Module 2

CH 4. LISTS

- **The list data type**

  A *list* is a value that contains multiple values in an ordered sequence. list begins with an opening square bracket and ends with a closing square bracket, []. Values inside the list are also called *items*. Items are separated with commas (that is, they are *comma-delimited*). For example, enter the following into the interactive shell:

```
>>> [1, 2, 3]
[1, 2, 3]

>>> ['cat', 'bat', 'rat', 'elephant']
 ['cat', 'bat', 'rat', 'elephant']

>>> ['hello', 3.1415, True, None, 42]
['hello', 3.1415, True, None, 42]

>>> spam = ['cat', 'bat', 'rat', 'elephant']
>>> spam
        ['cat', 'bat', 'rat', 'elephant']
```

  The spam variable is still assigned only one value: the list value. But the list value itself contains other values. The value [] is an empty list that contains no values, similar to '', the empty string.

Getting Individual Values in a List with Indexes

The list ['cat', 'bat', 'rat', 'elephant'] stored in a variable named spam. The Python code spam[0] would evaluate to 'cat', and spam[1] would evaluate to 'bat', and so on.

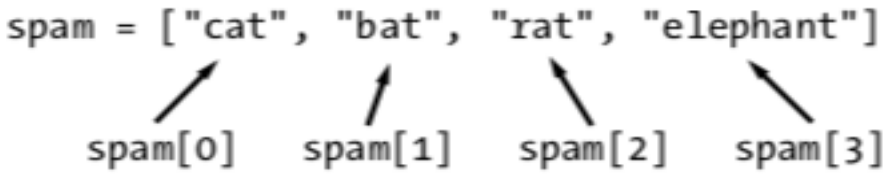


Figure 4-1: A list value stored in the variable spam, showing which value each index refers to

Example, type the following expressions into the interactive shell. Start by assigning a list to the variable spam.

```
>>> spam = ['cat', 'bat', 'rat', 'elephant']
>>> spam[0]
'cat'
>>> spam[1]
'bat'
>>> spam[2]
 'rat'
>>> spam[3]
'elephant'
>>> ['cat', 'bat', 'rat', 'elephant'][3]
'elephant'
>>> 'Hello ' + spam[0]
'Hello cat'
>>> 'The ' + spam[1] + ' ate the ' + spam[0] + '.'
'The bat ate the cat.'
```

Notice that the expression 'Hello ' + spam[0] evaluates to 'Hello ' + 'cat' because spam[0] evaluates to the string 'cat'. This expression in turn evaluates to the string value 'Hello cat'

Python will give you an IndexError error message if you use an index that exceeds the number of values in your list value.
E.G.

```
>>> spam = ['cat', 'bat', 'rat', 'elephant']
>>> spam[10000]
Traceback (most recent call last):
    File "<pyshell#9>", line 1, in <module>
      spam[10000]
  IndexError: list index out of range
```

Indexes can be only integer values, not floats. The following example will cause a TypeError error:
e.g.

```
>>> spam = ['cat', 'bat', 'rat', 'elephant']
>>> spam[1]
'bat'
>>> spam[1.0]
  Traceback (most recent call last):
    File "<pyshell#13>", line 1, in <module>
spam[1.0]
TypeError: list indices must be integers, not float
>>> spam[int(1.0)]
'bat'
```

Lists can also contain other list values. The values in these lists of lists can be accessed using multiple indexes, like so:

```
>>> spam = [['cat', 'bat'], [10, 20, 30, 40, 50]]
 >>> spam[0]
['cat', 'bat']
>>> spam[0][1]
'bat'
>>> spam[1][4]
50
```

The first index dictates which list value to use, and the second indicates the value within the list value. For example, spam[0][1] prints 'bat', the sec- ond value in the first list. If you only use one index, the program will print the full list value at that index.

Negative Indexes

The integer value -1 refers to the last index in a list, the value -2 refers to the second-to-last index in a list, and so on.

e.g.

```
>>> spam = ['cat', 'bat', 'rat', 'elephant'] >>> spam[-1]
'elephant'
>>> spam[-3]
'bat'
>>> 'The ' + spam[-1] + ' is afraid of the ' + spam[-3] + '.' '
The elephant is afraid of the bat.'
```

Getting Sublists with Slices

Just as an index can get a single value from a list, a *slice* can get several values from a list, in the form of a new list. A slice is typed between square brackets, like an index, but it has two integers separated by a colon. Notice the differ- ence between indexes and slices.

- spam[2] is a list with an index (one integer).
- spam[1:4] is a list with a slice (two integers).

In a slice, the first integer is the index where the slice starts. The second integer is the index where the slice ends. A slice goes up to, but will not include, the value at the second index. A slice evaluates to a new list value.

```
>>> spam = ['cat', 'bat', 'rat', 'elephant']
>>> spam[0:4]
['cat', 'bat', 'rat', 'elephant']
>>> spam[1:3]
['bat', 'rat']
>>> spam[0:-1]
 ['cat', 'bat', 'rat']
```

As a shortcut, you can leave out one or both of the indexes on either side of the colon in the slice. Leaving out the first index is the same as using 0, or the beginning of the list. Leaving out the second index is the same as using the length of the list, which will slice to the end of the list.

```
>>> spam = ['cat', 'bat', 'rat', 'elephant']
>>> spam[:2]
['cat', 'bat']
>>> spam[1:]
['bat', 'rat', 'elephant']
>>> spam[:]
['cat', 'bat', 'rat', 'elephant']
```

Getting a List's Length with len()

The len() function will return the number of values that are in a list value passed to it, just like it can count the number of characters in a string value.

```
>>> spam = ['cat', 'dog', 'moose']
>>> len(spam)
3
```

Changing Values in a List with Indexes

Normally a variable name goes on the left side of an assignment state- ment, like spam = 42. However, you can also use an index of a list to change the value at that index. For example, spam[1] = 'aardvark' means "Assign the value at index 1 in the list spam to the string 'aardvark'."

```
>>> spam = ['cat', 'bat', 'rat', 'elephant']
>>> spam[1] = 'aardvark'
>>> spam
['cat', 'aardvark', 'rat', 'elephant']
>>> spam[2] = spam[1]
>>> spam
['cat', 'aardvark', 'aardvark', 'elephant']
>>> spam[-1] = 12345
>>> spam
['cat', 'aardvark', 'aardvark', 12345]
```

List Concatenation and List Replication

The + operator can combine two lists to create a new list value in the same way it combines two strings into a new string value. The * operator can also be used with a list and an integer value to replicate the list

```
>>> [1, 2, 3] + ['A', 'B', 'C']
[1, 2, 3, 'A', 'B', 'C']
>>> ['X', 'Y', 'Z'] * 3
['X', 'Y', 'Z', 'X', 'Y', 'Z', 'X', 'Y', 'Z']
>>> spam = [1, 2, 3]
>>> spam = spam + ['A', 'B', 'C']
>>> spam
[1, 2, 3, 'A', 'B', 'C']
```

Removing Values from Lists with del Statements

The del statement will delete values at an index in a list. All of the values in the list after the deleted value will be moved up one index.

```
>>> spam = ['cat', 'bat', 'rat', 'elephant'] >>> del spam[2]
>>> spam
['cat', 'bat', 'elephant']

>>> del spam[2] >>> spam ['cat', 'bat']
```

- ## Working with lists

Instead of using multiple, repetitive variables, you can use a single variable that contains a list value.

```
catNames = []
while True:
    print('Enter the name of cat ' + str(len(catNames) + 1) +
      ' (Or enter nothing to stop.):')
    name = input()
    if name == '':
        break
    catNames = catNames + [name]  # list concatenation
print('The cat names are:')
for name in catNames:
    print('  ' + name)
```

Output:

```
Enter the name of cat 1 (Or enter nothing to stop.):
Zophie
Enter the name of cat 2 (Or enter nothing to stop.):
Pooka
Enter the name of cat 3 (Or enter nothing to stop.):
Simon
Enter the name of cat 4 (Or enter nothing to stop.):
Lady Macbeth
Enter the name of cat 5 (Or enter nothing to stop.):
Fat-tail
```

Enter the name of cat 6 (Or enter nothing to stop.):
Miss Cleo
Enter the name of cat 7 (Or enter nothing to stop.):

The cat names are:
Zophie
Pooka
Simon
Lady Macbeth
Fat-tail
Miss Cleo

The benefit of using a list is that your data is now in a structure, so your program is much more flexible in processing the data than it would be with several repetitive variables.

Using for Loops with Lists

E.g.
```
for i in [0, 1, 2, 3]:
    print(i)
```
Output:
0
1
2
3

A common Python technique is to use range(len(*someList*)) with a for loop to iterate over the indexes of a list. For example,

```
>>>supplies = ['pens', 'staplers', 'flame-throwers', 'binders']

>>> for i in range(len(supplies)):

        print('Index ' + str(i) + ' in supplies is: ' + supplies[i])
```

Output:
Index 0 in supplies is: pens
Index 1 in supplies is: staplers
Index 2 in supplies is: flame-throwers
Index 3 in supplies is: binders

The in and not in Operators

You can determine whether a value is or isn't in a list with the in and not in operators. Like other operators, in and not in are used in expressions and connect two values: a value to look for in a list and the list where it may be found. These expressions will evaluate to a Boolean value

```
>>> 'howdy' in ['hello', 'hi', 'howdy', 'heyas']
 True
>>> spam = ['hello', 'hi', 'howdy', 'heyas']
>>> 'cat' in spam
False
>>> 'howdy' not in spam
False
>>> 'cat' not in spam
True
```

Example :

```
myPets = ['Zophie', 'Pooka', 'Fat-tail']
print('Enter a pet name:')
name = input()
if name not in myPets:
   print('I do not have a pet named ' + name)
else:
   print(name + ' is my pet.')
```

Output:

```
Enter a pet name:
Footfoot
I do not have a pet named Footfoot
```

The Multiple Assignment Trick

The *multiple assignment trick* is a shortcut that lets you assign multiple vari- ables with the values in a list in one line of code. So instead of doing this:

```
>>> cat = ['fat', 'black', 'loud']
>>> size = cat[0]
>>> color = cat[1]
>>> disposition = cat[2]
```

you could type this line of code:

```
>>> cat = ['fat', 'black', 'loud']
>>> size, color, disposition = cat
```

The number of variables and the length of the list must be exactly equal, or Python will give you a ValueError:

```
>>> cat = ['fat', 'black', 'loud']
>>> size, color, disposition, name = cat
Traceback (most recent call last):
          File "<pyshell#84>", line 1, in <module>
            size, color, disposition, name = cat
        ValueError: need more than 3 values to unpack
```

Augmented Assignment operators

When assigning a value to a variable, you will frequently use the variable itself. For example, after assigning 42 to the variable spam, you would increase the value in spam by 1 with the following code:

```
>>> spam = 42
>>> spam = spam + 1
>>> spam
43
```

As a shortcut, you can use the augmented assignment operator += to do the same thing:

```
>>> spam = 42
 >>> spam += 1
>>> spam
43
```

Table 4-1: The Augmented Assignment Operators

Augmented assignment statement	Equivalent assignment statement
`spam = spam + 1`	`spam += 1`
`spam = spam - 1`	`spam -= 1`
`spam = spam * 1`	`spam *= 1`
`spam = spam / 1`	`spam /= 1`
`spam = spam % 1`	`spam %= 1`

Methods

A *method* is the same thing as a function, except it is "called on" a value.

Finding a Value in a List with the index() Method

List values have an index() method that can be passed a value, and if that value exists in the list, the index of the value is returned. If the value isn't in the list, then Python produces a ValueError error

```
>>> spam = ['hello', 'hi', 'howdy', 'heyas']
>>> spam.index('hello')
0
>>> spam.index('heyas')
3
>>> spam.index('howdy howdy howdy')

Traceback (most recent call last):
  File "<pyshell#31>", line 1, in <module>
    spam.index('howdy howdy howdy')
ValueError: 'howdy howdy howdy' is not in list
```

When there are duplicates of the value in the list, the index of its first appearance is returned. E.g.

```
>>> spam = ['Zophie', 'Pooka', 'Fat-tail', 'Pooka']
```

```
>>> spam.index('Pooka')
1
```

Adding Values to Lists with the append() and insert() Methods

To add new values to a list, use the append() and insert() methods.
E.g.

```
>>> spam = ['cat', 'dog', 'bat']
>>> spam.append('moose')
>>> spam
['cat', 'dog', 'bat', 'moose']
```

The previous append() method call adds the argument to the end of the list. The insert() method can insert a value at any index in the list. The first argument to insert() is the index for the new value, and the sec- ond argument is the new value to be inserted.
E.g.

```
>>> spam = ['cat', 'dog', 'bat']
>>> spam.insert(1, 'chicken')
>>> spam
['cat', 'chicken', 'dog', 'bat']
```

Methods belong to a single data type. The append() and insert() methods are list methods and can be called only on list values, not on other values such as strings or integers.

E.g Note the AttributeError error messages that show up:

```
>>> eggs = 'hello'
>>> eggs.append('world')
Traceback (most recent call last):
  File "<pyshell#19>", line 1, in <module>
    eggs.append('world')
AttributeError: 'str' object has no attribute 'append'
```

```
>>> bacon = 42
>>> bacon.insert(1, 'world')
Traceback (most recent call last):
  File "<pyshell#22>", line 1, in <module>
    bacon.insert(1, 'world')
AttributeError: 'int' object has no attribute 'insert'
```

Removing Values from Lists with remove()

The remove() method is passed the value to be removed from the list it is called on.

```
>>> spam = ['cat', 'bat', 'rat', 'elephant']
>>> spam.remove('bat')
>>> spam
['cat', 'rat', 'elephant']
```

Attempting to delete a value that does not exist in the list will result in a ValueError error. For example,

```
>>> spam = ['cat', 'bat', 'rat', 'elephant']
>>> spam.remove('chicken')
Traceback (most recent call last):
  File "<pyshell#11>", line 1, in <module>
    spam.remove('chicken')
ValueError: list.remove(x): x not in list
```

If the value appears multiple times in the list, only the first instance of the value will be removed.

E.g

```
>>> spam = ['cat', 'bat', 'rat', 'cat', 'hat', 'cat']
>>> spam.remove('cat')
>>> spam
['bat', 'rat', 'cat', 'hat', 'cat']
```

The remove() method is good when you know the value you want to remove from the list.

Sorting the Values in a List with the sort() Method

Lists of number values or lists of strings can be sorted with the sort() method. For example

```
>>> spam = [2, 5, 3.14, 1, -7]
>>> spam.sort()
>>> spam
[-7, 1, 2, 3.14, 5]
>>> spam = ['ants', 'cats', 'dogs', 'badgers', 'elephants']
>>> spam.sort()
>>> spam
['ants', 'badgers', 'cats', 'dogs', 'elephants']
```

You can also pass True for the reverse keyword argument to have sort() sort the values in reverse order

```
>>> spam.sort(reverse=True)
>>> spam
['elephants', 'dogs', 'cats', 'badgers', 'ants']
```

There are three things you should note about the sort() method. First, the sort() method sorts the list in place; don't try to capture the return value by writing code like spam = spam.sort(). Second, you cannot sort lists that have both number values *and* string values in them, since Python doesn't know how to compare these values. Type the following into the interactive shell and notice the TypeError error:

```
>>> spam = [1, 3, 2, 4, 'Alice', 'Bob']
>>> spam.sort()
Traceback (most recent call last):
          File "<pyshell#70>", line 1, in <module>
            spam.sort()
        TypeError: unorderable types: str() < int()
```

Third, sort() uses “ASCIIbetical order” rather than actual alphabetical order for sorting strings. This means uppercase letters come before lower- case letters. Therefore, the lowercase *a* is sorted so that it comes *after* the uppercase *Z*. For an example,

```
>>> spam = ['Alice', 'ants', 'Bob', 'badgers', 'Carol', 'cats']
>>> spam.sort()
>>> spam
['Alice', 'Bob', 'Carol', 'ants', 'badgers', 'cats']
```

If you need to sort the values in regular alphabetical order, pass str. lower for the key keyword argument in the sort() method call.

```
>>> spam = ['a', 'z', 'A', 'Z']
>>> spam.sort(key=str.lower)
 >>> spam
['a', 'A', 'z', 'Z']
```

This causes the sort() function to treat all the items in the list as if they were lowercase without actually changing the values in the list.

example Program: magic 8 Ball with a list

Open a new file editor window and enter the following code. Save it as *magic8Ball2.py*.

```
import random

messages = ['It is certain',
    'It is decidedly so',
    'Yes definitely',
    'Reply hazy try again',
    'Ask again later',
    'Concentrate and ask again',
    'My reply is no',
    'Outlook not so good',
    'Very doubtful']

print(messages[random.randint(0, len(messages) - 1)])
```

Notice the expression you use as the index into messages: random .randint(0, len(messages) - 1). This produces a random number to use
for the index, regardless of the size of messages. That is, you’ll get a ran- dom number between 0 and the value of len(messages) - 1. The benefit of this approach is that you can easily add and remove strings to the messages list without changing other lines of code. If you later update your code, there will be fewer lines you have to change and fewer chances for you to introduce bugs.

list-like types: Strings and tuples

Lists aren't the only data types that represent ordered sequences of values. For example, strings and lists are actually similar, if you consider a string to be a "list" of single text characters. Many of the things you can do with lists

can also be done with strings: indexing; slicing; and using them with for loops, with len(), and with the in and not in operators. To see this, enter the following into the interactive shell:

```
>>> name = 'Zophie'
>>> name[0]
'Z'
>>> name[-2]
'i'
>>> name[0:4]
'Zoph'
>>> 'Zo' in name
True
>>> 'z' in name
False
>>> 'p' not in name
False
>>> for i in name:
        print('* * * ' + i + ' * * *')

***Z** *
***o** *
 ***p** *
 ***h** *
***i** *
 ***e** *
```

Mutable and Immutable Data Types

lists and strings are different in an important way. A list value is a *mutable* data type: It can have values added, removed, or changed. However, a string is *immutable*: It cannot be changed. Trying to reassign a single character in a string results in a TypeError error,

```
>>> name = 'Zophie a cat'
>>> name[7] = 'the'

Traceback (most recent call last):
  File "<pyshell#50>", line 1, in <module>
    name[7] = 'the'
TypeError: 'str' object does not support item assignment
```

The proper way to "mutate" a string is to use slicing and concatenation to build a *new* string by copying from parts of the old string.

```
>>> name = 'Zophie a cat'
>>> newName = name[0:7] + 'the' + name[8:12]
>>> name
'Zophie a cat'
>>> newName
'Zophie the cat'
```

We used [0:7] and [8:12] to refer to the characters that we don't wish to replace. Notice that the original 'Zophie a cat' string is not modified because strings are immutable.
Although a list value *is* mutable, the second line in the following code does not modify the list eggs:

```
>>> eggs = [1, 2, 3]
>>> eggs = [4, 5, 6]
 >>> eggs
[4, 5, 6]
```

The list value in eggs isn't being changed here; rather, an entirely new and different list value ([4, 5, 6]) is overwriting the old list value ([1, 2, 3]). This is depicted in Figure 4-2.
If you wanted to actually modify the original list in eggs to contain [4, 5, 6], you would have to do something like this:

```
>>> eggs = [1, 2, 3]
 >>> del eggs[2]
>>> del eggs[1]
>>> del eggs[0]
>>> eggs.append(4)
>>> eggs.append(5)
 >>> eggs.append(6)
 >>> eggs
[4, 5, 6]
```

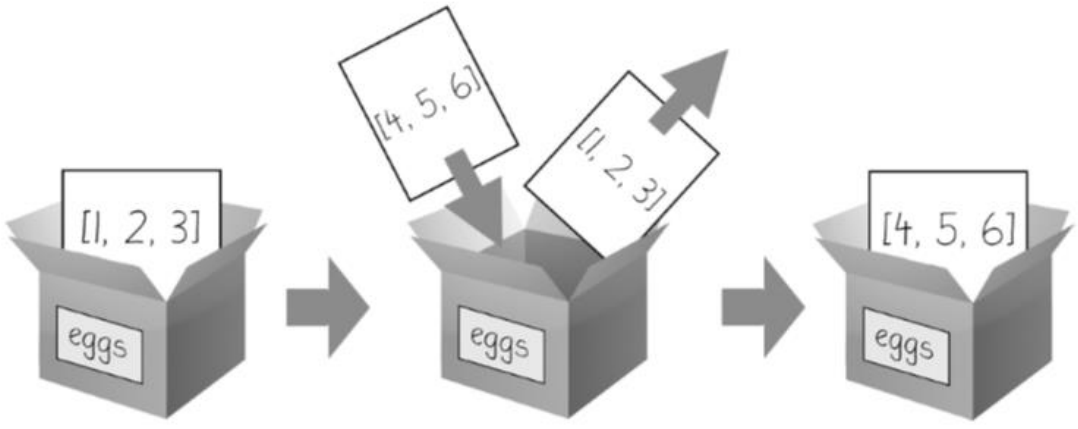


Figure 4-2: When eggs = [4, 5, 6] is executed, the contents of eggs are replaced with a new list value.

In the first example, the list value that eggs ends up with is the same list value it started with. It's just that this list has been changed, rather than overwritten. Figure 4-3 depicts the seven changes made by the first seven lines in the previous interactive shell example.

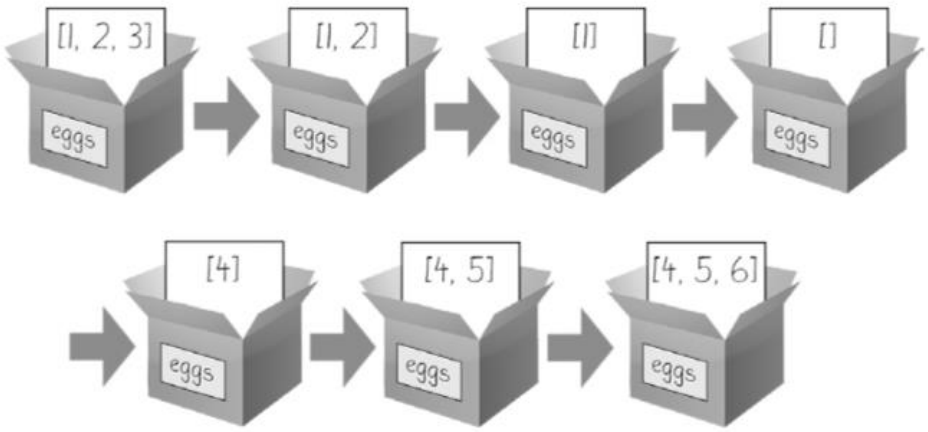


Figure 4-3: The del statement and the append() method modify the same list value in place.

Changing a value of a mutable data type (like what the del statement and append() method do in the previous example) changes the value in place, since the variable's value is not replaced with a new list value.

The Tuple Data Type

tuple data type, is an immutable form of the list data type.

The *tuple* data type is almost identical to the list data type, except in two ways. First, tuples are typed with parentheses, (and), instead of square brackets, [and]. For example,

```
>>> eggs = ('hello', 42, 0.5)
>>> eggs[0]
'hello'
>>> eggs[1:3]
(42, 0.5)
>>> len(eggs)
3
```

But the main way that tuples are different from lists is that tuples, like strings, are immutable. Tuples cannot have their values modified, appended, or removed.

```
>>> eggs = ('hello', 42, 0.5)
>>> eggs[1] = 99
Traceback (most recent call last):

  File "<pyshell#5>", line 1, in <module>
    eggs[1] = 99
TypeError: 'tuple' object does not support item assignment
```

If you have only one value in your tuple, you can indicate this by placing a trailing comma after the value inside the parentheses. Otherwise, Python will think you've just typed a value inside regular parentheses. The comma is what lets Python know this is a tuple value.

```
>>> type(('hello',))
<class 'tuple'>
>>> type(('hello'))
 <class 'str'>
```

Converting Types with the list() and tuple() Functions

Just like how str(42) will return '42', the string representation of the inte- ger 42, the functions list() and tuple() will return list and tuple versions
of the values passed to them

E.G notice that the return value is of a different data type than the value passed:

```
>>> tuple(['cat', 'dog', 5])
('cat', 'dog', 5)
>>> list(('cat', 'dog', 5))
 ['cat', 'dog', 5]
>>> list('hello')
['h', 'e', 'l', 'l', 'o']
```

Converting a tuple to a list is handy if you need a mutable version of a tuple value.

References

As you've seen, variables store strings and integer values. Enter the follow- ing into the interactive shell:

```
>>> spam = 42
>>> cheese = spam
>>> spam = 100
 >>> spam
100
>>> cheese
42
```

You assign 42 to the spam variable, and then you copy the value in spam and assign it to the variable cheese. When you later change the value in spam to 100, this doesn't affect the value in cheese. This is because spam and cheese are different variables that store different values.

But lists don't work this way. When you assign a list to a variable, you are actually assigning a list *reference* to the variable. A reference is a value that points to some bit of data, and a list reference is a value that points to a list. Here is some code that will make this distinction easier to understand. Enter this into the interactive shell:

```
>>> spam = [0, 1, 2, 3, 4, 5]
>>> cheese = spam
>>> cheese[1] = 'Hello!'
>>> spam
[0, 'Hello!', 2, 3, 4, 5]
>>> cheese
[0, 'Hello!', 2, 3, 4, 5]
```

This might look odd to you. The code changed only the cheese list, but it seems that both the cheese and spam lists have changed.
When you create the list, you assign a reference to it in the spam vari- able. But the next line copies only the list reference in spam to cheese, not the list value itself. This means the values stored in spam and cheese now both refer to the same list. There is only one underlying list because the list itself was never actually copied. So when you modify the first element of cheese, you are modifying the same list that spam refers to.

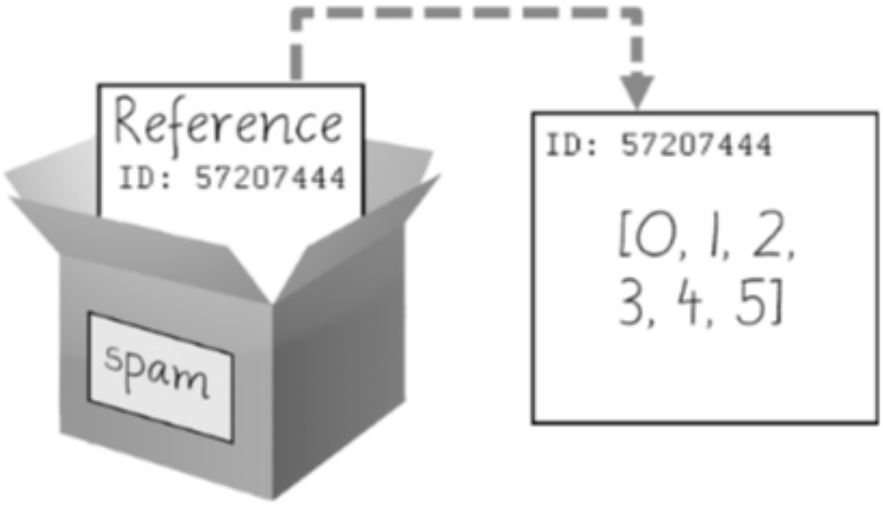


Figure 4-4: spam = [0, 1, 2, 3, 4, 5] stores a reference to a list, not the actual list.

Then, in Figure 4-5, the reference in spam is copied to cheese. Only a new reference was created and stored in cheese, not a new list. Note how both references refer to the same list.

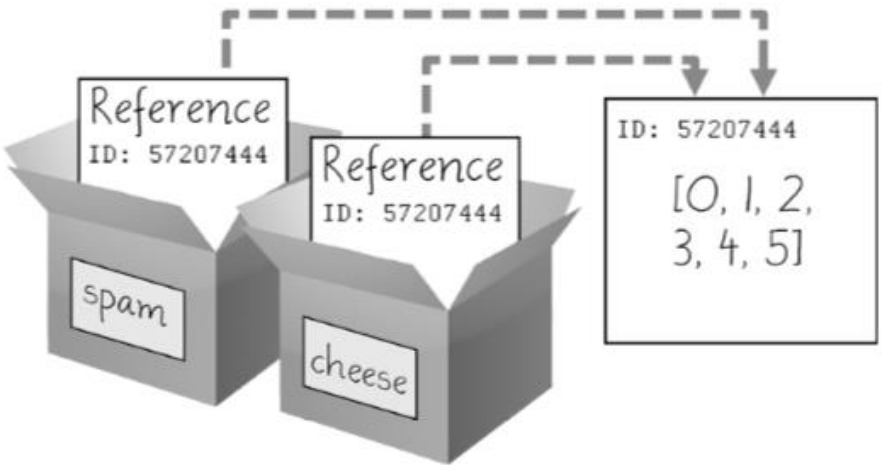


Figure 4-5: spam = cheese copies the reference, not the list.

When you alter the list that cheese refers to, the list that spam refers to is also changed, because both cheese and spam refer to the same list. You can see this in Figure 4-6.

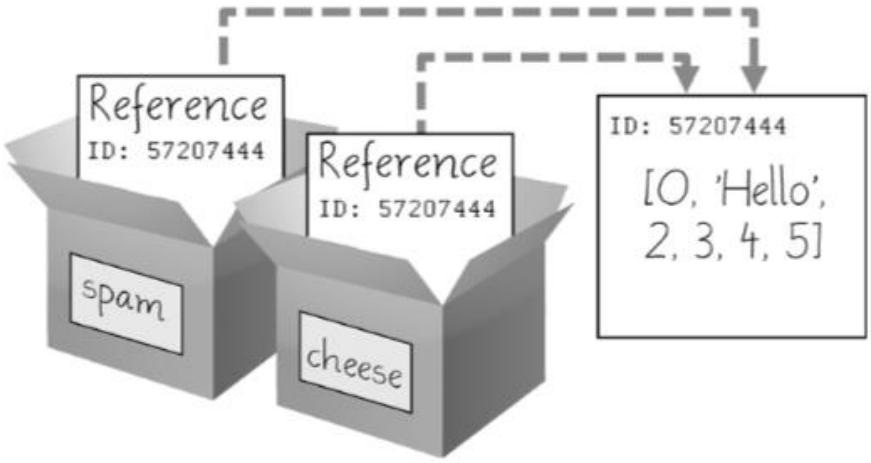


Figure 4-6: cheese[1] = 'Hello!' modifies the list that both variables refer to.

Variables will contain references to list values rather than list values themselves. But for strings and integer values, variables simply contain the string or integer value. Python uses references whenever variables must store values of mutable data types, such as lists or dictionaries. For values of immutable data types such as strings, integers, or tuples, Python vari- ables will store the value itself.

Although Python variables technically contain references to list or dic- tionary values, people often casually say that the variable contains the list or dictionary.

Passing References

References are particularly important for understanding how arguments get passed to functions. When a function is called, the values of the argu- ments are copied to the parameter variables. For lists (and dictionaries, which I'll describe in the next chapter), this means a copy of the reference is used for the parameter. To see the consequences of this, open a new file editor window, enter the following code, and save it as *passingReference.py*:

```
def eggs(someParameter):
   someParameter.append('Hello')
spam = [1, 2, 3]
eggs(spam)
print(spam)
```

Notice that when eggs() is called, a return value is not used to assign a new value to spam. Instead, it modifies the list in place, directly. When run, this program produces the following output:
[1, 2, 3, 'Hello']

Even though spam and someParameter contain separate references, they both refer to the same list. This is why the append('Hello') method call inside the function affects the list even after the function call has returned.
Keep this behavior in mind: Forgetting that Python handles list and dictionary variables this way can lead to confusing bugs.

The copy Module's copy() and deepcopy() Functions

Python provides a module named copy that provides both the copy() and deepcopy() functions. The first of these, copy.copy(), can be used to make a duplicate copy of a mutable value like a list or dictionary, not just a copy of a reference. Enter the following into the interactive shell:

```
>>> import copy
>>> spam = ['A', 'B', 'C', 'D'] >>> cheese = copy.copy(spam) >>> cheese[1] = 42
>>> spam
['A', 'B', 'C', 'D']
>>> cheese
['A', 42, 'C', 'D']
```

Now the spam and cheese variables refer to separate lists, which is why only the list in cheese is modified when you assign 42 at index 7. As you can see in Figure 4-7, the reference ID numbers are no longer the same for both vari- ables because the variables refer to independent lists.

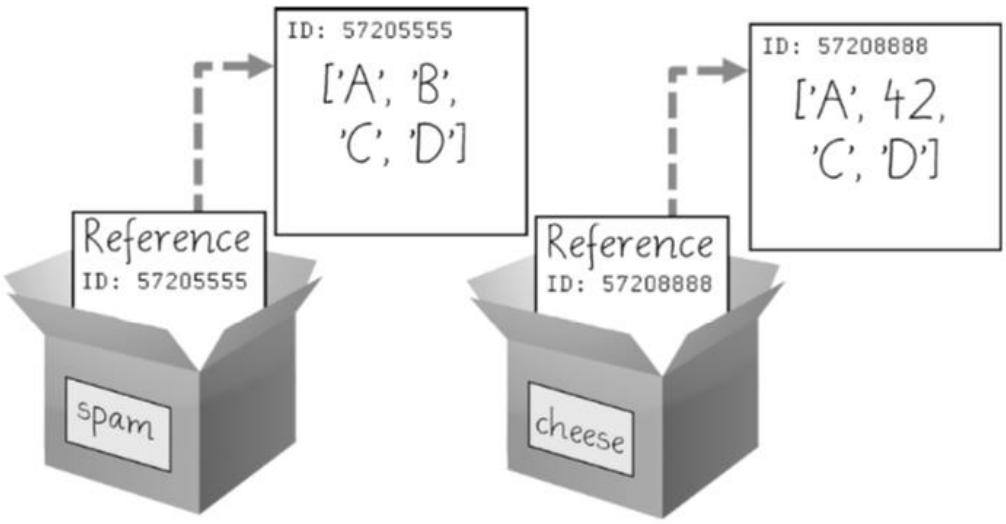


Figure 4-7: cheese = copy.copy(spam) creates a second list that can be modified independently of the first.

If the list you need to copy contains lists, then use the copy.deepcopy() function instead of copy.copy(). The deepcopy() function will copy these inner lists as well.

Summary

Lists are useful data types since they allow you to write code that works on a modifiable number of values in a single variable. Later in this book, you will see programs using lists to do things that would be difficult or impossible to do without them.

Lists are mutable, meaning that their contents can change. Tuples and strings, although list-like in some respects, are immutable and cannot be changed. A variable that contains a tuple or string value can be overwritten with a new tuple or string value, but this is not the same thing as modifying the existing value in place—like, say, the append() or remove() methods do on lists.

Variables do not store list values directly; they store *references* to lists. This is an important distinction when copying variables or passing lists as arguments in function calls. Because the value that is being copied is the list reference, be aware that any changes you make to the list might impact another variable in your program. You can use copy() or deepcopy() if you want to make changes to a list in one variable without modifying the origi- nal list.

CH 5. Dictionaries And Structuring Data

In this chapter, we will cover the dictionary data type, which provides a flexible way to access and organize data. Then, combining dictionaries with your knowledge of lists from the previous chapter, you'll learn how to create a data structure to model a tic-tac-toe board.

The dictionary data type:

A *dictionary* is a collection of many values. But unlike indexes for lists, indexes for dictionaries can use many different data types, not just integers. Indexes for dictionaries are called *keys*, and a key with its associ- ated value is called a *key-value pair*. In code, a dictionary is typed with braces, {}
e.g.
>>> myCat = {'size': 'fat', 'color': 'gray', 'disposition': 'loud'}

This assigns a dictionary to the myCat variable. This dictionary's keys are 'size', 'color', and 'disposition'. The values for these keys are 'fat', 'gray', and 'loud', respectively. You can access these values through their keys:

>>> myCat['size']
'fat'
>>> 'My cat has ' + myCat['color'] + ' fur.'
'My cat has gray fur.'

Dictionaries can still use integer values as keys, just like lists use inte- gers for indexes, but they do not have to start at 0 and can be any number.

>>> **spam = {12345: 'Luggage Combination', 42: 'The Answer'}**

Dictionaries vs. Lists

Unlike lists, items in dictionaries are unordered. The first item in a list named spam would be spam[0]. But there is no "first" item in a dictionary. While the order of items matters for determining whether two lists are the same, it does not matter in what order the key-value pairs are typed in a dic- tionary. Enter the following into the interactive shell:

>>> **spam = ['cats', 'dogs', 'moose']**
>>> bacon = ['dogs', 'moose', 'cats']
>>> **spam == bacon**
False
>>> **eggs = {'name': 'Zophie', 'species': 'cat', 'age': '8'}**
>>> **ham = {'species': 'cat', 'age': '8', 'name': 'Zophie'}**
>>> **eggs == ham**
True

Because dictionaries are not ordered, they can't be sliced like lists.

Trying to access a key that does not exist in a dictionary will result in a KeyError error message, much like a list's "out-of-range" IndexError error message. Enter the following into the interactive shell, and notice the error message that shows up because there is no 'color' key:

```
>>> spam = {'name': 'Zophie', 'age': 7}
>>> spam['color']
Traceback (most recent call last):
  File "<pyshell#1>", line 1, in <module>
    spam['color']
KeyError: 'color'
```

Though dictionaries are not ordered, the fact that you can have arbi- trary values for the keys allows you to organize your data in powerful ways. Say you wanted your program to store data about your friends' birthdays. You can use a dictionary with the names as keys and the birthdays as values. Open a new file editor window and enter the following code. Save it as *birth- days.py*.

```
birthdays = {'Alice': 'Apr 1', 'Bob': 'Dec 12', 'Carol': 'Mar 4'}

while True:
    print('Enter a name: (blank to quit)')
    name = input()
    if name == '':
break
    if name in birthdays:
        print(birthdays[name] + ' is the birthday of ' + name)
    else:
        print('I do not have birthday information for ' + name)
        print('What is their birthday?')
        bday = input()
        birthdays[name] = bday
        print('Birthday database updated.')
```

Output:

```
Enter a name: (blank to quit)
Alice
Apr 1 is the birthday of Alice
Enter a name: (blank to quit)
Eve
I do not have birthday information for Eve What is their birthday?
Dec 5
Birthday database updated. Enter a name: (blank to quit) Eve
Dec 5 is the birthday of Eve Enter a name: (blank to quit)
```

The keys(), values(), and items() Methods

There are three dictionary methods that will return list-like values of the dictionary's keys, values, or both keys and values: keys(), values(), and items(). The values returned by these methods are not true lists: They cannot be modified and do not have an append() method. But these data types (dict_keys, dict_values, and dict_items, respectively) *can* be used in for loops. To see how these methods work, enter the following into the interactive shell:

```
>>> spam = {'color': 'red', 'age': 42}
>>> for v in spam.values():
        print(v)
red
 42
```

Here, a for loop iterates over each of the values in the spam dictionary. A for loop can also iterate over the keys or both keys and values:

```
>>> for k in spam.keys():
        print(k)
color
age
>>> for i in spam.items():
        print(i)
('color', 'red')
('age', 42)
```

If you want a true list from one of these methods, pass its list-like return value to the list() function. Enter the following into the interactive shell:

```
>>> spam = {'color': 'red', 'age': 42}
>>> spam.keys()
dict_keys(['color', 'age'])
>>> list(spam.keys())
['color', 'age']
```

The list(spam.keys()) line takes the dict_keys value returned from keys() and passes it to list(), which then returns a list value of ['color', 'age'].

You can also use the multiple assignment trick in a for loop to assign the key and value to separate variables. Enter the following into the inter- active shell:

```
>>> spam = {'color': 'red', 'age': 42}
>>> for k, v in spam.items():
    print('Key: ' + k + ' Value: ' + str(v))
Key: age Value: 42
Key: color Value: red
```

Checking Whether a Key or Value Exists in a Dictionary

in and not operators are used to see whether a certain key or value exists in a dictionary

E.g.

```
>>> spam = {'name': 'Zophie', 'age': 7}
>>> 'name' in spam.keys()
True
>>> 'Zophie' in spam.values()
True
>>> 'color' in spam.keys()
False
>>> 'color' not in spam.keys()
 True
>>> 'color' in spam
False
```

The get() Method

Dictionaries have a get() method that takes two arguments: the key of the value to retrieve and a fallback value to return if that key does not exist.

Enter the following into the interactive shell:

```
>>> picnicItems = {'apples': 5, 'cups': 2}
>>> 'I am bringing ' + str(picnicItems.get('cups', 0)) + ' cups.'
'I am bringing 2 cups.'
>>> 'I am bringing ' + str(picnicItems.get('eggs', 0)) + ' eggs.'
 'I am bringing 0 eggs.'
```

Because there is no 'eggs' key in the picnicItems dictionary, the default value 0 is returned by the get() method.

Without using get(), the code would have caused an error message, such as in the following example:

```
>>> picnicItems = {'apples': 5, 'cups': 2}
>>> 'I am bringing ' + str(picnicItems['eggs']) + ' eggs.'
Traceback (most recent call last):
  File "<pyshell#34>", line 1, in <module>
    'I am bringing ' + str(picnicItems['eggs']) + ' eggs.'
KeyError: 'eggs'
```

The setdefault() Method

You'll often have to set a value in a dictionary for a certain key only if that key does not already have a value. The code looks something like this:

```
spam = {'name': 'Pooka', 'age': 5}
 if 'color' not in spam:
        spam['color'] = 'black'
```

The setdefault() method offers a way to do this in one line of code. The first argument passed to the method is the key to check for, and the second argument is the value to set at that key if the key does not exist. If the key does exist, the setdefault() method returns the key's value.

```
>>> spam = {'name': 'Pooka', 'age': 5}
>>> spam.setdefault('color', 'black')
'black'
>>> spam
{'color': 'black', 'age': 5, 'name': 'Pooka'}
 >>> spam.setdefault('color', 'white')
'black'
>>> spam
            {'color': 'black', 'age': 5, 'name': 'Pooka'}
```

The first time setdefault() is called, the dictionary in spam changes to {'color': 'black', 'age': 5, 'name': 'Pooka'}. The method returns the value 'black' because this is now the value set for the key 'color'. When spam.setdefault('color', 'white') is called next, the value for that key is *not* changed to 'white' because spam already has a key named 'color'.

The setdefault() method is a nice shortcut to ensure that a key exists.

program that counts the number of occurrences of each let- ter in a string.

```
message = 'It was a bright cold day in April, and the clocks were striking thirteen.'
count = {}
for character in message:
   count.setdefault(character, 0)
   count[character] = count[character] + 1
print(count)
```

Output:

```
{' ': 13, ',': 1, '.': 1, 'A': 1, 'I': 1, 'a': 4, 'c': 3, 'b': 1, 'e': 5, 'd': 3, 'g': 2, 'i':
6, 'h': 3, 'k': 2, 'l': 3, 'o': 2, 'n': 4, 'p': 1, 's': 3, 'r': 5, 't': 6, 'w': 2, 'y': 1}
```

From the output, you can see that the lowercase letter *c* appears 3 times, the space character appears 13 times, and the uppercase letter *A* appears
1 time. This program will work no matter what string is inside the message variable, even if the string is millions of characters long!

Pretty Printing

If you import the pprint module into your programs, you'll have access to the pprint() and pformat() functions that will "pretty print" a dictionary's values. This is helpful when you want a cleaner display of the items in a dictionary than what print() provides.

program that counts the number of occurrences of each let- ter in a string.

```
import pprint
message = 'It was a bright cold day in April, and the clocks were striking thirteen.'
count = {}
for character in message:
        count.setdefault(character, 0)
        count[character] = count[character] + 1
pprint.pprint(count)
```

This time, when the program is run, the output looks much cleaner,
with the keys sorted.

```
{' ': 13,
 ',': 1,
 '.': 1,
 'A': 1,
 'I': 1,
 'a': 4,
 'b': 1,
 'c': 3,
 'd': 3,
 'e': 5,
 'g': 2,
 'h': 3,
 'i': 6,
 'k': 2,
 'l': 3,
 'n': 4,
 'o': 2,
 'p': 1,
 'r': 5,
 's': 3,
 't': 6,
 'w': 2,
 'y': 1}
```

The pprint.pprint() function is especially helpful when the dictionary itself contains nested lists or dictionaries.
If you want to obtain the prettified text as a string value instead of dis- playing it on the screen, call pprint.pformat() instead. These two lines are equivalent to each other:

```
pprint.pprint(someDictionaryValue)
print(pprint.pformat(someDictionaryValue))
```

using data Structures to model real-world things

Computers have good memories. A program on a modern computer can easily store billions of strings

They model data to repre- sent a chessboard, and you can write code to work with this model.

This is where lists and dictionaries can come in. You can use them to model real-world things, like chessboards. For the first example, you'll use a game that's a little simpler than chess: tic-tac-toe.

A Tic-Tac-Toe Board

A tic-tac-toe board looks like a large hash symbol (#) with nine slots that can each contain an *X*, an *O*, or a blank. To repre- sent the board with a dictionary, you can assign each slot a string-value key, as shown in Figure 5-2.

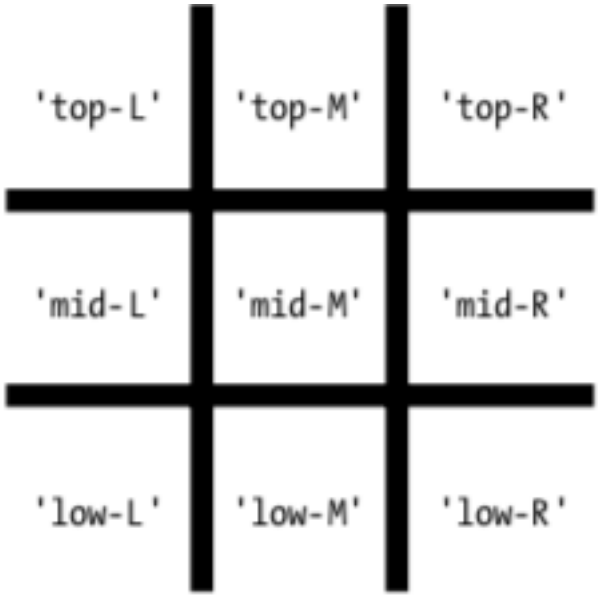


Figure 5-2: The slots of a tic-tac-toe board with their corresponding keys

This dictionary is a data structure that represents a tic-tac-toe board. Store this board-as-a-dictionary in a variable named theBoard. Open a new file editor window, and enter the following source code, saving it as *ticTacToe.py* :

```
theBoard = {'top-L': ' ', 'top-M': ' ', 'top-R': ' ',
            'mid-L': ' ', 'mid-M': ' ', 'mid-R': ' ',
            'low-L': ' ', 'low-M': ' ', 'low-R': ' '}
```

It will create and empty tic tac toe board

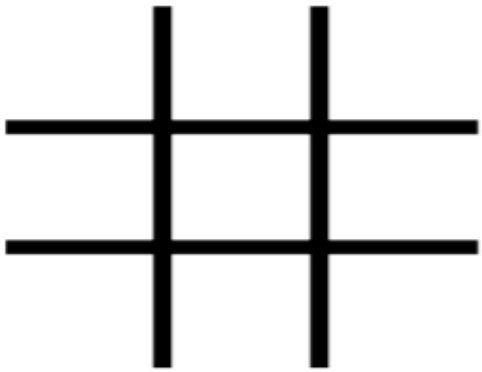


Figure 5-3: An empty tic-tac-toe board

Now If player X went first and chose the middle space, you could represent that board with this dictionary:

```
theBoard = {'top-L': ' ', 'top-M': ' ', 'top-R': ' ',
            'mid-L': ' ', 'mid-M': 'X', 'mid-R': ' ',
            'low-L': ' ', 'low-M': ' ', 'low-R': ' '}
```

The data structure in theBoard now represents the tic-tac-toe board in Figure 5-4.

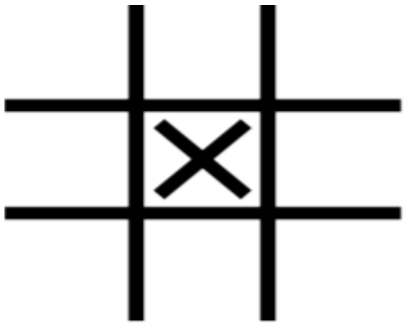


Figure 5-4: The first move

A board where player O has won by placing *O*s across the top might look like this:

```
theBoard = {'top-L': 'O', 'top-M': 'O', 'top-R': 'O',
            'mid-L': 'X', 'mid-M': 'X', 'mid-R': ' ',
            'low-L': ' ', 'low-M': ' ', 'low-R': 'X'}
```

The data structure in theBoard now represents the tic-tac-toe board in Figure 5-5.

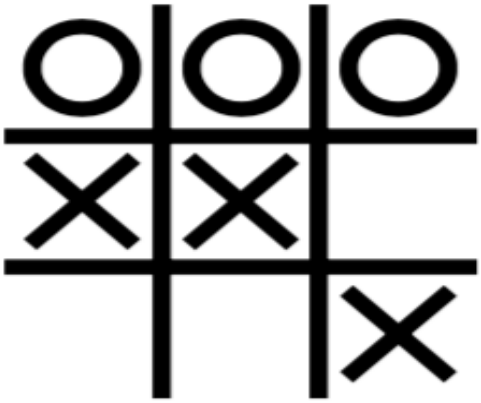


Figure 5-5: Player O wins.

Now Let's create a function to print the board dictionary onto the screen.

```
theBoard = {'top-L': ' ', 'top-M': ' ', 'top-R': ' ',
            'mid-L': ' ', 'mid-M': ' ', 'mid-R': ' ',
            'low-L': ' ', 'low-M': ' ', 'low-R': ' '}
def printBoard(board):
    print(board['top-L'] + '|' + board['top-M'] + '|' + board['top-R'])
    print('-+-+-')
    print(board['mid-L'] + '|' + board['mid-M'] + '|' + board['mid-R'])
    print('-+-+-')
    print(board['low-L'] + '|' + board['low-M'] + '|' + board['low-R'])
printBoard(theBoard)
```

When you run this program, printBoard() will print out a blank tic-tac- toe board like below

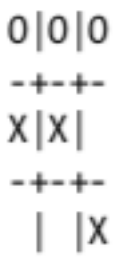
```
  |  |
-+-+-
  |  |
-+-+-
  |  |
```

The printBoard() function can handle any tic-tac-toe data structure you pass it. Try changing the code to the following:

theBoard = **{'top-L': 'O', 'top-M': 'O', 'top-R': 'O', 'mid-L': 'X', 'mid-M': 'X', 'mid-R': ' ', 'low-L': ' ', 'low-M': ' ', 'low-R': 'X'}**

```
def printBoard(board):
    print(board['top-L'] + '|' + board['top-M'] + '|' + board['top-R'])
    print('-+-+-')
    print(board['mid-L'] + '|' + board['mid-M'] + '|' + board['mid-R'])
    print('-+-+-')
    print(board['low-L'] + '|' + board['low-M'] + '|' + board['low-R'])
printBoard(theBoard)
```

Now when you run this program, the new board will be printed to the screen.



Now let's add code that allows the players to enter their moves. Modify the *ticTacToe.py* program to look like this:

theBoard = **{'top-L': ' ', 'top-M': ' ', 'top-R': ' ', 'mid-L': ' ', 'mid-M': ' ', 'mid-R': ' ', 'low-L': ' ', 'low-M': ' ', 'low-R': ' '}**

```
  def printBoard(board):
      print(board['top-L'] + '|' + board['top-M'] + '|' + board['top-R'])
      print('-+-+-')
      print(board['mid-L'] + '|' + board['mid-M'] + '|' + board['mid-R'])
      print('-+-+-')
      print(board['low-L'] + '|' + board['low-M'] + '|' + board['low-R'])
turn = 'X'
  for i in range(9):
          printBoard(theBoard)
          print('Turn for ' + turn + '. Move on which space?')
          move = input()
          theBoard[move] = turn
           if turn == 'X':
                turn = 'O'
           else:
                 turn = 'X'
printBoard(theBoard)
```

Output:

```
 | |
-+-+-
 | |
-+-+-
 | |
Turn for X. Move on which space?
mid-M
 | |
-+-+-
 |X|
-+-+-
 | |
Turn for O. Move on which space?
low-L
 | |
-+-+-
 |X|
-+-+-
O| |

--snip--

O|O|X
-+-+-
X|X|O
-+-+-
O| |X
Turn for X. Move on which space?
low-M
O|O|X
-+-+-
X|X|O
-+-+-
O|X|X
```

This isn't a complete tic-tac-toe game—for instance, it doesn't ever check whether a player has won—but it's enough to see how data structures can be used in programs.

Nested Dictionaries and Lists

Modeling a tic-tac-toe board was fairly simple: The board needed only a single dictionary value with nine key-value pairs. As you model more com- plicated things, you may find you need dictionaries and lists that contain other dictionaries and lists. Lists are useful to contain an ordered series of values, and dictionaries are useful for associating keys with values. For example, here's a program that uses a dictionary that contains other dic- tionaries in order to see who is bringing what to a picnic. The totalBrought() function can read this data structure and calculate the total number of an item being brought by all the guests.

```
allGuests = {'Alice': {'apples': 5, 'pretzels': 12},
             'Bob': {'ham sandwiches': 3, 'apples': 2},
             'Carol': {'cups': 3, 'apple pies': 1}}

def totalBrought(guests, item):
    numBrought = 0
    for k, v in guests.items():
        numBrought = numBrought + v.get(item, 0)
    return numBrought

print('Number of things being brought:')
print(' - Apples         ' + str(totalBrought(allGuests, 'apples')))
print(' - Cups           ' + str(totalBrought(allGuests, 'cups')))
print(' - Cakes          ' + str(totalBrought(allGuests, 'cakes')))
print(' - Ham Sandwiches ' + str(totalBrought(allGuests, 'ham sandwiches')))
print(' - Apple Pies     ' + str(totalBrought(allGuests, 'apple pies')))
```

Inside the totalBrought() function, the for loop iterates over the key- value pairs in guests. Inside the loop, the string of the guest's name is assigned to k, and the dictionary of picnic items they're bringing is assigned to v. If the item parameter exists as a key in this dictionary, it's value (the quantity) is added to numBrought. If it does not exist as a key, the get() method returns 0 to be added to numBrought.

The output of this program looks like this:

Number of things being brought:
- Apples 7
- Cups 3
- Cakes 0
- Ham Sandwiches 3
- Apple Pies 1

This may seem like such a simple thing to model that you wouldn't need to bother with writing a program to do it. But realize that this same totalBrought() function could easily handle a dictionary that contains thou- sands of guests, each bringing *thousands* of different picnic items. Then having this information in a data structure along with the totalBrought() function would save you a lot of time!

Summary

You learned all about dictionaries in this chapter. Lists and dictionaries are values that can contain multiple values, including other lists and dic- tionaries. Dictionaries are useful because you can map one item (the key) to another (the value), as opposed to lists, which simply contain a series of values in order. Values inside a dictionary are accessed using square brackets just as with lists. Instead of an integer index, dictionaries can have keys of a variety of data types: integers, floats, strings, or tuples. By organiz- ing a program's values into data structures, you can create representations of real-world objects. You saw an example of this with a tic-tac-toe board.

That just about covers all the basic concepts of Python programming! You'll continue to learn new concepts throughout the rest of this book,
but you now know enough to start writing some useful programs that can automate tasks. You might not think you have enough Python knowledge to do things such as download web pages, update spreadsheets, or send text messages, but that's where Python modules come in! These modules, writ- ten by other programmers, provide functions that make it easy for you to do all these things. So let's learn how to write real programs to do useful automated tasks.

CH 6 Manipulating Strings

working with Strings

String Literals

Typing string values in Python code is fairly straightforward: They begin and end with a single quote. But then how can you use a quote inside a string? Typing **'That is Alice's cat.'** won't work, because Python thinks the string ends after Alice, and the rest (s cat.') is invalid Python code. Fortunately, there are multiple ways to type strings.

Double Quotes

Strings can begin and end with double quotes, just as they do with single quotes. One benefit of using double quotes is that the string can have a single quote character in it. Enter the following into the interactive shell:

>>> **spam = "That is Alice's cat."**

Since the string begins with a double quote, Python knows that the single quote is part of the string and not marking the end of the string. However, if you need to use both single quotes and double quotes in the string, you'll need to use escape characters.

An *escape character* lets you use characters that are otherwise impossible to put into a string. An escape character consists of a backslash (\) followed by the character you want to add to the string.

E.g.

>>> **spam = 'Say hi to Bob\'s mother.'**

Python knows that since the single quote in Bob\'s has a backslash, it is not a single quote meant to end the string value. The escape characters \' and \" let you put single quotes and double quotes inside your strings, respectively.

Table 6-1: Escape Characters

Escape character	Prints as
\'	Single quote
\"	Double quote
\t	Tab
\n	Newline (line break)
\\	Backslash

E.g.

>>> **print("Hello there!\nHow are you?\nI\'m doing fine.")**

Hello there!
How are you?
I'm doing fine.

raw Strings

You can place an r before the beginning quotation mark of a string to make it a raw string. A *raw string* completely ignores all escape characters and prints any backslash that appears in the string. For example, type the fol- lowing into the interactive shell:

>>> **print(r'That is Carol\'s cat.')**

That is Carol\'s cat.

Because this is a raw string, Python considers the backslash as part of the string and not as the start of an escape character. Raw strings are help- ful if you are typing string values that contain many backslashes,

Multiline Strings with triple Quotes

While you can use the \n escape character to put a newline into a string, it is often easier to use multiline strings. A multiline string in Python begins and ends with either three single quotes or three double quotes. Any quotes, tabs, or newlines in between the “triple quotes” are considered part of the string. Python’s indentation rules for blocks do not apply to lines inside a multiline string.

E.g.

print('''Dear Alice,
Eve's cat has been arrested for catnapping, cat burglary, and extortion.

```
Sincerely,
Bob"')
```

Output

```
Dear Alice,
Eve's cat has been arrested for catnapping, cat burglary, and extortion.
Sincerely,
Bob
```

Notice that the single quote character in Eve's does not need to be escaped. Escaping single and double quotes is optional in raw strings. The following print() call would print identical text but doesn't use a multiline string:

```
print('Dear Alice,\n\nEve\'s cat has been arrested for catnapping, cat
burglary, and extortion.\n\nSincerely,\nBob')
```

Multiline Comments

While the hash character (#) marks the beginning of a comment for the rest of the line, a multiline string is often used for comments that span mul- tiple lines.

e.g.

```
"""This is a test Python program.
Written by Al Sweigart al@inventwithpython.com
This program was designed for Python 3, not Python 2.
"""
def spam():
    """This is a multiline comment to help
    explain what the spam() function does."""
    print('Hello!')
```

Indexing and Slicing Strings

Strings use indexes and slices the same way lists do. You can think of the string 'Hello world!' as a list and each character in the string as an item with a corresponding index.

'	H	e	l	l	o		w	o	r	l	d	!	'
	0	1	2	3	4	5	6	7	8	9	10	11	

The space and exclamation point are included in the character count, so 'Hello world!' is 12 characters long, from H at index 0 to ! at index 11.

E.g.
>>> **spam = 'Hello world!'**
>>> **spam[0]**
'H'
>>> **spam[4]**
'o'
>>> **spam[-1]**
'!'
>>> **spam[0:5]**
'Hello'
>>> spam[:5]
'Hello'
>>> spam[6:]
'world!'
Note that slicing a string does not modify the original string. You can capture a slice from one variable in a separate variable. Try typing the fol- lowing into the interactive shell:

>>> **spam = 'Hello world!'**
>>> **fizz = spam[0:5]**
>>> **fizz**
'Hello'

By slicing and storing the resulting substring in another variable, you can have both the whole string and the substring handy for quick, easy access.

The in and not in Operators with Strings

The in and not in operators can be used with strings just like with list values.

E.g.
>>> 'Hello' in 'Hello World'
True
>>> 'Hello' in 'Hello'
True
>>> 'HELLO' in 'Hello World'
False
>>> '' in 'spam'
True
>>> 'cats' not in 'cats and dogs'
False

useful String methods

The upper(), lower(), isupper(), and islower() String Methods

The upper() and lower() string methods return a new string where all the letters in the original string have been converted to uppercase or lower- case, respectively. Nonletter characters in the string remain unchanged.

```
>>> spam = 'Hello world!'
>>> spam = spam.upper()
>>> spam
'HELLO WORLD!'
>>> spam = spam.lower()
>>> spam
'hello world!'
```

Note that these methods do not change the string itself but return new string values.

The upper() and lower() methods are helpful if you need to make a case-insensitive comparison. The strings 'great' and 'GREat' are not equal to each other. But in the following small program, it does not matter whether the user types Great, GREAT, or grEAT, because the string is first converted to lowercase.

```
print('How are you?')
feeling = input()
if feeling.lower() == 'great':
    print('I feel great too.')
else:
    print('I hope the rest of your day is good.')
```

output:
How are you?
GREat
I feel great too.

The isupper() and islower() methods will return a Boolean True value if the string has at least one letter and all the letters are uppercase or lowercase, respectively. Otherwise, the method returns False. Enter the following into the interactive shell, and notice what each method call returns:

```
>>> spam = 'Hello world!'
>>> spam.islower()
False
>>> spam.isupper()
False
>>> 'HELLO'.isupper()
True
>>> 'abc12345'.islower()
True
>>> '12345'.islower()
```

False
>>> '12345'.isupper()
False

The isX String Methods

Along with islower() and isupper(), there are several string methods that have names beginning with the word *is*. These methods return a Boolean value that describes the nature of the string. Here are some common is*X* string methods:

- isalpha() returns True if the string consists only of letters and is not blank.
- isalnum() returns True if the string consists only of letters and numbers and is not blank.
- isdecimal() returns True if the string consists only of numeric characters and is not blank.
- isspace() returns True if the string consists only of spaces, tabs, and new- lines and is not blank.
- istitle() returns True if the string consists only of words that begin with an uppercase letter followed by only lowercase letters.

The is*X* string methods are helpful when you need to validate user input. For example, the following program repeatedly asks users for their age and a password until they provide valid input. Open a new file editor window and enter this program, saving it as *validateInput.py*:

```
1. while True:
2.     print('Enter your age:')
3.     age = input()
4.     if age.isdecimal():
5.         break
6.     print('Please enter a number for your age.')
7. while True:
8.     print('Select a new password (letters and numbers only):')
9.     password = input()
10.    if password.isalnum():
11.        break
12.    print('Passwords can only have letters and numbers.')
```

When run, the program's output looks like this:

```
Enter your age:
forty two
Please enter a number for your age.
Enter your age:
42
Select a new password (letters and numbers only):
secr3t!
Passwords can only have letters and numbers.
Select a new password (letters and numbers only):
secr3t
```

The startswith() and endswith() String Methods

The startswith() and endswith() methods return True if the string value they are called on begins or ends (respectively) with the string passed to the method; otherwise, they return False. Enter the following into the inter- active shell:

```
>>> 'Hello world!'.startswith('Hello')
True
>>> 'Hello world!'.endswith('world!')
True
>>> 'abc123'.startswith('abcdef')
False
>>> 'abc123'.endswith('12')
False
>>> 'Hello world!'.startswith('Hello world!')
True
>>> 'Hello world!'.endswith('Hello world!')
True
```

These methods are useful alternatives to the == equals operator if you need to check only whether the first or last part of the string, rather than the whole thing, is equal to another string.

The join() and split() String Methods

The join() method is useful when you have a list of strings that need to be joined together into a single string value. The join() method is called on a string, gets passed a list of strings, and returns a string. The returned string is the concatenation of each string in the passed-in list. For example, enter the following into the interactive shell:

```
>>> ', '.join(['cats', 'rats', 'bats'])
'cats, rats, bats'
>>> ' '.join(['My', 'name', 'is', 'Simon'])
'My name is Simon'
>>> 'ABC'.join(['My', 'name', 'is', 'Simon'])
 'MyABCnameABCisABCSimon'
```

Remember that join() is called on a string value and is passed a list value. (It's easy to accidentally call it the other way around.) The split() method does the opposite: It's called on a string value and returns a list of strings. Enter the following into the interactive shell:

```
>>> 'My name is Simon'.split()
['My', 'name', 'is', 'Simon']
```

You can pass a delimiter string to the split() method to specify a different string to split upon. For example, enter the following into the interactive shell:

```
>>> 'MyABCnameABCisABCSimon'.split('ABC')
['My', 'name', 'is', 'Simon']
>>> 'My name is Simon'.split('m')
['My na', 'e is Si', 'on']
```

A common use of split() is to split a multiline string along the newline characters. Enter the following into the interactive shell:

```
>>> spam = '''Dear Alice,
How have you been? I am fine. There is a container in the fridge that is labeled "Milk Experiment".
Please do not drink it.
Sincerely,
Bob'''
>>> spam.split('\n')
['Dear Alice,', 'How have you been? I am fine.', 'There is a container in the fridge', 'that is labeled "Milk Experiment".', '', 'Please do not drink it.', 'Sincerely,', 'Bob']
```

Passing split() the argument '\n' lets us split the multiline string stored in spam along the newlines and return a list in which each item corresponds to one line of the string.

The rjust() and ljust() string methods return a padded version of the string they are called on, with spaces inserted to justify the text. The first argument to both methods is an integer length for the justified string. Enter the following into the interactive shell:

```
>>> 'Hello'.rjust(10)
'     Hello'
>>> 'Hello'.rjust(20)
'               Hello'
>>> 'Hello World'.rjust(20)
'         Hello World'
>>> 'Hello'.ljust(10)
'Hello     '
```

'Hello'.rjust(10) says that we want to right-justify 'Hello' in a string of total length 10. 'Hello' is five characters, so five spaces will be added to its left, giving us a string of 10 characters with 'Hello' justified right.

An optional second argument to rjust() and ljust() will specify a fill character other than a space character. Enter the following into the inter- active shell:

```
>>> 'Hello'.rjust(20, '*')
```

```
'***************Hello'
>>> 'Hello'.ljust(20, '-')

'Hello---------------'
```

The center() string method works like ljust() and rjust() but centers the text rather than justifying it to the left or right. Enter the following into the interactive shell:

```
>>> 'Hello'.center(20)
'            Hello           '
>>> 'Hello'.center(20, '=')

 '=======Hello========'
```

These methods are especially useful when you need to print tabular data that has the correct spacing. Open a new file editor window and enter the following code, saving it as *picnicTable.py*:

```
def printPicnic(itemsDict, leftWidth, rightWidth):
    print('PICNIC ITEMS'.center(leftWidth + rightWidth, '-'))
    for k, v in itemsDict.items():
        print(k.ljust(leftWidth, '.') + str(v).rjust(rightWidth))
picnicItems = {'sandwiches': 4, 'apples': 12, 'cups': 4, 'cookies': 8000}
printPicnic(picnicItems, 12, 5)
printPicnic(picnicItems, 20, 6)
```

When you run this program, the picnic items are displayed twice. The first time the left column is 12 characters wide, and the right column is 5 characters wide. The second time they are 20 and 6 characters wide, respectively.

```
---PICNIC ITEMS--
sandwiches..    4
apples.....   12
cups.....    4
cookies..... 8000
-------PICNIC ITEMS-------
sandwiches.....     4
apples.....    12
cups.....     4
cookies.....  8000
```

Using rjust(), ljust(), and center() lets you ensure that strings are neatly aligned, even if you aren’t sure how many characters long your strings are.

Removing Whitespace with strip(), rstrip(), and lstrip()

The strip() string method will return a new string without any whitespace characters at the beginning or end.

The lstrip() and rstrip() methods will remove whitespace characters from the left and right ends, respectively. Enter the following into the interactive shell:

```
>>> spam = '    Hello World     '
>>> spam.strip()
'Hello World'
>>> spam.lstrip()
'Hello World     '
>>> spam.rstrip()
'    Hello World'
```

Copying and Pasting Strings with the pyperclip Module

The pyperclip module has copy() and paste() functions that can send text to and receive text from your computer's clipboard. Sending the output of your program to the clipboard will make it easy to paste it to an email, word processor, or some other software.

```
>>> import pyperclip
>>> pyperclip.copy('Hello world!')
>>> pyperclip.paste()
'Hello world!'
```

if something outside of your program changes the clipboard contents, the paste() function will return it. For example, if I copied this sentence to the clipboard and then called paste(), it would look like this:

```
>>> pyperclip.paste()
'For example, if I copied this sentence to the clipboard and then called paste(), it would look like this:'
```

Project: Password locker

Step 1: Program Design and Data Structures

You probably have accounts on many different websites. It's a bad habit to use the same password for each of them because if any of those sites has a security breach, the hackers will learn the password to all of your other accounts. It's best to use password manager software on your computer that uses one master password to unlock the password manager. Then you can copy any account password to the clipboard and paste it into the website's Password field.

Open a new file editor window and save the program as *pw.py*

```
#! python3
# pw.py - An insecure password locker program.
PASSWORDS = {'email': 'F7minlBDDuvMJuxESSKHFhTxFtjVB6',
        'blog': 'VmALvQyKAxiVH5G8v01if1MLZF3sdt',
        'luggage': '12345'}
```

Step 2: Handle Command Line Arguments

The command line arguments will be stored in the variable sys.argv. (See Appendix B for more information on how to use command line arguments in your programs.) The first item in the sys.argv list should always be a string containing the program's filename ('pw.py'), and the second item should

be the first command line argument. For this program, this argument is the name of the account whose password you want. Since the command line argument is mandatory, you display a usage message to the user if they forget to add it (that is, if the sys.argv list has fewer than two values in it). Make your program look like the following:

```
#! python3
# pw.py - An insecure password locker program.
PASSWORDS = {'email': 'F7minlBDDuvMJuxESSKHFhTxFtjVB6',
        'blog': 'VmALvQyKAxiVH5G8v01if1MLZF3sdt',
        'luggage': '12345'}

import sys
if len(sys.argv) < 2:

   print('Usage: python pw.py [account] - copy account password')
   sys.exit()
account = sys.argv[1]    # first command line arg is the account name
```

Step 3: Copy the Right Password

Now that the account name is stored as a string in the variable account, you need to see whether it exists in the PASSWORDS dictionary as a key. If so, you want to copy the key's value to the clipboard using pyperclip.copy(). (Since you're using the pyperclip module, you need to import it.) Note that you don't actually *need* the account variable; you could just use sys.argv[1] every- where account is used in this program. But a variable named account is much more readable than something cryptic like sys.argv[1].

```
#! python3
# pw.py - An insecure password locker program.
PASSWORDS = {'email': 'F7minlBDDuvMJuxESSKHFhTxFtjVB6',
        'blog': 'VmALvQyKAxiVH5G8v01if1MLZF3sdt',
        'luggage': '12345'}

import sys, pyperclip
```

```
 if len(sys.argv) < 2:

        print('Usage: py pw.py [account] - copy account password')
        sys.exit()
account = sys.argv[1]    # first command line arg is the account name
if account in PASSWORDS:
   pyperclip.copy(PASSWORDS[account])
   print('Password for ' + account + ' copied to clipboard.')
else:
   print('There is no account named ' + account)
```

On Windows, you can create a batch file to run this program with the win-r Run window. (For more about batch files, see Appendix B.) Type the following into the file editor and save the file as *pw.bat* in the *C:\Windows* folder:

```
@py.exe C:\Python34\pw.py %*
@pause
```

With this batch file created, running the password-safe program on Windows is just a matter of pressing win-r and typing pw <account name>.

Project: Adding Bullets to wiki markup

When editing a Wikipedia article, you can create a bulleted list by putting each list item on its own line and placing a star in front. But say you have a really large list that you want to add bullet points to. You could just type those stars at the beginning of each line, one by one. Or you could auto- mate this task with a short Python script.

he *bulletPointAdder.py* script will get the text from the clipboard, add a star and space to the beginning of each line, and then paste this new text to the clipboard. For example, if I copied the following text (for the Wikipedia article "List of Lists of Lists") to the clipboard:

```
Lists of animals
 Lists of aquarium life
 Lists of biologists by author abbreviation
 Lists of cultivars
```

and then ran the *bulletPointAdder.py* program, the clipboard would then con- tain the following:

```
 * Lists of animals
 * Lists of aquarium life
 * Lists of biologists by author abbreviation
 * Lists of cultivars
```

This star-prefixed text is ready to be pasted into a Wikipedia article as a bulleted list.

Step 1: Copy and Paste from the Clipboard

Step 2: Separate the Lines of Text and Add the Star

Step 3: Join the Modified Lines

```
#! python3
# bulletPointAdder.py - Adds Wikipedia bullet points to the start
# of each line of text on the clipboard.
import pyperclip
text = pyperclip.paste()
# Separate lines and add stars.
lines = text.split('\n')
for i in range(len(lines)):    # loop through all indexes for "lines" list
    lines[i] = '* ' + lines[i] # add star to each string in "lines" list
text = '\n'.join(lines)
pyperclip.copy(text)
```

When this program is run, it replaces the text on the clipboard with text that has stars at the start of each line. Now the program is complete, and you can try running it with text copied to the clipboard.

Summary

Text is a common form of data, and Python comes with many helpful string methods to process the text stored in string values. You will make use of indexing, slicing, and string methods in almost every Python program you write.

The programs you are writing now don’t seem too sophisticated—they don’t have graphical user interfaces with images and colourful text. So far, you’re displaying text with print() and letting the user enter text with input(). However, the user can quickly enter large amounts of text through the clip- board. This ability provides a useful avenue for writing programs that manip- ulate massive amounts of text. These text-based programs might not have flashy windows or graphics, but they can get a lot of useful work done quickly.

Another way to manipulate large amounts of text is reading and writing files directly off the hard drive. You’ll learn how to do this with Python in the next chapter.