

## 61A Lecture 29

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## Announcements

## Programs as Data

### A Scheme Expression is a Scheme List

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Scheme programs consist of expressions, which can be:

- Primitive expressions: 2 3.3 true + quotient
- Combinations: (quotient 10 2) (not true)

The built-in Scheme list data structure (which is a linked list) can represent combinations

```
scm> (list 'quotient 10 2)
(quotient 10 2)
scm> (eval (list 'quotient 10 2))
5
```

In such a language, it is straightforward to write a program that writes a program

(Demo)

## Macros

### Macros Perform Code Transformations

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A macro is an operation performed on the source code of a program before evaluation

Macros exist in many languages, but are easiest to define correctly in a language like Lisp

Scheme has a **define-macro** special form that defines a source code transformation

```
(define-macro (twice expr)
  (list 'begin expr expr))
> (twice (print 2))
2
2
```

Evaluation procedure of a macro call expression:

- Evaluate the operator sub-expression, which evaluates to a macro
- Call the macro procedure on the operand expressions *without evaluating them first*
- Evaluate the expression returned from the macro procedure

(Demo)

## For Macro

### Discussion Question

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Define a macro that evaluates an expression for each value in a sequence

```
(define (map fn vals)
  (if (null? vals)
      ()
      (cons (fn (car vals))
            (map fn (cdr vals)))))
scm> (map (lambda (x) (* x x)) '(2 3 4 5))
(4 9 16 25)
(define-macro (for sym vals expr)
  (list 'map _____ (list 'lambda (list sym) expr) vals))
```

```
scm> (for x '(2 3 4 5) (* x x))
(4 9 16 25)
```

(Demo)

## Quasi-Quotation

(Demo)