CS 152: *Programming Language Paradigms*

Macros

Prof. Tom Austin
San José State University

Creating control structures with Lambdas

Redefining if expressions

```
(define (my-if c thn els)
  (cond
    [(and (list? c) (empty? c)) els]
    [(and (number? c) (= 0 c))  els]
    [(and (boolean? c) (not c)) els]
    [else thn]))
```

Redefining if expressions

```
(my-if #t 1 0)   ;; returns 1
(my-if 1 1 0)    ;; also returns 1
(my-if #f 1 0)   ;; returns 0
(my-if '() 1 0) ;; also returns 0


(my-if #t
  (displayln "true")
  (displayln "false"))
```

Why didn't this approach work?

Scheme uses *eager evaluation*.

- Arguments are evaluated first
- Function body is evaluated second
- In our example, we need to evaluate arguments *lazily*
  - –that is, only when they are needed

Macros allow us to change the behavior of our language as we need.

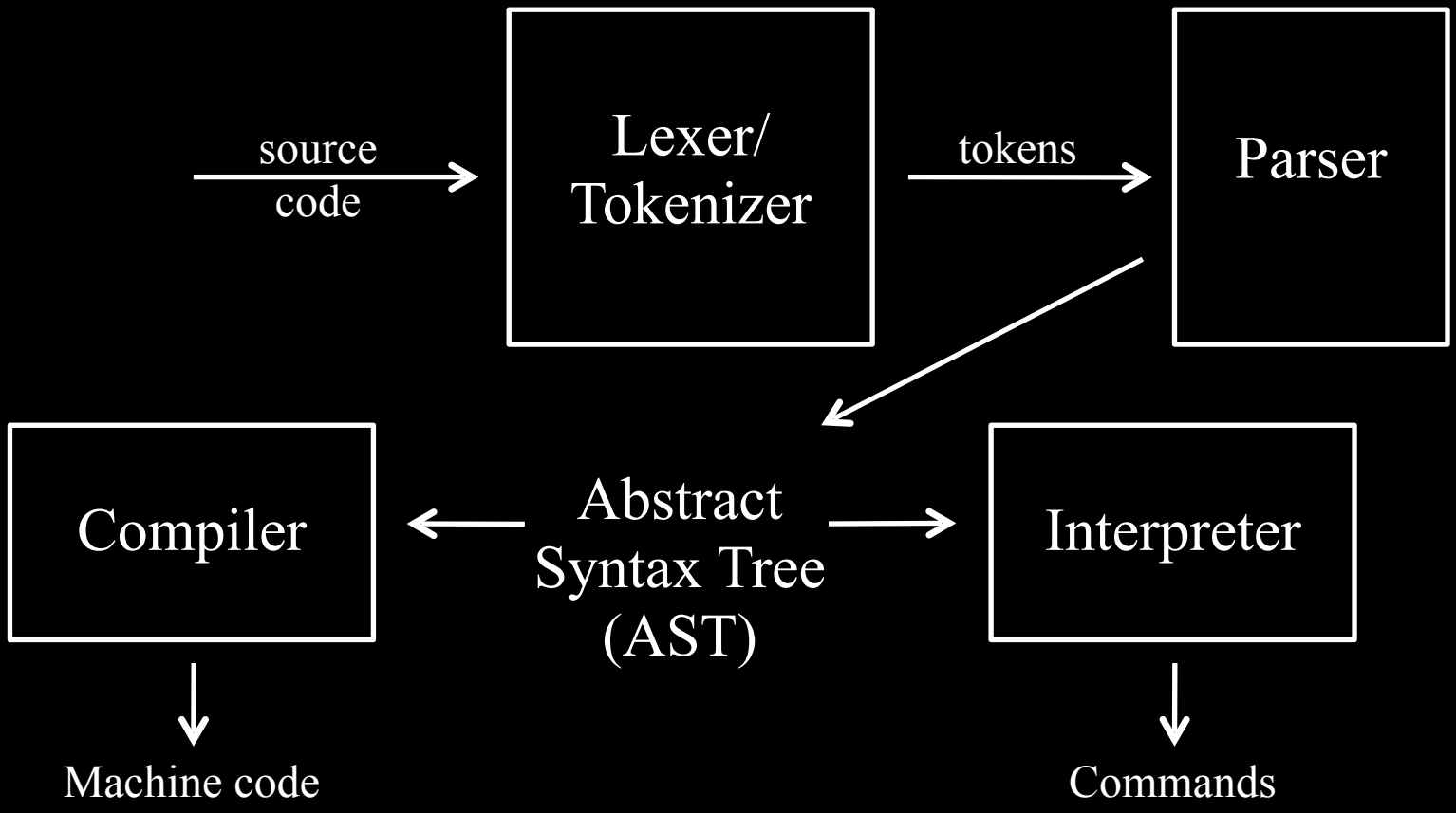
What is a macro?

- *macroinstruction.*
- A rule or pattern that specifies how an *input sequence* should be mapped to a *replacement sequence*.

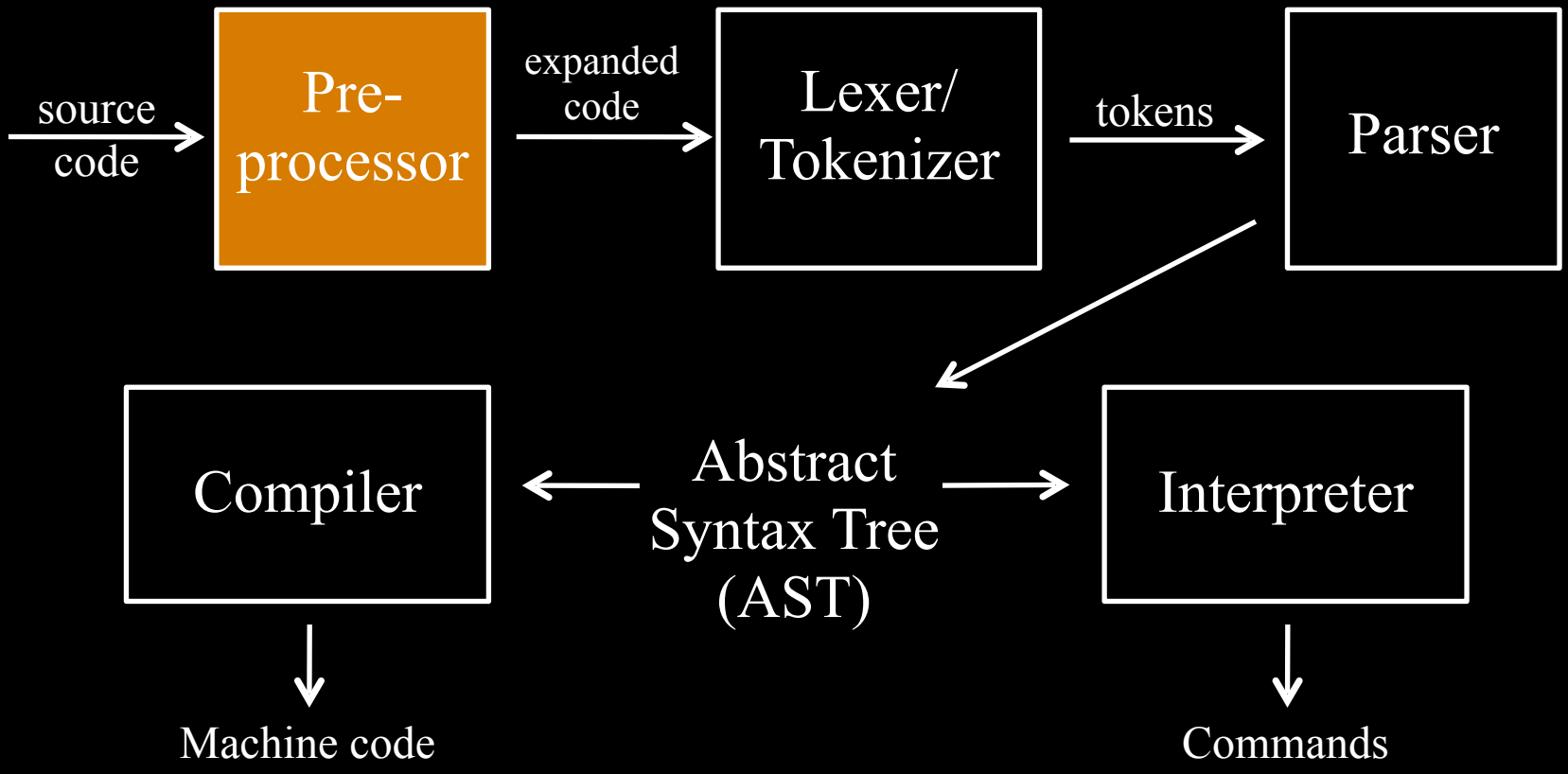
Text Substitution Macros

- Work by *expanding text*.
- Fast, but limited power.
- Example:
  - C preprocessor

A Review of Compilers



Some variants work at the token level, but the concept is the same.



Writing swap in C
(in class)

C preprocessor example

```
#define PI 3.14159

#define SWAP(a,b) {int tmp=a;a=b;b=tmp;}

int main(void) {
    int x=4, y=5, diam=7, circum=diam*PI;
    SWAP(x,y);
}
```

```
int main(void) {
    int x=4, y=5, diam=7, circum=diam*PI;
    SWAP(x,y);
}
```


```
int main(void) {
    int x=4, y=5, diam=7,
        circum=diam*3.14159;
    {int tmp=x;x=y;y=tmp;};
}
```

Many macro systems suffer from *inadvertent variable capture.*

Let's look at an example…

Accidental Capture Example (in class)

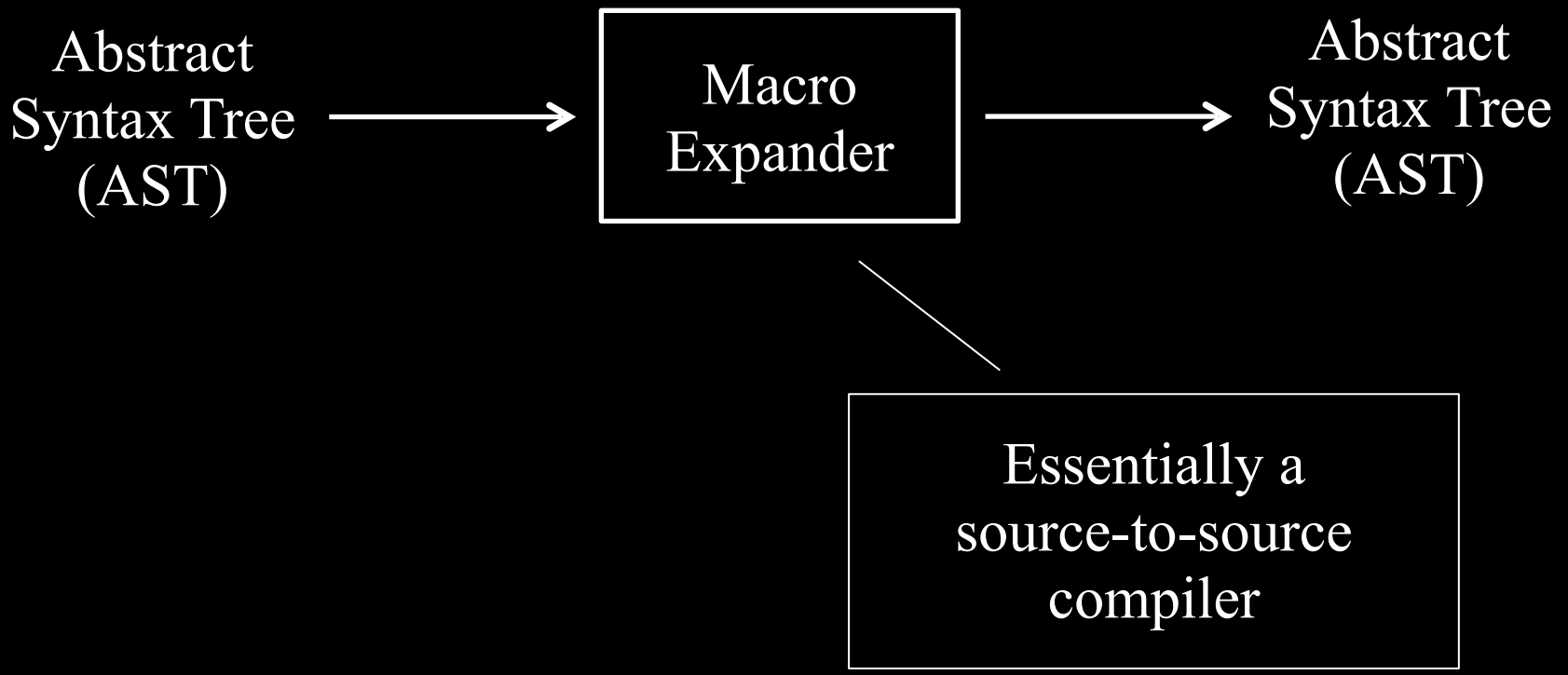
Hygiene

Hygienic macros are macros whose expansion is guaranteed not to cause the *accidental capture of identifiers*.

Syntactic macros

- Work on abstract syntax trees
- From the Lisp/Scheme family
  - Lisp programs *are* ASTs
- Powerful, but expensive

Macro expansion process



Macros in Scheme

- Scheme is noted for its powerful (and hygienic) macro system.
- Is it needed? Aren't lambdas enough?

```
(define (swap x y)
  (let ([tmp x])
    (set! x y)
    (set! y tmp)))

(let ([a 7][b 3])
  (swap a b)
  (displayln a)
  (displayln b))
```

What is the result?

Pattern Based Macros

- Preserves hygiene
- `define-syntax-rule`
  - matches the given pattern
  - transforms code following the specified template
- `define-syntax`
  - allows multiple patterns
  - supports a variable number of arguments (using the … syntax)

```
(define-syntax-rule (swap x y)
  (let ([tmp x])
    (set! x y)
    (set! y tmp)))
(let ([a 7][b 3])
  (swap a b)
  (displayln a)
  (displayln b))
```

What is the result?

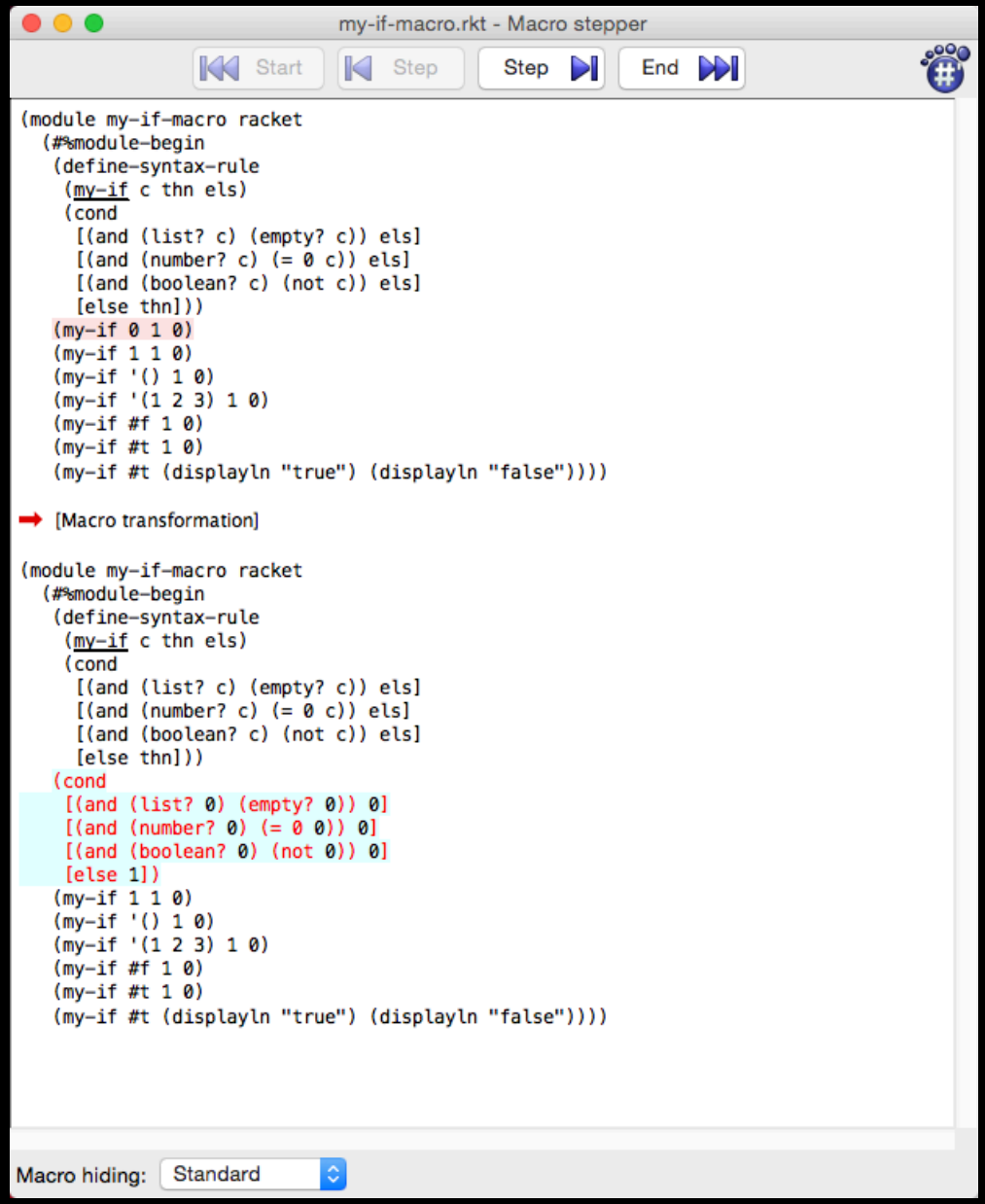
Broken version of `my-if`

```
(define
 (my-if c thn els)
  (cond [(and (list? c)
              (empty? c)) els]
        [(and (number? c)
              (= 0 c)) els]
        [(and (boolean? c)
              (not c)) els]
        [else thn]))
```

Corrected version of `my-if`

```
(define-syntax-rule
 (my-if c thn els)
  (cond [(and (list? c)
              (empty? c)) els]
        [(and (number? c)
              (= 0 c)) els]
        [(and (boolean? c)
              (not c)) els]
        [else thn]))
```

Using the Macro Stepper in DrRacket



Define-syntax swap function

```
(define-syntax swap
  (syntax-rules ()
      [(swap x y)
         (let ([tmp x])
           (set! x y)
           (set! y tmp))]))
```

`rotate` / `rotate-all`

(in class)

Lab

Using `define-syntax`, create a switch statement. Sample usage:

```
(define x 99)
(switch x
     [3 (displayln "x is 3")]
     [4 (displayln "x is 4")]
     [5 (displayln "x is 5")]
     [default (displayln
               "none of the above")])
```

For more reading on macros:

- Matthew Flatt, "Pattern-based macros", section 16.1 of "The Racket Guide". http://docs.racket-lang.org/guide/pattern-macros.html
- Greg Hendershott, "Fear of Macros". http://www.greghendershott.com/fear-of-macros/index.html