

7.2 Genetics, populations, evolution, ecosystems (A-Level Only) - Evolution and speciation – Questions

Q1.

(a) What is sympatric speciation?

(2)

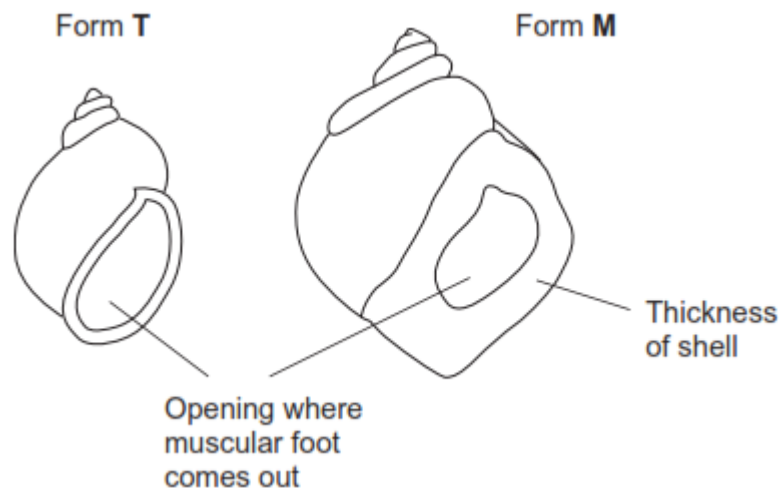
Littorina saxatilis is a snail found on rocky seashores. It has a shell and a muscular foot that it uses to move and to attach to rocks. Crabs are predators of this snail. The crabs use their claws to break open the snails' shells, or pull the snails from their shells.

Two forms of this snail are common in the UK.

Form **T** lives near the top of the shore. It lives in cracks in rock. Wave action is greatest near the top of the shore and there are very few crabs.

Form **M** lives on the middle shore. On the middle shore there are many crabs. Unlike form **T**, the snails of form **M** live on the open rock and not in cracks.

Forms **T** and **M** were produced by natural selection. The drawings show both forms of the snail.



The table shows features of these forms.

| Feature | Form of <i>Littorina saxatilis</i> | |
|---------------|------------------------------------|-------|
| | T | M |
| Size of shell | Small | Large |

| | | |
|--------------------------|-------|-------|
| Thickness of shell | Thin | Thick |
| Size of opening of shell | Large | Small |

- (b) Use this information to answer the following question.
 Give **two** differences between forms **T** and **M**.
 For each difference suggest how **one** environmental factor may have caused differential survival in the snail populations leading to this difference.

Difference 1 _____

Suggestion _____

Difference 2 _____

Suggestion _____

(4)

- (c) Scientists placed male and female snails of forms **T** and **M** into an aquarium. They recorded how many form **T** males mated with form **T** females and how many mated with form **M** females.

The scientists found that the probability of a form **T** male mating with a form **T** female was greater than 90 %. They interpreted this result as evidence that speciation was taking place.

Explain why.

(2)

(Total 8 marks)

Q2.

- (a) What is a gene pool?

(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.

(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.

- 5 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.
- 10 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.
- 15 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.

- 20 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).

(3)

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

1. _____

2. _____

(2)

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

(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.

(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.

(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).

(2)

(Total 15 marks)

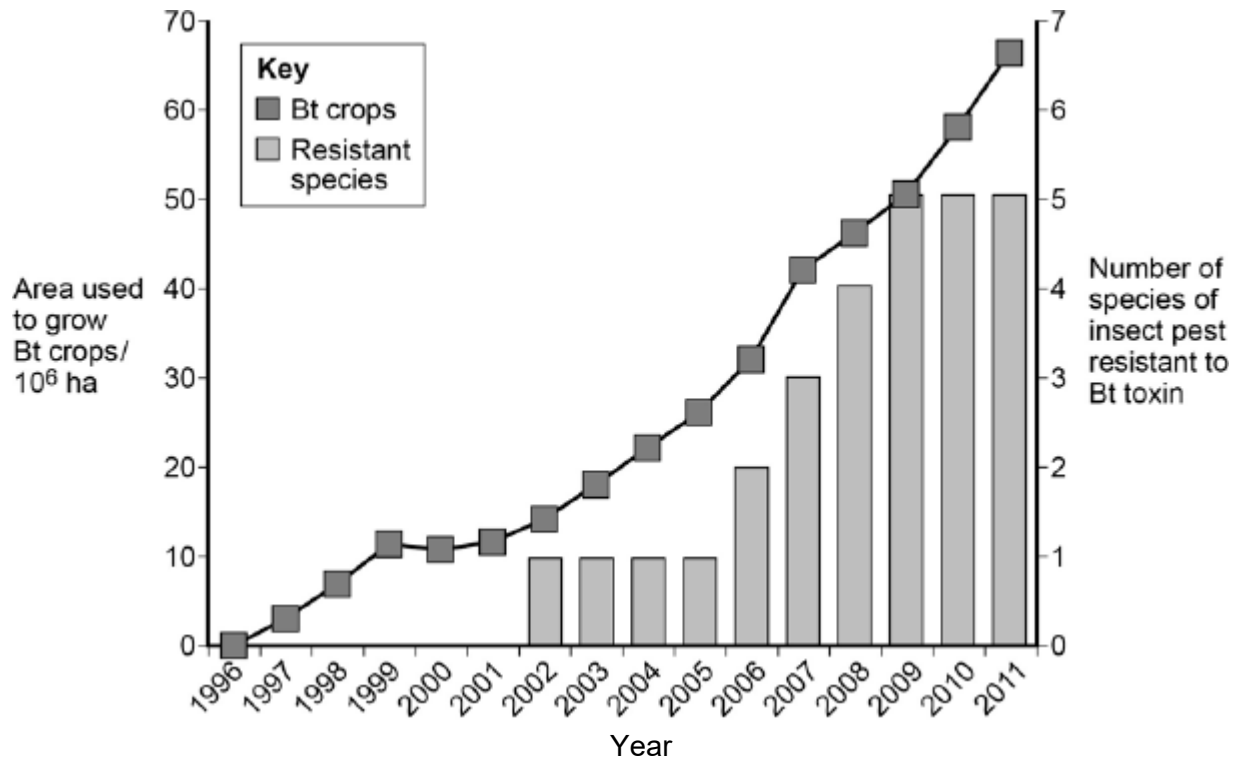
Q4.

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.

(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.

(Extra space) _____

(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.

(3)

(Total 8 marks)

Q5.

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.

(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.

(2)

(Total 7 marks)

Q6.

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

(6)

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

(4)

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

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

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

(5)

(Total 15 marks)

Q7.

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

| Red blood cell phenotype | Ratio of patients with severe malaria : patients |
|--------------------------|--|
|--------------------------|--|

| | with mild malaria |
|-------------------|-------------------|
| Sickle cell trait | 0.48 : 1 |
| Blood group A | 2.45 : 1 |
| Blood group O | 0.96 : 1 |

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

(2)

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

(Extra space) _____

(2)

- (c) The allele for normal haemoglobin in red blood cells is **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.

(Extra space) _____

(3)
(Total 7 marks)

Q8.

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.

(2)

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

(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)

Q9.

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)

Q10.

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

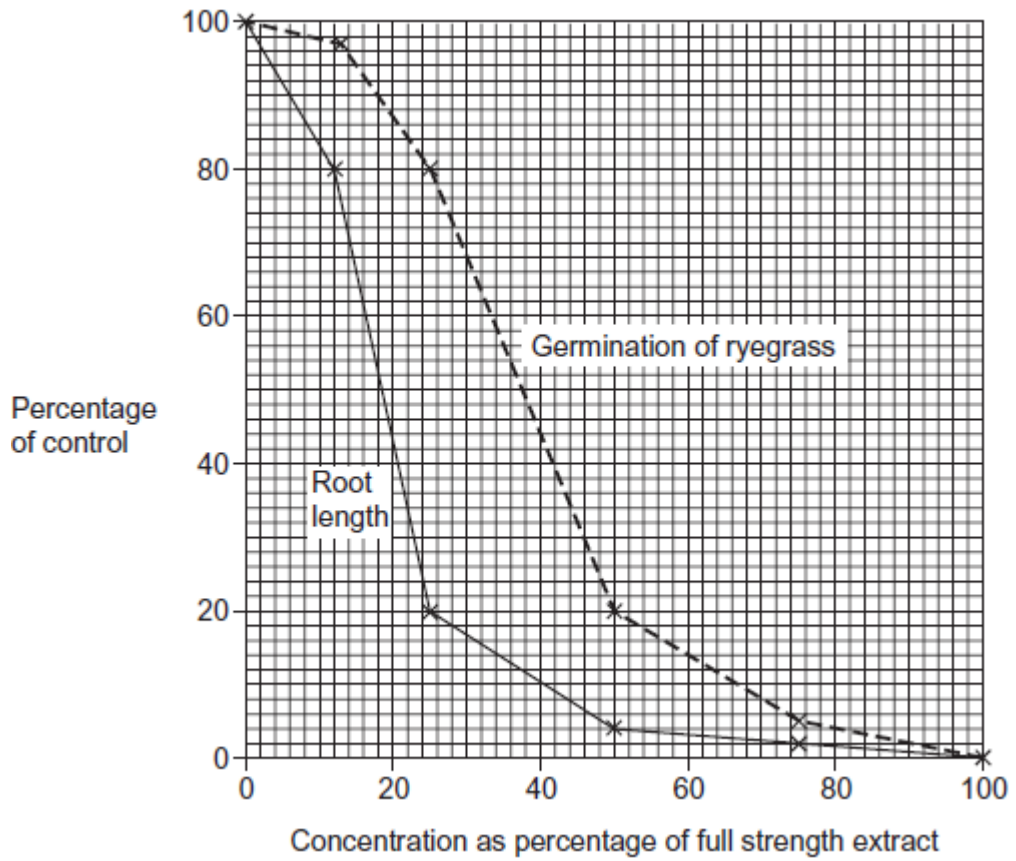
(5)
(Total 10 marks)

Q12.

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.

(2)

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

(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.

(2)

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

(Extra space)

(3)

(Total 9 marks)

Q13.

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.

(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.

(1)

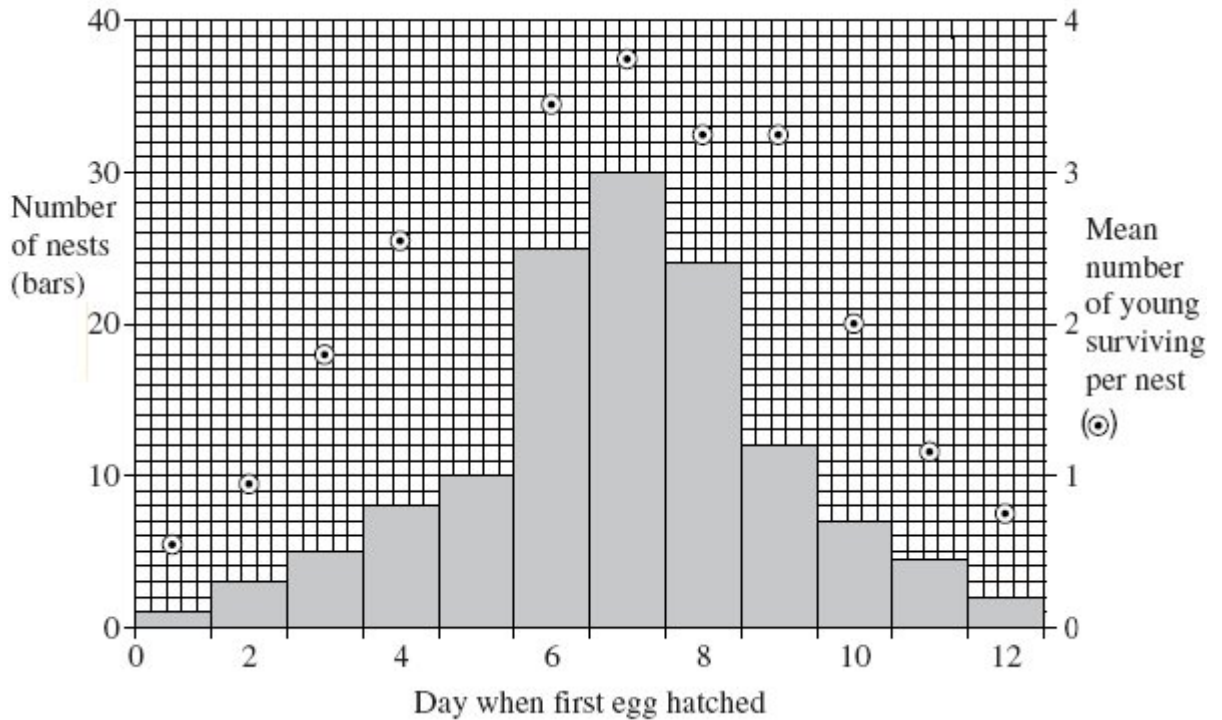
(ii) The further north, the greater the risk of snow. Use this information to explain how natural selection might have accounted for the effect of latitude on the percentage of white snow geese.

(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.

(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)

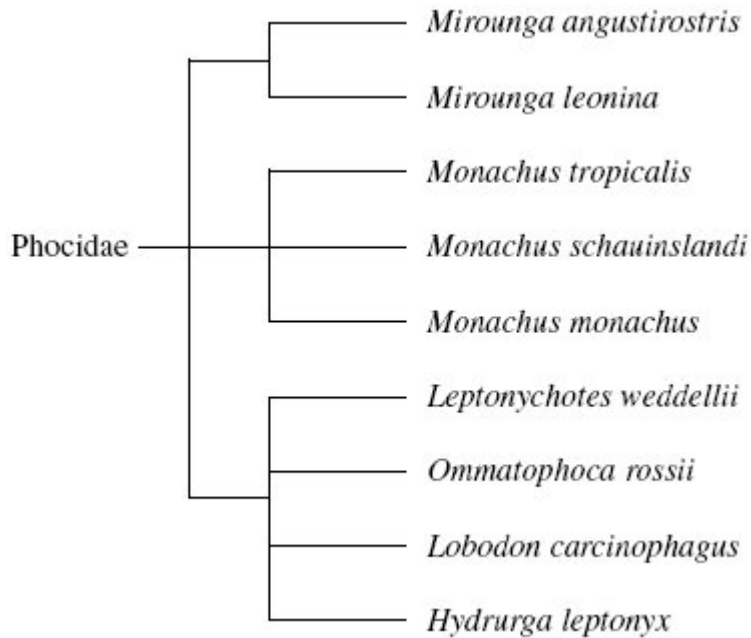
(Total 10 marks)

Q14.

- (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)

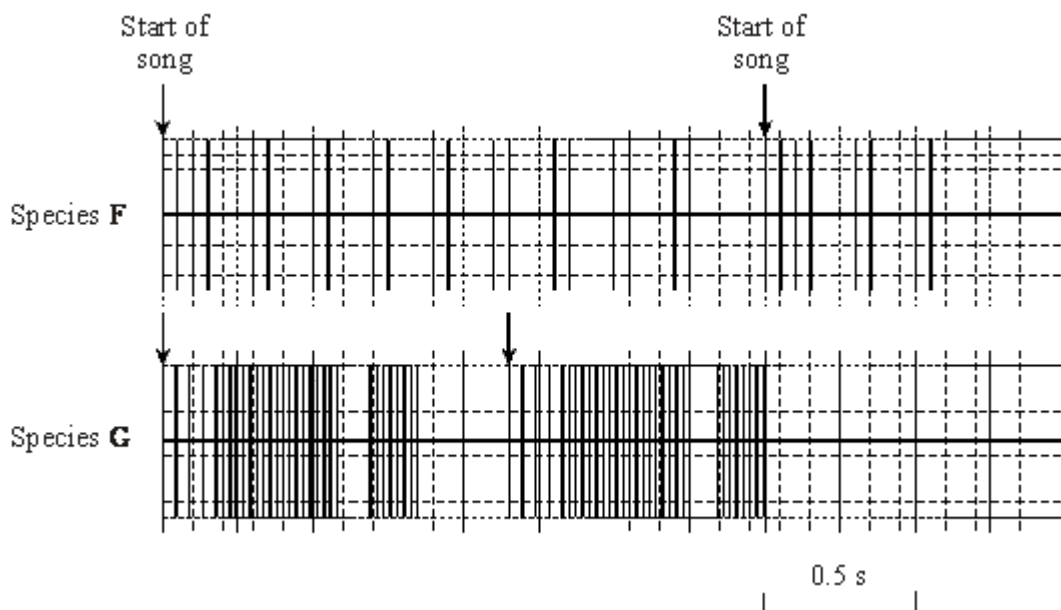
(Total 5 marks)

Q15.

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.

(2)
(Total 6 marks)

Q16.

(a) Individuals in a population show phenotypic variation.

Give the **two** types of factor that cause this variation.

1. _____

2. _____

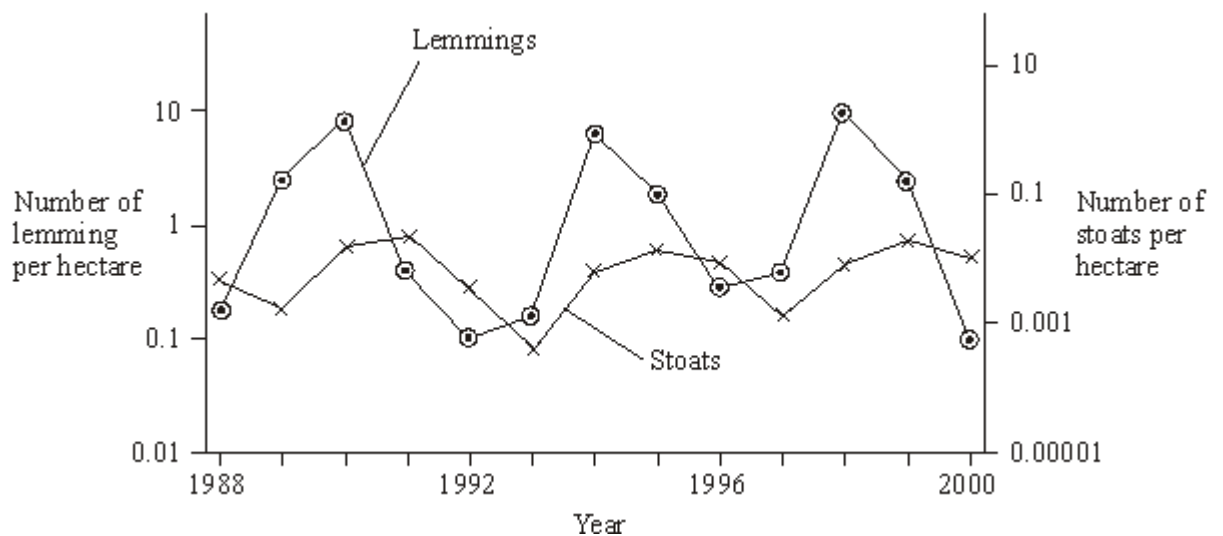
(2)

(b) What is allopatric speciation?

(2)
(Total 4 marks)

Q17.

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)

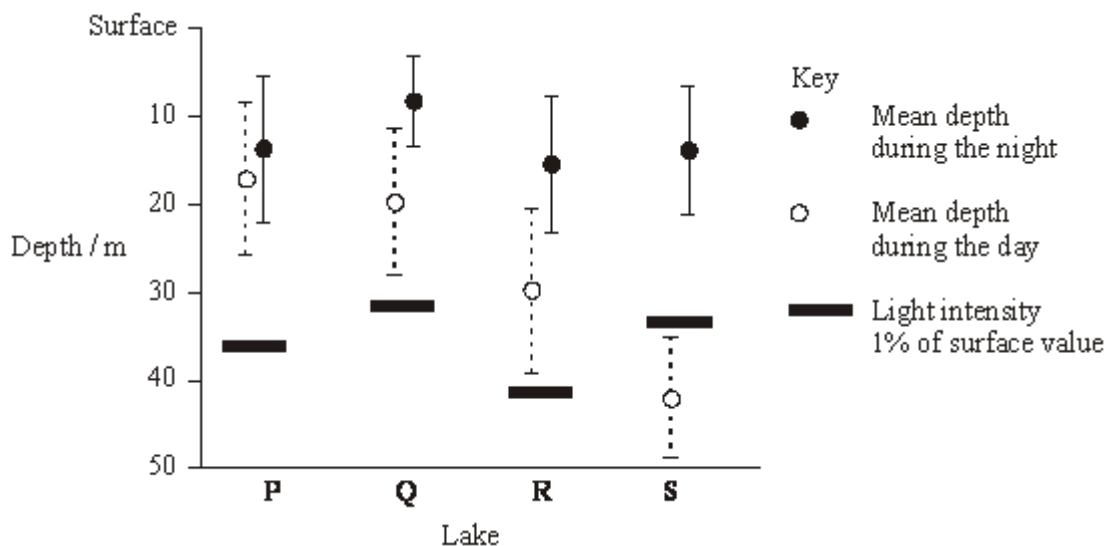
- (b) Lemmings often live in isolated populations. From time to time some lemmings move and join other populations. Explain how this movement is important in maintaining genetic variability in lemming populations which have large fluctuations in size.

(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.

Q18.

Zooplankton are very small animals which feed on algae (green protocists) 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)

Q19.

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

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

(2)

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

(4)

- (c) Many species of cichlids are similar in size and, apart from their colour, in appearance. Suggest how the variety of colour patterns displayed by these cichlids may help to maintain the fish as separate species.

(2)

(Total 8 marks)

Q20.

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.

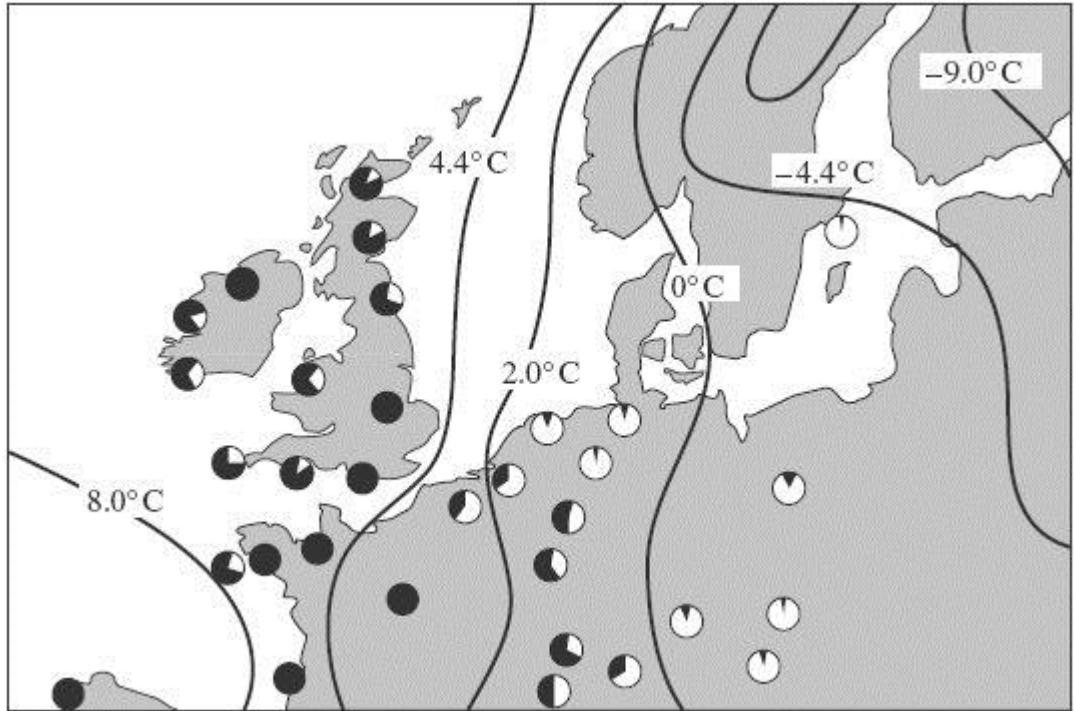
The map shows the proportions of the two types of plant in populations of clover from different areas in Europe. It also shows isotherms, lines joining places with the same mean January temperature.

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.

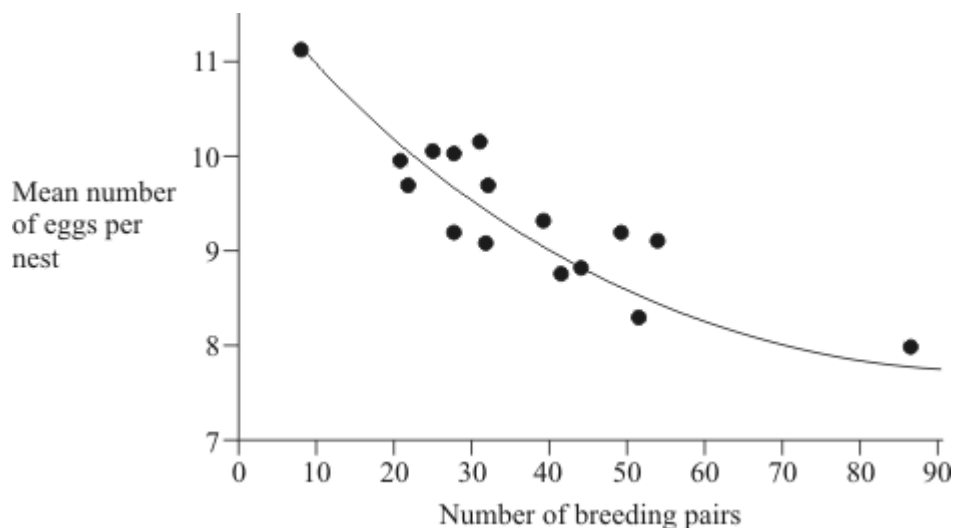
(4)

- (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)

Q21.

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.

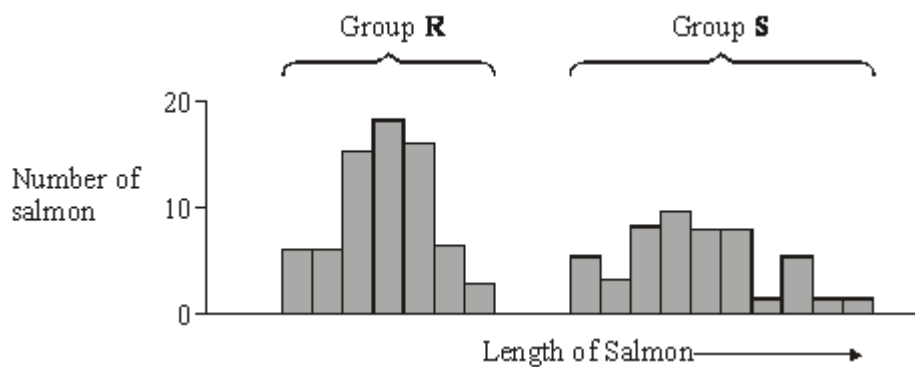
(1)

(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.

(3)
(Total 6 marks)

Q22.

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.

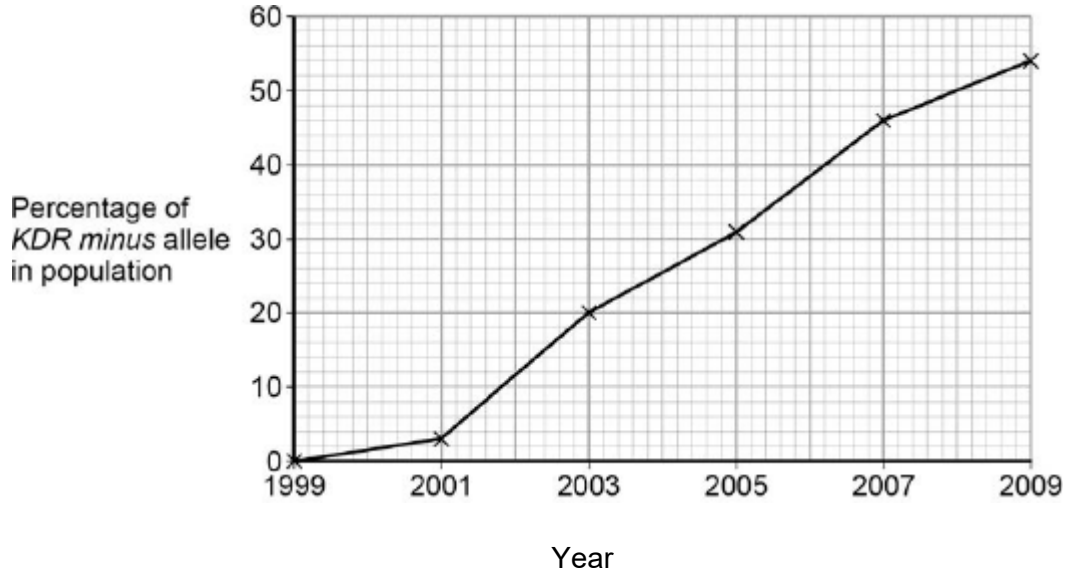
(2)

(Total 4 marks)

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.

(Extra space)

(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.

(2)

(Total 10 marks)