Evolution

These practice questions can be used by students and teachers and is

Suitable for AQA A Level 7402 Biology Topic Question

Level: AQA A LEVEL 7402

Subject: Biology

Exam Board: AQA A Level 7402

Topic: Evolution

To reduce the damage caused by insect pests, some farmers spray their fields of crop plants with

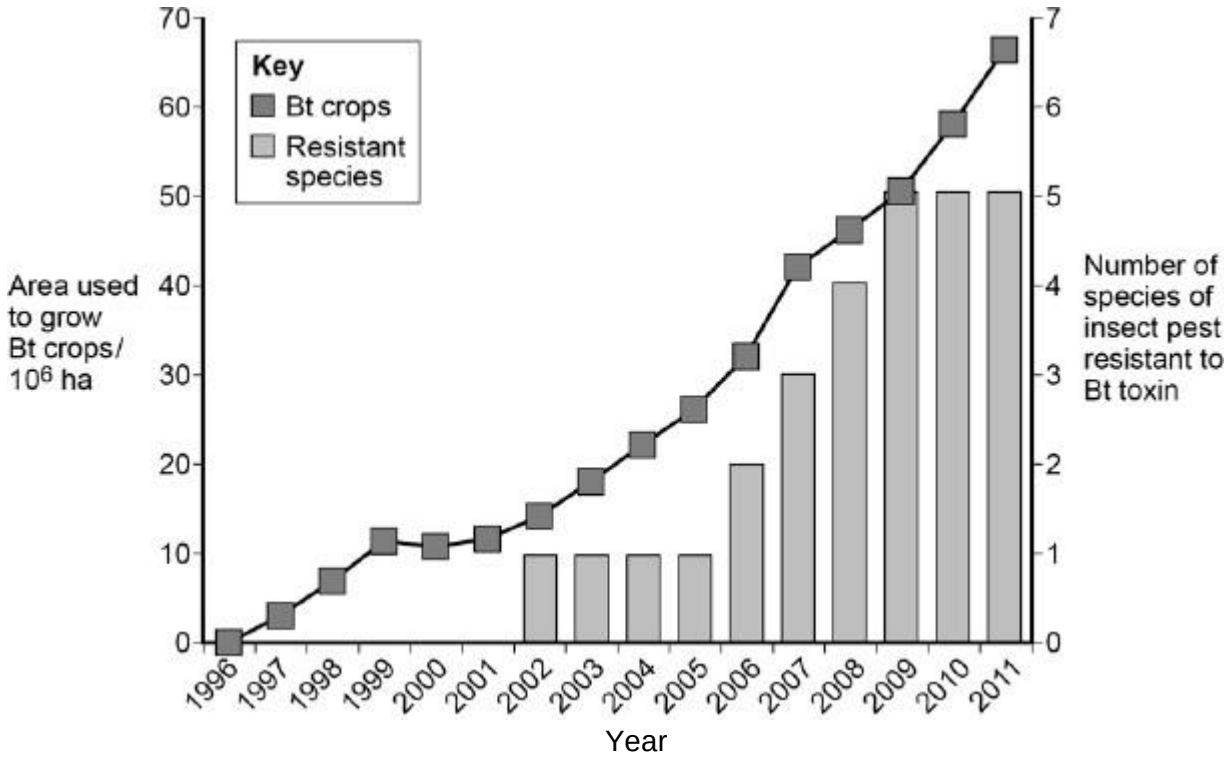
1

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 inone 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)

There are nine subspecies of giraffe. These subspecies evolved when populations of giraffe were

2

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)

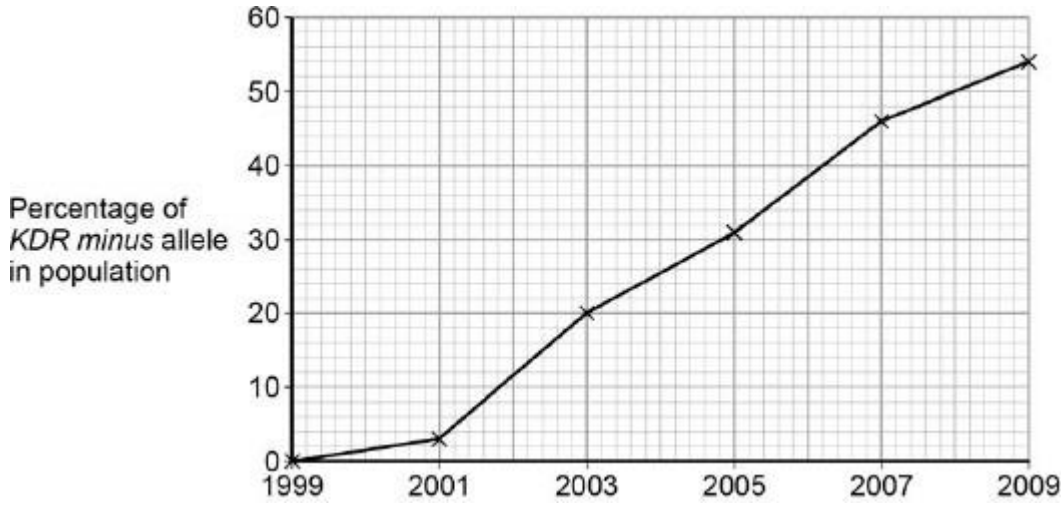
(Total 7 marks)

3 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 heterozygousfor 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.

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(2)

(Total 10 marks)

4 (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 concentrationof 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)

5 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 ofdeveloping severe malaria rather than mild malaria?

(Extra space)

(2)

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

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

(Extra space) _____

(3)

(Total 7 marks)

6 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 factorson 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)

7 (a) Energy enters most ecosystems through the light-dependent reaction of photosynthesis.

Describe what happens during the light-dependent reaction.

(5)

(b) Changes in ecosystems can lead to speciation. A high concentration of copper in soil istoxic 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.

(5)

(Total 10 marks)

Ecologists studied a community of fish in a lake.

8

(a) Explain what is meant by a community.

_____

_____

_____

(1)

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

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*(Extra space)*_____

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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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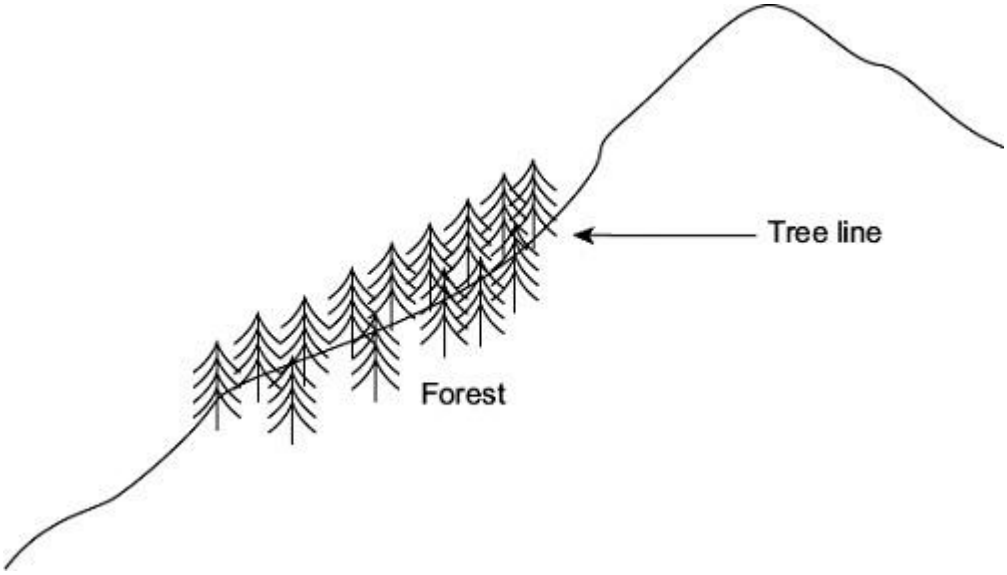
_____

_____

_____

(2)

9 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?

_____

_____

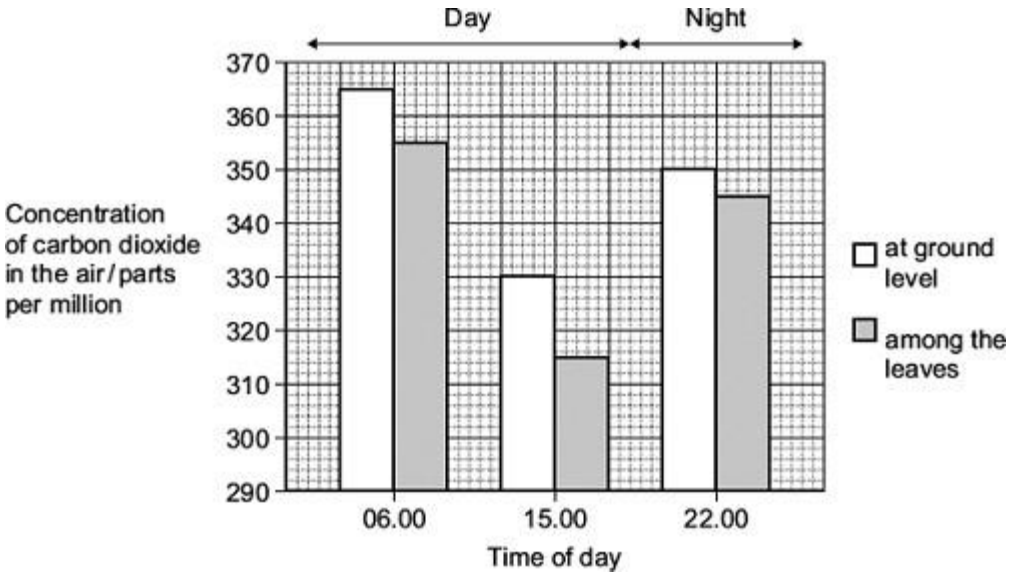
(1)

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

_____

(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.

(Extra space)

(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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*(Extra space)*_____

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(3)

(Total 9 marks)

10 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 homozygousrecessive 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?

_____

_____

(1)

(b) Several years later, scientists repeated their study on this population. They found that thefrequency 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 seaotters? Explain how this type of selection led to a decrease in the frequency of the recessive allele.

Type of selection _____

Explanation _____

_____

_____

_____

(2)

(Total 7 marks)

11 (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*.

_____

_____

_____

(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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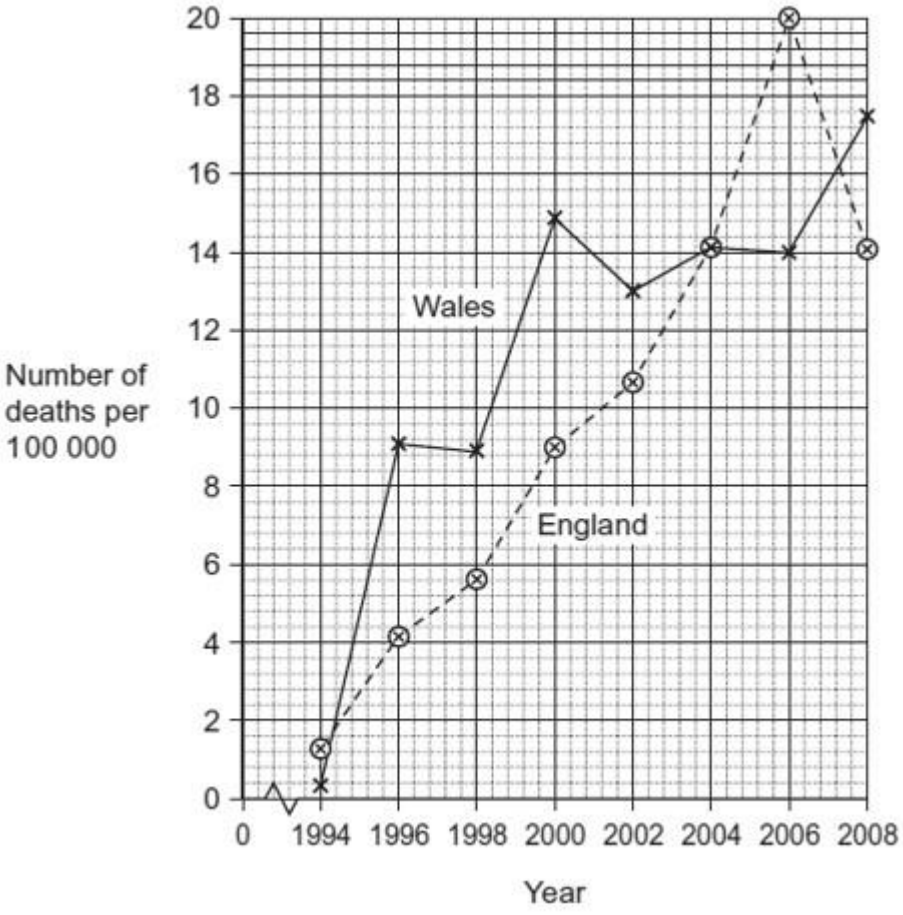
(2)

(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 theperiod 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.

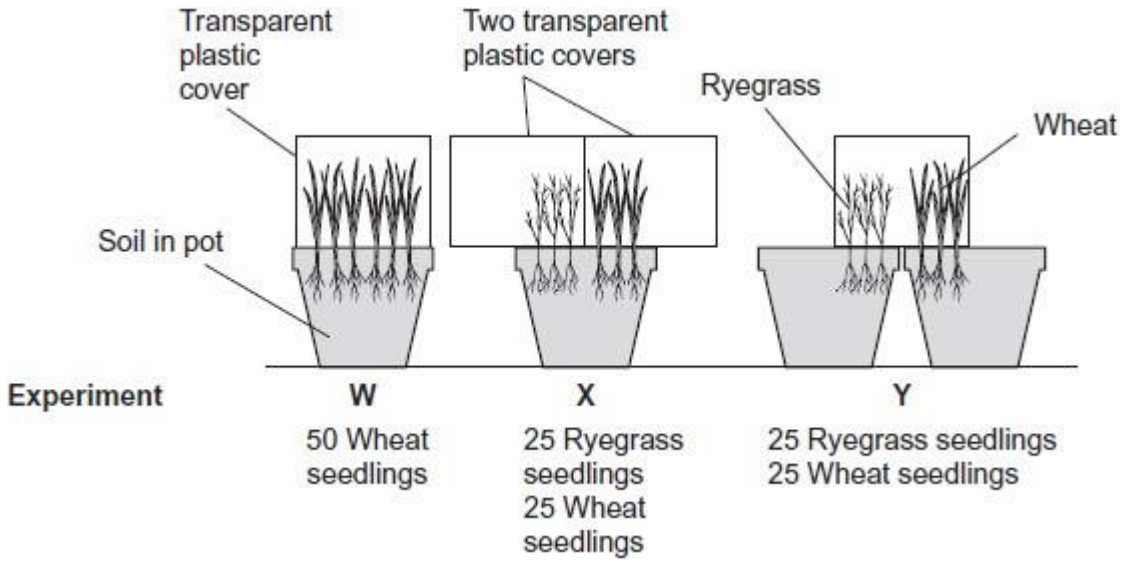
Answer _____

(2)

(Total 9 marks)

12 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.

(2)

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

(Extra space)

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(4)

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

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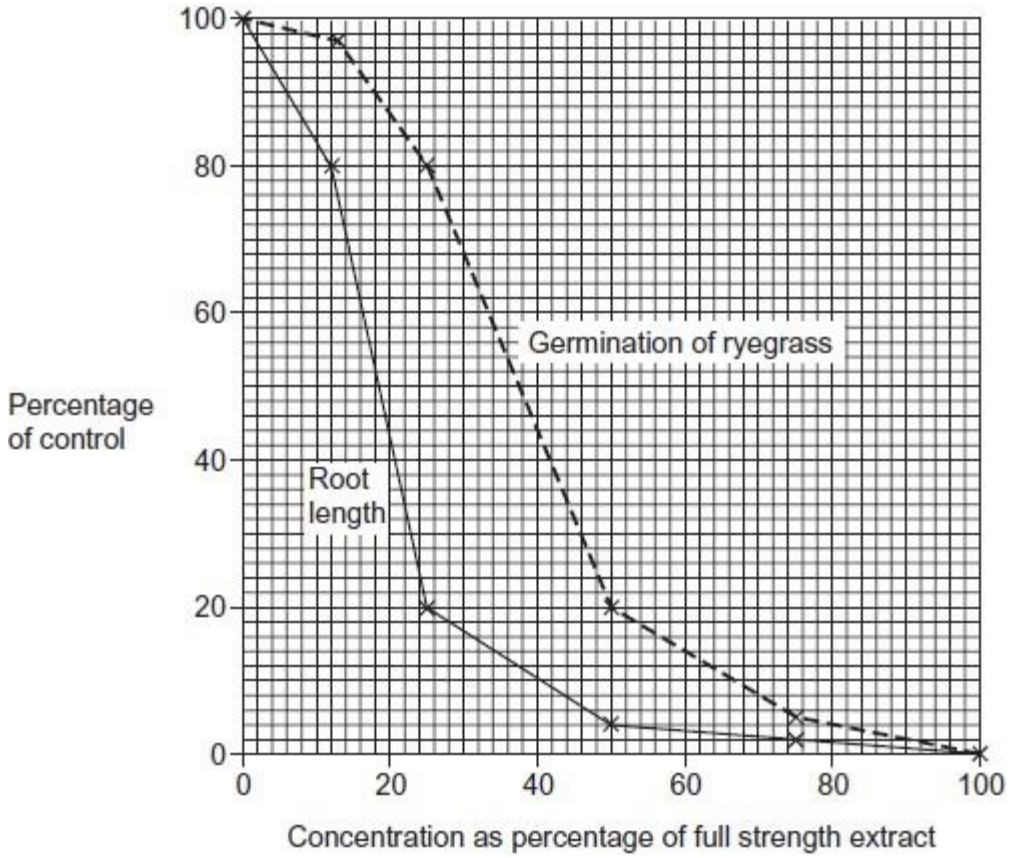
(2)

(Total 8 marks)

13 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. Thescientists 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 theconcentration of the extract.

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

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_____

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_____

(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 competewith 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)

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

(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.

(5)

(Total 10 marks)

15 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 theybreed. 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.

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(3)

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

_____

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_____

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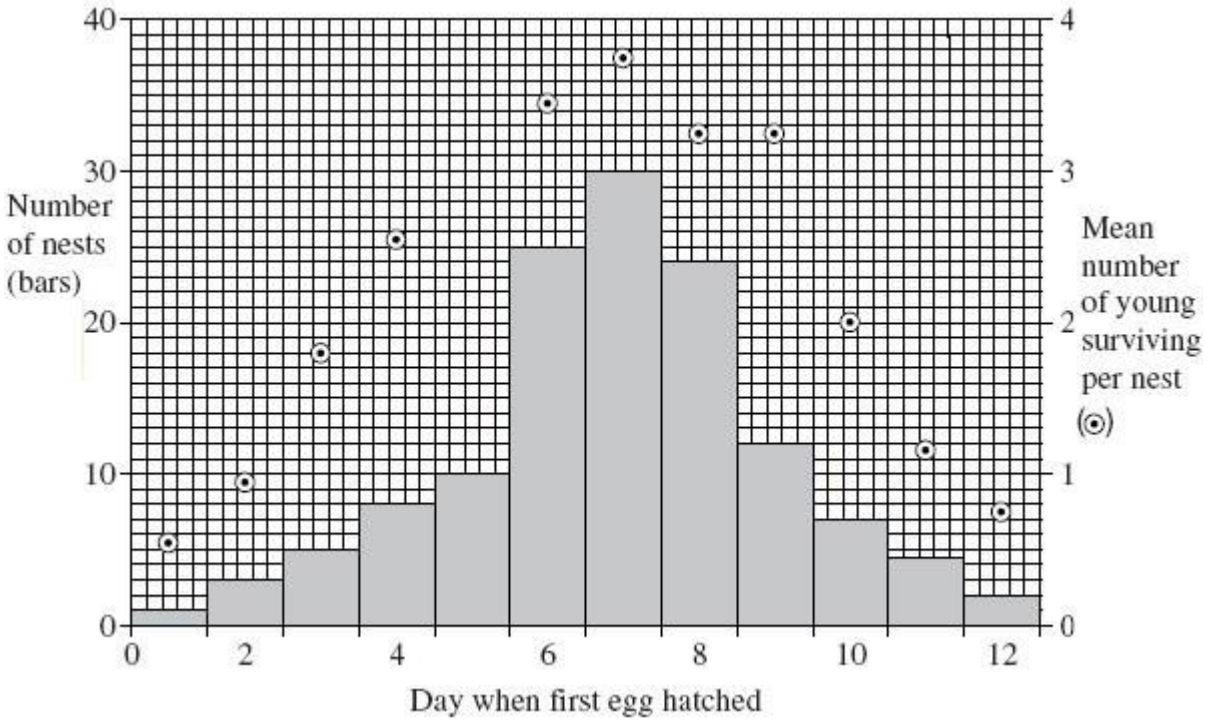
_____

(2)

(d) Snow geese breed in large colonies. Scientists studied the nests in one colony. For eachnest, 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?

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(1)

(ii) Describe the evidence for your answer.

_____

_____

(1)

(Total 10 marks)

16 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?

_____

_____

(1)

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

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(2)

(c) The scientists analysed the DNA on the Y chromosome and the DNA in the mitochondria ofthe 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.

_____

_____

(1)

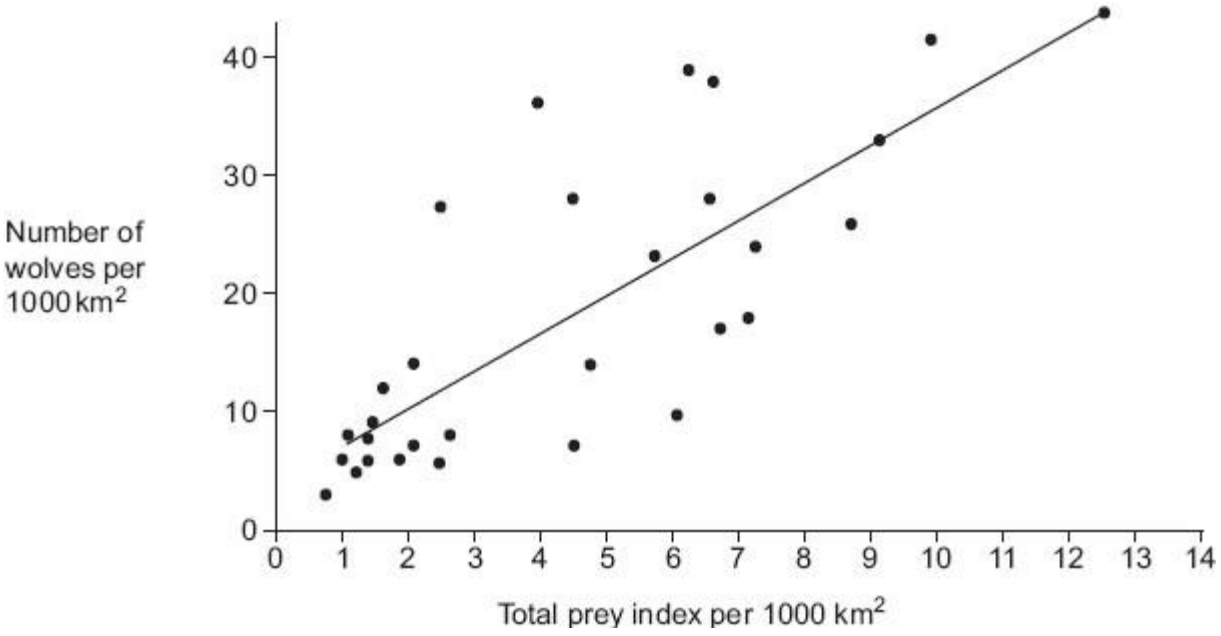
(ii) Suggest why DNA in the mitochondria helped them to reach this conclusion.

_____

_____

(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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_____

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(2)

(e) The ecologist calculated the total prey index by combining the prey indices and the totalnumber of animals of each species present in 1000 km^2. 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)

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

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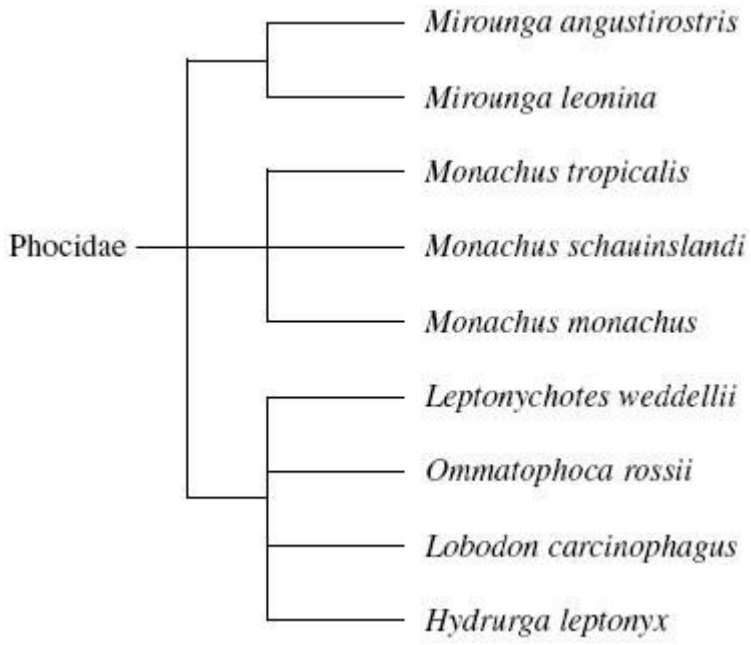
(1)

(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 anexample 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 theinformation 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.

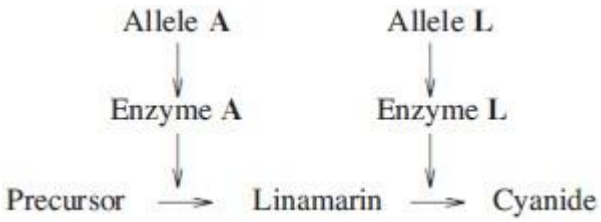
_____

_____

(1)

(Total 5 marks)

18 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.

_____

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(2)

(c) Two plants, heterozygous for both of these pairs of alleles, were crossed. What proportionof 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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(Extra space) _____

_____

(4)

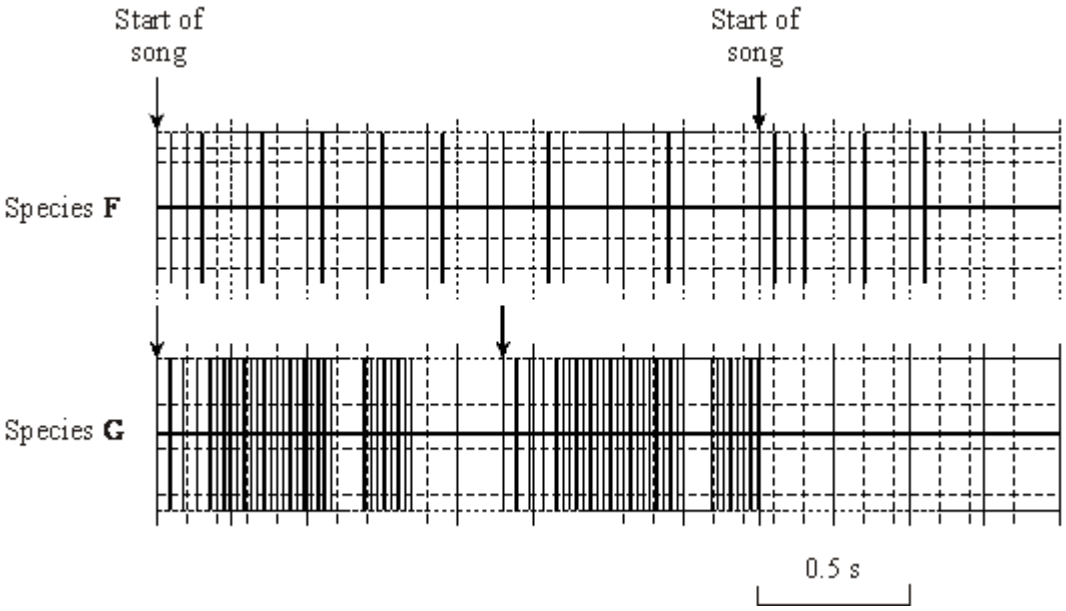
(Total 15 marks) Mole crickets are insects that live underground. At night, a male cricket produces a courtship

19

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 onespecies 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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_____

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(2)

(Total 6 marks)

20 (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 arisenby 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 differentchromosomes. 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 = _____

Parental phenotypes	Male Short, black hair	Female 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 malewhich 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)

21 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

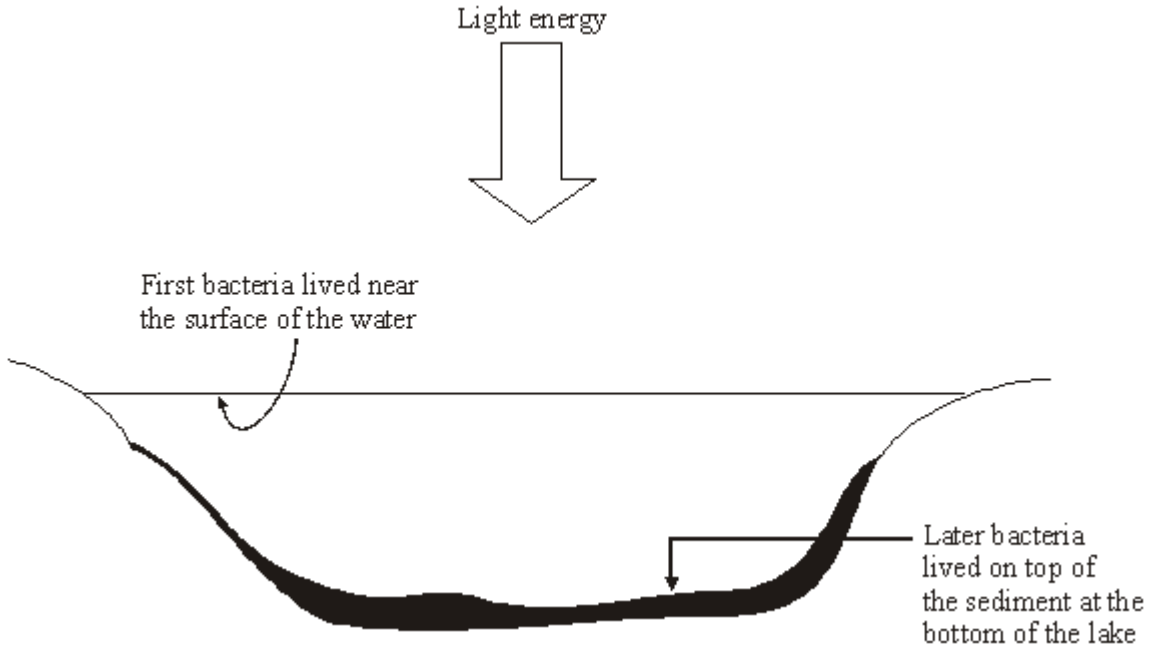
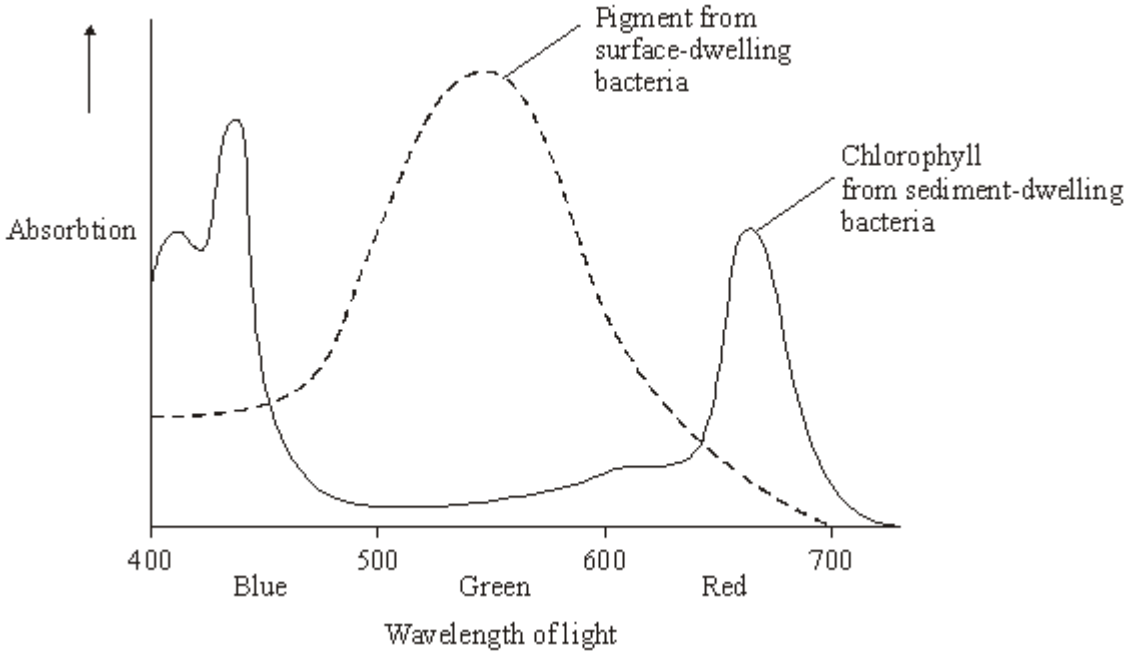


Figure 2



(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 sedimentdwelling bacteria containing a different photosynthetic pigment from those living near the surface of the water.

(6)

(Total 11 marks)

22

(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)

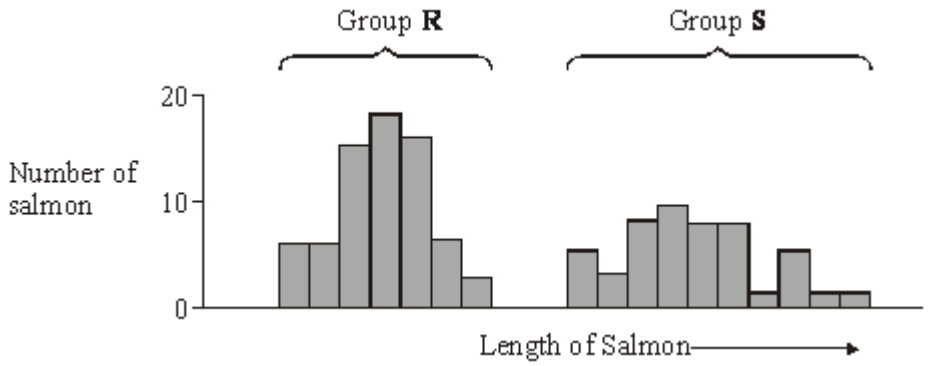
(b) Some humans have a genetic resistance to infection. A recessive allele gives increased resistance to infection by the malarial parasite. In a population, the proportion of babies born who are homozygous for this allele is 0.01. Use the Hardy-Weinberg equation to calculate the expected proportion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

Answer _____

(4)

(Total 9 marks)

23 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 consideredmore useful to compare standard deviations rather than ranges. Explain why.

_____

_____

_____

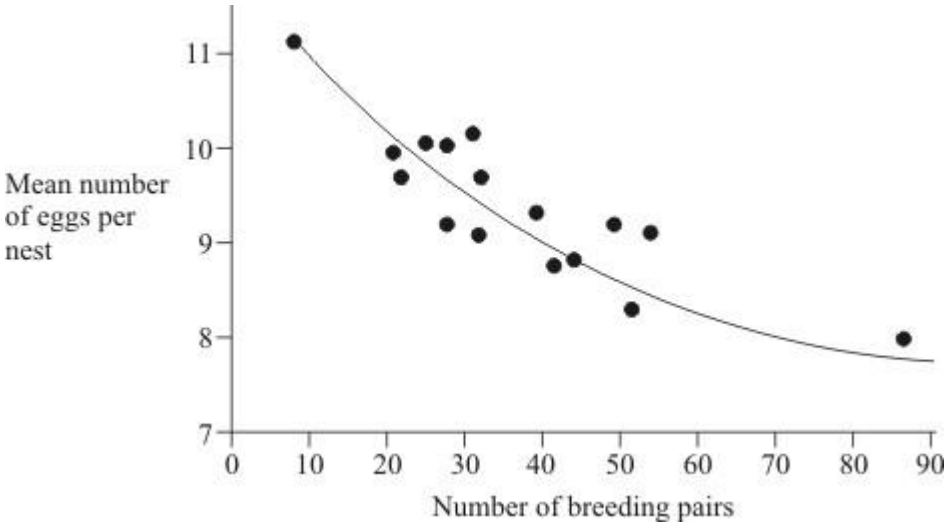
_____

(2)

(Total 4 marks)

24 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)

S (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.

_____

_____

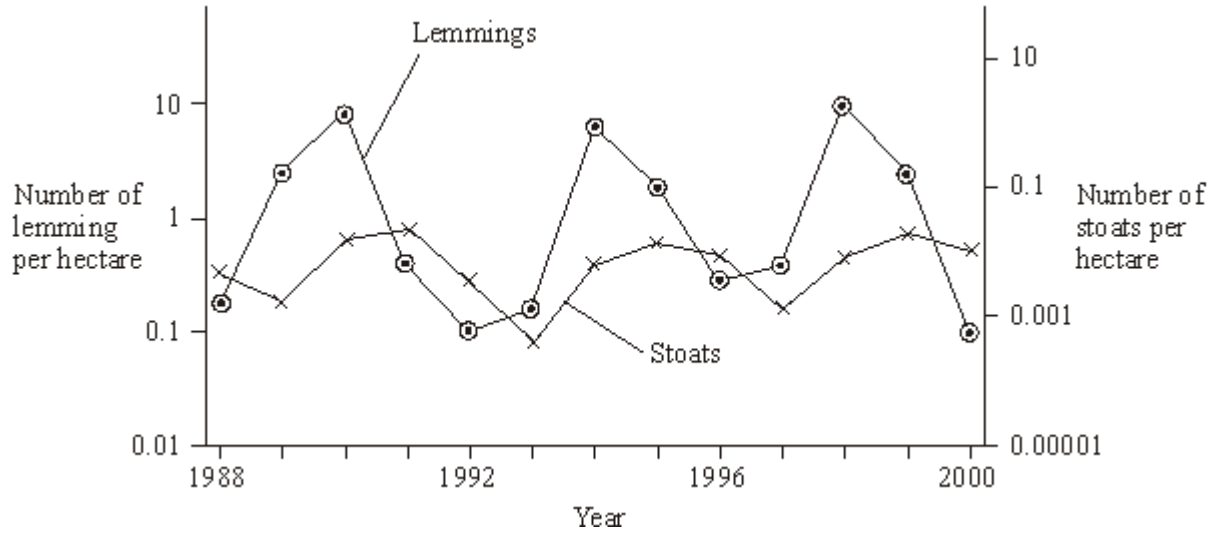
(1)

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

(3)

(Total 6 marks)

25 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)

S (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)

S (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.

(4)

(Total 12 marks)

S Clover plants have leaves all through the year. Some clover plants have leaves that

26

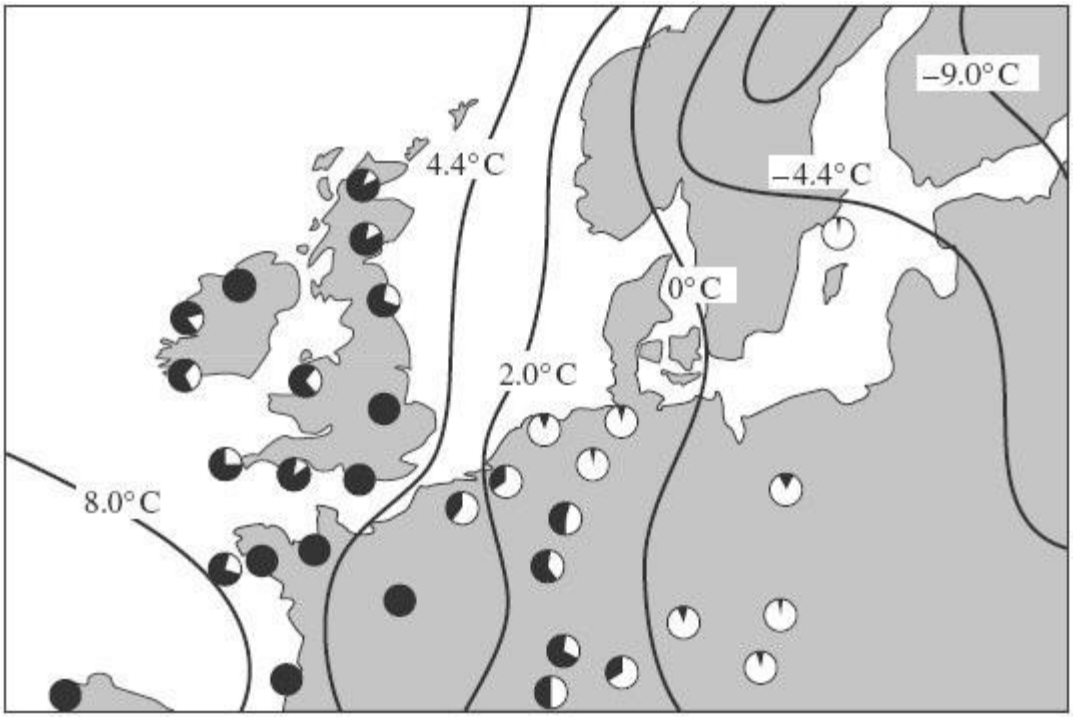
produce poisonous hydrogen cyanide gas when damaged. These cyanogenic plants are less likely to be eaten by snails. However, the leaves of these plants can be damaged by frost, resulting in the production of enough hydrogen cyanide to kill the plants. Acyanogenic plants do not produce hydrogen cyanide. 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 indifferent parts of Europe.

(4)

(b) Differences in cyanide production may affect the total number of clover plants growing indifferent 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)

27 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 minewaste.

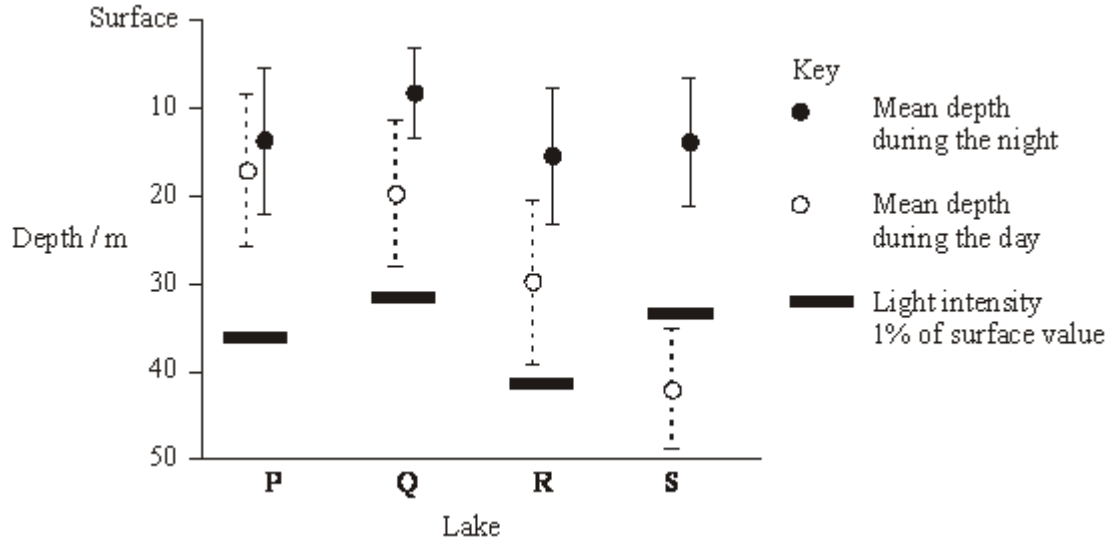
(4)

(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)

28 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.



S (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)

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

_____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

29 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 wasmuch 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)

30

(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)

31 (a) What is sympatric speciation?

_____

_____

_____

_____

(2)

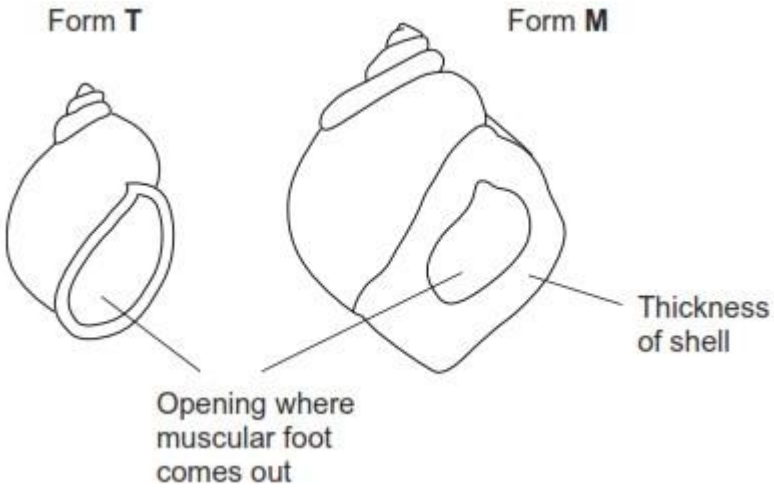
Littorina saxatilis is a snail found on rocky seashores. It has a shell and a muscular foot that it uses to move and to attach to rocks. Crabs are predators of this snail. The crabs use their claws to break open the snails' shells, or pull the snails from their shells.

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 *Littorina saxatilis*	
	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)

Mark schemes

1

(a) (No – no mark)

Graph / bar chart only shows number of species, not the name of the species.

1

(b) (No – no mark)

1. Mutations are spontaneous / random;
2. Only the rate of mutation is affected by environment;
3. Different species do not interbreed / do not produce fertile offspring;4. So mutation / gene / allele cannot be passed from one species to another.

Ignore references to correlation does not prove causation

4

(c)
1. Initially one / few insects with favourable mutation / allele;
2. Individuals with (favourable) mutation / allele will have more offspring;
3. Takes many generations for (favourable) mutation / allele to become the mostcommon allele (of this gene).

3

[8]

2

(a) 1. No interbreeding / gene pools are separate / geographic(al) isolation;

Accept: reproductive isolation as an alternative to no interbreeding.

2. Mutation linked to (different) markings/colours;
3. Selection/survival linked to (different) markings/colours;
4. Adapted organisms breed / differential reproductive success;

Note: 'passed on to offspring' on its own is not sufficient for reproduction.

5. Change/increase in allele frequency/frequencies;

5

(b) 1. (Compare DNA) base sequence / base pairing / (DNA) hybridisation;

Ignore: compare chromosomes / 'genetic make-up'.

Accept: (compare) genes / introns / exons.

*Note: reference to **only** comparing alleles is 1 max.*

2. Different in six (species) /different in different species / similar in three (subspecies) /similar in same species/subspecies;

Ignore: compare chromosomes / 'genetic make-up'.

Reject: 'same alleles/ same DNA bases in three species/subspecies'.

Note: mark point 2 can be awarded without mark point 1.

2

[7]

3

(a) 0.32.

Correct answer = 2 marks

Accept 32% for 1 mark max

Incorrect answer but identifying 2pq as heterozygous = 1 mark

2

(b) 1. Mutation produced *KDR minus* / resistance allele;
2. DDT use provides selection pressure;
3. Mosquitoes with *KDR minus* allele more likely (to survive) to reproduce; 4. Leading to increase in *KDR minus* allele in population.

4

(c) 1. Neurones remain depolarised;
2. So no action potentials / no impulse transmission.

2

(d) 1. (Mutation) changes shape of sodium ion channel (protein) / of receptor(protein);
2. DDT no longer complementary / no longer able to bind.

2

[10] (a) 1. Geographic(al) isolation;

4

2. Separate gene pools / no interbreeding / gene flow (between populations);

Accept: reproductive isolation

This mark should only be awarded in context of during the process of speciation. Do not credit if context is after speciation has occurred.

3. Variation due to mutation;
4. Different selection pressures / different abiotic / biotic conditions / environments / habitats;

Neutral: different conditions / climates if not qualified

Accept: named abiotic / biotic conditions

5. Different(ial) reproductive success / selected organisms (survive and) reproduce;

Accept: pass on alleles / genes to next generation as equivalent to reproduce

6. Leads to change / increase in allele frequency.

Accept: increase in proportion / percentage as equivalent to frequency

6

(b) 1. Capture / collect sample, mark and release;
2. Method of marking does not harm lizard / make it more visible to predators;
3. Leave sufficient time for lizards to (randomly) distribute (on island) beforecollecting a second sample;
4. (Population =) number in first sample × number in second sample divided bynumber of marked lizards in second sample / number recaptured.

4

(c) 1. High concentration of / increase in carbon dioxide linked with respiration at night / in darkness;

2. No photosynthesis in dark / night / photosynthesis only in light / day; *Neutral: less photosynthesis*

3. In light net uptake of carbon dioxide / use more carbon dioxide than produced / (rate of) photosynthesis greater than rate of respiration;

4. Decrease in carbon dioxide concentration with height;

More carbon dioxide absorbed higher up

Accept: less carbon dioxide higher up / more carbon dioxide lower down

5. (At ground level) less photosynthesis / less photosynthesising tissue / more respiration / more micro-organisms / micro-organisms produce carbon dioxide.

Neutral: less leaves unqualified or reference to animals

5

[15] (a) 1. Allows (valid) comparison;

5

2. Number / sample size may vary;

2

(b) 1. Increased chance of (severe malaria) with blood group A / decreased chance of (severe malaria) with sickle cell;

Accept: converse for mild malaria i.e. increased chance of mild malaria with sickle cell / decreased chance of mild malaria with blood group A.

Accept: if answer is comparative e.g. greatest risk of severe malaria with blood group A.

2. One mark for one of the following:

almost equal chance with blood group O / slightly greater chance of mild malaria with O / slightly lower chance of severe malaria with O / 2.5 x / 2.48 x / more than twice the chance of severe with blood group A / (almost) 50% / half the chance of severe malaria with sickle cell / twice the chance of mild malaria with sickle cell;

Neutral: answers which only refer to or use ratios.

2

(c) 1. Individuals with the **Hb**^{C} (allele) reproduce;

2. Pass on **Hb**^{C} (allele) which increases in frequency;

3. **Hb**^{A} **Hb**^{A} individuals less likely to survive / reproduce / frequency of **Hb**^{A} (allele) decreases;

3

[7]

6

(i) 1. Identical twins show genetic influence / differences between them show environmental influence;

Neutral: allows a comparison

It must be clear which set of twins is being referred to

2. Non-identical twins (also) show an environmental / non-genetic influence;

It must be clear which set of twins is being referred to

Do not credit repetition of bullet points in stem

2

(ii) Genes play a greater role / environment plays a lesser role;

Must be comparative

Neutral: genes are involved

Neutral: involves genes and the environment

1

(iii) Any suitable suggestion for a maximum of two marks e.g.:

Neutral: 'environment' as in question stem

Neutral: unqualified ideas such as health / lifestyle

1. Age;
2. Sex (non-identical twins);
3. Family / medical history (of mental illness);
4. No use of recreational drugs;
5. Ethnic origins;

2 max

[6]

7

(a) 1. Chlorophyll absorbs light energy;

Accept light energy 'hits' chlorophyll

Accept photon for light energy

2. Excites electrons / electrons removed (from chlorophyll);*Accept higher energy level as 'excites'*

3. Electrons move along carriers / electron transport chain releasing energy;

Accept movement of H^+ / protons across membrane releases energy

4. Energy used to join ADP and Pi to form ATP;

Negate 'produces energy' for either mark but not for both

Accept energy used for phosphorylation of ADP to ATP

Do not accept P as Pi

5. Photolysis of water produces protons, electrons and oxygen;

3. and 4.

6. NADP reduced by electrons / electrons and protons / hydrogen;

Accept NADP to NADPH (or equivalent) by addition of electrons / hydrogen

Do not accept NADP reduced by protons on their own

5 max

(b) 1. Variation / variety;

2. Mutation;

Do not accept answers which suggest the mutation is caused by copper

3. Some plants have allele to survive / grow / live in high concentration of copper / polluted soils;

Reference to immunity disqualifies this mark

Do not disqualify mark for references to allele providing resistance to copper

4. (Differential) reproductive success / adapted organisms reproduce;

5. Increase in frequency of allele;

6. No interbreeding (with other populations) / separate gene pool / gene pooldiffers (from other populations);

Accept reproductive isolation

5 max

[10]

8 (a) All the fish / all the species / all the populations / all the organisms;

Must indicate all / every species.

Reject answers that suggest other fish / organisms might be present.

1

(b) (i) 1. Capture sample, mark and release;

2. Appropriate method of marking suggested / method of marking does not harm fish;

E.g. Cutting a fin / attaching a tag / paint / marker.

3. Take second sample and count marked organisms;

May be awarded from equation if not given here.

4. $$\text{Population} = \frac{\text{No in sample}_1 \times \text{No in sample}_2}{\text{Number marked in sample}_2};$$

Accept any valid alternative to equation or answer expressed as a ratio.

3 max

(ii) One suitable reason;

Accept other valid answers, which must, however, relate to breeding / only works if population constant.

E.g. population increases / changes (between first and second sample)

1

(c) 1. With different mouth eats different food / has different way of feeding / specificmouth shape for specific food;

Catches more food and gas exchange are neutral

2. Competition between species / interspecific competition is reduced;

Reject intraspecific

2

[7] (a) (i) Non-living / physical / chemical factor / non biological;

9

Do not accept named factor unless general answer given.

1

(ii) Accept an abiotic factor that may limit photosynthesis / growth;

Reject altitude / height

Water

Named soil factor

Not "soil" / "weather"

Light

Carbon dioxide

Accept Oxygen

Incline / aspect

Wind / wind speed

1

(b) 1. Correct explanation for differences between day and night e.g. photosynthesises only during the daytime / no photosynthesis / only respiration at night;

2. Net carbon dioxide uptake during the day / in light

OR

No carbon dioxide taken up at night / in dark / carbon dioxide released at night / in dark;

3. At ground level more respiration / in leaves more photosynthesis;

4. Carbon dioxide produced at ground level / carbon dioxide taken up in leaves;

Principles

Comparing day and night / light and dark

1. Explanation in terms of photosynthesis / respiration

2. Effect on carbon dioxide production / uptake

Comparing leaves with ground level

3. Explanation in terms of photosynthesis / respiration

4. Effect on carbon dioxide production / uptake

2 and 4 must relate to why the change occurs

4

(c) 1. Variation in original colonisers / mutations took place;

2. Some better (adapted for) survival (in mountains);

2. Allow "advantage so able to survive"

3. Greater reproductive success;

4. Allele frequencies change;

4. Reject gene / genotype

3 max

[9]

10

(a) (i) Two marks for correct answer of 4;;

One mark for calculation involving 0.2 × 0.2 or 0.04;

2

(ii) 0.2 / the frequency remains the same;

Reject if wrong frequency is quoted

1

(b) (i) 1. There is a <u>probability</u> of 5% / 0.05;

2. That difference in frequencies / difference in results are due to <u>chance</u>;

Accept 95% probability changes in frequencies not different as a result of chance

2

(ii) 1. Directional;

2. The recessive allele confers disadvantage / the dominant allele confers advantage / more likely to survive / reproduce;

Assume "it" to refer to the recessive allele

2. References to selection do not gain credit as the term is in the question. Allow reference to phenotype / enzyme functionality (instead of allele) when describing advantage / disadvantage.

2

[7] (a) (i) Antibiotics kill other bacteria / *Clostridium* is resistant;

11

Less / no competition so (*Clostridium*) reproduces / replicates / multiplies / increases in number;

Reference to bacteria being 'immune' negates first marking point.

Reference to mitosis negates second marking point.

2

(ii) Immune system less effective / more likely to have other infections / been in hospital;

Accept: 'Weak / lower' immune system'.

1

(b) Attaches to <u>active site</u> (of enzyme);
(Methicillin) is a competitive inhibitor / prevents monomers / substrate attaching (to enzyme);

'Competes for active site' = 2 marks.

Neutral: 'Prevents monomers joining / attaching to each other'.

Allow one mark max for answers relating to non-competitive inhibitor changing active site / preventing substrate attaching. Do not penalise Methicillin forms an enzyme / substrate complex.

2

(c) (i) Have other illness / medical condition / 'weak' immune system / disease /infection;

Reject: Due to 'other factors', 'are smokers', 'are obese' unless related to disease or illness.

1

(ii) Increase up to 2006 / 20 (per 100 000) then decreases;

1

(iii) Correct answer in range of 52 – 59.1% = two marks;

Incorrect answer but shows change as between 4.8 – 5.2 / shows correct subtraction giving this change e.g. 14 – 9 = one mark.

2

[9] (a) Shows mass of wheat seedlings when grown on their own;

12

Allows percentage to be calculated / allows comparison / allows effect of competition to be seen;

2

(b) 1. Interspecific competition / ryegrass reduces growth of wheat;

2. Justification by using values;

100% with wheat but less when grown with ryegrass

3. Competition between shoots had a greater effect than competition betweenroots;

4. Justification by use of values;

*46% when shoots complete / in **Y** / 76% when roots compete / **X***

When marking please number marking points

E.g. 4✓ *means a mark awarded for point 4.*

4

(c) Growth involves enzymes / enzyme-controlled reactions;

Lower temperature means less kinetic energy / fewer collisions / fewer E–S complexes formed;

Wheat and ryegrass affected to a different extent;

Accept other valid physiological processes such as growth involves diffusion / lower temperature means less kinetic energy / molecules move slower.

2 max

[8] (a) Same number of ryegrass seedlings in distilled water;

13

1

(b) (i) Produce null hypothesis;

Carry out Spearman Rank correlation test / find correlation coefficient;

Use values to show P < critical value / find probability of results being due to chance;

Accept valid example

E.g. There is no correlation between inhibition of germination and the concentration of the extract.

2 max

(ii) May be another factor / named factor (that also inhibits germination);

e.g. amount of water in extract

1

(c) (i) Extract inhibits ryegrass germination / extract stops ryegrass starting to grow;

Inhibition of root length / causes ryegrass to have shorter roots;

2

(ii) Scientists crushed plants to get extract;

Plants might not secrete substances in the extract into the soil;

These substances might get broken down in the soil;

Wheat and ryegrass might not grow at the same time / wheat plants might not produce substance when ryegrass is growing;

Concentration of extract in the soil might be different from that in solution;

3 max

[9]

14 (a) 1. (Colonisation by) pioneer (species);

2. Change in environment / example of change caused by organisms present;

3. Enables other species to colonise / survive;

4. Change in diversity / biodiversity;

5. Stability increases / less hostile environment;

6. Climax community;

Example of change e.g. formation of soil / humus / organic matter / increase in nutrients;

Do not accept genetic diversity for mark point 4.

5 max

(b) 1. Geographical isolation;

2. Variation due to mutation;

3. Different environmental / abiotic / biotic conditions / selection pressures;

4. Selection for different / advantageous, features / characteristics / mutation / /allele / differential reproductive success / (selected) organisms survive and reproduce;

5. Leads to change in allele frequency;

In this question must refer to allele where appropriate, not gene.

5

[10] (a) Small surface area to volume ratio / more fat;

15

Lose less heat (to the environment) / for insulation when they are sitting on eggs;

2

(b) (i) The further north / higher the latitude, the higher the percentage (of white snowgeese);

1

(ii) Snow lying longer / melts slower further north / at greater latitudes;

White geese better camouflaged (further north);

Predation linked to survival / reproductive success;

Q *In order to gain the last marking point, candidates must explain how survival or reproductive success is affected.*

3

(c) Snow melts earlier / snow melts further north / less snow;

White geese decreasing as less well camouflaged / at disadvantage / blue geese increasing as better camouflaged / at an advantage;

2

(d) (i) Stabilising;

Do not accept stable

1

(ii) Few geese survive at the extremes / most survive from the middle of the range;

1

[10] (a) (i) To cut the DNA;

16

Reject breakdown, cutting out

1

(ii) To separate the (pieces of) DNA;

1

(b) Complimentary base sequence / complementary DNA; binds to both (haplotypes);

Label would show up in both;

Idea of complimentarity required

2

(c) (i) Y chromosome inherited / comes from male parents / only found in males;

1

(ii) Mitochondria in egg / female gamete / no mitochondria come from sperm / malegamete;

1

(d) (i) Allows comparison;

Different (sized) areas covered;

2

(ii) Wolves do not eat all of prey animal / do not eat (large) bones / skin;

Inedible parts make up different proportions / wolf eats different proportions;

2

(e) Limited by food / prey; as prey increases so do wolf numbers / positive correlation;

Large range so other factors involved;

2

[12]

17 (a) Kingdom / phylum / class;

1

(b) (i) 6;

1

(ii) Family;

1

(iii) The two species of *Mirounga* shared a common ancestor more recently than they did with *Monarchus tropicalis*;

1

(c) Difference in DNA / base sequence / alleles / genes;

1

[5]

18 (a) Cannot make (active) enzyme A (which converts precursor to linamarin) / cannot make linamarin;

1

(b) (i) **AL** + **Al** + **aL** + **al** ;

1

(ii) Meiosis separates alleles / homologous chromosomes / pairs of chromosomes;
Independent assortment / means either of **A** / **a** can go with either of **L** / **l**;

Accept "random segregation" but cancel if reference to crossing-over

2

(c) From parental genotypes: **AaLl** × **AaLl** (no mark)
Note: If wrong parental genotypes / wrong gametes: ALLOW correct derivation of offspring genotypes = 1 max

Correct derivation of offspring genotypes; max 2 marks if error in Punnett square

	AL	**Al**	**aL**	**al**
AL	AALL	AALl	AaLL	AaLl
Al	AALl	AAll	AaLl	Aall
aL	AaLL	AaLl	aaLL	aaLl
al	AaLl	Aall	aaLl	aall

Correct identification of offspring genotypes with at least one **A** and two **l** alleles (= grey cells in above table);
Correct proportion: 3 / 16 / 3:13 / 18.75% ;

3

(d) (i) There was no (significant) difference in damage between cyanogenic andacyanogenic / being cyanogenic has no effect;

1

(ii) The difference (from expected / from chance variation) is significant / difference / results not just due to chance;
Reject null hypothesis;
Being cyanogenic does help protect from slug damage;

3

(e) High slug population:
1. Find only cyanogenic plants / only cyanogenic plants survive;
2. (Cyanide release) limits / stops feeding by slugs / slugs killed;*Accept: converse argument re. acyanogenic plants*

Low slug population:
3. Find both types of plant;
4. Less selection pressure on plants from slugs / no selective advantage / noselection / described;

4

[15]

19

(a) (i) 2;

Allow 1.75

1

(ii) 30 / 60 ÷ answer to part (i) if incorrect;

Allow 34(.315)

1

(b) Song characteristic of species / differs between species;

Song linked to courtship at night / living underground;

2

(c) Females not attracted to call of male / does not recognise male;

Because of differences in song;

Necessary precursor to mating;

Hybrids are sterile;

2 max [6]

20

(a) Table completed as below:

Kingdom	Animalia / Animals
Phylum	Chordata
Class	Mammalia
Order	Rodentia
Family	Caviidae
Genus	*Cavia*
Species	*porcellus*

Column 1 correct;

Column 2 correct;

2

(b) Mutation occurs;

Correct e.g. of isolating mechanism
e.g.
temporal − different breeding seasons / feeding times /
ecological / behavioural − different courtship displays / different niches / habitats / feeding areas /
mechanical − mismatch of reproductive parts /

gamete incompatibility − sperm killed in female's reproductive tract /
hybrid inviability / hybrid infertility;
Ignore references to "genetic isolation" or "reproductive isolation"

Different selection pressures operate / changes in allele frequency / divergence of gene pools;

3

(c) Using candidate's symbols for alleles −
e.g. B = black, b = brown, S = short, s = long:

Parental genotypes <u>correct</u>: Male **A** SSBb Female **B** SsBB;

Gametes correctly <u>derived</u> from candidate's parental genotypes: SB Sb SB sB;

offspring genotypes correctly
<u>derived</u> from candidate's
suggested gametes − accept Punnett square or line diagram;

offspring genotypes <u>correct</u>: SSBB SsBB SSBb SsBb;

If monohybrid:cross ⇨ 0 marks

4

(d) There is no (significant) difference between observed and expected results / any differenceis due to chance;

1

[10] (a) Excitation of chlorophyll molecule / electrons / energy of (pairs of)

21

electrons raised to higher energy level;

Electron(s) emitted from chlorophyll molecule;

Electron(s) to electron transport chain;

Loss of energy by electron(s) along electron transport chain;

Energy lost by electron(s) is used to synthesise ATP;

From ADP + Pi;

"By electrons" need not be stated in each marking point if it can be reasonably inferred that the candidate is referring to electrons

max 5

(b) Little green light reaches bottom as absorbed by surface dwellers / water;
Red and blue not absorbed and so penetrate;
Variation in pigments of sediment dwellers;

Bacteria with chlorophyll at an advantage as chlorophyll absorbs red and blue; (Survive to) reproduce in greater numbers and pass on advantageous alleles / genes in greater numbers / increase in frequency of advantageous alleles in subsequent generations;
Increase in frequency / numbers of bacteria with chlorophyll;

6

22 **[11]** (a) 1. frequent use of antibiotic creates selection pressure / antibiotic kills bacteria;

2. bacteria with mutation / resistance have (selective) advantage over others / described;
3. (survive to) reproduce more than other types pass on advantageous allele / mutated allele in greater numbers;
4. frequency of (advantageous) allele increases in subsequent generations;

(penalise use of "gene" instead of allele once only)

5. frequency of resistant types increases in subsequent generations;

5

(b) correct answer = 0.18; And
three marks for three of: p + q = 1 and $p^2 + 2pq + q^2 = 1$;
$0.01 = q^2$; q = 0.1; p = 0.9 frequency of heterozygotes = 2pq = 2 × 0.1 × 0.9 / 2 × candidates p × candidates q;

4 max

23 **[9]** (a) (i) Continuous variation – range of values / not discrete categories / many categories / no gaps;

1

(ii) Crossing over / chiasmata;
Random segregation / independent assortment;
In meiosis I and meiosis II;

max 2

(b) Range influenced by single 'outlier' (*accept anomaly*) / converse for S.D.;
S.D. shows dispersion / spread about mean / range only shows highest and lowest values / extremes;
Or
S.D. allows statistical use;
Tests whether or not differences are significant;

max 2

[4]

24 (a) principle of intraspecific competition;

for amount of food available;
more energy needed to find food / less energy to produce eggs;

OR

number of territories;
more energy spent fighting / defending territory;

OR

availability as prey;
predators spend less time searching for nests;

2 max

(b) (i) age of bird - young or old birds produce fewer eggs; time of breeding - early or late breeding less food available / temperature effect; genotype - variation in genetic ability to produce eggs; quality of territory - description of some relevant resource in territory;
(reject food as resource in territory if given in(a))
predation of eggs - lays more to replace eaten eggs;

1 max

(ii) when high number of eggs, each individual young will receive less food; reference to mortality rates to disease / predators for low numbers of eggs; so in both cases low number of offspring will reach maturity / survive; so less likely to pass on genes / alleles;

3

[6] (a) 1 4 year cycles;

25

2 predator / stoat peaks after prey / lemming;
3 lemmings increase due to low numbers of stoats / available food;
4 more food for stoats so numbers increase;
5 increased predation reduces number of lemmings;
6 number of stoats decreases due to lack of food / starvation;

6

(b) smaller populations have fewer different alleles / more homozygosity / lessheterozygosity / smaller gene pool / lower genetic variability; migrants bring in new alleles / increase gene pool;

2

(c) geographical isolation of populations;variation present in population(s);
different environmental conditions / different selection pressures / different phenotypes selected;
change in genetic constitution of populations / gene pools / allele frequency;

4

[12]

(a) colder / below 0°C (January) areas, cyanogenic plants die in this cold / acyanogenic

26

survive; non-cyanogenic allele / gene passed on more often / its frequency increases; warmer (January) areas cyanogenic plants at advantage, because of less herbivore selection pressure / feeding; so cyanogenic survive more often to pass on cyanogenic allele / gene.

4 max

(b) large (and equal) number of quadrats in each area;
(reject several) random sampling method, described;
(accept described 'systematic' method) percentage cover / point hits per quadrat / count plants; mean / average value for each area; statistics test to see if differences significant.

4 max

[8] (a) variation present in (original population);

27

(copper) tolerant individuals more likely to survive;
(these reproduce and) pass on genes (to next generation / offspring);
more / increase (in frequency) of copper tolerance alleles / genes;

4

(b) 1. reproductively isolated / no interbreeding (due to different flowering times);
2. conditions different for two populations / different selection pressures;
3. different features or plants are selected or survive / different adaptations;
4. populations become (genetically) different / unable to produce fertile offspring;

4

[8] (a) zooplankton nearer surface at night;

28

algae only found at surface;
photosynthetic;
no / little light below 30 / 40m;

3

(b) (i) with increasing time predators have been present in the lake, the greater the depth at which the zooplankton occur during the day;

1

(ii) variation in migration behaviour; vertical migration reduces chance of predation / prey can't be seen in low light intensity; those that migrated more likely to reproduce; genes / alleles (for behaviour) passed to next generation; increase in frequency of gene / allele in population;

3 max

[7]

(a) breed together;

29 if fertile offspring, then same species;

2

(b) isolation of two populations; variation already present due to mutations;

different environmental conditions / selection pressures leading to selection of different features and hence different alleles; different frequency of alleles; separate gene pools / no interbreeding;

4

(c) selection of mate dependent on colour pattern;prevents interbreeding / keeps gene pools separate;

2

[8] (a) Genetic (factors)/genes/alleles/mutations/meiosis;

30 **1**

Environmental (factors)/environment;

1

(b) New species form from different populations/groups/gene pools;

1

In different areas/from isolated populations;

Accept alternatives/descriptions for 'populations'

1

[4] (a) Formation of new species / reproductive isolation;

31

Ignore ref. to mechanisms involved

From a population (living in the same area / place) / without geographical isolation;

2

(b) Small shell of T,

Accept converse statements

Wave action (greatest) at top of shore;

Note – pairs of statements – environmental factor; and possible effect on survival;

Only small snails can get into cracks in rock (to shelter);
Thick shell of M,
More crabs in middle shore;

No mark for giving differences

Thicker shelled snails less easy to break open;

OR

More rocks in middle shore to be moved by waves;
Thicker shelled snails less easily broken by rocks;
Large opening of T,
More wave action likely to wash snails away;
Larger opening, (suggests) snails with larger foot to hold on with less likely to be washed away;

OR

Smaller opening of M,
More crabs in middle shore;
Snails with smaller opening harder to get claws into;

4 max

(c) Reproductive isolation required for speciation;

Accept descriptions of reproductive isolation

Isolation by male choice / form T males nearly always choose form T female, so (nearly) reproductively isolated (from form M);
Behavioural isolation / mechanism;

2 max

[8]