Introducing DataFrames

DATA MANIPULATION WITH PANDAS

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What's the point of pandas?

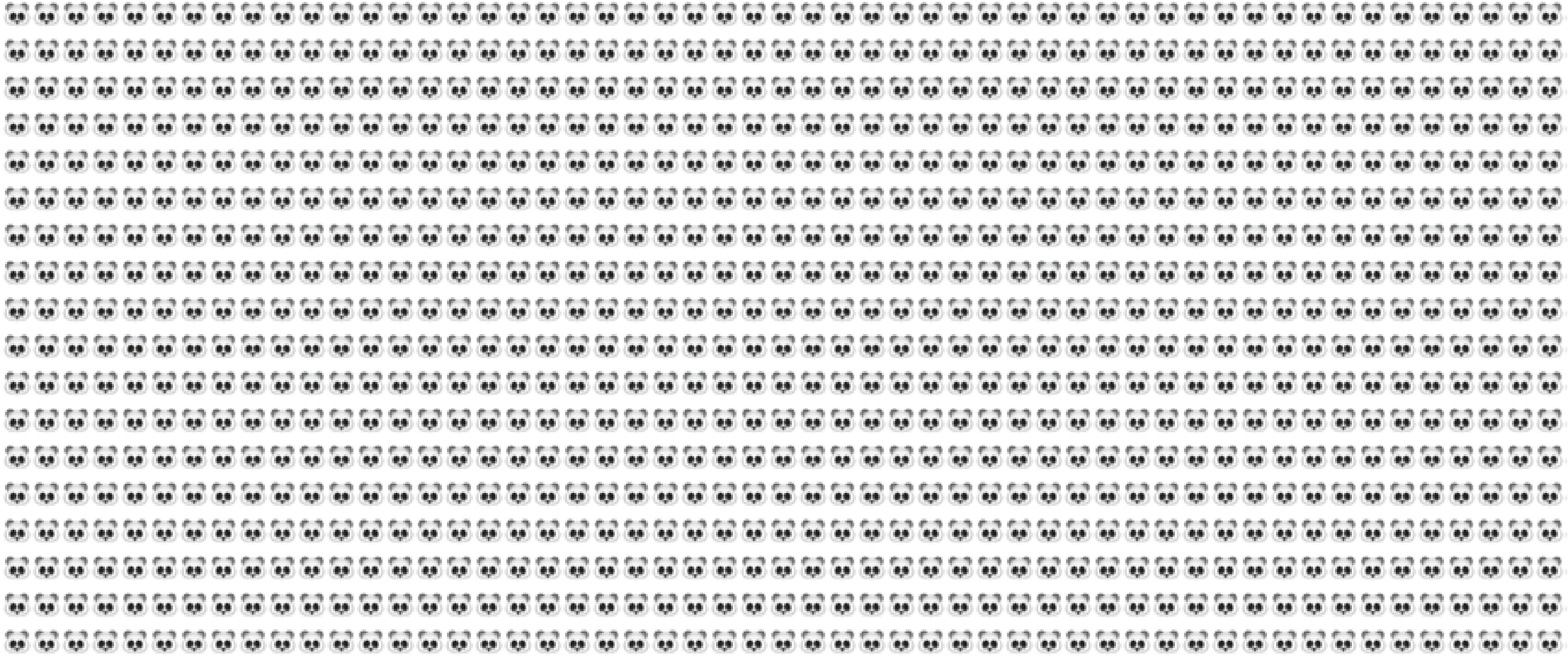
- Data Manipulation skill track
- Data Visualization skill track

Course outline

- **Chapter 1: DataFrames**
  - Sorting and subsetting
  - Creating new columns
- **Chapter 2: Aggregating Data**
  - Summary statistics
  - Counting
  - Grouped summary statistics
- **Chapter 3: Slicing and Indexing Data**
  - Subsetting using slicing
  - Indexes and subsetting using indexes
- **Chapter 4: Creating and Visualizing Data**
  - Plotting
  - Handling missing data
  - Reading data into a DataFrame

pandas is built on NumPy and Matplotlib

pandas is popular



[1] https://pypistats.org/packages/pandas

Rectangular data

Name	Breed	Color	Height (cm)	Weight (kg)	Date of Birth
Bella	Labrador	Brown	56	25	2013-07-01
Charlie	Poodle	Black	43	23	2016-09-16
Lucy	Chow Chow	Brown	46	22	2014-08-25
Cooper	Schnauzer	Gray	49	17	2011-12-11
Max	Labrador	Black	59	29	2017-01-20
Stella	Chihuahua	Tan	18	2	2015-04-20
Bernie	St. Bernard	White	77	74	2018-02-27

pandas DataFrames

```
print(dogs)
```

```
      name          breed  color  height_cm  weight_kg date_of_birth
0    Bella       Labrador  Brown         56         24    2013-07-01
1  Charlie         Poodle  Black         43         24    2016-09-16
2     Lucy      Chow Chow  Brown         46         24    2014-08-25
3   Cooper      Schnauzer   Gray         49         17    2011-12-11
4      Max       Labrador  Black         59         29    2017-01-20
5   Stella      Chihuahua    Tan         18          2    2015-04-20
6   Bernie  St. Bernard  White         77         74    2018-02-27
```

Exploring a DataFrame: .head()

```
dogs.head()
```

```
      name          breed  color  height_cm  weight_kg date_of_birth
0    Bella       Labrador  Brown         56         24    2013-07-01
1  Charlie         Poodle  Black         43         24    2016-09-16
2     Lucy      Chow Chow  Brown         46         24    2014-08-25
3   Cooper      Schnauzer   Gray         49         17    2011-12-11
4      Max       Labrador  Black         59         29    2017-01-20
```

Exploring a DataFrame: .info()

```
dogs.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7 entries, 0 to 6
Data columns (total 6 columns):
 #   Column         Non-Null Count  Dtype
 --  ------         --------------  -----
 0   name           7 non-null      object
 1   breed          7 non-null      object
 2   color          7 non-null      object
 3   height_cm      7 non-null      int64
 4   weight_kg      7 non-null      int64
 5   date_of_birth  7 non-null      object
dtypes: int64(2), object(4)
memory usage: 464.0+ bytes
```

Exploring a DataFrame: .shape

```
dogs.shape
```

```
(7, 6)
```

Exploring a DataFrame: .describe()

```
dogs.describe()
```

```
       height_cm  weight_kg
count   7.000000   7.000000
mean   49.714286  27.428571
std    17.960274  22.292429
min    18.000000   2.000000
25%    44.500000  19.500000
50%    49.000000  23.000000
75%    57.500000  27.000000
max    77.000000  74.000000
```

Components of a DataFrame: .values

```
dogs.values
```

```
array([['Bella', 'Labrador', 'Brown', 56, 24, '2013-07-01'],
       ['Charlie', 'Poodle', 'Black', 43, 24, '2016-09-16'],
       ['Lucy', 'Chow Chow', 'Brown', 46, 24, '2014-08-25'],
       ['Cooper', 'Schnauzer', 'Gray', 49, 17, '2011-12-11'],
       ['Max', 'Labrador', 'Black', 59, 29, '2017-01-20'],
       ['Stella', 'Chihuahua', 'Tan', 18, 2, '2015-04-20'],
       ['Bernie', 'St. Bernard', 'White', 77, 74, '2018-02-27']],
      dtype=object)
```

Components of a DataFrame: .columns and .index

```
dogs.columns
```

```
Index(['name', 'breed', 'color', 'height_cm', 'weight_kg', 'date_of_birth'],
dtype='object')
```

```
dogs.index
```

```
RangeIndex(start=0, stop=7, step=1)
```

pandas Philosophy

> There should be one -- and preferably only one -- obvious way to do it.

- *The Zen of Python* by Tim Peters, Item 13

[1] https://www.python.org/dev/peps/pep-0020/

Let's practice!

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Sorting and subsetting

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Sorting

```
dogs.sort_values("weight_kg")
```

	name	breed	color	height_cm	weight_kg	date_of_birth
5	Stella	Chihuahua	Tan	18	2	2015-04-20
3	Cooper	Schnauzer	Gray	49	17	2011-12-11
0	Bella	Labrador	Brown	56	24	2013-07-01
1	Charlie	Poodle	Black	43	24	2016-09-16
2	Lucy	Chow Chow	Brown	46	24	2014-08-25
4	Max	Labrador	Black	59	29	2017-01-20
6	Bernie	St. Bernard	White	77	74	2018-02-27

Sorting in descending order

```
dogs.sort_values("weight_kg", ascending=False)
```

	name	breed	color	height_cm	weight_kg	date_of_birth
6	Bernie	St. Bernard	White	77	74	2018-02-27
4	Max	Labrador	Black	59	29	2017-01-20
0	Bella	Labrador	Brown	56	24	2013-07-01
1	Charlie	Poodle	Black	43	24	2016-09-16
2	Lucy	Chow Chow	Brown	46	24	2014-08-25
3	Cooper	Schnauzer	Gray	49	17	2011-12-11
5	Stella	Chihuahua	Tan	18	2	2015-04-20

Sorting by multiple variables

```
dogs.sort_values(["weight_kg", "height_cm"])
```

	name	breed	color	height_cm	weight_kg	date_of_birth
5	Stella	Chihuahua	Tan	18	2	2015-04-20
3	Cooper	Schnauzer	Gray	49	17	2011-12-11
1	Charlie	Poodle	Black	43	24	2016-09-16
2	Lucy	Chow Chow	Brown	46	24	2014-08-25
0	Bella	Labrador	Brown	56	24	2013-07-01
4	Max	Labrador	Black	59	29	2017-01-20
6	Bernie	St. Bernard	White	77	74	2018-02-27

Sorting by multiple variables

```
dogs.sort_values(["weight_kg", "height_cm"], ascending=[True, False])
```

	name	breed	color	height_cm	weight_kg	date_of_birth
5	Stella	Chihuahua	Tan	18	2	2015-04-20
3	Cooper	Schnauzer	Gray	49	17	2011-12-11
0	Bella	Labrador	Brown	56	24	2013-07-01
2	Lucy	Chow Chow	Brown	46	24	2014-08-25
1	Charlie	Poodle	Black	43	24	2016-09-16
4	Max	Labrador	Black	59	29	2017-01-20
6	Bernie	St. Bernard	White	77	74	2018-02-27

Subsetting columns

```
dogs["name"]
```

```
0      Bella
1    Charlie
2       Lucy
3     Cooper
4        Max
5     Stella
6     Bernie
Name: name, dtype: object
```

Subsetting multiple columns

```
dogs[["breed", "height_cm"]]
```

```
          breed  height_cm
0      Labrador         56
1        Poodle         43
2     Chow Chow         46
3     Schnauzer         49
4      Labrador         59
5     Chihuahua         18
6  St. Bernard         77
```

```
cols_to_subset = ["breed", "height_cm"]
dogs[cols_to_subset]
```

```
          breed  height_cm
0      Labrador         56
1        Poodle         43
2     Chow Chow         46
3     Schnauzer         49
4      Labrador         59
5     Chihuahua         18
6  St. Bernard         77
```

Subsetting rows

```
dogs["height_cm"] > 50
```

```
0     True
1    False
2    False
3    False
4     True
5    False
6     True
Name: height_cm, dtype: bool
```

Subsetting rows

```
dogs[dogs["height_cm"] > 50]
```

```
     name         breed  color  height_cm  weight_kg date_of_birth
0   Bella      Labrador  Brown         56         24    2013-07-01
4     Max      Labrador  Black         59         29    2017-01-20
6  Bernie  St. Bernard  White         77         74    2018-02-27
```

Subsetting based on text data

```
dogs[dogs["breed"] == "Labrador"]
```

```
    name        breed  color  height_cm  weight_kg date_of_birth
0   Bella     Labrador  Brown         56         24    2013-07-01
4     Max     Labrador  Black         59         29    2017-01-20
```

Subsetting based on dates

```
dogs[dogs["date_of_birth"] < "2015-01-01"]
```

```
     name       breed  color  height_cm  weight_kg date_of_birth
0   Bella    Labrador  Brown         56         24    2013-07-01
2    Lucy  Chow Chow  Brown         46         24    2014-08-25
3  Cooper  Schnauzer   Gray         49         17    2011-12-11
```

Subsetting based on multiple conditions

```
is_lab = dogs["breed"] == "Labrador"
is_brown = dogs["color"] == "Brown"
dogs[is_lab & is_brown]
```

```
     name         breed  color  height_cm  weight_kg date_of_birth
0   Bella      Labrador  Brown         56         24    2013-07-01
```

```
dogs[ (dogs["breed"] == "Labrador") & (dogs["color"] == "Brown") ]
```

Subsetting using .isin()

```
is_black_or_brown = dogs["color"].isin(["Black", "Brown"])
dogs[is_black_or_brown]
```

	name	breed	color	height_cm	weight_kg	date_of_birth
0	Bella	Labrador	Brown	56	24	2013-07-01
1	Charlie	Poodle	Black	43	24	2016-09-16
2	Lucy	Chow Chow	Brown	46	24	2014-08-25
4	Max	Labrador	Black	59	29	2017-01-20

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New columns

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Adding a new column

```
dogs["height_m"] = dogs["height_cm"] / 100
print(dogs)
```

```
      name         breed  color  height_cm  weight_kg date_of_birth  height_m
0    Bella      Labrador  Brown         56         24    2013-07-01      0.56
1  Charlie        Poodle  Black         43         24    2016-09-16      0.43
2     Lucy     Chow Chow  Brown         46         24    2014-08-25      0.46
3   Cooper     Schnauzer   Gray         49         17    2011-12-11      0.49
4      Max      Labrador  Black         59         29    2017-01-20      0.59
5   Stella     Chihuahua    Tan         18          2    2015-04-20      0.18
6   Bernie  St. Bernard  White         77         74    2018-02-27      0.77
```

Doggy mass index

$$\text{BMI} = \text{weight in kg}/(\text{height in m})^2$$

```
dogs["bmi"] = dogs["weight_kg"] / dogs["height_m"] ** 2
print(dogs.head())
```

```
      name      breed  color  height_cm  weight_kg date_of_birth  height_m         bmi
0    Bella   Labrador  Brown         56         24    2013-07-01      0.56   76.530612
1  Charlie     Poodle  Black         43         24    2016-09-16      0.43  129.799892
2     Lucy  Chow Chow  Brown         46         24    2014-08-25      0.46  113.421550
3   Cooper  Schnauzer   Gray         49         17    2011-12-11      0.49   70.803832
4      Max   Labrador  Black         59         29    2017-01-20      0.59   83.309394
```

Multiple manipulations

```
bmi_lt_100 = dogs[dogs["bmi"] < 100]
bmi_lt_100_height  = bmi_lt_100.sort_values("height_cm", ascending=False)
bmi_lt_100_height[["name", "height_cm", "bmi"]]
```

```
     name  height_cm        bmi
4     Max         59  83.309394
0   Bella         56  76.530612
3  Cooper         49  70.803832
5  Stella         18  61.728395
```

Let's practice!

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Summary statistics

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Summarizing numerical data

```
dogs["height_cm"].mean()
```

```
49.714285714285715
```

- `.median()`, `.mode()`
- `.min()`, `.max()`
- `.var()`, `.std()`
- `.sum()`
- `.quantile()`

Summarizing dates

Oldest dog:

```
dogs["date_of_birth"].min()
```

```
'2011-12-11'
```

Youngest dog:

```
dogs["date_of_birth"].max()
```

```
'2018-02-27'
```

The .agg() method

```
def pct30(column):
    return column.quantile(0.3)
```

```
dogs["weight_kg"].agg(pct30)
```

```
22.599999999999998
```

Summaries on multiple columns

```
dogs[["weight_kg", "height_cm"]].agg(pct30)
```

```
weight_kg    22.6
height_cm    45.4
dtype: float64
```

Multiple summaries

```
def pct40(column):
    return column.quantile(0.4)
```

```
dogs["weight_kg"].agg([pct30, pct40])
```

```
pct30    22.6
pct40    24.0
Name: weight_kg, dtype: float64
```

Cumulative sum

```
dogs["weight_kg"]
```

```
0    24
1    24
2    24
3    17
4    29
5    2
6    74
Name: weight_kg, dtype: int64
```

```
dogs["weight_kg"].cumsum()
```

```
0      24
1      48
2      72
3      89
4     118
5     120
6     194
Name: weight_kg, dtype: int64
```

Cumulative statistics

- `.cummax()`
- `.cummin()`
- `.cumprod()`

Walmart

```
sales.head()
```

	store	type	dept	date	weekly_sales	is_holiday	temp_c	fuel_price	unemp
0	1	A	1	2010-02-05	24924.50	False	5.73	0.679	8.106
1	1	A	2	2010-02-05	50605.27	False	5.73	0.679	8.106
2	1	A	3	2010-02-05	13740.12	False	5.73	0.679	8.106
3	1	A	4	2010-02-05	39954.04	False	5.73	0.679	8.106
4	1	A	5	2010-02-05	32229.38	False	5.73	0.679	8.106

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Counting

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Avoiding double counting

Vet visits

```
print(vet_visits)
```

```
          date     name         breed  weight_kg
0   2018-09-02    Bella     Labrador      24.87
1   2019-06-07      Max     Labrador      28.35
2   2018-01-17   Stella    Chihuahua       1.51
3   2019-10-19     Lucy    Chow Chow      24.07
..         ...      ...          ...        ...
71  2018-01-20   Stella    Chihuahua       2.83
72  2019-06-07      Max    Chow Chow      24.01
73  2018-08-20     Lucy    Chow Chow      24.40
74  2019-04-22      Max     Labrador      28.54
```

Dropping duplicate names

```
vet_visits.drop_duplicates(subset="name")
```

```
          date     name         breed  weight_kg
0   2018-09-02    Bella      Labrador      24.87
1   2019-06-07      Max     Chow Chow      24.01
2   2019-03-19  Charlie        Poodle      24.95
3   2018-01-17   Stella     Chihuahua       1.51
4   2019-10-19     Lucy     Chow Chow      24.07
7   2019-03-30   Cooper     Schnauzer      16.91
10  2019-01-04   Bernie  St. Bernard      74.98
(6  2019-06-07      Max      Labrador      28.35)
```

Dropping duplicate pairs

```
unique_dogs = vet_visits.drop_duplicates(subset=["name", "breed"])
print(unique_dogs)
```

```
         date     name         breed  weight_kg
0  2018-09-02    Bella     Labrador      24.87
1  2019-03-13      Max    Chow Chow      24.13
2  2019-03-19  Charlie       Poodle      24.95
3  2018-01-17   Stella    Chihuahua       1.51
4  2019-10-19     Lucy    Chow Chow      24.07
6  2019-06-07      Max     Labrador      28.35
7  2019-03-30   Cooper    Schnauzer      16.91
10 2019-01-04   Bernie  St. Bernard      74.98
```

Easy as 1, 2, 3

```
unique_dogs["breed"].value_counts()
```

```
Labrador       2
Schnauzer      1
St. Bernard    1
Chow Chow      2
Poodle         1
Chihuahua      1
Name: breed, dtype: int64
```

```
unique_dogs["breed"].value_counts(sort=True)
```

```
Labrador       2
Chow Chow      2
Schnauzer      1
St. Bernard    1
Poodle         1
Chihuahua      1
Name: breed, dtype: int64
```

Proportions

```
unique_dogs["breed"].value_counts(normalize=True)
```

```
Labrador        0.250
Chow Chow       0.250
Schnauzer       0.125
St. Bernard     0.125
Poodle          0.125
Chihuahua       0.125
Name: breed, dtype: float64
```

Let's practice!

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Grouped summary statistics

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Summaries by group

```
dogs[dogs["color"] == "Black"]["weight_kg"].mean()
dogs[dogs["color"] == "Brown"]["weight_kg"].mean()
dogs[dogs["color"] == "White"]["weight_kg"].mean()
dogs[dogs["color"] == "Gray"]["weight_kg"].mean()
dogs[dogs["color"] == "Tan"]["weight_kg"].mean()
```

```
26.0
24.0
74.0
17.0
2.0
```

Grouped summaries

```
dogs.groupby("color")["weight_kg"].mean()
```

```
color
Black    26.5
Brown    24.0
Gray     17.0
Tan       2.0
White    74.0
Name: weight_kg, dtype: float64
```

Multiple grouped summaries

```
dogs.groupby("color")["weight_kg"].agg([min, max, sum])
```

```
       min  max  sum
color
Black   24   29   53
Brown   24   24   48
Gray    17   17   17
Tan      2    2    2
White   74   74   74
```

Grouping by multiple variables

```
dogs.groupby(["color", "breed"])["weight_kg"].mean()
```

```
color  breed
Black  Chow Chow      25
       Labrador       29
       Poodle         24
Brown  Chow Chow      24
       Labrador       24
Gray   Schnauzer      17
Tan    Chihuahua       2
White  St. Bernard    74
Name: weight_kg, dtype: int64
```

Many groups, many summaries

```
dogs.groupby(["color", "breed"])[["weight_kg", "height_cm"]].mean()
```

```
                 weight_kg  height_cm
color breed
Black Labrador          29         59
      Poodle            24         43
Brown Chow Chow         24         46
      Labrador          24         56
Gray  Schnauzer         17         49
Tan   Chihuahua         2          18
White St. Bernard       74         77
```

Let's practice!

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Pivot tables

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Group by to pivot table

```
dogs.groupby("color")["weight_kg"].mean()
```

```
color
Black    26
Brown    24
Gray     17
Tan       2
White    74
Name: weight_kg, dtype: int64
```

```
dogs.pivot_table(values="weight_kg",
                 index="color")
```

```
       weight_kg
color
Black       26.5
Brown       24.0
Gray        17.0
Tan          2.0
White       74.0
```

Different statistics

```
import numpy as np
dogs.pivot_table(values="weight_kg", index="color", aggfunc=np.median)
```

```
       weight_kg
color
Black       26.5
Brown       24.0
Gray        17.0
Tan          2.0
White       74.0
```

Multiple statistics

```
dogs.pivot_table(values="weight_kg", index="color", aggfunc=[np.mean, np.median])
```

```
           mean    median
      weight_kg weight_kg
color
Black      26.5      26.5
Brown      24.0      24.0
Gray       17.0      17.0
Tan         2.0       2.0
White      74.0      74.0
```

Pivot on two variables

```
dogs.groupby(["color", "breed"])["weight_kg"].mean()
```

```
dogs.pivot_table(values="weight_kg", index="color", columns="breed")
```

```
breed  Chihuahua  Chow Chow  Labrador  Poodle  Schnauzer  St. Bernard
color
Black        NaN        NaN      29.0    24.0        NaN          NaN
Brown        NaN       24.0      24.0     NaN        NaN          NaN
Gray         NaN        NaN       NaN     NaN       17.0          NaN
Tan          2.0        NaN       NaN     NaN        NaN          NaN
White        NaN        NaN       NaN     NaN        NaN         74.0
```

Filling missing values in pivot tables

```
dogs.pivot_table(values="weight_kg", index="color", columns="breed", fill_value=0)
```

breed	Chihuahua	Chow Chow	Labrador	Poodle	Schnauzer	St. Bernard
color						
Black	0	0	29	24	0	0
Brown	0	24	24	0	0	0
Gray	0	0	0	0	17	0
Tan	2	0	0	0	0	0
White	0	0	0	0	0	74

Summing with pivot tables

```
dogs.pivot_table(values="weight_kg", index="color", columns="breed",
                 fill_value=0, margins=True)
```

breed	Chihuahua	Chow Chow	Labrador	Poodle	Schnauzer	St. Bernard	All
color							
Black	0	0	29	24	0	0	26.500000
Brown	0	24	24	0	0	0	24.000000
Gray	0	0	0	0	17	0	17.000000
Tan	2	0	0	0	0	0	2.000000
White	0	0	0	0	0	74	74.000000
All	2	24	26	24	17	74	27.714286

Let's practice!

DATA MANIPULATION WITH PANDAS

Explicit indexes

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The dog dataset, revisited

```
print(dogs)
```

```
      name         breed  color  height_cm  weight_kg
0    Bella      Labrador  Brown         56         25
1  Charlie        Poodle  Black         43         23
2     Lucy     Chow Chow  Brown         46         22
3   Cooper     Schnauzer   Gray         49         17
4      Max      Labrador  Black         59         29
5   Stella     Chihuahua    Tan         18          2
6   Bernie  St. Bernard  White         77         74
```

.columns and .index

```
dogs.columns
```

```
Index(['name', 'breed', 'color', 'height_cm', 'weight_kg'], dtype='object')
```

```
dogs.index
```

```
RangeIndex(start=0, stop=7, step=1)
```

Setting a column as the index

```
dogs_ind = dogs.set_index("name")
print(dogs_ind)
```

```
              breed  color  height_cm  weight_kg
name
Bella       Labrador  Brown         56         25
Charlie       Poodle  Black         43         23
Lucy       Chow Chow  Brown         46         22
Cooper     Schnauzer   Grey         49         17
Max         Labrador  Black         59         29
Stella     Chihuahua    Tan         18          2
Bernie   St. Bernard  White         77         74
```

Removing an index

```
dogs_ind.reset_index()
```

```
      name         breed  color  height_cm  weight_kg
0    Bella      Labrador  Brown         56         25
1  Charlie        Poodle  Black         43         23
2     Lucy     Chow Chow  Brown         46         22
3   Cooper     Schnauzer   Grey         49         17
4      Max      Labrador  Black         59         29
5   Stella     Chihuahua    Tan         18          2
6   Bernie  St. Bernard  White         77         74
```

Dropping an index

```
dogs_ind.reset_index(drop=True)
```

```
          breed  color  height_cm  weight_kg
0      Labrador  Brown         56         25
1        Poodle  Black         43         23
2     Chow Chow  Brown         46         22
3     Schnauzer   Grey         49         17
4      Labrador  Black         59         29
5     Chihuahua    Tan         18          2
6  St. Bernard  White         77         74
```

Indexes make subsetting simpler

```
dogs[dogs["name"].isin(["Bella", "Stella"])]
```

```
     name       breed  color  height_cm  weight_kg
0   Bella   Labrador  Brown         56         25
5  Stella  Chihuahua    Tan         18          2
```

```
dogs_ind.loc[["Bella", "Stella"]]
```

```
           breed  color  height_cm  weight_kg
name
Bella    Labrador  Brown         56         25
Stella  Chihuahua    Tan         18          2
```

Index values don't need to be unique

```
dogs_ind2 = dogs.set_index("breed")
print(dogs_ind2)
```

```
                name  color  height_cm  weight_kg
breed
Labrador       Bella  Brown         56         25
Poodle       Charlie  Black         43         23
Chow Chow      Lucy  Brown         46         22
Schnauzer    Cooper   Grey         49         17
Labrador        Max  Black         59         29
Chihuahua    Stella    Tan         18          2
St. Bernard  Bernie  White         77         74
```

Subsetting on duplicated index values

```
dogs_ind2.loc["Labrador"]
```

```
           name  color  height_cm  weight_kg
breed
Labrador  Bella  Brown         56         25
Labrador    Max  Black         59         29
```

Multi-level indexes a.k.a. hierarchical indexes

```
dogs_ind3 = dogs.set_index(["breed", "color"])
print(dogs_ind3)
```

```
                      name  height_cm  weight_kg
breed       color
Labrador    Brown    Bella         56         25
Poodle      Black  Charlie         43         23
Chow Chow   Brown     Lucy         46         22
Schnauzer   Grey    Cooper         49         17
Labrador    Black      Max         59         29
Chihuahua   Tan     Stella         18          2
St. Bernard White   Bernie         77         74
```

Subset the outer level with a list

```
dogs_ind3.loc[["Labrador", "Chihuahua"]]
```

```
                  name  height_cm  weight_kg
breed     color
Labrador  Brown   Bella         56         25
          Black     Max         59         29
Chihuahua Tan     Stella        18          2
```

Subset inner levels with a list of tuples

```
dogs_ind3.loc[[("Labrador", "Brown"), ("Chihuahua", "Tan")]]
```

```
                  name  height_cm  weight_kg
breed     color
Labrador  Brown   Bella         56         25
Chihuahua Tan    Stella         18          2
```

Sorting by index values

```
dogs_ind3.sort_index()
```

```
                      name  height_cm  weight_kg
breed       color
Chihuahua   Tan      Stella         18          2
Chow Chow   Brown      Lucy         46         22
Labrador    Black       Max         59         29
            Brown     Bella         56         25
Poodle      Black   Charlie         43         23
Schnauzer   Grey     Cooper         49         17
St. Bernard White    Bernie         77         74
```

Controlling sort_index

```
dogs_ind3.sort_index(level=["color", "breed"], ascending=[True, False])
```

```
                     name  height_cm  weight_kg
breed       color
Poodle      Black  Charlie         43         23
Labrador    Black      Max         59         29
            Brown    Bella         56         25
Chow Chow   Brown     Lucy         46         22
Schanuzer   Grey    Cooper         49         17
Chihuahua   Tan     Stella         18          2
St. Bernard White   Bernie         77         74
```

Now you have two problems

- Index values are just data
- Indexes violate "tidy data" principles
- You need to learn two syntaxes

Temperature dataset

	date	city	country	avg_temp_c
0	2000-01-01	Abidjan	Côte D'Ivoire	27.293
1	2000-02-01	Abidjan	Côte D'Ivoire	27.685
2	2000-03-01	Abidjan	Côte D'Ivoire	29.061
3	2000-04-01	Abidjan	Côte D'Ivoire	28.162
4	2000-05-01	Abidjan	Côte D'Ivoire	27.547

Let's practice!

DATA MANIPULATION WITH PANDAS

Slicing and subsetting with .loc and .iloc

DATA MANIPULATION WITH PANDAS

Richie Cotton
Data Evangelist at DataCamp

datacamp

Slicing lists

```
breeds = ["Labrador", "Poodle",
          "Chow Chow", "Schnauzer",
          "Labrador", "Chihuahua",
          "St. Bernard"]
```

```
['Labrador',
 'Poodle',
 'Chow Chow',
 'Schnauzer',
 'Labrador',
 'Chihuahua',
 'St. Bernard']
```

```
breeds[2:5]
```

```
['Chow Chow', 'Schnauzer', 'Labrador']
```

```
breeds[:3]
```

```
['Labrador', 'Poodle', 'Chow Chow']
```

```
breeds[:]
```

```
['Labrador','Poodle','Chow Chow','Schnauzer',
 'Labrador','Chihuahua','St. Bernard']
```

Sort the index before you slice

```
dogs_srt = dogs.set_index(["breed", "color"]).sort_index()
print(dogs_srt)
```

```
                     name  height_cm  weight_kg
breed       color
Chihuahua   Tan     Stella         18          2
Chow Chow   Brown     Lucy         46         22
Labrador    Black      Max         59         29
            Brown    Bella         56         25
Poodle      Black  Charlie         43         23
Schnauzer   Grey    Cooper         49         17
St. Bernard White   Bernie         77         74
```

Slicing the outer index level

```
dogs_srt.loc["Chow Chow":"Poodle"]
```

breed	color	name	height_cm	weight_kg
Chow Chow	Brown	Lucy	46	22
Labrador	Black	Max	59	29
	Brown	Bella	56	25
Poodle	Black	Charlie	43	23

The final value **"Poodle"** *is included*

Full dataset

breed	color	name	height_cm	weight_kg
Chihuahua	Tan	Stella	18	2
Chow Chow	Brown	Lucy	46	22
Labrador	Black	Max	59	29
	Brown	Bella	56	25
Poodle	Black	Charlie	43	23
Schnauzer	Grey	Cooper	49	17
St. Bernard	White	Bernie	77	74

Slicing the inner index levels badly

```
dogs_srt.loc["Tan":"Grey"]
```

```
Empty DataFrame
Columns: [name, height_cm, weight_kg]
Index: []
```

Full dataset

breed	color	name	height_cm	weight_kg
Chihuahua	Tan	Stella	18	2
Chow Chow	Brown	Lucy	46	22
Labrador	Black	Max	59	29
	Brown	Bella	56	25
Poodle	Black	Charlie	43	23
Schnauzer	Grey	Cooper	49	17
St. Bernard	White	Bernie	77	74

Slicing the inner index levels correctly

```
dogs_srt.loc[
    ("Labrador", "Brown"):("Schnauzer", "Grey")]
```

		name	height_cm	weight_kg
breed	color			
Labrador	Brown	Bella	56	25
Poodle	Black	Charlie	43	23
Schnauzer	Grey	Cooper	49	17

Full dataset

		name	height_cm	weight_kg
breed	color			
Chihuahua	Tan	Stella	18	2
Chow Chow	Brown	Lucy	46	22
Labrador	Black	Max	59	29
	Brown	Bella	56	25
Poodle	Black	Charlie	43	23
Schnauzer	Grey	Cooper	49	17
St. Bernard	White	Bernie	77	74

Slicing columns

```
dogs_srt.loc[:, "name":"height_cm"]
```

		name	height_cm
breed	color		
Chihuahua	Tan	Stella	18
Chow Chow	Brown	Lucy	46
Labrador	Black	Max	59
	Brown	Bella	56
Poodle	Black	Charlie	43
Schnauzer	Grey	Cooper	49
St. Bernard	White	Bernie	77

Full dataset

		name	height_cm	weight_kg
breed	color			
Chihuahua	Tan	Stella	18	2
Chow Chow	Brown	Lucy	46	22
Labrador	Black	Max	59	29
	Brown	Bella	56	25
Poodle	Black	Charlie	43	23
Schnauzer	Grey	Cooper	49	17
St. Bernard	White	Bernie	77	74

Slice twice

```
dogs_srt.loc[
    ("Labrador", "Brown"):("Schnauzer", "Grey"),
    "name":"height_cm"]
```

breed	color	name	height_cm
Labrador	Brown	Bella	56
Poodle	Black	Charlie	43
Schanuzer	Grey	Cooper	49

Full dataset

breed	color	name	height_cm	weight_kg
Chihuahua	Tan	Stella	18	2
Chow Chow	Brown	Lucy	46	22
Labrador	Black	Max	59	29
	Brown	Bella	56	25
Poodle	Black	Charlie	43	23
Schnauzer	Grey	Cooper	49	17
St. Bernard	White	Bernie	77	74

Dog days

```
dogs = dogs.set_index("date_of_birth").sort_index()
print(dogs)
```

```
                name         breed  color  height_cm  weight_kg
date_of_birth
2011-12-11    Cooper    Schanuzer   Grey         49         17
2013-07-01     Bella     Labrador  Brown         56         25
2014-08-25      Lucy    Chow Chow  Brown         46         22
2015-04-20    Stella    Chihuahua    Tan         18          2
2016-09-16   Charlie       Poodle  Black         43         23
2017-01-20       Max     Labrador  Black         59         29
2018-02-27    Bernie  St. Bernard  White         77         74
```

Slicing by dates

```
# Get dogs with date_of_birth between 2014-08-25 and 2016-09-16
dogs.loc["2014-08-25":"2016-09-16"]
```

date_of_birth	name	breed	color	height_cm	weight_kg
2014-08-25	Lucy	Chow Chow	Brown	46	22
2015-04-20	Stella	Chihuahua	Tan	18	2
2016-09-16	Charlie	Poodle	Black	43	23

Slicing by partial dates

```
# Get dogs with date_of_birth between 2014-01-01 and 2016-12-31
dogs.loc["2014":"2016"]
```

```
                name      breed  color  height_cm  weight_kg
date_of_birth
2014-08-25       Lucy  Chow Chow  Brown         46         22
2015-04-20     Stella  Chihuahua    Tan         18          2
2016-09-16    Charlie     Poodle  Black         43         23
```

Subsetting by row/column number

```
print(dogs.iloc[2:5, 1:4])
```

```
       breed  color  height_cm
2  Chow Chow  Brown         46
3  Schnauzer   Grey         49
4   Labrador  Black         59
```

Full dataset

```
      name         breed  color  height_cm  weight_kg
0    Bella      Labrador  Brown         56         25
1  Charlie        Poodle  Black         43         23
2     Lucy     Chow Chow  Brown         46         22
3   Cooper     Schnauzer   Grey         49         17
4      Max      Labrador  Black         59         29
5   Stella     Chihuahua    Tan         18          2
6   Bernie  St. Bernard  White         77         74
```

Let's practice!

DATA MANIPULATION WITH PANDAS

Working with pivot tables

DATA MANIPULATION WITH PANDAS

Richie Cotton
Data Evangelist at DataCamp

datacamp

A bigger dog dataset

```
print(dog_pack)
```

```
          breed  color  height_cm  weight_kg
0         Boxer  Brown      62.64       30.4
1        Poodle  Black      46.41       20.4
2        Beagle  Brown      36.39       12.4
3     Chihuahua    Tan      19.70        1.6
4      Labrador    Tan      54.44       36.1
..           ...    ...        ...        ...
87        Boxer   Gray      58.13       29.9
88  St. Bernard  White      70.13       69.4
89       Poodle   Gray      51.30       20.4
90       Beagle  White      38.81        8.8
91       Beagle  Black      33.40       13.5
```

Pivoting the dog pack

```
dogs_height_by_breed_vs_color = dog_pack.pivot_table(
        "height_cm", index="breed", columns="color")
print(dogs_height_by_breed_vs_color)
```

color	Black	Brown	Gray	Tan	White
breed					
Beagle	34.500000	36.4500	36.313333	35.740000	38.810000
Boxer	57.203333	62.6400	58.280000	62.310000	56.360000
Chihuahua	18.555000	NaN	21.660000	20.096667	17.933333
Chow Chow	51.262500	50.4800	NaN	53.497500	54.413333
Dachshund	21.186667	19.7250	NaN	19.375000	20.660000
Labrador	57.125000	NaN	NaN	55.190000	55.310000
Poodle	48.036000	57.1300	56.645000	NaN	44.740000
St. Bernard	63.920000	65.8825	67.640000	68.334000	67.495000

.loc[] + slicing is a power combo

```
dogs_height_by_breed_vs_color.loc["Chow Chow":"Poodle"]
```

```
color           Black   Brown    Gray      Tan      White
breed
Chow Chow   51.262500   50.480     NaN  53.4975  54.413333
Dachshund   21.186667   19.725     NaN  19.3750  20.660000
Labrador    57.125000      NaN     NaN  55.1900  55.310000
Poodle      48.036000   57.130  56.645      NaN  44.740000
```

The axis argument

```
dogs_height_by_breed_vs_color.mean(axis="index")
```

```
color
Black    43.973563
Brown    48.717917
Gray     48.107667
Tan      44.934738
White    44.465208
dtype: float64
```

Calculating summary stats across columns

```
dogs_height_by_breed_vs_color.mean(axis="columns")
```

```
breed
Beagle          36.362667
Boxer           59.358667
Chihuahua       19.561250
Chow Chow       52.413333
Dachshund       20.236667
Labrador        55.875000
Poodle          51.637750
St. Bernard     66.654300
dtype: float64
```

Let's practice!

DATA MANIPULATION WITH PANDAS

Visualizing your data

DATA MANIPULATION WITH PANDAS

Maggie Matsui
Senior Content Developer at DataCamp

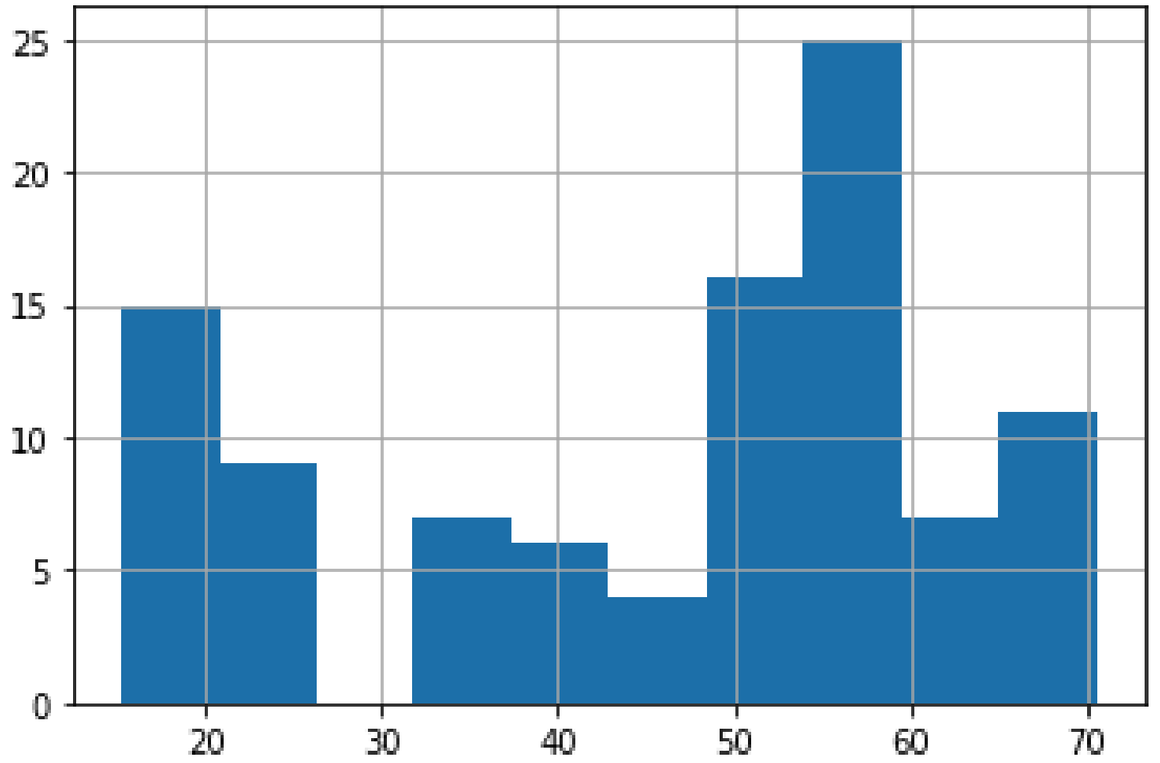
datacamp

Histograms

```
import matplotlib.pyplot as plt
```

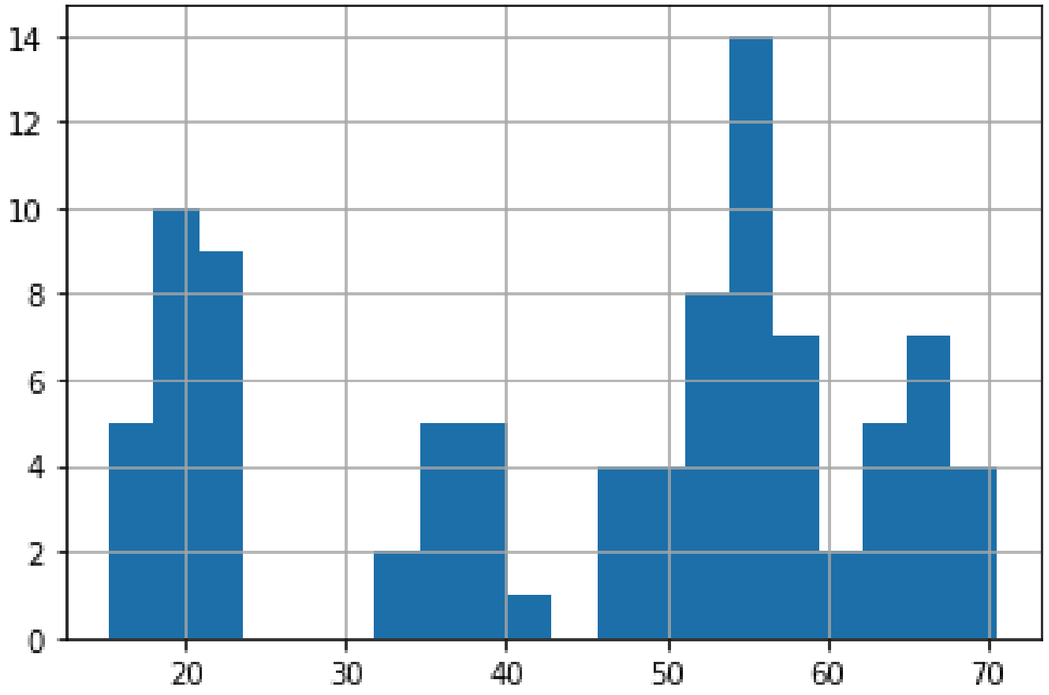
```
dog_pack["height_cm"].hist()
```

```
plt.show()
```

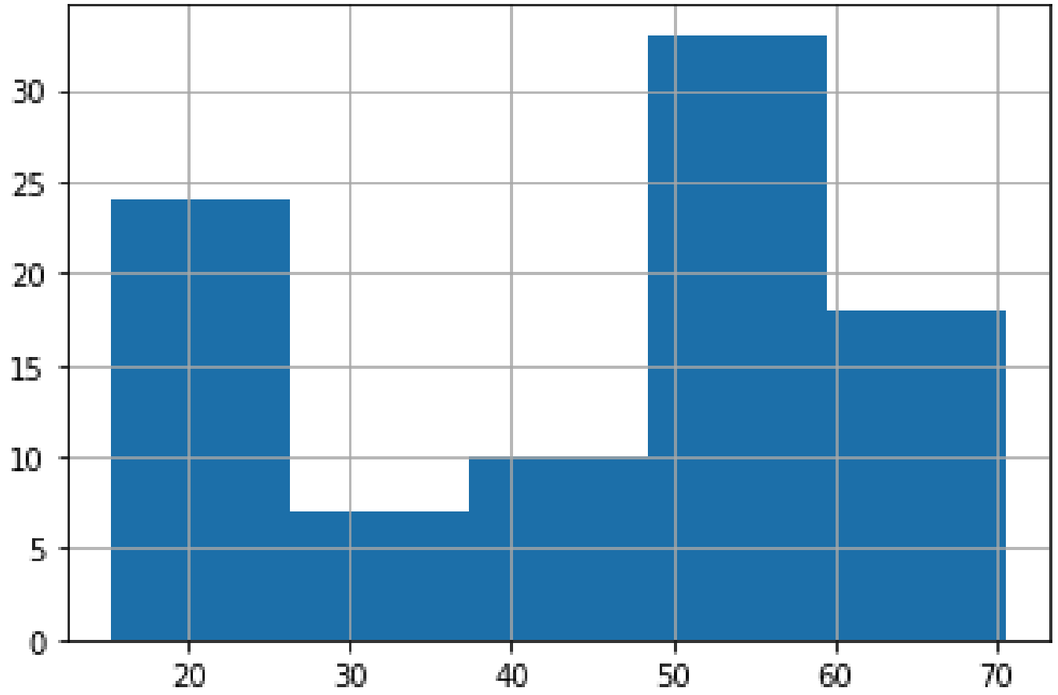


Histograms

```
dog_pack["height_cm"].hist(bins=20)
plt.show()
```




```
dog_pack["height_cm"].hist(bins=5)
plt.show()
```



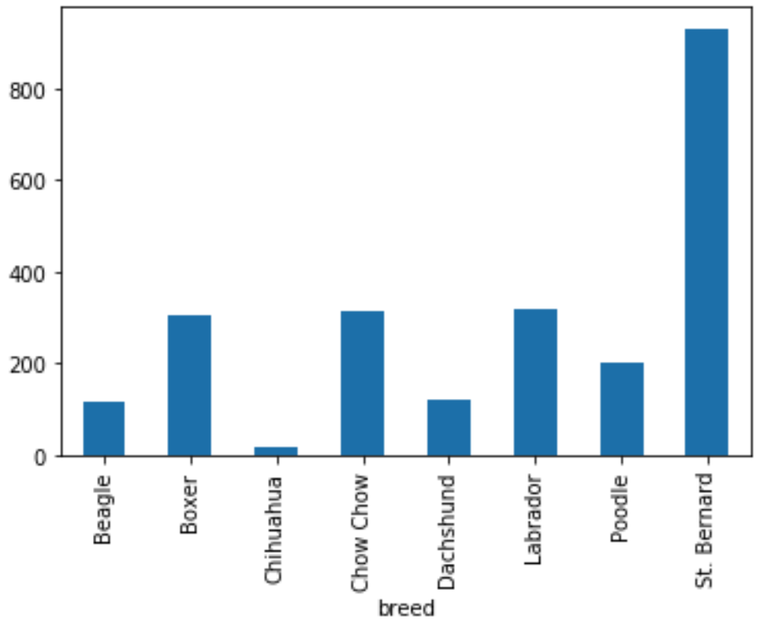
Bar plots

```
avg_weight_by_breed = dog_pack.groupby("breed")["weight_kg"].mean()
print(avg_weight_by_breed)
```

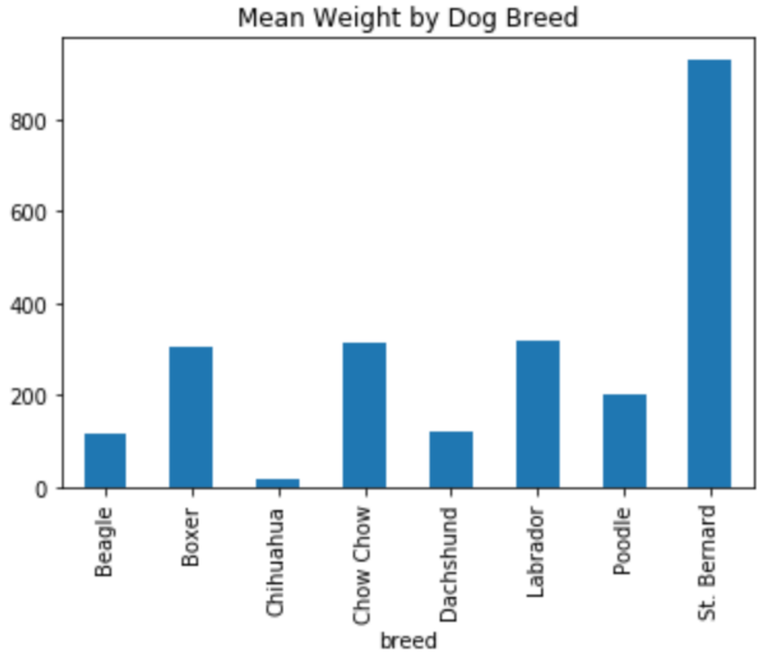
```
breed
Beagle          10.636364
Boxer           30.620000
Chihuahua        1.491667
Chow Chow       22.535714
Dachshund        9.975000
Labrador        31.850000
Poodle          20.400000
St. Bernard     71.576923
Name: weight_kg, dtype: float64
```

Bar plots

```
avg_weight_by_breed.plot(kind="bar")
plt.show()
```




```
avg_weight_by_breed.plot(kind="bar",
    title="Mean Weight by Dog Breed")
plt.show()
```

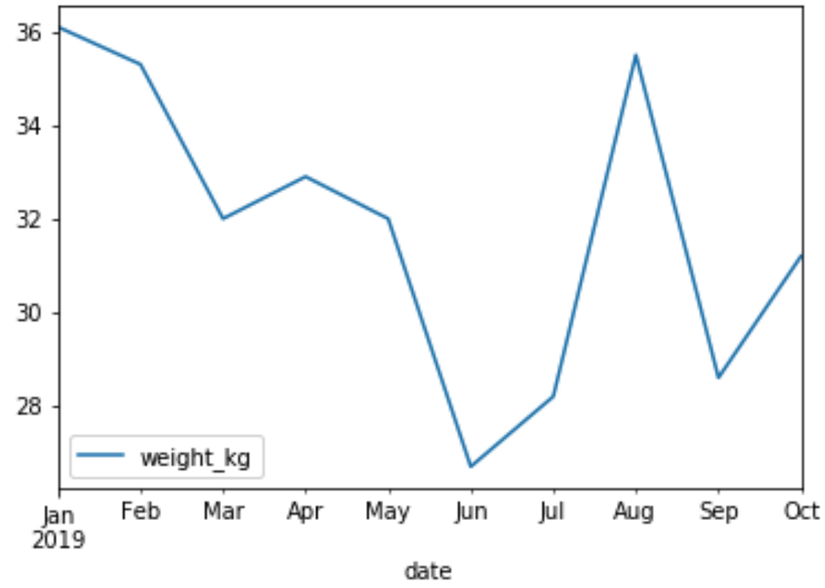


Line plots

```
sully.head()
```

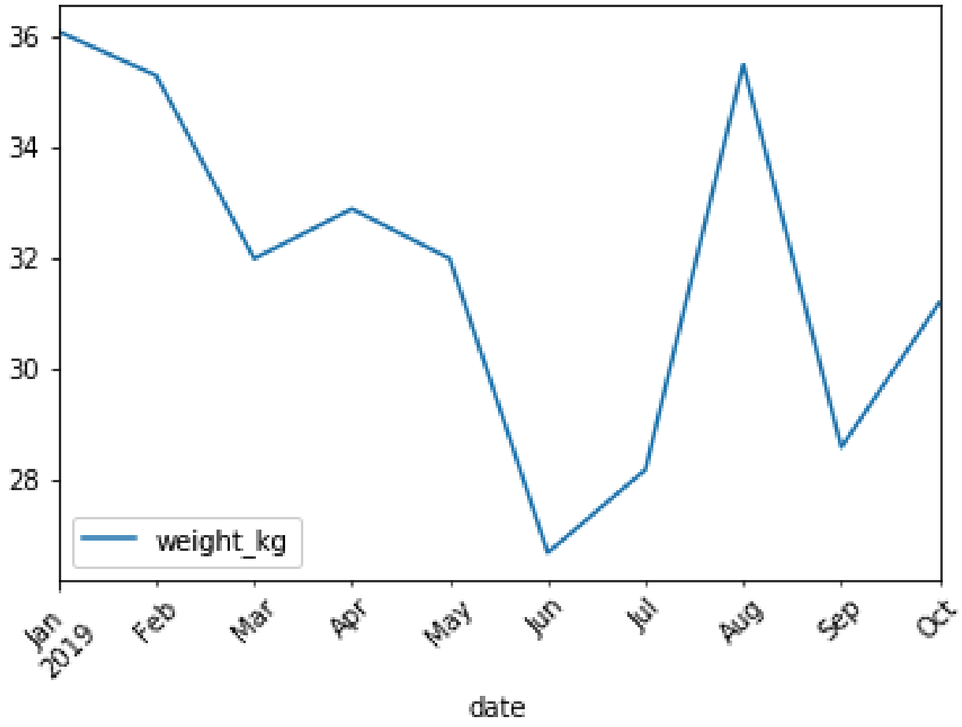
```
         date    weight_kg
0  2019-01-31         36.1
1  2019-02-28         35.3
2  2019-03-31         32.0
3  2019-04-30         32.9
4  2019-05-31         32.0
```

```
sully.plot(x="date",
           y="weight_kg",
           kind="line")
plt.show()
```



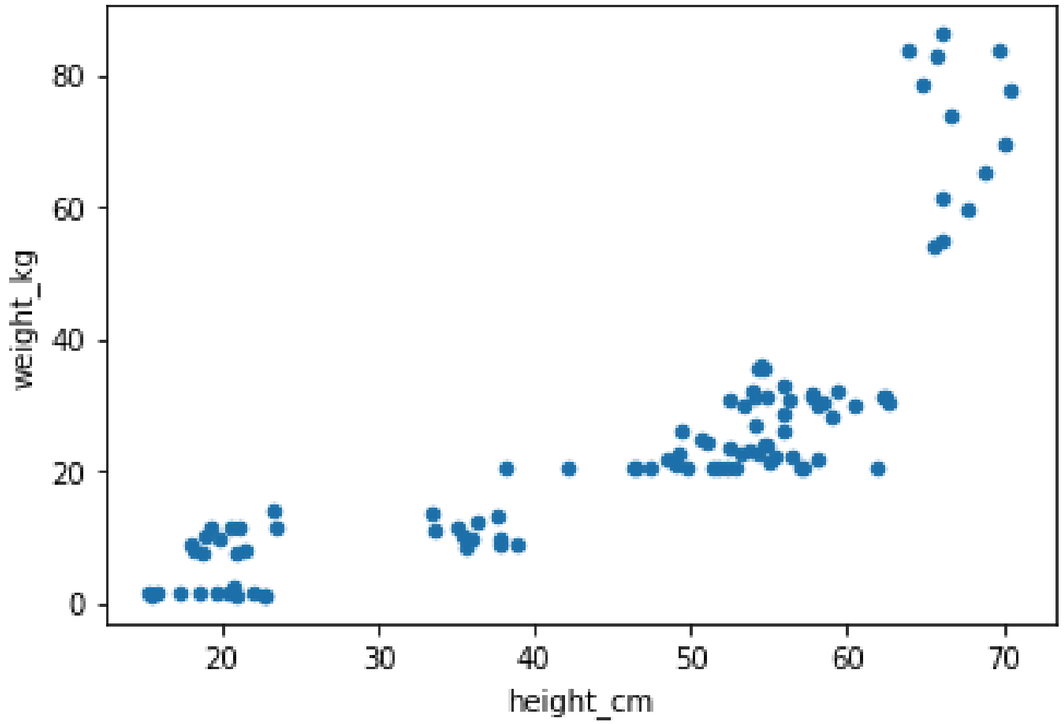
Rotating axis labels

```
sully.plot(x="date", y="weight_kg", kind="line", rot=45)
plt.show()
```



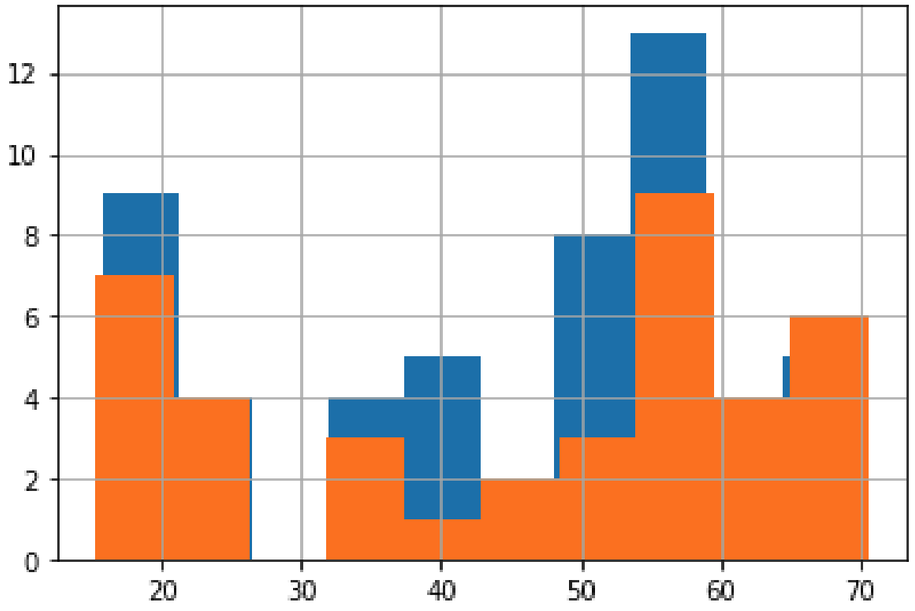
Scatter plots

```
dog_pack.plot(x="height_cm", y="weight_kg", kind="scatter")
plt.show()
```



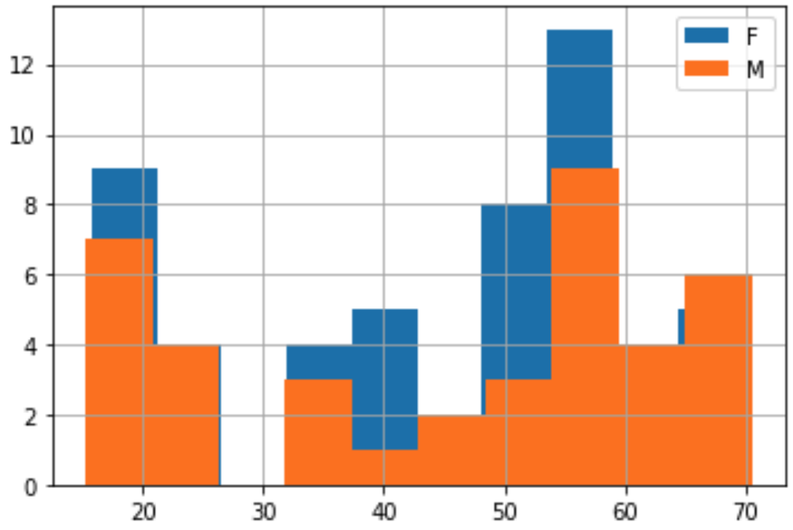
Layering plots

```
dog_pack[dog_pack["sex"]=="F"]["height_cm"].hist()
dog_pack[dog_pack["sex"]=="M"]["height_cm"].hist()
plt.show()
```



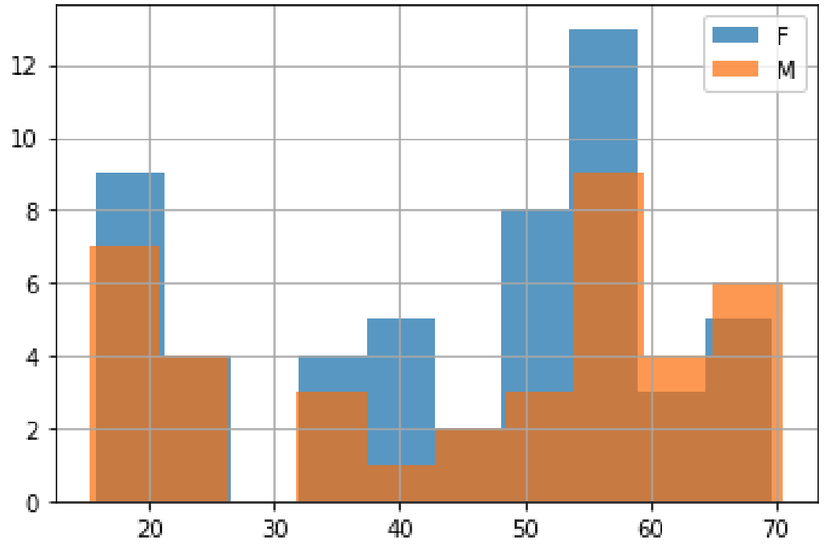
Add a legend

```
dog_pack[dog_pack["sex"]=="F"]["height_cm"].hist()
dog_pack[dog_pack["sex"]=="M"]["height_cm"].hist()
plt.legend(["F", "M"])
plt.show()
```



Transparency

```
dog_pack[dog_pack["sex"]=="F"]["height_cm"].hist(alpha=0.7)
dog_pack[dog_pack["sex"]=="M"]["height_cm"].hist(alpha=0.7)
plt.legend(["F", "M"])
plt.show()
```



Avocados

```
print(avocados)
```

```
            date          type  year  avg_price          size     nb_sold
0     2015-12-27  conventional  2015       0.95         small  9626901.09
1     2015-12-20  conventional  2015       0.98         small  8710021.76
2     2015-12-13  conventional  2015       0.93         small  9855053.66
...          ...           ...   ...        ...           ...         ...
1011  2018-01-21       organic  2018       1.63  extra_large     1490.02
1012  2018-01-14       organic  2018       1.59  extra_large     1580.01
1013  2018-01-07       organic  2018       1.51  extra_large     1289.07

[1014 rows x 6 columns]
```

Let's practice!

DATA MANIPULATION WITH PANDAS

Missing values

DATA MANIPULATION WITH PANDAS

Maggie Matsui
Senior Content Developer at DataCamp

What's a missing value?

Name	Breed	Color	Height (cm)	Weight (kg)	Date of Birth
Bella	Labrador	Brown	56	25	2013-07-01
Charlie	Poodle	Black	43	23	2016-09-16
Lucy	Chow Chow	Brown	46	22	2014-08-25
Cooper	Schnauzer	Gray	49	17	2011-12-11
Max	Labrador	Black	59	29	2017-01-20
Stella	Chihuahua	Tan	18	2	2015-04-20
Bernie	St. Bernard	White	77	74	2018-02-27

What's a missing value?

Name	Breed	Color	Height (cm)	Weight (kg)	Date of Birth
Bella	Labrador	Brown	56	?	2013-07-01
Charlie	Poodle	Black	43	23	2016-09-16
Lucy	Chow Chow	Brown	46	22	2014-08-25
Cooper	Schnauzer	Gray	49	?	2011-12-11
Max	Labrador	Black	59	29	2017-01-20
Stella	Chihuahua	Tan	18	2	2015-04-20
Bernie	St. Bernard	White	77	74	2018-02-27

Missing values in pandas DataFrames

```
print(dogs)
```

```
      name         breed  color  height_cm  weight_kg date_of_birth
0    Bella      Labrador  Brown         56        NaN    2013-07-01
1  Charlie        Poodle  Black         43       24.0    2016-09-16
2     Lucy     Chow Chow  Brown         46       24.0    2014-08-25
3   Cooper     Schnauzer   Gray         49        NaN    2011-12-11
4      Max      Labrador  Black         59       29.0    2017-01-20
5   Stella     Chihuahua    Tan         18        2.0    2015-04-20
6   Bernie  St. Bernard  White         77       74.0    2018-02-27
```

Detecting missing values

```
dogs.isna()
```

```
    name  breed  color  height_cm  weight_kg  date_of_birth
0  False  False  False      False       True          False
1  False  False  False      False      False          False
2  False  False  False      False      False          False
3  False  False  False      False       True          False
4  False  False  False      False      False          False
5  False  False  False      False      False          False
6  False  False  False      False      False          False
```

Detecting any missing values

```
dogs.isna().any()
```

```
name             False
breed            False
color            False
height_cm        False
weight_kg         True
date_of_birth    False
dtype: bool
```

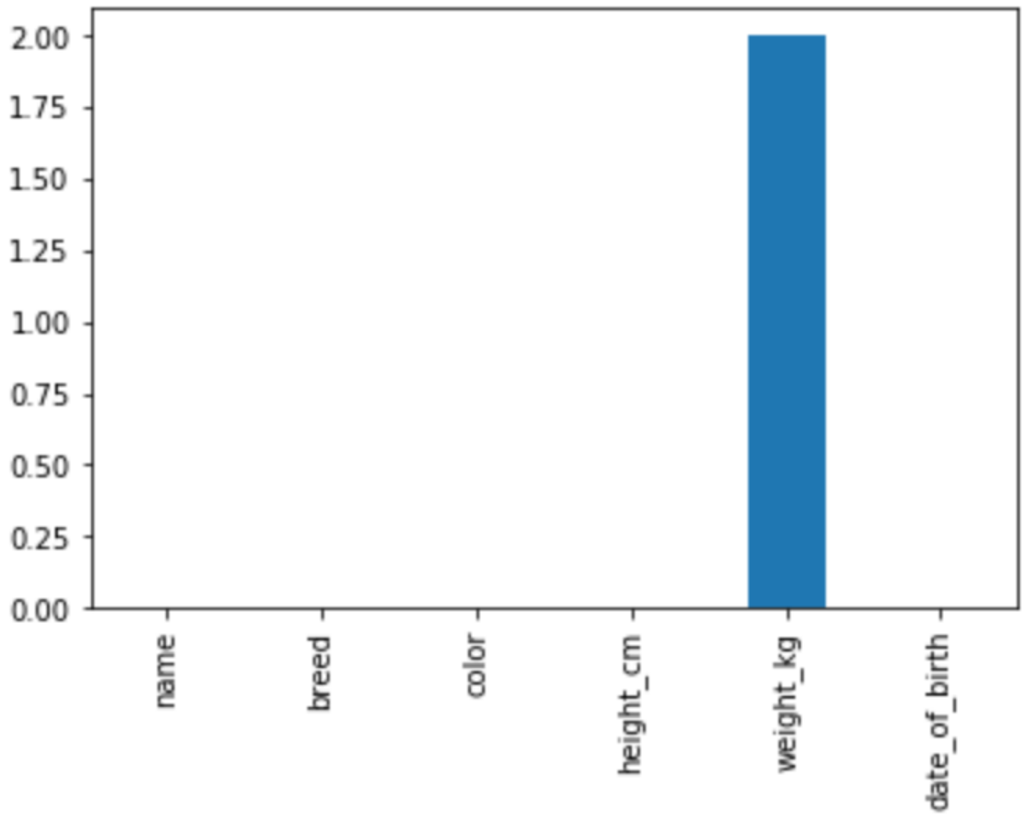
Counting missing values

```
dogs.isna().sum()
```

```
name             0
breed            0
color            0
height_cm        0
weight_kg        2
date_of_birth    0
dtype: int64
```

Plotting missing values

```
import matplotlib.pyplot as plt
dogs.isna().sum().plot(kind="bar")
plt.show()
```



Removing missing values

```
dogs.dropna()
```

```
      name         breed  color  height_cm  weight_kg date_of_birth
1  Charlie        Poodle  Black         43       24.0    2016-09-16
2     Lucy    Chow Chow  Brown         46       24.0    2014-08-25
4      Max     Labrador  Black         59       29.0    2017-01-20
5   Stella    Chihuahua    Tan         18        2.0    2015-04-20
6   Bernie  St. Bernard  White         77       74.0    2018-02-27
```

Replacing missing values

```
dogs.fillna(0)
```

	name	breed	color	height_cm	weight_kg	date_of_birth
0	Bella	Labrador	Brown	56	0.0	2013-07-01
1	Charlie	Poodle	Black	43	24.0	2016-09-16
2	Lucy	Chow Chow	Brown	46	24.0	2014-08-25
3	Cooper	Schnauzer	Gray	49	0.0	2011-12-11
4	Max	Labrador	Black	59	29.0	2017-01-20
5	Stella	Chihuahua	Tan	18	2.0	2015-04-20
6	Bernie	St. Bernard	White	77	74.0	2018-02-27

Let's practice!

DATA MANIPULATION WITH PANDAS

Creating DataFrames

DATA MANIPULATION WITH PANDAS

Maggie Matsui
Senior Content Developer at DataCamp

Dictionaries

```
my_dict = {
    "key1": value1,
    "key2": value2,
    "key3": value3
}
```

```
my_dict = {
    "title": "Charlotte's Web",
    "author": "E.B. White",
    "published": 1952
}
```

```
my_dict["key1"]
```

```
my_dict["title"]
```

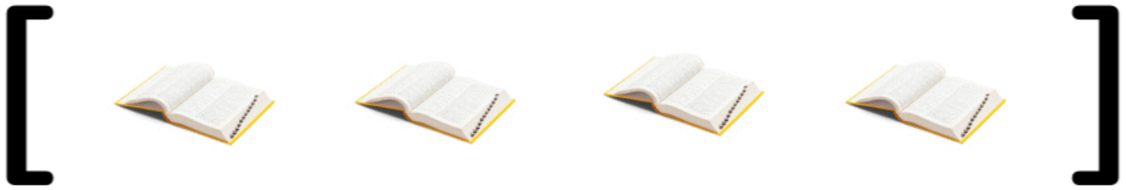
```
value1
```

```
Charlotte's Web
```

Creating DataFrames

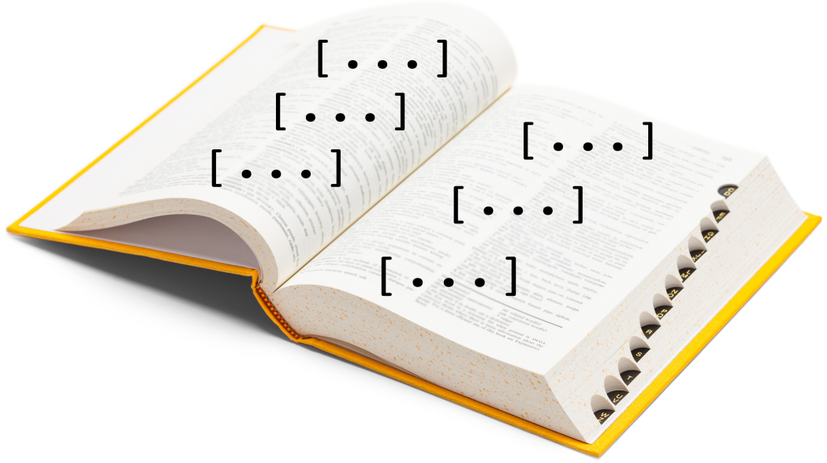
From a list of dictionaries

- Constructed row by row



From a dictionary of lists

- Constructed column by column



List of dictionaries - by row

name	breed	height (cm)	weight (kg)	date of birth
Ginger	Dachshund	22	10	2019-03-14
Scout	Dalmatian	59	25	2019-05-09

```
list_of_dicts = [
    {"name": "Ginger", "breed": "Dachshund", "height_cm": 22,
    "weight_kg": 10, "date_of_birth": "2019-03-14"},
    {"name": "Scout", "breed": "Dalmatian", "height_cm": 59,
    "weight_kg": 25, "date_of_birth": "2019-05-09"}
]
```

List of dictionaries - by row

name	breed	height (cm)	weight (kg)	date of birth
Ginger	Dachshund	22	10	2019-03-14
Scout	Dalmatian	59	25	2019-05-09

```
new_dogs = pd.DataFrame(list_of_dicts)
print(new_dogs)
```

```
    name       breed  height_cm  weight_kg date_of_birth
0  Ginger  Dachshund         22         10    2019-03-14
1   Scout  Dalmatian         59         25    2019-05-09
```

Dictionary of lists - by column

name	breed	height	weight	date of birth
Ginger	Dachshund	22	10	2019-03-14
Scout	Dalmatian	59	25	2019-05-09

- **Key** = column name
- **Value** = list of column values

```
dict_of_lists = {
    "name": ["Ginger", "Scout"],
    "breed": ["Dachshund", "Dalmatian"],
    "height_cm": [22, 59],
    "weight_kg": [10, 25],
    "date_of_birth": ["2019-03-14",
    "2019-05-09"]
}
new_dogs = pd.DataFrame(dict_of_lists)
```

Dictionary of lists - by column

name	breed	height (cm)	weight (kg)	date of birth
Ginger	Dachshund	22	10	2019-03-14
Scout	Dalmatian	59	25	2019-05-09

```
print(new_dogs)
```

```
     name       breed  height_cm  weight_kg date_of_birth
0  Ginger  Dachshund          22          10    2019-03-14
1   Scout  Dalmatian          59          25    2019-05-09
```

Let's practice!

DATA MANIPULATION WITH PANDAS

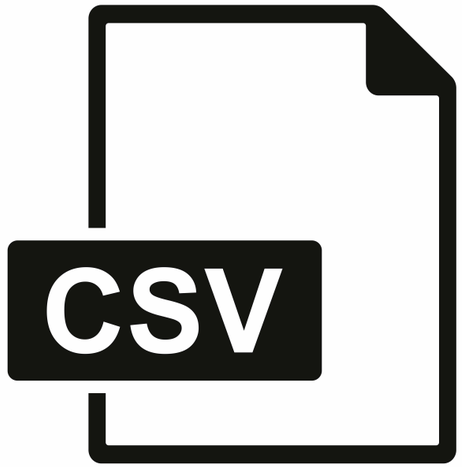
Reading and writing CSVs

DATA MANIPULATION WITH PANDAS

Maggie Matsui
Senior Content Developer at DataCamp

What's a CSV file?

- CSV = comma-separated values
- Designed for DataFrame-like data
- Most database and spreadsheet programs can use them or create them



Example CSV file

name	breed	height (cm)	weight (kg)	date of birth
Ginger	Dachshund	22	10	2019-03-14
Scout	Dalmatian	59	25	2019-05-09

new_dogs.csv

```
name,breed,height_cm,weight_kg,d_o_b
Ginger,Dachshund,22,10,2019-03-14
Scout,Dalmatian,59,25,2019-05-09
```

CSV to DataFrame

```
import pandas as pd
new_dogs = pd.read_csv("new_dogs.csv")
print(new_dogs)
```

```
     name       breed  height_cm  weight_kg date_of_birth
0  Ginger  Dachshund         22         10    2019-03-14
1   Scout  Dalmatian         59         25    2019-05-09
```

DataFrame manipulation

```
new_dogs["bmi"] = new_dogs["weight_kg"] / (new_dogs["height_cm"] / 100) ** 2
print(new_dogs)
```

```
     name       breed  height_cm  weight_kg date_of_birth         bmi
0  Ginger  Dachshund         22         10    2019-03-14  206.611570
1   Scout  Dalmatian         59         25    2019-05-09   71.818443
```

DataFrame to CSV

```
new_dogs.to_csv("new_dogs_with_bmi.csv")
```

new_dogs_with_bmi.csv

```
name,breed,height_cm,weight_kg,d_o_b,bmi
Ginger,Dachshund,22,10,2019-03-14,206.611570
Scout,Dalmatian,59,25,2019-05-09,71.818443
```

Let's practice!

DATA MANIPULATION WITH PANDAS

Wrap-up

DATA MANIPULATION WITH PANDAS

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Recap

- Chapter 1
  - Subsetting and sorting
  - Adding new columns
- Chapter 2
  - Aggregating and grouping
  - Summary statistics
- Chapter 3
  - Indexing
  - Slicing
- Chapter 4
  - Visualizations
  - Reading and writing CSVs

More to learn

- Joining Data with pandas
- Streamlined Data Ingestion with pandas
- Analyzing Police Activity with pandas
- Analyzing Marketing Campaigns with pandas

Congratulations!

DATA MANIPULATION WITH PANDAS