# CS 106A, Lecture 20
# HashMaps

suggested reading:

*Java Ch. 13.2*

# Learning Goals

- Know how to store data in and retrieve data from a **`HashMap`**.

WhatsTrending [completed]

```
Tweets file: EllenTweets.txt
#tbt: 42
#findingdory: 20
#laughdancepartner: 55
#laughdancepartnerâ€¦: 19
#edbypetsmart: 21
#littlebigshots: 18
#thebachelor: 16
#oscars: 19
#firstdates: 33
```

# Plan for today

- Recap: ArrayLists
- HashMaps
- Practice: Dictionary
- HashMaps as Counters
- Practice: What’s Trending
- Recap

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# Our First ArrayList

```
// Create an (initially empty) list
ArrayList<String> list = new ArrayList<>();
```

```
// Add an element to the back
list.add("Hello");    // now size 1
```

| |
|---|
| **“Hello”** |

```
list.add("there!");   // now size 2
```

| | |
|---|---|
| **“Hello”** | **“there!”** |

# ArrayList Methods

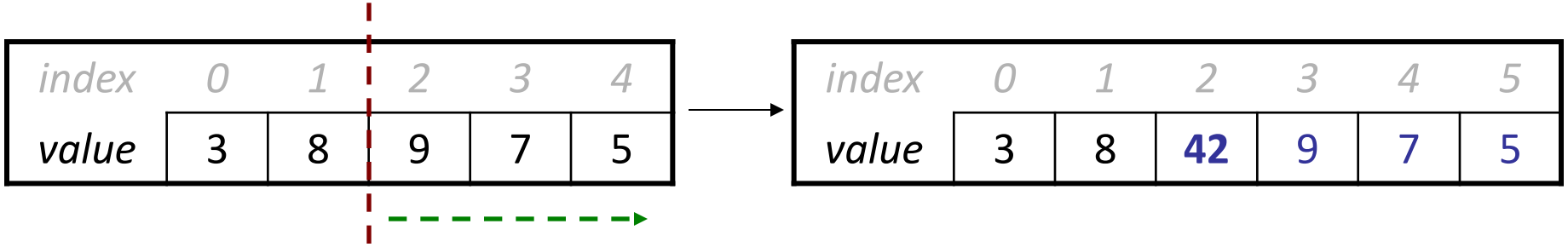
| | |
|---|---|
| `list.add(value);` | appends value at end of list |
| `list.add(index, value);` | inserts given value just before the given index, shifting subsequent values to the right |
| `list.clear();` | removes all elements of the list |
| `list.get(index)` | returns the value at given index |
| `list.indexOf(value)` | returns first index where given value is found in list (-1 if not found) |
| `list.isEmpty()` | returns `true` if the list contains no elements |
| `list.remove(index);` | removes/returns value at given index, shifting subsequent values to the left |
| `list.remove(value);` | removes the first occurrence of the value, if any |
| `list.set(index, value);` | replaces value at given index with given value |
| `list.size()` | returns the number of elements in the list |
| `list.toString()` | returns a string representation of the list such as `"[3, 42, -7, 15]"` |

# Insert/remove

- If you insert/remove in the front or middle of a list, elements **shift** to fit.

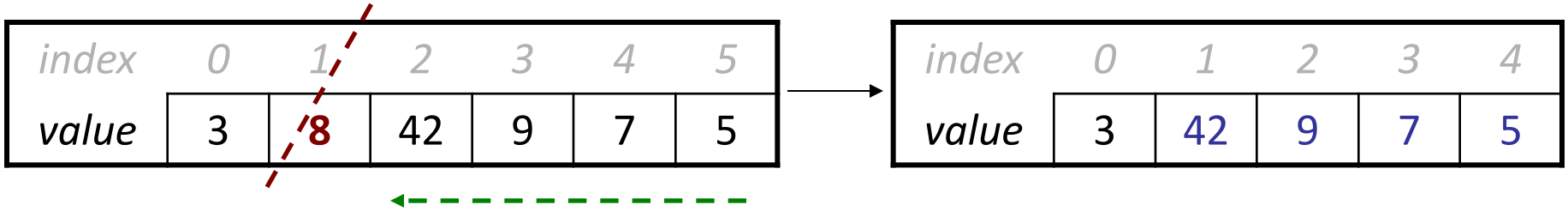
```
list.add(2, 42);
```

  - shift elements right to make room for the new element




```
list.remove(1);
```

  - shift elements left to cover the space left by the removed element



# ArrayLists + Primitives = 💔

| Primitive | "Wrapper" Class |
|---|---|
| `int` | `Integer` |
| `double` | `Double` |
| `boolean` | `Boolean` |
| `char` | `Character` |

# ArrayLists + Wrappers = ❤️

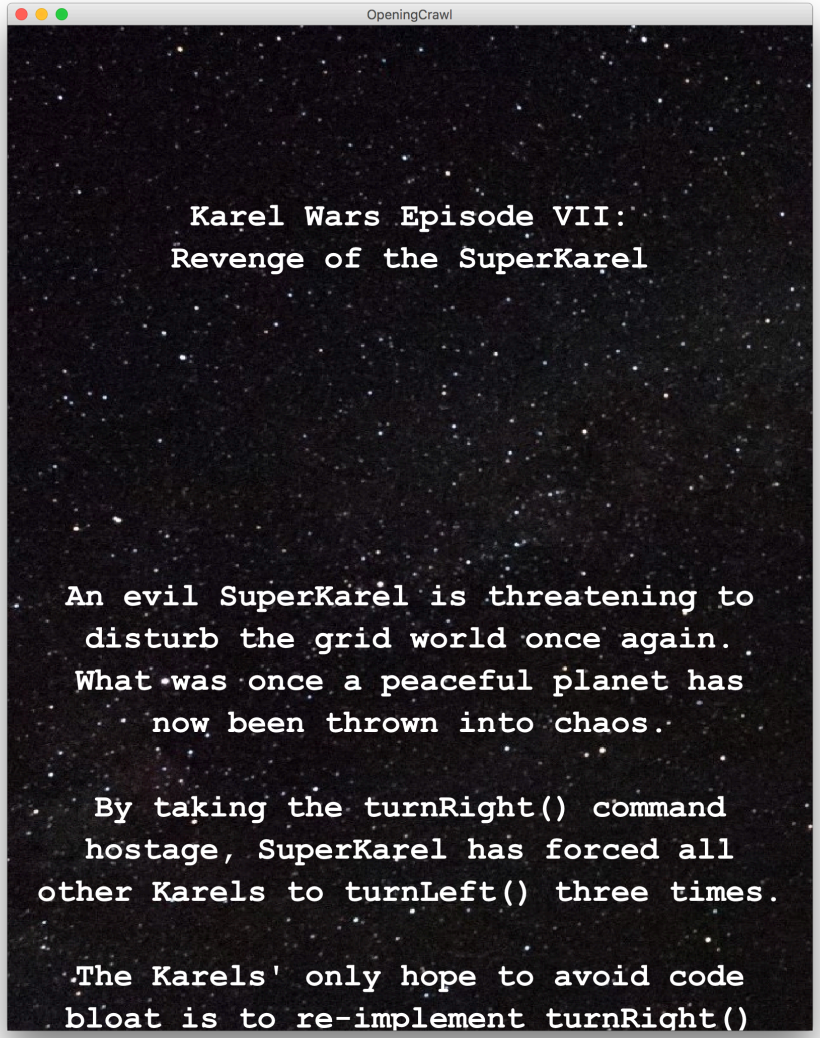
```
// Use wrapper classes when making an ArrayList
ArrayList<Integer> list = new ArrayList<>();

// Java converts Integer <-> int automatically!
int num = 123;
list.add(num);

int first = list.get(0);   // 123
```

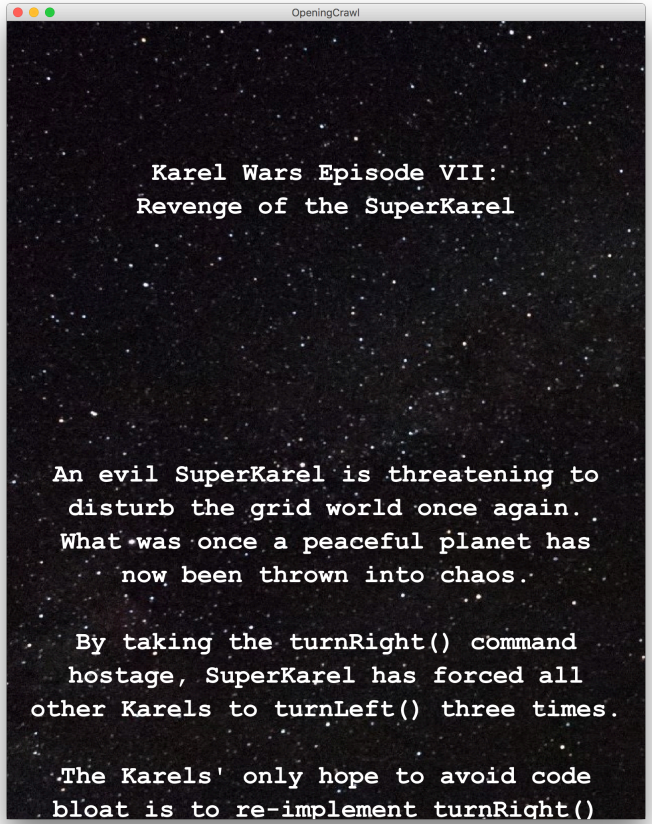
Conversion happens automatically!

# Example: Opening Crawl



# Example: Planner

- Let's write a program that emulates the Star Wars "opening crawl"
  - The program first reads in a text file
  - It then animates this text flowing upwards



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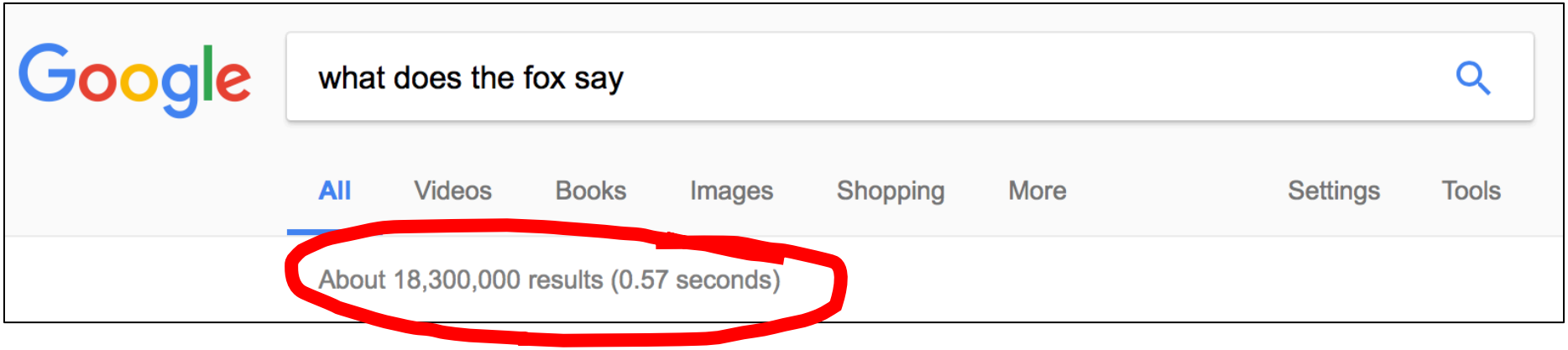
# Limitations of Lists

- Can only look up by *index* (int), not by String, etc.
- Cumbersome for preventing duplicate information
- Slow for lookup

| *index* | *0* | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* |
|---|---|---|---|---|---|---|---|---|---|---|
| *value* | 12 | 49 | -2 | 26 | 5 | 17 | -6 | 84 | 72 | 3 |

# How Is Webpage Lookup So Fast?



# Introducing… HashMaps!

- A variable type that represents a collection of **key-value pairs**
- You access values by *key*
- Keys and values can be any type of **object**
- Resizable – can add and remove pairs
- Has helpful methods for searching for keys

# HashMap Examples

- **Phone book:** name -> phone number
- **Search engine:** URL -> webpage
- **Dictionary**: word -> definition
- **Bank**: account # -> balance
- **Social Network**: name -> profile
- **Counter**: text -> # occurrences
- And many more…

# Our First HashMap

```
import java.util.*;
```

```
HashMap<String, String> myHashMap = new HashMap<>();
```

# Our First HashMap

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HashMap<String, String> myHashMap = new HashMap<>();
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# Our First HashMap

Type of keys your HashMap will store.

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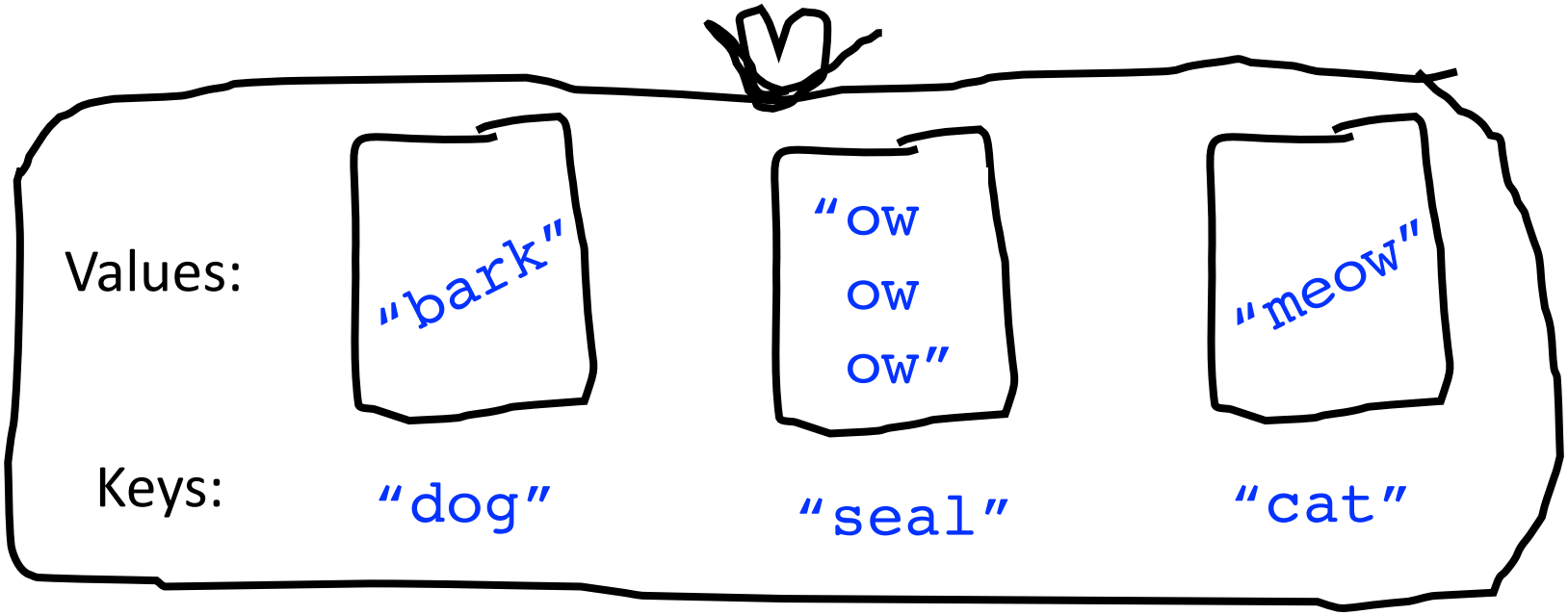
```

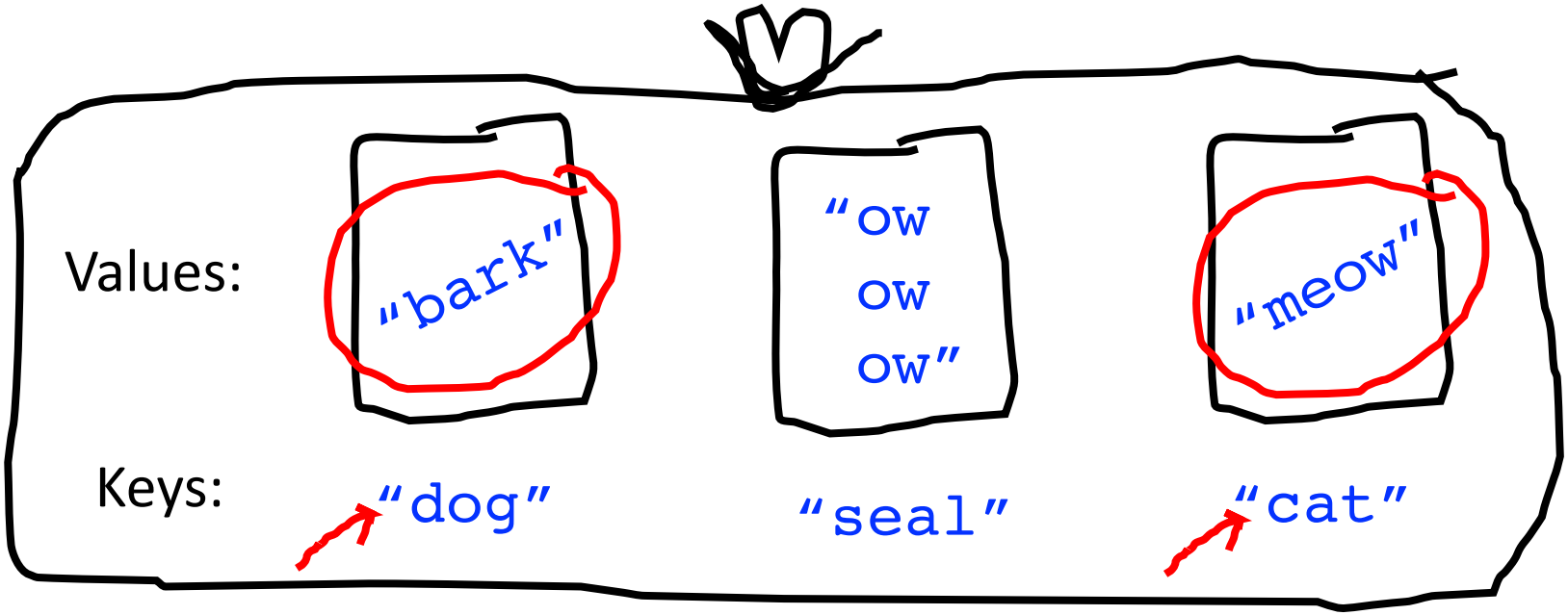
# Our First HashMap - Put

```
// Create an (initially empty) HashMap
HashMap<String, String> map = new HashMap<>();
map.put("dog", "bark"); // Add a key-value pair
map.put("cat", "meow"); // Add another pair
map.put("seal", "ow ow"); // Add another pair
map.put("seal", "ow ow ow"); // Overwrites!
```



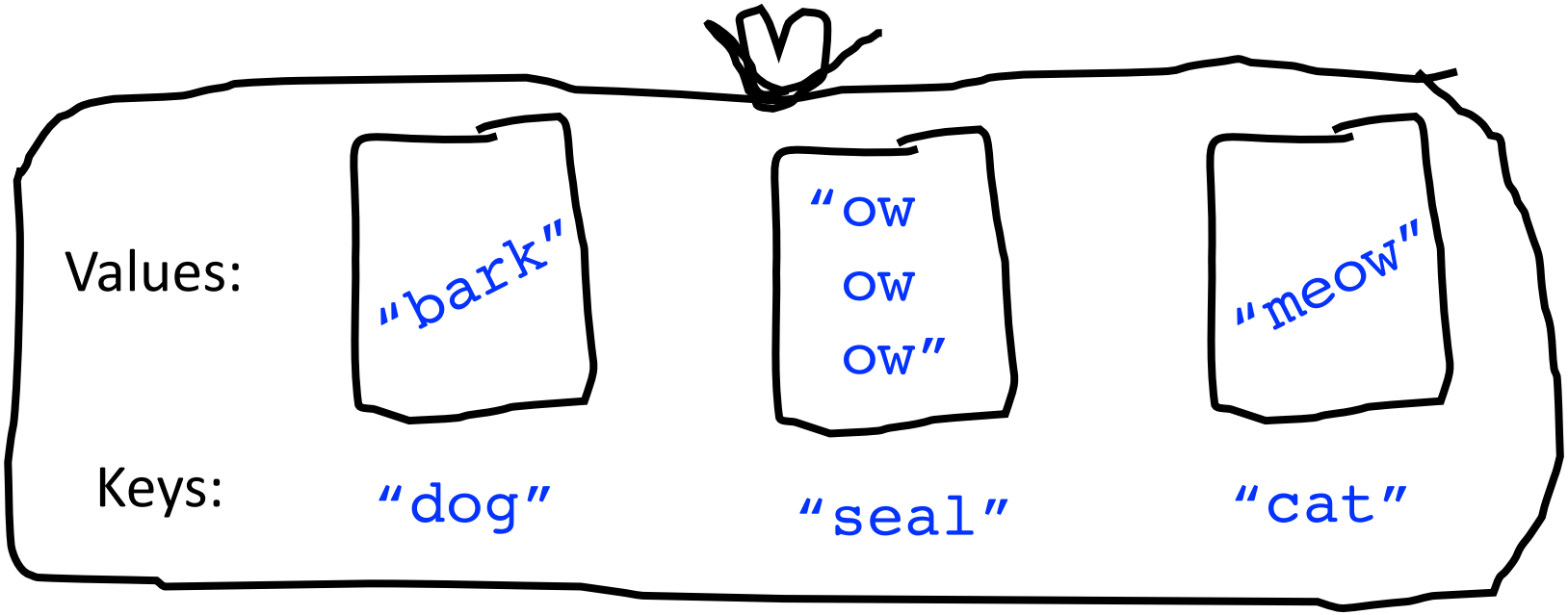
# Our First HashMap - Get

```
...
String s = map.get("dog"); // Get a value for a key
String s = map.get("cat"); // Get a value for a key
String s = map.get("fox"); // null
```



# Our First HashMap - Remove

```
...
map.remove("dog"); // Remove pair from map
map.remove("seal"); // Remove pair from map
map.remove("fox"); // Does nothing if not in map
```



# Review: HashMap Operations

- ***m*.put(*key*, *value*);** Adds a key/value pair to the map.

```
m.put("Eric", "650-123-4567");
```

  - Replaces any previous value for that key.

- ***m*.get(*key*)** Returns the value paired with the given key.

```
String phoneNum = m.get("Jenny");  // "867-5309"
```

  - Returns null if the key is not found.

- **m.remove(*key*);** Removes the given key and its paired value.

```
m.remove("Rishi");
```

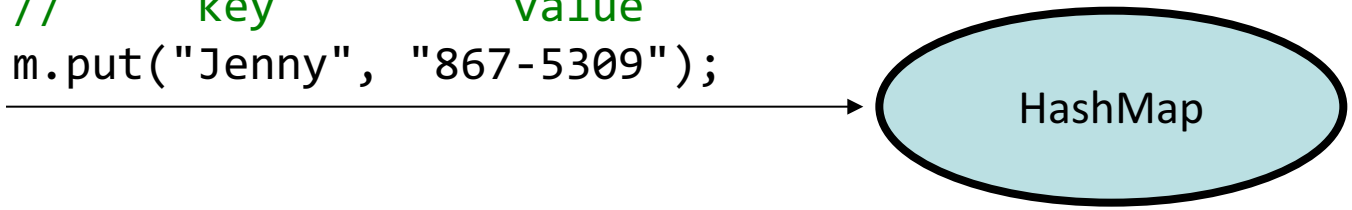
  - Has no effect if the key is not in the map.

| key | value |
|---|---|
| "Jenny" | → "867-5309" |
| "Mehran" | → "123-4567" |
| "Marty" | → "685-2181" |
| "Chris" | → "947-2176" |

# Using HashMaps

- A HashMap allows you to get from one half of a pair to the other.
  - Remembers one piece of information about every key.

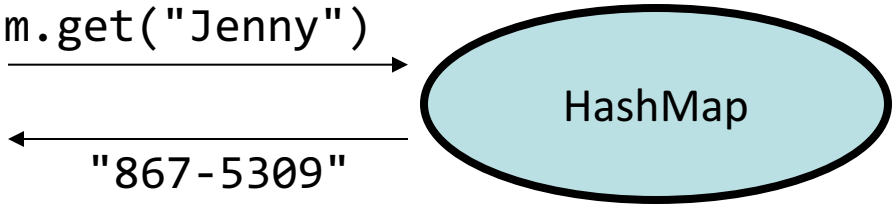
```
//      key          value
m.put("Jenny", "867-5309");
```




  - Later, we can supply only the key and get back the related value:

    Allows us to ask: *What is Jenny's phone number?*

```
m.get("Jenny")
```



# Practice: Map Mystery

**Q:** What are the correct map contents after the following code?

```
HashMap<String, String> map = new HashMap<>();
map.put("K", "Schwarz");
map.put("C", "Lee");
map.put("M", "Sahami");
map.put("M", "Stepp");
map.remove("Stepp");
map.remove("K");
map.put("J", "Cain");
map.remove("C, Lee");
```

**A.** {C=Lee, J=Cain, M=Stepp, M=Sahami}
**B.** {C=Lee, J=Cain, M=Stepp}
**C.** {J=Cain M=Sahami, M=Stepp}
**D.** {J=Cain, K=Schwarz, M=Sahami}
**E.** other

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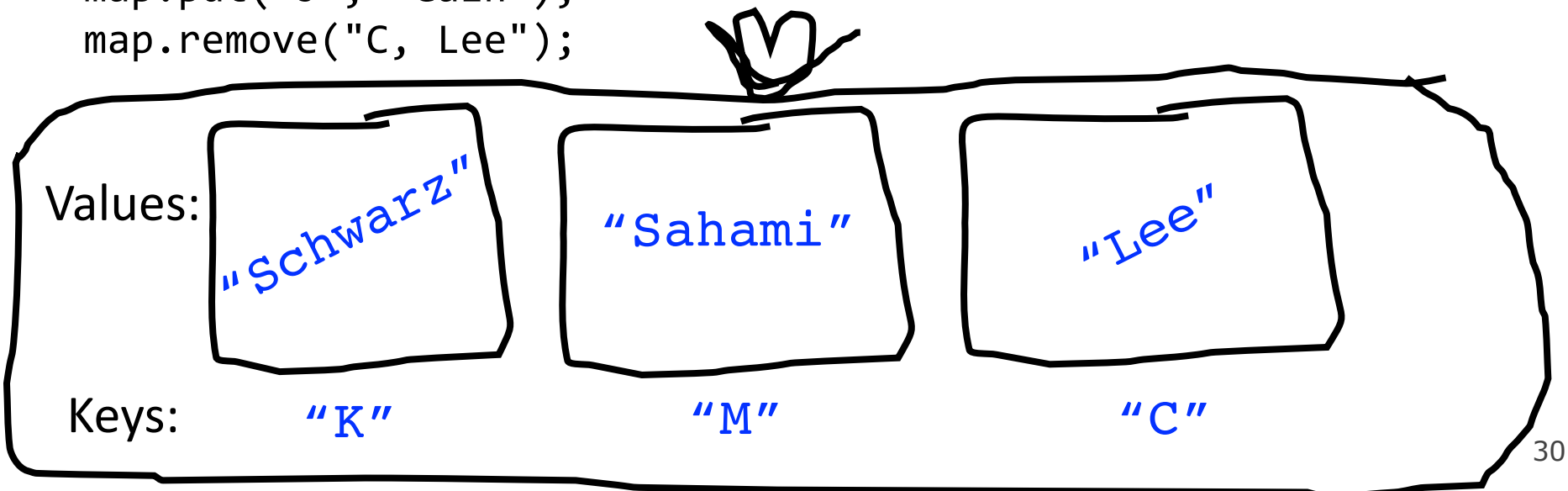

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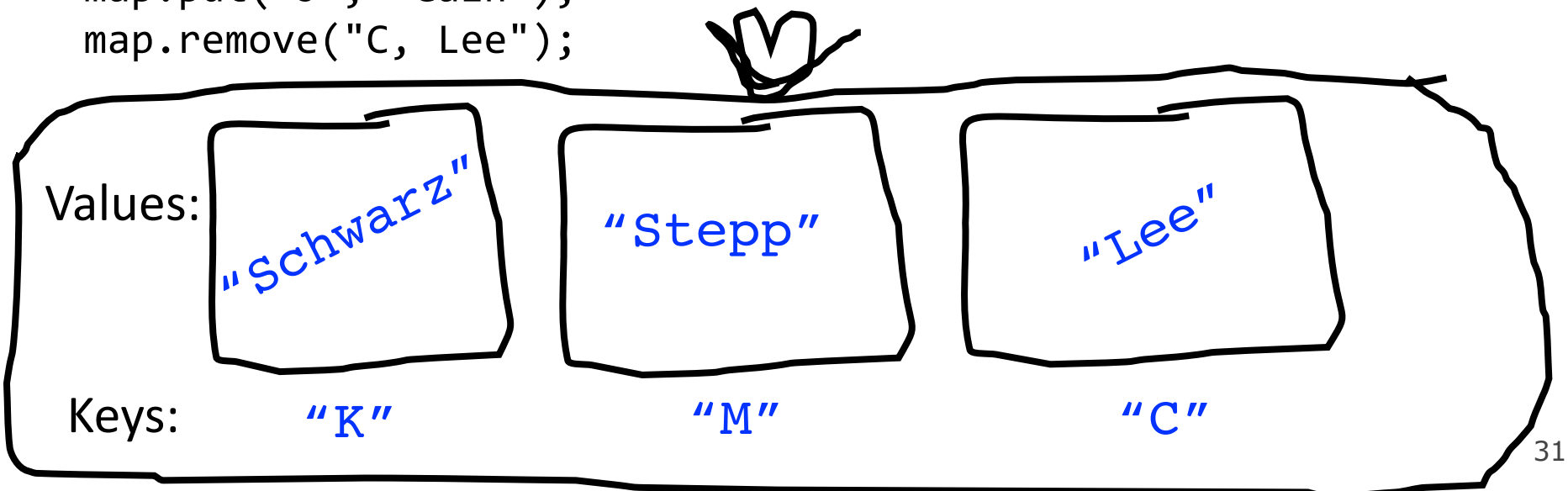

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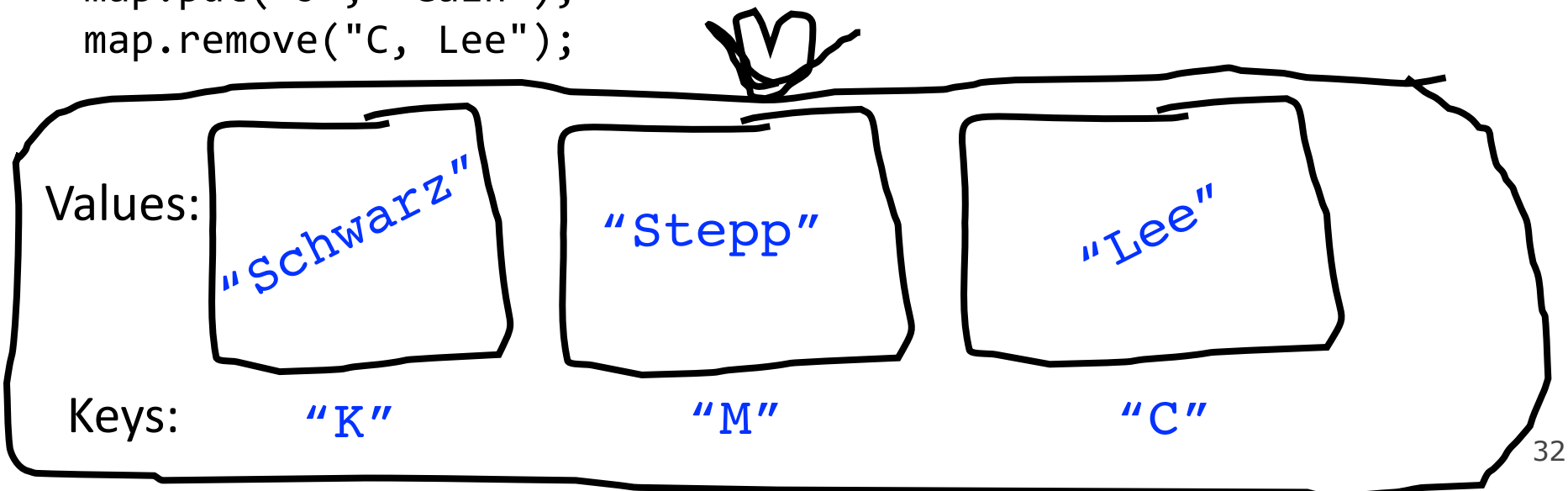

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```

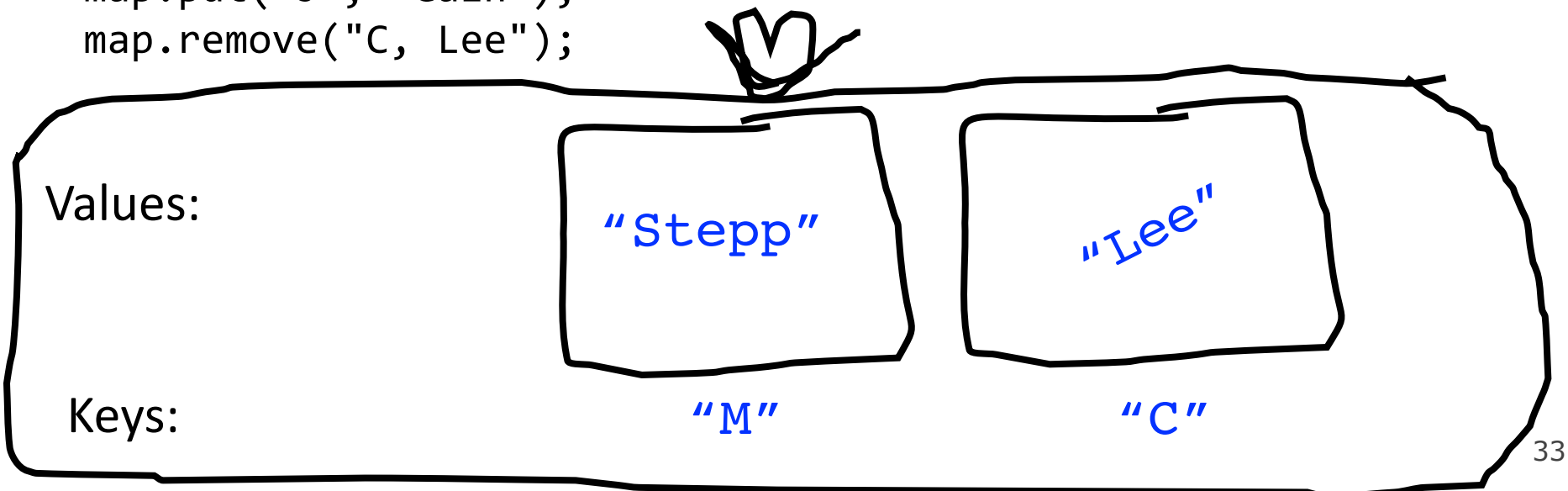

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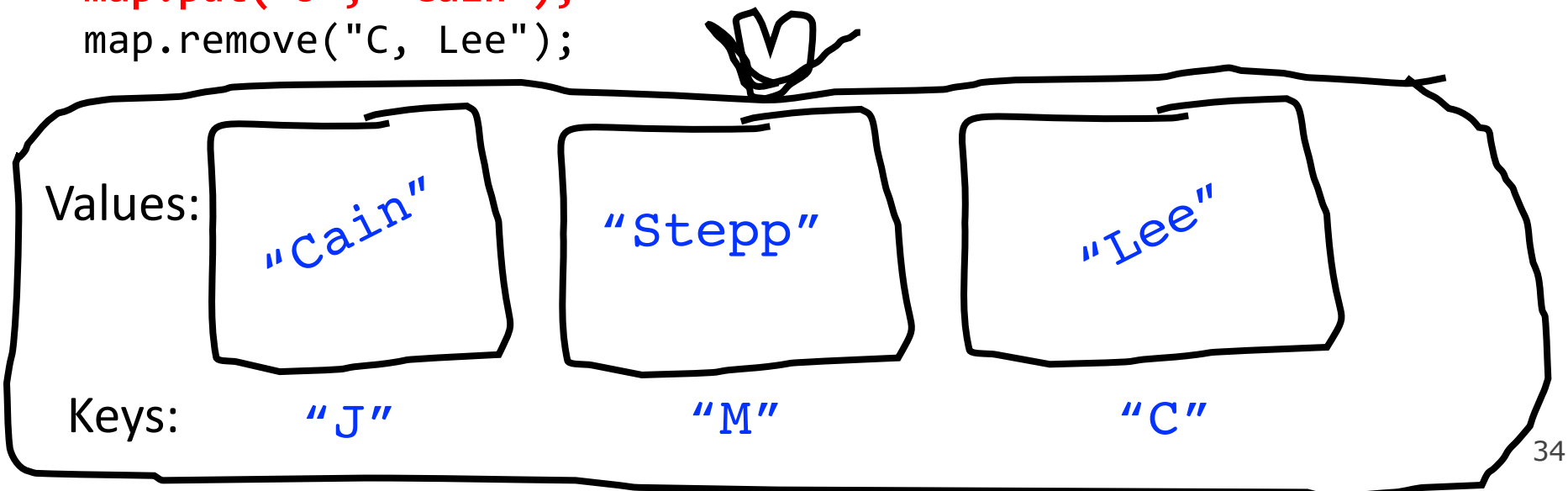

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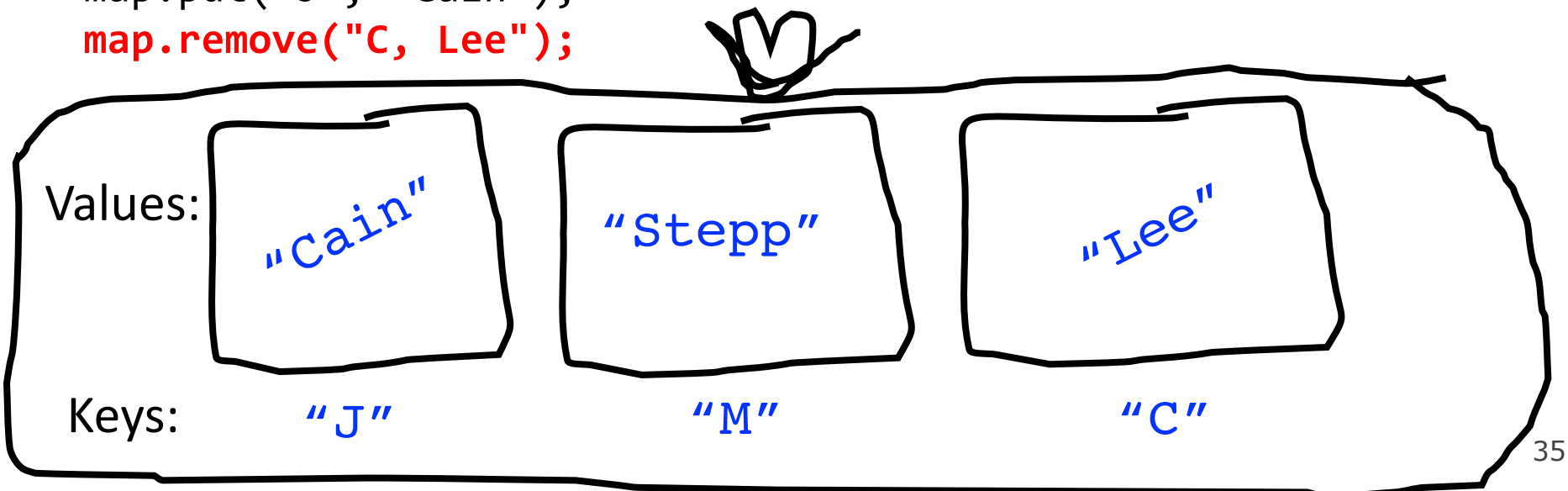

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# Exercise: Dictionary

- Write a program to read a dictionary of words and definitions from a file, then prompt the user for words to look up.
  - Example data from the dictionary input file:

```
abate
to lessen; to subside
pernicious
harmful, injurious
```

- How can a **HashMap** help us solve this problem?

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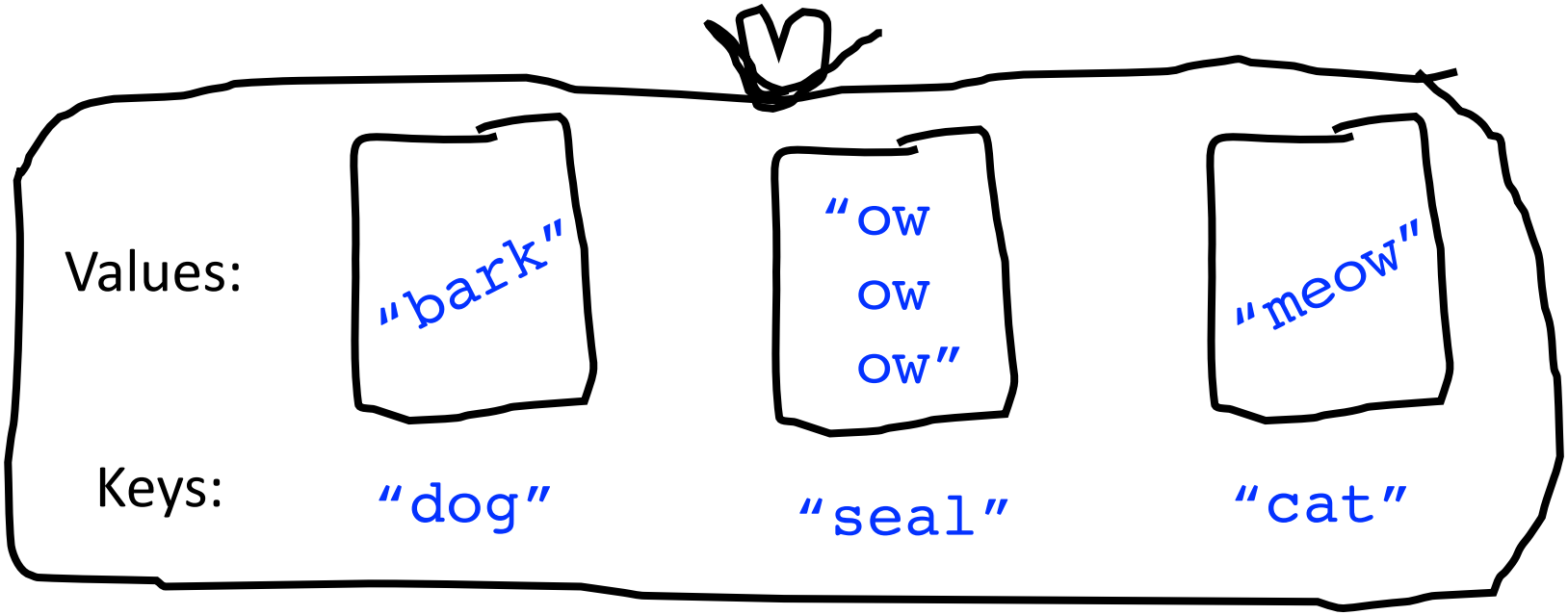
# Iterating Over HashMaps

```
...
for (String key : map.keySet()) {
  String value = map.get(key);
  // do something with key/value pair...
}
// Keys occur in an unpredictable order!
```



# Counting Exercise

- Write a program to count the number of occurrences of each unique word in a large text file (e.g. *Moby Dick* ).
  - Allow the user to type a word and report how many times that word appeared in the book.
  - Report all words that appeared in the book at least 500 times.

- How can a **map** help us solve this problem?
  - Think about scanning over a file containing this input data:

```
To be or not to be or to be a bee not two bees ...
^
```

# Maps and Tallying

- a map can be thought of as generalization of a tallying array
  - the "index" (key) doesn't have to be an `int`
  - count digits: `22092310907` →

| index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| value | 3 | 1 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |

```
// (R)epublican, (D)emocrat, (I)ndependent
```

  - count votes: `"RDDDDDDRRRRRDDDDDDRDRRIRDRRIRDRRID"`

| key | "R" | "D" | "I" |
|---|---|---|---|
| value | 16 | 14 | 3 |

| key | | value |
|---|---|---|
| "R" | → | 16 |
| "D" | → | 14 |
| "I" | → | 3 |

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# Practice: What's Trending?

- Social media can be used to monitor popular conversation topics.
- Write a program to count the frequency of **#hashtags** in tweets:
  - Read saved tweets from a large text file.
  - Report hashtags that occur at least 15 times.

- How can a **map** help us solve this problem?

Given these hashtags…

```
#stanford
#summer
#california
#stanford
```

We want to store...

```
"#stanford"   → 2
"#summer"     → 1
"#california" → 1
```

# Recap

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**Next time:** defining our own variable types

# Overflow (extra) slides

# Anagram exercise

- Write a program to find all **anagrams** of a word the user types.

```
Type a word [Enter to quit]: scared
Anagrams of scared:
cadres cedars sacred scared
```

- How can a **map** help us solve this problem?

# Anagram observation

- Every word has a *sorted form* where its letters are arranged into alphabetical order.

```
"fare"  → "aefr"
"fear"  → "aefr"
"swell" → "ellsw"
"wells" → "ellsw"
```

- Notice that anagrams have the same sorted form as each other.
  - How is this helpful for solving the problem?
  - Suppose we were given a **`sortLetters`** method. How to use it?

# Anagram solution

```
public String sortLetters(String s) { ... }   // assume this exists
...

// build map of {sorted form => all words with that sorted form}
HashMap<String, String> anagrams = new
    HashMap<String, String>();
try {
    Scanner input = new Scanner(new File("dictionary.txt"));
    while (true) {
        String word = input.next();
        String sorted = sortLetters(word);      // "acders"
        if (anagrams.containsKey(sorted)) {
            String rest = anagrams.get(sorted);
            anagrams.put(sorted, rest + " " + word);   // append
        } else {
            anagrams.put(sorted, word);         // new k/v pair
        }
        // {"acders" => "cadres caders sacred scared", ...}
    }
} catch (FileNotFoundException fnfe) {
    println("Error reading file: " + fnfe);
}
```

# Anagram solution cont'd.

```
// prompt user for words and look up anagrams in map
String word = readLine("Type a word [Enter to quit]: ");
while (word.length() > 0) {
    String sorted = sortLetters(word.toLowerCase());
    if (anagrams.containsKey(sorted)) {
        println("Anagrams of " + word + ":");
        println(anagrams.get(sorted));
    } else {
        println("No anagrams for " + word + ".");
    }
    word = readLine("Type a word [Enter to quit]: ");
}
```