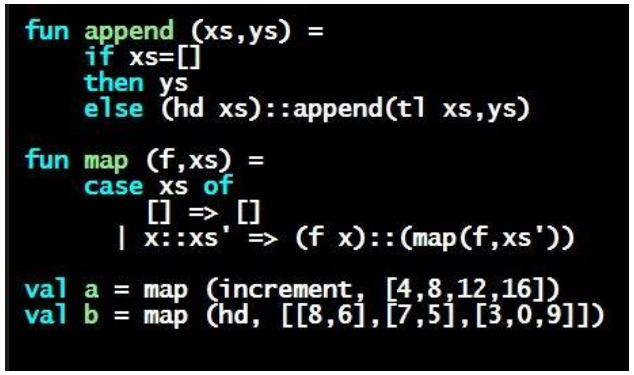

```
fun append (xs,ys) =
    if xs=[]
    then ys
    else (hd xs)::append(tl xs,ys)

fun map (f,xs) =
    case xs of
        [] => []
      | x::xs' => (f x)::(map(f,xs'))

val a = map (increment, [4,8,12,16])
val b = map (hd, [[8,6],[7,5],[3,0,9]])
```

Programming Languages

Dan Grossman

Using Streams

Streams

- A stream is an *infinite sequence* of values
  - So cannot make a stream by making all the values
  - Key idea: Use a thunk to delay creating most of the sequence
  - Just a programming idiom

A powerful concept for division of labor:

- Stream producer knows how create any number of values
- Stream consumer decides how many values to ask for

Some examples of streams you might (not) be familiar with:

- User actions (mouse clicks, etc.)
- UNIX pipes: **`cmd1 | cmd2`** has **`cmd2`** "pull" data from **`cmd1`**
- Output values from a sequential feedback circuit

Using streams

We will represent streams using pairs and thunks

Let a stream be a thunk that *when called* returns a pair:

```
'(next-answer . next-thunk)
```

So given a stream **`s`**, the client can get any number of elements

- First: **`(car (s))`**
- Second: **`(car ((cdr (s))))`**
- Third: **`(car ((cdr ((cdr (s))))))`**

(Usually bind **`(cdr (s))`** to a variable or pass to a recursive function)

Example using streams

This function returns how many stream elements it takes to find one for which tester does not return **`#f`**

- Happens to be written with a tail-recursive helper function

```
(define (number-until stream tester)
  (letrec ([f (lambda (stream ans)
                (let ([pr (stream)])
                  (if (tester (car pr))
                      ans
                      (f (cdr pr) (+ ans 1)))))])
    (f stream 1)))
```

- **`(stream)`** generates the pair
- So recursively pass **`(cdr pr)`**, the thunk for the rest of the infinite sequence