

Classes and Objects

Object Oriented Programming

Genome 559: Introduction to Statistical and
Computational Genomics

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A quick review

- Returning multiple values from a function

```
return [sum, prod]
```

- Pass-by-reference vs. pass-by-value

- Python passes arguments by reference
- Can be used (carefully) to edit arguments “in-place”

- Default Arguments

```
def printMulti(text, n=3):
```

- Keyword Arguments

```
runBlast("my_fasta.txt", matrix="PAM40")
```

A quick review – cont'

- **Modules:**

- A module is a file containing a set of related functions
- Python has numerous standard modules

- It is easy to create and use your own modules:

- Just put your functions in a separate file

- To use a module, you first have to import it:

`import utils`

- Use the dot notation:

`utils.makeDict()`

utils.py

```
# This function makes a dictionary
def makeDict(fileName):
    myFile = open(fileName, "r")
    myDict = {}
    for line in myFile:
        fields = line.strip().split("\t")
        myDict[fields[0]] = float(fields[1])
    myFile.close()
    return myDict

# This function reads a 2D matrix
def makeMatrix(fileName):
    < ... >
```

my_prog.py

```
import utils
import sys

Dict1 = utils.makeDict(sys.argv[1])
Dict2 = utils.makeDict(sys.argv[2])

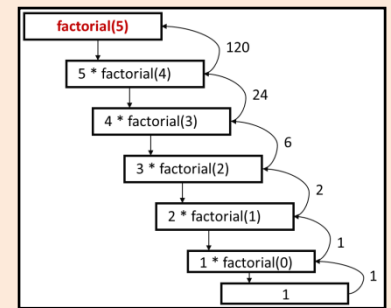
Mtrx = utils.makeMatrix("blsm.txt")

...
```

A quick review – cont'

■ Recursion:

- A function that calls itself
- Divide and conquer algorithms



■ Every recursion must have two key features:

1. There are one or more **base cases** for which no recursion is applied.
2. All recursion chains eventually end up at one of the base cases.

■ Examples:

- Factorial, string reversal
- **Binary search**
- Traversing trees
- **Merge sort**

■ Recursion vs. iteration



Classes and Objects

What is a class?

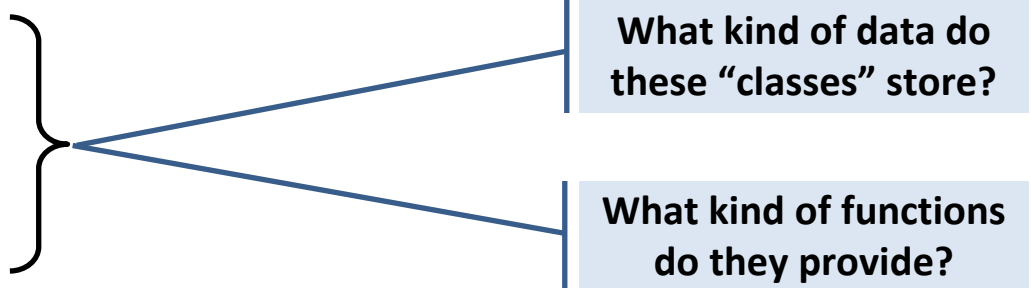
What is an object?

Why do we need them?

How do we use them?

How do we define new classes?

Classes

- A class defines the “type” of variables:
 1. What kind of data is stored
 2. What are the available functions
- Python includes (and you used) several built-in classes:
 - String
 - Dictionary
 - Number

The diagram shows a vertical list of three built-in classes: String, Dictionary, and Number. To the right of this list is a large right-facing curly bracket. From the middle of this bracket, two blue arrows point to the right. The top arrow points to a light blue rectangular box containing the text 'What kind of data do these “classes” store?'. The bottom arrow points to another light blue rectangular box containing the text 'What kind of functions do they provide?'.

 - What kind of data do these “classes” store?
 - What kind of functions do they provide?
- Modules may provide additional classes ...

Objects

- An object is an **instance** of a class:
 - **string** is a class
 - `my_str = "AGGCGT"` creates an object of the class string, called `my_str`.
- You can only have one class named "string"
- But .. You can have many string objects
 - `my_str = "AGGCGT"`
 - `your_str = "Thomas"`

Using objects

(surprise: you've been doing so all along)

```
>>> my_str = "ATCCGCG"  
>>> your_str = "Thomas"  
>>> print my_str.find("h")
```

2

Objects

Object methods

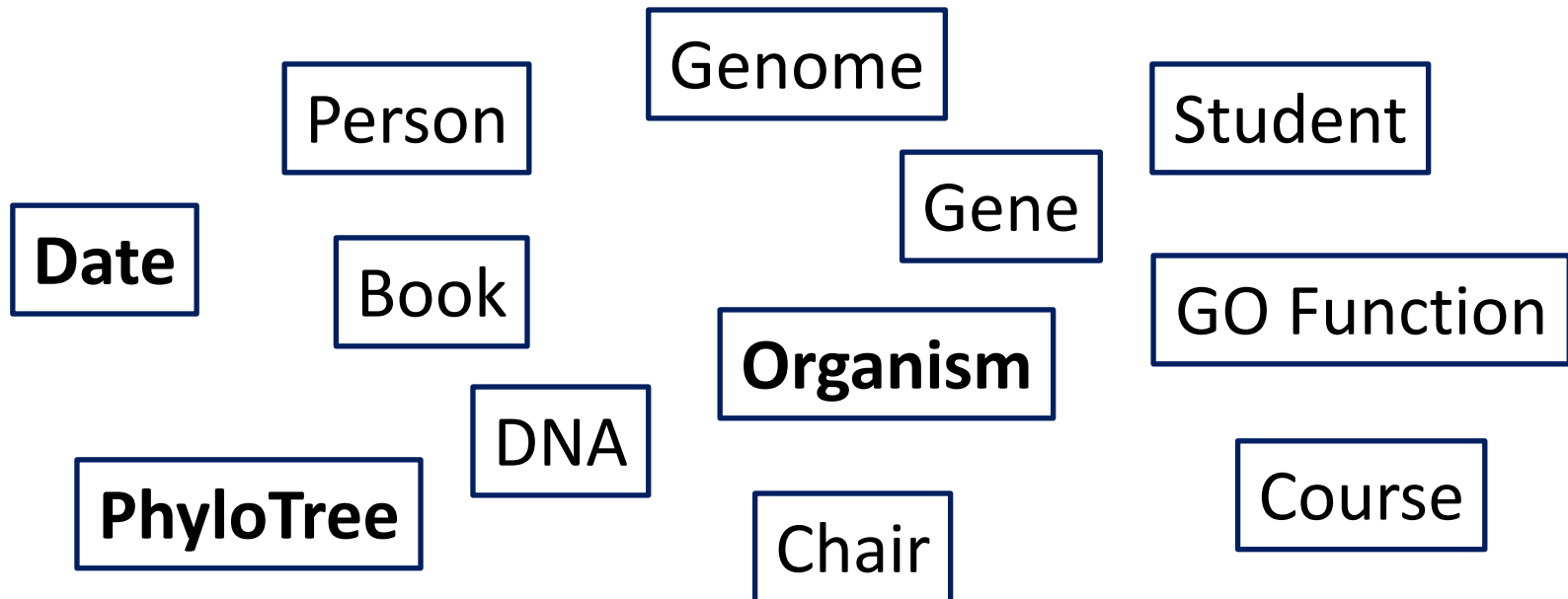
```
>>> print your_str.count("m")
```

1

This is useful ...

But ... why stop with built-in classes?

Wouldn't it be great if we could have many more classes?



This approach is known as

Object Oriented Programming (OOP)

(P.S. not supported in all programming languages)

Why classes?

- **Bundle together data and operations on data**
 - Keep related data together
 - Keep functions connected to the data they work on
- **Allow special operations appropriate to data**
 - “count” or “split” on a string;
 - “square root” on numbers
- **Allow context-specific meaning for common operations**
 - `x = 'a'; x*4` vs. `x = 42; x*4`
- **Help organize your code and facilitates modular design**
 - Large programs aren't just small programs on steroids

Why classes? The more profound answer

Why functions?

Technical factor

Allow to **reuse** your code
Help **simplify** & **organize** your code
Help to avoid **duplication** of code

Human factor

Human approach to problem solving:
Divide the task into smaller tasks
Hierarchical and **modular** solution

Why classes?

Technical factor

Bundle together data and operations
Allow context-specific operations
Help to **organize** your code

Human factor

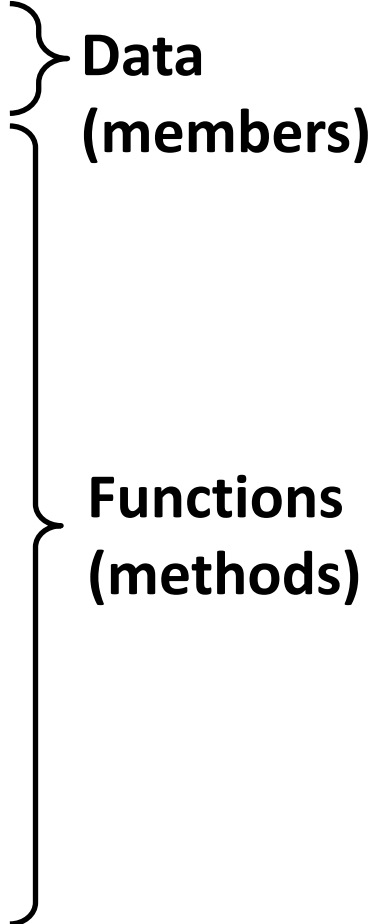
Human representation of the world:
Classify objects into categories
Each category/class is associated
with unique data/functions

Defining our first new class

- As an example, let's build a ***Date*** class



Defining our first new class

- As an example, let's build a ***Date*** class
 - An ideal *Date* class should ...
 - **store** day, month, and year
 - provide functions that **print** the date in different formats
 - provide functions to **add** or **subtract** a number of days from the date
 - provide a way to **find** the difference (in days) between 2 dates
 - **check** for errors:
 - Setting month to "January"
 - Copying the month without the associated day
 - 14 days after Feb 18 probably shouldn't be Feb 32
- 
- The diagram uses curly braces on the right side of the slide to group the class components. A brace labeled "Data (members)" groups the first two bullet points under the "An ideal Date class should ..." header: "store day, month, and year" and "provide functions that print the date in different formats". Another brace labeled "Functions (methods)" groups the remaining three bullet points: "provide functions to add or subtract a number of days from the date", "provide a way to find the difference (in days) between 2 dates", and "check for errors:" with its sub-bullets.

A very, very simple *Date* class

```
class Date:
```

```
    day = 0
```

```
    month = "None"
```

Note the
Format

Define the class *Date*

Create and initialize
class members
(not mandatory!!!)

A very, very simple *Date* class

```
class Date:
```

```
    day = 0
```

```
    month = "None"
```

Note the
Format

Define the class *Date*

Create and initialize
class members
(not mandatory!!!)

```
mydate = Date()
```

```
mydate.day = 15
```

```
mydate.month = "Jan"
```

```
print mydate
```

```
<__main__.Date instance at 0x1005380e0>
```

Create a new *Date*
object
(instance of the class *Date*)

Access and change
object members

Print object members

```
print mydate.day, mydate.month  
15 Jan
```

```
yourdate = mydate
```

Copy the object into
another object

Hmmm... a good start

- What do we have so far:
 - **Date data are bundled together (sort of ...)**
 - **Copying the whole thing at once is very handy**
- Still on our wish-list:
 - **We still have to handle printing the various details**
 - **Error checking - e.g., possible to forget to fill in the month**
 - **No Date operations (add, subtract, etc.)**

A slightly better *Date* class

```
mydate = Date()  
mydate.day = 15  
mydate.month= "Jan"
```

```
mydate.printUS()
```

```
Jan / 15
```

```
mydate.printUK()
```

```
15 . Jan
```

A slightly better *Date* class

class functions
(methods)

```
class Date:  
    day = 0  
    month = "None"
```

Special name "**self**" refers to the object in question (no matter what the caller named it).

```
    def printUS(self):  
        print self.month , "/" , self.day  
    def printUK(self):  
        print self.day , "." , self.month
```

```
mydate = Date()  
mydate.day = 15  
mydate.month= "Jan"
```

Call method
functions of this
Date object

```
mydate.printUS()  
Jan / 15
```

```
mydate.printUK()  
15 . Jan
```

Where did the
argument go?

We're getting there ...

- What do we have so far:
 - Date data are bundled together (sort of ...)
 - Copying the whole thing at once is very handy
 - **Printing is easy and provided as a service by the class**
- Still on our wish-list:
 - ~~■ We still have to handle printing the various details~~
 - Error checking - e.g., possible to forget to fill in the month
 - No Date operations (add, subtract, etc.)

```
class Date:  
    day = 0  
    month = "None"
```

```
mydate = Date()  
mydate.day = 15  
mydate.month= "Jan"
```

An even better *Date* class

```
class Date:
```

```
    def __init__(self, day, month):
```

```
        self.day = day
```

```
        self.month = month
```

```
    def printUS(self):
```

```
        print self.mon , "/" , self.day
```

```
    def printUK(self):
```

```
        print self.day , "." ,
```

```
mydate = Date(15, "Jan")
```

```
mydate.printUS()
```

```
Jan / 15
```

```
mydate2 = Date(22, "Nov")
```

```
mydate2.printUK()
```

```
22 . Nov
```

Special function "__init__" is called whenever a Date object instance is created. (class constructor)

It makes sure the object is properly initialized

Now, when "constructing" a new Date object, the caller MUST supply required data

Magical first arguments:

__init__ defined w/ 3 args; called w/ 2;
printUS defined w/ 1 arg; called w/ 0.

mydate passed in both cases as 1st arg, so each function knows on which object it is to act

Dreams do come true (sometimes)

- What do we have so far:
 - Date data are bundled together (sort of ...)
 - Copying the whole thing at once is very handy
 - Printing is easy and provided as a service by the class
 - **User MUST provide data when generating a new Date object**
- Still on our wish-list:
 - ~~■ We still have to handle printing the various details~~
 - ~~■ Error checking e.g., possible to forget to fill in the month~~
 - **No Date operations (add, subtract, etc.)**

Class declarations and usage - Summary

- The **class** statement defines a new class

```
class <class_name>:  
    <statements>  
    <statements> ...
```

- Remember the colon and indentation
- The special name **self** means the current object
 - *self*.<something> refers to instance variables of the class
 - *self* is automatically passed to each method as a 1st argument
- The special name **__init__** is the class constructor
 - Called whenever a new instance of the class is created
 - Every instance of the class will have all instance variables defined in the constructor
 - **Use it well!**

Sample problem #1

- Add a year data member to the *Date* class:
 1. Allow the class constructor to get an additional argument denoting the year
 2. If the year is not provided in the constructor, the class should assume it is 2018
(Hint: remember the default value option in function definition)
 3. When printing in US format, print all 4 digits of the year. When printing in UK format, print only the last 2 digits.
(Hint: *str(x)* will convert an integer *X* into a string)

```
>>> mydate = Date(15,"Jan",1976)
>>> mydate.printUK()
15 . Jan . 76
>>> mydate = Date(21,"Feb")
>>> mydate.printUS()
Feb / 21 / 2018
```


Solution #1

```
class Date:
    def __init__(self, day, month, year=2018):
        self.day = day
        self.mon = month
        self.year = year

    def printUS(self):
        print self.mon , "/" , self.day , "/" , self.year

    def printUK(self):
        print self.day , "." , self.mon , "." , str(self.year)[2:]
```

Sample problem #2

- Change the `Date` class such that the month is represented as a number rather than as a string.
(What did you have to do to make this change?)
- Add the function `addMonths(n)` to the class *Date*. This function should add n months to the current date.
Make sure to correctly handle transitions across years.
(Hint: the modulo operator, `%`, returns the remainder in division: $8 \% 3 \rightarrow 2$)

```
>>> mydate = Date(22, 11, 1976)
>>> mydate.printUK()
22 . 11 . 76
>>> mydate.addMonths(1)
>>> mydate.printUK()
22 . 12 . 76
>>> mydate.addMonths(3)
>>> mydate.printUK()
22 . 3 . 77
>>> mydate.addMonths(25)
>>> mydate.printUK()
22 . 4 . 79
```

Solution #2

```
class Date:
    def __init__(self, day, month, year=2018):
        self.day = day
        self.mon = month
        self.year = year

    def printUS(self):
        print self.mon , "/" , self.day , "/" , self.year

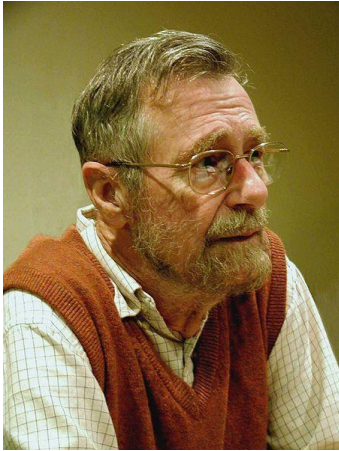
    def printUK(self):
        print self.day , "." , self.mon , "." , str(self.year)[2:]

    def addMonths(self, n=1):
        new_mon = self.mon + n
        self.year += (new_mon-1) / 12
        self.mon = (new_mon-1) % 12 + 1
```

Challenge Problem

1. Add the function `addDays(n)` to the class *Date*. This function should add `n` days to the current date. Make sure to correctly handle transitions across months AND across years (when necessary). Take into account the different number of days in each month.
2. Revise the *Date* class such that it will again work with the month's name (rather than its number), while preserving the functionality of the `addMonths` and `addDays` functions.

Code like a pro ...



Edsger Wybe Dijkstra
1930 –2002

*"Testing shows the presence,
not the absence of bugs."*

- Code running \neq code is correct or bug-free
- Be much more concerned about the bugs you don't see than the ones you do!!
- **Especially true in bioinformatics, high-throughput data analysis, and simulations**