

## 7.4 Genetics, populations, evolution, ecosystems (A-Level Only) - Populations in ecosystems 2 – Questions

### Q1.

Biologists studied the process of succession in an area of wasteland over a period of ten years. They calculated the index of diversity of the area every year. After three years, the index of diversity was 1.6. After ten years, it had risen to 4.3.

- (a) What information concerning the organisms present in the area is suggested by the increase in the index of diversity?

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(2)

- (b) The increase in the index of diversity is one indication that a biological succession is taking place in the area. Describe those features of a succession that would bring about an increase in the index of diversity.

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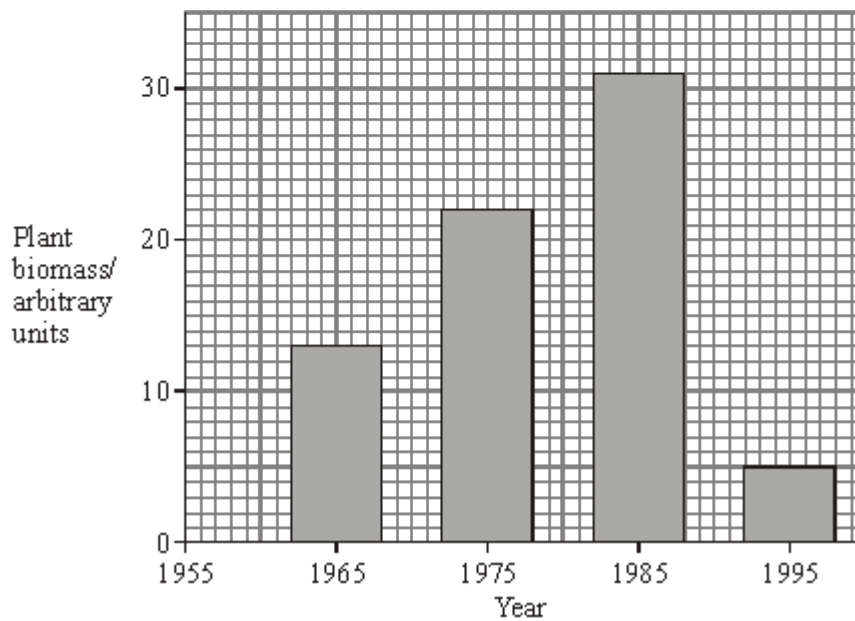
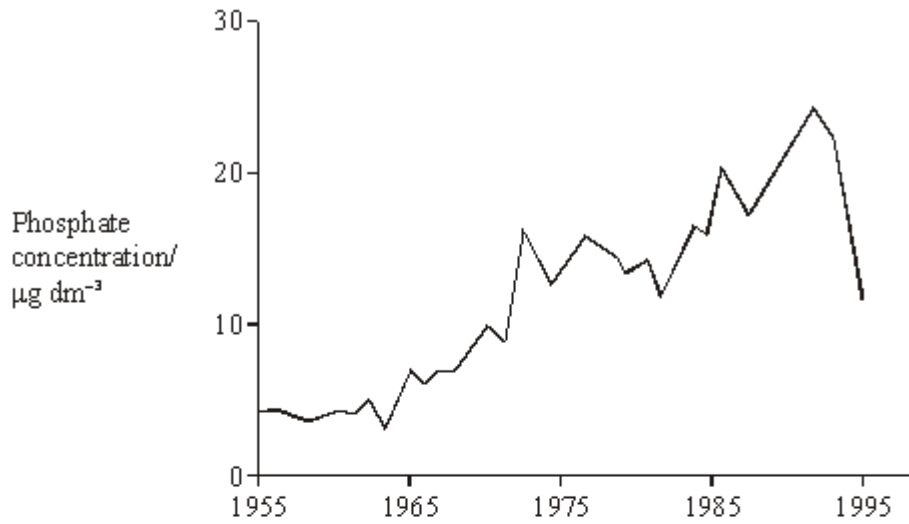
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(3)

(Total 5 marks)

### Q2.

Since 1965 there has been a steady rise in the phosphate concentration in the water of Lake Windermere. Scientists have monitored the phosphate concentration and plant biomass over a period of time. The results are shown in the graphs.



- (a) Suggest **one** source of the phosphate in the lake.

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(1)

- (b) Calculate the percentage decrease in plant biomass between 1985 and 1995. Show your working.

Answer \_\_\_\_\_

(2)

- (c) From these graphs, a student concluded that changes in phosphate concentration caused changes in plant biomass. Explain why this conclusion may not be valid.

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(2)

- (d) Between 1982 and 1992 the number of fish in the lake decreased. Explain how the change in phosphate concentration may have resulted in this decrease in the fish population.

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(6)

(Total 11 marks)

**Q3.**

- (a) Explain the meaning of these ecological terms.

Population \_\_\_\_\_

\_\_\_\_\_

Community \_\_\_\_\_

\_\_\_\_\_

(2)

- (b) Some students used the mark-release-recapture technique to estimate the size of a population of woodlice. They collected 77 woodlice and marked them before releasing them back into the same area. Later they collected 96 woodlice, 11 of which were marked.

(i) Give **two** conditions necessary for results from mark-release-recapture investigations to be valid.

1. \_\_\_\_\_

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2. \_\_\_\_\_

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(2)

(ii) Calculate the number of woodlice in the area under investigation. Show your working.

Answer \_\_\_\_\_

(2)

(c) Explain how you would use a quadrat to estimate the number of dandelion plants in a field measuring 100 m by 150 m.

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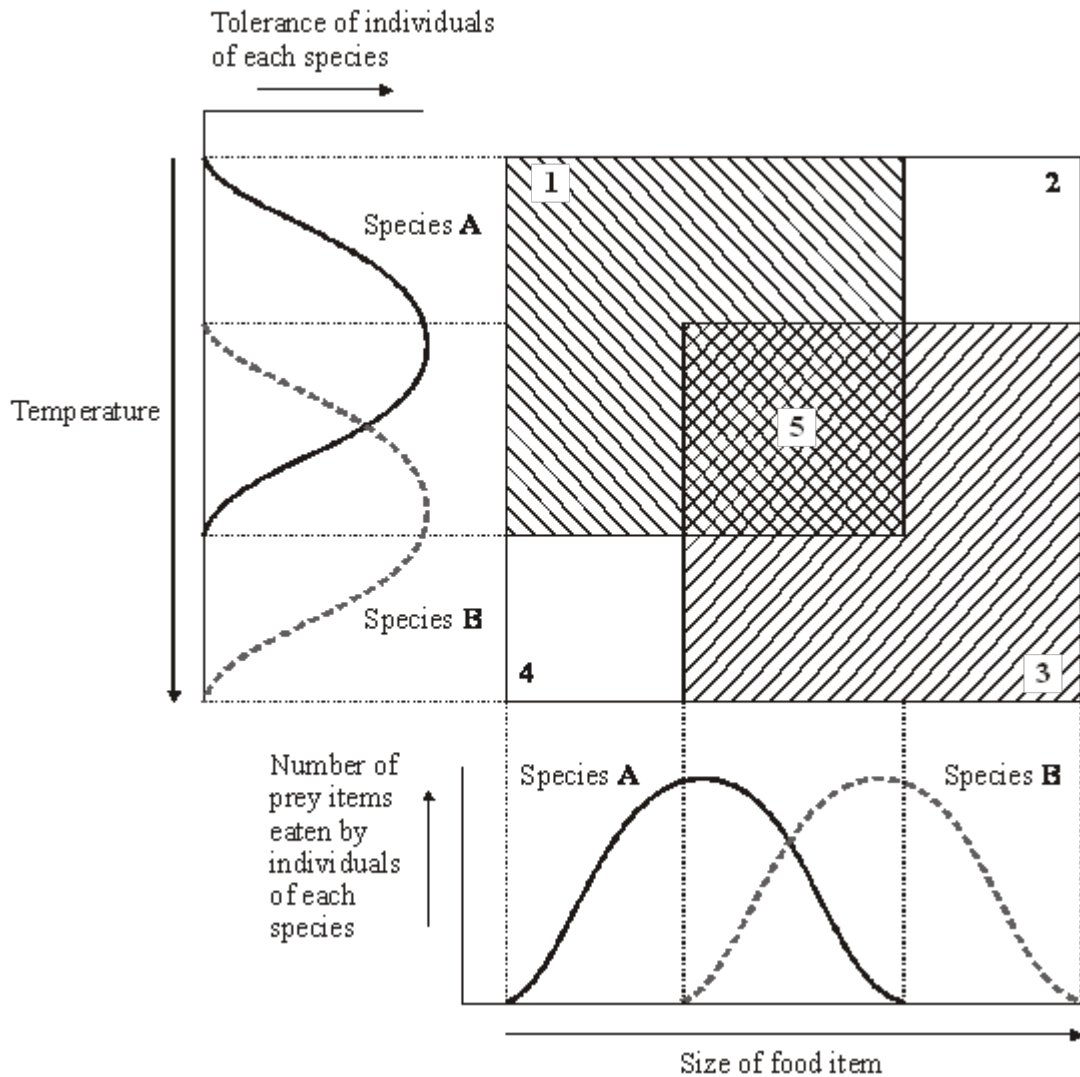
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(3)

(d) Two similar species of birds (species **A** and species **B**) feed on slightly different sized insects and have slightly different temperature preferences. The diagram represents the response of each species to these factors.



- (i) Which of the numbered boxes describes conditions which represent
- the niche of species **A** \_\_\_\_\_
- the niche of species **B** \_\_\_\_\_
- insects too small for species **B** and temperature too warm for species **A**; \_\_\_\_\_
- insects too large for species **A** and temperature too cool for species **B**? \_\_\_\_\_

(2)

- (ii) These two species are thought to have evolved as a result of sympatric speciation. Suggest how this might have occurred.

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(4)  
(Total 15 marks)

**Q4.**

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

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

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

**Table 1**

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

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(2)

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

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(2)

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

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(2)

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

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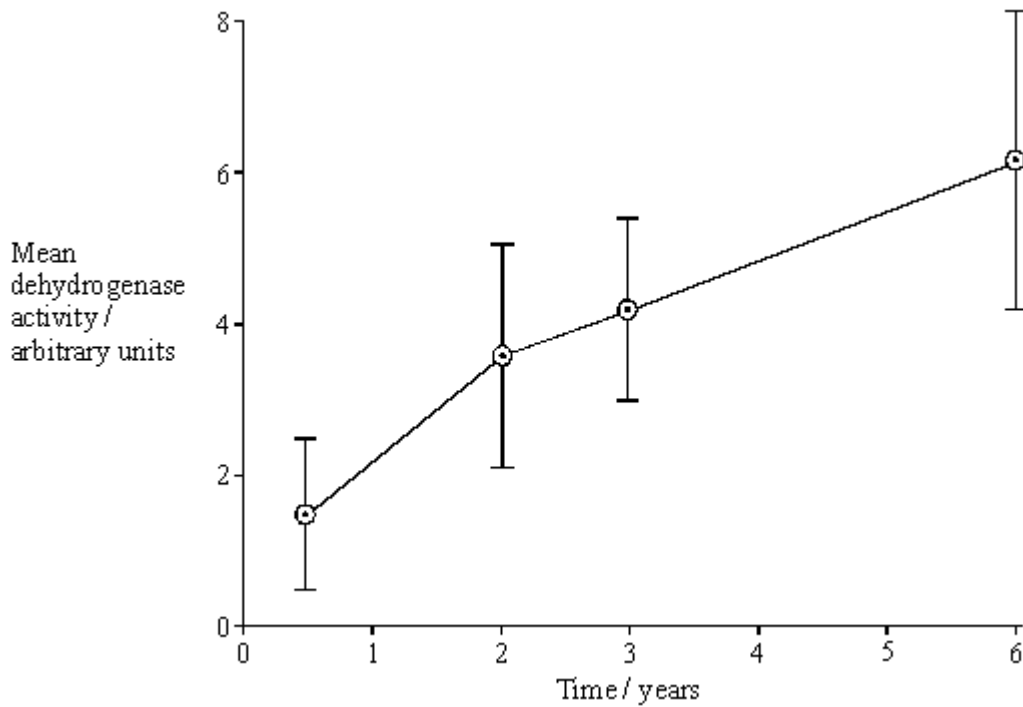
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(3)

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



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

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(2)

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

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

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(3)

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

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(3)

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

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

**Table 2**

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

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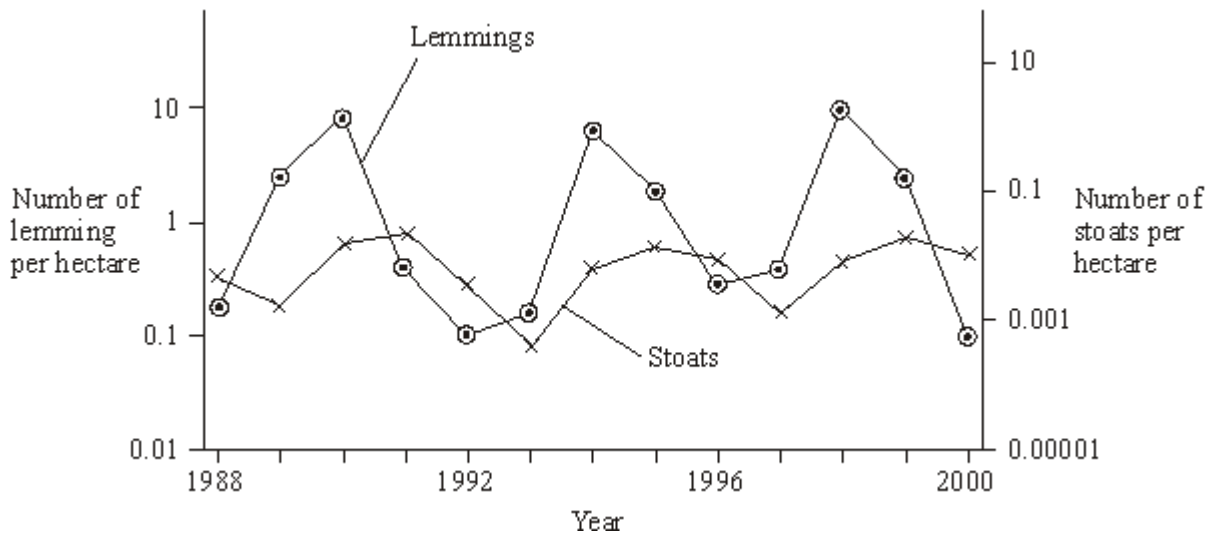
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(3)

(Total 20 marks)

**Q5.**

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.

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(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.

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(2)

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

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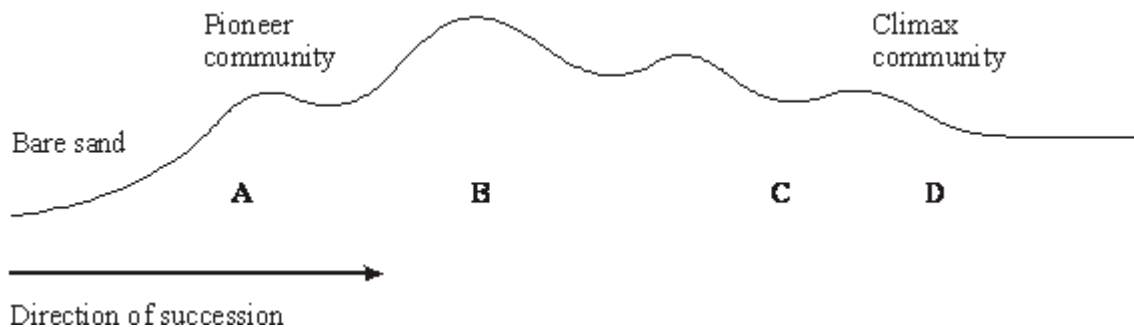
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(4)

(Total 12 marks)

**Q6.**

In a sand dune succession the pioneer community (**A**) colonises bare sand. This community is replaced over time by other communities (**B** and **C**) until a climax community of woodland (**D**) is formed.



- (a) The communities **A** to **D** are composed of different species. Explain how the change in species composition occurs in a succession.

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(3)

- (b) Which community, **A** to **D**, is the most stable? Explain what makes this the most stable community.

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(2)

- (c) Many species in the pioneer community are xerophytes. Suggest and explain how having sunken stomata is an advantage to these plants.

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(3)

- (d) Explain why it would be more appropriate to use a transect rather than random quadrats when investigating this succession.

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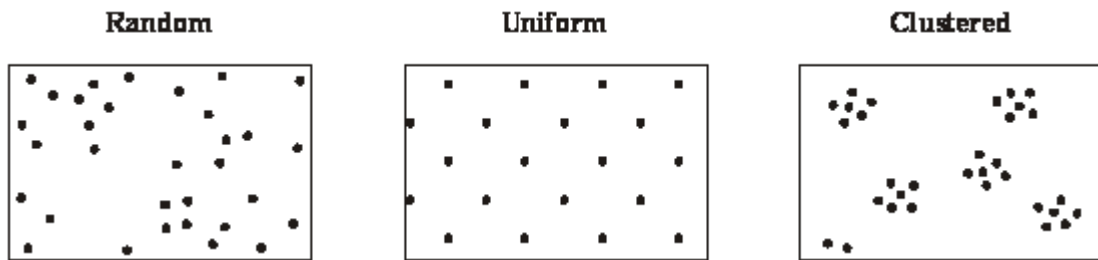
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(1)

(Total 9 marks)

**Q7.**

The diagrams show three types of plant distribution.



- (a) Describe how you would use quadrats to determine whether a particular plant species has a clustered or a random distribution.

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(3)

- (b) Some plants in a dry, hot desert have a uniform distribution and are widely spaced. Suggest how this type of distribution is an advantage to the plants.

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(2)

(Total 5 marks)

**Q8.**

The shore crab is common in Britain. It lives both in the sea and in river estuaries, where it feeds on a wide variety of species.

- (a) The shore crab has recently spread to, and has established large populations in, the coastal waters of the USA, where it is not a native species. Explain how the shore crab has been able to establish large populations and why this is causing concern to ecologists in the USA.

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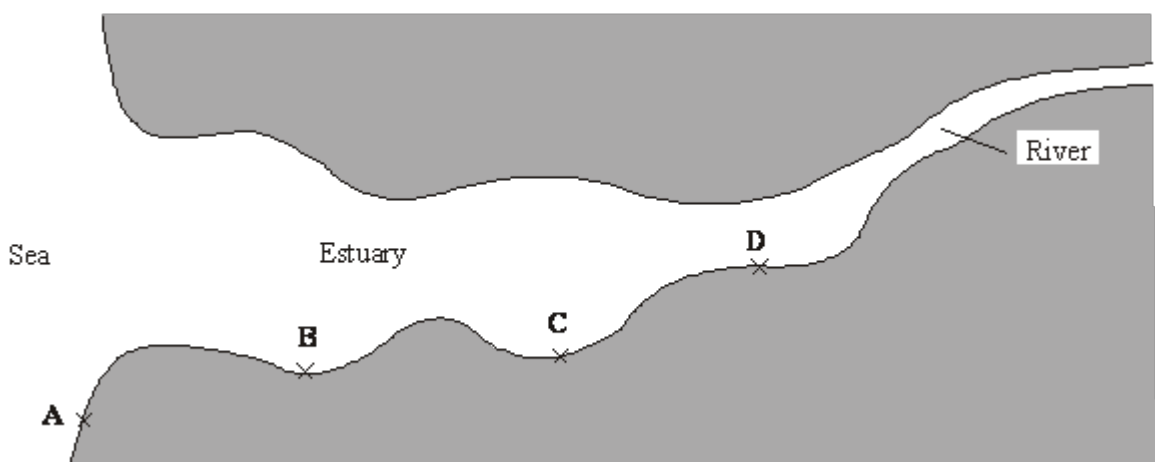
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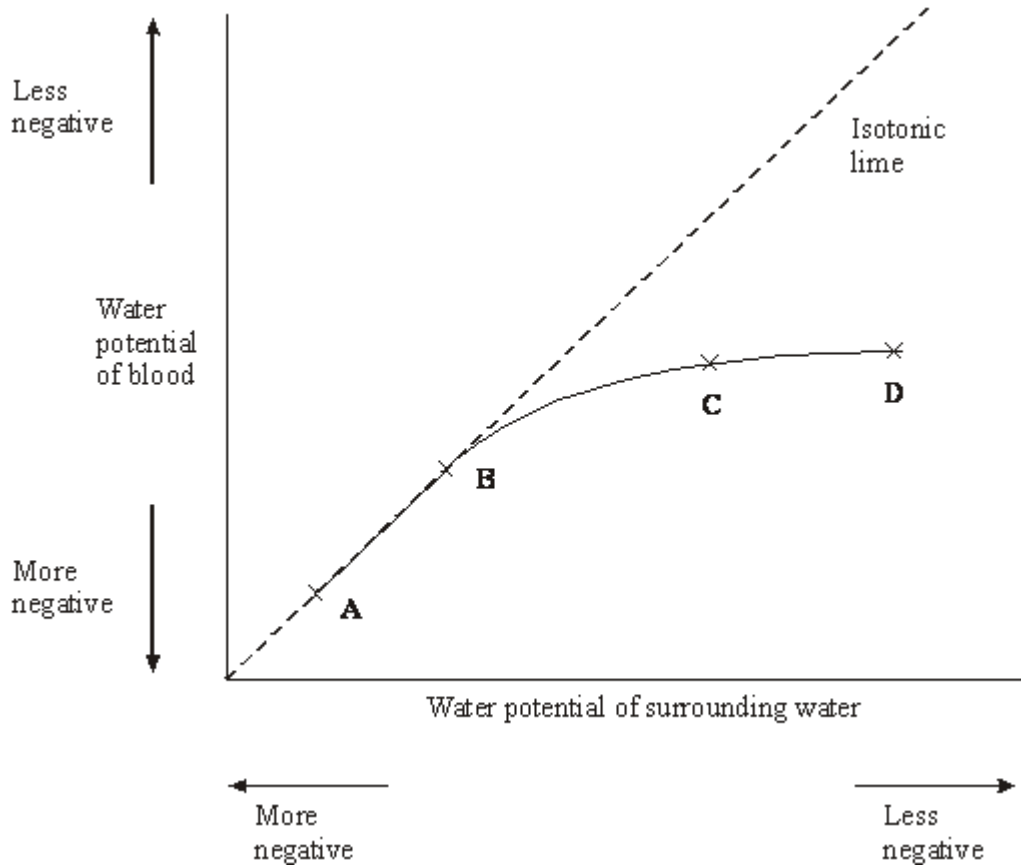
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(5)

In Britain, crabs living in an estuary and along the neighbouring coast were studied. Crabs were collected from four different sites, **A** to **D**, as shown in the map.



The graph shows the mean water potential of the blood of samples of crabs from the four sites in relation to the water potential of the environment at the same sites. The isotonic line shows values at which the water potential of the blood and surrounding water would be the same.



- (b) Describe the relationship between the mean water potential of the blood of the crabs and the water potential of the surrounding water.

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(1)

- (c) Is there any net movement of water in or out of the blood of the crabs at sites **A** and **B**? Explain your answer.

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(1)

- (d) Crabs living at sites **C** and **D** actively transport salts into their blood through their gills.

- (i) Explain how this enables crabs to survive at these sites.

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(2)

- (ii) Crabs are unable to control their body temperature. In winter, when the water temperature falls, crab populations at sites **C** and **D** migrate towards the sea. Suggest the advantage of this behaviour.

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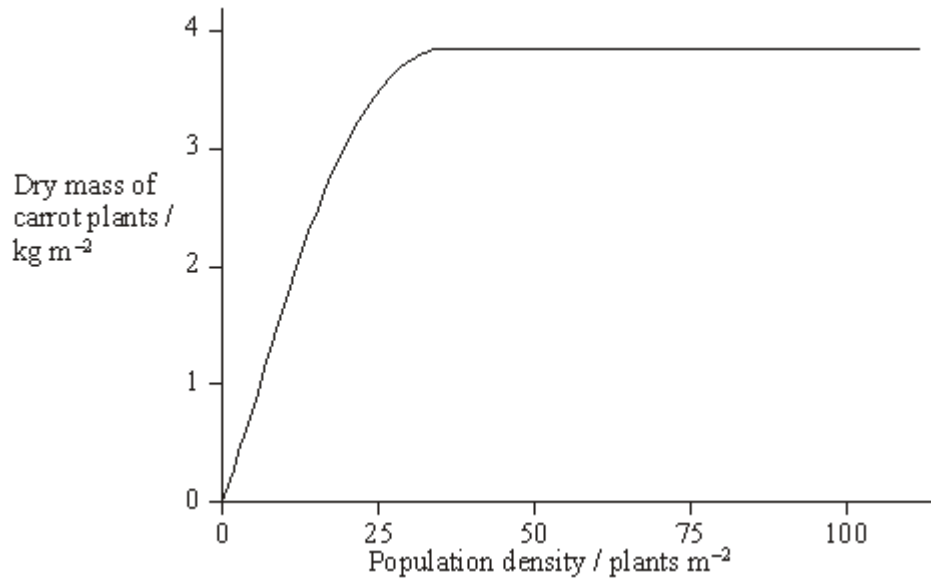
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(3)

(Total 12 marks)

**Q9.**

- (a) In an investigation, carrot seeds were planted at different densities. After 120 days, the dry mass of the carrot plants was measured. The results are shown in the graph.



- (i) What is the advantage of measuring the dry mass rather than the total mass of the carrot plants?

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(1)

- (ii) What type of competition is shown in this investigation?

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(1)

- (iii) Explain the shape of the curve.

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(b) Commercial growers want all the carrots to be the same size when harvested. Suggest **two** ways in which they can try to ensure this.

1. \_\_\_\_\_

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2. \_\_\_\_\_

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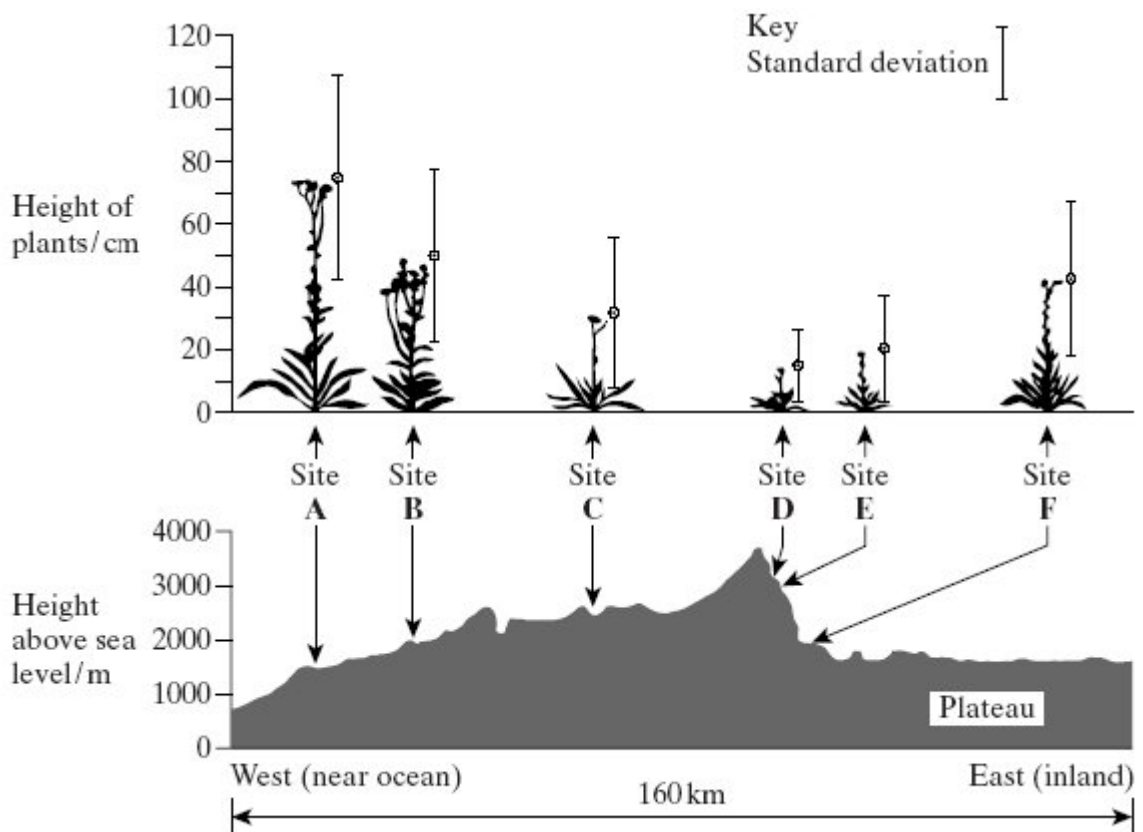
(Total 6 marks)

**Q10.**

Climatic factors, such as temperature and rainfall, vary greatly over short distances across mountain ranges. In an investigation, populations of the plant, *Achillea lanulosa*, were sampled from several sites on a transect across a mountain range. At each sampling site, seeds were collected at random. Each batch of seeds was germinated and grown to maturity under the same experimental conditions.

The diagram shows

- a profile indicating the position and altitude of the sampling sites
- the mean height of mature plants grown from each sample of seeds
- the standard deviation of heights of the mature plants grown from each sample of seeds.





(a) (i) Give **one** limitation of using a line transect to collect these data.

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(1)

(ii) Suggest how plants should be chosen at each sampling site to avoid bias and to be representative.

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(2)

(b) (i) What information does the bar representing standard deviation give about the plants in a sample?

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(1)

(ii) Describe what the results show about the variation of the height of the plants in relation to altitude.

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(2)

(iii) There was a significant difference between the mean heights of the plants grown from seeds taken from sites **A** and **D**. Describe the evidence from the information given which shows that this is likely to be due to genetic differences between the two populations.

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(1)

(Total 7 marks)

**Q11.**

(a) What is meant by a community?

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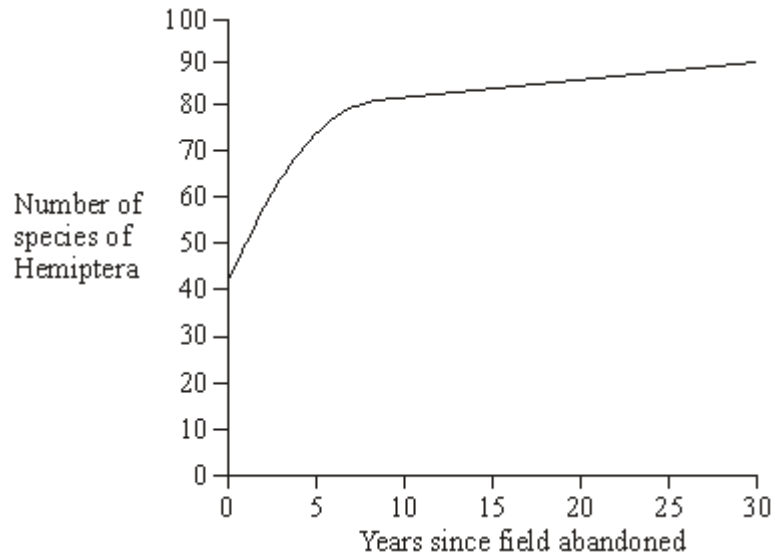
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(2)

- (b) A farmer stopped using a field for growing crops. Scientists studied succession in the field over the next 30 years. The graph shows the number of species of Hemiptera (an order of insects) present during that period.



Explain the increase in the number of species of Hemiptera.

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(3)

- (c) To calculate a diversity index at a given time, it is necessary to know the number of insects in each population. Name **one** method that could be used to estimate the total number of insects in a population.

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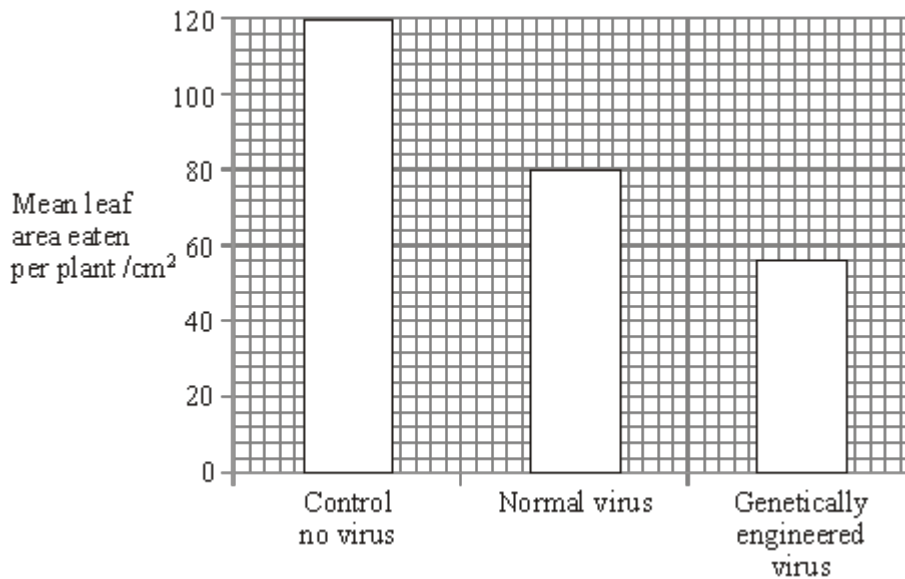
(1)

(Total 6 marks)

**Q12.**

Caterpillars damage crop plants by eating the leaves. There is a virus which kills caterpillars within a few days of infecting them. A genetically engineered form of the virus has been produced which contains a gene from a scorpion. This gene codes for production of a toxin specific to insects.

In an investigation, sample areas of crop were treated with either the normal or the genetically engineered virus. The bar chart shows the damage caused by caterpillars to the leaves of the crop plants.



- (i) How much more effective is the genetically engineered virus than the normal virus? Show your working.

Answer \_\_\_\_\_

(2)

- (ii) Explain why the area of leaf eaten is less when caterpillars are infected with the genetically engineered virus rather than with the normal virus.

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(2)

(Total 4 marks)

**Q13.**

A student investigated whether the abundance of the orange star lichen on the walls of a building was influenced by the direction the wall faced. The student recorded the number of colonies within a 50 cm<sup>2</sup> quadrat, placed one metre above the ground on each of three walls.

A  $\chi^2$  test was applied to the results.

- (a) Give a null hypothesis for this investigation.

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(1)

- (b) Complete the following table.

	Number of colonies on a wall facing		
	North	South	West
Observed	21	33	54
Expected			

(1)

- (c) How many degrees of freedom were in this  $\chi^2$  test?

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(1)

- (d) A  $\chi^2$  value of 15.5 was calculated from these results. This  $\chi^2$  value has a probability of less than 0.001. Explain what this means when applied to this investigation.

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(3)

- (e) Algae are green prototists. Lichens consist of a fungus and an alga living together in a relationship where both organisms benefit. Suggest how the relationship between the alga and the fungus allows the lichen to survive on an inorganic surface such as a wall.

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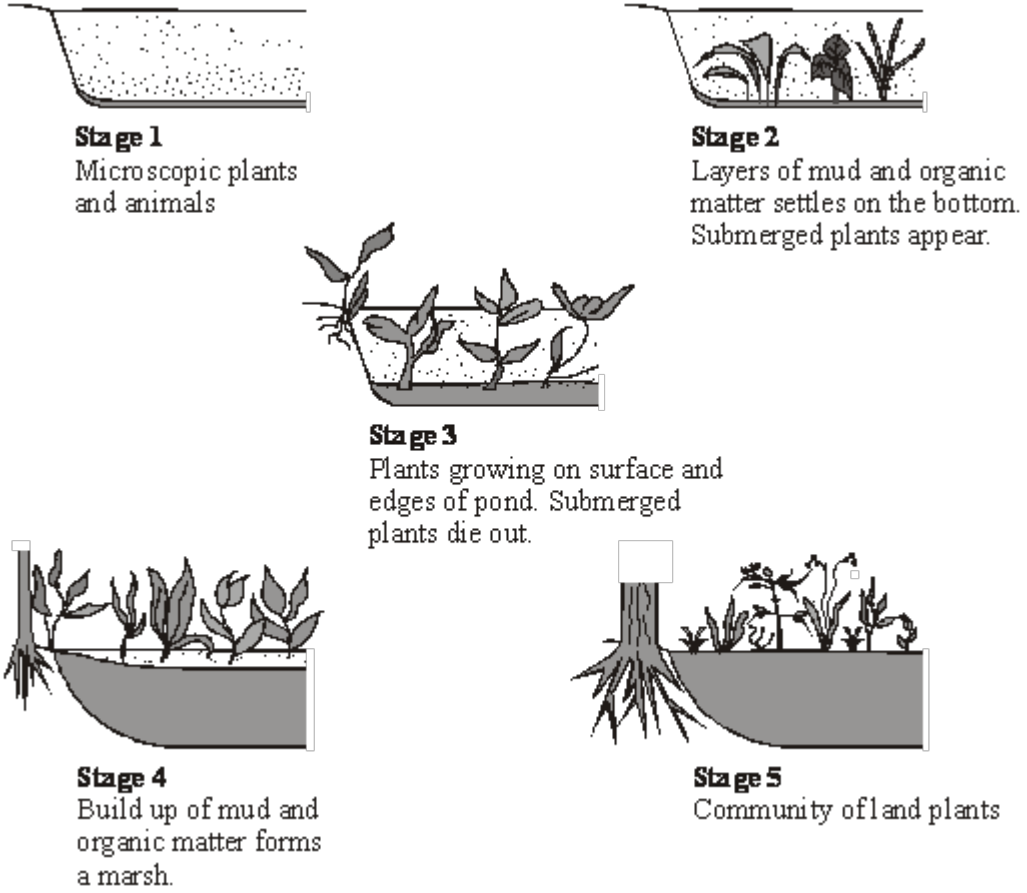
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(2)

(Total 8 marks)

**Q14.**

(a) The diagram shows a number of stages in an ecological succession in a lake.



Explain how the diagrams illustrate the features of an ecological succession.

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(6)

- (b) Several small rivers flow into this lake. These rivers flow through forested areas. Explain how deforestation might affect the process of succession in the lake.

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(2)

- (c) **Stage 5** illustrates the final stage of succession which is known as the climax community. During this stage the number of different species in the habitat and the size of each population remain fairly constant. Explain what limits the size of populations in a climax community.

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(5)

(Total 13 marks)

**Q15.**

A hormone has been shown to switch on a gene in fish, leading to the increased production of an enzyme. Experiments were carried out to investigate the effects of heavy metal ions on the production of this enzyme, with and without the hormone. The table shows the results.

	Amount of enzyme produced / percentage of maximum	
	Without hormone	With hormone
Heavy metal ion present		
None	16	100

Cadmium	15	55
Zinc	17	94
Copper	16	100

Explain how the results suggest that cadmium affects the action of the hormone.

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(Total 2 marks)

**Q16.**

Glaciers are masses of moving ice. When glaciers shrink, the thick covering of ice gradually disappears to leave behind bare land. Land exposed by a shrinking glacier in Alaska became covered by dense forest in 150 years.

- (a) Explain how succession resulted in the formation of the forest.

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(4)

- (b) In areas of poor drainage the soil is waterlogged. In these areas the climax community is bog dominated by the moss, *Sphagnum*. Explain why bog is described as the climax community.

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(1)

- (c) Waterlogged soils lack oxygen. Suggest why trees are unable to survive in waterlogged soils.

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(2)

- (d) The water and soil in *Sphagnum* bogs are usually acidic. Suggest why *Sphagnum* is not fully decomposed after it dies.

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(3)

(Total 10 marks)

**Q17.**

- (a) (i) What is meant by an *abiotic* factor?

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(1)

- (ii) Do abiotic factors exert a density-dependent or a density-independent effect on a population? Using an example, explain your answer.

Effect \_\_\_\_\_

Explanation \_\_\_\_\_

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(1)

- (b) Describe how you would collect the necessary data to estimate the size of a population by the mark-release-recapture technique.

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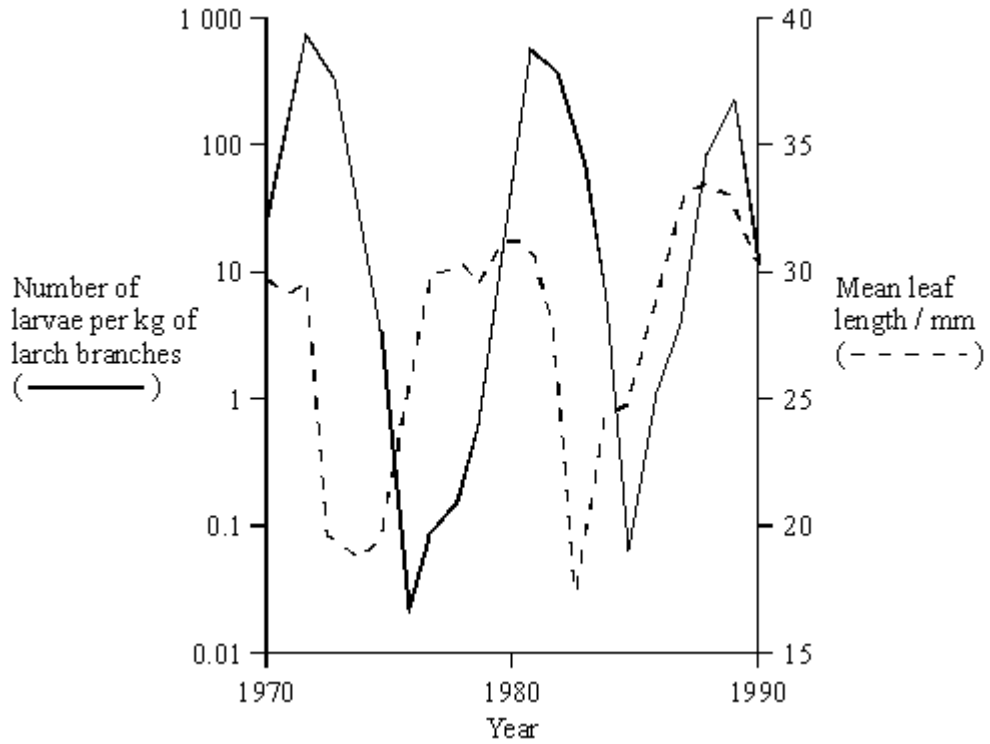
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**Q18.**

A species of moth occurs in forests in Switzerland. The moth larvae feed on the needle-shaped leaves of larch trees that grow in the forests. The graph shows the numbers of larvae and the mean length of leaves over a period of 20 years.



- (i) Describe how the population size of a species of bird that fed mainly on the moth larvae would be likely to change between 1970 and 1980.

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(2)

- (ii) Larch trees lose their leaves in autumn. When numbers of larvae are large in one year, the leaves in the following year are shorter. Suggest an explanation for this.

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(2)

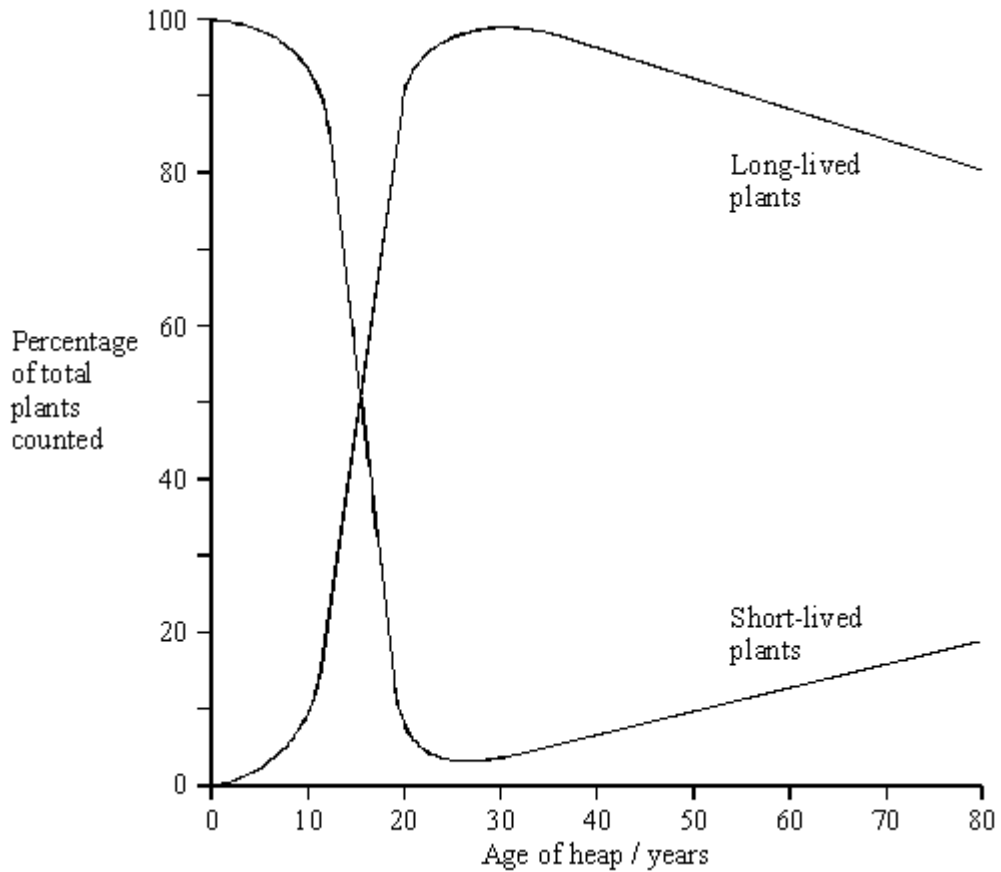
(Total 4 marks)

**Q19.**

Answers should be written in continuous prose, where appropriate.

Quality of Written Communication will be assessed in these answers.

The waste material from coal mines is deposited in pit heaps. A particular mine closed and the colonisation of an area of its pit heap was studied for a period of 80 years. Species of plants that were found growing on the pit heap were recorded in two categories, short-lived plants that grow for one or two years before dying and long-lived plants that continue to grow for several years. The graph shows the percentages of short-lived and long-lived plants on the pit heap.



(a) Using your knowledge of succession, suggest explanations for the changes in the percentages of short-lived and long-lived plants

(i) over the first 20 years;

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(ii) between 30 and 80 years.

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(6)

(b) Mine waste often contains metal ions at concentrations that are toxic to plants. Populations of two species of grass, red fescue and common bent, have been found on pit heaps contaminated with zinc ions.

Describe an experiment you would carry out in order to determine which of the two species has the greater tolerance to zinc ions in the soil.

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(3)

(Total 9 marks)

**Q20.**

The vegetation on a large heap of waste from an old mine was investigated. The table shows the results of the measurements of certain factors in 1m<sup>2</sup> frame quadrats placed on the south-facing slope.

Quadrat	Angle of slope / °	Vegetation cover / %	Moisture content of soil / %	pH of soil
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1	45	60	17.2	5.6
2	30	70	14.6	4.2
3	25	68	20.3	5.2
4	12	100	23.5	7.1
5	7	85	21.0	5.4
6	1	100	21.2	6.8

- (a) Which of the factors measured are abiotic?

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(1)

- (b) Describe how the investigators could obtain the value for vegetation cover in each quadrat.

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(2)

- (c) The correlation between vegetation cover and soil moisture content was tested statistically. These two factors were found to be positively correlated, and  $p < 0.05$ . Explain what this result means.

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(2)

- (d) At first the waste heap had no plants growing on it. Some of the first plants to colonise it were small herbaceous plants. Explain **one** way in which colonisation by herbaceous plants could change the physical environment.

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(2)

(Total 7 marks)

**Q21.**

The Solomon Islands are situated in the Pacific Ocean. The nearest large land mass is Australia, which is about 1500 km away. The biggest islands are mountainous, with large areas of tropical forest and a wide range of habitats. Some islands have a very high species diversity, and many species are endemic, that is they occur only in the Solomon Islands.

The table shows the total number of species on the islands in four vertebrate classes and the percentage which are endemic.

<b>Vertebrate class</b>	<b>Total number of species</b>	<b>Endemic species / %</b>
Mammals	53	36
Birds	223	20
Reptiles	61	16
Amphibians	17	53

- (a) How many reptile species are endemic?

\_\_\_\_\_

(1)

- (b) Suggest an explanation for the high proportion of endemic species on the Solomon Islands.

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(3)

(Total 4 marks)

**Q22.**

- (a) An ecosystem supports a certain size of population of a species. Predation is one biotic factor that can cause the size of this population to change.

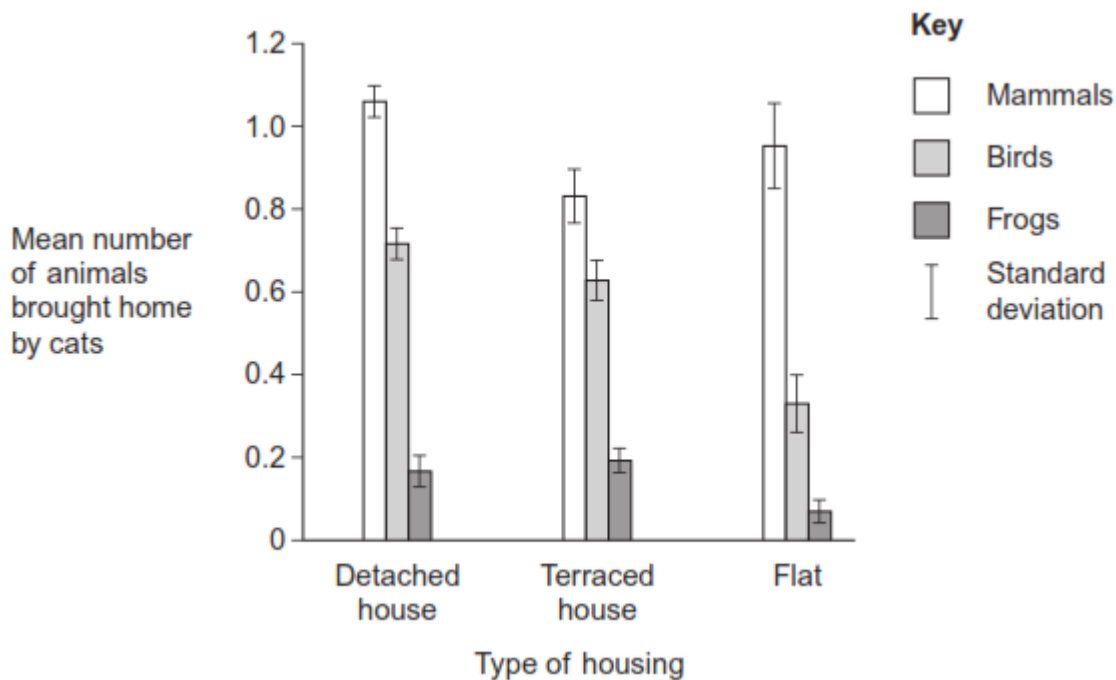
Give **one** other biotic factor that can cause the size of a population to change.

\_\_\_\_\_  
\_\_\_\_\_

(1)

- (b) Ecologists investigated predation by 555 domestic cats whose owners lived in different types of housing. They asked cat owners to record the number of mammals, birds and frogs that their cats brought home over a five-month period.

The graph shows their results.



(i) What do these data suggest about predation by domestic cats?

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(2)

(ii) Some scientists thought that the results of this investigation were **not** very reliable.

Suggest **one** reason why they might have thought that the results were **not** reliable.

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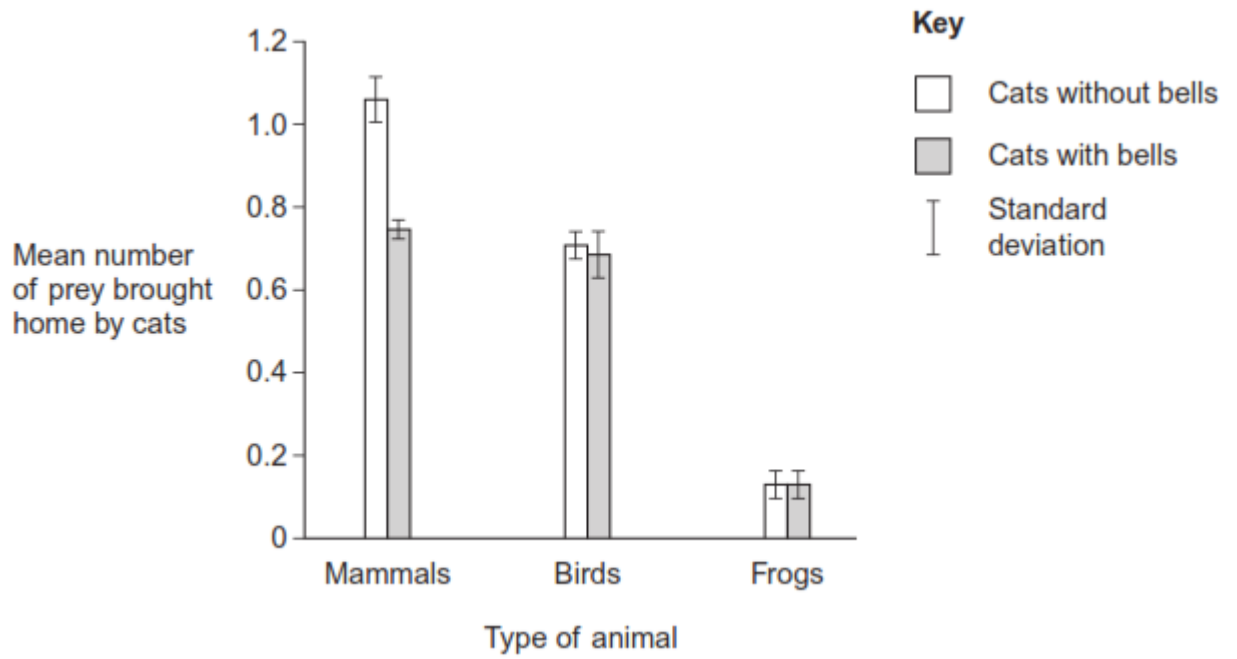


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(2)

(c) The ecologists investigated the effect of putting a bell on a cat's collar on its probability of catching prey. As in the first investigation, they asked cat owners to record the prey brought home by their cats. Half of the cats in this study had bells on their collars.

The graph shows the results.



(i) What was the hypothesis that the ecologists were investigating?

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(1)

(ii) What do these data suggest about the effect of putting a bell on a cat's collar?

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(2)

(Total 8 marks)

