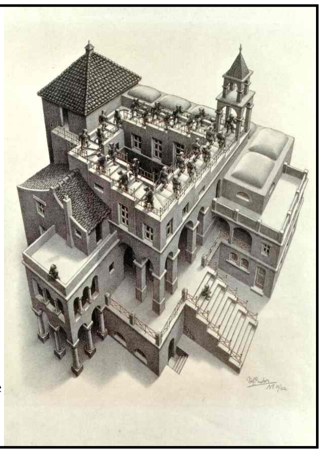
Lecture 5: Recursing on Lists



CS150: Computer Science
University of Virginia
Computer Science

Menu

- Implementing cons, car, cdr
- PS1
- List Recap
- List Recursion

Everyone who submitted a registration survey should have received an email yesterday with your PS2 partner. If you didn't come talk to me after class.

Implementing cons, car and cdr

```
(define (cons a b)
  (lambda (w) (if (w) a b)))

(define (car pair) (pair #t))
(define (cdr pair) (pair #f))
```

Scheme provides primitive implementations for cons, car, and cdr. But, we could define them ourselves.

CS150 PS Grading Scale

★Gold Star – Excellent Work. You got everything I wanted on this PS. (No Gold Stars on PS1)

★Green Star – Better than good work

★Blue Star – Good Work. You got most things on this PS, but some answers could be better.

★Silver Star – Some problems. Make sure you understand the solutions on today's slides.

PS1 Average: ★

No upper limit

★★ - Double Gold Star: exceptional work! Better than I expected anyone would do.

★★★- Triple Gold Star: Better than I thought possible (moviemosaic for PS1)

★★★★- Quadruple Gold Star: You have broken important new ground in CS which should be published in a major journal!

★★★★★- Quintuple Gold Star: You deserve to win a Turing Award! (a fast, general way to make the best non-repeating photomosaic on PS1, or a proof that it is impossible)

Question 2

- Without Evaluation Rules, Question 2 was "guesswork"
- Now you know the Evaluation Rules, you can answer Question 2 without any guessing!

2d

(100 + 100)

Evaluation Rule 3. Application.

a. Evaluate all the subexpressions

100 <primitive:+> 100

b. Apply the value of the first subexpression to the values of all the other subexpressions

Error: 100 is not a procedure, we only have apply rules for procedures!

2h

(if (not "cookies") "eat" "starve")

Evaluation Rule 4-if. Evaluate *Expression*$_0$. If it evaluates to **#f**, the value of the if expression is the value of *Expression*$_2$. Otherwise, the value of the if expression is the value of *Expression*$_1$.

Evaluate (not "cookies")

Evaluate (not "cookies")

Evaluation Rule 3. Application.

a. Evaluate all the subexpressions

<primitive:not> "cookies"

The quotes really matter here!

Without them what would cookies evaluate to?

b. Apply the value of the first subexpression to the values of all the other subexpressions

(not *v*) evaluates to **#t** if *v* is **#f**, otherwise it evaluates to **#f**. (SICP, p. 19)

So, (not "cookies") evaluates to **#f**

Defining not

(not *v*) evaluates to **#t** if *v* is **#f**, otherwise it evaluates to **#f**.

(SICP, p. 19)

```
(define (not v) (if v #f #t))
```

2h

(if (not "cookies") "eat" "starve")

Evaluation Rule 4-if. Evaluate *Expression*$_0$. If it evaluates to **#f**, the value of the if expression is the value of *Expression*$_1$. Otherwise, the value of the if expression is the value of *Expression*$_2$.

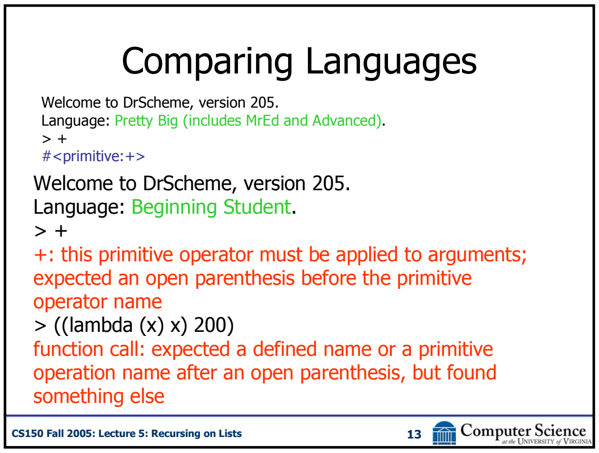
Evaluate (not "cookies") => **#f**

So, value of if is value of *Expression*$_2$

=> **"starve"**

DrScheme Languages

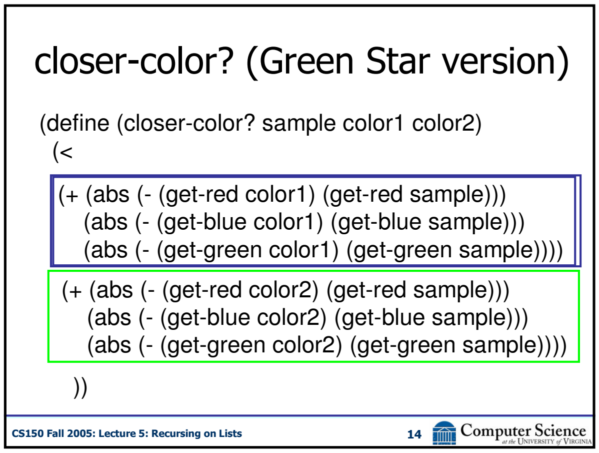
- If you didn't set the language correctly in DrScheme, you got different answers!
- The "Beginning Student" has different evaluation rules
  - The rules are more complex
  - But, they gave more people what they expected



Comparing Languages

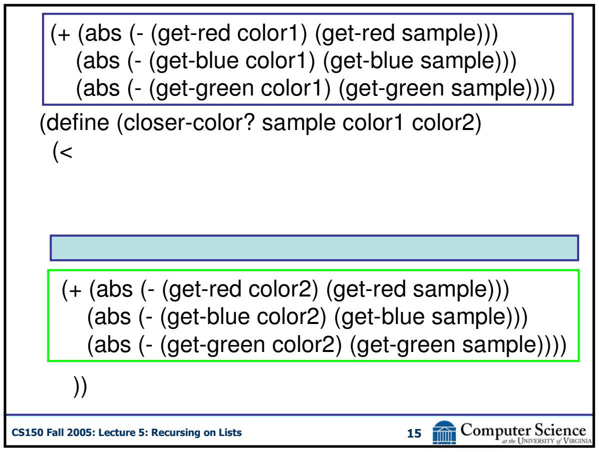
```
Welcome to DrScheme, version 205.
Language: Pretty Big (includes MrEd and Advanced).
> +
#<primitive:+>
```

```
Welcome to DrScheme, version 205.
Language: Beginning Student.
> +
+: this primitive operator must be applied to arguments;
expected an open parenthesis before the primitive
operator name
> ((lambda (x) x) 200)
function call: expected a defined name or a primitive
operation name after an open parenthesis, but found
something else
```



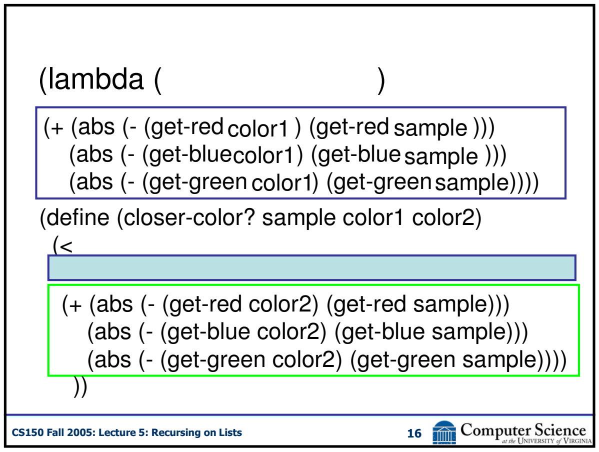
closer-color? (Green Star version)

```
(define (closer-color? sample color1 color2)
  (<
   (+ (abs (- (get-red color1) (get-red sample)))
      (abs (- (get-blue color1) (get-blue sample)))
      (abs (- (get-green color1) (get-green sample))))
   (+ (abs (- (get-red color2) (get-red sample)))
      (abs (- (get-blue color2) (get-blue sample)))
      (abs (- (get-green color2) (get-green sample))))
   ))
```

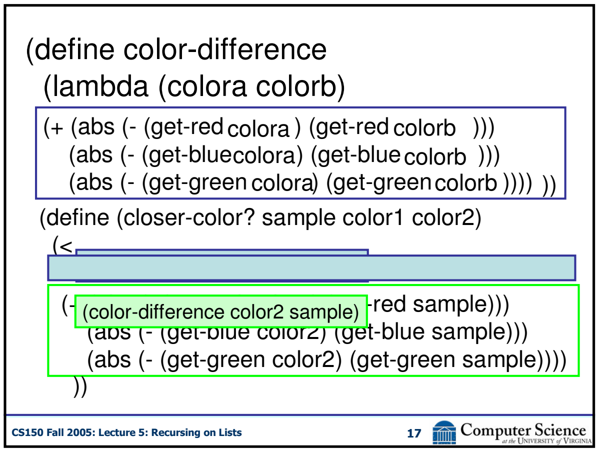


```
(+ (abs (- (get-red color1) (get-red sample)))
   (abs (- (get-blue color1) (get-blue sample)))
   (abs (- (get-green color1) (get-green sample))))
(define (closer-color? sample color1 color2)
  (<

   (+ (abs (- (get-red color2) (get-red sample)))
      (abs (- (get-blue color2) (get-blue sample)))
      (abs (- (get-green color2) (get-green sample))))
   ))
```

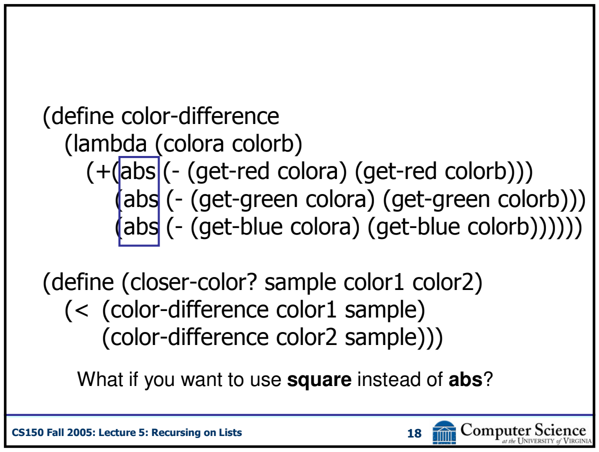


```
(lambda (                    )
(+ (abs (- (get-red color1 ) (get-red sample )))
   (abs (- (get-blue color1) (get-blue sample )))
   (abs (- (get-green color1) (get-green sample))))
(define (closer-color? sample color1 color2)
  (<
   (+ (abs (- (get-red color2) (get-red sample)))
      (abs (- (get-blue color2) (get-blue sample)))
      (abs (- (get-green color2) (get-green sample))))
   ))
```



```
(define color-difference
  (lambda (colora colorb)
(+ (abs (- (get-red colora ) (get-red colorb  )))
   (abs (- (get-blue colora) (get-blue colorb  )))
   (abs (- (get-green colora) (get-green colorb )))) ))
(define (closer-color? sample color1 color2)
  (<

   (- (color-difference color2 sample) -red sample)))
      (abs (- (get-blue color2) (get-blue sample)))
      (abs (- (get-green color2) (get-green sample))))
   ))
```



```
(define color-difference
  (lambda (colora colorb)
    (+(abs (- (get-red colora) (get-red colorb)))
      (abs (- (get-green colora) (get-green colorb)))
      (abs (- (get-blue colora) (get-blue colorb))))))

(define (closer-color? sample color1 color2)
  (<  (color-difference color1 sample)
      (color-difference color2 sample)))
```

What if you want to use **square** instead of **abs**?

```
(define color-difference
  (lambda (cf)
   (lambda (colora colorb)
     (+ (cf (- (get-red colora) (get-red colorb)))
        (cf (- (get-green colora) (get-green colorb)))
        (cf (- (get-blue colora) (get-blue colorb)))))))

(define (closer-color? sample color1 color2)
   (< (color-difference color1 sample)
      (color-difference color2 sample)))
```

```
(define color-difference
  (lambda (cf)
    (lambda (colora colorb)
      (+ (cf (- (get-red colora) (get-red colorb))
         (cf (- (get-green colora) (get-green colorb))
         (cf (- (get-blue colora) (get-blue colorb))))))))

(define (closer-color? sample color1 color2)
  (< ((color-difference square) color1 sample)
     ((color-difference square) color2 sample)))
```

The Patented RGB RMS Method

```
/* This is a variation of RGB RMS error. The final square-root has been eliminated to */
/* speed up the process. We can do this because we only care about relative error. */
/* HSV RMS error or other matching systems could be used here, as long as the goal of */
/* finding source images that are visually similar to the portion of the target image */
/* under consideration is met. */
for(i = 0; i > size; i++) {
rt = (int) ((unsigned char)rmas[i] – (unsigned
char)image->r[i]);
gt = (int) ((unsigned char)gmas[i] – (unsigned char)
image->g[i];
bt = (int) ((unsigned char)bmas[i] – (unsigned
char)image->b[i];
result += (rt*rt+gt*gt+bt*bt);
}
```

Your code should never look like this! Use **new lines** and **indenting** to make it easy to understand the structure of your code! (Note: unless you are writing a patent. Then the goal is to make it as hard to understand as possible.)

The Patented RGB RMS Method

```
rt = rmas[i] - image->r[i];
gt = gmas[i] - image->g[i];
bt = bmas[i] - image->b[i];
result += (rt*rt + gt*gt + bt*bt);
```

Patent requirements:

1. new – must not be previously available
   (ancient Babylonians made mosaics)
2. useful
3. nonobvious

4 out of 32 or you came up with this method!
(most of rest used abs instead, which works as well)

List Recap

- A *list* is either:

  a pair where the second part is a *list*

  or **null** (note: book uses **nil**)

- Pair primitives:

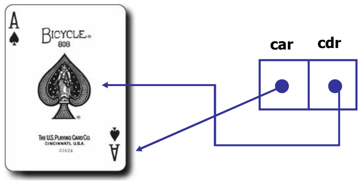
  (cons a b) Construct a pair <a, b>

  (car pair) First part of a pair

  (cdr pair) Second part of a pair

Problem Set 2: Programming with Data

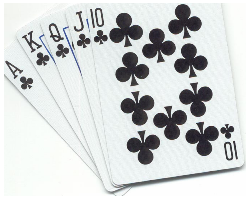
- Representing a card



Pair of rank (Ace) and suit (Spades)

Problem Set 2: Programming with Data

- Representing a card: (cons <rank> <suit>)
- Representing a hand



```
(list (make-card Ace clubs)
      (make-card King clubs)
      (make-card Queen clubs)
      (make-card Jack clubs)
      (make-card 10 clubs)
```

Programming with Lists

- Defining length

Charge

- PS2 is longer and harder than PS1
  - Start early
  - Use help: staffed lab hours, office hours, classmates
- If you do not have a PS2 partner, come up now