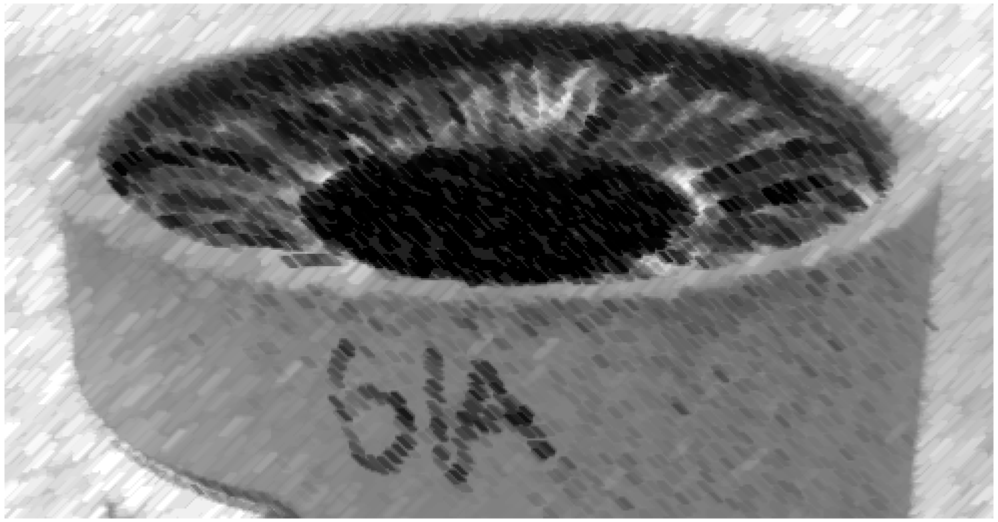

CS61A Lecture 4

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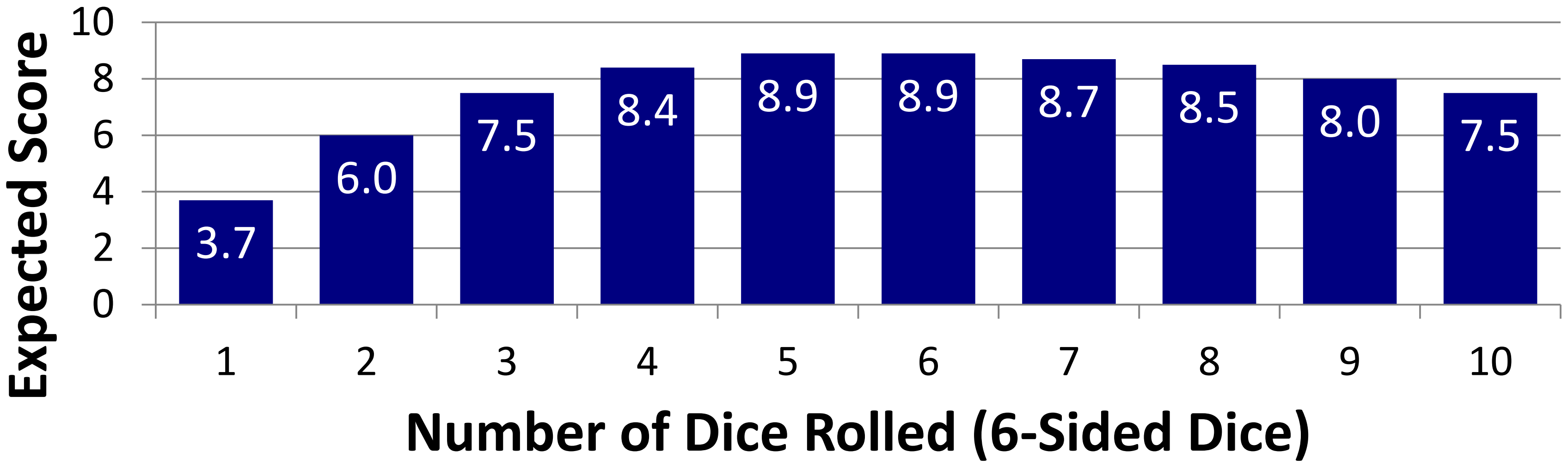
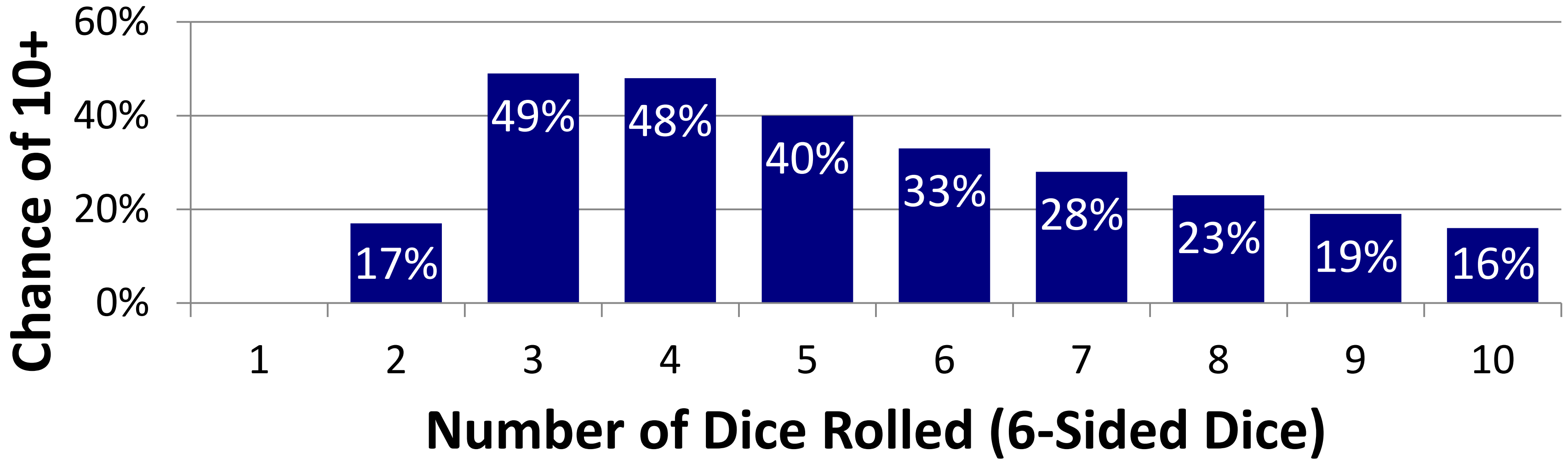
UC Berkeley
January 30, 2013

Announcements

- Reminder: hw1 due tonight
- In-class quiz on Friday
  - Covers through Wednesday’s lecture
  - Bring a writing implement
- Hog project out
  - Get started early!
  - Try it out online! See the announcement on the website

The Game of Hog





Environment Diagrams

- Every expression is evaluated in the context of an environment
- So far, the current environment is either:
  - The global frame alone, or
  - A local frame, followed by the global frame
- **Important properties of environments:**
  - An environment is a sequence of frames
  - The earliest frame that contains a binding for a name determines the value that the name evaluates to
- The *scope* of a name is the region of code that has access to it

Environment of Function Application

The environment in which a function is applied consists of:

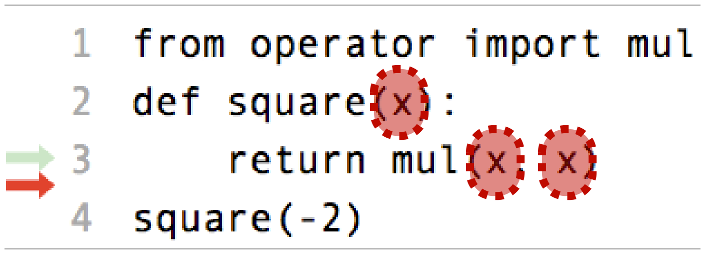
- A *new* local frame *each* time the function is *applied*
- The environment in which the function was *defined*
  - We refer to this as *lexical scoping*
  - So far, this is just the global frame
  - The *current* state of the environment is used, not the state when the function definition was executed

Formal Parameters

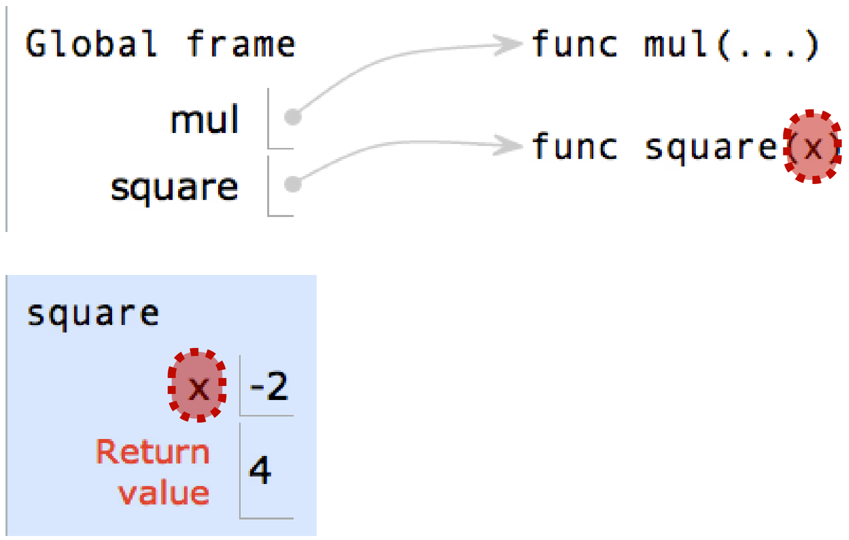
```
def square(x):
    return mul(x, x)
```

vs

```
def square(y):
    return mul(y, y)
```



```
from operator import mul
def square(x):
    return mul(x, x)
square(-2)
```



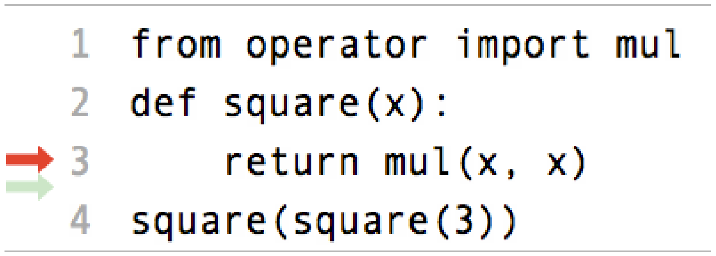
Formal parameters have local scope

Example: http://goo.gl/boCk0

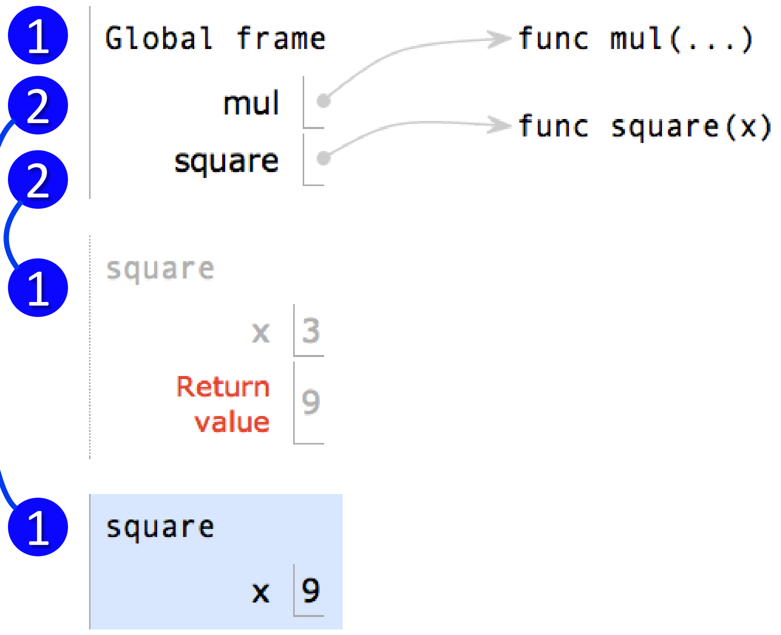
Multiple Environments in a Diagram

What happens when to the local frame when a function returns?

- It sticks around until Python realizes it is no longer needed
- We will soon see cases where it is needed after the call

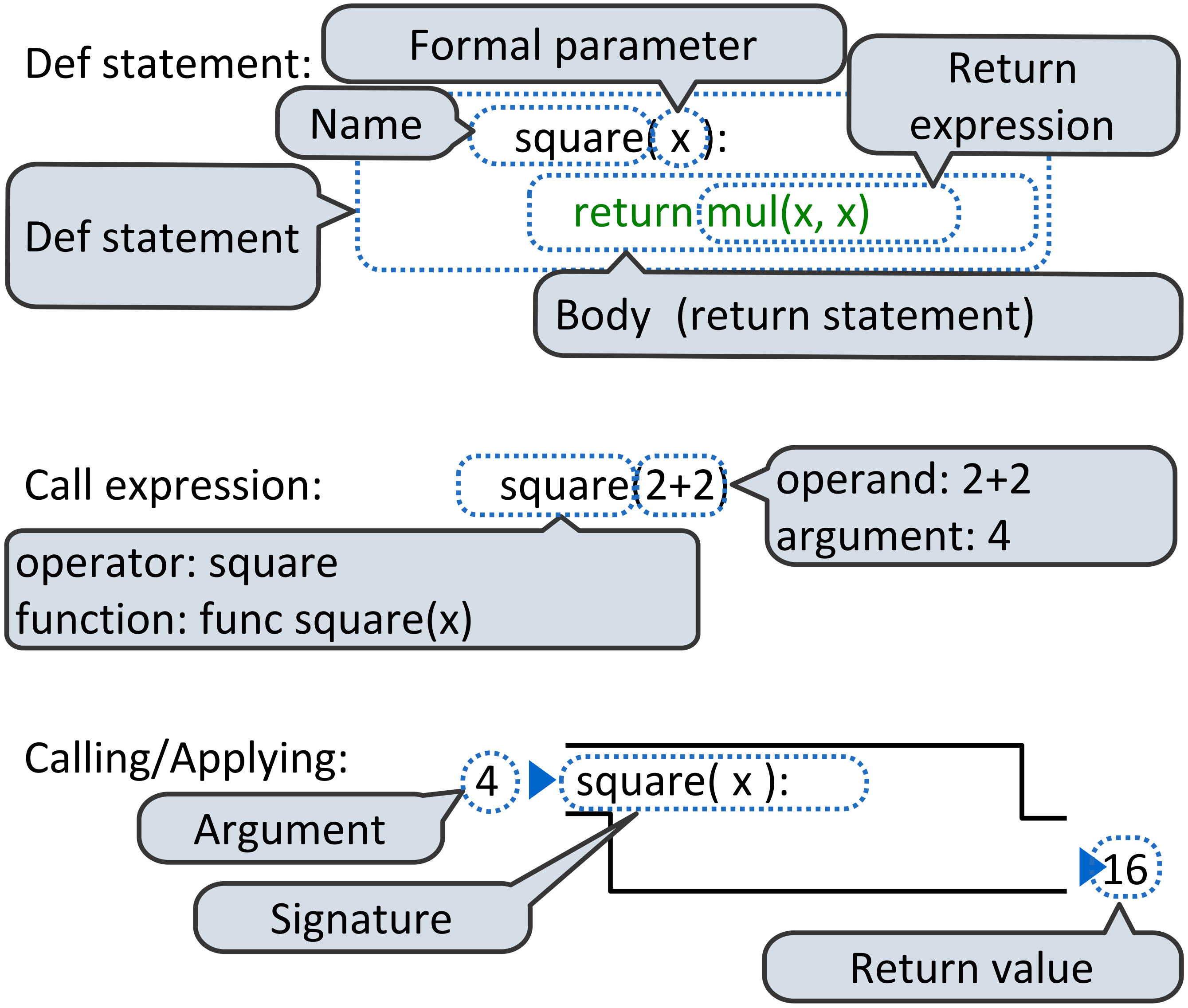


```
from operator import mul
def square(x):
    return mul(x, x)
square(square(3))
```



Example: http://goo.gl/hrfnV

Life Cycle of a User-Defined Function



What happens?

Function created

Name bound

Op's evaluated

Function called with argument(s)

Evaluates to return value below

New frame!

Params bound

Body executed

Python Feature Demonstration

Operators

Multiple Return Values

Docstrings

Doctests

Default Arguments

Statements

Statements

A *statement* is executed by the interpreter to perform an action

Types of statements we have seen so far

- An assignment

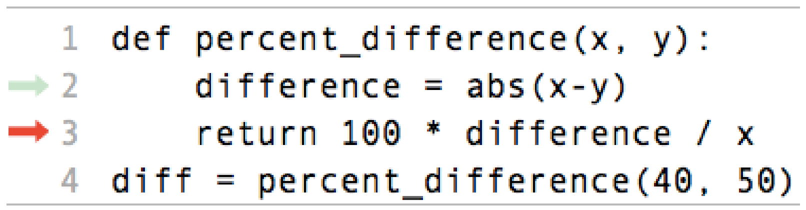
```
radius = 10
```

- A function definition

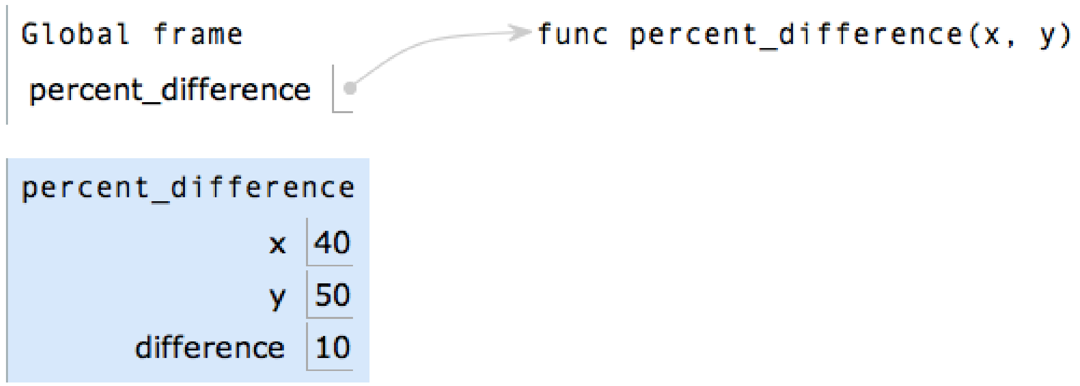
```
def square(x):
    return x * x
```

- Returns, imports, assertions

Local Assignment



```python
def percent_difference(x, y):
    difference = abs(x-y)
    return 100 * difference / x
diff = percent_difference(40, 50)
```



Execution rule for assignment statements:

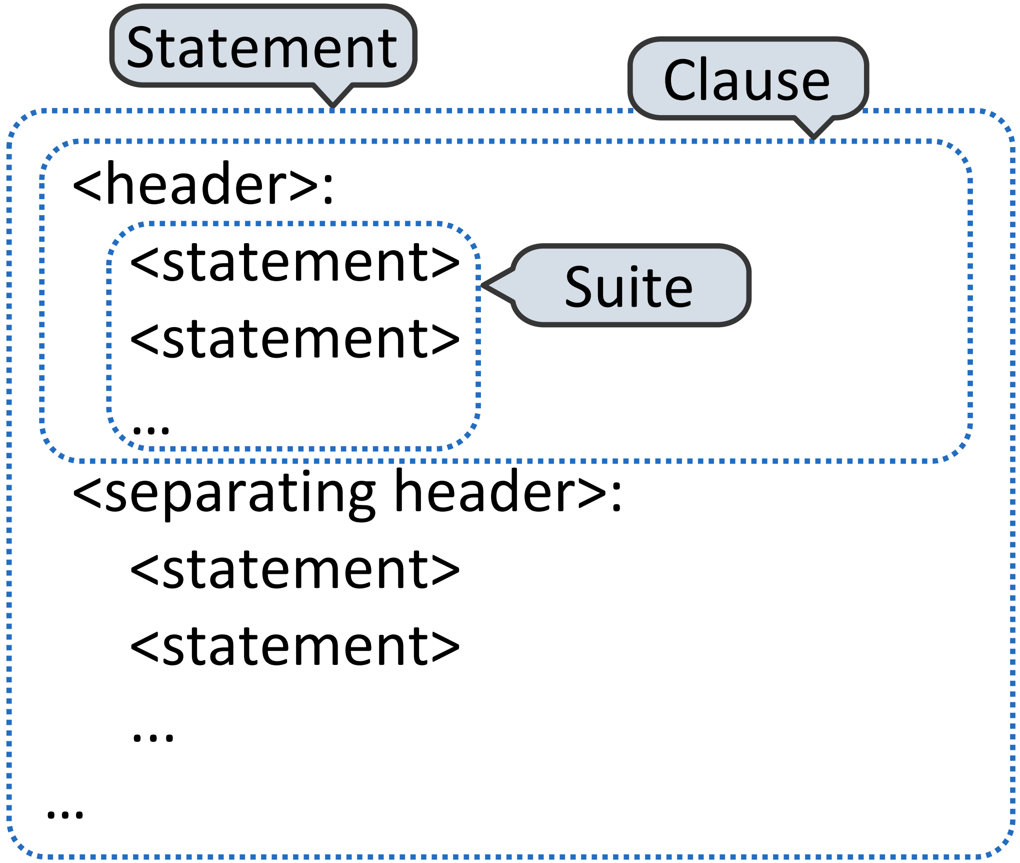
1. Evaluate all expressions right of =, from left to right.
2. Bind the names on the left the resulting values in the first frame of the current environment.

Example: http://goo.gl/1pyzL

Compound Statements

A function definition is a *compound statement*

Compound statements:



```
<header>:
    <statement>
    <statement>
    ...
<separating header>:
    <statement>
    <statement>
    ...
...
```

The first header determines a statement's type

The header of a clause "controls" the suite that follows

Compound Statements

Compound statements:

```
<header>:
    <statement>
    <statement>
    ...
<separating header>:
    <statement>
    <statement>
    ...
...
```

Suite

A suite is a sequence of statements

To "execute" a suite means to execute its sequence of statements, in order

Execution rule for a sequence of statements:

1. Execute the first
2. Unless directed otherwise, execute the rest

Conditional Statements

```
def absolute_value(x):
    """Return the absolute value of x."""
    if x > 0:
        return x
    elif x == 0:
        return 0
    else:
        return -x
```

1 statement,
3 clauses,
3 headers,
3 suites

Execution rule for conditional statements:

Each clause is considered in order.

1. Evaluate the header's expression.
2. If it is a true value,
   execute the suite & skip the remaining clauses.

Boolean Contexts

George Boole

```
def absolute_value(x):
    """Return the absolute value of x."""
    if x > 0:
        return x
    elif x == 0:
        return 0
    else:
        return -x
```

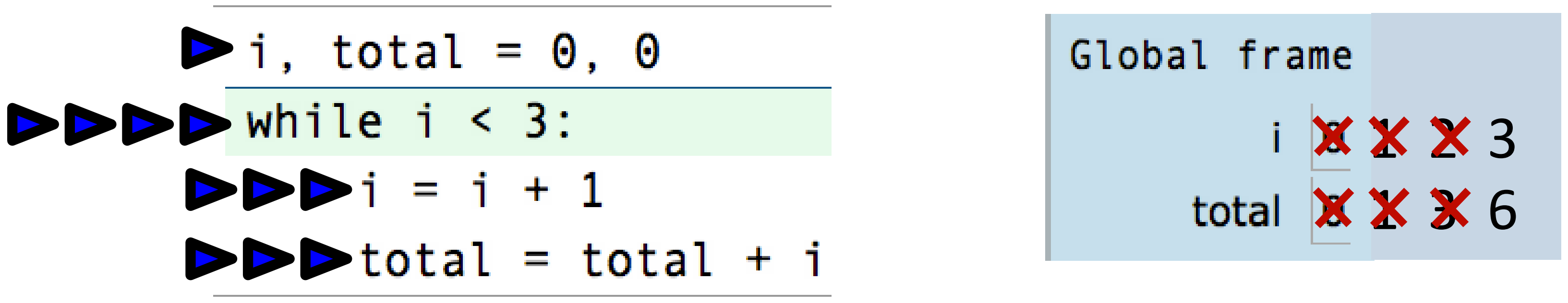
Two boolean contexts

False values in Python: False, 0, "", None (more to come)

True values in Python: Anything else (True)

Read Section 1.5.4!

Iteration



```
i, total = 0, 0
while i < 3:
    i = i + 1
    total = total + i
```

Execution rule for while statements:

1. Evaluate the header's expression.
2. If it is a true value,
   execute the (whole) suite,
   then return to step 1.

Example: http://goo.gl/mk7Sc

Locally Defined Functions

Functions can be defined inside other functions

What happens when a def is executed?

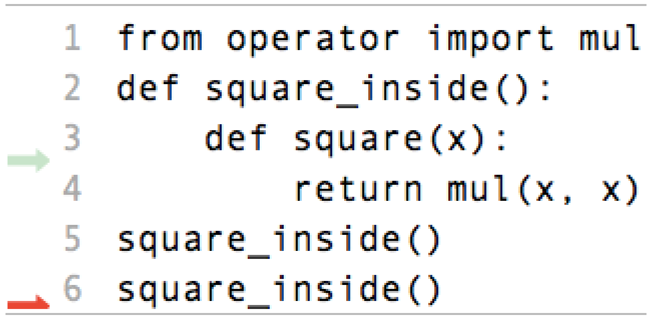
1. Create a function value with the given signature and body
2. Bind the given name to that value in the current frame

The name can then be used to call the function.

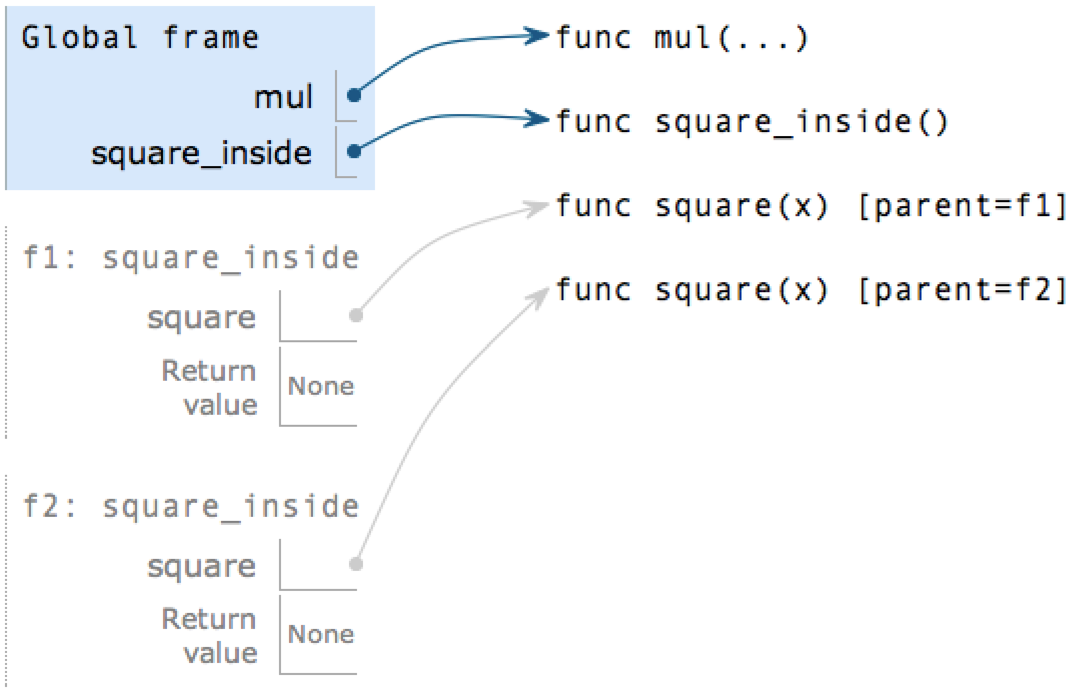
```
def sum_of_squares(n):
    """Sum of the squares of the integers 1 to n"""
    def square(x):
        return mul(x, x)
    total, k = 0, 1
    while k <= n:
        total, k = total + square(k), k + 1
    return total
```

Locally Defined Functions

The inner definition is executed each time the outer function is called



```
from operator import mul
def square_inside():
    def square(x):
        return mul(x, x)
square_inside()
square_inside()
```



Example: http://goo.gl/pnU8f

Functions as Return Values

Locally defined functions can be returned

They have access to the frame in which they are defined

A function that returns a function

```
def make_adder(n):
    """Return a function that adds n to its argument.

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

The name add_three is bound to a function

A local def statement

Can refer to names in the enclosing function

Call Expressions as Operators

`make_adder(1)(2)`

`make_adder(1)   (   2   )`

Operator

Operand 0

An expression that evaluates to a function value

An expression that evaluates to any value

```
def make_adder(n):
    def adder(k):
        return add(n, k)
    return adder
```