such as the one that holds foreign libraries) that are configured relative to the main library-collection path.
- 'orig-dir — the current directory at start-up, which can be useful in converting a relative-path result from (find-system-path 'exec-file) or (find-system-path 'run-file) to a complete path.

Changed in version 6.0.0.3 of package base: Added PLTUSERHOME.
Changed in version 6.9.0.1: Added 'host-config-dir and 'host-collects-dir.
Changed in version 7.8.0.9: Added 'cache-dir, and changed to use XDG directories as preferred on Unix with the previous paths as a fallback, and with similar adjustments for Mac OS.

```
(path-list-string->path-list str
                             default-path-list)
 → (listof (or/c path? 'same))
  str : (or/c string? bytes?)
  default-path-list : (listof (or/c path? 'same))
```

Parses a string or byte string containing a list of paths, and returns a list of paths. On Unix and Mac OS, paths in a path-list string are separated by a `:`; on Windows, paths are separated by a `;`, and all `"`s in the string are discarded. Whenever the path list contains an empty path, the list *`default-path-list`* is spliced into the returned list of paths. Parts of *`str`* that do not form a valid path are not included in the returned list. The given *`str`* must not contain a nul character or nul byte.

Changed in version 8.0.0.10 of package `base`: Changed to allow `'same` in *`default-path-list`*.

```
(find-executable-path  program
                      [related
                       deepest?]) → (or/c path? #f)
  program : path-string?
  related : (or/c path-string? #f) = #f
  deepest? : any/c = #f
```

Finds a path for the executable *`program`*, returning `#f` if the path cannot be found.

On Windows, if *`program`* is not found and it has no file extension, then the search starts over with `".exe"` added to *`program`*, and the result is `#f` only if the path with `".exe"` also cannot be found. The result includes the extension `".exe"` if only *`program`* with the extension is found.

If *`related`* is not `#f`, then it must be a relative path string, and the path found for *`program`* must be such that the file or directory *`related`* exists in the same directory as the executable. The result is then the full path for the found *`related`*, instead of the path for the executable.

This procedure is used by the Racket executable to find the standard library collection directory (see §18.2 “Libraries and Collections”). In this case, *`program`* is the name used to start Racket and *`related`* is `"collects"`. The *`related`* argument is used because, on Unix and Mac OS, *`program`* may involve a sequence of soft links; in this case, *`related`* determines which link in the chain is relevant.

If *`related`* is not `#f`, then when `find-executable-path` does not find a *`program`* that is a link to another file path, the search can continue with the destination of the link. Further links are inspected until *`related`* is found or the end of the chain of links is reached. If *`deepest?`* is `#f` (the default), then the result corresponds to the first path in a chain of links for which *`related`* is found (and further links are not actually explored); otherwise, the result corresponds to the last link in the chain for which *`related`* is found.

If *program* is a pathless name, `find-executable-path` gets the value of the `PATH` environment variable; if this environment variable is defined, `find-executable-path` tries each path in `PATH` as a prefix for *program* using the search algorithm described above for path-containing *program*s. If the `PATH` environment variable is not defined, *program* is prefixed with the current directory and used in the search algorithm above. (On Windows, the current directory is always implicitly the first item in `PATH`, so `find-executable-path` checks the current directory first on Windows.)

Changed in version 8.1.0.7 of package `base`: Added search with `".exe"` on Windows.

15.2.2 Files

```
(file-exists? path) → boolean?
  path : path-string?
```

Returns `#t` if a file (not a directory) *path* exists, `#f` otherwise.

On Windows, `file-exists?` reports `#t` for all variations of the special filenames (e.g., `"LPT1"`, `"x:/baddir/LPT1"`).

```
(link-exists? path) → boolean?
  path : path-string?
```

Returns `#t` if a link *path* exists, `#f` otherwise.

The predicates `file-exists?` or `directory-exists?` work on the final destination of a link or series of links, while `link-exists?` only follows links to resolve the base part of *path* (i.e., everything except the last name in the path).

This procedure never raises the `exn:fail:filesystem` exception.

On Windows, `link-exists?` reports `#t` for both symbolic links and junctions.

Changed in version 6.0.1.12 of package `base`: Added support for links on Windows.

```
(file-or-directory-type path [must-exist?])
 → (or/c 'file 'directory 'link 'directory-link #f)
  path : path-string?
  must-exist? : any/c = #f
```

Reports whether *path* refers to a file, directory, link, or directory link (in the case of Windows; see also `make-file-or-directory-link`), assuming that *path* can be accessed.

If *path* cannot be accessed, the result is `#f` if *must-exist?* is `#f`, otherwise the `exn:fail:filesystem` exception is raised.

Added in version 7.8.0.5 of package base.

```
(delete-file path) → void?
  path : path-string?
```

Deletes the file with path *path* if it exists, otherwise the exn:fail:filesystem exception is raised. If *path* is a link, the link is deleted rather than the destination of the link.

On Windows, if an initial attempt to delete the file fails with a permission error and the value of current-force-delete-permissions is true, then delete-file attempts to change the file's permissions (to allow writes) and then delete the file; the permission change followed by deletion is a non-atomic sequence, with no attempt to revert a permission change if the deletion fails.

On Windows, delete-file can delete a symbolic link, but not a junction. Use delete-directory to delete a junction.

On Windows, beware that if a file is deleted while it remains in use by some process (e.g., a background search indexer), then the file's content will eventually go away, but the file's name remains occupied until the file is no longer used. As long as the name remains occupied, attempts to open, delete, or replace the file will trigger a permission error (as opposed to a file-exists error). A common technique to avoid this pitfall is to move the file to a generated temporary name before deleting it. See also delete-directory/files.

Changed in version 6.1.1.7 of package base: Changed Windows behavior to use current-force-delete-permissions.

```
(rename-file-or-directory old
                          new
                         [exists-ok?]) → void?
  old : path-string?
  new : path-string?
  exists-ok? : any/c = #f
```

Renames the file or directory with path *old*—if it exists—to the path *new*. If the file or directory is not renamed successfully, the exn:fail:filesystem exception is raised.

This procedure can be used to move a file/directory to a different directory (on the same filesystem) as well as rename a file/directory within a directory. Unless *exists-ok?* is provided as a true value, *new* cannot refer to an existing file or directory, but the check is not atomic with the rename operation on Unix and Mac OS. Even if *exists-ok?* is true, *new* cannot refer to an existing file when *old* is a directory, and vice versa.

If *new* exists and is replaced, the replacement is atomic on Unix and Mac OS, but it is not guaranteed to be atomic on Windows. Furthermore, if *new* exists and is opened by any process for reading or writing, then attempting to replace it will typically fail on Windows. See also call-with-atomic-output-file.

If *old* is a link, the link is renamed rather than the destination of the link, and it counts as a file for replacing any existing *new*.

On Windows, beware that a directory cannot be renamed if any file within the directory is open. That constraint is particularly problematic if a search indexer is running in the background (as in the default Windows configuration). A possible workaround is to combine `copy-directory/files` and `delete-directory/files`, since the latter can deal with open files, although that sequence is obviously not atomic and temporarily duplicates files.

```
(file-or-directory-modify-seconds  path
                                  [secs-n]) → exact-integer?
  path : path-string?
  secs-n : #f = #f
(file-or-directory-modify-seconds path
                                  secs-n) → void?
  path : path-string?
  secs-n : exact-integer?
(file-or-directory-modify-seconds  path
                                  [secs-n
                                   fail-thunk]) → any
  path : path-string?
  secs-n : (or/c exact-integer? #f) = #f
  fail-thunk : (-> any)
             = (lambda () (raise (make-exn:fail:filesystem ....)))
```

Returns the file or directory's last modification date in seconds since the epoch (see also §15.6 "Time") when *secs-n* is not provided or is `#f`.

For FAT filesystems on Windows, directories do not have modification dates. Therefore, the creation date is returned for a directory, but the modification date is returned for a file.

If *secs-n* is provided and not `#f`, the access and modification times of *path* are set to the given time.

On error (e.g., if no such file exists), then *fail-thunk* is called (through a tail call) to produce the result of the `file-or-directory-modify-seconds` call. If *fail-thunk* is not provided, an error raises `exn:fail:filesystem`.

```
(file-or-directory-permissions path [mode])
 → (listof (or/c 'read 'write 'execute))
  path : path-string?
  mode : #f = #f
(file-or-directory-permissions path mode) → (integer-in 0 65535)
  path : path-string?
  mode : 'bits
(file-or-directory-permissions path mode) → void
  path : path-string?
```

```
mode : (integer-in 0 65535)
```

When given one argument or `#f` as the second argument, returns a list containing `'read`, `'write`, and/or `'execute` to indicate permission the given file or directory path by the current user and group. On Unix and Mac OS, permissions are checked for the current effective user instead of the real user.

If `'bits` is supplied as the second argument, the result is a platform-specific integer encoding of the file or directory properties (mostly permissions), and the result is independent of the current user and group. The lowest nine bits of the encoding are somewhat portable, reflecting permissions for the file or directory's owner, members of the file or directory's group, or other users:

- `#o400` : owner has read permission
- `#o200` : owner has write permission
- `#o100` : owner has execute permission
- `#o040` : group has read permission
- `#o020` : group has write permission
- `#o010` : group has execute permission
- `#o004` : others have read permission
- `#o002` : others have write permission
- `#o001` : others have execute permission

See also `user-read-bit`, etc. On Windows, permissions from all three (owner, group, and others) are always the same, and read and execute permission are always available. On Unix and Mac OS, higher bits have a platform-specific meaning.

If an integer is supplied as the second argument, it is used as an encoding of properties (mostly permissions) to install for the file.

In all modes, the `exn:fail:filesystem` exception is raised on error (e.g., if no such file exists).

```
(file-or-directory-stat path [as-link?])
 → (and/c (hash/c symbol? any/c) hash-eq?)
  path : path-string?
  as-link? : boolean? = #f
```

Returns a hash with the following keys and values, where each value currently is a nonnegative exact integer:

- `'device-id` : device ID
- `'inode` : inode number
- `'mode` : mode bits (see below)
- `'hardlink-count` : number of hard links
- `'user-id` : numeric user ID of owner
- `'group-id` : numeric group ID of owner
- `'device-id-for-special-file` : device ID (if special file)
- `'size` : size of file or symbolic link in bytes
- `'block-size` : size of filesystem blocks
- `'block-count` : number of used filesystem blocks
- `'access-time-seconds` : last access time in seconds since the epoch
- `'modify-time-seconds` : last modification time in seconds since the epoch
- `'change-time-seconds` : last status change time in seconds since the epoch
- `'creation-time-seconds` : creation time in seconds since the epoch
- `'access-time-nanoseconds` : last access time in nanoseconds since the epoch
- `'modify-time-nanoseconds` : last modification time in nanoseconds since the epoch
- `'change-time-nanoseconds` : last status change time in nanoseconds since the epoch
- `'creation-time-nanoseconds` : creation time in nanoseconds since the epoch

If *`as-link?`* is a true value, then if *`path`* refers to a symbolic link, the stat information of the link is returned instead of the stat information of the referenced filesystem item.

The mode bits are the bits for permissions and other data, as returned from the Posix `stat`/`lstat` functions or the Windows `_wstat64` function, respectively. To select portions of the bit pattern, use the constants `user-read-bit`, etc.

Depending on the operating system and filesystem, the "nanoseconds" timestamps may have less than nanoseconds precision. For example, in one environment a timestamp may be `1234567891234567891` (nanoseconds precision) and in another environment `1234567891000000000` (seconds precision).

Values that aren't available for a platform/filesystem combination may be set to `0`. For example, this applies to the `'user-id` and `'group-id` keys on Windows. Also, Posix platforms provide the status change timestamp, but not the creation timestamp; for Windows it's the opposite.

If *as-link?* is #f and *path* isn't accessible, the exn:fail:filesystem exception is raised. This exception is also raised if *as-link?* is a true value and *path* can't be resolved, i.e., is a dangling link.

Added in version 8.3.0.7 of package base.

```
(file-or-directory-identity path [as-link?])
 → exact-positive-integer?
  path : path-string?
  as-link? : any/c = #f
```

Returns a number that represents the identity of *path* in terms of the device and file or directory that it accesses. This function can be used to check whether two paths correspond to the same filesystem entity under the assumption that the path's entity selection does not change.

If *as-link?* is a true value, then if *path* refers to a filesystem link, the identity of the link is returned instead of the identity of the referenced file or directory (if any).

```
(file-size path) → exact-nonnegative-integer?
  path : path-string?
```

Returns the (logical) size of the specified file in bytes. On Mac OS, this size excludes the resource-fork size. On error (e.g., if no such file exists), the exn:fail:filesystem exception is raised.

```
(copy-file  src
            dest
           [exists-ok?/pos
            #:exists-ok? exists-ok?
            #:permissions permissions
            #:replace-permissions? replace-permissions?]) → void?
  src : path-string?
  dest : path-string?
  exists-ok?/pos : any/c = #f
  exists-ok? : any/c = exists-ok?/pos
  permissions : (or/c #f (integer-in 0 65535)) = #f
  replace-permissions? : any/c = #t
```

Creates the file *dest* as a copy of *src*, if *dest* does not already exist. If *dest* already exists and *exists-ok?* is #f, the copy fails and the exn:fail:filesystem:exists? exception is raised; otherwise, if *dest* exists, its content is replaced with the content of *src*.

If *src* refers to a link, the target of the link is copied, rather than the link itself. If *dest* refers to a link and *exists-ok?* is true, the target of the link is updated.

File permissions are transferred from *src* to *dest*, unless *permissions* is supplied as non-#f on Unix and Mac OS, in which case *permissions* is used for *dest*. Beware that permissions are transferred without regard for the process's umask setting by default, but see *replace-permissions?* below. On Windows, the modification time of *src* is also transferred to *dest*; if *permissions* is supplied as non-#f, then after copying, *dest* is set to read-only or not depending on whether the #o2 bit is present in *permissions*.

The *replace-permissions?* argument is used only on Unix and Mac OS. When *dest*s is created, it is created with *permissions* or the permissions of *src*; however, the process's umask may unset bits in the requested permissions. When *dest* already exists (and *exists-ok?* is true), then the permissions of *dest* are initially left as-is. Finally, when *replace-permissions?* is a true value, then the permissions of *dest* are set after the file content is copied to *permissions* or the permissions of *src*, without modification by umask.

The *exists-ok?/pos* by-position argument is for backward compatibility. That by-position argument can be supplied, or the *exists-ok?* keyword argument can be supplied, but the exn:fail:contract exception is raised if both are supplied.

Changed in version 8.7.0.9 of package base: Added #:exists-ok?, #:permissions, and #:replace-permissions? arguments.

```
(make-file-or-directory-link to path) → void?
  to : path-string?
  path : path-string?
```

Creates a link *path* to *to*. The creation will fail if *path* already exists. The *to* need not refer to an existing file or directory, and *to* is not expanded before writing the link. If the link is not created successfully,the exn:fail:filesystem exception is raised.

On Windows XP and earlier, the exn:fail:unsupported exception is raised. On later versions of Windows, the creation of links tends to be disallowed by security policies. Windows distinguishes between file and directory links, and a directory link is created only if *to* parses syntactically as a directory (see path->directory-path). Furthermore, a relative-path link is parsed specially by the operating system; see §15.1.4 "Windows Paths" for more information. When make-file-or-directory-link succeeds, it creates a symbolic link as opposed to a junction or hard link. Beware that directory links must be deleted using delete-directory instead of delete-file.

Changed in version 6.0.1.12 of package base: Added support for links on Windows.

```
(current-force-delete-permissions) → boolean?
(current-force-delete-permissions force?) → void?
  force? : any/c
 = #t
```

A parameter that determines on Windows whether `delete-file` and `delete-directory` attempt to change a file or directory's permissions to delete it. The default value is `#t`.

15.2.3 Directories

See also: `rename-file-or-directory`, `file-or-directory-modify-seconds`, `file-or-directory-permissions`.

```
(current-directory) → (and/c path? complete-path?)
(current-directory path) → void?
  path : path-string?
```

A parameter that determines the current directory for resolving relative paths.

When the parameter procedure is called to set the current directory, the path argument is cleansed using `cleanse-path`, simplified using `simplify-path`, and then converted to a directory path with `path->directory-path`; cleansing and simplification raise an exception if the path is ill-formed. Thus, the current value of `current-directory` is always a cleansed, simplified, complete, directory path.

The path is not checked for existence when the parameter is set.

On Unix and Mac OS, the initial value of the parameter for a Racket process is taken from the `PWD` environment variable—if the value of the environment variable identifies the same directory as the operating system's report of the current directory.

```
(current-directory-for-user) → (and/c path? complete-path?)
(current-directory-for-user path) → void?
  path : path-string?
```

Like `current-directory`, but for use only by `srcloc->string` for reporting paths relative to a directory.

Normally, `current-directory-for-user` should stay at its initial value, reflecting the directory where a user started a process. A tool such as DrRacket, however, implicitly lets a user select a directory (for the file being edited), in which case updating `current-directory-for-user` makes sense.

```
(current-drive) → path?
```

Returns the current drive name Windows. For other platforms, the `exn:fail:unsupported` exception is raised. The current drive is always the drive of the current directory.

```
(directory-exists? path) → boolean?
  path : path-string?
```

Returns `#t` if *`path`* refers to a directory, `#f` otherwise.

```
(make-directory path [permissions]) → void?
  path : path-string?
  permissions : (integer-in 0 65535) = #o777
```

Creates a new directory with the path *`path`*. If the directory is not created successfully, the `exn:fail:filesystem` exception is raised.

The *`permissions`* argument specifies the permissions of the created directory, where an integer representation of permissions is treated the same as for `file-or-directory-permissions`. On Unix and Mac OS, these permissions bits are combined with the process's umask. On Windows, *`permissions`* is not used.

Changed in version 8.3.0.5 of package `base`: Added the *`permissions`* argument.

```
(delete-directory path) → void?
  path : path-string?
```

Deletes an existing directory with the path *`path`*. If the directory is not deleted successfully, the `exn:fail:filesystem` exception is raised.

On Windows, if an initial attempt to delete the directory fails with a permission error and the value of `current-force-delete-permissions` is true, then `delete-file` attempts to change the directory's permissions (to allow writes) and then delete the directory; the permission change followed by deletion is a non-atomic sequence, with no attempt to revert a permission change if the deletion fails.

Changed in version 6.1.1.7 of package `base`: Changed Windows behavior to use `current-force-delete-permissions`.

```
(directory-list [path #:build? build?]) → (listof path?)
  path : path-string? = (current-directory)
  build? : any/c = #f
```

See also the `in-directory` sequence constructor.

Returns a list of all files and directories in the directory specified by *`path`*. If *`build?`* is `#f`, the resulting paths are all path elements; otherwise, the individual results are combined with *`path`* using `build-path`. On Windows, an element of the result list may start with `\\?\REL\\`.

The resulting paths are always sorted using `path<?`.

```
(filesystem-root-list) → (listof path?)
```

Returns a list of all current root directories. Obtaining this list can be particularly slow on Windows.

15.2.4 Detecting Filesystem Changes

Many operating systems provide notifications for filesystem changes, and those notifications are reflected in Racket by filesystem change events.

```
(filesystem-change-evt? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a filesystem change event, `#f` otherwise.

```
(filesystem-change-evt path [failure-thunk])
 → (or/c filesystem-change-evt? any)
  path : path-string?
  failure-thunk : (or/c (-> any) #f) = #f
```

Creates a *filesystem change event*, which is a synchronizable event that becomes ready for synchronization after a change to *path*:

- If *path* refers to a file, the event becomes ready for synchronization when the file's content or attributes change, or when the file is deleted.
- If *path* refers to a directory, the event becomes ready for synchronization if a file or subdirectory is added, renamed, or removed within the directory.

The event also becomes ready for synchronization if it is passed to `filesystem-change-evt-cancel`.

Finally, depending on the precision of information available from the operating system, the event may become ready for synchronization under other circumstances. For example, on Windows, an event for a file becomes ready when any file changes within in the same directory as the file.

After a filesystem change event becomes ready for synchronization, it stays ready for synchronization. The event's synchronization result is the event itself.

If the current platform does not support filesystem-change notifications, then the `exn:fail:unsupported` exception is raised if *failure-thunk* is not provided as a procedure, or *failure-thunk* is called in tail position if provided. Similarly, if there is any operating-system error when creating the event (such as a non-existent file), then the `exn:fail:filesystem` exception is raised or *failure-thunk* is called.

Creation of a filesystem change event allocates resources at the operating-system level. The resources are released at latest when the event is sychronized and ready for synchronization, when the event is canceled with `filesystem-change-evt-cancel`, or when the garbage collector determine that the filesystem change event is unreachable. See also `system-type` in `'fs-change` mode.

A filesystem change event is placed under the management of the current custodian when it is created. If the custodian is shut down, `filesystem-change-evt-cancel` is applied to the event.

Changed in version 7.3.0.8 of package `base`: Allow `#f` for *`failure-thunk`*.

```
(filesystem-change-evt-ready? evt) → boolean?
  evt : filesystem-change-evt?
```

Equivalent to `(and (sync/timeout 0 evt) #t)`.

Added in version 8.18.0.6 of package `base`.

```
(filesystem-change-evt-cancel evt) → void?
  evt : filesystem-change-evt?
```

Causes *`evt`* to become immediately ready for synchronization, whether it was ready or not before, and releases the resources (at the operating-system level) for tracking filesystem changes.

15.2.5 Declaring Paths Needed at Run Time

```
(require racket/runtime-path)        package: base
```

The bindings documented in this section are provided by the `racket/runtime-path` library, not `racket/base` or `racket`.

The `racket/runtime-path` library provides forms for accessing files and directories at run time using a path that are usually relative to an enclosing source file. Unlike using `collection-path`, `define-runtime-path` exposes each run-time path to tools like the executable and distribution creators, so that files and directories needed at run time are carried along in a distribution.

In addition to the bindings described below, `racket/runtime-path` provides `#%datum` in phase level 1, since string constants are often used as compile-time expressions with `define-runtime-path`.

```
(define-runtime-path id maybe-runtime?-id expr)

maybe-runtime?-id =
                  | #:runtime?-id runtime?-id
```

Uses *`expr`* as both a compile-time (i.e., phase 1) expression and a run-time (i.e., phase 0) expression. In either context, *`expr`* should produce a path, a string that represents a path, a list of the form `(list 'lib str ...+)`, or a list of the form `(list 'so str)` or `(list` 'so str vers). If runtime?-id is provided, then it is bound in the context of expr to #f for the compile-time instance of expr and #t for the run-time instance of expr.

For run time, id is bound to a path that is based on the result of expr. The path is normally computed by taking a relative path result from expr and adding it to a path for the enclosing file (which is computed as described below). However, tools like the executable creator can also arrange (by colluding with racket/runtime-path) to have a different base path substituted in a generated executable. If expr produces an absolute path, it is normally returned directly, but again may be replaced by an executable creator. In all cases, the executable creator preserves the relative locations of all paths within a given package (treating paths outside of any package as being together). When expr produces a relative or absolute path, then the path bound to id is always an absolute path.

If expr produces a list of the form (list 'lib str ...+), the value bound to id is an absolute path. The path refers to a collection-based file similar to using the value as a module path.

If expr produces a list of the form (list 'so str) or (list 'so str vers), the value bound to id can be either str or an absolute path; it is an absolute path when searching in the Racket-specific shared-object library directories (as determined by get-lib-search-dirs) locates the path. In this way, shared-object libraries that are installed specifically for Racket get carried along in distributions. The search tries each directory in order; within a directory, the search tries using str directly, then it tries adding each version specified by vers—which defaults to '(#f)—along with a platform-specific shared-library extension—as produced by (system-type 'so-suffix). A vers can be a string, or it can be a list of strings and #f.

If expr produces a list of the form (list 'share str), the value bound to id can be either str or an absolute path; it is an absolute path when searching in the directories reported by find-user-share-dir and find-share-dir (in that order) locates the path. In this way, files that are installed in Racket's "share" directory get carried along in distributions.

If expr produces a list of the form (list 'module module-path var-ref) or (list 'so str (list str-or-false ...)), the value bound to id is a module path index, where module-path is treated as relative (if it is relative) to the module that is the home of the variable reference var-ref, where var-ref can be #f if module-path is absolute. In an executable, the corresponding module is carried along, including all of its dependencies.

For compile-time, the expr result is used by an executable creator—but not the result when the containing module is compiled. Instead, expr is preserved in the module as a compile-time expression (in the sense of begin-for-syntax). Later, at the time that an executable is created, the compile-time portion of the module is executed (again), and the result of expr is the file or directory to be included with the executable. The reason for the extra compile-time execution is that the result of expr might be platform-dependent, so the result should not be stored in the (platform-independent) bytecode form of the module; the platform at executable-creation time, however, is the same as at run time for the executable. Note that expr is still evaluated at run time; consequently, avoid procedures like collection-path, which depends on the source installation, and instead use relative paths and forms like `(list 'lib str ...+)`.

If a path is needed only on some platforms and not on others, use `define-runtime-path-list` with an *expr* that produces an empty list on platforms where the path is not needed.

Beware that if *expr* produces the path of a directory when creating an executable, the directory's full content (including any subdirectories) is included with the executable or eventual distribution.

Also beware that `define-runtime-path` in a phase level other than 0 does not cooperate properly with an executable creator. To work around that limitation, put `define-runtime-path` in a separate module—perhaps a submodule created by `module`—then export the definition, and then the module containing the definition can be `require`d into any phase level. Using `define-runtime-path` in a phase level other than 0 logs a warning at expansion time.

The enclosing path for a `define-runtime-path` is determined as follows from the `define-runtime-path` syntactic form:

- If the form has a source module according to `syntax-source-module`, then the source location is determined by preserving the original expression as a syntax object, extracting its source module path at run time (again using `syntax-source-module`), and then resolving the resulting module path index. Note that `syntax-source-module` is based on a syntax object's lexical information, not its source location.
- If the expression has no source module, the `syntax-source` location associated with the form is used, if is a string or path.
- If no source module is available, and `syntax-source` produces no path, then `current-load-relative-directory` is used if it is not `#f`. Finally, `current-directory` is used if all else fails.

In the latter two cases, the path is normally preserved in (platform-specific) byte form, but if the enclosing path corresponds to a result of `collection-file-path`, then the path is record as relative to the corresponding module path.

Changed in version 6.0.1.6 of package `base`: Preserve relative paths only within a package.
Changed in version 7.5.0.7: Added support for `'share` in *expr*.

Examples:

```
; Access a file "data.txt" at run-time that is originally
; located in the same directory as the module source file:
(define-runtime-path data-file "data.txt")
(define (read-data)
  (with-input-from-file data-file
```

```
      (lambda ()
        (read-bytes (file-size data-file)))))

  ; Load a platform-specific shared object (using ffi-lib)
  ; that is located in a platform-specific sub-directory of the
  ; module's source directory:
  (define-runtime-path libfit-path
    (build-path "compiled" "native" (system-library-subpath #f)
                (path-replace-suffix "libfit"
                                     (system-type 'so-suffix))))
  (define libfit (ffi-lib libfit-path))

  ; Load a platform-specific shared object that might be installed
  ; as part of the operating system, or might be installed
  ; specifically for Racket:
  (define-runtime-path libssl-so
    (case (system-type)
      [(windows) '(so "ssleay32")]
      [else '(so "libssl")]))
  (define libssl (ffi-lib libssl-so))
```

Changed in version 6.4 of package base: Added `#:runtime?-id`.

```
(define-runtime-paths (id ...) maybe-runtime?-id expr)
```

Like `define-runtime-path`, but declares and binds multiple paths at once. The *`expr`* should produce as many values as *`id`*s.

```
(define-runtime-path-list id maybe-runtime?-id expr)
```

Like `define-runtime-path`, but *`expr`* should produce a list of paths.

```
(define-runtime-module-path-index id maybe-runtime?-id module-path-
expr)
```

Similar to `define-runtime-path`, but *`id`* is bound to a module path index that encapsulates the result of *`module-path-expr`* relative to the enclosing module.

Use `define-runtime-module-path-index` to bind a module path that is passed to a reflective function like `dynamic-require` while also creating a module dependency for building and distributing executables.

```
(runtime-require module-path)
```

Similar to `define-runtime-module-path-index`, but creates the distribution dependency without binding a module path index. When `runtime-require` is used multiple times within a module with the same *module-path*, all but the first use expands to an empty begin.

```
(define-runtime-module-path id module-path)
```

Similar to define-runtime-path, but *id* is bound to a resolved module path. The resolved module path for *id* corresponds to *module-path* (with the same syntax as a module path for require), which can be relative to the enclosing module.

The define-runtime-module-path-index form is usually preferred, because it creates a weaker link to the referenced module. Unlike define-runtime-module-path-index, the define-runtime-module-path form creates a for-label dependency from an enclosing module to *module-path*. Since the dependency is merely for-label, *module-path* is not instantiated or visited when the enclosing module is instantiated or visited (unless such a dependency is created by other requires), but the code for the referenced module is loaded when the enclosing module is loaded.

```
(runtime-paths module-path)
```

This form is mainly for use by tools such as executable builders. It expands to a quoted list containing the run-time paths declared by *module-path*, returning the compile-time results of the declaration exprs, except that paths are converted to byte strings. The enclosing module must require (directly or indirectly) the module specified by *module-path*, which is an unquoted module path. The resulting list does *not* include module paths bound through define-runtime-module-path.

15.2.6 More File and Directory Utilities

```
(require racket/file)        package: base
```

The bindings documented in this section are provided by the racket/file and racket libraries, but not racket/base.

```
(file->string path [#:mode mode-flag]) → string?
  path : path-string?
  mode-flag : (or/c 'binary 'text) = 'binary
```

Reads all characters from *path* and returns them as a string. The *mode-flag* argument is the same as for open-input-file.

```
(file->bytes path [#:mode mode-flag]) → bytes?
  path : path-string?
  mode-flag : (or/c 'binary 'text) = 'binary
```

Reads all characters from *path* and returns them as a byte string. The *mode-flag* argument is the same as for open-input-file.

```
(file->value path [#:mode mode-flag]) → any
  path : path-string?
  mode-flag : (or/c 'binary 'text) = 'binary
```

Reads a single S-expression from *path* using `read`. The *mode-flag* argument is the same as for `open-input-file`.

```
(file->list path [proc #:mode mode-flag]) → (listof any/c)
  path : path-string?
  proc : (input-port? . -> . any/c) = read
  mode-flag : (or/c 'binary 'text) = 'binary
```

Repeatedly calls *proc* to consume the contents of *path*, until `eof` is produced. The *mode-flag* argument is the same as for `open-input-file`.

```
(file->lines  path
             [#:mode mode-flag
              #:line-mode line-mode]) → (listof string?)
  path : path-string?
  mode-flag : (or/c 'binary 'text) = 'binary
  line-mode : (or/c 'linefeed 'return 'return-linefeed 'any 'any-one)
            = 'any
```

Read all characters from *path*, breaking them into lines. The *line-mode* argument is the same as the second argument to `read-line`, but the default is `'any` instead of `'linefeed`. The *mode-flag* argument is the same as for `open-input-file`.

```
(file->bytes-lines  path
                   [#:mode mode-flag
                    #:line-mode line-mode]) → (listof bytes?)
  path : path-string?
  mode-flag : (or/c 'binary 'text) = 'binary
  line-mode : (or/c 'linefeed 'return 'return-linefeed 'any 'any-one)
            = 'any
```

Like `file->lines`, but reading bytes and collecting them into lines like `read-bytes-line`.

```
(display-to-file  v
                  path
                 [#:mode mode-flag
                  #:exists exists-flag]) → void?
  v : any/c
  path : path-string?
```

```
mode-flag : (or/c 'binary 'text) = 'binary
exists-flag : (or/c 'error 'append 'update
                    'replace 'truncate 'truncate/replace)
            = 'error
```

Uses `display` to print *v* to *path*. The *mode-flag* and *exists-flag* arguments are the same as for `open-output-file`.

```
(write-to-file  v
                path
               [#:mode mode-flag
                #:exists exists-flag]) → void?
  v : any/c
  path : path-string?
  mode-flag : (or/c 'binary 'text) = 'binary
  exists-flag : (or/c 'error 'append 'update
                      'replace 'truncate 'truncate/replace)
              = 'error
```

Like `display-to-file`, but using `write` instead of `display`.

```
(display-lines-to-file  lst
                        path
                       [#:separator separator
                        #:mode mode-flag
                        #:exists exists-flag]) → void?
  lst : list?
  path : path-string?
  separator : any/c = #"\n"
  mode-flag : (or/c 'binary 'text) = 'binary
  exists-flag : (or/c 'error 'append 'update
                      'replace 'truncate 'truncate/replace)
              = 'error
```

Displays each element of *lst* to *path*, adding *separator* after each element. The *mode-flag* and *exists-flag* arguments are the same as for `open-output-file`.

```
(copy-directory/files
  src
  dest
 [#:keep-modify-seconds? keep-modify-seconds?
  #:preserve-links? preserve-links?])
→ void?
  src : path-string?
  dest : path-string?
  keep-modify-seconds? : any/c = #f
  preserve-links? : any/c = #f
```

Copies the file or directory `src` to `dest`, raising `exn:fail:filesystem` if the file or directory cannot be copied, possibly because `dest` exists already. If `src` is a directory, the copy applies recursively to the directory's content. If a source is a link and `preserve-links?` is `#f`, the target of the link is copied rather than the link itself; if `preserve-links?` is `#t`, the link is copied.

If `keep-modify-seconds?` is `#f`, then file copies keep only the properties kept by `copy-file`. If `keep-modify-seconds?` is true, then each file copy also keeps the modification date of the original.

Changed in version 6.3 of package `base`: Added the `#:preserve-links?` argument.

```
(delete-directory/files  path
                        [#:must-exist? must-exist?]) → void?
  path : path-string?
  must-exist? : any/c = #t
```

Deletes the file or directory specified by `path`, raising `exn:fail:filesystem` if the file or directory cannot be deleted. If `path` is a directory, then `delete-directory/files` is first applied to each file and directory in `path` before the directory is deleted.

If `must-exist?` is true, then `exn:fail:filesystem` is raised if `path` does not exist. If `must-exist?` is false, then `delete-directory/files` succeeds if `path` does not exist (but a failure is possible if `path` initially exists and is removed by another thread or process before `delete-directory/files` deletes it).

On Windows, `delete-directory/files` attempts to move a file into the temporary-file directory before deleting it, which avoids problems caused by deleting a file that is currently open (e.g., by a search indexer running as a background process). If the move attempt fails (e.g., because the temporary directory is on a different drive than the file), then the file is deleted directly with `delete-file`.

Changed in version 7.0 of package `base`: Added Windows-specific file deletion.

```
(find-files
 predicate
 [start-path
  #:skip-filtered-directory? skip-filtered-directory?
  #:follow-links? follow-links?])
→ (listof path?)
 predicate : (path? . -> . any/c)
 start-path : (or/c path-string? #f) = #f
 skip-filtered-directory? : any/c = #f
 follow-links? : any/c = #f
```

Traverses the filesystem starting at `start-path` and creates a list of all files and directories for which *predicate* returns true. If *start-path* is #f, then the traversal starts from (current-directory). In the resulting list, each directory precedes its content.

The *predicate* procedure is called with a single argument for each file or directory. If *start-path* is #f, the argument is a pathname string that is relative to the current directory. Otherwise, it is a path building on *start-path*. Consequently, supplying (current-directory) for *start-path* is different from supplying #f, because *predicate* receives complete paths in the former case and relative paths in the latter. Another difference is that *predicate* is not called for the current directory when *start-path* is #f.

If *skip-filtered-directory?* is true, then when *predicate* returns #f for a directory, the directory's content is not traversed.

If *follow-links?* is true, the find-files traversal follows links, and links are not included in the result. If *follow-links?* is #f, then links are not followed, and links are included in the result.

If *start-path* does not refer to an existing file or directory, then *predicate* will be called exactly once with *start-path* as the argument.

The find-files procedure raises an exception if it encounters a directory for which directory-list fails.

Changed in version 6.3.0.11 of package base: Added the #:skip-filtered-directory? argument.

```
(pathlist-closure  path-list
                  [#:path-filter path-filter
                   #:follow-links? follow-links?])
 → (listof path?)
  path-list : (listof path-string?)
  path-filter : (or/c #f (path? . -> . any/c)) = #f
  follow-links? : any/c = #f
```

Given a list of paths, either absolute or relative to the current directory, returns a list such that

- if a nested path is given, all of its ancestors are also included in the result (but the same ancestor is not added twice);
- if a path refers to directory, all of its descendants are also included in the result, except as omitted by *path-filter*;
- ancestor directories appear before their descendants in the result list, as long as they are not misordered in the given *path-list*.

If *path-filter* is a procedure, then it is applied to each descendant of a directory. If *path-filter* returns #f, then the descendant (and any of its descendants, in the case of a subdirectory) are omitted from the result.

If *follow-links?* is true, then the traversal of directories and files follows links, and the link paths are not included in the result. If *follow-links?* is #f, then the result list includes paths to link and the links are not followed.

Changed in version 6.3.0.11 of package base: Added the #:path-filter argument.

```
(fold-files  proc
             init-val
            [start-path
             follow-links?]) → any
  proc : (or/c (path? (or/c 'file 'dir 'link) any/c
                 . -> . any/c)
               (path? (or/c 'file 'dir 'link) any/c
                 . -> . (values any/c any/c)))
  init-val : any/c
  start-path : (or/c path-string? #f) = #f
  follow-links? : any/c = #t
```

Traverses the filesystem starting at *start-path*, calling *proc* on each discovered file, directory, and link. If *start-path* is #f, then the traversal starts from (current-directory).

The *proc* procedure is called with three arguments for each file, directory, or link:

- If *start-path* is #f, the first argument is a pathname string that is relative to the current directory. Otherwise, the first argument is a pathname that starts with *start-path*. Consequently, supplying (current-directory) for *start-path* is different from supplying #f, because *proc* receives complete paths in the former case and relative paths in the latter. Another difference is that *proc* is not called for the current directory when *start-path* is #f.
- The second argument is a symbol, either 'file, 'dir, or 'link. The second argument can be 'link when *follow-links?* is #f, in which case the filesystem traversal does not follow links. If *follow-links?* is #t, then *proc* will only get a 'link as a second argument when it encounters a dangling symbolic link (one that does not resolve to an existing file or directory).
- The third argument is the accumulated result. For the first call to *proc*, the third argument is *init-val*. For the second call to *proc* (if any), the third argument is the result from the first call, and so on. The result of the last call to *proc* is the result of fold-files.

The *proc* argument is used in an analogous way to the procedure argument of foldl, where its result is used as the new accumulated result. There is an exception for the case of a directory (when the second argument is 'dir): in this case the procedure may return two values, the second indicating whether the recursive scan should include the given directory or not. If it returns a single value, the directory is scanned. In the cases of files or links (when the second argument is 'file or 'link), a second value is permitted but ignored.

If the *start-path* is provided but no such path exists, or if paths disappear during the scan, then an exception is raised.

```
(make-directory* path) → void?
  path : path-string?
```

Creates directory specified by *path*, creating intermediate directories as necessary, and never failing if *path* exists already.

If *path* is a relative path and the current directory does not exist, then make-directory* will not create the current directory, because it considers only explicit elements of *path*.

```
(make-parent-directory* path) → void?
  path : path-string?
```

Creates the parent directory of the path specified by *path*, creating intermediate directories as necessary, and never failing if an ancestor of *path* exists already.

If *path* is a filesystem root or a relative path with a single path element, then no directory is created. Like make-directory*, if *path* is a relative path and the current directory does not exist, then make-parent-directory* will not create it.

Added in version 6.1.1.3 of package base.

```
(make-temporary-file [template
                      #:copy-from copy-from
                      #:base-dir base-dir
                      compat-copy-from
                      compat-base-dir])
 → (and/c path? complete-path?)
  template : string? = "rkttmp~a"
  copy-from : (or/c path-string? #f 'directory) = #f
  base-dir : (or/c path-string? #f) = #f
  compat-copy-from : (or/c path-string? #f 'directory)
                   = copy-from
  compat-base-dir : (or/c path-string? #f) = base-dir
```

Creates a new temporary file and returns its path. Instead of merely generating a fresh file name, the file is actually created; this prevents other threads or processes from picking the same temporary name.

The *template* argument must be a format string suitable for use with format and one additional string argument (which will contain only digits). By default, if *template* produces a relative path, it is combined with the result of (find-system-path 'temp-dir) using build-path; alternatively, *template* may produce an absolute path, in which case (find-system-path 'temp-dir) is not consulted. If *base-dir* is provided and non-#false, *template* must not produce a complete path, and *base-dir* will be used instead of (find-system-path 'temp-dir). Using *base-dir* is generally more reliable than including directory components in *template*: it avoids subtle bugs from manipulating paths as string and eleminates the need to sanitize format escape sequences.

On Windows, *template* may produce an absolute path which is not a complete path (see §15.1.4 "Windows Paths") when *base-dir* is absent or #f (in which case it will be resolved relative to (current-directory)) or if *base-dir* is a drive specification (in which case it will be used as with build-path). If *base-dir* is any other kind of path, it is an error for *template* to produce an absolute path.

When the *template* argument is not provided, if there is source location information for the callsite of make-temporary-file, a template string is generated based on the source location: the default is "rkttmp~a" only when no source location information is available (e.g. if make-temporary-file is used in a higher-order position).

If *copy-from* is provided as path, the temporary file is created as a copy of the named file (using copy-file). If *copy-from* is #f, the temporary file is created as empty. As a special case, for backwards compatibility, if *copy-from* is 'directory, then the temporary "file" is created as a directory: for clarity, prefer make-temporary-directory for creating temporary directories.

When a temporary file is created, it is not opened for reading or writing when the path is returned. The client program calling make-temporary-file is expected to open the file with the desired access and flags (probably using the 'truncate flag; see open-output-file) and to delete it when it is no longer needed.

The by-position arguments *compat-copy-from* and *compat-base-dir* are for backwards compatibility: if provided, they take precedence over the #:copy-from and #:base-dir keyword variants. Supplying by-position arguments prevents make-temporary-file from generating a *template* using the source location.

Changed in version 8.4.0.3 of package base: Added the #:copy-from and #:base-dir arguments.

```
(make-temporary-directory [template
                           #:base-dir base-dir])
 → (and/c path? complete-path?)
  template : string? = "rkttmp~a"
  base-dir : (or/c path-string? #f) = #f
```

Like make-temporary-file, but creates a directory, rather than a regular file.

As with make-temporary-file, if the *template* argument is not provided, a template string is generated from the source location of the call to make-temporary-directory when possible: the default is "rkttmp~a" only when no source location information is available.

Added in version 8.4.0.3 of package base.

```
(make-temporary-file*  prefix
                       suffix
                      [#:copy-from copy-from
                       #:base-dir base-dir])
 → (and/c path? complete-path?)
  prefix : bytes?
  suffix : bytes?
  copy-from : (or/c path-string? #f) = #f
  base-dir : (or/c path-string? #f) = #f
(make-temporary-directory*  prefix
                            suffix
                           [#:base-dir base-dir])
 → (and/c path? complete-path?)
  prefix : bytes?
  suffix : bytes?
  base-dir : (or/c path-string? #f) = #f
```

Like make-temporary-file and make-temporary-directory, respectively, but, rather than using a template for format, the path is based on (bytes-append *prefix* generated *suffix*), where generated is a byte string chosen by the implementation to produce a unique path. If there is source location information for the callsite of make-temporary-file* or make-temporary-directory*, generated will incorporate that information. The resulting path is combined with *base-dir* as with make-temorary-file.

Added in version 8.4.0.3 of package base.

```
 (call-with-atomic-output-file
  file
  proc
 [#:security-guard security-guard
  #:rename-fail-handler rename-fail-handler])
 → any
  file : path-string?
  proc : (output-port? path? . -> . any)
  security-guard : (or/c #f security-guard?) = #f
  rename-fail-handler : (or/c #f (exn:fail:filesystem? path? . -> . any))
                      = #f
```

Opens a temporary file for writing in the same directory as *file*, calls *proc* to write to the temporary file, and then atomically (except on Windows) moves the temporary file in place of *file*. The move simply uses rename-file-or-directory on Unix and Mac OS, and it uses rename-file-or-directory on Windows if *rename-fail-handler* is provided;

otherwise, on Windows, the moves uses an extra rename step (see below) on Windows to avoid problems due to concurrent readers of *file*.

The *proc* function is called with an output port for the temporary file, plus the path of the temporary file. The result of *proc* is the result of `call-with-atomic-output-file`.

The `call-with-atomic-output-file` function arranges to delete temporary files on exceptions.

Windows prevents programs from deleting or replacing files that are open, but it allows renaming of open files. Therefore, on Windows, `call-with-atomic-output-file` by default creates a second temporary file *extra-tmp-file*, renames *file* to *extra-tmp-file*, renames the temporary file written by *proc* to *file*, and finally deletes *extra-tmp-file*. Since that process is not atomic, however, `rename-file-or-directory` is used if *rename-fail-handler* is provided, where `rename-file-or-directory` has some chance of being atomic, since that the source and destination of the moves will be in the same directory; any filesystem exception while attempting to rename the file is send to *rename-fail-handler*, which can re-`raise` the exception or simply return to try again, perhaps after a delay. In addition to a filesystem exception, the *rename-fail-handler* procedure also receives the temporary file path to be moved to `path`. The *rename-fail-handler* argument is used only on Windows.

Changed in version 7.1.0.6 of package `base`: Added the `#:rename-fail-handler` argument.

```
(get-preference  name
                [failure-thunk
                 flush-mode
                 filename
                 #:use-lock? use-lock?
                 #:timeout-lock-there timeout-lock-there
                 #:lock-there lock-there])              → any
  name : symbol?
  failure-thunk : (-> any) = (lambda () #f)
  flush-mode : any/c = 'timestamp
  filename : (or/c path-string? #f) = #f
  use-lock? : any/c = #t
  timeout-lock-there : (or/c (path? . -> . any) #f) = #f
  lock-there :  (or/c (path? . -> . any) #f)
             = (make-handle-get-preference-locked
                0.01 name failure-thunk flush-mode filename
                #:lock-there timeout-lock-there)
```

Extracts a preference value from the file designated by `(find-system-path 'pref-file)`, or by *filename* if it is provided and is not `#f`. In the former case, if the preference file doesn't exist, `get-preferences` attempts to read an old preferences file, and then a `"racket-prefs.rktd"` file in the configuration directory (as reported by `find-config-dir`), instead. If none of those files exists, the preference set is empty.

The preference file should contain a list of symbol–value lists written with the default parameter settings. Keys starting with `racket:`, `mzscheme:`, `mred:`, and `plt:` in any letter case are reserved for use by Racket implementors. If the preference file does not contain a list of symbol–value lists, an error is logged via `log-error` and *`failure-thunk`* is called.

The result of `get-preference` is the value associated with *`name`* if it exists in the association list, or the result of calling *`failure-thunk`* otherwise.

Preference settings are cached (weakly) across calls to `get-preference`, using `(path->complete-path filename)` as a cache key. If *`flush-mode`* is provided as `#f`, the cache is used instead of re-consulting the preferences file. If *`flush-mode`* is provided as `'timestamp` (the default), then the cache is used only if the file has a timestamp that is the same as the last time the file was read. Otherwise, the file is re-consulted.

On platforms for which `preferences-lock-file-mode` returns `'file-lock` and when *`use-lock?`* is true, preference-file reading is guarded by a lock; multiple readers can share the lock, but writers take the lock exclusively. If the preferences file cannot be read because the lock is unavailable, *`lock-there`* is called on the path of the lock file; if *`lock-there`* is `#f`, an exception is raised. The default *`lock-there`* handler retries about 5 times (with increasing delays between each attempt) before trying *`timeout-lock-there`*, and the default *`timeout-lock-there`* triggers an exception.

See also `put-preferences`. For a more elaborate preference system, see `preferences:get`.

Old preferences files: When a *`filename`* is not provided and the file indicated by `(find-system-path 'pref-file)` does not exist, the following paths are checked for compatibility with old versions of Racket:

- Windows: `(build-path (find-system-path 'pref-dir) 'up "PLT Scheme" "plt-prefs.ss")`
- Mac OS: `(build-path (find-system-path 'pref-dir) "org.plt-scheme.prefs.ss")`
- Unix: `(expand-user-path "~/.plt-scheme/plt-prefs.ss")`

```
(put-preferences  names
                  vals
                 [locked-proc
                  filename])  → void?
  names : (listof symbol?)
  vals : list?
  locked-proc : (or/c #f (path? . -> . any)) = #f
  filename : (or/c #f path-string?) = #f
```

Installs a set of preference values and writes all current values to the preference file designated by (find-system-path 'pref-file), or *filename* if it is supplied and not #f.

The *names* argument supplies the preference names, and *vals* must have the same length as *names*. Each element of *vals* must be an instance of a built-in data type whose write output is readable (i.e., the print-unreadable parameter is set to #f while writing preferences).

Current preference values are read from the preference file before updating, and a write lock is held starting before the file read, and lasting until after the preferences file is updated. The lock is implemented by the existence of a file in the same directory as the preference file; see preferences-lock-file-mode for more information. If the directory of the preferences file does not already exist, it is created.

If the write lock is already held, then *locked-proc* is called with a single argument: the path of the lock file. The default *locked-proc* (used when the *locked-proc* argument is #f) reports an error; an alternative thunk might wait a while and try again, or give the user the choice to delete the lock file (in case a previous update attempt encountered disaster and locks are implemented by the presence of the lock file).

If *filename* is #f or not supplied, and the preference file does not already exist, then values read from the "defaults" collection (if any) are written for preferences that are not mentioned in *names*.

```
(preferences-lock-file-mode) → (or/c 'exists 'file-lock)
```

Reports the way that the lock file is used to implement preference-file locking on the current platform.

The 'exists mode is currently used on all platforms except Windows. In 'exists mode, the existence of the lock file indicates that a write lock is held, and readers need no lock (because the preferences file is atomically updated via rename-file-or-directory).

The 'file-lock mode is currently used on Windows. In 'file-lock mode, shared and exclusive locks (in the sense of port-try-file-lock?) on the lock file reflect reader and writer locks on the preference-file content. (The preference file itself is not locked, because a lock would interfere with replacing the file via rename-file-or-directory.)

```
(make-handle-get-preference-locked  delay
                                    name
                                   [failure-thunk
                                    flush-mode
                                    filename
                                    #:lock-there lock-there
                                    #:max-delay max-delay])
 → (path-string? . -> . any)
  delay : real?
```

```
name : symbol?
failure-thunk : (-> any) = (lambda () #f)
flush-mode : any/c = 'timestamp
filename : (or/c path-string? #f) = #f
lock-there : (or/c (path? . -> . any) #f) = #f
max-delay : real? = 0.2
```

Creates a procedure suitable for use as the `#:lock-there` argument to `get-preference`, where the *`name`*, *`failure-thunk`*, *`flush-mode`*, and *`filename`* are all passed on to `get-preference` by the result procedure to retry the preferences lookup.

Before calling `get-preference`, the result procedure uses `(sleep delay)` to pause. Then, if `(* 2 delay)` is less than *`max-delay`*, the result procedure calls `make-handle-get-preference-locked` to generate a new retry procedure to pass to `get-preference`, but with a *`delay`* of `(* 2 delay)`. If `(* 2 delay)` is not less than *`max-delay`*, then `get-preference` is called with the given *`lock-there`*, instead.

```
(call-with-file-lock/timeout  filename
                              kind
                              thunk
                              failure-thunk
                             [#:lock-file lock-file
                              #:delay delay
                              #:max-delay max-delay]) → any
  filename : (or/c path-string? #f)
  kind : (or/c 'shared 'exclusive)
  thunk : (-> any)
  failure-thunk : (-> any)
  lock-file : (or/c #f path-string?) = #f
  delay : (and/c real? (not/c negative?)) = 0.01
  max-delay : (and/c real? (not/c negative?)) = 0.2
```

Obtains a lock for the filename *`lock-file`* and then calls *`thunk`*. The *`filename`* argument specifies a file path prefix that is used only to generate the lock filename when *`lock-file`* is `#f`. Specifically, when *`lock-file`* is `#f`, then `call-with-file-lock/timeout` uses `make-lock-file-name` to build the lock filename. If the lock file does not yet exist, it is created; beware that the lock file is *not* deleted by `call-with-file-lock/timeout`.

When *`thunk`* returns, `call-with-file-lock/timeout` releases the lock, returning the result of *`thunk`*. The `call-with-file-lock/timeout` function will retry after *`delay`* seconds and continue retrying with exponential backoff until delay reaches *`max-delay`*. If `call-with-file-lock/timeout` fails to obtain the lock, *`failure-thunk`* is called in tail position. The *`kind`* argument specifies whether the lock is `'shared` or `'exclusive` in the sense of `port-try-file-lock?`.

Examples:

```
> (call-with-file-lock/timeout filename 'exclusive
    (lambda () (printf "File is locked\n"))
    (lambda () (printf "Failed to obtain lock for file\n")))
File is locked
> (call-with-file-lock/timeout #f 'exclusive
    (lambda ()
      (call-with-file-lock/timeout filename 'shared
        (lambda () (printf "Shouldn't get here\n"))
        (lambda () (printf "Failed to obtain lock for file\n"))))
    (lambda () (printf "Shouldn't get here either\n"))
    #:lock-file (make-lock-file-name filename))
Failed to obtain lock for file
```

```
(make-lock-file-name path) → path?
  path : (or/c path-string? path-for-some-system?)
(make-lock-file-name dir name) → path?
  dir : (or/c path-string? path-for-some-system?)
  name : path-element?
```

Creates a lock filename by prepending `"_LOCK"` on Windows (i.e., when `cross-system-type` reports `'windows`) or `".LOCK"` on other platforms to the file portion of the path.

Example:

```
> (make-lock-file-name "/home/george/project/important-file")
#<path:/home/george/project/.LOCKimportant-file>
```

```
file-type-bits : #o170000
socket-type-bits : #o140000
symbolic-link-type-bits : #o120000
regular-file-type-bits : #o100000
block-device-type-bits : #o060000
directory-type-bits : #o040000
character-device-type-bits : #o020000
fifo-type-bits : #o010000
set-user-id-bit : #o004000
set-group-id-bit : #o002000
sticky-bit : #o001000
user-permission-bits : #o000700
user-read-bit : #o000400
user-write-bit : #o000200
user-execute-bit : #o000100
group-permission-bits : #o000070
group-read-bit : #o000040
group-write-bit : #o000020
```

```
group-execute-bit : #o000010
other-permission-bits : #o000007
other-read-bit : #o000004
other-write-bit : #o000002
other-execute-bit : #o000001
```

Constants that are useful with `file-or-directory-permissions`, `file-or-directory-stat` and bitwise operations such as `bitwise-ior`, and `bitwise-and`.

15.3 Networking

15.3.1 TCP

```
(require racket/tcp)        package: base
```

The bindings documented in this section are provided by the `racket/tcp` and `racket` libraries, but not `racket/base`.

For information about TCP in general, see *TCP/IP Illustrated, Volume 1* by W. Richard Stevens.

```
(tcp-listen  port-no
            [max-allow-wait
             reuse?
             hostname])      → tcp-listener?
  port-no : listen-port-number?
  max-allow-wait : exact-nonnegative-integer? = 4
  reuse? : any/c = #f
  hostname : (or/c string? #f) = #f
```

Creates a "listening" server on the local machine at the port number specified by *`port-no`*. If *`port-no`* is 0 the socket binds to an ephemeral port, which can be determined by calling `tcp-addresses`. The *`max-allow-wait`* argument determines the maximum number of client connections that can be waiting for acceptance. (When *`max-allow-wait`* clients are awaiting acceptance, no new client connections can be made.)

If the *`reuse?`* argument is true, then `tcp-listen` will create a listener even if the port is involved in a `TIME_WAIT` state. Such a use of *`reuse?`* defeats certain guarantees of the TCP protocol; see Stevens's book for details. Furthermore, on many modern platforms, a true value for *`reuse?`* overrides `TIME_WAIT` only if the listener was previously created with a true value for *`reuse?`*.

If *`hostname`* is `#f` (the default), then the listener accepts connections to all of the listening machine's addresses. Otherwise, the listener accepts connections only at the interface(s) associated with the given hostname. For example, providing "127.0.0.1" as *hostname* creates a listener that accepts only connections to "127.0.0.1" (the loopback interface) from the local machine.

Racket implements a listener with multiple sockets, if necessary, to accommodate multiple addresses with different protocol families. On Linux, if *hostname* maps to both IPv4 and IPv6 addresses, then the behavior depends on whether IPv6 is supported and IPv6 sockets can be configured to listen to only IPv6 connections: if IPv6 is not supported or IPv6 sockets are not configurable, then the IPv6 addresses are ignored; otherwise, each IPv6 listener accepts only IPv6 connections.

On variants of Unix and MacOS that support `FD_CLOEXEC`, a listener socket is given that flag so that it is not shared with a subprocess created by `subprocess`.

The return value of `tcp-listen` is a *TCP listener*. This value can be used in future calls to `tcp-accept`, `tcp-accept-ready?`, and `tcp-close`. Each new TCP listener value is placed into the management of the current custodian (see §14.7 "Custodians").

If the server cannot be started by `tcp-listen`, the `exn:fail:network` exception is raised.

A TCP listener can be used as a synchronizable event (see §11.2.1 "Events"). A TCP listener is ready for synchronization when `tcp-accept` would not block; the synchronization result of a TCP listener is the TCP listener itself.

Changed in version 8.11.1.6 of package `base`: Changed to use `FD_CLOEXEC` where supported by the operating system.

```
(tcp-connect  hostname
              port-no
             [local-hostname
              local-port-no]) → input-port? output-port?
  hostname : string?
  port-no : port-number?
  local-hostname : (or/c string? #f) = #f
  local-port-no : (or/c port-number? #f) = #f
```

Attempts to connect as a client to a listening server. The *hostname* argument is the server host's Internet address name, and *port-no* is the port number where the server is listening.

(If *hostname* is associated with multiple addresses, they are tried one at a time until a connection succeeds. The name "localhost" generally specifies the local machine.)

The optional *local-hostname* and *local-port-no* specify the client's address and port. If both are `#f` (the default), the client's address and port are selected automatically. If *local-hostname* is not `#f`, then *local-port-no* must be non-`#f`. If *local-port-no* is non-`#f` and *local-hostname* is `#f`, then the given port is used but the address is selected automatically.

Two values are returned by `tcp-connect`: an input port and an output port. Data can be received from the server through the input port and sent to the server through the output port. If the server is a Racket program, it can obtain ports to communicate to the client with `tcp-accept`. These ports are placed into the management of the current custodian (see §14.7 "Custodians").

Initially, the returned input port is block-buffered, and the returned output port is block-buffered. Change the buffer mode using `file-stream-buffer-mode`. When a TCP output port is block-buffered, Nagle's algorithm is disabled for the port, which corresponds to setting the `TCP_NODELAY` socket option.

Both of the returned ports must be closed to terminate the TCP connection. When both ports are still open, closing the output port with `close-output-port` sends a TCP close to the server (which is seen as an end-of-file if the server reads the connection through a port). In contrast, `tcp-abandon-port` (see below) closes the output port, but does not send a TCP close until the input port is also closed.

Note that the TCP protocol does not support a state where one end is willing to send but not read, nor does it include an automatic message when one end of a connection is fully closed. Instead, the other end of a connection discovers that one end is fully closed only as a response to sending data; in particular, some number of writes on the still-open end may appear to succeed, though writes will eventually produce an error.

On variants of Unix and MacOS that support `FD_CLOEXEC`, a connection socket is given that flag so that it is not shared with a subprocess created by `subprocess`.

If a connection cannot be established by `tcp-connect`, the `exn:fail:network` exception is raised.

Changed in version 8.8.0.8 of package `base`: Changed block buffering to imply `TCP_NODELAY`.
Changed in version 8.11.1.6: Changed to use `FD_CLOEXEC` where supported by the operating system.

```
(tcp-connect/enable-break  hostname
                           port-no
                          [local-hostname]
                           local-port-no)
 → input-port? output-port?
  hostname : string?
  port-no : port-number?
  local-hostname : (or/c string? #f) = #f
  local-port-no : (or/c port-number? #f)
```

Like `tcp-connect`, but breaking is enabled (see §10.6 "Breaks") while trying to connect. If breaking is disabled when `tcp-connect/enable-break` is called, then either ports are returned or the `exn:break` exception is raised, but not both.

```
(tcp-accept listener) → input-port? output-port?
```

```
listener : tcp-listener?
```

Accepts a client connection for the server associated with *listener*. If no client connection is waiting on the listening port, the call to `tcp-accept` will block. (See also `tcp-accept-ready?`.)

Two values are returned by `tcp-accept`: an input port and an output port. Data can be received from the client through the input port and sent to the client through the output port. These ports are placed into the management of the current custodian (see §14.7 "Custodians").

In terms of buffering and connection states, the ports act the same as ports from `tcp-connect`.

On variants of Unix and MacOS that support `FD_CLOEXEC`, an accepted socket is given that flag so that it is not shared with a subprocess created by `subprocess`.

If a connection cannot be accepted by `tcp-accept`, or if the listener has been closed, the `exn:fail:network` exception is raised.

Changed in version 8.11.1.6 of package `base`: Changed to use `FD_CLOEXEC` where supported by the operating system.

```
(tcp-accept/enable-break listener) → input-port? output-port?
  listener : tcp-listener?
```

Like `tcp-accept`, but breaking is enabled (see §10.6 "Breaks") while trying to accept a connection. If breaking is disabled when `tcp-accept/enable-break` is called, then either ports are returned or the `exn:break` exception is raised, but not both.

```
(tcp-accept-ready? listener) → boolean?
  listener : tcp-listener?
```

Tests whether an unaccepted client has connected to the server associated with *listener*. If a client is waiting, the return value is `#t`, otherwise it is `#f`. A client is accepted with the `tcp-accept` procedure, which returns ports for communicating with the client and removes the client from the list of unaccepted clients.

If the listener has been closed, the `exn:fail:network` exception is raised.

```
(tcp-close listener) → void?
  listener : tcp-listener?
```

Shuts down the server associated with *listener*. All unaccepted clients receive an end-of-file from the server; connections to accepted clients are unaffected.

If the listener has already been closed, the `exn:fail:network` exception is raised.

The listener's port number may not become immediately available for new listeners (with the default *reuse?* argument of `tcp-listen`). For further information, see Stevens's explanation of the `TIME_WAIT` TCP state.

```
(tcp-listener? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a TCP listener created by `tcp-listen`, `#f` otherwise.

```
(tcp-accept-evt listener) → evt?
  listener : tcp-listener?
```

Returns a synchronizable event (see §11.2.1 "Events") that is ready for synchronization when `tcp-accept` on *listener* would not block. The synchronization result is a list of two items, which correspond to the two results of `tcp-accept`. (If the event is not chosen in a `sync`, no connections are accepted.) The ports are placed into the management of the custodian that is the current custodian (see §14.7 "Custodians") at the time that `tcp-accept-evt` is called.

```
(tcp-abandon-port tcp-port) → void?
  tcp-port : tcp-port?
```

Like `close-output-port` or `close-input-port` (depending on whether *tcp-port* is an input or output port), but if *tcp-port* is an output port and its associated input port is not yet closed, then the other end of the TCP connection does not receive a TCP close message until the input port is also closed.

The TCP protocol does not include a "no longer reading" state on connections, so `tcp-abandon-port` is equivalent to `close-input-port` on input TCP ports.

```
(tcp-addresses tcp-port [port-numbers?])
 → (or/c (values string? string?)
         (values string? port-number?
                 string? listen-port-number?))
  tcp-port : (or/c tcp-port? tcp-listener? udp?)
  port-numbers? : any/c = #f
```

Returns two strings when *port-numbers?* is `#f` (the default). The first string is the Internet address for the local machine as viewed by the given TCP port's connection, for the TCP listener, or the UDP socket. (When a machine serves multiple addresses, as it usually does if you count the loopback device, the result is connection-specific or listener-specific.) If a listener or UDP socket is given and it has no specific host, the first string result is `"0.0.0.0"`. The second string is the Internet address for the other end of the connection, or always `"0.0.0.0"` for a listener or unconnected UDP socket.

If *port-numbers?* is true, then four results are returned: a string for the local machine's address, an exact integer between `1` and `65535` for the local machine's port number, a string for the remote machine's address, and an exact integer between `1` and `65535` for the remote machine's port number or `0` for a listener.

If the given port, listener, or socket has been closed, the `exn:fail:network` exception is raised.

```
(tcp-port? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a *TCP port*—which is a port returned by `tcp-accept`, `tcp-connect`, `tcp-accept/enable-break`, or `tcp-connect/enable-break`—`#f` otherwise.

```
port-number? : contract?
```

Equivalent to `(integer-in 1 65535)`.

Added in version 6.3 of package `base`.

```
listen-port-number? : contract?
```

Equivalent to `(integer-in 0 65535)`.

Added in version 6.3 of package `base`.

15.3.2 UDP

```
(require racket/udp)        package: base
```

The bindings documented in this section are provided by the `racket/udp` and `racket` libraries, but not `racket/base`.

For information about UDP in general, see *TCP/IP Illustrated, Volume 1* by W. Richard Stevens.

```
(udp-open-socket [family-hostname
                  family-port-no]) → udp?
  family-hostname : (or/c string? #f) = #f
  family-port-no : (or/c port-number? #f) = #f
```

Creates and returns a *UDP socket* to send and receive datagrams (broadcasting is allowed). Initially, the socket is not bound or connected to any address or port.

If *family-hostname* or *family-port-no* is not `#f`, then the socket's protocol family is determined from these arguments. The socket is *not* bound to the hostname or port number.

For example, the arguments might be the hostname and port to which messages will be sent through the socket, which ensures that the socket's protocol family is consistent with the destination. Alternately, the arguments might be the same as for a future call to `udp-bind!`, which ensures that the socket's protocol family is consistent with the binding. If neither *`family-hostname`* nor *`family-port-no`* is non-`#f`, then the socket's protocol family is IPv4.

On variants of Unix and MacOS that support `FD_CLOEXEC`, a socket is given that flag so that it is not shared with a subprocess created by `subprocess`.

Changed in version 8.11.1.6 of package `base`: Changed to use `FD_CLOEXEC` where supported by the operating system.

```
(udp-bind!  udp-socket
            hostname-string
            port-no
           [reuse?])         → void?
  udp-socket : udp?
  hostname-string : (or/c string? #f)
  port-no : listen-port-number?
  reuse? : any/c = #f
```

Binds an unbound *`udp-socket`* to the local port number *`port-no`*. If *`port-no`* is 0 the *`udp-socket`* is bound to an ephemeral port, which can be determined by calling `udp-addresses`.

If *`hostname-string`* is `#f`, then the socket accepts connections to all of the listening machine's IP addresses at *`port-no`*. Otherwise, the socket accepts connections only at the IP address associated with the given name. For example, providing `"127.0.0.1"` as *`hostname-string`* typically creates a listener that accepts only connections to `"127.0.0.1"` from the local machine.

A socket cannot receive datagrams until it is bound to a local address and port. If a socket is not bound before it is used with a sending procedure `udp-send`, `udp-send-to`, etc., the sending procedure binds the socket to a random local port. Similarly, if an event from `udp-send-evt` or `udp-send-to-evt` is chosen for a synchronization (see §11.2.1 "Events"), the socket is bound; if the event is not chosen, the socket may or may not become bound.

The binding of a bound socket cannot be changed, with one exception: on some systems, if the socket is bound automatically when sending, if the socket is disconnected via `udp-connect!`, and if the socket is later used again in a send, then the later send may change the socket's automatic binding.

If *`udp-socket`* is already bound or closed, the `exn:fail:network` exception is raised.

If the *`reuse?`* argument is true, then `udp-bind!` will set the `SO_REUSEADDR` socket option before binding, permitting the sharing of access to a UDP port between many processes on a single machine when using UDP multicast.

```
(udp-connect! udp-socket
              hostname-string
              port-no)          → void?
  udp-socket : udp?
  hostname-string : (or/c string? #f)
  port-no : (or/c port-number? #f)
```

Connects the socket to the indicated remote address and port if *hostname-string* is a string and *port-no* is an exact integer.

If *hostname-string* is `#f`, then *port-no* also must be `#f`, and the port is disconnected (if connected). If one of *hostname-string* or *port-no* is `#f` and the other is not, the `exn:fail:contract` exception is raised.

A connected socket can be used with `udp-send` (not `udp-send-to`), and it accepts datagrams only from the connected address and port. A socket need not be connected to receive datagrams. A socket can be connected, re-connected, and disconnected any number of times.

If *udp-socket* is closed, the `exn:fail:network` exception is raised.

```
(udp-send-to  udp-socket
              hostname
              port-no
              bstr
             [start-pos
              end-pos])   → void?
  udp-socket : udp?
  hostname : string?
  port-no : port-number?
  bstr : bytes?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Sends `(subbytes bytes start-pos end-pos)` as a datagram from the unconnected *udp-socket* to the socket at the remote machine `hostname-address` on the port *port-no*. The *udp-socket* need not be bound or connected; if it is not bound, `udp-send-to` binds it to a random local port. If the socket's outgoing datagram queue is too full to support the send, `udp-send-to` blocks until the datagram can be queued.

If *start-pos* is greater than the length of *bstr*, or if *end-pos* is less than *start-pos* or greater than the length of *bstr*, the `exn:fail:contract` exception is raised.

If *udp-socket* is closed or connected, the `exn:fail:network` exception is raised.

```
(udp-send udp-socket bstr [start-pos end-pos]) → void?
  udp-socket : udp?
  bstr : bytes?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `udp-send-to`, except that *udp-socket* must be connected, and the datagram goes to the connection target. If *udp-socket* is closed or unconnected, the `exn:fail:network` exception is raised.

```
(udp-send-to* udp-socket
              hostname
              port-no
              bstr
             [start-pos
              end-pos])  → boolean?
  udp-socket : udp?
  hostname : string?
  port-no : port-number?
  bstr : bytes?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `udp-send-to`, but never blocks; if the socket's outgoing queue is too full to support the send, `#f` is returned, otherwise the datagram is queued and the result is `#t`.

```
(udp-send* udp-socket bstr [start-pos end-pos]) → boolean?
  udp-socket : udp?
  bstr : bytes?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `udp-send`, except that (like `udp-send-to`) it never blocks and returns `#f` or `#t`.

```
(udp-send-to/enable-break udp-socket
                          hostname
                          port-no
                          bstr
                         [start-pos
                          end-pos])  → void?
  udp-socket : udp?
  hostname : string?
  port-no : port-number?
  bstr : bytes?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like udp-send-to, but breaking is enabled (see §10.6 "Breaks") while trying to send the datagram. If breaking is disabled when udp-send-to/enable-break is called, then either the datagram is sent or the exn:break exception is raised, but not both.

```
(udp-send/enable-break  udp-socket
                        bstr
                       [start-pos
                        end-pos])   → void?
  udp-socket : udp?
  bstr : bytes?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like udp-send, except that breaks are enabled like udp-send-to/enable-break.

```
(udp-receive!  udp-socket
               bstr
              [start-pos
               end-pos])   → exact-nonnegative-integer?
                             string?
                             port-number?
  udp-socket : udp?
  bstr : (and/c bytes? (not immutable?))
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Accepts up to *end-pos*-*start-pos* bytes of *udp-socket*'s next incoming datagram into *bstr*, writing the datagram bytes starting at position *start-pos* within *bstr*. The *udp-socket* must be bound to a local address and port (but need not be connected). If no incoming datagram is immediately available, udp-receive! blocks until one is available.

Three values are returned: the number of received bytes (between 0 and *end-pos*-*start-pos*, a hostname string indicating the source address of the datagram, and an integer indicating the source port of the datagram. If the received datagram is longer than *end-pos*-*start-pos* bytes, the remainder is discarded.

If *start-pos* is greater than the length of *bstr*, or if *end-pos* is less than *start-pos* or greater than the length of *bstr*, the exn:fail:contract exception is raised.

```
(udp-receive!*  udp-socket
                bstr
               [start-pos
                end-pos])
 → (or/c exact-nonnegative-integer? #f)
   (or/c string? #f)
   (or/c port-number? #f)
```

```
  udp-socket : udp?
  bstr : (and/c bytes? (not immutable?))
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `udp-receive!`, except that it never blocks. If no datagram is available, the three result values are all `#f`.

```
(udp-receive!/enable-break  udp-socket
                            bstr
                           [start-pos
                            end-pos])
 → exact-nonnegative-integer?
   string?
   port-number?
  udp-socket : udp?
  bstr : (and/c bytes? (not immutable?))
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Like `udp-receive!`, but breaking is enabled (see §10.6 "Breaks") while trying to receive the datagram. If breaking is disabled when `udp-receive!/enable-break` is called, then either a datagram is received or the `exn:break` exception is raised, but not both.

```
(udp-set-receive-buffer-size! udp-socket
                              size)      → void?
  udp-socket : udp?
  size : exact-positive-integer?
```

Set the receive buffer size (`SO_RCVBUF`) for *udp-socket*. Using a larger buffer can minimize packet loss that can occur due to slow polling of a connection, including during a major garbage collection.

If *size* is greater than the maximum allowed by the system, the `exn:fail:network` exception is raised.

Added in version 7.1.0.11 of package `base`.

```
(udp-close udp-socket) → void?
  udp-socket : udp?
```

Closes *udp-socket*, discarding unreceived datagrams. If the socket is already closed, the `exn:fail:network` exception is raised.

```
(udp? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a socket created by `udp-open-socket`, `#f` otherwise.

```
(udp-bound? udp-socket) → boolean?
  udp-socket : udp?
```

Returns `#t` if *udp-socket* is bound to a local address and port, `#f` otherwise.

```
(udp-connected? udp-socket) → boolean?
  udp-socket : udp?
```

Returns `#t` if *udp-socket* is connected to a remote address and port, `#f` otherwise.

```
(udp-send-ready-evt udp-socket) → evt?
  udp-socket : udp?
```

Returns a synchronizable event (see §11.2.1 "Events") that is in a blocking state when `udp-send-to` on *udp-socket* would block. The synchronization result is the event itself.

```
(udp-receive-ready-evt udp-socket) → evt?
  udp-socket : udp?
```

Returns a synchronizable event (see §11.2.1 "Events") that is in a blocking state when `udp-receive!` on *udp-socket* would block. The synchronization result is the event itself.

```
(udp-send-to-evt  udp-socket
                  hostname
                  port-no
                  bstr
                 [start-pos
                  end-pos])  → evt?
  udp-socket : udp?
  hostname : string?
  port-no : port-number?
  bstr : bytes?
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Returns a synchronizable event. The event is in a blocking state when `udp-send-to` on *udp-socket* would block. Otherwise, if the event is chosen in a synchronization, data is sent as for `(udp-send-to udp-socket hostname-address port-no bstr start-pos end-pos)`, and the synchronization result is `#<void>`. (No bytes are sent if the event is not chosen.)

```
(udp-send-evt  udp-socket
               bstr
              [start-pos
               end-pos])  → evt?
```

```
udp-socket : udp?
bstr : bytes?
start-pos : exact-nonnegative-integer? = 0
end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Returns a synchronizable event. The event is ready for synchronization when `udp-send` on *udp-socket* would not block. Otherwise, if the event is chosen in a synchronization, data is sent as for `(udp-send-to udp-socket bstr start-pos end-pos)`, and the synchronization result is `#<void>`. (No bytes are sent if the event is not chosen.) If *udp-socket* is closed or unconnected, the `exn:fail:network` exception is raised during a synchronization attempt.

```
(udp-receive!-evt  udp-socket
                   bstr
                  [start-pos
                   end-pos])   → evt?
  udp-socket : udp?
  bstr : (and/c bytes? (not immutable?))
  start-pos : exact-nonnegative-integer? = 0
  end-pos : exact-nonnegative-integer? = (bytes-length bstr)
```

Returns a synchronizable event. The event is ready for synchronization when `udp-receive` on *udp-socket* would not block. Otherwise, if the event is chosen in a synchronization, data is received into *bstr* as for `(udp-receive! udp-socket bytes start-pos end-pos)`, and the synchronization result is a list of three values, corresponding to the three results from `udp-receive!`. (No bytes are received and the *bstr* content is not modified if the event is not chosen.)

```
(udp-addresses udp-port [port-numbers?])
 → (or/c (values string? string?)
         (values string? listen-port-number?
                 string? listen-port-number?))
  udp-port : udp?
  port-numbers? : any/c = #f
```

Returns two strings when *port-numbers?* is `#f` (the default). The first string is the Internet address for the local machine a viewed by the given UDP socket's connection. (For most machines, the answer corresponds to the current machine's only Internet address, but when a machine serves multiple addresses, the result is connection-specific.) The second string is the Internet address for the other end of the connection.

If *port-numbers?* is true, then four results are returned: a string for the local machine's address, an exact integer between `1` and `65535` for the local machine's port number or `0` if the socket is unbound, a string for the remote machine's address, and an exact integer between `1` and `65535` for the remote machine's port number or `0` if the socket is unconnected.

If the given port has been closed, the `exn:fail:network` exception is raised.

```
(udp-set-ttl! udp-socket ttl) → void?
  udp-socket : udp?
  ttl : byte?
(udp-ttl udp-socket) → byte?
  udp-socket : udp?
```

Sets or retrieves the current time-to-live setting of *udp-socket*.

Time-to-live settings correspond to the `IP_TTL` setting of the socket.

Added in version 7.5.0.5 of package `base`.

```
(udp-multicast-join-group! udp-socket
                           multicast-addr
                           hostname)      → void?
  udp-socket : udp?
  multicast-addr : string?
  hostname : (or/c string? #f)
(udp-multicast-leave-group! udp-socket
                            multicast-addr
                            hostname)      → void?
  udp-socket : udp?
  multicast-addr : string?
  hostname : (or/c string? #f)
```

Adds or removes *udp-socket* to a named multicast group.

The *multicast-addr* argument must be a valid IPv4 multicast IP address; for example, `"224.0.0.251"` is the appropriate address for the mDNS protocol. The *hostname* argument selects the interface that the socket uses to receive (not send) multicast datagrams; if *hostname* is `#f` or `"0.0.0.0"`, the kernel selects an interface automatically.

Leaving a group requires the same *multicast-addr* and *hostname* arguments that were used to join the group.

```
(udp-multicast-interface udp-socket) → string?
  udp-socket : udp?
(udp-multicast-set-interface! udp-socket
                              hostname)  → void?
  udp-socket : udp?
  hostname : (or/c string? #f)
```

Retrieves or sets the interface that *udp-socket* uses to send (not receive) multicast datagrams. If the result or *hostname* is either `#f` or `"0.0.0.0"`, the kernel automatically selects an interface when a multicast datagram is sent.

```
(udp-multicast-set-loopback! udp-socket
                             loopback?) → void?
  udp-socket : udp?
  loopback? : any/c
(udp-multicast-loopback? udp-socket) → boolean?
  udp-socket : udp?
```

Sets or checks whether *udp-socket* receives its own multicast datagrams: a #t result or a true value for *loopback?* indicates that self-receipt is enabled, and #f indicates that self-receipt is disabled.

Loopback settings correspond to the IP_MULTICAST_LOOP setting of the socket.

```
(udp-multicast-set-ttl! udp-socket ttl) → void?
  udp-socket : udp?
  ttl : byte?
(udp-multicast-ttl udp-socket) → byte?
  udp-socket : udp?
```

Sets or retrieves the current time-to-live setting of *udp-socket*.

Time-to-live settings correspond to the IP_MULTICAST_TTL setting of the socket.

The time-to-live setting should almost always be 1, and it is important that this number is as low as possible. In fact, these functions seldom should be used at all. See the documentation for your platform's IP stack.

15.4 Processes

```
(subprocess  stdout
             stdin
             stderr
            [group]
             command
             arg ...)
 → subprocess?
   (or/c (and/c input-port? file-stream-port?) #f)
   (or/c (and/c output-port? file-stream-port?) #f)
   (or/c (and/c input-port? file-stream-port?) #f)
  stdout : (or/c (and/c output-port? file-stream-port?) #f)
  stdin : (or/c (and/c input-port? file-stream-port?) #f)
  stderr : (or/c (and/c output-port? file-stream-port?) #f 'stdout)
  group :  (or/c #f 'new subprocess)
        = (and (subprocess-group-enabled) 'new)
  command : path-string?
  arg : (or/c path? string-no-nuls? bytes-no-nuls?)
```

```
(subprocess  stdout
             stdin
             stderr
            [group]
             command
             exact
             arg)
 → subprocess?
   (or/c (and/c input-port? file-stream-port?) #f)
   (or/c (and/c output-port? file-stream-port?) #f)
   (or/c (and/c input-port? file-stream-port?) #f)
  stdout : (or/c (and/c output-port? file-stream-port?) #f)
  stdin : (or/c (and/c input-port? file-stream-port?) #f)
  stderr : (or/c (and/c output-port? file-stream-port?) #f)
  group :  (or/c #f 'new subprocess)
        = (and (subprocess-group-enabled) 'new)
  command : path-string?
  exact : 'exact
  arg : string?
```

Creates a new process in the underlying operating system to execute *command* asynchronously, providing the new process with environment variables `current-environment-variables`. See also `system` and `process` from `racket/system`.

On Unix and Mac OS, subprocess creation is separate from starting the program indicated by *command*. In particular, if *command* refers to a non-existent or non-executable file, an error will be reported (via standard error and a non-0 exit code) in the subprocess, not in the creating process.

The *command* argument is a path to a program executable, and the *arg*s are command-line arguments for the program. See `find-executable-path` for locating an executable based on the `PATH` environment variable. On Unix and Mac OS, command-line arguments are passed as byte strings, and string *arg*s are converted using the current locale's encoding (see §13.1.1 "Encodings and Locales"). On Windows, command-line arguments are passed as strings, and byte strings are converted using UTF-8.

For information on the Windows command-line conventions, see Microsoft's documentation source or search for "command line parsing" at `http://msdn.microsoft.com/`.

On Windows, a process natively receives a single command-line argument string, unlike Unix and Mac OS processes that natively receive an array of arguments. A Windows command-line string is constructed from *command* and *arg*s following a Windows convention so that a typical application can parse it back to an array of arguments, but beware that an application may parse the command line in a different way. In particular, *take special care when supplying a* `command` *that refers to a* `".bat"` *or* `".cmd"` *file*, because the command-line string delivered to the process will be parsed as a `cmd.exe` command, which is effectively a different syntax than the convention that `subprocess` uses to encode command-line arguments; supplying unsanitized *arg*s could enable parsing of arguments as commands. To enable more control over the command-line string that is delivered to a process, the first *arg* can be replaced with `'exact`, which triggers a Windows-specific behavior: the sole *arg* is used exactly as the command-line for the subprocess. If `'exact` is provided on a non-Windows platform, the `exn:fail:contract` exception is raised.

When provided as a port, *stdout* is used for the launched process's standard output, *stdin* is used for the process's standard input, and *stderr* is used for the process's standard error. All provided ports must be file-stream ports. Any of the ports can be `#f`, in which case a system pipe is created and returned by `subprocess`. The *stderr* argument can be `'stdout`, in which case the same file-stream port or system pipe that is supplied as standard output is also used for standard error. For each port or `'stdout` that is provided, no pipe is created and the corresponding returned value is `#f`. If *stdout* or *stderr* is a port for which `port-waiting-peer?` returns true, then `subprocess` waits for the port to become ready for writing before proceeding with the subprocess creation.

If *group* is `'new`, then the new process is created as a new OS-level process group. In that case, `subprocess-kill` attempts to terminate all processes within the group, which may include additional processes created by the subprocess. See `subprocess-kill` for details. If *group* is a subprocess, then that subprocess must have been created with `'new`, and the new subprocess will be added to the group; adding to the group will succeed only on Unix and Mac OS, and only in the same cases that `subprocess-kill` would have an effect (i.e., the subprocess is not known to have terminated), otherwise it will fail silently.

Beware that creating a group may interfere with the job control in an interactive shell, since job control is based on process groups.

The `subprocess` procedure returns four values:

- a *subprocess* value representing the created process;
- an input port piped from the process's standard output, or `#f` if *stdout* was a port;
- an output port piped to the process's standard input, or `#f` if *stdin* was a port;
- an input port piped from the process's standard error, or `#f` if *stderr* was a port or `'stdout`.

Important: All ports returned from `subprocess` must be explicitly closed, usually with `close-input-port` or `close-output-port`.

A file-stream port for communicating with a subprocess is normally a pipe with a limited capacity. Beware of creating deadlock by serializing a write to a subprocess followed by a read, while the subprocess does the same, so that both processes end up blocking on a write because the other end must first read to make room in the pipe. Beware also of waiting for a subprocess to finish without reading its output, because the subprocess may be blocked attempting to write output into a full pipe.

The returned ports are file-stream ports (see §13.1.5 "File Ports"), and they are placed into the management of the current custodian (see §14.7 "Custodians"). The `exn:fail` exception is raised when a low-level error prevents the spawning of a process or the creation of operating system pipes for process communication.

The `current-subprocess-custodian-mode` parameter determines whether the subprocess itself is registered with the current custodian so that a custodian shutdown calls `subprocess-kill` for the subprocess.

The `current-subprocess-keep-file-descriptors` parameter determines how file descriptors and handles in the current process are shared with the subprocess. File descriptors (on Unix and Mac OS) or handles (on Windows) represented by *stdin*, *stdout*, and *stderr* are always shared with the subprocess. File descriptors and handles that are replaced by newly created pipes (when the corresponding *stdin*, *stdout*, and *stderr* argument is `#f`) are not shared. Sharing for other file descriptors and handles depends on the parameter value:

- 'inherited (the default) — other handles that are inherited on Windows are shared with the subprocess; file descriptors that lack the FD_CLOEXEC flag on Unix and Mac OS variants that support the flag are also shared; and no other file descriptors are shared on variants of Unix and Mac OS that do not support FD_CLOEXEC.
- 'all — like 'inherited, except on variants of Unix and Mac OS that do not support FD_CLOEXEC, in which case all file descriptors are shared.
- '() — no additional file descriptors are shared, not even ones that are inherited on Windows or lacking the FD_CLOEXEC flag.

A subprocess can be used as a synchronizable event (see §11.2.1 "Events"). A subprocess value is ready for synchronization when subprocess-wait would not block; the synchronization result of a subprocess value is the subprocess value itself.

Example:

```
(define-values (sp out in err)
  (subprocess #f #f #f "/bin/ls" "-l"))
(printf "stdout:\n~a" (port->string out))
(printf "stderr:\n~a" (port->string err))
(close-input-port out)
(close-output-port in)
(close-input-port err)
(subprocess-wait sp)
```

Changed in version 6.11.0.1 of package base: Added the *group* argument.
Changed in version 7.4.0.5: Added waiting for a fifo without a reader as *stdout* and/or *stderr*.
Changed in version 8.3.0.4: Added current-subprocess-custodian-mode support.
Changed in version 8.11.1.6: Changed the treatment of file-descriptor sharing on variants of Unix and Mac OS that support FD_CLOEXEC.

```
(subprocess-wait subproc) → void?
  subproc : subprocess?
```

Blocks until the process represented by *subproc* terminates. The *subproc* value also can be used with sync and sync/timeout.

```
(subprocess-status subproc) → (or/c 'running
                                    exact-nonnegative-integer?)
  subproc : subprocess?
```

Returns 'running if the process represented by *subproc* is still running, or its exit code otherwise. The exit code is an exact integer, and 0 typically indicates success. If the process terminated due to a fault or signal, the exit code is non-zero.

```
(subprocess-kill subproc force?) → void?
  subproc : subprocess?
  force? : any/c
```

Terminates the subprocess represented by *subproc*. The precise action depends on whether *force?* is true, whether the process was created in its own group by setting the subprocess-group-enabled parameter to a true value, and the current platform:

- *force?* is true, not a group, all platforms: Terminates the process if the process still running.
- *force?* is false, not a group, on Unix or Mac OS: Sends the process an interrupt signal instead of a kill signal.
- *force?* is false, not a group, on Windows: No action is taken.
- *force?* is true, a group, on Unix or Mac OS: Terminates all processes in the group, but only if subprocess-status has never produced a non-'running result for the subprocess and only if functions like subprocess-wait and sync have not detected the subprocess's completion. Otherwise, no action is taken (because the immediate process is known to have terminated while the continued existence of the group is unknown).
- *force?* is true, a group, on Windows: Terminates the process if the process still running.
- *force?* is false, a group, on Unix or Mac OS: The same as when *force?* is #t, but when the group is sent a signal, it is an interrupt signal instead of a kill signal.
- *force?* is false, a group, on Windows: All processes in the group receive a CTRL-BREAK signal (independent of whether the immediate subprocess has terminated).

If an error occurs during termination, the exn:fail exception is raised.

```
(subprocess-pid subproc) → exact-nonnegative-integer?
  subproc : subprocess?
```

Returns the operating system's numerical ID (if any) for the process represented by *subproc*. The result is valid only as long as the process is running.

```
(subprocess? v) → boolean?
  v : any/c
```

Returns #t if *v* is a subprocess value, #f otherwise.

```
(current-subprocess-custodian-mode)
 → (or/c #f 'kill 'interrupt)
(current-subprocess-custodian-mode mode) → void?
  mode : (or/c #f 'kill 'interrupt)
```

A parameter that determines whether a subprocess (as created by `subprocess` or wrappers like `process`) is registered with the current custodian. If the parameter value is `#f`, then the subprocess is not registered with the custodian—although any created ports are registered. If the parameter value is `'kill` or `'interrupt`, then the subprocess is shut down through `subprocess-kill`, where `'kill` supplies a `#t` value for the *force?* argument and `'interrupt` supplies a `#f` value. The shutdown may occur either before or after ports created for the subprocess are closed.

Custodian-triggered shutdown is limited by details of process handling in the host system. For example, `process` and `system` may create an intermediate shell process to run a program, in which case custodian-based termination shuts down the shell process and probably not the process started by the shell. See also `subprocess-kill`. Process groups (see `subprocess-group-enabled`) can address some limitations, but not all of them.

```
(subprocess-group-enabled) → boolean?
(subprocess-group-enabled on?) → void?
  on? : any/c
```

A parameter that determines whether a subprocess is created as a new process group by default. See `subprocess` and `subprocess-kill` for more information.

```
(current-subprocess-keep-file-descriptors)
 → (or/c 'inherited 'all '())
(current-subprocess-keep-file-descriptors keeps) → void?
  keeps : (or/c 'inherited 'all '())
```

A parameter that determines how file descriptors (on Unix and Mac OS) and handles (on Windows) are shared in a subprocess as created by `subprocess` or wrappers like `process`. See `subprocess` for more information.

Added in version 8.3.0.4 of package `base`.

```
(shell-execute verb
               target
               parameters
               dir
               show-mode) → #f
  verb : (or/c string? #f)
  target : string?
  parameters : string?
```

```
dir : path-string?
show-mode : symbol?
```

Performs the action specified by *verb* on *target* in Windows. For platforms other than Windows, the `exn:fail:unsupported` exception is raised.

For example,

```
(shell-execute #f "http://racket-lang.org" ""
               (current-directory) 'sw_shownormal)
```

Opens the Racket home page in a browser window.

The *verb* can be `#f`, in which case the operating system will use a default verb. Common verbs include `"open"`, `"edit"`, `"find"`, `"explore"`, and `"print"`.

The *target* is the target for the action, usually a filename path. The file could be executable, or it could be a file with a recognized extension that can be handled by an installed application.

The *parameters* argument is passed on to the system to perform the action. For example, in the case of opening an executable, the *parameters* is used as the command line (after the executable name).

The *dir* is used as the current directory when performing the action.

The *show-mode* sets the display mode for a Window affected by the action. It must be one of the following symbols; the description of each symbol's meaning is taken from the Windows API documentation.

- `'sw_hide` or `'SW_HIDE` — Hides the window and activates another window.
- `'sw_maximize` or `'SW_MAXIMIZE` — Maximizes the window.
- `'sw_minimize` or `'SW_MINIMIZE` — Minimizes the window and activates the next top-level window in the z-order.
- `'sw_restore` or `'SW_RESTORE` — Activates and displays the window. If the window is minimized or maximized, Windows restores it to its original size and position.
- `'sw_show` or `'SW_SHOW` — Activates the window and displays it in its current size and position.
- `'sw_showdefault` or `'SW_SHOWDEFAULT` — Uses a default.
- `'sw_showmaximized` or `'SW_SHOWMAXIMIZED` — Activates the window and displays it as a maximized window.

- 'sw_showminimized or 'SW_SHOWMINIMIZED — Activates the window and displays it as a minimized window.
- 'sw_showminnoactive or 'SW_SHOWMINNOACTIVE — Displays the window as a minimized window. The active window remains active.
- 'sw_showna or 'SW_SHOWNA — Displays the window in its current state. The active window remains active.
- 'sw_shownoactivate or 'SW_SHOWNOACTIVATE — Displays a window in its most recent size and position. The active window remains active.
- 'sw_shownormal or 'SW_SHOWNORMAL — Activates and displays a window. If the window is minimized or maximized, Windows restores it to its original size and position.

If the action fails, the exn:fail exception is raised. If the action succeeds, the result is #f.

In future versions of Racket, the result may be a subprocess value if the operating system did returns a process handle (but if a subprocess value is returned, its process ID will be 0 instead of the real process ID).

15.4.1 Simple Subprocesses

```
(require racket/system)        package: base
```

The bindings documented in this section are provided by the racket/system and racket libraries, but not racket/base.

```
(system command [#:set-pwd? set-pwd?]) → boolean?
  command : (or/c string-no-nuls? bytes-no-nuls?)
  set-pwd? : any/c = (member (system-type) '(unix macosx))
```

Executes a shell command synchronously (i.e., the call to system does not return until the subprocess has ended). On Unix and Mac OS, /bin/sh is used as the shell, while cmd.exe or command.com (if cmd.exe is not found) is used on Windows. The *command* argument is a string or byte string containing no nul characters. If the command succeeds, the return value is #t, #f otherwise.

See also subprocess for notes about error handling and the limited buffer capacity of subprocess pipes.

If *set-pwd?* is true, then the PWD environment variable is set to the value of (current-directory) when starting the shell process.

See also current-subprocess-custodian-mode and subprocess-group-enabled, which affect the subprocess used to implement system.

The resulting process writes to `(current-output-port)`, reads from `(current-input-port)`, and logs errors to `(current-error-port)`. To gather the process's non-error output to a string, for example, use `with-output-to-string`, which sets `current-output-port` while calling the given function:

```
(with-output-to-string (lambda () (system "date")))
```

```
(system* command arg ... [#:set-pwd? set-pwd?]) → boolean?
  command : path-string?
  arg : (or/c path? string-no-nuls? bytes-no-nuls?)
  set-pwd? : any/c = (member (system-type) '(unix macosx))
(system* command
         exact
         arg
        [#:set-pwd? set-pwd?]) → boolean?
  command : path-string?
  exact : 'exact
  arg : string?
  set-pwd? : any/c = (member (system-type) '(unix macosx))
```

Like `system`, except that *command* is a filename that is executed directly (instead of through a shell command; see `find-executable-path` for locating an executable based on the `PATH` environment variable), and the *arg*s are the arguments. The executed file is passed the specified string arguments (which must contain no nul characters).

On Windows, the first argument after *command* can be `'exact`, and the final *arg* is a complete command line. See `subprocess` for details and for a specific warning about using a *command* that refers to a `".bat"` or `".cmd"` file.

```
(system/exit-code command
                 [#:set-pwd? set-pwd?]) → byte?
  command : (or/c string-no-nuls? bytes-no-nuls?)
  set-pwd? : any/c = (member (system-type) '(unix macosx))
```

Like `system`, except that the result is the exit code returned by the subprocess. A `0` result normally indicates success.

```
(system*/exit-code command
                   arg ...
                  [#:set-pwd? set-pwd?]) → byte?
  command : path-string?
  arg : (or/c path? string-no-nuls? bytes-no-nuls?)
  set-pwd? : any/c = (member (system-type) '(unix macosx))
(system*/exit-code command
                   exact
                   arg
                  [#:set-pwd? set-pwd?]) → byte?
```

```
command : path-string?
exact : 'exact
arg : string?
set-pwd? : any/c = (member (system-type) '(unix macosx))
```

Like `system*`, but returns the exit code like `system/exit-code`.

```
(process command [#:set-pwd? set-pwd?])
 → (list input-port?
         output-port?
         exact-nonnegative-integer?
         input-port?
         ((or/c 'status 'wait 'interrupt 'kill) . -> . any))
  command : (or/c string-no-nuls? bytes-no-nuls?)
  set-pwd? : any/c = (member (system-type) '(unix macosx))
```

Executes a shell command asynchronously (using `/bin/sh` on Unix and Mac OS, `cmd.exe` or `command.com` on Windows). The result is a list of five values:

See also `subprocess` for notes about error handling and the limited buffer capacity of subprocess pipes.

- an input port piped from the subprocess's standard output,
- an output port piped to the subprocess's standard input,
- the system process id of the subprocess,
- an input port piped from the subprocess's standard error, and
- a procedure of one argument, either `'status`, `'wait`, `'interrupt`, `'exit-code` or `'kill`:
  - `'status` returns the status of the subprocess as one of `'running`, `'done-ok`, or `'done-error`.
  - `'exit-code` returns the integer exit code of the subprocess or `#f` if it is still running.
  - `'wait` blocks execution in the current thread until the subprocess has completed.
  - `'interrupt` sends the subprocess an interrupt signal on Unix and Mac OS, and takes no action on Windows. The result is `#<void>`.
  - `'kill` terminates the subprocess and returns `#<void>`. Note that the immediate process created by `process` is a shell process that may run another program; terminating the shell process may not terminate processes that the shell starts, particularly on Windows.

On Unix and Mac OS, if *command* runs a single program, then `/bin/sh` typically runs the program in such a way that it replaces `/bin/sh` in the same process. For reliable and precise control over process creation, however, use `process*`.

Important: All three ports returned from `process` must be explicitly closed with `close-input-port` or `close-output-port`.

If *set-pwd?* is true, then PWD is set in the same way as system.

See also current-subprocess-custodian-mode and subprocess-group-enabled, which affect the subprocess used to implement process. In particular, the 'interrupt and 'kill process-control messages are implemented via subprocess-kill, so they can affect a process group instead of a single process.

```
(process* command
          arg ...
         [#:set-pwd? set-pwd?]) → list?
  command : path-string?
  arg : (or/c path? string-no-nuls? bytes-no-nuls?)
  set-pwd? : any/c = (member (system-type) '(unix macosx))
(process* command
          exact
          arg
         [#:set-pwd? set-pwd?]) → list?
  command : path-string?
  exact : 'exact
  arg : string?
  set-pwd? : any/c = (member (system-type) '(unix macosx))
```

Like process, except that *command* is a filename that is executed directly like system*, and the *arg*s are the arguments.

On Windows, as for system*, the first *arg* can be replaced with 'exact. See also subprocess for a specific warning about using a *command* that refers to a ".bat" or ".cmd" file.

```
(process/ports out
               in
               error-out
               command
              [#:set-pwd? set-pwd?]) → list?
  out : (or/c #f output-port?)
  in : (or/c #f input-port?)
  error-out : (or/c #f output-port? 'stdout)
  command : (or/c path? string-no-nuls? bytes-no-nuls?)
  set-pwd? : any/c = (member (system-type) '(unix macosx))
```

Like process, except that *out* is used for the process's standard output, *in* is used for the process's standard input, and *error-out* is used for the process's standard error. Any of the ports can be #f, in which case a system pipe is created and returned, as in process. If *error-out* is 'stdout, then standard error is redirected to standard output. For each port or 'stdout that is provided, no pipe is created, and the corresponding value in the returned list is #f.

```
(process*/ports  out
                 in
                 error-out
                 command
                 arg ...
                [#:set-pwd? set-pwd?]) → list?
  out : (or/c #f output-port?)
  in : (or/c #f input-port?)
  error-out : (or/c #f output-port? 'stdout)
  command : path-string?
  arg : (or/c path? string-no-nuls? bytes-no-nuls?)
  set-pwd? : any/c = (member (system-type) '(unix macosx))
(process*/ports  out
                 in
                 error-out
                 command
                 exact
                 arg
                [#:set-pwd? set-pwd?]) → list?
  out : (or/c #f output-port?)
  in : (or/c #f input-port?)
  error-out : (or/c #f output-port? 'stdout)
  command : path-string?
  exact : 'exact
  arg : string?
  set-pwd? : any/c = (member (system-type) '(unix macosx))
```

Like `process*`, but with the port handling of `process/ports`.

The contracts of `system` and related functions may signal a contract error with references to the following functions.

```
(string-no-nuls? x) → boolean?
  x : any/c
```

Ensures that *x* is a string and does not contain `"\u0000"`.

```
(bytes-no-nuls? x) → boolean?
  x : any/c
```

Ensures that *x* is a byte-string and does not contain `#"\0"`.

15.5 Logging

A *logger* accepts events that contain information to be logged for interested parties. A *log receiver* represents an interested party that receives logged events asynchronously. Each event has a topic and level of detail, and a log receiver subscribes to logging events at a certain level of detail (and lower) for a specific topic or for all topics. The levels, in increasing order of detail, are `'none`, `'fatal`, `'error`, `'warning`, `'info`, and `'debug`. The `'none` level is intended for specifying receivers, and messages logged at that level are never sent to subscribers.

To help organize logged events, a logger can have a default topic and/or a parent logger. Every event reported to a logger is propagated to its parent (if any), and the event message is prefixed with the logger's topic (if any) if the message doesn't already have a topic. Furthermore, events that are propagated from a logger to its parent can be filtered by level and topic.

On start-up, Racket creates an initial logger that is used to record events from the core run-time system. For example, a `'debug` event is reported for each garbage collection (see §1.1.6 "Garbage Collection"). For this initial logger, two log receivers are also created: one that writes events to the process's original error output port, and one that writes events to the system log. The level of written events in each case is system-specific, and the default can be changed through command-line flags (see §18.1.4 "Command Line") or through environment variables:

- If the `PLTSTDERR` environment variable is defined and is not overridden by a command-line flag, it determines the level of the log receiver that propagates events to the original error port.

  The environment variable's value can be a ⟨*level*⟩: `none`, `fatal`, `error`, `warning`, `info`, or `debug` (from low detail to high detail); all events at the corresponding level of detail or lower are printed. After an initial ⟨*level*⟩, the value can contain whitespace-separated specifications of the form ⟨*level*⟩`@`⟨*topic*⟩, which prints events whose topics match ⟨*topic*⟩ only at the given ⟨*level*⟩ or higher (where a ⟨*topic*⟩ contains any character other than whitespace or `@`). Leading and trailing whitespace is ignored. For example, the value `"error debug@GC"` prints all events at the `'error` level and higher, but prints events for the topic `'GC` at the `'debug` level and higher (which includes all levels).

  The default is `"error"`.

- If the `PLTSTDOUT` environment variable is defined and is not overridden by a command-line flag, it determines the level of the log receiver that propagates events to the original output port. The possible values are the same as for `PLTSTDERR`.

  The default is `"none"`.

- If the `PLTSYSLOG` environment variable is defined and is not overridden by a command-line flag, it determines the level of the log receiver that propagates events to the system log. The possible values are the same as for `PLTSTDERR`.

The default is "none" for Unix or "error" for Windows and Mac OS.

The current-logger parameter determines the *current logger* that is used by forms such as log-warning. On start-up, the initial value of this parameter is the initial logger. The run-time system sometimes uses the current logger to report events. For example, the bytecode compiler sometimes reports 'warning events when it detects an expression that would produce a run-time error if evaluated.

Changed in version 6.6.0.2 of package base: Prior to version 6.6.0.2, parsing of PLTSTDERR and PLTSYSLOG was very strict. Leading and trailing whitespace was forbidden, and anything other than exactly one space character separating two specifications was rejected.
Changed in version 6.90.0.17: Added PLTSTDOUT.

15.5.1 Creating Loggers

```
(logger? v) → boolean?
  v : any/c
```

Returns #t if *v* is a logger, #f otherwise.

```
(make-logger [topic
              parent
              propagate-level
              propagate-topic ...]
              ...)                      → logger?
  topic : (or/c symbol? #f) = #f
  parent : (or/c logger? #f) = #f
  propagate-level : log-level/c = 'debug
  propagate-topic : (or/c #f symbol?) = #f
```

Creates a new logger with an optional topic and parent.

The optional *propagate-level* and *propagate-topic* arguments constrain the events that are propagated from the new logger to *parent* (when *parent* is not #f) in the same way that events are described for a log receiver in make-log-receiver. By default, all events are propagated to *parent*.

Changed in version 6.1.1.3 of package base: Removed an optional argument to specify a notification callback, and added *propagate-level* and *propagate-topic* constraints for events to propagate.

```
(logger-name logger) → (or/c symbol? #f)
  logger : logger?
```

Reports *logger*'s default topic, if any.

```
(current-logger) → logger?
(current-logger logger) → void?
  logger : logger?
```

A parameter that determines the current logger.

```
(define-logger id maybe-parent)

maybe-parent =
             | #:parent parent-expr

  parent-expr : (or/c logger? #f)
```

Defines `log-`*`id`*`-fatal`, `log-`*`id`*`-error`, `log-`*`id`*`-warning`, `log-`*`id`*`-info`, and `log-`*`id`*`-debug` as forms like `log-fatal`, `log-error`,`log-warning`, `log-info`, and `log-debug`. The `define-logger` form also defines *`id`*`-logger`, which is a logger with default topic `'`*`id`* that is a child of the result of *`parent-expr`* (if *`parent-expr`* does not produce `#f`), or of `(current-logger)` if *`parent-expr`* not provided; the `log-`*`id`*`-fatal`, etc. forms use this new logger. The new logger is created when `define-logger` is evaluated.

Changed in version 7.1.0.9 of package `base`: Added the `#:parent` option.

15.5.2 Logging Events

```
(log-message  logger
              level
             [topic]
              message
             [data
              prefix-message?]) → void?
  logger : logger?
  level : log-level/c
  topic : (or/c symbol? #f) = (logger-name logger)
  message : string?
  data : any/c = #f
  prefix-message? : any/c = #t
```

Reports an event to *`logger`*, which in turn distributes the information to any log receivers attached to *`logger`* or its ancestors that are interested in events at *`level`* or higher. If *`level`* is `'none`, the logged message is not sent to any receiver.

Log receivers can filter events based on *`topic`*. In addition, if *`topic`* and *`prefix-message?`* are not `#f`, then *`message`* is prefixed with the topic followed by `": "` before it is sent to receivers.

Changed in version 6.0.1.10 of package `base`: Added the *prefix-message?* argument.
Changed in version 7.2.0.7: Made the *data* argument optional.
Changed in version 8.10.0.5: Changed `'none` handling to consistently suppress the message.

```
(log-level? logger level [topic]) → boolean?
  logger : logger?
  level : log-level/c
  topic : (or/c symbol? #f) = #f
```

Reports whether any log receiver attached to *logger* or one of its ancestors is interested in *level* events (or potentially lower) for *topic*. If *topic* is `#f`, the result indicates whether a log receiver is interested in events at *level* for any topic. If *level* is `'none`, the result is always `#f`.

Use this function to avoid work generating an event for `log-message` if no receiver is interested in the information; this shortcut is built into `log-fatal`, `log-error`, `log-warning`, `log-info`, `log-debug`, and forms bound by `define-logger`, however, so it should not be used with those forms.

The result of this function can change if a garbage collection determines that a log receiver is no longer accessible (and therefore that any event information it receives will never become accessible).

Changed in version 6.1.1.3 of package `base`: Added the *topic* argument.
Changed in version 8.10.0.5: Changed the result for `'none` to be consistently `#f`.

```
(log-max-level logger [topic]) → (or/c log-level/c #f)
  logger : logger?
  topic : (or/c symbol? #f) = #f
```

Similar to `log-level?`, but reports the maximum-detail level of logging for which `log-level?` on *logger* and *topic* returns `#t`. The result is `#f` if `log-level?` with *logger* and *topic* currently returns `#f` for all levels.

Changed in version 6.1.1.3 of package `base`: Added the *topic* argument.

```
(log-all-levels logger) → (list/c (or/c #f log-level/c)
                                  (or/c #f symbol?)
                                  ... ...)
  logger : logger?
```

Summarizes the possible results of `log-max-level` on all possible interned symbols. The result list contains a sequence of symbols and `#f`, where the first, third, etc., list element corresponds to a level, and the second, fourth, etc., list element indicates a corresponding topic. The level is the result that `log-max-level` would produce for the topic, where the level for the `#f` topic (which is always present in the result list) indicates the result for any interned-symbol topic that does not appear in the list.

The result is suitable as a sequence of arguments to `make-log-receiver` (after a logger argument) to create a new receiver for events that currently have receivers in *logger*.

Added in version 6.1.1.4 of package `base`.

```
(log-level-evt logger) → evt?
  logger : logger?
```

Creates a synchronizable event that is ready for synchronization when the result of `log-level?`, `log-max-level`, or `log-all-levels` can be different than before `log-level-evt` was called. The event's synchronization result is the event itself.

The condition reported by the event is a conservative approximation: the event can become ready for synchronization even if the results of `log-level?`, `log-max-level`, and `log-all-levels` are unchanged. Nevertheless, the expectation is that events produced by `log-level-evt` become ready infrequently, because they are triggered by the creation of a log receiver.

Added in version 6.1.1.4 of package `base`.

```
(log-fatal string-expr)
(log-fatal format-string-expr v ...)
(log-error string-expr)
(log-error format-string-expr v ...)
(log-warning string-expr)
(log-warning format-string-expr v ...)
(log-info string-expr)
(log-info format-string-expr v ...)
(log-debug string-expr)
(log-debug format-string-expr v ...)
```

Log an event with the current logger, evaluating *string-expr* or `(format format-string-expr v ...)` only if the logger has receivers that are interested in the event. In addition, the current continuation's continuation marks are sent to the logger with the message string.

These form are convenient for using the current logger, but libraries should generally use a logger for a specific topic—typically through similar convenience forms generated by `define-logger`.

For each `log-level`,

```
(log-level string-expr)
```

is equivalent to

```
(let ([l (current-logger)])
  (when (log-level? l 'level)
    (log-message l 'level string-expr
                 (current-continuation-marks))))
```

while

```
(log-level format-string-expr v ...)
```

is equivalent to

```
(log-level (format format-string-expr v ...))
```

15.5.3 Receiving Logged Events

```
(log-receiver? v) → boolean?
  v : any/c
```

Returns #t if *v* is a log receiver, #f otherwise.

```
(make-log-receiver logger level [topic ...] ...) → log-receiver?
  logger : logger?
  level : log-level/c
  topic : (or/c #f symbol?) = #f
```

Creates a log receiver to receive events of detail *level* and lower as reported to *logger* and its descendants, as long as either *topic* is #f or the event's topic matches *topic*.

A log receiver is a synchronizable event. It becomes ready for synchronization when a logging event is received, so use sync to receive a logged event. The log receiver's synchronization result is an immutable vector containing four values: the level of the event as a symbol, an immutable string for the event message, an arbitrary value that was supplied as the last argument to log-message when the event was logged, and a symbol or #f for the event topic.

Multiple pairs of *level* and *topic* can be provided to indicate different specific *level*s for different *topic*s (where *topic* defaults to #f only for the last given *level*). A *level* for a #f *topic* applies only to events whose topic does not match any other provided *topic*. If the same *topic* is provided multiple times, the *level* provided with the last instance in the argument list takes precedence.

15.5.4 Additional Logging Functions

```
(require racket/logging)        package: base
```

The bindings documented in this section are provided by the `racket/logging` library, not `racket/base` or `racket`.

```
(log-level/c v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a valid logging level (`'none`, `'fatal`, `'error`, `'warning`, `'info`, or `'debug`), `#f` otherwise.

Added in version 6.3 of package `base`.

```
(with-intercepted-logging  interceptor
                           proc
                          [#:logger logger]
                           level
                          [topic ...]
                           ...)              → any
  interceptor : (-> (vector/c
                     log-level/c
                     string?
                     any/c
                     (or/c symbol? #f))
                    any)
  proc : (-> any)
  logger : logger? = #f
  level : log-level/c
  topic : (or/c #f symbol?) = #f
```

Runs *proc*, calling *interceptor* on any log event that the execution of *proc* emits to `current-logger` at the specified levels and topics. If `#:logger` is specified, intercepts events sent to that logger, otherwise uses a new child logger of the current logger. Returns whatever *proc* returns.

Example:

```
> (let ([warning-counter 0])
    (with-intercepted-logging
      (lambda (l)
        (when (eq? (vector-ref l 0)
                   'warning)
          (set! warning-counter (add1 warning-counter))))
      (lambda ()
        (log-warning "Warning!")
        (log-warning "Warning again!")
        (+ 2 2))
      'warning)
```

```
    warning-counter)
2
```

Added in version 6.3 of package `base`.
Changed in version 6.7.0.1: Added `#:logger` argument.

```
(with-logging-to-port  port
                       proc
                      [#:logger logger]
                       level
                      [topic ...]
                       ...)             → any
  port : output-port?
  proc : (-> any)
  logger : logger? = #f
  level : log-level/c
  topic : (or/c #f symbol?) = #f
```

Runs *proc*, outputting any logging that the execution of *proc* emits to `current-logger` at the specified levels and topics. If `#:logger` is specified, intercepts events sent to that logger, otherwise uses a new child logger of the current logger. Returns whatever *proc* returns.

Example:

```
> (let ([my-log (open-output-string)])
    (with-logging-to-port my-log
      (lambda ()
        (log-warning "Warning World!")
        (+ 2 2))
      'warning)
    (get-output-string my-log))
"Warning World!\n"
```

Added in version 6.3 of package `base`.
Changed in version 6.7.0.1: Added `#:logger` argument.

15.6 Time

```
(current-seconds) → exact-integer?
```

Returns the current time in seconds since *the epoch*: midnight UTC, January 1, 1970.

```
(current-inexact-milliseconds) → real?
```

Returns the current time in milliseconds since the epoch. The result may contain fractions of a millisecond.

Example:

```
> (current-inexact-milliseconds)
1289513737015.418
```

In this example, `1289513737015` is in milliseconds and `418` is in microseconds.

```
(current-inexact-monotonic-milliseconds) → real?
```

Returns the number of milliseconds since an unspecified starting time. Unlike `current-inexact-milliseconds`, which is sensitive to the system clock and may therefore retreat or advance more quickly than real time if the system clock is adjusted, results from `current-inexact-monotonic-milliseconds` will always advance with real time within a Racket process, but results across processes are not comparable.

Example:

```
> (current-inexact-monotonic-milliseconds)
12772.418
```

Added in version 8.1.0.4 of package `base`.

```
(seconds->date secs-n [local-time?]) → date*?
  secs-n : real?
  local-time? : any/c = #t
```

Takes *secs-n*, a time in seconds since the epoch (like the value of `(current-seconds)`, `(file-or-directory-modify-seconds path)`, or `(/ (current-inexact-milliseconds) 1000))`, and returns an instance of the `date*` structure type. Note that *secs-n* can include fractions of a second. If *secs-n* is too small or large, the `exn:fail` exception is raised.

The resulting `date*` reflects the time according to the local time zone if *local-time?* is `#t`, otherwise it reflects a date in UTC.

```
(struct date (second
              minute
              hour
              day
              month
              year
              week-day
              year-day
              dst?
              time-zone-offset)
```

```
    #:extra-constructor-name make-date
    #:transparent)
  second : (integer-in 0 60)
  minute : (integer-in 0 59)
  hour : (integer-in 0 23)
  day : (integer-in 1 31)
  month : (integer-in 1 12)
  year : exact-integer?
  week-day : (integer-in 0 6)
  year-day : (integer-in 0 365)
  dst? : boolean?
  time-zone-offset : exact-integer?
```

Represents a date. The *second* field reaches `60` only for leap seconds. The `week-day` field is `0` for Sunday, `1` for Monday, etc. The `year-day` field is `0` for January 1, `1` for January 2, etc.; the `year-day` field reaches `365` only in leap years.

The `dst?` field is `#t` if the date reflects a daylight-saving adjustment. The `time-zone-offset` field reports the number of seconds east of UTC (GMT) for the current time zone (e.g., Pacific Standard Time is `-28800`), including any daylight-saving adjustment (e.g., Pacific Daylight Time is `-25200`). When a `date` record is generated by `seconds->date` with `#f` as the second argument, then the `dst?` and `time-zone-offset` fields are `#f` and `0`, respectively.

The `date` constructor accepts any value for `dst?` and converts any non-`#f` value to `#t`.

The value produced for the `time-zone-offset` field tends to be sensitive to the value of the `TZ` environment variable, especially on Unix platforms; consult the system documentation (usually under `tzset`) for details.

See also the `racket/date` library.

```
(struct date* date (nanosecond time-zone-name)
    #:extra-constructor-name make-date*)
  nanosecond : (integer-in 0 999999999)
  time-zone-name : (and/c string? immutable?)
```

Extends `date` with nanoseconds and a time zone name, such as `"MDT"`, `"Mountain Daylight Time"`, or `"UTC"`.

When a `date*` record is generated by `seconds->date` with `#f` as the second argument, then the `time-zone-name` field is `"UTC"`.

The `date*` constructor accepts a mutable string for `time-zone-name` and converts it to an immutable one.

```
(current-milliseconds) → exact-integer?
```

Like `current-inexact-milliseconds`, but coerced to a fixnum (possibly negative). Since the result is a fixnum, the value increases only over a limited (though reasonably long) time on a 32-bit platform.

```
(current-process-milliseconds [scope]) → exact-integer?
  scope : (or/c #f thread? 'subprocesses) = #f
```

Returns an amount of processor time in fixnum milliseconds that has been consumed by on the underlying operating system, including both user and system time.

- If *scope* is `#f`, the reported time is for all Racket threads and places.
- If *scope* is a thread, the result is specific to the time while the thread ran, but it may include time for other places. The more a thread synchronizes with other threads, the less precisely per-thread processor time is recorded.
- If *scope* is `'subprocesses`, the result is the sum of process times for known-completed subprocesses (see §15.4 "Processes")—and known-completed children of the subprocesses, etc., on Unix and Mac OS—across all places.

The precision of the result is platform-specific, and since the result is a fixnum, the value increases only over a limited (though reasonably long) time on a 32-bit platform.

Changed in version 6.1.1.4 of package `base`: Added `'subprocesses` mode.

```
(current-gc-milliseconds) → exact-integer?
```

Returns the amount of processor time in fixnum milliseconds that has been consumed by Racket's garbage collection so far. This time is a portion of the time reported by `(current-process-milliseconds)`, and is similarly limited.

```
(time-apply proc lst) → list?
                        exact-integer?
                        exact-integer?
                        exact-integer?
  proc : procedure?
  lst : list?
```

Collects timing information for a procedure application.

Four values are returned: a list containing the result(s) of applying *proc* to the arguments in *lst*, the number of milliseconds of CPU time required to obtain this result, the number of "real" milliseconds required for the result, and the number of milliseconds of CPU time (included in the first result) spent on garbage collection.

The reliability of the timing numbers depends on the platform. If multiple Racket threads are running, then the reported time may include work performed by other threads.

```
(time body ...+)
```

Reports `time-apply`-style timing information for the evaluation of `expr` directly to the current output port. The result is the result of the last *body*.

15.6.1 Date Utilities

```
(require racket/date)        package: base
```

For more date & time operations, see the Gregor: Date and Time documentation or srfi/19

The bindings documented in this section are provided by the `racket/date` library, not `racket/base` or `racket`.

```
(current-date) → date*?
```

An abbreviation for `(seconds->date (* 0.001 (current-inexact-milliseconds)))`.

```
(date->string date [time?]) → string?
  date : date?
  time? : any/c = #f
```

Converts a date to a string. The returned string contains the time of day only if *time?*. See also `date-display-format`.

```
(date-display-format) → (or/c 'american
                              'chinese
                              'german
                              'indian
                              'irish
                              'iso-8601
                              'rfc2822
                              'julian)
(date-display-format format) → void?
  format : (or/c 'american
                 'chinese
                 'german
                 'indian
                 'irish
                 'iso-8601
                 'rfc2822
                 'julian)
```

Parameter that determines the date string format. The initial format is `'american`.

```
(date->seconds date [local-time?]) → exact-integer?
  date : date?
  local-time? : any/c = #t
```

Finds the representation of a date in platform-specific seconds. If the platform cannot represent the specified date, `exn:fail` exception is raised.

The `week-day`, `year-day` fields of *`date`* are ignored. The `dst?` and `time-zone-offset` fields of *`date`* are also ignored; the date is assumed to be in local time by default or in UTC if *`local-time?`* is `#f`.

```
(date*->seconds date [local-time?]) → real?
  date : date?
  local-time? : any/c = #t
```

Like `date->seconds`, but returns an exact number that can include a fraction of a second based on `(date*-nanosecond date)` if *`date`* is a `date*` instance.

```
(find-seconds  second
               minute
               hour
               day
               month
               year
              [local-time?]) → exact-integer?
  second : (integer-in 0 61)
  minute : (integer-in 0 59)
  hour : (integer-in 0 23)
  day : (integer-in 1 31)
  month : (integer-in 1 12)
  year : exact-integer?
  local-time? : any/c = #t
```

Finds the representation of a date in platform-specific seconds. The arguments correspond to the fields of the `date` structure—in local time by default or UTC if *`local-time?`* is `#f`. If the platform cannot represent the specified date, an error is signaled, otherwise an integer is returned.

Changed in version 9.0.0.4 of package `base`: Allow negative numbers for *`year`*.

```
(date->julian/scaliger date) → exact-integer?
  date : date?
```

Converts a date structure (up to 2099 BCE Gregorian) into a Julian date number. The returned value is not a strict Julian number, but rather Scaliger's version, which is off by one for easier calculations.

```
(julian/scaliger->string date-number) → string?
  date-number : exact-integer?
```

Converts a Julian number (Scaliger's off-by-one version) into a string.

```
(date->julian/scalinger date) → exact-integer?
  date : date?
(julian/scalinger->string date-number) → string?
  date-number : exact-integer?
```

The same as `date->julian/scaliger` and `julian/scaliger->string`, but misspelled.

15.7 Environment Variables

An *environment variable set* encapsulates a partial mapping from byte strings to byte strings. A Racket process's initial environment variable set is connected to the operating system's environment variables: accesses or changes to the set read or change operating-system environment variables for the Racket process.

Since Windows environment variables are case-insensitive, environment variable set's key byte strings on Windows are case-folded. More precisely, key byte strings are coerced to a UTF-8 encoding of characters that are converted to lowercase via `string-locale-downcase`.

The current environment variable set, which is determined by the `current-environment-variables` parameter, is propagated to a subprocess when the subprocess is created.

```
(environment-variables? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is an environment variable set, `#f` otherwise.

```
(current-environment-variables) → environment-variables?
(current-environment-variables env) → void?
  env : environment-variables?
```

A parameter that determines the environment variable set that is propagated to a subprocess and that is used as the default set for `getenv` and `putenv`.

```
(bytes-environment-variable-name? v) → boolean?
  v : any/c
```

Returns #t if *v* is a byte string and if it is valid for an environment variable name. An environment variable name must contain no bytes with the value 0 or 61, where 61 is (char->integer #\=). On Windows, an environment variable name also must have a non-zero length.

```
(make-environment-variables name val ... ...)
 → environment-variables?
  name : bytes-environment-variable-name?
  val : bytes-no-nuls?
```

Creates a fresh environment variable set that is initialized with the given *name* to *val* mappings.

```
(environment-variables-ref env name)
 → (or/c #f (and/c bytes-no-nuls? immutable?))
  env : environment-variables?
  name : bytes-environment-variable-name?
```

Returns the mapping for *name* in *env*, returning #f if *name* has no mapping.

Normally, *name* should be a byte-string encoding of a string using the default encoding of the current locale. On Windows, *name* is coerced to a UTF-8 encoding and case-normalized.

```
(environment-variables-set! env
                            name
                            maybe-bstr
                           [fail])      → any
  env : environment-variables?
  name : bytes-environment-variable-name?
  maybe-bstr : (or/c bytes-no-nuls? #f)
  fail : (-> any) = (lambda ()
                      (raise (make-exn:fail ....)))
```

Changes the mapping for *name* in *env* to *maybe-bstr*. If *maybe-bstr* is #f and *env* is the initial environment variable set of the Racket process, then the operating system environment-variable mapping for *name* is removed.

Normally, *name* and *maybe-bstr* should be a byte-string encoding of a string using the default encoding of the current locale. On Windows, *name* is coerced to a UTF-8 encoding and case-normalized, and *maybe-bstr* is coerced to a UTF-8 encoding if *env* is the initial environment variable set of the Racket process.

On success, the result of environment-variables-set! is #<void>. If *env* is the initial environment variable set of the Racket process, then attempting to adjust the operating system environment-variable mapping might fail for some reason, in which case *fail* is called in tail position with respect to the environment-variables-set!. The default *fail* raises an exception.

```
(environment-variables-names env)
 → (listof (and/c bytes-environment-variable-name? immutable?))
  env : environment-variables?
```

Returns a list of byte strings that corresponds to names mapped by `env`.

```
(environment-variables-copy env) → environment-variables?
  env : environment-variables?
```

Returns an environment variable set that is initialized with the same mappings as `env`.

```
(getenv name) → (or/c string-no-nuls? #f)
  name : string-environment-variable-name?
(putenv name value) → boolean?
  name : string-environment-variable-name?
  value : string-no-nuls?
```

Convenience wrappers for `environment-variables-ref` and `environment-variables-set!` that convert between strings and byte strings using the current locale's default encoding (using `#\?` as the replacement character for encoding errors) and always using the current environment variable set from `current-environment-variables`. The `putenv` function returns `#t` for success and `#f` for failure.

```
(string-environment-variable-name? v) → boolean?
  v : any/c
```

Returns `#t` if `v` is a string and if its encoding using the current locale's encoding is valid for an environment variable name according to `bytes-environment-variable-name?`.

15.8 Environment and Runtime Information

```
(system-type [mode])
 → (or/c symbol? string? bytes? exact-positive-integer? vector? #f)
  mode : (or/c 'os 'os* 'arch 'word 'vm 'gc 'link 'machine 'target-machine
               'so-suffix 'so-mode 'fs-change 'cross)
       = 'os
```

Returns information about the operating system, build mode, or machine for a running Racket. (Installation tools should use `cross-system-type`, instead, to support cross-installation.)

In `'os` mode, the possible symbol results are:

- 'unix
- 'windows
- 'macosx

Prior to the introduction of 'os* and 'arch modes, (system-library-subpath #f) could be used to obtain this information somewhat indirectly.

In 'os* mode, the result is similar to 'os mode, but refined to a specific operating system, such as 'linux or 'freebsd, instead of a generic 'unix classification.

In 'arch mode, the result is a symbol representing an architecture. Possible results include 'x86_64, 'i386, 'aarch64, 'arm (32-bit), and 'ppc (32-bit).

In 'word mode, the result is either 32 or 64 to indicate whether Racket is running as a 32-bit program or 64-bit program.

See §19.2 "Racket Virtual Machine Implementations" for more information about the 'vm and 'gc mode results.

In 'vm mode, the possible symbol results are (see also §1.5 "Implementations"):

- 'racket
- 'chez-scheme

In 'gc mode, the possible symbol results are (see also §1.5 "Implementations"):

- 'cgc — when (system-type 'vm) is 'racket
- '3m — when (system-type 'vm) is 'racket
- 'cs — when (system-type 'vm) is 'chez-scheme

In 'link mode, the possible symbol results are:

- 'static (Unix)
- 'shared (Unix)
- 'dll (Windows)
- 'framework (Mac OS)

Future ports of Racket may expand the list of 'os, 'os*, 'arch, 'vm, 'gc, and 'link results.

In 'machine mode, then the result is a string, which contains further details about the current machine in a platform-specific format.

In 'target-machine mode, the result is a symbol for the running Racket's native bytecode format, or it is #f if there is no native format other than the machine-independent format.

If the result is a symbol, then `compile-target-machine?` returns `#t` when applied to the symbol; see also `current-compile-target-machine`.

In `'so-suffix` mode, then the result is a byte string that represents the file extension used for shared objects on the current platform. The byte string starts with a period, so it is suitable as a second argument to `path-replace-suffix`.

In `'so-mode` mode, then the result is `'local` if foreign libraries should be opened in "local" mode by default (as on most platforms) or `'global` if foreign libraries should be opened in "global" mode.

In `'fs-change` mode, the result is an immutable vector of four elements. Each element is either `#f` or a symbol, where a symbol indicates the presence of a property and `#f` indicates the absence of a property. The possible symbols, in order, are:

- `'supported` — `filesystem-change-evt` can produce a filesystem change event to monitor filesystem changes; if this symbol is not first in the vector, all other vector elements are `#f`
- `'scalable` — resources consumed by a filesystem change event are effectively limited only by available memory, as opposed to file-descriptor limits; this property is `#f` on Mac OS and BSD variants of Unix
- `'low-latency` — creation and checking of a filesystem change event is practically instantaneous; this property is `#f` on Linux
- `'file-level` — a filesystem change event can track changes at the level of a file, as opposed to the file's directory; this property is `#f` on Windows

In `'cross` mode, the result reports whether cross-platform build mode has been selected (through the `-C` or `--cross` argument to `racket`; see §18.1.4 "Command Line"). The possible symbols are:

- `'infer` — infer cross-platform mode based on whether `(system-type)` and `(cross-system-type)` report the same symbol
- `'force` — use cross-platform mode, even if the current and target system types are the same, because the current and target executables can be different

Changed in version 6.8.0.2 of package `base`: Added `'vm` mode.
Changed in version 6.9.0.1: Added `'cross` mode.
Changed in version 7.1.0.6: Added `'target-machine` mode.
Changed in version 7.9.0.6: Added `'os*` and `'arch` modes.

```
(system-language+country) → string?
```

Returns a string to identify the current user's language and country.

On Unix and Mac OS, the string is five characters: two lowercase ASCII letters for the language, an underscore, and two uppercase ASCII letters for the country. On Windows, the string can be arbitrarily long, but the language and country are in English (all ASCII letters or spaces) separated by an underscore.

On Unix, the result is determined by checking the `LC_ALL`, `LC_TYPE`, and `LANG` environment variables, in that order (and the result is used if the environment variable's value starts with two lowercase ASCII letters, an underscore, and two uppercase ASCII letters, followed by either nothing or a period). On Windows and Mac OS, the result is determined by system calls.

```
(system-library-subpath [mode]) → path?
  mode : (or/c 'cgc '3m 'cs #f) = (system-type 'gc)
```

Returns a relative directory path. This string can be used to build paths to system-specific files. For example, when Racket is running on Solaris on a Sparc architecture, the subpath starts `"sparc-solaris"`, while the subpath for Windows on an i386 architecture starts `"win32\\i386"`.

The optional *mode* argument specifies the relevant garbage-collection variant, which one of the possible results of `(system-type 'gc)`: `'cgc`, `'3m`, or `'cs`. It can also be `#f`, in which case the result is independent of the garbage-collection variant.

Installation tools should use `cross-system-library-subpath`, instead, to support cross-installation.

Changed in version 7.0 of package `base`: Added `'cs` mode.

```
(version) → (and/c string? immutable?)
```

Returns an immutable string indicating the currently executing version of Racket.

```
(banner) → (and/c string? immutable?)
```

Returns an immutable string for Racket's start-up banner text (or the banner text for an embedding program, such as GRacket). The banner string ends with a newline.

```
(current-command-line-arguments)
 → (vectorof (and/c string? immutable?))
(current-command-line-arguments argv) → void?
  argv : (vectorof string?)
```

A parameter that is initialized with command-line arguments when Racket starts (not including any command-line arguments that were treated as flags for the system).

On Unix and Mac OS, command-line arguments are provided to the Racket process as byte strings. The arguments are converted to strings using `bytes->string/locale` and `#\uFFFD` as the encoding-error character.

```
(current-thread-initial-stack-size) → exact-positive-integer?
(current-thread-initial-stack-size size) → void?
  size : exact-positive-integer?
```

A parameter that provides a hint about how much space to reserve for a newly created thread's local variables. The actual space used by a computation is affected by JIT compilation, but it is otherwise platform-independent.

```
(vector-set-performance-stats! results [thd]) → void?
  results : (and/c vector?
                   (not/c immutable?))
  thd : (or/c thread? #f) = #f
```

Sets elements in *results* to report current performance statistics. If *thd* is not `#f`, a particular set of thread-specific statistics are reported, otherwise a different set of global (within the current place) statistics are reported.

For global statistics, up to 12 elements are set in the vector, starting from the beginning. If *results* has n elements where $n < 12$, then the n elements are set to the first n performance-statistics values. The reported statistics values are as follows, in the order that they are set within *results*:

- `0`: The same value as returned by `current-process-milliseconds`.
- `1`: The same value as returned by `current-milliseconds`.
- `2`: The same value as returned by `current-gc-milliseconds`.
- `3`: The number of garbage collections performed since start-up within the current place.
- `4`: The number of thread context switches performed since start-up.
- `5`: The number of internal stack overflows handled since start-up (BC only; 0 for CS).
- `6`: The number of threads currently scheduled for execution (i.e., threads that are running, not suspended, and not unscheduled due to a synchronization).
- `7`: The number of syntax objects read from compiled code since start-up (BC only; 0 for CS).
- `8`: The number of hash-table searches performed (BC only; 0 for CS). When this counter reaches the maximum value of a fixnum, it overflows to the most negative fixnum.

- 9: The number of additional hash slots searched to complete hash searches using double hashing (BC only; 0 for CS). When this counter reaches the maximum value of a fixnum, it overflows to the most negative fixnum.
- 10: The number of bytes allocated for machine code that is not reported by current-memory-use (BC only; 0 for CS).
- 11: The peak number of allocated bytes just before a garbage collection.

For thread-specific statistics, up to 4 elements are set in the vector:

- 0: #t if the thread is running, #f otherwise (same result as thread-running?).
- 1: #t if the thread has terminated, #f otherwise (same result as thread-dead?).
- 2: #t if the thread is currently blocked on a synchronizable event (or sleeping for some number of milliseconds), #f otherwise.
- 3: The number of bytes currently in use for the thread's continuation (BC only; 0 for CS).

Changed in version 6.1.1.8 of package base: Added vector position 11 for global statistics.

15.9 Command-Line Parsing

```
(require racket/cmdline)        package: base
```

The bindings documented in this section are provided by the racket/cmdline and racket libraries, but not racket/base.

```
(command-line optional-name-expr optional-argv-expr
              flag-clause ...
              finish-clause)
```

```
optional-name-expr =
                   | #:program name-expr

optional-argv-expr =
                   | #:argv argv-expr

       flag-clause = #:multi flag-spec ...
                   | #:once-each flag-spec ...
                   | #:once-any flag-spec ...
                   | #:final flag-spec ...
                   | #:usage-help string ...
                   | #:help-labels string ...
                   | #:ps string ...

         flag-spec = (flags id ... help-spec body ...+)
                   | (flags => handler-expr help-expr)

             flags = flag-string
                   | (flag-string ...+)

         help-spec = string
                   | (string-expr ...+)

     finish-clause =
                   | #:args arg-formals body ...+
                   | #:handlers handlers-exprs

       arg-formals = rest-id
                   | (arg ...)
                   | (arg ...+ . rest-id)

               arg = id
                   | [id default-expr]

    handlers-exprs = finish-expr arg-strings-expr
                   | finish-expr arg-strings-expr help-expr
                   | finish-expr arg-strings-expr help-expr
                     unknown-expr
```

Parses a command line according to the specification in the `flag-clause`s.

The `name-expr`, if provided, should produce a path or string to be used as the program name for reporting errors when the command-line is ill-formed. It defaults to `(find-system-path 'run-file)`. When a path is provided, only the last element of the path is used to report an error.

The *argv-expr*, if provided, must evaluate to a list or a vector of strings. It defaults to `(current-command-line-arguments)`.

The command-line is disassembled into flags, each possibly with flag-specific arguments, followed by (non-flag) arguments. Command-line strings starting with `-` or `+` are parsed as flags, but arguments to flags are never parsed as flags, and integers and decimal numbers that start with `-` or `+` are not treated as flags. Non-flag arguments in the command-line must appear after all flags and the flags' arguments. No command-line string past the first non-flag argument is parsed as a flag. The built-in `--` flag signals the end of command-line flags; any command-line string past the `--` flag is parsed as a non-flag argument.

A `#:multi`, `#:once-each`, `#:once-any`, or `#:final` clause introduces a set of command-line flag specifications. The clause tag indicates how many times the flag can appear on the command line:

- `#:multi` — Each flag specified in the set can be represented any number of times on the command line; i.e., the flags in the set are independent and each flag can be used multiple times.
- `#:once-each` — Each flag specified in the set can be represented once on the command line; i.e., the flags in the set are independent, but each flag should be specified at most once. If a flag specification is represented in the command line more than once, the `exn:fail` exception is raised.
- `#:once-any` — Only one flag specified in the set can be represented on the command line; i.e., the flags in the set are mutually exclusive. If the set is represented in the command line more than once, the `exn:fail` exception is raised.
- `#:final` — Like `#:multi`, except that no argument after the flag is treated as a flag. Note that multiple `#:final` flags can be specified if they have short names; for example, if `-a` is a `#:final` flag, then `-aa` combines two instances of `-a` in a single command-line argument.

A normal flag specification has four parts:

- *flags* — a flag string, or a set of flag strings. If a set of flags is provided, all of the flags are equivalent. Each flag string must be of the form `"-x"` or `"+x"` for some character *x*, or `"--x"` or `"++x"` for some sequence of characters *x*. An *x* cannot contain only digits or digits plus a single decimal point, since simple (signed) numbers are not treated as flags. In addition, the flags `"--"`, `"-h"`, and `"--help"` are predefined and cannot be changed.
- *id*s — identifier that are bound to the flag's arguments. The number of identifiers determines how many arguments can be provided on the command line with the flag, and the names of these identifiers will appear in the help message describing the flag. The *id*s are bound to string values in the *body*s for handling the flag.

- *help-spec* — a string or sequence of strings that describes the flag. This string is used in the help message generated by the handler for the built-in `-h` (or `--help`) flag. A single literal string can be provided, or any number of expressions that produce strings; in the latter case, strings after the first one are displayed on subsequent lines.

- *body*s — expressions that are evaluated when one of the *flags* appears on the command line. The flags are parsed left-to-right, and each sequence of *body*s is evaluated as the corresponding flag is encountered. When the *body*s are evaluated, the preceding *id*s are bound to the arguments provided for the flag on the command line.

A flag specification using `=>` escapes to a more general method of specifying the handler and help strings. In this case, the handler procedure and help string list returned by *handler-expr* and *help-expr* are used as in the *table* argument of `parse-command-line`.

A `#:usage-help` clause inserts text lines immediately after the usage line. Each string in the clause provides a separate line of text.

A `#:help-labels` clause inserts text lines into the help table of command-line flags. Each string in the clause provides a separate line of text.

A `#:ps` clause inserts text lines at the end of the help output. Each string in the clause provides a separate line of text.

After the flag clauses, a final clause handles command-line arguments that are not parsed as flags:

- Supplying no finish clause is the same as supplying `#:args () (void)`.

- For an `#:args` finish clause, identifiers in *arg-formals* are bound to the leftover command-line strings in the same way that identifiers are bound for a `lambda` expression. Thus, specifying a single *id* (without parentheses) collects all of the leftover arguments into a list. The effective arity of the *arg-formals* specification determines the number of extra command-line arguments that the user can provide, and the names of the identifiers in *arg-formals* are used in the help string. When the command-line is parsed, if the number of provided arguments cannot be matched to identifiers in *arg-formals*, the `exn:fail` exception is raised. Otherwise, `args` clause's *body*s are evaluated to handle the leftover arguments, and the result of the last *body* is the result of the `command-line` expression.

- A `#:handlers` finish clause escapes to a more general method of handling the leftover arguments. In this case, the values of the expressions are used like the last two to four arguments `parse-command-line`.

Example:

```
(define verbose-mode (make-parameter #f))
```

```
(define profiling-on (make-parameter #f))
(define optimize-level (make-parameter 0))
(define link-flags (make-parameter null))

(define file-to-compile
  (command-line
   #:program "compiler"
   #:once-each
   [("-v" "--verbose") "Compile with verbose messages"
                       (verbose-mode #t)]
   [("-p" "--profile") "Compile with profiling"
                       (profiling-on #t)]
   #:once-any
   [("-o" "--optimize-1") "Compile with optimization level 1"
                          (optimize-level 1)]
   ["--optimize-2"        (; show help on separate lines
                           "Compile with optimization level 2,"
                           "which includes all of level 1")
                          (optimize-level 2)]
   #:multi
   [("-l" "--link-flags") lf ; flag takes one argument
                          "Add a flag <lf> for the linker"
                          (link-flags (cons lf (link-flags)))]
   #:args (filename) ; expect one command-line argument: <file-
name>
   ; return the argument as a filename to compile
   filename))
```

```
(parse-command-line  name
                     argv
                     table
                     finish-proc
                     arg-help-strs
                    [help-proc
                     unknown-proc]) → any
  name : (or/c string? path?)
  argv : (or/c (listof string?) (vectorof string?))
  table : (listof (cons/c symbol? list?))
  finish-proc : (list? any/c ... . -> . any)
  arg-help-strs : (listof string?)
  help-proc : (string? . -> . any) = (lambda (str) ....)
  unknown-proc : (string? . -> . any) = (lambda (str) ...)
```

Parses a command-line using the specification in *table*. For an overview of command-line parsing, see the `command-line` form, which provides a more convenient notation for most purposes.

The *table* argument to this procedural form encodes the information in command-line's clauses, except for the args clause. Instead, arguments are handled by the *finish-proc* procedure, and help information about non-flag arguments is provided in *arg-help-strs*. In addition, the *finish-proc* procedure receives information accumulated while parsing flags. The *help-proc* and *unknown-proc* arguments allow customization that is not possible with command-line.

When there are no more flags, *finish-proc* is called with a list of information accumulated for command-line flags (see below) and the remaining non-flag arguments from the command-line. The arity of *finish-proc* determines the number of non-flag arguments accepted and required from the command-line. For example, if *finish-proc* accepts either two or three arguments, then either one or two non-flag arguments must be provided on the command-line. The *finish-proc* procedure can have any arity (see procedure-arity) except 0 or a list of 0s (i.e., the procedure must at least accept one or more arguments).

The *arg-help-strs* argument is a list of strings identifying the expected (non-flag) command-line arguments, one for each argument. If an arbitrary number of arguments are allowed, the last string in *arg-help-strs* represents all of them.

The *help-proc* procedure is called with a help string if the -h or --help flag is included on the command line. If an unknown flag is encountered, the *unknown-proc* procedure is called just like a flag-handling procedure (as described below); it must at least accept one argument (the unknown flag), but it may also accept more arguments. The default *help-proc* displays the string and exits and the default *unknown-proc* raises the exn:fail exception.

A *table* is a list of flag specification sets. Each set is represented as a pair of two items: a mode symbol and a list of either help strings or flag specifications. A mode symbol is one of 'once-each, 'once-any, 'multi, 'final, 'help-labels, 'usage-help, or 'ps with the same meanings as the corresponding clause tags in command-line. For the 'help-labels, 'usage-help or 'ps mode, a list of help strings is provided. For the other modes, a list of flag specifications is provided, where each specification maps a number of flags to a single handler procedure. A specification is a list of three items:

- A list of strings for the flags defined by the spec. See command-line for information about the format of flag strings.
- A procedure to handle the flag and its arguments when one of the flags is found on the command line. The arity of this handler procedure determines the number of arguments consumed by the flag: the handler procedure is called with a flag string plus the next few arguments from the command line to match the arity of the handler procedure. The handler procedure must accept at least one argument to receive the flag. If the handler accepts arbitrarily many arguments, all of the remaining arguments are passed to the handler. A handler procedure's arity must either be a number or an arity-at-least value.

  The return value from the handler is added to a list that is eventually passed to *finish-proc*. If the handler returns #<void>, no value is added onto this list. For all non-#<void> values returned by handlers, the order of the values in the list is the same as the order of the arguments on the command-line.

- A non-empty list for constructing help information for the spec. The first element of the list describes the flag; it can be a string or a non-empty list of strings, and in the latter case, each string is shown on its own line. Additional elements of the main list must be strings to name the expected arguments for the flag. The number of extra help strings provided for a spec must match the number of arguments accepted by the spec's handler procedure.

The following example is the same as the core example for `command-line`, translated to the procedural form:

```
(parse-command-line "compile" (current-command-line-arguments)
  `((once-each
     [("-v" "--verbose")
      ,(lambda (flag) (verbose-mode #t))
      ("Compile with verbose messages")]
     [("-p" "--profile")
      ,(lambda (flag) (profiling-on #t))
      ("Compile with profiling")])
    (once-any
     [("-o" "--optimize-1")
      ,(lambda (flag) (optimize-level 1))
      ("Compile with optimization level 1")]
     [("--optimize-2")
      ,(lambda (flag) (optimize-level 2))
      (("Compile with optimization level 2,"
        "which implies all optimizations of level 1"))])
    (multi
     [("-l" "--link-flags")
      ,(lambda (flag lf) (link-flags (cons lf (link-flags))))
      ("Add a flag <lf> for the linker" "lf")]))
   (lambda (flag-accum file) file)
   '("filename"))
```

15.10 Additional Operating System Functions

```
(require racket/os)
```
package: `base`

The `racket/os` library additional functions for querying the operating system.

Added in version 6.3 of package `base`.

```
(gethostname) → string?
```

Returns a string for the current machine's hostname (including its domain).

```
(getpid) → exact-integer?
```

Returns an integer identifying the current process within the operating system.

16 Memory Management

16.1 Weak Boxes

A *weak box* is similar to a normal box (see §4.14 “Boxes”), but when the garbage collector (see §1.1.6 “Garbage Collection”) can prove that the content value of a weak box is only reachable via weak references, the content of the weak box is replaced with `#f`. A *weak reference* is a reference through a weak box, through a key reference in a weak hash table (see §4.15 “Hash Tables”), through a value in an ephemeron where the value can be replaced by `#f` (see §16.2 “Ephemerons”), or through a custodian (see §14.7 “Custodians”).

```
(make-weak-box v) → weak-box?
  v : any/c
```

Returns a new weak box that initially contains `v`.

```
(weak-box-value weak-box [gced-v]) → any/c
  weak-box : weak-box?
  gced-v : any/c = #f
```

Returns the value contained in `weak-box`. If the garbage collector has proven that the previous content value of `weak-box` was reachable only through a weak reference, then `gced-v` (which defaults to `#f`) is returned.

```
(weak-box? v) → boolean?
  v : any/c
```

Returns `#t` if `v` is a weak box, `#f` otherwise.

16.2 Ephemerons

An *ephemeron* [Hayes97] is a generalization of a weak box (see §16.1 “Weak Boxes”). Instead of just containing one value, an ephemeron holds two values: one that is considered the value of the ephemeron and another that is the ephemeron’s key. Like the value in a weak box, the value in an ephemeron may be replaced by `#f`, but when the *key* is no longer reachable (except possibly via weak references) instead of when the value is no longer reachable.

As long as an ephemeron’s value is retained, the reference is considered a non-weak reference. References to the key via the value are treated specially, however, in that the reference does not necessarily count toward the key’s reachability. A weak box can be seen as a specialization of an ephemeron where the key and value are the same.

One particularly common use of ephemerons is to combine them with a weak hash table (see §4.15 "Hash Tables") to produce a mapping where the memory manager can reclaim key–value pairs even when the value refers to the key; see `make-ephemeron-hash`. A related use is to retain a reference to a value as long as any value for which it is an impersonator is reachable; see `impersonator-ephemeron`.

More precisely,

- the value in an ephemeron is replaced by `#f` when the automatic memory manager can prove that either the ephemeron or the key is reachable only through weak references (see §16.1 "Weak Boxes"); and
- nothing reachable from the value in an ephemeron counts toward the reachability of an ephemeron key (whether for the same ephemeron or another), unless the same value is reachable through a non-weak reference, or unless the value's ephemeron key is reachable through a non-weak reference (see §16.1 "Weak Boxes" for information on weak references).

```
(make-ephemeron key v) → ephemeron?
  key : any/c
  v : any/c
```

Returns a new ephemeron whose key is *key* and whose value is initially *v*.

```
(ephemeron-value ephemeron [gced-v retain-v]) → any/c
  ephemeron : ephemeron?
  gced-v : any/c = #f
  retain-v : any/c = #f
```

Returns the value contained in *ephemeron*. If the garbage collector has proven that the key for *ephemeron* is only weakly reachable, then the result is *gced-v* (which defaults to `#f`).

The *retain-v* argument is retained as reachable until the ephemeron's value is extracted. It is useful, for example, when *ephemeron* was obtained through a weak, `eq?`-based mapping from *key* and *ephemeron* was created with *key* as the key; in that case, supplying *key* as *retain-v* ensures that *ephemeron* retains its value long enough for it to be extracted, even if *key* is otherwise unreachable.

Changed in version 7.1.0.10 of package `base`: Added the *retain-v* argument.

```
(ephemeron? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is an ephemeron, `#f` otherwise.

16.3 Wills and Executors

A *will executor* manages a collection of values and associated *will* procedures (a.k.a. *finalizers*). The will procedure for each value is ready to be executed when the value has been proven (by the garbage collector) to be unreachable, except through weak references (see §16.1 “Weak Boxes”) or as the registrant for other will executors. A will is useful for triggering clean-up actions on data associated with an unreachable value, such as closing a port embedded in an object when the object is no longer used.

Calling the `will-execute` or `will-try-execute` procedure executes a will that is ready in the specified will executor. A will executor is also a synchronizable event, so `sync` or `sync/timeout` can be used to detect when a will executor has ready wills. Wills are not executed automatically, because certain programs need control to avoid race conditions. However, a program can create a thread whose sole job is to execute wills for a particular executor.

If a value is registered with multiple wills (in one or multiple executors), the wills are readied in the reverse order of registration. Since readying a will procedure makes the value reachable again, the will must be executed and the value must be proven again unreachable through only weak references before another of the wills is readied or executed. However, wills for distinct unreachable values are readied at the same time, regardless of whether the values are reachable from each other.

A will executor’s registrant is held non-weakly until after the corresponding will procedure is executed. Thus, if the content value of a weak box (see §16.1 “Weak Boxes”) is registered with a will executor, the weak box’s content is not changed to `#f` until all wills have been executed for the value and the value has been proven again reachable through only weak references.

A will executor can be used as a synchronizable event (see §11.2.1 “Events”). A will executor is ready for synchronization when `will-execute` would not block; the synchronization result of a will executor is the will executor itself.

These examples show how to run cleanup actions when no synchronization is necessary. It simply runs the registered executors as they become ready in another thread.

Examples:

```
> (define an-executor (make-will-executor))
> (void
   (thread
    (λ ()
      (let loop ()
        (will-execute an-executor)
        (loop)))))
> (define (executor-proc v) (printf "a-box is now garbage\n"))
> (define a-box-to-track (box #f))
```

```
> (will-register an-executor a-box-to-track executor-proc)
> (collect-garbage)
> (set! a-box-to-track #f)
> (collect-garbage)
a-box is now garbage
```

```
(make-will-executor) → will-executor?
```

Returns a new will executor with no managed values.

```
(will-executor? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a will executor, `#f` otherwise.

```
(will-register executor v proc) → void?
  executor : will-executor?
  v : any/c
  proc : (any/c . -> . any)
```

Registers the value *v* with the will procedure *proc* in the will executor *executor*. When *v* is proven unreachable, then the procedure *proc* is ready to be called with *v* as its argument via `will-execute` or `will-try-execute`. The *proc* argument is strongly referenced until the will procedure is executed.

```
(will-execute executor) → any
  executor : will-executor?
```

Invokes the will procedure for a single "unreachable" value registered with the executor *executor*. The values returned by the will procedure are the result of the `will-execute` call. If no will is ready for immediate execution, `will-execute` blocks until one is ready.

```
(will-try-execute executor [v]) → any
  executor : any/c
  v : any/c = #f
```

Like `will-execute` if a will is ready for immediate execution. Otherwise, *v* is returned.

Changed in version 6.90.0.4 of package `base`: Added the *v* argument.

16.4 Garbage Collection

Set the `PLTDISABLEGC` environment variable (to any value) before Racket starts to disable garbage collection. Set the `PLT_INCREMENTAL_GC` environment variable to a value that starts with `1`, `y`, or `Y` to request incremental mode at all times for the 3m implementation of Racket, but calling `(collect-garbage 'incremental)` in a program with a periodic task is generally a better mechanism for requesting incremental mode. Set the `PLT_INCREMENTAL_GC` environment variable to a value that starts with `0`, `n`, or `N` to disable incremental-mode requests (in all implementations of Racket).

Each garbage collection logs a message (see §15.5 "Logging") at the `'debug` level with topic `'GC`. In the CS and 3m implementations of Racket, "major" collections are also logged at the `'debug` level with the topic `'GC:major`. In the CS and 3m implementations of Racket, the data portion of the message is an instance of a `gc-info` prefab structure type with 10 fields as follows, but future versions of Racket may use a `gc-info` prefab structure with additional fields:

```
(struct gc-info (mode pre-amount pre-admin-amount code-amount
                      post-amount post-admin-amount
                      start-process-time end-process-time
                      start-time end-time)
  #:prefab)
```

- The `mode` field is a symbol `'major`, `'minor`, or `'incremental`; `'major` indicates a collection that inspects all memory, `'minor` indicates collection that mostly inspects just recent allocations, and `'incremental` indicates a minor collection that performs extra work toward the next major collection.

  Changed in version 6.3.0.7 of package `base`: Changed first field from a boolean (`#t` for `'major`, `#f` for `'minor`) to a mode symbol.

- The `pre-amount` field reports place-local memory use (i.e., not counting the memory use of child places) in bytes at the time that the garbage collection started. Additional bytes registered via `make-phantom-bytes` are included.

- The `pre-admin-amount` is a larger number that includes memory use for the garbage collector's overhead, such as space on memory pages that are mapped but not currently used.

- The `code-amount` field reports additional memory use for generated native code (which is the same just before and after a garbage collection, since it is released via finalization).

- The `post-amount` and `post-admin-amount` fields correspond to `pre-amount` and `pre-admin-amount`, but after garbage collection. In typical configurations, the difference between `post-amount` and `pre-amount` contributes to `post-admin-amount`, since reclaimed pages tend to stay in reserve with the expectation that they'll be needed again (but the pages are released if multiple collections pass without need for the pages).

- The `start-process-time` and `end-process-time` fields report processor time (in the sense of `current-process-milliseconds`) at the start and end of garbage collection. The difference between the times is the processor time consumed by collection.

- The `start-time` and `end-time` fields report real time (in the sense of `current-inexact-milliseconds`) at the start and end of garbage collection. The difference between the times is the real time consumed by garbage collection.

The format of the logged message's text is subject to change. Currently, after a prefix that indicates the place and collection mode, the text has the format

⟨*used*⟩`(`⟨*admin*⟩`)` `[`⟨*code*⟩`]; free` ⟨*reclaimed*⟩`(`⟨*adjust*⟩`)` ⟨*elapsed*⟩ `@` ⟨*timestamp*⟩

⟨*used*⟩	Collectable memory in use just prior to garbage collection
⟨*admin*⟩	Additional memory used as to manage collectable memory
⟨*code*⟩	Additional memory used for generated machine code
⟨*reclaimed*⟩	Collectable memory reclaimed by garbage collection
⟨*adjust*⟩	Negation of change to administrative memory minus ⟨*reclaimed*⟩
⟨*elapsed*⟩	Processor time used to perform garbage collection
⟨*timestamp*⟩	Processor time since startup of garbage collection's start

Changed in version 6.3.0.7 of package `base`: Added `PLT_INCREMENTAL_GC`.
Changed in version 7.6.0.9: Added major-collection logging for the topic `'GC:major`.

```
(collect-garbage [request]) → void?
  request : (or/c 'major 'minor 'incremental) = 'major
```

Requests an immediate garbage collection or requests a garbage-collection mode, depending on *`request`*:

- `'major` — Forces a "major" collection, which inspects all memory. Some effectively unreachable data may remain uncollected, because the collector cannot prove that it is unreachable.

  This mode of `collect-garbage` procedure provides some control over the timing of collections, but garbage will obviously be collected even if this procedure is never called—unless garbage collection is disabled by setting `PLTDISABLEGC`.

- `'minor` — Requests a "minor" collection, which mostly inspects only recent allocations. If minor collection is not supported (e.g., when `(system-type 'gc)` returns `'cgc`) or if the next collection must be a major collection, no collection is performed. More generally, minor collections triggered by `(collect-garbage 'minor)` do not cause major collections any sooner than they would occur otherwise.

- `'incremental` — Does not request an immediate collection, but requests extra effort going forward to avoid major collections, even if it requires more work per minor collection to incrementally perform the work of a major collection. This incremental-mode request expires at the next major collection.

The intent of incremental mode is to significantly reduce pause times due to major collections, but incremental mode may imply longer minor-collection times and higher memory use. Currently, incremental mode is only meaningful for CS and 3m Racket implementations; it has no effect in other Racket implementations.

If the `PLT_INCREMENTAL_GC` environment variable's value starts with `0`, `n`, or `N` on start-up, then incremental-mode requests are ignored.

Changed in version 6.3 of package `base`: Added the *`request`* argument.
Changed in version 6.3.0.2: Added `'incremental` mode.
Changed in version 7.7.0.4: Added `'incremental` effect for Racket CS.

```
(current-memory-use [mode]) → exact-nonnegative-integer?
  mode : (or/c #f 'cumulative 'peak custodian?) = #f
```

Returns information about memory use:

- If *`mode`* is `#f` (the default), the result is an estimate of the number of bytes reachable from any custodian.
- If *`mode`* is `'cumulative`, returns an estimate of the total number of bytes allocated since start up, including bytes that have since been reclaimed by garbage collection.
- If *`mode`* is `'peak`, returns the maximum number of allocated bytes just before any garbage collection in the Racket process since its start.
- If *`mode`* is a custodian, returns an estimate of the number of bytes of memory occupied by reachable data from *`mode`*. This estimate is calculated by the last garbage collection, and can be 0 if none occurred (or if none occurred since the given custodian was created). The `current-memory-use` function does *not* perform a collection by itself; doing one before the call will generally decrease the result (or increase it from 0 if no collections happened yet).

  When Racket is compiled without support for memory accounting, the estimate is the same as when *`mode`* is `#f` (i.e., all memory) for any individual custodian. See also `custodian-memory-accounting-available?`.

See also `vector-set-performance-stats!`.

Changed in version 6.6.0.3 of package `base`: Added `'cumulative` mode.
Changed in version 8.10.0.3: Added `'peak` mode.

```
(dump-memory-stats v ...) → any
  v : any/c
```

Dumps information about memory usage to the low-level error port or console.

Various combinations of *v* arguments can control the information in a dump. The information that is available depends on your Racket build; check the end of a dump from a particular build to see if it offers additional information; otherwise, all *v*s are ignored.

16.5 Phantom Byte Strings

A *phantom byte string* is a small Racket value that is treated by the Racket memory manager as having an arbitrary size, which is specified when the phantom byte string is created or when it is changed via `set-phantom-bytes!`.

A phantom byte string acts as a hint to Racket's memory manager that memory is allocated within the process but through a separate allocator, such as through a foreign library that is accessed via `ffi/unsafe`. This hint is used to trigger garbage collections or to compute the result of `current-memory-use`.

```
(phantom-bytes? v) → boolean?
  v : any/c
```

Returns `#t` if *v* is a phantom byte string, `#f` otherwise.

```
(make-phantom-bytes k) → phantom-bytes?
  k : exact-nonnegative-integer?
```

Creates a phantom byte string that is treated by the Racket memory manager as being *k* bytes in size. For a large enough *k*, the `exn:fail:out-of-memory` exception is raised—either because the size is implausibly large, or because a memory limit has been installed with `custodian-limit-memory`.

```
(set-phantom-bytes! phantom-bstr k) → phantom-bytes?
  phantom-bstr : phantom-bytes?
  k : exact-nonnegative-integer?
```

Adjusts the size of a phantom byte string as it is treated by the Racket memory manager.

For example, if the memory that *phantom-bstr* represents is released through a foreign library, then `(set-phantom-bytes! phantom-bstr 0)` can reflect the change in memory use.

When *k* is larger than the current size of *phantom-bstr*, then this function can raise `exn:fail:out-of-memory`, like `make-phantom-bytes`.

17 Unsafe Operations

```
(require racket/unsafe/ops)        package: base
```

All functions and forms provided by `racket/base` and `racket` check their arguments to ensure that the arguments conform to contracts and other constraints. For example, `vector-ref` checks its arguments to ensure that the first argument is a vector, that the second argument is an exact integer, and that the second argument is between `0` and one less than the vector's length, inclusive.

Functions provided by `racket/unsafe/ops` are *unsafe*. They have certain constraints, but the constraints are not checked, which allows the system to generate and execute faster code. If arguments violate an unsafe function's constraints, the function's behavior and result is unpredictable, and the entire system can crash or become corrupted.

All of the exported bindings of `racket/unsafe/ops` are protected in the sense of `protect-out`, so access to unsafe operations can be prevented by adjusting the code inspector (see §14.10 "Code Inspectors").

17.1 Unsafe Numeric Operations

```
(unsafe-fx+ a ...) → fixnum?
  a : fixnum?
(unsafe-fx- a b ...) → fixnum?
  a : fixnum?
  b : fixnum?
(unsafe-fx* a ...) → fixnum?
  a : fixnum?
(unsafe-fxquotient a b) → fixnum?
  a : fixnum?
  b : fixnum?
(unsafe-fxremainder a b) → fixnum?
  a : fixnum?
  b : fixnum?
(unsafe-fxmodulo a b) → fixnum?
  a : fixnum?
  b : fixnum?
(unsafe-fxabs a) → fixnum?
  a : fixnum?
```

For fixnums: Unchecked versions of `fx+`, `fx-`, `fx*`, `fxquotient`, `fxremainder`, `fxmodulo`, and `fxabs`.

Changed in version 7.0.0.13 of package `base`: Allow zero or more arguments for `unsafe-fx+` and `unsafe-fx*` and allow one or more arguments for `unsafe-fx-`.

```
(unsafe-fxand a ...) → fixnum?
  a : fixnum?
(unsafe-fxior a ...) → fixnum?
  a : fixnum?
(unsafe-fxxor a ...) → fixnum?
  a : fixnum?
(unsafe-fxnot a) → fixnum?
  a : fixnum?
(unsafe-fxlshift a b) → fixnum?
  a : fixnum?
  b : fixnum?
(unsafe-fxrshift a b) → fixnum?
  a : fixnum?
  b : fixnum?
(unsafe-fxrshift/logical a b) → fixnum?
  a : fixnum?
  b : fixnum?
```

For fixnums: Unchecked versions of `fxand`, `fxior`, `fxxor`, `fxnot`, `fxlshift`, `fxrshift`, and `fxrshift/logical`.

Changed in version 7.0.0.13 of package `base`: Allow zero or more arguments for `unsafe-fxand`, `unsafe-fxior`, and `unsafe-fxxor`.
Changed in version 8.8.0.5: Added `unsafe-fxrshift/logical`.

```
(unsafe-fxpopcount a) → fixnum?
  a : (and/c fixnum? (not/c negative?))
(unsafe-fxpopcount32 a) → fixnum?
  a : (and/c fixnum? (integer-in 0 #xFFFFFFFF))
(unsafe-fxpopcount16 a) → fixnum?
  a : (and/c fixnum? (integer-in 0 #xFFFF))
```

For fixnums: Unchecked versions of `fxpopcount`, `fxpopcount32`, and `fxpopcount16`.

Added in version 8.5.0.6 of package `base`.

```
(unsafe-fx+/wraparound a b) → fixnum?
  a : fixnum?
  b : fixnum?
(unsafe-fx-/wraparound [a] b) → fixnum?
  a : fixnum? = 0
  b : fixnum?
(unsafe-fx*/wraparound a b) → fixnum?
  a : fixnum?
  b : fixnum?
```

```
(unsafe-fxlshift/wraparound a b) → fixnum?
  a : fixnum?
  b : fixnum?
```

For fixnums: Unchecked versions of fx+/wraparound, fx-/wraparound, fx*/wraparound, and fxlshift/wraparound.

Added in version 7.9.0.6 of package base.
Changed in version 8.15.0.12: Changed unsafe-fx-/wraparound to accept a single argument.

```
(unsafe-fx= a b ...) → boolean?
  a : fixnum?
  b : fixnum?
(unsafe-fx< a b ...) → boolean?
  a : fixnum?
  b : fixnum?
(unsafe-fx> a b ...) → boolean?
  a : fixnum?
  b : fixnum?
(unsafe-fx<= a b ...) → boolean?
  a : fixnum?
  b : fixnum?
(unsafe-fx>= a b ...) → boolean?
  a : fixnum?
  b : fixnum?
(unsafe-fxmin a b ...) → fixnum?
  a : fixnum?
  b : fixnum?
(unsafe-fxmax a b ...) → fixnum?
  a : fixnum?
  b : fixnum?
```

For fixnums: Unchecked versions of fx=, fx<, fx>, fx<=, fx>=, fxmin, and fxmax.

Changed in version 7.0.0.13 of package base: Allow one or more argument, instead of allowing just two.

```
(unsafe-fl+ a ...) → flonum?
  a : flonum?
(unsafe-fl- a b ...) → flonum?
  a : flonum?
  b : flonum?
(unsafe-fl* a ...) → flonum?
  a : flonum?
(unsafe-fl/ a b ...) → flonum?
  a : flonum?
  b : flonum?
```

```
(unsafe-flabs a) → flonum?
  a : flonum?
```

For flonums: Unchecked versions of `fl+`, `fl-`, `fl*`, `fl/`, and `flabs`.

Changed in version 7.0.0.13 of package `base`: Allow zero or more arguments for `unsafe-fl+` and `unsafe-fl*` and one or more arguments for `unsafe-fl-` and `unsafe-fl/`.

```
(unsafe-fl= a b ...) → boolean?
  a : flonum?
  b : flonum?
(unsafe-fl< a b ...) → boolean?
  a : flonum?
  b : flonum?
(unsafe-fl> a b ...) → boolean?
  a : flonum?
  b : flonum?
(unsafe-fl<= a b ...) → boolean?
  a : flonum?
  b : flonum?
(unsafe-fl>= a b ...) → boolean?
  a : flonum?
  b : flonum?
(unsafe-flmin a b ...) → flonum?
  a : flonum?
  b : flonum?
(unsafe-flmax a b ...) → flonum?
  a : flonum?
  b : flonum?
```

For flonums: Unchecked versions of `fl=`, `fl<`, `fl>`, `fl<=`, `fl>=`, `flmin`, and `flmax`.

Changed in version 7.0.0.13 of package `base`: Allow one or more argument, instead of allowing just two.

```
(unsafe-flround a) → flonum?
  a : flonum?
(unsafe-flfloor a) → flonum?
  a : flonum?
(unsafe-flceiling a) → flonum?
  a : flonum?
(unsafe-fltruncate a) → flonum?
  a : flonum?
```

For flonums: Unchecked (potentially) versions of `flround`, `flfloor`, `flceiling`, and `fltruncate`. Currently, these bindings are simply aliases for the corresponding safe bindings.

```
(unsafe-flsingle a) → flonum?
  a : flonum?
```

For flonums: Unchecked (potentially) version of `flsingle`.

Added in version 7.8.0.7 of package `base`.

```
(flbit-field a start end) → exact-nonnegative-integer?
  a : flonum?
  start : (integer-in 0 64)
  end : (integer-in 0 64)
```

For flonums: Unchecked version of `flbit-field`.

Added in version 7.8.0.7 of package `base`.

```
(unsafe-flsin a) → flonum?
  a : flonum?
(unsafe-flcos a) → flonum?
  a : flonum?
(unsafe-fltan a) → flonum?
  a : flonum?
(unsafe-flasin a) → flonum?
  a : flonum?
(unsafe-flacos a) → flonum?
  a : flonum?
(unsafe-flatan a) → flonum?
  a : flonum?
(unsafe-fllog a) → flonum?
  a : flonum?
(unsafe-flexp a) → flonum?
  a : flonum?
(unsafe-flsqrt a) → flonum?
  a : flonum?
(unsafe-flexpt a b) → flonum?
  a : flonum?
  b : flonum?
```

For flonums: Unchecked (potentially) versions of `flsin`, `flcos`, `fltan`, `flasin`, `flacos`, `flatan`, `fllog`, `flexp`, `flsqrt`, and `flexpt`. Currently, some of these bindings are simply aliases for the corresponding safe bindings.

```
(unsafe-make-flrectangular a b)
 → (and/c complex?
          (lambda (c) (flonum? (real-part c)))
          (lambda (c) (flonum? (imag-part c))))
  a : flonum?
  b : flonum?
(unsafe-flreal-part a) → flonum?
  a : (and/c complex?
             (lambda (c) (flonum? (real-part c)))
             (lambda (c) (flonum? (imag-part c))))
(unsafe-flimag-part a) → flonum?
  a : (and/c complex?
             (lambda (c) (flonum? (real-part c)))
             (lambda (c) (flonum? (imag-part c))))
```

For flonums: Unchecked versions of `make-flrectangular`, `flreal-part`, and `flimag-part`.

```
(unsafe-fx->fl a) → flonum?
  a : fixnum?
(unsafe-fl->fx a) → fixnum?
  a : flonum?
```

Unchecked versions of `fx->fl` and `fl->fx`.

Changed in version 7.7.0.8 of package `base`: Changed `unsafe-fl->fx` to truncate.

```
(unsafe-flrandom rand-gen) → (and flonum? (>/c 0) (</c 1))
  rand-gen : pseudo-random-generator?
```

Unchecked version of `flrandom`.

17.2 Unsafe Character Operations

```
(unsafe-char=? a b ...) → boolean?
  a : char?
  b : char?
(unsafe-char<? a b ...) → boolean?
  a : char?
  b : char?
(unsafe-char>? a b ...) → boolean?
  a : char?
  b : char?
```

```
(unsafe-char<=? a b ...) → boolean?
  a : char?
  b : char?
(unsafe-char>=? a b ...) → boolean?
  a : char?
  b : char?
(unsafe-char->integer a) → fixnum?
  a : char?
```

Unchecked versions of `char=?`, `char<?`, `char>?`, `char<=?`, `char>=?`, and `char->integer`.

Added in version 7.0.0.14 of package `base`.

17.3 Unsafe Compound-Data Operations

```
(unsafe-car p) → any/c
  p : pair?
(unsafe-cdr p) → any/c
  p : pair?
(unsafe-mcar p) → any/c
  p : mpair?
(unsafe-mcdr p) → any/c
  p : mpair?
(unsafe-set-mcar! p v) → void?
  p : mpair?
  v : any/c
(unsafe-set-mcdr! p v) → void?
  p : mpair?
  v : any/c
```

Unsafe variants of `car`, `cdr`, `mcar`, `mcdr`, `set-mcar!`, and `set-mcdr!`.

```
(unsafe-cons-list v rest) → (and/c pair? list?)
  v : any/c
  rest : list?
```

Unsafe variant of `cons` that produces a pair that claims to be a list—without checking whether *rest* is a list.

```
(unsafe-list-ref lst pos) → any/c
  lst : pair?
  pos : (and/c exact-nonnegative-integer? fixnum?)
(unsafe-list-tail lst pos) → any/c
  lst : any/c
  pos : (and/c exact-nonnegative-integer? fixnum?)
```

Unsafe variants of `list-ref` and `list-tail`, where *pos* must be a fixnum, and *lst* must start with at least `(add1 pos)` (for `unsafe-list-ref`) or *pos* (for `unsafe-list-tail`) pairs.

```
(unsafe-set-immutable-car! p v) → void?
  p : pair?
  v : any/c
(unsafe-set-immutable-cdr! p v) → void?
  p : pair?
  v : any/c
```

As their oxymoronic names should suggest, there is *no generally correct way* to use these functions. They may be useful nevertheless, as a last resort, in settings where pairs are used in a constrained way and when making correct assumptions about Racket's implementation (including limits on the compiler's optimizations).

Some pitfalls of using `unsafe-set-immutable-car!` and `unsafe-set-immutable-cdr!`:

- Functions that consume a pair may take advantage of immutability, such as computing a list's length once and expecting the list to retain that length, or checking a list against a contract and expecting the contract to hold thereafter.
- The result of `list?` for a pair may be cached internally, so that changing the `cdr` of a pair from a list to a non-list or vice versa may cause `list?` to produce the wrong value—for the mutated pair or for another pair that reaches the mutated pair.
- The compiler may reorder or even optimize away a call to `car` or `cdr` on the grounds that pairs are immutable, in which case a `unsafe-set-immutable-car!` or `unsafe-set-immutable-cdr!` may not have an effect on the use of `car` or `cdr`.

Added in version 7.9.0.18 of package `base`.

```
(unsafe-unbox b) → any/c
  b : box?
(unsafe-set-box! b k) → void?
  b : box?
  k : any/c
(unsafe-unbox* v) → any/c
  v : (and/c box? (not/c impersonator?))
(unsafe-set-box*! v val) → void?
  v : (and/c box? (not/c impersonator?))
  val : any/c
```

Unsafe versions of `unbox` and `set-box!`, where the `box*` variants can be faster but do not work on impersonators.

```
(unsafe-box*-cas! loc old new) → boolean?
  loc : box?
  old : any/c
  new : any/c
```

Unsafe version of `box-cas!`. Like `unsafe-set-box*!`, it does not work on impersonators.

```
(unsafe-vector-length v) → fixnum?
  v : vector?
(unsafe-vector-ref v k) → any/c
  v : vector?
  k : fixnum?
(unsafe-vector-set! v k val) → void?
  v : vector?
  k : fixnum?
  val : any/c
(unsafe-vector-copy v [start end]) → vector?
  v : vector?
  start : fixnum? = 0
  end : fixnum? = (vector-length v)
(unsafe-vector-set/copy v [pos] val) → vector?
  v : vector?
  pos : fixnum? = 0
  val : any/c
(unsafe-vector-append v ...) → vector?
  v : vector?
(unsafe-vector*-length v) → fixnum?
  v : (and/c vector? (not/c impersonator?))
(unsafe-vector*-ref v k) → any/c
  v : (and/c vector? (not/c impersonator?))
  k : fixnum?
(unsafe-vector*-set! v k val) → void?
  v : (and/c vector? (not/c impersonator?))
  k : fixnum?
  val : any/c
(unsafe-vector*-cas! v k old-val new-val) → boolean?
  v : (and/c vector? (not/c impersonator?))
  k : fixnum?
  old-val : any/c
  new-val : any/c
(unsafe-vector*-copy v [start end]) → vector?
  v : vector?
  start : fixnum? = 0
  end : fixnum? = (vector-length v)
```

```
(unsafe-vector*-set/copy v pos val) → vector?
  v : vector?
  pos : fixnum?
  val : any/c
(unsafe-vector*-append v ...) → vector?
  v : vector?
```

Unsafe versions of `vector-length`, `vector-ref`, `vector-set!`, `vector-cas!`, `vector-copy`, `vector-set/copy`, and `vector-append`, where the `vector*` variants can be faster but do not work on impersonators.

A vector's size can never be larger than a fixnum, so even `vector-length` always returns a fixnum.

Changed in version 6.11.0.2 of package `base`: Added `unsafe-vector*-cas!`.
Changed in version 8.11.1.9: Added `unsafe-vector-copy`, `unsafe-vector*-copy`, `unsafe-vector-set/copy`, `unsafe-vector*-set/copy`, `unsafe-vector-append`, and `unsafe-vector*-append`.

```
(unsafe-vector*->immutable-vector! v)
 → (and/c vector? immutable?)
  v : (and/c vector? (not/c impersonator?))
```

Similar to `vector->immutable-vector`, but potentially destroys *v* and reuses it space, so *v* must not be used after calling `unsafe-vector*->immutable-vector!`.

Added in version 7.7.0.6 of package `base`.

```
(unsafe-string-length str) → fixnum?
  str : string?
(unsafe-string-ref str k)
 → (and/c char? (lambda (ch) (<= 0 (char->integer ch) 255)))
  str : string?
  k : fixnum?
(unsafe-string-set! str k ch) → void?
  str : (and/c string? (not/c immutable?))
  k : fixnum?
  ch : char?
```

Unsafe versions of `string-length`, `string-ref`, and `string-set!`. The `unsafe-string-ref` procedure can be used only when the result will be a Latin-1 character. A string's size can never be larger than a fixnum (so even `string-length` always returns a fixnum).

```
(unsafe-string->immutable-string! str)
 → (and/c string? immutable?)
  str : string?
```

Similar to string->immutable-string, but potentially destroys *str* and reuses it space, so *str* must not be used after calling unsafe-string->immutable-string!.

Added in version 7.7.0.6 of package base.

```
(unsafe-bytes-length bstr) → fixnum?
  bstr : bytes?
(unsafe-bytes-ref bstr k) → byte?
  bstr : bytes?
  k : fixnum?
(unsafe-bytes-set! bstr k b) → void?
  bstr : (and/c bytes? (not/c immutable?))
  k : fixnum?
  b : byte?
(unsafe-bytes-copy!  dest
                     dest-start
                     src
                    [src-start
                     src-end])   → void?
  dest : (and/c bytes? (not/c immutable?))
  dest-start : fixnum?
  src : bytes?
  src-start : fixnum? = 0
  src-end : fixnum? = (bytes-length src)
```

Unsafe versions of bytes-length, bytes-ref, bytes-set!, and bytes-copy!. A bytes's size can never be larger than a fixnum (so even bytes-length always returns a fixnum).

Changed in version 7.5.0.15 of package base: Added unsafe-bytes-copy!.

```
(unsafe-bytes->immutable-bytes! bstr)
 → (and/c bytes? immutable?)
  bstr : bytes?
```

Similar to bytes->immutable-bytes, but potentially destroys *bstr* and reuses it space, so *bstr* must not be used after calling unsafe-bytes->immutable-bytes!.

Added in version 7.7.0.6 of package base.

```
(unsafe-fxvector-length v) → fixnum?
  v : fxvector?
(unsafe-fxvector-ref v k) → fixnum?
  v : fxvector?
  k : fixnum?
```

```
(unsafe-fxvector-set! v k x) → void?
  v : fxvector?
  k : fixnum?
  x : fixnum?
```

Unsafe versions of `fxvector-length`, `fxvector-ref`, and `fxvector-set!`. A fxvector's size can never be larger than a fixnum (so even `fxvector-length` always returns a fixnum).

```
(unsafe-flvector-length v) → fixnum?
  v : flvector?
(unsafe-flvector-ref v k) → flonum?
  v : flvector?
  k : fixnum?
(unsafe-flvector-set! v k x) → void?
  v : flvector?
  k : fixnum?
  x : flonum?
```

Unsafe versions of `flvector-length`, `flvector-ref`, and `flvector-set!`. A flvector's size can never be larger than a fixnum (so even `flvector-length` always returns a fixnum).

```
(unsafe-f64vector-ref vec k) → flonum?
  vec : f64vector?
  k : fixnum?
(unsafe-f64vector-set! vec k n) → void?
  vec : f64vector?
  k : fixnum?
  n : flonum?
```

Unsafe versions of `f64vector-ref` and `f64vector-set!`.

```
(unsafe-s16vector-ref vec k) → (integer-in -32768 32767)
  vec : s16vector?
  k : fixnum?
(unsafe-s16vector-set! vec k n) → void?
  vec : s16vector?
  k : fixnum?
  n : (integer-in -32768 32767)
```

Unsafe versions of `s16vector-ref` and `s16vector-set!`.

```
(unsafe-u16vector-ref vec k) → (integer-in 0 65535)
  vec : u16vector?
  k : fixnum?
(unsafe-u16vector-set! vec k n) → void?
  vec : u16vector?
  k : fixnum?
  n : (integer-in 0 65535)
```

Unsafe versions of `u16vector-ref` and `u16vector-set!`.

```
(unsafe-stencil-vector mask v ...) → stencil-vector?
  mask : (integer-in 0 (sub1 (expt 2 (stencil-vector-mask-width))))
  v : any/c
(unsafe-stencil-vector-mask vec)
 → (integer-in 0 (sub1 (expt 2 (stencil-vector-mask-width))))
  vec : stencil-vector?
(unsafe-stencil-vector-length vec)
 → (integer-in 0 (sub1 (stencil-vector-mask-width)))
  vec : stencil-vector?
(unsafe-stencil-vector-ref vec pos) → any/c
  vec : stencil-vector?
  pos : exact-nonnegative-integer?
(unsafe-stencil-vector-set! vec pos v) → void?
  vec : stencil-vector?
  pos : exact-nonnegative-integer?
  v : any/c
(unsafe-stencil-vector-update vec
                              remove-mask
                              add-mask
                              v ...)      → stencil-vector?
  vec : stencil-vector?
  remove-mask : (integer-in 0 (sub1 (expt 2 (stencil-vector-mask-width))))
  add-mask : (integer-in 0 (sub1 (expt 2 (stencil-vector-mask-width))))
  v : any/c
```

Unsafe variants of `stencil-vector`, `stencil-vector-mask`, `stencil-vector-length`, `stencil-vector-ref`, `stencil-vector-set!`, and `stencil-vector-update`.

Added in version 8.5.0.7 of package `base`.

```
(unsafe-struct-ref v k) → any/c
  v : any/c
  k : fixnum?
(unsafe-struct-set! v k val) → void?
  v : any/c
  k : fixnum?
  val : any/c
(unsafe-struct*-ref v k) → any/c
  v : (not/c impersonator?)
  k : fixnum?
(unsafe-struct*-set! v k val) → void?
  v : (not/c impersonator?)
  k : fixnum?
  val : any/c
```

```
(unsafe-struct*-cas! v k old-val new-val) → boolean?
  v : (not/c impersonator?)
  k : fixnum?
  old-val : any/c
  new-val : any/c
```

Unsafe field access and update for an instance of a structure type, where the `struct*` variants can be faster but do not work on impersonators. The index *k* must be between `0` (inclusive) and the number of fields in the structure (exclusive). In the case of `unsafe-struct-set!`, `unsafe-struct*-set!`, and `unsafe-struct*-cas!`, the field must be mutable. The `unsafe-struct*-cas!` operation is analogous to `box-cas!` to perform an atomic compare-and-set.

Changed in version 6.11.0.2 of package `base`: Added `unsafe-struct*-cas!`.

```
(unsafe-struct*-type v) → struct-type?
  v : any/c
```

Similar to `struct-info`, but without an inspector check, returning only the first result, and without support for impersonators.

Added in version 8.8.0.3 of package `base`.

```
(unsafe-mutable-hash-iterate-first hash) → (or/c #f any/c)
  hash : (and/c hash? (not/c immutable?) hash-strong?)
(unsafe-mutable-hash-iterate-next hash pos) → (or/c #f any/c)
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  pos : any/c
(unsafe-mutable-hash-iterate-key hash pos) → any/c
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  pos : any/c
(unsafe-mutable-hash-iterate-key hash
                                 pos
                                 bad-index-v) → any/c
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  pos : any/c
  bad-index-v : any/c
(unsafe-mutable-hash-iterate-value hash
                                   pos) → any/c
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  pos : any/c
(unsafe-mutable-hash-iterate-value hash
                                   pos
                                   bad-index-v) → any/c
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  pos : any/c
  bad-index-v : any/c
```

```
(unsafe-mutable-hash-iterate-key+value hash
                                        pos) → any/c any/c
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  pos : any/c
(unsafe-mutable-hash-iterate-key+value hash
                                        pos
                                        bad-index-v)
 → any/c any/c
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  pos : any/c
  bad-index-v : any/c
(unsafe-mutable-hash-iterate-pair hash pos) → pair?
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  pos : any/c
(unsafe-mutable-hash-iterate-pair hash
                                   pos
                                   bad-index-v) → pair?
  hash : (and/c hash? (not/c immutable?) hash-strong?)
  pos : any/c
  bad-index-v : any/c
(unsafe-immutable-hash-iterate-first hash) → (or/c #f any/c)
  hash : (and/c hash? immutable?)
(unsafe-immutable-hash-iterate-next hash
                                     pos) → (or/c #f any/c)
  hash : (and/c hash? immutable?)
  pos : any/c
(unsafe-immutable-hash-iterate-key hash
                                    pos) → any/c
  hash : (and/c hash? immutable?)
  pos : any/c
(unsafe-immutable-hash-iterate-key hash
                                    pos
                                    bad-index-v) → any/c
  hash : (and/c hash? immutable?)
  pos : any/c
  bad-index-v : any/c
(unsafe-immutable-hash-iterate-value hash
                                      pos) → any/c
  hash : (and/c hash? immutable?)
  pos : any/c
(unsafe-immutable-hash-iterate-value hash
                                      pos
                                      bad-index-v) → any/c
  hash : (and/c hash? immutable?)
  pos : any/c
  bad-index-v : any/c
```

```
(unsafe-immutable-hash-iterate-key+value hash
                                         pos) → any/c any/c
  hash : (and/c hash? immutable?)
  pos : any/c
(unsafe-immutable-hash-iterate-key+value hash
                                         pos
                                         bad-index-v)
 → any/c any/c
  hash : (and/c hash? immutable?)
  pos : any/c
  bad-index-v : any/c
(unsafe-immutable-hash-iterate-pair hash
                                    pos) → pair?
  hash : (and/c hash? immutable?)
  pos : any/c
(unsafe-immutable-hash-iterate-pair hash
                                    pos
                                    bad-index-v) → pair?
  hash : (and/c hash? immutable?)
  pos : any/c
  bad-index-v : any/c
(unsafe-weak-hash-iterate-first hash) → (or/c #f any/c)
  hash : (and/c hash? hash-weak?)
(unsafe-weak-hash-iterate-next hash pos) → (or/c #f any/c)
  hash : (and/c hash? hash-weak?)
  pos : any/c
(unsafe-weak-hash-iterate-key hash pos) → any/c
  hash : (and/c hash? hash-weak?)
  pos : any/c
(unsafe-weak-hash-iterate-key hash
                              pos
                              bad-index-v) → any/c
  hash : (and/c hash? hash-weak?)
  pos : any/c
  bad-index-v : any/c
(unsafe-weak-hash-iterate-value hash pos) → any/c
  hash : (and/c hash? hash-weak?)
  pos : any/c
(unsafe-weak-hash-iterate-value hash
                                pos
                                bad-index-v) → any/c
  hash : (and/c hash? hash-weak?)
  pos : any/c
  bad-index-v : any/c
```

```
(unsafe-weak-hash-iterate-key+value hash
                                    pos) → any/c any/c
  hash : (and/c hash? hash-weak?)
  pos : any/c
(unsafe-weak-hash-iterate-key+value hash
                                    pos
                                    bad-index-v) → any/c any/c
  hash : (and/c hash? hash-weak?)
  pos : any/c
  bad-index-v : any/c
(unsafe-weak-hash-iterate-pair hash pos) → pair?
  hash : (and/c hash? hash-weak?)
  pos : any/c
(unsafe-weak-hash-iterate-pair hash
                               pos
                               bad-index-v) → pair?
  hash : (and/c hash? hash-weak?)
  pos : any/c
  bad-index-v : any/c
(unsafe-ephemeron-hash-iterate-first hash) → (or/c #f any/c)
  hash : (and/c hash? hash-ephemeron?)
(unsafe-ephemeron-hash-iterate-next hash
                                    pos) → (or/c #f any/c)
  hash : (and/c hash? hash-ephemeron?)
  pos : any/c
(unsafe-ephemeron-hash-iterate-key hash
                                   pos) → any/c
  hash : (and/c hash? hash-ephemeron?)
  pos : any/c
(unsafe-ephemeron-hash-iterate-key hash
                                   pos
                                   bad-index-v) → any/c
  hash : (and/c hash? hash-ephemeron?)
  pos : any/c
  bad-index-v : any/c
(unsafe-ephemeron-hash-iterate-value hash
                                     pos) → any/c
  hash : (and/c hash? hash-ephemeron?)
  pos : any/c
(unsafe-ephemeron-hash-iterate-value hash
                                     pos
                                     bad-index-v) → any/c
  hash : (and/c hash? hash-ephemeron?)
  pos : any/c
  bad-index-v : any/c
```

```
(unsafe-ephemeron-hash-iterate-key+value hash
                                          pos) → any/c any/c
  hash : (and/c hash? hash-ephemeron?)
  pos : any/c
(unsafe-ephemeron-hash-iterate-key+value hash
                                          pos
                                          bad-index-v)
 → any/c any/c
  hash : (and/c hash? hash-ephemeron?)
  pos : any/c
  bad-index-v : any/c
(unsafe-ephemeron-hash-iterate-pair hash
                                     pos) → pair?
  hash : (and/c hash? hash-ephemeron?)
  pos : any/c
(unsafe-ephemeron-hash-iterate-pair hash
                                     pos
                                     bad-index-v) → pair?
  hash : (and/c hash? hash-ephemeron?)
  pos : any/c
  bad-index-v : any/c
```

Unsafe versions of `hash-iterate-key` and similar procedures. These operations support chaperones and impersonators.

Each unsafe ...`-first` and ...`-next` procedure may return, instead of a number index, an internal representation of a view into the hash structure, enabling faster iteration. The result of these ...`-first` and ...`-next` functions should be given as *pos* to the corresponding unsafe accessor functions.

If the *pos* provided to an accessor function for a mutable *hash* was formerly a valid hash index but is no longer a valid hash index for *hash*, and if *bad-index-v* is not provided, then the `exn:fail:contract` exception is raised. No behavior is specified for a *pos* that was never a valid hash index for *hash*. Note that *bad-index-v* argument is technically not useful for the `unsafe-immutable-hash-iterate-` functions, since an index cannot become invalid for an immutable *hash*.

Added in version 6.4.0.6 of package `base`.
Changed in version 7.0.0.10: Added the optional *bad-index-v* argument.
Changed in version 8.0.0.10: Added `ephemeron` variants.

```
(unsafe-make-srcloc source
                    line
                    column
                    position
                    span)     → srcloc?
  source : any/c
```

```
line : (or/c exact-positive-integer? #f)
column : (or/c exact-nonnegative-integer? #f)
position : (or/c exact-positive-integer? #f)
span : (or/c exact-nonnegative-integer? #f)
```

Unsafe version of `srcloc`.

Added in version 7.2.0.10 of package `base`.

17.4 Unsafe Extflonum Operations

```
(unsafe-extfl+ a b) → extflonum?
  a : extflonum?
  b : extflonum?
(unsafe-extfl- a b) → extflonum?
  a : extflonum?
  b : extflonum?
(unsafe-extfl* a b) → extflonum?
  a : extflonum?
  b : extflonum?
(unsafe-extfl/ a b) → extflonum?
  a : extflonum?
  b : extflonum?
(unsafe-extflabs a) → extflonum?
  a : extflonum?
```

Unchecked versions of `extfl+`, `extfl-`, `extfl*`, `extfl/`, and `extflabs`.

```
(unsafe-extfl= a b) → boolean?
  a : extflonum?
  b : extflonum?
(unsafe-extfl< a b) → boolean?
  a : extflonum?
  b : extflonum?
(unsafe-extfl> a b) → boolean?
  a : extflonum?
  b : extflonum?
(unsafe-extfl<= a b) → boolean?
  a : extflonum?
  b : extflonum?
(unsafe-extfl>= a b) → boolean?
  a : extflonum?
  b : extflonum?
```

```
(unsafe-extflmin a b) → extflonum?
  a : extflonum?
  b : extflonum?
(unsafe-extflmax a b) → extflonum?
  a : extflonum?
  b : extflonum?
```

Unchecked versions of `extfl=`, `extfl<`, `extfl>`, `extfl<=`, `extfl>=`, `extflmin`, and `extflmax`.

```
(unsafe-extflround a) → extflonum?
  a : extflonum?
(unsafe-extflfloor a) → extflonum?
  a : extflonum?
(unsafe-extflceiling a) → extflonum?
  a : extflonum?
(unsafe-extfltruncate a) → extflonum?
  a : extflonum?
```

Unchecked (potentially) versions of `extflround`, `extflfloor`, `extflceiling`, and `extfltruncate`. Currently, these bindings are simply aliases for the corresponding safe bindings.

```
(unsafe-extflsin a) → extflonum?
  a : extflonum?
(unsafe-extflcos a) → extflonum?
  a : extflonum?
(unsafe-extfltan a) → extflonum?
  a : extflonum?
(unsafe-extflasin a) → extflonum?
  a : extflonum?
(unsafe-extflacos a) → extflonum?
  a : extflonum?
(unsafe-extflatan a) → extflonum?
  a : extflonum?
(unsafe-extfllog a) → extflonum?
  a : extflonum?
(unsafe-extflexp a) → extflonum?
  a : extflonum?
(unsafe-extflsqrt a) → extflonum?
  a : extflonum?
(unsafe-extflexpt a b) → extflonum?
  a : extflonum?
  b : extflonum?
```

Unchecked (potentially) versions of `extflsin`, `extflcos`, `extfltan`, `extflasin`, extflacos, extflatan, extfllog, extflexp, extflsqrt, and extflexpt. Currently, some of these bindings are simply aliases for the corresponding safe bindings.

```
(unsafe-fx->extfl a) → extflonum?
  a : fixnum?
(unsafe-extfl->fx a) → fixnum?
  a : extflonum?
```

Unchecked (potentially) versions of fx->extfl and extfl->fx.

Changed in version 7.7.0.8 of package base: Changed unsafe-fl->fx to truncate.

```
(unsafe-extflvector-length v) → fixnum?
  v : extflvector?
(unsafe-extflvector-ref v k) → extflonum?
  v : extflvector?
  k : fixnum?
(unsafe-extflvector-set! v k x) → void?
  v : extflvector?
  k : fixnum?
  x : extflonum?
```

Unchecked versions of extflvector-length, extflvector-ref, and extflvector-set!. A extflvector's size can never be larger than a fixnum (so even extflvector-length always returns a fixnum).

17.5 Unsafe Impersonators and Chaperones

```
(unsafe-impersonate-procedure proc
                              replacement-proc
                              prop
                              prop-val ...
                              ...)
 → (and/c procedure? impersonator?)
  proc : procedure?
  replacement-proc : procedure?
  prop : impersonator-property?
  prop-val : any
```

Like impersonate-procedure, but assumes that *replacement-proc* calls *proc* itself. When the result of unsafe-impersonate-procedure is applied to arguments, the arguments are passed on to *replacement-proc* directly, ignoring *proc*. At the same time, impersonator-of? reports #t when given the result of unsafe-impersonate-procedure and *proc*.

If *proc* is itself an impersonator that is derived from impersonate-procedure* or chaperone-procedure*, beware that *replacement-proc* will not be able to call it correctly. Specifically, the impersonator produced by unsafe-impersonate-procedure will not get passed to a wrapper procedure that was supplied to impersonate-procedure* or chaperone-procedure* to generate *proc*.

Finally, unlike impersonate-procedure, unsafe-impersonate-procedure does not specially handle impersonator-prop:application-mark as a *prop*.

The unsafety of unsafe-impersonate-procedure is limited to the above differences from impersonate-procedure. The contracts on the arguments of unsafe-impersonate-procedure are checked when the arguments are supplied.

As an example, assuming that f accepts a single argument and is not derived from impersonate-procedure* or chaperone-procedure*, then

```
(λ (f)
  (unsafe-impersonate-procedure
   f
   (λ (x)
     (if (number? x)
         (error 'no-numbers!)
         (f x)))))
```

is equivalent to

```
(λ (f)
  (impersonate-procedure
   f
   (λ (x)
     (if (number? x)
         (error 'no-numbers!)
        x))))
```

Similarly, with the same assumptions about f, the following two procedures *wrap-f1* and *wrap-f2* are almost equivalent; they differ only in the error message produced when their arguments are functions that return multiple values (and that they update different global variables). The version using unsafe-impersonate-procedure will signal an error in the let expression about multiple return values, whereas the one using impersonate-procedure signals an error from impersonate-procedure about multiple return values.

```
(define log1-args '())
(define log1-results '())
(define wrap-f1
  (λ (f)
    (impersonate-procedure
```

```
      f
      (λ (arg)
        (set! log1-args (cons arg log1-args))
        (values (λ (res)
                  (set! log1-results (cons res log1-results))
                  res)
                arg)))))

(define log2-args '())
(define log2-results '())
(define wrap-f2
  (λ (f)
    (unsafe-impersonate-procedure
      f
      (λ (arg)
        (set! log2-args (cons arg log2-args))
        (let ([res (f arg)])
          (set! log2-results (cons res log2-results))
          res)))))
```

Added in version 6.4.0.4 of package `base`.

```
(unsafe-chaperone-procedure proc
                            wrapper-proc
                            prop
                            prop-val ...
                            ...)
 → (and/c procedure? chaperone?)
  proc : procedure?
  wrapper-proc : procedure?
  prop : impersonator-property?
  prop-val : any
```

Like `unsafe-impersonate-procedure`, but creates a chaperone. Since *`wrapper-proc`* will be called in lieu of *`proc`*, *`wrapper-proc`* is assumed to return a chaperone of the value that *`proc`* would return.

Added in version 6.4.0.4 of package `base`.

```
(unsafe-impersonate-vector vec
                           replacement-vec
                           prop
                           prop-val ...
                           ...)
 → (and/c vector? impersonator?)
  vec : vector?
```

```
replacement-vec : (and/c vector? (not/c impersonator?))
prop : impersonator-property?
prop-val : any/c
```

Like `impersonate-vector`, but instead of going through interposition procedures, all accesses to the impersonator are dispatched to *replacement-vec*.

The result of `unsafe-impersonate-vector` is an impersonator of *vec*.

Added in version 6.9.0.2 of package `base`.

```
(unsafe-chaperone-vector vec
                         replacement-vec
                         prop
                         prop-val ...
                         ...)
 → (and/c vector? chaperone?)
  vec : vector?
  replacement-vec : (and/c vector? (not/c impersonator?))
  prop : impersonator-property?
  prop-val : any/c
```

Like `unsafe-impersonate-vector`, but the result of `unsafe-chaperone-vector` is a chaperone of *vec*.

Added in version 6.9.0.2 of package `base`.

17.6 Unsafe Assertions

```
(unsafe-assert-unreachable) → none/c
```

Like `assert-unreachable`, but the contract of `unsafe-assert-unreachable` is never satisfied, and the "unsafe" implication is that anything at all can happen if a call to `unsafe-assert-unreachable` is reached.

The compiler may take advantage of its liberty to pick convenient or efficient behavior in place of a call to `unsafe-assert-unreachable`. For example, the expression

```
(lambda (x)
  (if (pair? x)
      (car x)
      (unsafe-assert-unreachable)))
```

may be compiled to code equivalent to

```
(lambda (x) (unsafe-car x))
```

because choosing to make (unsafe-assert-unreachable) behave the same as (unsafe-car x) makes both branches of the if the same, and then pair? test can be eliminated.

Added in version 8.0.0.11 of package base.

17.7 Unsafe Structure Type Properties

```
(require racket/unsafe/struct-type-property)    package: base
```

The bindings documented in this section are provided by the racket/unsafe/struct-type-property library, not racket/base or racket.

```
(unsafe-make-struct-type-property/guard-calls-no-arguments
 name
[guard
 supers
 can-impersonate?
 accessor-name
 contract-str
 realm])
→ struct-type-property?
  (any/c . -> . boolean?)
  procedure?
name : symbol?
guard : (or/c procedure? #f 'can-impersonate) = #f
supers : (listof (cons/c struct-type-property?  = null
                         (any/c . -> . any/c)))
can-impersonate? : any/c = #f
accessor-name : (or/c symbol? #f) = #f
contract-str : (or/c string? symbol? #f) = #f
realm : symbol? = 'racket
```

The same as make-struct-type-property, but asserts that *guard* does not call any procedures that are contained in its property-value argument. Similarly, no procedure in *supers* calls a contained procedure, and properties in *supers* have no guards or conversions that call contained procedures.

Asserting that given procedures are not called by a property's guards can reduce checks and improve optimization on operations for structure types that use the property. Specifically, when the property created by unsafe-make-struct-type-property/guard-calls-no-arguments is used in a structure-type declaration, and when a value that is given for the property includes procedures that refer back to the structure-type declaration's bindings (which is a common pattern for method-like properties), the compiler can more easily conclude that the defined name that is referenced in a property value cannot be referenced too early.

Added in version 8.18.0.18 of package `base`.

17.8 Unsafe Undefined

```
(require racket/unsafe/undefined)
```
package: `base`

The bindings documented in this section are provided by the `racket/unsafe/undefined` library, not `racket/base` or `racket`.

The constant `unsafe-undefined` is used internally as a placeholder value. For example, it is used by `letrec` as a value for a variable that has not yet been assigned a value. Unlike the `undefined` value exported by `racket/undefined`, however, the `unsafe-undefined` value should not leak as the result of a safe expression, and it should not be passed as an optional argument to a procedure (because it may count as "no value provided"). Expression results that potentially produce `unsafe-undefined` can be guarded by `check-not-unsafe-undefined`, so that an exception can be raised instead of producing an `undefined` value.

The `unsafe-undefined` value is always `eq?` to itself.

Added in version 6.0.1.2 of package `base`.
Changed in version 6.90.0.29: Procedures with optional arguments sometimes use the `unsafe-undefined` value internally to mean "no argument supplied."

```
unsafe-undefined : any/c
```

The unsafe "undefined" constant.

See above for important constraints on the use of `unsafe-undefined`.

```
(check-not-unsafe-undefined v sym) → any/c
  v : any/c
  sym : symbol?
```

Checks whether *v* is `unsafe-undefined`, and raises `exn:fail:contract:variable` in that case with an error message along the lines of "*sym*: undefined; use before initialization." If *v* is not `unsafe-undefined`, then *v* is returned.

```
(check-not-unsafe-undefined/assign v sym) → any/c
  v : any/c
  sym : symbol?
```

The same as `check-not-unsafe-undefined`, except that the error message (if any) is along the lines of "*sym*: undefined; assignment before initialization."

```
(chaperone-struct-unsafe-undefined v) → any/c
  v : any/c
```

Chaperones *v* if it is a structure (as viewed through some inspector). Every access of a field in the structure is checked to prevent returning `unsafe-undefined`. Similarly, every assignment to a field in the structure is checked (unless the check disabled as described below) to prevent assignment of a field whose current value is `unsafe-undefined`.

When a field access would otherwise produce `unsafe-undefined` or when a field assignment would replace `unsafe-undefined`, the `exn:fail:contract` exception is raised.

The chaperone's field-assignment check is disabled whenever `(continuation-mark-set-first #f prop:chaperone-unsafe-undefined)` returns `unsafe-undefined`. Thus, a field-initializing assignment—one that is intended to replace the `unsafe-undefined` value of a field—should be wrapped with `(with-continuation-mark prop:chaperone-unsafe-undefined unsafe-undefined ....)`.

```
prop:chaperone-unsafe-undefined : struct-type-property?
```

A structure type property that causes a structure type's constructor to produce a chaperone of an instance in the same way as `chaperone-struct-unsafe-undefined`.

The property value should be a list of symbols used as field names, but the list should be in reverse order of the structure's fields. When a field access or assignment would produce or replace `unsafe-undefined`, the `exn:fail:contract:variable` exception is raised if a field name is provided by the structure property's value, otherwise the `exn:fail:contract` exception is raised.

18 Running Racket

18.1 Running Racket or GRacket

The core Racket run-time system is available in two main variants:

- Racket, which provides the primitives libraries on which `racket/base` is implemented. On Unix and Mac OS, the executable is called `racket`. On Windows, the executable is called `Racket.exe`.
- GRacket, which is a GUI variant of `racket` to the degree that the system distinguishes them. On Unix, the executable is called `gracket`, and single-instance flags and X11-related flags are handled and communicated specially to the `racket/gui/base` library. On Windows, the executable is called `GRacket.exe`, and it is a GUI application (as opposed to a console application) that implements single-instance support. On Mac OS, the `gracket` script launches `GRacket.app`.

18.1.1 Initialization

On start-up, the top-level environment contains no bindings—not even `#%app` for function application. Primitive modules with names that start with `#%` are defined, but they are not meant for direct use, and the set of such modules can change. For example, the `'#%kernel` module is eventually used to bootstrap the implementation of `racket/base`.

The first action of Racket or GRacket is to initialize `current-library-collection-paths` to the result of `(find-library-collection-paths pre-extras extras)`, where *`pre-extras`* is normally `null` and *`extras`* are extra directory paths provided in order in the command line with `-S`/`--search`. An executable created from the Racket or GRacket executable can embed paths used as *`pre-extras`*.

Racket and GRacket next `require` `racket/init` and `racket/gui/init`, respectively, but only if the command line does not specify a `require` flag (`-t`/`--require`, `-l`/`--lib`, or `-u`/`--require-script`) before any `eval`, `load`, or read-eval-print-loop flag (`-e`/`--eval`, `-f`/`--load`, `-r`/`--script`, `-m`/`--main`, or `-i`/`--repl`). The initialization library can be changed with the `-I` configuration option. The `configure-runtime` submodule of the initialization library or the `'configure-runtime` property of the initialization library's language is used before the library is instantiated; see §18.1.5 "Language Run-Time Configuration".

After potentially loading the initialization module, expression `eval`s, files `load`s, and module `require`s are executed in the order that they are provided on the command line. If any raises an uncaught exception, then the remaining `eval`s, `load`s, and `require`s are skipped. If the first `require` precedes any `eval` or `load` so that the initialization library is skipped, then the `configure-runtime` submodule of the required module or the `'configure-runtime` property of the required module's library language is used before the module is instantiated; see §18.1.5 "Language Run-Time Configuration".

After running all command-line expressions, files, and modules, Racket or GRacket then starts a read-eval-print loop for interactive evaluation if no command line flags are provided other than configuration options. For Racket, the read-eval-print loop is run by calling `read-eval-print-loop` from `racket/repl`. For GRacket, the read-eval-print loop is run by calling `graphical-read-eval-print-loop` from `racket/gui/base`. If any command-line argument is provided that is not a configuration option, then the read-eval-print-loop is not started, unless the `-i`/`--repl` flag is provided on the command line to specifically re-enable it.

In addition, just before the read-eval-print loop is started, Racket runs `racket/interactive` and GRacket runs `racket/gui/interactive`, unless a different interactive file is specified in the the installation's `"config.rktd"` file found in `(find-config-dir)`, or the file `"interactive.rkt"` is found in `(find-system-path 'addon-dir)`. If the `-q`/`--no-init-file` flag is specified on the command line, then no interactive file is run.

Finally, before Racket or GRacket exits, it calls the procedure that is the current value of `executable-yield-handler` in the main thread, unless the `-V`/`--no-yield` command-line flag is specified. Requiring `racket/gui/base` sets this parameter call `(racket 'yield)`.

Changed in version 6.7 of package `base`: Run `racket/interactive` file rather than directly running `(find-system-path 'init-file)`.
Changed in version 6.90.0.30: Run a read-eval-print loop by using `racket/repl` or `racket/gui/base` instead of `racket/base` or `racket/gui/init`.

18.1.2 Exit Status

The default exit status for a Racket or GRacket process is non-zero if an error occurs during a command-line `eval` (via `-e`, etc.), `load` (via `-f`, `-r`, etc.), or `require` (via `-l`, `-t`, etc.)—or, more generally, if the abort handler of the prompt surrounding those evalutions is called—but only when no read-eval-print loop is started. Otherwise, the default exit status is `0`.

In all cases, a call to `exit` (when the default exit handler is in place) can end the process with a specific status value.

18.1.3 Init Libraries

```
(require racket/init)
```
package: `base`

The racket/init library is the default start-up library for Racket. It re-exports the racket, racket/enter and racket/help libraries, and it sets current-print to use pretty-print.

```
(require racket/interactive)
```
package: base

The racket/interactive is the default start up library when the REPL begins. It is not run if the -q/--no-init-file is specified. The interactive file can be changed by modifying 'interactive-file in the "config.rktd" file found in (find-config-dir). Alternative, if the file "interactive.rkt" exists in (find-system-path 'addon-dir) it is run rather than the installation wide interactive module.

The default interactive module starts xrepl and runs the (find-system-path 'init-file) file in the users home directory. A different interactive file can keep this behavior by requiring racket/interactive.

Added in version 6.7 of package base.

```
(require racket/language-info)
```
package: base

The racket/language-info library provides a get-info function that takes any value and returns another function; the returned function takes a key value and a default value, and it returns '(#(racket/runtime-config configure #f)) if the key is 'configure-runtime or the default value otherwise.

See also §17.3.6 "Module-Handling Configuration" in *The Racket Guide*.

The vector '#(racket/language-info get-info #f) is suitable for attaching to a module as its language info to get the same language information as the racket/base language.

```
(require racket/runtime-config)
```
package: base

The racket/runtime-config library provides a configure function that takes any value and sets print-as-expression to #t.

The vector #(racket/runtime-config configure #f) is suitable as a member of a list of runtime-configuration specification (as returned by a module's language-information function for the key 'configure-runtime) to obtain the same runtime configuration as for the racket/base language.

18.1.4 Command Line

The Racket and GRacket executables recognize the following command-line flags:

- File and expression options:
  - -e ⟨*expr*⟩ or --eval ⟨*expr*⟩ : evals ⟨*expr*⟩. The results of the evaluation are printed via current-print.

- -f ⟨*file*⟩ or --load ⟨*file*⟩ : loads ⟨*file*⟩; if ⟨*file*⟩ is "-", then expressions are read and evaluated from standard input.
- -t ⟨*file*⟩ or --require ⟨*file*⟩ : requires ⟨*file*⟩, and then requires (submod (file "⟨*file*⟩") main) if available.
- -l ⟨*path*⟩ or --lib ⟨*path*⟩ : requires (lib "⟨*path*⟩"), and then requires (submod (lib "⟨*path*⟩") main) if available.
- -p ⟨*package*⟩ : requires (planet "⟨*package*⟩"), and then requires (submod (planet "⟨*package*⟩") main) if available.
- -r ⟨*file*⟩ or --script ⟨*file*⟩ : loads ⟨*file*⟩ as a script. This flag is like -f ⟨*file*⟩ plus -N ⟨*file*⟩ to set the program name and -- to cause all further command-line elements to be treated as non-flag arguments.

  Despite its name, --script is not usually used for Unix scripts. See §21.2 "Scripts" for more information on scripts.
- -u ⟨*file*⟩ or --require-script ⟨*file*⟩ : requires ⟨*file*⟩ as a script; This flag is like -t ⟨*file*⟩ plus -N ⟨*file*⟩ to set the program name and -- to cause all further command-line elements to be treated as non-flag arguments.
- -k ⟨*n*⟩ ⟨*m*⟩ ⟨*p*⟩ : Loads code embedded in the executable from file position ⟨*n*⟩ to ⟨*m*⟩ and from ⟨*m*⟩ to ⟨*p*⟩. (On Mac OS, ⟨*n*⟩, ⟨*m*⟩, and ⟨*p*⟩ are relative to a __PLTSCHEME segment in the executable. On Windows, they are relative to a resource of type 257 and ID 1. On Unix using ELF, they are relative to the .rackprog segment in the executable.) The first range is loaded in every new place, and any modules declared in that range are considered predefined in the sense of module-predefined?. This option is normally embedded in a stand-alone binary that also embeds Racket code.
- -Y ⟨*file*⟩ ⟨*n*⟩ ⟨*m*⟩ ⟨*p*⟩ : Like -k ⟨*n*⟩ ⟨*m*⟩ ⟨*p*⟩, but reading from ⟨*file*⟩ (without any adjustment for a segment or resource offset).
- -m or --main : Evaluates a call to main as bound in the top-level environment. All of the command-line arguments that are not processed as options (i.e., the arguments put into current-command-line-arguments) are passed as arguments to main. The results of the call are printed via current-print.

  The call to main is constructed as an expression (main *arg-str* ...) where the lexical context of the expression gives #%app and #%datum bindings as #%plain-app and #%datum, but the lexical context of main is the top-level environment.

• Interaction options:

- -i or --repl : Runs an interactive read-eval-print loop, using either read-eval-print-loop (Racket) or graphical-read-eval-print-loop (GRacket) after showing (banner) and loading (find-system-path 'init-file). In the case of Racket, (read-eval-print-loop) is followed by (newline). For GRacket, supply the -z/--text-repl configuration option to use read-eval-print-loop (and newline) instead of graphical-read-eval-print-loop.
- -n or --no-lib : Skips requiring the initialization library (i.e., racket/init or racket/gui/init, unless it is changed with the -I flag) when not otherwise disabled.

- `-v` or `--version` : Shows `(banner)`.
- `-K` or `--back` : GRacket, Mac OS only; leave application in the background.
- `-V` `--no-yield` : Skips final `executable-yield-handler` action, which normally waits until all frames are closed, etc. in the main eventspace before exiting for programs that use `racket/gui/base`.

• *Configuration options*:

- `-y` or `--make` : Enables automatic generation and update of compiled `".zo"` files for modules loaded in the initial namespace. Specifically, the result of `(make-compilation-manager-load/use-compiled-handler)` is installed as the compiled-load handler before other module-loading actions. **Caution:** This flag is intended for use in interactive settings; using it in a script is probably a bad idea, because concurrent invocations of the script may collide attempting to update compiled files, or there may be filesystem-permission issues. Using `-c`/`--no-compiled` cancels the effect of `-y`/`--make`.
- `-c` or `--no-compiled` : Disables loading of compiled `".zo"` files, by initializing `use-compiled-file-paths` to `null`. Use judiciously: this effectively ignores the content of all `"compiled"` subdirectories, so that any used modules are compiled on the fly—even `racket/base` and its dependencies—which leads to prohibitively expensive run times.
- `-q` or `--no-init-file` : Skips loading `(find-system-path 'init-file)` for `-i`/`--repl`.
- `-z` or `--text-repl` : GRacket only; changes `-i`/`--repl` to use `textual-read-eval-print-loop` instead of `graphical-read-eval-print-loop`.
- `-I` ⟨*path*⟩ : Sets `(lib "`⟨*path*⟩`")` as the path to `require` to initialize the namespace, unless namespace initialization is disabled. Using this flag can effectively set the language for the read-eval-print loop and other top-level evaluation.
- `-X` ⟨*dir*⟩ or `--collects` ⟨*dir*⟩ : Sets ⟨*dir*⟩ as the path to the main collection of libraries by making `(find-system-path 'collects-dir)` produce ⟨*dir*⟩. If ⟨*dir*⟩ is an empty string, then `(find-system-path 'collects-dir)` returns `"."`, but `current-library-collection-paths` is initialized to the empty list, and `use-collection-link-paths` is initialized to `#f`.
- `-S` ⟨*dir*⟩ or `--search` ⟨*dir*⟩ : Adds ⟨*dir*⟩ to the default library collection search path after the main collection directory. If the `-S`/`--dir` flag is supplied multiple times, the search order is as supplied.
- `-G` ⟨*dir*⟩ or `--config` ⟨*dir*⟩ : Sets the directory that is returned by `(find-system-path 'config-dir)`.
- `-A` ⟨*dir*⟩ or `--addon` ⟨*dir*⟩ : Sets the directory that is returned by `(find-system-path 'addon-dir)`.
- `-U` or `--no-user-path` : Omits user-specific paths in the search for collections, C libraries, etc. by initializing the `use-user-specific-search-paths` parameter to `#f`.

- -A ⟨*dir*⟩ or --addon ⟨*dir*⟩ : Sets the directory that is returned by (find-system-path 'addon-dir).
- -R ⟨*paths*⟩ or --compiled ⟨*paths*⟩ : Sets the initial value of the current-compiled-file-roots parameter, overriding any PLTCOMPILEDROOTS setting. The ⟨*paths*⟩ argument is parsed in the same way as PLTCOMPILEDROOTS (see current-compiled-file-roots).
- -C or --cross : Select cross-platform build mode, causing (system-type 'cross) to report 'force, and sets the current configuration of (find-system-path 'config-dir), (find-system-path 'collects-dir), and (find-system-path 'addon-dir), to be the results of (find-system-path 'host-config-dir), (find-system-path 'host-collects-dir), and (find-system-path 'host-addon-dir), respectively. If -C or --cross is provided multiple times, only the first instance has an effect.
- -N ⟨*file*⟩ or --name ⟨*file*⟩ : sets the name of the executable as reported by (find-system-path 'run-file) to ⟨*file*⟩.
- -E ⟨*file*⟩ or --exe ⟨*file*⟩ : sets the name of the executable as reported by (find-system-path 'exec-file) to ⟨*file*⟩.
- -J ⟨*name*⟩ or --wm-class ⟨*name*⟩ : GRacket, Unix only; sets the WM_CLASS program class to ⟨*name*⟩ (while the WM_CLASS program name is derived from the executable name or a -N/--name argument).
- -j or --no-jit : Disables the native-code just-in-time compiler by setting the eval-jit-enabled parameter to #f.
- -M or --compile-any : Enables machine-independent bytecode by setting the current-compile-target-machine parameter to #f.
- -d or --no-delay : Disables on-demand parsing of compiled code and syntax objects by setting the read-on-demand-source parameter to #f.
- -b or --binary : Requests binary mode, instead of text mode, for the process's input, out, and error ports. This flag currently has no effect, because binary mode is always used.
- -W ⟨*levels*⟩ or --warn ⟨*levels*⟩ : Sets the logging level for writing events to the original error port. The possible ⟨*level*⟩ values are the same as for the PLTSTDERR environment variable. See §15.5 "Logging" for more information.
- -O ⟨*levels*⟩ or --stdout ⟨*levels*⟩ : Sets the logging level for writing events to the original output port. The possible ⟨*level*⟩ values are the same as for the PLTSTDOUT environment variable. See §15.5 "Logging" for more information.
- -L ⟨*levels*⟩ or --syslog ⟨*levels*⟩ : Sets the logging level for writing events to the system log. The possible ⟨*level*⟩ values are the same as for the PLTSYSLOG environment variable. See §15.5 "Logging" for more information.

• Meta options:

- -Z : The argument following this flag is ignored. This flag can be handy in some impoverished scripting environments to replace or cancel another command-line argument.

- `--` : No argument following this flag is itself used as a flag.
- `-h` or `--help` : Shows information about the command-line flags and start-up process and exits, ignoring all other flags.

If at least one command-line argument is provided, and if the first one after any configuration option is not a flag, then a `-u`/`--require-script` flag is implicitly added before the first non-flag argument.

If no command-line arguments are supplied other than configuration options, then the `-i`/`--repl` flag is effectively added.

For GRacket on Unix, the follow flags are recognized when they appear at the beginning of the command line, and they count as configuration options (i.e., they do not disable the read-eval-print loop or prevent the insertion of `-u`/`--require-script`):

- `-display` ⟨*display*⟩ : Sets the X11 display to use.
- `-geometry` ⟨*arg*⟩, `-bg` ⟨*arg*⟩, `-background` ⟨*arg*⟩, `-fg` ⟨*arg*⟩, `-foreground` ⟨*arg*⟩, `-fn` ⟨*arg*⟩, `-font` ⟨*arg*⟩, `-iconic`, `-name` ⟨*arg*⟩, `-rv`, `-reverse`, `+rv`, `-selectionTimeout` ⟨*arg*⟩, `-synchronous`, `-title` ⟨*arg*⟩, `-xnllanguage` ⟨*arg*⟩, or `-xrm` ⟨*arg*⟩ : Standard X11 arguments that are mostly ignored but accepted for compatibility with other X11 programs. The `-synchronous` flag behaves in the usual way.
- `-singleInstance` : If an existing GRacket is already running on the same X11 display, if it was started on a machine with the same hostname, and if it was started with the same name as reported by `(find-system-path 'run-file)`—possibly set with the `-N`/`--name` command-line argument—then all non-option command-line arguments are treated as filenames and sent to the existing GRacket instance via the application file handler (see `application-file-handler`).

Similarly, on Mac OS, a leading switch starting with `-psn_` is treated as a special configuration option. It indicates that Finder started the application, so the current input, output, and error output are redirected to a GUI window.

Multiple single-letter switches (the ones preceded by a single `-`) can be collapsed into a single switch by concatenating the letters, as long as the first switch is not `--`. The arguments for each switch are placed after the collapsed switches (in the order of the switches). For example,

`-ifve` ⟨*file*⟩ ⟨*expr*⟩

and

`-i -f` ⟨*file*⟩ `-v -e` ⟨*expr*⟩

are equivalent. If a collapsed `--` appears before other collapsed switches in the same collapsed set, it is implicitly moved to the end of the collapsed set.

Extra arguments following the last option are available from the `current-command-line-arguments` parameter.

Changed in version 6.90.0.17 of package `base`: Added `-O`/`--stdout`.
Changed in version 7.1.0.5: Added `-M`/`--compile-any`.
Changed in version 7.8.0.6: Added `-Z`.
Changed in version 8.0.0.10: Added `-E`.
Changed in version 8.0.0.11: Added `-Y`.
Changed in version 8.4.0.1: Added `-y`/`--make`.

18.1.5 Language Run-Time Configuration

See also §17.3.6 "Module-Handling Configuration" in *The Racket Guide*.

A module can have a `configure-runtime` submodule that is `dynamic-require`d before the module itself when a module is the main module of a program. Normally, a `configure-runtime` submodule is added to a module by the module's language (i.e., by the `#%module-begin` form among a `module`'s initial bindings). The body of a `configure-runtime` submodule typically sets parameters, possibly including `current-interaction-info`.

Alternatively or in addition, an older protocol is in place. When a module is implemented using `#lang`, the language after `#lang` can specify configuration actions to perform when a module using the language is the main module of a program. The language specifies run-time configuration by

- attaching a `'module-language` syntax property to the module as read from its source (see `module` and `module-compiled-language-info`);
- having the function indicated by the `'module-language` syntax property recognize the `'configure-runtime` key, for which it returns a list of vectors; each vector must have the form `(vector mp name val)` where *mp* is a module path, *name* is a symbol, and *val* is an arbitrary value; and
- having each function called as `((dynamic-require mp name) val)` configure the run-time environment, typically by setting parameters such as `current-print`.

A `'configure-runtime` query returns a list of vectors, instead of directly configuring the environment, so that the indicated modules to be bundled with a program when creating a stand-alone executable; see §2 "`raco exe`: Creating Stand-Alone Executables" in *raco: Racket Command-Line Tools*.

For information on defining a new `#lang` language, see `syntax/module-reader`.

18.1.6 Language Expand Configuration

A module `lang` can have a `configure-expand` submodule that is `dynamic-require`d before the expansion of another module that is implemented as `(module name lang ....)`. The submodule is loaded in a root namespace, the same as a reader module. The submodule should provide `enter-parameterization` and `exit-parameterization` as procedures that each take no arguments and return a parameterization:

- `enter-parameterization` for `lang` is called at the start of an expansion of a module `(module name lang ....)`, and the parameterization wraps the module expansion via `call-with-parameterization`.
- `exit-parameterization` is called for `lang` if the expansion of `(module name lang ....)` triggers expansion of other modules, typically because they are `required` by the module being expanded. In that case, `exit-parameterization` is called to obtain a parameterization that is put in place around a call to `enter-parameterization` for the language of the module newly being expanded.

The `current-parameterization` procedure works as a default for both `enter-parameterization` and `exit-parameterization`.

The parameterization produced by a `enter-parameterization` typically sets parameters that affect error reporting during expansion, such as `error-syntax->string-handler`. The parameterization produced by `exit-parameterization` should generally revert any changes made by `enter-parameterization` while keeping other parameter values intact (such as `current-load-relative-directory`). To communicate from a use of `enter-parameterization` to a nested use of `exit-parameterization`, use a private parameter.

The `enter-parameterization` and `exit-parameterization` procedures are expected to build on the current parameterization, but they should generally not mutate current parameters, since that mutation would extend beyond the use of the returned parameterization. Instead, use `parameterize` to create a new parameterization with updated parameter values. The `enter-parameterization` and `exit-parameterization` should also not operate on the current namespace, since that can interfere with module expansion.

Added in version 8.8.0.6 of package `base`.

18.2 Libraries and Collections

A *library* is a `module` declaration for use by multiple programs. Racket further groups libraries into *collections*. Typically, collections are added via *packages* (see *Package Management in Racket*); the package manager works outside of the Racket core, but it configures the core run-time system through collection links files.

Libraries in collections are referenced through lib paths (see require) or symbolic shorthands. For example, the following module uses the "getinfo.rkt" library module from the "setup" collection, and the "cards.rkt" library module from the "games" collection's "cards" subcollection:

```
#lang racket
(require (lib "setup/getinfo.rkt")
         (lib "games/cards/cards.rkt"))
....
```

This example is more compactly and more commonly written using symbolic shorthands:

```
#lang racket
(require setup/getinfo
         games/cards/cards)
....
```

When an identifier *id* is used in a require form, it is converted to (lib *rel-string*) where *rel-string* is the string form of *id*.

A *rel-string* in (lib *rel-string*) consists of one or more path elements that name collections, and then a final path element that names a library file; the path elements are separated by /. If *rel-string* contains no /s, then /main.rkt is implicitly appended to the path. If *rel-string* contains / but does not end with a file suffix, then .rkt is implicitly appended to the path.

Libraries also can be distributed via PLaneT packages. Such libraries are referenced through a planet module path (see require) and are downloaded by Racket on demand, instead of referenced through collections.

The translation of a planet or lib path to a module declaration is determined by the module name resolver, as specified by the current-module-name-resolver parameter.

18.2.1 Collection Search Configuration

For the default module name resolver, the search path for collections is determined by the current-library-collection-links parameter and the current-library-collection-paths parameter:

- The most primitive collection-based modules are located in "collects" directory relative to the Racket executable. Libraries for a collection are grouped within a directory whose name matches the collection name. The path to the "collects" directory is normally included in current-library-collection-paths.

- Collection-based libraries also can be installed other directories, perhaps user-specific, that are structured like the "collects" directory. Those additional directories can be included in the current-library-collection-paths parameter either dynamically, through command-line arguments to racket, or by setting the PLTCOLLECTS environment variable; see find-library-collection-paths.

- Collection links files provide a mapping from top-level collection names to directories, plus additional "collects"-like directories (that have subdirectories with names that match collection names). Each collection links file to be searched is referenced by the current-library-collection-links parameter; the parameter references the file, and not the file's content, so that changes to the file can be detected and affect later module resolution. See also find-library-collection-links.

- The current-library-collection-links parameter's value can also include hash tables that provide the same content as collection links files: a mapping from collection names in symbol form to a list of paths for the collection, or from #f to a list of "collects"-like paths.

- Finally, the current-library-collection-links parameter's value includes #f to indicate the point in the search process at which the module-name resolver should check current-library-collection-paths relative to the files and hash tables in current-library-collection-links.

To resolve a module reference *rel-string*, the default module name resolver searches collection links in current-library-collection-links from first to last to locate the first directory that contains *rel-string*, splicing a search through in current-library-collection-paths where in current-library-collection-links contains #f. The filesystem tree for each element in the link table and search path is effectively *spliced* together with the filesystem trees of other path elements that correspond to the same collection. Some Racket tools rely on unique resolution of module path names, so an installation and configuration should not allow multiple files to match the same collection and file combination.

The value of the current-library-collection-links parameter is initialized by the racket executable to the result of (find-library-collection-links), and the value of the current-library-collection-paths parameter is initialized to the result of (find-library-collection-paths).

18.2.2 Collection Links

Collection links files are used by collection-file-path, collection-path, and the default module name resolver to locate collections before trying the (current-library-collection-paths) search path. The collection links files to use are determined by the current-library-collection-links parameter, which is initialized to the result of find-library-collection-links.

A collection links file is `read` with default reader parameter settings to obtain a list. Every element of the list must be a link specification with one of the forms `(list string encoded-path)`, `(list string encoded-path regexp)`, `(list 'root encoded-path)`, `(list 'root encoded-path regexp)`, `(list 'static-root encoded-path)`, `(list 'static-root encoded-path regexp)`. A *string* names a top-level collection, in which case *encoded-path* describes a path that can be used as the collection's path (directly, as opposed to a subdirectory of *encoded-path* named by *string*). A `'root` entry, in contrast, acts like an path in `(current-library-collection-paths)`. A `'static-root` entry is like a `'root` entry, but where the immediate content of the directory is assumed not to change unless the collection links file changes. Each *encoded-path* is either a string, a byte string that is converted to a path with `bytes->path`, or a list of relative path-element byte strings, `'up`, and `'same` indicators that are combined with `build-path` with the byte strings converted with `bytes->path-element`. If *encoded-path* describes a relative path, it is relative to the directory containing the collection links file. If *regexp* is specified in a link, then the link is used only if `(regexp-match? regexp (version))` produces a true result.

A single top-level collection can have multiple links in a collection links file, and any number of `'root` entries can appear. The corresponding paths are effectively spliced together, since the paths are tried in order to locate a file or sub-collection.

The `raco link` command-link tool can display, install, and remove links in a collection links file. See §9 "`raco link`: Library Collection Links" in *raco: Racket Command-Line Tools* for more information.

Changed in version 8.1.0.6 of package `base`: Changed *encoded-path* to allow bytes strings and lists.

18.2.3 Collection Paths and Parameters

```
(find-library-collection-paths [pre-extras
                                post-extras
                                config]
                                name)       → (listof path?)
  pre-extras : (listof path-string?) = null
  post-extras : (listof path-string?) = null
  config : hash? = (read-installation-configuration-table)
  name : (get-installation-name config)
```

Produces a list of paths, which is normally used to initialize `current-library-collection-paths`, as follows:

- The path produced by `(build-path (find-system-path 'addon-dir) name "collects")` is the first element of the default collection path list, unless the value of the `use-user-specific-search-paths` parameter is `#f`.

- Extra directories provided in *pre-extras* are included next to the default collection path list, converted to complete paths relative to the executable.

- If the directory specified by (find-system-path 'collects-dir) is absolute, or if it is relative (to the executable) and it exists, then it is added to the end of the default collection path list.

- Extra directories provided in *post-extras* are included last in the default collection path list, converted to complete paths relative to the executable.

- If *config* has a value for 'collects-search-dirs, then it is used in place of the default collection path list (as constructed by the preceding three bullets), and the default is spliced in place of any #f within the 'collects-search-dirs list. If *config* does not have a 'collects-search-dirs value, then the default collection path list is used.

- If the PLTCOLLECTS environment variable is defined, it is combined with the default list using path-list-string->path-list, as long as the value of use-user-specific-search-paths is true. If it is not defined or if the value use-user-specific-search-paths is #f, the collection path list as constructed by the preceding four bullets is used directly.

  Note that on Unix and Mac OS, paths are separated by :, and on Windows by ;. Also, path-list-string->path-list splices the default paths at an empty path, for example, with many Unix shells you can set PLTCOLLECTS to ":‘pwd‘", "‘pwd‘:", or "‘pwd‘" to specify search the current directory after, before, or instead of the default paths, respectively.

Changed in version 8.4.0.3 of package base: Added the *config* and *name* arguments.

```
(find-library-collection-links [config] name)
 → (listof (or/c #f (and/c path? complete-path?)))
  config : hash? = (read-installation-configuration-table)
  name : (get-installation-name config)
```

Produces a list of paths and #f, which is normally used to initialize current-library-collection-links, as follows:

- The list starts with #f, which causes the default module name resolver, collection-file-path, and collection-path to try paths in current-library-collection-paths before collection links files.

- As long as the values of use-user-specific-search-paths and use-collection-link-paths are true, the second element in the result list is the path of the user–specific collection links file, which is (build-path (find-system-path 'addon-dir) *name* "links.rktd") by default, but it can be replaced by a 'links-file value in *config*.

- As long as the value of `use-collection-link-paths` is true, the rest of the list contains a result like that of `get-links-search-files`, but using *`config`* if supplied instead of reading the installation's `"config.rktd"` file. Typically, that result is a list with a single path, `(build-path (find-config-dir) "links.rktd")`.

Changed in version 8.4.0.3 of package `base`: Added the *`config`* and *`name`* arguments.

```
(collection-file-path  file
                       collection ...+
                      [#:check-compiled? check-compiled?])
 → path?
  file : path-string?
  collection : path-string?
  check-compiled? : any/c = (regexp-match? #rx"[.]rkt$" file)
(collection-file-path  file
                       collection ...+
                       #:fail fail-proc
                      [#:check-compiled? check-compiled?]) → any
  file : path-string?
  collection : path-string?
  fail-proc : (string? . -> . any)
  check-compiled? : any/c = (regexp-match? #rx"[.]rkt$" file)
```

Returns the path to the file indicated by *`file`* in the collection specified by the *`collection`*s, where the second *`collection`* (if any) names a sub-collection, and so on. The search uses the values of `current-library-collection-links` and `current-library-collection-paths`.

See also `collection-search` in `setup/collection-search`.

If *`file`* is not found, but *`file`* ends in `".rkt"` and a file with the suffix `".ss"` exists, then the directory of the `".ss"` file is used. If *`file`* is not found and the `".rkt"`/`".ss"` conversion does not apply, but a directory corresponding to the *`collection`*s is found, then a path using the first such directory is returned.

If *`check-compiled?`* is true, then the search also depends on `use-compiled-file-paths` and `current-compiled-file-roots`; if *`file`* is not found, then a compiled form of *`file`* with the suffix `".zo"` is checked in the same way as the default compiled-load handler. If a compiled file is found, the result from `collection-file-path` reports the location that *`file`* itself would occupy (if it existed) for the found compiled file.

Finally, if the collection is not found, and if *`fail-proc`* is provided, then *`fail-proc`* is applied to an error message (that does not start `"collection-file-path:"` or otherwise claim a source), and its result is the result of `collection-file-path`. If *`fail-proc`* is not provided and the collection is not found, then the `exn:fail:filesystem` exception is raised.

Examples:

```
> (collection-file-path "main.rkt" "racket" "base")
#<path:path/to/collects/racket/base/main.rkt>
> (collection-file-path "sandwich.rkt" "bologna")
```

collection-file-path: collection not found
collection: "bologna"
in collection directories:
/Users/robby/snapshot/racket/racket/collects/
... [215 additional linked and package directories]

Changed in version 6.0.1.12 of package `base`: Added the *`check-compiled?`* argument.

```
(collection-path collection ...+) → path?
  collection : path-string?
(collection-path collection
                 ...+
                 #:fail fail-proc) → any
  collection : path-string?
  fail-proc : (string? . -> . any)
```

> **NOTE:** This function is deprecated; use `collection-file-path`, instead. Collection splicing implies that a given collection can have multiple paths, such as when multiple packages provide modules for a collection.

Like `collection-file-path`, but without a specified file name, so that a directory indicated by *`collection`*s is returned.

When multiple directories correspond to the collection, the first one found in the search sequence (see §18.2.1 "Collection Search Configuration") is returned.

```
(current-library-collection-paths)
 → (listof (and/c path? complete-path?))
(current-library-collection-paths paths) → void?
  paths : (listof (and/c path-string? complete-path?))
```

Parameter that determines a list of complete directory paths for finding libraries (as referenced in `require`, for example) through the default module name resolver and for finding paths through `collection-path` and `collection-file-path`. See §18.2.1 "Collection Search Configuration" for more information.

```
(current-library-collection-links)
 → (listof (or/c #f
                 (and/c path? complete-path?)
                 (hash/c (or/c (and/c symbol? module-path?) #f)
                         (listof (and/c path? complete-path?)))))
```

```
(current-library-collection-links paths) → void?
  paths : (listof (or/c #f
                        (and/c path-string? complete-path?)
                        (hash/c (or/c (and/c symbol? module-path?) #f)
                                (listof (and/c path-string? complete-path?)))))
```

Parameter that determines collection links files, additional paths, and the relative search order of `current-library-collection-paths` for finding libraries (as referenced in `require`, for example) through the default module name resolver and for finding paths through `collection-path` and `collection-file-path`. See §18.2.1 "Collection Search Configuration" for more information.

```
(use-user-specific-search-paths) → boolean?
(use-user-specific-search-paths on?) → void?
  on? : any/c
```

Parameter that determines whether user-specific paths, which are in the directory produced by `(find-system-path 'addon-dir)`, are included in search paths for collections and other files. For example, the initial value of `find-library-collection-paths` omits the user-specific collection directory when this parameter's value is `#f`.

If `-U` or `--no-user-path` argument to `racket`, then `use-user-specific-search-paths` is initialized to `#f`.

```
(use-collection-link-paths) → boolean?
(use-collection-link-paths on?) → void?
  on? : any/c
```

Parameter that determines whether collection links files are included in the result of `find-library-collection-links`.

If this parameter's value is `#f` on start-up, then collection links files are effectively disabled permanently for the Racket process. In particular, if an empty string is provided as the `-X` or `--collects` argument to `racket`, then not only is `current-library-collection-paths` initialized to the empty list, but `use-collection-link-paths` is initialized to `#f`.

```
(read-installation-configuration-table)
 → (and/c hash? immutable?)
```

Returns the content of the installation's `"config.rktd"` file (see §19 "Installation Configuration and Search Paths") as long as that content is a hash table, and otherwise returns an empty hash table.

Added in version 8.4.0.3 of package `base`.

18.3 Interactive Help

```
(require racket/help)        package: base
```

The bindings documented in this section are provided by the `racket/help` and `racket/init` libraries, which means that they are available when the Racket executable is started with no command-line arguments. They are not provided by `racket/base` or `racket`.

```
help
(help string ...)
(help id)
(help id #:from module-path)
(help #:search datum ...)
```

For general help, see the main documentation page.

The `help` form searches the documentation and opens a web browser (using the user's selected browser) to display the results.

See `net/sendurl` for information on how the user's browser is launched to display help information.

A simple `help` or `(help)` form opens the main documentation page.

The `(help string ...)` form—using literal strings, as opposed to expressions that produce strings—performs a string-matching search. For example,

```
(help "web browser" "firefox")
```

searches the documentation index for references that include the phrase "web browser" or "firefox."

A `(help id)` form looks for documentation specific to the current binding of `id`. For example,

```
(require net/url)
(help url->string)
```

opens a web browser to show the documentation for `url->string` from the `net/url` library.

For the purposes of `help`, a `for-label` require introduces a binding without actually executing the `net/url` library—for cases when you want to check documentation, but cannot or do not want to run the providing module.

```
(require racket/gui) ; does not work in racket
(require (for-label racket/gui)) ; ok in racket
(help frame%)
```

If `id` has no for-label and normal binding, then `help` lists all libraries that are known to export a binding for `id`.

The `(help id #:from module-path)` variant is similar to `(help id)`, but using only the exports of `module-path`. (The `module-path` module is required `for-label` in a temporary namespace.)

```
(help frame% #:from racket/gui) ; equivalent to the above
```

The `(help #:search datum ...)` form is similar to `(help string ...)`, where any non-string form of `datum` is converted to a string using `display`. No `datum` is evaluated as an expression.

For example,

```
(help #:search "web browser" firefox)
```

also searches the documentation index for references that include the phrase “web browser” or “firefox.”

18.4 Interaction Configuration

```
(require racket/interaction-info)
```
package: `base`

The bindings documented in this section are provided by the `racket/interaction-info` library, not `racket/base` or `racket`.

The `racket/interaction-info` library provides a way to register a langauge’s configuration for a `read-eval-print` loop and editor.

```
(current-interaction-info)
 → (or/c #f (vector/c module-path? symbol? any/c))
(current-interaction-info info) → void?
  info : (or/c #f (vector/c module-path? symbol? any/c))
```

A parameter that provides configuration for a language for use by interactive development tools, such as a command-line evaluation prompt with syntax coloring and indentation support. This parameter is typically set by a `configure-runtime` module; see also §18.1.5 “Language Run-Time Configuration”.

Instead of providing configuration information directly, the `current-interaction-info` parameter specifies a module to load, a exported function to call, and data to pass as an argument to the exported function. The result of that function should be another one that accepts two arguments: a symbol indicating the kind of information requested (as defined by external tools), and a default value that normally should be returned if the symbol is not recognized.

For information on defining a new #lang language, see syntax/module-reader.

Added in version 8.3.0.2 of package base.

18.5 Interactive Module Loading

The racket/rerequire and racket/enter libraries provide support for loading, reloading, and using modules.

18.5.1 Entering Modules

```
(require racket/enter)        package: base
```

The bindings documented in this section are provided by the racket/enter and racket/init libraries, which means that they are available when the Racket executable is started with no command-line arguments. They are not provided by racket/base or racket.

```
(enter! module-path)
(enter! #f)
(enter! module-path flag ...+)

flag = #:quiet
     | #:verbose-reload
     | #:verbose
     | #:dont-re-require-enter
```

Intended for use in a REPL, such as when racket is started in interactive mode. When a *module-path* is provided (in the same sense as for require), the corresponding module is loaded or invoked via dynamic-rerequire, and the current namespace is changed to the body of the module via module->namespace. When #f is provided, then the current namespace is restored to the original one.

Additional *flag*s can customize aspects of enter!:

- The #:verbose, #:verbose-reload, and #:quiet flags correspond to 'all, 'reload, and 'none verbosity for dynamic-rerequire. The default corresponds to #:verbose-reload.

- After switching namespaces to the designated module, `enter!` automatically requires `racket/enter` into the namespace, so that `enter!` can be used to switch namespaces again. In some cases, requiring `racket/enter` might not be desirable (e.g., in a tool that uses `racket/enter`); use the `#:dont-re-require-enter` flag to disable the require.

```
(dynamic-enter! mod
               [#:verbosity verbosity
                #:re-require-enter? re-require-enter?]) → void?
  mod : (or/c module-path? #f)
  verbosity : (or/c 'all 'reload 'none) = 'reload
  re-require-enter? : any/c = #t
```

Procedure variant of `enter!`, where *verbosity* is passed along to `dynamic-rerequire` and *re-require-enter?* determines whether `dynamic-enter!` requires `racket/enter` in a newly entered namespace.

Added in version 6.0.0.1 of package `base`.

18.5.2 Loading and Reloading Modules

```
(require racket/rerequire)        package: base
```

The bindings documented in this section are provided by the `racket/rerequire` library, not `racket/base` or `racket`.

```
(dynamic-rerequire module-path
                   [#:verbosity verbosity]) → (listof path?)
  module-path : module-path?
  verbosity : (or/c 'all 'reload 'none) = 'reload
```

Like `(dynamic-require module-path 0)`, but with reloading support. The `dynamic-rerequire` function is intended for use in an interactive environment, especially via `enter!`.

If invoking *module-path* requires loading any files, then modification dates of the files are recorded. If the file is modified, then a later `dynamic-rerequire` re-loads the module from source; see also §1.1.9.4 "Module Redeclarations". Similarly if a later `dynamic-rerequire` transitively `require`s a modified module, then the required module is re-loaded. Re-loading support works only for modules that are first loaded (either directly or indirectly through transitive `require`s) via `dynamic-rerequire`.

The returned list contains the absolute paths to the modules that were reloaded on this call to `dynamic-rerequire`. If the returned list is empty, no modules were changed or loaded.

When `enter!` loads or re-loads a module from a file, it can print a message to `(current-error-port)`, depending on *verbosity*: `'all` prints a message for all loads and re-loads, `'reload` prints a message only for re-loaded modules, and `'none` disables printouts.

18.6 Debugging

Racket's built-in debugging support is limited to context (i.e., "stack trace") information that is printed with an exception. In some cases, for BC implementation of Racket, disabling the JIT compiler can affect context information. For the CS implementation of Racket, setting the `PLT_CS_DEBUG` environment variable causes compilation to record expression-level context information, instead of just function-level information.

The `errortrace` library supports more consistent (independent of the compiler) and precise context information. The `racket/trace` library provides simple tracing support. Finally, the DrRacket programming environment provides much more debugging support.

18.6.1 Tracing

```
(require racket/trace)        package: base
```

The bindings documented in this section are provided by the `racket/trace` library, not `racket/base` or `racket`.

The `racket/trace` library mimics the tracing facility available in Chez Scheme.

```
(trace id ...)
```

Each *id* must be bound to a procedure in the environment of the `trace` expression, and must not be imported from another module. Each *id* is `set!`ed to a new procedure that traces procedure calls and returns by printing the arguments and results of the call via `current-trace-notify`. If multiple values are returned, each value is displayed starting on a separate line.

When traced procedures invoke each other, nested invocations are shown by printing a nesting prefix. If the nesting depth grows to ten and beyond, a number is printed to show the actual nesting depth.

The `trace` form can be used on an identifier that is already traced. In this case, assuming that the variable's value has not been changed, `trace` has no effect. If the variable has been changed to a different procedure, then a new trace is installed.

Tracing respects tail calls to preserve loops, but its effect may be visible through continuation marks. When a call to a traced procedure occurs in tail position with respect to a previous traced call, then the tailness of the call is preserved (and the result of the call is not printed for the tail call, because the same result will be printed for an enclosing call). Otherwise, however, the body of a traced procedure is not evaluated in tail position with respect to a call to the procedure.

The result of a `trace` expression is `#<void>`.

Examples:

```
> (define (f x) (if (zero? x) 0 (add1 (f (sub1 x)))))
> (trace f)
> (f 10)
>(f 10)
> (f 9)
> >(f 8)
> > (f 7)
> > >(f 6)
> > > (f 5)
> > > >(f 4)
> > > > (f 3)
> > > > >(f 2)
> > > > > (f 1)
> > > >[10] (f 0)
< < < <[10] 0
< < < < < 1
< < < < <2
< < < < 3
< < < <4
< < < 5
< < <6
< < 7
< <8
< 9
<10
10
```

`trace` can also be used to debug syntax transformers. This is verbose to do directly with `trace`; refer to `trace-define-syntax` for a simpler way to do this.

Examples:

```
> (require (for-syntax racket/trace))
> (begin-for-syntax
    (define let
      (syntax-rules ()
        [(_ ([x v]) e) ((lambda (x) e) v)]))
    (trace let))
```

```
> (define-syntax let let)
> (let ([x 120]) x)
>(_let #<syntax:eval:9:0 (let ((x 120)) x)>)
<#<syntax:eval:9:0 ((lambda (x) x) 120)>
120
```

When tracing syntax transformers, it may be helpful to modify `current-trace-print-args` and `current-trace-print-results` to make the trace output more readable; see `current-trace-print-args` for an extended example.

```
(trace-define id expr)
(trace-define (head args) body ...+)
```

The `trace-define` form is short-hand for first defining a function then tracing it. This form supports all `define` forms.

Examples:

```
> (trace-define (f x) (if (zero? x) 0 (add1 (f (sub1 x)))))
> (f 5)
>(f 5)
> (f 4)
> >(f 3)
> > (f 2)
> > >(f 1)
> > > (f 0)
< < < 0
< < <1
< < 2
< <3
< 4
<5
5
```

Examples:

```
> (trace-define ((+n n) x) (+ n x))
> (map (+n 5) (list 1 3 4))
>(+n 5)
<#<procedure>
'(6 8 9)
```

```
(trace-define-syntax id expr)
(trace-define-syntax (head args) body ...+)
```

The `trace-define-syntax` form is short-hand for first defining a syntax transformer then tracing it. This form supports all `define-syntax` forms.

For example:

Examples:

```
> (trace-define-syntax fact
    (syntax-rules ()
      [(_ x) 120]))
> (fact 5)
>(fact #<syntax:eval:15:0 (fact 5)>)
<#<syntax:eval:15:0 120>
120
```

By default, `trace` prints out syntax objects when tracing a syntax transformer. This can result in too much output if you do not need to see, e.g., source information. To get more readable output by printing syntax objects as datums, we can modify the `current-trace-print-args` and `current-trace-print-results`. See `current-trace-print-args` for an example.

```
(trace-lambda [#:name id] args expr)
```

The `trace-lambda` form enables tracing an anonymous function. This form will attempt to infer a name using `syntax-local-infer-name`, or a name can be specified using the optional `#:name` argument. A syntax error is raised if a name is not given and a name cannot be inferred.

Example:

```
> ((trace-lambda (x) 120) 5)
>(eval:16:0 5)
<120
120
```

```
(trace-let id ([arg expr] ...+) body ...+)
```

The `trace-let` form enables tracing a named let.

Example:

```
> (trace-let f ([x 5])
    (if (zero? x)
        1
        (* x (f (sub1 x)))))
```

```
>(f 5)
> (f 4)
> >(f 3)
> > (f 2)
> > >(f 1)
> > > (f 0)
< < < 1
< < <1
< < 2
< <6
< 24
<120
120
```

```
(untrace id ...)
```

Undoes the effects of the `trace` form for each *id*, `set!`ing each *id* back to the untraced procedure, but only if the current value of *id* is a traced procedure. If the current value of a *id* is not a procedure installed by `trace`, then the variable is not changed.

The result of an `untrace` expression is `#<void>`.

```
(current-trace-notify) → (string? . -> . any)
(current-trace-notify proc) → void?
  proc : (string? . -> . any)
```

A parameter that determines the way that trace output is displayed. The string given to *proc* is a trace; it does not end with a newline, but it may contain internal newlines. Each call or result is converted into a string using `pretty-print`. The parameter's default value prints the given string followed by a newline to `(current-output-port)`.

```
(trace-call id proc #:<kw> kw-arg ...) → any/c
  id : symbol?
  proc : procedure?
  kw-arg : any/c
```

Calls *proc* with the arguments supplied in *args*, and possibly using keyword arguments. Also prints out the trace information during the call, as described above in the docs for `trace`, using *id* as the name of *proc*.

```
(current-trace-print-args) → (-> symbol?
                                  list?
                                  (listof keyword?)
                                  list?
                                  number?
                                  void?)
```

```
(current-trace-print-args trace-print-args) → void?
  trace-print-args : (-> symbol?
                         list?
                         (listof keyword?)
                         list?
                         number?
                         void?)
```

The value of this parameter is invoked to print out the arguments of a traced call. It receives the name of the function, the function's ordinary arguments, its keywords, the values of the keywords, and a number indicating the depth of the call.

Modifying this and `current-trace-print-results` is useful to to get more readable or additional output when tracing syntax transformers. For example, we can use `debug-scopes` to add scopes information to the trace, (see `debug-scopes` for an example), or remove source location information to just display the shape of the syntax object

In this example, we update the printers `current-trace-print-args` and `current-trace-print-results` by storing the current printers (`ctpa` and `ctpr`) to cast syntax objects to datum using `syntax->datum` and then pass the transformed arguments and results to the previous printer. When tracing, syntax arguments will be displayed without source location information, shortening the output.

Examples:

```
> (require (for-syntax racket/trace))
> (begin-for-syntax
    (current-trace-print-args
      (let ([ctpa (current-trace-print-args)])
        (lambda (s l kw l2 n)
          (ctpa s (map syntax->datum l) kw l2 n))))
    (current-trace-print-results
      (let ([ctpr (current-trace-print-results)])
        (lambda (s r n)
         (ctpr s (map syntax->datum r) n)))))
> (trace-define-syntax fact
    (syntax-rules ()
      [(_ x) 120]))
> (fact 5)
>(fact '(fact 5))
<120
120
```

We must take care when modifying these parameters, especially when the transformation makes assumptions about or changes the type of the argument/result of the traced identifier. This modification of `current-trace-print-args` and `current-trace-print-`

results is an imperative update, and will affect all traced identifiers. This example assumes all arguments and results to *all traced functions* will be syntax objects, which is the case only if you are only tracing syntax transformers. If used as-is, the above code could result in type errors when tracing both functions and syntax transformers. It would be better to use syntax->datum only when the argument or result is actually a syntax object, for example, by defining maybe-syntax->datum as follows.

Examples:

```
> (require (for-syntax racket/trace))
> (begin-for-syntax
    (define (maybe-syntax->datum syn?)
      (if (syntax? syn?)
          (syntax->datum syn?)
          syn?))
    (current-trace-print-args
      (let ([ctpa (current-trace-print-args)])
        (lambda (s l kw l2 n)
          (ctpa s (map maybe-syntax->datum l) kw l2 n))))
    (current-trace-print-results
      (let ([ctpr (current-trace-print-results)])
        (lambda (s l n)
         (ctpr s (map maybe-syntax->datum l) n))))

  (trace-define (precompute-fact syn n) (datum-
>syntax syn (apply * (build-list n add1)))))
> (trace-define (run-time-fact n) (apply * (build-list n add1)))
> (require (for-syntax syntax/parse))
> (trace-define-syntax (fact syn)
    (syntax-parse syn
      [(_ x:nat) (precompute-fact syn (syntax->datum #'x))]
      [(_ x) #'(run-time-fact x)]))
> (fact 5)
>(fact '(fact 5))
>(precompute-fact '(fact 5) 5)
<120
120
> (fact (+ 2 3))
>(fact '(fact (+ 2 3)))
<'(run-time-fact (+ 2 3))
>(run-time-fact 5)
<120
120
```

```
(current-trace-print-results) → (-> symbol?
                                     list?
                                     number?
                                     any)
(current-trace-print-results trace-print-results) → void?
  trace-print-results : (-> symbol?
                            list?
                            number?
                            any)
```

The value of this parameter is invoked to print out the results of a traced call. It receives the name of the function, the function's results, and a number indicating the depth of the call.

```
(current-prefix-in) → string?
(current-prefix-in prefix) → void?
  prefix : string?
```

This string is used by the default value of `current-trace-print-args` indicating that the current line is showing the a call to a traced function.

It defaults to `">"`.

```
(current-prefix-out) → string?
(current-prefix-out prefix) → void?
  prefix : string?
```

This string is used by the default value of `current-trace-print-results` indicating that the current line is showing the result of a traced call.

It defaults to `"<"`.

18.7 Controlling and Inspecting Compilation

Racket programs and expressions are compiled automatically and on-the-fly. The `raco make` tool (see §1 "`raco make`: Compiling Source to Bytecode") can compile a Racket module to a compiled `".zo"` file, but that kind of ahead-to-time compilation simply allows a program takes to start more quickly, and it does not affect the performance of a Racket program.

18.7.1 Compilation Modes

All Racket variants suppose a machine-independent compilation mode, which generates compiled `".zo"` files that work with all Racket variants on all platforms. To select machine-independent compilation mode, set the `current-compile-target-machine` parameter to

#f or supplying the --compile-any/-M flag on startup. See current-compile-target-machine for more information.

Other compilation modes depend on the Racket implementation (see §1.5 "Implementations").

BC Compilation Modes

The BC implementation of Racket supports two compilation modes: bytecode and machine-independent. The bytecode format is also machine-independent in the sense that it works the same on all operating systems for the BC implementation of Racket, but it does not work with the CS implementation of Racket.

Bytecode is further compiled to machine code at run time, unless the JIT compiler is disabled. See eval-jit-enabled.

CS Compilation Modes

The CS implementation of Racket supports several compilation modes: machine code, machine-independent, interpreted, and JIT. Machine code is the primary mode, and the machine-independent mode is the same as for BC. Interpreted mode uses an interpreter at the level of core linklet forms with no compilation. JIT mode triggers compilation of individual function forms on demand.

The default mode is a hybrid of machine-code and interpreter modes, where interpreter mode is used only for the outer contour of an especially large linklet, and machine-code mode is used for functions that are small enough within that outer contour. "Small enough" is determined by the PLT_CS_COMPILE_LIMIT environment variable, and the default value of 10000 means that most Racket modules have no interpreted component. The #:unlimited-compile option for #%declare disables interpreted mode for the enclosing module. Check 'info logging at the 'linklet topic (e.g., set PLTSTDERR to info@linklet) to discover when compilation is restricted to smaller functions by PLT_CS_COMPILE_LIMIT.

JIT compilation mode is used only if the PLT_CS_JIT environment variable is set on startup, otherwise pure interpreter mode is used only if PLT_CS_INTERP is set on startup, and the default hybrid machine code and interpreter mode is used if PLT_CS_MACH is set and PLT_CS_JIT is not set or if none of those environment variables is set. A module compiled in any mode can be loaded into the CS variant of Racket independent of the current compilation mode.

The PLT_CS_DEBUG environment variable, as described in §18.6 "Debugging", affects only compilation in machine-code mode. Generated machine code is much larger when PLT_CS_DEBUG is enabled, but performance is not otherwise affected.

18.7.2 Inspecting Compiler Passes

When the PLT_LINKLET_SHOW environment variable is set on startup, the Racket process's standard error shows intermediate compiled forms whenever a Racket form is compiled. For all Racket variants, the output shows one or more linklets that are generated from the original Racket form.

For the CS implementation of Racket, a "schemified" version of the linklet is also shown as the translation of the linklet form to a Chez Scheme procedure form. The output also indicates which modules and linklets the compiler is working on.

The following environment variables imply PLT_LINKLET_SHOW and show additional intermediate compiled forms or adjust the way forms are displayed:

- PLT_LINKLET_SHOW_GENSYM — prints full generated names, instead of abbreviations; the default behavior corresponds to Chez Scheme's 'pretty/suffix mode for print-gensym
- PLT_LINKLET_SHOW_PRE_JIT — shows a schemified forms before a transformation to JIT mode, which applies only when PLT_CS_JIT is set
- PLT_LINKLET_SHOW_LAMBDA — shows individual schemified forms that are compiled within a larger form that has an interpreted outer contour
- PLT_LINKLET_SHOW_POST_LAMBDA — shows an outer form after inner individual forms are compiled
- PLT_LINKLET_SHOW_POST_INTERP — shows an outer form after its transformation to interpretable form
- PLT_LINKLET_SHOW_JIT_DEMAND — shows JIT compilation of form that were previously prepared by compilation with PLT_CS_JIT set
- PLT_LINKLET_SHOW_KNOWN — show recorded known-binding information alongside a schemified form
- PLT_LINKLET_SHOW_CP0 — show a schemified form after transformation by Chez Scheme's front-end optimizer
- PLT_LINKLET_SHOW_PASSES — show the intermediate form of a schemified linklet after the specified passes (listed space-separated) in Chez Scheme's internal representation; the special name all will show the intermediate form after all Chez Scheme passes
- PLT_LINKLET_SHOW_ASSEMBLY — show the compiled form of a schemified linklet in Chez Scheme's abstraction of machine instructions

When the PLT_LINKLET_TIMES environment variable is set on startup, then Racket prints cumulative timing information about compilation and evaluation times on exit. When the PLT_EXPANDER_TIMES environment variable is set, information about macro-expansion time is printed on exit.

Changed in version 8.8.0.10 of package base: Added special pass name all to PLT_LINKLET_SHOW_PASSES.
Changed in version 8.11.1.2: Added module and linklet info to output.

18.8 Kernel Forms and Functions

```
#lang racket/kernel
```
package: base

The racket/kernel library is a cross-phase persistent module that provides a minimal set of syntactic forms and functions.

"Minimal" means that racket/kernel includes only forms that are built into the Racket compiler and only functions that are built into the run-time system. Currently, the set of bindings is not especially small, nor is it particularly well-defined, since the set of built-in functions can change frequently. Use racket/kernel with care, and beware that its use can create compatibility problems.

The racket/kernel module exports all of the bindings in the grammar of fully expanded programs (see §1.2.3.1 "Fully Expanded Programs"), but it provides #%plain-lambda as lambda and λ, #%plain-app as #%app, and #%plain-module-begin as #%module-begin. Aside from #%datum (which expands to quote), racket/kernel provides no other syntactic bindings.

The racket/kernel module also exports many of the function bindings from racket/base, and it exports a few other functions that are not exported by racket/base because racket/base exports improved variants. The exact set of function bindings exported by racket/kernel is unspecified and subject to change across versions.

```
(require racket/kernel/init)
```
package: base

The racket/kernel/init library re-provides all of racket/kernel. It also provides #%top-interaction, which makes racket/kernel/init useful with the -I command-line flag for racket.

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