FUNCTIONS

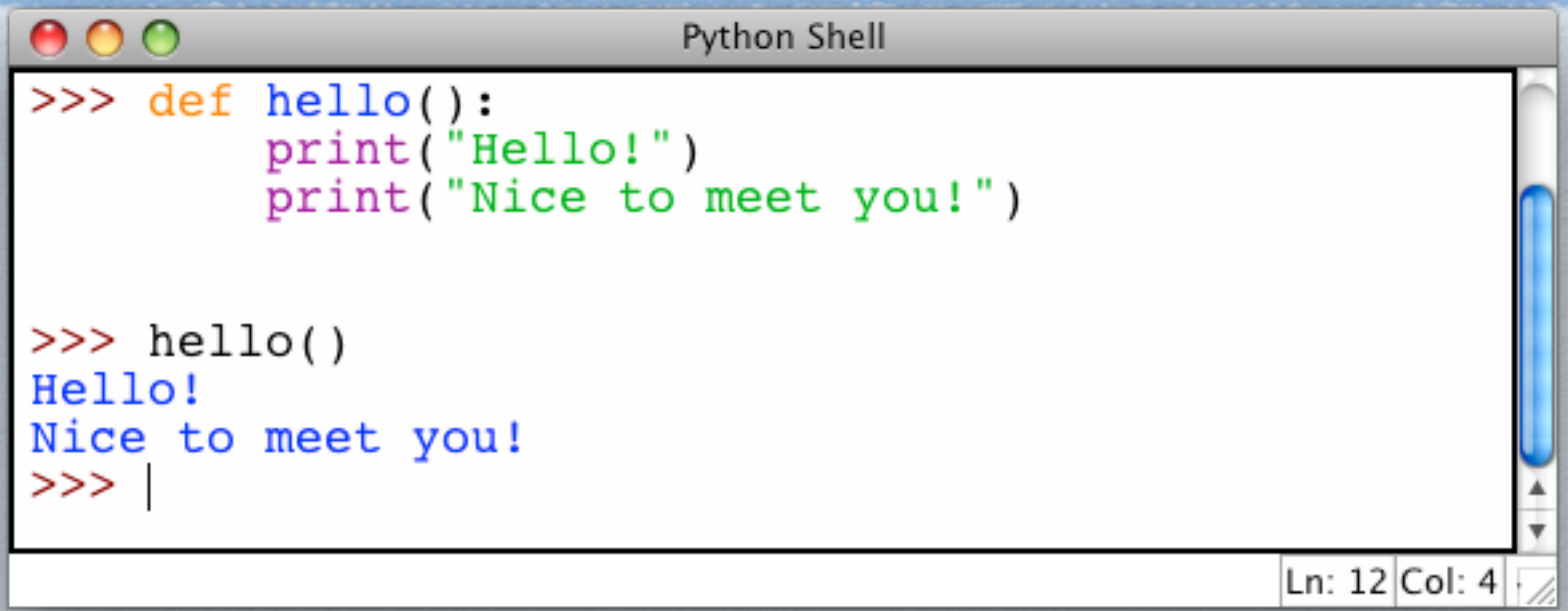
Learning Outcomes

- To understand why programmers divide programs up into sets of cooperating functions.
- To be able to define new functions in Python
- To understand the details of function calls and parameter passing in Python
- To write programs that use functions to reduce code duplication and increase program modularity.

FUNCTIONS

- A portion of code within a larger program, which performs a specific task and is relatively independent of the remaining code.

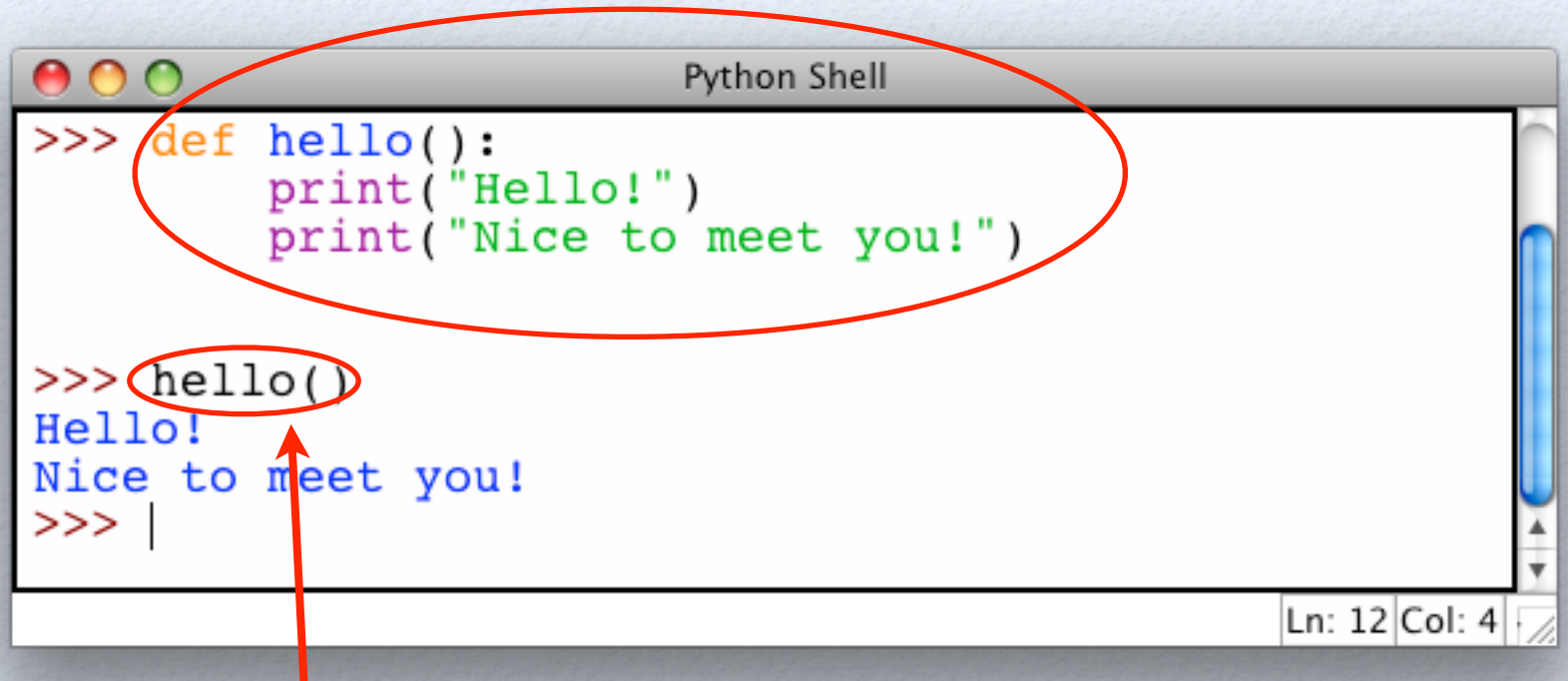
YOU'VE SEEN THIS ALREADY



- We have **defined** a function called hello()
- A **function** is a sequence of program statements with a name.
- Once we have defined the function, we can execute the programming statements anytime by referring to the function name.

Defining and invoking functions

This is the **function definition**.
It creates the function.



We are **calling**, or **invoking**, the function here.
In other words, we are using the function.
Once a function has been defined, we can call it whenever we like.

Defining and Calling Functions

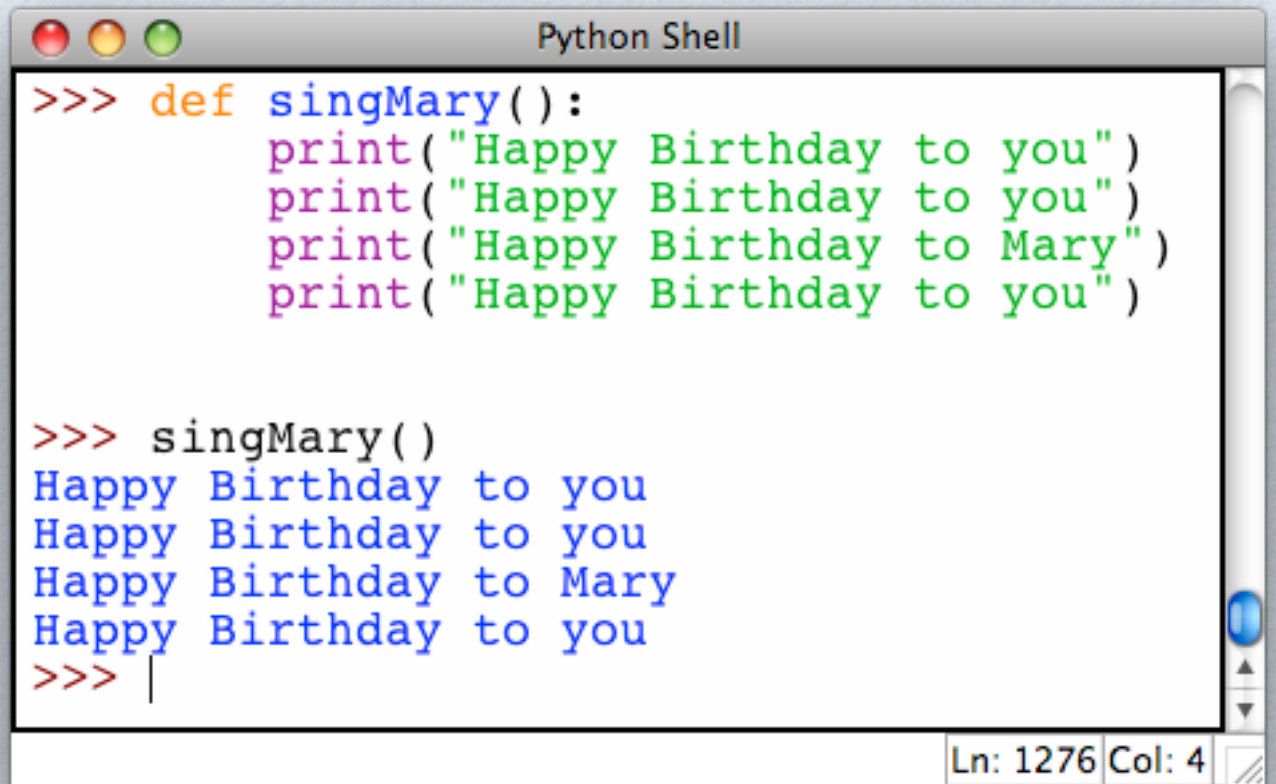
- A function definition looks like this:

```
def <name> (<formal-parameters>):
        <body>
```

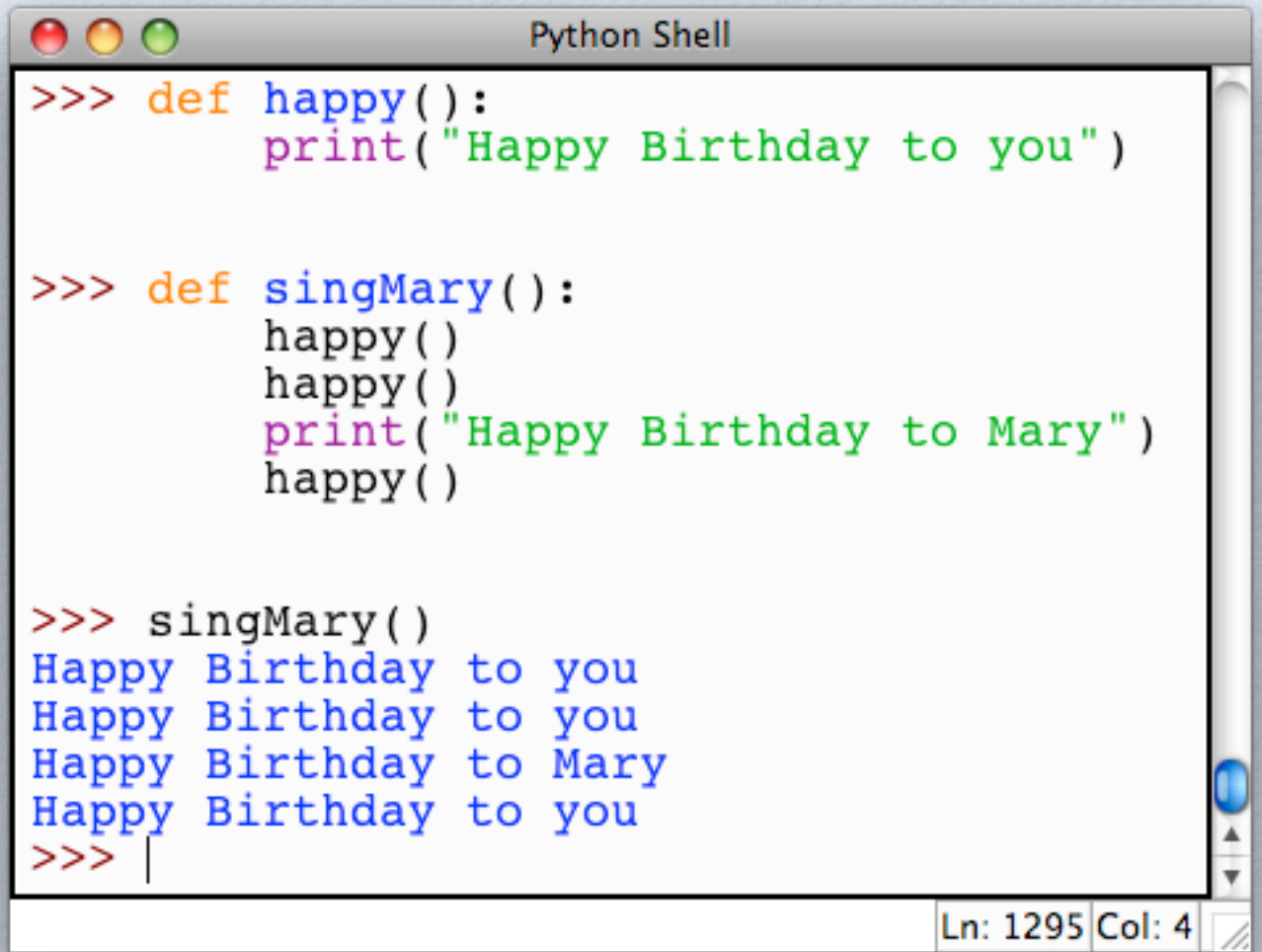
- A function is called using its name, followed by a list of *actual parameter values*, or *arguments*.

```
<name> (<actual-parameter-values>)
```

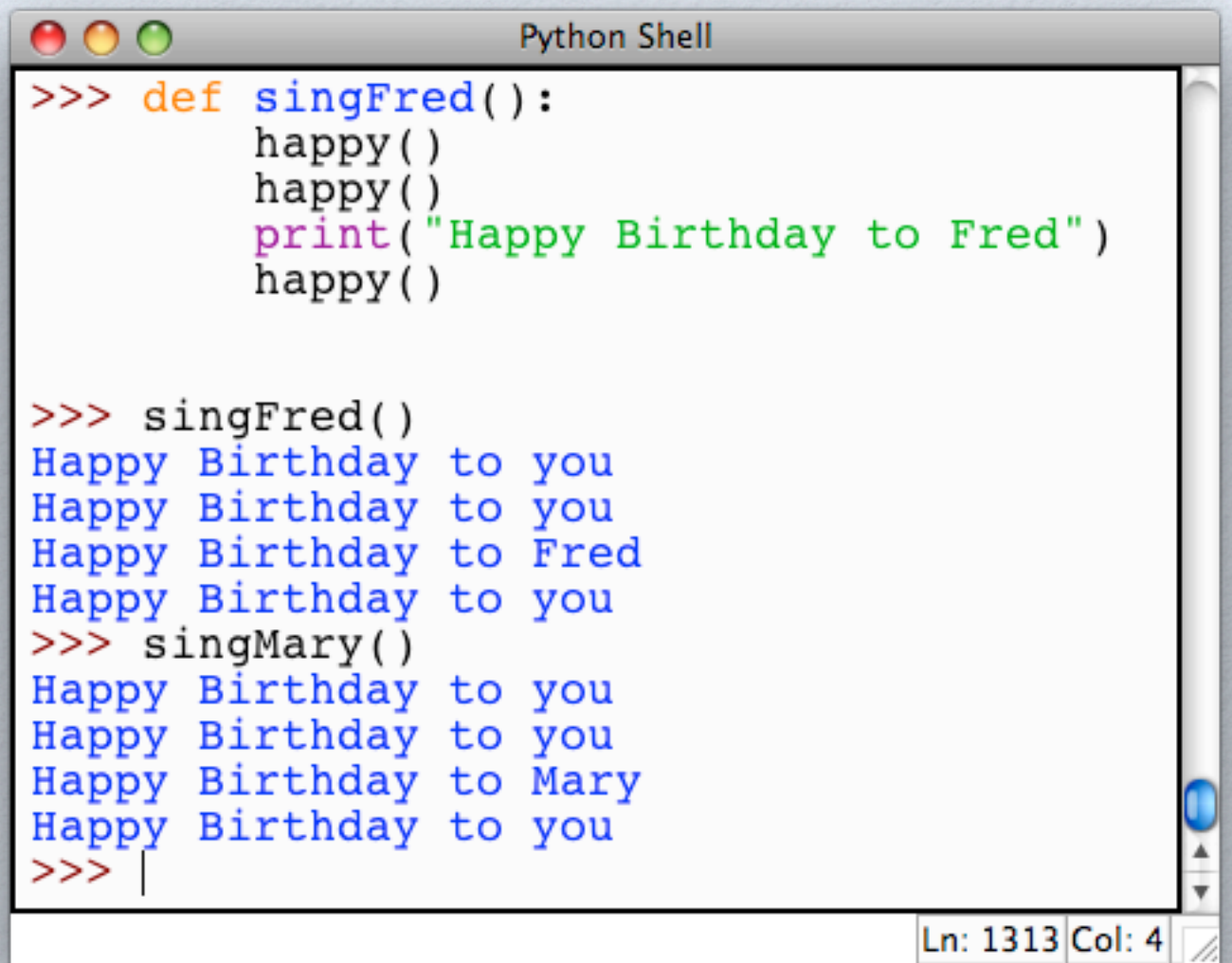
ANOTHER EXAMPLE



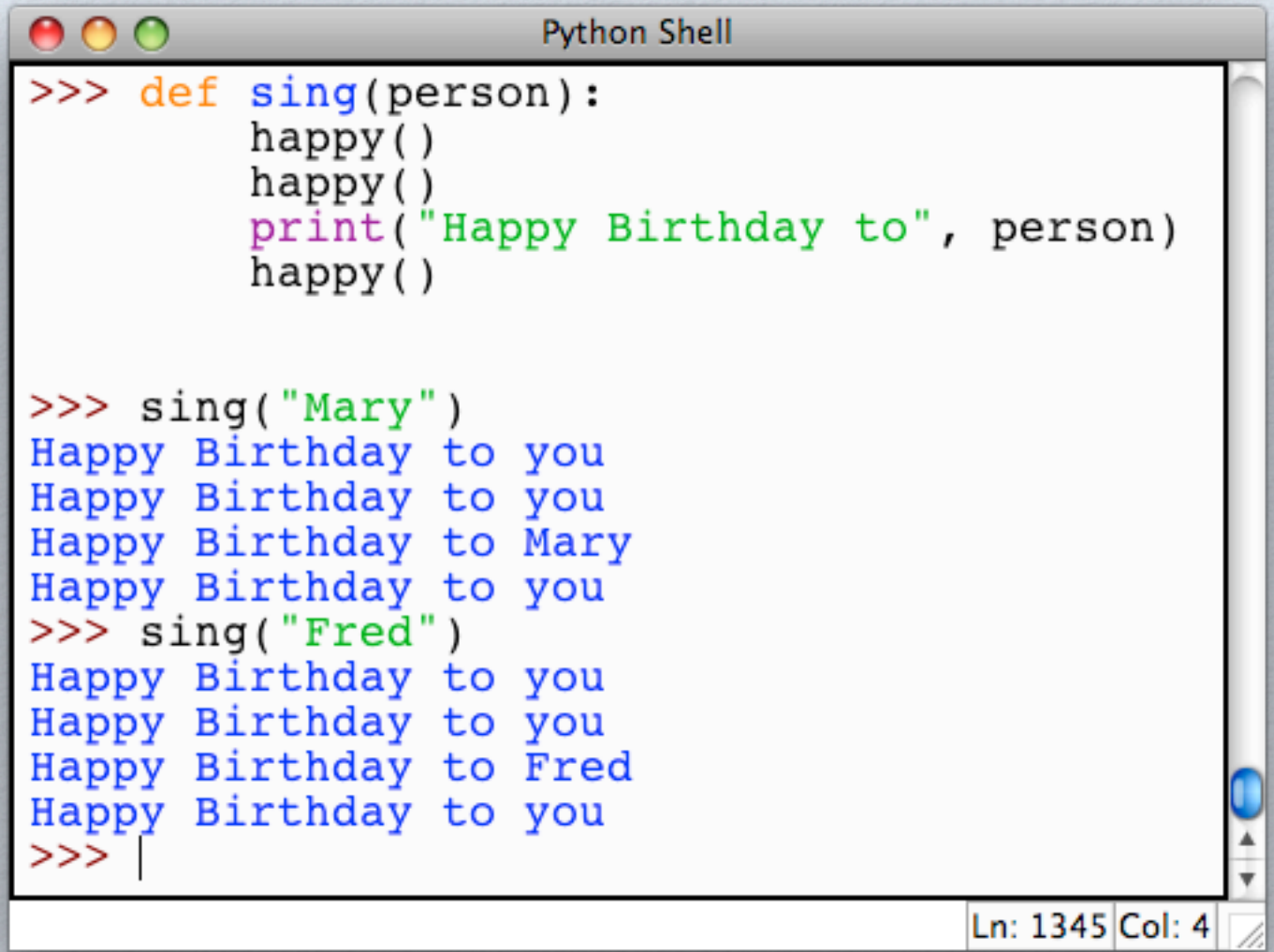
Functions can call other functions



Defined functions can be called by more than one function



FUNCTIONS WITH PARAMTERS

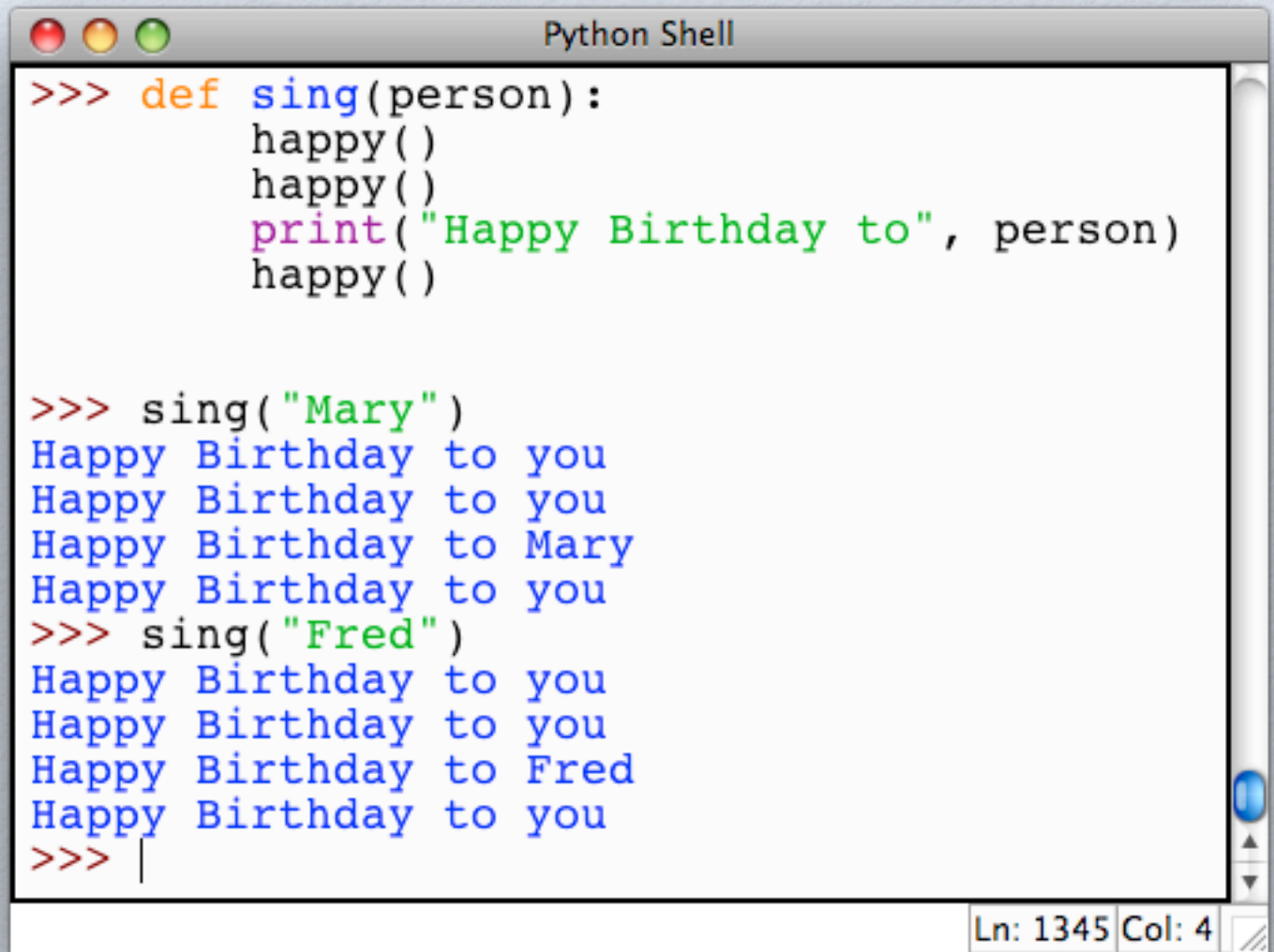


- **Parameters** are customizable parts of a function
- They are variables that are **initialized** when the function is executed.
- We provide the value of the parameter when we call the function.

When a function is called

- When we call a function, a five-step process happens:
- Step 1: The calling function suspends execution at the point of the call.
- Step 2: The function starts running. Any formal parameter variables are created.
- Step 3: The formal parameters variables are initialized with the values supplied by the actual parameter values in the call.
- Step 4: The body of the function is executed.
- Step 5: Program flow continues at the point just after the function was called.

EXAMPLE


Python Shell
>>> def sing(person):
happy()
happy()
print("Happy Birthday to", person)
happy()
>>> sing("Mary")
Happy Birthday to you
Happy Birthday to you
Happy Birthday to Mary
Happy Birthday to you
>>> sing("Fred")
Happy Birthday to you
Happy Birthday to you
Happy Birthday to Fred
Happy Birthday to you
>>>
Ln: 1345 Col: 4

TRACING THE FLOWS

```
def happy():
    print("Happy birthday to you")
```

```
def sing(person):
    happy()
    happy()
    print("Happy birthday to", person)
    happy()
```

person "Mary"

"Mary"

```
sing("Mary")
sing("Fred")
```

EXERCISE

- What are the outputs of the programs below?

exercise1.py

exercise1.py (~/comp201/Lectures/07 Function...

```
1  def myFunction():
2          print("-", end="")
3
4  def main():
5          print("A", end="")
6          myFunction()
7          print("B", end="")
8          myFunction()
9          print("C", end="")
10         myFunction()
11
12 main()
```

exercise2.py

exercise2.py (~/comp201/Lectures/07 Function...

```
1  def myFunction(c):
2          print(c, end="")
3
4  def main():
5          c = "A"
6          myFunction(c)
7          c = "B"
8          myFunction(c)
9          c = "C"
10         myFunction(c)
11
12 main()
```

EXERCISE

- What is the output of the program below?

```
def grunt():
    print "growl"

def squark():
    print "squeak"
    print "honk"

def main():
    print "howl"
    squark()
    print "beep"
    grunt()
    squark()

main()
```

EXERCISE

- Fill in the blanks below with the following words (one word per blank):

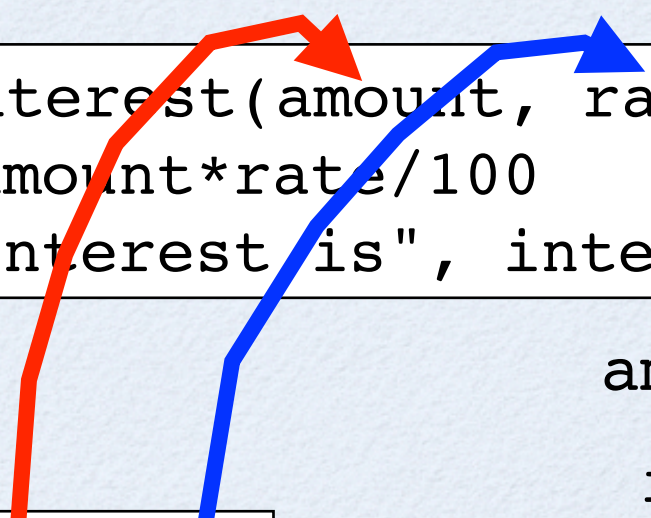
  sequentially functions block indented executed

- Program statements are _____ in a defined order. Execution starts with the first non-_____ statement in the program which is not a function definition. Execution continues _____ through each program _____ jumping into _____ when these are called.

Multiple Parameters

- A function can have more than one parameter.
- When a function definition has multiple parameters, the actual parameter in a function call are matched up with the formal parameters **by position**.

```
def calculateInterest(amount, rate):
    interest = amount*rate/100
    print("The interest is", interest)
```



amount	150
rate	3

```
>>> calculateInterest(150, 3)
```

Functions Returning Values

- We have seen the following before:

```
x = math.sqrt(4)    # x will get the value 2
```

```
y = len("Hello")    # y will get the value 5
```

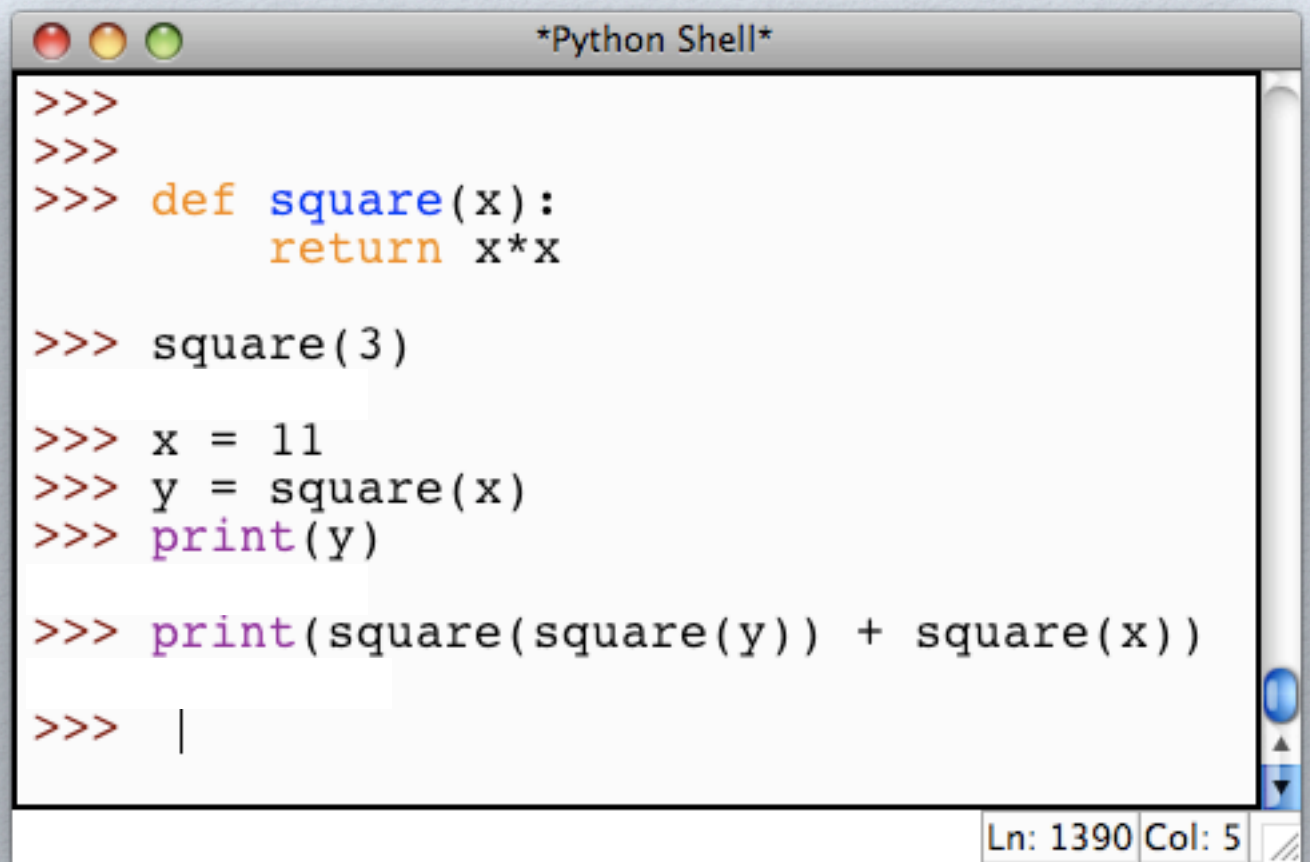
```
distance = milesToKm(20)
```

- Anything that has a pair of parentheses (`()`) at the end is a function in Python.
- So these functions are giving "answers"!

Functions Returning Answers

- To make a function return an answer, we use the **return** keyword, and put the value that we want to use as the function's answer after the return.
- The value of the function will then be equals to its answer.

FILL IN THE OUTPUT



- Can you trace the flow of the last statement?

EXERCISE

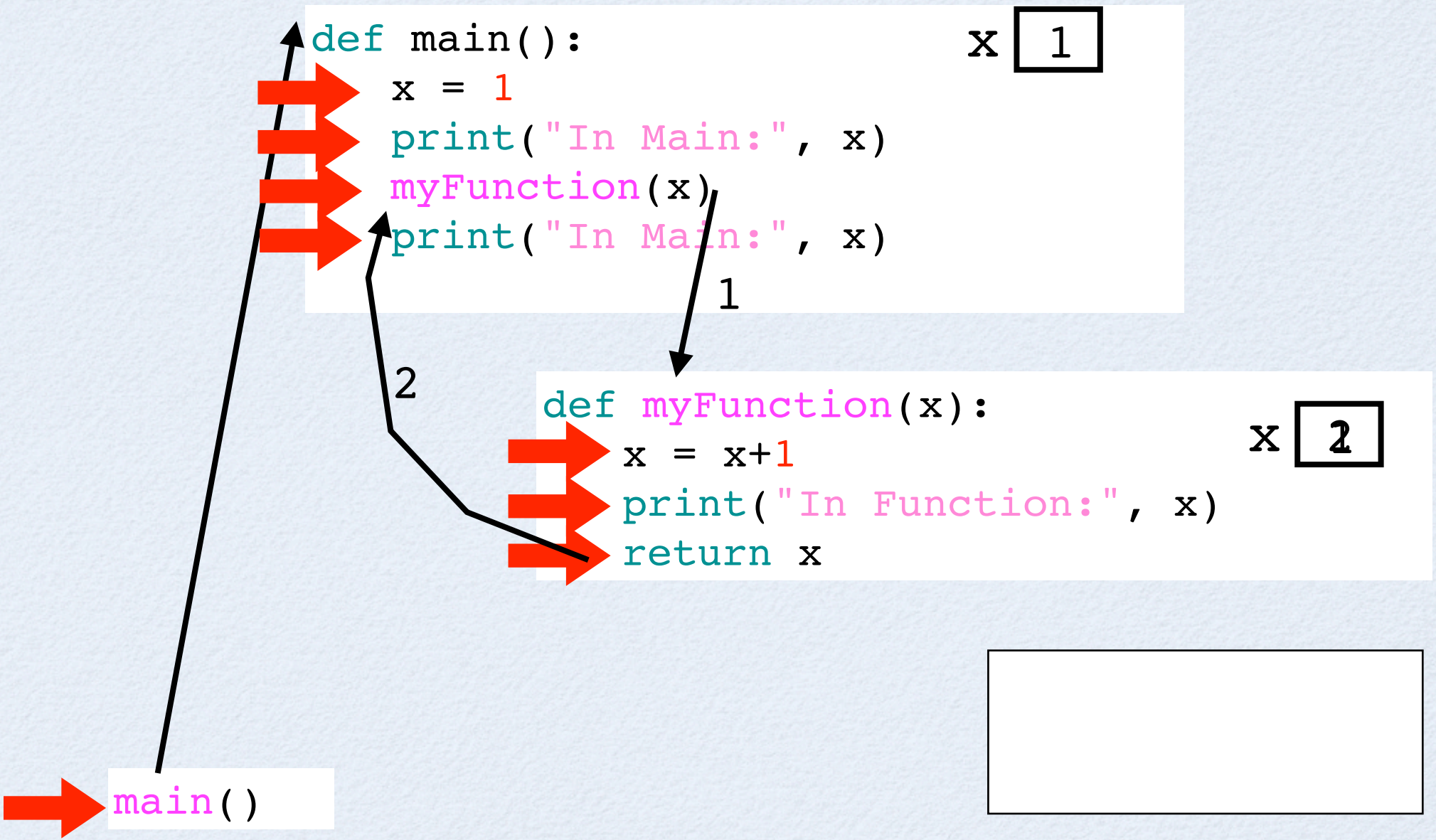
- What is the output of this program?

```
def myFunction(x):
    x = x+1
    print("In Function:", x)
    return x

def main():
    x = 1
    print("In Main:", x)
    myFunction(x)
    print("In Main:", x)
    myFunction(x)
    print("In Main:", x)

main()
```

Local Variables

- Note how both `main()` and `myFunction()` both had a variable called `x`.
- However, a change to `x` in `myFunction()` did not affect the value of `x` in `main()`.
- That's because there are two variables, one belonging to `myFunction()`, and one belonging to `main()`.
- Both are called `x` but they are independent.

TRACING THE FLOWS



EXERCISE

- What is the output of this program?

```
def myFunction(x):
    x = x+1
    print("In Function:", x)
    return x

def main():
    x = 1
    print("In Main:", x)
    x = myFunction(x)
    print("In Main:", x)
    x = myFunction(x)
    print("In Main:", x)

main()
```

EXERCISE

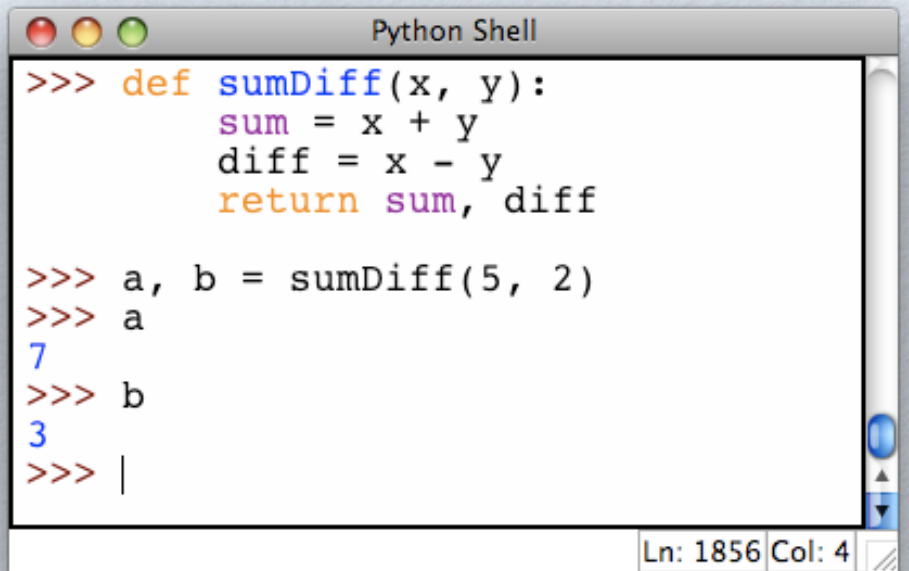
- Write a function, `countDown()`, that will work with the given `main()` function to generate *exactly* the given output.
- Hint: use a definite loop with a range, and `print()` with `end=" "`

```
def main():
    count = eval(input("Give me a whole number: "))
    countDown(count)

main()
```

```
C:\> python countDown.py
Give me a whole number: 10
10 9 8 7 6 5 4 3 2 1 Go!
C:\>
```

Multiple Return Values

- Unlike some other programming languages (e.g. C, Java), Python allows functions to return multiple values.
- A function with multiple return values should be placed into a simultaneous assignment program statement.
- As with parameters, when multiple values are returned, they are assigned to the variables by position



Objects as Parameters

- So far, we have been passing simple values (such as numbers) into the functions as arguments.
- However, *anything* can be passed into a function as an argument.
- This includes strings, objects, lists, etc.

PASSING BY VALUES

```
def addInterest(amount, rate):
    interest = amount*rate/100
    amount = amount + interest

def main():
    amount = 100
    rate = 3
    print("1. Amt:", amount)
    addInterest(amount, rate)
    print("2. Amt:", amount)

main()
```

- From previous slides, we know that in this program:
  - The variable `amount` in `addInterest()` and the variable `amount` in `main()` are two different variables.
  - A change to `amount` in `addInterest()` will not change the value of `amount` in `main()`

Passing by Values

```
def addInterest(amount, rate):
    interest = amount*rate/100
    amount = amount + interest

def main():
    amount = 100
    rate = 3
    print("1. Amt:", amount)
    addInterest(amount, rate)
    print("2. Amt:", amount)

main()
```

- What is happening here is:
  - The **value** of the variable `amount` gets passed to the function `addInterest()`.
  - The function makes its own variable called `amount`, and copies the passed value into the new variable.
  - As this is a new variable, any changes do not affect `main()`'s `amount`.
- This is called **passing by value**.

How about this program?

```
def addInterests(amounts, rate):
   for i in range(len(amounts)):
      interest = amounts[i]*rate/100
      amounts[i] = amounts[i] + interest

def main():
   amounts = [1000, 2000, 3500, 4800]
   rate = 3
   print("Before:", amounts)
   addInterests(amounts, rate)
   print("After:", amounts)

main()
```

```
J:\> python CalculateInterests.py
Before: [1000, 2000, 3500, 4800]
After: [1030.0, 2060.0, 3605.0, 4944.0]
J:\>
```

Functions and Lists

- Unlike the previous example, it seems that the function is able to modify the contents of the `amounts` list!
- But didn't we just say that parameters are passed by value? Then how can the function `addInterests()` make changes to the list in `main()`?

Functions and Lists

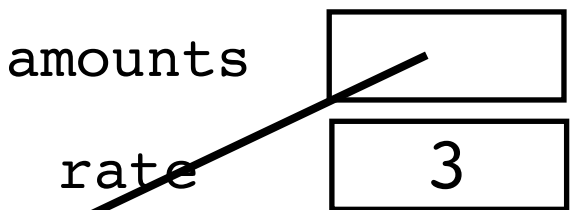
- Recall that variables in Python are only able to store one number at a time.
- So the variable `amounts` in main() actually stores the **reference** of the list.
- When the function addInterests() is called, what gets passed is the value of the variable `amounts` -- which is the **reference** of the list.

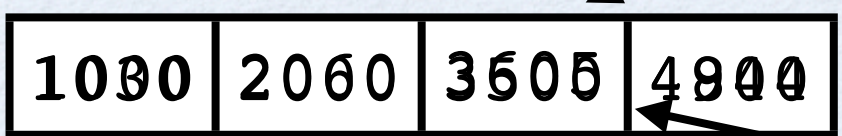
FUNCTIONS AND LISTS

```
main()
```

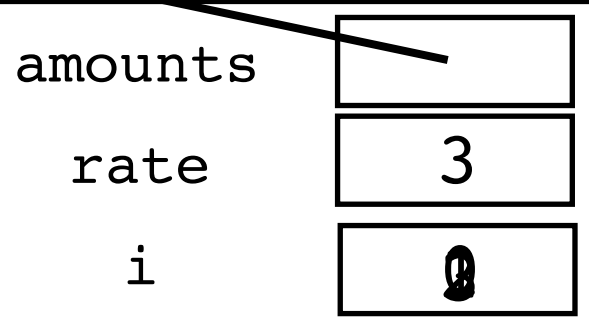
```
Before: [1000, 2000, 3500, 4800]
After: [1030, 2060, 3605, 4944]
```

```
def main():
    amounts = [1000, 2000, 3500, 4800]
    rate = 3
    print("Before:", amounts)
    addInterests(amounts, rate)
    print("After:", amounts)
```






```
def addInterests(amounts, rate):
    for i in range(len(amounts)):
        amounts[i] = amounts[i]*(1+rate/100)
```



Passing Parameters

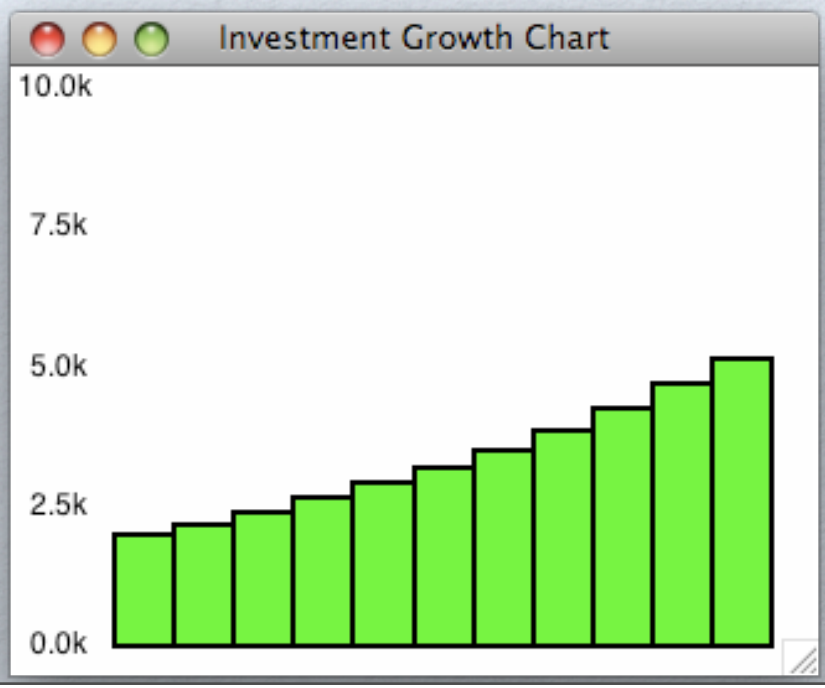
- In Summary:
  - All parameters are passed by value (i.e. the value of the parameter variable gets sent over to the function)
  - If the parameter is a number, then changes to the parameter variable in the function will not affect the variable in `main()` (or the calling function).
  - However, if the parameter is a reference to a mutable object (such as a list or a graphics object), then changes to the state of the object will be visible in `main()`.

Why are functions useful?

- Functions are useful for several reasons:
  - They (usually) make the program shorter and save effort on the part of the programmer.
  - They reduce the possibility of errors.
  - Properly named and used, they make the program more readable.

EXAMPLE

- Consider the following output and the program code (on the following page) that generates it.
- Without seeing the rest of the program, what do the functions `createLabeledWindow()` and `drawBar()` do?
- What are the steps taken by the program?
- Supposing we want to change the y-axis labels to one label per 2k, rather than 2.5k. Which function would you need to change?
- How do we know?



EXAMPLE

```
def main():
  principal = eval(input("How much did you invest?"))
  rate = eval(input("What is the interest per annum?"))

  window = createLabeledWindow()
  drawBar(window, 0, principal)
  for year in range(1, 11):
    principal = principal * (1+interest/100)
    drawBar(window, year, principal)

  input("Press <enter> to quit")
  win.close()
```

SUMMARY

- A properly designed program will use functions and comments to make itself **readable** and **maintainable.**
- With properly named and designed functions, the program can go a long way towards being **self-documenting**.
- We will talk more about program design later in the semester.
- For now, focus on using functions to make your code **modular** by separating repeated statements into functions.

You now know...

- Why programmers divide programs up into sets of cooperating functions.
- How to define new functions in Python
- The details of function calls and parameter passing in Python
- How to write programs that use functions to reduce code duplication and increase program modularity.