"Inheritance is new code that reuses old code. Polymorphism is old code that reuses new code."
Polymorphism

- Another feature of OOP
- literally “having many forms”
- object variables in Java are *polymorphic*
- object variables can refer to objects of their declared type AND any objects that are descendants of the declared type

```java
Property p = new Property();
p = new Railroad(); // legal!
p = new Utility(); // legal!
p = new Street();
Object obj1; // = what?
```
Data Type

- object variables have:
  - a **declared type**. Also called the static type.
  - a **dynamic type**. What is the actual type of the pointee at run time or when a particular statement is executed.

- Method calls are syntactically legal if the method is in the declared type *or any ancestor* of the declared type.

- The actual method that is executed at runtime is based on the dynamic type
  - dynamic dispatch
Clicker Question 1

Consider the following class declarations:

```java
public class BoardSpace
public class Property extends BoardSpace
public class Street extends Property
public class Railroad extends Property
```

Which of the following statements would cause a syntax error? (Assume all classes have a zero argument constructor.)

A. Object obj = new Railroad();
B. Street s = new BoardSpace();
C. BoardSpace b = new Street();
D. Railroad r = new Street();
E. More than one of these
Method LookUp

- To determine if a method is legal the compiler looks in the class based on the declared type
  - if it finds it great, if not go to the super class and look there
  - continue until the method is found, or the Object class is reached and the method was never found. (Compile error)

- To determine which method is actually executed the runtime system (abstractly):
  - starts with the actual run time class of the object that is calling the method
  - search the class for that method
  - if found, execute it, otherwise go to the super class and keep looking
  - repeat until a version is found

- Is it possible the runtime system won’t find a method?
Clicker Question 2

What is output by the code to the right when run?

A. !!live
B. !eggegg
C. !egglive
D. !!!
E. Something else

```java
public class Animal {
    public String bt(){ return "!"; }
}

public class Mammal extends Animal {
    public String bt(){ return "live"; }
}

public class Platypus extends Mammal {
    public String bt(){ return "egg"; }
}

Animal a1 = new Animal();
Animal a2 = new Platypus();
Mammal m1 = new Platypus();
System.out.print( a1.bt() );
System.out.print( a2.bt() );
System.out.print( m1.bt() );
```
What is output by the code to the right when run? Think carefully about the dynamic type.

A. MeowWoof
B. MeowEm
C. EmWoof
D. EmEm
E. Something else

```java
class Animal {
    public void show() {
        System.out.print(speak());
    }
    public String speak() { return "Em"; }
}
class Dog extends Animal {
    public String speak() { return "Woof"; }
}
class Cat extends Animal {
    public void show() {
        System.out.print("Meow");
    }
}
Cat patches = new Cat();
Dog velvet = new Dog();
patches.show();
velvet.show();
```
Why Bother?

- Inheritance allows programs to model relationships in the real world
  - if the program follows the model it may be easier to write
- Inheritance allows code reuse
  - complete programs faster (especially large programs)
- Polymorphism allows code reuse in another way
- Inheritance and polymorphism allow programmers to create *generic algorithms*
Genericity

- One of the goals of OOP is the support of code reuse to allow more efficient program development
- If an algorithm is essentially the same, but the code would vary based on the data type, genericity allows only a single version of that code to exist
- In Java, there are 2 ways of doing this
  1. polymorphism and the inheritance requirement
  2. generics
A Generic List Class
Back to IntList

- We may find IntList useful, but what if we want a List of Strings? Rectangles? Lists?
  - What if I am not sure?
- Are the List algorithms different if I am storing Strings instead of ints?
- How can we make a generic List class?
Generic List Class

- required changes
- How does `toString` have to change?
  - why?!?!
  - A good example of why keyword `this` is necessary from `toString`
- What can a `List` hold now?
- How many `List` classes do I need?
After altering the data type of the elements to Objects how many lines of code in the toString method, originally from the IntList class, need to be changed?

A. 0
B. 1
C. 2
D. 3
E. >= 4
Writing an `equals` Method

- How to check if two objects are equal?

  ```java
  if(objA == objA)
      // does this work?
  ```

- Why not this

  ```java
  public boolean equals(List other)
  ```

- Because

  ```java
  public void foo(List a, Object b)
      if( a.equals(b) )
          System.out.println( same )
  ```

  - what if `b` is really a `List`?
equals method

- read the javadoc carefully!
- Must handle null
- Parameter must be Object
  - otherwise overloading instead of overriding
  - causes
- must handle cases when parameter is not same data type as calling object
  - instanceof or getClass()
- don't rely on toString and String's equals
the createASet example

public Object[] createASet(Object[] items)
{
    /*
     * pre: items != null, no elements of items = null
     * post: return an array of Objects that represents a set of the elements in items. (all duplicates removed)
     */

    {5, 1, 2, 3, 2, 3, 1, 5} -> {5, 1, 2, 3}
createASet examples

String[] sList = {"Texas", "texas", "Texas", "Texas", "UT", "texas"};
Object[] sSet = createASet(sList);
for(int i = 0; i < sSet.length; i++)
    System.out.println( sSet[i] );

Object[] list = {"Hi", 1, 4, 3.3, true, new ArrayList(), "Hi", 3.3, 4};
Object[] set = createASet(list);
for(int i = 0; i < set.length; i++)
    System.out.println( set[i] );