INTRODUCTION TO PYTHON: DAY ONE

STEPHANIE SPIELMAN

BIG DATA IN BIOLOGY SUMMER SCHOOL, 2015
CENTER FOR COMPUTATIONAL BIOLOGY AND BIOINFORMATICS
UNIVERSITY OF TEXAS AT AUSTIN

TOPICS WE'LL COVER:

Day One, May 26th

- UNIX / Bash
- Python data structures and basic operations

Day Two, May 27th

- Control flow in Python (if, for, while)

Day Three, May 28th

- Writing functions in Python
- File input/output

Day Four, May 29th

- Python modules
- BioPython: Handling sequence data
- Scripting

WHAT YOU WILL GAIN FROM THIS COURSE

- **You will NOT learn Python (in just 4 afternoons)**

WHAT YOU WILL GAIN FROM THIS COURSE

- **You will NOT learn Python (in just 4 afternoons)**
- **The idea is to give you the *resources* and the *skills* to continue learning and applying these concepts on your own**

WHAT YOU WILL GAIN FROM THIS COURSE

- **You will NOT learn Python (in just 4 afternoons)**
- **The idea is to give you the *resources* and the *skills* to continue learning and applying these concepts on your own**

- **…Ok, you'll learn some Python ☺**

WHY LEARN COMPUTER PROGRAMMING?

- Speed
- Automation
- Repeatability

WHY LEARN PYTHON?

- **Higher-level language with extensive functionality**
  - Well-documented
  - Widely-used
  - Very readable and user-friendly
  - Excellent for handling text and files
- **The main drawback is speed**

COMPUTERS ARE STUPID

No, really.

LET'S BEGIN WITH UNIX

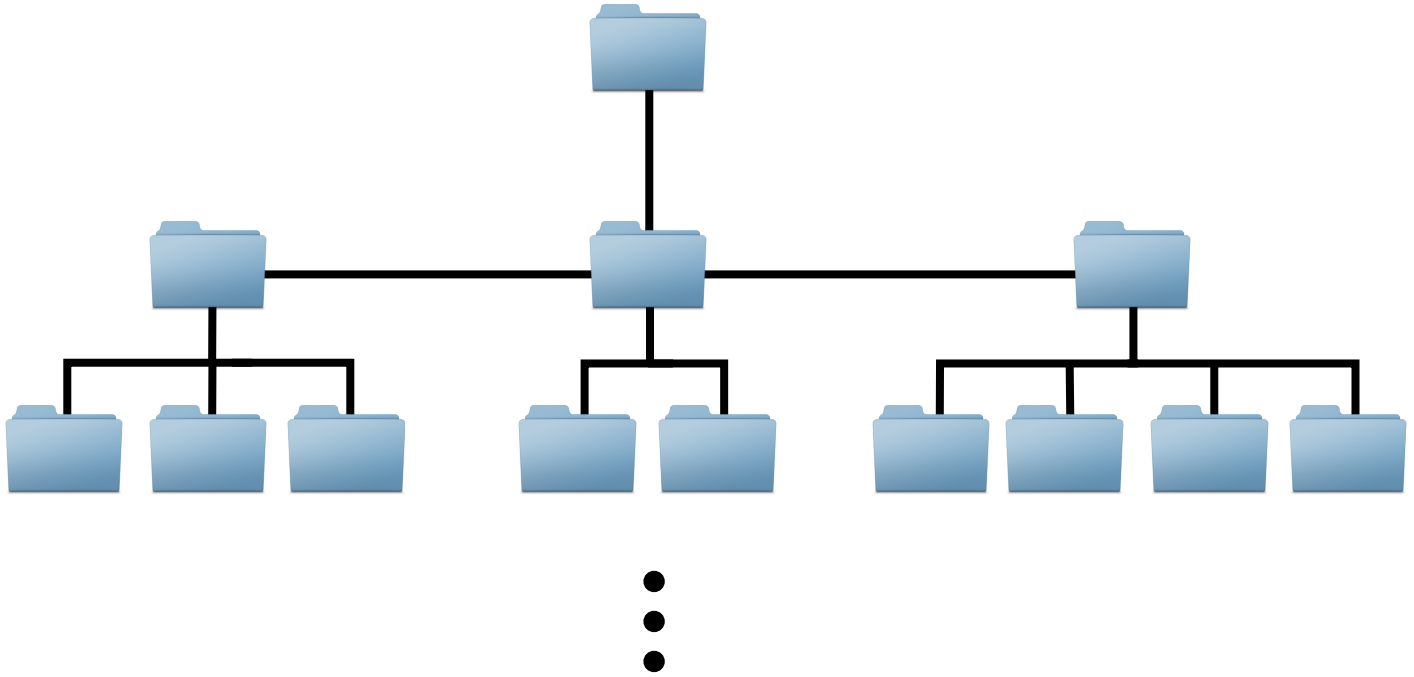
- **UNIX is a computer operating system**
  - Mac and Linux are built on UNIX, but PCs are not ☹

LET'S BEGIN WITH UNIX

- **UNIX is a computer operating system**
  - Mac and Linux are built on UNIX, but PCs are not ☹
- **We interact with this system using a *shell*.**
  - We'll use Bash (bourne-again shell)

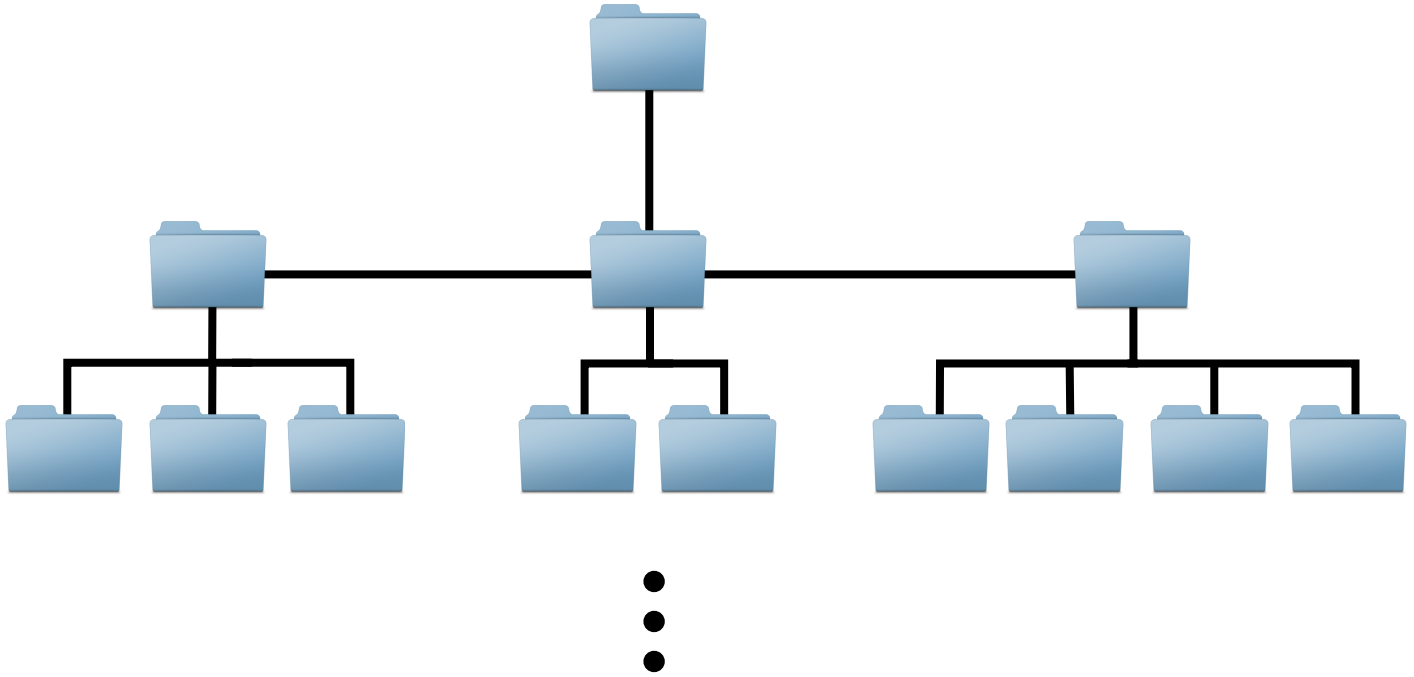
NAVIGATING UNIX SYSTEMS

Files and directories in UNIX systems are organized *hierarchically*



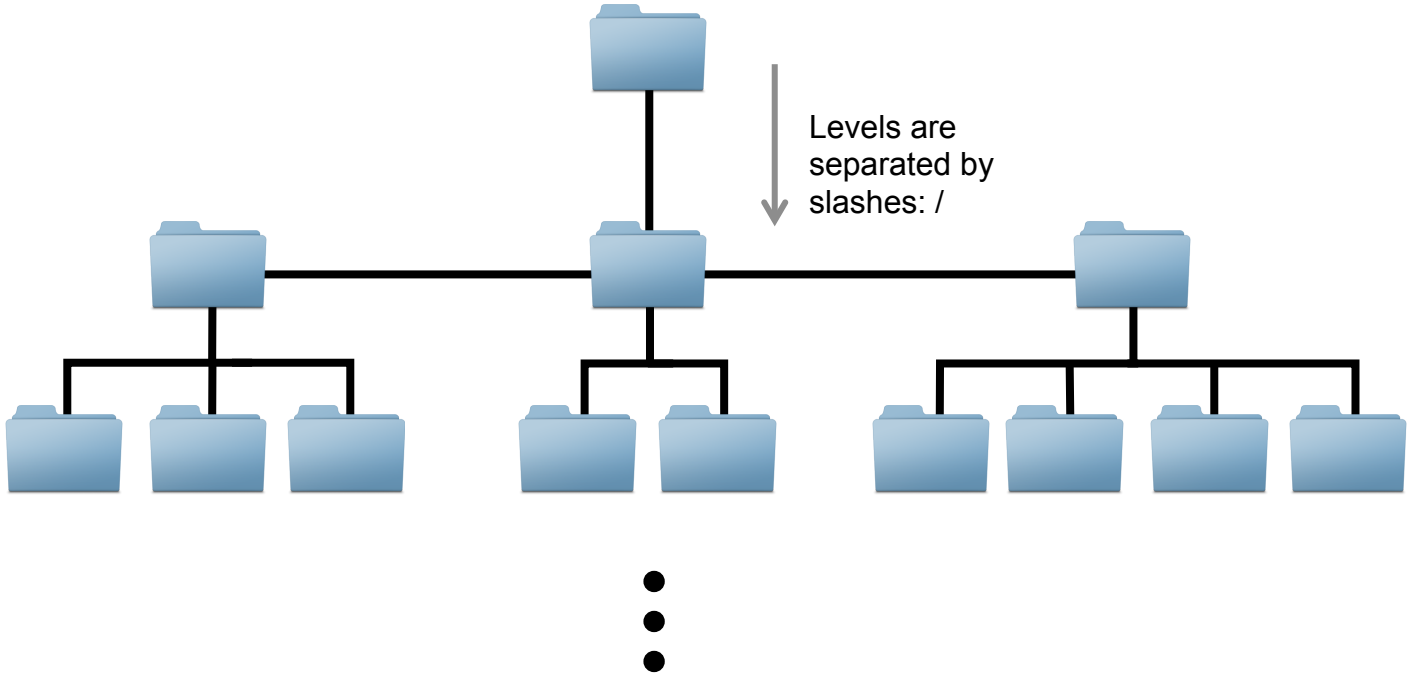
NAVIGATING UNIX SYSTEMS

Every file/directory has a specific address, or path, in the hierarchy



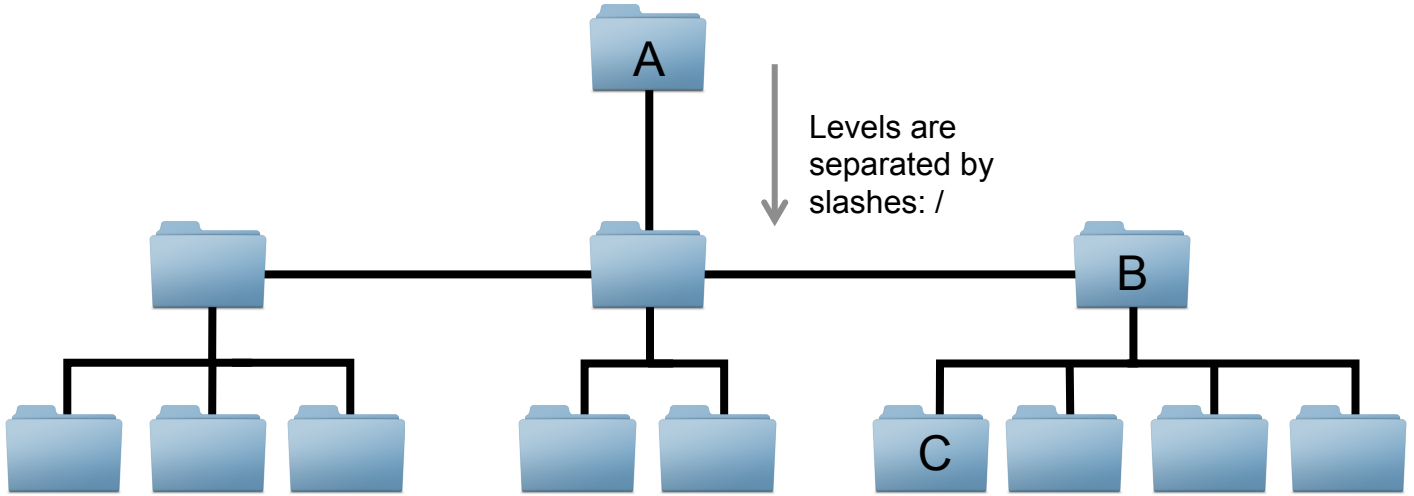
NAVIGATING UNIX SYSTEMS

Every file/directory has a specific address, or path, in the hierarchy



NAVIGATING UNIX SYSTEMS

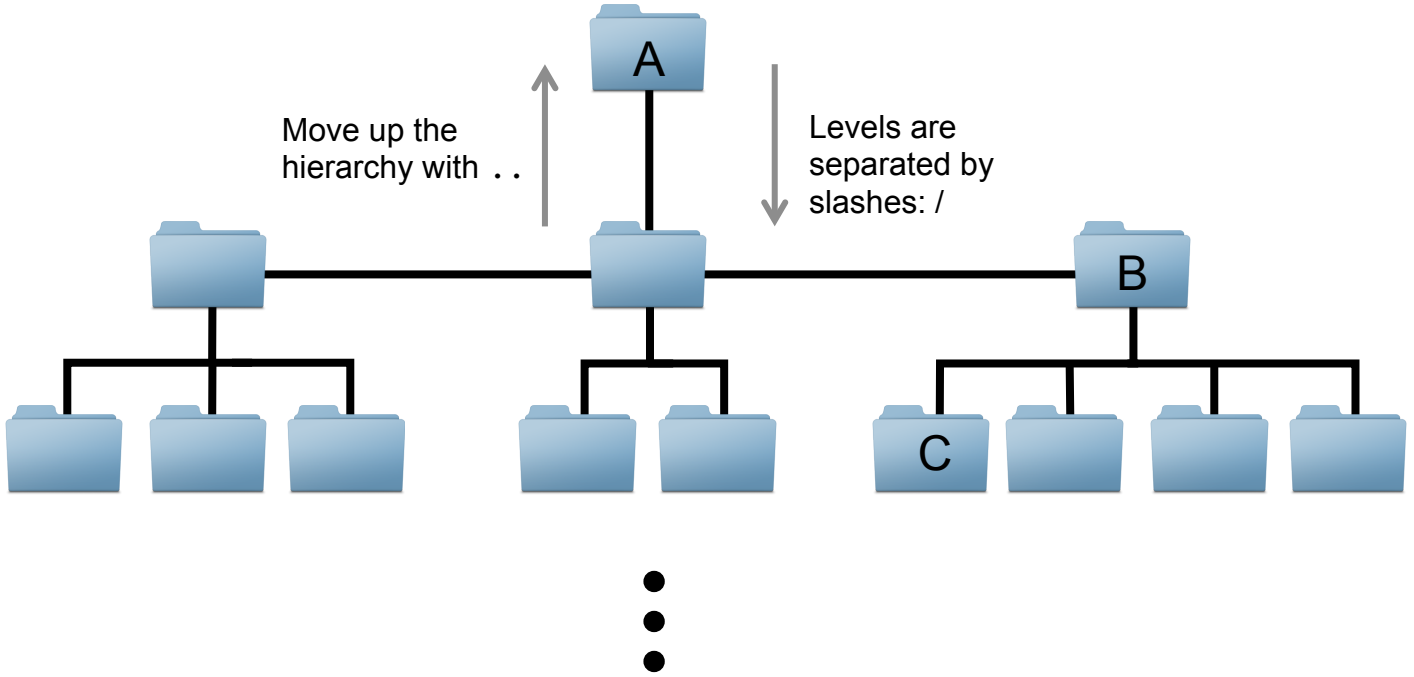
Every file/directory has a specific address, or path, in the hierarchy



The path from A to C is B/C

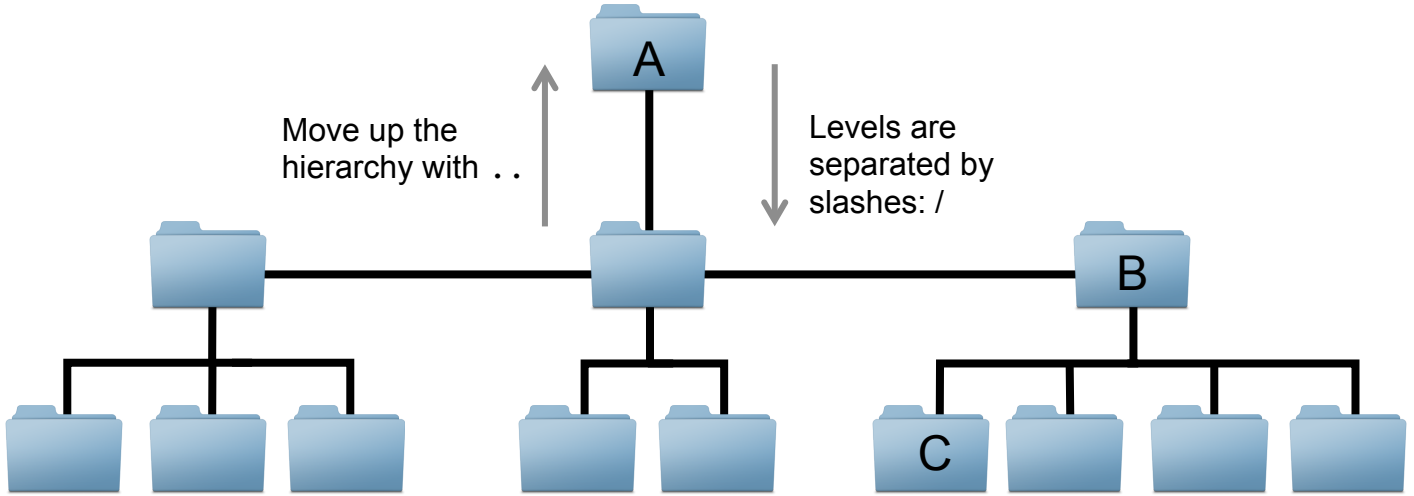
NAVIGATING UNIX SYSTEMS

Every file/directory has a specific address, or path, in the hierarchy



NAVIGATING UNIX SYSTEMS

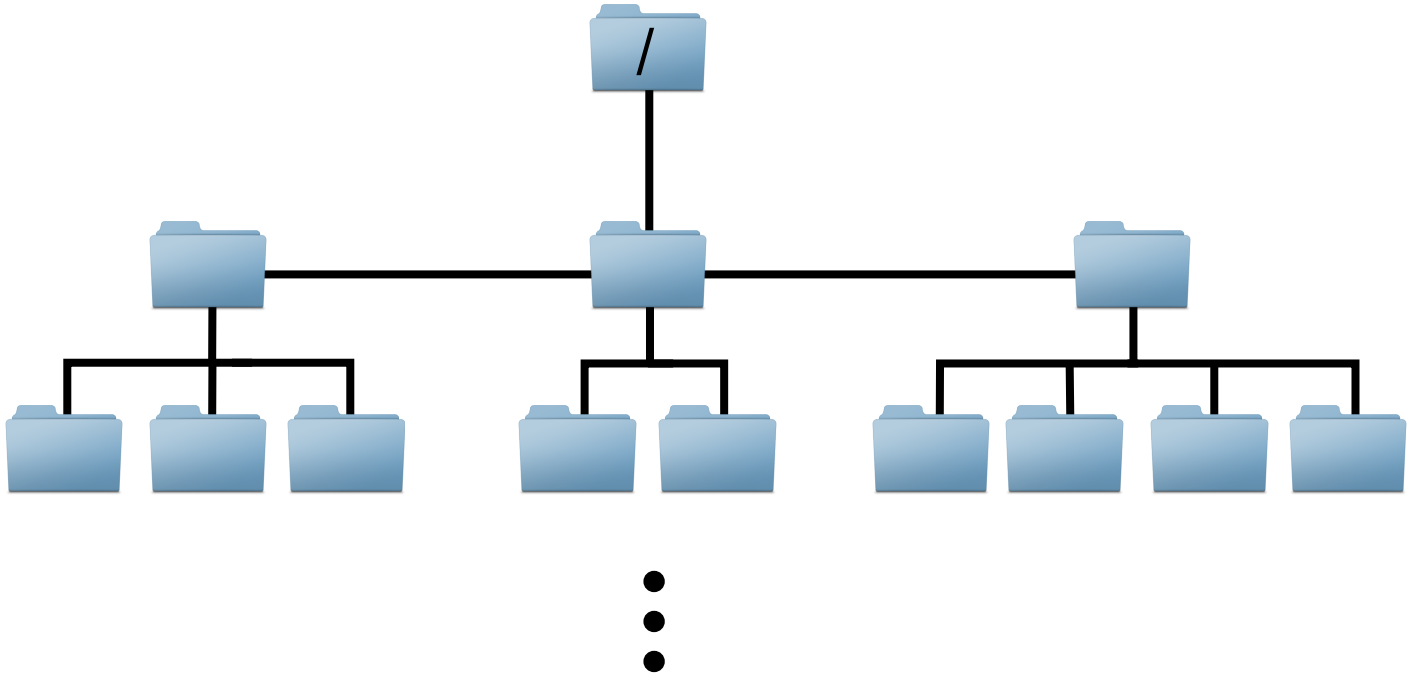
Every file/directory has a specific address, or path, in the hierarchy



The path from C to A is . . / . .

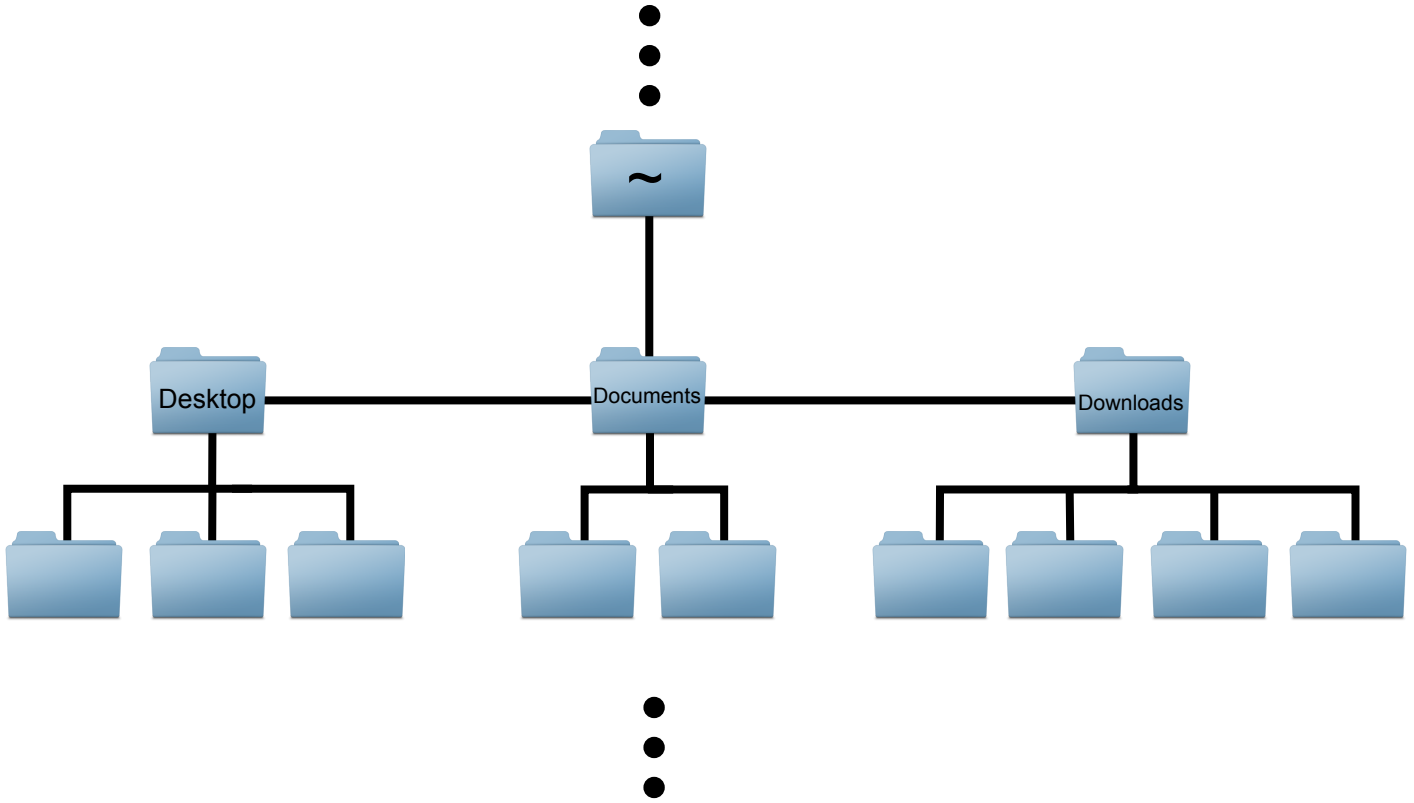
NAVIGATING UNIX SYSTEMS

The *top-level* directory is called *root*, and is denoted with single slash



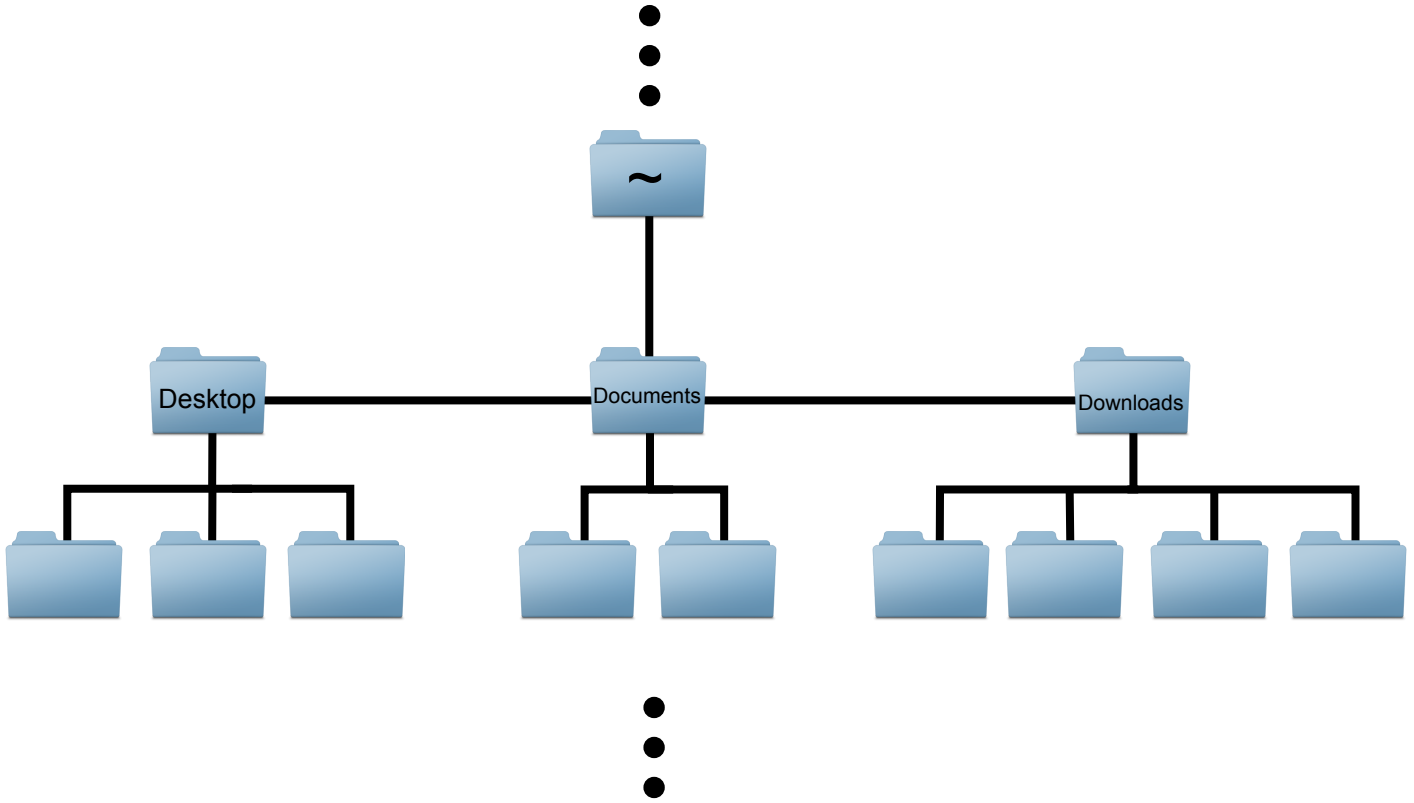
NAVIGATING UNIX SYSTEMS

Your *home directory* is where you live



NAVIGATING UNIX SYSTEMS

Your *home directory* is where you live



The *full path* to my home directory is `/Users/sjspielman/`

NAVIGATING UNIX SYSTEMS

We move around in our file system with the command `cd` (*c*hange *d*irectory)

- Absolute, or full, path is the path *from the root*
- Relative path is the path *from the working directory* (i.e., where you are)

BASIC UNIX COMMANDS

- **All UNIX commands are actually *little computer programs***

BASIC UNIX COMMANDS

UNIX Command	What it does
`cd`	**C**hange **D**irectory
`pwd`	**P**rint **W**orking **D**irectory (gives the full path)
`ls`	**Ls**t (contents of a directory
`mv`	**Mov**e a file or directory (original not retained!)
`cp`	**Cop**y a file or directory (original *is* retained)
`rm`	**Rem**ove a file or directory *forever* (NOT A TRASHCAN)
`mkdir`	**Mak**e a new **dir**ectory
`echo`	Prints to screen
`touch`	Create a new (empty) file
`man`	**Man**ual (shows documentation for a given command)

…And UNIX symbols/shortcuts!

- Typing tab "auto-completes"
- The greater-than sign, >, will re-direct printing to a file (overwrites the file!)
- Two greater-than signs, >>, will also re-direct, but will *append* to the file

ENTER, PYTHON!

- **Python is an *interpreted* language**
  - We can code either using the interpreter directly or using *scripts* (text files with python code)

ENTER, PYTHON!

- **Python is an *interpreted* language**
  - We can code either using the interpreter directly or using *scripts* (text files with python code)

- **Python is an *object-oriented language***

ENTER, PYTHON!

- **Python is an *interpreted* language**
  - We can code either using the interpreter directly or using *scripts* (text files with python code)

- **Python is an *object-oriented language***
  - Objects have *methods* and *attributes*

```
object.method()
object.attribute
```

PYTHON DATA TYPES

- **Each defined variable has a *name*, *value*, and *type***
  - The *type* determines what you can do with the variable

PYTHON DATA TYPES

- **Each defined variable has a *name*, *value*, and *type***
  - The *type* determines what you can do with the variable
- **We will cover these basic types:**
  - Integers
  - Floats
  - Lists
  - Strings
  - Dictionaries (tomorrow)

INTEGERS AND FLOATS

```
# Define some integer variables
a = 5
b = -33
c = 0


# Define some float variables
d = 5.67
e = -33.2
f = 0.
```

INTEGERS AND FLOATS

```
# Define some integer variables
a = 5
b = -33
c = 0
```

Integers are *counting numbers*

```
# Define some float variables
d = 5.67
e = -33.2
f = 0.
```

Floats have *decimals*

INTEGERS AND FLOATS

```
# Define some integer variables
a = 5
b = -33
c = 0


# Define some float variables
d = 5.67
e = -33.2
f = 0.
```

The name of this variable is f.
The value of this variable is 0.
The type of this variable is float.

INTEGERS AND FLOATS

```
# Define some integer variables
a = 5
b = -33
c = 0

# Define some float variables
d = 5.67
e = -33.2
f = 0.
```

Comments are denoted with hashtags

MATHEMATICAL OPERATIONS

- **Standard symbols**
  - +, -, *, /, %

MATHEMATICAL OPERATIONS

- **Standard symbols**
  - +, -, *, /, %

```
# Define variables and math them
a = 5
b = -33
c = a + b  #c now has a value -28
```

MATHEMATICAL OPERATIONS

- **Standard symbols**
  - +, -, *, /, %

```
# Define variables and math them
a = 5
b = -33
c = a + b  #c now has a value -28
```

What type of variable is c?

MATHEMATICAL OPERATIONS

- **Standard symbols**
  - +, -, *, /, %

```
# Define variables and math them
a = 5
b = -33
c = a + b  #c now has a value -28
```

```
# Define variables and math them
a = 5.0
b = -33
c = a + b  #c now has a value -28.0
```

MATHEMATICAL OPERATIONS

- **Standard symbols**
  - +, -, *, /, %

```
# Define variables and math them
a = 5
b = -33
c = a + b  #c now has a value -28
```

```
# Define variables and math them
a = 5.0
b = -33
c = a + b  #c now has a value -28.0
```

What type of variable is c now?

RESULTS FOLLOW THE INPUT TYPES!

```
# Dividing two integers results in an integer
a = 5
b = 7
c = a / b
```

RESULTS FOLLOW THE INPUT TYPES!

```
# Dividing two integers results in an integer
a = 5
b = 7
c = a / b

# Use print statements to see output
print c
    0
```

RESULTS FOLLOW THE INPUT TYPES!

```
# Dividing two integers results in an integer
a = 5
b = 7
c = a / b

# Use print statements to see output
print c
    0

# The solution is to make one of the variables a float

        a = 5.
        b = 7
        c = a / b
        print c
          0.714285714
```

RESULTS FOLLOW THE INPUT TYPES!

```
# Dividing two integers results in an integer
a = 5
b = 7
c = a / b

# Use print statements to see output
print c
    0

# The solution is to make one of the variables a float
```

```
a = 5.
b = 7
c = a / b
print c
  0.714285714
```

```
a = 5
b = 7
c = a / float(b)
print c
  0.714285714
```

MODIFYING THE VALUE IN PLACE

- **Mathematical symbols followed by an equals sign will change the variable value *in place***

MODIFYING THE VALUE IN PLACE

- **Mathematical symbols followed by an equals sign will change the variable value *in place***
  - +=, -=, *=, /=

MODIFYING THE VALUE IN PLACE

- **Mathematical symbols followed by an equals sign will change the variable value *in place***

```
# Increment by 5
a = 77
a += 5
print a
    83
```

```
# Multiply by 8
b = 2.5
b *= 8
print b
    20.0
```

PYTHON LISTS

- **Lists are defined with brackets: []**

PYTHON LISTS

- **Lists are defined with brackets: []**

```
# Define a list
a = [1, 3, 5, 7, 9]

# Define another list
b = [1, 3.1, -5, 7, 9.001]

# Define another list with *strings* (stay tuned!)
c = [1, 3.1, -5, 7, 9.001, "woah", "dude"]

# Define another list..of lists!
d = [ [1, 2, 3], [11, 22, 33], [7.55, -9] ]
```

PYTHON LISTS

- **Lists are defined with brackets: []**

```
# Define a list
a = [1, 3, 5, 7, 9]

# Define another list
b = [1, 3.1, -5, 7, 9.001]

# Define another list with *strings* (stay tuned!)
c = [1, 3.1, -5, 7, 9.001, "woah", "dude"]

# Define another list..of lists!
d = [ [1, 2, 3], [11, 22, 33], [7.55, -9] ]
```

What do you notice about the variable types inside these lists?

INDEXING IN PYTHON

```
d = [1, 3, 5, 7, 9, 11, 13]
     0  1  2  3  4  5   6    ← Indexing starts from 0!
```

INDEXING IN PYTHON

```
d = [1, 3, 5, 7, 9, 11, 13]
     0  1  2  3  4  5   6    ← Indexing starts from 0!


# Index the second entry in d using brackets []
print d[1]
   3
```

INDEXING IN PYTHON

```
d = [1, 3, 5, 7, 9, 11, 13]
     0  1  2  3  4  5   6    ← Indexing starts from 0!


# Index the second entry in d using brackets []
print d[1]
   3

# Index a slice of the list with [x:y]
print d[1:4]
   [3, 5, 7]
```

INDEXING IN PYTHON

```
d = [1, 3, 5, 7, 9, 11, 13]
     0  1  2  3  4  5   6    ← Indexing starts from 0!


# Index the second entry in d using brackets []
print d[1]
    3

# Index a slice of the list with [x:y]
print d[1:4]
   [3, 5, 7]
```

In [x:y], x is inclusive and y is exclusive

INDEXING IN PYTHON

```
d = [1, 3, 5, 7, 9, 11, 13]
     0  1  2  3  4  5   6    ← Indexing starts from 0!


# Index the second entry in d using brackets []
print d[1]
    3

# Index a slice of the list with [x:y]
print d[1:4]
   [3, 5, 7]   In [x:y], x is inclusive and y is exclusive

# x and y defaults are 0 and "last index"
```

INDEXING IN PYTHON

```
d = [1, 3, 5, 7, 9, 11, 13]
     0  1  2  3  4  5   6    ← Indexing starts from 0!


# Index the second entry in d using brackets []
print d[1]
    3

# Index a slice of the list with [x:y]
print d[1:4]
    [3, 5, 7]
```

In [x:y], x is inclusive and y is exclusive

```
# x and y defaults are 0 and "last index"
print d[3:]  # assumes go through end of list
    [7, 9, 11, 13]
```

INDEXING IN PYTHON

```
d = [1, 3, 5, 7, 9, 11, 13]
     0  1  2  3  4  5   6    ← Indexing starts from 0!


# Index the second entry in d using brackets []
print d[1]
    3

# Index a slice of the list with [x:y]
print d[1:4]
   [3, 5, 7]   In [x:y], x is inclusive and y is exclusive

# x and y defaults are 0 and "last index"
print d[3:]  # assumes go through end of list
   [7, 9, 11, 13]
print d[:5]  # assumes start at beginning of list
   [1, 3, 5, 7, 9]
```

INDEXING IN PYTHON

```
d = [1,  3,  5,  7,  9,  11,  13]
     0   1   2   3   4   5    6   ← Indexing starts from 0!
    -7  -6  -5  -4  -3  -2   -1   ← Negative indexing

# Index the last entry in d using brackets []
print d[-1]
    13
```

COMMON LIST METHODS

```
# Define a list
a = [1, 3, 5, 7, 9, 11, 13]
```

COMMON LIST METHODS

```
# Define a list
a = [1, 3, 5, 7, 9, 11, 13]

# The .append() method adds a value to the end of the list
a.append(15)
print a
    [1, 3, 5, 7, 9, 11, 13, 15]
```

COMMON LIST METHODS

```
# Define a list
a = [1, 3, 5, 7, 9, 11, 13]

# The .append() method adds a value to the end of the list
a.append(15)
print a
    [1, 3, 5, 7, 9, 11, 13, 15]

# The .index() method extracts the index of a given value
print a.index(3)
    1
```

COMMON LIST METHODS

```
# Define a list
a = [1, 3, 5, 7, 9, 11, 13]

# The .append() method adds a value to the end of the list
a.append(15)
print a
    [1, 3, 5, 7, 9, 11, 13, 15]

# The .index() method extracts the index of a given value
print a.index(3)
    1

# The .pop() method removes a certain index from the list
print a.pop(1)
    [1, 5, 7, 9, 11, 13]
```

COMMON LIST METHODS

```
# Define a list
a = [1, 3, 5, 7, 9, 11, 13]

# The .append() method adds a value to the end of the list
a.append(15)
print a
    [1, 3, 5, 7, 9, 11, 13, 15]

# The .index() method extracts the index of a given value
print a.index(3)
    1

# The .pop() method removes a certain index from the list
print a.pop(1)
    [1, 5, 7, 9, 11, 13]

print a.pop() # Default behavior removes last index
    [1, 3, 5, 7, 9, 11]
```

PYTHON STRINGS

- **Strings are defined with quotes: " " or ' '**

PYTHON STRINGS

- **Strings are defined with quotes: " " or ' '**

```
# Define some example strings
a = "s"
b = "python"
c = "I love python!"
d = "55"
```

PYTHON STRINGS

- **Strings are defined with quotes: " " or ' '**

```
# Define some example strings
a = "s"
b = "python"
c = "I love python!"
d = "55"
```

Why is d a string and not an integer?

PYTHON STRINGS

- **Strings are defined with quotes: " " or ' '**

```
# Define some example strings
a = "s"
b = "python"
c = "I love python!"
d = "55"
```

- **We can index strings just like lists**

PYTHON STRINGS

- **Strings are defined with quotes: " " or ' '**

```
# Define some example strings
a = "s"
b = "python"
c = "I love python!"
d = "55"
```

- **We can index strings just like lists**

```
print b[3] # the printed value is also a string
    h

print c[:6]
   I love
```

COMMON STRING METHODS

```
# Define a string
s = "This is an example string."
```

COMMON STRING METHODS

```
# Define a string
s = "This is an example string."

# The .upper() method makes the string uppercase
print s.upper()
    THIS IS AN EXAMPLE STRING.
```

COMMON STRING METHODS

```
# Define a string
s = "This is an example string."

# The .upper() method makes the string uppercase
print s.upper()
    THIS IS AN EXAMPLE STRING.

# The .lower() method makes the string lowercase
print s.lower()
    this is an example string.
```

COMMON STRING METHODS

```
# Define a string
s = "This is an example string."

# The .upper() method makes the string uppercase
print s.upper()
    THIS IS AN EXAMPLE STRING.

# The .lower() method makes the string lowercase
print s.lower()
    this is an example string.

# The .count() method counts occurrences of a given character
print s.count("i")
     3
```

COMMON STRING METHODS

```
# Define a string
s = "This is an example string."

# The .upper() method makes the string uppercase
print s.upper()
    THIS IS AN EXAMPLE STRING.

# The .lower() method makes the string lowercase
print s.lower()
    this is an example string.

# The .count() method counts occurrences of a given character
print s.count("i")
     3

# The .split() method splits on a character, returns a list
print s.split("i")
    ["Th", "s ", "s an example str", "ng."]
```

STRINGS VS LISTS

- **Strings cannot be modified in place**
  - You must *re-define* the string to change it.
- **Lists can be modified in place**

STRINGS ARE IMMUTABLE

```
# Strings *will not* change when methods are called
s = "example"
s.upper()
print s
    example
```

STRINGS ARE IMMUTABLE

```
# Strings *will not* change when methods are called
s = "example"
s.upper()
print s
    example

# But if we re-define s when calling .upper()...
s = s.upper()
print s
    EXAMPLE
```

STRINGS ARE IMMUTABLE

```
# Strings *will not* change when methods are called
s = "example"
s.upper()
print s
    example

# But if we re-define s when calling .upper()...
s = s.upper()
print s
    EXAMPLE

# We'll get *an error* if we try too much
s[2] = "A"
```

```
Traceback (most recent call last):
  TypeError: 'str' object does not support item assignment
```

LISTS ARE MUTABLE

```
# Lists *will* change when methods are called
f = [1, 2, 3]
f.append(4)
print f
    [1, 2, 3, 4]
```

LISTS ARE MUTABLE

```
# Lists *will* change when methods are called
f = [1, 2, 3]
f.append(4)
print f
    [1, 2, 3, 4]

# We can use indexing to re-write items in lists
f[2] = 77.8
print f
    [1, 2, 77.8, 4]
```

A NOTE ON METHODS

- **Methods are functions *specific to a certain object***
- **Functions are/can be much more general:**

```
s = "python"
print len(s)  # number of characters
    6

d = ["p", "y", "t", "h", "o", "n"]
print len(d)  # number of items
    6
```

A NOTE ON PRINT STATEMENTS

- **To print *more than one thing*, join items together with +, *as strings***

A NOTE ON PRINT STATEMENTS

```
pi = 3.1415

print pi
    3.1415

# To print a string and a float, re-cast the float to a string
print "The value of pi is" + str(pi)
    The value of pi is 3.1415
```

A NOTE ON PRINT STATEMENTS

```
pi = 3.1415

print pi
    3.1415

# To print a string and a float, re-cast the float to a string
print "The value of pi is" + str(pi)
    The value of pi is 3.1415


# Print statements that won't work:
print "The value of pi is" str(pi)
print "The value of pi is" + pi
print "The value of pi is" pi
print "The value of pi is pi"
```

A NOTE ON PRINT STATEMENTS

```
pi = 3.1415

print pi
    3.1415

# To print a string and a float, re-cast the float to a string
print "The value of pi is" + str(pi)
    The value of pi is 3.1415


# Print statements that won't work:
print "The value of pi is" str(pi)  # missing a +
print "The value of pi is" + pi     # can't join float and str
print "The value of pi is" pi       # lotsa problems
print "The value of pi is pi"       # ok, this works, kinda!
```

A NOTE ON PRINT STATEMENTS

With + and re-casting, we can print anything!

```
myname = "Stephanie"
myage = 26
myhometown = "Naples, Florida"

print "The Intro to Python instructor is named " + myname +
". She is " + str(myage) + " years old, and she is from " +
myhometown + "."
```

```
The Intro to Python instructor is named Stephanie. She is
26 years old, and she is from Naples, Florida.
```

BE CAUTIOUS: PYTHON2 VS PYTHON3

- **Print statements no longer exist in Python3 ! Instead, there is a print *function***

BE CAUTIOUS: PYTHON2 VS PYTHON3

- **Print statements no longer exist in Python3 ! Instead, there is a print *function***

```
pi = 3.1415

# Python2
print pi

# Python3
print(pi)
```

EXERCISE BREAK