Exercise 12.1

Yes, the number of foxes changes.

However, note that although this has a high probability of happening, it is not guaranteed to and will ultimately depend upon the initial state of the simulation.

Exercise 12.2

Yes, in general it changes each time `simulateOneStep()` is invoked.

Sometimes the number increase and other times it decreases. It probably simulates the birth and death of foxes.

Once again, note that it is highly probably that it will change but there are some states of the simulation when it will not change over the course of a single step.

Exercise 12.3

No, the rates vary.

Exercise 12.4

The numbers of foxes and rabbits goes up and down. The simulation will stop before the end of the specified number of steps if either animal dies out completely.

Exercise 12.5

No, it is not an identical simulation.

Yes, it exhibits similar patterns.

Exercise 12.6

Yes, sometimes the foxes or rabbits die out completely. If there are many foxes near the rabbit groupings then they may eat all the rabbits. If there are not many rabbits, or the foxes become isolated from them, then the foxes may die of hunger.

Exercise 12.9

The `reset()` method of the `Randomizer` must be called first, because this affects the creation of the initial populations following a reset in the `Simulator`.

Exercise 12.11

Distinguishing between genders is only useful if a more accurate simulation of breeding is included in the model. Given the other simplifications in the model, it is unlikely that more accurate breeding patterns would add in a significant way to the lessons learned from the model. Similar effects on numbers are likely to be achievable through other, simpler modifications to existing parameters – such as the breeding frequency or litter sizes.

Exercise 12.12

One observation is that the 'environment' is treated as completely uniform – any animal can occupy any part of it. A real environment would be far less uniform than this.

Feeding has also been treated simplistically, with their being no resource constraints on the rabbits, for instance. In practice, a very large population of rabbits would eat themselves out of their food supply.

Exercise 12.13

Making the breeding probability of the rabbits much lower has the result that the foxes die out quickly because they don't have enough food. Increasing the breeding probability of the rabbits make them spread faster.

Exercise 12.15

Increasing the maximum age for foxes doesn't seem to have a big impact on the number of foxes, suggesting that their survival is largely determined by available food rather than age.http://media.pearsoncmg.com/intl/ema/ema_uk_he_barnes_bluej_3/solutions/resources/zuul-with-transporter.zip

Exercise 12.16

Yes, in some configurations the foxes or the rabbits disappear completely while in others a balance seems to exist.

Exercise 12.17

Yes the size does affect the likelihood of species surviving. With a small field (30x30, say) this is easy to observe.

Exercise 12.18

Running two equal-sized fields, each with half the original area does not seem to affect the viability of the populations over reasonably long runs in this particular model.

Exercise 12.19

As Exercise 12.17 illustrates, an uneven division resulting in too small an area for one of the partitions will likely lead to extinction of one of the species.

Exercise 12.20

The modified findFood() method:

```
    private Location findFood(Location location)
    {
        List<Location> adjacent =
field.adjacentLocations(location);
        Iterator<Location> it = adjacent.iterator();
        Location rabbitLocation = null;
        while(it.hasNext()) {
            Location where = it.next();
            Object animal = field.getObjectAt(where);
            if(animal instanceof Rabbit) {
                Rabbit rabbit = (Rabbit) animal;
                if(rabbit.isAlive()) {
                    rabbit.setDead();
                    foodLevel = RABBIT_FOOD_VALUE;
                    rabbitLocation = where;
                }
            }
        }
        return rabbitLocation;
    }
```

Exercise 12.21

To implement the suggested changes we need a field with maximum food value:

```
    private static final int MAX_FOOD_VALUE = 20;
```

And replace the statement:

```
    foodLevel = RABBIT_FOOD_VALUE;
```

with the statements:

```
    foodLevel += RABBIT_FOOD_VALUE;
    if(foodLevel > MAX_FOOD_VALUE) {
        foodLevel = MAX_FOOD_VALUE;
    }
```

Depending on the maximum food value, the foxes seem to survive longer.

Exercise 12.22

The normal fluctuations in numbers often means that the absolute number of individuals for a particular species drops very low from time to time – a single-digit figure, for instance. It only requires a run of 'bad luck' – i.e., random variation – such as the few remaining foxes heading away from the rabbits instead of towards them, or breeding in low numbers for a few cycles – to take the population over the cliff-edge of extinction. While this might have a low probability in normal circumstances, the probability will never be zero.

It might be worth adding monitoring output to the simulation to show just how low the population levels become, from time to time.

Exercise 12.23

It appears to be less likely that a balance is established if all animals start at age zero.

Exercise 12.24

It still appears to be difficult to establish a working balanced relationship.

The relative size of the initial populations doesn't have a big impact on the outcome of the simulation.

Exercise 12.26

The advantage would be avoiding any possible inconsistency between the content of the `Field` and the lists of animals.

The disadvantage is that it takes time to generate the lists.

Exercise 12.27

There are dead rabbits in the rabbit list that do not appear in the field. This is because the `hunt()` method in fox is able to eat rabbits from the field, but it does not have access to the rabbit list in order to remove them.

Exercise 12.28

The similar class fields are:

```
    private static final int BREEDING_AGE;
    private static final int MAX_AGE;
    private static final double BREEDING_PROBABILITY;
    private static final int MAX_LITTER_SIZE;
    private static final Random rand = Randomizer.getRandom();
```

The fox has an additional class field:

```
    private static final int RABBIT_FOOD_VALUE;
```

The similar instance fields are:

```
    private int age;
    private boolean alive;
    private Location location;
    private Field field;
```

The fox has an additional instance field:

```
    private int foodLevel;
```

The constructors are similar, except that the Fox constructor also initializes its food level.

The similar methods are:

```
    private void incrementAge() //except for the values of the 
static fields
    private int breed() //except for the values of the static 
fields
    private boolean canBreed() //except for the values of the 
static fields
    public Location getLocation()
    public boolean isAlive()
    private void setDead()
    public void setLocation(Location location)
```

The Rabbit class has these methods that the Fox class doesn't have:

```
    private void giveBirth(List<Rabbit> newRabbits)
    public void run(List<Rabbit> newRabbits)
```

And the Fox class has these methods that the Rabbit class doesn't have:

```
    private void giveBirth(List<Fox> newFoxes)
    public void hunt(List<Fox> newFoxes)
    private void incrementHunger()
    private Location findFood(Location location)
```

Exercise 12.29

The truly identical methods are:

```
    public Location getLocation()
    public boolean isAlive()
    private void setDead()
    public void setLocation(Location location)
```

Exercise 12.30

In this case, no. Because it is most likely that we would want to change the value in the future to values different for the `Fox` and the `Rabbit`.

In general it depends on the actual field. If it can truly be considered a field that will always have the same value for both the `Rabbit` and the `Fox`, then it would make sense to treat methods that use that field as identical.

Exercise 12.31

A good way to test it would be to build a set of unit tests that tests the parts of the program that are likely to be affected by the changes. This could be done by creating JUnit test classes for `Fox` and `Rabbit`.

After each small change to the program we should run the unit tests to see if the program still behaves as expected.

Running the program is also a good way to test this program, because it is easy to spot serious errors from the visual output of the program.

Exercise 12.32

See the project `foxes-and-rabbits-v2`.

Exercise 12.33

We have avoided code duplication.

The classes `Fox` and `Rabbit` are smaller.

If we want to add new animals in the future, we already have some functionality available in the `Animal` class.

Exercise 12.34

We can't treat the `Animals` as `Objects` because `Object` does not define an `act()` method that we need to use.

Exercise 12.35

Yes, a class must be declared abstract if it has abstract methods.

Exercise 12.36

Yes, a class can be declared as abstract even though it does not contain any abstract methods.

Exercise 12.37

If you want to prohibit instantiation of a class you could declare it abstract.

If you know that the class will never be instantiated, declaring it abstract would help other programmers in understanding the code

Exercise 12.38

`AbstractCollection`, `AbstractSet`, `AbstractMap`, `AbstractList`, `AbstractSequentialList`.

You can see that a class is abstract in the documentation. The first line below the heading says something like:

```
  public abstract class AbstractCollection
```

To see which concrete classes extend them, take a look at the class diagram in the solution to Exercise 8.15.

Exercise 12.39

Yes, you can see that a method is abstract in the API documentation. For instance, in the left column of the *Method Summary*.

We need to know this if we want to extend an abstract class with a concrete class. This tells us which methods that we as a minimum must implement.

Exercise 12.40

Because we use abstract methods in the `Animal` class which are overridden in the two subclasses `Rabbit` and `Fox`. To understand this behavior it is necessary to understand method overriding.

Exercise 12.41

See: `12-41-foxes-and-rabbits`

Exercise 12.42

The graph shows the rise and fall of population numbers of the two species over time. Observe how rises in the fox population tend to follow slightly behind rises in the rabbit population, and then lead on to falls in rabbit numbers, and consequent falls in fox numbers. These linked cycles clearly show how closely related the population numbers are.

Exercise 12.46

We need to put in the definition of the abstract `getBreedingAge()` in the `Animal` class:

```
 protected abstract int getBreedingAge();
```

An implementation of this can be found in the next exercise.

Exercise 12.47

See: `12-47-foxes-and-rabbits`

Exercise 12.48

Yes, `breed()` can be moved to the `Animal` class. We then also have to create methods to access the two static fields:

http://media.pearsoncmg.com/intl/ema/ema_uk_he_barnes_bluej_3/solutions/resources/foxes-and-rabbits-10.37.zipBREEDING_PROBABILITY and MAX_LITTER_SIZE. Just as we did in the two previous exercises.

Exercise 12.50

The changes we have made to the Animal, Rabbit and Fox classes did not require us to modify other classes except the Simulator class (disregarding Exercise 12.41 where we created the PopulationGenerator). This tells us that the original program had a low degree of coupling and good encapsulation.

Exercise 12.51

See: 12-51-foxes-and-rabbits

Exercise 12.52

Yes it is possible. See: 12-52-foxes-and-rabbits

Define an abstract method in Animal that returns a new born Animal:

```
    /**
     * Create a new animal. An animal may be created with age
     * zero (a new born) or with a random age.
     *
     * @param randomAge If true, the animal will have a random
age.
     * @param field The field currently occupied.
     * @param location The location within the field.
     */
    abstract protected Animal createAnimal(boolean randomAge,
                                           Field field, Location
location);
```

This makes it possible to move giveBirth() from Fox and Rabbit to Animal as follows:

```
    /**
     * Check whether or not this animal is to give birth at this
step.
     * New births will be made into free adjacent locations.
     * @param newborn A list to add newly born animals to.
     */
    protected void giveBirth(List<Animal> newborn)
    {
        // New rabbits are born into adjacent locations.
        // Get a list of adjacent free locations.
        Field field = getField();
        List<Location> free =
field.getFreeAdjacentLocations(getLocation());
        int births = breed();
        for(int b = 0; b < births && free.size() > 0; b++) {
            Location loc = free.remove(0);
            newborn.add(createAnimal(false, field, loc));
        }
    }
```

Note that this calls `createAnimal()` rather than creating either a `Fox` or a `Rabbit` directly. `Fox` and `Rabbit` define concrete versions of `createAnimal()`, such as:

```
    protected Animal createAnimal(boolean randomAge, Field field,
Location location)
    {
        return new Rabbit(randomAge, field, location);
    }
```

Exercise 12.53http://media.pearsoncmg.com/intl/ema/ema_uk_he_barnes_bluej_3/solutions/resources/foxes-and-rabbits-10.41.zip

It is necessary to add the import statement of `java.util.List` to the `Actor` class - but that is all.

Of course, we also need to specify that `Animal` extends `Actor`.

Furthermore, we should update the text of the `Field` class (variable names and comments) to reflect the use of `Actors` instead of `Animals`.

Exercise 12.54

Classes that extend `Actor` will now have to implement it instead.

Exercise 12.55

The fields are static and public fields. Interfaces only allow public static final fields.

Exercise 12.56

There are the following errors in this interface:

- The fields `THRESHOLD` and `value` are declared private which is not allowed. They must be public.
- The field `value` needs to be initialized explicitly.
- It is not allowed to have constructors in interfaces.
- The implementation of `getThreshold()` must be declared as `default` if it has an implementation.

Exercise 12.57

See: `12-57-foxes-and-rabbits`

The number of hunters varies. This is because the newly born animals just get placed into the field without checking whether an actor already occupies that field.

Only a few changes is necessary in the other classes:
- A new method needs to be introduced in the `Field` class: `getRandomLocation()`
- The `populate()` method needs to be updated to also create hunters.

Exercise 12.58

`ArrayList:`	
	`ensureCapacity`
	`removeRange`
	`trimToSize`
`LinkedList:`	
	`addFirst`
	`addLast`
	`getFirst`
	`getLast`
	`removeFirst`
	`removeLast`

The reason that these methods are not defined in the `List` interface is that the methods are not common to all lists, but are specific for that type of list implementation.

Exercise 12.60

The following interfaces are mentioned: `List, Comparator, Comparable.`

`replaceAll`, `sort` and `spliterator` have default implementations in the List interface.

Exercise 12.61

An implementation of a class implementing the `Comparable` interface:

```
/**
 * A class representing some kind of coffee.
 */
public class Coffee implements Comparable<Coffee>
{
    // The strength of the coffee
    private int strength;

    /**
     * Create a new coffee with the given strength
     */
    public Coffee(int strength)
    {
        this.strength = strength;
    }

    public int compareTo(Coffee other)
    {
        int otherStrength = other.strength;
        if (strength > otherStrength) {
            return 1;
        }
        else if (strength < otherStrength) {
            return -1;
        }
        else {
            return 0;
        }
    }

    public String toString()
    {
        return "" + strength;
    }
}
```

And a class to test that it is sorted correctly:

```
import java.util.ArrayList;
import java.util.Collection;
import java.util.Collections;
import java.util.Iterator;
import java.util.List;

public class Test
{
    public void testComparable()
    {
        List<Coffee> coffees = new ArrayList<>();
        coffees.add(new Coffee(10));
        coffees.add(new Coffee(2));
        coffees.add(new Coffee(10));
        coffees.add(new Coffee(20));
        coffees.add(new Coffee(5));
        Collections.sort(coffees);

        System.out.println("Coffees in order of strength:");
        for(Coffee type : coffees) {
            System.out.println(type);
        }
    }
}
```

Exercise 12.63

See: `12-63-foxes-and-rabbits`

Exercise 12.64

In the program below, we have created a list of views that all get updated when required.

This has been done in a way that allows any number of views to be added. To avoid making a lot of changes to the `Simulator` class, we have created a new kind of view (named `MultiView`) that can delegate the method calls to several other views.

See: `12-64-foxes-and-rabbits`

Exercise 12.66

The `PriorityQueue` class might be useful for ordering events.

Exercise 12.68

(This is a duplication of earlier exercises.)

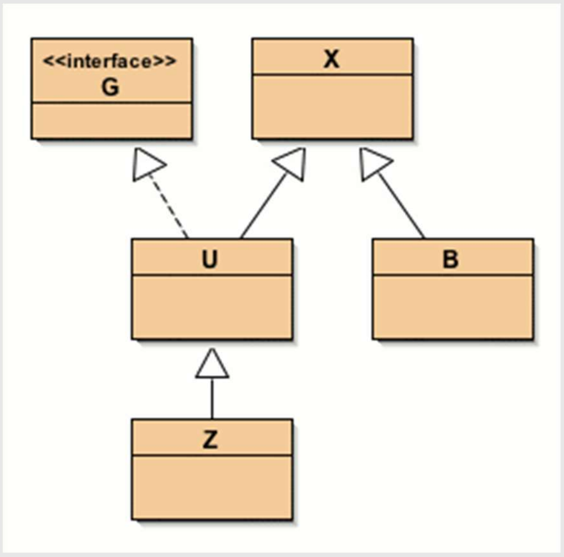
a) Yes, an abstract class can have concrete methods. That is just the way it is - if it couldn't have concrete methods it would almost be the same as a Java interface.

b) No, a concrete class can not have abstract methods. If it could, it would not be possible to instantiate an object of that class. What implementation should be run when you try to invoke an abstract method that is not implemented?

c) Yes, you can have an abstract class without any abstract methods. See exercise 12.32.

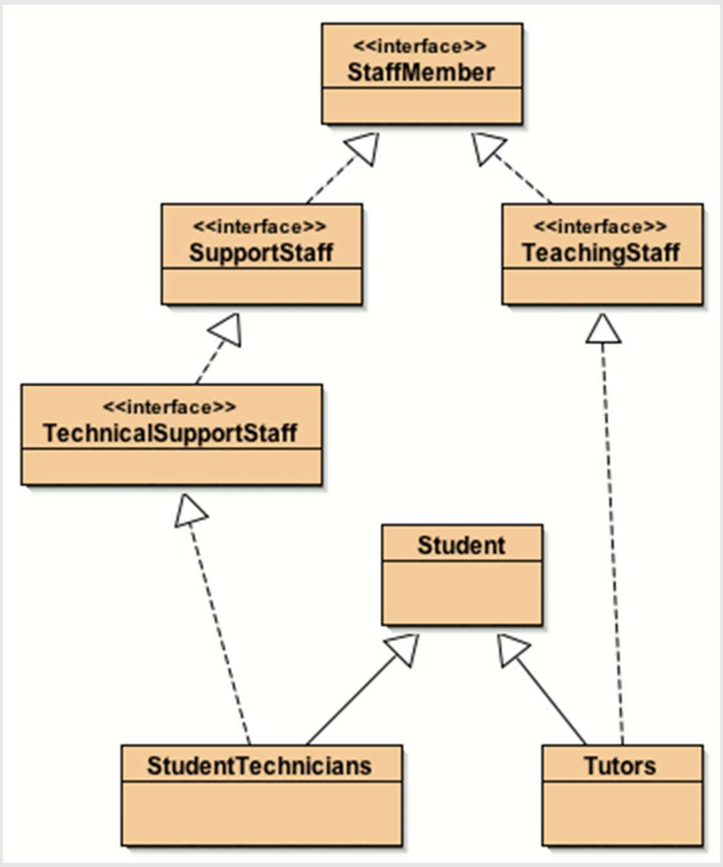
Exercise 12.69

All the types could be interfaces. Because G and X both are super classes for U (legal: g = u, x = u), and do not have any relationship between them (illegal: g = x, x = g), at least one of G or X must be an interface.



Exercise 12.70

Several possible hierarchies could be created. This is one example:



Exercise 12.71

The reason for the `Adapter` classes is a convenience for programmers. If a programmer knows that only a few of the methods from an interface are going to be used, it is still necessary to write an implementation for all the methods in the interface. If the `Adapter` class is used instead, a programmer can just override the few methods that are needed.

A common use of adapter classes is for instance the `MouseAdapter`. The `MouseListener` interface contains five methods to listen for mouse events. If you only want to listen for events when the mouse is clicked you would have to write something like this with the interface:

```
import java.awt.event.MouseListener;
import java.awt.event.MouseEvent;

public class ClickPrinter implements MouseListener
{
    public void mouseClicked(MouseEvent e)
    {
        System.out.println("Mouse clicked");
    }

    public void mousePressed(MouseEvent e)
    {
    }

    public void mouseReleased(MouseEvent e)
    {
    }

    public void mouseEntered(MouseEvent e)
    {
    }

    public void mouseExited(MouseEvent e)
    {
    }
}
```

And with the `MouseAdapter` it would look like this:

```
import java.awt.event.MouseAdapter;
import java.awt.event.MouseEvent;

public class Main extends MouseAdapter
{
    public void mouseClicked(MouseEvent e)
    {
        System.out.println("Mouse clicked");
    }
}
```

Exercise 12.72

We need to give the `TreeSet` some way of knowing how to sort the elements. This can be done in two ways. Either we let `Person` implement the `Comparable` interface or we create a new class which extends `Comparator` and knows how to compare `Person` objects. In Exercise 12.60 we did something similar where we used the `Comparable` interface. So we will try it out with the `Comparator` this time.

The Person class:

```
public class Person
{
    private int age;

    public Person(int age)
    {
        this.age = age;
    }

    public int getAge()
    {
        return age;
    }

    public boolean equals(Object other)
    {
        if(other instanceof Person) {
            return this.age == ((Person) other).age;
        }
        else {
            return false;
        }
    }

    public String toString()
    {
        return "" + age;
    }
}
```

The `PersonComparator`:

```
import java.util.Comparator;

public class PersonComparator implements Comparator<Person>
{
    public int compare(Person p1, Person p2)
    {
        if(p1.getAge() < p2.getAge()) {
            return -1;
        }
        else if(p1.getAge() == p2.getAge()) {
            return 0;
        }
        else { //(p1.getAge() > p2.getAge())
            return 1;
        }
    }
}
```

A test class:

```
import java.util.Set;
import java.util.TreeSet;
import java.util.Iterator;

public class Test
{
    public static void runTest()
    {
        Set<Person> persons = new TreeSet<>(new
PersonComparator());
        persons.add(new Person(32));
        persons.add(new Person(17));
        persons.add(new Person(13));
        persons.add(new Person(35));
        persons.add(new Person(27));
        Iterator<Person> iter = persons.iterator();
        while (iter.hasNext()) {
            System.out.println(iter.next());
        }
    }
}
```