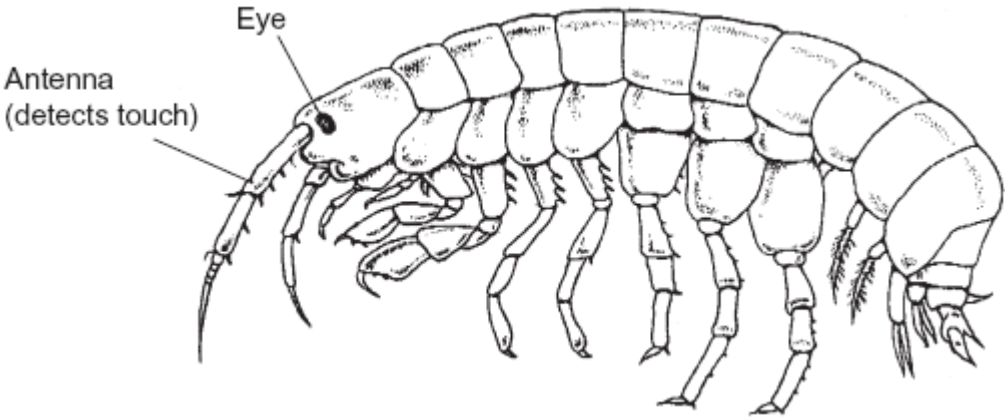
GENETIC DIVERSITY AND ADAPTATION 2 – QUESTIONS

Q1.

Figure 1 shows a fresh-water shrimp.

Figure 1



Biologists collected shrimps from a stream inside a cave and from the same stream when it was in the open.

They measured the maximum diameter of each shrimp's eye. They also measured the length of its antenna. From these measurements they calculated the mean values for each site. **Figure 2** shows their results.

Figure 2

	Shrimps from the stream	
	Inside the cave	In the open
Mean diameter of eye /mm	0.09	0.24
Mean length of antenna /mm	8.46	5.81

(a) The biologists measured the maximum diameter of each shrimp's eye.

Explain why they measured the **maximum** diameter.

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_____

(1)

(b) A scientist working many years earlier suggested that animals which live in caves had similar adaptations. These adaptations included

- smaller eyes
- greater use of sense organs such as those involved in detecting touch.

(i) Do the data in **Figure 2** support this scientist's suggestion? Explain your answer.

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(2)

(ii) The data in **Figure 2** are mean values. Explain how standard deviations of these cmean values would help you to interpret the data in **Figure 2**.

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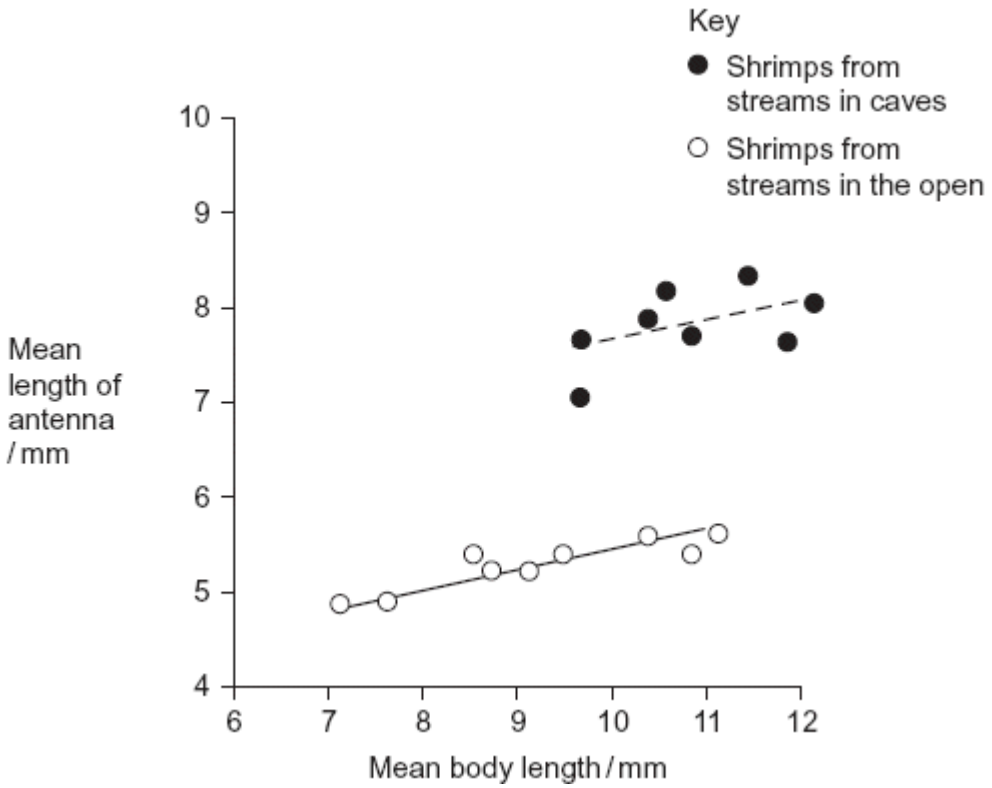
(2)

(c) The biologists investigated shrimps living in other streams. They measured the length of the antennae of these shrimps. They also measured their body length. **Figure 3** shows the mean antenna length plotted against mean body length for each site.

Figure 3



(i) What does the information in the graph suggest about the body lengths of shrimps living in caves and living in the open?

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(2)

(ii) Do the data in the graph support the conclusion that shrimps with longer bodies have longer antennae? Give the reason for your answer.

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(1)

Other biologists investigated the genetic diversity of these shrimps. **Figure 4** shows some of the data they collected.

Figure 4

Gene	Allele	Percentage of shrimps with this allele in steam	
		Inside a cave	In the open
PGI	**A**	0.9	2.5
	B	0.0	3.3

	C	98.2	66.4
	D	0.9	6.6
	E	0.0	21.3
ACO2	**J**	0.0	5.6
	K	0.0	76.7
	L	100.0	17.8

(d) The biologists concluded that the shrimps in the open had a higher genetic diversity than those in the cave. Explain how the data in **Figure 4** support this conclusion.

(1)

(e) The percentage of shrimps with allele **L** in the cave is different from the percentage of shrimps with allele **L** in the open. Use your knowledge of the founder effect to suggest a reason for this difference.

(3)

(f) The biologists who studied these shrimps wanted to know if the shrimps living in the cave were the same species as those living in the open. They used breeding experiments to investigate this.

(i) Describe how the biologists should carry out these breeding experiments.

(ii) The results of breeding experiments would help the biologists to decide whether the shrimps were the same species. Explain how.

(3)

(Total 15 marks)

Q2.

(a) The number of patients infected with the bacterium MRSA has increased in some hospitals. Scientists have suggested ways to reduce the transmission of MRSA in hospitals. Suggest **two** ways to reduce the transmission of MRSA in hospitals.

1. _____

_____

2. _____

_____

(2)

(b) The minimum inhibitory concentration (MIC) is the lowest concentration of a substance that prevents the growth of a microorganism.

When antibiotics are prescribed for treating patients, higher doses than the MIC are recommended. Suggest **two** reasons why.

1. _____

_____

2. _____

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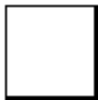
(2)

Scientists tested a new group of drugs for their effectiveness against four species of bacteria. The scientists used MICs to compare the effectiveness of four drugs. The results are shown in the table.

	Minimum inhibitory concentration / µg cm^{-3}			
Drug	*Escherichia coli*	*Staphylococcus aureus*	*Enterococcus faecalis*	*Pseudomonas aeruginosa*
P	0.39	0.049	0.049	3.13
Q	1.54	0.049	0.195	3.13
R	0.39	0.049	0.195	1.56
S	1.56	0.098	0.390	12.50

(c) Which of the four drugs is

(i) most effective against *Enterococcus faecalis*?



(1)

(ii) least effective against all the species of bacteria used?

☐

(1)

(d) The effectiveness of these drugs was tested in double-blind trials using human volunteers. In a double-blind trial neither the volunteers nor the scientists know which treatment a particular volunteer is receiving.

(i) Suggest **two** ways in which a double-blind trial improves reliability.

1. _____

_____

2. _____

_____

(2)

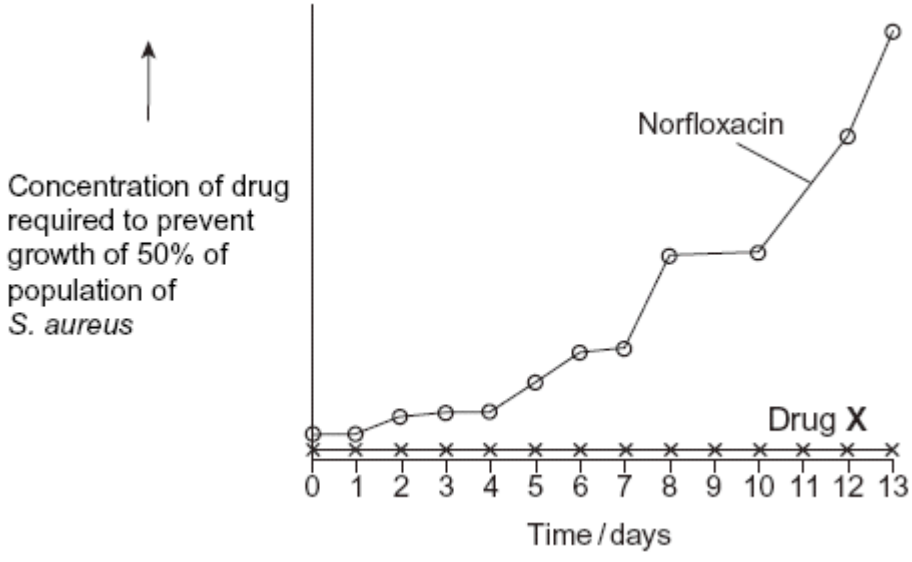
(ii) Suggest **two** factors the scientists should have considered when selecting adult volunteers for this trial.

1. _____

2. _____

(2)

(e) Scientists investigated resistance of the bacterium, *S. aureus* to the antibiotic Norfloxacin. They grew the bacteria in a medium containing a low concentration of Norfloxacin. The concentration of Norfloxacin that they added killed some of the bacteria. It did not kill all of them. Every 24 hours, they removed a sample of the bacteria from the culture. They tested the sample to find the concentration of Norfloxacin that prevented the growth of 50 % of the bacteria in the sample.
The scientists then used the same method to investigate the resistance of *S. aureus* to a new drug, drug **X**. The results of both investigations are shown in the graph.



Describe the results obtained with Norfloxacin.

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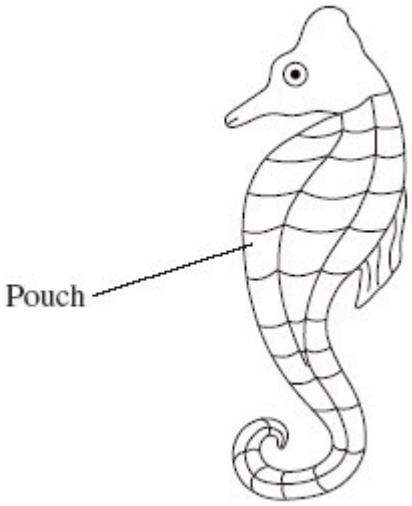
(1)

(Total 11 marks)

Q3.

The diagram shows a seahorse. A seahorse is a fish. Mating in seahorses begins with courtship behaviour. After this, the female transfers her unfertilised eggs to the male's pouch. Most male fish fertilise eggs that have been released into the sea. However, a male seahorse fertilises the eggs while they are inside his pouch. The fertilised eggs stay in the pouch where they develop into young seahorses.



(a) Give **two** ways in which courtship behaviour increases the probability of successful mating.

1. _____

_____

2. _____

_____

(2)

(b) Give **one** way in which reproduction in seahorses increases the probability of

(i) fertilisation

_____

_____

(1)

(ii) survival of young seahorses.

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_____

(1)

Scientists investigated the effect of total body length on the selection of a mate in one Australian species of seahorse. The scientists used head length as a measure of total body length.

(c) (i) Use the diagram to suggest why the scientists measured head length rather than total body length.

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(1)

(ii) Suggest why the scientists were able to use head length as a measure of total body length.

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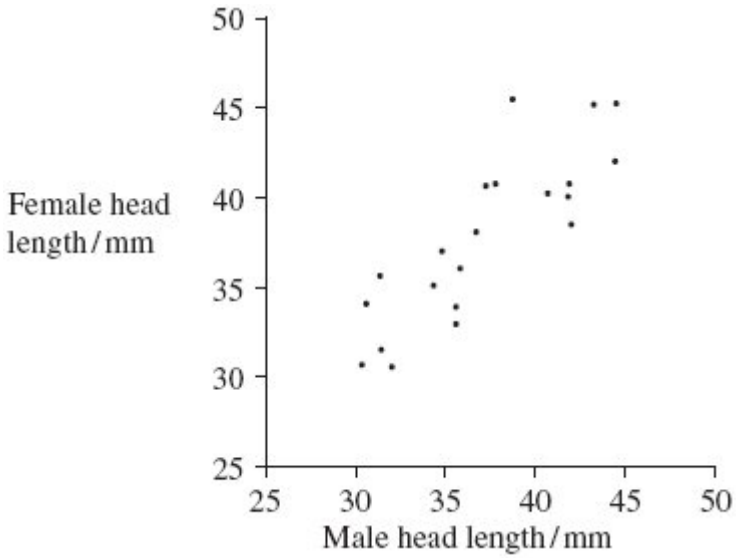
(1)

The scientists measured the head lengths of the female and male of a number of pairs. The results are shown in the graph.



(d) The scientists concluded that total body length affects the selection of a mate. Explain how the results support this conclusion.

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(1)

(e) A female with a head length of 50 mm selected a mate. Explain how you could use the graph to predict the total head length of the mate selected.

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(2)

(f) Scientists studied two species of North American seahorse. They thought that these two species are closely related. Describe how comparisons of biological molecules in these two species could be used to find out if they are closely related.

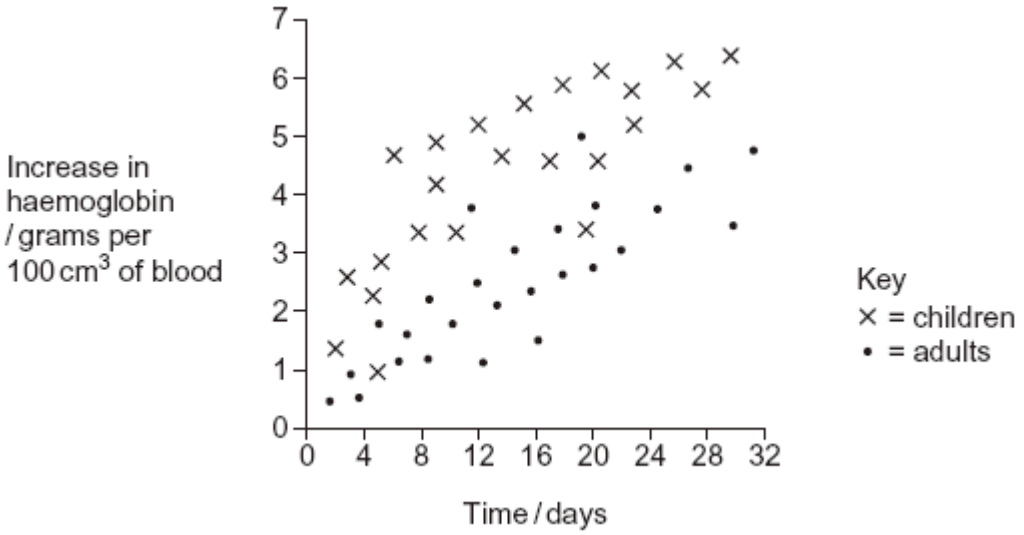
(6)

(Total 15 marks)

Q4.

(a) Haemoglobin contains iron. One type of anaemia is caused by a lack of iron. This type of anaemia can be treated by taking tablets containing iron. A number of patients were given a daily dose of 120 mg of iron. **Figure 1** shows the effect of this treatment on the increase in the concentration of haemoglobin in their red blood cells.

Figure 1



(i) Give **one** difference in the response of adults and children to this treatment.

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_____

(1)

(ii) You could use the graph to predict the effect of this treatment on the increase in haemoglobin content of an adult after 40 days. Explain how.

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(2)

(iii) Haemoglobin has a quaternary structure. Explain what is meant by a quaternary structure.

_____

_____

(1)

(b) (i) Pernicious anaemia is another type of anaemia. One method of identifying pernicious anaemia is to measure the diameter of the red blood cells in a sample of blood that has been diluted with an isotonic salt solution. Explain why an isotonic salt solution is used to dilute the blood sample.

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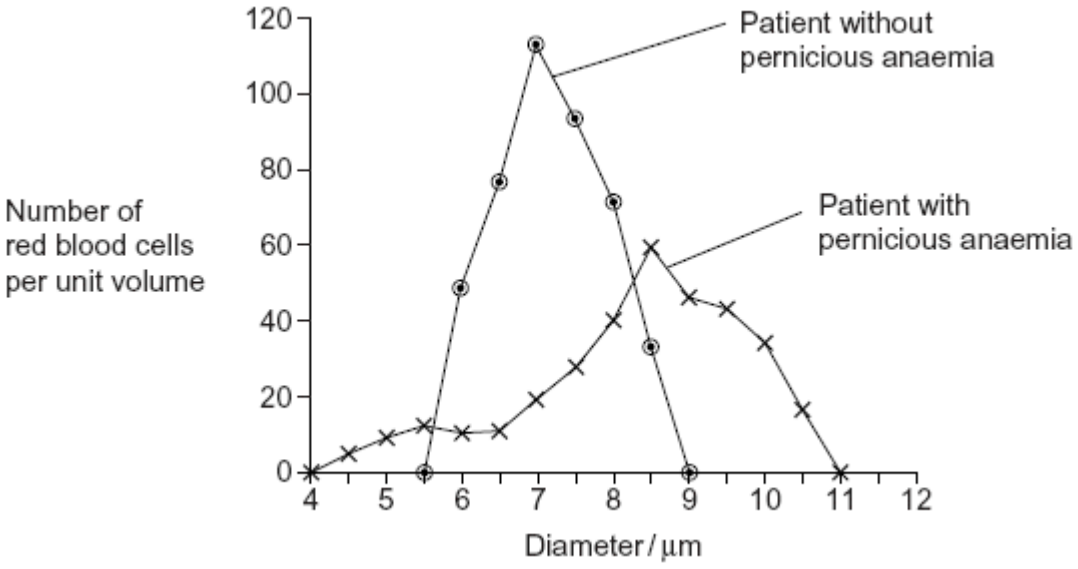
(3)

(ii) A technician compared the red blood cells in two blood samples of equal volume. One sample was from a patient with pernicious anaemia, the other was from a patient who did not have pernicious anaemia. **Figure 2** shows some of the results she obtained.

Figure 2



Describe **two** differences between the blood samples.

1. _____

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2. _____

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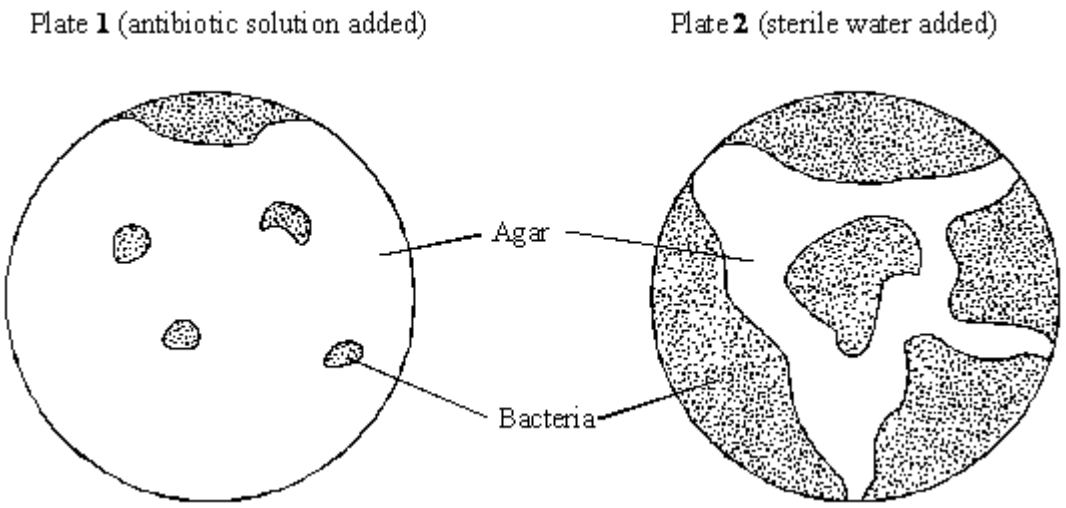
(2)

(Total 9 marks)

Q5.

(a) In an investigation, two sterile agar plates were inoculated with bacteria from the same culture. Then, using a syringe, 2 cm^3 of an antibiotic solution were added to plate **1** and 2 cm^3 of sterile water were added to plate **2**. The diagram shows the plates after 24 hours.



(i) At the start of the investigation, the agar was sterilised. Explain why.

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(1)

(ii) The water was added to plate **2** as a control. Explain why this control was necessary.

_____

_____

(1)

(b) Explain why some bacteria were able to grow on plate **1**.

_____

_____

(1)

(Total 3 marks)

Q6.

Finches are small birds. Fourteen species of finch are found on the Galapagos Islands.

(a) What is a species?

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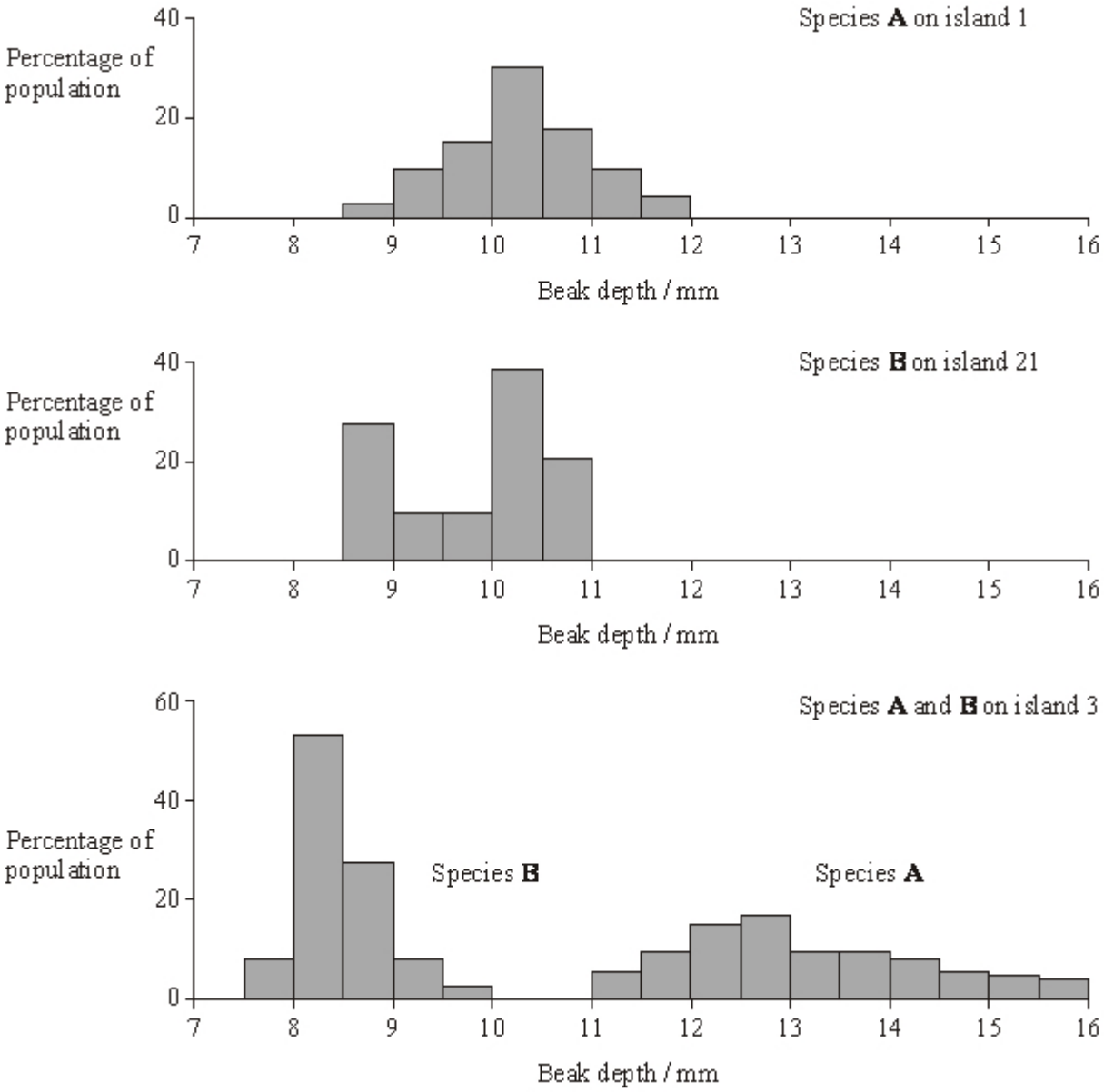
_____

(2)

(b) Measurements were made of the beak depth of two species of finch (species **A** and species **B**) on different islands. Species **A** is found on island 1, species **B** is found on island 2. Both species are found on island 3. They are thought to have colonised

island 3 from islands 1 and 2 respectively. The graphs show the ranges of beak depths of the two species on the different islands.



What type of natural selection took place in the populations of both species after they had colonised island 3? Explain your answer.

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_____

(3)

(Total 5 marks)

Q7.

There is evidence that the first photosynthetic organisms were primitive water-dwelling bacteria. The very first of these lived near the surface of the water in lakes and contained a purple pigment that absorbed light most strongly in the green region of the spectrum. Later, other bacteria evolved that lived on the top of sediment at the bottom of the lakes (**Figure 1**). Gene mutations had enabled these bacteria to synthesise chlorophyll instead of the purple pigment present in the bacteria living near to the surface. Chlorophyll absorbs light most strongly in the blue and red regions of the spectrum (**Figure 2**).

Figure 1

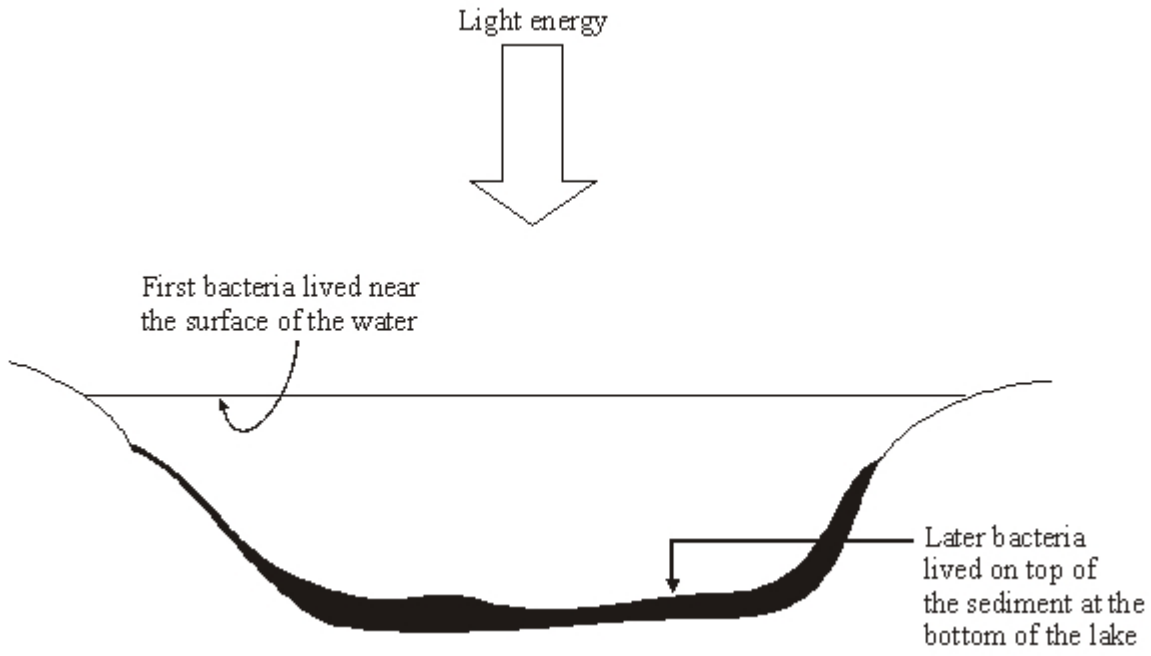
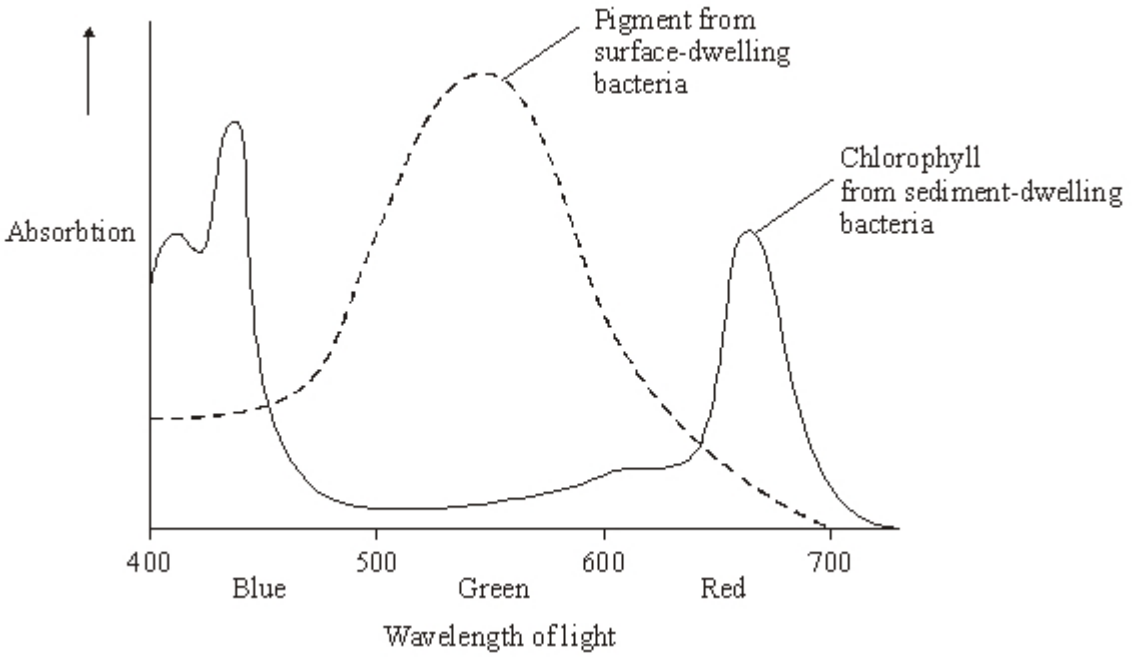


Figure 2



(a) Describe how light energy absorbed by chlorophyll molecules is used to synthesise ATP.

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(5)

(b) Use **Figure 2** to explain how natural selection would favour the evolution of sediment-dwelling bacteria containing a different photosynthetic pigment from those living near the surface of the water.

(6)

(Total 11 marks)

Q8.

(a) Some antibiotics bind with specific receptors in the plasma membranes of bacteria. The structure of these receptors is determined genetically. Bacteria can become resistant to an antibiotic because a gene mutation results in an altered receptor.

Explain how resistance to an antibiotic could become widespread in a bacterial population following a gene mutation conferring resistance in just one bacterium.

(5)

(b) Some humans have a genetic resistance to infection. A recessive allele gives increased resistance to infection by the malarial parasite. In a population, the proportion of babies born who are homozygous for this allele is 0.01. Use the Hardy-Weinberg equation to calculate the expected proportion of heterozygotes in this population. Show your working.

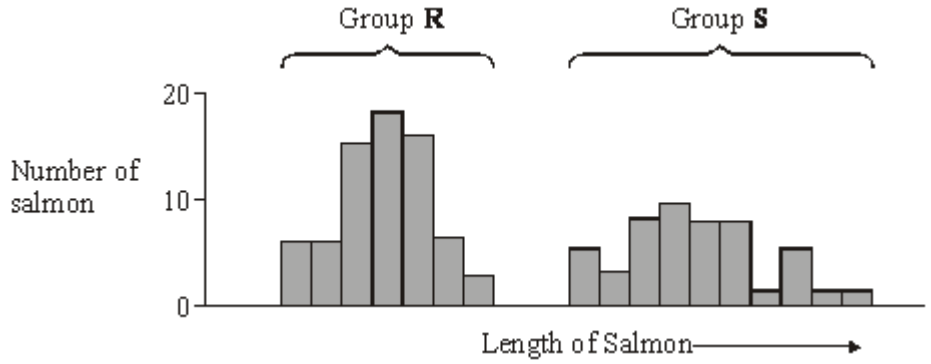
Answer _____

(4)

(Total 9 marks)

Q9.

The graph shows the variation in length of 86 Atlantic salmon.



(a) Give **two** possible causes of this variation that result from meiosis during gamete formation.

1. _____

_____

2. _____

_____

(2)

(b) When comparing variation in size between two groups of organisms, it is often considered more useful to compare standard deviations rather than ranges. Explain why.

_____

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_____

_____

(2)

(Total 4 marks)

Q10.

(a) Explain what is meant by stabilising selection and describe the circumstances under which it takes place.

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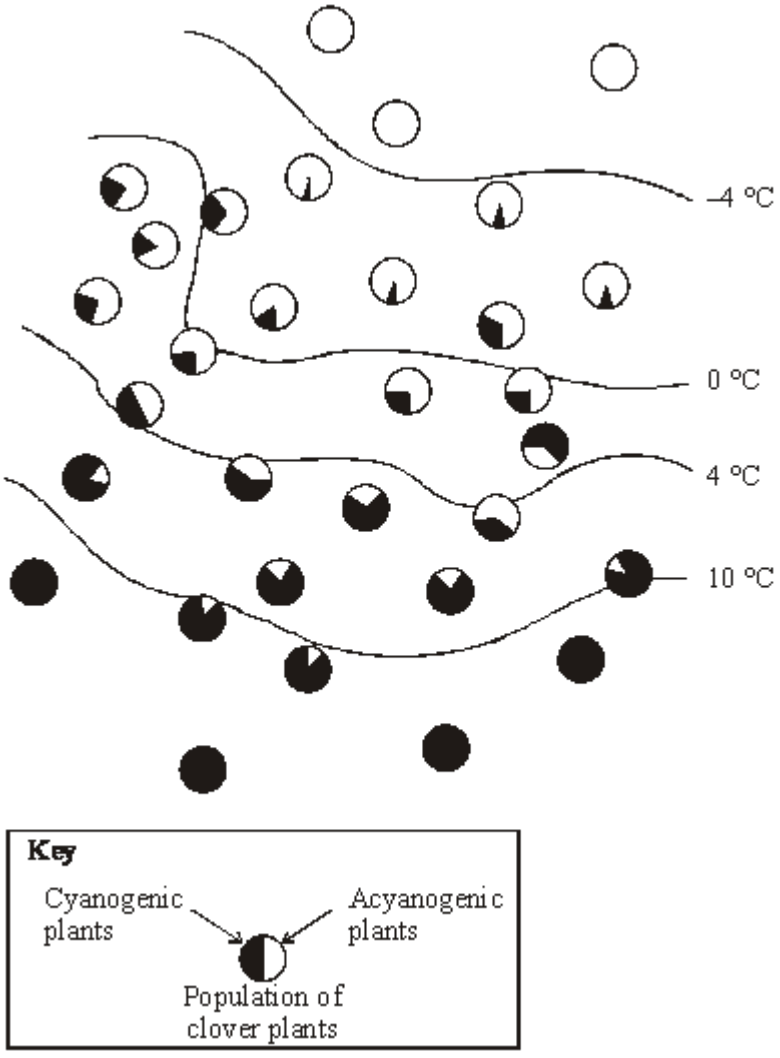
(5)

(b) Some European clover plants can produce cyanide. Those plants that can produce cyanide are called cyanogenic; those that cannot produce cyanide are called acyanogenic. Cyanide is toxic to the cells of animals and plants.

When the leaves of cyanogenic plants are damaged by slugs, or exposed to low temperatures, membranes within the cells are broken. This causes the release of the enzymes that control the reactions which produce cyanide.

The proportions of cyanogenic and acyanogenic plants in clover populations were determined in different parts of Europe. These are shown in the diagram below, together with the mean minimum winter temperatures. Slugs are not usually active at temperatures below 0 °C.



Explain the proportions of cyanogenic and acyanogenic plants in clover populations growing in the area where the mean minimum winter temperature is below –4°C and in the area where it is above 10 °C.

(5)

(Total 10 marks)

Q11.

Lake Malawi in East Africa contains around 400 different species of cichlids which are small, brightly coloured fish. All these species have evolved from a common ancestor.

(a) Describe **one** way in which scientists could find out whether cichlids from two different populations belong to the same species.

(2)

(b) During the last 700 000 years there have been long periods when the water level was much lower and Lake Malawi split up into many smaller lakes. Explain how speciation of the cichlids may have occurred following the formation of separate, smaller lakes.

(4)

(c) Many species of cichlids are similar in size and, apart from their colour, in appearance. Suggest how the variety of colour patterns displayed by these cichlids

may help to maintain the fish as separate species.

_____

_____

_____

_____

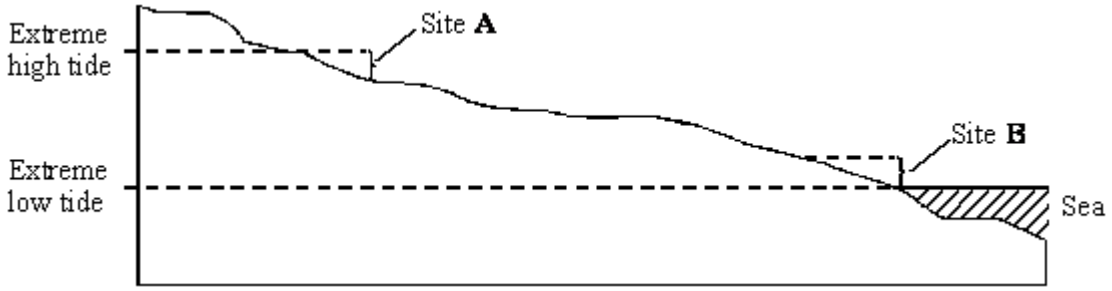
(2)

(Total 8 marks)

Q12.

Parts of the sea shore form a very hostile environment for living organisms. Twice each day the incoming and outgoing tides alternately cover the organisms on the sea shore with water and then leave them exposed. The force of the waves could also dislodge any organisms that were not firmly attached.

The diagram shows a section through a rocky shore. Two sites were studied: site **A** was on the upper shore and site **B** on the lower shore.



The table shows the seaweeds that were found growing at sites **A** and **B**.

Site A: upper shore	Mean number per m²	Site B: lower shore	Mean number per m²
Ascophyllum nodosum	2	*Corallina officinalis*	31
Fucus spiralis	10	*Fucus serratus*	8
Fucus vesiculosus	4	*Laminaria digitata*	15
Pelvetia canaliculata	6	*Laminaria hyperborea*	3
		Laminaria saccharina	6
		Laurencia pinnatifida	18
		Palmaria palmata	6
Index of diversity		Index of diversity	4.77

(a) (i) Use the formula $d = \frac{N(N-1)}{\Sigma n(n-1)}$

where **d** = index of diversity
N = total number of organisms of all species
n = total number of organisms of a particular species

to calculate the index of diversity for the seaweeds growing at site **A**.

Show your working.

Index of diversity at site **A** = _____

(2)

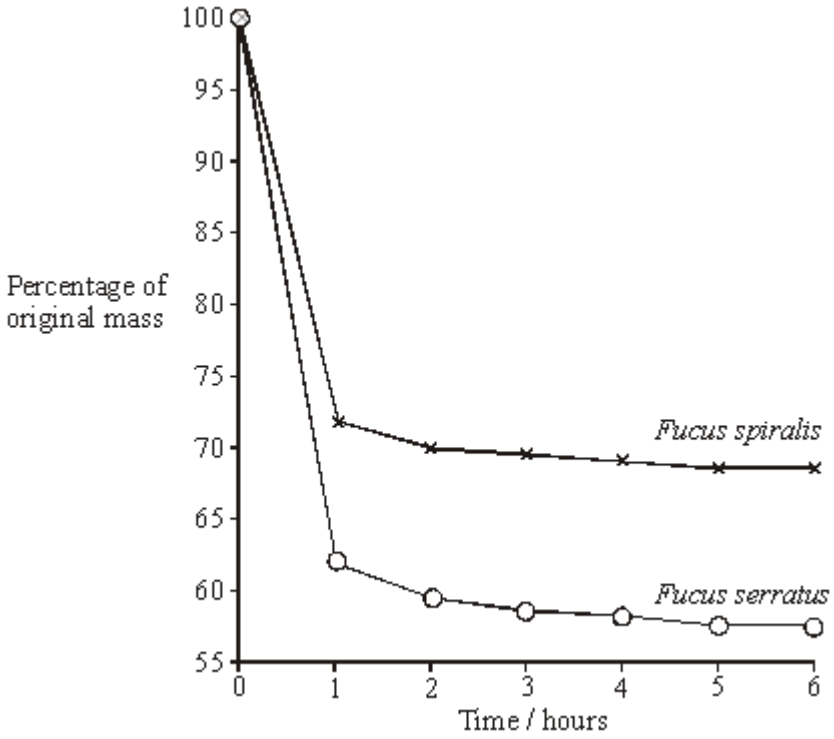
(ii) Give **one** advantage of calculating the index of diversity rather than just recording the number of species present.

_____

_____

(1)

(b) Availability of water is one abiotic factor which determines the distribution of seaweeds. The graph shows loss in mass due to water evaporation for two of the seaweed species. The two seaweeds belong to the same genus but one was found only on the upper shore and the other only on the lower shore.



Explain how the results shown in the graph relate to the distribution of these two seaweeds on the sea shore.

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_____

_____

(3)

(Total 6 marks)

Q13.

When coal is mined by open-cast mining, the top layer of soil is first scraped off and stored in a large heap. Once mining has finished, the area can be reclaimed. Soil from this store is then spread back over the surface.

Some of the bacteria living in the soil store respire aerobically and some respire anaerobically. **Table 1** shows the numbers of aerobic and anaerobic bacteria found at different depths in a soil store.

Depth / cm	**Mean number of bacteria per gram of soil (× 10^7)**			
	Aerobic bacteria		Anaerobic bacteria	
	after 1 month	after 6 months	after 1 month	after 6 months
0	12.0	12.1	0.6	0.8
50	10.4	8.6	0.8	1.3
100	10.1	6.1	0.7	4.1
150	10.0	3.2	0.7	7.9
200	11.6	0.8	0.7	8.4
250	11.9	0.7	0.8	8.8
300	11.0	0.8	0.6	9.1

Table 1

(a) Some of the soil used to determine bacterial numbers was collected from the surface of the soil store. Describe how you would ensure that this soil was collected at random.

_____

_____

_____

_____

(2)

(b) (i) Describe how the numbers of aerobic bacteria after 6 months change with depth.

_____

_____

_____

_____

(2)

(ii) Explain the difference in the numbers of aerobic bacteria at a depth of 300 cm between 1 and 6 months.

_____

_____

_____

_____

(2)

(c) Explain how the changes in bacterial numbers which take place at 150 cm illustrate the process of succession.

_____

_____

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_____

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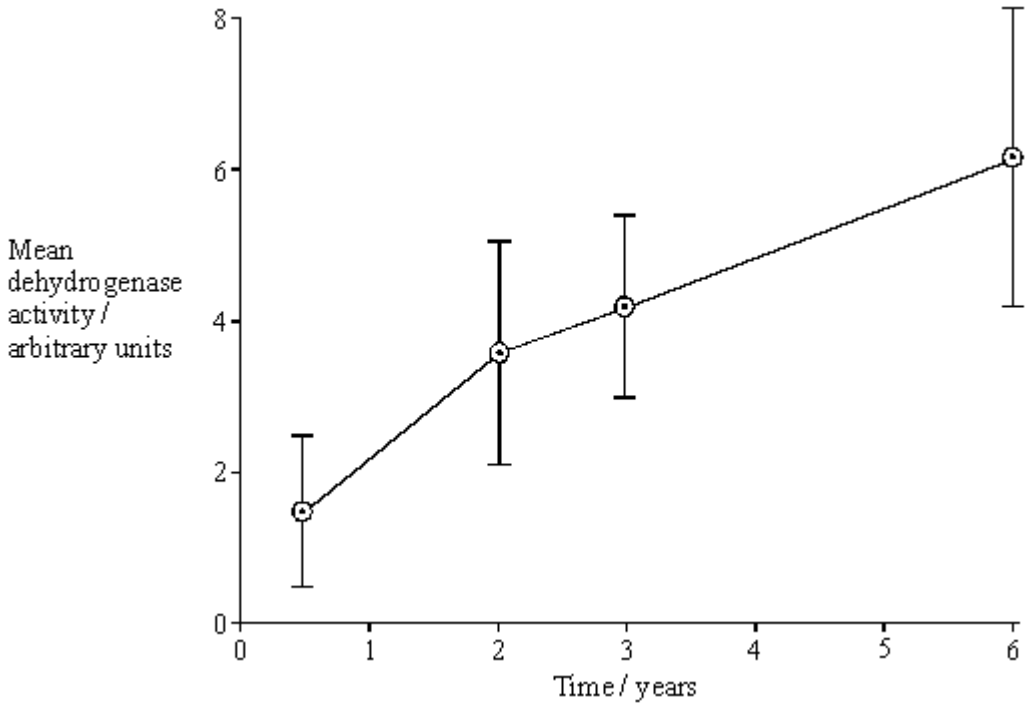
(3)

Dehydrogenase is an enzyme involved in aerobic respiration. Dehydrogenase activity in a soil sample can be used as a measure of the activity of aerobic bacteria. The graph shows the mean dehydrogenase activity of soil samples taken from the same depth in a soil store at different times. The bars on the graph represent two standard errors above and below the mean.



(d) (i) From what depth in the soil store would you expect these soil samples to have been taken? Use information from **Table 1** to explain your answer.

_____

_____

_____

_____

(2)

(ii) How would you expect dehydrogenase activity to vary with depth after 6 months?

Use information from **Table 1** to explain your answer.

_____

_____

_____

_____

_____

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(3)

(e) What do the error bars tell you about the difference between the mean dehydrogenase activity at 6 months and 3 years? Explain your answer in terms of probability and chance.

_____

(3)

(f) **Table 2** shows the dehydrogenase activity and the number of aerobic bacteria present in some soil samples.

Dehydrogenase activity / arbitrary units	Number of aerobic bacteria per gram of soil (× 10^7)
13.1	12.0
9.2	8.7
5.5	6.5
3.0	4.6
2.2	2.7
0.4	0.6

Table 2

A sample of soil was found to have dehydrogenase activity of 8.7 arbitrary units. Explain how you would use the data in **Table 2** to predict the likely number of aerobic bacteria in 1 g of this soil sample.

(3)

(Total 20 marks)

Q14.

IQ test scores have been used as a measure of intelligence. Genetic and environmental factors may both be involved in determining intelligence. In an investigation of families with adopted children, the mean IQ scores of the adopted children was closer to the mean IQ scores of their adoptive parents than to that of their biological parents.

(a) Explain what the results of this investigation suggest about the importance of genetic and environmental factors in determining intelligence.

(1)

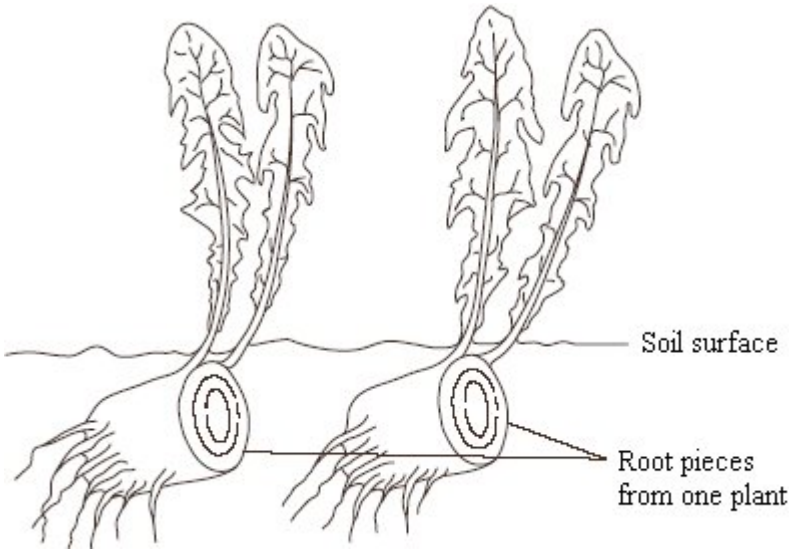
(b) Explain how data from studies of identical twins and non-identical twins could provide further evidence about the genetic control of intelligence.

(4)

(Total 5 marks)

Q15.

It is difficult to get rid of dandelions from a garden because small pieces of the root are able to grow into new plants if left behind in the soil. This is shown in the drawing.



(a) Explain why the plants produced form a clone.

_____

_____

(2)

(b) Suggest **one** reason why the plants in a clone may not be identical in appearance.

_____

_____

(1)

(c) Most plants produce seeds after fertilisation in sexual reproduction. However, dandelions produce small, windblown seeds without fertilisation taking place. Suggest **two** advantages to the dandelion of being able to reproduce from these seeds, as well as from pieces of root.

Advantage 1 _____

_____

Advantage 2 _____

_____

(2)

(Total 5 marks)

Q16.

(a) Explain how crossing over can contribute to genetic variation.

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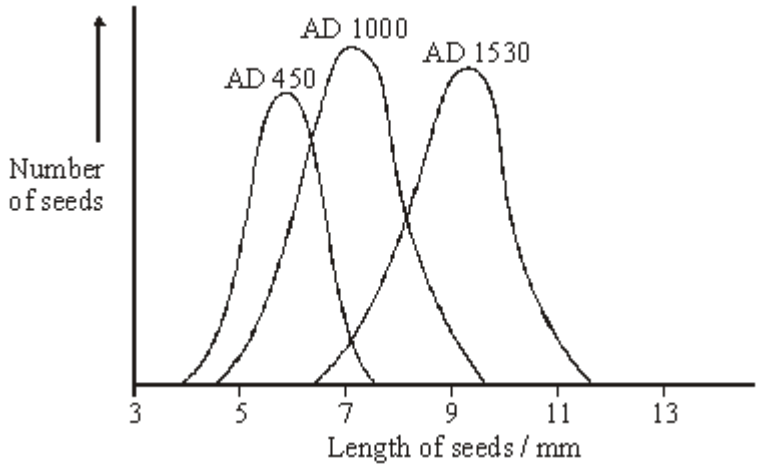
_____

(3)

(b) Maize seeds were an important food crop for the people who lived in Peru. The seeds could be kept for long periods. Each year, some were sown to grow the next crop. Archaeologists have found well-preserved stores. The graph shows the lengths of seeds collected from three stores of different ages.



(i) Within each store the maize seeds showed a range of different lengths. Explain **one** cause of this variation.

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(2)

(ii) Use your knowledge of genetics and selection to explain the changes in the mean length of the seeds between AD 450 and AD 1530.

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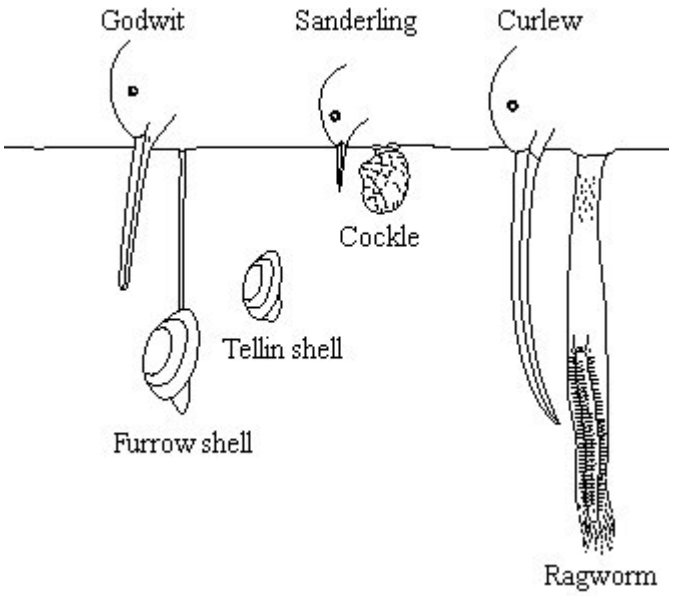
(4)

(Total 9 marks)

Q17.

Some birds feed on animals found in mud in estuaries. The drawing shows the heads of three species of these birds and their prey.



(a) Use the information in the drawing to explain how interspecific competition between the birds is reduced.

(2)

(b) Explain how competition might have played a part in the evolution of the long curved beak of the curlew.

(4)

(c) Mud higher up the shore receives fresh water draining from the land. Ragworms are able to survive in this mud because they can tolerate the absorption of water into their tissues. Explain what causes a ragworm to absorb water when higher up the shore.

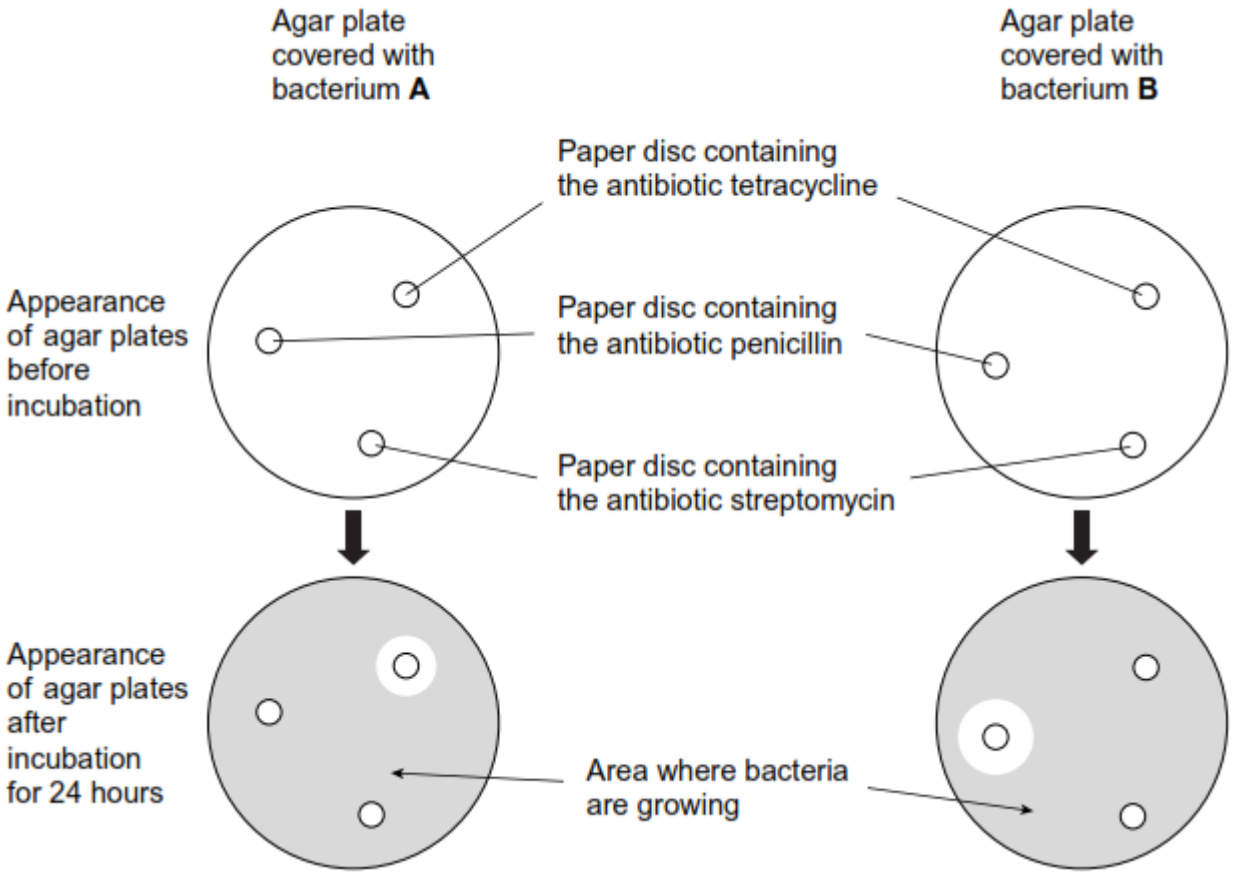
(2)

(Total 8 marks)

Q18.

A student was provided with two agar plates. She transferred a culture of bacterium **A** onto one plate and a culture of bacterium **B** to the second plate. She placed paper discs containing antibiotics on the surface of the agar. She then incubated the plates for 24 hours.

The diagram shows the agar plates before and after incubation.



(a) The student used a pair of forceps to place the paper discs onto the surface of the agar.

Explain why she passed the forceps through a Bunsen flame before and after each time she used them.

(2)

(b) Explain the appearance of the agar plates after incubation.

(*Extra space*)

(4)

(Total 6 marks)

Q19.

Antimicrobial proteins (AMPs), found in the skin of the African clawed frog, can kill bacteria. When AMPs are injected into humans, they are broken down by protease enzymes. Scientists have produced a number of AMPs that are not broken down by proteases. They did this by making these AMPs from man-made amino acids containing fluorine. The AMPs containing fluorine were found to be more effective in killing bacteria than AMPs without fluorine.

(a) Name the type of reaction involved when a protease enzyme breaks down an AMP.

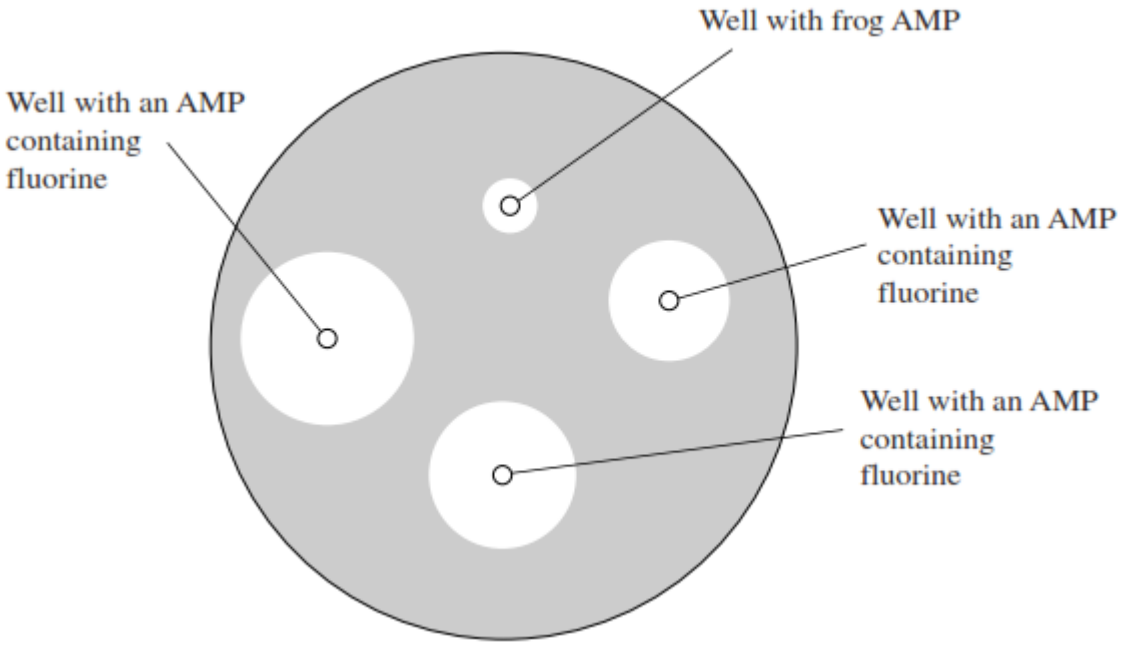
(1)

(b) Suggest why protease enzymes cannot break down AMPs made from amino acids containing fluorine.

(2)

(c) Scientists carried out an investigation to compare the effectiveness of AMPs containing fluorine and a frog AMP. They inoculated an agar plate with a culture of one species of bacterium. They cut four wells in the agar. They placed a frog AMP in one well. They put three different man-made AMPs containing fluorine in the other three wells. They incubated the plate for 48 hours. After incubation, there were clear areas around each well where the bacteria had not grown.

The appearance of the plate after incubation is shown below.



(i) Give **one** example of aseptic technique that the scientists would have used during this investigation.

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(1)

(ii) What conclusions could the scientists draw from these results?

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(Extra space) _____

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(3)
(Total 7 marks)