61A Lecture 4

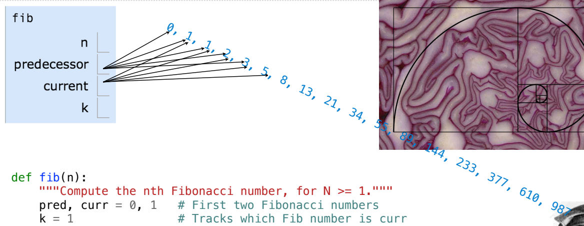
Monday, September 8

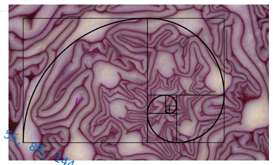
Announcements

- Homework 1 due Wednesday 9/10 at 2pm. Late homework is not accepted!
- Homework parties on Monday 9/8 (**Today!**)
  - 3pm-4pm in Wozniak Lounge in Soda Hall (100 person capacity)
  - 6pm-8pm in 2050 Valley Life Sciences Building (408 person capacity)
- More sections for students without prior programming experience! http://cs61a.org
- Take-home quiz 1 starts Wednesday 9/10 at 3pm, due Thursday 9/11 at 11:59pm
  - Open-computer, but no external resources or friends
  - Content Covered: Lectures through last Friday 9/5 (same topics as Homework 1)
- Project 1 due next Wednesday 9/17 at 11:59pm

Iteration Example

The Fibonacci Sequence





```
def fib(n):
    """Compute the nth Fibonacci number, for N >= 1."""
    pred, curr = 0, 1   # First two Fibonacci numbers
    k = 1               # Tracks which Fib number is curr
    while k < n:
        pred, curr = curr, pred + curr
        k = k + 1
    return curr
```

The next Fibonacci number is the sum of the current one and its predecessor

Discussion Question 1

n^2

$(n+1)^2$

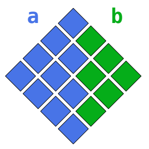
$2 \cdot (n+1)$

$n^2 + 1$

$n \cdot (n+1)$

What does pyramid compute?

```
def pyramid(n):
    a, b, total = 0, n, 0
    while b:
        a, b = a+1, b-1
        total = total + a + b
    return total
```



Designing Functions

Characteristics of Functions

	`def square(x):`
	`"""Return X * X."""`
		`def fib(n):`
		`"""Compute the nth Fibonacci number, for N >= 1."""`

A function's domain is the set of all inputs it might possibly take as arguments.	*x is a real number*	*n is an integer greater than or equal to 1*
A function's range is the set of output values it might possibly return.	*returns a non-negative real number*	*returns a Fibonacci number*
A pure function's behavior is the relationship it creates between input and output.	*return value is the square of the input*	*return value is the nth Fibonacci number*

A Guide to Designing Function

Give each function exactly one job.

not

Don't repeat yourself (DRY). Implement a process just once, but execute it many times.

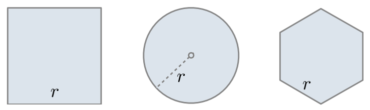
Define functions generally.

Generalization

Generalizing Patterns with Arguments

Regular geometric shapes relate length and area.

Shape:



Area: $\boxed{1} \cdot r^2$ $\boxed{\pi} \cdot r^2$ $\boxed{\frac{3\sqrt{3}}{2}} \cdot r^2$

Finding common structure allows for shared implementation

(Demo)

Higher-Order Functions

Generalizing Over Computational Processes

The common structure among functions may be a computational process, rather than a number.

$$\sum_{k=1}^{5} \boxed{k} = 1 + 2 + 3 + 4 + 5 \qquad = 15$$

$$\sum_{k=1}^{5} \boxed{k^3} = 1^3 + 2^3 + 3^3 + 4^3 + 5^3 \qquad = 225$$

$$\sum_{k=1}^{5} \boxed{\frac{8}{(4k-3) \cdot (4k-1)}} = \frac{8}{3} + \frac{8}{35} + \frac{8}{99} + \frac{8}{195} + \frac{8}{323} \qquad = 3.04$$

(Demo)

Summation Example

```
def cube(k):
    return pow(k, 3)

def summation(n, term):
    """Sum the first n terms of a sequence.

    >>> summation(5, cube)
    225
    """
    total, k = 0, 1
    while k <= n:
        total, k = total + term(k), k + 1
    return total
```

Function of a single argument (*not called "term"*)

A formal parameter that will be bound to a function

The cube function is passed as an argument value

0 + 1 + 8 + 27 + 64 + 125

The function bound to term gets called here

Functions as Return Values

(Demo)

Locally Defined Functions

Functions defined within other function bodies are bound to names in a local frame

A function that returns a function

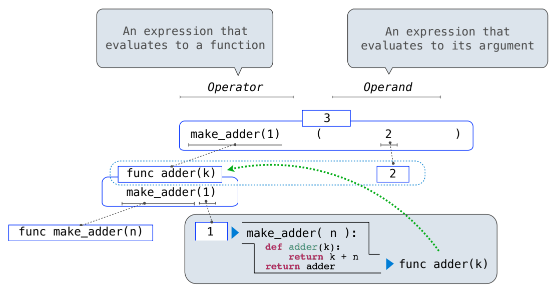
```
def make_adder(n):
    """Return a function that takes one argument k and returns k + n.

    >>> add_three = make_adder(3)
    >>> add_three(4)
    7
    """
    def adder(k):
        return k + n
    return adder
```

The name add_three is bound to a function

A def statement within another def statement

Can refer to names in the enclosing function

Call Expressions as Operator Expressions



The Purpose of Higher-Order Functions

Functions are first-class: Functions can be manipulated as values in our programming language.

Higher-order function: A function that takes a function as an argument value or returns a function as a return value

Higher-order functions:

- Express general methods of computation
- Remove repetition from programs
- Separate concerns among functions

The Game of Hog

(Demo)