Hygienic Literate Programming:
ChezWEB

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What this talk is not

I am not proselytizing literate programming

You will not learn to program in a literate style

You will not learn to use ChezWEB (it’s not hard enough for a talk)
What this talk is

About programming DSLs

About Scheme macros

About `syntax-case`

About hygiene in DSLs
Literate Programming

Writing programs to be read by humans

An emphasis on appropriate use of prose and code

Implemented many different ways

Available for Scheme: SchemeWEB, Scribble/LP, noweb, &c.

Traditional systems emphasize a special syntax for code lifting
Traditional Example

@ This code will be lifted out.
@<Compute factorial@>=
(let fact ([n 1]) (if (= n max) n (* n (fact (1+ n))))))
@ Used here.
@p
(define (factorial max) @<Compute factorial@>)
Hygiene and Literate Programming

Traditional approaches copy and paste text verbatim

Completely unhygienic

Sort of “dynamic scope” introduced into the language

Not visible or always obvious in woven output.

Claim: this is bad for coding reliability and for our mental models
; This code is be lifted out.
(@< (|Compute factorial|)
  (let fact ([n 1])
    (if (= n max) n (* n (fact (1+ n))))))
; Used here.
(define (factorial max) |Compute factorial|)

Literate programming code lifting/reordering is just another Scheme macro
What should this macro be?
PUT ON YOUR MACRO HATS
Our Macro Challenge

(@< name (captures ...) (exports ...) body+ ...)

10
(let ([x 'inner-x] [y 'inner-y])
  (define-syntax (grab-x z)
    (syntax-case z ()
      [(k)
        (with-syntax ([x (datum->syntax #'k 'x)])
          #'(list x y))]))
  (let ([x 'outer-x] [y 'outer-y])
    (grab-x)))
  ;; => '(outer-x inner-y)
(let ([x 'inner-x] [y 'inner-y])
    (define-syntax (grab-x z)
        (syntax-case z ()
            [(k)
                (with-syntax ([x (datum->syntax #\'k 'x)])
                    #'(list x y))])
    (let ([x 'outer-x] [y 'outer-y])
        (grab-x)))
    ;; => '(outer-x inner-y)
(let ([x 'inner-x] [y 'inner-y])
  (define-syntax (grab-x z)
    (syntax-case z ()
      [( k )
        (with-syntax ([ x (datum->syntax #'k 'x)])
          #'(list x y))])
  (let ([x 'outer-x] [y 'outer-y])
    (grab-x)))
;;; => '(outer-x inner-y)
The traditional version

(define-syntax (@< x)
  (syntax-case x ()
    [(_ name (c ...) (e ...) b1 b2 ...)
      #'(define-syntax (name x)
         (datum->syntax x '(begin b1 b2 ...)))]))
(define-syntax (@< x)
  (syntax-case x ()
    [(_ name (c ...) (e ...) b1 b2 ...)
      #'(define-synta (name x)
         (datum->syntax x '(begin b1 b2 ...))))]
)

(let ([x 3])
  (@< ex1 (x) (y) (define y (list x))
    (let ([x 0] [list '(1)]) ex1 (append y list)))
; => '(0 1)
(define-syntax (@< x)
  (syntax-case x ()
    [(_ name (c ...) (e ...) b1 b2 ...)
      #'(define-syntax (name x)
          (datum->syntax x '(begin b1 b2 ...))))])
(let ([x 3])
  (@< ex1 (x) (y) (define y (list x))
    (let ([x 0] [list '(1)]) ex1 (append y list))))

(let ([x.0 3])
  (let ([x.1 0] [list.2 '(1)])
    (letrec* ([y.3 (list.2 x.1)])
      (#2%append y.3 list.2))))
Our “Principles”

**Hygiene.** No definition in the body of a code section shall be visible to the surrounding context of a section reference unless that binding is explicitly exported by the code section at the point of definition.

**Referential Transparency.** Free variables in the body of a code section will always refer to the nearest lexical binding at the definition site of the code section, unless the identifier is explicitly noted as a capture at the definition site, in which case the binding to a captured variable will refer to the nearest lexical binding at the reference site of the code section.
Go full hygienic

```
(define-syntax (@< x)
  (syntax-case x ()
    [(_ n (c ...) (e ...) b1 b2 ...)
      #'(define-syntax (n x)
         (syntax-case x ()
           [(_ c ... e ...) #'(begin b1 b2 ...)])))]
)
```
Fails

(define-syntax (@< x)
  (syntax-case x ()
    [(_ n (c ...) (e ...) b1 b2 ...)
      #'(define-syntax (n x)
          (syntax-case x ()
            [(_ c ... e ...) #'(begin b1 b2 ...)])))]))

(let ()
  (@< ex2 () (make-x x?) (define-record-type x))
  (ex2 make-x x?)
  (x? (make-x)))
; => #t
(define-syntax (@< x)
  (syntax-case x ()
    [(_ n (c ...) (e ...) b1 b2 ...)
     #'(define-syntax (n x)
         (syntax-case x ()
           [(_ c ... e ...) #'(begin b1 b2 ...)])])])
(let ()
  (@< ex2 () (make-x x?) (define-record-type x))
  (ex2 make-x x?)
  (x? (make-x))
)
(letrec* (... [make-x.2 <make constructor>]
  [x?.3 <make predicate>]
  ...) (x? (make-x)))
(define-syntax (/*@< x)
(syntax-case x ()
  [(_ n (c ...) (e ...) b1 b2 ...)
    ’(define-syntax (n x)
        (syntax-case x ()
          [n (identifier? ’n)
            (with-implicit (n c ... e ...) #’(begin b1 b2 ...))]))]))})
Core problem

We want to be able to use and reference the same values in different contexts.

Link or alias the two contexts together so that they point to the same locations.

(define-syntax inner
  (identifier-syntax
    [inner outer]
    [(set! inner val) (set! outer val)]))
Chez Scheme nicety

(alias inner outer)
Linking with alias

(define-syntax (@< x)
  (syntax-case x ()
    [(_ n (c ...) (e ...) b1 b2 ...)
      '(define-syntax (n x)
         (syntax-case x ()
           [n (identifier? #')
              (with-syntax ([(ic (... ...)) #'(c ...)])
                [(ie (... ...)) #'(e ...)]
                [(oc (... ...))
                  (datum->syntax x '(c ...))]
                [(oe (... ...))
                  (datum->syntax x '(e ...))]]
              #'(begin
                  (alias ic oc) (... ...)
                  b1 b2 ...
                  (alias oe ie) (... ...)))])))
)
Encapsulating bodies with modules

```
(define-syntax (@< x)
  (syntax-case x ()
    [(_ n (c ...) (e ...) b1 b2 ...)
      #'(define-syntax (n x)
          (syntax-case x ()
            [ n (identifier? #'n)
              (with-syntax ([(ic (... ...)) #'(c ...)]
                            [(ie (... ...)) #'(e ...)]
                            [(oc (... ...))
                             (datum->syntax x '(c ...))]
                            [(oe (... ...))
                             (datum->syntax x '(e ...))])
              #'(module (oe (... ...))
                       (alias ic oc) (... ...)
                       (module (ie (... ...))
                         b1 b2 ...)
                       (alias oe ie) (... ...)]))))]
  ))
```
(define-syntax (@< x)
  (syntax-case x ()
    [(\_ n (\_ c ...) (\_ e ...) b1 b2 ...)
      #'(define-syntax (n x)
          (syntax-case x ()
            [\_ n (identifier? #\'n)
              (with-syntax ([
                (ic (... ...)) #\'(c ...)]
                [(ie (... ...)) #\'(e ...)]
                [(oe (... ...))
                  (datum->syntax x 'c ...)]
                [(oe (... ...))
                  (datum->syntax x 'e ...)])
                #\'(module (oe (... ...)))
                (alias ic oc) (... ...)
                (module (ie (... ...))
                  ((... ...) b1) ((... ...) b2) ...)
                (alias oe ie) (... ...)))]))])
Limitations

We cannot do alpha renaming like the first version.

Hygienic version can do alpha renaming.

You can only use this where expressions are evaluated.

Only does definitions, but easily extended to values.

Question: why was this not the first thing that everyone thinks of?
Thank you.
(let ()
  (define a 1)
  (define-syntax (m x)
    (syntax-case x ()
      [(_ a) #'(y here)])
  (define-syntax (y x)
    (syntax-case x ()
      [(_ k) (datum->syntax #'k 'a)])
  (m a))