Introduction to Data Science using Python

Abhijit Dasgupta, PhD

Plans for this workshop

We're meeting today and tomorrow 1:30 - 3:00 pm

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Day 1	Day 2
Why Python for Data Science?	Data visualization
A Python Primer	Statistical modeling
Pandas for data munging	Machine learning

Scope

Obviously we are going to cover each topic at a high level, given time constraints. I intend to give you a taste for what is possible

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There are much more detailed resources available as Jupyter notebooks.

https://github.com/districtdatalabs/Brookings_Python_DS

Topic	Notebook
Python primer	00_python_primer
Numpy and the data science stack (not covered)	01_python_tools_ds
Pandas for data munging	02_python_pandas
Data visualization	03_python_vis
Statistical modeling	04_python_stat
Machine learning	05_python_learning

Running notebooks on Binder

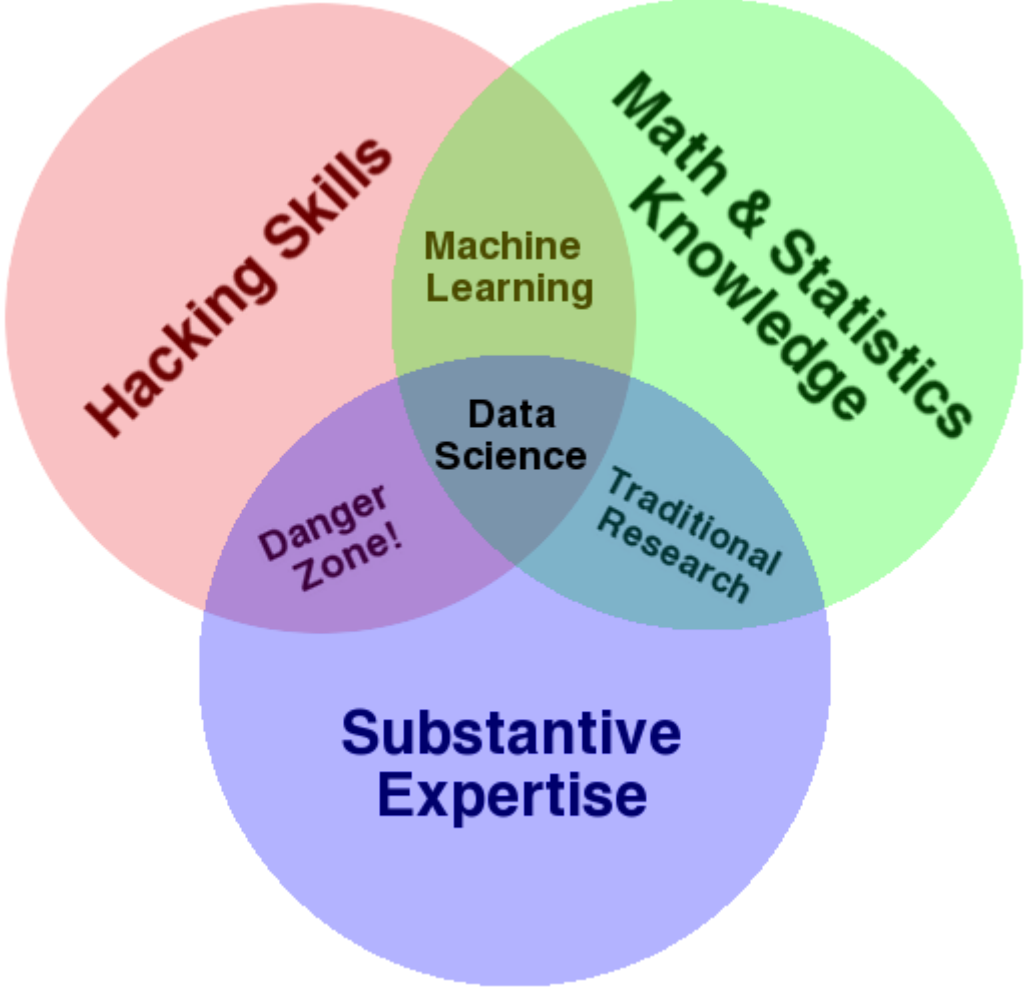
Binder is a free service that allows Python resources to be run on the web from Github repositories.

Binder demo

Why Python for Data Science?

Who is a data scientist?

One definition



Unclear definition

- Statistician
- Computer scientist
- Database engineer
- Software engineer
- Data engineer
- Mathematician

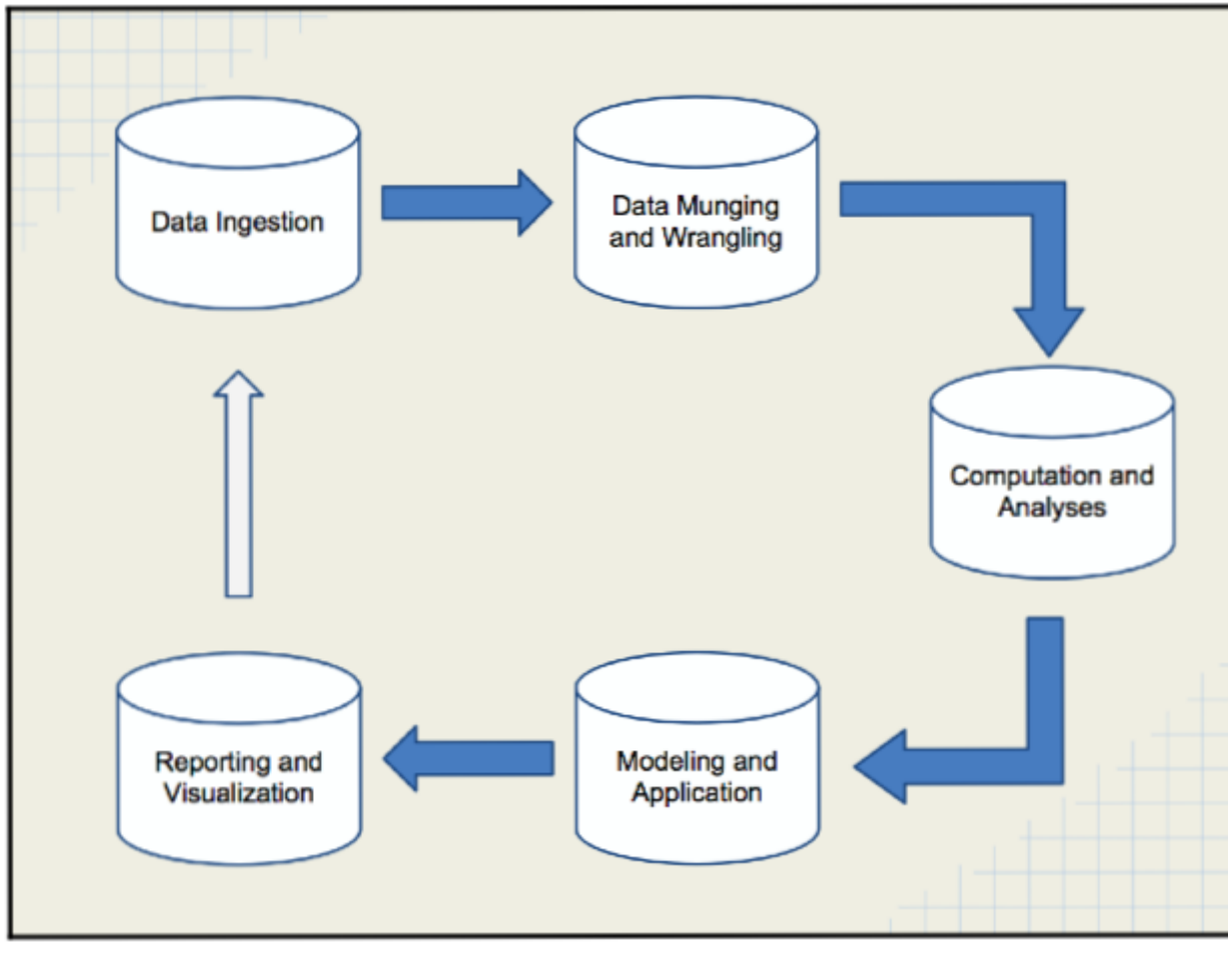
Some of the best ones I know are neurobiologists and physicists

A broad umbrella

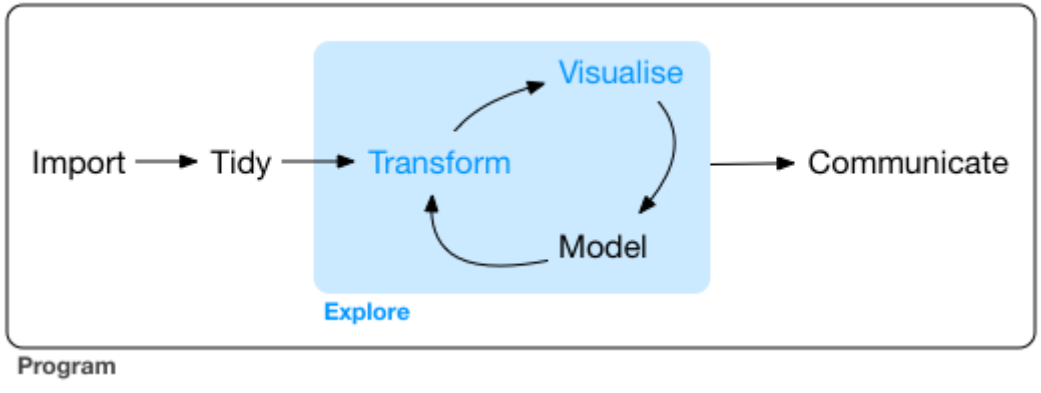
Anyone who wants to work with data to solve problems within particular domains

Data Science

What it involves



What it involves



What it involves

1. Managing and cleaning data
2. Interest in exploring relationships between things, informed by domain knowledge
3. Statistical know-how
4. Computational skills
5. Tools

We're here for the tools

The main two tools are

1. Python (https://www.python.org)
2. R (https://www.r-project.org)

There is a perpetual flame war between the two camps

That is not important

Why Python?

Pros

1. Very popular general purpose programming language
2. Strong ecosystem through packages (over 230K projects)
3. Succint syntax
4. Reasonably fast while also relatively easy to program
    - Computational time vs Developer time
5. Self-documenting
6. Easier to integrate into production pipelines that already use Python
    - Web frameworks (Django, Flask, ...)
    - Workflow managers (Luigi, ...)
7. Increasingly strong Data Science Stack

Cons

1. Not a rich-enough ecosystem for some purposes
2. More computer science-y, less statistical
3. Poorer frameworks for display and dissemination of information

These are areas where R tends to shine.

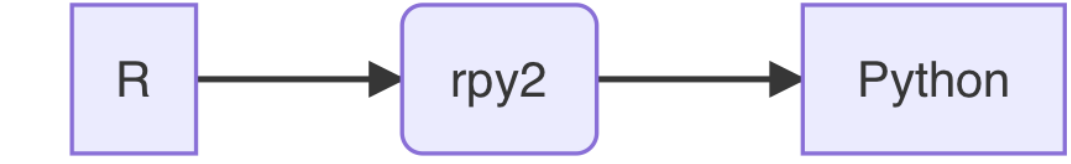
Python Data Science stack

Contributed packages over past 30 years

- To emulate Matlab
    - Numpy
    - Scipy
    - Matplotlib
- To emulate Maple
    - Sympy
- To add statistics/data science
    - Pandas
    - Various data visualization packages
        - seaborn
        - plotly

- Many more user-contributed packages
- The basic philosophy has been to concentrate on a few monolithic comprehensive packages
    - statsmodels (Statistics)
    - scikit-learn (Machine Learning)
    - pillow (Image analysis)
    - nltk (Natural Language Processing)
    - tensorflow & PyTorch (Deep learning)
    - PyMC3 (Bayesian learning)

Python as glue



- The `rpy2` Python package is not developed on Windows
- The `reticulate` R package actually works quite well

1. Data I/O
    - We can read data from a variety of formats into Python
        - Some proprietary
        - R, SAS, Stata, SQL, Parquet, JSON
2. There are ways of running R, SAS, others from within Python
3. The Jupyter sub-ecosystem allows the same interface for many languages
    - R, SAS, Julia, Haskell, Javascript

A Python Primer

Python is a popular, general purpose scripting language. The TIOBE index ranks Python as the third most popular programming language after C and Java, while this recent article in IEEE Computer Society says

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> *"Python can be used for web and desktop applications, GUI-based desktop applications, machine learning, data science, and network servers. The programming language enjoys immense community support and offers several open-source libraries, frameworks, and modules that make application development a cakewalk." (Belani, 2020)*

Python is a modular language

Python is not a monolithic language but is comprised of

1. a base programming language
2. numerous modules or libraries that add functionality to the language.

Python is a scripting language

Python is a scripting language

Using Python requires typing!!

1. You write *code* in Python
2. that is then interpreted by the Python interpreter
3. to make the computer implement your instructions.

Your code is like a recipe that you write for the computer.

Python is a *high-level language* in that the code is English-like and human-readable and understandable, which reduces the time needed for a person to create the recipe.

It is a language in that it has nouns (*variables* or *objects*), verbs (*functions*) and a structure or grammar that allows the programmer to write recipes for different functionalities.

Scripting can be frustrating in the beginning. You will find that the code you wrote doesn't work "for some reason", though it looks like you wrote it fine. The first things I look for, in order, are

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One thing that is important to note in Python: **case is important!**. If we have two objects named `data` and `Data`, they will refer to different things.

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One thing that is important to note in Python: **case is important!**. If we have two objects named `data` and `Data`, they will refer to different things.

1. Did I spell all the variables and functions correctly
2. Did I close all the brackets I have opened
3. Did I finish all the quotes I started, and paired single- and double-quotes
4. Did I already import the right module for the function I'm trying to use.
5. Do I have the right indentations in my code.

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5. Do I have the right indentations in my code.

These may not make sense right now, but as we go into Python, I hope you will remember these to help debug your code.

An example

Let's consider the following piece of Python code:

In [1]:
```
# set a splitting point
split_point = 3

# make two empty lists
lower = []; upper = []

# Split numbers from 0 to 9 into two groups,
# one lower or equal to the split point and
# one higher than the split point

for i in range(10):  # count from 0 to 9
    if i <= split_point:
        lower.append(i)
    else:
        upper.append(i)

print("lower:", lower)
print("upper:", upper)
```

```
lower: [0, 1, 2, 3]
upper: [4, 5, 6, 7, 8, 9]
```

In [ ]:

```
split_point = 3
```

In [ ]:
```
split_point = 3
```

This takes the number 3 and stores it in the **variable** `split_point`. Variables are just names where some Python object is stored. It really works as an address to some particular part of your computer's memory, telling the Python interpreter to look for the value stored at that particular part of memory. Variable names allow your code to be human-readable since it allows you to write expressive names to remind yourself what you are storing. The rules of variable names are:

1. Variable names must start with a letter or underscore
2. The rest of the name can have letters, numbers or underscores
3. Names are case-sensitive

In [ ]:

```
lower = []; upper = []
```

In [ ]:
```
lower = []; upper = []
```

The semi-colon tells Python that, even though written on the same line, a particular instruction ends at the semi-colon, then another piece of instruction is written.

Lists are a catch-all data structure that can store different kinds of things, In this case we'll use them to store numbers.

In [ ]:

```
for i in range(10):  # count from 0 to 9
    if i <= split_point
        lower.append(i)
    else:
        upper.append(i)
```

In [ ]:

```
for i in range(10):  # count from 0 to 9
    if i <= split_point
        lower.append(i)
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        upper.append(i)
```

This is a *for-loop*.

1. State with the numbers 0-9 (this is achieved in `range(10)`)
2. Loop through each number, naming it `i` each time
    A. Computer programs allow you to over-write a variable with a new value
3. If the number currently stored in `i` is less than or equal to the value of `split_point`, i.e., 3 then add it to the list `lower`. Otherwise add it to the list `upper`

In [ ]:

```
for i in range(10):  # count from 0 to 9
    if i <= split_point:
        lower.append(i)
    else:
        upper.append(i)
```

In [ ]:

```
for i in range(10):  # count from 0 to 9
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        lower.append(i)
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        upper.append(i)
```

Note the indentation in the code. **This is not by accident**. Python understands the extent of a particular block of code within a for-loop (or within a `if` statement) using the indentations.

In this segment there are 3 code blocks:

1. The for-loop as a whole (1st indentation)
2. The `if` statement testing if the number is less than or equal to the split point, telling Python what to do if the test is true
3. The `else` statement stating what to do if the test in the `if` statement is false

In [ ]:

```
print("lower:", lower)
print("upper:", upper)
```

In [ ]:

```
print("lower:", lower)
print("upper:", upper)
```

The `print` statement adds some text, and then prints out a representation of the object stored in the variable being printed. In this example, this is a list, and is printed as

```
lower: [0, 1, 2, 3]
upper: [4, 5, 6, 7, 8, 9]
```

We will expand on these concepts in the next few sections.

Some general rules on Python syntax

1. Comments are marked by `#`
2. A statement is terminated by the end of a line, or by a `;`.
3. Indentation specifies blocks of code within particular structures. Whitespace at the beginning of lines matters. Typically you want to have 2 or 4 spaces to specify indentation, not a tab (\t) character. This can be set up in your IDE.
4. Whitespace within lines does not matter, so you can use spaces liberally to make your code more readable
5. Parentheses (`()`) are for grouping pieces of code or for calling functions.

Data types

Numbers

1. Floats (decimal numbers) : `float`
2. Integers : `int`

Numbers

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2. Integers : `int`

Operation	Result
x + y	The sum of x and y
x - y	The difference of x and y
x * y	The product of x and y
x / y	The quotient of x and y
- x	The negative of x
abs(x)	The absolute value of x
x ** y	x raised to the power y
int(x)	Convert a number to integer
float(x)	Convert a number to floating point

In [4]:
```
x = 3; y = 5

(2*x) -  (5 * y**2)
```

Out[4]:
```
-119
```

Strings

Strings

In [10]:
```
first_name = 'Abhijit'
last_name = "Dasgupta"

'jit' in last_name
```

Out[10]:
```
False
```

String operations

In [ ]:

```
first_name + last_name

first_name*3

"gup" in last_name
```

Truthiness

Truthiness means evaluating the truth of a statement. This typically results in a Boolean object, which can take values `True` and `False`, but Python has several equivalent representations. The following values are considered the same as False:

> *`None`, `False`, zero (`0`, `0L`, `0.0`), any empty sequence (`[]`, `''`, `()`), and a few others*

All other values are considered True. Usually we'll denote truth by `True` and the number `1`.

Operation	Result
x < y	x is strictly less than y
x <= y	x is less than or equal to y
x == y	x equals y (note, it's 2 = signs)
x != y	x is not equal to y
x > y	x is strictly greater than y
x >= y	x is greater or equal to y

We can chain these comparisons using Boolean operations

Operation	Result
x | y	Either x is true or y is true or both
x & y	Both x and y are true
not x	if x is true, then false, and vice versa

In [13]:
```
x = 5

(x < 3) | (x <= 7)
```

Out[13]:
```
True
```

Variables are like individual ingredients in your recipe. It's *mis en place* or setting the table for any operations (*functions*) we want to do to them.

- Variables are like *nouns*,
- which will be acted on by verbs (*functions*).

In the next section we'll look at collections of variables. These collections are important in that it allows us to organize our variables with some structure.

Data structures

1. Lists (`[]`)
2. Tuples (`()`)
3. Dictionaries or dicts (`{}`)

Lists are baskets that can contain different kinds of things. They are ordered, so that there is a first element, and a second element, and a last element, in order. However, the *kinds* of things in a single list doesn't have to be the same type.

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Tuples are basically like lists, except that they are *immutable*, i.e., once they are created, individual values can't be changed. They are also ordered, so there is a first element, a second element and so on.

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Dictionaries are **unordered** key-value pairs, which are very fast for looking up things. They work almost like hash tables. Dictionaries will be very useful to us as we progress towards the PyData stack. Elements need to be referred to by *key*, not by position.

In [14]:

```
test_list = ["apple", 3, True, "Harvey", 48205]
test_tuple = ("apple", 3, True, "Harvey", 48205)

test_list[0]
```

Out[14]:

```
'apple'
```

index	0	1	2	3	4
element	'apple'	3	True	'Harvey'	48205
counting backwards	-5	-4	-3	-2	-1

In [ ]:

```
contact = {
    "first_name": "Abhijit",
    "last_name": "Dasgupta",
    "Age": 48,
    "address": "124 Main St",
    "Employed": True,
}
```

In [ ]:

```
contact['first_name']
contact['address']
```

In [ ]:
```
contact['first_name']
contact['address']
```

In [ ]:
```
contact.keys()
contact.values()
```

Operations

Loops

```
pseudocode
Start with a list of datasets, one for each state
for each state
    compute and store fraction of votes that are Republican
    compute and store fraction of votes that are Democratic
```

In [ ]:

```
for i in range(len(test_list)):
    print(test_list[i])
```

In [ ]:

```
for i in range(len(test_list)):
    print(test_list[i])
```

In [ ]:

```
for u in test_list:
    print(u)
```

In [ ]:

```
test_list2 = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
mysum = 0
for u in test_list2:
    mysum = mysum + u
print(mysum)
```

`enumerate` automatically creates both the index and the value for each element of a list.

In [15]:
```
L = [0, 2, 4, 6, 8]
for i, val in enumerate(L):
    print(i, val)
```

```
0 0
1 2
2 4
3 6
4 8
```

`zip` puts multiple lists together and creates a composite iterator. You can have any number of iterators in zip, and the length of the result is determined by the length of the shortest iterator.

In [16]:

```
first = ["Han", "Luke", "Leia", "Anakin"]
last = ["Solo", "Skywalker", "Skywaker", "Skywalker"]
types = ['light','light','light','light/dark/light']

for val1, val2, val3 in zip(first, last, types):
    print(val1, val2, ' : ', val3)
```

```
Han Solo  :  light
Luke Skywalker  :  light
Leia Skywaker  :  light
Anakin Skywalker  :  light/dark/light
```

List comprehensions

In [ ]:

```
test_list2 = [1,2,3,4,5,6]

squares = [u**2 for u in test_list2]
squares
```

Conditional evaluation

```
pseudocode
if Condition 1 is true then
    do Recipe 1
else if (elif) Condition 2 is true then
  do Recipe 2
else
  do Recipe 3
```

In [17]:

```
x = [-2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
y = []  # an empty list

for u in x:
    if u < 0:
        y.append("Negative")
    elif u % 2 == 1:  # what is remainder when dividing by 2
        y.append("Odd")
    else:
        y.append("Even")

print(y)
```

```
['Negative', 'Negative', 'Even', 'Odd', 'Even', 'Odd', 'Even', 'Odd', 'Eve
n', 'Odd', 'Even', 'Odd', 'Even']
```

Functions

Functions

In [ ]:

```
def my_mean(x):
    y = 0
    for u in x:
        y += u
    y = y / len(x)
    return y
```

A Python function must start with the keyword `def` followed by the name of the function, the arguments within parentheses, and then a colon. The actual code for the function is indented, just like in for-loops and if-elif-else structures. It ends with a `return` function which specifies the output of the function.

In [18]:

```
def my_mean(x):
    """
  A function to compute the mean of a list of numbers.

  INPUTS:
  x : a list containing numbers

  OUTPUT:
  The arithmetic mean of the list of numbers
  """
    y = 0
    for u in x:
        y = y + u
    y = y / len(x)
    return y
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  """
    y = 0
    for u in x:
        y = y + u
    y = y / len(x)
    return y
```

In [19]:
```
help(my_mean)
```

```
Help on function my_mean in module __main__:

my_mean(x)
    A function to compute the mean of a list of numbers.

    INPUTS:
    x : a list containing numbers

    OUTPUT:
```

The arithmetic mean of the list of numbers

Pandas (Python Data Analysis)

- Data ingestion
- Data cleaning and transformation
- Data can be passed on to modeling and visualization packages

Activating packages for use

- Use the `import` command
- Maybe provide an alias for the package

Activating packages for use

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In [21]:
```
import numpy as np
import pandas as pd
```

Data import

Format type	Description	reader	writer
text	CSV	read_csv	to_csv
	Excel	read_excel	to_excel
text	JSON	read_json	to_json
binary	Feather	read_feather	to_feather
binary	SAS	read_sas	
SQL	SQL	read_sql	to_sql

In [22]:

```
mtcars = pd.read_csv('data/mtcars.csv')
```

In [22]:
```
mtcars = pd.read_csv('data/mtcars.csv')
```

> *One of the big differences between a spreadsheet program and a programming language from the data science perspective is that you have to load data into the programming language. It's not "just there" like Excel. This is a good thing, since it allows the common functionality of the programming language to work across multiple data sets, and also keeps the original data set pristine. Excel users can run into problems and corrupt their data if they are not careful.*

Exploring data

Creating a DataFrame

In [29]:

```
rng = np.random.RandomState(25)
d2 = pd.DataFrame(rng.normal(0,1, (4, 5)),
                  columns = ['A','B','C','D','E'],
                  index = ['a','b','c','d'])
d2
```

Out[29]:

	A	B	C	D	E
a	0.228273	1.026890	-0.839585	-0.591182	-0.956888
b	-0.222326	-0.619915	1.837905	-2.053231	0.868583
c	-0.920734	-0.232312	2.152957	-1.334661	0.076380
d	-1.246089	1.202272	-1.049942	1.056610	-0.419678

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d2
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Out[29]:

	A	B	C	D	E
a	0.228273	1.026890	-0.839585	-0.591182	-0.956888
b	-0.222326	-0.619915	1.837905	-2.053231	0.868583
c	-0.920734	-0.232312	2.152957	-1.334661	0.076380
d	-1.246089	1.202272	-1.049942	1.056610	-0.419678

A DataFrame has (mutable)

- An `index` (row names)
- A `column` (column names)‘

In [30]:
```
d2.columns
d2.index
```

Out[30]:
```
Index(['a', 'b', 'c', 'd'], dtype='object')
```

In [31]:

```
df = pd.DataFrame({
    'A':3.,
    'B':rng.random_sample(5),
    'C': pd.Timestamp('20200512'),
    'D': np.array([6] * 5),
    'E': pd.Categorical(['yes','no','no','yes','no']),
    'F': 'NIH'})
df
```

Out[31]:

	A	B	C	D	E	F
0	3.0	0.481343	2020-05-12	6	yes	NIH
1	3.0	0.516502	2020-05-12	6	no	NIH
2	3.0	0.383048	2020-05-12	6	no	NIH
3	3.0	0.997541	2020-05-12	6	yes	NIH
4	3.0	0.514244	2020-05-12	6	no	NIH

You can also use a `dict` to create a `DataFrame`. If elements aren't of the same size, errors will be thrown, unless it is a single element. Then it will be repeated.

Slicing and dicing a DataFrame

In [32]:
```
df['B']
df.B
```

Out[32]:
```
0    0.481343
1    0.516502
2    0.383048
3    0.997541
4    0.514244
Name: B, dtype: float64
```

There are two extractor functions in `pandas`:

- `loc` extracts by label (index label, column label, slice of labels, etc.
- `iloc` extracts by index (integers, slice objects, etc.

In [34]:
```
df.loc[1:3, 'C']
```

Out[34]:
```
1   2020-05-12
2   2020-05-12
3   2020-05-12
Name: C, dtype: datetime64[ns]
```

You can also extract rows by condition (filter)

In [35]:
```
df = pd.DataFrame(np.random.randn(5, 3), index = ['a','c','e', 'f','g'], columns = ['one'
df['four'] = 20 # add a column named "four", which will all be 20
df['five'] = df['one'] > 0
df
```

Out[35]:

	one	two	three	four	five
a	-0.847315	0.663926	0.182211	20	False
c	1.682927	-0.056388	0.244149	20	True
e	0.185502	0.554072	-0.739743	20	True
f	-0.151335	-0.172999	-0.656354	20	False
g	0.672965	-0.680025	-0.065153	20	True

In [37]:
```
df[(df.one > 1) & (df.three < 0)]

df.query('(one > 1) & (three > 0)')
```

Out[37]:

	one	two	three	four	five
c	1.682927	-0.056388	0.244149	20	True

Replacing values

In [41]:

```
#df2.replace(0, -9) # replace 0 with -9

df.replace({'one': {5: 500}, 'three':{0:-9, 8:800}})
```

Out[41]:

	one	two	three	four	five
a	-0.847315	0.663926	0.182211	20	False
c	1.682927	-0.056388	0.244149	20	True
e	0.185502	0.554072	-0.739743	20	True
f	-0.151335	-0.172999	-0.656354	20	False
g	0.672965	-0.680025	-0.065153	20	True

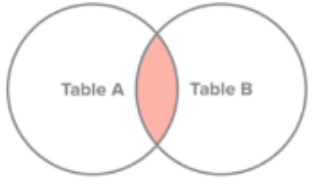
Joins

There are basically four kinds of joins:

pandas	R	SQL	Description
left	left_join	left outer	keep all rows on left
right	right_join	right outer	keep all rows on right
outer	outer_join	full outer	keep all rows from both
inner	inner_join	inner	keep only rows with common keys

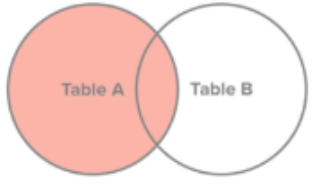
Joins

Inner Join



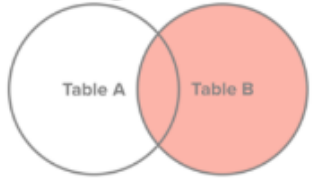
Select all records from Table A and Table B, where the join condition is met.

Left Join



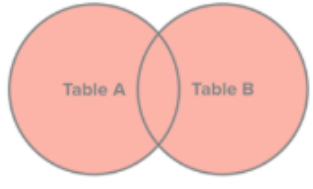
Select all records from Table A, along with records from Table B for which the join condition is met (if at all).

Right Join



Select all records from Table B, along with records from Table A for which the join condition is met (if at all).

Full Join



Select all records from Table A and Table B, regardless of whether the join condition is met or not.

In [42]:

```
survey = pd.read_csv('data/survey_survey.csv')
visited = pd.read_csv('data/survey_visited.csv')
```

In [43]:

```
pd.merge(survey, visited, left_on = 'taken', right_on = 'ident', how = 'left')
# survey.merge(visited, left_on = 'taken', right_on = 'ident', how = 'left')
```

Out[43]:

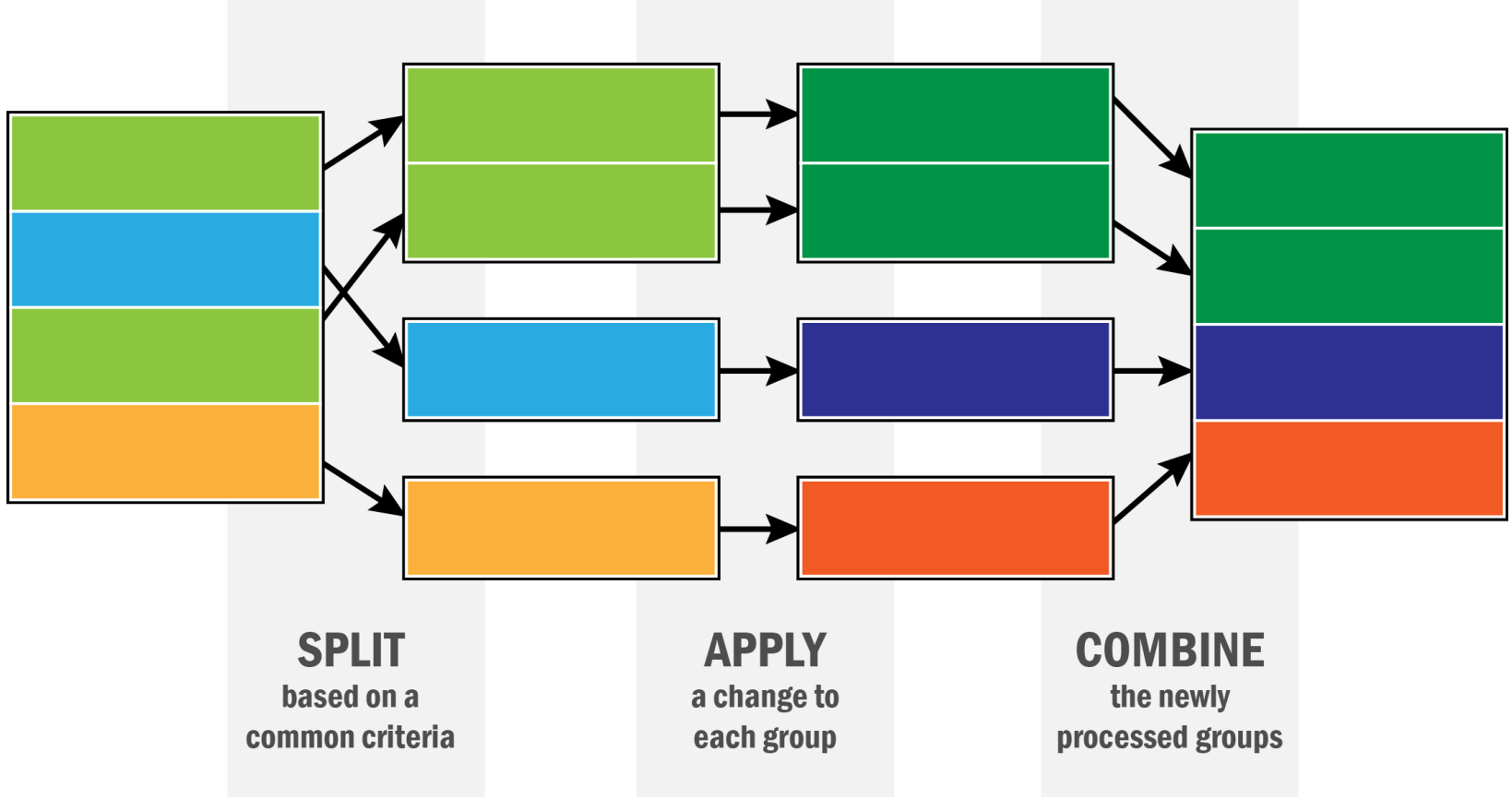
	taken	person	quant	reading	ident	site	dated
0	619	dyer	rad	9.82	619	DR-1	1927-02-08
1	619	dyer	sal	0.13	619	DR-1	1927-02-08
2	622	dyer	rad	7.80	622	DR-1	1927-02-10
3	622	dyer	sal	0.09	622	DR-1	1927-02-10
4	734	pb	rad	8.41	734	DR-3	1939-01-07
5	734	lake	sal	0.05	734	DR-3	1939-01-07
6	734	pb	temp	-21.50	734	DR-3	1939-01-07
7	735	pb	rad	7.22	735	DR-3	1930-01-12
8	735	NaN	sal	0.06	735	DR-3	1930-01-12
9	735	NaN	temp	-26.00	735	DR-3	1930-01-12
10	751	pb	rad	4.35	751	DR-3	1930-02-26
11	751	pb	temp	-18.50	751	DR-3	1930-02-26
12	751	lake	sal	0.10	751	DR-3	1930-02-26
13	752	lake	rad	2.19	752	DR-3	NaN
14	752	lake	sal	0.09	752	DR-3	NaN
15	752	lake	temp	-16.00	752	DR-3	NaN
16	752	roe	sal	41.60	752	DR-3	NaN
17	837	lake	rad	1.46	837	MSK-4	1932-01-14
18	837	lake	sal	0.21	837	MSK-4	1932-01-14
19	837	roe	sal	22.50	837	MSK-4	1932-01-14
20	844	roe	rad	11.25	844	DR-1	1932-03-22

Here, the left dataset is `survey` and the right one is `visited`.

Since we're doing a left join, we keed all the rows from `survey` and add columns from `visited`, matching on the common key, called "taken" in one dataset and "ident" in the other.

Note that the rows of `visited` are repeated as needed to line up with all the rows with common "taken" values.

Data aggregation and split-apply-combine



In [44]:

```
gapminder =  pd.read_csv('data/gapminder.tsv', sep = '\t')
gapminder.head()
```

Out[44]:

	country	continent	year	lifeExp	pop	gdpPercap
0	Afghanistan	Asia	1952	28.801	8425333	779.445314
1	Afghanistan	Asia	1957	30.332	9240934	820.853030
2	Afghanistan	Asia	1962	31.997	10267083	853.100710
3	Afghanistan	Asia	1967	34.020	11537966	836.197138
4	Afghanistan	Asia	1972	36.088	13079460	739.981106

In [45]:
```
gapminder.groupby('country')['lifeExp'].mean()
```

Out[45]:
```
country
Afghanistan            37.478833
Albania                68.432917
Algeria                59.030167
Angola                 37.883500
Argentina              69.060417
                           ...
Vietnam                57.479500
West Bank and Gaza     60.328667
Yemen, Rep.            46.780417
Zambia                 45.996333
Zimbabwe               52.663167
Name: lifeExp, Length: 142, dtype: float64
```

In [ ]:

```
gapminder.groupby('country').get_group('United Kingdom')
```

In [46]:
```
gapminder.groupby('continent').lifeExp.agg(np.median) # Medians
```

Out[46]:
```
continent
Africa      47.7920
Americas    67.0480
Asia        61.7915
Europe      72.2410
Oceania     73.6650
Name: lifeExp, dtype: float64
```

In [47]:
```
gapminder.groupby('year').agg({'lifeExp': np.mean, 'pop': np.median, 'gdpPercap': np.medi
```

Out[47]:

	year	lifeExp	pop	gdpPercap
0	1952	49.057620	3943953.0	1968.528344
1	1957	51.507401	4282942.0	2173.220291
2	1962	53.609249	4686039.5	2335.439533
3	1967	55.678290	5170175.5	2678.334741
4	1972	57.647386	5877996.5	3339.129407
5	1977	59.570157	6404036.5	3798.609244
6	1982	61.533197	7007320.0	4216.228428
7	1987	63.212613	7774861.5	4280.300366
8	1992	64.160338	8688686.5	4386.085502
9	1997	65.014676	9735063.5	4781.825478
10	2002	65.694923	10372918.5	5319.804524
11	2007	67.007423	10517531.0	6124.371109