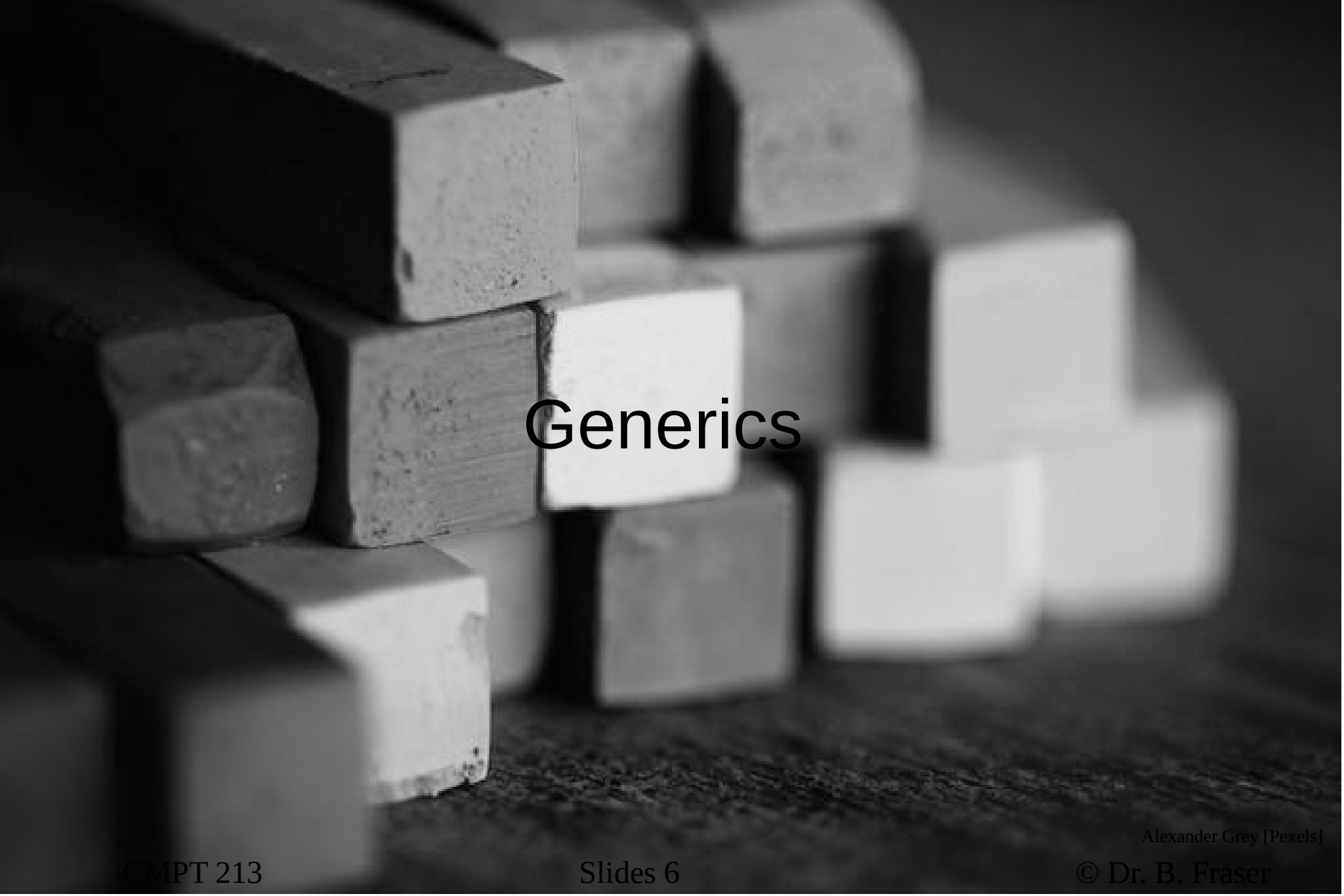


Generics

Alexander Grey [Pexels]

Generics

- Generic Type Examples
  List<Car>

  ArrayList<Fruit>
- ..
  - Generics give Java code
    ..
  - Code is written once, but handles different types.
    Selection is done at compile-time.
- It’s different than Runtime Polymorphism
  - .. gives runtime polymorphism
  - Code is written once, but handles different types.
    Selection is done at run-time.

Generics and Different Types

- Generics handle any object type
  - Code written with a generic can handle **any** type of object, not just ones related via inheritance.
  - The same ArrayList code can make:
    - an ArrayList of Cars, or
    - an ArrayList of Fruit,
    - ... etc.
- Once created, an object of type ArrayList<Car> cannot handle Fruit:
  - Compiler knows an ArrayList<Car> object holds Cars

```
ArrayList<Car> myCars = new ArrayList<>();
Car firstCar = myCars.get(0);
```

Generic Method

- Generic Method
  - A method which has a..
  - It can use this type parameter as a regular type
- Can call a generic method with any type of object
  - Compiler ensures that it preserves the type

T is the type parameter

```
public <T> List<T> makeIntoList(T obj1, T obj2)  {
    List<T> myList = new ArrayList<>();
    myList.add(obj1);
    myList.add(obj2);
    return myList;
}
```

Generic Method Example

```
public class GenericMethod {

    public static <T> List<T> makeIntoList(T obj1, T obj2){
        List<T> myList = new ArrayList<>();
        myList.add(obj1);
        myList.add(obj2);
        return myList;
    }

    public static void main(String[] args) {

        List<String> myStrings = makeIntoList("Hello", "World");
        List<Integer> myIntegers = makeIntoList(5, 10);


        Car car1 = new Car("Forester", 2050);
        Car car2 = new Car("Model T", 1920);
        List<Car> myCars = makeIntoList(car1, car2);
    }
}
```

Generic Class

- Generic Classes
  have a type parameter for the whole class

```
public class ShippingCrate<T> {
    private T item;

    public ShippingCrate(T item) {
        this.item = item;
    }

    public T getItem() {
        return item;
    }

    public void printLabel() {
        System.out.println("One shipping crate containing: ");
        System.out.println("     " + item.toString());
    }
}
```

Generic Interfaces

- Generic Interfaces
  - Like a class, has a type parameter for the whole interface.
  - Very useful to make flexible code

- Can use
  ..
  for client code to provide an implementation which fills in a part of our algorithm.
- Our object is then typed to the type the client needs.

```
// Create an object that, given an item,
// provides the description you want.
public interface Describer<T> {
    String getDescription(T item);
}
```

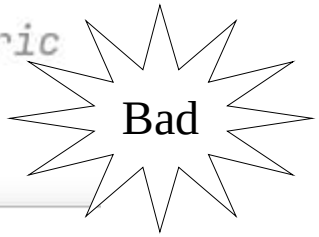
Arrays and Generics

(Covariant vs Invariant Types)
(Reified vs Type Erasure)

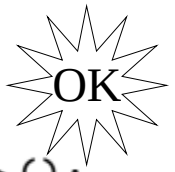
Arrays and Generics Don't Play Well

- ..

```
// Cannot create an array of anything generic
new List<String>[2];
new List<E>[2];
```



Generic array creation not allowed




```
// You *CAN* create a generic of arrays:
List<String[]> myStrings = new ArrayList<String[]>();
List<E[]> myThings = new ArrayList<E[]>();
```

- Why?
  - Java's type system guarantees that when using generics Java will not throw a runtime cast exceptions.
  - If you have a collection of TeddyBears, get() must always gives you a teddy bear! ... *but it's complicated...*

```
List<TeddyBear> bears = new ArrayList<>();
TeddyBear myBear = bears.get(0);
```

Understanding Covariant

- Let A be a subtype of B.
- Variance refers to if a language allows an array (or list) of A to be used instead of an array (or list) of B

```
Object[] data = new Long[10];
```

Variance:
Some languages allow this; others do not.

- Java arrays are covariant:
  - ..
- You can write code to use B[], and instead pass it A[]!

```
public class ArrayCovariant {
    static int countLength(Object[] data) {
        return data.length;
    }

    public static void main(String[] args) {
        String[] strings = {"Broken", "Type"};
        Object[] objects = strings;
        System.out.println(countLength(strings));
        System.out.println(countLength(objects));
    }
}
```

Understanding Covariant (cont)

- With covariant types, must..
  - Since it will accept a different type, it’s possible to write code that violates the type system.

```
public class ArrayCovariant {

    public static void main(String[] args) {
        String[] strings = {"Broken", "Type"};
        Object[] objects = strings;    // OK; Covariant!

        // Generates runtime exception: ArrayStoreException
        objects[0] = 5;
    }
}
```

  - objects is of type Object[], which is a subtype of String[]
  - objects[] is of type Object[], so compiler lets us put in an Integer
  - But, the array only stores String, so must runtime check!

Understanding Invariant

- Generics (such as lists) are invariant:
  - ..
  - If you need a List<B>, you cannot use List<A> instead.
- Compile time checking of types!

```
// Demonstrate invariant type
// **Will not compile**
ArrayList<Object> data = new ArrayList<String>();
```

Required type: ArrayList <Object>

Provided: ArrayList <String>

Covariant vs Invariant Types

- Covariant seems more flexible; is it better?
  - ..
  - With covariant types, we need to do runtime type checking.
  - With invariant types, the compile does all our checking!

```
// With covariant arrays, this is a _runtime_ error
Object[] objectArray = new Long[1];
objectArray[0] = "I don't fit in!";   // Runtime error

// With invariant generics, this is a _compile time_ error
List<Object> objectList = new ArrayList<Long>(); // Compile time error!
objectList.add("I don't fit in!");
```

- Heuristic:

..

  - Advice given in Effective Java (3rd ed) by Joshua Bloch

Type Erasure

- Java generics only know about their type parameters at compile time.
  - ..
  - Since the type system is strong for generics, the compile is able to enforce all type constraints so that we don’t need to check at runtime.
- Reification
  - ..
    arrays know and enforce their element types at runtime.
  - ..
    generics do not enforce their element types at runtime.

Summary

- Inheritance
  - Provides run-time polymorphism
- Generic
  - Provides compile-time polymorghism
  - Generic methods
    Written once, work on any (specific) type of object
  - Generic class
    Handle any (specific) type of object
  - Generic interface
    Provides flexible ability to the strategy pattern
- Arrays are covariant types (reified);
  Generics are invariant types (type-erasure).