CS134:

Lists & Mutability

Announcements & Logistics

- **HW 4** due tonight at 10pm
- **Lab 4** today/tomorrow
  - **Part 1** due Wed/Thur at 10pm
    - We will run some tests and return automated feedback
  - **Part 2** is due next week (but there is no lab next week!)
    - We'll provide info on students help and TA hours during reading days on Wed (since Friday could be Mountain Day)

Do You Have Any Questions?

Last Time

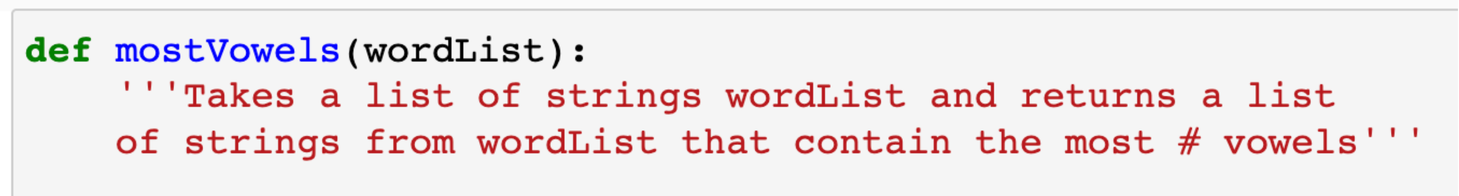
- Learned about **list comprehensions** and accessing **lists of lists**
- Used our knowledge about lists and loops to analyze "interesting" properties of our student data
    - Focused on maintaining the state of variables when looping, and how to update state based on conditionals
    - Example functions: `characterList, yearList`

Today's Plan

- Learn how to find max/min values in a list (when we can't use the `min()` and `max()` functions)
- Review old and new list methods that modify the list:
  - `.append(), .extend(), .insert(), .remove(), .pop(), .sort()`
- Discuss implications of **mutability** in Python in more detail

Exercise: Student Fun Facts!

- Write a function `mostVowels` that can be used to compute the list of students with the most vowels in their first name. (Hint: use `countVowels()` which returns the number of vowels in a string.)



```
def mostVowels(wordList):
    '''Takes a list of strings wordList and returns a list
    of strings from wordList that contain the most # vowels'''
```

- General strategy for finding max in list of lists?
  - Initialize a max value BEFORE the loop to a very small number
  - If you see a value bigger than max while looping, update max

Exercise: Student Fun Facts!

- Write a function `mostVowels` that can be used to compute the list of students with the most vowels in their first name. (Hint: use `countVowels()` which returns the number of vowels in a string.)
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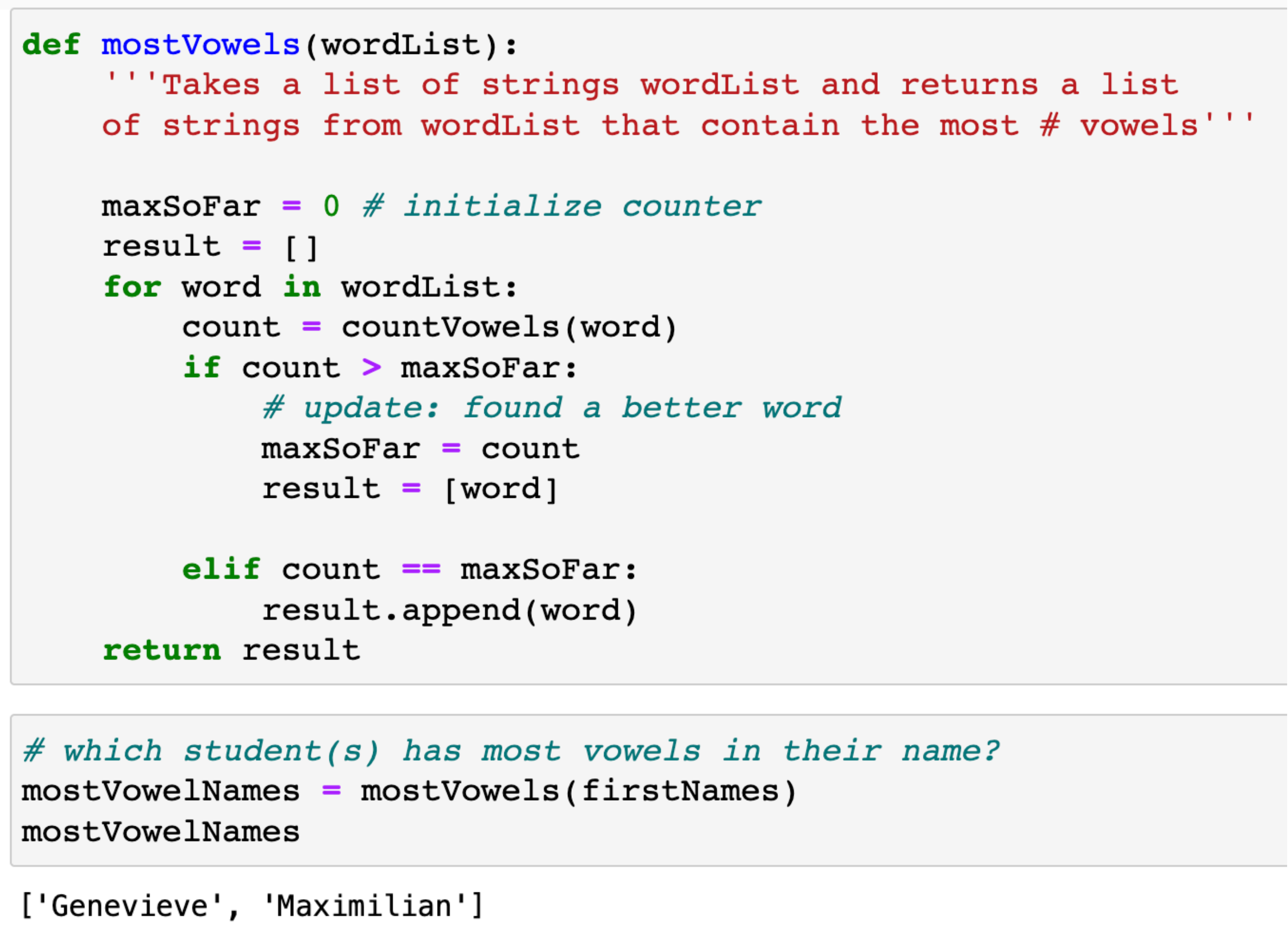


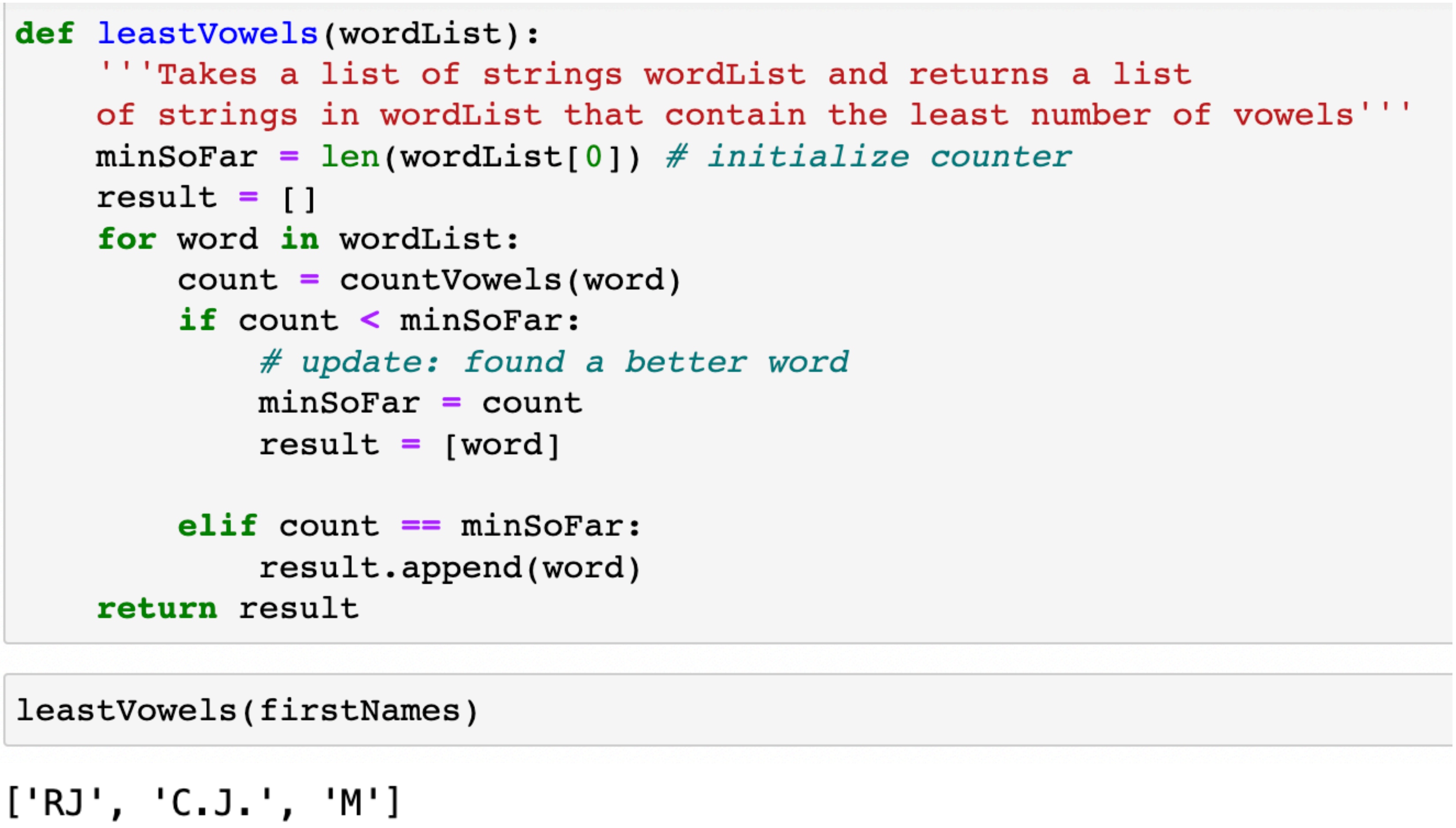
```
def mostVowels(wordList):
    '''Takes a list of strings wordList and returns a list
    of strings from wordList that contain the most # vowels'''

    maxSoFar = 0 # initialize counter
    result = []
    for word in wordList:
        count = countVowels(word)
        if count > maxSoFar:
            # update: found a better word
            maxSoFar = count
            result = [word]

        elif count == maxSoFar:
            result.append(word)
    return result
```

```
# which student(s) has most vowels in their name?
mostVowelNames = mostVowels(firstNames)
mostVowelNames
```

```
['Genevieve', 'Maximilian']
```

Exercise: Student Fun Facts!

- Write a function **`leastVowels`** that can be used to compute the list of students with the least vowels in their first name. (Hint: use **`countVowels()`** again.)



```
def leastVowels(wordList):
    '''Takes a list of strings wordList and returns a list
    of strings in wordList that contain the least number of vowels'''
    minSoFar = len(wordList[0]) # initialize counter
    result = []
    for word in wordList:
        count = countVowels(word)
        if count < minSoFar:
            # update: found a better word
            minSoFar = count
            result = [word]

        elif count == minSoFar:
            result.append(word)
    return result
```

```
leastVowels(firstNames)
```

```
['RJ', 'C.J.', 'M']
```

List Mutability

A quick review of old and new methods that modify a list:

```
.append(), .extend(),
.pop(), .insert(), .remove(), .sort()
```

Direct Modification: Element Assignment

`myList[index] = item` : though not a method, an assignment to a specific index can modify a list directly (this won't work using strings!)

Example.

```
myList[1] = 7  # assign 7 to index 1 of myList
```

myList Before

`[1, 2, 3, 4]`

myList After

`[1, 7, 3, 4]`

append()

`myList.append(item)` : appends item to end of list

Example.

```
myList.append(5)   # insert 5 at the end of the list
```

myList Before	myList After
[1, 7, 3, 4]	[1, 7, 3, 4, 5]

extend()

`myList.extend([itemList])` : appends all the items in `itemList` to the end of `myList.`

Example.

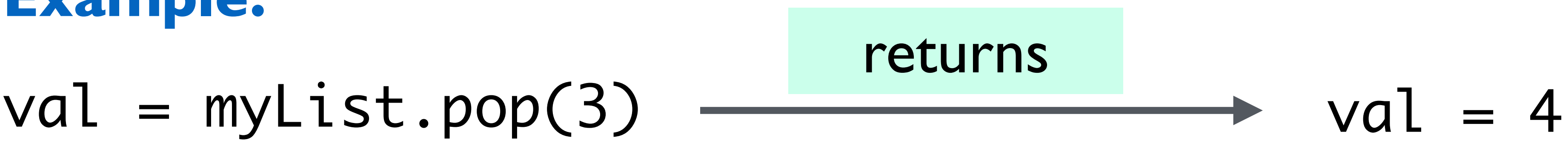
```
myList.extend([6, 8]) # insert both 6 and 8 at the end of the list
```

myList Before	myList After
[1, 7, 3, 4, 5]	[1, 7, 3, 4, 5, 6, 8]

pop()

`myList.pop(index)` : Removes the item at **a given index** (`int`) **and returns it**. If no index is given, by default, `pop()` removes and returns the **last item** from the list.

Example.



```
val = myList.pop(3)
```

returns

```
val = 4
```

myList Before

```
[1, 7, 3, 4, 5, 6, 8]
```

myList After

```
[1, 7, 3, 5, 6, 8]
```

pop()

`myList.pop(index) :` Removes the item at **a given index** (`int`) **and returns it**. If no index is given, by default, `pop()` removes and returns the **last item** from the list.

Example.

No Index

returns

```
val = myList.pop()
```

```
val = 8
```

`myList` Before

```
[1, 7, 3, 5, 6, 8]
```

`myList` After

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

insert()

`myList.insert(index, item)` : inserts item at index (`int`) in `myList`, all items to the right of index shift over to make room

Example.

```
myList.insert(0,11)  # insert 11 at index 0
```

myList Before	myList After
[1, 7, 3, 5, 6]	[11, 1, 7, 3, 5, 6]

insert()

`myList.insert(index, item)` : inserts item at index (`int`) in `myList`, all items to the right of index shift over to make room

inserting at an index out of range

Example.

```
myList.insert(10,12)   # insert 12 at index 10
```

`myList` Before	`myList` After
`[11, 1, 7, 3, 5, 6]`	`[11, 1, 7, 3, 5, 6, 12]`

remove()

`myList.remove(item)` : removes first occurrence of `item` from `myList`, all items to the right of removed item shift to the left by one

(Unlike pop(), item is not returned!)

Example.

```
myList.remove(12)    # remove 12 from myList
```

myList Before

```
[11, 1, 7, 3, 5, 6, 12]
```

myList After

```
[11, 1, 7, 3, 5, 6]
```

DO NOT USE remove() IN LAB 4!!!!!!

DO NOT USE

`.remove()`

IN LAB 04!

sort()

`myList.sort() :` sorts the list *in place* in ascending order

Example.

```
myList.sort()    # sort by mutating myList
```

myList Before

myList After

```
[11, 1, 7, 3, 5, 6]
```

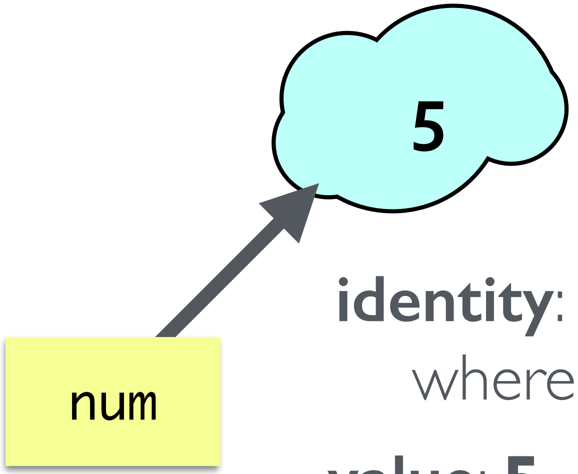
```
[1, 3, 5, 6, 7, 11]
```

Identity and Value

Value vs Identity

- Python is an **object oriented language:** everything is an object!
- An **object's identity** never changes once it has been created; think of it as the object's ***address*** in memory
  - The `id()` function returns an integer representing an object's identity (or address)
- An **object's value** is the value assigned to the object when it is created

```
>>> num = 5
>>> id(num)
4486937008
```



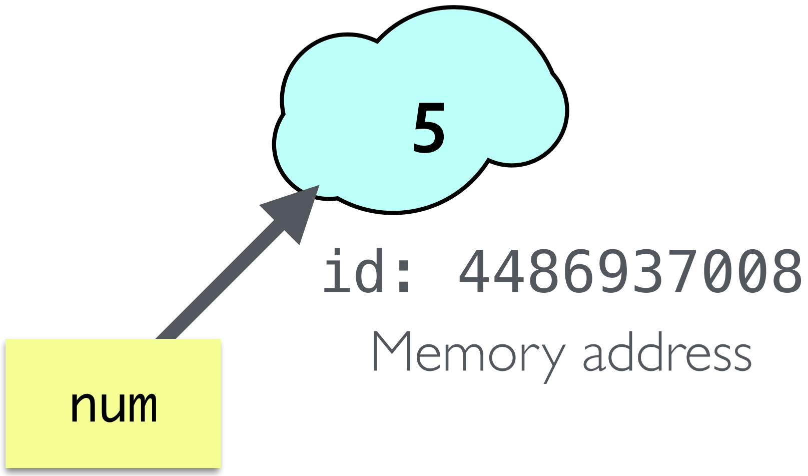
identity: mem address where **5** is stored

value: **5**

Value vs Identity

- An **object's** **identity** never changes once it has been created; think of it as the object's ***address*** in memory
- On the other hand, an **object's** **value** can change
  - Objects whose values can change are called **mutable**; objects whose values cannot change are called **immutable**

```
>>> num = 5
>>> id(num)
4486937008
```



id: 4486937008

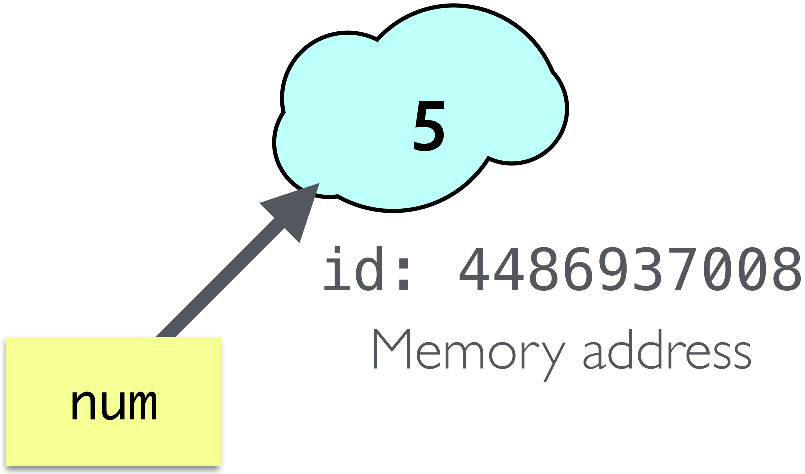
Memory address

Variable names like **num** point to memory addresses of stored value

Comparing Value vs Identity

- The `==` operator compares the **value** of an object (i.e., are the contents of the objects the same?)
- The `is` operator compares the **identity** of two objects (i.e., do they have the same memory address?)
  - `var1 is var2` is equivalent to `id(var1) == id(var2)`

```
>>> num = 5
>>> id(num)
4486937008
```



5

num

id: 4486937008

Memory address

Variable names like `num` point to memory addresses of stored value

Mutability in Python

Strings, Ints, Floats are Immutable

- Once you create them, their value **cannot** be changed!
- All functions and methods that manipulate these objects return a ***new object*** and ***do not modify*** the original object

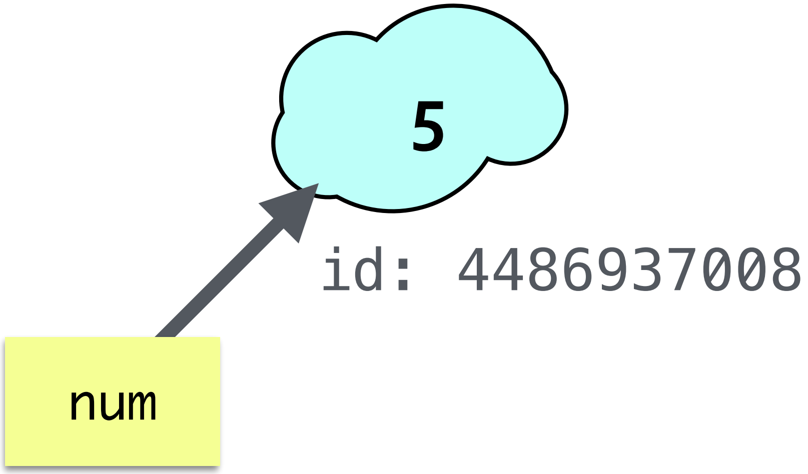
Lists are Mutable

- List values **can** be changed
- We just reviewed how we can mutate/change what's in a list using methods**;** these methods ***modify*** original list
- If we use sequence operators on lists, these functions and operations return a ***new list*** and ***do not modify*** the original list

Ints, Floats are Immutable

```
>>> num = 5
>>> id(num)
4486937008

>>> num = num + 1
>>> id(num)
```

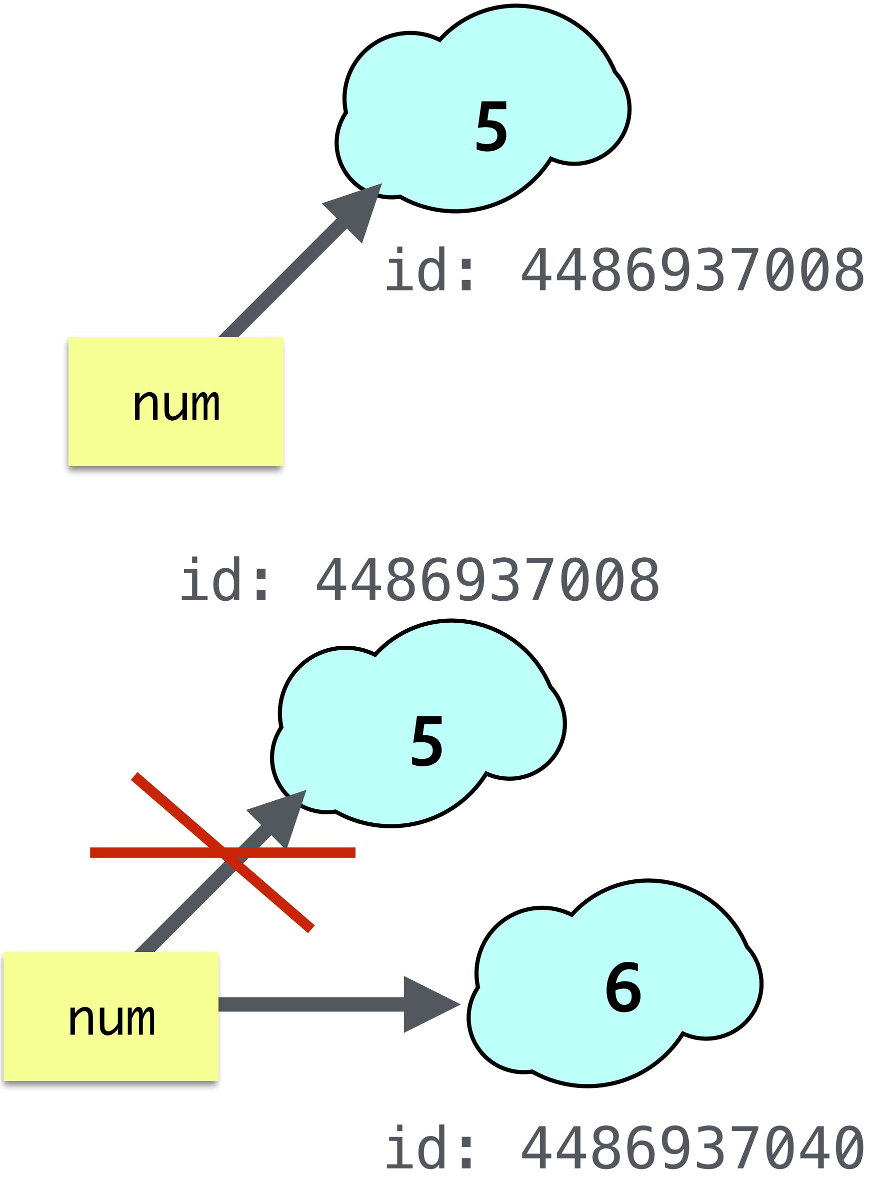
Has the identity of **num** changed?



Attempts to change an immutable object create a new object

Ints, Floats are Immutable

```
>>> num = 5
>>> id(num)
4486937008

>>> num = num + 1
>>> id(num)
4486937040
```

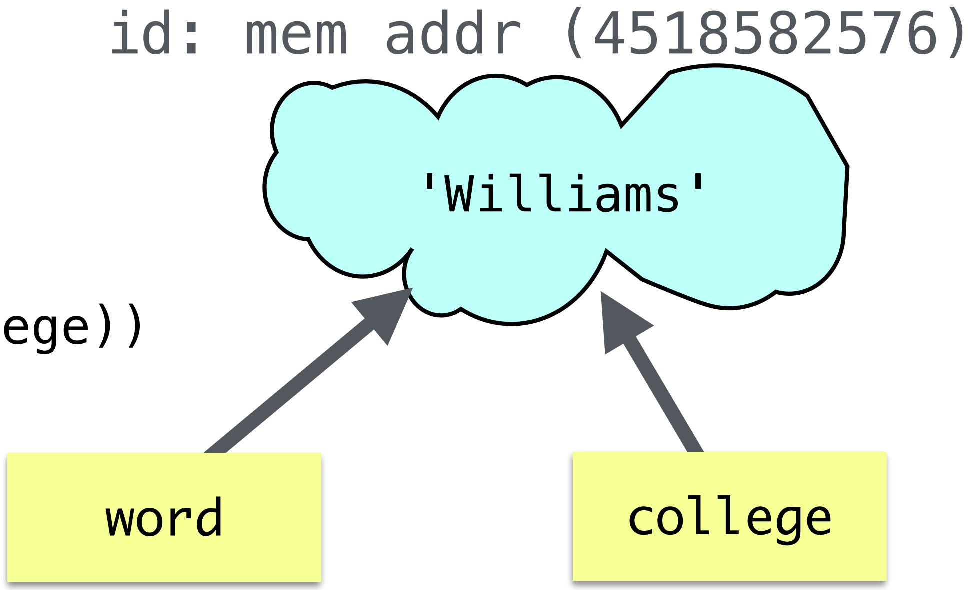


Identity of ints cannot be changed,
`num` assumes a **new** identity

Attempts to change an immutable object create a new object

Strings are Immutable

```
>>> word = "Williams"
>>> college = word
>>> word == college
True

>>> print(id(word), id(college))
4518582576 4518582576

>>> word is college
True
```



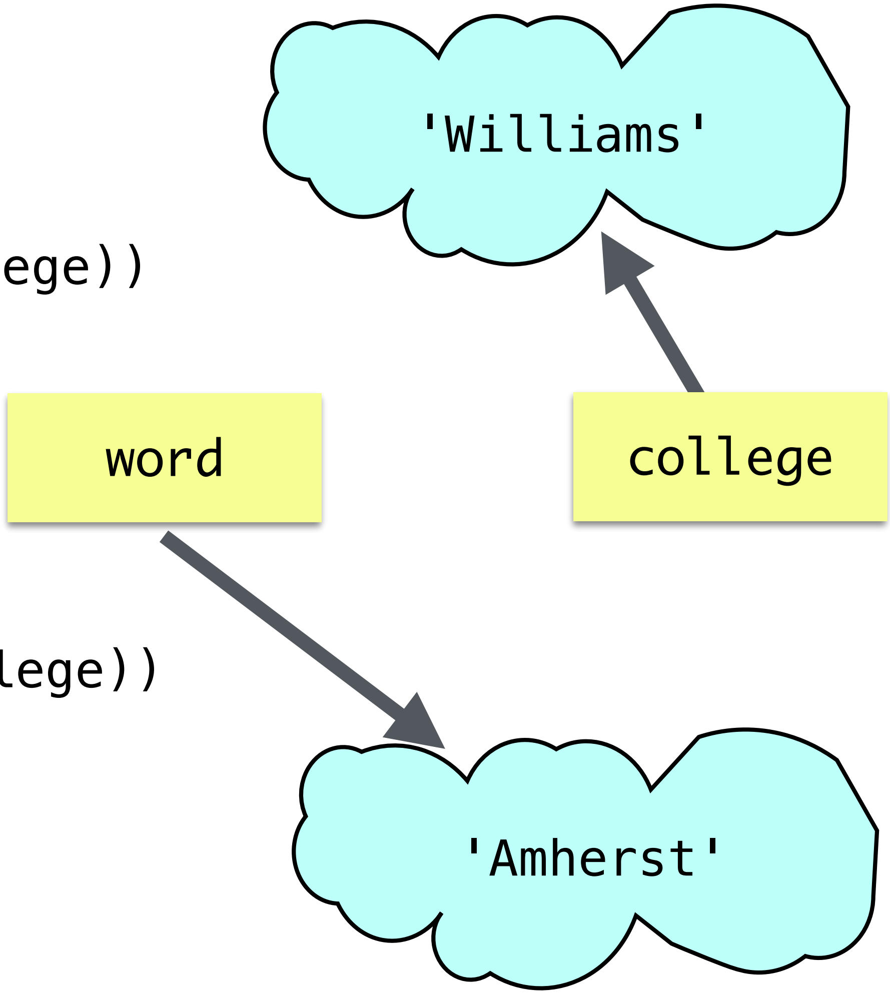
Variable names point to memory addresses of stored value

Even though word and college have the same identity and value, if we update one of them, it just assumes a new identity!

Attempts to change an immutable object create a new object

Strings are Immutable

```
>>> word = "Williams"
>>> college = word
>>> word == college
True

>>> print(id(word), id(college))
4518582576 4518582576

>>> word is college
True

>>> word = "Amherst"
>>> print(id(word), id(college))
4518871920 4518582576

>>> word is college
False
```



'Williams'

word

college

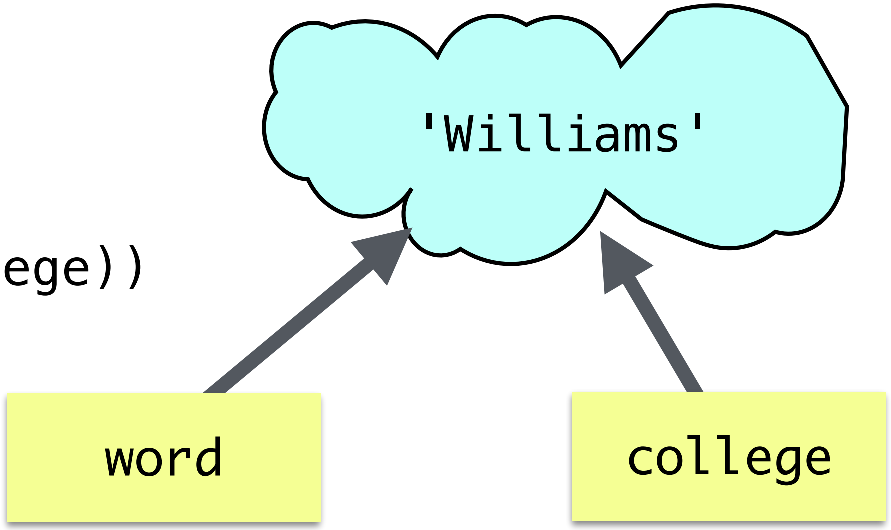
'Amherst'

Attempts to change an immutable object create a new object

Strings are Immutable

```
>>> word = "Williams"
>>> college = "Williams"
>>> word == college
True

>>> print(id(word), id(college))
4518582576 4518582576

>>> word is college
True
```

id: mem addr (4518582576)



'Williams'

word

college

Variable names point to memory addresses of stored value

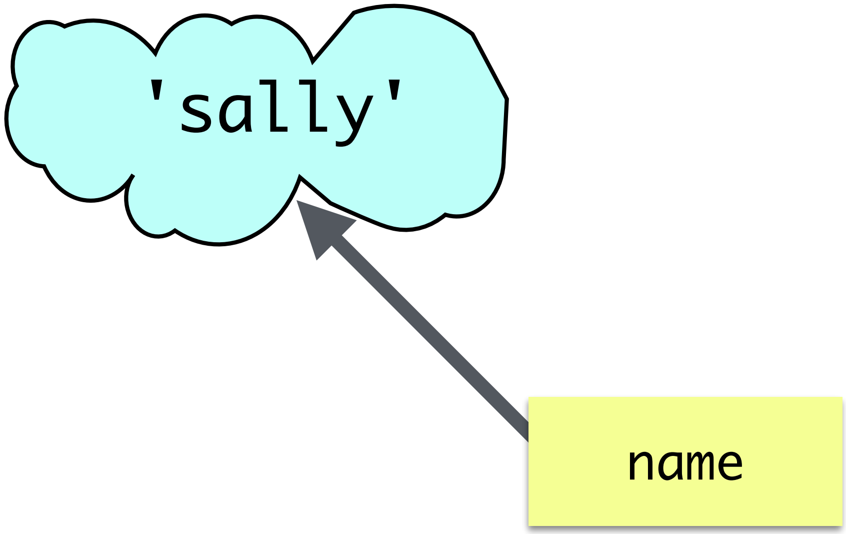
Even though we created word and college separately, they still point to the same memory address. This is a (confusing) optimization in Python.

Immutable objects that are == also share an identity

String Methods/Operations Return New Strings

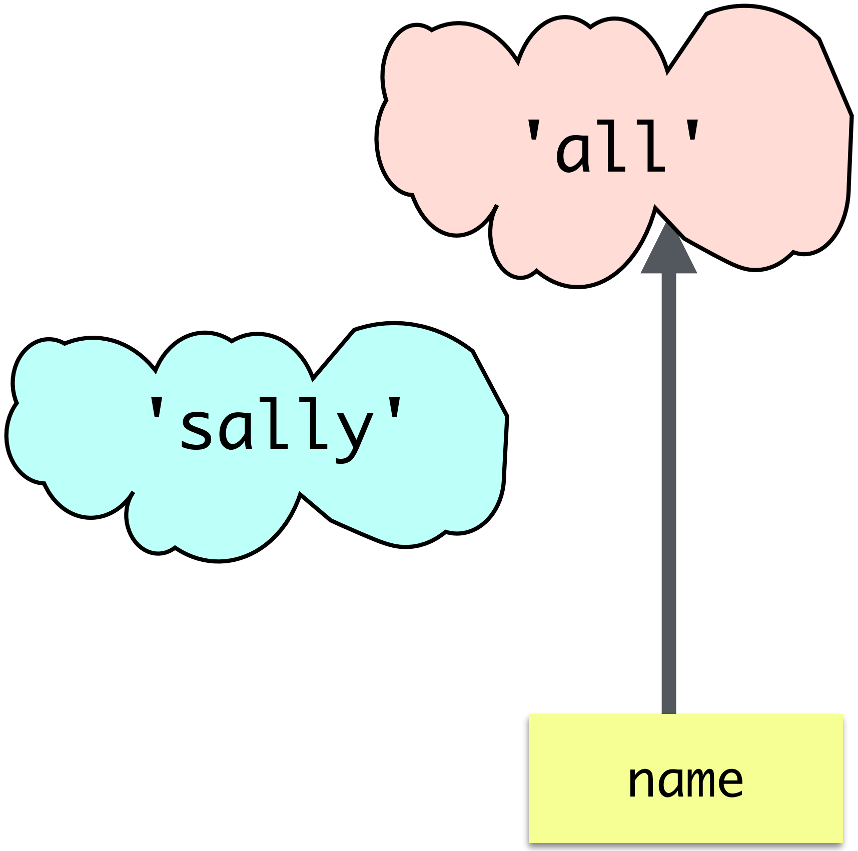
- String methods like `.lower(), .upper()` return a **new string**
- Sequence operations, like slicing `[:]`, return **new sequences**

```
>>> name = "sally"
>>> id(name)
4574657776
```



String Methods/Operations Return New Strings

- String methods like `.lower(), .upper()` return a **new string**
- Sequence operations, like slicing `[:]`, return **new sequences**



```
>>> name = "sally"
>>> id(name)
4574657776

>>> name = name[1:4]
>>> id(name)
4574684720
```

Sequence Operations Return New Sequences

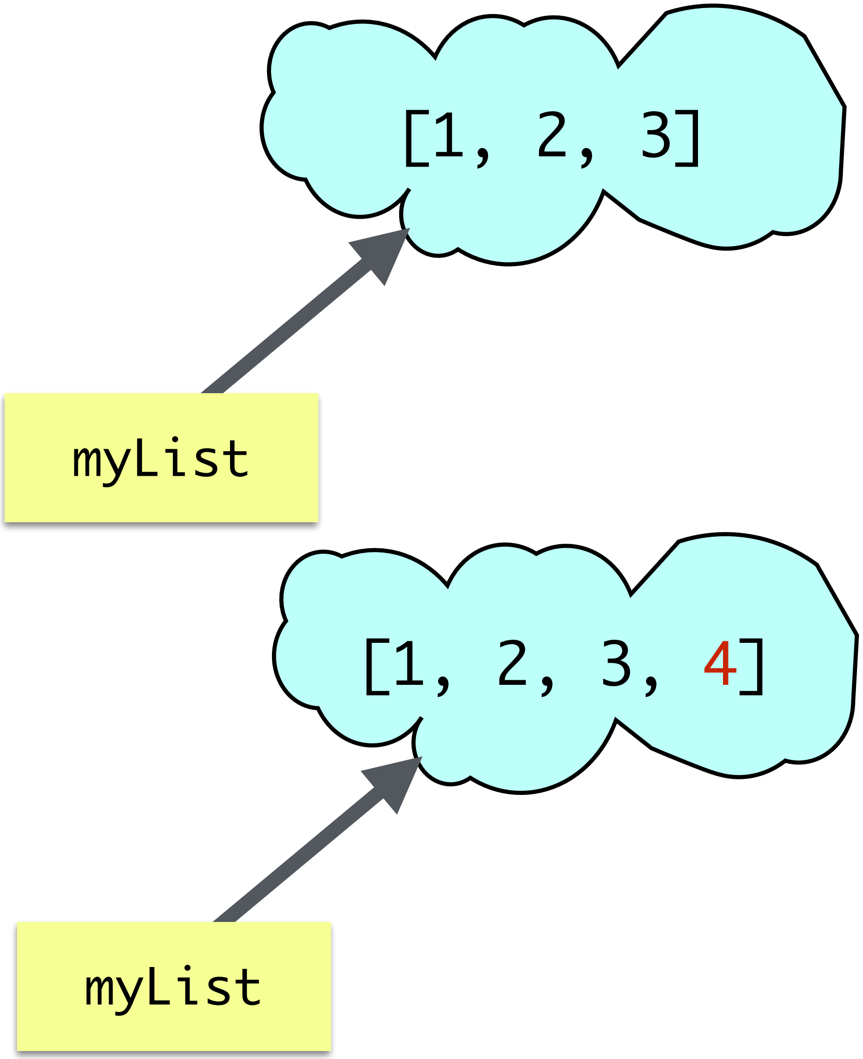
- The following operations, that can be performed on both **lists** and **strings**, and always return a **new list/string**
  - `[::]` slicing operator: returns a new sliced sequence
  - assignment of a new sequence to a variable
    - `names = 'Iris and Jeannie'`
    - `myList = [1, 2, 3]`
  - concatenation (+) always creates a new sequence

Lists are Mutable

```
>>> myList = [1, 2, 3]
>>> id(myList)
4418551104

>>> myList.append(4)
>>> id(myList)
4418551104
```

Note: Value changes, identity stays the same

More on this next time!



Value of list objects can change, keeping identity the same

The end!

Lab 4

Lab 4 Goals

- In Lab 4 you will implement several voting algorithms and helpful functions for manipulating election data

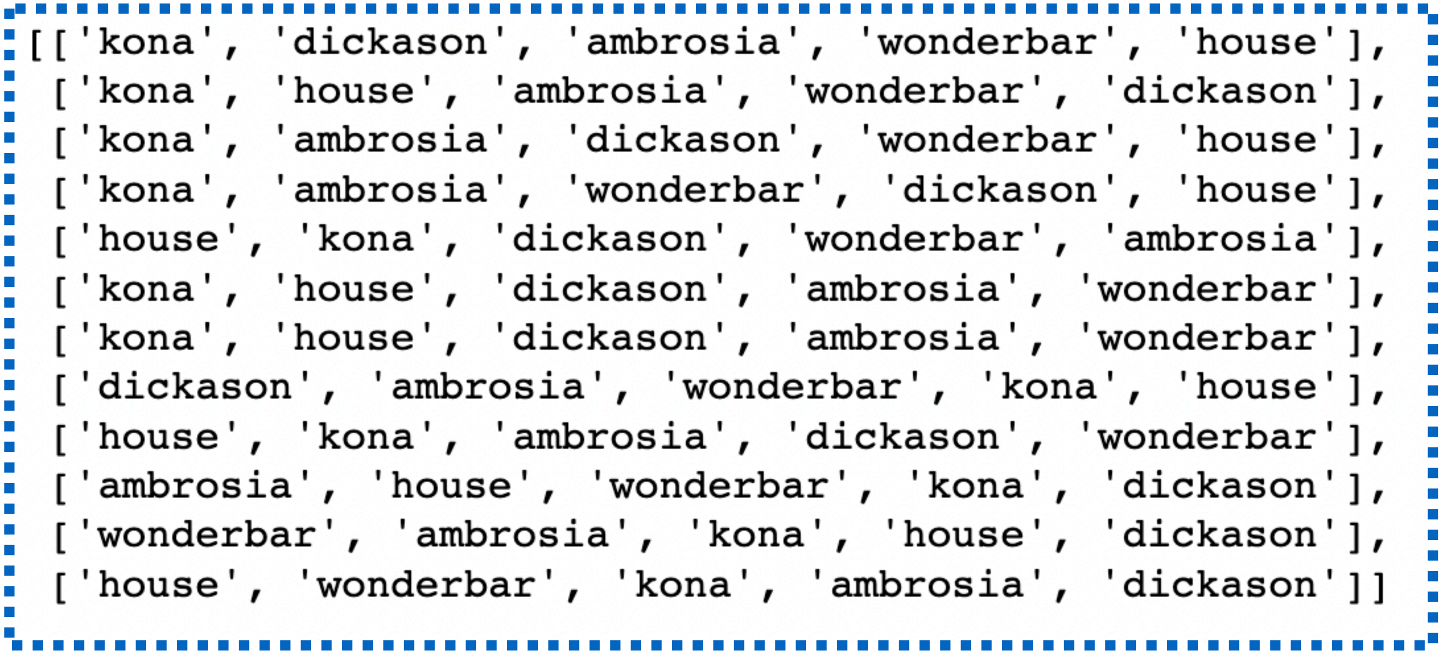
- Lab 4 will give you experience with :
    - Lists of strings
    - Lists of lists of strings
    - Loops
    - Using string and list methods
    - File reading

- Pay close attention to expected input (lists of strings, list of lists of strings, etc) and expected output

Ballot Data

- Ballot data is represented in various text files
- Each line represents a single voter's ranked choices

```
# different types of coffee
filename = "csv/coffee.csv"
with open(filename) as coffeeTypes:
   allCoffee = []
   for coffee in coffeeTypes:
      allCoffee.append(coffee.strip().split(‘,'))
print(allCoffee)
```



```
[['kona', 'dickason', 'ambrosia', 'wonderbar', 'house'],
 ['kona', 'house', 'ambrosia', 'wonderbar', 'dickason'],
 ['kona', 'ambrosia', 'dickason', 'wonderbar', 'house'],
 ['kona', 'ambrosia', 'wonderbar', 'dickason', 'house'],
 ['house', 'kona', 'dickason', 'wonderbar', 'ambrosia'],
 ['kona', 'house', 'dickason', 'ambrosia', 'wonderbar'],
 ['kona', 'house', 'dickason', 'ambrosia', 'wonderbar'],
 ['dickason', 'ambrosia', 'wonderbar', 'kona', 'house'],
 ['house', 'kona', 'ambrosia', 'dickason', 'wonderbar'],
 ['ambrosia', 'house', 'wonderbar', 'kona', 'dickason'],
 ['wonderbar', 'ambrosia', 'kona', 'house', 'dickason'],
 ['house', 'wonderbar', 'kona', 'ambrosia', 'dickason']]
```

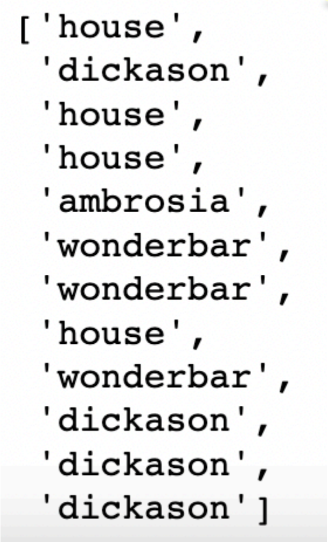
Working with Ballot Data

```
>>> allCoffee[1] # access second inner list
['kona', 'house', 'ambrosia', 'wonderbar', 'dickason']
```

```
>>> allCoffee[0][1] # access second element in first inner list
'dickason'
```

```
>>> # access second character of second element of first inner list
>>> allCoffee[0][1][1]
'i'
```

```
>>> # create a list of only last elements of inner lists
>>> lastCoffee = [coffee[-1] for coffee in allCoffee]
>>> lastCoffee
```



```
['house',
 'dickason',
 'house',
 'house',
 'ambrosia',
 'wonderbar',
 'wonderbar',
 'house',
 'wonderbar',
 'dickason',
 'dickason',
 'dickason']
```

You'll use string and list methods to process the data and implement several different voting algorithms

Remember

`mostVowels(..)` and `leastVowels(..)`

from lecture!

The end!