

[301] Function Scope

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Learning Objectives Today

Understand **local variables**

- When are they created?
- When do they die?
- When are they shared?
- Where are they stored? (frames)

Understand **global variables**

- How are they accessed? (global keyword)
- Where are they stored? (global frame)

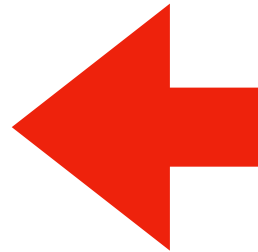
Understand argument passing

- Meaning of “pass by value”

Today's Outline

Context

- Examples



Frames

Demos: Local Variables

Demos: Global Variables

Demos: Argument Passing

Context

Often (in life and programming), the same name can mean different things in different contexts

- Examples?

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- Examples?
- Human name: **Matthew** (who is in the room?)
- Street address: **534 State Street** (what city are we in?)
- Functions: **speak** (cat module or dog module?)
- Files: **main.ipynb** (which directory are we in?)

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- How do we know what a variable name is referring to?

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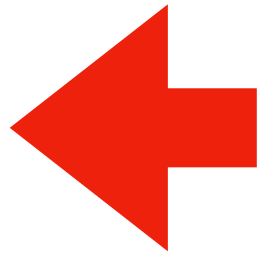
Python programs will often have different variables with the same name

- How do we keep variable names organized? **with groups called “frames”**
- How do we know what a variable name is referring to? **we’ll learn some rules for this**

Today's Outline

Context

Frames



Demos: Local Variables

Demos: Global Variables

Demos: Argument Passing

Frames

Every time a function is invoked (i.e., called), the invocation gets a new “**frame**” for holding variables

- The parameters also exist in a frame

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Global frame

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When a variable name is used, Python looks two places:

- 1 the function invocation's frame
- 2 the global frame

Example from Think Python (3.8)

```
→ 1 def print_twice(bruce):  
2     print(bruce)  
3     print(bruce)  
4  
5 def cat_twice(part1, part2):  
6     cat = part1 + part2  
→ 7     print_twice(cat)  
8  
9 line1 = 'Bing tiddle'  
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11 cat_twice(line1, line2)
```

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line1 and line2 will be in the global frame

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Downey illustrates like this
(this is called a stack diagram)

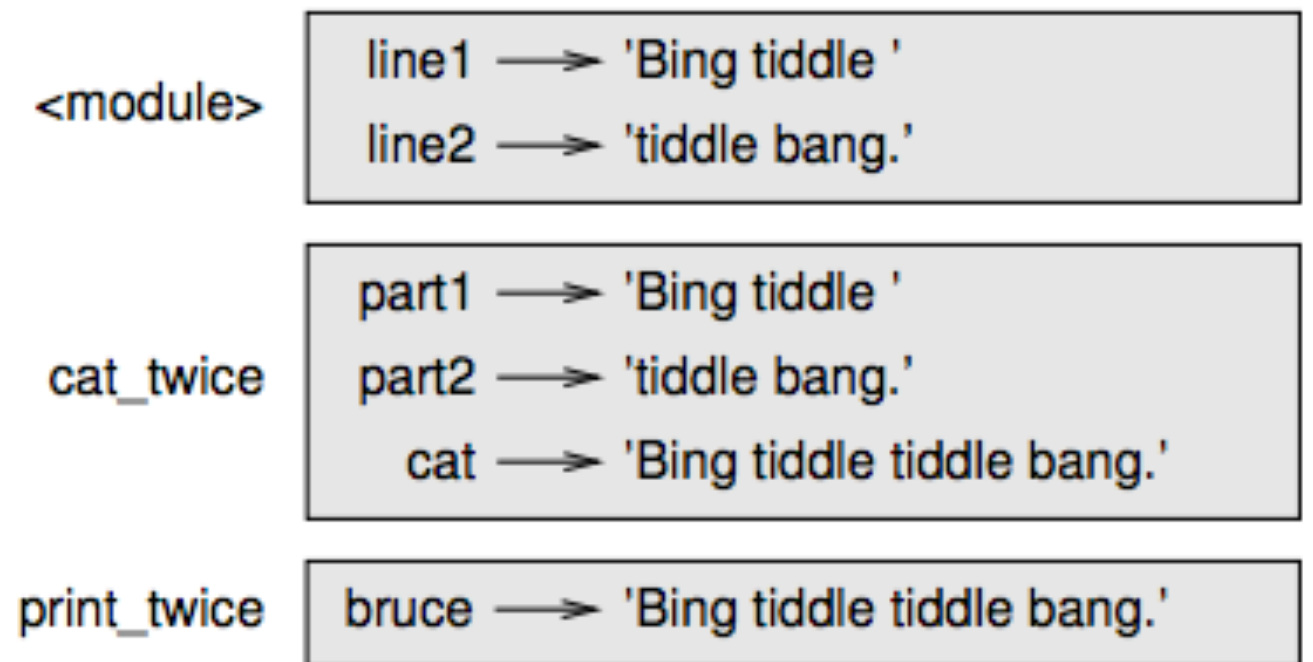


Figure 3.1: Stack diagram.

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```

this code can access: line1, line2

global frame



<module>

line1 → 'Bing tiddle '
line2 → 'tiddle bang.'

cat_twice

part1 → 'Bing tiddle '
part2 → 'tiddle bang.'
cat → 'Bing tiddle tiddle bang.'

print_twice

bruce → 'Bing tiddle tiddle bang.'

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2     print(bruce)  
3     print(bruce)  
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5 def cat_twice(part1, part2):  
6     cat = part1 + part2  
→ 7     print_twice(cat)    can access: line1, line2, part1, part2, cat  
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9 line1 = 'Bing tiddle'  
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11 cat_twice(line1, line2)
```

global frame



<module>

line1	→	'Bing tiddle '
line2	→	'tiddle bang.'



cat_twice

part1	→	'Bing tiddle '
part2	→	'tiddle bang.'
cat	→	'Bing tiddle tiddle bang.'

print_twice

bruce	→	'Bing tiddle tiddle bang.'
-------	---	----------------------------

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print_twice

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3     print(bruce)    can access: line1, line2, bruce  
4  
5 def cat_twice(part1, part2):  
6     cat = part1 + part2  
7     print_twice(cat)    we call the variables that can currently be  
8                             accessed "in scope" and variables that  
9                             cannot be "out of scope"  
9 line1 = 'Bing tiddle'  
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```

global frame



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line1 → 'Bing tiddle '
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**Arguments are copied to parameters:
this is called “pass by value”**

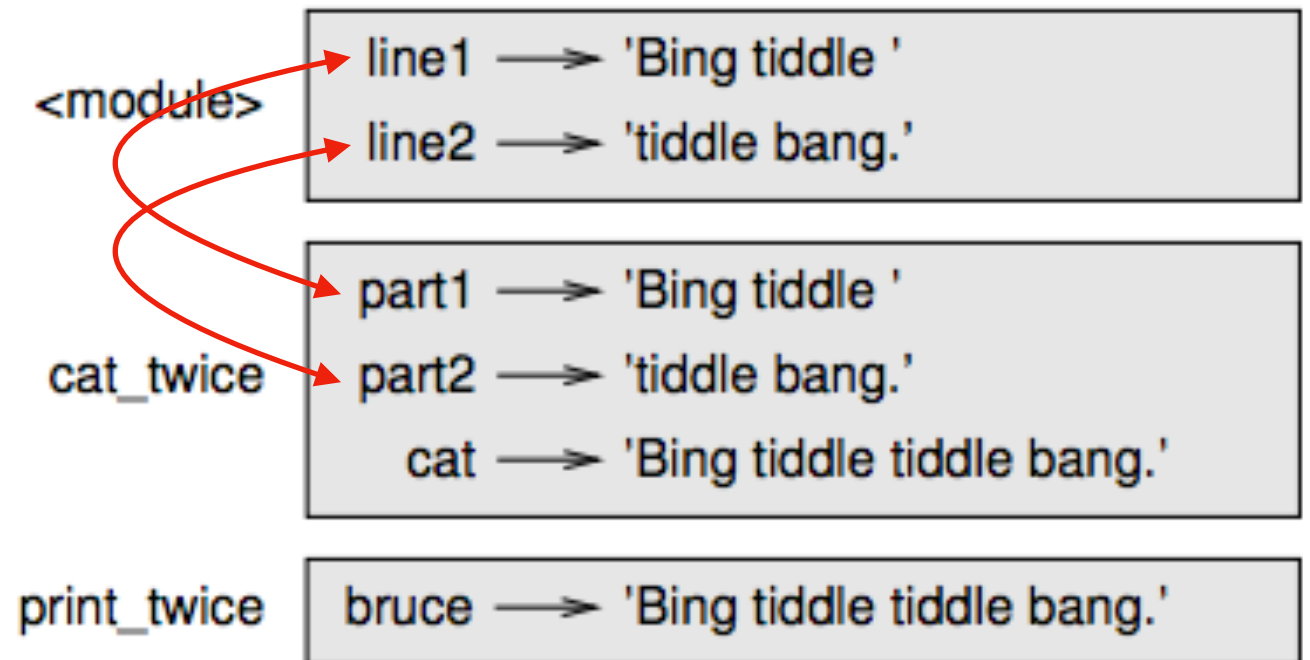


Figure 3.1: Stack diagram.

Think Python vs PythonTutor

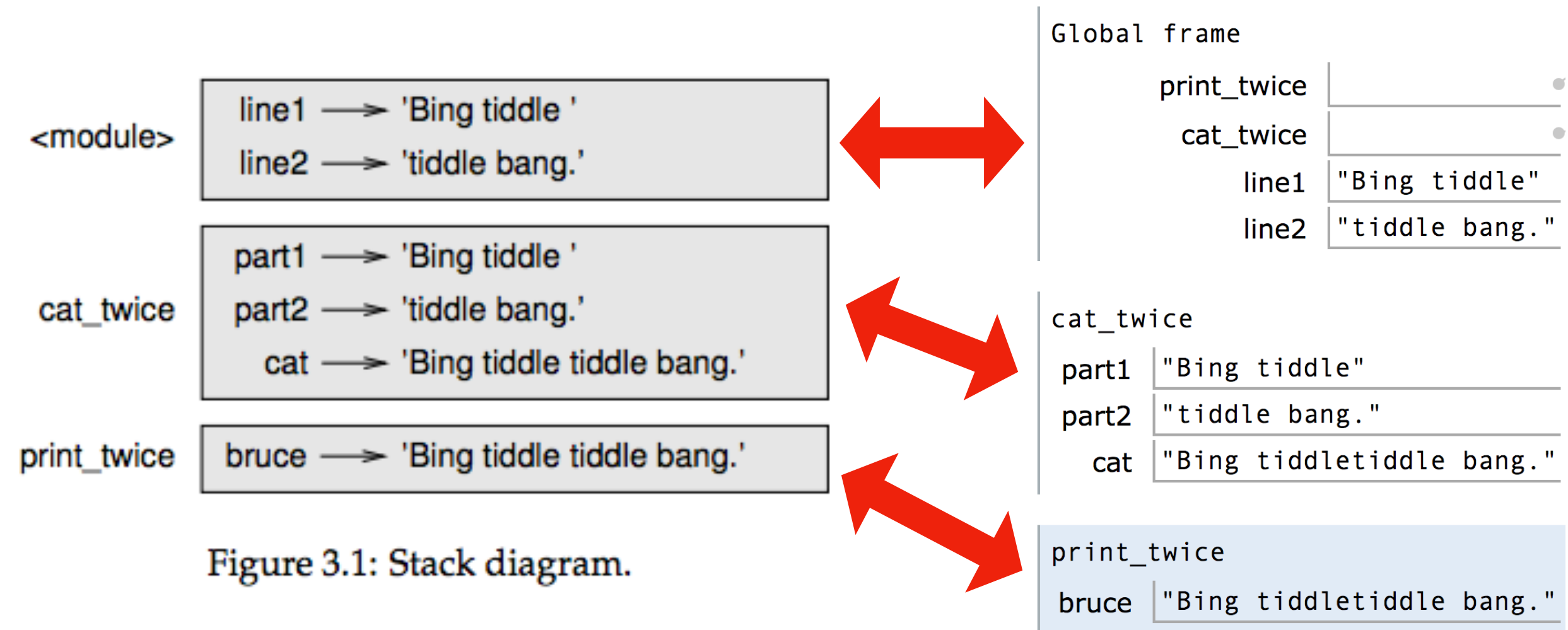
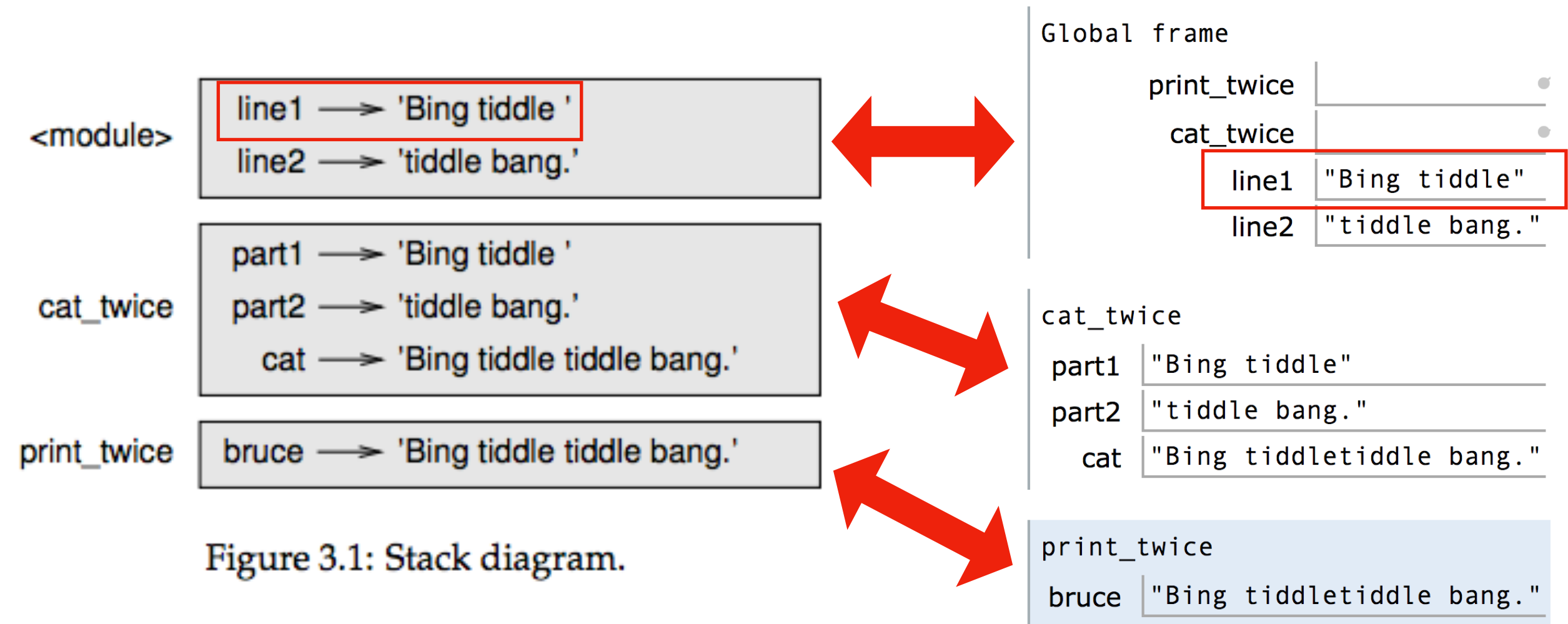


Figure 3.1: Stack diagram.

Think Python vs PythonTutor



Difference 1: PythonTutor uses boxes instead of arrows

Think Python vs PythonTutor

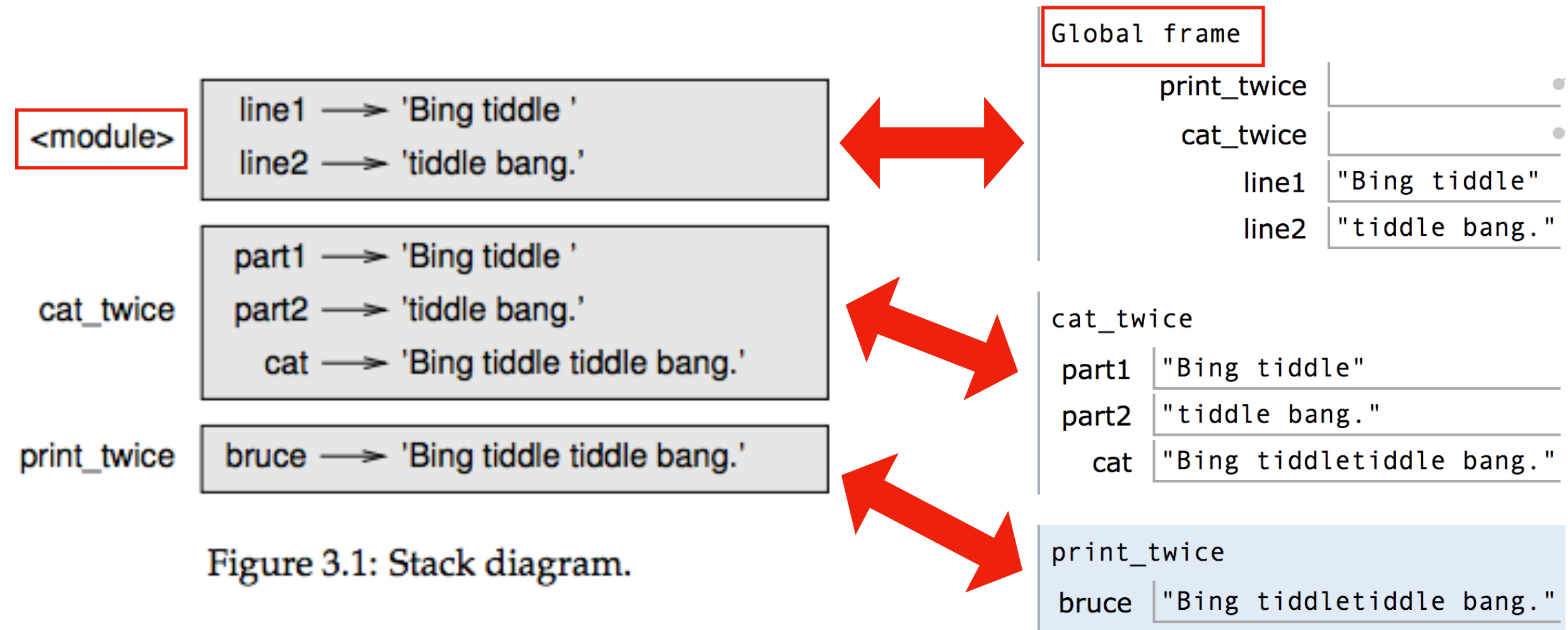


Figure 3.1: Stack diagram.

Difference 2: PythonTutor more clearly indicates the global frame

Think Python vs PythonTutor

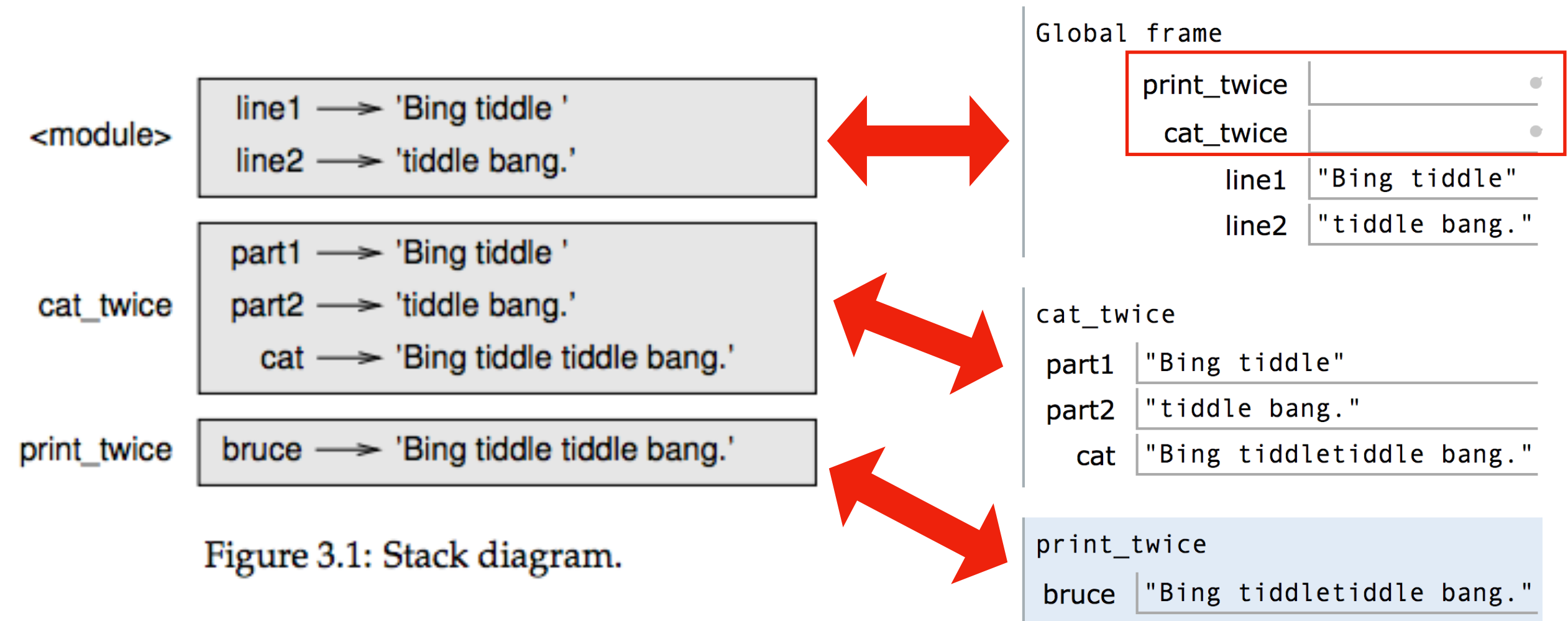


Figure 3.1: Stack diagram.

Difference 3: PythonTutor also shows function definitions in the global frame

Think Python vs PythonTutor



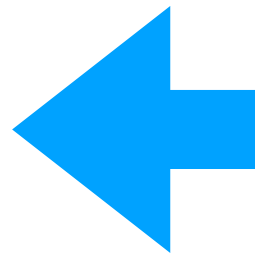
Difference 3: PythonTutor also shows function definitions in the global frame

Today's Outline

Context

Frames

Demos: Local Variables



Demos: Global Variables

Demos: Argument Passing

Lessons about Local Variables

```
def set_x():  
    x = 100
```

```
print(x)
```

Lesson 1: functions don't execute unless they're called

Lessons about Local Variables

```
def set_x():  
    x = 100
```

```
set_x()  
print(x)
```

Lesson 2: variables created in a function die after function returns

Lessons about Local Variables

```
def count():  
    x = 1  
    x += 1  
    print(x)
```

```
count()  
count()  
count()
```

Lesson 3: variables start fresh every time a function is called again

Lessons about Local Variables

```
def display_x():  
    print(x)
```

```
def main():  
    x = 100  
    display_x()
```

```
main()
```

**Lesson 4: you can't see the variables of other function invocations,
even those that call you**

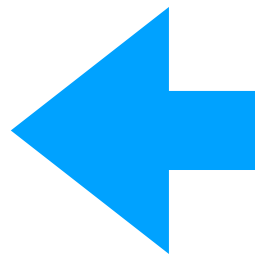
Today's Outline

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Demos: Local Variables

Demos: Global Variables



Demos: Argument Passing

Lessons about Global Variables

```
msg = 'hello' # global, outside any func
```

```
def greeting():  
    print(msg)
```

```
print('before: ' + msg)  
greeting()  
print('after: ' + msg)
```

Lesson 5: you can generally just use global variables inside a function

Lessons about Global Variables

```
msg = 'hello'
```

```
def greeting():  
    msg = 'welcome!'  
    print('greeting: ' + msg)
```

```
print('before: ' + msg)  
greeting()  
print('after: ' + msg)
```

**Lesson 6: if you do an assignment to a variable in a function,
Python assumes you want it local**

Lessons about Global Variables

```
msg = 'hello'
```

```
def greeting():  
    print('greeting: ' + msg)  
    msg = 'welcome!'
```

```
print('before: ' + msg)  
greeting()  
print('after: ' + msg)
```

Lesson 7: assignment to a variable should be before its use in a function, even if there's a global variable with the same name

Lessons about Global Variables

```
msg = 'hello'
```

```
def greeting():  
    global msg  
    print('greeting: ' + msg)  
    msg = 'welcome!'
```

```
print('before: ' + msg)  
greeting()  
print('after: ' + msg)
```

Lesson 8: use a global declaration to prevent Python from creating a local variable when you want a global variable

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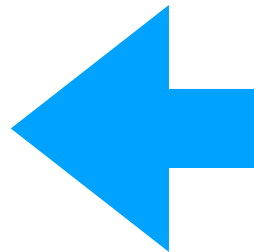
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Demos: Local Variables

Demos: Global Variables

Demos: Argument Passing



Lessons about Argument Passing

```
def f(x):  
    x = 'B'  
    print('inside: ' + x)
```

```
val = 'A'  
print('before: ' + val)  
f(val)  
print('after: ' + val)
```

Lesson 9: in Python, arguments are "passed by value", meaning reassignments to a parameter don't change the argument outside

Lessons about Argument Passing

```
x = 'A'

def f(x):
    x = 'B'
    print('inside: ' + x)

print('before: ' + x)
f(x)
print('after: ' + x)
```

Lesson 10: it's irrelevant whether the argument (outside) and parameter (inside) have the same variable name