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LECTURE 2

Pandas, Part I

Introduction to `pandas` syntax, operators, and functions

Data 100/Data 200, Spring 2025 @ UC Berkeley

Narges Norouzi and Josh Grossman

Goals for This Lecture

Lecture 02, Data 100 Spring 2025

- Introduce pandas, an important Python library for working with data
- Key data structures: DataFrames, Series, Indices
- Extracting data: `loc, iloc, []`

This is the first of a three-lecture sequence about pandas.

Get ready: lots of code incoming!

- Lecture: introduce high-level concepts
- Lab, homework: practical experimentation

- Tabular data
- Series, DataFrames, and Indices
- Data extraction with `loc`, `iloc`, and `[]`

Agenda

Lecture 02, Data 100 Spring 2025

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Tabular Data

Lecture 02, Data 100 Spring 2025

- **Tabular data**
- Series, DataFrames, and Indices
- Data extraction with `loc`, `iloc`, and `[]`

Recall the Data Science Lifecycle

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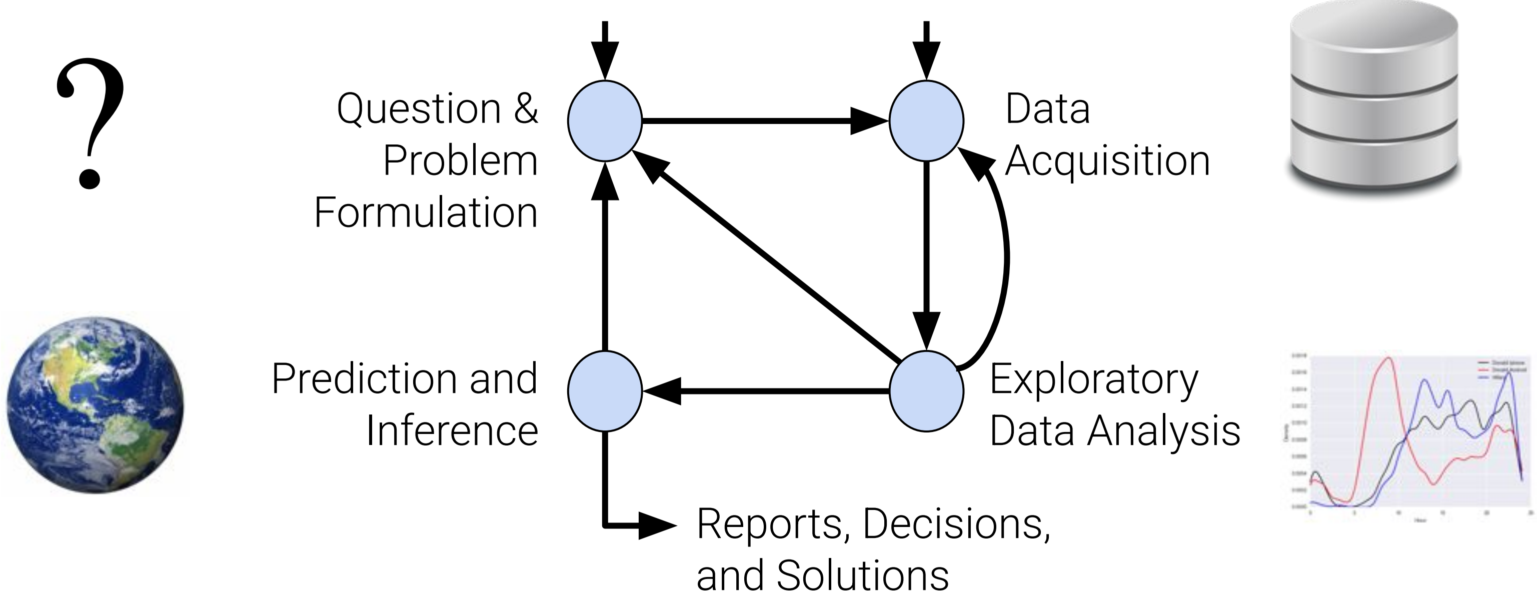

Question & Problem Formulation

Data Acquisition

Exploratory Data Analysis

Prediction and Inference

Reports, Decisions, and Solutions

Plan for First Few Weeks

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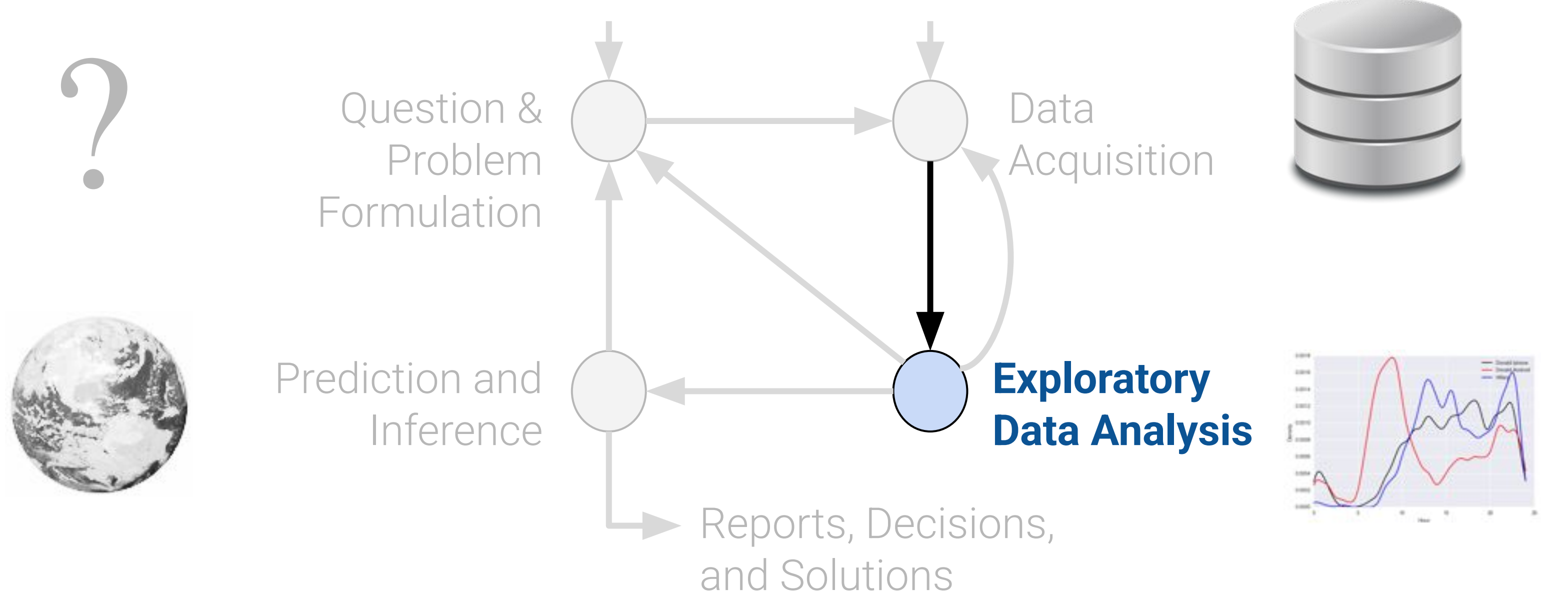

Question & Problem Formulation

Data Acquisition

Exploratory Data Analysis

Prediction and Inference

Reports, Decisions, and Solutions

(Weeks 1 and 2)

Exploring and Cleaning Tabular Data

From `datascience` to `pandas`

(Weeks 2 and 3)

Data Science in Practice

EDA, Data Cleaning, Text processing (regular expressions)

Congratulations!!!

You **have collected** or **have been given** a box of data.

What does this "data" actually look like?
How will you work with it?

Data Scientists Love Tabular Data

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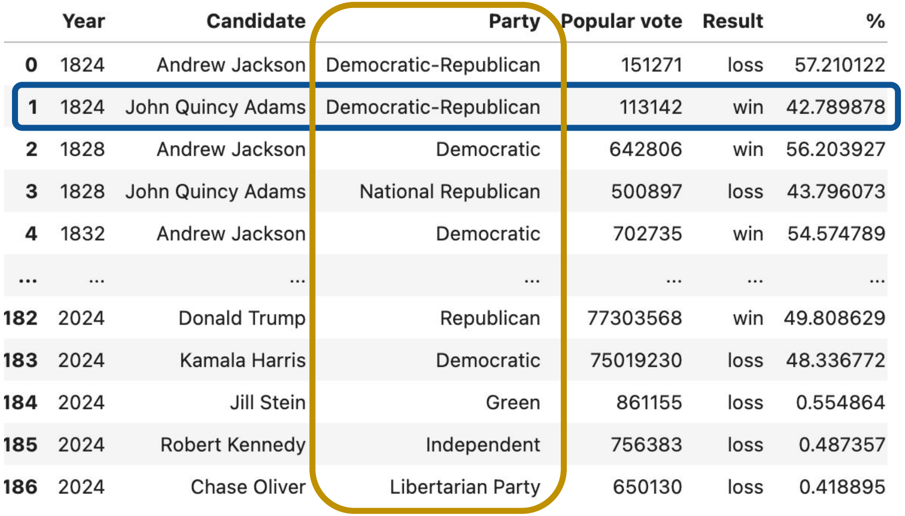
"Tabular data" = data in a table.

Typically:



	Year	Candidate	Party	Popular vote	Result	%
0	1824	Andrew Jackson	Democratic-Republican	151271	loss	57.210122
1	1824	John Quincy Adams	Democratic-Republican	113142	win	42.789878
2	1828	Andrew Jackson	Democratic	642806	win	56.203927
3	1828	John Quincy Adams	National Republican	500897	loss	43.796073
4	1832	Andrew Jackson	Democratic	702735	win	54.574789
...	...	...	...	...	...	...
182	2024	Donald Trump	Republican	77303568	win	49.808629
183	2024	Kamala Harris	Democratic	75019230	loss	48.336772
184	2024	Jill Stein	Green	861155	loss	0.554864
185	2024	Robert Kennedy	Independent	756383	loss	0.487357
186	2024	Chase Oliver	Libertarian Party	650130	loss	0.418895

A **row** represents one observation (here, a single person running for president in a particular year).

A **column** represents some characteristic, or feature, of that observation (here, the political party of that person).

In Data 8, you worked with the `datascience` library using `Tables`.

In Data 100 (and beyond), we'll use an industry-standard library called `pandas`.

Introducing the Standard Python Data Science Tool: pandas

The Python Data Analysis Library

Stands for "panel data"

The (unofficial) Data 100 logo

a cartoon panda

Introducing the Standard Python Data Science Tool: pandas

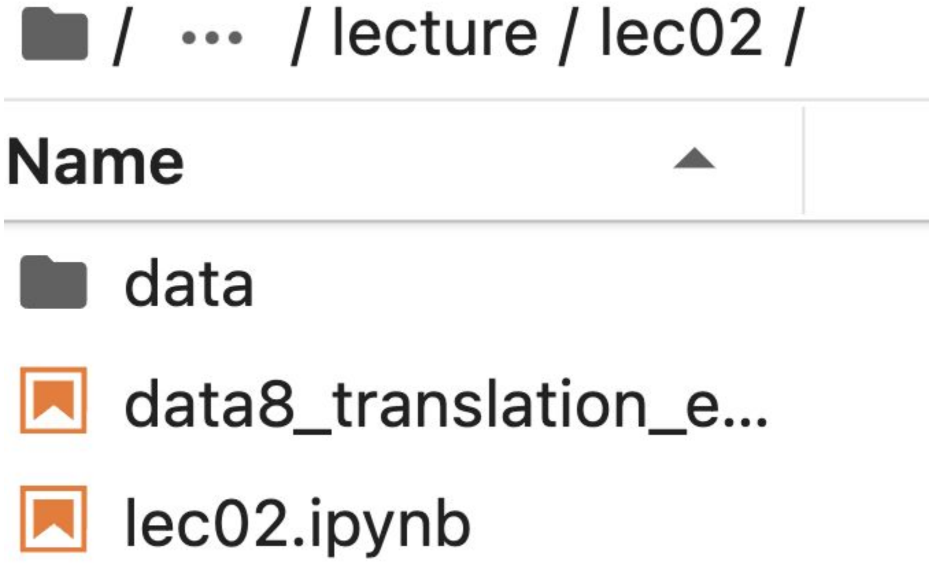
Using pandas, we can:

- Arrange data in a tabular format.
- Extract useful information filtered by specific conditions.
- Operate on data to gain new insights.
- Apply `NumPy` functions to our data (our friends from Data 8).
- Perform vectorized computations to speed up our analysis (Lab 1).

pandas is the standard tool across research and industry for working with tabular data.

> The first two weeks of Data 100 will serve as a "bootcamp" in helping you build familiarity with operating on data with pandas.
>
> Your Data 8 knowledge will serve you well! Much of our work will be in translating syntax.

Contents



/ ··· / lecture / lec02 /

Name

data

data8_translation_e...

lec02.ipynb

Data used in this lecture

Unofficial `datascience` -> `pandas` translations

Primary notebook for lecture

DataFrames, Series, and Indices

Lecture 02, Data 100 Spring 2025

- Tabular data
- **DataFrames, Series, and Indices**
- Data extraction with `loc`, `iloc`, and `[]`

DataFrames

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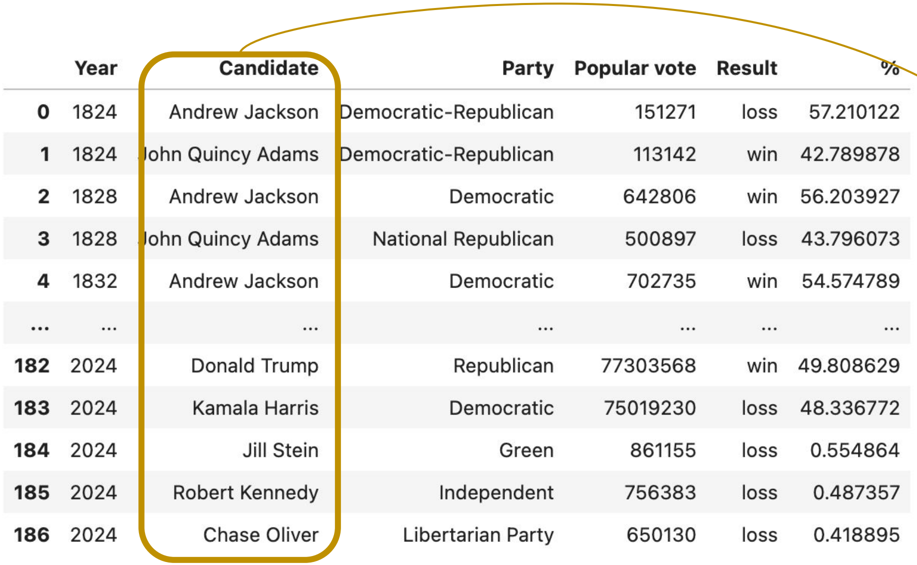
In the "language" of pandas, we call a table a **DataFrame**.

We think of **DataFrames** as collections of named columns, called **Series**.



	Year	Candidate	Party	Popular vote	Result	%
0	1824	Andrew Jackson	Democratic-Republican	151271	loss	57.210122
1	1824	John Quincy Adams	Democratic-Republican	113142	win	42.789878
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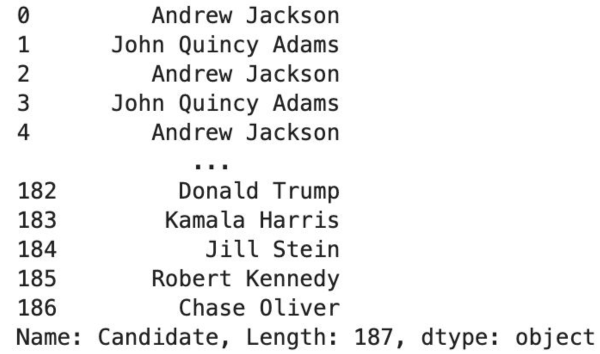
4	1832	Andrew Jackson	Democratic	702735	win	54.574789
...	...	...	...	...	...	...
182	2024	Donald Trump	Republican	77303568	win	49.808629
183	2024	Kamala Harris	Democratic	75019230	loss	48.336772
184	2024	Jill Stein	Green	861155	loss	0.554864
185	2024	Robert Kennedy	Independent	756383	loss	0.487357
186	2024	Chase Oliver	Libertarian Party	650130	loss	0.418895

A DataFrame



```
0          Andrew Jackson
1       John Quincy Adams
2          Andrew Jackson
3       John Quincy Adams
4          Andrew Jackson
              ...
182          Donald Trump
183         Kamala Harris
184            Jill Stein
185        Robert Kennedy
186          Chase Oliver
Name: Candidate, Length: 187, dtype: object
```

A Series named "Candidate"

Series

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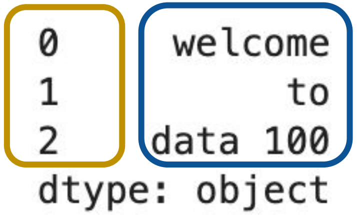
A **Series** is a 1-dimensional array-like object. It contains:

- A sequence of **values** of the same type.
- A sequence of data labels, called the **index**.

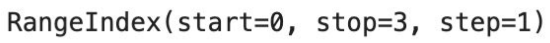
pd is the conventional alias for **pandas**

```python
import pandas as pd
s = pd.Series(["welcome", "to", "data 100"])
```



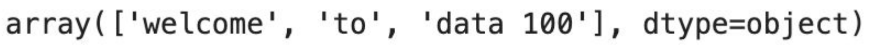
```
0     welcome
1          to
2    data 100
dtype: object
```

Index, accessed by calling `s.index`



```
RangeIndex(start=0, stop=3, step=1)
```

Values, accessed by calling `s.values`



```
array(['welcome', 'to', 'data 100'], dtype=object)
```

Series - Custom Index

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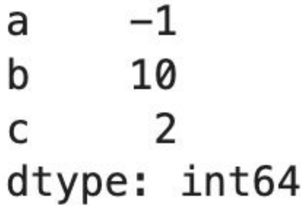
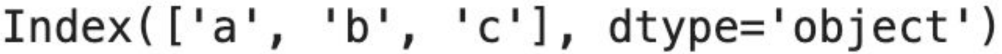
- We can provide index labels for items in a **Series** by passing an index list.

```
s = pd.Series([-1, 10, 2], index = ["a", "b", "c"])
```



```
a    -1
b    10
c     2
dtype: int64
```

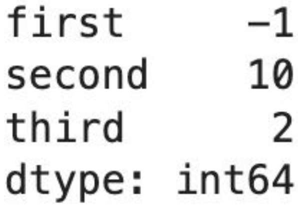
```
s.index
```



```
Index(['a', 'b', 'c'], dtype='object')
```

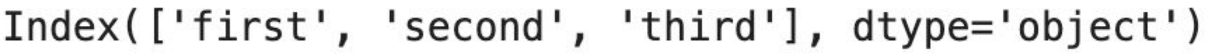
- A **Series** index can also be changed.

```
s.index = ["first", "second", "third"]
```



```
first     -1
second    10
third      2
dtype: int64
```

```
s.index
```

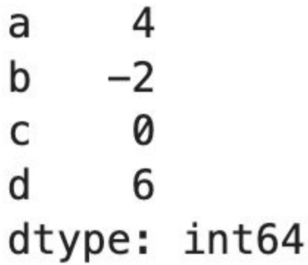


```
Index(['first', 'second', 'third'], dtype='object')
```

Selection in `Series`

- We can select a single value or a set of values in a **`Series`** using:
  - A single label
  - A list of labels
  - A filtering condition

```
s = pd.Series([4, -2, 0, 6], index = ["a", "b", "c", "d"])
```



```
a     4
b    -2
c     0
d     6
dtype: int64
```

Selection in `Series`

- We can select a single value or a set of values in a `Series` using:
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    - A filtering condition

```
s = pd.Series([4, -2, 0, 6], index = ["a", "b", "c", "d"])
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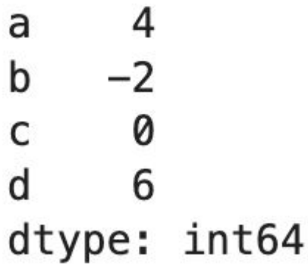

```
a     4
b    -2
c     0
d     6
dtype: int64
```

```
s["a"]
```

```
4
```

Selection in `Series`

- We can select a single value or a set of values in a `Series` using:
  - A single label
  - **A list of labels**
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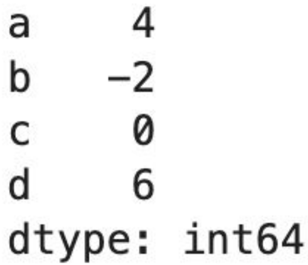
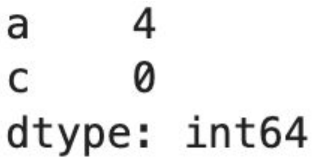
```



```
a    4
b   -2
c    0
d    6
dtype: int64
```

```
s[["a", "c"]]
```



```
a    4
c    0
dtype: int64
```

Selection in `Series`

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- We can select a single value or a set of values in a **`Series`** using:
  - A single label
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  - **A filtering condition**

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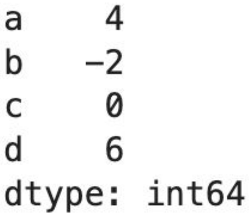
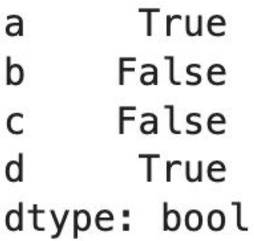
```



```
a     4
b    -2
c     0
d     6
dtype: int64
```

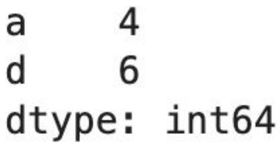
- Say we want to select values in the **`Series`** that satisfy a particular condition:
  1) Apply a boolean condition to the **`Series`**. This creates a **new `Series` of boolean values**.
  2) Index into our **`Series`** using this boolean condition. **`pandas`** will select only the entries in the **`Series`** that satisfy the condition.

```
s > 0
```



```
a     True
b    False
c    False
d     True
dtype: bool
```

```
s[s > 0]
```



```
a    4
d    6
dtype: int64
```

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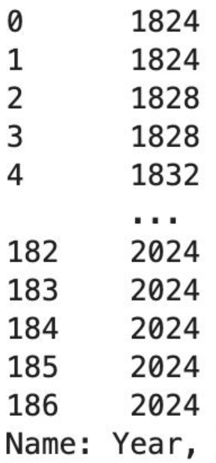
What is the output of the following code?

Click **Present with Slido** or install our Chrome extension to activate this poll while presenting.

DataFrames of Series!

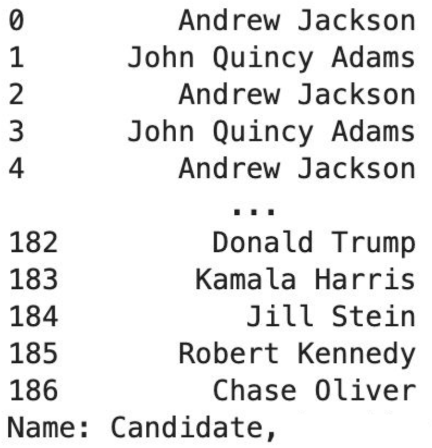
Typically, we will work with **Series** using the perspective that they are columns in a **DataFrame**.

We can think of a **DataFrame** as a collection of **Series** that all share the same **Index**.



```
0      1824
1      1824
2      1828
3      1828
4      1832
       ...
182    2024
183    2024
184    2024
185    2024
186    2024
Name: Year,
```

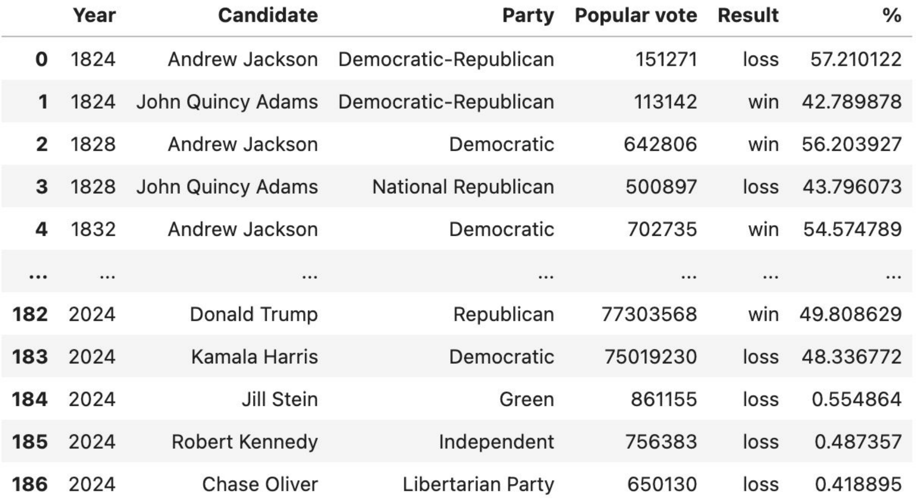
The Series **"Year"**



```
0          Andrew Jackson
1       John Quincy Adams
2          Andrew Jackson
3       John Quincy Adams
4          Andrew Jackson
               ...
182          Donald Trump
183         Kamala Harris
184            Jill Stein
185        Robert Kennedy
186          Chase Oliver
Name: Candidate,
```

The Series **"Candidate"**

[...]



	Year	Candidate	Party	Popular vote	Result	%
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4	1832	Andrew Jackson	Democratic	702735	win	54.574789
...	...	...	...	...	...	...
182	2024	Donald Trump	Republican	77303568	win	49.808629
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186	2024	Chase Oliver	Libertarian Party	650130	loss	0.418895

The DataFrame **elections**

Non-native English speaker note: The plural of "series" is "series". Sorry.

Creating a `DataFrame`

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The syntax of creating `DataFrame` is:

```
pandas.DataFrame(data, index, columns)
```

Many approaches exist for creating a `DataFrame`. Here, we will go over the most popular ones.

- From a CSV file.
- Using a list and column name(s).
- From a dictionary.
- From a `Series`.

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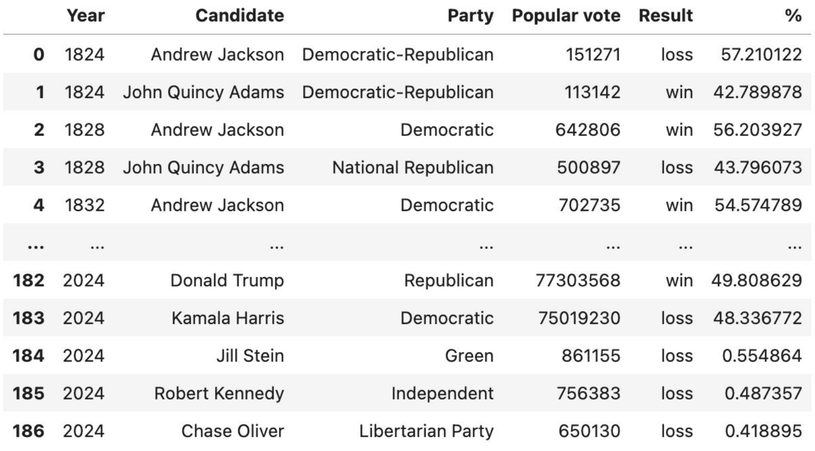
- Using a list and column name(s).
- From a dictionary.
- From a **`Series`**.

```
elections = pd.read_csv("data/elections.csv")
```



	Year	Candidate	Party	Popular vote	Result	%
0	1824	Andrew Jackson	Democratic-Republican	151271	loss	57.210122
1	1824	John Quincy Adams	Democratic-Republican	113142	win	42.789878
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3	1828	John Quincy Adams	National Republican	500897	loss	43.796073
4	1832	Andrew Jackson	Democratic	702735	win	54.574789
...	...	...	...	...	...	...
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The DataFrame **`elections`**

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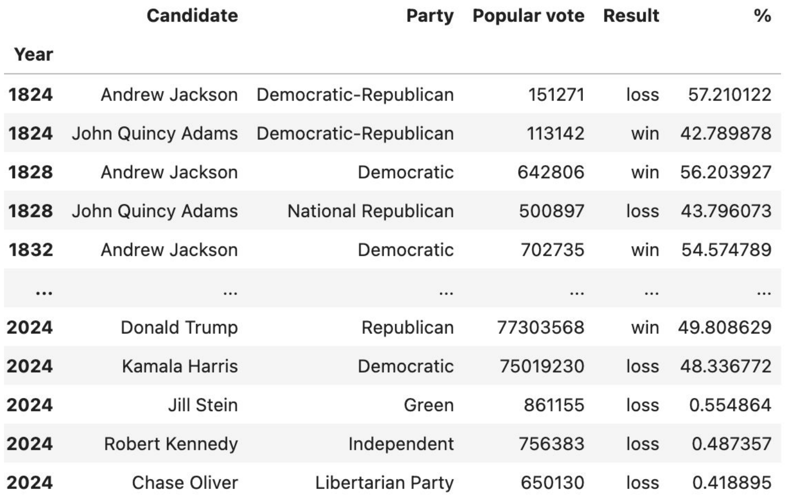
- **From a CSV file**.
- Using a list and column name(s).
- From a dictionary.
- From a `Series`.

```
elections = pd.read_csv("data/elections.csv", index_col="Year")
```



	Candidate	Party	Popular vote	Result	%
Year					
1824	Andrew Jackson	Democratic-Republican	151271	loss	57.210122
1824	John Quincy Adams	Democratic-Republican	113142	win	42.789878
1828	Andrew Jackson	Democratic	642806	win	56.203927
1828	John Quincy Adams	National Republican	500897	loss	43.796073
1832	Andrew Jackson	Democratic	702735	win	54.574789
...	...	...	...	...	...
2024	Donald Trump	Republican	77303568	win	49.808629
2024	Kamala Harris	Democratic	75019230	loss	48.336772
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2024	Robert Kennedy	Independent	756383	loss	0.487357
2024	Chase Oliver	Libertarian Party	650130	loss	0.418895

The DataFrame `elections` with `"Year"` as `Index`

Creating a DataFrame

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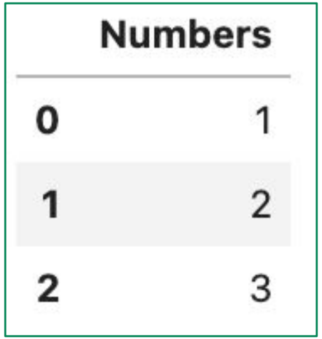
Many approaches exist for creating a **DataFrame**. Here, we will go over the most popular ones.

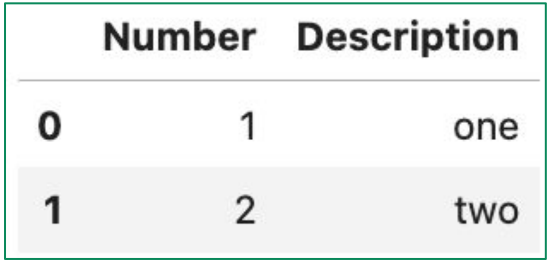
- From a CSV file.
- **Using a list and column name(s)**.
- From a dictionary.
- From a **Series**.

```
pd.DataFrame([1, 2, 3],
             columns=["Numbers"])
```

```
pd.DataFrame([[1, "one"], [2, "two"]],
             columns = ["Number", "Description"])
```



	Numbers
0	1
1	2
2	3



	Number	Description
0	1	one
1	2	two

Creating a DataFrame

Many approaches exist for creating a **DataFrame**. Here, we will go over the most popular ones.

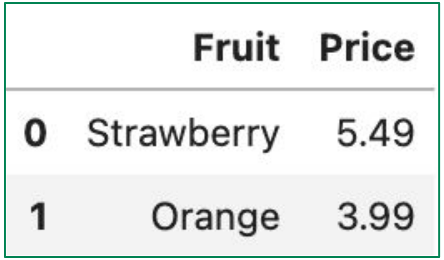
- From a CSV file.
- Using a list and column name(s).
- **From a dictionary**.
- From a **Series**.

Specify columns of the **DataFrame**

```
pd.DataFrame({"Fruit":["Strawberry", "Orange"],
              "Price": [5.49, 3.99]})
```

```
pd.DataFrame([{"Fruit":"Strawberry", "Price":5.49},
              {"Fruit":"Orange", "Price":3.99}])
```

Specify rows of the **DataFrame**



	Fruit	Price
0	Strawberry	5.49
1	Orange	3.99

Creating a DataFrame

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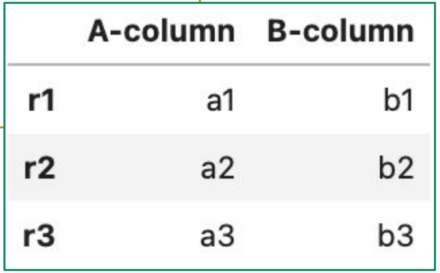
Many approaches exist for creating a **DataFrame**. Here, we will go over the most popular ones.

- From a CSV file.
- Using a list and column name(s).
- From a dictionary.
- **From a Series**.

```
s_a = pd.Series(["a1", "a2", "a3"], index = ["r1", "r2", "r3"])
s_b = pd.Series(["b1", "b2", "b3"], index = ["r1", "r2", "r3"])

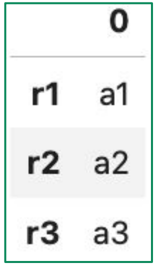
pd.DataFrame({"A-column":s_a, "B-column":s_b})
```



	A-column	B-column
r1	a1	b1
r2	a2	b2
r3	a3	b3

```
pd.DataFrame(s_a)
```

```
s_a.to_frame()
```



	0
r1	a1
r2	a2
r3	a3

Indices Are Not Necessarily Row Numbers

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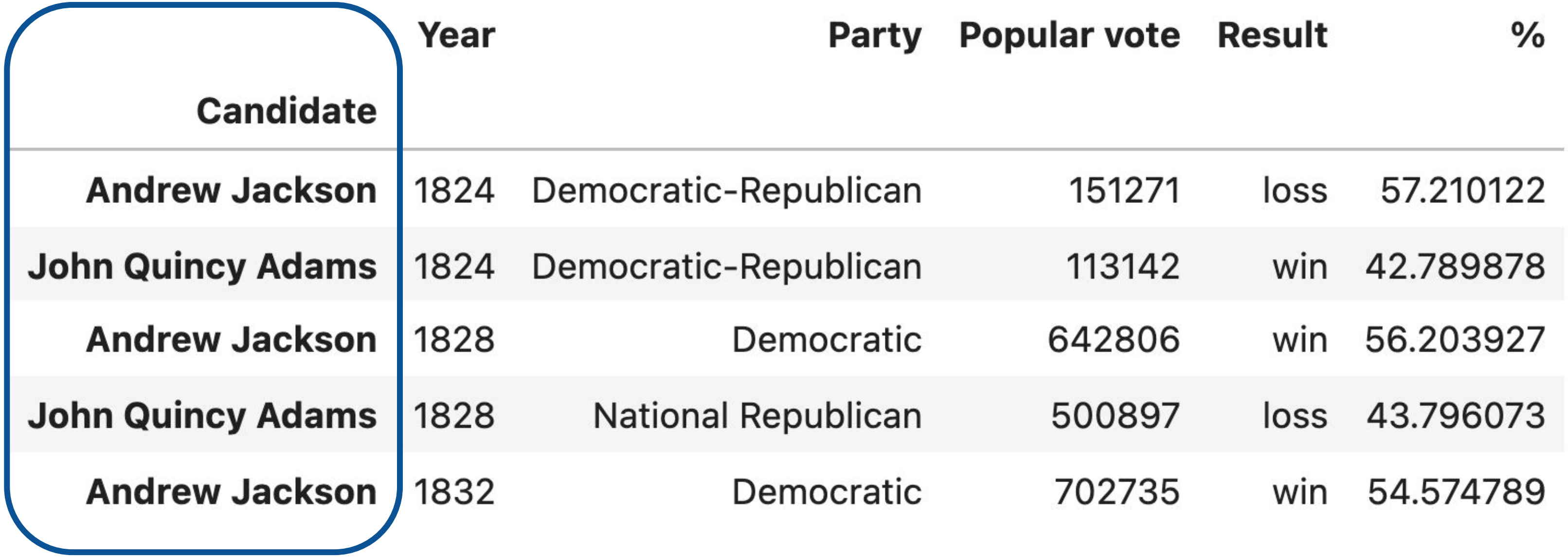
An **Index** (a.k.a. row labels) can also:

- Be non-numeric.
- Have a name, e.g. "Candidate".

```
# Creating a DataFrame from a CSV file and specifying the Index column
elections = pd.read_csv("data/elections.csv", index_col = "Candidate")
```

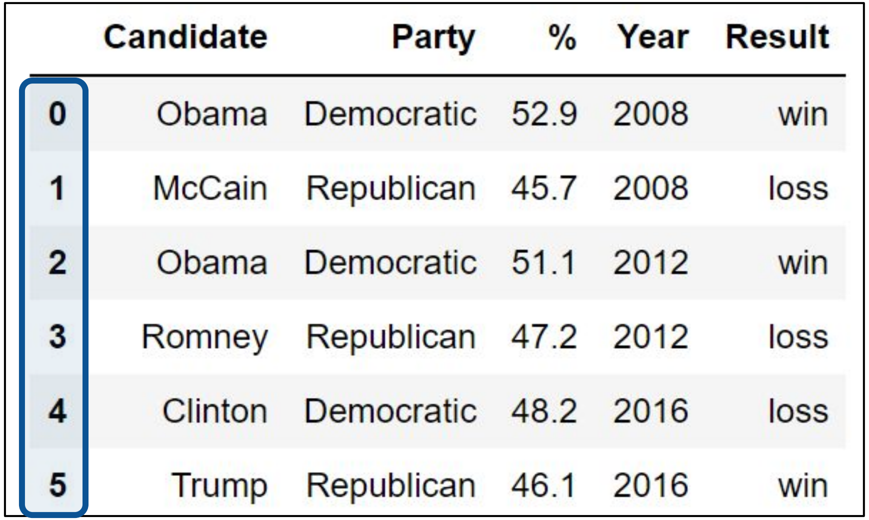


	Year	Party	Popular vote	Result	%
Candidate					
Andrew Jackson	1824	Democratic-Republican	151271	loss	57.210122
John Quincy Adams	1824	Democratic-Republican	113142	win	42.789878
Andrew Jackson	1828	Democratic	642806	win	56.203927
John Quincy Adams	1828	National Republican	500897	loss	43.796073
Andrew Jackson	1832	Democratic	702735	win	54.574789

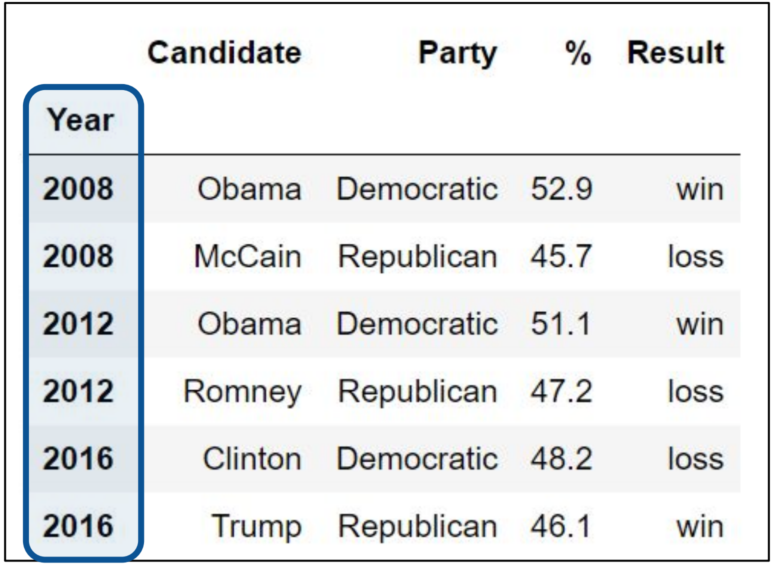
Indices Are Not Necessarily Unique

The row labels that constitute an index do not have to be unique.

- Left: The **index** values are all unique and numeric, acting as a row number.
- Right: The **index** values are named and non-unique.



	Candidate	Party	%	Year	Result
0	Obama	Democratic	52.9	2008	win
1	McCain	Republican	45.7	2008	loss
2	Obama	Democratic	51.1	2012	win
3	Romney	Republican	47.2	2012	loss
4	Clinton	Democratic	48.2	2016	loss
5	Trump	Republican	46.1	2016	win



	Candidate	Party	%	Result
Year				
2008	Obama	Democratic	52.9	win
2008	McCain	Republican	45.7	loss
2012	Obama	Democratic	51.1	win
2012	Romney	Republican	47.2	loss
2016	Clinton	Democratic	48.2	loss
2016	Trump	Republican	46.1	win

Modifying Indices

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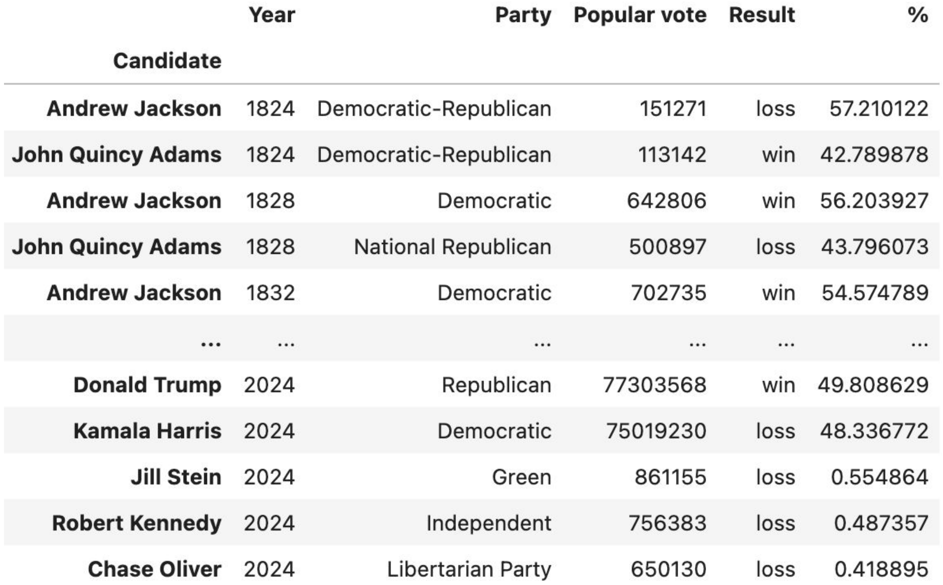
- We can select a new column and set it as the index of the `DataFrame`.

Example: Setting the index to the "Candidate" column.

```
elections.set_index("Candidate")
```



	Year	Party	Popular vote	Result	%
Candidate					
Andrew Jackson	1824	Democratic-Republican	151271	loss	57.210122
John Quincy Adams	1824	Democratic-Republican	113142	win	42.789878
Andrew Jackson	1828	Democratic	642806	win	56.203927
John Quincy Adams	1828	National Republican	500897	loss	43.796073
Andrew Jackson	1832	Democratic	702735	win	54.574789
...	...	...	...	...	...
Donald Trump	2024	Republican	77303568	win	49.808629
Kamala Harris	2024	Democratic	75019230	loss	48.336772
Jill Stein	2024	Green	861155	loss	0.554864
Robert Kennedy	2024	Independent	756383	loss	0.487357
Chase Oliver	2024	Libertarian Party	650130	loss	0.418895

Resetting the `Index`

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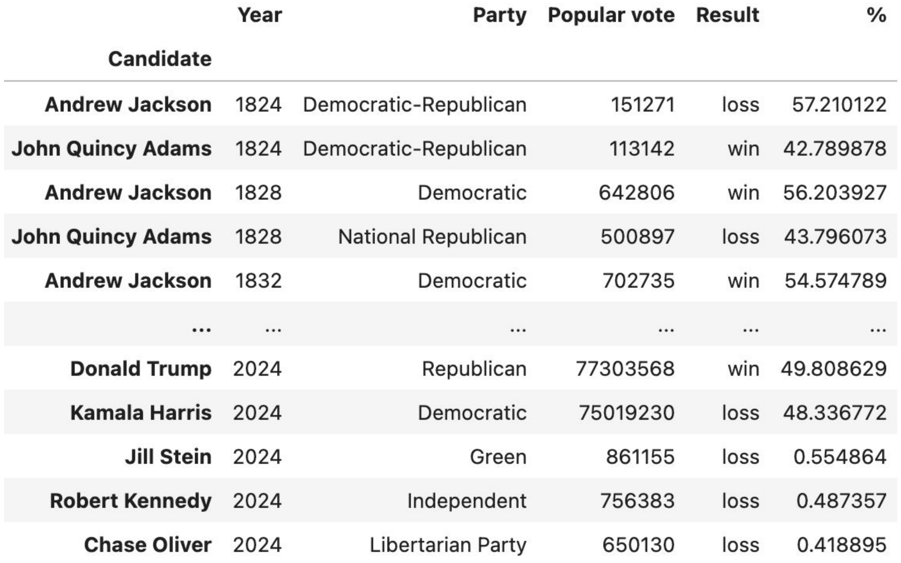
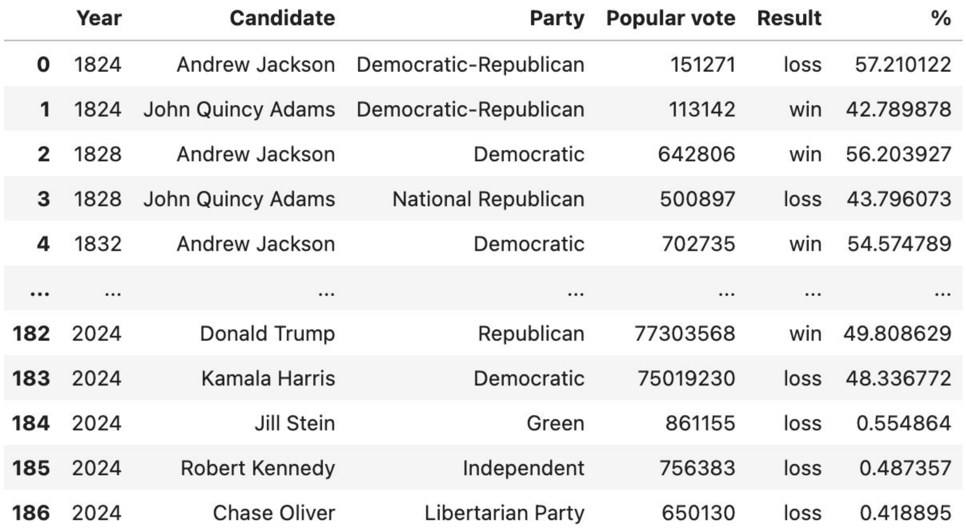
- We can change our mind and reset the **`Index`** back to the default list of integers.

```python
elections.reset_index()
```



	Year	Party	Popular vote	Result	%
Candidate					
Andrew Jackson	1824	Democratic-Republican	151271	loss	57.210122
John Quincy Adams	1824	Democratic-Republican	113142	win	42.789878
Andrew Jackson	1828	Democratic	642806	win	56.203927
John Quincy Adams	1828	National Republican	500897	loss	43.796073
Andrew Jackson	1832	Democratic	702735	win	54.574789
...	...	...	...	...	...
Donald Trump	2024	Republican	77303568	win	49.808629
Kamala Harris	2024	Democratic	75019230	loss	48.336772
Jill Stein	2024	Green	861155	loss	0.554864
Robert Kennedy	2024	Independent	756383	loss	0.487357
Chase Oliver	2024	Libertarian Party	650130	loss	0.418895

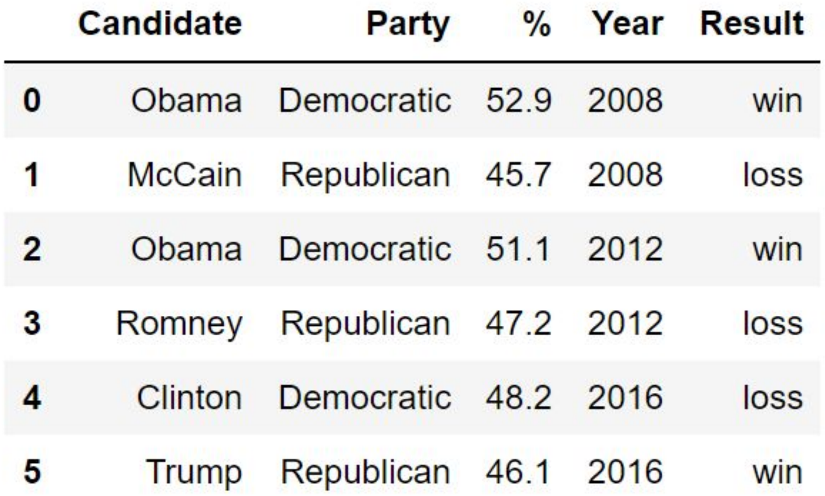


	Year	Candidate	Party	Popular vote	Result	%
0	1824	Andrew Jackson	Democratic-Republican	151271	loss	57.210122
1	1824	John Quincy Adams	Democratic-Republican	113142	win	42.789878
2	1828	Andrew Jackson	Democratic	642806	win	56.203927
3	1828	John Quincy Adams	National Republican	500897	loss	43.796073
4	1832	Andrew Jackson	Democratic	702735	win	54.574789
...	...	...	...	...	...	...
182	2024	Donald Trump	Republican	77303568	win	49.808629
183	2024	Kamala Harris	Democratic	75019230	loss	48.336772
184	2024	Jill Stein	Green	861155	loss	0.554864
185	2024	Robert Kennedy	Independent	756383	loss	0.487357
186	2024	Chase Oliver	Libertarian Party	650130	loss	0.418895

Column Names Are Usually Unique!

Column names in `pandas` are almost always unique.

- Example: Really shouldn't have two columns named "`Candidate`".



	Candidate	Party	%	Year	Result
0	Obama	Democratic	52.9	2008	win
1	McCain	Republican	45.7	2008	loss
2	Obama	Democratic	51.1	2012	win
3	Romney	Republican	47.2	2012	loss
4	Clinton	Democratic	48.2	2016	loss
5	Trump	Republican	46.1	2016	win

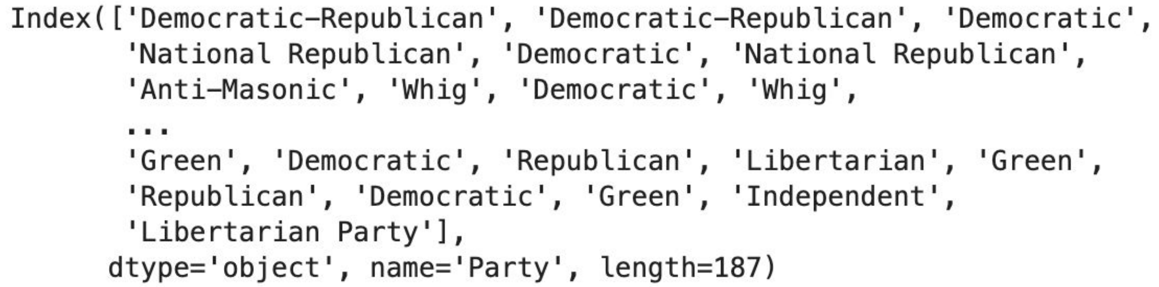
Retrieving the Index, Columns, and shape

Sometimes you'll want to extract the list of row and column labels.

```
elections.set_index("Party")
```

For row labels, use `DataFrame.index`:

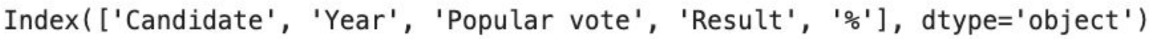
```
elections.index
```



```
Index(['Democratic-Republican', 'Democratic-Republican', 'Democratic',
       'National Republican', 'Democratic', 'National Republican',
       'Anti-Masonic', 'Whig', 'Democratic', 'Whig',
       ...
       'Green', 'Democratic', 'Republican', 'Libertarian', 'Green',
       'Republican', 'Democratic', 'Green', 'Independent',
       'Libertarian Party'],
      dtype='object', name='Party', length=187)
```

For column labels, use `DataFrame.columns`:

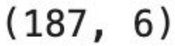
```
elections.columns
```



```
Index(['Candidate', 'Year', 'Popular vote', 'Result', '%'], dtype='object')
```

For shape of the `DataFrame` we use `DataFrame.shape`:

```
elections.shape
```



```
(187, 6)
```

The Relationship Between DataFrames, Series, and Indices

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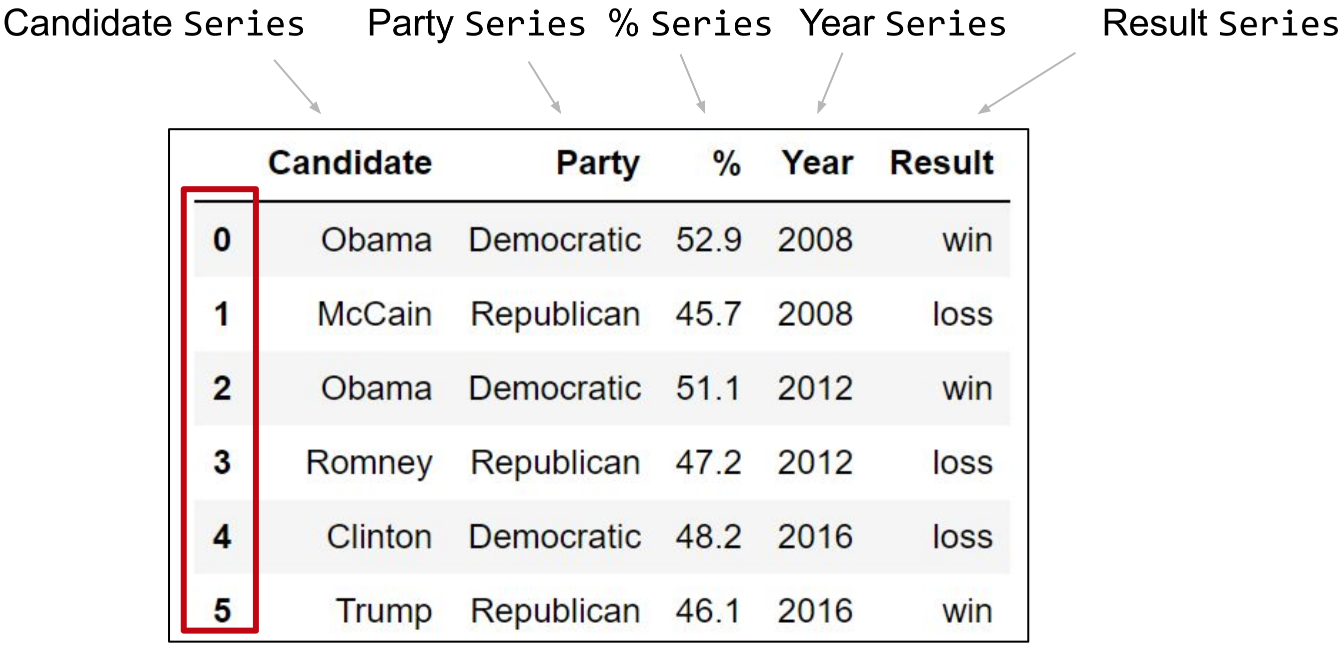
We can think of a **`DataFrame`** as a collection of **`Series`** that all share the same **`Index`**.

- Candidate, Party, %, Year, and Result **`Series`** all share an **`Index`** from 0 to 5.



Candidate `Series`   Party `Series`   % `Series`   Year `Series`   Result `Series`

	Candidate	Party	%	Year	Result
0	Obama	Democratic	52.9	2008	win
1	McCain	Republican	45.7	2008	loss
2	Obama	Democratic	51.1	2012	win
3	Romney	Republican	47.2	2012	loss
4	Clinton	Democratic	48.2	2016	loss
5	Trump	Republican	46.1	2016	win

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slido

Which of the following lines of code creates this DataFrame?

Click **Present with Slido** or install our Chrome extension to activate this poll while presenting.

The `DataFrame` API

The API for the **`DataFrame`** class is enormous.

- API: "Application Programming Interface".
- The API is the set of abstractions supported by the class.

Full documentation is at https://pandas.pydata.org/docs/reference/api/pandas.DataFrame.html

- Compare with the **`Table`** class from Data8: http://data8.org/datascience/tables.html
- We will only consider a tiny portion of this API.

We want you to get familiar with the real world programming practice of… Googling!

- Answers to your questions are often found in the **`pandas`** documentation, Stack Overflow, etc.

Interlude

Break!

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Data Extraction with `loc`, `iloc`, and `[ ]`

Lecture 02, Data 100 Spring 2025

- Tabular data
- DataFrames, Series, and Indices
- **Data extraction with `loc`, `iloc`, and `[]`**

Extracting Data

One of the most basic tasks for manipulating a `DataFrame` is to extract rows and columns of interest. As we'll see, the large `pandas` API means there are many ways to do things.

Common ways we may want to extract data:

- Grab the first or last `n` rows in the `DataFrame`.
- Grab data with a certain label.
- Grab data at a certain position.

We'll find that all three of these methods are useful to us in data manipulation tasks.

`.head` and `.tail`

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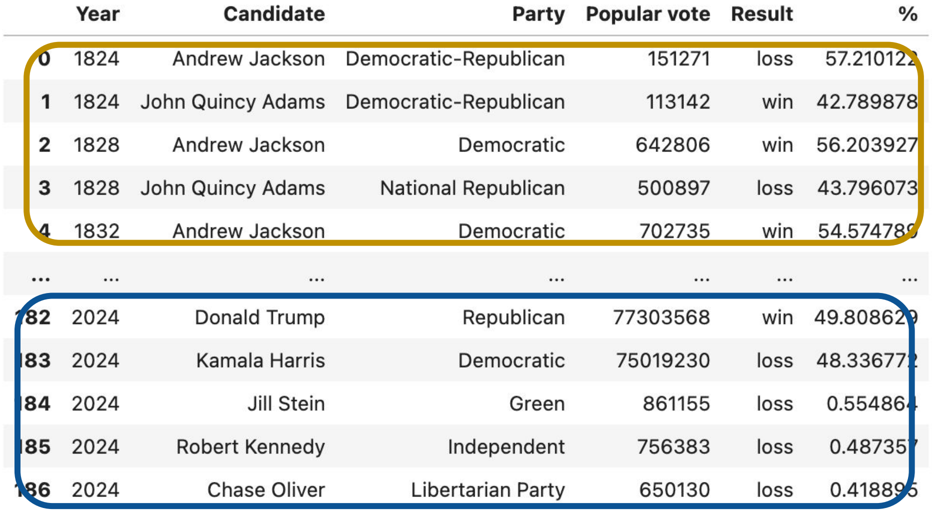
The simplest scenarios: We want to extract the first or last **`n`** rows from the **`DataFrame`**.

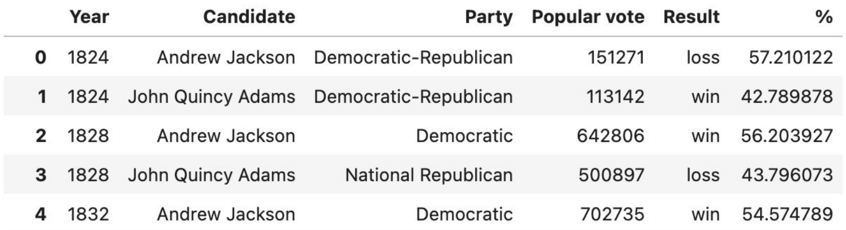
- **`df.head(n)`** will return the first **`n`** rows of the DataFrame **`df`**.
- **`df.tail(n)`** will return the last **`n`** rows.

`elections`



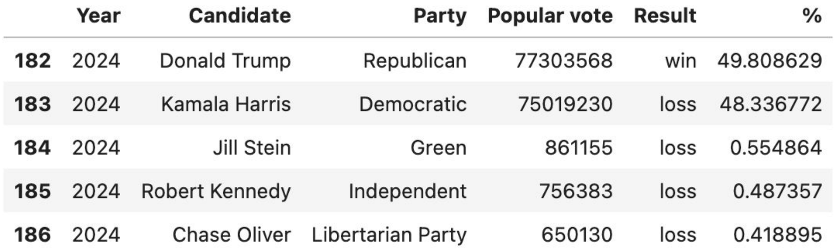
	Year	Candidate	Party	Popular vote	Result	%
0	1824	Andrew Jackson	Democratic-Republican	151271	loss	57.210122
1	1824	John Quincy Adams	Democratic-Republican	113142	win	42.789878
2	1828	Andrew Jackson	Democratic	642806	win	56.203927
3	1828	John Quincy Adams	National Republican	500897	loss	43.796073
4	1832	Andrew Jackson	Democratic	702735	win	54.574789
...	...	...	...	...	...	...
182	2024	Donald Trump	Republican	77303568	win	49.808629
183	2024	Kamala Harris	Democratic	75019230	loss	48.336772
184	2024	Jill Stein	Green	861155	loss	0.554864
185	2024	Robert Kennedy	Independent	756383	loss	0.487357
186	2024	Chase Oliver	Libertarian Party	650130	loss	0.418895

`elections.head(5)`



	Year	Candidate	Party	Popular vote	Result	%
0	1824	Andrew Jackson	Democratic-Republican	151271	loss	57.210122
1	1824	John Quincy Adams	Democratic-Republican	113142	win	42.789878
2	1828	Andrew Jackson	Democratic	642806	win	56.203927
3	1828	John Quincy Adams	National Republican	500897	loss	43.796073
4	1832	Andrew Jackson	Democratic	702735	win	54.574789

`elections.tail(5)`



	Year	Candidate	Party	Popular vote	Result	%
182	2024	Donald Trump	Republican	77303568	win	49.808629
183	2024	Kamala Harris	Democratic	75019230	loss	48.336772
184	2024	Jill Stein	Green	861155	loss	0.554864
185	2024	Robert Kennedy	Independent	756383	loss	0.487357
186	2024	Chase Oliver	Libertarian Party	650130	loss	0.418895

Label-based Extraction: `.loc`

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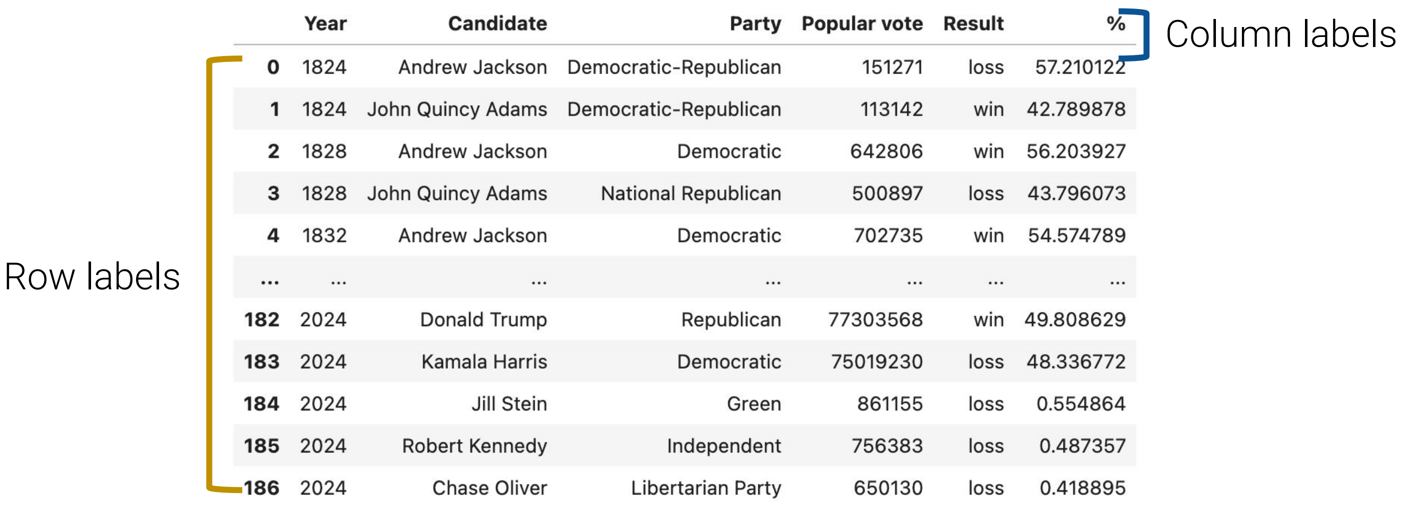
A more complex task: We want to extract data with specific column or index labels.

```
df.loc[row_labels, column_labels]
```

The `.loc` accessor allows us to specify the ***labels*** of rows and columns we wish to extract.

- We describe "labels" as the bolded text at the top and left of a `DataFrame`.



Column labels

Row labels

	Year	Candidate	Party	Popular vote	Result	%
0	1824	Andrew Jackson	Democratic-Republican	151271	loss	57.210122
1	1824	John Quincy Adams	Democratic-Republican	113142	win	42.789878
2	1828	Andrew Jackson	Democratic	642806	win	56.203927
3	1828	John Quincy Adams	National Republican	500897	loss	43.796073
4	1832	Andrew Jackson	Democratic	702735	win	54.574789
...	...	...	...	...	...	...
182	2024	Donald Trump	Republican	77303568	win	49.808629
183	2024	Kamala Harris	Democratic	75019230	loss	48.336772
184	2024	Jill Stein	Green	861155	loss	0.554864
185	2024	Robert Kennedy	Independent	756383	loss	0.487357
186	2024	Chase Oliver	Libertarian Party	650130	loss	0.418895

Label-based Extraction: `.loc`

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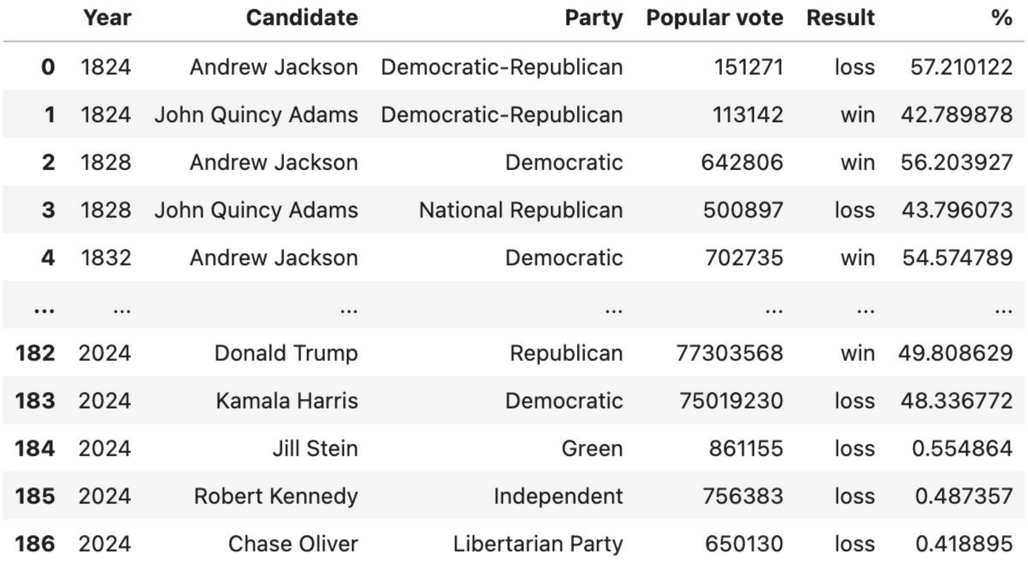
Arguments to `.loc` can be:

- A list.
- A slice (syntax is inclusive of the right hand side of the slice).
- A single value.



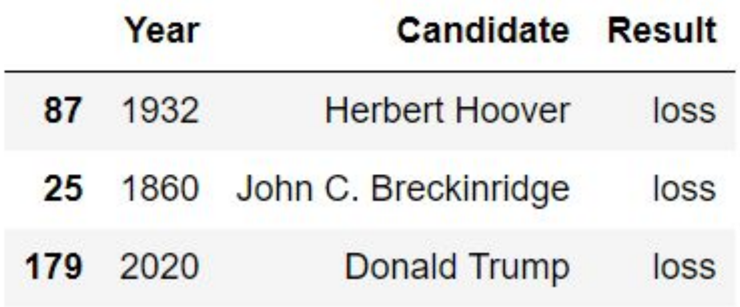
	Year	Candidate	Party	Popular vote	Result	%
0	1824	Andrew Jackson	Democratic-Republican	151271	loss	57.210122
1	1824	John Quincy Adams	Democratic-Republican	113142	win	42.789878
2	1828	Andrew Jackson	Democratic	642806	win	56.203927
3	1828	John Quincy Adams	National Republican	500897	loss	43.796073
4	1832	Andrew Jackson	Democratic	702735	win	54.574789
...	...	...	...	...	...	...
182	2024	Donald Trump	Republican	77303568	win	49.808629
183	2024	Kamala Harris	Democratic	75019230	loss	48.336772
184	2024	Jill Stein	Green	861155	loss	0.554864
185	2024	Robert Kennedy	Independent	756383	loss	0.487357
186	2024	Chase Oliver	Libertarian Party	650130	loss	0.418895

Label-based Extraction: `.loc`

Arguments to `.loc` can be:

- **A list.**
- A slice (syntax is inclusive of the right hand side of the slice).
- A single value.

```
elections.loc[[87, 25, 179], ["Year", "Candidate", "Result"]]
```



	Year	Candidate	Result
87	1932	Herbert Hoover	loss
25	1860	John C. Breckinridge	loss
179	2020	Donald Trump	loss

Select the columns with labels "Year", "Candidate", and "Result".

Select the rows with labels 87, 25, and 179.

Label-based Extraction: `.loc`

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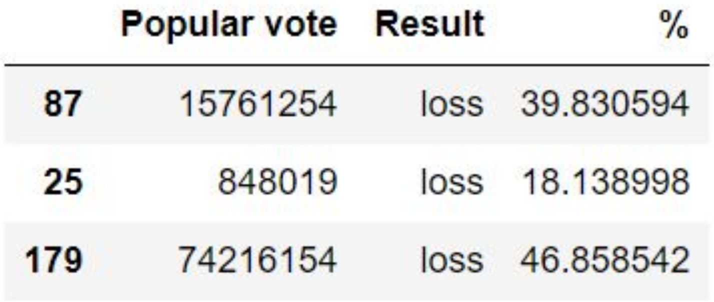
Arguments to `.loc` can be:

- A list.
- **A slice** (syntax is **inclusive of the right hand side of the slice**).
- A single value.

```
elections.loc[[87, 25, 179], "Popular vote":"%"]
```

Select all columns *starting* from "Popular vote" *until* "%".

Select the rows with labels 87, 25, and 179.



	Popular vote	Result	%
87	15761254	loss	39.830594
25	848019	loss	18.138998
179	74216154	loss	46.858542

Label-based Extraction: `.loc`

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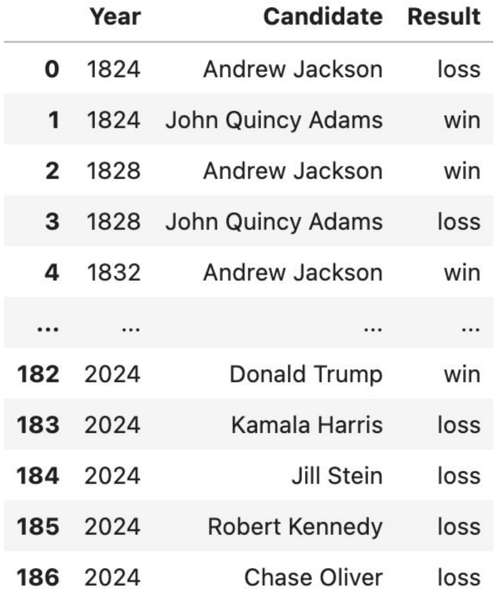
To extract *all* rows or *all* columns, use a colon (`:`)

```
elections.loc[:, ["Year", "Candidate", "Result"]]
```

All rows for the columns with labels "Year", "Candidate", and "Result".

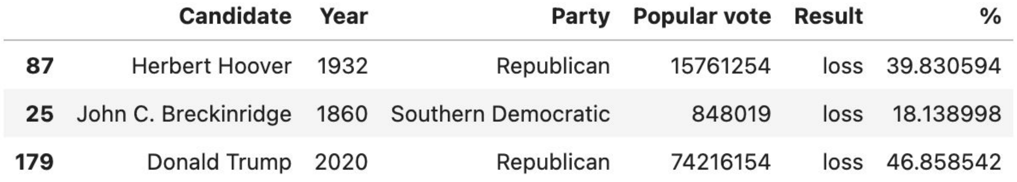
Ellipses (...) indicate more rows not shown. →



	Year	Candidate	Result
0	1824	Andrew Jackson	loss
1	1824	John Quincy Adams	win
2	1828	Andrew Jackson	win
3	1828	John Quincy Adams	loss
4	1832	Andrew Jackson	win
...	...	...	...
182	2024	Donald Trump	win
183	2024	Kamala Harris	loss
184	2024	Jill Stein	loss
185	2024	Robert Kennedy	loss
186	2024	Chase Oliver	loss

```
elections.loc[[87, 25, 179], :]
```

All columns for the rows with labels 87, 25, 179.



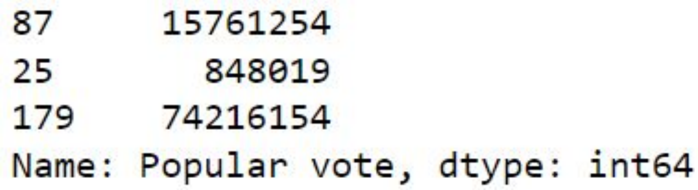
	Candidate	Year	Party	Popular vote	Result	%
87	Herbert Hoover	1932	Republican	15761254	loss	39.830594
25	John C. Breckinridge	1860	Southern Democratic	848019	loss	18.138998
179	Donald Trump	2020	Republican	74216154	loss	46.858542

Label-based Extraction: `.loc`

Arguments to `.loc` can be:

- A list.
- A slice (syntax is inclusive of the right hand side of the slice).
- **A single value.**

```
elections.loc[[87, 25, 179], "Popular vote"]
```



```
87      15761254
25        848019
179     74216154
Name: Popular vote, dtype: int64
```

Wait, what? Why did everything get so ugly?

We've extracted a subset of the "Popular vote" column as a `Series`.

```
elections.loc[0, "Candidate"]
```

```
'Andrew Jackson'
```

We've extracted the string value with row label 0 and column label "Candidate".

Lecture 2 ended here!

We will cover the rest in lecture 3

Integer-based Extraction: `.iloc`

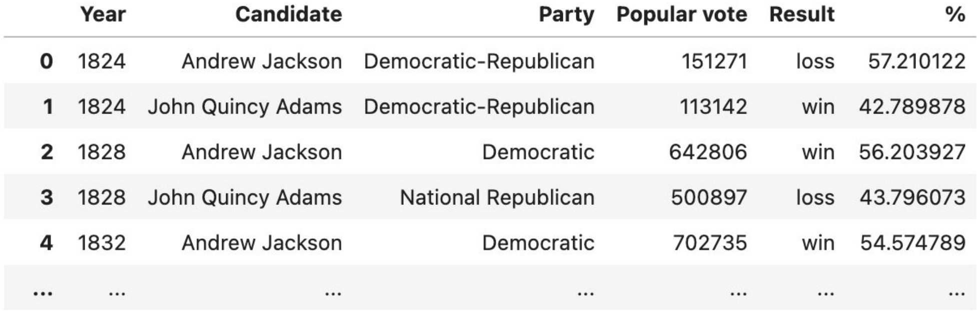
A different scenario: We want to extract data according to its *position*.

- Example: Grab the 1st, 2nd, and 3rd columns of the `DataFrame`.

```
df.iloc[row_integers, column_integers]
```

The `.iloc` accessor allows us to specify the ***integers*** of rows and columns we wish to extract.

- Python convention: The first position has integer index 0.



		0	1	2	3	4	5
		Year	**Candidate**	**Party**	**Popular vote**	**Result**	**%**
0	**0**	1824	Andrew Jackson	Democratic-Republican	151271	loss	57.210122
1	**1**	1824	John Quincy Adams	Democratic-Republican	113142	win	42.789878
2	**2**	1828	Andrew Jackson	Democratic	642806	win	56.203927
3	**3**	1828	John Quincy Adams	National Republican	500897	loss	43.796073
4	**4**	1832	Andrew Jackson	Democratic	702735	win	54.574789
	...	...	...	...	...	...	...

Column integers

Row integers

Integer-based Extraction: `.iloc`

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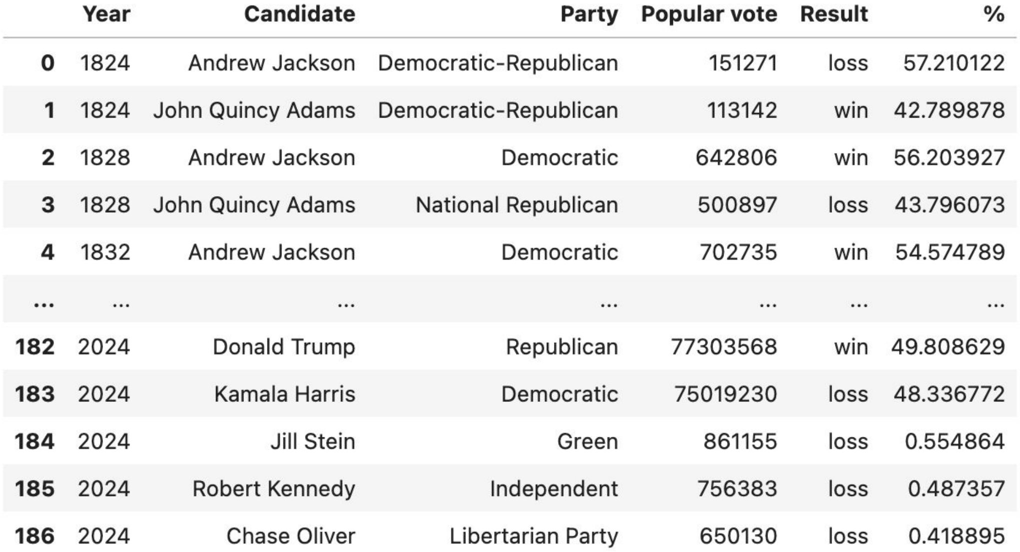
Arguments to `.iloc` can be:

- A list.
- A slice (syntax is **exclusive** of the right hand side of the slice).
- A single value.



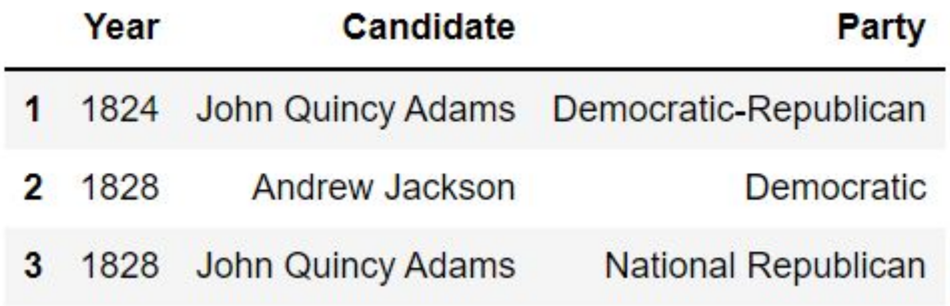
	Year	Candidate	Party	Popular vote	Result	%
0	1824	Andrew Jackson	Democratic-Republican	151271	loss	57.210122
1	1824	John Quincy Adams	Democratic-Republican	113142	win	42.789878
2	1828	Andrew Jackson	Democratic	642806	win	56.203927
3	1828	John Quincy Adams	National Republican	500897	loss	43.796073
4	1832	Andrew Jackson	Democratic	702735	win	54.574789
...	...	...	...	...	...	...
182	2024	Donald Trump	Republican	77303568	win	49.808629
183	2024	Kamala Harris	Democratic	75019230	loss	48.336772
184	2024	Jill Stein	Green	861155	loss	0.554864
185	2024	Robert Kennedy	Independent	756383	loss	0.487357
186	2024	Chase Oliver	Libertarian Party	650130	loss	0.418895

Integer-based Extraction: `.iloc`

Arguments to `.iloc` can be:

- **A list.**
- A slice (syntax is **exclusive** of the right hand side of the slice).
- A single value.

```
elections.iloc[[1, 2, 3], [0, 1, 2]]
```



	Year	Candidate	Party
1	1824	John Quincy Adams	Democratic-Republican
2	1828	Andrew Jackson	Democratic
3	1828	John Quincy Adams	National Republican

Select the columns at positions 0, 1, and 2.

Select the rows at positions 1, 2, and 3.

Integer-based Extraction: `.iloc`

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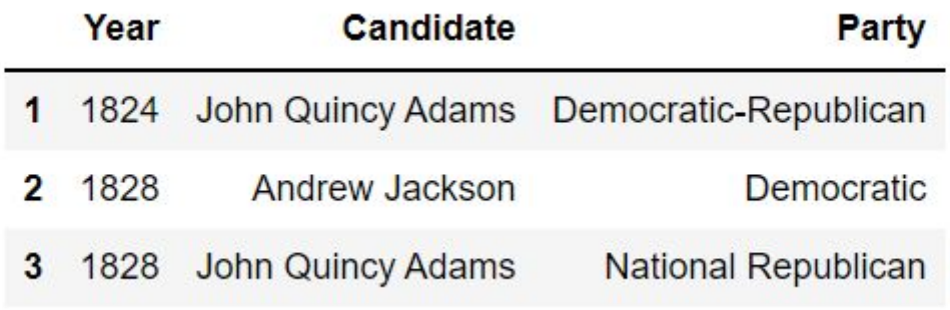
Arguments to `.iloc` can be:

- A list.
- **A slice** (syntax is **exclusive of the right hand side of the slice**).
- A single value.

```
elections.iloc[[1, 2, 3], 0:3]
```



	Year	Candidate	Party
1	1824	John Quincy Adams	Democratic-Republican
2	1828	Andrew Jackson	Democratic
3	1828	John Quincy Adams	National Republican

Select the rows at positions 1, 2, and 3.

Select *all* columns from integer 0 *to* integer 2.

Remember: integer-based slicing is right-end exclusive!

Integer-based Extraction: `.iloc`

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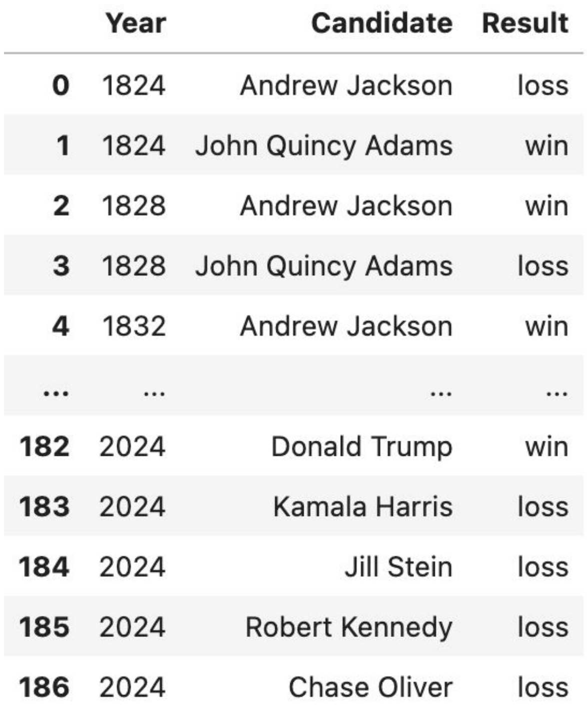
Just like `.loc`, we can use a colon with `.iloc` to extract all rows or all columns.

```
elections.iloc[:, 0:3]
```



	Year	Candidate	Result
0	1824	Andrew Jackson	loss
1	1824	John Quincy Adams	win
2	1828	Andrew Jackson	win
3	1828	John Quincy Adams	loss
4	1832	Andrew Jackson	win
...	...	...	...
182	2024	Donald Trump	win
183	2024	Kamala Harris	loss
184	2024	Jill Stein	loss
185	2024	Robert Kennedy	loss
186	2024	Chase Oliver	loss

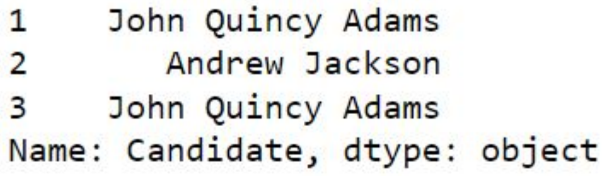
Grab all rows of the columns at integers 0 to 2.

Integer-based Extraction: `.iloc`

Arguments to `.iloc` can be:

- A list.
- A slice (syntax is exclusive of the right hand side of the slice).
- **A single value.**

```
elections.iloc[[1, 2, 3], 1]
```



```
1     John Quincy Adams
2        Andrew Jackson
3     John Quincy Adams
Name: Candidate, dtype: object
```

As before, the result for a single value argument is a `Series`.

We have extracted row integers 1, 2, and 3 from the column at position 1.

```
elections.iloc[0, 1]
```

```
'Andrew Jackson'
```

We've extracted the string value with row position 0 and column position 1.

`.loc` vs `.iloc`

Remember:

- `.loc` performs label-based extraction
- `.iloc` performs integer-based extraction

When choosing between `.loc` and `.iloc`, you'll usually choose `.loc`.

- Safer: If the order of data gets shuffled in a public database, your code still works.
- Readable: Easier to understand what `elections.loc[:, ["Year", "Candidate", "Result"]]` means than `elections.iloc[:, [0, 1, 4]]`

`.iloc` can still be useful.

- Example: If you have a `DataFrame` of movie earnings sorted by earnings, can use `.iloc` to get the median earnings for a given year (index into the middle).

… Just When It Was All Making Sense

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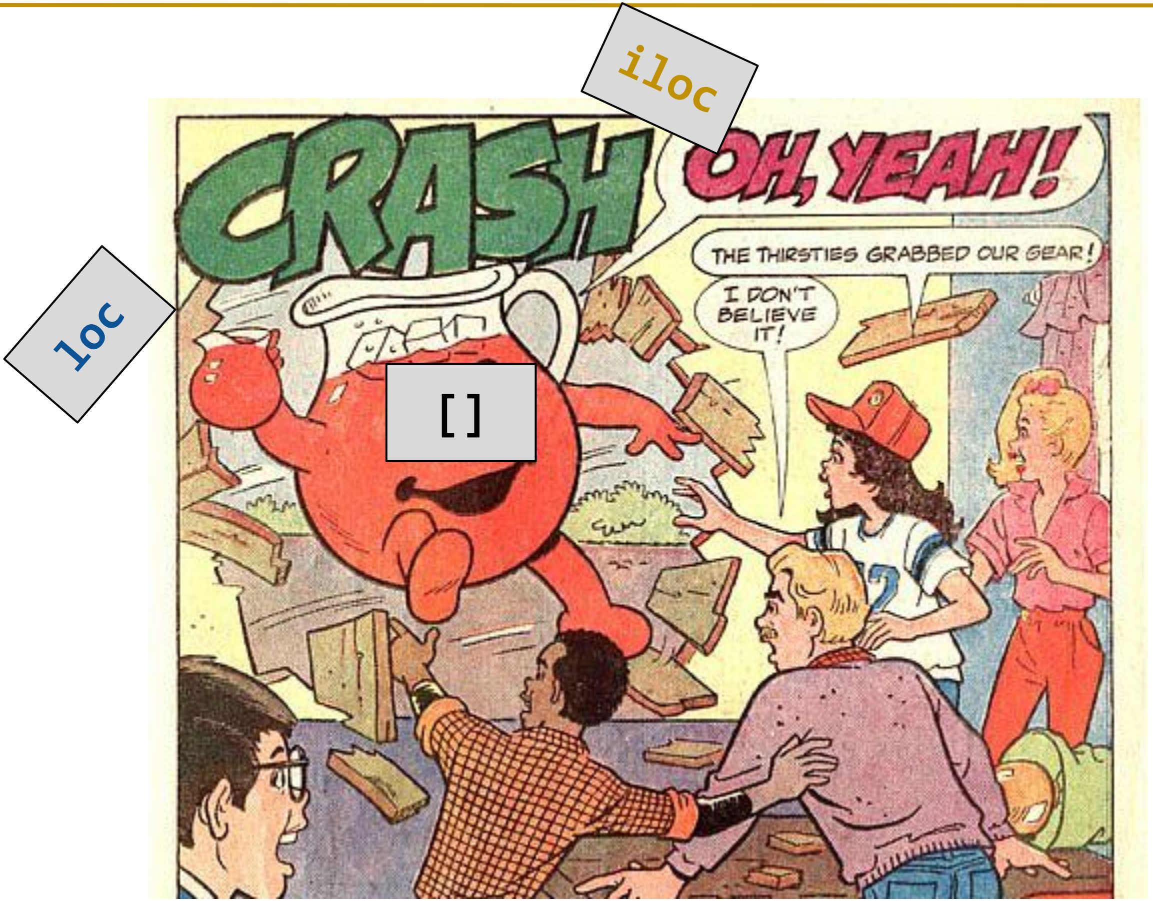


Context-dependent Extraction: [ ]

Selection operators:

- `.loc` selects items by **label**. First argument is rows, second argument is columns.
- `.iloc` selects items by **integer**. First argument is rows, second argument is columns.
- `[]` only takes one argument, which may be:
  - A slice of **row numbers**.
  - A list of **column labels**.
  - A single **column label**.

That is, `[]` is context sensitive.

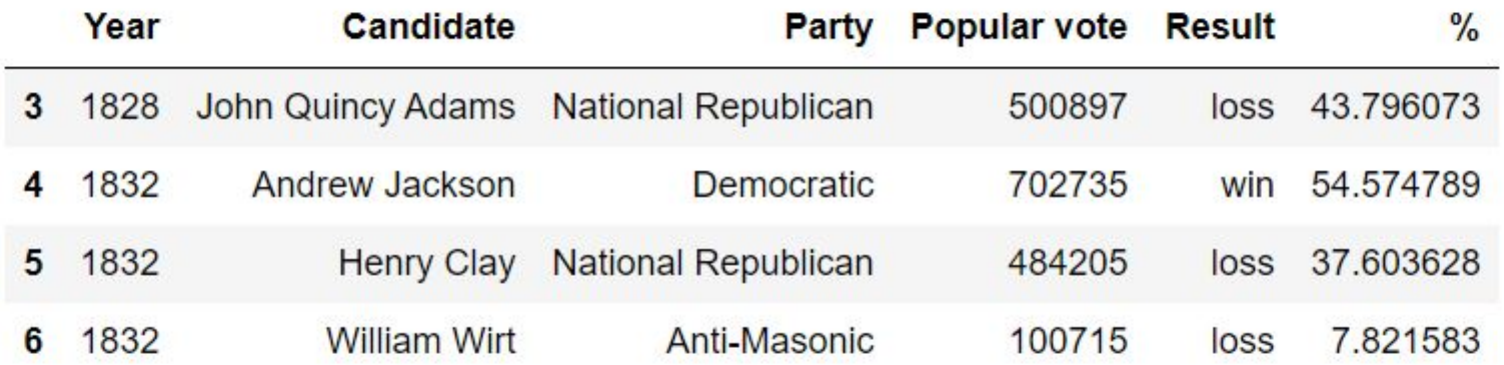
Let’s see some examples.

Context-dependent Extraction: [ ]

`[ ]` only takes one argument, which may be:

- **A slice of row integers**.
- A list of column labels.
- A single column label.

```
elections[3:7]
```



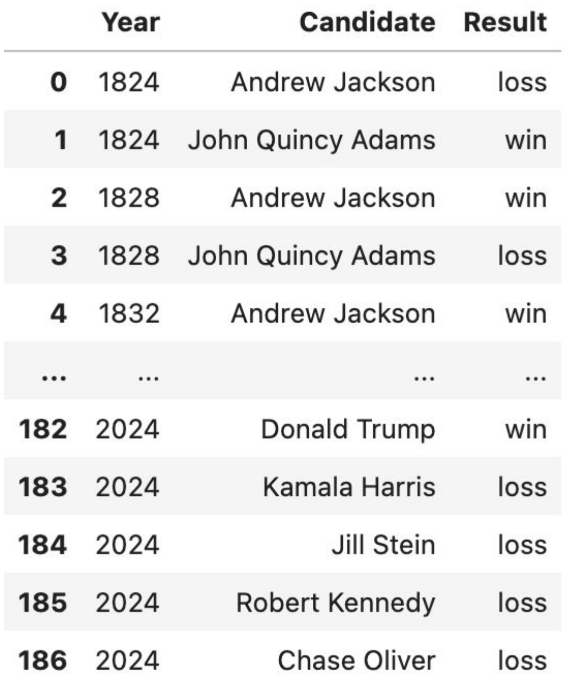
	Year	Candidate	Party	Popular vote	Result	%
3	1828	John Quincy Adams	National Republican	500897	loss	43.796073
4	1832	Andrew Jackson	Democratic	702735	win	54.574789
5	1832	Henry Clay	National Republican	484205	loss	37.603628
6	1832	William Wirt	Anti-Masonic	100715	loss	7.821583

Context-dependent Extraction: [ ]

`[ ]` only takes one argument, which may be:

- A slice of row numbers.
- **A list of column labels.**
- A single column label.

```
elections[["Year", "Candidate", "Result"]]
```



	Year	Candidate	Result
0	1824	Andrew Jackson	loss
1	1824	John Quincy Adams	win
2	1828	Andrew Jackson	win
3	1828	John Quincy Adams	loss
4	1832	Andrew Jackson	win
...	...	...	...
182	2024	Donald Trump	win
183	2024	Kamala Harris	loss
184	2024	Jill Stein	loss
185	2024	Robert Kennedy	loss
186	2024	Chase Oliver	loss

Context-dependent Extraction: [ ]

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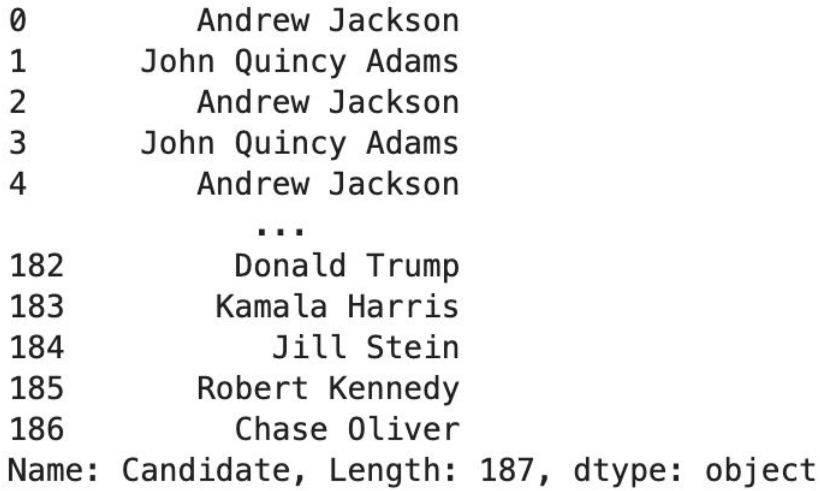
`[ ]` only takes one argument, which may be:

- A slice of row numbers.
- A list of column labels.
- **A single column label.**

```
elections["Candidate"]
```



```
0             Andrew Jackson
1          John Quincy Adams
2             Andrew Jackson
3          John Quincy Adams
4             Andrew Jackson
                   ...
182             Donald Trump
183            Kamala Harris
184               Jill Stein
185           Robert Kennedy
186             Chase Oliver
Name: Candidate, Length: 187, dtype: object
```

Extract the "Candidate" column as a `Series`.

Why Use [ ]?

In short: [ ] can be much more concise than `.loc` or `.iloc`

- Consider the case where we wish to extract the "Candidate" column. It is far simpler to write `elections["Candidate"]` than it is to write `elections.loc[:, "Candidate"]`

In practice, [ ] is often used over `.iloc` and `.loc` in data science work. Typing time adds up!

slido

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Which of the following statements correctly returns the value "blue fish" from the "weird" DataFrame?

ⓘ Click **Present with Slido** or install our Chrome extension to activate this poll while presenting.

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LECTURE 2

Pandas, Part I

Content credit: Acknowledgments