Sharing, mutability, and immutability

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UW CSE 160

Winter 2021

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Copying and mutation

```
list1 = ["e1", "e2", "e3", "e4"]
list2 = list1
list3 = list(list1)    # make a copy; also "list1[:]"
print(list1, list2, list3)
list1.append("e5")
list2.append("e6")
list3.append("e7")
print(list1, list2, list3)
list1 = list3
list1.append("e8")
print(list1, list2, list3)
```

Variable reassignment vs. Object mutation

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

Reassigning is **always** done via the syntax:

```
myvar = 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

Two syntaxes:

```
left_expr = right_expr
```

```
expr.method(args…)
```

Examples:

```
mylist[3] = myvalue
```

```
mylist.append(myvalue)
```

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

Example: Variable reassignment or Object mutation?

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```
def no_change(lst):
    """does NOT modify what lst refers to,
    instead re-binds lst"""
    lst = lst + [99]
def change_val(lst):
    """modifies object lst refers to"""
    lst[0] = 13
def append_val(lst):
    """modifies object lst refers to"""
    lst.append(99)
lst2 = [1, 2]
no_change(lst2)
change_val(lst2)
append_val(lst2)
```

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:

```
[3, 1, 4, 1, 5, 9]
[3, 1, 4] + [1, 5, 9]
mylist = [[3, 1], [4, 1]]
```

Here the right hand side of = is a constructor

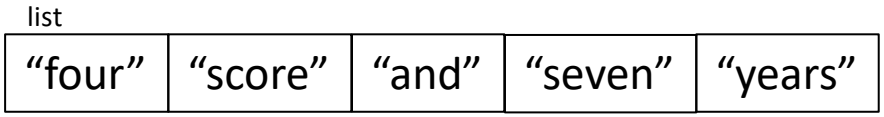
- An **access** expression evaluates to an **existing** value:

```
mylist[1]
```

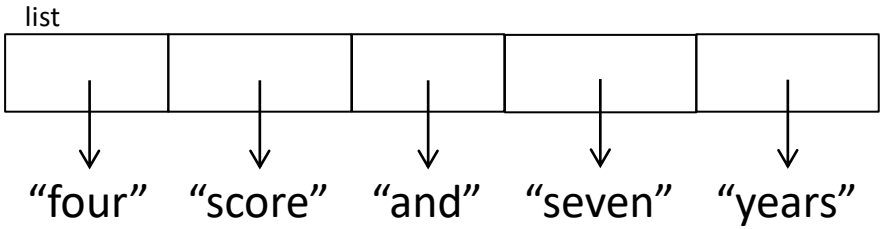
- What does a function call evaluate to?

An aside: List notation

- Possibly misleading notation:



- More accurate, but more verbose, notation:



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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

```
mylist = [1, 2, 3]
otherlist = mylist
mylist.append(4)
```

`mylist is otherlist` ⇒ True

`mylist` and `otherlist` refer to the *exact same object*

`mylist == [1, 2, 3, 4]` ⇒ True

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

`mylist is [1, 2, 3, 4]` ⇒ False

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

Moral: Use == to check for equality, NOT is

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

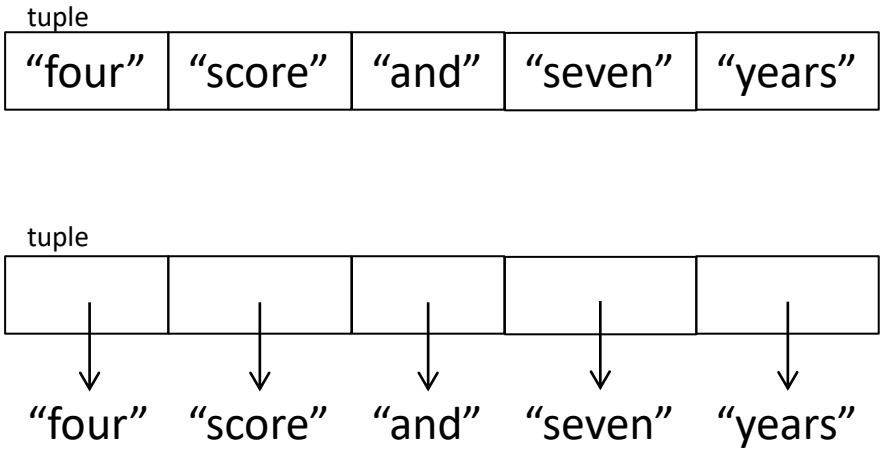
```
a = 5                    5 is always an int
a = [1, 2, 3, 4]         [1, 2, 3, 4] is always a list
```

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

New datatype: tuple

A tuple represents an ordered sequence of values

Example:



Tuple operations

Constructors

- Literals: Use parentheses

```
("four", "score", "and", "seven", "years")
(3, 1) + (4, 1)  => (3, 1, 4, 1)
```

Queries

- Just like lists:

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

Mutators

- None!

Immutable datatype

- An immutable datatype is one that doesn't have any functions in the third category:
  - Constructors
  - Queries
  - Mutators: None!
- Immutable datatypes:
  - int, float, boolean, string, function, tuple, *frozenset*
- Mutable datatypes:
  - list, dictionary, set

Tuples are immutable
Lists are mutable

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

mylist = [1, 2, 3]
mytuple = (1, 2, 3)
updaterecord(mylist, 1, 10)
print(mylist)
updaterecord(mytuple, 1, 10)
print(mytuple)
```

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Increment Example

```
def increment(uniquewords, word):
    """increment the count for word"""
    if word in uniquewords:
         uniquewords[word] = uniquewords[word] + 1
    else:
         uniquewords[word] = 1
mywords = dict()
increment(mywords, "school")
print(mywords)
def increment(value):
     """increment the value???"""
     value = value + 1
myval = 5
increment(myval)
print(myval)
```

Increment Example (cont.)

```
>>> def increment(uniquewords, word):
...     """increment the count for word"""
...     if word in uniquewords:
                uniquewords[word] = uniquewords[word] + 1
        else:
                uniquewords[word] = 1

>>> mywords = dict()
>>> increment(mywords, "school")
>>> print(mywords)
{'school': 1}

>>> def increment(value):
...     """increment the value???"""
...     value = value + 1
>>> myval = 5
>>> increment(myval)
>>> print(myval)
5
```

Python's *Data Model*

- All data is represented by *objects*
- Each object has:
  - an *identity*
    - Never changes
    - Think of this as address in memory
    - Test with **`is`** (but you rarely need to do so)
  - a *type*
    - Never changes
  - a *value*
    - Can change for *mutable* objects
    - Cannot change for *immutable* objects
    - Test with **==**

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

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