

COMP 204: Computer programming for Life Sciences

Python programming: Lists

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based on material from Mathieu Blanchette, Christopher J.F. Cameron and Carlos G. Oliver

The need for compound data types

Until now, our variable could only hold one value at a time... except for Strings, which is a sequence of many characters.

This is limited. If we want to store 1000 numbers, we would need 1000 variables!

```
1 weight1 = 45.6
2 weight2 = 12.3
3 weight3 = 24.5
4 ...
5 weight999 = 45.2
6 weight1000 = 42.4
```

And what if we don't know the number of elements ahead of time?

Compound data types - Lists and Tuples

Compound types allow us to store multiple values in one variable. The most basic compound type is called a **Sequence**. There are many types of Sequences:

- ▶ Strings: Specifically for chains of characters
- ▶ Lists:
 - ▶ Ordered collection of objects of *any number of objects of any types*
 - ▶ Mutable: They can grow or shrink, and their content can be modified
 - ▶ Useful when the number of objects to be stored is not known ahead of time
- ▶ Tuples:
 - ▶ Ordered collection of objects of a *fixed number* of objects of *any types*
 - ▶ Immutable: Once created, a tuple cannot be modified. Returns new objects when attempting to update
 - ▶ Useful when the number of objects to be stored is known ahead of time
 - ▶ Allows faster operations than lists

Lists and Tuples - examples

A *list* is created using *square brackets*, with items separated by commas

A *tuple* is created using *parentheses*, with items separated by commas.

```
1 # a list of 5 integers
2 ages = [10, 20, 30, 40, 50]
3
4 # a list of 3 strings
5 names = ["Sarah", "John", "Mary"]
6
7 # a list of both strings and integers
8 mixed = ["Bill", 50, "Amy", 32, "Roger", 76]
9
10 # an empty list
11 L = [ ]
12
13
14 # Example of tuples:
15
16 # a tuple of 3 float
17 xyz = (0.3, -0.5, 1.2)
18
19 # a tuple of one string and one integer
20 carbon = ("C", 12)
```

Lists and Tuples - more examples

The elements of lists or tuples can themselves be objects of compound types!

```
1 # a list of tuples (atom, mass)
2 periodicTable = [ ("H",1), ("C",12), ("N", 14) ]
3
4 # a list of lists
5 molecules = [ ["C", "O", "O"], ["N", "O"], ["O", "O"] ]
6
7 # a list of tuples, where each tuple is a
8 # pair of a String and a list of Strings
9 moleculesWithNames = [ ("carbon dioxyde", ["C", "O", "O"]),
10                        ("nitrous oxyde", ["N", "O"] ) ]
```

Accessing elements of Lists or Tuples - indexing

Like for Strings, we can access elements of lists or tuples by *indexing*.

Note: this example uses a List, but the same works for a Tuple.

```
1 names = ["Sarah", "Zheng", "Amol", "Vladimir", "Juanita"]
2
3 firstName = names[0]    # Sarah
4 secondName = names[1]  # Zheng
5 lastName = names[4]     # Juanita
6
7 nbNames = len(names)   # 5
8
9 lastName = names[nbNames - 1] # Still Juanita
10 wrong = names[nbNames] # Error: list index out of range
11
12 penultimateName = names[nbNames - 2] # Vladimir
13
14 lastName = names[-1]    # Juanita
15 penultimateName = names[-2] # Vladimir
16
17 someNames = names[1:3]  # ["Zheng", "Amol"]
18 allButFirst = names[1:5] # ["Zheng", "Amol", "Vladimir",
    "Juanita"]
19 allButLast = names[0:4] # ["Sarah", "Zheng", "Amol",
    "Vladimir"]
```

Accessing elements of Lists or Tuples - indexing

We can also access value in a nested list

```
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4 # a list of lists
5 molecules = [ ["C","O","O"], ["N","O"], ["O","O"] ]
6
7 # a list of tuples, where each tuple is a
8 # pair of a String and a list of Strings
9 moleculesWithNames = [ ("carbon dioxyde", ["C","O","O"]),
10                        ("nitrous oxyde", ["N","O"] ) ]
11
12 # indexing tuple value in a list
13 periodicTable[1][1] # 12
14
15 # indexing list value inside a tuple inside another list
16 moleculesWithNames[1][1][0] # "N"
```

Modifying the content of a List

Because lists are *mutable*, their content can be modified.

```
1 names = ["Sarah", "Zheng", "Amol", "Vladimir", "Juanita"]
2
3 names[1] = "Lin" # Zheng is replaced by Lin
4 names[4] = "Consuela" # Juanita is replaced by Consuela
5
6 names[5] = "John" # Error: Index of out range
7
8 # we can replace multiple elements of the list at once
9 names[2:4] = ["Prakash", "Boris"]
10
11 # or replace a portion of a list with another one
12 names[2:4] = ["Prakash", "Boris", "John", "Paul"]
```

Note: This would not work on tuples, because they are immutable.

Assigning by copy versus assigning by reference

Assignments of values to variables behaves differently for simple and compound types:

Assigning by copy

- ▶ For simple types (int, float, boolean), writing `b = a` creates a new variable `b`, separate from `a`, whose value is set to that of `a`

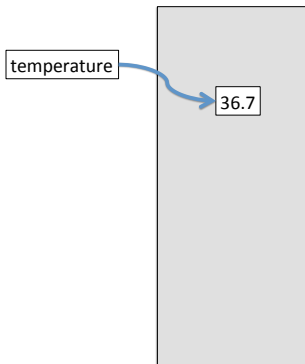
Assigning by reference

- ▶ For compound types (lists, tuples, and more), writing `b = a` creates a new variable `b` that refers to the same compound object as `a`. Modifying the content of `a` also modifies the content of `b`.

```
# example with a simple type (e.g. float)
temperature = 36.7
newTemperature = temperature
print(temperature, newTemperature) # 36.7 36.7
temperature = 37.2
print(temperature, newTemperature) # 37.2 36.7
```

```
# example with a compound type (e.g. list)
names = ["Sarah", "Zheng", "Amol"]
otherNames = names
names[1] = "Lin" # Zheng is replaced by Lin
print(names, otherNames) # ["Sarah", "Lin", "Amol"]
                        # ["Sarah", "Lin", "Amol"]
otherNames[2] = "Ahmed"
print(names, otherNames) # ["Sarah", "Lin", "Ahmed"]
                        # ["Sarah", "Lin", "Ahmed"]
```

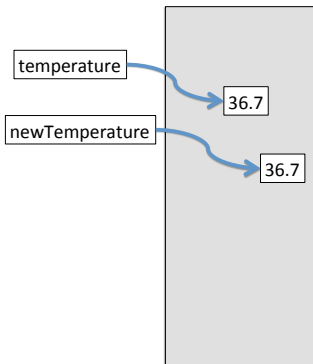
Global variables Computer memory



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print(names, otherNames) # ["Sarah", "Lin", "Amol"]
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otherNames[2] = "Ahmed"
print(names, otherNames) # ["Sarah", "Lin", "Ahmed"]
                        # ["Sarah", "Lin", "Ahmed"]
```

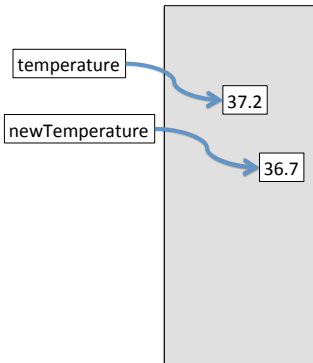
Global variables Computer memory



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print(names, otherNames) # ["Sarah", "Lin", "Ahmed"]
                        # ["Sarah", "Lin", "Ahmed"]
```

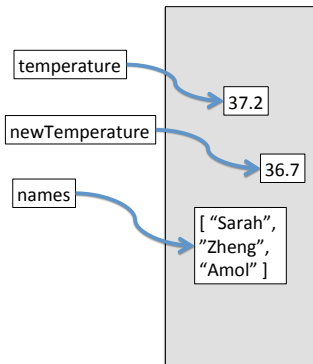
Global variables Computer memory



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# example with a compound type (e.g. list)
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names[1] = "Lin" # Zheng is replaced by Lin
print(names, otherNames) # ["Sarah", "Lin", "Amol"]
                        # ["Sarah", "Lin", "Amol"]
otherNames[2] = "Ahmed"
print(names, otherNames) # ["Sarah", "Lin", "Ahmed"]
                        # ["Sarah", "Lin", "Ahmed"]
```

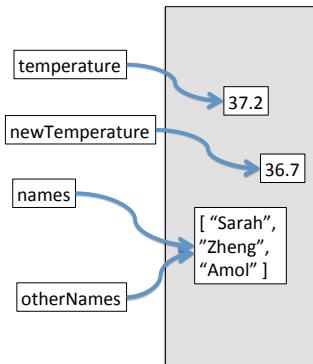
Global variables Computer memory



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# example with a compound type (e.g. list)
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otherNames = names
names[1] = "Lin" # Zheng is replaced by Lin
print(names, otherNames) # ["Sarah", "Lin", "Amol"]
                        # ["Sarah", "Lin", "Amol"]
otherNames[2] = "Ahmed"
print(names, otherNames) # ["Sarah", "Lin", "Ahmed"]
                        # ["Sarah", "Lin", "Ahmed"]
```

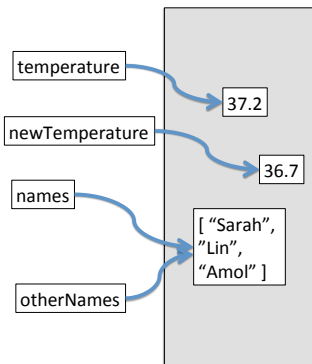
Global variables Computer memory



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# example with a simple type (e.g. float)
temperature = 36.7
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print(temperature, newTemperature) # 36.7 36.7
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```

```
# example with a compound type (e.g. list)
names = ["Sarah", "Zheng", "Amol"]
otherNames = names
names[1] = "Lin" # Zheng is replaced by Lin
print(names, otherNames) # ["Sarah", "Lin", "Amol"]
                        # ["Sarah", "Lin", "Amol"]
otherNames[2] = "Ahmed"
print(names, otherNames) # ["Sarah", "Lin", "Ahmed"]
                        # ["Sarah", "Lin", "Ahmed"]
```

Global variables Computer memory

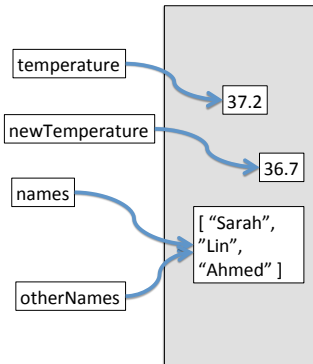


Important: Here, both variables `names` and `otherNames` point to the *same* list. So modifying the `names` list also modifies the content of `otherNames`. `names` and `otherNames` are *aliases* for the same list.

```
# example with a simple type (e.g. float)
temperature = 36.7
newTemperature = temperature
print(temperature, newTemperature) # 36.7 36.7
temperature = 37.2
print(temperature, newTemperature) # 37.2 36.7
```

```
# example with a compound type (e.g. list)
names = ["Sarah", "Zheng", "Amol"]
otherNames = names
names[1] = "Lin" # Zheng is replaced by Lin
print(names, otherNames) # ["Sarah", "Lin", "Amol"]
                        # ["Sarah", "Lin", "Amol"]
otherNames[2] = "Ahmed"
print(names, otherNames) # ["Sarah", "Lin", "Ahmed"]
                        # ["Sarah", "Lin", "Ahmed"]
```

Global variables Computer memory



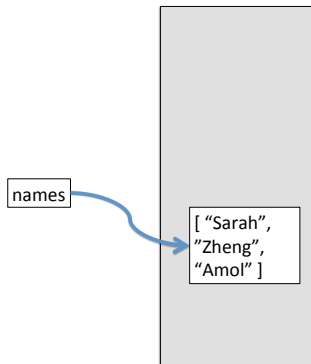
... and vice-versa modifying the content of the list `otherNames` also modifies `names`

Cloning lists

What if we want `names` and `otherNames` to actually correspond to different lists, but we want `otherNames` to be initialized from `names`?

```
names = ["Sarah", "Zheng", "Amol"]  
otherNames = names[:]  
names[1] = "Lin" # Zheng is replaced by Lin  
print(names, otherNames) # ["Sarah", "Lin", "Amol"]  
                        # ["Sarah", "Zheng", "Amol"]
```

Global variables Computer memory

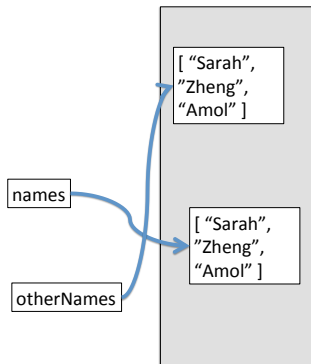


Cloning lists

What if we want `names` and `otherNames` to actually correspond to different lists, but we want `otherNames` to be initialized from `names`?

```
names = ["Sarah", "Zheng", "Amol"]  
otherNames = names[:]  
names[1] = "Lin" # Zheng is replaced by Lin  
print(names, otherNames) # ["Sarah", "Lin", "Amol"]  
                        # ["Sarah", "Zheng", "Amol"]
```

Global variables Computer memory



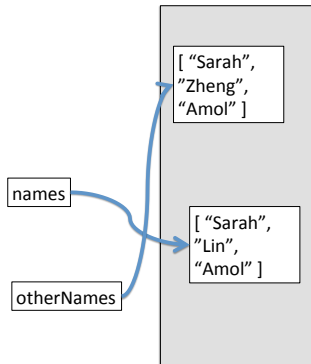
Note the use of `[:]`. This is what tells the interpreter to clone the `names` list. Now `names` and `otherNames` point to *different* lists, which just happen to contain identical content.

Cloning lists

What if we want `names` and `otherNames` to actually correspond to different lists, but we want `otherNames` to be initialized from `names`?

```
names = ["Sarah", "Zheng", "Amol"]
otherNames = names[:]
names[1] = "Lin" # Zheng is replaced by Lin
print(names, otherNames) # ["Sarah", "Lin", "Amol"]
                        # ["Sarah", "Zheng", "Amol"]
```

Global variables Computer memory



Changing `names` does not change `otherNames`.

More on adding items to a list

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

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

.insert(index, someObject) inserts an item at a given index

► Moves the remaining items to the right

```
1 names = ["Zheng", "Amol"]
2 otherNames = ["Chris", "Irene"]
3
4 names.append("Bill") # names is now
5                       # ["Zheng", "Amol", "Bill"]
6
7 names.extend(otherNames) # names is now
8                           # ["Zheng", "Amol", "Bill", "Chris", "Irene"]
9
10 names.insert(2, "Laura") # names is now
11                          # ["Zheng", "Amol", "Laura", "Bill", "Chris", "Irene"]
```

Deleting items from a list

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

```
1 names = ["Sarah", "Zheng", "Amol", "Vladimir"]
2
3 del names[1] # removes Zheng from the list
4             # names is now ["Sarah", "Amol", "Vladimir"]
5
6 del names[0:2] # removed Sarah and Amol
7             # names is now ["Vladimir"]
```

.pop(index) will remove an individual and return it

```
1 names = ["Sarah", "Zheng", "Amol", "Vladimir"]
2
3 removedName = names.pop(2)
4 # names is now ["Sarah", "Zheng", "Vladimir"]
5 # removedName is now "Amol"
```

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

Deleting items from a list

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

```
1 names = [ "Sarah", "Zheng", "Amol", "Vladimir", "Zheng" ]
2
3 names.remove("Zheng")
4 # names is now [ "Sarah", "Vladimir", "Amol", "Zheng" ]
5
6 names.remove("Zheng")
7 # names is now [ "Sarah", "Vladimir", "Amol" ]
8
9 names.remove("Billy") # causes exception: not in list
```

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

Searching lists

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

```
1 names = [ "Sarah", "Zheng", "Amol", "Vladimir", "Zheng" ]
2
3 indexVlad = names.index("Vladimir") # indexVlad is 3
4
5 indexZheng = names.index("Zheng") # indexZheng is 1
6
7 indexBob = names.index("Bob") # ValueError Exception
8                               # Bob is not in list
```

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

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

.count(someObject) returns the number of occurrences of the object in the list

```
1 names = [ "Sarah", "Zheng", "Amol", "Vladimir", "Zheng" ]
2
3 nbZheng = names.count("Zheng") # 2
4 nbAmol = names.count("Amol") # 1
5 nbBob = names.count("Bob") # 0
```

Reversing the order of a list

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

```
1 names = ["Sarah", "Zheng", "Amol", "Vladimir", "Zheng"]
2
3 names.reverse()
4 # names is now ["Zheng", "Vladimir", "Amol", "Zheng", "Sarah"]
```

Reversing is fast

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

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 *clone* 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'
```