Compsci 101
Pancakes, While loops, Parallel Lists
Part 1 of 3

Susan Rodger
Nikki Washington
February 25, 2021

```
while BOOL_CONDITION:
    LOOP_BODY
    # modify variables, affect expression
```

Chad Jenkins

- Professor at Univ of Michigan
- Ph.D at USC
- Robotics
  - problems in interactive robotics and human-robot interaction
- Several committees such as CRA-WP

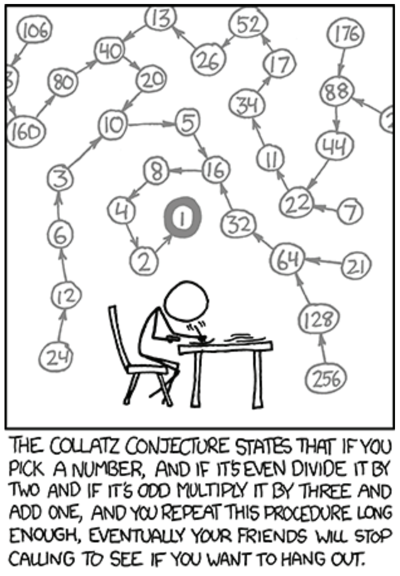
"For robots to be useful in the real world, anyone, not only technical specialists, must be able to easily train and control them"

"We're moving past treating robots as remote-control devices. We're helping them learn"

When is a game of chess over?

- If you were to write a program to play chess
  - how many rounds in a game?

https://xkcd.com/710/



THE COLLATZ CONJECTURE STATES THAT IF YOU PICK A NUMBER, AND IF IT'S EVEN DIVIDE IT BY TWO AND IF IT'S ODD MULTIPLY IT BY THREE AND ADD ONE, AND YOU REPEAT THIS PROCEDURE LONG ENOUGH, EVENTUALLY YOUR FRIENDS WILL STOP CALLING TO SEE IF YOU WANT TO HANG OUT.

Collatz Conjecture (Hailstone)

If number is even
    Divide by 2
If number is odd
    multiply by 3 and add 1

Why Solve This? In Python?

- https://en.wikipedia.org/wiki/Collatz_conjecture
- We want to illustrate an indefinite loop
  - One of many mathematical sequences, but …
- There's an XKCD comic about it!
  - Not everyone enjoys XKCD, but …
- Mathematics is foundational in computer science, but
  - Not everyone enjoys logic/math puzzles, but …

Developing and Reasoning about While Loops

- Don't know: *how many times* loop executes
  - *a priori* knowledge, we'll know afterword
- Do know: condition that should be true after loop
  - Its negation is the expression for `BOOL_CONDITION` (loop guard)

```
while BOOL_CONDITION:
    LOOP_BODY
    # modify variables, affect expression
```

History: From while to for loops

while loop (sum list)

```
lst = [4,1,8,9]
s = 0
i = 0
while i < len(lst):
    s += lst[i]
    i += 1
print(s)
```

for loop (sum list)

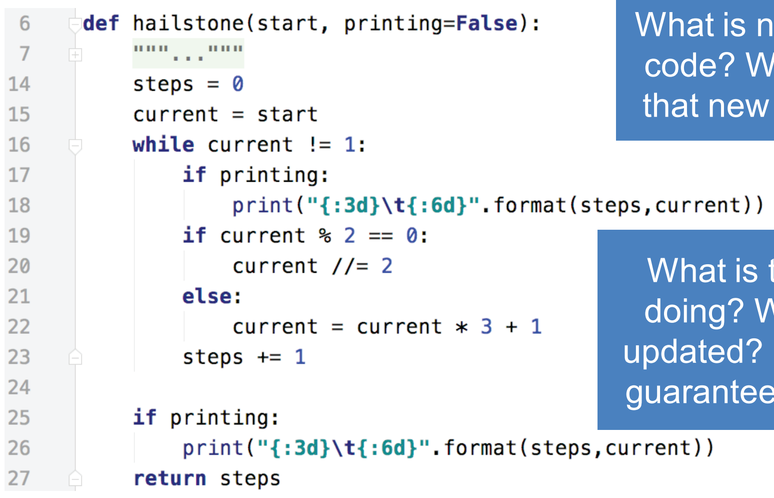
```
lst = [4,1,8,9]
s = 0
for n in lst:
    s += n
print(s)
```

Concrete Example: Collatz/Hailstone

- Don't know: *how many times* loop executes
  - some numbers: long sequences, others short
- Do know: condition that should be true after loop
  - It's negation is the expression for loop guard!
  - What is true after loop below finishes?

```
while value != 1:
    loop body
    # modify value somehow
```

Collatz Code



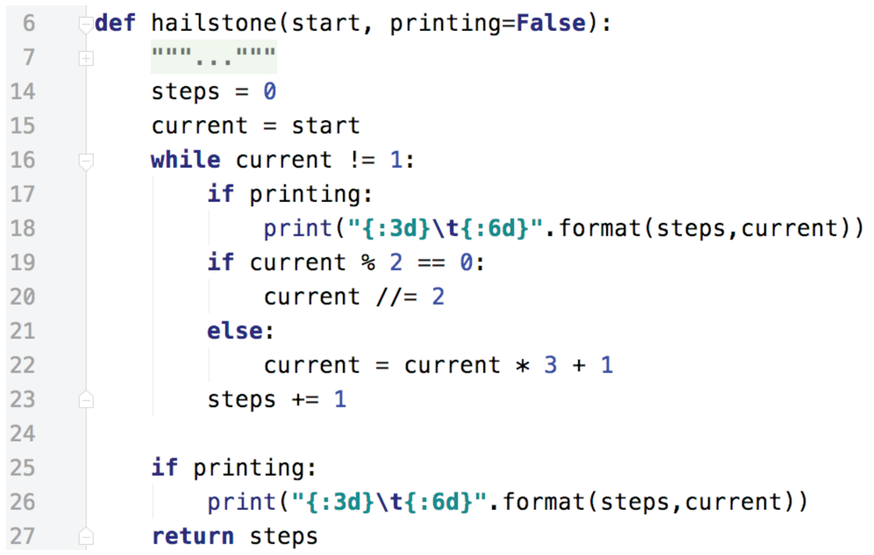
```python
def hailstone(start, printing=False):
    """..."""
    steps = 0
    current = start
    while current != 1:
        if printing:
            print("{:3d}\t{:6d}".format(steps,current))
        if current % 2 == 0:
            current //= 2
        else:
            current = current * 3 + 1
        steps += 1

    if printing:
        print("{:3d}\t{:6d}".format(steps,current))
    return steps
```

What is new in this code? What does that new stuff do?

What is this code doing? What gets updated? Is the loop guaranteed to stop?

Collatz code



```python
def hailstone(start, printing=False):
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    steps = 0
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    if printing:
        print("{:3d}\t{:6d}".format(steps,current))
    return steps
```

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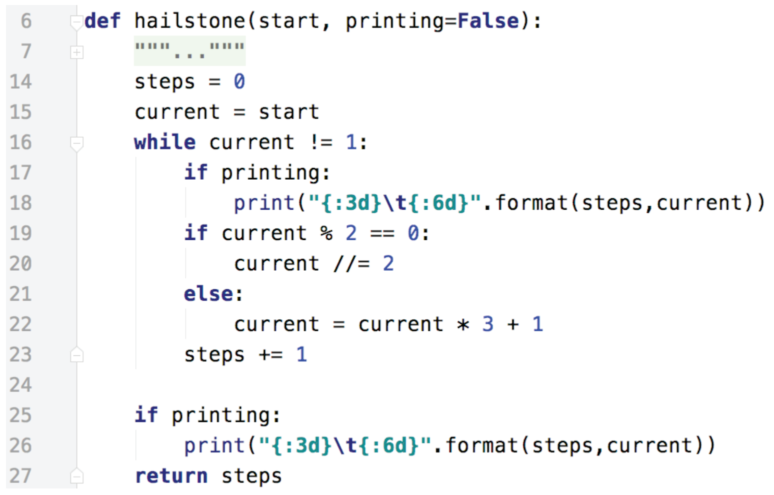
Collatz Code



```python
def hailstone(start, printing=False):
    """..."""
    steps = 0
    current = start
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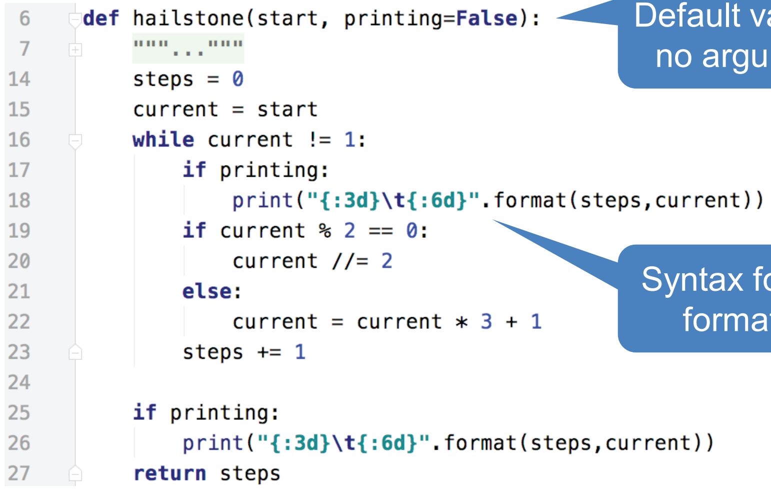
        else:
            current = current * 3 + 1
        steps += 1

    if printing:
        print("{:3d}\t{:6d}".format(steps,current))
    return steps
```

Collatz: New stuff



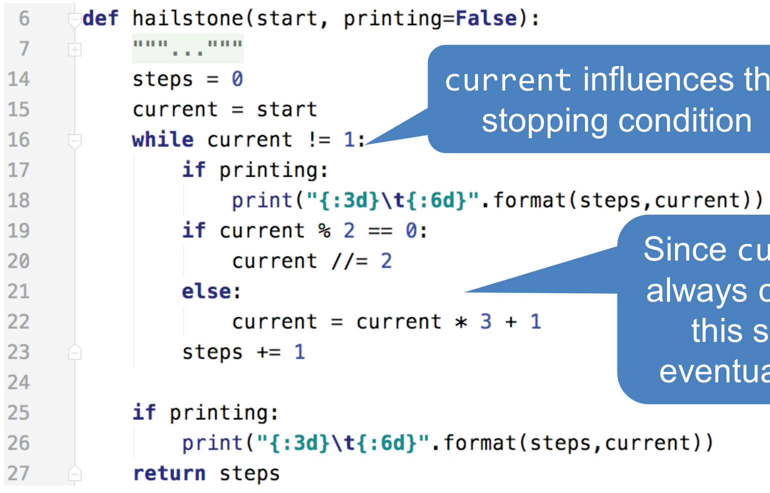
```
def hailstone(start, printing=False):
    """..."""
    steps = 0
    current = start
    while current != 1:
        if printing:
            print("{:3d}\t{:6d}".format(steps,current))
        if current % 2 == 0:
            current //= 2
        else:
            current = current * 3 + 1
        steps += 1

    if printing:
        print("{:3d}\t{:6d}".format(steps,current))
    return steps
```

Default value, if no argument

Syntax for nicer formatting

Collatz: Guaranteed to stop?



```
def hailstone(start, printing=False):
    """..."""
    steps = 0
    current = start
    while current != 1:
        if printing:
            print("{:3d}\t{:6d}".format(steps,current))
        if current % 2 == 0:
            current //= 2
        else:
            current = current * 3 + 1
        steps += 1

    if printing:
        print("{:3d}\t{:6d}".format(steps,current))
    return steps
```

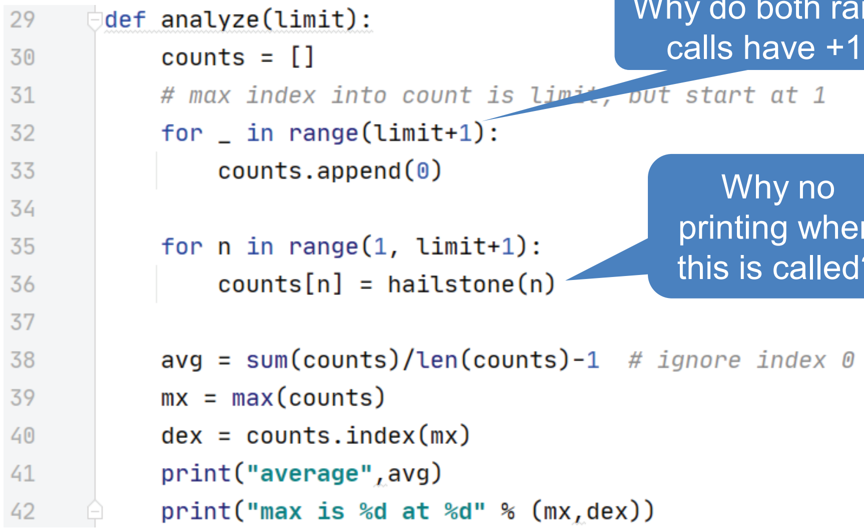
`current` influences the stopping condition

Since `current` is always changed, this should eventually stop

Collatz Data – Average no. of steps

- How do we gather data for numbers <= 10,000?
  - In general for numbers in range(low,high) ?
  - Call function, store result, store 10,000 results?
- We'd like counts[k] to be length of sequence for k
  - How do we allocate 10,000 list elements?
  - Like there is `"hello" * 3`
  - There is `[0] * 10000`

Think: Analysis in Collatz.py



```
def analyze(limit):
    counts = []
    # max index into count is limit, but start at 1
    for _ in range(limit+1):
        counts.append(0)

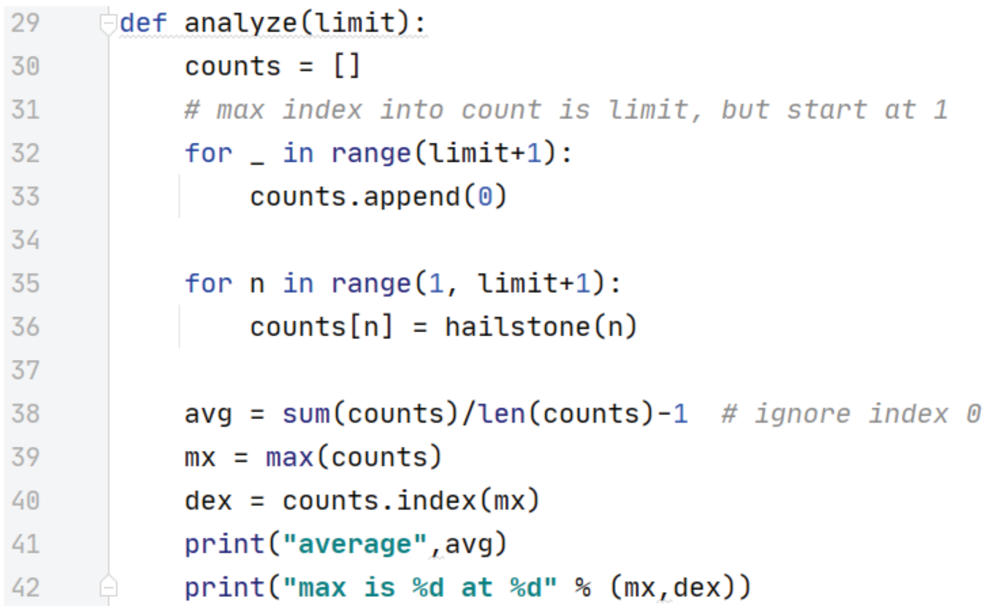
    for n in range(1, limit+1):
        counts[n] = hailstone(n)

    avg = sum(counts)/len(counts)-1  # ignore index 0
    mx = max(counts)
    dex = counts.index(mx)
    print("average",avg)
    print("max is %d at %d" % (mx,dex))
```

Why do both range calls have +1?

Why no printing when this is called?

Analysis in Collatz.py



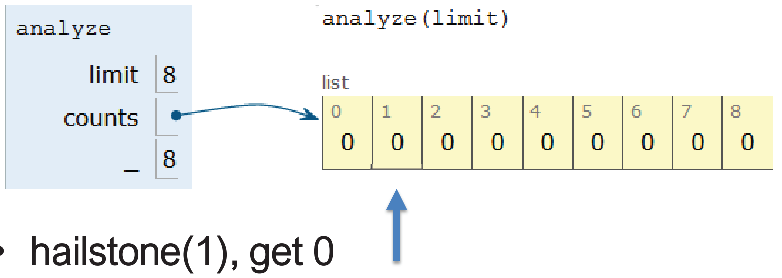
```
def analyze(limit):
    counts = []
    # max index into count is limit, but start at 1
    for _ in range(limit+1):
        counts.append(0)

    for n in range(1, limit+1):
        counts[n] = hailstone(n)

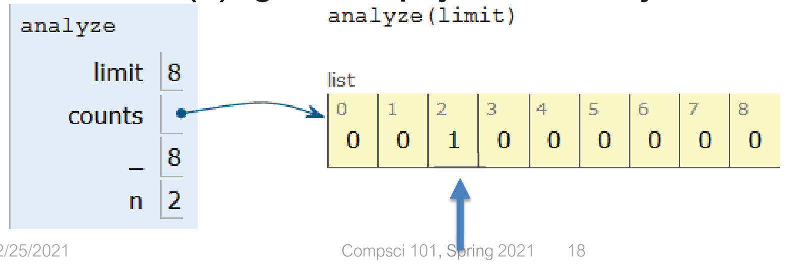
    avg = sum(counts)/len(counts)-1  # ignore index 0
    mx = max(counts)
    dex = counts.index(mx)
    print("average",avg)
    print("max is %d at %d" % (mx,dex))
```

counts list when limit is 8?

- Counts is of size 8+1, we ignore slot 0

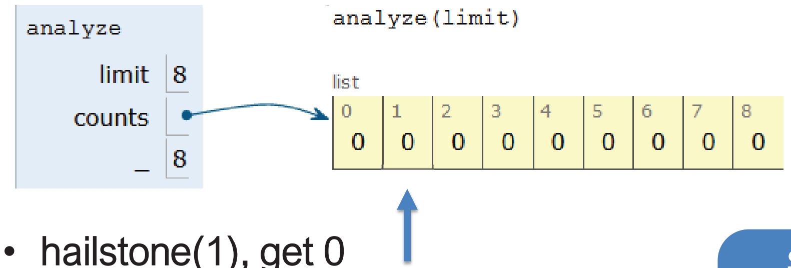


- hailstone(1), get 0
- hailstone(2), get 1 step, just divide by 2



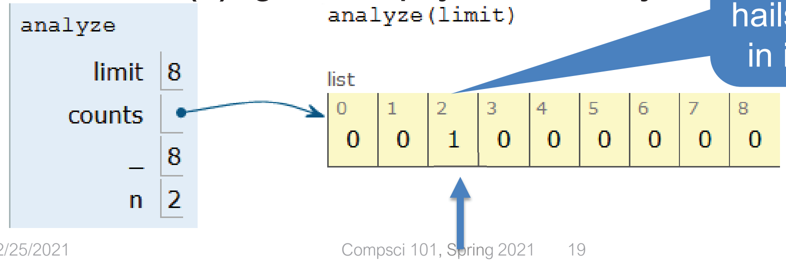
counts list when limit is 8?

- Counts is of size 8+1, we ignore slot 0



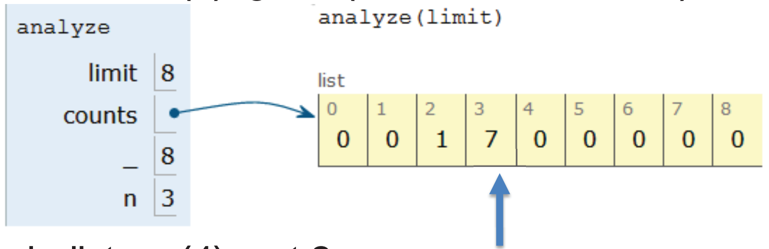
- hailstone(1), get 0
- hailstone(2), get 1 step, just divide by 2

Store answer for hailstone(2) in index 2

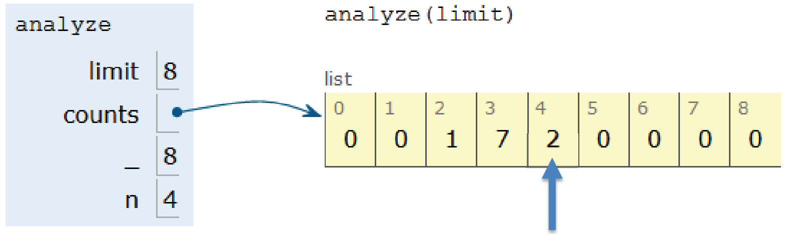


counts list when limit is 8?

- hailstone(3), get 7 (10, 5, 16, 8, 4, 2, 1)

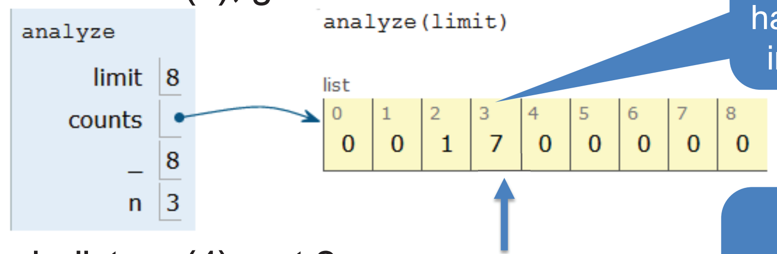


- hailstone(4), get 2



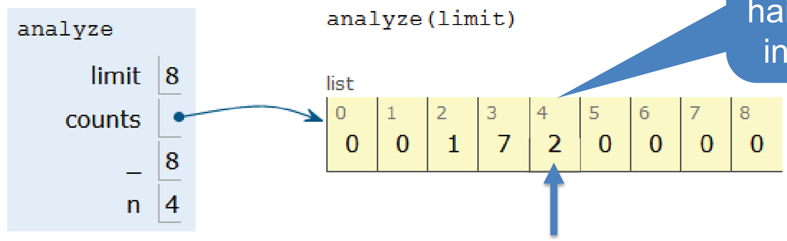
counts list when limit is 8?

- hailstone(3), get 7



Store answer for hailstone(3) in index 3

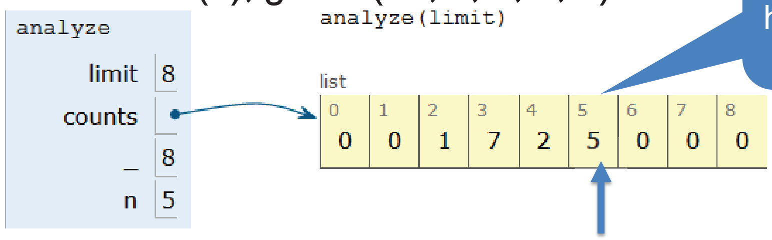
- hailstone(4), get 2



Store answer for hailstone(4) in index 4

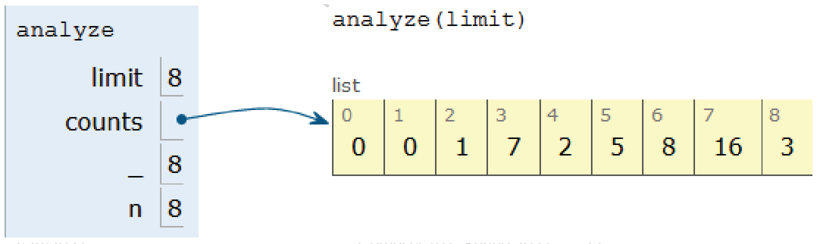
counts list when limit is 8?

- hailstone(5), get 5 (16, 8, 4, 2, 1)



Store answer for hailstone(5) in index 5

- And so on…..
- Hailstone(6) is 8, hailstone(7) is 16, hailstone(8) is 3



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Parallel Lists

- Case Study: FileFrequency.py
- We'd like to analyze word occurrences
  - Google N-Gram, it's easy to do, but …
  - What about occurrences of "cgat" in genome?
  - What about Rotten Tomatoes?
- This code is built using the tools that we have
  - In the future, learn of more efficient structures
- We'll use an API for opening files

High Level View

- We will use parallel lists to track data
  - Each word is stored in a list named **`words`**
  - Word's count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

```
["apple", "fox", "vacuum", "lime"]
[5,2,25,15]
```

- What happens when we read a word?

Read word "apple"?

High Level View

- We will use parallel lists to track data
  - Each word is stored in a list named **`words`**
  - Word's count is stored in a list named **`counts`**
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```
["apple", "fox", "vacuum", "lime"]
[6,2,25,15]
```

- What happens when we read a word?

Read word "apple"?

High Level View

- We will use parallel lists to track data
  - Each word is stored in a list named **`words`**
  - Word's count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

```
["apple", "fox", "vacuum", "lime"]
[6,2,25,15]
```

- What happens when we read a word?

Read word "banana"?

High Level View

- We will use parallel lists to track data
  - Each word is stored in a list named **`words`**
  - Word's count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

```
["apple", "fox", "vacuum", "lime”,
"banana"]
[6,2,25,15]
```

Add into words

- What happens when we read a word?

Read word "banana"?

High Level View

- We will use parallel lists to track data
  - Each word is stored in a list named **`words`**
  - Word’s count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

```
["apple", "fox", "vacuum", "lime”,
"banana"]
[6,2,25,15,0]
```

Expand counts

- What happens when we read a word?

Read word “banana”?

High Level View

- We will use parallel lists to track data
  - Each word is stored in a list named **`words`**
  - Word’s count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

```
["apple", "fox", "vacuum", "lime”,
"banana"]
[6,2,25,15,1]
```

Add one

- What happens when we read a word?

Read word “banana”?

Pseudo-code for getFileData

Step 3 of 7 steps: Generalize

- Let user choose a file to open
- Read each line of the file
  - Process each word on the line
    - If word never seen before? Add to words and counts
    - Update # occurrences using .index and location

- Think: What would we do for each color when doing step 5 (translate to code) of the 7 steps?

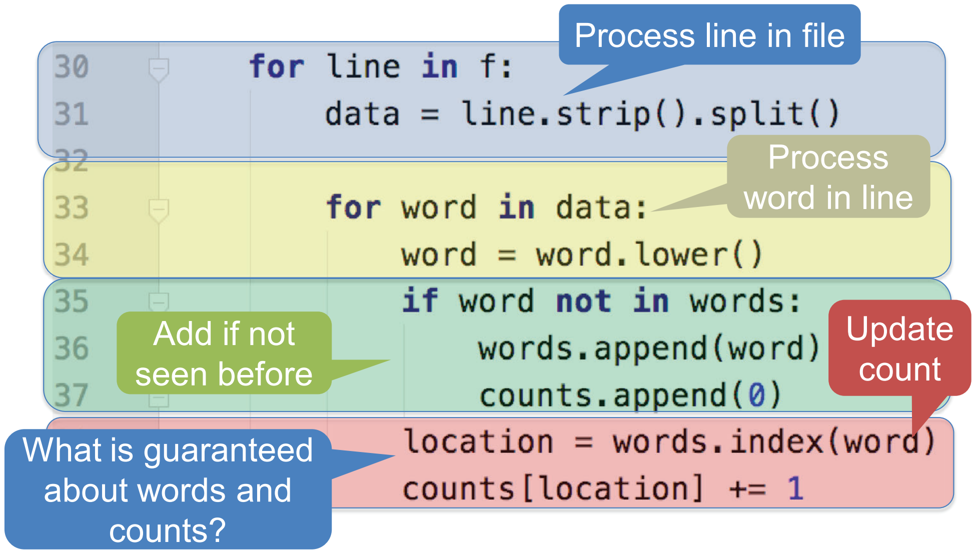
Pseudo-code for getFileData

- Let user choose a file to open
- Read each line of the file
  - FOR LOOP
  - Process each word on the line
    - SPLIT, FOR LOOP
    - If word never seen before? Add to words and counts
      – IF STATEMENT, UPDATE LIST
    - Update # occurrences using .index and location
      – UPDATE LIST, USE INDEX FUNCTION

Pseudo-code for getFileData

- Let user choose a file to open
  - SOME KIND OF CODE CHOOSES A FILE
- Read each line of the file
  - FOR LOOP
  - Process each word on the line
    - SPLIT, FOR LOOP
    - If word never seen before? Add to words and counts
      - IF STATEMENT, UPDATE LIST
    - Update # occurrences using .index and location
      - UPDATE LIST, USE INDEX FUNCTION

From Pseudo to Code



```
    for line in f:
        data = line.strip().split()

        for word in data:
            word = word.lower()
            if word not in words:
                words.append(word)
                counts.append(0)
            location = words.index(word)
            counts[location] += 1
```

Comparing Two Approaches

- Why do we have a loop in a loop?
  - Code mirrors structure:
    - file has lines, lines have words
- Notice:
  - `.strip`
  - `.split`
  - `.lower`
  - `not in`
  - `.append`
  - `.index`
  - `+=`

Outer loop

Inner loop

```
for line in f:
    data = line.strip().split()

    for word in data:
        word = word.lower()
        if word not in words:
            words.append(word)
            counts.append(0)
        location = words.index(word)
        counts[location] += 1
```

Comparing Two Approaches

- Why do we have only one loop?
  - Code mirrors structure, which is better?
  - File is a sequence of characters!!

```
for word in f.read().lower().split():
    if word not in words:
        words.append(word)
        counts.append(0)
    location = words.index(word)
    counts[location] += 1
```

Comparing Two Approaches

- Why do we have only one loop?
  - Code mirrors structure, which is better?
  - File is a sequence of characters!!

Same in both

```
for word in f.read().lower().split():
    if word not in words:
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    location = words.index(word)
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