Polymorphism

Normally, when declaring and initializing variables that hold objects, we use the same data type on both sides of the equals sign:

```
SimpleCanvas canvas = new SimpleCanvas();
ArrayList<String> list = new ArrayList<String>();
Scanner scanner = new Scanner(System.in);
```

However, polymorphism allows us to replace a base class object with a derived class object:

```
public class Base { }
public class Derived extends Base { }
Base baseObject = new Derived();
```

When this occurs, the variable `baseObject` has two different types: the *declared type*, which is the data type that the variable is declared as in the code, and the *actual type*, which is the type of the object that is actually stored in the computer's memory. In the line of code above, the declared type of `baseObject` is `Base`, whereas the actual type is `Derived`.

The declared type of a variable determines which methods Java will allow you to call on it, whereas the actual type determines which implementation of those methods is executed when the program runs.

Example:

```
public class Base {
   public void f() { System.out.println("Base f"); }
   public void g() { System.out.println("Base g"); }
}

public class Derived extends Base {
   public void f() { System.out.println("Derived f"); }
   public void h() { System.out.println("Derived h"); }
}

Base baseObject = new Base();
Derived derivedObject = new Derived();
Base polymorphObject = new Derived();

baseObject.f();                 // Prints Base f
baseObject.g();                 // Prints Base g
derivedObject.f();              // Prints Derived f
derivedObject.g();              // Prints Base g
derivedObject.h();              // Prints Derived h
polymorphObject.f();            // Prints Derived f
polymorphObject.g();            // Prints Base g
// polymorphObject.h();         // Illegal!  Cannot call a derived-only method on an
                                // object declared as a base type.
```

But we can test the actual type of an object and then cast it to access a derived-only method on an object declared as a base type:

```
if (polymorphObject instanceof Derived) {
   ((Derived)polymorphObject).h();                  // Prints Derived h
}
```

or with this syntax, which creates a new automatically-cast variable for you (the "`der`" variable here):

```
if (polymorphObject instanceof Derived der) {
   der.h();                                         // Prints Derived h
}
```

The substitution that polymorphism lets us do – substitute a derived object where a base object is needed – typically is seen in four places in code:

- Variable declarations (as seen above)
- Passing an object to a function/method
- Returning an object from a function/method
- Storing an object in another object or data structure (like in an ArrayList)

Passing an object to a function/method:

```
void function(Base baseObject) {
      baseObject.f();               // may print Base f or Derived f
      baseObject.g();               // prints Base g
      // baseObject.h():            // always illegal (unless you use a cast)
}

Base baseObject = new Base();
Derived derivedObject = new Derived();

function(baseObject);               // fine
function(derivedObject);            // fine
```

Returning an object from a function/method:

```
Base function() {
      Base b = new Base();
      Derived d = new Derived();
      // return b or d, Java will let either one be returned
}

Base baseObject = function();       // legal, we just don't know if baseObject's
                                    // actual type is Base or Derived.
baseObject.f();                     // may print Base f or Derived f
baseObject.g();                     // prints Base g
// baseObject.h();                  // always illegal (unless you use a cast)
```

Storing an object in another object or data structure (like in an ArrayList):

```
ArrayList<Base> list = new ArrayList<Base>();

Base baseObject = new Base();
Derived derivedObject = new Derived();

list.add(baseObject);
list.add(derivedObject);

for (int i = 0; i < list.size(); i++) {   // or use enhanced for loop syntax
    Base b = list.get(i);
    b.f();                    // may print Base f or Derived f
    b.g();                    // prints Base g
    // b.h();                 // always illegal (unless you use a cast)
}
```