



INTERMEDIATE PYTHON FOR DATA SCIENCE

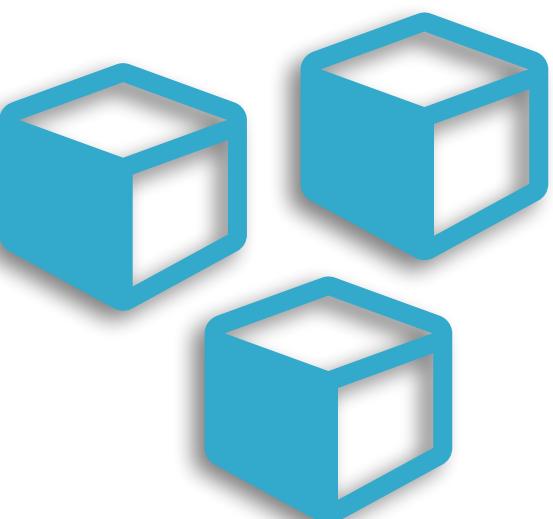
Basic Plots with Matplotlib



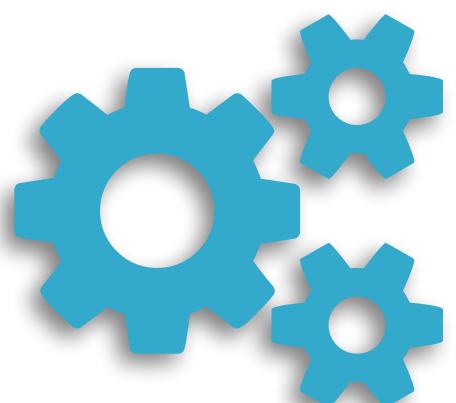
- Visualization



- Data Structures



- Control Structures

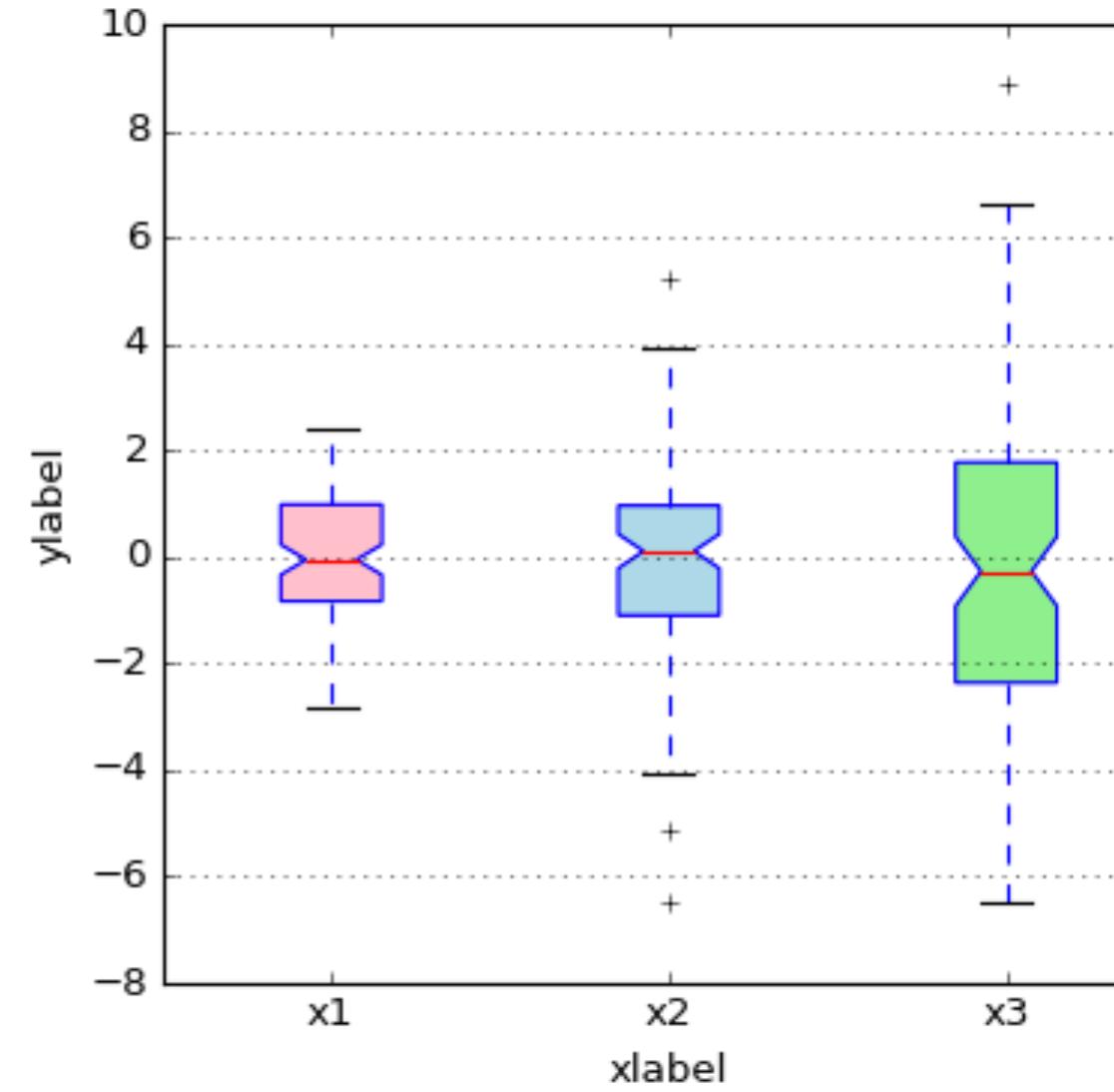
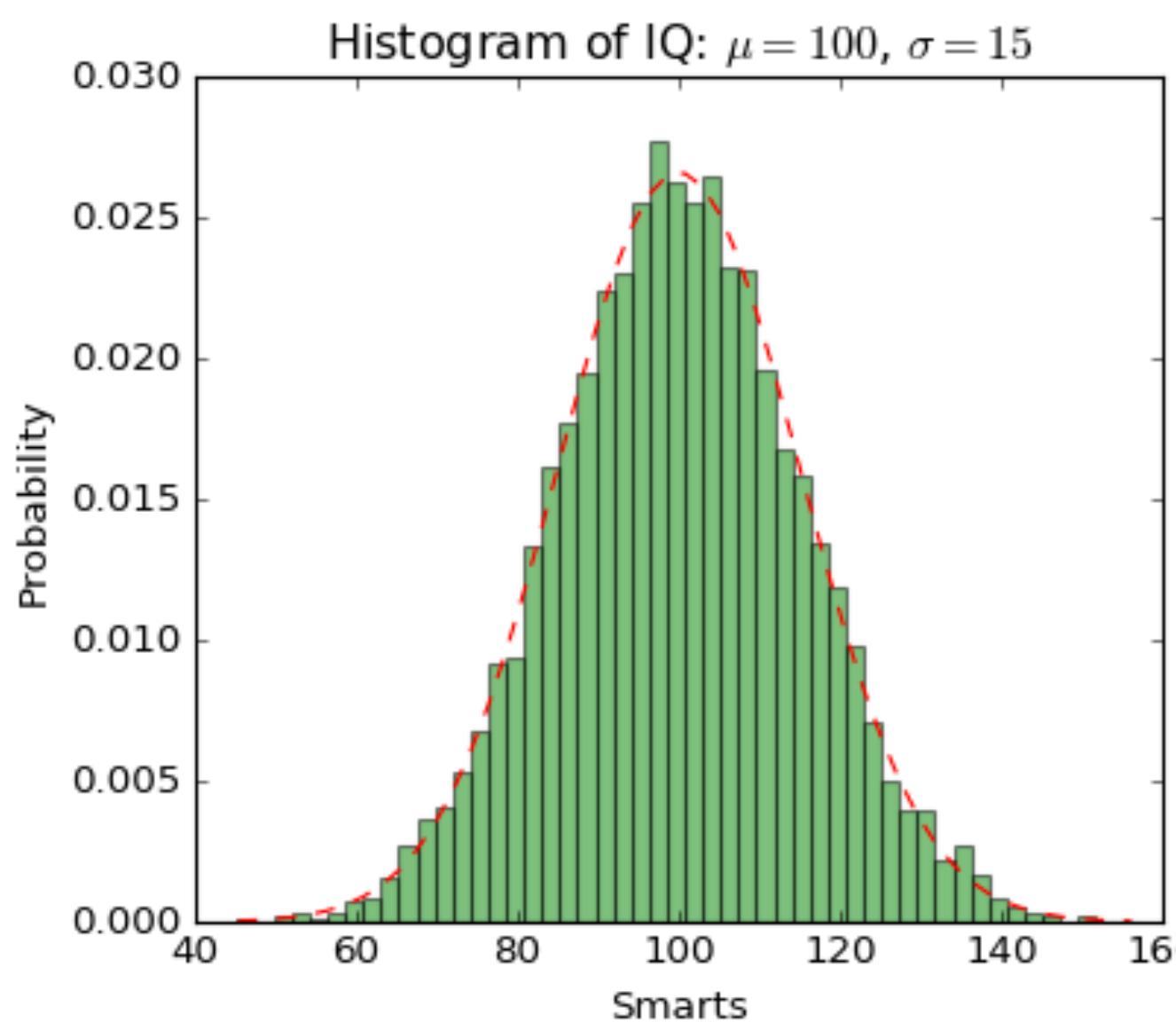


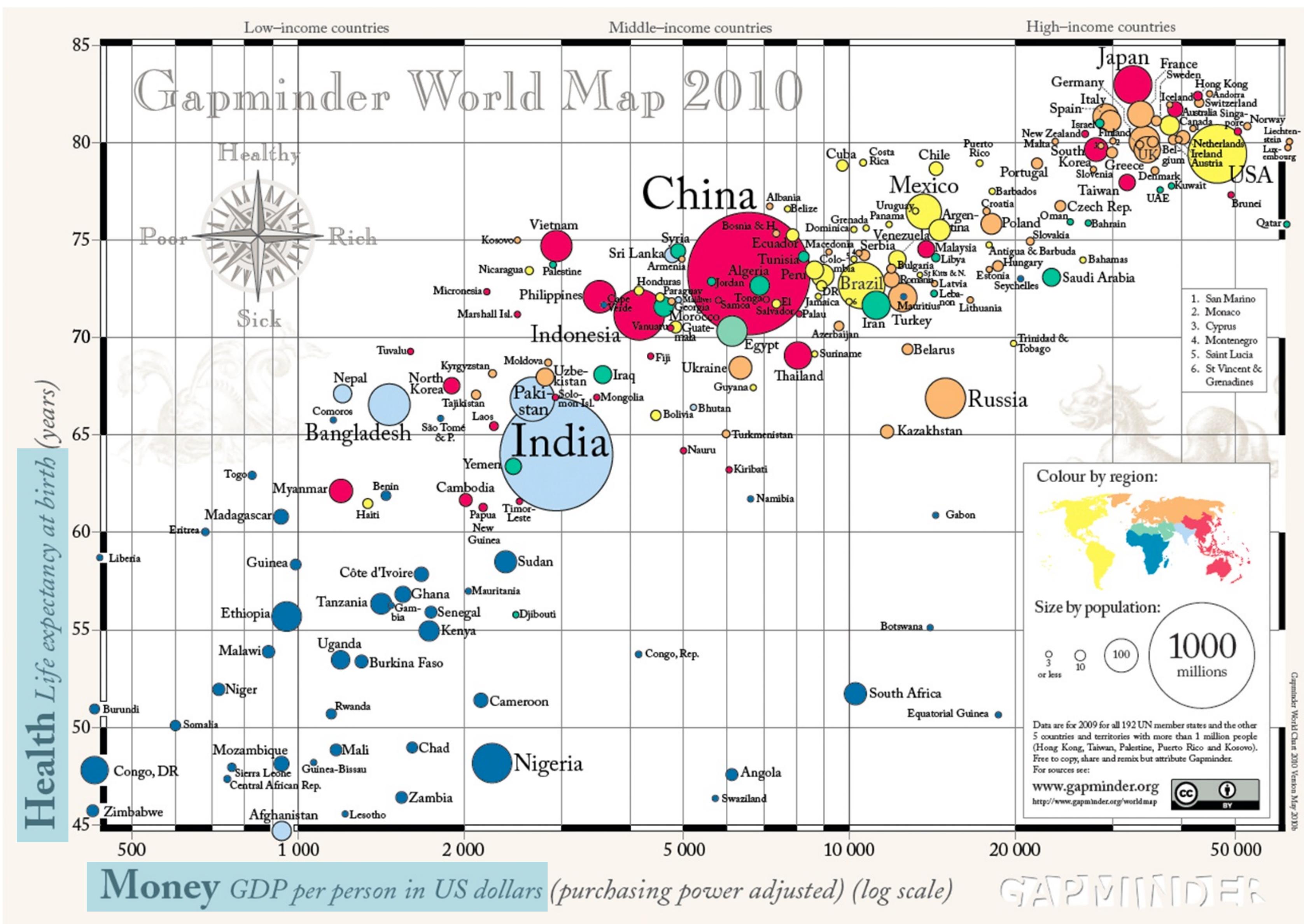
- Case Study



Data Visualization

- Very important in Data Analysis
 - Explore data
 - Report insights





Matplotlib

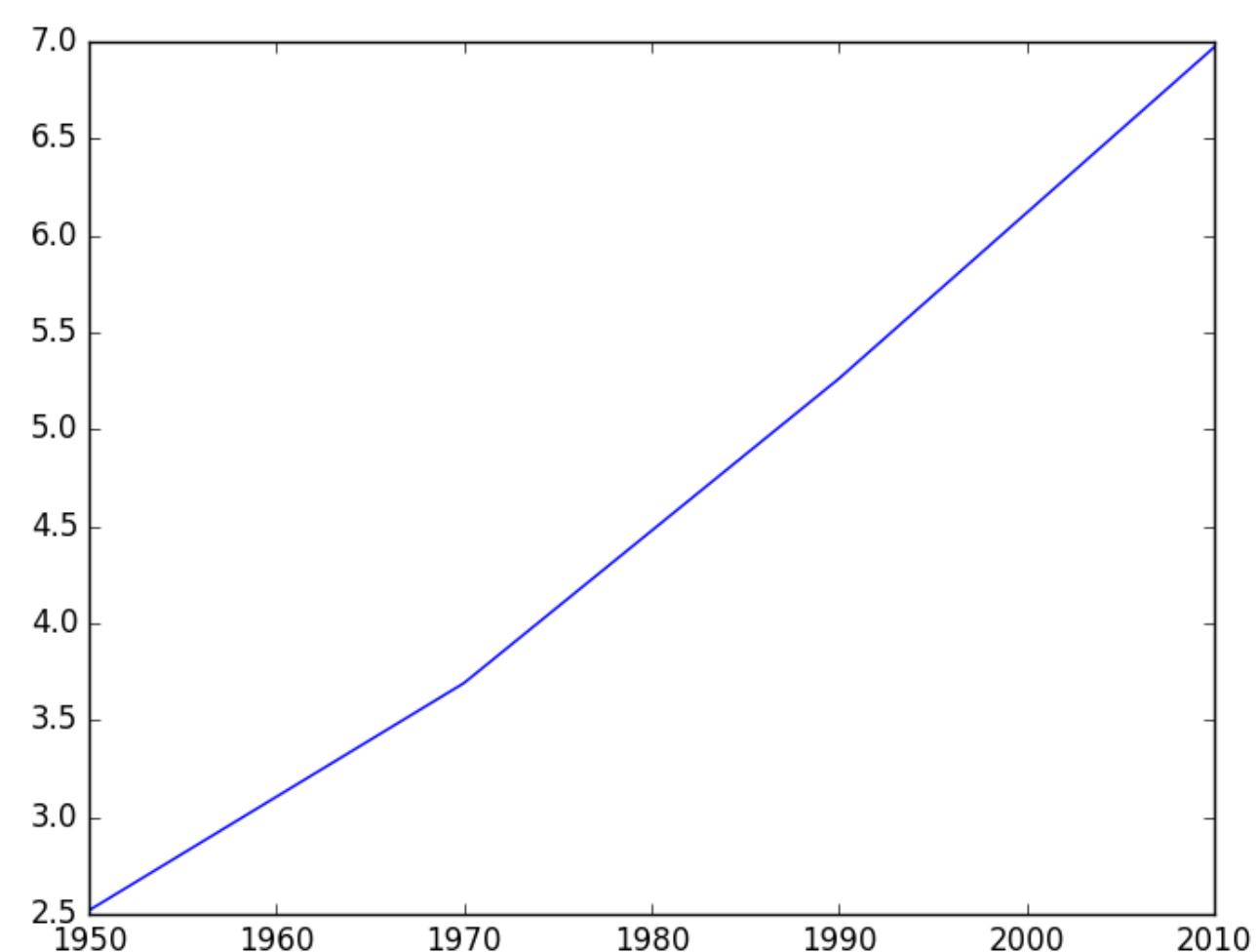
```
In [1]: import matplotlib.pyplot as plt
```

```
In [2]: year = [1950, 1970, 1990, 2010]
```

```
In [3]: pop = [2.519, 3.692, 5.263, 6.972]
```

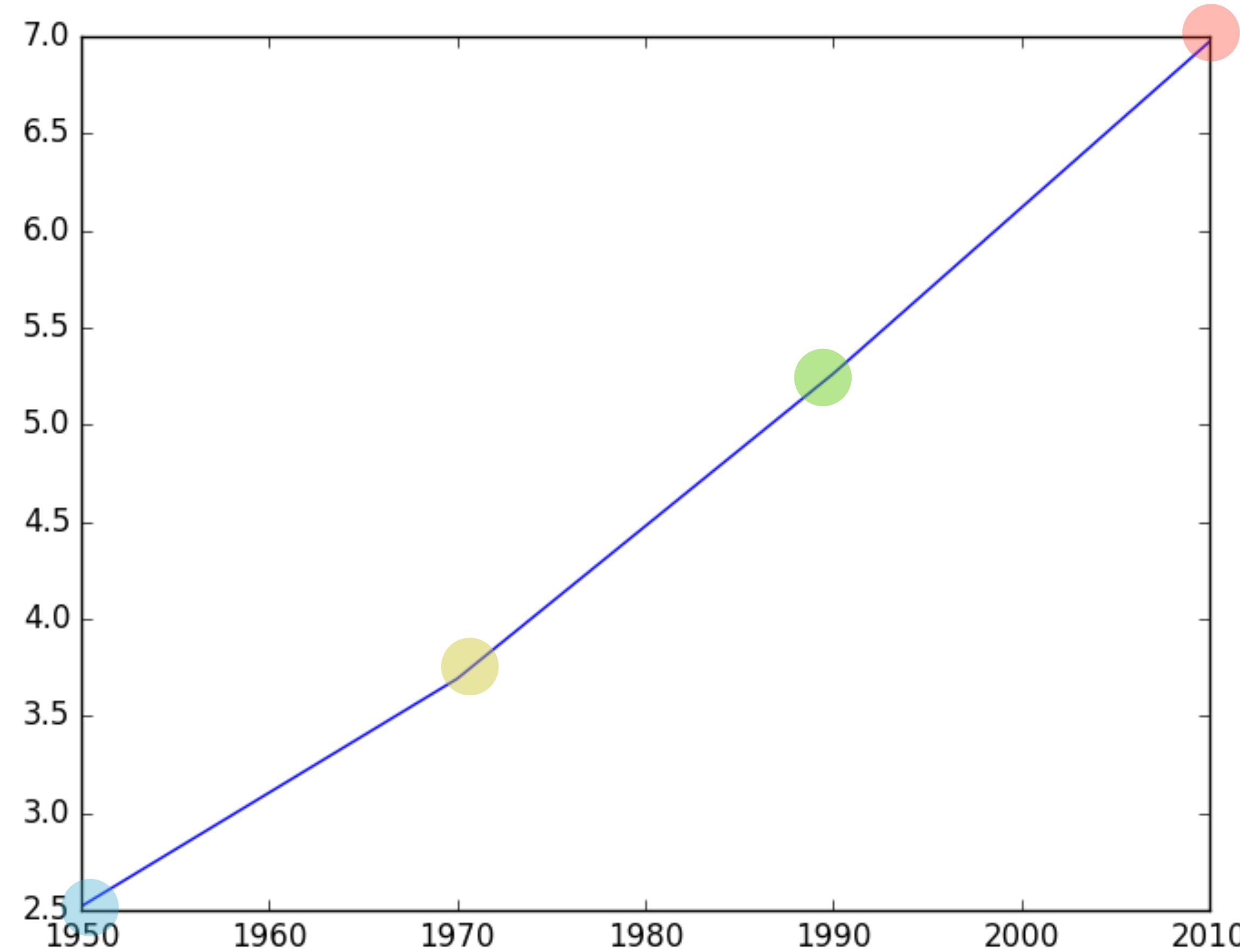
```
In [4]: plt.plot(year, pop)  
       x      y
```

```
In [5]: plt.show()
```



Matplotlib

```
year = [1950, 1970, 1990, 2010]
pop = [2.519, 3.692, 5.263, 6.972]
```



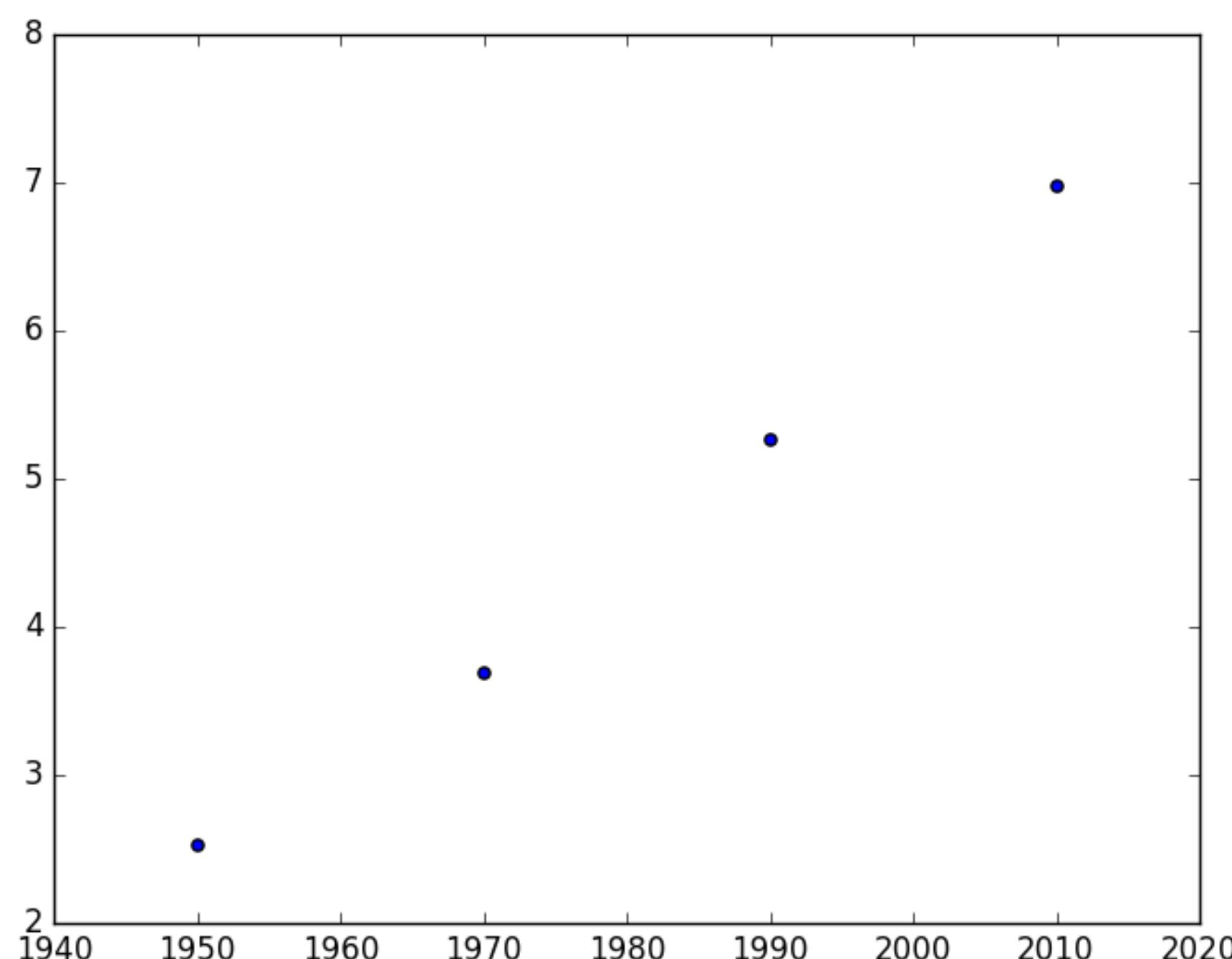


Scatter plot

```
In [1]: import matplotlib.pyplot as plt  
In [2]: year = [1950, 1970, 1990, 2010]  
In [3]: pop = [2.519, 3.692, 5.263, 6.972]  
In [4]: plt.plot(year, pop)  
In [5]: plt.show()
```

Scatter plot

```
In [1]: import matplotlib.pyplot as plt  
In [2]: year = [1950, 1970, 1990, 2010]  
In [3]: pop = [2.519, 3.692, 5.263, 6.972]  
In [4]: plt.scatter(year, pop)  
In [5]: plt.show()
```



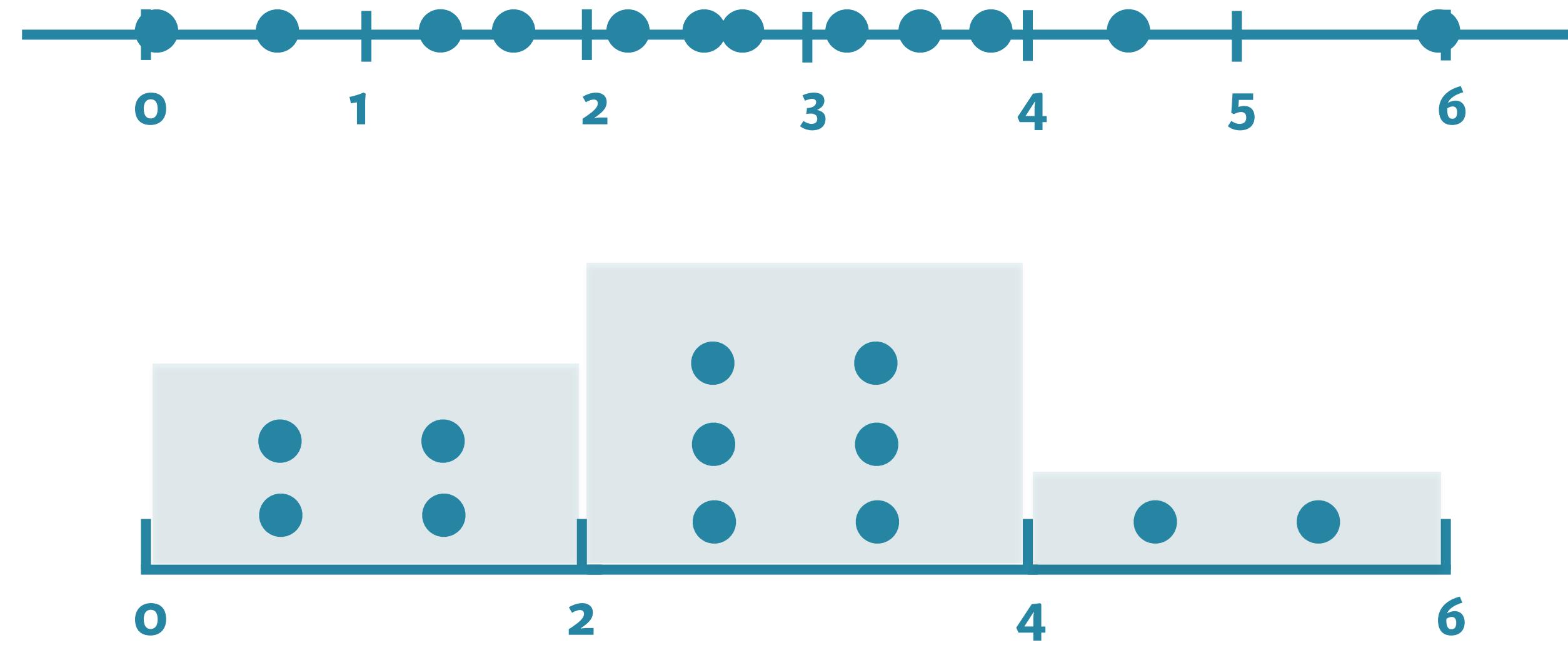


INTERMEDIATE PYTHON FOR DATA SCIENCE

Histogram

Histogram

- Explore dataset
- Get idea about distribution



Matplotlib

```
In [1]: import matplotlib.pyplot as plt
```

```
In [2]: help(plt.hist)
```

Help on function hist in module matplotlib.pyplot:

```
hist(x, bins=10, range=None, normed=False, weights=None,  
cumulative=False, bottom=None, histtype='bar', align='mid',  
orientation='vertical', rwidth=None, log=False, color=None,  
label=None, stacked=False, hold=None, data=None, **kwargs)
```

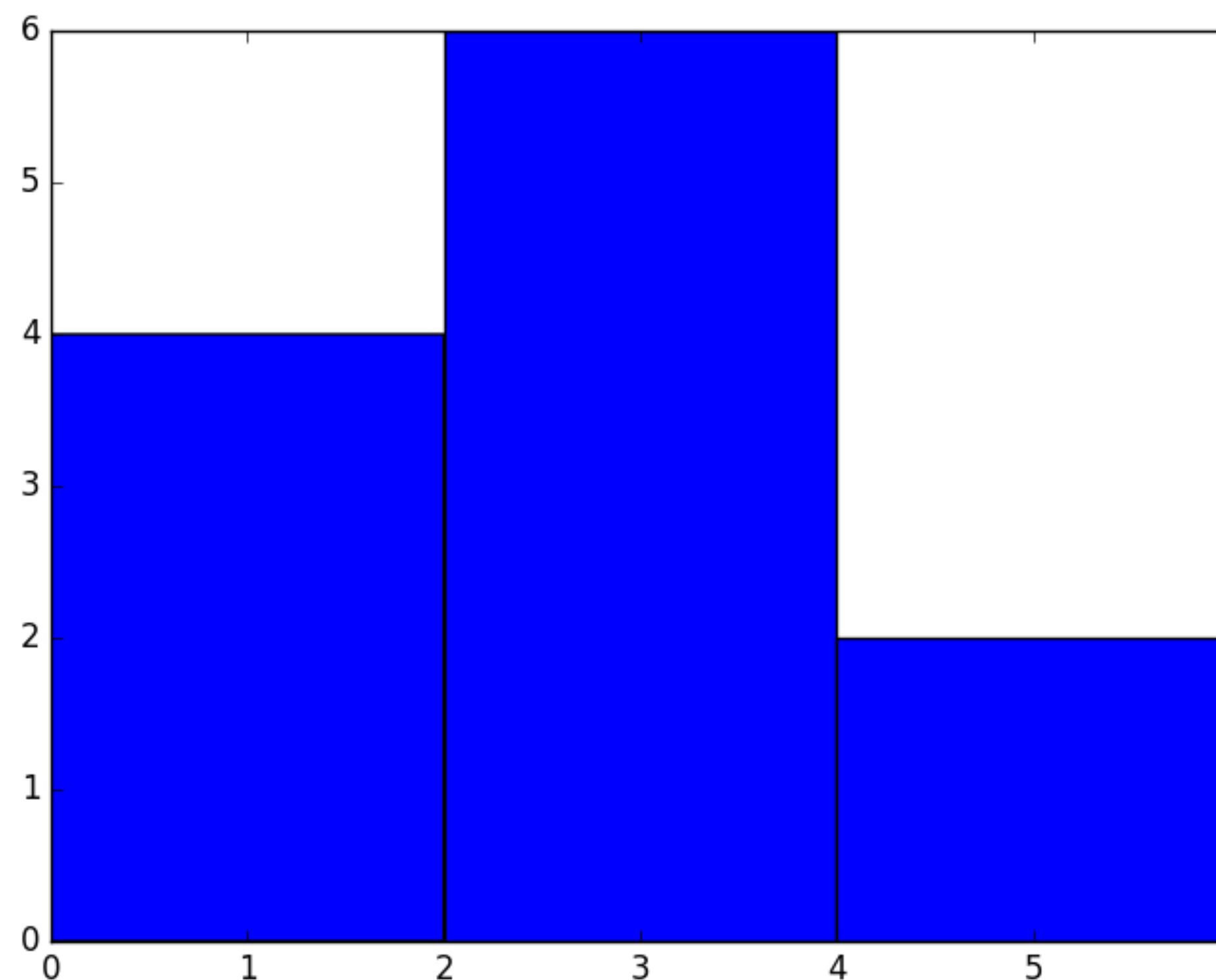
Plot a histogram.

Compute and draw the histogram of `*x*`. The return value is a tuple `(*n*, *bins*, *patches*)` or `([*n0*, *n1*, ...], *bins*, [*patches0*, *patches1*,...])` if the input contains multiple data.

...

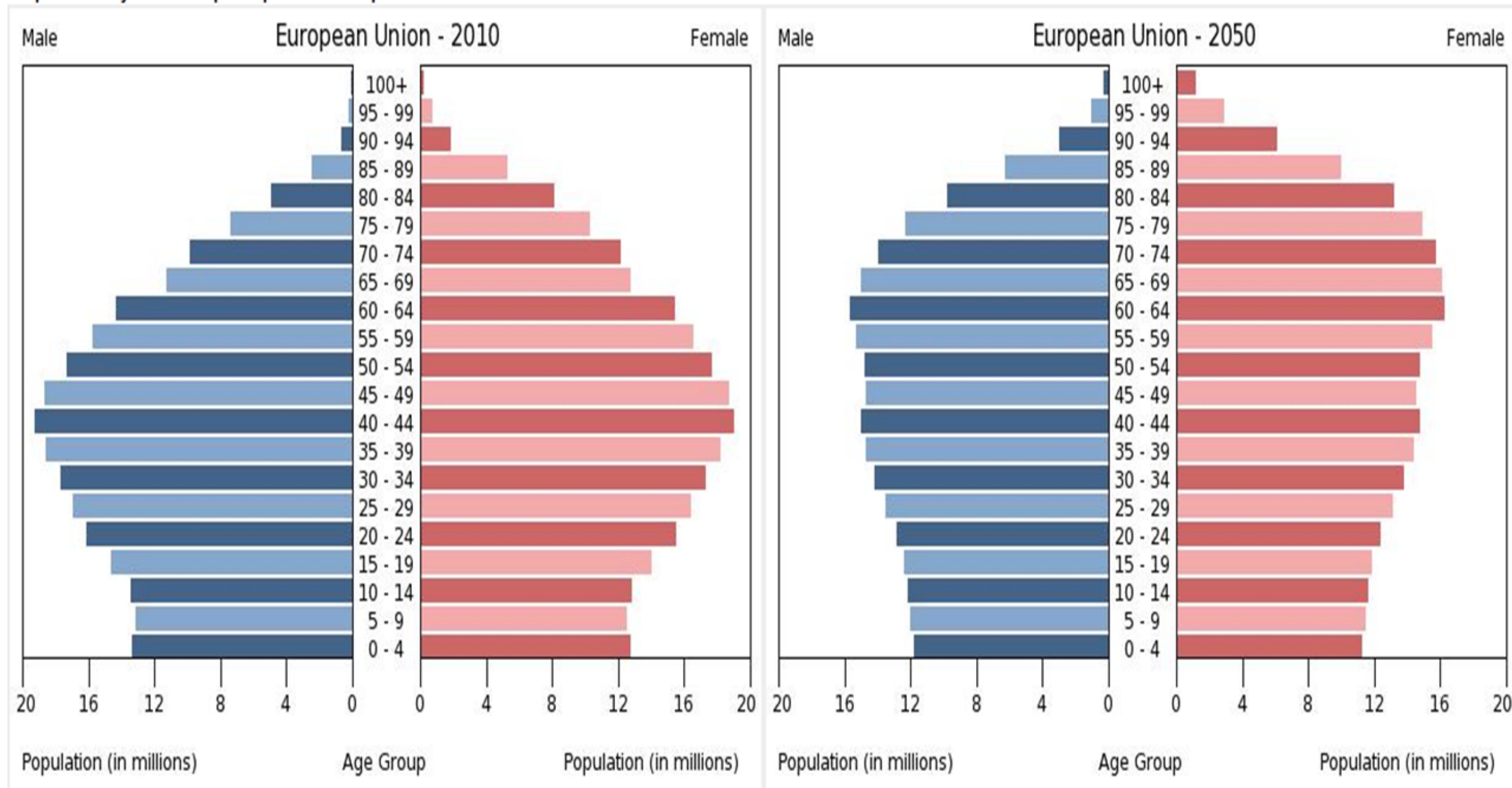
Matplotlib example

```
In [3]: values = [0,0.6,1.4,1.6,2.2,2.5,2.6,3.2,3.5,3.9,4.2,6]  
In [4]: plt.hist(values, bins = 3)  
In [5]: plt.show()
```



Population Pyramid

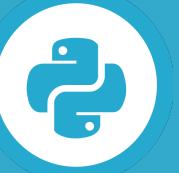
Population Pyramid Graph - Special - European Union - TOTAL FOR SELECTED REGION





INTERMEDIATE PYTHON FOR DATA SCIENCE

Customization



Data Visualization

- Many options
 - Different plot types
 - Many customizations
- Choice depends on
 - Data
 - Story you want to tell



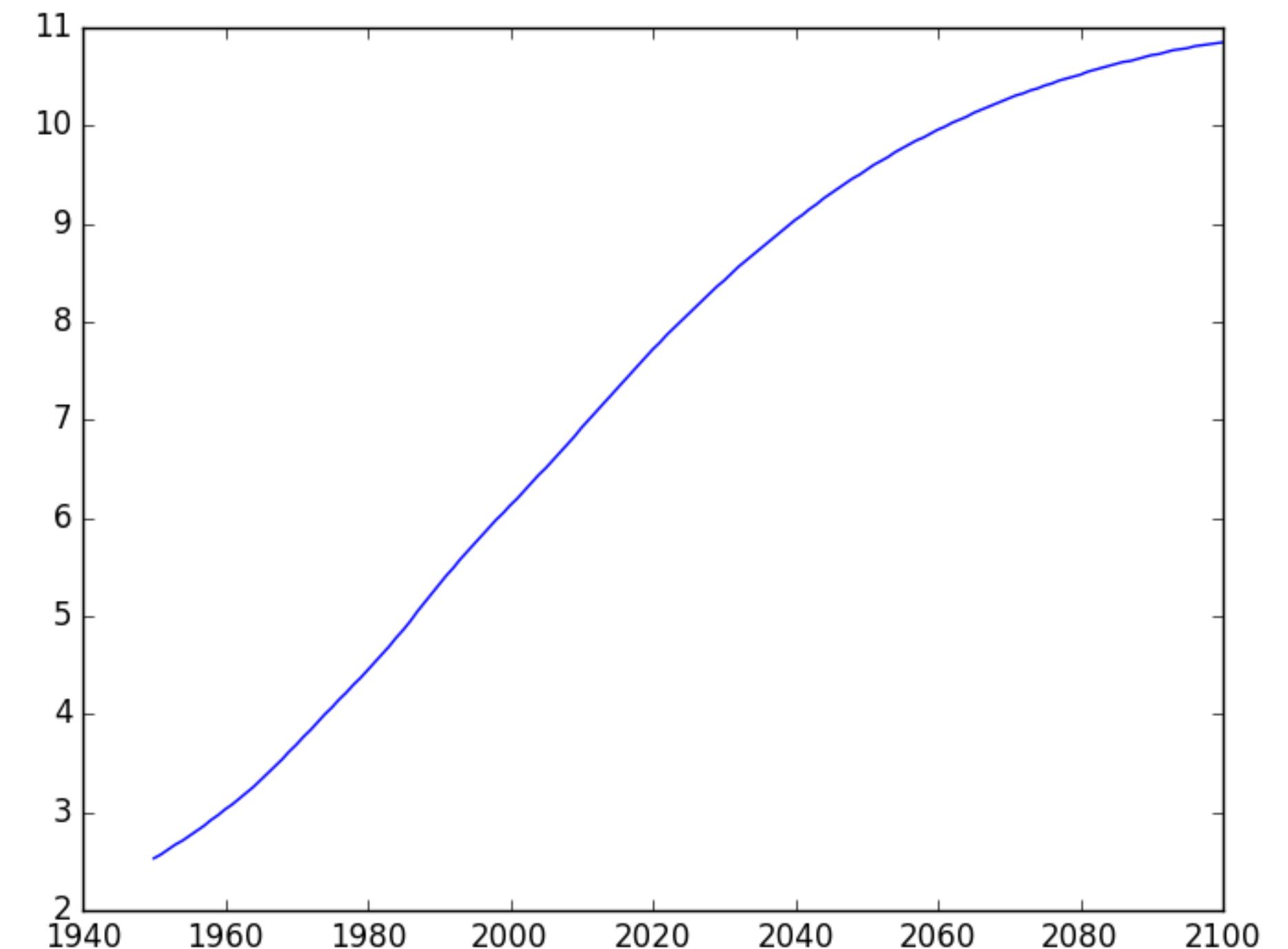
Basic Plot

population.py

```
import matplotlib.pyplot as plt
year = [1950, 1951, 1952, ..., 2100]
pop = [2.538, 2.57, 2.62, ..., 10.85]

plt.plot(year, pop)

plt.show()
```



Axis labels

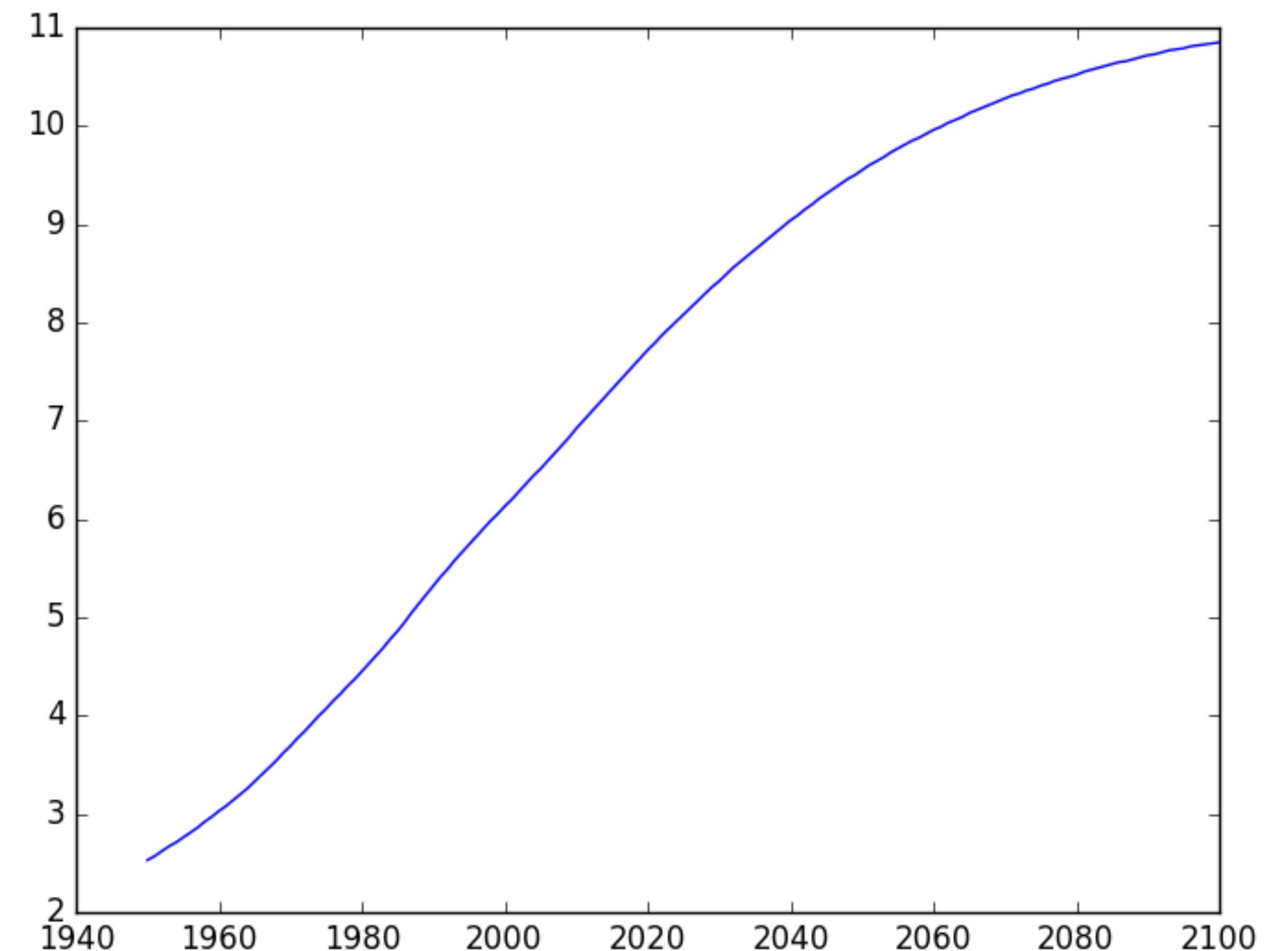
 population.py

```
import matplotlib.pyplot as plt
year = [1950, 1951, 1952, ..., 2100]
pop = [2.538, 2.57, 2.62, ..., 10.85]

plt.plot(year, pop)

plt.xlabel('Year')
plt.ylabel('Population')

plt.show()
```



Axis labels

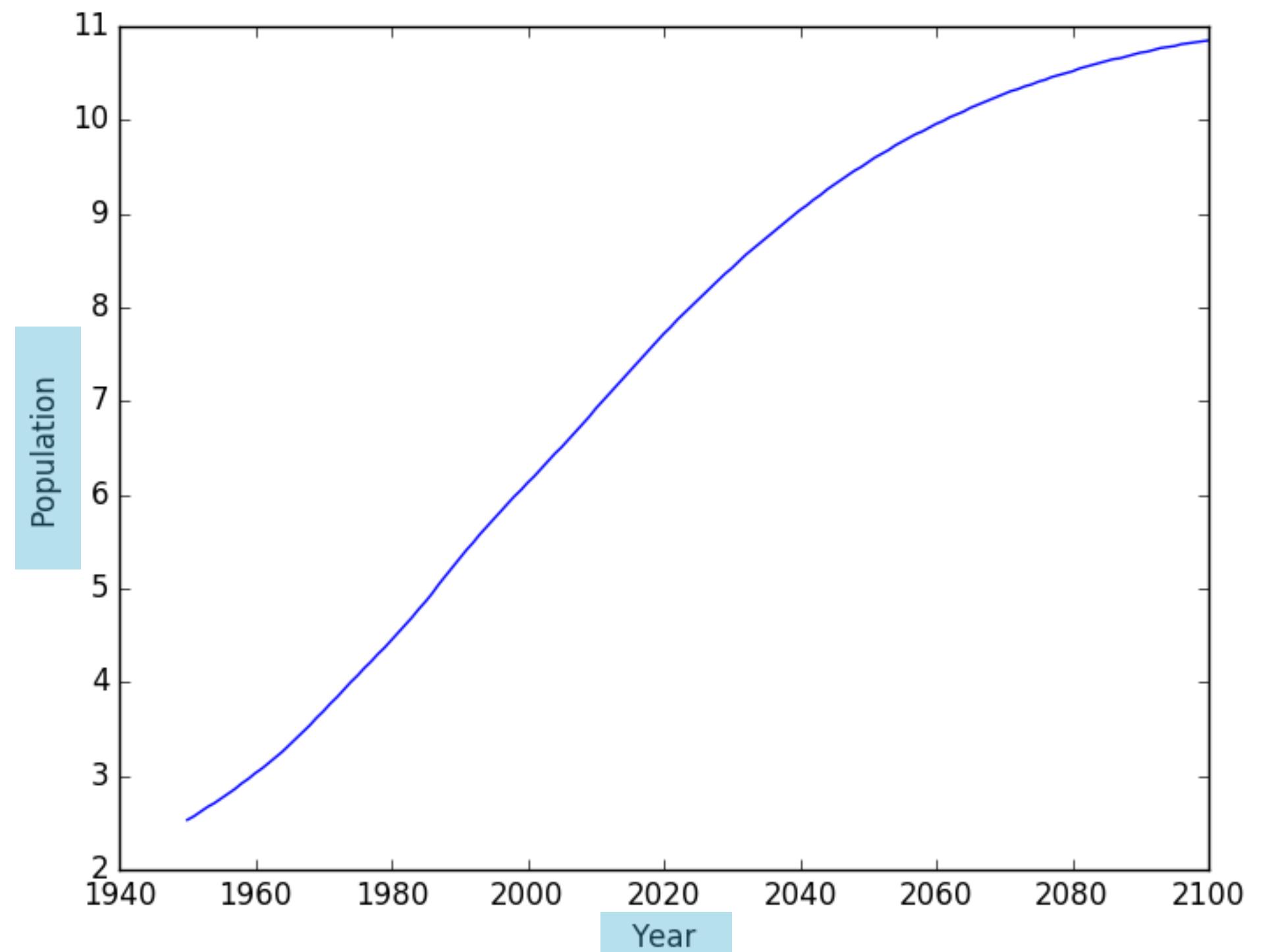
 population.py

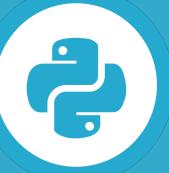
```
import matplotlib.pyplot as plt
year = [1950, 1951, 1952, ..., 2100]
pop = [2.538, 2.57, 2.62, ..., 10.85]

plt.plot(year, pop)

plt.xlabel('Year')
plt.ylabel('Population')

plt.show()
```





Title

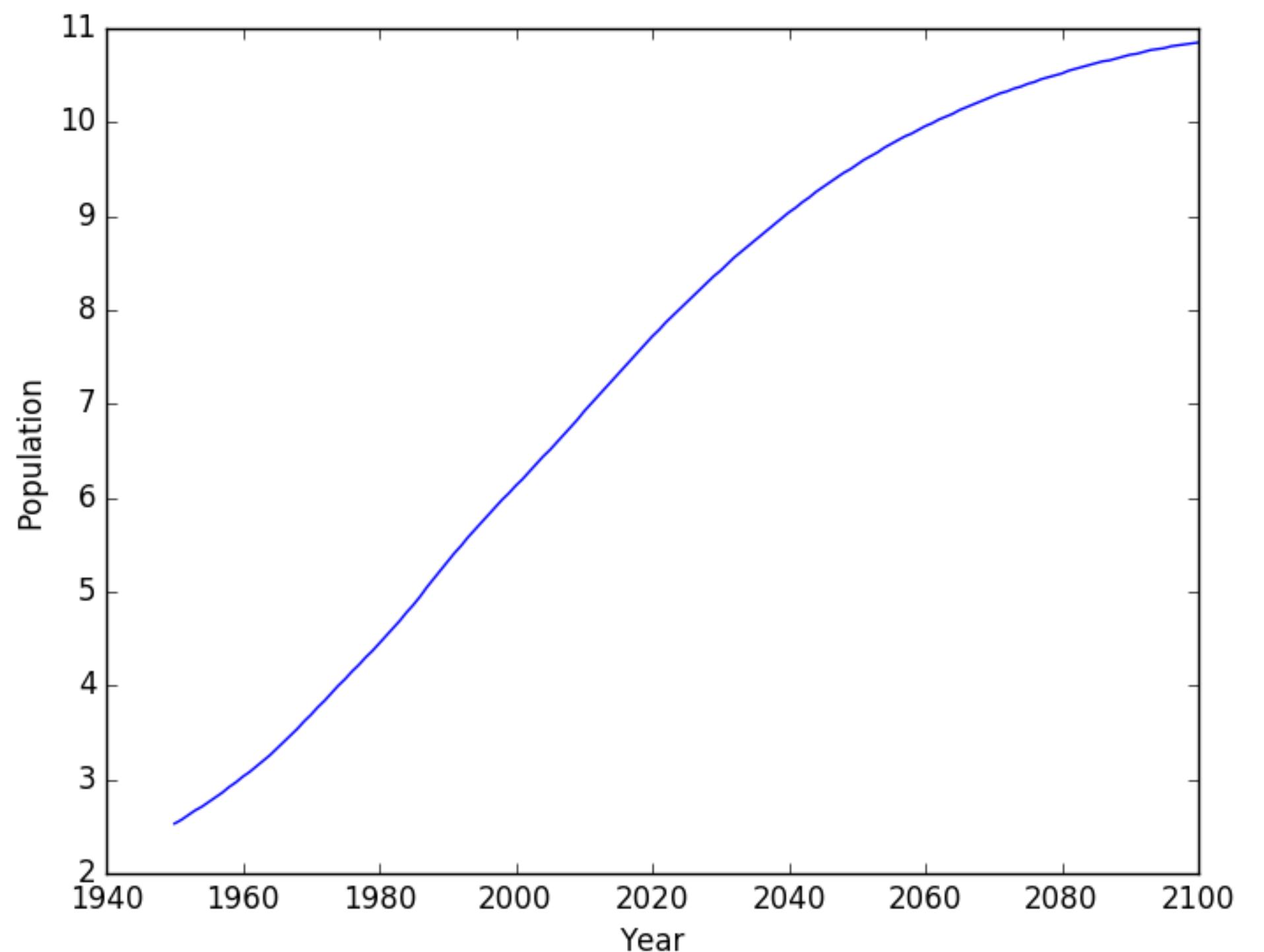
population.py

```
import matplotlib.pyplot as plt
year = [1950, 1951, 1952, ..., 2100]
pop = [2.538, 2.57, 2.62, ..., 10.85]

plt.plot(year, pop)

plt.xlabel('Year')
plt.ylabel('Population')
plt.title('World Population Projections')

plt.show()
```





Title

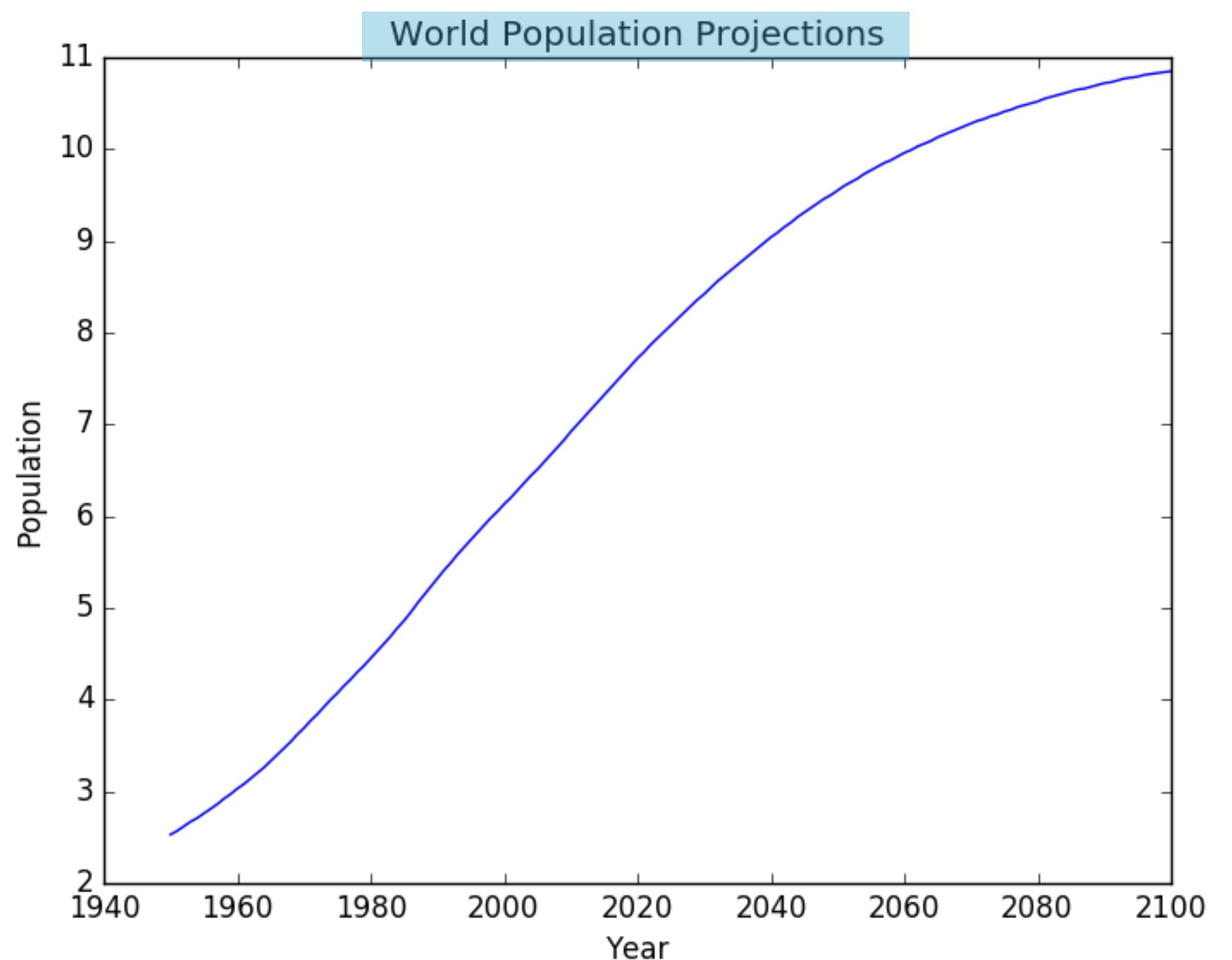
population.py

```
import matplotlib.pyplot as plt
year = [1950, 1951, 1952, ..., 2100]
pop = [2.538, 2.57, 2.62, ..., 10.85]

plt.plot(year, pop)

plt.xlabel('Year')
plt.ylabel('Population')
plt.title('World Population Projections')

plt.show()
```





Ticks

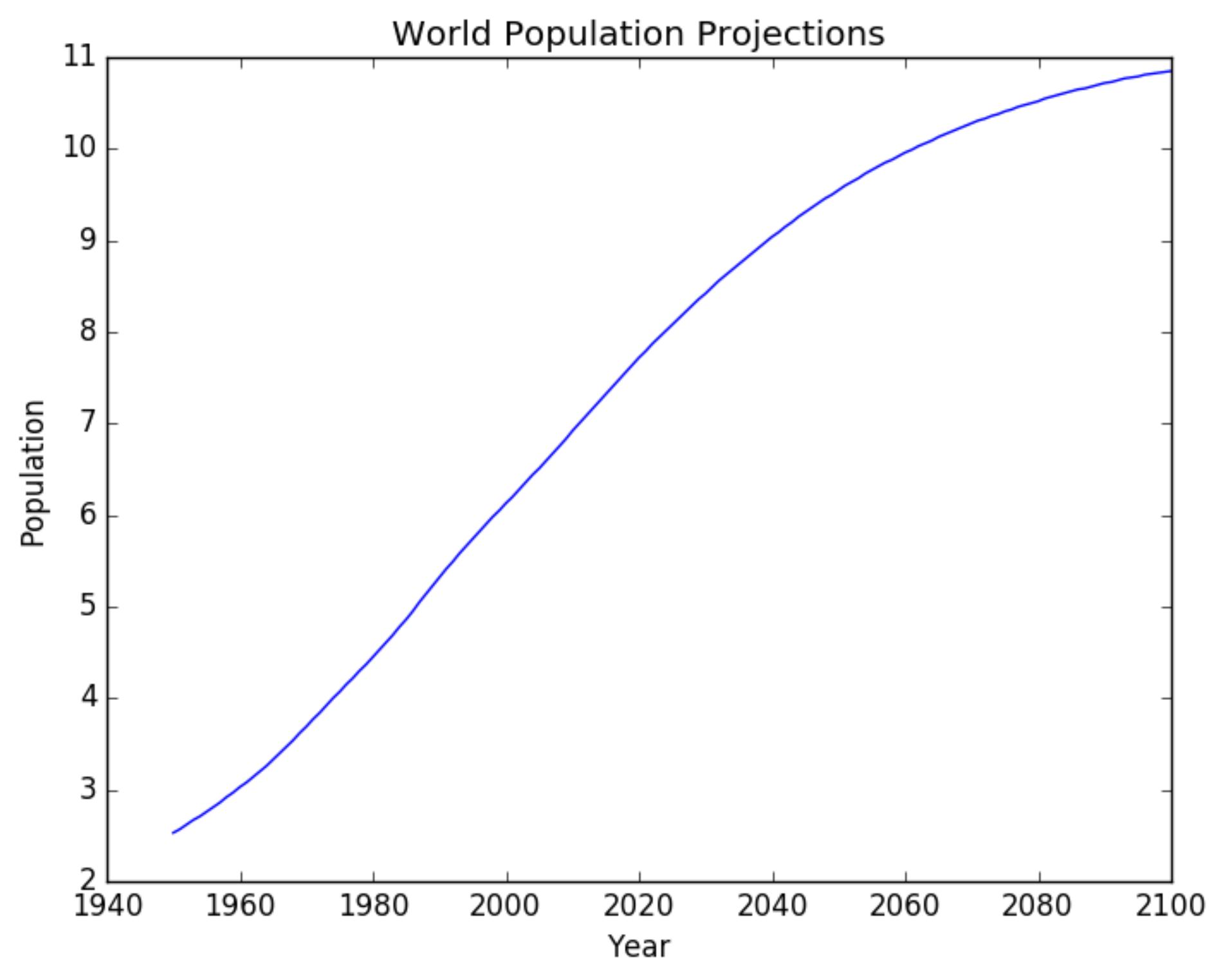
population.py

```
import matplotlib.pyplot as plt
year = [1950, 1951, 1952, ..., 2100]
pop = [2.538, 2.57, 2.62, ..., 10.85]

plt.plot(year, pop)

plt.xlabel('Year')
plt.ylabel('Population')
plt.title('World Population Projections')
plt.yticks([0, 2, 4, 6, 8, 10])

plt.show()
```





Ticks

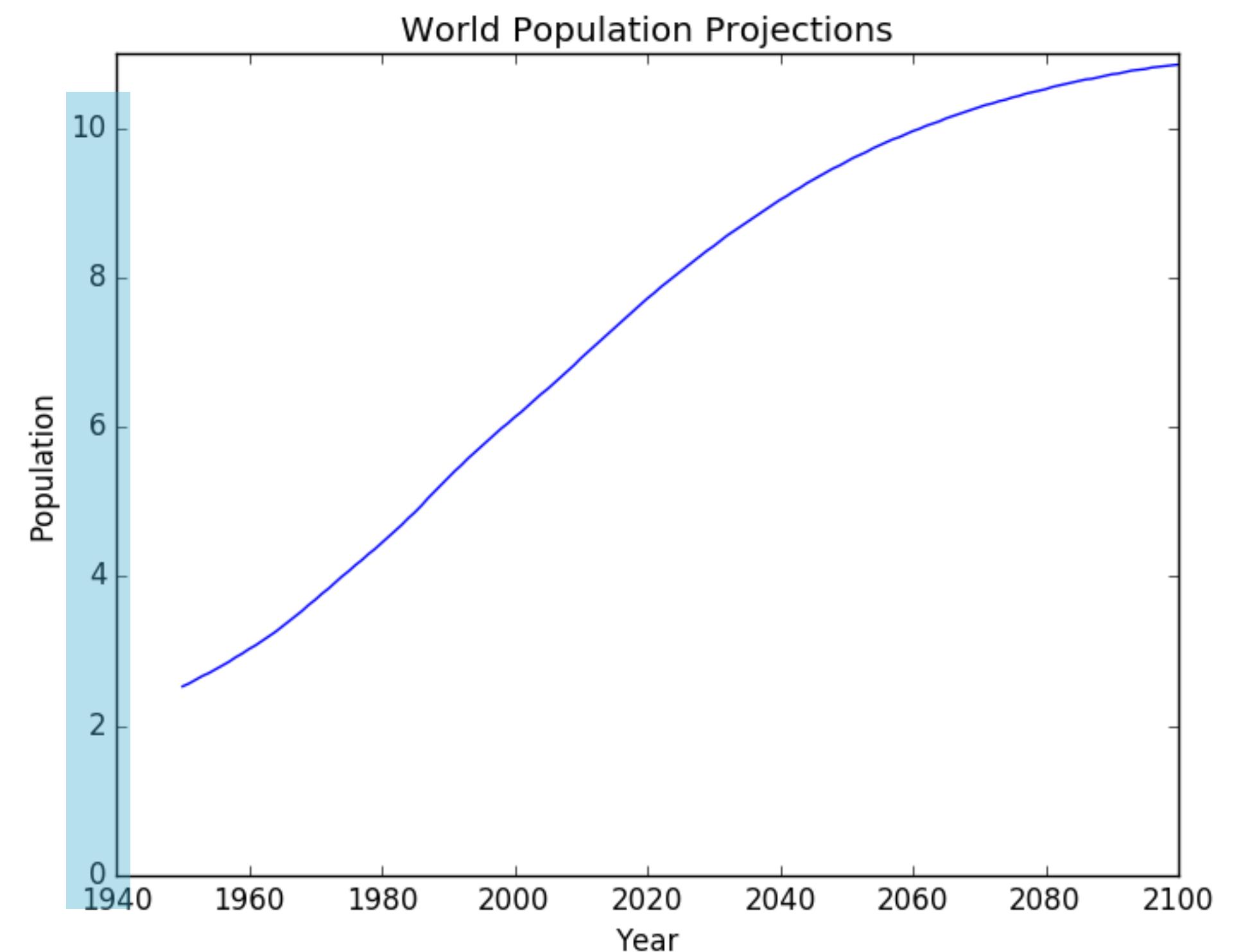
population.py

```
import matplotlib.pyplot as plt
year = [1950, 1951, 1952, ..., 2100]
pop = [2.538, 2.57, 2.62, ..., 10.85]

plt.plot(year, pop)

plt.xlabel('Year')
plt.ylabel('Population')
plt.title('World Population Projections')
plt.yticks([0, 2, 4, 6, 8, 10])

plt.show()
```





Ticks (2)

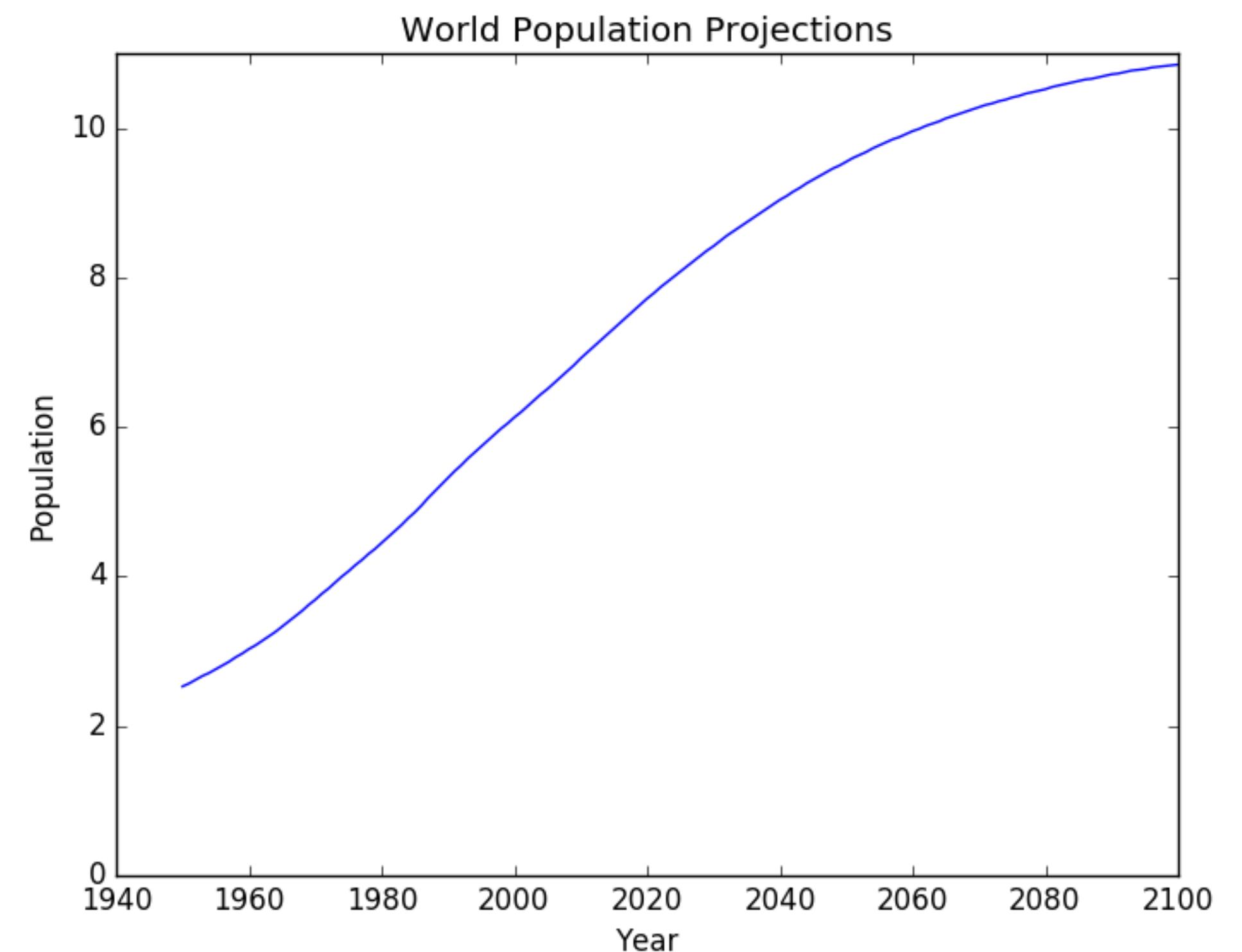
population.py

```
import matplotlib.pyplot as plt
year = [1950, 1951, 1952, ..., 2100]
pop = [2.538, 2.57, 2.62, ..., 10.85]

plt.plot(year, pop)

plt.xlabel('Year')
plt.ylabel('Population')
plt.title('World Population Projections')
plt.yticks([0, 2, 4, 6, 8, 10],
           ['0', '2B', '4B', '6B', '8B', '10B'])

plt.show()
```





Ticks (2)

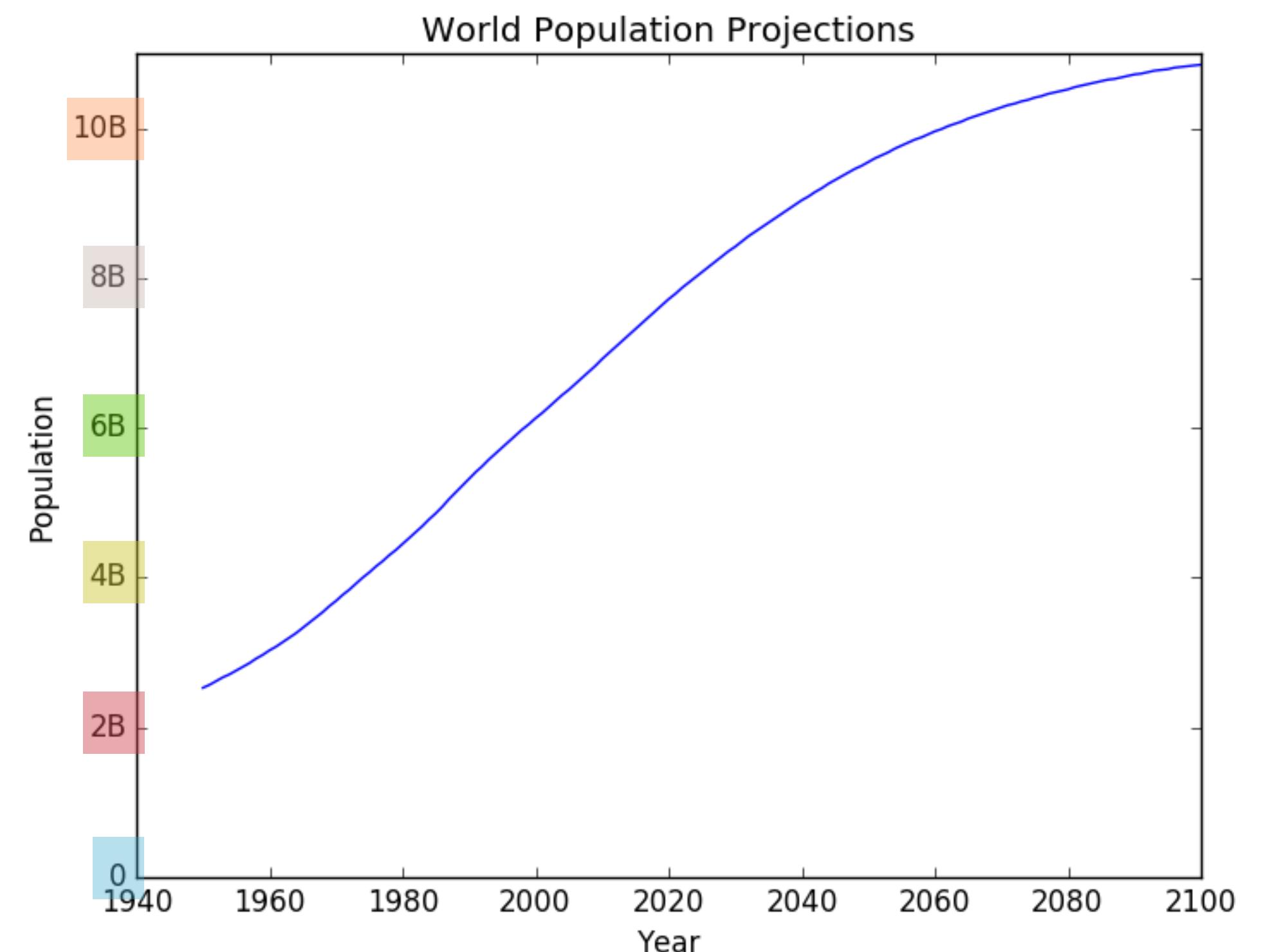
population.py

```
import matplotlib.pyplot as plt
year = [1950, 1951, 1952, ..., 2100]
pop = [2.538, 2.57, 2.62, ..., 10.85]

plt.plot(year, pop)

plt.xlabel('Year')
plt.ylabel('Population')
plt.title('World Population Projections')
plt.yticks([0, 2, 4, 6, 8, 10],
           ['0', '2B', '4B', '6B', '8B', '10B'])

plt.show()
```



Add historical data

 population.py

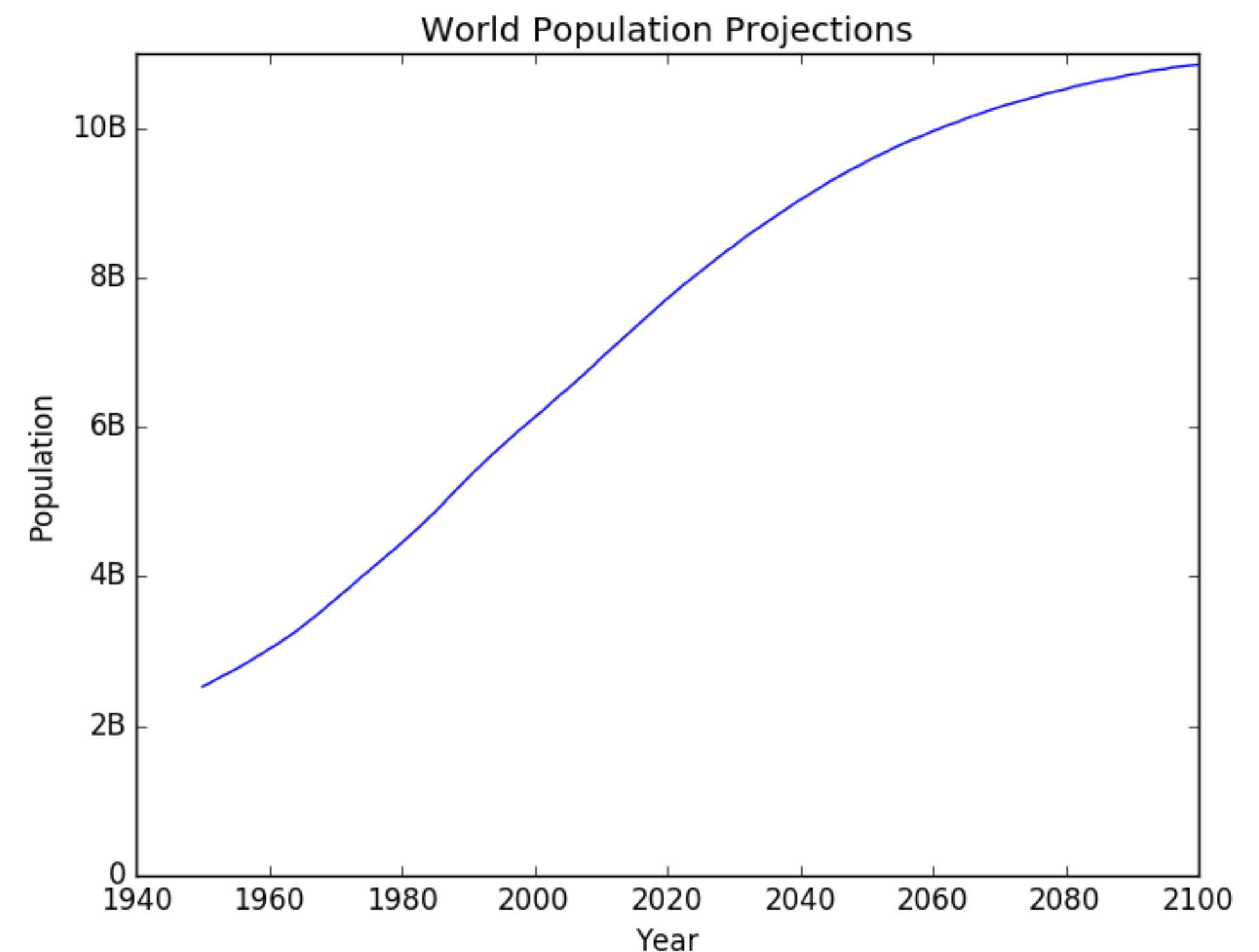
```
import matplotlib.pyplot as plt
year = [1950, 1951, 1952, ..., 2100]
pop = [2.538, 2.57, 2.62, ..., 10.85]

# Add more data
year = [1800, 1850, 1900] + year
pop = [1.0, 1.262, 1.650] + pop

plt.plot(year, pop)

plt.xlabel('Year')
plt.ylabel('Population')
plt.title('World Population Projections')
plt.yticks([0, 2, 4, 6, 8, 10],
           ['0', '2B', '4B', '6B', '8B', '10B'])

plt.show()
```





Add historical data

population.py

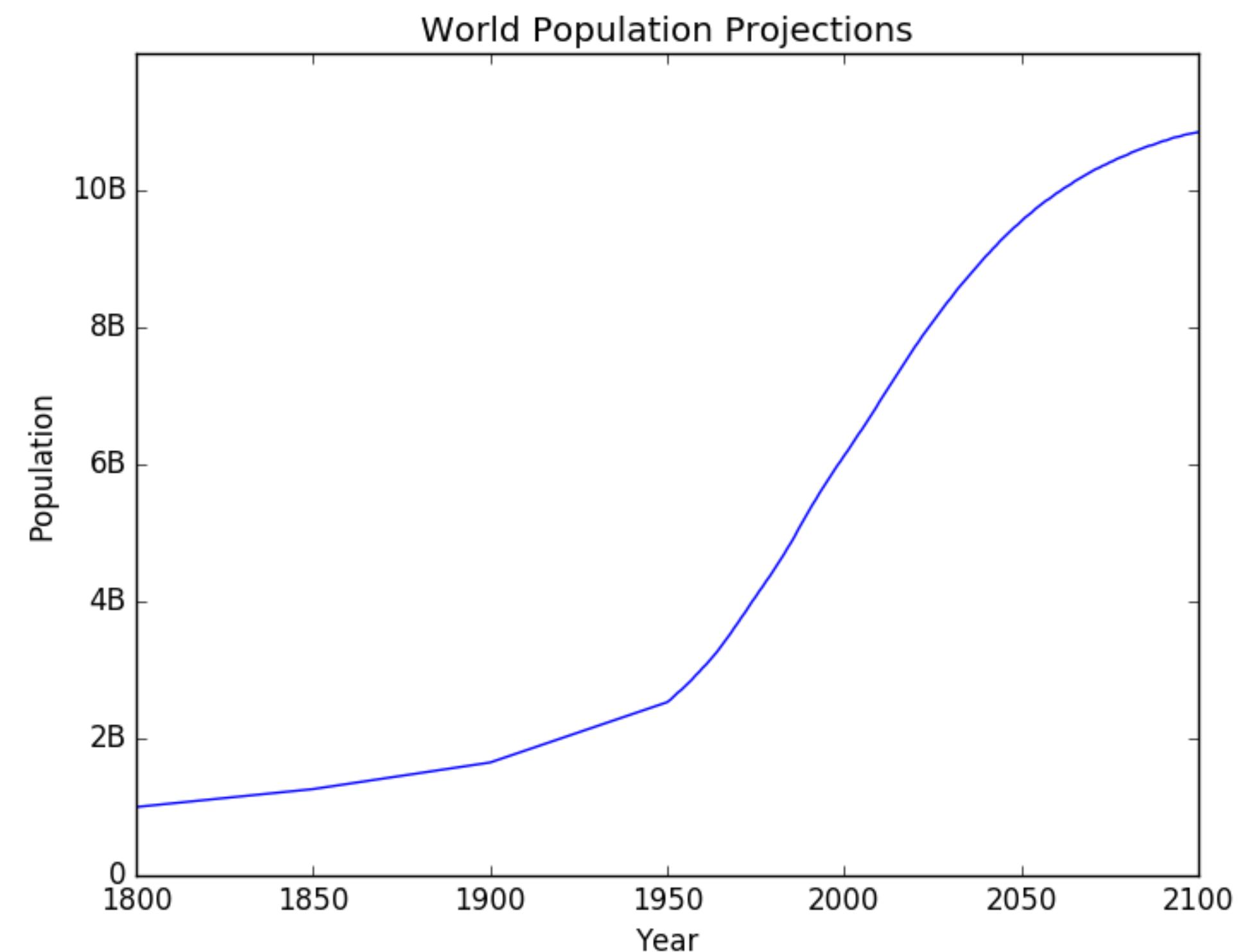
```
import matplotlib.pyplot as plt
year = [1950, 1951, 1952, ..., 2100]
pop = [2.538, 2.57, 2.62, ..., 10.85]

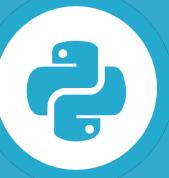
# Add more data
year = [1800, 1850, 1900] + year
pop = [1.0, 1.262, 1.650] + pop

plt.plot(year, pop)

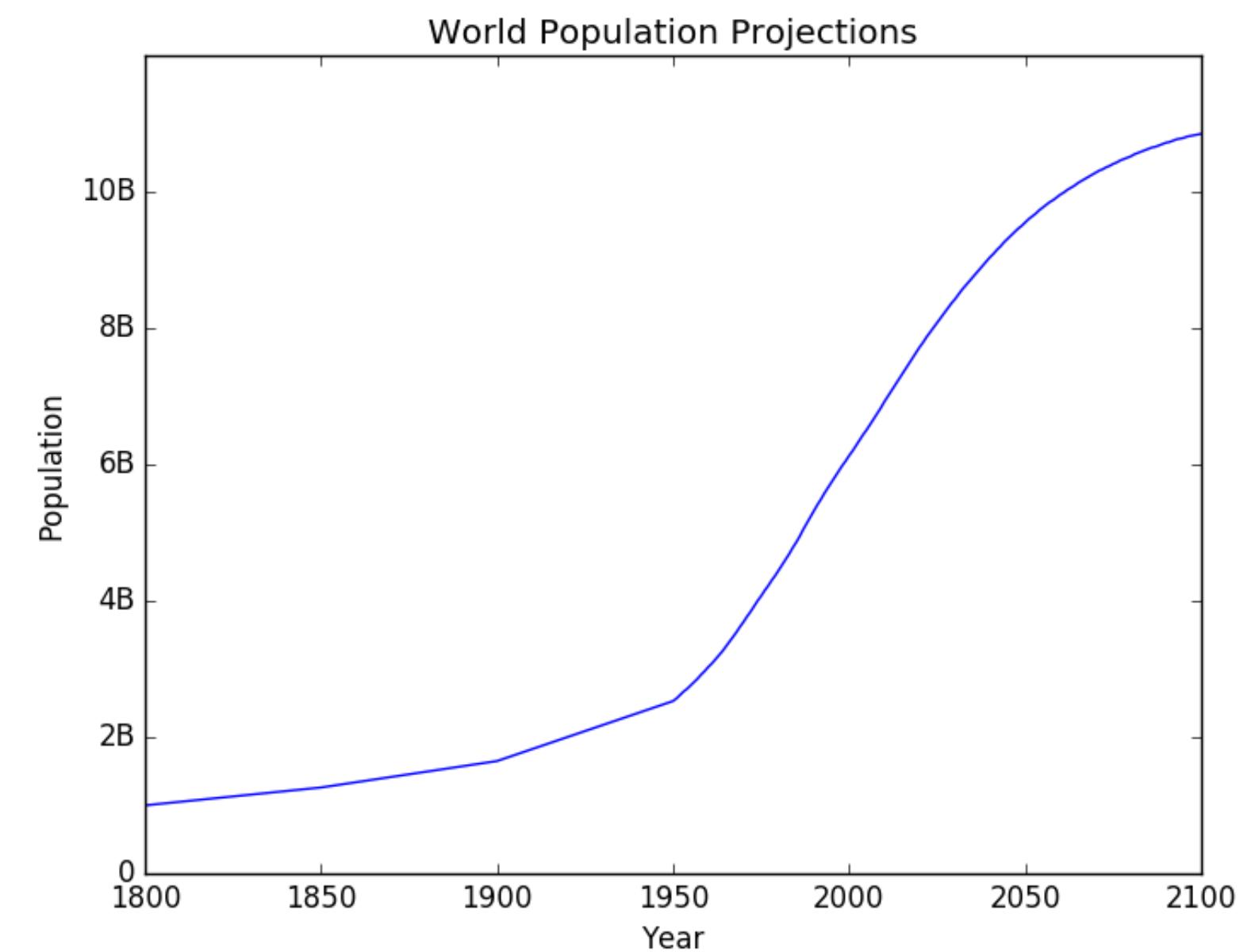
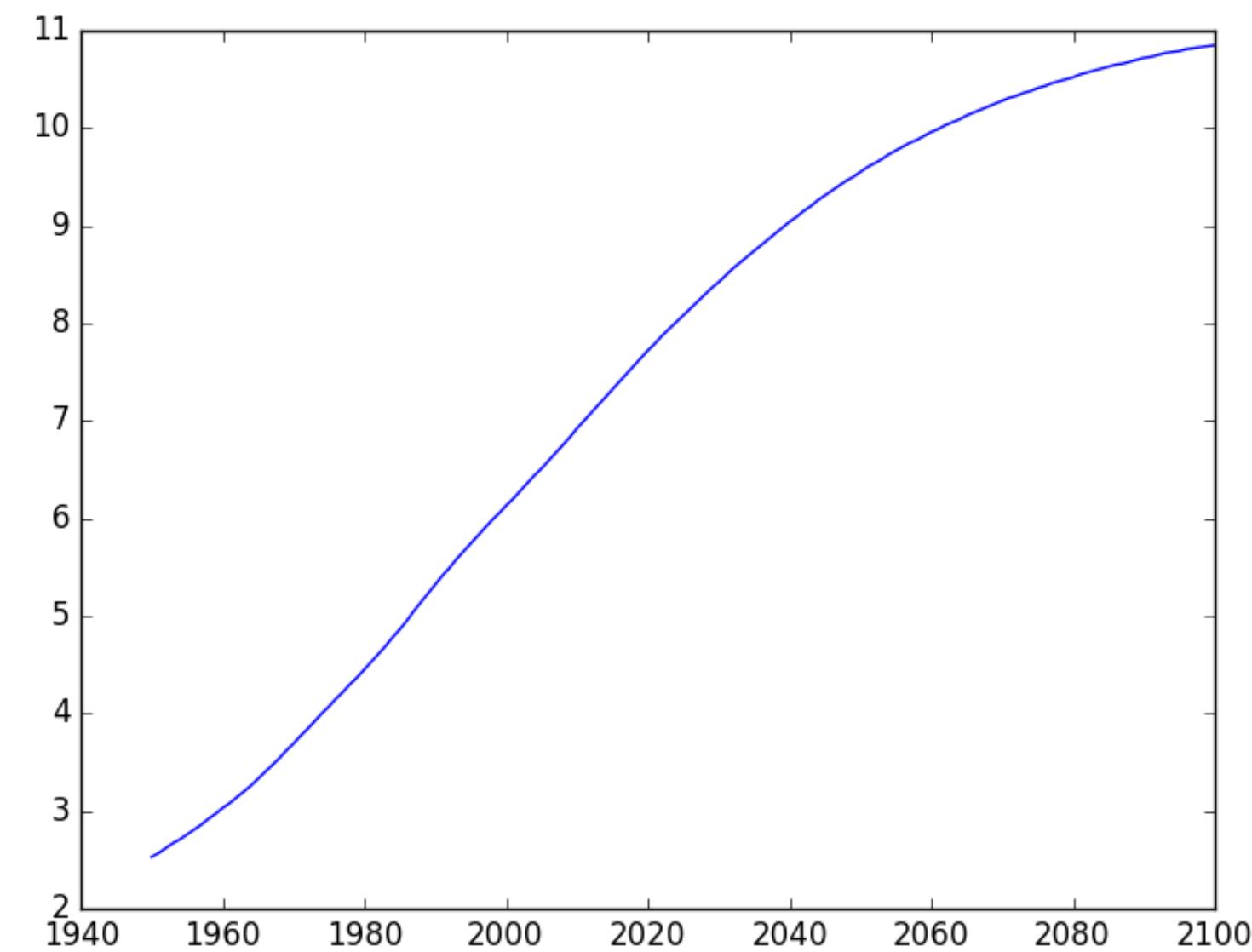
plt.xlabel('Year')
plt.ylabel('Population')
plt.title('World Population Projections')
plt.yticks([0, 2, 4, 6, 8, 10],
           ['0', '2B', '4B', '6B', '8B', '10B'])

plt.show()
```





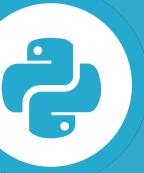
Before vs After





INTERMEDIATE PYTHON FOR DATA SCIENCE

Dictionaries, Part 1



List

```
In [1]: pop = [30.55, 2.77, 39.21]
```

```
In [2]: countries = ["afghanistan", "albania", "algeria"]
```

```
In [3]: ind_alb = countries.index("albania")
```

```
In [4]: ind_alb
```

```
Out[4]: 1
```

Not convenient
Not intuitive

```
In [5]: pop[ind_alb]
```

```
Out[5]: 2.77
```

Dictionary

```
In [1]: pop = [30.55, 2.77, 39.21]
```

```
In [2]: countries = ["afghanistan", "albania", "algeria"]
```

```
...
```

```
In [6]: world = {"afghanistan":30.55, "albania":2.77, "algeria":39.21}
```

```
In [7]: world["albania"]
```

```
Out[7]: 2.77
```

dict_name[key]

result: value



INTERMEDIATE PYTHON FOR DATA SCIENCE

Dictionaries, Part 2



Recap

```
In [1]: world = {"afghanistan":30.55, "albania":2.77, "algeria":39.21}
```

```
In [2]: world["albania"]  
Out[2]: 2.77
```

```
In [3]: world = {"afghanistan":30.55, "albania":2.77,  
                 "algeria":39.21, "albania":2.81}
```

```
In [4]: world  
Out[4]: {'afghanistan': 30.55, 'albania': 2.81, 'algeria': 39.21}
```

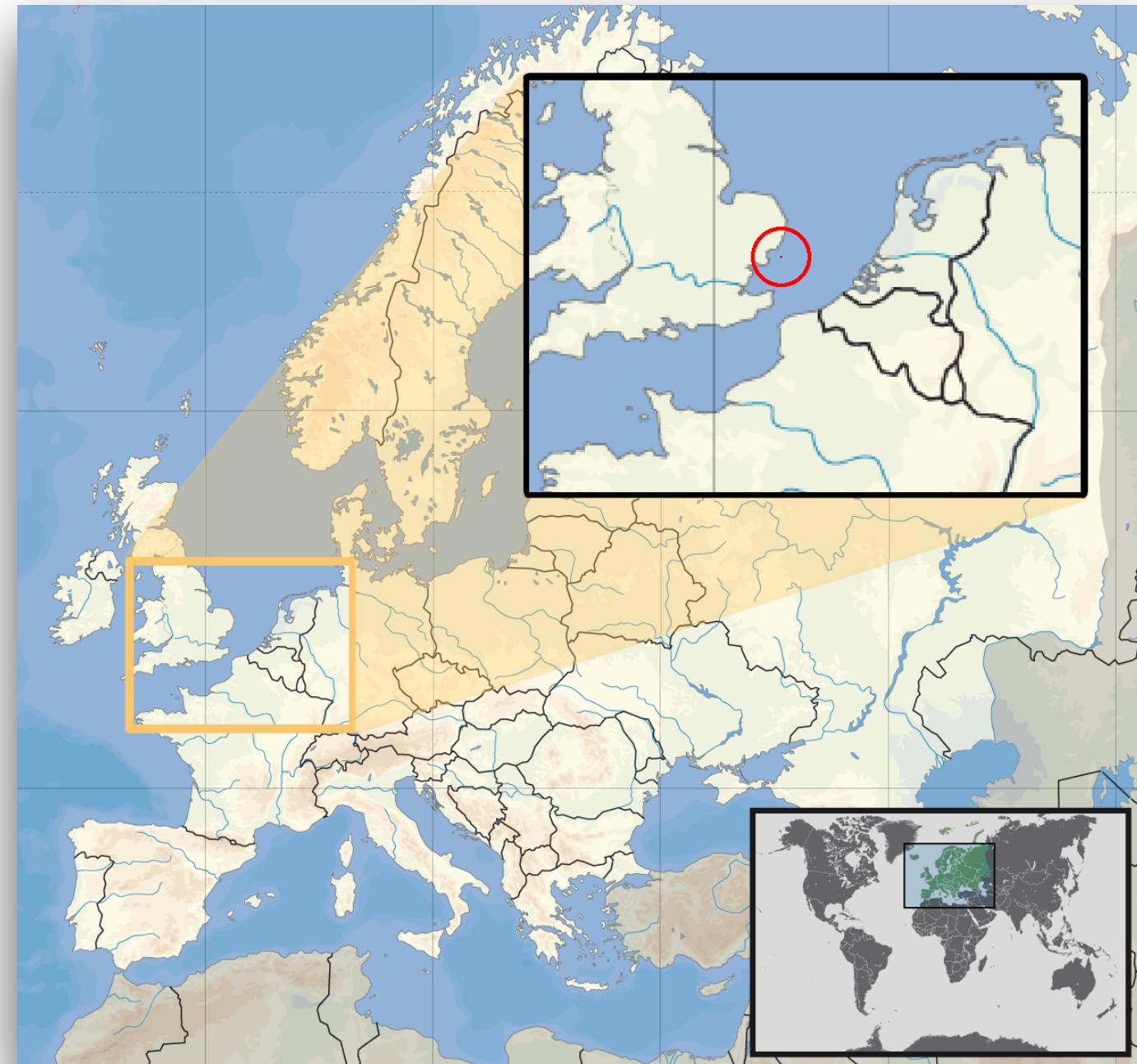
 keys have to be "immutable" objects

```
In [5]: {0:"hello", True:"dear", "two":"world"}  
Out[5]: {0: 'hello', True: 'dear', 'two': 'world'}
```

```
In [6]: {[{"just", "to", "test"}]: "value"}  
TypeError: unhashable type: 'list'
```



Principality of Sealand





Dictionary

```
In [8]: world["sealand"] = 0.000027
```

```
In [9]: world
```

```
Out[9]: {'afghanistan': 30.55, 'albania': 2.81,  
         'algeria': 39.21, 'sealand': 2.7e-05}
```

```
In [10]: "sealand" in world
```

```
Out[10]: True
```

```
In [11]: world["sealand"] = 0.000028
```

```
In [12]: world
```

```
Out[12]: {'afghanistan': 30.55, 'albania': 2.81,  
          'algeria': 39.21, 'sealand': 2.8e-05}
```

```
In [13]: del(world["sealand"])
```

```
In [14]: world
```

```
Out[14]: {'afghanistan': 30.55, 'albania': 2.81, 'algeria': 39.21}
```



List vs Dictionary

List	Dictionary
Select, update and remove: []	Select, update and remove: []
Indexed by range of numbers	Indexed by unique keys
Collection of values order matters select entire subsets	Lookup table with unique keys



INTERMEDIATE PYTHON FOR DATA SCIENCE

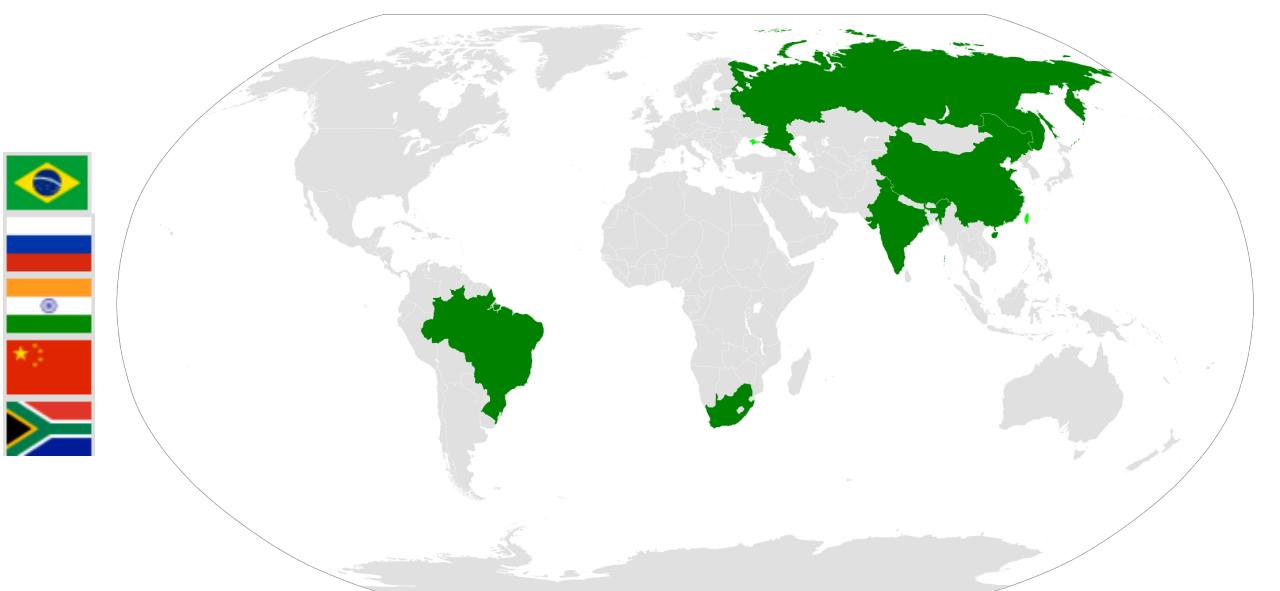
Pandas, Part 1



Tabular dataset examples

temperature	measured_at	location
76	2016-01-01 14:00:01	valve
86	2016-01-01 14:00:01	compressor
72	2016-01-01 15:00:01	valve
88	2016-01-01 15:00:01	compressor
68	2016-01-01 16:00:01	valve
78	2016-01-01 16:00:01	compressor

row = observations
column = variable



country	capital	area	population
Brazil	Brasilia	8.516	200.4
Russia	Moscow	17.10	143.5
India	New Delhi	3.286	1252
China	Beijing	9.597	1357
South Africa	Pretoria	1.221	52.98



Datasets in Python

- 2D Numpy array?
 - One data type
- Pandas!
 - High level data manipulation tool
 - Wes McKinney
 - Built on Numpy
 - DataFrame

country	capital	area	population
Brazil	Brasilia	8.516	200.4
Russia	Moscow	17.10	143.5
India	New Delhi	3.286	1252
China	Beijing	9.597	1357
South Africa	Pretoria	1.221	52.98

str

str

float

float



DataFrame

```
In [1]: brics
```

```
Out[1]:
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



DataFrame

```
In [1]: brics
```

```
Out[1]:
```

	country	capital	area	population	observations
BR	Brazil	Brasilia	8.516	200.40	
RU	Russia	Moscow	17.100	143.50	
IN	India	New Delhi	3.286	1252.00	
CH	China	Beijing	9.597	1357.00	
SA	South Africa	Pretoria	1.221	52.98	



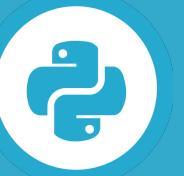
DataFrame

```
In [1]: brics
```

```
Out[1]:
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98

variables



DataFrame

In [1]: brics

Out[1]:

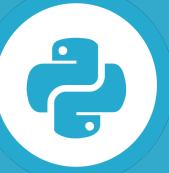
```
Out[1]:
```

	country	capital	area	population	column labels
BR	Brazil	Brasilia	8.516	200.40	
RU	Russia	Moscow	17.100	143.50	
IN	India	New Delhi	3.286	1252.00	
CH	China	Beijing	9.597	1357.00	
SA	South Africa	Pretoria	1.221	52.98	

row labels

Column labels

columns with different types



DataFrame from Dictionary

```
In [2]: dict = {  
    "country": ["Brazil", "Russia", "India", "China", "South Africa"],  
    "capital": ["Brasilia", "Moscow", "New Delhi", "Beijing", "Pretoria"],  
    "area": [8.516, 17.10, 3.286, 9.597, 1.221]  
    "population": [200.4, 143.5, 1252, 1357, 52.98] }
```

keys (column labels)

values (data, column by column)

```
In [3]: import pandas as pd
```

```
In [4]: brics = pd.DataFrame(dict)
```



DataFrame from Dictionary (2)

```
In [5]: brics
```

```
Out[5]:
```

```
   area    capital      country  population
0  8.516  Brasilia    Brazil        200.40
1 17.100     Moscow    Russia        143.50
2  3.286  New Delhi   India       1252.00
3  9.597    Beijing   China       1357.00
4  1.221   Pretoria  South Africa    52.98
```

```
In [6]: brics.index = ["BR", "RU", "IN", "CH", "SA"]
```

```
In [7]: brics
```

```
Out[7]:
```

```
   area    capital      country  population
BR  8.516  Brasilia    Brazil        200.40
RU 17.100     Moscow    Russia        143.50
IN  3.286  New Delhi   India       1252.00
CH  9.597    Beijing   China       1357.00
SA  1.221   Pretoria  South Africa    52.98
```



DataFrame from CSV file

 brics.csv

```
,country,capital,area,population
BR,Brazil,Brasilia,8.516,200.4
RU,Russia,Moscow,17.10,143.5
IN,India,New Delhi,3.286,1252
CH,China,Beijing,9.597,1357
SA,South Africa,Pretoria,1.221,52.98
```

CSV = comma-separated values



DataFrame from CSV file

```
In [8]: brics = pd.read_csv("path/to/brics.csv")
```

```
In [9]: brics
```

```
Out[9]:
```

```
country      capital     area  population  
0       Brazil    Brasilia  8.516      200.40  
1       Russia     Moscow  17.100      143.50  
2        IN        New Delhi  3.286     1252.00  
3        CH         Beijing  9.597     1357.00  
4       SA    South Africa  1.221      52.98
```

```
In [6]: brics = pd.read_csv("path/to/brics.csv", index_col = 0)
```

```
In [7]: brics
```

```
Out[7]:
```

```
country  population     area      capital  
BR        Brazil      200  8515767    Brasilia  
RU        Russia      144  17098242    Moscow  
IN        India       1252 3287590  New Delhi  
CH        China       1357 9596961    Beijing  
SA    South Africa      55 1221037    Pretoria
```

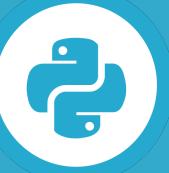
brics.csv

,country,capital,area,population
BR,Brazil,Brasilia,8.516,200.4
RU,Russia,Moscow,17.10,143.5
IN,India,New Delhi,3.286,1252
CH,China,Beijing,9.597,1357
SA,South Africa,Pretoria,1.221,52.98



INTERMEDIATE PYTHON FOR DATA SCIENCE

Pandas, Part 2



brics

```
In [1]: import pandas as pd
```

```
In [2]: brics = pd.read_csv("path/to/brics.csv", index_col = 0)
```

```
In [3]: brics
```

```
Out[3]:
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



Index and Select Data

- Square brackets
- Advanced methods
 - loc
 - iloc

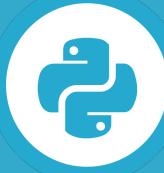


Column Access []

```
In [4]: brics["country"]  
Out[4]:  
BR          Brazil  
RU          Russia  
IN          India  
CH          China  
SA          South Africa  
Name: country, dtype: object
```

```
In [5]: type(brics["country"])  
Out[5]: pandas.core.series.Series 1D labelled array
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



Column Access []

```
In [6]: brics[["country"]]
```

```
Out[6]:
```

```
country
BR      Brazil
RU      Russia
IN      India
CH      China
SA      South Africa
```

```
In [7]: type(brics[["country"]])
```

```
Out[7]: pandas.core.frame.DataFrame
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



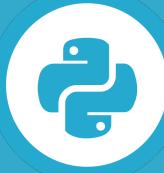
Column Access []

```
In [8]: brics[["country", "capital"]]
```

```
Out[8]:
```

```
country    capital
BR          Brazil   Brasilia
RU          Russia   Moscow
IN          India    New Delhi
CH          China    Beijing
SA          South Africa Pretoria
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



Row Access []

```
In [9]: brics[1:4]
```

```
Out[9]:
```

	country	capital	area	population
RU	Russia	Moscow	17.100	143.5
IN	India	New Delhi	3.286	1252.0
CH	China	Beijing	9.597	1357.0

indexes		country	capital	area	population
0	BR	Brazil	Brasilia	8.516	200.40
1	RU	Russia	Moscow	17.100	143.50
2	IN	India	New Delhi	3.286	1252.00
3	CH	China	Beijing	9.597	1357.00
4	SA	South Africa	Pretoria	1.221	52.98



Discussion []

- Square brackets: limited functionality
- Ideally
 - 2D Numpy arrays
 - `my_array[rows , columns]`
- Pandas
 - `loc` (label-based)
 - `iloc` (integer position-based)



Row Access loc

```
In [10]: brics.loc["RU"]
```

```
Out[10]:
```

```
country      Russia
capital      Moscow
area         17.1
population   143.5
Name: RU, dtype: object
```

```
In [11]: brics.loc[["RU"]]
```

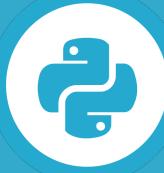
```
Out[11]:
```

```
   country  capital   area  population
RU      Russia    Moscow  17.1        143.5
```

Row as Pandas Series

DataFrame

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



Row Access loc

```
In [10]: brics.loc["RU"]
```

```
Out[10]:
```

```
country      Russia
capital      Moscow
area         17.1
population   143.5
Name: RU, dtype: object
```

```
In [11]: brics.loc[["RU"]]
```

```
Out[11]:
```

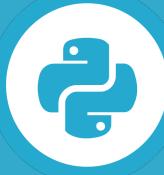
```
    country capital area  population
RU    Russia   Moscow  17.1        143.5
```

```
In [12]: brics.loc[["RU", "IN", "CH"]]
```

```
Out[12]:
```

```
    country      capital      area  population
RU    Russia      Moscow  17.100      143.5
IN    India       New Delhi  3.286      1252.0
CH    China       Beijing  9.597      1357.0
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



Row & Column loc

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98

```
In [13]: brics.loc[["RU", "IN", "CH"], ["country", "capital"]]
```

```
Out[13]:
```

```
country    capital
RU    Russia      Moscow
IN    India       New Delhi
CH    China        Beijing
```



Row & Column loc

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98

```
In [13]: brics.loc[["RU", "IN", "CH"], ["country", "capital"]]
```

```
Out[13]:
```

```
country    capital
RU    Russia      Moscow
IN    India       New Delhi
CH    China        Beijing
```



```
In [14]: brics.loc[:, ["country", "capital"]]
```

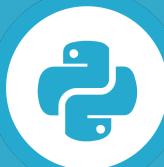
```
Out[14]:
```

```
country    capital
BR    Brazil      Brasilia
RU    Russia      Moscow
IN    India       New Delhi
CH    China        Beijing
SA  South Africa Pretoria
```



Recap

- Square brackets
 - Column access `brics[["country", "capital"]]`
 - Row access: only through slicing `brics[1:4]`
- loc (label-based)
 - Row access `brics.loc[["RU", "IN", "CH"]]`
 - Column access `brics.loc[:, ["country", "capital"]]`
 - Row & Column access `brics.loc[["RU", "IN", "CH"], ["country", "capital"]]`



Row Access iloc

```
In [15]: brics.loc[["RU"]]
```

```
Out[15]:
```

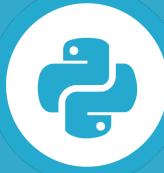
```
country capital area population
RU    Russia   Moscow  17.1      143.5
```

```
In [16]: brics.iloc[[1]]
```

```
Out[16]:
```

```
country capital area population
RU    Russia   Moscow  17.1      143.5
```

		country	capital	area	population
0	BR	Brazil	Brasilia	8.516	200.40
1	RU	Russia	Moscow	17.100	143.50
2	IN	India	New Delhi	3.286	1252.00
3	CH	China	Beijing	9.597	1357.00
4	SA	South Africa	Pretoria	1.221	52.98



Row Access iloc

```
In [17]: brics.loc[["RU", "IN", "CH"]]
```

```
Out[17]:
```

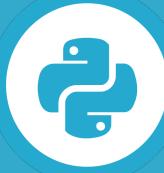
	country	capital	area	population
RU	Russia	Moscow	17.100	143.5
IN	India	New Delhi	3.286	1252.0
CH	China	Beijing	9.597	1357.0

```
In [18]: brics.iloc[[1,2,3]]
```

```
Out[18]:
```

	country	capital	area	population
RU	Russia	Moscow	17.100	143.5
IN	India	New Delhi	3.286	1252.0
CH	China	Beijing	9.597	1357.0

		country	capital	area	population
0	BR	Brazil	Brasilia	8.516	200.40
1	RU	Russia	Moscow	17.100	143.50
2	IN	India	New Delhi	3.286	1252.00
3	CH	China	Beijing	9.597	1357.00
4	SA	South Africa	Pretoria	1.221	52.98



Row & Column iloc

		0	1	2	3
0	BR	country Brazil	capital Brasilia	area 8.516	population 200.40
1	RU	Russia	Moscow	17.100	143.50
2	IN	India	New Delhi	3.286	1252.00
3	CH	China	Beijing	9.597	1357.00
4	SA	South Africa	Pretoria	1.221	52.98

```
In [19]: brics.loc[["RU", "IN", "CH"], ["country", "capital"]]
```

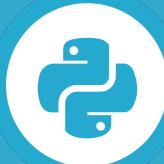
```
Out[19]:
```

```
country    capital
RU      Russia      Moscow
IN      India      New Delhi
CH      China      Beijing
```

```
In [20]: brics.iloc[[1,2,3], [0, 1]]
```

```
Out[20]:
```

```
country    capital
RU      Russia      Moscow
IN      India      New Delhi
CH      China      Beijing
```



Row & Column iloc

```
In [21]: brics.loc[:, ["country", "capital"]]
```

```
Out[21]:
```

	country	capital
BR	Brazil	Brasilia
RU	Russia	Moscow
IN	India	New Delhi
CH	China	Beijing
SA	South Africa	Pretoria

```
In [22]: brics.iloc[:, [0,1]]
```

```
Out[22]:
```

	country	capital
BR	Brazil	Brasilia
RU	Russia	Moscow
IN	India	New Delhi
CH	China	Beijing
SA	South Africa	Pretoria

	0	1	2	3
0	country	capital	area	population
1	BR	Brazil	8.516	200.40
2	RU	Russia	17.100	143.50
3	IN	India	3.286	1252.00
4	CH	China	9.597	1357.00
5	SA	South Africa	1.221	52.98



INTERMEDIATE PYTHON FOR DATA SCIENCE

Comparison Operators



Numpy Recap

```
In [1]: import numpy as np
In [2]: np_height = np.array([1.73, 1.68, 1.71, 1.89, 1.79])
In [3]: np_weight = np.array([65.4, 59.2, 63.6, 88.4, 68.7])
In [4]: bmi = np_weight / np_height ** 2

In [5]: bmi
Out[5]: array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])

In [6]: bmi > 23
Out[6]: array([False, False, False,  True, False], dtype=bool)

In [7]: bmi[bmi > 23]
Out[7]: array([ 24.747])
```

Code from Intro to Python for Data Science, Chapter 4

Comparison operators: how Python values relate



Numeric Comparisons

```
In [8]: 2 < 3  
Out[8]: True
```

```
In [9]: 2 == 3  
Out[9]: False
```

```
In [10]: 2 <= 3  
Out[10]: True
```

```
In [11]: 3 <= 3  
Out[11]: True
```

```
In [12]: x = 2
```

```
In [13]: y = 3
```

```
In [14]: x < y  
Out[14]: True
```



Other Comparisons

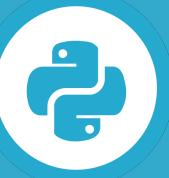
```
In [15]: "carl" < "chris"  
Out[15]: True
```

```
In [16]: 3 < "chris"  
TypeError: unorderable types: int() < str()
```

```
In [17]: 3 < 4.1  
Out[17]: True
```

```
In [18]: bmi  
Out[18]: array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
```

```
In [19]: bmi > 23  
Out[19]: array([False, False, False,  True, False], dtype=bool)
```



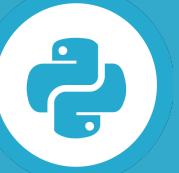
Comparators

<	strictly less than
<=	less than or equal
>	strictly greater than
>=	greater than or equal
==	equal
!=	not equal



INTERMEDIATE PYTHON FOR DATA SCIENCE

Boolean Operators



Boolean Operators

- and
- or
- not



and

```
In [1]: True and True  
Out[1]: True
```

```
In [2]: False and True  
Out[2]: False
```

```
In [3]: True and False  
Out[3]: False
```

```
In [4]: False and False  
Out[4]: False
```

```
In [5]: x = 12
```

True True

```
In [6]: x > 5 and x < 15  
Out[6]: True
```



or

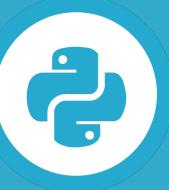
```
In [7]: True or True  
Out[7]: True
```

```
In [8]: False or True  
Out[8]: True
```

```
In [9]: True or False  
Out[9]: True
```

```
In [10]: False or False  
Out[10]: False
```

```
In [11]: y = 5  
          True      False  
In [12]: y < 7 or y > 13  
Out[12]: True
```



not

```
In [13]: not True  
Out[13]: False
```

```
In [14]: not False  
Out[14]: True
```



Numpy

```
In [19]: bmi      # calculation of bmi left out  
Out[19]: array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
```

```
In [20]: bmi > 21  
Out[20]: array([ True, False,  True,  True,  True], dtype=bool)
```

```
In [21]: bmi < 22  
Out[22]: array([ True,  True,  True, False,  True], dtype=bool)
```

```
In [23]: bmi > 21 and bmi < 22  
ValueError: The truth value of an array with more than one element  
is ambiguous. Use a.any() or a.all()
```



Numpy

logical_and()
logical_or()
logical_not()

```
In [19]: bmi      # calculation of bmi left out  
Out[19]: array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
```

```
In [20]: bmi > 21  
Out[20]: array([ True, False,  True,  True,  True], dtype=bool)
```

```
In [21]: bmi < 22  
Out[22]: array([ True,  True,  True, False,  True], dtype=bool)
```

```
In [23]: bmi > 21 and bmi < 22  
ValueError: The truth value of an array with more than one element  
is ambiguous. Use a.any() or a.all()
```

```
In [24]: np.logical_and(bmi > 21, bmi < 22)  
Out[24]: array([ True, False,  True, False,  True], dtype=bool)
```

```
In [25]: bmi[np.logical_and(bmi > 21, bmi < 22)]  
Out[25]: array([ 21.852,  21.75 ,  21.441])
```



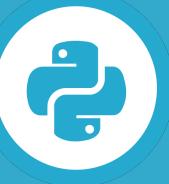
INTERMEDIATE PYTHON FOR DATA SCIENCE

if, elif, else



Overview

- Comparison Operators
 - <, >, >=, <=, ==, !=
- Boolean Operators
 - and, or, not
- Conditional Statements
 - if, else, elif



if

if condition :
 expression

control.py

```
z = 4  True
if z % 2 == 0 :
    print("z is even")
```

Output:

z is even



if

control.py

```
z = 4  True
if z % 2 == 0 :
    print("z is even")
```

```
if condition :
    expression
expression # not part of if
```



Output:

z is even



if

if condition :
 expression

control.py

```
z = 4
if z % 2 == 0 :
    print("checking " + str(z))
    print("z is even")
```

Output:

```
checking 4
z is even
```



if

control.py

```
z = 5  False
if z % 2 == 0 :
    print("checking " + str(z))
    print("z is even")
```

Not executed

Output:



else

control.py

```
z = 5  False
if z % 2 == 0 :
    print("z is even")
else :
    print("z is odd") ←
```

```
if condition :
    expression
else :
    expression
```



Output:

z is odd



elif

control.py

```
z = 3
if z % 2 == 0 : False
    print("z is divisible by 2")
elif z % 3 == 0 : True
    print("z is divisible by 3")
else :
    print("z is neither divisible by 2 nor by 3")
```

```
if condition :
    expression
elif condition :
    expression
else :
    expression
```



Output:

z is divisible by 3



elif

control.py

```
z = 6
if z % 2 == 0 : True
    print("z is divisible by 2")
elif z % 3 == 0 : Never reached
    print("z is divisible by 3")
else :
    print("z is neither divisible by 2 nor by 3")
```

```
if condition :
    expression
elif condition :
    expression
else :
    expression
```



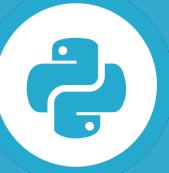
Output:

z is divisible by 2



INTERMEDIATE PYTHON FOR DATA SCIENCE

Filtering Pandas DataFrame



brics

```
In [1]: import pandas as pd
```

```
In [2]: brics = pd.read_csv("path/to/brics.csv", index_col = 0)
```

```
In [3]: brics
```

```
Out[3]:
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



Goal

- Select countries with area over 8 million km²
- 3 steps
 - Select the area column
 - Do comparison on area column
 - Use result to select countries

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



Step 1: Get column

```
In [4]: brics["area"]
```

```
Out[4]:
```

```
BR      8.516
RU     17.100
IN      3.286
CH      9.597
SA      1.221
```

```
Name: area, dtype: float64
```

Alternatives:

```
brics.loc[:, "area"]
```

```
brics.iloc[:, 2]
```

Need Pandas Series

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



Step 2: Compare

```
In [4]: brics["area"]
```

```
Out[4]:
```

```
BR    8.516  
RU   17.100  
IN    3.286  
CH    9.597  
SA    1.221
```

```
Name: area, dtype: float64
```

```
In [5]: brics["area"] > 8
```

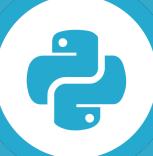
```
Out[5]:
```

```
BR    True  
RU    True  
IN   False  
CH    True  
SA   False
```

```
Name: area, dtype: bool
```

```
In [6]: is_huge = brics["area"] > 8
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



Step 3: Subset DF

```
In [7]: is_huge
```

```
Out[7]:
```

```
BR      True  
RU      True  
IN     False  
CH      True  
SA     False
```

```
Name: area, dtype: bool
```

```
In [8]: brics[is_huge]
```

```
Out[8]:
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.4
RU	Russia	Moscow	17.100	143.5
CH	China	Beijing	9.597	1357.0

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



Summary

```
In [9]: is_huge = brics["area"] > 8
```

```
In [10]: brics[is_huge]
```

```
Out[10]:
```

```
country    capital      area  population
BR        Brazil     Brasilia   8.516      200.4
RU        Russia     Moscow    17.100      143.5
CH        China      Beijing   9.597      1357.0
```

```
In [11]: brics[brics["area"] > 8]
```

```
Out[11]:
```

```
country    capital      area  population
BR        Brazil     Brasilia   8.516      200.4
RU        Russia     Moscow    17.100      143.5
CH        China      Beijing   9.597      1357.0
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



Boolean operators

```
In [12]: import numpy as np
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98

```
In [13]: np.logical_and(brics["area"] > 8, brics["area"] < 10)
```

```
Out[13]:
```

```
BR      True  
RU     False  
IN     False  
CH      True  
SA     False
```

```
Name: area, dtype: bool
```

```
In [14]: brics[np.logical_and(brics["area"] > 8, brics["area"] < 10)]
```

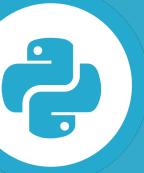
```
Out[14]:
```

```
   country    capital    area  population  
BR    Brazil    Brasilia  8.516       200.4  
CH    China     Beijing  9.597      1357.0
```



INTERMEDIATE PYTHON FOR DATA SCIENCE

while loop



if-elif-else

control.py

```
z = 6  
if z % 2 == 0 :  True  
    print("z is divisible by 2") Executed  
elif z % 3 == 0 :  
    print("z is divisible by 3")  
else :  
    print("z is neither divisible by 2 nor by 3")  
... Moving on
```

Goes through construct only once!

While loop = repeated if statement

While

```
while condition :  
    expression
```



- Numerically calculating model
- "repeating action until condition is met"
- Example
 - Error starts at 50
 - Divide error by 4 on every run
 - Continue until error no longer > 1



While

Error starts at 50
Divide error by 4 on every run
Continue until error no longer > 1

while condition :
 expression

while_loop.py

```
error = 50.0

while error > 1 :
    error = error / 4
    print(error)
```



While

while_loop.py

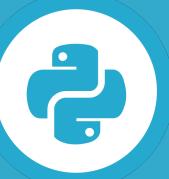
```
error = 50.0
      50.0
while error > 1 : True
    error = error / 4
    print(error)
```

while condition :
expression



Output:

12.5



While

while_loop.py

```
error = 50.0
      12.5
while error > 1 : True
    error = error / 4
    print(error)
```

while condition :
expression



Output:

```
12.5
3.125
```



While

while_loop.py

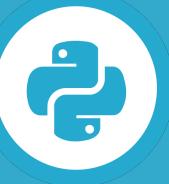
```
error = 50.0
      3.125
while error > 1 : True
    error = error / 4
    print(error)
```

while condition :
expression



Output:

```
12.5
3.125
0.78125
```



While

while_loop.py

```
error = 50.0
      0.78125
while error > 1 : False
    error = error / 4    not executed
    print(error)
```

while condition :
expression



Output:

```
12.5
3.125
0.78125
```



While

while_loop.py

```
error = 50.0

while error > 1 : always True
    # error = error / 4
    print(error)
```

Output:

```
50
50
50
50
50
50
50
50
50
...
...
```

DataCamp: session disconnected
Local system: Control + C

while condition :
expression





INTERMEDIATE PYTHON FOR DATA SCIENCE

for loop



for loop

```
for var in seq :  
    expression
```



"for each var in seq, execute expression"



fam

 family.py

```
fam = [1.73, 1.68, 1.71, 1.89]
print(fam)
```

Output:

```
[1.73, 1.68, 1.71, 1.89]
```



fam

family.py

```
fam = [1.73, 1.68, 1.71, 1.89]
print(fam[0])
print(fam[1])
print(fam[2])
print(fam[3])
```

Output:

```
1.73
1.68
1.71
1.89
```



for loop

family.py

```
fam = [1.73, 1.68, 1.71, 1.89]  
for height in fam :  
    print(height)
```

for var in seq :
 expression





for loop

family.py

```
fam = [1.73, 1.68, 1.71, 1.89]  
for height in fam :  
    print(height)
```

for var in seq :
 expression



first iteration
height = 1.73

Output:
1.73



for loop

family.py

```
fam = [1.73, 1.68, 1.71, 1.89]  
for height in fam :  
    print(height)
```

for var in seq :
 expression



second iteration
height = 1.68

Output:

```
1.73  
1.68
```



for loop

for var in seq :
 expression

 family.py

```
fam = [1.73, 1.68, 1.71, 1.89]  
  
for height in fam :  
    print(height)
```

no access to indexes

Output:

```
1.73  
1.68  
1.71  
1.89
```



for loop

for var in seq :
 expression

 family.py

```
fam = [1.73, 1.68, 1.71, 1.89]  
???
```

Output:

```
1.73 index 0: 1.73  
1.68 index 1: 1.68  
1.71 index 2: 1.71  
1.89 index 3: 1.89
```



enumerate

for var in seq :
 expression

 family.py

```
fam = [1.73, 1.68, 1.71, 1.89]

for index, height in enumerate(fam) :
    print("index " + str(index) + ": " + str(height))
```

Output:

```
index 0: 1.73
index 1: 1.68
index 2: 1.71
index 3: 1.89
```



Loop over string

```
for var in seq :  
    expression
```

 strloop.py

```
for c in "family" :  
    print(c.capitalize())
```

Output:

```
F  
A  
M  
I  
L  
Y
```



INTERMEDIATE PYTHON FOR DATA SCIENCE

Loop Data Structures

Part 1



Dictionary

for var in seq :
expression

dictloop.py

```
world = { "afghanistan":30.55,  
          "albania":2.77,  
          "algeria":39.21 }  
  
for key, value in world :  
    print(key + " -- " + str(value))
```

Output:

ValueError: too many values to unpack (expected 2)



Dictionary

for var in seq :
expression

dictloop.py

```
world = { "afghanistan":30.55,  
          "albania":2.77,  
          "algeria":39.21 }  
  
for key, value in world.items() :  
    print(key + " -- " + str(value))
```

Output:

```
algeria -- 39.21  
afghanistan -- 30.55  
albania -- 2.77
```



Dictionary

dictloop.py

```
world = { "afghanistan":30.55,  
          "albania":2.77,  
          "algeria":39.21 }
```

key value

```
for k, v in world.items() :  
    print(k + " -- " + str(v))
```

for var in seq :
 expression



Output:

```
algeria -- 39.21  
afghanistan -- 30.55  
albania -- 2.77
```



Numpy Arrays

for var in seq :
 expression

nploop.py

```
import numpy as np
np_height = np.array([1.73, 1.68, 1.71, 1.89, 1.79])
np_weight = np.array([65.4, 59.2, 63.6, 88.4, 68.7])
bmi = np_weight / np_height ** 2

for val in bmi :
    print(val)
```

Output:

21.852
20.975
21.750
24.747
21.441



2D Numpy Arrays

for var in seq :
expression

np2dloop.py

```
import numpy as np
np_height = np.array([1.73, 1.68, 1.71, 1.89, 1.79])
np_weight = np.array([65.4, 59.2, 63.6, 88.4, 68.7])
meas = np.array([np_height, np_weight])

for val in meas :
    print(val)
```

Output:

```
[ 1.73  1.68  1.71  1.89  1.79]
[ 65.4  59.2  63.6  88.4  68.7]
```



2D Numpy Arrays

np2dloop.py

```
import numpy as np
np_height = np.array([1.73, 1.68, 1.71, 1.89, 1.79])
np_weight = np.array([65.4, 59.2, 63.6, 88.4, 68.7])
meas = np.array([np_height, np_weight])

for val in np.nditer(meas) :
    print(val)
```

Output:

1.73
1.68
1.71
1.89
1.79

for var in seq :
 expression



Output (cont):

65.4
59.2
63.6
88.4
68.7



Recap

- Dictionary
 - `for key, val in my_dict.items() :`
- Numpy array
 - `for val in np.nditer(my_array) :`



INTERMEDIATE PYTHON FOR DATA SCIENCE

Loop Data Structures

Part 2

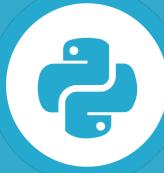


brics

 dfloop.py

```
import pandas as pd  
brics = pd.read_csv("brics.csv", index_col = 0)
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98



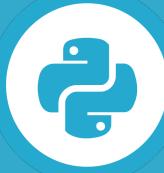
for, first try

dfloop.py

```
import pandas as pd  
brics = pd.read_csv("brics.csv", index_col = 0)  
  
for val in brics :  
    print(val)
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98

Output:
country
capital
area
population



iterrows

dfloop.py

```
import pandas as pd  
brics = pd.read_csv("brics.csv", index_col = 0)
```

```
for lab, row in brics.iterrows() :  
    print(lab)  
    print(row)
```

Output:

```
BR  
country          Brazil  
capital        Brasilia  
area            8.516  
population     200.4  
Name: BR, dtype: object  
...  
IN ...
```

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98

Output (cont):

```
RU  
country          Russia  
capital        Moscow  
area            17.1  
population     143.5  
Name: RU, dtype: object  
IN ...
```



Selective print

dfloop.py

```
import pandas as pd  
brics = pd.read_csv("brics.csv", index_col = 0)  
  
for lab, row in brics.iterrows() :  
    print(lab + " : " + row["capital"])
```

		country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40	
RU	Russia	Moscow	17.100	143.50	
IN	India	New Delhi	3.286	1252.00	
CH	China	Beijing	9.597	1357.00	
SA	South Africa	Pretoria	1.221	52.98	

Output:

BR: Brasilia
RU: Moscow
IN: New Delhi
CH: Beijing
SA: Pretoria



Add column

dfloop.py

```
import pandas as pd  
brics = pd.read_csv("brics.csv", index_col = 0)  
  
for lab, row in brics.iterrows():  
    brics.loc[lab, "name_length"] = len(row["country"])  
print(brics)
```

Creating Series on every iteration

Output:

	country	capital	area	population	name_length
BR	Brazil	Brasilia	8.516	200.40	6
RU	Russia	Moscow	17.100	143.50	6
IN	India	New Delhi	3.286	1252.00	5
CH	China	Beijing	9.597	1357.00	5
SA	South Africa	Pretoria	1.221	52.98	12



apply

dfloop.py

```
import pandas as pd  
brics = pd.read_csv("brics.csv", index_col = 0)  
  
brics["name_length"] = brics["country"].apply(len)  
  
print(brics)
```

Output:

	country	capital	area	population	name_length
BR	Brazil	Brasilia	8.516	200.40	6
RU	Russia	Moscow	17.100	143.50	6
IN	India	New Delhi	3.286	1252.00	5
CH	China	Beijing	9.597	1357.00	5
SA	South Africa	Pretoria	1.221	52.98	12

	country	capital	area	population
BR	Brazil	Brasilia	8.516	200.40
RU	Russia	Moscow	17.100	143.50
IN	India	New Delhi	3.286	1252.00
CH	China	Beijing	9.597	1357.00
SA	South Africa	Pretoria	1.221	52.98

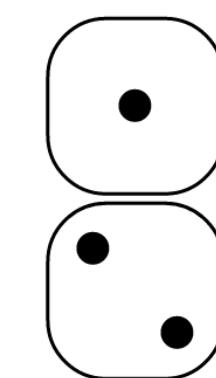


INTERMEDIATE PYTHON FOR DATA SCIENCE

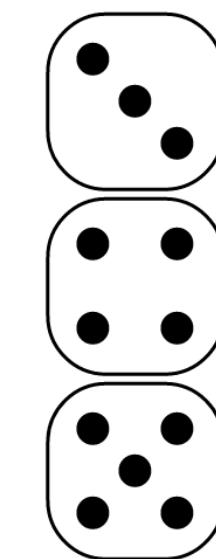
Random Numbers



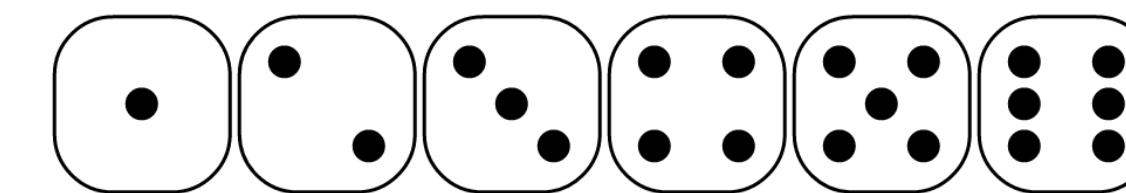
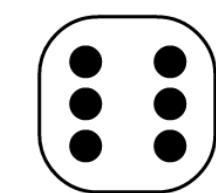
100 x



-1



+1



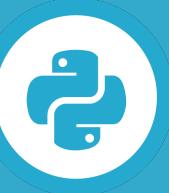
+1 +2 +3 +4 +5 +6



Can't go below step 0

0.1 % chance of falling down the stairs

Bet: you'll reach step 60



How to solve?

- Analytical
- Simulate the process
 - Hacker statistics!



Random Generators

```
In [1]: import numpy as np
```

```
In [2]: np.random.rand()  
Out[2]: 0.9535543896720104
```

```
In [3]: np.random.seed(123)
```

```
In [4]: np.random.rand()  
Out[4]: 0.6964691855978616  
In [5]: np.random.rand()  
Out[5]: 0.28613933495037946
```

```
In [6]: np.random.seed(123)
```

```
In [7]: np.random.rand()  
Out[7]: 0.696469185597861  
In [8]: np.random.rand()  
Out[8]: 0.28613933495037946
```

Pseudo-random numbers
Mathematical formula
Starting from a seed

Same seed: same random numbers!
Ensures "reproducibility"



Coin Toss

game.py

```
import numpy as np  
np.random.seed(123)  
coin = np.random.randint(0, 2)  
print(coin)
```

Randomly generate 0 or 1

Output:

0



Coin Toss

game.py

```
import numpy as np
np.random.seed(123)
coin = np.random.randint(0,2)
print(coin)
if coin == 0:
    print("heads")
else:
    print("tails")
```

Output:

0

heads

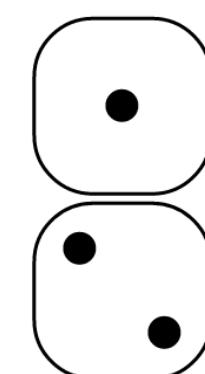


INTERMEDIATE PYTHON FOR DATA SCIENCE

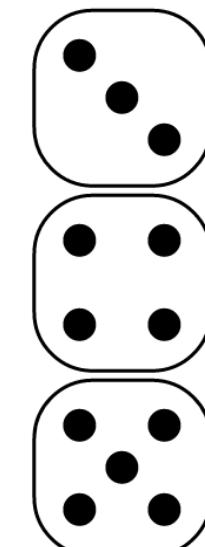
Random Walk



Random Step



-1



+1

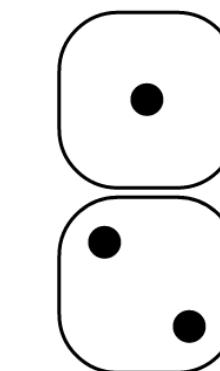


+1 +2 +3 +4 +5 +6

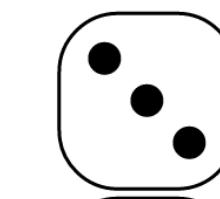
Random Walk



100 x



-1



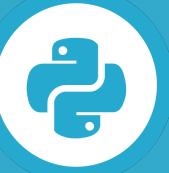
+1



+1 +2 +3 +4 +5 +6

Known in Science

- Path of molecules
- Gambler's financial status



Heads or Tails

headtails.py

```
import numpy as np
np.random.seed(123)
outcomes = []
for x in range(10) :
    coin = np.random.randint(0, 2)
    if coin == 0 :
        outcomes.append("heads")
    else :
        outcomes.append("tails")
print(outcomes)
```

0: heads
1: tails

Output:

```
['heads', 'tails', 'heads', 'heads', 'heads',
 'heads', 'heads', 'tails', 'tails', 'heads']
```



Heads or Tails: Random Walk

headtailsrw.py

```
import numpy as np
np.random.seed(123)
tails = [0]
for x in range(10) :
    coin = np.random.randint(0, 2)
    tails.append(tails[x] + coin)
```

```
print(tails)
```

Output:

```
[0, 0, 1, 1, 1, 1, 1, 1, 2, 3, 3]
```

Step to Walk

outcomes

```
['heads', 'tails', 'heads', 'heads', 'heads',
 'heads', 'heads', 'tails', 'tails', 'heads']
```

tails

Output:

```
[0, 0, 1, 1, 1, 1, 1, 1, 2, 3, 3]
```

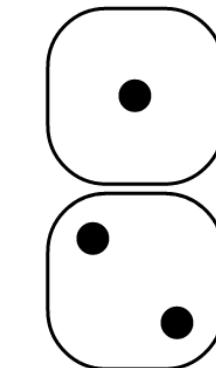


INTERMEDIATE PYTHON FOR DATA SCIENCE

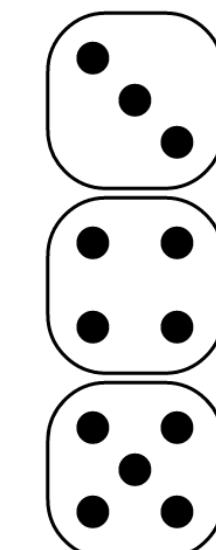
Distribution



100 x



-1



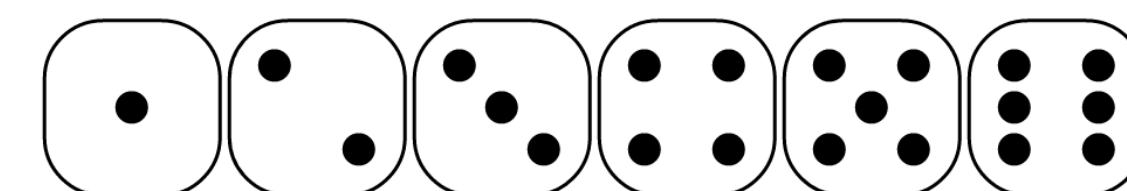
+1

Each random walk has an end point

Simulate 10,000 times: 10,000 end points

Distribution!

Calculate chances!



+1 +2 +3 +4 +5 +6





Random Walk

headtailsrw.py

```
import numpy as np
np.random.seed(123)
tails = [0]
for x in range(10) :
    coin = np.random.randint(0,2)
    tails.append(tails[x] + coin)
```



100 runs

 distribution.py

```
import numpy as np
np.random.seed(123)
final_tails = []
for x in range(100) :
    tails = [0]
    for x in range(10) :
        coin = np.random.randint(0,2)
        tails.append(tails[x] + coin)
    final_tails.append(tails[-1])
print(final_tails)
```

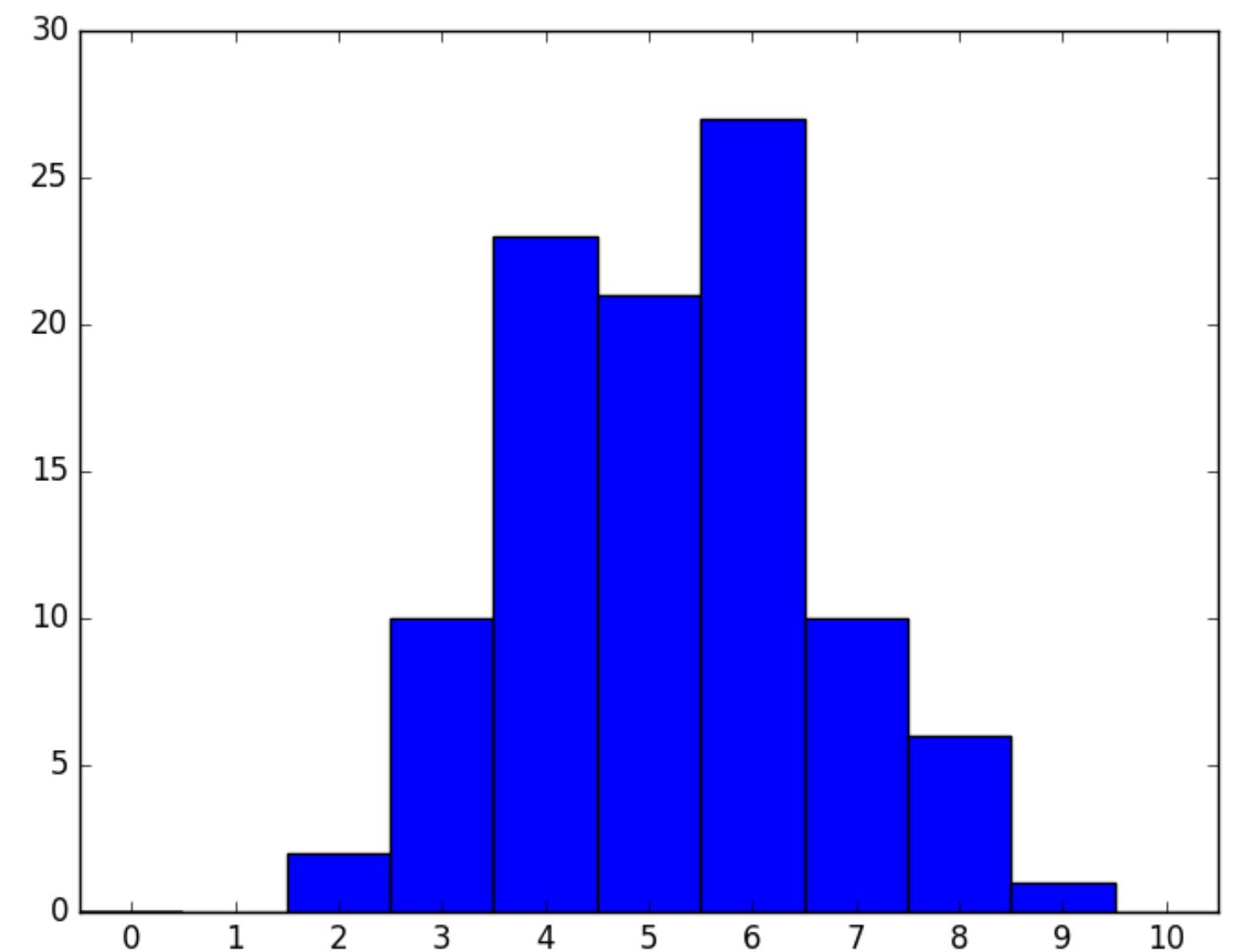
Output:

```
[3, 6, 4, 5, 4, 5, 3, 5, 4, 6, 6, 8, 6, 4, 7, 5, 7,
4, 3, 3, 4, 5, 8, 5, 6, 5, 7, 6, 4, 5, 8, 5, 8, 4,
6, 6, 3, 4, 5, 4, 7, 8, 9, 4, 3, 4, 5, 6, 4, 2, 6,
6, 5, 7, 5, 4, 5, 5, 6, 7, 6, 6, 6, 3, ..., 7]
```

Histogram, 100 runs

 distribution.py

```
import numpy as np
import matplotlib.pyplot as plt
np.random.seed(123)
final_tails = []
for x in range(100) :
    tails = [0]
    for x in range(10) :
        coin = np.random.randint(0,2)
        tails.append(tails[x] + coin)
    final_tails.append(tails[-1])
plt.hist(final_tails, bins = 10)
plt.show()
```

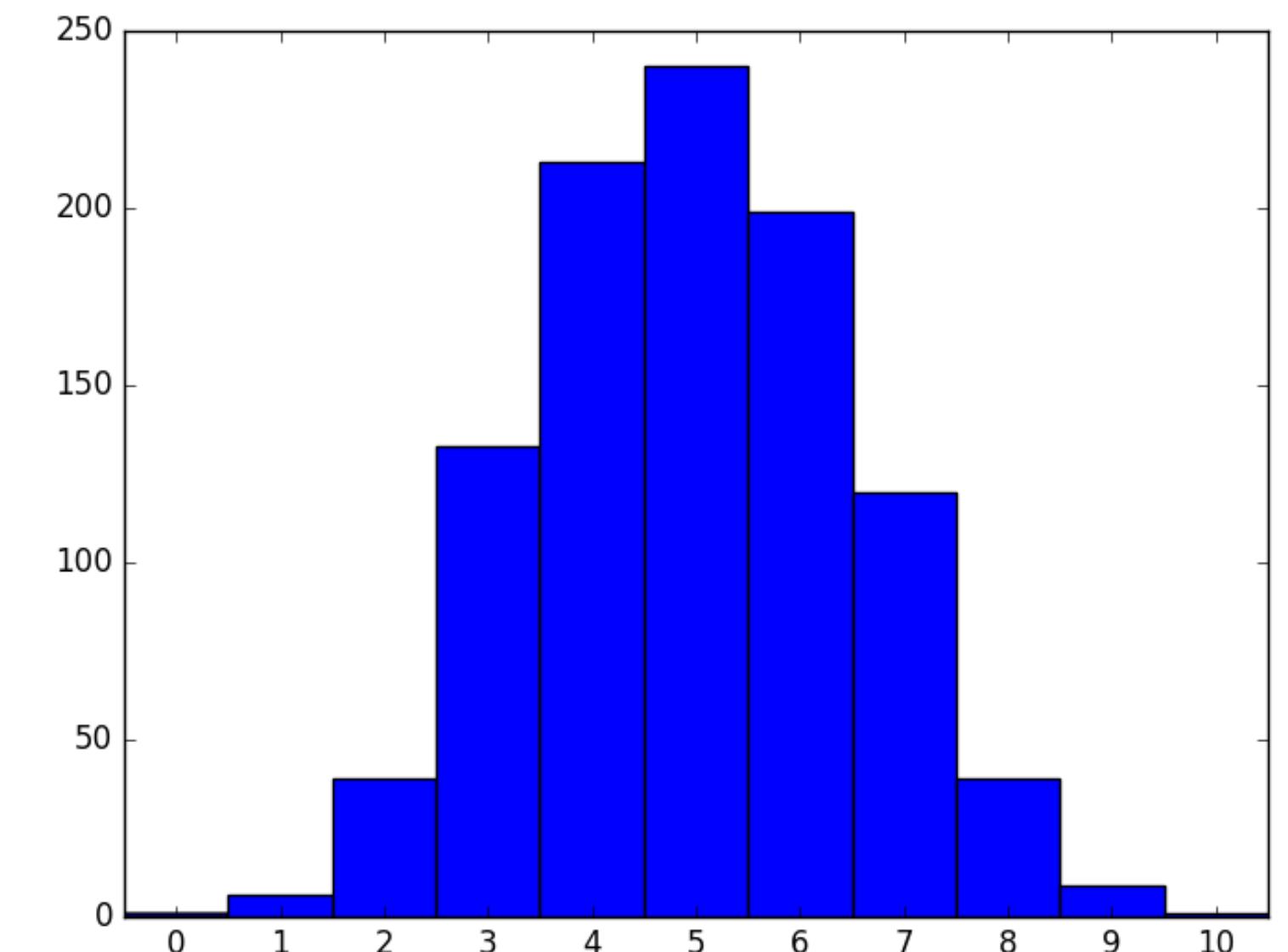


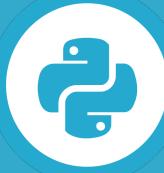


Histogram, 1.000 runs

`distribution.py`

```
import numpy as np
import matplotlib.pyplot as plt
np.random.seed(123)
final_tails = []
for x in range(1000) :
    tails = [0]
    for x in range(10) :
        coin = np.random.randint(0,2)
        tails.append(tails[-1] + coin)
    final_tails.append(tails[-1])
plt.hist(final_tails, bins = 10)
plt.show()
```





Histogram, 10.000 runs

 distribution.py

```
import numpy as np
import matplotlib.pyplot as plt
np.random.seed(123)
final_tails = []
for x in range(10000) :
    tails = [0]
    for x in range(10) :
        coin = np.random.randint(0,2)
        tails.append(tails[x] + coin)
    final_tails.append(tails[-1])
plt.hist(final_tails, bins = 10)
plt.show()
```

