COMP 250

Lecture 33

type conversion
polymorphism (intro only)
Class class

Nov. 24, 2017

Primitive Type Conversion

double
float

non-integers

long
int
short

integers

char
byte
boolean

In COMP 273, you will learn details of how number representations are related to each other.

But you should have some intuitive ideas….

https://docs.oracle.com/javase/tutorial/java/nutsandbolts/datatypes.html

Primitive Type Conversion

wider

Here, wider usually (but not always) means more bytes.

	number of bytes
double	8
float	4
long	8
int	4
short	2
char	2
byte	1
boolean	1

narrower

Examples

```
int          i = 3;
double    d = 4.2;
             d = i ;                    // widening
```

Examples

```
int          i = 3;
double    d = 4.2;
             d = i ;                    // widening

             d  =   5.3 * i;            // widening     (by "promotion")
             i   =   (int)    d;        // narrowing   (by casting)
float        f   =   (float)  d;        // narrowing   (by casting)
```

For primitive types, both widening and narrowing change the bit representation. (See COMP 273.)

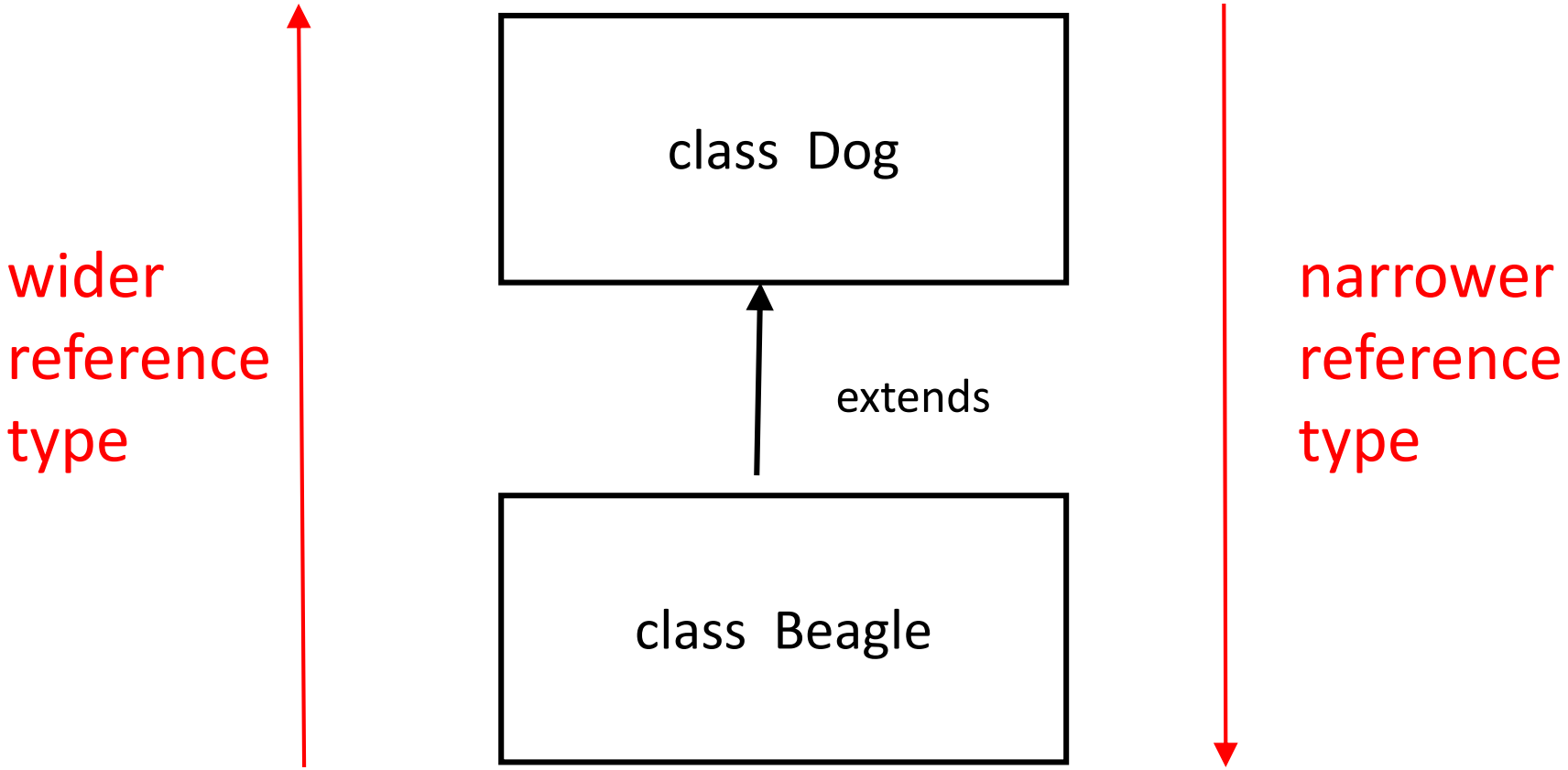
For narrowing conversions, you get a compiler error if you don't cast.

Examples

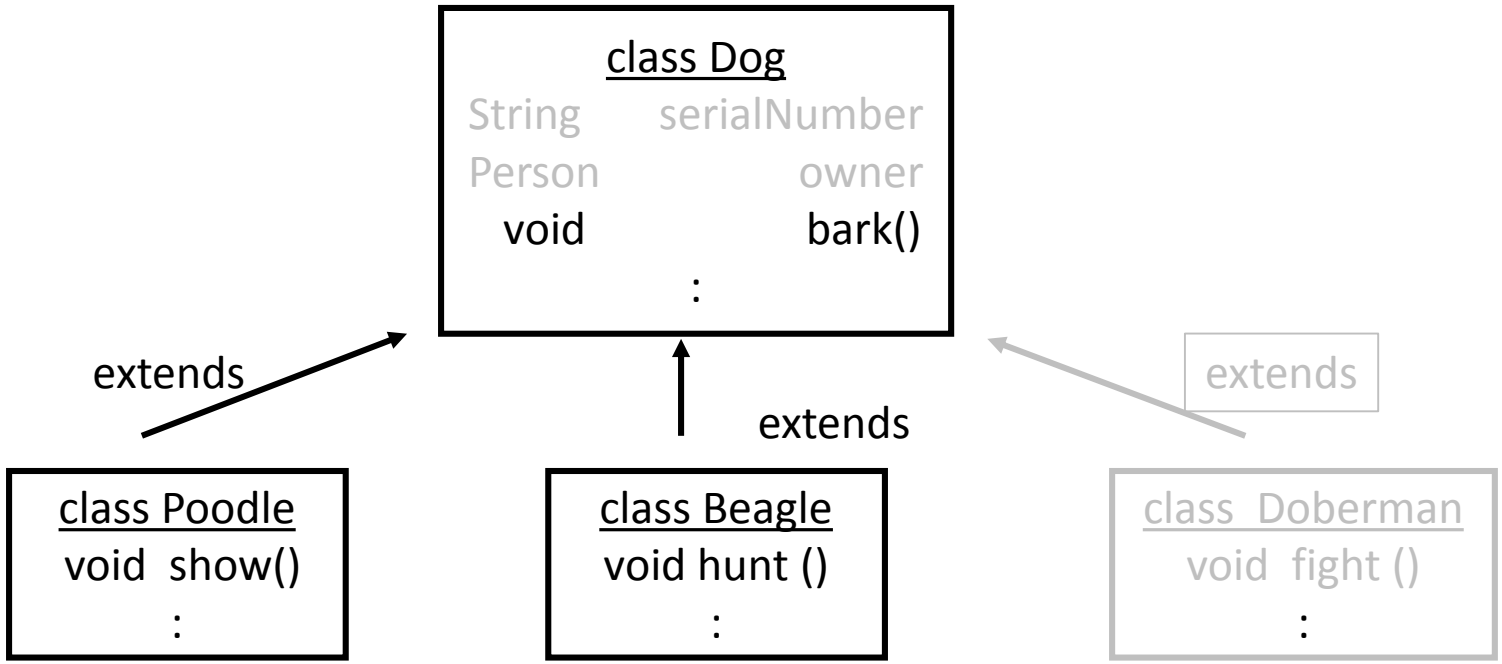
```
int          i = 3;
double    d = 4.2;
          d = i ;                    // widening

          d  =   5.3 * i;            // widening     (by "promotion")
          i   =   (int)    d;        // narrowing   (by casting)
float     f   =   (float)  d;        // narrowing   (by casting)

char      c = 'g';
int          index  =  c;                  //  widening
          c  =  (char) index;          // narrowing
```



Although a subclass is narrower, it has more fields and methods than the superclass (in that it inherits all fields and methods from superclass).


class Dog
String serialNumber
Person owner
void bark()
:
extends
extends
extends
class Poodle
void show()
:
class Beagle
void hunt ()
:
class Doberman
void fight ()
:

```
Dog myDog = new Beagle();  // upcast, widening
```

This is similar to:

```
double myDouble = 3;  // from int to double.
```

```
Dog       myDog   =   new Beagle();       // Upcast,  widen.

Poodle    myPoodle  =   myDog;


              myDog.show()
```

```
Dog       myDog   =   new Beagle();       // Upcast,  widen.


Poodle    myPoodle  =   myDog;          // Compiler error.

          // Implicit downcast Dog to Poodle is not allowed.

           myDog.show()                  //  Compiler error.

                                  //   Poodle has show() method,
                                  //   but Dog  does not.
```

```
Dog       myDog   =   new Beagle();        // Upcasting.

Poodle    myPoodle   =   (Poodle)   myDog;    //  Downcast
                                               //  Narrowing

          myPoodle.show()

          ((Poodle)  myDog).show()
```

```
Dog       myDog   =   new Beagle();        // Upcasting.


Poodle    myPoodle   =   (Poodle)   myDog;

          //    allowed by compiler

           myPoodle.show()        //    allowed by compiler
                                  //   but runtime error:   Dog object
                                  //    does not have show()  method

          ((Poodle)  myDog).show()

//   allowed by compiler,  but runtime error for same reason
```

Most of examples above concerned compile time issues.

We next examine runtime issues.

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Class class

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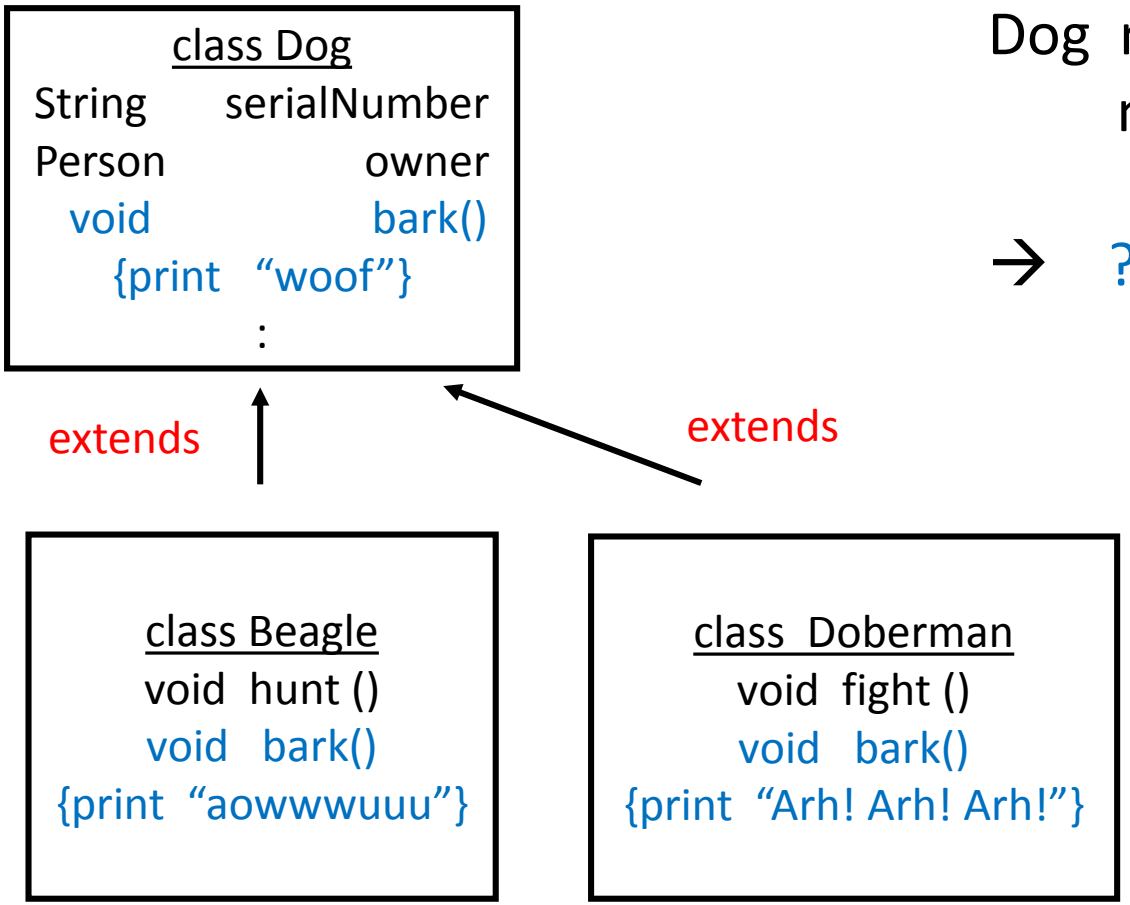
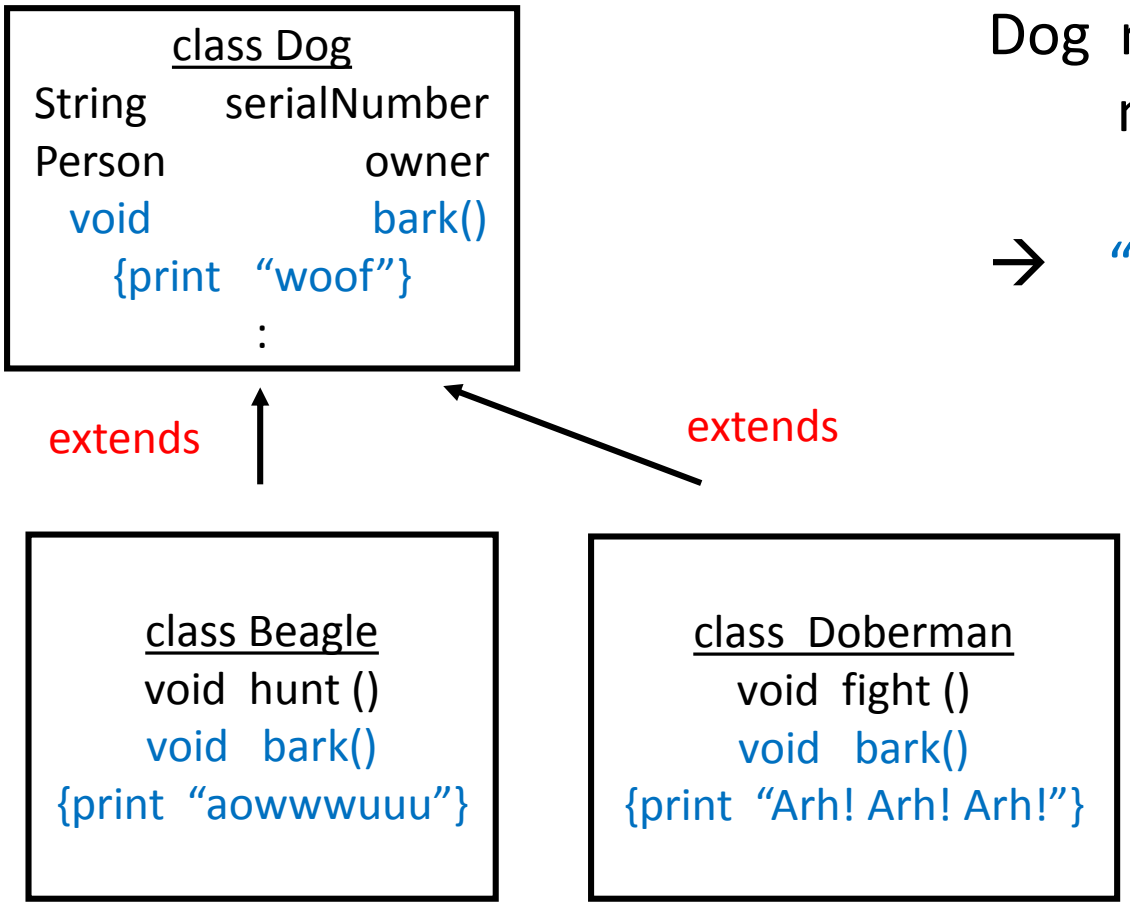
Recall example from lecture 30




```
Dog  myDog = new Beagle();
     myDog.bark();
```

→ ?????? (which bark?)

Recall example from lecture 30




```
Dog  myDog = new Beagle();
     myDog.bark();
```

→ "aowwwuuu"

Polymorphism

“poly” = multiple

“morph” = form

We have seen the idea already:

The object type (run time) can be *the same or narrower* than the declared type (compile time).

More general discussion about polymorphism in higher level courses e.g. COMP 302.

Polymorphism

(the following is an important idea, not a formal definition)

Compile time:

Suppose a reference variable has a declared type:

```
C    varC ;    //   C is a class
A    varA ;    //   A  is an abstract class
I    varI  ;    //  I  is an interface
```

Runtime:

varC can reference any object of class C or any object of a class that extends C.

varA can reference any object whose class extends abstract class A.

varI can reference any object whose class implements interface I.

```
boolean  b;
Object    obj;

:

if ( b )
     obj = new Cat();
else
     obj = new Dog();

:

System.out.print( obj  );

//   Which  toString() method that gets called
//   depends on the object referenced by obj.
```

(See Exercises for more examples.)

How does (runtime) polymorphism work?

To answer this question, I first need to explain how classes are represented in a running program.

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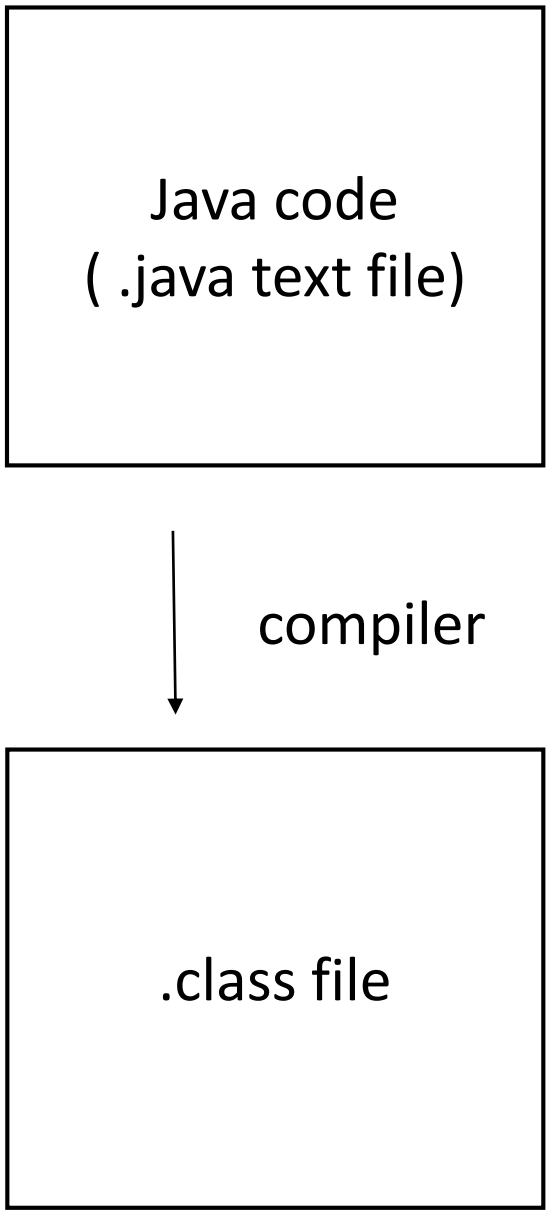

Java code
(.java text file)
compiler
.class file

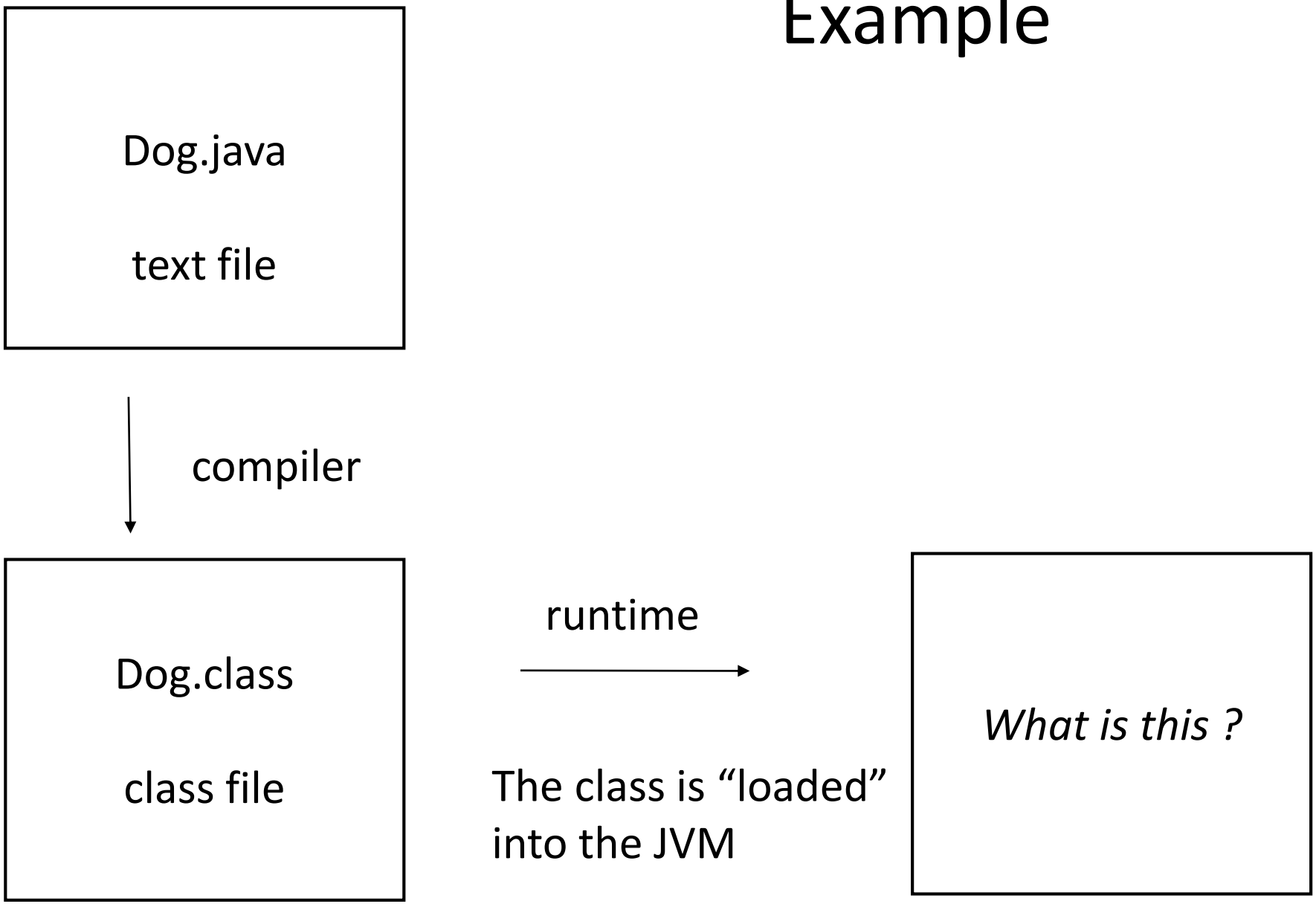
Java .class file ("byte code")

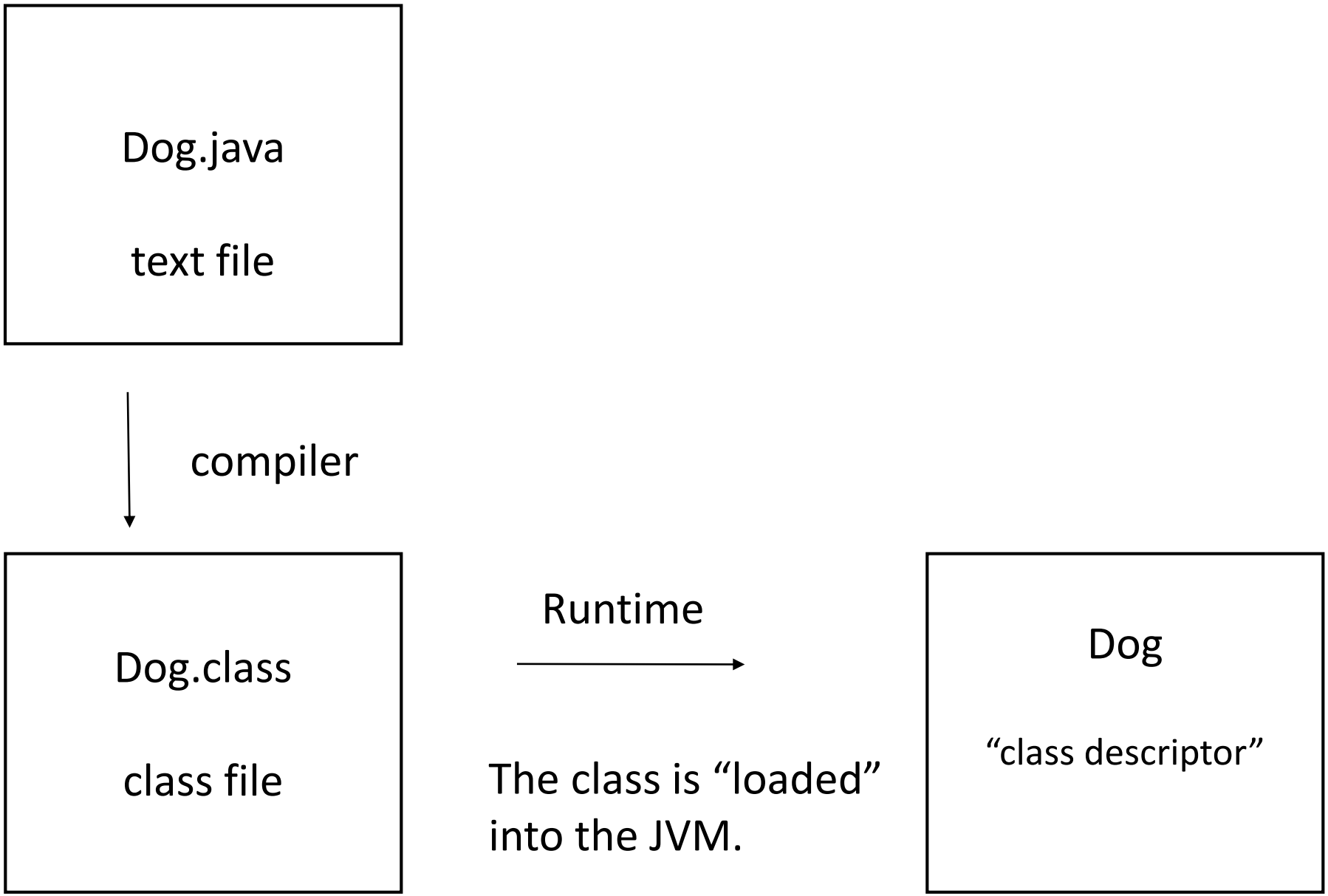
It has a specific format for information such as:

- the class name
- fields (names, types)
- methods (signature, return type, instructions)
- superclass
- ….

https://docs.oracle.com/javase/specs/jvms/se7/html/jvms-4.html

Example

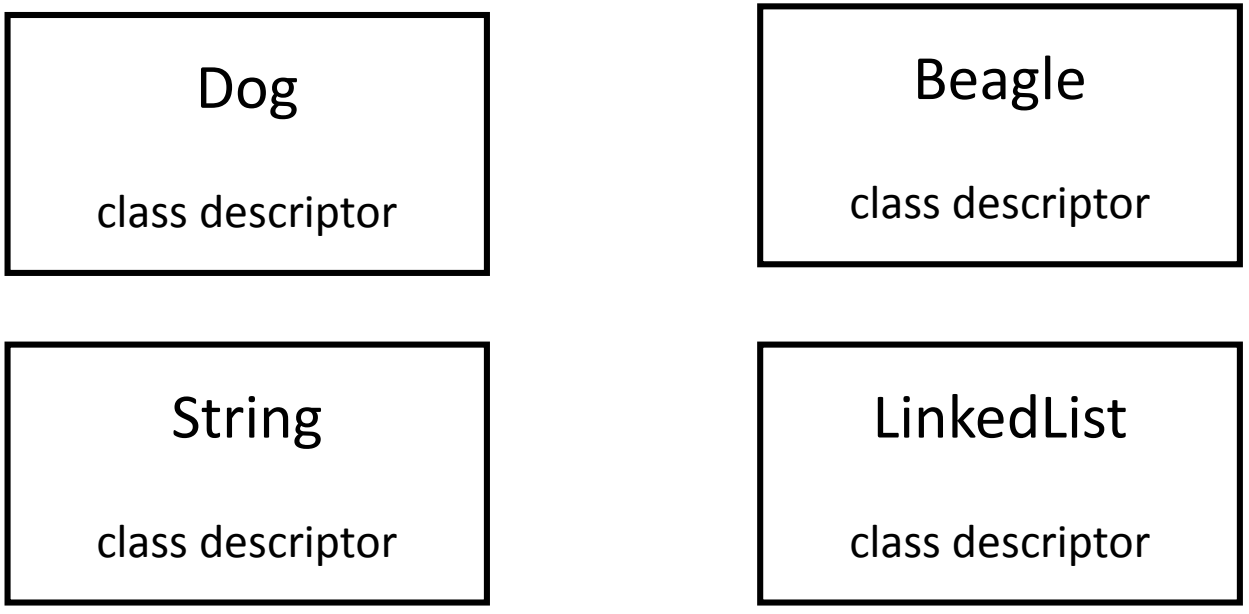

Dog.java
text file
compiler
Dog.class
class file
runtime
The class is “loaded” into the JVM
What is this ?


Dog.java
text file
compiler
Dog.class
class file
Runtime
The class is “loaded” into the JVM.
Dog
“class descriptor”

The term “class descriptor” is not standard. So don’t look it up.

It is an *object* that contains all the information about a class.

If it is an object, then what class is it an instance of ?



A “class descriptor” is an instance of the Class class.

It has many methods:

class Class

Class	getSuperClass()
Method[ ]	getMethods( )
Field[ ]	getFields( )
String	getName( )
	:

A Dog object is an instance of the Dog class.

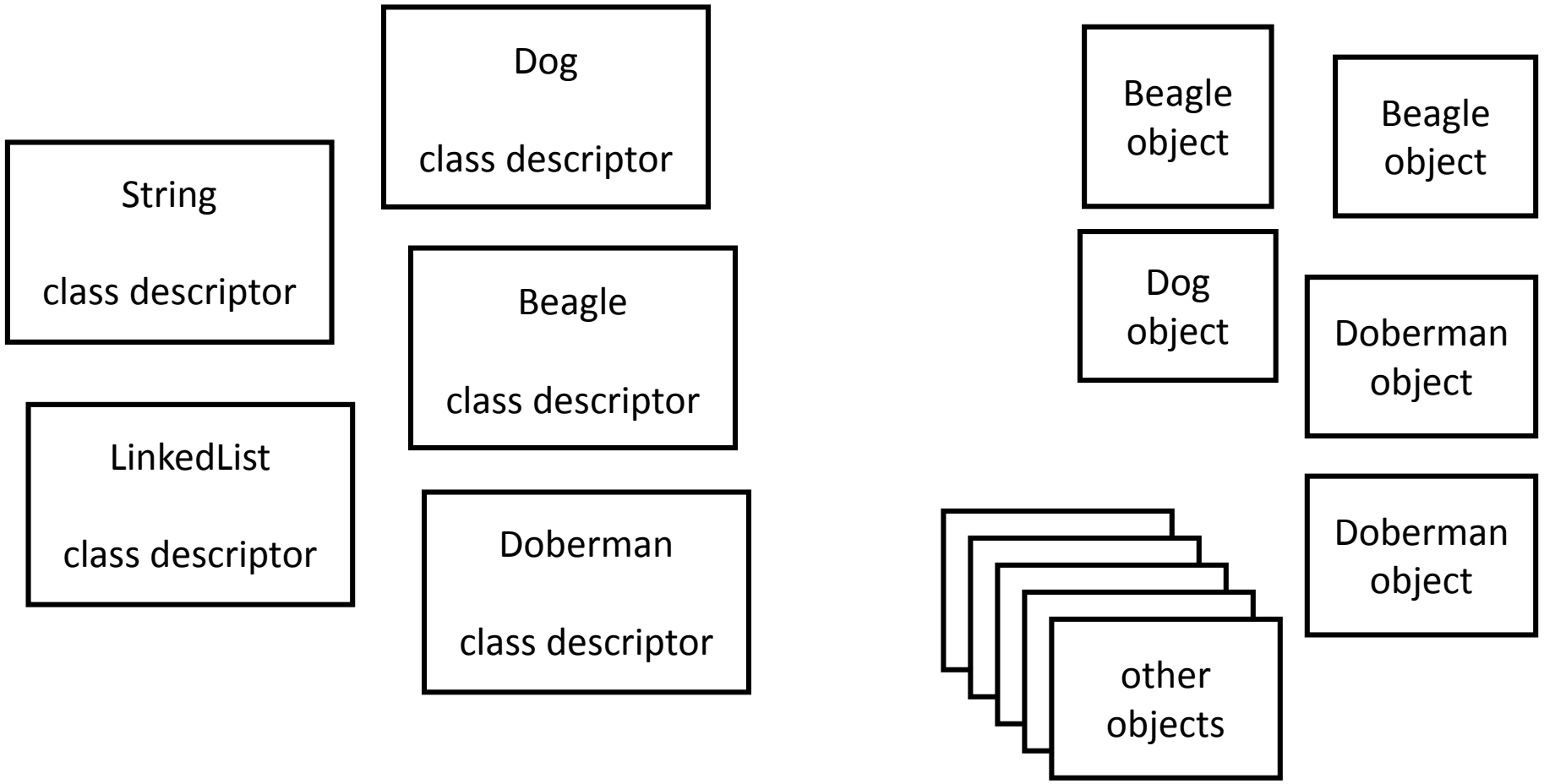
A String object is an instance of the String class.

An Object object is an instance of the Object class.

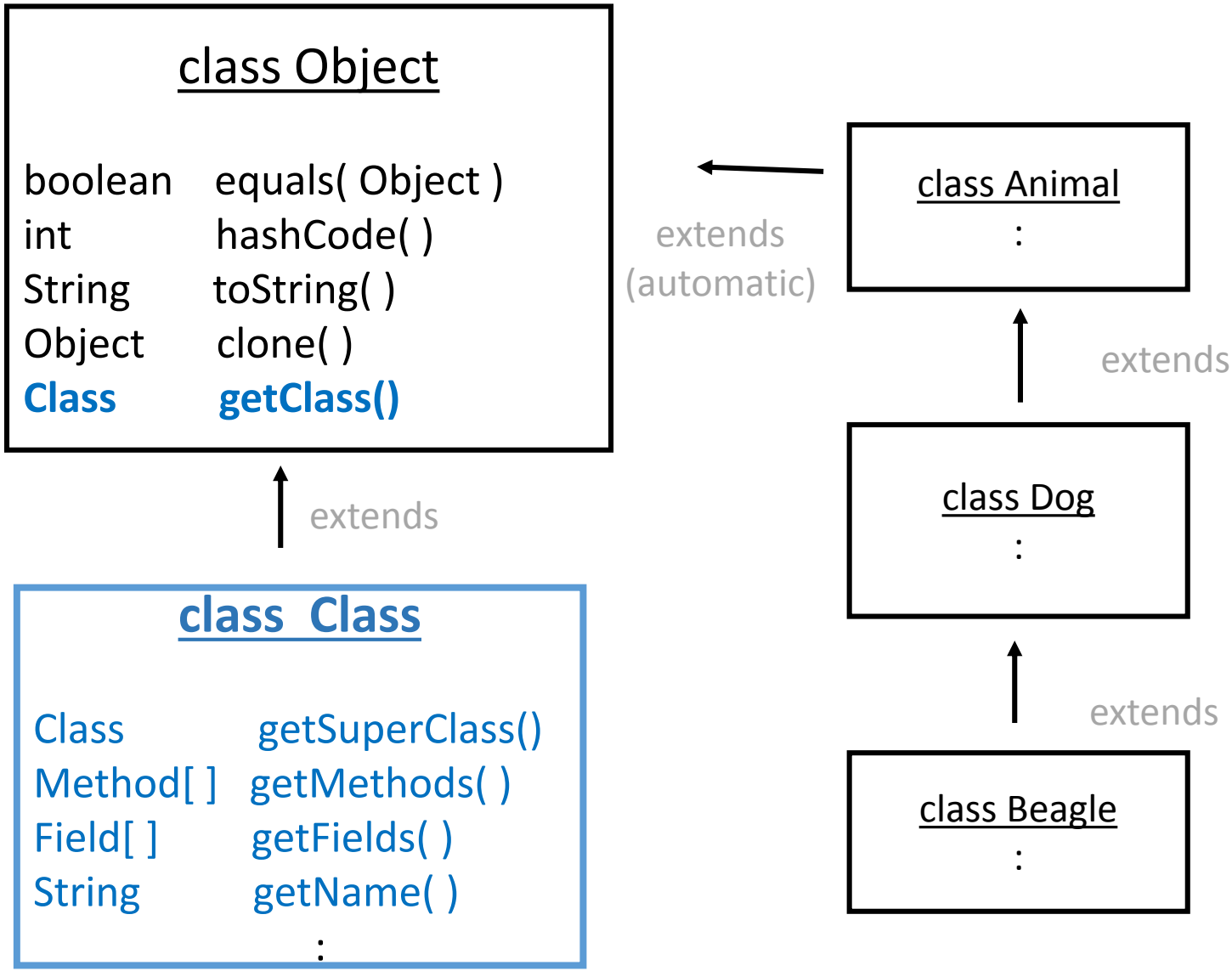
A Class object (“class descriptor” object*) is an instance of the Class class.*

Each class descriptor is an instance of the Class class.

This figure shows objects in a running Java program.

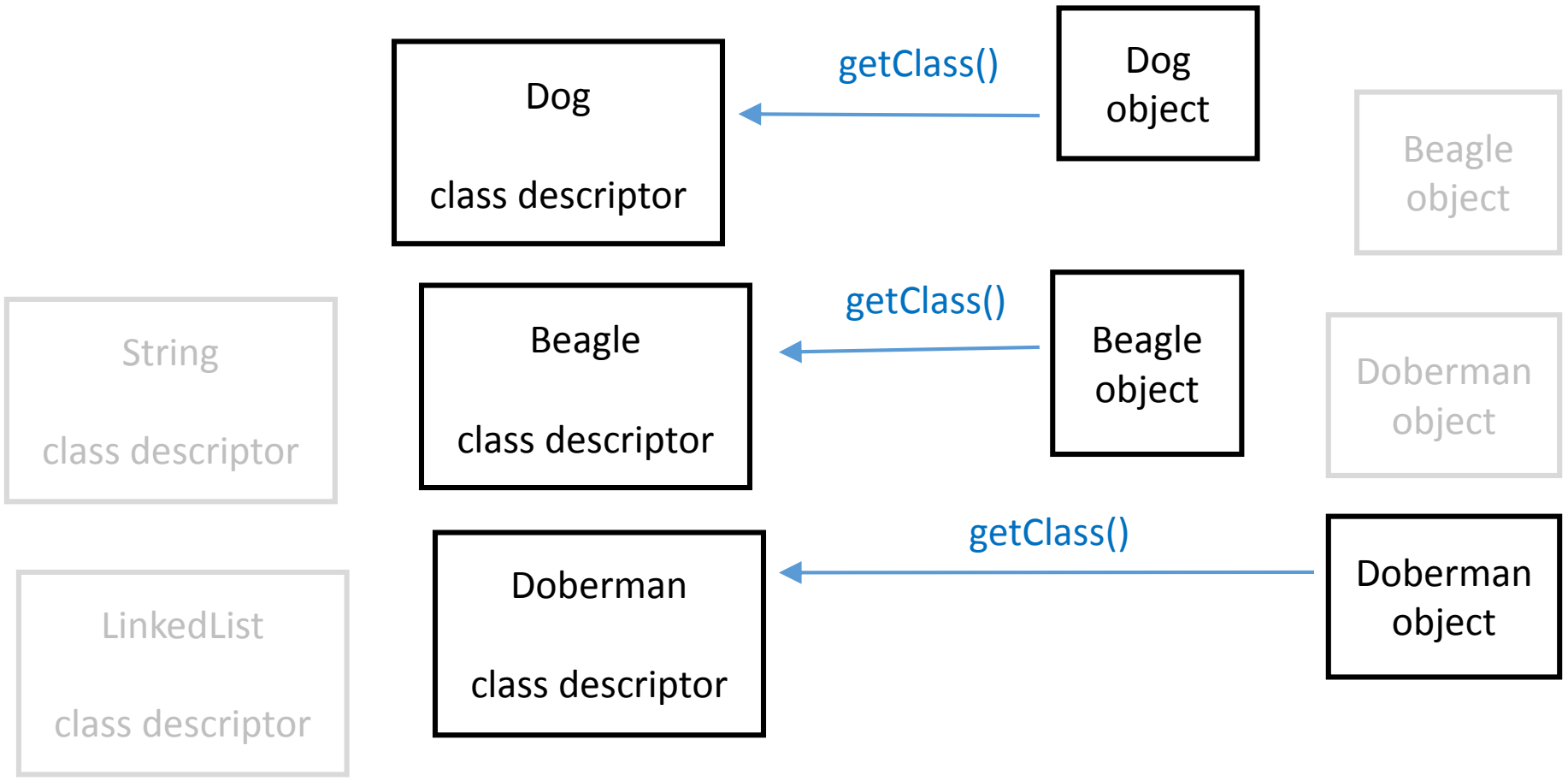


This figure shows classes
in the Java class hierarchy.



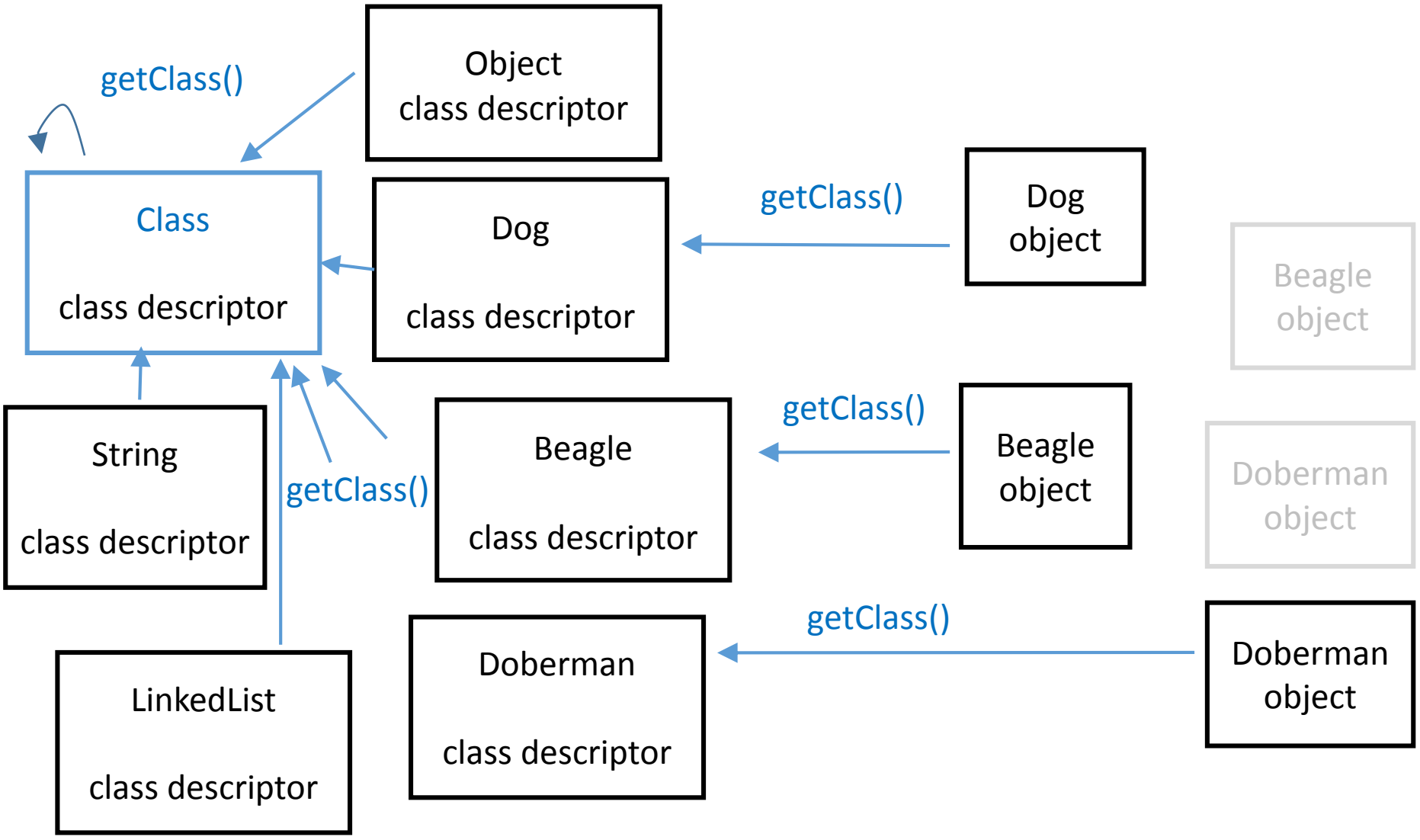
All classes inherit the Object.getClass() method which returns the class descriptor for that object.

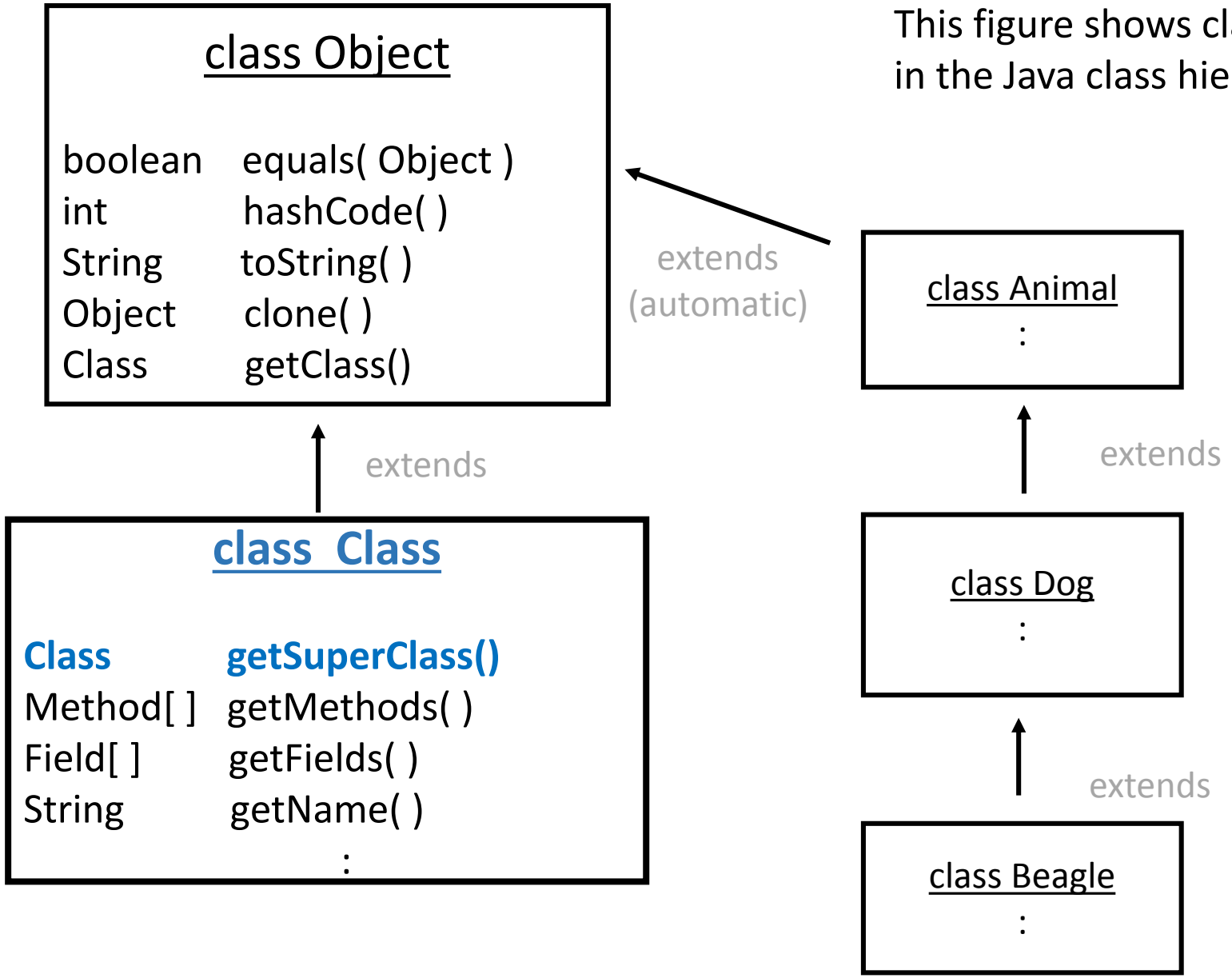
This figure shows objects in a running Java program.



All classes inherit the Object.getClass() method, which returns the class descriptor for that object.

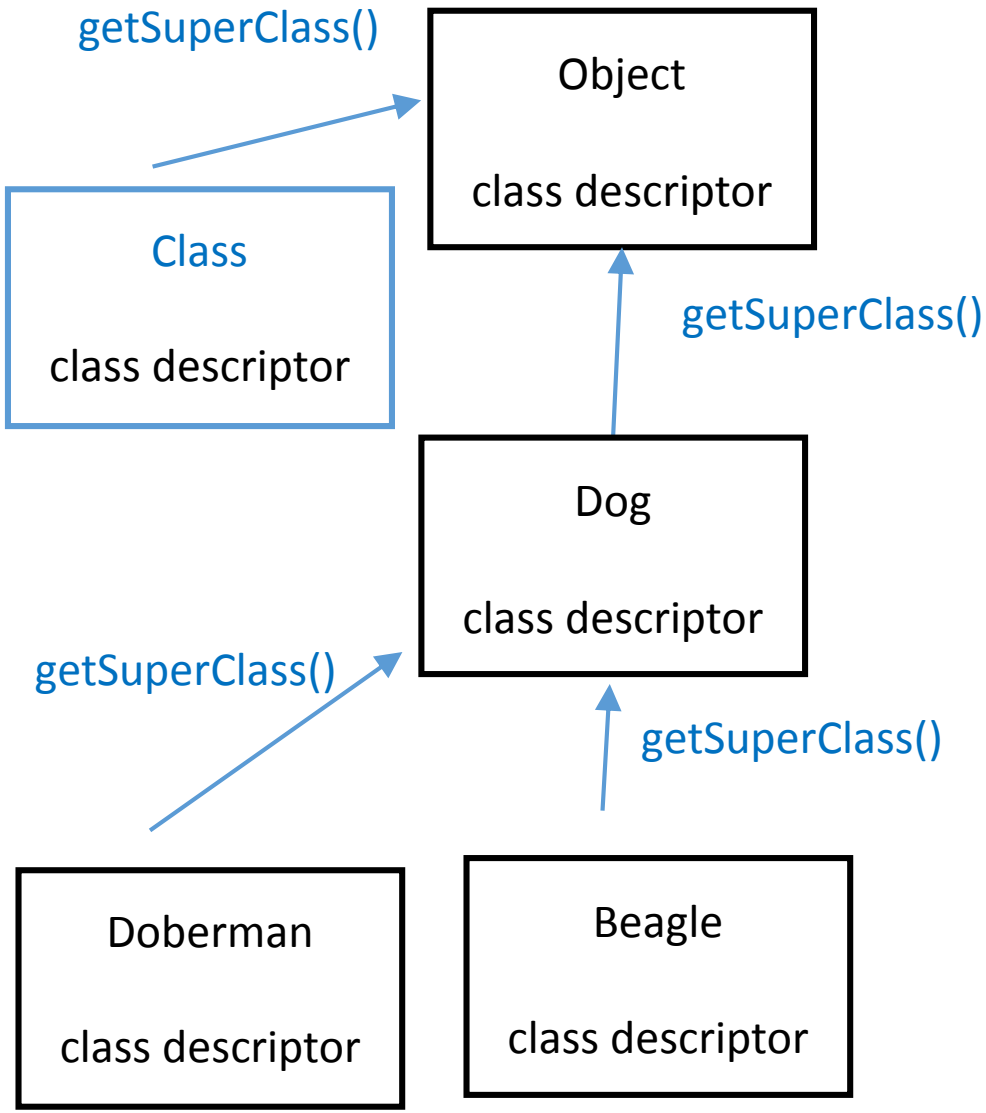
This figure shows objects in a running Java program.

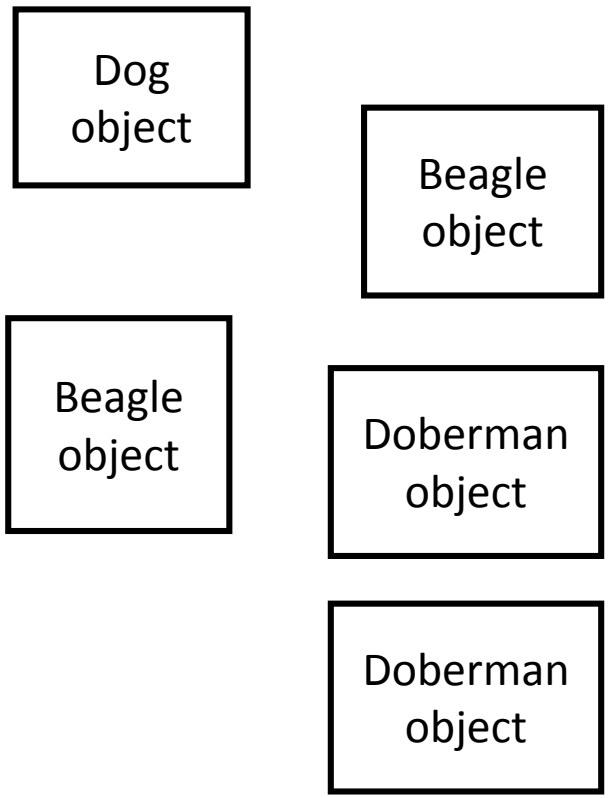




This figure shows classes in the Java class hierarchy.

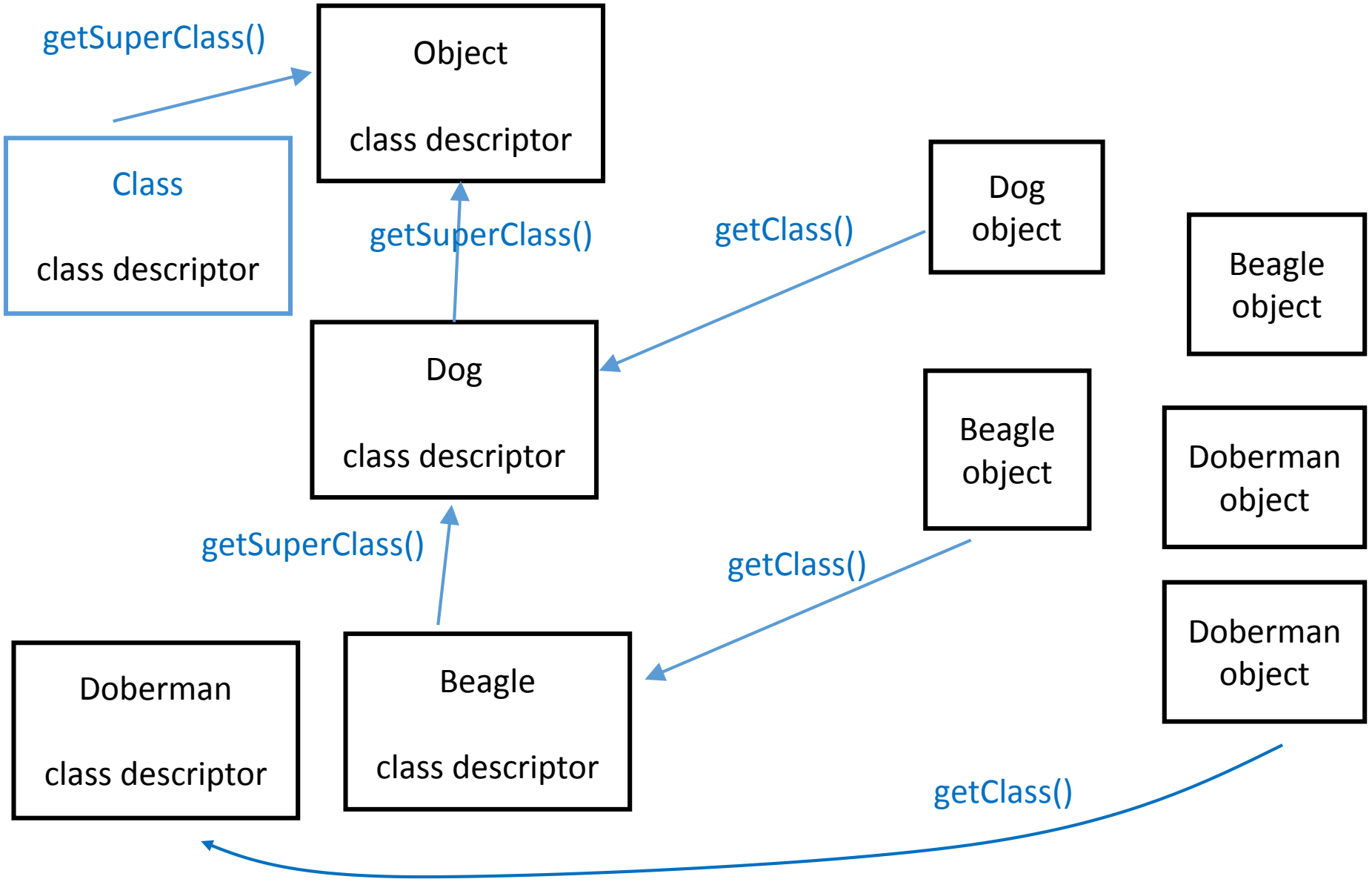
This figure shows objects in a running Java program.





The getSuperClass() method cannot be invoked by the objects above. Why not?

This figure shows objects
in a running Java program.



We’ll see more about how this works next week…