Computer Science

CSC380: Principles of Data Science

Data Analysis, Collection, and Visualization 2

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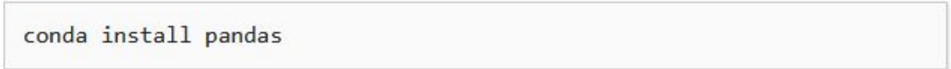
Pandas

Pandas

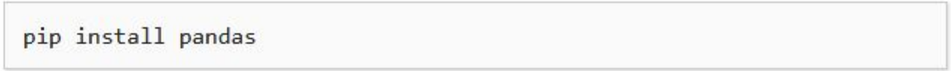
Open source library for data handling and manipulation in high-performance environments.

Installation If you are using Anaconda package manager,



```
conda install pandas
```

Or if you are using PyPi (pip) package manager,

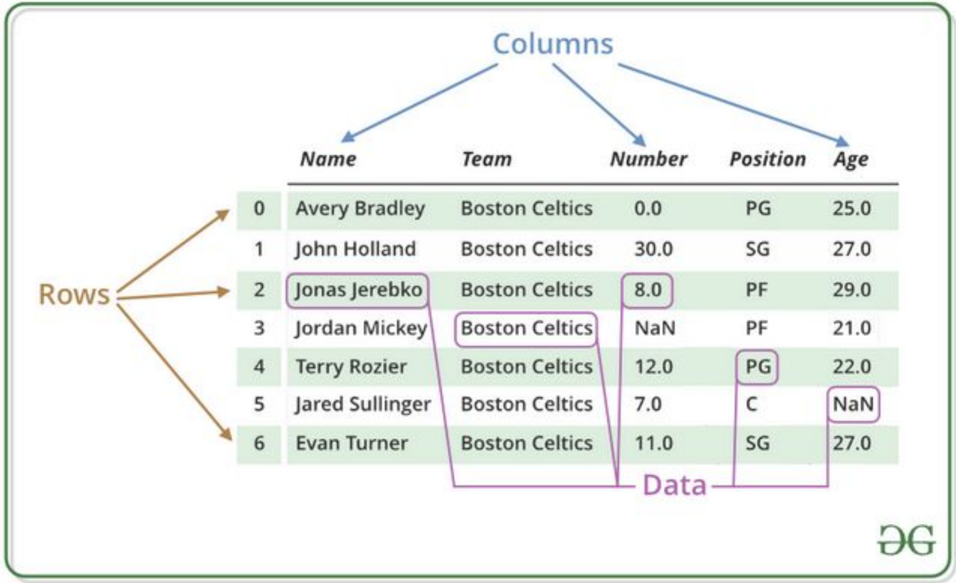


```
pip install pandas
```

See Pandas documentation for more detailed instructions
https://pandas.pydata.org/docs/getting_started/install.html

DataFrame

Primary data structure : Essentially a table



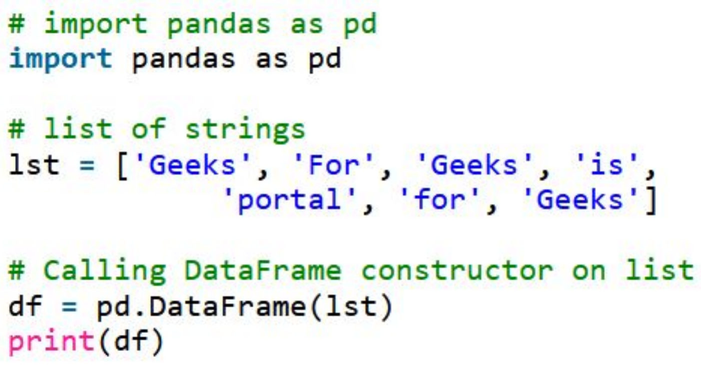
	Name	Team	Number	Position	Age
0	Avery Bradley	Boston Celtics	0.0	PG	25.0
1	John Holland	Boston Celtics	30.0	SG	27.0
2	Jonas Jerebko	Boston Celtics	8.0	PF	29.0
3	Jordan Mickey	Boston Celtics	NaN	PF	21.0
4	Terry Rozier	Boston Celtics	12.0	PG	22.0
5	Jared Sullinger	Boston Celtics	7.0	C	NaN
6	Evan Turner	Boston Celtics	11.0	SG	27.0

Q: how is it different from numpy array?

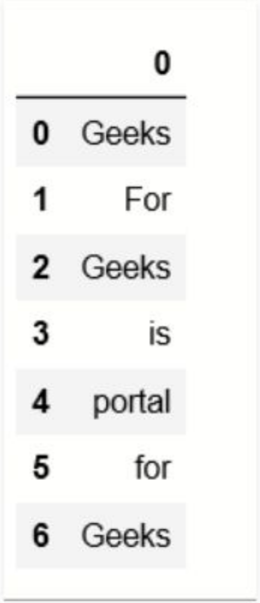
- Numpy arrays are more efficient
- Pandas dataframes are more flexible

DataFrame Example

Create and print an entire DataFrame



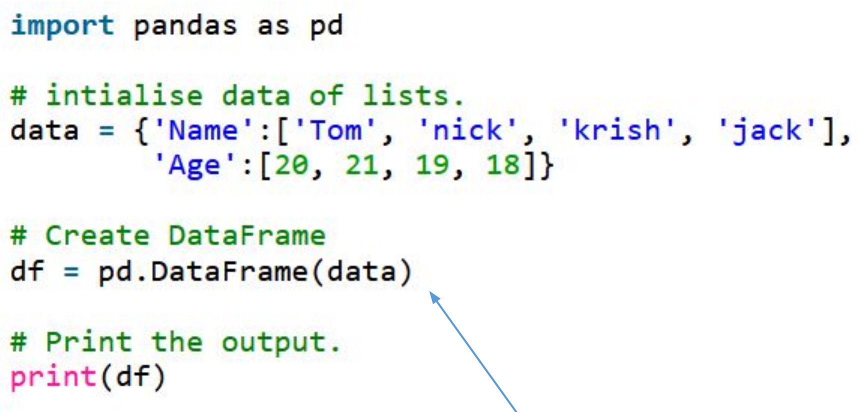
```
# import pandas as pd
import pandas as pd

# list of strings
lst = ['Geeks', 'For', 'Geeks', 'is',
            'portal', 'for', 'Geeks']

# Calling DataFrame constructor on list
df = pd.DataFrame(lst)
print(df)
```



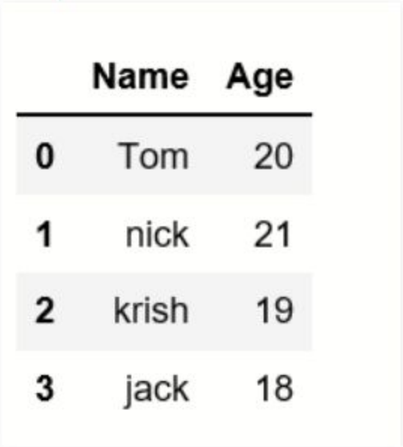
	0
0	Geeks
1	For
2	Geeks
3	is
4	portal
5	for
6	Geeks

DataFrame Example

Can create named columns using dictionary



```
import pandas as pd

# intialise data of lists.
data = {'Name':['Tom', 'nick', 'krish', 'jack'],
        'Age':[20, 21, 19, 18]}

# Create DataFrame
df = pd.DataFrame(data)

# Print the output.
print(df)
```

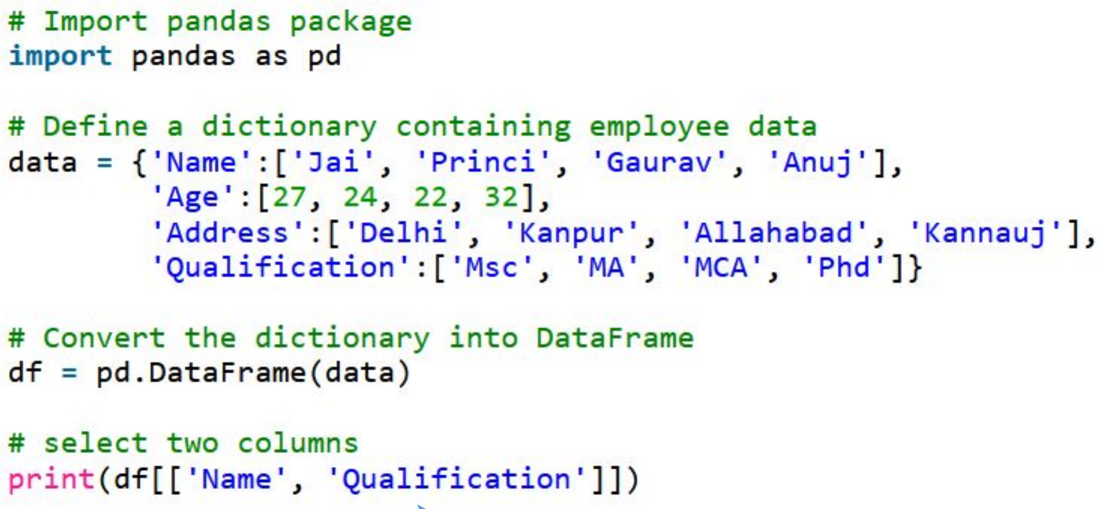


	Name	Age
0	Tom	20
1	nick	21
2	krish	19
3	jack	18

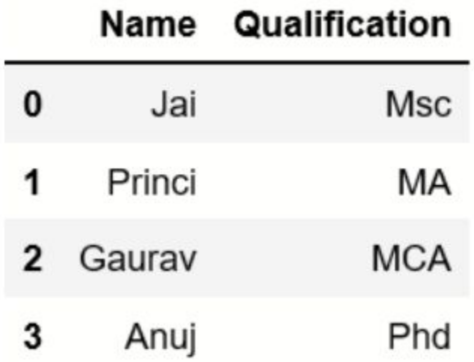
all data must have the same length

DataFrame : Selecting Columns

Select columns to print by name,



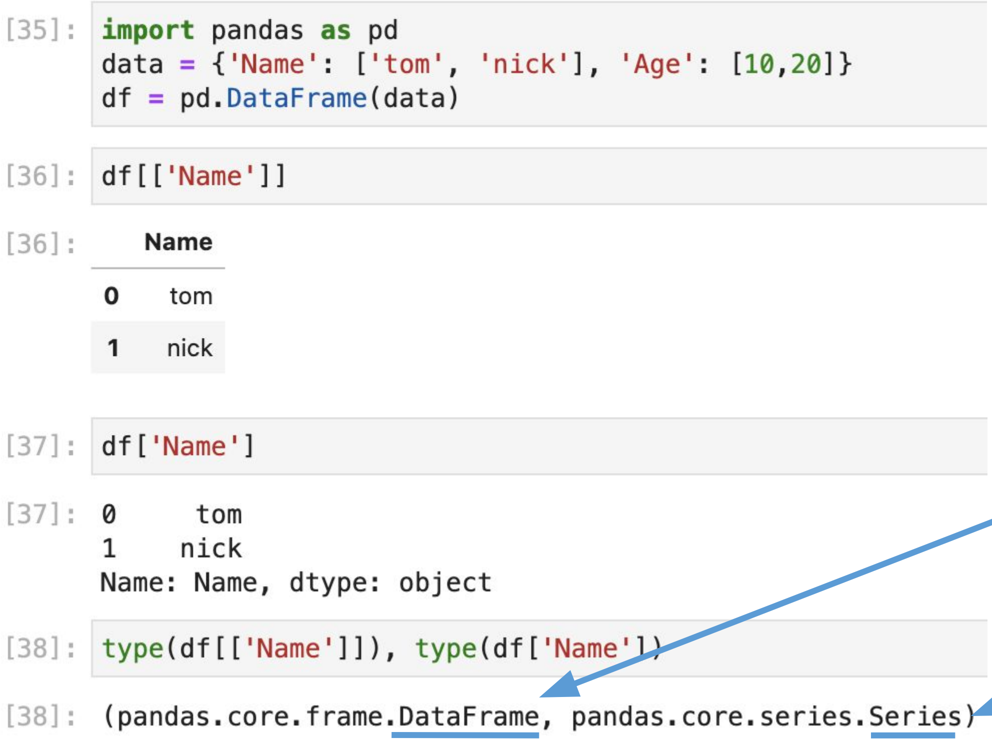
```
# Import pandas package
import pandas as pd

# Define a dictionary containing employee data
data = {'Name':['Jai', 'Princi', 'Gaurav', 'Anuj'],
        'Age':[27, 24, 22, 32],
        'Address':['Delhi', 'Kanpur', 'Allahabad', 'Kannauj'],
        'Qualification':['Msc', 'MA', 'MCA', 'Phd']}

# Convert the dictionary into DataFrame
df = pd.DataFrame(data)

# select two columns
print(df[['Name', 'Qualification']])
```



	Name	Qualification
0	Jai	Msc
1	Princi	MA
2	Gaurav	MCA
3	Anuj	Phd

access columns by name, not the column index!

DataFrame : Selecting Columns

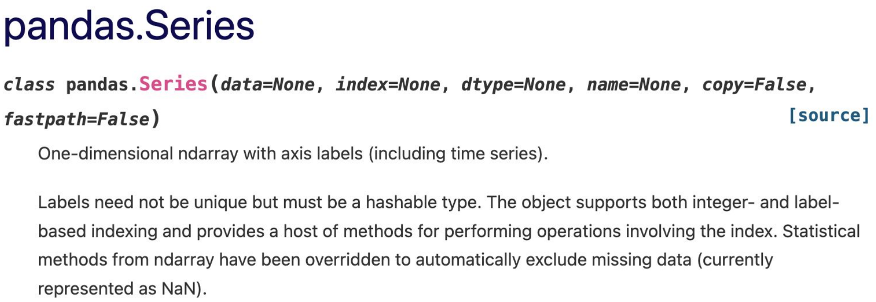


```
[35]: import pandas as pd
      data = {'Name': ['tom', 'nick'], 'Age': [10,20]}
      df = pd.DataFrame(data)

[36]: df[['Name']]
```

[36]:

	Name
0	tom
1	nick

```
[37]: df['Name']

[37]: 0     tom
      1    nick
      Name: Name, dtype: object

[38]: type(df[['Name']]), type(df['Name'])

[38]: (pandas.core.frame.DataFrame, pandas.core.series.Series)
```



pandas.Series

class **pandas.Series**(*data=None*, *index=None*, *dtype=None*, *name=None*, *copy=False*, *fastpath=False*) [source]

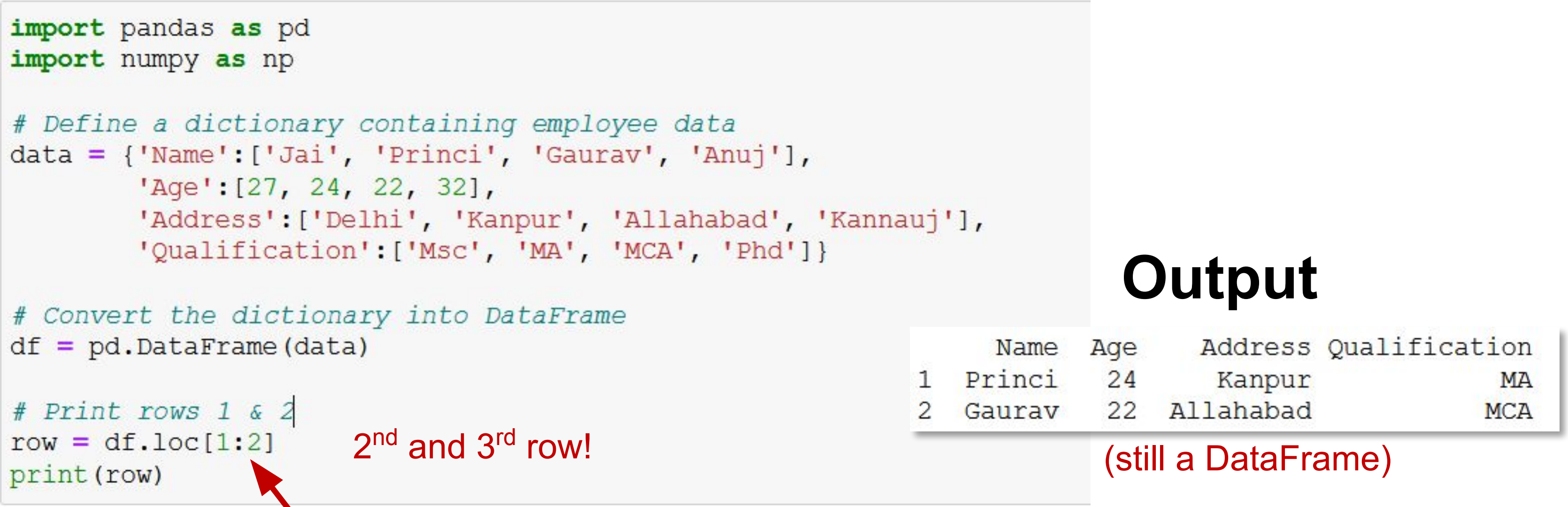
One-dimensional ndarray with axis labels (including time series).

Labels need not be unique but must be a hashable type. The object supports both integer- and label-based indexing and provides a host of methods for performing operations involving the index. Statistical methods from ndarray have been overridden to automatically exclude missing data (currently represented as NaN).

still a DataFrame

essentially, a ‘named’ array

DataFrame : Selecting Rows



```
import pandas as pd
import numpy as np

# Define a dictionary containing employee data
data = {'Name':['Jai', 'Princi', 'Gaurav', 'Anuj'],
        'Age':[27, 24, 22, 32],
        'Address':['Delhi', 'Kanpur', 'Allahabad', 'Kannauj'],
        'Qualification':['Msc', 'MA', 'MCA', 'Phd']}

# Convert the dictionary into DataFrame
df = pd.DataFrame(data)

# Print rows 1 & 2
row = df.loc[1:2]
print(row)
```

2nd and 3rd row!

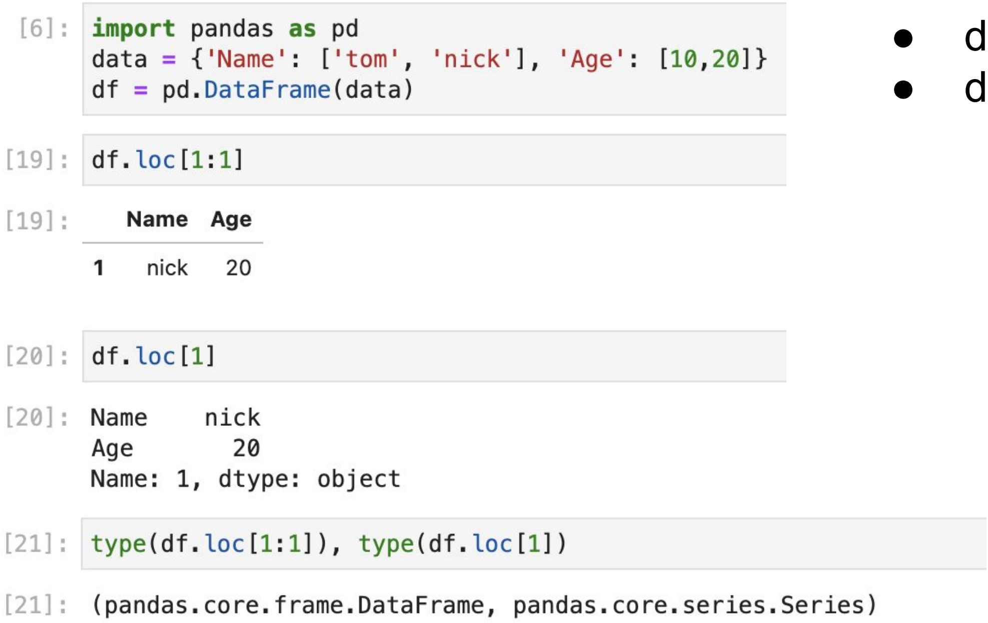
Output

```
     Name  Age    Address Qualification
1  Princi   24     Kanpur            MA
2  Gaurav   22  Allahabad           MCA
```

(still a DataFrame)

1:2 includes 2! annoying! this is not python standard!!!

DataFrame : Selecting Rows



```
[6]: import pandas as pd
     data = {'Name': ['tom', 'nick'], 'Age': [10,20]}
     df = pd.DataFrame(data)
```

```
[19]: df.loc[1:1]
```

[19]:

	Name	Age
1	nick	20

```
[20]: df.loc[1]
```

```
[20]: Name    nick
      Age       20
      Name: 1, dtype: object
```

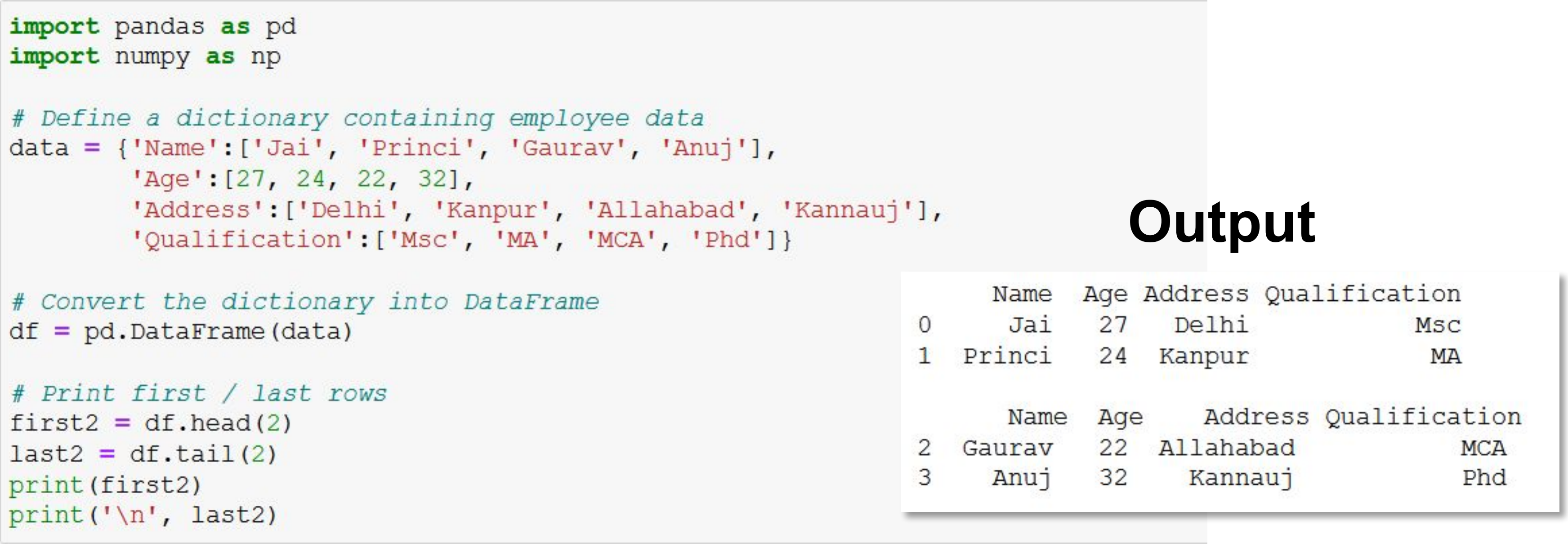
```
[21]: type(df.loc[1:1]), type(df.loc[1])
```

```
[21]: (pandas.core.frame.DataFrame, pandas.core.series.Series)
```

- df.loc[1:1] is DataFrame object
- df.loc[1] is a series

DataFrame : Selecting Rows

`head()` and `tail()` select rows from beginning / end



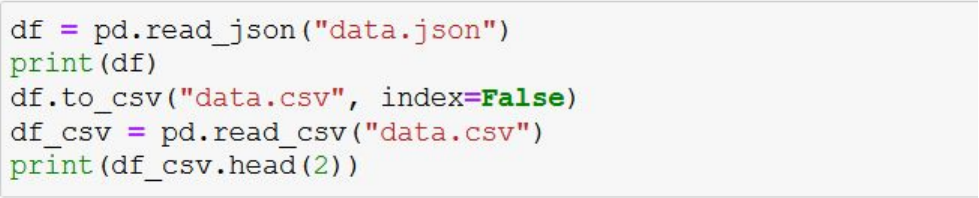
```python
import pandas as pd
import numpy as np

# Define a dictionary containing employee data
data = {'Name':['Jai', 'Princi', 'Gaurav', 'Anuj'],
        'Age':[27, 24, 22, 32],
        'Address':['Delhi', 'Kanpur', 'Allahabad', 'Kannauj'],
        'Qualification':['Msc', 'MA', 'MCA', 'Phd']}

# Convert the dictionary into DataFrame
df = pd.DataFrame(data)

# Print first / last rows
first2 = df.head(2)
last2 = df.tail(2)
print(first2)
print('\n', last2)
```

Output

```
     Name  Age Address Qualification
0     Jai   27   Delhi           Msc
1  Princi   24  Kanpur            MA

     Name  Age    Address Qualification
2  Gaurav   22  Allahabad           MCA
3    Anuj   32    Kannauj           Phd
```

Reading Data from Files

Easy reading / writing of standard formats,

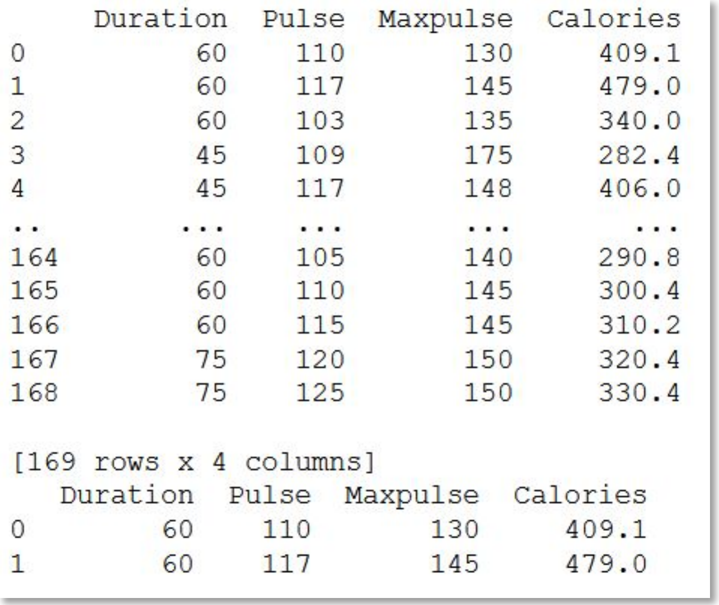


```
df = pd.read_json("data.json")
print(df)
df.to_csv("data.csv", index=False)
df_csv = pd.read_csv("data.csv")
print(df_csv.head(2))
```

example: twitter api returns search results in json format.

index ↓

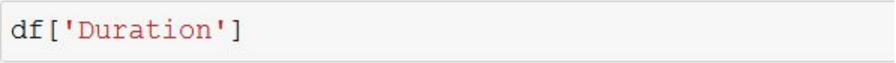
Output



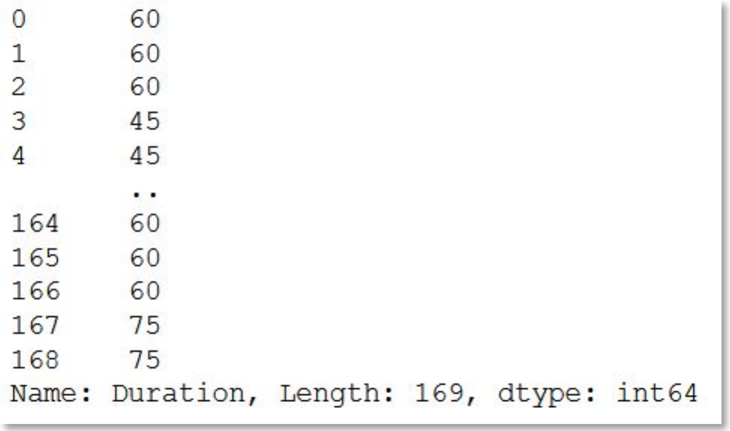
```
     Duration  Pulse  Maxpulse  Calories
0          60    110       130     409.1
1          60    117       145     479.0
2          60    103       135     340.0
3          45    109       175     282.4
4          45    117       148     406.0
..        ...    ...       ...       ...
164        60    105       140     290.8
165        60    110       145     300.4
166        60    115       145     310.2
167        75    120       150     320.4
168        75    125       150     330.4

[169 rows x 4 columns]
   Duration  Pulse  Maxpulse  Calories
0        60    110       130     409.1
1        60    117       145     479.0
```

Data Structure Conversions

Working with DataFrames outside of Pandas can be tricky,



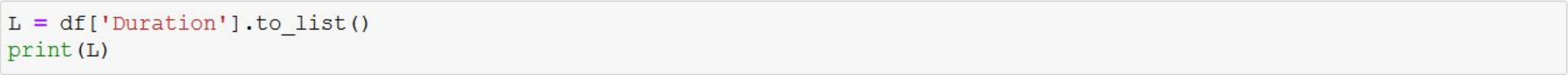
```
df['Duration']
```



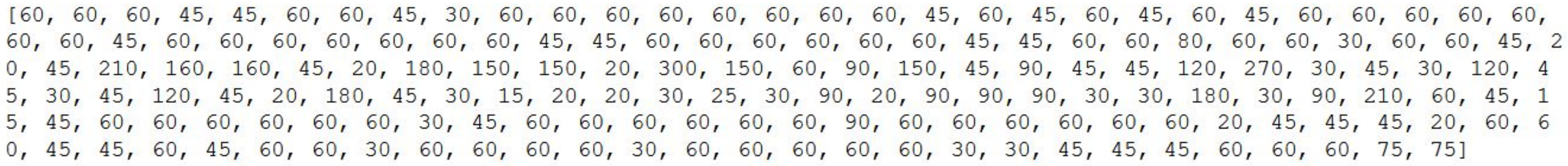
```
0       60
1       60
2       60
3       45
4       45
        ..
164     60
165     60
166     60
167     75
168     75
Name: Duration, Length: 169, dtype: int64
```

Q: does it return a DataFrame object or Series object?

We can easily convert to built-in types, for example to a list.



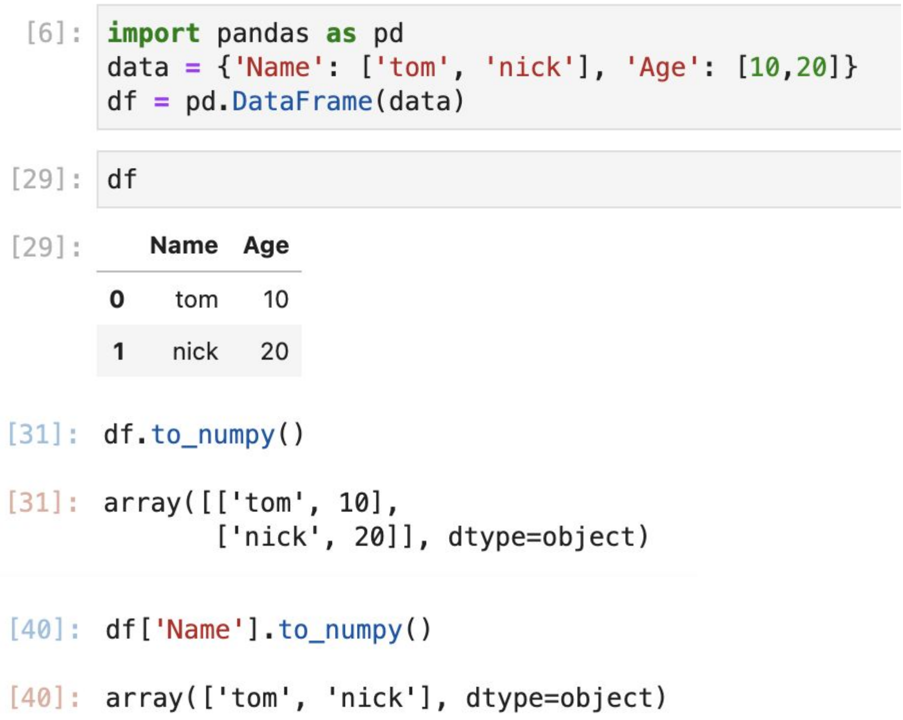
```
L = df['Duration'].to_list()
print(L)
```



```
[60, 60, 60, 45, 45, 60, 60, 45, 30, 60, 60, 60, 60, 60, 60, 60, 60, 45, 60, 45, 60, 45, 60, 45, 60, 60, 60, 60, 60,
60, 60, 45, 60, 60, 60, 60, 60, 60, 60, 45, 45, 60, 60, 60, 60, 60, 60, 45, 45, 60, 60, 80, 60, 60, 30, 60, 60, 45, 2
0, 45, 210, 160, 160, 45, 20, 180, 150, 150, 20, 300, 150, 60, 90, 150, 45, 90, 45, 45, 120, 270, 30, 45, 30, 120, 4
5, 30, 45, 120, 45, 20, 180, 45, 30, 15, 20, 20, 30, 25, 30, 90, 20, 90, 90, 90, 30, 30, 180, 30, 90, 210, 60, 45, 1
5, 45, 60, 60, 60, 60, 60, 60, 30, 45, 60, 60, 60, 60, 60, 60, 90, 60, 60, 60, 60, 60, 60, 20, 45, 45, 45, 20, 60, 6
0, 45, 45, 60, 45, 60, 60, 30, 60, 60, 60, 60, 30, 60, 60, 60, 60, 60, 30, 30, 45, 45, 45, 60, 60, 60, 75, 75]
```

Data Structure Conversions

Or, to a numpy array.



```
[6]: import pandas as pd
     data = {'Name': ['tom', 'nick'], 'Age': [10,20]}
     df = pd.DataFrame(data)
```

```
[29]: df
```

[29]:

	Name	Age
0	tom	10
1	nick	20

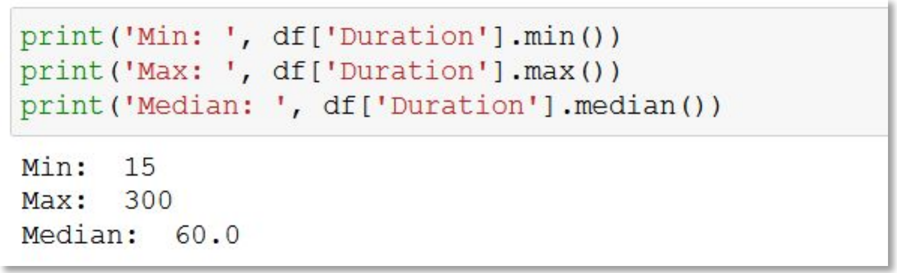
```
[31]: df.to_numpy()

[31]: array([['tom', 10],
             ['nick', 20]], dtype=object)
```

```
[40]: df['Name'].to_numpy()

[40]: array(['tom', 'nick'], dtype=object)
```

`to_numpy()`: defined on `Index`, `Series`, and `DataFrame` objects

Summary Statistics

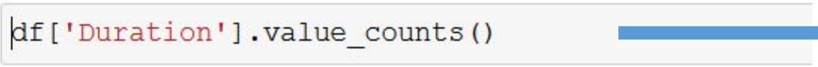
Easily compute summary statistics on data



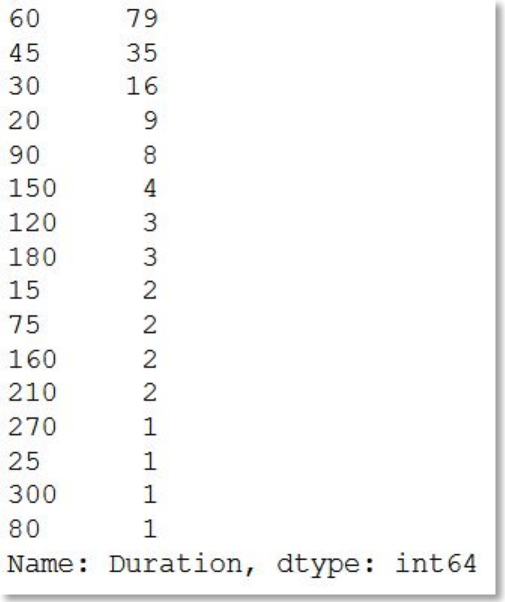
```
print('Min: ', df['Duration'].min())
print('Max: ', df['Duration'].max())
print('Median: ', df['Duration'].median())
```

```
Min:   15
Max:   300
Median:   60.0
```

Can also count occurrences of unique values,



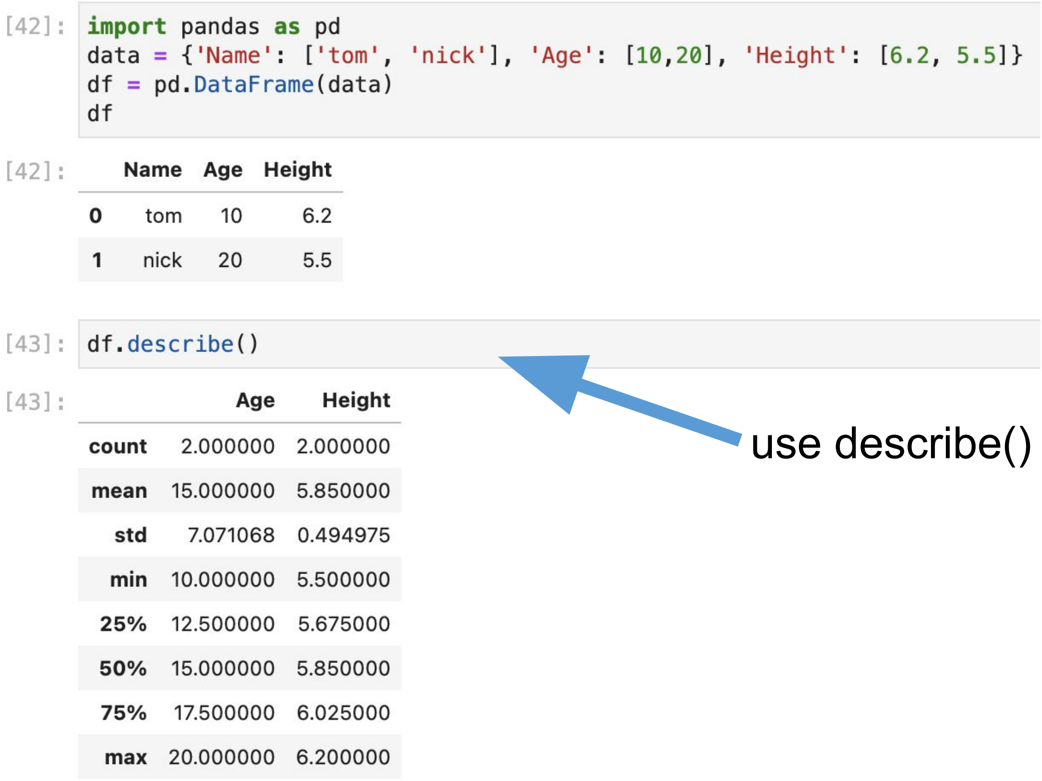
```
df['Duration'].value_counts()
```



```
60      79
45      35
30      16
20       9
90       8
150      4
120      3
180      3
15       2
75       2
160      2
210      2
270      1
25       1
300      1
80       1
Name: Duration, dtype: int64
```

s = df[‘Duration’].value_counts()
s[60]=79.

Summary Statistics



```
[42]: import pandas as pd
      data = {'Name': ['tom', 'nick'], 'Age': [10,20], 'Height': [6.2, 5.5]}
      df = pd.DataFrame(data)
      df
```

```
[42]:    Name  Age  Height
      0   tom   10     6.2
      1  nick   20     5.5
```

```
[43]: df.describe()
```

```
[43]:              Age    Height
      count   2.000000  2.000000
      mean   15.000000  5.850000
      std     7.071068  0.494975
      min    10.000000  5.500000
      25%    12.500000  5.675000
      50%    15.000000  5.850000
      75%    17.500000  6.025000
      max    20.000000  6.200000
```

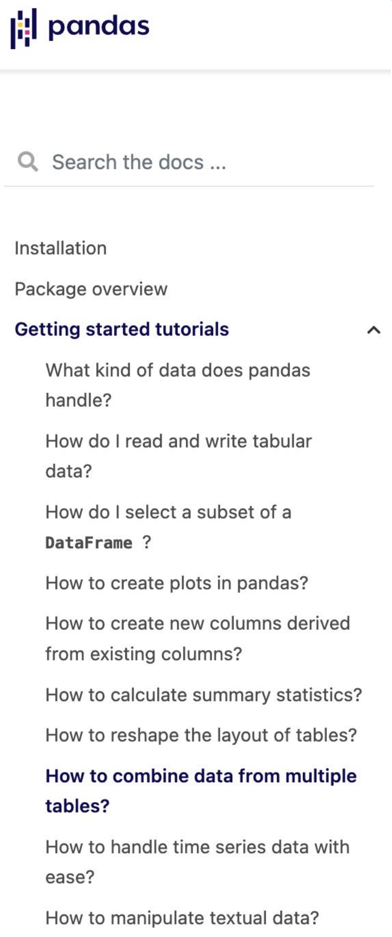
use describe() to get a summary of the data

More on Pandas

Many database operations are available

- You can specify index, which can speed up some operations
- You can do ‘join’
- You can do ‘where’ clause to filter the data
- You can do ‘group by’

More on Pandas



pandas

Search the docs ...

- Installation
- Package overview
- **Getting started tutorials**
  - What kind of data does pandas handle?
  - How do I read and write tabular data?
  - How do I select a subset of a `DataFrame` ?
  - How to create plots in pandas?
  - How to create new columns derived from existing columns?
  - How to calculate summary statistics?
  - How to reshape the layout of tables?
  - **How to combine data from multiple tables?**
  - How to handle time series data with ease?
  - How to manipulate textual data?

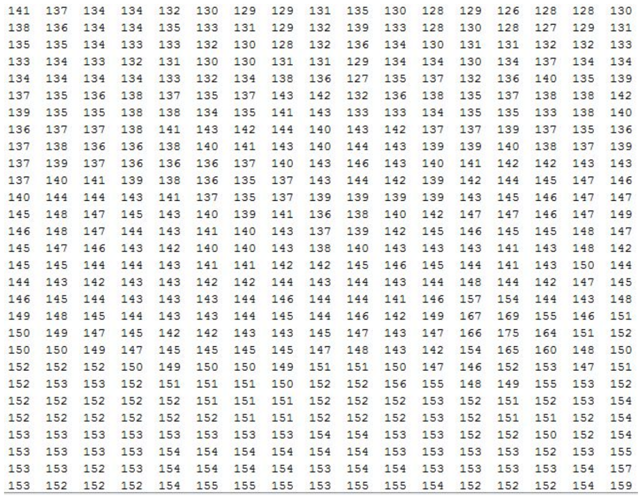
Doing it by yourself helps a lot!

Data Visualization

Outline

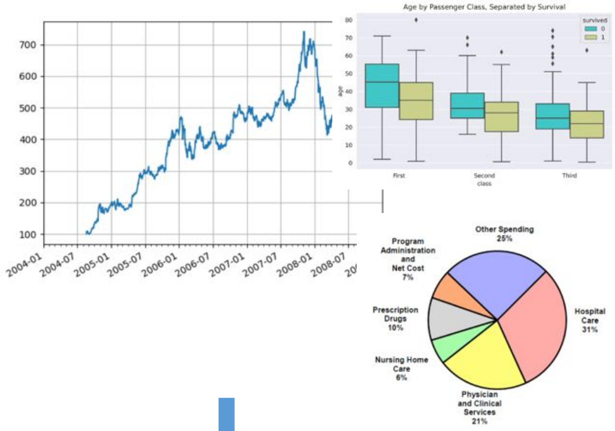
- Data Collection and Sampling
- Data Visualization
- Data Summarization

Data Analysis, Exploration, and Visualization



141	137	134	134	132	130	129	129	131	135	130	128	129	126	128	128	130
138	136	134	134	135	133	131	129	132	139	133	128	130	128	127	129	131
135	135	134	133	133	132	130	128	132	136	134	130	131	131	132	132	133
133	134	133	132	131	130	130	131	131	129	134	134	130	134	137	134	134
134	134	134	134	133	132	134	138	136	127	135	137	132	136	140	135	139
137	135	136	138	137	135	137	143	142	132	136	138	135	137	138	138	142
139	135	135	138	138	134	135	141	143	133	133	134	135	135	133	138	140
136	137	137	138	141	143	142	144	140	143	142	137	137	139	137	135	136
137	138	136	136	138	140	141	143	140	144	143	139	139	140	138	137	139
137	139	137	136	136	136	137	140	143	146	143	140	141	142	142	143	143
137	140	141	139	138	136	135	137	143	144	142	139	142	144	145	147	146
140	144	144	143	141	137	135	137	139	139	139	139	143	145	146	147	147
145	148	147	145	143	140	139	141	136	138	140	142	147	147	146	147	149
146	148	147	144	143	141	140	143	137	139	142	145	146	145	145	148	147
145	147	146	143	142	140	140	143	138	140	143	143	143	141	143	148	142
145	145	144	144	143	141	141	142	142	145	146	145	144	141	143	150	144
144	143	142	143	143	142	142	144	143	144	143	144	148	144	142	147	145
146	145	144	143	143	143	144	146	144	144	141	146	157	154	144	143	148
149	148	145	144	143	143	144	145	144	146	142	149	167	169	155	146	151
150	149	147	145	142	142	143	143	145	147	143	147	166	175	164	151	152
150	150	149	147	145	145	145	145	147	148	143	142	154	165	160	148	150
152	152	152	150	149	150	150	149	151	151	150	147	146	152	153	147	151
152	153	153	152	151	151	151	150	152	152	156	155	148	149	155	153	152
152	152	152	152	152	151	151	151	152	152	152	153	152	151	152	153	154
152	152	152	152	152	152	151	151	152	152	152	153	152	151	151	152	154
153	153	153	153	153	153	153	153	154	154	153	153	152	152	150	152	154
153	153	153	153	154	154	154	154	154	154	153	153	153	153	152	153	155
153	153	152	153	154	154	154	154	153	154	154	153	153	153	153	154	157
153	152	152	152	154	155	155	155	153	155	155	154	152	152	152	154	159

Encoding



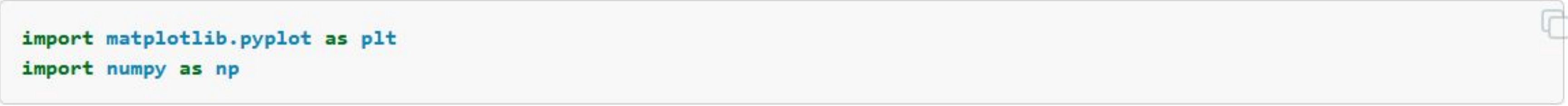
Iterate

Visual Perception

Understanding

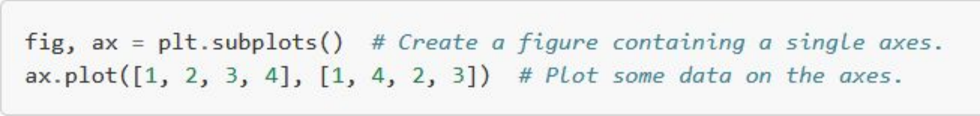
Data visualization in Python…

matplotlib

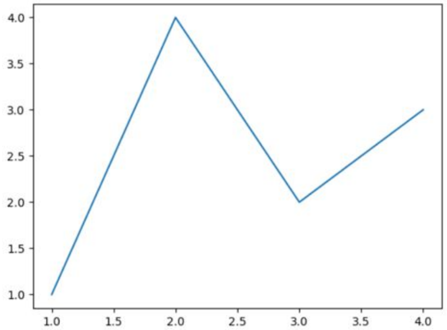


```
import matplotlib.pyplot as plt
import numpy as np
```

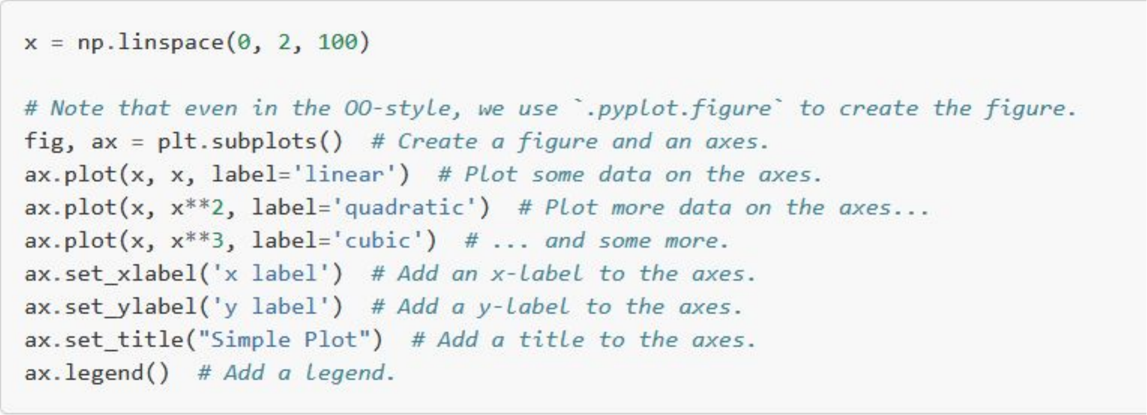
Create a simple figure with an axis object,



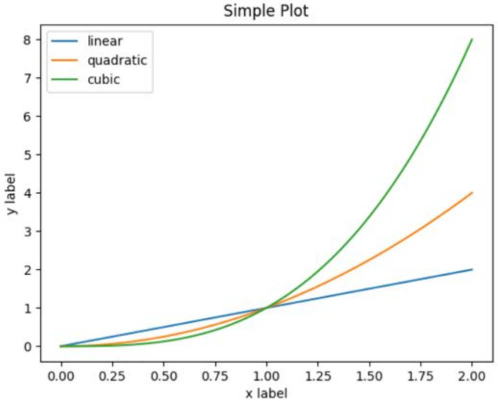
```
fig, ax = plt.subplots()  # Create a figure containing a single axes.
ax.plot([1, 2, 3, 4], [1, 4, 2, 3])  # Plot some data on the axes.
```



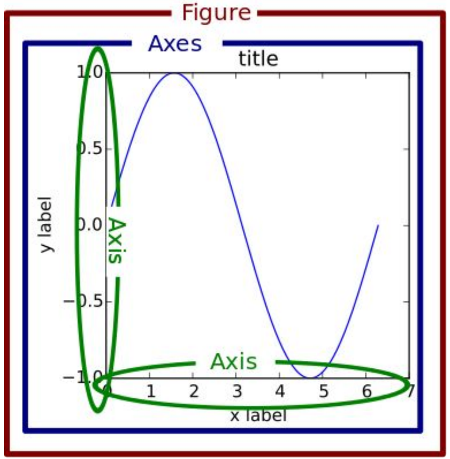
A more complicated plot…



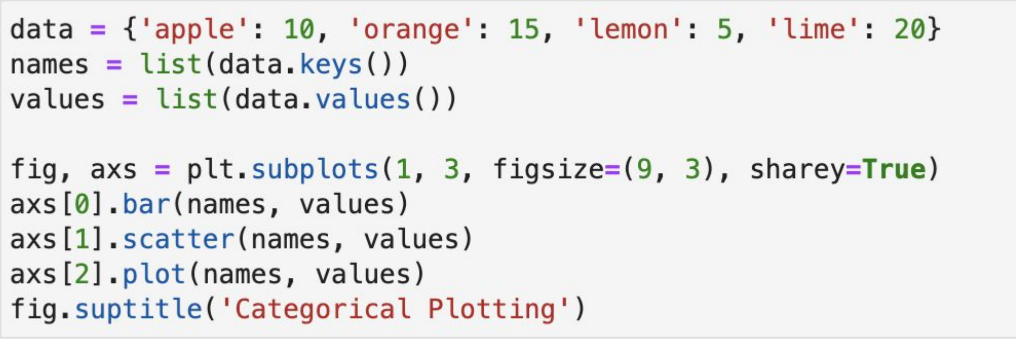
```
x = np.linspace(0, 2, 100)

# Note that even in the OO-style, we use `.pyplot.figure` to create the figure.
fig, ax = plt.subplots()  # Create a figure and an axes.
ax.plot(x, x, label='linear')  # Plot some data on the axes.
ax.plot(x, x**2, label='quadratic')  # Plot more data on the axes...
ax.plot(x, x**3, label='cubic')  # ... and some more.
ax.set_xlabel('x label')  # Add an x-label to the axes.
ax.set_ylabel('y label')  # Add a y-label to the axes.
ax.set_title("Simple Plot")  # Add a title to the axes.
ax.legend()  # Add a legend.
```



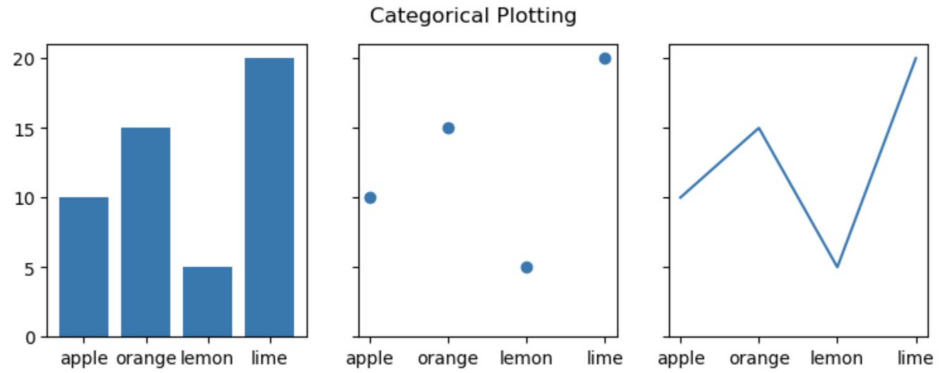
Axes vs Axis

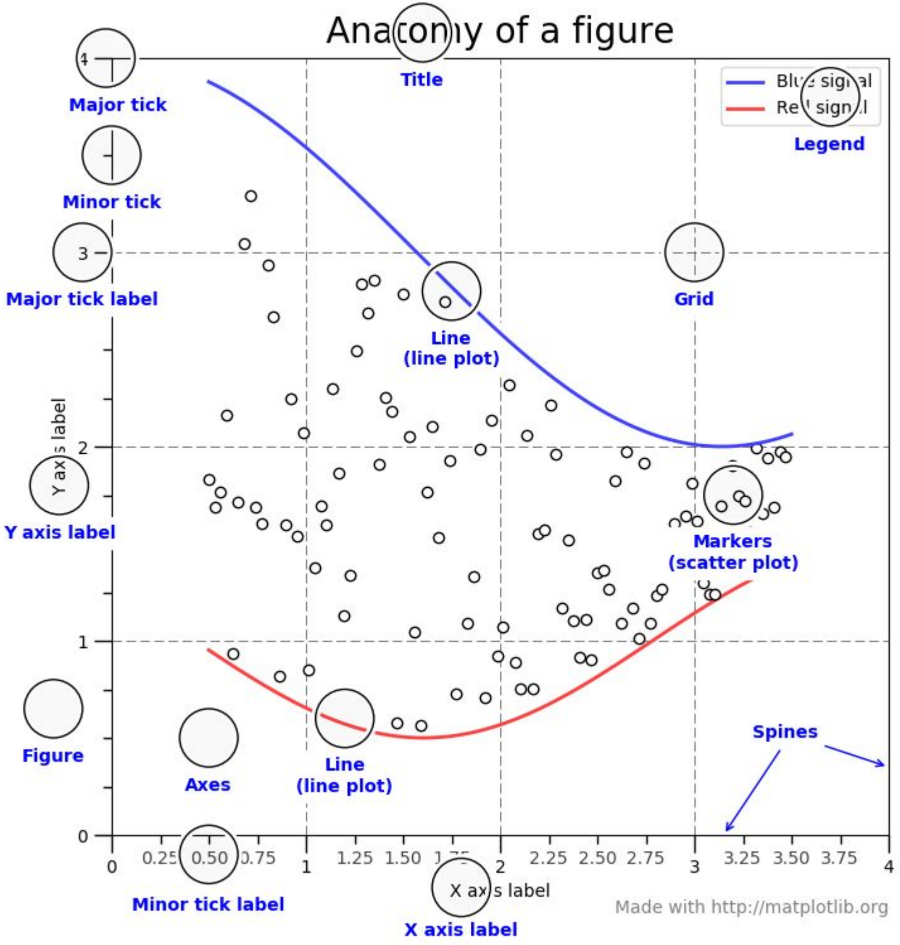


subplot() function: draw multiple plots in one figure



```
data = {'apple': 10, 'orange': 15, 'lemon': 5, 'lime': 20}
names = list(data.keys())
values = list(data.values())

fig, axs = plt.subplots(1, 3, figsize=(9, 3), sharey=True)
axs[0].bar(names, values)
axs[1].scatter(names, values)
axs[2].plot(names, values)
fig.suptitle('Categorical Plotting')
```





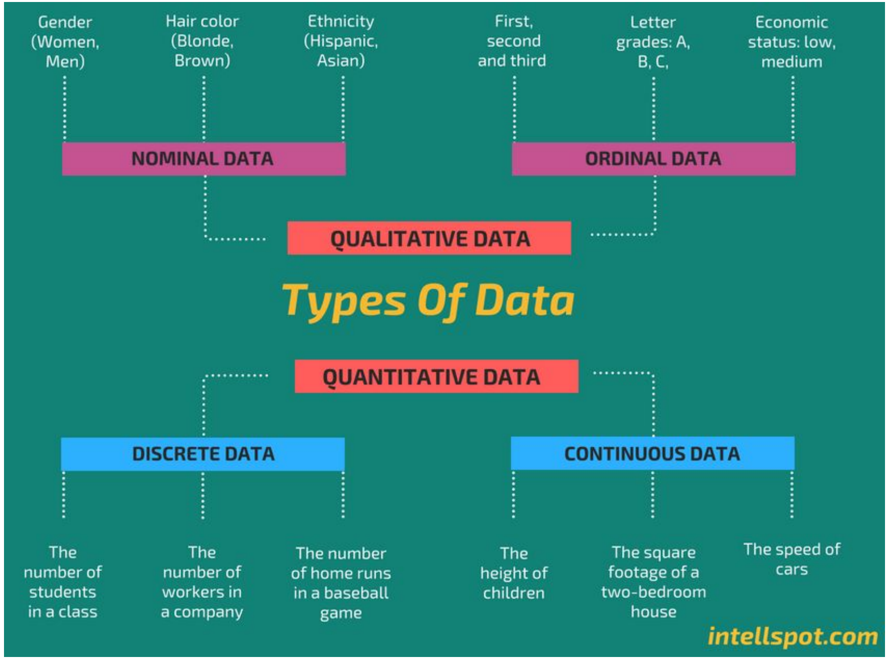
components of a Matplotlib figure

Documentation + tutorials:

https://matplotlib.org/

Types of Data

Data come in many forms, each requiring different approaches & models


Gender (Women, Men)
Hair color (Blonde, Brown)
Ethnicity (Hispanic, Asian)
First, second and third
Letter grades: A, B, C,
Economic status: low, medium
NOMINAL DATA
ORDINAL DATA
QUALITATIVE DATA
Types Of Data
QUANTITATIVE DATA
DISCRETE DATA
CONTINUOUS DATA
The number of students in a class
The number of workers in a company
The number of home runs in a baseball game
The height of children
The square footage of a two-bedroom house
The speed of cars
intellspot.com

Qualitative or **categorical** : can partition data into classes

Quantitative : can perform mathematical operations (e.g., addition, subtraction, ordering)

*We often refer to different types of data as **variables***

Categorical Variables

Examples

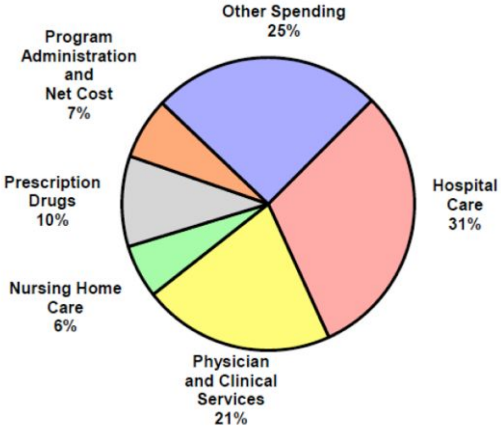
- Roll of a die: 1,2,3,4,5 or 6
- Blood Type: A, B, AB, or O
- Political Party: Democrat, Republican, etc.
- Type of Rock: Igneous, Sedimentary, or Metamorphic
- Word Identity: NP, VP, N, V, Adj, Adv, etc.

Numerical data can be categorical or quantitative depending on context

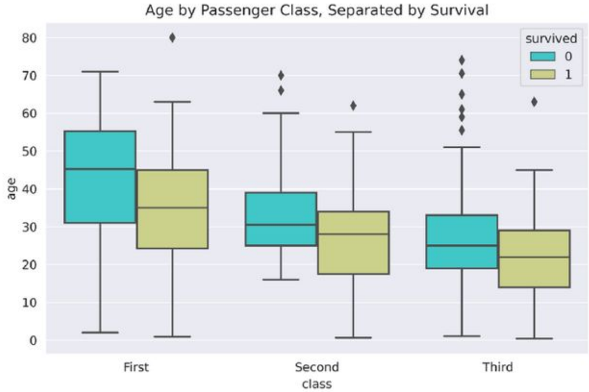
Conversion: Quantitative data can be converted to categorical by defining ranges:

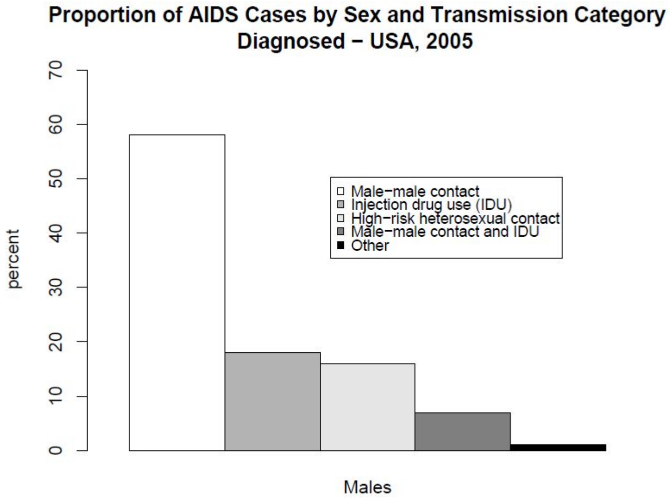
- Small [0, 10cm), Medium [10, 100cm), Large [100cm, 1m), XL [1m, -)
- Low [less than -100dB), Moderate [-100dB, -50dB), Loud [over -50dB)

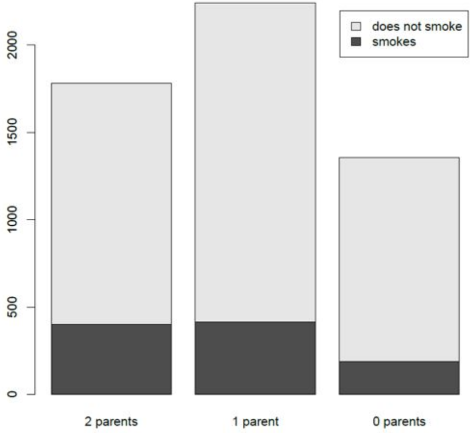
Visualizing Categorical Variables



	student smokes	student does not smoke	total
2 parents smoke	400	1380	1780
1 parent smokes	416	1823	2239
0 parents smoke	188	1168	1356
total	1004	4371	5375

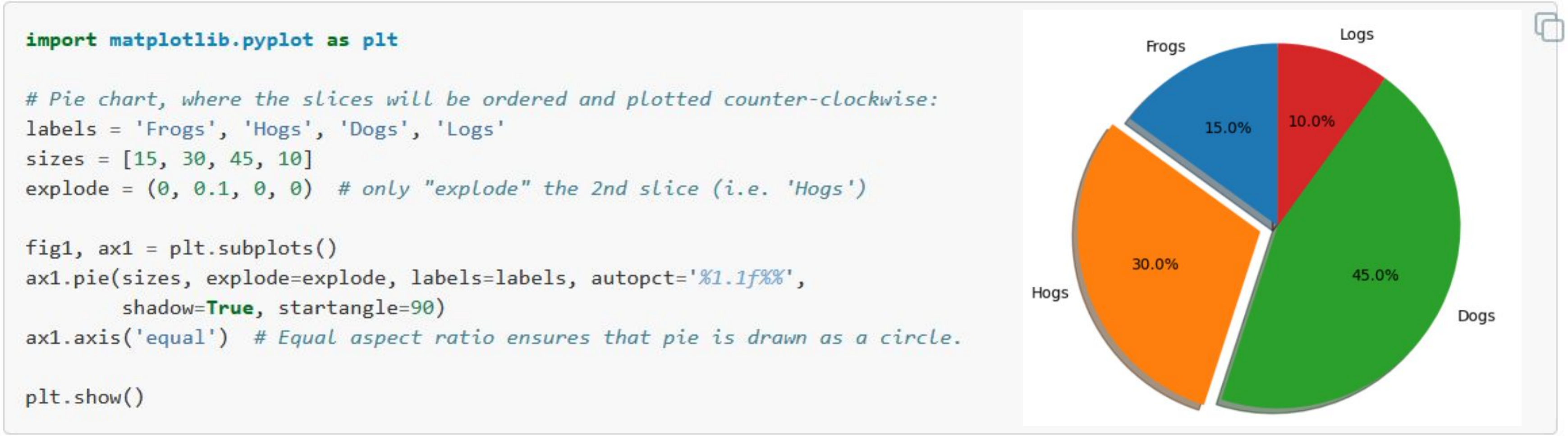

Age by Passenger Class, Separated by Survival


Proportion of AIDS Cases by Sex and Transmission Category Diagnosed – USA, 2005



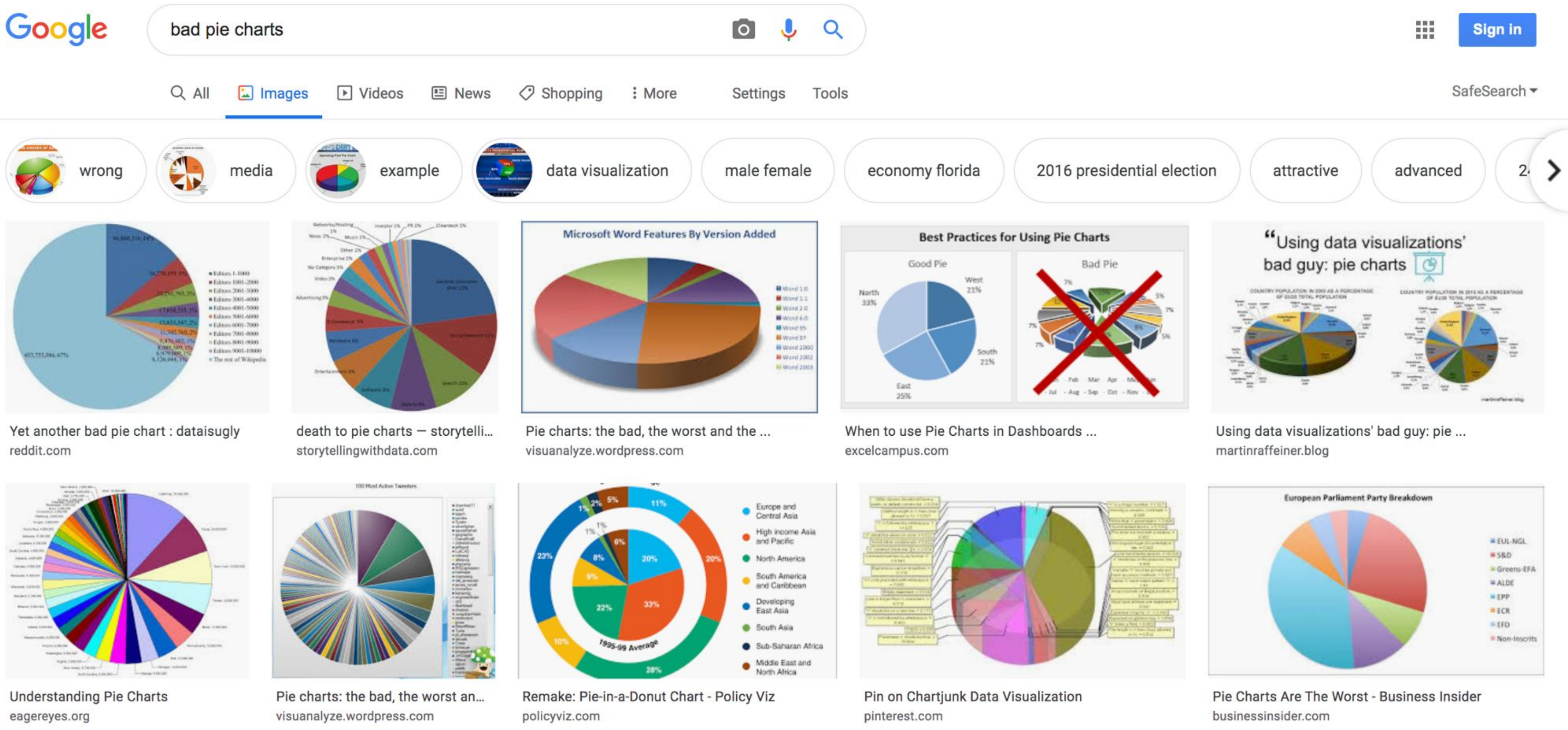
Pie Chart

Circular chart divided into sectors, illustrating relative magnitudes in frequencies or percentage. In a pie chart, <u>the area is proportional to the quantity it represents.</u>



```
import matplotlib.pyplot as plt

# Pie chart, where the slices will be ordered and plotted counter-clockwise:
labels = 'Frogs', 'Hogs', 'Dogs', 'Logs'
sizes = [15, 30, 45, 10]
explode = (0, 0.1, 0, 0)  # only "explode" the 2nd slice (i.e. 'Hogs')

fig1, ax1 = plt.subplots()
ax1.pie(sizes, explode=explode, labels=labels, autopct='%1.1f%%',
        shadow=True, startangle=90)
ax1.axis('equal')  # Equal aspect ratio ensures that pie is drawn as a circle.

plt.show()
```

Maybe the biggest problem with pie charts is that they have been so often done poorly...



Yet another bad pie chart : dataisugly
reddit.com

death to pie charts — storytelli...
storytellingwithdata.com

Pie charts: the bad, the worst and the ...
visuanalyze.wordpress.com

When to use Pie Charts in Dashboards ...
excelcampus.com

Using data visualizations' bad guy: pie ...
martinraffeiner.blog

Understanding Pie Charts
eagereyes.org

Pie charts: the bad, the worst an...
visuanalyze.wordpress.com

Remake: Pie-in-a-Donut Chart - Policy Viz
policyviz.com

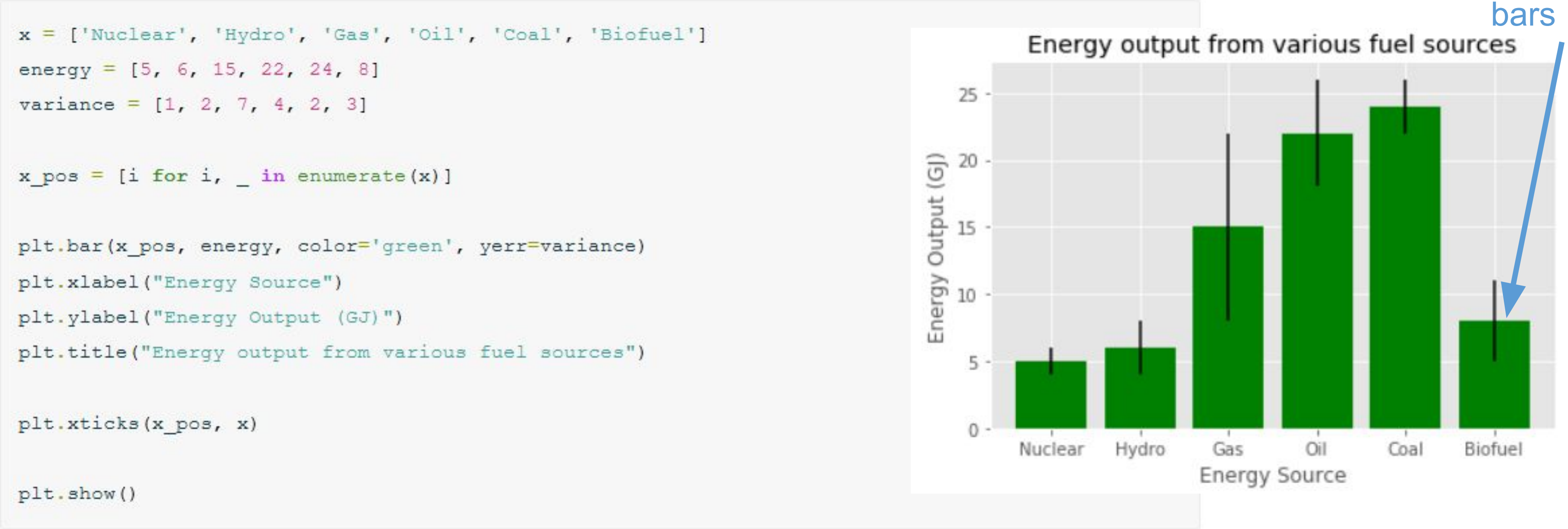
Pin on Chartjunk Data Visualization
pinterest.com

Pie Charts Are The Worst - Business Insider
businessinsider.com

Bar Chart

We perceive differences in height / length better than area…

`plt.bar()`



```
x = ['Nuclear', 'Hydro', 'Gas', 'Oil', 'Coal', 'Biofuel']
energy = [5, 6, 15, 22, 24, 8]
variance = [1, 2, 7, 4, 2, 3]

x_pos = [i for i, _ in enumerate(x)]

plt.bar(x_pos, energy, color='green', yerr=variance)
plt.xlabel("Energy Source")
plt.ylabel("Energy Output (GJ)")
plt.title("Energy output from various fuel sources")

plt.xticks(x_pos, x)

plt.show()
```

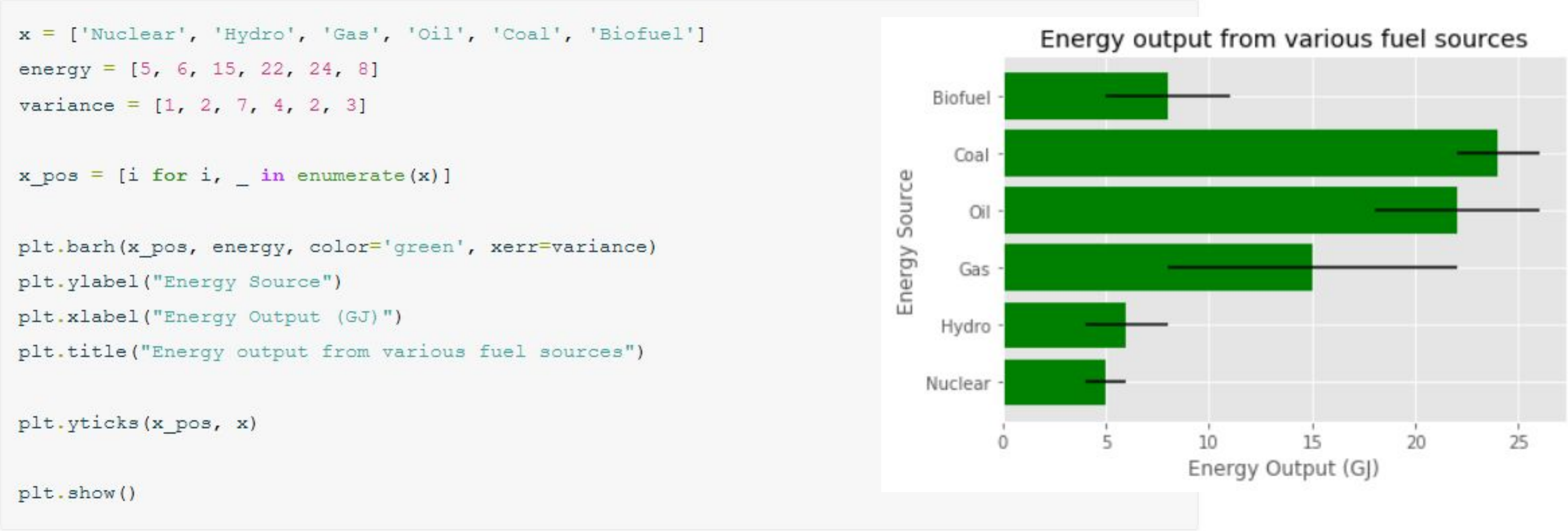
error bars

[Source: https://benalexkeen.com/bar-charts-in-matplotlib/]

Bar Chart

Horizontal version.

`plt.barh()`

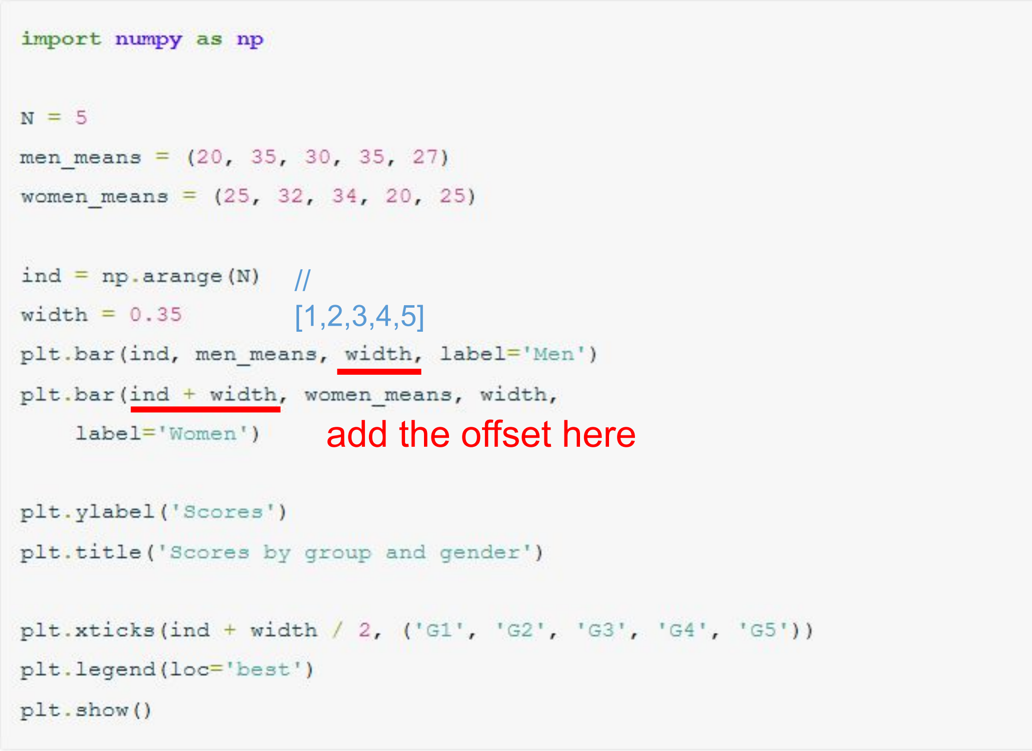


```
x = ['Nuclear', 'Hydro', 'Gas', 'Oil', 'Coal', 'Biofuel']
energy = [5, 6, 15, 22, 24, 8]
variance = [1, 2, 7, 4, 2, 3]

x_pos = [i for i, _ in enumerate(x)]

plt.barh(x_pos, energy, color='green', xerr=variance)
plt.ylabel("Energy Source")
plt.xlabel("Energy Output (GJ)")
plt.title("Energy output from various fuel sources")

plt.yticks(x_pos, x)

plt.show()
```

[Source: https://benalexkeen.com/bar-charts-in-matplotlib/]

Bar Chart

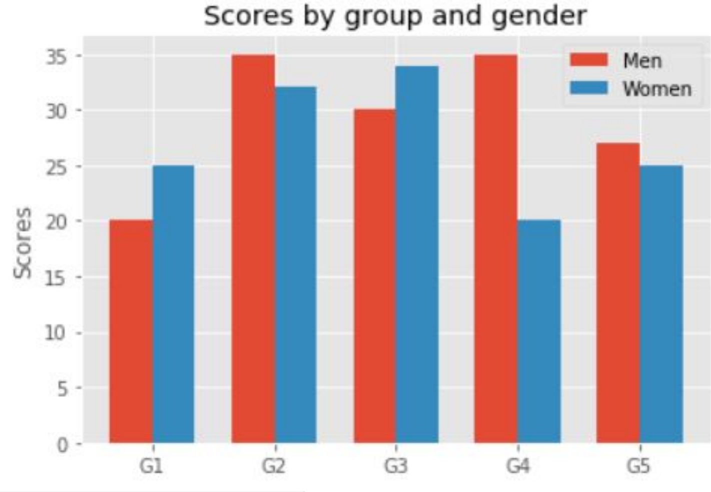
Multiple groups of bars…



```
import numpy as np

N = 5
men_means = (20, 35, 30, 35, 27)
women_means = (25, 32, 34, 20, 25)

ind = np.arange(N)
width = 0.35
plt.bar(ind, men_means, width, label='Men')
plt.bar(ind + width, women_means, width,
    label='Women')

plt.ylabel('Scores')
plt.title('Scores by group and gender')

plt.xticks(ind + width / 2, ('G1', 'G2', 'G3', 'G4', 'G5'))
plt.legend(loc='best')
plt.show()
```

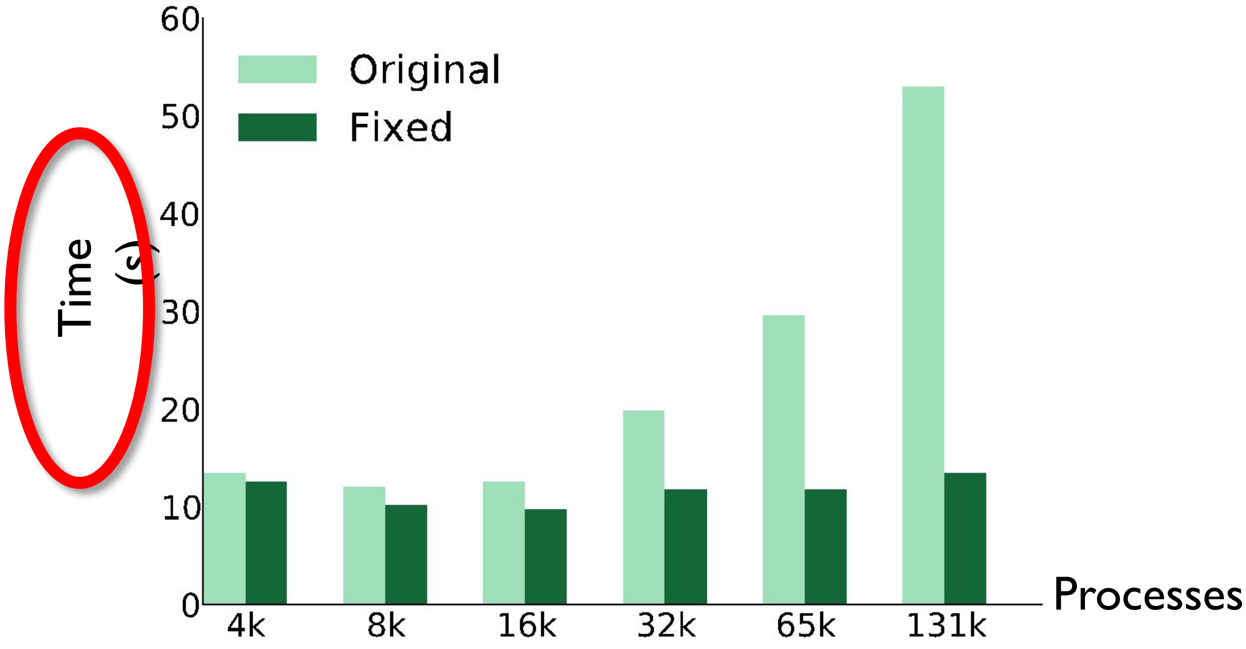
// [1,2,3,4,5]

add the offset here



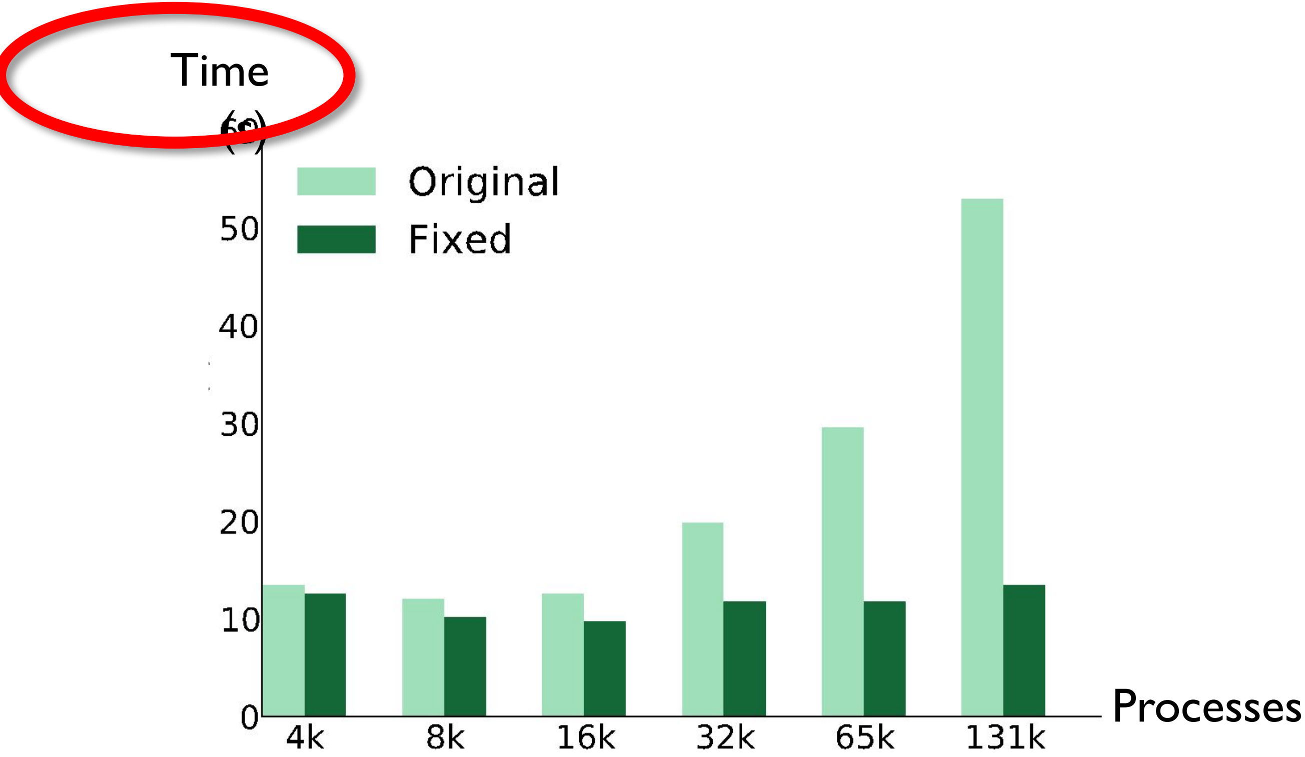
[Source: https://benalexkeen.com/bar-charts-in-matplotlib/]

Labels on the y-axis need not be vertical



[Source: Kate Isaacs]

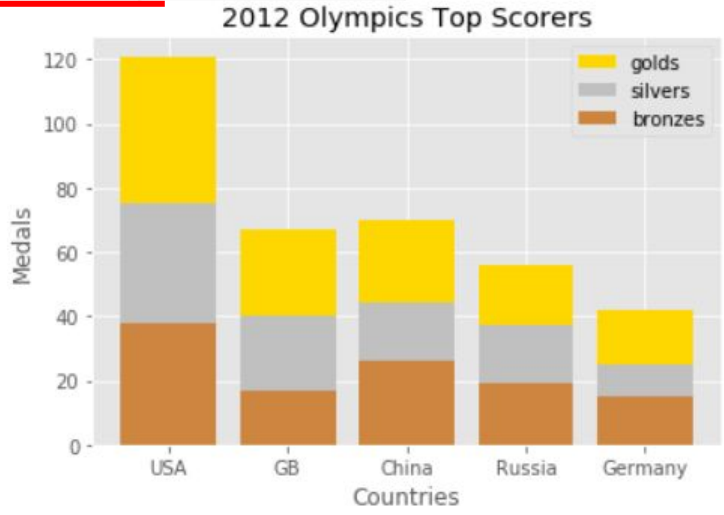
Labels on the y-axis need not be vertical



[Source: Kate Isaacs]

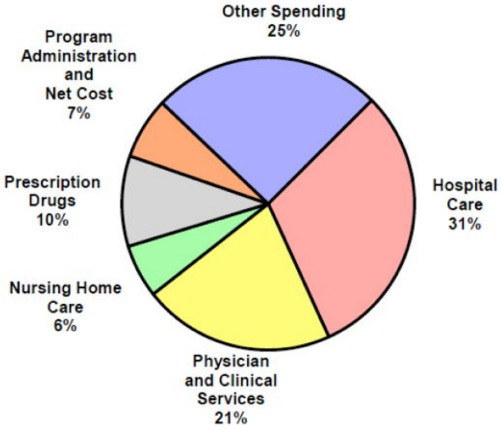
Stacked Bar Chart

```
countries = ['USA', 'GB', 'China', 'Russia', 'Germany']
bronzes = np.array([38, 17, 26, 19, 15])
silvers = np.array([37, 23, 18, 18, 10])
golds = np.array([46, 27, 26, 19, 17])
ind = [x for x, _ in enumerate(countries)]

plt.bar(ind, golds, width=0.8, label='golds', color='gold', bottom=silvers+bronzes)
plt.bar(ind, silvers, width=0.8, label='silvers', color='silver', bottom=bronzes)
plt.bar(ind, bronzes, width=0.8, label='bronzes', color='#CD853F')

plt.xticks(ind, countries)
plt.ylabel("Medals")
plt.xlabel("Countries")
plt.legend(loc="upper right")
plt.title("2012 Olympics Top Scorers")

plt.show()
```

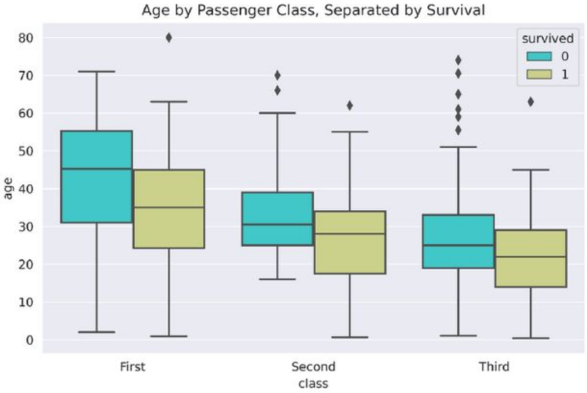


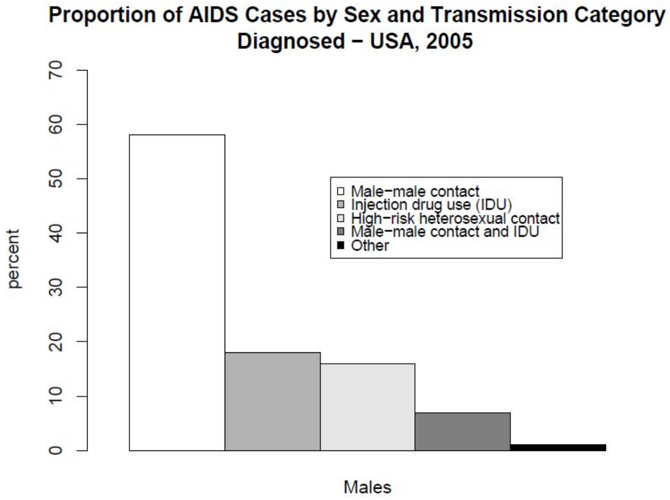
[Source: https://benalexkeen.com/bar-charts-in-matplotlib/]

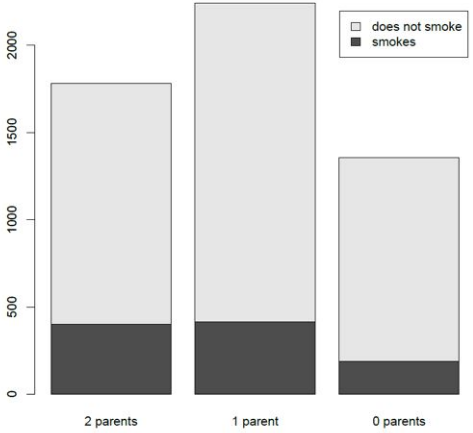
Visualizing Categorical Variables



	student smokes	student does not smoke	total
2 parents smoke	400	1380	1780
1 parent smokes	416	1823	2239
0 parents smoke	188	1168	1356
total	1004	4371	5375



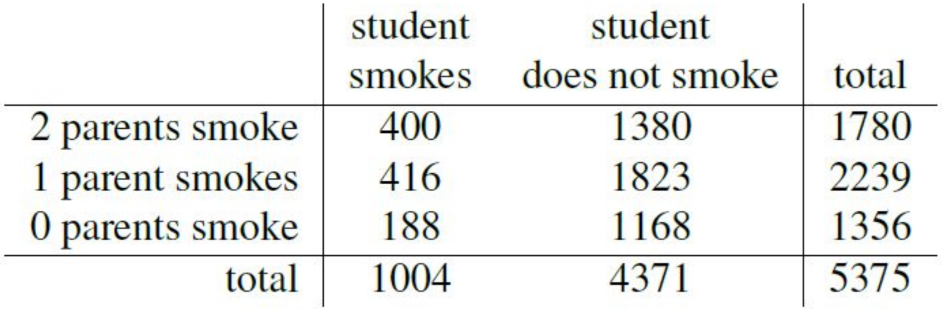




Two-Way Table

Also called contingency table or cross tabulation table…

Frequency

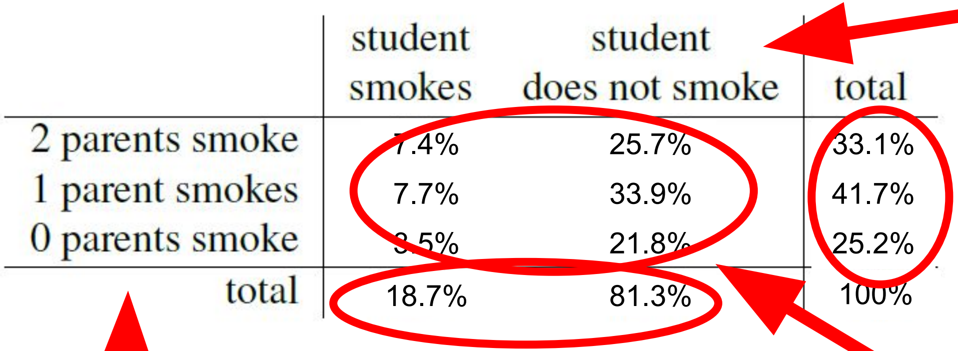


	student smokes	student does not smoke	total
2 parents smoke	400	1380	1780
1 parent smokes	416	1823	2239
0 parents smoke	188	1168	1356
total	1004	4371	5375

Two-Way Table

Also called <u>contingency table</u> or <u>cross tabulation table</u>…

Relative Frequency



	student smokes	student does not smoke	total
2 parents smoke	7.4%	25.7%	33.1%
1 parent smokes	7.7%	33.9%	41.7%
0 parents smoke	3.5%	21.8%	25.2%
total	18.7%	81.3%	100%

Column Variable

Marginal Distribution Of Row Variable

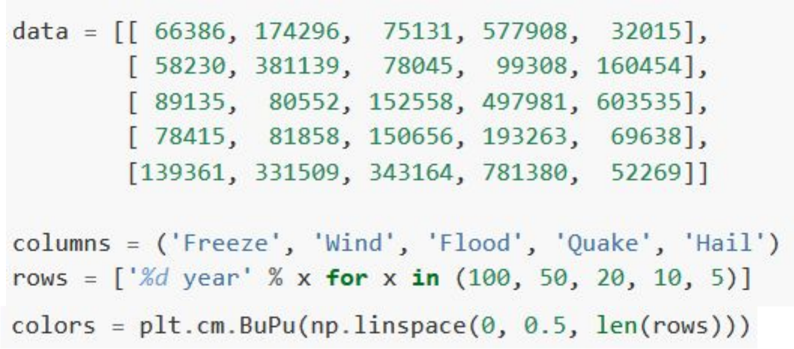
Row Variable

Marginal Distribution Of Column Variable

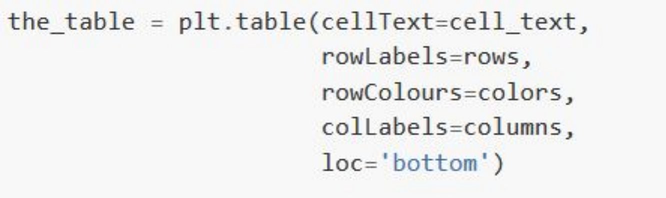
Joint Distribution

Q: how do you compute the conditional probability P(student smokes | 2 parents smoke)?

Two-Way Table

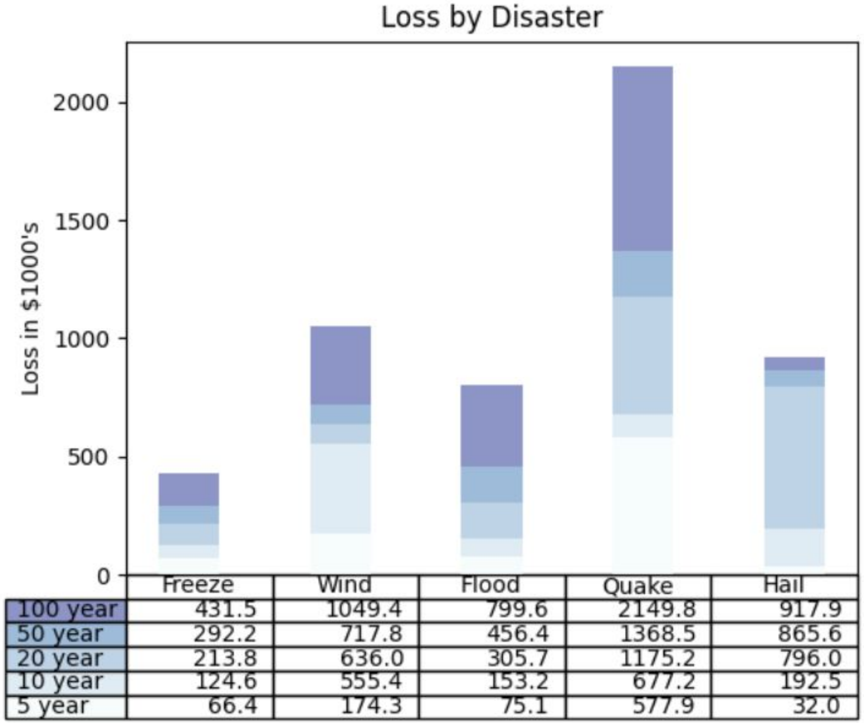


```
data = [[ 66386, 174296,  75131, 577908,  32015],
        [ 58230, 381139,  78045,  99308, 160454],
        [ 89135,  80552, 152558, 497981, 603535],
        [ 78415,  81858, 150656, 193263,  69638],
        [139361, 331509, 343164, 781380,  52269]]

columns = ('Freeze', 'Wind', 'Flood', 'Quake', 'Hail')
rows = ['%d year' % x for x in (100, 50, 20, 10, 5)]
colors = plt.cm.BuPu(np.linspace(0, 0.5, len(rows)))
```



```
the_table = plt.table(cellText=cell_text,
                      rowLabels=rows,
                      rowColours=colors,
                      colLabels=columns,
                      loc='bottom')
```

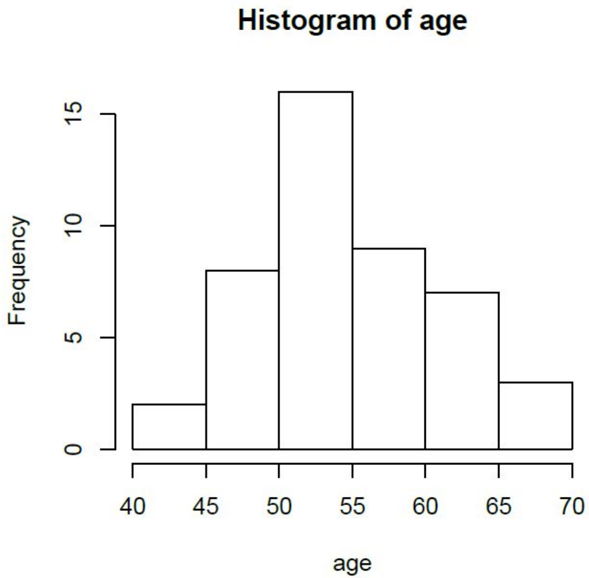
Adding stacked bars requires more steps, full code here: [*https://matplotlib.org/stable/gallery/misc/table_demo.html*](https://matplotlib.org/stable/gallery/misc/table_demo.html)



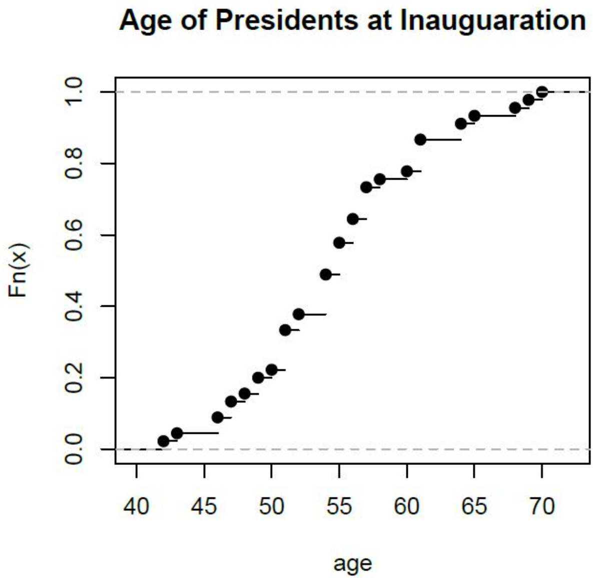
	Freeze	Wind	Flood	Quake	Hail
100 year	431.5	1049.4	799.6	2149.8	917.9
50 year	292.2	717.8	456.4	1368.5	865.6
20 year	213.8	636.0	305.7	1175.2	796.0
10 year	124.6	555.4	153.2	677.2	192.5
5 year	66.4	174.3	75.1	577.9	32.0

Histogram

Empirical approximation of (quantitative) data generating distribution



Histogram of age



Age of Presidents at Inauguaration

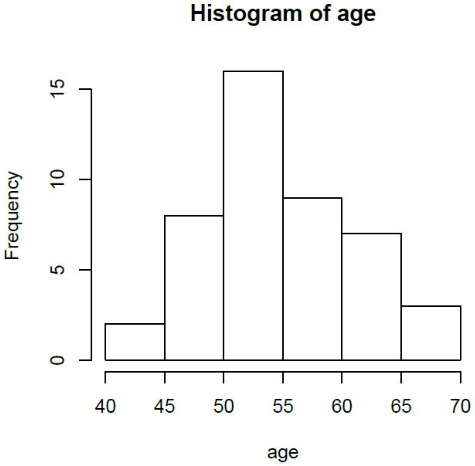
Empriical Cumulative Distribution Function

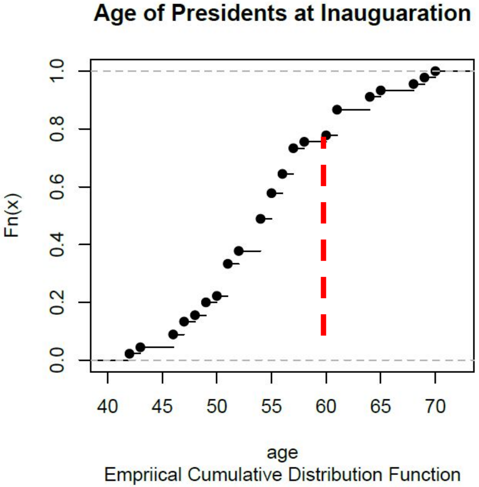
Empirical CDF for each x gives P(X<x),

$$F_n(x) = \frac{1}{n}\#(\text{observations less than or equal to x})$$

Quantile / Percentile

Question Is 60yrs old for a US president? Why or why not?





Empirical CDF for each x gives P(X<x),

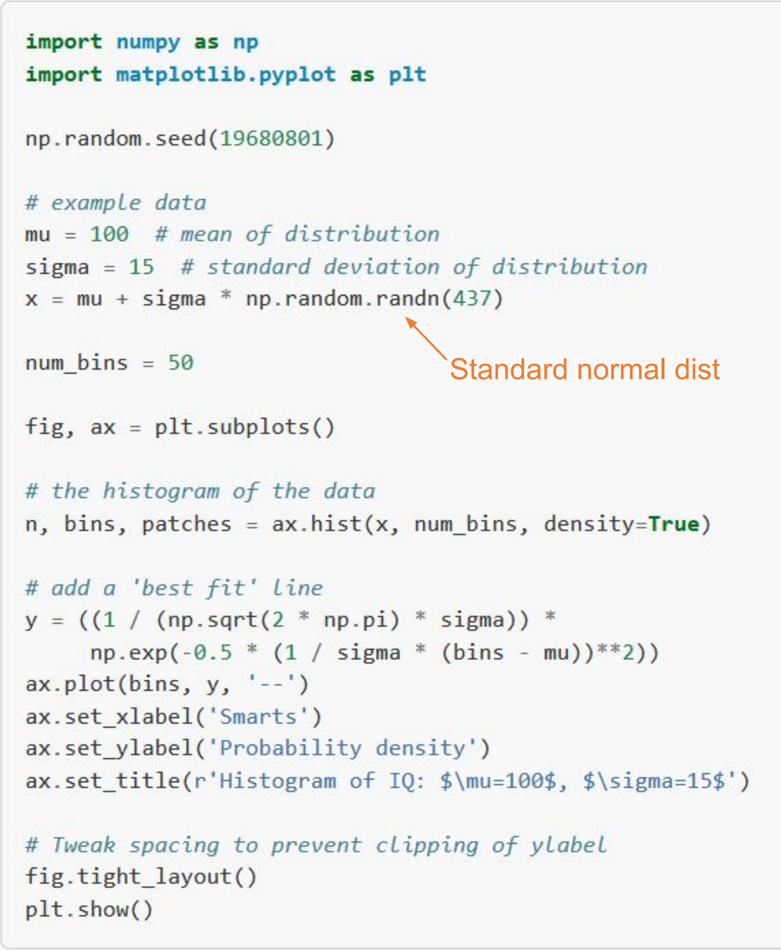
$$F_n(x) = \frac{1}{n} \#(\text{observations less than or equal to x})$$

Compute probability of being <60,

$$F_n(60) \approx 0.8$$

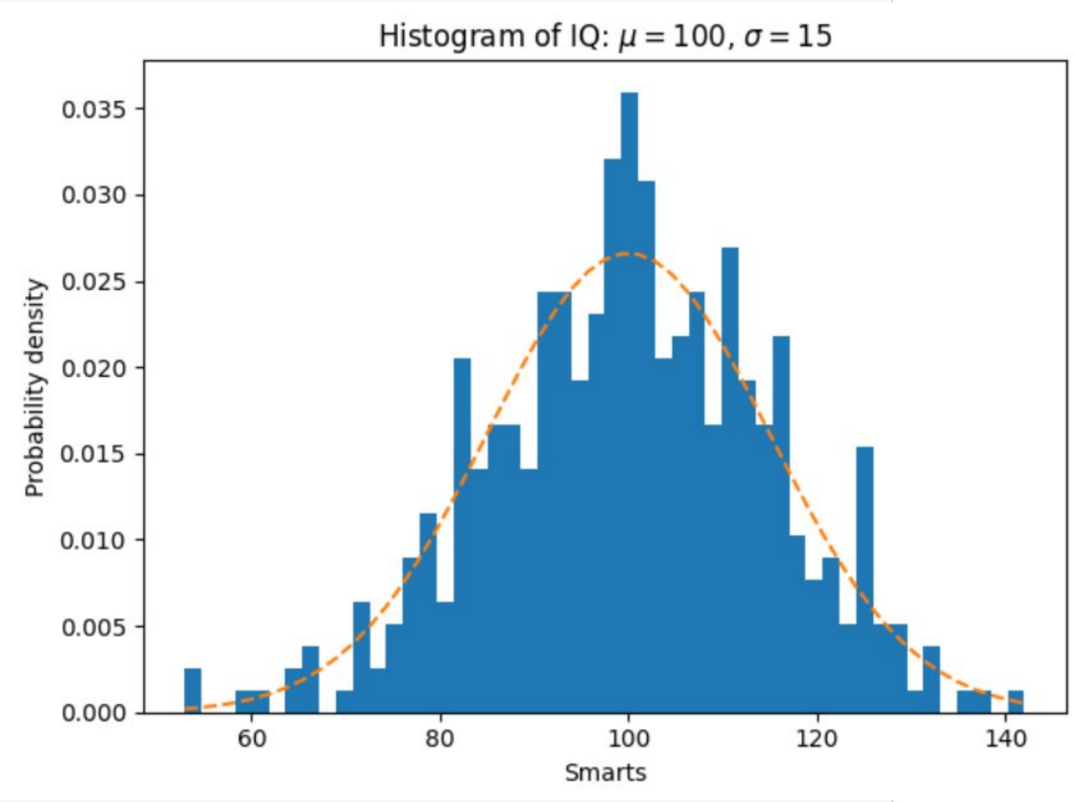
0.8 Quantile or 80th Percentile → About 80% of presidents younger than 60

Histogram



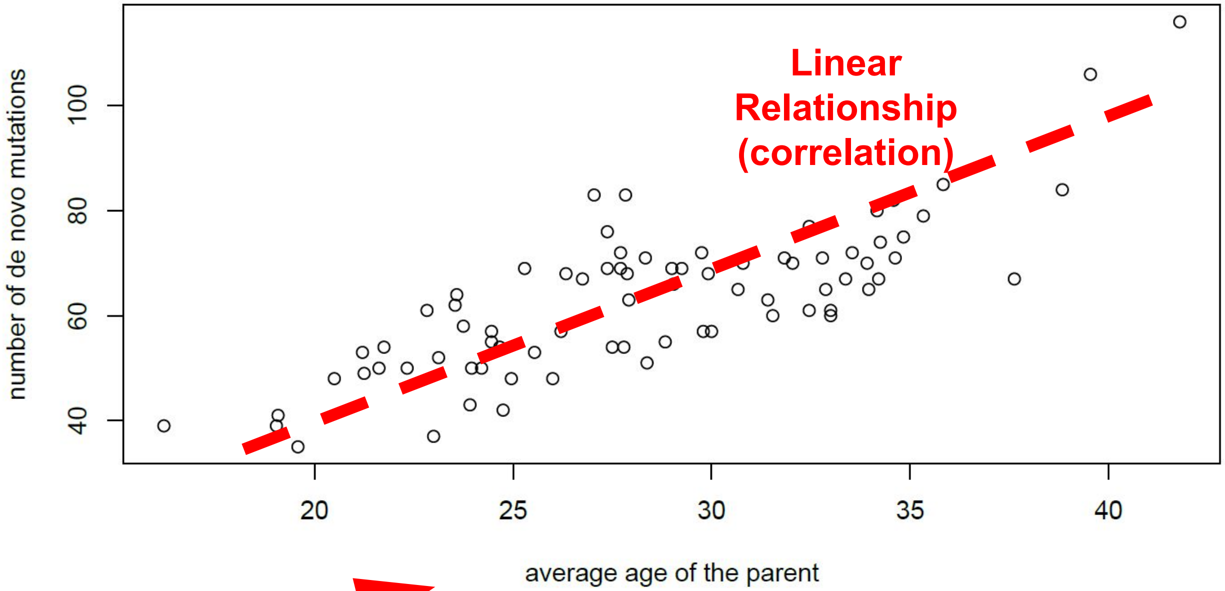
```
import numpy as np
import matplotlib.pyplot as plt

np.random.seed(19680801)

# example data
mu = 100  # mean of distribution
sigma = 15  # standard deviation of distribution
x = mu + sigma * np.random.randn(437)

num_bins = 50

fig, ax = plt.subplots()

# the histogram of the data
n, bins, patches = ax.hist(x, num_bins, density=True)

# add a 'best fit' line
y = ((1 / (np.sqrt(2 * np.pi) * sigma)) *
     np.exp(-0.5 * (1 / sigma * (bins - mu))**2))
ax.plot(bins, y, '--')
ax.set_xlabel('Smarts')
ax.set_ylabel('Probability density')
ax.set_title(r'Histogram of IQ: $\mu=100$, $\sigma=15$')

# Tweak spacing to prevent clipping of ylabel
fig.tight_layout()
plt.show()
```

Standard normal dist



Scatterplot

Compares relationship between two quantitative variables…



Linear Relationship (correlation)

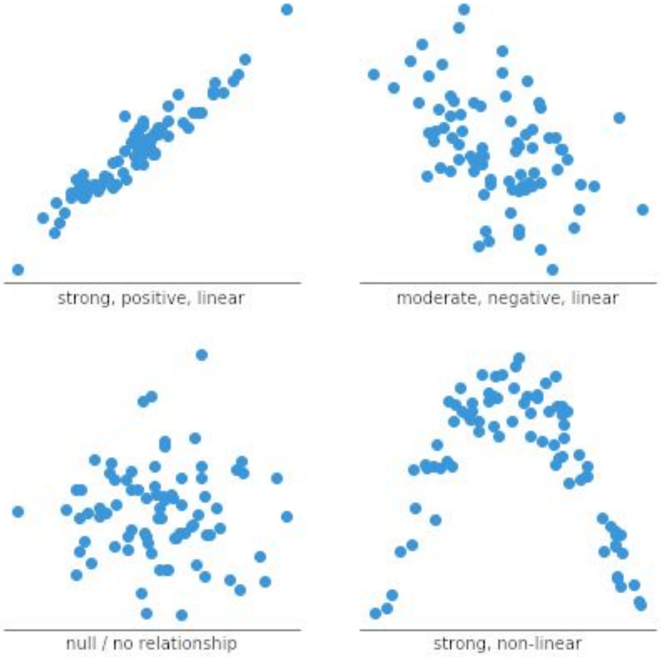
Target (or response) Variable

Explanatory Variable

Also: predictor, descriptor, input

Scatterplot

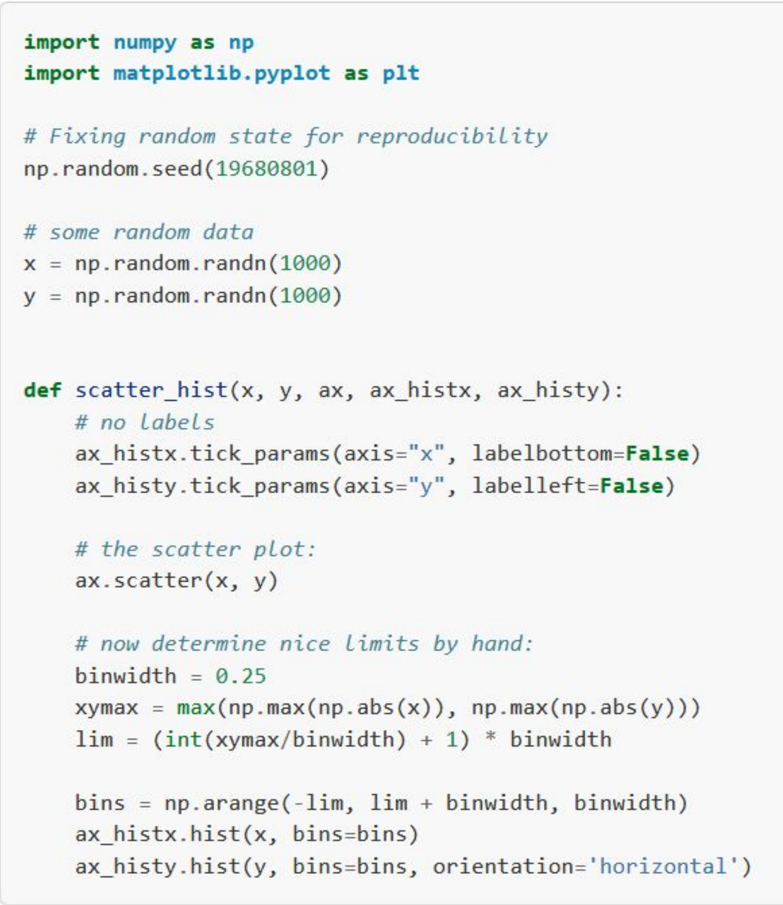
Compares relationship between two quantitative variables…



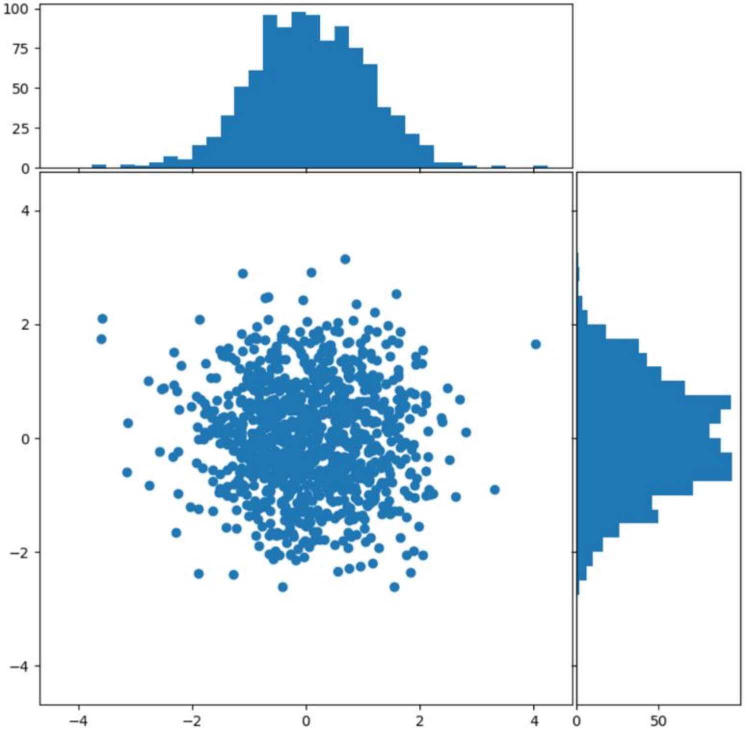
Relationship can also be:

- Nonlinear (e.g. “curvy”)
- Clustered or grouped

Scatterplot + Histogram



```
import numpy as np
import matplotlib.pyplot as plt

# Fixing random state for reproducibility
np.random.seed(19680801)

# some random data
x = np.random.randn(1000)
y = np.random.randn(1000)


def scatter_hist(x, y, ax, ax_histx, ax_histy):
    # no labels
    ax_histx.tick_params(axis="x", labelbottom=False)
    ax_histy.tick_params(axis="y", labelleft=False)

    # the scatter plot:
    ax.scatter(x, y)

    # now determine nice limits by hand:
    binwidth = 0.25
    xymax = max(np.max(np.abs(x)), np.max(np.abs(y)))
    lim = (int(xymax/binwidth) + 1) * binwidth

    bins = np.arange(-lim, lim + binwidth, binwidth)
    ax_histx.hist(x, bins=bins)
    ax_histy.hist(y, bins=bins, orientation='horizontal')
```



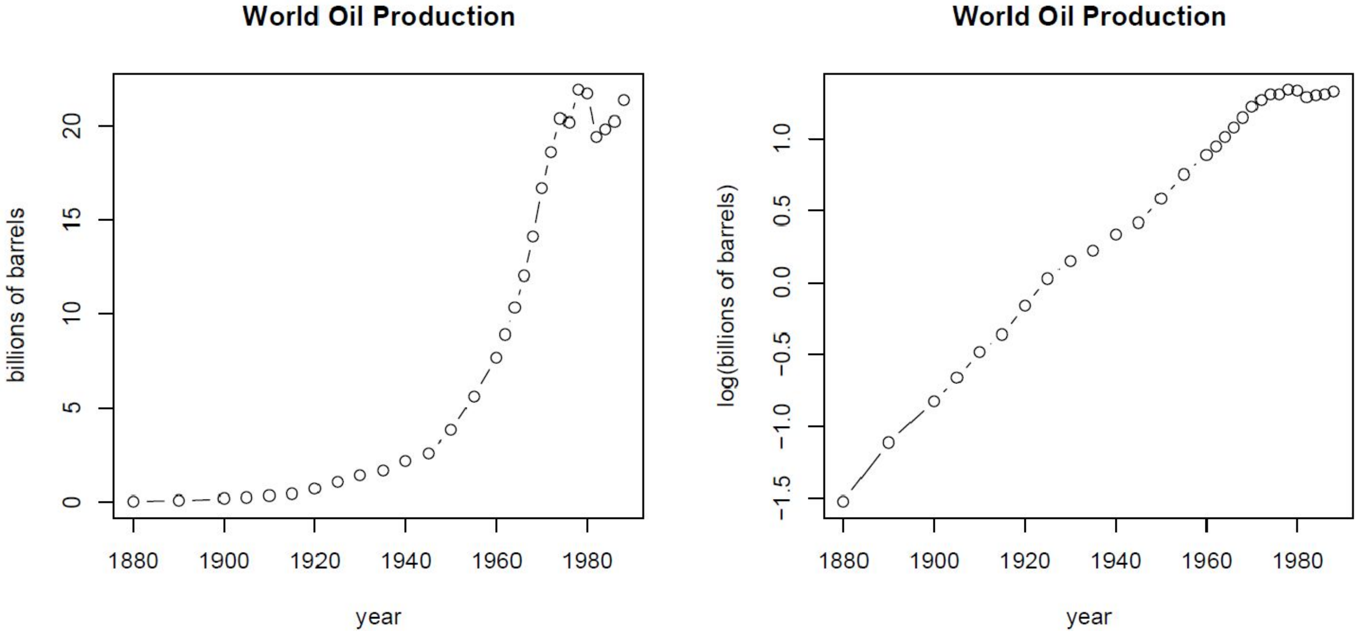
Full Code:
https://matplotlib.org/stable/gallery/lines_bars_and_markers/scatter_hist.html

Logarithm Scale

Changing limits and base of y-scale highlights different aspects…

if y = e^x, then log(y) = x
if y = b^x, then log(y) = log(b)*x

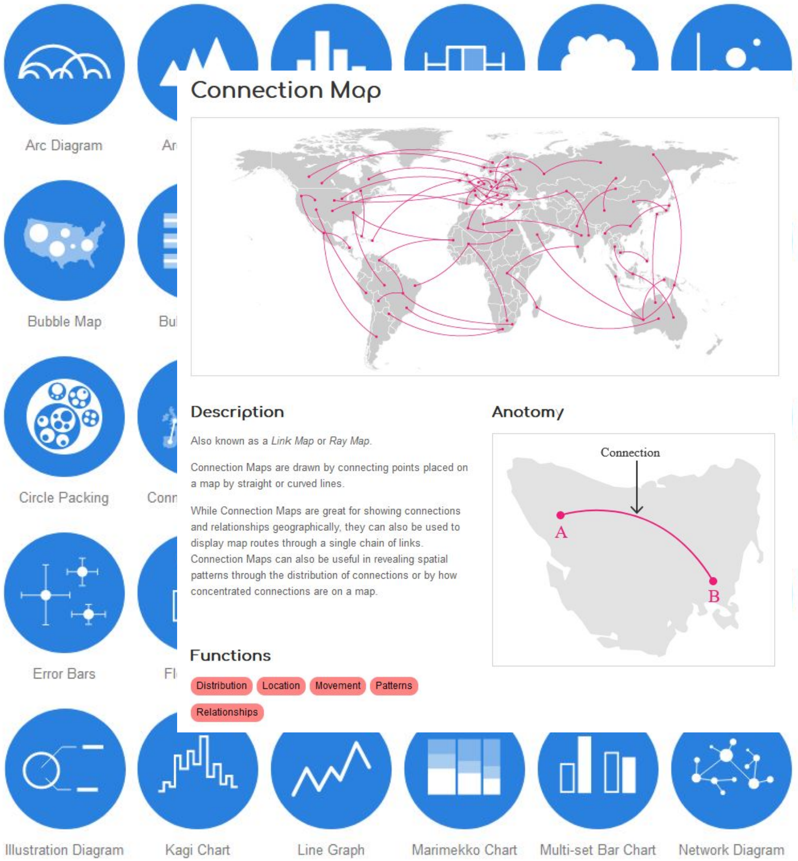
=> becomes linear in x



…log-scale emphasizes relative changes in smaller quantities

More Visualization Resources

datavizcatalogue.com



Connection Map

Description

Also known as a *Link Map* or *Ray Map*.

Connection Maps are drawn by connecting points placed on a map by straight or curved lines.

While Connection Maps are great for showing connections and relationships geographically, they can also be used to display map routes through a single chain of links. Connection Maps can also be useful in revealing spatial patterns through the distribution of connections or by how concentrated connections are on a map.

Anotomy

Functions

matplotlib.org

scikit-learn.org