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

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- **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

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]

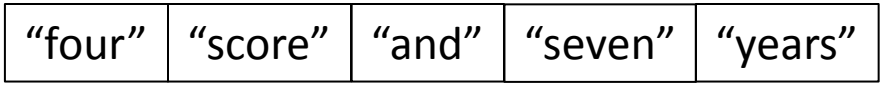
  [3, 1, 4, 1, 5, 9]

  mylist = [[3, 1], [4, 1]]
- An access expression evaluates to an existing value

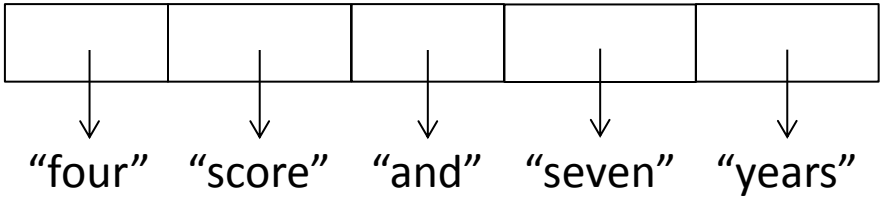
  mylist[1]
- What does a function call evaluate to?

An aside: List notation

- Possibly misleading notation:



- More accurate, but more verbose, notation:



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]

The object identity test "`is`" is rarely used

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

Aside: how did tuples get their name?

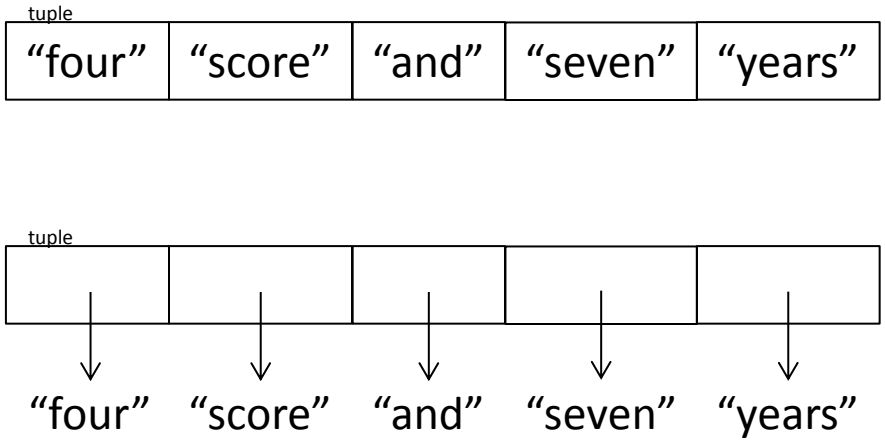
- sing**leton**
- **pair**
- d**ouble**
- tr**iple**
- quad**ruple**
- quin**tuple**
- sex**tuple**
- sep**tuple**
- oc**tuple**
- no**nuple**
- de**cuple**

Notice that the last 5 letters in these words are always **tuple**

New datatype: tuple

A tuple represents an ordered sequence of values

Example:



Tuple operations

Constructors

- Literals: Just like lists, but round the square brackets

```
("four", "score", "and", "seven", "years")
```

- Also `(3, 1) + (4, 1)` => (3, 1, 4, 1), etc.

Queries

- Just like lists

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

Not every value may be placed in a set

- Set elements must be immutable values
  - int, float, bool, string, *tuple*
  - *not*: list, set, dictionary
- **Goal**: only set operations change the set
  - after "`myset.add(x)`", `x in myset` ⇒ True
  - `y in myset` always evaluates to the same value

  Both conditions should hold until `myset` is changed
- **Mutable elements can violate these goals**

```
list1 = ["a", "b"]
list2 = list1
list3 = ["a", "b"]
myset = { list1 }          ⇐ Hypothetical; actually illegal in Python
list1 in myset ⇒ True
list3 in myset ⇒ True
list2.append("c")
list1 in myset ⇒ ???
list3 in myset ⇒ ???
```

Not every value is allowed to be a key

- Keys must be immutable values
  - int, float, bool, string, *tuple*
  - *not*: list, set, dictionary
- **Goal**: only dictionary operations change the keyset
  - after "`mydict[x] = y`", `mydict[x]` ⇒ y
  - if `a == b`, then `mydict[a] == mydict[b]`

  These conditions should hold until `mydict` is changed
- **Mutable keys can violate these goals**

```
list1 = ["a", "b"]
list2 = list1
list3 = ["a", "b"]
mydict = {}
mydict[list1] = "z"
mydict[list3] ⇒ "z"
list2.append("c")
mydict[list1] ⇒ ???
mydict[list3] ⇒ ???
```

⇐ Hypothetical; actually illegal in Python

Python's *Data Model*

- Everything is an *object*
- Each object has:
  - an *identity*
    - Never changes
    - 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
  - numbers, strings, tuples
- Mutable
  - lists and dictionaries

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

Tuples are immuatble
Lists are mutable

```
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
```

Mutable and Immutable Types

```
>>> def increment(uniquewords, word):
...     """increment the count for word"""
...     if uniquewords.has_key(word):
                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
```