# Data Collections (Sequences)

It’s complicated

# Sequence in Python

- Indexed collection
  - Strings
  - Lists
  - Tuples

- Non-indexed collection:
  - Sets
  - Dictionary

# Lists and Tuples

- Belongs to a type of data structure called arrays

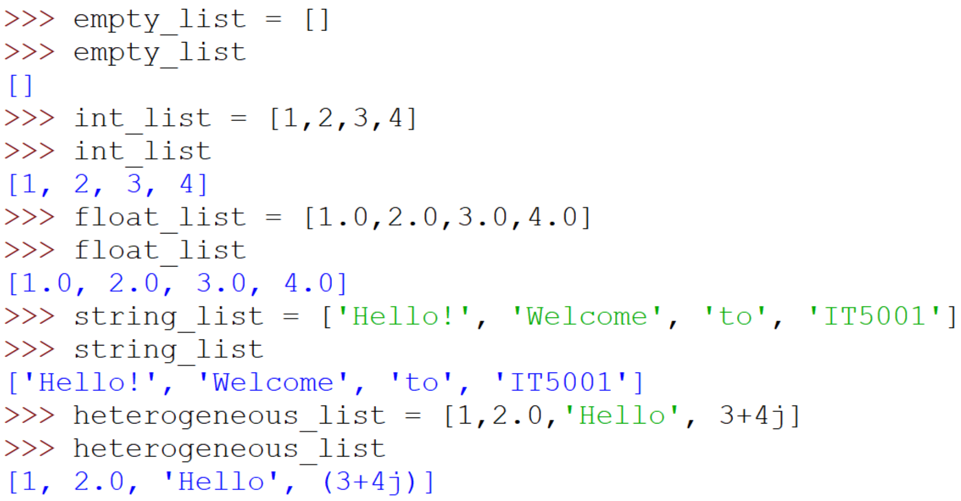
- Intrinsic ordering
  - Easy to retrieve data from the array

- Lists
  - Mutable
  - Dynamic Arrays

- Tuples
  - Immutable
  - Static Arrays

# Lists

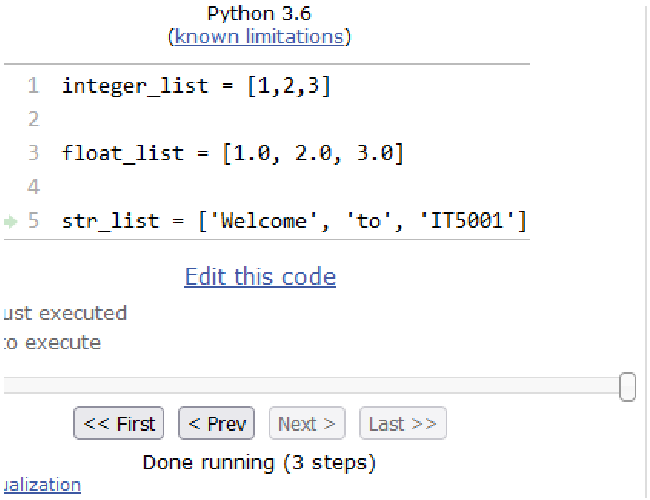
- Ordered sequence of data types
  - Homogeneous sequence
    - Sequence of integers
    - Sequence of floats
    - Sequence of strings
    - Sequence of lists
    - Sequence of functions, etc.
  - Heterogeneous sequence
    - mix of integers, floats, strings, etc.



```
>>> empty_list = []
>>> empty_list
[]
>>> int_list = [1,2,3,4]
>>> int_list
[1, 2, 3, 4]
>>> float_list = [1.0,2.0,3.0,4.0]
>>> float_list
[1.0, 2.0, 3.0, 4.0]
>>> string_list = ['Hello!', 'Welcome', 'to', 'IT5001']
>>> string_list
['Hello!', 'Welcome', 'to', 'IT5001']
>>> heterogeneous_list = [1,2.0,'Hello', 3+4j]
>>> heterogeneous_list
[1, 2.0, 'Hello', (3+4j)]
```

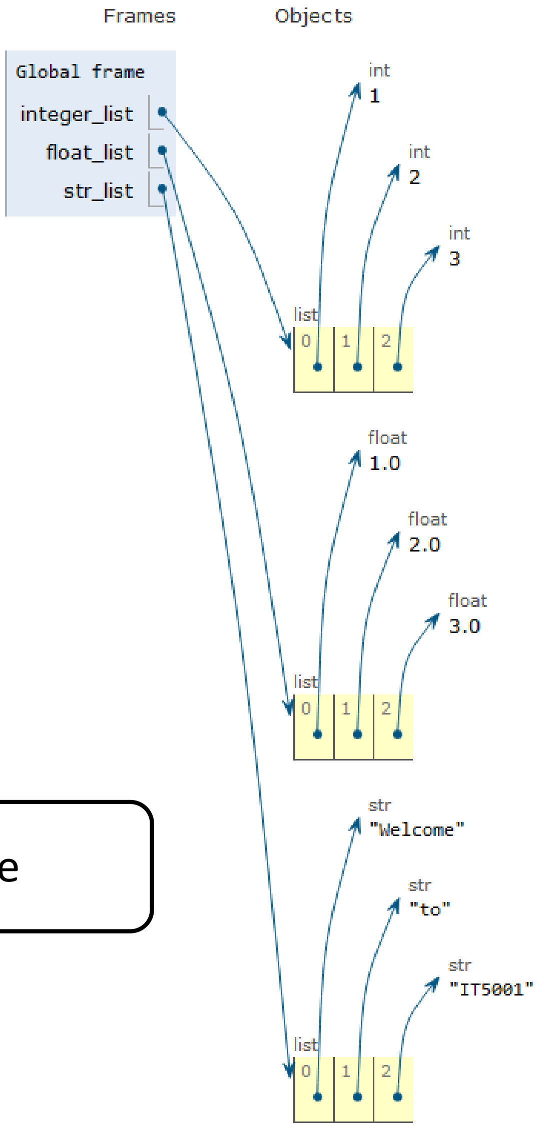
- Defined using square brackets - [ ]

# Lists are Referential Arrays



Python 3.6
(known limitations)

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

float_list = [1.0, 2.0, 3.0]

str_list = ['Welcome', 'to', 'IT5001']
```



Lists store addresses of its items in sequence

# All Indexed Sequences can…

| | |
|---|---|
| `a[i]` | return i-th element of a |
| `a[i:j]` | returns elements i up to j-1 |
| `len(a)` | returns numbers of elements in sequence |
| `min(a)` | returns smallest value in sequence |
| `max(a)` | returns largest value in sequence |
| `x in a` | returns True if x is a part of a |
| `a + b` | concatenates a and b |
| `n * a` | creates n copies of sequence a |

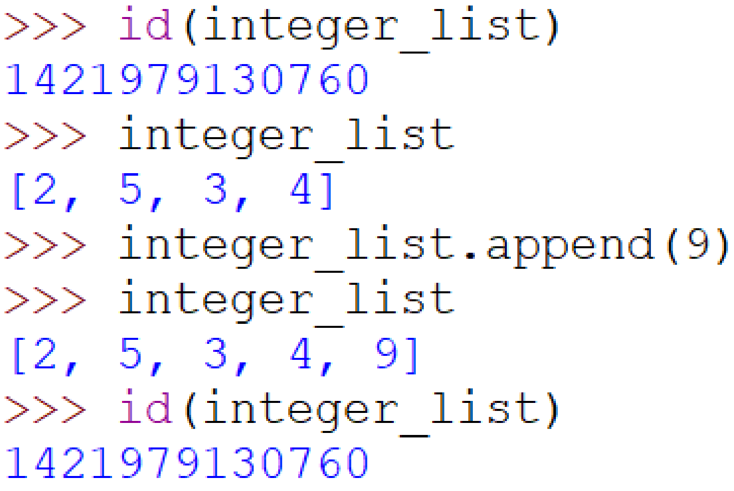
```
>>> int_list = [1,2,3,4]
>>> print(f'Element at index = 1 is {int_list[1]}')
Element at index = 1 is 2
>>> print(f'Elements at index = [1,3) are {int_list[1:3]}')
Elements at index = [1,3) are [2, 3]
>>> print(f'Number of Elements  = {len(int_list)}')
Number of Elements  = 4
>>> print(f'Smallest Element in the List = {min(int_list)}')
Smallest Element in the List = 1
>>> print(f'Largest Element in the List = {max(int_list)}')
Largest Element in the List = 4
>>> print(f'Is element 2 in the list: {2 in int_list}')

Is element 2 in the list: True
>>> another_int_list = [5,6,7,8]
>>> print(f'Concatenated List: {int_list+another_int_list}')
Concatenated List: [1, 2, 3, 4, 5, 6, 7, 8]
>>> print(f'Repeated list: {int_list*3}')
Repeated list: [1, 2, 3, 4, 1, 2, 3, 4, 1, 2, 3, 4]
```

# Lists are mutable

- Elements can be replaced
- Elements can be added
- Elements can be removed
  - A specific element
    - If element occurs multiple times, removes first occurrence
  - Element at a specific location (index)
  - From the end of the list
- Elements can be sorted
  - sort()
  - Sorted()
- Elements can be reversed

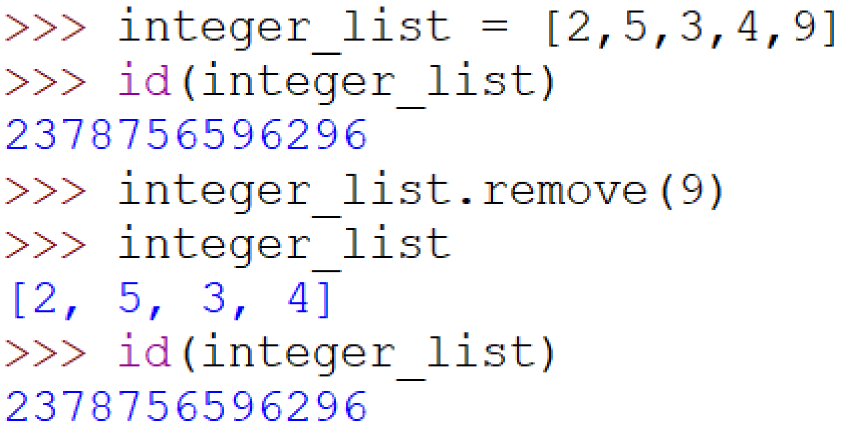
# Lists are Dynamic-Size Arrays

Elements can be added (appended) to the list

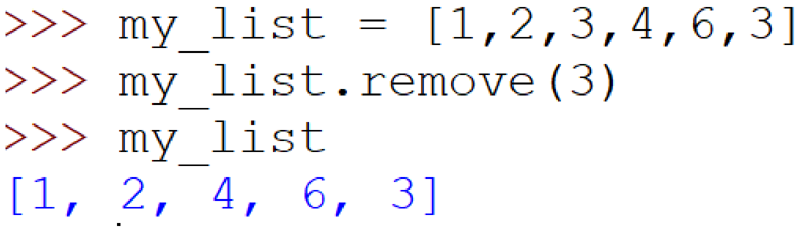


```
>>> id(integer_list)
1421979130760
>>> integer_list
[2, 5, 3, 4]
>>> integer_list.append(9)
>>> integer_list
[2, 5, 3, 4, 9]
>>> id(integer_list)
1421979130760
```

Elements can be removed from the list

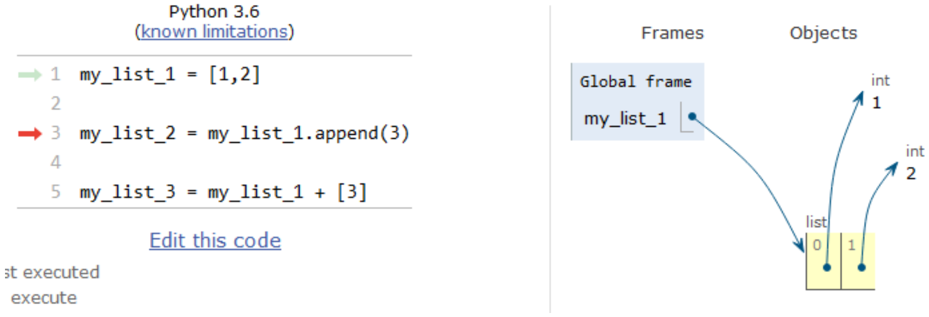


```
>>> integer_list = [2,5,3,4,9]
>>> id(integer_list)
2378756596296
>>> integer_list.remove(9)
>>> integer_list
[2, 5, 3, 4]
>>> id(integer_list)
2378756596296
```



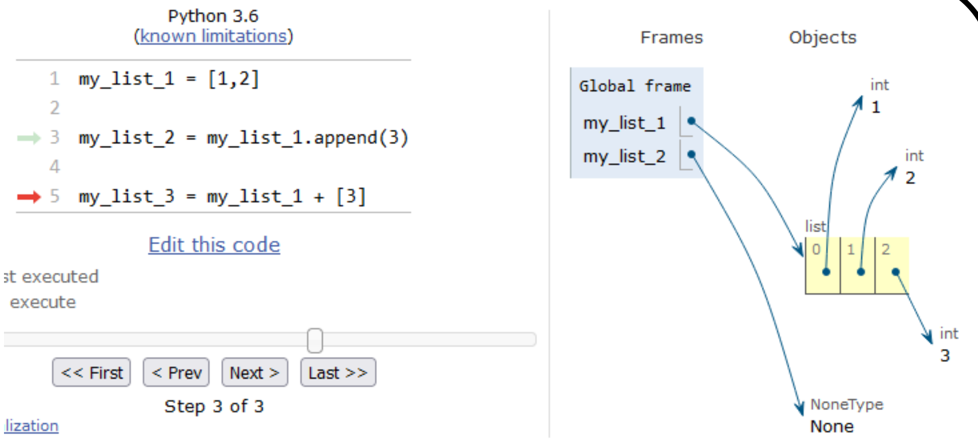
```
>>> my_list = [1,2,3,4,6,3]
>>> my_list.remove(3)
>>> my_list
[1, 2, 4, 6, 3]
```

# Append Vs Concatenation



```
my_list_1 = [1,2]

my_list_2 = my_list_1.append(3)

my_list_3 = my_list_1 + [3]
```

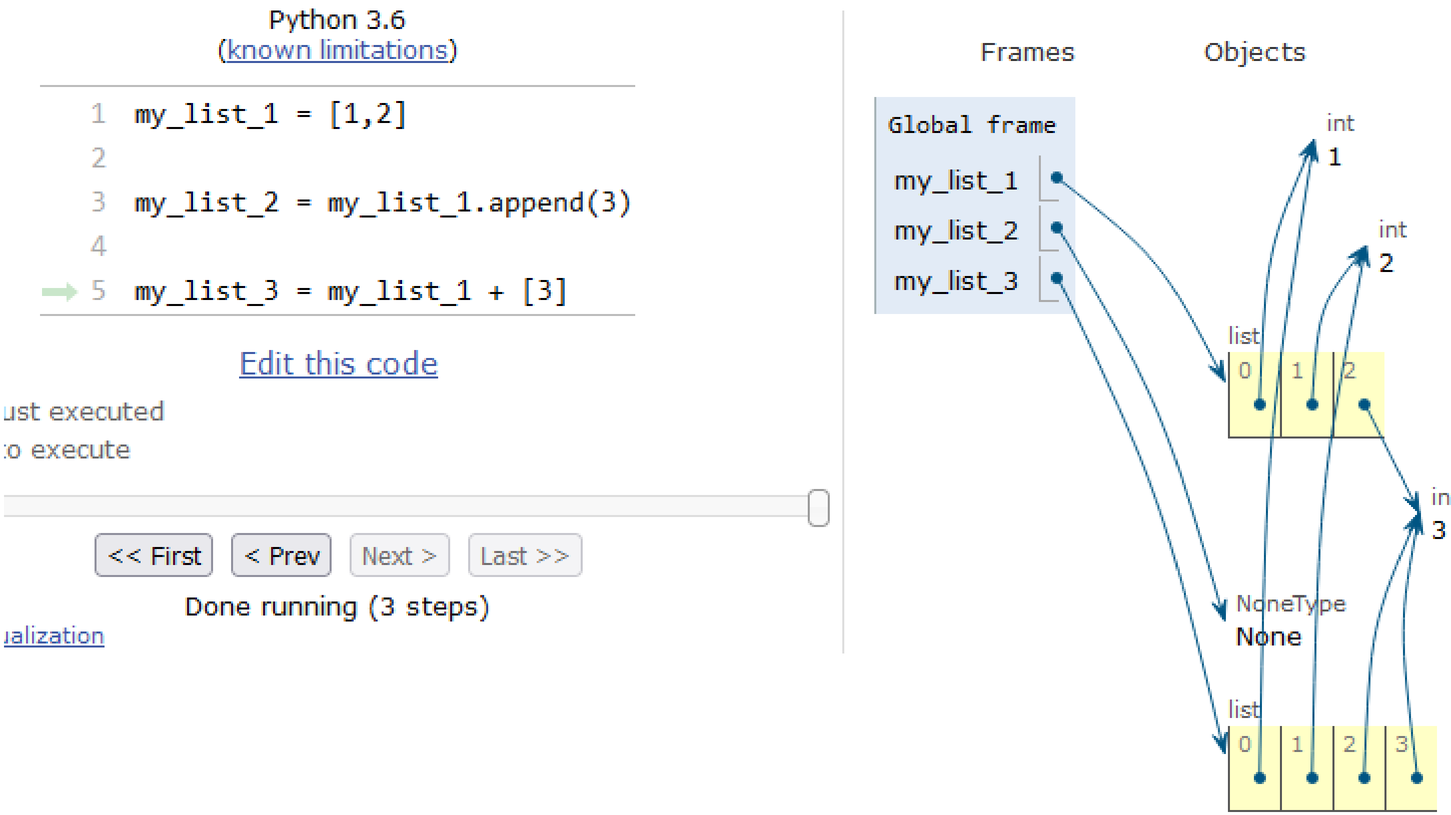
1



```
my_list_1 = [1,2]

my_list_2 = my_list_1.append(3)

my_list_3 = my_list_1 + [3]
```

2

# Append Vs Concatenation



Python 3.6
(known limitations)

```
my_list_1 = [1,2]

my_list_2 = my_list_1.append(3)

my_list_3 = my_list_1 + [3]
```

Edit this code

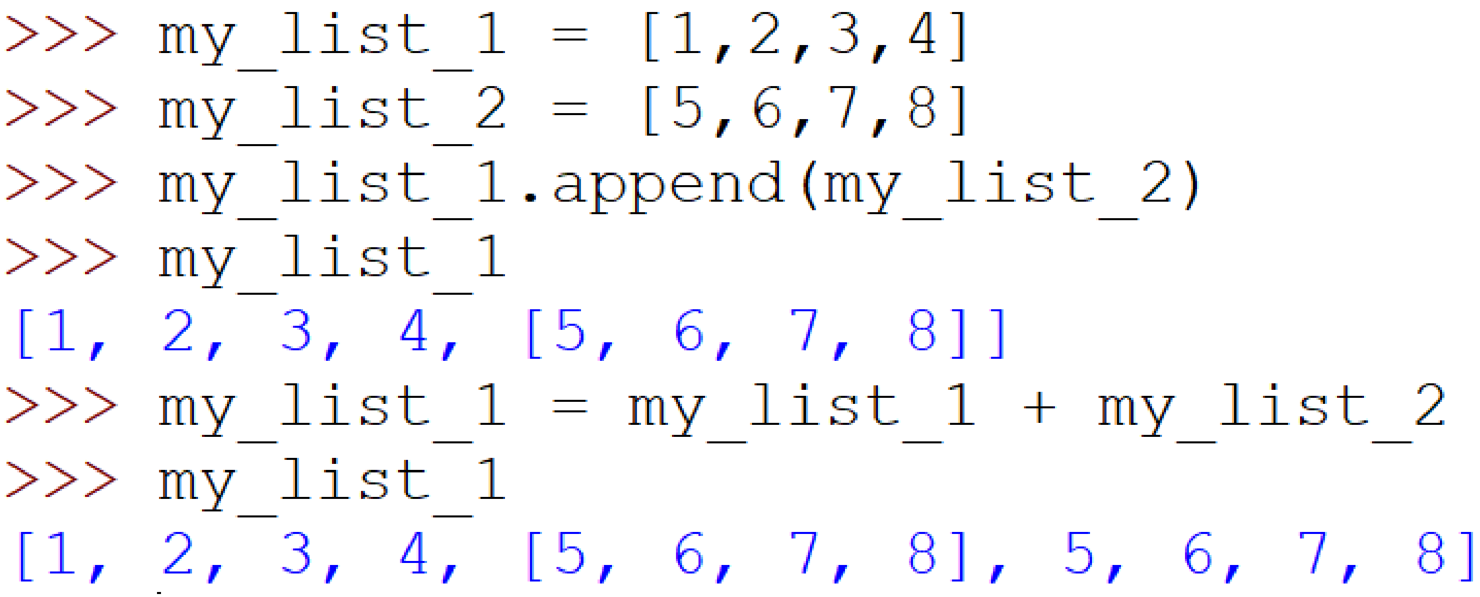
ust executed
o execute

Done running (3 steps)

ualization

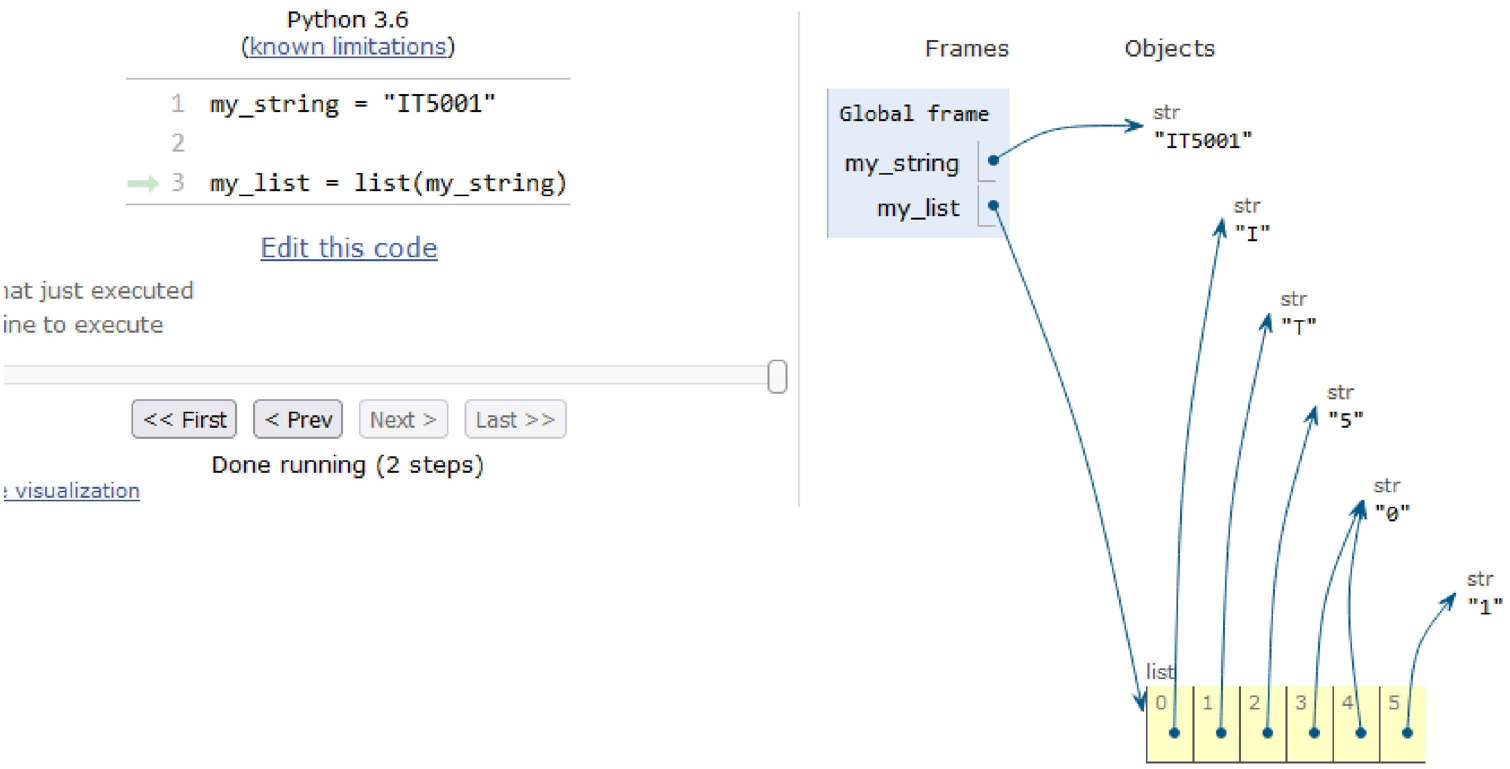
3

# Append Vs Concatenation



```
>>> my_list_1 = [1,2,3,4]
>>> my_list_2 = [5,6,7,8]
>>> my_list_1.append(my_list_2)
>>> my_list_1
[1, 2, 3, 4, [5, 6, 7, 8]]
>>> my_list_1 = my_list_1 + my_list_2
>>> my_list_1
[1, 2, 3, 4, [5, 6, 7, 8], 5, 6, 7, 8]
```

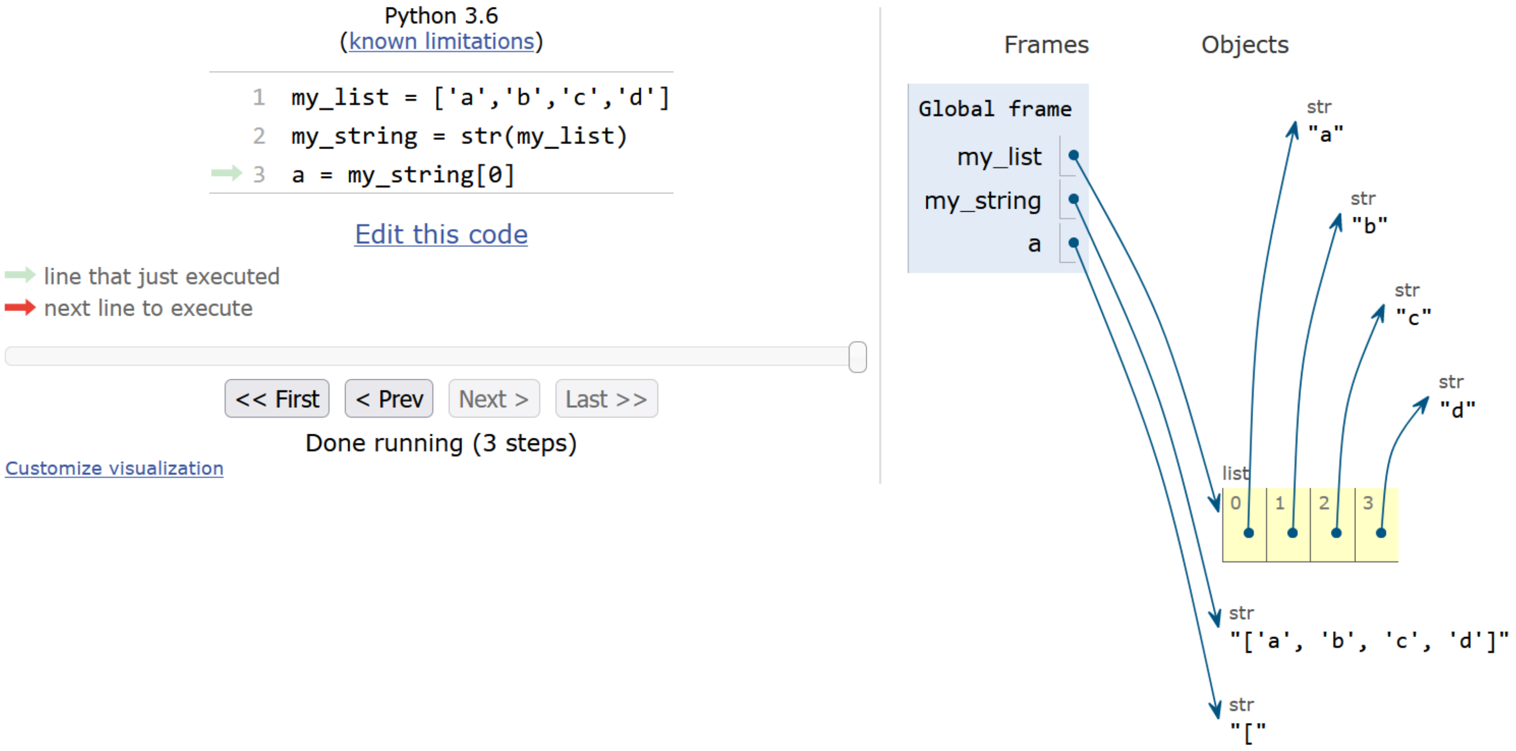
# Strings to Lists and Vice-Versa



```
my_string = "IT5001"

my_list = list(my_string)
```

Done running (2 steps)

# Strings to Lists and Vice-Versa



Python 3.6
(known limitations)

```
my_list = ['a','b','c','d']
my_string = str(my_list)
a = my_string[0]
```

Edit this code

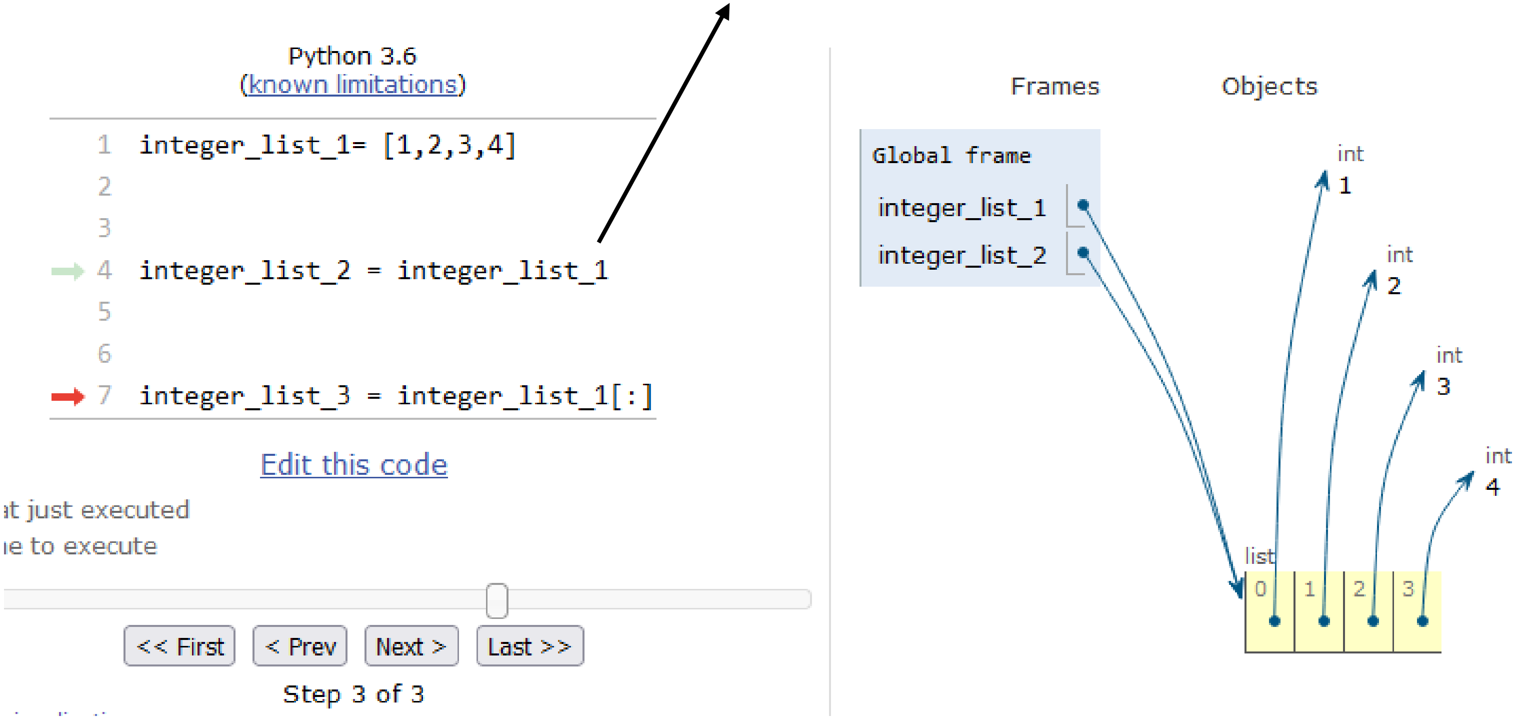
line that just executed
next line to execute

Done running (3 steps)

Customize visualization

# Aliasing vs Cloning

Aliasing



Python 3.6
(known limitations)

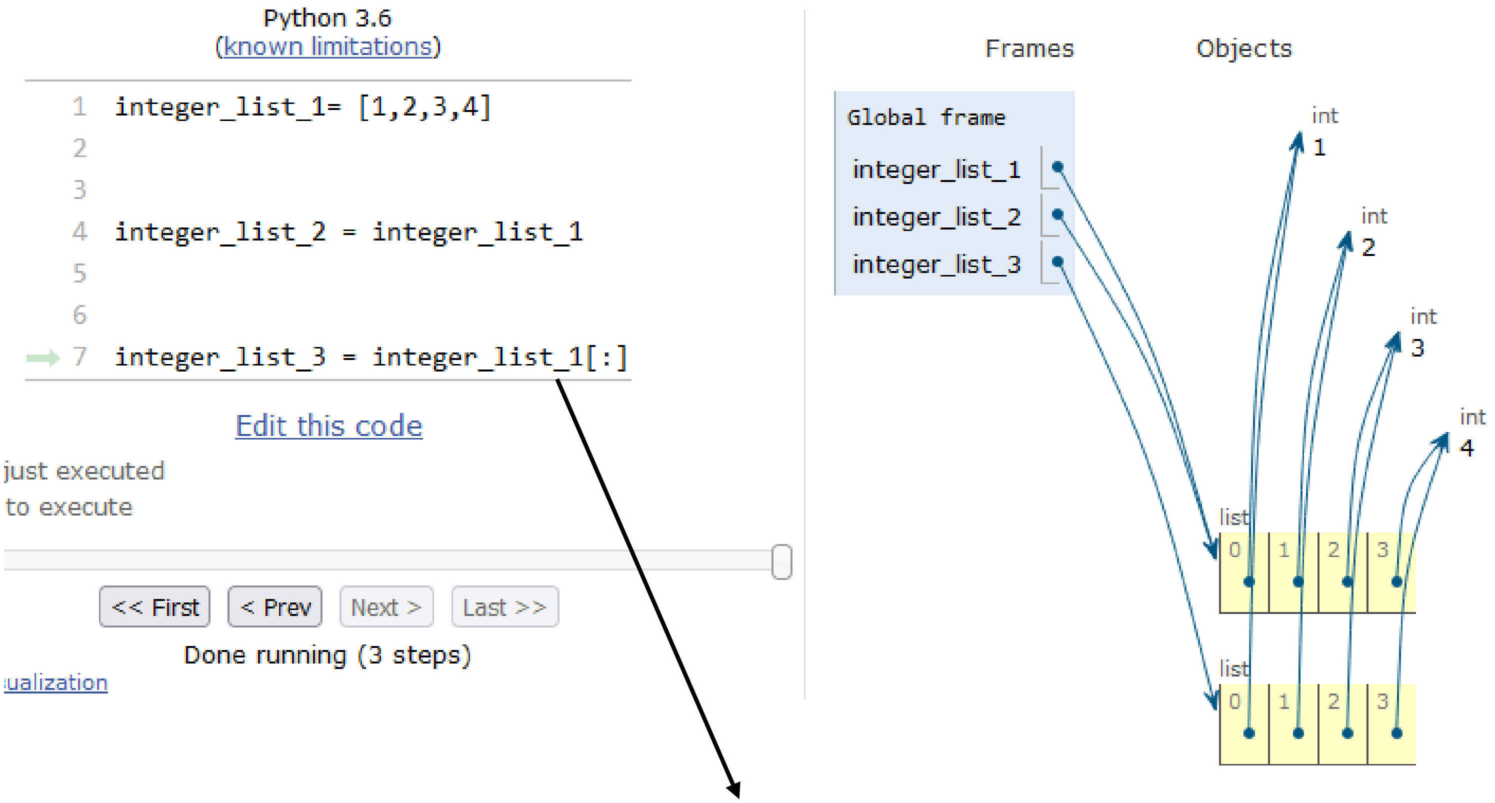
```
integer_list_1= [1,2,3,4]


integer_list_2 = integer_list_1


integer_list_3 = integer_list_1[:]
```

Edit this code

ıt just executed
ıe to execute

Step 3 of 3

# Aliasing vs Cloning



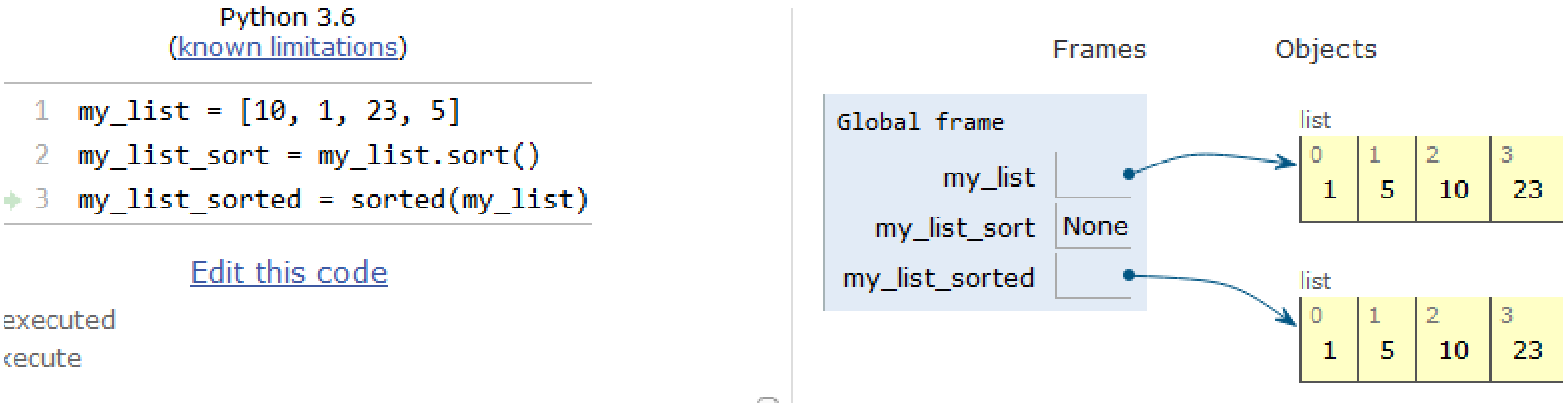
```
integer_list_1= [1,2,3,4]


integer_list_2 = integer_list_1


integer_list_3 = integer_list_1[:]
```

Cloning

# Sort vs Sorted

- sort() method mutates the list

- sorted() method creates a new sorted list without mutating the original list



```
my_list = [10, 1, 23, 5]
my_list_sort = my_list.sort()
my_list_sorted = sorted(my_list)
```

Frames

Objects

Global frame

| | |
|---|---|
| my_list | ● |
| my_list_sort | None |
| my_list_sorted | ● |

list

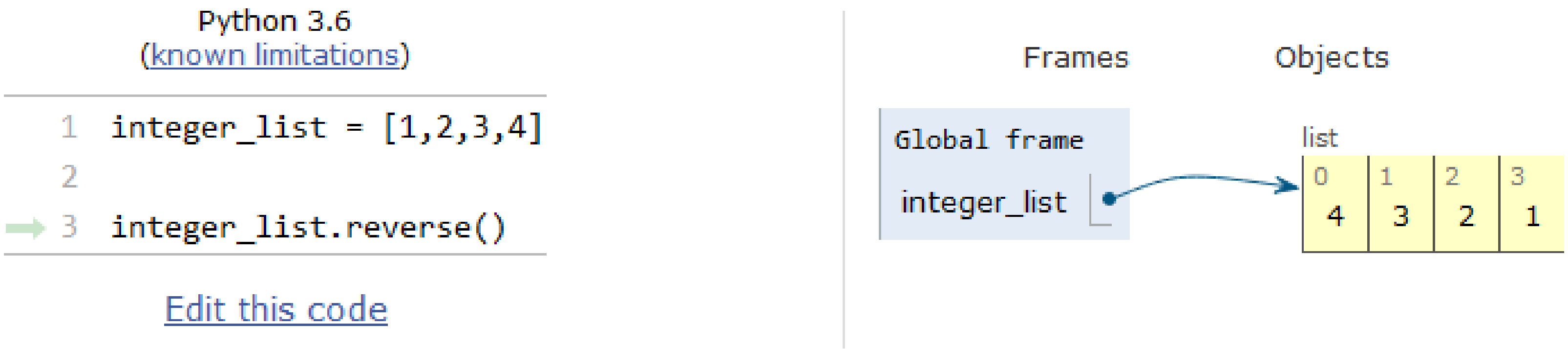
| 0 | 1 | 2 | 3 |
|---|---|---|---|
| 1 | 5 | 10 | 23 |

list

| 0 | 1 | 2 | 3 |
|---|---|---|---|
| 1 | 5 | 10 | 23 |

# Reverse

- reverse() method mutates the list

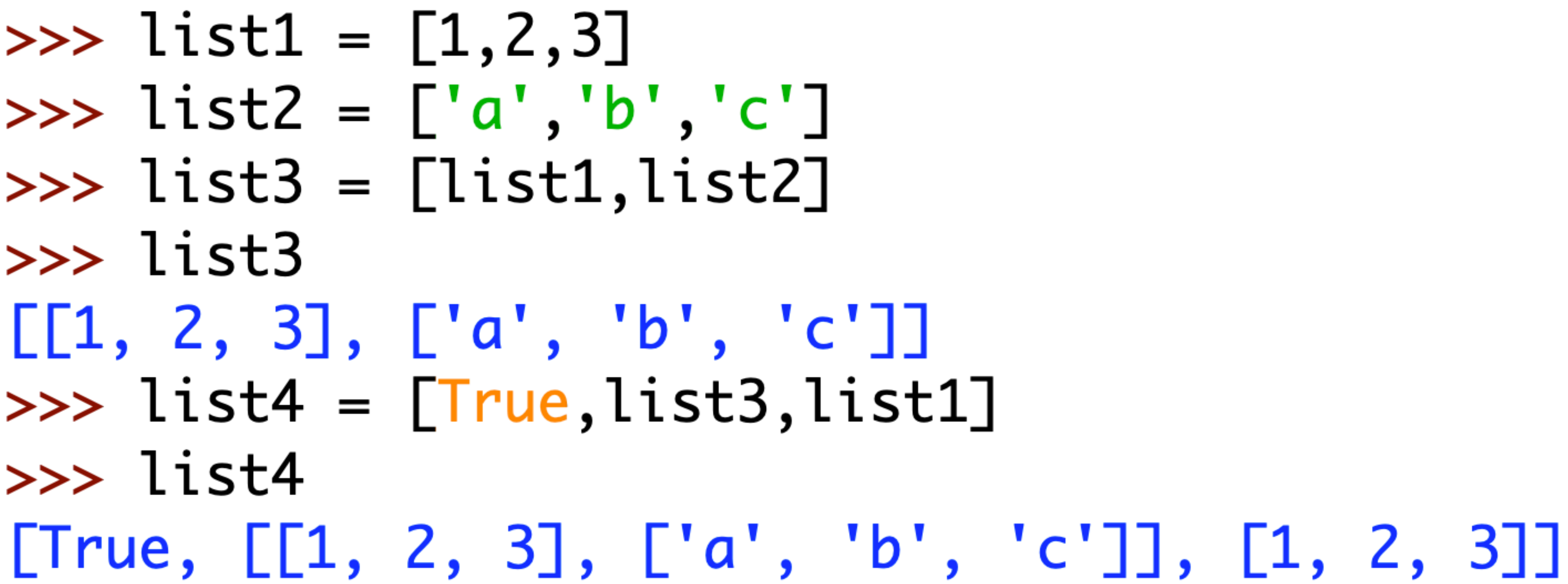


```
integer_list = [1,2,3,4]

integer_list.reverse()
```

| 0 | 1 | 2 | 3 |
|---|---|---|---|
| 4 | 3 | 2 | 1 |

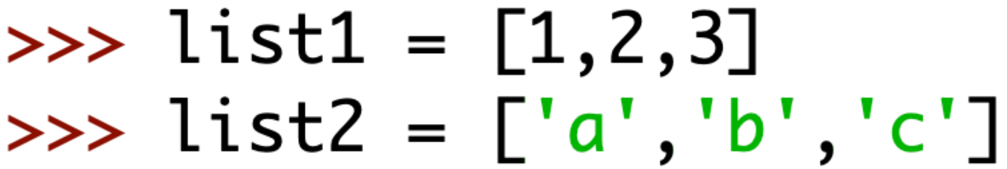
# Lists of Anything

- A list of ….
  - – Lists?

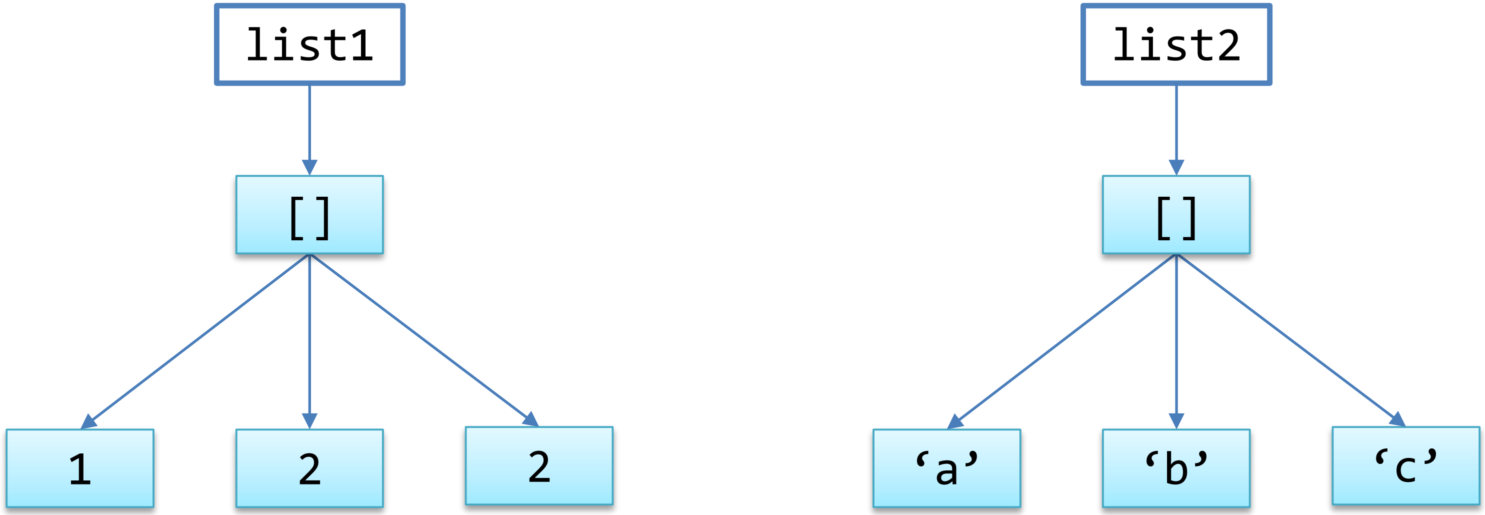


```
>>> list1 = [1,2,3]
>>> list2 = ['a','b','c']
>>> list3 = [list1,list2]
>>> list3
[[1, 2, 3], ['a', 'b', 'c']]
>>> list4 = [True,list3,list1]
>>> list4
[True, [[1, 2, 3], ['a', 'b', 'c']], [1, 2, 3]]
```

# Block Diagram

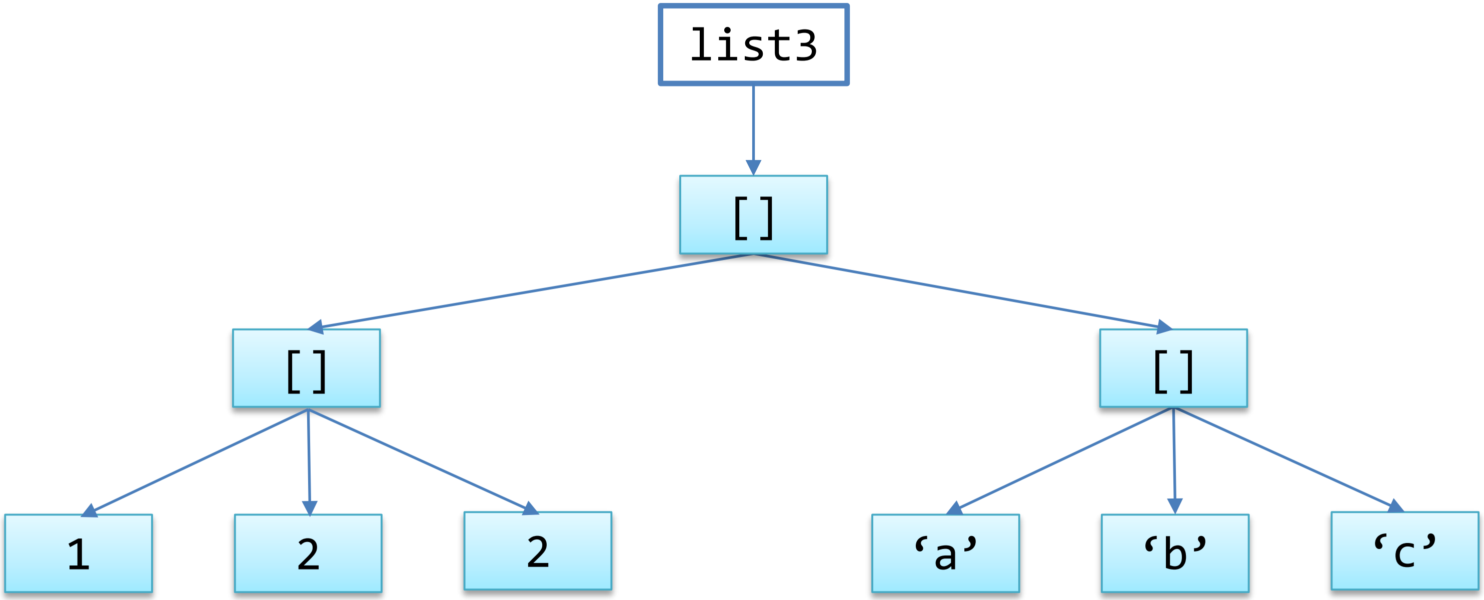


```
>>> list1 = [1,2,3]
>>> list2 = ['a','b','c']
```



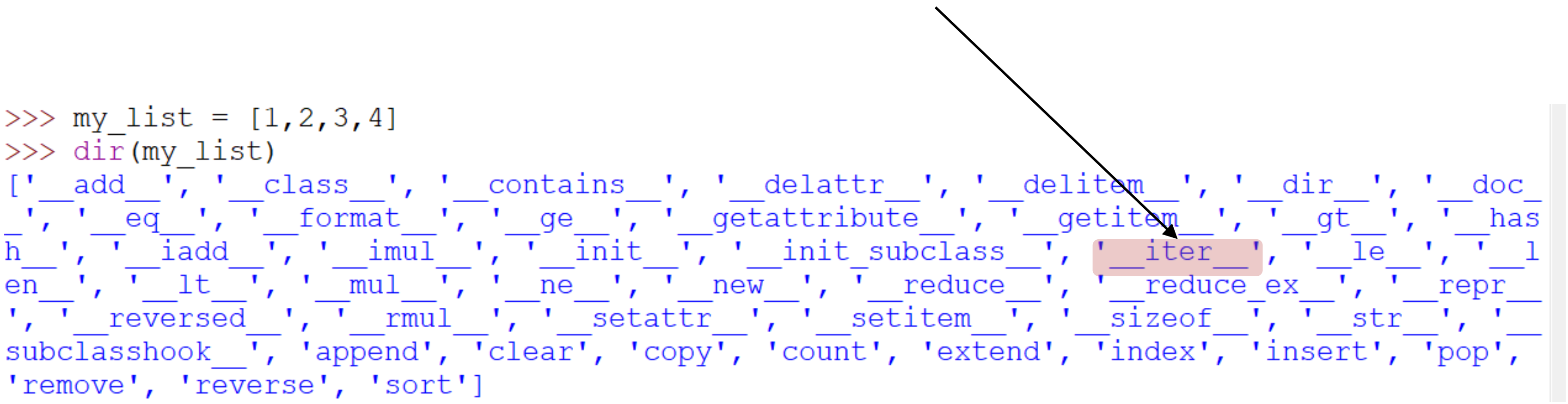
# Block Diagram

```
>>> list3 = [list1,list2]
>>> list3
[[1, 2, 3], ['a', 'b', 'c']]
```

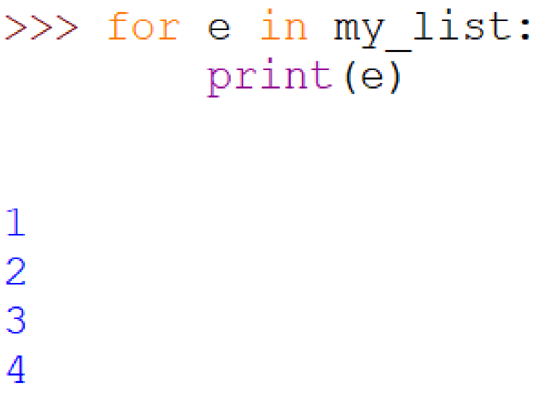


# Lists are Iterable

due to this method



```
>>> my_list = [1,2,3,4]
>>> dir(my_list)
['__add__', '__class__', '__contains__', '__delattr__', '__delitem__', '__dir__', '__doc_
_', '__eq__', '__format__', '__ge__', '__getattribute__', '__getitem__', '__gt__', '__has
h__', '__iadd__', '__imul__', '__init__', '__init_subclass__', '__iter__', '__le__', '__l
en__', '__lt__', '__mul__', '__ne__', '__new__', '__reduce__', '__reduce_ex__', '__repr__
', '__reversed__', '__rmul__', '__setattr__', '__setitem__', '__sizeof__', '__str__', '__
subclasshook__', 'append', 'clear', 'copy', 'count', 'extend', 'index', 'insert', 'pop',
'remove', 'reverse', 'sort']
```



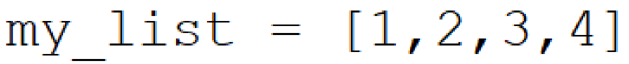
```
>>> for e in my_list:
        print(e)


1
2
3
4
```

# For loop

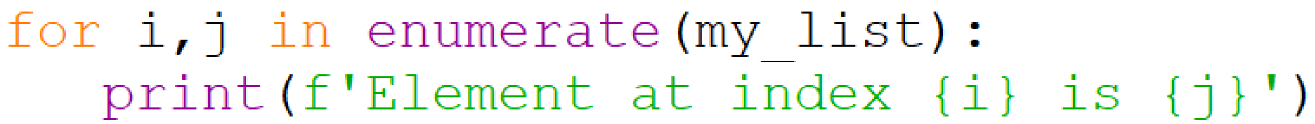
```
>>> for i in range(0,5):
        print (i)


0
1
2
3
4
```

```
>>> for i in [0,1,2,3,4]:
        print(i)


0
1
2
3
4
```

# For Loop

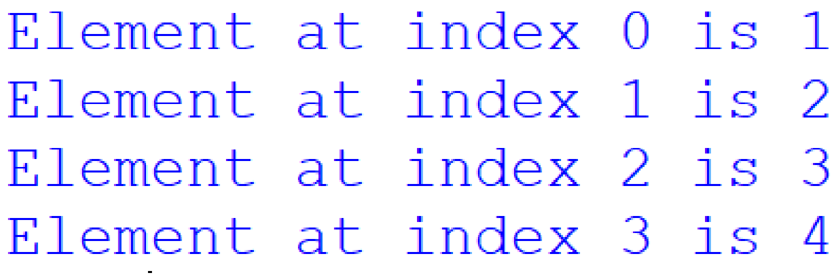


```
my_list = [1,2,3,4]
```



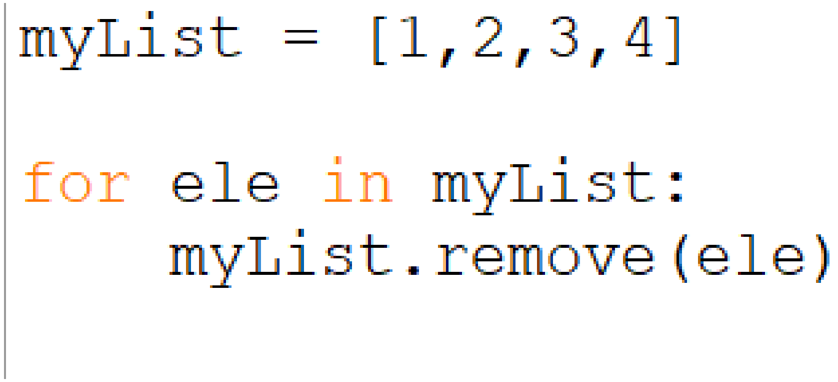
```
for i,j in enumerate(my_list):
    print(f'Element at index {i} is {j}')
```

**Output:**



```
Element at index 0 is 1
Element at index 1 is 2
Element at index 2 is 3
Element at index 3 is 4
```

# Never do this

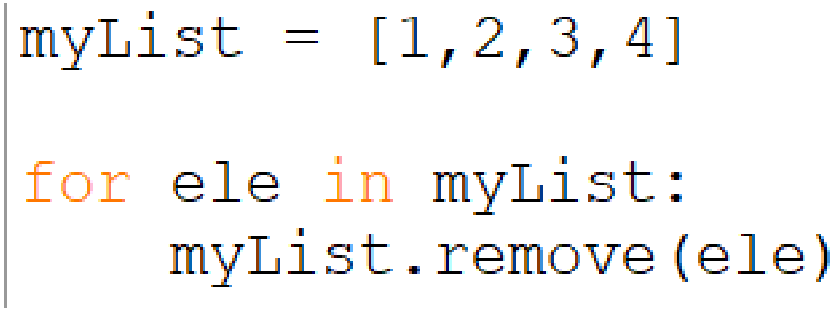


```
myList = [1,2,3,4]

for ele in myList:
    myList.remove(ele)
```

Why?

# Mutation and Iteration

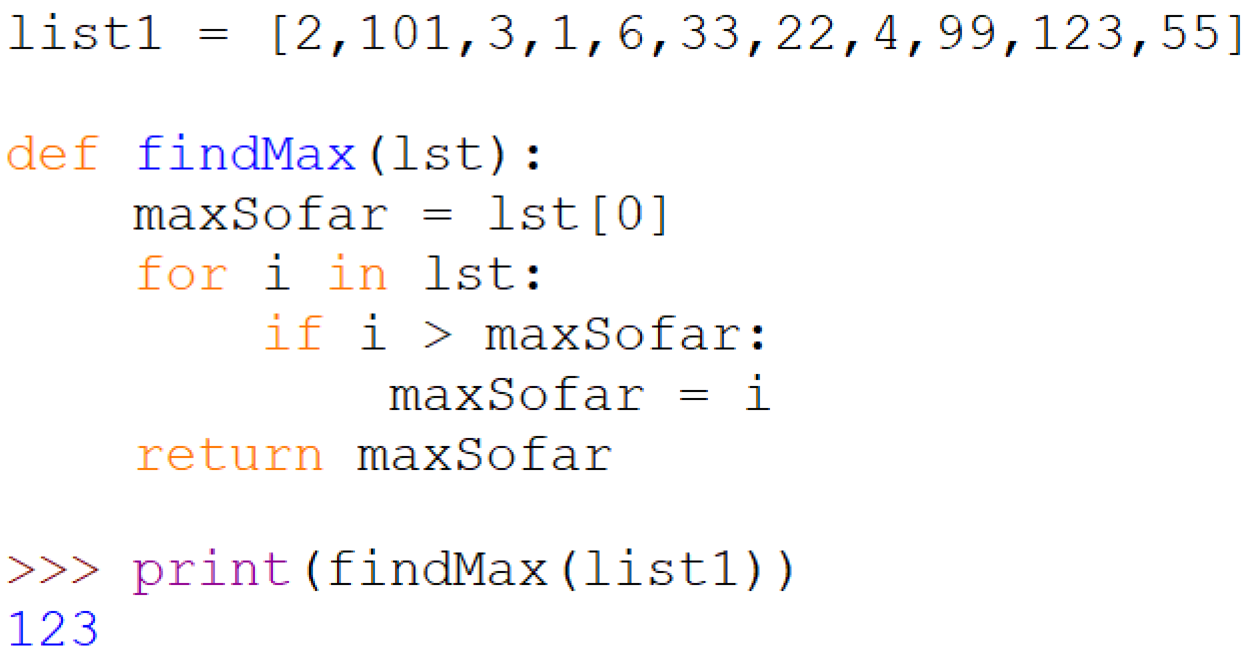
- Avoid mutating a list while iterating over the list



```
myList = [1,2,3,4]

for ele in myList:
    myList.remove(ele)
```

- *next()*  method uses an index to retrieve the elements from *myList*
-  *remove()* method mutates the *myList*, but the index in *next()* method will not be updated

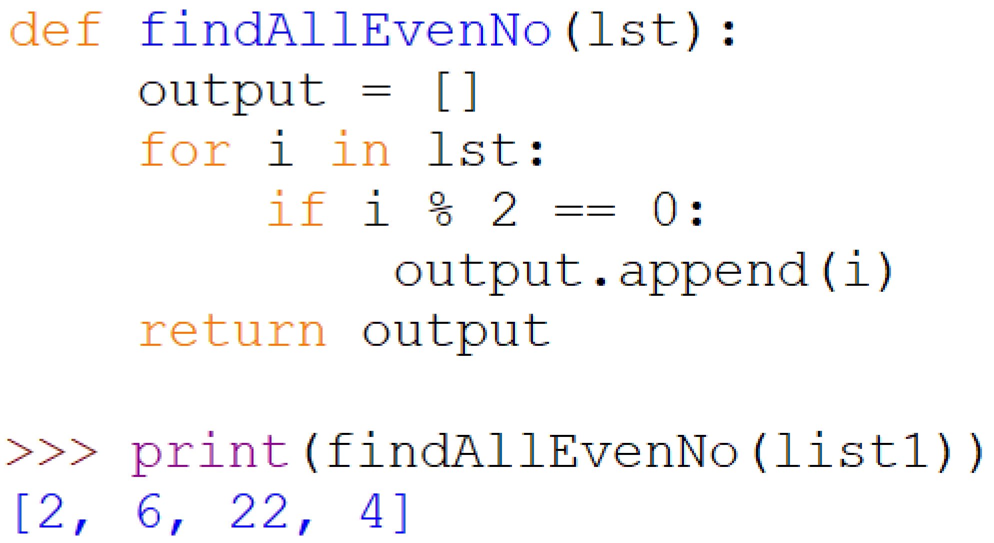
# Example: Find Max in A List of No.



```
list1 = [2,101,3,1,6,33,22,4,99,123,55]

def findMax(lst):
    maxSofar = lst[0]
    for i in lst:
        if i > maxSofar:
            maxSofar = i
    return maxSofar

>>> print(findMax(list1))
123
```

- Is there any potential problem?

# Example: Find all Even Numbers



```
def findAllEvenNo(lst):
    output = []
    for i in lst:
        if i % 2 == 0:
            output.append(i)
    return output

>>> print(findAllEvenNo(list1))
[2, 6, 22, 4]
```

# List Comprehensions

- Provides a concise way to apply an operation to the items in iterable object and store the result as a list

- Syntax:
  - [*expr* for *elem* in *iterable* if *test*]

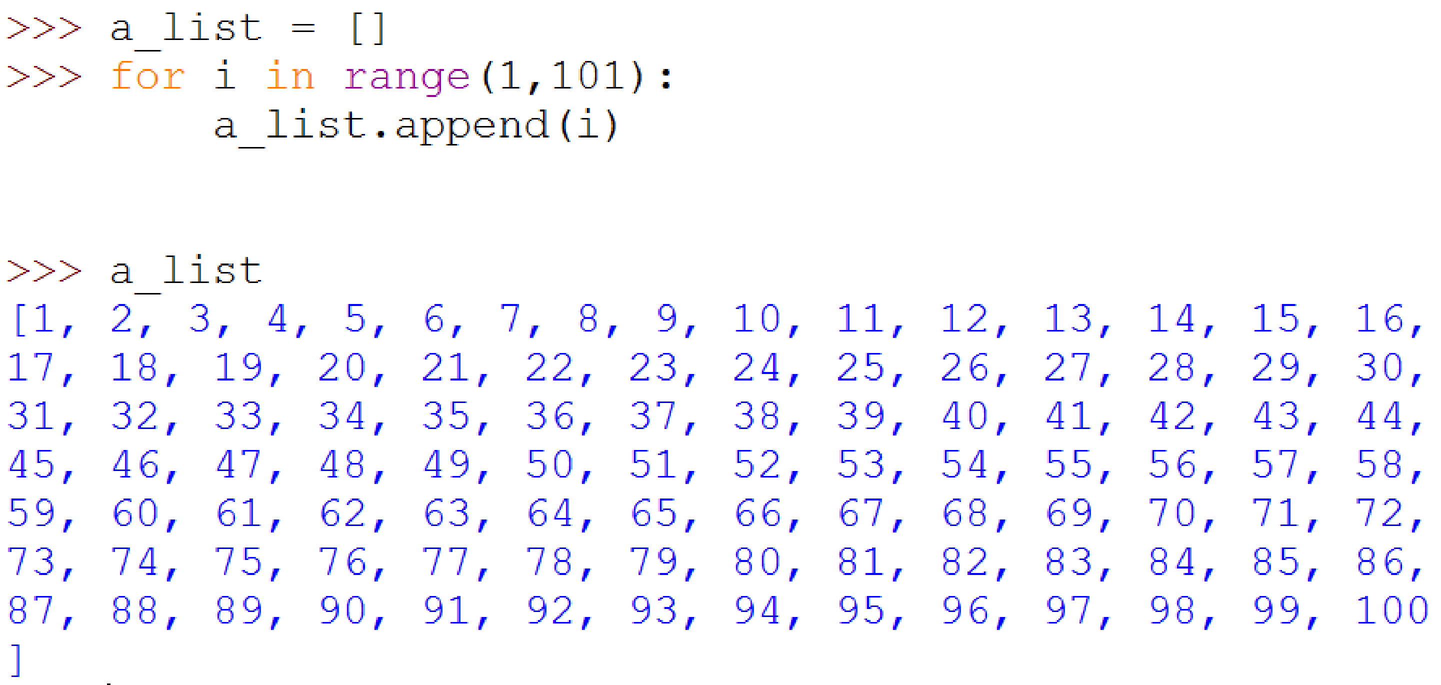
- Returns an iterable

# List Comprehension

- Todo:
  - create a list:

```
a_list = [1,2,3,4,5,6,…… , 100]
```

- You can



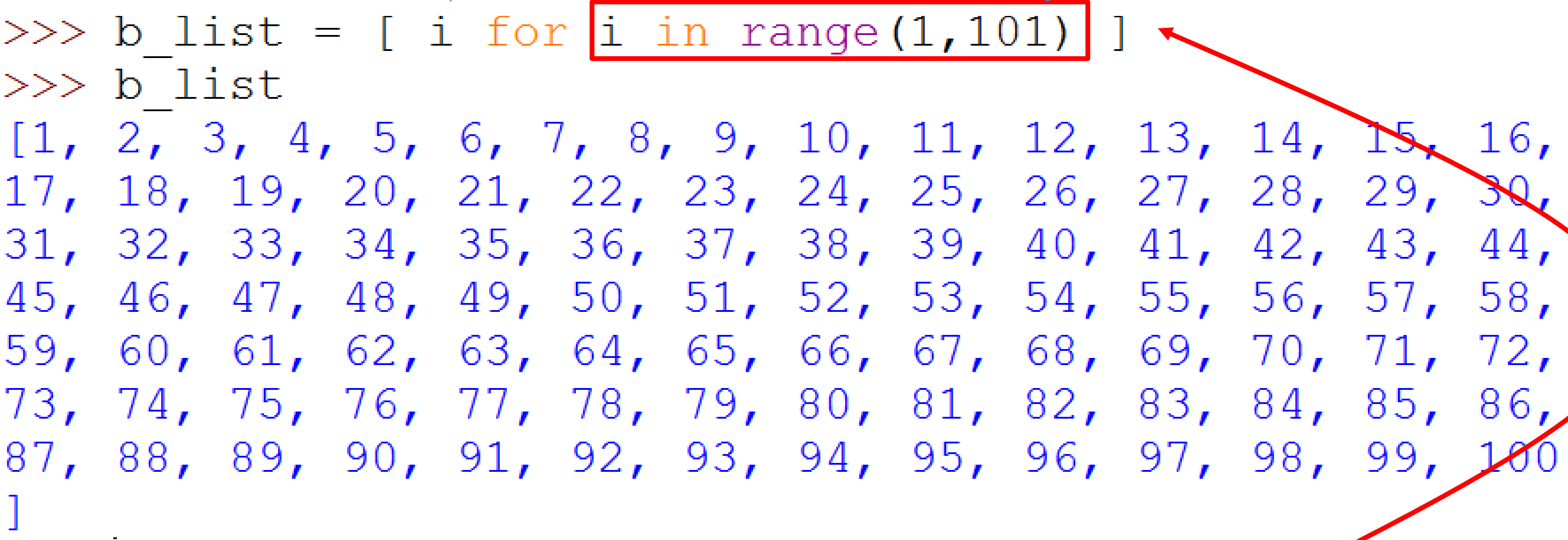
```
>>> a_list = []
>>> for i in range(1,101):
	a_list.append(i)


>>> a_list
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16,
17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44,
45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58,
59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72,
73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86,
87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
]
```

# List Comprehension

- Or

The item really in the list

every i between 1 and 101 (exclusive)



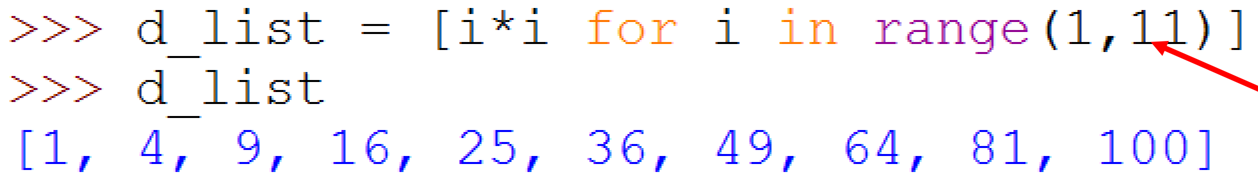
```
>>> b_list = [ i for i in range(1,101) ]
>>> b_list
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16,
17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30,
31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44,
45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58,
59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72,
73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86,
87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
]
```

$$b = \{i | i \in [1,101)\}$$

Compare to ordinary math equation

# List Comprehension

- How do I produce a list of first 10 squared numbers?



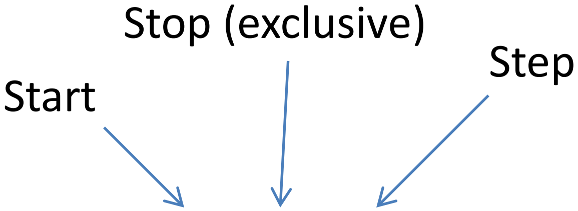
```
>>> d_list = [i*i for i in range(1,11)]
>>> d_list
[1, 4, 9, 16, 25, 36, 49, 64, 81, 100]
```

$$b = \{i^2 | i \in [1,101)\}$$

Compare to ordinary math equation

# List Comprehension

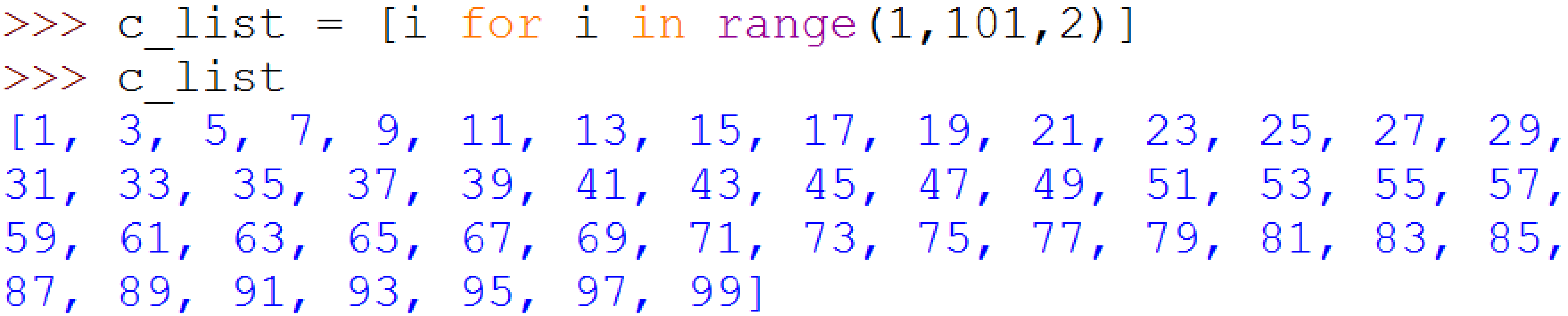
- How do I produce a list of odd numbers less than 100
  - Like string slicing



Stop (exclusive)

Step

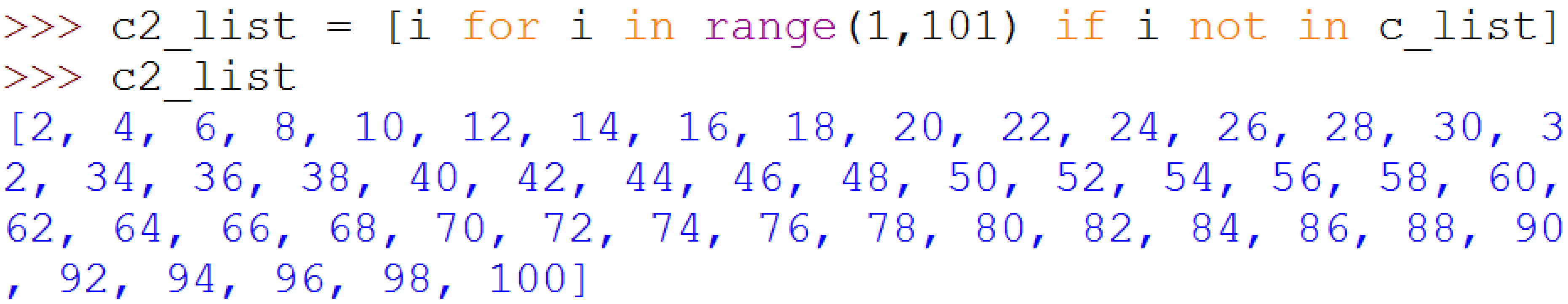
Start



```
>>> c_list = [i for i in range(1,101,2)]
>>> c_list
[1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29,
31, 33, 35, 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57,
59, 61, 63, 65, 67, 69, 71, 73, 75, 77, 79, 81, 83, 85,
87, 89, 91, 93, 95, 97, 99]
```

# List Comprehension

- How do I produce a list of even numbers less than 100
  - Similar to the previous one but start with 2
  - Or



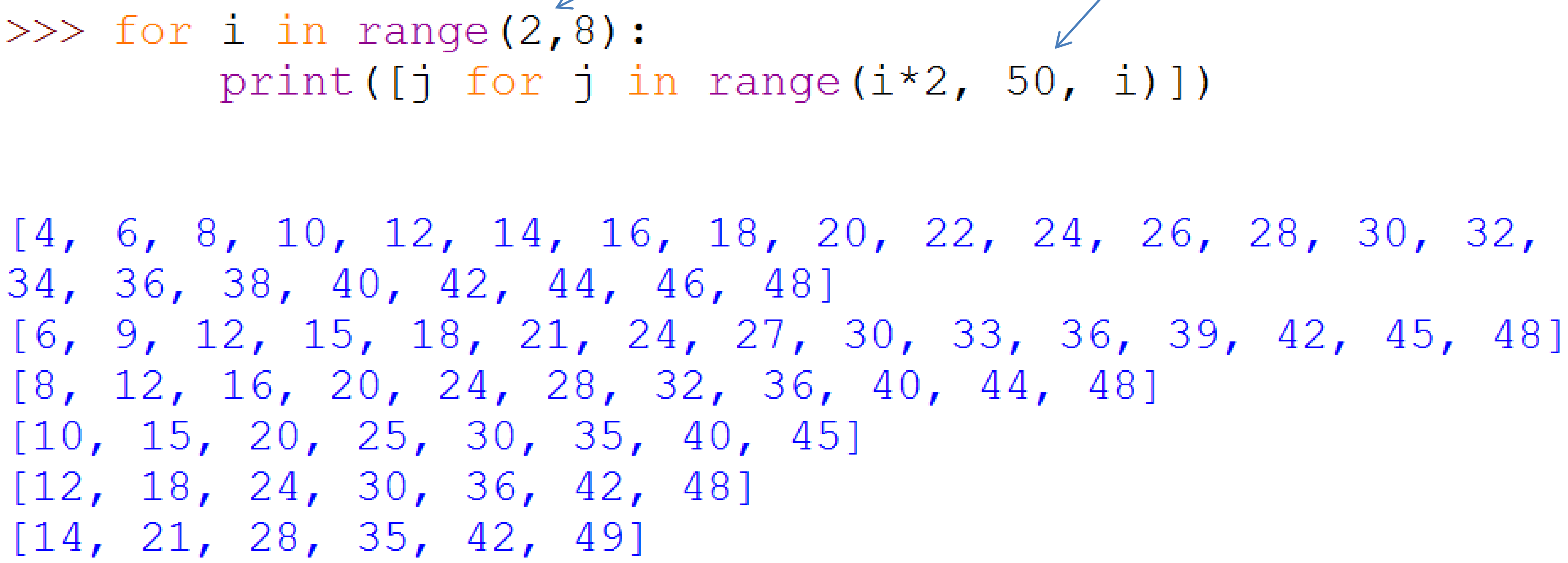
```
>>> c2_list = [i for i in range(1,101) if i not in c_list]
>>> c2_list
[2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 3
2, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60,
62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90
, 92, 94, 96, 98, 100]
```

# Advance: Generate Prime Numbers

- Let’s generate all the prime numbers < 50
- First, generate all the non-prime numbers <50

i is from 2 to 7
(7 = sqrt(50))

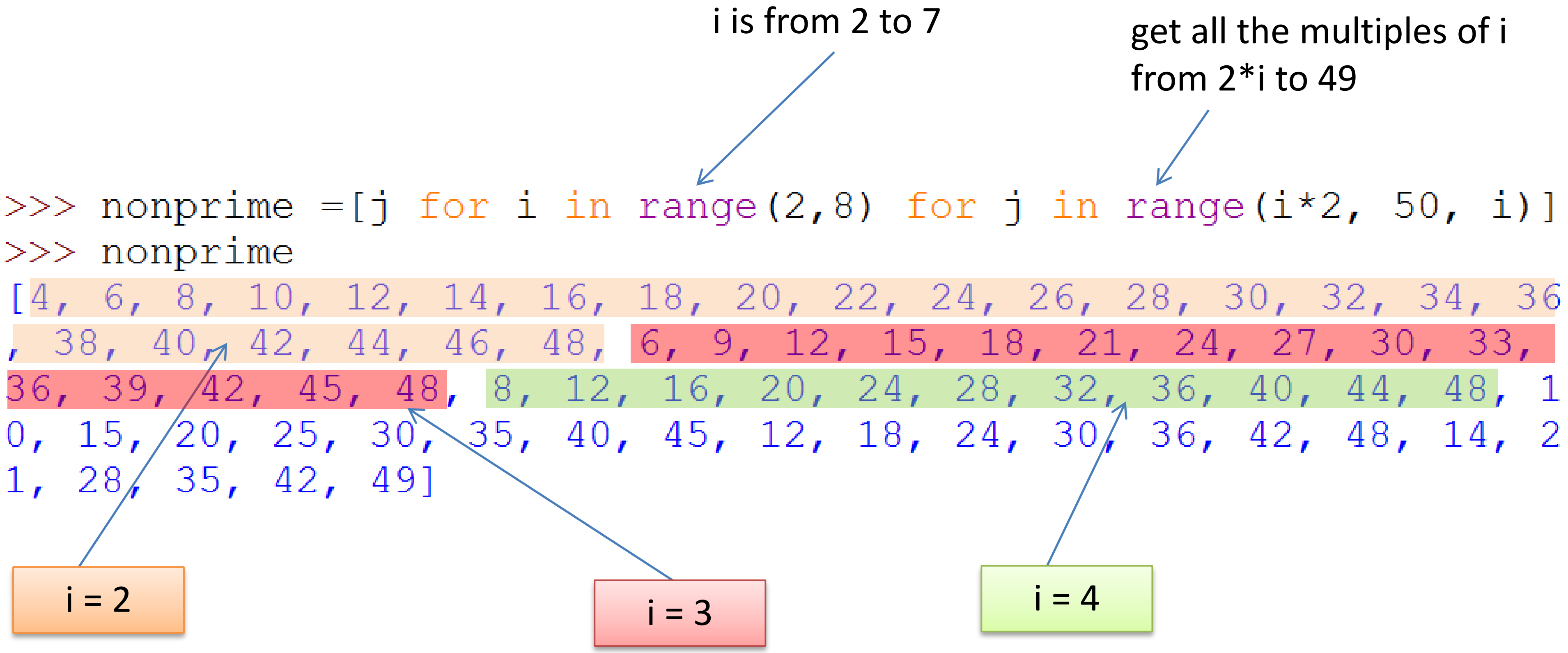
get all the multiples of i
from 2*i to 49



```
>>> for i in range(2,8):
        print([j for j in range(i*2, 50, i)])


[4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32,
34, 36, 38, 40, 42, 44, 46, 48]
[6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45, 48]
[8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48]
[10, 15, 20, 25, 30, 35, 40, 45]
[12, 18, 24, 30, 36, 42, 48]
[14, 21, 28, 35, 42, 49]
```

# Advance: Generate Prime Numbers

- Let’s generate all the prime numbers < 50
- First, generate all the non-prime numbers <50



```
>>> nonprime =[j for i in range(2,8) for j in range(i*2, 50, i)]
>>> nonprime
[4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36
, 38, 40, 42, 44, 46, 48, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33,
36, 39, 42, 45, 48, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 1
0, 15, 20, 25, 30, 35, 40, 45, 12, 18, 24, 30, 36, 42, 48, 14, 2
1, 28, 35, 42, 49]
```

i is from 2 to 7

get all the multiples of i from 2*i to 49

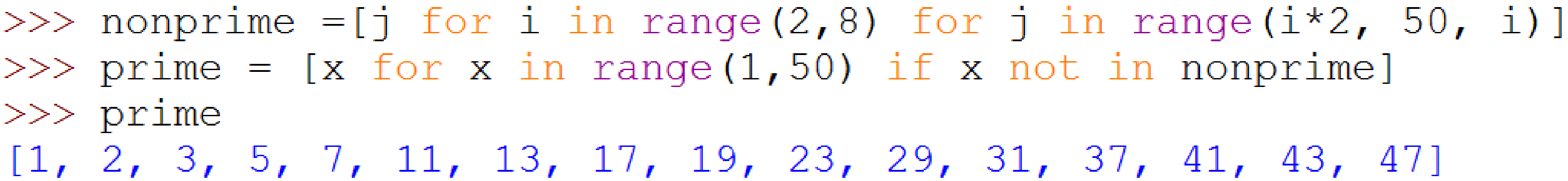
i = 2

i = 3

i = 4

# Generate Prime Numbers

- Let’s generate all the prime numbers < 50
- First, generate all the non-prime numbers <50
- Prime numbers are the numbers NOT in the list above



```
>>> nonprime =[j for i in range(2,8) for j in range(i*2, 50, i)]
>>> prime = [x for x in range(1,50) if x not in nonprime]
>>> prime
[1, 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47]
```

# Generator Expressions

- Provides a generator that can be used to iterate over without explicitly generating the list of items
- Syntax:
  - (*expr* for *elem* in *iterable* if *test*)
- Returns an iterator
- Requires less memory than list
  - Check!

# Generator Expressions

```
num = 4
# square each term using list comprehension
my_square_list = [x**2 for x in range(num)]
my_square_generator = (x**2 for x in range(num))

for k in my_square_list:
    print(k)

for k in my_square_generator:
    print(k)
```

Output:

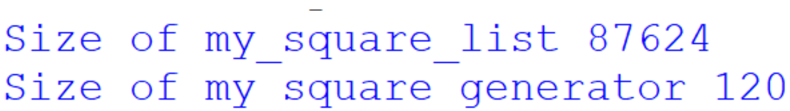
```
0
1
4
9
0
1
4
9
```

Which is better?

# Generator Expressions

```python
num = 10**4
# square each term using list comprehension
my_square_list = [x**2 for x in range(num)]
my_square_generator = (x**2 for x in range(num))

import sys
print(f'Size of my_square_list {sys.getsizeof(my_square_list)}')
print(f'Size of my_square_generator {sys.getsizeof(my_square_generator)}')
```

Output:



```
Size of my_square_list 87624
Size of my square generator 120
```

# Sequence in Python

- Indexed collection
  - Strings
  - Lists
  - Tuples

- Non-indexed collection:
  - Sets
  - Dictionary

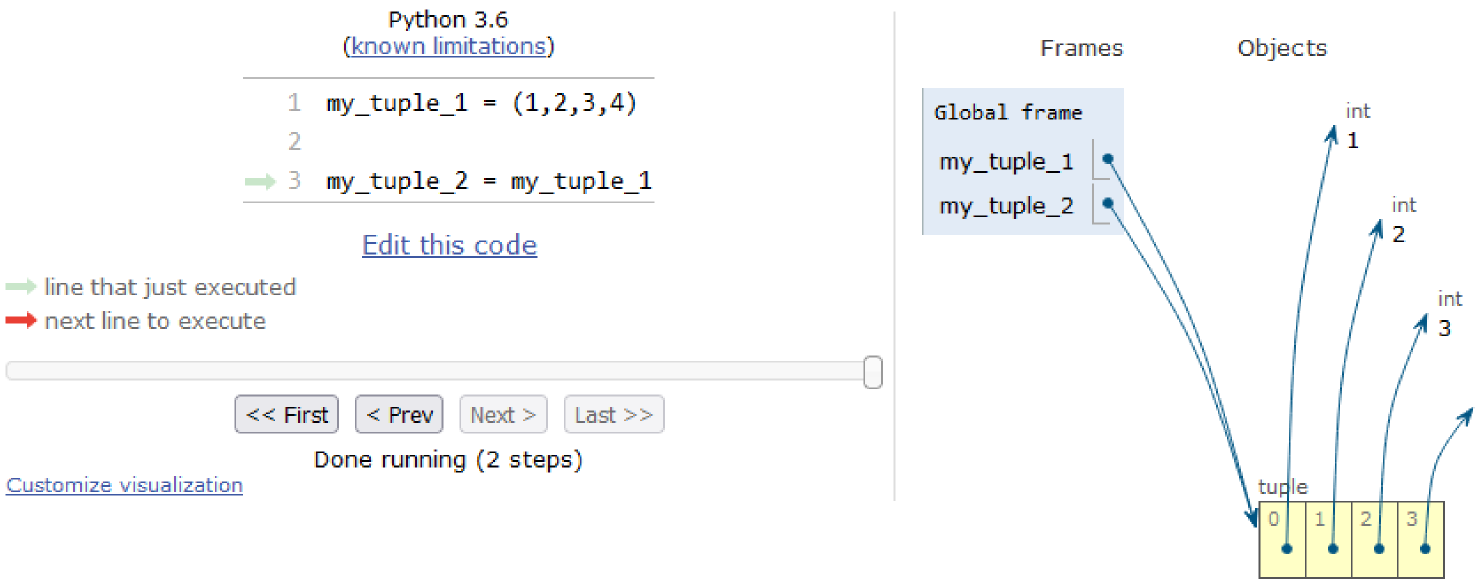
# Tuples

- A static and an immutable array/list

- Syntax:
  - int_tuple = (1,2,3)
  - float_tuple = (1.0,2.0,3.0)
  - str_tuple = (‘hi’,’IT5001’)
  - mixed_tuple = (1,1.0,’IT5001

| Task | Syntax |
|---|---|
| Return i-th element | a[i] |
| Return elements from i to j-1 | a[i:j] |
| Return number of elements | len(a) |
| Return smallest value in sequence | min(a) |
| Return largest value in sequence | max(a) |
| Returns if an element is part of sequence | x in a |
| Concatenates two sequences | a + b |
| Creates n copies of a  sequence | a * n |

# Tuples: Example 1



Python 3.6
(known limitations)

```
my_tuple_1 = (1,2,3,4)

my_tuple_2 = my_tuple_1
```

Edit this code

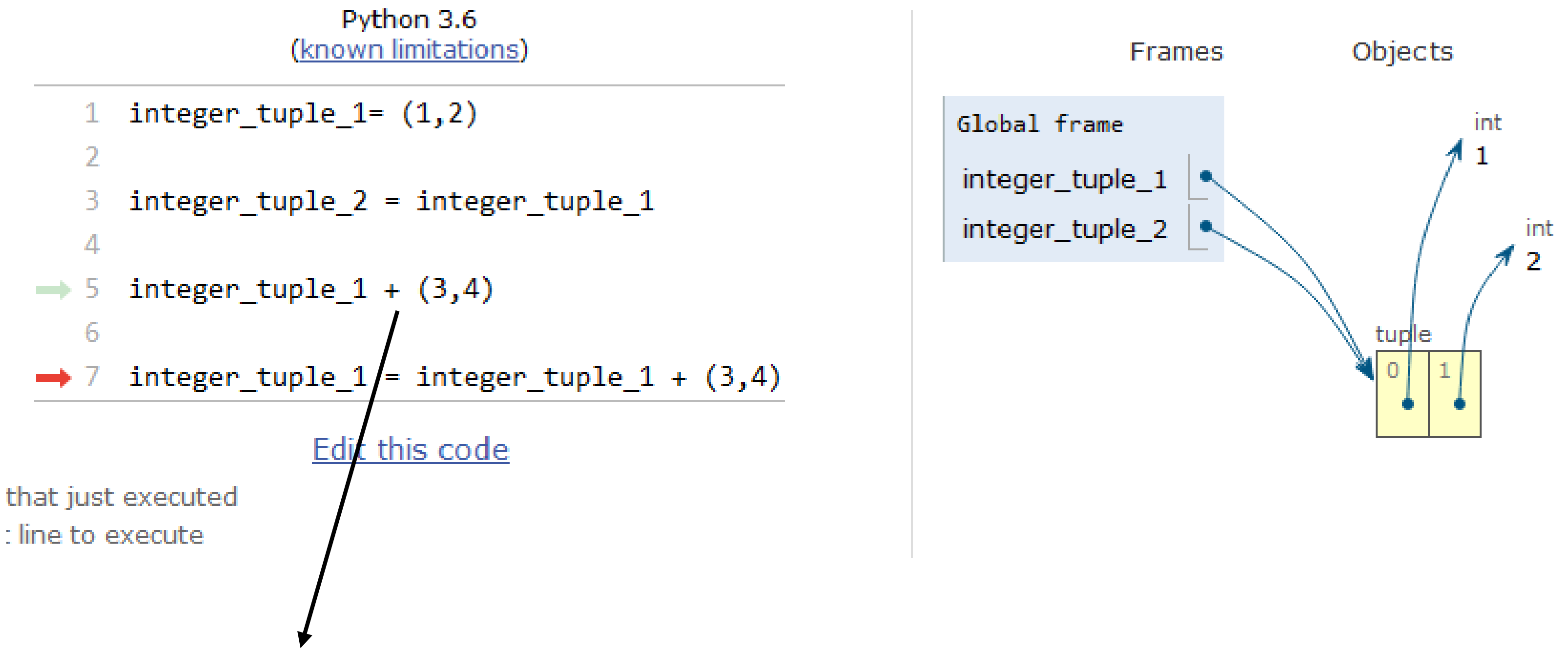
line that just executed

next line to execute

Done running (2 steps)

Customize visualization

# Tuples: Example 2



Python 3.6
(known limitations)

```
integer_tuple_1= (1,2)

integer_tuple_2 = integer_tuple_1

integer_tuple_1 + (3,4)

integer_tuple_1 = integer_tuple_1 + (3,4)
```

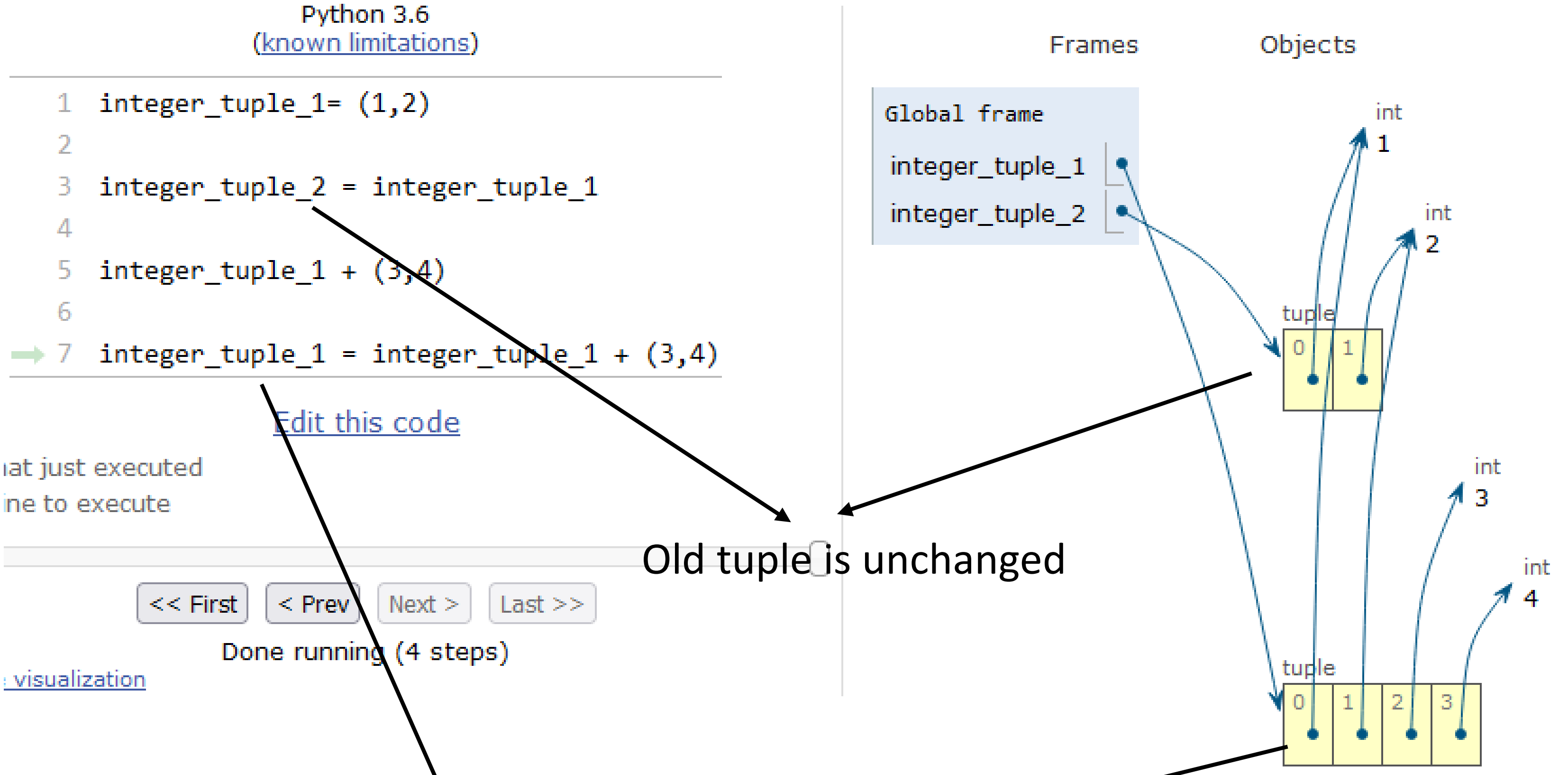
Edit this code

that just executed
: line to execute

Immutable:

creates a new tuple – but not assigned

# Tuples: Example 2



```
integer_tuple_1= (1,2)

integer_tuple_2 = integer_tuple_1

integer_tuple_1 + (3,4)

integer_tuple_1 = integer_tuple_1 + (3,4)
```

Done running (4 steps)

Old tuple is unchanged

Creates a new tuple and assigned to integer_tuple_1

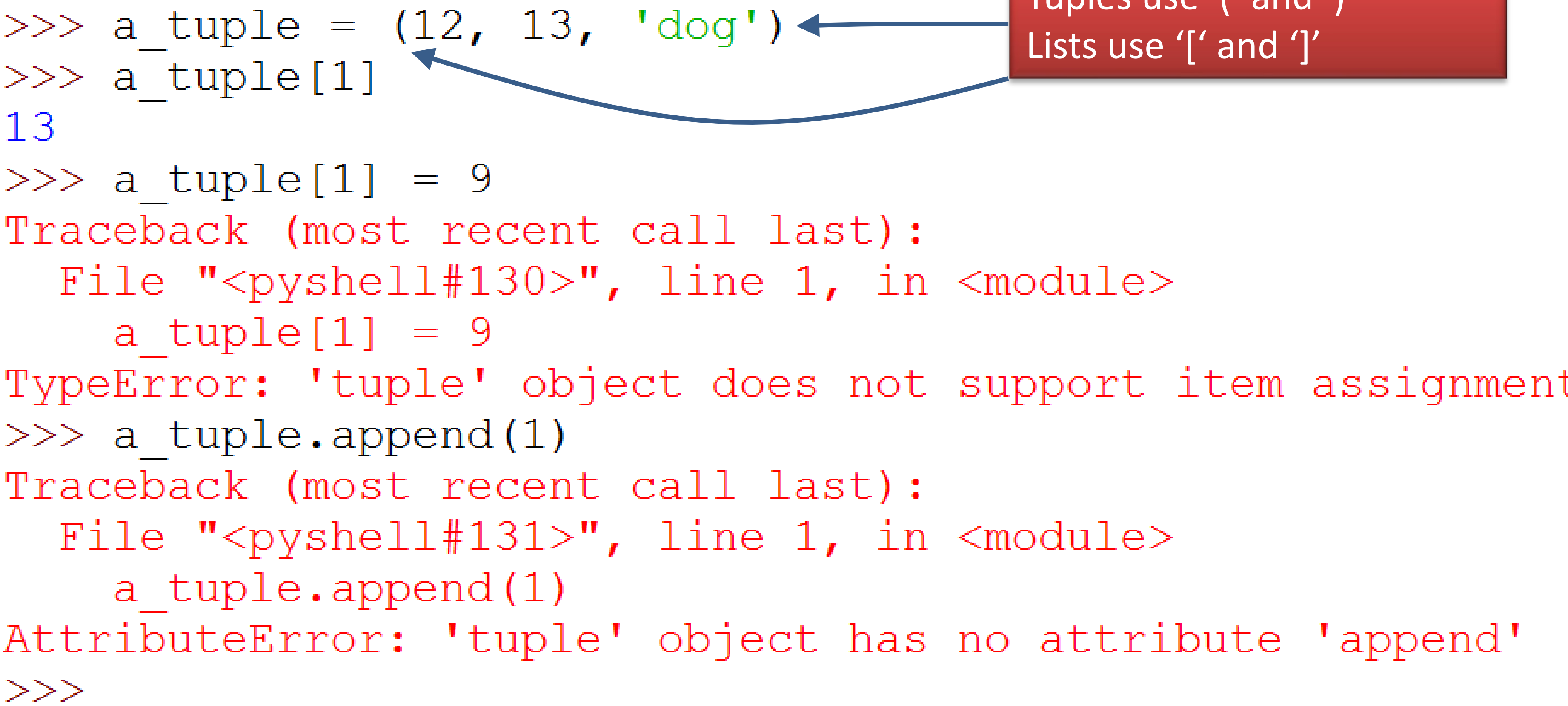
# Lists and Tuples

- Similarities:
  - List and Tuple are
    - Indexed
    - Iterable
  - Both can store heterogeneous data types

- Differences:
  - List is mutable
  - Tuple is immutable

# Tuple

- A Tuple is basically a list but
  - CANNOT be modified

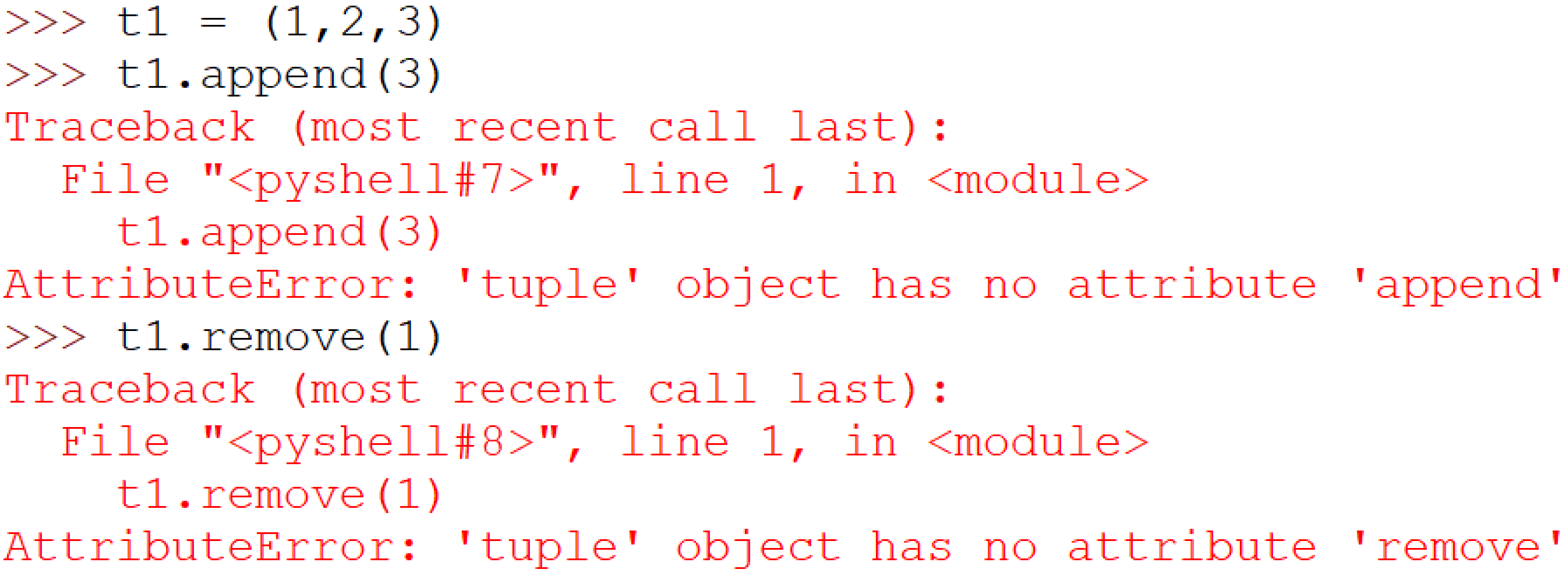


```
>>> a_tuple = (12, 13, 'dog')
>>> a_tuple[1]
13
>>> a_tuple[1] = 9
Traceback (most recent call last):
  File "<pyshell#130>", line 1, in <module>
    a_tuple[1] = 9
TypeError: 'tuple' object does not support item assignment
>>> a_tuple.append(1)
Traceback (most recent call last):
  File "<pyshell#131>", line 1, in <module>
    a_tuple.append(1)
AttributeError: 'tuple' object has no attribute 'append'
>>>
```

Tuples use ‘(‘ and ‘)’
Lists use ‘[‘ and ‘]’

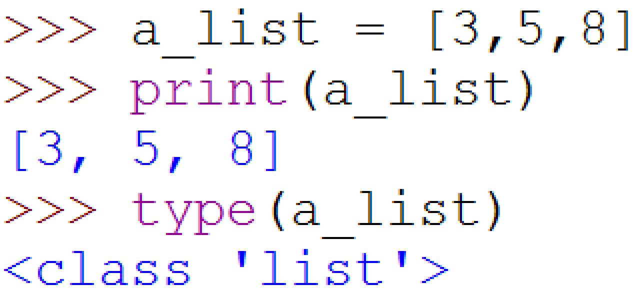
# Tuple

- A Tuple is basically a list but
  - CANNOT be modified



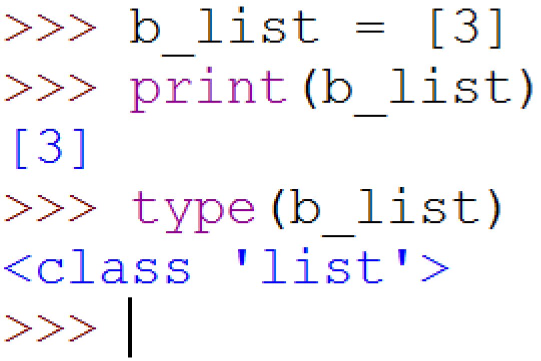
```
>>> t1 = (1,2,3)
>>> t1.append(3)
Traceback (most recent call last):
  File "<pyshell#7>", line 1, in <module>
    t1.append(3)
AttributeError: 'tuple' object has no attribute 'append'
>>> t1.remove(1)
Traceback (most recent call last):
  File "<pyshell#8>", line 1, in <module>
    t1.remove(1)
AttributeError: 'tuple' object has no attribute 'remove'
```

# For a Singleton of List and Tuple…

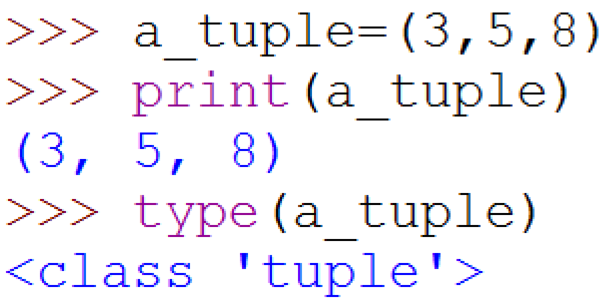


```
>>> a_list = [3,5,8]
>>> print(a_list)
[3, 5, 8]
>>> type(a_list)
<class 'list'>
```

- a list with only one element

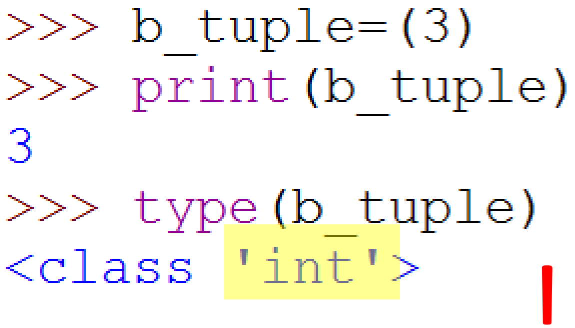


```
>>> b_list = [3]
>>> print(b_list)
[3]
>>> type(b_list)
<class 'list'>
>>> 
```



```
>>> a_tuple=(3,5,8)
>>> print(a_tuple)
(3, 5, 8)
>>> type(a_tuple)
<class 'tuple'>
```

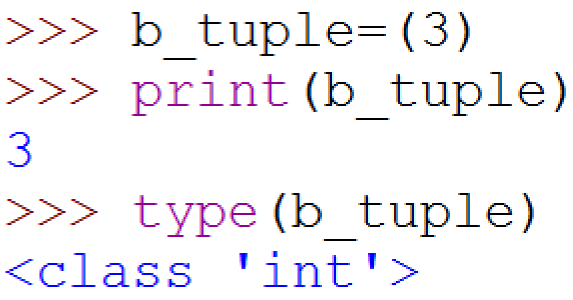
- a tuple with only one element



```
>>> b_tuple=(3)
>>> print(b_tuple)
3
>>> type(b_tuple)
<class 'int'>
```

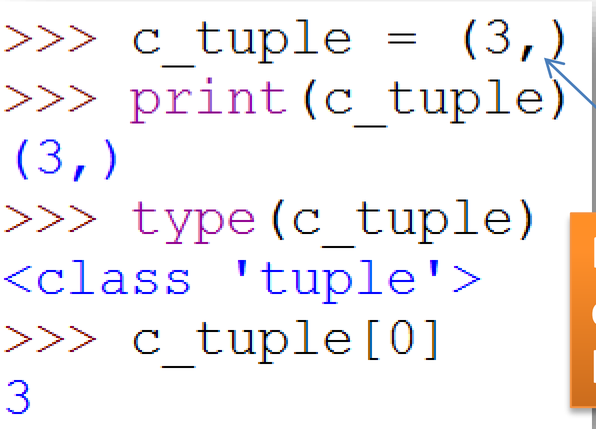
!!!

# A Tuple with only one element



```
>>> b_tuple=(3)
>>> print(b_tuple)
3
>>> type(b_tuple)
<class 'int'>
```

- Correct way



```
>>> c_tuple = (3,)
>>> print(c_tuple)
(3,)
>>> type(c_tuple)
<class 'tuple'>
>>> c_tuple[0]
3
```

Note the comma here

# But then, why use Tuple? Or List?

Or when to use Tuple? When to use List?

# English Grammar

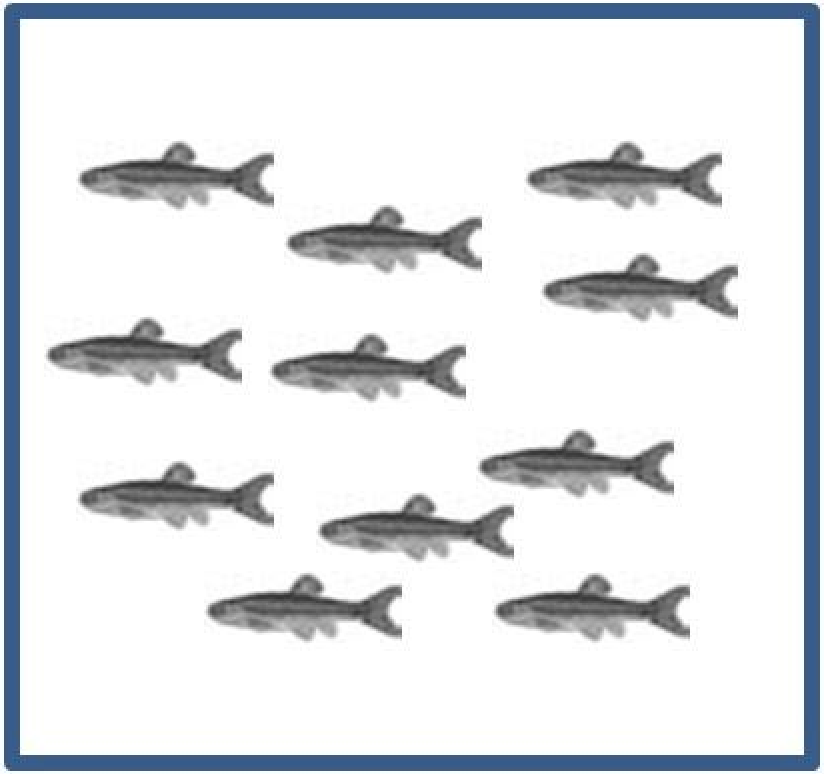
- Which sentence is grammatically correct?
  - “I have more than one fish. Therefore, I have many ***fish***”
  - “I have more than one fish. Therefore, I have many ***fishes***”

- Both of them are grammatically correct!
  - But they mean different things

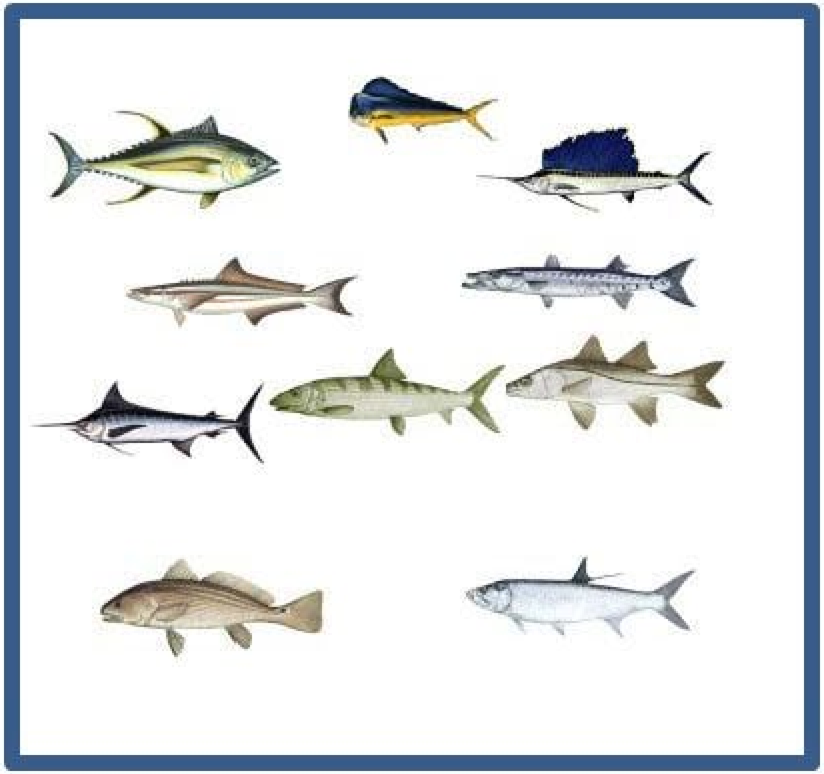
# Fish vs Fishes

- The plural of fish is usually ***fish***.
- When referring to more than one species of fish, especially in a scientific context, you can use ***fishes*** as the plural.

# Fish vs. Fishes



"This tank is full of fish."



"The ocean is full of fishes."

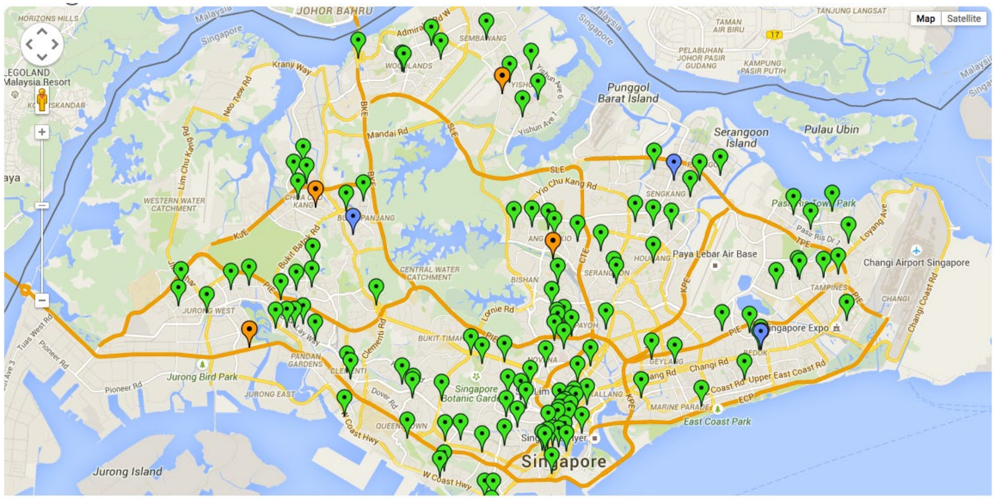
# List vs Tuple, **Cultural** Reason

- List
  - Usually stores a large collection of data with the same type (homogenous)
  - E.g. List of 200 student names in a class
- Tuple
  - Usually stores a small collections of items with various data types/concepts (heterogeneous )
  - E.g. A single student record with name (*string*), student number(*string*) and mark(*integer*)

But, violating this "culture" will NOT cause any syntax error

# An Example

- To store the data on a map
  - These are the locations of **100** nice restaurants in Singapore
  - The location of each restaurant is recorded as the coordinates value of x and y
    - (100,50)
    - (30, 90)
    - (50, 99)
    - etc…



# An Example

- I will code like this

```
    locations_of_nice_restaurants = [(100,50),
                                     (30,90), (50,90)]
```

- Is it

1. a tuple of tuples,
2. a tuple of lists,
3. [✓ a list of tuples, or]
4. a list of lists?

# Find all the restaurants near me

- I will code like this

```
locations_of_nice_restaurants = [(100,50),
                              (30,90), (50,90)]
```

shortened the name

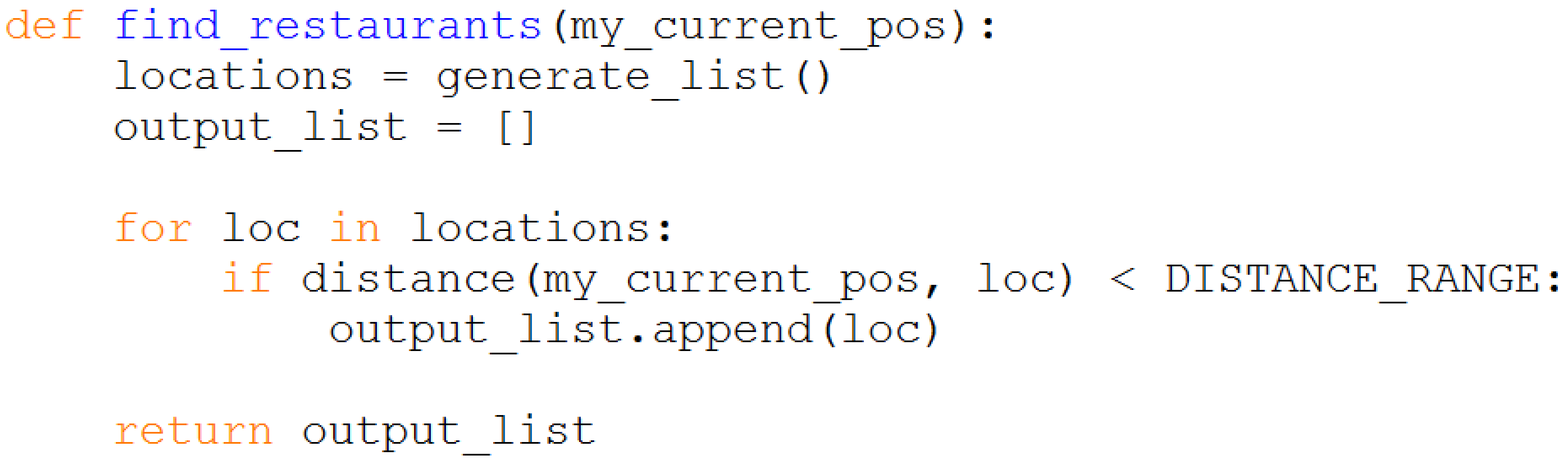
```
def find_restaurants(my_current_pos):
    locations = generate_list()
    output_list = []

    for loc in locations:
        if distance(my_current_pos, loc) < DISTANCE_RANGE:
            output_list.append(loc)

    return output_list
```

```
def find_restaurants(my_current_pos):
    locations = generate_list()
    output_list = []

    for loc in locations:
        if distance(my_current_pos, loc) < DISTANCE_RANGE:
            output_list.append(loc)

    return output_list

def generate_list():
    output_list = []
    for i in range(NO_RESTAURANTS):
        output_list.append( (random.randint(1,SIZE_OF_SG),
                             random.randint(1,SIZE_OF_SG)))
    return output_list

def distance(p1,p2):
    return sqrt( square(p1[0]-p2[0]) + square(p1[1]-p2[1]))

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

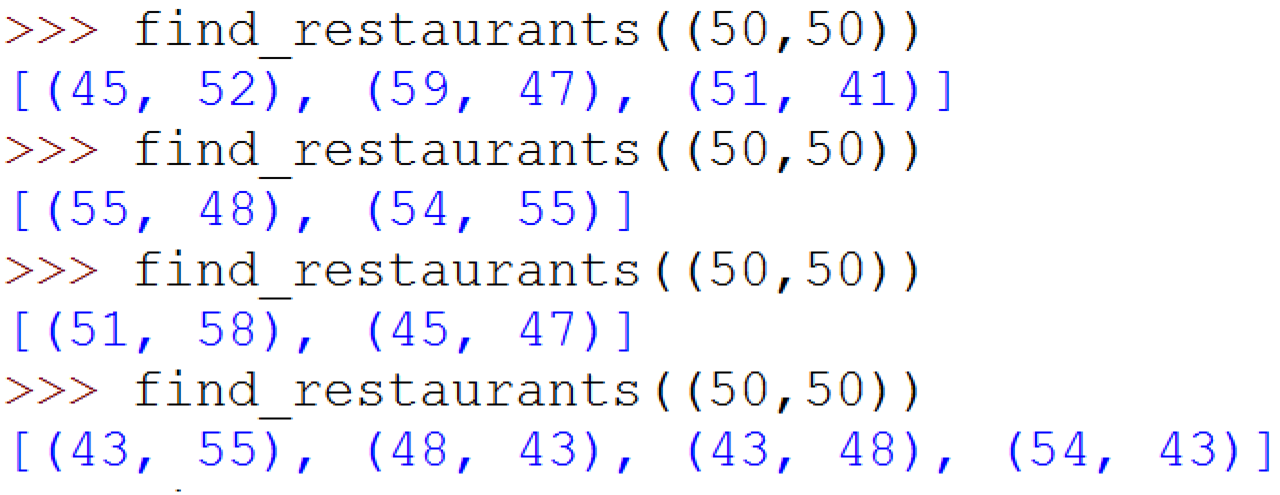
Just a fake function to generate the list for this demo

A list

A tuple



```python
def find_restaurants(my_current_pos):
    locations = generate_list()
    output_list = []

    for loc in locations:
        if distance(my_current_pos, loc) < DISTANCE_RANGE:
            output_list.append(loc)

    return output_list
```



```
>>> find_restaurants((50,50))
[(45, 52), (59, 47), (51, 41)]
>>> find_restaurants((50,50))
[(55, 48), (54, 55)]
>>> find_restaurants((50,50))
[(51, 58), (45, 47)]
>>> find_restaurants((50,50))
[(43, 55), (48, 43), (43, 48), (54, 43)]
```

# Challenge:
# Find the nearest THREE restaurants

Instead of ALL

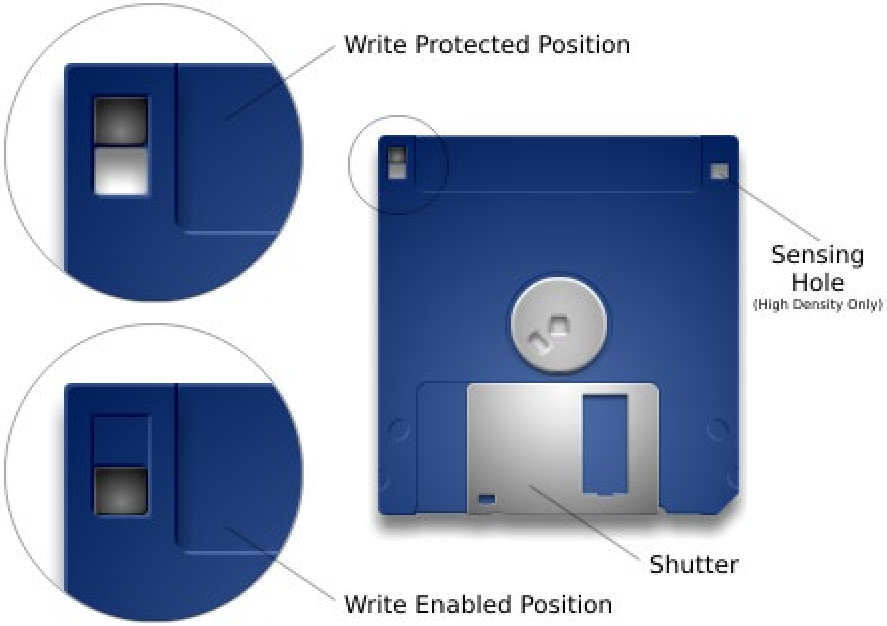
# List vs Tuple, **Cultural** Reason

- List
  - Usually stores a large collection of data with the same type (homogenous)
  - E.g. List of 200 student names in a class
- Tuple
  - Usually stores a small collections of items with various data types/concepts (heterogeneous )
  - E.g. A single student record with name (*string*), student number(*string*) and mark(*integer*)

But, violating this “culture” will NOT cause any syntax error

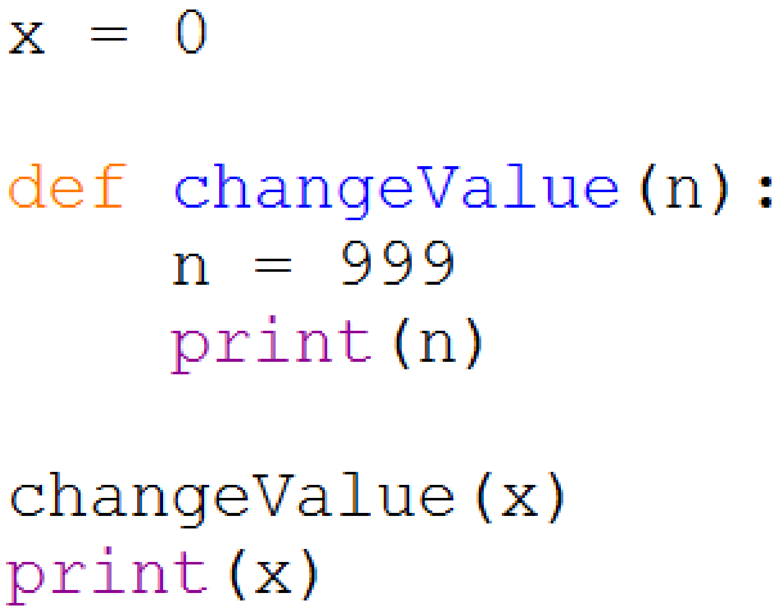
# List vs Tuple, **Technical** Reasons

- Immutable vs mutable
  - Tuple is Write protected (Immutable)



- List can be changed within a function
  - NOT passed by value
  - Mutable

# Recap: Primitive Data Types

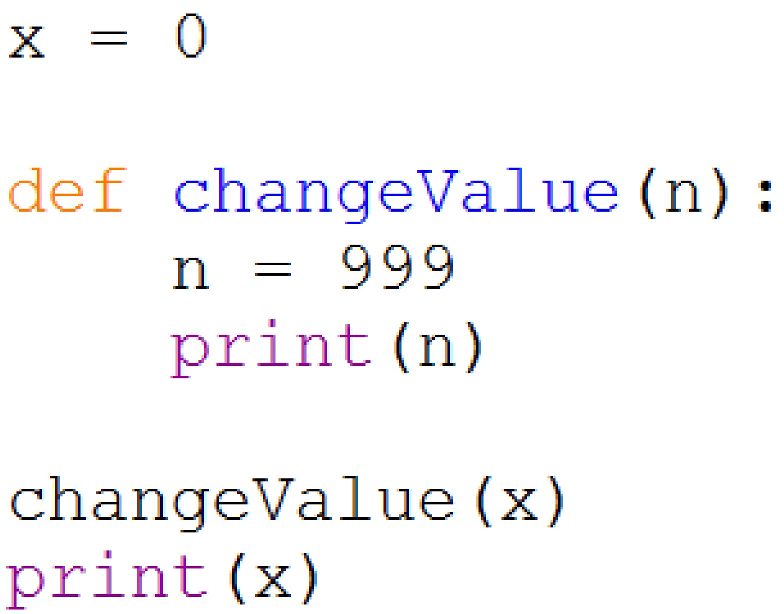


```
x = 0

def changeValue(n):
    n = 999
    print(n)

changeValue(x)
print(x)
```

- The `print` () in “`changeValue`” will print 999
- But how about the last `print(x)?`
  - Will x becomes 999?

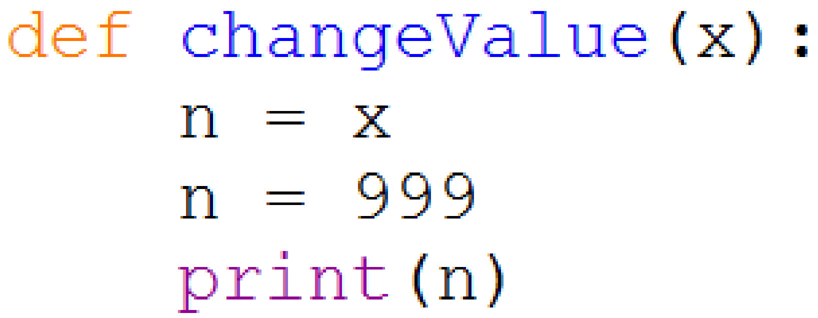
- (So actually this function will NOT change the value of x)

# Recap: Primitive Data Types



```
x = 0

def changeValue(n):
    n = 999
    print(n)

changeValue(x)
print(x)
```

- n is another copy of x
- You can deem it as

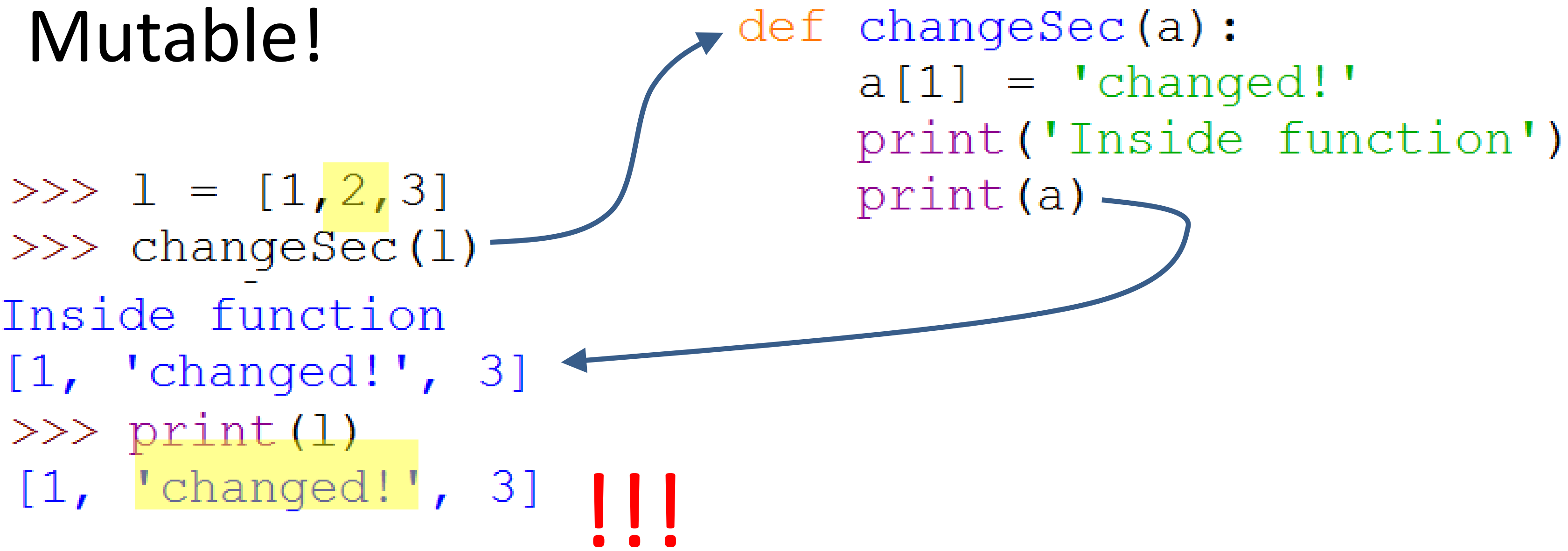


```
def changeValue(x):
    n = x
    n = 999
    print(n)
```

**Pass By Values**

# But for List

- Mutable!



```
def changeSec(a):
    a[1] = 'changed!'
    print('Inside function')
    print(a)
```

```
>>> l = [1,2,3]
>>> changeSec(l)
Inside function
[1, 'changed!', 3]
>>> print(l)
[1, 'changed!', 3]
```

!!!

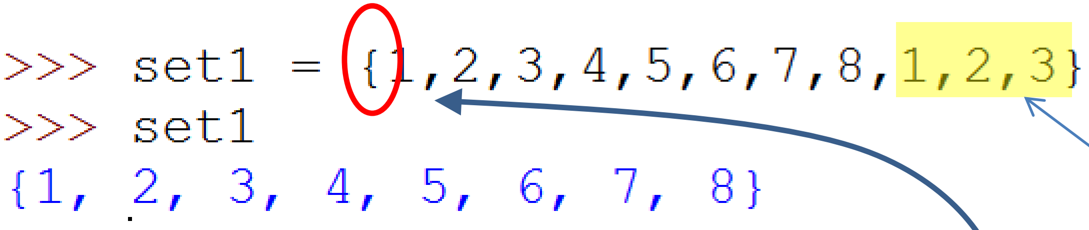
# Sequence in Python

- Indexed collection
  - Strings
  - Lists
  - Tuples

- Non-indexed collection:
  - Sets
  - Dictionary

# Sets

- A set is an **unordered** collection of **immutable** elements with **no duplicate** elements
  - Unordered: You **cannot** get a single element by its index like s[2]
  - No duplicate: every element exists only once in a set



```
>>> set1 = {1,2,3,4,5,6,7,8,1,2,3}
>>> set1
{1, 2, 3, 4, 5, 6, 7, 8}
```

Tuples use '(' and ')'
Lists use '[' and ']'
Sets use '{' and '}'

Python Removes duplicates for you

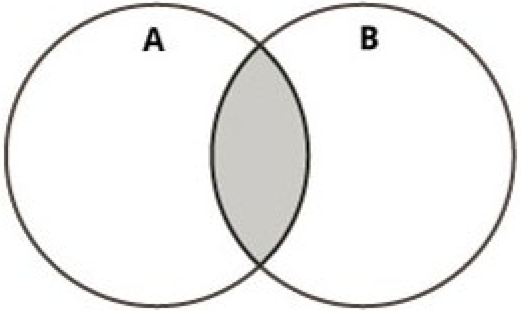
# Sets

- Some operations are not available because sets are NOT indexed

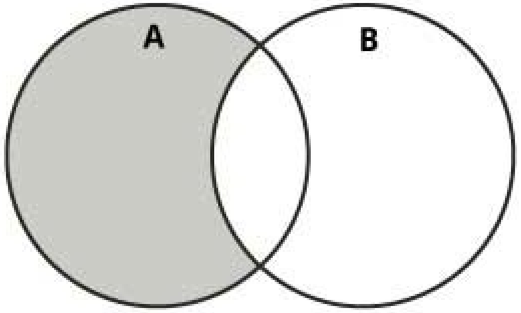
| | |
|---|---|
| ~~a[i]~~ | ~~return i-th element of a~~ |
| ~~a[i:j]~~ | ~~returns elements i up to j-1~~ |
| len(a) | returns numbers of elements in sequence |
| min(a) | returns smallest value in sequence |
| max(a) | returns largest value in sequence |
| x in a | returns True if x is a part of a |
| ~~a + b~~ | ~~concatenates a and b~~ |
| ~~n * a~~ | ~~creates n copies of sequence a~~ |

# Set Operations

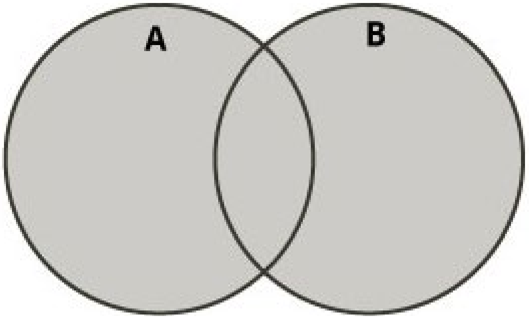
- Intersection



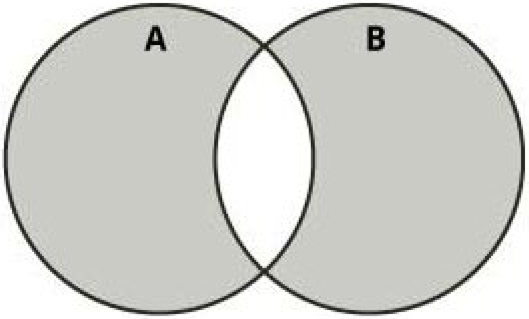
- A – B



- Union

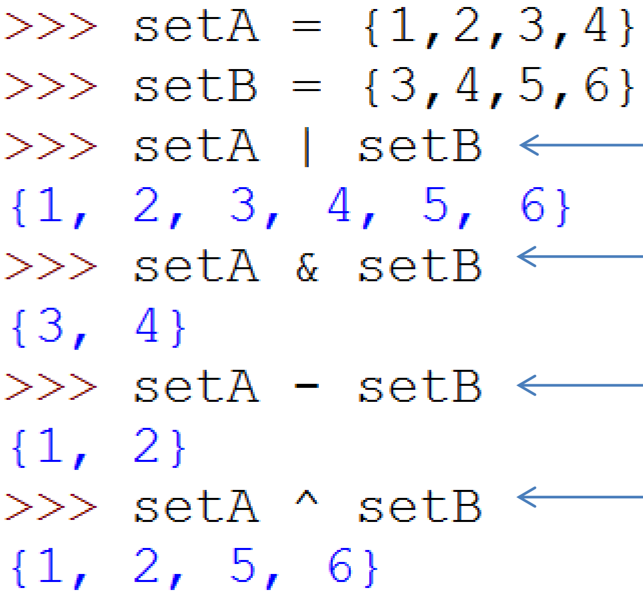


- Symmetric Difference



# Sets

- Usual set operations



```
>>> setA = {1,2,3,4}
>>> setB = {3,4,5,6}
>>> setA | setB
{1, 2, 3, 4, 5, 6}
>>> setA & setB
{3, 4}
>>> setA - setB
{1, 2}
>>> setA ^ setB
{1, 2, 5, 6}
```

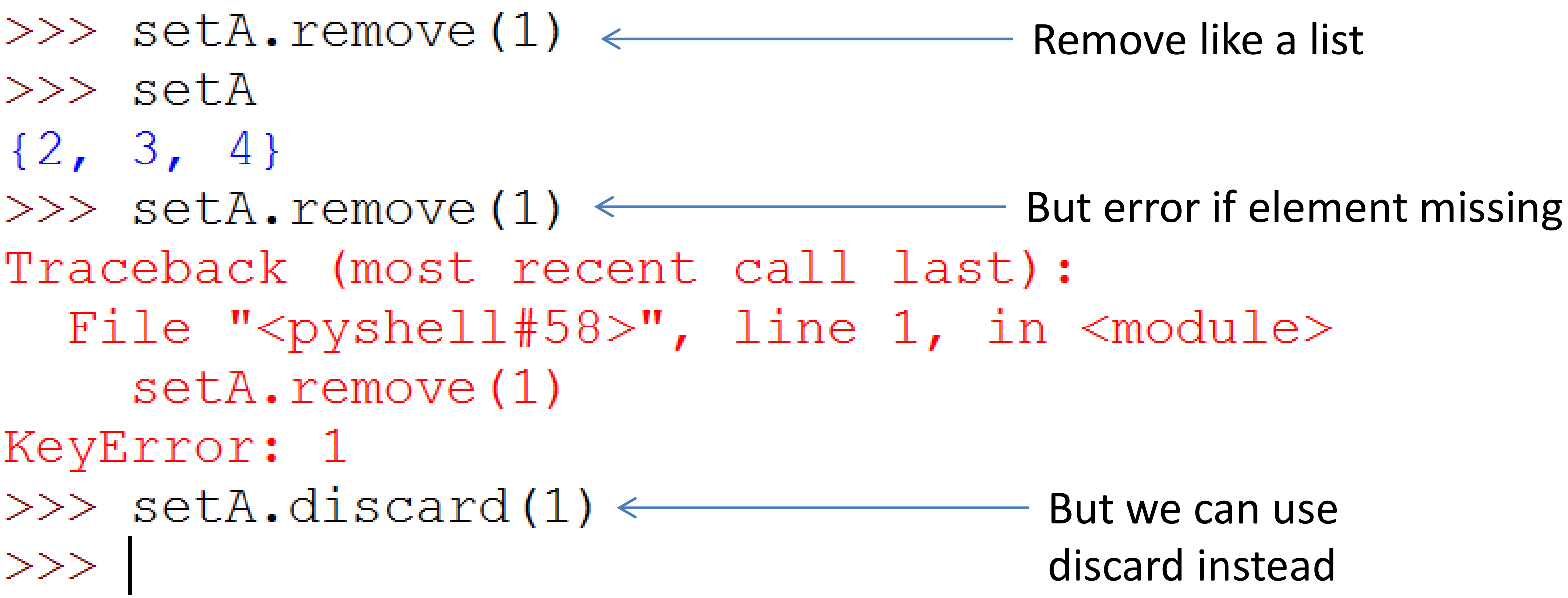
Union

Intersection

A - B

(A | B) – A & B

# Sets



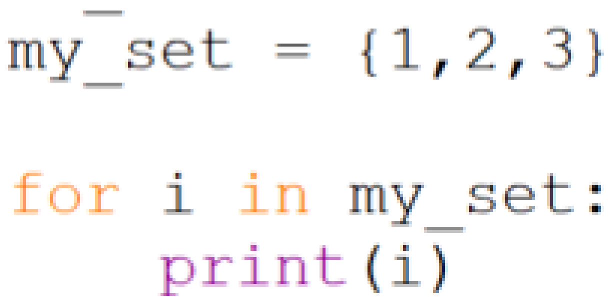
```
>>> setA.remove(1)
>>> setA
{2, 3, 4}
>>> setA.remove(1)
Traceback (most recent call last):
  File "<pyshell#58>", line 1, in <module>
    setA.remove(1)
KeyError: 1
>>> setA.discard(1)
>>> 
```

Remove like a list

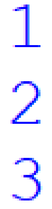
But error if element missing

But we can use discard instead

# Sets are Iterable

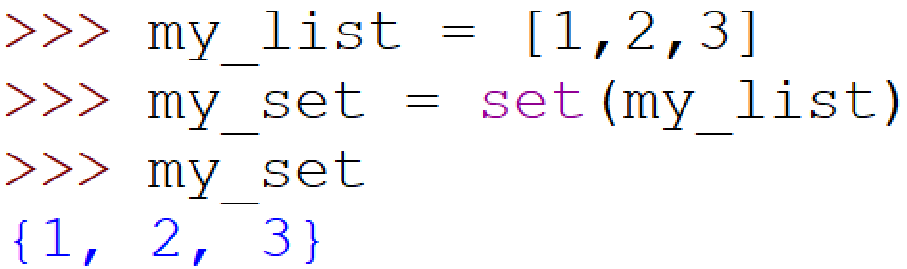


```
my_set = {1,2,3}

for i in my_set:
    print(i)
```

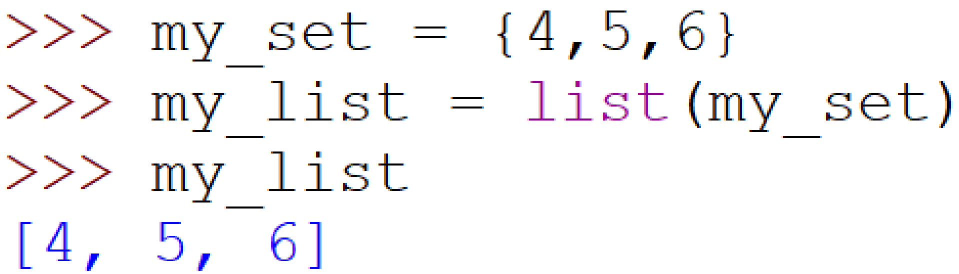


```
1
2
3
```

# Set from List and Vice-Versa



```
>>> my_list = [1,2,3]
>>> my_set = set(my_list)
>>> my_set
{1, 2, 3}
```



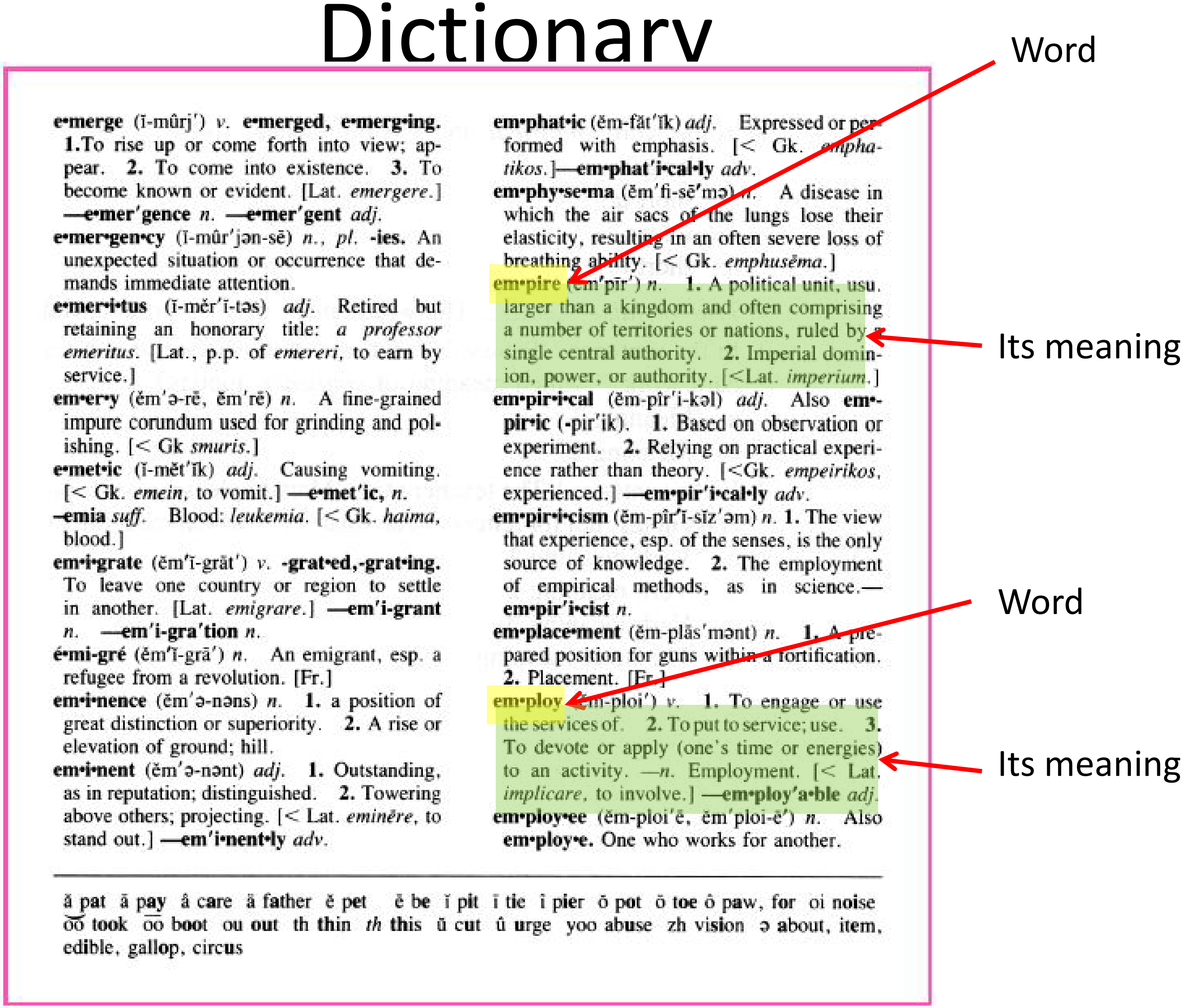
```
>>> my_set = {4,5,6}
>>> my_list = list(my_set)
>>> my_list
[4, 5, 6]
```

# Sequence in Python

- Indexed collection
  - Strings
  - Lists
  - Tuples

- Non-indexed collection:
  - Sets
  - Dictionary

# Dictionarv



**e•merge** (ĭ-mûrj′) *v.* **e•merged, e•merg•ing.** **1.**To rise up or come forth into view; appear. **2.** To come into existence. **3.** To become known or evident. [Lat. *emergere.*] **—e•mer′gence** *n.* **—e•mer′gent** *adj.*

**e•mer•gen•cy** (ĭ-mûr′jən-sē) *n., pl.* **-ies.** An unexpected situation or occurrence that demands immediate attention.

**e•mer•i•tus** (ĭ-mĕr′ĭ-təs) *adj.* Retired but retaining an honorary title: *a professor emeritus.* [Lat., p.p. of *emereri*, to earn by service.]

**em•er•y** (ĕm′ə-rē, ĕm′rē) *n.* A fine-grained impure corundum used for grinding and polishing. [< Gk *smuris.*]

**e•met•ic** (ĭ-mĕt′ĭk) *adj.* Causing vomiting. [< Gk. *emein*, to vomit.] **—e•met′ic,** *n.*

**-emia** *suff.* Blood: *leukemia.* [< Gk. *haima*, blood.]

**em•i•grate** (ĕm′ĭ-grāt′) *v.* **-grat•ed,-grat•ing.** To leave one country or region to settle in another. [Lat. *emigrare.*] **—em′i-grant** *n.* **—em′i-gra′tion** *n.*

**é•mi-gré** (ĕm′ĭ-grā′) *n.* An emigrant, esp. a refugee from a revolution. [Fr.]

**em•i•nence** (ĕm′ə-nəns) *n.* **1.** a position of great distinction or superiority. **2.** A rise or elevation of ground; hill.

**em•i•nent** (ĕm′ə-nənt) *adj.* **1.** Outstanding, as in reputation; distinguished. **2.** Towering above others; projecting. [< Lat. *eminēre*, to stand out.] **—em′i•nent•ly** *adv.*

**em•phat•ic** (ĕm-făt′ĭk) *adj.* Expressed or performed with emphasis. [< Gk. *emphatikos.*]**—em•phat′i•cal•ly** *adv.*

**em•phy•se•ma** (ĕm′fĭ-sē′mə) *n.* A disease in which the air sacs of the lungs lose their elasticity, resulting in an often severe loss of breathing ability. [< Gk. *emphusēma.*]

**em•pire** (ĕm′pīr′) *n.* **1.** A political unit, usu. larger than a kingdom and often comprising a number of territories or nations, ruled by a single central authority. **2.** Imperial dominion, power, or authority. [<Lat. *imperium.*]

**em•pir•i•cal** (ĕm-pîr′ĭ-kəl) *adj.* Also **em•pir•ic** (-pir′ik). **1.** Based on observation or experiment. **2.** Relying on practical experience rather than theory. [<Gk. *empeirikos*, experienced.] **—em•pir′i•cal•ly** *adv.*

**em•pir•i•cism** (ĕm-pîr′ĭ-sĭz′əm) *n.* **1.** The view that experience, esp. of the senses, is the only source of knowledge. **2.** The employment of empirical methods, as in science.—**em•pir′i•cist** *n.*

**em•place•ment** (ĕm-plās′mənt) *n.* **1.** A prepared position for guns within a fortification. **2.** Placement. [Fr.]

**em•ploy** (ĕm-ploi′) *v.* **1.** To engage or use the services of. **2.** To put to service; use. **3.** To devote or apply (one's time or energies) to an activity. *—n.* Employment. [< Lat. *implicare*, to involve.] **—em•ploy′a•ble** *adj.*

**em•ploy•ee** (ĕm-ploi′ē, ĕm′ploi-ē′) *n.* Also **em•ploy•e.** One who works for another.

ă pat ā pay â care ä father ĕ pet ē be ĭ pit ī tie î pier ŏ pot ō toe ô paw, for oi noise o͝o took o͞o boot ou out th thin *th* this ŭ cut û urge yoo abuse zh vision ə about, item, edible, gallop, circus

Word

Its meaning

Word

Its meaning

# Dictionary

- You search for the word in the dictionary
- Then look for its meaning

Word

Meaning

- Each word has a correspondent meaning

# Python Dictionary

- You search for the key in the dictionary
- Then look for its value

- Each key has a correspondent value

key : value pair

```
>>> students = {'A100000X':'John', 'A123456X':'Peter',
'A999999X':'Paul'}
>>> students['A123456X']
'Peter'
```

Tuples use '(' and ')'
Lists use '[' and ']'
Sets and Dict use '{' and '}'

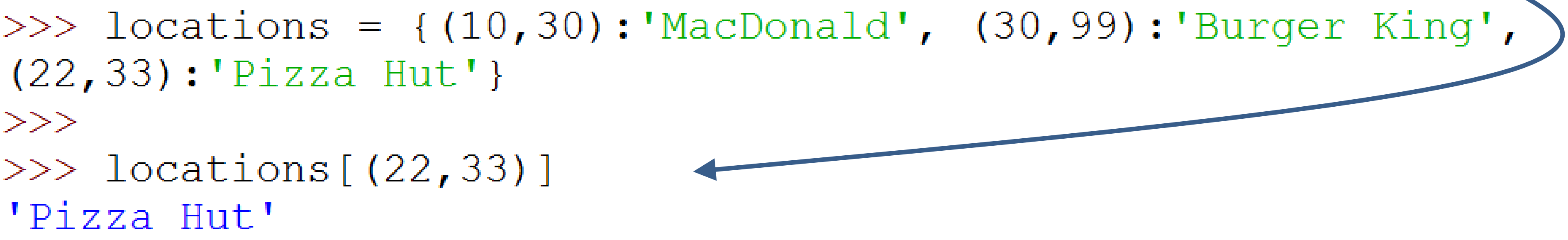
# An Example

- To store the data on a map
  - These are the locations of **100** nice restaurants in Singapore
  - The location of each restaurant is recorded as the coordinates value of x and y and name
  - (10,20):Pizza Hut

Map
Satellite
JOHOR BAHRU
LEGOLAND Malaysia Resort
Punggol
Barat Island
Serangoon Island
Pulau Ubin
Paya Lebar Air Base
Changi Airport Singapore
Singapore Expo
East Coast Park
Jurong Bird Park
Singapore Botanic Gardens
Jurong Island
Singapore
WESTERN WATER CATCHMENT
CENTRAL WATER CATCHMENT
JURONG WEST
JURONG EAST
BISHAN
SENGKANG
TAMPINES

# Python Dictionary

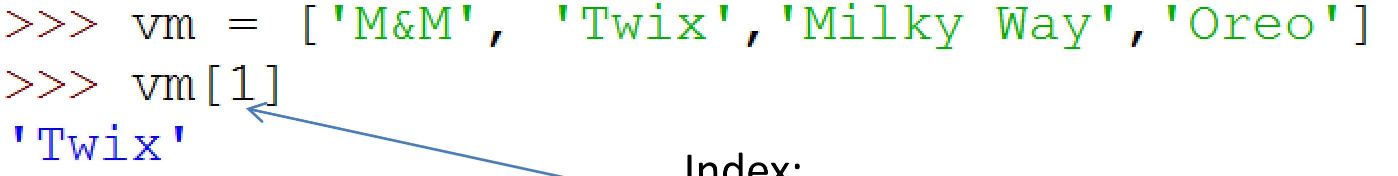
- Key: location
- Value: restaurant name
- After you searched for the nearest restaurants, you want to know their names



```
>>> locations = {(10,30):'MacDonald', (30,99):'Burger King',
(22,33):'Pizza Hut'}
>>>
>>> locations[(22,33)]
'Pizza Hut'
```

# Recap: List

- Or tuples



```
>>> vm = ['M&M', 'Twix','Milky Way','Oreo']
>>> vm[1]
'Twix'
```

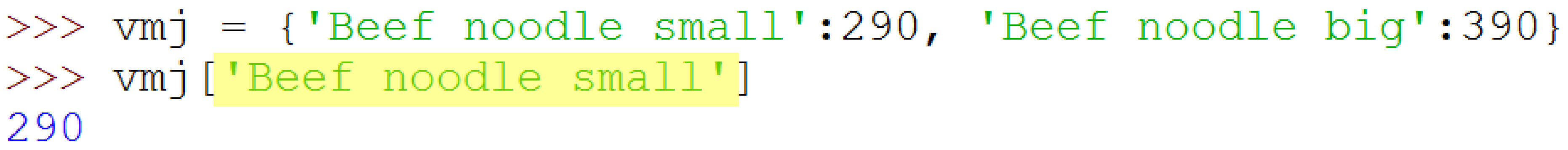
Index:
From 0 to len(a)-1

Input a number

Output an item

# But when you go to Japan

- You are not inputting a number (index)!



```
>>> vmj = {'Beef noodle small':290, 'Beef noodle big':390}
>>> vmj['Beef noodle small']
290
```

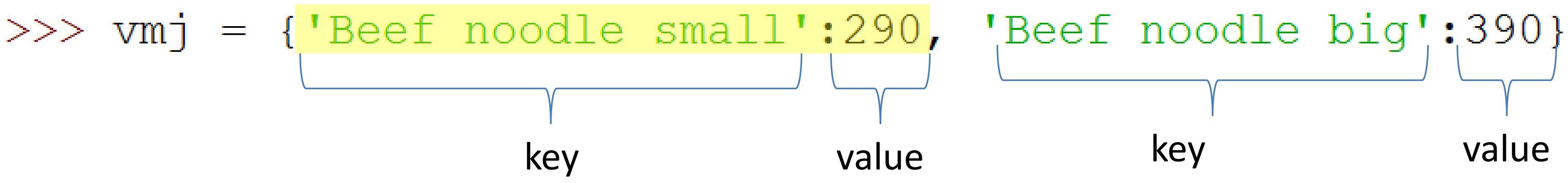
Input ~~a number~~ a name

↓

Output an item

# To set up a dictionary

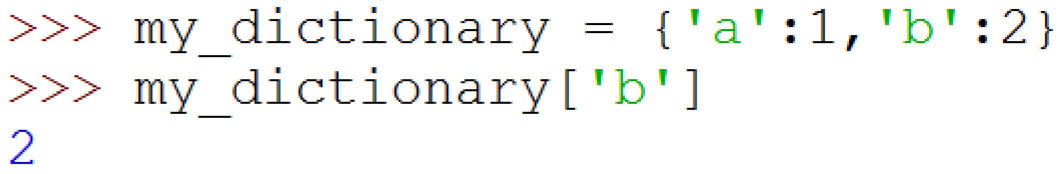
- Each pair has a key and a value



```
>>> vmj = {'Beef noodle small':290, 'Beef noodle big':390}
```

# What is Dictionary?

- Key is on the left, Value on the right



```
>>> my_dictionary = {'a':1,'b':2}
>>> my_dictionary['b']
2
```

- Summary: A data structure used for “When I give you X, give me Y”
- Can store any type
- Called HashTable in some other languages

# How is a Dictionary Useful?

- Keep Track of Things by Key!
  - Eg, keeping track of stocks of fruits

```
my_stock = {“apples”:450”,”oranges”:412}
my_stock[“apples”]
>>> 450

my_stock[“apples”]  + my_stock[“oranges”]
>>> 862
```

# How is a Dictionary Useful?

- Keep Track of Things by Key!
  - When you want to get an associated operation (eg, alphabets to numeric integers)

```
my_alphabet_index = {‘a’:1,’b’:2… ‘z’:26}
my_alphabet_index[‘z’]
>>> 26
```

# Dictionary Methods

- Access (VERY FAST! - Almost instant!)
- Assignment
- Removal
- Other Dictionary Methods

# Dictionary Access

```
>>> my_fruit_inventory = {“apples”:450,”oranges”:200}
>>> my_fruit_inventory[“apples”]
450
>>> my_fruit_inventory.get(“apples”)
450
>>> my_fruit_inventory[“pears”]
KeyError!
>>> my_fruit_inventory.get(“pears”)
None
```

****Cannot access keys which don’t exist!****

- Accessing with [] will crash if does not exist
- Accessing with .get() will NOT crash if key does not exist

# Dictionary Assignment

```
>>> my_fruit_inventory[“pears”] = 100
>>> print(my_fruit_inventory)
{“apples”:450, ”oranges”:200, “pears”:100}
```

- Caution: This OVERWRITES existing values!

```
>>> my_fruit_inventory[“oranges”] = 100
>>> print(my_fruit_inventory)
{“apples”:450, ”oranges”:100, “pears”:100}
```

# Dictionary Removal

```
>>> my_fruit_inventory =
{“apples”:450,”oranges”:200}

>>> my_fruit_inventory.pop(“apples”)
>>> print(my_fruit_inventory)
{‘oranges’:200}
```

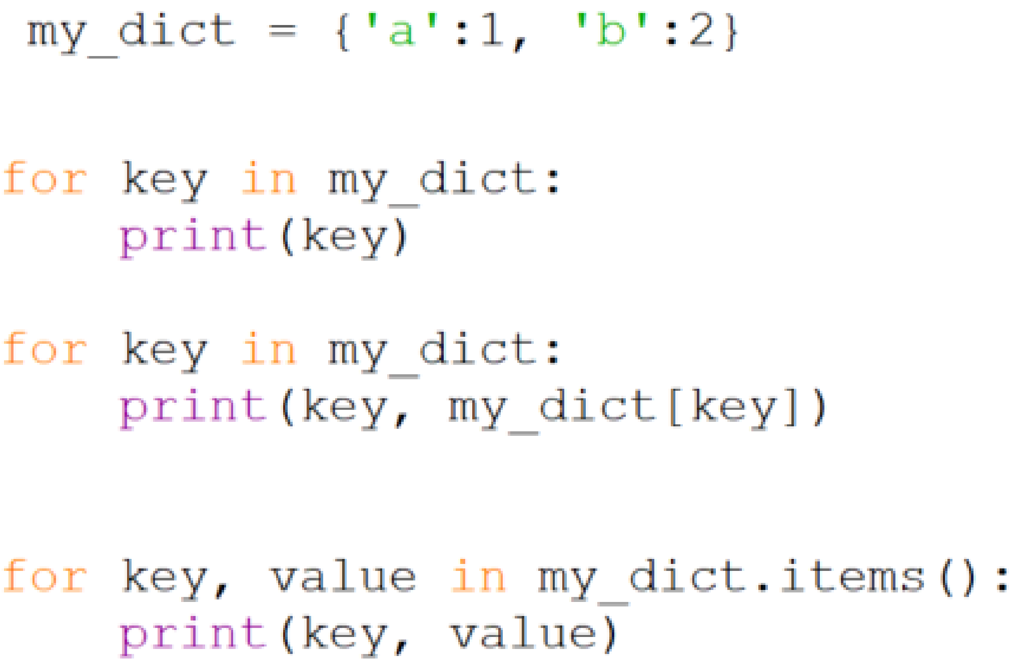
- OR

```
>>> del my_fruit_inventory[“apples”]
```

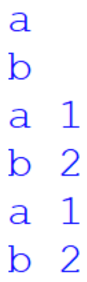
# Other Dictionary Methods

| | |
|---|---|
| `.clear()` | clear all |
| `.copy()` | make a copy |
| `.keys()` | return all keys |
| `.values()` | return all values |
| `.items()` | return all keys + values |

# Dictionary is Iterable



```
 my_dict = {'a':1, 'b':2}

for key in my_dict:
    print(key)

for key in my_dict:
    print(key, my_dict[key])


for key, value in my_dict.items():
    print(key, value)
```



```
a
b
a 1
b 2
a 1
b 2
```

# Sequence in Python

- Indexed
  - Strings
  - Lists
  - Tuples

- Non-indexed collection:
  - Sets
  - Dictionary