Sharing, mutability, and immutability

Ruth Anderson

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Topics for Today

- **variables** and **objects**
- Changing/creating **bindings** vs. changing/modifying **objects**
- **Mutability** vs. **immutability**
- Review of **types**

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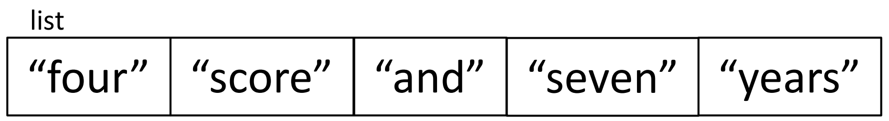
Copying and mutation

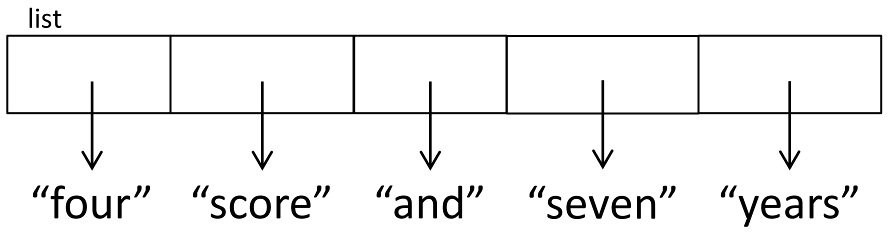
```
list1 = ["e1", "e2"]
list2 = list1
list3 = list(list1)    # make a copy; also “list1[:]”
print(list1, list2, list3)
list1.append("e3")
list2.append("e4")
list3.append("e5")
print(list1, list2, list3)
list1 = list3
list1.append("e6")
print(list1, list2, list3)
```

An aside: List notation

- Possibly misleading notation:



- More accurate, but more verbose, notation:



Variable (re)assignment vs. Object mutation

- **(Re)assigning** a variable changes a ***binding,*** it does not change (mutate) any **object**

(Re)assigning is **always** done via the syntax:

```
my_var = expr
```

```
size = 6
list2 = list1
```

Changes what the variables `size` and `list2` are **bound** to

- **Mutating (changing) an object** does not change any **variable** binding

Changes something about the ***object*** that `my_list` refers to

Two syntaxes:

```
left_expr = right_expr

expr.method(args…)
```

Examples:

```
my_list[3] = val

my_list.append(val)
```

New and old values

- Every **expression** evaluates to a value
  - It might be a new value
  - It might be a value that already exists
- A **constructor** evaluates to a **new** value:

```
lst1 = [3, 1, 4, 1, 5, 9]
lst2 = [3, 1, 4] + [1, 5, 9]
lst3 = [[3, 1], [4, 1]]
```

In all 3 examples here the right hand side of = is a constructor

- An **access** expression evaluates to an **existing** value:

```
x = lst1[1]
y = my_dict["rea"]
```

- What does a function call evaluate to?

```
z = mystery(arg)
```

Example: Variable reassignment or Object mutation?

```
def change_val(lst):
    lst[0] = 13
def append_val(lst):
    lst.append(99)
def mystery(lst):
    lst = lst + [99]
    return lst

lst2 = [1, 2]
change_val(lst2)
append_val(lst2)
lst3 = mystery(lst2)
```

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Example: Lists of lists

```
def make_new_grid(input_grid):
    """Make a new grid that is a copy of input_grid.
    Set location [0][0] in new grid to be 99.
    Do not modify input_grid."""
    new_grid = []
    for row in input_grid:
        new_grid.append(row)
    new_grid[0][0] = 99
    return new_grid

grid1 = [[1, 2, 3], [4, 5, 6]]
grid2 = make_new_grid(grid1)
print("grid1:", grid1)
print("grid2:", grid2)
```

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Aside: Object identity

- An object’s **identity** never changes
- Can think of it as its **address in memory**
- Its value of the object (the thing it represents) may change

```
my_list = [1, 2, 3]
other_list = my_list
my_list.append(4)
```

`my_list is other_list` ⇒ True

`my_list` and `other_list` refer to the *exact same object*

`my_list == [1, 2, 3, 4]` ⇒ True

The object `my_list` refers to is equal to the object [1,2,3,4] (but they are two different objects)

`my_list is [1, 2, 3, 4]` ⇒ False

The object `my_list` refers to is ***not the exact same object*** as the object [1,2,3,4]

Use == to check for equality, NOT is

Aside: Using is with `None` is o.k: `if x is None:`

Object type and variable type

- An **object's** type never changes
- A **variable** can get rebound to a value of a different type

Example: The variable **`a`** can be bound to an int or a list

`a = 5`	5 is always an int
`a = [1, 2, 3, 4]`	`[1, 2, 3, 4]` is always a list

- A **type** indicates:
  - what operations are allowed
  - the set of representable values
  - **`type(object)`** returns the type of an object

New datatype: tuple

- Like lists, tuples represents an <u>ordered</u> sequence of values
- Like strings, tuples are *immutable*
- The elements of a tuple can be anything (including mutable types)

Examples:

```
()
(4, 7, 9)
("hi", [1, 2], 5)
```

Tuple operations

Constructors

- Literals: Use parentheses

```
("four", "score", "and", "seven", "years")
(3, 1) + (4, 1)   => (3, 1, 4, 1)  # creates a new tuple!
```

Queries

- Can index just like lists:

```
tup = ("four", "score", "and", "seven", "years")
print(tup[0])        => "four"
print(tup[-1])       => "years"
```

Mutators

- Like strings, tuples are *immutable*, so have no mutators

Immutable datatype

- An ***immutable*** datatype is one that doesn't have any functions in the third category:
  - Constructors
  - Queries
  - Mutators: Does not have any!
- **Immutable datatypes**:
  - int, float, boolean, string, tuple, *frozenset*
- **Mutable datatypes**:
  - list, dictionary, set

Remember:
Not every value may be placed in a set

- Set *elements* must be **immutable** values
  - int, float, bool, string, *tuple*
  - *not*: list, set, dictionary
- The set itself is **mutable** (e.g. we can add and remove elements)

- **Aside:** *frozenset* must contain immutable values and is itself immutable (cannot add and remove elements)

Remember: Not every value is allowed to be a key in a dictionary

- Remember: Dictionaries hold **key:value** pairs
- **Keys** must be **immutable**
  - int, float, bool, string, *tuple of immutable types*
  - *not*: list, set, dictionary
- **Values** in a dictionary can be **mutable**
- The dictionary itself is **mutable** (e.g. we can add and remove elements)

Mutable and Immutable Types

- **Immutable** datatypes:
  - int, float, boolean, string, function, tuple, *frozenset*
- **Mutable** datatypes:
  - list, dictionary, set

Note: a set is mutable, but a *frozenset* is immutable

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Tuples are immutable
Lists are mutable

```
def update_record(record, position, value):
    """Change the value at the given position"""
    record[position] = value

my_list = [1, 2, 3]
my_tuple = (1, 2, 3)
update_record(my_list, 1, 10)
print(my_list)
update_record(my_tuple, 1, 10)
print(my_tuple)
```

Increment Example

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```
def increment_count(words_dict, word):
    """increment the count for word"""
    if word in words_dict:
         words_dict[word] = words_dict[word] + 1
    else:
         words_dict[word] = 1
def increment_val(value):
     """increment the value???"""
     value = value + 1

my_words = dict()
increment_count(my_words, "school")
print(my_words)
my_val = 5
increment_val(my_val)
print(my_val)
```