

# Discussion 02: More Environments and Recursion

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# Agenda

1. Feedback!
2. Attendance
3. Announcements
4. Check Your Understanding
5. Recursion
6. Environment diagrams again (slides skipped in class)
7. Lambdas (slides skipped in class)

# **Thanks for your feedback! Some common trends:**

Too much talking, not enough "doing"

- I will blab a bit less
- If I go through slides too quickly, check them out later online!

# Attendance

Sign in at [tiny.cc/jerrydisc](https://tiny.cc/jerrydisc)

# Announcements

## **Homework 2 due Tuesday**

- HW Party in 247 Cory Monday 6:30pm-8:30pm

**Sign ups for CSM sections are open!** Sections start next week

Piazza — please, no public code!

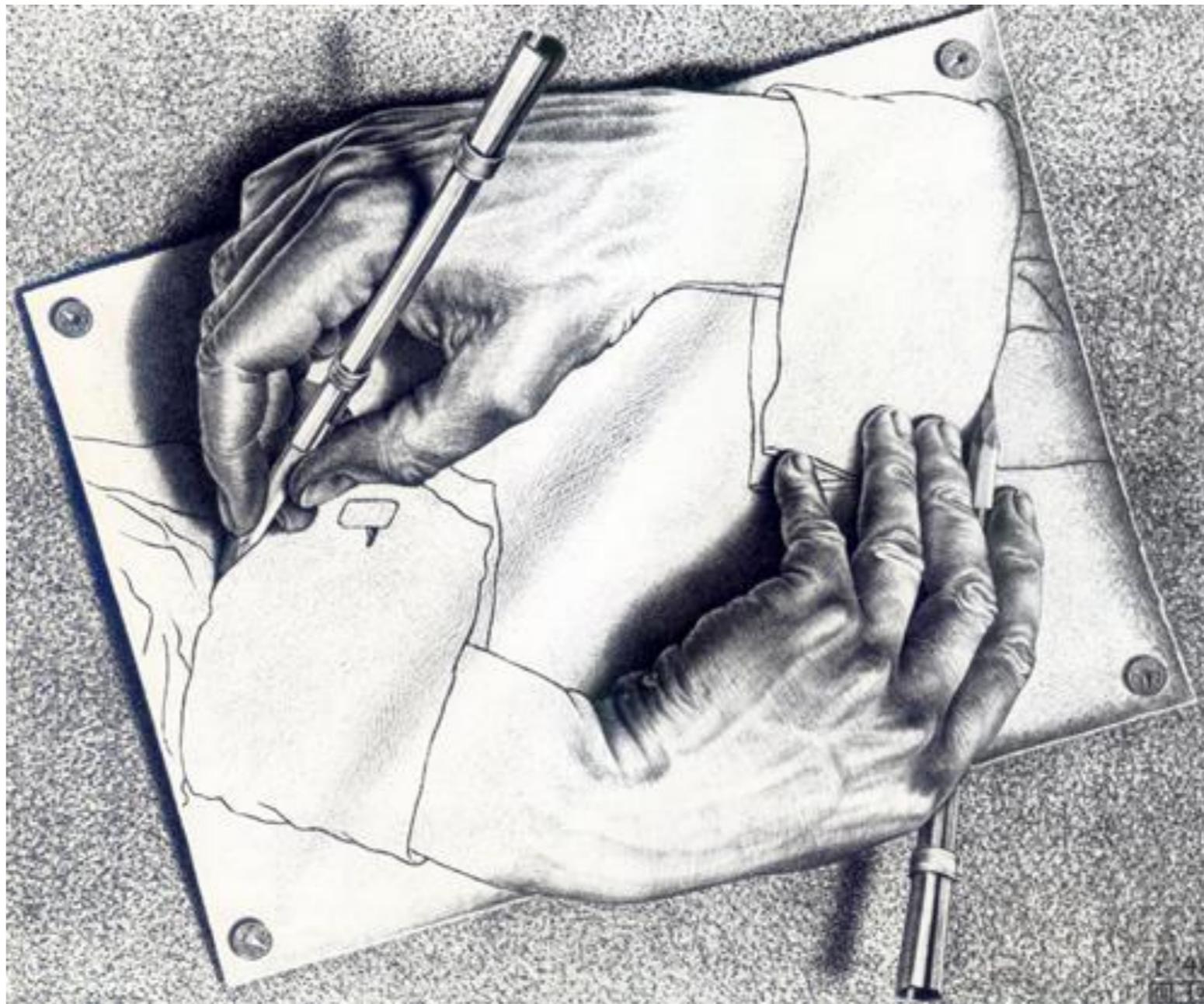
# Check Your Understanding

```
square = lambda x: x * x
```

```
def test(f, x):  
    if f(x) % 2 == 0:  
        return lambda g, x: g(square, x)  
    else:  
        return f(x)
```

```
print(test(lambda s: s // 2, 20)(test, 7))
```

# Recursion



*Drawing Hands* by M. C. Escher

# Recursion

## **Recursion, what is it good for?**

- Recursive data structures later on
- Can be used to reason about tricky problems, but...
  - In practice, iteration is often faster and cheaper

# Recursion

Components of a recursive function

- **Base case**, a simple stopping condition
- **Recursive calls** on smaller problem
- **Putting it together**: solve our prob using recursive result

**Leap of faith**: assume our recursive function solves any smaller version of the problem

# Recursion

Factorial example

```
def factorial(n):  
    if n == 0:  
        return 1  
    return n * factorial(n - 1)
```

# Recursion

Fast Exponentiation

```
def exp(b, n):  
    if n == 0:  
        return 1  
    if n % 2 == 0:  
        return exp(b ** 2, n / 2)  
    else:  
        return b * exp(b, n - 1)
```

# Recursion

What's Wrong?

```
def hailstone (n) :  
    print (n)  
    if n == 1:  
        return  
    elif n % 2 == 0:  
        hailstone (n - 1)  
    else:  
        hailstone (n - 1)
```

# Recursion

What's Wrong?

```
def hailstone (n) :  
    print (n)  
    if n == 1:  
        return  
    elif n % 2 == 0:  
        n = n // 2  
        hailstone (n - 1)  
    else:  
        n = 3 * n + 1  
        hailstone (n - 1)
```

# Tree Recursion

Recursive functions can sometimes require more than one call!

$$\text{Fib}(n) = \text{Fib}(n - 1) + \text{Fib}(n - 2)$$

Very powerful, but also potentially very slow (why?)

Useful when you want to represent choices (e.g. taking one stair or two stairs)

# Environment Diagrams

**New:** Names can also be bound to functions!

Some rules:

- **Function call: create and number new frame** (f1, f2, etc.)  
— always start in global frame
- **Assignment:** write variable name and expression value
- **Def statements:** record function name and bind function object. Remember parent frame!
- **Frames return values** upon completion (Global is special)

# Environment Diagrams

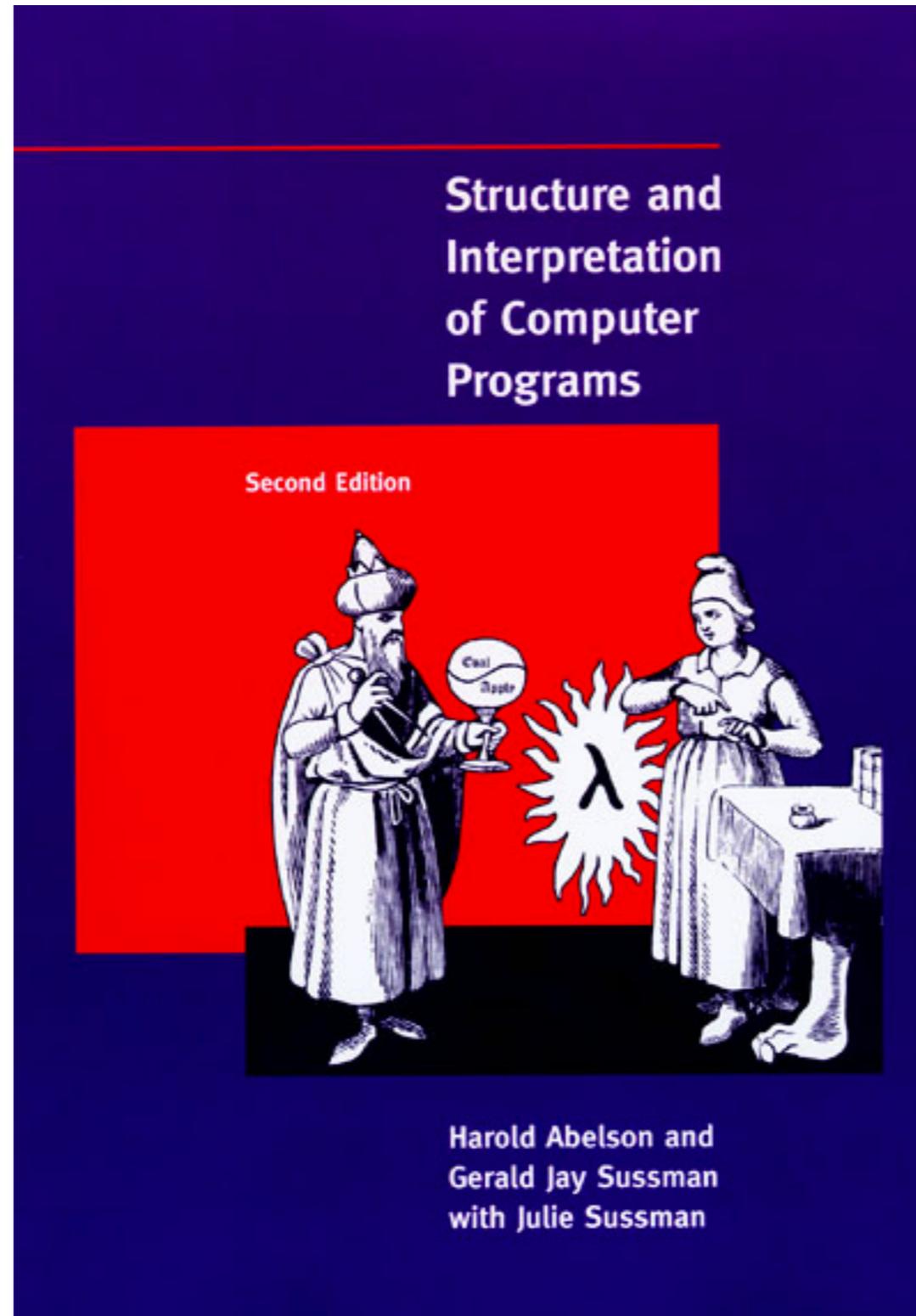
From Kevin Chen's Fall 2015 Review (<https://goo.gl/Z6GNwi>)

```
x = 2
def dread(pirate):
    x = 30
    def roberts(westley):
        x = 400
        return westley + pirate(x)

    return roberts(x)

dread(lambda spot: x + spot)
```

# A Lambda Detour



# A Lambda Detour

```
(lambda x, y: x + y * y)(4, 5)
```

Lambda definition

Lambda call

Result (after currying):

```
(lambda x = 4, y = 5: x + y * y)
```