Organizing Data

- Sequences
  - ➢ Tuples
  - ➢ Lists
- Dictionaries
- Reading for this Lecture
  - Dawson, Chapter 4 (p. 104 to end) and 5
  - http://introcs.cs.princeton.edu/python/14array

Keeping Track of Data

- So far, in our programs, we have treated data in our programs as individual pieces, completely separate from one another
- This has worked for now, but as our programs become more complex, that will be impractical
- We are best served by finding ways to **organize** the data in our programs – so that we can keep track of it.
- We want to be able to create, use, and modify it *in a predictable, logical manner.*

Keeping Track of Data

- Python, like most programming languages, has a number of structures that will aid us in this.
- In some respects, as you will see, some of these structures are quite similar to one another.
- Despite this, they also have several differences, as well.
- For this reason, your program planning should include knowing what structure you are using…
- …and **why**!

Strings Revisited

- One very obvious (and common) form of data organization is the use of strings.
- After all, a string is actually a *sequence* of data points – specifically, characters.
- Organizing the characters into this form allows us to efficiently read, write, and modify text. We can:
  - ➢ Combine strings
  - ➢ Iterate (i.e., loop) through their characters
  - ➢ Extract single characters
  - ➢ Extract substrings

Sequences

- In fact, we can have sequences of **<u>any</u>** kind of data, *<u>regardless of type</u>*.
- In addition to the *<u>string</u>* form – a sequence of characters – we can also have sequences of:
  - Numbers
  - Booleans
  - Strings
  - Other sequences!
- After all, in Python, a sequence itself is an object
- In some programming languages, a sequence can contain only items of a particular type.
- Python, however, is more flexible in this, as we will see.

Tuples

- The most basic sequence in Python is probably the ***tuple***
- A tuple is more or less just like a *string*, except that it can contain ***any*** kind of objects
- The syntax for creating a tuple is:

```
variable = (first, second,..., last)
```

- Examples:

```
names = (“Bob”, “Susan”, “Jill”)
id_numbers = (123, 456, 789)
booleans = (True, False, True)
items = (“Bob”, 456, True)
```

← Items can be of different types, too

Tuples

- As with strings…
  - A tuple can be *empty*. `empty_tup = ()`
  - A tuple can be a condition. An empty tuple would be considered **`False`**, while a non-empty one would be considered **`True`**
  - You can print a tuple

```
names = (“Bob”, “Susan”, “Jill”)
print(names)
```

Prints as:

```
('Bob', 'Susan', 'Jill')
```

Tuples

```
names = (“Bob”, “Susan”, “Jill”)
```

- A tuple has a <u>length</u>. **`len(names)`** would evaluate to a result of <u>**3**</u>
- You can <u>loop</u> through a tuple:

```
for name in names:
    print (name)
```

```
Bob
Susan
Jill
```

- You can <u>concatenate</u> tuples:

```
names += (“Bill”, “Jack”)
print (names)
```

<u>Prints as:</u> `('Bob', 'Susan', 'Jill', 'Bill', 'Jack')`

Tuples

```
names = (“Bob”, “Susan”, “Jill”, “Bill”, “Jack”)
```

- You can use indices to get individual elements and slices of tuples, using the same syntax as with strings.

```
print(“First item :”, names[0])
print(“Second item :”, names[1])
print(“Last item :”, names[4])
print(“Last item:”, names[len(names)-1]
```

```
Bob
Susan
Jack
Jack
```

```
print (names[1:4])
```

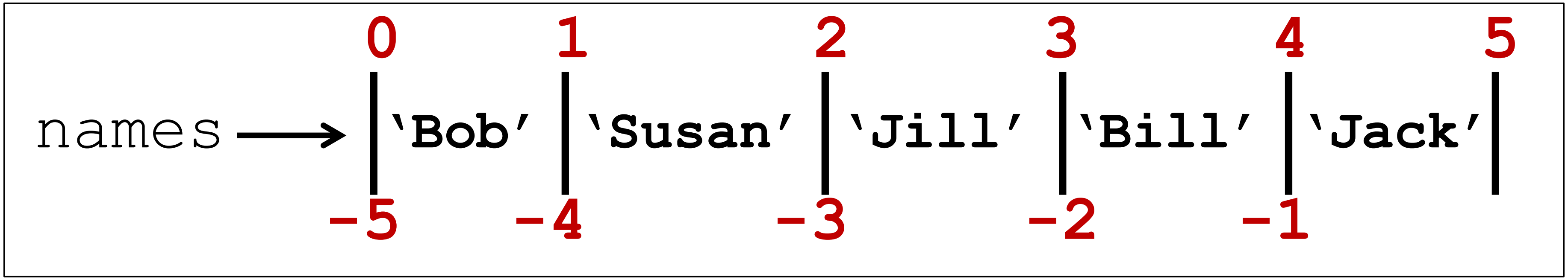
Prints as:

```
('Susan', 'Jill', 'Bill')
```

- Just a slice of a string is a new string, a slice of a tuple is, in fact *a new tuple*

Tuples

- The other details about sequence positions – such as negative indices – also apply to tuples



```
                 0       1           2          3          4        5
names ──────→   |'Bob' |'Susan'    |'Jill'    |'Bill'    |'Jack'  |
               -5      -4          -3         -2         -1
```

- As with strings, a tuple is immutable. Even if the individual items within the tuple are mutable, the tuple itself – as a structure – is not.
- Tuple elements cannot be added, removed, or replaced.
- As with strings, the most you can do is create a **new** tuple out of other, existing ones.

Examples using tuples:

- **hero's_inventory.py**
  - Simple example of the creation and use of tuples – namely, printing the tuple as a whole versus its individual elements
- **hero's_inventory2.py**
  - More complex example illustrating:
    - Use of `len()` function
    - Use of `in` operator
    - Indexing
    - Slicing
    - Concatenation
- **word_jumble.py**
  - Extended example of developing a program for a word game

Lists

- One major limitation of tuples is their immutability
- It would be nice to have a sequence that you can actually change, rather than simply creating a new one each time
- Python also has a mutable sequence, in the form of the **list** – a structure very similar to tuples, but with many important differences.

Creating Lists

- If you recall, you would create a *tuple* this way:

```
names = ("Bob", "Susan", "Jill")
```

- In contrast, you would create a **list** this way:

```
names = ["Bob", "Susan", "Jill"]
```

- In other words, the only difference in the syntax for creating is *the pair of symbols encasing the sequence*

parentheses - tuple

```
variable = (first, second,..., last)
```

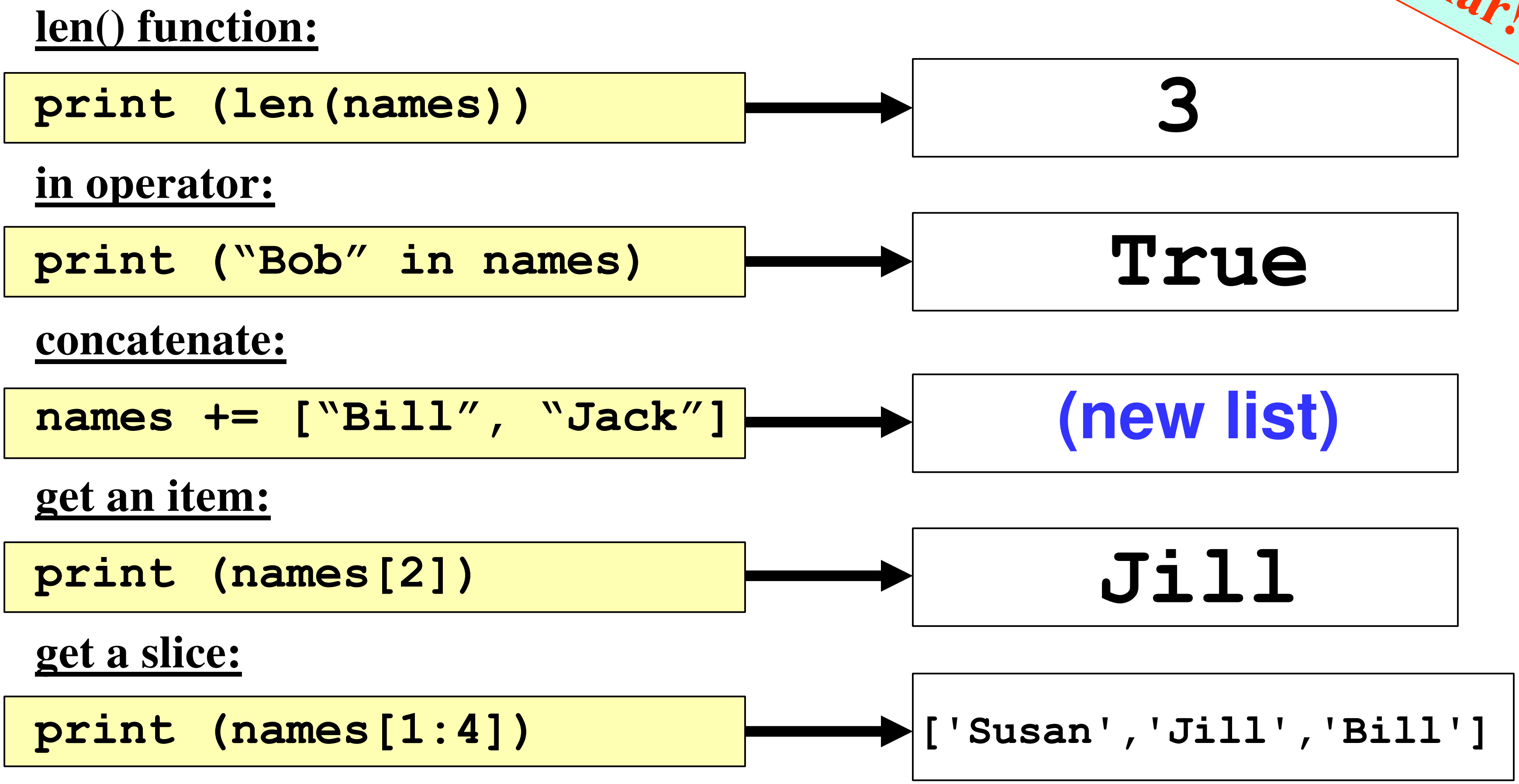
square brackets - list

```
variable = [first, second,..., last]
```

List Syntax

Much is familiar!

```
names = [“Bob”, Susan”, “Jill”]
```



len() function:

```
print (len(names))
```

3

in operator:

```
print (“Bob” in names)
```

True

concatenate:

```
names += [“Bill”, “Jack”]
```

(new list)

get an item:

```
print (names[2])
```

Jill

get a slice:

```
print (names[1:4])
```

```
['Susan','Jill','Bill']
```

List Mutability

```
names = [“Bob”, “Susan”, “Jill” , “Bill”, “Jack”]
```

- However, the fact that lists are ***mutable*** means they have some additional options

Replace an item:

```
names[2] = “Jenny”
```

```
[“Bob”, “Susan”, “Jenny” , “Bill”, “Jack”]
```

Replace a slice:

```
names[1:4] = ["Joe", "Sue”, “Rob”, “Jane”]
```

```
[“Bob”, "Joe", "Sue”, “Rob”, “Jane”, “Jack”]
```

Delete an item:,

```
del names[2]
```

"Sue" is gone

```
[“Bob”, "Joe", “Rob”, “Jane”, “Jack”]
```

Delete a slice:

```
del names[1:4]
```

"Joe", "Rob", "Jane" are gone

```
[“Bob”, “Jack”]
```

List Use and Methods

- We can see *list mutability* in action in the program **hero's_inventory3.py**
- In addition, Python has several functions/methods you can use for manipulating lists.
- See **high_scores.py**
- The list methods used in that program – along with other methods – are in the textbook in **Table 5.1 on page 132**.

Dictionaries

- In addition to sequences, another useful way to organize data is in terms of *key-value pairings*
- This is the case with a **dictionary**, where data is organized like so:

```
key1 → value1
key2 → value2
key3 → value3
      ⋮
```

- You can then use a specific **key** to retrieve a particular **value** from the dictionary.

Creating Dictionaries

```
key1 → value1
key2 → value2
       ⋮
```

- **Syntax:**

```
variable = { first_key : first_value,
            second_key : second_value,
                     ⋮
            last_key   : last_value }
```

- Keys must be of an ***immutable*** type, but values can be of ***any*** type

- Each key in the dictionary *must be unique*; otherwise, duplicated keys would create ambiguity

Using Dictionaries

- Let’s create a dictionary:

```
info = { “name” : “John Doe”,
         “school” : “UMB”,
         “ID” : 12345,
         “GPA” : 3.7 }
```

- **Now, we can…**

Fetch a value by key:

```
print(“My name is: ” + info[“name”])
```

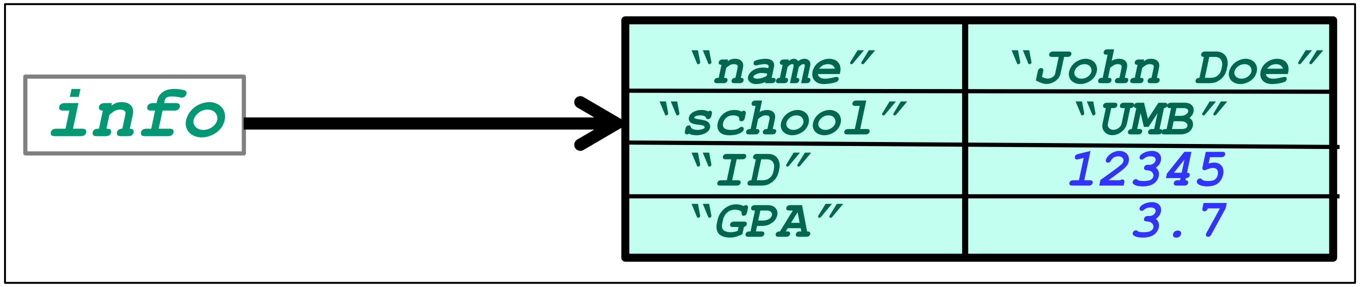
```
My name is: John Doe
```

See if key exists:

```
print(“Has major: ” + str(“major” in info))
```

```
Has major: False
```

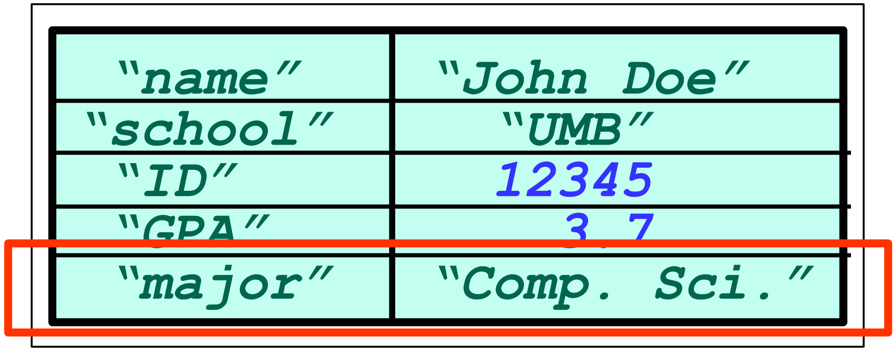
Using Dictionaries



“name”	“John Doe”
“school”	“UMB”
“ID”	12345
“GPA”	3.7

Add a new entry (*key-value pair*):

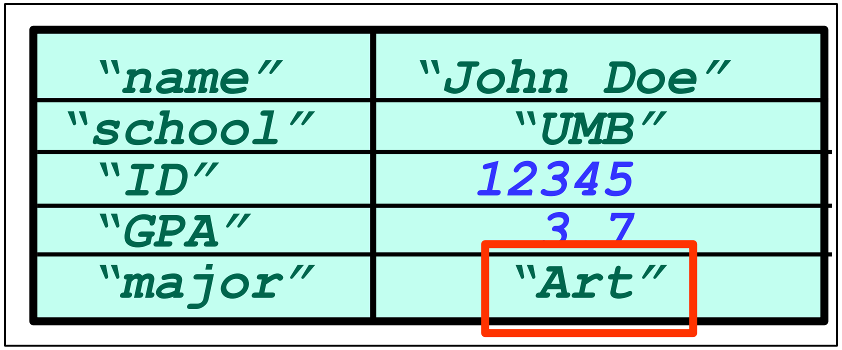
```
info[“major”] = “Comp. Sci.”
```



“name”	“John Doe”
“school”	“UMB”
“ID”	12345
“GPA”	3.7
“major”	“Comp. Sci.”

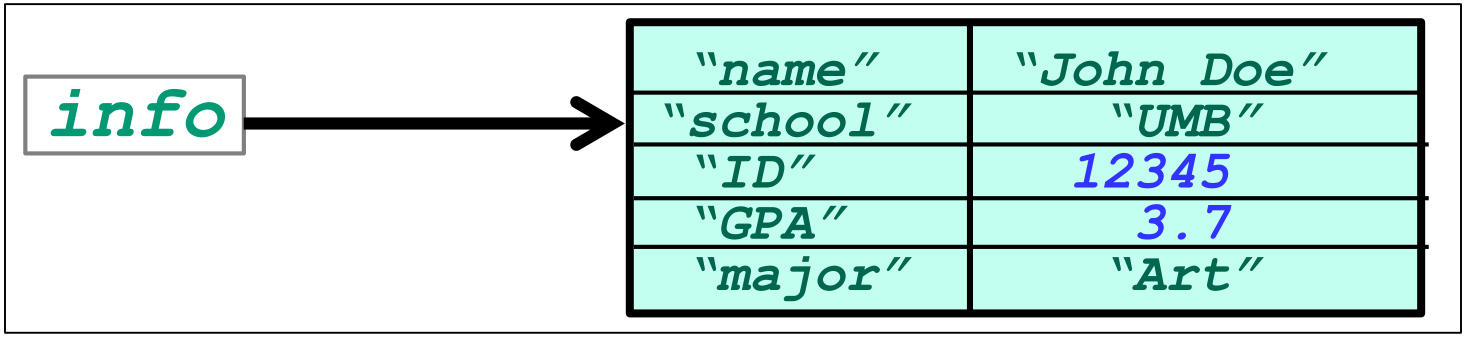
Replace an entry:

```
info[“major”] = “Art”
```



“name”	“John Doe”
“school”	“UMB”
“ID”	12345
“GPA”	3.7
“major”	“Art”

Using Dictionaries



“name”	“John Doe”
“school”	“UMB”
“ID”	12345
“GPA”	3.7
“major”	“Art”

Delete an entry by key:

```
del info[“major”]
```

“name”	“John Doe”
“school”	“UMB”
“ID”	12345
“GPA”	3.7

Fetch a value by key (with default):

```
print(“Major:” info.get(“major”, “Undeclared”)
```

Key "major" does not exist, so get gives us the default

```
Major: Undeclared
```

Dictionary Use and Methods

- We can see an extended example in the program **geek_translator.py**
- This program depicts the use of a dictionary to organize data about words and their definitions
- We see the **dynamism** of the structure
- Other dictionary methods can be seen in the textbook in **<u>Table 5.2 on page 148</u>**.

Nested Structures

- We stated earlier that tuples, lists, and dictionaries can hold values of any type
- This means that those values can actually be **other** tuples, lists, and dictionaries!
- Nested structures can be very useful for keeping track of many pieces of data that are related to one another in some respect.
- Consider **high_scores2.py**

Example: Nested Dictionaries

```
book = { “title”    : “How to Program”,
          “author”  : “John Doe”,
         “pub_year” : 2016,
         “chapters” : { 1 : “Printing Text”,
                        2 : “Making Strings”,
                        3 : “Using Variables” },
         “price”    : 27.50                        }
```

- Variable **book** refers to a dictionary with the keys **“title”**, **“author”**, **“pub_year”**, **“chapters”**, and **“price”**
- However, the value at **book[“chapters”]** is *another dictionary*, with the keys **1**, **2**, and **3**

Example: Nested Dictionaries

```
book = { “title”    : “How to Program”,
          “author”  : “John Doe”,
         “pub_year” : 2016,
         “chapters” : { 1 : “Printing Text”,
                        2 : “Making Strings”,
                        3 : “Using Variables” },
         “price”    : 27.50                          }
```

- To get the title of the third chapter, we would use the following expression:

```
book[“chapters”][3]
```

- We could also add a fourth chapter:

```
book[“chapters”][4] = “Writing Expressions”
```

Example: A Tuple of Dictionaries

```
books = (
          { “title”    : “How to Program”,
            “author”    : “John Doe”,
            “pub_year” : 2016,
             “price”    : 27.50              } ,

           { “title”    : “Calculus”,
            “author”    : “Jane Doe”,
            “pub_year” : 2015,
             “price”    : 39.95              } ,

           { “title”    : “Biology”,
            “author”    : “Jim Doe”,
            “pub_year” : 2016,
             “price”    : 87.29              }
                                               )
print (books[1][“price”])
print (books[2][“pub_year”])
```