

Alexandria Manual

draft version

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1 Hash Tables

ensure-gethash *key hash-table &optional default* [Macro]

Like `gethash`, but if `key` is not found in the `hash-table` saves the `default` under `key` before returning it. Secondary return value is true if `key` was already in the table.

copy-hash-table *table &key key test size rehash-size rehash-threshold* [Function]

Returns a copy of hash table `table`, with the same keys and values as the `table`. The copy has the same properties as the original, unless overridden by the keyword arguments.

Before each of the original values is set into the new hash-table, `key` is invoked on the value. As `key` defaults to `cl:identity`, a shallow copy is returned by default.

maphash-keys *function table* [Function]

Like `maphash`, but calls `function` with each key in the hash table `table`.

maphash-values *function table* [Function]

Like `maphash`, but calls `function` with each value in the hash table `table`.

hash-table-keys *table* [Function]

Returns a list containing the keys of hash table `table`.

hash-table-values *table* [Function]

Returns a list containing the values of hash table `table`.

hash-table-alist *table* [Function]

Returns an association list containing the keys and values of hash table `table`.

hash-table-plist *table* [Function]

Returns a property list containing the keys and values of hash table `table`.

alist-hash-table *alist &rest hash-table-initargs* [Function]

Returns a hash table containing the keys and values of the association list `alist`. Hash table is initialized using the `hash-table-initargs`.

plist-hash-table *plist &rest hash-table-initargs* [Function]

Returns a hash table containing the keys and values of the property list `plist`. Hash table is initialized using the `hash-table-initargs`.

2 Data and Control Flow

define-constant *name initial-value &key test documentation* [Macro]

Ensures that the global variable named by **name** is a constant with a value that is equal under **test** to the result of evaluating **initial-value**. **test** is a /function designator/ that defaults to `eql`. If **documentation** is given, it becomes the documentation string of the constant.

Signals an error if **name** is already a bound non-constant variable.

Signals an error if **name** is already a constant variable whose value is not equal under **test** to result of evaluating **initial-value**.

destructuring-case *keyform &body clauses* [Macro]

destructuring-case, **-ccase**, and **-ecase** are a combination of **case** and **destructuring-bind**. **keyform** must evaluate to a cons.

Clauses are of the form:

```
((CASE-KEYS . DESTRUCTURING-LAMBDA-LIST) FORM*)
```

The clause whose **case-keys** matches **car** of **key**, as if by **case**, **ccase**, or **ecase**, is selected, and FORMs are then executed with **cdr** of **key** is destructured and bound by the **destructuring-lambda-list**.

Example:

```
(defun dcase (x)
  (destructuring-case x
    (:foo a b)
    (format nil "foo: ~S, ~S" a b))
    (:bar &key a b)
    (format nil "bar, ~S, ~S" a b))
    (((:alt1 :alt2) a)
    (format nil "alt: ~S" a))
    ((t &rest rest)
    (format nil "unknown: ~S" rest))))

(dcase (list :foo 1 2))           ; => "foo: 1, 2"
(dcase (list :bar :a 1 :b 2))    ; => "bar: 1, 2"
(dcase (list :alt1 1))           ; => "alt: 1"
(dcase (list :alt2 2))           ; => "alt: 2"
(dcase (list :quux 1 2 3))       ; => "unknown: 1, 2, 3"

(defun decase (x)
  (destructuring-case x
    (:foo a b)
    (format nil "foo: ~S, ~S" a b))
    (:bar &key a b)
    (format nil "bar, ~S, ~S" a b))
    (((:alt1 :alt2) a)
    (format nil "alt: ~S" a))))
```

```

(decase (list :foo 1 2))      ; => "foo: 1, 2"
(decase (list :bar :a 1 :b 2)) ; => "bar: 1, 2"
(decase (list :alt1 1))     ; => "alt: 1"
(decase (list :alt2 2))     ; => "alt: 2"
(decase (list :quux 1 2 3)) ; =| error

```

ensure-functionf *&rest places* [Macro]

Multiple-place modify macro for **ensure-function**: ensures that each of **places** contains a function.

multiple-value-prog2 *first-form second-form &body forms* [Macro]

Evaluates **first-form**, then **second-form**, and then **forms**. Yields as its value all the value returned by **second-form**.

named-lambda *name lambda-list &body body* [Macro]

Expands into a lambda-expression within whose **body name** denotes the corresponding function.

nth-value-or *nth-value &body forms* [Macro]

Evaluates **form** arguments one at a time, until the **nth-value** returned by one of the forms is true. It then returns all the values returned by evaluating that form. If none of the forms return a true **nth** value, this form returns **nil**.

if-let *bindings &body (then-form &optional else-form)* [Macro]

Creates new variable bindings, and conditionally executes either **then-form** or **else-form**. **else-form** defaults to **nil**.

bindings must be either single binding of the form:

```
(variable initial-form)
```

or a list of bindings of the form:

```

((variable-1 initial-form-1)
 (variable-2 initial-form-2)
 ...
 (variable-n initial-form-n))

```

All initial-forms are executed sequentially in the specified order. Then all the variables are bound to the corresponding values.

If all variables were bound to true values, the **then-form** is executed with the bindings in effect, otherwise the **else-form** is executed with the bindings in effect.

when-let *bindings &body forms* [Macro]

Creates new variable bindings, and conditionally executes **forms**.

bindings must be either single binding of the form:

```
(variable initial-form)
```

or a list of bindings of the form:

```

((variable-1 initial-form-1)
 (variable-2 initial-form-2)
 ...
 (variable-n initial-form-n))

```

All initial-forms are executed sequentially in the specified order. Then all the variables are bound to the corresponding values.

If all variables were bound to true values, then **forms** are executed as an implicit **progn**.

when-let* *bindings &body forms* [Macro]

Creates new variable bindings, and conditionally executes **forms**.

bindings must be either single binding of the form:

```
(variable initial-form)
```

or a list of bindings of the form:

```
((variable-1 initial-form-1)
 (variable-2 initial-form-2)
 ...
 (variable-n initial-form-n))
```

Each initial-form is executed in turn, and the variable bound to the corresponding value. Initial-form expressions can refer to variables previously bound by the **when-let***.

Execution of **when-let*** stops immediately if any initial-form evaluates to **nil**. If all initial-forms evaluate to true, then **forms** are executed as an implicit **progn**.

switch *whole (object &key test key) &body clauses* [Macro]

Evaluates first matching clause, returning its values, or evaluates and returns the values of **default** if no keys match.

cswitch *whole (object &key test key) &body clauses* [Macro]

Like **switch**, but signals a continuable error if no key matches.

eswitch *whole (object &key test key) &body clauses* [Macro]

Like **switch**, but signals an error if no key matches.

whichever *&rest possibilities env* [Macro]

Evaluates exactly one of **possibilities**, chosen at random.

xor *&rest datums* [Macro]

Evaluates its arguments one at a time, from left to right. If more than one argument evaluates to a true value no further **datums** are evaluated, and **nil** is returned as both primary and secondary value. If exactly one argument evaluates to true, its value is returned as the primary value after all the arguments have been evaluated, and **t** is returned as the secondary value. If no arguments evaluate to true **nil** is returned as primary, and **t** as secondary value.

disjoin *predicate &rest more-predicates* [Function]

Returns a function that applies each of **predicate** and **more-predicate** functions in turn to its arguments, returning the primary value of the first predicate that returns true, without calling the remaining predicates. If none of the predicates returns true, **nil** is returned.

- conjoin** *predicate &rest more-predicates* [Function]
Returns a function that applies each of **predicate** and **more-predicate** functions in turn to its arguments, returning **nil** if any of the predicates returns false, without calling the remaining predicates. If none of the predicates returns false, returns the primary value of the last predicate.
- compose** *function &rest more-functions* [Function]
Returns a function composed of **function** and **more-functions** that applies its arguments to each in turn, starting from the rightmost of **more-functions**, and then calling the next one with the primary value of the last.
- ensure-function** *function-designator* [Function]
Returns the function designated by **function-designator**: if **function-designator** is a function, it is returned, otherwise it must be a function name and its **fdefinition** is returned.
- multiple-value-compose** *function &rest more-functions* [Function]
Returns a function composed of **function** and **more-functions** that applies its arguments to each in turn, starting from the rightmost of **more-functions**, and then calling the next one with all the return values of the last.
- curry** *function &rest arguments* [Function]
Returns a function that applies **arguments** and the arguments it is called with to **function**.
- rcurry** *function &rest arguments* [Function]
Returns a function that applies the arguments it is called with and **arguments** to **function**.

3 Conses

- proper-list** [Type]
 Type designator for proper lists. Implemented as a **satisfies** type, hence not recommended for performance intensive use. Main usefulness as a type designator of the expected type in a **type-error**.
- circular-list** [Type]
 Type designator for circular lists. Implemented as a **satisfies** type, so not recommended for performance intensive use. Main usefulness as the expected-type designator of a **type-error**.
- appendf** *place &rest lists env* [Macro]
 Modify-macro for **append**. Appends **lists** to the place designated by the first argument.
- nconcf** *place &rest lists env* [Macro]
 Modify-macro for **nconc**. Concatenates **lists** to place designated by the first argument.
- remove-from-plistf** *place &rest keys env* [Macro]
 Modify macro for **remove-from-plist**.
- delete-from-plistf** *place &rest keys env* [Macro]
 Modify macro for **delete-from-plist**.
- reversef** *place env* [Macro]
 Modify-macro for **reverse**. Copies and reverses the list stored in the given place and saves back the result into the place.
- nreversef** *place env* [Macro]
 Modify-macro for **nreverse**. Reverses the list stored in the given place by destructively modifying it and saves back the result into the place.
- unionf** *place list &rest args env* [Macro]
 Modify-macro for **union**. Saves the union of **list** and the contents of the place designated by the first argument to the designated place.
- nunionf** *place list &rest args env* [Macro]
 Modify-macro for **nunion**. Saves the union of **list** and the contents of the place designated by the first argument to the designated place. May modify either argument.
- doplist** (*key val plist &optional values*) *&body body* [Macro]
 Iterates over elements of **plist**. **body** can be preceded by declarations, and is like a **tagbody**. **return** may be used to terminate the iteration early. If **return** is not used, returns **values**.
- circular-list-p** *object* [Function]
 Returns true if **object** is a circular list, **nil** otherwise.

- `circular-tree-p` *object* [Function]
Returns true if `object` is a circular tree, `nil` otherwise.
- `proper-list-p` *object* [Function]
Returns true if `object` is a proper list.
- `alist-plist` *alist* [Function]
Returns a property list containing the same keys and values as the association list `alist` in the same order.
- `plist-alist` *plist* [Function]
Returns an association list containing the same keys and values as the property list `plist` in the same order.
- `circular-list` *&rest elements* [Function]
Creates a circular list of `elements`.
- `make-circular-list` *length &key initial-element* [Function]
Creates a circular list of `length` with the given `initial-element`.
- `ensure-car` *thing* [Function]
If `thing` is a `cons`, its `car` is returned. Otherwise `thing` is returned.
- `ensure-cons` *cons* [Function]
If `cons` is a `cons`, it is returned. Otherwise returns a fresh `cons` with `cons` in the `car`, and `nil` in the `cdr`.
- `ensure-list` *list* [Function]
If `list` is a list, it is returned. Otherwise returns the list designated by `list`.
- `flatten` *tree* [Function]
Traverses the tree in order, collecting non-null leaves into a list.
- `lastcar` *list* [Function]
Returns the last element of `list`. Signals a type-error if `list` is not a proper list.
- `(setf lastcar)` [Function]
Sets the last element of `list`. Signals a type-error if `list` is not a proper list.
- `proper-list-length` *list* [Function]
Returns length of `list`, signalling an error if it is not a proper list.
- `mappend` *function &rest lists* [Function]
Applies `function` to respective element(s) of each `list`, appending all the all the result list to a single list. `function` must return a list.
- `map-product` *function list &rest more-lists* [Function]
Returns a list containing the results of calling `function` with one argument from `list`, and one from each of `more-lists` for each combination of arguments. In other words, returns the product of `list` and `more-lists` using `function`.
- Example:

```
(map-product 'list '(1 2) '(3 4) '(5 6))
=> ((1 3 5) (1 3 6) (1 4 5) (1 4 6)
    (2 3 5) (2 3 6) (2 4 5) (2 4 6))
```

remove-from-plist *plist &rest keys* [Function]

Returns a property-list with same keys and values as `plist`, except that keys in the list designated by `keys` and values corresponding to them are removed. The returned property-list may share structure with the `plist`, but `plist` is not destructively modified. Keys are compared using `eq`.

delete-from-plist *plist &rest keys* [Function]

Just like `remove-from-plist`, but this version may destructively modify the provided `plist`.

set-equal *list1 list2 &key test key* [Function]

Returns true if every element of `list1` matches some element of `list2` and every element of `list2` matches some element of `list1`. Otherwise returns false.

setp *object &key test key* [Function]

Returns true if `object` is a list that denotes a set, `nil` otherwise. A list denotes a set if each element of the list is unique under `key` and `test`.

4 Sequences

proper-sequence [Type]
 Type designator for proper sequences, that is proper lists and sequences that are not lists.

deletef *place item &rest remove-keywords env* [Macro]
 Modify-macro for **delete**. Sets *place* designated by the first argument to the result of calling **delete** with *item*, *place*, and the **remove-keywords**.

removef *place item &rest remove-keywords env* [Macro]
 Modify-macro for **remove**. Sets *place* designated by the first argument to the result of calling **remove** with *item*, *place*, and the **remove-keywords**.

rotate *sequence &optional n* [Function]
 Returns a sequence of the same type as **sequence**, with the elements of **sequence** rotated by **n**: **n** elements are moved from the end of the sequence to the front if **n** is positive, and **-n** elements moved from the front to the end if **n** is negative. **sequence** must be a proper sequence. **n** must be an integer, defaulting to 1.

If absolute value of **n** is greater than the length of the sequence, the results are identical to calling **rotate** with

(***** (**signum** **n**) (**mod** **n** (**length** **sequence**))).

Note: the original sequence may be destructively altered, and result sequence may share structure with it.

shuffle *sequence &key start end* [Function]
 Returns a random permutation of **sequence** bounded by **start** and **end**. Original sequence may be destructively modified, and share storage with the original one. Signals an error if **sequence** is not a proper sequence.

random-elt *sequence &key start end* [Function]
 Returns a random element from **sequence** bounded by **start** and **end**. Signals an error if the **sequence** is not a proper non-empty sequence, or if **end** and **start** are not proper bounding index designators for **sequence**.

empty *sequence* [Function]
 Returns true if **sequence** is an empty sequence. Signals an error if **sequence** is not a sequence.

sequence-of-length-p *sequence length* [Function]
 Return true if **sequence** is a sequence of length **length**. Signals an error if **sequence** is not a sequence. Returns **false** for circular lists.

length= *&rest sequences* [Function]
 Takes any number of sequences or integers in any order. Returns true iff the length of all the sequences and the integers are equal. Hint: there's a compiler macro that expands into more efficient code if the first argument is a literal integer.

- copy-sequence** *type sequence* [Function]
Returns a fresh sequence of **type**, which has the same elements as **sequence**.
- first-elt** *sequence* [Function]
Returns the first element of **sequence**. Signals a type-error if **sequence** is not a sequence, or is an empty sequence.
- (setf first-elt)** [Function]
Sets the first element of **sequence**. Signals a type-error if **sequence** is not a sequence, is an empty sequence, or if **object** cannot be stored in **sequence**.
- last-elt** *sequence* [Function]
Returns the last element of **sequence**. Signals a type-error if **sequence** is not a proper sequence, or is an empty sequence.
- (setf last-elt)** [Function]
Sets the last element of **sequence**. Signals a type-error if **sequence** is not a proper sequence, is an empty sequence, or if **object** cannot be stored in **sequence**.
- starts-with** *object sequence &key test key* [Function]
Returns true if **sequence** is a sequence whose first element is **eq1** to **object**. Returns **nil** if the **sequence** is not a sequence or is an empty sequence.
- starts-with-subseq** *prefix sequence &rest args &key return-suffix &allow-other-keys* [Function]
Test whether the first elements of **sequence** are the same (as per **TEST**) as the elements of **prefix**.
If **return-suffix** is **t** the functions returns, as a second value, a displaced array pointing to the sequence after **prefix**.
- ends-with** *object sequence &key test key* [Function]
Returns true if **sequence** is a sequence whose last element is **eq1** to **object**. Returns **nil** if the **sequence** is not a sequence or is an empty sequence. Signals an error if **sequence** is an improper list.
- ends-with-subseq** *suffix sequence &key test* [Function]
Test whether **sequence** ends with **suffix**. In other words: return true if the last (length **SUFFIX**) elements of **sequence** are equal to **suffix**.
- map-combinations** *function sequence &key start end length copy* [Function]
Calls **function** with each combination of **length** constructable from the elements of the subsequence of **sequence** delimited by **start** and **end**. **start** defaults to 0, **end** to length of **sequence**, and **length** to the length of the delimited subsequence. (So unless **length** is specified there is only a single combination, which has the same elements as the delimited subsequence.) If **copy** is true (the default) each combination is freshly allocated. If **copy** is false all combinations are **eq** to each other, in which case consequences are specified if a combination is modified by **function**.

map-derangements *function sequence &key start end copy* [Function]

Calls **function** with each derangement of the subsequence of **sequence** denoted by the bounding index designators **start** and **end**. Derangement is a permutation of the sequence where no element remains in place. **sequence** is not modified, but individual derangements are **eq** to each other. Consequences are unspecified if calling **function** modifies either the derangement or **sequence**.

map-permutations *function sequence &key start end length copy* [Function]

Calls **function** with each permutation of **length** constructable from the subsequence of **sequence** delimited by **start** and **end**. **start** defaults to 0, **end** to length of the sequence, and **length** to the length of the delimited subsequence.

5 IO

`read-file-into-string` *pathname* &key *buffer-size external-format* [Function]

Return the contents of the file denoted by `pathname` as a fresh string.

The `external-format` parameter will be passed directly to `with-open-file` unless it's `nil`, which means the system default.

`read-file-into-byte-vector` *pathname* [Function]

Read `pathname` into a freshly allocated (unsigned-byte 8) vector.

6 Macro Writing

once-only *specs &body forms* [Macro]

Evaluates **forms** with symbols specified in **specs** rebound to temporary variables, ensuring that each **initform** is evaluated only once.

Each of **specs** must either be a symbol naming the variable to be rebound, or of the form:

```
(symbol initform)
```

Bare symbols in **specs** are equivalent to

```
(symbol symbol)
```

Example:

```
(defmacro cons1 (x) (once-only (x) '(cons ,x ,x)))
(let ((y 0)) (cons1 (incf y))) => (1 . 1)
```

with-gensyms *names &body forms* [Macro]

Binds each variable named by a symbol in **names** to a unique symbol around **forms**.

Each of **names** must either be either a symbol, or of the form:

```
(symbol string-designator)
```

Bare symbols appearing in **names** are equivalent to:

```
(symbol symbol)
```

The string-designator is used as the argument to **gensym** when constructing the unique symbol the named variable will be bound to.

with-unique-names *names &body forms* [Macro]

Alias for **with-gensyms**.

featurep *feature-expression* [Function]

Returns **t** if the argument matches the state of the ***features*** list and **nil** if it does not. **feature-expression** can be any atom or list acceptable to the reader macros **#+** and **#-**.

parse-body *body &key documentation whole* [Function]

Parses **body** into (values remaining-forms declarations doc-string). Documentation strings are recognized only if **documentation** is true. Syntax errors in **body** are signalled and **whole** is used in the signal arguments when given.

parse-ordinary-lambda-list *lambda-list &key normalize* [Function]

allow-specializers normalize-optional normalize-keyword normalize-auxiliary

Parses an ordinary lambda-list, returning as multiple values:

1. Required parameters.
2. Optional parameter specifications, normalized into form:

```
(name init suppliedp)
```
3. Name of the rest parameter, or **nil**.
4. Keyword parameter specifications, normalized into form:

`((keyword-name name) init suppliedp)`

5. Boolean indicating `&allow-other-keys` presence.
6. `&aux` parameter specifications, normalized into form
`(name init)`.

Signals a `program-error` if the lambda-list is malformed.

7 Symbols

ensure-symbol *name &optional package* [Function]

Returns a symbol with name designated by **name**, accessible in package designated by **package**. If symbol is not already accessible in **package**, it is interned there. Returns a secondary value reflecting the status of the symbol in the package, which matches the secondary return value of **intern**.

Example:

```
(ensure-symbol :cons :cl) => cl:cons, :external
```

format-symbol *package control &rest arguments* [Function]

Constructs a string by applying **arguments** to string designator **control** as if by **format** within **with-standard-io-syntax**, and then creates a symbol named by that string.

If **package** is **nil**, returns an uninterned symbol, if **package** is **t**, returns a symbol interned in the current package, and otherwise returns a symbol interned in the package designated by **package**.

make-keyword *name* [Function]

Interns the string designated by **name** in the **keyword** package.

make-gensym *name* [Function]

If **name** is a non-negative integer, calls **gensym** using it. Otherwise **name** must be a string designator, in which case calls **gensym** using the designated string as the argument.

make-gensym-list *length &optional x* [Function]

Returns a list of **length** gensyms, each generated as if with a call to **make-gensym**, using the second (optional, defaulting to "G") argument.

symbolicate *&rest things* [Function]

Concatenate together the names of some strings and symbols, producing a symbol in the current package.

8 Arrays

array-index [Type]

Type designator for an index into array of **length**: an integer between 0 (inclusive) and **length** (exclusive). **length** defaults to **array-dimension-limit**.

array-length [Type]

Type designator for a dimension of an array of **length**: an integer between 0 (inclusive) and **length** (inclusive). **length** defaults to **array-dimension-limit**.

copy-array *array &key element-type fill-pointer adjustable* [Function]

Returns an undisplaced copy of **array**, with same fill-pointer and adjustability (if any) as the original, unless overridden by the keyword arguments.

9 Types

string-designator [Type]

A string designator type. A string designator is either a string, a symbol, or a character.

coercef *place type-spec env* [Macro]

Modify-macro for **coerce**.

of-type *type* [Function]

Returns a function of one argument, which returns true when its argument is of **type**.

type= *type1 type2* [Function]

Returns a primary value of **t** if **type1** and **type2** are the same type, and a secondary value that is true if the type equality could be reliably determined: primary value of **nil** and secondary value of **t** indicates that the types are not equivalent.

10 Numbers

maxf *place &rest numbers env* [Macro]
 Modify-macro for **max**. Sets place designated by the first argument to the maximum of its original value and **numbers**.

minf *place &rest numbers env* [Macro]
 Modify-macro for **min**. Sets place designated by the first argument to the minimum of its original value and **numbers**.

binomial-coefficient *n k* [Function]
 Binomial coefficient of **n** and **k**, also expressed as **n** choose **k**. This is the number of **k** element combinations given **n** choices. **n** must be equal to or greater than **k**.

count-permutations *n &optional k* [Function]
 Number of **k** element permutations for a sequence of **n** objects. **k** defaults to **n**

clamp *number min max* [Function]
 Clamps the **number** into [**min**, **max**] range. Returns **min** if **number** is lesser than **min** and **max** if **number** is greater than **max**, otherwise returns **number**.

lerp *v a b* [Function]
 Returns the result of linear interpolation between **A** and **b**, using the interpolation coefficient **v**.

factorial *n* [Function]
 Factorial of non-negative integer **n**.

subfactorial *n* [Function]
 Subfactorial of the non-negative integer **n**.

gaussian-random *&optional min max* [Function]
 Returns two gaussian random double floats as the primary and secondary value, optionally constrained by **min** and **max**. Gaussian random numbers form a standard normal distribution around 0.0d0.

Sufficiently positive **min** or negative **max** will cause the algorithm used to take a very long time. If **min** is positive it should be close to zero, and similarly if **max** is negative it should be close to zero.

iota *n &key start step* [Function]
 Return a list of **n** numbers, starting from **start** (with numeric contagion from **step** applied), each consecutive number being the sum of the previous one and **step**. **start** defaults to 0 and **step** to 1.

Examples:

```
(iota 4)                => (0 1 2 3)
(iota 3 :start 1 :step 1.0) => (1.0 2.0 3.0)
(iota 3 :start -1 :step -1/2) => (-1 -3/2 -2)
```

map-iota *function n &key start step* [Function]

Calls **function** with **n** numbers, starting from **start** (with numeric contagion from **step** applied), each consecutive number being the sum of the previous one and **step**. **start** defaults to 0 and **step** to 1. Returns **n**.

Examples:

```
(map-iota #'print 3 :start 1 :step 1.0) => 3
;;; 1.0
;;; 2.0
;;; 3.0
```

mean *sample* [Function]

Returns the mean of **sample**. **sample** must be a sequence of numbers.

median *sample* [Function]

Returns median of **sample**. **sample** must be a sequence of real numbers.

variance *sample &key biased* [Function]

Variance of **sample**. Returns the biased variance if **biased** is true (the default), and the unbiased estimator of variance if **biased** is false. **sample** must be a sequence of numbers.

standard-deviation *sample &key biased* [Function]

Standard deviation of **sample**. Returns the biased standard deviation if **biased** is true (the default), and the square root of the unbiased estimator for variance if **biased** is false (which is not the same as the unbiased estimator for standard deviation). **sample** must be a sequence of numbers.