When we talked about `Object`, I mentioned that all Java classes are "built" on top of that.

This came up when talking about the Java standard equals operator:

```java
    boolean equals(Object obj);
```

When this came up, I said we'd return to talk about it in more detail towards the end of the semester…
Inheritance

• In OO langs a new class can **extend** an existing class.

• Every class that doesn’t explicitly extend some other class will still extend **Object**.

• The existing class is called the **base** or **super** class.

• The new (typically called the **derived** or **sub**) class will inherit the static and instance variables and methods from the **base**.

• However, it might not have direct access to some of the things it inherits!

• Base references can be used to point to derived objects.

---

Syntax

```java
Public Class Base { }

Public Class Derived Extends Base { }
```
In addition to public, private, and the default levels, there is an additional one that was briefly mentioned called protected.

With this level, a protected variable or method can be accessed by the class or by any class derived from it or by other classes in the same package as the class.

### Access / Visibility Summary

<table>
<thead>
<tr>
<th>Modifier</th>
<th>Within Class</th>
<th>Within Package</th>
<th>Subclass (more Wed/Fri)</th>
<th>Outsiders</th>
</tr>
</thead>
<tbody>
<tr>
<td>public</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>protected</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>default</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>private</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>
Example: InheritanceHitsAndMisses
What can and can't we access from where?

More on Casting
You can always cast a derived class back down to its base class.

If you try to cast a base object into a derived class it will throw a runtime error.

- This is important if you have (for example) an array of base references but you think the object at the end of the reference is actually a derived one and you want to access something in that part of the object.
- We can (and probably should) test before casting so we can handle things ourselves.
Will this…

0% 1. Not compile.
0% 2. Compile but crash.
0% 3. Compile and run fine.
0% 4. No idea.

\texttt{X \texttt{var} = \texttt{new A}();}

Will this…

0% 1. Not compile.
0% 2. Compile but crash.
0% 3. Compile and run fine.
0% 4. No idea.

\texttt{A \texttt{var} = \texttt{new X}();}
Will this…

0% 1. Not compile.
0% 2. Compile but crash.
0% 3. Compile and run fine.
0% 4. No idea.

\[
Y \text{ var } = \text{new } X();
\]

Class X extends Class A
Class Y extends Class A

Will this…

0% 1. Not compile.
0% 2. Compile but crash.
0% 3. Compile and run fine.
0% 4. No idea.

\[
X \text{ var1 } = \text{new } X();
A \text{ var2 } = (A)\text{var1};
\]
Class X extends Class A
Class Y extends Class A

Will this...

0%  1. Not compile.
0%  2. Compile but crash.
0%  3. Compile and run fine.
0%  4. No idea.

```java
A var1 = new A();
X var2 = (X)var1;
```

**instanceof**

Before casting, you might want to test to make sure you are correct about the type.

```java
if (objectRef instanceof DerivedName) {
    ((DerivedName)objectRef).funInDer();
}
```
Overriding Methods

- It is possible for a derived class to **override** a method that has been defined and implemented in the base class.
- The overriding method needs to have the same name and parameter list and return type as the one in the base class.

An interesting issue arises if you have base reference pointing at a derived object if you then use that reference to invoke an overridden method.
- Which version does it invoke?
- It depends on the language! In Java it will invoke the derived version. In C++ it will invoke the base version.

Some methods **Object** gives you…

```java
boolean equals(Object);
Class getClass();
int hashCode();
String toString();
```

Also a variety of methods useful for multi-threaded programming…
equals

The default `equals` inherited from `Object` checks to see if the two references are to the same exact object in memory.

The following is likely how it should be overridden...

```java
public boolean equals (Object other) {
    if (other == null) {
        return false;
    }
    else if (this.getClass() != other.getClass()) {
        return false;
    }
    else {
        //cast other and do real equals tests here
    }
}
```

"Is A" versus "Has A"

Many of the classes we have written have "contained" other types.

We could say that a `Restaurant` "has a" `String` and "has a" `SortedListOfImmutables` as "has a" another `SortedListOfImmutables`.

This is referred to as class `composition`.

With inheritance if `D` is derived from `B`, we typically say that a `D"is a"` `B`. 
How to make a Stack?

In **Java**, rather than extend a list structure you might want to just use one (composition). This way your Stack can have push() and pop() but not have the methods "visible" that it would inherit.

```java
public class Stack<Type> {
    private ArrayList<Type> mydata;
    :  
    :  
    :  
}
```

Some other languages have other options…

Shadow Variables

One thing to be aware of is the names of any variables declared in the base class.

- If you declare a variable with the same name in the derived class then that is the one that is seen by default (though the one it inherited from the base is still inside the object too).
- Within a method of the derived class (but not in places in the rest of the project) you can access the base's version by using `super` to refer to the variable from the base (also known as the super) class.
Constructors
When a derived object's constructor is called, before the body of it is executed, the base class' constructor will be called.

If a derived class has a copy constructor, the base class' regular constructor will be called before the body of the derived class' copy constructor is executed unless the derived class' copy constructor explicitly calls the base copy constructor.

Multiple Inheritance
Some languages that support polymorphism support multiple inheritance.
• Java is NOT one of those languages. Why?

Consider base classes: Helicopter, Jet
Consider a new class: HeliJet
• Could be good use of polymorphism.
• Could create challenges like naming conflicts if both bases classes have a matching field since they would be at the same "level".
Multiple Interfaces

In the previous example, if Helicopter and Jet both defined a String name and HeliJet was built by extending both of them, you would have two different name objects.

What if Helicopter and Jet were interfaces and HeliJet implemented both? Is there any potential for conflict or confusion?