Big Fish

A function that gets the big fish (> 5 lbs):

```
; big : list-of-nums -> list-of-nums
(define (big l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (cond
     [(> (first l) 5)
      (cons (first l) (big (rest l)))]
     [else (big (rest l))])]))

(check-expect (big empty) empty)
(chexk-expect (big '(7 4 9)) '(7 9))
```

Big Fish

Better with `local`:

```
; big : list-of-nums -> list-of-nums
(define (big l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define big-rest (big (rest l)))]
      (cond
       [(> (first l) 5)
        (cons (first l) big-rest)]
       [else big-rest]))]))
```

Suppose we also need to find huge fish...

Huge Fish

Huge fish (> 10 lbs):

```
; huge : list-of-nums -> list-of-nums
(define (huge l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define h-rest (huge (rest l)))]
      (cond
       [(> (first l) 10)
        (cons (first l) h-rest)]
       [else h-rest]))]))
```

How do you suppose I made this slide?

Cut and Paste!

The Trouble With Cut and Paste

```
; big : list-of-nums -> list-of-nums
(define (big l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (cond
     [(> (first l) 5)
      (cons (first l) (big (rest l)))]
     [else (big (rest l))])]))
```

cut and paste

```
; huge : list-of-nums -> list-of-nums
(define (huge l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (cond
     [(> (first l) 10)
      (cons (first l) (huge (rest l)))]
     [else (huge (rest l))])]))
```

The Trouble With Cut and Paste

```
; big : list-of-nums -> list-of-nums
(define (big l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (cond
     [(> (first l) 5)
      (cons (first l) (big (rest l)))]
     [else (big (rest l))])]))
```

cut and paste

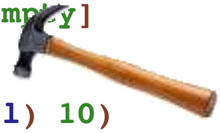
```
; huge : list-of-nums -> list-of-nums
(define (huge l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (cond
     [(> (first l) 10)
      (cons (first l) (huge (rest l)))]
     [else (huge (rest l))])]))
```

The Trouble With Cut and Paste

```
; big : list-of-nums -> list-of-nums
(define (big l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (cond
     [(> (first l) 5)
      (cons (first l) (big (rest l)))]
     [else (big (rest l))])]))
```

cut and paste

```
; huge : list-of-nums -> list-of-nums
(define (huge l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (cond
     [(> (first l) 10)
      (cons (first l) (huge (rest l)))]
     [else (huge (rest l))])]))
```



After cut-and-paste, improvement is twice as hard

The Trouble With Cut and Paste

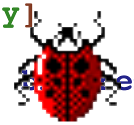
```
; big : list-of-nums -> list-of-nums
(define (big l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define big-rest (big (rest l)))]
      (cond
       [(> (first l) 5)
        (cons (first l) big-rest)]
       [else big-rest]))]))
```

cut and paste

```
; huge : list-of-nums -> list-of-nums
(define (huge l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define h-rest (huge (rest l)))]
      (cond
       [(> (first l) 10)
        (cons (first l) h-rest)]
       [else h-rest]))]))
```

The Trouble With Cut and Paste

```
; big : list-of-nums -> list-of-nums
(define (big l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define big-rest (big (rest l)))]
      (cond
       [(> (first l) 5)
        (cons (first l) big-rest)]
       [else big-rest]))]))
```

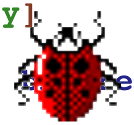


cut and paste

```
; huge : list-of-nums -> list-of-nums
(define (huge l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define h-rest (huge (rest l)))]
      (cond
       [(> (first l) 10)
        (cons (first l) h-rest)]
       [else h-rest]))]))
```

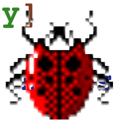
The Trouble With Cut and Paste

```
; big : list-of-nums -> list-of-nums
(define (big l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define big-rest (big (rest l)))]
      (cond
       [(> (first l) 5)
        (cons (first l) big-rest)]
       [else big-rest]))]))
```



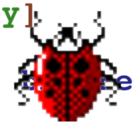
cut and paste

```
; huge : list-of-nums -> list-of-nums
(define (huge l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define h-rest (huge (rest l)))]
      (cond
       [(> (first l) 10)
        (cons (first l) h-rest)]
       [else h-rest]))]))
```



After cut-and-paste, bugs multiply

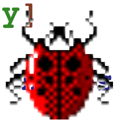
The Trouble With Cut and Paste



```
; big : list-of-nums -> list-of-nums
(define (big l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define big-rest (big (rest l)))]
      (cond
       [(> (first l) 5)
        (cons (first l) big-rest)]
       [else big-rest]))]))
```

cut and paste

Avoid cut and paste!



```
; huge : list-of-nums -> list-of-nums
(define (huge l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define h-rest (huge (rest l)))]
      (cond
       [(> (first l) 10)
        (cons (first l) h-rest)]
       [else h-rest]))]))
```

After cut-and-paste, bugs multiply

How to Avoid Cut-and-Paste

Start with the original function...

```
; big : list-of-nums -> list-of-nums
(define (big l)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define big-rest (big (rest l)))]
      (cond
       [(> (first l) 5)
        (cons (first l) big-rest)]
       [else big-rest]))]))
```

How to Avoid Cut-and-Paste

... and add arguments for parts that should change

```
; bigger : list-of-nums num -> list-of-nums
(define (bigger l n)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define r (bigger (rest l) n))]
      (cond
       [(> (first l) n)
        (cons (first l) r)]
       [else r]))]))

(define (big l) (bigger l 5))

(define (huge l) (bigger l 10))
```

Small Fish

Now we want the small fish:

```
; smaller : list-of-nums num -> list-of-nums
(define (smaller l n)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define r (smaller (rest l) n))]
      (cond
       [(< (first l) n)
        (cons (first l) r)]
       [else r]))]))

(define (small l) (smaller l 5))
```

No! Don’t cut and paste!

Sized Fish

```
; sized : list-of-nums num ... -> list-of-nums
(define (sized l n COMP)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define r
              (sized (rest l) n COMP))]
      (cond
       [(COMP (first l) n)
        (cons (first l) r)]
       [else r]))]))

    (define (bigger l n) (sized l n >))
    (define (smaller l n) (sized l n <))
```

Does this work? What is the contract for **sized**?

Functions as Values

The definition

```
(define (bigger l n) (sized l n >))
```

works because *functions are values*

- `10` is a `num`
- `false` is a `bool`
- `<` is a `(num num -> bool)`

So the contract for `sized` is

```
; list-of-nums num (num num -> bool)
; -> list-of-nums
```

Sized Fish

```
; sized : list-of-nums num (num num -> bool)
; -> list-of-nums
(define (sized l n COMP)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define r
              (sized (rest l) n COMP))]
      (cond
       [(COMP (first l) n)
        (cons (first l) r)]
       [else r]))]))

   (define (tiny l) (sized l 2 <))
   (define (medium l) (sized l 5 =))
```

Sized Fish

```
; sized : list-of-nums num (num num -> bool)
; -> list-of-nums
(define (sized l n COMP)
  (cond
   [(empty? l) empty]
   [(cons? l)
    (local [(define r
              (sized (rest l) n COMP))]
      (cond
       [(COMP (first l) n)
        (cons (first l) r)]
       [else r]))]))
```

How about all fish between 3 and 7 lbs?

Mediumish Fish

```
; btw-3-and-7 : num num -> bool
(define (btw-3-and-7 a ignored-zero)
  (and (>= a 3)
       (<= a 7)))

(define (mediumish l) (sized l 0 btw-3-and-7))
```

- Programmer-defined functions are values, too
- Note that the contract of **`btw-3-and-7`** matches the kind expected by **`sized`**

But the ignored **`0`** suggests a simplification of **`sized`**...

A Generic Number Filter

```
 ; filter-nums : (num -> bool) list-of-num
 ; -> list-of-num
 (define (filter-nums PRED l)
   (cond
    [(empty? l) empty]
    [(cons? l)
     (local [(define r
               (filter-nums PRED (rest l)))]
       (cond
        [(PRED (first l))
         (cons (first l) r)]
        [else r]))]))

(define (btw-3&7 n) (and (>= n 3) (<= n 7)))
(define (mediumish l) (filter-nums btw-3&7 l))
```

Big and Huge Fish, Again

```
(define (more-than-5 n)
  (> n 5))
(define (big l)
  (filter-nums more-than-5 l))

(define (more-than-10 n)
  (> n 10))
(define (huge l)
  (filter-nums more-than-10 l))
```

The **`more-than-5`** and **`more-than-10`** functions are really only useful to **`big`** and **`huge`**

We could make them **`local`** to clarify...

Big and Huge Fish, Improved

```
(define (big l)
  (local [(define (more-than-5 n)
                 (> n 5))]
    (filter-nums more-than-5 l)))

(define (huge l)
  (local [(define (more-than-10 n)
                 (> n 10))]
    (filter-nums more-than-10 l)))
```

Cut and paste alert!

You don’t think I typed that twice, do you?

Big and Huge Fish, Generalized

```
(define (bigger-than l m)
  (local [(define (more-than-m n)
                  (> n m))]
    (filter-nums more-than-m l)))

(define (big l) (bigger-than l 5))
(define (huge l) (bigger-than l 10))
```

Big Example

```
...
(define (bigger-than l m)
  (local [(define (more-than-m n)
            (> n m))]
    (filter-nums more-than-m l)))
(define (big l) (bigger-than l 5)) ...
(big '(7 4 9))
(huge '(7 4 9))
```

→

```
...
(define (bigger-than l m)
  (local [(define (more-than-m n)
            (> n m))]
    (filter-nums more-than-m l)))
...
(bigger-than '(7 4 9) 5)
(huge '(7 4 9))
```

Big Example

```
...
(define (bigger-than l m)
  (local [(define (more-than-m n)
            (> n m))]
    (filter-nums more-than-m l)))
...
(bigger-than '(7 4 9) 5)
(huge '(7 4 9))
```

→

```
...
(local [(define (more-than-m n)
          (> n 5))]
  (filter-nums more-than-m '(7 4 9)))
(huge '(7 4 9))
```

Big Example

```
...
(local [(define (more-than-m n)
          (> n 5))]
  (filter-nums more-than-m '(7 4 9)))
(huge '(7 4 9))
```

→

```
...
(define (more-than-m42 n)
  (> n 5))
(filter-nums more-than-m42 '(7 4 9))
(huge '(7 4 9))
```

Big Example

```
...
(define (more-than-m42 n)
  (> n 5))
(filter-nums more-than-m42 '(7 4 9))
(huge '(7 4 9))
```

→

```
...
(define (more-than-m42 n)
  (> n 5))
'(7 9)
(huge '(7 4 9))
```

after many steps

Big Example

```
...
(define (more-than-m42 n)
  (> n 5))
'(7 9)
(huge '(7 4 9))
```

→

```
...
(define (bigger-than l m)
  (local [(define (more-than-m n)
            (> n m))]
    (filter-nums more-than-m l)))
...
(define (more-than-m42 n)
  (> n 5))
'(7 9)
(bigger-than '(7 4 9) 10)
```

Big Example

```
...
(define (bigger-than l m)
  (local [(define (more-than-m n)
            (> n m))]
    (filter-nums more-than-m l)))
...
(define (more-than-m42 n)
  (> n 5))
'(7 9)
(bigger-than '(7 4 9) 10)
```

→

```
...
(define (more-than-m42 n)
  (> n 5))
'(7 9)
(local [(define (more-than-m n)
          (> n 10))]
  (filter-nums more-than-m '(7 4 9)))
```

Big Example

```
...
(define (more-than-m42 n)
  (> n 5))
'(7 9)
(local [(define (more-than-m n)
          (> n 10))]
  (filter-nums more-than-m '(7 4 9)))
```

→

```
...
(define (more-than-m42 n)
  (> n 5))
'(7 9)
(define (more-than-m79 n)
  (> n 10))
(filter-nums more-than-m79 '(7 4 9))
```

Etc.

Abstraction

- Avoiding cut and paste is ***abstraction***
- No real programming task succeeds without it

You will lose points after HW 6 for cut-and-paste code