COMP 364: Computer Tools for Life Sciences

Python programming: Lists

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Key course information

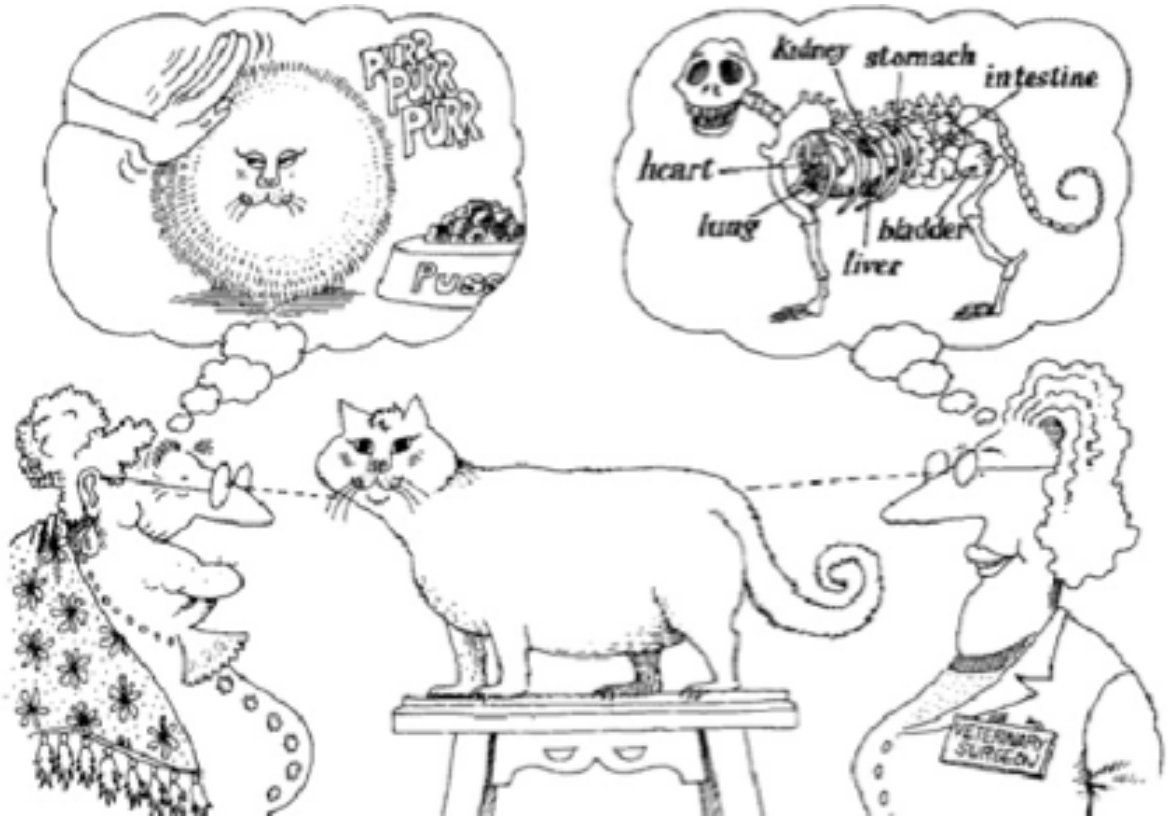
Quiz #1 is now available!

- Available on MyCourses (multiple choice questions)
- Quiz #1 closes at 11:59:59 pm on Monday, September 18th
- Multiple choice questions covering topics from the last two weeks
- Quizzes should be completed individually

Assignment #1 is now available!

- Available through the course website: `http://cs.mcgill.ca/~cgonza11/COMP_364/`
- Due: September 29th at 11:59:59 pm
- Please start early and see the TAs for help

Abstraction



Abstract data types

Abstract data types (ADT) are logical descriptions of how to view data and operations allowed regardless of implementation

- Concerned only with what the data is representing
- Not with how it will eventually be constructed

ADTs allow us to separate specification from implementation

- Specification: what kind of thing are we working on? what operations can be performed?
- Implementation: how the thing and its operations are coded

ADTs make programs easier to understand and modify

- Which helps makes a program good

Data structures

The implementing of an ADT is often referred to as a **data structure**

- Provides a physical view of the data using some collection of programming constructs and primitive data types
- Allows for an implementation-independent view of the data
  - Many different ways to implement an ADT

Implementation independence allows the programmer to switch the details of the implementation

- Without changing the way the user interacts with it
- The user can remain focused on the problem-solving process

Sequences

The most basic data structure in Python is the **sequence**

- Each element of a sequence is assigned a number - its position or index
- If the length of the sequence is N
  - The first index is zero
  - The second index is one
  - ...
  - The last index is $N - 1$

The two most common types of sequences are:

- Lists - dynamic in size and mutable
- Tuples - fixed size and immutable

Mutability

Some objects in Python are **mutable**

- Meaning that they can be altered
- E.g., lists, dictionaries, sets

While others are **immutable**

- Cannot be changed but rather return new objects when attempting to update
- E.g., int, float, tuple, bool, string

When does mutability matter?

Mutability example

Example of a very inefficient use of memory:

```
1       string = ""
2       # strings: [""]
3       string += "How"
4       # strings: ["","How","How"]
5       string += " are"
6       # strings: ["","How","How","are","How are"]
7       string += " you?"
8       # strings: ["","How","How","are","How are",
9       #             " you?","How are you?"]
```

Strings are **immutable**

- Concatenating two strings together actually creates a third
  - Which is the combination of the previous two

Lists vs. tuples

Lists

- When you don't have a constant set of values
  - I.e., unknown length
  - Allows you to add/remove items from the sequence

Tuples

- Are faster than lists
- If you're defining a constant set of values
  - All you're ever going to do is iterate through it
  - Use a tuple instead of a list
- Code is safer if you 'write-protect' data that does not need to be changed

Creating lists

To create a list:

```
1    L = [] # empty list
2    L = [expression, ...]
```

Python also has a built-in **list** type to create lists:

```
1    L = list()
2    L = list(sequence)
```

The sequence can be any kind of sequence object, including tuples

If you pass in another list, the **list** function makes a copy

Creating lists #2

Python creates a new list every time the [ ] expression is executed

- Python never creates a new list if you assign a list to a variable

```
1    A = B = [] # both variables point to the same list
2
3    A = []
4    B = A # both variables point to the same list
5
6    A = []; B = [] # independent lists
```

Printing lists

To print a list in Python

```
1    L = [0,1,2,3,4,5,6,7,8,9]
2    print(L) # prints '[0,1,2,3,4,5,6,7,8,9]'
```

.join() allows us to format the print statement

- As long as all items are strings

```
1    "".join(L)  # prints '123456789'
2    ",".join(L) # prints '1,2,3,4,5,6,7,8,9'
```

Accessing lists

len(L) will return the number of items in a list

```
1    L = [0,1,2,3,4,5,6,7,8,9]
2    n = len(L)
3    print(n) # prints '10'
```

L[i] returns the sequence item at index *i*

- The first item in a list has index 0
- The last item in a list has index $n - 1$

```
1    first_item = L[0]
2    last_item = L[9]
3    print(last_item is L[-1]) # prints 'True', why?
```

If you pass in a negative index, Python adds the length of the list to the index

Accessing lists #2

L[i:j] will return a new list that contains all items between *i* and *j*

```
1     seq = L[0:3]
2     print(seq) # prints ??
```

Lists also support **slicing**:

```
1     seq = L[start:stop:step]
2     seq = L[::2]  # get every other item,
3                   # starting with the first
4     seq = L[1::2] # get every other item,
5                   # starting with the second
```

Note: slicing is not inclusive of the stop index, [start:stop)

If an index is outside the list, Python raises an IndexError exception

Modifying lists

Lists allow for the assignment of individual items or slices

```
1    L[i] = obj # obj can be an int, string, etc.
2    L[i:j] = sequence
```

Operations that modify the list will modify it in place

- if multiple variables point to the same list, all variables will be updated

```
1    L = [0,1,2,3,4,5,6,7,8,9]
2    M = L # M points to L
3
4    # modify only L
5    index=3
6    L[index] = obj
7    print(M[index]) # prints value of 'obj'
```

Adding items to a list

.append() adds a single item to the end of the list

.extend() adds items from another list to the end of the list

.insert() inserts an item at a given index

- Moves the remaining items to the right

```
1    L.append(item)
2    L.extend(sequence)
3    L.insert(index, item)
```

Deleting items from a list

del statement can be used to remove an item or slice of items

```
1    del L[i]
2    del L[i:j]
```

.pop() will remove an individual and return it

```
1    item = L.pop()  # last item
2    item = L.pop(0) # first item
3    item = L.pop(index)
```

del statement and **.pop()** behave quite similar, except **.pop()** returns the removed item

Deleting items from a list #2

.remove() removes the first instance of a matching item in a list

```
1    L = [0,1,2,3,4,5,6,3,7,8,9]
2    L.remove(3)
3    print(L) # prints '[0,1,2,4,5,6,3,7,8,9]'
```

If no matching item is found in the list, Python raises a ValueError exception

Reversing the order of a list

.reverse() allows you to quickly reverse the order of a list

```
1    L = [0,1,2,3,4,5,6,7,8,9]
2    L.reverse()
3    print(L) # prints '[9,8,7,6,5,4,3,2,1,0]'
```

Reversing is fast

- Temporarily reversing a list can often speed things up
- Remove and insert many items at the end of the list

```
1    L.reverse()
2    # append/insert/pop/delete at far end
3    L.reverse()
```

Searching lists

.index() returns the index of the first matching item in a list

```
1    L = [1,2,3,4,5,5,6,7,8,9,10]
2    index = L.index(5)
3    print(index) # prints '4'
```

.index() performs a linear search, and stops at the first match

- If no matching item is found, Python raises a ValueError exception

Sorting lists

.sort() sorts a list in place

```
1    L = [2,1,3,4,5,1,6]
2    L.sort()
3    print(L) # prints '[1,1,2,3,4,5,6]'
```

If you require a copy of the sorted list, use the **sorted()** function

```
1    L = [2,1,3,4,5,1,6]
2    sorted_L = sorted(L)
3    print(L) # prints '[2,1,3,4,5,1,6]'
4    print(sorted_L) # prints '[1,1,2,3,4,5,6]'
```

Other useful functions/methods

min() returns the smallest item in a list

```
1    L = [0,1,2,3,4,5,6,7,8,9]
2    print(min(L)) # prints '0'
```

max() returns the largest items in a list

```
1    print(max(L)) # prints '9'
```

In the future, we will learn how to apply these functions to non-integer sequences

Mutability example #2

A more efficient and pythonic way:

```
1    L = [""]
2    L.append("How")    # L = ["","How"]
3    L.append(" are")   # L = ["","How"," are"]
4    L.append(" you?") # L = ["","How"," are"," you?"]
5    print("".join(L)) # prints 'How are you?'
```

Takes advantage of a single mutable list object to gather strings

- Then allocates a single result string to store data
- Reduces the total number of objects allocated by almost half

pythonic: code follows proper syntax and conventions of the Python community

- Uses the language in the way it is intended to be used