Chapter 5 - Generic Programming

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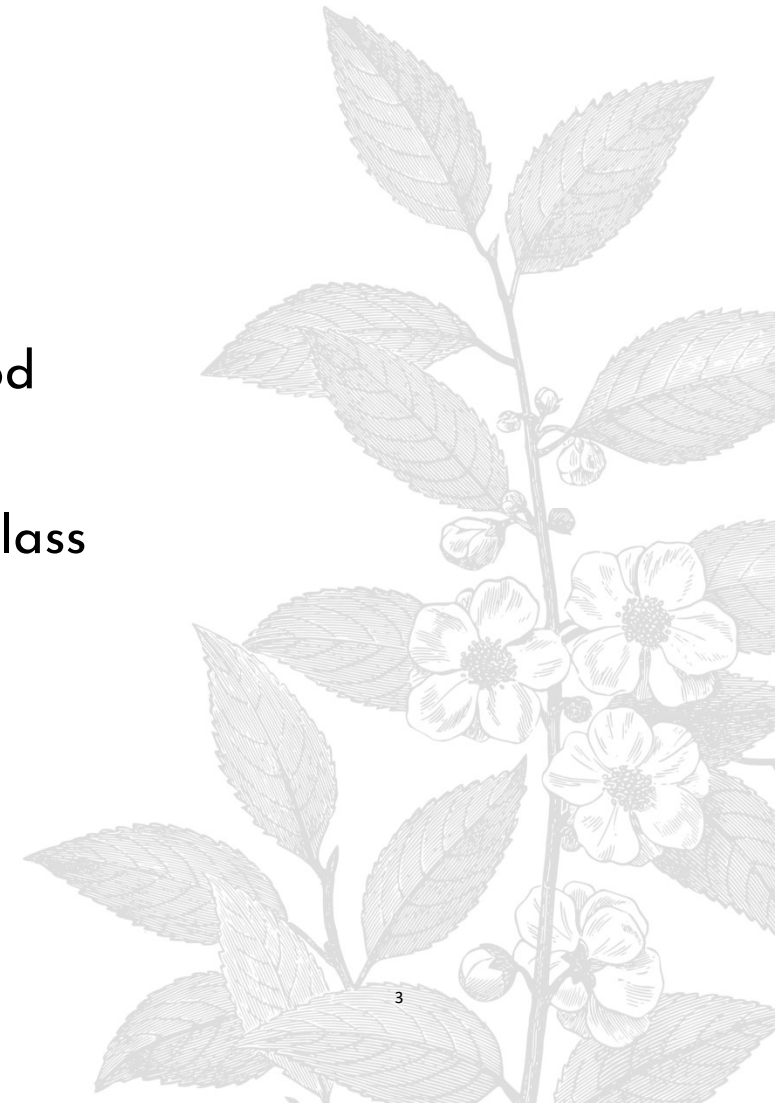
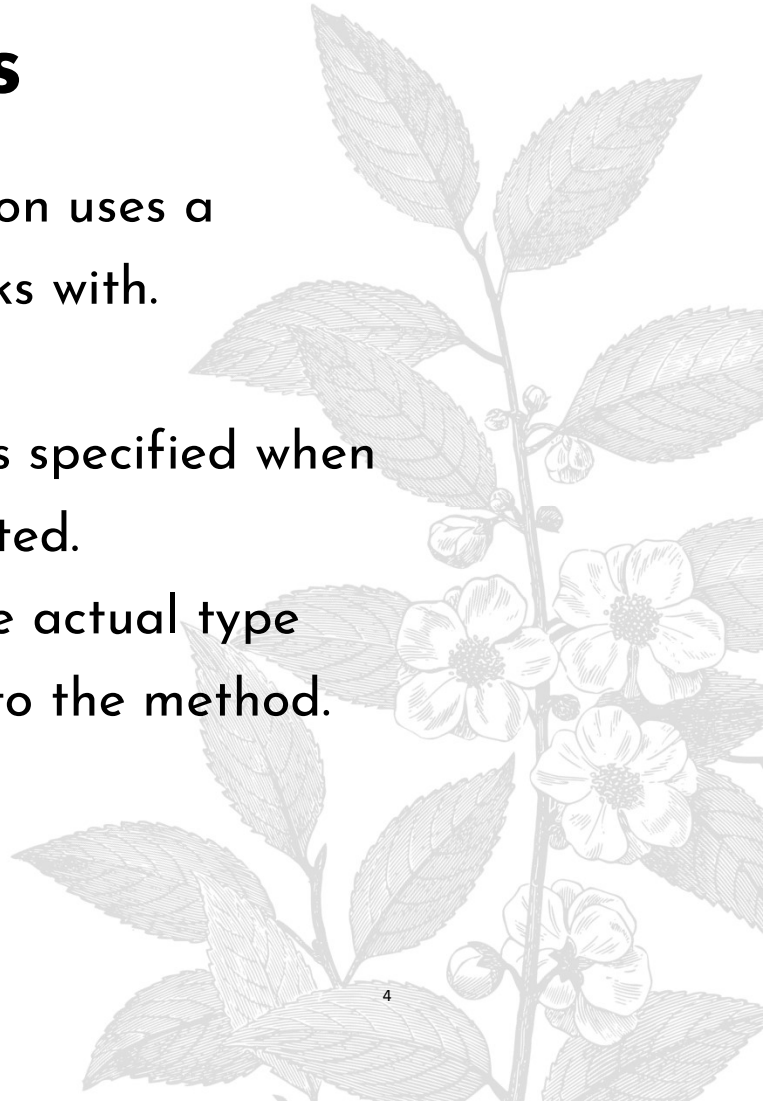
Generic Programming

- ✓Introduction to Generics
- ✓Writing a Generic Class
- ✓Passing Objects of a Generic Class to a Method
- ✓Writing Generic Methods
- ✓Constraining a Type Parameter in a Generic Class
- ✓Inheritance and Generic Classes
- ✓Defining Multiple Parameter Types
- ✓Generics and Interfaces
- ✓Restrictions of the Use of Generic Types



Generic Classes and Methods

- ✓A generic class or method is one whose definition uses a placeholder for one or more of the types it works with.
- ✓The placeholder is really a type parameter
- ✓For a generic class, the actual type argument is specified when an object of the generic class is being instantiated.
- ✓For a generic method, the compiler deduces the actual type argument from the type of data being passed to the method.



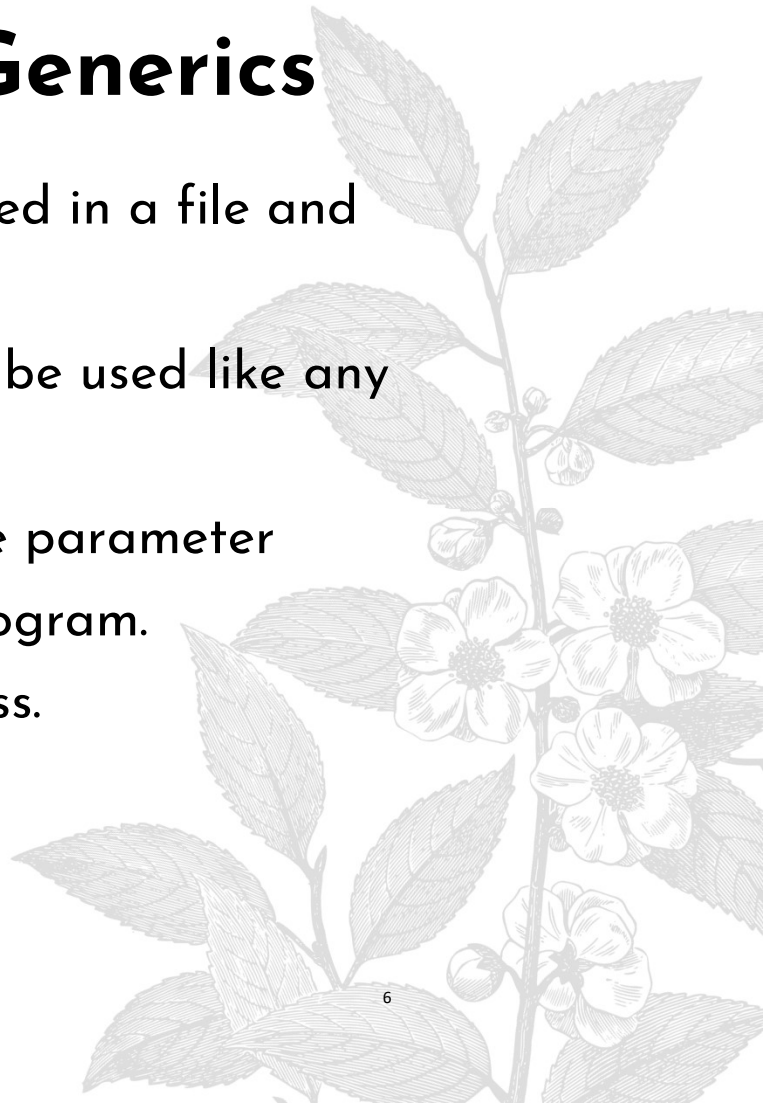
Parameterized Classes and Generics

- ✓The ArrayList class is generic: the definition of the class uses a type parameter for the type of the elements that will be stored.
  - ArrayList<String> specifies a version of the generic ArrayList class that can hold String elements only.
  - ArrayList<Integer> specifies a version of the generic ArrayList class that can hold Integer elements only.
- ✓Starting with version 5.0, Java allows class definitions with parameters for types
- ✓These classes that have type parameters are called parameterized class or generic definitions, or, simply, generics

Parameterized Classes and Generics

- ✓A class definition with a type parameter is stored in a file and compiled just like any other class.
- ✓Once a parameterized class is compiled, it can be used like any other class.
- ✓However, the class type plugged in for the type parameter must be specified before it can be used in a program.
- ✓Doing this is said to instantiate the generic class.

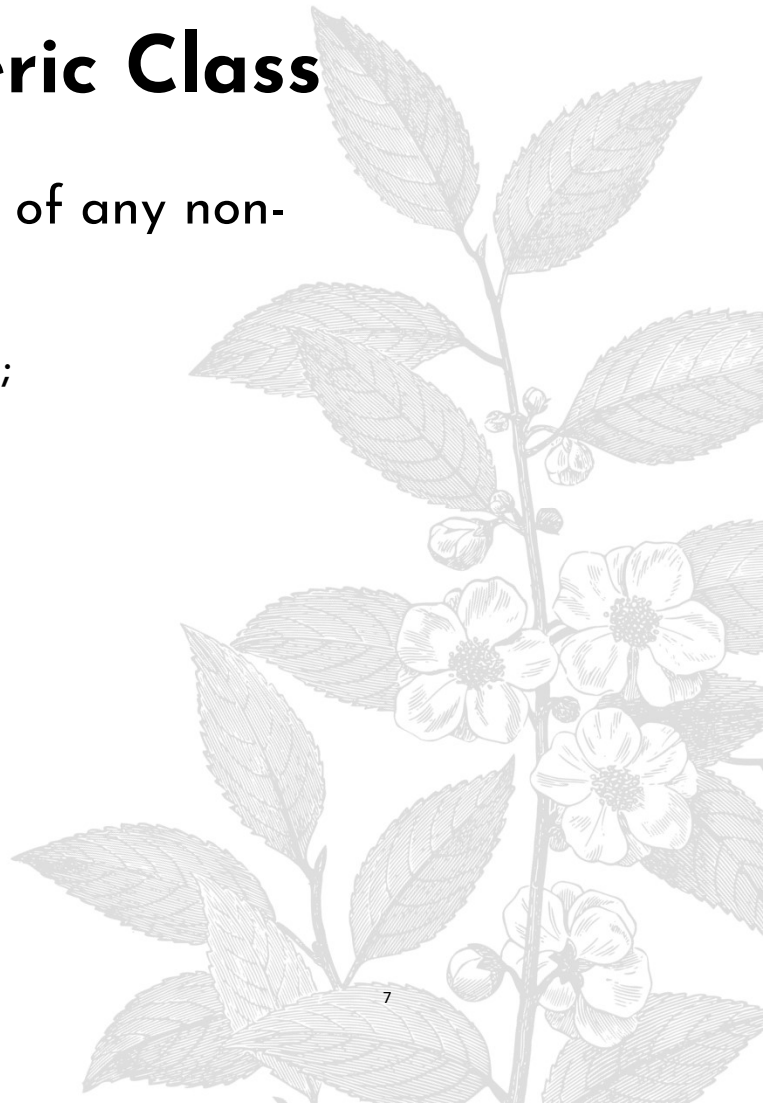
```
Sample<String> object = new Sample<String>();
```



Instantiation and Use of a Generic Class

- ✓ ArrayList<String> is used as if it was the name of any non-generic class:

```
ArrayList<String> myList = new ArrayList<String>();
myList.add("Java is fun");
String str = myList.get(0);
```



A Class Definition with a Type Parameter

Display 14.4 A Class Definition with a Type Parameter

```
1   public class Sample<T>
2   {
3       private T data;

4       public void setData(T newData)
5       {
6           data = newData;
7       }

8       public T getData()
9       {
10          return data;
11      }
12  }
```

T is a parameter for a type.

A Class Definition with a Type Parameter

- ✓A class that is defined with a parameter for a type is called a generic class or a parameterized class
- ✓The type parameter is included in angular brackets after the class name in the class definition heading.
- ✓Any non-keyword identifier can be used for the type parameter, but by convention, the parameter starts with an uppercase letter.
- ✓The type parameter can be used like other types used in the definition of a class.

Generic Class Definition: An Example

Display 14.5 A Generic Ordered Pair Class

```
1  public class Pair<T>
2  {
3      private T first;
4      private T second;

5      public Pair()
6      {
7          first = null;
8          second = null;
9      }

10     public Pair(T firstItem, T secondItem)
11     {
12         first = firstItem;
13         second = secondItem;
14     }
15     public void setFirst(T newFirst)
16     {
17         first = newFirst;
18     }

19     public void setSecond(T newSecond)
20     {
21         second = newSecond;
22     }

23     public T getFirst()
24     {
25         return first;
26     }
```

Constructor headings do not include the type parameter in angular brackets.

(continued)

Display 14.5 A Generic Ordered Pair Class

```
27      public T getSecond()
28      {
29          return second;
30      }

31      public String toString()
32      {
33          return ( "first: " + first.toString() + "\n"
34                   + "second: " + second.toString() );
35      }
36
37      public boolean equals(Object otherObject)
38      {
39          if (otherObject == null)
40              return false;
41          else if (getClass() != otherObject.getClass())
42              return false;
43          else
44          {
45              Pair<T> otherPair = (Pair<T>)otherObject;
46              return (first.equals(otherPair.first)
47                 && second.equals(otherPair.second));
48          }
49      }
50  }
```

Display 14.7 Using Our Ordered Pair Class and Automatic Boxing

```
1  import java.util.Scanner;

2  public class GenericPairDemo2
3  {
4     public static void main(String[] args)
5     {
6          Pair<Integer> secretPair =
7               new Pair<Integer>(42, 24);
8
9          Scanner keyboard = new Scanner(System.in);
10         System.out.println("Enter two numbers:");
11         int n1 = keyboard.nextInt();
12         int n2 = keyboard.nextInt();
13         Pair<Integer> inputPair =
14             new Pair<Integer>(n1, n2);
15         if (inputPair.equals(secretPair))
16         {
17             System.out.println("You guessed the secret numbers");
18             System.out.println("in the correct order!");
19         }
20         else
21         {
22             System.out.println("You guessed incorrectly.");
23             System.out.println("You guessed");
24             System.out.println(inputPair);
25             System.out.println("The secret numbers are");
26             System.out.println(secretPair);
27         }
28    }
29 }
```

Automatic boxing allows you to use an `int` *argument for an* `Integer` *parameter.*

A Generic Constructor

- ✓Although the class name in a parameterized class definition has a type parameter attached, the type parameter is not used in the heading of the constructor definition:

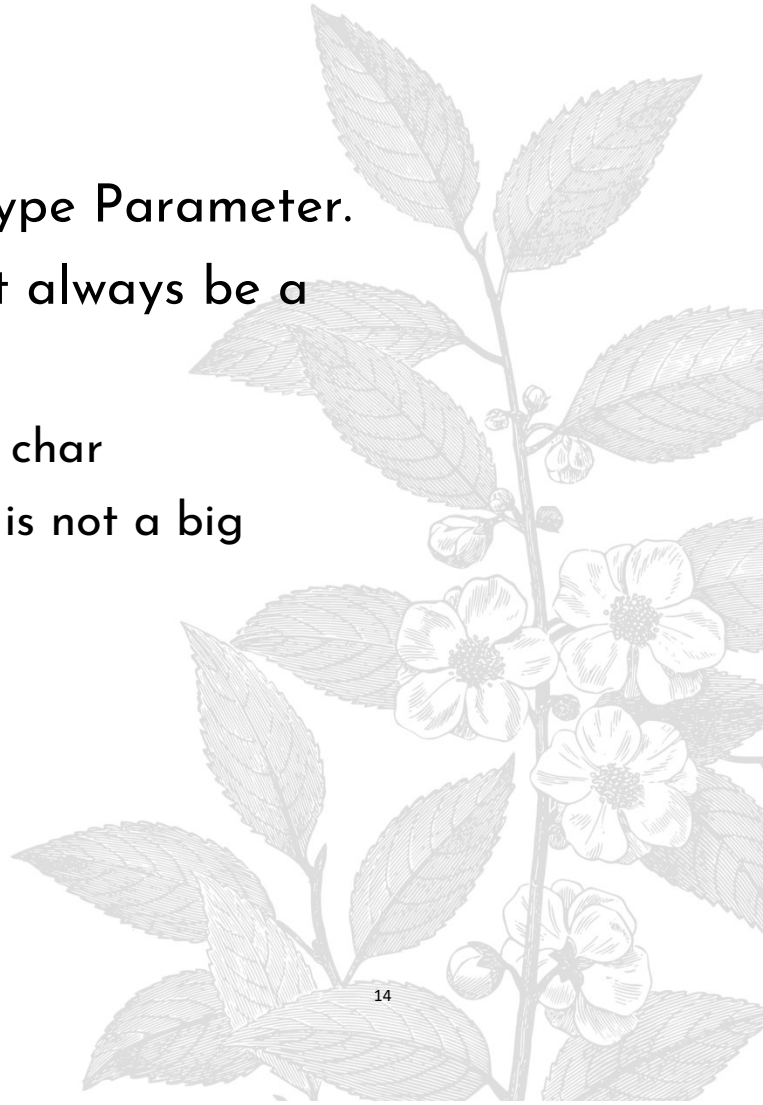
  public Pair<T>()
- ✓A constructor can use the type parameter as the type for a parameter of the constructor, but in this case, the angular brackets are not used:

  public Pair(T first, T second)
- ✓However, when a generic class is instantiated, the angular brackets are used:

  Pair<String> pair = new Pair<STring>("Happy", "Day");

A Primitive Type

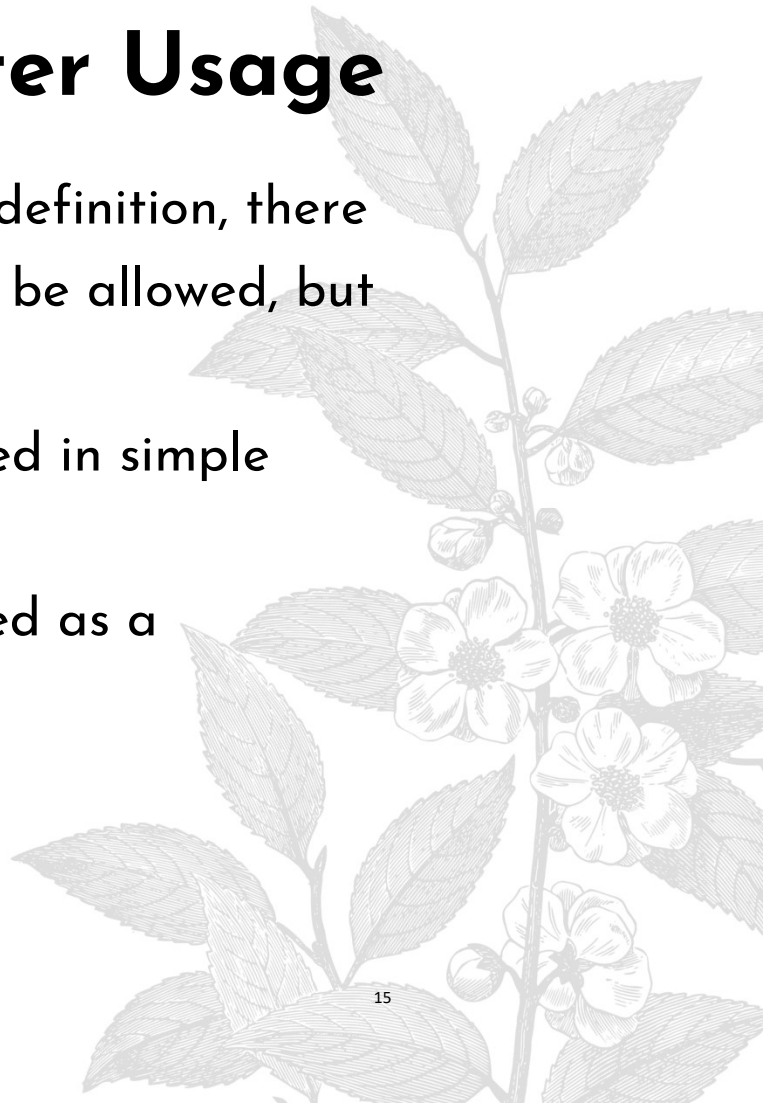
- ✓A Primitive Type Cannot be Plugged in for a Type Parameter.
- ✓The type plugged in for a type parameter must always be a reference type:
  - It cannot be a primitive type such as int, double, or char
  - However, now that Java has automatic boxing, this is not a big restriction.



Limitations on Type Parameter Usage

- ✓Within the definition of a parameterized class definition, there are places where an ordinary class name would be allowed, but a type parameter is not allowed.
- ✓In particular, the type parameter cannot be used in simple expressions using new to create a new object
- ✓For instance, the type parameter cannot be used as a constructor name or like a constructor:

```
T object = new T();
T[] a = new T[10];
```

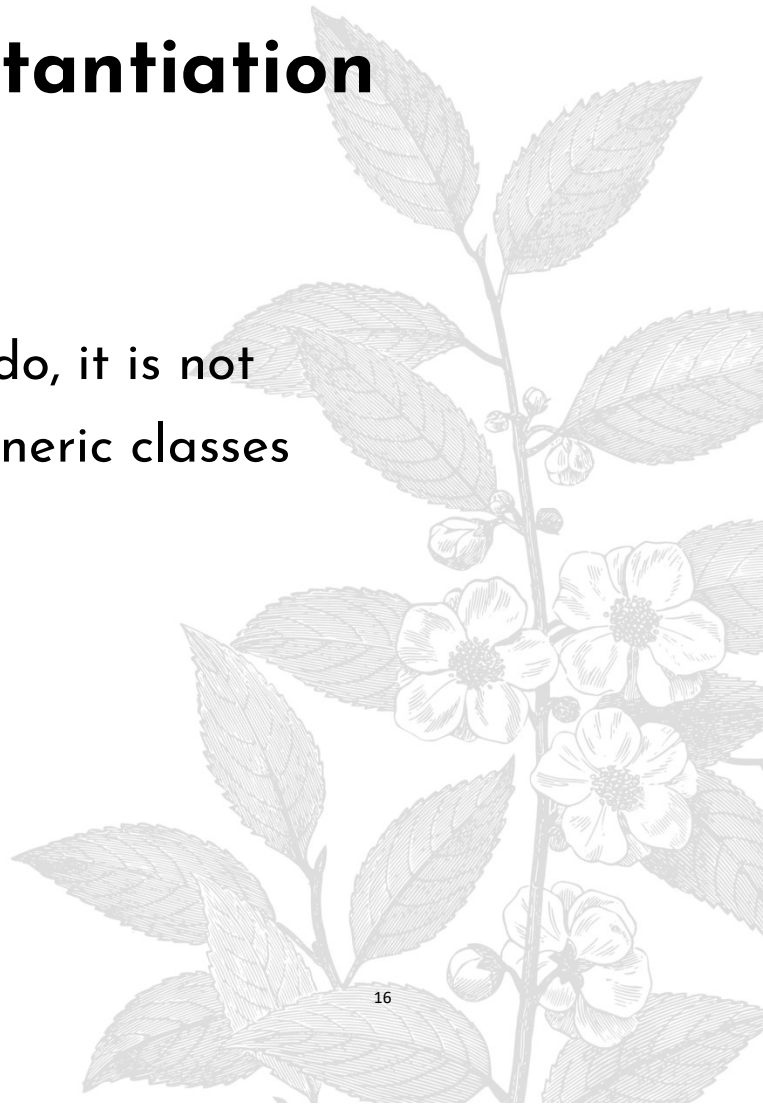


Limitations on Generic Class Instantiation

- ✓Arrays such as the following are illegal:

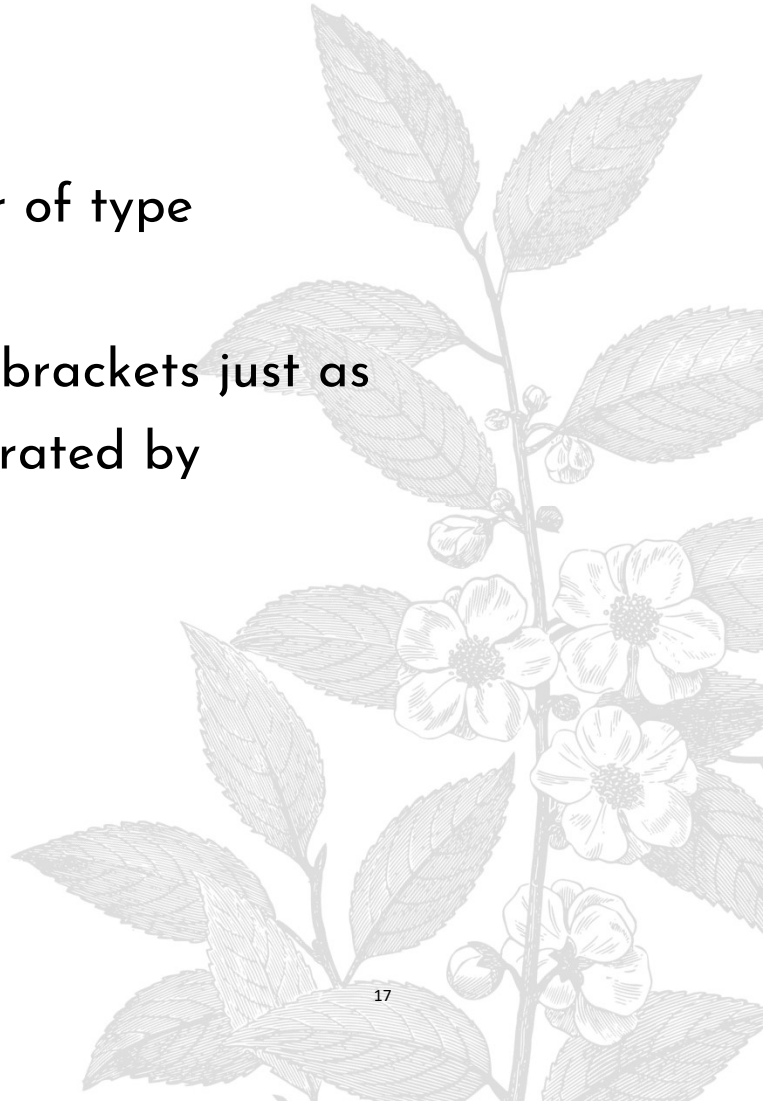
  Pair<String>[] a = new Pair<String>[10];

- ✓Although this is a reasonable thing to want to do, it is not allowed given the way that Java implements generic classes



Multiple Type Parameters

- ✓A generic class definition can have any number of type parameters.
- ✓Multiple type parameters are listed in angular brackets just as in the single type parameter case, but are separated by commas.



Multiple Type Parameters

Display 14.8 Multiple Type Parameters

```
1  public class TwoTypePair<T1, T2>
2  {
3      private T1 first;
4      private T2 second;

5      public TwoTypePair()
6      {
7          first = null;
8          second = null;
9      }

10     public TwoTypePair(T1 firstItem, T2 secondItem)
11     {
12         first = firstItem;
13         second = secondItem;
14     }
15     public void setFirst(T1 newFirst)
16     {
17         first = newFirst;
18     }

19     public void setSecond(T2 newSecond)
20     {
21         second = newSecond;
22     }

23     public T1 getFirst()
24     {
25         return first;
26     }
```

(continued)

Display 14.8 Multiple Type Parameters

```
27      public T2 getSecond()
28      {
29          return second;
30      }

31      public String toString()
32      {
33          return ( "first: " + first.toString() + "\n"
34                   + "second: " + second.toString() );
35      }
36
37      public boolean equals(Object otherObject)
38      {
39          if (otherObject == null)
40              return false;
41          else if (getClass() != otherObject.getClass())
42              return false;
43          else
44          {
45              TwoTypePair<T1, T2> otherPair =
46                          (TwoTypePair<T1, T2>)otherObject;
47              return (first.equals(otherPair.first)
48                  && second.equals(otherPair.second));
49          }
50      }
51  }
```

The first `equals` *is the* `equals` *of the type* `T1`*. The second* `equals` *is the* `equals` *of the type* `T2`*.*

Display 14.9 Using a Generic Class with Two Type Parameters

```
1  import java.util.Scanner;

2  public class TwoTypePairDemo
3  {
4     public static void main(String[] args)
5     {
6          TwoTypePair<String, Integer> rating =
7               new TwoTypePair<String, Integer>("The Car Guys", 8);

8          Scanner keyboard = new Scanner(System.in);
9          System.out.println(
10                    "Our current rating for " + rating.getFirst());
11         System.out.println(" is " + rating.getSecond());

12         System.out.println("How would you rate them?");
13         int score = keyboard.nextInt();
14         rating.setSecond(score);
15         System.out.println(
16                    "Our new rating for " + rating.getFirst());
17         System.out.println(" is " + rating.getSecond());
18    }
19 }
```

Program Output:

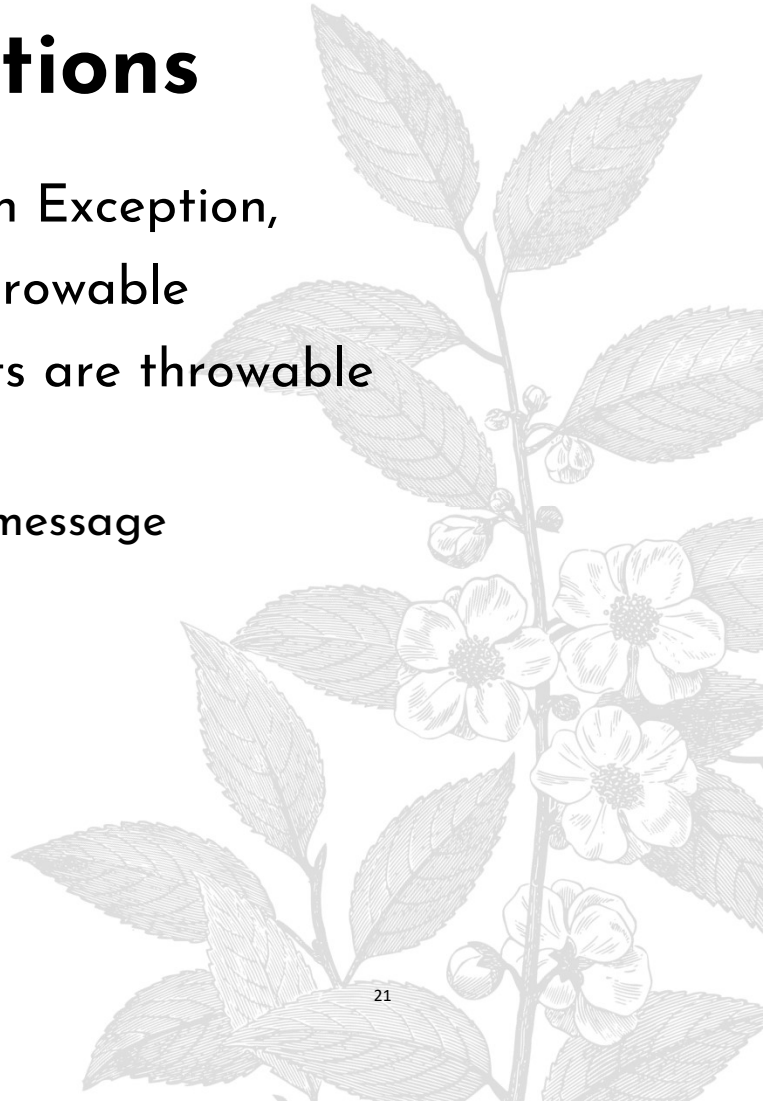
SAMPLE DIALOGUE

```
Our current rating for The Car Guys
is 8
How would you rate them?
10
Our new rating for The Car Guys
is 10
```

A Generic Classes and Exceptions

- ✓It is not permitted to create a generic class with Exception, Error, Throwable, or any descendent class of Throwable
- ✓A generic class cannot be created whose objects are throwable

  public class GEx<T> extends Exception
  - The above example will generate a compiler error message



Bounds for Type Parameters

- ✓Sometimes it makes sense to restrict the possible types that can be plugged in for a type parameter T.
- ✓For instance, to ensure that only classes that implement the Comparable interface are plugged in for T, define a class as follows:

  public class RClass<T extends Comparable>
- ✓"extends Comparable" serves as a bound on the type parameter T.
- ✓Any attempt to plug in a type for T which does not implement the Comparable interface will result in a compiler error message.

Bounds for Type Parameters

- ✓A bound on a type may be a class name (rather than an interface name)
- ✓Then only descendent classes of the bounding class may be plugged in for the type parameters:
  public class ExClass<T extends Class1>
- ✓A bounds expression may contain multiple interfaces and up to one class.
- ✓If there is more than one type parameter, the syntax is as follows:
  public class Two<T1 extends Class1, T2 extends Class2 & Comparable>

Bounds for Type Parameters

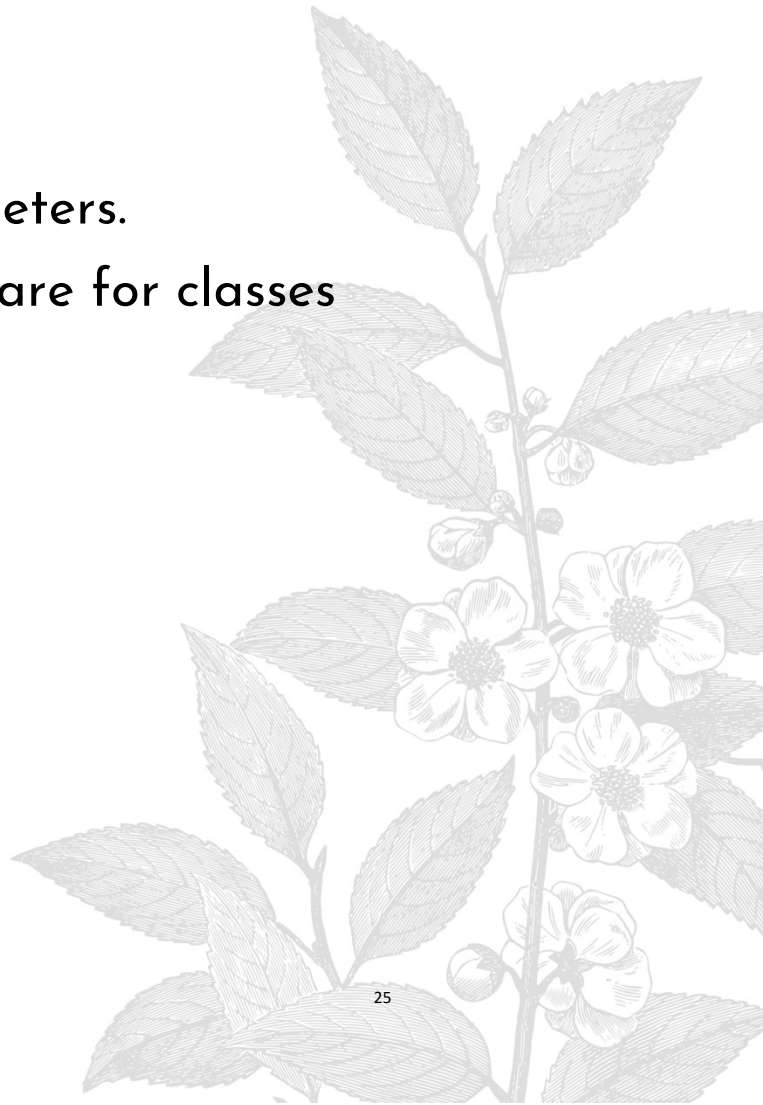
Display 14.10 A Bounded Type Parameter

```
1   public class Pair<T extends Comparable>
2   {
3       private T first;
4       private T second;

5       public T max()
6       {
7           if (first.compareTo(second) <= 0)
8               return first;
9           else
10              return second;
11      }
```

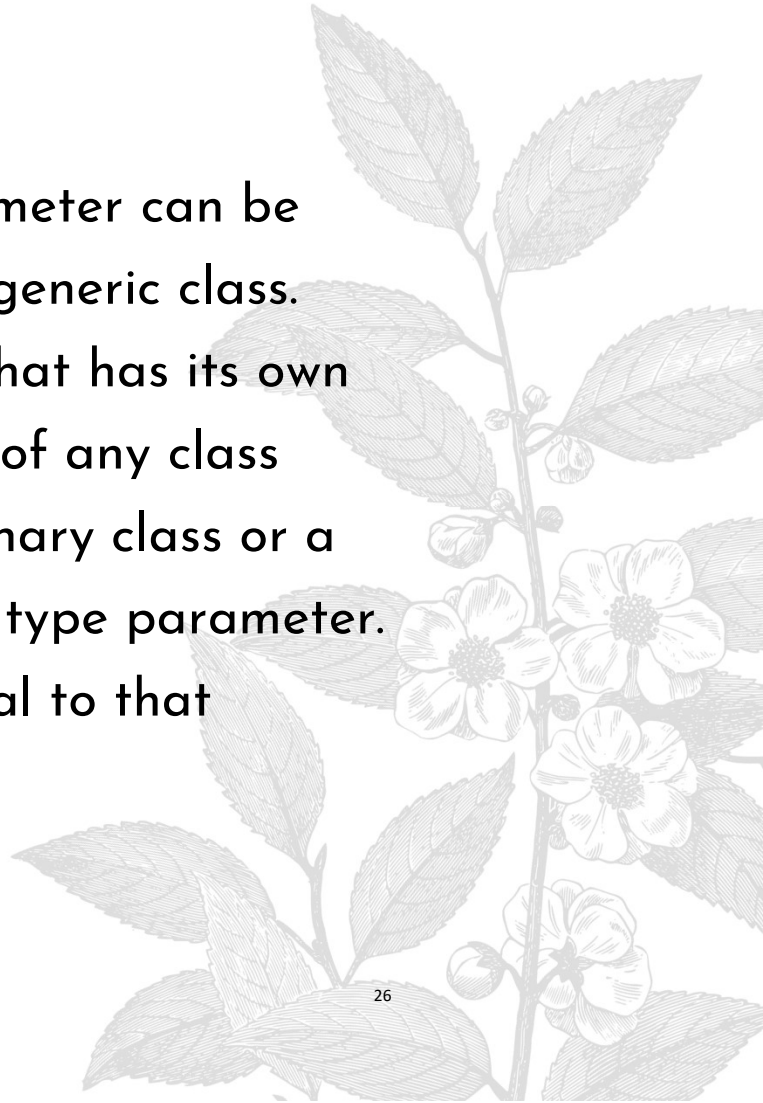
Generic Interfaces

- ✓An interface can have one or more type parameters.
- ✓The details and notation are the same as they are for classes with type parameters.



Generic Methods

- ✓When a generic class is defined, the type parameter can be used in the definitions of the methods for that generic class.
- ✓In addition, a generic method can be defined that has its own type parameter that is not the type parameter of any class
- ✓A generic method can be a member of an ordinary class or a member of a generic class that has some other type parameter.
- ✓The type parameter of a generic method is local to that method, not to the class.



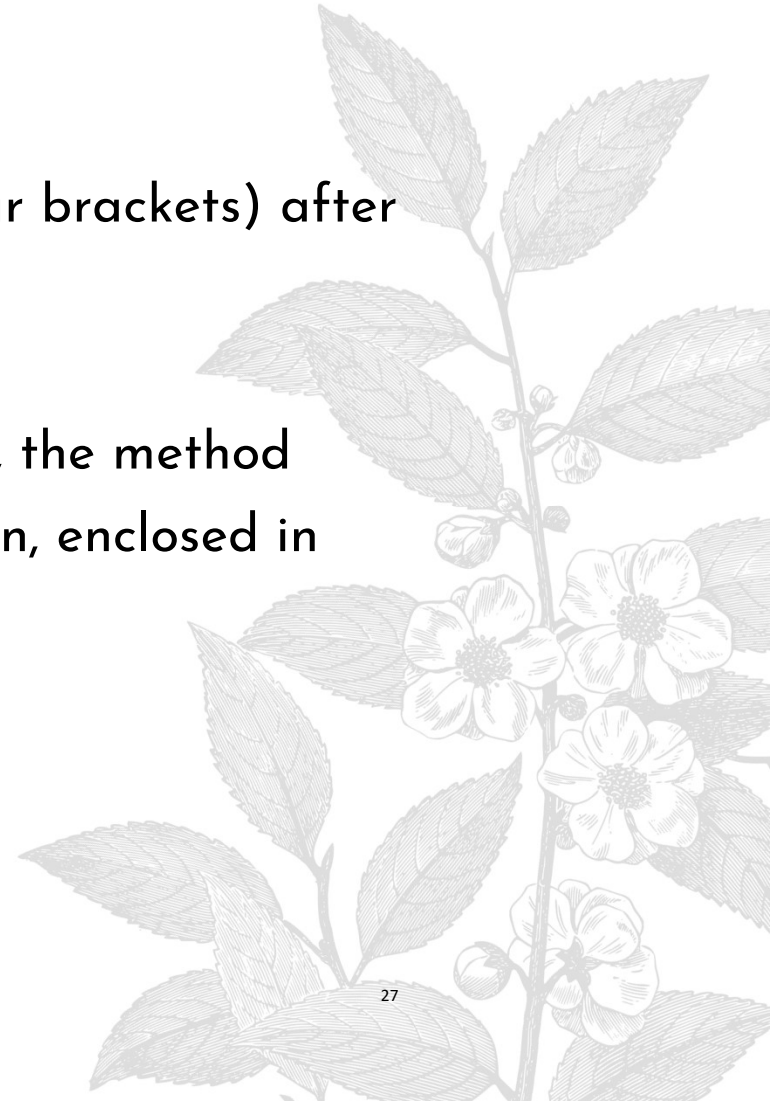
Generic Methods

- ✓The type parameter must be placed (in angular brackets) after all the modifiers, and before the returned type:

  public static <T> T genMethod(T[] a)

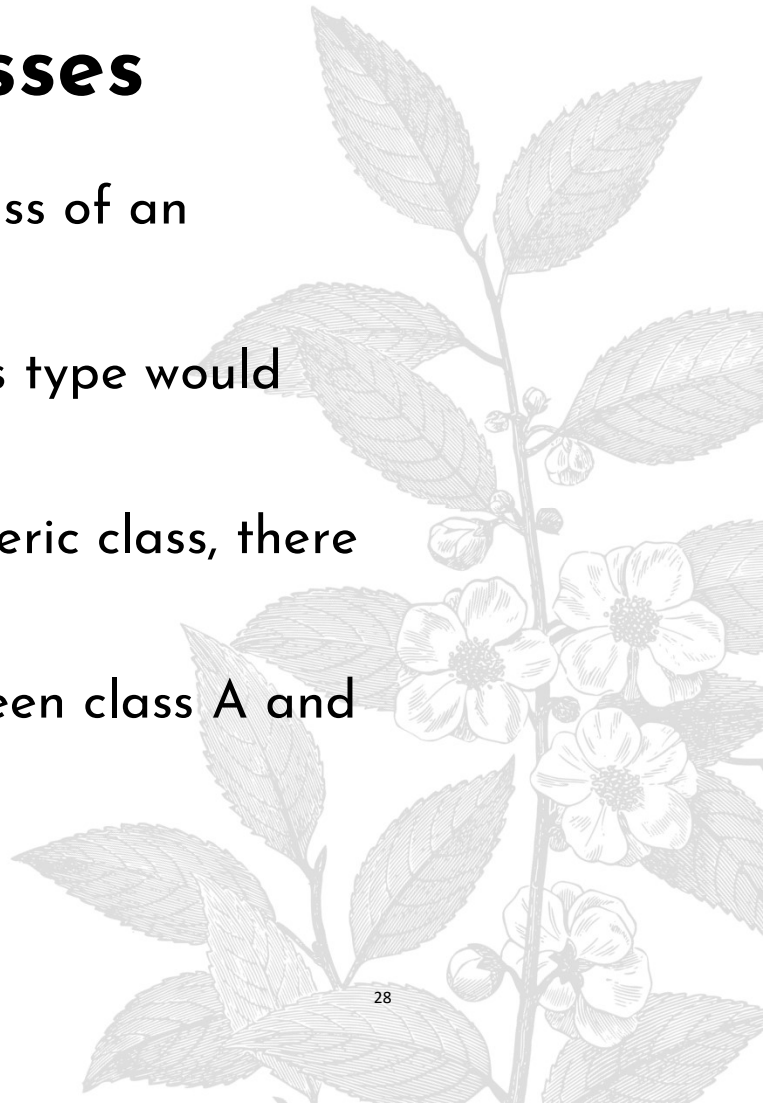
- ✓When one of these generic methods is invoked, the method name is prefaced with the type to be plugged in, enclosed in angular brackets

  String s = NonG.<String>genMethod(c);



Inheritance with Generic Classes

- ✓A generic class can be defined as a derived class of an ordinary class or of another generic class
- ✓As in ordinary classes, an object of the subclass type would also be of the superclass type
- ✓Given two classes: A and B, and given G: a generic class, there is no relationship between G<A> and G<B>
- ✓This is true regardless of the relationship between class A and B, e.g., if class B is a subclass of class A



Type Parameter Naming Conventions

- ✓By convention, type parameter names are single, uppercase letters.
- ✓The most commonly used type parameter names are:
  - E - Element (used extensively by the Java Collections Framework)
  - K - Key
  - N - Number
  - T - Type
  - V - Value