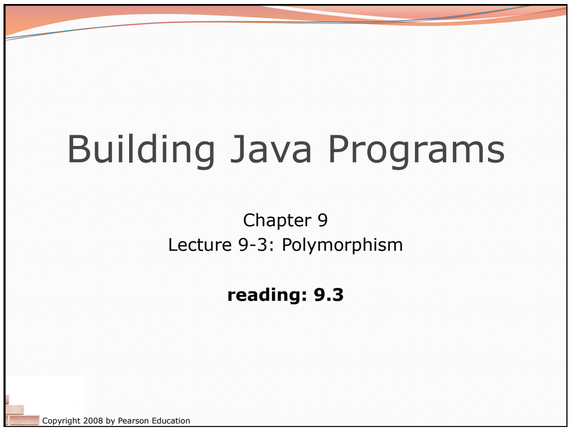
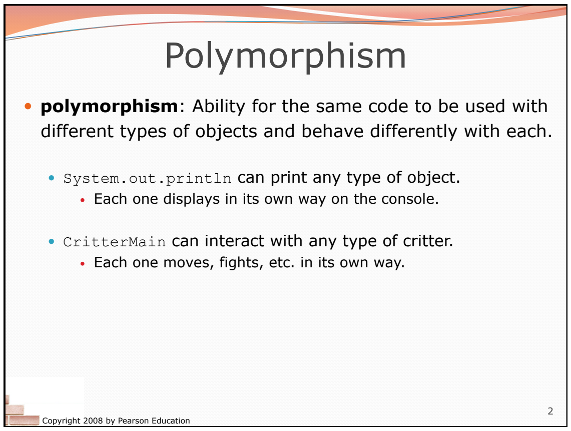


Building Java Programs

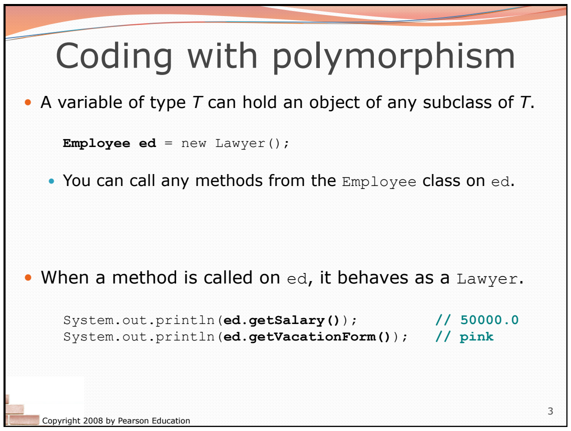
Chapter 9
Lecture 9-3: Polymorphism

reading: 9.3



Polymorphism

- **polymorphism**: Ability for the same code to be used 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

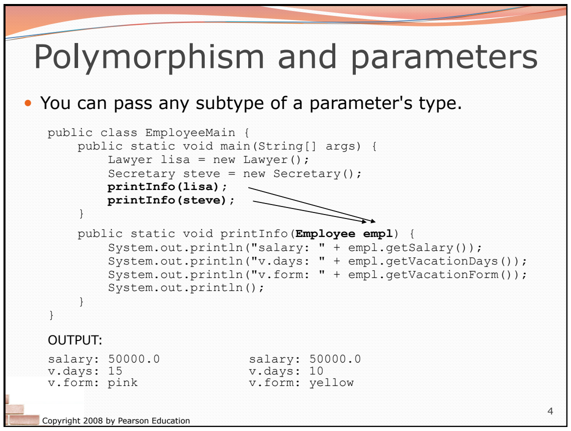
- A variable of type *T* can hold an object of any subclass of *T*.

```
Employee ed = new Lawyer();
```

  - You can call any methods from the `Employee` class on `ed`.

- When a method is called on `ed`, it behaves as a `Lawyer`.

```
System.out.println(ed.getSalary());          // 50000.0
System.out.println(ed.getVacationForm());    // pink
```



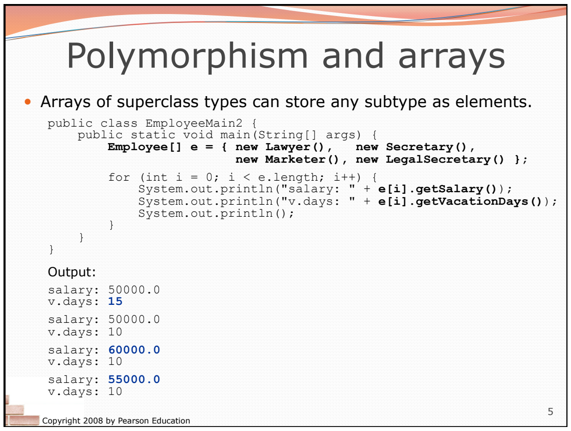
Polymorphism and parameters

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

```
public class EmployeeMain {
    public static void main(String[] args) {
        Lawyer lisa = new Lawyer();
        Secretary steve = new Secretary();
        printInfo(lisa);
        printInfo(steve);
    }

    public static void printInfo(Employee empl) {
        System.out.println("salary: " + empl.getSalary());
        System.out.println("v.days: " + empl.getVacationDays());
        System.out.println("v.form: " + empl.getVacationForm());
        System.out.println();
    }
}
```

OUTPUT:

```
salary: 50000.0           salary: 50000.0
v.days: 15                v.days: 10
v.form: pink              v.form: yellow
```



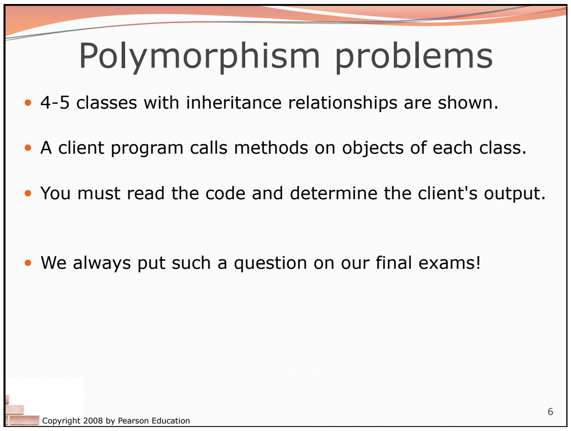
Polymorphism and arrays

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

```
public class EmployeeMain2 {
    public static void main(String[] args) {
        Employee[] e = { new Lawyer(),   new Secretary(),
                         new Marketer(), new LegalSecretary() };

        for (int i = 0; i < e.length; i++) {
            System.out.println("salary: " + e[i].getSalary());
            System.out.println("v.days: " + e[i].getVacationDays());
            System.out.println();
        }
    }
}
```

Output:

```
salary: 50000.0
v.days: 15

salary: 50000.0
v.days: 10

salary: 60000.0
v.days: 10

salary: 55000.0
v.days: 10
```



Polymorphism problems

- 4-5 classes with inheritance relationships are shown.
- A client program calls methods on objects of each class.
- You must read the code and determine the client's output.
- We always put such a question on our final exams!

A polymorphism problem

- Suppose that the following four classes have been declared:

```
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");
    }
}
```

A polymorphism problem

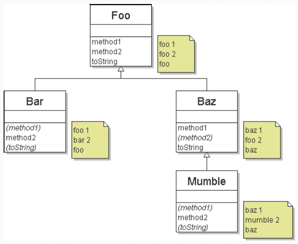
```
public class Baz extends Foo {
    public void method1() {
        System.out.println("baz 1");
    }

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

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

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

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

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

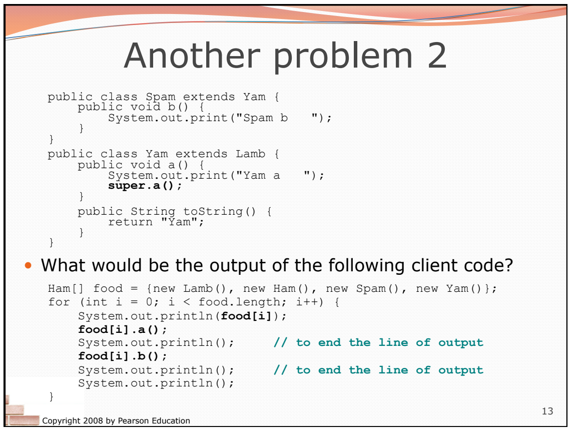
- Output:

```
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";
    }
}
```

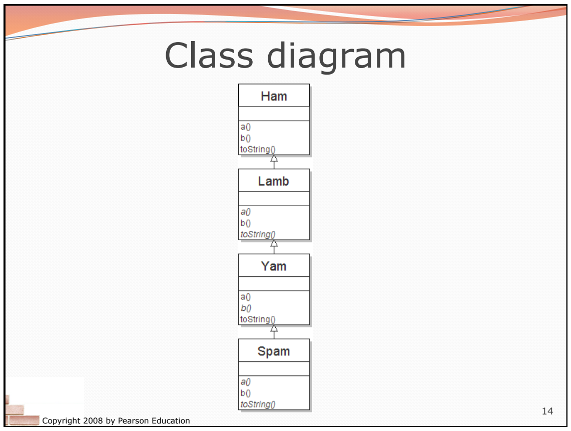


Another problem 2

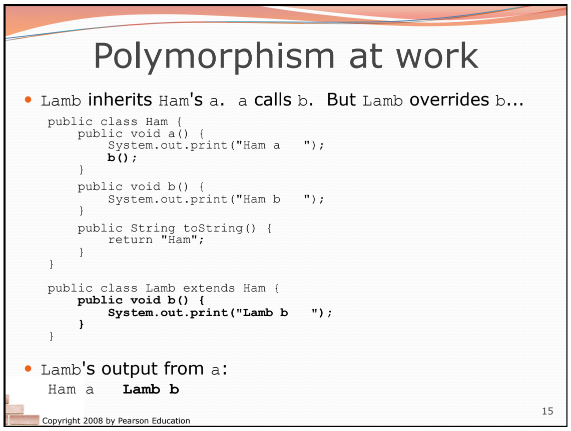
```
public class Spam extends Yam {
    public void b() {
        System.out.print("Spam b   ");
    }
}
public class Yam extends Lamb {
    public void a() {
        System.out.print("Yam a   ");
        super.a();
    }

    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



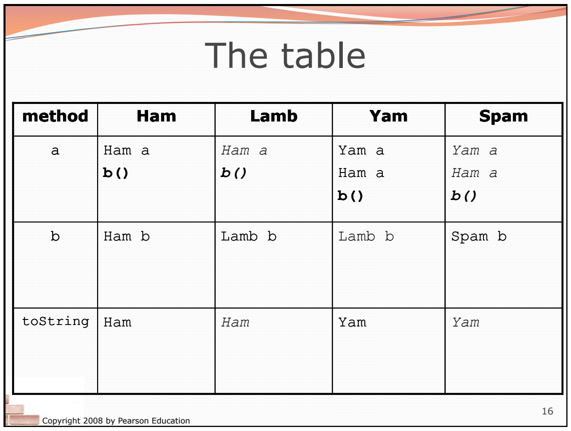
Polymorphism at work

- 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   ");
    }
}
```

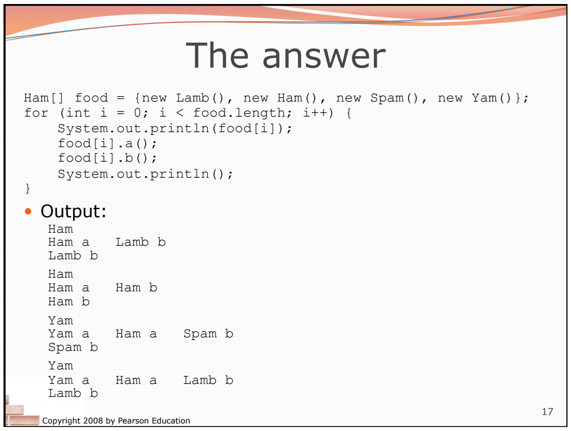
- Lamb's output from a:

```
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*

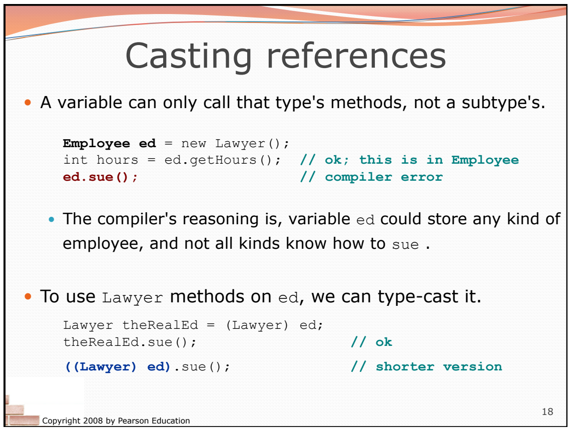


The answer

```
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
```



Casting references

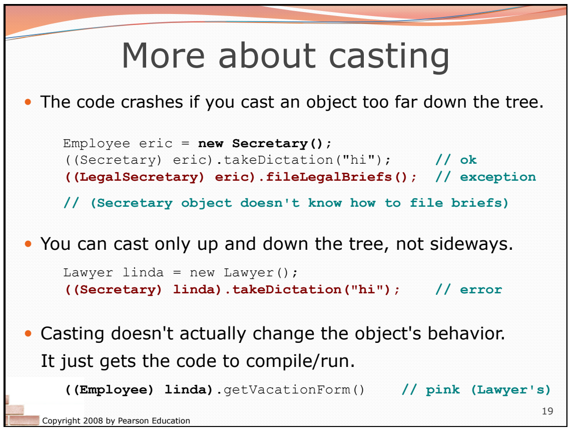
- A variable can only call that type's methods, not a subtype's.

```
Employee ed = new Lawyer();
int hours = ed.getHours();  // ok; this is in Employee
ed.sue();                   // compiler error
```

  - The compiler's reasoning is, variable ed could store any kind of employee, and not all kinds know how to sue .

- To use Lawyer methods on ed, we can type-cast it.

```
Lawyer theRealEd = (Lawyer) ed;
theRealEd.sue();                 // ok
((Lawyer) ed).sue();             // shorter version
```



More about casting

- The code crashes if you cast an object too far down the tree.

```
Employee eric = new Secretary();
((Secretary) eric).takeDictation("hi");     // ok
((LegalSecretary) eric).fileLegalBriefs();  // exception

// (Secretary object doesn't know how to file briefs)
```

- You can cast only up and down the tree, not sideways.

```
Lawyer linda = new Lawyer();
((Secretary) linda).takeDictation("hi");    // error
```

- Casting doesn't actually change the object's behavior.
  It just gets the code to compile/run.

```
((Employee) linda).getVacationForm()    // pink (Lawyer's)
```