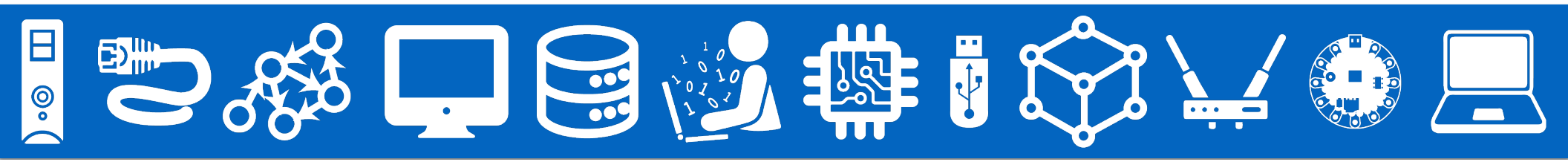
CS134:
Strings, Lists, & Ranges



Announcements & Logistics

- **Lab 1** feedback returned last week
- **Lab 2** feedback coming soon (by Wed)
- **Lab 3** is tonight/tomorrow, due Wed/Thur at 10pm
  - Covers lists, strings, and loops!
- **HW 3** due tonight on Glow

Do You Have Any Questions?

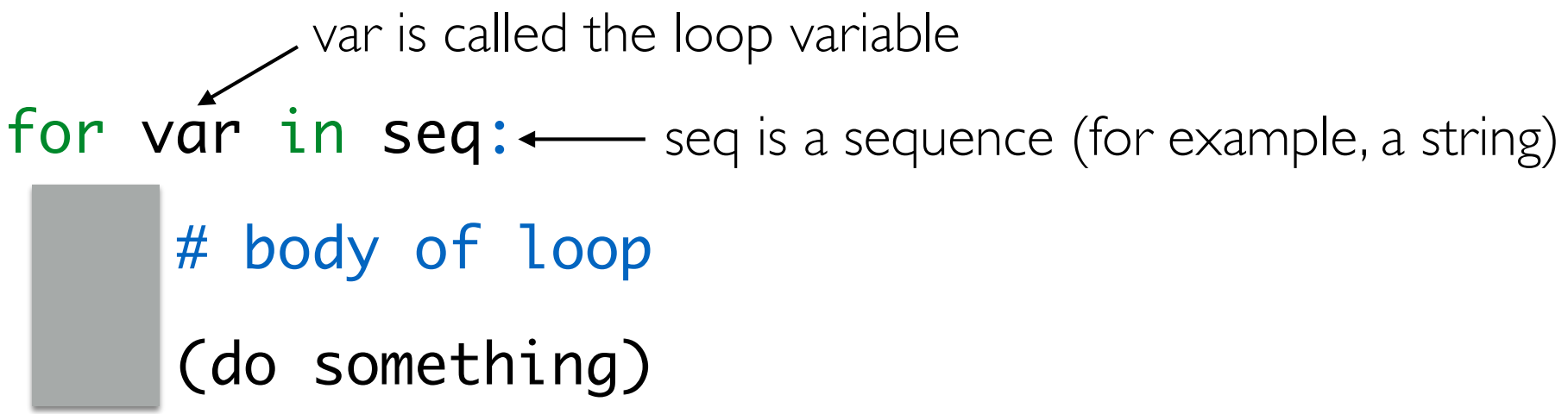
Last Time

- Reviewed iterating over **sequences** with **for loops**
  - Used **accumulation variables** to collect "items" from sequences
- Introduced new sequence: **lists**
  - Learned how to index, slice, concatenate, iterate over lists just like we did with strings

Recap: Iterating with `for` Loops

- Suppose we want to perform an action **for each element** in a sequence
- This is called **looping** or **iterating** over the elements of a sequence

- Syntax of a for loop:



Recap: Counting Vowels

- We can use a for loop to improve our `countVowels()` function
- Notice how `count` "accumulates" values in the loop
- We call `count` an **accumulation variable**
- Works for any string!

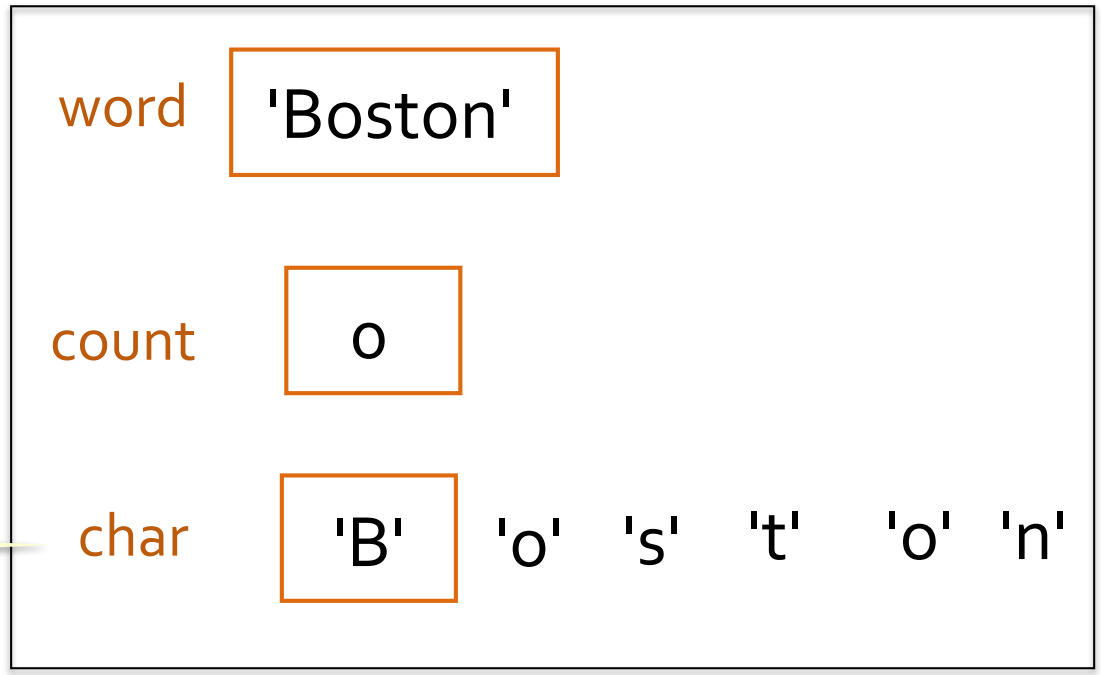
```
def countVowels(word):
    '''Takes a string as input and returns
    the number of vowels in it'''

    count = 0 # initialize the counter

    # iterate over the word one character at a time
    for char in word:
        if isVowel(char): # call helper function
            count += 1
    return count
```

Counting Vowels: Tracing the Loop

- How are the local variables updated as the loop runs?

```
def countVowels(word):
    '''Returns number of vowels in the word'''
    count = 0
    for char in word:
        if isVowel(char):
            count += 1
    return count
```

countVowels('Boston')



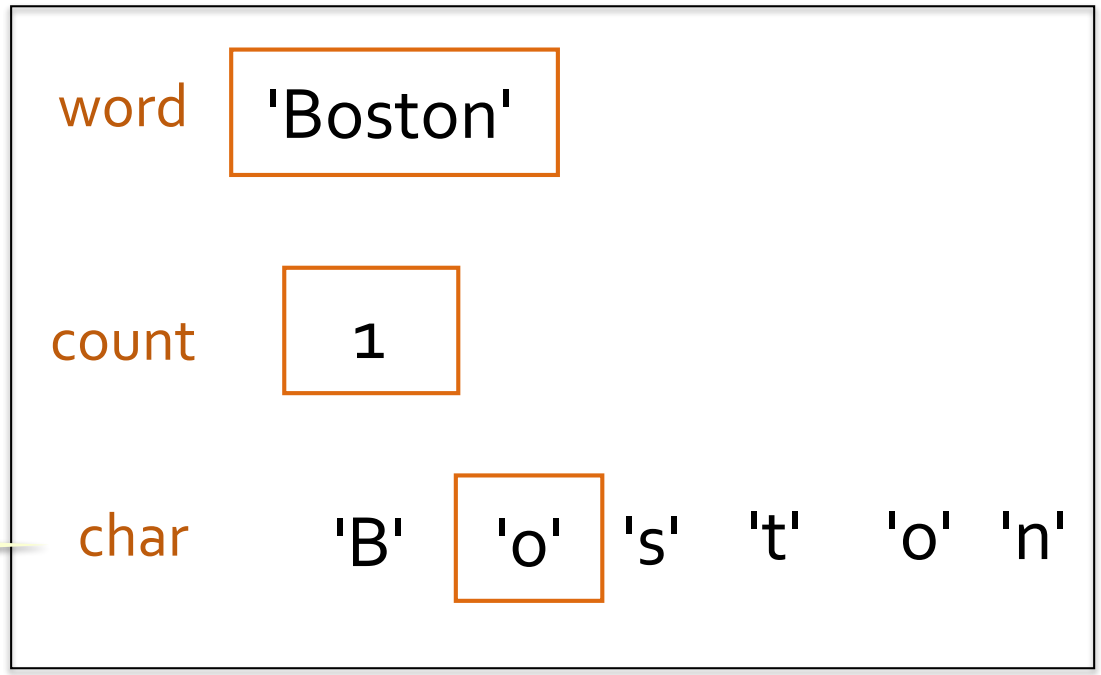
Loop variable

Counting Vowels: Tracing the Loop

- How are the local variables updated as the loop runs?

```
def countVowels(word):
    '''Returns number of vowels in the word'''
    count = 0
    for char in word:
        if isVowel(char):
            count += 1
    return count
```

countVowels('Boston')

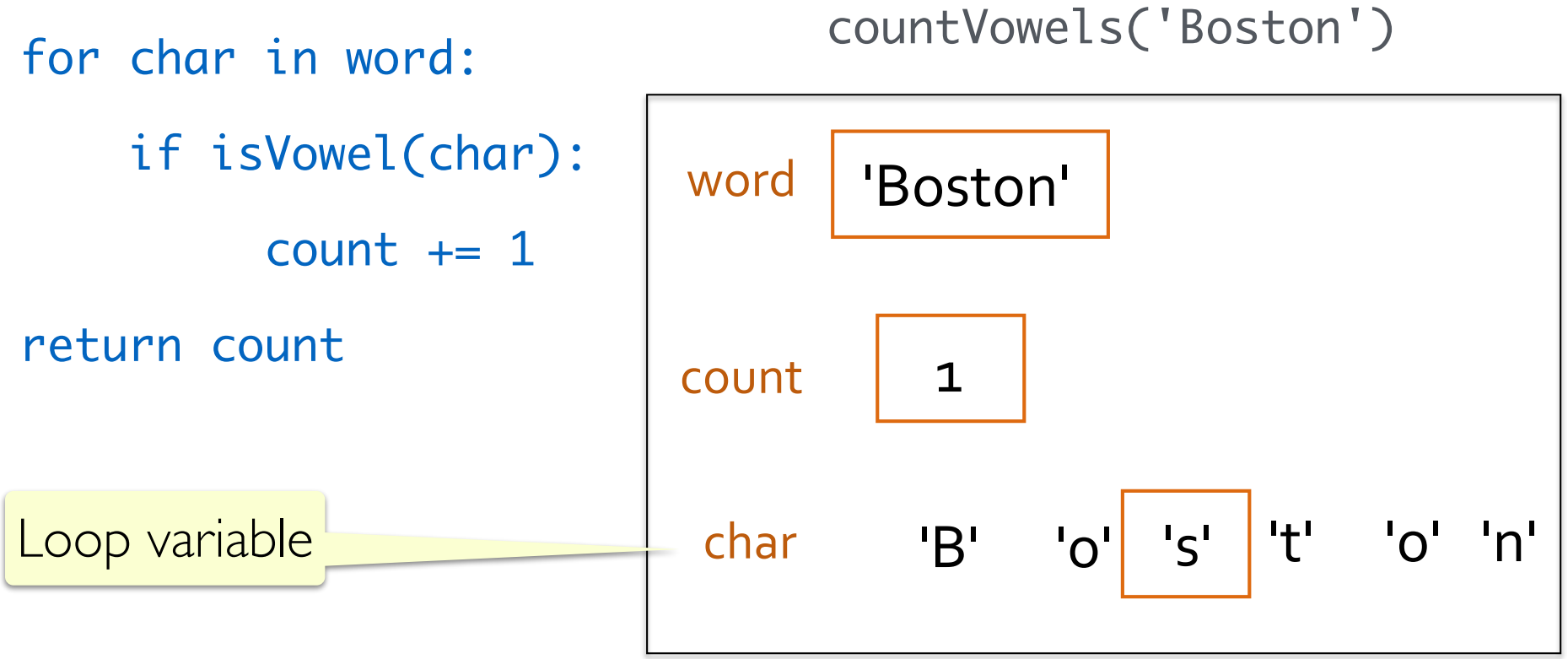


Loop variable

Counting Vowels: Tracing the Loop

- How are the local variables updated as the loop runs?

```
def countVowels(word):
    '''Returns number of vowels in the word'''
    count = 0
    for char in word:
        if isVowel(char):
            count += 1
    return count
```

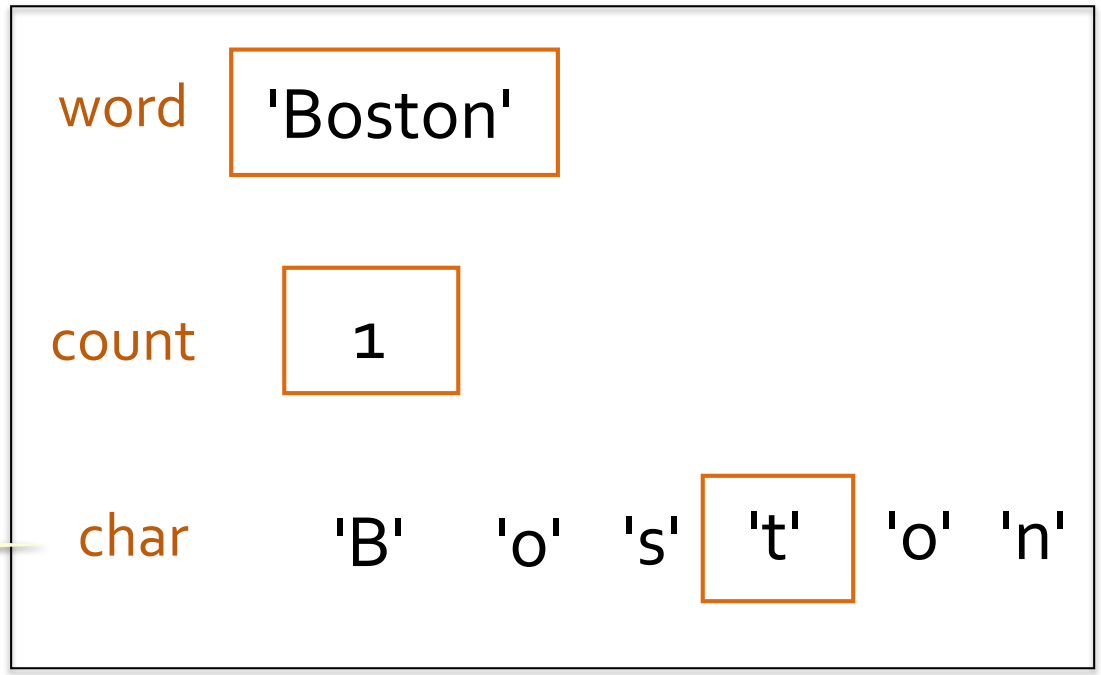


Counting Vowels: Tracing the Loop

- How are the local variables updated as the loop runs?

```
def countVowels(word):
    '''Returns number of vowels in the word'''
    count = 0
    for char in word:
        if isVowel(char):
            count += 1
    return count
```

countVowels('Boston')

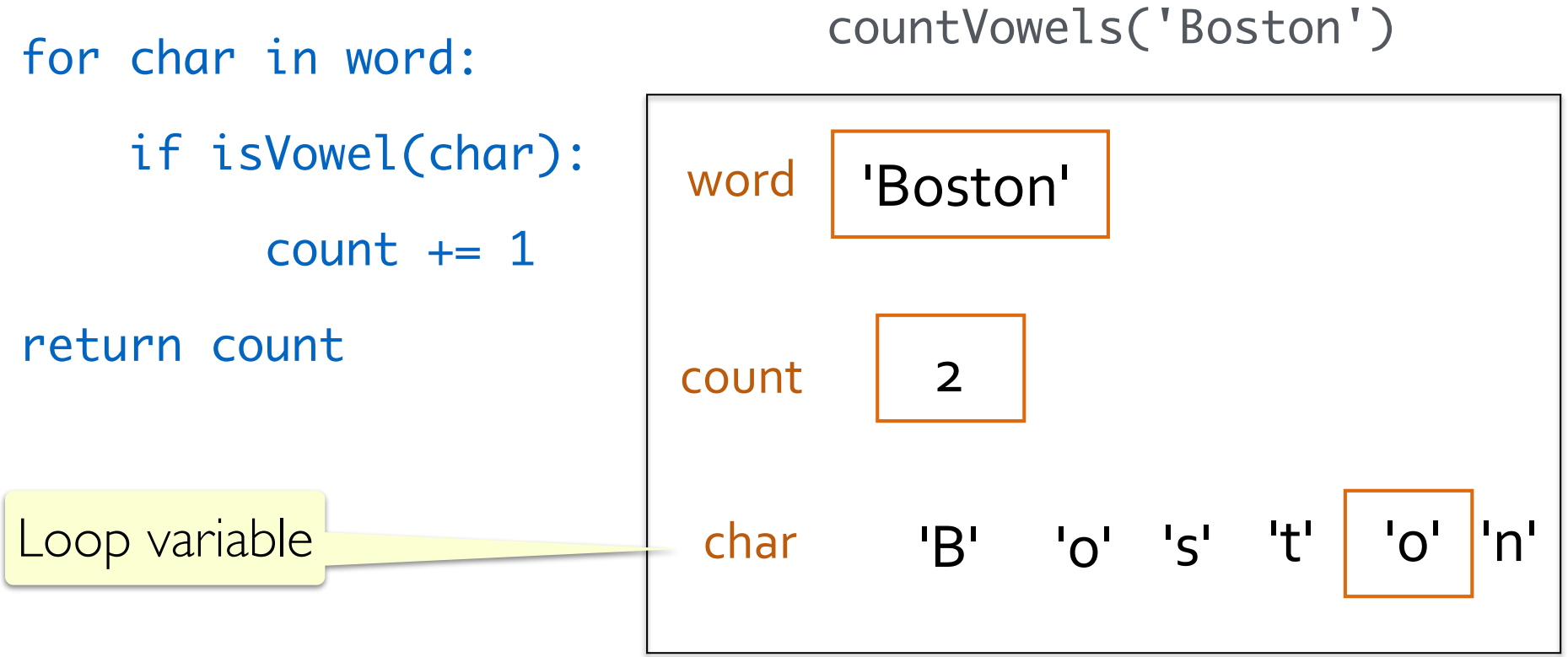


Loop variable

Counting Vowels: Tracing the Loop

- How are the local variables updated as the loop runs?

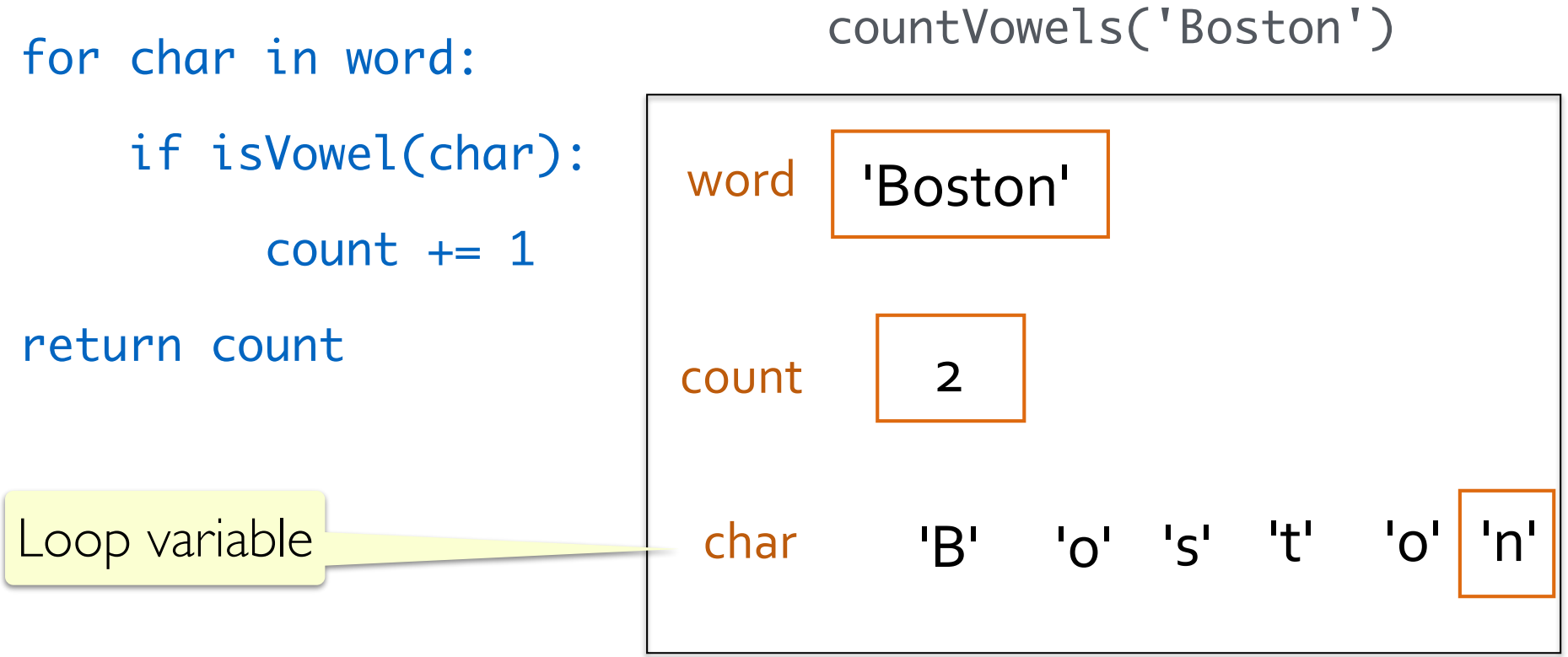
```
def countVowels(word):
    '''Returns number of vowels in the word'''
    count = 0
    for char in word:
        if isVowel(char):
            count += 1
    return count
```



Counting Vowels: Tracing the Loop

- How are the local variables updated as the loop runs?

```
def countVowels(word):
    '''Returns number of vowels in the word'''
    count = 0
    for char in word:
        if isVowel(char):
            count += 1
    return count
```



Recap: `wordStartEnd`

- Write a function that iterates over a given list of words **`wordList`**, and returns a (new) list containing all the words in **`wordList`** that start and end with the same letter (ignoring case).

```
def wordStartEnd(wordList):
    '''Takes a list of words and returns a list of words in it
    that start and end with the same letter'''
    # initialize accumulation variable (of type list)
    result = []
    for word in wordList: # iterate over list

        #check for empty strings before indexing
        if len(word) != 0:
            if word[0].lower() == word[-1].lower():
                result += [word] # concatenate to resulting list
    return result # notice the indentation of return
```

Recap: `wordStartEnd`

- Write a function that iterates over a given list of words **`wordList`**, and returns a (new) list containing all the words in **`wordList`** that start and end with the same letter (ignoring case).

```
def wordStartEnd(wordList):
    '''Takes a list of words and returns a list c
    that start and end with the same letter'''
    # initialize accumulation variable (of type l
    result = []
    for word in wordList: # iterate over list

        #check for empty strings before indexing
        if len(word) != 0:
            if word[0].lower() == word[-1].lower():
                result += [word] # concaten
    return result # notice the indentation of re
```

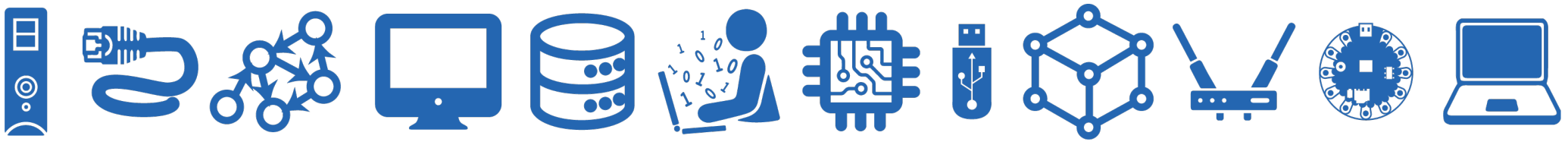
Accumulating in a list. Always initialize our accumulation variable before we enter loop.

List concatenation

Today's Plan

- Learn about **nested for loops**
- Review **sequence** operations
- Review **list** and **string** operations (so far!)
  - Discuss convenient method and functions for working with strings and lists (we'll continue to expand on this in upcoming lectures)
  - Investigate list **mutability** versus string **immutability**
- (Maybe) Learn about one more sequence: **ranges**

Nested Loops



Nested Loops

- A **for loop** body can contain one (or more!) additional **for loops**:
  - Called **nested for loops**
  - Conceptually similar to nested conditionals
- Example: What do you think is printed by the following Python code?

```
# What does this do?

def mysteryPrint(word1, word2):
    """Prints something"""
    for char1 in word1:
        for char2 in word2:
            print(char1, char2)
```

```
mysteryPrint('123', 'abc')
```

In [9]:
```
# What does this do?

def mysteryPrint(word1, word2):
    """Prints something"""
    for char1 in word1:
        for char2 in word2:
            print(char1, char2)
```

In [11]:
```
mysteryPrint('123', 'abc')
```

```
1 a    char1 = 1 char2 = a
1 b              char2 = b
1 c              char2 = c
2 a    char1 = 2 char2 = a
2 b              char2 = b
2 c              char2 = c
3 a    char1 = 3 char2 = a
3 b              char2 = b
3 c              char2 = c
```

Inner loop (w/ char2 and word2) runs to completion on **each iteration** of the outer loop

Nested Loops

- Let's look at another example involving lists of strings
- What is printed by the nested loop below?

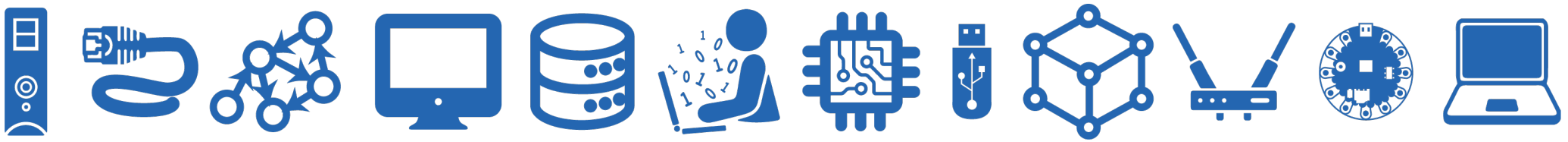
```
# What does this print?

for letter in ['b','d','r','s']:
    for suffix in ['ad', 'ib', 'ump']:
        print(letter + suffix)
```

In [12]:
```
# What does this print?

for letter in ['b','d','r','s']:
    for suffix in ['ad', 'ib', 'ump']:
        print(letter + suffix)
```

```
bad
bib
bump
dad
dib
dump
rad
rib
rump
sad
sib
sump
```

Inner loop (w/ suffixes) runs to completion on **each iteration** of the outer loop (w/ prefixes)

Lists and Strings Revisited



Sequence Operations

Operation	Result
`seq[i]`	The `i`'th item of `seq`, when starting with index 0
`seq[si:ee]`	slice (subsequence) of `seq` from `si` to `ee`
`seq[si:ee:s]`	slice of `seq` from `si` to `ee` with step `s`
`len(seq)`	length of `seq`
`seq1 + seq2`	The concatenation of `seq1` and `seq2`
`x in seq`	True if `x` is contained within `seq`
`x not in seq`	False if `x` is contained within `seq`
`seq*n, n*seq`	`n` copies of `seq` concatenated
`min(seq)`	smallest item of `seq`
`max(seq)`	largest item of `seq`

All of these operators work on both **strings** and **lists**!

Sequence Operations with Strings

```
"a" in "aeiou"  # in operator
```

```
True
```

```
"b" not in "aeiou" # not in operator
```

```
True
```

```
"CS" + "134" # concatenation with +
```

```
'CS134'
```

```
"abc" * 3 # * operator
```

```
'abcabcabc'
```

```
myString = "abc"
myString[1]  # indexing with []
```

```
'b'
```

```
myString[1:2] # slicing with [:]
```

```
'b'
```

```
# using negative step in slicing
myString[::-1]
```

```
'cba'
```

```
len(myString) # length function
```

```
3
```

```
# min function (finds smallest character)
min(myString)
```

```
'a'
```

```
# max function (finds largest character)
max(myString)
```

```
'c'
```

Sequence Operations with Lists

```
1 in [1, 2, 3] # in operator
```

```
True
```

```
1 not in [1, 2, 3] # not in operator
```

```
False
```

```
[1] + [2] # concatenation with +
```

```
[1, 2]
```

```
[1, 2] * 3 # * operator
```

```
[1, 2, 1, 2, 1, 2]
```

```
myList = [1, 2, 3]
myList[1] # indexing with []
```

```
2
```

```
myList[1:2] # slicing with [:]
```

```
[2]
```

```
# slicing with negative step
myList[::-1]
```

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

```
len(myList)  # len function
```

```
3
```

```
min(myList)  # min function
```

```
1
```

```
max(myList) # max function
```

```
3
```

String Methods

- What about the `.upper()` & `.lower()` methods?
- Return new string containing lowercase/uppercase characters from original string

```
>>> astring = "Pixel"
>>> astring.upper()
'PIXEL'
>>> astring.lower()
'pixel'
```

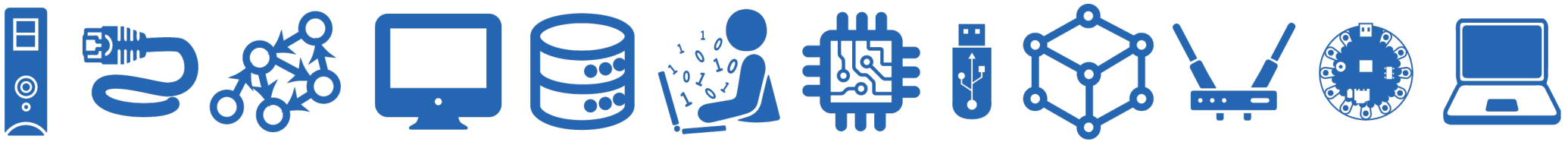
String Methods

- What about the `.upper()` & `.lower()` methods?
- Will they work on lists?

String **methods** are invoked using dot notation and ONLY work on strings!

```
>>> alist = ['P', 'i', "Xe", 'L']
>>> alist.upper()
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
AttributeError: 'list' object has no attribute
'upper'

>>> alist.islower()
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
AttributeError: 'list' object has no attribute
'islower'
```

String Operations, Methods, and Functions



`str()` function

- `str()` function allows us to convert other data types to strings

```
>>> classList = ['C', 's', "CI", 1, 3, 4]
>>> str(classList)
"['C', 's', 'CI', 1, 3, 4]"

>>> str(134)
'134'
>>> str(6.02)
'6.02'
```

Converting a list to a string in this way is somewhat limiting

List to Strings: `join()`

- Given a list of strings, the `.join()` string **method**, when applied to a string `separator`, concatenates the strings together with the string `separator` between them
- `.join()` requires a list to be passed as a **parameter**, and elements of the list must be strings

```
>>> songList = ["Mary", "had", "a", "bicycle"]
>>> '*'.join(songList)
'Mary*had*a*bicycle'

>>> '_'.join(songList)
'Mary_had_a_bicycle'

>>> ' '.join(songList)
'Mary had a bicycle'
```

'*' is a string, songList is a list that is passed as a parameter

This is a string!

String to Lists: `split()`

- `.split()` is a string **method** that splits strings at "spaces" (the default separator) and returns a list of (sub)strings
- Can optionally specify other **delimiters** (or separators) as well

phrase is a string

```
>>> phrase = "What a lovely day"
>>> phrase.split()
['What', 'a', 'lovely', 'day']
```

.split( ) returns a list of strings

Blank space is default separator (ignores punctuation)

```
>>> newPhrase = "What a *lovely*      day!"
>>> newPhrase.split()
['What', 'a', '*lovely*', 'day!']
```

```
>>> lovelyDays = "Friday, Saturday,Sunday"
>>> lovelyDays.split(',')
['Friday', ' Saturday', 'Sunday']
```

use , as separator instead

Remove whitespace w/ `strip()`

- The `.strip()` string method strips away whitespace and (sometimes hidden) new line (\n) characters from the beginning and end of strings and **returns a new string**

```
>>> word = "   ** Cozy Autumns **   "
>>> word.strip()
'** Cozy Autumns **'
```

```
>>> "\nHello World\n".strip()
'Hello World'
```

More Useful String Methods!

- `word.find(s)`
  - Return the first (or last) position (index) of string s in word. Returns -1 if not found.
- `char.isspace()`
  - Returns **`True`** if char is not empty `("")` and char is composed of white space (or lowercase, uppercase, alphabetic letters, digits, or either letters or digits).
  - Can also do: `islower(), isupper(), isalpha(), isdigit(), isalnum()`.
- `word.count(s)`
  - Returns the number of (non-overlapping) occurrences of s in word
- `word.index(s)`
  - Return the lowest index in word where substring s is found. Returns ValueError if not found.
- `word.replace(old, new)`
  - Returns a new string with all occurrences of substring old in word replaced by new.
- Many, many more: see `pydoc3 str`

String Methods in Action

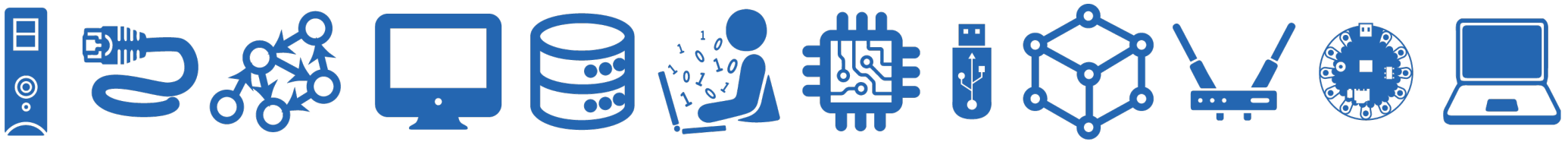
Returned value

```
word = 'Williams College'
word.split()                          ['Williams','College']
word.upper()                             'WILLIAMS COLLEGE'
word.lower()                             'williams college'
word.replace('iams', 'herst')          'Willherst College'
word.replace('mith', 'herst')         'Williams College'
newWord = '   Spacey College   '
newWord.strip()                          'Spacey College'
myList = ['Williams', 'College']
' '.join(myList)                         'Williams College'
```

Notice how methods use dot notation

Important note: Strings are immutable. None of these operations change/affect the original string. They all return a new string!

List Operations, Methods, and Functions



`list()` Function

- `list()` function, when given another sequence (like a string), returns a list of elements in the sequence

```
word = "Computer Science!"
```

```
list(word) # can turn a string into a list of its characters
```

```
['C',
 'o',
 'm',
 'p',
 'u',
 't',
 'e',
 'r',
 ' ',
 'S',
 'c',
 'i',
 'e',
 'n',
 'c',
 'e',
 '!']
```

```
list(str(3.14159265))
```

```
['3', '.', '1', '4', '1', '5', '9', '2', '6', '5']
```

Modifying Lists

- Lists are **mutable** data structures
  - This means we can update them (delete things from them, add things to them, etc.)
- List **concatenation** (using +) ***creates a new list*** and ***does not modify*** any existing list
  - **Important point: Concatenating to a list returns a new list!**

- We can also **append to or extend a list**, which ***modifies*** the existing list
  - The list **method** `myList.append(item)` ***modifies*** the list `myList` by adding `item` to it at the end
  - The list **method** `myList.extend(otherList)` ***modifies*** the list `myList` by adding all elements from `otherList` to `myList` at the end
  - Often more efficient to append/extend rather than concatenate
  - But we have to be very careful when modifying the list
  - **Important point: Appending to or extending a list modifies the existing list!**

Adding elements to a List

- Here are a few examples that show how to use the list **.append()** method vs + operator to add items to the end of an existing list

```
numList = [1, 2, 3, 4, 5]
```

```
numList + [6]
```

list concatenation

```
[1, 2, 3, 4, 5, 6]
```

this is a **new** list!

```
numList # numList has not changed
```

```
[1, 2, 3, 4, 5]
```

```
numList.append(6)
```

list append, notice dot notation

```
numList # numList has been updated to include 6
```

```
[1, 2, 3, 4, 5, 6]
```

More Useful List Methods

- `myList.extend(itemList)`: ***appends all items*** in `itemList` to the end of `myList` (modifying `myList`)
- `myList.count(item)`: counts and returns the number (`int`) of times `item` appears in `myList`
- `myList.index(item)`: returns the first index (`int`) of item in myList if it is present, else throws an error

```
myList = [1, 7, 3, 4, 5]
```

```
myList.extend([6, 4])
```

```
myList
```

```
[1, 7, 3, 4, 5, 6, 4]
```

```
myList.count(4)
```

```
2
```

```
myList.index(3)
```

```
2
```

```
myList.index(10)
```

```
---------------------------
ValueError
<ipython-input-38-14d2e386c720>
----> 1 myList.index(10)

ValueError: 10 is not in list
```

Summarizing Mutability in Strings vs Lists

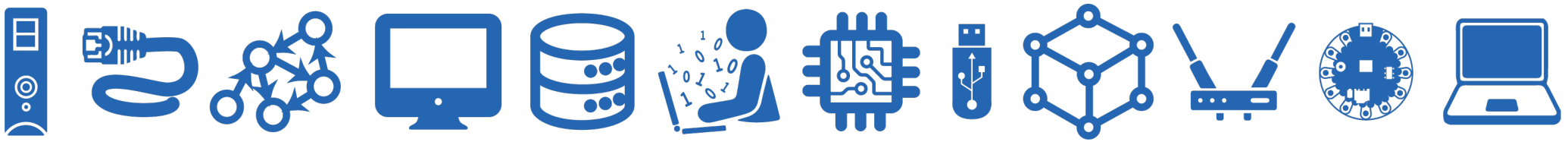
Strings are immutable

- Once you create a string, it cannot be changed!
- All operations that we have seen on strings ***return a new string*** and ***do not modify*** the original string

Lists are mutable

- Lists are mutable (or changeable) sequences
- You can concatenate items to a list using +, but this ***does not*** change the list
- You can append items using append() method, and this ***does*** change the list

Ranges



Moving on: Ranges (another sequence!)

- Python provides an easy way to iterate over numerical sequences using **ranges**, **another sequence data type**
- When the `range()` function is given two integer arguments, it returns a ***range object*** of all integers starting at the first and up to, *but not including*, the second; if the first integer is 0, it may be omitted.
- To see the values included in the range, we can pass our range to the `list()` function which returns a **list** of them

```
In [1]: range(0,10)
Out[1]: range(0, 10)

In [2]: type(range(0, 10))
Out[2]: range
```

```
In [3]: list(range(0, 10))
Out[3]: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]

In [4]: list(range(10))
Out[4]: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

Moving on: Ranges (another sequence!)

- Python provides an easy way to iterate over numerical sequences using **ranges**, **another sequence data type**
- When the `range()` function is given two integer arguments, it returns a ***range object*** of all integers starting at the first and up to, *but not including*, the second; if the first integer is 0, it may be omitted.
- To see the values included in the range, we can pass our range to the `list()` function which returns a **list** of them

A range is a type of sequence in Python (like string and list)

```
In [1]: range(0,10)
Out[1]: range(0, 10)

In [2]: type(range(0, 10))
Out[2]: range
```

To see elements in range, pass range to list() function

First argument omitted, defaults to 0

```
In [3]: list(range(0, 10))
Out[3]: [0, 1, 2, 3

In [4]: list(range(10))
Out[4]: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

Loops and Ranges to Print Patterns

- Sometimes we might use a **for loop**, not to iterate over a sequence, but just to **repeat** a task over and over. The following loops print a pattern to the screen. (Look closely at the indentation!)
-

```
# what does this print?

for i in range(5):
    print('$' * i)
for j in range(5):
    print('*' * j)
```

```
# what does this print?

for i in range(5):
    print('$' * i)
    for j in range(i):
        print('*' * i)
```

What are the values of i and j???

Iterating Over Ranges

```
# what does this print?

for i in range(5):
    print('$' * i)
for j in range(5):
    print('*' * j)
```

```
# what does this print?

for i in range(5):
    print('$' * i)
    for j in range(i):
        print('*' * i)
```

Iterating Over Ranges

```
# what does this print?

for i in range(5):
    print('$' * i)
for j in range(5):
    print('*' * j)
```

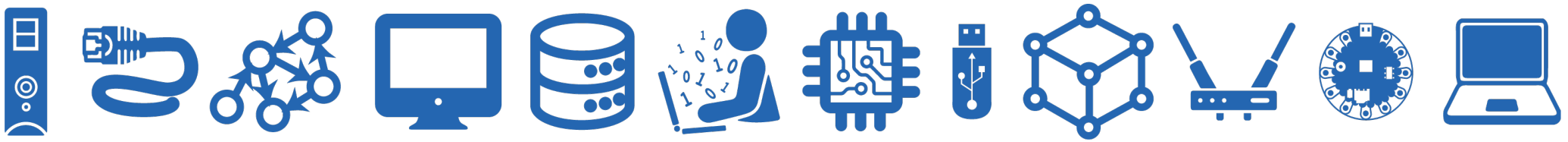
```
            i = 0
$           i = 1
$$          i = 2
$$$         i = 3
$$$$        i = 4
            j = 0
*           j = 1
**          j = 2
***         j = 3
****        j = 4
```

```
# what does this print?

for i in range(5):
    print('$' * i)
    for j in range(i):
        print('*' * i)
```

```
            i = 0
$           i = 1
*               j = 0
$$          i = 2
**              j = 0
**              j = 1
$$$         i = 3
***             j = 0
***             j = 1
***             j = 2
$$$$        i = 4
****            j = 0
****            j = 1
****            j = 2
****            j = 3
```

i, not j!

Lab 3



Lab 3: Goals

- In this lab, you will accomplish two tasks:
  - Construct a **module** of tools for manipulating **strings** and **lists** of strings (in `wordTools.py`)
  - Use your toolbox to answer some (fun?) trivia questions (in `puzzles.py`)
- You will gain experience with the following:
  - **Sequences** (**lists** and **strings**), and associated **operators/methods**
  - Writing simple and nested **for loops**
  - Writing **doctests** to test your functions

Testing Functions: Doctests

- We have already seen two ways to test a function
  - You can run your code 1) interactively or 2) as a script
- Python's **doctest** module allows you to embed test cases and expected output directly into a function's docstring
- To use the doctest module, we must import it using:
  `from doctest import testmod`
- To make sure the test cases are run when the program is run as a script from the terminal, we then need to call `testmod()`.
- To ensure that the tests are not run in interactive Python, we place this command within a "guarded" if block:
  `if __name__ == '__main__':`

Testing Functions: Doctests

```
def isVowel(char):
    """Takes a letter as input and returns true if and only if it is a vowel.
    >>> isVowel('e')
    True
    >>> isVowel('U')
    True
    >>> isVowel('t')
    False
    >>> isVowel('Z')
    False
    """
    return char.lower() in 'aeiou'
```

```
if __name__ == '__main__':
    # the following code tests the tests in the docstrings ('doctests').
    # as you add tests, re-run this as a script to test your work
    from doctest import testmod  # this import is necessary when testing
    testmod()  # test this module, according to the doctests
```

Run the doctests only when file is executed as a script