CSCI 136:
Data Structures
and
Advanced Programming

Lecture 6

Composition

Instructor: Dan Barowy

Williams

Outline

UniCS

Study tip

Boxes and arrows

Biased random sampling

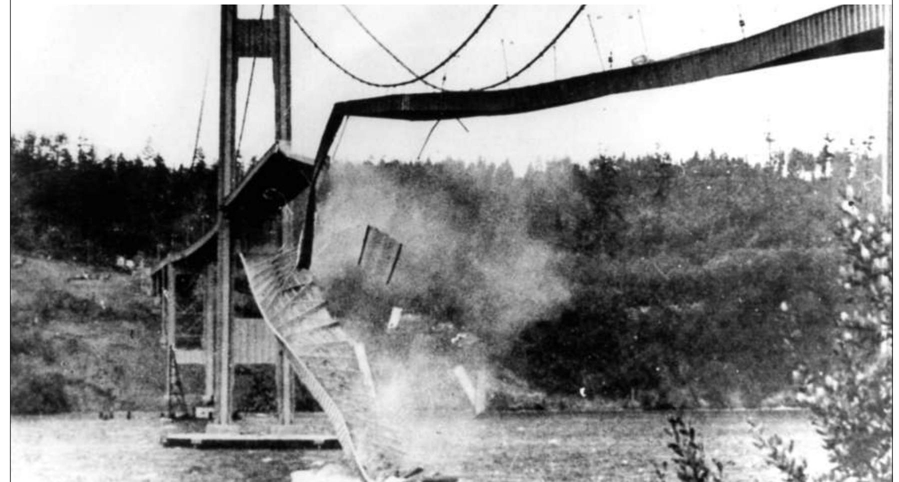
`Dictionary<K,V>`

Quiz

(remember to write your name!)

Life skill #6

"Failure is always an option."



Life skill #6

"'Failure is always an option' came up as a joke … when we were screwing something up over and over again, but it's an awesome way to think about the scientific method. We tend to think about science as … a scientist saying, "I want to prove this thing," and then coming up with an experiment to prove it. Nothing could be further from the truth … [In reality, the] scientist simply says, "I wonder if?" and then builds a methodology to test whether [the] theory is correct, or even to figure out what [the] theory might be. So to think that an experiment could "fail" is ludicrous. **Every experiment tells you something, even if it's just don't do that experiment the same way again.**" — Adam Savage

---

Assume that your code will fail, and build-in checks.

E.g., `toString()`.

Hint!

```
class FrequencyList {
    private Vector<Association<String,Integer>> mylist;

    ...

    public String toString() {
        String s = "[ ";
        for (Association<String,Integer> a : mylist) {
            s += "'" + a.getKey()
              + "' = “
              + a.getValue() + " ";
        }
        return s + "]";
    }
}
```

Q: Why do I have to use `.equals()` to compare `String` objects?

A:

When comparing values, use ==

When comparing objects, use .equals()

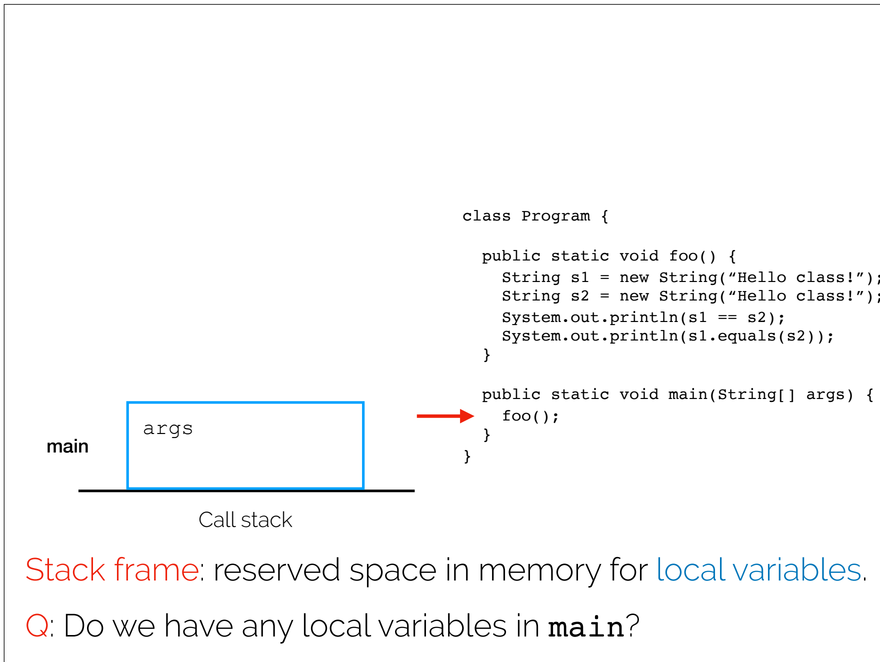
Boxes and arrows
(aka "the data structure inside every computer")

A simple program.

```
class Program {

  public static void foo() {
    String s1 = new String("Hello class!");
    String s2 = new String("Hello class!");
    System.out.println(s1 == s2);
    System.out.println(s1.equals(s2));
  }

  public static void main(String[] args) {
    foo();
  }
}
```

```
class Program {

  public static void foo() {
    String s1 = new String("Hello class!");
    String s2 = new String("Hello class!");
    System.out.println(s1 == s2);
    System.out.println(s1.equals(s2));
  }

→ public static void main(String[] args) {
    foo();
  }
}
```

Call stack



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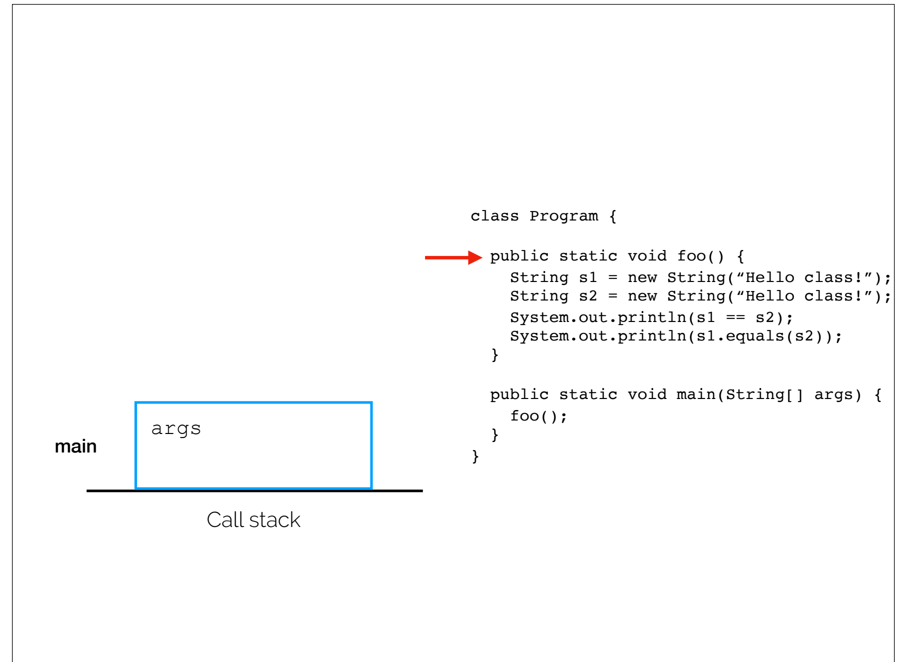
System.out.println(s1.equals(s2));
}
public static void main(String[] args) {
foo();
}
}
main
args
Call stack
Stack frame: reserved space in memory for local variables.
Q: Do we have any local variables in main?



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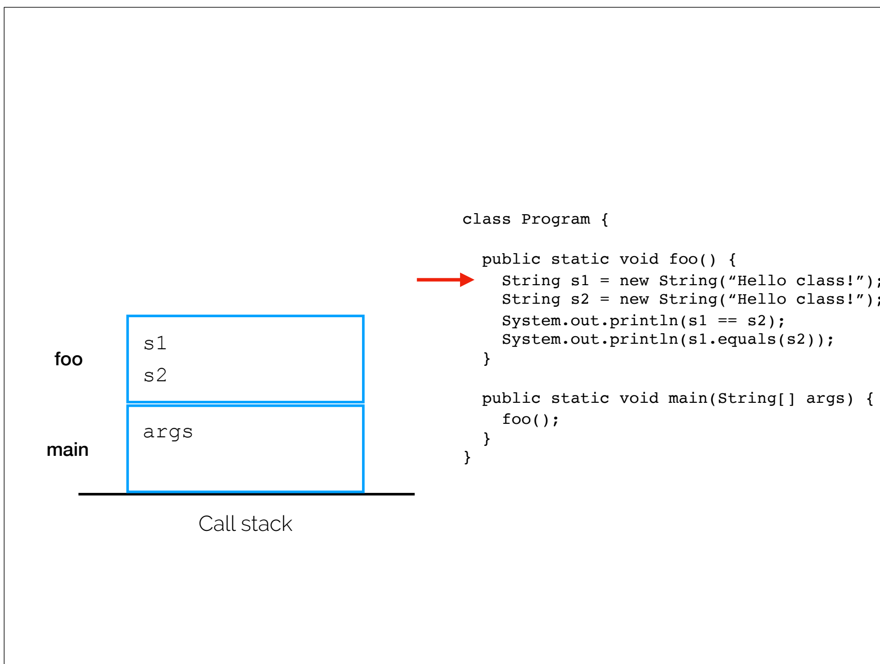
Call stack



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String s1 = new String("Hello class!");
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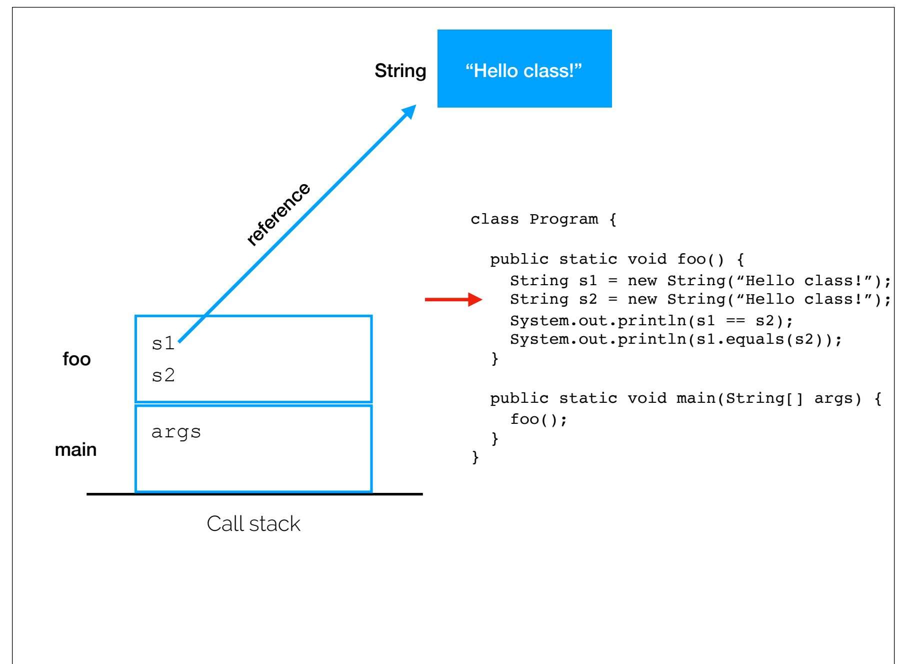
}
}
foo
s1
s2
main
args
Call stack



String
"Hello class!"
reference
class Program {
public static void foo() {
String s1 = new String("Hello class!");
String s2 = new String("Hello class!");
System.out.println(s1 == s2);
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}
public static void main(String[] args) {
foo();
}
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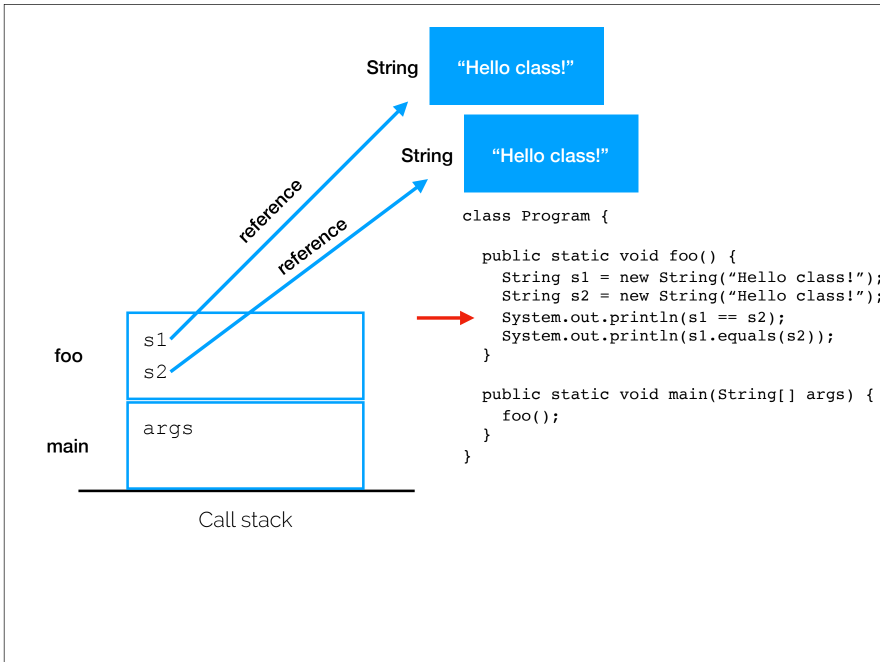
foo
s1
s2
main
args
Call stack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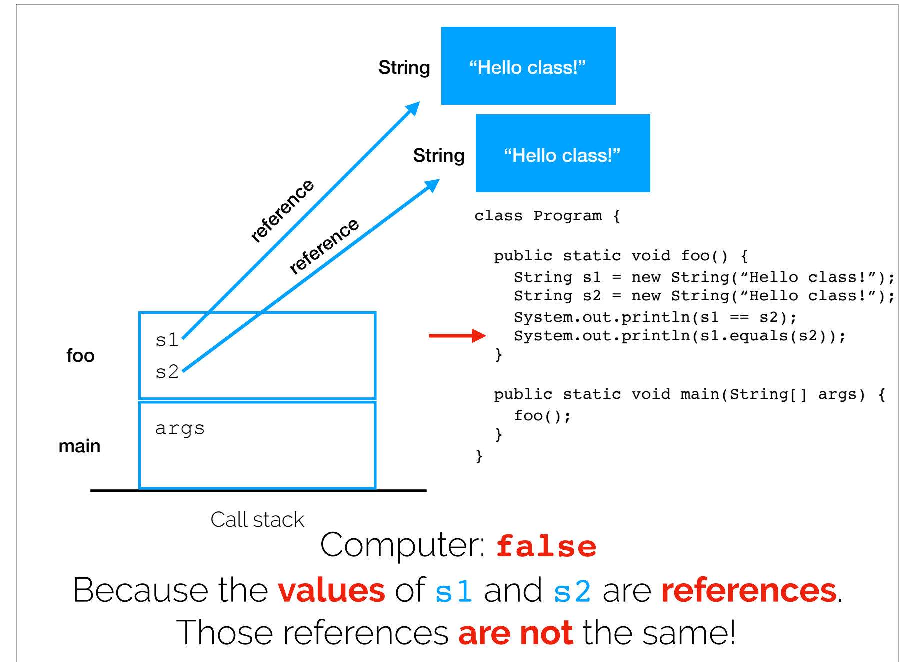
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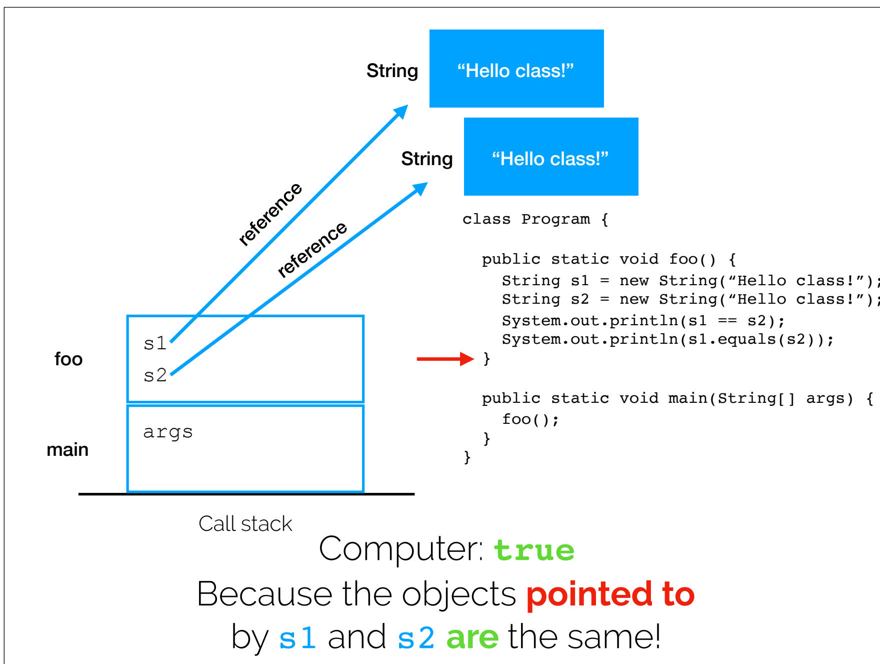
System.out.println(s1 == s2);
System.out.println(s1.equals(s2));
}
public static void main(String[] args) {
foo();
}
}
Computer: false
Because the values of s1 and s2 are references.
Those references are not the same!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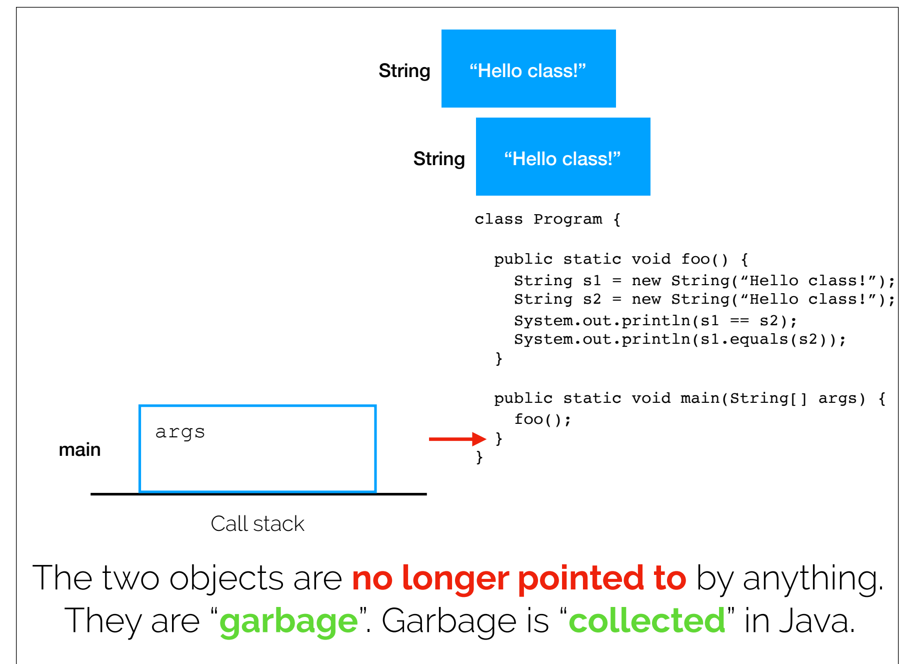
System.out.println(s1 == s2);
System.out.println(s1.equals(s2));
}
public static void main(String[] args) {
foo();
}
}
Computer: true
Because the objects pointed to
by s1 and s2 are the same!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System.out.println(s1 == s2);
System.out.println(s1.equals(s2));
}
public static void main(String[] args) {
foo();
}
}
The two objects are no longer pointed to by anything.
They are "garbage". Garbage is "collected" in Java.

```
class Program {

  public static void foo() {
    String s1 = new String("Hello class!");
    String s2 = new String("Hello class!");
    System.out.println(s1 == s2);
    System.out.println(s1.equals(s2));
  }

  public static void main(String[] args) {
    foo();
  }
}
```

Call stack

The program is now **terminated**.

Biased sampling

What does this program do?

```
Random r = new Random();
int num = r.nextInt(10);
```

Chooses a value between 0 and 9 inclusive with uniformly random probability.

I.e., all values are equally likely.

What if we want to specify the likelihood?

letter	likelihood
'a'	1
'b'	6
'c'	3

A naïve algorithm

'a'	'b'	'b'	'b'	'b'	'b'	'b'	'c'	'c'	'c'
0	1	2	3	4	5	6	7	8	9

```
char[] arr = new char[10];
// … code to fill array …
Random r = new Random();
int num = r.nextInt(10);
char c = arr[num];
```

A better algorithm

letter	likelihood
'a'	1
'b'	6
'c'	3

1. Compute the **sum of the likelihoods** (here: **10**).
2. Choose a number **n** between **0 … sum** (exclusive) uniformly randomly.
3. For each letter, subtract the **likelihood** from **n**.
4. When **n becomes negative**, you've "found" the right letter.

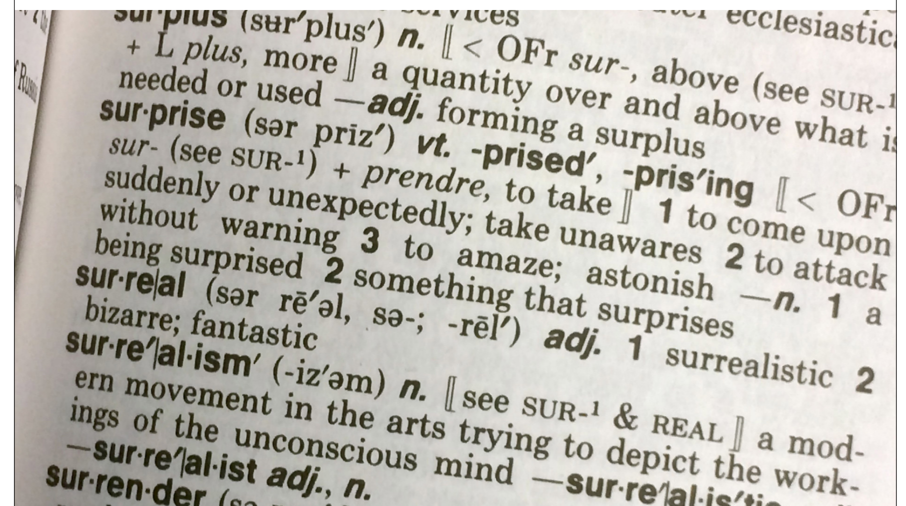
Try it at home!

Notice that you get the **same answer** had you used the naïve method.

'a'	'b'	'b'	'b'	'b'	'b'	'b'	'c'	'c'	'c'
0	1	2	3	4	5	6	7	8	9

1. Compute the **sum of the likelihoods** (here: **10**).
2. Choose a number **n** between **0 … sum** (exclusive) uniformly randomly.
3. For each letter, subtract the **likelihood** from **n**.
4. When **n becomes negative**, you've "found" the right letter.

Dictionary data structure


sur·plus (sur′plus′) ***n.*** ‖ < OFr *sur-*, above (see SUR-1 + L *plus*, more ‖ a quantity over and above what is needed or used —***adj.*** forming a surplus
sur·prise (sər prīz′) ***vt.*** **-prised′**, **-pris′ing** ‖ < OFr *sur-* (see SUR-1) + *prendre*, to take ‖ **1** to come upon suddenly or unexpectedly; take unawares **2** to attack without warning **3** to amaze; astonish —***n.*** **1** a being surprised **2** something that surprises
sur·re|al (sər rē′əl, sə-; -rēl′) ***adj.*** **1** surrealistic **2** bizarre; fantastic
sur·re′al·ism′ (-iz′əm) ***n.*** ‖ see SUR-1 & REAL ‖ a modern movement in the arts trying to depict the workings of the unconscious mind —**sur·re′al·is′tic** —**sur·re′al·ist** ***adj.***, ***n.***
sur·ren·der

Wouldn't it be great if we could look up words in a Java dictionary like this?

```
Dictionary<String,String> d = …
// … code that populates d
d.lookup("computer science");
```

Given **key**

Returns **value** (something like: `"blah blah blah computers"`)

```java
import structure5.*;

class Dictionary<K,V> {
    private Vector<Association<K,V>> v;

    public Dictionary() {
        v = new Vector<>();
    }

    public void add(K key, V value) {
        Association<K,V> a = new Association<>(key, value);
        int i = v.indexOf(a);
        if (i == -1) {
            // add new entry
            v.add(a);
        } else {
            // update
            v.get(i).setValue(value);
        }
    }

    public V lookup(K key) {
        for (Association<K,V> a : v) {
            if (a.getKey().equals(key)) {
                return a.getValue();
            }
        }
        return null;
    }

    public static void main(String[] args) {
        Dictionary<String,String> d = new Dictionary<>();
        d.add("computer science", "blah blah blah computers");
        System.out.println(d.lookup("computer science");
    }
}
```

Recap & Next Class

Today we learned:

- Boxes and arrows (memory!)
- Biased sampling
- `Dictionary<K,V>`

Next class:

- Recursion