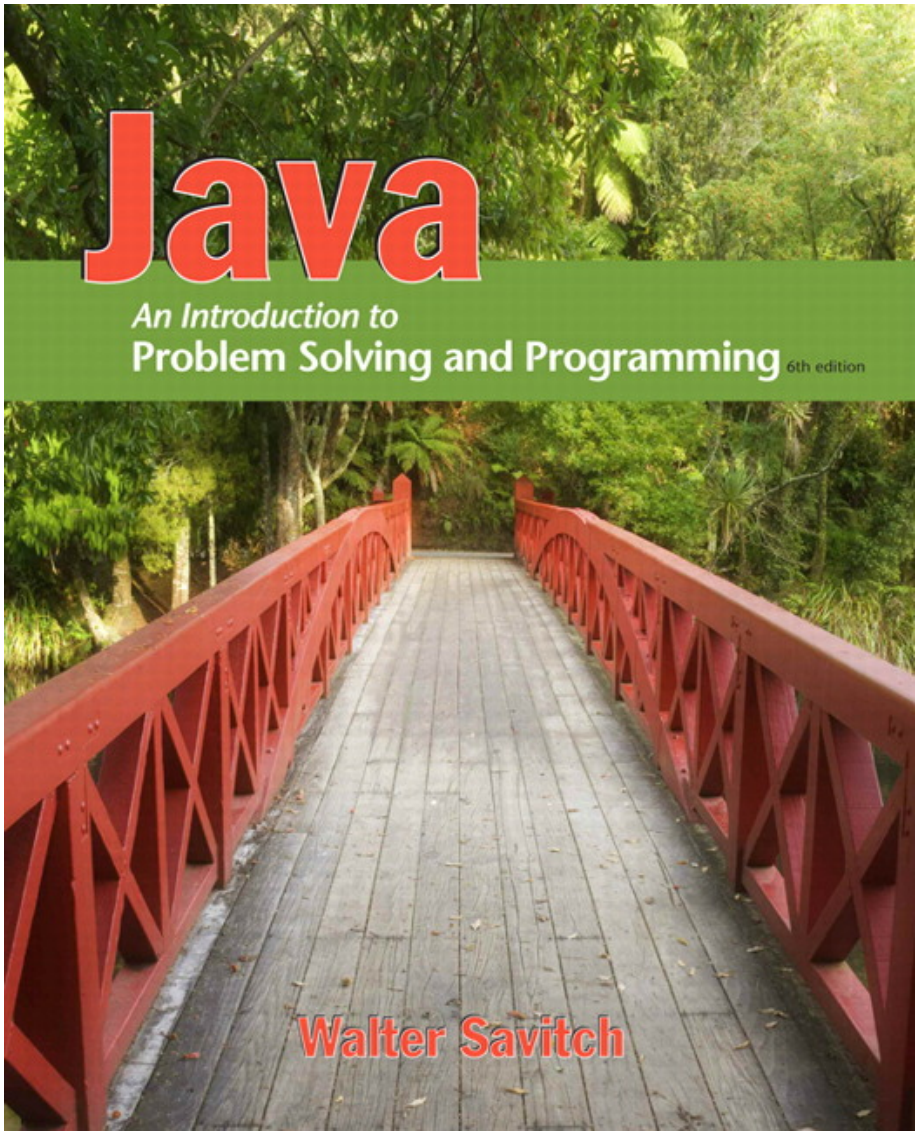


Defining Classes and Methods 5

FIGURE 5.1 A Class as a Blueprint

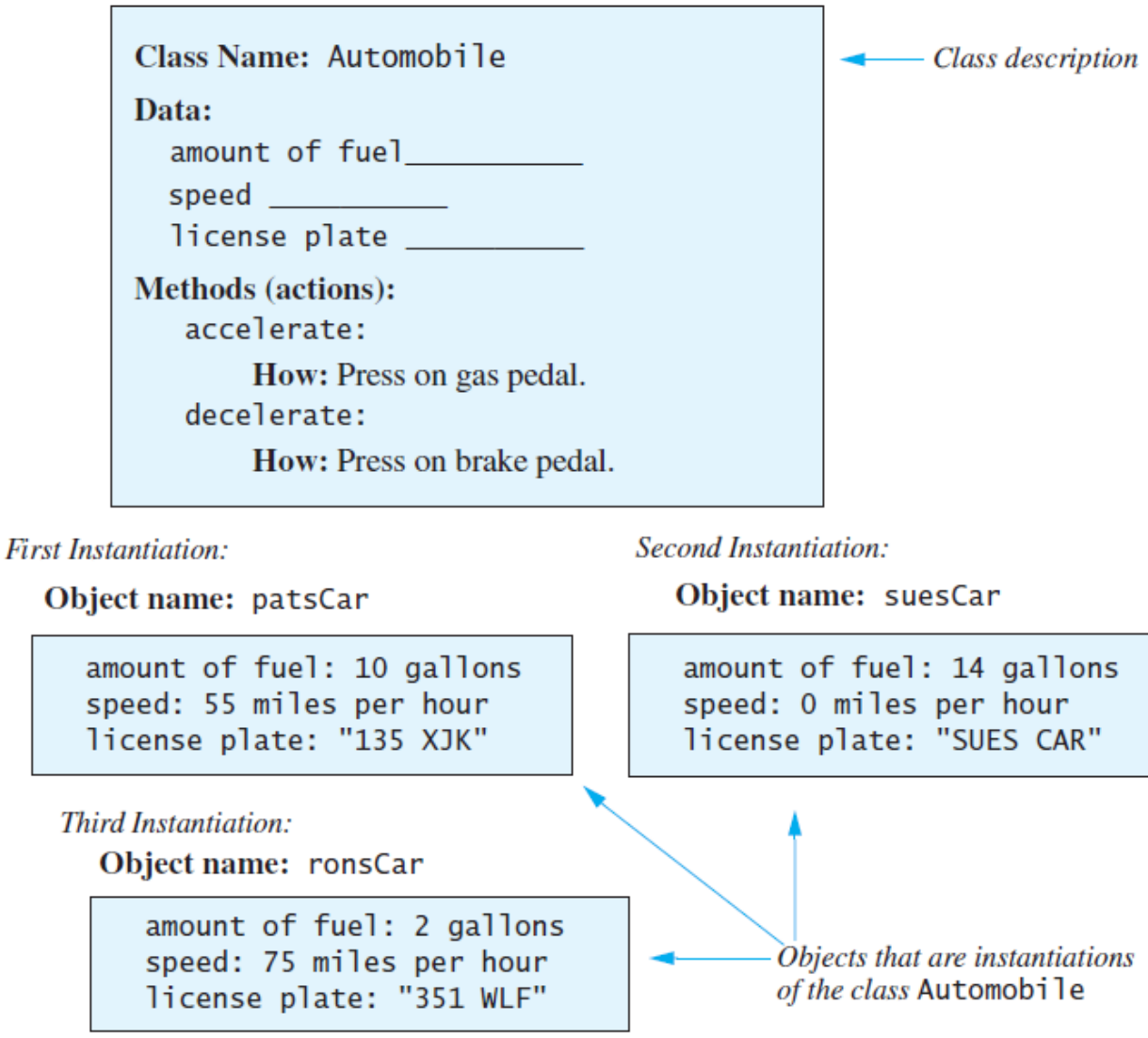
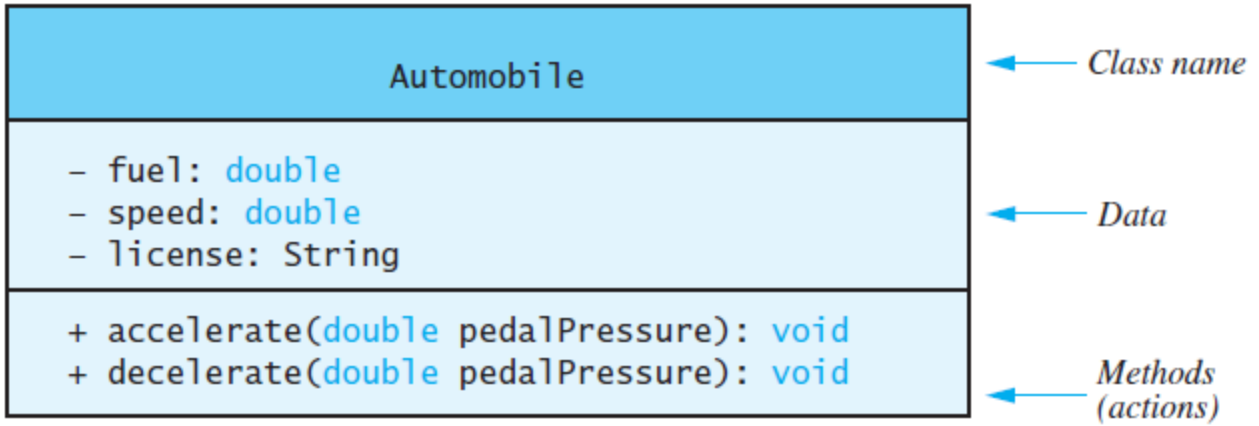


FIGURE 5.2 A Class Outline as a UML Class Diagram



LISTING 5.1 Definition of a Dog Class

```
public class Dog
{
    public String name;
    public String breed;
    public int age;
    public void writeOutput()
    {
        System.out.println("Name: " + name);
        System.out.println("Breed: " + breed);
        System.out.println("Age in calendar years: " +
                           age);
        System.out.println("Age in human years: " +
                           getAgeInHumanYears());
        System.out.println();
    }
    public int getAgeInHumanYears()
    {
        int humanAge = 0;
        if (age <= 2)
        {
            humanAge = age * 11;
        }
        else
        {
            humanAge = 22 + ((age-2) * 5);
        }
            return humanAge;
    }
}
```

Later in this chapter we will see that the modifier `public` *for instance variables should be replaced with* `private`.

LISTING 5.2 Using the Dog Class and Its Methods

```
public class DogDemo
{
    public static void main(String[] args)
    {
        Dog balto = new Dog();
        balto.name = "Balto";
        balto.age = 8;
        balto.breed = "Siberian Husky";
        balto.writeOutput();

        Dog scooby = new Dog();
        scooby.name = "Scooby";
        scooby.age = 42;
        scooby.breed = "Great Dane";
        System.out.println(scooby.name + " is a " +
                           scooby.breed + ".");
        System.out.print("He is " + scooby.age +
                         " years old, or ");
        int humanYears = scooby.getAgeInHumanYears();
        System.out.println(humanYears + " in human years.");
    }
}
```

Sample Screen Output

```
Name: Balto
Breed: Siberian Husky
Age in calendar years: 8
Age in human years: 52

Scooby is a Great Dane.
He is 42 years old, or 222 in human years.
```

LISTING 5.3 A Species Class Definition—First Attempt
(part 1 of 2)

We will give a better version of this class later in this chapter.

```
import java.util.Scanner;
public class SpeciesFirstTry
{
    public String name;
    public int population;
    public double growthRate;

    public void readInput()
    {
        Scanner keyboard = new Scanner(System.in);
        System.out.println("What is the species' name?");
        name = keyboard.nextLine();
        System.out.println("What is the population of the " +
                           "species?");
        population = keyboard.nextInt();
```

Later in this chapter you will see that the modifier `public` *for instance variables should be replaced with* `private`.

```
        System.out.println("Enter growth rate " +
                           "(% increase per year):");
        growthRate = keyboard.nextDouble();
    }
    public void writeOutput()
    {
        System.out.println("Name = " + name);
        System.out.println("Population = " + population);
        System.out.println("Growth rate = " + growthRate + "%");
    }
    public int getPopulationIn10()
    {
        int result = 0;
        double populationAmount = population;
        int count = 10;
        while ((count > 0) && (populationAmount > 0))
        {
            populationAmount = populationAmount +
                               (growthRate / 100) *
                               populationAmount;
            count--;
        }
        if (populationAmount > 0)
                result = (int)populationAmount;
        return result;
    }
}
```

LISTING 5.4 Using the Species Class and Its Methods
(part 1 of 2)

```
public class SpeciesFirstTryDemo
{
    public static void main(String[] args)
    {
        SpeciesFirstTry speciesOfTheMonth = new SpeciesFirstTry();
        System.out.println("Enter data on the Species of "+
                           "the Month:");

        speciesOfTheMonth.readInput();
        speciesOfTheMonth.writeOutput();
        int futurePopulation =
            speciesOfTheMonth.getPopulationIn10();
        System.out.println("In ten years the population will be "
                           + futurePopulation);
        //Change the species to show how to change
        //the values of instance variables:
        speciesOfTheMonth.name = "Klingon ox";
        speciesOfTheMonth.population = 10;
        speciesOfTheMonth.growthRate = 15;
        System.out.println("The new Species of the Month:");
        speciesOfTheMonth.writeOutput();
        System.out.println("In ten years the population will "
                "be " + speciesOfTheMonth.getPopulationIn10());
    }
}
```

Sample Screen Output

```
Enter data on the Species of the Month:
What is the species' name?
Ferengie fur ball
What is the population of the species?
1000
Enter growth rate (% increase per year):
-20.5
Name = Ferengie fur ball
Population = 1000
Growth rate = 20.5%
In ten years the population will be 100
The new Species of the Month:
Name = Klingon ox
Population = 10
Growth rate = 15.0%
In ten years the population will be 40
```

LISTING 5.5 Local Variables

This class definition is in a file named BankAccount.java.

```
/**
This class is used in the program LocalVariablesDemoProgram.
*/
public class BankAccount
{
    public double amount;
    public double rate;
    public void showNewBalance()
    {
        double newAmount = amount + (rate / 100.0) *
                                                amount;
        System.out.println("With interest added, the new amount
                           is $" + newAmount);
    }
}
```

This does not change the value of the variable newAmount in main.

Two different variables named newAmount

This program is in a file named LocalVariableDemoProgram.java.

```
/**
A toy program to illustrate how local variables behave.
*/
public class LocalVariablesDemoProgram
{
    public static void main(String[] args)
    {
        BankAccount myAccount = new BankAccount();
        myAccount.amount = 100.00;
        myAccount.rate = 5;

        double newAmount = 800.00;
        myAccount.showNewBalance();
        System.out.println("I wish my new amount were $" +
                           newAmount);
    }
}
```

Screen Output *Chapter 6 will fix the appearance of dollar amounts.*

```
With interest added, the new amount is $105.0
I wish my new amount were $800.0
```

LISTING 5.6 A Method That Has a Parameter

We will give an even better version of the class later in the chapter.

```
import java.util.Scanner;
public class SpeciesSecondTry
{
    <The declarations of the instance variables name, population,
    and growthRate are the same as in Listing 5.3.>
    <The definitions of the methods readInput and writeOutput
    are the same as in Listing 5.3.>
    /**
    Returns the projected population of the receiving object
    after the specified number of years.
    */
    public int predictPopulation(int years)
    {
        int result = 0;
        double populationAmount = population;
        int count = years;
        while ((count > 0) && (populationAmount > 0))
        {
            populationAmount = (populationAmount +
            (growthRate / 100) * populationAmount);
            count--;
        }
        if (populationAmount > 0)
            result = (int)populationAmount;
        return result;
    }
}
```

LISTING 5.7 Using a Method That Has a Parameter

```
/**
Demonstrates the use of a parameter
with the method predictPopulation.
*/
public class SpeciesSecondTryDemo
{
    public static void main(String[] args)
    {
        SpeciesSecondTry speciesOfTheMonth = new
                                  SpeciesSecondTry();
        System.out.println("Enter data on the Species of the " +
                           "Month:");
        speciesOfTheMonth.readInput();
        speciesOfTheMonth.writeOutput();
        int futurePopulation =
            speciesOfTheMonth.predictPopulation(10);
        System.out.println("In ten years the population will be " +
                           futurePopulation);
        //Change the species to show how to change
        //the values of instance variables:
        speciesOfTheMonth.name = "Klingon ox";
        speciesOfTheMonth.population = 10;
        speciesOfTheMonth.growthRate = 15;
        System.out.println("The new Species of the Month:");
        speciesOfTheMonth.writeOutput();
        System.out.println("In ten years the population will be " +
                           speciesOfTheMonth.predictPopulation(10));
    }
}
```

Sample Screen Output

The output is exactly the same as in Listing 5.4.

LISTING 5.8 A Class with Private Instance Variables

We will give an even better version of this class later in the chapter.

```
import java.util.Scanner;
public class SpeciesThirdTry
{
    private String name;
    private int population;
    private double growthRate;
    <The definitions of the methods readInput, writeOutput, and
    predictPopulation are the same as in Listing 5.3 and
    Listing 5.6.>
}
```

LISTING 5.9 A Class of Rectangles

```
/**
Class that represents a rectangle.
*/
public class Rectangle
{
    private int width;
    private int height;
    private int area;

    public void setDimensions(int newWidth, int newHeight)
    {
        width = newWidth;
        height = newHeight;
        area = width * height;
    }
    public int getArea()
    {
        return area;
    }
}
```

LISTING 5.10 Another Class of Rectangles

```
/**
Another class that represents a rectangle.
*/
public class Rectangle2
{
    private int width;
    private int height;
    public void setDimensions(int newWidth, int newHeight)
    {
        width = newWidth;
        height = newHeight;
    }
    public int getArea()
    {
        return width * height;
    }
}
```

LISTING 5.11 A Class with Accessor and Mutator Methods

```
import java.util.Scanner;
public class SpeciesFourthTry
{
    private String name;
    private int population;
    private double growthRate;

    <The definitions of the methods readInput, writeOutput, and
     predictPopulation go here. They are the same as in Listing
     5.3 and Listing 5.6.>
    public void setSpecies(String newName, int newPopulation,
                           double newGrowthRate)
    {
        name = newName;
        if (newPopulation >= 0)
            population = newPopulation;
        else
        {
                System.out.println(
                          "ERROR: using a negative population.");
                System.exit(0);
        }
        growthRate = newGrowthRate;
    }
    public String getName()
    {
        return name;
    }
    public int getPopulation()
    {
        return population;
    }
    public double getGrowthRate()
    {
        return growthRate;
    }
}
```

Yes, we will define an even better version of this class later.

A mutator method can check to make sure that instance variables are set to proper values.

LISTING 5.12 Using a Mutator Method *(part 1 of 2)*

```
import java.util.Scanner;
/**
Demonstrates the use of the mutator method setSpecies.
*/
public class SpeciesFourthTryDemo
{
    public static void main(String[] args)
    {
        SpeciesFourthTry speciesOfTheMonth =
                                    new SpeciesFourthTry();
        System.out.println("Enter number of years to project:");
        Scanner keyboard = new Scanner(System.in);
        int numberOfYears = keyboard.nextInt();

        System.out.println(
                    "Enter data on the Species of the Month:");
        speciesOfTheMonth.readInput();
        speciesOfTheMonth.writeOutput();

        int futurePopulation =
        speciesOfTheMonth.predictPopulation(numberOfYears);
        System.out.println("In " + numberOfYears +
                           " years the population will be " +
                           futurePopulation);
        //Change the species to show how to change
        //the values of instance variables:
        speciesOfTheMonth.setSpecies("Klingon ox", 10, 15);
        System.out.println("The new Species of the Month:");
        speciesOfTheMonth.writeOutput();

        futurePopulation =
              speciesOfTheMonth.predictPopulation(numberOfYears);
        System.out.println("In " + numberOfYears +
                           " years the population will be " +
                           futurePopulation);
    }
}
```

Sample Screen Output

```
Enter number of years to project:
10
Enter data on the Species of the Month:
What is the species' name?
Ferengie fur ball
```

LISTING 5.13 The Purchase Class *(part 1 of 3)*

```
import java.util.Scanner;
/**
Class for the purchase of one kind of item, such as 3 oranges.
Prices are set supermarket style, such as 5 for $1.25.
*/
public class Purchase
{
    private String name;
    private int groupCount;     //Part of a price, like the 2 in
                                //2 for $1.99.
    private double groupPrice;  //Part of a price, like the $1.99
                                // in 2 for $1.99.
    private int numberBought;   //Number of items bought.
    public void setName(String newName)
    {
        name = newName;
    }
    /**
    Sets price to count pieces for $costForCount.
    For example, 2 for $1.99.
    */
    public void setPrice(int count, double costForCount)
    {
        if ((count <= 0) || (costForCount <= 0))
        {
            System.out.println("Error: Bad parameter in " +
                               "setPrice.");
            System.exit(0);
        }
        else
        {
            groupCount = count;
            groupPrice = costForCount;
        }
    }
```

```
public void setNumberBought(int number)
{
    if (number <= 0)
    {
        System.out.println("Error: Bad parameter in " +
                           "setNumberBought.");
        System.exit(0);
    }
    else
        numberBought = number;
}
```

```
/**
Reads from keyboard the price and number of a purchase.
*/
public void readInput()
{
    Scanner keyboard = new Scanner(System.in);
    System.out.println("Enter name of item you are purchasing:");
    name = keyboard.nextLine();
    System.out.println("Enter price of item as two numbers.");
    System.out.println("For example, 3 for $2.99 is entered as");
    System.out.println("3 2.99");
    System.out.println("Enter price of item as two numbers, " +
                       "now:");
    groupCount = keyboard.nextInt();
    groupPrice = keyboard.nextDouble();

    while ((groupCount <= 0) || (groupPrice <= 0))
    { //Try again:
        System.out.println("Both numbers must " +
                           "be positive. Try again.");
        System.out.println("Enter price of " +
                           "item as two numbers.");
        System.out.println("For example, 3 for " +
                           "$2.99 is entered as");
        System.out.println("3 2.99");
        System.out.println(
                         "Enter price of item as two numbers, now:");
        groupCount = keyboard.nextInt();
        groupPrice = keyboard.nextDouble();
    }
    System.out.println("Enter number of items purchased:");
    numberBought = keyboard.nextInt();

    while (numberBought <= 0)
    { //Try again:
        System.out.println("Number must be positive. " +
                           "Try again.");
        System.out.println("Enter number of items purchased:");
        numberBought = keyboard.nextInt();
    }
}
```

```
    /**
    Displays price and number being purchased.
    */
    public void writeOutput()
    {
        System.out.println(numberBought + " " + name);
        System.out.println("at " + groupCount +
                           " for $" + groupPrice);
    }
    public String getName()
    {
        return name;
    }
    public double getTotalCost()
    {
        return (groupPrice / groupCount) * numberBought;
    }
    public double getUnitCost()
    {
        return groupPrice / groupCount;
    }
    public int getNumberBought()
    {
        return numberBought;
    }
}
```

LISTING 5.14 Use of the Purchase Class

```
public class PurchaseDemo
{
    public static void main(String[] args)
    {
        Purchase oneSale = new Purchase();
        oneSale.readInput();
        oneSale.writeOutput();
        System.out.println("Cost each $" + oneSale.getUnitCost());
        System.out.println("Total cost $" +
                oneSale.getTotalCost());
    }
}
```

Sample Screen Output

```
Enter name of item you are purchasing:
pink grapefruit
Enter price of item as two numbers.
For example, 3 for $2.99 is entered as
3 2.99
Enter price of item as two numbers, now:
4 5.00
Enter number of items purchased:
0
Number must be positive. Try again.
Enter number of items purchased:
3
3 pink grapefruit
at 4 for $5.0
Cost each $1.25
Total cost $3.75
```

LISTING 5.15 Methods Calling Other Methods

```
import java.util.Scanner;
public class Oracle
{
    private String oldAnswer = "The answer is in your heart.";
    private String newAnswer;
    private String question;

    public void chat()
    {
        System.out.print("I am the oracle. ");
        System.out.println("I will answer any one-line question.");
        Scanner keyboard = new Scanner(System.in);
        String response;
        do
        {
            answer();
            System.out.println("Do you wish to ask " +
                "another question?");
            response = keyboard.next();
        } while (response.equalsIgnoreCase("yes"));
        System.out.println("The oracle will now rest.");
    }
```

```
    private void answer()
    {
        System.out.println("What is your question?");
        Scanner keyboard = new Scanner(System.in);
        question = keyboard.nextLine();
        seekAdvice();
        System.out.println("You asked the question:");
        System.out.println(" " + question);
        System.out.println("Now, here is my answer:");
        System.out.println(" " + oldAnswer);
        update();
    }
    private void seekAdvice()
    {
        System.out.println("Hmm, I need some help on that.");
        System.out.println("Please give me one line of advice.");
        Scanner keyboard = new Scanner(System.in);
        newAnswer = keyboard.nextLine();
        System.out.println("Thank you. That helped a lot.");
    }
    private void update()
    {
        oldAnswer = newAnswer;
    }
}
```

LISTING 5.16 Oracle Demonstration Program *(part 1 of 2)*

```
public class OracleDemo
{
    public static void main(String[] args)
    {
        Oracle delphi = new Oracle();
        delphi.chat();
    }
}
```

Sample Screen Output

```
I am the oracle. I will answer any one-line question.
What is your question?
What time is it?
Hmm, I need some help on that.
Please give me one line of advice.
Seek and ye shall find the answer.
Thank you. That helped a lot.
You asked the question:
   What time is it?
Now, here is my answer:
   The answer is in your heart.
Do you wish to ask another question?
yes
What is your question?
What is the meaning of life?
Hmm, I need some help on that.
```

```
Please give me one line of advice.
Ask the car guys.
Thank you. That helped a lot.
You asked the question:
    What is the meaning of life?
Now, here is my answer:
    Seek and ye shall find the answer.
Do you wish to ask another question?
no
The oracle will now rest.
```

FIGURE 5.3 A Well-Encapsulated Class Definition

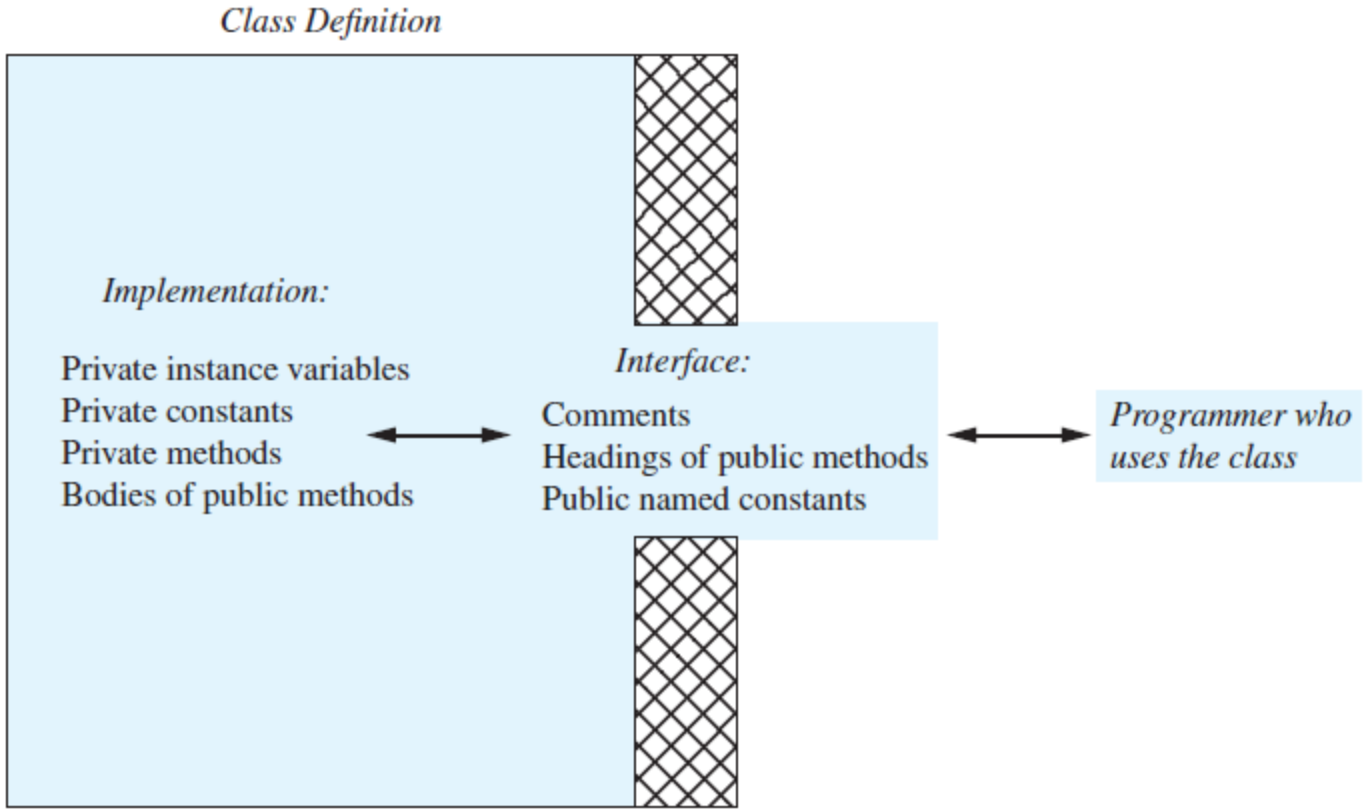
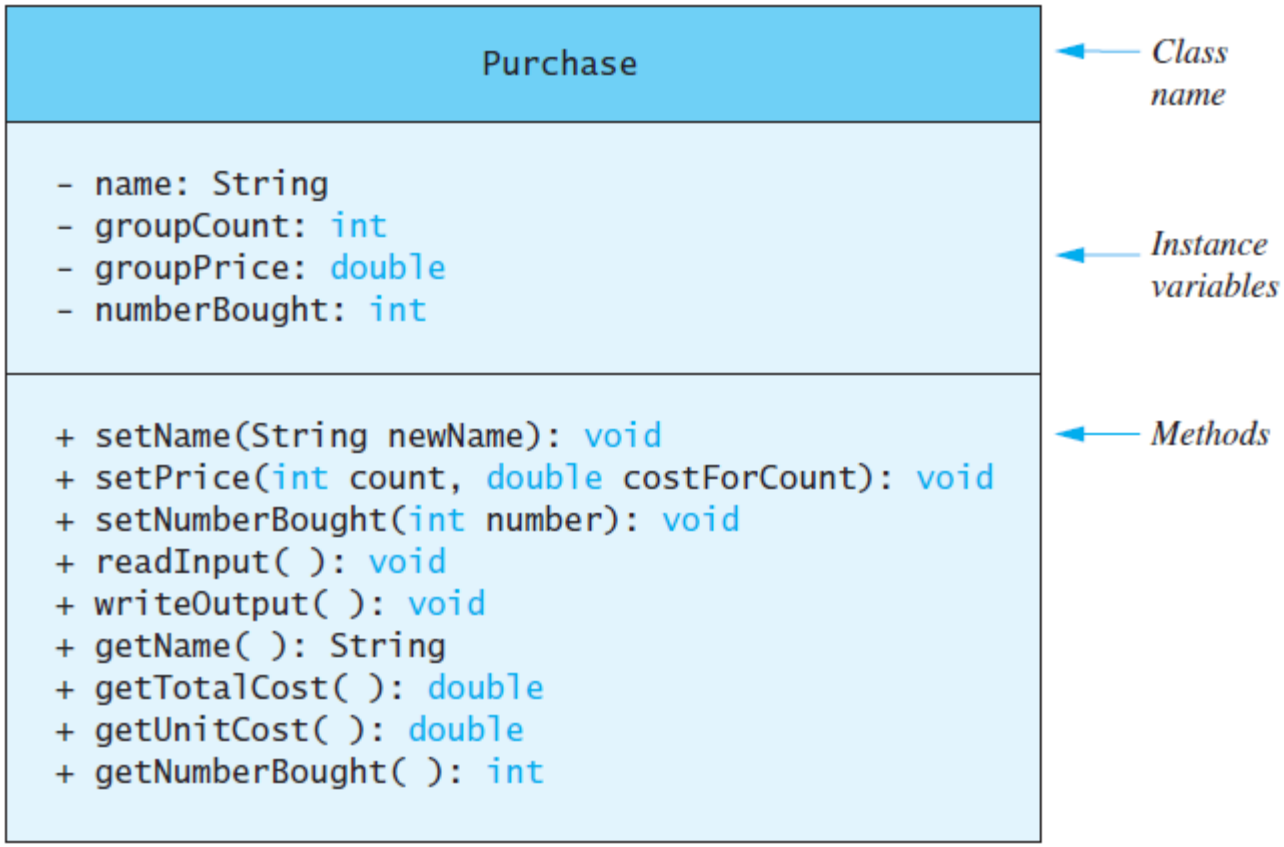
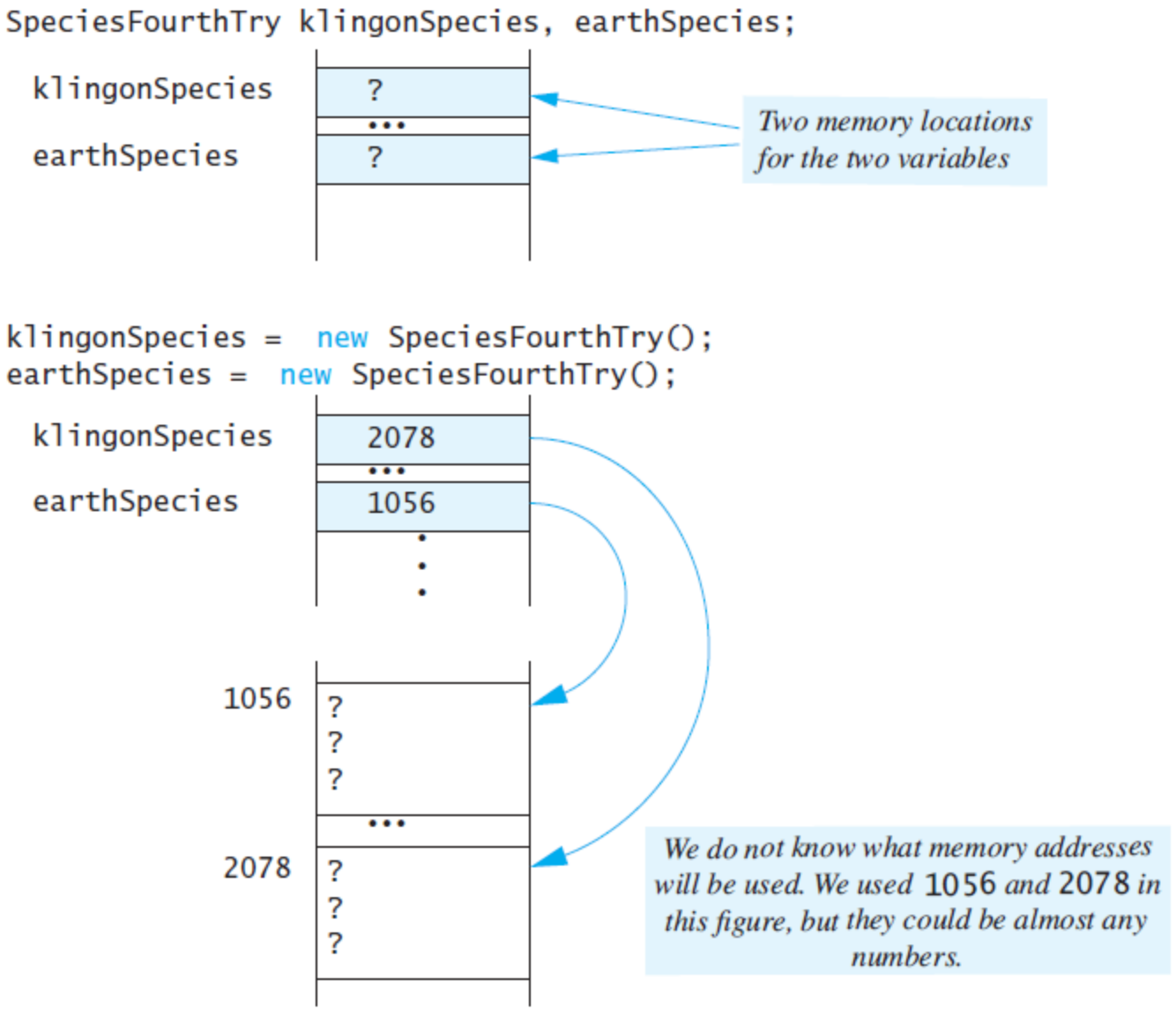


FIGURE 5.4 **A UML Class Diagram for the Class Purchase (Listing 5.13)**

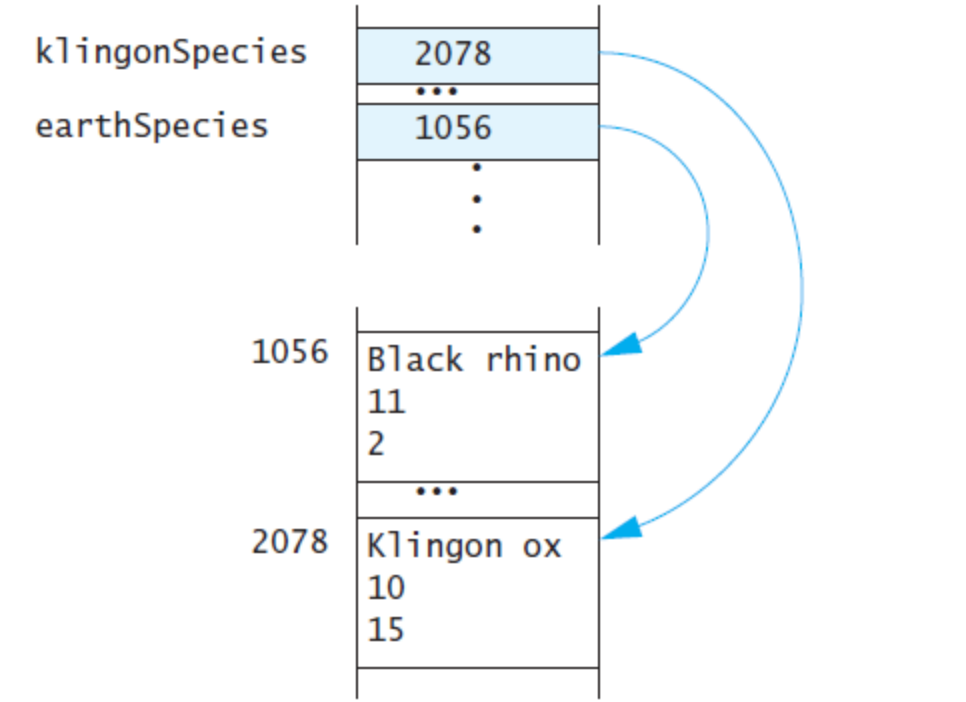


A minus sign (−) means the member is private.
A plus sign (+) means the member is public.

FIGURE 5.5 Behavior of Class Variables



```
klingonSpecies.setSpecies("Klingon ox", 10, 15);
earthSpecies.setSpecies("Black rhino", 11, 2);
```



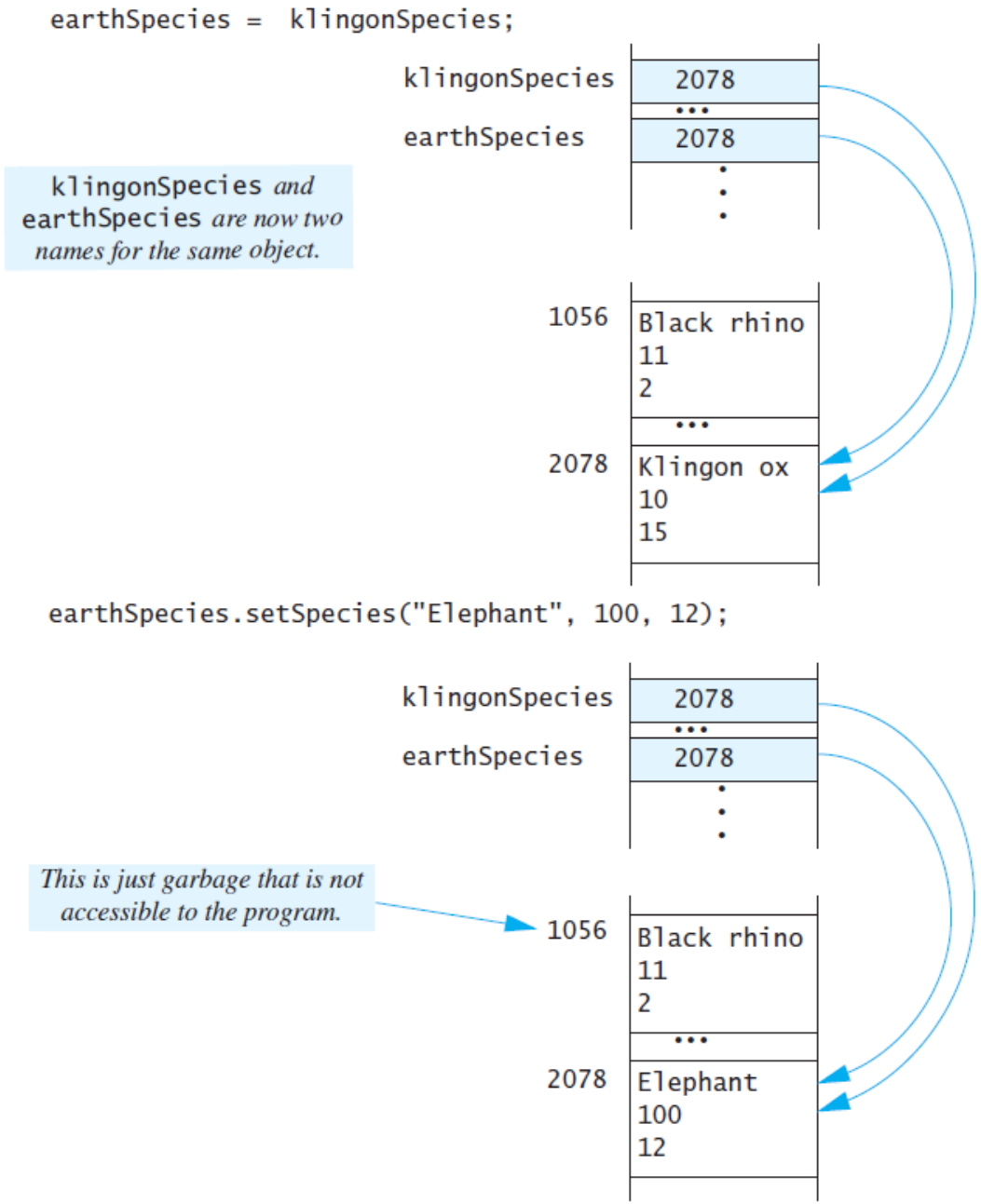
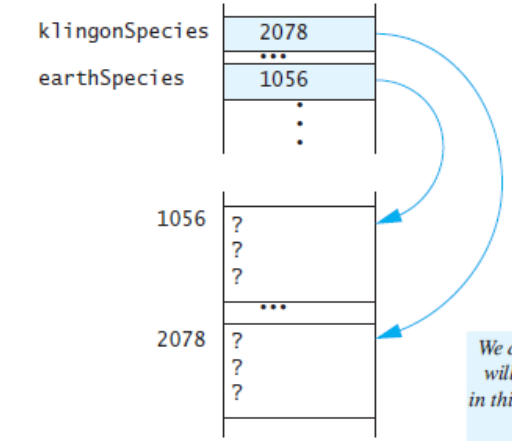


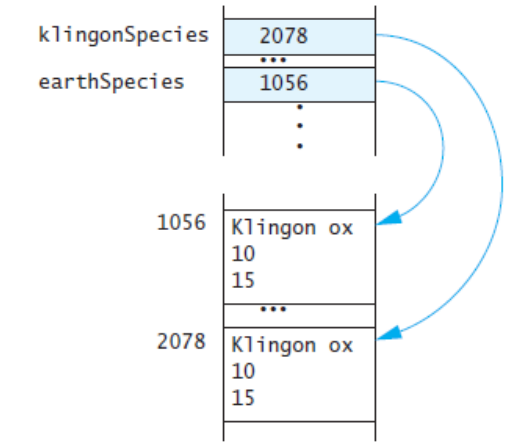
FIGURE 5.6 The Dangers of Using == with Objects

```
klingonSpecies =  new SpeciesFourthTry();
earthSpecies =  new SpeciesFourthTry();
```



We do not know what memory addresses will be used. We used 1056 *and* 2078 *in this figure, but they could be almost any numbers.*

```
klingonSpecies.setSpecies("Klingon ox", 10, 15);
earthSpecies.setSpecies("Klingon ox", 10, 15);
```




```
if (klingonSpecies == earthSpecies)
    System.out.println("They are EQUAL.");
else
    System.out.println("They are NOT equal.");
```

The output is `They are Not equal`, *because* 2078 *is not equal to* 1056.

LISTING 5.17 Defining an `equals` Method

```
import java.util.Scanner;
public class Species
{
    private String name;
    private int population;
    private double growthRate;

    <The definition of the methods readInput, writeOutput, and
     predictPopulation go here. They are the same as in
     Listing 5.3 and Listing 5.6.>
    <The definition of the methods setSpecies, getName,
     getPopulation, and getGrowthRate go here. They are the
     same as in Listing 5.11.>

    public boolean equals(Species otherObject)
    {
        return (this.name.equalsIgnoreCase(otherObject.name)) &&
               (this.population == otherObject.population) &&
               (this.growthRate == otherObject.growthRate);
    }
}
```

`equalsIgnoreCase` *is a method of the class* `String`.

LISTING 5.18 Demonstrating an `equals` Method *(part 1 of 2)*

```
public class SpeciesEqualsDemo
{
    public static void main(String[] args)
    {
        Species s1 = new Species(), s2 = new Species();

        s1.setSpecies("Klingon ox", 10, 15);
        s2.setSpecies("Klingon ox", 10, 15);

        if (s1 == s2)
            System.out.println("Match with ==.");
        else
            System.out.println("Do Not match with ==.");
        if (s1.equals(s2))
            System.out.println("Match with the method " +
                               "equals.");
        else
            System.out.println("Do Not match with the method " +
                               "equals.");
        System.out.println("Now change one Klingon ox to " +
                           "lowercase.");
```

```
        s2.setSpecies("klingon ox", 10, 15); //Use lowercase
        if (s1.equals(s2))
            System.out.println("Match with the method equals.");
        else
            System.out.println("Do Not match with the method " +
                               "equals.");
    }
}
```

Screen Output

```
Do Not match with ==.
Match with the method equals.
Now change one Klingon ox to lowercase.
Match with the method equals.
```

LISTING 5.19 The Complete Species Class *(part 1 of 2)*

This is the same class definition as in Listing 5.17, but with all the details shown.

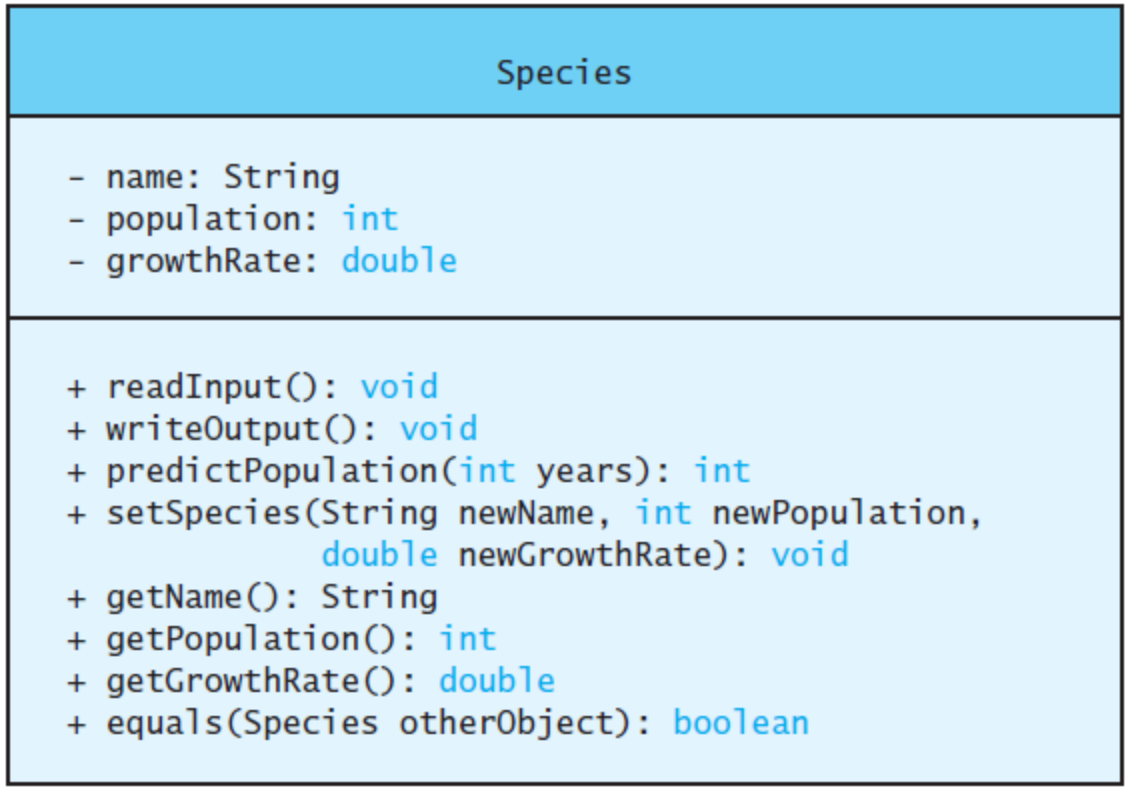
```
import java.util.Scanner;
/**
Class for data on endangered species.
*/
public class Species
{
    private String name;
    private int population;
    private double growthRate;

    public void readInput()
    {
        Scanner keyboard = new Scanner(System.in);
        System.out.println("What is the species' name?");
        name = keyboard.nextLine();

        System.out.println(
                        "What is the population of the species?");
        population = keyboard.nextInt();
        while (population < 0)
        {
            System.out.println("Population cannot be negative.");
            System.out.println("Reenter population:");
            population = keyboard.nextInt();
        }
        System.out.println(
                        "Enter growth rate (% increase per year):");
        growthRate = keyboard.nextDouble();
    }
```

```
public void writeOutput()
{
    System.out.println("Name = " + name);
    System.out.println("Population = " + population);
    System.out.println("Growth rate = " + growthRate + "%");
}
/**
Precondition: years is a nonnegative number.
Returns the projected population of the receiving object
after the specified number of years.
*/
public int predictPopulation(int years)
{
    int result = 0;
    double populationAmount = population;

    int count = years;
    while ((count > 0) && (populationAmount > 0))
    {
        populationAmount = (populationAmount +
                            (growthRate / 100) *
                             populationAmount);
        count--;
    }
    if (populationAmount > 0)
        result = (int)populationAmount;
    return result;
}
```

```
    public void setSpecies(String newName, int newPopulation,
                           double newGrowthRate)
    {
        name = newName;
        if (newPopulation >= 0)
            population = newPopulation;
        else
        {
            System.out.println("ERROR: using a negative " +
                               "population.");
            System.exit(0);
        }
        growthRate = newGrowthRate;
    }
    public String getName()
    {
        return name;
    }
    public int getPopulation()
    {
        return population;
    }

    public double getGrowthRate()
    {
         return growthRate;
    }
    public boolean equals(Species otherObject)
    {
         return (name.equalsIgnoreCase(otherObject.name)) &&
                (population == otherObject.population) &&
                (growthRate == otherObject.growthRate);
    }
}
```

This version of `equals` *is equivalent to the version in Listing 5.17. Here, the keyword* `this` *is understood to be there implicitly.*

FIGURE 5.7 **Class Diagram for the Class Species in Listing 5.19**



LISTING 5.20 Sample Tests for the Species Class

```
public class SpeciesTest
{
    public static void main(String[] args)
    {
        Species testSpecies = new Species();

        // Test the setSpecies method
        testSpecies.setSpecies("Tribbles", 100, 50);
        if (testSpecies.getName().equals("Tribbles") &&
            (testSpecies.getPopulation() == 100) &&
            (testSpecies.getGrowthRate() >= 49.99) &&
            (testSpecies.getGrowthRate() <= 50.01))
        {
             System.out.println("Pass: setSpecies test.");
        }
        else
        {
             System.out.println("FAIL: setSpecies test.");
        }

        // Test the predictPopulation method
        if ((testSpecies.predictPopulation(-1) == 100) &&
            (testSpecies.predictPopulation(1) == 150) &&
            (testSpecies.predictPopulation(5) == 759))

        {
             System.out.println("Pass: predictPopulation test.");
        }
        else
        {
             System.out.println("FAIL: predictPopulation test.");
        }
    }
}
```

Sample Screen Output

```
Pass: setSpecies test.
Pass: predictPopulation test.
```

LISTING 5.21 A Demonstration Class *(part 1 of 2)*

```
import java.util.Scanner;
/**
This version of the class Species is only a toy example designed
to demonstrate the difference between parameters of a class type
and parameters of a primitive type.
*/
public class DemoSpecies
{
    private String name;
    private int population;
    private double growthRate;
    /**
    Tries to set intVariable equal to the population of this
    object. But arguments of a primitive type cannot be
    changed.
    */
    public void tryToChange(int intVariable)
    {
        intVariable = this.population;
    }
    /**
    Tries to make otherObject reference this object.
    But arguments of a class type cannot be replaced.
    */
    public void tryToReplace(DemoSpecies otherObject)
    {
        otherObject = this;
    }
    /**
    Changes the data in otherObject to the data in this object,
    which is unchanged.
    */
```

```
    public void change(DemoSpecies otherObject)
    {
        otherObject.name = this.name;
        otherObject.population = this.population;
        otherObject.growthRate = this.growthRate;
    }
    <The rest of the class definition is the same as that of the class
    Species in Listing 5.19.>
}
```

LISTING 5.22 Parameters of a Class Type Versus Parameters of a Primitive Type

```
public class ParametersDemo
{
    public static void main(String[] args)
    {
        DemoSpecies s1 = new DemoSpecies(),
                    s2 = new DemoSpecies();
        s1.setSpecies("Klingon ox", 10, 15);
        int aPopulation = 42;
        System.out.println("aPopulation BEFORE calling " +
                           "tryToChange: " + aPopulation);
        s1.tryToChange(aPopulation);
        System.out.println("aPopulation AFTER calling " +
                           "tryToChange: aPopulation);
        s2.setSpecies("Ferengie Fur Ball", 90, 56);
        System.out.println("s2 BEFORE calling tryToReplace: ");
        s2.writeOutput();
        s1.tryToReplace(s2);
        System.out.println("s2 AFTER calling tryToReplace: ");
        s2.writeOutput();
        s1.change(s2);
        System.out.println("s2 AFTER calling change: ");
        s2.writeOutput();
    }
}
```

Screen Output

```
aPopulation BEFORE calling tryToChange: 42
aPopulation AFTER calling tryToChange: 42
s2 BEFORE calling tryToReplace:
Name = Ferengie Fur Ball
Population = 90
Growth Rate = 56.0%
s2 AFTER calling tryToReplace:
Name = Ferengie Fur Ball
Population = 90
Growth Rate = 56.0%
s2 AFTER calling change:
Name = Klingon ox
Population = 10
Growth Rate = 15.0%
```

An argument of a primitive type cannot change in value.

An argument of a class type cannot be replaced.

An argument of a class type can change in state.

FIGURE 5.8 Some Methods in the Class `Graphics`

Graphics_Object`.drawOval(`*X*`, `*Y*`, `*Width*`, `*Height*`)` Draws the outline of an oval having the specified width and height at the point (*X*, *Y*).
Graphics_Object`.fillOval(`*X*`, `*Y*`, `*Width*`, `*Height*`)` Same as `drawOval`, but the oval is filled in.
Graphics_Object`.drawArc(`*X*`, `*Y*`, `*Width*`, `*Height*`, `*Start_Angle*`, `*ArcAngle*`)` Draws an arc—that is, draws part of an oval. See the graphics supplement section of Chapter 1 for details.
Graphics_Object`.fillArc(`*X*`, `*Y*`, `*Width*`, `*Height*`, `*Start_Angle*`, `*ArcAngle*`)` Same as `drawArc`, but the visible portion of the oval is filled in.
Graphics_Object`.drawRect(`*X*`, `*Y*`, `*Width*`, `*Height*`)` Draws the outline of a rectangle of the specified width and height at the point (*X*, *Y*).
Graphics_Object`.fillRect(`*X*`, `*Y*`, `*Width*`, `*Height*`)` Same as `drawRect`, but the rectangle is filled in.
Graphics_Object`.drawLine(`*X1*`, `*Y1*`, `*X2*`, `*Y2*`)` Draws a line between points (*X1*, *Y1*) and (*X2*, *Y2*).
Graphics_Object`.drawString(`*A_String*`, `*X*`, `*Y*`)` Writes the specified string starting at the point (*X*, *Y*).
Graphics_Object`.setColor(`*Color_Object*`)` Sets the color for subsequent drawings and text. The color stays in effect until it is changed by another invocation of `setColor`.

LISTING 5.23 Using a Method for a Recurrent Subtask
(part 1 of 3)

```
import javax.swing.JApplet;
import java.awt.Graphics;
import java.awt.Color;

public class MultipleFaces extends JApplet
{
    public static final int FACE_DIAMETER = 50;
    public static final int X_FACE0 = 10;
    public static final int Y_FACE0 = 5;

    public static final int EYE_WIDTH = 5;
    public static final int EYE_HEIGHT = 10;
    public static final int X_RIGHT_EYE0 = 20;
    public static final int Y_RIGHT_EYE0 = 15;
    public static final int X_LEFT_EYE0 = 45;
    public static final int Y_LEFT_EYE0 = Y_RIGHT_EYE0;

    public static final int NOSE_DIAMETER = 5;
    public static final int X_NOSE0 = 32;
    public static final int Y_NOSE0 = 25;

    public static final int MOUTH_WIDTH = 30;
    public static final int MOUTH_HEIGHT0 = 0;
```

```
public static final int X_MOUTH0 = 20;
public static final int Y_MOUTH0 = 35;
public static final int MOUTH_START_ANGLE = 180;
public static final int MOUTH_EXTENT_ANGLE = 180;
/**
g is the drawing area. pos indicates the position of the
face. As pos increases, the face is drawn lower and further
to the right.
*/
private void drawFaceSansMouth(Graphics g, int pos)
{
    g.setColor(Color.BLACK);
    g.drawOval(X_FACE0 + 50 * pos, Y_FACE0 + 30 * pos,
               FACE_DIAMETER, FACE_DIAMETER);
    //Draw eyes:
    g.setColor(Color.BLUE);
    g.fillOval(X_RIGHT_EYE0 + 50 * pos, Y_RIGHT_EYE0 + 30 * pos,
               EYE_WIDTH, EYE_HEIGHT);
    g.fillOval(X_LEFT_EYE0 + 50 * pos, Y_LEFT_EYE0 + 30 * pos,
               EYE_WIDTH, EYE_HEIGHT);
    //Draw nose:
    g.setColor(Color.BLACK);
    g.fillOval(X_NOSE0 + 50 * pos, Y_NOSE0 + 30 * pos,
               NOSE_DIAMETER, NOSE_DIAMETER);
}
```

```
public void paint(Graphics canvas)
{
    int i;
    for (i = 0; i < 5; i++)
    {//Draw one face:
    if (i % 2 == 0)//If i is even,
        { //make face yellow
            canvas.setColor(Color.YELLOW);
            canvas.fillOval(X_FACE0 + 50 * i,
                    Y_FACE0 + 30 * i,
                    FACE_DIAMETER, FACE_DIAMETER);
    }
    drawFaceSansMouth(canvas, i);
    //Draw mouth:
    canvas.setColor(Color.RED);
    canvas.drawArc(X_MOUTH0 + 50 * i, Y_MOUTH0 + 30 * i,
                MOUTH_WIDTH, MOUTH_HEIGHT0 + 3 * i,
                MOUTH_START_ANGLE, MOUTH_EXTENT_ANGLE);
    }
    //i == 5
```

```
        //Draw kissing face:
        drawFaceSansMouth(canvas, i);
        //Draw mouth in shape of a kiss:
        canvas.setColor(Color.RED);
        canvas.fillOval(X_MOUTH0 + 50 * i + 10, Y_MOUTH0 + 30 * i,
                        MOUTH_WIDTH - 20, MOUTH_WIDTH - 20);
        //Add text:
        canvas.setColor(Color.BLACK);
        canvas.drawString("Kiss, Kiss.",
             X_FACE0 + 50 * i + FACE_DIAMETER, Y_FACE0 + 30 * i);
        //Draw blushing face:
        i++;
        //Draw face circle:
        canvas.setColor(Color.PINK);
        canvas.fillOval(X_FACE0 + 50 * i, Y_FACE0 + 30 * i,
                                FACE_DIAMETER, FACE_DIAMETER);
        drawFaceSansMouth(canvas, i);
        //Draw mouth:
        canvas.setColor(Color.RED);
        canvas.drawArc(X_MOUTH0 + 50 * i, Y_MOUTH0 + 30 * i,
                        MOUTH_WIDTH, MOUTH_HEIGHT0 + 3 * (i - 2),
                        MOUTH_START_ANGLE, MOUTH_EXTENT_ANGLE);
        //Add text:
        canvas.setColor(Color.BLACK);
        canvas.drawString("Tee Hee.",
            X_FACE0 + 50 * i + FACE_DIAMETER, Y_FACE0 + 30 * i);
    }
}
```

Applet Output

The drawing produced is identical to the one shown in Listing 4.9 except for some of the colors used to draw the faces.

LISTING 5.24 Adding Labels to an Applet

```
import javax.swing.JApplet;
import javax.swing.JLabel;
import java.awt.Color;
import java.awt.Container;
import java.awt.FlowLayout;

/**
 An applet that uses a label to display text.
*/
public class LabelDemo extends JApplet
{
    public void init()
    {
        Container contentPane = getContentPane();
        contentPane.setBackground(Color.WHITE);
        //Create labels:
        JLabel label1 = new JLabel("Hello ");
        JLabel label2 = new JLabel("out there!");
        //Add labels:
        contentPane.setLayout(new FlowLayout());
        contentPane.add(label1);
        contentPane.add(label2);
    }
}
```

Applet Output