Sharing, mutability, and immutability

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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?

Example: Lists of lists

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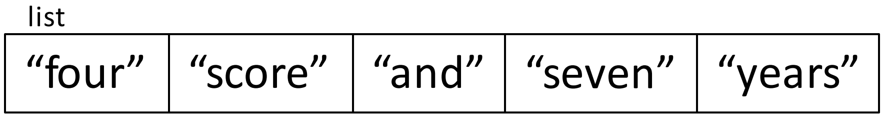
```
def make_new_grid(grid):
    new_grid = []
    for row in grid:
        new_grid.append(row)
    new_grid[0][0] = 99
    return new_grid

grid1 = [[1, 2, 3], [4, 5, 6]]
grid2 = make_new_grid(grid1)
grid2[0][1] = 88
```

Be careful you do not unintentionally change parts of an input parameter!

An aside: List notation

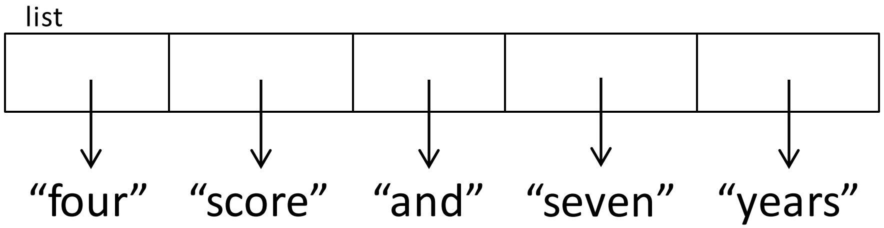
- Possibly misleading notation:



list

“four” “score” “and” “seven” “years”

- More accurate, but more verbose, notation:



list

“four” “score” “and” “seven” “years”

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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]

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 ordered 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)

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 **`==`**

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

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

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

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Increment Example

```
def increment(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
my_words = dict()
increment(my_words, "school")
print(my_words)
def increment(value):
    """increment the value???"""
    value = value + 1
my_val = 5
increment(my_val)
print(my_val)
```

Increment Example (cont.)

```
>>> def increment(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

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

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