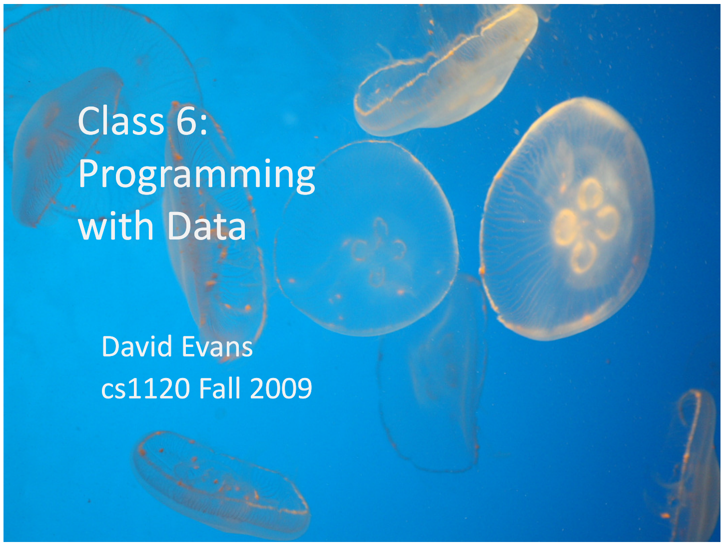

Class 6: Programming with Data

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cs1120 Fall 2009

Returning Problem Sets Problem

Input: unordered set of cs1120 students

Output: cs1120 students in lexicographic order by UVa ID

What is a good algorithm for getting all of you in order by UVa ID?

Ways to Design Programs

1. Think about what you want to **do**, and turn that into code.
2. Think about what you need to **represent**, and design your code around that.

Which is better?

History of Scheme

- Scheme [Guy Steele & Gerry Sussman, 1975]

  Guy Steele co-designed Scheme and created the first Scheme interpreter for his 4th year project

  More recently, Steele specified Java [1995]
  - "Conniver" [1973] and "Planner" [1967]
- Based on LISP [John McCarthy, 1958]
  - Based on Lambda Calculus [Alonzo Church, 1930s]
  - Last few lectures in course

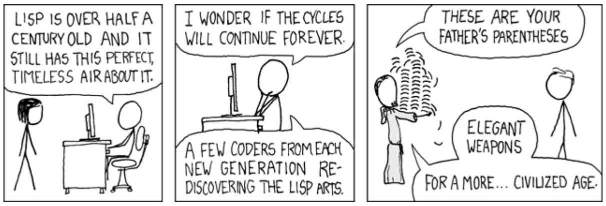
LISP

"**L**ots of **I**nsipid **S**illy **P**arentheses"

"**LIS**t **P**rocessing language"

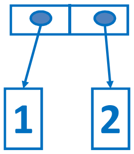
Lists are pretty important – hard to write a useful Scheme program without them.

Making Lists



Making a Pair

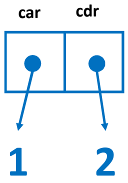
```
> (cons 1 2)
(1 . 2)
```



cons **cons**tructs a pair

Splitting a Pair

```
> (car (cons 1 2))
1
> (cdr (cons 1 2))
2
```



car extracts first part of a pair
cdr extracts second part of a pair

Why “car” and “cdr”?

- Original (1950s) LISP on IBM 704
  - Stored cons pairs in memory registers
  - **car** = “**C**ontents of the **A**ddress part of the **R**egister”
  - **cdr** = “**C**ontents of the **D**ecrement part of the **R**egister” (“could-er”)
- Doesn’t matter unless you have an IBM 704
- Think of them as **first** and **rest**

```
(define first car)
(define rest cdr)
```

(The DrScheme “Pretty Big” language already defines these, but they are not part of standard Scheme)

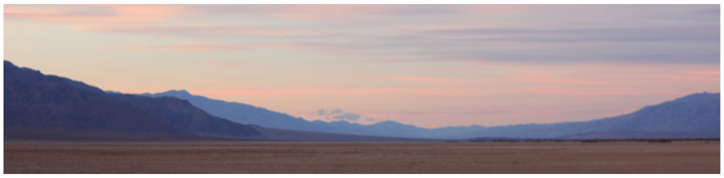
Implementing cons, car and cdr

```
(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.

Pairs are fine, but how do we make threesomes?



Triple

A **triple** is just a **pair** where one of the parts is a **pair**!

```
(define (triple a b c)
  (cons a (cons b c)))
(define (t-first t) (car t))
(define (t-second t) (car (cdr t)))
(define (t-third t) (cdr (cdr t)))
```

Quadruple

A **quadruple** is a pair where the second part is a **triple**

```
(define (quadruple a b c d)
   (cons a (triple b c d)))
(define (q-first q) (car q))
(define (q-second q) (t-first (cdr t)))
(define (q-third t) (t-second (cdr t)))
(define (q-fourth t) (t-third (cdr t)))
```

Multuples

- A **quintuple** is a pair where the second part is a **quadruple**
- A **sextuple** is a pair where the second part is a **quintuple**
- A **septuple** is a pair where the second part is a **sextuple**
- An **octuple** is group of octupi
- A ? is a pair where the second part is a …?

Lists

List ::= **(cons** *Element List***)**

A *list* is a pair where the second part is a *list*.

One big problem: how do we stop?
This only allows infinitely long lists!

Lists

List ::= **(cons** *Element List***)**

List ::=

It's hard to write this!

A *list* is either:
   a pair where the second part is a *list*
or, empty

Null

List ::= **(cons** *Element List***)**

List ::= **null**

A *list* is either:
   a pair where the second part is a *list*
or, empty (**null**)

List Examples

```
> null
()
> (cons 1 null)
(1)
> (list? null)
#t
> (list? (cons 1 2))
#f
> (list? (cons 1 null))
#t
```

More List Examples

```
> (list? (cons 1 (cons 2 null)))
#t
> (car (cons 1 (cons 2 null)))
1
> (cdr (cons 1 (cons 2 null)))
(2)
```

Recap

- A *list* is either:

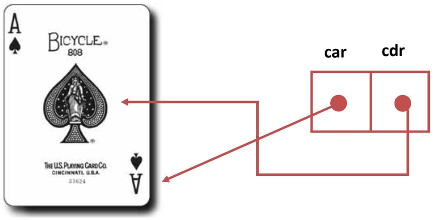
  a pair where the second part is a *list*

  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

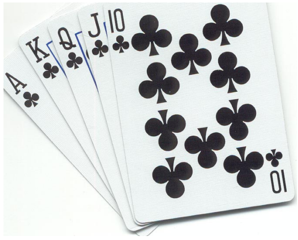


Pair of rank (Ace) and suit (Spades)

Problem Set 2:
Programming with Data

- Representing a card:

  (define (make-card rank suit) (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))
```

list-trues

Define a procedure that takes as input a list, and produces as output the number of non-false values in the list.

(list-trues null) → **0**

(list-trues (list 1 2 3)) → **3**

(list-trues (list false (list 2 3 4))) → **1**

Charge

- Now, you know **everything** you need for Problem Set 2 (and PS3 and PS4)
  - Help hours Sunday, Monday, Tuesday, Wednesday
- **Probably a Quiz Wednesday**
  - Course book through Sec. 5.4 and GEB reading
- Class Wednesday and Friday:
  - **Lots of examples programming with procedures and recursive definitions**