AQA A-LEVEL · 7402

BIOLOGY



EXAM QUESTION PACK

3.4.4 GENETIC DIVERSITY AND ADAPTATION

SCORE	PERCENTAGE
/490	%

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Q1.

(a) A student used a dilution series to investigate the number of cells present in a liquid culture of bacteria.

Describe how he made a 1 in 10 dilution and then used **this** to make a 1 in 1000 dilution of the original liquid culture of bacteria.

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(3)

(b) Using an optical microscope, the student determined there were 15 cells in 0.004 mm^3 of the 1 in 1000 dilution of the culture.

Calculate the number of cells in 1 cm^3 of undiluted liquid culture.

Answer = _____ Number of cells

(2)

(c) The student looked at cells in the 1 in 10 dilution during his preliminary work. He decided **not** to use this dilution to determine the number of cells in the undiluted liquid culture.

Suggest an explanation for the student's decision.

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(2)

(d) On some farms, animals are routinely given antibiotics in their food.

Scientists investigated whether these farm animals had antibiotic-resistant bacteria in their intestines. They tested the bacteria for resistance to two antibiotics, tetracycline and streptomycin.

Their results are shown in the table.

Antibiotic	**Percentage of antibiotic-resistant bacteria**
Tetracycline	29
Streptomycin	13

Suggest and explain **one** reason why bacteria resistant to tetracycline are more common than bacteria resistant to streptomycin in these farm animals.

(2)

(e) In recent years, these farm animals have not been given tetracycline in their food. Despite this, the percentage of bacteria resistant to tetracycline has remained constant.

Suggest **one** reason why.

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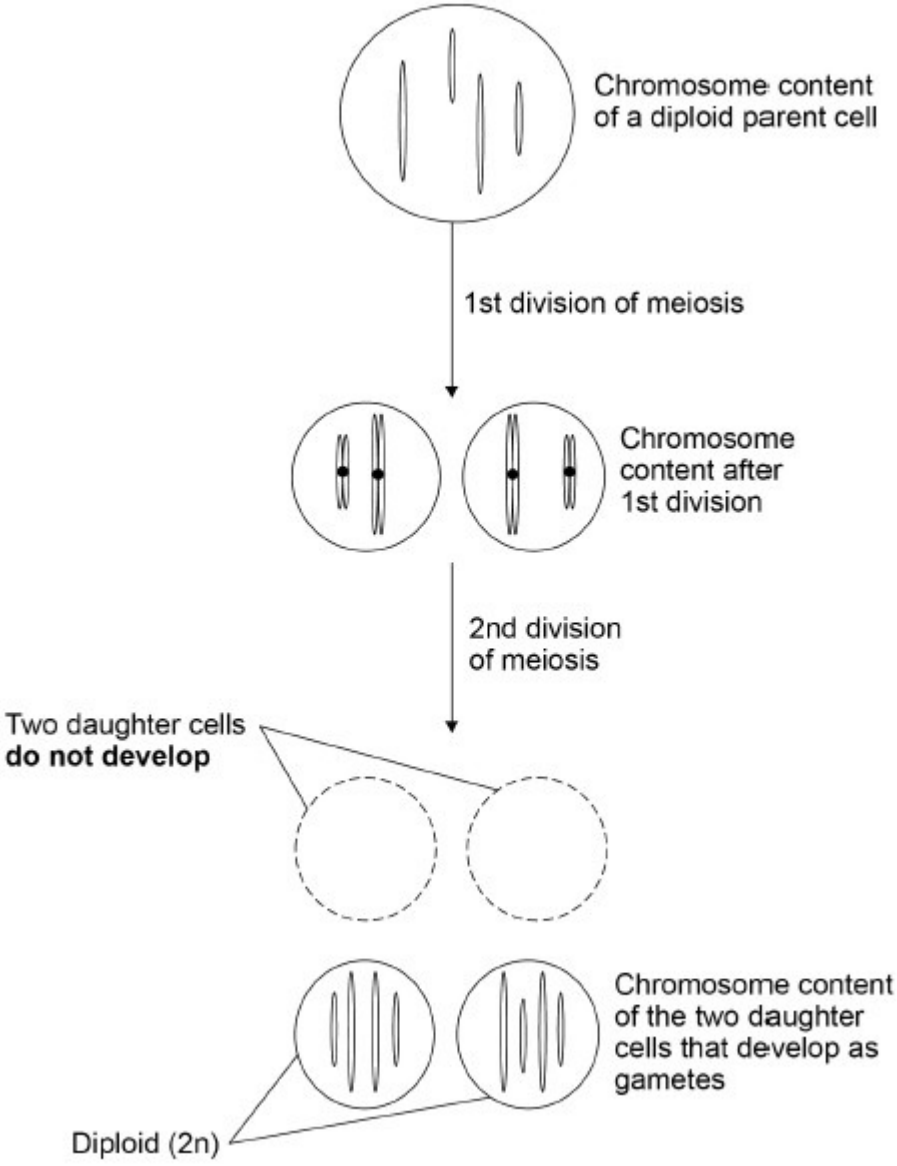
(1)

(Total 10 marks)

Q2.

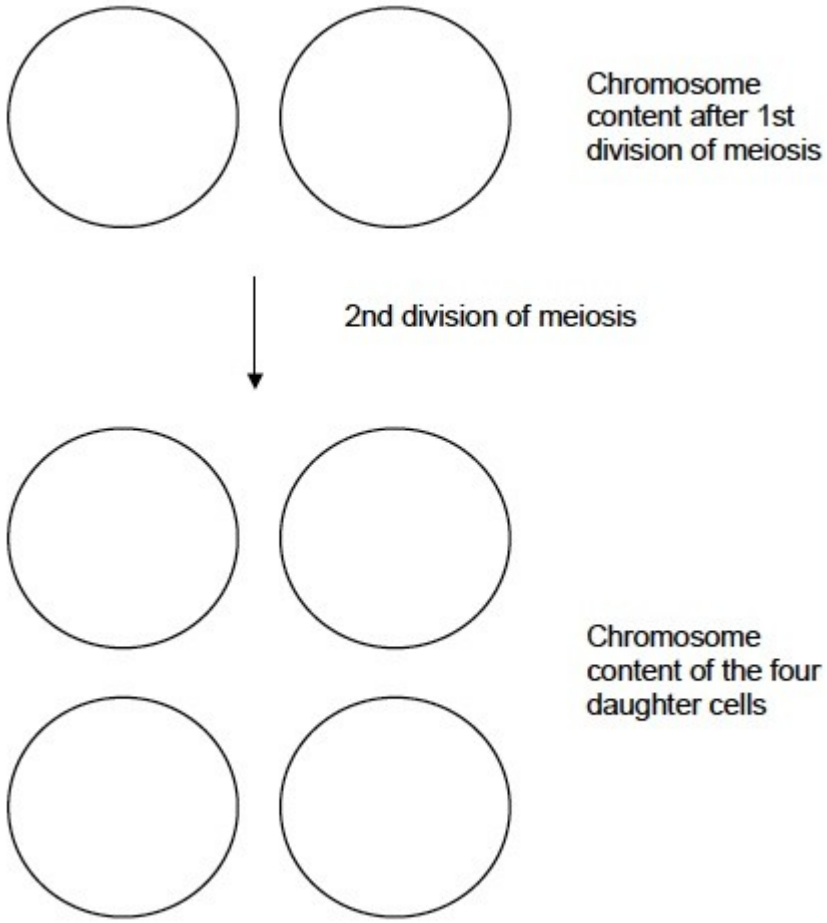
Figure 1 shows a faulty form of meiosis that can occur in some plants.

Figure 1



(a) Complete **Figure 2** to show the chromosome content of the cells that would result from a normal meiotic division of the diploid parent cell shown in **Figure 1**.

Figure 2



(2)

(b) If two diploid (2n) gametes fuse at fertilisation, it can result in the growth of a tetraploid plant which has 4 copies of each chromosome.

Red clover is a plant grown to produce cattle feed. Tetraploid red clover plants produce a higher yield than diploid red clover plants.

Whether a red clover plant produces 2n gametes is genetically controlled.

Scientists investigated the possibility of breeding red clover plants that only produced 2n gametes.

- In breeding cycle 0, they grew red clover plants and identified plants that produced 2n gametes.
- In breeding cycle 1, they used the plants producing 2n gametes to produce offspring.
- In breeding cycles 2 and 3, they identified plants producing 2n gametes and used these to produce offspring.

Their results are shown in the table.

	Observed		**Expected**	
Breeding cycle	Number of plants that **did not** produce 2n gametes	Number of plants that **did** produce 2n gametes	Number of plants that **did not** produce 2n gametes	Number of plants that **did** produce 2n gametes

0	50	4	50	4
1	14	42		
2	2	44		
3	0	56		

The scientists used the following null hypothesis.

'The proportion of plants that produce 2n gametes will not change from one breeding cycle to the next.'

Complete the table to show the **expected number** of plants that **did not** produce 2n gametes and the expected number of plants that **did** produce 2n gametes after 1 cycle.
Give each answer to the nearest whole number.

(2)

(c) The scientists tested their null hypothesis using the chi-squared statistical test.
After 1 cycle their calculated chi-squared value was 350
The critical value at P=0.05 is 3.841

What does this result suggest about the difference between the observed and expected results and what can the scientists therefore conclude?

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(2)

(d) Use your knowledge of directional selection to explain the results shown in the table.

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(3)
(Total 9 marks)

Q3.

Lactose is the main sugar in milk and is hydrolysed by the enzyme lactase. Lactase is essential to newborn mammals as milk is their only source of food. Most mammals stop producing lactase when they start feeding on other food sources. Humans are an exception to this because some continue to produce lactase as adults. The ability to continue producing lactase is known as lactase persistence (LP) and is controlled by a dominant allele. A number of hypotheses based on different selection pressures have been put forward to explain LP in humans.

(a) One hypothesis for LP in humans suggests that the selective pressure was related to some human populations farming cattle as a source of milk.

Describe how farming cattle as a source of milk could have led to an increase in LP.

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(4)

(b) Use the information provided to explain why the number of people showing LP would **rapidly** increase once selection for this condition had been established.

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(2)

(c) Lactase persistence is caused by a mutation in DNA. This mutation does not occur in the gene coding for lactase.

Suggest and explain how this mutation causes LP.

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(2)

(Total 8 marks)

Q4.

Ammonia in soil is oxidised to nitrites and nitrates by species of nitrifying bacteria.

Scientists investigated whether two soils with a different pH contained different communities of nitrifying bacteria. These communities consist of all the nitrifying bacteria of different species in each soil. They took samples of soil from two sites, **A** and **B**.

They measured the pH of the samples and found that

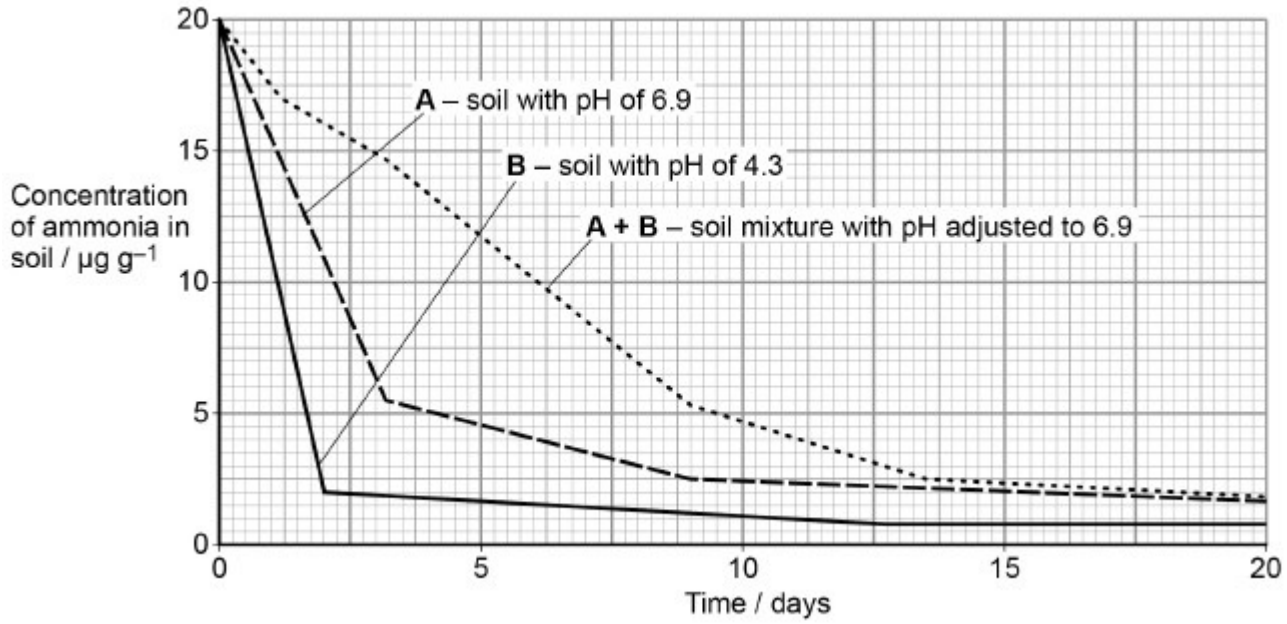
- the soil from site **A** had a pH of 6.9
- the soil from site **B** had a pH of 4.3

The scientists measured the concentration of ammonia in soil samples over 20 days. Each sample contained the same concentration of ammonia at the start and had the same mass. They recorded the concentration of ammonia in

- soil **A** with a pH of 6.9
- soil **B** with a pH of 4.3
- a mixture of equal masses of soils **A** and **B** with its pH adjusted to 6.9

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

Figure 1



(a) The scientists used units of µg g^{-1} for the concentration of ammonia in soil.

Suggest why, in this investigation, the scientists used these units.

µg _____

_____

_____

_____

_____

g^{-1} _____

_____

_____

_____

_____

(2)

(b) Calculate the difference in the rate of breakdown of ammonia per day between day 0 and day 2 in soil **A** and soil **B**.

Show your working and the units for your answer.

Difference in rate = _____

(2)

(c) The scientists concluded that the soil mixture experiment showed there were different communities of bacteria in soils A and B.

What evidence from **Figure 1** supports their conclusions? Give reasons for your answer.

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(3)

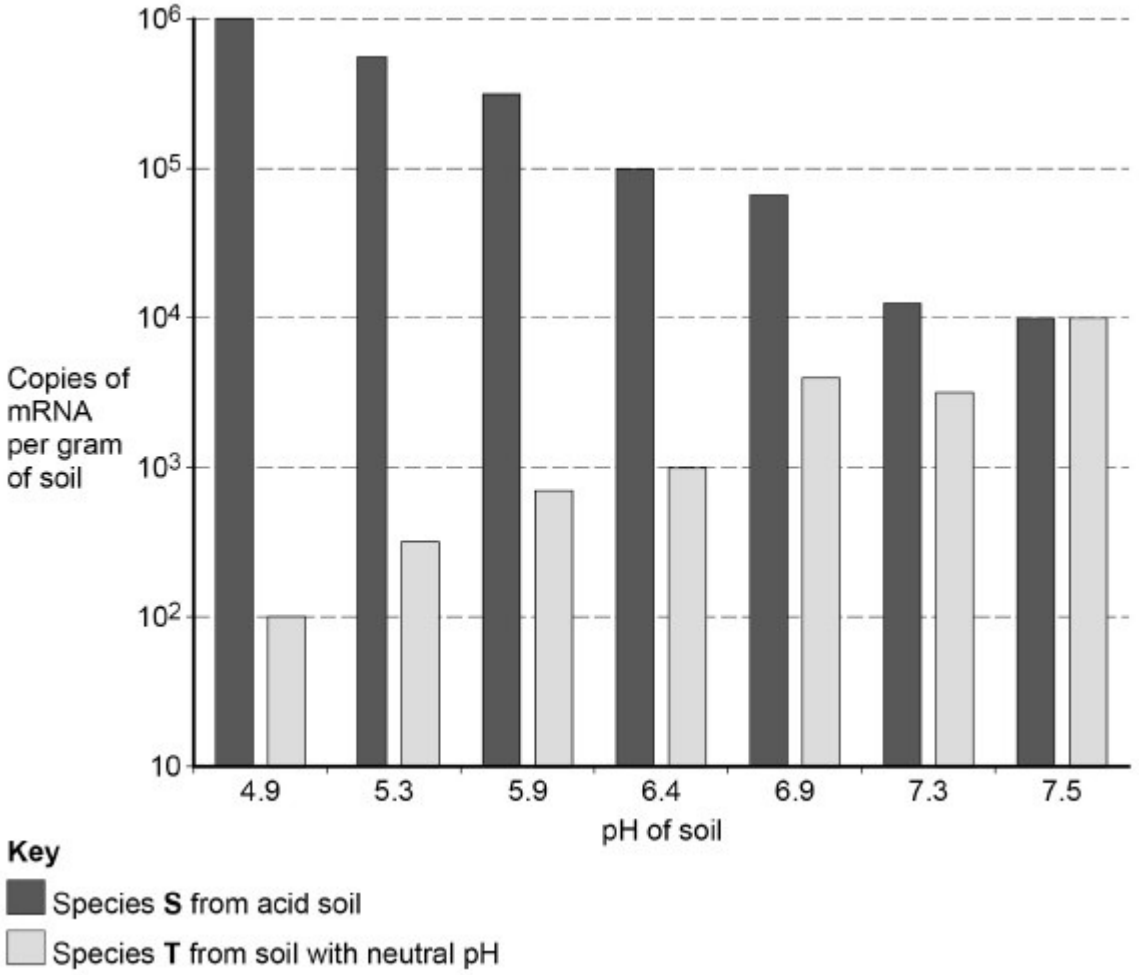
The oxidation of ammonia by nitrifying bacteria involves the enzyme ammonia monooxygenase. Each species of nitrifying bacteria has its own specific *amoA* gene that codes for production of ammonia monooxygenase.

In a second investigation, the scientists determined the expression of the *amoA* gene in two species of bacteria, **S** and **T**. Species **S** was from acid soil and species T was from soil with a neutral pH.

The scientists grew cultures of each species separately in soils of different pH. They determined the amount of mRNA from the *amoA* gene in each culture.

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

Figure 2



(d) In which species was the number of copies of mRNA more affected by changes in soil pH from 4.9 to 7.5? Use a calculation to support your answer.

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(2)

(e) This method allowed the scientists to estimate the expression of the *amoA* gene in each culture but not the growth of the bacterial population in each culture.

Explain why.

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(4)

(f) The scientists set up their cultures in sterile glass bottles.

Suggest **one** suitable method for sterilising the bottles and explain why it was necessary to sterilise them.

(2)

(Total 15 marks)

Q5.

A student investigated the effect of three types of disinfectant on the growth of *Lactobacillus* bacteria.

During the investigation, the student:

- boiled the agar before pouring the agar plates
- transferred 0.5 cm^3 of a diluted liquid culture of *Lactobacillus* onto each agar plate
- left some agar plates as controls
- added to other agar plates different concentrations of the disinfectants as shown in the table in part (a).

After 2 days, she counted the number of colonies of bacteria on each agar plate.

(a) Explain the purpose of:

boiling the agar _____

_____

_____

_____

transferring the same volume of liquid culture onto each agar plate.

_____

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(2)

The three disinfectants used by the student were Lysol, propan-2-ol and ammonia.

The table shows the student's results.

Concentration of disinfectant / arbitrary units	Number of colonies of bacteria		
	Lysol	Propan-2-ol	Ammonia
0	300	300	300
5	0	290	300
10	0	195	295
15	0	0	275
20	0	0	240

The liquid culture the student transferred was diluted by 1 in 10 000 (10^{-4}).

(b) Use information in this question to calculate how many bacteria were present in 1 cm^3 of undiluted liquid culture.

Answer = _____

(2)

(c) The student concluded that the minimum concentration of propan-2-ol needed to stop the growth of *Lactobacillus* was 15 units. This conclusion is incorrect.

Describe how you could obtain a more accurate estimate of the minimum concentration of propan-2-ol needed to stop the growth of this species of bacterium.

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(2)

(Total 6 marks)

Q6.

Read the following passage.

Azidothymidine (AZT) is a drug used to treat people infected with human immunodeficiency virus (HIV). It inhibits the enzyme that synthesises DNA from HIV RNA. This does not destroy HIV in the body but stops or slows the development of AIDS.

In the past, some people who took AZT on its own eventually developed AIDS. Some of the HIV in their bodies had become resistant to AZT. To prevent this from happening, people infected with HIV are now treated with highly active antiretroviral therapy (HAART). This involves taking AZT with other anti-HIV drugs at the same time.

AZT is taken in low doses. This is because people who took high doses over long periods of time suffered muscle wastage. It was found that high doses of AZT inhibit replication of mitochondria.

Use information from the passage and your own knowledge to answer the questions.

(a) Suggest and explain why AZT does not destroy HIV in the body but stops or slows the development of AIDS (lines 3–4).

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(4)

(b) Suggest and explain **two** advantages of using HAART (lines 7–9).

Advantage 1 _____

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_____

Advantage 2 _____

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_____

_____

(4)

(c) Suggest why high doses of AZT lead to muscle wastage (lines 10–11).

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(2)

(Total 10 marks)

Q7.

Scientists investigated treatment of a human bladder infection caused by a species of bacterium. This species of bacterium is often resistant to the antibiotics currently used for treatment.

They investigated the use of a new antibiotic to treat the bladder infection. The new antibiotic inhibits the bacterial ATP synthase enzyme.

(a) Place a tick (✔) in the appropriate box next to the equation which represents the reaction catalysed by ATP synthase.

$ATP \longrightarrow ADP + P_i + H_2O$ ☐

$ATP + H_2O \longrightarrow ADP + P_i$ ☐

$ADP + P_i \longrightarrow ATP + H_2O$ ☐

$ADP + P_i + H_2O \longrightarrow ATP$ ☐

(1)

(b) The new antibiotic is safe to use in humans because it does **not** inhibit the ATP synthase found in human cells.

Suggest why human ATP synthase is not inhibited and bacterial synthase is inhibited.

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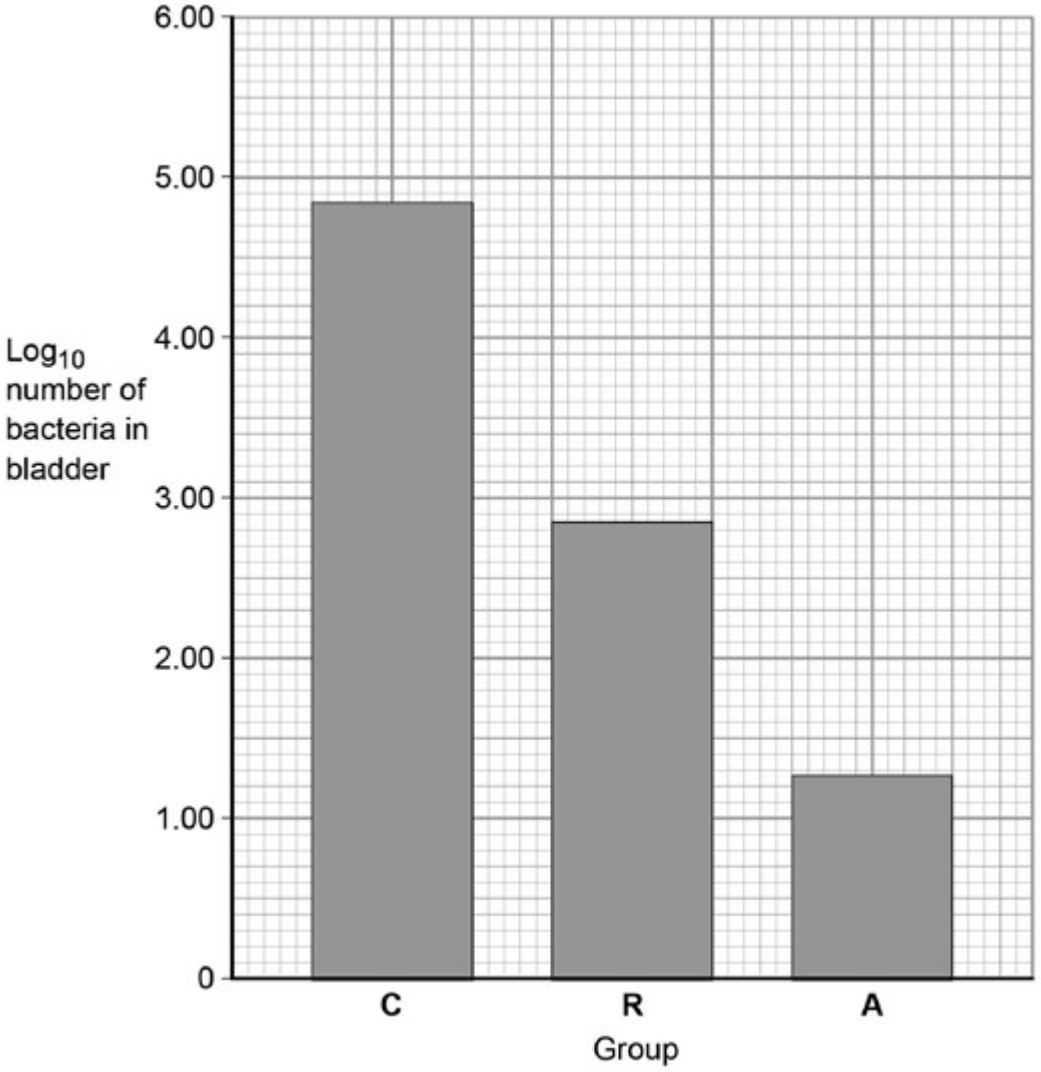
(1)

(c) The scientists tested the new antibiotic on mice with the same bladder infection. They divided these mice into three groups, **C**, **R** and **A**.

- Group **C** was the control (untreated).
- Group **R** was treated with an antibiotic currently used against this bladder infection.
- Group **A** was treated with the new antibiotic.

They removed samples from the bladder of these mice after treatment and estimated the total number of bacteria in the bladder.

Their results are shown in the graph.



The antibiotics were given to the mice at a dose of 25 mg kg^{-1} per day.

Calculate how much antibiotic would be given to a 30 g mouse each day.

Show your working.

Answer = _____ mg

(2)

(d) Calculate the percentage difference in actual numbers of bacteria in group **A** compared with group **R**. The actual number of bacteria can be calculated from the $\log_{10}$ value by using the 10^x function on a calculator.

Show your working.

Answer = _____ %

(2)

(e) The scientists suggested that people newly diagnosed with this bladder infection should be treated with both the current antibiotic and the new antibiotic.

Explain why the scientists made this suggestion.

Use information from the graph in part (c) and your knowledge of evolution of antibiotic resistance in bacteria in your answer.

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(3)

(Total 9 marks)

Q8.

Read the following passage.

Some insect species feed on the leaves of plants. These leaf-chewers bite off pieces of leaves. Other insect species feed on sap from phloem or xylem. These sap-feeders have sharp, piercing mouthparts that they insert directly into either xylem or phloem. Leaf-chewers and insects that feed on xylem sap are active feeders; this means they use their jaw muscles to obtain their food. In contrast, insects that feed on phloem sap are passive feeders; this means they do not use their jaw muscles to take up sap from phloem.

Feeding on phloem sap presents two problems. Firstly, phloem sap has sa high sugar concentration. This could lead to a high pressure of liquid in the insect's gut because of water entering the gut from the insect's body tissues. A phloem-sap-feeder polymerises some of these sugars into polysaccharides which are passed out of its anus as 'honey dew'. The secondproblem is that phloem sap has a low concentration of amino acids. Phloem-sap-feeding insects rely on bacteria in their guts to produce amino acids. Each phloem-sap-feeding insect receives a few of these bacteria from its parent. This has resulted in a reduction in the genetic diversity of the bacteria found within these insects.

A scientist investigated the effect of three different insects on the growth of a plant called the goldenrod. He found that leaf-chewing insects and xylem-sap-feeding insects caused a much greater reduction in total

leaf area than did phloem-sap-feeding insects.

Use the information from the passage and your own knowledge to answer the following questions.

(a) Phloem-sap-feeders are passive feeders (lines 6–7).
Phloem-sap-feeders do not use their jaw muscles to take up sap from phloem.

Explain why they can take up sap without using their jaw muscles.

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(3)

(b) A phloem-sap-feeder polymerises some of these sugars into polysaccharides (line 12-13).
Suggest the advantage of this.

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(2)

(c) Each phloem-sap-feeding insect receives a few of these bacteria from its parent. (lines 16–17).

Suggest how this has caused a reduction in genetic diversity of the bacteria.

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(2)

(d) A scientist found that leaf-chewers and xylem-sap-feeders had a greater effect on

plant growth than phloem-sap-feeders (lines 20–22).

Other than environmental factors, give **two** features the scientist would have controlled in his experiment to ensure this conclusion was valid.

1. _____

_____

2. _____

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(2)

(e) The scientist used the reduction in total leaf area of the experimental plants as an indicator of plant growth.

Outline a method by which you could find the area of a plant leaf.

_____

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(1)

(Total 10 marks)

Q9.

(a) Name the process by which bacterial cells divide.

_____

(1)

A microbiologist investigated the ability of different plant oils to kill the bacterium *Listeria monocytogenes*. She cultured the bacteria on agar plates. She obtained the bacteria from a broth culture.

(b) Describe **two** aseptic techniques she would have used when transferring a sample of broth culture on to an agar plate.
Explain why each was important.

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(4)

The microbiologist tested five different plant oils at two different temperatures and determined the minimum concentration of plant oil that killed the *L. monocytogenes*.

The table below shows her results.

Plant oil	**Minimum concentration of plant oil that killed *Listeria monocytogenes* / percentage**	
	4 °C	**35 °C**
Bay	0.10	0.04
Cinnamon	0.08	0.08
Clove	0.05	0.05
Nutmeg	>1.00	0.05
Thyme	0.02	0.03

(c) Which plant oil is least effective at killing *L. monocytogenes* at 35 °C?

_____

(1)

L. monocytogenes is a pathogen of great concern to the food industry, especially in foods stored in refrigeration conditions (4 °C) where, unlike most food-borne pathogens, it is able to multiply. It has been suggested that plant oils, together with refrigeration may help to reduce the growth of *L. monocytogenes*.

(d) What conclusions can be drawn about the effectiveness of using plant oils with refrigeration to reduce food-borne infections caused by *L. monocytogenes*?

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(3)

(e) Plant oils are hydrophobic and can cross the cell-surface membrane of the bacterium. The low temperature of 4 °C can slow the rate of entry of plant oils into

the cells.

Suggest how the low temperature slows the rate of entry.

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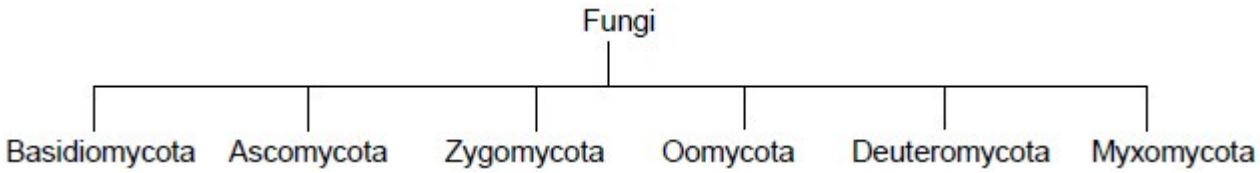
(1)

(Total 10 marks)

Q10.

Figure 1 shows one way in which the kingdom Fungi can be classified.

Figure 1



(a) Name the taxon represented by Zygomycota.

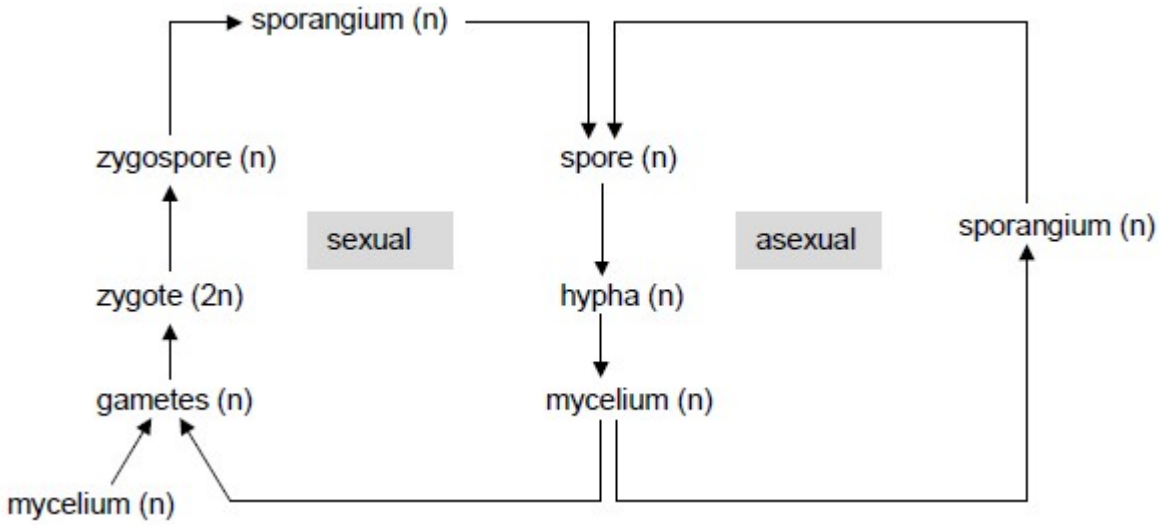
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(1)

Rhizopus is a member of the Zygomycota. It has thread-like hyphae that form a mass, called a mycelium, across its food source. Vertical hyphae form spore-carrying sporangia. A new hypha grows from each spore.

Figure 2 shows the life cycle of *Rhizopus*.

Figure 2



(b) Write the letter **M** on **Figure 2** to show where meiosis occurs.

(1)

(c) **Figure 2** shows that *Rhizopus* is able to reproduce both asexually and sexually.
Suggest and explain **one** advantage of asexual reproduction and **one** advantage of sexual reproduction in this life cycle.

Asexual _____

_____

_____

Sexual _____

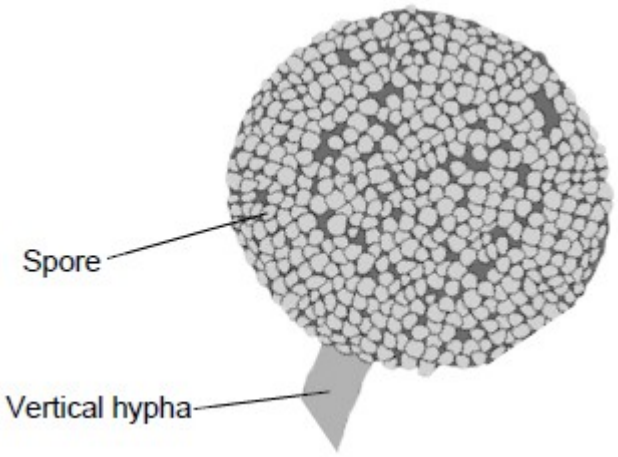
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(2)

Figure 3 shows one spore-carrying sporangium from *Rhizopus*. The magnification of **Figure 3** is × 700.

Figure 3



(d) The hypha supporting the spore-carrying sporangium is vertical.
Suggest **one** advantage of the hypha being vertical.

_____

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(1)

(e) A scientist wanted to calculate the mean volume of *Rhizopus* spores.
Describe how she could use **Figure 3** do this.
You may assume the spores are perfectly spherical.

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(3)

(Total 8 marks)

Q11.

Bacterial meningitis is a potentially fatal disease affecting the membranes around the brain. *Neisseria meningitidis* (Nm) is a leading cause of bacterial meningitis.

(a) In the UK, children are vaccinated against this disease. Describe how vaccination can lead to protection against bacterial meningitis.

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(6)

(b) Penicillin has been the antibiotic of choice for the treatment of bacterial meningitis. Since the year 2000, strains of *Neisseria meningitidis* that are resistant to penicillin, sulfonamides and rifampin have been discovered in the UK.

Describe how a population of *Neisseria meningitidis* (Nm) can become resistant to these antibiotics.

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(4)

(c) Contrast the structure of a bacterial cell and the structure of a human cell.

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(5)

(Total 15 marks)

Q12.

The table shows the taxons and the names of the taxons used to classify one species of otter. They are **not** in the correct order.

	Taxon	**Name of taxon**
J	Family	Mustelidae
K	Kingdom	Animalia
L	Genus	Lutra
M	Class	Mammalia
N	Order	Carnivora
O	Phylum	Chordata
P	Domain	Eukarya

Q	Species	lutra

(a) Put letters from the table above into the boxes in the correct order. Some boxes have been completed for you.

		O	**M**			**L**	**Q**

(1)

(b) Give the scientific name of this otter.

_____

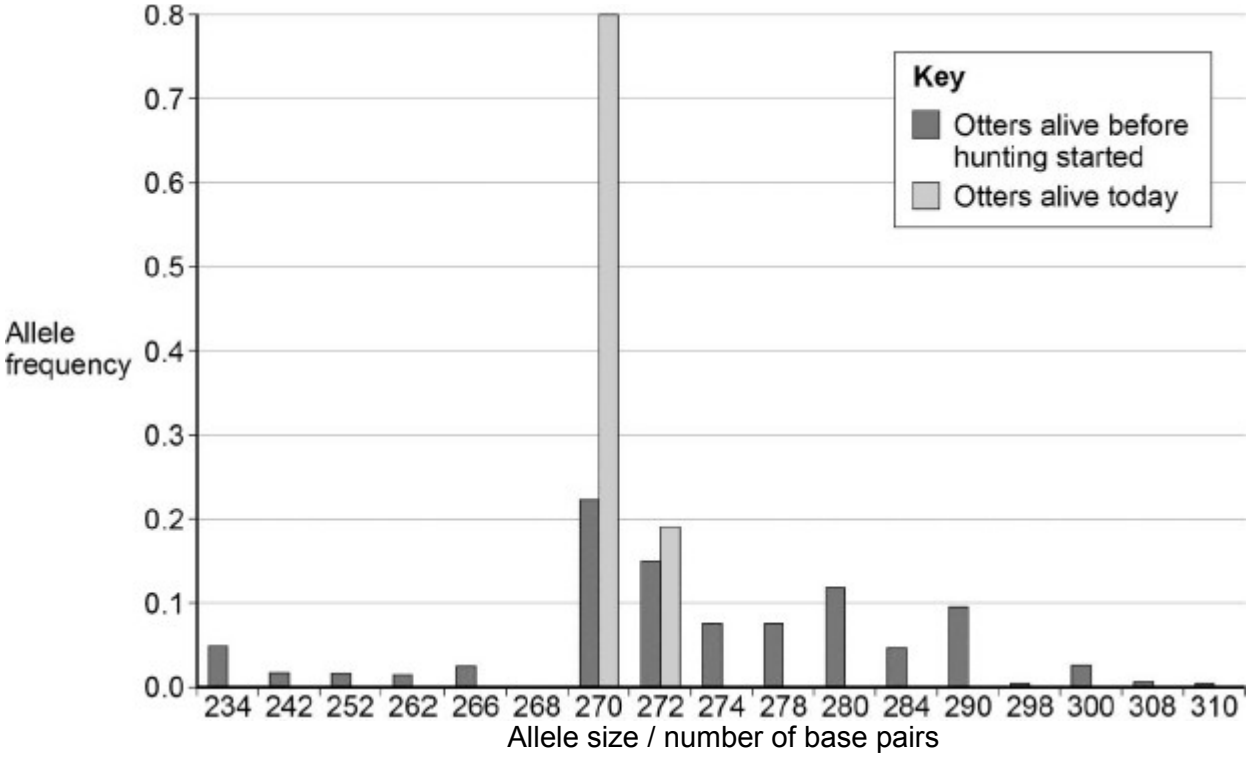
(1)

Scientists investigated the effect of hunting on the genetic diversity of otters. Otters are animals that were killed in very large numbers for their fur in the past.

The scientists obtained DNA from otters alive today and otters that were alive before hunting started.

For each sample of DNA, they recorded the number of base pairs in alleles of the same gene. Mutations change the numbers of base pairs over time.

The figure below shows the scientists' results.



(c) The scientists obtained DNA from otters that were alive before hunting started.

Suggest **one** source of this DNA.

_____

_____

(1)

(d) What can you conclude about the effect of hunting on genetic diversity in otters? Use data from the figure above to support your answer.

_____

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(2)

(e) Some populations of animals that have never been hunted show very low levels of genetic diversity.

Other than hunting, suggest **two** reasons why populations might show very low levels of genetic diversity.

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2. _____

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(2)

(Total 7 marks)

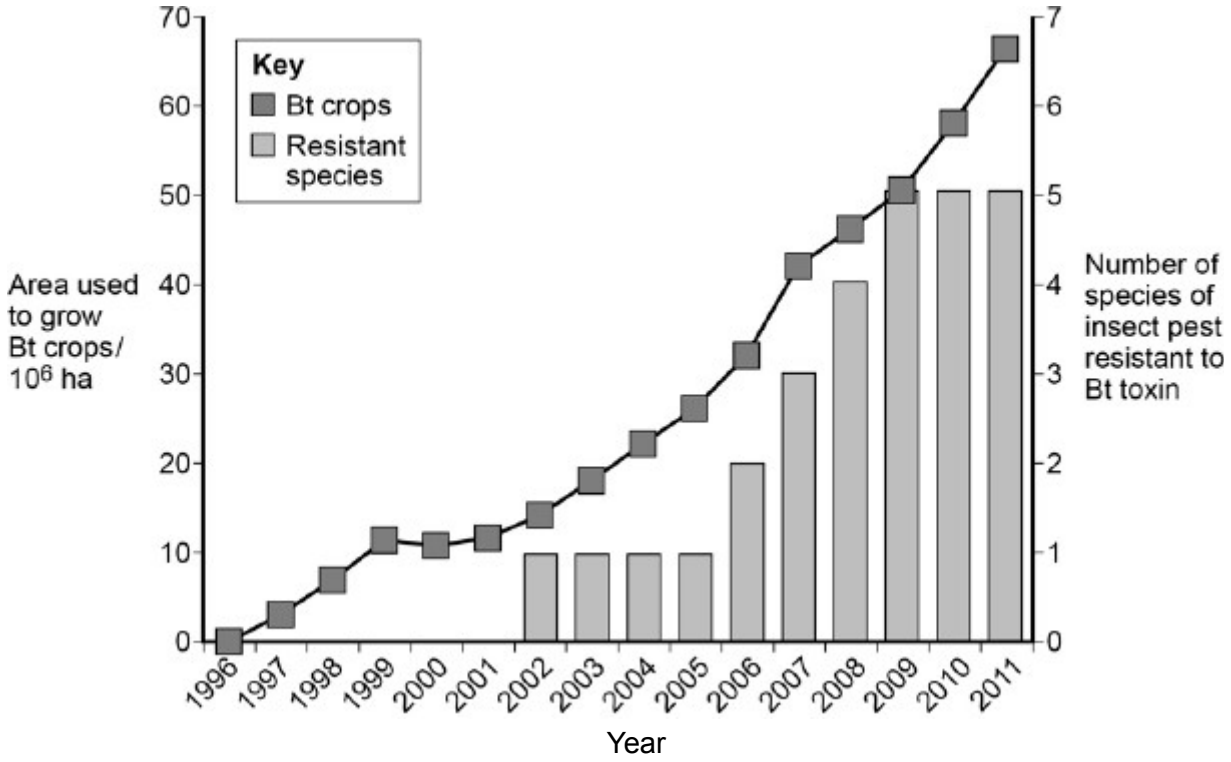
Q13.

To reduce the damage caused by insect pests, some farmers spray their fields of crop plants with pesticide. Many of these pesticides have been shown to cause environmental damage.

Bt plants have been genetically modified to produce a toxin that kills insect pests. The use of Bt crop plants has led to a reduction in the use of pesticides.

Scientists have found that some species of insect pest have become resistant to the toxin produced by the Bt crop plants.

The figure below shows information about the use of Bt crops and the number of species of insect pest resistant to the Bt toxin in one country.



(a) Can you conclude that the insect pest resistant to Bt toxin found in the years 2002 to 2005 was the same insect species? Explain your answer.

_____

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(1)

(b) One farmer stated that the increase in the use of Bt crop plants had caused a mutation in one of the insect species and that this mutation had spread to other species of insect. Was he correct? Explain your answer.

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(4)

(c) There was a time lag between the introduction of Bt crops and the appearance of the first insect species that was resistant to the Bt toxin.
Explain why there was a time lag.

_____

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(3)

(Total 8 marks)

Q14.

Table 1 shows how a bird called the bluethroat (*Luscinia svecica*) is classified by biologists.

Table 1

Taxon	Name of taxon
Domain	Eukaryota
	Animalia
	Chordata
	Aves
	Passeriformes
	Muscicapidae
Genus	
Species	

(a) Complete **Table 1** by filling the seven blank spaces with the correct terms.

(2)

A group of scientists investigated genetic diversity in different species of bird. For each species, the scientists:

- collected feathers from a large number of birds
- extracted DNA from cells attached to each feather
- analysed the samples of DNA to find genetic diversity.

Table 2 summarises their results.

Table 2

Species of bird	Number of genes examined	Number of genes examined that showed genetic diversity

Willow flycatcher	708	197
House finch	269	80
Bluethroat	232	81

(b) In this investigation, what is meant by **genetic diversity?**

_____

_____

(1)

(c) The scientists concluded that the bluethroat showed greater genetic diversity than the willow flycatcher. Explain why they reached this conclusion. Use calculations to support your answer.

_____

_____

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(2)

(Total 5 marks)

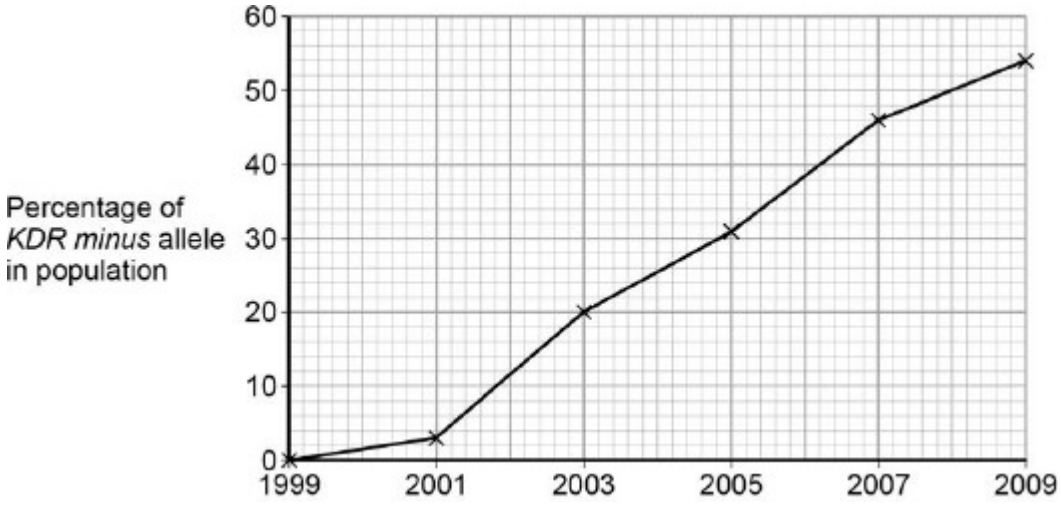
Q15.

Malaria is a disease that is spread by insects called mosquitoes. In Africa, DDT is a pesticide used to kill mosquitoes, to try to control the spread of malaria.

Mosquitoes have a gene called *KDR*. Today, some mosquitoes have an allele of this gene, *KDR minus*, that gives them resistance to DDT. The other allele, *KDR plus*, does not give resistance.

Scientists investigated the frequency of the *KDR minus* allele in a population of mosquitoes in an African country over a period of 10 years.

The figure below shows the scientists' results.



Year

(a) Use the Hardy–Weinberg equation to calculate the frequency of mosquitoes heterozygous for the *KDR* gene in this population in 2003.

Show your working.

Frequency of heterozygotes in population in 2003 _____

(2)

(b) Suggest an explanation for the results in the figure above.

_____

_____

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_____

(4)

The *KDR plus* allele codes for the sodium ion channels found in neurones.

(c) When DDT binds to a sodium ion channel, the channel remains open all the time. Use this information to suggest how DDT kills insects.

_____

_____

_____

_____

(2)

(d) Suggest how the *KDR minus* allele gives resistance to DDT.

_____

_____

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_____

(2)

(Total 10 marks)

Q16.

Iodine has many uses. One use is as an antiseptic to kill bacteria and another is helping apple farmers decide when to harvest their apples.

Iodine solution has been used as an antiseptic on wounds for over 150 years. At first, its use in hospitals was limited because it irritated people's skin. In the 1950s, iodine solution was made into providone iodine that caused less skin irritation. A surgeon investigated how effective providone iodine was at killing bacteria on skin.

The surgeon treated the forearms of 25 people in 4 ways.

Treatment **A** − no washing
Treatment **B** − washed with soap and water only
Treatment **C** − washed with soap and water then rubbed with Hex scrub for 5 minutes (Hex scrub was the treatment the surgeon used at that time to wash a patient's skin before surgery)
Treatment **D** − washed with soap and water then rubbed with providone iodine for 5 minutes

After each treatment, the surgeon collected bacteria by rubbing each person's skin with a sterile cotton swab. He put the swab into sterile liquid agar. He then poured the agar into a Petri dish and allowed it to set. He incubated the Petri dish and when bacterial colonies had grown, he counted them.

The surgeon's results are shown in the table below.

Treatment	Mean number of bacterial colonies (± standard deviation)
A	401.6 (±96.4)
B	191.4 (±63.7)
C	25.9 (±15.6)
D	0.7 (±1.5)

(a) Suggest **three** factors the surgeon kept constant when sampling from the skin and growing the bacterial colonies.

1. _____

_____

2. _____

_____

3. _____

_____

(3)

(b) Calculate the percentage difference in mean number of bacterial colonies for Treatment **D** compared with Treatment **A**. Show your working.

Answer _____ %

(2)

(c) Treatment **D** produced a mean of 0.7 colonies and a standard deviation of ±1.5. What does this suggest about the number of colonies on the Petri dish?

_____

_____

_____

(1)

(d) After this investigation, the surgeon wanted to test the effectiveness of providone iodine when used on patients who were about to have surgery.
In this new investigation, the test group was given Treatment **D**.
Suggest and explain the treatment that he should give to the control group to ensure that this is an ethical investigation.

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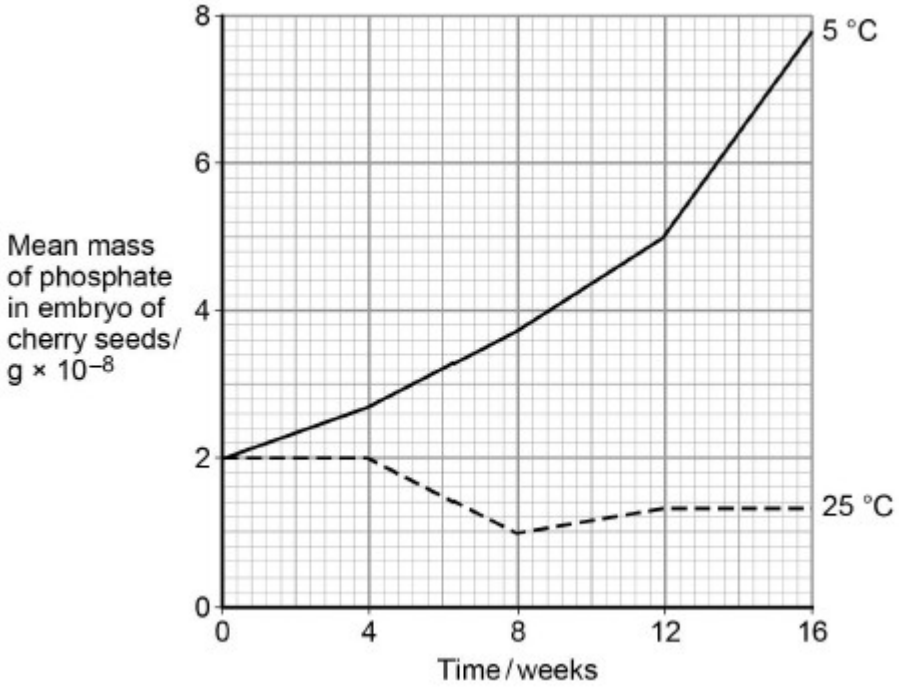
(2)

(Total 8 marks)

Q17.

The seeds of some plant species require chilling (exposure to low temperatures) before the embryos they contain grow into plants. During chilling, storage molecules in the seed that contain phosphate are broken down and phosphates are transported to the embryo. Scientists investigated the change in the mass of phosphate in the embryos of cherry seeds exposed to two different temperatures for 16 weeks.

The following graph shows their results.



(a) Phospholipids are one of the storage molecules found in cherry seeds.

Name the type of reaction used to break down phospholipids to release phosphate.

_____

(1)

(b) The scientists concluded that an increase in phosphate in the embryo was linked to growth of the embryo.

Suggest **two** reasons why an increase in phosphate can be linked to growth of the embryo.

1. _____

_____

_____

2. _____

_____

_____

(2)

(c) Calculate the ratio of the mean mass of phosphate found at 5 °C to the mean mass of phosphate found at 25 °C after 9 weeks of chilling.

Ratio = _____

(1)

(d) The chilling requirement of seeds of certain plant species is considered to be an adaptation for survival in countries with seasonal changes in environmental conditions.

Suggest how this adaptation may enable these plant species to survive and respond to seasonal changes.

_____

_____

_____

_____

_____

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_____

(3)

(Total 7 marks)

Q18.

(a) HIV attaches to a specific protein receptor on helper T cells. A low percentage of people have a mutation of the *CCR5* gene which codes for this protein receptor. This mutation results in a non-functional protein receptor.

Explain how this mutation can result in the production of a non-functional protein receptor.

_____

_____

_____

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_____

_____

(4)

(b) People with the *CCR5* mutation show a greater resistance to developing AIDS.

Explain why.

_____

_____

_____

_____

_____

(2)

(c) The frequency of the *CCR5* mutation is highest in Europe. Scientists have collected data on the history and number of HIV infections in Europe. Using these data, scientists have concluded that the high frequency of the *CCR5* mutation is not due to natural selection in response to HIV.

Suggest **two** reasons why scientists reached this conclusion.

1. _____

_____

2. _____

_____

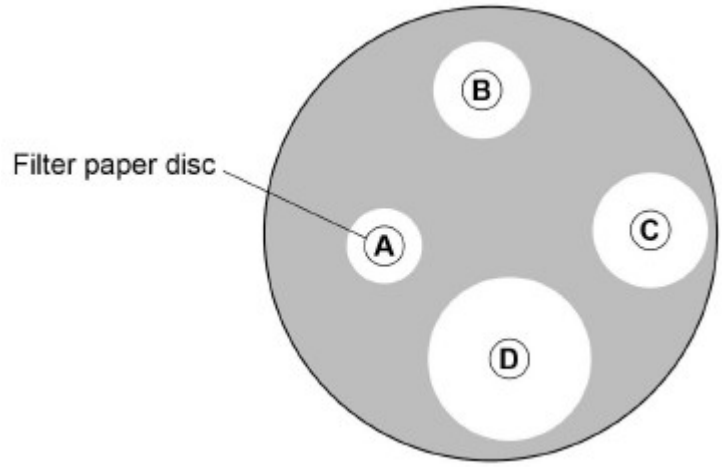
(2)

(Total 8 marks)

Q19.

A student investigated the effectiveness of four different concentrations, **A**, **B**, **C** and **D**, of the same disinfectant on the growth of a bacterium. He grew a culture of this bacterium on nutrient agar (a solid growth medium) in a Petri dish. The student then cut out four filter paper discs and soaked each disc in one of the four concentrations. He then placed the discs on the nutrient agar in the Petri dish. He then left the Petri dish at 25 °C for 24 hours.

The diagram below shows the appearance of the Petri dish after 24 hours.



(a) Explain why there is a clear zone around each paper disc.

_____

_____

(1)

(b) The student researched information on this disinfectant prior to carrying out his investigation. On the basis of this research, the student used a maximum concentration of disinfectant of 40%.

Use the diagram to explain why.

_____

_____

_____

(1)

(c) Suggest **two** variables the student should control in using the filter paper discs in this investigation.

1. _____

_____

2. _____

_____

(2)

(d) Use the areas of the clear zones in the diagram above to determine how many times more effective concentration **D** is than concentration **B**. Show your working.

Answer = _____

(2)

(Total 6 marks)

Q20.

(a) What is the name of a position of a gene on a chromosome?

_____

(1)

(b) What is meant by genetic diversity?

_____

_____

(1)

A geneticist investigated genetic diversity in four different breeds of dog. She compared DNA base sequences of the same genes from a large number of dogs from each breed.

The geneticist calculated the mean genetic diversity for each breed of dog. The value of this mean was between 0 and 1.

- A mean value of 1 shows maximum genetic diversity.
- A mean value of 0 shows no genetic diversity.

Her results are shown in the table

Breed of dog	**Mean genetic diversity**	**Standard deviation**
Airedale terrier	0.51	± 0.03
Bull terrier	0.38	± 0.02
Jack Russell terrier	0.76	± 0.01
Miniature terrier	0.47	± 0.02

(c) What do these data show about the differences in genetic diversity between these breeds of dog?

_____

_____

_____

_____

_____

(3)

(d) Miniature terriers were first bred from bull terriers in the 19th century.

Suggest **one** explanation for the observed difference in genetic diversity between

miniature terriers and bull terriers.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q21.

Scientists investigated the presence of bacteria resistant to the antibiotic neomycin in turkeys, chickens and the farmers who kept the turkeys and chickens. They looked for *Escherichia coli* (*E. coli*) resistant to neomycin. At 46 farms, the scientists obtained samples of bacteria from faeces of turkeys, turkey farmers, chickens and chicken farmers. The turkey farmers very often used turkey food containing neomycin. The chicken farmers did not use chicken food containing neomycin very often.

The bacteria were grown on nutrient agar in cultures. The nutrient agar contained neomycin. Any resistant bacteria grew and divided to form visible colonies.

The results are shown in the table

Samples taken from	**Percentage of samples of faeces containing *E. coli* resistant to neomycin**
Turkeys	81
Turkeys farmers	57
Chickens	24
Chicken farmers	8

(a) Suggest **two** hypotheses the scientists were testing in this investigation.

Hypothesis 1 _____

_____

_____

Hypothesis 2 _____

_____

_____

(2)

(b) (i) Describe what the results in the table show.

_____

_____

_____

_____

_____

(2)

(ii) Suggest and explain **one** reason for the observed differences in percentage of neomycin-resistant *E. coli* in turkeys and chickens.

_____

_____

_____

_____

_____

(2)

(c) The scientists followed strict safety guidelines when collecting samples of faeces. Apart from the risk of contamination from *E. coli* this was especially important when collecting samples from humans.

Explain why.

_____

_____

_____

(1)

(d) Use the information provided to identify and explain **one** way in which the scientists increased the reliability of their method.

_____

_____

_____

_____

_____

(2)

(e) Suggest how the scientists could use DNA to investigate whether the neomycin-resistant bacteria in farmers were identical to the strain of bacteria in the birds they kept.

_____

(2)

(f) At one time, most animal feeds contained antibiotics that increased the rate of animal growth. In the UK, fewer animal feeds now contain antibiotics.

Suggest reasons why.

(4)

(Total 15 marks)

Q22.

(a) A mutation can lead to the production of a non-functional enzyme. Explain how.

_____

(6)

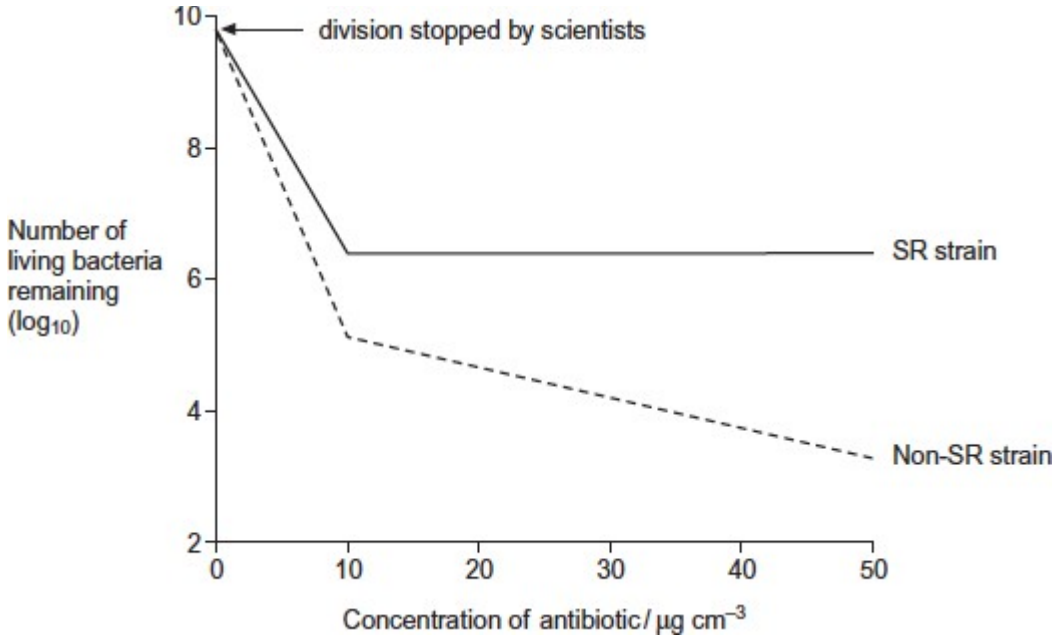
Scientists investigated the effect of a specific antibiotic on two strains of the same species of bacterium.

- One strain, SR, shows a **stringent response** in the presence of this antibiotic. Part of this response involves stopping cell division. This gives this strain a greater resistance to the effects of this antibiotic.
- The other strain, non-SR, cannot carry out a stringent response.

The scientists grew cultures of the SR strain and the non-SR strain containing the same number of bacterial cells. They then stopped each strain from dividing and exposed them to different concentrations of the antibiotic. After a fixed time, the scientists estimated the number of living bacteria remaining in the cultures.

Figure 1 shows their results.

Figure 1



(b) Describe differences in the effect of increasing the concentration of antibiotic on the SR strain and the non-SR strain.

_____

_____

_____

_____

_____

(2)

(c) One way in which the stringent response gives resistance to this antibiotic is by stopping cell division.

The scientists concluded that stopping cell division is not the **only** way in which the

stringent response gives resistance to this antibiotic.

Explain how **Figure 1** supports this conclusion.

_____

_____

_____

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_____

(2)

(d) The stringent response involves a number of enzyme-catalysed reactions.

Explain how scientists could use this knowledge to design drugs that make the treatment of infections caused by the SR strain more successful.

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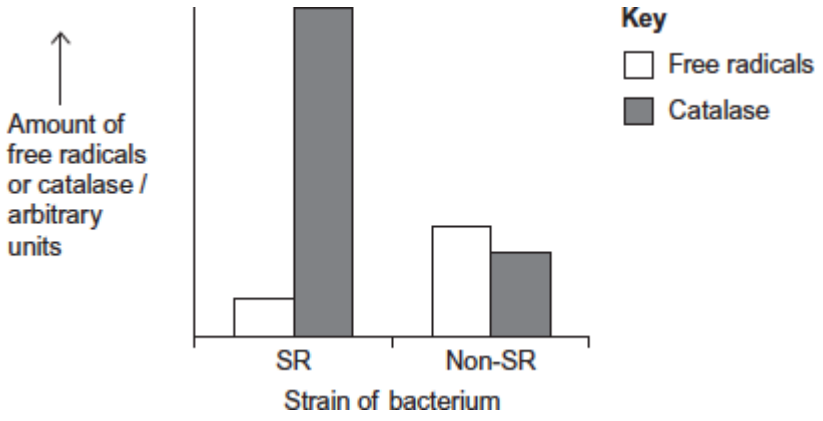
(2)

The antibiotic damages the bacterium by causing the production of substances called free radicals.

The scientists exposed the SR strain and the non-SR strain to the antibiotic. They then measured the amounts of free radicals and an enzyme called catalase in both strains.

Figure 2 shows their results.

Figure 2



(e) Use the information provided and **Figure 2** to suggest an explanation for the greater resistance of the SR strain to this antibiotic.

_____

_____

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_____

(3)

(Total 15 marks)

Q23.

(a) Explain how the structure of DNA is related to its functions.

_____

_____

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_____

_____

(6)

Scientists investigated three genes, **C**, **D** and **E**, involved in controlling cell division. They studied the effect of mutations in these genes on the risk of developing lung cancer.

The scientists analysed genes **C**, **D** and **E** from healthy people and people with lung cancer.

- If a person had a normal allele for a gene, they used the symbol N.
- If a person had two mutant alleles for a gene, they used the symbol M.

They used their data to calculate the risk of developing lung cancer for people with different combinations of N and M alleles of the genes. A risk value of 1.00 indicates no increased risk. The following table shows the scientists' results.

Gene C	Gene D	Gene E	Risk of

			developing lung cancer
N	N	N	1.00
M	N	N	1.30
N	N	M	1.78
N	M	N	1.45

N = at least one copy of the normal allele is present
M = two copies of the mutant allele are present

(b) What do these data suggest about the relative importance of the mutant alleles of genes **C**, **D** and **E** on **increasing** the risk of developing lung cancer? Explain your answer.

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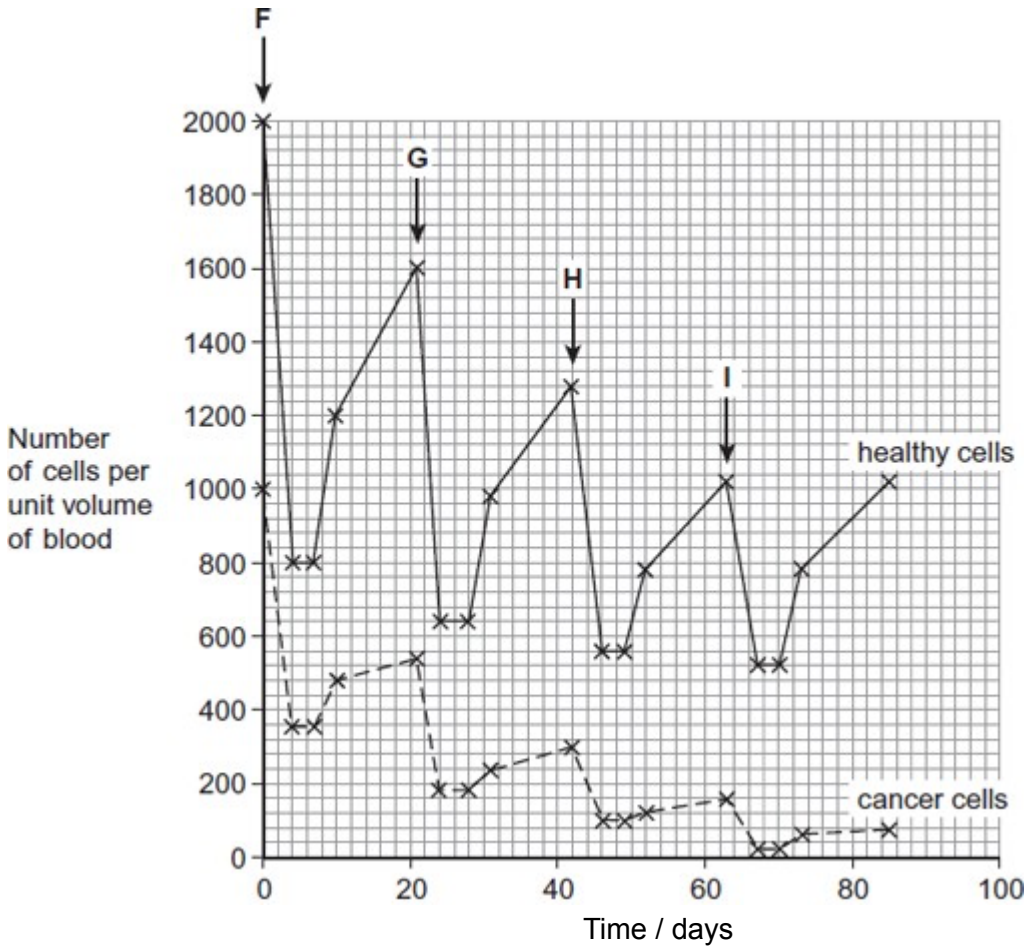
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(3)

Chemotherapy is the use of a drug to treat cancer. The drug kills dividing cells.
The figure below shows the number of healthy cells and cancer cells in the blood of a patient receiving chemotherapy. The arrows labelled **F** to **I** show when the drug was given to the patient.



(c) Calculate the rate at which healthy cells were killed between days 42 and 46.

_____ cells killed per unit volume of blood per day

(1)

(d) Describe similarities and differences in the response of healthy cells and cancer cells to the drug between times **F** and **G**.

_____

_____

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_____

_____

_____

(3)

(e) More cancer cells could be destroyed if the drug was given more frequently.

Suggest why the drug was **not** given more frequently.

_____

_____

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_____

(2)

(Total 15 marks)

Q24.

The Amish are a group of people who live in America. This group was founded by 30 Swiss people, who moved to America many years ago. The Amish do not usually marry people from outside their own group.

One of the 30 Swiss founders had a genetic disorder called Ellis-van Creveld syndrome. People with this disorder have heart defects, are short and have extra fingers and toes. Ellis-van Creveld syndrome is caused by a faulty allele.

In America today, about 1 in 200 Amish people are born with Ellis-van Creveld syndrome. This disorder is very rare in people in America who are not Amish.

(a) In America today, there are approximately 1250 Amish people who have Ellis-van Creveld syndrome. Use the information provided to calculate the current Amish population of America.

Amish population _____

(1)

(b) The faulty allele that causes Ellis-van Creveld syndrome is the result of a mutation of a gene called *EVC.* This mutation leads to the production of a protein that has one amino acid missing.

(i) Suggest how a mutation can lead to the production of a protein that has one amino acid missing.

_____

_____

_____

_____

_____

(2)

(ii) Suggest how the production of a protein with one amino acid missing may lead to a genetic disorder such as Ellis-van Creveld syndrome.

_____

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_____

(2)

(Total 5 marks)

Q25.

The Amazonian forest today contains a very high diversity of bird species.

- Over the last 2 000 000 years, long periods of dry climate caused this forest to separate into a number of smaller forests.
- Different plant communities developed in each of these smaller forests.
- Each time the climate became wetter again, the smaller forests grew in size and merged to reform the Amazonian forest.

(a) Use the information provided to explain how a very high diversity of bird species has developed in the Amazonian forest.

_____

_____

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_____

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_____

(5)

(b) Speciation is far less frequent in the reformed Amazonian forest. Suggest one reason for this.

_____

_____

_____

(1)

(Total 6 marks)

Q26.

(a) There are ethical and economic arguments for maintaining biodiversity.

(i) Suggest **one** ethical argument for maintaining biodiversity.

_____

_____

_____

(1)

(ii) Suggest **one** economic argument for maintaining biodiversity.

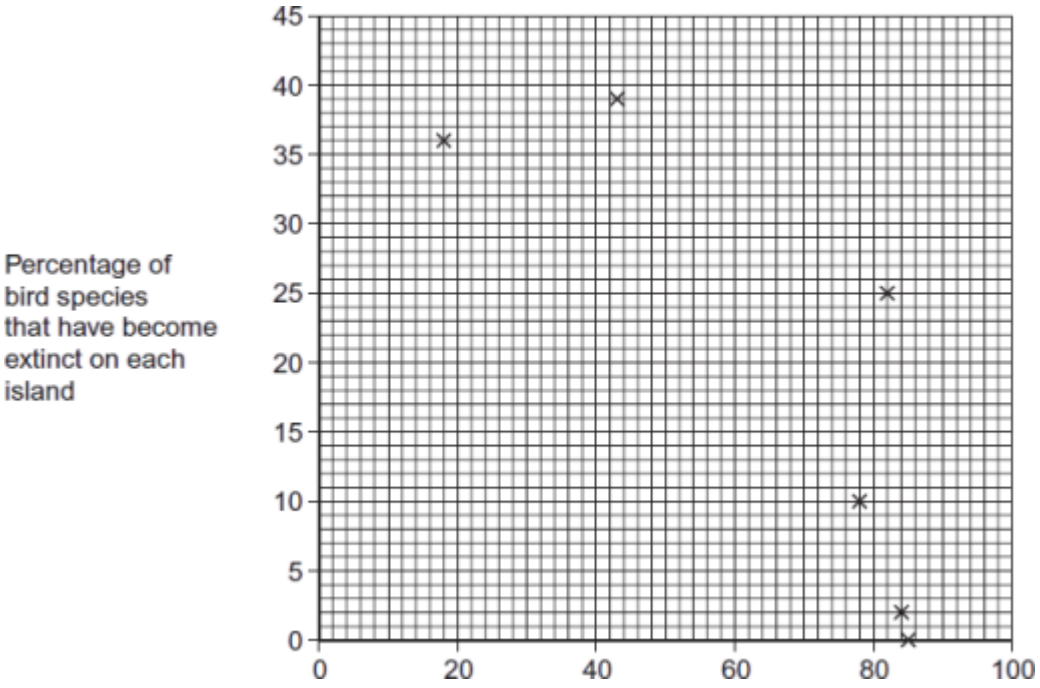
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(1)

Ecologists calculated the percentage of bird species that have become extinct on six islands in the last one hundred years. They also calculated the percentage of original forest area remaining on each island after the same time period. The graph shows their results.



remaining on each island

(b) Explain the relationship between the percentage of original forest area remaining and the percentage of bird species that have become extinct.

_____

_____

_____

_____

_____

(2)

(c) What **two** measurements would the ecologists have needed to obtain to calculate the index of diversity of birds on each island?

1. _____

2. _____

(2)

(d) The ecologists noted that the species of birds surviving on the coldest islands had a larger body size than those surviving on warmer islands.

Explain how a larger body size is an adaptation to a colder climate

_____

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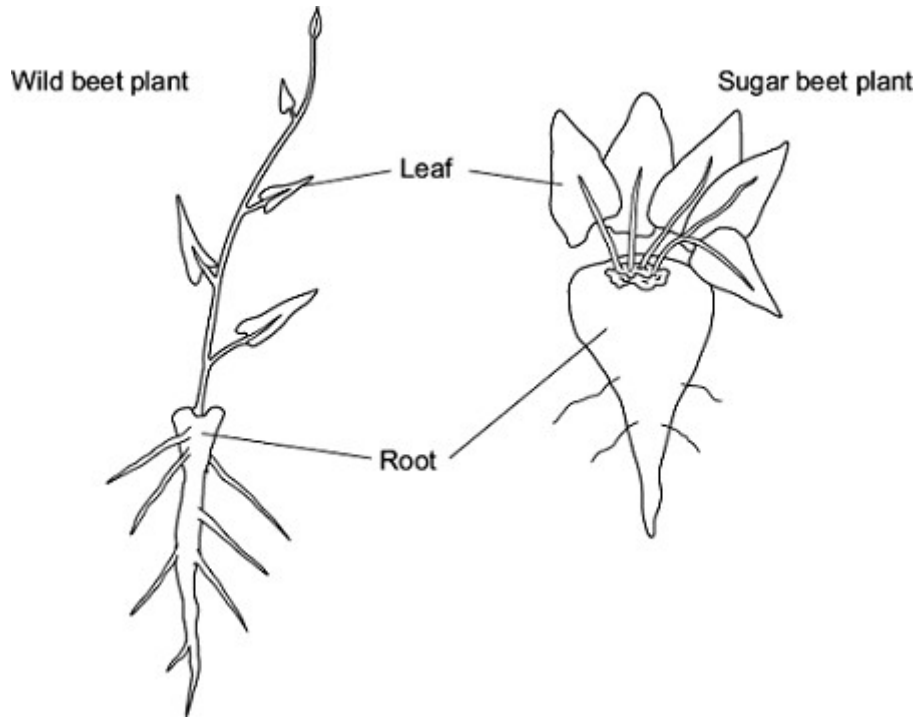
(2)

(Total 8 marks)

Q27.

Sugar beet is a crop grown for the sugar stored in its root. The sugar is produced by photosynthesis in the leaves of the plant. Plant breeders selected high-yielding wild beet plants. They used these plants to produce a strain of sugar beet to grow as a crop.

The drawings show a wild beet plant and a sugar beet plant. The drawings are to the same scale.



(a) Use the drawings to describe **two** ways in which a sugar beet plant is different from a wild beet plant.

Explain how each of these differences would give an increased yield of sugar.

Difference 1 _____

_____

Explanation _____

_____

Difference 2 _____

_____

Explanation _____

_____

(4)

(b) Sugar beet plants have been selected for a faster rate of growth.

Suggest how the faster rate of growth may increase profit for a farmer.

_____

_____

_____

(1)

(c) Describe and explain how selection will have affected the genetic diversity of sugar beet.

_____

_____

_____

_____

_____

(2)

(Total 7 marks)

Q28.

Phenylketonuria is a disease caused by mutations of the gene coding for the enzyme PAH. The table shows part of the DNA base sequence coding for PAH. It also shows a mutation of this sequence which leads to the production of non-functioning PAH.

DNA base sequence coding for PAH	C	A	G	T	T	C	G	C	T	A	C	G
DNA base sequence coding for non-functioning PAH	C	A	G	T	T	C	C	C	T	A	C	G

(a) (i) What is the maximum number of amino acids for which this base sequence could code?

(1)

(ii) Explain how this mutation leads to the formation of non-functioning PAH.

_____

_____

_____

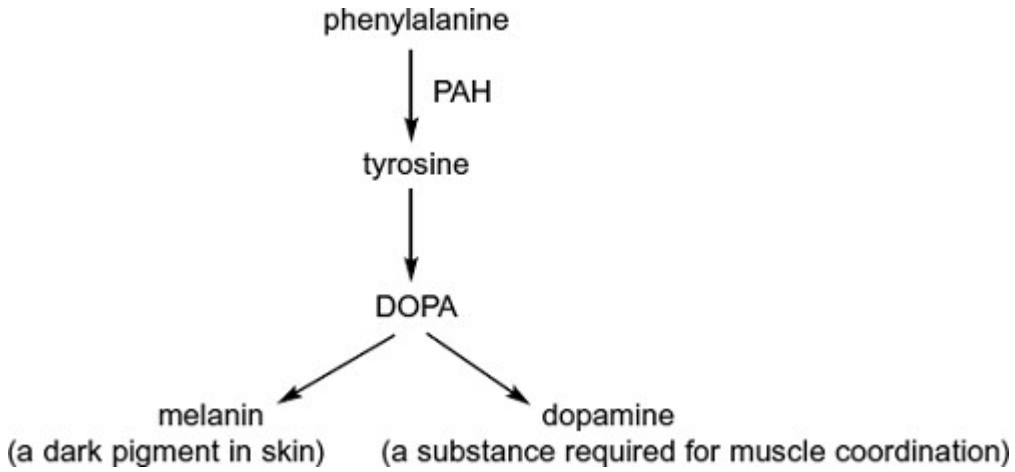
_____

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_____

(3)

PAH catalyses a reaction at the start of two enzyme-controlled pathways.
The diagram shows these pathways.



(b) Use the information in the diagram to give **two** symptoms you might expect to be visible in a person who produces non-functioning PAH.

1. _____

2. _____

(2)

(c) One mutation causing phenylketonuria was originally only found in one population in central Asia. It is now found in many different populations across Asia. Suggest how the spread of this mutation may have occurred.

_____

_____

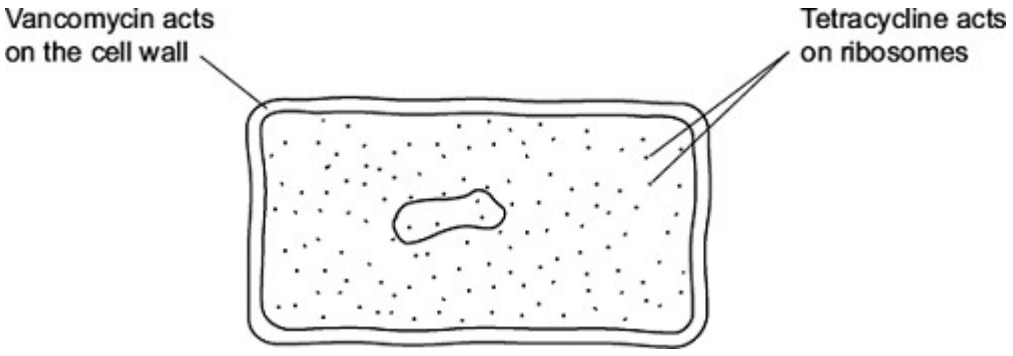
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(1)

(Total 7 marks)

Q29.

The diagram shows the structure of a bacterium and the sites of action of two antibiotics.



(a) (i) Use information in the diagram to explain why vancomycin does **not** affect human cells.

_____

_____

(1)

(ii) Use information in the diagram to explain how tetracycline prevents bacterial growth.

_____

_____

(1)

(b) Frequent treatment with vancomycin can result in resistant strains of bacteria. Explain how.

_____

_____

_____

_____

_____

_____

(2)

(Total 4 marks)

Q30.

(a) Explain what is meant by genetic diversity.

_____

_____

(1)

(b) Apart from genetic factors what other type of factor causes variation within a species?

_____

(1)

(c) The spotted owl is a bird. Numbers of spotted owls have decreased over the past 50 years. Explain how this decrease may affect genetic diversity.

_____

_____

_____

_____

_____

(2)

(Total 4 marks)

Q31.

(a) *Clostridium difficile* is a bacterium that is present in the gut of up to 3% of healthy adults and 66% of healthy infants.

(i) *C. difficile* rarely causes problems, either in healthy adults or in infants. This is because its numbers are kept low by competition with harmless bacteria that normally live in the intestine.

Use this information to explain why some patients treated with antibiotics can be affected by *C. difficile*.

_____

_____

_____

_____

_____

(2)

(ii) Suggest why older people are more likely to be affected by *C. difficile*.

_____

_____

_____

(1)

(b) The antibiotic methicillin inhibits the enzyme transpeptidase. This enzyme is used by some bacteria to join monomers together during cell wall formation. Methicillin has a similar structure to these monomers. Use this information to explain how methicillin inhibits the enzyme transpeptidase.

_____

_____

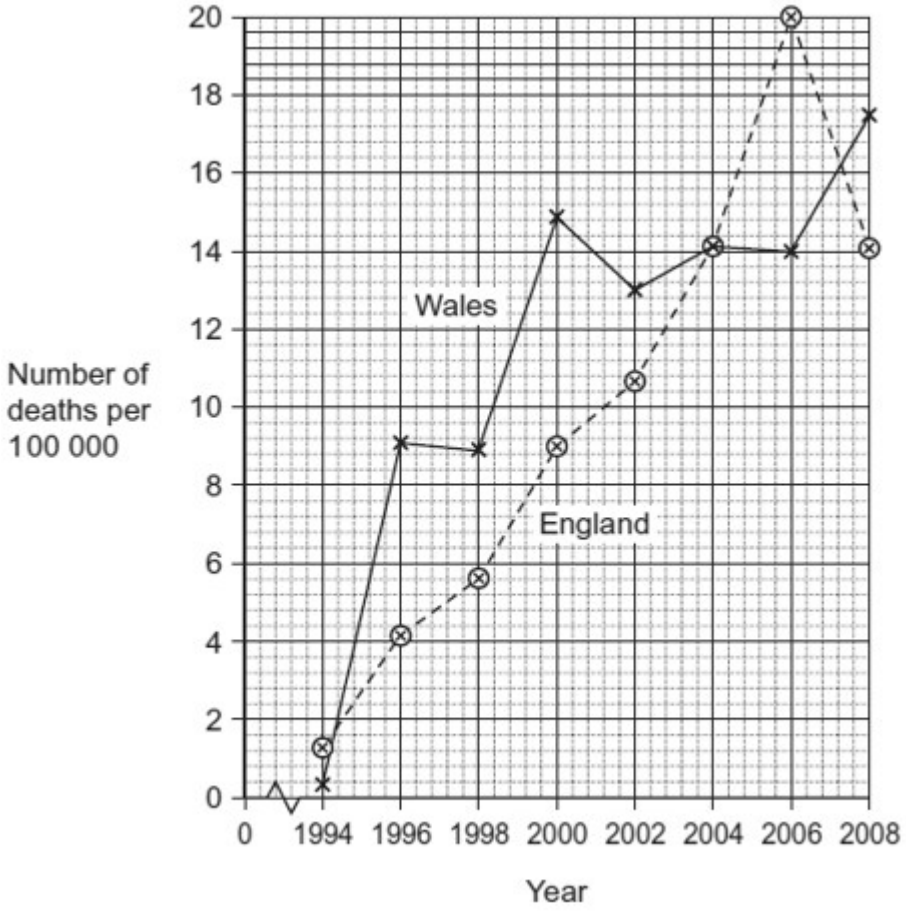
_____

_____

_____

(2)

(c) MRSA is a variety of *Staphylococcus aureus*. It is difficult to treat infections caused by this bacterium because it is resistant to methicillin and to some other antibiotics. As a result, some patients who are already very ill may die if they become infected with MRSA. The graph shows the number of deaths in England and Wales between 1994 and 2008 caused by MRSA.



(i) It may be difficult to identify MRSA as the actual cause of death. Explain why.

_____

_____

_____

(1)

(ii) Describe the change in the number of deaths caused by MRSA in England in the period shown in the graph.

_____

_____

_____

(1)

(iii) Calculate the percentage increase in the number of deaths caused by MRSA in Wales from 1996 to 2006. Show your working.

Answer _____

(2)

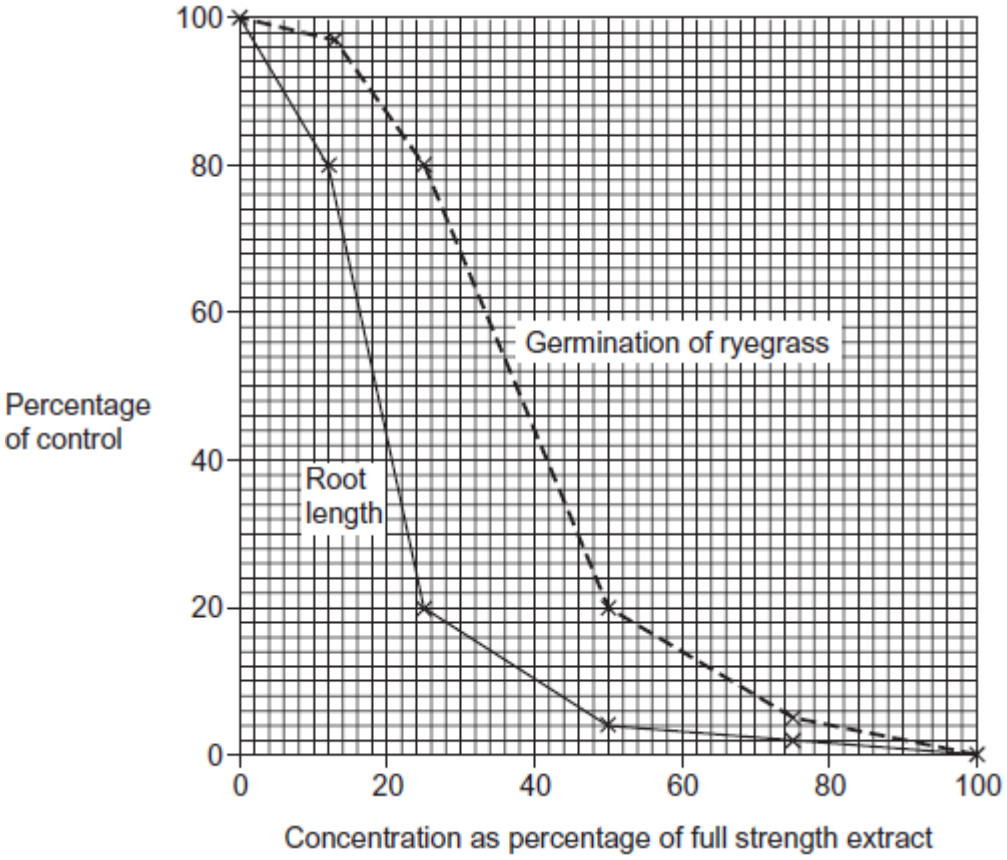
(Total 9 marks)

Q32.

Australian scientists investigated one aspect of competition between wheat and ryegrass.

- They crushed up some wheat plants and mixed the crushed plants with distilled water.
- Water-soluble substances in the crushed plants dissolved in the distilled water. The scientists called this solution the *full-strength* extract.
- The scientists then made a series of dilutions of the full-strength extract.
- They put ryegrass seeds into each dilution and recorded how many seeds germinated (started to grow). If the seeds germinated, they measured the lengths of the roots of the seedlings.
- They presented their results as percentages of a control experiment.

The graph shows the effects of different concentrations of the extract on the germination of ryegrass and on the length of the roots of the seedlings that grew from them.



(a) Describe the control that the scientists set up in this investigation.

_____

_____

(1)

(b) The scientists found a positive correlation between the inhibition of germination and the concentration of the extract.

(i) Describe how they could find out whether this correlation was significant.

_____

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(2)

(ii) Explain why a correlation does **not** mean that the extract caused inhibition of germination.

_____

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(1)

(c) The scientists concluded that wheat plants produce substances that help them to compete with ryegrass.

(i) Give evidence from the investigation to support this conclusion.

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(2)

(ii) Why might their conclusion **not** be valid?

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(3)
(Total 9 marks)

Q33.

The body markings of cheetahs vary, in particular the pattern of bands on their tails. Cheetahs are solitary animals but the young stay with their mother until they are between 14 and 18 months old.

Scientists investigated the banding pattern on the tails of cheetahs living in the wild.

- They drove a car alongside a walking cheetah and used binoculars to study the tail pattern.
- They gave each cheetah a banding pattern score based on the width of the dark and light bands on the end of the tail.
- They scored the width of the bands on the right and left side of the tail using a 5 point scale of width.

A typical pattern on the right side of one cheetah's tail is shown in **Figure 1**.

Figure 1

Band number 1 2 3 4 5 6 7



Band width score 3 1 1 4 3 3 3

The scientists collected data from each cheetah on four separate occasions. **Figure 2** shows the data for one of the cheetahs.

Figure 2

Side of tail	Mean band width score (± standard deviation)						
	Band 1	**Band 2**	**Band 3**	**Band 4**	**Band 5**	**Band 6**	**Band 7**
Right	3.00 (± 0.82)	1.00 (± 0.00)	1.00 (± 0.00)	3.75 (± 0.50)	2.75 (± 0.50)	3.00 (± 0.00)	3.00 (± 0.00)
Left	3.75 (± 0.50)	3.25 (± 0.50)	2.00 (± 0.50)	3.00 (± 0.00)	2.00 (± 0.00)	2.50 (± 0.50)	3.00 (± 0.50)

(a) The scientists only used data from cheetahs which were fully grown. Suggest why.

_____

_____

(1)

(b) The scientists estimated the width of the bands on the same cheetah on four separate occasions. They did not always get the same score.

(i) Give **two** pieces of evidence from **Figure 2** which show that the scientists sometimes obtained different scores for the same band.

1. _____

_____

2. _____

_____

(2)

(ii) The method the scientists used resulted in them getting different scores for the same band. Suggest why.

_____

_____

(1)

(c) What is the evidence from **Figure 2** that the dark and light bands do **not** form rings of equal width around the tail?

_____

_____

(1)

(d) The scientists found the difference in banding pattern between

- offspring in the same family
- cheetahs chosen randomly.

Explain how scientists could use this information to show that some variation in tail banding was genetic.

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(3)

(Total 8 marks)

Q34.

The table shows some differences between three varieties of banana plant.

	Variety **A**	Variety **B**	Variety **C**

Number of chromosomes in a leaf cell	22	33	44
Growth rate of fruit / cm^3 $week^{-1}$	2.9	6.9	7.2
Breaking strength of leaf / arbitrary units	10.8	9.4	7.8

(a) (i) How many chromosomes are there in a male gamete from variety **C**?

(1)

(ii) Variety **B** cannot produce fertile gametes. Use information in the table to explain why.

(2)

In some countries very strong winds may occur. Banana growers in these countries choose to grow variety **B**.

(b) (i) Use the data in the table to explain why banana growers in these countries choose to grow variety **B** rather than variety **A**.

(1)

(ii) Use the data in the table to explain why banana growers in these countries choose to grow variety **B** rather than variety **C**.

(1)

(c) Banana growers can only grow new variety **B** plants from suckers. Suckers grow from cells at the base of the stem of the parent plant.

Use your knowledge of cell division to explain how growing variety **B** on a large scale will affect the genetic diversity of bananas.

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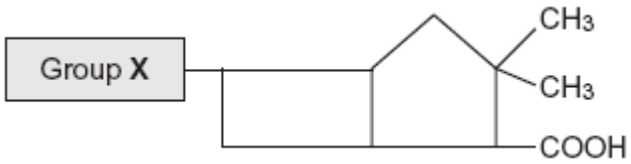
(2)

(Total 7 marks)

Q35.

Penicillins are antibiotics. Some bacteria produce an enzyme that breaks down one sort of penicillin.

(a) There are different sorts of penicillin. All of these have the same basic chemical structure shown in the diagram but group **X** is different.



A bacterial infection that cannot be treated with one sort of penicillin can be treated with a different sort. Use your knowledge of enzyme action to explain why the different sort of penicillin is effective in treating the infection.

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(3)

(b) Farmers often keep large numbers of cattle together. Farmers used to give cattle food which had antibiotics added to it.

(i) Suggest how adding antibiotics to the food of the cattle increased profit for the farmers.

_____

_____

_____

_____

(2)

(ii) Adding antibiotics to the food of cattle is now banned in many countries. Use your knowledge of selection to explain why adding antibiotics was banned.

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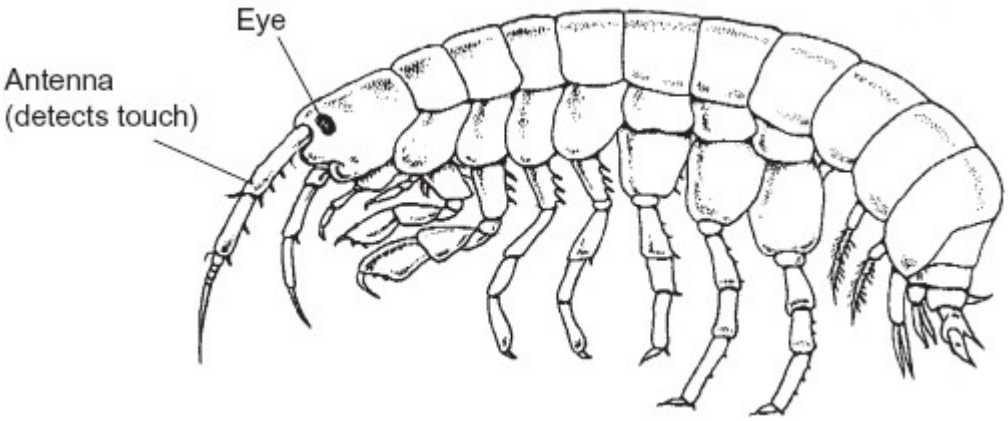
(2)

(Total 7 marks)

Q36.

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.

_____

_____

_____

(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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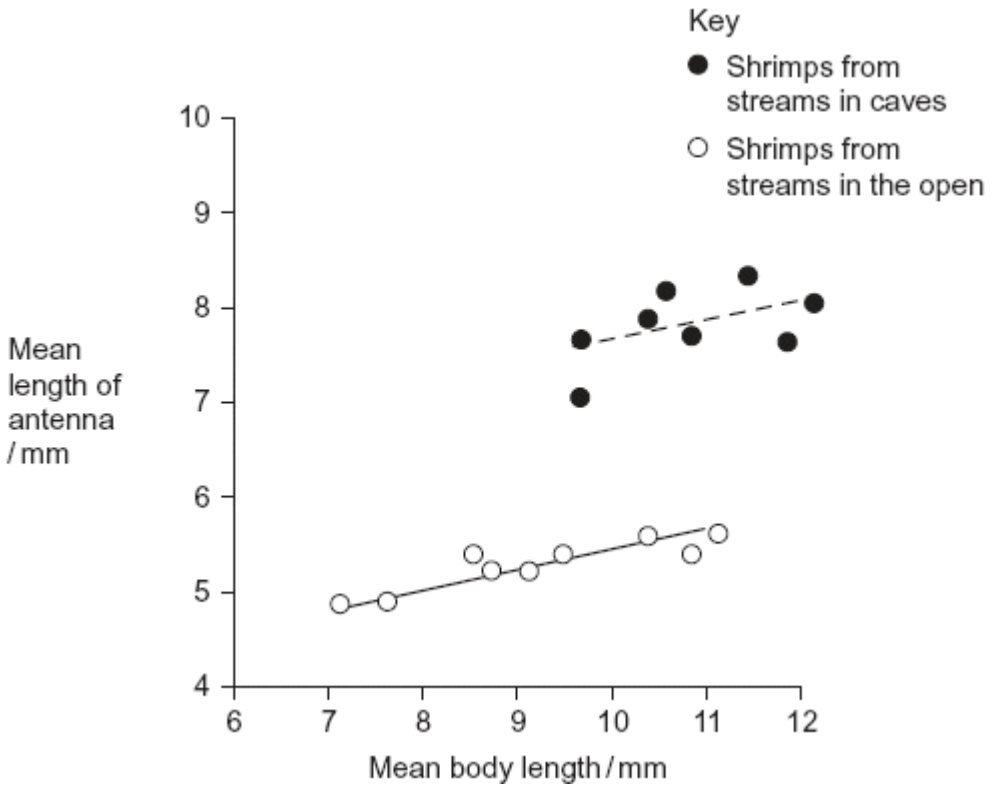
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(2)

(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?

_____

_____

_____

_____

_____

(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.

_____

_____

_____

(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.

_____

_____

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_____

_____

(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)

Q37.

(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. _____

_____

(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. _____

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(2)

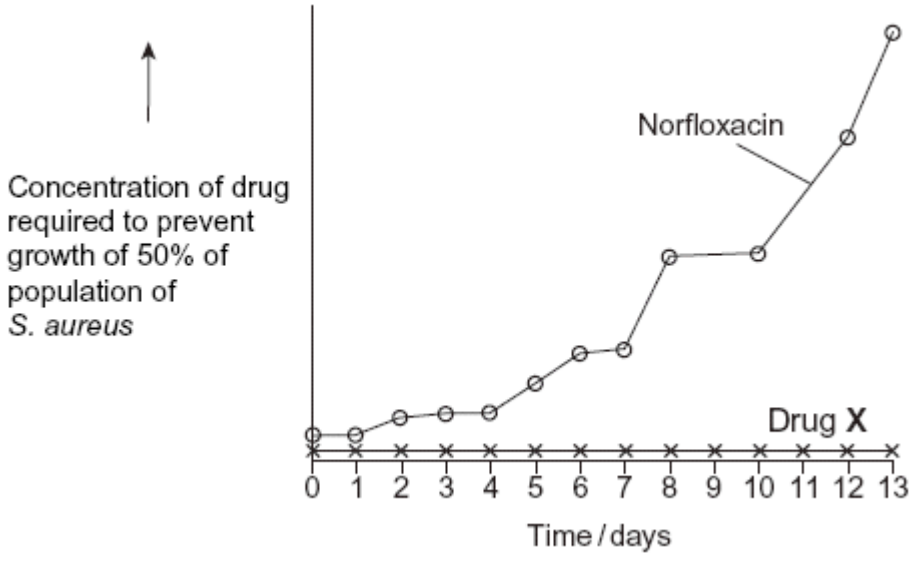
(ii) Suggest **two** factors the scientists should have considered when selecting adult volunteers for this trial.

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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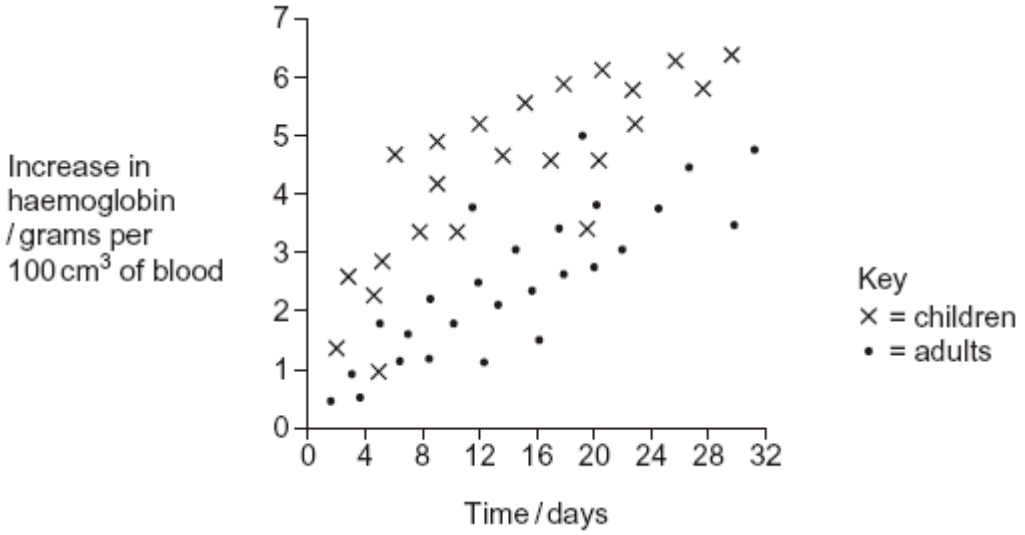
(1)

(Total 11 marks)

Q38.

(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.

_____

_____

(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.

_____

_____

_____

_____

(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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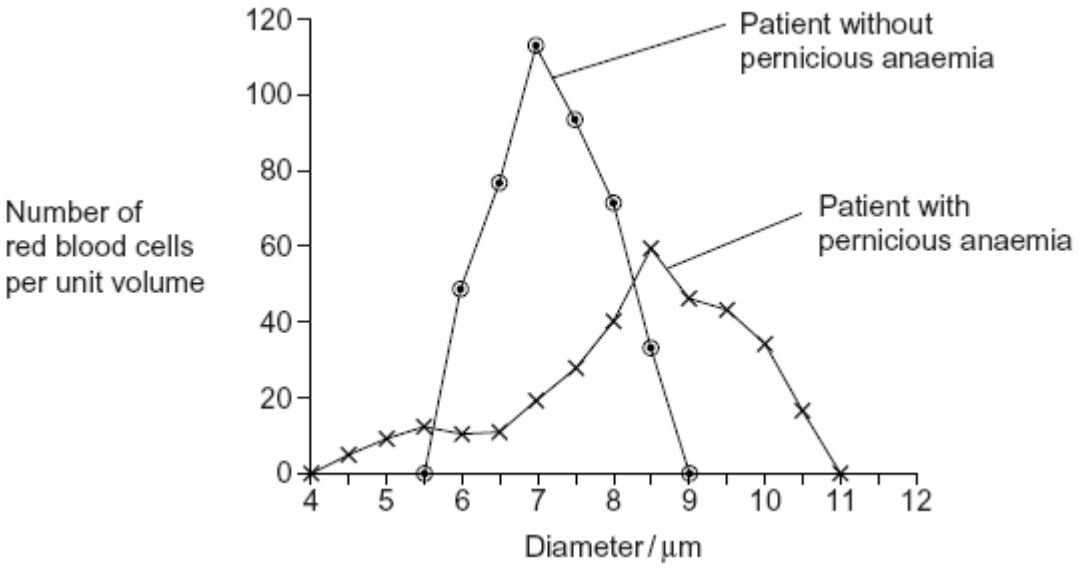
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(3)

(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. _____

_____

2. _____

_____

(2)
(Total 9 marks)

Q39.

During the last 50 years, there have been changes in the climate of the UK. One of the main changes is temperature. The data in the following resources all relate to southern England.

Figure 1 shows the mean temperatures for January and February combined.

Figure 1

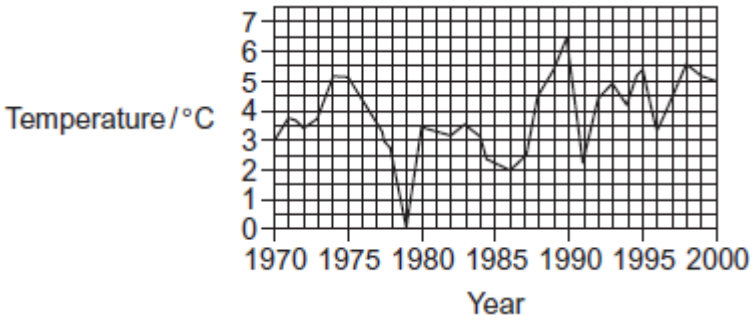
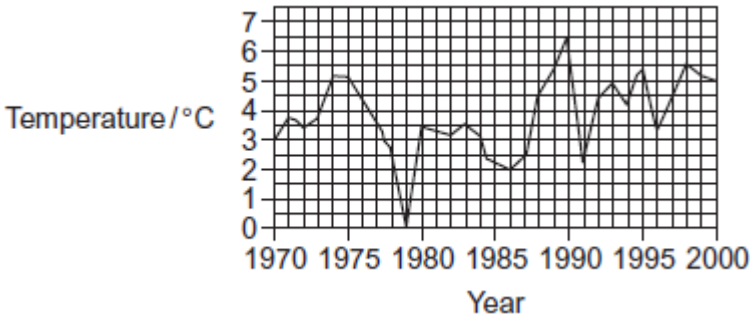


Figure 2 shows the mean temperatures for March.

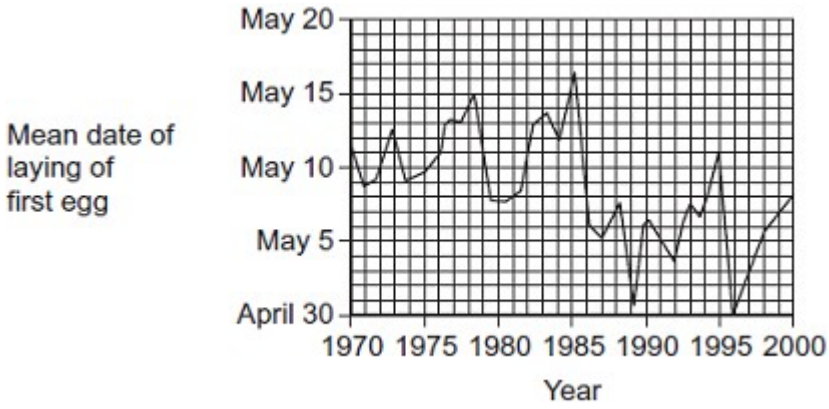
Figure 2



Birds, such as chaffinches, have been recorded as breeding earlier. Chaffinches build nests. When the nest is complete, the female lays eggs until she has produced a full clutch of 4 to 6 eggs. After the eggs hatch, the parent birds feed the young on insects.

Figure 3 shows the mean date on which chaffinches laid their first egg.

Figure 3



The data from which this graph was drawn were collected by volunteers. They used standard record cards. The volunteers used one record card for each nest they found. Each card was used to record

- the geographical location
- the habitat in which the nest site was situated
- the date of each visit to the nest by the volunteer
- the number of eggs present in the nest at each visit.

Visits were made to the nests at least once every 5 days.

(a) Do the data in **Figure 1** and **Figure 2** support the idea that there has been a rise in the mean temperatures in southern England between 1970 and 2000? Explain your answer.

_____

_____

_____

_____

_____

(2)

(b) Describe briefly how you would use a statistical test to find whether there is a significant correlation between mean March temperature and the date when chaffinches laid their first egg.

_____

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_____

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_____

(3)

(c) In chaffinches, the date of laying the first egg is determined by a number of factors. These include day length and temperature. What is the advantage to the bird of

egglaying being determined by

(i) daylength

_____

_____

_____

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_____

(2)

(ii) temperature?

_____

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(2)

(d) Scientists found that there was a correlation between mean annual temperature and the date when chaffinches laid the first egg. Can you conclude that higher temperatures cause earlier laying of the first egg?
Explain your answer.

_____

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(2)

(e) How does the way in which the data were collected affect the conclusions which can be drawn from **Figure 3**?

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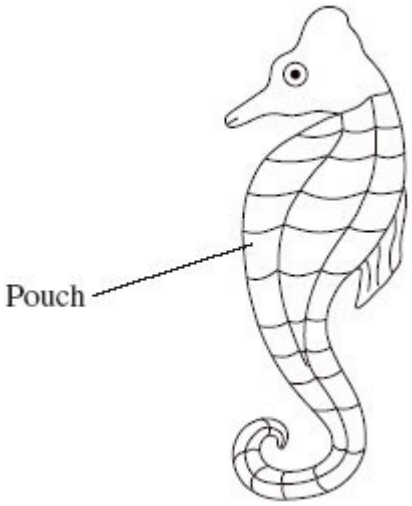
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(2)

(Total 13 marks)

Q40.

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.

_____

_____

(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)

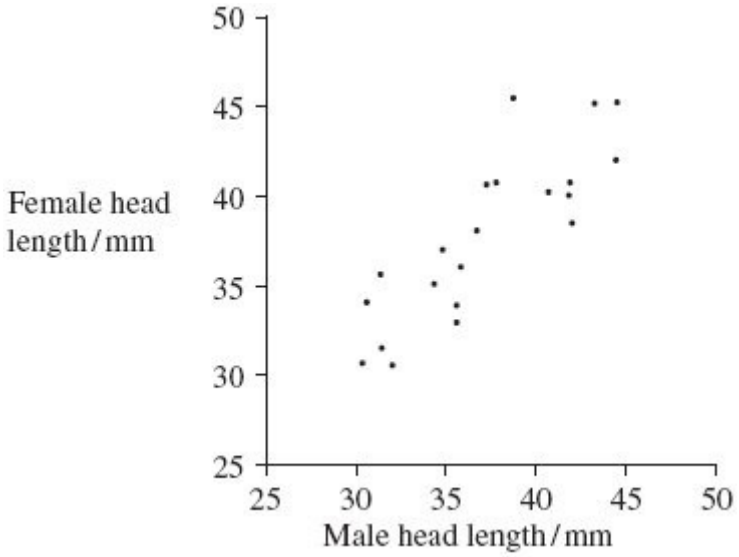
(ii) Suggest why the scientists were able to use head length as a measure of total body length.

_____

_____

(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.

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(6)

(Total 15 marks)

Q41.

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

(a) What is a species?

_____

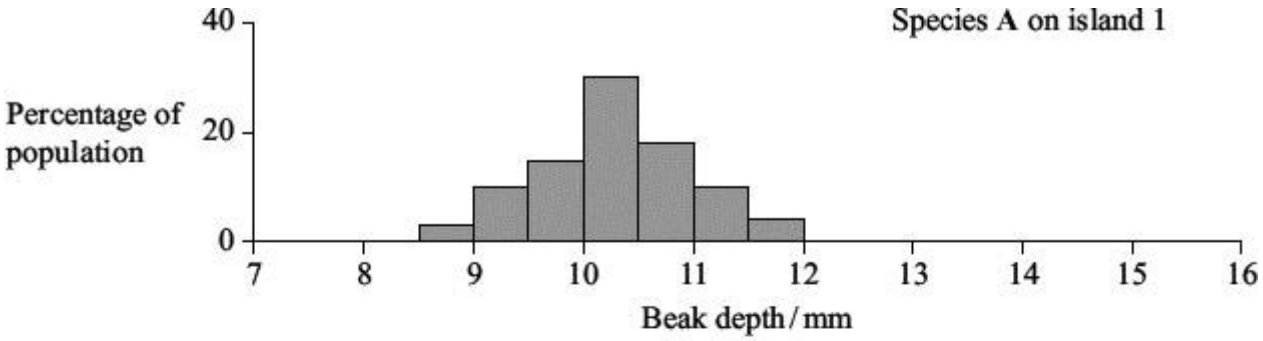
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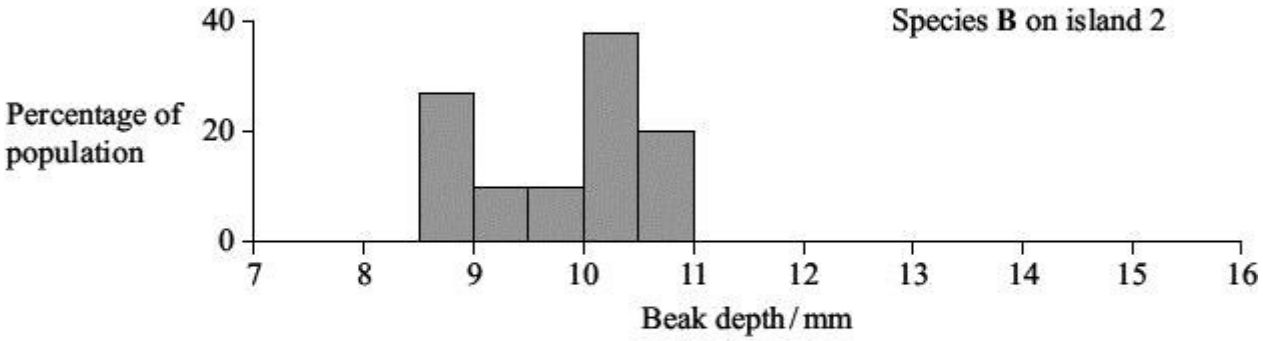
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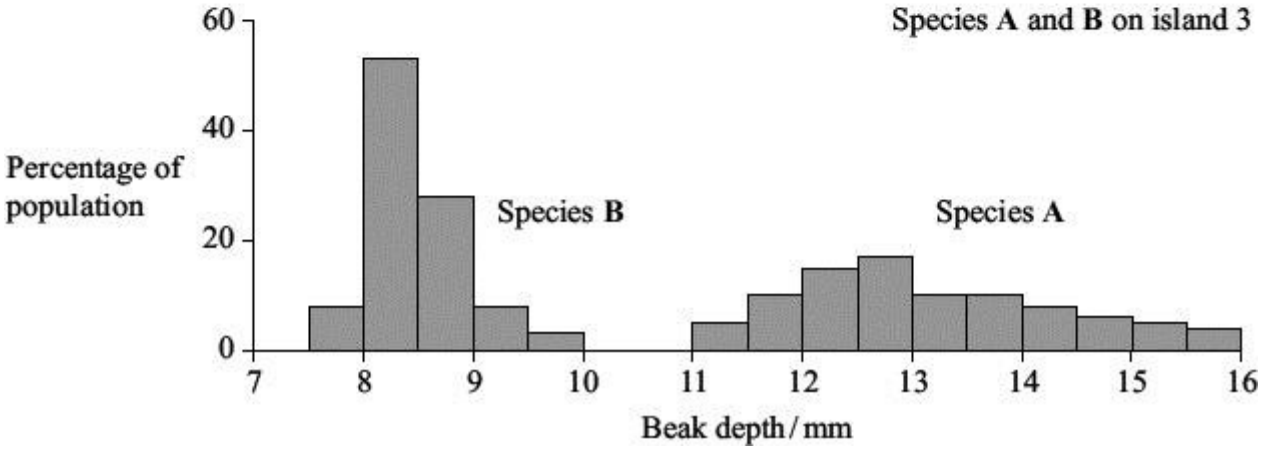
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(2)

(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)

Q42.

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

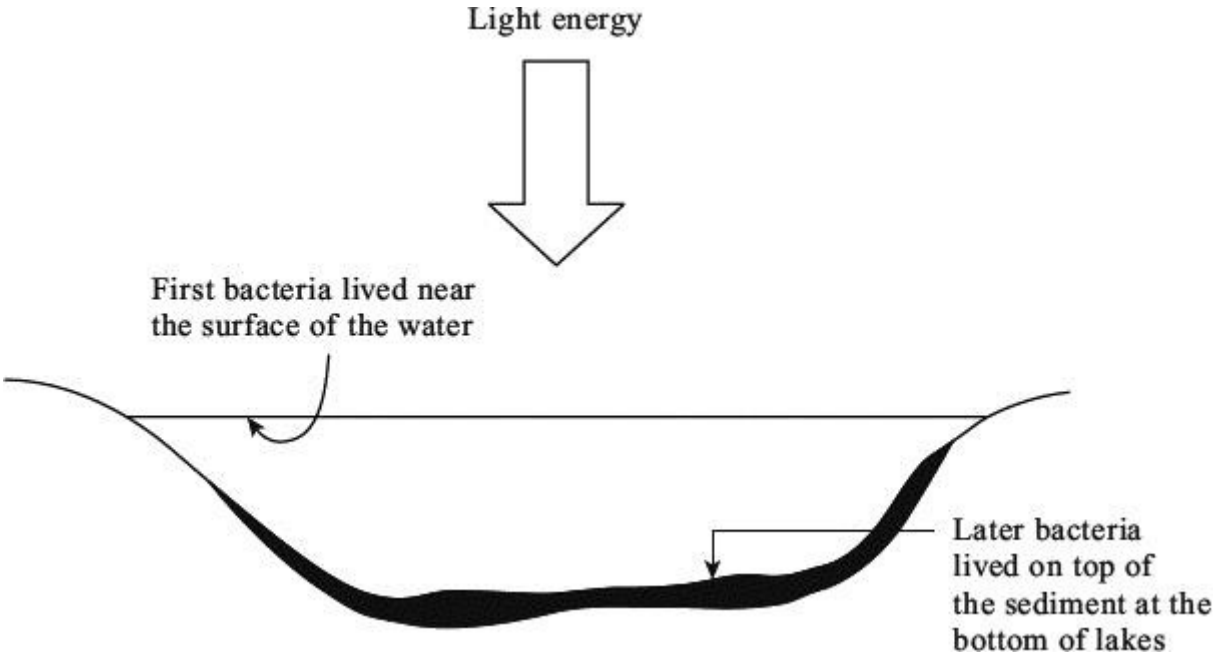
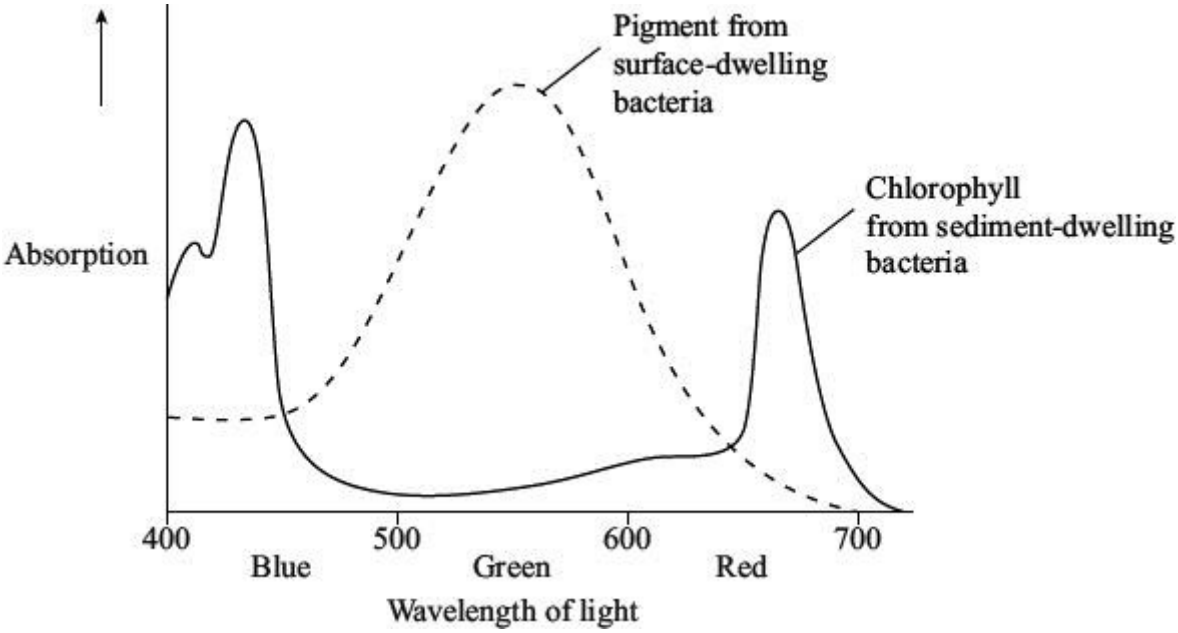


Figure 2



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

_____

_____

_____

(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)

Q43.

(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.

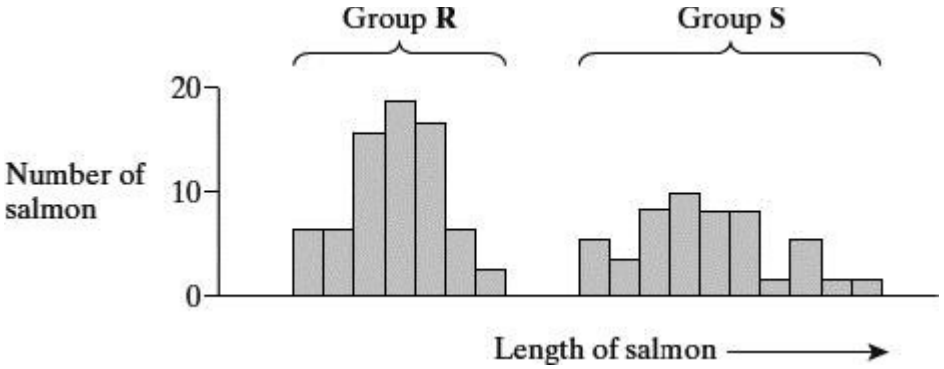
Answer _____

(4)

(Total 9 marks)

Q44.

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.

_____

_____

_____

_____

(2)

(Total 4 marks)

Q45.

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

_____

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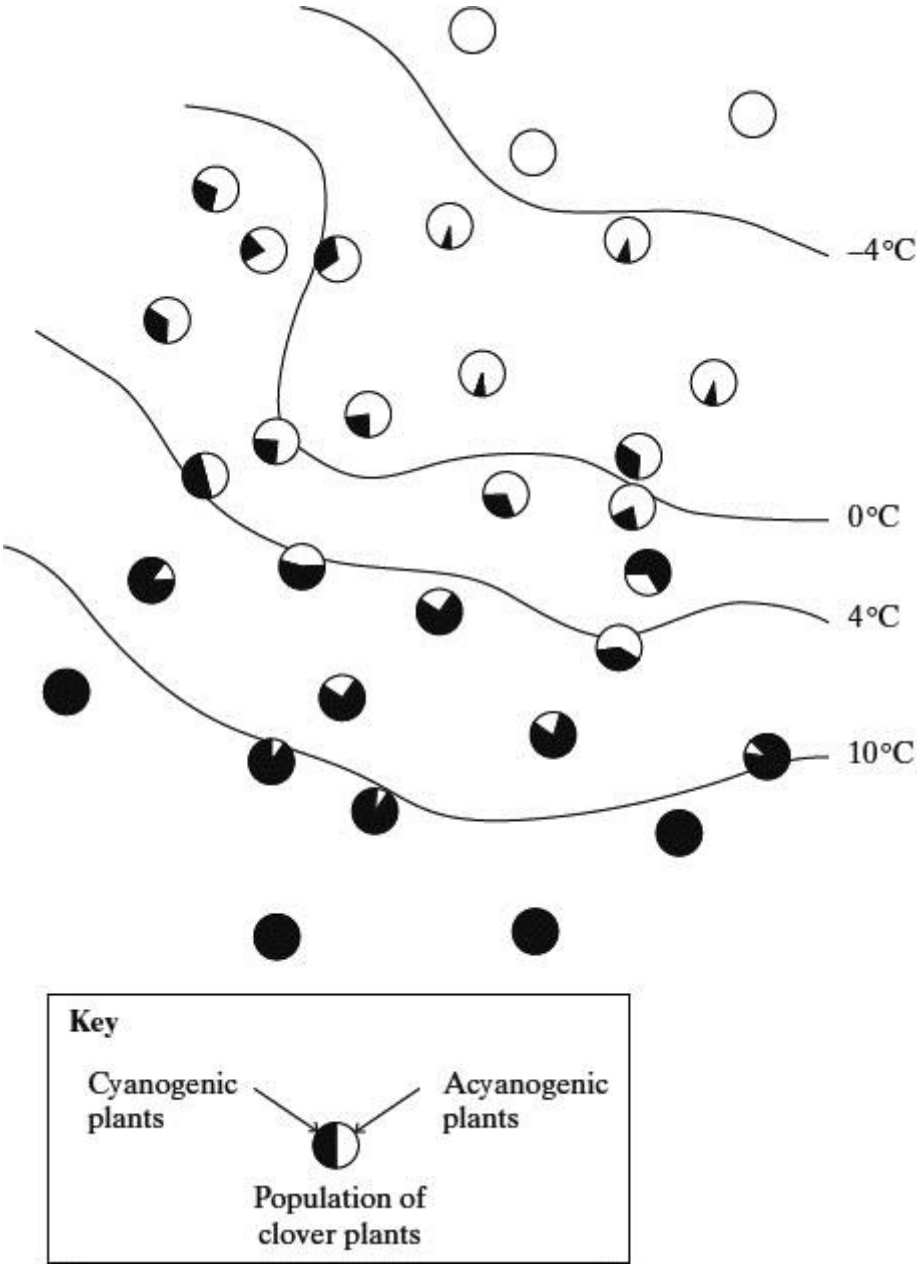
(5)

(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.

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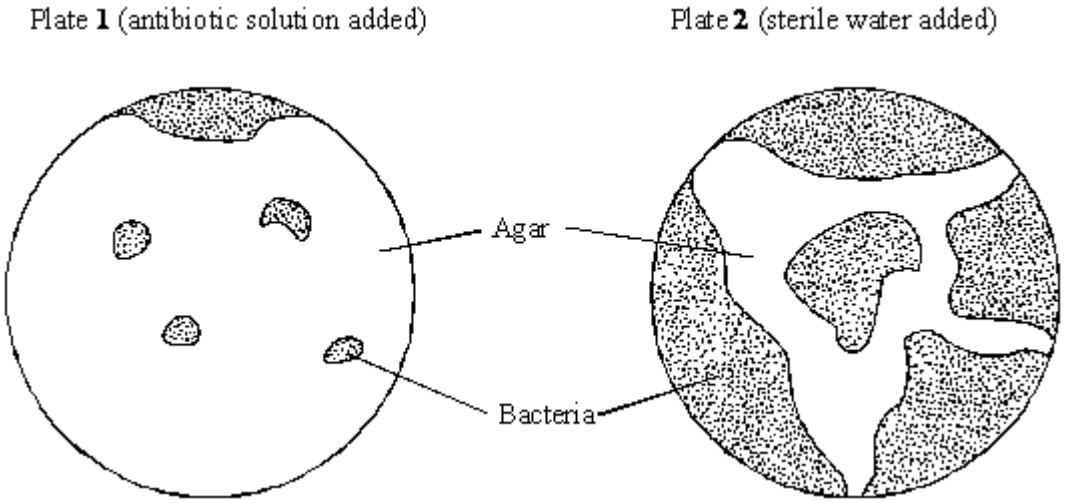
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(5)

(Total 10 marks)

Q46.

(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.

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_____

(1)

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

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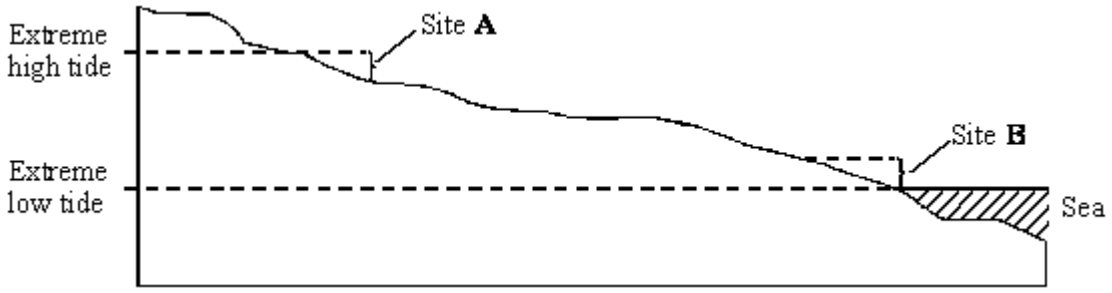
(1)

(Total 3 marks)

Q47.

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 m^2	Site B: lower shore	Mean number per m^2
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)

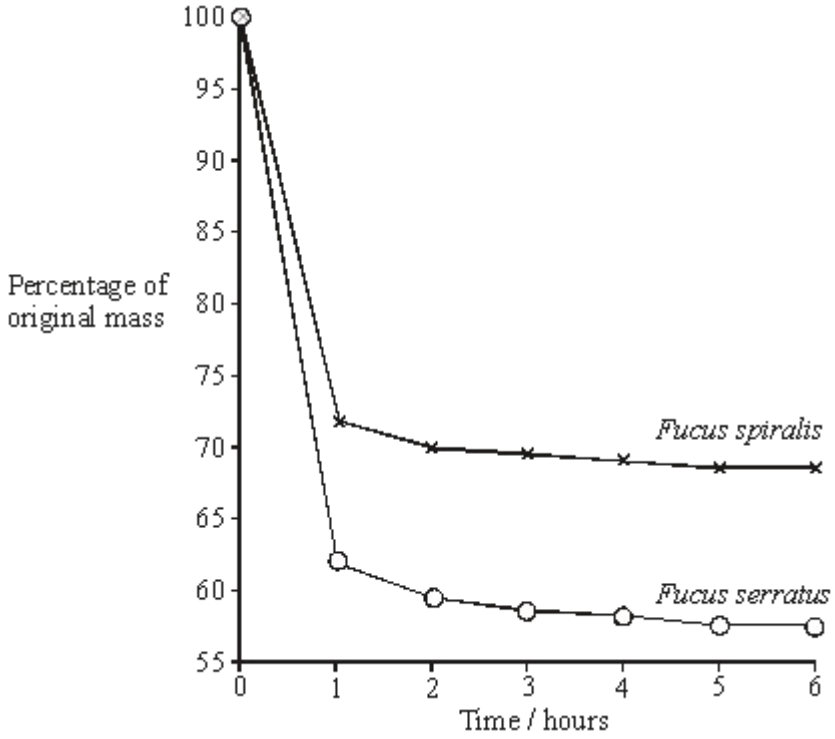
(ii) Give **one** advantage of calculating the index of diversity rather than just recording the number of species present.

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(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)

Q48.

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.

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(2)

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

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(2)

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

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(2)

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

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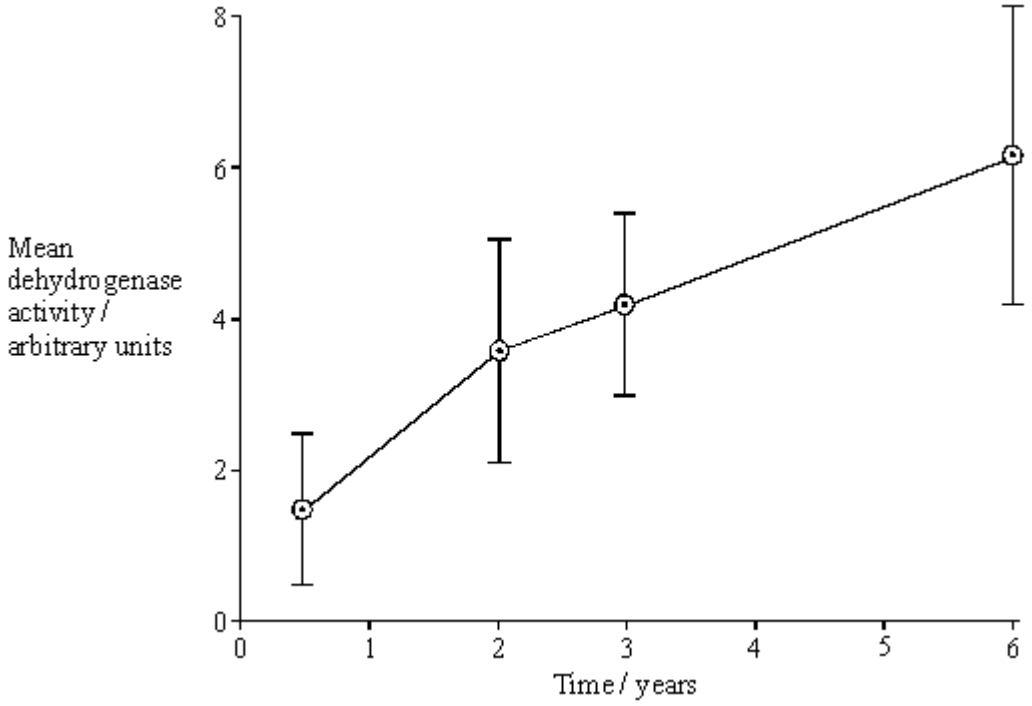
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(3)

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.

_____

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(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.

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(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 ($\times 10^7$)**
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.

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(3)

(Total 20 marks)

Q49.

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.

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(1)

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

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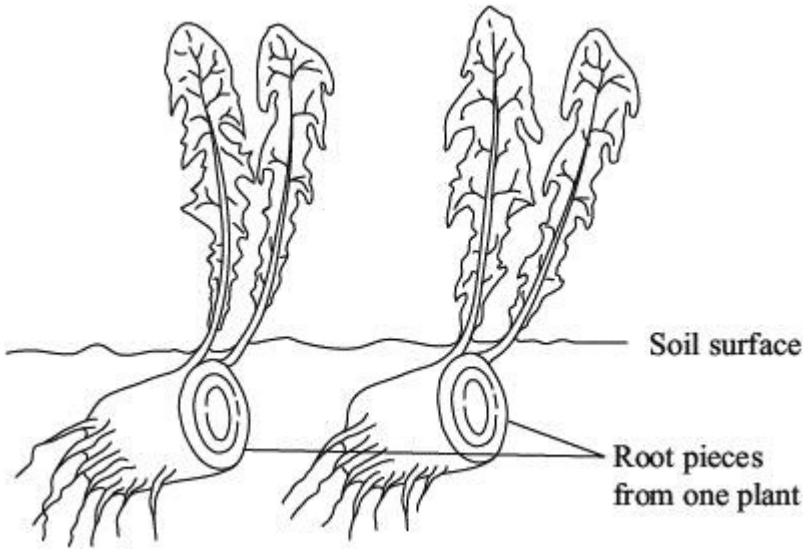
(4)

(Total 5 marks)

Q50.

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.

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(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)

Q51.

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.

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(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.

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(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.

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(2)

(Total 8 marks)

Q52.

Yarrow is a herbaceous plant which grows in California at altitudes from 1500 m to 3000 m. The mean height of the stems of plants growing at 3000 m is smaller than that of plants growing at 1500 m.

(a) The higher the altitude, the lower the mean temperature. Explain how the lower temperature at high altitude reduces the growth of plants.

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(4)

(b) The relative contribution of environmental and genetic factors on the growth of the plants was investigated. Samples of young plants were taken and grown outdoors in prepared plots at altitudes of 1500 m and 3000 m.

Altitude at which young plants were collected / m	Mean maximum height of stems of plants / cm	
	Grown at 1500 m	Grown at 3000 m
1500	80.4	35.3
3000	31.5	24.7

Describe the evidence from the table that the variation in height is

(i) partly genetically determined;

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(1)

(ii) partly environmentally determined.

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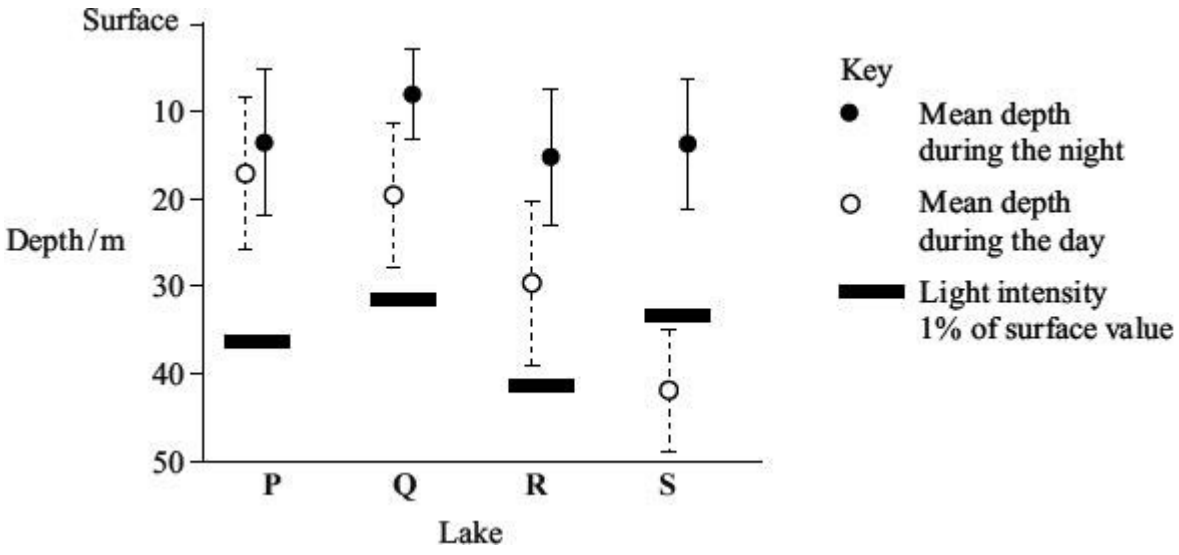
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(1)

(Total 6 marks)

Q53.

Zooplankton are very small animals which feed on algae (green protoctists) found in lakes. The chart shows the mean depth of zooplankton populations in four lakes, **P** to **S**, during the day and the night. It also shows the standard deviations of the means. The depth at which the light intensity is 1% of the surface light intensity is also shown.



(a) Explain the evidence that the zooplankton feed at night.

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(3)

(b) Predatory fish, which hunt by sight, are present in some of the lakes. These fish have been present in the lakes for different lengths of time.

Lake	Estimated length of time predatory fish have been present / years
P	0
Q	5
R	25
S	Over 1000

(i) Describe the relationship between the depth of the zooplankton during the day and the length of time predators have been present in the lake.

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(1)

(ii) Suggest how the differences in behaviour of the zooplankton populations in the four lakes might have evolved.

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(3)

(Total 7 marks)

Q54.

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

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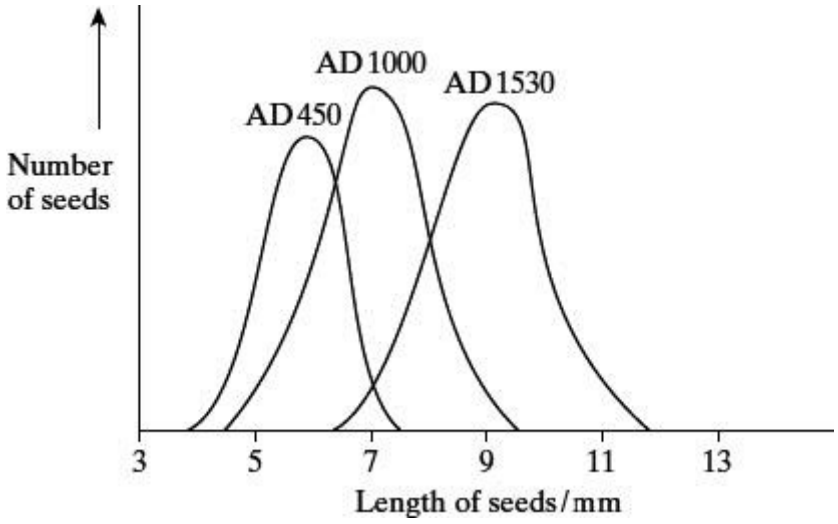
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(3)

(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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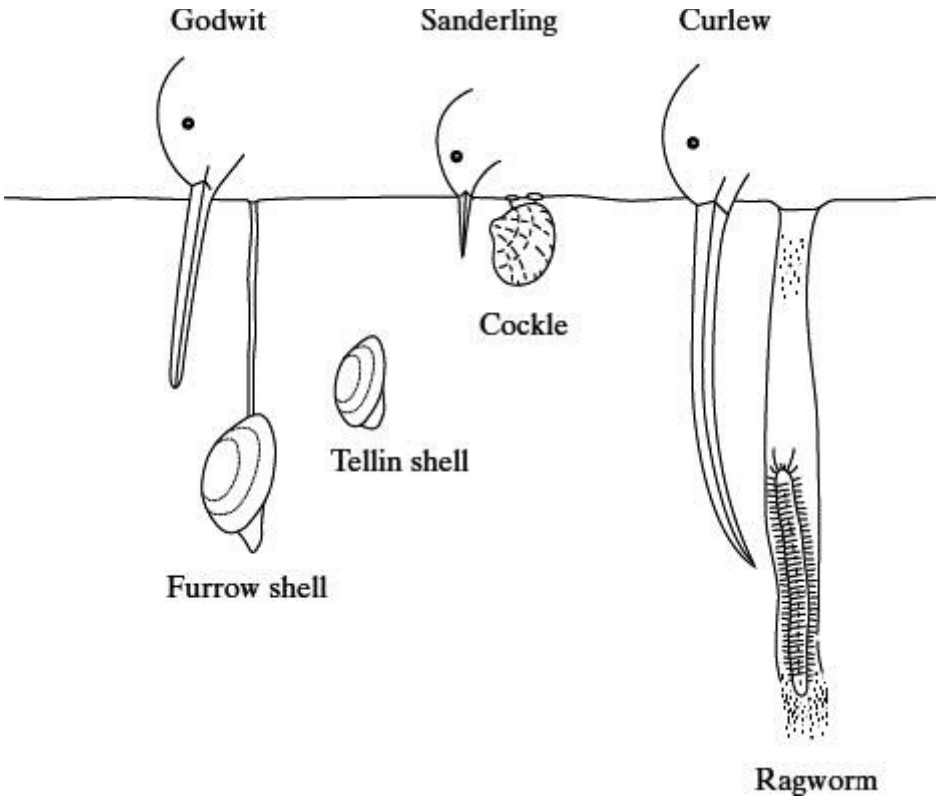
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(4)

(Total 9 marks)

Q55.

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.

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(2)

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

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(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.

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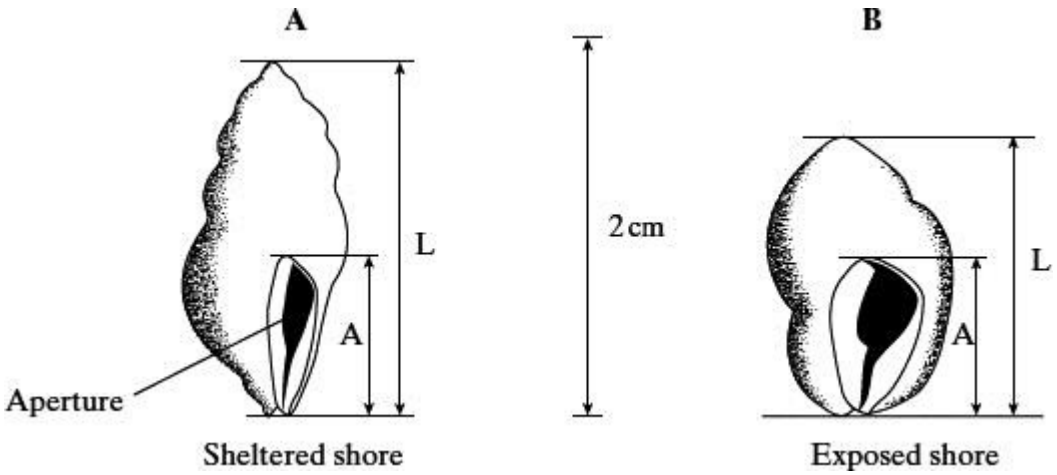
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(2)

(Total 8 marks)

Q56.

The drawings show two dogwhelks taken from two different populations. Dogwhelk **A** came from a sheltered shore and dogwhelk **B** from a shore exposed to heavy wave action. The dogwhelks attach themselves to rocks with a muscular foot which comes out through the aperture. The shell length : aperture length ratios (L/A) were calculated. The mean and standard deviation for each population are shown under the drawings.



mean L/A ratio = 1.91	mean L/A ratio = 1.78
standard deviation = 0.19	standard deviation = 0.10

(a) Describe how you would collect a random sample of each population.

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(3)

(b) What do the standard deviations tell you about the two populations of dogwhelks?

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(2)

(c) Suggest how the effect of wave action on the two populations of dogwhelks could result in differences between

(i) the mean L/A ratios;

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(ii) the standard deviations.

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(4)

(Total 9 marks)