5. Defining Classes and Methods

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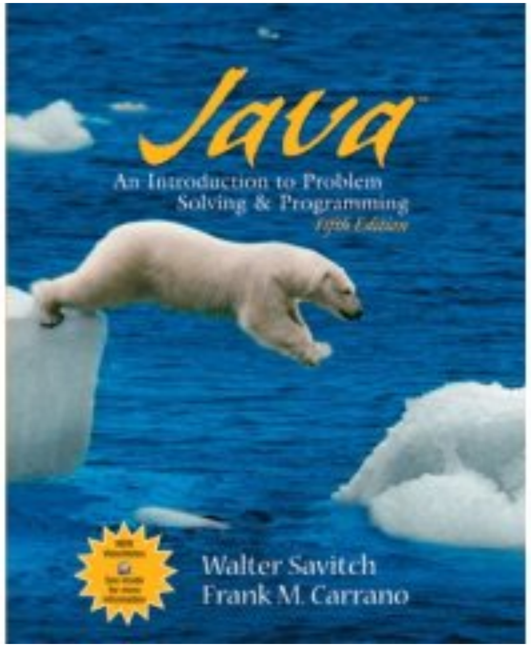
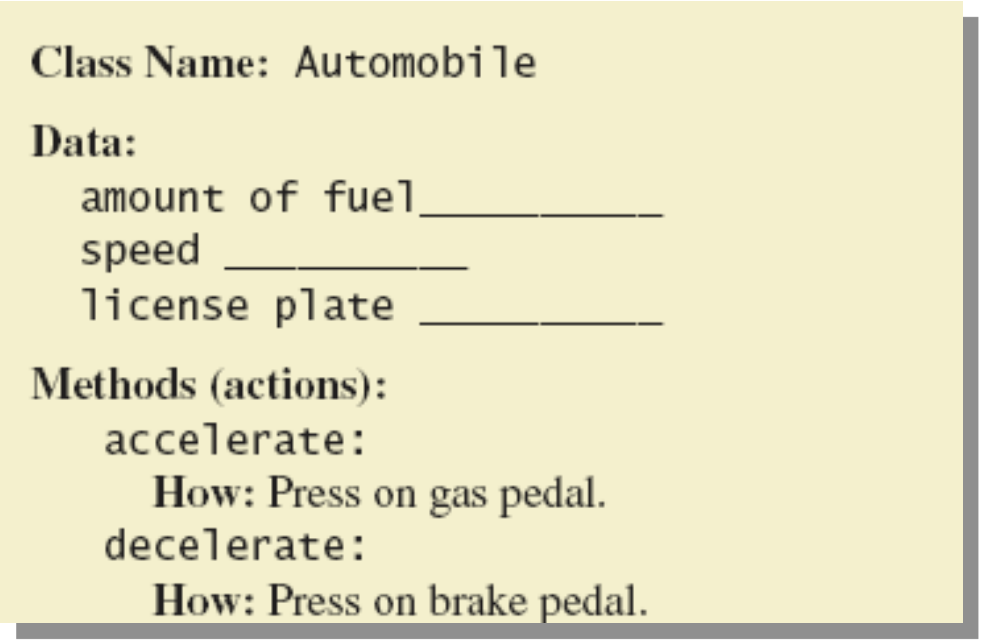


Objectives

- Describe and define concepts of class, class object
- Describe use of parameters in a method
- Use modifiers `public`, `private`
- Define *accessor*, *mutator* class methods
- Write method *pre- and postconditions*
- Describe purpose of `javadoc`
- Describe references, variables, parameters of a class type

Class and Method Definitions

- Figure 5.1 A class as a blueprint



Class Name: Automobile

Data:

amount of fuel__________
speed __________
license plate __________

Methods (actions):

accelerate:

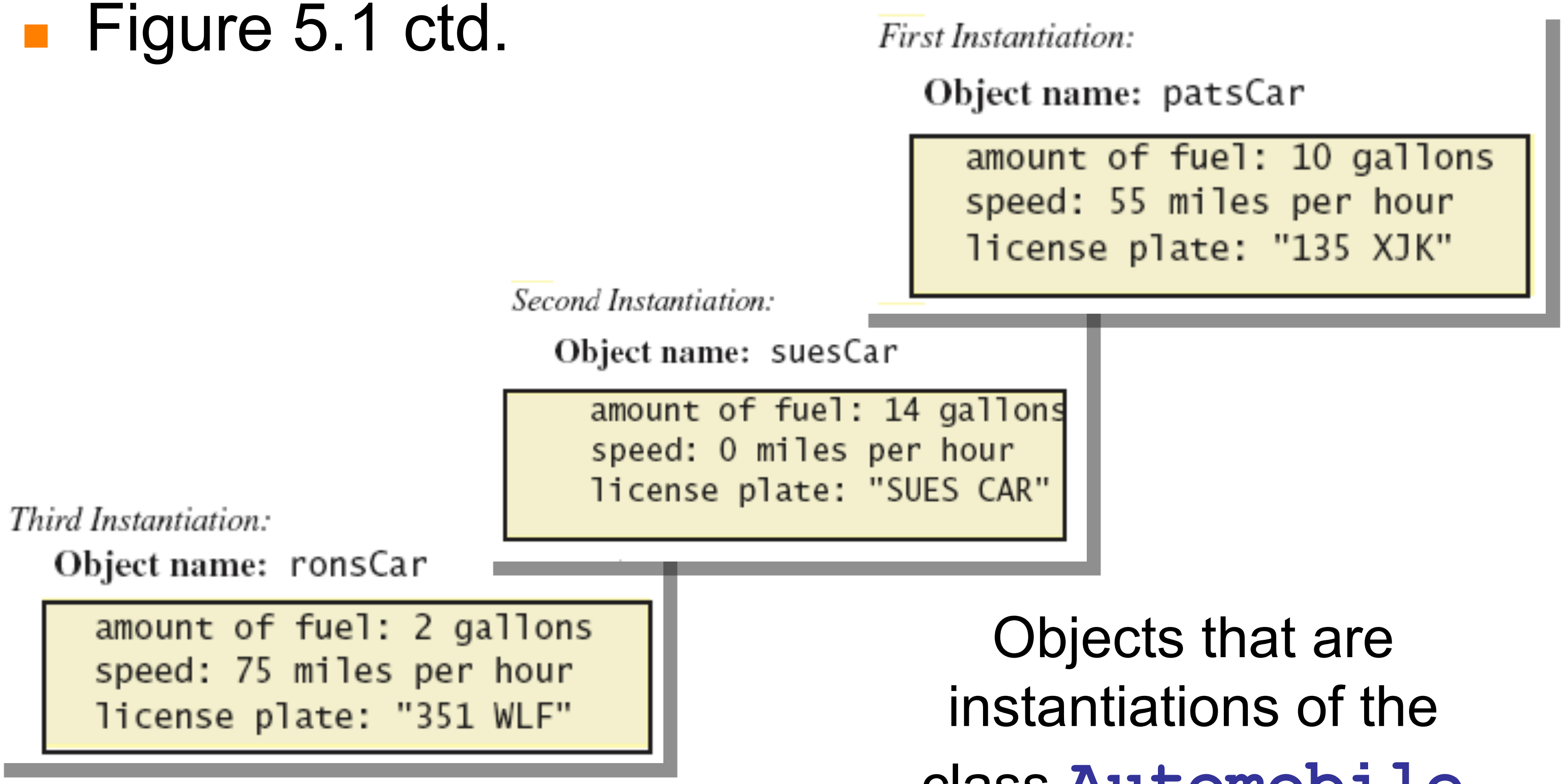
How: Press on gas pedal.

decelerate:

How: Press on brake pedal.

Class and Method Definitions

- Figure 5.1 ctd.



First Instantiation:

Object name: `patsCar`

```
amount of fuel: 10 gallons
speed: 55 miles per hour
license plate: "135 XJK"
```

Second Instantiation:

Object name: `suesCar`

```
amount of fuel: 14 gallons
speed: 0 miles per hour
license plate: "SUES CAR"
```

Third Instantiation:

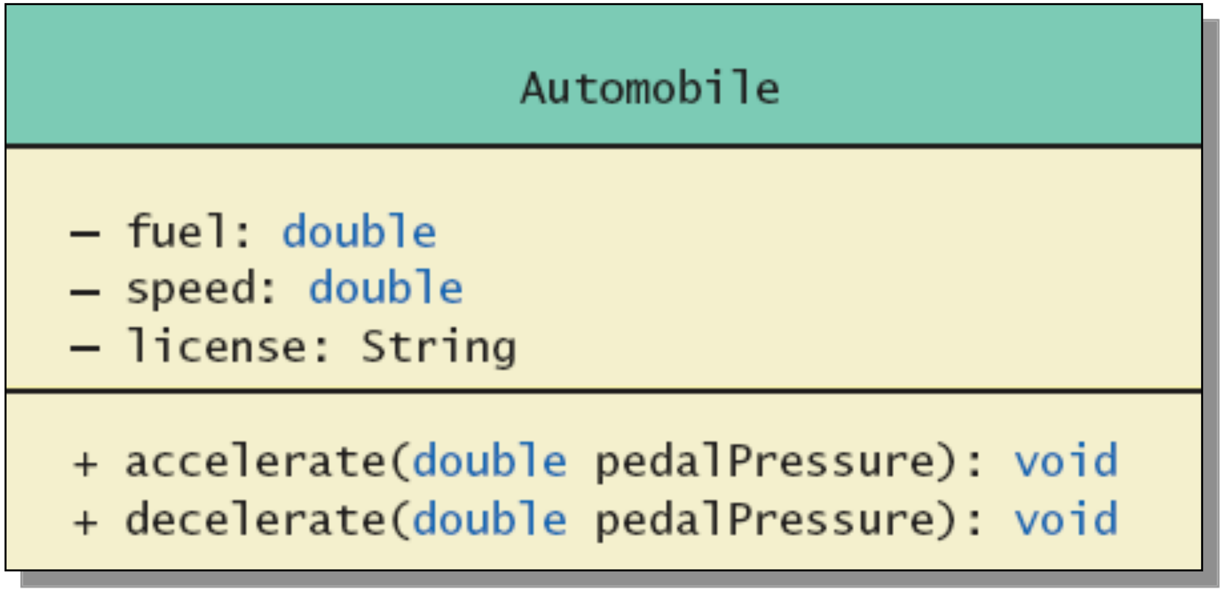
Object name: `ronsCar`

```
amount of fuel: 2 gallons
speed: 75 miles per hour
license plate: "351 WLF"
```

Objects that are instantiations of the class **`Automobile`**

Class and Method Definitions

- Figure 5.2 A class outline as a UML class diagram



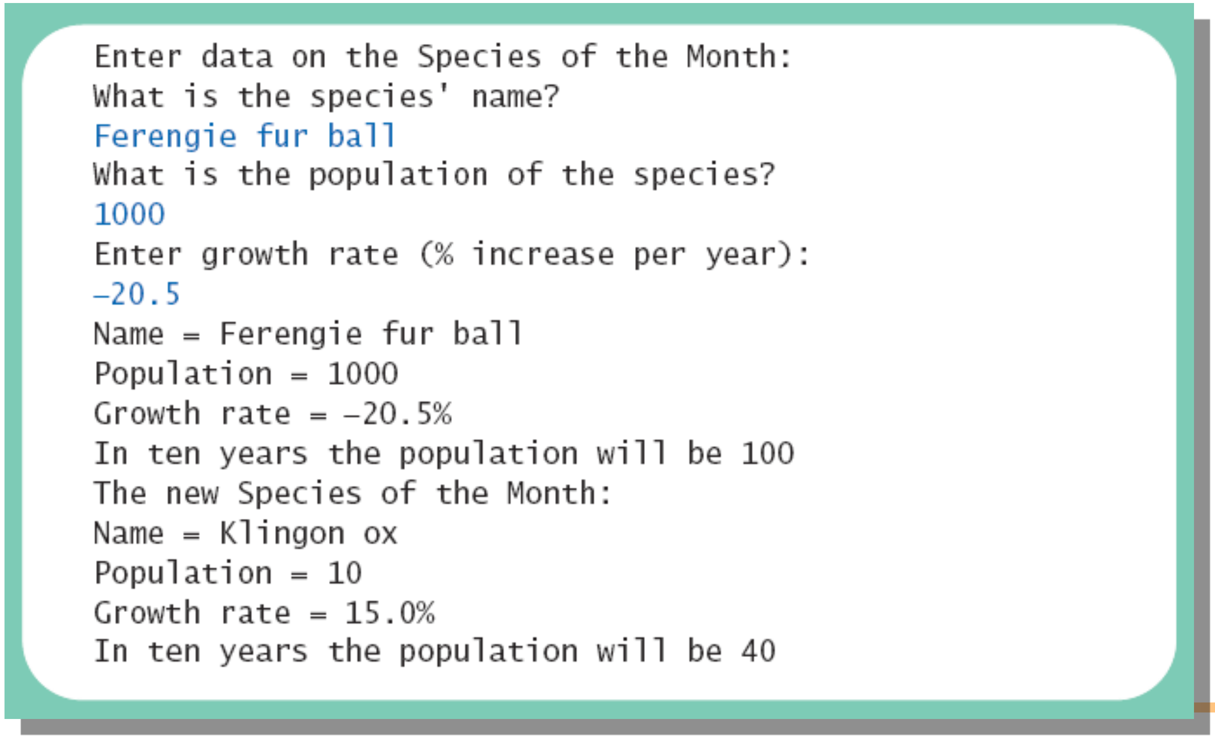
```
Automobile

- fuel: double
- speed: double
- license: String

+ accelerate(double pedalPressure): void
+ decelerate(double pedalPressure): void
```

Instance Variable

- View sample program, listing 5.1
  `class SpeciesFirstTry`
- Note class has
  - Three pieces of data (instance variables)
  - Three behaviors
- Each instance of this type has its own copies of the data items
- Use of `public`
  - No restrictions on how variables used

Using a Class and Its Methods

- **`class SpeciesFirstTryDemo`**



```
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
```

Methods

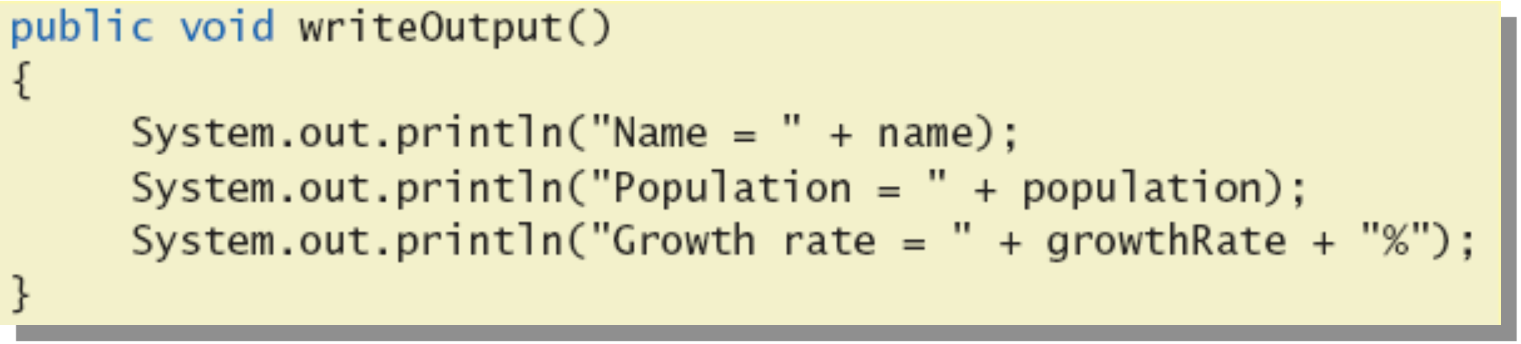
- When you use a method you "invoke" or "call" it
- Two kinds of Java methods
  - Return a single item
  - Perform some other action: a **`void`** method
- The method **`main`** is a **`void`** method
  - Invoked by the system
  - Not by the application program

Methods

- Calling a method that returns a value
- Calling a void method
  - Write the invocation followed by a semicolon
  - Resulting statement performs the action defined by the method

Defining **`void`** Methods

- Consider method **`writeOutput`**



```
public void writeOutput()
{
     System.out.println("Name = " + name);
     System.out.println("Population = " + population);
     System.out.println("Growth rate = " + growthRate + "%");
}
```

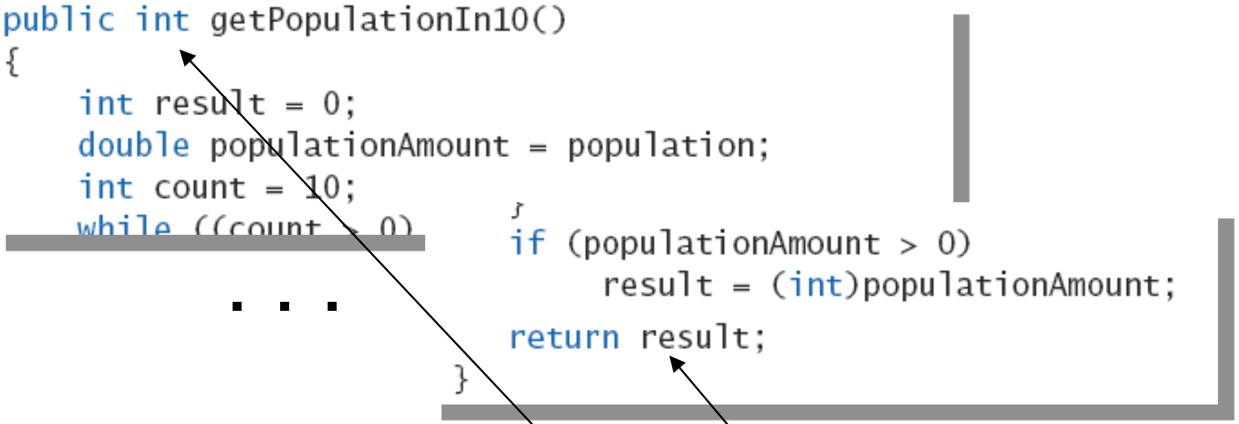
- Method definitions appear inside class definition
  - Can be used only with objects of that class

Defining `void` Methods

- Most method definitions we will see as `public`
- Method does not return a value
  - Specified as a `void` method
- Heading includes parameters
- Body enclosed in braces `{ }`
- Think of method as defining an action to be taken

Methods That Return a Value

- Consider method `getPopulationIn10( )`



```
public int getPopulationIn10()
{
    int result = 0;
    double populationAmount = population;
    int count = 10;
    while ((count > 0)
        . . .
    if (populationAmount > 0)
        result = (int)populationAmount;
    return result;
}
```

- Heading declares type of value to be returned
- Last statement executed is `return`

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The keyword `this`

- Referring to instance variables outside the class must use
  - Name of an object of the class
  - Followed by a dot
  - Name of instance variable
- Inside the class
  - Use name of variable alone
  - The object (unnamed) is understood to be there

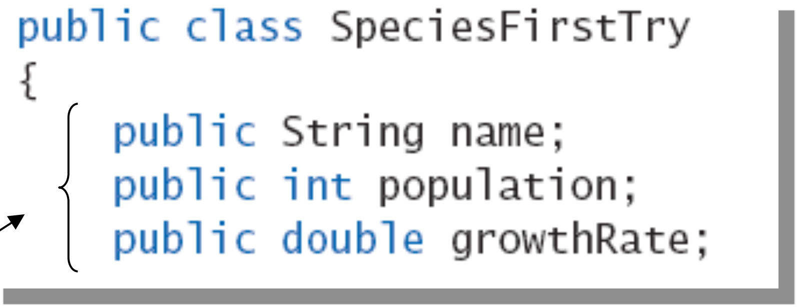
The Keyword `this`

- Inside the class the unnamed object can be referred to with the name **`this`**
- Example

```
this.name = keyboard.nextLine();
```

- The keyword **`this`** stands for the receiving object
- We will seem some situations later that require the **`this`**

Local Variables

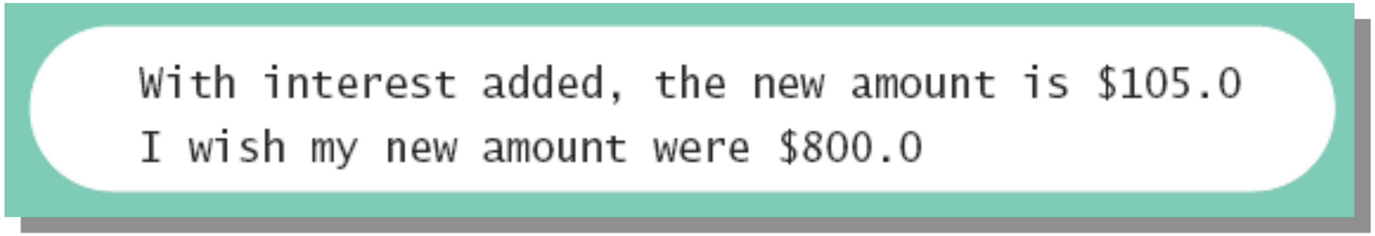


```
public class SpeciesFirstTry
{
    public String name;
    public int population;
    public double growthRate;
```

- Note beginning of class in listing 5.1
- Variables declared inside the class are considered *local* variables
  - May be used only inside this class
- Variable with same name inside a different class is considered a different variable
- All variables declared in method **`main`** are local to **`main`**

Local Variables

- **`class BankAccount`**
- **`class LocalVariablesDemoProgram`**
- Note two different variables **`newAmount`**
  - Note different values output

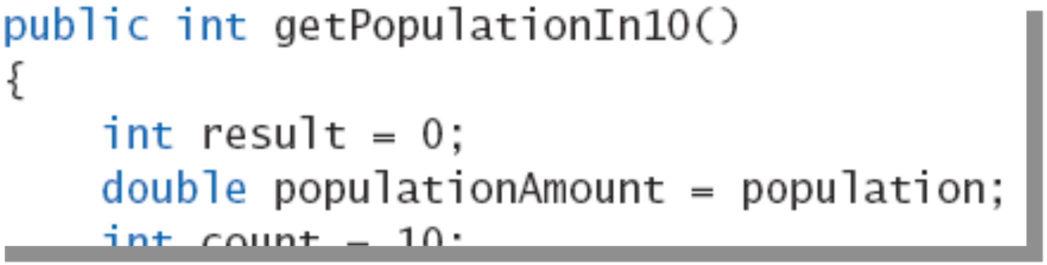


```
With interest added, the new amount is $105.0
I wish my new amount were $800.0
```

Blocks and scope

- Recall compound statements
  - Enclosed in braces { }
- When you declare a variable within a compound statement
  - The compound statement is called a *block*
  - The scope of the variable is from its declaration to the end of the block
- Variable declared outside the block usable both outside and inside the block

Parameters of Primitive Type



```
public int getPopulationIn10()
{
    int result = 0;
    double populationAmount = population;
    int count = 10;
```

- Recall method declaration in listing 5.1
  - Note it only works for 10 years
  - We can make it more versatile by giving the method a parameter to specify how many years
- **`class SpeciesSecondTry`**

Parameters of Primitive Type

- Note the declaration

  ```
  public int predictPopulation(int years)
  ```

  - The *formal* parameter is `years`

- Calling the method

  ```
  int futurePopulation =
   speciesOfTheMonth.predictPopulation(10);
  ```

  - The *actual* parameter is the integer 10

- `class SpeciesSecondClassDemo`

Parameters of Primitive Type

- Parameter names are local to the method
- When method invoked
  - Each parameter initialized to value in corresponding actual parameter
  - Primitive actual parameter cannot be altered by invocation of the method
- Automatic type conversion performed

```
byte -> short -> int ->
            long -> float -> double
```

Information Hiding, Encapsulation: Outline

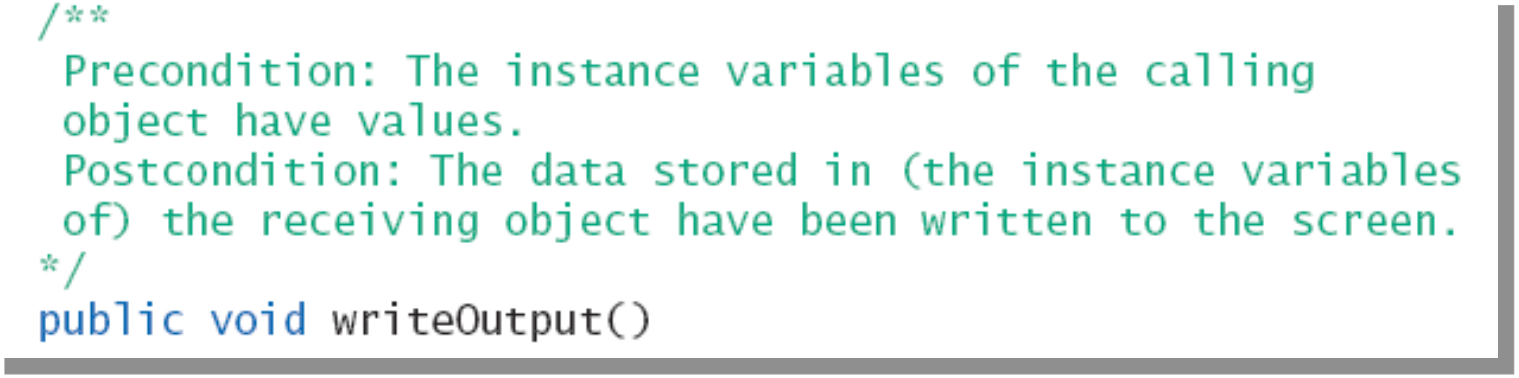
- Information Hiding
- Pre- and Postcondition Comments
- The public and private Modifiers
- Methods Calling Methods
- Encapsulation
- Automatic Documentation with `javadoc`
- UML Class Diagrams

Information Hiding

- Programmer using a class method need not know details of implementation
  - Only needs to know *what* the method does
- Information hiding:
  - Designing a method so it can be used without knowing details
- Also referred to as *abstraction*
- Method design should separate *what* from *how*

Pre- and Postcondition Comments

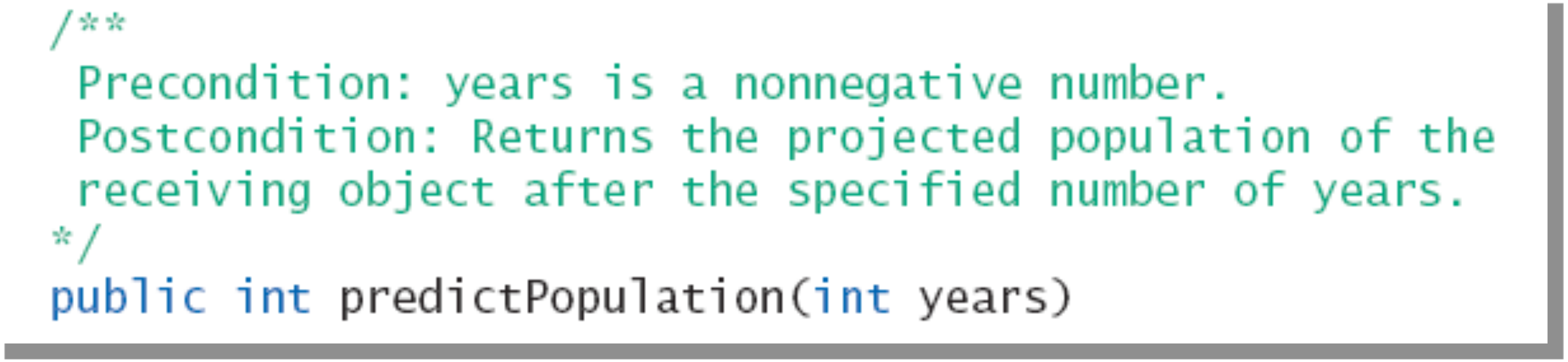
- Precondition comment
  - States conditions that must be true before method is invoked
- Example



```
/**
 Precondition: The instance variables of the calling
 object have values.
 Postcondition: The data stored in (the instance variables
 of) the receiving object have been written to the screen.
*/
public void writeOutput()
```

Pre- and Postcondition Comments

- Postcondition comment
  - Tells what will be true after method executed
- Example



```
/**
 Precondition: years is a nonnegative number.
 Postcondition: Returns the projected population of the
 receiving object after the specified number of years.
*/
public int predictPopulation(int years)
```

The `public` and `private` Modifiers

- Type specified as `public`
  - Any other class can directly access that object by name
- Classes generally specified as `public`
- Instance variables usually not `public`
  - Instead specify as `private`
- `class SpeciesThirdTry`

Programming Example

- Demonstration of need for private variables
- View sample code, listing 5.7
- Statement such as

  ```
  box.width = 6;
  ```

  is illegal since width is `private`

  - Keeps remaining elements of the class consistent in this example

Programming Example

- Another implementation of a Rectangle class
- View sample code, listing 5.8
  `class Rectangle2`
- Note `setDimensions` method
  - This is the only way the `width` and `height` may be altered outside the class

Accessor and Mutator Methods

- When instance variables are private must provide methods to access values stored there
  - Typically named `getSomeValue`
  - Referred to as an accessor method
- Must also provide methods to change the values of the private instance variable
  - Typically named `setSomeValue`
  - Referred to as a mutator method

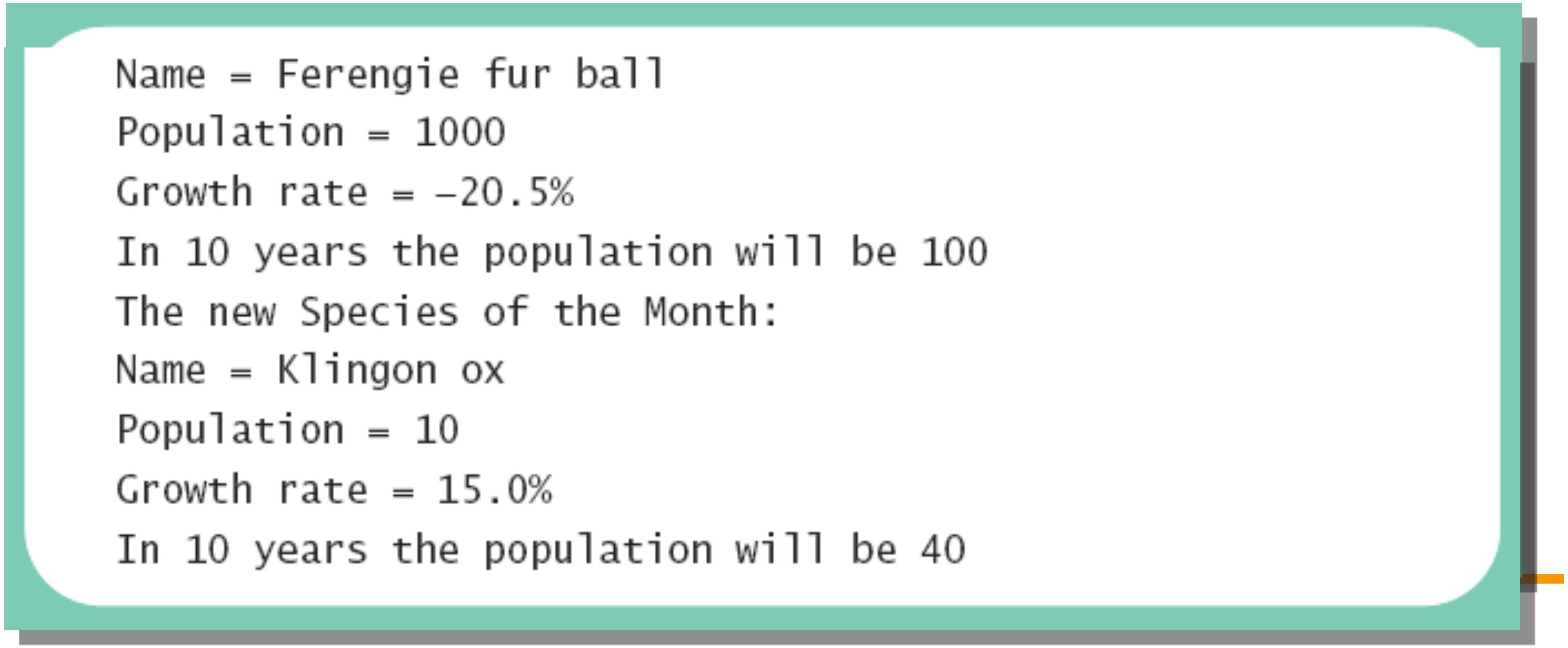
Accessor and Mutator Methods

- Consider an example class with accessor and mutator methods
- View sample code, listing 5.9

  `class SpeciesFourthTry`
- Note the mutator method
  - **`setSpecies`**
- Note accessor methods
  - **`getName`**, **`getPopulation`**, **`getGrowthRate`**

Accessor and Mutator Methods

- Using a mutator method
- `classSpeciesFourthTryDemo`

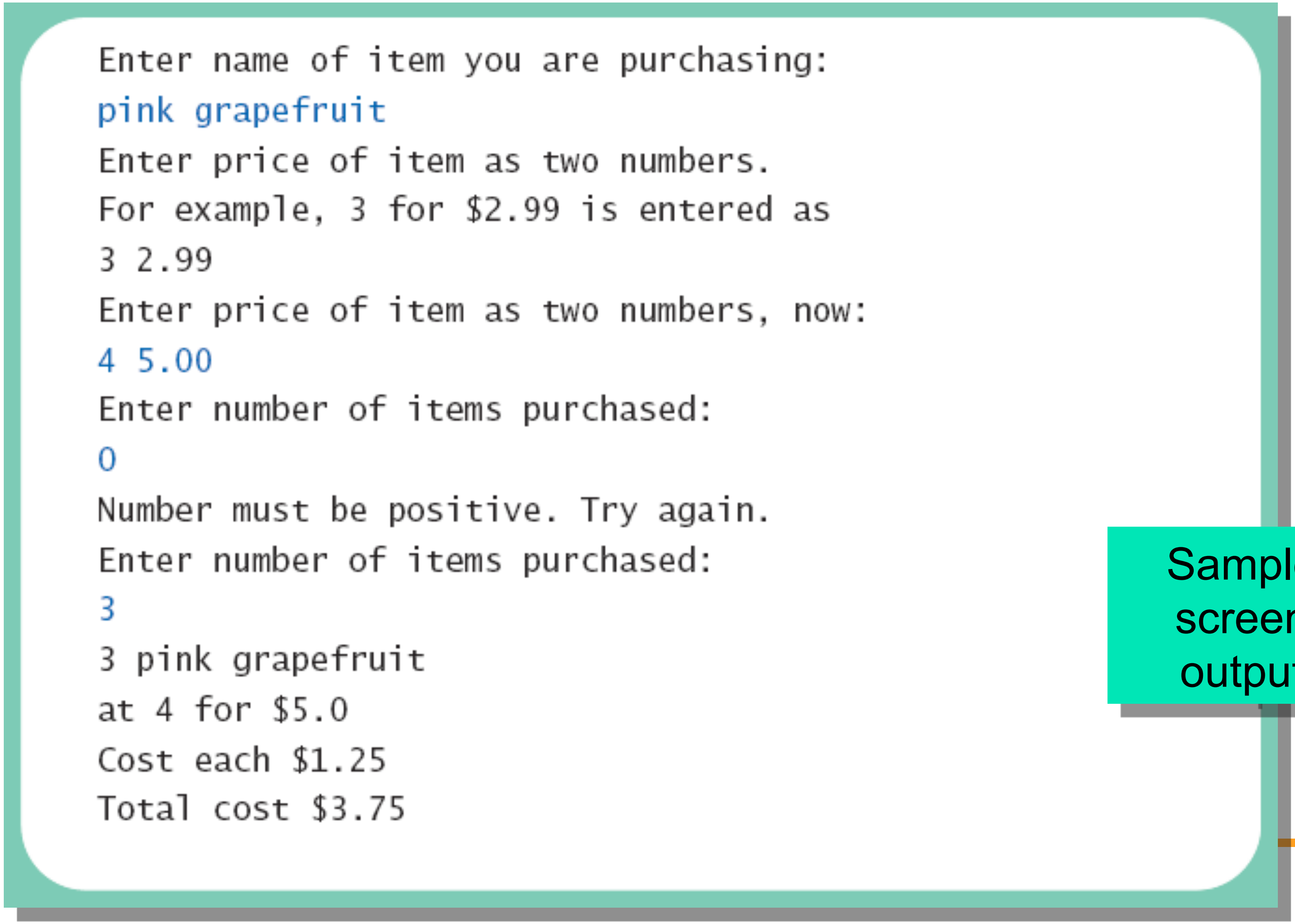


```
Name = Ferengie fur ball
Population = 1000
Growth rate = -20.5%
In 10 years the population will be 100
The new Species of the Month:
Name = Klingon ox
Population = 10
Growth rate = 15.0%
In 10 years the population will be 40
```

Programming Example

- A Purchase class
- View sample code, listing 5.11
  `class Purchase`
  - Note use of private instance variables
  - Note also how mutator methods check for invalid values
- View demo program, listing 5.12
  `class purchaseDemo`

Programming Example



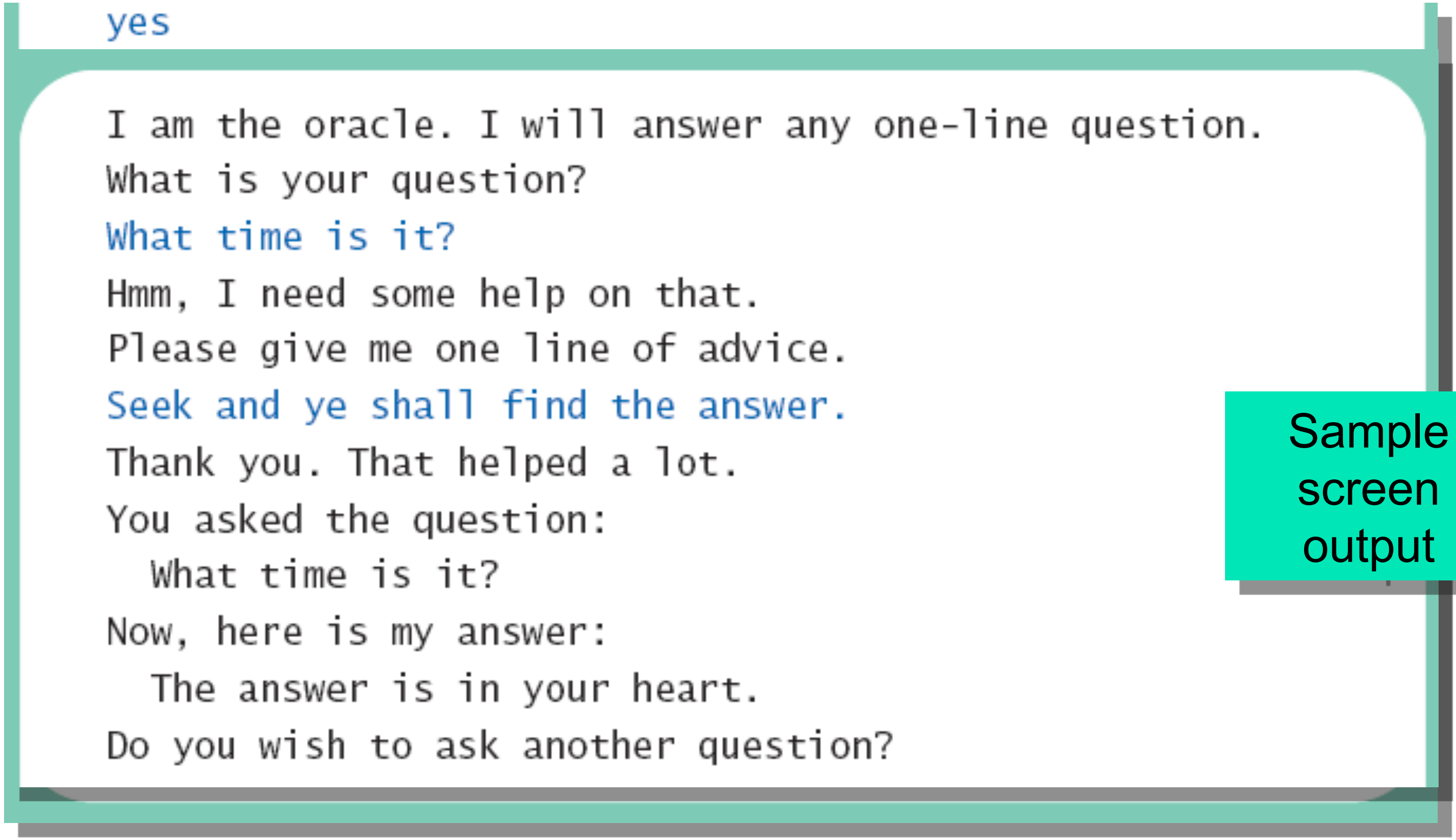
```
Enter name of item you are purchasing:
pink grapefruit
Enter price of item as two numbers.
For example, 3 for $2.99 is entered as
3 2.99
Enter price of item as two numbers, now:
4 5.00
Enter number of items purchased:
0
Number must be positive. Try again.
Enter number of items purchased:
3
3 pink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

Sample screen output

Methods Calling Methods

- A method body may call any other method
- If the invoked method is within the same class
  - Need not use prefix of receiving object
- View sample code, listing 5.13
  class Oracle
- View demo program, listing 5.14
  class OracleDemo

Methods Calling Methods



```
yes

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?
```

Sample screen output

Encapsulation

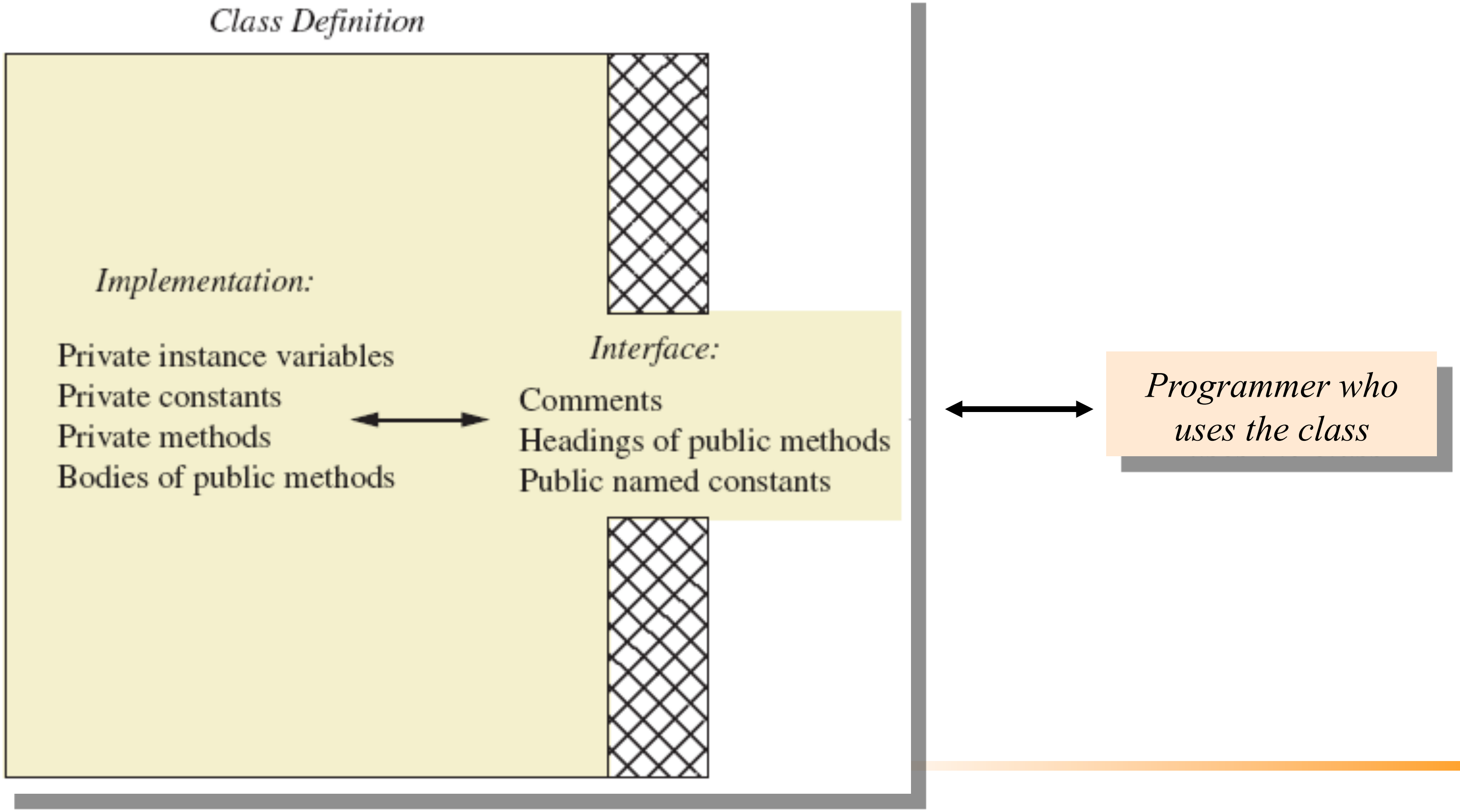
- Consider example of driving a car
  - We see and use break pedal, accelerator pedal, steering wheel – know what they do
  - We do not see mechanical details of how they do their jobs
- Encapsulation divides class definition into
  - Class interface
  - Class implementation

Encapsulation

- A *class interface*
  - Tells what the class does
  - Gives headings for public methods and comments about them
- A *class implementation*
  - Contains private variables
  - Includes definitions of public and private methods

Encapsulation

- Figure 5.3 A well encapsulated class definition



Encapsulation

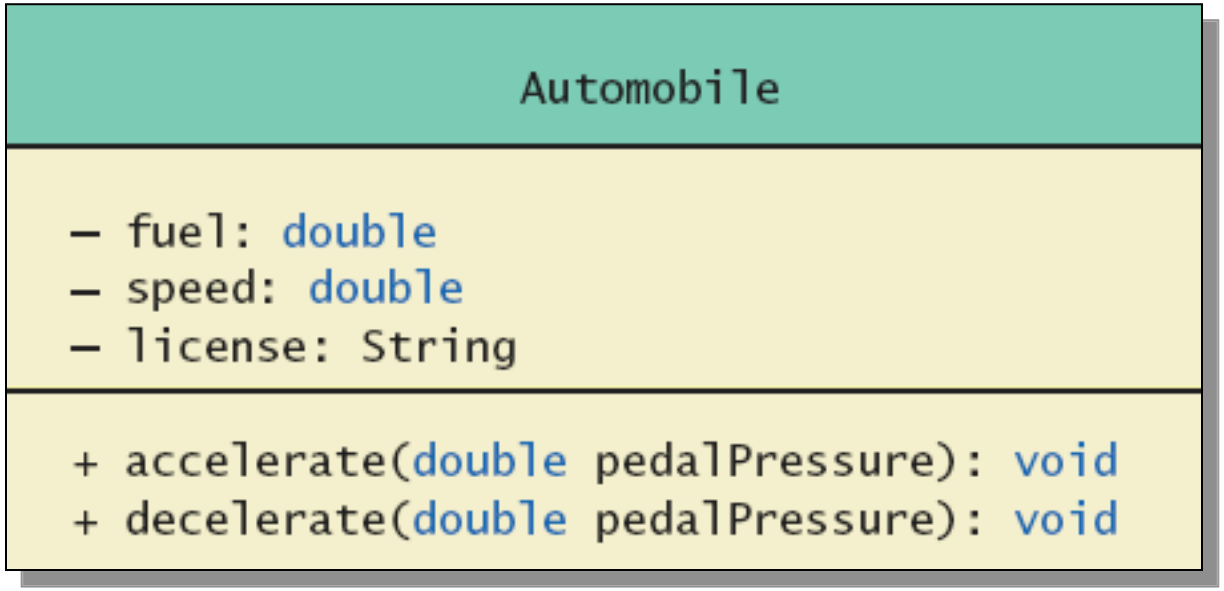
- Preface class definition with comment on how to use class
- Declare all instance variables in the class as private
- Provide public accessor methods to retrieve data Provide public methods manipulating data
  - Such methods could include public mutator methods.
- Place a comment before each public method heading that fully specifies how to use method.
- Make any helping methods private.
- Write comments within class definition to describe implementation details.

Automatic Documentation `javadoc`

- Generates documentation for class interface
- Comments in source code must be enclosed in `/**   */`
- Utility `javadoc` will include
  - These comments
  - Headings of public methods
- Output of `javadoc` is HTML format

UML Class Diagrams

- Recall Figure 5.2 A class outline as a UML class diagram



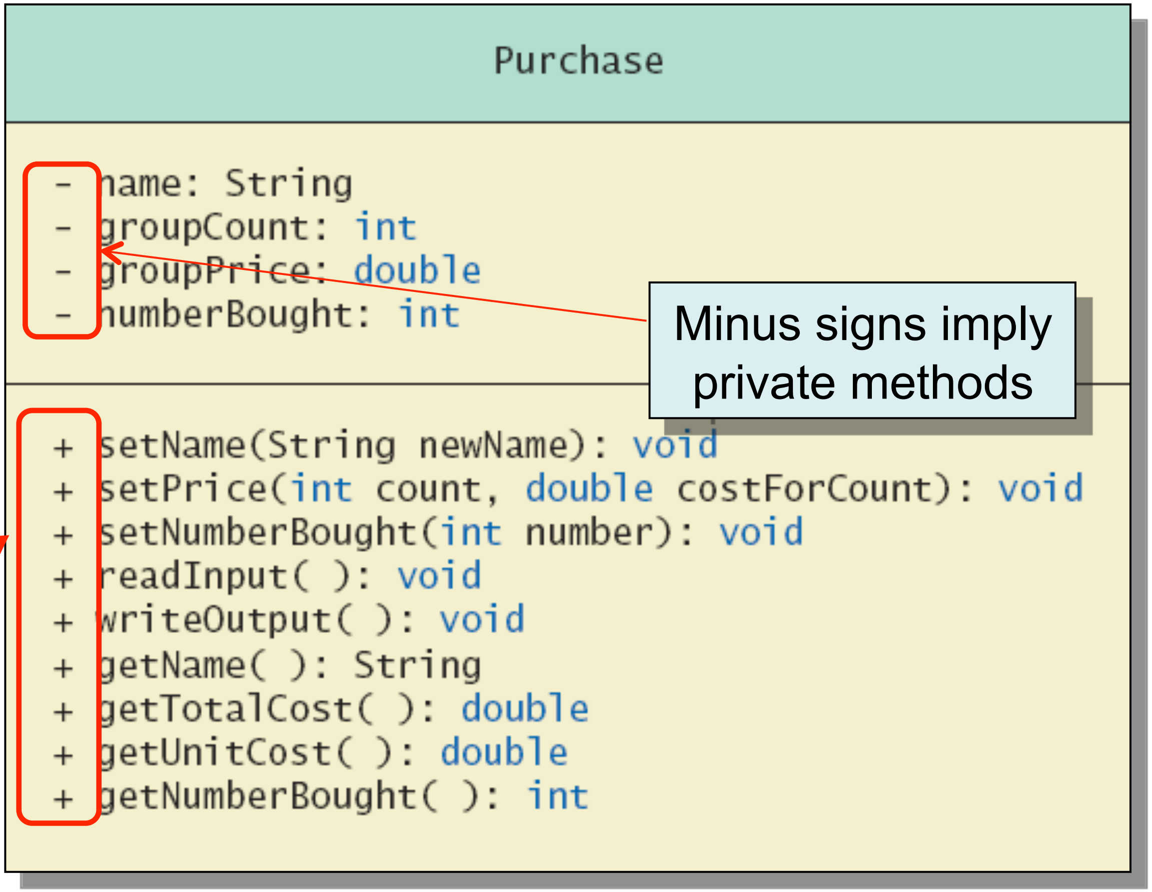
Automobile

```
– fuel: double
– speed: double
– license: String
```

```
+ accelerate(double pedalPressure): void
+ decelerate(double pedalPressure): void
```

UML Class Diagrams

- Note Figure 5.4 for the **`Purchase`** class



```
Purchase

- name: String
- groupCount: int
- groupPrice: double
- numberBought: int

+ setName(String newName): void
+ setPrice(int count, double costForCount): void
+ setNumberBought(int number): void
+ readInput( ): void
+ writeOutput( ): void
+ getName( ): String
+ getTotalCost( ): double
+ getUnitCost( ): double
+ getNumberBought( ): int
```

Minus signs imply private methods

Plus signs imply public methods

UML Class Diagrams

- Contains more than interface, less than full implementation
- Usually written *before* class is defined
- Used by the programmer defining the class
    - Contrast with the interface used by programmer who uses the class

Objects and References: Outline

- Variables of a Class Type
- Defining an equals Method for a Class
- Boolean-Valued Methods
- Parameters of a Class Type

Variables of a Class Type

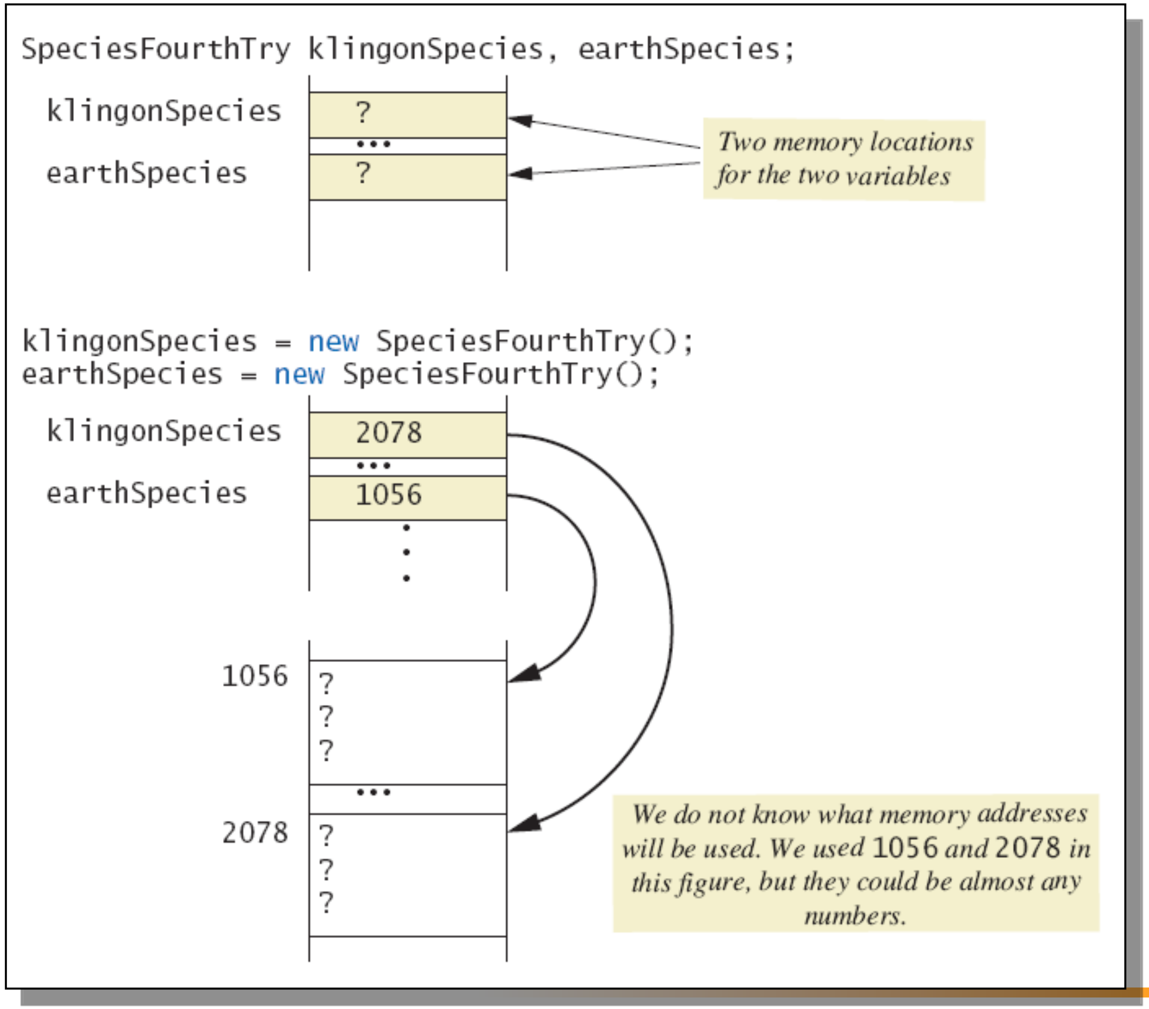
- All variables are implemented as a memory location
- Data of *primitive type* stored in the memory location assigned to the variable
- Variable of *class type* contains memory address of object named by the variable

Variables of a Class Type

- Object itself not stored in the variable
  - Stored elsewhere in memory
  - Variable contains address of where it is stored
- Address called the *reference* to the variable
- A *reference type* variable holds references (memory addresses)
  - This makes memory management of class types more efficient

Variables of a Class Type

- Behavior of class variables



```
SpeciesFourthTry klingonSpecies, earthSpecies;
```

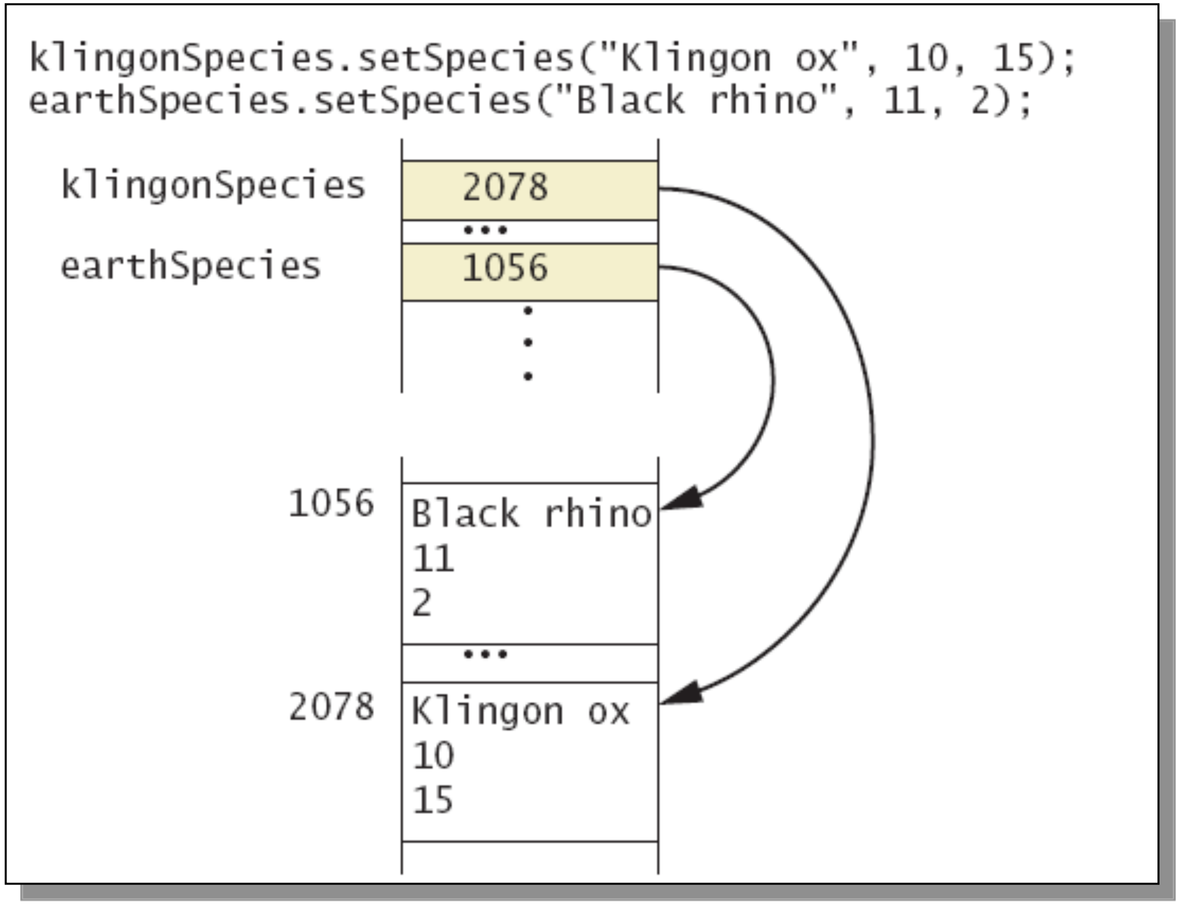
Two memory locations for the two variables

```
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.

Variables of a Class Type

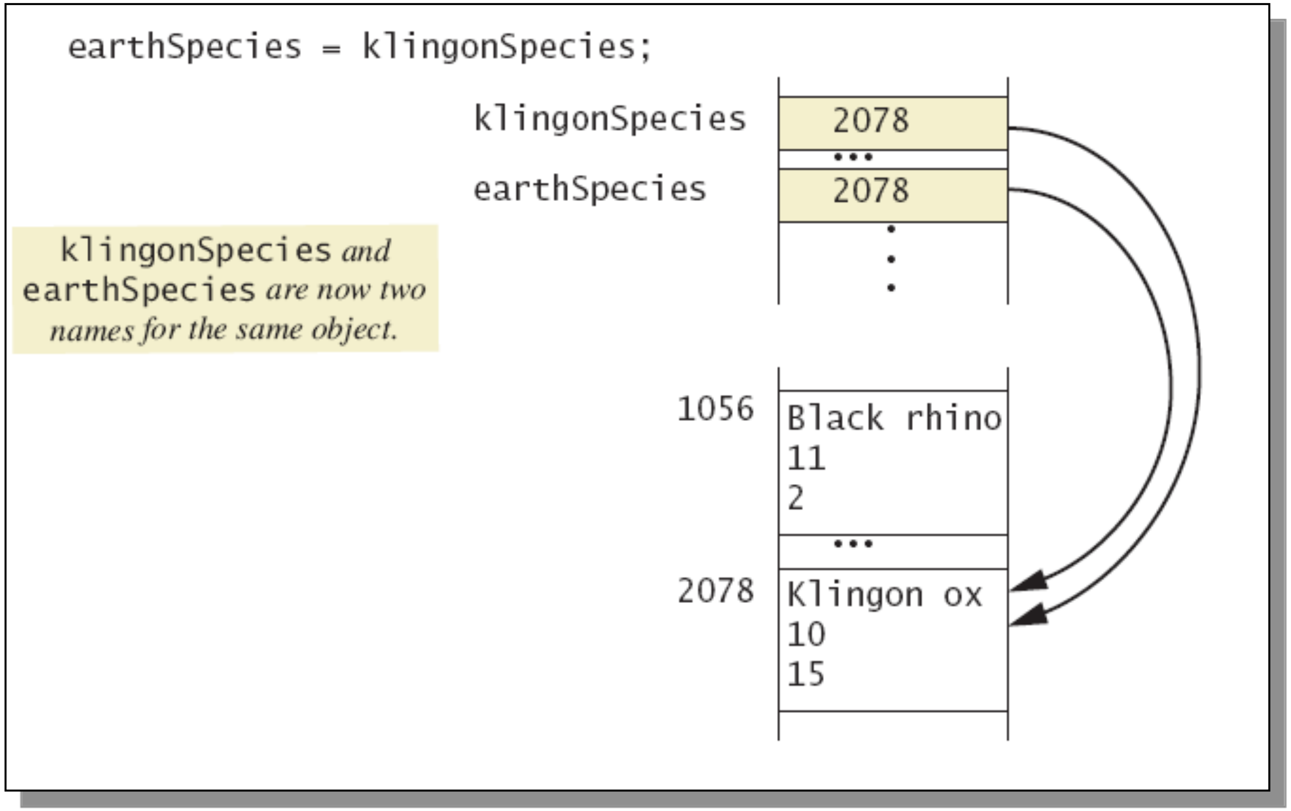
- Behavior of class variables



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

Variables of a Class Type

- Behavior of class variables

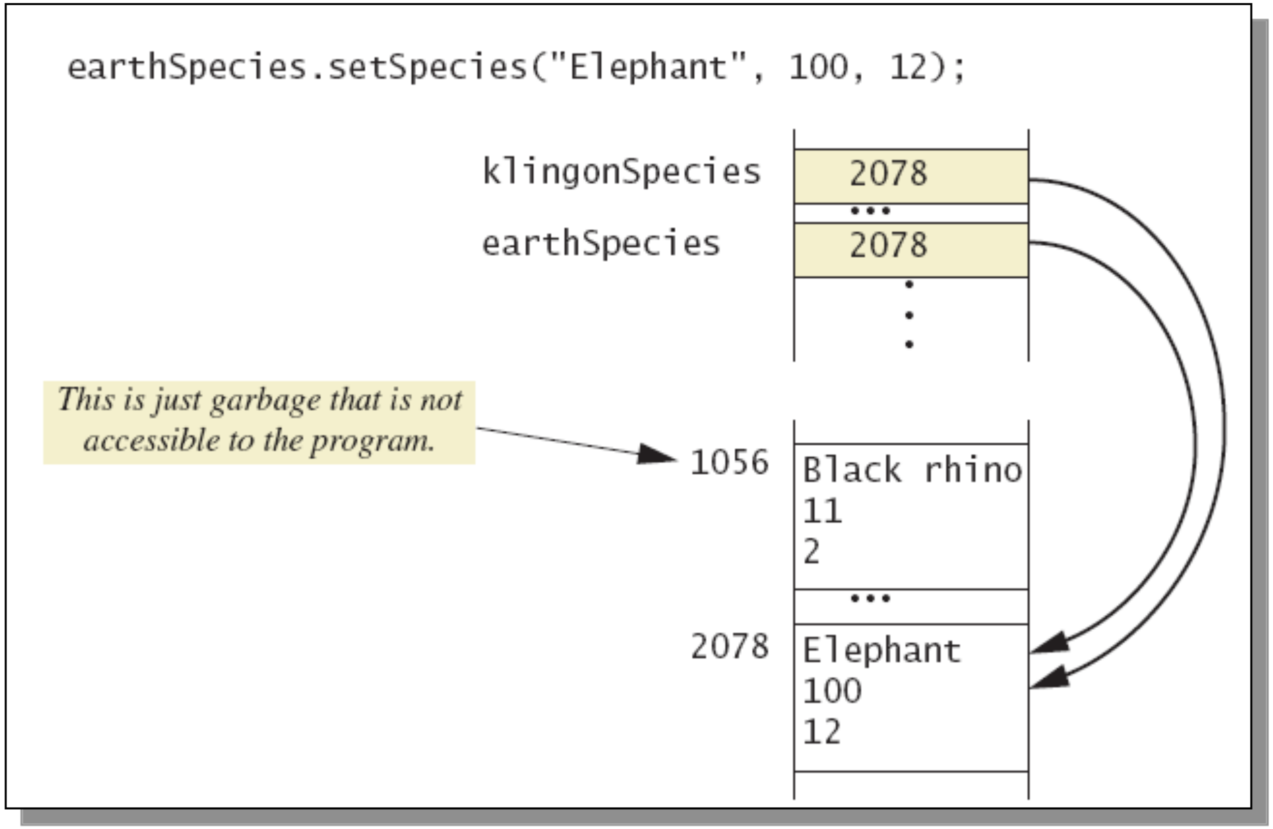


```
earthSpecies = klingonSpecies;
```

klingonSpecies and earthSpecies are now two names for the same object.

Variables of a Class Type

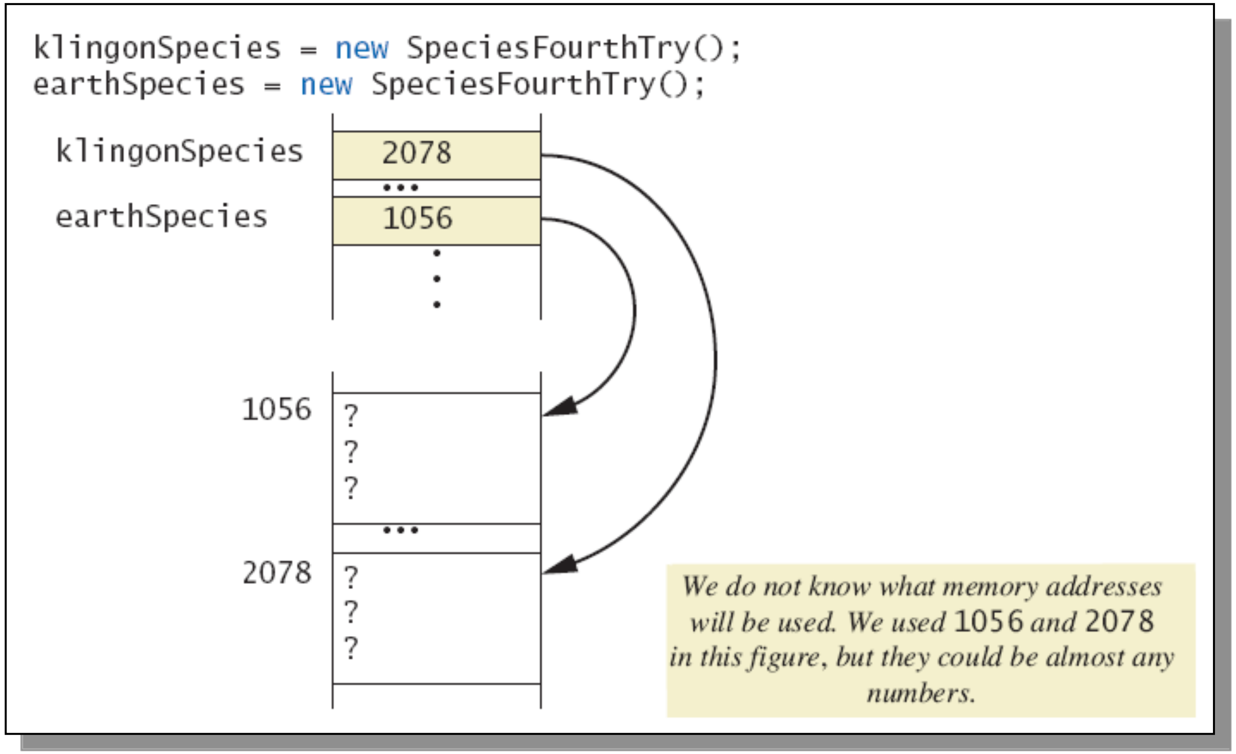
- Behavior of class variables



```
earthSpecies.setSpecies("Elephant", 100, 12);
```

Variables of a Class Type

- Dangers of using **==** with objects

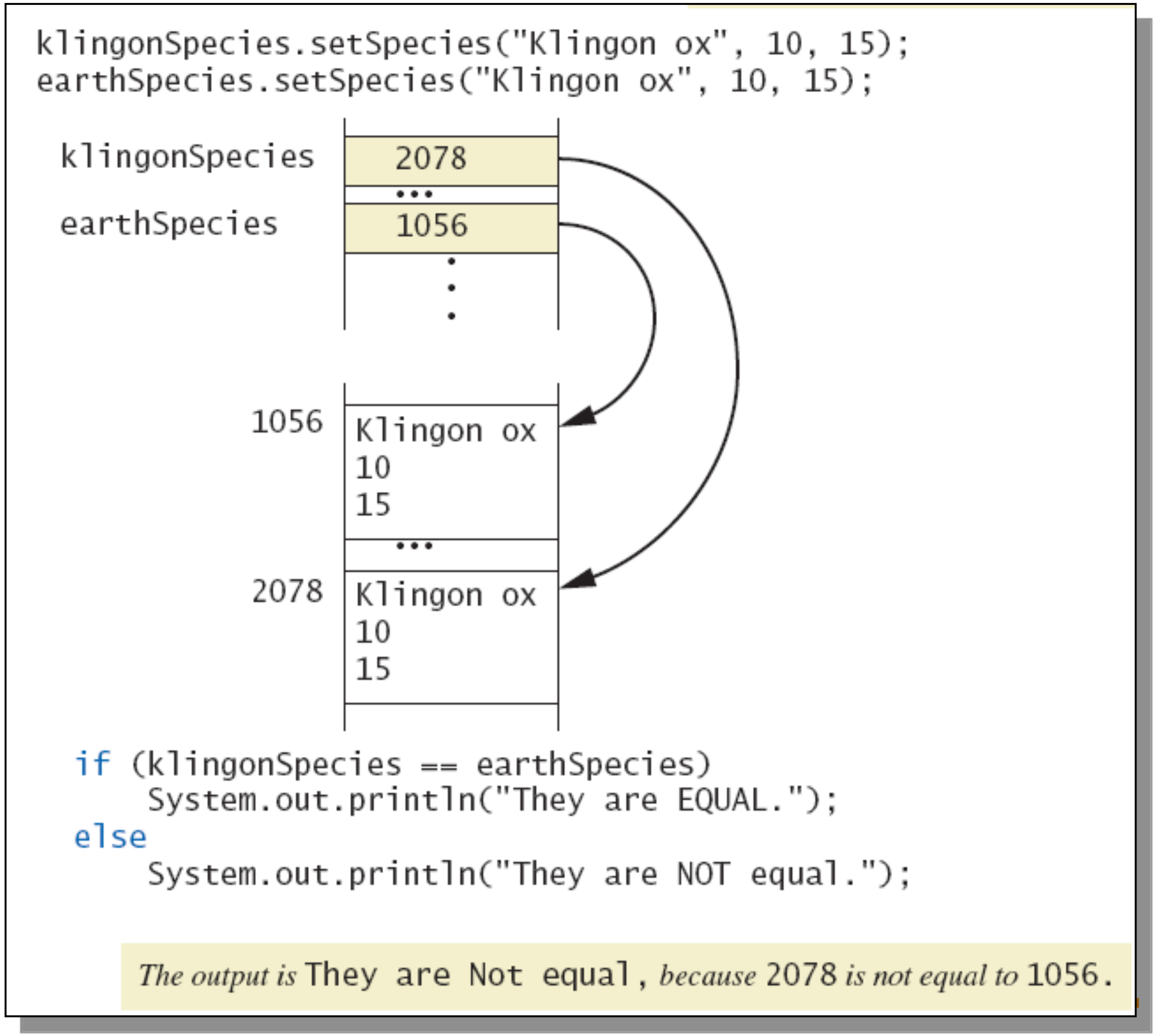


```
klingonSpecies = new SpeciesFourthTry();
earthSpecies = new SpeciesFourthTry();
```

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.

Variables of a Class Type

- Dangers of using **==** with objects



```
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`.

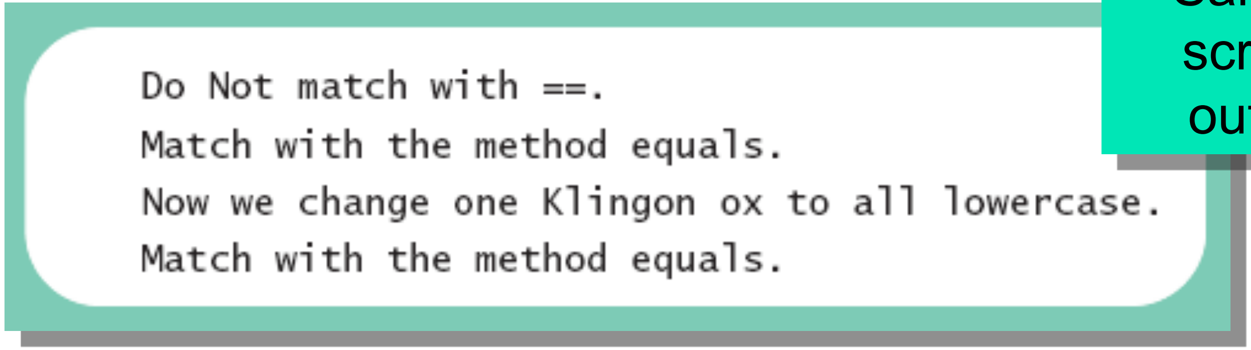
Defining an `equals` Method

- As demonstrated by previous figures
  - We cannot use == to compare two objects
  - We must write a method for a given class which will make the comparison as needed
- View sample code

  `class Species`
- The `equals` for this class method used same way as `equals` method for `String`

Demonstrating an **`equals`** Method

- View sample program, listing 5.16
  `class SpeciesEqualsDemo`
- Note difference in the two comparison methods **`==`** versus **`.equals( )`**

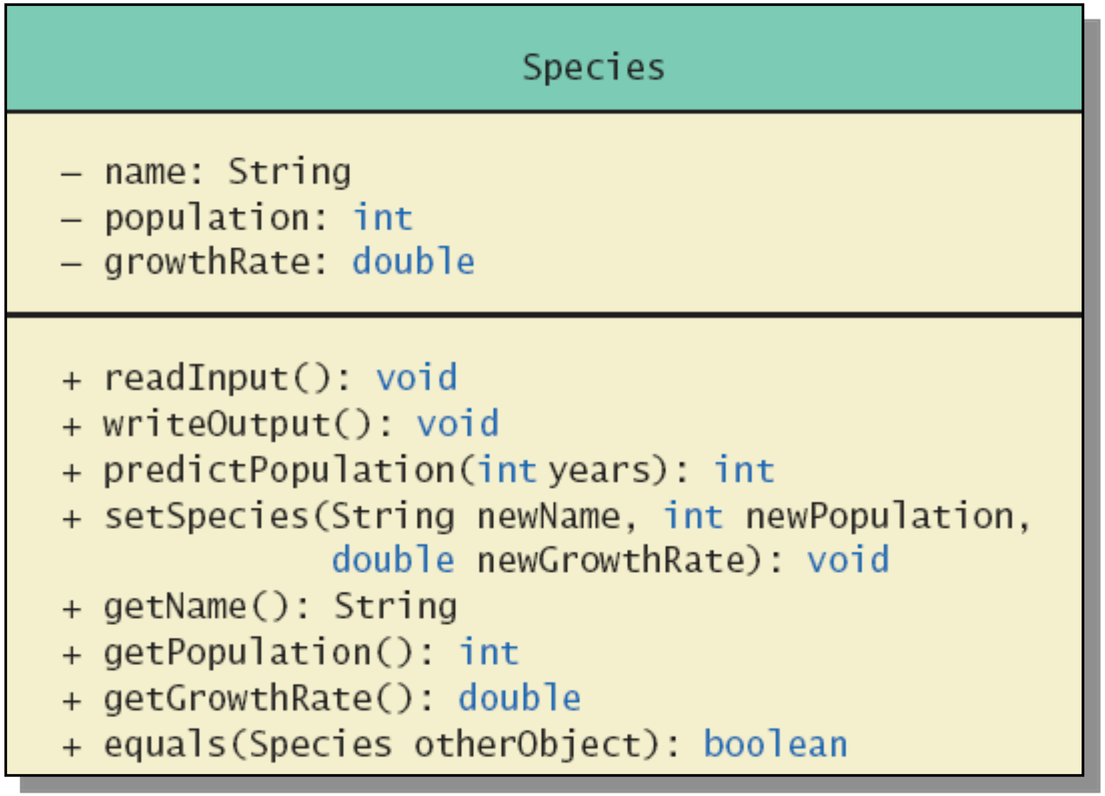


```
Do Not match with ==.
Match with the method equals.
Now we change one Klingon ox to all lowercase.
Match with the method equals.
```

Sample screen output

Programming Example

- View sample code
  class **`Species`**
- Figure 5.7
  Class Diagram
  for the class
  `Species`
  in listing 5.17



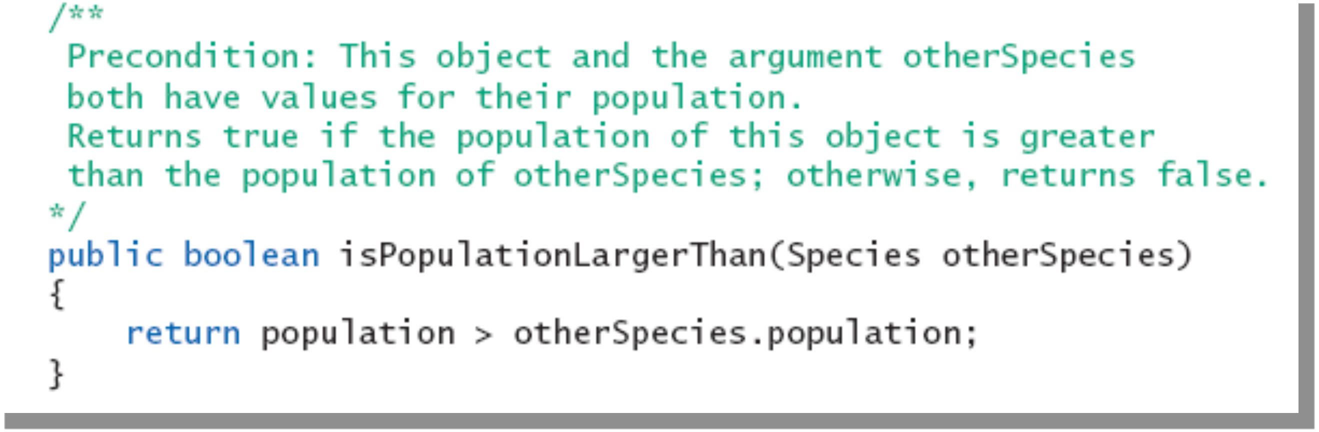
```
                    Species

 – name: String
 – population: int
 – growthRate: double

 + readInput(): void
 + writeOutput(): void
 + predictPopulation(int years): int
 + setSpecies(String newName, int newPopulation,
              double newGrowthRate): void
 + getName(): String
 + getPopulation(): int
 + getGrowthRate(): double
 + equals(Species otherObject): boolean
```

Boolean-Valued Methods

- Methods can return a value of type **`boolean`**
- Use a **`boolean`** value in the **`return`** statement
- Note method from listing 5.17



```
/**
 Precondition: This object and the argument otherSpecies
 both have values for their population.
 Returns true if the population of this object is greater
 than the population of otherSpecies; otherwise, returns false.
*/
public boolean isPopulationLargerThan(Species otherSpecies)
{
    return population > otherSpecies.population;
}
```

Parameters of a Class Type

- When assignment operator used with objects of class type
  - Only memory address is copied
- Similar to use of parameter of class type
  - Memory address of actual parameter passed to formal parameter
  - Formal parameter may access public elements of the class
  - Actual parameter thus can be changed by class methods

Programming Example

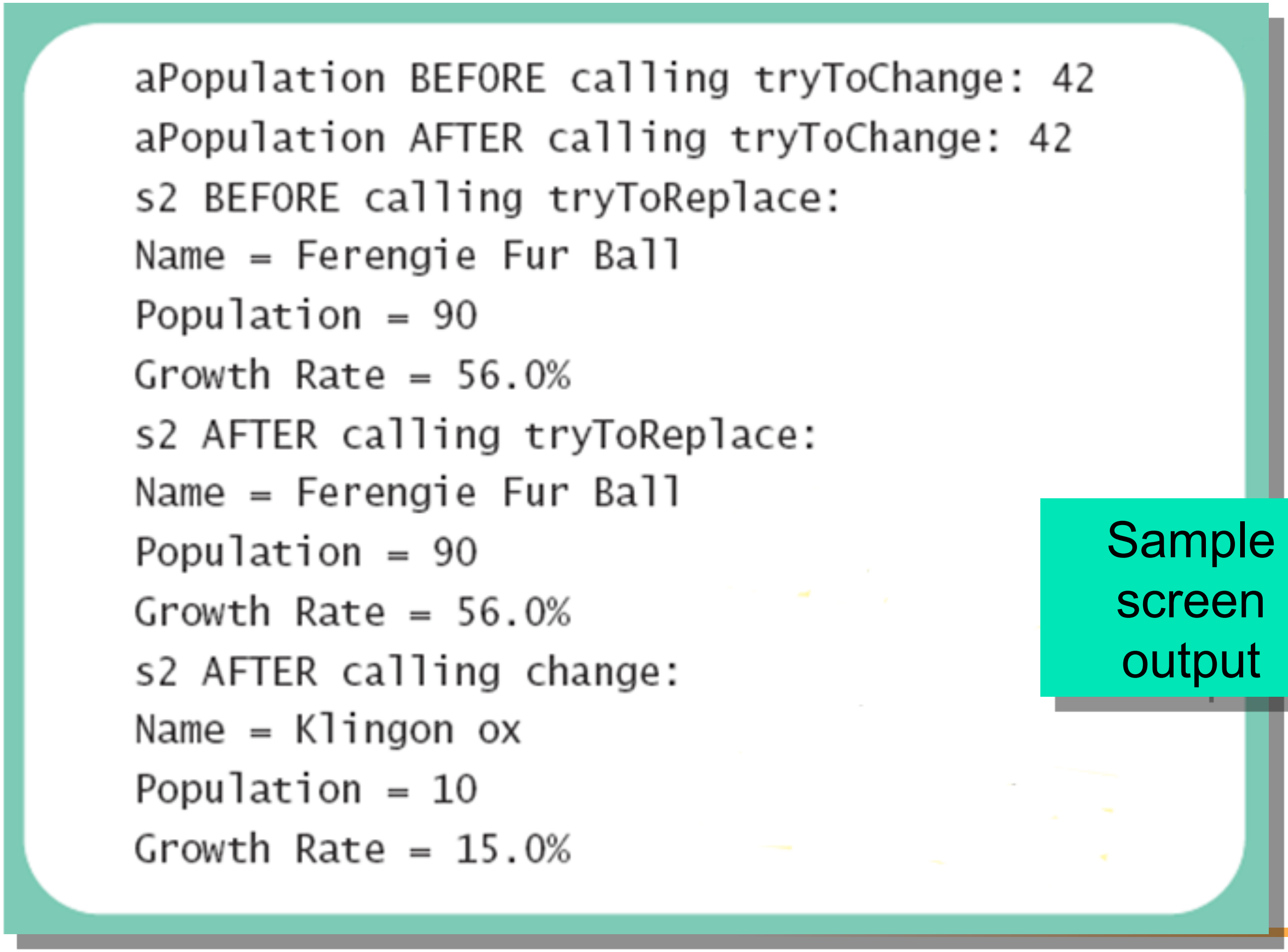
- View sample code, listing 5.18

  `class DemoSpecies`

  - Note different parameter types and results
- View sample program, listing 5.19
  - Parameters of a class type versus parameters of a primitive type

    `class ParametersDemo`

Programming Example



```
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%
```

Sample screen output

Summary

- Classes have
  - Instance variables to store data
  - Method definitions to perform actions
- Instance variables should be private
- Class needs accessor, mutator methods
- Methods may be
  - Value returning methods
  - Void methods that do not return a value

Summary

- Keyword `this` used within method definition represents invoking object
- Local variables defined within method definition
- Formal arguments must match actual parameters with respect to number, order, and data type
- Formal parameters act like local variables

Summary

- Parameter of primitive type initialized with value of actual parameter
  - Value of actual parameter not altered by method
- Parameter of class type initialized with address of actual parameter object
  - Value of actual parameter may be altered by method calls
- A method definition can include call to another method in same or different class

Summary

- Precondition comment states conditions that must be true before method invoked
- Postcondition comment describes resulting effects of method execution
- Utility program `javadoc` creates documentation
- Class designers use UML notation to describe classes
- Operators `=` and `==` behave differently with objects of class types (vs. primitive types)