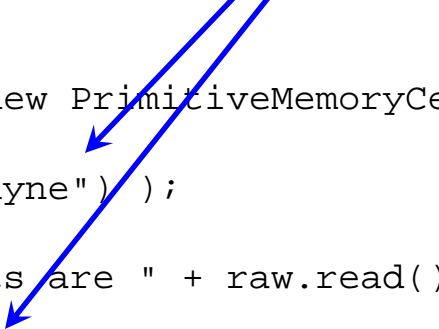


```
public class PrimitiveMemoryCell {  
    private Object storedValue;  
  
    public Object read() {  
        return storedValue;  
    }  
  
    public void write( Object x ) {  
        storedValue = x;  
    }  
}
```

PrimitiveMemoryCell is an old-style Java "generic" class.

Used without a parameter, we obtain a very flexible storage unit... so flexible that it could hold anything at all...

```
. . .  
PrimitiveMemoryCell raw = new PrimitiveMemoryCell ();  
raw.write( new String("anodyne") );  
System.out.println("Contents are " + raw.read());  
raw.write( new Integer(100) );  
System.out.println("Contents are " + raw.read());
```



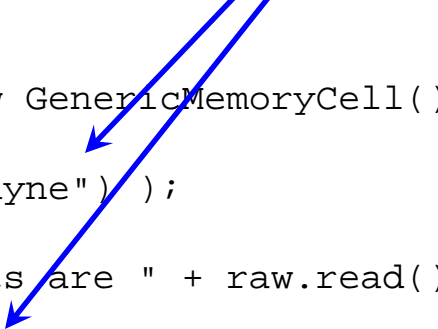
# Simple Formal Java Generic Class

```
public class GenericMemoryCell<T> {  
    private T storedValue;  
  
    public T read() {  
        return storedValue;  
    }  
  
    public void write( T x ) {  
        storedValue = x;  
    }  
}
```

GenericMemoryCell is a formal Java generic class.

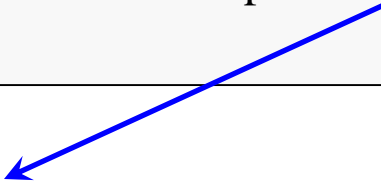
Used without a parameter, we still obtain a very flexible storage unit... so flexible that it could hold anything at all...

```
. . .  
GenericMemoryCell raw = new GenericMemoryCell();  
raw.write( new String("anodyne") );  
System.out.println("Contents are " + raw.read());  
raw.write( new Integer(100) );  
System.out.println("Contents are " + raw.read());
```



But, used with a parameter, we can create a parameterized Java class:

```
. . .  
GenericMemoryCell<String> MC = new GenericMemoryCell<String>();  
MC.write( new String("anodyne") );  
System.out.println("Contents are " + MC.read());
```



Operations on the object MC are type-checked at compile time to be sure we are only using MC to store objects of type String.

```
MC.write( new Integer(100) );
```

```
exGMC.java:9: write(java.lang.String) in  
GenericMemoryCell<java.lang.String>  
cannot be applied to (java.lang.Integer)  
MC.write( new Integer(100) );
```

The `contains()` method can be used to search an array holding objects of any type.

```
public static <T> boolean contains( T[] array, T x) {  
  
    for ( T value : array ) {  
        if ( x.equals(value) )  
            return true;  
    }  
    return false;  
}
```

```
Integer[] array = new Integer[10];  
for (int pos = 0; pos < 10; pos++) {  
    array[pos] = pos * pos;  
}  
  
if ( contains( array, new Integer(15) ) ) {  
    System.out.println("Found value in array.");  
}  
else {  
    System.out.println("Could not find value in array.");  
}
```

```
public static <T> T findMax( T[] array) {  
  
    int maxIndex = 0;  
  
    for ( int i = 1; i < array.length; i++) {  
  
        if ( array[i].compareTo(array[maxIndex]) > 0 )  
            maxIndex = i;  
    }  
  
    return array[maxIndex];  
}
```

```
D:\Summer2010\3114\Notes\Code\Generics>javac exFindMax1.java  
exFindMax1.java:20: cannot find symbol  
symbol   : method compareTo(T)  
location: class java.lang.Object  
        if ( array[i].compareTo(array[maxIndex]) > 0 )  
                        ^  
1 error
```

Problem:

There is no way for the Java compiler to know that the generic type `T` will represent an actual type that implements the method `compareTo()` used in the test within the loop.

So, this will not do...

```
public static <T extends Comparable<T> > T findMax( T[] array) {  
  
    int maxIndex = 0;  
  
    for ( int i = 1; i < array.length; i++) {  
  
        if ( array[i].compareTo(array[maxIndex]) > 0 )  
            maxIndex = i;  
    }  
  
    return array[maxIndex];  
}
```

This restricts the type parameter T to be a type that implements the interface Comparable<T>, guaranteeing that the call to compareTo ( ) is valid.

```
public static <T extends Comparable<T> > T findMax( T[] array) {  
  
    int maxIndex = 0;  
  
    for ( int i = 1; i < array.length; i++) {  
  
        if ( array[i].compareTo(array[maxIndex]) > 0 )  
            maxIndex = i;  
    }  
  
    return array[maxIndex];  
}
```

## Problem:

Suppose that Shape implements Comparable<Shape>, and that Square extends Shape, so that we know Square implements Comparable<Shape>.

Then Square would not satisfy the condition used above, even though the necessary method is, in fact, available.

So, this will not do... in all cases...

```
public static <T extends Comparable<? super T> > T findMax( T[] array) {  
  
    int maxIndex = 0;  
  
    for ( int i = 1; i < array.length; i++) {  
  
        if ( array[i].compareTo(array[maxIndex]) > 0 )  
            maxIndex = i;  
    }  
  
    return array[maxIndex];  
}
```

We need a restriction that allows T to be derived from a superclass that itself implements Comparable( )...

The bound used here does so...



```
public static <T extends Comparable<? super T> > T findMax( T[] array) {  
  
    . . .  
}
```

## Wildcards:

The symbol ' ? ' is a *wildcard*.

A wildcard represents an arbitrary class, and is followed by a restriction.

In this case, the restriction is that the arbitrary class must be a superclass of T.

So, this says that T must extend a base class X which is-a Comparable<X>.

So, T is-a Comparable<X>.

So, T implements the required method and all is well.

The compiler translates generic and parameterized types by a technique called *type erasure*.

Basically, it elides all information related to type parameters and type arguments.

For instance, the parameterized type `List<String>` is translated to type `List`, which is the so-called *raw type*.


The same happens for the parameterized type `List<Long>`; it also appears as `List` in the bytecode.

After translation by type erasure, all information regarding type parameters and type arguments has disappeared.

As a result, all instantiations of the same generic type share the same runtime type, namely the raw type.

The use of type erasure limits the usefulness\* of formal Java generics. For example:

```
public class Foo<T> {  
    private T[] array;           // fine  
  
    public Foo(int Sz) {  
        T[] array = new T[Sz];  
    }  
}
```



Illegal:

When the code is compiled, T will be replaced by its bound (which may be merely Object).

The compiler also auto-generates a typecast for the return value from new.

The typecast will fail because Object [ ] is-not-a T [ ].

**\*vs C++ templates**