[220 / 319] 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)

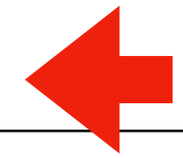
Understand **global variables**

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

Understand argument passing

- Meaning of "pass by value"

Read: Downey Ch 3 ("Parameters and Arguments" to end)
Link to Slides
Interactive Exercises

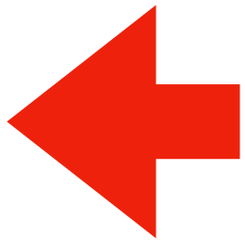


don't memorize the examples,
learn the rules of Python

sample question: *why did PyTutor do this thing I didn't expect at this specific line (ask us!)*

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

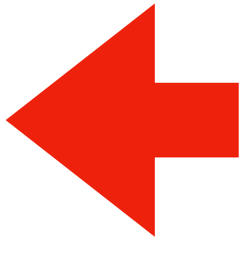
- Examples?
- Human name: Ethan (who is in the room?)
- Street address: 534 State Street (what city are we in?)
- Functions: speak (cat module or dog module?)
- Files: main.ipynb (which directory are we in?)

Our code 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

Global frame

- There is always one global frame that all functions can access

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'
10 line2 = 'tiddle bang.'
11 cat_twice(line1, line2)
```

two frames will exist during the time we're executing in print_twice

line1 and line2 will be in the global frame

you don't generally see or interact with frames when programming, but it's an important mental model

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

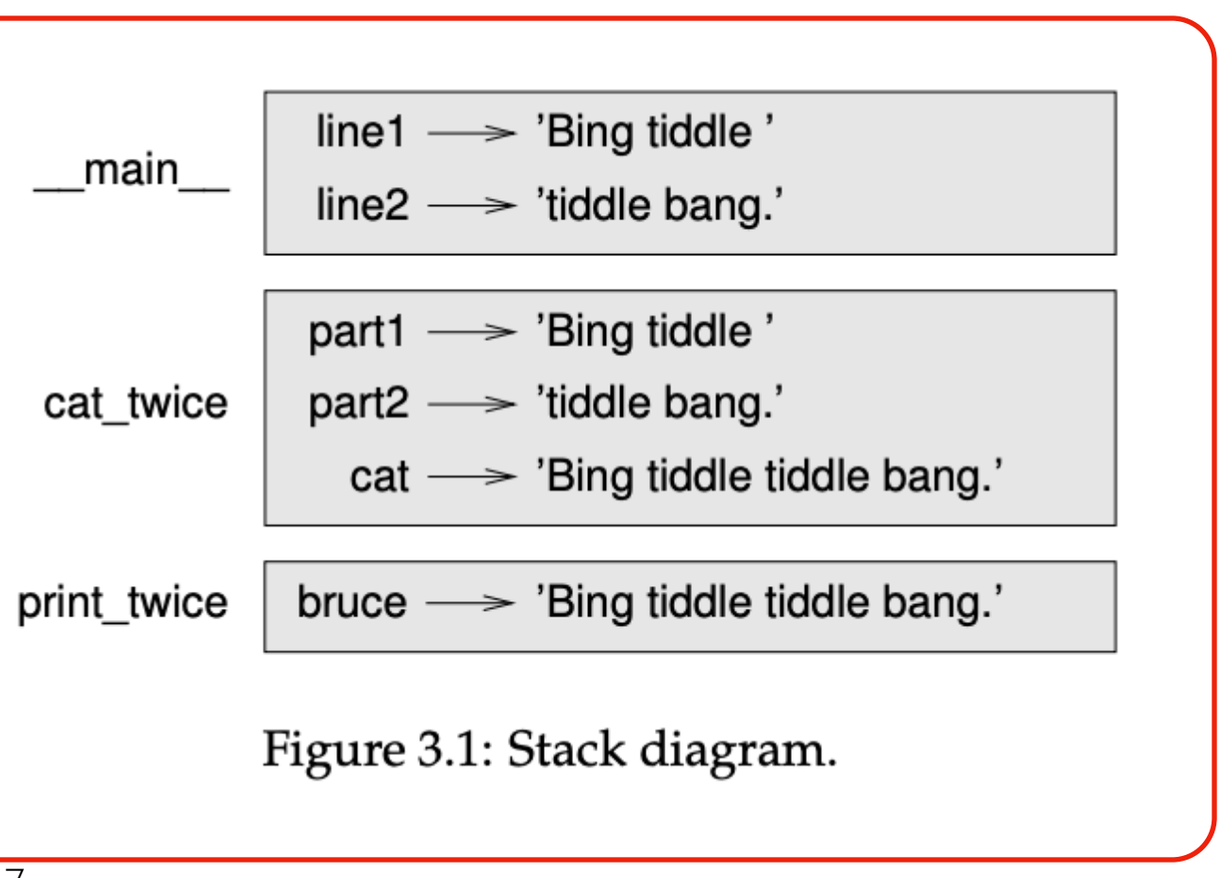


Figure 3.1: Stack diagram.

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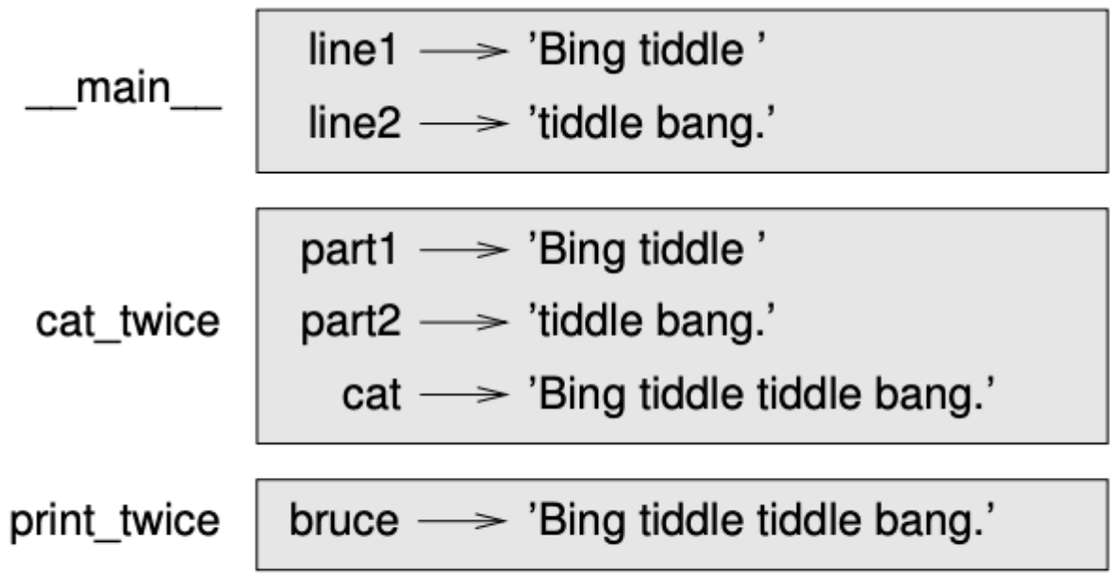
```

this code can access: `line1, line2`

global frame



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```
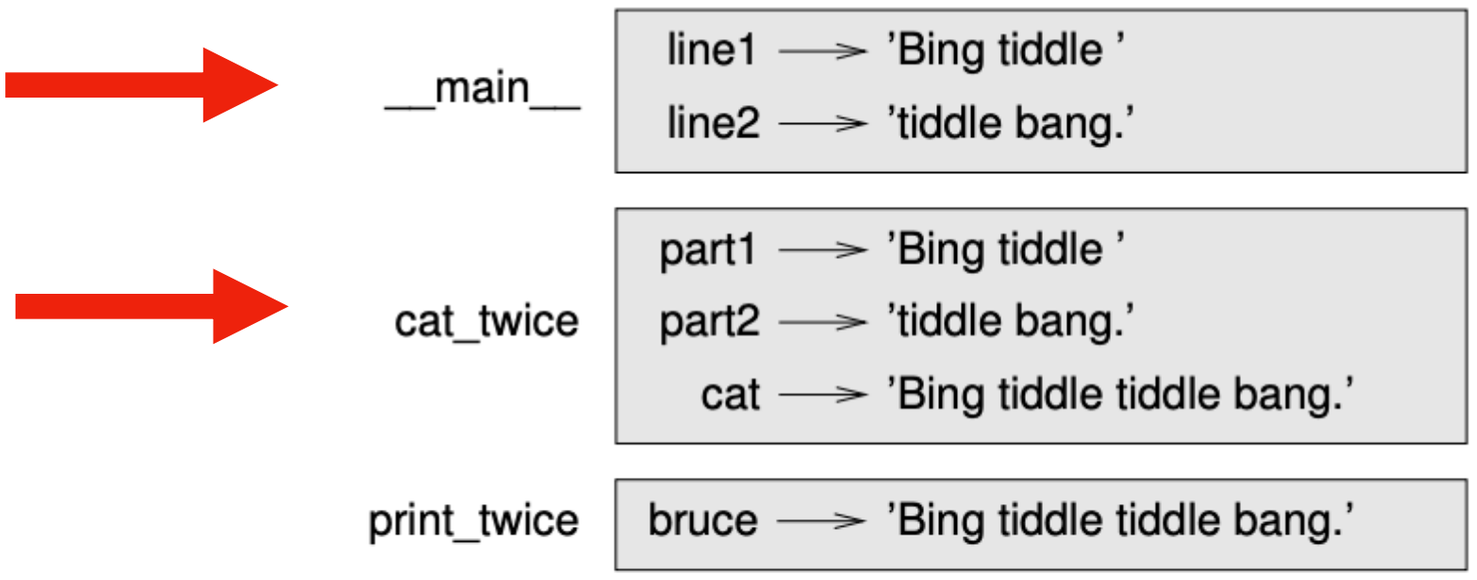

can access: `line1, line2, part1, part2, cat`

global frame



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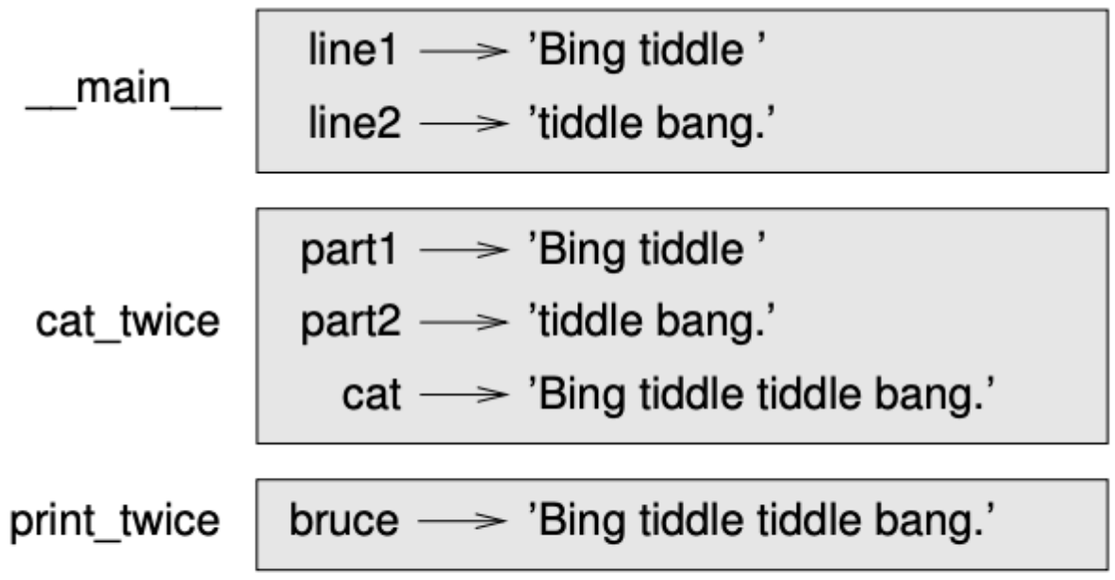
```

can access: `line1, line2, bruce`

we call the variables that can currently be accessed "in scope" and variables that cannot be "out of scope"

global frame



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```
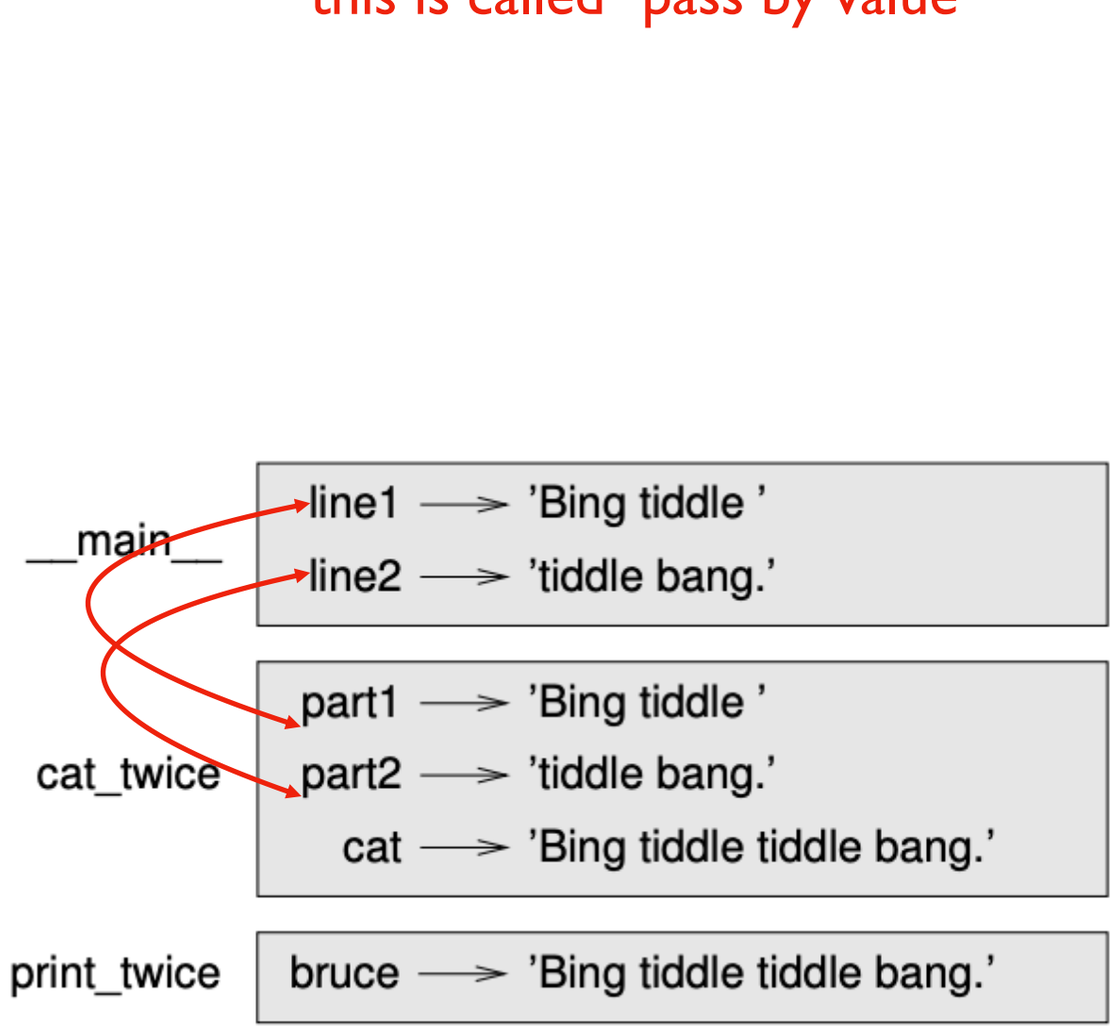

Arguments are copied to parameters:
this is called "pass by value"



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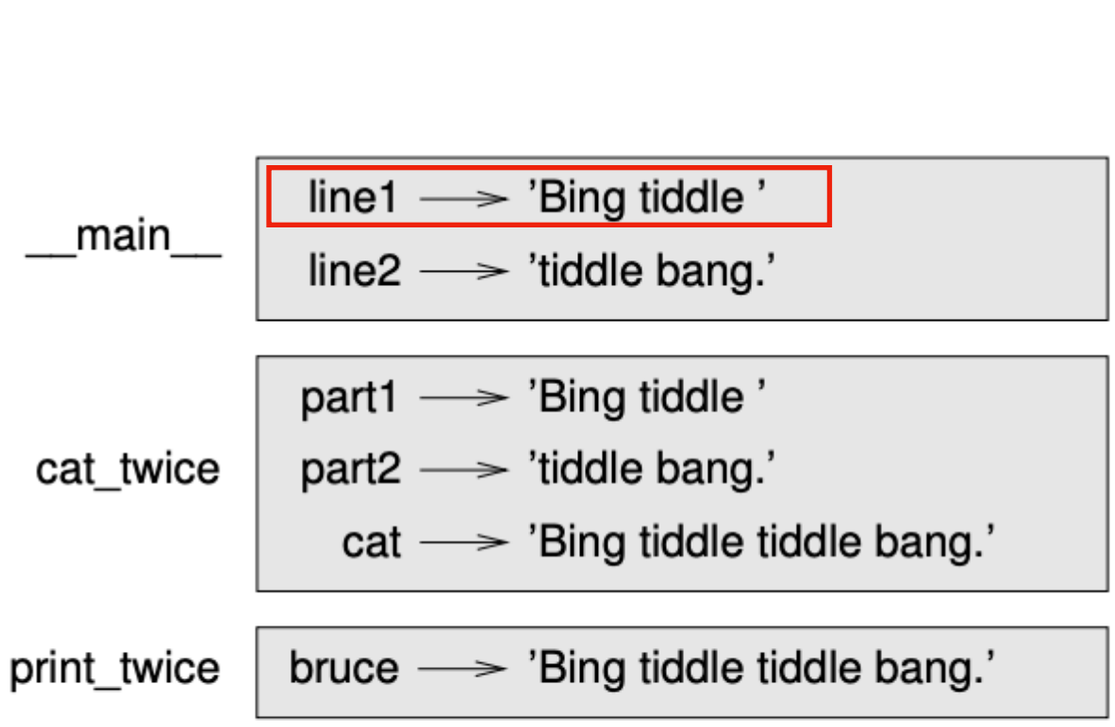
Think Python vs PythonTutor



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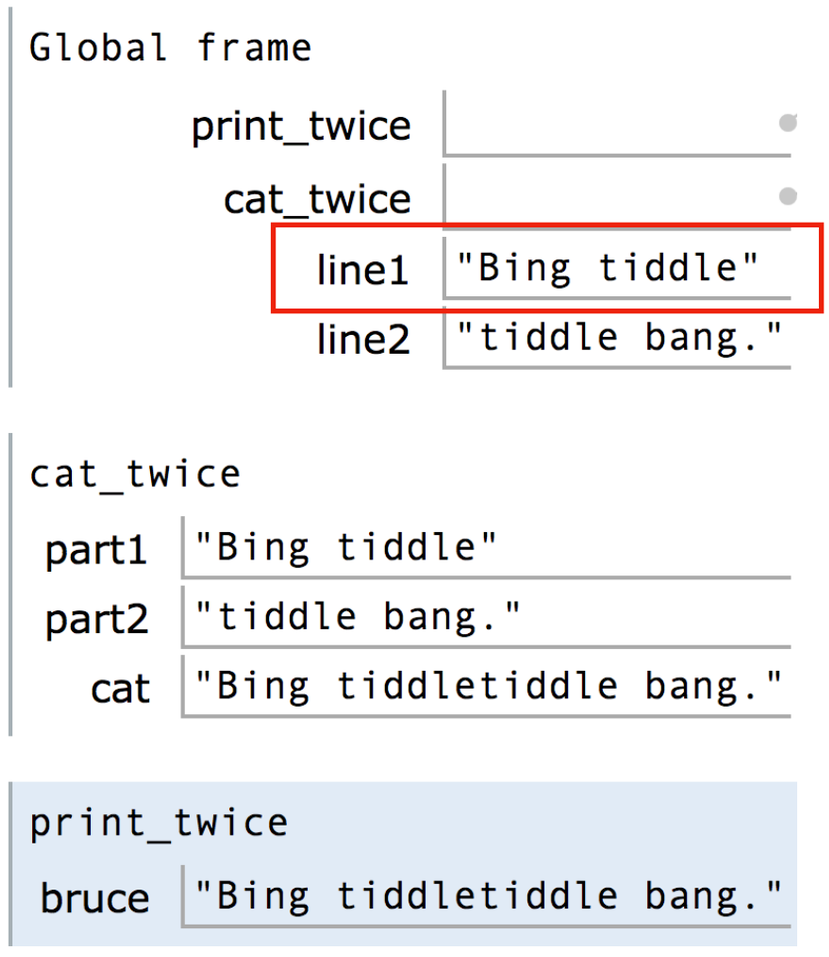
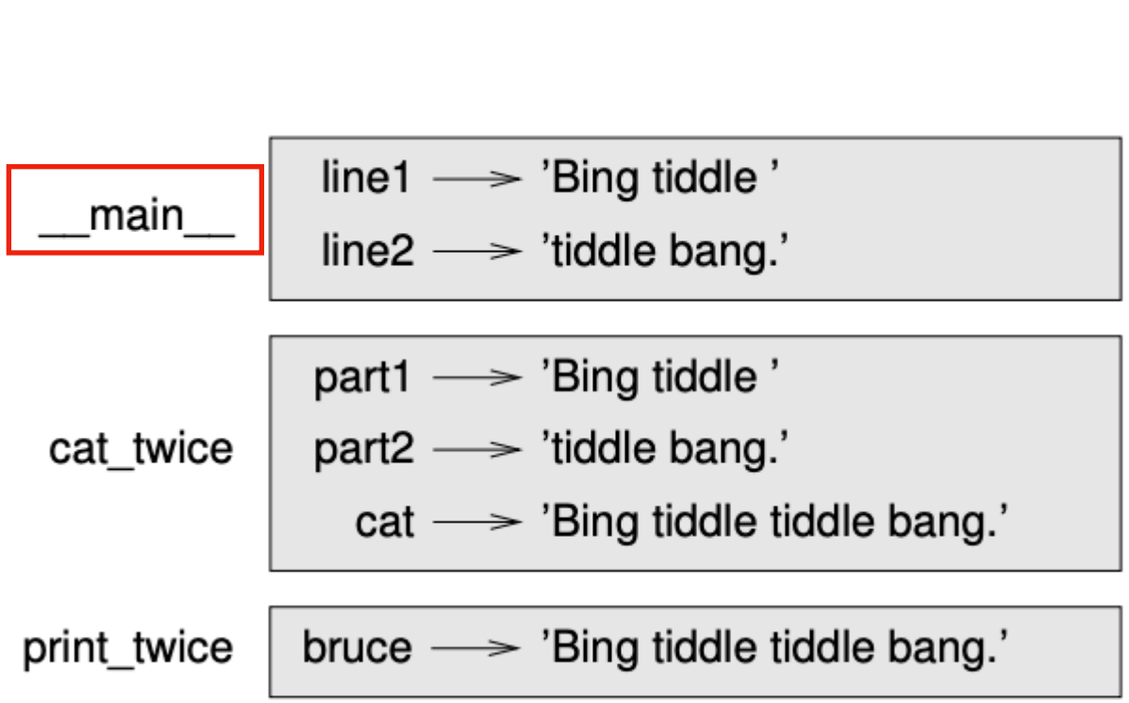


Difference 1: PythonTutor uses boxes instead of arrows (by default)

Think Python vs PythonTutor



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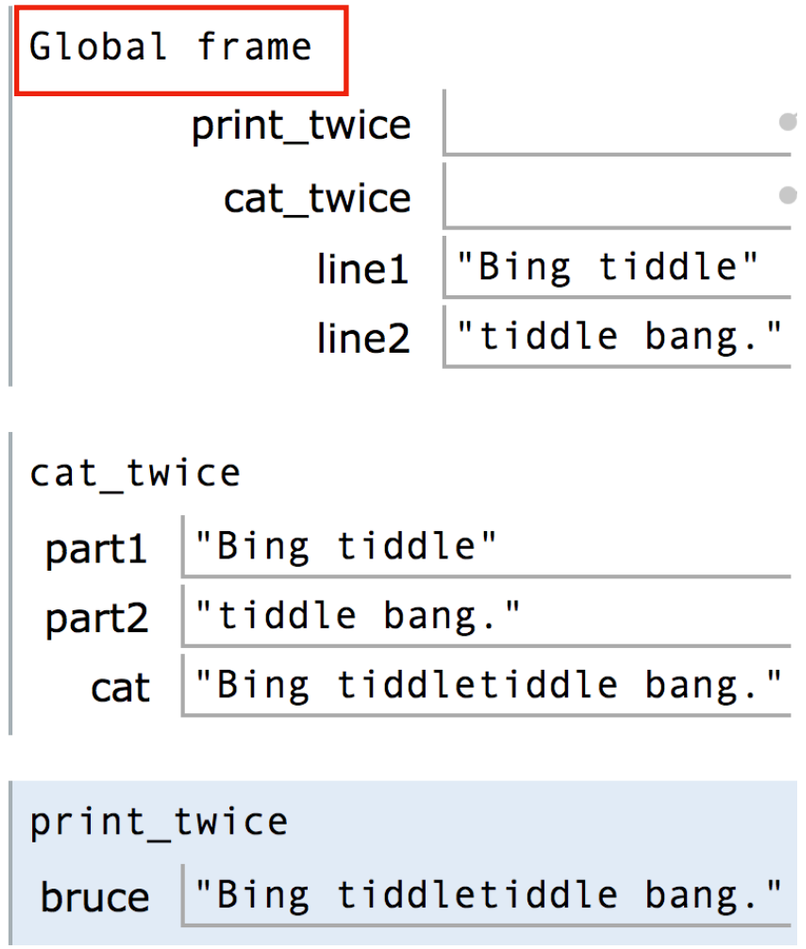


Difference 2: PythonTutor uses the term global frame

Think Python vs PythonTutor

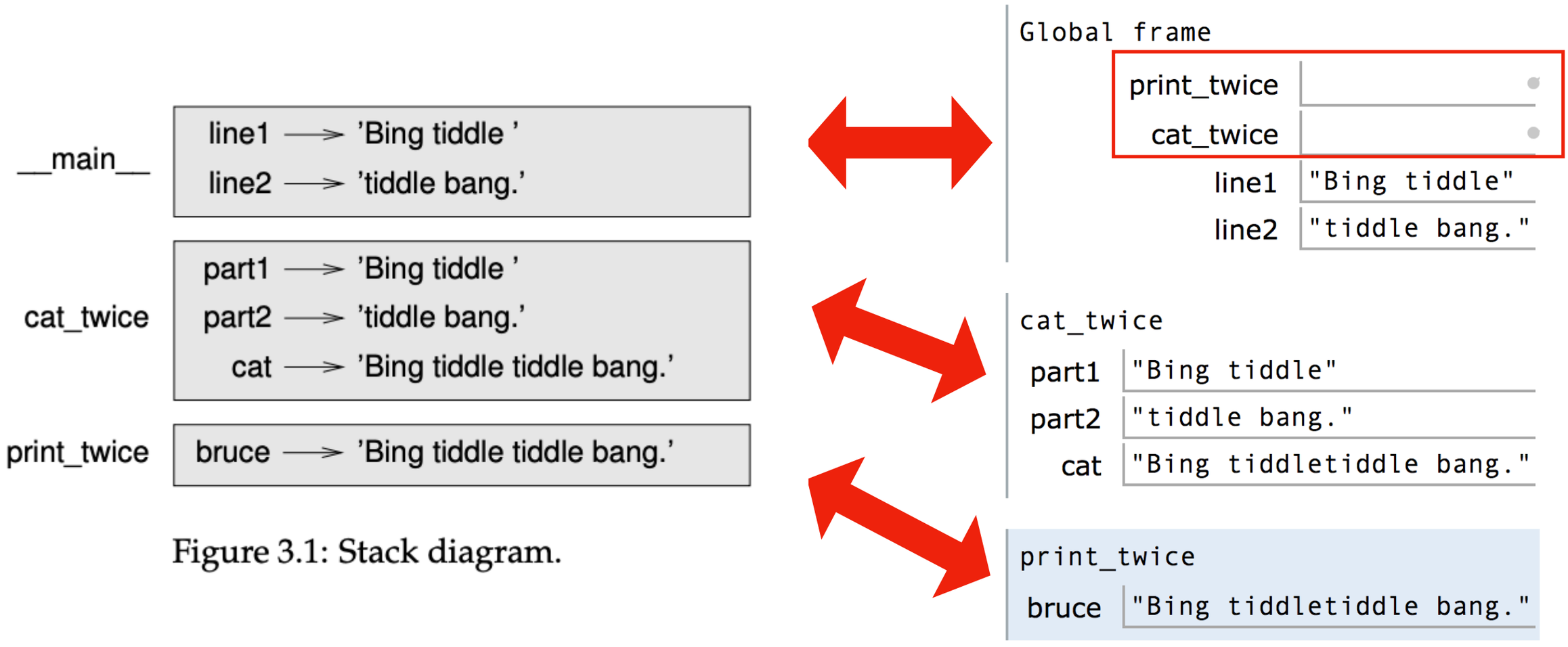
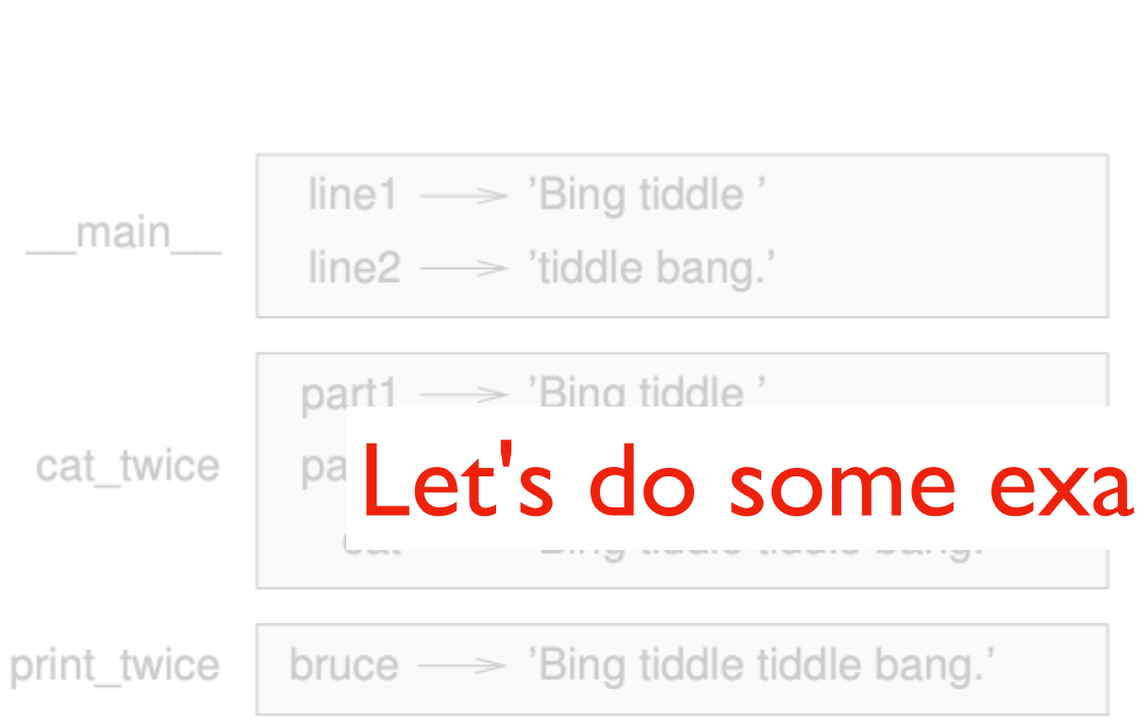


Figure 3.1: Stack diagram.

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

Think Python vs PythonTutor



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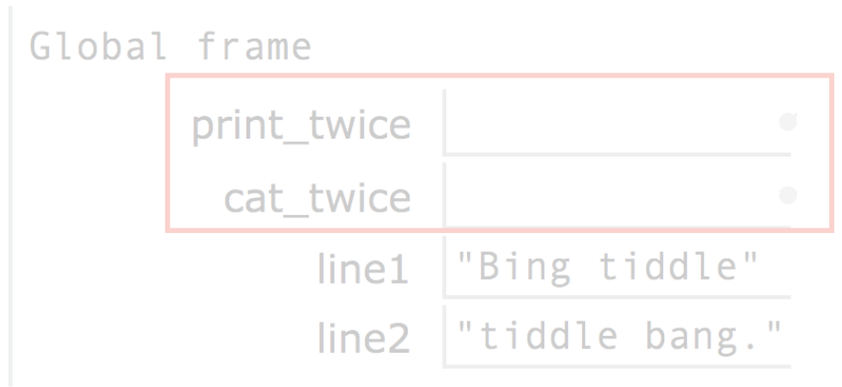
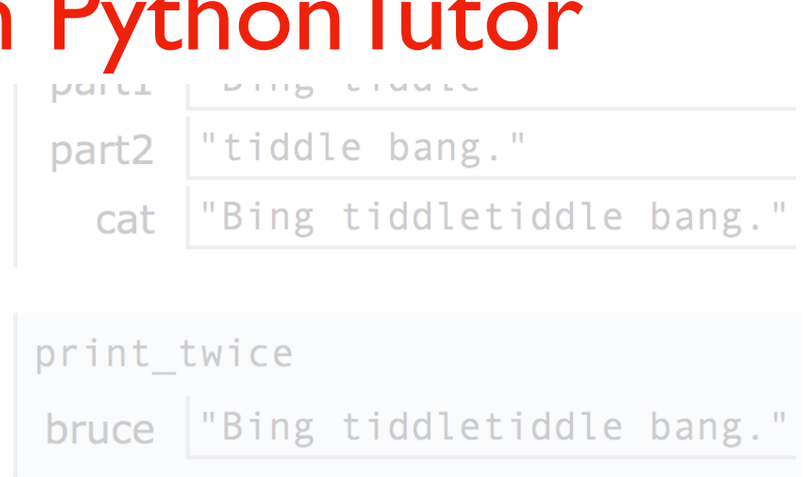


Let's do some examples in PythonTutor



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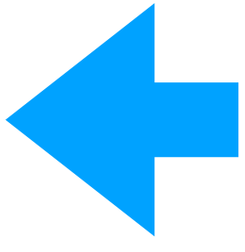
Today's Outline

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

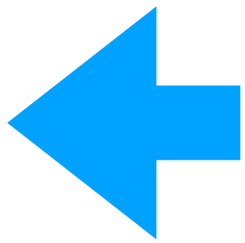
Today's Outline

Context

Frames

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

Today's Outline

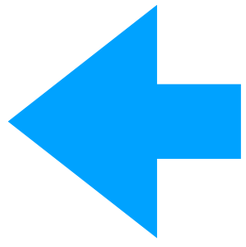
Context

Frames

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

Lesson Summary

Local

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

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

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

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

Global

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

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

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

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

Parameters

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

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