Hello Python!

What you will learn

- Python
- Specifically for Data Science
- Store data
- Manipulate data
- Tools for data analysis

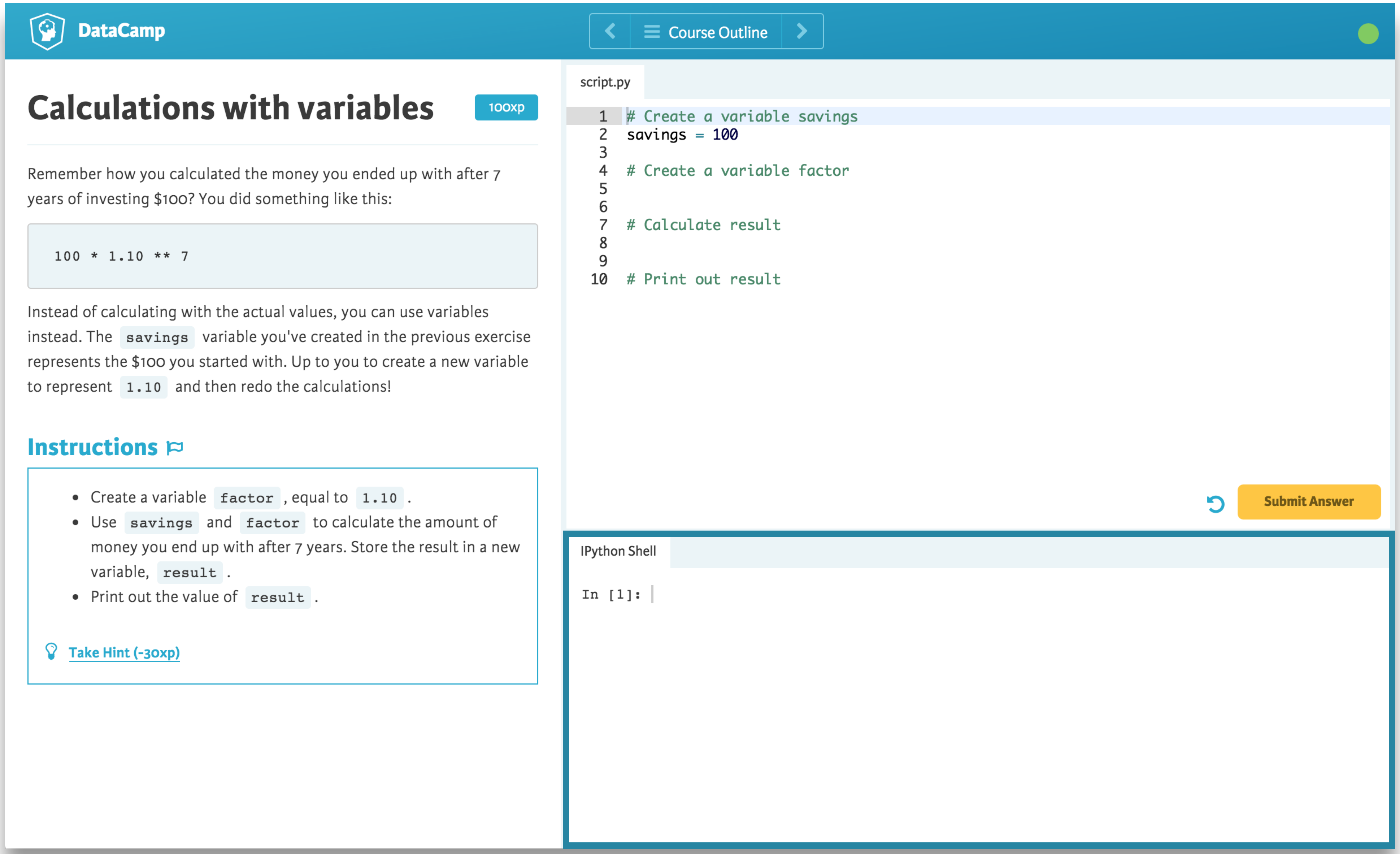
How you will learn

Python

- Guido Van Rossum
- General Purpose: build anything
- Open Source! Free!
- Python Packages, also for Data Science
    - Many applications and fields
- Version 3.x - https://www.python.org/downloads/

IPython Shell

Execute Python commands



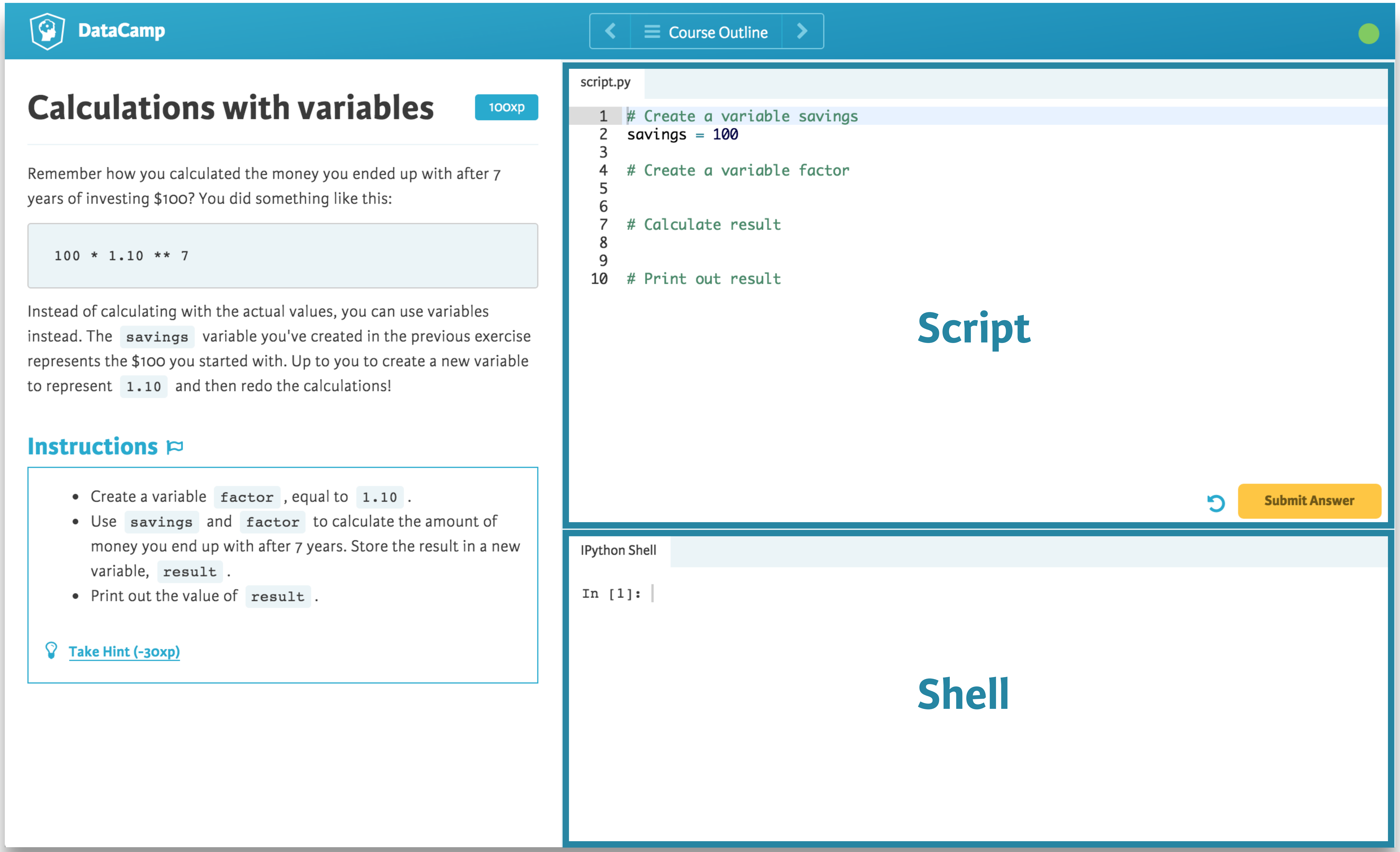
IPython Shell

Python Script

- Text Files - .py
- List of Python Commands
- Similar to typing in IPython Shell

Python Script

DataCamp Interface



Let’s practice!

INTRO TO PYTHON FOR DATA SCIENCE

Variables and Types

Variable

- Specific, case-sensitive name
- Call up value through variable name
- 1.79 m - 68.7 kg

```
In [1]: height = 1.79

In [2]: weight = 68.7

In [3]: height
Out[3]: 1.79
```

Calculate BMI

```
In [1]: height = 1.79

In [2]: weight = 68.7

In [3]: height
Out[3]: 1.79

In [4]: 68.7 / 1.79 ** 2
Out[4]: 21.4413

In [5]: weight / height ** 2
Out[5]: 21.4413

In [6]: bmi = weight / height ** 2

In [7]: bmi
Out[7]: 21.4413
```

$$\text{BMI} = \frac{\text{weight}}{\text{height}^2}$$

Reproducibility

my_script.py

```
height = 1.79
weight = 68.7
bmi = weight / height ** 2
print(bmi)
```

```
Output:
21.4413
```

Reproducibility

my_script.py

```
height = 1.79
weight = 74.2
bmi = weight / height ** 2
print(bmi)
```

```
Output:
23.1578
```

Python Types

```
In [8]: type(bmi)
Out[8]: float

In [9]: day_of_week = 5

In [10]: type(day_of_week)
Out[10]: int
```

Python Types (2)

```
In [11]: x = "body mass index"

In [12]: y = 'this works too'

In [13]: type(y)
Out[13]: str

In [14]: z = True

In [15]: type(z)
Out[15]: bool
```

Python Types (3)

```
In [16]: 2 + 3
Out[16]: 5

In [17]: 'ab' + 'cd'
Out[17]: 'abcd'
```

Different type = different behavior!

Let’s practice!

Python Lists

Python Data Types

- `float` - real numbers
- `int` - integer numbers
- `str` - string, text
- `bool` - `True`, `False`

```
In [1]: height = 1.73

In [2]: tall = True
```

- Each variable represents single value

Problem

- Data Science: many data points
- Height of entire family

```
In [3]: height1 = 1.73

In [4]: height2 = 1.68

In [5]: height3 = 1.71

In [6]: height4 = 1.89
```

- Inconvenient

Python List

[a, b, c]

```
In [7]: [1.73, 1.68, 1.71, 1.89]
Out[7]: [1.73, 1.68, 1.71, 1.89]

In [8]: fam = [1.73, 1.68, 1.71, 1.89]

In [9]: fam
Out[9]: [1.73, 1.68, 1.71, 1.89]
```

- Name a collection of values
- Contain any type
- Contain different types

Python List

[a, b, c]

```
In [10]: fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]

In [11]: fam
Out[11]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
```

```
["liz", 1.73]
["emma", 1.68]
["mom", 1.71]
["dad", 1.89]
```

Python List

[a, b, c]

```
In [10]: fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]

In [11]: fam
Out[11]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]


In [11]: fam2 = [["liz", 1.73],
                 ["emma", 1.68],
                 ["mom", 1.71],
                 ["dad", 1.89]]

In [12]: fam2
Out[12]: [['liz', 1.73], ['emma', 1.68],
          ['mom', 1.71], ['dad', 1.89]]
```

List type

```
In [13]: type(fam)
Out[13]: list

In [14]: type(fam2)
Out[14]: list
```

- Specific functionality
- Specific behavior

Let’s practice!

Subsetting Lists

Subsetting lists

```
In [1]: fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]

In [2]: fam
Out[2]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
```

index: 0 1 2 3 4 5 6 7

"zero-based indexing"

Subsetting lists

```
In [1]: fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]

In [2]: fam
Out[2]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
    index:  0       1       2       3       4       5       6       7


In [3]: fam[3]
Out[3]: 1.68
```

Subsetting lists

```
In [1]: fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]

In [2]: fam
Out[2]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
    index:   0      1       2       3      4      5      6      7


In [3]: fam[3]
Out[3]: 1.68

In [4]: fam[6]
Out[4]: 'dad'
```

Subsetting lists

```
In [1]: fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]

In [2]: fam
Out[2]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
    index:  0       1       2       3       4       5       6       7
           -8      -7      -6      -5      -4      -3      -2      -1

In [3]: fam[3]
Out[3]: 1.68

In [4]: fam[6]
Out[4]: 'dad'

In [5]: fam[-1]
Out[5]: 1.89
```

Subsetting lists

```
In [1]: fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]

In [2]: fam
Out[2]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
    index:  0      1      2      3      4      5      6      7
           -8     -7     -6     -5     -4     -3     -2     -1

In [3]: fam[3]
Out[3]: 1.68

In [4]: fam[6]
Out[4]: 'dad'

In [5]: fam[-1]
Out[5]: 1.89

In [6]: fam[-2]
Out[6]: 'dad'
```

List slicing

```
In [7]: fam
Out[7]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
               0      1       2       3      4      5      6     7

In [8]: fam[3:5]
Out[8]: [1.68, 'mom']
```

[start : end]

inclusive **exclusive**

List slicing

```
In [7]: fam
Out[7]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
           0      1       2      3      4     5      6     7

In [8]: fam[3:5]
Out[8]: [1.68, 'mom']

In [9]: fam[1:4]
Out[9]: [1.73, 'emma', 1.68]
```

[start : end]

inclusive **exclusive**

List slicing

```
In [7]: fam
Out[7]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
           0        1        2       3      4      5      6      7

In [8]: fam[3:5]
Out[8]: [1.68, 'mom']

In [9]: fam[1:4]
Out[9]: [1.73, 'emma', 1.68]

In [10]: fam[:4]
Out[10]: ['liz', 1.73, 'emma', 1.68]
```

List slicing

```
In [7]: fam
Out[7]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]
                 0      1       2       3      4      5      6      7

In [8]: fam[3:5]
Out[8]: [1.68, 'mom']

In [9]: fam[1:4]
Out[9]: [1.73, 'emma', 1.68]

In [10]: fam[:4]
Out[10]: ['liz', 1.73, 'emma', 1.68]

In [11]: fam[5:]
Out[11]: [1.71, 'dad', 1.89]
```

Let’s practice!

Manipulating Lists

List Manipulation

- Change list elements
- Add list elements
- Remove list elements

Changing list elements

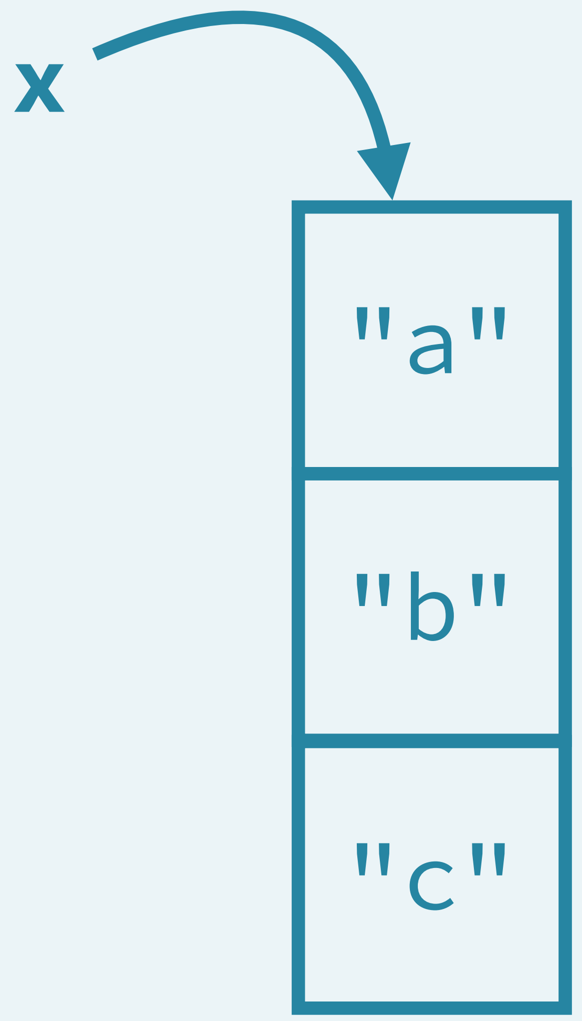
```
In [1]: fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]

In [2]: fam
Out[2]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]

In [3]: fam[7] = 1.86

In [4]: fam
Out[4]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.86]

In [5]: fam[0:2] = ["lisa", 1.74]

In [6]: fam
Out[6]: ['lisa', 1.74, 'emma', 1.68, 'mom', 1.71, 'dad', 1.86]
```

Adding and removing elements

```
In [7]: fam + ["me", 1.79]
Out[7]: ['lisa', 1.74,'emma', 1.68,
                         'mom', 1.71, 'dad', 1.86, 'me', 1.79]

In [8]: fam_ext = fam + ["me", 1.79]



In [9]: del(fam[2])

In [10]: fam
Out[10]: ['lisa', 1.74, 1.68, 'mom', 1.71, 'dad', 1.86]

In [11]: del(fam[2])

In [12]: fam
Out[12]: ['lisa', 1.74, 'mom', 1.71, 'dad', 1.86]
```

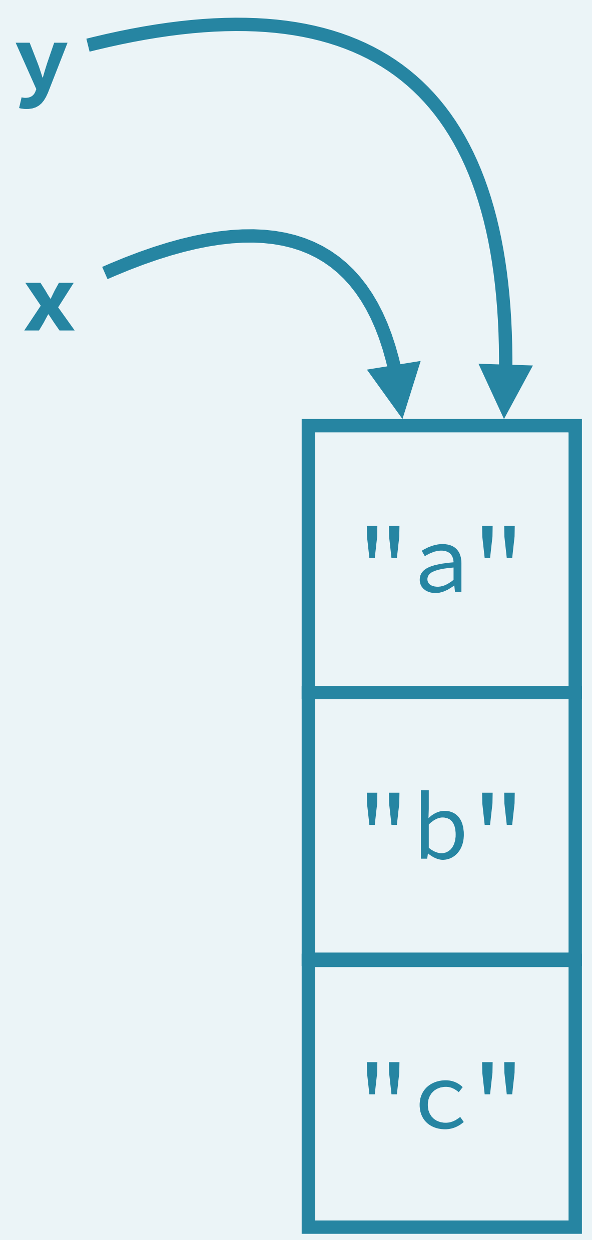
Behind the scenes (1)

```
In [13]: x = ["a", "b", "c"]

In [14]: y = x
```



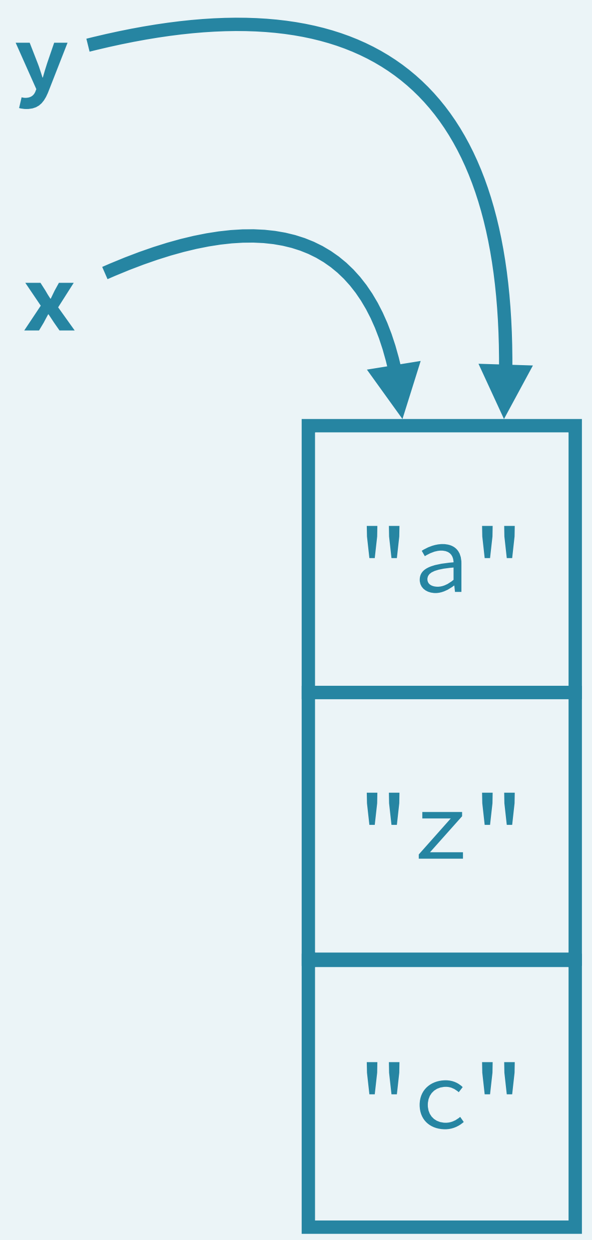
Behind the scenes (1)

```
In [13]: x = ["a", "b", "c"]

In [14]: y = x

In [15]: y[1] = "z"

In [16]: y
Out[16]: ['a', 'z', 'c']

In [17]: x
Out[17]: ['a', 'z', 'c']
```



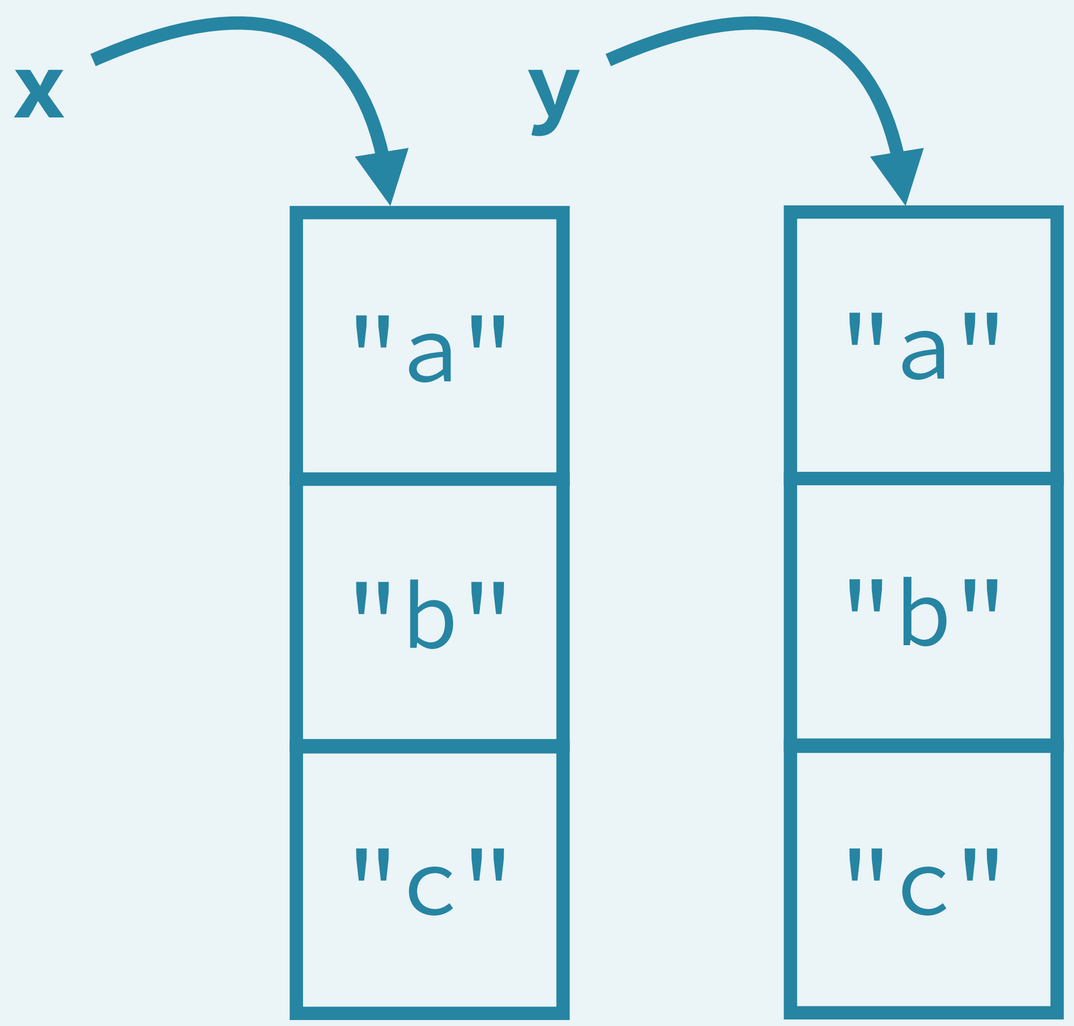
Behind the scenes (1)

```
In [13]: x = ["a", "b", "c"]

In [14]: y = x

In [15]: y[1] = "z"

In [16]: y
Out[16]: ['a', 'z', 'c']

In [17]: x
Out[17]: ['a', 'z', 'c']
```



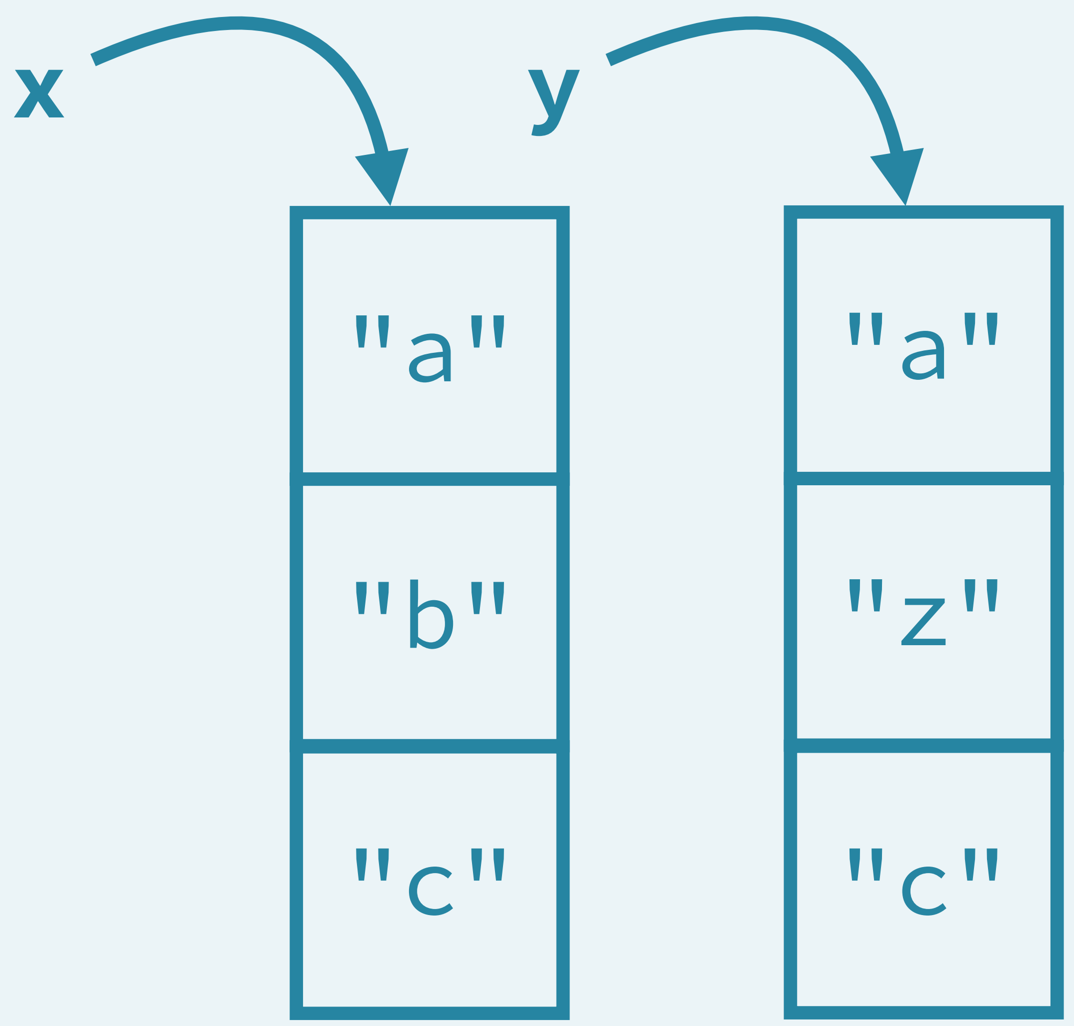
Behind the scenes (2)

```
In [18]: x = ["a", "b", "c"]

In [19]: y = list(x)

In [20]: y = x[:]

In [21]: y[1] = "z"
```



Behind the scenes (2)

```
In [18]: x = ["a", "b", "c"]

In [19]: y = list(x)

In [20]: y = x[:]

In [21]: y[1] = "z"

In [22]: x
Out[22]: ['a', 'b', 'c']
```



Let’s practice!

Functions

Functions

- Nothing new!
- `type()`
- Piece of reusable code
- Solves particular task
- Call function instead of writing code yourself

Example

```
In [1]: fam = [1.73, 1.68, 1.71, 1.89]

In [2]: fam
Out[2]: [1.73, 1.68, 1.71, 1.89]

In [3]: max(fam)
Out[3]: 1.89
```

[1.73, 1.68, 1.71, 1.89] → max() → 1.89

Example

```
In [1]: fam = [1.73, 1.68, 1.71, 1.89]

In [2]: fam
Out[2]: [1.73, 1.68, 1.71, 1.89]

In [3]: max(fam)
Out[3]: 1.89

In [4]: tallest = max(fam)

In [5]: tallest
Out[5]: 1.89
```

round()

```
In [6]: round(1.68, 1)
Out[6]: 1.7

In [7]: round(1.68)
Out[7]: 2

In [8]: help(round)
```

Open up documentation

```
  Help on built-in function round in module builtins:

  round(...)
      round(number[, ndigits]) -> number

      Round a number to a given precision in decimal digits
      (default 0 digits). This returns an int when called with
      one argument, otherwise the same type as the number.
      ndigits may be negative.
```

round()

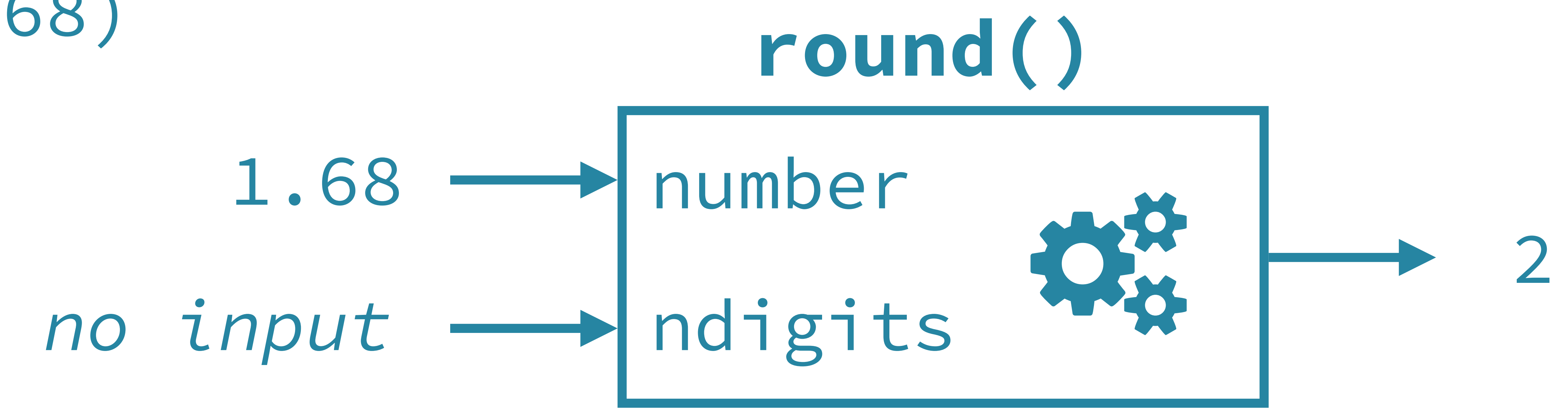
```
In [8]: help(round)

  round(...)
      round(number[, ndigits]) -> number

      Round a number to a given precision in decimal digits
      (default 0 digits). This returns an int when called with
      one argument, otherwise the same type as the number.
      ndigits may be negative.
```

```
round(1.68, 1)
```

round()

```
In [8]: help(round)

  round(...)
      round(number[, ndigits]) -> number

      Round a number to a given precision in decimal digits
      (default 0 digits). This returns an int when called with
      one argument, otherwise the same type as the number.
      ndigits may be negative.
```

```
round(1.68)
```



round()

```
In [8]: help(round)

  round(...)
      round(number[, ndigits]) -> number

      Round a number to a given precision in decimal digits
      (default 0 digits). This returns an int when called with
      one argument, otherwise the same type as the number.
      ndigits may be negative.
```

```
round(number)

round(number, ndigits)
```

Find functions

- How to know?
- Standard task -> probably function exists!
- The internet is your friend

Let’s practice!

Methods

Built-in Functions

- Maximum of list: `max()`
- Length of list or string: `len()`
- Get index in list: ?
- Reversing a list: ?

Back 2 Basics

		type	examples of methods
`In [1]: sister = "liz"`	Object	`str`	`capitalize()` `replace()`
`In [2]: height = 1.73`	Object	`float`	`bit_length()` `conjugate()`
`In [3]: fam = ["liz", 1.73, "emma", 1.68, "mom", 1.71, "dad", 1.89]`	Object	`list`	`index()` `count()`

Methods: Functions that belong to objects

list methods

```
In [4]: fam
Out[4]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]

In [5]: fam.index("mom")
Out[5]: 4

In [6]: fam.count(1.73)
Out[6]: 1
```

"Call method `index()` on `fam`"

`str` methods

```
In [7]: sister
Out[7]: 'liz'

In [8]: sister.capitalize()
Out[8]: 'Liz'

In [9]: sister.replace("z", "sa")
Out[9]: 'lisa'
```

Methods

- Everything = object
- Object have methods associated, depending on type

```
In [10]: sister.replace("z", "sa")
Out[10]: 'lisa'

In [11]: fam.replace("mom", "mommy")
AttributeError: 'list' object has no attribute 'replace'

In [12]: sister.index("z")
Out[12]: 2

In [13]: fam.index("mom")
Out[13]: 4
```

Methods (2)

```
In [14]: fam
Out[14]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89]

In [15]: fam.append("me")

In [16]: fam
Out[16]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89, 'me']

In [17]: fam.append(1.79)

In [18]: fam
Out[18]: ['liz', 1.73, 'emma', 1.68, 'mom', 1.71, 'dad', 1.89, 'me', 1.79]
```

Summary

- Functions

```
In [11]: type(fam)
Out[11]: list
```

- Methods: call functions *on* objects

```
In [12]: fam.index("dad")
Out[12]: 6
```

Let’s practice!

Packages

Motivation

- Functions and methods are powerful
- All code in Python distribution?
    - Huge code base: messy
    - Lots of code you won't use
    - Maintenance problem

Packages

```
pkg/
  mod1.py
  mod2.py
  ...
```

- Directory of Python Scripts
- Each script = module
- Specify functions, methods, types
- Thousands of packages available
    - Numpy
    - Matplotlib
    - Scikit-learn

Install package

- http://pip.readthedocs.org/en/stable/installing/
- Download `get-pip.py`
- Terminal:
  - `python3 get-pip.py`
  - `pip3 install numpy`

Import package

```
In [1]: import numpy

In [2]: array([1, 2, 3])
NameError: name 'array' is not defined

In [3]: numpy.array([1, 2, 3])
Out[3]: array([1, 2, 3])

In [4]: import numpy as np

In [5]: np.array([1, 2, 3])
Out[5]: array([1, 2, 3])

In [6]: from numpy import array

In [7]: array([1, 2, 3])
Out[7]: array([1, 2, 3])
```

from numpy import array

my_script.py

```
from numpy import array

fam = ["liz", 1.73, "emma", 1.68,
       "mom", 1.71, "dad", 1.89]

...

fam_ext = fam + ["me", 1.79]

...

print(str(len(fam_ext)) + " elements in fam_ext")

...

np_fam = array(fam_ext)
```

Using Numpy, but not very clear

import numpy

my_script.py

```
import numpy

fam = ["liz", 1.73, "emma", 1.68,
       "mom", 1.71, "dad", 1.89]

...

fam_ext = fam + ["me", 1.79]

...

print(str(len(fam_ext)) + " elements in fam_ext")

...

np_fam = numpy.array(fam_ext)
```

Clearly using Numpy

Let’s practice!

NumPy

Lists Recap

- Powerful
- Collection of values
- Hold different types
- Change, add, remove
- Need for Data Science
  - Mathematical operations over collections
  - Speed

Illustration

```
In [1]: height = [1.73, 1.68, 1.71, 1.89, 1.79]

In [2]: height
Out[2]: [1.73, 1.68, 1.71, 1.89, 1.79]

In [3]: weight = [65.4, 59.2, 63.6, 88.4, 68.7]

In [4]: weight
Out[4]: [65.4, 59.2, 63.6, 88.4, 68.7]

In [5]: weight / height ** 2
TypeError: unsupported operand type(s) for **: 'list' and 'int'
```

Solution: NumPy

- Numeric Python
- Alternative to Python List: NumPy Array
- Calculations over entire arrays
- Easy and Fast
- Installation
    - In the terminal: `pip3 install numpy`

NumPy

```
In [6]: import numpy as np

In [7]: np_height = np.array(height)

In [8]: np_height
Out[8]: array([ 1.73,  1.68,  1.71,  1.89,  1.79])

In [9]: np_weight = np.array(weight)

In [10]: np_weight
Out[10]: array([ 65.4,  59.2,  63.6,  88.4,  68.7])

In [11]: bmi = np_weight / np_height ** 2

In [12]: bmi
Out[12]: array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
```

NumPy

Element-wise calculations

```
In [6]: import numpy as np

In [7]: np_height = np.array(height)

In [8]: np_height
Out[8]: array([ 1.73,  1.68,  1.71,  1.89,  1.79])

In [9]: np_weight = np.array(weight)

In [10]: np_weight
Out[10]: array([ 65.4,  59.2,  63.6,  88.4,  68.7])

In [11]: bmi = np_weight / np_height ** 2

In [12]: bmi
Out[12]: array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
```

```
= 65.5/1.73 ** 2
```

Comparison

```
In [13]: height = [1.73, 1.68, 1.71, 1.89, 1.79]

In [14]: weight = [65.4, 59.2, 63.6, 88.4, 68.7]

In [15]: weight / height ** 2
TypeError: unsupported operand type(s) for **: 'list' and 'int'



In [16]: np_height = np.array(height)

In [17]: np_weight = np.array(weight)

In [18]: np_weight / np_height ** 2
Out[18]: array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])
```

NumPy: remarks

```
In [19]: np.array([1.0, "is", True])
Out[19]:
array(['1.0', 'is', 'True'],
      dtype='<U32')

In [20]: python_list = [1, 2, 3]

In [21]: numpy_array = np.array([1, 2, 3])

In [22]: python_list + python_list
Out[22]: [1, 2, 3, 1, 2, 3]

In [23]: numpy_array + numpy_array
Out[23]: array([2, 4, 6])
```

NumPy arrays: contain only one type

Different types: different behavior!

NumPy Subsetting

```
In [24]: bmi
Out[24]: array([ 21.852,  20.975,  21.75 ,  24.747,  21.441])

In [25]: bmi[1]
Out[25]: 20.975

In [26]: bmi > 23
Out[26]: array([False, False, False,  True, False], dtype=bool)

In [27]: bmi[bmi > 23]
Out[27]: array([ 24.747])
```

Let’s practice!

2D NumPy Arrays

Type of NumPy Arrays

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

In [2]: np_height = np.array([1.73, 1.68, 1.71, 1.89, 1.79])

In [3]: np_weight = np.array([65.4, 59.2, 63.6, 88.4, 68.7])

In [4]: type(np_height)
Out[4]: numpy.ndarray

In [5]: type(np_weight)
Out[5]: numpy.ndarray
```

ndarray = N-dimensional array

2D NumPy Arrays

```
In [6]: np_2d = np.array([[1.73, 1.68, 1.71, 1.89, 1.79],
                          [65.4, 59.2, 63.6, 88.4, 68.7]])

In [7]: np_2d
Out[7]:
array([[  1.73,   1.68,   1.71,   1.89,   1.79],
       [ 65.4 ,  59.2 ,  63.6 ,  88.4 ,  68.7 ]])

In [8]: np_2d.shape
Out[8]: (2, 5)

In [9]: np.array([[1.73, 1.68, 1.71, 1.89, 1.79],
                  [65.4, 59.2, 63.6, 88.4, "68.7"]])
Out[9]:
array([['1.73', '1.68', '1.71', '1.89', '1.79'],
       ['65.4', '59.2', '63.6', '88.4', '68.7']],
      dtype='<U32')
```

2 rows, 5 columns

Single type!

Subsetting

	0	1	2	3	4	
array([[	1.73,	1.68,	1.71,	1.89,	1.79],	0
[	65.4,	59.2,	63.6,	88.4,	68.7]])	1

```
In [10]: np_2d[0]
Out[10]: array([ 1.73,  1.68,  1.71,  1.89,  1.79])

In [11]: np_2d[0][2]
Out[11]: 1.71

In [12]: np_2d[0,2]
Out[12]: 1.71
```

Subsetting

	0	1	2	3	4	
array([[	1.73,	1.68,	1.71,	1.89,	1.79],	0
[	65.4,	59.2,	63.6,	88.4,	68.7]])	1

```
In [10]: np_2d[0]
Out[10]: array([ 1.73,  1.68,  1.71,  1.89,  1.79])

In [11]: np_2d[0][2]
Out[11]: 1.71

In [12]: np_2d[0,2]
Out[12]: 1.71

In [13]: np_2d[:,1:3]
Out[13]:
array([[  1.68,   1.71],
       [ 59.2 ,  63.6 ]])
```

Subsetting

	0	1	2	3	4	
array([[	1.73,	1.68,	1.71,	1.89,	1.79],	0
[	65.4,	59.2,	63.6,	88.4,	68.7]])	1

```
In [10]: np_2d[0]
Out[10]: array([ 1.73,  1.68,  1.71,  1.89,  1.79])

In [11]: np_2d[0][2]
Out[11]: 1.71

In [12]: np_2d[0,2]
Out[12]: 1.71

In [13]: np_2d[:,1:3]
Out[13]:
array([[  1.68,   1.71],
       [ 59.2 ,  63.6 ]])

In [14]: np_2d[1,:]
Out[14]: array([ 65.4,  59.2,  63.6,  88.4,  68.7])
```

Let's practice!

NumPy: Basic Statistics

Data analysis

- Get to know your data
- Little data -> simply look at it
- Big data -> ?

City-wide survey

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

In [2]: np_city = ... # Implementation left out

In [3]: np_city
Out[3]:
array([[  1.64,   71.78],
       [  1.37,   63.35],
       [  1.6 ,   55.09],
       ...,
       [  2.04,   74.85],
       [  2.04,   68.72],
       [  2.01,   73.57]])
```

NumPy

```
In [4]: np.mean(np_city[:,0])
Out[4]: 1.7472

In [5]: np.median(np_city[:,0])
Out[5]: 1.75

In [6]: np.corrcoef(np_city[:,0], np_city[:,1])
Out[6]:
array([[ 1.      , -0.01802],
       [-0.01803,  1.      ]])

In [7]: np.std(np_city[:,0])
Out[7]: 0.1992
```

- `sum(), sort(), ...`
- Enforce single data type: speed!

Generate data

distribution mean

distribution standard dev.

number of samples

```
In [8]: height = np.round(np.random.normal(1.75, 0.20, 5000), 2)

In [9]: weight = np.round(np.random.normal(60.32, 15, 5000), 2)

In [10]: np_city = np.column_stack((height, weight))
```

Let's practice!