Inheritance

Practicum 3 – 100 points

- Coming up in week 13: Apr 17th- scantron
- Covers material from weeks 1 – 10
  - Chapter 2
  - Chapter 3
  - Chapter 4 - all sections except 4.10
  - Chapter 5 - all sections except 5.9 and 5.10
  - Chapter 6
  - Chapter 8 - sections 8.1, 8.2, 8.3
  - Chapter 9 - all sections except 9.10 and 9.11
- Practice Questions and Review guide released on Monday

Practicum Retake

- During the time allotted for finals – NO NEW FINAL
  - We are on Monday, May 8th at 7:30 PM – 10PM
    - 7:30 – Practicum 1 Retake
    - 8:20 – Practicum 2 Retake
    - 9:10 – Practicum 3 Retake
  - Show up on time – but do not interrupt current test takers
- Most recent score will be recorded
- YOU MUST HAVE AT LEAST 200 POINTS ON ALL PRATICUMS TO GET ANYTHING BETTER THAN A **D+**
  - There is a total of 300 possible points on the practicums

Example

```
class Student
{
public:
    Student();
    void setMajor(string m);
    void display() const;
private:
    string major_;
};
```

Example – can we create an instance of Student in main()

```
class Student
{
public:
    Student();
    void setMajor(string m);
    void display() const;
private:
    string major_;
};
```

Today

- Inheritance

Inheritance

- In the real-world, inheritance is the process by which one object (or class of objects) is assigned traits/characteristics based on a larger class that it belongs to.
- Can think of it as an “is a” relationship.

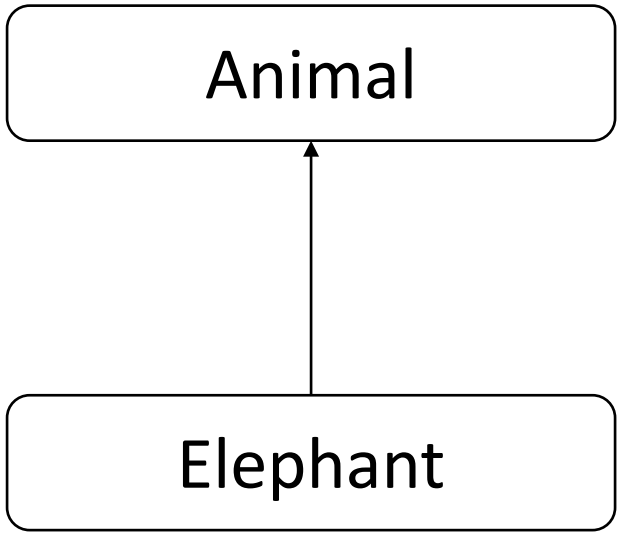
Examples:

- Every car is a vehicle.
- Every sedan is a car.

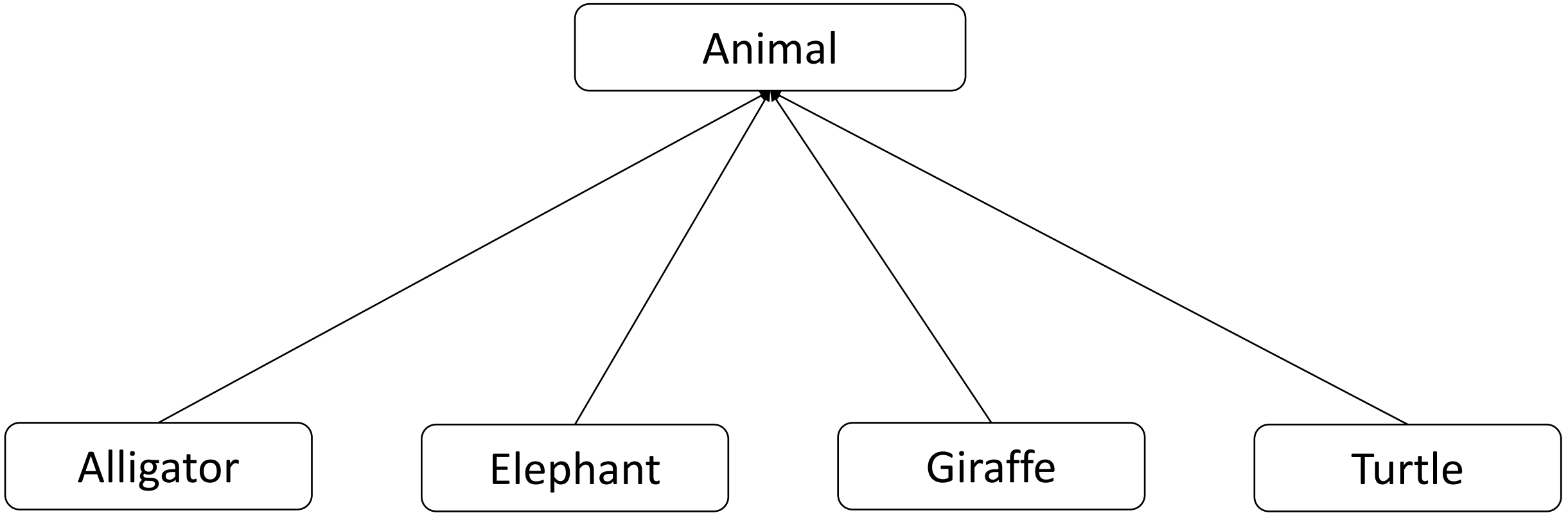
Example

- We have elephant objects in our program…
- We now want to add Giraffes as well

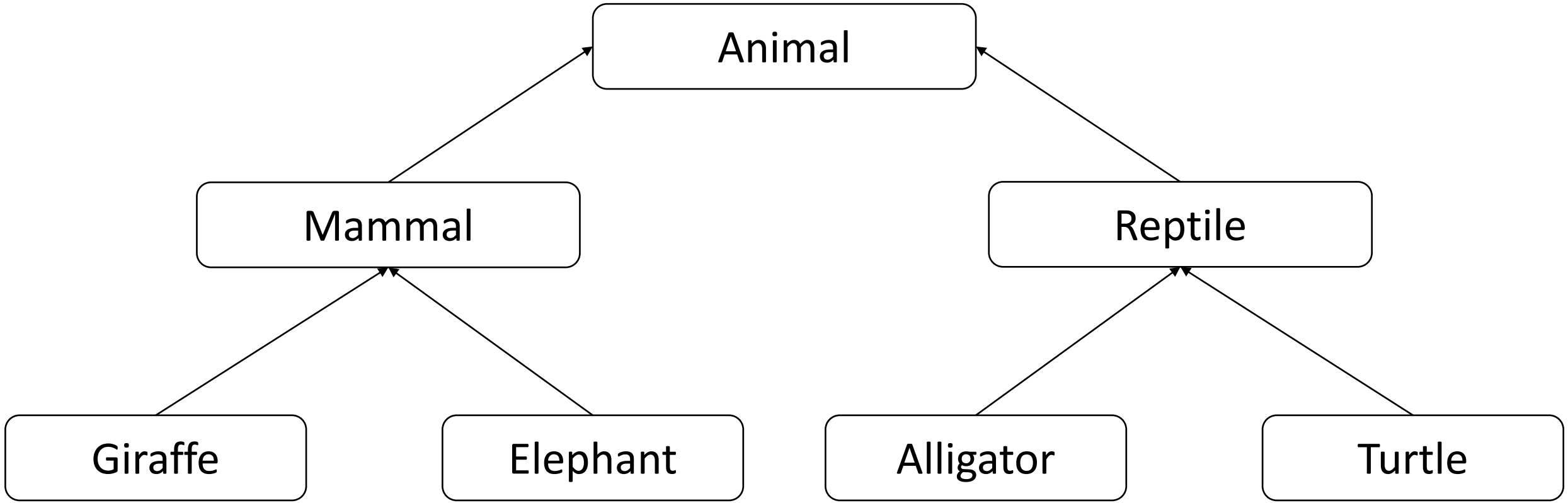
Example – single inheritance



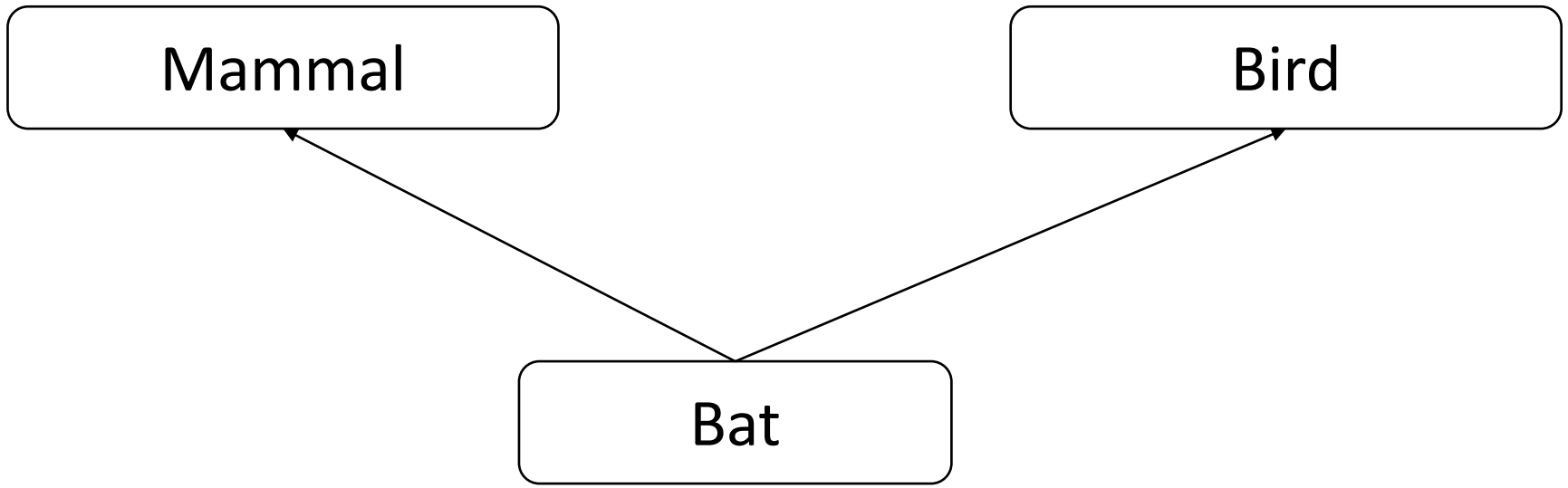
Example – hierarchical inheritance



Example – multilevel inheritance



Example – multiple inheritance



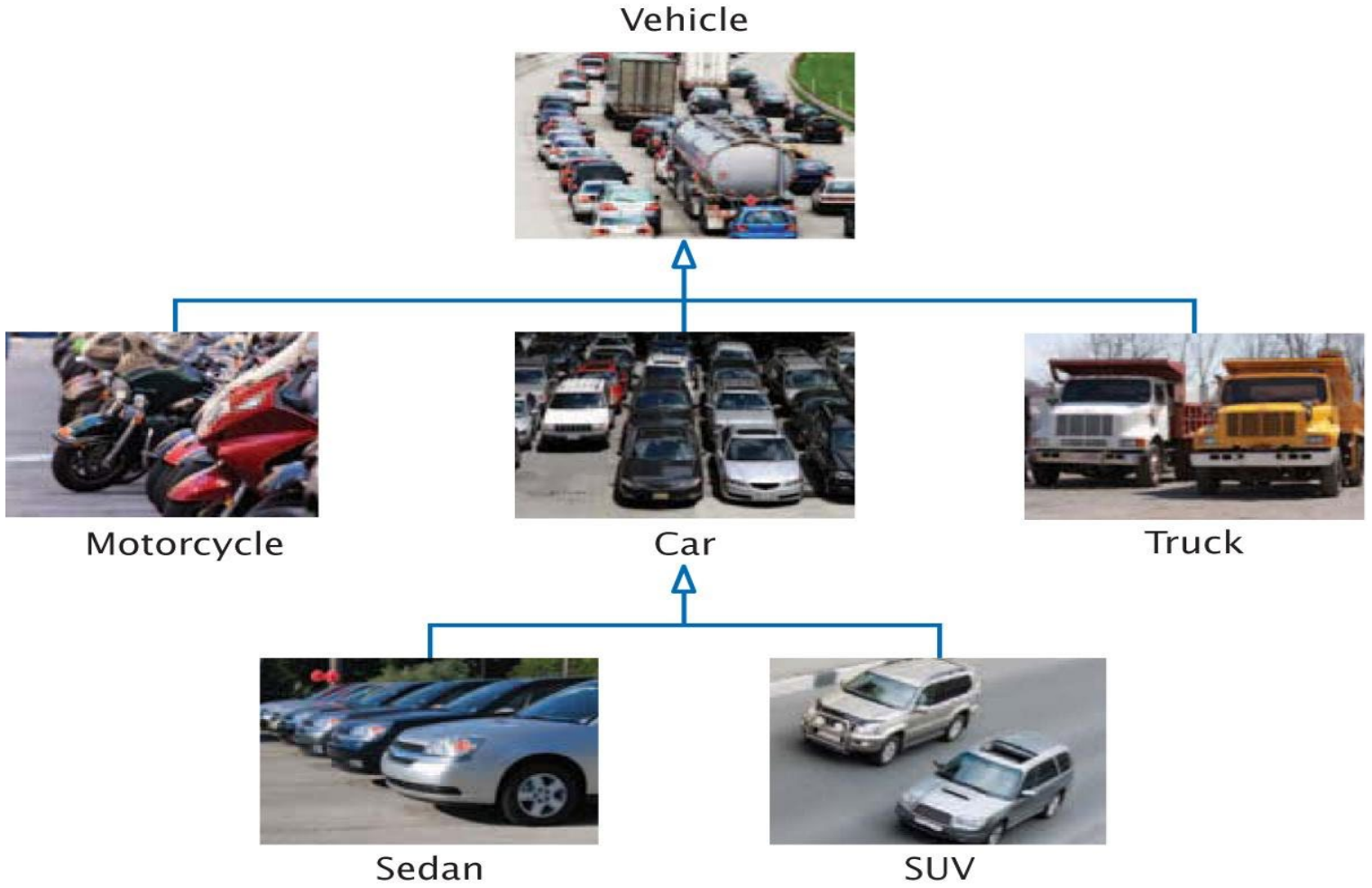
Inheritance

- In object-oriented design, *inheritance* is a relationship between a more general class (called the **base class**) and a more specialized class (called the **derived class**).

- The derived class *inherits* data and behavior from the base class.

- Every car **is a** vehicle.
- IS-A denotes ***inheritance*.**

Inheritance: The IS-A Relationship

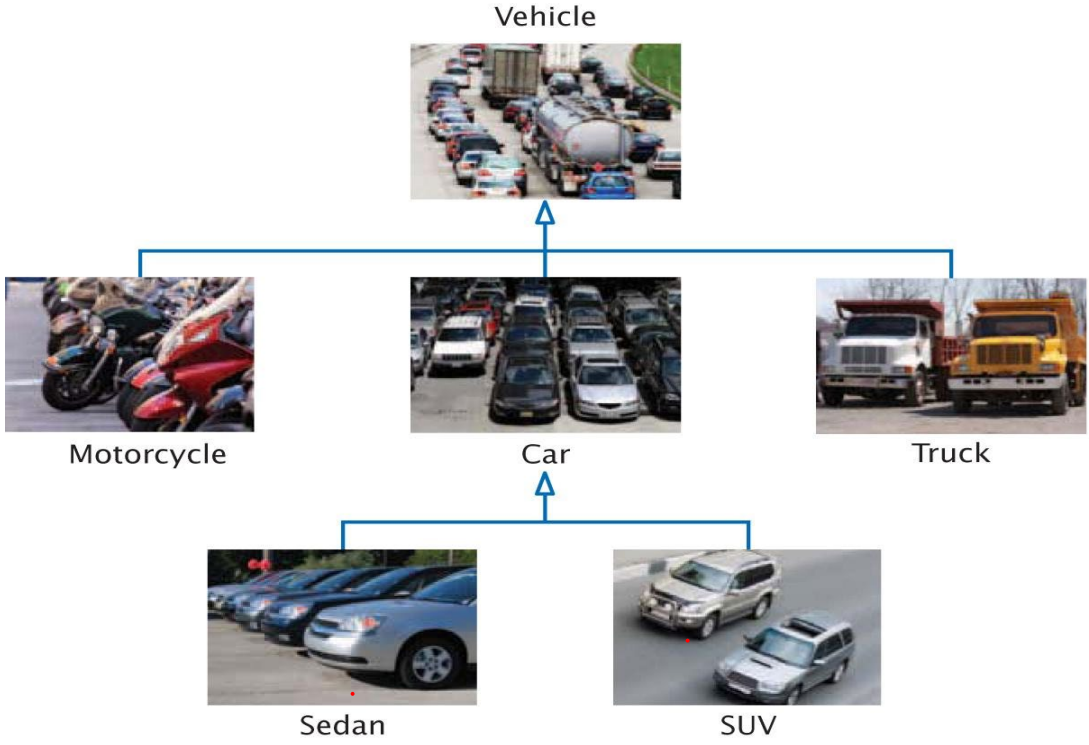


Question: In each of those examples, which is the base class and which is the derived class?

Inheritance

Classes become more specific as you go deeper into the inheritance hierarchy.

- Vehicle is most general
- Car has all the properties of a vehicle, plus some specific to cars
- Sedan has all the properties of a car, plus some specific to sedans
  - Sedans and SUVs inherit properties specific to cars



Substitution Principle

- The substitution principle states that you can always use a derived-class object when a base-class object is expected.

- You cannot use a base-class object when a derived-class object is expected

Example: `double gasMileage(Vehicle v)`

- Since a car IS-A vehicle, we can supply a **`Car`** object to such an algorithm or function, and it will work correctly.

Person Hierarchy

People on a campus take on different roles:

- Student
- Employee
- Faculty
- Staff
- TA

- Can we sketch out this inheritance hierarchy?

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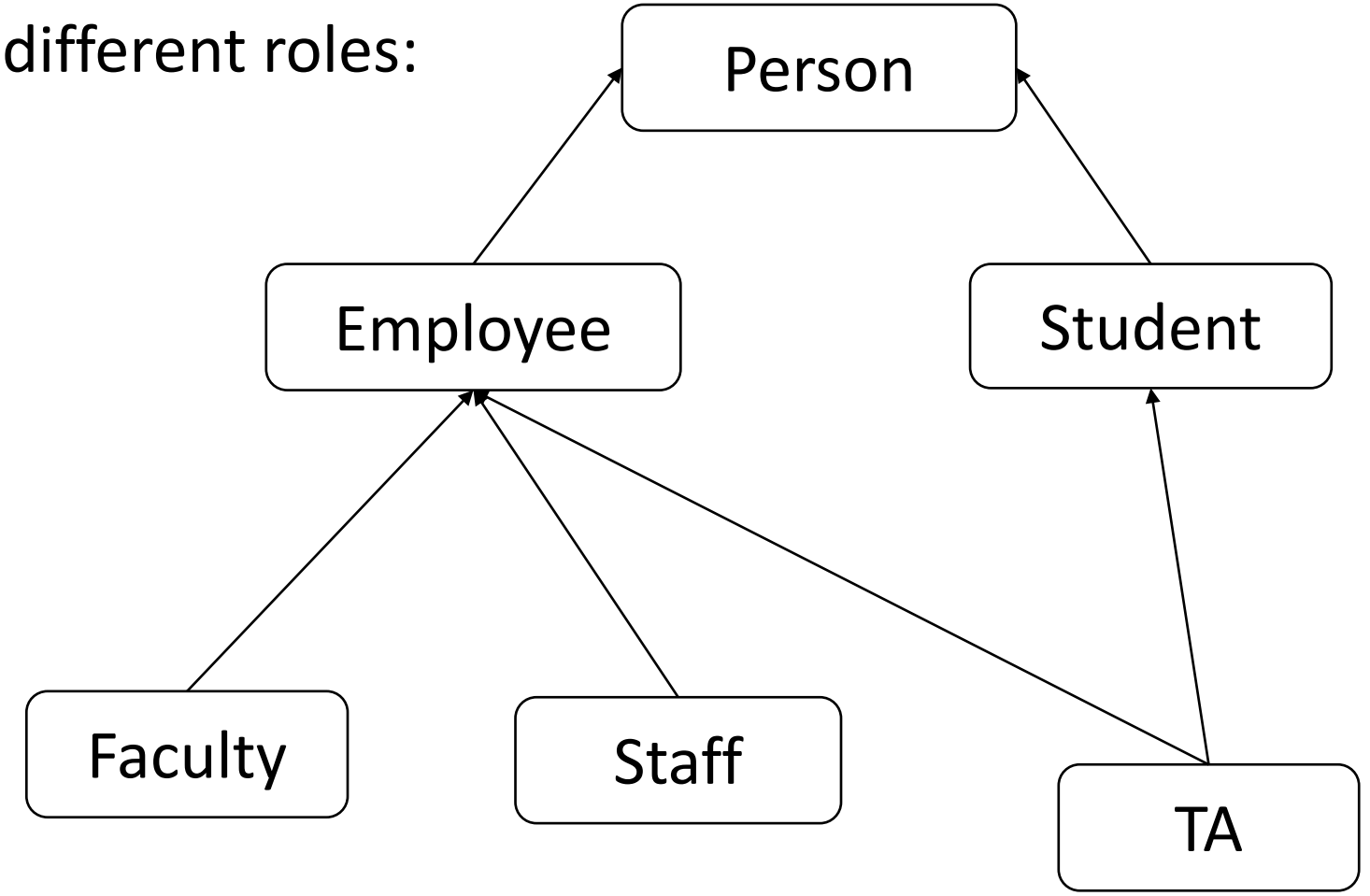

Base class: Person

- Member functions: setName, setBirthday, display, constructor(s)
- Data members: name_, birthday_

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We want an object of person type to work like this:

1) First, the programmer sets the name and the birthday (stored in the Person object)

2) Then, the programmer asks the Person object info to be displayed to the user

Implementing derived classes

- Now that Person class was the bare bones, most basic version of a person. We want different roles!
- Each role is a Person.

  (e.g., a student is a Person)
- So we start with the base class (Person) …
- … then write code for what makes each different type of role a special version of the more general Person type

Implementing derived classes

Write code for what makes each different type of role a special version of the more general Person type

- Through inheritance, each of the derived classes have the data members and member functions that we set up in the base Person class
- AND we can define new stuff that makes the derived classes special!

Derived classes: Student

```
class Student : public Person
{
      public:
      // new and/or changed member functions go here
      private:
      // additional data members go here
};
```

- The : denotes inheritance
- The public reserved word is needed for technical reasons
  - We want to inherit publicly, otherwise we wouldn't be able to use our Person member functions except within Student

public inheritance

```
class Base
{
  public:
     int a;
  protected:
     int b;
  private:
     int c;
};
```

```
class Derived: public Base
{
   // a is public
   // b is protected
   // c is not accessible from Derived
};
```

protected inheritance

```
class Base
{
  public:
     int a;
  protected:
     int b;
  private:
     int c;
};
```

```
class Derived: protected Base
{
   // a is protected
   // b is protected
   // c is not accessible from Derived
};
```

private inheritance

```
class Base
{
  public:
     int a;
  protected:
     int b;
  private:
     int c;
};
```

```
class Derived: private Base
{
   // a is private
   // b is private
   // c is not accessible from Derived
};
```

Derived classes: Student

Let’s analyze what we need to do to make our specialized derived class.

1) We have name and birthday from the base Person class

2) But now need to set several data members that reside in Student…

3) … which means we need to display the info a little bit differently.

→ we will do what is called overriding a member function

(overriding = rewrite a specialized version for our derived class)

Derived classes: Student

Member functions/data members we need to add/modify:

- Member functions: setMajor, display, constructor(s)
- Data members: major_

Derived classes: Student

```
class Student : public Person
{
public:
        Student();
        void setMajor(string m);
        void display() const;
private:
        string major_;
};
```

```
class Person
{
public:
    Person();
    void setName(string person_name);
    void setBirthday(string date);
    void display() const;

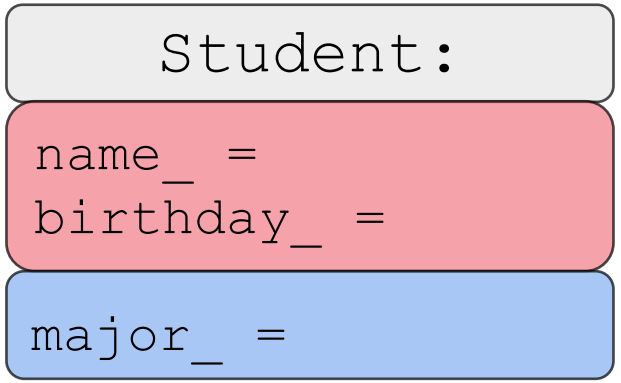
private:
    string name_;
    string birthday_;
};
```

- We first specify the class we are inheriting from (Person) …
- … then only need to specify the differences (new or modified)
- You could slap this derived class definition right below the base class definition

Derived classes: Student

Student is one type, but made up of two parts:

- One part is inherited from Person (name, birthday)
- Another part is new (major)



Member functions from the base class are public:

```
Student s1;
s1.setName("ABC"); // calls public member function of base class - okay!
```

Derived classes: Student

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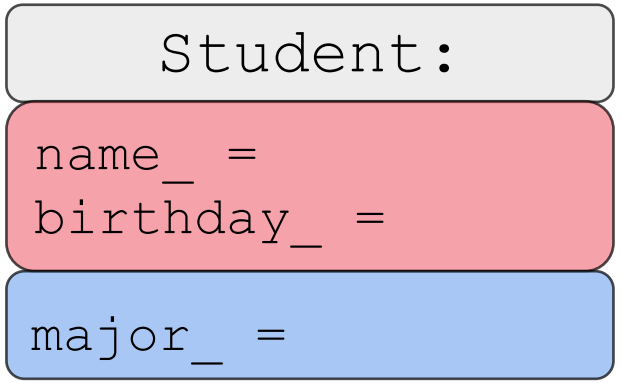
- One part is inherited from Person (name, birthday)
- Another part is new (major)



But data members from the base class are still private:

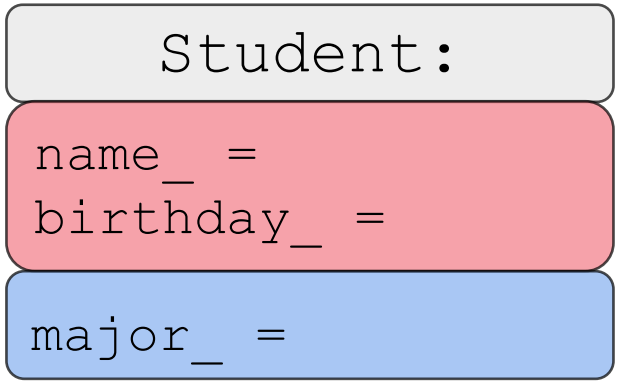
```
Student s1;
s1.name_ = "ABC"; // ERROR!
     ^-- here, the answer data member is private to the
     Question class, so even the derived type cannot access
     it
```

Derived classes: Student

Moral of the story:

- When writing the Student member functions, we cannot directly access the private data members from the Person class
- Just like any other function, we must use our getters from the base class

parts:



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```

Derived classes: overriding member functions

- Recall that our design requires that the display member function be rewritten in the Student class.

→ This is called overriding a member function

Person display member function:

1) cout the name and birthday

Student display member function:

1) cout the name and birthday
2) then cout the major

Derived classes: overriding member functions

The second part is easy – just print out the derived-class **major** data member:

```
void Student::display() const
{
      // Display the info
      …
      // Display major
      cout << "Major: " << major << endl;
}
```

Derived classes: overriding member functions

The first part ***seems*** easy -- just call the **display** function in the **Person** class

```
void Student::display() const
{
      // Display the info
      display(); // ERROR: calls the Student
      version of display
      // Display major
      cout << "Major: " << major << endl;
}
```

Derived classes: overriding member functions

The first part ***seems*** easy -- just call the **display** function in the **Person** class

```
void Student::display() const
{
      // Display the info
      Person::display(); // Calls the Person  version
      of display
      // Display major
      cout << "Major: " << major << endl;
}
```

We remedy this by forcing it to call the Person version by prefixing with Person::

Derived classes: overriding member functions

- Note that we do not necessarily need to use the base class's function.
- We could have just rewritten the code to display the name and birthday.
- But in that case, we'd need a getter for the name and birthday data members, which are private.
- So we would need a new getter for name and birthday in the Person class

Class Inheritance

Hierarchies showing an **is a** relationship

- Ex: A car is a vehicle
- Ex: An apartment is a household

Base class vs **derived class**

- Base = most general
- Derived = more specific

Derived classes

- New member functions, data members
- Overriding old member functions

Resources

- Textbook: 10.4.3, Common error 10.5
- https://www.geeksforgeeks.org/access-modifiers-in-c/
- https://www.programiz.com/cpp-programming/public-protected-private-inheritance
- Example 1, 2 and 3 only @ https://www.programiz.com/cpp-programming/function-overriding