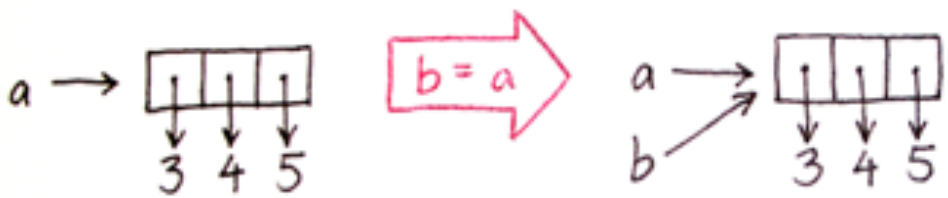
SAMS
Programming - Section C

Week 3 - Lecture 1:
Lists



July 17, 2017

Builtin Data Types

Python name	Description	Values
NoneType	absence of value	None
bool (boolean)	Boolean values	True, False
int (integer)	integer values	-2^{63} to $2^{63}-1$
long	large integer values	all integers
float	fractional values	e.g. 3.14
complex	complex values	e.g. 1+5j
str (string)	text	e.g. "Hello World!"
list	a list of values	e.g. [2, "hi", 3.14]

●●●

String vs List

string	**list**
s = “hw2-1 was hard”	a = [1, 3.14, “hi”, True]
A sequence (string) of characters.	A sequence of arbitrary objects.
immutable	mutable
~~s[0] = “H”~~	a[0] = 100

Lists: basic usage

```
a = []              # creates an empty list
b = list()          # also creates an empty list
c = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
d = list(range(1, 11))        d = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
e = [1, 3.14, None, True, "Hi", [1, 2, 3]]

for i in range(len(c)):
    print(c[i])

for item in e:
    print(item)

print(e[1:4])
e[2] = 0
d += [11]
print(d[::2])
```

Lists: basic usage

```
print([1, 2, 3] + [4, 5, 6])          [1, 2, 3, 4, 5, 6]
a = [0] * 5
print(a)                              [0, 0, 0, 0, 0]

if (1 in a):
    print("1 is in the list a.")

if (1 not in a):
    print("1 is not in the list a.")

b = [0, 0, 0, 0, 0]

if (a == b):
    print("a and b contain the same elements.")
```

Lists: built-in functions

```
a = list(range(1, 11))

print(len(a))

print(min(a))

print(max(a))

print(sum(a))

a = [4, 5, 1, 3, 2, 8, 7, 6, 9, 10]

a = sorted(a)

print(a)                    [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

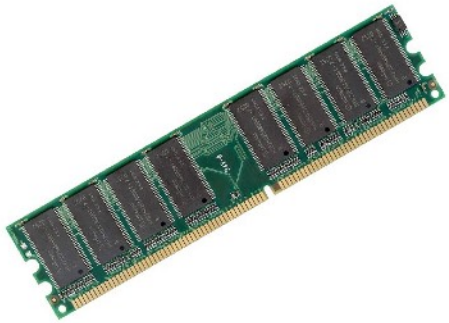
Lists: interesting example

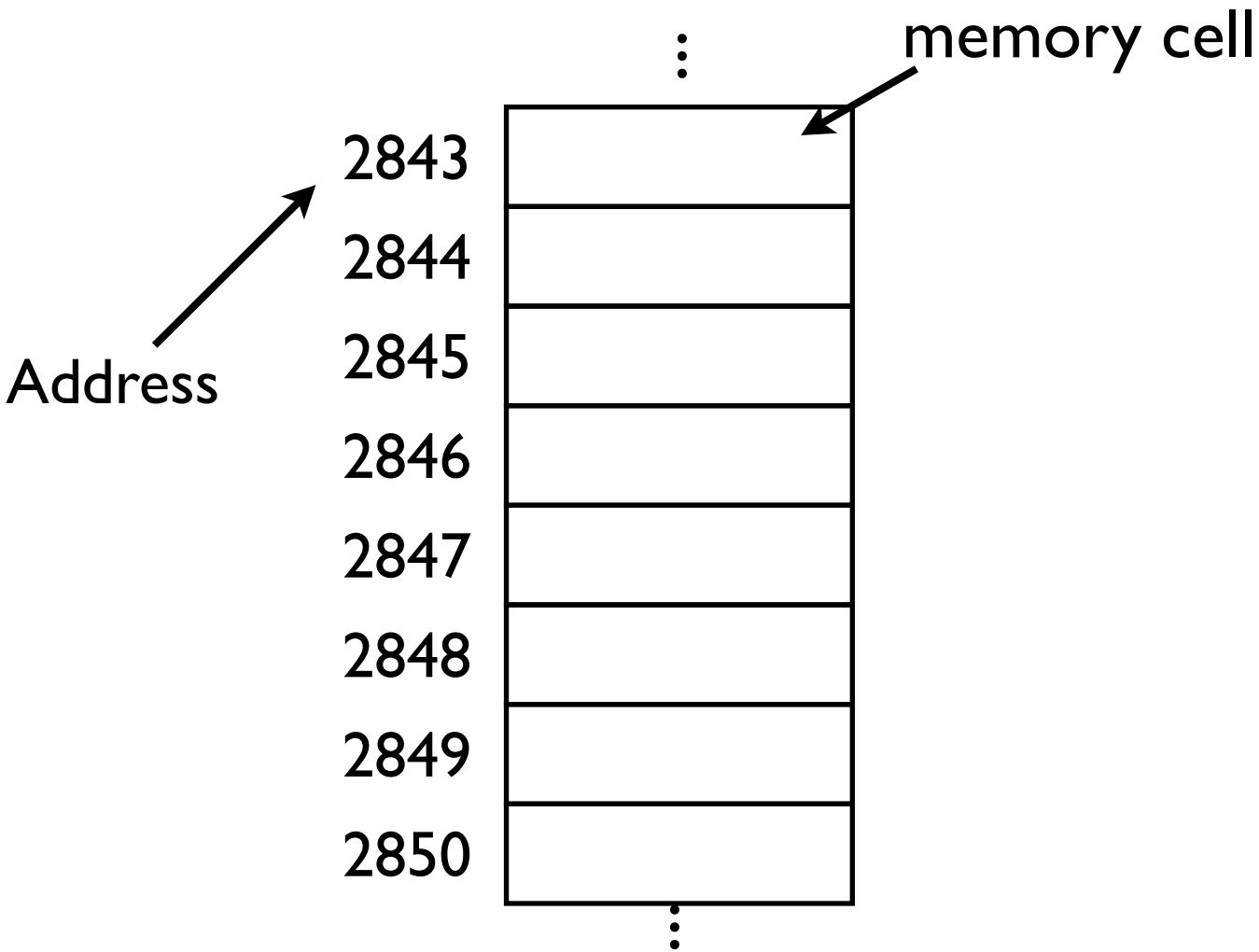
```
x = 1
y = x
x += 1
print(x, y)          2  1
```

```
x = [1, 2, 3]
y = x
x[0] = 4
print(x, y)          [4, 2, 3]  [4, 2, 3]
```

immutable vs mutable

Main memory (RAM)

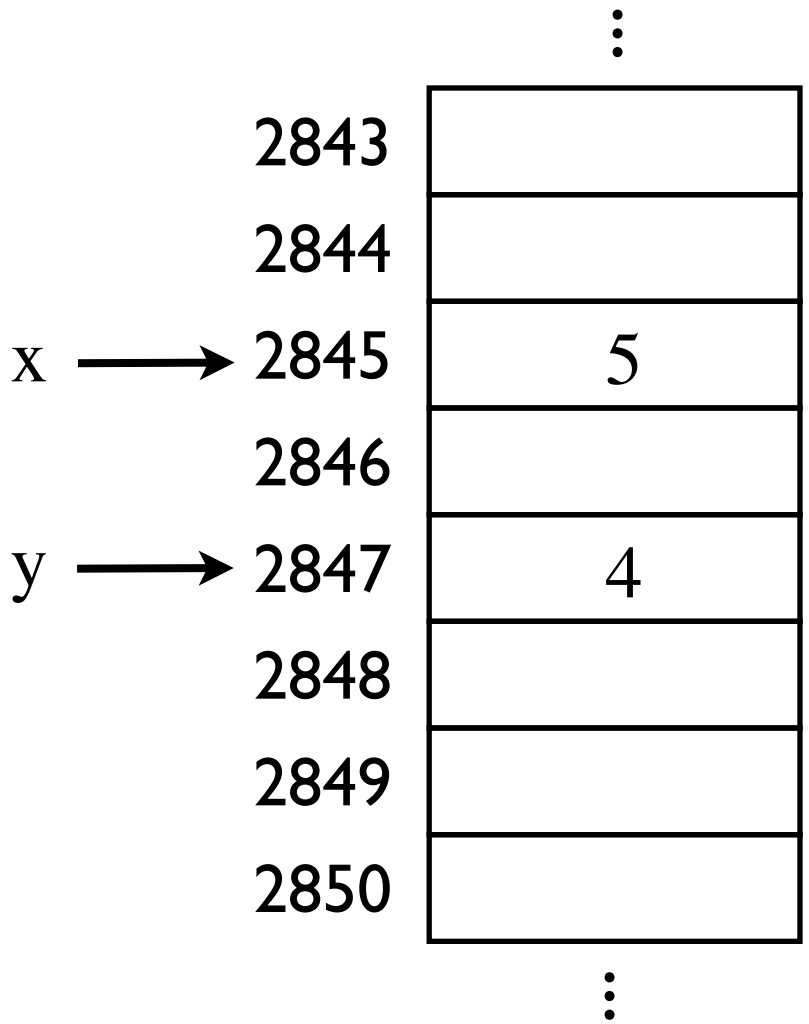




immutable vs mutable

Immutable objects

```
x = 5
y = 4
x = 1
y -= 2
```



immutable vs mutable

Immutable objects

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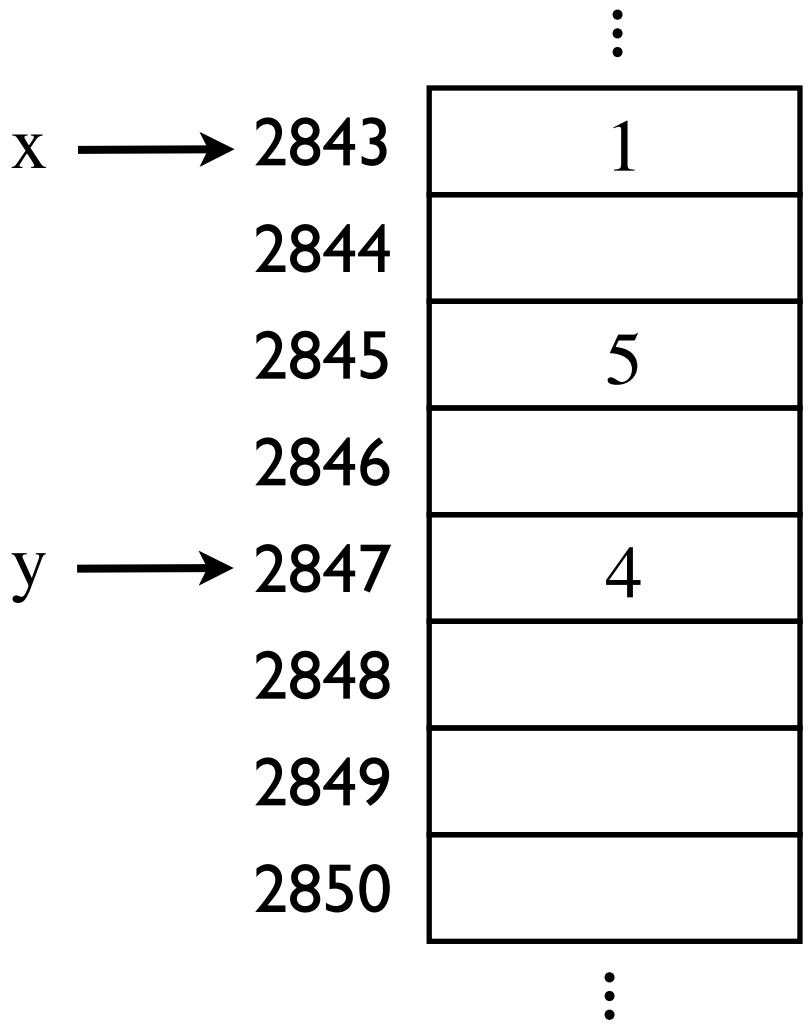

immutable vs mutable

Immutable objects

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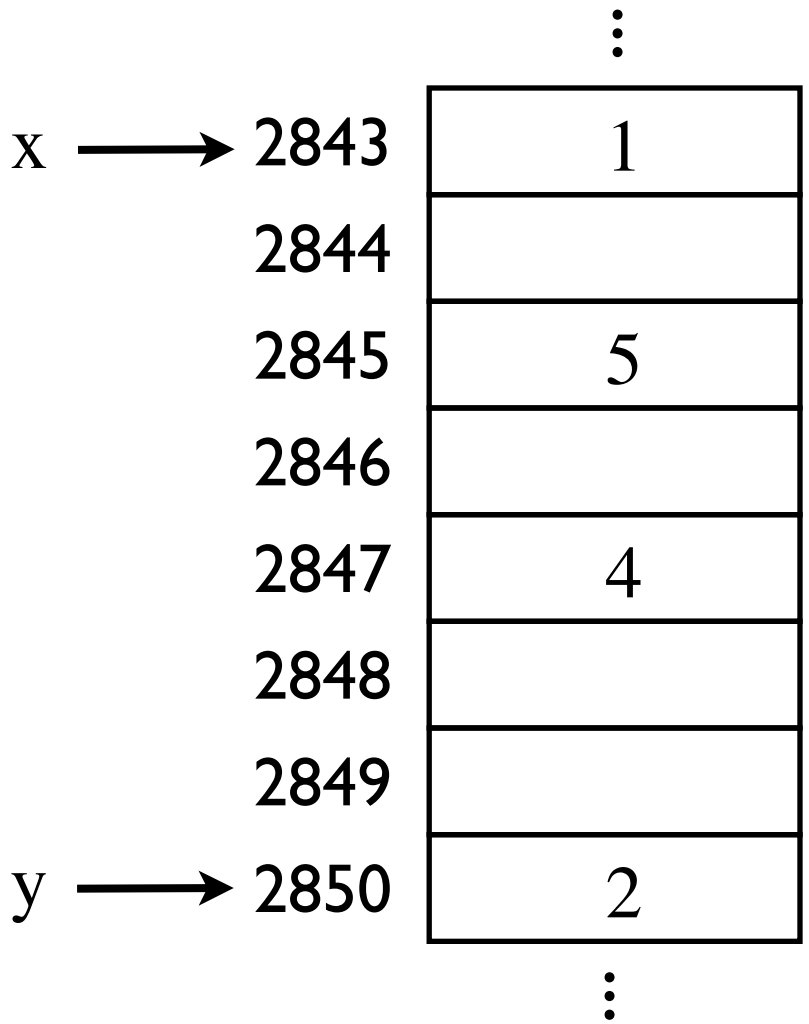

immutable vs mutable

Immutable objects

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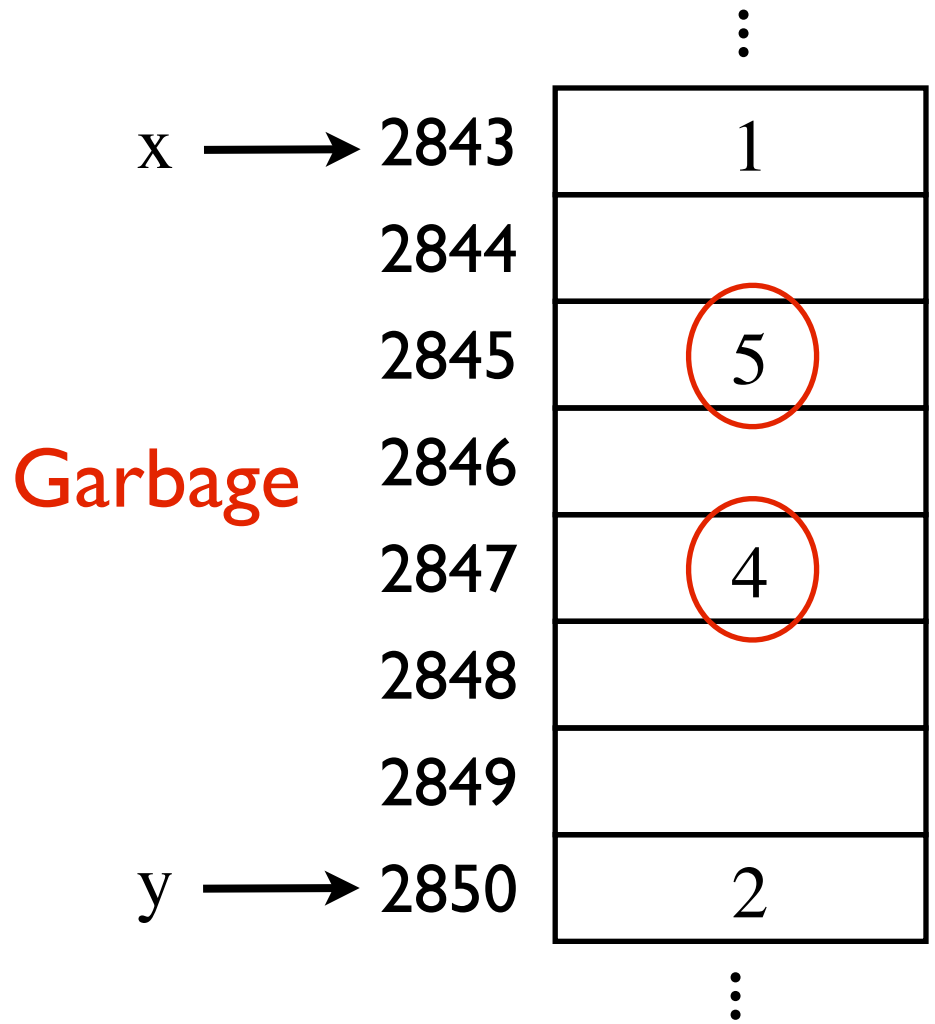
y -= 2



immutable vs mutable

Immutable objects

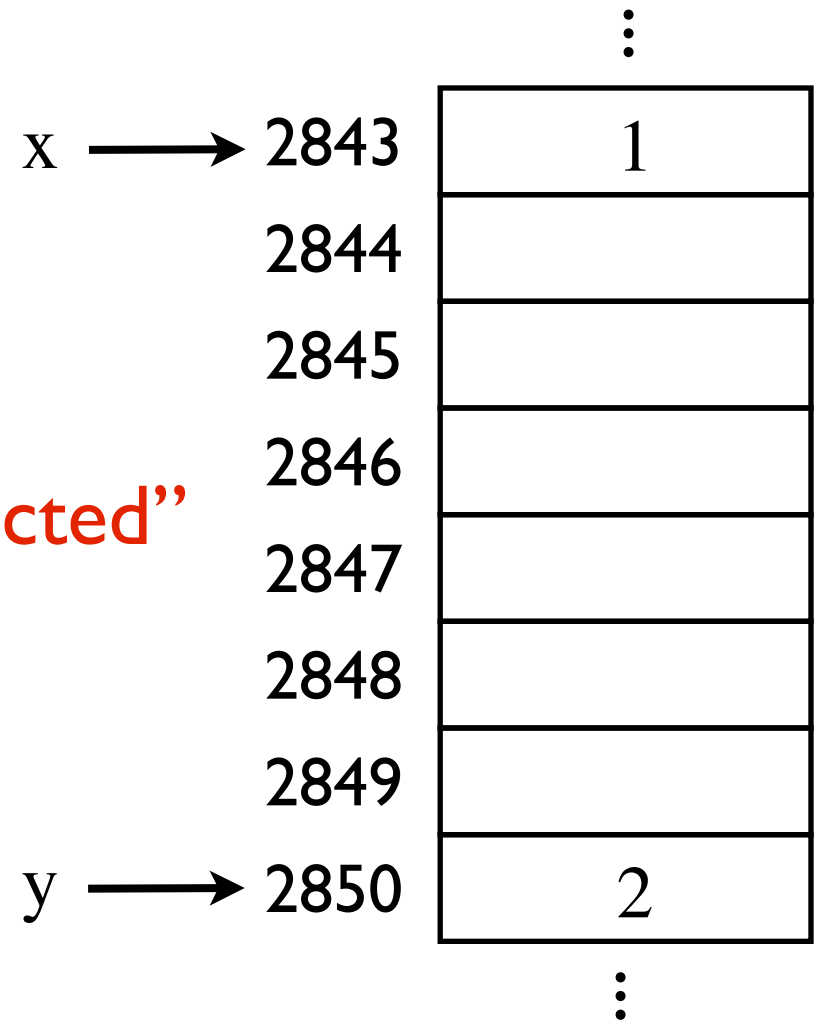
x = 5

y = 4

x = 1

y -= 2

"Garbage is collected"

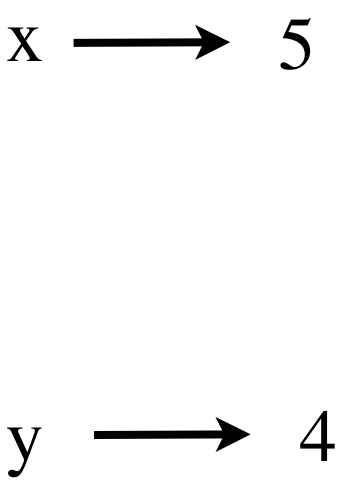


immutable vs mutable

Immutable objects

x = 5

y = 4



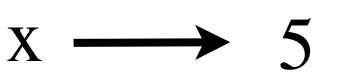
immutable vs mutable

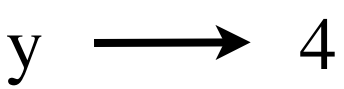
Immutable objects

x = 5

y = 4

x = 1





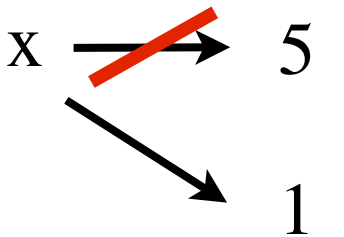
immutable vs mutable

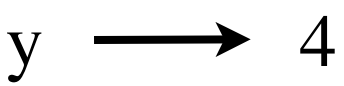
Immutable objects

x = 5

y = 4

x = 1





immutable vs mutable

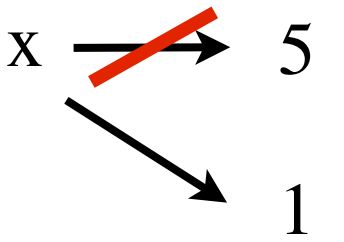
Immutable objects

x = 5

y = 4

x = 1

y -= 2



immutable vs mutable

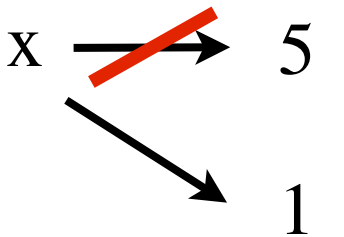
Immutable objects

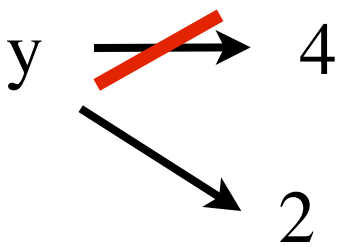
x = 5

y = 4

x = 1

y -= 2

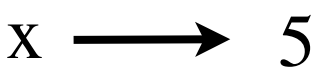




immutable vs mutable

Immutable objects

x = 5

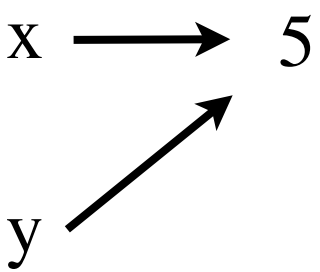


immutable vs mutable

Immutable objects

x = 5

y = x



immutable vs mutable

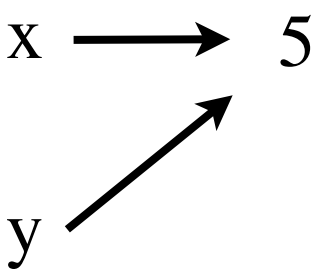
Immutable objects

```
x = 5

y = x

x += 1


print(x, y)
```



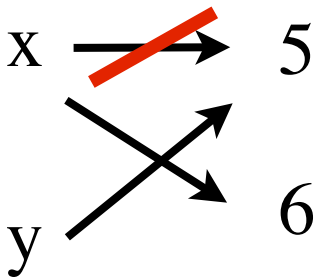
immutable vs mutable

Immutable objects

```
x = 5

y = x

x += 1
```




```
print(x, y)        6  5
```

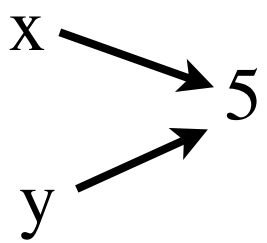
immutable vs mutable

Immutable objects

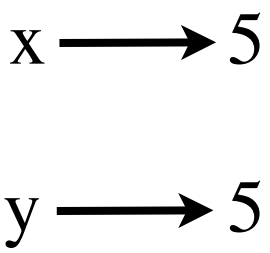
x = 5

y = x

In reality:



In practice:

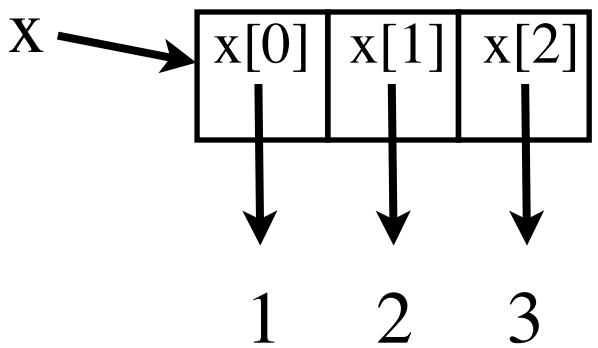


if you change one,
the other is not affected

immutable vs mutable

Mutable objects

$x = [1, 2, 3]$



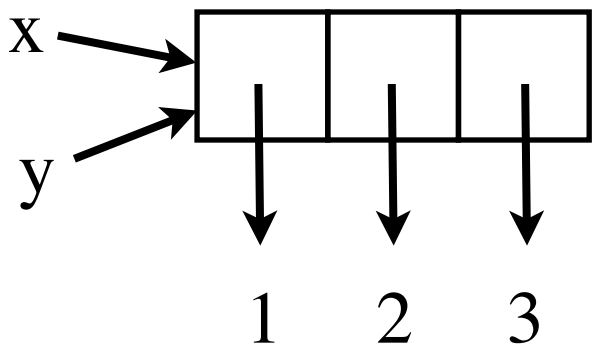
So **actually**,
a list is a sequence of references (variables)!

immutable vs mutable

Mutable objects

$x = [1, 2, 3]$

$y = x$



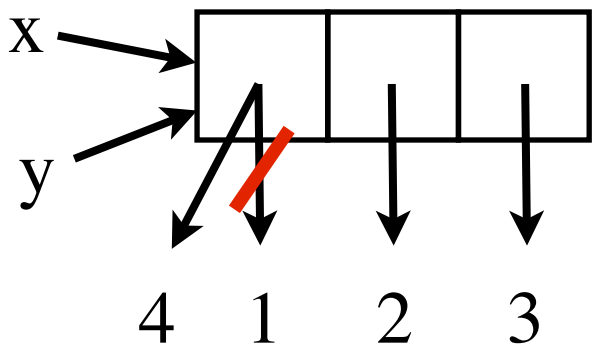
immutable vs mutable

Mutable objects

$x = [1, 2, 3]$

$y = x$

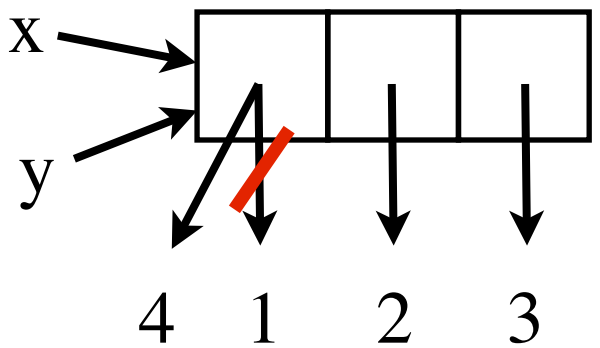
$x[0] = 4$



immutable vs mutable

Mutable objects

```
x = [1, 2, 3]
y = x
x[0] = 4
print(y[0])      4
```

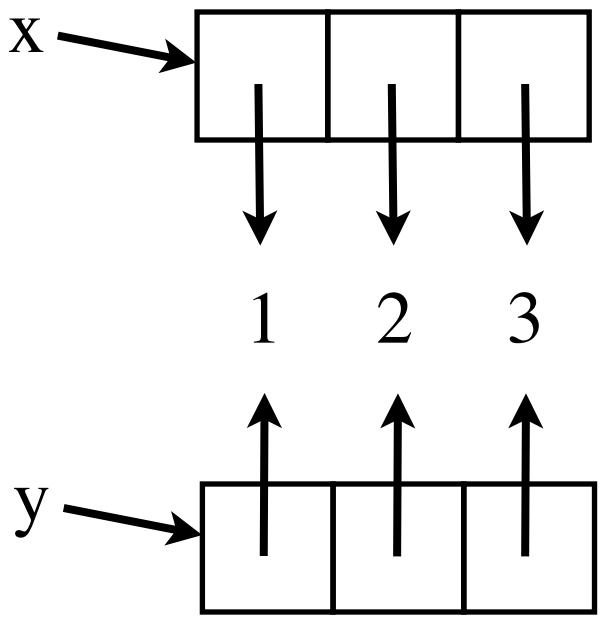


x and y are **aliases**.

immutable vs mutable

Mutable objects

```
x = [1, 2, 3]
y = [1, 2, 3]
```




```
print(x == y)        True
print(x is y)        False
print(x[0] is y[0])  True
```

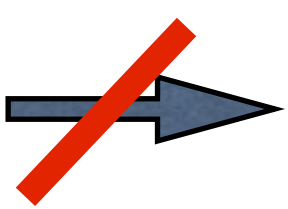
immutable vs mutable

With simpler data types, immutabality is useful.
(no side effects)

With complex data types, mutability and aliasing is useful.
(avoid copying large data)

Suppose you have a list of names.

You add another name to the list



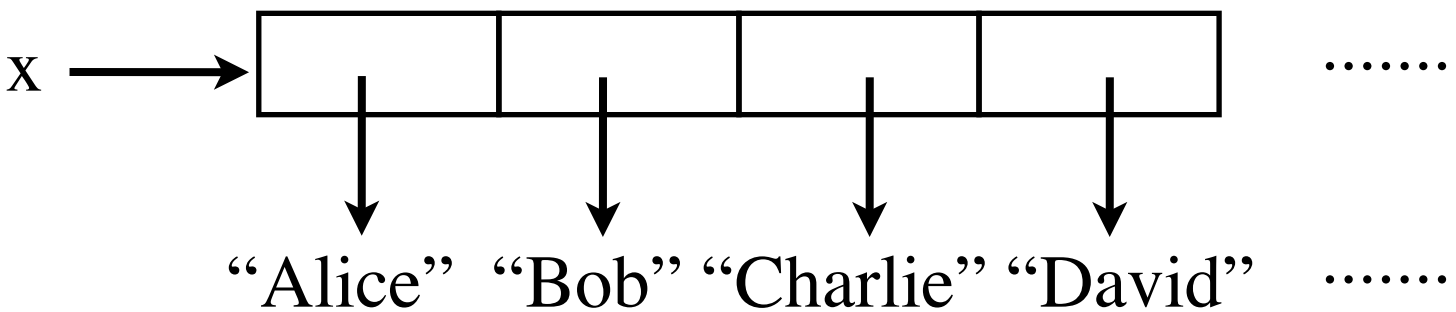
copy the whole list.

immutable vs mutable

If lists were <u>immutable</u>:

x = [“Alice”, “Bob”, “Charlie”, “David”, ...]

a million names



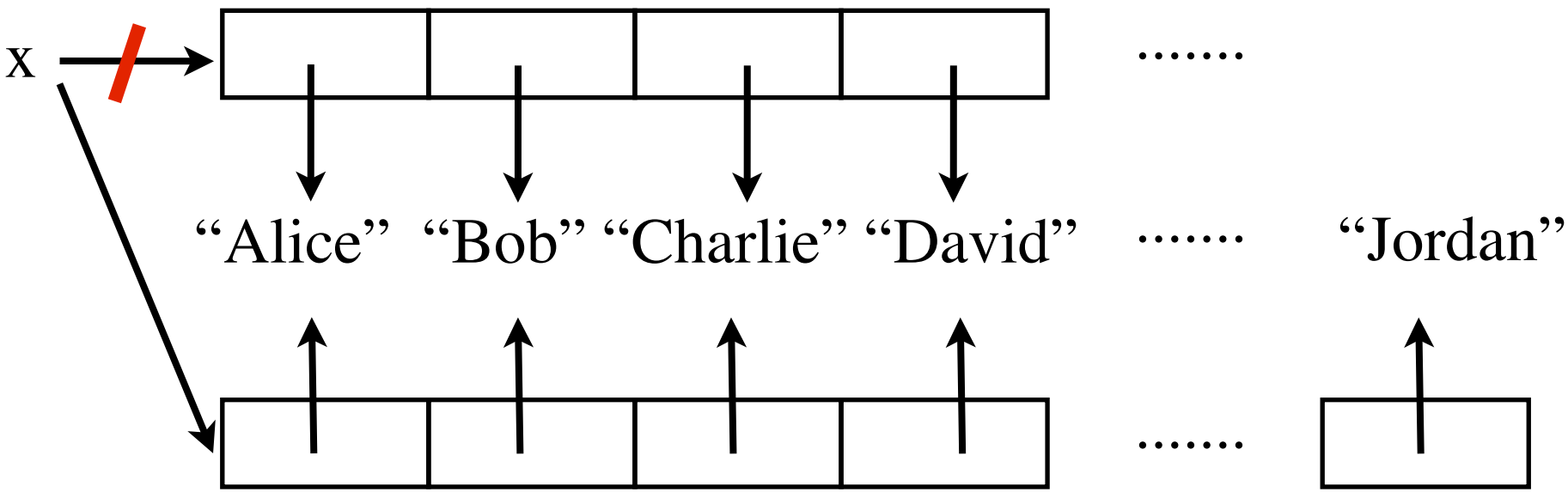
immutable vs mutable

If lists were **immutable**:

x = [“Alice”, “Bob”, “Charlie”, “David”, ...]

x += [“Jordan”]

a million names



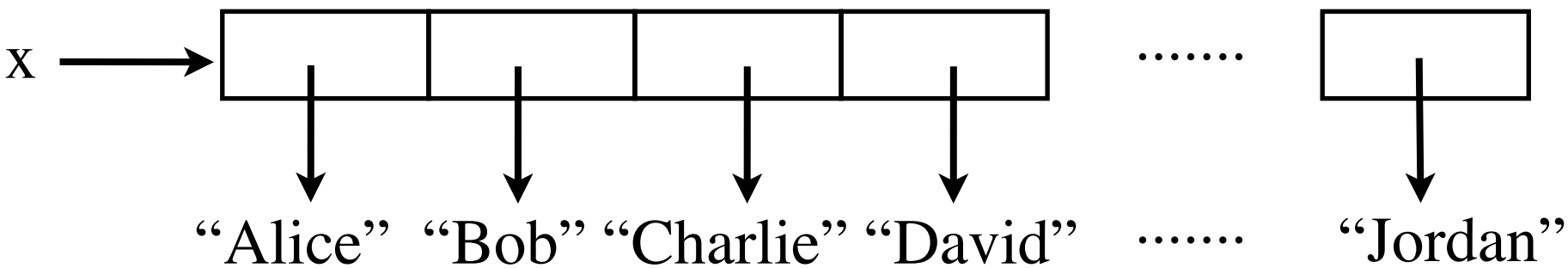
immutable vs mutable

But lists are **mutable**

x = [“Alice”, “Bob”, “Charlie”, “David”, ...]

a million names

x += [“Jordan”]



immutable vs mutable

```
def square(x):
    x = x**2
    return x

n = 5
squaredNum = square(n)
print(n, squaredNum)
```

5 25

```
def square(a):
    for i in range(len(a)):
        a[i] = a[i]**2
    return a

b = [1, 2, 3]
squaredList = square(b)
print(b, squaredList)
```

[1, 4, 9] [1, 4, 9]

Original b is **destroyed**

immutable vs mutable

```
def square(x):
    x = x**2
    return x


n = 5

squaredNum = square(n)

print(n, squaredNum)
```

5 25

```
import copy


def square(a):
    a = copy.copy(a)
    for i in range(len(a)):
        a[i] = a[i]**2
    return a

b = [1, 2, 3]

squaredList = square(b)

print(b, squaredList)
```

[1, 2, 3] [1, 4, 9]

Original b is **not** destroyed

immutable vs mutable

Strings vs Lists

names = “Alice,Bob,Charlie,…” a million names

Suppose you want to change Bob to William.

```
def changeName(s, oldName, newName):
    return s.replace(oldName, newName)
```

Creates a new string with a million names.

changeName(names, “Bob”, “William”)

names and s are aliases.

but this doesn’t have side-effects (names doen’t change).

immutable vs mutable

Strings vs Lists

```
names = ["Alice", "Bob", .....]
```

a million names

```
def changeName(a, oldName, newName):
    for index in range(len(a)):
        if (a[index] == oldName):
            a[index] = newName

changeName(names, "Bob", "William")
```

names and a are aliases.

changes to a also change names.

The list of names is never duplicated/recreated.

immutable vs mutable

Strings vs Lists

Immutable ----> make copy every time you change it.

If dealing with huge strings, or
need to modify a string many times:

convert the string to a list first:

```
longText = list("Once upon a time, in a land far far away...")
```

converting the list back to a string:

```
longTextString = "".join(longText)
```

Digression: Alan Turing (1912-1954)

British mathematician, logician, cryptanalyst, computer scientist.

Father of computer science and artificial intelligence.

List operators and methods

2 types:

Destructive

- modifies original list

Non-destructive

- does not modify original list
- creates a new list

(with strings, for example, this is what happens)

List operators and methods

Adding elements

Destructive

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

```
a.extend([5, 6])
```
a = [1, 2, 3, 4, 5, 6]

```
a += [7, 8]   # same as extend
```
a = [1, 2, 3, 4, 5, 6, 7, 8]

```
a.insert(1, 1.5)
```
a = [1, 1.5, 2, 3, 4, 5, 6, 7, 8]

NonDestructive

```
a = [1, 2, 3]
b = a + [4]
```
b = [1, 2, 3, 4] a = [1, 2, 3]

```
c = b + [5, 6]
```
c = [1, 2, 3, 4, 5, 6]

b = [1, 2, 3, 4]

```
d = c[:1] + [1.5] + c[1:]
```
d = [1, 1.5, 2, 3, 4, 5, 6]

IMPORTANT!

```
a = [1, 2, 3]
b = a
a += [4]
print(a)    [1, 2, 3, 4]
print(b)    [1, 2, 3, 4]
```

```
a = [1, 2, 3]
b = a
a = a + [4]
print(a)        [1, 2, 3, 4]
print(b)        [1, 2, 3]
```

a += [4] **not same as** a = a + [4]

List operators and methods

Removing elements

Destructive

```
a = [1, 2, 3, 1, 2, 3, 1, 2, 3]
a.remove(3)
    a = [1, 2, 1, 2, 3, 1, 2, 3]
a.remove(3)
    a = [1, 2, 1, 2, 1, 2, 3]
a.pop()
    a = [1, 2, 1, 2, 1, 2]
print(a.pop(0))  1
    a = [2, 1, 2, 1, 2]
a[1:3] = [ ]
    a = [2, 1, 2]
del a[1:]
    a = [2]
```

NonDestructive

```
a = [2, 1, 2, 1, 2]
b = a[:1] + a[3:]
  b = [2, 1, 2]   a = [2, 1, 2, 1, 2]
```

List operators and methods

Common Mistakes

```
def remove(someList, element):
    for index in range(len(someList)):
        if (someList[index] == element):
            someList.pop(index)
```

Index range changes every time you pop.

```
def total(someList):
    t = 0
    while(someList != []):
        t += someList.pop()
    return t
```

Never change the list if you don't need to!

```
a = [1, 2, 3, 1, 2, 3, 1, 2, 3]
print(total(a))    18
print(a)           []
```

List operators and methods

sort vs sorted

Destructive

```
a = [1, 2, 3, 1, 2, 3]
a.sort()
```

a = [1, 1, 2, 2, 3, 3]

NonDestructive

```
a = [1, 2, 3, 1, 2, 3]
b = sorted(a)
```

b = [1, 1, 2, 2, 3, 3]

a = [1, 2, 3, 1, 2, 3]

List operators and methods

finding an element

```
a = [1, 2, 3, 1, 2, 3]

print(a.index(2))        1

print(a.find(2))         ERROR:  no method called 'find'

print(a.index(4))        ERROR:  4 is not in the list
```

```
if (4 in a):
    print("4 is at index", a.index(4))
else:
    print("4 is not in the list.")
```

List operators and methods

others

https://docs.python.org/3/library/stdtypes.html#typesseq-mutable

https://docs.python.org/3/tutorial/datastructures.html#more-on-lists

Summary

Destructive (modifies the given list)	**NonDestructive**
+=	+, *
every method that manipulates the list	functions
del statement	slicing

Be careful about aliasing
(especially with function parameters)

Tuples

The immutable brother of lists

Tuples

```
myTuple = (1, 2, 3, 4, 5, 6, 7, 8, 9, 10)

myTuple = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10    # not recommended

myTuple = (1, "hello", 3.14, True)

myTuple = (1,)          # Put comma for one element tuple

myTuple[0] = 2          ERROR
```

parallel assignments

```
(x, y) = (1, 2)
```

Tuples

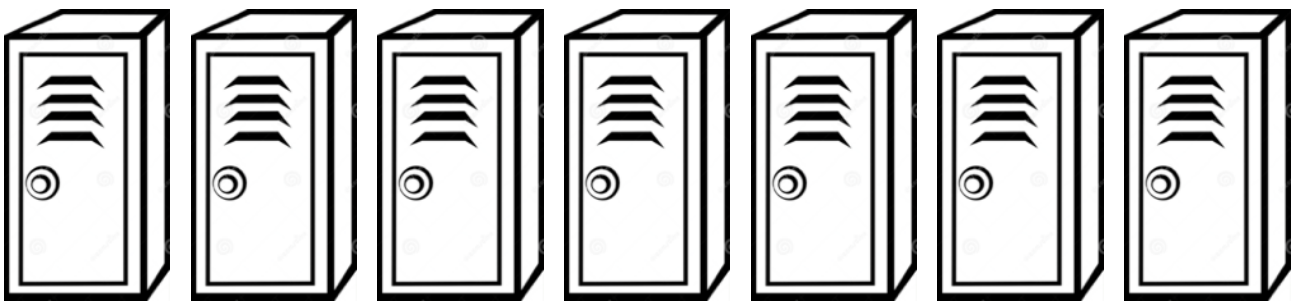
return multiple values in a function

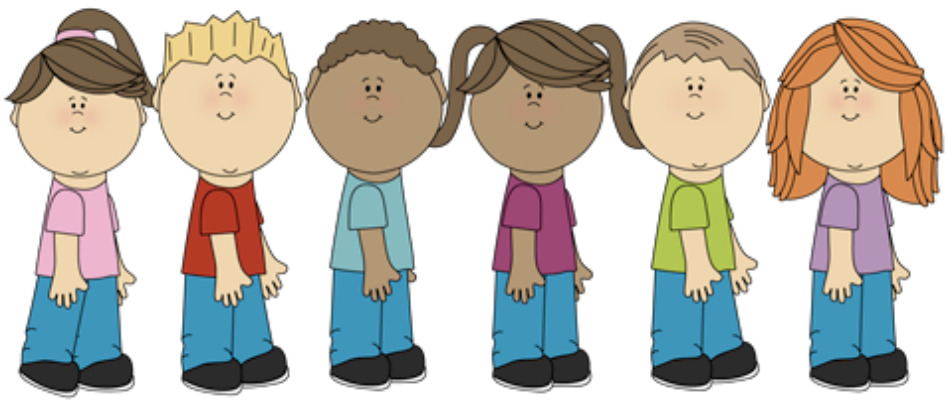
```
def firstPrimeInList(a):
    for i in range(len(a)):
        if (isPrime(a[i])):
            return (i, a[i])
    return -1
```

Exercise Problem

Lockers Problem

1 2 3 4 5 6 7 ... n





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