

# foreign-c a portable foreign function interface for R7RS Schemes

## foreign-c

foreign-c is a C foreign function interface (FFI) library for R7RS Schemes. It is portable in the sense that it supports multiple implementations, as opposed to being portable by conforming to some specification.

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## Implementation support tables

Required versions:

- Guile  $\geq 3$
- STklos  $> 2.10$

### Primitives 1 table

	c-type-size	c-bytevector-u8-set!	c-byt
<b>Chibi</b>	X	X	
<b>Chicken</b>	X	X	
<b>Gauche</b>	X	X	
<b>Guile</b>	X	X	
<b>Kawa</b>	X	X	

	c-type-size	c-bytevector-u8-set!	c-byt
<b>Mosh</b>	X	X	
<b>Racket</b>	X	X	
<b>Saggittarius</b>	X	X	
<b>STklos</b>	X	X	
<b>Ypsilon</b>	X	X	

## Primitives 2 table

Chibi  
**Chicken**  
Gauche  
**Guile**  
Kawa  
**Mosh**  
**Racket**  
**Saggittarius**  
STklos  
**Ypsilon**

## Test files pass

	primitives.scm
Chibi	X
<b>Chicken</b>	X
Gauche	X
<b>Guile</b>	X
Kawa	X
Mosh	X
Racket	X
<b>Saggittarius</b>	X
STklos	X
Ypsilon	X

## Installation

Eithe download the latest release from <https://git.sr.ht/~retropikzel/foreign-c/refs> or git clone, preferably with a tag, and copy the *foreign* directory to your library directory.

Example assuming libraries in directory *snow*:

```
git clone https://git.sr.ht/~retropikzel/foreign-c --branch
LATEST_VERSION
```

```
mkdir -p snow
cp -r foreign-c/foreign snow/
make -C snow/foreign/c SCHEME_IMPLEMENTATION_NAME
```

With most implementations the make command does not compile anything. When that is the case it will say “Nothing to build on SCHEME\_IMPLEMENTATION\_NAME.”

## Documentation

### Types

Types are given as symbols, for example 'int8 or 'pointer.

- int8
- uint8
- int16
- uint16
- int32
- uint32
- int64
- uint64
- char
- unsigned-char
- short
- unsigned-short
- int
- unsigned-int
- long
- unsigned-long
- float
- double
- pointer
  - c-bytevector on Scheme side
- callback
  - Callback function
- void
  - Can not be argument type, only return type

### Primitives 1

**(c-type-size type)**

Returns the size of given C type.

**(define-c-library scheme-name headers object-name options)**

Takes a scheme-name to bind the library to, list of C headers as strings, shared-object name and options.

The C header strings should not contain “<” or “>”, they are added automatically.

The name of the shared object should not contain suffix like .so or .dll. Nor should it contain any prefix like "lib".

Options:

- additional-versions
  - Search for additional versions of shared object, given shared object "c" and additional versions "6" "7" on linux the files "libc", "libc.6", "libc.7" are searched for.
  - Can be either numbers or strings
- additional-paths
  - Give additional paths to search shared objects from

Example:

```
(define-c-library libc
  (list "stdlib.h")
  "c"
  '((additional-versions (" " "0" "6"))
    (additional-paths ("."))))
```

Note that libc is exported by this library so you might not need to load it.

## Notes

- Do not cond-expand inside the arguments, that might lead to problems on some implementations.
- Do not store options in variables, that might lead to problems on some implementations.
- Pass the headers using quote
  - As '(...) and not (list...)
- Pass the options using quote
  - As '(...) and not (list...)

**(define-c-procedure** *scheme-name shared-object c-name return-type argument-type*)

Takes a scheme-name to bind the C procedure to, shared-object where the function is looked from, c-name of the function as symbol, return-type and argument-types.

Defines a new foreign function to be used from Scheme code.

Example:

```
(cond-expand
  (windows (define-c-library libc '("stdlib.h") "ucrtbase"
    '()))
  (else (define-c-library libc '("stdlib.h") "c" '("6"))))
(define-c-procedure c-puts libc 'puts 'int '(pointer))
(c-puts "Message brought to you by foreign-c!")
```

## Notes

- Pass the return-types using quote
  - As '(...) and not (list...)

**(c-bytevector? *obj*)**

Returns **#t** if *obj* is c-bytevector, otherwise returns **#f**.

**(c-bytevector-u8-set! *c-bytevector k byte*)**

If K is not a valid index of c-bytevector the behaviour is undefined.

Stores the byte in element k of c-bytevector.

**(c-bytevector-u8-ref *c-bytevector k*)**

If K is not a valid index of c-bytevector the behaviour is undefined.

Returns the byte at index k of c-bytevector.

**(c-bytevector-pointer-set! *c-bytevector k pointer*)**

If K is not a valid index of c-bytevector the behaviour is undefined.

Stores the pointer(which is also c-bytevector) in element k of c-bytevector.

**(c-bytevector-pointer-ref *c-bytevector k pointer*)**

If K is not a valid index of c-bytevector the behaviour is undefined.

Returns the pointer(which is also c-bytevector) at index k of c-bytevector.

## Primitives 2

**(define-c-callback *scheme-name return-type argument-types procedure*)**

Takes scheme-name to bind the Scheme procedure to, return-type, argument-types and procedure as in place lambda.

Defines a new Sceme function to be used as callback to C code.

Example:

```
; Load the shared library
(cond-expand
  (windows (define-c-library libc-stdlib '("stdlib.h")
    "ucrtbase" '()))
  (else (define-c-library '("stdlib.h") "c" '("" "6"))))

; Define C function that takes a callback
(define-c-procedure qsort libc-stdlib 'qsort 'void '(pointer int
int callback))
```

```

; Define our callback
(define-c-callback compare
  'int
  '(pointer pointer)
  (lambda (pointer-a pointer-b)
    (let ((a (c-bytevector-sint-get pointer-a
      (native-endianness) 0))
          (b (c-bytevector-sint-get pointer-b
      (native-endianness) 0)))
      (cond ((> a b) 1)
            ((= a b) 0)
            ((< a b) -1))))))

; Create new array of ints to be sorted
(define array (make-c-bytevector (* (c-type-size 'int) 3)))
(c-bytevector-s32-native-set! array (* (c-type-size 'int) 0) 3)
(c-bytevector-s32-native-set! array (* (c-type-size 'int) 1) 2)
(c-bytevector-s32-native-set! array (* (c-type-size 'int) 2) 1)

(display array)
(newline)
;> (3 2 1)

; Sort the array
(qsort array 3 (c-type-size 'int) compare)

(display array)
(newline)
;> (1 2 3)

```

## c-bytevector

Foreign-c c-bytevector interface is copied from R6RS bytevectors, with some added functionality for C null pointers and manual memory management.

### (make-c-null)

Returns a null C pointer.

### (c-null? *obj*)

Returns **#t** if *obj* is a null C pointer, otherwise returns **#f**.

### (c-free *c-bytevector*)

Frees *c-bytevector* from memory.

### (call-with-address-of *c-bytevector* *thunk*)

Calls *thunk* with address pointer of *c-bytevector*.

Since the support for calling C functions taking pointer address arguments, ones prefixrd with & in C, varies, some additional ceremony is needed on the Scheme side.

Example:

Calling from C:

```
//void func(int** i);  
func(&i);
```

Calling from Scheme:

```
(define cbv (make-bytevector (c-type-size 'int)))  
(call-with-address-of  
  cbv  
  (lambda (address)  
    (func address)))  
; Use cbv here
```

The passed c-bytevector, in example named *cbv*, should only be used **after** call to *call-with-address-of* ends.

**(bytevector->c-bytevector *bytevector*)**

Returns a newly allocated c-bytevector of the bytes of *bytevector*.

**(c-bytevector->bytevector)**

Returns a newly allocated bytevector of the bytes of *c-bytevector*.

**(native-endianness)**

Returns the endianness symbol associated implementation's preferred endianness (usually that of the underlying machine architecture). This may be any <endianness symbol>, including a symbol other than big and little.

**(make-c-bytevector *k*)**

**(make-c-bytevector *k fill*)**

Returns a newly allocated c-bytevector of *k* bytes.

If the *fill* argument is missing, the initial contents of the returned c-bytevector are unspecified.

If the *fill* argument is present, it's value must confine to C `uint8_t` values , it specifies the initial value for the bytes of the c-bytevector

**(c-bytevector-s8-set! *c-bytevector k byte*)**

If *k* is not a valid index of c-bytevector the behaviour is undefined.

Stores the *byte* in element *k* of *c-bytevector*.



**(c-bytevector-s8-ref** *c-bytevector k*)

If *k* is not a valid index of *c-bytevector* the behaviour is undefined.

Returns the byte at index *k* of *c-bytevector*.

**(c-bytevector-char-set!** *c-bytevector k char*)

If *k* is not a valid index of *c-bytevector* the behaviour is undefined.

Stores the *char* in element *k* of *c-bytevector*.

**(c-bytevector-char-ref** *c-bytevector k*)

If *k* is not a valid index of *c-bytevector* the behaviour is undefined.

Returns the char at index *k* of *c-bytevector*.

**(c-bytevector-uchar-set!** *c-bytevector k char*)

If *k* is not a valid index of *c-bytevector* the behaviour is undefined.

Stores the unsigned *char* in element *k* of *c-bytevector*.

**(c-bytevector-uchar-ref** *c-bytevector k*)

If *k* is not a valid index of *c-bytevector* the behaviour is undefined.

Returns the unsigned char at index *k* of *c-bytevector*.

**(c-bytevector-uint-ref** *c-bytevector k endianness size*)

**(c-bytevector-sint-ref** *c-bytevector k endianness size*)

**(c-bytevector-uint-set!** *c-bytevector k n endianness size*)

**(c-bytevector-sint-set!** *c-bytevector k n endianness size*)

Size must be a positive exact integer object. If *k*, ..., *k* + *size* − 1 is not valid indices of *c-bytevector* the behavior is unspecified.

The *c-bytevector-uint-ref* procedure retrieves the exact integer object corresponding to the unsigned representation of size *size* and specified by *endianness* at indices *k*, ..., *k* + *size* − 1.

The *c-bytevector-sint-ref* procedure retrieves the exact integer object corresponding to the two's-complement representation of size *size* and specified by *endianness* at indices *k*, ..., *k* + *size* − 1. For *c-bytevector-uint-set!*, *n* must be an exact integer object in the interval {0, ..., 256<sup>*size*</sup> − 1}.

The *c-bytevector-uint-set!* procedure stores the unsigned representation of size *size* and specified by *endianness* into *c-bytevector* at indices *k*, ..., *k* + *size* − 1.

The ...-set! procedures return unspecified values.

Examples:

```
(define cbv (make-c-bytevector (c-type-size 'int)))
(c-bytevector-sint-set! cbv 0 100 (native-endianness) (c-type-size 'int))
(c-bytevector-sint-ref cbv 0 (native-endianness) (c-type-size 'int))
> 100
```

**(c-bytevector-u16-ref** *c-bytevector k endianness*)  
**(c-bytevector-s16-ref** *c-bytevector k endianness*)  
**(c-bytevector-u16-native-ref** *c-bytevector k*)  
**(c-bytevector-s16-native-ref** *c-bytevector k*)  
**(c-bytevector-u16-set!** *c-bytevector k n endianness*)  
**(c-bytevector-s16-set!** *c-bytevector k n endianness*)  
**(c-bytevector-u16-native-set!** *c-bytevector k n*)  
**(c-bytevector-s16-native-set!** *c-bytevector k n*)

$K$  must be a valid index of *c-bytevector* ; so must  $k + 1$ . For *c-bytevector-u16-set!* and *c-bytevector-u16-native-set!*,  $n$  must be an exact integer object in the interval  $\{0, \dots, 216 - 1\}$ . For *c-bytevector-s16-set!* and *c-bytevector-s16-native-set!*,  $n$  must be an exact integer object in the interval  $\{-215, \dots, 215 - 1\}$ .

These retrieve and set two-byte representations of numbers at indices  $k$  and  $k + 1$ , according to the endianness specified by *endianness*. The procedures with u16 in their names deal with the unsigned representation; those with s16 in their names deal with the two's-complement representation.

The procedures with native in their names employ the native endianness, and work only at aligned indices:  $k$  must be a multiple of 2.

The ...-set! procedures return unspecified values.

**(c-bytevector-u32-ref** *c-bytevector k endianness*)  
**(c-bytevector-s32-ref** *c-bytevector k endianness*)  
**(c-bytevector-u32-native-ref** *c-bytevector k*)  
**(c-bytevector-s32-native-ref** *c-bytevector k*)  
**(c-bytevector-u32-set!** *c-bytevector k n endianness*)  
**(c-bytevector-s32-set!** *c-bytevector k n endianness*)  
**(c-bytevector-u32-native-set!** *c-bytevector k n*)  
**(c-bytevector-s32-native-set!** *c-bytevector k n*)

$K, \dots, k + 3$  must be valid indices of *bytevector*. For *c-bytevector-u32-set!* and *bytevector-u32-native-set!*,  $n$  must be an exact integer object in the interval  $\{0, \dots, 232 - 1\}$ . For *bytevector-s32-set!* and *bytevector-s32-native-set!*,  $n$  must be an exact integer object in the interval  $\{-231, \dots, 232 - 1\}$ .

These retrieve and set four-byte representations of numbers at indices  $k, \dots, k + 3$ , according to the endianness specified by *endianness*. The procedures with u32 in their names deal with the unsigned representation; those with s32 with the two's-complement representation.

The procedures with native in their names employ the native endianness, and work only at aligned indices:  $k$  must be a multiple of 4.

The ...-set! procedures return unspecified values.

**(c-bytevector-u64-ref *c-bytevector* *k* *endianness*)**  
**(c-bytevector-s64-ref *c-bytevector* *k* *endianness*)**  
**(c-bytevector-u64-native-ref *c-bytevector* *k*)**  
**(c-bytevector-s64-native-ref *c-bytevector* *k*)**  
**(c-bytevector-u64-set! *c-bytevector* *k* *n* *endianness*)**  
**(c-bytevector-s64-set! *c-bytevector* *k* *n* *endianness*)**  
**(c-bytevector-u64-native-set! *c-bytevector* *k* *n*)**  
**(c-bytevector-s64-native-set! *c-bytevector* *k* *n*)**

$K, \dots, k + 7$  must be valid indices of *c-bytevector*. For c-bytevector-u64-set! and c-bytevector-u64-native-set!, *n* must be an exact integer object in the interval  $\{0, \dots, 264 - 1\}$ . For c-bytevector-s64-set! and c-bytevector-s64-native-set!, *n* must be an exact integer object in the interval  $\{-263, \dots, 264 - 1\}$ .

These retrieve and set eight-byte representations of numbers at indices  $k, \dots, k + 7$ , according to the endianness specified by *endianness*. The procedures with u64 in their names deal with the unsigned representation; those with s64 with the two's-complement representation.

The procedures with native in their names employ the native endianness, and work only at aligned indices: *k* must be a multiple of 8.

The ...-set! procedures return unspecified values.

**(c-bytevector-ieee-single-native-ref)**  
**(c-bytevector-ieee-single-ref)**

$K, \dots, k + 3$  must be valid indices of *c-bytevector*. For c-bytevector-ieee-single-native-ref, *k* must be a multiple of 4.

These procedures return the inexact real number object that best represents the IEEE-754 single-precision number represented by the four bytes beginning at index *k*.

**(c-bytevector-ieee-double-native-ref)**  
**(c-bytevector-ieee-double-ref)**

$K, \dots, k + 7$  must be valid indices of *c-bytevector*. For c-bytevector-ieee-double-native-ref, *k* must be a multiple of 8.

These procedures return the inexact real number object that best represents the IEEE-754 double-precision number represented by the eight bytes beginning at index *k*.

**(c-bytevector-ieee-single-native-set!)**  
**(c-bytevector-ieee-single-set!)**

$K, \dots, k + 3$  must be valid indices of *c-bytevector*. For c-bytevector-ieee-single-native-set!, *k* must be a multiple of 4.

These procedures store an IEEE-754 single-precision representation of  $x$  into elements  $k$  through  $k + 3$  of `bytevector`, and return unspecified values.

**(c-bytevector-ieee-double-native-set!)**  
**(c-bytevector-ieee-double-set!)**

$K, \dots, k + 7$  must be valid indices of `bytevector`. For `c-bytevector-ieee-double-native-set!`,  $k$  must be a multiple of 8.

These procedures store an IEEE-754 double-precision representation of  $x$  into elements  $k$  through  $k + 7$  of `bytevector`, and return unspecified values.

**(string->c-utf8 *string*)**

Returns a newly allocated (unless empty) `c-bytevector` that contains the UTF-8 encoding of the given string.

**(c-utf8->string *c-bytevector*)**

Returns a newly allocated (unless empty) string whose character sequence is encoded by the given `c-bytevector`.

## Utilities

### libc

Since the library uses C standard internally, and that is most likely library to have different name on different operating systems. For example `libc.so` on Linux, `ucrtbase.dll` on windows and `libroot.so` on Haiku. It makes sense to export it, saving the users the trouble of figuring out which named shared library they should load.

See `foreign/c/libc.scm` to see which headers are included and what shared libraries are loaded.

Example:

```
(define-c-procedure c-puts libc 'puts 'int '(pointer))  
(c-puts "Message brought to you by foreign-c!")
```

## Environment variables

Setting environment variables like this on Windows works for this library:

```
set "FOREIGN_C_LOAD_PATH=C:\Program Files (x86)/foo/bar"
```

### FOREIGN\_C\_LOAD\_PATH

To add more paths to where foreign c looks for libraries set `FOREIGN_C_LOAD_PATH` to paths separated by `;` on windows, and `:` on other operating systems.