15. Lists are Objects

Topics:

- References
- Alias
- More on Slicing

Comparing Lists

You can use == to compare two lists

```
>>> x = [10,20,30,40]
>>> y = [10,20,30,40]
>>> x==y
True
```

Comparing Lists

You can use == to compare two lists

```
x -->  0 --->  10        y -->  0 --->  10
       1 --->  20               1 --->  20
       2 --->  30               2 --->  30
       3 --->  40               3 --->  40
```

The Boolean expression x==y is True because x and y have the same length and identical values in each element

Comparing Lists

You can use == to compare two lists

```
>>> x = [1,2,3]
>>> y = [1.0,2.0,3.0]
>>> x==y
True
```

If there are ints and floats, convert everything to float then compare

Comparing Lists

Do not use <, <= , > , >= to compare two lists

```
>>> x = [10,20,30,40]
>>> y = [11,21,31,41]
>>> x<y
True
>>> y<x
True
```

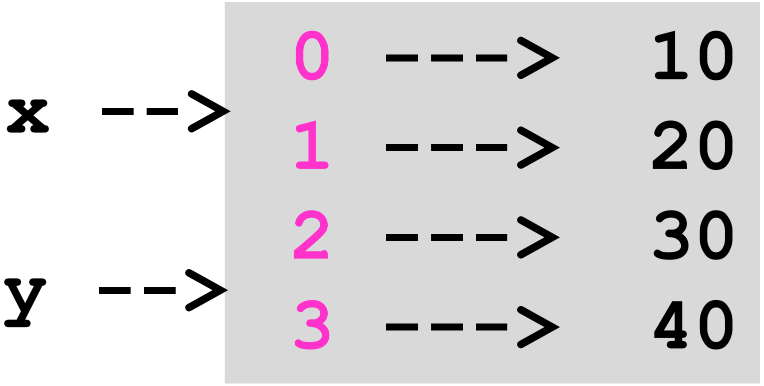
Unpredictable

Aliasing

This:

```
x = [10,20,30,40]
y = x
```

Results in this:



```
         0 --->  10
x -->    1 --->  20
         2 --->  30
y -->    3 --->  40
```

Aliasing

```
               0 ---->   10
x -->          1 ---->   20
y -->          2 ---->   30
               3 ---->   40
```

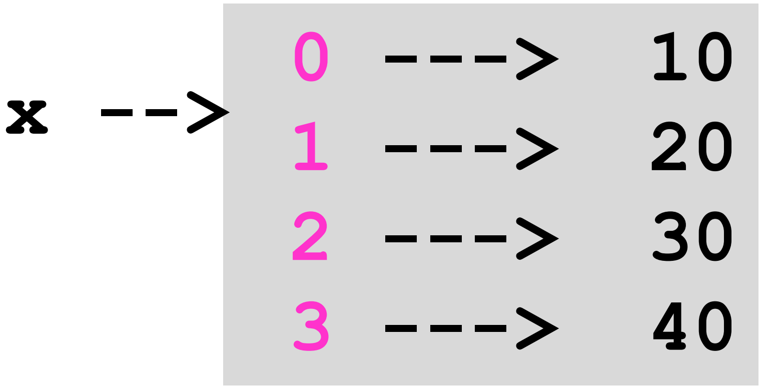
Things to say:

x and y are variables that refer to the same list object.

The object is aliased because it has more than one name.

Tracking Changes

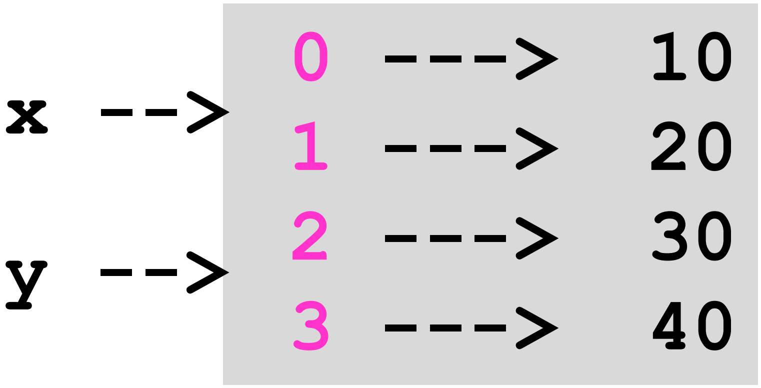
```
● x = [10,20,30,40]
  y = x
  y = [1,2,3]
```



```
x --> 0 ---> 10
      1 ---> 20
      2 ---> 30
      3 ---> 40
```

Tracking Changes

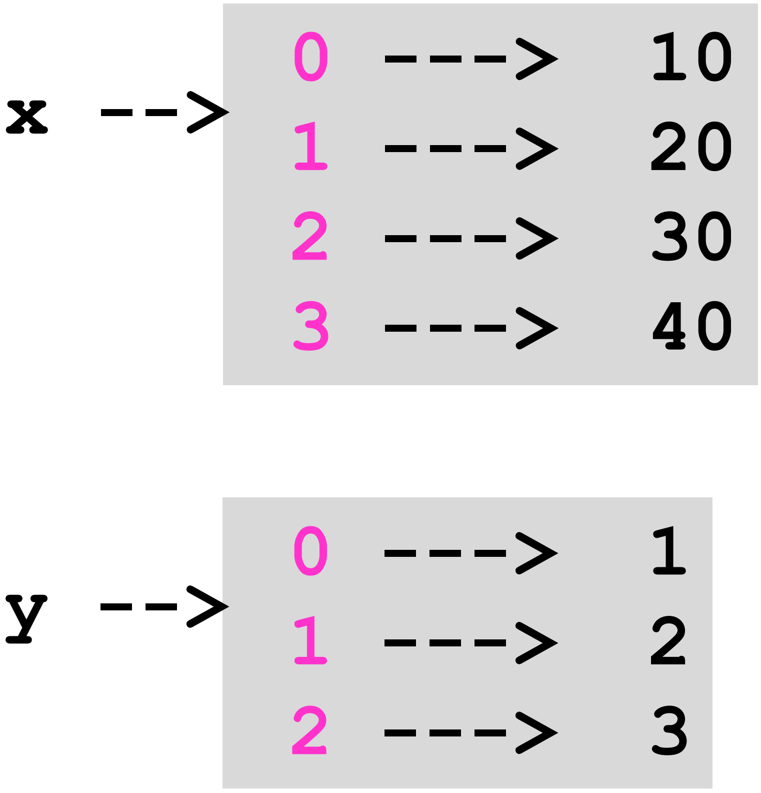
```
  x = [10,20,30,40]
● y = x
  y = [1,2,3]
```



```
            0 ---> 10
x -->
            1 ---> 20

            2 ---> 30
y -->
            3 ---> 40
```

Tracking Changes

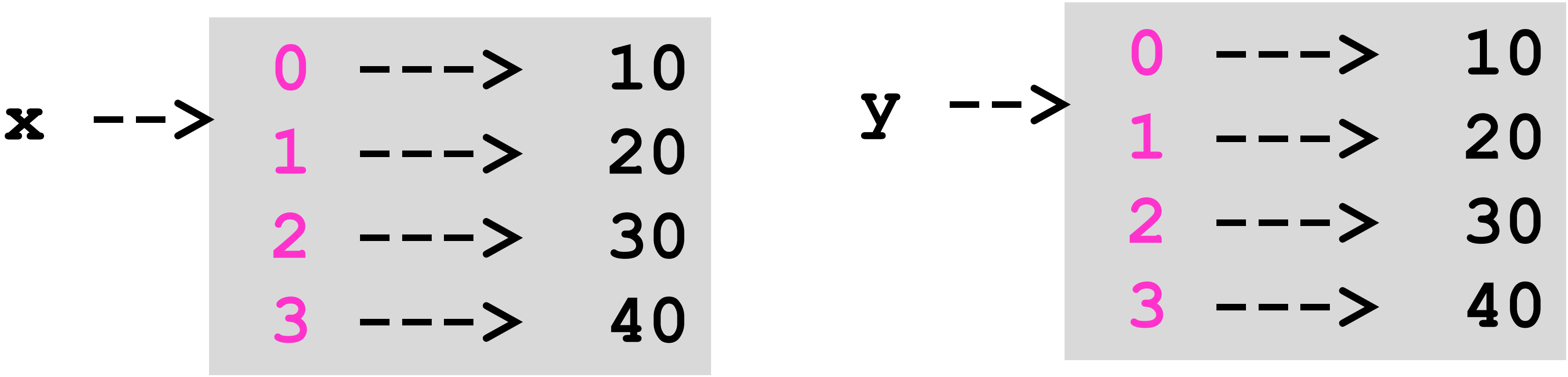
```
  x = [10,20,30,40]
  y = x
● y = [1,2,3]
```



```
         0 --->  10
x -->    1 --->  20
         2 --->  30
         3 --->  40

         0 --->  1
y -->    1 --->  2
         2 --->  3
```

The is Operator

```
>>> x = [10,20,30,40]
>>> y = [10,20,30,40]
>>> x is y
False
```

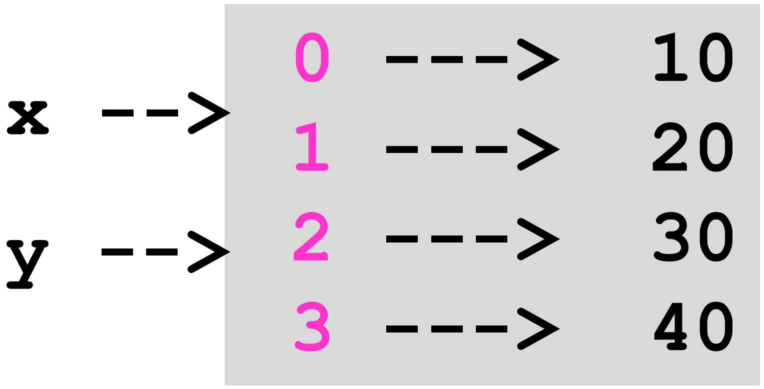


```
x -->  0 ---> 10        y -->  0 ---> 10
       1 ---> 20               1 ---> 20
       2 ---> 30               2 ---> 30
       3 ---> 40               3 ---> 40
```

Even though the two lists have the same component values. x and y do not refer to the same object.

The is Operator

```
>>> x = [10,20,30,40]
>>> y = x
>>> x is y
True
```

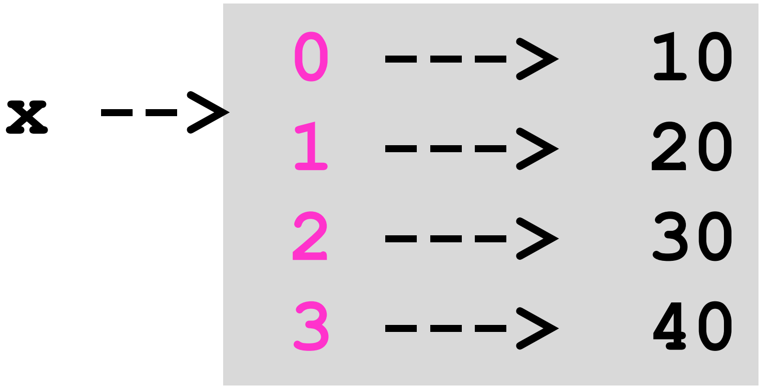


```
              0 --->  10
x -->
              1 --->  20

y -->         2 --->  30

              3 --->  40
```

x and y refer to the same object

Making a Copy of a List

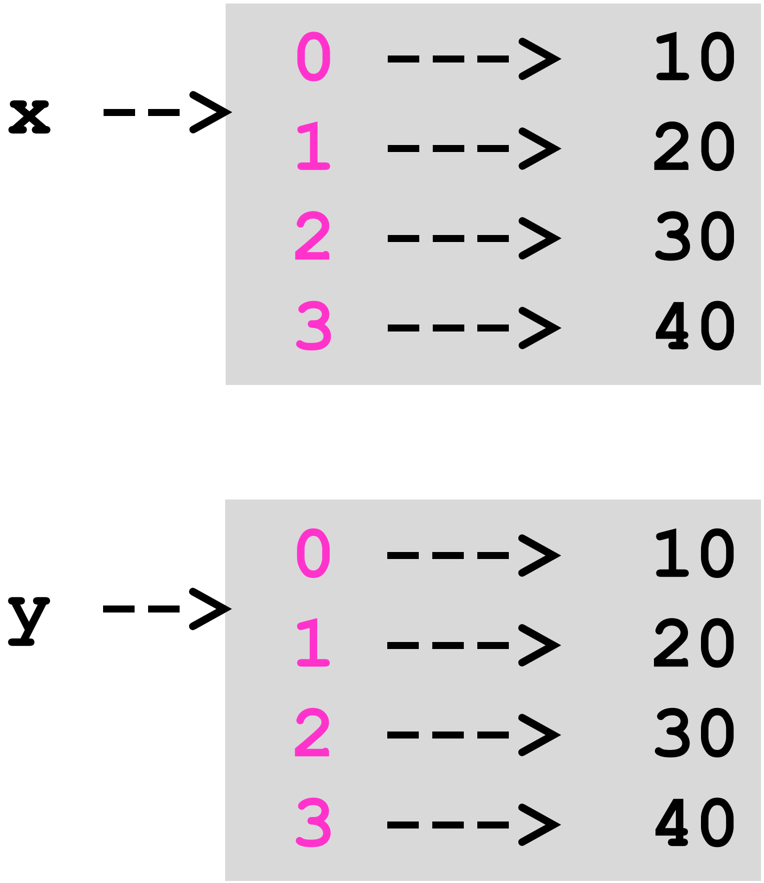
-
  ```
  x = [10,20,30,40]
  y = list(x)
  ```



```
x -->   0 --->  10
        1 --->  20
        2 --->  30
        3 --->  40
```

Making a Copy of a List

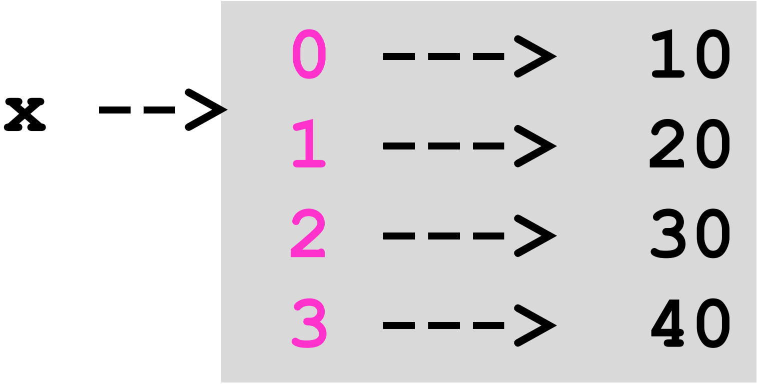
```
  x = [10,20,30,40]
● y = list(x)
```



```
          0 ---> 10
x -->     1 ---> 20
          2 ---> 30
          3 ---> 40

          0 ---> 10
y -->     1 ---> 20
          2 ---> 30
          3 ---> 40
```

Slices Create new Objects

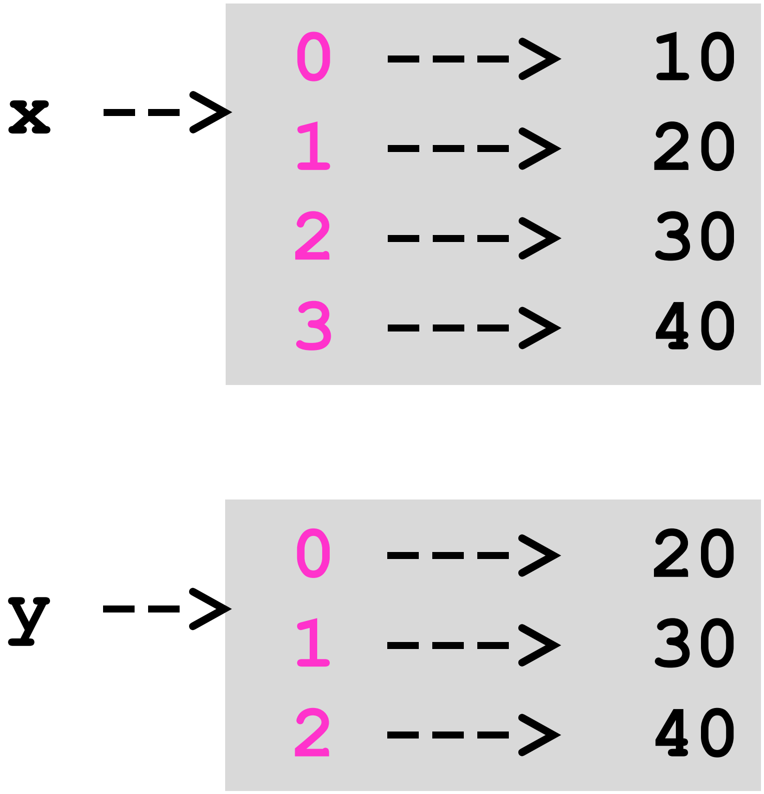
```
x = [10,20,30,40]
y = x[1:]
```



```
x -->  0 --->  10
       1 --->  20
       2 --->  30
       3 --->  40
```

Slices Create New Objects

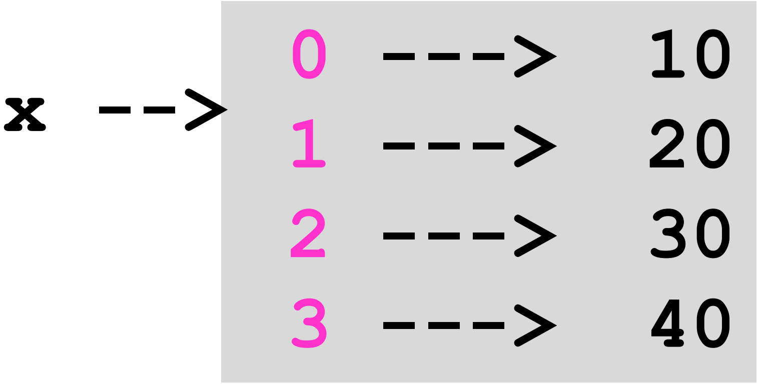
```
x = [10,20,30,40]
y = x[1:]
```



```
x -->   0 --->  10
        1 --->  20
        2 --->  30
        3 --->  40

y -->   0 --->  20
        1 --->  30
        2 --->  40
```

Careful!

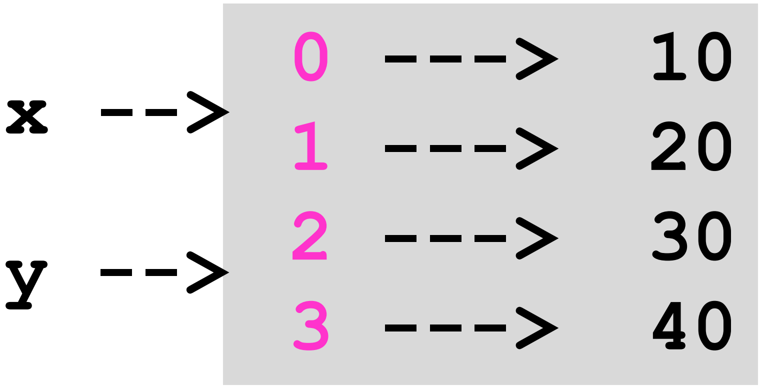
```
x = [10,20,30,40]
y = x
y = x[1:]
```



```
         0 --->  10
x -->    1 --->  20
         2 --->  30
         3 --->  40
```

Careful!

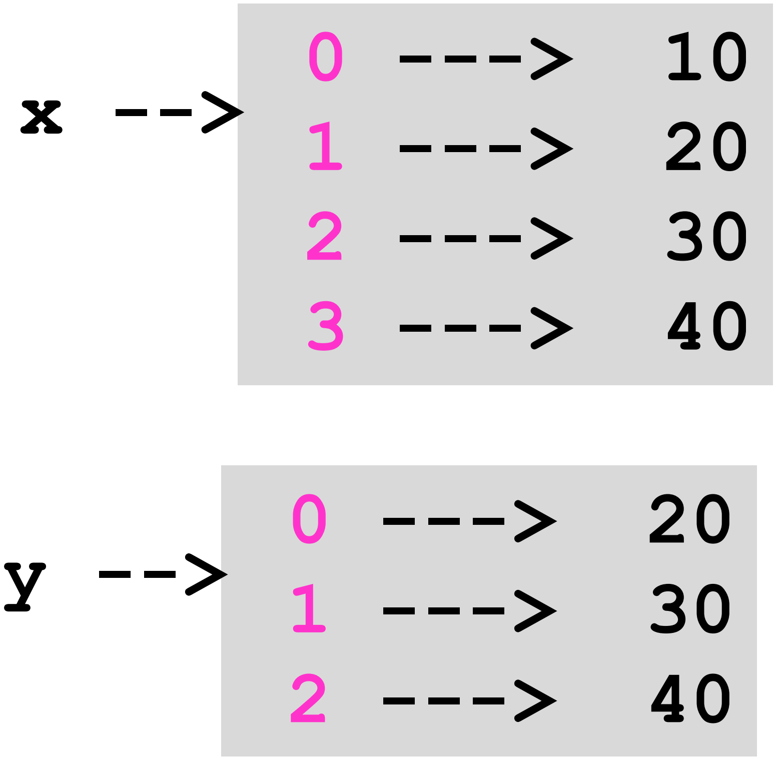
```
  x = [10,20,30,40]
● y = x
  y = x[1:]
```



```
        0 --->   10
x -->   1 --->   20
        2 --->   30
y -->   3 --->   40
```

Careful!

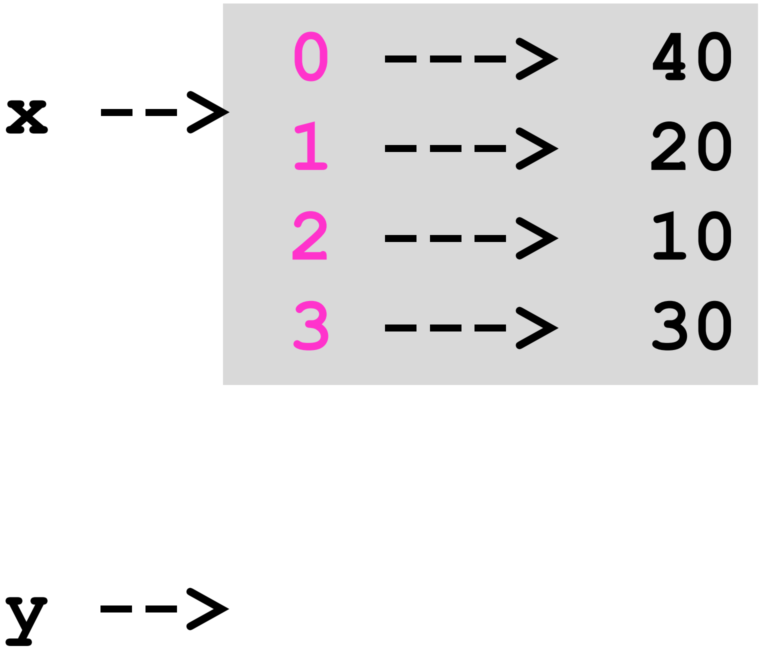
```
  x = [10,20,30,40]
  y = x
● y = x[1:]
```



```
x -->   0 --->  10
        1 --->  20
        2 --->  30
        3 --->  40

y -->   0 --->  20
        1 --->  30
        2 --->  40
```

Void Functions

```
x = [40,20,10,30]
y = x.sort()
```



```
x -->   0 ---> 40
        1 ---> 20
        2 ---> 10
        3 ---> 30

y -->
```

Void Functions

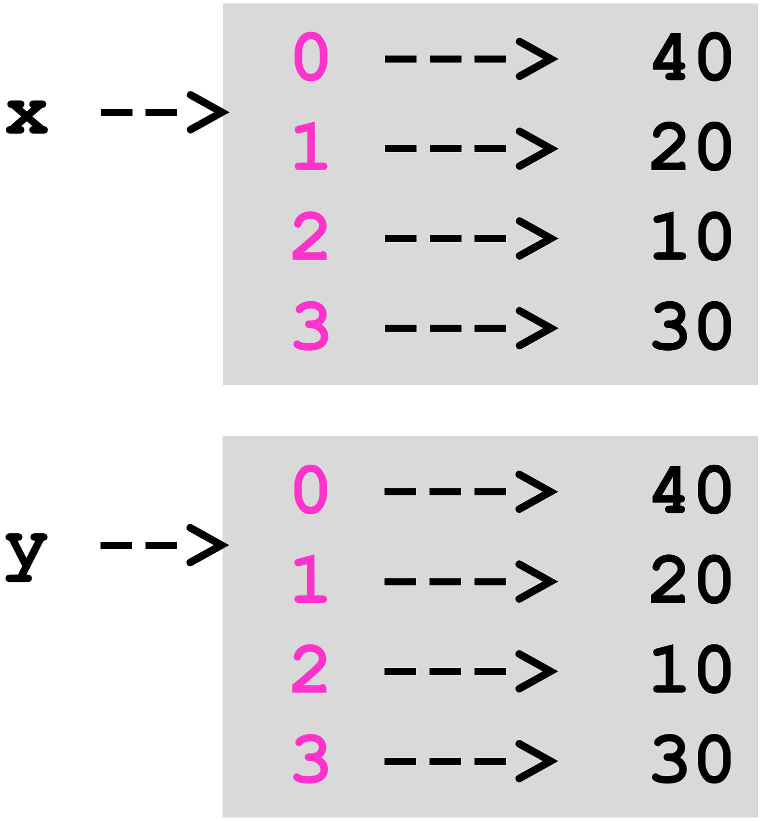
```
  x = [40,20,10,30]
● y = x.sort()
```

```
             0 --->  10
x -->        1 --->  20
             2 --->  30
             3 --->  40


y --> None
```

Void Functions return None, a special type

Void Functions

```
  x = [40,20,10,30]
● y = list(x)
  y.sort()
```

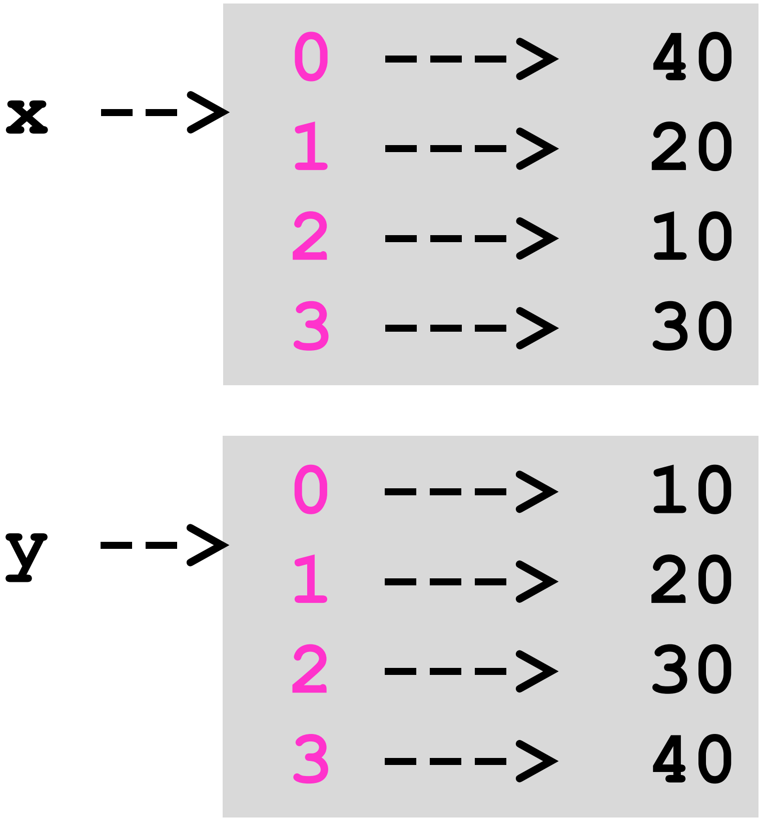


```
        0 --->  40
x -->   1 --->  20
        2 --->  10
        3 --->  30

        0 --->  40
y -->   1 --->  20
        2 --->  10
        3 --->  30
```

Void Functions return None, a special type

Void Functions

```
x = [40,20,10,30]
y = list(x)
y.sort()
```



```
         0 ---> 40
x -->    1 ---> 20
         2 ---> 10
         3 ---> 30

         0 ---> 10
y -->    1 ---> 20
         2 ---> 30
         3 ---> 40
```

Void Functions return None, a special type

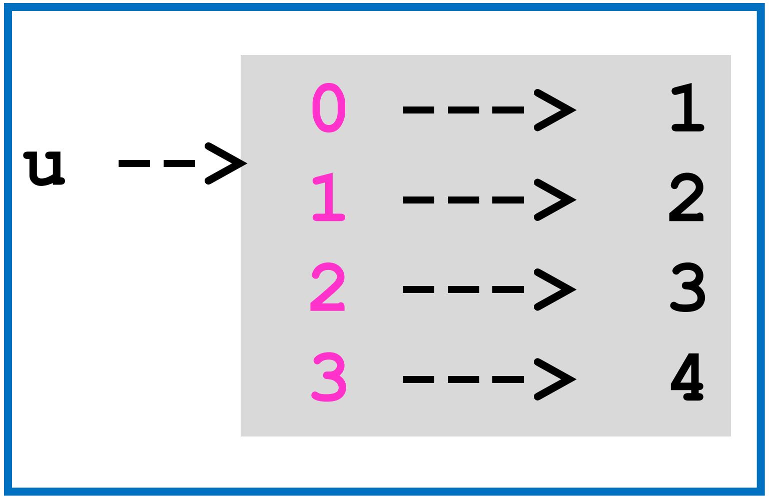
Understanding Function Calls

```
def f(x):
    x = x[1:]
    print x

if __name__ == '__main__':
    u = [1,2,3,4]
    f(u)
    print u
```

Looks like f deletes the 0-th character in x

Understanding Function Calls

```
def f(x):
    x = x[1:]
    print x

if __name__ blabla
  ● u = [1,2,3,4]
    f(u)
    print u
```



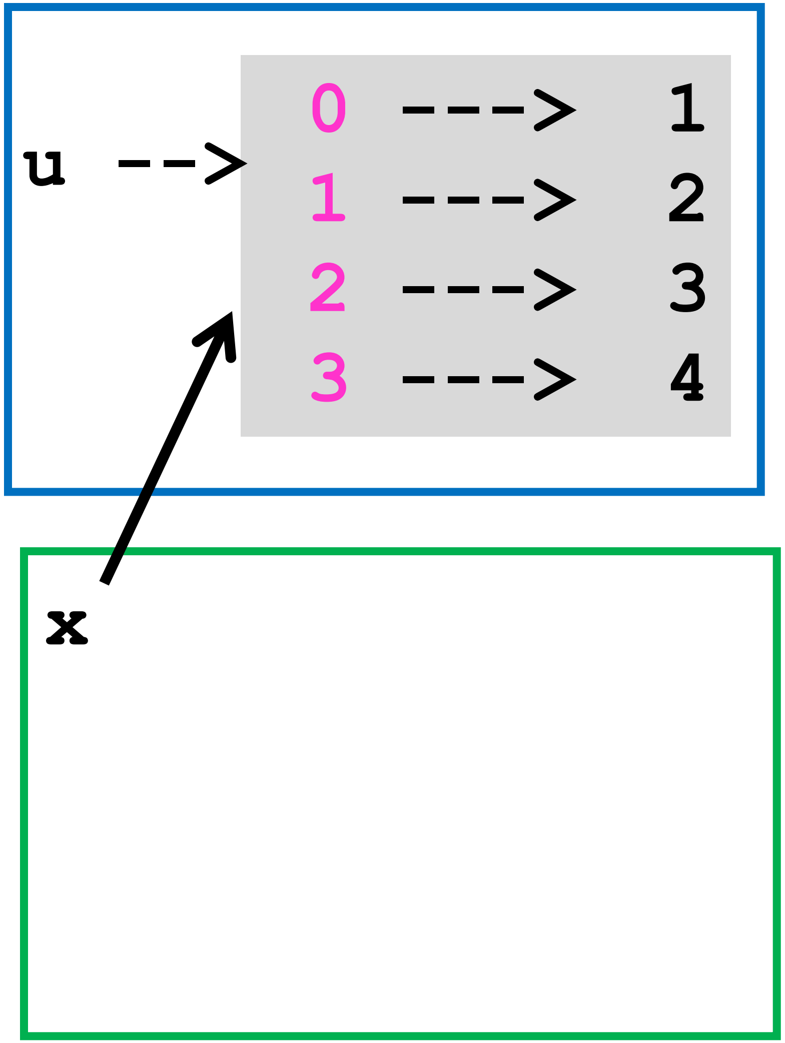
```
u -->  0 ---> 1
       1 ---> 2
       2 ---> 3
       3 ---> 4
```

Follow the red dot and watch for impact…

Understanding Function Calls

```
def f(x):
    x = x[1:]
    print x

if __name__ blabla
    u = [1,2,3,4]
    f(u)
    print u
```

Parameter x initially refers to the same object as u

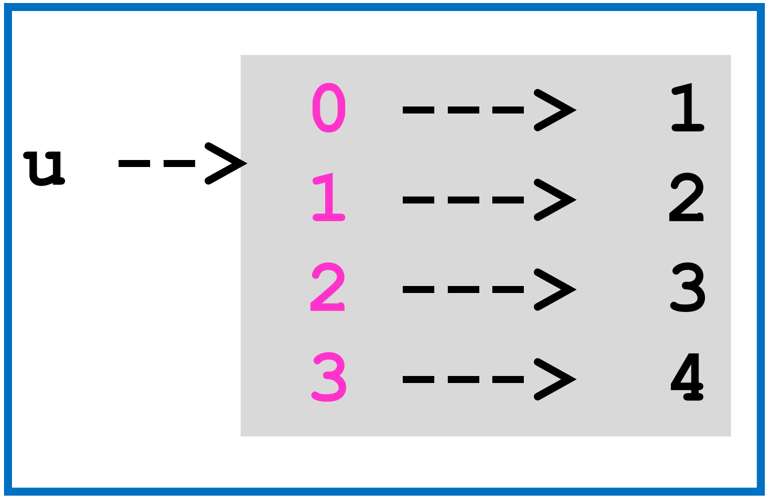


u -->

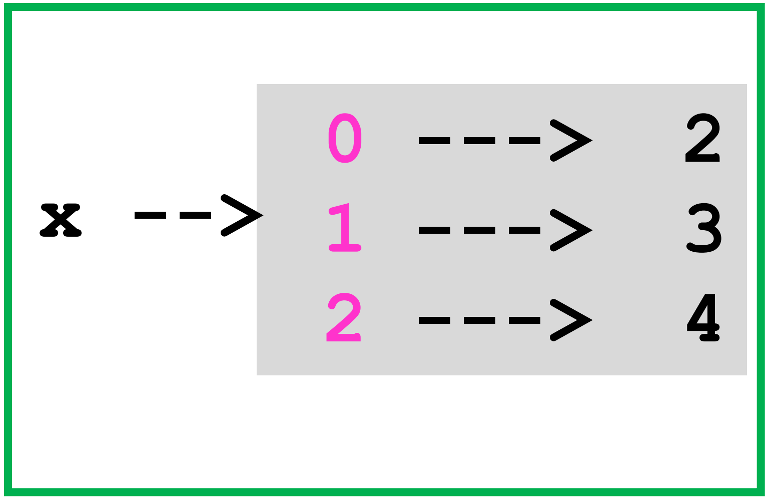
```
0 ---> 1
1 ---> 2
2 ---> 3
3 ---> 4
```

Understanding Function Calls

```
def f(x):
   ● x = x[1:]
     print x

if __name__ blabla
     u = [1,2,3,4]
     f(u)
     print u
```



```
        0 ---> 1
u -->   1 ---> 2
        2 ---> 3
        3 ---> 4
```



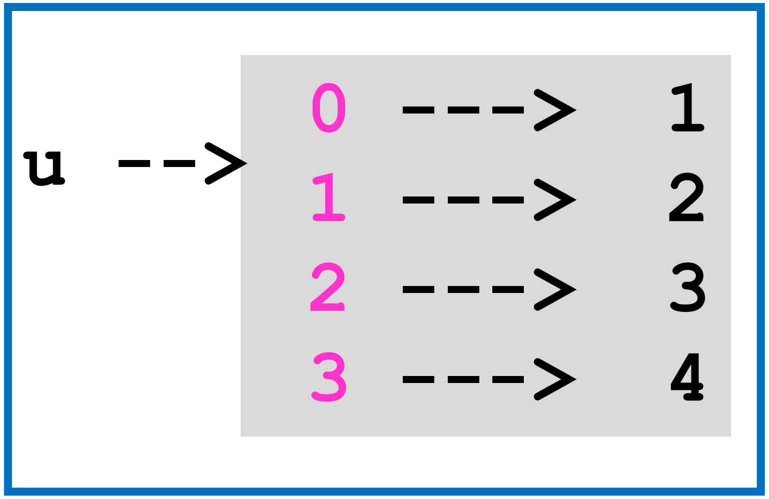
```
        0 ---> 2
x -->   1 ---> 3
        2 ---> 4
```

x[1:] creates a new object and x will refer to it

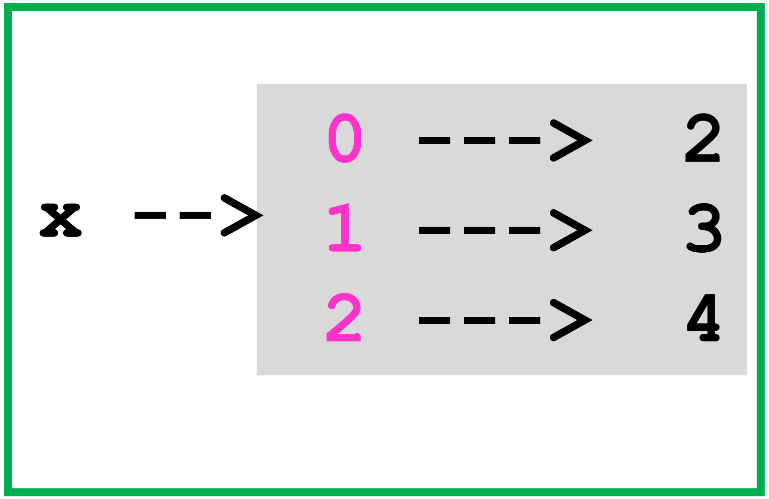
Understanding Function Calls

```
def f(x):
    x = x[1:]
  ● print x

if __name__ blabla
    u = [1,2,3,4]
    f(u)
    print u
```

2 3 4 is printed



```
u -->  0 ---> 1
       1 ---> 2
       2 ---> 3
       3 ---> 4
```

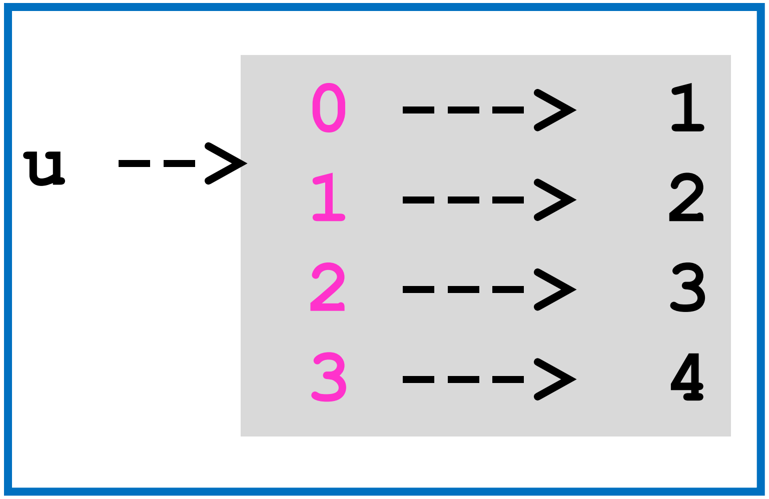


```
x -->  0 ---> 2
       1 ---> 3
       2 ---> 4
```

Understanding Function Calls

```
def f(x):
    x = x[1:]
    print x

if __name__ blabla
    u = [1,2,3,4]
    f(u)
    print u
```

1 2 3 4 is printed



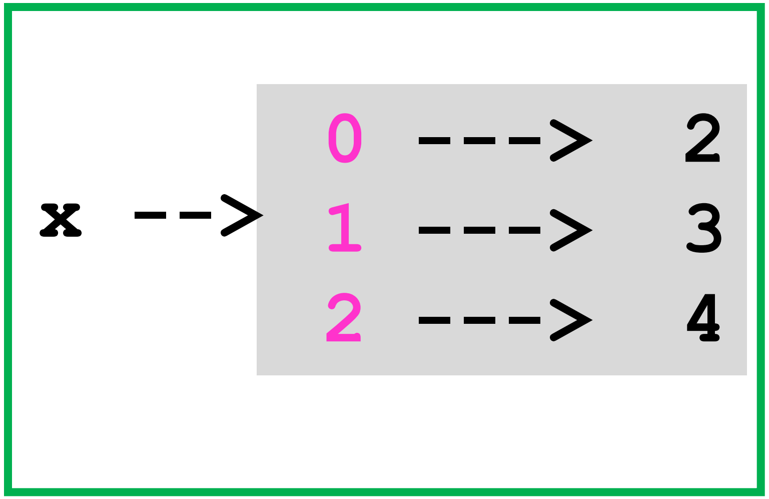
u -->

0 ---> 1

1 ---> 2

2 ---> 3

3 ---> 4



x -->

0 ---> 2

1 ---> 3

2 ---> 4

Example: The Perfect Shuffle

Permuting the items in a list comes up a lot.

Here is a famous example called the perfect shuffle:

Before:	10	20	30	40	50	60	70	80
After:	10	50	20	60	30	70	40	80

Executing the Perfect Shuffle

The given list:

10	20	30	40	50	60	70	80

Cut it in half:

10	20	30	40

50	60	70	80

The Re-assemble Process:

Alternately choose from the "half" lists.

Executing the Perfect Shuffle

The given list:

10	20	30	40	50	60	70	80

Cut it in half:

10	20	30	40

50	60	70	80

The Re-assemble Process:

10

Alternately choose from the "half" lists.

Executing the Perfect Shuffle

The given list:

10	20	30	40	50	60	70	80

Cut it in half:

10	20	30	40

50	60	70	80

The Re-assemble Process:

10	50

Alternately choose from the "half" lists.

Executing the Perfect Shuffle

The given list:

10	20	30	40	50	60	70	80

Cut it in half:

10	20	30	40

50	60	70	80

The Re-assemble Process:

10	50	20

Alternately choose from the "half" lists.

Executing the Perfect Shuffle

The given list:

10	20	30	40	50	60	70	80

Cut it in half:

10	20	30	40

50	60	70	80

The Re-assemble Process:

10	50	20	60

Alternately choose from the "half" lists.

Executing the Perfect Shuffle

The given list:

10	20	30	40	50	60	70	80

Cut it in half:

10	20	30	40

50	60	70	80

The Re-assemble Process:

10	50	20	60	30

Alternately choose from the “half” lists.

Executing the Perfect Shuffle

The given list:

10	20	30	40	50	60	70	80

Cut it in half:

10	20	30	40

50	60	70	80

The Re-assemble Process:

10	50	20	60	30	70

Alternately choose from the “half” lists.

Executing the Perfect Shuffle

The given list:

10	20	30	40	50	60	70	80

Cut it in half:

10	20	30	40

50	60	70	80

The Re-assemble Process:

10	50	20	60	30	70	40

Alternately choose from the “half” lists.

Executing the Perfect Shuffle

The given list:

10	20	30	40	50	60	70	80

Cut it in half:

10	20	30	40

50	60	70	80

The Re-assemble Process:

10	50	20	60	30	70	40	80

Alternately choose from the "half" lists.

Implementation 1

```
def PF1(x):
   n = len(x)
   m = n/2
   top = list(x[:m])
   bot = list(x[m:])
   for k in range(m):
         x[2*k]    = top[k]
         x[2*k+1] = bot[k]
```

Make a copy of the top and bottom halves

They become the even-indexed and odd-indexed entries

This is a Void function. It returns None.
However, it permutes the values in the list referenced by x according to the perfect shuffle.

Implementation 2

```
def PF2(x):
    n = len(x)
    m = n/2
    y = []
    for k in range(m):
        y.append(x[k])
        y.append(x[k+m])
    return y
```

Build y up through repeated appending

x[k] comes from the top half of the list, x[k+m] comes from the bottom half.

This is a fruitful function. It returns a reference to a list that is the perfect shuffle of the list referenced by x

Perfect Shuffle Cycles

Question:

Given a length-n list x where n is even, how many perfect shuffle updates are required before we cycle back to the original x?

Perfect Shuffle Cycles

Solution Using the Void function PF1:

```
# Assume x0 is a given list
x = list(x0)
PF1(x)
numPFs = 1
while x!=x0:
   PF1(x)
   numPFs+=1
print numPFs
```

Perfect Shuffle Cycles

Solution Using the Fruitful function PF2:

```
# Assume x0 is a given list
x = PF2(x0)
numPFs = 1
while x!=x0:
   x = PF2(x)
   numPFs+=1
print numPFs
```

Sample Outputs

```
    n      numPFs
--------------------
      8      3
     52      8
    444    442
   1000     36
  10000    300
 100000    540
```