Java Generics

Slides derived from the work of
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Arrays Class

Provides, among other things, static methods for sorting primitive arrays of different types (byte, char, int, double)

- Problems with this?

Arrays Class

Problems with this?

- Separate implementation for each type
- Each new type needs a new implementation

Solutions?

Arrays Class

Solutions?

- Could provide a static method that sorts an array of Objects
- But what does it mean to compare two arbitrary Objects so that we can establish an ordering between them?
  - For example a String and an Integer?

We really need a way of talking generically about a homogeneous array of Objects

Java Generics

- A type becomes a parameter to a class and/or a method:

```
public ClassName<T>{
    :
}
```

- T is the variable type that is assigned when we use the class
- Within the class definition, we can “pretend” that it is a real type (parameters, variable declarations and return types)

GenericQueue example …

Standard Generic Type Names

- E - Element (used extensively by the Java Collections Framework)
- K - Key
- N - Number
- T - Type
- V – Value

Notes

- Lab 7 deadline is Sunday
- No office hours on Friday
  - We are still available for appointments and for email
- Exam II: now on Nov 4 (from Nov 2)
- Project 3 deadline: now Nov 2 (from Nov 4)

Advantages of Generics

- Code reuse
  - ArrayList, Java Collections Framework
- Specific types are checked at compile time (as opposed to everything having to be an Object)
  - Reduces runtime errors
- Easier to read and understand code when we can be very explicit about types

Notes

- Primitive types cannot be used as generic types
  - Must use the wrapper classes
- Type erasure: generics are checked at compile time, not at runtime
  - This decision was driven to maintain backward compatibility
  - Not a serious issue most of the time

Implications of Type Erasure

- Cannot construct objects of type E

```
E myData = new E();  // illegal code
```

- Cannot construct arrays of type E

```
E[] elements = new E[capacity]; // illegal
```

  - Solution to the latter: create an array of objects and then cast to array of E

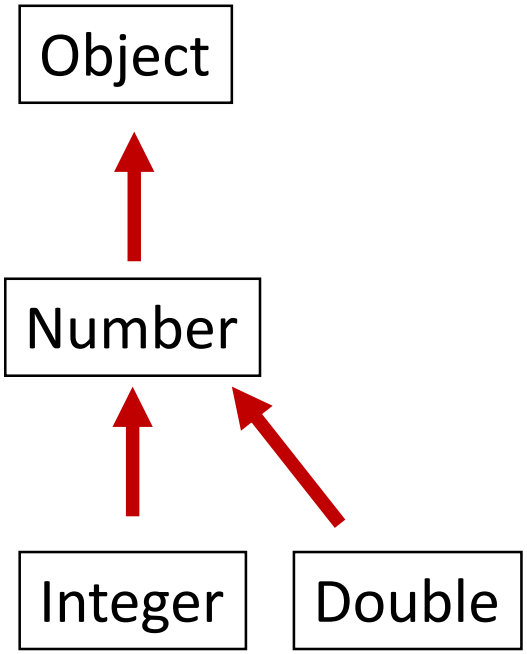
Implications of Type Erasure

- instanceof() cannot distinguish same class with different generic, because it is done at run time
  - ArrayList<Integer> and ArrayList<String> are the same type using instanceof
- Exception classes cannot be generic
- Static data cannot be of a generic type

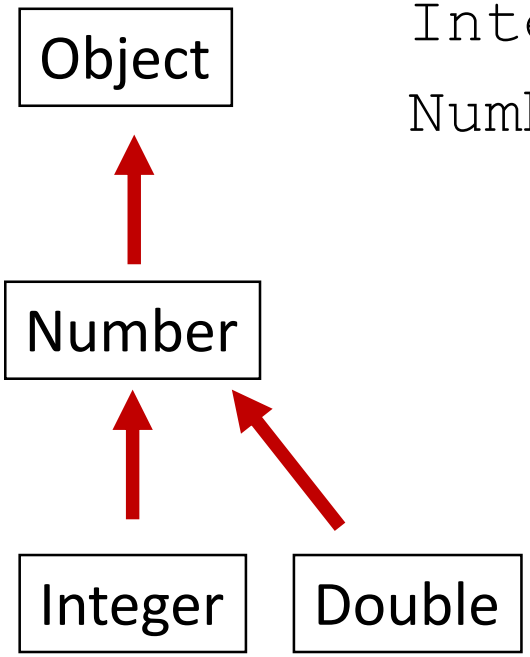
Inheritance and Generics

- In many situations, we might have more than one generic type as part of a class or method definition
- These could be arbitrary types or we might want them to have some specific relationship
  - For example: we might want T1 to be a superclass of T2

Class Hierarchies

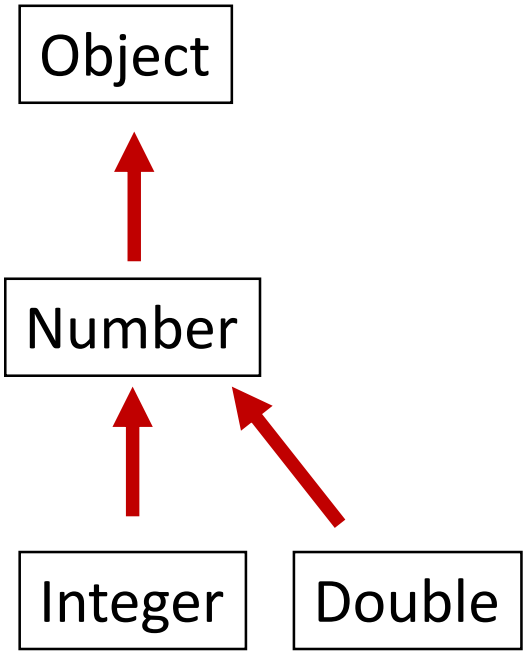


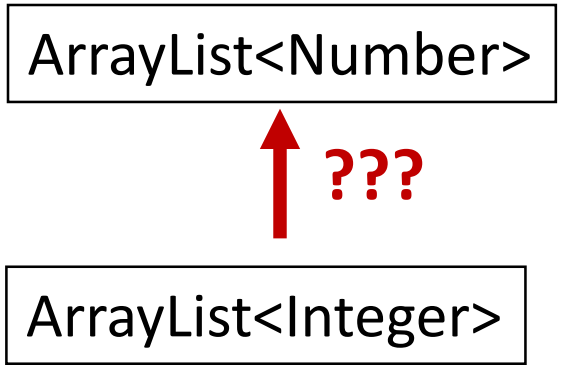
Class Hierarchies




```
Integer i = new Integer(42);
Number n = new Integer(1138);
```

Class Hierarchies





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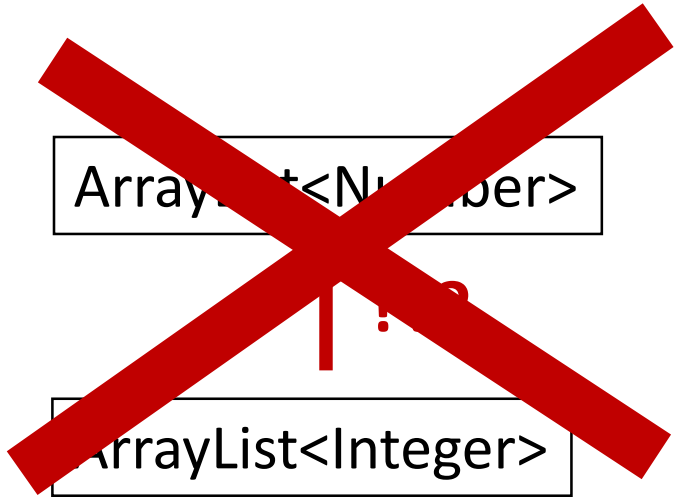
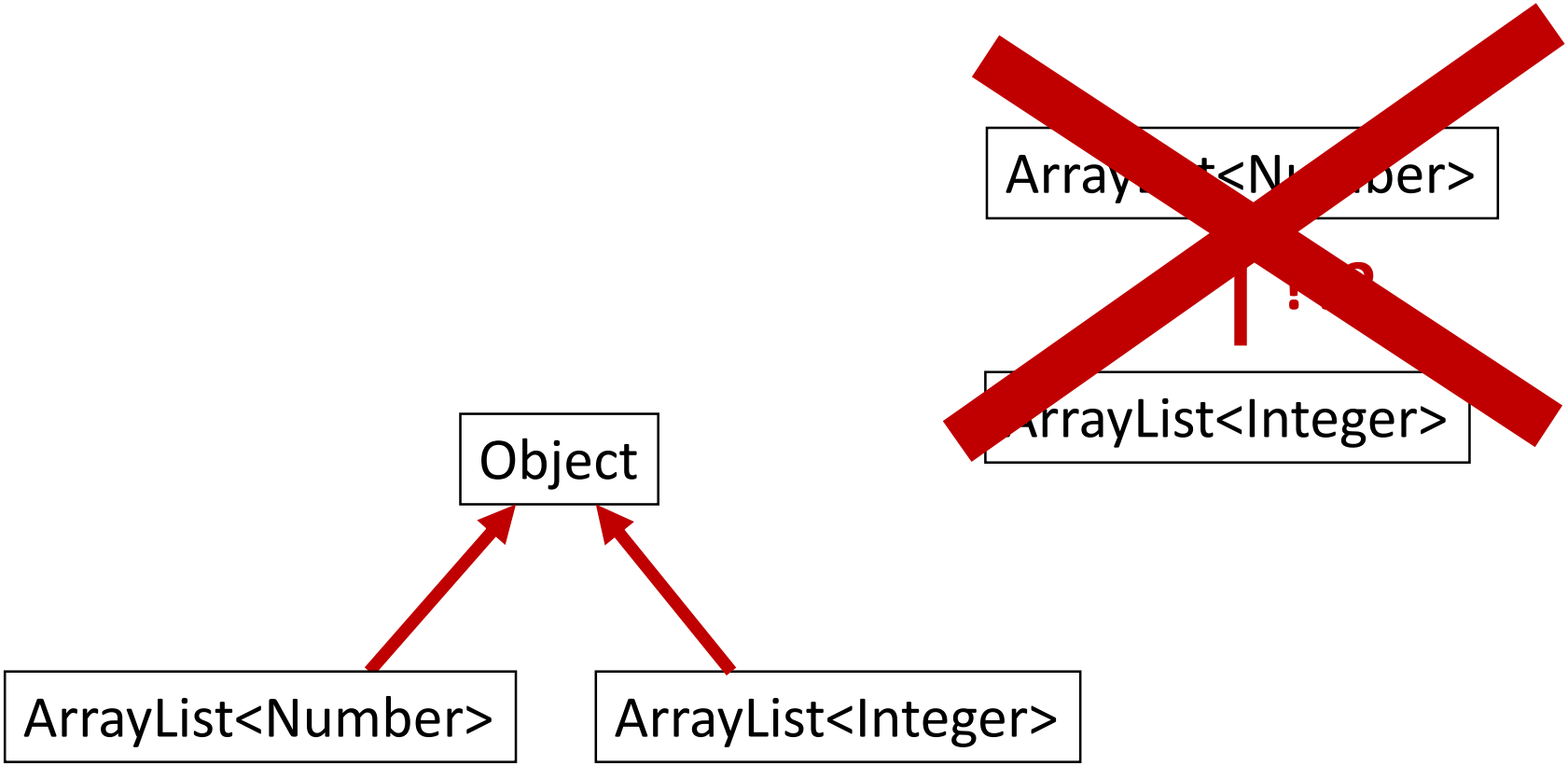


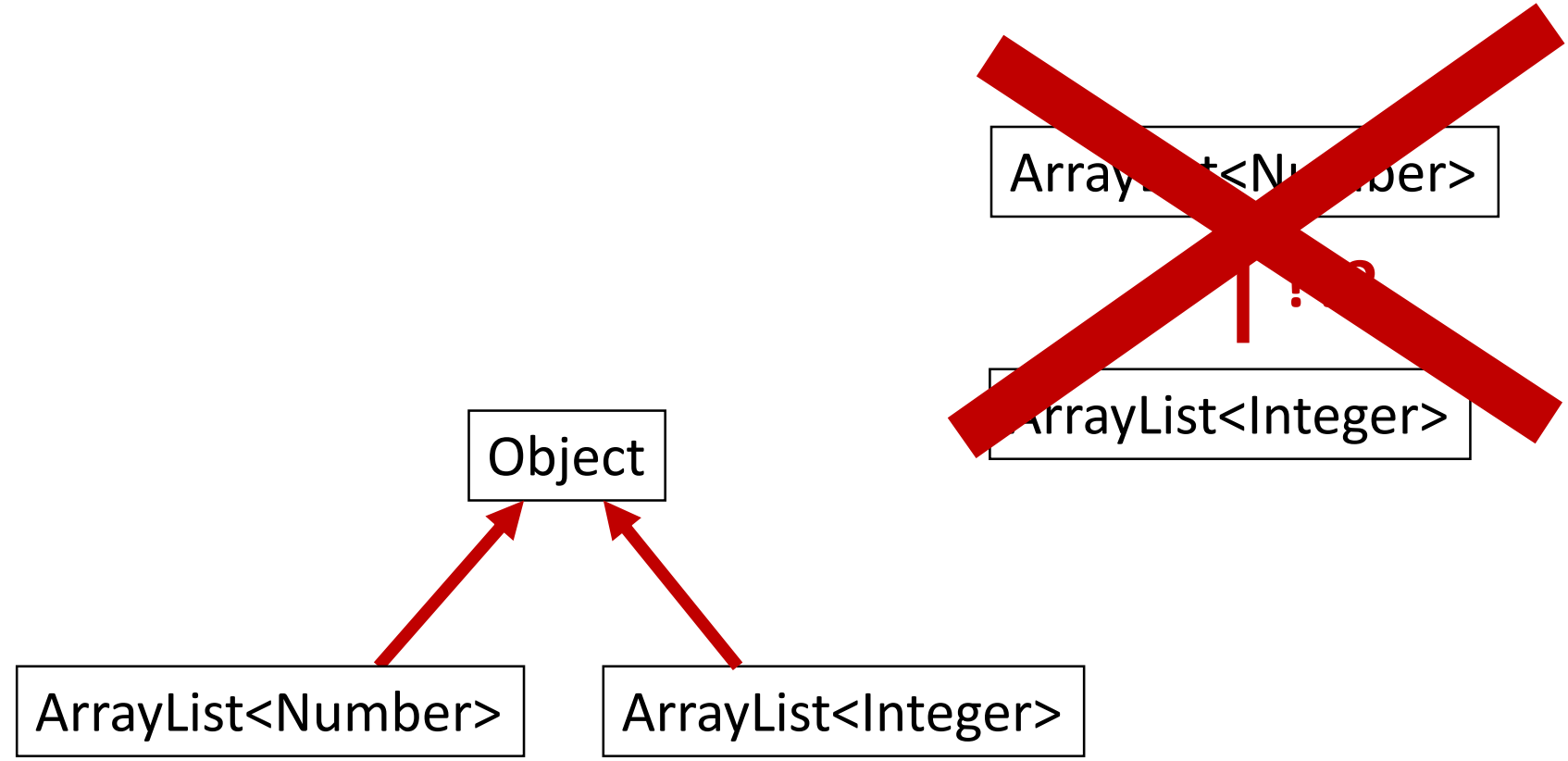
Class Hierarchies



The only common ancestor is Object…

GenericTest example

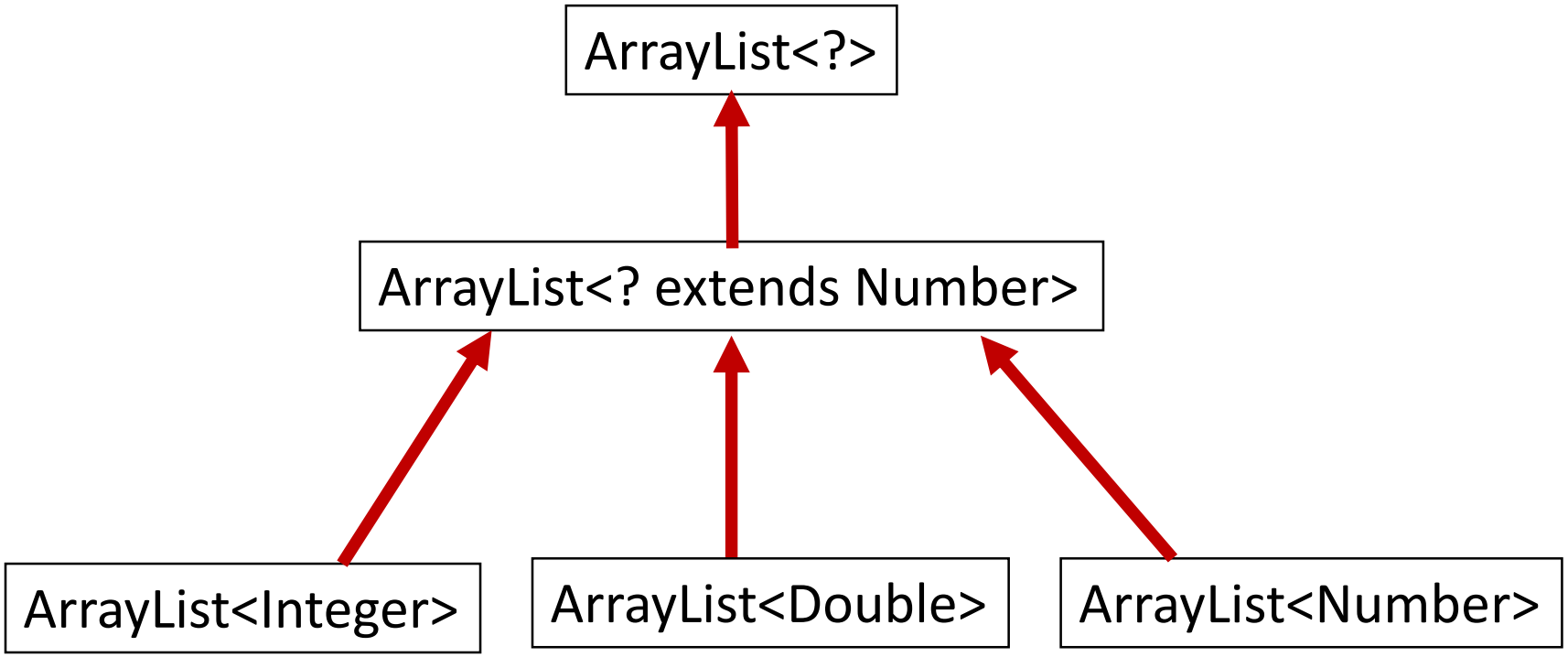
Class Hierarchies



The only common ancestor is Object…

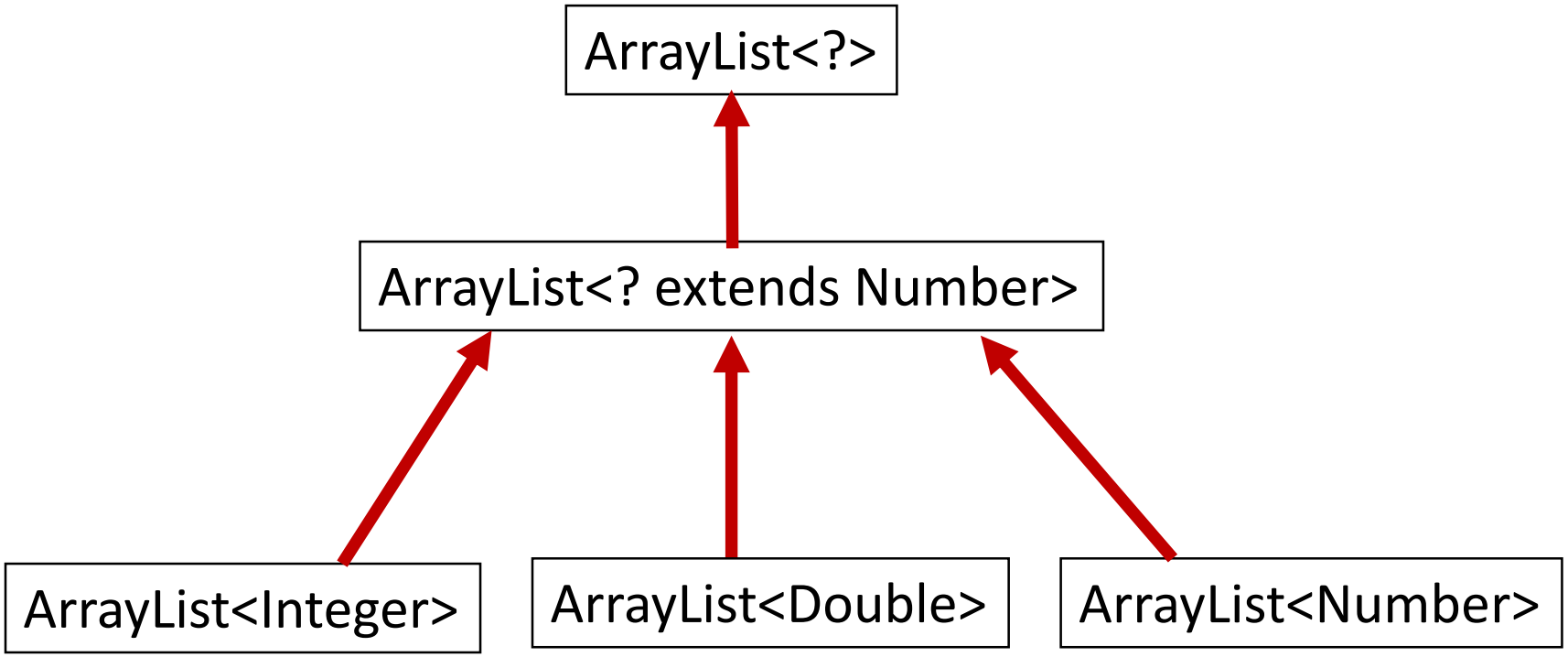
Wildcards

But, there is a hierarchy that we can use…



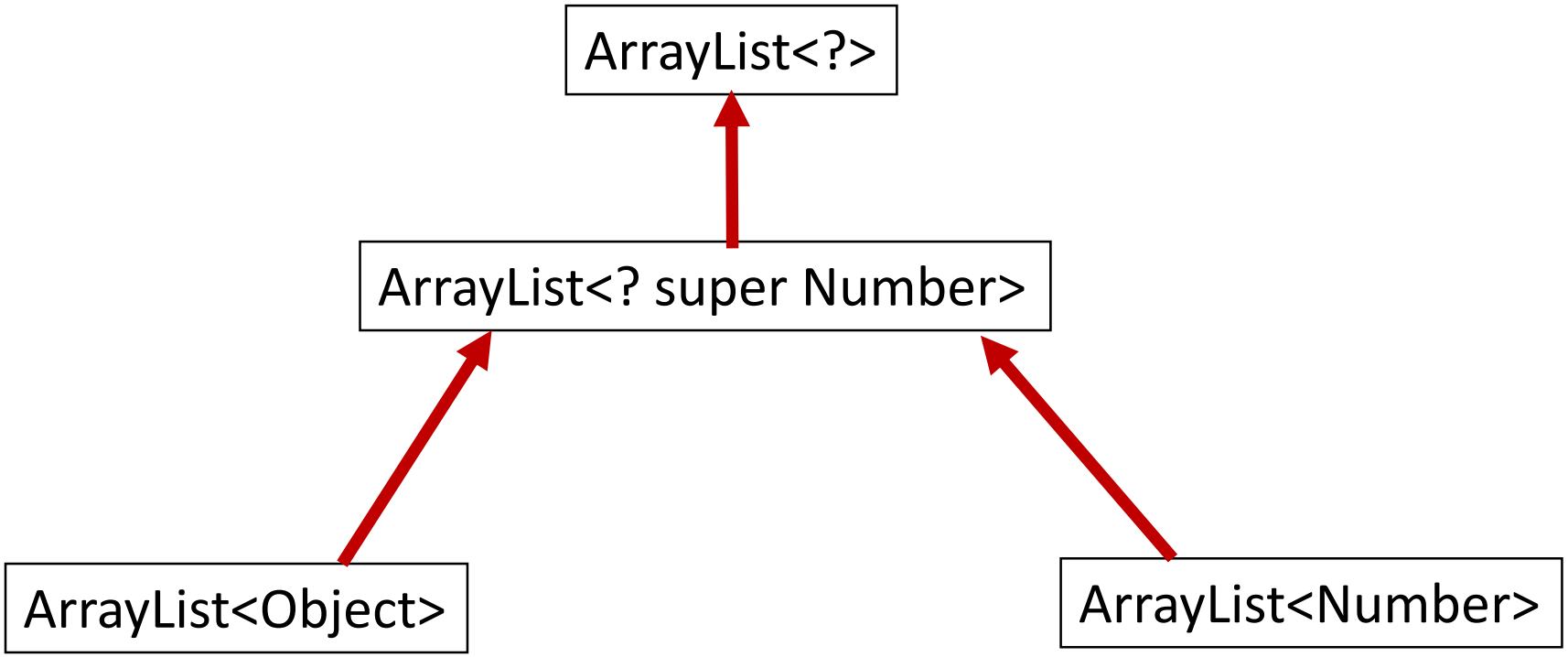
Wildcards

```
ArrayList<Integer> list1 = new ArrayList<Integer>();
ArrayList<? extends Number> list2 = list1;   // Legal
```



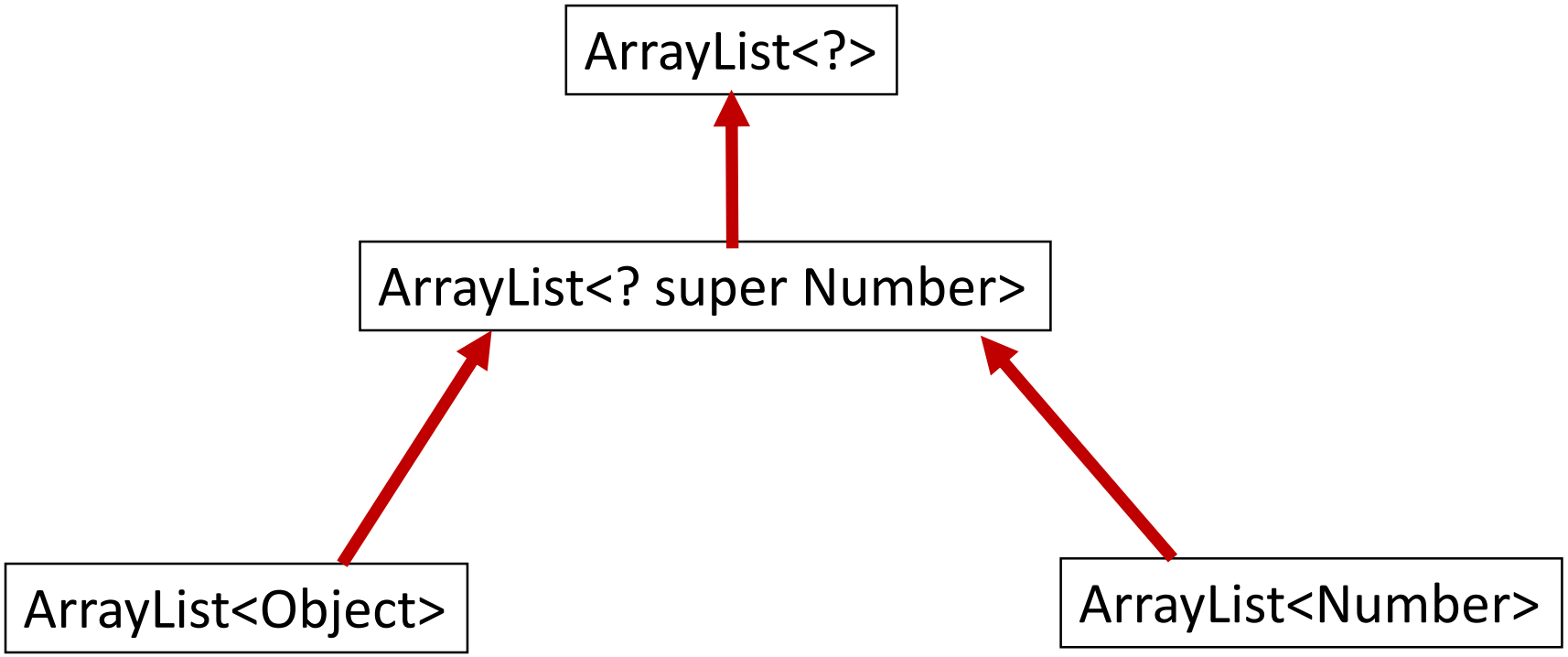
Wildcards

The complement…



Wildcards

```
ArrayList<Object> list1 = new ArrayList<Object>();
ArrayList<? super Number> list2 = list1;   // Legal
```



Wildcard Example I

Return to Arrays in Java API

```
binarySearch(T[] a, T key, Comparator<? super T> c)
```

- The class that is passed as the third parameter must implement the Comparator interface or have a superclass that implements the Comparator interface

Wildcard Example II

Examine Collections in Java API: copy list

```
public static<T> void
    copy (List<? super T> dest, List<? extends T> src)
```

- The <T> before the method name determines the base type
- The source must be a class that is or extends T
- The destination must be a class that is or is a superclass of T

Wildcards and Generic Types

- Give us a tremendous amount of flexibility
- Wildcard types are defined and checked at compile time
  - Reduce runtime errors!
- Project 2: <? extends StatisticsAbstract>
- Lab 7: we will define:
  - Generic notion of a Card<T>
  - Generic notion of a Deck<E extends Card<T>, T>