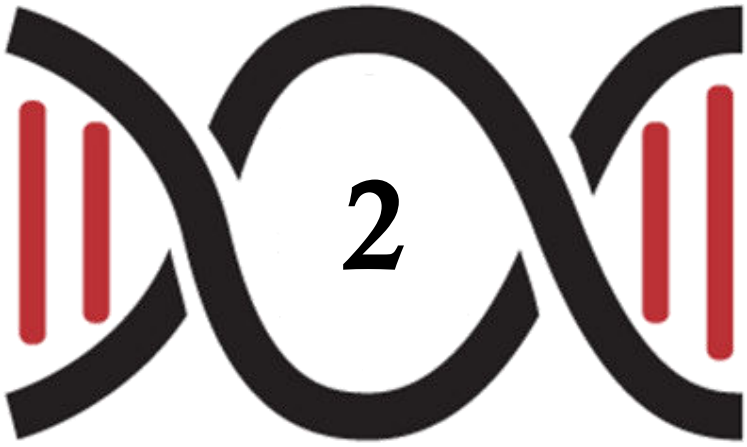
LONDON SCIENCE COLLEGE

AQA A2 BIOLOGY

TOPIC 7

GENETICS/POPULATION/EVOLUTION/ECOSYSTEMS



1 (a) On islands in the Caribbean, there are almost 150 species of lizards belonging to the genus *Anolis*. Scientists believe that these species evolved from two species found on mainland USA. Explain how the Caribbean species could have evolved.

(6)

(b) *Anolis sagrei* is a species of lizard that is found on some of the smallest Caribbean islands. Describe how you could use the mark-release-recapture method to estimate the number of *Anolis sagrei* on one of these islands.

(4)

(c) Large areas of tropical forest are still found on some Caribbean islands. The concentration of carbon dioxide in the air of these forests changes over a period of 24 hours and at different heights above ground.

Use your knowledge of photosynthesis and respiration to describe and explain how the concentration of carbon dioxide in the air changes:

- over a period of 24 hours
- at different heights above ground.

(5)

(Total 15 marks)

2 Some populations of flies are becoming resistant to insecticides intended to kill them.

Scientists developed a method for finding out whether a fly was carrying a recessive allele, **r**, that gives resistance to an insecticide. The dominant allele, **R**, of this gene does not give resistance.

The scientists:

- crossed flies with genotype **RR** with flies with genotype **rr**
- obtained DNA samples from the parents and offspring
- used the same restriction endonuclease enzymes on each sample, to obtain DNA fragments.

(a) Explain why the scientists used the same restriction endonuclease enzymes on each DNA sample.

.....

.....

.....

.....

(2)

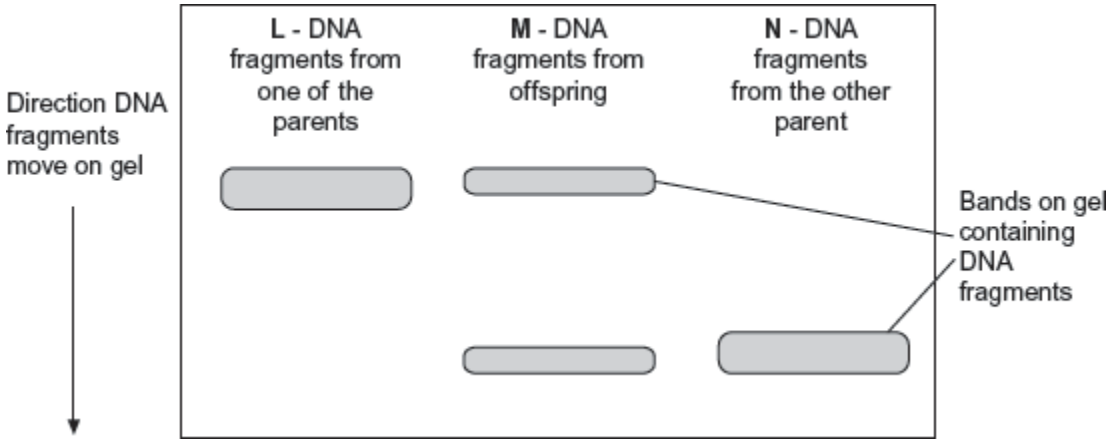
The scientists added two different primers to each sample of DNA fragments for the polymerase chain reaction (PCR).

- Primer A3 only binds to a 195 base-pair fragment from allele **r**.
- Primer A4 only binds to a 135 base-pair fragment from allele **R**.

The scientists separated the DNA fragments produced by the PCR on a gel where shorter fragments move further in a given time.

Their results are shown in **Figure 1**.

Figure 1



(b) Explain why primer A3 and primer A4 only bind to specific DNA fragments.

.....

.....

.....

.....

(2)

(c) Use all the information given to explain the results in **Figure 1**.

.....

.....

.....

.....

.....

.....

[Extra space] .....

.....

.....

(3)

(d) The scientists wanted to know on which chromosome the gene with alleles **R** and **r** was located. From the flies with genotype **RR**, they obtained cells that were in mitosis and added a labelled DNA probe specific for allele **R**. They then looked at the cells under an optical microscope.

Explain why they used cells that were in mitosis.

.....

.....

.....

.....

(2)

(e) Another group of scientists thought that pesticide resistance in some flies was related to increased activity of an enzyme called P450 monooxygenase (PM).
This enzyme breaks down insecticides.

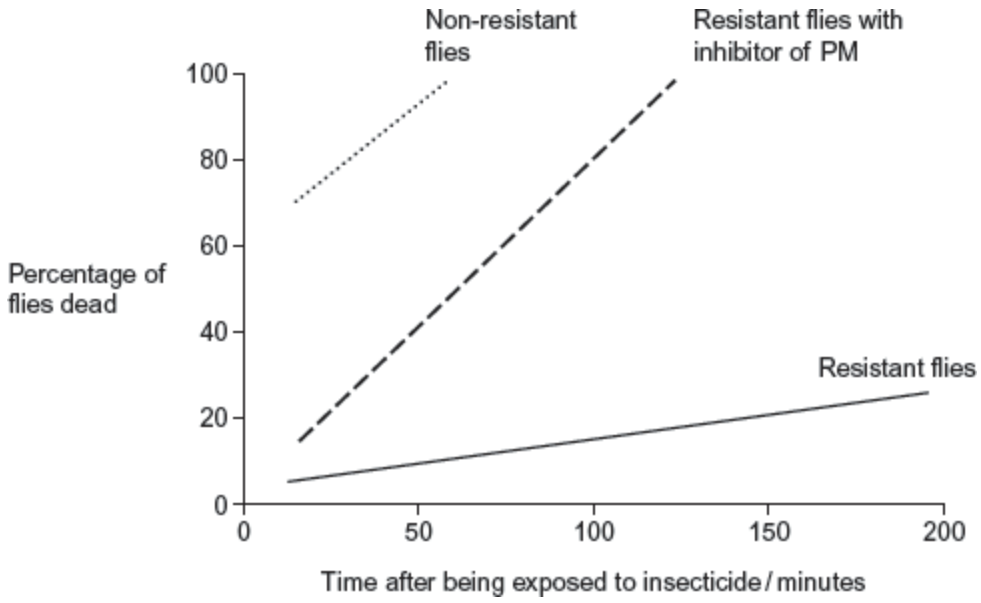
The scientists obtained large numbers of resistant and non-resistant flies. They then set up the following experiments.

- Non-resistant flies exposed to insecticide.
- Resistant flies exposed to insecticide.
- Resistant flies treated with an inhibitor of PM and then exposed to insecticide.

They then determined the percentage of flies that were dead at different times after being exposed to insecticide.

Figure 2 shows their results.

Figure 2



(i) Explain why the scientists carried out the control experiment with the non-resistant flies.

.....

.....

.....

.....

.....

(2)

(ii) The scientists concluded that the resistance of the flies to the insecticide is partly due to increased activity of PM but other factors are also involved.

Explain how these data support this conclusion.

.....

.....

.....

.....

.....

.....

[Extra space] .....

.....

.....

.....

(4)

(Total 15 marks)

3 In birds, **males are XX** and **females are XY**.

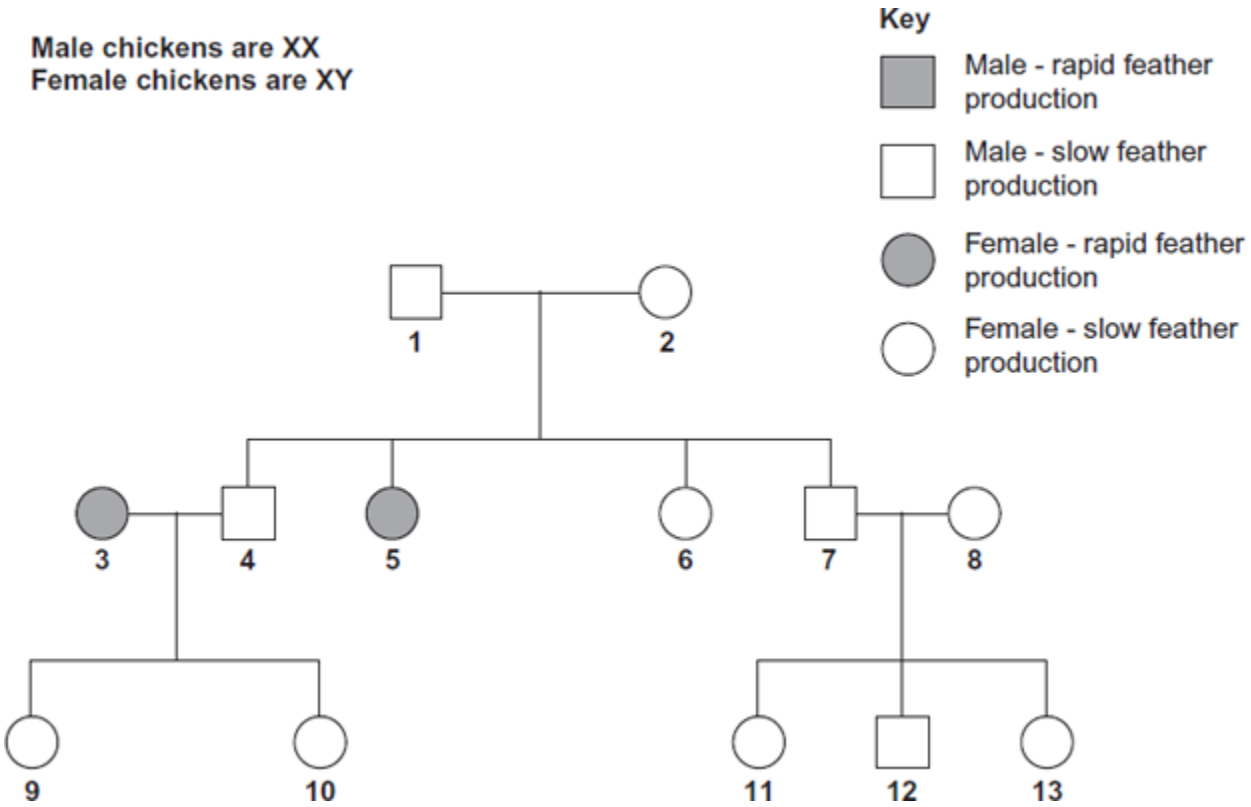
(a) Use this information to explain why recessive, sex-linked characteristics are more common in female birds than in male birds.

.....

.....

(1)

(b) In chickens, a gene on the X chromosome controls the rate of feather production. The allele for slow feather production, **F**, is dominant to the allele for rapid feather production, **f**. The following figure shows the results produced from crosses carried out by a farmer.



(i) Explain **one** piece of evidence from the figure which shows that the allele for rapid feather production is recessive.

.....

.....

.....

.....

(2)

(ii) Give all the possible genotypes of the following chickens from the figure.

Chicken 5 .....

Chicken 7 .....

(2)

(iii) A cross between two chickens produced four offspring. Two of these were males with rapid feather production and two were females with slow feather production. Give the genotypes of the parents.

.....

(1)

(c) Feather colour in one species of chicken is controlled by a pair of codominant alleles which are **not** sex-linked. The allele $\mathbf{C^B}$ codes for black feathers and the allele $\mathbf{C^W}$ codes for white feathers. Heterozygous chickens are blue-feathered.

On a farm, 4% of the chickens were black-feathered. Use the Hardy-Weinberg equation to calculate the percentage of this population that you would expect to be blue-feathered. Show your working.

Answer ..... %

(3)
(Total 9 marks)

4 Malaria is a disease that destroys red blood cells. Scientists investigated whether certain red blood cell phenotypes were associated with developing severe or mild malaria. They compared the red blood cell phenotypes of hospital patients suffering from severe malaria with the red blood cell phenotypes of patients suffering from mild malaria. The results are shown in the table.

Red blood cell phenotype	**Ratio of patients with severe malaria : patients with mild malaria**
Sickle cell trait	0.48 : 1
Blood group A	2.45 : 1
Blood group O	0.96 : 1

(a) Explain the advantage of presenting the results as a ratio.

.....

.....

.....

.....

.....

(2)

(b) What do these data show about the effect of red blood cell phenotypes on the chance of developing severe malaria rather than mild malaria?

.....

.....

.....

.....

(Extra space) .....

.....

(2)

(c) The allele for normal haemoglobin in red blood cells is $\mathbf{Hb^A}$. In some parts of Africa where malaria occurs there is a high frequency in the population of the allele $\mathbf{Hb^C}$.
Individuals possessing the $\mathbf{Hb^C}$ allele have a lower chance of developing severe malaria.
Severe malaria causes a large number of deaths in Africa.

Explain the high frequency of the $\mathbf{Hb^C}$ allele in areas where malaria occurs.

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

(3)
(Total 7 marks)

5 Hydrilla (*Hydrilla verticillata*) is an aquatic plant which has become a major pest of waterways in parts of the USA. Hydrilla is not a native species of the USA. It was introduced into natural habitats from aquariums. In many freshwater habitats it has rapidly become the dominant plant species.

(a) In many freshwater habitats Hydrilla has rapidly become the dominant plant species.
Suggest **two** reasons why.

1.....

.....

2.....

.....

(2)

(b) The spread of Hydrilla has had economic consequences for commercial activities and for the government's environmental agency.
Suggest **two** economic consequences of the spread of Hydrilla.

1.....

.....

2.....

.....

(2)

(c) Scientists investigated the effect of the chemical fluridone as a method of controlling Hydrilla. The study was carried out using samples of Hydrilla grown under controlled laboratory conditions. Several samples of the plant were grown at different concentrations of fluridone. The results are shown in the following table.

	Days of treatment			
	0	20	40	60
Concentration of fluridone / μg dm^{-3}	**Mean biomass of Hydrilla / g**			
0.0	5.0	16.4	20.4	33.4
0.5	5.0	14.1	18.2	31.3
1.0	5.0	9.7	8.9	7.4
5.0	5.0	4.6	2.8	1.3
25.0	5.0	3.2	1.6	0.4

(i) The scientists obtained the biomass of each sample by heating it at 75 °C for 2 hours. They then weighed the sample, reheated it for 15 minutes and weighed it again. They continued this cycle of reheating and weighing until they found the sample had a constant mass.

Explain how this method helped to provide a reliable measurement of the biomass.

.....

.....

.....

.....

(2)

(ii) A scientist reviewed the results of this investigation. He suggested that fluridone should be used in the habitat at a concentration of 5.0 μg dm^{-3} rather than at the other concentrations tested. Use the information provided and your knowledge of chemical control to explain why he made this suggestion.

.....

.....

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

.....

.....

(4)

(d) Scientists have also investigated the use of an integrated system to control Hydrilla. This involved using fluridone and a fungus as a biological control agent. They set up four different experiments.

- Experiment **1** – Hydrilla left untreated
- Experiment **2** – Hydrilla treated with the fungus
- Experiment **3** – Hydrilla treated with fluridone
- Experiment **4** – Hydrilla treated with both fluridone and the fungus.

The scientists determined the biomass of Hydrilla at the end of each experiment.

(i) Experiment **1** acted as a control. Explain why the scientists carried out experiment **1**.

.....

.....

(1)

(ii) The scientists isolated the fungus from the tissue of Hydrilla growing in its country of origin. Suggest **two** possible advantages of using this fungus as the biological control agent.

1.....

.....

2.....

.....

(2)

(iii) The treatment in experiment **4** was the most effective. Use your knowledge of integrated pest control systems to suggest why the treatment in experiment **4** was the most effective.

.....

.....

.....

.....

(Extra space) .....

.....

(2)
(Total 15 marks)

6 Ecologists used a method called proportional sampling to estimate the population size of an animal species. This method is based on assumptions. Two of the assumptions are given below.

1. They know the size of the area, **A**, where the animal population lives.
2. The animals are uniformly distributed in this area.

To carry out the method, the ecologists:

- chose a region of known size, **R**, inside area **A**
- counted the number of animals in region **R**. They called this number **S**
- assumed that the number, **S**, would be in proportion to the size of the total population, **P**, in area **A**.

(a) Proportional sampling can be used to estimate the population size of a species that is uniformly distributed.

(i) What is a **species**?

.....

.....

.....

(1)

(ii) What is meant by **uniformly distributed**?

.....

.....

.....

(1)

(b) Use the letters **A**, **R** and **S** to write an equation showing how proportional sampling is used to estimate the total size of a population, **P**. Show your working.

P = ...

(2)

(c) Population size can be estimated using proportional sampling or mark-release-recapture.

(i) How do the assumptions made in proportional sampling differ from those made in mark-release-recapture?

.....

.....

.....

.....

.....

(2)

(ii) Give **one** assumption about the animals caught that is made in both methods.

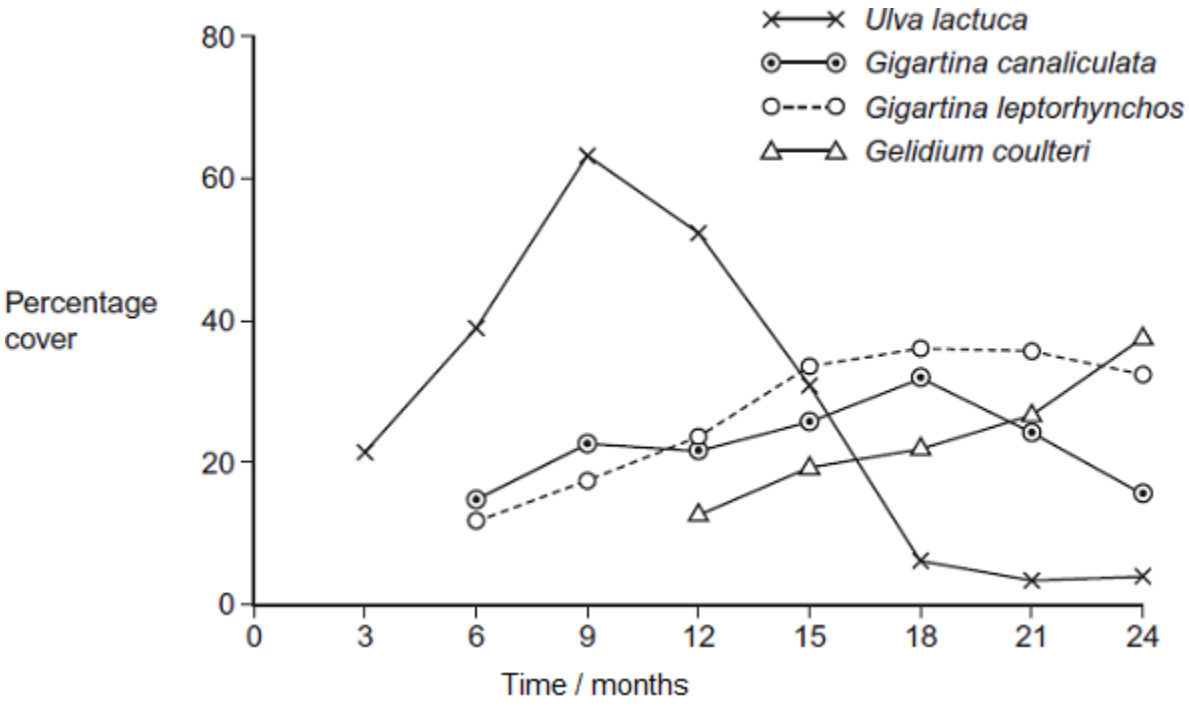
.....

.....

.....

(1)
(Total 7 marks)

7 Algae are photosynthesising organisms. Some algae grow on rocky shores. A scientist investigated succession involving different species of algae. He placed concrete blocks on a rocky shore. At regular intervals over 2 years, he recorded the percentage cover of algal species on the blocks. His results are shown in the graph.



(a) Name the pioneer species.

.....

(1)

(b) (i) The scientist used percentage cover rather than frequency to record the abundance of algae present. Suggest why.

.....

.....

.....

(1)

(ii) Some scientists reviewing this investigation were concerned about the validity of the results because of the use of concrete blocks.
Suggest **one** reason why these scientists were concerned about using concrete blocks for the growth of algae.

.....

.....

.....

(1)

(c) Use the results of this investigation to describe and explain the process of succession.

.....

.....

.....

.....

.....

.....

.....

.....

(Extra space).....

.....

.....

.....

(4)
(Total 7 marks)

8 (a) Explain what is meant by the term phenotype.

.....

.....

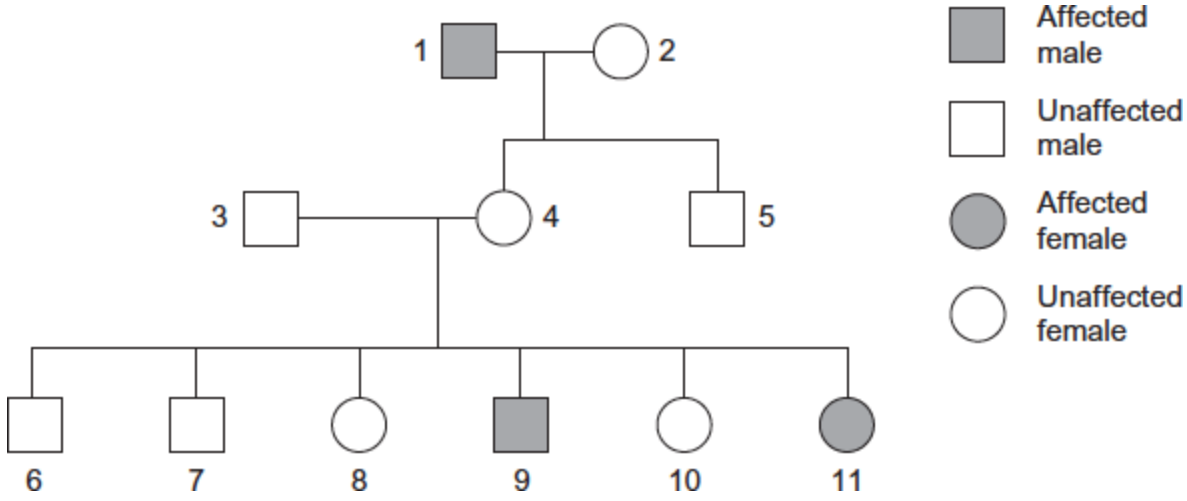
.....

.....

.....

(2)

(b) Tay-Sachs disease is a human inherited disorder. Sufferers of this disease often die during childhood. The allele for Tay-Sachs disease **t,** is recessive to allele **T**, present in unaffected individuals. The diagram shows the inheritance of Tay-Sachs in one family.



(i) Explain **one** piece of evidence from the diagram which proves that the allele for Tay-Sachs disease is recessive.

.....

.....

.....

.....

.....

(2)

(ii) Explain **one** piece of evidence from the diagram which proves that the allele for Tay-Sachs disease is **not** on the X chromosome.

.....

.....

.....

.....

.....

(2)

(c) (i) In a human population, one in every 1000 children born had Tay-Sachs disease. Use the Hardy-Weinberg equation to calculate the percentage of this population you would expect to be heterozygous for this gene. Show your working.

Answer = ... %

(3)

(ii) The actual percentage of heterozygotes is likely to be lower in future generations than the answer to part (c)(i). Explain why.

.....

.....

.....

(1)

(Total 10 marks)

9 **Essay**

You should write your essay in continuous prose.

Your essay will be marked for its scientific accuracy. It will also be marked for your selection of relevant material from different parts of the specification and for the quality of your written communication.

The maximum number of marks that can be awarded is

Scientific	16
Breadth of knowledge	3
Relevance	3
Quality of written communication	3

Write an essay on the following topic:

There are many different types of relationships and interactions between organisms.

(Total 25 marks)

10 Researchers investigated some characteristics of people from different parts of England. In the north of England they selected 200 people and recorded their phenotypes for three different characteristics.

Their results are shown in the figure below.

Phenotype produced by dominant allele	Number of people	Phenotype produced by recessive allele	Number of people
Tongue roller	131	Non-tongue roller	58
Right-handed	182	Left-handed	14
Straight thumb	142	Hitch-hiker thumb	50

(a) Calculate the ratio of straight thumb to hitch-hiker thumb in this study.

Ratio = ...

(1)

(b) The numbers for the tongue rolling and thumb characteristics do not add up to 200.
For each characteristic suggest **one** reason why the numbers do **not** add up to 200.

Tongue rolling .....

.....

.....

Thumb .....

.....

.....

(2)

(c) One student looked at the researchers' results and concluded that 91% of people in the UK are right-handed.
Do you agree with this conclusion? Give reasons for your answer.

.....

.....

.....

.....

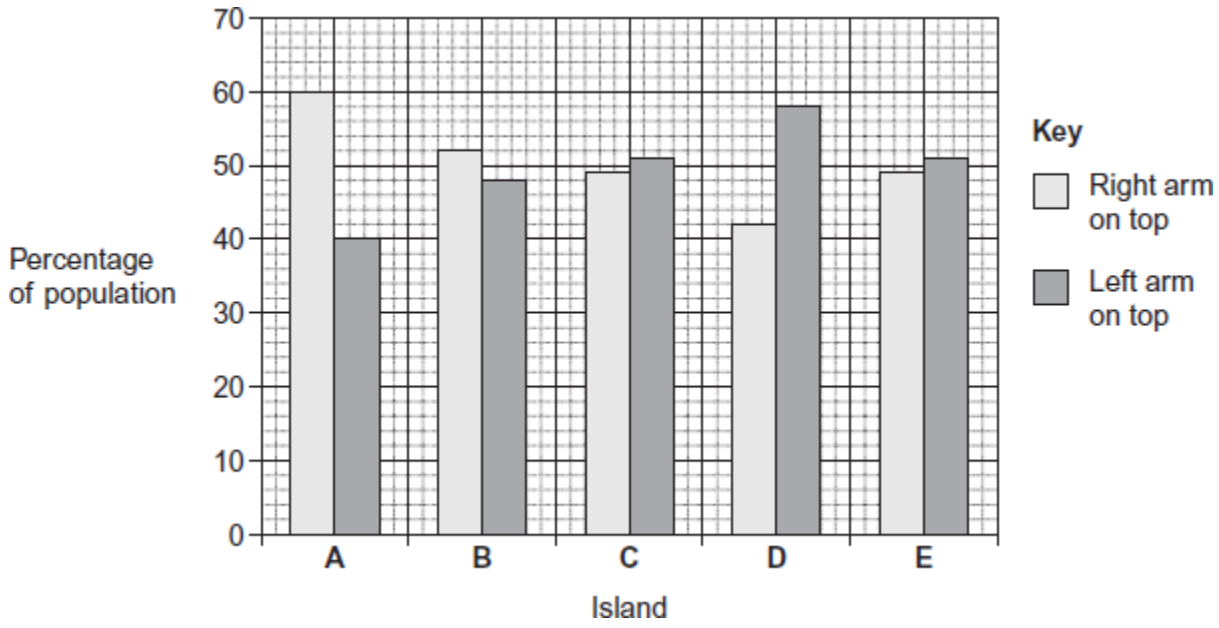
.....

(2)
(Total 5 marks)

11 When most people fold their arms, they either always have their left arm on top, **L**, or always have their right arm on top, **R**. A geneticist investigated this characteristic on five small islands, **A, B, C, D** and **E**.

Her results are shown in **Figure 1**.

Figure 1



On one of the islands she recorded the arm-folding characteristics of parents and their children.

These results are shown in **Figure 2**.

Figure 2

Arm-folding of parents	Arm-folding of the children / %	
	Right arm on top, R	**Left arm on top, L**
R and **R**	41	59
R and **L**	45	55
L and **L**	44	56

The geneticist concluded that arm-folding is not determined by a single gene with a dominant allele and a recessive allele.

(a) The geneticist investigated arm-folding on five small islands.

(i) Use information from **Figure 1** to describe the results she obtained.

.....

.....

.....

.....

.....

(2)

(ii) Suggest advantages of using island populations in this investigation.

.....

.....

.....

.....

.....

(2)

(b) The geneticist concluded that arm-folding is **not** determined by a single gene with a dominant allele and a recessive allele.

Use information from **Figure 2** to explain why she reached this conclusion.

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

(3)

(c) In another study, the geneticist investigated arm-folding in genetically identical twins. Data from this study supported her conclusion from the island study.

Suggest the evidence she found that supported her conclusion.

.....

.....

.....

(1)
(Total 8 marks)

12 The Hardy-Weinberg equation is

$$p^2 + 2pq + q^2 = 1$$

The Hardy-Weinberg equation can be used to estimate the frequency of a recessive allele in a population. Haemochromatosis is a condition caused by a recessive allele.
In one country, 1 in every 400 people was found to have haemochromatosis.

Describe how you would use the Hardy-Weinberg equation to calculate the frequency of people who are healthy but carriers (heterozygotes) of the allele for haemochromatosis.

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

.....

(Total 3 marks)