Introduction to Classes

Objects

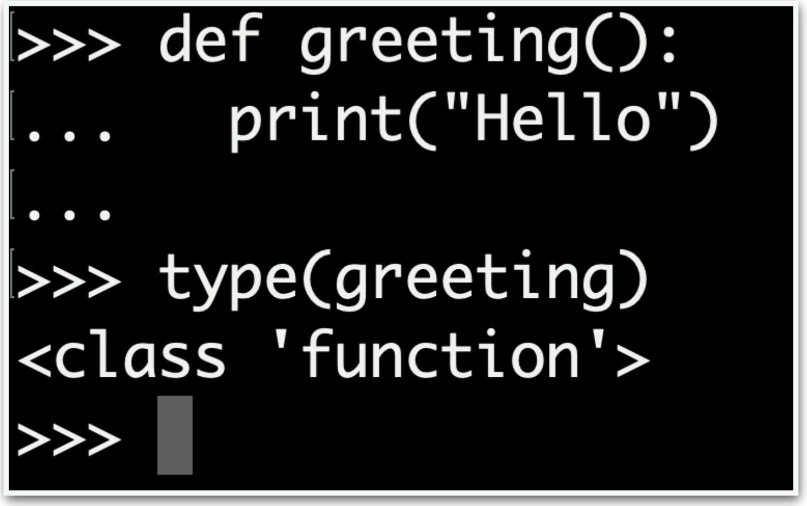
- Python supports many different kinds of data

```
1234     3.14159     "Hello"     [1, 5, 7, 11, 13]
{"CA": "California", "MA": "Massachusetts"}
```

- Each of these is an **object**, and every object has:
  - a **type**
  - an internal **data representation**
  - a set of functions for **interaction** with the object
- An object is an **instance** of a type
  - `1234` is an instance of an **int**
  - `"hello"` is an instance of a **string**

EVERYTHING IN PYTHON IS AN OBJECT (AND HAS A TYPE)

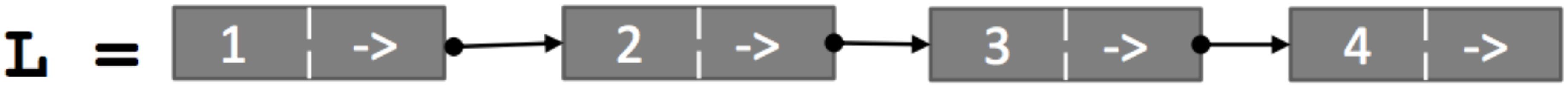
- Python is an **“object-oriented” language**
- **Question.** What is an object?
- Objects are a **data abstraction** that capture:
  - An **internal representation** (through data **attributes**)
  - An **interface** for interacting with the object
    - through **methods** (aka procedures /functions)
    - defines behavior but hides implementation



```
>>> def greeting():
...     print("Hello")
...
>>> type(greeting)
<class 'function'>
>>> 
```

Example: `[1,2,3,4]` has type `List`

- Lists are represented internally by a sequence of cells connected via pointers (called linked list)



- This representation is **private**
    - The user doesn't need to know it to use list object
- How do manipulate lists? (interface through methods)
    - `L.append(), L.extend(),` etc.
- **Summary**.
    - Internal representation of objects should be private.
    - Objects are manipulated through associated methods/ functions.

Creating Our Own Types: Classes

- We can create our own type by **defining our own class**
- Creating a class involves
    - Defining the **class name and its attributes**
        - E.g., someone wrote the code to implement a `list class`
- Using the class involves
    - Creating **new instances** (objects)
        - E.g., `L = list()`
    - Doing operations on the instances
        - E.g., `L.append(3)`

Defining Our Own Type: Book class

Name of class (convention capital first letter)

Optional parent class

```
class Book(object):
    """This class represents a book"""
    # define attributes here
    # indented body of class definition
```

- **Creating an instance of the class**:

```
b1 = Book()
```

Object/instance of class Book

Data Attributes or Instance Variables

- Objects have “state,” which is typically held in **instance variables** or (a very Pythonic terms:) **attributes**.
- For example, an object of class Book may have attributes like the name of the book and its author
- We could assign these attributes directly to an instance of the class but **we should never do this**

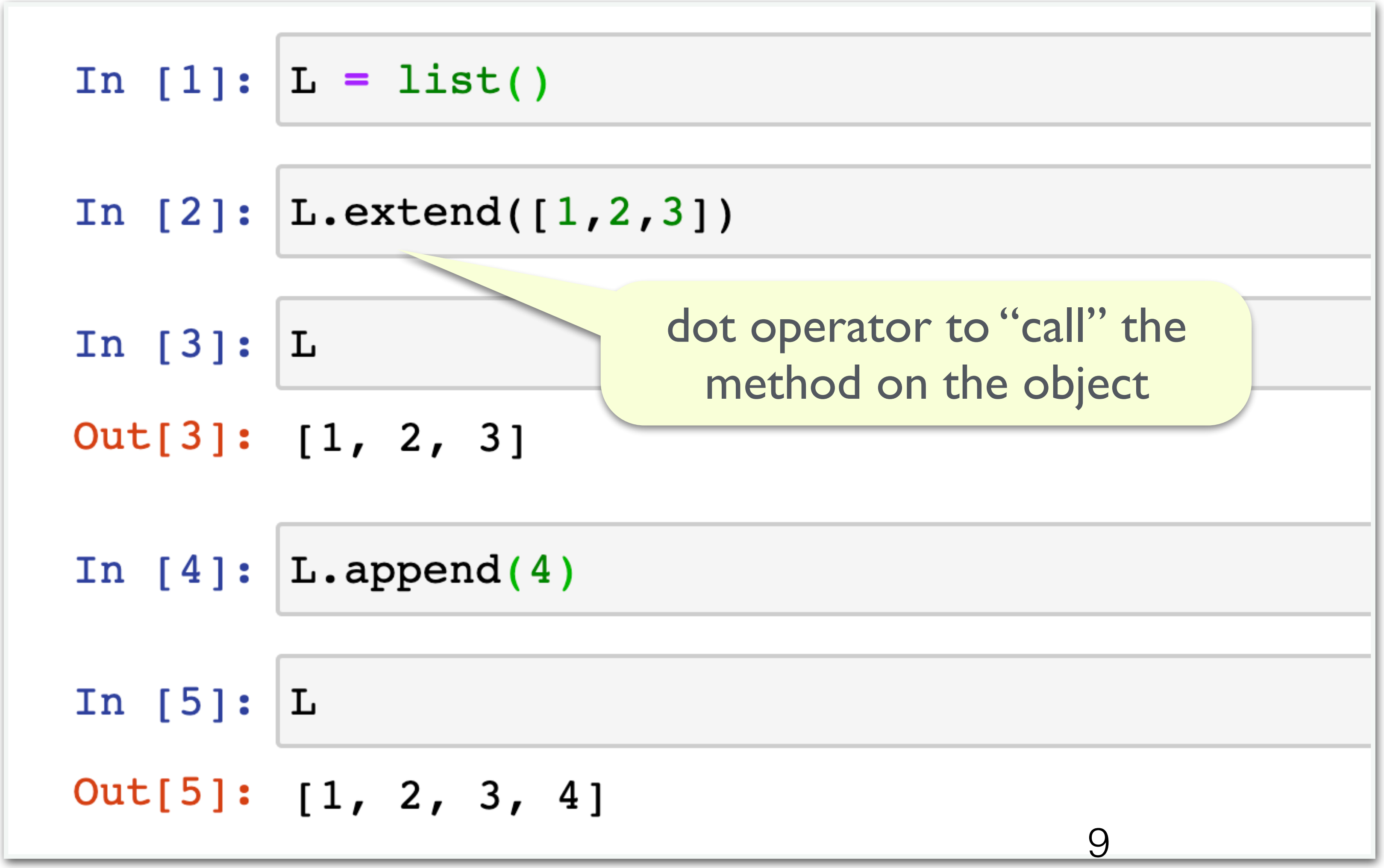
```
b1 = Book()

b1.name = “Emma”

b1.author = “Jane Austen”
```

Attributes should typically not be be assigned outside class definition

Classes: Methods

Methods or Procedural Attributes

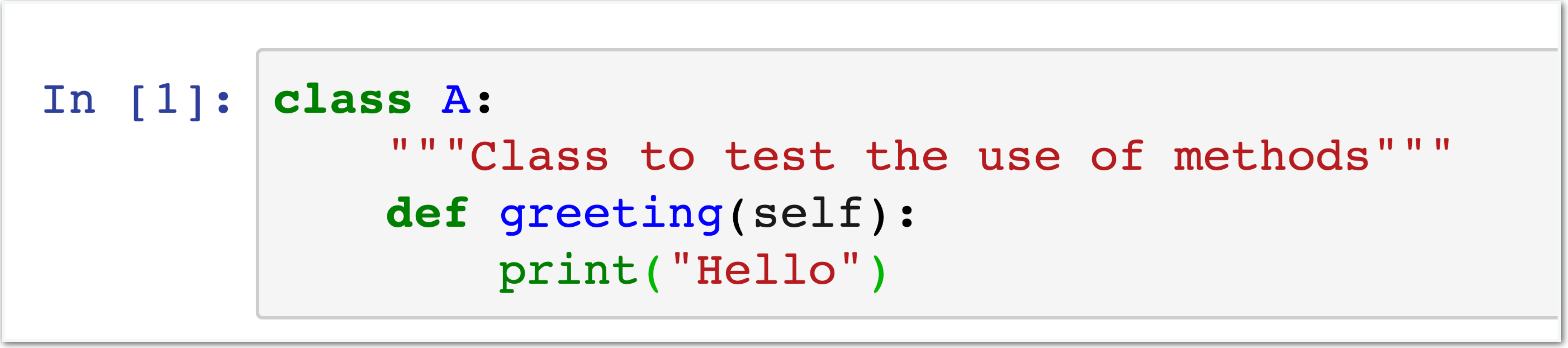
- Think of methods as object-specific functions
- They are defined as part of the class definition and describe how to interact with the class objects
- Example, methods for the list class



```
In [1]: L = list()

In [2]: L.extend([1,2,3])

In [3]: L
Out[3]: [1, 2, 3]

In [4]: L.append(4)

In [5]: L
Out[5]: [1, 2, 3, 4]
```

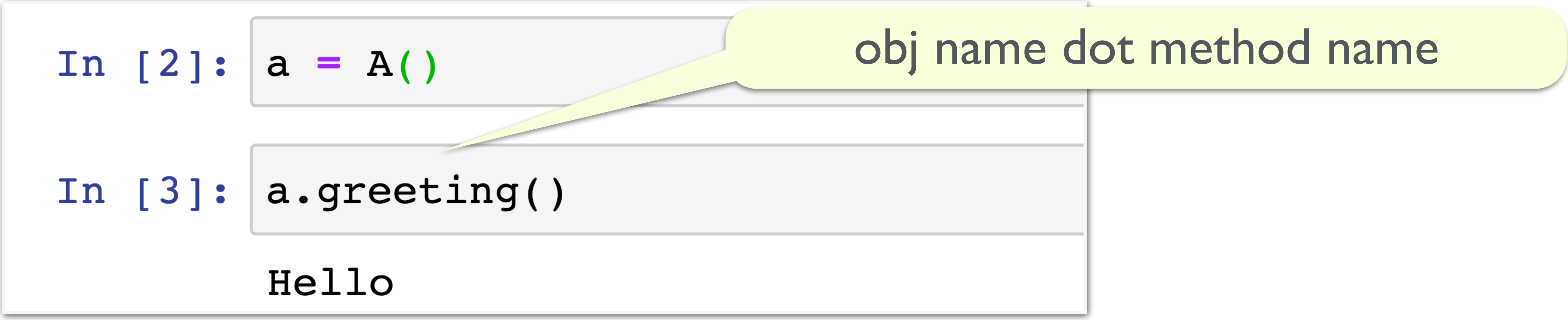
dot operator to “call” the method on the object

Our First Method



```
In [1]: class A:
            """Class to test the use of methods"""
            def greeting(self):
                print("Hello")
```

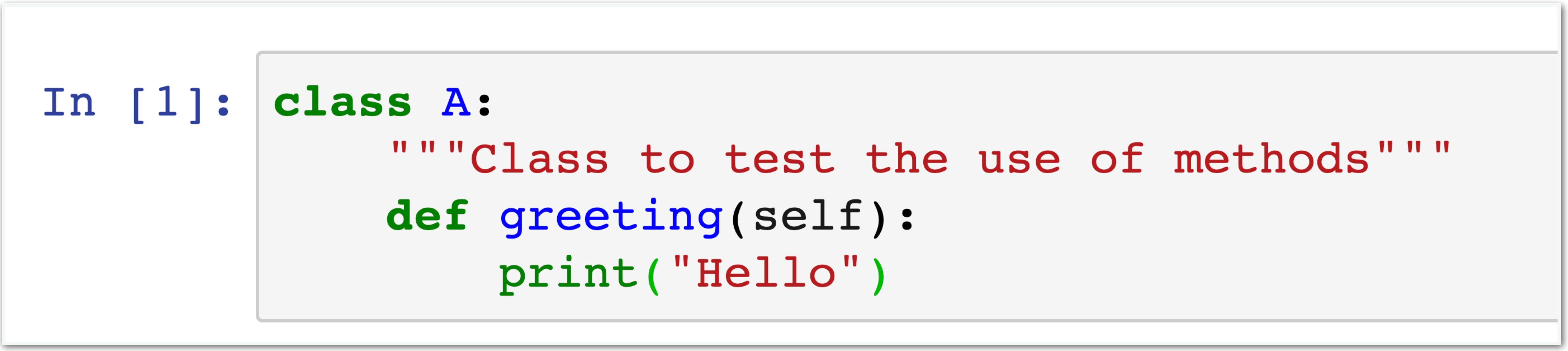
- How do we call the greeting?
    - We create an instance of the class and call the method on that instance using the dot operator as follows:



```
In [2]: a = A()

In [3]: a.greeting()

        Hello
```

obj name dot method name

Understanding Method Calls



```
In [1]: class A:
            """Class to test the use of methods"""
            def greeting(self):
                print("Hello")
```

- The following two calls are equivalent:

```
a = A()

a.greeting() # method 1

A.greeting(a) # method 2
```

Preferred/Standard way

`self` Parameter

- Even though method definitions have `self` as the first parameter (and we use this variable inside the method body), we don’t pass this parameter explicitly
- This is because whenever we call a method on an object, the object itself is passed as the first parameter
- Methods are object specific-functions and this lets us access the object’s properties via the methods directly
- In some languages this parameter is implicit but in Python it is explicit and by convention named `self`

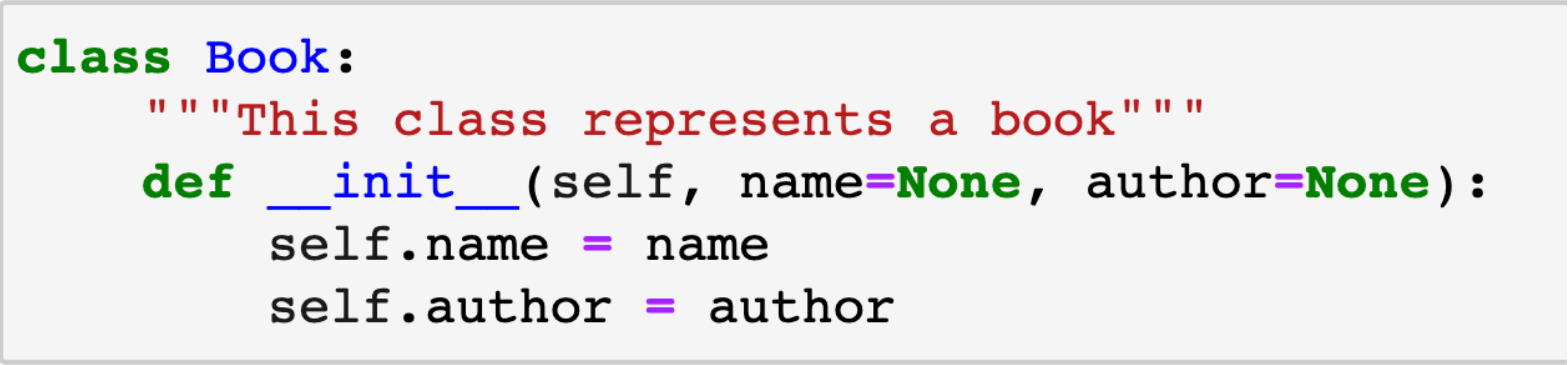
Summary of Methods

- A method differs from a function only in two aspects:
  - It **belongs to a class**, and it is defined within a class
  - Its purpose is to provide an interface to access/manipulate objects
  - The first parameter in the definition of a method attribute is **the reference to the calling instance**.
  - This parameter that references the calling object is (by convention) called “**self**".

__init__

Initializing a Class: `__init__`

- While Python allows you to assign attributes to instances of a class on the fly (and outside the class), it is not the proper way to do so.
- You should never assign or modify attributes of an object manually
- Data attributes should be initialized as part of the class definition
- We can achieve this by the Python's special method `__init__`.
- `__init__`: **Special method** that lets us define how to create an instance of a class, by initializing some data attributes

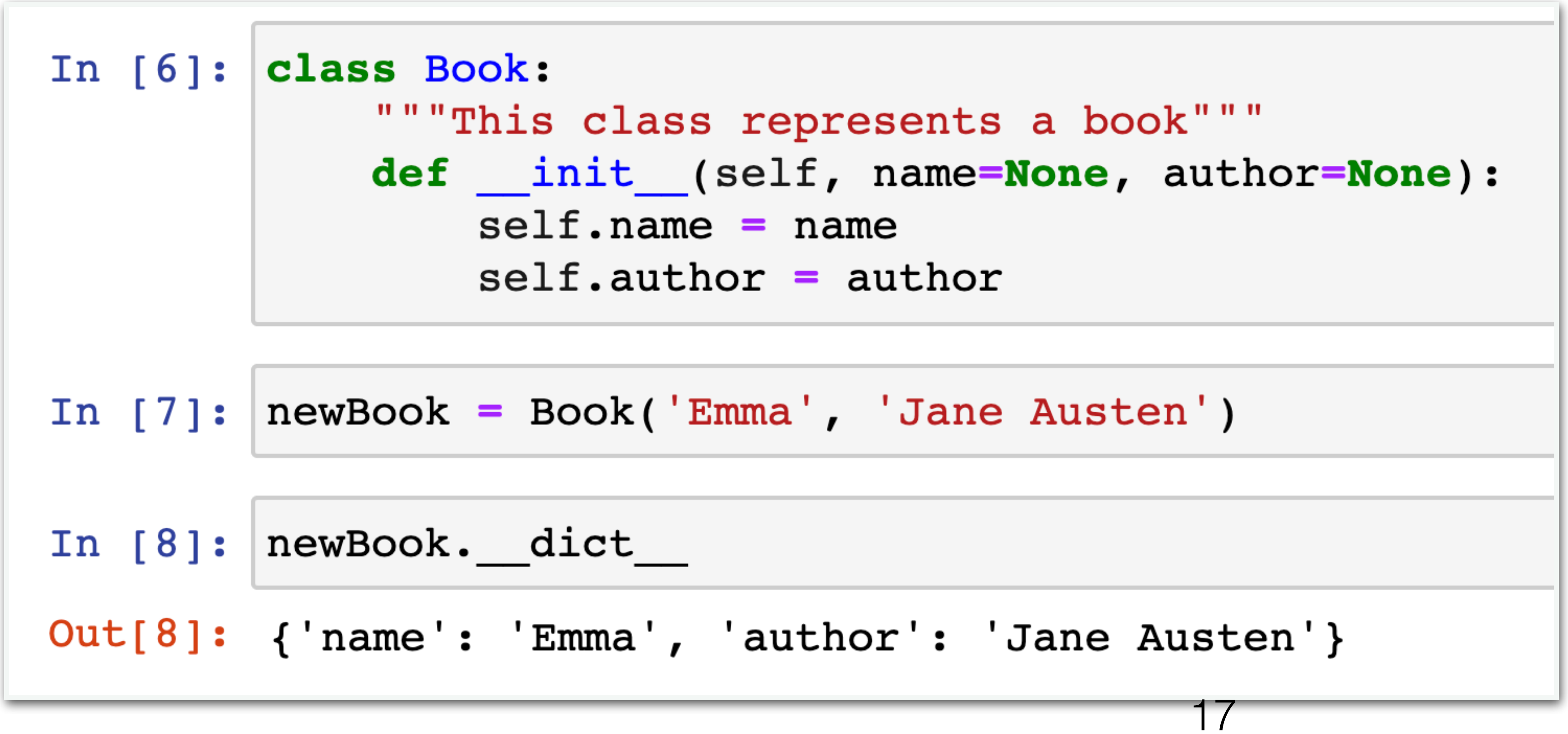


```python
class Book:
    """This class represents a book"""
    def __init__(self, name=None, author=None):
        self.name = name
        self.author = author
```

`__slots__`

Avoid Dynamically Created Attributes

- Attributes of objects are stored in a dictionary `__dict__`
- Like any other dictionary, you can add items to `__dict__` on the fly and there are no predetermined set of keys
- This is why we can dynamically add attributes to objects (even though this is not recommended)



```
In [6]: class Book:
            """This class represents a book"""
            def __init__(self, name=None, author=None):
                self.name = name
                self.author = author

In [7]: newBook = Book('Emma', 'Jane Austen')

In [8]: newBook.__dict__

Out[8]: {'name': 'Emma', 'author': 'Jane Austen'}
```

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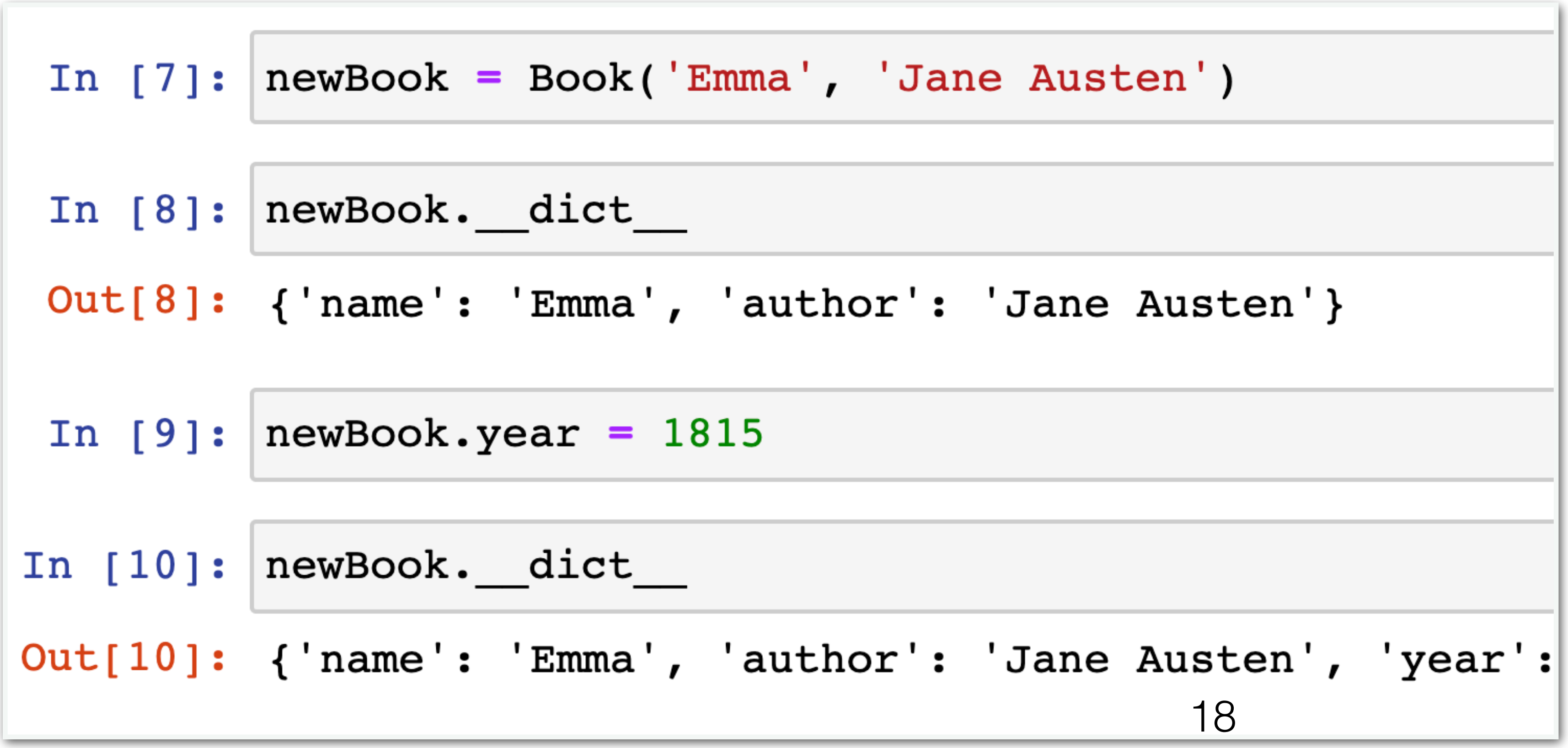
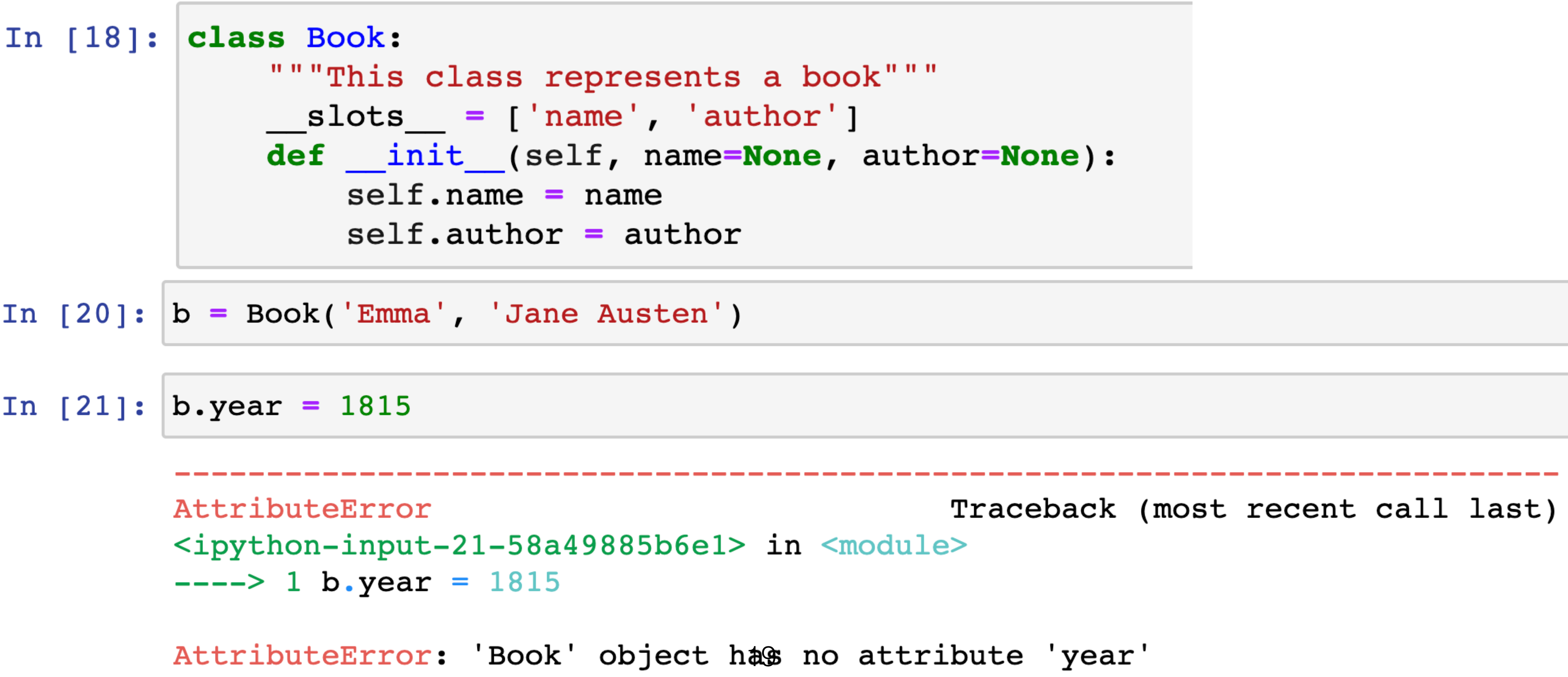


```
In [7]: newBook = Book('Emma', 'Jane Austen')

In [8]: newBook.__dict__

Out[8]: {'name': 'Emma', 'author': 'Jane Austen'}

In [9]: newBook.year = 1815

In [10]: newBook.__dict__

Out[10]: {'name': 'Emma', 'author': 'Jane Austen', 'year':
```

__slots__

- Dynamic creation and assignment of attributes is not desirable
- Slots provide a clean way to avoid this: instead of having a dynamic dict that stores the attributes as (key, value) pairs, slots provide a static structure which prohibits addition of attributes



```
In [18]: class Book:
             """This class represents a book"""
             __slots__ = ['name', 'author']
             def __init__(self, name=None, author=None):
                 self.name = name
                 self.author = author

In [20]: b = Book('Emma', 'Jane Austen')

In [21]: b.year = 1815

         ---------------------------------------------------------------------------
         AttributeError                            Traceback (most recent call last)
         <ipython-input-21-58a49885b6e1> in <module>
         ----> 1 b.year = 1815

         AttributeError: 'Book' object has no attribute 'year'
```

More Methods for the Book Class

Methods and Data Abstraction

- Methods of a class typically fall into two categories
    - **accessor methods** (that give us ready-only access to the object's attributes)
    - **mutator methods** (that let us modify the object's attributes)
- Ideally, we do not allow the user direct access to the object's attributes
- Instead we control access to state through methods
- This approach enforces **data abstraction**
    - Methods provide a public interface
    - Attributes are part of the private implementation

Defining More Methods

- We define the following methods in the class definition of `Book` to provide an interface to our book objects:
  - `numWordsName` that returns the number of words in the name of the book
  - `sameAuthorAs` that takes another book object as parameter and checks if the two books have the same author or not
  - `yearSincePub` that takes in the current year and returns the number of years since the book was published
- Find the implementation and invocations of these methods in the Jupyter Notebook for the lecture.

Acknowledgments

These slides have been adapted from:

- http://cs111.wellesley.edu/spring19 and
- https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-0001-introduction-to-computer-science-and-programming-in-python-fall-2016/
- https://www.python-course.eu/python3_object_oriented_programming.php