



Welcome to Programming Bootcamp!

(Please sign-in in the back)



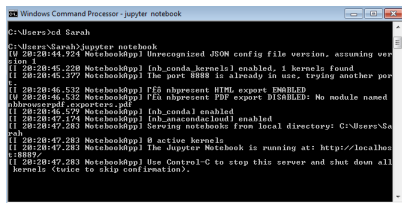
Goal

Get you comfortable enough with Python basics that you can easily learn more on your own when the course is done.

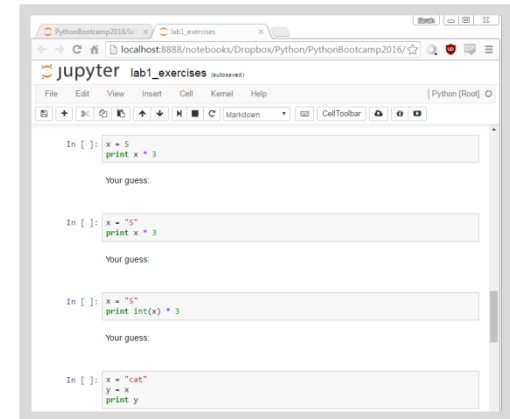
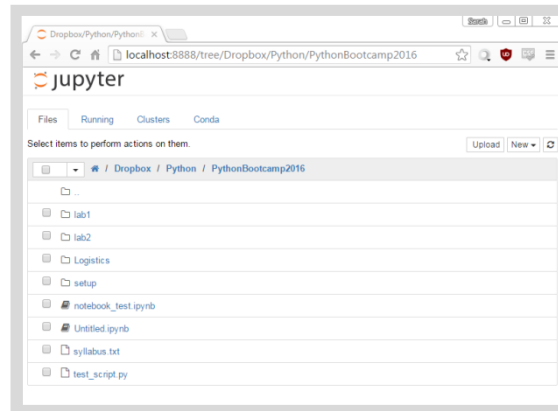


Advice for getting the most out of this course

- **Do the problem sets!!**
- Review the answers when they are released
- Always try to solve problems yourself first
- BUT: don't be afraid to ask questions when you get stuck!



```
C:\Users\Sarah>jupyter notebook
[I 20:28:44.324 NotebookApp] Recognized JSON config file version, assuming ver
...
[I 20:28:47.283 NotebookApp] The Jupyter Notebook is running at: http://localhost:8888/
Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).
```



Jupyter Server

- Do not close this window until you are completely done!
- You can't use this terminal window while the server is running
- To end the server: Ctrl+C twice
- This server is not accessible from the internet (there are ways you could make it accessible, but it's not by default).

Jupyter File Browser

- Do not close this tab until you are completely done!
- The files shown are all on your computer.
- Although it uses your web browser, it does not use the internet.
- Think of it as just a viewer/navigator for files on your computer.
- Click a notebook (.ipynb file) to open it.

Jupyter Notebook

- You can have many notebooks open at once.
- Closing this tab does not actually terminate the notebook (it'll keep running in the background).
- To terminate the notebook, go to File > Close and Halt
- When you edit this notebook here, you are editing the notebook on your computer.
- When you save this notebook here, you are saving it on your computer.
- Make sure to save before closing.

Conventions used in these slides

- Text written in `fixed width font` represents actual Python code or terminal commands.
- Color Codes:
 - code **comments** will be `green`
 - **reserved words** and **built-in functions** will be `blue`

Introduction to Programming and Python

Programming Bootcamp 2018

Session 1 – 7/18/2018

Lecturer: Apexa Modi

Today's topics

1. What is a program?
2. Writing and running Python code
3. Print statements
4. Error messages
5. Variables & data types
6. Basic math

Note: If you're following along online, see the notes panel (below the slides) for some additional clarifying information.

1. What is a program?

What is a program?

Program - A set of instructions that tells the computer how to perform a task.

The words "program" and "script" can often be used interchangeably, though "script" is generally used to describe quicker, simpler programs.

What is a programming language?

- Computers only understand binary (0's and 1's)
- Writing code in binary is very hard for humans.
- So, programming languages were created:
 - Human writes code in human-friendly language
 - An "interpreter" or "compiler" translates the code into computer language
 - The computer runs the translated code
- Python is just one of many such "human-friendly" programming languages.

Why learn Python?

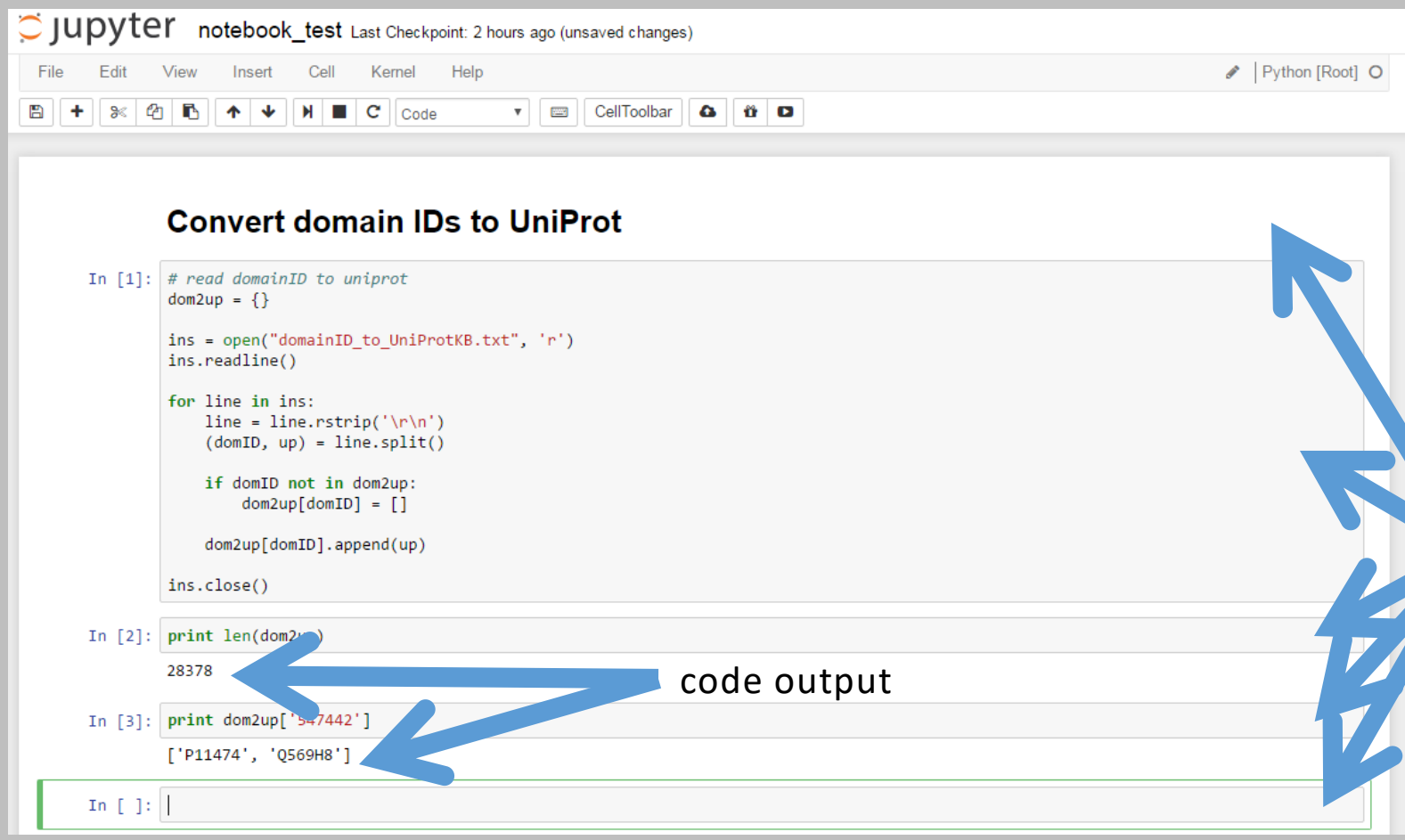
- It's a particularly simple and easy to learn language
- It's widely used by scientists
- Personal preference

2. Writing and running Python code

Two main ways to use Python

- Using Jupyter Notebooks:
 - write code in "cells" and then execute individual cells, one at a time
 - run in the web browser; requires notebook viewer
- Using scripts:
 - write code in a file and then execute the whole file at once
 - run from the terminal

Jupyter Notebooks



The screenshot displays the Jupyter Notebook interface. At the top, the title bar shows "jupyter notebook_test" and "Last Checkpoint: 2 hours ago (unsaved changes)". Below this is a menu bar with "File", "Edit", "View", "Insert", "Cell", "Kernel", and "Help". A toolbar with various icons is positioned below the menu bar. The main area contains a code cell titled "Convert domain IDs to UniProt". The code in the cell reads:

```
In [1]: # read domainID to uniprot
dom2up = {}

ins = open("domainID_to_UniProtKB.txt", 'r')
ins.readline()

for line in ins:
    line = line.rstrip('\r\n')
    (domID, up) = line.split()

    if domID not in dom2up:
        dom2up[domID] = []

    dom2up[domID].append(up)

ins.close()
```

Below the code cell, the output of the code is displayed:

```
In [2]: print len(dom2up)
28378

In [3]: print dom2up['547442']
['P11474', 'Q569H8']
```

At the bottom, there is an empty input cell labeled "In []: |".

Blue arrows point from the text "code output" to the output of the second and third code cells. Another set of blue arrows points from the text "cells (text or code)" to the code cells themselves.

Using Jupyter Notebooks (do this now)

1. Open a terminal window
2. (Optional) Navigate to a convenient directory
 - the directory where you launch Jupyter becomes the root for that session, and you will only be able to access directories within that root directory.
 - use `cd <directoryName>` and `cd ..` to move around
3. Launch the notebook with the following command:

`jupyter notebook`

```
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. All rights reserved.

C:\Windows\System32>cd ..
C:\Windows>cd ..
C:\>cd Users
C:\Users>cd Sarah
C:\Users\Sarah>jupyter notebook
```

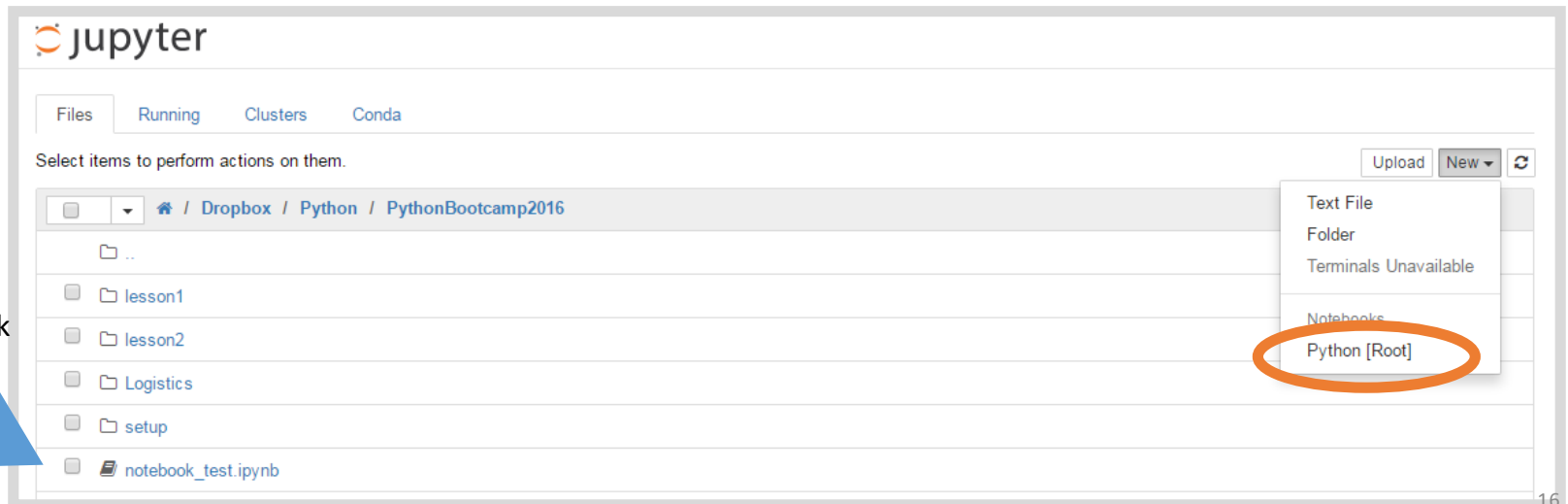
Example (on Windows)

```
9801a79c84fd:~ mishrar2$ pwd
/Users/mishrar2
9801a79c84fd:~ mishrar2$ ls
Anaconda3-4.3.1-MacOSX-x86_64.sh  Music
AnacondaProjects                 Pictures
Applications                     Public
Desktop                         anaconda
Documents                       anaconda3
Downloads                       igv
Library                         seaborn-data
Movies
9801a79c84fd:~ mishrar2$ jupyter notebook
```

Example (on Mac)

Using Jupyter Notebooks (do this now)

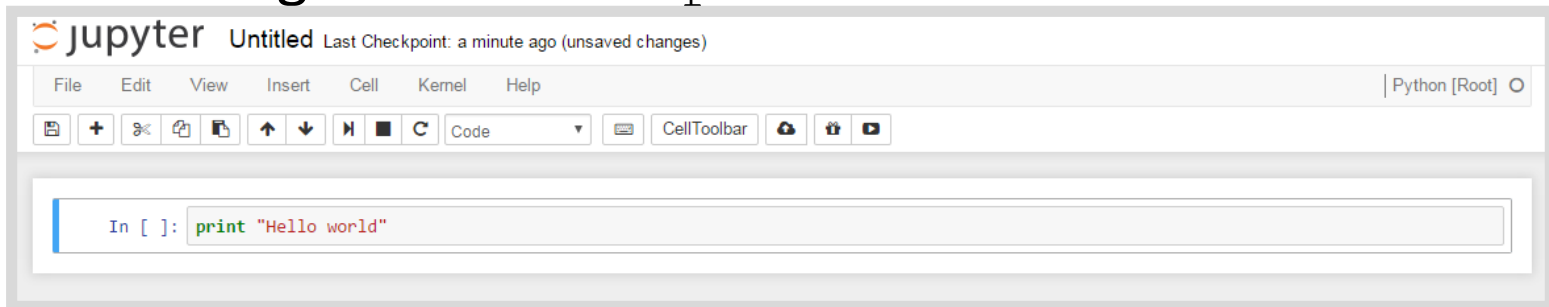
4. A web browser window should pop up. This is the Jupyter file browser.
5. Navigate to the folder where you would like the new Jupyter notebook to be.
6. Click 'New' in the upper right corner and select 'Python' to create a new notebook.



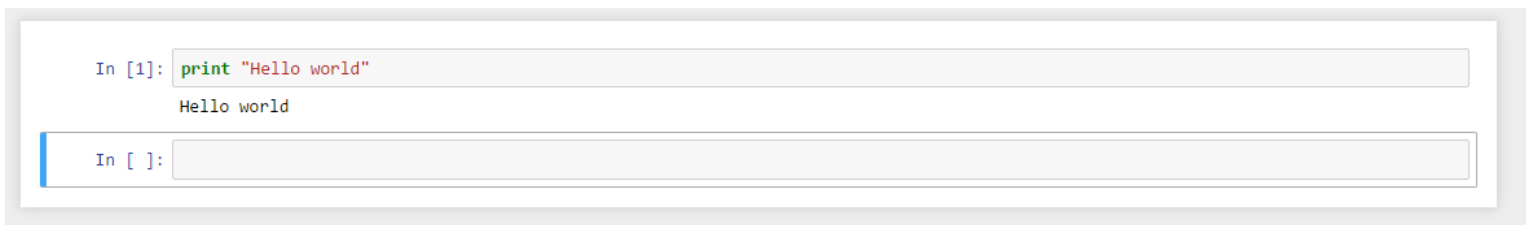
Jupyter file browser

Using Jupyter Notebooks (do this now)

7. You will start off with a single empty code cell. Type the following into the cell: `print "Hello world"`



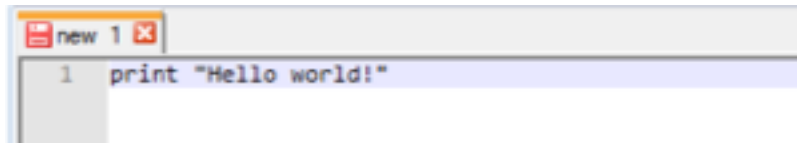
8. Hit Shift+Enter to run the cell. This will execute the code in the cell and then create a new empty cell below.



Using scripts

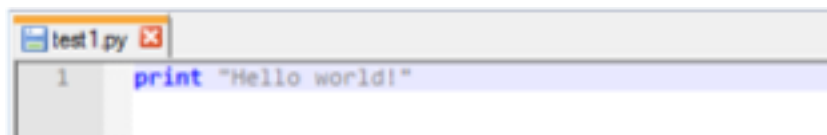
Step 1: Creating a script

- Open a plain text editor (Notepad++, TextWrangler)
- Type the following:



```
1 print "Hello world!"
```

- Save your file in your lab1 folder as `test1.py`
- *Note:* Depending on your text editor, you may notice some of the code has changed colors. This is called syntax highlighting:



```
1 print "Hello world!"
```

Using scripts

Step 2: Running the script

- Open your terminal and navigate to the folder where you saved your script (use `cd`, `ls`, and `pwd`).
- Once in the correct folder, type:
`python test1.py`
- Python will now attempt to execute your script. If there are no errors in your code, you should see something like this:

```
Sarah@Russet ~/Dropbox/Python/PythonBootcamp2013/lab1
$ python test1.py
Hello world!
```

So which method should I use?

- Notebooks are nice because you can see the output as you go along, rather than having to execute it as one monolithic script.
- Scripts are easier to share (because they're plain text) & can be run from the command line
- Bottom line:
 - For learning & exploratory analysis: Jupyter Notebooks
 - For anything else: scripts

3. Print statements

Print statements

`print` `"Hello world!"`

command text
aka "*function*" aka "*string*"

- This is called a *print statement*.
- The `print` function prints text (or other content) to the screen.
- In order to print a line of text (called a *string* in the programming world), we must enclose the text in quotes. Note that the quotes were not printed to the screen.

Test out printing (do this now)

Try the following in a Jupyter notebook
(remember it's Shift+Enter to run a cell)

```
print "Hello" + "world"  
print "Hello", "world"  
print 123  
print 1 + 2  
print 2 * 3  
print "1 + 2"  
print "1 + 2 =", 1 + 2, "!"
```

Variations on the print statement

Code	Output	Reason
<code>print "hello world"</code>	hello world	The text in quotes is printed as typed (the quotes are not printed)
<code>print "hello" + "world"</code>	helloworld	"Adding" strings together concatenates them
<code>print "hello"</code> <code>print "world"</code>	hello world	A "newline" (return) is inserted after each print statement
<code>print "hello",</code> <code>print "world"</code>	hello world	Adding the comma at the end of the print statement suppresses the automatic newline
<code>print "hello", "world"</code>	hello world	adding a comma also allows you to print multiple things in one print statement. (this will be useful when we start using variables.) Notice that a space was automatically inserted between the words
<code>print "hello" * 3</code>	hellohellohello	Print something multiple times.
<code>print 5</code>	5	You can print numbers (no quotes)
<code>print 1 + 2</code>	3	You can also print the results of math operations

4. Understanding error messages

Understanding error messages

Type the following in a new notebook cell and hit Shift+Enter:

```
print hello
```

Understanding error messages

Type the following in a new notebook cell and hit Shift+Enter:

```
print hello
```

Output:

```
-----  
NameError                                Traceback (most recent call last)  
<ipython-input-1-9553ee03b645> in <module>()  
----> 1 print hello  
NameError: name 'hello' is not defined
```

Understanding error messages

```
-----  
NameError                                Traceback (most recent call last)  
<ipython-input-1-9553ee03b645> in <module>()  
----> 1 print hello  
NameError: name 'hello' is not defined
```

This is a typical Python error message. It gives you several pieces of useful information to help you figure out what went wrong:

1. **A line number** - This is the line in your program where the error occurred. If you are using a script, the first thing you should do is find this line and examine it.
2. **An explanation** - This message should give you some idea of the nature of the error.

Sometimes these messages are hard to understand. If you can't figure out what's wrong, your best bet is to copy and paste the "explanation" part of the error message into Google. Look for forum posts of other people who got your same error.

Understanding error messages

```
-----  
---  
  
NameError                                Traceback (most recent call last)  
<ipython-input-1-9553ee03b645> in <module>()  
  
----> 1 print hello  
NameError: name 'hello' is not defined
```

So what went wrong here?

- We forgot to put quotes around `hello`. When Python sees a word with no quotes around it, it assumes that word is a *variable*.
- Since we did not create a variable called `hello` yet, Python displays an error message.
- If we had been running a script, Python would have terminated the execution of the entire script as soon as the error was encountered.

5. Variables and data types

Introduction to variables

What is a variable?

- You can think of variables as little boxes that we put data in. You name each box so that you can refer to it and use it in your code. This gives your code flexibility (for reasons you will see soon).
- Creating a variable is sometimes called *declaring* or *defining* a variable. This needs to be done before you can use the variable.
- You can name your variables almost anything, but avoid using names that are also commands in Python (e.g. don't name a variable "print")

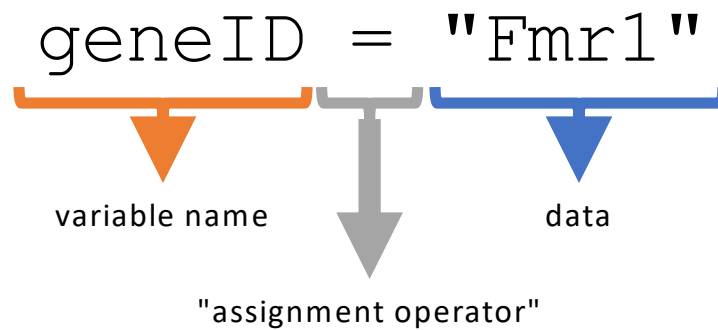
Introduction to variables

For example:

```
geneID = "Fmr1"
```


Introduction to variables

For example:



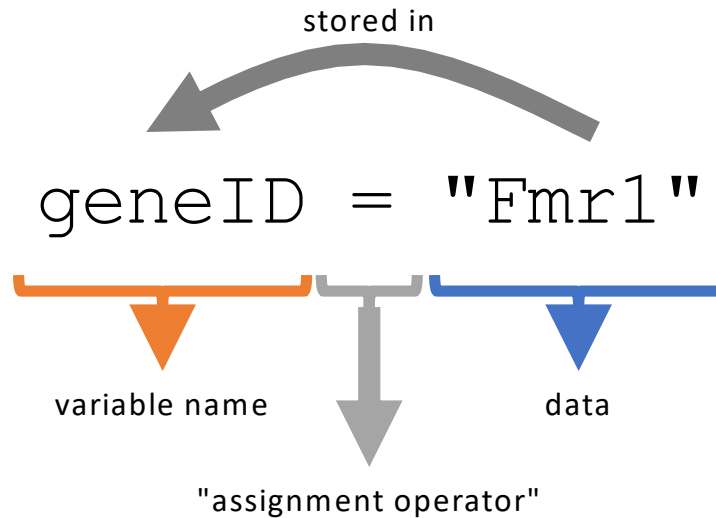
The diagram illustrates the components of the assignment statement `geneID = "Fmr1"`. The text is centered, with three horizontal brackets underneath it. The first bracket, under `geneID`, is orange and has an orange arrow pointing down to the text "variable name". The second bracket, under the equals sign `=`, is gray and has a gray arrow pointing down to the text "\"assignment operator\"". The third bracket, under `"Fmr1"`, is blue and has a blue arrow pointing down to the text "data".

```
geneID = "Fmr1"
```

variable name "assignment operator" data

Introduction to variables

For example:



In english: Store the value "Fmr1" in "geneID"

Important: Choosing variable names

What words are ok to use for variable names?

- **Rules** (if you break these, you'll get errors):
 - only letters, numbers, and underscores can be used in a variable name
 - the variable name can not begin with a number
 - you can not use any of the python reserved words as a variable name
 - the capitalization of your variables matters. For example, geneID and geneid would be considered different variables.
- **Conventions** (recommended):
 - begin a variable name with a lower case letter
 - use a name that is descriptive of the info stored in the variable
 - if your variable name is more than one word squished together, use camelCase or under_scores to make it easier to read.

Examples of variable names

Good variable names:

- `geneID`
- `personCount`
- `input_file`
- `avgGeneCount`

Bad variable names:

- `3rdColumn` (illegal)
- `sdasqweksf` (gibberish)
- `person#` (illegal)
- `class` (reserved word)

Python reserved words

The following words have special meaning to python and cannot be used as variable names:

and	as	assert	break	class	continue
def	del	elif	else	except	exec
finally	for	from	global	if	import
in	is	lambda	nonlocal	not	or
pass	raise	return	try	while	with
yield	True	False	None		

If you get a weird error for a variable, check if it's on this list.

Question 1

What will this code print?

```
geneID = "Fmr1"  
print geneID
```

Question 1

What will this code print?

```
geneID = "Fmr1"  
print geneID
```

Result

```
Fmr1
```

Question 2

What will this code print?

```
apples = 5  
oranges = 10  
fruit = apples + oranges  
print fruit
```


Question 2

What will this code print?

```
apples = 5  
oranges = 10  
fruit = apples + oranges  
print fruit
```

Result

15

Question 3

What will this code print?

```
apples = 5  
oranges = 10  
print apples + oranges
```

Question 3

What will this code print?

```
apples = 5  
oranges = 10  
print apples + oranges
```

Result

15

Question 4

What will this code print?

```
apples = 5  
oranges = 10  
print apples, oranges
```

Question 4

What will this code print?

```
apples = 5  
oranges = 10  
print apples, oranges
```

Result

```
5 10
```

Question 5

What will this code print?

```
apples = 5  
oranges = 10  
print "I have", apples, "apples"
```

Question 5

What will this code print?

```
apples = 5  
oranges = 10  
print "I have", apples, "apples"
```

Result

```
I have 5 apples
```

Question 6

What will this code print?

```
people = 3  
people = people + 1  
print people
```


Question 6

What will this code print?

```
people = 3  
people = people + 1  
print people
```

Result

4

Question 7

What will this code print?

```
people = 3  
animals = 4  
people = animals  
print people  
print animals
```

Question 7

What will this code print?

```
people = 3  
animals = 4  
people = animals  
print people  
print animals
```

Result

```
4  
4
```

Question 8

What will this code print?

```
name = "Joe Shmo"
```

```
age = 20
```

```
print name, "will be", (age + 1), "next year"
```

Question 8

What will this code print?

```
name = "Joe Shmo"  
age = 20  
print name, "will be", (age + 1), "next year"
```

Result

```
Joe Shmo will be 21 next year
```

Question 9

What will this code print?

```
yourAge = "16"  
print "You will be", (yourAge + 1), "next year"
```

Question 9

What will this code print?

```
yourAge = "16"  
print "You will be", (yourAge + 1), "next year"
```

Result

You will be

```
-----  
TypeError                                Traceback (most recent call last)  
<ipython-input-3-8072ce5634fd> in <module>()  
      1 yourAge = "16"  
----> 2 print "You will be", (yourAge + 1), "next year"  
TypeError: cannot concatenate 'str' and 'int' objects
```

Question 9

What will this code print?

```
yourAge = "16"  
print "You will be", (yourAge + 1), "next year"
```

Result

You will be

```
-----  
TypeError                                Traceback (most recent call last)  
<ipython-input-3-8072ce5634fd> in <module>()  
      1 yourAge = "16"  
----> 2 print "You will be", (yourAge + 1), "next year"  
TypeError: cannot concatenate 'str' and 'int' objects
```

What happened?

- We put the number 16 in quotes--this makes it a string instead of an integer!
- Python can't do addition with strings, so it gives an error message.
- Notice that it starts to print the message, but fails when we try to do the addition.

Variable data types

- Data comes in different types – numbers, words, letters, etc.
- In Python, certain types of data are treated differently. There are four main "**data types**" we'll be working with:
 1. **String** - a *string* is just another word for text. You can think of it as "a string of letters/characters". Strings are enclosed in double or single quotes to distinguish them from variables and commands (ex: "This is a string!" 'So is this!')
 2. **Integer ("int")** - this refers to whole numbers (same as in real life). In programming, integers are handled differently than non-integers, which is why we make this distinction.
 3. **Floating point numbers ("float")** - numbers with decimals.
 4. **Booleans** – True or False (1 or 0). We'll talk more about this later.

Converting between data types

As we've seen, different types of data are treated differently by Python:

```
print 1 + 1
```

```
2
```

No quotes; treated as integers → **sum**

```
print "1" + "1"
```

```
11
```

Quotes; treated as strings → **concatenate**

```
print 1 + "1"
```

Mixed; not compatible! → **error**

```
-----  
TypeError
```

```
Traceback (most recent call last)
```

```
<ipython-input-3-8e7c33e93d16> in <module>()
```

```
----> 1 print 1 + "1"
```

```
TypeError: unsupported operand type(s) for +: 'int' and 'str'
```

Converting between data types

- Sometimes we'll want to convert one data type into another.
- Python provides simple built-in functions for a few types of conversions.
- Here's a partial list:

Function	Conversion type	Works on...
<code>str()</code>	Converts variable into a string	Integers, floats, booleans (and others)
<code>int()</code>	Converts variable into an integer	Numbers in string form Floats (decimal will be truncated) Booleans (True → 1, False → 0)
<code>float()</code>	Converts variable into a float (decimal)	Numbers in string form Integers (.0 will be added) Booleans (True → 1.0, False → 0.0)

Examples of conversion

```
print 1 + int("1")
```

2

```
print "1" + str(1)
```

11

```
print float("1")
```

1.0



Now this works!

6. Basic math operations

Doing math in Python

Math in Python uses most of the symbols and conventions you're already used to:

```
print 2 + 2
```

4

```
print 5 * 5
```


25

```
print 2 + 5 * 5
```

27

```
print (2 + 5) * 5
```

35



Order of operations
(P.E.M.D.A.S.) is maintained

Doing math in Python

There are a few differences, however:

```
print 5 ** 2
```

25



Use ** for exponents

```
print 5 % 2
```

1



Use % to get remainders
(aka "modulus" or "mod")

Doing math in Python

The most important thing to watch out for is **integer division**:

```
print 6 / 2
```

3

```
print 5 / 2
```


2

```
print 5 / 3
```

1

```
print 5 / 4
```

1



Why are all of these answers rounded down?

Integer division

- Whenever you divide two integers, python always returns an integer answer
- Since integers are always whole numbers, python just truncates off the decimal
- To get a proper answer, **at least one of the numbers being divided must be a float:**

```
print 5.0 / 2
```

```
2.5
```

```
print 5 / 2.0
```

```
2.5
```

```
print 5 / float(2)
```

```
2.5
```

This is a very common source of errors, so keep it in mind when you divide!
When in doubt, convert one number with `float()`.

List of math operators

Operation	Result
$x + y$	sum of x and y
$x - y$	difference of x and y
$x * y$	product of x and y
x / y	quotient of x and y
$x // y$	(floored) quotient of x and y
$x \% y$	remainder of x / y
$x ** y$	x to the power y