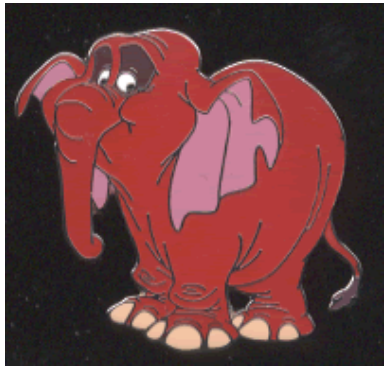
Introduction to Object-Oriented Programming

- Objects and classes
- Encapsulation and information hiding
- Mental exercises
  - Classification and exemplification
  - Aggregation and decomposition
  - Generalization and specialization
- Inheritance
- Polymorphism and dynamic binding
- Java an example of an object-oriented programming language
  - Program example
  - History of Java
  - Comparison to C/C+

Objects and Classes

Mammal
Two-legs
Very large brains
Omnivorous (plants + meat)



Mammal
Tusks
Four legs
Herbivorous (plant eater)

The Object Concept

- An object is an *encapsulation* of data.

- An object has
  - identity (a unique reference)
    - social security number (cpr), employee number, passport number
  - state, also called characteristics (variables)
    - hungry, sad, drunk, running, alive
  - behavior (methods)
    - eat, drink, wave, smile, kiss

- An object is an instance of an *class*.
  - A class is often called an *Abstract Data Type (ADT)*.

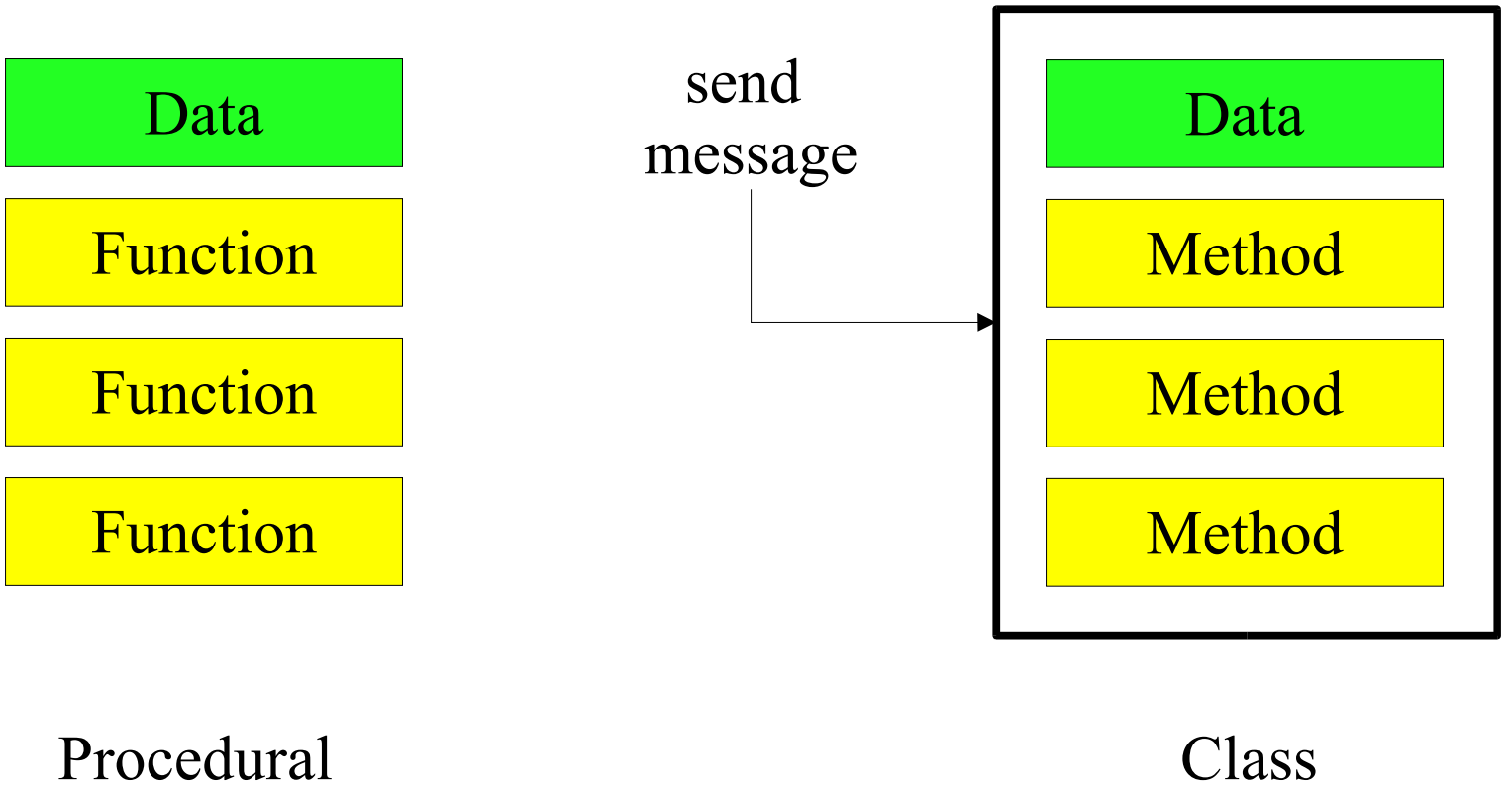
The Class Concept

- A class is a collection of *objects* (or *values*) and a corresponding set of *methods*.
- A class encapsulates the data representation and makes data access possible at a higher level of abstraction.

- Example 1: A set of vehicles with operations for starting, stopping, driving, get km/liter, etc.
- Example 2: A time interval, start time, end time, duration, overlapping intervals, etc.
- Example 3: A string, upper case, compare, lower case, etc.
  - **`str.equals(otherStr)`** – class/Java style
  - **`strcmp(str, otherStr)`** – C style

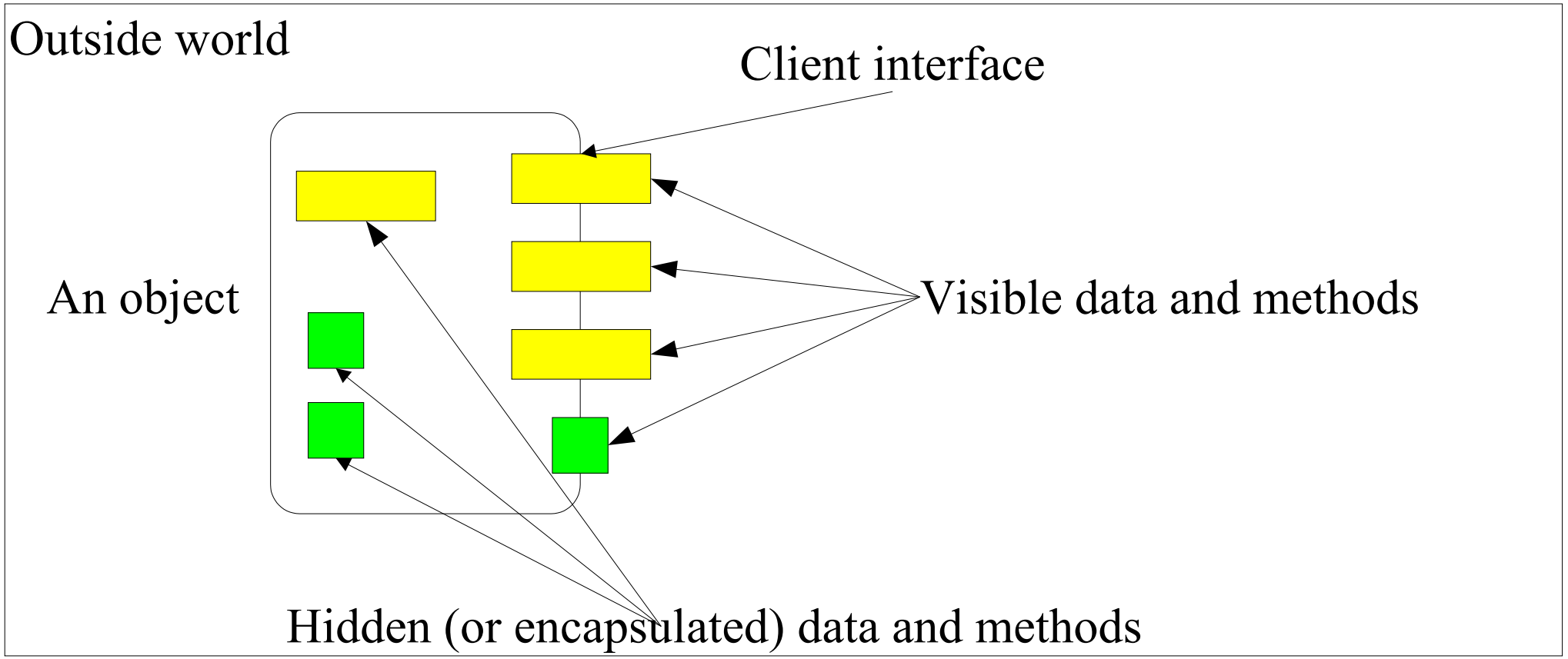
Encapsulation and Information Hiding

- Data can be encapsulated such that it is invisible to the "outside world".
- Data can only be accessed via methods.



Encapsulation and Information Hiding, cont.

- What the “outside world” cannot see it cannot depend on!
- The object is a “fire-wall” between the object and the “outside world”.
- The hidden data and methods can be changed without affecting the “outside world”.



Class vs. Object

Class

- A description of the *common properties* of a set of objects.
- A concept.
- A class is a part of a program.

- Example 1: Person

- Example 2: Album

Object

- A representation of the *properties* of a single instance.
- A phenomenon.
- An object is part of data and a program execution.

- Example 1: Bill Clinton, Bono, Viggo Jensen.
- Example 2: A Hard Day's Night, Joshua Tree, Rickie Lee Jones.

Connection between Object and Class

- In object-oriented programming we write classes
  - The text files we create contain classes!
  - Static
  - "One"
- Objects are created *from* classes
  - A class contains a "receipe" on how to make objects
  - Dynamic
  - "Many"

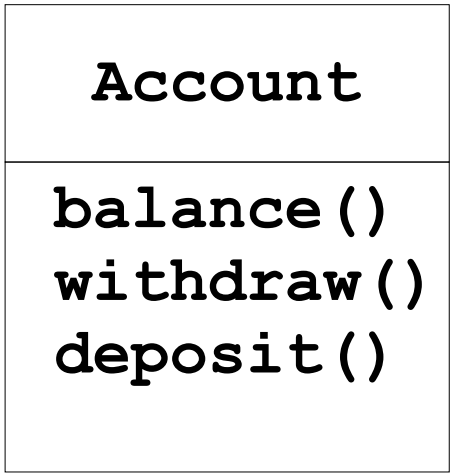
Ingrediens
250 g digestive biscuits food processor
125 g soft brown sugar saucepan
125 g butter wooden spoon
50 g raisins 18 cm sandwich tin (greased)
3 tablespoons cocoa powder fridge
1 egg, beaten knife
25 g = 1 oz
2.5 cm = 1 inch
Process
blend
bake

source http://www.icbl.hw.ac.uk/ltdi/cookbook/chocolate_cake/

source http://www.filflora.com

Type and Interface

- An object has type and an interface.



- To get an object

```
Account a = new Account()
Account b = new Account()
```

- To send a message

```
a.withdraw()
b.deposit()
a.balance()
```

Instantiating Classes

- An instantiation is a mechanism where objects are created from a class.
- Always involves storage allocation for the object.
- A mechanism where objects are given an initial state.

Static Instantiating

- In the declaration part of a program.
- A static instance is implicitly created

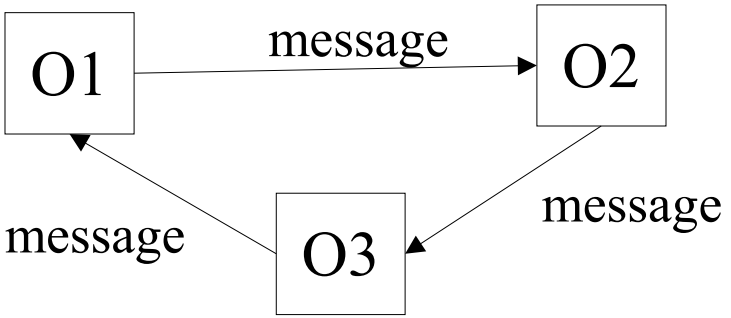
Dynamic Instantiating

- In the method part of a program.
- A dynamic instance is created explicitly with a special command.

Interaction between Objects

- Interaction between objects happens by *messages* being send.
- A message activates a method on the calling object.

- An object O1 interacts with another object O2 by calling a method on O2 (must be part of the client interface).
  - "O1 sends O2 a message"
- O1 and O2 must be *related* to communicate.
- The call of a method corresponds to a function (or procedure) call in a non-object-oriented language such as C or Pascal.



Phenomenon and Concept

- A *phenomenon* is a thing in the "real" world that has individual existence.
  - an object
- A *concept* is a generalization, derived from a set of phenomena and based on the common properties of these phenomena.
  - a class

- Characteristics of a concept
  - A name
  - *Intension*, the set of properties of the phenomenon
  - *Extension*, the set of phenomena covered by the concept.

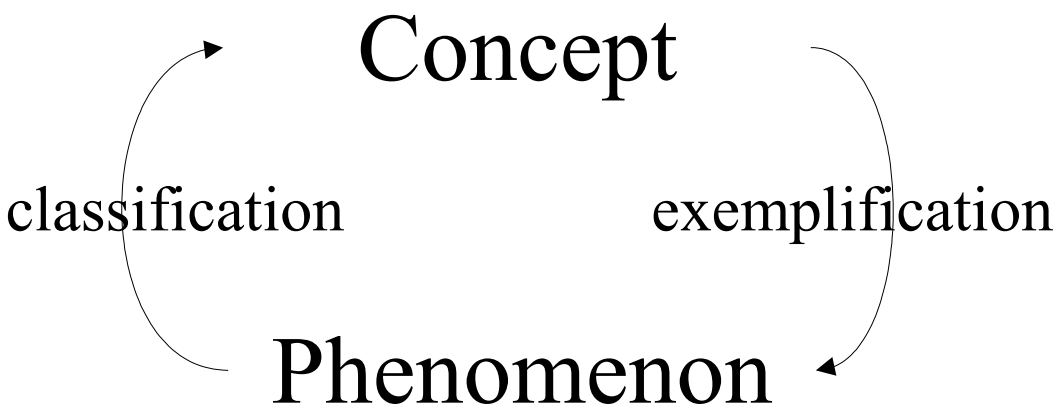
Classification and Exemplification, Examples

- hat, 23, 34, mouse, telephone, book, 98, 45.34, hello
  - numbers: 23, 34, 98, 45.34
  - words: hat, mouse, telephone, book, hello

- mouse, tyrannosaurus rex, allosaurus, elephant, velociraptor
  - dinosaur: tyrannosaurus rex, allosaurus, velociraptor
  - mammal: mouse, elephant

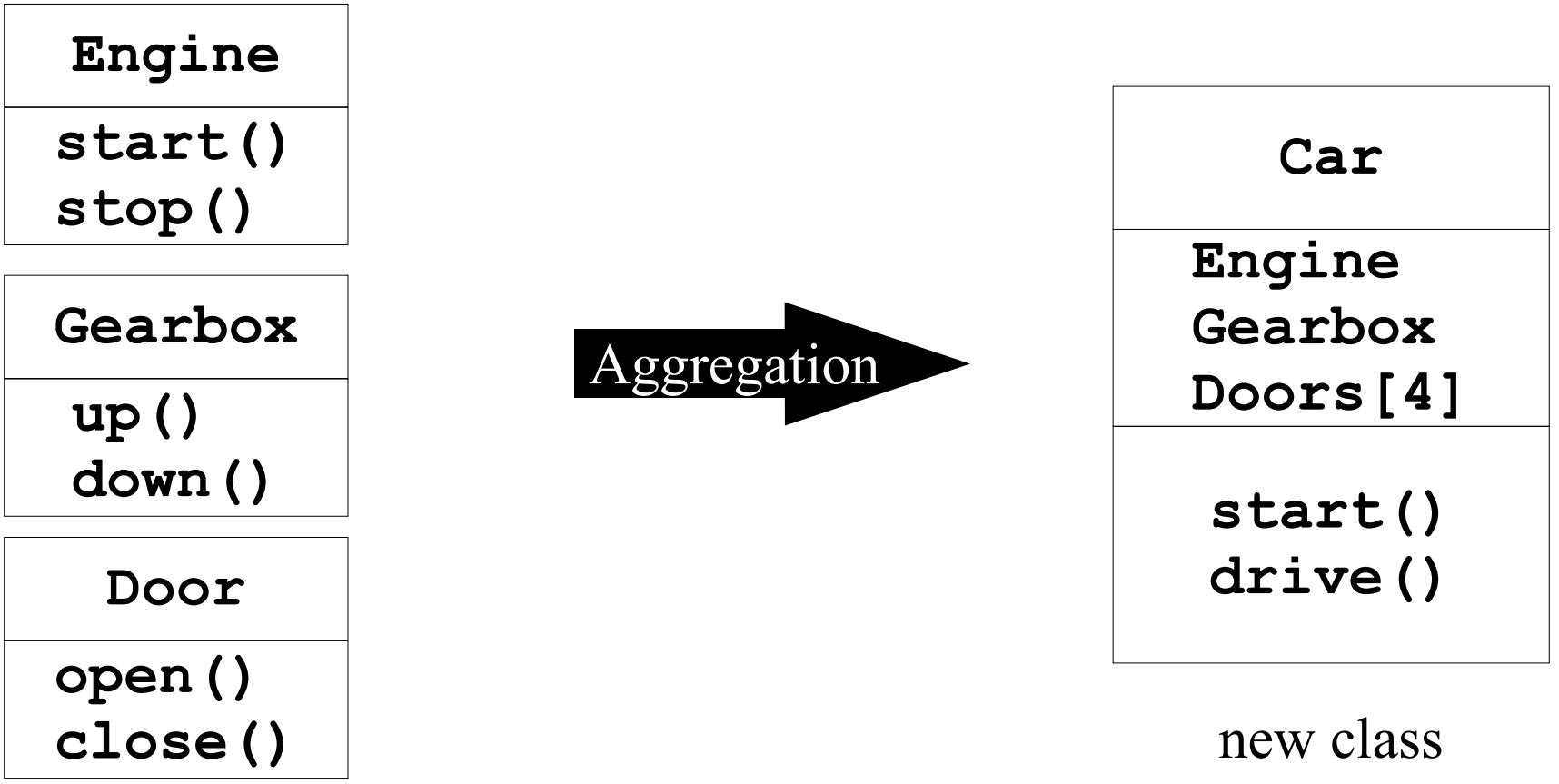
Classification and Exemplification, cont.

- A *classification* is a description of which phenomena that belongs to a concept.
- An *exemplification* is a phenomenon that covers the concept



Aggregation and Decomposition, Example

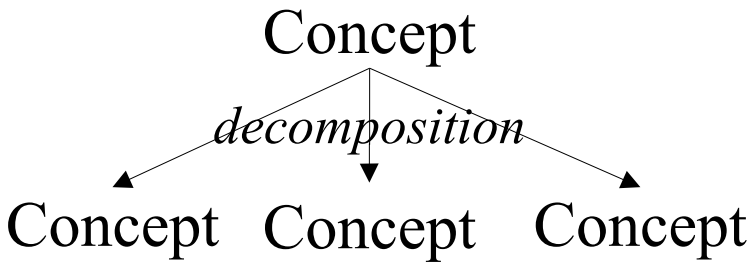
- Idea: make new objects by combining existing objects.
- *Reusing the implementation!*

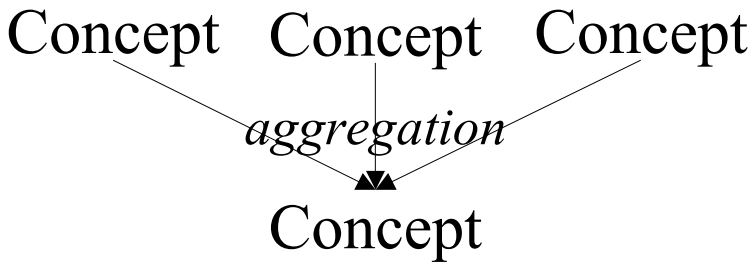


- **`Car`** "has-a" **`Gearbox`** and **`Car`** "has-an" **`Engine`**

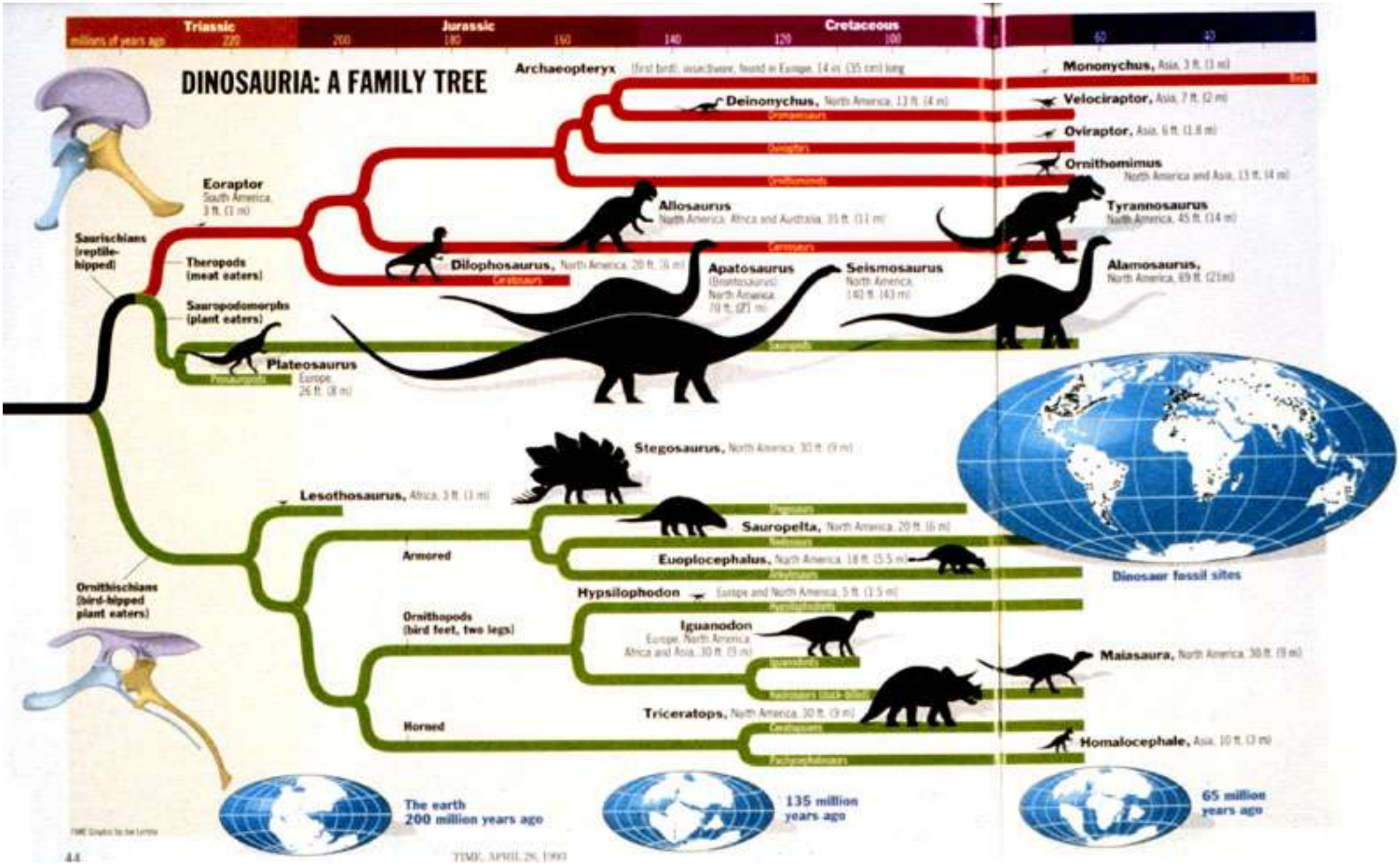
Aggregation and Decomposition

- An *aggregation* consists of a number of (sub-)concepts which collectively is considered a new concept.
- A *decomposition* splits a single concept into a number of (sub-)concepts.





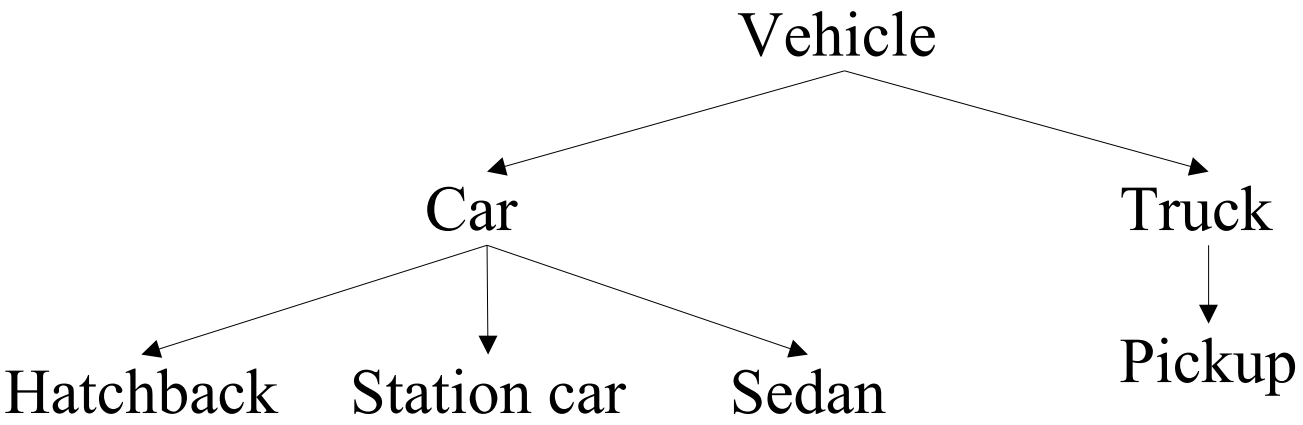
Generalization and Specialization



source : www.geology.ucdavis.edu/ ~GEL12/dinosauria.Html

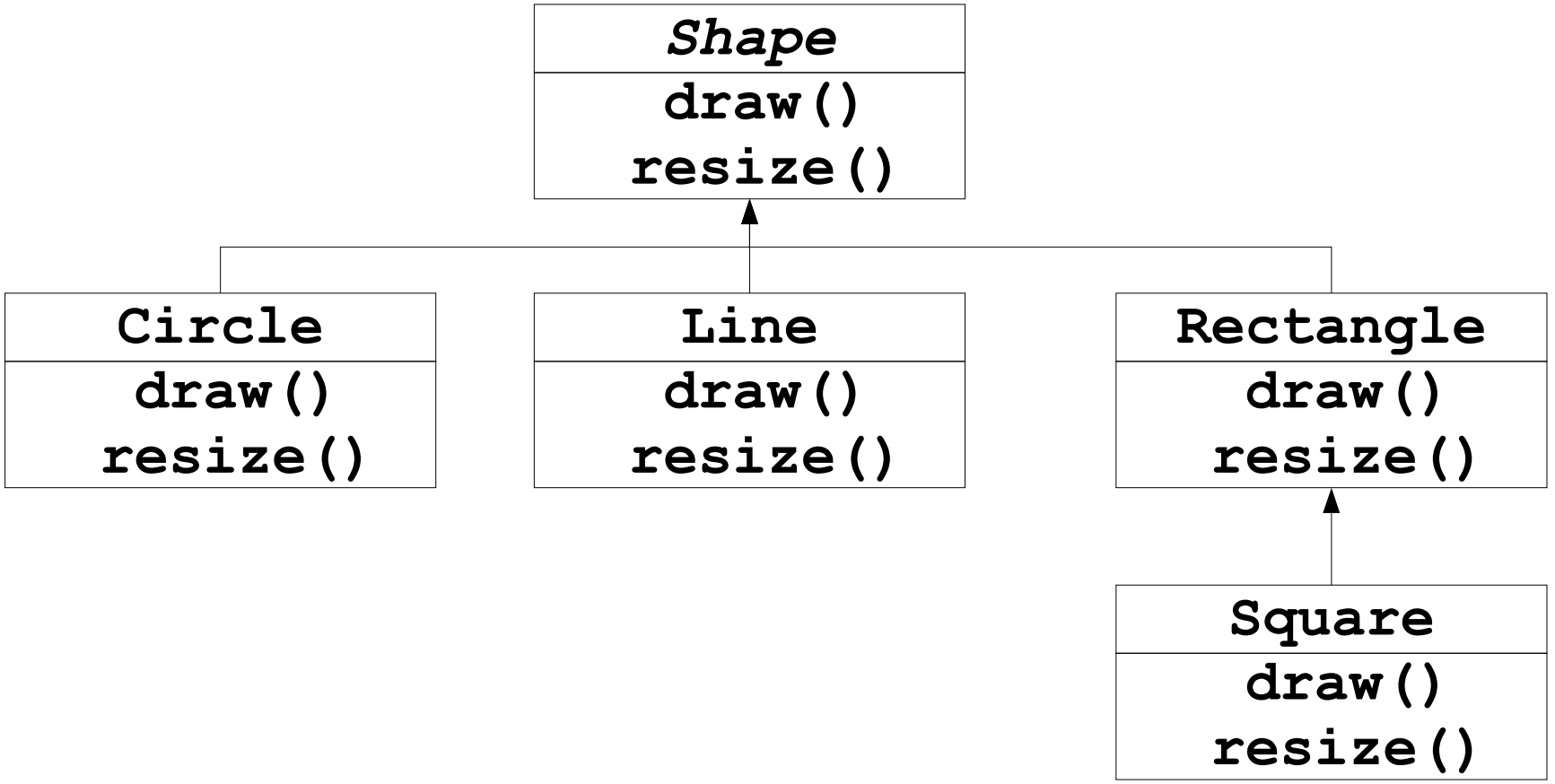
Generalization and Specialization, cont.

- *Generalization* creates a concept with a broader scope.
- *Specialization* creates a concept with a narrower scope.
- *Reusing the interface!*



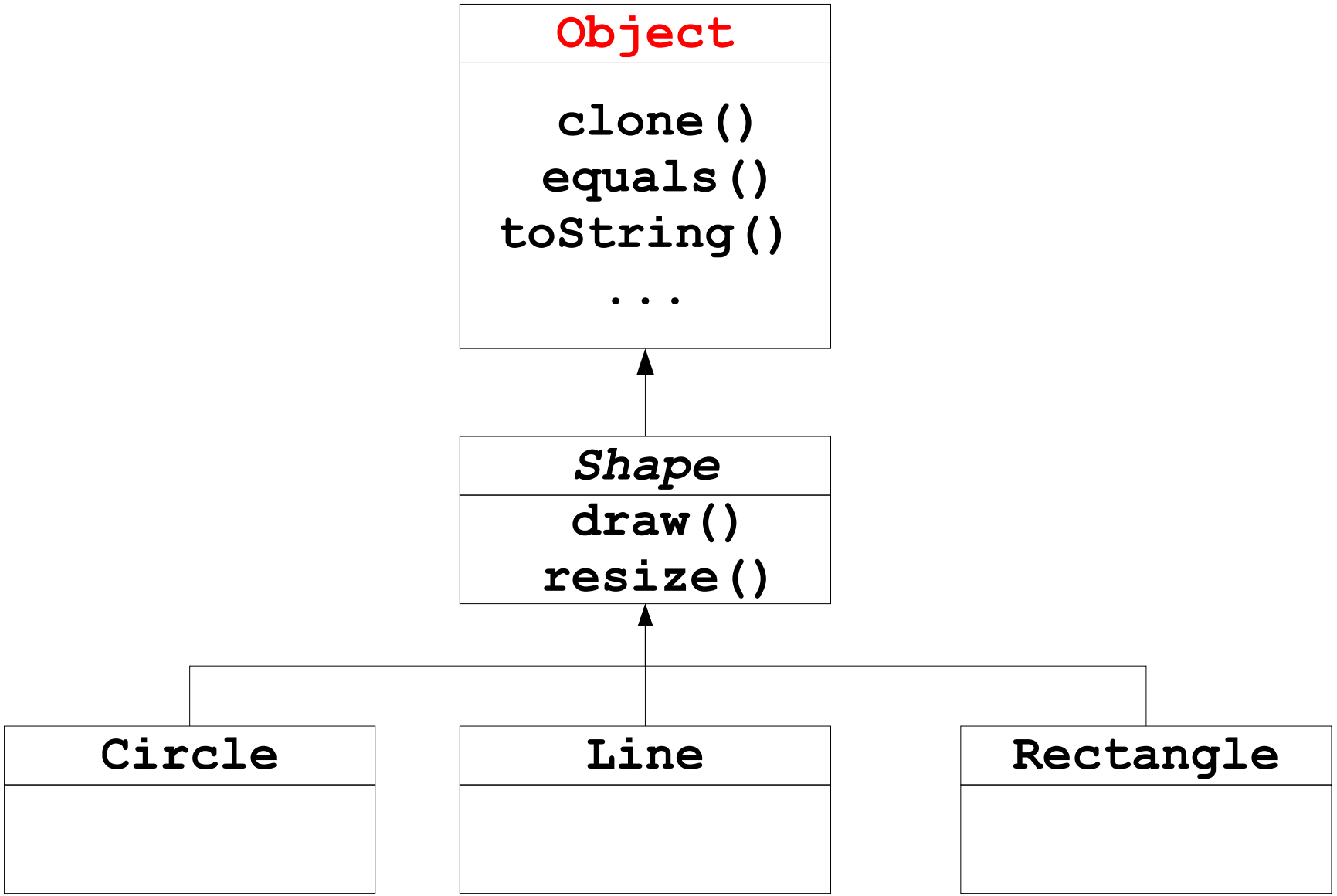
Generalization and Specialization, Example

- *Inheritance*: get the interface from the general class.
- Objects related by inheritance are all of the same type.



- **Square** "is-a" **Shape** or **Square** "is-like-a" **Shape**

Generalization and Specialization in Java



Polymorphism and Dynamic Binding

```
void doSomething(Shape s){
  s.draw();  // "magically" calls the specific class
  s.resize();
}
Circle c = new Circle();
Line l = new Line();
Rectangle r = new Rectangle();

doSomething(c);          // dynamic binding
doSomething(l);
doSomething(r);
```

- *Polymorphism*: One piece of code works with all shape objects.
- *Dynamic binding*: How polymorphism is implemented.

Benefit Generalization and Specialization

- Take previous Shape class hierarchy
  - remove inheritance
  - remove general and abstract class **`Shape`**

`Rectangle`
`draw()` **`resize()`**

`Square`
`draw()` **`resize()`**

`Circle`
`draw()` **`resize()`**

`Line`
`draw()` **`resize()`**

Code Example, Revisited

```
void doSomething(Circle c){
  c.draw();
  c.resize();
}
void doSomething(Line l){
  l.draw();
  l.resize();
}
```

```
void doSomething(Rectangle r){
  r.draw();
  r.resize();
}
void doSomething(Square s){
  s.draw();
  s.resize();
}
```

```
Circle c = new Circle();
Line l = new Line();
Rectangle r = new Rectangle();

doSomething(c);
doSomething(l);
doSomething(r);
```

Similar code is repeated

Java Program Structure

```
// comment on the class
public class MyProg {
  String s = ”Viggo”;

  /**
   * The main method (comment on method)
   */
  public static void main (String[] args){
    // just write some stuff
    System.out.println ("Hello World");  }
}
```

variable

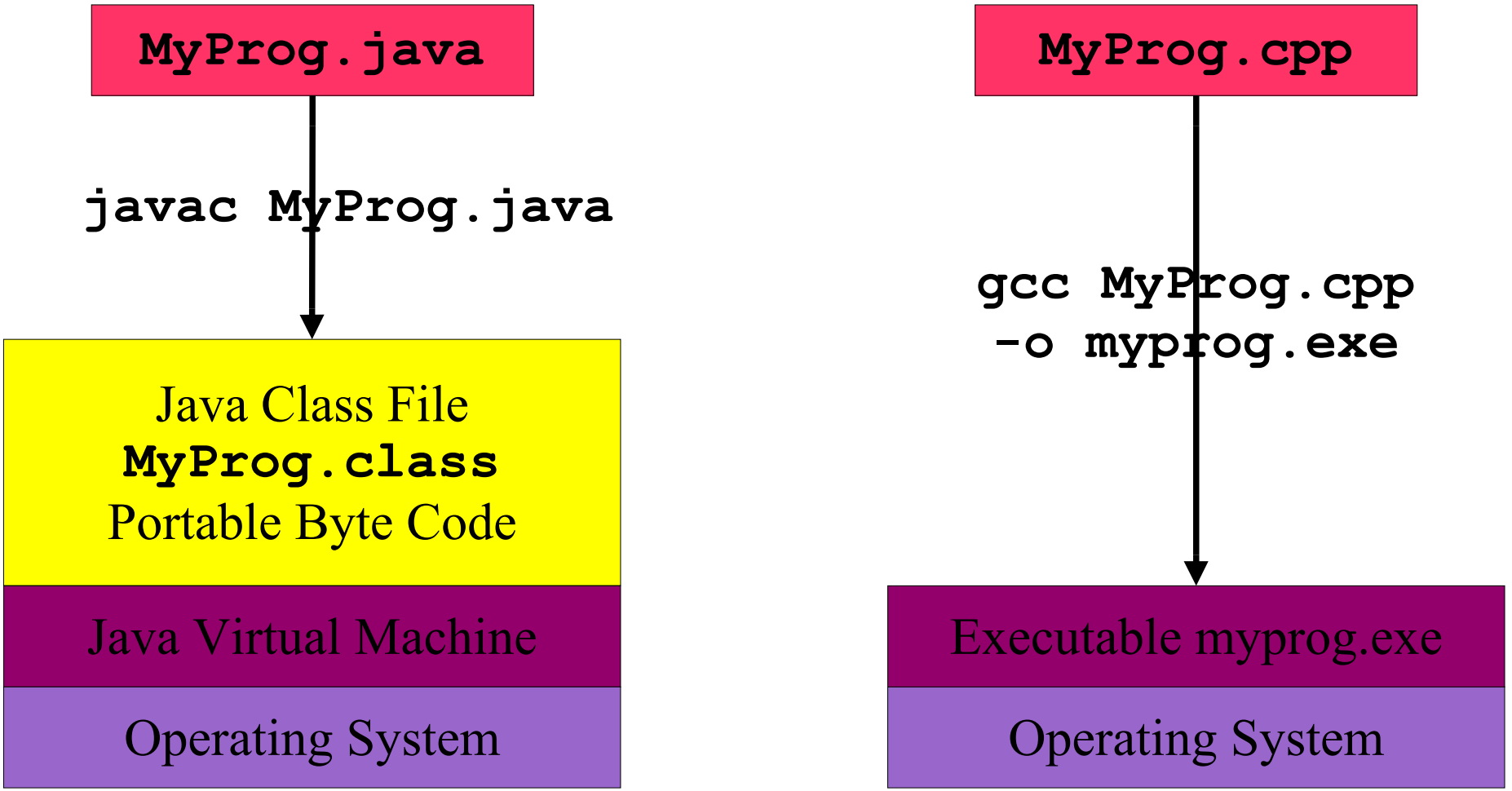
method header

method body

Java Class Example **Car**

```
/** A simple class modeling a car. */
public class Car {
    // instance variables
    private String make;
    private String model;
    private double price;
    // constructor
    public Car(String m, String mo, double p) {
        make = m; model = mo; price = p;
    }
    // string representation of the car
    public String toString() {
        return "make: " + make + " model: "
         + model + " price: " + price;
    }
}
```

Byte Code vs. Executable



Java/C# world

C++ world

History of Java

- 1990 Oak (interactive television, big failure)
- 1994 Java (for the Internet)
  - Main feature: "Write Once, Run Any Where"
    => wrap the operating system so they all look the same
- Designed for
  - A fresh start (no backward compatibility)
  - “Pure” OOP: C++ Syntax, Smalltalk style
  - Improvements over C++ much harder to write a bad program
  - Internet programming
    - Very hard to create a virus
    - Run in a web browser (and at the server)
  - There is a speed issue (from Java 1.3 and up much better)
- C# Microsoft's “Java-Killer” project release 2001
  - Language very similar to Java
  - Commen-Language Runtime (CLR) supports 30+ languages

Difference from C/C++

- Everything resides in a class
  - variables and methods
- Garbage collection
  - bye bye **`malloc()`**, **`free()`**, and **`sizeof()`**
- Error and exception handling handling
- No global variables or methods
- No local static variables
- No separation of declaration and implementation
  - Bye bye header files
- No explicit pointer operations (uses references)
- No preprocessor (but something similar)
- Has fewer “dark corners”
- Has a much larger standard library (Java Developer Kit or JDK)

Summary

- Classes are “recipes” for creating objects
- All objects are instances of classes
- Encapsulation
  - Key feature of object-oriented programming
  - Separation of interface from implementation
  - It is not possible to access the hidden/encapsulated parts of an object
- Aggregation and decomposition
  - “has-a” relationship
- Generalization and specialization (inheritance)
  - “is-a” or “is-like-a” relationship
- Polymorpishm/dynamic binding
  - Softening static typing

Common Mistakes and Errors

```
// what is ugly here?
public class main {
    public static void main(String[] args){
        System.out.println(“Hello World”);}
}
// what is wrong here?
public class MyClass {
    public void static main(string[] args){
        system.out.println(“Hello World”);}
}

// what is ugly here?
public class MyClass {
    public static void main(String[] args){
        System.out.println(“Hello World”);}
};
```

Structuring by Program or Data?

- What are the actions of the program vs. which data does the program act on.
- *Top-down:* Stepwise program refinement
- *Bottom-up*: Focus on the stable data parts then add methods

- Object-oriented programming is bottom-up. Programs are structure with outset in the data.
  - C and Pascal programs are typically implemented in a more top-down fashion.

Pure Object-Oriented Languages

Five rules [source: Alan Kay]

- Everything in an object.
- A program is a set of objects telling each other what to do by sending messages.
- Each object has its own memory (made up by other objects).
- Every object has a type.
- All objects of a specific type can receive the same messages.

Java breaks some of these rules in the name of efficiency.