SICP

God's Programming Book

Lecture-02 Functions

Functions

Slides Adapted from cs61a of UC Berkeley

Expressions

Types of expressions

An expression describes a computation and evaluates to a value.

$18 + 69$

$\frac{6}{23}$

$\sin \pi$

$\log_2 1024$

2^{100}

$f(x)$

$\sqrt{3493161}$

$7 \bmod 2$

$\sum_{i=1}^{100} i$

$\lim_{x \to \infty} \frac{1}{x}$

$\binom{69}{18}$

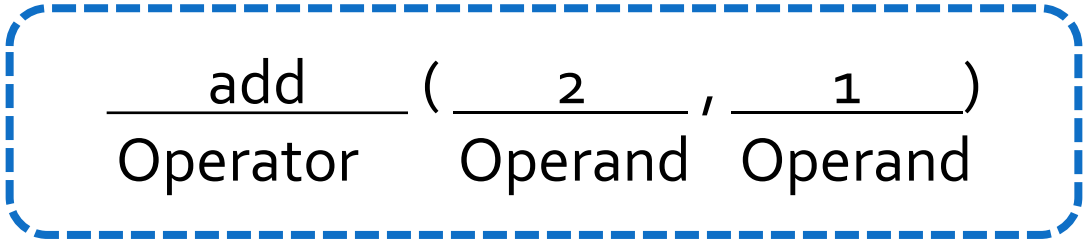
$|-1869|$

Call Expressions in Python

All expressions can use function call notation.

(Demo)

Anatomy of a Call Expression

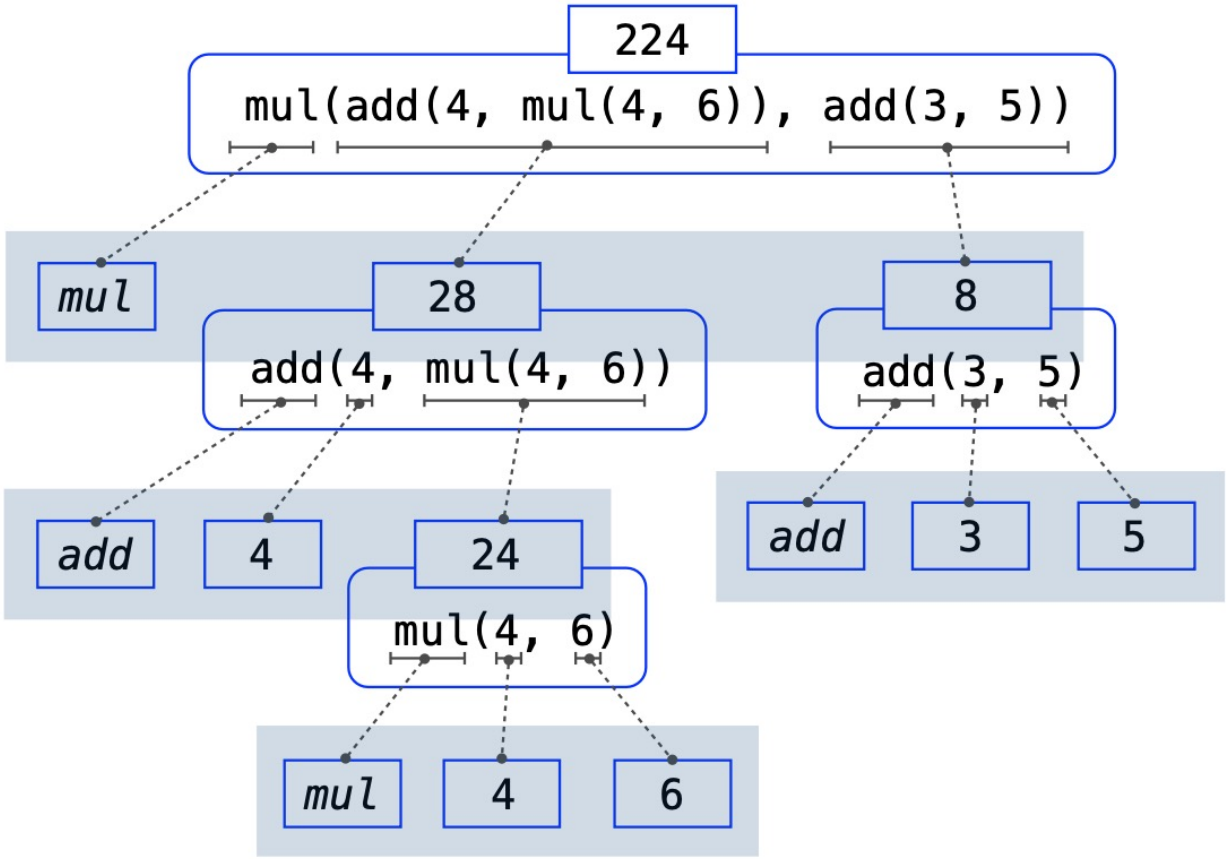


Operators and operands are also expressions, so they evaluate to values.

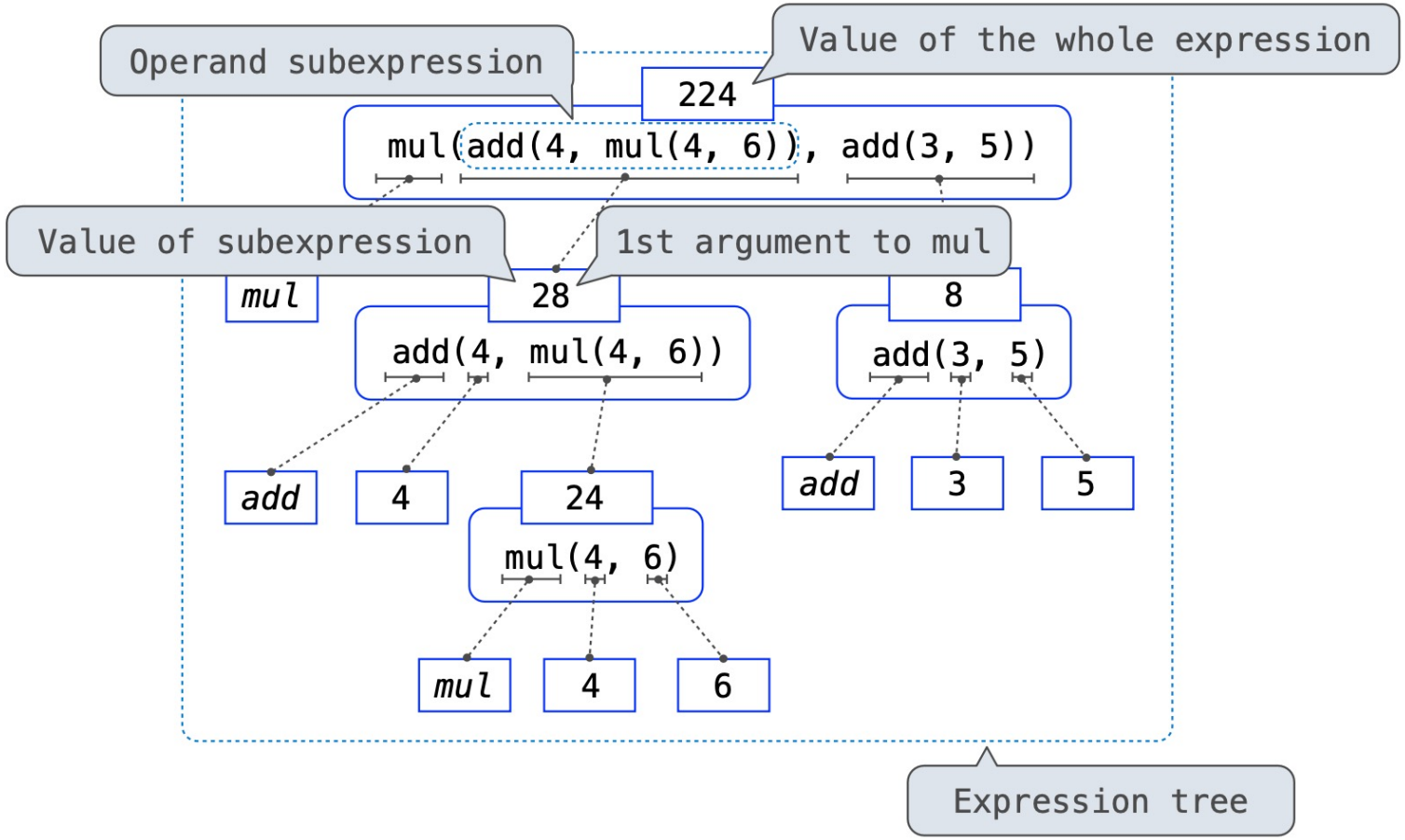
Evaluation procedure for call expressions:

1. Evaluate the operator and then the operand subexpressions
2. Apply the function that is the value of the operator to the arguments that are the values of the operands

Evaluating Nested Expressions



Evaluating Nested Expressions

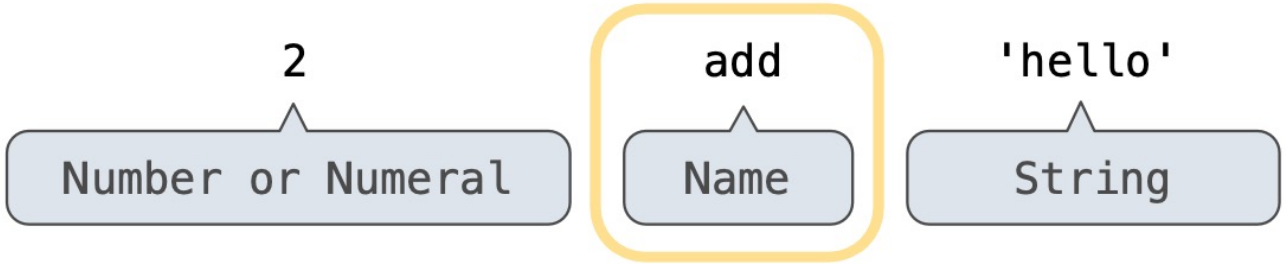


Names, Assignment, and User-Defined Functions

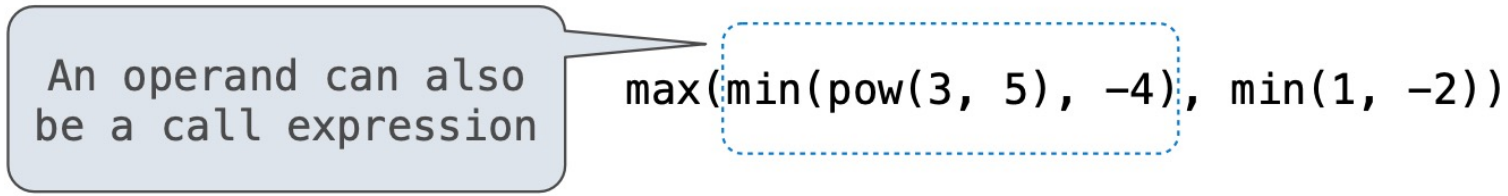
(Demo)

Types of Expressions

- Primitive Expressions:



- Call Expressions:

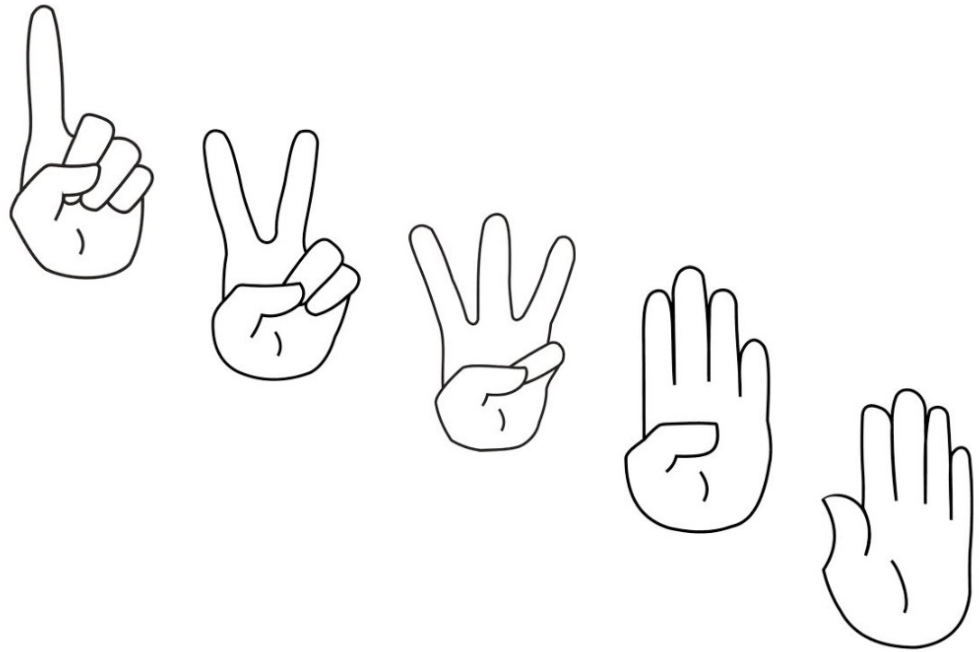


Discussion Question 1

What is the value of the final expression in this sequence?

```
>>> f = min
>>> f = max
>>> g, h = min, max
>>> max = g
>>> max(f(2, g(h(1, 5), 3)), 4)
```

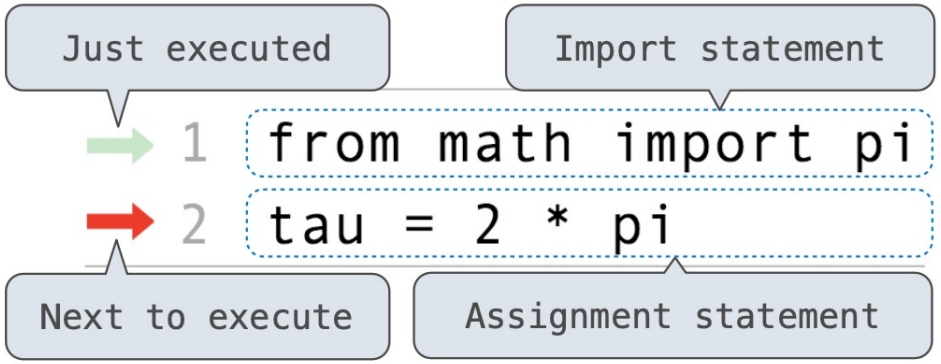
???

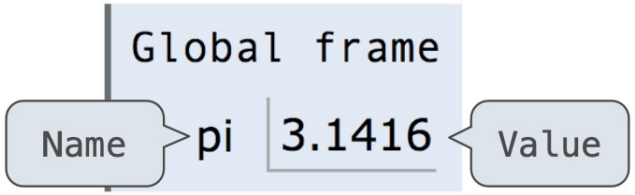


Environment Diagrams

Environment Diagrams

Environment diagrams visualize the interpreter's process.





Code (left):

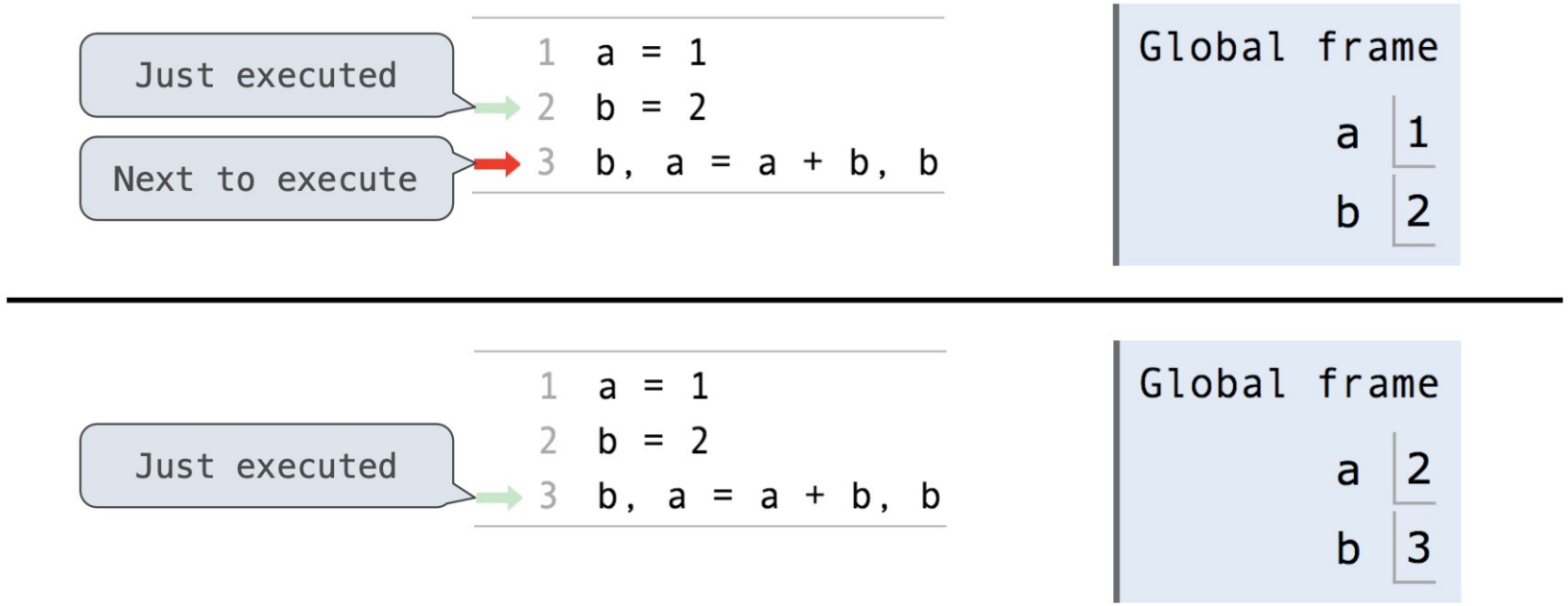
- Statements and expressions
- Arrows indicate evaluation order

Frames (right):

- Each name is bound to a value
- Within a frame, a name cannot be repeated

(Demo)

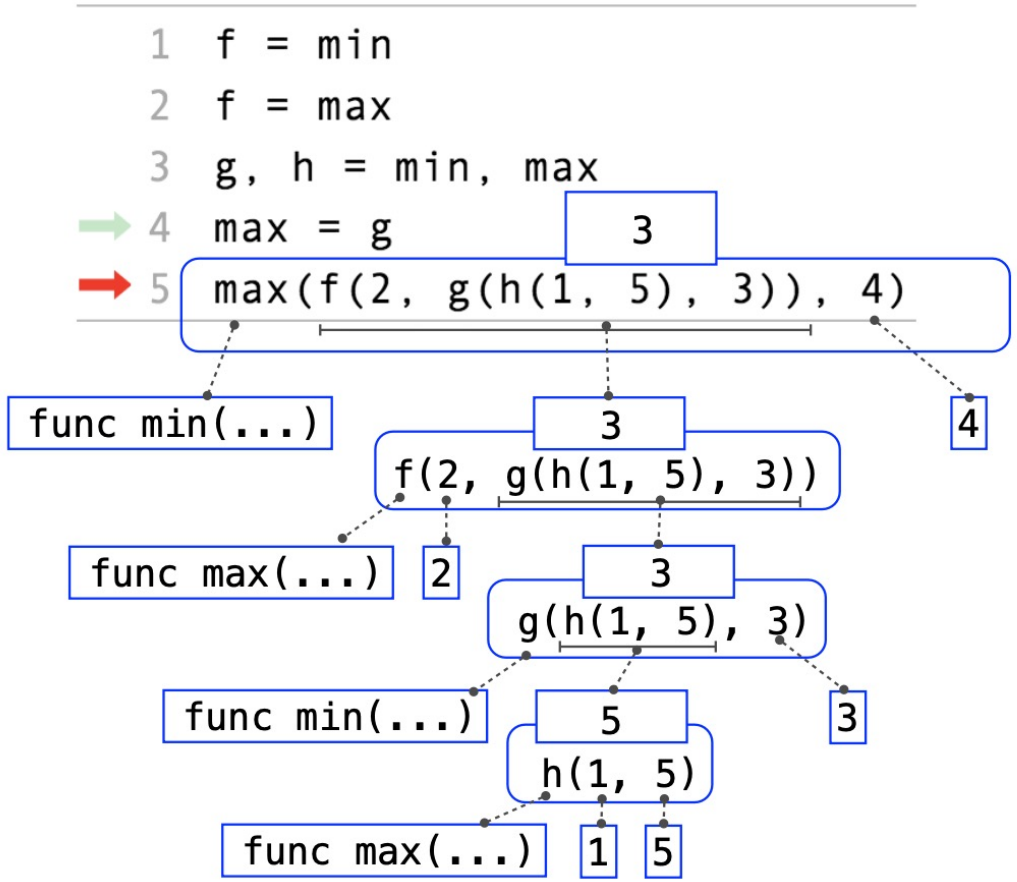
Assignment Statements

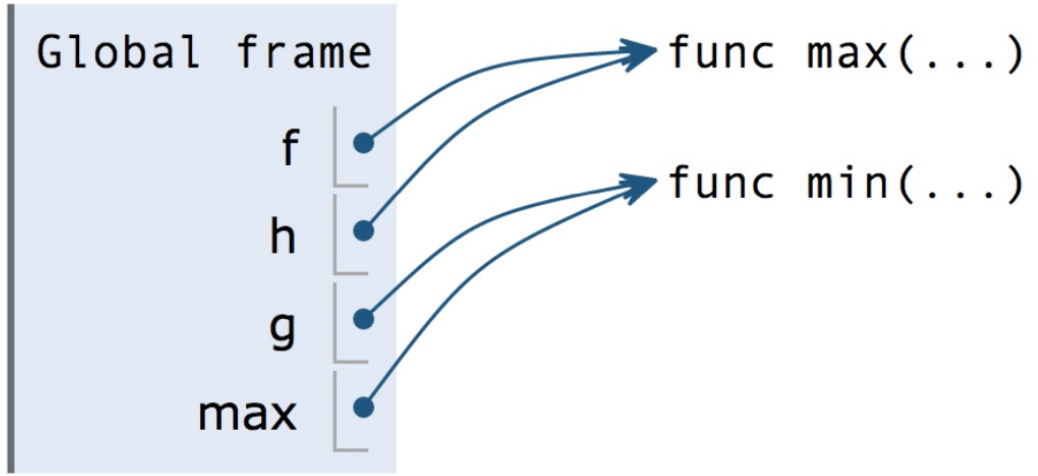


Execution rule for assignment statements:

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

Discussion Question 1 Solution





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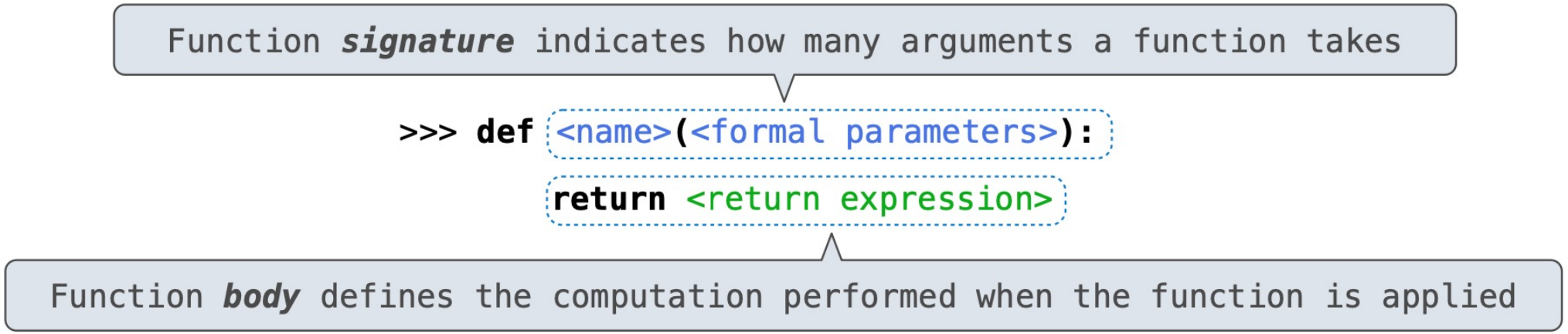
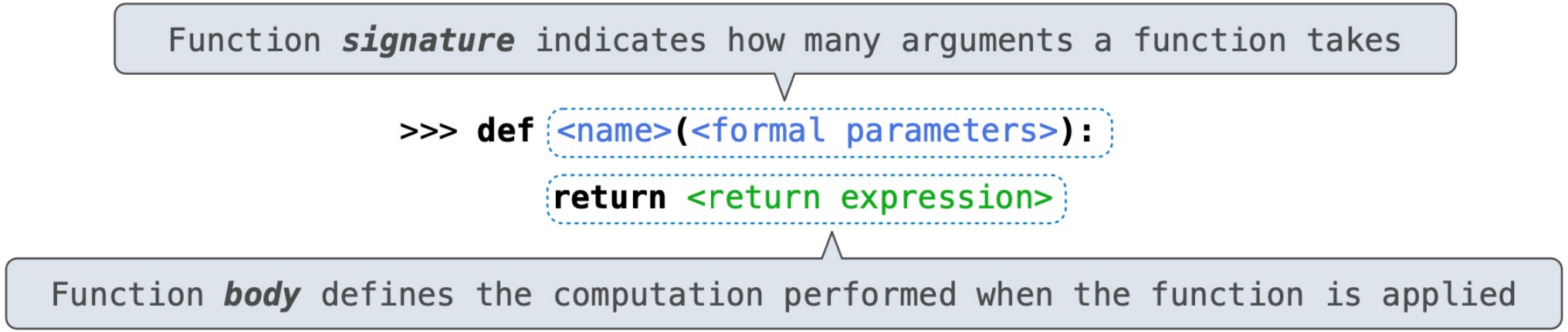
Defining Functions

Defining Functions

- Assignment is a simple means of abstraction: binds names to values
- Function definition is a more powerful means of abstraction: binds names to expressions



Defining Functions



Execution procedure for def statements:

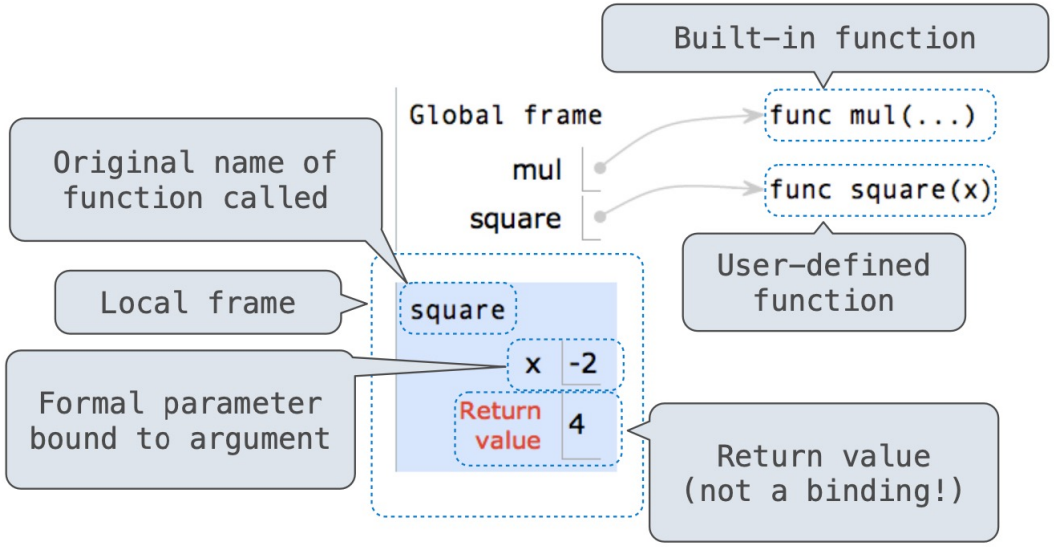
1. Create a function with signature <name>(<formal parameters>)
2. Set the body of that function to be everything indented after the first line
3. Bind <name> to that function in the current frame

Calling User-Defined Functions

Procedure for calling/applying user-defined functions:

1. Add a local frame, forming a new environment
2. Bind the function's formal parameters to its arguments in that frame
3. Execute the body of the function in that new environment

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



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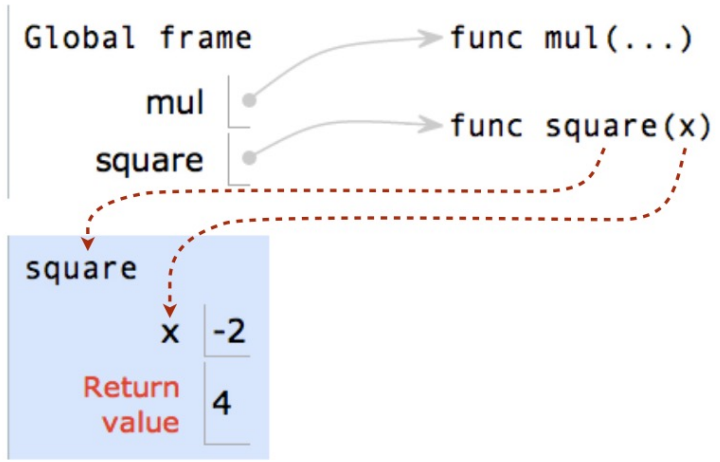
A function's signature has all the information needed to create a local frame



Looking Up Names In Environments

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.

Most important two things I'll say all day:

- An environment is a sequence of frames.
- A name evaluates to the value bound to that name in the earliest frame of the current environment in which that name is found.

Looking Up Names In Environments

E.g., to look up some name in the body of the square function:

- Look for that name in the local frame.
- If not found, look for it in the global frame.
  - (Built-in names like "max" are in the global frame too, but we don't draw them in environment diagrams.)

(Demo)

Thanks for Listening