AQA A-LEVEL · 7402

BIOLOGY



EXAM QUESTION PACK

3.7.3 EVOLUTION AND SPECIATION

SCORE	PERCENTAGE
/281	%

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Q1.

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)

Q2.

(a) What is a gene pool?

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(1)

(b) Lord Howe Island in the Tasman Sea possesses two species of palm tree which have arisen via sympatric speciation. The two species diverged from each other after the island was formed 6.5 million years ago. The flowering times of the two species are different.

Using this information, suggest how these two species of palm tree arose by sympatric speciation.

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(5)

(Total 6 marks)

Q3.

Alzheimer's disease (AD) is a non-reversible brain disorder that develops over a

number of years. At the start of 2014 the number of Americans with AD was estimated to be 5.4 million. Every 30 seconds another person in America develops AD.

In the brain of a person with AD there is a lower concentration of acetylcholine. This affects communication between nerve cells and initially results in memory loss and confusion. Some of the symptoms of AD that are associated with communication between nerve cells are reduced by taking the drug donepezil. Donepezil inhibits the enzyme acetylcholinesterase.

A gene mutation called E280A found on chromosome 14 causes early-onset AD at a mean age of 49 years. The age at which the E280A mutation is expressed to cause AD varies.
Yaramul is a town in a historically isolated region of the Andes Mountains. The population of this town has the highest frequency of the E280A mutation in the world. The origin of the E280A mutation in this population has been traced back to a common ancestor in the 17th century. Natural selection has not reduced the frequency of the E280A mutation in the population.

This autosomal dominant mutation involves a change in triplet 280 from GAA to GCA. Scientists analysed chromosome 14 from 102 individuals from Yaramul. They recorded a sample size of 204 and detected 75 E280A mutations but only 74 potential AD cases. The scientists identified individuals with the mutation by whole genome sequencing. They had decided that a DNA probe would not be a suitable method to detect the E280A mutation.

(a) Assuming no one with AD died in 2014, calculate the annual percentage increase in AD cases in America for 2014 (lines 2–4).

Answer = _____ %

(2)

(b) Explain how donepezil could improve communication between nerve cells (lines 7–9).

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(3)

(c) Suggest and explain **two** reasons why there is a high frequency of the E280A mutation in Yaramul (lines 13–15).

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2. _____

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(2)

(d) Explain why natural selection has **not** reduced the frequency of the E280A mutation in the population (lines 16–17).

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(2)

(e) The age at which the E280A mutation is expressed to cause AD can vary (lines 11–12).

Suggest and explain **one** reason for this.

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(2)

(f) One scientific study which analysed chromosome 14 involved 102 individuals. The scientists recorded a sample size of 204. In this sample they detected 75 E280A mutations but only 74 potential AD cases (lines 19–21).

Suggest explanations for the figures the scientists recorded.

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(2)

(g) Suggest why a DNA probe for the mutated triplet was **not** considered a suitable method for detection of the E280A mutation (lines 22–23).

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(2)

(Total 15 marks)

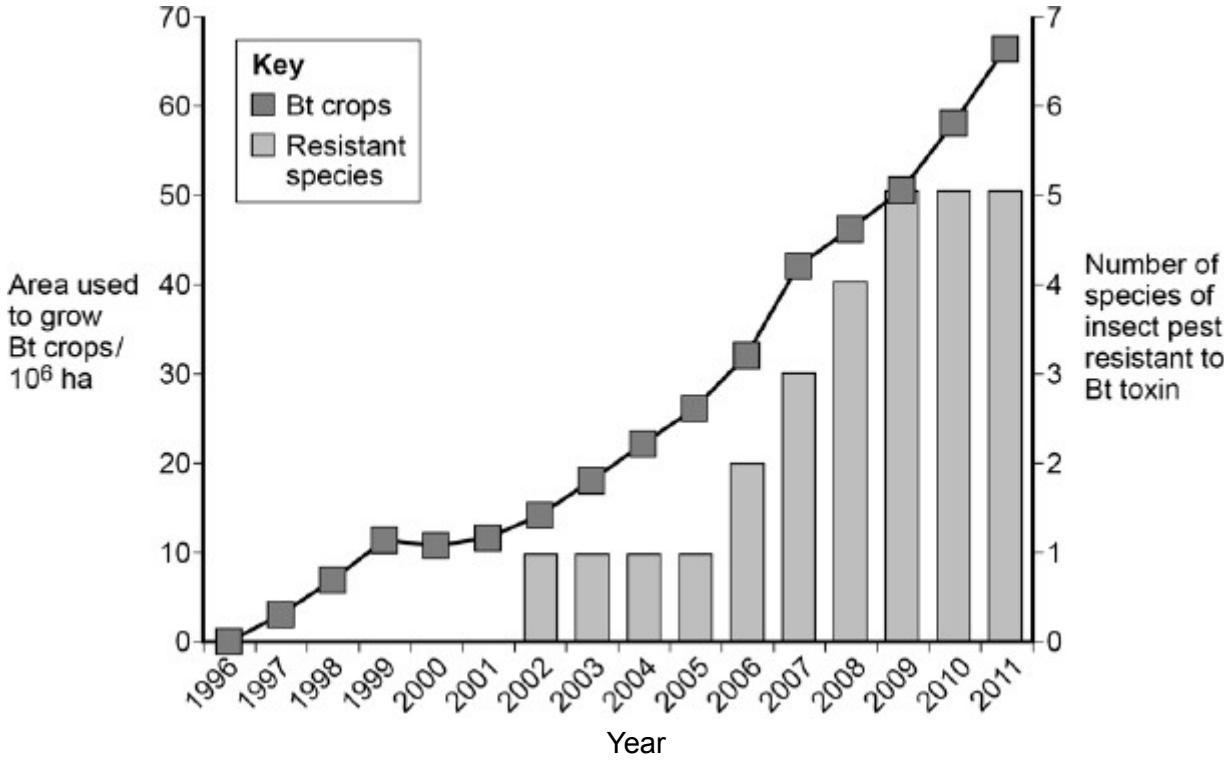
Q4.

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)

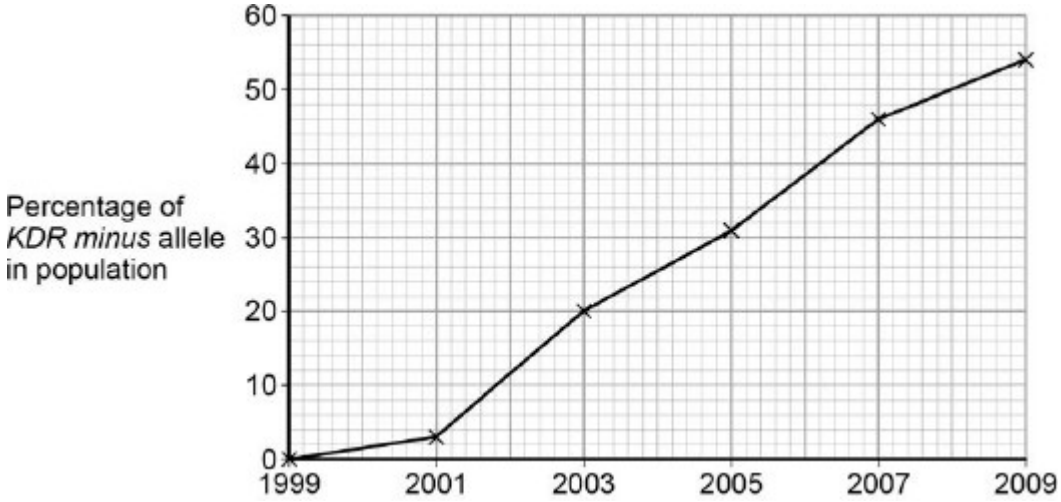
Q5.

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.



(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.

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(2)

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

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(2)

(Total 10 marks)

Q6.

There are nine subspecies of giraffe. These subspecies evolved when populations of giraffe were separated for long time periods. Each subspecies has distinct coloured skin markings. Some biologists have suggested that up to six of these subspecies should be classified as different species.

(a) Explain how different subspecies of giraffe may have evolved from a common ancestor.
Use information from the passage in your answer.

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(5)

(b) Biologists compared the mitochondrial DNA of the different subspecies of giraffe. They used the results from comparing this DNA to conclude that six of the nine

subspecies are separate species.

Suggest how they came to this conclusion.

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(2)

(Total 7 marks)

Q7.

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

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(6)

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

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(4)

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

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

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

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(5)

(Total 15 marks)

Q8.

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

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

Blood group O	0.96 : 1

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

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(2)

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

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(2)

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

Explain the high frequency of the **Hb^C** allele in areas where malaria occurs.

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(3)

(Total 7 marks)

Q9.

Schizophrenia is a mental illness. Doctors investigated the relative effects of genetic and environmental factors on the development of schizophrenia. They used sets of identical twins and non-identical twins in their investigation. At least one twin in each set had developed schizophrenia.

- Identical twins are genetically identical.

- Non-identical twins are not genetically identical.
- The members of each twin pair were raised together.

The table shows the percentage of cases where both twins had developed schizophrenia.

Type of twin	Percentage of cases where both twins had developed schizophrenia
Identical	50
Non-identical	15

(i) Explain why both types of twin were used in this investigation.

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(2)

(ii) What do these data suggest about the relative effects of genetic and environmental factors on the development of schizophrenia?

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(1)

(iii) Suggest **two** factors that the scientists should have taken into account when selecting the twins to be used in this study.

1. _____

2. _____

(2)

(Total 5 marks)

Q10.

(a) Energy enters most ecosystems through the light-dependent reaction of photosynthesis. Describe what happens during the light-dependent reaction.

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(5)

(b) Changes in ecosystems can lead to speciation. A high concentration of copper in soil is toxic to most plants. In some areas where the soil is polluted with copper, populations of grasses are found to be growing. These populations of grass belong to a species also found growing on unpolluted soils.

It has been suggested that a new species of grass may evolve on soil that has been polluted with copper. Explain how this new species might evolve.

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(5)

(Total 10 marks)

Q11.

Ecologists studied a community of fish in a lake.

(a) Explain what is meant by a community.

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(1)

(b) (i) The ecologists could have used the mark-release-recapture method to estimate the number of one species of fish in the lake. Describe how.

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(3)

(ii) This species of fish breeds at a certain time of the year. During this fish-breeding season, the mark-release-recapture technique might **not** give a reliable estimate.
Suggest **one** reason why.

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(1)

(c) The ecologists found that each species of fish had adaptations to its niche. One of these adaptations was the shape of its mouth.

Suggest how the shape of mouth is an adaptation to its niche.

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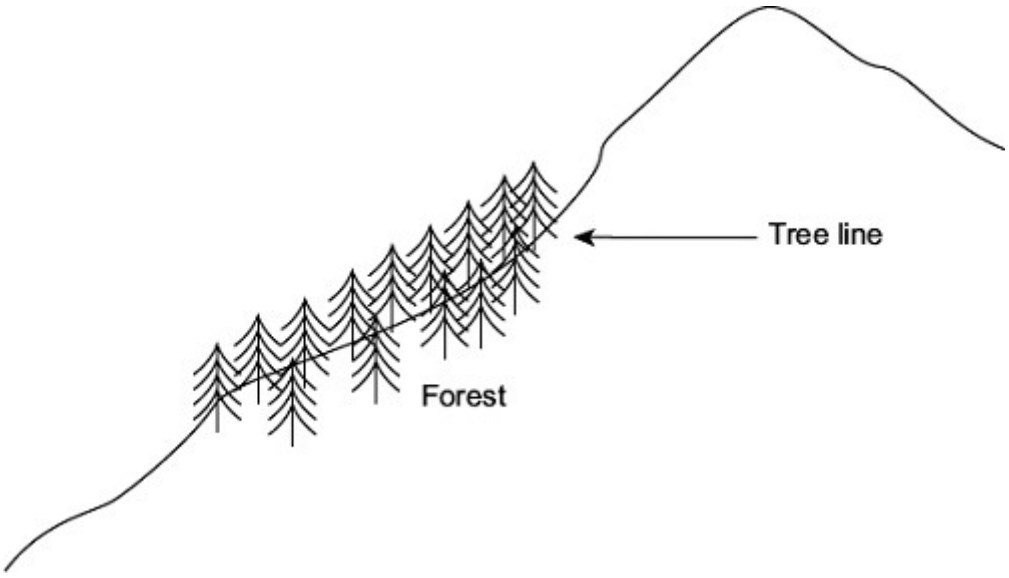
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(2)

(Total 7 marks)

Q12.

Mountains are harsh environments. The higher up the mountain, the lower the temperature becomes. The diagram shows a forest growing on the side of a mountain. The upper boundary of the forest is called the tree line. Trees do not grow above the tree line.



(a) (i) The position of the tree line is determined by abiotic factors.
What is meant by an abiotic factor?

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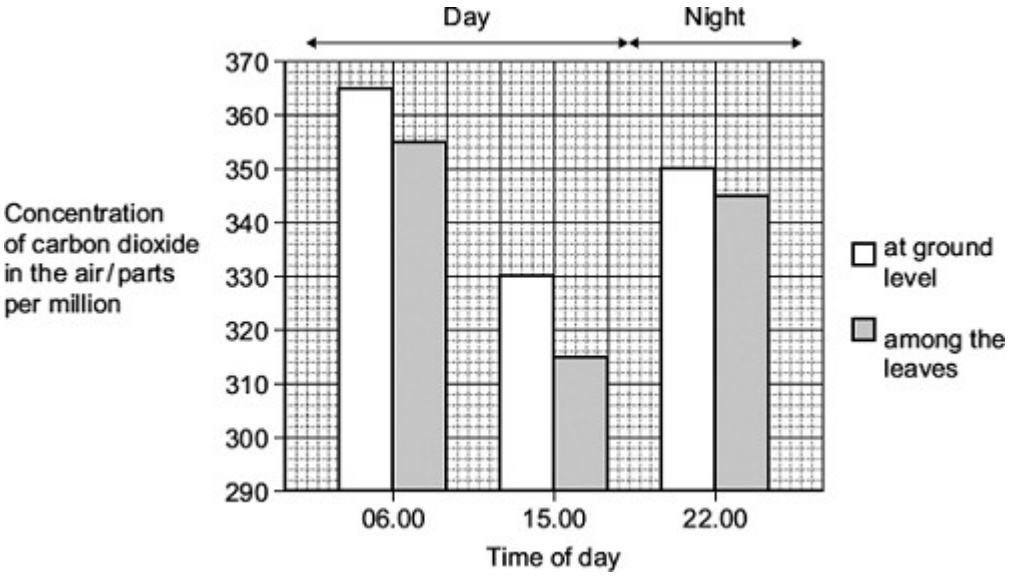
(1)

(ii) Other than temperature, suggest **one** abiotic factor that is likely to affect the position of the tree line on the mountain.

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(1)

(b) Scientists measured the concentration of carbon dioxide in the air in one part of the forest. They took measurements at different times of day and at two different heights above the ground. Their results are shown in the bar chart.



Use your knowledge of photosynthesis and respiration to explain the data in the bar chart.

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(4)

(c) The population of trees in the forest evolved adaptations to the mountain environment.
Use your knowledge of selection to explain how.

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(3)

(Total 9 marks)

Q13.

(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*.

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(2)

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

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(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.

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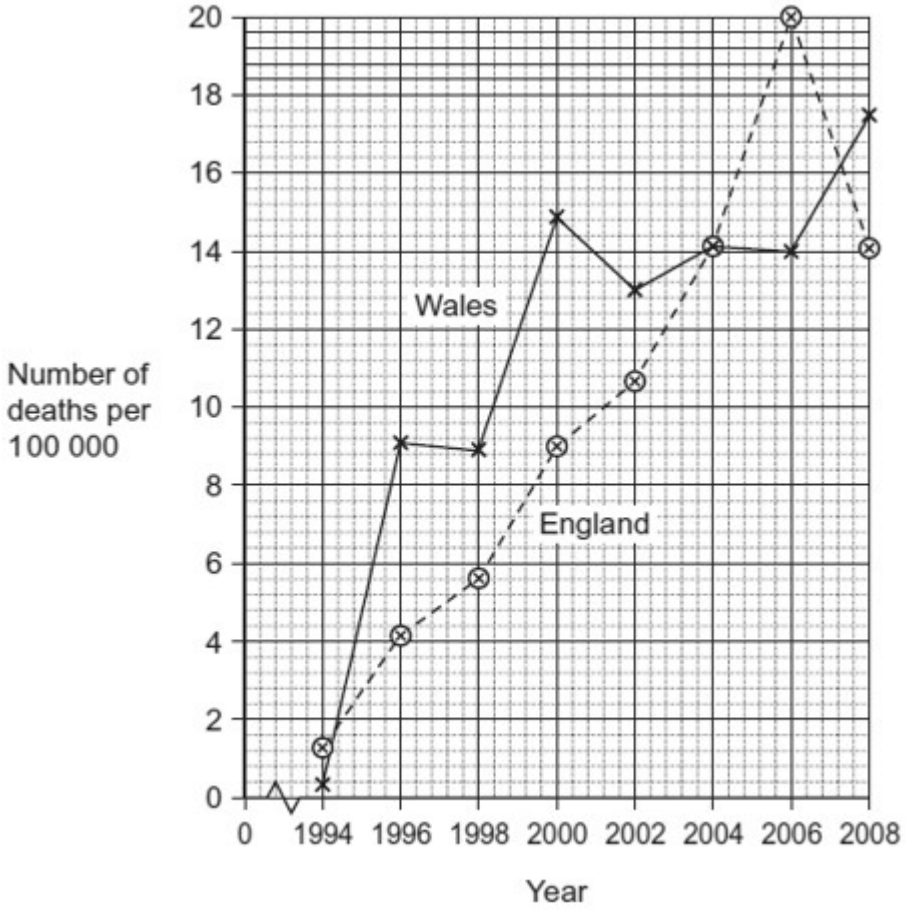
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(2)

(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.

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(1)

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

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(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)

Q14.

Sea otters were close to extinction at the start of the 20th century. Following a ban on hunting sea otters, the sizes of their populations began to increase. Scientists studied the frequencies of two alleles of a gene in one population of sea otters. The dominant allele, **T**, codes for an enzyme. The other allele, **t**, is recessive and does not produce a functional enzyme.

In a population of sea otters, the allele frequency for the recessive allele, **t**, was found to be 0.2.

(a) (i) Use the Hardy-Weinberg equation to calculate the percentage of homozygous recessive sea otters in this population. Show your working.

Answer _____ %

(2)

(ii) What does the Hardy-Weinberg principle predict about the frequency of the **t** allele after another 10 generations?

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(1)

(b) Several years later, scientists repeated their study on this population. They found that the frequency of the recessive allele had decreased.

(i) A statistical test showed that the difference between the two frequencies of the **t** allele was significant at the P = 0.05 level.

Use the terms **probability** and **chance** to help explain what this means.

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(2)

(ii) What type of natural selection appears to have occurred in this population of sea otters? Explain how this type of selection led to a decrease in the frequency of the recessive allele.

Type of selection _____

Explanation _____

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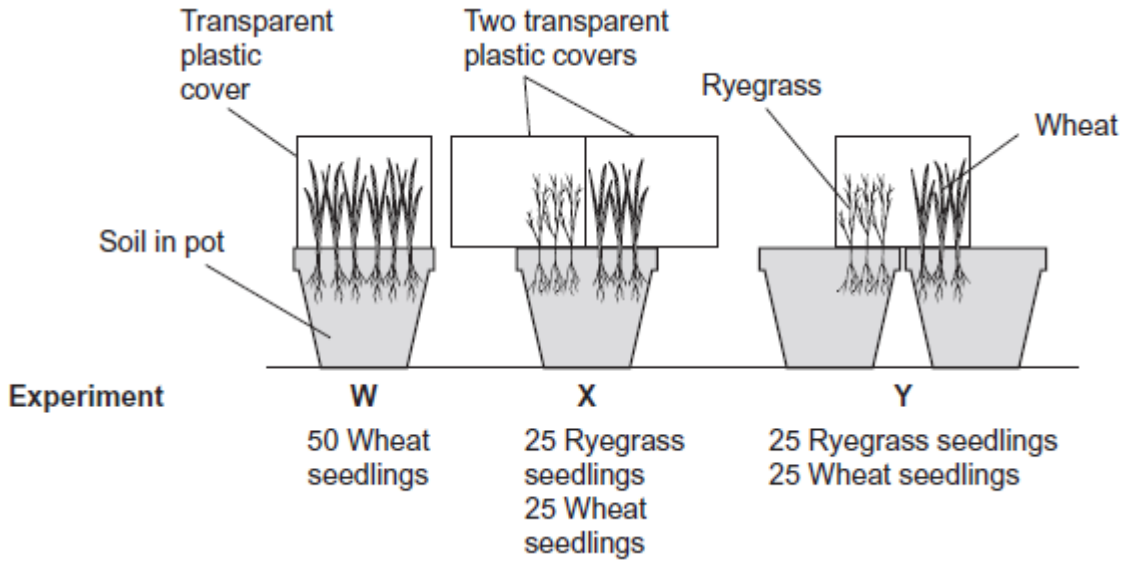
(2)

(Total 7 marks)

Q15.

Wheat is an important cereal crop. Ryegrass is a weed in wheat fields. Wheat and ryegrass belong to the grass family.

Scientists investigated competition between wheat and ryegrass seedlings. They set up three experiments **W, X**, and **Y** as shown in the diagram.



The table shows the mean dry mass of the wheat seedlings as a percentage of their dry mass when grown alone.

	Experiment		
	W	**X**	**Y**
Mean dry mass of wheat seedlings as a percentage of their dry mass when grown alone	100	76	46

(a) Experiment **W** was a control experiment. Explain the purpose of the control

experiment in this investigation.

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(2)

(b) What can you conclude from this investigation about competition between wheat and ryegrass? Use the data in the table to support your answer.

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(4)

(c) Explain how a decrease in temperature could affect the outcome of this investigation.

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(2)

(Total 8 marks)

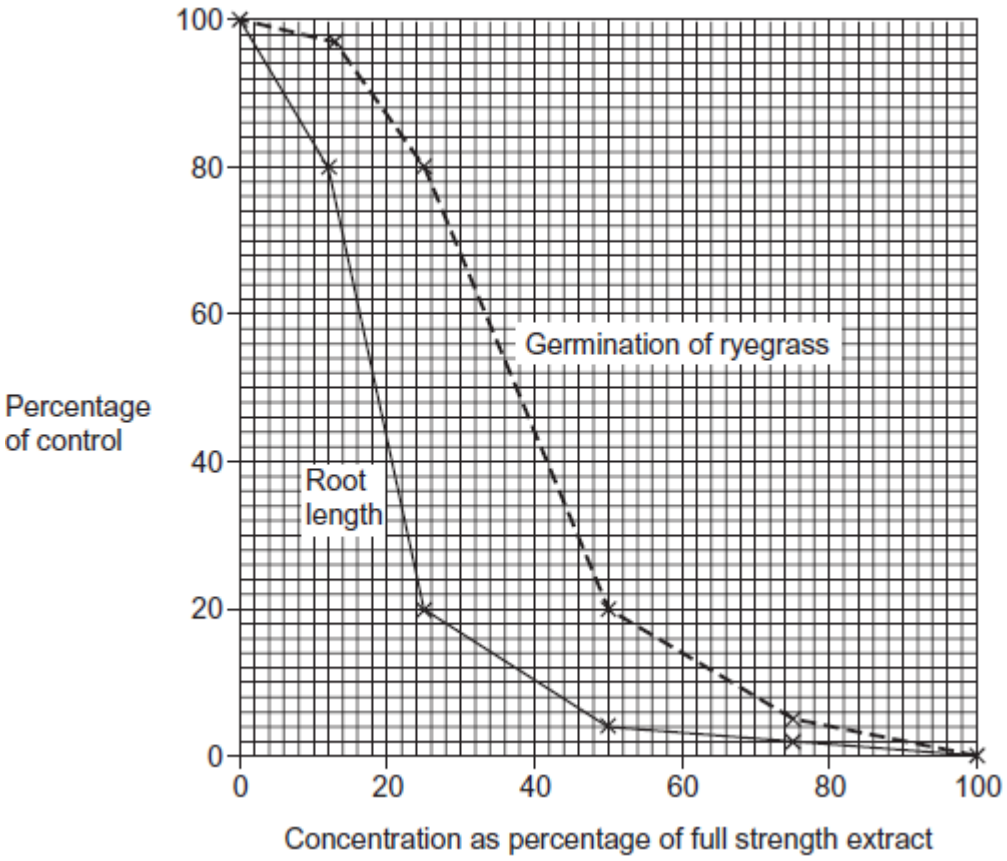
Q16.

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.

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(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)

Q17.

(a) Succession occurs in natural ecosystems. Describe and explain how succession occurs.

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(5)

(b) Changes in ecosystems can lead to speciation. In Southern California 10 000 years ago a number of interconnecting lakes contained a single species of pupfish.

Increasing temperatures caused evaporation and the formation of separate, smaller lakes and streams. This led to the formation of a number of different species of pupfish. Explain how these different species evolved.

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(5)

(Total 10 marks)

Q18.

There are wolves in many European countries. Scientists investigated the genetic diversity of these wolves. They collected samples of DNA from the mitochondria of wolves from different countries. For each sample they identified which haplotypes were present in the DNA. A haplotype is a particular sequence of bases on DNA. Mutations can produce new haplotypes.

Country	Number of wolves sampled	Number of different haplotypes in mitochondrial DNA
Spain	84	3
Portugal	19	2

Italy	101	1
France	7	1
Bulgaria	29	6
Sweden	93	1

The scientists wanted to find out whether one of the haplotypes in the Portuguese wolves was the same as one of those in the Spanish wolves. They used a restriction endonuclease, electrophoresis and a labelled DNA probe.

(a) For what purpose did they use

(i) the restriction endonuclease

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(1)

(ii) electrophoresis?

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(1)

(b) Explain why the labelled DNA probe could be used to find out whether the haplotypes were the same.

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(2)

(c) The scientists analysed the DNA on the Y chromosome and the DNA in the mitochondria of the Swedish wolves. They concluded that the Swedish wolf population descended from one male wolf from Finland and one female wolf from Russia.

(i) Explain why DNA on the Y chromosome helped them to reach this conclusion.

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(1)

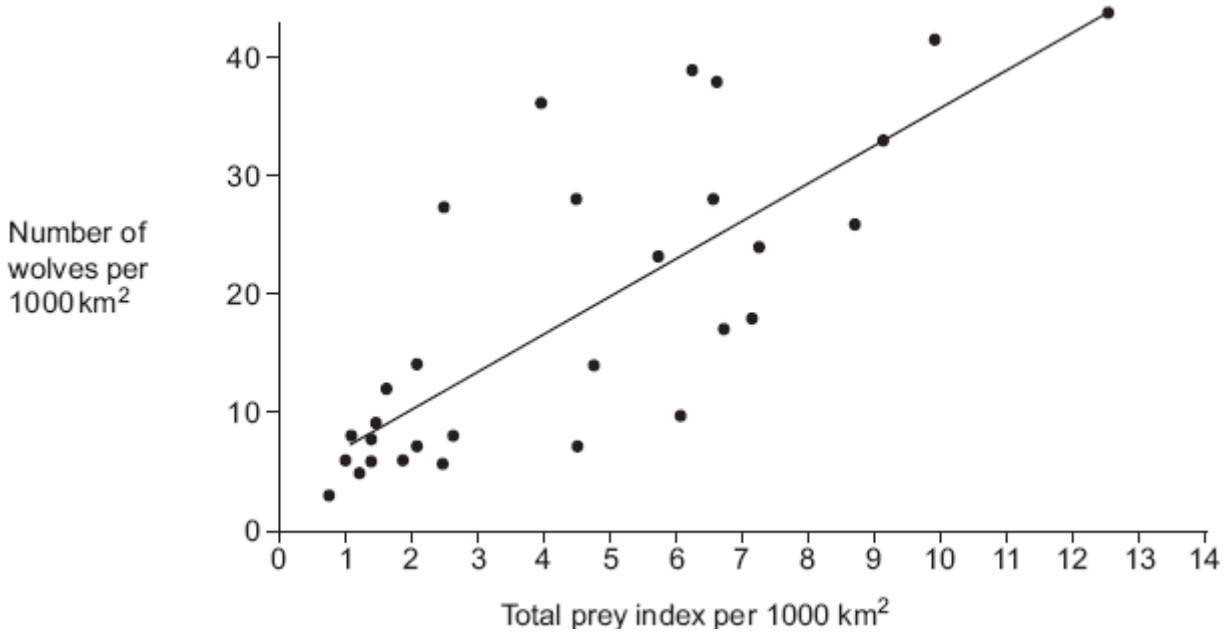
(ii) Suggest why DNA in the mitochondria helped them to reach this conclusion.

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(1)

Wolves eat different mammals. An ecologist investigated factors that affect wolf numbers in North America. He collected data from different field studies carried out in different places. The graph shows his results.



(d) (i) The wolf numbers are given per unit area. Explain why.

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(2)

(ii) The ecologist calculated the total prey index for each of the places that had been studied. In order to do this, he gave each prey species a value based on how much food was available to wolves from the prey animal concerned. He called this value the prey index.

The ecologist considered that the prey index gave a better idea of the food available than the prey biomass in kg. Suggest why the prey index gives a better idea of food available.

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(2)

(e) The ecologist calculated the total prey index by combining the prey indices and the total number of animals of each species present in 1000 km². He plotted this information on the graph. What does the graph suggest about the factors that

determine wolf numbers in North America? Explain your answer.

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(2)

(Total 12 marks)

Q19.

Snow geese fly north to the Arctic in the spring and form breeding colonies. Different colonies form at different latitudes. The greater the latitude, the further north is the colony. The further north a breeding colony forms, the colder the temperature and the greater the risk of snow.

(a) There is a positive correlation between the size of snow geese and how far north they breed. A large size results in snow geese being adapted for breeding in colder conditions. Explain how.

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(2)

Snow geese are either white or blue in colour. The table shows the percentage of white snow geese in colonies at different latitudes at different times over a 40-year period. The blank cells in the table are years for which no figures are available.

Colony	Latitude in degrees north	Percentage of white snow geese each year			
		1930	1950	1960	1970
A	72	100		100	100
B	71		> 99	> 99	> 99
C	66	95	85	76	
D	63	86	75	67	65
E	55		62		28

(b) (i) Describe how the percentage of white snow geese varies with distance north.

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(1)

(ii) The further north, the greater the risk of snow. Use this information to explain how natural selection might have accounted for the effect of latitude on the percentage of white snow geese.

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(3)

(c) The percentage of white snow geese in these colonies changed over the period shown in the table. Use your knowledge of climate change to suggest an explanation.

_____

_____

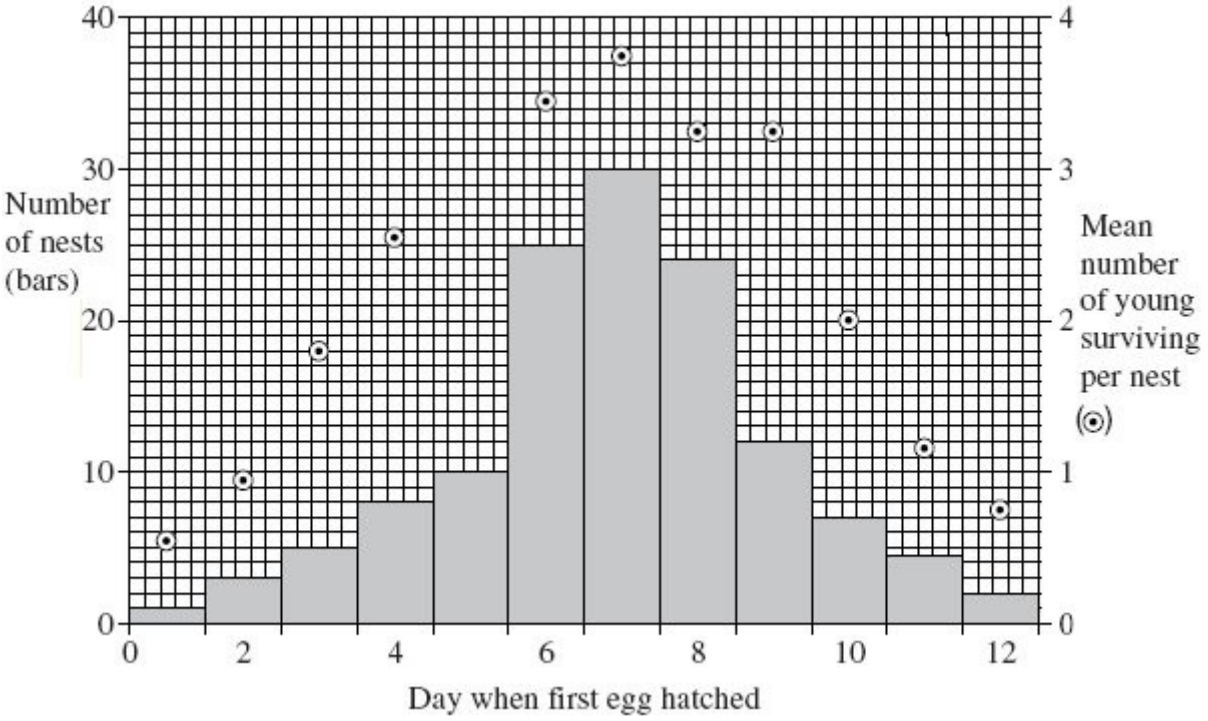
_____

_____

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(2)

(d) Snow geese breed in large colonies. Scientists studied the nests in one colony. For each nest, they recorded the day on which the first egg hatched. They also recorded the number of young that survived from the nest. They used the data to plot a graph.



(i) What type of natural selection is shown in the graph?

_____

(1)

(ii) Describe the evidence for your answer.

_____

_____

(1)

(Total 10 marks)

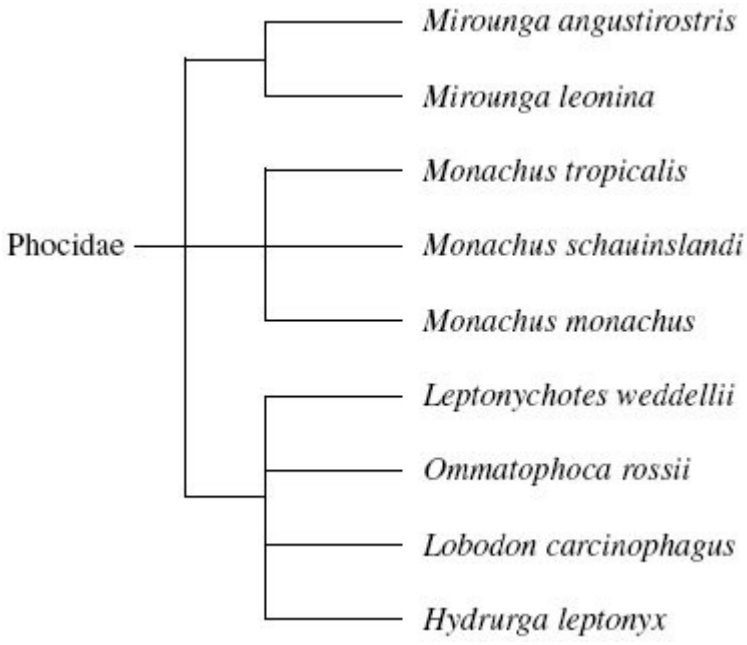
Q20.

(a) An order is a taxonomic group. All seals belong to the same order. Name **one** other taxonomic group to which all seals belong.

_____

(1)

(b) The diagram shows how some species of seal are classified.



(i) How many different genera are shown in this diagram?

(1)

(ii) All the seals shown in the diagram are members of the Phocidae. Phocidae is an example of a taxonomic group. Of which taxonomic group is it an example?

_____

(1)

(iii) The diagram is based on the evolutionary history of the seals. What does the information in the diagram suggest about the common ancestors of *Mirounga angustirostris*, *Mirounga leonina* and *Monachus tropicalis*?

_____

_____

_____

(1)

(c) A species of seal shows genetic diversity. Explain what is meant by genetic diversity.

_____

_____

(1)

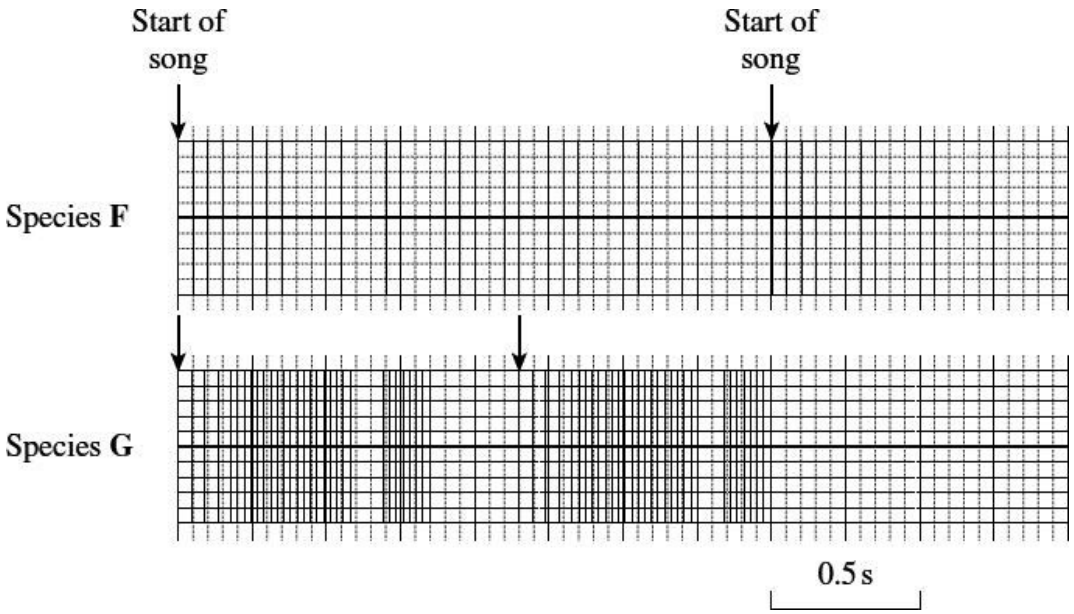
(Total 5 marks)

Q21.

Mole crickets are insects that live underground. At night, a male cricket produces a courtship song. A female cricket is attracted by this song and mates with the male.

Scientists investigated courtship in two species of mole cricket. They found that female mole crickets were only attracted to the song produced by a male of the same species.

The charts show recordings of typical songs of two species of mole cricket.



(a) The song of species **F** is repeated at regular intervals. The arrows on the chart show the beginning of each song.

(i) Calculate the time taken for one complete song.

Answer_____seconds

(1)

(ii) Calculate the rate of singing in songs per minute.

Answer_____songs per minute

(1)

(b) Explain why courtship song is an important part of species recognition in mole crickets.

_____

_____

_____

_____

(2)

(c) The scientists produced hybrids between the two crickets by fertilising eggs from one species with sperms from the other. The male hybrids had songs that had some features of one parent species and some features of the other. Suggest why the male hybrids were not able to reproduce.

_____

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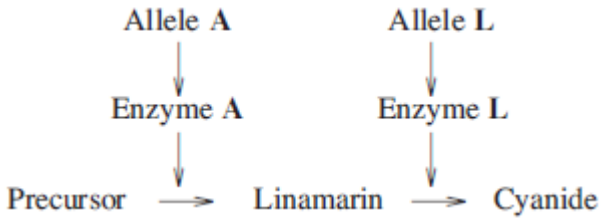
_____

(2)

(Total 6 marks)

Q22.

Cyanide is a poisonous substance. Cyanogenic clover plants produce cyanide when their tissues are damaged. The ability to produce cyanide is controlled by genes at loci on two different chromosomes. The dominant allele, **A**, of one gene controls the production of an enzyme which converts a precursor to linamarin. The dominant allele, **L**, of the second gene controls the production of an enzyme which converts linamarin to cyanide. This is summarised in the diagram.



(a) Acyanogenic clover plants cannot produce cyanide. Explain why a plant with the genotype **aaLl** cannot produce cyanide.

_____

_____

(1)

(b) A clover plant has the genotype **AaLl**.

(i) Give the genotypes of the male gametes which this plant can produce.

_____

(1)

(ii) Explain how meiosis results in this plant producing gametes with these genotypes.

_____

_____

_____

_____

(2)

(c) Two plants, heterozygous for both of these pairs of alleles, were crossed. What proportion of the plants produced from this cross would you expect to be acyanogenic but able to produce linamarin? Use a genetic diagram to explain your

answer.

(3)

In an investigation, cyanogenic and acyanogenic plants were grown together in pots. Slugs were placed in each pot and records were kept of the number of leaves damaged by the feeding of the slugs over a period of 7 days. The results are shown in **Table 1**.

Table 1

	Undamaged	**Damaged**
Cyanogenic plants	160	120
Acyanogenic plants	88	192

(d) A x^2 test was carried out on the results.

(i) Suggest the null hypothesis that was tested.

_____

_____

(1)

(ii) x^2 was calculated. When this value was looked up in a table, it was found to correspond to a probability of less than 0.05. What conclusion can you draw from this?

_____

_____

_____

_____

_____

_____

(3)

A second investigation was carried out in a field of grass which had been undisturbed for

many years. **Table 2** shows the population density of slugs and the numbers of cyanogenic and acyanogenic clover plants at various places in the field.

Table 2

Population density of slugs	Number of acyanogenic clover plants per m^2	Number of cyanogenic clover plants per m^2
Very low	26	10
Low	17	26
High	0	10
Very high	0	5

(e) Explain the proportions of the two types of clover plant in different parts of the field.

_____

_____

_____

_____

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_____

(4)

(Total 15 marks)

Q23.

(a) The guinea pig, *Cavia porcellus*, is a small mammal. Complete the table to show the classification of the guinea pig.

Kingdom	
	Chordata
	Mammalia
	Rodentia
Family	Caviidae
Genus	
Species	

(2)

(b) In South America, there are several species of guinea pig. They are thought to have arisen by sympatric speciation.
Explain how sympatric speciation may have occurred.

_____

_____

_____

_____

_____

_____

(3)

(c) In guinea pigs, hair length and hair colour are controlled by two genes on different chromosomes. The hair may be either long or short and its colour either black or brown.

A male guinea pig and a female guinea pig both had short, black hair. The male was homozygous for hair length, and the female was homozygous for hair colour. Repeated crossings of these two guinea pigs resulted in offspring of four different genotypes, all of which had short, black hair.

Complete the genetic diagram to explain these results. Write in the box the symbols you will use to represent the alleles.

Allele for short hair = _____	Allele for long hair = _____
Allele for black hair = _____	Allele for brown hair = _____

	Male	Female
Parental phenotypes	Short, black hair	Short, black hair
Parental genotypes	_____	_____
Gamete genotypes	_____	_____

Offspring genotypes _____

Offspring phenotypes Short, black hair

(4)

(d) In another investigation, the same female guinea pig was twice mated with another male which had long, brown hair. Of the 14 offspring, 10 had short, black hair and 4 had long, black hair. The investigators expected equal numbers of offspring with these two phenotypes. They used a χ^2 test to determine whether the observed results fitted the expected 1:1 ratio.

Give a suitable null hypothesis for the investigation.

_____

_____

(1)

(Total 10 marks)

Q24.

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

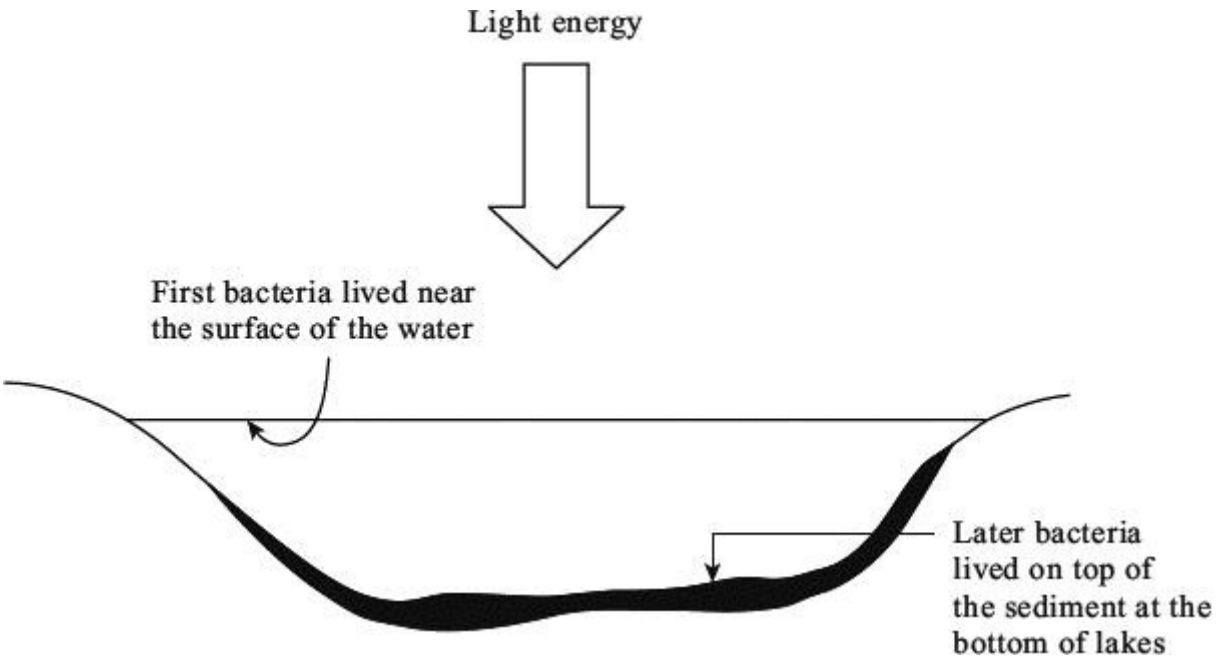
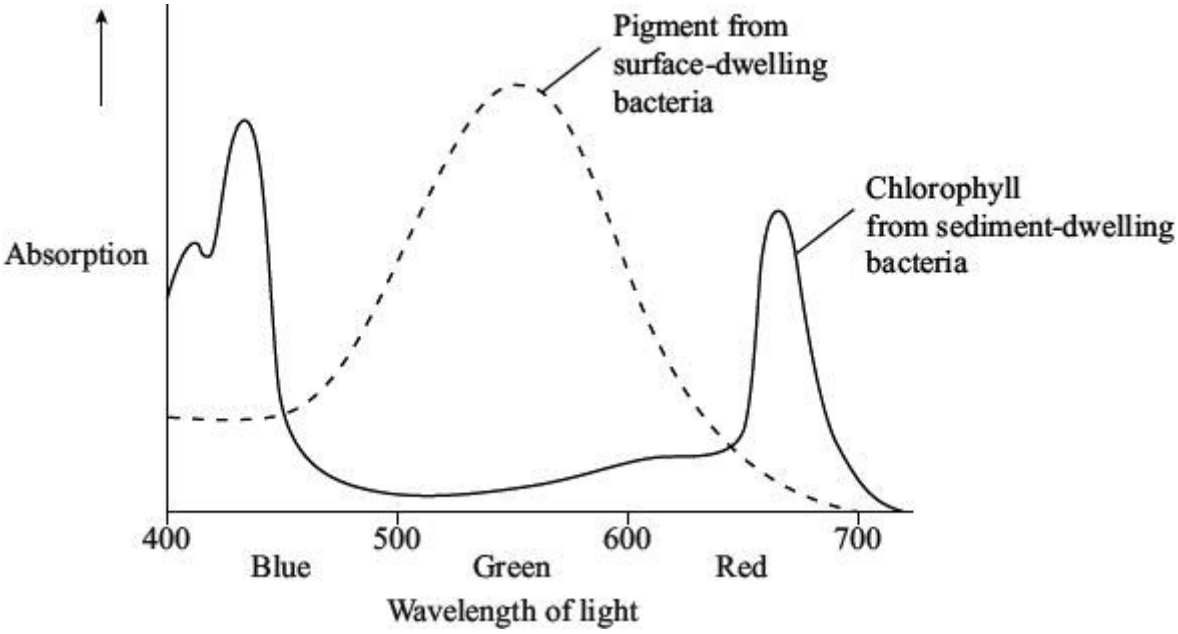


Figure 2



(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.

_____

_____

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_____

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_____

(6)

(Total 11 marks)

Q25.

(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.

_____

_____

_____

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_____

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_____

_____

(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.

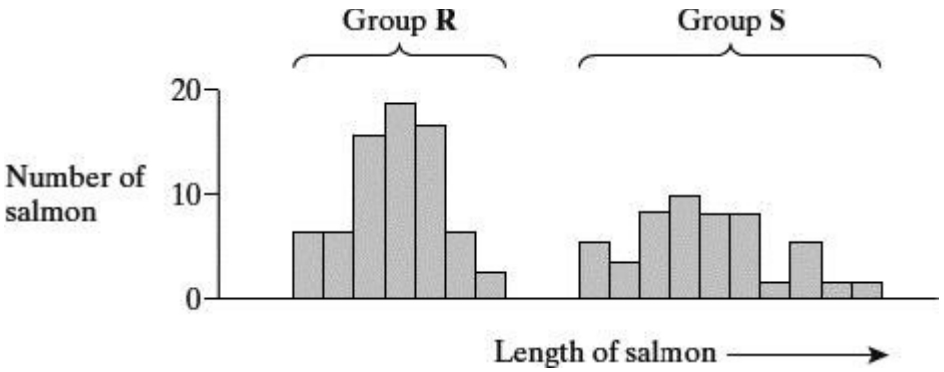
Answer _____

(4)

(Total 9 marks)

Q26.

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



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

1. _____

_____

2. _____

_____

(2)

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

_____

_____

_____

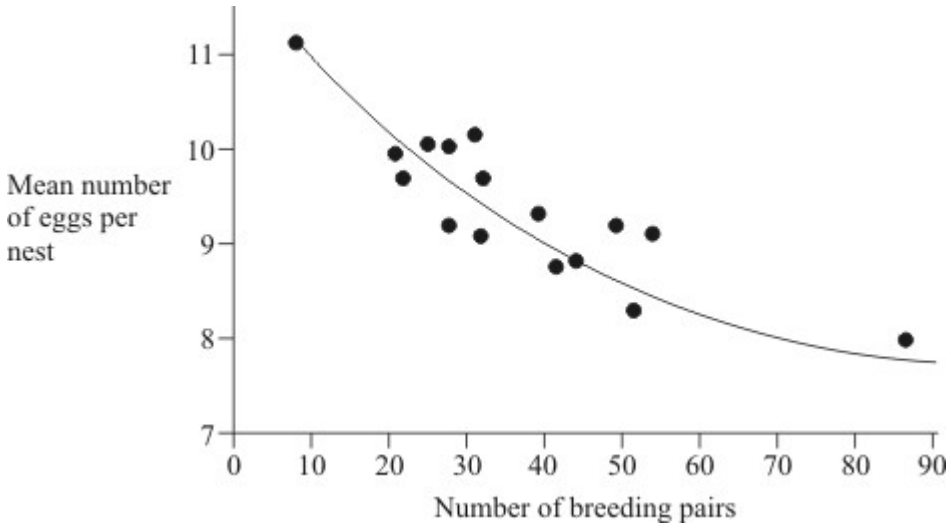
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(2)

(Total 4 marks)

Q27.

Great tits are small birds. The graph shows the relationship between the number of breeding pairs in the population and the mean number of eggs per nest in different years in a wood.



(a) Explain the relationship shown by the graph.

_____

_____

_____

_____

(2)

(b) Female great tits usually lay between 3 and 14 eggs in a nest.

(i) In the same year, the birds do not all lay the same number of eggs. Explain how **one** factor, other than the number of breeding pairs, could influence the number of eggs laid by a great tit.

_____

_____

(1)

(ii) Natural selection influences the number of eggs laid. Explain why great tits that lay fewer than 3 eggs per nest or more than 14 eggs per nest are at a selective disadvantage.

_____

_____

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_____

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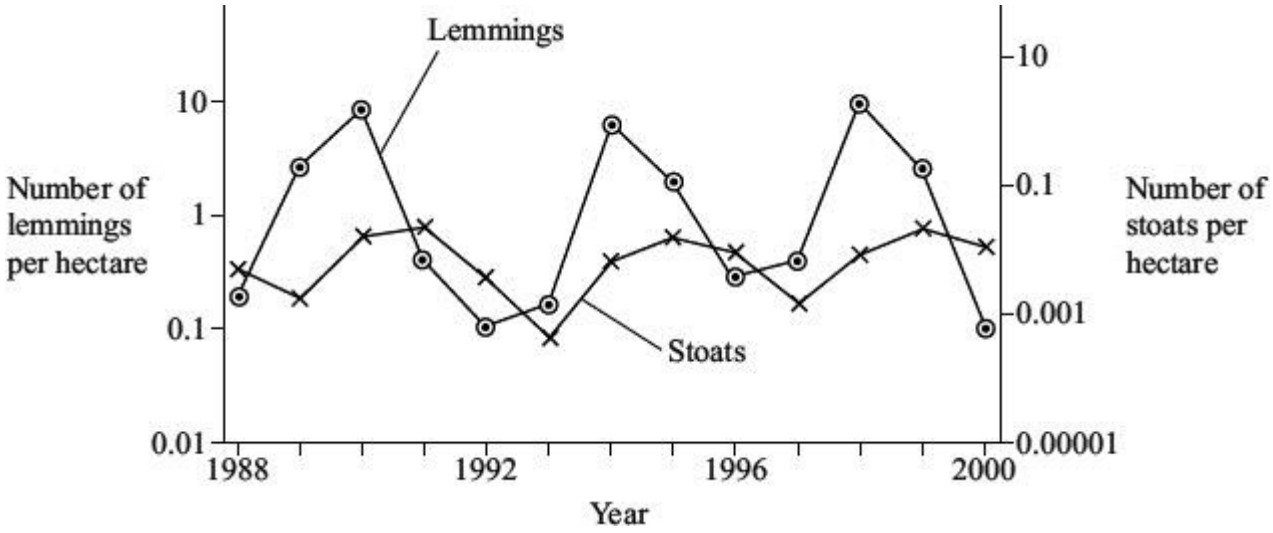
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(3)

(Total 6 marks)

Q28.

Lemmings are small mammals which live in the Arctic. Their main predator is the stoat, a small carnivorous mammal, which feeds almost entirely on lemmings. The graph shows the changes in the numbers of lemmings and stoats from 1988 to 2000.



(a) Describe and explain the changes which occur in the lemming and stoat populations.

(6)

(b) Lemmings often live in isolated populations. From time to time some lemmings move and join other populations. Explain how this movement is important in maintaining genetic variability in lemming populations which have large fluctuations in size.

_____

_____

(2)

(c) James Bay is a large ocean bay in northern Canada. It was formed by the melting of glaciers. One species of lemming inhabits the eastern side of James Bay and another species of lemming inhabits the western side. Before the glaciers melted there was only one species of lemming present. Explain how two species of lemming evolved from the original species.

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(4)

(Total 12 marks)

Q29.

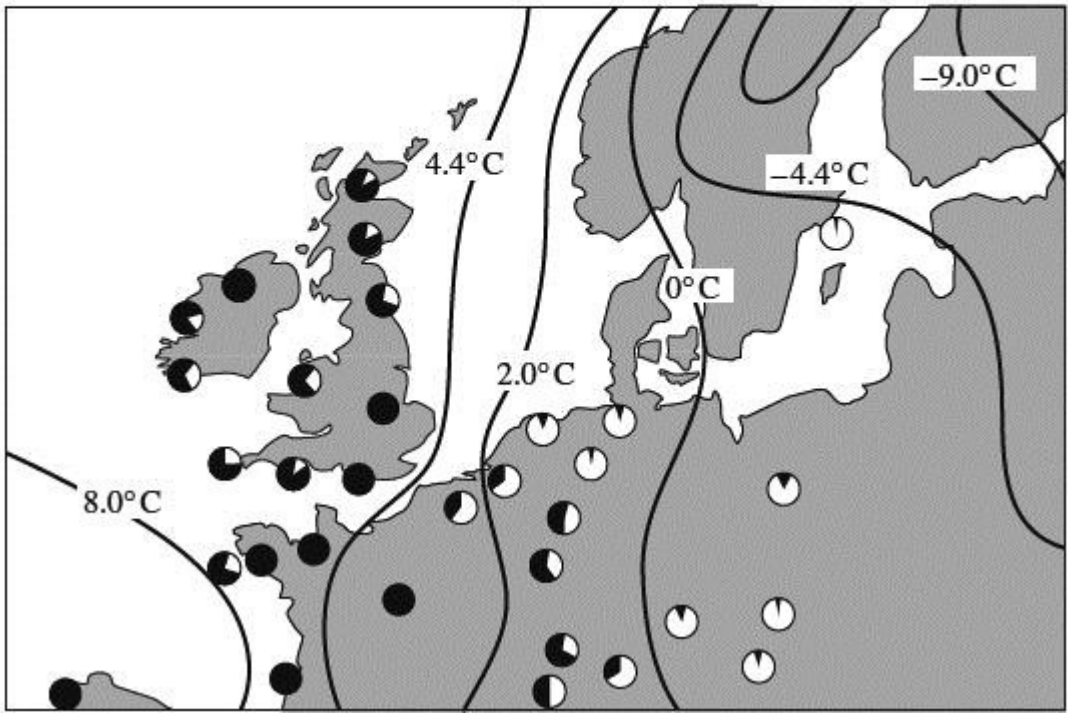
Clover plants have leaves all through the year. Some clover plants have leaves that produce poisonous hydrogen cyanide gas when damaged. These cyanogenic plants are less likely to be eaten by snails. However, the leaves of these plants can be damaged by frost, resulting in the production of enough hydrogen cyanide to kill the plants. Acyanogenic plants do not produce hydrogen cyanide. This characteristic is genetically controlled.

The map shows the proportions of the two types of plant in populations of clover from different areas in Europe. It also shows isotherms, lines joining places with the same mean January temperature.

Key

Black area represents proportion of plants able to produce cyanide (cyanogenic)

White area represents proportion of plants not able to produce cyanide (acyanogenic)



(a) Explain how different proportions of cyanogenic plants may have evolved in populations in different parts of Europe.

(4)

(b) Differences in cyanide production may affect the total number of clover plants growing in different areas. Describe how you would use quadrats in an investigation to determine whether or not there is a difference in the number of clover plants in two large areas of equal size.

_____

_____

_____

_____

_____

_____

(4)

(Total 8 marks)

Q30.

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

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

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

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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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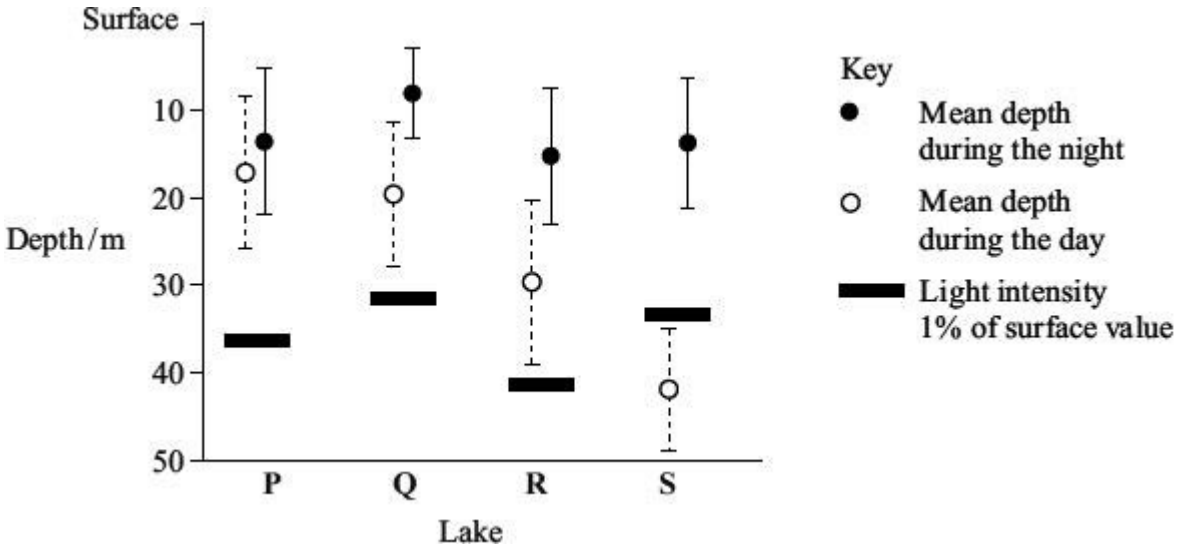
_____

(2)

(Total 8 marks)

Q31.

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.

_____

_____

_____

_____

(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.

_____

_____

(1)

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

_____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

Q32.

In an investigation, the tolerance to copper ions of the grass *Agrostis tenuis* was determined. Samples were taken of plants growing in waste from a copper mine and from nearby areas just outside the mine. The mean copper tolerance of plants from the mine waste was found to be four times higher than that of plants in the surrounding area.

(a) Explain how natural selection could produce a copper-tolerant population in the mine waste.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(b) Copper-tolerant *Agrostis tenuis* plants flower at a different time from those which are not copper-tolerant. Explain how this might eventually lead to the production of a

new species of *Agrostis*.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 8 marks)