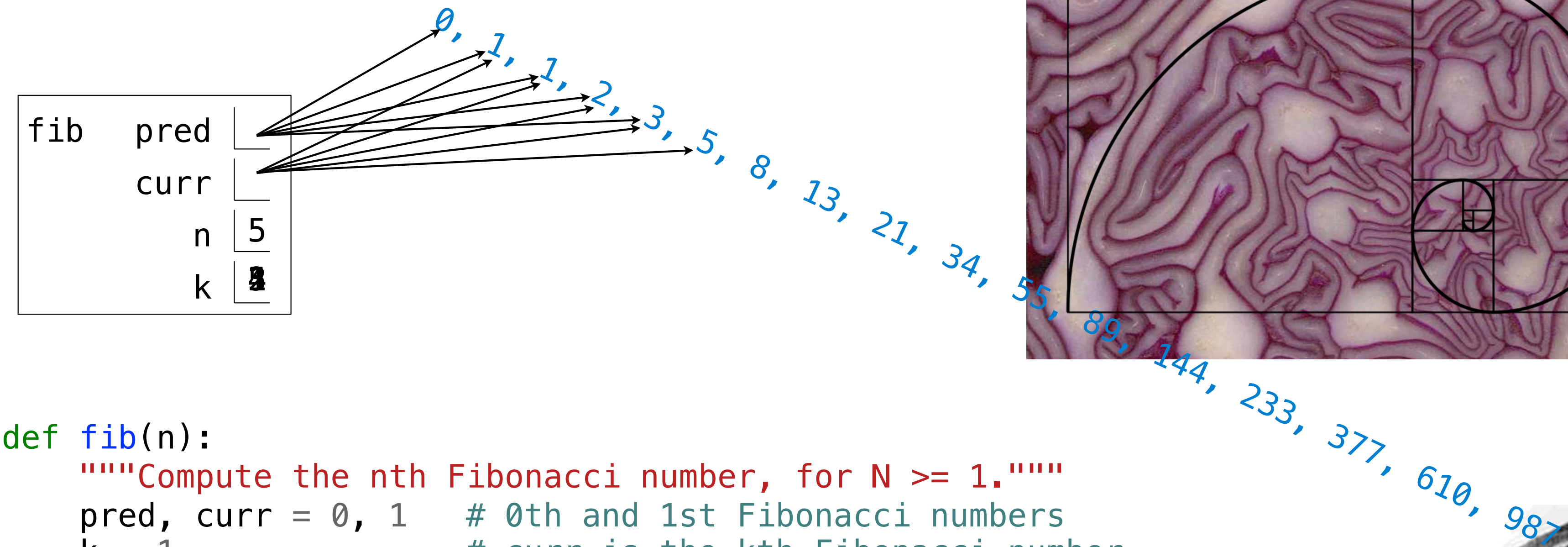
61A Lecture 4

Announcements

Iteration Example

The Fibonacci Sequence



```
def fib(n):
    """Compute the nth Fibonacci number, for N >= 1."""
    pred, curr = 0, 1   # 0th and 1st Fibonacci numbers
    k = 1               # curr is the kth Fibonacci number
    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

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377

Is this alternative definition of fib the same or different from the original fib?

```
def fib(n):
    """Compute the nth Fibonacci number?"""
    pred, curr = 0, 1   pred, curr = 1, 0
    k = 1               k = 0
    while k < n:
        pred, curr = curr, pred + curr
        k = k + 1
    return curr
```

(Demo)

Designing Functions

Describing 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, but make it apply to many related situations

```
>>> round(1.23)     >>> round(1.23, 1)     >>> round(1.23, 0)     >>> round(1.23, 5)
1                   1.2                    1                      1.23
```

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

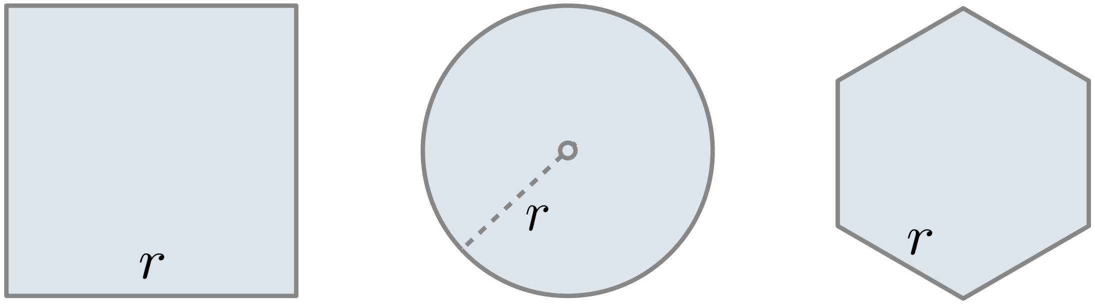
(Demo)

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

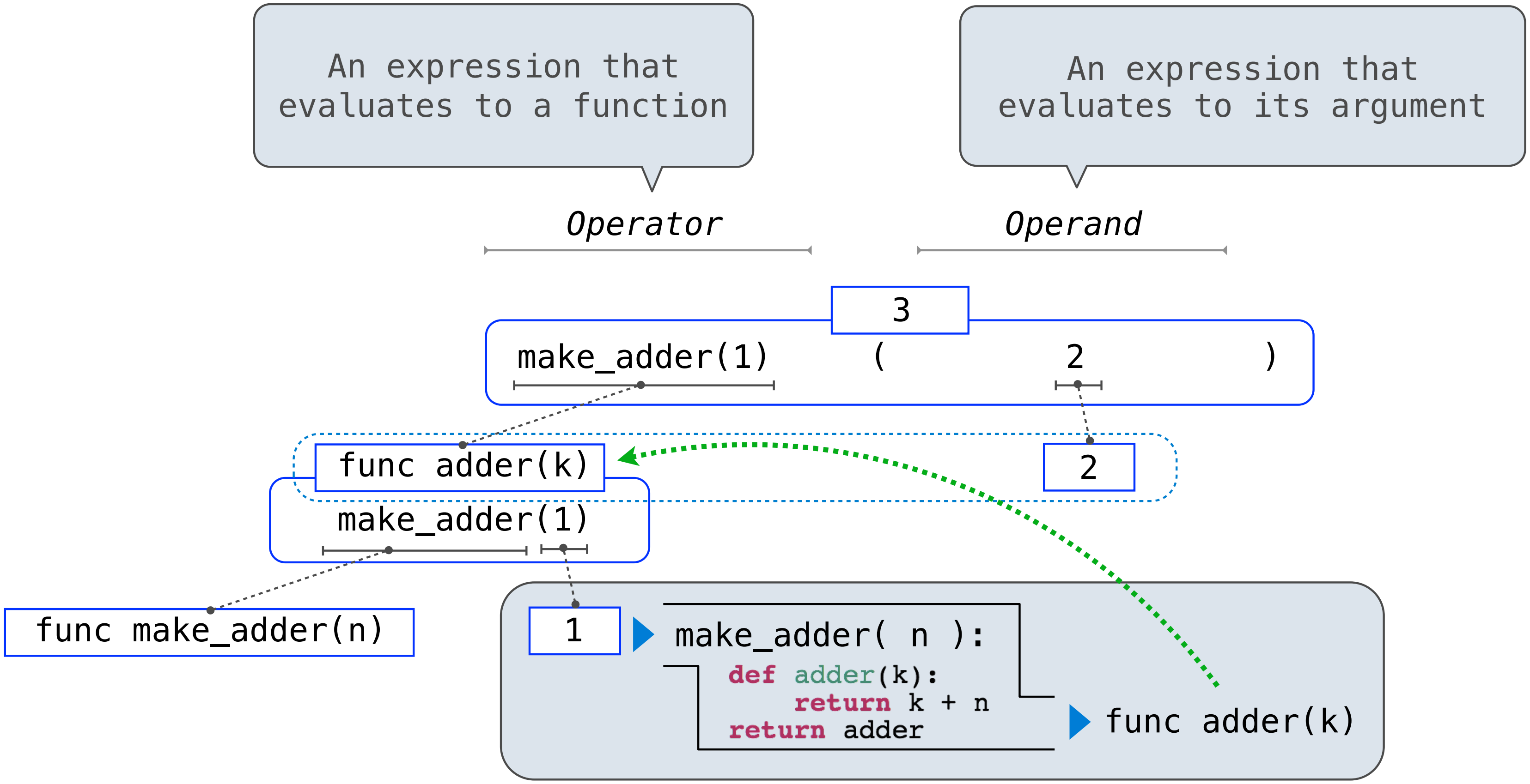
```
def make_adder(n):
    """Return a function that takes one argument k and returns k + n.

    >>> 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


An expression that evaluates to a function
An expression that evaluates to its argument
Operator
Operand
3
make_adder(1) (2)
func adder(k)
2
make_adder(1)
func make_adder(n)
1
make_adder(n):
def adder(k):
    return k + n
return adder
func adder(k)