Some slides contain lots of animation.

Interfaces

covering

** Interfaces & a little more on Abstract Classes

** Multiple Inheritance

Chapter 6 (section 6.1) – “Big Java” book
Chapter 8 – “Head First Java” book
Chapter 15 – “Introduction to Java Programming” book
Chapter 4 – “Java in a Nutshell” book

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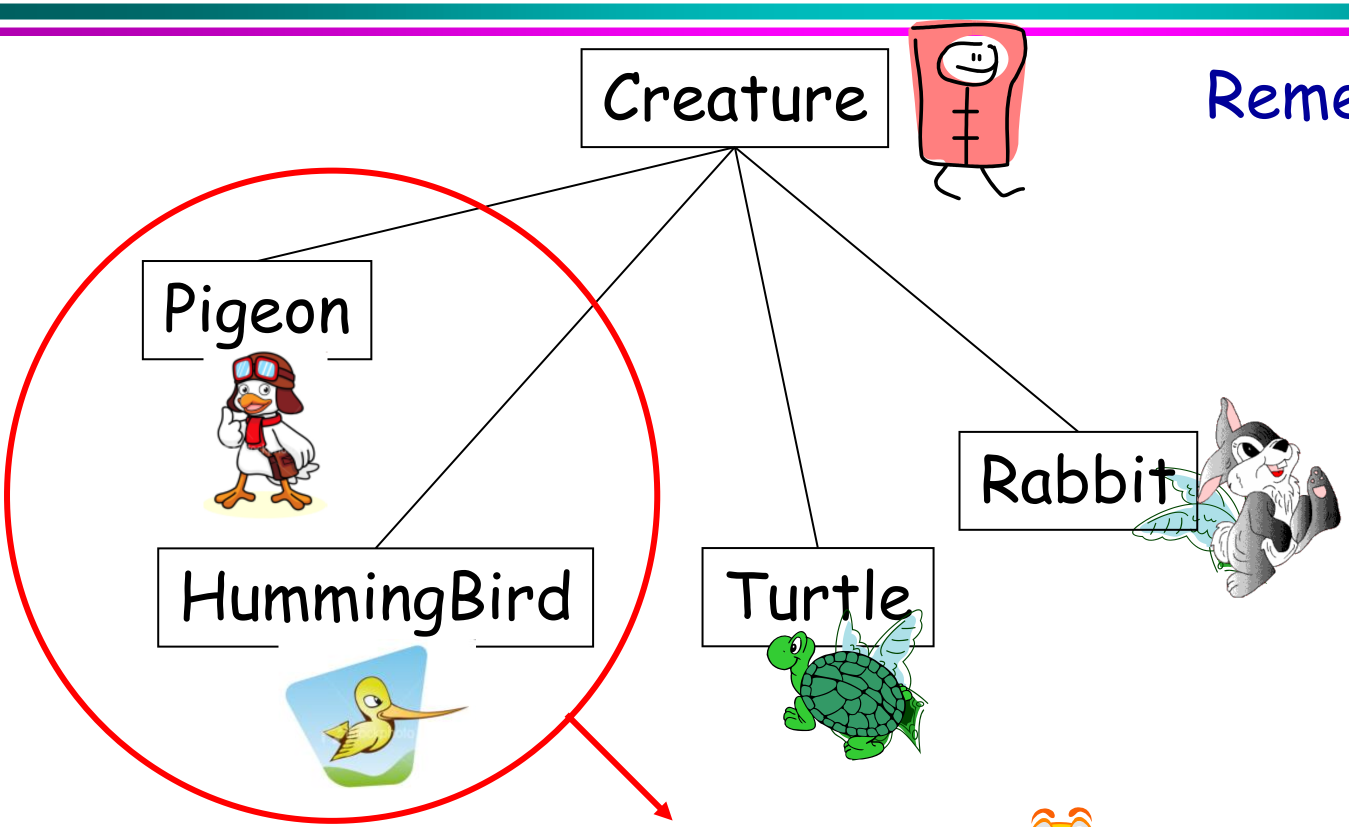
More creatures (*before* `abstract`)



Remember?

```
Creature
-----------------
String name;
String tailType;
Color color;
int speed;
-----------------
run();
swim();
fly();
```

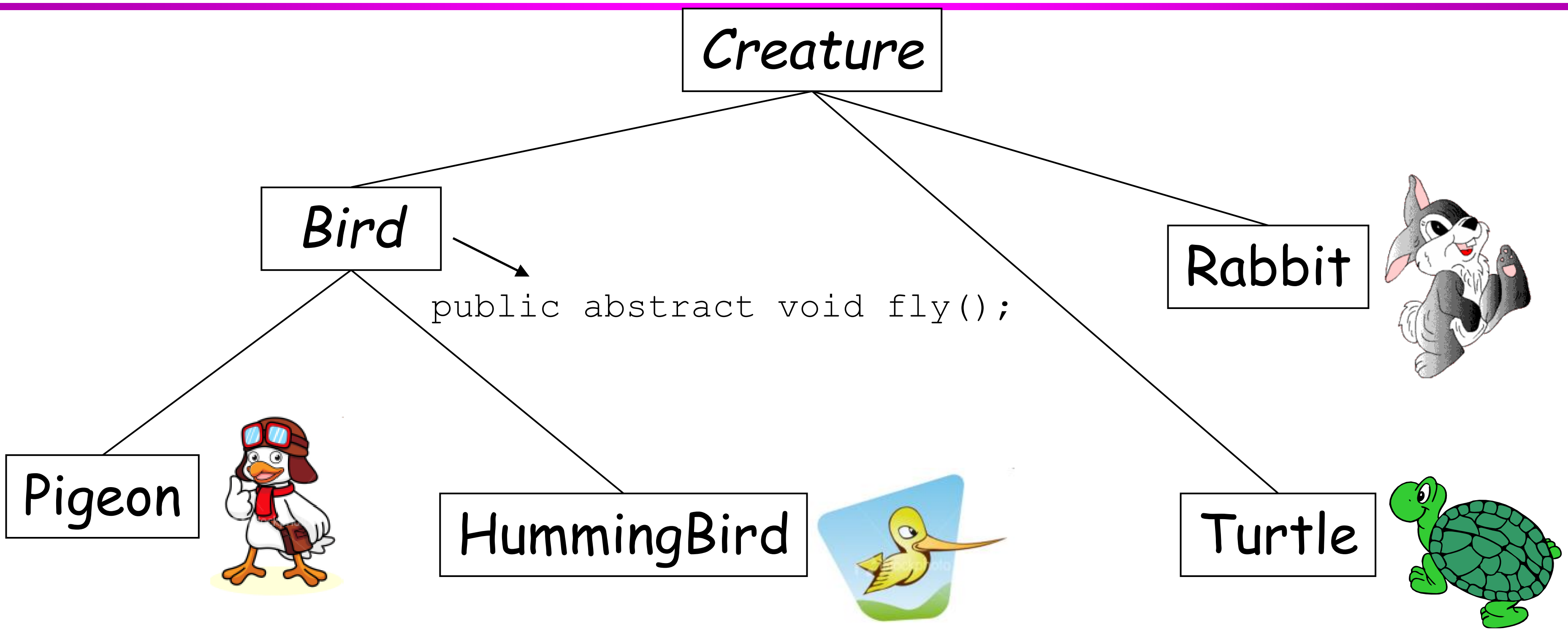
but if we put in a generic fly method in Creature so would Rabbits and Turtles!!

The classes that need to *fly* implement the `fly()` method.

Instead of providing generic methods in `Creature`, we could make the `fly()` method abstract.

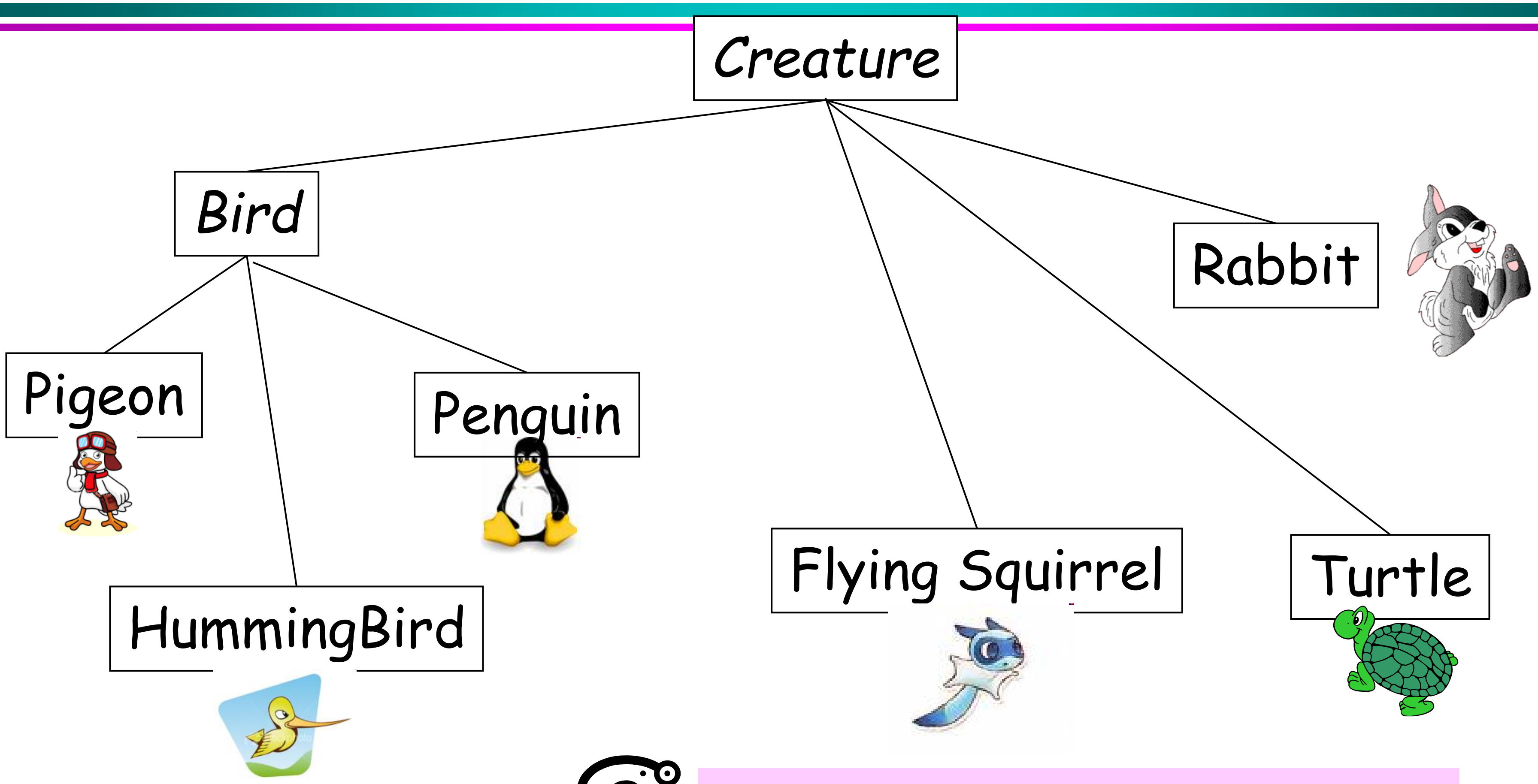
All subclasses of the then abstract class `Creature` must provide a `fly()` method. Even those that do not *fly*!

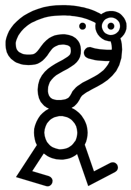
Creating multiple `abstract` parents



Now Birds can *fly*, but Rabbits and Turtles remain grounded!

Let us add more `Creatures` (1/3)

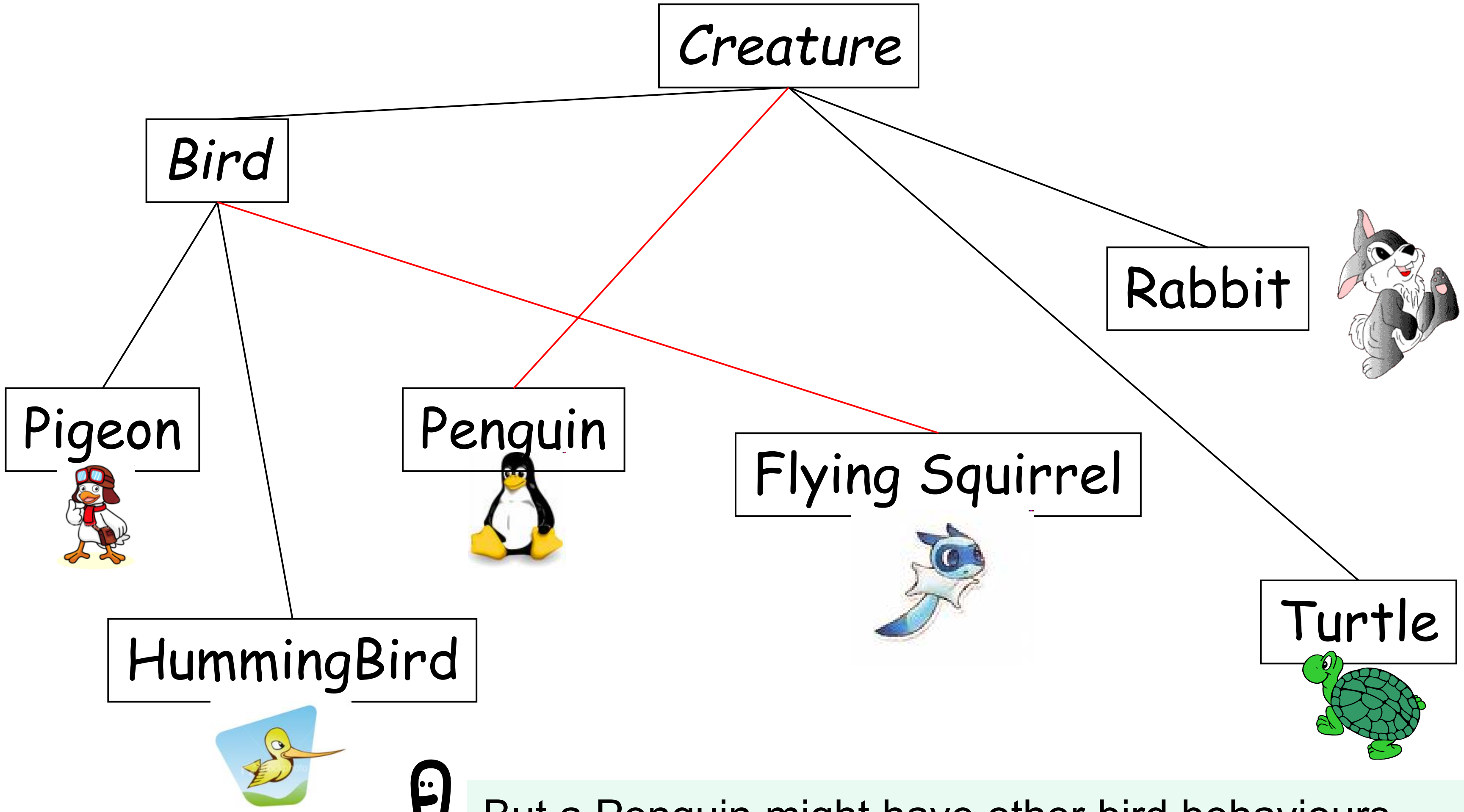




Do Penguins fly?
And how about flying mammals?

Let us add more `Creatures` (2/3)

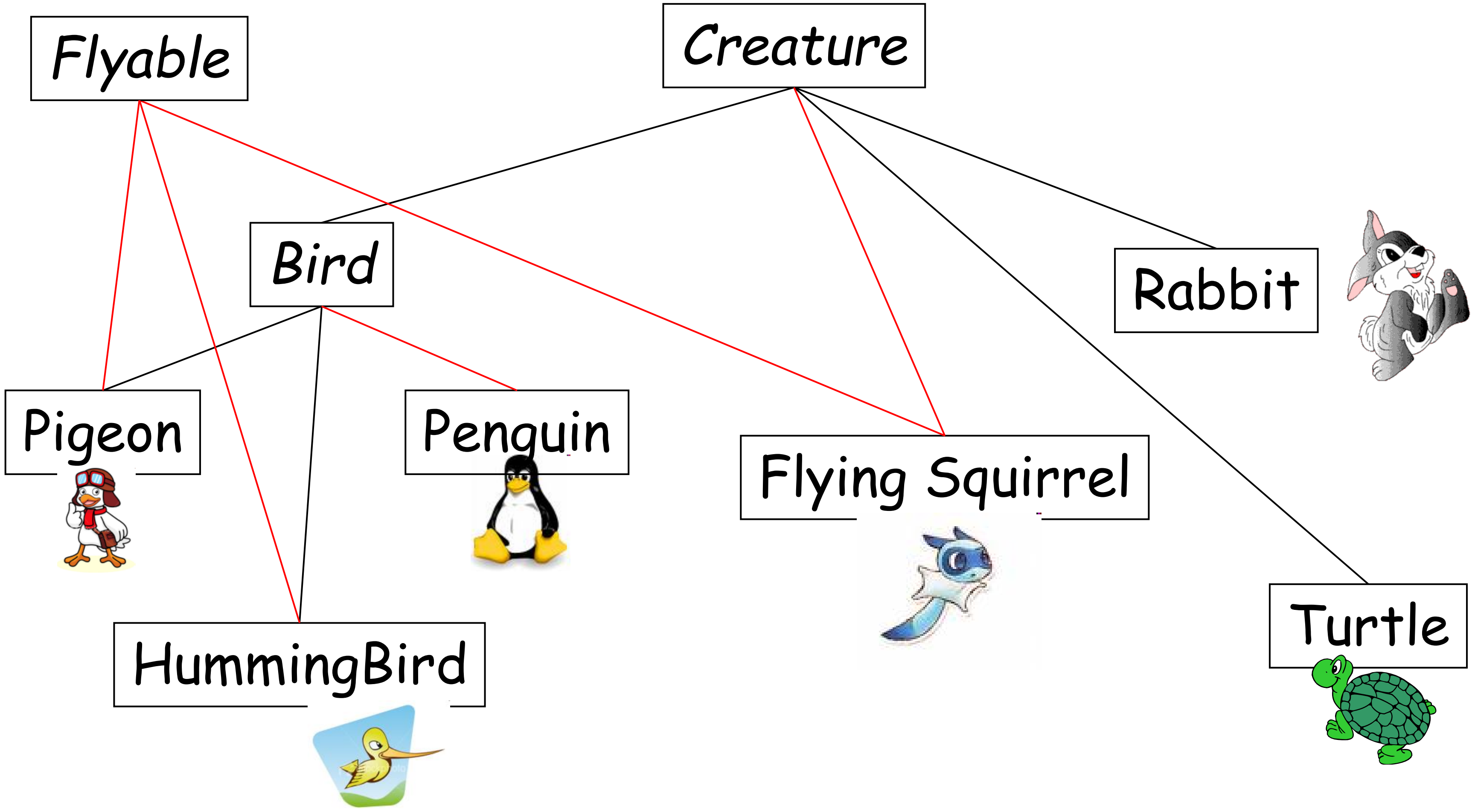
- How can we make a *penguin not fly* and a *flying squirrel fly*?



But a Penguin might have other bird behaviours …
And a Flying Squirrel is not a bird!

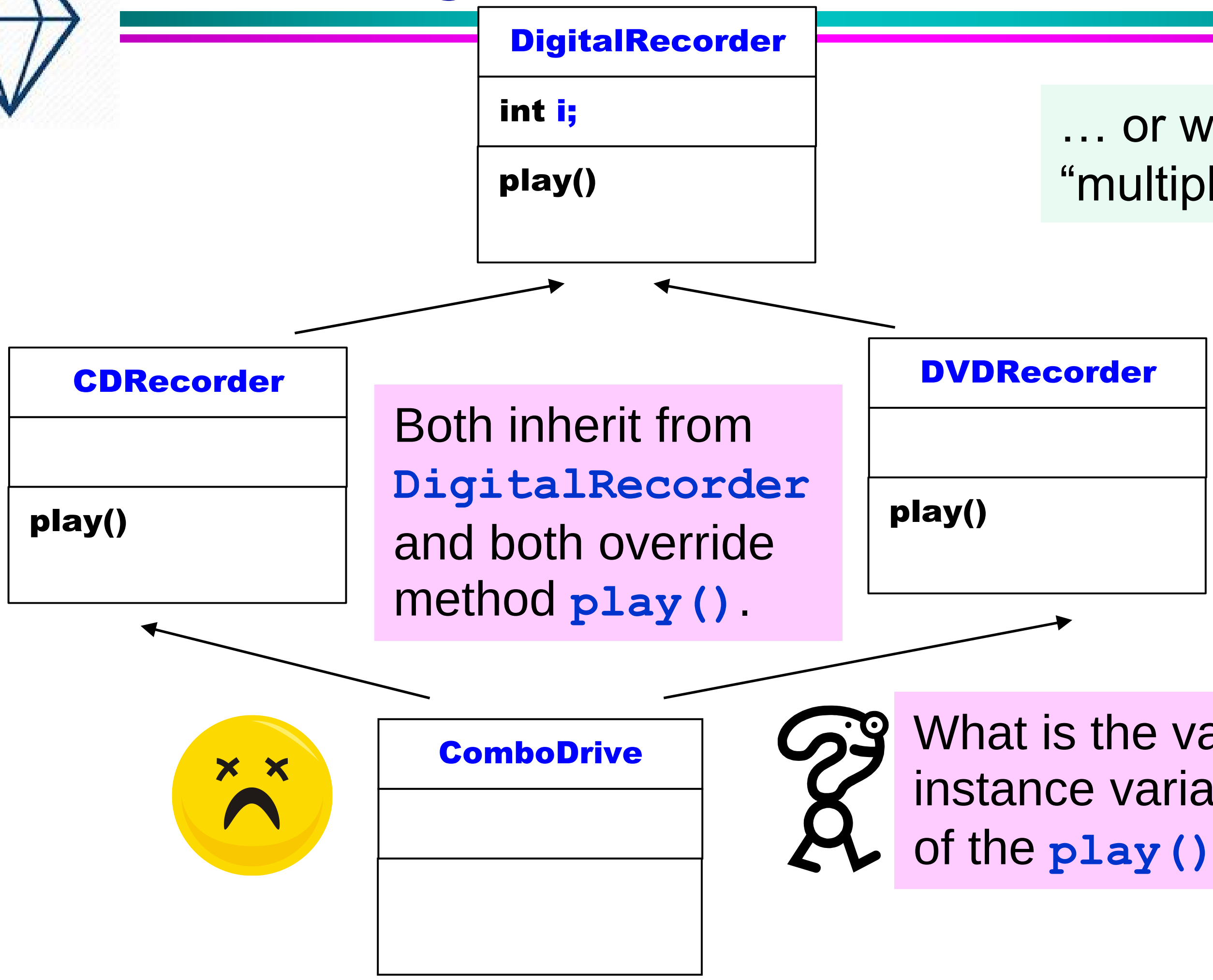
Let us add more `Creatures` (3/3)

- Why not have two parents? Then only creatures that *fly* have the parent *Flyable* ...



"Deadly Diamond Problem" …

… or why we cannot have "multiple inheritance" in Java



Both inherit from `DigitalRecorder` and both override method `play()`.

What is the value of the inherited instance variable `i`? Which version of the `play()` method is inherited?

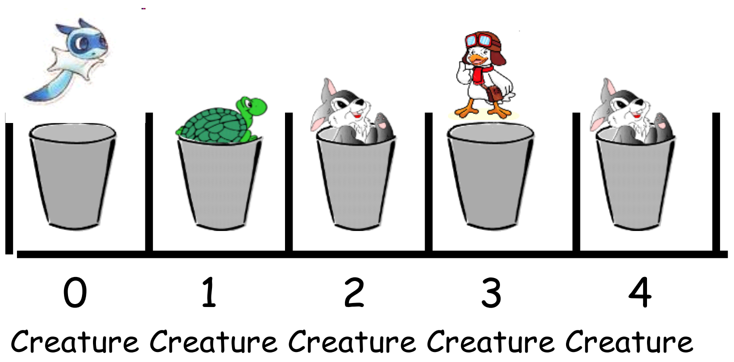
- Java's "multiple inheritance" is *at interface level* only!
  - If you've already got class A and class B, and you want to extend A and B together to generate class C, forget about it. You can't do that!
- Only interfaces can do multiple inheritance … at design level.

Interfaces

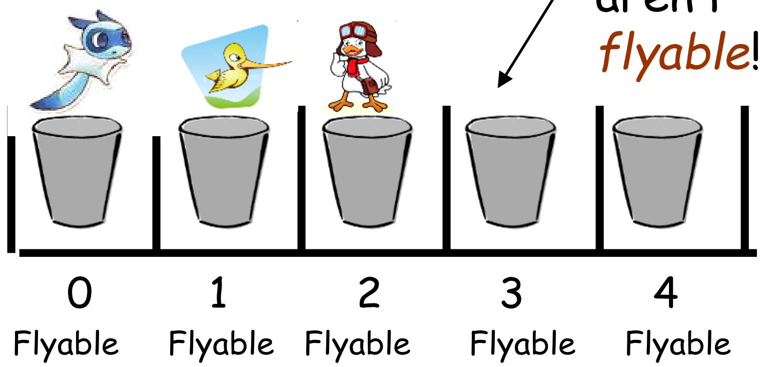
- An interface is like a **100%** abstract class.

An interface allows polymorphic capabilities without the problems of multiple inheritance.

Note: you can't put *turtle* in here – they aren't *flyable*!!



or



- Since an interface has <u>**NO**</u> implemented methods, multiple inheritance is not a problem, as no class inherits a "finished" method.

From Java SE8, **interfaces** can also have `default` and `static` methods. More about this, later in these slides …

interface Flyable

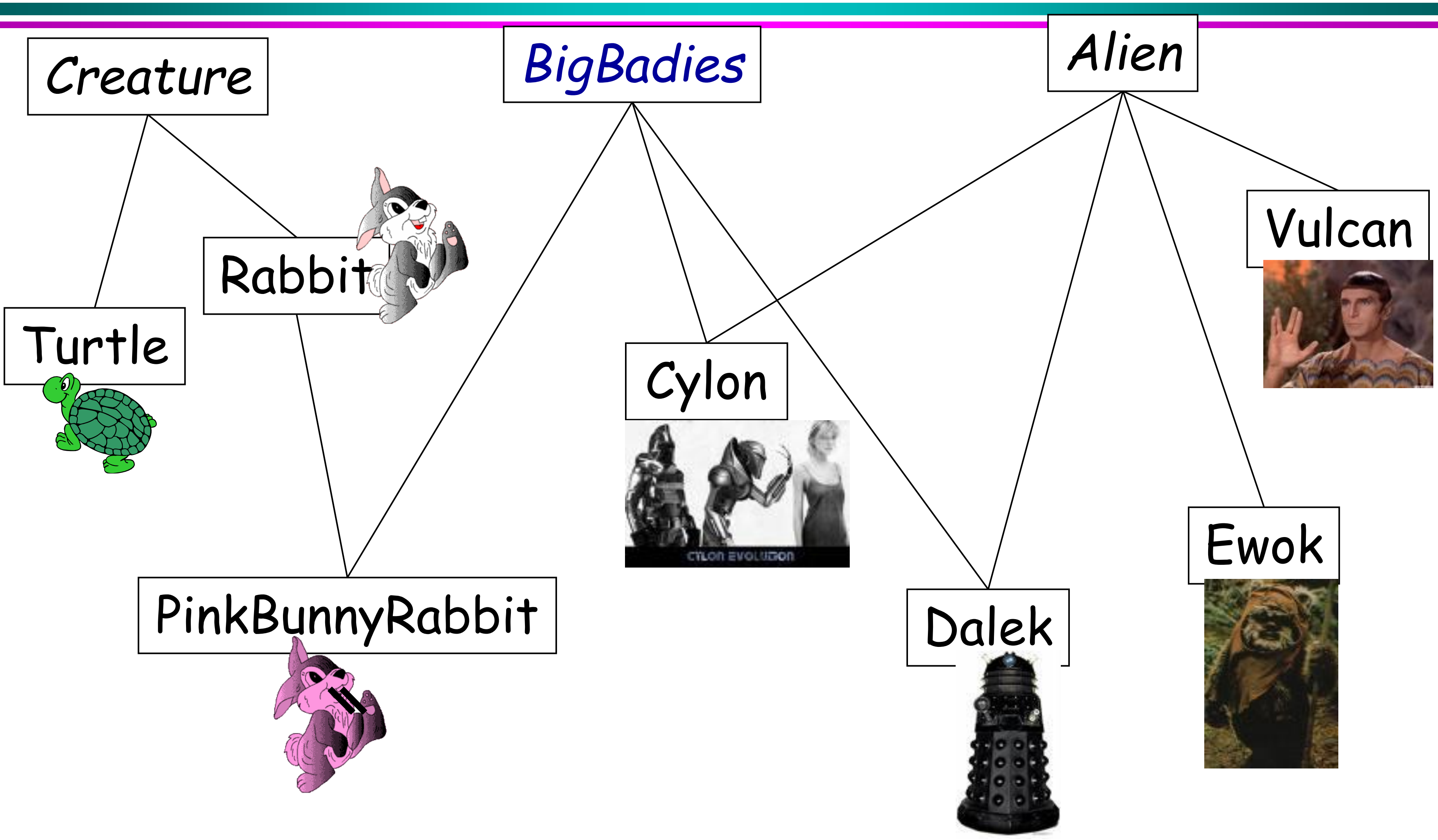
```
public interface Flyable {
   public abstract void fly();   // OR public void fly();
     // Even if you don't declare the method abstract or
     // public, it is!!!
}
```

```
public class FlyingSquirrel extends Creature
                                    implements Flyable {
   public void fly() {
     // some code
   }
   public void run(int duration) {
     // some code
   }
}
```

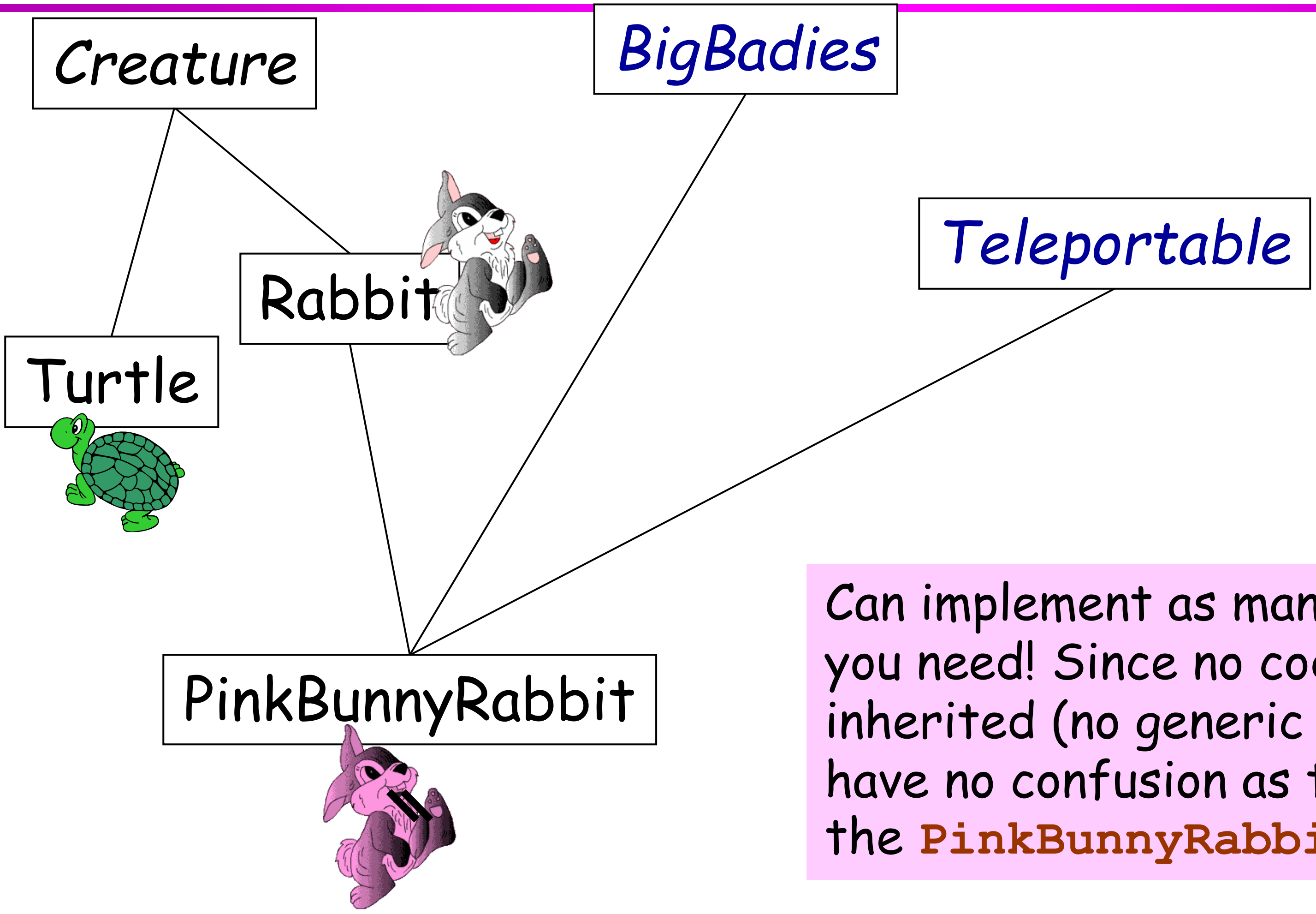
must provide implementation, as you "said" you are Flyable

must provide implementation, as you "said" you are a Creature

Interfaces can be used across *different inheritance trees*



Multiple interfaces



Can implement as many interfaces as you need! Since no code is actually inherited (no generic methods), you have no confusion as to which method the **`PinkBunnyRabbit`** has inherited!

extends and *implements*

- A class can only `extend` 1 class:
  - meaning 1 class can only have 1 parent;
  - a `PinkBunnyRabbit` can only have one direct parent – `Rabbit`.

- A class can `implement` as many interfaces as it likes!
  - A `PinkBunnyRabbit` can *be* (via interfaces) a `BigBadies` and `Teleportable`.

Interfaces

- At *design time*, we can write code that needn't worry about the *implementation* of any class that implements **`Flyable`** **`(or BigBadies or Teleportable)`**
  - We can treat the implementation as a black box, and rest safe in the knowledge that it must provide **`fly()`**.

- Interfaces are then like *certificates*, which say "I provide these services".
  - You *can't* make an instance of an interface so e.g.,

```
Flyable friend = new Flyable(); // ERROR!
```

Practice Exercise 1

- Which of the following is a *correct interface*?

```
interface A {
   void print() {
      // some code
   }
}
```

```
abstract interface B {
   print();
}
```

```
abstract interface C extends I1, I2 {
   abstract void print() {
      // some code
   };
}
```

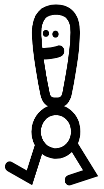
```
interface D {
   void print();
}
```

Notes on Abstract Classes & Interfaces

- Neither **abstract classes** and **interfaces** can have an instance made of them.
- If you don't provide *any* method implementation, then use an **interface** instead of an **abstract class**.
- A class can **implement** many interfaces, but **extends** only one superclass.
- Interfaces are how Java provides (a kind of) *multiple inheritance*.
- If even one method in a class is declared to be abstract, then the whole class must be declared abstract.
- Both abstract classes and interfaces *can* contain constants, which will be inherited by classes that *extend* or *implement* them, respectively.

Example (1/2): Abstract Class *versus* Interface

```
public interface Countable {
  int x = 20;
  int y = 30;       // declaring interface constants
  void counting(); // declaring an interface method
}
public class Example implements Countable {
  int x = 1;
  int y = 2;
  int sum = 0;
  public void counting() { // implements interface method
    sum = x + y;
    System.out.println("Sum is " + sum);
  }
}   public class Example1 extends Example implements Countable {
      int sub = 0;
      public void counting() {
        // implements interface abstract method
        sub = Countable.y - super.x;
        System.out.println("Sub is " + sub);
      }
    }
```



Unnecessary to provide an *implementation* for **counting()** at this level.

Example (2/2): Abstract Class *versus* Interface

```
public class ResultOfCount {
  public static void main(String args[]) {
    Example x = new Example();
    x.counting();
    Example1 y = new Example1();
    y.counting();
  }
}
```

- Analysis of program:
  - Output of the program:

    ```
    Sum is 3
    Sub is 29
    ```

  - The **`counting()`** method is implemented (overridden) by two classes that implement the **`Countable`** interface.
  - An interface may have many methods. If a class implements an interface, but only implements some of its methods, then this class becomes an abstract class; it cannot be instantiated.

… and things for you to try out!

Example: Abstract Classes & Interfaces Implementation

```
interface InterfaceExample {
  void method1();
  void method2();
}
class Example1 implements InterfaceExample {
  public void method1() {
    // implement 1st method
  }
}
class Example2 extends Example1 {
  public void method2() {
    // implement the 2nd method
  }
}
```

`Example1` implements **`method1()`**, but not **`method2()`** so it cannot be instantiated.

`Example2` implements **`method2()`** (and inherited **`method1()`** from **`Example1`**), so it can be instantiated.

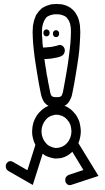
Extending an Interface

- Like classes, *interfaces can be extended* as well.

```
interface Father {
  int age = 30;
  void wash();
}
interface Mother {
  long bank_account = 100000;
  void cook();
}
interface Child extends Father, Mother {
  void cry(boolean tear);
}
```

Child inherits from **Father** and **Mother** and has the following:

```
  int age = 30; (!!)
  long bank_account = 100000;
  void wash();
  void cook();
  void cry(boolean tear);
```



This example tells us *how to pack several interfaces together*.

Name Conflicts

- What happens if **`Father`** interface and **`Mother`** interface contain *same named methods* and *variables* (constants)?
  - *Same named methods*:
    - If they have different parameters, then **`Child`** interface has both (this is same as *overloading*).
    - If they differ by only return type, then *error*.
    - If the two methods are identical, only keep one.
  - *Same named constants*: we keep both constants. To refer to them, *use parent interface name* as prefix.
    - **Example**:
      - If both **`Father`** and **`Mother`** contain an **`age`** variable, then **`Child`** interface contains both.
      - To refer to them, we use: **`Father.age`** or **`Mother.age`**.

Java Interfaces: before/after Java SE8

- Before Java SE8, interfaces could have:
  - constant fields (e.g. `public static final int x = 10;`);
  - `abstract` methods (e.g. `public abstract void doStuff();`)

- From Java SE8, interfaces can also have:
  - `default` methods → Allow developers to add new functionality to interfaces, without impacting any existing classes that are already implementing the interface.
    - Can be overridden in the class that implements the interface.
    - Provide backward compatibility for existing interfaces.
  - `static` methods → Allow developers to define utility methods in the interface.
    - Are similar to `default` methods, but cannot be overridden in the class that implements the interface.

For interfaces with same `default` method signatures, invoke `super` on relevant interface.

Example: Interface with `default` and `static` methods

```
public interface Interviewer {
  public abstract void conductInterview(String name);
  default void submitInterviewStatus() {
    System.out.println("Accept");
  }
  static void bookIntRoom(String day, int duration) {
    System.out.println("Interview on: " + day);
    System.out.println("Book room for: " + duration + " hour(s)");
  }
}
```

```
public class Manager implements Interviewer {
  public void conductInterview(String name) {
    System.out.println("Interview for " + name);
  }
}
```

```
public class Project {
  public static void main(String[] args) {
    Manager mgr = new Manager();
    mgr.conductInterview("Jane Smith");
    Interviewer.bookIntRoom("Monday", 1);
    mgr.submitInterviewStatus();
  }
}
```

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Practice Exercise 2

- What is the output of the program below? Explain.

```java
public interface TestInterface1 {
  default void show() {
    System.out.println("Default TestInterface1");
  }
}
```

```java
public interface TestInterface2 {
  default void show() {
    System.out.println("Default TestInterface2");
  }
}
```

```java
public class TestClass implements TestInterface1,
                                  TestInterface2 {
  public void show() {
    TestInterface1.super.show();
    TestInterface2.super.show();
  }
  public static void main(String[] args) {
    TestClass d = new TestClass();
    d.show();
  }
}
```

… and things for you to try out!

Practice Exercise 3

- What will happen if each of the statements is inserted where indicated in the code?

```
public interface MyConstants {
   int r = 4;
   int s = 6;
   // INSERT CODE HERE
}
```

1. `final double circumference = 2*Math.PI*r;`
2. `int total = total + r + s;`
3. `int AREA = r*s;`
4. `public static MAIN = 15;`
5. `protected int CODE = 31337;`