CS 134:
Files & List Comprehensions

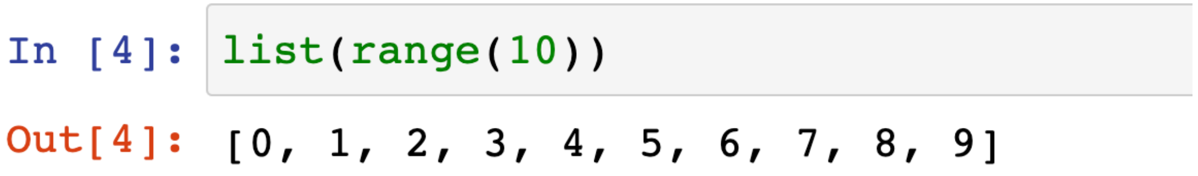
Announcements & Logistics

- **Homework 4** due next Mon at 11 pm
- **Lab 4** posted today
  - Two week lab!
  - Automated feedback returned after Part 1 (due next week at usual time)
    - You can fix your mistakes!
  - We'll grade everything after you submit Part 2 on second week
  - Gain experience with lists, strings, file reading, lists of lists

Do You Have Any Questions?

Last Time

- Learned about adding items to lists using **+**, **append()**, and **extend()**
  - Began thinking about side effects of mutability in lists
- Summarized important string and list methods and operations (so far)
  - Sequence operators and functions
  - String methods
  - List methods
- Looked at **ranges** as an easy way to generate numerical sequences



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

Today’s Plan

- Discuss **file reading** using lists and strings
- Learn about **list comprehensions** as a way to simplify list accumulations
- Introduce lists of lists (aka 2D lists)

Reading Data from Files

Working with Files in Python

- File I/O is a very common and important operation
- `open(filename, mode)` is a built-in Python function for working with files
  - `filename` is a path to a file as a string
  - `mode` is a string where
    - `'r'` - open for reading (default)
    - `'w'` - open for writing (will overwrite previous contents)
    - `'a'` - open for appending (will not overwrite previous contents)
- Whenever you open a file, you must also close it to avoid memory leaks
- We will use the `with open … as` code block, which keeps the file open within it, and **automatically closes the file after existing the block**
- We can **iterate** over the **lines of a text file** just as we iterated over strings and lists in previous lectures

Opening Files: `with … as`

Path to file on computer as a string

```
with open(filename) as inputFile:
        # do something with file
```

Variable name for your file

Note. **(syntax)** Indentation defines the body of the with block where the file is open

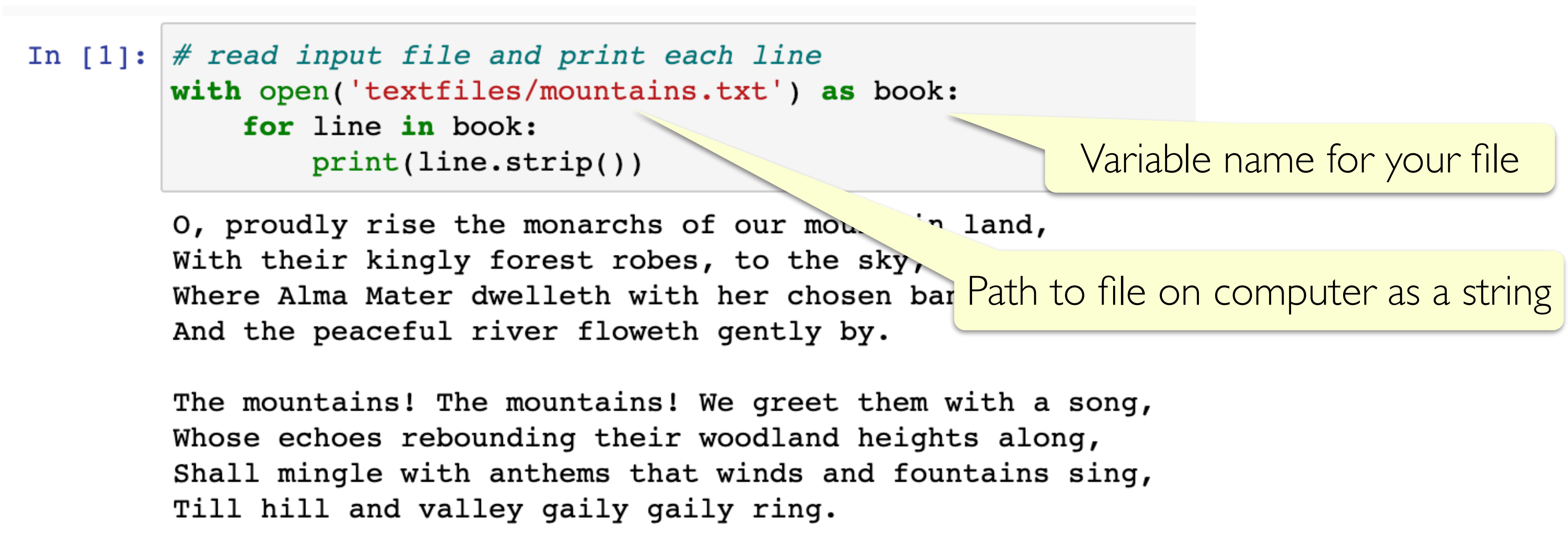
```
f = open(filename, 'r')
… file operations involving f …
f.close()
```

⟺

```
with open(filename, 'r') as f:
    … file operations involving f …
    # f implicitly closed
    # when with is done.
```

Iterating over Lines in a File

- Within a `with open(filename) as inputFile:` block, we can iterate over the lines in the file just as we would iterate over any sequence such as lists, strings, or ranges
- The end of a line in the text file is determined by the special newline character `'\n'`
- Example: We have a text file `mountains.txt` within a directory `textfiles`, so we can iterate and print each line as follows:



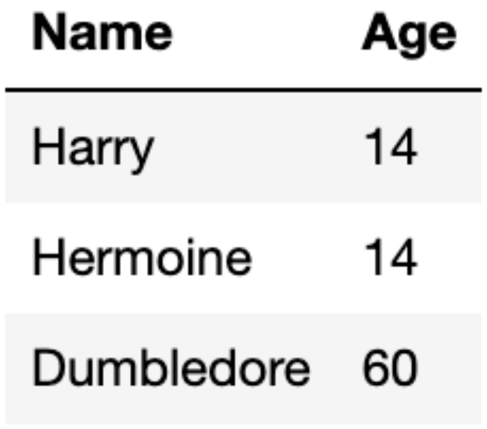
Variable name for your file
Path to file on computer as a string

```
In [1]: # read input file and print each line
        with open('textfiles/mountains.txt') as book:
            for line in book:
                print(line.strip())
```

```
O, proudly rise the monarchs of our mou      n land,
With their kingly forest robes, to the sky,
Where Alma Mater dwelleth with her chosen bar
And the peaceful river floweth gently by.

The mountains! The mountains! We greet them with a song,
Whose echoes rebounding their woodland heights along,
Shall mingle with anthems that winds and fountains sing,
Till hill and valley gaily gaily ring.
```

Common File Type: CSVs

- A CSV (Comma Separated Values) file is a specific type of plain text file that stores "tabular" data
- Each row of a table is a line in the text file, with each column on the row separated by commas
- This format is a common import and export format for spreadsheets and databases



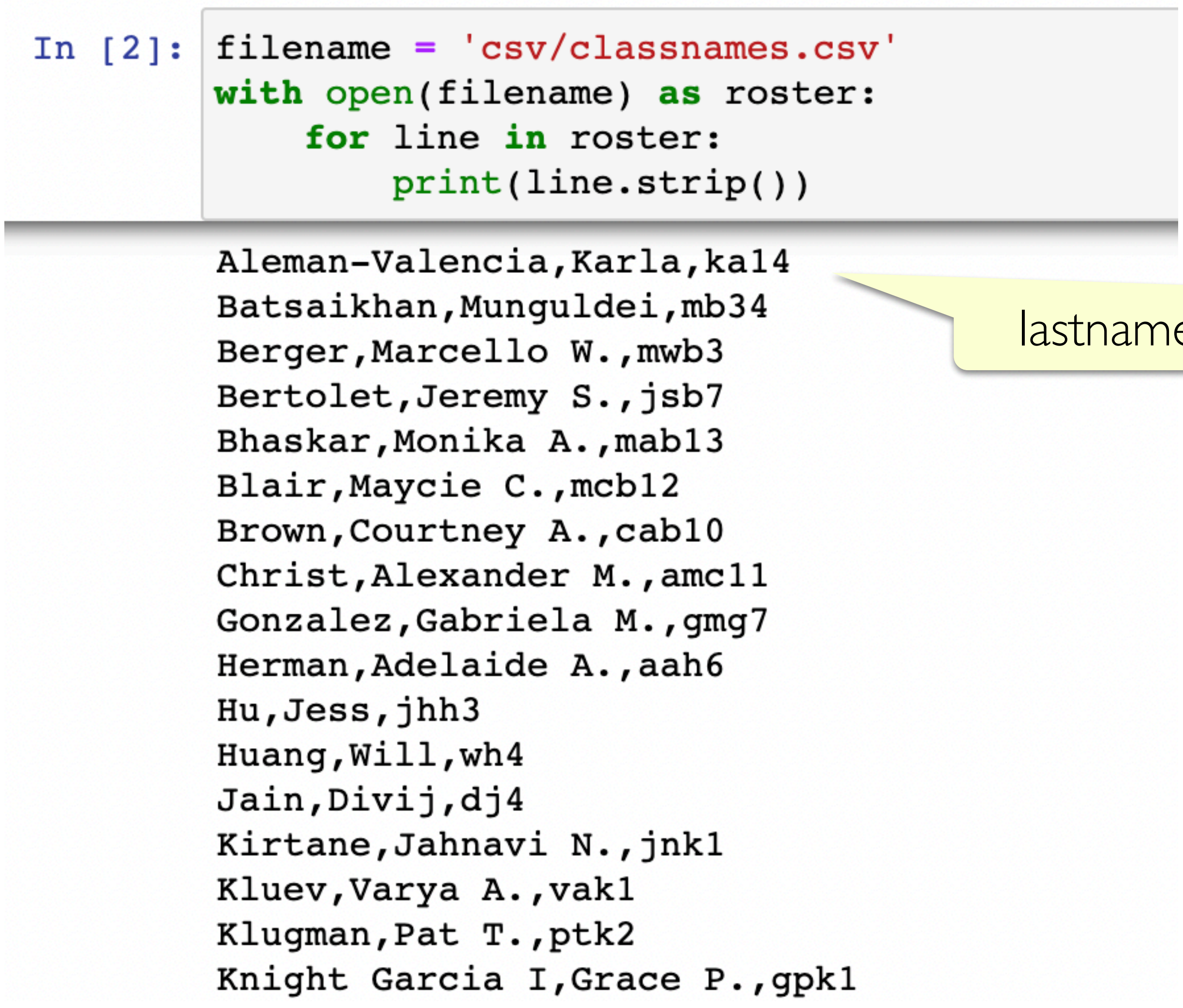
Name	Age
Harry	14
Hermoine	14
Dumbledore	60

CSV form:

```
Name,Age
Harry,14
Hermoine,14
Dumbledore,60
```

Working with CSVs

- Since CSVs are just text files, we can process them in the same way
- Might require additional post-processing/splitting using string methods



```
In [2]: filename = 'csv/classnames.csv'
        with open(filename) as roster:
            for line in roster:
                print(line.strip())
```

```
Aleman-Valencia,Karla,ka14
Batsaikhan,Munguldei,mb34
Berger,Marcello W.,mwb3
Bertolet,Jeremy S.,jsb7
Bhaskar,Monika A.,mab13
Blair,Maycie C.,mcb12
Brown,Courtney A.,cab10
Christ,Alexander M.,amc11
Gonzalez,Gabriela M.,gmg7
Herman,Adelaide A.,aah6
Hu,Jess,jhh3
Huang,Will,wh4
Jain,Divij,dj4
Kirtane,Jahnavi N.,jnk1
Kluev,Varya A.,vak1
Klugman,Pat T.,ptk2
Knight Garcia I,Grace P.,gpk1
```

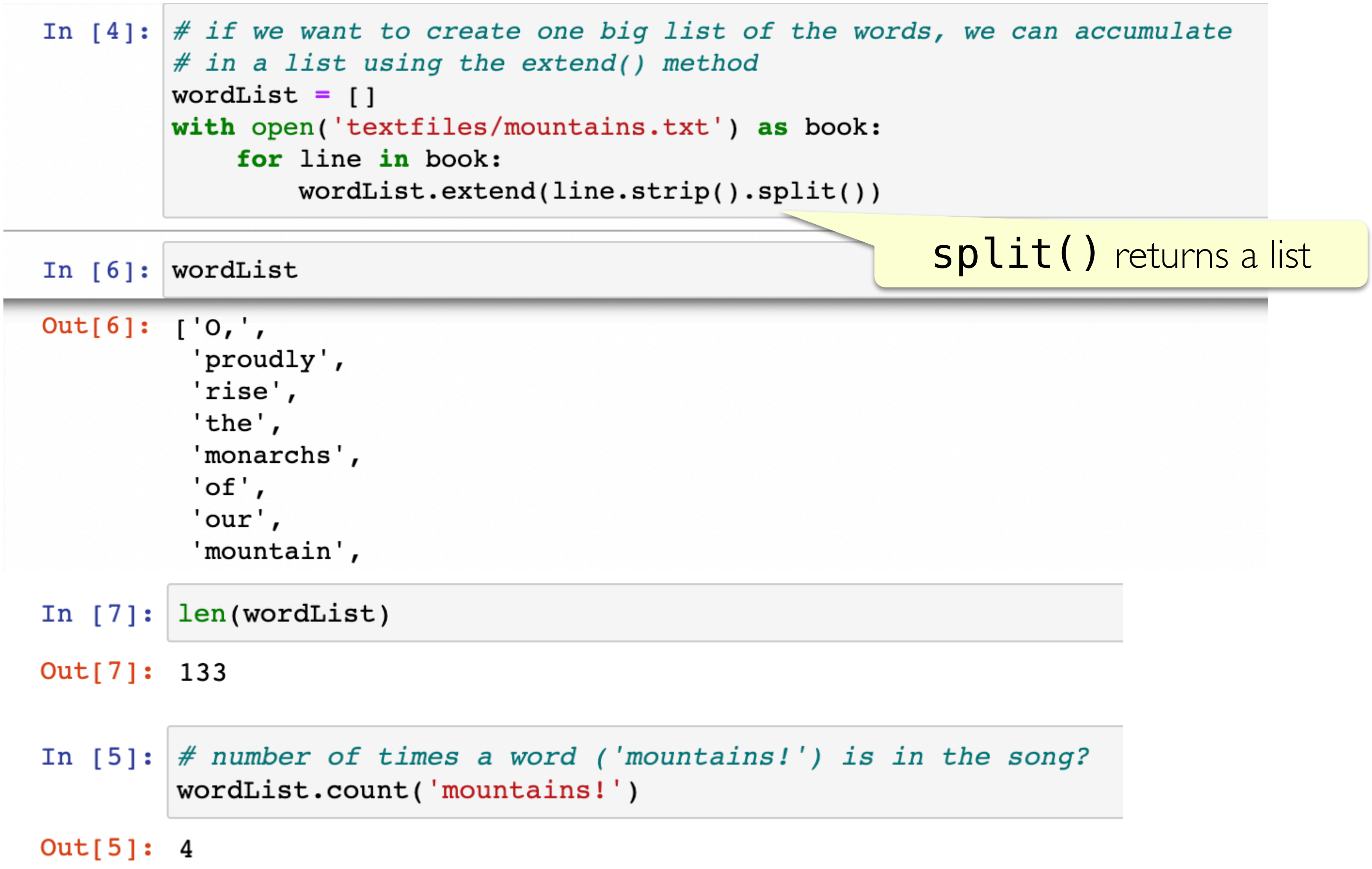
lastname, firstname, unix

Useful String and List Methods in File Reading

- Now that we know how to read files, we can use our favorite list and string methods to work with the data
  - `line.strip():` Remove any leading/trailing white space or "\n"
  - `line.split(‘,’):` Separate a **comma-separated** sequence of words
  - `' '.join(line.split(',')):` Create a single "big" string with words separated by spaces instead of commas
  - `myList.extend():` Create lists of words while iterating over the file
  - `myList.count(ele):` Count the occurrence of various elements
  - …and so on!

Data Analysis

- Some examples (more on Jupyter!)



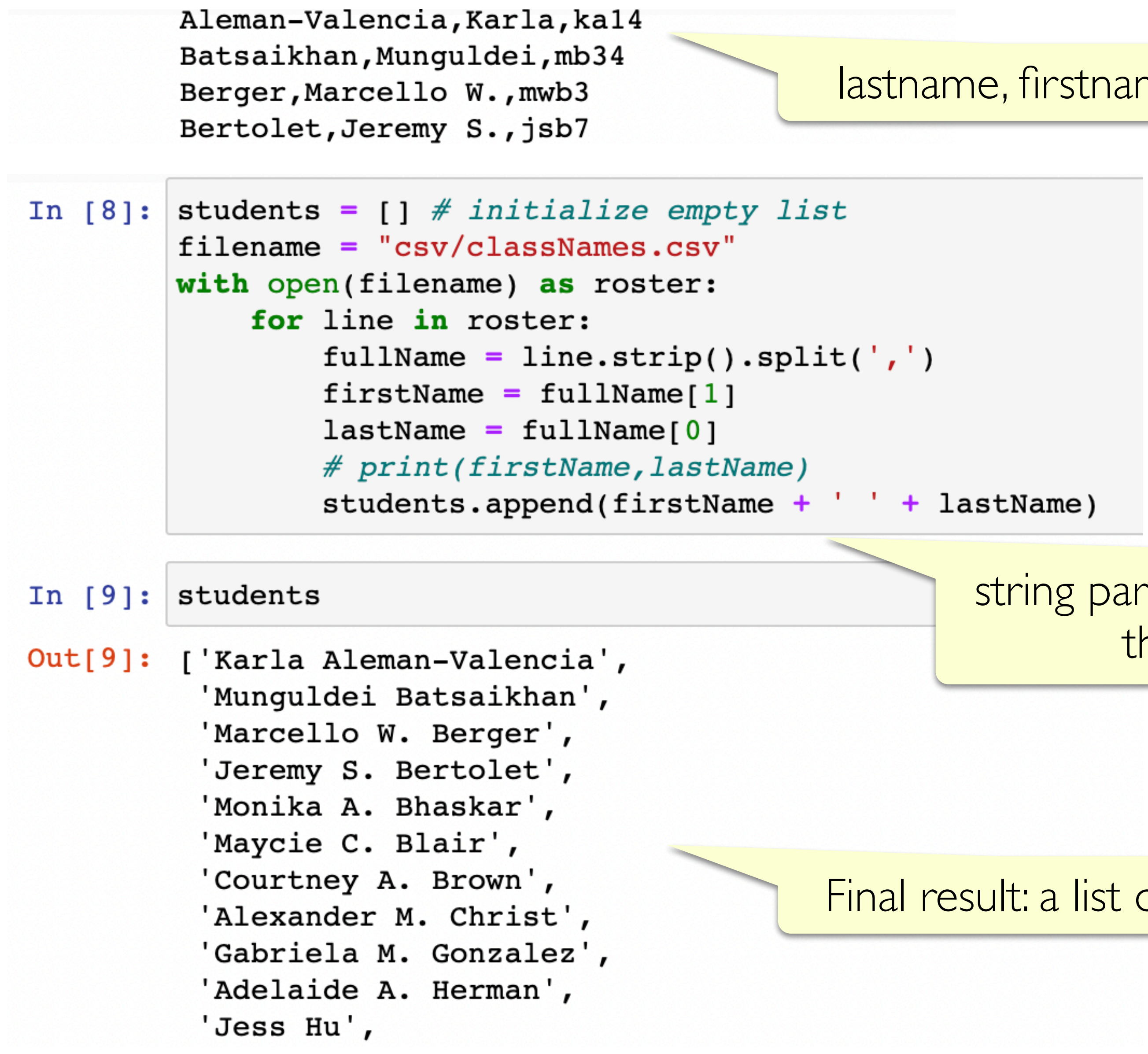
```
In [4]: # if we want to create one big list of the words, we can accumulate
        # in a list using the extend() method
        wordList = []
        with open('textfiles/mountains.txt') as book:
            for line in book:
                wordList.extend(line.strip().split())
```

split() returns a list

```
In [6]: wordList

Out[6]: ['O,',
         'proudly',
         'rise',
         'the',
         'monarchs',
         'of',
         'our',
         'mountain',

In [7]: len(wordList)

Out[7]: 133

In [5]: # number of times a word ('mountains!') is in the song?
        wordList.count('mountains!')

Out[5]: 4
```

Data Analysis w/ CSVs

- Convert our last, first, unix CSV (snippet shown below) into a list of names



```
Aleman-Valencia,Karla,ka14
Batsaikhan,Munguldei,mb34
Berger,Marcello W.,mwb3
Bertolet,Jeremy S.,jsb7
```

lastname, firstname, unix

```
In [8]: students = [] # initialize empty list
        filename = "csv/classNames.csv"
        with open(filename) as roster:
            for line in roster:
                fullName = line.strip().split(',')
                firstName = fullName[1]
                lastName = fullName[0]
                # print(firstName,lastName)
                students.append(firstName + ' ' + lastName)
```

string parsing to find first and last names; then append string to list

```
In [9]: students

Out[9]: ['Karla Aleman-Valencia',
         'Munguldei Batsaikhan',
         'Marcello W. Berger',
         'Jeremy S. Bertolet',
         'Monika A. Bhaskar',
         'Maycie C. Blair',
         'Courtney A. Brown',
         'Alexander M. Christ',
         'Gabriela M. Gonzalez',
         'Adelaide A. Herman',
         'Jess Hu',
```

Final result: a list of strings

List Patterns: Map & Filter

- When working with files, it is common to store data in **lists**
  - When processing lists, there are common patterns that appear
- **Mapping:** Iterate over a list and return a new list that results from ***performing an operation on each element*** of a given sequence (list)
  - E.g., take a list of integers `numList` and return a new list which contains the square of each number in `numList`
- **Filtering:** Iterate over a list and return a new list that results from ***keeping only those elements of the list that satisfy some condition***
  - E.g., take a list of integers `numList` and return a new list which contains only the even numbers in `numList`
- Python allows us to implement these patterns succinctly using **list comprehensions**

List Comprehensions

Mapping List Comprehension (perform operation on each element)

```
newList = [expression for item in sequence]
```

Filtering List Comprehension (only keep some elements)

```
newList = [item for item in sequence if conditional]
```

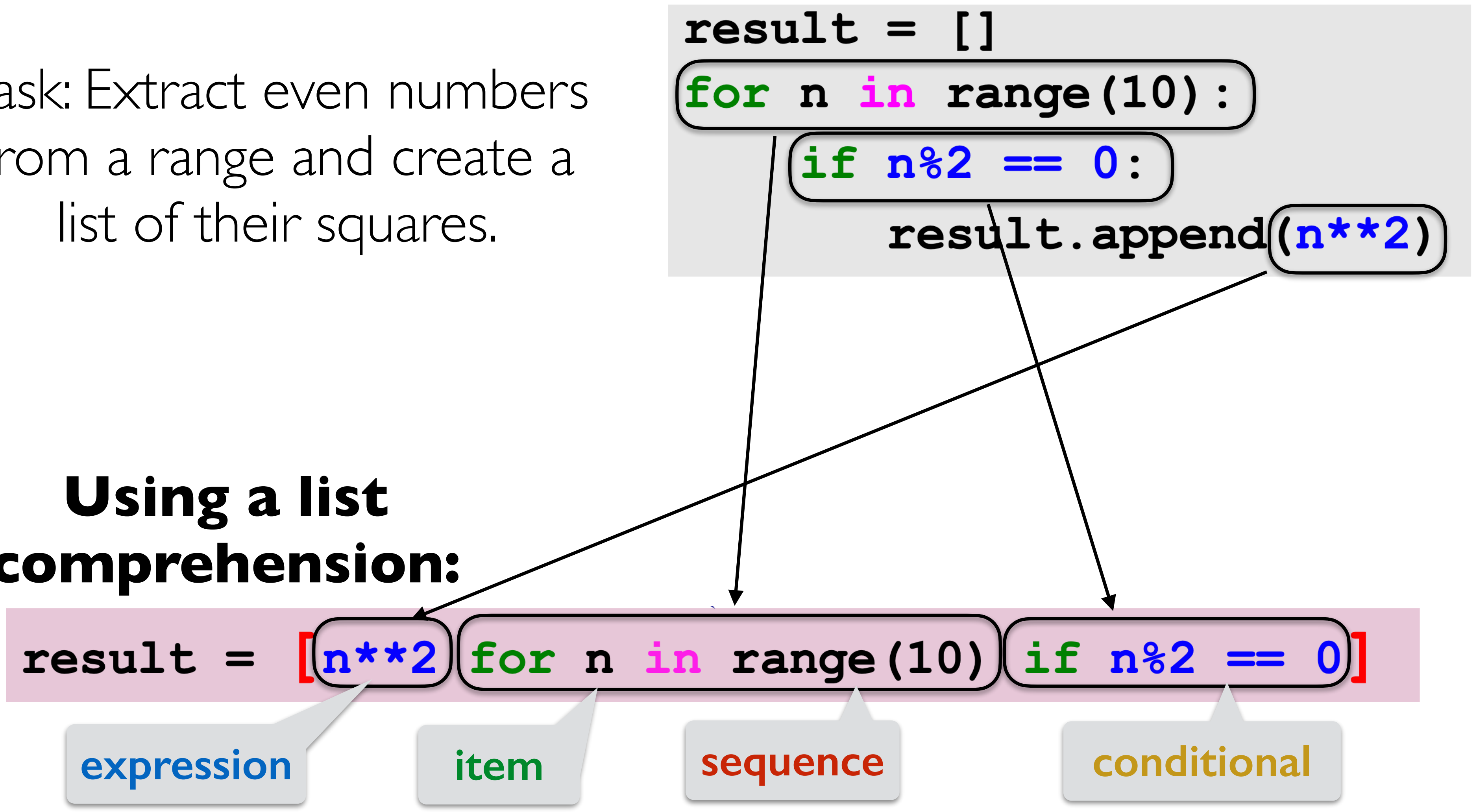
- Important points:
  - List comprehensions always start with an **expression** (even a variable name like "item" is an expression!)
  - We **never use append( )** in list comprehensions
  - We can **combine mapping and filtering** into a single list comprehension:

```
newList = [expression for item in sequence if conditional]
```

Dissecting List Comprehensions

```
newList = [expression for item in sequence if conditional]
```

Task: Extract even numbers from a range and create a list of their squares.



```
result = []
for n in range(10):
    if n%2 == 0:
        result.append(n**2)
```

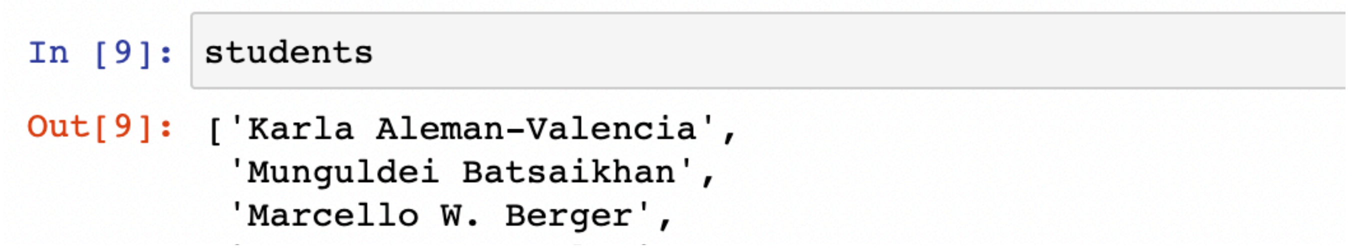
Using a list comprehension:

```
result = [n**2 for n in range(10) if n%2 == 0]
```

All list comprehensions can be rewritten using a for loop!

Using List Comprehensions

- **List comprehensions** are often convenient when working with files
- Recall our list of student names from before

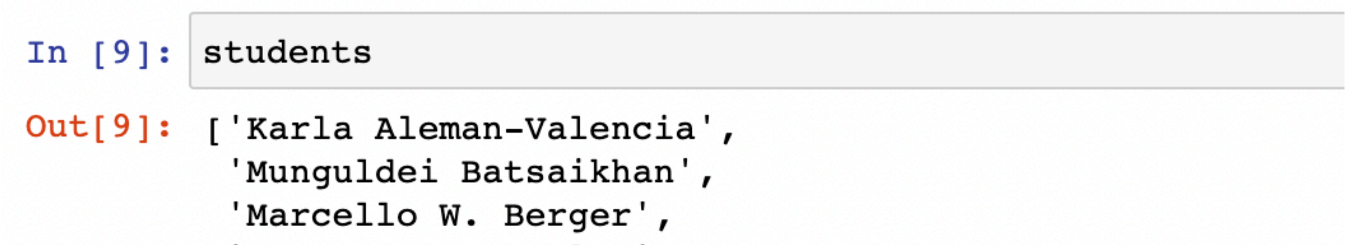


```
In [9]: students

Out[9]: ['Karla Aleman-Valencia',
         'Munguldei Batsaikhan',
         'Marcello W. Berger',
```

- Example: How can we find the list of student names that begin with a vowel? (Hint: we'll use our `isVowel()` function again from before)
  - Idea:
    - Iterate over students (list of strings)
    - For each name in list, check if first letter is a vowel
    - If it is, add name to result list

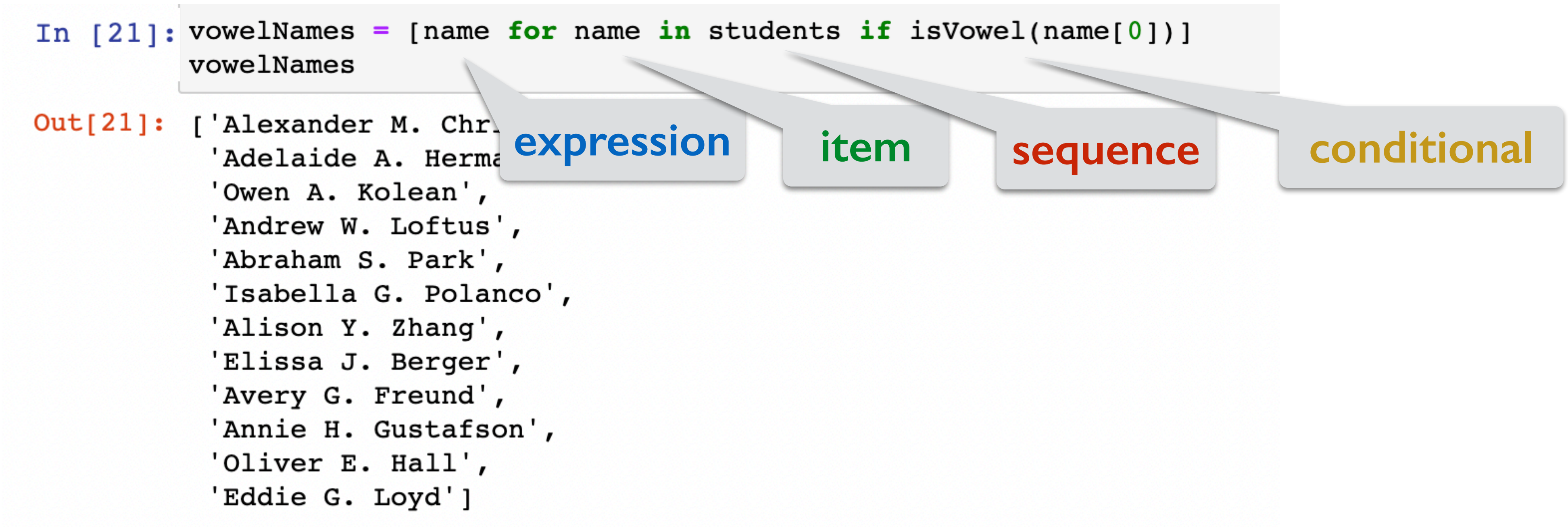
Using List Comprehensions

- **List comprehensions** are often convenient when working with files
- Recall our list of student names from before



```
In [9]:  students

Out[9]:  ['Karla Aleman-Valencia',
          'Munguldei Batsaikhan',
          'Marcello W. Berger',
```

- Example: How can we find the list of student names that begin with a vowel? (Hint: we'll use our `isVowel()` function again from before)



```
In [21]: vowelNames = [name for name in students if isVowel(name[0])]
         vowelNames

Out[21]: ['Alexander M. Chr
          'Adelaide A. Herma
          'Owen A. Kolean',
          'Andrew W. Loftus',
          'Abraham S. Park',
          'Isabella G. Polanco',
          'Alison Y. Zhang',
          'Elissa J. Berger',
          'Avery G. Freund',
          'Annie H. Gustafson',
          'Oliver E. Hall',
          'Eddie G. Loyd']
```

Lists of Lists!

- We have already seen lists of strings
- We can also have **lists of lists** (sometimes called a two-dimensional list)!
- Often arise when using list comprehensions
- Suppose we have a **list of lists of strings** called `myList`
- `word = myList[a][b] (# word is a string)`
    - `a` is index into "***outer***" list (identifies ***which inner list*** we want)
    - `b` is index into "***inner***" list (identifies ***which element*** within the inner list)

```
             b
             ↓                               myList[1][0]?
myList = [ [‘cat’, ’frog’],                      ‘dog’
           [‘dog’, ‘toad’], ←—— a
           [‘cow’, ‘duck’] ]
```

We Don't Talk About ~~Bruno~~ Data Types

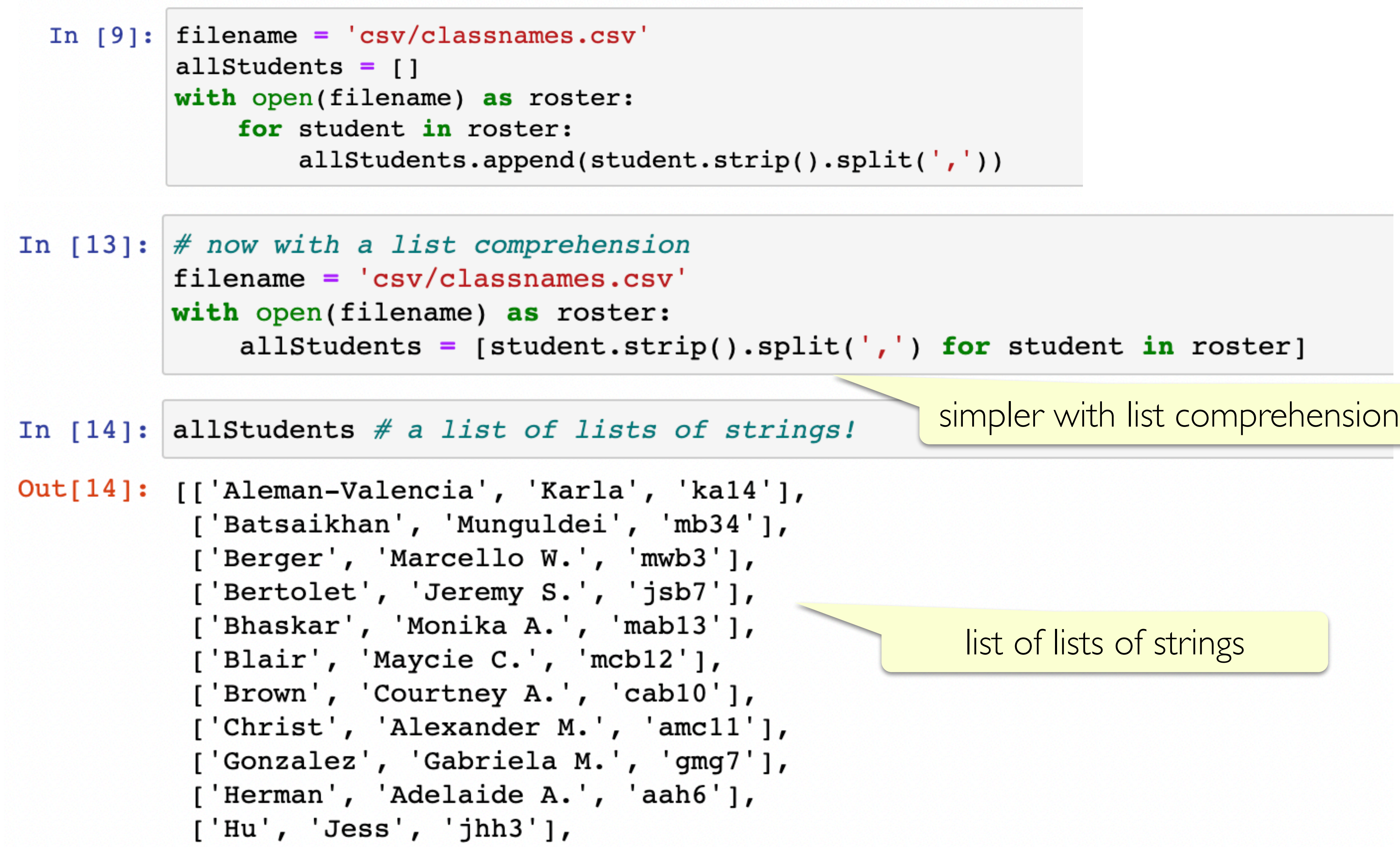
- Python is a loosely typed programming language
  - We don't explicitly declare data types of variables
  - But like Bruno, the creepy uncle in Encanto who lurks behind the walls and predicts the future, data types are always there
  - It's important to make sure we pay attention to what a function expects, especially with lists and strings! (remember this in Lab 4)
- Lists of lists of strings versus list of strings:

```
myList = [ ['cat', 'frog'],  myList = ['cat', 'frog',
           ['dog', 'toad'],            'dog', 'toad',
           ['cow', 'duck'] ]           'cow', 'duck']
```

```
myList[1][0] is 'dog'    myList[1][0] is 'f'
```

Data Analysis

- Suppose we want to create a list of lists of strings using our student data



```
In [9]:  filename = 'csv/classnames.csv'
          allStudents = []
          with open(filename) as roster:
              for student in roster:
                  allStudents.append(student.strip().split(','))
```

```
In [13]:  # now with a list comprehension
          filename = 'csv/classnames.csv'
          with open(filename) as roster:
              allStudents = [student.strip().split(',') for student in roster]
```

simpler with list comprehension

```
In [14]:  allStudents # a list of lists of strings!

Out[14]:  [['Aleman-Valencia', 'Karla', 'ka14'],
           ['Batsaikhan', 'Munguldei', 'mb34'],
           ['Berger', 'Marcello W.', 'mwb3'],
           ['Bertolet', 'Jeremy S.', 'jsb7'],
           ['Bhaskar', 'Monika A.', 'mab13'],
           ['Blair', 'Maycie C.', 'mcb12'],
           ['Brown', 'Courtney A.', 'cab10'],
           ['Christ', 'Alexander M.', 'amc11'],
           ['Gonzalez', 'Gabriela M.', 'gmg7'],
           ['Herman', 'Adelaide A.', 'aah6'],
           ['Hu', 'Jess', 'jhh3'],
```

list of lists of strings

More Examples!

- Let’s write some functions to answer questions about student names
- Student fun facts! :-)