Abstract classes

Object-Oriented Programming

Outline

- Abstract classes
- Abstract methods
- Design pattern: Template method
- Dynamic & static binding
- Upcasting & Downcasting

- Readings:
  - HFJ: Ch. 8.
  - GT: Ch. 8.

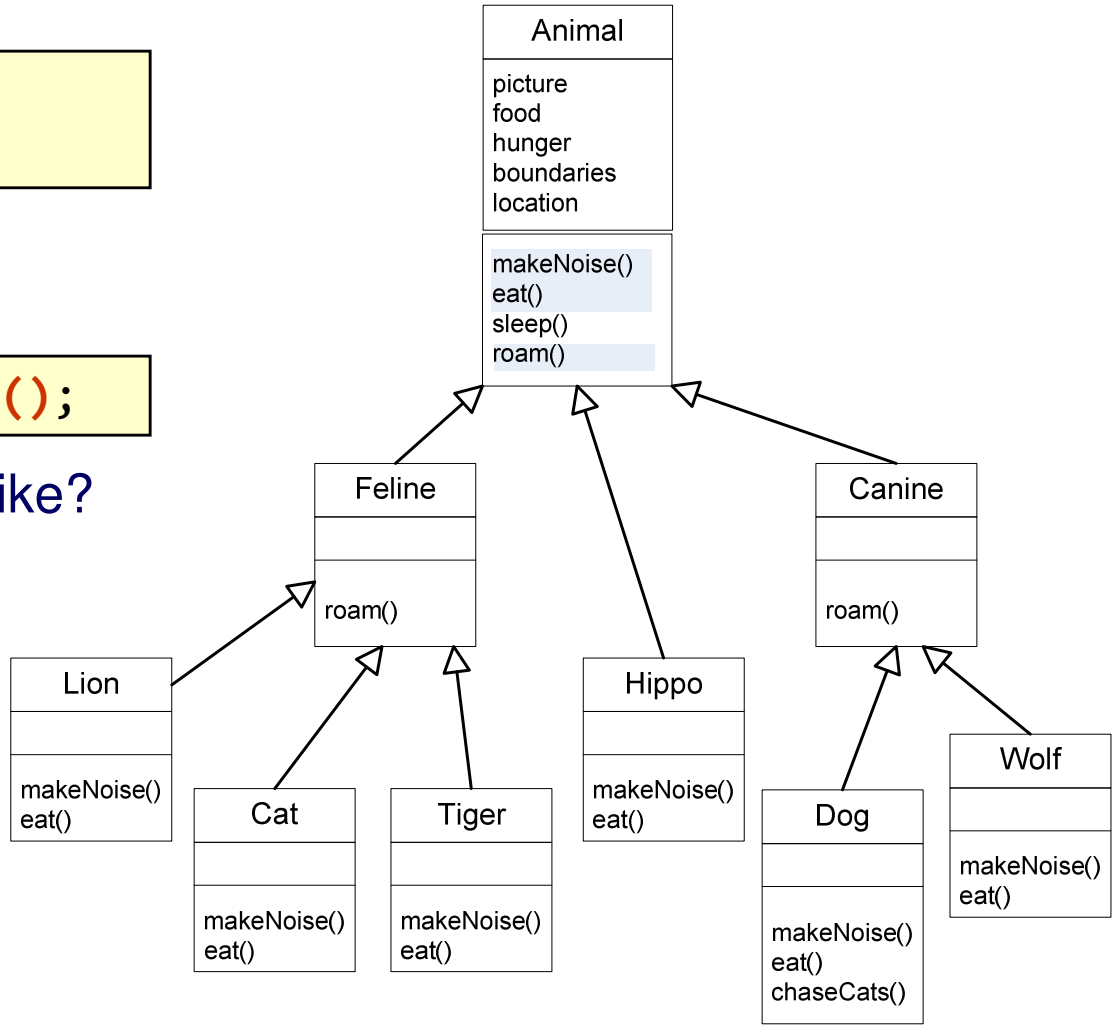
Our previous design

```
Dog d = new Dog();
Cat c = new Cat();
```

Fine. But…

```
Animal anim = new Animal();
```

What does an Animal look like?



What does an Animal look like?

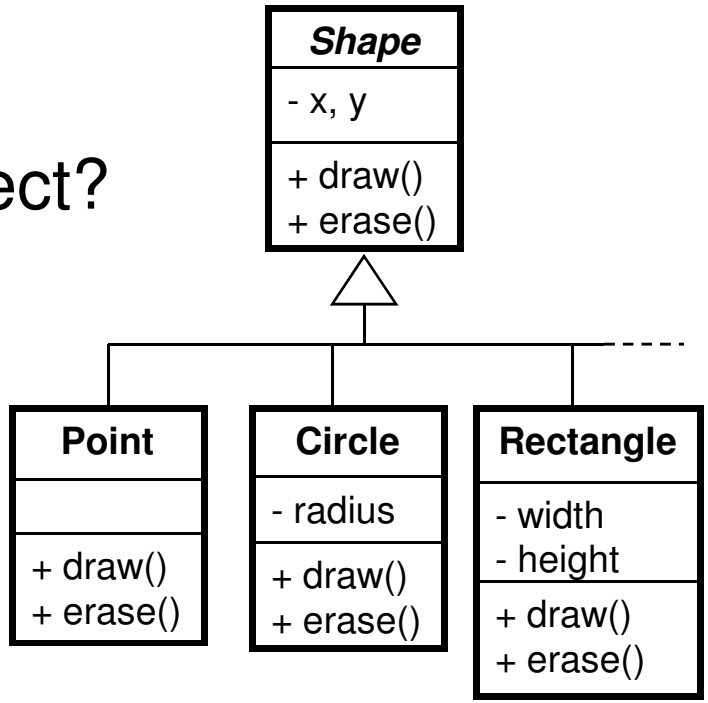
- What does a **`new Animal()`** object *look* like?
- What are the values of its instance variables?
- What should makeNoise(), eat(), and roam() do?

- **Do we ever need an Animal object?**

Animal
picture food hunger boundaries location
makeNoise() eat() sleep() roam()

What does a Shape look like?

- What does a generic Shape object look like?
- How to *draw()* it?
- Do we ever need a Shape object?



Abstract classes

- Some classes just should **not** be instantiated!
  - We want Circle and Triangle objects, but no Shape objects.
    We want Dogs and Cats, but no Animal objects…
- Make those generic classes **abstract** classes

```
abstract class Animal { ... }
```

  - The compiler will guarantee that no instances of abstract classes are created.
  - But object references of abstract class types are allowed.

```
Animal a = new Animal(); // Error!!!
Animal anim = new Dog(); // no error.
```

```
abstract public class Animal {
  public void eat() {}
  ...
}

-----------------------------------
public class MakeAnimal {
  public void go() {
    Animal a;
    a = new Hippo();
    a = new Animal();
    a.eat();
  }
}
```

This is OK.
You can always assign a subclass object to a super class reference, even if the superclass is abstract.

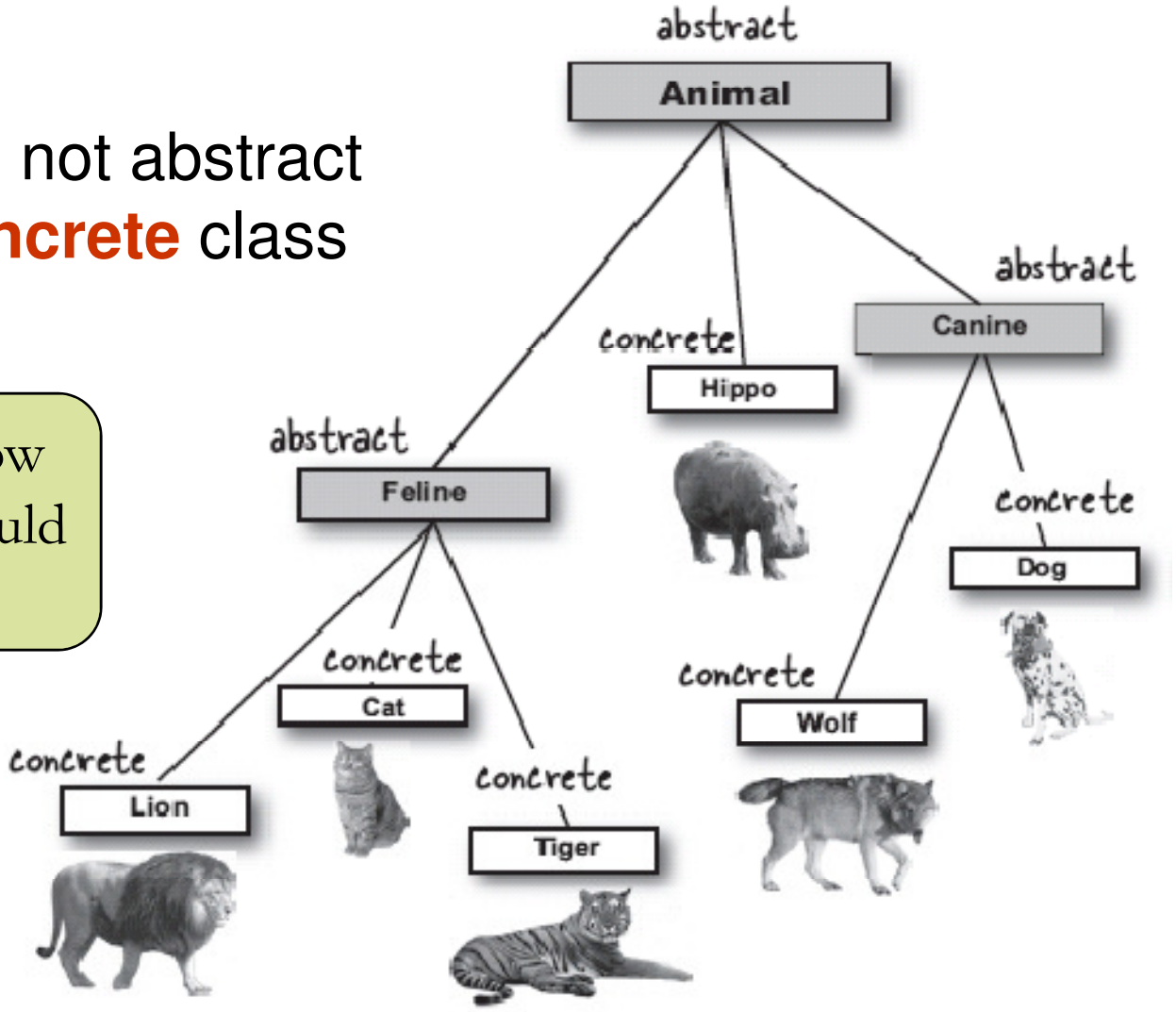
class Animal is marked abstract, so the compiler will NOT let you do create an instance of Animal.

```
% javac MakeAnimal.java

MakeAnimal.java:5: Animal is abstract;
cannot be instantiated
    a = new Animal();
        ^
1 error
```

Abstract vs. Concrete

- A class that is not abstract is called a **concrete** class

How do we know when a class should be abstract?



Abstract vs. Concrete

- mobile phone
- smart phone
- iPhone
- iPhone 4
- iPhone 4S

Abstract methods

- How do we implement?
  - Animal.makeNoise(), eat()…
  - We can't think of a generic implementation that is *useful*

```
public void makeNoise() {
  System.out.print("Hmm");
}
```

- So, we mark those methods **abstract**.
- Abstract methods has no body.

```
abstract public class Animal {
  public abstract void makeNoise();
  ...
```

No method body!
End it with a semicolon.

Abstract methods

- If you declared a *method* abstract,
  you must mark the *class* abstract, as well. You can't have a concrete class with an abstract method.

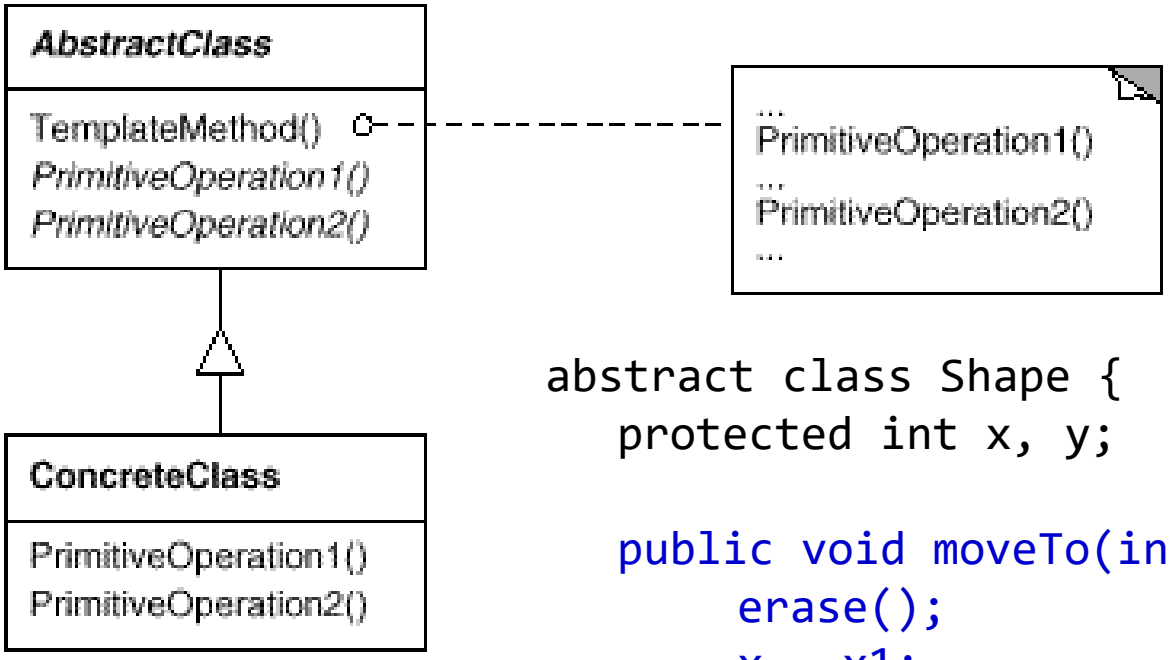
- An abstract class means that it must be *extended*.
- An abstract method means that it must be *overriden*.

- A concrete subclass must have all the inherited abstract methods implemented.

```
abstract public class Shape {
   protected int x, y;
   Shape(int _x, int _y) {
      x = _x;
      y = _y;
   }
   abstract public void draw();
   abstract public void erase();
   public void moveTo(int _x, int _y) {
      erase();
      x = _x;
      y = _y;
      draw();
   }
}
```

```
public class Circle extends Shape {
   private int radius;
   public Circle(int _x, int _y, int _r) {
      super(_x, _y);
      radius = _r;
   }
   public void draw() {
      System.out.println("Draw circle at "+x+","+y);
   }
   public void erase() {
      System.out.println("Erase circle at "+x+","+y);
   }
}
```

Design pattern: Template method

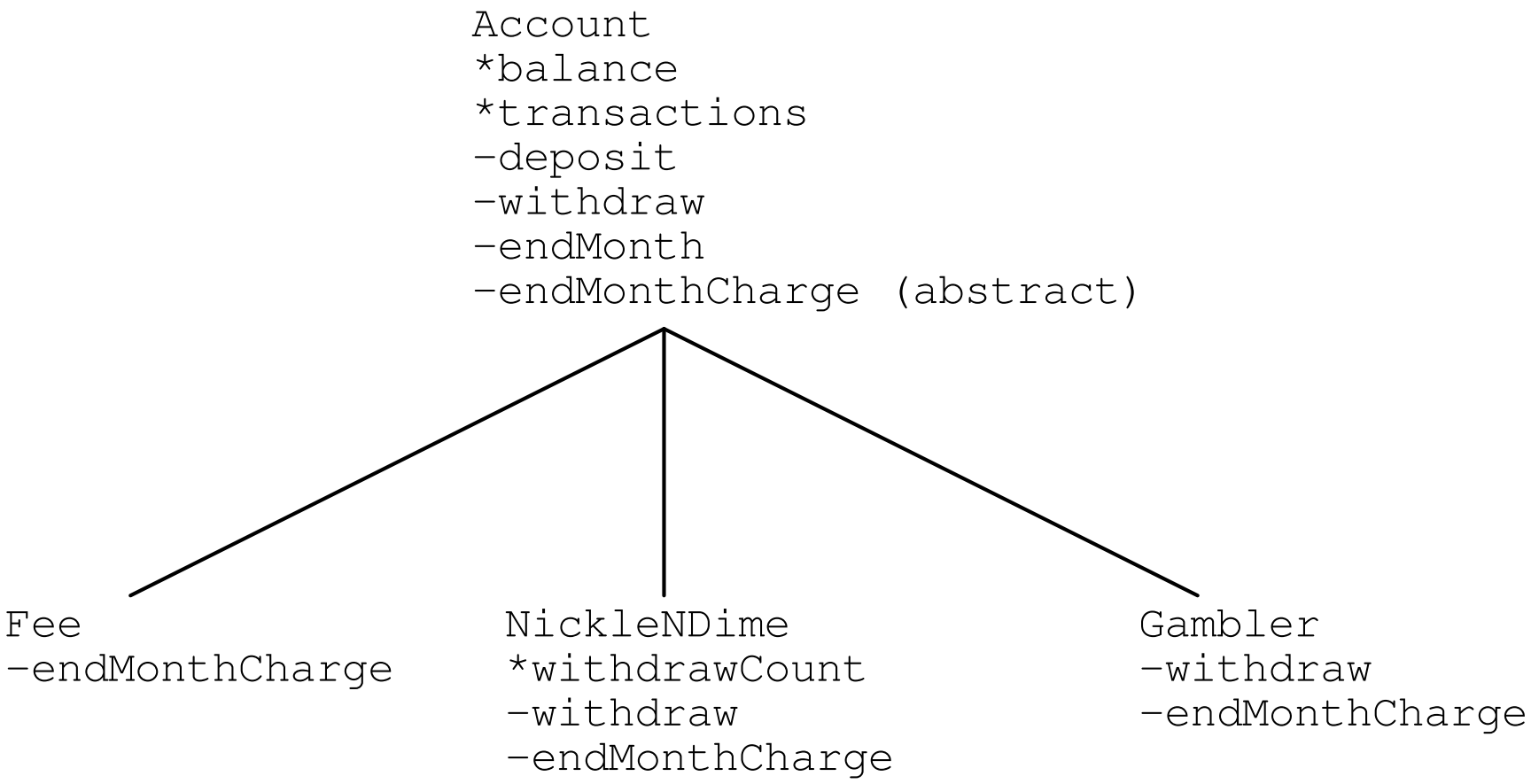



```
abstract class Shape {
   protected int x, y;

   public void moveTo(int x1, int y1) {
        erase();
        x = x1;
        y = y1;
        draw();
   }
   abstract public void erase();
   abstract public void draw();
}
```

Account example

- You need to store information for bank accounts: current balance, and the total number of transactions for each account.
- The goal for the problem is to avoid duplicating code between the three types of account.
- An account needs to respond to the following messages:
  - constructor(initialBalance)
  - deposit(amount)
  - withdraw(amount)
  - endMonth(): Apply the end-of-month charge, print out a summary, zero the transaction count.
- The end-of-month charge is calculated depending on types of Accounts
  - *Normal* : Fixed $5.0 fee at the end of the month
  - *Nickle 'n Dime*: $1.00 fee for each withdrawal charged at the end of the month
  - *Gambler*:
    - With probability 0.49 there is no fee and no deduction to the balance
    - With probability 0.51 the fee is twice the amount withdrawn

Class design diagram




```
public class AnimalList {
  private Animal[] animals = new Animal[5];
  private int nextIndex = 0;

  public void add(Animal a) {
    if (nextIndex < animals.length) {
      animals[nextIndex] = a;
      System.out.print("Animal added at " + nextIndex);
      nextIndex++;
    }
  }
}
```

```
public class AnimalTestDrive {
  public static void main(String [] args) {
    AnimalList list = new AnimalList();
    Dog d = new Dog();
    Cat c = new Cat();
    list.add(d);
    list.add(c);
  }
}
```

```
public class AnimalList {
  private Animal[] animals = new Animal[5];
  private int nextIndex = 0;

  public Animal get(int index) {
    return animals[index];
  }

  public void add(Animal a) {
    if
    }
  }
}
```

AnimalList
Animal[] animals int nextIndex
add(Animal a) get(int index)

```
public class DogTestDrive {
  public static void main(String [] args) {
    AnimalList list = new AnimalList();
    Dog d = new Dog();
    list.add(d);
    d = list.get(0); // Error!
    d.chaseCats();
  }
}
```

```
% javac DogTestDrive.java
DogTestDrive.java:6: incompatible types
found   : Animal
required: Dog
    d = list.get(0);
                 ^
```

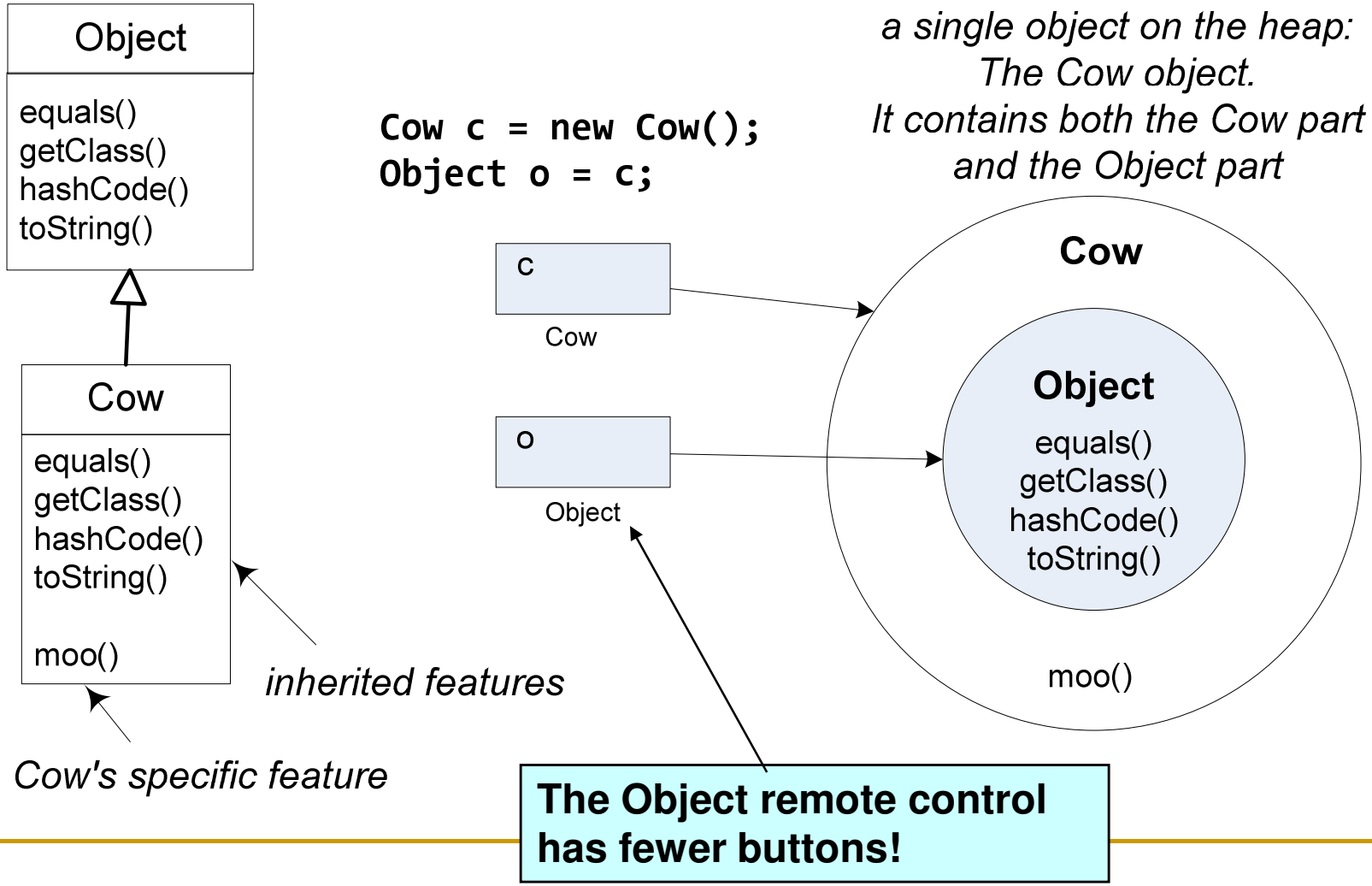
The compiler doesn't know that list.get() refers to a Dog object!

```
public class AnimalList {
  private Animal[] animals = new Animal[5];
  private int nextIndex = 0;

  public Animal get(int index) {
    return animals[index];
  }

  public void add(Animal a) {
    if
    }
  }
}
```

```
public class DogTestDrive {
  public static void main(String [] args) {
    AnimalList list = new AnimalList();
    Dog d = new Dog();
    list.add(d);

    Animal a = list.get(0); // We know the object is a Dog!
    a.chaseCats(); // Error! Animal doesn't have chaseCats()!
  }
}
```

The compiler doesn't know that a refers to a Dog object!

Subclass object & the inherited part



The rules

- Which method version get invoked depends on the object type.
- Whether a method call is allowed depends on the reference type – *what buttons the remote control has*.

```
Object o = new Cow();
o.toString();
o.moo();
```

  - Cow's `toString()` is invoked because o is now refering to an Cow object.
  - `o.toString()` is allowed because Object has toString(). But `o.moo()` is not allowed because Object does not has moo()

Dynamic & static binding

- Method binding: connect a method call to a method body
- Static/early binding: performed by compiler/linker before the program is run.
  - The only option of procedural languages.
- Dynamic/late binding: performed during run-time
  - Java uses late binding, except for static, final, and private methods.
    - private methods are implicitly final.

Casting

```
Object o = new Cow();
o.toString();
o.moo(); // Error!
```

- How to make the Cow act like a Cow, again?
  - Use an **explicit** cast:

```
Object o = new Cow();
o.toString();
Cow c = (Cow) o;
c.moo(); // no error
```

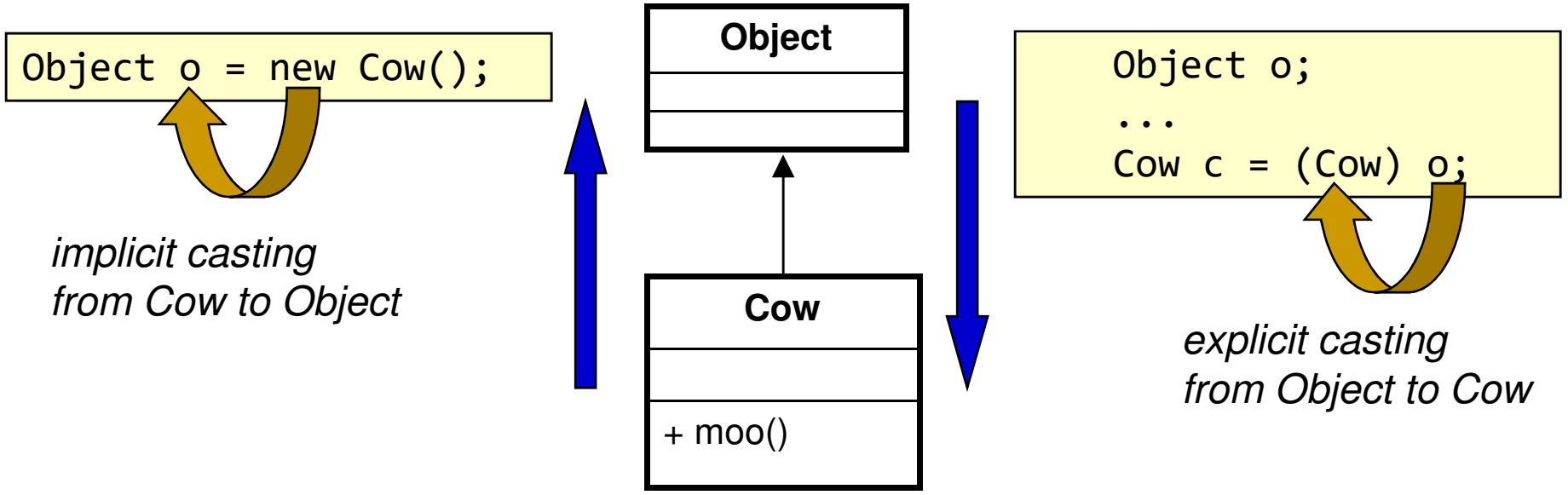
( ): cast operator, casting to the type Cow

- Explicit cast is not always possible:

```
Object o = new Cat();
Cow c = (Cow) o;  // no compile-time error
c.moo(); // run-time error
```

Upcasting & down casting

- Upcasting:
  casting *up* the diagram.
- Downcasting:
  casting *down* the diagram.



Abstract super class

- As a super class
  - A common superclass for several subclasses
  - Factor up common behavior
  - Define the methods all the subclasses respond to
- As an abstract class
  - Force concrete subclasses to override methods that are declared as abstract in the super class
    - Circle, Triangle must implement their own draw() and erase()
  - Forbid creation of instants of the abstract superclass
    - Shape objects are not allowed