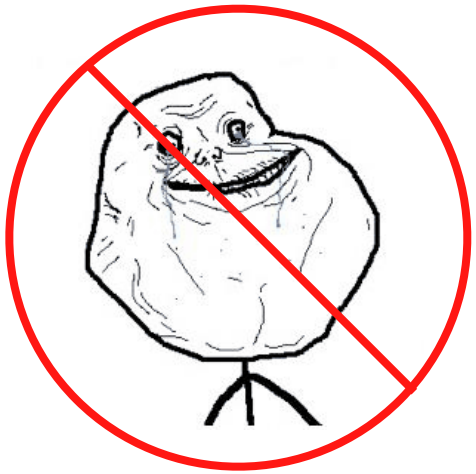
61A Lecture 5

Wednesday, September 5

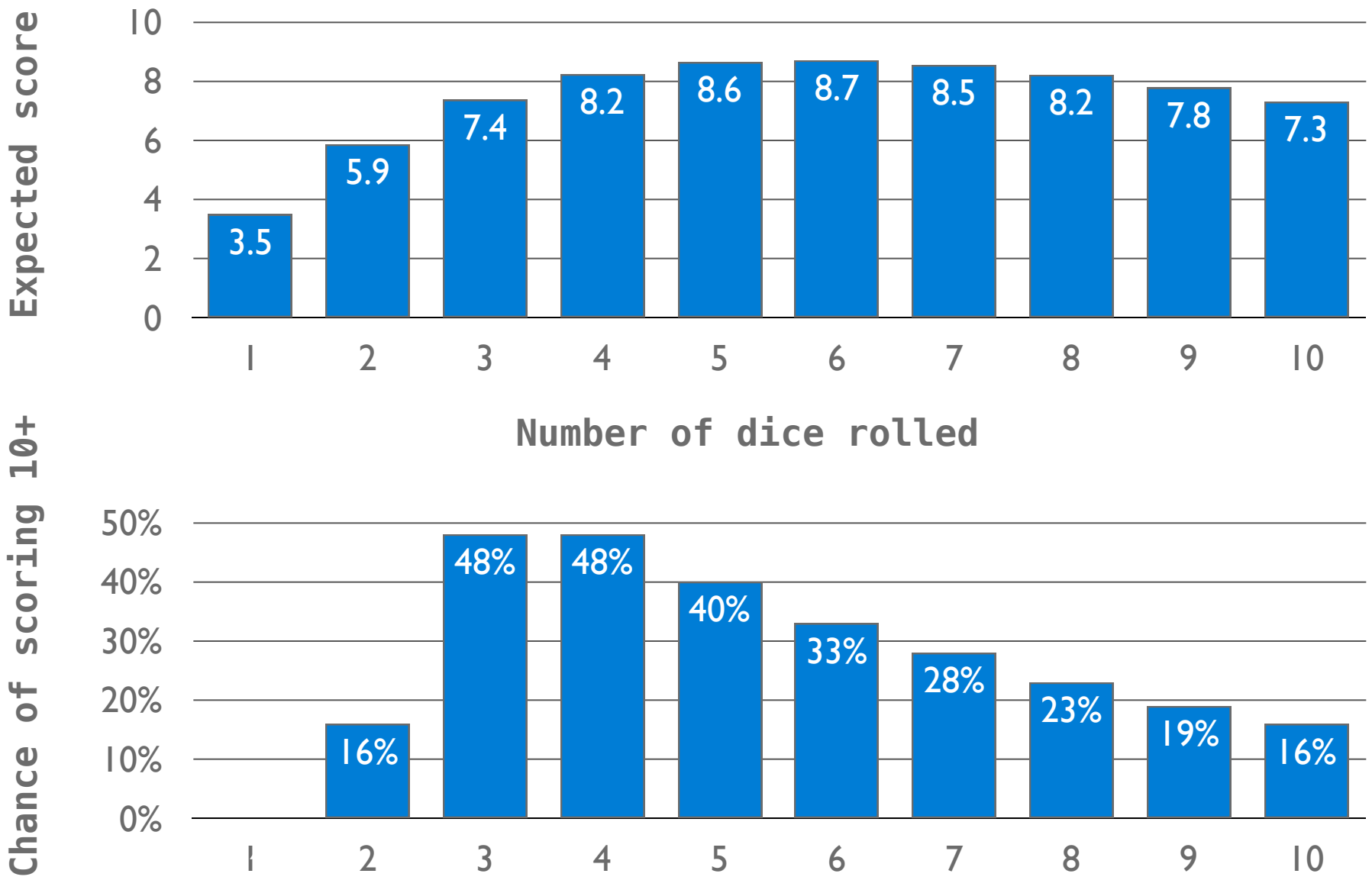
Office Hours: You Should Go!

You are not alone!



http://inst.eecs.berkeley.edu/~cs61a/fa12/staff.html

The Game of Hog



Environments Enable Higher-Order Functions

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

Functions as arguments:

Our current environment model handles that already!

We'll discuss an example today

Functions as return values:

We need to extend our model a little

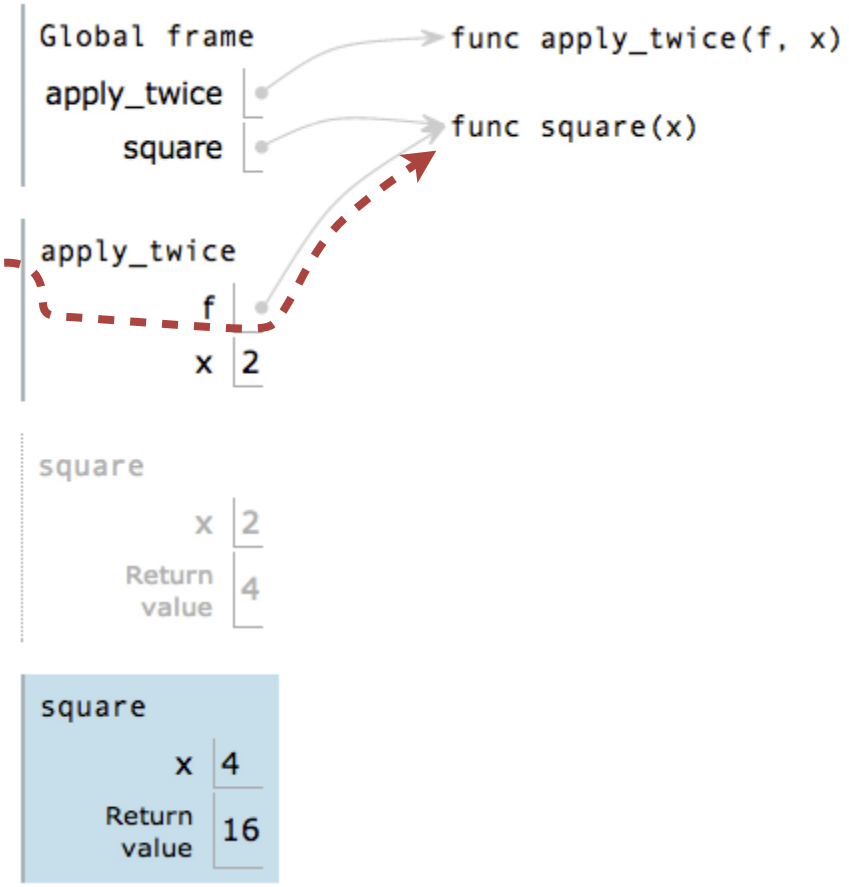
Functions need to know where they were defined

Almost everything stays the same

(demo)

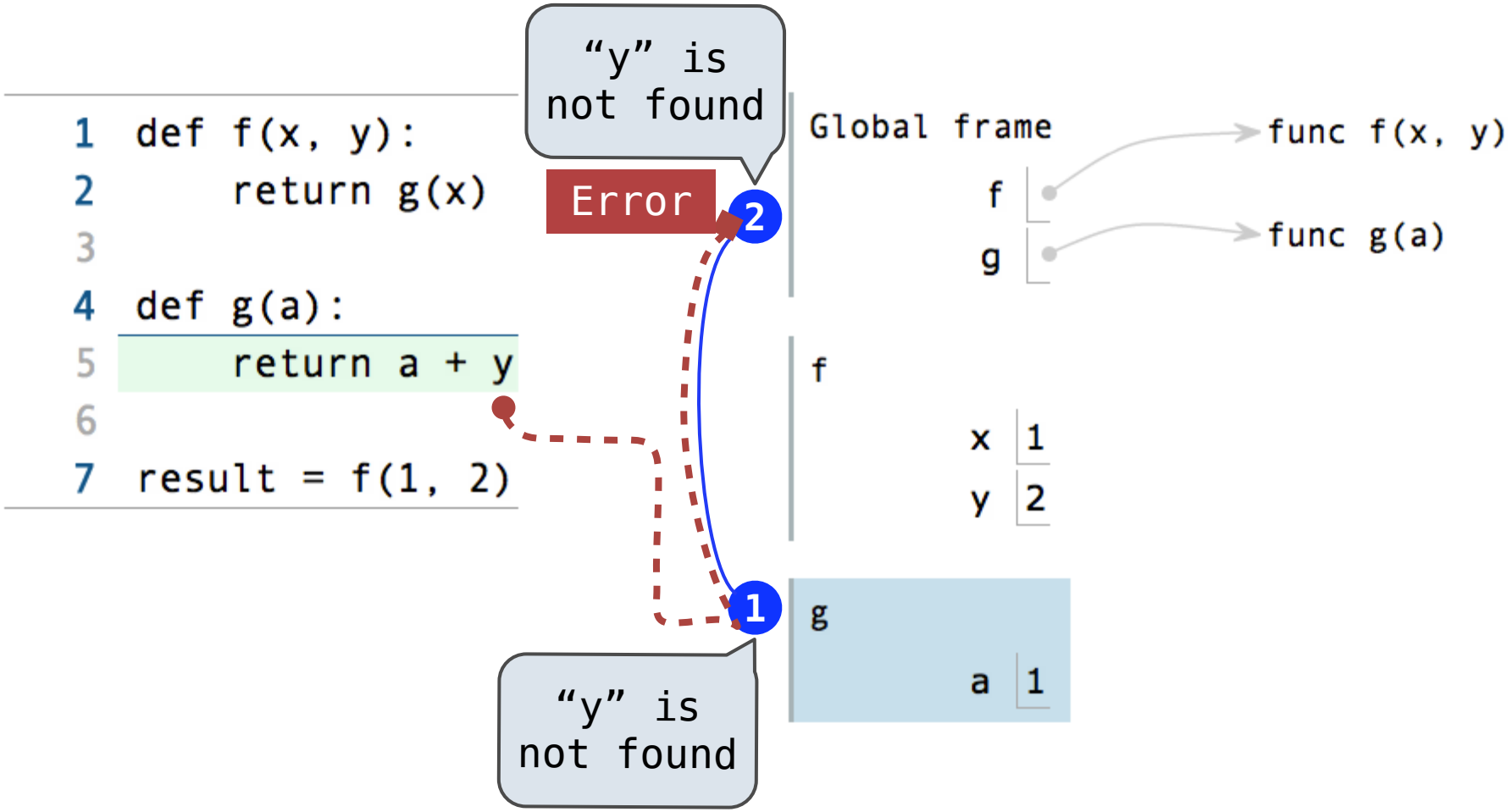
Names Bound to Functional Arguments

```
1 def apply_twice(f, x):
2     return f(f(x))
3
4 def square(x):
5     return x * x
6
7 result = apply_twice(square, 2)
```



Example: http://goo.gl/Gbtc5

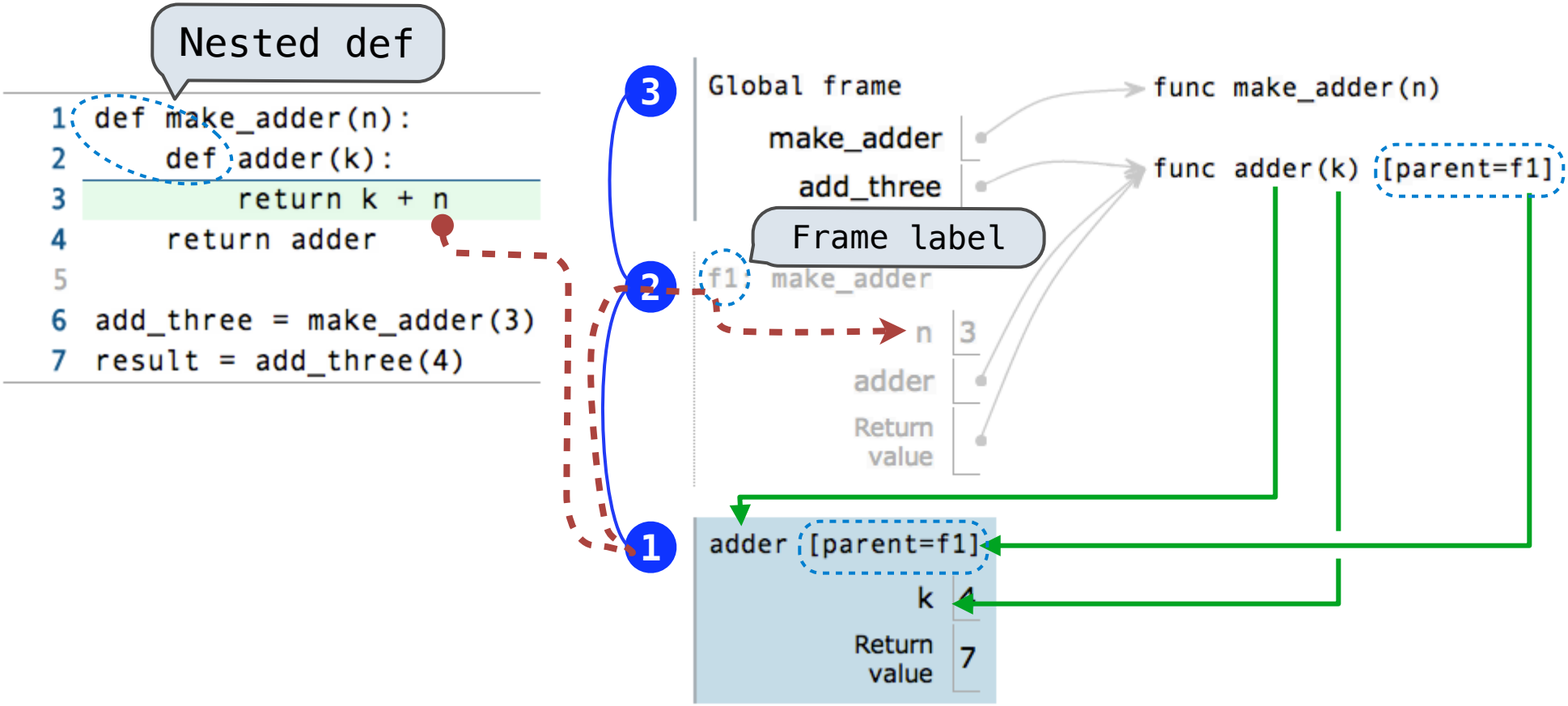
Non-Nested Functions Calls Have One Local Frame



- An environment is a sequence of frames
- An environment for a non-nested function (no def within def) consists of one local frame, followed by the global frame

Example: http://goo.gl/tgT5H

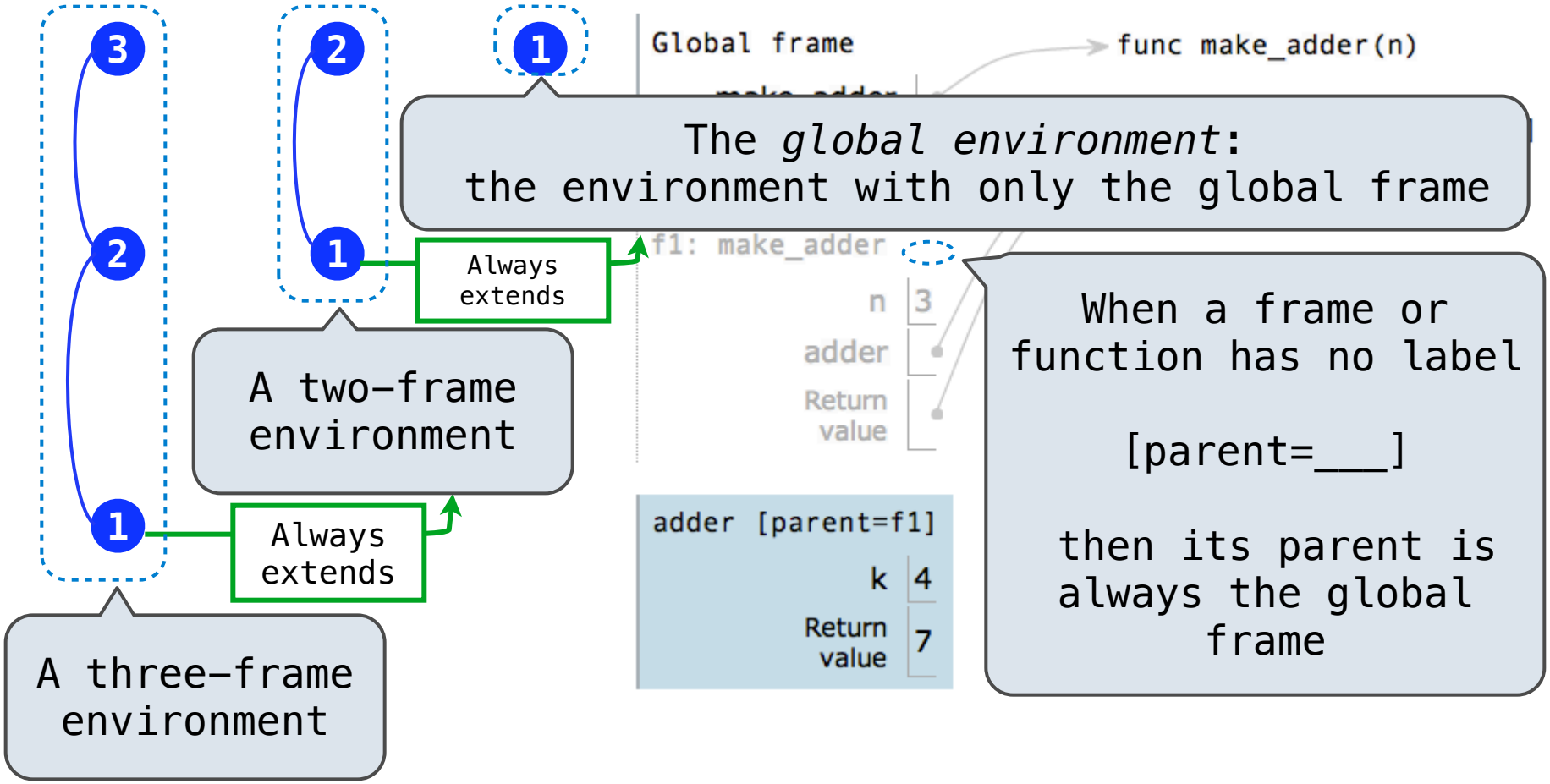
Environment Diagrams for Nested Def Statements



- Every user-defined **function** has a ***parent frame***
- The parent of a **function** is the frame in which it was *defined*
- Every local **frame** has a ***parent frame***
- The parent of a **frame** is the parent of the function *called*

Example: http://goo.gl/L9G2q

The Structure of Environments



A frame *extends* the environment that begins with its parent

How to Draw an Environment Diagram

When defining a function:

1. Create a function value with signature *<name>*(*<formal parameters>*)
2. For nested definitions, label the parent as the first frame of the current environment
3. Bind *<name>* to the function value in the first frame of the current environment

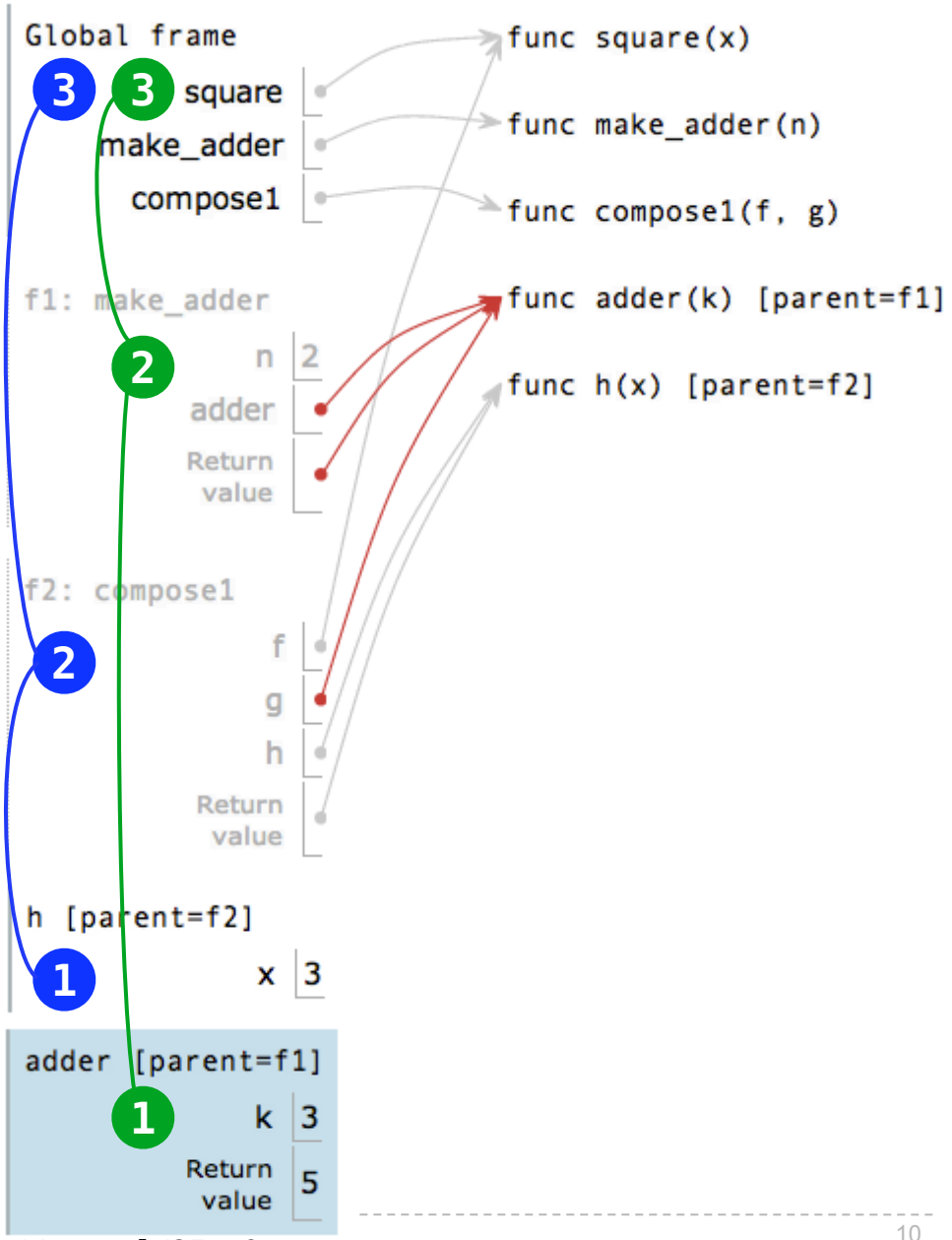
When calling a function:

1. Add a local frame labeled with the *<name>* of the function
2. If the function has a parent label, copy it to this frame
3. Bind the *<formal parameters>* to the arguments in this frame
4. Execute the body of the function in the environment that starts with this frame

The Environment for Function Composition

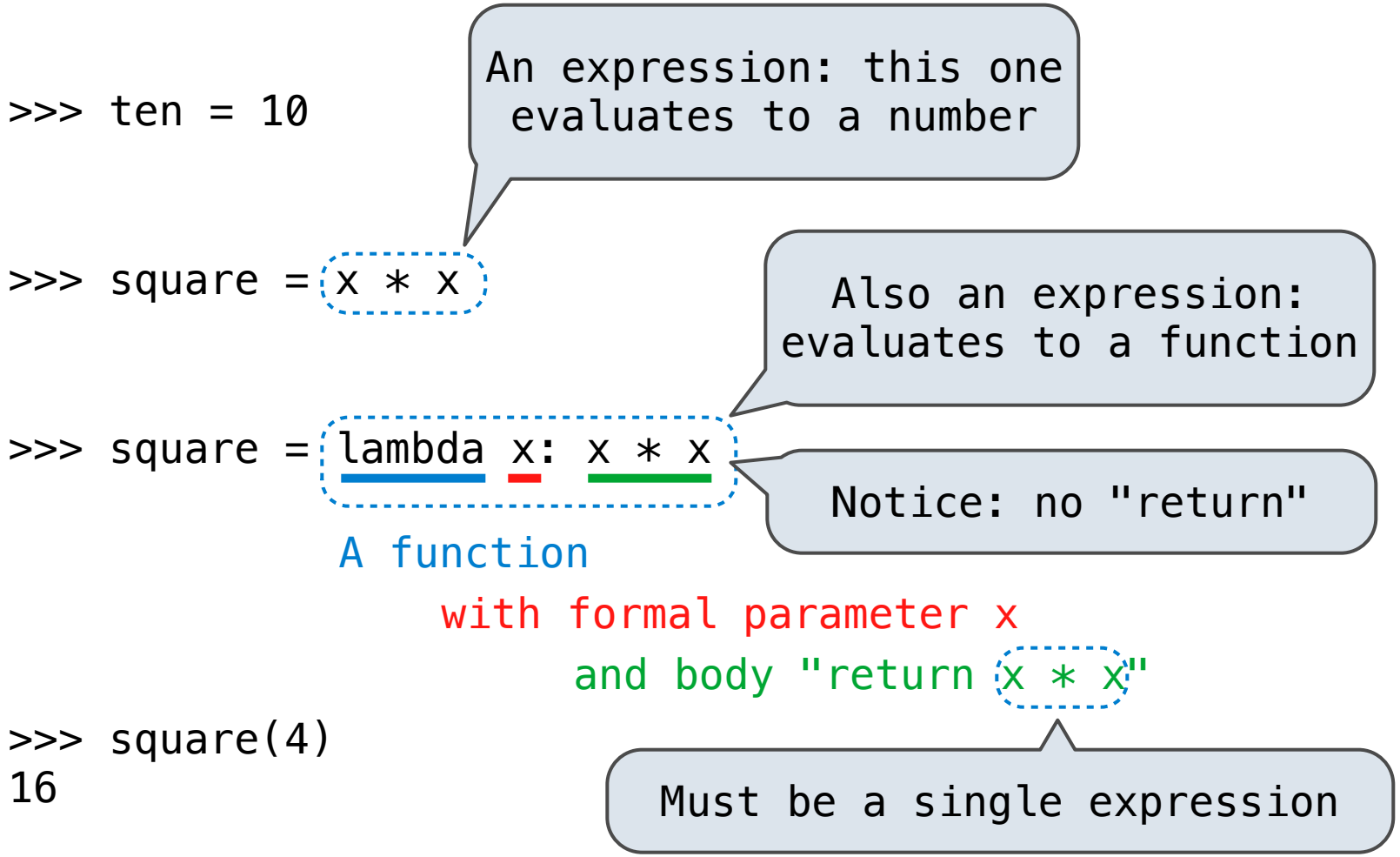
```
1  def square(x):
2      return x * x
3
4  def make_adder(n):
5      def adder(k):
6          return k + n
7      return adder
8
9  def compose1(f, g):
10     def h(x):
11         return f(g(x))
12     return h
13
14 compose1(square, make_adder(2))(3)
```

Return value of make_adder is an argument to compose1



Example: http://goo.gl/2IuEO

Lambda Expressions



Lambda expressions are rare in Python, but important in general

More Higher-Order Function Examples

(Demo)