Composite Types in Python

Lesson Objectives

At the end of this lesson, you should be able to:

- Discuss the concept of composite types
- Explain the importance of composite types
- Use composite types in Python to solve problems

Topic Outline

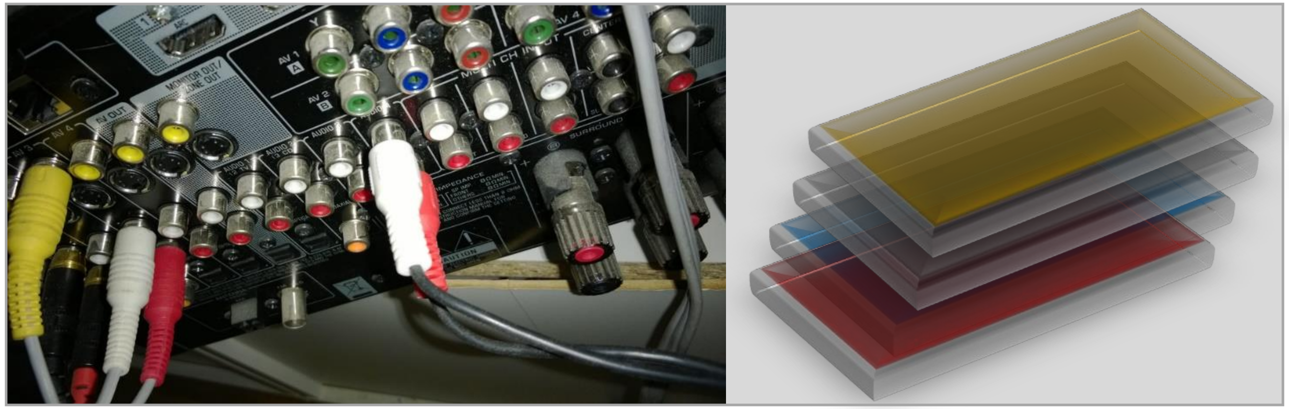
What are Composite Types/ Data Structure?

Why are Composite Types/ Data Structure Important?

Three Common Data Structures in Python (and Their Operations):

- List
- Tuples
- Dictionaries

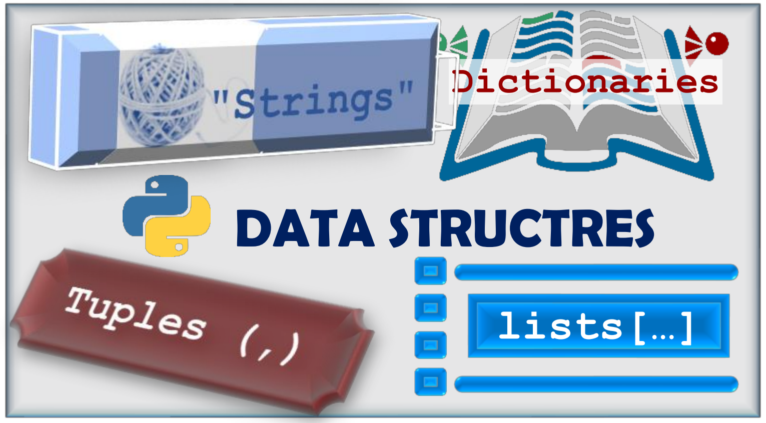
What is a Composite Type?



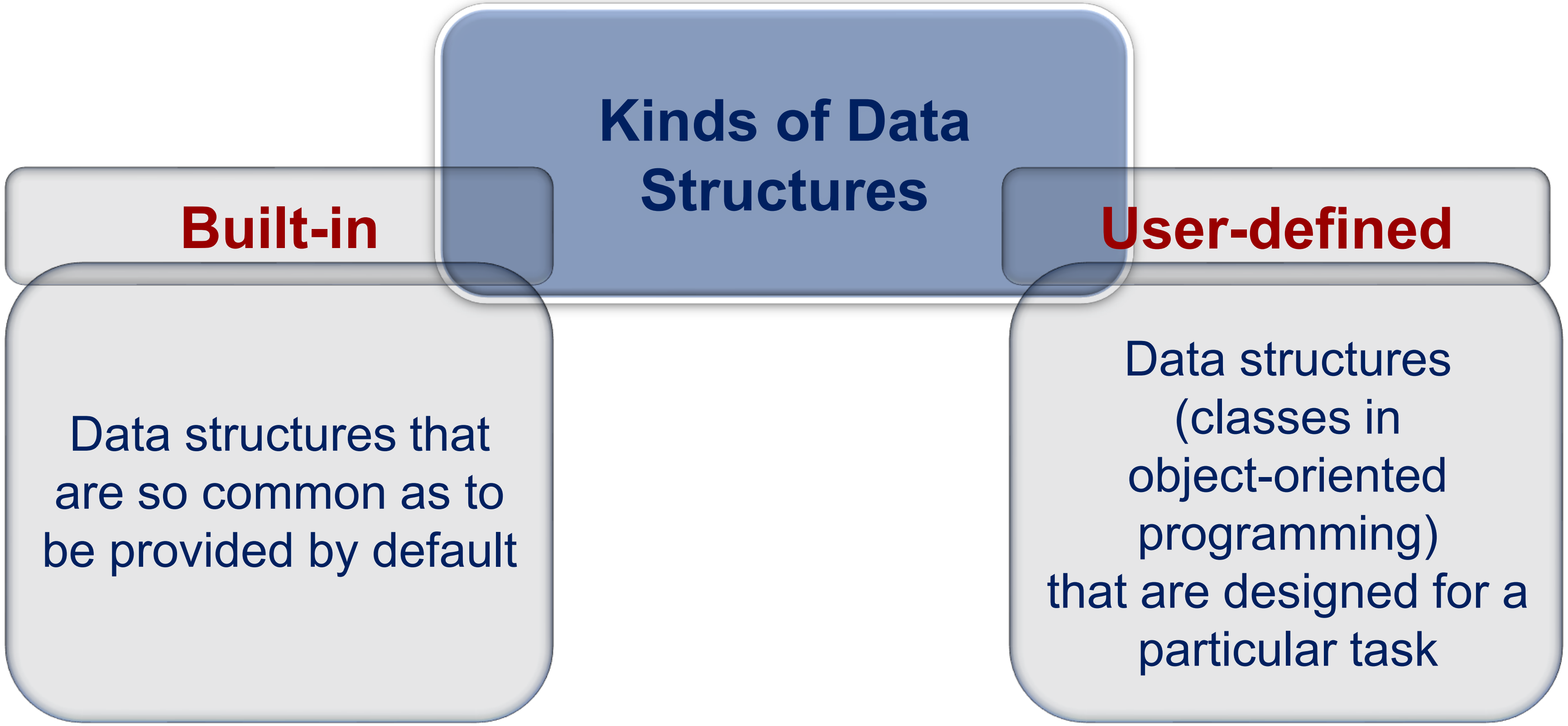
- A **data type**, which is constructed (composed) **using primitive** and **other composite types**.
- A **new data type** made from existing ones.

Data Structures

- **Particular ways of storing data** to make some operations easier or more efficient
  - They are tuned for certain tasks, and they are often associated with algorithms
- Different data structures have different characteristics
  - One suited to solving a certain problem may not be suited for another problem



Data Structures (Cont’d)



Kinds of Data Structures

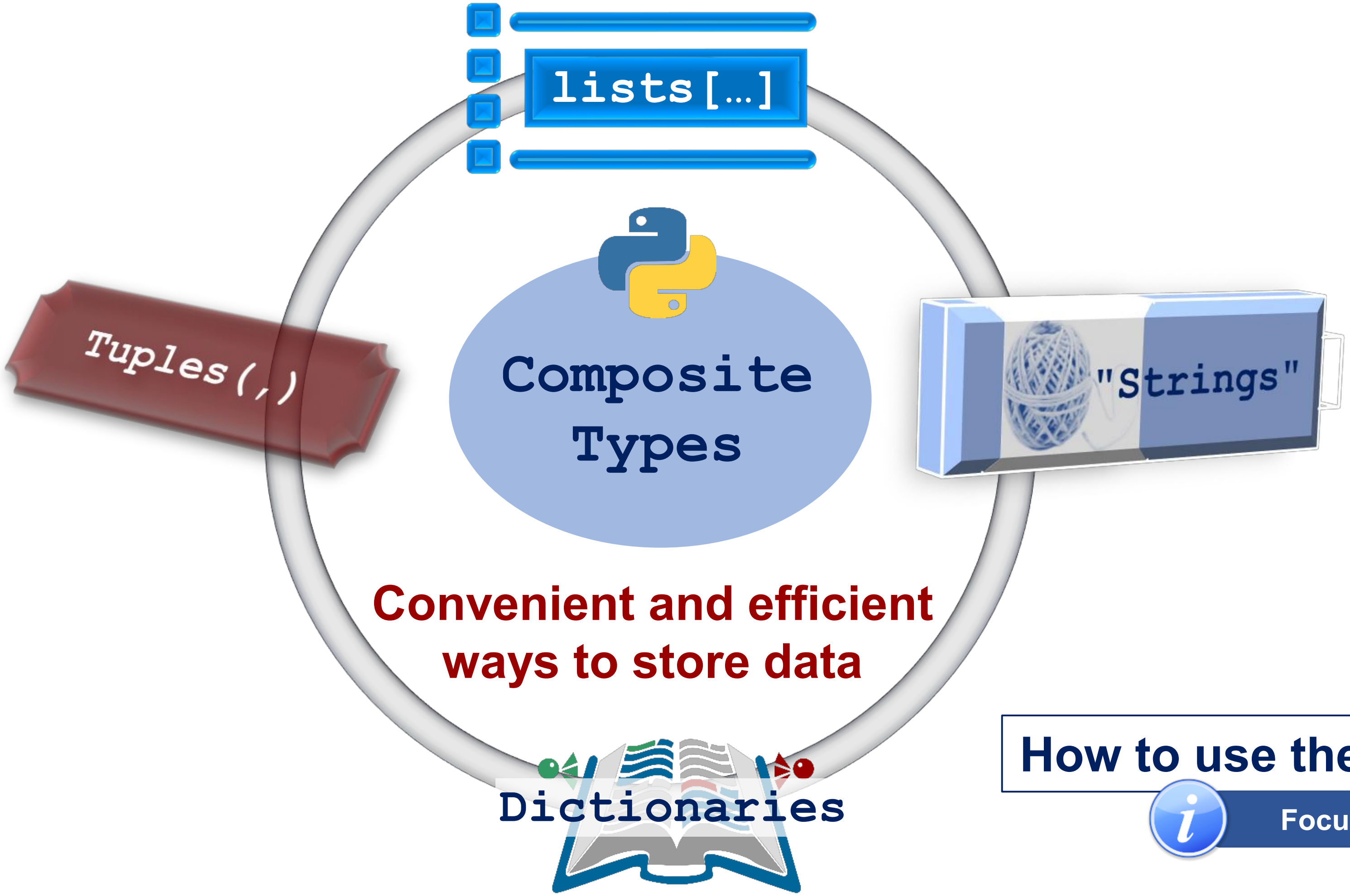
Built-in

Data structures that are so common as to be provided by default

User-defined

Data structures (classes in object-oriented programming) that are designed for a particular task

Composite Types in Python



Convenient and efficient ways to store data

How to use them?

Focus of this lesson

lists [...]

Python Lists

Python List is an **ordered sequence of items**.

Recall

We have already covered a type of sequence: **Strings**

- A string is a sequence of characters.

Creating a List

- As with all data structures, lists have a **constructor**.
- **Constructors** have the same name as the data structures.

`l = list()` → Creates an empty list

`l = list(*arg*)` → Takes an iterable data structure as an argument and add each item of **`arg`** to the constructed list **`l`**

- **Shortcut**: use of **square brackets `[]`** to indicate explicit items. → `l = [...]`

Creating a List: Example

```
aList = list('abc')
  aList ⇒ ['a', 'b', 'c']

newList = [1, 3.14159, 'a', True]
```

Lists: Similarities with Strings

- **concatenate**: `+` (only for lists – not string + list)
- **repeat**: `*`
- **indexing**: the `[ ]` operator), e.g., `lst[3]` → 4th item in the list
- **slicing**: `[:]`
- **membership**: the `in` operator
- **length**: the `len()` function

Lists: Differences with Strings

- Lists can contain **a mixture of python objects (types)**; strings can **only hold characters**.

  E.g. `l = [1, 'bill', 1.2345, True]`

- Lists are **mutable**; their values can be changed, while strings are **immutable**.

- Lists are designated with `[ ]`, with elements separated by commas; strings use "".

List Structure

```
myList = [1, 'a', 3.14159, True]
```

myList	1	'a'	3.14159	True
Index Forward	0	1	2	3
Index Backward	–4	–3	–2	–1

`myList[1]` → 'a'

`myList[:3]` → [1, 'a', 3.14159]

[ ] ? Indexing on Lists

[ ] means a list and it is also used to retrieve index.

`['a', 'b', 'c'][1]` → ‘b’

`[0, 1, 2][0]` → 0

`[0][0]` → 0

Content is important!

Index is always at the end of the expression and is preceded by something (variable, **sequence**).

Lists of Lists

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

What is the second element of the list?

```
myLst[1][0]     #apply from left to right

myLst[1] → [1, 2, 3]

[1, 2, 3][0] → 1

[1, [2, [3, 4]], 5][1][1][0] → ?
```

[2, [3, 4]]

1 2 3

Operators

`+`

e.g. `[1, 2, 3] + [4]` → **[1, 2, 3, 4]**

`*`

e.g. `[1, 2, 3] * 2` → **[1, 2, 3, 1, 2, 3]**

`in`

e.g. `1 in [1, 2, 3]` → **True**

List Functions

`len(lst)` Number of elements in list (top level)

e.g. `len([1, [1, 2], 3])` → 3

`min(lst)` Minimum element in the list

`max(lst)` Maximum element in the list

`sum(lst)` Sum of the elements, numeric only

Iterate on the List

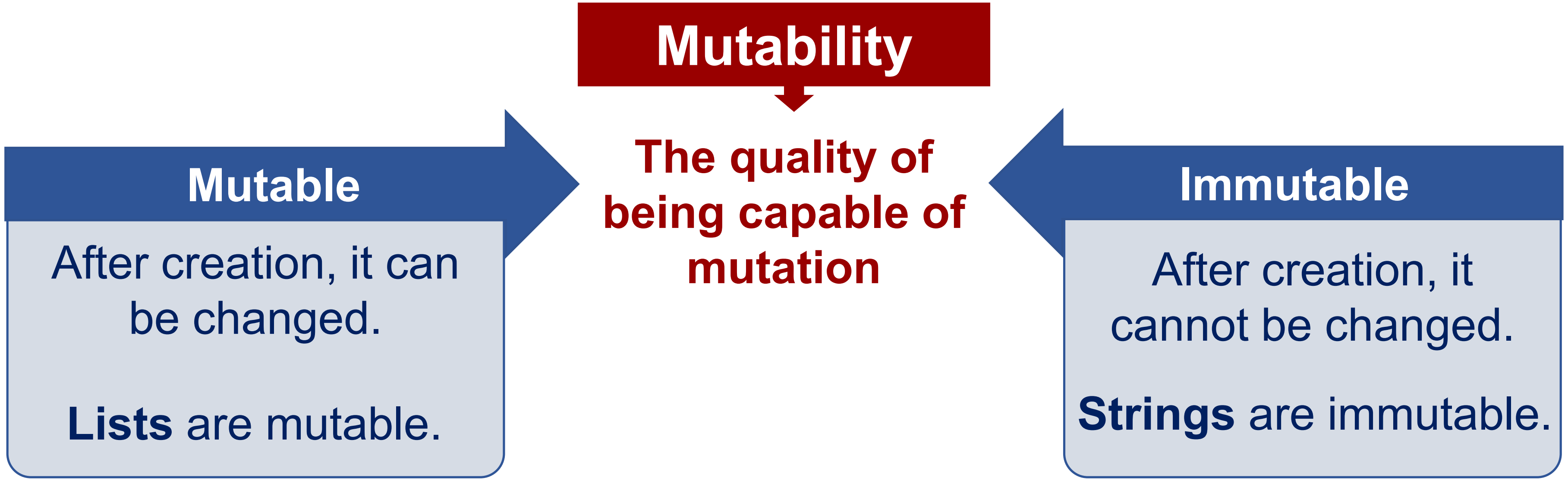
```
for element in [1, [1, 2], 'a', True]:
    print(element)
```

What do you think is the print output?

Answer:

```
1
[1, 2]
‘a’
True
```

Mutable vs. Immutable



Mutability

The quality of being capable of mutation

Mutable

After creation, it can be changed.

Lists are mutable.

Immutable

After creation, it cannot be changed.

Strings are immutable.

Immutable (Strings): Examples

```
myStr = 'abc'
myStr[0] = 'z' #not possible
newStr= myStr.replace('a', 'z') #make a new string
```

Lists as Mutable

The object's contents can be changed.

```
myLst = [1, 2, 3]
myLst[0] = 127
print(myLst)
```

What do you think is the output?

Answer: → [127, 2, 3]

List Methods

A list is mutable and can be changed:

```
myList[0] = 'a'       #index assignment
myList.append(e)      // e: element to append
myList.extend(L)      // L: a list
myList.pop(i)         // i: index (default: -1)
myList.insert(i,e)
myList.remove(e)
myList.sort()
myList.reverse()
```

List Methods: Example

```
myList = [1,3]                  [1, 3]
myList[0] = 'a'                 ['a', 3]
myList.append(2)                ['a', 3, 2]

lst = [6,5]
myList.extend(lst)              ['a', 3, 2, 6, 5]

myList.extend(5)                ERROR!

element = myList.pop()          ['a', 3, 2, 6]
print(element)                  5

myList.append([8,9])            ['a', 3, 2, 6, [8,9]]
```

List Methods: Example (Cont’d)

```
                             ['a', 3, 2, 6]
myList.insert(0, 'b')        ['b', 'a', 3, 2, 6]
myList.insert(-1, 'b')       ['b', 'a', 3, 2, 'b', 6]
myList.insert(10, 'c')       ['b', 'a', 3, 2, 'b', 6, 'c']
myList.remove('b')           ['a', 3, 2, 'b', 6, 'c']

myList.sort()                TypeError!!

myList.remove('b')           ['a', 3, 2, 6, 'c']
myList.remove('a')           [3, 2, 6, 'c']
myList.remove('c')           [3, 2, 6]

myList.remove('d')           ValueError!!

myList.sort()                [2, 3, 6]

myList.reverse()             [6, 3, 2]
```

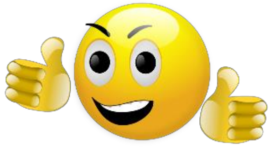
Return Values

- When compared to string methods, most of these list methods do not return a value.

- This is because lists are mutable so the methods modify the list directly; there is no need to return a new list.

NO
Return Value

Remember the python standard is your friend!



Warning about Results

```
myLst = [4, 7, 1, 2]
myLst = myLst.sort()
myLst ⇒ None     #what happened?
```

What is the return value of `myLst.sort()`?

Be careful of what you are assigning!

WARNING

String Method: split()

- The string method **split()** generates a sequence of characters by splitting the string at certain split-characters.
  - Default split-character: **white space**.
- The string method, **split()**, returns a list.

```
splitLst = 'this is a test'.split()
print(splitLst)
```

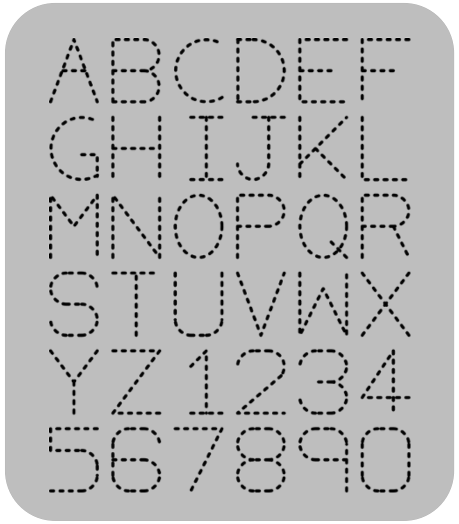
→ ['this', 'is', 'a', 'test']

Sorting

- Only lists have a **built-in sorting method**.

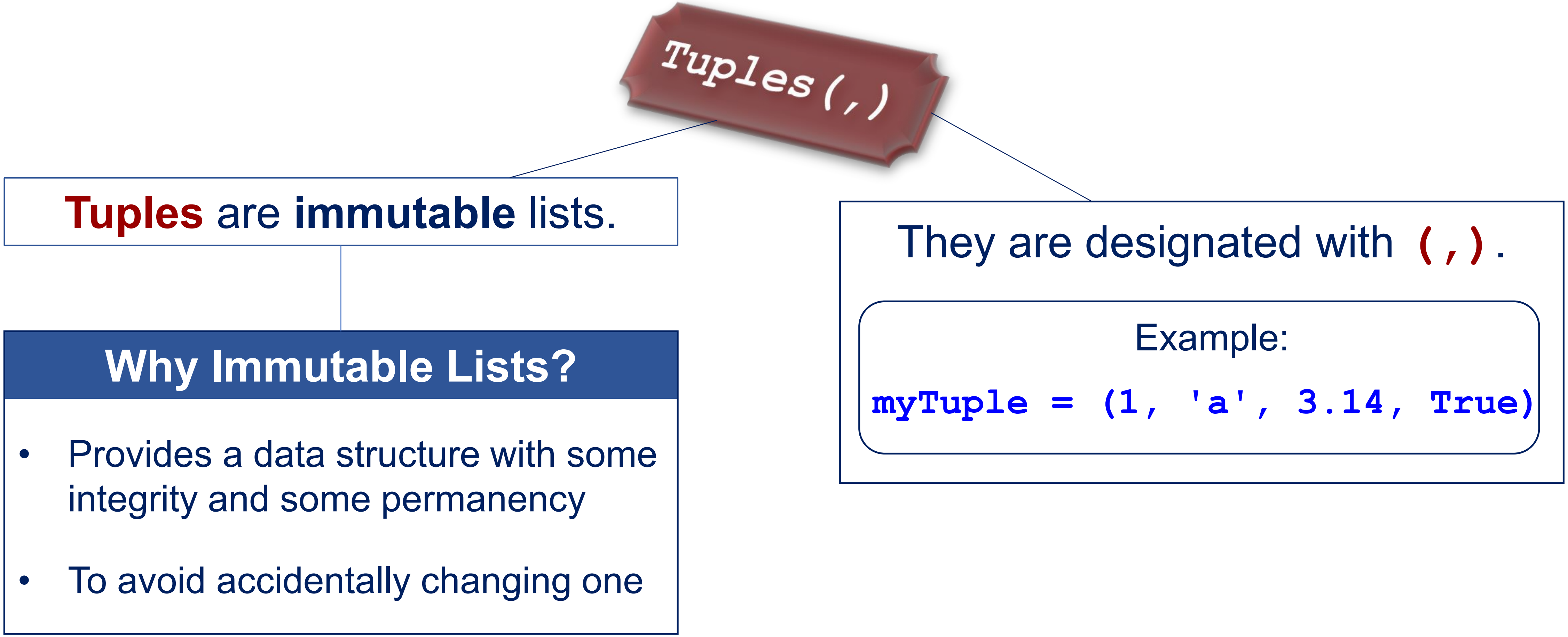
- Thus, data could be converted to a list if it needs sorting.

```
myLst = list('xyzabc') #iterable to constructor
myLst → ['x', 'y', 'z', 'a', 'b', 'c']
myLst.sort() → ['a', 'b', 'c', 'x', 'y', 'z']
# convert back to a string
sortStr = ''.join(myLst) → 'abcxyz'
```



Tuples(,)

Tuples



Tuples are **immutable** lists.

Why Immutable Lists?

- Provides a data structure with some integrity and some permanency
- To avoid accidentally changing one

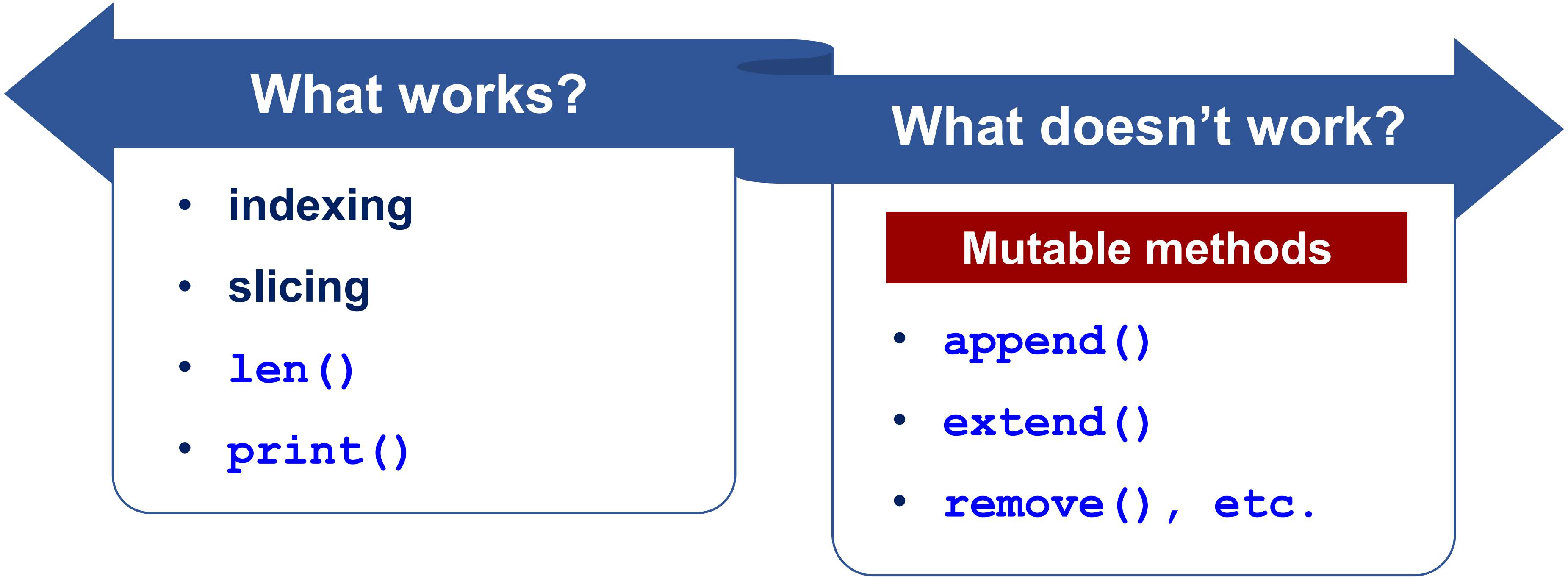
They are designated with **(,)**.

Example:

```
myTuple = (1, 'a', 3.14, True)
```

Lists vs. Tuples

Everything that works for a list works for a tuple **except** methods that modify the tuple.



What works?

- indexing
- slicing
- `len()`
- `print()`

What doesn't work?

Mutable methods

- `append()`
- `extend()`
- `remove(), etc.`

Commas Create Tuples

For tuples:

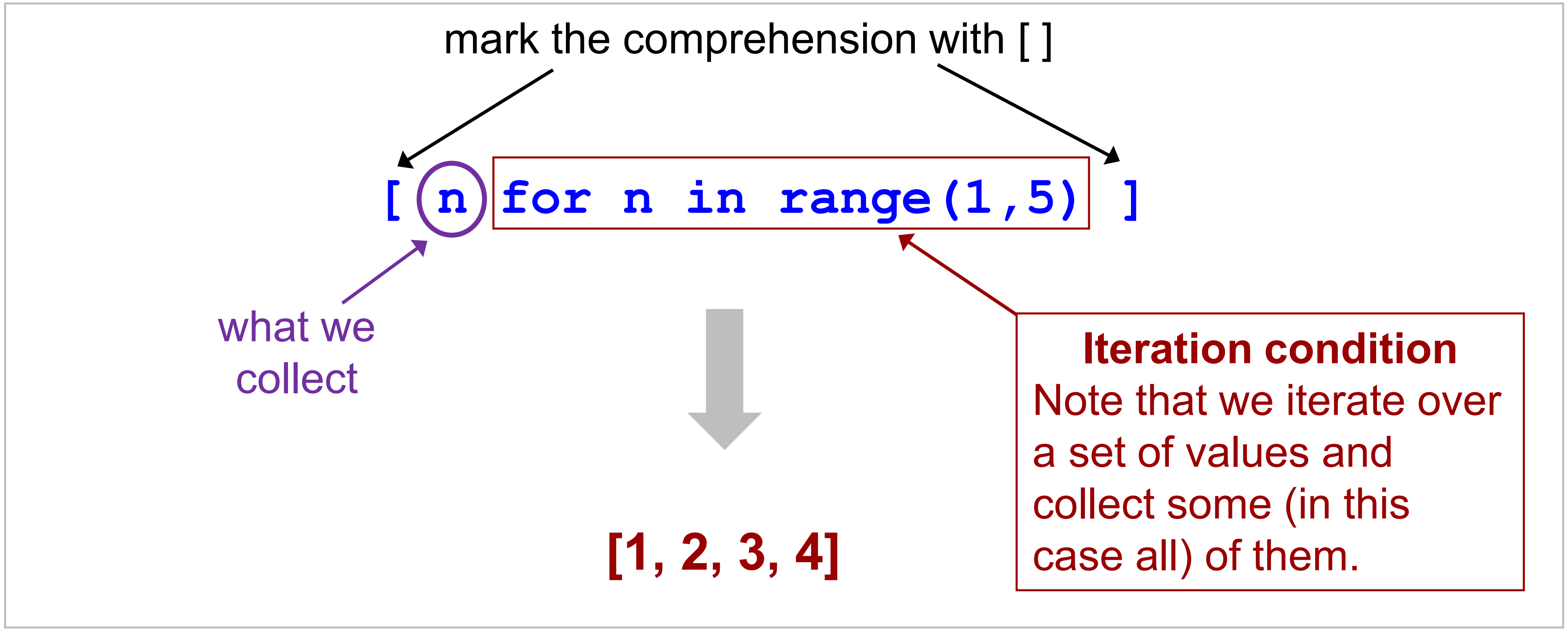
- **comma** can be thought of as the **operator** that makes a tuple
- while the **round bracket ( )** simply acts as a **grouping**

```
myTuple = 1,2        # creates (1,2)
myTuple = (1,)       # creates (1)
myTuple = (1)        # creates 1 not (1)
myTuple = 1,         # creates (1)
```

List Comprehension

Constructing List

List comprehension: syntactic structure for concise construction of lists



mark the comprehension with [ ]

```
[ n for n in range(1,5) ]
```

what we collect

[1, 2, 3, 4]

Iteration condition
Note that we iterate over a set of values and collect some (in this case all) of them.

Other Examples

```
[n**2 for n in range(1,6)]
```

→ [1, 4, 9, 16, 25]

```
[x + y for x in range(1,5) for y in range (1,4)]
```

→ ?

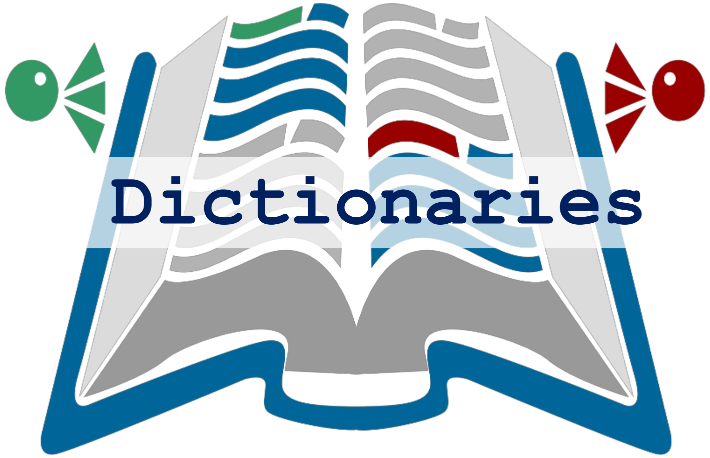
It is as if we had done the following:

```
myList = [ ]
for x in range (1,5):
  for y in range (1,4):
    myList.append(x+y)
```

```
[c for c in "Hi There Mom" if c.isupper()]
```

→ [‘H’, ‘T’, ‘M’]

Dictionaries



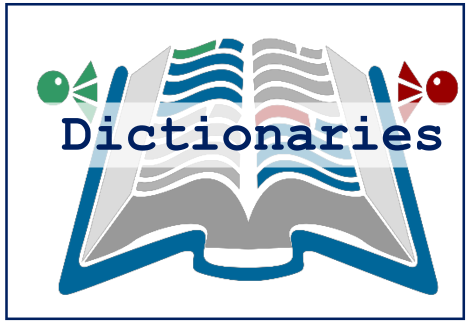
What is Dictionary?

- In data structure terms, a **dictionary** is better termed as an **associative array**, or **associative list**, or a **map**.

- You can think of it as a **list of pairs**.

    - The **key**, which is the **first element** of the pair, is used to retrieve the **second element**, which is the **value**.

- Thus, we map a key to a value.



Key:Value

- The **key** acts as a “lookup” to find the associated value.
- Just like a dictionary, you look up a word by its spelling to find the associated definition.
- A dictionary can be searched to locate the value associated with a key.

Python Dictionary

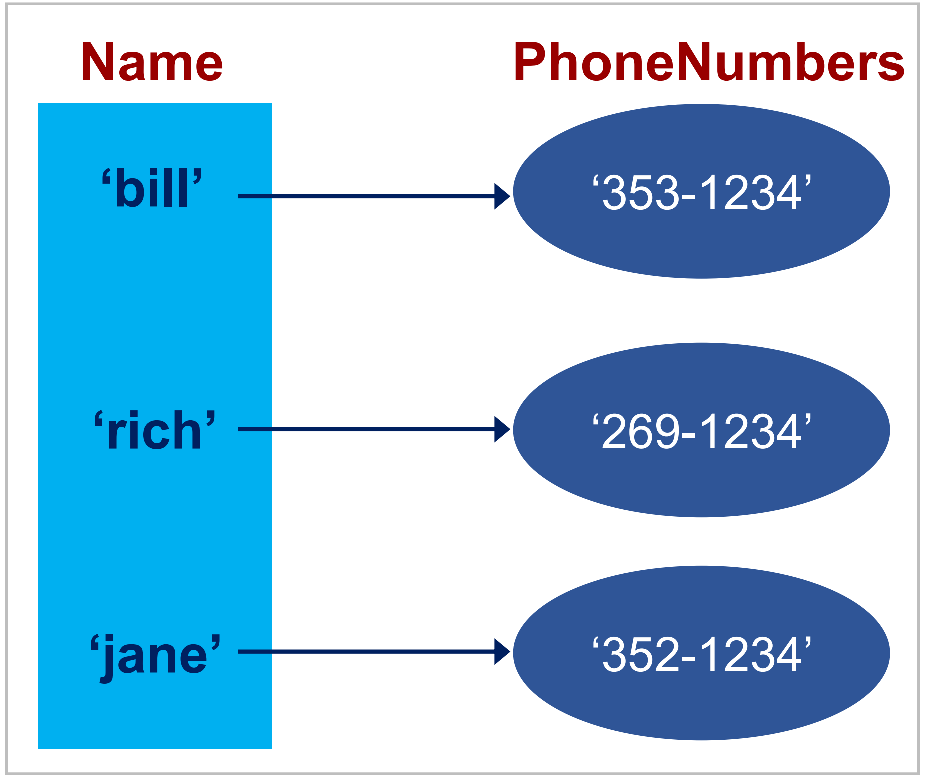
{ } marker: used to create a dictionary

: marker: used to create **key:value** pairs

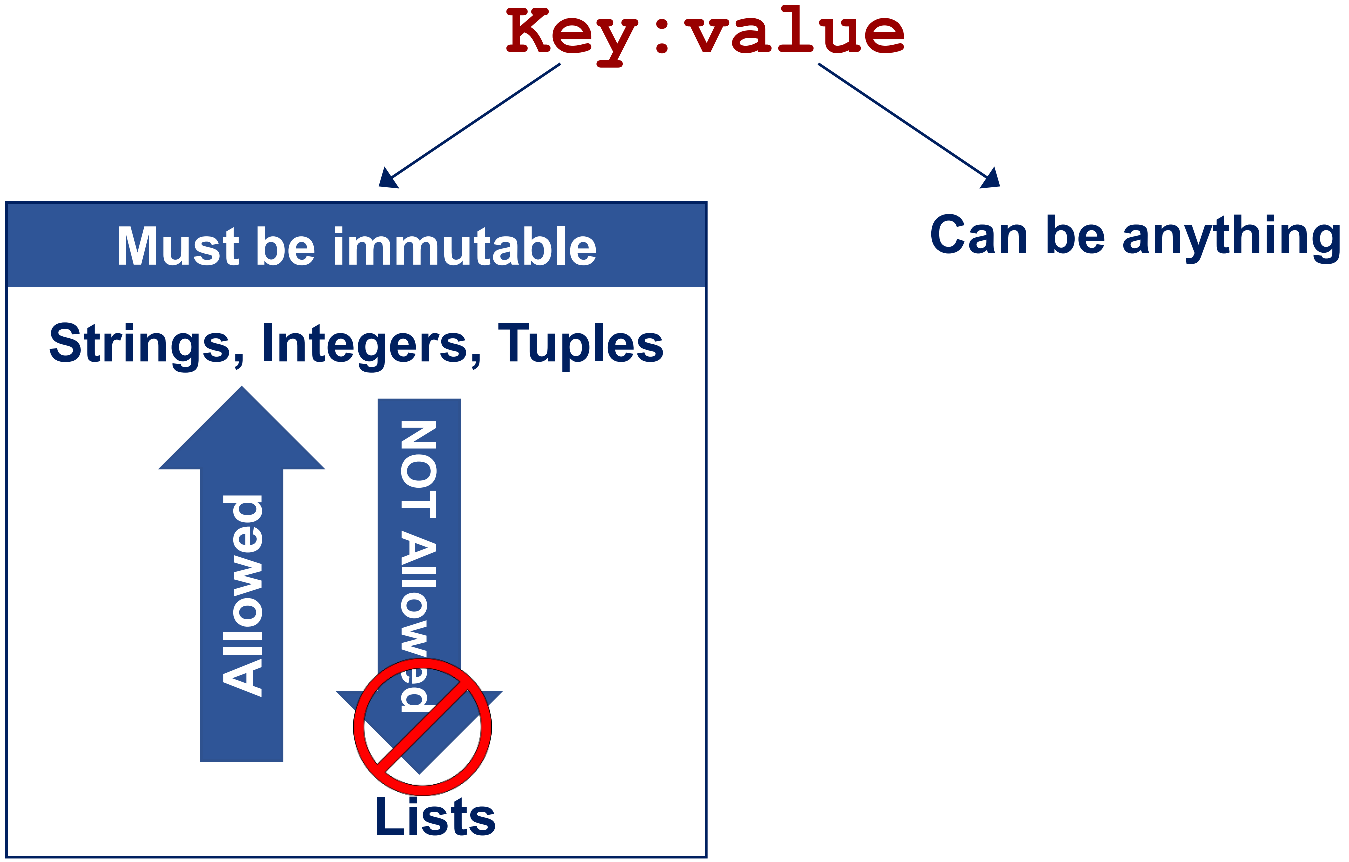
```
contacts = {'bill': '353-1234',
            'rich': '269-1234',
            'jane': '352-1234’}

print(contacts)
```

```
{'jane': '352-1234',
 'bill': '353-1234',
 'rich': '269-1234'}
```



What are Keys and Values?



Collection vs. Sequence

Dictionaries are **collections** but they are **not sequences** like lists, strings, or tuples.

- There is **no order** to the elements of a dictionary.
- In fact, the order (for example, when printed) might change as elements are added or deleted.

So, how do you access dictionary elements?

Access to Dictionary

Access requires **[ ]** and the **key** is the index.

`myDict = {}` → **an empty dictionary**

`myDict['bill'] = 25` → **add the pair `'bill':25`**

`print(myDict['bill'])` → **print 25**

`del myDic['bill']` → **remove the pair `'bill':25`**

Dictionaries are Mutable

Like lists, dictionaries are mutable.

- You can change the object via various operations, such as index assignment.

```
myDict = {'bill':3, 'rich':10}

print(myDict['bill'])         # prints 3
myDict['bill'] = 100          # change value
print(myDict['bill'])         # prints 100

del myDict['rich']            # remove 'rich':10
del myDict['rich']            # KeyError
```

Dictionary Operations

Like others, dictionaries respond to these:

`len(myDict)` → **number** of **key:value pairs** in the dictionary

`element in myDict` → boolean; is **element** a **key** in the dictionary?

`for key in myDict` → iterate through the **keys** of a dictionary

Other Methods and Operations

`myDict.items()` → return all the **key:value** pairs

`myDict.keys()` → return all the keys

`myDict.values()` → return all the values

`myDict.clear()` → empty the dictionary

`myDict.update(yourDict)` → for each key in `yourDict`, update `myDict` with that **key:value** pair

Iterating on a Dictionary

```
for key in myDict:
    print(key)
```

→ prints all the keys

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

→ prints all the key:value pairs

```
for value in myDict.values():
    print(value)
```

→ prints all the values

Summary

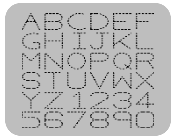
In this lesson, we have learnt:

- The concept of composite types
- Built-in composite types in the Python programming language:
  - List
  - Tuple
  - Dictionary

References for Images

No.	Slide No.	Image	Reference
1	5		Gabovitch, I. (2014). AV Out In HDMI In Jack Plug Red White Yellow Audio and Video Mixer Backside [Online Image]. Retrieved May 17, 2018 from https://www.flickr.com/photos/qubodup/12248078123.
2	6		Python Logo [Online Image]. Retrieved April 24, 2018 from https://pixabay.com/en/language-logo-python-2024210/.
3	6, 8, 37, 38		By Ephemeron - Own work, based on File:Dynamic Dictionary Logo.png, CC BY-SA 3.0, retrieved May 18, 2018 from https://commons.wikimedia.org/w/index.php?curid=7361291.
4	6, 8		String [Online Image]. Retrieved April 24, 2018 https://pixabay.com/en/string-twine-ball-twined-isolated-314346/.
5	10		Search [Online Image]. Retrieved April 18, 2018 from https://pixabay.com/en/database-search-database-search-icon-2797375/.

References for Images

No.	Slide No.	Image	Reference
6	17, 20, 22, 42		Question problem [Online Image]. Retrieved April 18, 2018 from https://pixabay.com/en/question-problem-think-thinking-622164/.
7	21		Survey icon [Online Image]. Retrieved April 18, 2018 from https://pixabay.com/en/survey-icon-survey-icon-2316468/.
8	26		Smiley 11 [Online Image]. Retrieved April 18, 2018 from http://www.publicdomainfiles.com/show_file.php?id=13545100814144.
9	27		By Unknown - From the Open Clip Art Gallery - http://openclipart.org/, CC0, retrieved May 16, 2018 from https://commons.wikimedia.org/w/index.php?curid=1849852.
10	29		Alphabet [Online Image]. Retrieved May 17, 2018 from https://pixabay.com/en/alphabet-letters-numbers-digits-40515/.