Topic 32 - Polymorphism

Clicker 1

- What is output by the following code?

```
Critter c1 = new Hippo(7);
System.out.print(c1.toString());
```

A. 7

B. ?

C. null

D. No output due to a syntax error

E. No output due to a runtime error

Polymorphism

- **polymorphism**: Ability for the same method to be called with different types of objects and behave differently with each.
  - `System.out.println` can print any type of object.
    - Each one displays in its own way on the console.
  - `CritterMain` can interact with any type of critter.
    - Each one moves, fights, etc. in its own way.

Coding with polymorphism

- **A variable of type *T* can refer to an object of type T *and* any descendants of *T*.**

```
Critter c1 = new Hippo(7);
```

  - You can call any methods from the `Critter` class on `c1`.

- When a method is called on `c1`, it behaves as a `Hippo`.

```
System.out.println(c1.getColor);      // GRAY
System.out.println(c1.toString());    // 7
```

Polymorphism and parameters

- You can pass any subtype of a parameter's type.

```
public class CriiterMain {
    public static void main(String[] args) {
        Hippo henry = new Hippo(7);
        Bird angry = new Bird();
        printInfo(henry);
        printInfo(angry);
    }

    public static void printInfo(Critter crit) {
      System.out.println(" eat?: " + crit.eat());
      System.out.println(" fight: " + crit.fight("?"));
      System.out.println(" move: " + crit.getMove());
      System.out.println();
    }
}
```

OUTPUT???

Polymorphism and arrays

- Arrays of superclass types can store any subtype as elements.

```
public class CritterMain2 {
    public static void main(String[] args) {
        Critter[] crits = { new Bird(),   new Vulture(),
                            new Hippo(7), new Ant(true) };

        for (Critter crit : crits) {
            System.out.println(" color: " + crit.getColor());
            System.out.println("  move: " + crit.getMove());
            System.out.println();
        }
    }
}
```

Output:

A polymorphism problem

```
public class Foo {
  public void method1() {
    System.out.println("foo 1");
  }

  public void method2() {
    System.out.println("foo 2");
  }

  public String toString() {
    return "foo";
  }
}

public class Bar extends Foo {
  public void method2() {
    System.out.println("bar 2");
  }
}
```

```
public class Baz extends Foo {
  public void method1() {
    System.out.println("baz 1");
  }

  public String toString() {
    return "baz";
  }
}

public class Mumble extends Baz {
  public void method2() {
   System.out.println("mumble 2");
  }
}
```

A polymorphism problem

```
}
```

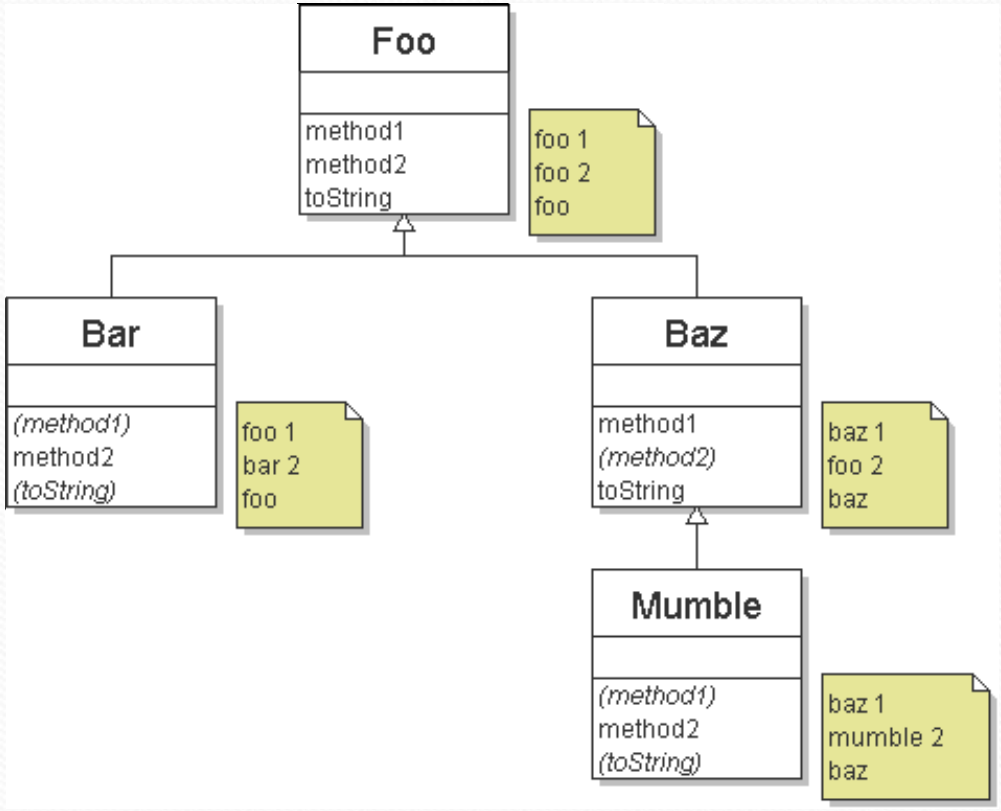
- What would be the output of the following client code?

```
Foo[] foos = {new Baz(), new Bar(), new Mumble(), new Foo()};
for (int i = 0; i < foos.length; i++) {
    System.out.println(foos[i]);
    foos[i].method1();
    foos[i].method2();
    System.out.println();
}
```

method	Foo	Bar	Baz	Mumble
method1				
method2				
toString				

Diagramming the classes

- Add classes from top (superclass) to bottom (subclass).
- Include all inherited methods.



Finding output with tables

method	Foo	Bar	Baz	Mumble
method1	foo 1	*foo 1*	baz 1	*baz 1*
method2	foo 2	bar 2	*foo 2*	mumble 2
toString	foo	*foo*	baz	*baz*

Polymorphism answer

```
Foo[] foos = {new Baz(), new Bar(), new Mumble(), new Foo()};
for (int i = 0; i < foos.length; i++) {
    System.out.println(foos[i]);
    foos[i].method1();
    foos[i].method2();
    System.out.println();
}
```

- Output:

```
baz
baz 1
foo 2

foo
foo 1
bar 2

baz
baz 1
mumble 2

foo
foo 1
foo 2
```

Another problem

- The order of the classes is jumbled up.
- The methods sometimes call other methods (tricky!).

```
public class Lamb extends Ham {
    public void b() {
        System.out.print("Lamb b   ");
    }
}

public class Ham {
    public void a() {
        System.out.print("Ham a   ");
        b();
    }

    public void b() {
        System.out.print("Ham b   ");
    }

    public String toString() {
        return "Ham";
    }
}
```

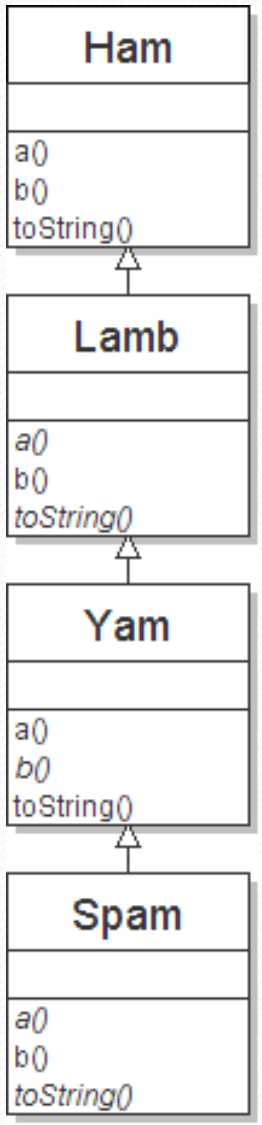
Another problem 2

```
public class Spam extends Yam {
    public void b() {
        System.out.print("Spam b   ");
    }
}
public class Yam extends Lamb {
    public void a() {
        System.out.print("Yam a   ");
        super.a();
    }
    public String toString() {
        return "Yam";
    }
}
```

- What would be the output of the following client code?

```
Ham[] food = {new Lamb(), new Ham(), new Spam(), new Yam()};
for (int i = 0; i < food.length; i++) {
    System.out.println(food[i]);
    food[i].a();
    System.out.println();      // to end the line of output
    food[i].b();
    System.out.println();      // to end the line of output
    System.out.println();
}
```

Class diagram



Polymorphism at work

- `Lamb` inherits `Ham`'s `a`. `a` calls `b`. But `Lamb` overrides `b`...

```
public class Ham {
    public void a() {
        System.out.print("Ham a   ");
        b();
    }

    public void b() {
        System.out.print("Ham b   ");
    }

    public String toString() {
        return "Ham";
    }
}

public class Lamb extends Ham {
    public void b() {
        System.out.print("Lamb b   ");
    }
}
```

- `Lamb`'s output from `a`:

```
Ham a   Lamb b
```

The table

method	Ham	Lamb	Yam	Spam
a	Ham a **b()**	*Ham a* ***b()***	Yam a Ham a **b()**	*Yam a* *Ham a* ***b()***
b	Ham b	Lamb b	Lamb b	Spam b
toString	Ham	*Ham*	Yam	*Yam*

The answer

```
Ham[] food = {new Lamb(), new Ham(), new Spam(), new Yam()};
for (int i = 0; i < food.length; i++) {
    System.out.println(food[i]);
    food[i].a();
    food[i].b();
    System.out.println();
}
```

- Output:

```
Ham
Ham a   Lamb b
Lamb b

Ham
Ham a   Ham b
Ham b

Yam
Yam a   Ham a   Spam b
Spam b

Yam
Yam a   Ham a   Lamb b
Lamb b
```

Overriding Object's equals Method

- The Object class contains this method:

```
public boolean equals(Object obj) {
    return this == obj; }
```

- many classes override this method
- many students mistakenly *overload* the method
- many headaches when placing objects in data structures

Overriding Object's equals Method

- overriding equals correctly follows a pattern
- So, it isn't that hard, if you follow the pattern
- Override equals for a Standard Playing Card
- Override equals for a Snake Critter
  - Demo array of Critter objects