LECTURE 9
STRUCTURED DATA

Fundamentals of Programming - COMP1005

Department of Computing
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Updated 29/4/21

Copyright Warning

Learning Outcomes

- Understand and implement structured data processing in Python using the pandas library
- Understand and critique the value of reproducible research
- Apply and create Python notebooks to support exploratory research

MORE DATA TYPES

Lecture 9

Data Types

- We've been working with:
  - Strings
  - Floats, integers, Booleans
  - Lists
  - Arrays
- We will now extend this by learning about:
  - Tuples
  - Sets
  - Dictionaries

Tuples

- We've used tuples already:
  - data = np.zeros((3, 3, 3))
  - **(3, 3, 3)** is a tuple
- Tuples are created as comma separated values, usually enclosed in brackets
- Tuples look a bit like lists, but they are immutable – structure cannot be changed
  - They can include mutable objects (e.g. lists) so, in those cases, their contents can be changed
- So, we can't append or del with Tuples
- They are ordered, so we can work with them as sequences.

Tuple example

```
tup1 = ('spam', 'eggs', 42)
tup2 = (1, 4, 9, 16, 25 )
tup3 = "yes", "oui", "ja", "si"

print(tup1)
print(tup2)
print(tup3)
```

```
('spam', 'eggs', 42)
(1, 4, 9, 16, 25)
('yes', 'oui', 'ja', 'si')
```

Tuples are sequences

```
tup1 = ('spam', 'eggs', 42)
tup2 = (1, 4, 9, 16, 25 )
tup3 = "yes", "oui", "ja",
"si"

print(tup1[2])

print(tup2[1:-1])

for i in tup3:
   print(i)

print(tup1 + tup2)

print(tup1 * 2)

print(len(tup2))
```

```
42

(4, 9, 16)

yes
oui
ja
si

('spam', 'eggs', 42, 1, 4,
9, 16, 25)

('spam', 'eggs', 42, 'spam',
'eggs', 42)

5
```

Sets

- We've already used set operations to check if a letter is a vowel, e.g.

```
vowels = 'aeiou'
if letter in vowels:
  vowelcount += 1
```

- Sets are unordered (not a sequence), and there are no duplicates
- Sets are defined using {} ie.

```
vowels = {'a','e','i','o','u'}
```

- We can check if an item is **in** a set or **not in** it

```
if letter not in vowels:
```

https://www.learnpython.org/en/Sets

Set Theory – just here as background

- A set is any collection of objects, e.g. a set of vertices
- The objects in a set are called the **elements** of the set
- Repetition and order are not important
  - {2, 3, 5} = {5, 2, 3} = {5, 2, 3, 2, 2, 3}
- Sets can be written in predicate form:
  - {1, 2, 3, 4} = {x : x is a positive integer less than 5}
  - Read the colon as "such that" such that, also $\{x | x$ is a….}
- The empty set is $\{\} = \emptyset$ all empty sets are equal

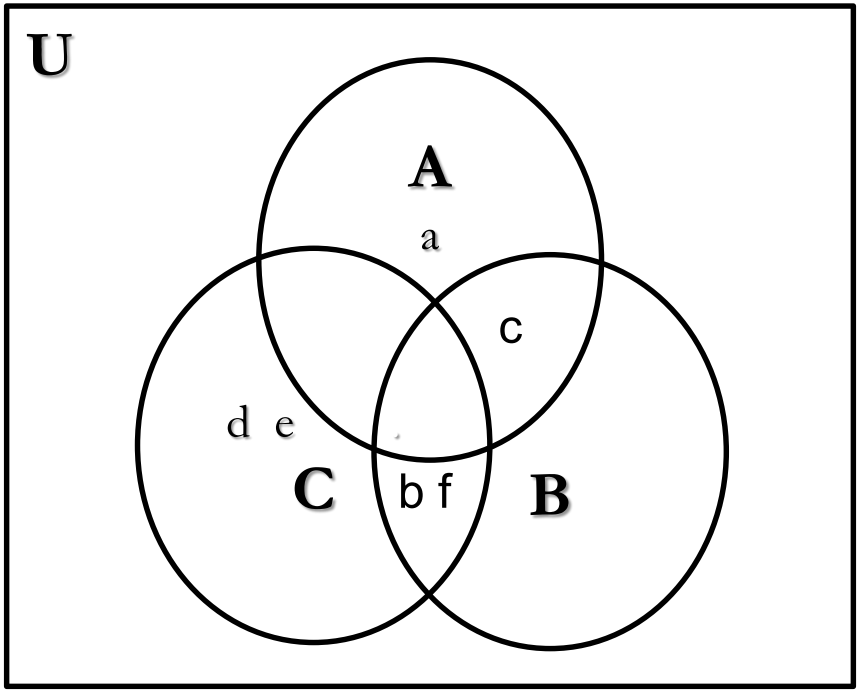
Set Theory based on http://www.maths.manchester.ac.uk/~avb/0n1_pdf/0N1_All.pdf

Set Theory – Operations on Sets

- Union
  - $A \cup B = \{ x : x \in A \text{ or } x \in B \}$
- Intersection
  - $A \cap B = \{ x : x \in A \text{ and } x \in B \}$
- Universal Set
  - All sets under consideration will be subsets of a background set, called the Universal Set, U
- Complement
  - $A' = \{ x : x \in U \text{ and } x \notin A \}$

Set Theory – Example

- Let:
  - $U = \{a, b, c, d, e, f\}$
  - $A = \{a, c\}$, $B = \{b, c, f\}$
    $C = \{b, d, e, f\}$.
- Then:
  - $B \cup C = \{b, c, d, e, f\}$
  - $A \cap (B \cup C) = \{c\}$
  - $A' = \{b, d, e, f\}$
    $= C$
  - $A' \cap (B \cup C) = C \cap (B \cup C) = \{b, d, e, f\} = C$



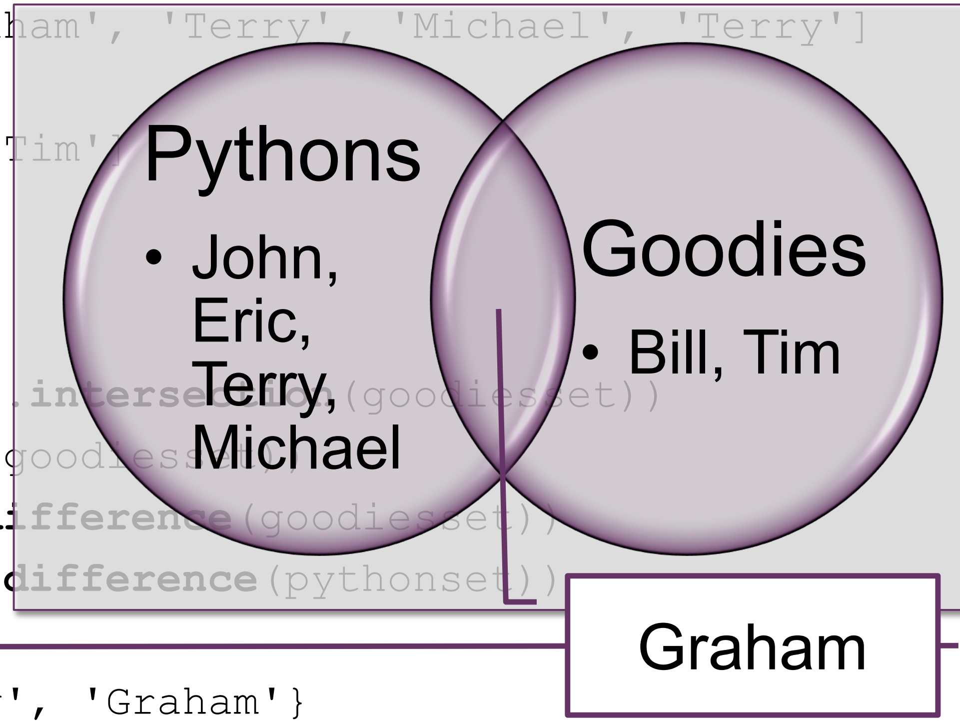
Set creation and operations

```
pythonlist = ['John', 'Eric', 'Graham', 'Terry', 'Michael', 'Terry']
pythonset = set(pythonlist)
goodieslist = ['Bill', 'Graham', 'Tim']
goodiesset = set(goodieslist)
print(pythonset)
print(goodiesset)
print('Intersection = ', pythonset.intersection(goodiesset))
print('Union = ', pythonset.union(goodiesset))
print('Difference = ', pythonset.difference(goodiesset))
print('Difference = ', goodiesset.difference(pythonset))
```

```
{'Eric', 'John', 'Michael', 'Terry', 'Graham'}
{'Tim', 'Bill', 'Graham'}
Intersection =  {'Graham'}
Union =  {'John', 'Michael', 'Tim', 'Bill', 'Eric', 'Terry', 'Graham'}
Difference =  {'Eric', 'John', 'Terry', 'Michael'}
Difference =  {'Bill', 'Tim'}
```

Set creation and operations

```
pythonlist = ['John', 'Eric', 'Graham', 'Terry', 'Michael', 'Terry']
pythonset = set(pythonlist)
goodieslist = ['Bill', 'Graham', 'Tim']
goodiesset = set(goodieslist)
print(pythonset)
print(goodiesset)
print('Intersection = ', pythonset.intersection(goodiesset))
print('Union = ', pythonset.union(goodiesset))
print('Difference = ', pythonset.difference(goodiesset))
print('Difference = ', goodiesset.difference(pythonset))
```




```
{'Eric', 'John', 'Michael', 'Terry', 'Graham'}
{'Tim', 'Bill', 'Graham'}
Intersection =  {'Graham'}
Union =  {'John', 'Michael', 'Tim', 'Bill', 'Eric', 'Terry', 'Graham'}
Difference =  {'Eric', 'John', 'Terry', 'Michael'}
Difference =  {'Bill', 'Tim'}
```

Dictionaries

- Dictionaries are mapping from a key, to a value
- Traditional dictionaries map words to meanings
- We might want to map towns to populations, years or months to total rainfall, student ID to student name
- The dictionary itself is not ordered - it is a set of key:value pairs
- Keys must be immutable
- We can add, **del**ete and overwrite

https://learnpythonthehardway.org/book/ex39.html

Dictionary – The Meaning of Liff

```
liff = {'Duddo': 'The most deformed potato in any given collection of potatoes.',
        'Fring': 'The noise made by a lightbulb that has just shone its last.',
        'Tonypandy': ' The voice used by presenters on children\'s television programmes.'}
liff['Wawne'] = 'A badly supressed yawn.'
liff['Woking'] = 'Standing in the kitchen wondering what you came in here for.'
print(liff)
print(liff['Duddo'])
print(liff['Fring'])
print(liff.keys())
del liff['Fring']
print(liff.keys())
```

The Meaning of Liff and
The Deeper Meaning of Liff,
by Douglas Adams and John Lloyd

http://liff.hivemind.net/

Dictionary – The Meaning of Liff

```
OUTPUT
{'Fring': 'The noise made by a lightbulb that has just shone its last.', 'Wawne': 'A badly supressed yawn.', 'Duddo': 'The most deformed potato in any given collection of potatoes.', 'Tonypandy': " The voice used by presenters on children's television programmes.", 'Woking': 'Standing in the kitchen wondering what you came in here for.'}

The most deformed potato in any given collection of potatoes.

The noise made by a lightbulb that has just shone its last.
dict_keys(['Woking', 'Fring', 'Wawne', 'Tonypandy', 'Duddo'])
dict_keys(['Woking', 'Wawne', 'Tonypandy', 'Duddo'])
```

Dictionary - Populations

```
pops = {'New South Wales': 7757843,
        'Victoria' : 6100877,
        'Queensland' : 4860448,
        'South Australia' : 1710804,
        'Western Australia' : 2623164,
        'Tasmania': 519783,
        'Northern Territory' : 245657,
        'Australian Capital Territory': 398349}
print(pops['Victoria'])
for p in pops:
   print(p)
for k in pops.keys():
   print(k, ' : ', pops[k])
```

Australian Demographic Statistics, Sep 2016
http://www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0

Dictionary – Populations (output)

```
6100877

Tasmania
Western Australia
Victoria
Queensland
South Australia
Northern Territory
Australian Capital Territory
New South Wales

Tasmania  :  519783
Western Australia  :  2623164
Victoria  :  6100877
Queensland  :  4860448
South Australia  :  1710804
Northern Territory  :  245657
Australian Capital Territory  :  398349
New South Wales  :  7757843
```

```
print(pops['Victoria'])
```

```
for p in pops:
   print(p)
```

```
for k in pops.keys():
   print(k, ' : ', pops[k])
```

Dictionaries

- We can list the keys, or the values, or both...

```
for p in pops:
   print(p)
```

Tasmania
Western Australia
…
Australian Capital Territory
New South Wales

```
for k in pops.keys():
   print(pops[k])
```

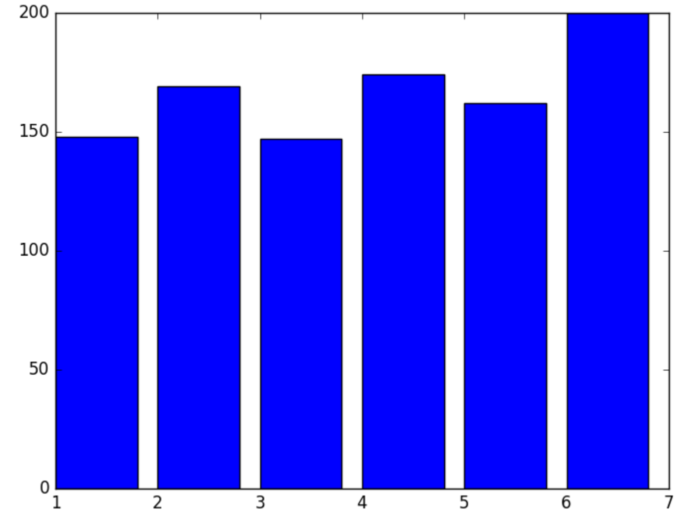
519783
2623164 ← **CLUE FOR PRAC QUESTION**
…
7757843

```
for k in pops.keys():
   print(k, ': ', pops[k])
```

Tasmania: 519783
Western Australia: 2623164
…
New South Wales: 7757843

Dice toss with maps

- 1000 random dice tosses and plot the results:




```
import random
import matplotlib.pyplot as plt

dicecount = {1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0}

for i in range(1000):
    toss = random.randint(1,6)
    dicecount[toss] += 1

plt.bar(dicecount.keys(), dicecount.values())
plt.show()
```

And something more challenging…

- Find the frequency of each of the words in a text…

```
import sys

punctuation = '~!@#$%^&*()_+{}|:"<>?`=[]\\;\',./'

if len(sys.argv) <2 :
   filename = 'grimm.txt'
else:
   filename = sys.argv[1]

book = open(filename).read()
bookP = book.translate(str.maketrans('','',punctuation))
words = bookP.lower().split()
print(len(words))
print(words[:10])
```

1139
['rumpelstiltskin', 'by', 'the', 'side', 'of', 'a', 'wood', 'in', 'a', 'country']

And something more challenging…

- Then calculate frequencies using a dictionary…

```
wordfreq = {}                     # empty dictionary
for word in words:                # for each word
    if word not in wordfreq:      # if it's not in dict
        wordfreq[word] = 0        # create a key/val pair
    wordfreq[word] += 1           # increment count[word]

print(len(wordfreq))              # 390 unique, 1139 total
print(wordfreq)
```

- There are many alternative packages with extensive support for analysing text (e.g. nltk) – but this is a good starting point

STRUCTURED DATA

Fundamentals of Programming

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Structured data

- When we downloaded the weather data, we ignored the header lines…
  ...but they gave more information about the structure of the data
- We can go beyond lists and arrays for storing data
- Data frames look after the structure of the data – column labels, grouping, operations
- We will use pandas to create data frames

Python Data Analysis Library

- The Pandas library:
  - provides data structures
  - produces high-quality plots with matplotlib
  - integrates nicely with other libraries that use NumPy
- To use pandas, we start with an import:

```
import pandas as pd
```

Dataframes

- A DataFrame is a 2-dimensional data structure that can store data of different types in columns
  - including characters, integers, floating point values, factors and more...
- It is similar to a spreadsheet or an SQL table or the data.frame in R
- A DataFrame always has an index (0-based)
- An index refers to the position of an element in the data structure
- The index values can be overridden, but can cause problems – don't do it!

http://www.datacarpentry.org/python-ecology-lesson/01-starting-with-data/

Building a dataframe

- Dataframes can be defined as dictionaries, keys are labels, values are lists

```
import pandas as pd
df = pd.DataFrame({'AAA' : [4, 5, 6, 7],
    'BBB' : [10,20,30,40], 'CCC': [100,50,-30,-50]})
print(df)
print(df.describe())
```

	AAA	BBB	CCC
0	4	10	100
1	5	20	50
2	6	30	-30
3	7	40	-50

	AAA	BBB	CCC
count	4.000000	4.000000	4.000000
mean	5.500000	25.000000	17.500000
std	1.290994	12.909944	69.940451
min	4.000000	10.000000	-50.000000
25%	4.750000	17.500000	-35.000000
50%	5.500000	25.000000	10.000000
75%	6.250000	32.500000	62.500000
max	7.000000	40.000000	100.000000

Reading in a CSV file

- surveys_df = pd.read_csv("surveys.csv")
- No need for splitting etc – all done for you!

```
record_id  month  day  year  plot_id species_id sex  hindfoot_length  weight
0          1      7    16   1977        2         NL   M                32   NaN
1          2      7    16   1977        3         NL   M                33   NaN
2          3      7    16   1977        2         DM   F                37   NaN
3          4      7    16   1977        7         DM   M                36   NaN
4          5      7    16   1977        3         DM   M                35   NaN
...
35544      35545     12    31   2002       15     AH   NaN             NaN   NaN
35545      35546     12    31   2002       15     AH   NaN             NaN   NaN
35546      35547     12    31   2002       10     RM     F              15    14
35547      35548     12    31   2002        7     DO     M              36    51
35548      35549     12    31   2002        5     NaN  NaN             NaN   NaN

[35549 rows x 9 columns]
```

Types within dataframes

type(surveys_df)

- returns:

<class 'pandas.core.frame.DataFrame'>

surveys_df.dtypes

- returns:

```
record_id          int64
month              int64
day                int64
year               int64
plot_id            int64
species_id        object
sex               object
hindfoot_length  float64
weight           float64
dtype: object
```

Describing dataframes

surveys_df.columns

```
Index(['record_id', 'month', 'day', 'year', 'plot_id', 'species_id', 'sex','hindfoot_length', 'weight'],
      dtype='object')
```

surveys_df.shape

```
(35549, 9)
```

surveys_df.head()

```
 record_id  month  day   year  plot_id species_id sex  hindfoot_length  \
0         1      7   16  1977        2         NL   M             32.0
1         2      7   16  1977        3         NL   M             33.0
2         3      7   16  1977        2         DM   F             37.0
3         4      7   16  1977        7         DM   M             36.0
4         5      7   16  1977        3         DM   M             35.0

   weight
0     NaN
1     NaN
2     NaN
3     NaN
4     NaN
```

surveys_df.head(15)
surveys_df.tail()

Calculating statistics

surveys_df.columns.values

array(['record_id', 'month', 'day', 'year', 'plot_id', 'species_id', 'sex', 'hindfoot_length', 'weight'], dtype=object)

- The pd.unique function tells us all of the unique values in the species_id column.

pd.unique(surveys_df['species_id'])

array(['NL', 'DM', 'PF', 'PE', 'DS', 'PP', 'SH', 'OT', 'DO', 'OX', 'SS', 'OL', 'RM', nan, 'SA', 'PM', 'AH', 'DX', 'AB', 'CB', 'CM', 'CQ', 'RF', 'PC', 'PG', 'PH', 'PU', 'CV', 'UR', 'UP', 'ZL', 'UL', 'CS', 'SC', 'BA', 'SF', 'RO', 'AS', 'SO', 'PI', 'ST', 'CU', 'SU', 'RX', 'PB', 'PL', 'PX', 'CT', 'US'], dtype=object)

Summary statistics

- **surveys_df['weight'].describe()**

```
count 32283.000000
mean 42.672428
std 36.631259
min 4.000000
25% 20.000000
50% 37.000000
75% 48.000000
max 280.000000
Name: weight, dtype: float64
```

The **pandas function describe** will return descriptive stats including: mean, median, max, min, std and count for a column in the data (if it has numeric data)

- We can also extract one specific metric using...

surveys_df['weight']**.min()**
surveys_df['weight']**.max()**
surveys_df['weight']**.mean()**
surveys_df['weight']**.std()**
surveys_df['weight']**.count()**

Grouping data

- # Group data by sex

sorted_data = surveys_df.groupby('sex')

- # summary statistics for all numeric columns by sex
- **sorted_data.describe()**
- # provide the mean for each numeric column by sex
- **sorted_data.mean()**

```
  record_id     month     day       year      plot_id \
sex
F 18036.412046 6.583047 16.007138 1990.644997 11.440854
M 17754.835601 6.392668 16.184286 1990.480401 11.098282
  hindfoot_length weight
sex
F 28.836780 42.170555
M 29.709578 42.995379
```

Counting and Maths functions

- We can count the number of samples by species

```
species_counts = surveys_df.groupby('species_id')\
                ['record_id'].count()
print(species_counts)
```

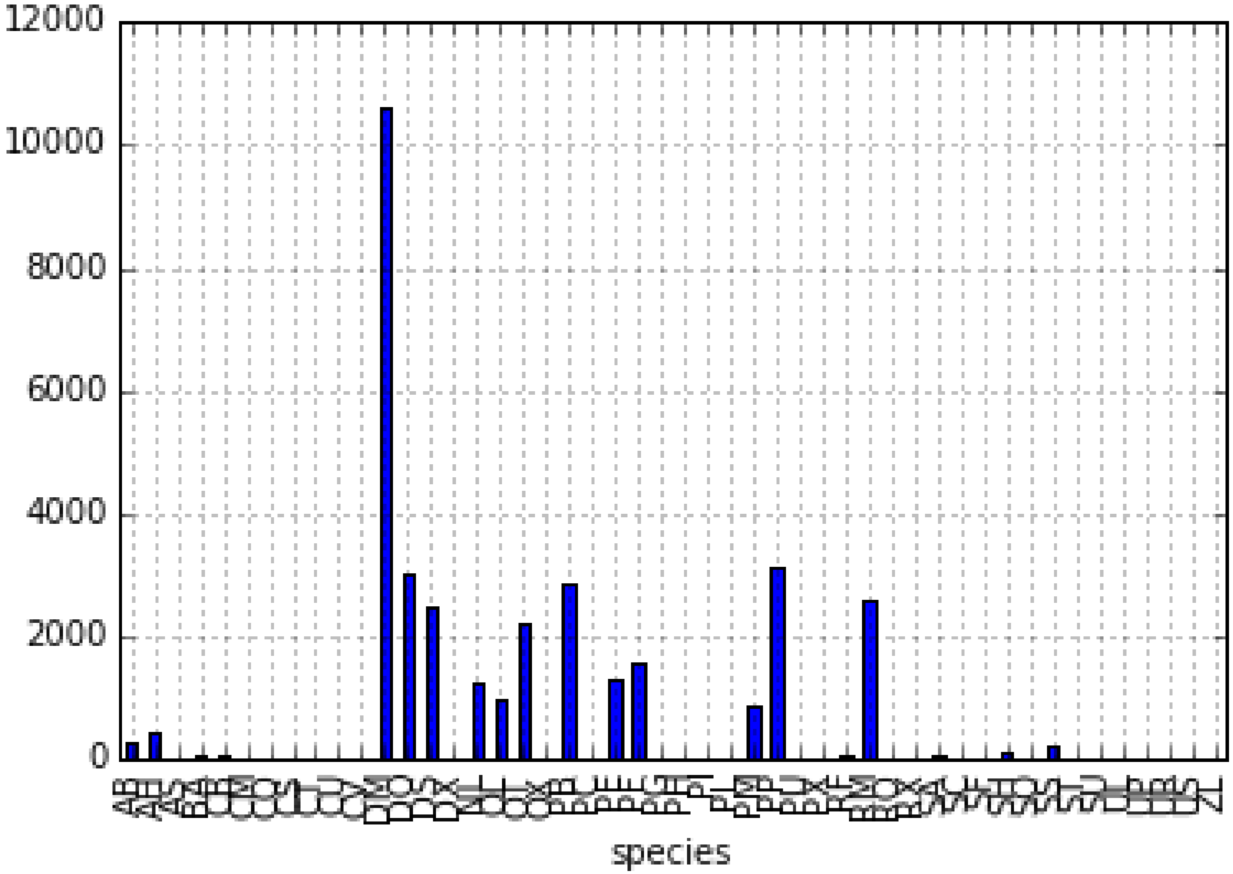
- Or, we can count just the rows that have the species “DO”

```
surveys_df.groupby('species_id')['record_id'].count()['DO']
```

- Basic Maths Functions
  - We can perform maths functions on entire columns of our data
  - # multiply all weight values by 2.2 surveys_df['weight']*2.2

Simple plotting

species_counts.plot(kind='bar')



Slicing

select rows 0, 1, 2 (row 3 is not selected)
surveys_df[0:3]
select the first 5 rows (rows 0, 1, 2, 3, 4)
surveys_df[:5]
select the last element in the list
surveys_df[-1]

- **loc** indexes by labels, **iloc** indexes by position (integers)

iloc[row slicing, column slicing]
surveys_df.iloc[0:3, 1:4]
select all columns for rows of index values 0 and 10 surveys_df.loc[[0, 10], :]
select three columns for row 0
surveys_df.loc[0, ['species_id', 'plot_id', 'weight']]
All columns for rows, 0, 10 and 35549
surveys_df.loc[[0, 10, 35549], :]

Subsetting data using criteria

surveys_df[surveys_df.year == 2002]

record_id month day year plot_id species_id sex hindfoot_length weight

33320 33321 1 12 2002 1 DM M 38 44

33321 33322 1 12 2002 1 DO M 37 58

33322 33323 1 12 2002 1 PB M 28 45

...

35546 35547 12 31 2002 10 RM F 15 14

35547 35548 12 31 2002 7 DO M 36 51

35548 35549 12 31 2002 5 NaN NaN NaN NaN

[2229 rows x 9 columns]

- Or we can select all rows that do not contain the year 2002:

surveys_df[surveys_df.year **!= 2002**]

- We can define sets of criteria too:

surveys_df[(surveys_df.year **>= 1980**) & (surveys_df.year **<=1985**)]

Copying dataframes

- As with other objects we've worked with (arrays, lists…) assigning an object to a variable just points them to the same place.
- Need to use **copy()** to make a separate object.
- **Copy** uses the dataframe's copy() method

true_copy_surveys_df = surveys_df.copy()

- A **Reference** is created using the = operator

ref_surveys_df = surveys_df

- Slices and views of a dataframe are using a reference to the original data – any changes will change the original

That's it for now…

- We'll do more with dataframes in the practicals
- There is a lot more they can do…

- Think about how this might affect how we work with datasets we have used already – do they have column names that we could work with... and csv files can be read in using pandas...

REPRODUCIBLE RESEARCH

Fundamentals of Programming

Lecture 9

Reproducible Research

- A key value of scientific research is that it is reproducible
- When we share or publish our research, others should be able to reproduce our results
- Many journals now ask for data and code along with submitted papers
- Reviewers can then check the data and code to verify the results

About Project Jupyter

- Project Jupyter is an open source project was born out of the IPython Project in 2014
- The project aims to support interactive data science and scientific computing across all programming languages
- Jupyter is 100% open source software, free for all to use and released under the liberal terms of the modified BSD license

- Dynamic developers, cutting edge scientists as well as everyday users work together to further Jupyter's best-in-class tools.

http://jupyter.org/about.html

Jupyter notebooks

- Notebook documents (or “notebooks”, all lower case) are documents which contain both computer code (e.g. python) and rich text elements (paragraph, equations, figures, links, etc...).
- Notebook documents are both
  - human-readable documents containing the analysis description and the results (figures, tables, etc..)
  - executable documents which can be run to perform data analysis

http://jupyter-notebook-beginner-guide.readthedocs.io/en/latest/what_is_jupyter.html

Jupyter notebook app

- The *Jupyter Notebook App* is a server-client application that allows editing and running notebook documents via a web browser
- The *Jupyter Notebook App* can be executed on a local desktop requiring no internet access or can be installed on a remote server and accessed through the internet
- In addition to displaying/editing/running notebook documents, the *Jupyter Notebook App* has a **dashboard**
  - a "control panel" showing local files and allowing to open notebook documents or shutting down their kernels.

Notebook kernels

- A notebook *kernel* is a “computational engine” that executes the code contained in a Notebook document.
- The *ipython kernel* executes python code
- Kernels for many other languages exist
- When you open a Notebook document, the associated *kernel* is automatically launched
- When the notebook is *executed* (either cell-by-cell or with menu *Cell -> Run All*), the *kernel* performs the computation and produces the results
- We could work on Python 3.6 or 2.7 (etc) kernels

Notebook dashboard

- The *Notebook Dashboard* is the component which is shown first when you launch Jupyter Notebook App
- The *Notebook Dashboard* is mainly used to open notebook documents, and to manage the running kernels (visualize and shutdown)
- The *Notebook Dashboard* has other features similar to a file manager, namely navigating folders and renaming/deleting files

Running Jupyter

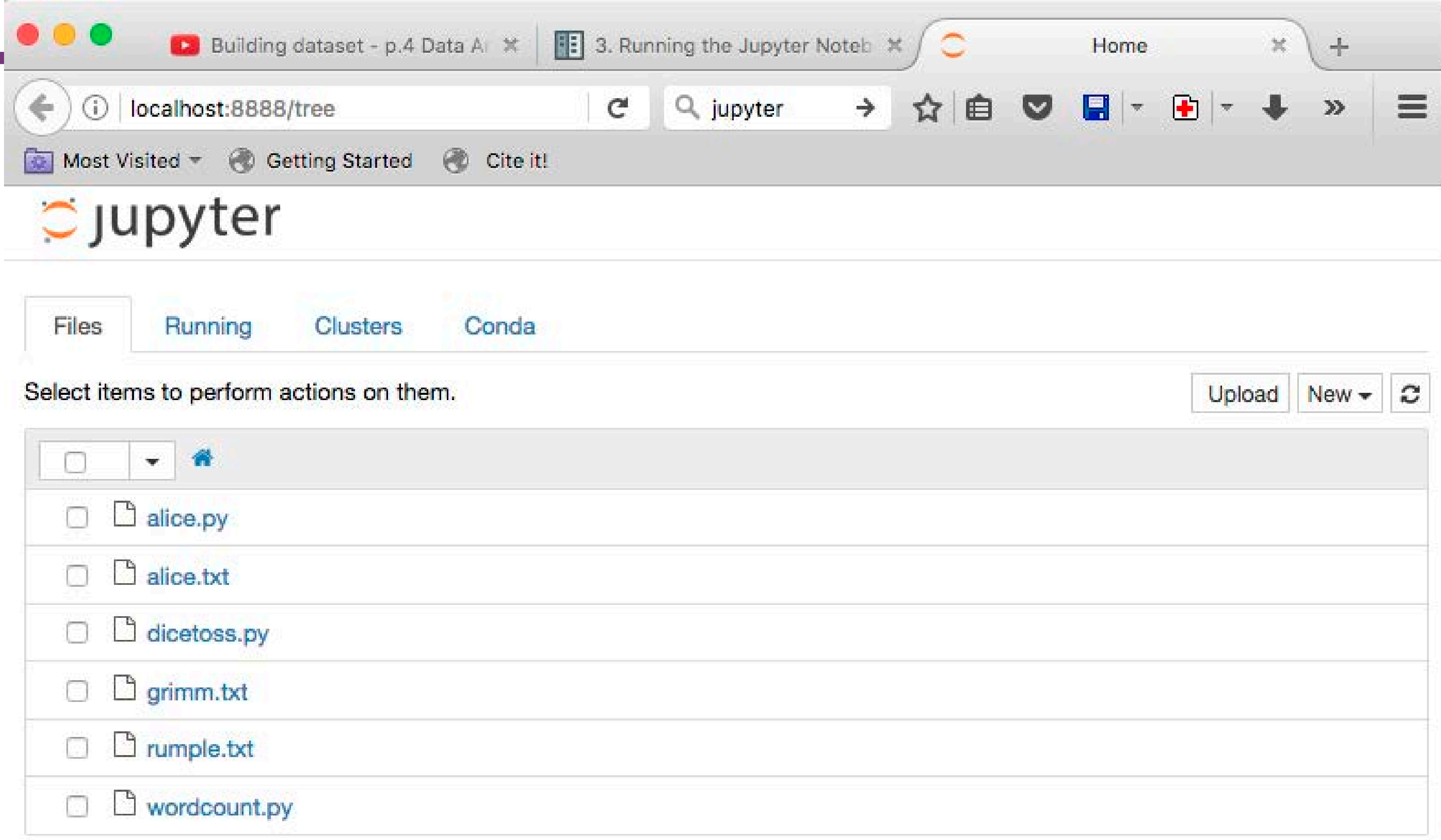
- Type **jupyter notebook** at the command line in the directory with your notebooks

```
M-A0009607-S:Lecture8 $ jupyter notebook
[I 13:01:47.692 NotebookApp] [nb_conda_kernels] enabled, 2 kernels found
[I 13:01:49.571 NotebookApp] ✓ nbpresent HTML export ENABLED
[W 13:01:49.572 NotebookApp] ✗ nbpresent PDF export DISABLED: No module named 'nbbrowserpdf'
[I 13:01:49.619 NotebookApp] [nb_conda] enabled
[I 13:01:49.832 NotebookApp] [nb_anacondacloud] enabled
[I 13:01:49.865 NotebookApp] Serving notebooks from local directory: /Users/username/Fundamentals/Lecture8
[I 13:01:49.865 NotebookApp] 0 active kernels
[I 13:01:49.865 NotebookApp] The Jupyter Notebook is running at: http://localhost:8888/
[I 13:01:49.865 NotebookApp] Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).
```

Shutting down jupyter

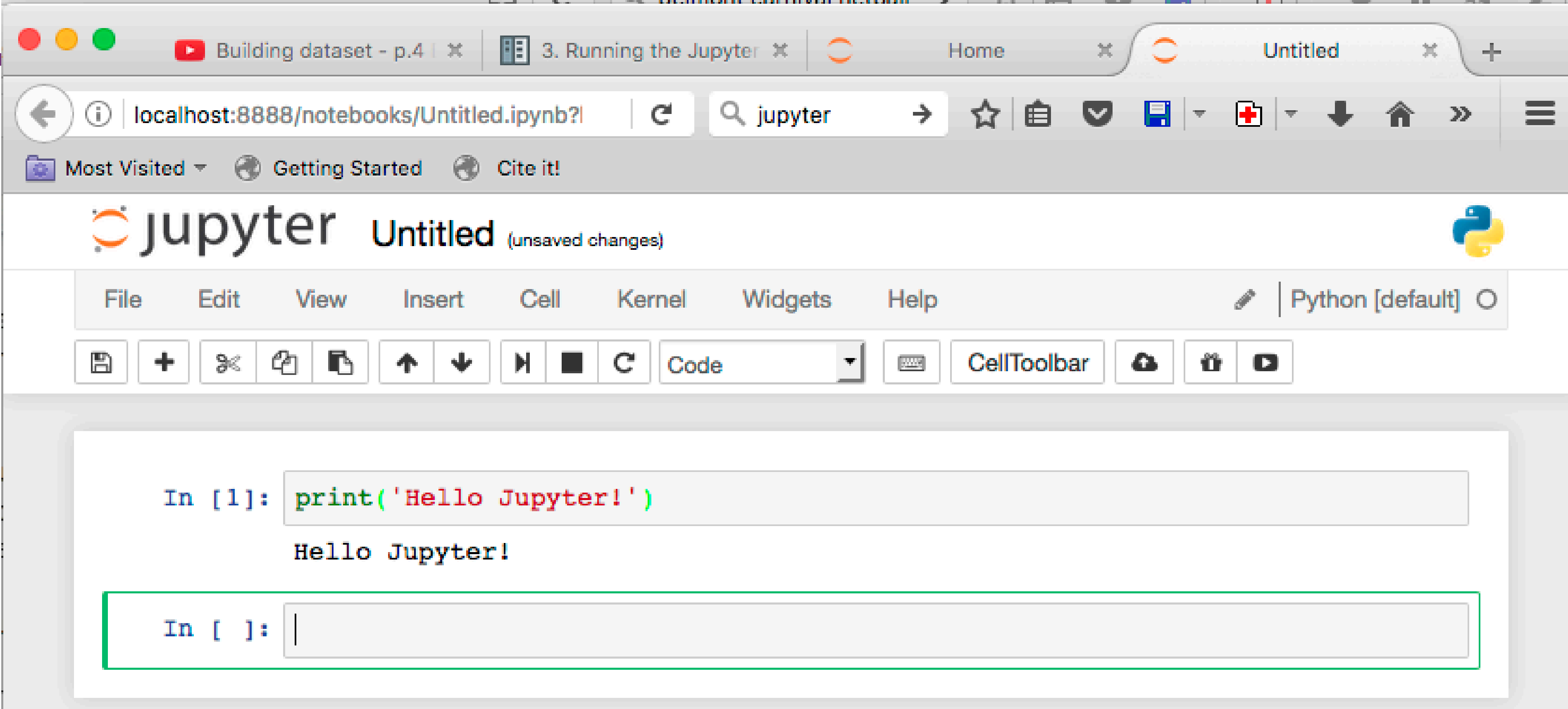
- Type control-C in the terminal window you ran jupyter from...

```
^C[I 13:05:23.645 NotebookApp] interrupted
Serving notebooks from local directory: /Users/username/Fundamentals/Lecture8
0 active kernels
The Jupyter Notebook is running at: http://localhost:8888/
Shutdown this notebook server (y/[n])? y
[C 13:05:26.181 NotebookApp] Shutdown confirmed
[I 13:05:26.181 NotebookApp] Shutting down kernels
M-A0009607-S:Lecture8 $
```



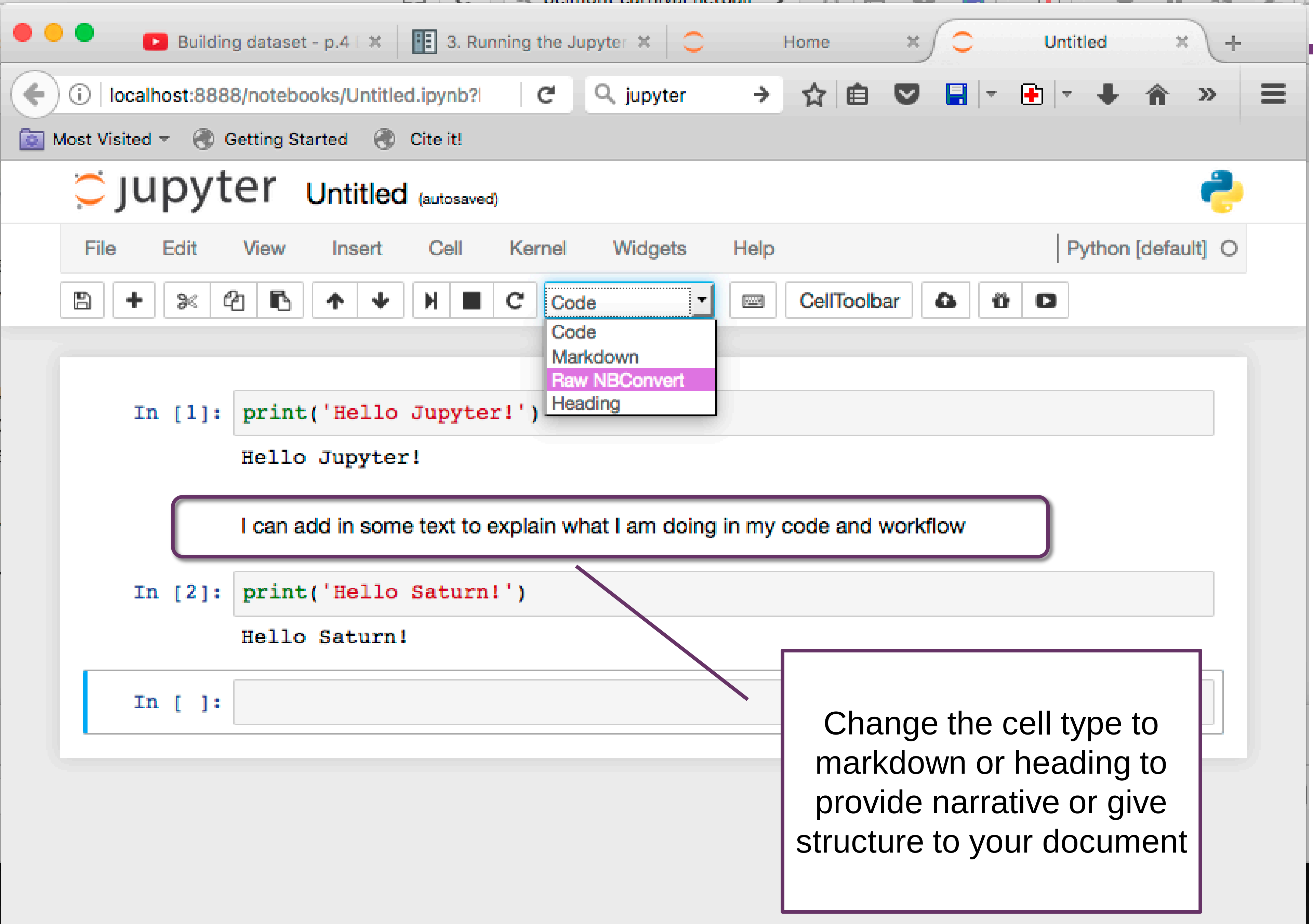
Jupyter dashboard

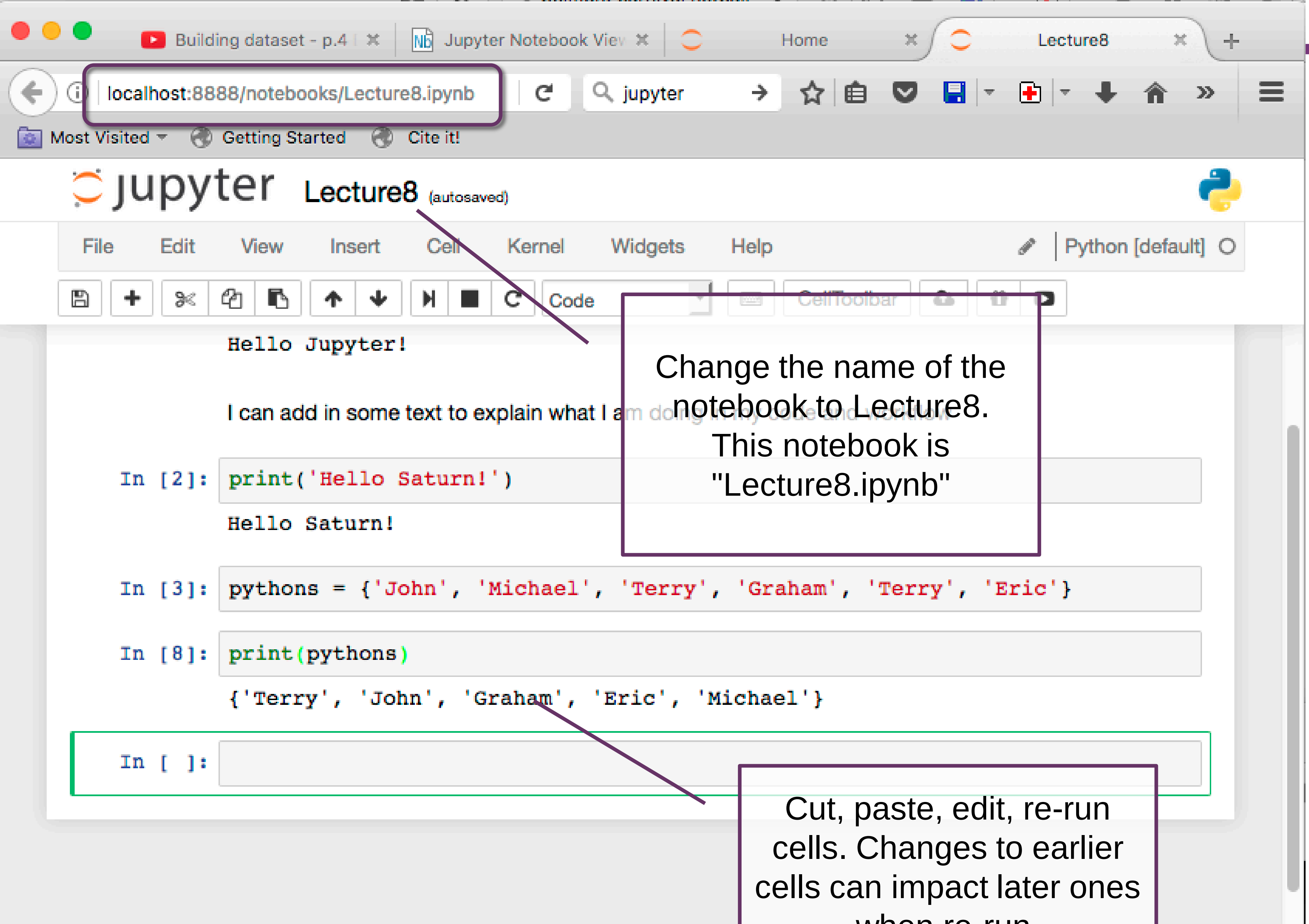
- Create a new notebook using default kernel…



Jupyter notebook

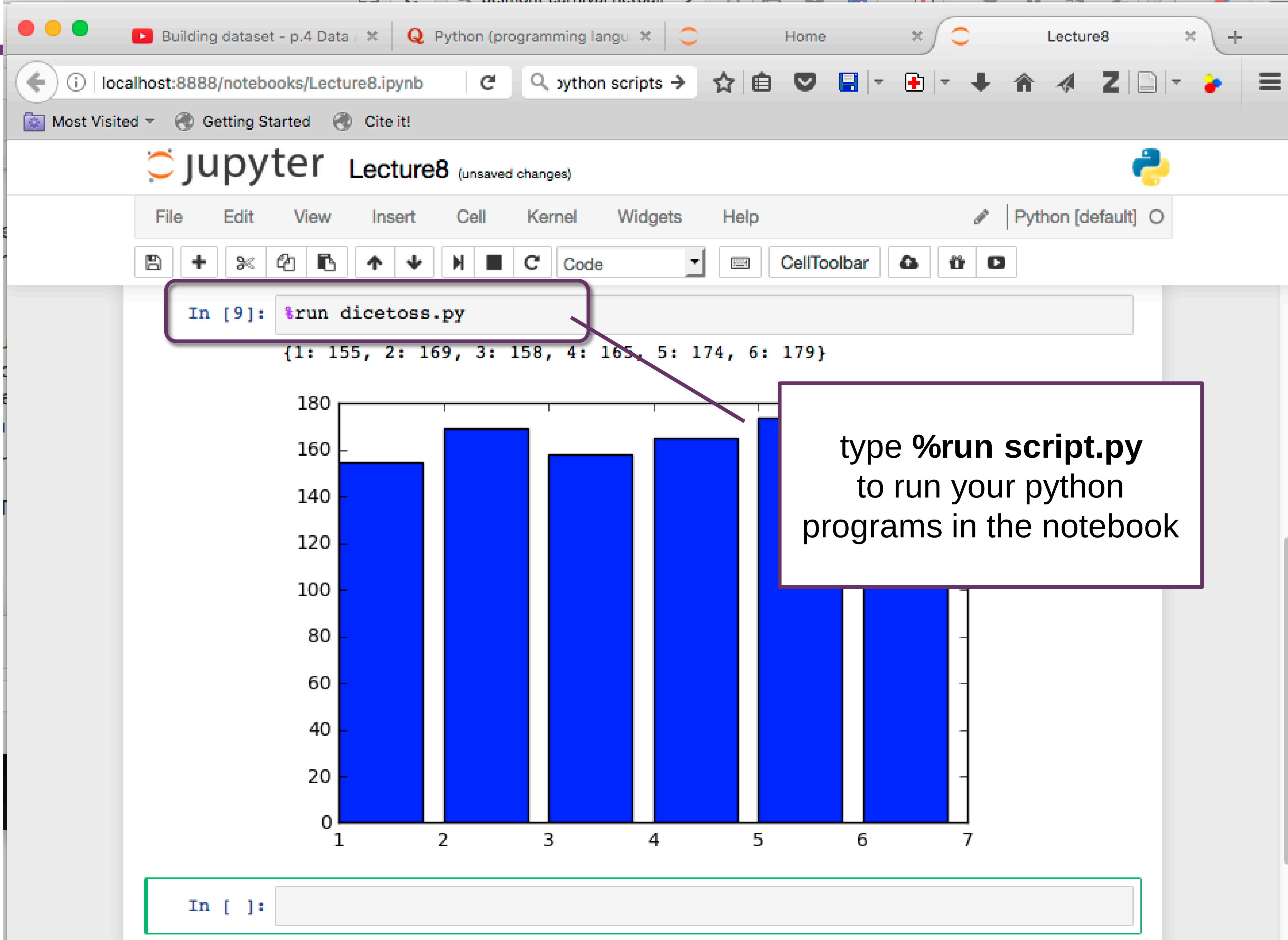
- Type in some Python code
- shift-enter to run the code


Building dataset - p.4
3. Running the Jupyter
Home
Untitled
localhost:8888/notebooks/Untitled.ipynb?
jupyter
Most Visited
Getting Started
Cite it!
jupyter Untitled (autosaved)
File Edit View Insert Cell Kernel Widgets Help
Python [default]
Code
CellToolbar
Code
Markdown
Raw NBConvert
Heading
In [1]: print('Hello Jupyter!')
Hello Jupyter!
I can add in some text to explain what I am doing in my code and workflow
In [2]: print('Hello Saturn!')
Hello Saturn!
In [ ]:
Change the cell type to markdown or heading to provide narrative or give structure to your document

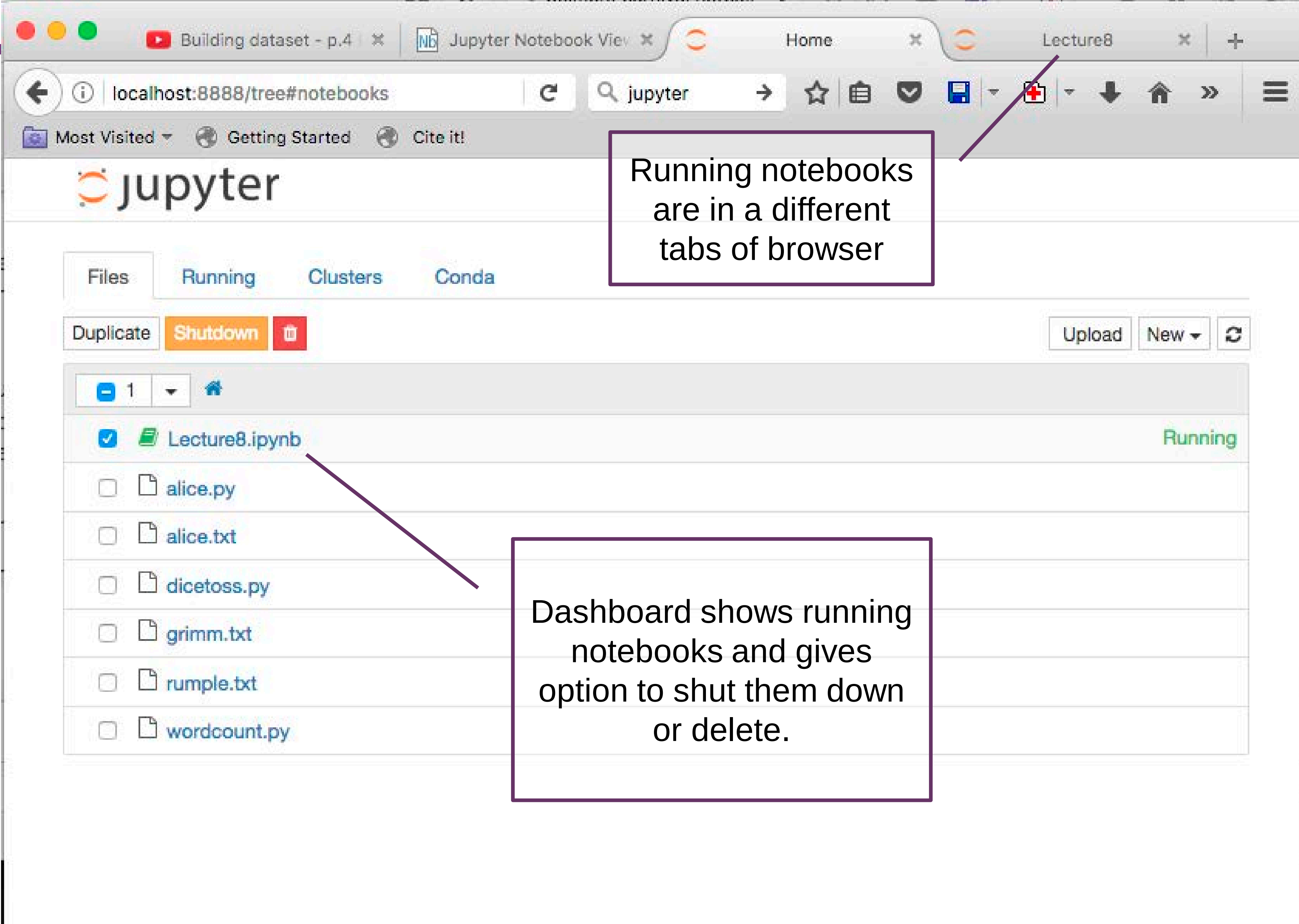


Change the name of the notebook to Lecture8. This notebook is "Lecture8.ipynb"

Cut, paste, edit, re-run cells. Changes to earlier cells can impact later ones when re-run.



type **%run script.py**
to run your python
programs in the notebook



Running notebooks are in a different tabs of browser

Dashboard shows running notebooks and gives option to shut them down or delete.

Reproducibility and notebooks

- A notebook lets you:
  - explore ideas
  - present workflows
  - show overall logic of research process
  - refine analysis or workflow over time
  - create presentations
- It may even be useful for your assignment!

Reproducibility and provenance

- Notebooks maintain metadata and context information – vital for provenance and reproducibility

Versions

In [1]:
```
%reload_ext version_information
%version_information numpy, scipy, matplotlib
```

Out[1]:

Software	Version
Python	2.7.10 64bit [GCC 4.2.1 (Apple Inc. build 5577)]
IPython	3.2.1
OS	Darwin 14.1.0 x86_64 i386 64bit
numpy	1.9.2
scipy	0.16.0
matplotlib	1.4.3
Sat Aug 15 11:30:23 2015 JST	

Some examples to explore

- Notebooks can be shared, some galleries:
- Main gallery for Jupyter project:
  - https://github.com/jupyter/jupyter/wiki/A-gallery-of-interesting-Jupyter-Notebooks
- Fabian Pedregosa's notebook gallery
  - http://nb.bianp.net/
- Example: an excellent matplotlib notebook
  - http://nbviewer.jupyter.org/github/jrjohansson/scientific-python-lectures/blob/master/Lecture-4-Matplotlib.ipynb

Building dataset - p.4 Data | Jupyter Notebook Viewer | Home | Lecture8

nbviewer.jupyter.org/github/jrjohanssor

jupyter gallery

Most Visited | Getting Started | Cite it!

different kind of plots. See the matplotlib plot gallery for a complete list of available plot types: http://matplotlib.org/gallery.html. Some of the more useful ones are show below:

In [46]:
```
n = np.array([0,1,2,3,4,5])
```

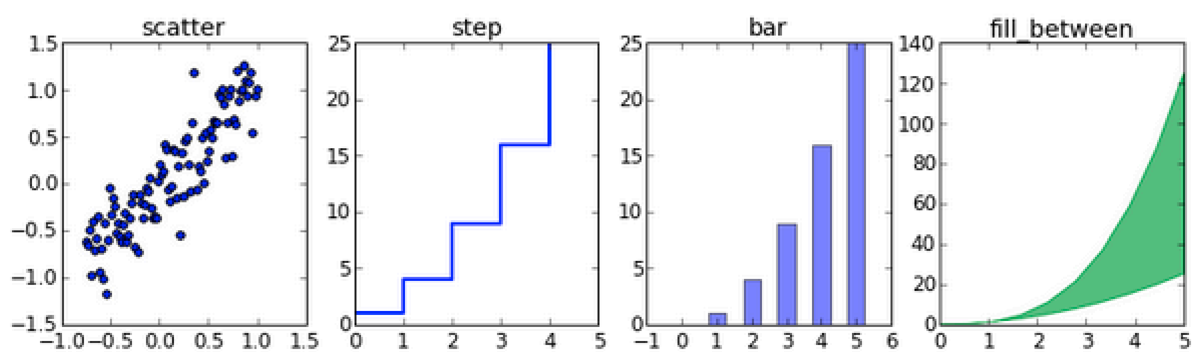
In [47]:
```
fig, axes = plt.subplots(1, 4, figsize=(12,3))

axes[0].scatter(xx, xx + 0.25*np.random.randn(len(xx)))
axes[0].set_title("scatter")

axes[1].step(n, n**2, lw=2)
axes[1].set_title("step")

axes[2].bar(n, n**2, align="center", width=0.5, alpha=0.5)
axes[2].set_title("bar")

axes[3].fill_between(x, x**2, x**3, color="green", alpha=0.5);
axes[3].set_title("fill_between");
```



In [48]:
```
# polar plot using add_axes and polar projection
```

translate | Highlight All | Match Case | Whole Words

Matplotlib notebook

Summary

- We've learnt a few more datatypes
- We've looked at how to use and implement structured data processing in Python using the pandas library
- We can see the value of reproducible research
- We can create and use Python notebooks to support exploratory research