CS3:
Introduction to Symbolic Programming

Lecture 7:
Advanced Recursion

Fall 2006

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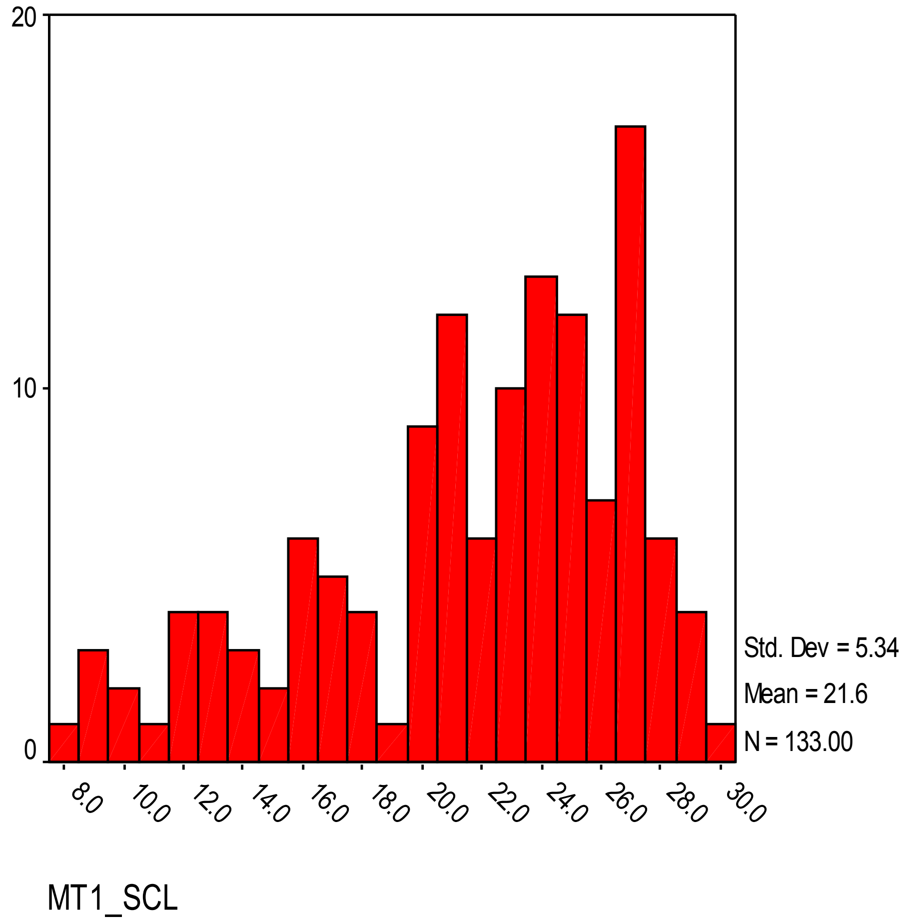
Schedule

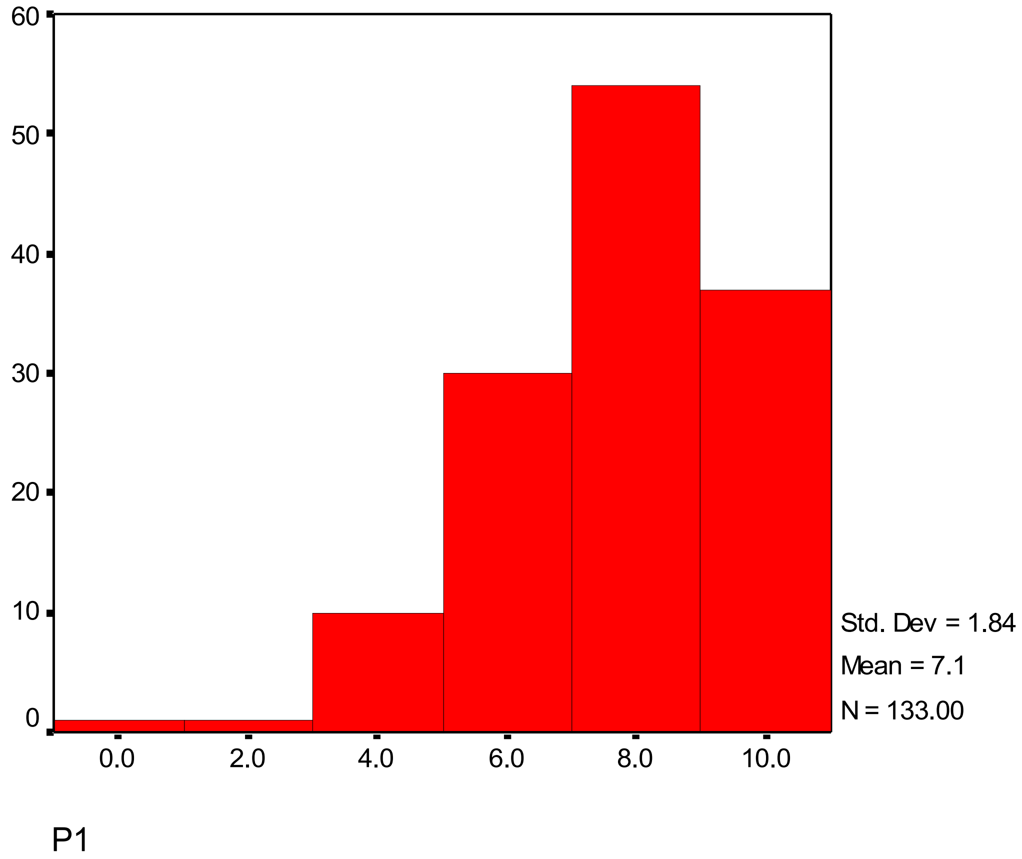
6	Oct 2-6	Lecture: *Midterm 1* Lab: Recursion II
7	Oct 9-13	Advanced recursion
8	Oct 16-20	Finishing recursion Miniproject #2: Number names
9	Oct 23-27	Introduction to Higher Order Procedures
10	Oct 30 -Nov 3	More HOF
11	Nov 6-10	Finish HOF Miniproject #3: Election processing

Midterm 1

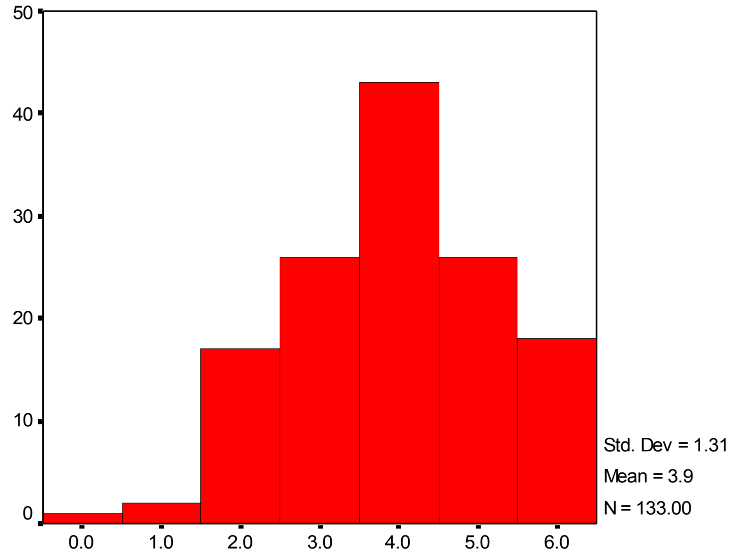
- **You did quite well (IMO)**
- **Solutions will be available soon on the portal (check announcements).**

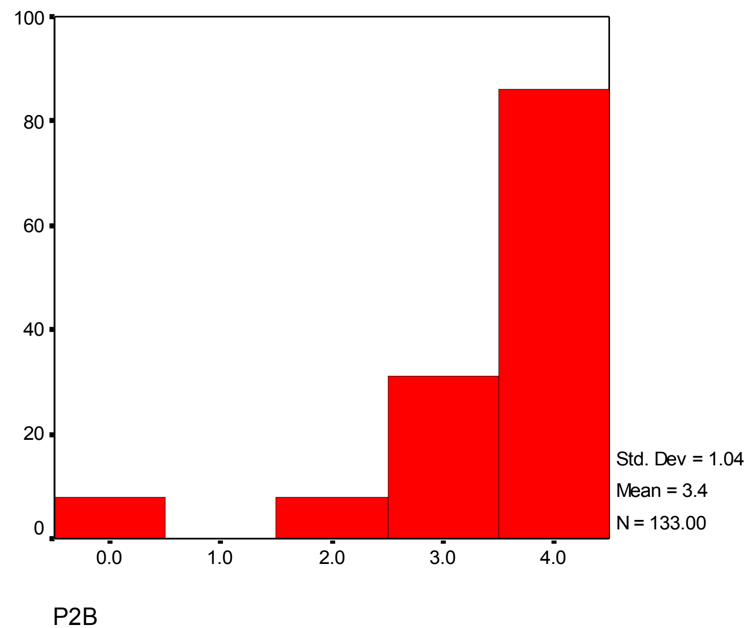


Question 1: fill in the blanks



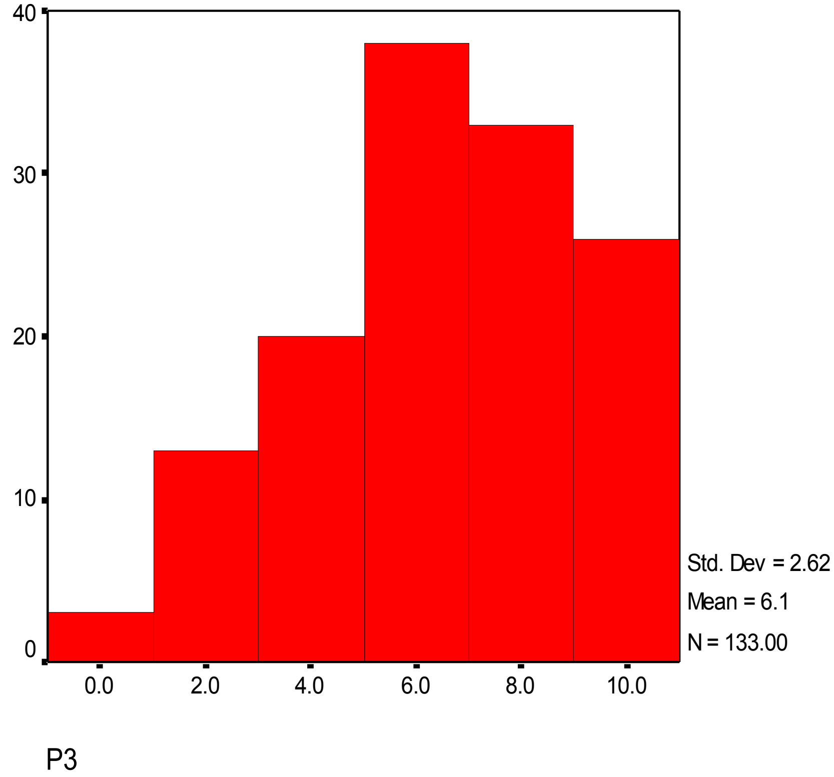
Q2: Writing `stressed?`, `within-10?`



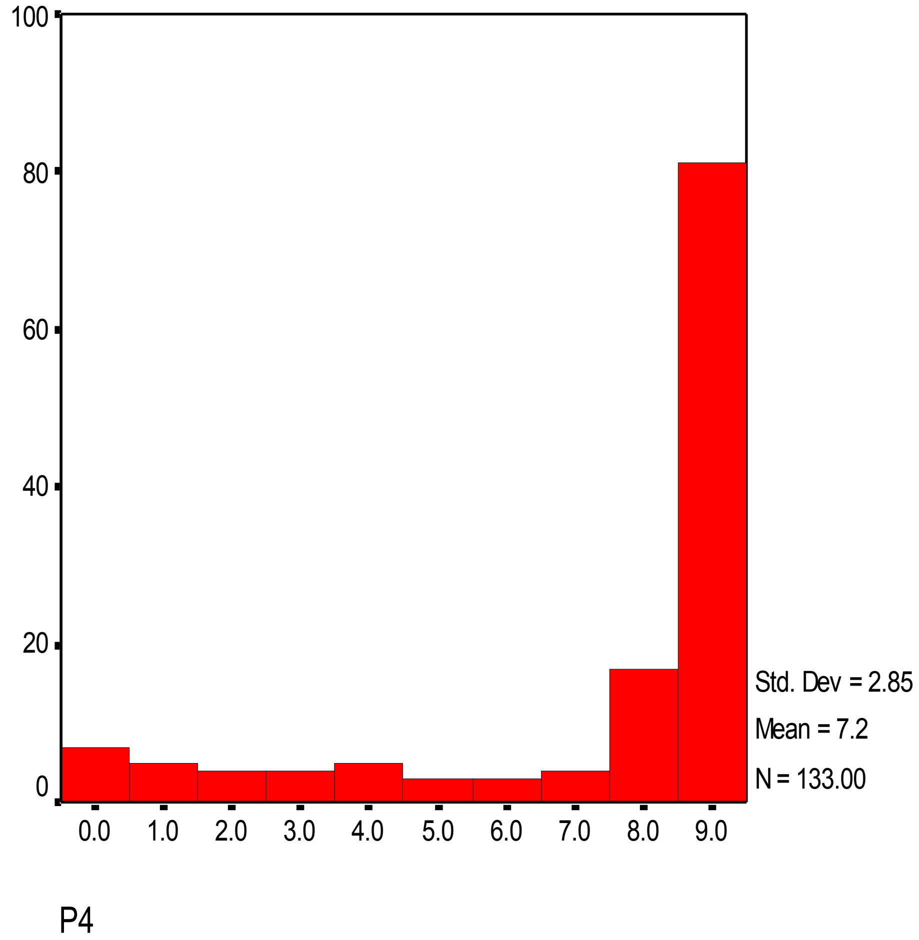


Q3: `tuesday-span`

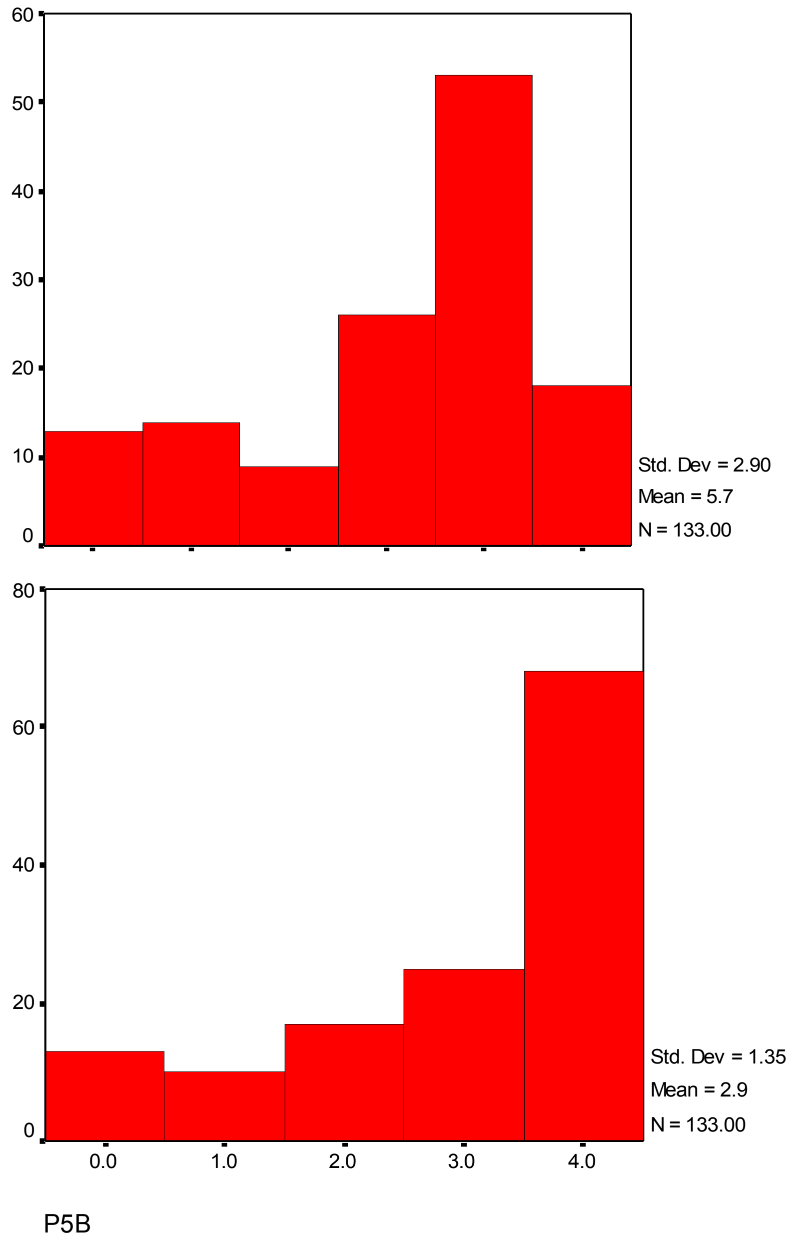
- **While we were generous, most of you got the basic idea**



Q4: translating a sentence



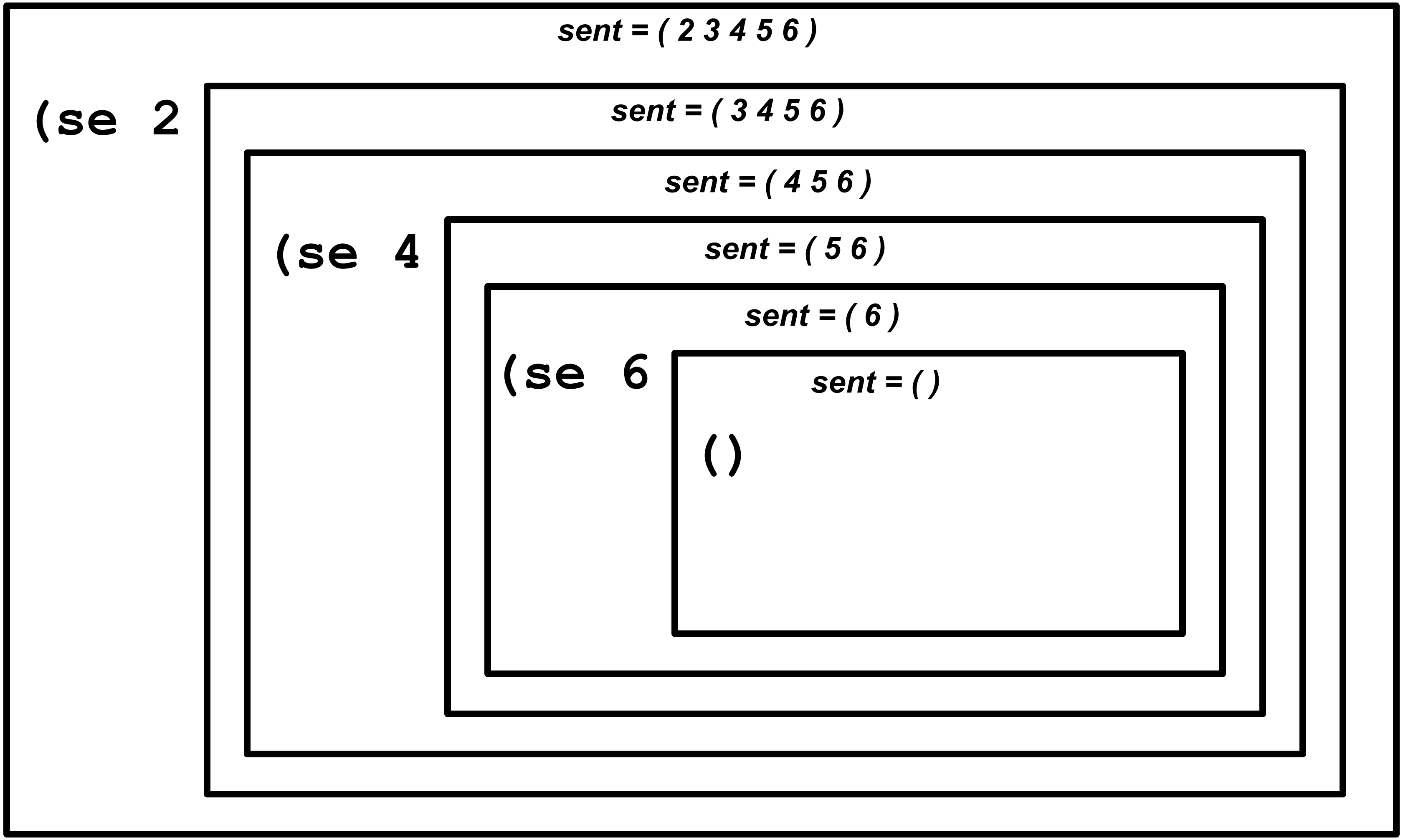
Q5: Data abstraction with `tutors`



Problem: ***find all the even numbers in sentence of numbers***

```
(define (find-evens sent)
  (cond ((empty? sent)          ;base case
         '()              )
        ((odd? (first sent)) ;rec case 1
         (find-evens (bf sent)) )
        (else                 ;rec case 2: even
         (se (first sent)
             (find-evens (bf sent))) )
        ))
```

```
> (find-evens '(2 3 4 5 6))
```




```
➔ (se 2 (se 4 (se 6 ()))
➔ (2 4 6)
```

Why is recursion hard?

- **ONE function:**
  - replicates itself,
  - knows how to stop,
  - knows how to combine the “replications”

- **There are many ways to think about recursion: you absolutely do not need to understand all of them.**

  - "down-up": recursion as an extension of writing many specific functions

  - "many base cases": recursion as using a clone, once you have many base cases

Patterns in basic recursion

- **Mapping**
  - does something to every part of the input sentence
  - E.g., square-all
- **Counting**
  - Counts the number of elements that satisfy a predicate
  - E.g., count-vowels, count-evens
- **Finding**
  - Return the first element that satisfies predicate (or, return rest of sentence)
  - E.g., member, member-even

- **Filtering**
  - Keep or discard elements of input sentence
  - E.g., `keep-evens`
- **Testing**
  - A predicate that checks that *every* or *any* element of input satistfies a test
  - E.g., `all-even?`
- **Combining**
  - Combines the elements in some way…
  - E.g., `sentence-sum`

What recursions aren't covered by these patterns?

- Weird ones like `reverse`, or `downup`
  - `... bowling ...`
- "Advanced" recursions:
  - *when it does more than one thing at a time*
  - Ones that don't traverse a single sentence
    - E.g., `mad-libs` takes a sentence of replacement words [e.g., `'(fat Henry three)`] and a sentence to mutate [e.g., `'(I saw a * horse named * with * legs)`]
  - Tree recursion: multiple recursive calls in a single recursive step

Advanced recursions (1/3)

"when it does more than one thing at a time"

- **Ones that traverse multiple sentences**
  - **E.g., `mad-libs` takes a sentence of replacement words [e.g., `'(fat Henry three)`] and a sentence to mutate [e.g.,**

    `'(I saw a * horse named * with * legs)`**]**

Advanced recursions (2/3)

- **Recursions that have an *inner* and an *outer* recursion**

```
(no-vowels '(I like to type)) → ("" lk t typ)

(l33t '(I like to type)) → (i 1i/<3 +0 +yP3)

(strip-most-popular-letter '(cs3 is the best class)) →
   (c3 i the bet cla))

(occurs-in? 'abc 'abxcde) → #f
```

Advanced recursions (3/3)

- **Tree recursion: multiple recursive calls in a single recursive step**

- **There are many, many others**

Tree recursion: fibonacci

- **The fibonacci sequence:**

  1 1 2 3 5 8 13 21 34 55

```
(define (fib n)
   (if (<= n 2)
       1                        ;; base case
       (+ (fib (- n 1))         ;; recursive case
          (fib (- n 2)))))
```

sub-sentence

Write the procedure sub-sentence, which returns a middle section of a sentence. It takes three parameters; the first identifies the index to start the middle section, and will be 1 or greater; the second identifies the length of the middle section, and will be 0 or greater; and the last is the sentence to work with.

Do *not* use any helper procedures.

Do *not* use the item procedure in your solution.

```
(sub-sentence 2 3 '(a b c d e f g)) → (b c d)
(sub-sentence 3 2 '(a b)) → ()
(sub-sentence 3 0 '(a b c d e) → ()
(sub-sentence 3 9 '(a b c d e) → (c d e)
```

sub-sentence

```
(define (sub-sentence start len sent)
  (cond ((empty? sent)
          '())
        ((> start 1)
         (sub-sentence (- start 1) len (bf sent)))
        ((> len 0)
         (se (first sent)
             (sub-sentence start (- len 1)(bf sent))))
        (else
         '())
        ))
```