Generic Types

"Get your data structures correct first, and the rest of the program will write itself."
- *David Jones*

An Array-Based List

- Started with a list of ints
- Don't want to have to write a new list class for every data type we want to store in lists
- Moved to an array of `Object`s to store the elements of the list

```
// from array based list
private Object[] myCon;
```

Using the **`Object`** Class

- In Java, all classes inherit from exactly one other class, except **`Object`** which is at the top of the class hierarchy
- **`Object`** variables can refer to objects of their declared type and any descendants
  - polymorphism
- Thus, if the internal storage container is of type **`Object`**, it can hold anything
  - primitives handled by *wrapping* them in objects:
    - int – Integer
    - char – Character, etc.

Difficulties with `Object`

- *Creating* generic containers using the **`Object`** data type and polymorphism is relatively straight forward
- Using these generic containers leads to some difficulties
  - Casting
  - Type checking
- Code examples on the following slides

Question 1

- What is output by the following code?

```
GenericList list = new GenericList(); // 1
String name = "Olivia";
list.add(name); // 2
System.out.print( list.get(0).charAt(2) );// 3
```

A. `i`

B. No output due to syntax error at line // 1

C. No output due to syntax error at line // 2

D. No output due to syntax error at line // 3

E. No output due to runtime error.

Code Example - Casting

- Assume a list class

```
ArrayList li = new ArrayList();
li.add("Hi");
System.out.println( li.get(0).charAt(0) );
// previous line has syntax error
// return type of get is Object
// Object does not have a charAt method
// compiler relies on declared type
System.out.println(
      ((String)li.get(0)).charAt(0) );
// must cast to a String
```

Code Example – Type Checking

```
//pre: all elements of li are Strings
public void printFirstChar(ArrayList li) {
      String temp;
      for(int i = 0; i < li.size(); i++) {
            temp = (String)li.get(i);
            if( temp.length() > 0 )
                  System.out.println(
                        temp.charAt(0) );
      }
}
// what happens if pre condition not met?
```

Too Generic?

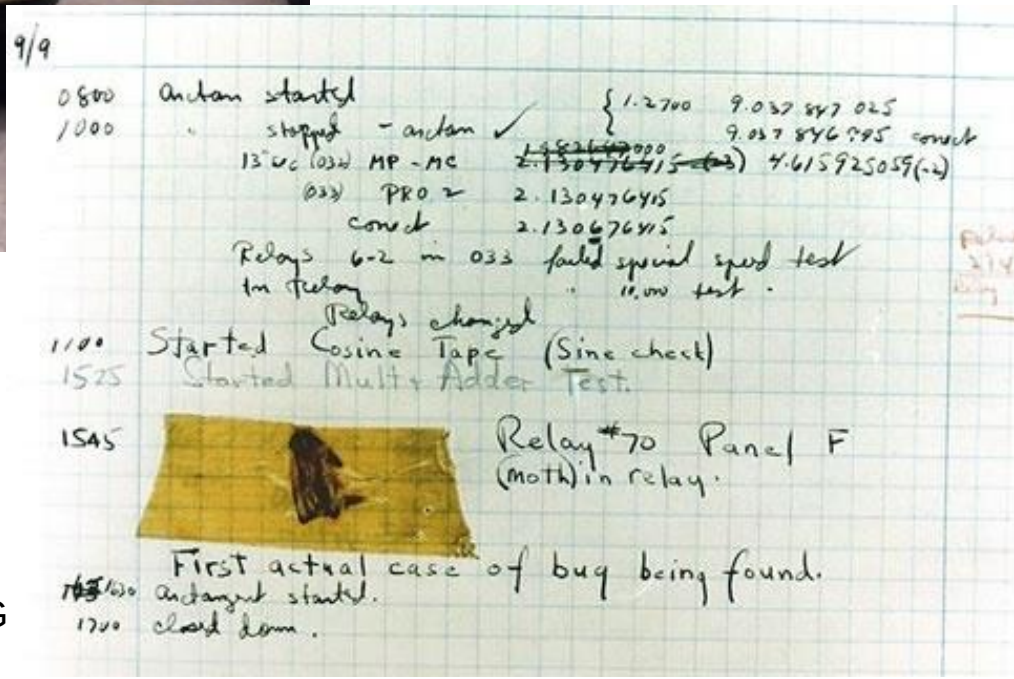
- Does the compiler allow this?

```
ArrayList list = new ArrayList();
list.add( "Olivia" );
list.add( new Integer(12) );
list.add( new Rectangle() );
list.add( new ArrayList() );
```

A. Yes

B. No

Is this a bug or a feature?



"Fixing" the Method

```
//pre: all elements of li are Strings
public void printFirstChar(ArrayList li) {
      String temp;
      for(int i = 0; i < li.size(); i++) {
            if( li.get(i) instanceof String ){
                  temp = (String)li.get(i);
                  if( temp.length() > 0 )
                        System.out.println(
                              temp.charAt(0) );
            }
      }
}
```

Generic Types

- Java has syntax for *parameterized data types*
- Referred to as *Generic Types* in most of the literature
- A traditional parameter *has* a data type and can store various values just like a variable

```
public void foo(int x)
```

- Generic Types are like parameters, but the data type for the parameter is *data type*
  - like a variable that stores a data type
  - this is an abstraction. Actually, all data type info is erased at compile time

Making our Array List Generic

- Data type variables declared in class header

```
public class GenericList<E>
```

- The `<E>` is the declaration of a data type parameter for the class
  - any legal identifier: `Foo`, `AnyType`, `Element`, `DataTypeThisListStores`
  - Sun style guide recommends terse identifiers
- The value E stores will be filled in whenever a programmer creates a new `GenericList`

```
GenericList<String> li =
                new GenericList<String>();
```

Modifications to GenericList

- instance variable

```
private E[] myCon;
```

- Parameters on
  - add, insert, remove, insertAll
- Return type on
  - get
- Changes to creation of internal storage container

```
myCon = (E[])new Object[DEFAULT_SIZE];
```

- Constructor header does not change

Modifications to GenericList

- Careful with the equals method
- Recall type information is actually erased
- Use of wildcard
- Rely on the elements equals methods

Using Generic Types

- Back to Java's ArrayList

```
ArrayList list1 = new ArrayList();
```

  - still allowed, a "raw" ArrayList
  - works just like our first pass at GenericList
  - casting, lack of type safety

Using Generic Types

```
ArrayList<String> list2 =
                  new ArrayList<String>();
```

– for list2 `E` stores `String`

```
list2.add( "Isabelle" );
System.out.println(
    list2.get(0).charAt(2) ); //ok
list2.add( new Rectangle() );
// syntax error
```

Parameters and Generic Types

- Old version

```
//pre: all elements of li are Strings
public void printFirstChar(ArrayList li){
```

- New version

```
//pre: none
public void printFirstChar(ArrayList<String> li){
```

- Elsewhere

```
ArrayList<String> list3 = new ArrayList<String>();
printFirstChar( list3 ); // ok
ArrayList<Integer> list4 = new ArrayList<Integer>();
printFirstChar( list4 ); // syntax error
```

Generic Types and Subclasses

```
ArrayList<Shape> list5 =
          new ArrayList<Shape>();
list5.add( new Rectangle() );
list5.add( new Square() );
list5.add( new Circle() );
// all okay
```

- `list5` can store `Shape` objects and any descendants of `Shape`