

4.7 Genetic Information, Variation and Relationship – Investigating Biodiversity Questions.

Q1.

The UK government pays farmers to leave grassy strips around the edges of fields of crops. These grassy strips contain a variety of plant species. Leaving the strips is an attempt to encourage biodiversity of animals.

(a) Give **two** reasons why the grassy strips increase the biodiversity of animals.

1. _____

2. _____

(2)

A group of scientists investigated the effect of grassy strips on the biodiversity of soil animals.

- They divided a field into plots measuring 25 m × 5 m, with a 5-metre-wide grassy strip of land between each plot.
- Each year, they planted wheat in each of the plots.
- In the fifth year, they removed samples of soil from each plot where wheat was growing and from the grassy strips around them.
- They sorted each soil sample by hand for 40 minutes to collect the soil animals within the sample.

(b) The scientists decided to collect animals from the soil samples for 40 minutes.

Suggest how the scientists decided that 40 minutes was an appropriate time.

(2)

(c) The table below shows how the scientists published their results. They calculated mean values and two times the standard deviation (SD) of the mean.

Two standard deviations above and below the mean includes 95.4% of the data.

Group of animals	Mean number of animals per m² (± 2 × SD)		Mean number of species per m² (± 2 × SD)	
	Soil under wheat crop	Soil under grassy strips	Soil under wheat crop	Soil under grassy strips

Beetles	41.2 (\pm 6.4)	80.1 (\pm 10.1)	10.0 (\pm 1.6)	17.3 (\pm 1.0)
Centipedes	18.4 (\pm 3.6)	13.5 (\pm 1.0)	1.8 (\pm 0.3)	2.1 (\pm 0.2)
Earthworms	244.5 (\pm 27.1)	281.2 (\pm 39.4)	3.8 (\pm 0.3)	5.1 (\pm 0.2)
Millipedes	38.4 (\pm 12.2)	36.2 (\pm 2.9)	3.5 (\pm 0.3)	3.2 (\pm 0.2)
Woodlice	0.0	73.9 (\pm 8.5)	0.0	2.8 (\pm 0.2)

It would **not** be possible to calculate an index of diversity from the results in the table.

Explain why.

(1)

A summary of this research was published in a farming magazine. The journalist concluded that creating grassy strips around fields had little effect on the diversity of soil animals.

Do you agree with this conclusion?

Use evidence from the table to justify your answer.

(4)

(Total 9 marks)

Q2.

A student investigated the distribution of plants in a heathland.

The table below shows the number of plants he found in a sample area of 1 m².

Species of plant	Number counted in 1 m ²
Common heather	2
Red fescue	14
Vetch	2
White clover	8

(a) What is the species richness of this sample?

(1)

(b) Calculate the index of diversity of this sample. Show your working.

Use the following formula to calculate the index of diversity.

$$d = \frac{N(N - 1)}{\sum n(n - 1)}$$

where N is the total number of organisms of all species
and n is the total number of organisms of each species

Index of diversity = _____

(2)

(c) Suggest how this student would obtain data to give a more precise value for the index of diversity of this habitat.

(2)

(Total 5 marks)

Q3.

Species richness and an index of diversity can be used to measure biodiversity within a

community.

- (a) What is the difference between these two measures of biodiversity?

(1)

Scientists investigated the biodiversity of butterflies in a rainforest. Their investigation lasted several months.

The scientists set one canopy trap and one understorey trap at five sites.

- The canopy traps were set among the leaves of the trees 16–27 m above ground level.
- The understorey traps were set under trees at 1.0–1.5 m above ground level.

The scientists recorded the number of each species of butterfly caught in the traps. The table below summarises their results.

Species of butterfly	Mean number of butterflies		P value
	In canopy	In understorey	
<i>Prepona laertes</i>	15	0	< 0.001
<i>Archaeoprepona demophon</i>	14	37	< 0.001
<i>Zaretis itys</i>	25	11	> 0.05
<i>Memphis arachne</i>	89	23	< 0.001
<i>Memphis offa</i>	21	3	< 0.001
<i>Memphis xenocles</i>	32	8	< 0.001

- (b) The traps in the canopy were set at 16–27 m above ground level. Suggest why there was such great variation in the height of the traps.

(1)

- (c) By how many times is the species diversity in the canopy greater than in the understorey? Show your working.

Use the following formula to calculate species diversity.

$$d = \frac{N(N - 1)}{\sum n(n - 1)}$$

where N is the total number of organisms of all species and n is the total number of organisms of each species.

Answer = _____

(3)

- (d) The scientists carried out a statistical test to see if the difference in the distribution of each species between the canopy and understorey was due to chance. The P values obtained are shown in the table.

Explain what the results of these statistical tests show.

(Extra space) _____

(3)

(Total 8 marks)

Q4.

Ecologists investigated the size of an insect population on a small island. They used a mark-release-recapture method. To mark the insects they used a fluorescent powder. This powder glows bright red when exposed to ultraviolet (UV) light.

- (a) The ecologists captured insects from a number of sites on the island. Suggest how they decided where to take their samples.

(2)

- (b) Give **two** assumptions made when using the mark-release-recapture method.

1. _____

2. _____

(2)

(c) Suggest the advantage of using the fluorescent powder in this experiment.

(2)

The ecologists did **not** release any of the insects they captured 1–5 days after release of the marked insects.

The table below shows the ecologists' results.

Days after release	Number of marked insects remaining in population	Number of insects captured	Number of captured insects that were marked
1	1508	524	78
2	1430	421	30
3	1400	418	18
4	1382	284	2
5	1380	232	9

(d) Calculate the number of insects on this island 1 day after release of the marked insects.

Show your working.

Answer = _____

(2)

(e) The ecologists expected to obtain the same result from their calculations of the number of insects on this island on each day during the period 1–5 days after release. In fact, their estimated number increased after day 1.

During the same period, the number of insects they caught decreased.

The method used by the ecologists might have caused these changes.

Use the information provided to suggest **one** way in which the method used by the

ecologists might have caused the increase in their estimates of the size of the insect population.

(2)

(Total 10 marks)

Q5.

- (a) What is meant by species diversity?

(1)

- (b) Give **two** pieces of information needed to calculate an index of diversity for a community.

1. _____

2. _____

(2)

- (c) A scientist investigated the effect sewage entering a river had on the distribution of organisms living in the river. Where sewage entered the river, he found a high density of organisms but a low index of diversity.

Suggest how sewage entering the river could explain the scientist's findings.

(2)

- (d) A second scientist repeated the investigation of the first scientist at the same place. The second scientist obtained a high index of diversity.

- (i) Explain how the second set of results affects the ability of the scientists to

make any conclusions about the effect of sewage on the index of diversity.

(2)

- (ii) Suggest the additional steps that should be taken by the scientists before they are able to make any conclusions about the effect of sewage entering this river.

(1)

(Total 8 marks)

Q6.

- (a) What **two** measurements are needed to calculate an index of diversity?

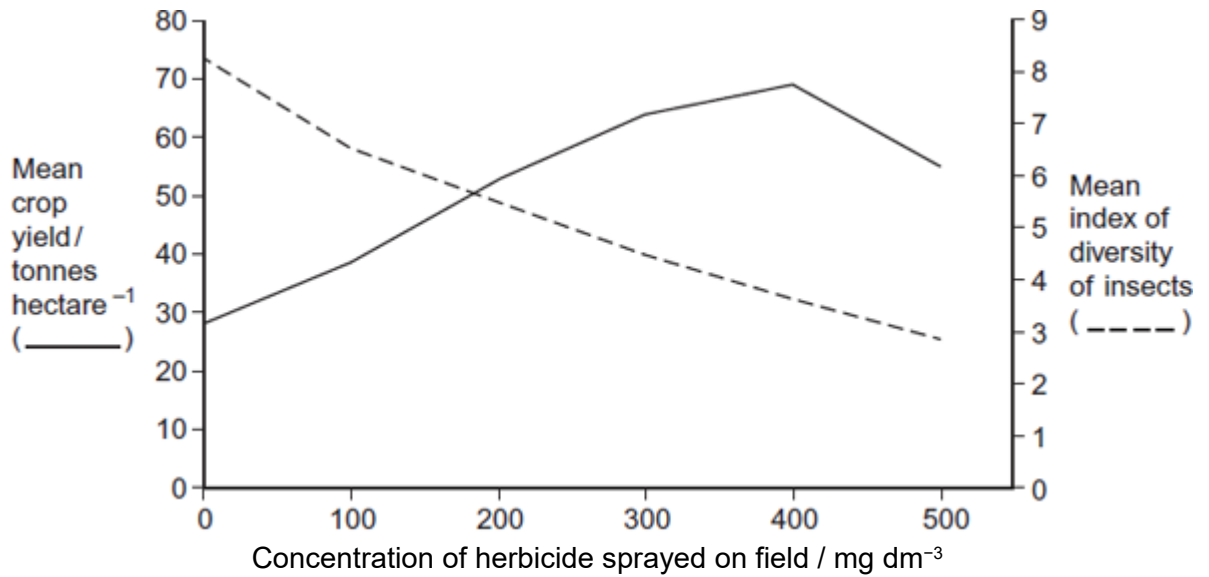
1. _____

2. _____

(2)

- (b) A herbicide is a chemical used to kill weeds. Ecologists investigated the effect of a herbicide on crop yield and the diversity of insects. They sprayed different fields with the same volume of different concentrations of the herbicide. At harvest, the ecologists determined the mean crop yield and the mean index of diversity of insects for fields that had received the same concentration of the herbicide.

The figure below shows their results.



- (i) Some fields acted as controls. They were sprayed with a solution that did not contain the herbicide. Explain the purpose of these control fields.

(1)

- (ii) Suggest an explanation for the relationship between the concentration of herbicide and the mean crop yield.

(2)

- (iii) Explain the relationship between the concentration of herbicide and the mean index of diversity of insects.

(Extra space) _____

Q7.

Scientists investigated the species of insects found in a wood and in a nearby wheat field. The scientists collected insects by placing traps at sites chosen at random both in the wood and in the wheat field.

The table shows the data collected in the wood and in the wheat field.

Species of insect	Number of organisms of each species	
	Wood	Wheat field
Bird-cherry oat aphid	0	216
Beech aphid	563	0
Large white butterfly	20	0
Lacewing	12	3
7-spot ladybird	36	0
2-spot ladybird	9	1
Total number of organisms of all species	640	220

- (a) The scientists collected insects at sites chosen at random. Explain the importance of the sites being chosen at random.

(1)

- (b) (i) Use the formula

$$d = \frac{N(N-1)}{\sum n(n-1)}$$

to calculate the index of diversity for the insects caught in the wood, where

d = index of diversity

N = total number of organisms of all species

n = total number of organisms of each species

Show your working.

Answer _____

(2)

- (ii) Without carrying out any further calculations, estimate whether the index of diversity for the wheat field would be higher or lower than the index of diversity for the wood.

Explain how you arrived at your answer.

(2)

- (c) A journalist concluded that this investigation showed that farming reduces species diversity.
Evaluate this conclusion.

(2)

- (d) Farmers were offered grants by the government to plant hedges around their fields.
Explain the effect planting hedges could have on the index of diversity for animals.

(2)

(Total 9 marks)

Q8.

(a) A student investigated the diversity of plants at several sites on a golf course. At each site she took a large number of random samples.

(i) Explain the importance of taking a large number of samples at each site.

(1)

(ii) Explain the importance of taking samples at random.

(1)

The student collected data from one part of the golf course and calculated an index of diversity.

The table shows her data.

Species	Number of plants per m ²
Sheep's fescue	11
Creeping buttercup	6
Clover	5
Dandelion	2
Sheep's sorrel	1
Lady's bedstraw	7
Stemless thistle	4

The index of diversity can be calculated from the formula

$$d = \frac{N(N - 1)}{\sum n(n - 1)}$$

where

d = index of diversity

N = total number of organisms of all species

n = total number of organisms of each species

- (b) Use the formula to calculate the index of diversity for the plants on this part of the golf course. Show your working.

Answer _____

(2)

- (c) The golf course was surrounded by undeveloped grassland from which it had been produced.

The golf course had

- some areas of very short grass which was cut frequently
- some areas of longer grass which was cut less frequently
- some areas of long grass and shrubs which were never cut.

The index of diversity for the insects on the golf course was higher than that for the surrounding undeveloped grassland.

Explain the effect of developing this golf course on the index of diversity of insects.

(Extra space) _____

(3)

(Total 7 marks)

Q9.

Costa Rica is a Central American country. It has a high level of species diversity.

- (a) There are over 12 000 species of plants in Costa Rica. Explain how this has resulted in a high species diversity of animals.

(2)

- (b) The number of species present is one way to measure biodiversity. Explain why an index of diversity may be a more useful measure of biodiversity.

(2)

- (c) Crops grown in Costa Rica are sprayed with pesticides. Pesticides are substances that kill pests. Scientists think that pollution of water by pesticides has reduced the number of species of frog.

- (i) Frogs lay their eggs in pools of water. These eggs are small. Use this information to explain why frogs' eggs are very likely to be affected by pesticides in the water.

(2)

- (ii) An increase in temperature leads to evaporation of water. Suggest how evaporation may increase the effect of pesticides on frogs' eggs.

(1)

(Total 7 marks)

Q10.

- (a) What information is required to calculate an index of diversity for a particular community?

(b) Farmers clear tropical forest and grow crops instead. Explain how this causes the diversity of insects in the area to decrease.

Farmers manage the ditches that drain water from their fields. If they do not, the ditches will become blocked by plants. Biologists investigated the effects of two different ways of managing ditches on farmland birds.

- Ditch **A** was cleared of plants on both banks
- Ditch **B** was cleared of plants on one bank.

The graph shows the number of breeding birds of all species along the two ditches, before and after management.



(c) (i) The points on the graph have been joined with straight lines rather than with a smooth curve. Explain why they have been joined with straight lines.

(1)

- (ii) It would have been useful to have had a control ditch in this investigation. Explain why.

(1)

- (d) A farmer who wanted to increase the diversity of birds on his land read about this investigation.

He concluded that clearing the plants from one bank would not decrease diversity as much as clearing the plants from both banks. Evaluate this conclusion.

(3)

(Total 9 marks)

Q11.

- (a) A fish uses its gills to absorb oxygen from water. Explain how the gills of a fish are adapted for efficient gas exchange.

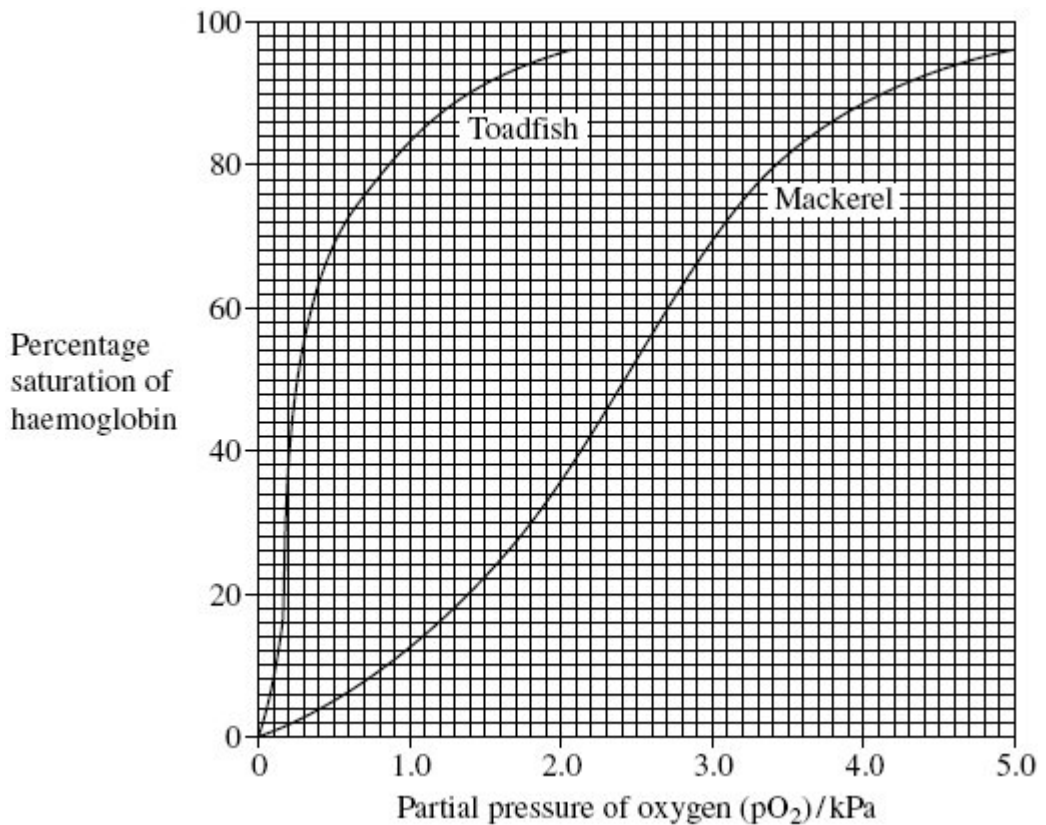
(6)

Mackerel live in the surface waters of the sea. Toadfish live on the seabed in deep water.

- (b) The concentration of oxygen is higher in the surface waters than it is in water close to the seabed. Suggest why.

(2)

- (c) The graph shows oxygen dissociation curves for toadfish haemoglobin and for mackerel haemoglobin.



Explain how the shape of the curve for toadfish haemoglobin is related to where the toadfish is normally found.

(2)

- (d) Scientists analysed the sequence of amino acids in one polypeptide chain in the haemoglobin of four different species of ape. The only difference they found affected the amino acids at three positions in the polypeptide chain. Their results are shown in the table. The letters are abbreviations for particular amino acids.

Species	Position 87	Position 104	Position 125
Chimpanzee	T	R	P
Bonobo	T	R	P
Gorilla	T	K	P
Orang utan	K	R	Q

What information do the data in the table suggest about the relationships between the chimpanzee, the bonobo and the gorilla? Explain your answer.

(2)

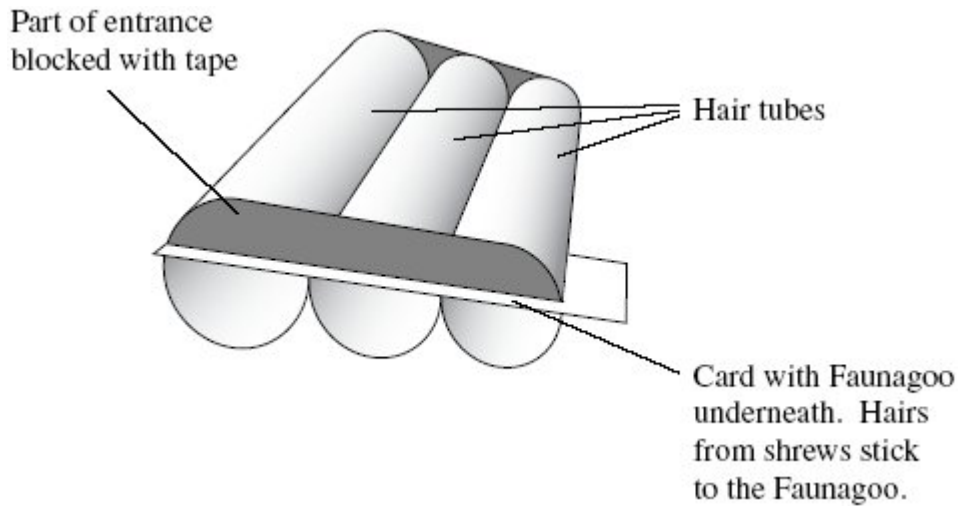
(Total 12 marks)

Q12.

Shrews are small mammals. Three species of shrew live in mainland Britain. The table shows some features of these shrews.

Species	Mean body mass / g	Mean length of head and body / mm	Food
Common shrew	10	79	Mainly insects and other small invertebrates
Pygmy shrew	5	58	
Water shrew	13	85	

A team of biologists investigated a method of estimating the abundance of shrews. They used plastic tubes, called hair tubes. Some of the hairs from a shrew that enters one of these tubes stick to glue in the tube. These hairs can be used to identify the species of shrew. The diagram shows a set of these hair tubes.



- (a) (i) Faunagoo is a glue that remains sticky after wetting and drying. Explain the advantage of using Faunagoo in these hair tubes.

(1)

- (ii) The diagram shows that the biologists partly blocked the entrances to the tubes with tape. Suggest why they partly blocked the entrances.

(1)

- (b) The biologists needed to find a way of distinguishing between the hairs of the three species of shrew. They collected hairs from shrews of each species. For each species, they selected hairs at random and made different measurements.

Explain why the biologists selected the hairs at random.

(1)

- (c) Repeatable measurements are measurements of the same feature that are very similar.

In this investigation, each measurement was made by two observers. This helped the team to check the repeatability of these measurements.

- (i) Explain why it was important to check the repeatability of the measurements.

(2)

- (ii) You could use a scatter diagram to check the repeatability of measurements made by two observers. Describe how.

(2)

- (d) The biologists used hair tubes to find the abundance of shrews along the edges of some fields. They also used traps that caught shrews without harming them. They selected areas where all three species of shrew were present.

- They put sets of hair tubes at 5 m intervals along the edges of the fields. They inspected the tubes one week later and recorded the number of sets of tubes that contained shrew hairs. They called this the hair tube index.
- At each site where they used hair tubes, they set traps immediately after using the hair tubes. They recorded the number of different shrews caught in these traps.

- (i) The research team found the hair tube index. Explain why they could not use the hair tubes to find the total number of shrews present.

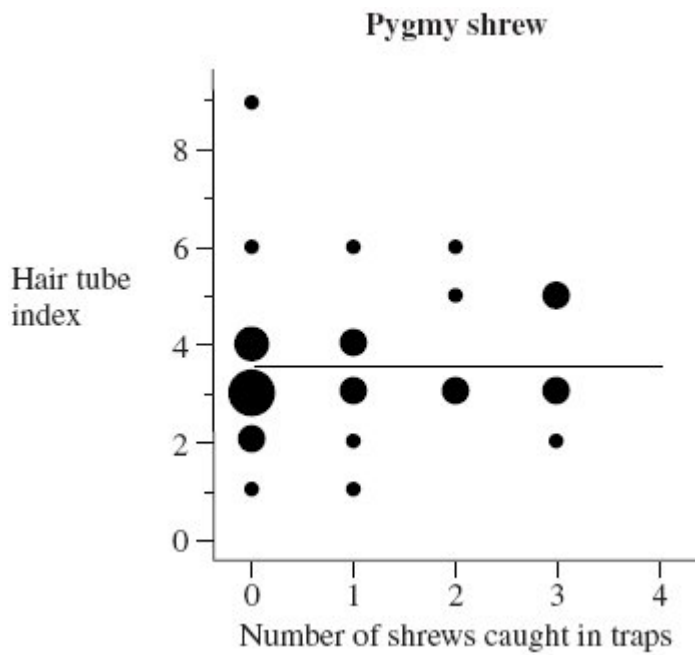
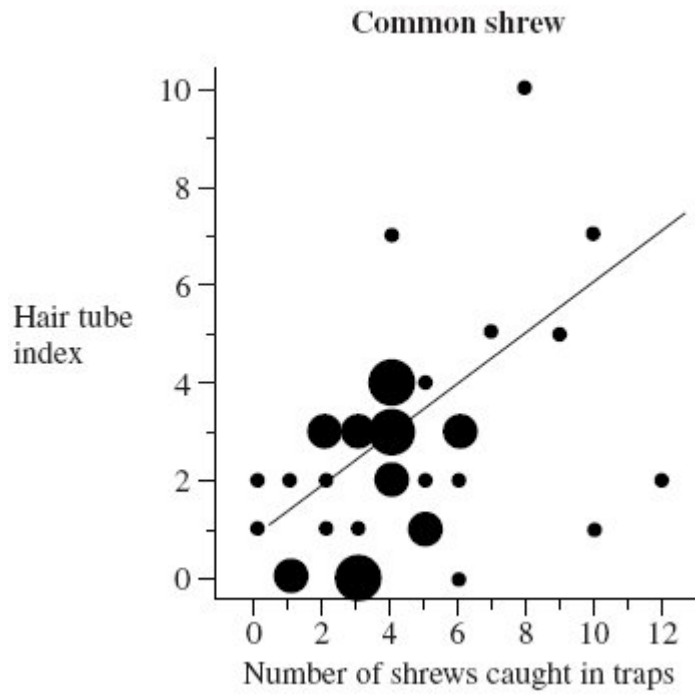
(1)

- (ii) The research team set the traps immediately after using the hair tubes. Explain why setting the traps immediately after using the hair tubes would make comparisons between the two methods more reliable.

(2)

The graphs are types of scatter diagram called bubble plots. They show hair tube index plotted against the number of shrews caught in traps. The area of the bubble is

proportional to the number of records plotted.



- (e) Explain why a statistical test was necessary in analysing the results for the common shrew. Use the terms chance and probability in your answer.

(2)

- (f) (i) The biologists concluded that hair tubes were a reliable way of measuring the abundance of common shrews. Give evidence from the graph to support this conclusion.

(1)

- (ii) Use information in this question to evaluate the use of hair tubes as a way of measuring the abundance of pygmy shrews.

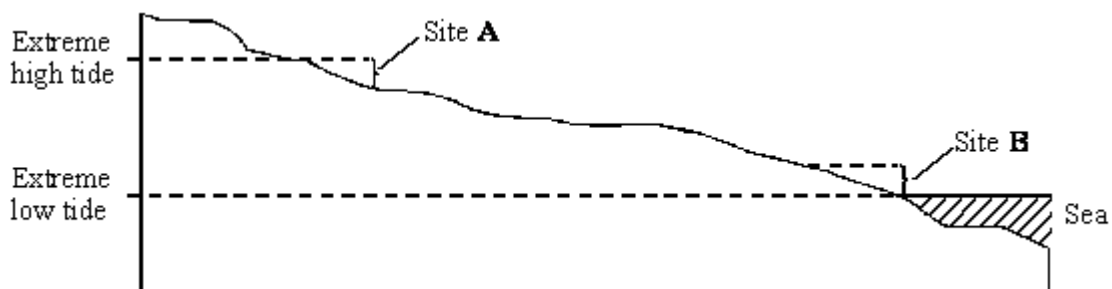
(2)

(Total 15 marks)

Q13.

Parts of the sea shore form a very hostile environment for living organisms. Twice each day the incoming and outgoing tides alternately cover the organisms on the sea shore with water and then leave them exposed. The force of the waves could also dislodge any organisms that were not firmly attached.

The diagram shows a section through a rocky shore. Two sites were studied: site **A** was on the upper shore and site **B** on the lower shore.



The table shows the seaweeds that were found growing at sites **A** and **B**.

Site A: upper shore	Mean number per m ²	Site B: lower shore	Mean number per m ²
<i>Ascophyllum nodosum</i>	2	<i>Corallina officinalis</i>	31
<i>Fucus spiralis</i>	10	<i>Fucus serratus</i>	8
<i>Fucus vesiculosus</i>	4	<i>Laminaria digitata</i>	15
<i>Pelvetia canaliculata</i>	6	<i>Laminaria hyperborea</i>	3
		<i>Laminaria saccharina</i>	6
		<i>Laurencia pinnatifida</i>	18
		<i>Palmaria palmata</i>	6

Index of diversity		Index of diversity	4.77
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(a) (i) Use the formula
$$d = \frac{N(N-1)}{\sum n(n-1)}$$

where **d** = index of diversity
N = total number of organisms of all species
n = total number of organisms of a particular species

to calculate the index of diversity for the seaweeds growing at site **A**.
 Show your working.

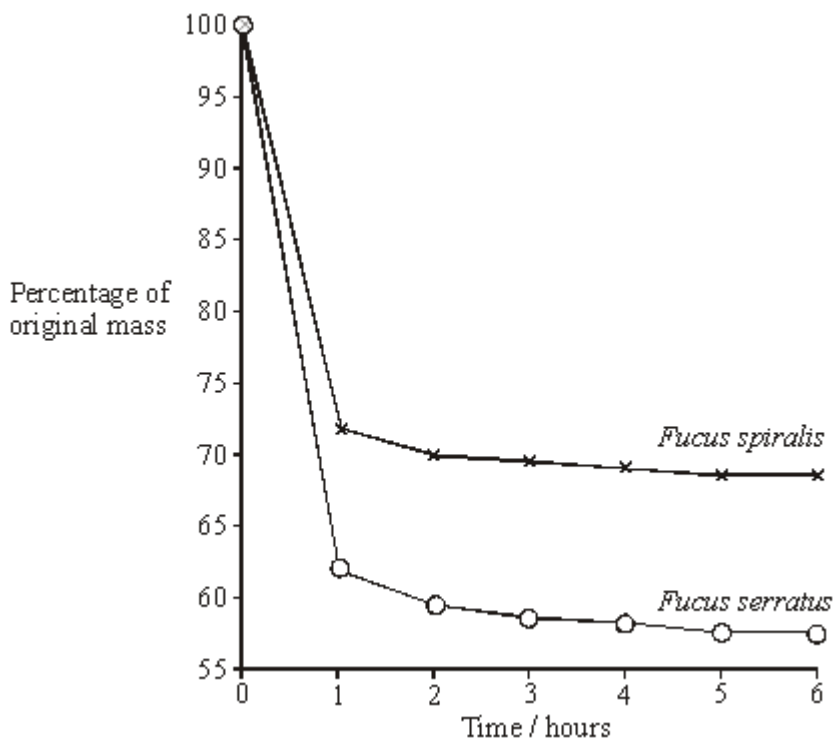
Index of diversity at site **A** = _____

(2)

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

(1)

(b) Availability of water is one abiotic factor which determines the distribution of seaweeds. The graph shows loss in mass due to water evaporation for two of the seaweed species. The two seaweeds belong to the same genus but one was found only on the upper shore and the other only on the lower shore.



Explain how the results shown in the graph relate to the distribution of these two seaweeds on the sea shore.

(3)
(Total 6 marks)

Q14.

- (a) The cheetah, *Acinonyx jubatus*, and other cat species belong to the family Felidae. Complete the table to show the classification of the cheetah.

Kingdom	Animalia
	Chordata
	Mammalia
	Carnivora
Family	Felidae
Genus	

(2)

- (b) This system of classification is described as hierarchical. Explain what is meant by a hierarchical classification.

(1)

- (c) Despite differences in form, leopards, tigers and lions are classified as different species of the same genus. Cheetahs, although similar in form to leopards, are classified in a different genus.

- (i) Describe **one** way by which different species may be distinguished.

(1)

- (ii) Suggest **two** other sources of evidence which scientists may have used to classify cheetahs and leopards in different genera.

1. _____

2. _____

(2)
 (Total 6 marks)

Q15.

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 1m² frame quadrats placed on the south-facing slope.

Quadrat	Angle of slope / °	Vegetation cover / %	Moisture content of soil / %	pH of soil
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?

(1)

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

(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.

(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.

(2)

(Total 7 marks)

