

AQA A-LEVEL • 7402

BIOLOGY



EXAM QUESTION PACK

3.4.7 INVESTIGATING DIVERSITY

SCORE

/ 491

PERCENTAGE

%

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Q1.

- (a) Compare and contrast the DNA in eukaryotic cells with the DNA in prokaryotic cells.

(5)

- (b) Haemoglobins are chemically similar molecules found in many different species.

Differences in the primary structure of haemoglobin molecules can provide evidence of phylogenetic (evolutionary) relationships between species.

Explain how.

(5)

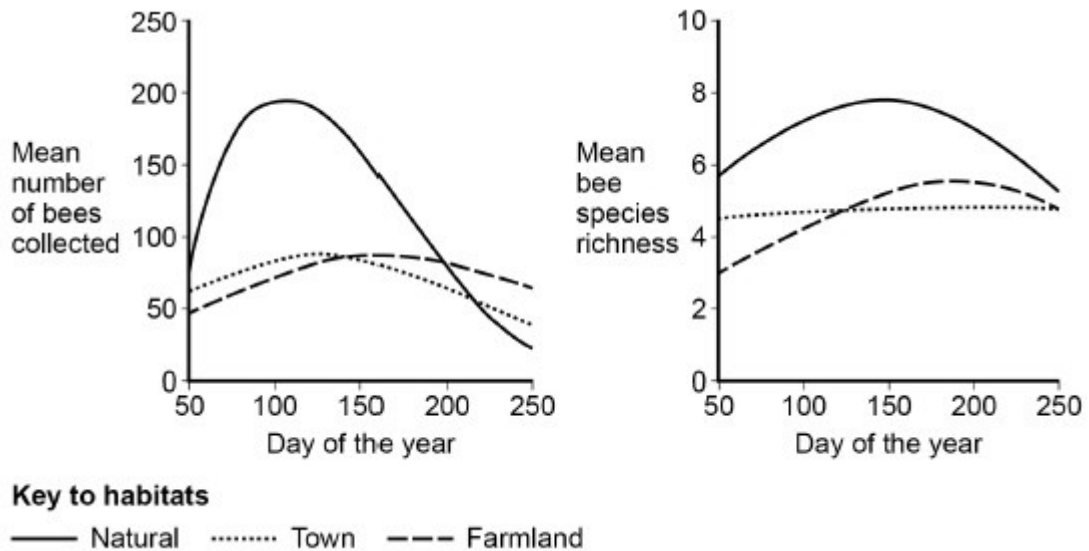
(Total 10 marks)

Q2.

Bees are flying insects that feed on nectar made in flowers. There are many different species of bee.

Scientists investigated how biodiversity of bees varied in three different habitats during a year. They collected bees from eight sites of each habitat four times per year for three years.

The scientists' results are shown below in the graphs in the form they presented them.



(a) What is meant by 'species richness'?

(1)

(b) From the data in the graphs, a student made the following conclusions.

1. The natural habitat is most favourable for bees.
2. The town is the least favourable for bees.

Do the data in the graphs support these conclusions? Explain your answer.

1. The natural habitat is most favourable for bees.

2. The town is the least favourable for bees.

(4)

- (c) The scientists collected bees using a method that was ethical and allowed them to identify accurately the species to which each belonged.

In each case, suggest **one** consideration the scientists had taken into account to make sure their method

1. was ethical.

2. allowed them to identify accurately the species to which each belonged.

(2)

1. _____
- _____
- _____
- _____
- _____
- _____

(2)

(2)
(Total 11 marks)

Q3.

A student investigated the effect of three types of disinfectant on the growth of *Lactobacillus* bacteria.

During the investigation, the student:

- boiled the agar before pouring the agar plates
- transferred 0.5 cm³ of a diluted liquid culture of *Lactobacillus* onto each agar plate
- left some agar plates as controls
- added to other agar plates different concentrations of the disinfectants as shown in the table in part (a).

After 2 days, she counted the number of colonies of bacteria on each agar plate.

(a) Explain the purpose of:

boiling the agar _____

transferring the same volume of liquid culture onto each agar plate.

(2)

The three disinfectants used by the student were Lysol, propan-2-ol and ammonia.

The table shows the student's results.

Concentration of disinfectant / arbitrary units	Number of colonies of bacteria		
	Lysol	Propan-2-ol	Ammonia
0	300	300	300
5	0	290	300
10	0	195	295
15	0	0	275
20	0	0	240

The liquid culture the student transferred was diluted by 1 in 10 000 (10^{-4}).

- (b) Use information in this question to calculate how many bacteria were present in 1 cm³ of undiluted liquid culture.

Answer = _____

(2)

- (c) The student concluded that the minimum concentration of propan-2-ol needed to stop the growth of *Lactobacillus* was 15 units. This conclusion is incorrect.

Describe how you could obtain a more accurate estimate of the minimum concentration of propan-2-ol needed to stop the growth of this species of bacterium.

(2)

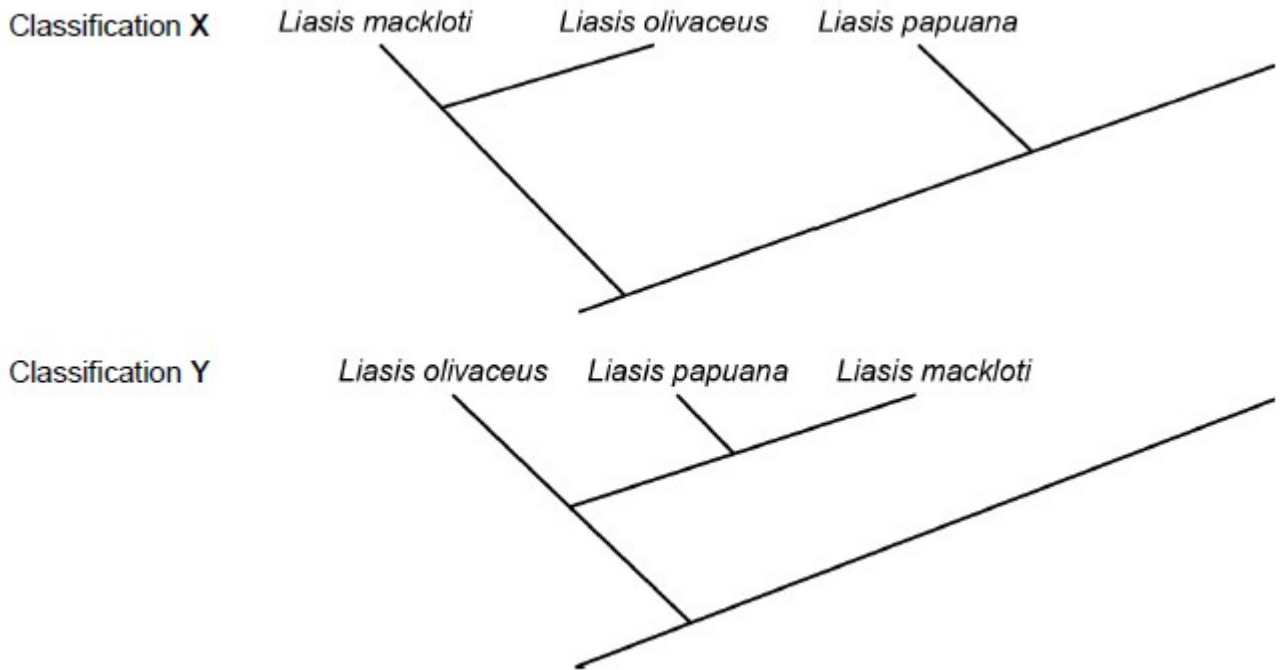
(Total 6 marks)

Q4.

The diagram shows two different ways of classifying the same three species of snake.

- Classification **X** is based on the frequency of observable characteristics
- Classification **Y** is based on other comparisons of genetic characteristics.

All three species of snake belong to the Python family.



- (a) What do these classifications suggest about the evolutionary relationships between these species of snake?

Classification X _____

Classification Y _____

(2)

- (b) Complete the table below to show the missing names of the taxa when classifying these snakes.

Taxon (hierarchical order)	Name
	Eukaryote
	Animal
	Chordata
	Reptilia

	Squamata
Family	Python

(1)

- (c) There is a debate about the name of one of these species of snake. Some scientists name it *Liasis papuana* and other scientists name it *Apodora papuana*.

Give the name of the taxon about which the scientists disagree.

(1)

- (d) State **three** comparisons of genetic diversity that the scientists used in order to generate Classification Y.

1.

2.

3.

(3)

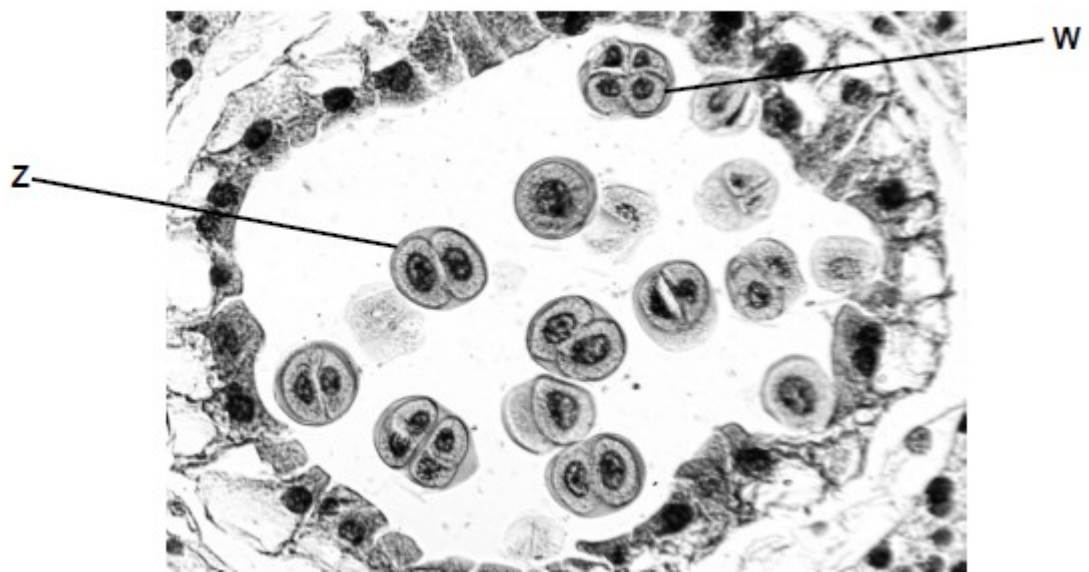
(Total 7 marks)

Q5.

- (a) Contrast how an optical microscope and a transmission electron microscope work **and** contrast the limitations of their use when studying cells.

(6)

- (b) The diagram shows an image from an optical microscope of meiosis occurring in a flower bud of a flowering plant. **W** and **Z** are undergoing meiosis.



Explain the appearance of **W** and **Z**.

(4)

- (c) An environmental scientist investigated a possible relationship between air pollution and the size of seeds produced by one species of tree.

He was provided with a very large number of seeds collected from a population of trees in the centre of a city and also a very large number of seeds collected from a

population of trees in the countryside.

Describe how he should collect and process data from these seeds to investigate whether there is a difference in seed size between these two populations of trees.

(5)

(Total 15 marks)

Q6.

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 m ² ($\pm 2 \times \text{SD}$)		Mean number of species per m ² ($\pm 2 \times \text{SD}$)	
	Soil under wheat crop	Soil under grassy strips	Soil under wheat crop	Soil under grassy strips
Beetles	41.2 (± 6.4)	80.1 (± 10.1)	10.0 (± 1.6)	17.3 (± 1.0)
Centipedes	18.4 (± 3.6)	13.5 (± 1.0)	1.8 (± 0.3)	2.1 (± 0.2)
Earthworms	244.5 (± 27.1)	281.2 (± 39.4)	3.8 (± 0.3)	5.1 (± 0.2)
Millipedes	38.4 (± 12.2)	36.2 (± 2.9)	3.5 (± 0.3)	3.2 (± 0.2)
Woodlice	0.0	73.9 (± 8.5)	0.0	2.8 (± 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)

Q7.

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)

Q8.

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.

(3)

(Total 8 marks)

Q9.

Table 1 shows how a bird called the bluethroat (*Luscinia svecica*) is classified by biologists.

Table 1

Taxon	Name of taxon
Domain	Eukaryota
	Animalia

	Chordata
	Aves
	Passeriformes
	Muscicapidae
Genus	
Species	

(a) Complete **Table 1** by filling the seven blank spaces with the correct terms.

(2)

A group of scientists investigated genetic diversity in different species of bird. For each species, the scientists:

- collected feathers from a large number of birds
- extracted DNA from cells attached to each feather
- analysed the samples of DNA to find genetic diversity.

Table 2 summarises their results.

Table 2

Species of bird	Number of genes examined	Number of genes examined that showed genetic diversity
Willow flycatcher	708	197
House finch	269	80
Bluethroat	232	81

(b) In this investigation, what is meant by **genetic diversity**?

(1)

(c) The scientists concluded that the bluethroat showed greater genetic diversity than the willow flycatcher. Explain why they reached this conclusion. Use calculations to support your answer.

(2)

Q10.

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)

Q11.

- (a) Human papilloma virus (HPV) is the main cause of cervical cancer. A vaccine has been developed to protect girls and women from HPV.

Describe how giving this vaccine leads to production of antibody against HPV.

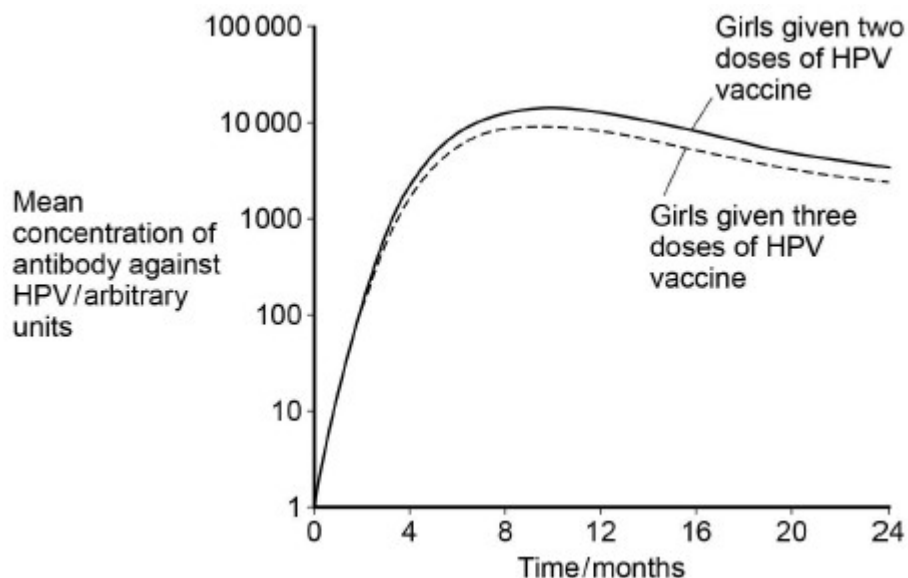
(4)

(b) Doctors investigated whether it was better to give two or three doses of the HPV vaccine. They determined the mean concentration of antibody against HPV in blood samples from girls who were given either two or three doses of the vaccine.

- Girls given two doses received an initial vaccination, followed by a second at 6 months.
- Girls given three doses received an initial vaccination, followed by a second at 1 month and a third at 6 months.

The doctors measured the concentration of antibody each month.

The results are shown below.



What do these results suggest about whether it is better to give two or three doses of the vaccine? Give reasons for your answer.

(2)

- (c) The doctors carried out a statistical test to determine whether the antibody concentrations were significantly different in girls given two doses of the vaccine, compared with those given three doses. They determined the mean concentrations of antibody 9 months after the first dose of vaccine.

What statistical test should the doctors have used? Give the reason for your choice.

Test _____

Reason _____

(1)

- (d) There is genetic diversity within HPV.

Give **two** ways doctors could use base sequences to compare different types of HPV.

1. _____

2. _____

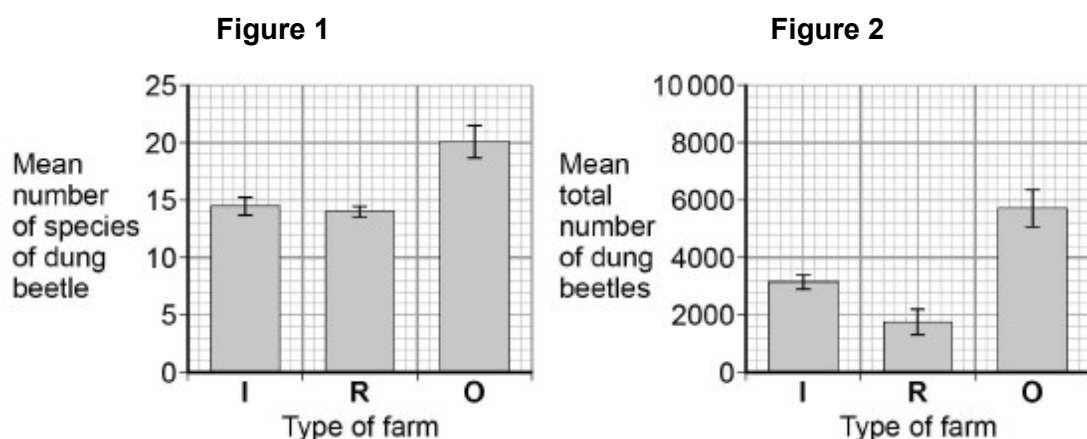
(2)

(Total 9 marks)

Q12.

Scientists investigated the effect of different types of animal farming on the diversity and number of dung beetles. They determined the number of dung beetle species and their total number on intensive (I), rough grazing (R) and organic (O) farms.

Figure 1 and **Figure 2** show some of their results.



Key: I Standard deviation

- (a) What is the mean species richness for dung beetles on the rough grazing farms?

(1)

- (b) In addition to the information provided in **Figures 1 and 2**, what other measurement is required to calculate an index of diversity for dung beetles?

(1)

- (c) Explain what the standard deviations suggest about the difference in mean total number of dung beetles between the different types of farm.

(2)

- (d) The scientists placed traps to collect the dung beetles at sites chosen at random.
Explain the importance of the sites being chosen at random.

(1)

- (e) On the intensive farms, the farmers had removed hedges to increase land for grazing. This resulted in a decrease in the diversity of birds on these farms.

Explain why the removal of hedges caused a decrease in the diversity of birds.

(3)
(Total 8 marks)

Q13.

(a) Explain what is meant by a

(i) phylogenetic group

(1)

(ii) species.

(2)

The classification of tigers and clouded leopards is shown in **Table 1**.

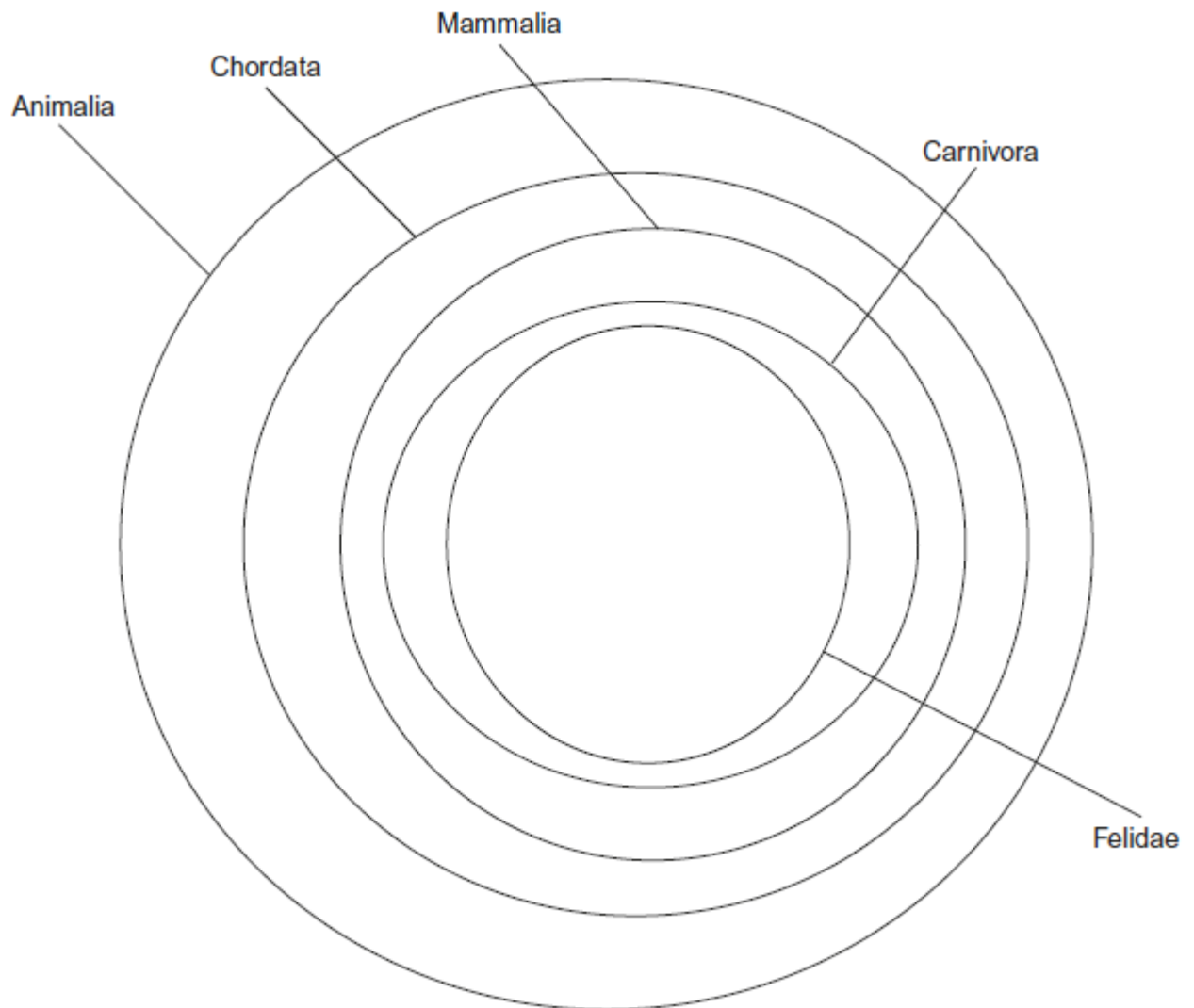
Table 1

Taxonomic group	Tiger	Clouded Leopard
Kingdom	Animalia	Animalia
	Chordata	Chordata
	Mammalia	Mammalia
Order	Carnivora	Carnivora
	Felidae	Felidae
	Panthera	Neofelis
Species	Tigris	Nebulosa

(b) Complete **Table 1** by adding the **four** other taxonomic groups to which the tiger and clouded leopard belong.

(1)

The circles in the diagram represent the hierarchy of taxonomic groups for the classification shown in **Table 1**.



- (c) Draw additional circles on the diagram and label them to include all the information about the tiger and clouded leopard shown in **Table 1**.

(2)

Table 2 shows part of the nucleotide sequence in a gene in populations of tigers living in different parts of the world.

Table 2

Siberian tiger	G C A C C G T
South China tiger	A C G C C G C
Sumatran tiger	A C G C C G C

- (d) Explain what the information in **Table 2** suggests about the phylogenetic relationships between these tigers.

(2)
(Total 8 marks)

Q14.

- (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)

Q15.

Scientists investigated the presence of bacteria resistant to the antibiotic neomycin in turkeys, chickens and the farmers who kept the turkeys and chickens. They looked for *Escherichia coli* (*E. coli*) resistant to neomycin. At 46 farms, the scientists obtained samples of bacteria from faeces of turkeys, turkey farmers, chickens and chicken farmers. The turkey farmers very often used turkey food containing neomycin. The chicken farmers did not use chicken food containing neomycin very often.

The bacteria were grown on nutrient agar in cultures. The nutrient agar contained neomycin. Any resistant bacteria grew and divided to form visible colonies.

The results are shown in the table

Samples taken from	Percentage of samples of faeces containing <i>E. coli</i> resistant to neomycin
Turkeys	81
Turkeys farmers	57
Chickens	24
Chicken farmers	8

- (a) Suggest **two** hypotheses the scientists were testing in this investigation.

Hypothesis 1 _____

Hypothesis 2 _____

(2)

- (b) (i) Describe what the results in the table show.

(2)

- (ii) Suggest and explain **one** reason for the observed differences in percentage of neomycin-resistant *E. coli* in turkeys and chickens.

(2)

- (c) The scientists followed strict safety guidelines when collecting samples of faeces. Apart from the risk of contamination from *E. coli* this was especially important when collecting samples from humans.

Explain why.

(1)

- (d) Use the information provided to identify and explain **one** way in which the scientists increased the reliability of their method.

(2)

- (e) Suggest how the scientists could use DNA to investigate whether the neomycin-

resistant bacteria in farmers were identical to the strain of bacteria in the birds they kept.

(2)

- (f) At one time, most animal feeds contained antibiotics that increased the rate of animal growth. In the UK, fewer animal feeds now contain antibiotics.

Suggest reasons why.

(4)

(Total 15 marks)

Q16.

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

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

(5)

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

Suggest how they came to this conclusion.

(2)

(Total 7 marks)

Q17.

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

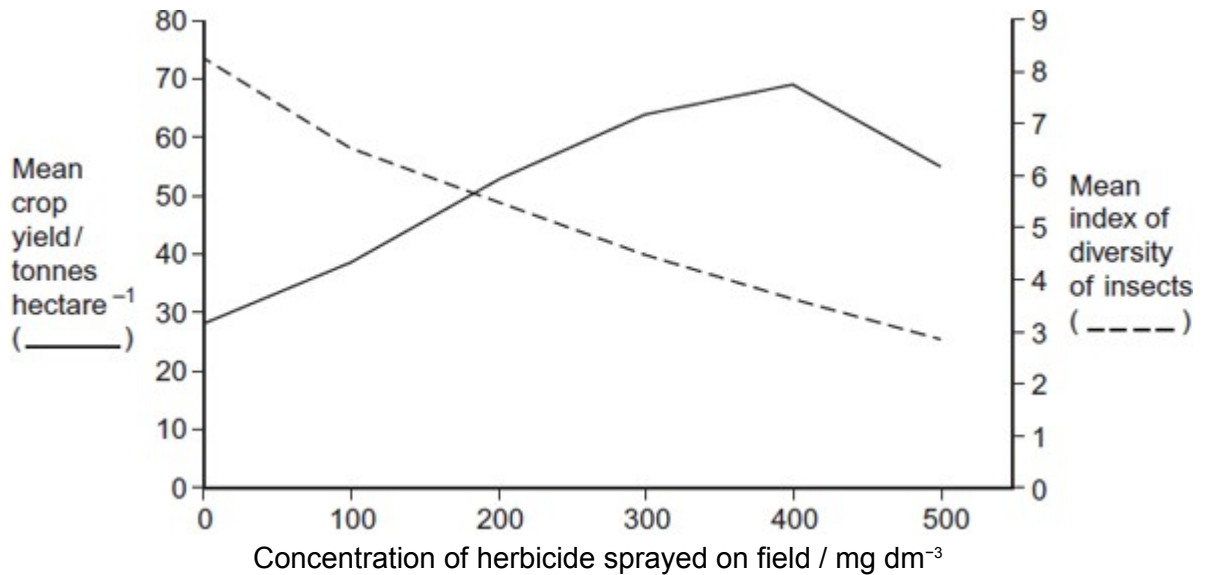
1. _____

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.

(3)

(Total 8 marks)

Q18.

Farmland previously used for growing crops was left for 30 years and developed into woodland. During this period, ecologists recorded an increase in the diversity of birds in the area.

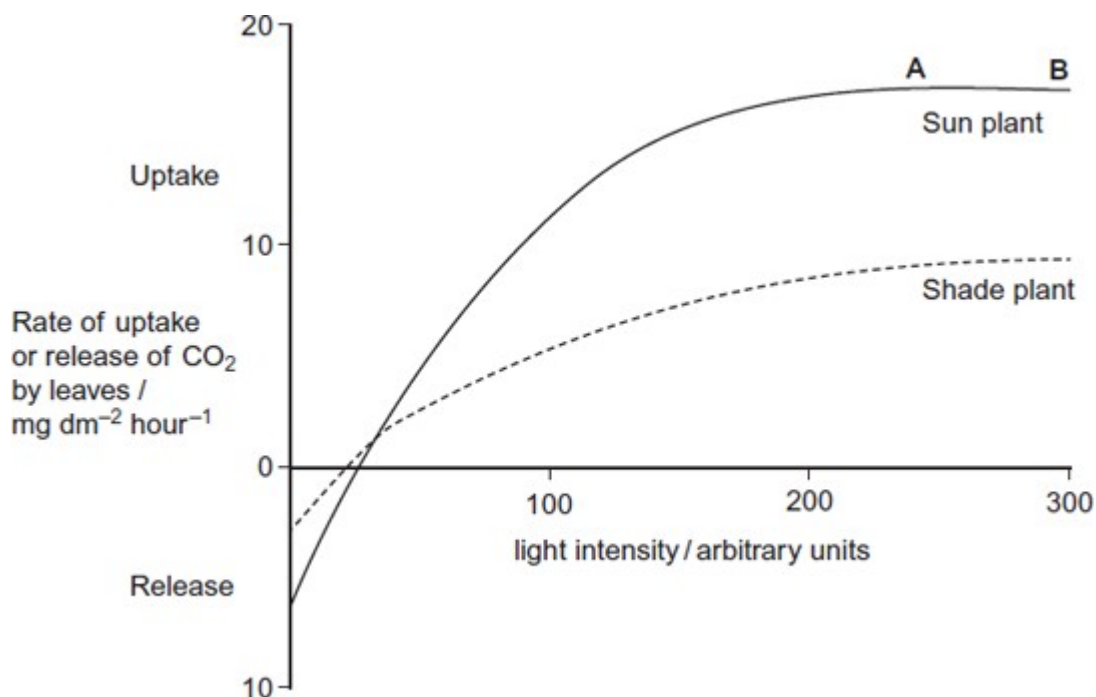
- (a) Name the process that resulted in the development of woodland from farmland.

(1)

- (b) Explain the increase in the diversity of birds as the woodland developed.

(3)

- (c) The ecologists also investigated photosynthesis in two species of plant found in the woodland. One of the species was adapted to growing in bright sunlight (sun plant) and the other was adapted to growing in the shade (shade plant). The ecologists' results are shown in the figure below.



- (i) Give **two** factors which could be limiting the rate of photosynthesis in the sun plant between points **A** and **B** on the figure.

1.

2.

(1)

- (ii) Explain why CO₂ uptake is a measure of net productivity.

(1)

- (iii) Use the information in the figure to explain how the shade plant is better adapted than the sun plant to growing at low light intensities.

(2)

(Total 8 marks)

Q19.

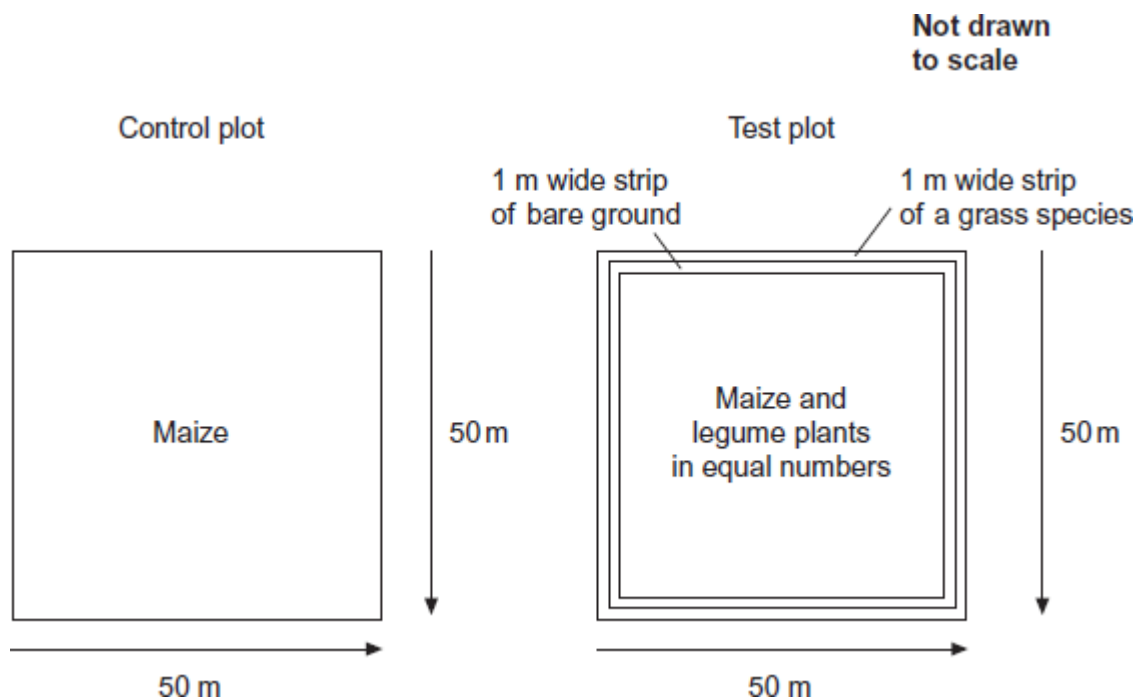
During the light-independent reaction of photosynthesis, carbon dioxide is converted into organic substances. Describe how.

(Total 6 marks)

Q20.

Stemborers are insect pests that feed on maize plants. Scientists investigated the effect of **push-pull** stimuli on the control of these pests.

For this investigation, the scientists divided a large field into plots measuring 50 m × 50 m. They then designated each plot as a control plot or a test plot. The following figure shows what they planted in each type of plot.



The legumes planted with the maize drive stemborers away.
The grass species attracts stemborers.

The table below shows the scientists' results.

Plots	Mean percentage damage to maize plants	Mean maize grain yield / tonnes per hectare ($\pm$ standard deviation)	Mean production costs per farmer / \$ per hectare ($\pm$ standard deviation)	Mean total income for farmer / \$ per hectare ($\pm$ standard deviation)
Control	29.6	1.5 (± 0.2)	250 (± 0.7)	329 (± 5.9)
Test	6.7	3.7 (± 0.3)	278 (± 1.1)	679 (± 10.2)

- (a) In the test plot of land, identify the push stimulus and the pull stimulus.

Push stimulus _____

Pull stimulus _____

(1)

- (b) When measuring the mean percentage damage to maize plants, 60 plants from each test plot were selected at random and examined.
Describe how the maize plants could be selected at random.

(3)

- (c) In the test plot, bare ground was left between the maize and the grass species. Suggest an explanation why.

(2)

- (d) The legume plants have nodules containing nitrogen-fixing bacteria on their roots. Explain how nitrogen-fixing bacteria could increase the growth of the maize.

(2)

- (e) A year after this investigation, the government of one country decided that their farmers should use these **push-pull** stimuli. How do these data support this decision?

(3)

(Total 11 marks)

Q21.

Organisms can be classified using a hierarchy of phylogenetic groups.

(a) Explain what is meant by:

(i) a hierarchy

(2)

(ii) a phylogenetic group.

(1)

(b) Cytochrome c is a protein involved in respiration. Scientists determined the amino acid sequence of human cytochrome c. They then:

- determined the amino acid sequences in cytochrome c from five other animals
- compared these amino acid sequences with that of human cytochrome c
- recorded the number of differences in the amino acid sequence compared with human cytochrome c.

The table shows their results.

Animal	Number of differences in the amino acid sequence compared with human cytochrome c
A	1
B	12
C	12
D	15
E	21

(i) Explain how these results suggest that animal **A** is the most closely related to

humans.

(2)

- (ii) A student who looked at these results concluded that animals **B** and **C** are more closely related to each other than to any of the other animals.

Suggest **one** reason why this might **not** be a valid conclusion.

(1)

- (iii) Cytochrome c is more useful than haemoglobin for studying how closely related different organisms are. Suggest **one** reason why.

(1)

(Total 7 marks)

Q22.

Malaria is a disease caused by a parasite. Scientists investigated the effect of malaria on competition between two species of *Anolis* lizard on a small Caribbean island. They sampled both populations by collecting lizards from a large number of sites on the island.

- (a) (i) Explain the importance of collecting lizards from a large number of sites.

(1)

- (ii) Describe **one** method the scientists could have used to ensure that the sites were chosen without bias.

(2)

- (iii) The population number of both species of lizard varied at different times of the year. Suggest **two** reasons why.

1. _____

2. _____

(2)

The scientists investigated the percentage of lizards of both species that were infected with malaria at different sites on the island. They collected samples of both lizards at intervals of 3 months for 1 year. They also recorded the elevation (height above sea level) of each site. Some of their results are shown in the table.

Site	Elevation of collection site / metres	Total number of <i>A. gingivinus</i> collected in one year	Percentage of <i>A. gingivinus</i> infected with malaria	Total number of <i>A. wattsi</i> collected in one year	Percentage of <i>A. wattsi</i> infected with malaria
1	10	13	0	0	0
2	80	30	0	0	0
3	120	35	23	3	0
4	200	40	30	7	0
5	300	52	46	12	0
6	315	35	31	13	1
7	370	155	37	79	2
8	414	124	44	68	4

- (b) When analysing their results, the scientists used the percentage of lizards infected at each site, rather than the number of lizards infected. Explain why.

(2)

- (c) A preliminary study suggested that malarial infections were more common at higher elevations. Use the information provided to evaluate this suggestion.

(2)

- (d) (i) As a result of this investigation, the scientists concluded that the presence of malaria provided a competitive advantage to *A. wattsi*. Use the information provided to explain how they reached this conclusion.

(2)

- (ii) The malarial parasite of *Anolis* lizards destroys both red and white blood cells. Suggest how an increase in the percentage of *A. gingivinus* infected with malaria could result in *A. wattsi* having a competitive advantage.

(2)

- (iii) The scientists carried out a statistical test to determine whether the correlation between the number of *A. wattsi* collected and the percentage of *A. gingivinus* infected was significant. They obtained a value for P of < 0.01 .

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

(2)
(Total 15 marks)

Q23.

Hummingbirds belong to the order Apodiformes. One genus in this order is *Topaza*.

- (a) (i) Name **one** other taxonomic group to which all members of the Apodiformes belong.

(1)

- (ii) Name the taxonomic group between order and genus.

(1)

The crimson topaz and the fiery topaz are hummingbirds.

Biologists investigated whether the crimson topaz and the fiery topaz are different species of hummingbird, or different forms of the same species.

They caught large numbers of each type of hummingbird. For each bird they

- recorded its sex
- recorded its mass
- recorded the colour of its throat feathers
- took a sample of a blood protein.

The table shows some of their results.

	Crimson topaz		Fiery topaz	
	Male	Female	Male	Female
Mean mass / g ($\pm$ standard deviation)	13.6 (± 1.9)	10.8 (± 1.3)	14.2 (± 1.6)	11.6 (± 0.63)
Colour of throat feathers	Green	Grey edges	Yellowish green	No grey edges

- (b) Explain how the standard deviation helps in the interpretation of these data.

(2)

- (c) The biologists analysed the amino acid sequences of the blood protein samples from these hummingbirds.

Explain how these sequences could provide evidence as to whether the crimson topaz and the fiery topaz are different species.

(2)

(Total 6 marks)

Q24.

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)

Q25.

A student investigated the rate of respiration of yeast cells. He set up a conical flask with a suspension of yeast in some apple juice. He took samples of the mixture at different times and found the number of yeast cells.

His results are recorded in the table below.

Time from start of investigation/days	Mean number of yeast cells ($\times 10^6$) per cm^3
3	7.413
4	8.912
8	16.595
9	19.952
10	23.442
11	23.703

- (a) The student set up a suspension of yeast in apple juice. Apple juice contains all the nutrients that yeast requires for growth. Name **two** types of nutrients present in the apple juice that are essential for the growth and reproduction of yeast cells.

1. _____

2. _____

(2)

- (b) The student counted the yeast cells in a sample of the suspension. Give **one** precaution the student should have taken to make sure he obtained a representative sample. Explain how this precaution would result in a representative sample.

(2)

- (c) Calculate the percentage increase of yeast cells between day 3 and day 4. *Show your working.*

Answer _____

(2)

- (d) The increase in the number of yeast cells was less between days 10 and 11 than it was between days 3 and 4.
Give **two** reasons why.

1. _____

2. _____

(2)

(Total 8 marks)

Q26.

- (a) Scientists can use protein structure to investigate the evolutionary relationships between different species. Explain why.

(2)

- (b) Comparing the base sequence of genes provides more evolutionary information than comparing the structure of proteins. Explain why.

(2)
(Total 4 marks)

Q27.

- (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.

(3)

(Total 7 marks)

Q28.

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)

Q29.

The Harvest Index is the percentage of dry biomass that is harvested and used.

Barley is a cereal. It is grown for its grain. Researchers collected data to calculate the Harvest Index of barley growing in a small field. They obtained their measurements from

quadrats at different places in the field. Their results are shown in the following table.

Quadrat number	Dry biomass of barley plants / g m ⁻²	Dry biomass of barley grain harvested / g m ⁻²
1	80	42
2	75	37
3	82	41
4	93	39

- (a) Use the data for quadrat number **4** in the table to calculate the Harvest Index for barley. Show your working.

Harvest Index = _____

(2)

- (b) Plant breeders are trying to produce barley plants with shorter stems. Explain how this would increase the Harvest Index.

(1)

- (c) The values for the biomass of the barley plants are different in each quadrat. Suggest an explanation for this difference.

(2)

- (d) The researchers measured the dry biomass of the barley plants and the barley grain. What is the advantage of using dry biomass for these measurements?

(2)
(Total 7 marks)

Q30.

Herbicides are substances that kill weeds. Three farmers wanted to know which herbicide to use to control weeds in fields of barley. They chose eleven fields of barley and used a different herbicide in each field. Four weeks later they collected, counted and weighed the weeds in each field. Their results are shown in **Figure 1** and **Figure 2**.

Figure 1

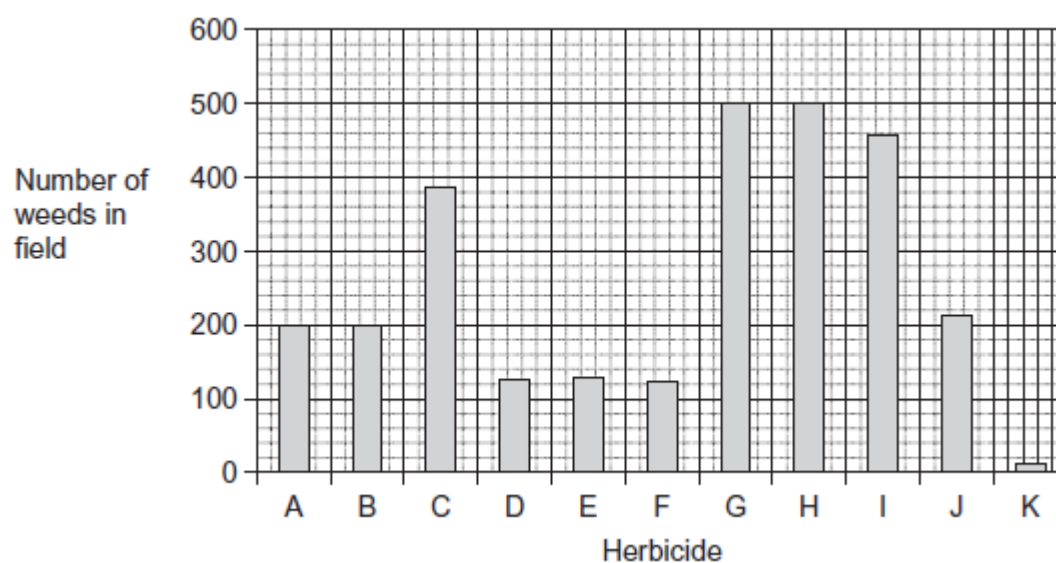
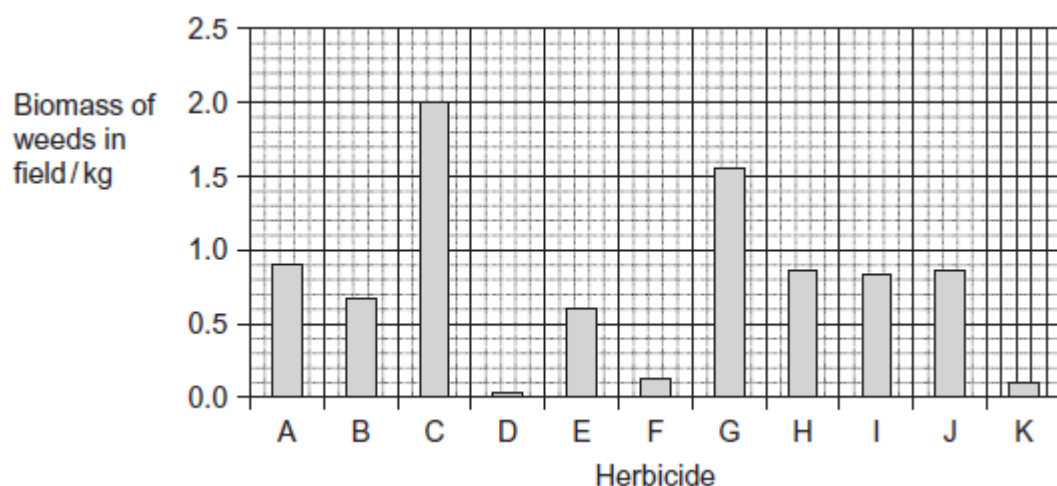


Figure 2



- (a) Describe the difference in biomass of **each** of the weed plants in fields treated with herbicides **G** and **H**. Explain how you arrived at your answer.
-

(2)

- (b) The farmers decided that **K** would be the best herbicide to use. Explain why herbicide **K** would give a higher crop yield.

(2)

- (c) The farmers carried out their investigation during the summer. Suggest **one** advantage and **one** disadvantage of carrying out this investigation during the summer.

Advantage _____

Disadvantage _____

(2)

- (d) One of the farmers told a local newspaper reporter of their findings. The newspaper published an article with the following headline: "Local farmers show scientists the way to bigger crop yields." Was this headline justified? Explain your answer.

Q31.

The body markings of cheetahs vary, in particular the pattern of bands on their tails. Cheetahs are solitary animals but the young stay with their mother until they are between 14 and 18 months old.

Scientists investigated the banding pattern on the tails of cheetahs living in the wild.

- They drove a car alongside a walking cheetah and used binoculars to study the tail pattern.
- They gave each cheetah a banding pattern score based on the width of the dark and light bands on the end of the tail.
- They scored the width of the bands on the right and left side of the tail using a 5 point scale of width.

A typical pattern on the right side of one cheetah's tail is shown in **Figure 1**.

Figure 1

Band number 1 2 3 4 5 6 7



Band width score 3 1 1 4 3 3 3

The scientists collected data from each cheetah on four separate occasions. **Figure 2** shows the data for one of the cheetahs.

Figure 2

Side of tail	Mean band width score ($\pm$ standard deviation)						
	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7
Right	3.00 ($\pm$ 0.82)	1.00 ($\pm$ 0.00)	1.00 ($\pm$ 0.00)	3.75 ($\pm$ 0.50)	2.75 ($\pm$ 0.50)	3.00 ($\pm$ 0.00)	3.00 ($\pm$ 0.00)
Left	3.75 ($\pm$ 0.50)	3.25 ($\pm$ 0.50)	2.00 ($\pm$ 0.50)	3.00 ($\pm$ 0.00)	2.00 ($\pm$ 0.00)	2.50 ($\pm$ 0.50)	3.00 ($\pm$ 0.50)

- (a) The scientists only used data from cheetahs which were fully grown. Suggest why.

(1)

- (b) The scientists estimated the width of the bands on the same cheetah on four

separate occasions. They did not always get the same score.

- (i) Give **two** pieces of evidence from **Figure 2** which show that the scientists sometimes obtained different scores for the same band.

1. _____

2. _____

(2)

- (ii) The method the scientists used resulted in them getting different scores for the same band. Suggest why.

(1)

- (c) What is the evidence from **Figure 2** that the dark and light bands do **not** form rings of equal width around the tail?

(1)

- (d) The scientists found the difference in banding pattern between

- offspring in the same family
- cheetahs chosen randomly.

Explain how scientists could use this information to show that some variation in tail banding was genetic.

(3)

(Total 8 marks)

Q32.

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

(1)

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

(3)

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.

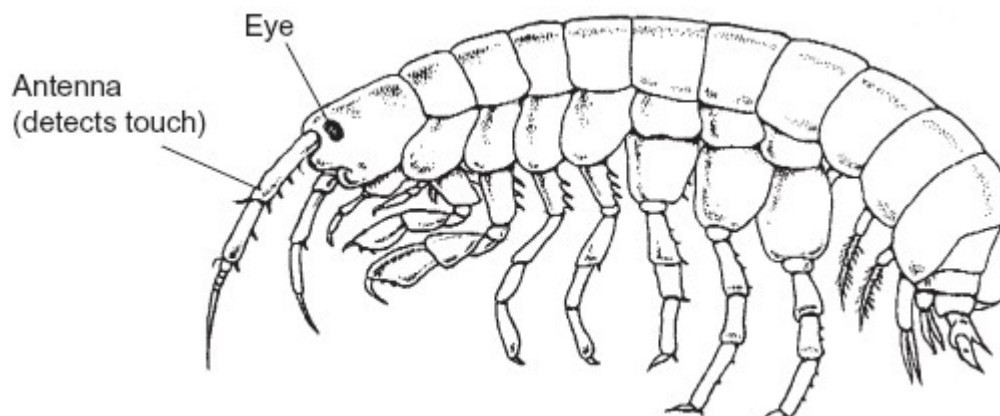
(3)

(Total 9 marks)

Q33.

Figure 1 shows a fresh-water shrimp.

Figure 1



Biologists collected shrimps from a stream inside a cave and from the same stream when it was in the open.

They measured the maximum diameter of each shrimp's eye. They also measured the length of its antenna. From these measurements they calculated the mean values for each site. **Figure 2** shows their results.

Figure 2

	Shrimps from the stream	
	Inside the cave	In the open
Mean diameter of eye /mm	0.09	0.24
Mean length of antenna /mm	8.46	5.81

- (a) The biologists measured the maximum diameter of each shrimp's eye.

Explain why they measured the **maximum** diameter.

(1)

- (b) A scientist working many years earlier suggested that animals which live in caves had similar adaptations. These adaptations included

- smaller eyes
- greater use of sense organs such as those involved in detecting touch.

- (i) Do the data in **Figure 2** support this scientist's suggestion? Explain your answer.

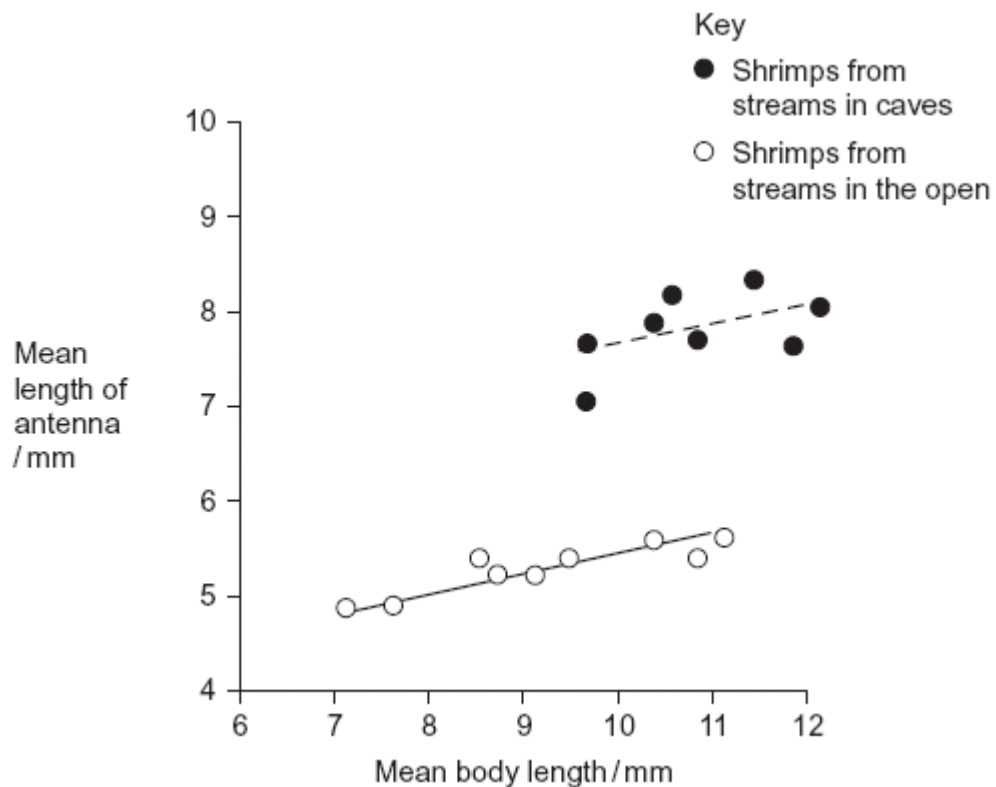
(2)

- (ii) The data in **Figure 2** are mean values. Explain how standard deviations of these mean values would help you to interpret the data in **Figure 2**.

(2)

- (c) The biologists investigated shrimps living in other streams. They measured the length of the antennae of these shrimps. They also measured their body length. **Figure 3** shows the mean antenna length plotted against mean body length for each site.

Figure 3



- (i) What does the information in the graph suggest about the body lengths of shrimps living in caves and living in the open?

(2)

- (ii) Do the data in the graph support the conclusion that shrimps with longer bodies have longer antennae? Give the reason for your answer.

(1)

Other biologists investigated the genetic diversity of these shrimps. **Figure 4** shows some of the data they collected.

Figure 4

Gene	Allele	Percentage of shrimps with this allele in steam	
		Inside a cave	In the open
PGI	A	0.9	2.5
	B	0.0	3.3
	C	98.2	66.4
	D	0.9	6.6
	E	0.0	21.3
ACO2	J	0.0	5.6
	K	0.0	76.7
	L	100.0	17.8

- (d) The biologists concluded that the shrimps in the open had a higher genetic diversity than those in the cave. Explain how the data in **Figure 4** support this conclusion.

(1)

- (e) The percentage of shrimps with allele **L** in the cave is different from the percentage of shrimps with allele **L** in the open. Use your knowledge of the founder effect to suggest a reason for this difference.

(3)

- (f) The biologists who studied these shrimps wanted to know if the shrimps living in the cave were the same species as those living in the open. They used breeding experiments to investigate this.

- (i) Describe how the biologists should carry out these breeding experiments.

- (ii) The results of breeding experiments would help the biologists to decide whether the shrimps were the same species. Explain how.

(3)

(Total 15 marks)

Q34.

Cytochrome c is a protein found in all eukaryotes. In humans it consists of 102 amino acids. Biologists have compared the amino acid sequence in some other species with that in humans. The table shows amino acids 9 to 13 in the amino acid sequences of cytochrome c from four species.

Species	Amino acid in this position in cytochrome c				
	9	10	11	12	13
Human	Ile	Phe	Ile	Met	Lys
Chicken	Ile	Phe	Val	Gln	Lys
Dogfish	Val	Phe	Val	Gln	Lys
Chimpanzee	Ile	Phe	Ile	Met	Lys

- (a) What do the results suggest about the relationship between humans and the other three species?

(2)

- (b) Suggest **one** advantage of using cytochrome c to determine relationships between species.

(1)

- (c) Comparing the base sequence of a gene provides more information than comparing the amino acid sequence for which the gene codes. Explain why.

(2)

(Total 5 marks)

Q35.

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

(1)

(ii) electrophoresis?

(1)

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

(2)

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

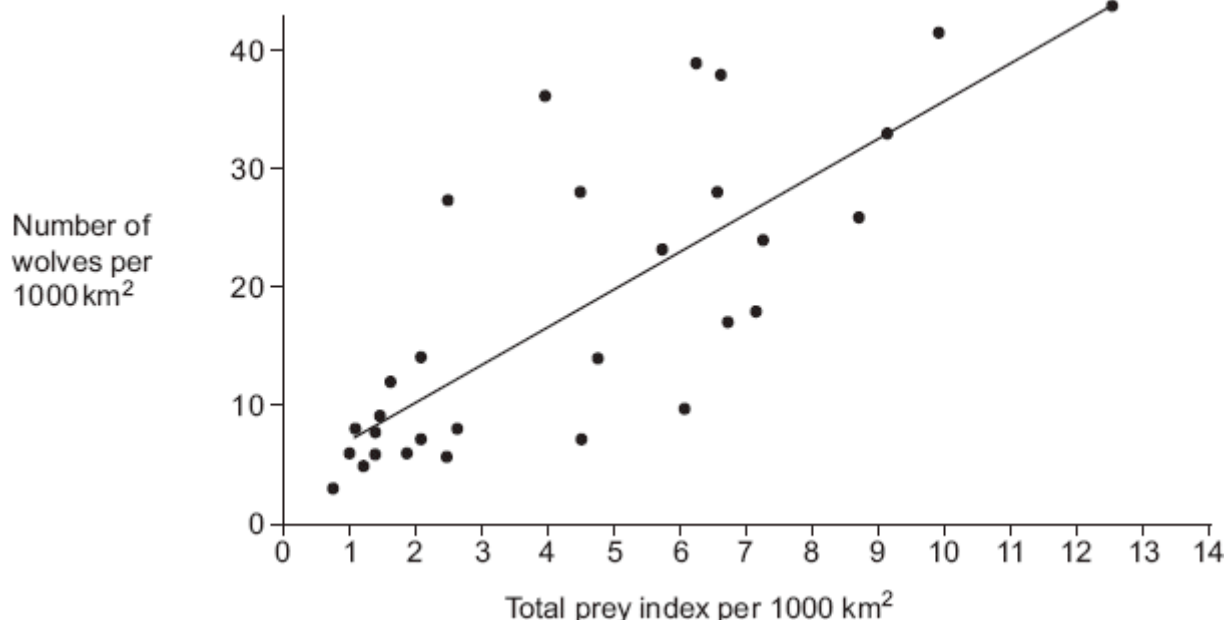
(i) Explain why DNA on the Y chromosome helped them to reach this conclusion.

(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.

(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.

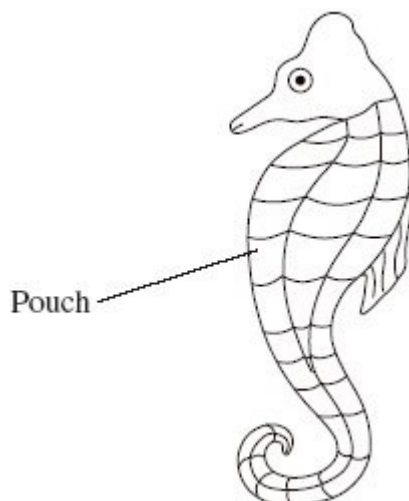
(2)

- (e) The ecologist calculated the total prey index by combining the prey indices and the total number of animals of each species present in 1000 km². He plotted this information on the graph. What does the graph suggest about the factors that determine wolf numbers in North America? Explain your answer.

(2)
(Total 12 marks)

Q36.

The diagram shows a seahorse. A seahorse is a fish. Mating in seahorses begins with courtship behaviour. After this, the female transfers her unfertilised eggs to the male's pouch. Most male fish fertilise eggs that have been released into the sea. However, a male seahorse fertilises the eggs while they are inside his pouch. The fertilised eggs stay in the pouch where they develop into young seahorses.



- (a) Give **two** ways in which courtship behaviour increases the probability of successful mating.

1. _____

2. _____

(2)

- (b) Give **one** way in which reproduction in seahorses increases the probability of

- (i) fertilisation

(1)

- (ii) survival of young seahorses.

(1)

Scientists investigated the effect of total body length on the selection of a mate in one Australian species of seahorse. The scientists used head length as a measure of total body length.

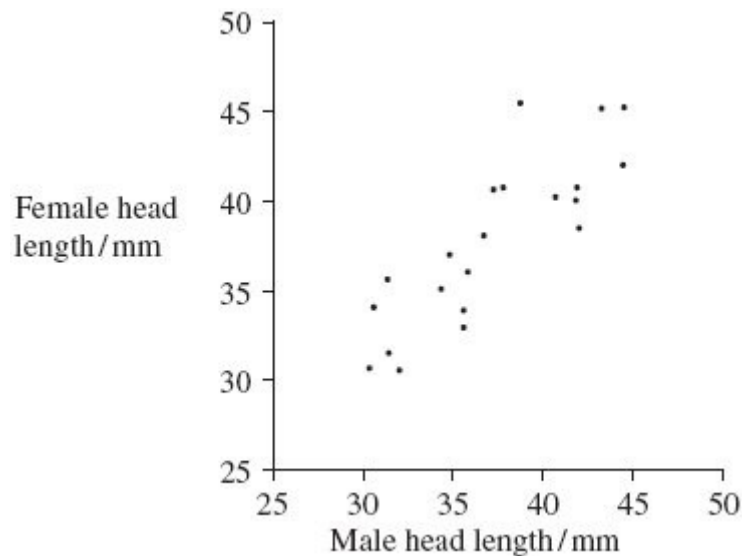
- (c) (i) Use the diagram to suggest why the scientists measured head length rather than total body length.

(1)

- (ii) Suggest why the scientists were able to use head length as a measure of total body length.

(1)

The scientists measured the head lengths of the female and male of a number of pairs. The results are shown in the graph.



- (d) The scientists concluded that total body length affects the selection of a mate. Explain how the results support this conclusion.

(1)

- (e) A female with a head length of 50 mm selected a mate. Explain how you could use the graph to predict the total head length of the mate selected.

- [illegible]

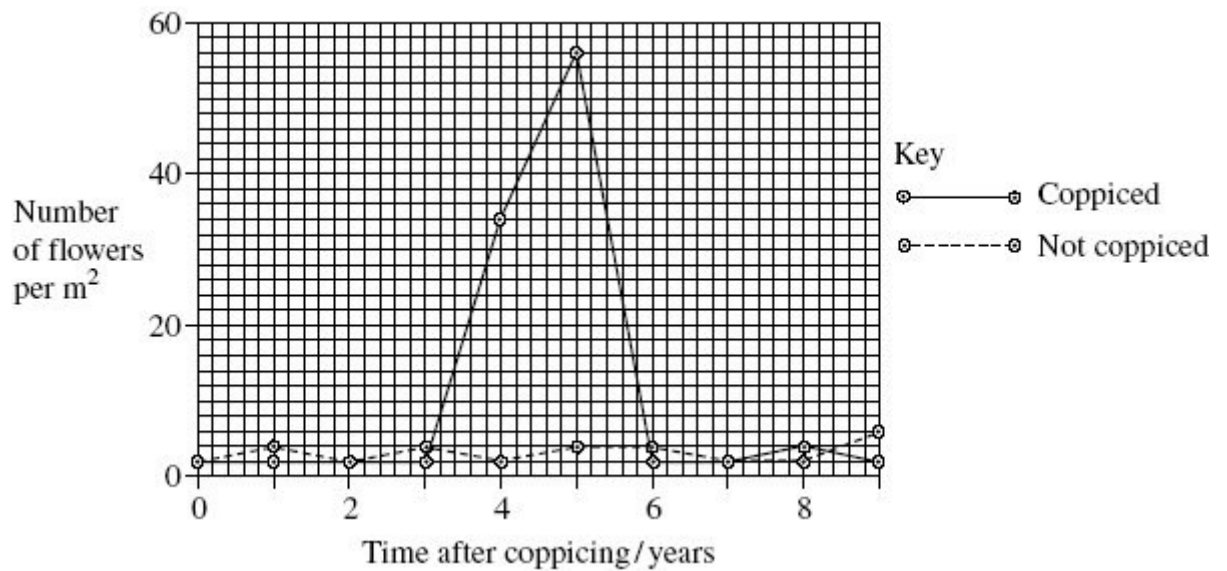
(Total 15 marks)

Q37.

Woods can be coppiced to provide a continuous supply of useful logs and poles. Coppicing involves cutting down some trees in a wood to leave stumps. New shoots grow from the stumps. After about 15 years, these trees can be coppiced again.

Because coppicing produces a wood with patches of light and shade, the diversity of plants and animals in a coppiced wood is high.

Ecologists investigated the effect of coppicing on the flowering of wild daffodils growing in a wood in Cumbria. Some areas of the wood were coppiced and some areas were not. The graph shows some results from this investigation.



(a) You could collect data for the coppiced plots by using quadrats.

(i) Describe how you would place the quadrats at random.

(2)

(ii) Describe how you would decide the number of quadrats to use in order to collect representative data.

(2)

(b) Members of the public visit this wood to see wild daffodils in flower. Explain how the information in the graph could help the owners to manage the wood so that there were many wild daffodils in flower every year.

(2)

- (c) The ecologists analysed the relationship between the number of daffodils in flower in the whole wood and data collected from a nearby weather station for the previous year.

They used the Spearman rank correlation test. The table shows their results.

Month	Climatic factor	Correlation coefficient	Statistical significance
July	Total rainfall	+ 0.65	significant
August	Total rainfall	+ 0.74	significant
July	Monthly mean temperature	– 0.78	significant
August	Monthly mean temperature	– 0.65	significant

The ecologists concluded that a wet, cool summer produces good flowering the following spring. Do you support this conclusion? Use the data in the table to explain your answer.

(2)

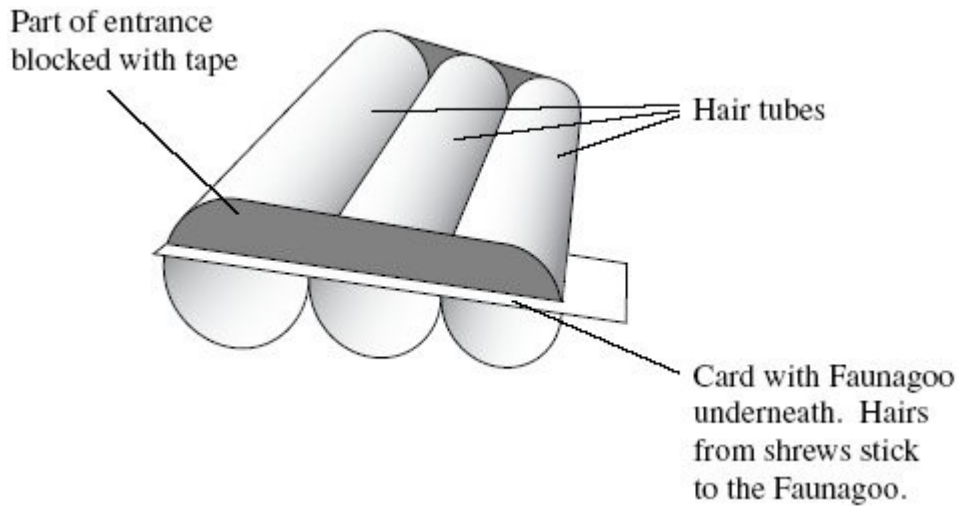
(Total 8 marks)

Q38.

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.

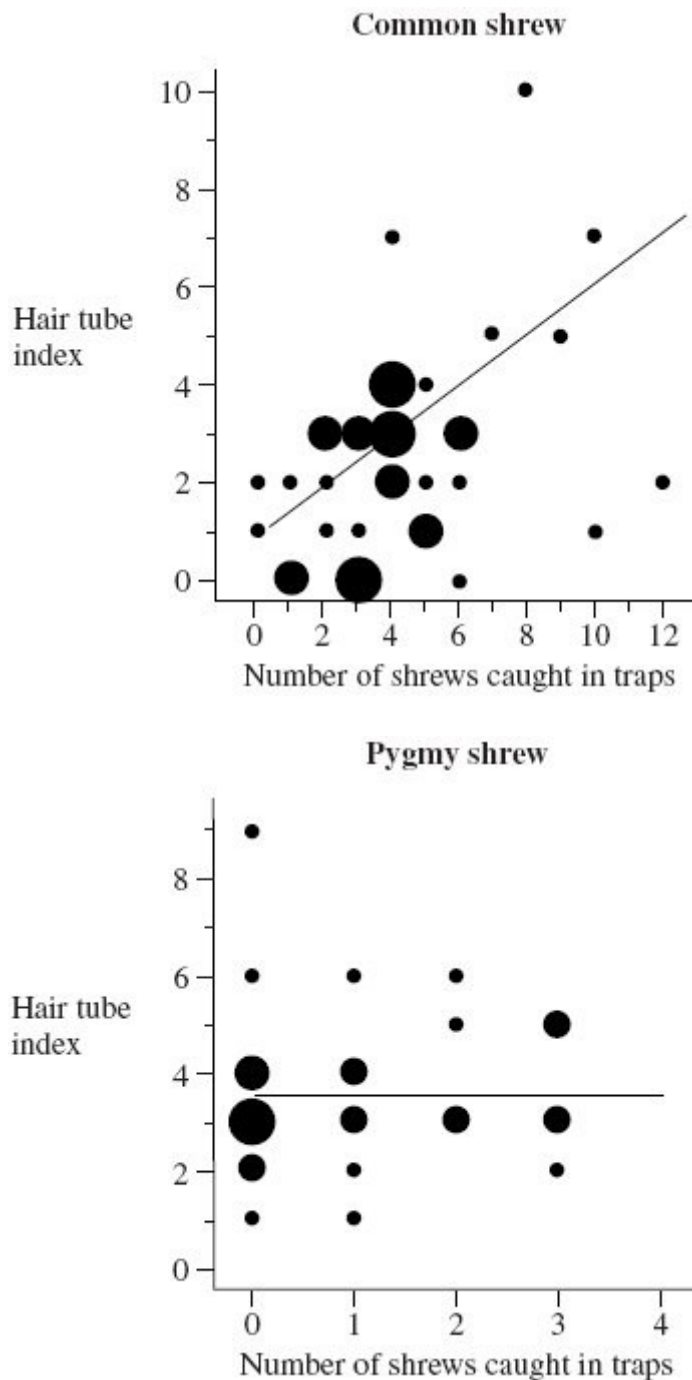
(1)

- (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)

Q39.

- (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)

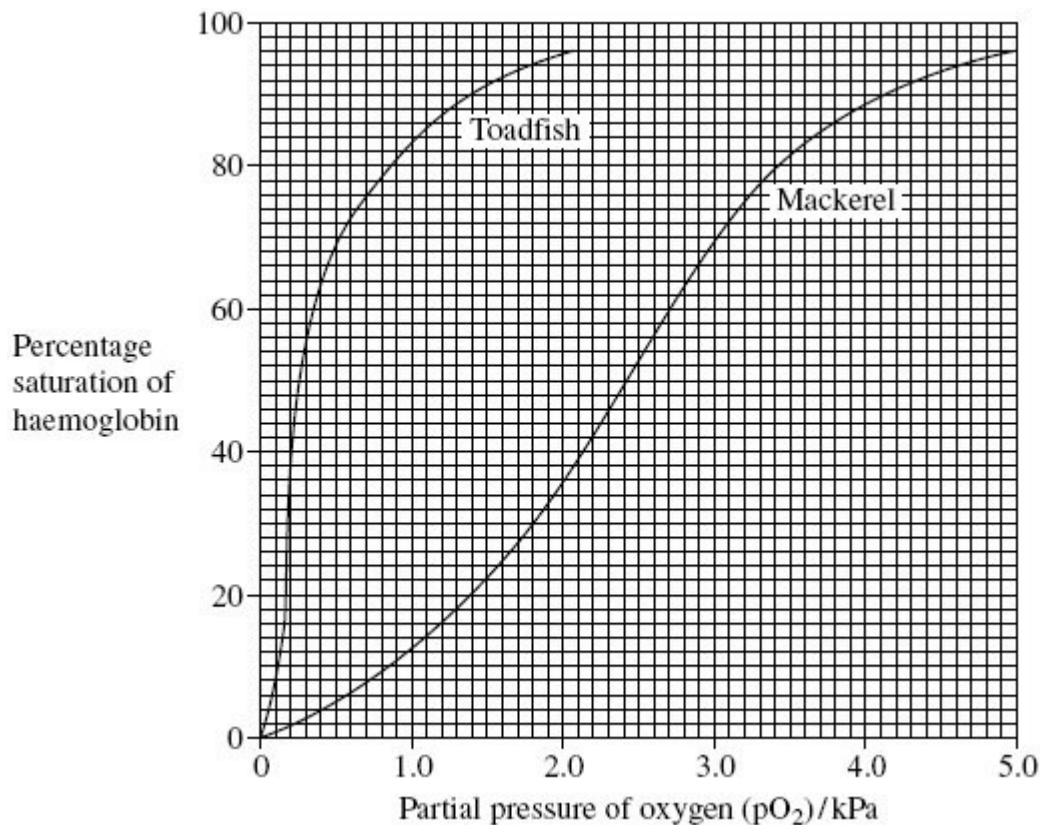
Mackerel live in the surface waters of the sea. Toadfish live on the seabed in deep water.

- (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)

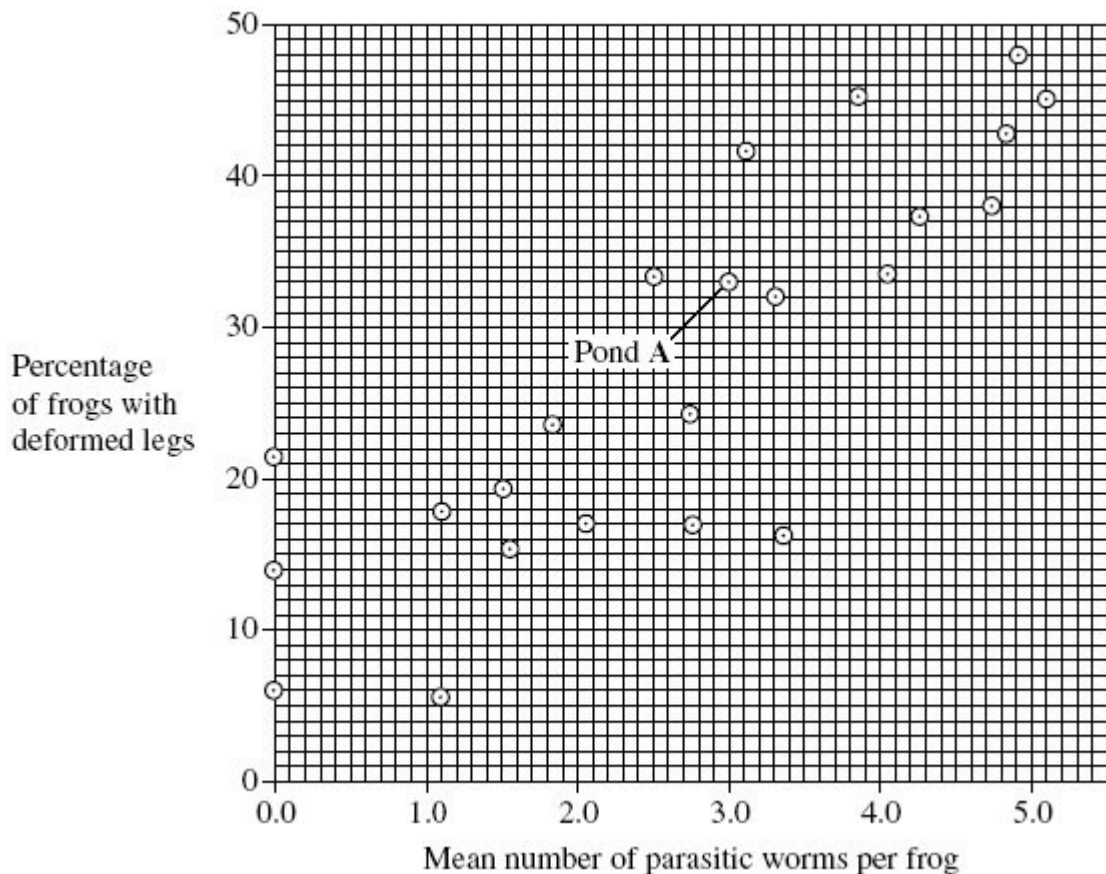
(Total 12 marks)

Q40.

- (a) In the USA, members of the public found many frogs with deformed legs. Scientists investigated this. They collected samples of the frogs. They wanted to get reliable data. Give **one** feature of the sample, other than a large sample size, that would help to make sure that their data were reliable.

(1)

The team of scientists then investigated frogs in ponds. The team measured many different factors and then analysed their results. The graph shows the relationship between the percentage of frogs with deformed legs and the mean number of parasitic worms found in the frogs.



- (b) The scientists collected a sample of three frogs from pond **A**. What was the total number of parasitic worms found in these three frogs?

(1)

- (c) One scientist suggested that the parasites caused the deformed legs found in frogs. Does the graph support this suggestion? Explain your answer.

(4)

- (d) The scientists wrote a paper. In their discussion they wrote that they found very few ponds that were free from human influence. The few that they did find were only in mountainous areas.

The scientists could not draw any reliable conclusions about whether human influence contributed to the frogs' deformed legs. Explain why each of the following meant that they could not draw reliable conclusions.

- (i) There were very few ponds free from human influence.

(1)

- (ii) The ponds free from human influence were found only in mountainous areas.

(2)

In a second investigation, another research team investigated deformed legs in frogs in a different way.

- They chose six ponds, all of which contained parasitic worms. Three of the ponds were close to fields and received agricultural run-off from these fields. The other three ponds did not receive agricultural run-off.
- They built two cages in each of the six ponds. One cage in each pond allowed parasitic worms to enter and one cage did not.
- They put frogs that were not infected with parasitic worms into all twelve cages.

The table shows the results of this second investigation.

	Percentage of frogs with deformed limbs					
	Ponds with agricultural run-off			Ponds with no agricultural run-off		
Pond number	1	2	3	4	5	6
Cage with mean mesh diameter of 500 μm	22	27	24	3	4	7
Cage with mean mesh diameter of 75 μm	0	0	0	0	0	0

- (e) One of the boxes in the table has been shaded. Describe the information given in the shaded box.

(2)

- (f) What conclusions can you draw from the data in the table about the factors causing deformed leg in frogs? Explain your answer.

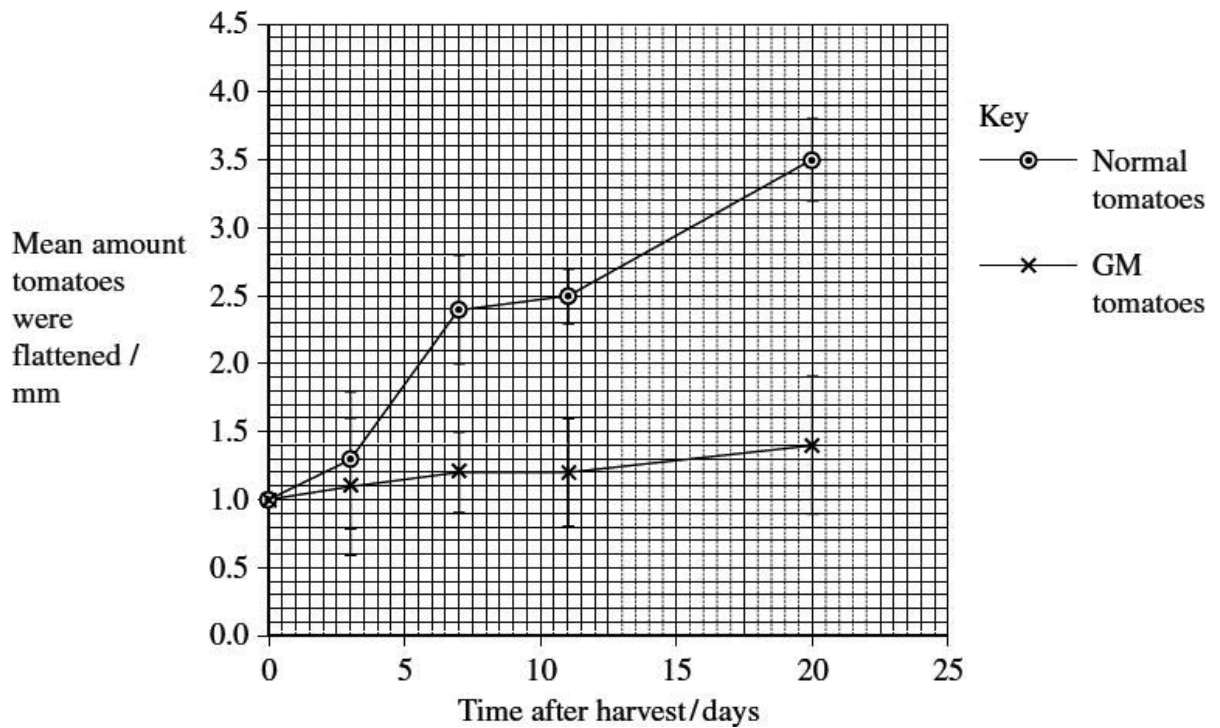
(4)

(Total 15 marks)

Q41.

Tomatoes become softer as they ripen. This is due partly to the breakdown of pectin by the enzyme pectinase. Scientists have produced a genetically modified variety of tomato plant (GM tomato) that produces tomatoes that ripen more slowly. The DNA of the GM tomato plant has been altered so it does not produce pectinase.

Scientists tested the ripeness of normal and GM tomatoes. They placed a 500 g mass on top of tomatoes at different times after they were harvested. The scientists measured the amount the tomatoes flattened. The following figure shows the results. The error bars represent standard deviation.



- (a) The scientists used tomatoes of the same size in the technique described above to measure ripeness. Explain why.

(2)

- (b) What do the standard deviation bars suggest about the difference in ripeness of the two varieties of tomato at 7 days? Explain your answer.

(2)

(Total 4 marks)

Q42.

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?

(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.

(3)

(Total 5 marks)

Q43.

Deforestation often involves clearing large areas of forest for use as agricultural land.

- (a) Deforestation reduces the diversity index of an area cleared in this way. Explain why.

(2)

- (b) Because the forest soil is often nutrient-poor, nitrogen-containing fertilisers may be applied to ensure good crop yields. Use your knowledge of the nitrogen cycle to explain the potential benefit of applying a fertiliser containing ammonium nitrate rather than one containing potassium nitrate.

Q44.

Mayflies are insects which lay their eggs in streams and rivers. The nymphs which hatch from the eggs live in the water for several years.

Mayfly nymphs were collected by disturbing the gravel of a stream bed. A net placed immediately downstream caught any animals which were washed out of the gravel. Eight samples were collected from shallow, fast-flowing parts of the stream and eight from deeper, slow-flowing parts. Nymphs from two different families of mayfly were found. The results are given in the table.

	Family Caenidae		Family Baetidae	
	Shallow water	Deep water	Shallow water	Deep water
Mean number of nymphs	2.38	12.88	24.50	6.00
Standard deviation	1.51	7.92	6.72	1.51

- (a) Describe how you would have collected the samples in order to ensure they were representative of the habitats being investigated and could be compared with each other.

(3)

- (b) Which **one** of the four samples showed the greatest variation within the sample? Give evidence from the table for your answer.

(1)

- (c) The two families of mayfly nymph occupy different ecological niches.

- (i) What is meant by the term *ecological niche*?

(1)

- (ii) Describe the evidence in the table which suggests that the two families of mayflies occupy different ecological niches.

(1)

- (iii) Explain the advantage to these two families of mayflies of occupying different ecological niches.

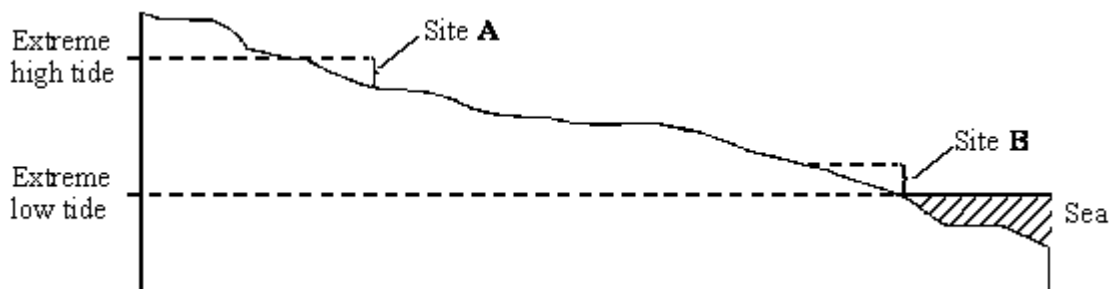
(2)

(Total 8 marks)

Q45.

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> <i>Palmaria palmata</i>	18 6
Index of diversity		Index of diversity	4.77

- (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.

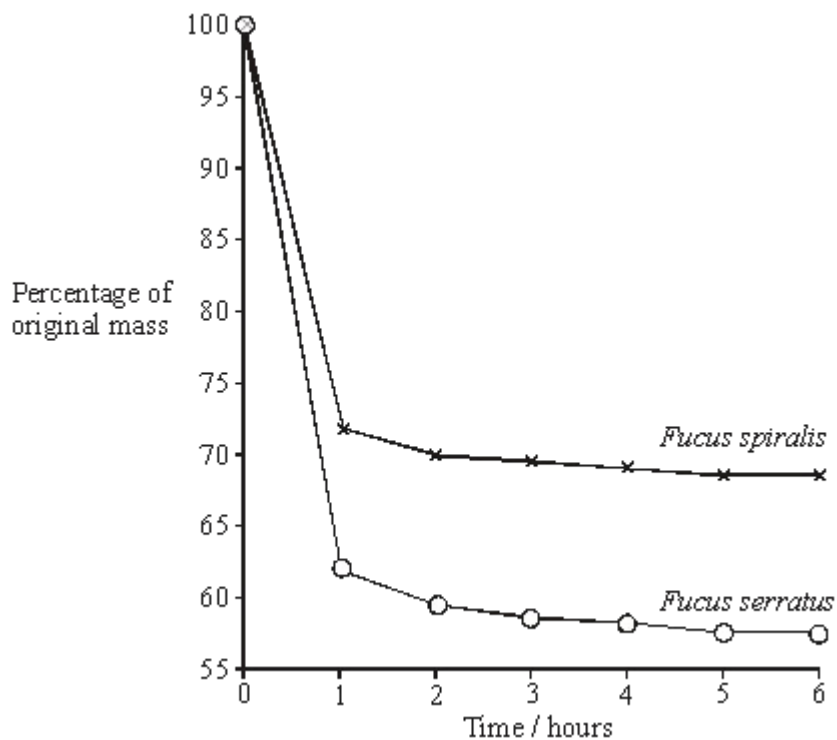
Index of diversity at site **A** = _____

(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)

Q46.

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.

(2)

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

(2)

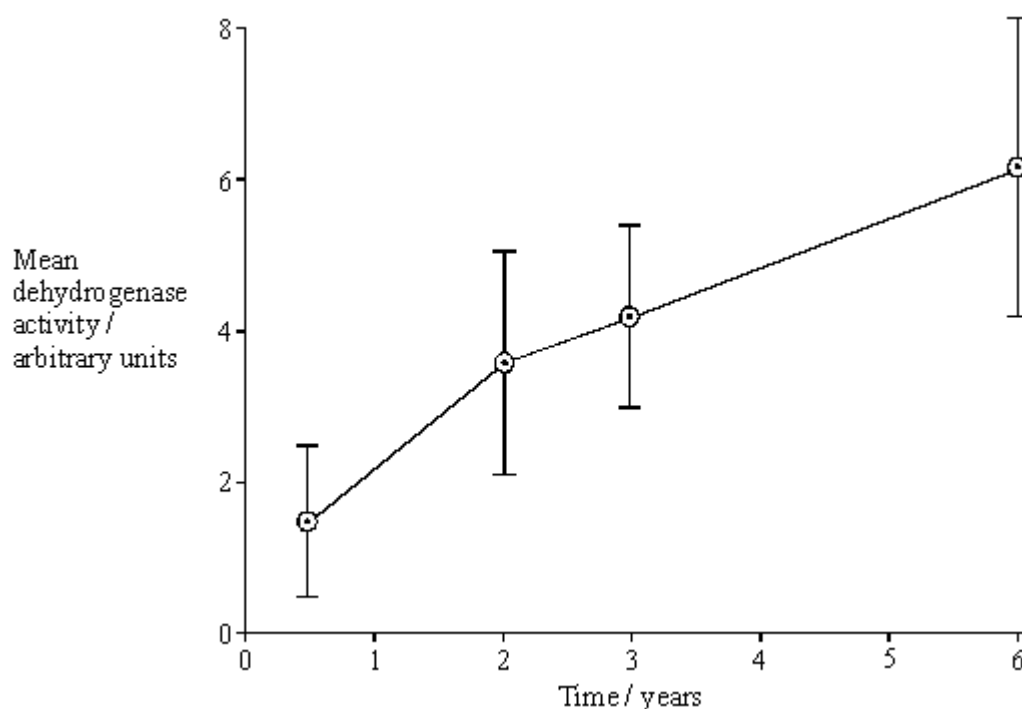
- (ii) Explain the difference in the numbers of aerobic bacteria at a depth of 300 cm between 1 and 6 months.

(2)

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

(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.

(2)

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

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

(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.

(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.

(3)
(Total 20 marks)

Q47.

- (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)

Q48.

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

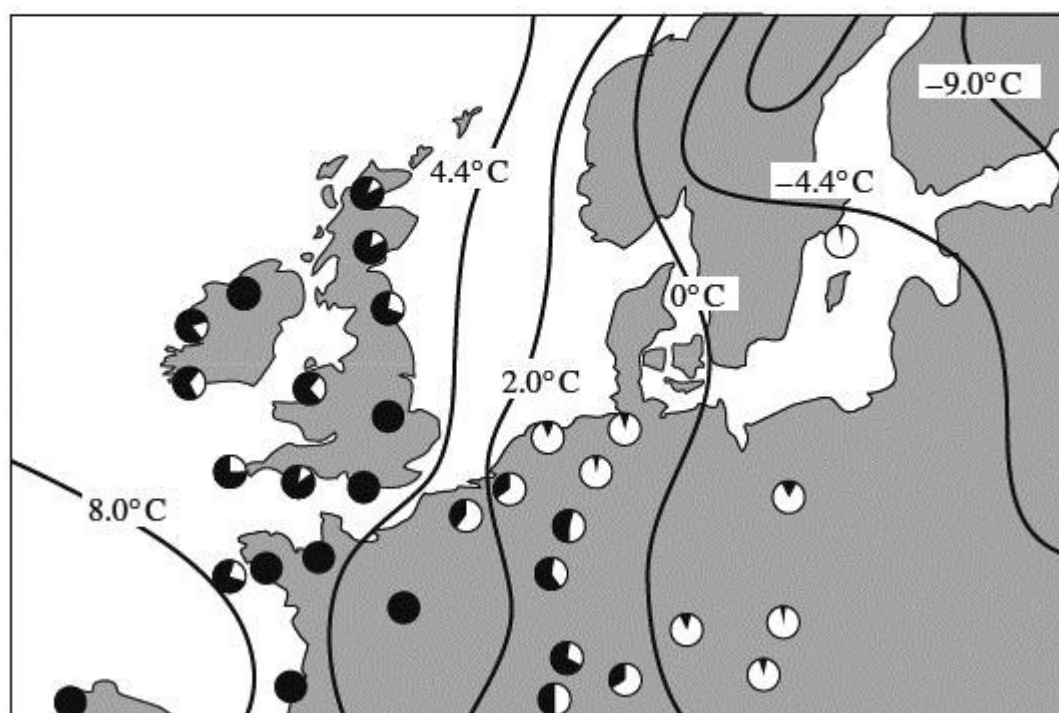
The map shows the proportions of the two types of plant in populations of clover from different areas in Europe. It also shows isotherms, lines joining places with the same mean January temperature.

Key

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



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



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

(4)

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

(4)

(Total 8 marks)

Q49.

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

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

(2)

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

(4)

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

(2)

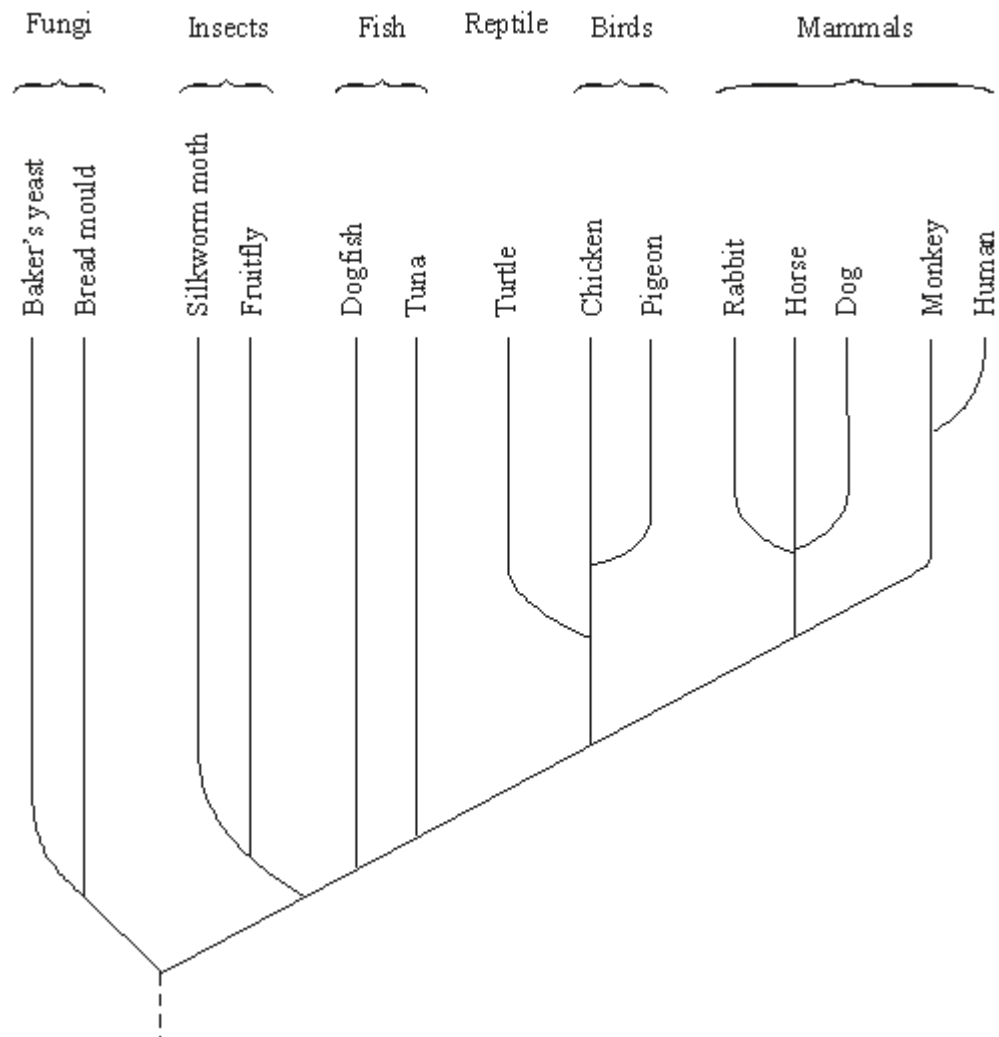
(Total 8 marks)

Q50.

- (a) Explain the principles which biologists use to classify organisms into groups.

(3)

Cytochrome c is a protein with about 100 amino acids and is present in all eukaryotic organisms. It has the same three-dimensional shape in all species, but only 30 of the amino acids are the same in all species. The amino acid sequence of cytochrome c has been used to construct the phylogenetic tree shown below.



(b) Name the kingdoms represented in this phylogenetic tree.

_____ (1)

(c) What does the phylogenetic tree show about the evolutionary relationship between fungi and insects?

 _____ (2)

(d) Suggest how information on amino acid sequences is used to construct a phylogenetic tree.

(2)

- (e) Suggest **one** advantage and **one** disadvantage of using cytochrome c to construct a phylogenetic tree.

Advantage

Disadvantage

(2)

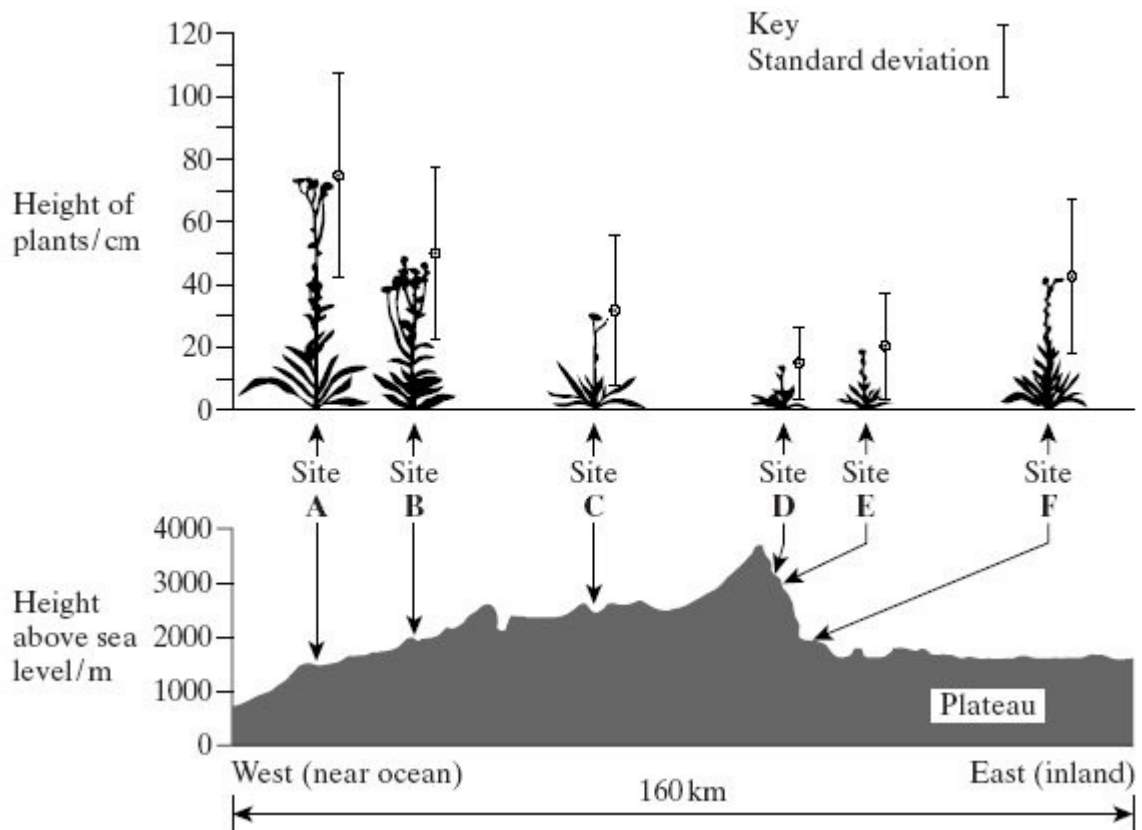
(Total 10 marks)

Q51.

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.

(1)

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

(2)

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

(1)

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

(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.

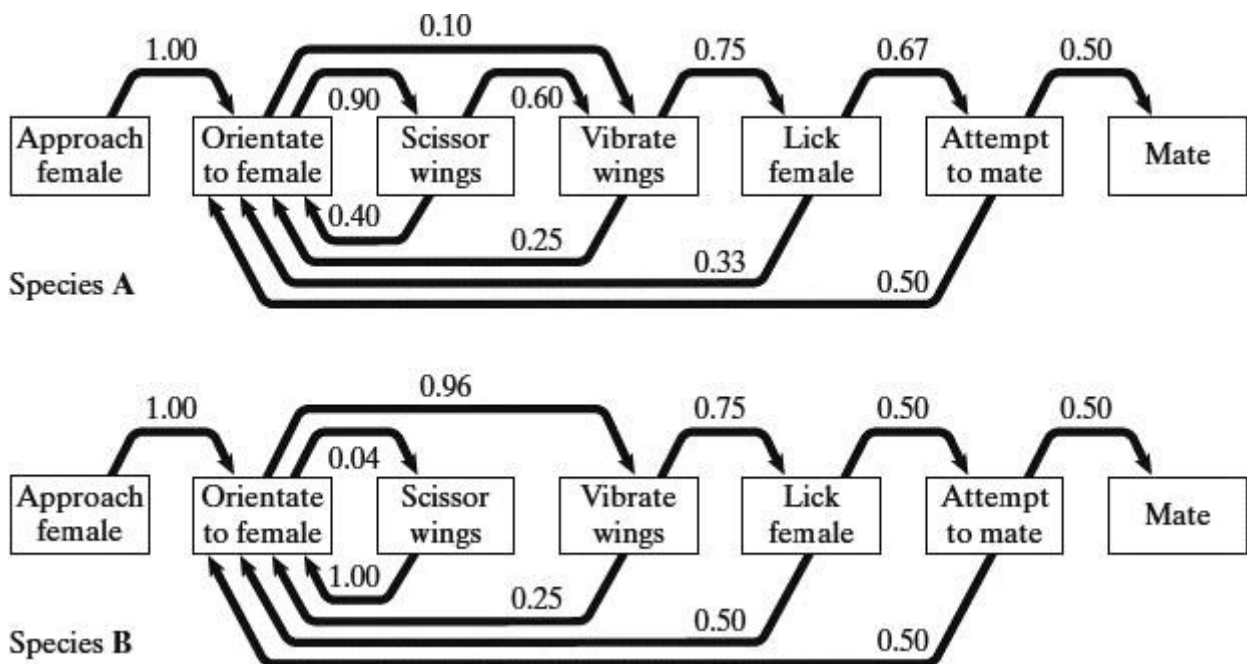
(1)

(Total 7 marks)

Q52.

Courtship and mating in fruitflies can occur equally well in the light or dark.

The diagrams show the courtship sequence of males from two closely related species of fruitfly (species **A** and species **B**). The numbers show the probability of one courtship element following from another.



- (a) Once a male of species **A** has orientated to the female, what is the probability that he will perform each courtship element once only and then attempt to mate? Show your working.

(2)

- (b) Suggest how the courtship sequences provide evidence to support the claim that the two species are

- (i) closely related;

(1)

- (ii) separate species.

(1)

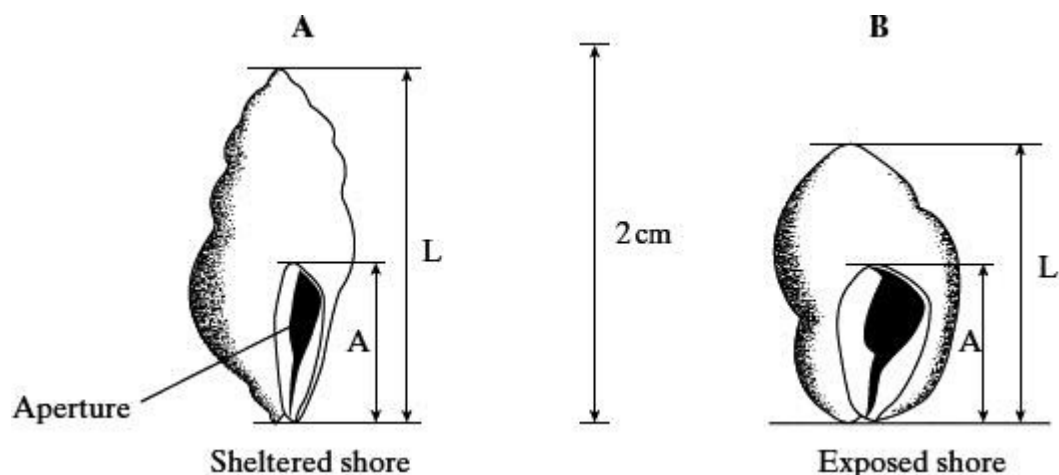
- (c) During courtship, vibration of the wings creates a sound. The sound is different in the two species of fruitfly. Explain how this prevents mating between members of different species.

(2)

(Total 6 marks)

Q53.

The drawings show two dogwhelks taken from two different populations. Dogwhelk **A** came from a sheltered shore and dogwhelk **B** from a shore exposed to heavy wave action. The dogwhelks attach themselves to rocks with a muscular foot which comes out through the aperture. The shell length : aperture length ratios (L/A) were calculated. The mean and standard deviation for each population are shown under the drawings.



mean L/A ratio = 1.91
standard deviation = 0.19

mean L/A ratio = 1.78
standard deviation = 0.10

- (a) Describe how you would collect a random sample of each population.

(3)

- (b) What do the standard deviations tell you about the two populations of dogwhelks?

(2)

- (c) Suggest how the effect of wave action on the two populations of dogwhelks could result in differences between

- (i) the mean L/A ratios;

- (ii) the standard deviations.

(4)

(Total 9 marks)

Q54.

This question should be written in continuous prose, where appropriate.

Quality of Written Communication will be assessed in these answers.

- (a) Use your knowledge of classification to arrange *class*, *phylum*, *genus* and *family* in order of decreasing number of species.

largest number of
species

smallest number of
species

(1)

- (b) Cytochrome c is a protein involved in one of the reactions of aerobic respiration in a mitochondrion. The molecular structure of cytochrome c from different species has been analysed. More similarities are present in the structure of cytochrome c in closely related species than in distantly related species.

- (i) Explain what is meant when two species are described as being *closely related*.

(1)

- (ii) A difference in the molecular structure of cytochrome c may arise in a small population that becomes geographically isolated. Explain how the difference may arise and how it may spread in the population.

(4)

(Total 6 marks)

Q55.

In an investigation, the population density of plants in a regularly cut lawn was compared with that in a lawn which was only cut occasionally. The table shows the results.

Species	Mean population density / number of plants per m ²		Result of statistical test value of p
	Regularly cut lawn	Occasionally cut lawn	

Daisy	36.0	18.6	< 0.02
Dandelion	10.8	3.4	< 0.05
Field buttercup	1.2	10.0	< 0.01
Ribwort plantain	4.3	2.8	> 0.5
Greater plantain	0.9	1.5	> 0.5

- (a) Describe a practical technique which you could use to find the mean population density of daisies on a lawn.

(3)

- (b) Give the null hypothesis for the statistical test on the population density of daisies.

(1)

- (c) What conclusions can be drawn from the results of this investigation?

(3)

(Total 7 marks)

Q56.

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)

Mark schemes

Q1.

(a) Comparisons

1. Nucleotide structure is identical;
Accept labelled diagram or description of nucleotide as phosphate, deoxyribose and base
2. Nucleotides joined by phosphodiester bond;

OR

Deoxyribose joined to phosphate (in sugar, phosphate backbone);

3. DNA in mitochondria / chloroplasts same / similar (structure) to DNA in prokaryotes;
Accept shorter than nuclear DNA/is circular not linear/is not associated with protein/histones unlike nuclear DNA;

Contrasts

4. Eukaryotic DNA is longer;
5. Eukaryotic DNA contain introns, prokaryotic DNA does not;
6. Eukaryotic DNA is linear, prokaryotic DNA is circular;
7. Eukaryotic DNA is associated with / bound to protein / histones, prokaryotic DNA is not;

5 max

- (b)
1. Mutations change base / nucleotide (sequence);
Reject if mutation in amino acid
 2. (Causing) change in amino acid sequence;
 3. Mutations build up over time;
 4. More mutations / more differences (in amino acid / base / nucleotide sequence / primary structure) between distantly related species;

OR

Few(er) mutations / differences (in amino acid / base / nucleotide sequence / primary structure) in closely related species;

5. Distantly related species have earlier common ancestor;

OR

Closely related species have recent common ancestor;

Accept "order" for "sequence"

If neither MP4 or MP5 accept for 1 mark, idea of more mutations /differences as evidence of earlier common

Q2.

- (a) (A measure of) the number of (different) species in a community;

For 'community' accept 'habitat/ecosystem/one area/environment'

Reject 'in a population'.

1

- (b) **Yes, natural best, because**

1. Peak of (mean) bee numbers in natural habitat is highest;

For accept description for 'peak'.

2. The (mean) number of bees was higher in the natural habitat until day 200;

2. For 'day 200' accept any day between 190 and 210.

2. For 'until day 200' accept 'for 200 days'.

3. (Mean) species richness in natural habitat higher at all times;

No, natural not best, because

4. Lowest (mean) number of bees after day 220;

4. For 'day 220' accept any day between 210 and 230.

Yes, town worst, because

5. Peak of species richness higher in both natural and farmland

OR

Species richness lowest in town from day 125;

For 'day 125' accept any day between 115 and 135.

No, town not worst, because

(Mean) species richness is lower in farmland until day 125;

For 'day 125' accept any day between 115 and 135.

For 'until day 125' accept 'for 125 days'.

7. Similar (mean) number of bees to farmland;

OR

(Mean) number of bees lower in farmland until day 140;

For 'day 140' accept any day between day 130 and 150.

For 'until day 140' accept 'for 140 days'

General, no, because

8. Index of diversity of bees not measured

OR

The number of bees of each species is not known;

4 max

- (c) 1. Must not harm the bees
OR
Must allow the bee to be released unchanged;
2. Must allow close examination
OR
Use a key (to identify the species);
Accept method that allows close examination
Ignore references to DNA sequencing
Accept 'use photographs/specimens (to identify species)'
- (d) 1. Collect at more times of the year **so** more points on graph/better line (of best fit) on graph;
Both suggestion and explanation is required for each mark point.
The explanation must relate to the graph.
2. Counted number of individuals in each species **so** that they could calculate index of diversity;
3. Collected from more sites/more years **to** increase accuracy of (mean) data;
For 'accuracy' accept 'representative'.
- (e) 1. *A. chlorogaster* and *A. piperi* are more closely related (to each other than to *P. pruinosa*);
Must be a comparative statement.
Accept A. chlorogaster and A. piperi share a more recent/closer common ancestor (than they do with P. pruinosa);
Ignore references to A. chlorogaster and A. piperi not being related to P. pruinosa or not having a common ancestor with P. pruinosa.
2. Because they are in the same genus;

2

[11]

Q3.

- (a) 1. So no contamination / other bacteria;
2. So same number of bacteria transferred **to** allow comparison;
1. *Accept sterilisation / kills all (bacteria)*
2. *Allow amount / concentration for number*
- (b) 6 000 000
OR

2

$$6 \times 10^6;$$

1 mark for 3 000 000

OR

$$3 \times 10^6$$

Allow 1 mark for 600 (in 1cm³ of diluted culture)

2

- (c) 1. (Several) values between 10 and 15 (units);
 2. Repetitions of each;
 1. *Accept descriptions of this*
 Ignore repeat the investigation / repeat at 10 and 15 units.

2

[6]

Q4.

- (a) 1. (Without genetic analysis / **X**) *mackloti* and *olivaceus* have a more recent common ancestor with each other (than with *papuana*);
 2. (Genetic analysis indicates / **Y**) *papuana* and *mackloti* have a more recent common ancestor with one another (than with *olivaceus*);
 Accept 'more closely related to' for 'more recent common ancestor'

2

(b)

Domain	Eukaryote
Kingdom	Animal
Phylum	Chordata
Class	Reptilia
Order	Squamata
Family	Python

;

All 5 correct = 1 mark

Any errors = 0 marks

1

- (c) Genus / genera;
 If the response has two answers no mark is awarded.

1

- (d) 1. The (base) sequence of DNA;
 Accept 'DNA hybridisation'
 2. The (base) sequence of mRNA;
 3. The amino acid sequence (of proteins);

3

[7]

Q5.

- (a) 1. TEM use electrons **and** optical use light;
 2. TEM allows a greater resolution;

3. (So with TEM) smaller organelles / named cell structure can be observed
OR
greater detail in organelles / named cell structure can be observed;
 4. TEM view only dead / dehydrated specimens **and** optical (can) view live specimens;
 5. TEM does not show colour **and** optical (can);
 6. TEM requires thinner specimens;
 7. TEM requires a more complex/time consuming preparation;
 8. TEM focuses using magnets **and** optical uses (glass) lenses;
3. *'clearer' is not equivalent to 'detail'*
 4. *Accept 'Only optical can view live specimens'*
 5. *Accept 'Only optical can show colour'*
 7. *Accept 'TEM requires a more difficult preparation'*
- Ignore references to artefacts*

6 max

- (b)
1. **W** has 4 cells / nuclei since it is at the (end of) 2nd division (of meiosis);
 2. **Z** has 2 cells/nuclei since it is at the (end of) 1st division (of meiosis);
 3. **W** shows haploid cells / cells containing n chromosomes;
 4. (Cells in) **W** contain half the (mass of) DNA of (Cells in) **Z**;
- OR**
(between **Z** and **W**) chromatids have separated;
OR
In **Z** homologous chromosomes have separated;
- Ignore 'Z shows diploid cells / contains 2n chromosomes'*
4. *Accept 'W contains half the amount of DNA of Z'*

4

- (c)
1. Use random sample of seeds (from each population);
 2. Use (large enough) sample to be representative of whole population;
 3. Indication of what size was measured e.g. mass;
 4. Calculate a mean and standard deviation (for each population);
 5. Use the (Student's) t-test;
 6. Analyse whether there is a significant difference between (the means of) the two populations;
1. *Accept described, suitable method of random sampling.*
 1. *Reject description of inappropriate method of random sampling (e.g. random coordinates in the field / use of quadrats)*
 2. *Accept 'running mean does not change'*
 2. *For representative accept 'reliable, reproducible, repeatable' OR a mean close to the true value.*
 5. *Accept 'Use 95% confidence limits'*
 6. *Reject unqualified references to results being significant*

5 max

[15]

Q6.

- (a) Any **two** valid reasons;

e.g.

1. Increase in plant diversity leads to more types of food for animals;

2. Increase in variety of animals leads to increase in predator species;

3. Increase in niche / habitat

2 max

(b) 1. Repeat soil sorting for different times and record number of species collected;

2. Find optimum time / time beyond which further sorting does not lead to increase in animal species found

2

(c) 1. No data on number of individuals in each

$$\text{species / diversity index} = \frac{N(N-1)}{\sum n(n-1)}$$

1

(d) Principle:

1. Overlap of $2 \times \text{SD}$ shows probability of differences (in means) being due to chance is greater than 0.95;

Allow converse of MP1

Credit MP1 wherever it appears

Agree:

2. No difference in number of earthworms and millipedes (per m²)

3. No difference in number of species of centipedes or millipedes.

Disagree:

4. More beetles and woodlice in grassy strips;

5. More species of beetles, earthworms, woodlice in grassy strips.

4 max

[9]

Q7.

(a) 4:

1

(b) 2.68(6).

If answer incorrect:

$$\sum n(n-1) = 242 = 1 \text{ mark}$$

$$N(N-1) = 650 = 1 \text{ mark}$$

2

(c) 1. Take more samples and find mean;

2. Method for randomised samples described.

Allow larger area = 1 mark

2

[5]

Q8.

- (a) Species richness measures only number of (different) species / does not measure number of individuals.

1

- (b) Trees vary in height.

1

- (c) 1. Index for canopy is 3.73;
2. Index for understorey is 3.30;
3. Index in canopy is 1.13 times bigger;

If either or both indices incorrect, allow correct calculation from student's values.

3

- (d) 1. For *Zaretis itys*, difference in distribution is probably due to chance / probability of being due to chance is more than 5%;
2. For all species other than *Zaretis itys*, difference in distribution is (highly) unlikely to be due to chance;
3. Because $P < 0.001$ which is highly significant / is much lower than 5%.

3

[8]**Q9.**

- (a) 1. Kingdom, Phylum, Class, Order, Family;
2. *Luscinia svecica*.

1 mark for each correct column

Allow Genus and Species if both placed in box for species but not if both placed in genus box

2

- (b) Number of different alleles of each gene.

Accept number of different base sequences (found) in each gene

1

- (c) 1. Has greater proportion of genes / percentage of genes showing diversity;
2. Percentage is 35% compared with 28% / proportion is 0.35 compared with 0.28.

Allow correct figures that are not rounded up, i.e., 34.9% / 0.349 and 27.8% / 0.278

2

[5]**Q10.**

- (a) 1. Draw grid over (map of) area;
2. Select squares / coordinates at random.

2

- (b) 1. No emigration / immigration;
2. No losses to predation;
3. Marking does not affect survival;
4. Birth rate and death rate equal;
5. (In this case) all belong to one population.

2 max

- (c) 1. Only glows brightly with UV, so doesn't make insects more visible;
 2. So doesn't affect / increase predation;
OR
 1. Glows brightly with UV marking visible;
 2. So makes it easy to pick out labelled insects.

2

- (d) 10 130.
 Tolerance of ± 1

$$N = \frac{M \times C}{R} = 1 \text{ marks}$$

2

- (e) 1. Scientists removed large numbers of insects (which were not returned) from same area / same population;
 2. Affecting ratio of marked to unmarked.

2

[10]

Q11.

- (a) 1. Vaccine/it contains antigen (from HPV);
Term 'antigen' may be first mentioned with point 2
 2. Displayed on antigen-presenting cells;
Accept named example, e.g. macrophage/phagocyte/B cells
 3. Specific helper T cell (detects antigen and) stimulates specific B cell;
Accept 'helper T cell with receptor on surface' for 'specific' and B cells with receptor/antibody on surface that bind to antigen for 'specific'
 4. B cell divides/goes through mitosis/forms clone to give plasma cells;
 5. B cell/plasma cell produces antibody;

4 max

- (b) 1. Two (doses) because got more antibody;
Accept more effective in producing antibody
 2. With three doses, second dose/dose at 1 month doesn't lead to production of any more antibody (than the two-dose group)/get same/similar response;
 3. Three doses would be more expensive/less popular with parents/girls (and serves no purpose);
Accept 'less painful'

2 max

- (c) t-test, because comparing two means;
Mark for correct test and explanation correct
Accept 'comparing the mean'
Reject 'to show that the results/means are significant'

1

- (d) 1. Compare (base sequences of) DNA;
 2. Look for mutations/named mutations (that change the base sequence);
 3. Compare (base sequences of) (m)RNA;
1 and 3 accept triplet/codon sequences for comparisons
Ignore references to 'introns/non-coding DNA'

Q12.

- (a) 14; 1
- (b) Number (of individuals) in each species (of dung beetle);
Accept: population of each species. 1
- (c) 1. No overlap in standard deviations;
Accept: no overlap in error bars.
2. (Difference in mean total) significant/is not due to chance/is real; 2
- (d) No bias;
Ignore: 'representative sample'. 1
- (e) 1. Removes species/types of plant/insect;
Accept: decrease in plant/insect diversity.
2. Fewer food sources;
Ignore: less food.
Accept: less variety of food.
Accept: removes a food source.
3. Fewer habitats/niches;
Accept: loss/removal/destruction/ of a habitat.
Accept: no habitat.
Ignore: homes/shelters. 3

Q13.

- (a) (i) (Grouped according to) evolutionary links/history/relationships / common ancestry;
Ignore: closely related, factors, characteristics
Ignore: genetically similar 1
- (ii) 1. Able to reproduce;
Accept: smallest taxonomic group/groups of organisms with same genes/ chromosomes/same number of chromosomes
Accept: breed for 'reproduce'
Ignore: mate
Reject: genetically identical
Ignore: similar genes/chromosomes
2. To produce fertile offspring;
Ignore: that are 'viable' 2
- (b) Phylum

Class
Family
Genus;

Accept: plural answers phyla / genera / families

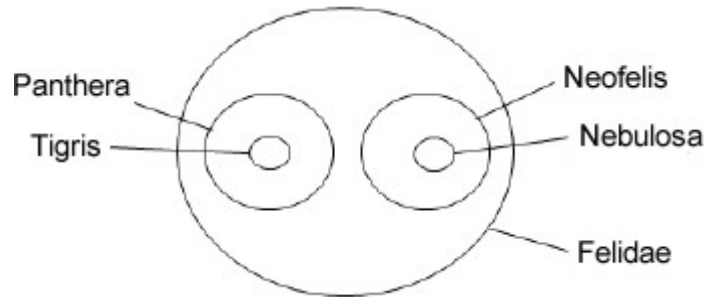
Accept phonetic answers

phyllem/phylem/fylum/fyla/phylae/phyli/jenus/ jenera/familys

All 4 in correct order for 1 mark

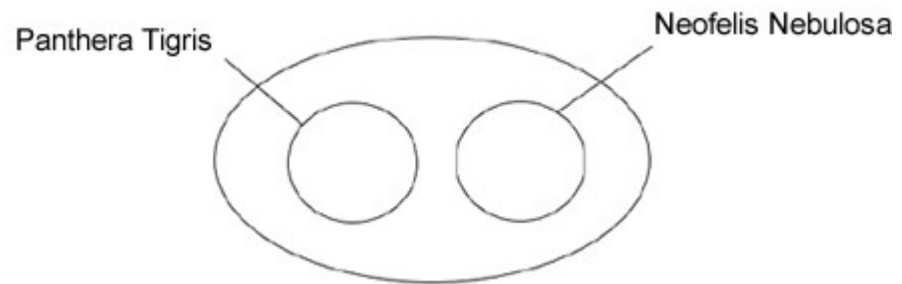
1

- (c) 1. Two circles/with two inner circles with no overlap;



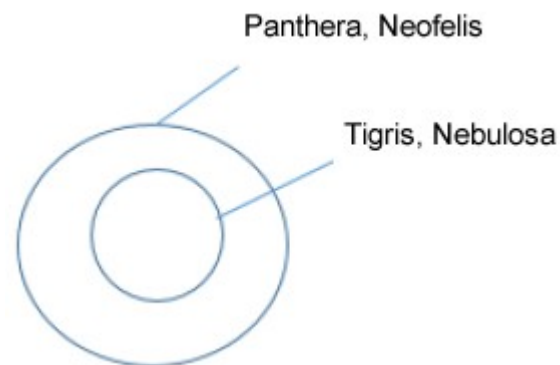
= 2 marks

OR



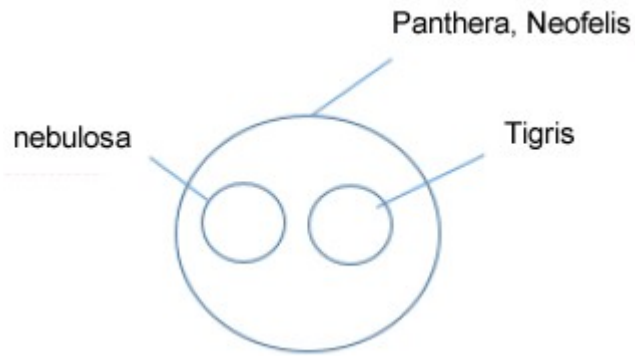
= 2 marks

OR



= 1 mark

OR



= 1 mark

2. Labels correct;
Ignore underlining / capitals
Accept: P tigris/ N nebulosa
Accept phonetic spelling

2

- (d) 1. South China and Sumatran tigers share a more recent common ancestor;
Accept: more closely related (statement must be comparative)
Accept: a labelled hierarchy
2. (because) identical/same/matching (nucleotide) sequences;
Accept: converse for Siberian tiger eg Siberian is less closely related to South China AND Sumatran tigers



2

[8]

Q14.

- (a) 1. Number of species in a community;
Accept: number of species in a habitat/area/ecosystem
Accept: species richness
Accept: all the species for number of species
Ignore: variation/diversity
Reject: in a population
- (b) 1. Number of (organisms of) each species;
Accept: 'population' for number and accept individual for organism.
Accept: 'species richness'
2. Total number of organisms (of all species) / Total number of species;
Idea of grand total of all organisms, not just number of different species

1

2

- (c) 1. Described effect of sewage (eg oxygen depletion/is toxic/kills);
Accept: increase in BOD
Accept: eutrophication/description of eutrophication
2. Prevents some/many species colonising/ reproducing/remaining;
Accept: only a few species survive
3. Sewage is food source for (individuals of) some/a few/species;
4. (So) increase only in their numbers;

Max 2

- (d) (i) 1. Results are not repeatable / are not representative / unreliable / conflict / contradict;
Accept: different / don't agree
Ignore: not valid/not reproducible/inaccurate
2. Can't make any conclusions;

2

- (ii) Do repeats to find a pattern/distribution/mean (of index of diversity);
Accept: use a different technique to obtain more reliable evidence;
Need idea of more than one repeat
Accept: calculate an average
Accept: at different times
Accept: statistical test to see if results differ significantly

1

[8]

Q15.

- (a) 1. Type of feed affects (antibiotic) resistant bacteria (in animals);
Accept: null hypotheses
Accept predictions, for example
More antibiotic resistant bacteria form in animals fed with antibiotics in their food
2. (Antibiotic) resistant resistant infect /are passed on to animals/farmer / resistant resistant are passed between animals;
Accept: bird to bird/bird to human/human to human
Accept: a link (exists) between (antibiotic) resistance in animals and their keepers/farmers – as lowest level QWC
3. Incidence of (antibiotic) resistant resistant differs in chickens and turkeys;
Accept: a comparison, eg 'more resistant bacteria in chickens than turkeys'
4. Incidence of (antibiotic) resistant resistant differs in chicken farmers and turkey farmers;
Accept: a comparison, eg 'more resistant bacteria in chickens than turkeys'

Max 2

- (b) (i) 1. Large(r) percentage of resistant bacteria in

- turkeys/low(er) percentage of resistant bacteria
in chickens;
Accept: E coli for bacteria
Ignore: number, eg. ignore 'more'/'fewer' turkeys/chickens
2. Large(r) percentage of resistant bacteria in turkey
farmers/low(er) percentage of resistant bacteria in
chicken farmers;

2
- (ii) 1. (More) antibiotic in turkey feed kills (more) non-
resistant bacteria / resistant bacteria survive;
Accept: antibiotic creates selection pressure
Survive must be explicit, not implied by 'reproduce'
2. (Resistant bacteria) reproduce / pass on gene for
resistance;

2
- (c) (Human) faeces contain pathogens;
Accept: harmful organisms

1
- (d) 1. Large number of farms / farmers (surveyed) / 46;
'Reliable' is used in the question stem
2. So results are (likely to be) representative / can identify
anomalous results;
Ignore: reproducible / accurate / valid / reliable
*Accept valid explanation of replicates minimising effects of
chance*

2
- (e) 1. (DNA) hybridisation (of gene for resistance in bacteria
taken from bird and farmer);
2. (Identical) strands separate at high(est) temperature;

OR
3. Compare base/nucleotide sequence (of gene for resistance
in bacteria taken from bird and farmer);
4. (Identical strains) have identical/same base sequences
Mark in pairs, do not mix and match.
*Accept: bacteria in bird and farmer/both types of bacteria
have identical base sequences = 2 marks*

2
- (f) 1. (Antibiotic use has) increased cases of bacterial
resistance;
Accept: number
2. Transfer/horizontal transmission of (resistance) gene to
pathogens/harmful bacteria;
Accept: conjugation
3. (Antibiotic) resistant bacteria cause harm / medical
treatments less effective;
Accept: superbug
4. Avoids side effects on animals;
5. Increased demand for organic food;

6. Antibiotic/resistant bacteria could be present in human food;
7. High cost of antibiotics;
8. Legislation has controlled antibiotic use;

Accept: EU/government guidelines

4 max

[15]

Q16.

- (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]

Q17.

- (a) 1. Number of (individuals of) each species;
Accept: 'population' for 'number'
2. Total number of individuals / number of species;
Accept: 'species richness'
MP2 allows for other types of diversity index
- (b) (i) (Shows) results are due to the herbicide / are not due to another factor / (to) compare the effect of using and not using the herbicide / shows the effect of adding the herbicide;
Neutral: allows a comparison
Neutral: ensures results are due to the independent variable
Reject: 'insecticide'
Accept: 'pesticide'

2

1

- (ii) 1. (More) weeds killed so more crops / plants survive / higher yield /

- less competition;
2. High concentrations (of herbicide) harm / damage / kill / are toxic to crops / plants;
Accept: 'pesticide'
Neutral: 'insecticide'
Accept: use of figures (eg 400+)

2

- (iii) 1. Reduced plant diversity / fewer plant species / fewer varieties of plant;
Accept: 'weed' for 'plant'
Neutral: fewer plants
Accept: only one crop species remains
2. Fewer habitats / niches;
Q *Neutral: fewer homes / shelters*
3. Fewer food sources / varieties of food;
Neutral: less food

3

[8]

Q18.

- (a) Succession;
Ignore any word in front of succession e.g. secondary / ecological succession.
Neutral 'forestation'.
- (b) 1. Greater variety / diversity of plants / insects / more plant / insect species;
Neutral: more plants.
2. More food sources / more varieties of food;
Neutral: more food / more / greater food source (singular).
3. Greater variety / more habitats / niches;
Accept: more nesting sites.
Q *Neutral: more homes / shelters.*
- (c) (i) Temperature and carbon dioxide;
Neutral: water, chlorophyll.
- (ii) Shows (gross) photosynthesis / productivity minus respiration / more carbon dioxide used in photosynthesis than produced in respiration;
Correct answers are often shown as: net productivity = (gross) photosynthesis – (minus) respiration.
- (iii) 1. (Shade plant) has lower (rate of) respiration / respiratory losses / less CO₂ released at 0 light intensity / in dark;

1

3

1

1

Accept use of figures.

Accept: lower compensation point.

2. Greater (net) productivity / less sugars / glucose used / more sugars / glucose available;

Neutral: any references to rate of photosynthesis.

2

[8]

Q19.

1. Carbon dioxide combines with ribulose biphosphate / RuBP;

2. Produces two glycerate (3-)phosphate / GP;

Accept: any answer which indicates that 2 x as much GP produced from one RuBP.

3. GP reduced to triose phosphate / TP;

Must have idea of reduction. This may be conveyed by stating m.p. 4.

4. Using reduced NADP;

***Reject:** Any reference to reduced NAD for m.p.4 but allow reference to reduction for m.p. 3.*

5. Using energy from ATP;

Must be in context of GP to TP.

6. Triose phosphate converted to glucose / hexose / RuBP / ribulose biphosphate / named organic substance;

[6]

Q20.

- (a) Push – legume

Pull – grass;

Both needed for mark

1

- (b) 1. Set up tape measures on two sides of the plot / make grid of plot;
Allow 'Number each plant'. With this approach mp3 cannot be awarded.

2. Use random number table / calculator / generator;

Allow 'Select from a hat' idea.

3. To generate coordinates;

3

- (c) 1. To prevent competition between the maize and the grass;

2. For light / nutrients / water;

OR

3. Idea of limits movement of pest (between grass and maize);
 4. Only eating / damaging grass;
- 2 max
- (d) 1. Nitrogen-fixing bacteria convert nitrogen (in the air) into ammonium compounds (in the soil) which are converted into nitrates / nitrification occurs;
Accept 'ammonia' for 'ammonium compounds'.
2. Maize uses nitrates (in soil) for amino acid / protein / ATP / nucleotide production;
*2. Must be in the context of maize.
 Ignore ionic formulae unless only these are given.*
- 2
- (e) 1. Reduced % damage to maize plants / increased maize grain yield;
2. Calculation to justify mp 1;
3. Standard deviation shows no overlap but need stats to show significance of this difference;
4. More profit / net income / greater income than additional cost (with push-pull);
5. \$322 extra / 408% more / \$401 v \$79 profit;
*Accept '\$350 extra income compared to \$28 extra spend'.
 Mp5 gains credit for both mp4 and 5*
- 3 max

[11]

Q21.

- (a) (i) 1. Groups within groups;
1. accept idea of larger groups at the top / smaller groups at the bottom
2. No overlap (between groups);
- 2
- (ii) (Grouped according to) evolutionary links / history / relationships / common ancestry;
*Neutral: closely related
 Neutral: genetically similar*
- 1
- (b) (i) 1. (Only) one amino acid different / least differences / similar amino acid sequence / similar primary structure;
2. (So) similar DNA sequence / base sequence;
- 2
- (ii) 1. Compared with humans / not compared with each other;
Accept: degenerate code / more than one triplet (codes) for an amino acid

2. Differences may be at different positions / different amino acids affected / does not show where the differences are (in the sequence);

1 max

- (iii) 1. All organisms respire / have cytochrome c;
Accept: converse arguments for haemoglobin
 1. *Accept 'more' instead of 'all'*
 1. *Accept 'animals' instead of organisms* □
2. (Cytochrome c structure) is more conserved / less varied (between organisms);
 2. *Neutral: cytochrome c is conserved*

1 max

[7]

Q22.

- (a) (i) Reliable / representative / for statistical tests;
Accept: identify anomalies
Neutral: accurate / valid / bias
- (ii) 1. Find coordinates (on a grid) / split area into squares / number the sites;
 1. *Ignore references to tape measures, metre rulers etc*
2. Method of generating / finding random numbers eg calculator / computer / random number generator / random numbers table;
 2. *Accept: numbers out of a hat / use of dice*
- (iii) 1. Breeding (of lizards);
Neutral: weather / climate / hurricanes / hibernation / migration / emigration / immigration
2. Food source / prey;
3. Predator;
4. Variation in malarial infection;
5. Temperature variation;
6. Availability of water eg drought / □rainy season'
- (b) 1. Number in sample varies;
2. Allow a (valid) comparison;
- (c) 1. (Overall) positive correlation (for either / both species);
Neutral: only one study / no repeats
2. Reference to (site) 5 / 300 metres;

1

2

2 max

2

3. Limited results for *A. wattsi* / small sample / number / percentage infected for *A. wattsi*;

2 max

- (d) (i) 1. Fewer *A. wattsi* infected / more *A. gingivinus* infected;
2. Higher number of *A. wattsi* present when higher percentage / number of *A. gingivinus* infected / no *A. wattsi* present when *A. gingivinus* has zero infection;
2
- (ii) 1. Reduced immunity / increased susceptibility to disease;
1. *Accept: idea that energy / resources are used to combat malaria*
2. Reduced oxygen transport / uptake / respiration / reduced activity / movement;
2
- (iii) 1. There is a probability of less than 1% / 0.01;
1. *Reject: probability is / equal to 1% / 0.01;*
1. *Reject 0.01% / 5% / 0.05 / 0.05%*
2. That result(s) / correlation / it is due to chance;
2. *Allow correct interpretation using above (incorrect) figures eg there is a probability of less than 5% that the results are due to chance =1 mark*

OR

3. There is a probability of more than 99% / 0.99;
4. That result(s) / correlation / it is not due to chance;
Note: there is a probability of more than 5% that the results are due to chance =0 marks
3. *Reject: probability is / equal to 99% / 0.99;*
3. *Reject 0.99% / 95% / 0.95 / 0.95%*
4. *Allow correct interpretation of above figures ie 0.99% / 95% / 0.95 / 0.95% but reject if less than*

2

[15]

Q23.

- (a) (i) Kingdom / phylum / class;
Accept Animalia / animal kingdom / Chordata / Chordates / Aves
Allow phonetic spelling
1
- (ii) Family;
1
- (b) 1. Shows the spread of the data / how data varies;
1. *Reject range.*

Accept varies from the mean

2. Overlap = no difference / due to chance / not significant;
2. Allow converse

2

- (c) 1. Different species would have different amino acid sequences;
Accept more closely related = more similar sequence
2. Amino acid sequence is the result of DNA / alleles / base sequence;
References to incorrect statements about coding negates second mark

2

[6]

Q24.

- (a) Removes bias;

1

- (b) (i) 1. 1.28 / 1.29 / 1.285 / 1.3
1. Ignore more than 3dp
2. Answer incorrect but shows clear understanding of Σ
2. $\Sigma = 318250$. Allow mark if denominator written out. Incorrect denominator but evidence of understanding gains mark

2

- (ii) Diversity index would be lower (NO MARK)
Assume wheat field if site unspecified

1. Fewer species / Beech aphid / Large white butterfly / 7-spot ladybird absent / only three species / species diversity lower / mostly one species / mostly bird-cherry aphid;
1. Allow species richness in context of few species
2. Fewer plant species;
2. Allow one type of food source if clearly plant

2

- (c) For:

1. Data support the claim / evidence supports claim;
1. Ignore reference to correlation / causation

Against:

2. Only wheat field / only comparing with wood / one type of habitat / only insects considered;

2 max

- (d) 1. Greater variety of plants;
2. Another habitat / more habitats / places to live / niches / another food source / more food types;

2. Answers referring to 'more food' should not be credited.
Allow reference to either animal or plant as foods

2

[9]

Q25.

- (a) 1. Carbohydrate / sugar / named carbohydrate;
2. Minerals / named mineral ion;
Accept alternatives for mineral such as inorganic substances / ions. Accept symbol for ion. Accept incorrect symbols providing that answers are not ambiguous.
3. Amino acids / protein;
4. Vitamins;

2 max

- (b) 1. Shake / stir / mix;
2. Even distribution of yeast / cells;
Accept other terms with a similar meaning for both points

2

- (c) Two marks for correct answer of 20 / 20.2 / 20.22;;

One mark for incorrect answer in which student clearly shows increase as 8.912 – 7.413 or as 1.499;

Ignore references to 10⁶

2

- (d) 1. More competition;
2. Less oxygen;
3. Less glucose / sugar / carbohydrate / respiratory substrate;
4. Ethanol / alcohol becomes toxic / inhibits respiration / inhibits reproduction;
5. Fall in pH;

2 max

[8]

Q26.

- (a) 1. Closer the (amino acid) sequence the closer the relationship;
2. (Protein structure) related to (DNA) base / triplet sequence;
Amino acid sequence is related to (DNA) base / triplet sequence = two marks;

2

- (b) 1. Reference to base triplets / triplet code / more bases than amino acids / longer base sequence than amino acid sequence;
Different (base) triplets code for same amino acids = 2

marks;

Degeneracy of triplet code = 2 marks

2. Introns / non-coding DNA / degeneracy of code / more than one code for each amino acid;

Ignore reference to codon.

2

[4]

Q27.

- (a) (i) Produces a more reliable mean / average / makes sure sample was representative / reduce effect of extreme values / identify anomalies;

Ignore references to chance

1

- (ii) Removes bias;

1

- (b) Two marks for correct answer of 5.8;

One mark for incorrect answer that clearly shows denominator as 216;

2

- (c) 1. Increase in variety of plants / shrubs / grass;

2. More habitats / niches;

3. Greater variety of food sources / more food sources;

Answers only referring to 'more food' should not be credited

3

[7]

Q28.

- (a) Greater variety / different foods;

More habitats / niches;

Answers only referring to 'more food' should not be credited but allow 'more food sources'.

2

- (b) Also measures number of individuals in a species / different proportions of species;

Some species may be present in low / high numbers;

First marking point can only be awarded if there is a reference to species.

2

- (c) (i) Large surface area to volume (ratio) / permeable / thin (outer layer);
Correct reference to diffusion;

Accept (Eggs) cannot move (out of water) for 1 mark

2

- (ii) Concentration (of pesticide) is increased;

1

Q29.

- (a) Two marks for correct answer, 41.9 / 42 ;;
One mark for incorrect answer of 0.42; 2
- (b) Increases proportion of crop that is used / greater proportion is grain / reduces proportion of crop that is not used / is not grain; 1
- (c) Quadrats from different parts of field;
Biotic / abiotic factors / named biotic / abiotic factor different; 2
- (d) Water (in plants and grain);
Varies; 2

[7]

Q30.

- (a) Greater when treated with herbicide **G**;
Same number but total biomass larger;
Can be shown by figures 2
- (b) Fewer weeds left to produce seeds;
Less contamination of crop (by weeds); / fewer weeds to separate from crop; / less competition (between crop and weeds); 2
- (c) **Advantage**
Weeds growing fast / photosynthesising fast so effect will be seen / will have large effect;
- Disadvantage**
No information about winter / other seasons / weeds not growing fast / could kill (beneficial) insects / crop may be harvested before effects noticeable;
One mark for advantage and one mark for disadvantage 2
- (d) **Limitations of investigation**
1. No control / untreated field;
2. Amount of herbicide may be different;
3. May be differences between fields; Eg soil Nutrients / fertiliser added Type of weed Microclimates
4. May be different number of weeds (at start);
- Limitations of results**
5. No replicates / one set of data;
6. Field size may vary / not specified;

Scientific Research

7. Scientific research / example of scientific research has led to greater yield;

When marking please number the marking points

e.g.  means a mark award for point 5

5 max

[11]

Q31.

- (a) Banding pattern changes as cheetah gets older / difficult to judge as tail is short / fluffy; 1
- (b) (i) Mean not (always) a whole number;
Standard deviation not (always) zero; 2
- (ii) Movement of tail / angle of sight / confused it with another band / subjective estimation;
*Accept reference to **Figure 1***
E.g. Bands 2 and 3 have same thickness but look different 1
- (c) Band width not the same on both sides of tail; 1
- (d) Offspring of the same family will be more similar genetically;
As have same mother (and father) / parent;
Expect to see more differences in randomly chosen cheetahs; 3

[8]

Q32.

- (a) Number of a / each (species);
Accept answers expressed differently providing they convey this information.
Ignore extra information if it does not contradict answer. 1
- (b) 1. Lower diversity of plants / few species of plants / less variety of plants / few plant layers;
2. Few sources / types of food / feeding sites; / few habitats / niches;
3. Fewer (species of) herbivore so few (species of) carnivores; 3
- (c) (i) Cannot predict / do not know intermediate values; 1
- (ii) To see what would happen / compare with no management work / to see if numbers fell anyway / To show that it was not a factor;
Management as a term not required. Allow explanations. 1
- (d) 1. Total number of birds along ditch B / ditch with one side cleared greater

than along ditch A / ditch with both sides cleared;

2. But only gives data for all birds / does not give data for species / data not about diversity;
3. Single ditch / single occasion / not repeated / no control;

Principles:

Correct from evidence

Total number not diversity

Flaws in technique

3

[9]

Q33.

- (a) (So results) can be compared / so measurement is the same each time / because eye is not perfectly round / uniform;

Accept eye opens to different amounts

1

- (b) (i) 1. Eye (diameter) is smaller and antennae longer;
2. Antennae detecting touch;
3. Data only refers to shrimps / data may not apply to all animals / only in one area;

The principle here is that candidate has recognised that both features confirm suggestion. Exact wording does not matter.

2 max

- (ii) 1. Standard deviation gives a measure of spread / variation;
2. More standard deviations overlap, the less likely it is that differences are real / significant / the more likely they are caused by chance;

Do not accept range

Accept converse.

Although we are looking for the idea of significance, we cannot require this term.

2

- (c) (i) Qualitative statement about
- difference in size /
- difference in variation /
- overlap in size;

Quantitative statement about

difference in size /

difference in variation /

overlap in size;

Supported by relevant two sets of figures from graph;;

Note simplistic answer involving a quantitative statement gains 1 mark.

More specific answer involving quantitative information gains 2 marks.

2

- (ii) (No) for same body length, antenna are longer / antenna are shorter / some with longer body have short antennae / some with shorter body length have longer antennae;

OR

(Yes) positive correlation in open / in cave;

Habitat not critical as a term.

Must refer to idea of same habitat

Accept description

1

- (d) More alleles of each gene / shrimps in open have all the alleles;

Candidates are required to use the information from the table. Must therefore refer to alleles.

1

- (e) 1. A small number of shrimps were / went into the cave;
2. All / high proportion of shrimps had allele L;
3. Cave population descended from these / these reproduce;

3

- (f) (i) 1. Cross shrimps from two sites / watch courtship;
2. Breed young together / observe mating;
3. Allow 1 mark for any method of improving quality of results e.g. carry out reciprocal crosses / large number of crosses / isolate beforehand;
Other valid equivalent suggestions should be accepted.

- (ii) If same species the shrimps would breed, producing fertile young / courtship species specific;

Accept any form of evidence – mating / laying eggs / giving birth to young.

3

[15]

Q34.

- (a) Most closely (related) to chimpanzee / most recent common ancestor;

1

Least (related) to dogfish / least recent common ancestor;

Allow 'chicken is second' to chimpanzee as equivalent to second mark point.

Allow answers which compare similarity in DNA / genetic

material.

Marks should not be awarded for answers which only compare amino acid sequences without any indication of relationships.

Allow 'monkey' for chimpanzee and 'fish' for dogfish

1

- (b) Is present in all eukaryotes;

1

- (c) Reference to base triplet / triplet code / more bases than amino acids / longer base sequence than amino acid sequence;

Introns / non-coding DNA; / same amino acid may be coded for / DNA code is degenerate;

Reject different amino acids are formed / produced.

Ignore reference to codon.

2

[5]

Q35.

- (a) (i) To cut the DNA;

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 complementarity 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 / male gamete;

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]

Q36.

- (a) Recognition of same species;

Stimulates release of gametes;

Recognition of mate / opposite gender;

Indication of sexual maturity / fertility;

2 max

- (b) (i) Internal fertilisation / fertilisation occurs in pouch / limited area;

***Q** The term fertilisation is not required in the answer but must be implied.*

1

- (ii) Protection from predators (developing in pouch);

1

- (c) (i) Less stress caused to seahorse / quicker / more accurate method / body is curved / head is linear;

***Q** Do not accept "easier" unless qualified.*

1

- (ii) Head length proportional to body length / or described;

1

- (d) Positive correlation between head / body lengths of male and female / female and male with similar head / body lengths pair together;

1

- (e) Use line of best fit;

And extrapolate / extend line as required;

2

- (f) (Compare) DNA;

Sequence of bases / nucleotides;

Compare same / named protein;

Sequence of amino acids / primary structure;

Immunological evidence – not a mark

Inject (seahorse) protein / serum into animal;

(Obtain) antibodies / serum;

Add protein / serum / plasma from other (seahorse) species;

Amount of precipitate indicates relationship;

***Q** The marks awarded for reference to DNA and sequence of*

bases / nucleotides must be in a different context to DNA hybridisation.

6 max

[15]

Q37.

- (a) (i) Method of positioning quadrats,
E.g. Find direction and distance from specified point / find coordinates on a grid / split area into squares;

Method of generating random numbers;

E.g. From calculator / telephone directory / numbers drawn from a hat;

Last point represents minimum answer

Q Do not credit any method that relies on throwing a quadrat

2

- (ii) Calculate running mean / description of running mean;

When enough quadrats, this shows little change / levels out (if plotted as a graph);

Enough to carry out a statistical test;

A large number to make sure results are reliable;

Ignore terms that are not incorrect

Regards large numbers as 10 / 10% +

Need to make sure work can be carried out in the time available;

2 max

- (b) Coppice different parts of the wood at different times;

As data show many daffodils flowering 4 / 5 years after coppicing;

Q Second point needs specific reference to the graph, numbers and time after coppicing. Accept any correct answer that does this.

2

- (c) Positive correlation between rainfall and flowering / the higher the rainfall, the more daffodil flowers;

Negative correlation / the higher the temperature the fewer daffodils in flower;

All statistically significant so not likely to be / not due to chance;

2 max

[8]

Q38.

- (a) (i) Will work in all weather conditions / hairs will stick to it even if shrew / animal is wet / withstand rain;

1

- (ii) So shrews come into contact with glue;

1

- (b) Avoids bias / allows statistical tests to be carried out;
Allow description 1
- (c) (i) Increases the reliability of the measurements;
If measurements are repeatable, differences less likely to be due to measurement / personal error / anomalies unlikely;
Accept advantages of repeatable results. E.g. identifying anomalies / remove errors 2
- (ii) Plot graph / scatter diagram of one set of results against the other;
Q To gain first marking point, candidates must say what has been plotted.
Expect to see points lying close to line / Line should slope upwards / show positive correlation;
If what is being plotted is not clear, second point cannot be awarded.
OR
Plot measurement against hair number;
Look for overlying / corresponding points; 2
- (d) (i) One mark for a valid explanation based on individual shrews entering more than one hair tube / many hairs from same shrew / shrews enter without leaving hair; 1
- (ii) Rules out differences due to changes in population / changes in environmental conditions;
That could be produced by births / deaths / migration / specific example of environmental conditions affects results; 2
- (e) (A statistical test) determines the probability of results being due to chance;
Enables null hypothesis / description of null hypothesis to be accepted / rejected / determines whether correlation / result is significant; 2
- (f) (i) (Curve / line of best fit shows) positive correlation / description of positive correlation; 1
- (ii) Curve / line of best fit (almost) parallel to x-axis / horizontal / level / no correlation / index is independent of number of shrews;
Hair tubes with positive results when no shrews trapped;
Small size of shrews means shrews may not trigger traps; 2 max

[15]

Q39.

- (a) 1. Large surface area provided by lamellae / filaments increases diffusion / makes diffusion efficient;;

*Q Candidates are required to refer to lamellae or filaments.
Do not penalise for confusion between two*

2. Thin epithelium / distance between water and blood;
3. Water and blood flow in opposite directions / countercurrent;
4. (Point 4) maintains concentration gradient (along gill) / equilibrium not reached / as water always next to blood with lower concentration of oxygen;
5. Circulation replaces blood saturated with oxygen;
6. Ventilation replaces water (as oxygen removed);

6

- (b) Mixing of air and water (at surface);

Air has higher concentration of oxygen than water;

Diffusion into water;

Plants / seaweeds near surface / in light;

Produce oxygen by photosynthesis;

2 max

- (c) Not much oxygen near sea bed;

Toadfish haemoglobin (nearly) saturated / loads readily at / has higher affinity for oxygen at low partial pressure (of oxygen);

2

- (d) The chimpanzee and the bonobo are more closely related (than to the gorilla);

They have identical amino acids / one of the amino acids is different in the gorilla;

2

[12]

Q40.

- (a) Randomly collected / collected from many ponds / same species / same time of year;

*Accept other answers providing they might reasonably
impact on data*

1

- (b) 9;

1

- (c) Curve / line of best fit;

Shows upward slope / positive correlation / description of positive correlation;

Correlation does not necessarily mean causation;

Some other factor might be involved;

Some ponds had no worms but had frogs with deformed legs;

Q No mark awarded for "yes" or "no"

4 max

- (d) (i) Sample too small to establish a pattern / to be representative / to identify anomalies;

1

- (ii) Must compare like with like / must be a fair test;

Note that fair test is acceptable if used in context defined in How Science Works glossary

Some factors differ in mountains / named factor differs in mountains;

2

- (e) 27% of the frogs had deformed legs in pond 2;

Agricultural run-off and cage mesh diameter of 500 μm ;

2

- (f) Worms cause deformed legs;

Deformed legs in 500 μm mesh cages / deformed legs when worms in cage;

Run off (on its own) does not cause deformed legs;

No deformed legs with run off and 75 μm mesh / no worms;

When run off present makes effect of worms worse;

Quantitative statement e.g. increased by factor of 7 to 8 times;

4 max

[15]

Q41.

- (a) To enable (valid) comparison;

Bigger / smaller tomatoes could compress more easily;

2

- (b) SD bars do not overlap ;

Difference (in ripeness) is real;

More variation in normal tomatoes (than in GM tomatoes);

2 max

[4]

Q42.

- (a) Increase in number of species;

Increase in numbers of some species;

- (b) Initial environment hostile / few organisms adapted;

These organisms change the environment / suitable example;

More niches / more habitats;

Allowing other organisms to become established;

max. 3

[5]

Q43.

- (a) deforestation removes many habitats / niches fewer species / fewer types of organisms;

(do not credit just fewer organisms);

2

- (b) 1. nitrate ions in fertiliser available / absorbed immediately;
2. ammonium converted to nitrate by nitrifying bacteria
3. fertiliser would provide only the initial release of nitrate / potassium nitrate;

3

[5]

Q44.

- (a) Samples collected at random;
Method for choosing random sites – random coordinates / position from tables / calculator / other suitable means;

Other named factor constant e.g.:

Same size of net / same width of opening of net / use of one quadrat / Quadrats of same size / of stated size / same area disturbed / collect each Sample for same time;

3

- (b) *Caenidae* in deep water – because highest standard deviation / 'S.D.= 7.92'

1

- (c) (i) An organism's role / in the ecosystem / community;
[ALLOW refs. To trophic levels / named]
(IGNORE refs. To habitat)

1

- (ii) *Caenidae* found mainly in deep water AND *Baetidae* in shallow water / one family mainly in deep water AND the other in shallow water;

1

- (iii) Reduces competition for named factor – e.g. food / shelter / O₂ ;
To ensure both types survive / otherwise better adapted type displaces other type;
OR

Q45.

- (a) (i) EITHER: Correct answer: 3.45 / 3.44 / 3.4 = 2 marks
OR: Understanding of $\sum n(n-1)$ / use of
 134 / (2 + 90 + 12 + 30)
 + wrong answer = 1 mark

max 2

- (ii) Takes account of number of individuals / abundance /
 population size (as well as number of species);

1

- (b) The species at A / *F.spiralis* loses less water /
 loses water less rapidly / loses less mass;

The species at A / *F.spiralis* better adapted to / can survive where
 exposed for longer / to drier conditions;

The species at A / *F.spiralis* avoids competition For named aspect
 – e.g. light / substratum / space / CO₂;

ACCEPT converse argument re. F. serratus

3

Q46.

- (a) Tapes / string / axes laid out at right angles / grid area;
Method of obtaining random co-ordinates;
Do not allow "Use random number generator"

2

- (b) (i) Decrease then remain constant;
 From 200 cm / over 150 cm;

2

- (ii) Oxygen decreasing because soil becomes more compacted / not
 replaced;
 Decrease in oxygen leads to fewer aerobes surviving;

2

- (c) Anaerobic bacteria replace aerobic as oxygen decreased by aerobic bacteria;
 Remove competition;
 Aerobic bacteria no longer able to survive in these conditions;

3

- (d) (i) Near the surface / in top 50 cm;
 Table shows decrease with time at greater depths;

2

- (ii) Decrease;
 Fewer aerobic bacteria with depth;
 Oxygen concentration decreases / less oxygen at depth;

3

- (e) Probability greater than 95% / 0.95;
Results are not due to chance / results are significant;
Because bars do not overlap; 3
- (f) Plot as graph;
Draw line of best fit;
Read off appropriate value; 3
- [20]

Q47.

- (a) phylum, class, order;
species, *Acinonyx jubatus*; 2
- (b) larger groups containing smaller groups; 1
- (c) (i) do not interbreed to produce fertile offspring / different DNA /
different niches; 1
- (ii) fossil record;
evolutionary history / phylogeny;
biochemical differences e.g. DNA / proteins / cytochromes;
homologous features / named feature;
karyotype / number and form of chromosomes;
(discount any example credited in (i)) 2
- [6]

Q48.

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

Q49.

- (a) breed together;
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]

Q50.

- (a) large groups are divided into smaller groups;
(*not just 'hierarchical'*)
members of a group have features in common based on anatomy
/ fossils / embryology / DNA / specific aspect of cell biology
/ homologous structures;

reflects evolutionary history; 3
- (b) fungi and animals; 1
- (c) (insects and fungi) have common ancestor;
they diverged a long time ago / before others referred to in phylogenetic tree; 2
- (d) those with similar sequences put in same groups / are more closely related;
the greater difference in amino acid sequence the longer ago the groups
diverged; 2
- (e) A - present in all (eukaryotic) species or organisms / quantifiable;
D - extinct species not considered / no timing of events available / only limited
number of amino acid sequences / can't include prokaryotic species 2
- [10]

Q51.

- (a) (i) transect line may not go through representative areas / may avoid certain
areas; 1
- (ii) large sample;
how random coordinates are generated / how random places
chosen; 2
- (b) (i) spread of values around the mean height of the plant; 1
- (ii) smaller plants at higher altitude;
greater the altitude the lower the standard deviation ;

reference to figures to make a comparison;

2 max

- (iii) the plants measured were grown under uniform conditions;

1

[7]

Q52.

- (a) principle of sequential multiplication ($0.9 \times 0.6 \times 0.75 \times 0.67$);
0.27;

(correct answer 2 marks)

2

- (b) (i) similar sequence / actions / sign stimuli;

1

- (ii) additional action in sequence(species A) / scissor wings blocks
sequence in B;

1

- (c) (acts as) sign stimulus;
responds only to species-specific sound;

2

[6]

Q53.

- (a) generation of random co-ordinates;
use of 10 or more quadrats;
collection of all dog whelks in quadrat;

3

- (b) greater variation for sheltered population / population A;
range / spread around the mean;

(or converse)

2

- (c) (i) smaller ratio means relatively larger foot / population B has
relatively large foot;
better able to grip;
larger / longer shells have greater area exposed / are subject
to greater force;

- (ii) wave action limits the max. L / A ratio / extremes;
valid point about age, e.g. greater age range on sheltered
shore / live longer on sheltered shore;

*(allow shell size marking point in either (c)(i)
or (c)(ii) but only credit once)*

4 max

[9]

Q54.

- (a) phylum, class, family, genus;

1

- (b) (i) more recent common ancestor / DNA in common;

- (ii) mutation causes variation;
genes (coding) for protein / cytochrome c with different structures;
EITHER
individuals with a modified cytochrome c have a selective
advantage / are selected for / these individuals are more likely to survive
to have offspring / have more offspring;
(must link a comparison of survival to reproduction)
gene / allele frequency changes over generations / time;
OR
changed structure does not affect protein function;
these structural differences accumulate over time;

4

[6]

Q55.

- (a) random sampling method;
use of large numbers / many / 10 or more quadrats in each area;
counting daisies and dividing by area;
- (b) the cutting has no effect;
- (c) daisy, dandelion, buttercup show (statistically) significant differences;
no significant effect on plantains;
comment on relative significance of daisy / dandelion / buttercup;
regular cutting linked to significant increase in density of daisy / dandelion;
linked to significant decrease in density of buttercup;
(no marks if significance idea omitted)

3

1

3 max

[7]

Q56.

- (a) angle, moisture and pH
(all required)
- (b) system for subdividing quadrat into, e.g. many squares;
method of estimating cover in small squares, e.g. counting those where cover
over 50%, or cover at points (of intersection);
(not just 'count squares with vegetation' unless very small)
- (c) increasing vegetation cover is related to increasing moisture content
(allow 'affects' moisture content or vice versa, not 'causes');

correlation is significant / not due to chance / can reject null hypothesis
/ only 1 in 20 / 5% probability that the correlation is due to chance;
- (d) factor; and linked effect e.g.

1

2

2

wind-blown particles trapped;

accumulation of soil;

OR

accumulation of organic / dead / decomposed matter / humus;

increase in mineral ions / improved water retention / improved soil structure;

OR

nitrogen fixation;

increased nitrate concentration / improved soil fertility;

2 max

[7]

Examiner reports

Q1.

In question (a), it was clear that some students had been taught how to respond to the command 'compare and contrast'. They produced well-organised answers, although these largely concentrated on the differences between the two types of DNA and seldom referred to similarities. Students who wrote lists about each type of DNA and did not make clear comparisons and contrasts, did not gain marks. A significant number of students compared prokaryotic cells with eukaryotic cells (such as "DNA floats in the cytoplasm, but in eukaryotes it is contained in a nucleus") or they compared DNA with RNA.

Misconceptions were common; for example, "prokaryotic DNA is single stranded", "it contains uracil", "it is not replicated semi-conservatively", "it contains ribose", "viruses are prokaryotes", "DNA is an alpha helix", "all prokaryotes have plasmids". Very few students (0.3%) achieved five marks and not many (1.9%) got four marks. Many answers showed little evidence of knowledge beyond GCSE level; for example, "DNA consists of four named bases", "DNA is made of a sugar, a phosphate and four bases". Knowledge about nucleotides was given in very few answers. The low quality of answers (the mean mark on this question was only 0.79 out of 5), along with evidence of frequent misconceptions, gave examiners a sense that section 3.4.1 of the specification about DNA structure is not well understood.

In (b), it was evident that students had difficulty with this topic and many answers (56.4%) gained no credit. Some students were diverted because the question referred to haemoglobin, and went into long detail on levels of protein structure and physiological adaptations to different oxygen environments; for example, mammals at different altitudes. Those who discussed evolutionary relationships often gave vague answers that referred to sharing a common ancestor or being related, rather than use ideas like more differences would indicate a more distant relationship and an earlier common ancestor. Very few students considered what caused the differences in the primary structure of haemoglobin, consequently little mention was made of mutation, which is the process underpinning species change in evolution. Few considered why these differences accumulated over time. Many answers achieved two marks, and rarely more than three marks. The mean mark on this question was only 0.46 out of 5.

Q2.

67.1% of students could answer question (a), a test of recall from section 3.4.6 of the specification. Once again, many students confused the terms population and community, and the terms species richness and an index of diversity.

Question (b) was the first opportunity on the paper for students to interpret scientific evidence and demonstrate Assessment Objective 3 skills. The question, 'Do the data in the figure support these conclusions?', should have demonstrated that careful use of these data would be required in the answer. Both conclusions were comparative statements, natural habitat being the *most* favourable and town habitat being the *least* favourable, and so the marking points were linked to comparative statements between the habitats. A description of one habitat alone was, thus, not sufficient to gain credit. Numbers were provided on the axes and so quoting days of the year was expected in the answers. This question provides a good example to demonstrate the importance of using and quoting the correct evidence from the data when trying to support the conclusions. It is also a good example of how times from the x-axis of the graph should be used to illustrate where observed trends begin and end. Some 76.6% of students were able to gain at least one mark; only 7.9% scored four marks.

In part (c), the majority of students appreciated that the bees should not be harmed and

so gained the first mark. Many students got confused with mark-release-recapture techniques but, since no population estimate was being made in this investigation, this was not relevant.

Question (d) was designed to test practical skills with the command 'suggest and explain', so an improvement with a specific explanation of how that change would improve the data was required. It was hoped that A-level students could be specific about why collecting more data would be beneficial. For example, they were told that these graphs were drawn following collection from four data points – students should be aware from their graphical work that this would not result in an accurate line of best fit, or that intermediate points could not be determined from these few data points. Similarly, statements related to the improved *accuracy* of the (mean) data were few and far between; simple statements referring to collecting from more sites, or for more years, are not sufficient to gain marks when asked to give an explanation. Students should be encouraged to use an appropriate term from the published glossary – “to make the results reliable” was not sufficient to gain credit. Very, very few students could use their knowledge of section 3.4.6 to point out that these data would have been more meaningful if numbers of each species had been counted so that an index of diversity could be calculated. Worryingly, 71% of students failed to score here; less than 2% gained both available marks.

Question (e) was answered well, with most students (62.1%) understanding the binomial system for naming of species and linking it to their evolutionary relationship. Some students suggested that the two *Andrena* species were unrelated to *Peponapis pruinosa* and that they did not share a common ancestor – this was not creditworthy.

Q3.

For question (a), only 7.6% of students scored two marks. Most students were able to explain the purpose of boiling the agar, though the most common error was to copy the stem and state “so it could be poured”. Explaining the purpose of transferring the same volume of liquid culture onto each agar plate was beyond most students. Some did not understand the term ‘culture’, thinking it just meant food. There were many generic answers, such as “to make it a fair test”, “to control variables”, and “so only the independent variable affects the dependent variable”. The words valid, reliable, accurate and precise were also thrown at the answer.

Question (b) was not a difficult maths question; it simply involved multiplying three numbers together. Despite this, only 15.6% of students scored two marks.

For question (c), over half of the students were able to access the first marking point, but very few scored the second. There were not any real mistakes with mark point two; it was just omitted.

Q4.

This question is based on sections 3.4.5 and 3.4.7 of the specification. For question (d), only 14% of students could name the three comparisons that are stated in the specification for investigating genetic diversity (other than the observable characteristics that had been used to generate Classification X). Although this method is no longer in the specification, DNA hybridisation was accepted as a method of comparing DNA base sequences.

Q5.

- (a) The command word here was **contrast** and so statements showing clear differences between the use of the two microscopes were required to gain credit. Most students demonstrated sound knowledge of the optical and electron microscopes, but few

managed to gain all six marks for relevant contrasting statements. Many suggested that no organelles could be seen with an optical microscope, rather than only larger organelles being visible. Some referred to SEMs and 3D images; neither was relevant here.

- (b) There were many good answers here, with over 70% of students scoring 2 marks and over 40% gaining 3 marks. Mark point 4 was the least often awarded. Students often failed to gain mark point 3 because they stated that **W** contained half the genetic material of **Z**, rather than specifying half the DNA. Several students discussed these cells as if they were human cells rather than plant cells, mentioning 23 pairs of chromosomes originally, or 23 chromosomes in cells in **W**. Some students named stages of meiosis in their answer. These were ignored as this is not expected knowledge; we were only looking for the outcomes of 1st and 2nd meiotic divisions.
- (c) The full range of 0 – 5 marks was seen in similar proportions here (although slightly fewer with full marks). The main reason for the discrimination was how fully each student used the information from the question stem. The two groups of seeds to be investigated had been collected already, and the investigation that was needed was simply to find out if there was a difference in size of these seeds. Many students gave extensive answers relating to how to collect the seeds from the environment, and how to measure the pollution – neither of which was relevant to the question. Many students selected an inappropriate statistical test or listed several options, which could not be given credit, even if t-test was amongst the list of possibilities (see note about the 'list rule' in the final paragraph of "General Comments" above).

Q11.

Question (a) was a very good discriminator. 19% obtained all four marks, 14% failed to score and equal percentages obtained one, two or three marks. Many students had the idea that a vaccine contains antigen and knowledge of antigen-presenting cells was common. There were also many correct statements about plasma/B cells releasing antibodies. Fewer students had the idea of a B cell dividing to form plasma cells. Not many students were able to express clearly the idea of a specific helper T cell or B cell detecting, or responding to, a specific antigen. Quite a few students got confused between the roles of T cells and B cells. Some students wrote at length about memory cells and secondary responses, neither of which was required to answer the question. As in some other questions, this inclusion of irrelevant material often generated additional pages and wasted time that could have been spent on other questions.

Most students obtained one mark in (b) for suggesting greater antibody production with two vaccinations. Almost none went on to make any other suggestion.

In the mathematical requirements section of the specification (pages 62-66), selection and use of a statistical test is not emboldened and so is required content for both AS level and full A-level. This is different from the legacy specification and answers to (c) indicated that most students had not learnt this. Only 6% of students could name the t-test and give the reason as testing the difference between means. Further guidance about teaching statistics is provided in the support materials on the AQA website.

The examiners were expecting statements from the specification in answers to (d). In 'Investigating diversity' (section 3.4.7), genetic diversity is compared (amongst other ways) by looking at base sequences of DNA and base sequences of mRNA. Very few students (3%) came up with both of these but some (27%) managed to express one of them.

Q12.

- (a) 70% of students correctly gave 14 as the answer. Some students used **Figure 2** rather than **Figure 1** or provided a definition of species richness.
- (b) Surprisingly, less than 50% of students obtained this mark. Many students suggested that the additional information required was the total number of all dung beetles rather than the number of individuals in each species.
- (c) Almost two thirds of students failed to obtain a mark on this question. It was evident that many students did not fully understand what was meant by standard deviations. Also a large number of students used the results in **Figure 1** rather than **Figure 2**. Most students who did refer to no overlap in standard deviations were able to relate this to there being a significant difference in mean total to obtain both mark points.
- (d) Three out of every four students correctly explained that choosing sites at random would prevent bias. Responses failing to gain credit often referred to 'controlling variables' or 'a fair test'.
- (e) Most students obtained at least one mark usually by referring to the removal of a habitat for the birds. A significant number of these students then gained a second mark by referring to a decrease in food sources. Very few students obtained maximum marks as they did not relate the removal of hedges to the loss of plant/insect species. Often students showed understanding but did not gain credit due to the use of imprecise terminology and/or poor quality of communication. Common examples of this included, 'less food', 'less homes' and 'less shelters'. A small minority of students misinterpreted this question and discussed reduction in genetic diversity.

Q13.

- (a)
 - (i) Only about two thirds of students were able to define successfully the term 'phylogenetic group'. Many explained why organisms are placed into an individual group without defining the term.
 - (ii) A majority of students achieved both marks for the definition of 'species'. That members of the same species produce fertile offspring is well understood, although some students regarded 'mating' as equivalent to 'reproduction', which cost them a mark.
- (b) Ordering of the phylogenetic groups is very well understood, with very few failing to achieve a mark. Phonetic spellings of these common biological terms was frequent.
- (c) Students demonstrated a good understanding of the non-overlapping nature of genus and species groupings by drawing concentric circles with no intersect. Many failed to draw a separate circle for each genus so achieved only a single mark because they had not made full use of all the information given in the table.
- (d) Most students used the information on base sequences correctly to identify the closer phylogenetic relationship between Sumatran and South China tigers without always stating clearly that their common ancestor was more recent or the tigers are more closely related. Some gained no mark by making a comparison in which they said the nucleotide sequences were 'similar' rather than 'identical'.

Q14.

- (a) Almost as many achieved this mark as did not, so the definition of species diversity is not well known. Some confusion exists between species diversity and genetic diversity. Many students referred incorrectly to diversity within a 'population' so

missed completely the point that the definition focussed on a collection of species. Instead of using 'number' in their definition, some students mentioned 'range' to suggest that they regarded diversity as a measure between two extremes.

- (b) Most students achieved a mark for demonstrating they knew that the number of each species is relevant in the calculation, but, for many, their poor quality of written communication prevented the award of a second mark. For example, a common error was to refer to 'number of species' rather than make clear the importance of a 'grand total of organisms'.
- (c) Many students showed a good appreciation of the principles of diversity and density and achieved both marks. The imprecise use of terms prevented some from achieving any marks, eg, 'organism' rather than 'species'; 'thrive' rather than 'reproduce' and 'hostile' rather than a precisely described effect of sewage.
- (d)
 - (i) The principle that repeatable results are a requirement in order to be able to draw conclusions was well understood. Unfortunately, some students only offered a comment about the observed difference in results and did not go further to state that it prevented the scientist from coming to a conclusion. Others gave an imprecise comment about the scientist being less able to draw a conclusion or they gave reasons why the two investigations might have produced differing results or they offered suggestions on how to improve the quality of findings.
 - (ii) Very few students gained the mark here either because they referred only to making a 'single repeat', or they repeated the investigation by changing the independent variable, and hardly any went further to confirm what the repeats would need to show before conclusions could be made.

Q15.

- (a) Most students demonstrated a sound understanding of the principle that a hypothesis is a statement that is tested by an investigation. Predictions were most often given and many gave null hypotheses. Marks were missed when students failed to make any reference to 'resistance' in the context of bacteria, and it was not uncommon for the resistance to be linked to the animal or human rather than to *Escherichia coli*.
- (b)
 - (i) Many students showed good skill and precision by selecting the right information from the table and made careful references to 'percentages' and 'resistance' to gain full marks.
 - (ii) The principle of natural selection is well understood, but often marks were missed because of a misconception that antibiotics cause mutations. Imprecise expressions were common, such as 'bacteria thrive' or they 'grow' rather than they 'reproduce'. Occasionally, students wrote that 'resistant alleles survived', with no role implied for the bacteria that contained them.
- (c) Approximately a quarter of students achieved the mark on this question because they made a clear link between human faeces and contaminating pathogens. Many mentioned *Escherichia coli*, which the question explicitly told them not to do, and poor written communication was evident in answers suggesting that what is spread is a 'disease' rather than an 'agent of disease'.
- (d) The principle of measuring the reliability of the design of an investigation is very well understood, with the majority of answers gaining two marks. Some students misread

the question because they suggested changes in the design to increase reliability, and others did not notice 'reliability' was given in the question's stem so it should not have been included as an answer.

- (e) This question differentiated well. Students made appropriate suggestions using either DNA hybridisation or nucleotide sequencing to address the context of this question; some wrote at length about both of these techniques. A minority of responses discussed using antibodies to compare the similarities, possibly they think DNA is a kind of protein.
- (f) Few students achieved more than three marks on this question because many tended to dwell far too long on giving a full explanation of how natural selection increased cases of resistance; they did not look to give broader reasons relating to society's view. Contamination of the human food chain, avoiding adverse side effects, the generation of superbugs, and high costs were common answers, although students giving more than any two of these was rare. Very few answers contained suggestions about changes in legislation and, although prevention of the horizontal and vertical transmission of genes conferring resistance was often cited, it was rare for students to make clear the principle of avoiding transmission of resistance into other harmful bacteria, so this marking point was not often awarded.

Q16.

- (a) This question proved to be a very effective discriminator. 60% of students were able to obtain at least three marks often by reciting the basic principles of speciation. The marks most frequently credited referred to geographical isolation, differential reproductive success and change in allele frequency. Many of these students failed to gain further credit as they did not use the specific information provided on the coloured skin markings. Better answers applied this information, outlining that mutations could result in particular skin colourations and selection for these giraffes could eventually lead to speciation. Consequently, only 10% of students achieved maximum marks.
- (b) One in every three students obtained both marks. These students provided clear explanations on how the mitochondrial DNA of different giraffes could be compared to determine if they were the same species. The most frequently used method was to compare DNA base sequences. Students obtaining a single mark often failed to outline specifically how they would compare mitochondrial DNA. However, these students gained credit for stating that the DNA of different species of giraffes would have more differences than would subspecies.

Q17.

Parts (a), (b)(ii) and (b)(iii) proved to be good discriminators.

- (a) 70% of students scored full marks. Those who scored one mark often gave both alternatives of the second mark point. Weaker responses often lacked clarity; for example, 'number of individuals' and 'different species within a population'. Students who failed to score often thought that the 'size of the area' and 'standard deviation values' are needed to calculate an index of diversity. It should be noted that although the specification requires students to be able to calculate one specific index of diversity, the mark scheme was amended so that other types of index of diversity could be credited.
- (b) (i) Most students were aware that the purpose of the control fields was to ensure that the results are due to the herbicide, or not due to another factor. Those who failed to score typically gave stock How Science Works responses, which

could apply to any investigation. These usually referred to comparing groups or results, ensuring that the results were due to the independent variable, or simply that these fields acted as controls. Students should be reminded of the need to relate their answers to the specific investigation or context outlined.

- (ii) Half of students scored one mark and this was usually for appreciating that the herbicide killed more weeds, which led to less competition. However, the ability to explain the effect of high concentrations of herbicide, in terms of damage to the crop, proved to be a good discriminator. Unfortunately, many students did not read information in the introduction carefully enough. They thought that the herbicide killed insects, which meant that fewer crops were eaten. The weakest responses usually went no further than to describe the graph.
- (iii) Just under half of students scored at least two marks. This was usually for 'fewer habitats' and 'fewer food sources'. It was only the best responses that referred to 'fewer plant species' being present. Similarly, the ability to express these ideas discriminated well. Weaker responses often referred to 'less food' and 'less plants', which were not credited. As mentioned in part (i), some students wrongly thought that the herbicide killed insects, which directly led to a decrease in their index of diversity.

Q18.

- (a) Over 95% of students correctly named the process as succession. Speciation was the most common incorrect response.
- (b) Most students obtained at least one mark, usually for stating that more habitats would be available. Many of these students also referred to a greater variety of food sources although a significant minority simply stated there would be more food, which was not credited. Approximately a third of students gained all three marks by also indicating that as the woodland developed there would be an increase in the variety of plants.
- (c)
 - (i) 50% of students correctly gave temperature and carbon dioxide as the two limiting factors. Most who did not referred to water rather than temperature. However, humidity, mineral ions / nutrients, oxygen, pH, light intensity and chlorophyll were also given as limiting factors. Only rarely were two incorrect factors selected.
 - (ii) Most students referred to the uptake of carbon dioxide in photosynthesis and its release during respiration but did not fully explain net productivity. Some students got the use / production of carbon dioxide in photosynthesis / respiration the wrong way round. Almost a third of students did gain this mark, almost invariably by stating that net productivity = gross productivity minus respiration.
 - (iii) This question was not answered well. Very few students were able to use the information in **Figure 2** to explain how the shade plant is better adapted to gain both marks. The lower rate of respiration was recognised but the lower release of carbon dioxide was usually described at low light intensities rather than at 0 or in the dark. The idea of greater productivity in the shade plant was less frequently described. Most answers related to photosynthesis and many students gained no marks. As in part (ii), the uptake and release of carbon dioxide was sometimes wrongly assigned to respiration and / or photosynthesis. The surface area of the leaves, amount of chlorophyll and number of stomata were also incorrectly used as part of some students'

explanations.

Q19.

This question was well answered by most students, with over 75% of students obtaining four or more marks. The most commonly awarded marks were; carbon dioxide combining with RuBP, the formation of 2GP from this reaction, the reduction of GP to TP and the formation of a named compound, usually glucose or RuBP from TP. Approximately one in every four students specifically mentioned that ATP provides the energy for the reduction of GP to TP. A much higher percentage of students stated that reduced NADP is essential for the reduction of GP to TP. However, there was a significant minority of students who referred to reduced NAD rather than reduced NADP.

Q20.

- (a) This question was intended as a gentle introduction to ensure the students had read and thought through the resource material and 95% of students gained this mark.
- (b) This was a high-scoring question, with 65% of students gaining all three marks and 95% gaining two or more. Students who failed to obtain a third mark usually numbered each individual plant, rather than using a coordinate system, or missed out the first step of generating a grid.
- (c) Students struggled to suggest why bare ground was left. If they thought about competition, they generally answered successfully and scored marking points 1 and 2. The idea of there being less movement of the pest between the maize and grass was rarely expressed clearly.
- (d) Very poor understanding of the nitrogen cycle was frequently seen. Many students had the N-fixing bacteria providing 'the plant' with proteins, demonstrated poor understanding of nitrogen fixation and the use of nitrates by plants or failed to distinguish between the legume and the maize.
- (e) Most students achieved marking point 1, for identifying a trend in the data. Fewer went on to use the data in a calculation to justify the trend they had reported. Many had the idea of an improved profit, although some expressed this very poorly, but few used the data to calculate the actual increase in profit in order to gain marking point 5. Virtually no students made reference to the standard deviations shown in the data.

Q21.

Parts (a)(i), (a)(ii) and (b)(i) proved to be good discriminators.

- (a)
 - (i) One-third of students were aware that a hierarchy contains groups within groups, with no overlap. However, the 'no overlap' concept was often missed. Similarly, it was disappointing that nearly forty percent of students failed to score, considering that a simple definition from the specification was required. Weaker responses often referred to the idea of ranking, dominance or importance. There were also some very confused responses, which focused on predators and prey in the context of a pyramid of numbers.
 - (ii) Half of students were aware that a phylogenetic group is based on evolutionary links or history. Students who failed to score often focused on one syllable of the word 'phylogenetic'. Consequently, the responses 'a group within a hierarchy' and 'has similar genes' were often seen.

- (b) (i) Almost all students scored at least one mark for recognising that animal **A** has the least number of differences in the amino acid sequence. However, the ability to go back one step and relate this to a similar DNA sequence discriminated well. Weaker responses often lacked detail, eg 'similar DNA' and 'similar genes'. Similarly, a minority referred to the 'amino acid base sequence' or thought that DNA is made of amino acids.
- (ii) Most students gained the mark for recognising that the amino acid sequences were compared with humans or not with each other. Fewer mentioned that different amino acids may be affected in each sequence. Similarly, responses that referred to the degeneracy of the genetic code were rare. Weaker responses usually relied on vague, stock *How Science Works* phrases in relation to possible flaws in the methodology. They usually referred to a lack of repeats, the inability to control certain variables or the absence of a control group. Again, a minority of students confused DNA and protein structures.
- (iii) One-third of students were aware that all organisms respire, or that fewer organisms have haemoglobin. Some were given benefit of the doubt in terms of haemoglobin structure varying more due to the environment. This was accepted in terms of evolutionary change, rather than the effects of pH or pCO_2 . Students who made a direct reference to these factors causing the structure of haemoglobin to vary more did not gain credit. Weaker responses often stated that haemoglobin would vary less than cytochrome c, or that cytochrome c was the same in all organisms.

Q22.

- (a) (i) Almost eighty percent of students obtained this mark, usually by stating that this method helps to make the samples 'representative' or 'reliable'.
- (ii) The vast majority of students gained at least one mark for referring to using coordinates or dividing an area into squares. Most of these students gained a second mark for describing a method of generating random numbers. Some students incorrectly referred to the mark, release and recapture method.
- (iii) Almost fifty percent of students gained two marks for providing two valid reasons for changes in the population of lizards at different times of the year. Breeding, predators, prey and temperature changes were common correct responses. Responses such as 'weather' or 'climate' were not credited and limited most of the other students to one mark.
- (b) This was generally answered well, with many students gaining both marks. The most common scoring point was the idea of allowing a valid comparison. Some students failed to note that the numbers in the samples vary and obtained one mark. Incorrect responses often referred to reliability.
- (c) Considering the data provided were not particularly complex, it was disappointing to note that forty percent of students scored zero for this question. The most common scoring mark point was for referring to the results at site 5 for *A. gingivinus*. Relatively few students gained a second mark by referring to a positive correlation or to the limited results for *A. watti*.
- (d) (i) The vast majority of students gained one mark for stating that more *A. gingivinus* than *A. watti* are infected. Many students then tried to explain why this might be the case (more die so less competition for food etc), rather than trying to give further explanations of how they reached the conclusion. As a result, very few students obtained two marks.

- (ii) A significant minority of students did not use the information provided on the destruction of blood cells and gained zero marks. Students who did use this information often referred to the increased susceptibility to disease due to destruction of white blood cells. There were slightly fewer marks gained for the effects caused by a reduction in red blood cells.
- (iii) Less than fifty percent of students obtained both marks. Although students understood that the P value represented probability, the less than symbol < was often interpreted as 'is' or 'equal to'. Other errors included referring to 0.01% rather than 1% probability or the correlation not being due to chance (with 0.01/1%). Some students correctly used a probability of more than 99% / 0.99 that the correlation is not due to chance.

Q23.

- (a)
 - (i) Almost all students gained this mark.
 - (ii) Again, almost all gained this mark, with many writing a mnemonic of one form or another in the margin.
- (b) Most students gained the first mark for a simple definition of standard deviation in terms of the spread of the data. A few failed to gain the mark by using the word 'range' as an alternative to 'spread'. The interpretation of standard deviation in terms of overlap was less well understood, and very few students suggested that a low standard deviation was related to closely grouped and therefore reliable data.
- (c) The majority of low marks gained in this question resulted from students failing to respond to the question '...these sequences (i.e. the amino acid sequences) could provide evidence ...' and going on to describe how different DNA base sequences would give different proteins. Although students seemed to appreciate that different species have different amino acid sequences in the same protein, few could link this to differences in the DNA base sequence. Students seemed unclear about the relationships between the DNA base sequences and the amino acid sequence, and the use of incorrect terminology made their answers even more opaque.

Q24.

- (a) This question was generally answered well, with the better students able to explain the importance of random collection in the context of the investigation rather than simply turning out the phrase 'avoiding bias'.
- (b)
 - (i) Most students understood the summation process even though they made mistakes in another part of the calculation. A significant number of answers went up to 5 or 6 decimal places which, although not penalised, should be avoided. The mathematical requirements of the specification do state the 'use of an appropriate number of significant figures'. A significant number of students use the space available as rough working rather than for setting out the logic by which they arrived at the answer. A tangled mass of numbers did not always allow the examiners to credit incorrect responses for an understanding of underlying principles.
 - (ii) Most students made reasonable attempts at this section. Most correct references were to the reduction in species number and to the predominance of the bird-cherry aphid. Incorrect references were made to totals of all organisms and totals of all species. Weaker students assumed that the fewer organisms in total, the lower the biodiversity. Some wrote, incorrectly, about genetic diversity.

- (c) Instead of evaluating the conclusion given, a significant number of students wrote their own conclusions about the effects of farming on the environment and the mechanisms by which these were brought about. Answers were often vague and did not refer to the data provided.
- (d) Generally answered well; almost all students offered responses, often with good explanations relating to increasing variety of habitats and food sources.

Q25.

- (a) This question produced many excellent responses in which students identified appropriate types of nutrient. Where marks were not awarded it was generally for duplication as in suggesting both glucose and sugars or nitrates and phosphates, or for lack of precision with answers such as nitrogen and carbon.
- (b) Answers based on bias, accuracy and reliability suggested to the members of the moderating team that many students attempted to adapt poor recall of existing marking guidelines to the requirements of the question. Those who thought about this particular investigation appreciated, however, that a suspension of yeast cells would be inclined to settle and would therefore need to be stirred.
- (c) Although most students calculated the percentage increase in yeast cells correctly, working was not infrequently poorly set out and extremely difficult to follow. If there had been errors, it would have been very difficult on such scripts to have awarded credit for demonstrating the principles involved.
- (d) The commonest reason for failing to gain full credit here was because of insufficiently detailed responses. As Question (a) asked for two types of nutrients present in the apple juice, rather more than "lack of nutrients" was required by way of response.

Q26.

- (a) Over 40% of students failed to score on this question. Many of these students suggested that proteins consist of bases and the confusion between bases and amino acids pervaded their responses. Although a number of students did correctly refer to the sequence of amino acids, only better students linked the similarity of the amino acid sequence with a close evolutionary relationship between different species.
- (b) This question also proved challenging with less than 50% of students gaining any marks. However, a significant number of students did gain one mark for reference to the triplet code and students appreciating the degeneracy of this code were able to gain both marks. Some students gained credit by referring to introns or non-coding DNA.

Q27.

- (a)
 - (i) Slightly more than half the students obtained this mark, often for mentioning the idea of identifying anomalies or that the sample would be representative of the population. Answers failing to gain credit often lacked sufficient detail with responses such as 'to make the results reliable' or 'to calculate an average' being commonplace.
 - (ii) Almost 95% of students gained this mark by mentioning the removal of bias.
- (b) Two thirds of students correctly carried out the calculation and obtained both marks.

Approximately 5% of students obtained a principle method mark having calculated an incorrect answer.

- (c) This question proved to be a fairly effective discriminator. Surprisingly, a significant minority of students suggested that there would be a decrease in the variety of insects on the golf course despite the stem of the question indicating that diversity would be higher. However, most students did mention an increase in habitats for one mark. Many also appreciated there would be an increase in the variety of food sources although references to 'more food' were not credited. Only the very best students mentioned an increase in the variety of plants.

Q28.

- (a) This proved to be a very effective discriminator with almost equal numbers of candidates scoring two, one or zero marks. A significant number of candidates referred to 'more food' rather than a greater variety of foods. Vague terms such as 'more shelter' were not accepted as an alternative to more habitats.
- (b) Very few candidates obtained both marks in this question. However, almost half the candidates gained one mark for indicating that the index of diversity measures the number of species and the number of individuals. Better candidates used this information to explain that an index of diversity would be more useful where some species were only present in low or high numbers.
- (c)
 - (i) This proved a very demanding question with two thirds of candidates scoring zero. Despite the cue that 'these eggs are small' relatively few candidates correctly linked this to a large surface area to volume ratio. Only a small percentage of these candidates then referred to diffusion. It was very disappointing to see responses describing pesticides moving by osmosis.
 - (ii) The majority of candidates appreciated that evaporation of water would increase the concentration of the pesticide.

Q29.

- (a) The Harvest Index was calculated correctly by most candidates.
- (b) It was relatively uncommon to encounter convincing answers to this question. Although most candidates implied that a greater proportion of the crop would be grain, they did not always make the point with sufficient clarity. Problems arose over use of the word "crop" which was variously used to mean anything from grain to the entire plant.
- (c) This question generated some good responses and most candidates were able to suggest that a named abiotic factor varied. Many, however, failed to complete their answers by referring to sampling taking place in different parts of the field.
- (d) Most candidates were able to gain full credit for their answers to this question although some failed to mention that content would vary.

Q30.

- (a) There were many excellent and clearly focused answers to this question.
- (b) Most candidates were able to point out that the herbicide would reduce the number of weeds and suggest that this would lead to reduced competition for a specified resource.

- (c) Candidates found this question challenging. In discussing advantages, arguments were often based inappropriately on the rate of growth of the crop rather than that of the weeds. Acceptable disadvantages were seldom suggested and many answers were based on incorrect climatic generalisations.
- (d) Many candidates wrote lengthy answers that focused on experimental design in general terms rather than on the design of this particular investigation. Such responses usually identified the lack of a control, small sample size and the possibility of confounding variables. Those who followed the procedure through, and considered each step carefully, were often able to make further points.

Q31.

- (a) There was widespread recognition that tail band width would be likely to change with age.
- (b) In part (a), many candidates lacked the mathematical understanding to appreciate that a mean which had a value with decimal places suggested that measurements of the same band must differ. Likewise, they did not appreciate that a standard deviation with a value other than zero indicated variation in the measurements of the same band. However in part (b), having read the description of the procedure, most recognised that viewing an animal's tail through binoculars from a moving vehicle was likely to give rise to inconsistent data.
- (c) Most candidates correctly used the data about the width of bands from the left and right sides of the tail as evidence that rings of equal width were not found.
- (d) The most frequently awarded mark was for showing an understanding that unrelated animals would be expected to show more variation than animals from the same family. It was less usual to find a link to the idea that members of one family are genetically closely related, or a reference to the animals' parentage.

Q32.

- (a) Those candidates who could explain with sufficient clarity that it was necessary to determine the number of each species present were able to gain credit. A surprising number of candidates knew that an equation was involved and could quote it with some degree of accuracy. Many revealed, however, little knowledge of what the various terms represented.
- (b) Part (a) should have indicated to candidates that the thrust of this question was species diversity. Unfortunately the term diversity triggered many candidates to respond in terms of selection, genetic bottlenecks or the founder effect. The approach to this question was further influenced by a poor understanding of the concept of a species with many candidates apparently of the impression that all insects are members of the same species. Better candidates however approached the question in an appropriate way, and although they did not always appear to appreciate that clearing forest and planting crops would lower the plant diversity and hence the variety of available food, they were able to make worthwhile comments.
- (c) In part (i), many candidates showed an unfamiliarity with the idea that joining points on a graph with straight lines indicated uncertainty over the reliability of intermediate points. Answers to part (ii) were rather better with most candidates clearly understanding the nature of controls even if they enjoyed less success in explaining why a control would be necessary in the investigation described.
- (d) The best candidates understood the requirements of a question requiring evaluation

and were able to link the changes in breeding birds shown on the graph with species diversity. They also indicated that the data referred to total number of birds and not diversity and point out the shortcomings at arriving at conclusions based on limited data. Those who did not gain significant credit, not infrequently failed to read the axes with sufficient care or did not appreciate why the points had been joined with straight lines. Evaluate was occasionally regarded as having the same meaning as Explain. Explanations gained little if any credit.

Q33.

- (a) Although a considerable number of candidates gained credit for their answers to this part of the question, others offered inappropriate suggestions. Many of these were yet again centred on the converse and attempted to explain why they did not measure the minimum diameter.
- (b) There was evidence from the answers to part (i) that many candidates still fail to absorb material presented in the stem of a question or look critically at data in tables and graphs. Thus, although most appreciated that shrimps that lived in caves had smaller eyes and longer antennae than those that lived in the open, they were unable to point out either that the antennae were responsible for detecting touch or that these data only referred to shrimps. More limited candidates often suggested that shrimps either had eyes or sense organs. Those candidates who avoided explaining standard deviation in terms of range, generally gained at least one mark for part (ii). Better candidates were also aware that overlap in the values of standard deviation was important in indicating whether differences were attributable to chance or were significant.
- (c) In part (i), most candidates made an appropriate qualitative statement about the body lengths of the shrimps concerned but few supported this with data from the graph. Some appeared distracted by antennal length and failed to identify the thrust of the question. Part (ii) was generally well answered.
- (d) Most candidates appeared to have understood the information in the graph but could not always explain this with sufficient clarity to gain credit. Thus, although an answer relating to cave shrimps and ocean shrimps (interpreted as shrimps living in open streams) could be awarded credit, one that merely referred to shrimps in streams could not. There were also many sweeping statements such as that “the percentage of shrimps was higher in the open for all alleles”. This was clearly not correct. More credit might have been awarded had candidates based their wording more carefully on that supplied in the column headings in the table.
- (e) One of the key phrases in this question was “Use your knowledge of the founder effect”. This should have indicated that candidates were required to apply this concept to the example provided in the question. A significant number failed to do this and opted instead to discuss the difference in percentages in terms of either natural selection or genetic bottlenecks. Such approaches rarely gained credit. Others offered extremely general explanations that made no reference either to shrimps or to allele L. These accounts often incorporated volcanic eruptions and hunting to extinction. Answers were further marred by imprecise language with the term “species” used in a variety of ways that had an adverse effect on the sense of the argument presented. Some candidates again turned the question round and attempted unsuccessfully to use their knowledge of the founder effect to explain the percentage of shrimps with the allele L in the open.
- (f) Candidates who answered this question successfully either suggested breeding cave shrimps with those living in the open to see if fertile offspring were produced, or looking at whether courtship behaviour led to successful mating. Although both of

these approaches were acceptable, those based on DNA hybridisation and protein analysis were not. Those candidates who chose to discuss crossing shrimps often suggested procedures that would not have guaranteed the relevant parentage. Attempts were made to add detail and there were some valid comments about repeats and carrying out reciprocal crosses. However, there was much discussion about the ethics of experimental work and the perceived cruelty of such experiments that could not be given credit.

Q34.

- (a) Most candidates obtained at least one mark for stating that humans are most closely related to chimpanzees. Approximately half the candidates also gained the second marking point by indicating that humans are least closely related to dogfish.
- (b) Many candidates used the stem of the question to state correctly that cytochrome is found in all eukaryotes. Incorrect responses usually referred to cytochrome being present in all species.
- (c) Many candidates did refer to the base triplet code and gained a single mark point. Better candidates referred to introns or to different base triplets coding for the same amino acid. However, a significant number of candidates failed to gain any marks, often describing a base triplet as a gene.

Q35.

- (a) Most candidates had some understanding of the function of restriction endonuclease but were not always sure of its role in the investigation described. Thus, there were numerous references to the enzyme “cutting out” particular sections of DNA, these pieces ranging from haplotypes, to genes and even chromosomes. Most candidates correctly suggested that electrophoresis would be involved in separating the DNA fragments, although some were clearly of the opinion that it was the chains of DNA that were separated.
- (b) Candidates were generally able to describe the complementary base sequence present on the probe but seldom progressed to explain how it could be used to show that the haplotypes concerned were the same.
- (c) The majority of candidates linked the Y-chromosome to male inheritance in part (i) although a significant number suggested that the Y-chromosome was inherited from the female. Part (ii) was targeted at stronger candidates, but very few could suggest that mitochondria could only be passed to the offspring in the cytoplasm of the egg.
- (d) The responses to part (i) suggested that while many candidates were aware that giving the units per unit area enabled comparison, they were uncertain as to what was being compared. The most frequent suggestion was that it allowed wolves to be compared with prey numbers. Others wrote about the territorial behaviour of wolves or suggested that the mobility of the animals made counting over a larger area too difficult. In part (ii), better candidates appreciated that wolves ate only part of their prey and that the amount eaten differed with different species of prey.
- (e) Although the positive correlation between prey index and wolf numbers was usually recognised, few progressed to state that this suggested that food must be limiting population size. Unfortunately, the few who pointed out that other factors might possibly be involved rarely linked this conclusion to the spread of data on the graph.

Q36.

- (a) Most candidates had little difficulty obtaining at least one mark often for stating that courtship behavior enables recognition of the same species. Over a third of candidates gained a second mark. These candidates often linked courtship behaviour to sexual maturity or to the release of gametes. Most candidates failing to gain two marks often provided only one suggestion or there was a lack of clarity in their answers.
- (b)
 - (i) Almost two thirds of candidates gained this mark. Most candidates used the information in the stem of the question to explain that fusion between gametes would be more likely within a limited area.
 - (ii) Less than half the candidates obtained this mark by indicating that developing within the pouch protected young seahorses from predators.
- (c)
 - (i) Most candidates gained this mark often by stating that the curved tail made it difficult to obtain an accurate measurement of body length.
 - (ii) This proved slightly more difficult with a number of candidates providing the same answer as in (c)(i). Nevertheless, over 60% of candidates did obtain the mark by suggesting that body length is proportional to head length.
- (d) The vast majority of candidates obtained this mark by describing the trend of seahorses with similar head/body lengths pairing together.
- (e) This was generally well answered with most candidates obtaining the first marking point by referring to drawing a line of best fit. Over 50% of candidates gained the second mark by explaining how extrapolation of the graph could be used to predict the total head length of selected mate.
- (f) This question proved an excellent discriminator. The vast majority of candidates described how DNA hybridisation could be used to find out if the two species of seahorses are closely related. Not surprisingly, the quality of the descriptions of DNA hybridisation varied considerably and a variety of alternative methods were credited. Most candidates gained a couple of marks for naming the technique and for the principle of mixing the DNA strands of the two species. Many candidates also appreciated that a higher temperature would be required to separate hybrid strands from closely related species. A maximum of four marks was available for a full description of DNA hybridisation.

Other methods described included; comparing DNA base sequences, comparing amino acid sequences and immunological studies. There was considerable confusion between the first two methods with many candidates referring to 'amino acid sequences of DNA'. Few candidates appreciated that the same or a named protein should be studied when comparing amino acid sequences. Descriptions of immunological investigations were relatively infrequent and apart from some notable exceptions, were generally of poor quality displaying little understanding of even the basic principles. Nevertheless, over a third of candidates obtained four or more marks for this question with many providing outstanding detailed descriptions of the various methods involved.

Q37.

The first part of the question was based the requirement for candidates to carry out fieldwork as detailed in the section titled Investigative and practical skills. The question progressed to consider the application of elementary statistical analysis to the results obtained from such an investigation.

- (a) Part (i) was targeted at grade E candidates and there were many correct answers involving some method of creating a grid and the use of a random number generator. Those who did not gain full credit usually failed to indicate how they might turn the random points that they had obtained into areas that would be sampled. Two approaches to part (ii) were acceptable. Some of the best candidates had clearly encountered the use of a running mean and were able to describe the underlying principles with sufficient clarity to gain both of the available marks. The other approach was to discuss the compromise between reliability and time available. Many answers, however, ignored the question requirements and simply suggested what they considered would be a suitable number of quadrats to “collect representative data”.
- (b) Many of the less able candidates demonstrated either an inability to make use of information provided or a failure to apply common sense. Thus there were significant references both to coppicing the daffodils and to felling the whole wood at improbably frequent intervals. Those who understood the concept did not always read the graph with sufficient accuracy and described daffodil numbers rising to a peak at 3 years or there being more plants between 3 and 6 years.
- (c) The requirement for candidates to be able to apply elementary statistical analysis to the results of ecological investigations should have ensured a degree of familiarity with the concepts of a correlation coefficient and statistical significance. All that was really required here was to identify the positive correlation between the number of daffodils in flower and total rainfall, and the negative correlation with monthly mean temperature. Some candidates foundered because they misinterpreted the correlation coefficients as mean values. Others failed to link the climatic factors with the flowering of daffodils with the result that many of the statements made were vague and imprecise.

Q38.

Unit 4 will test the principles underlying *How Science Works* with a question that will be similar in format to this. In order to provide a genuine test of the objectives involved and the appropriate degree of stretch and challenge, candidates must expect to encounter investigations with which they are unfamiliar. While it was encouraging to note that most candidates responded well to the unfamiliar, many failed to gain credit for those parts of the question that depended rather more heavily on basic factual knowledge.

- (a) Many candidates appreciated the way in which the hair traps worked and offered sensible suggestions to both parts of this question.
- (b) The importance of random selection in avoiding bias was appreciated by many.
- (c) Most candidates clearly had some appreciation of the importance of checking the repeatability of the measurements. There were frequent, and acceptable, references in part (i) to reliability. Better candidates also wrote of avoiding measurement and personal errors. Part (ii) created more in the way of difficulties, partly because it was unclear in many instances as to precisely what had been plotted. Very few candidates appeared to have encountered scatter diagrams with many responses being based on plotting the two sets of measurements and then comparing the positions of the pairs of points that resulted. An alternative approach, suggested by many, was to construct histograms and compare these. As the question specifically called for using a scatter diagram, this approach could not be given credit.
- (d) The many candidates who answered part (i) in terms of the difficulty of establishing the relationship between the number of hairs and the number of visits by a shrew were able to gain credit. Part (ii) proved more challenging and a considerable

number of candidates misinterpreted the question. They considered “setting traps immediately after using the hair tubes” in a geographical rather than a temporal sense. Others embarked on lengthy discussions of the advantages of using the mark-release-recapture technique and produced responses which had little if any relevance to the question asked. The very best candidates, however, linked time to population change and produced appropriate answers.

- (e) Although many candidates discussed specific statistical tests in their answers to this question, it was clear that they had little understanding of the role of such tests in determining the probability of an event being due to chance. There were frequent references to greater accuracy and reliability and even to the use of statistical tests being “more scientific. It was also disappointing to note the many responses that referred to neither or only a single one of the terms specifically required in the response.
- (f) It was clear from the many correct answers to part (i) that candidates had clearly understood the bubble plots despite their unfamiliarity. A significant number, however, introduced the term “correlation” without making it clear that in this case a positive correlation existed between the hair tube index and the number of shrews trapped. The absence of correlation in the case of the pygmy shrews was usually indicated, and better candidates pointed out that the hair tube index indicated that hairs were present even when shrews had not been caught in the traps.

Q39.

- (a) Candidates showed a good understanding of the adaptations of gills for efficient gas exchange. Although there were some who wrote in very general terms about ‘gills’, most candidates linked surface area to the possession of gill filaments or lamellae and to diffusion. The principle of counter-current flow was frequently mentioned and it was clear that most candidates had an excellent understanding of this concept. Some illustrated their answers with diagrams and these were occasionally very helpful.
Candidates should be aware, however, that marks can only be awarded for diagrams that are properly labelled. There were numerous sketches on which were written figures that might have represented anything. Some points were made less frequently or less convincingly. There was relatively little mention of the roles of ventilation and circulation in maintaining the concentration gradient and many struggled to describe the short diffusion path in sufficient detail to gain credit. There were also a number of frequent misconceptions. These included references to air passing over the gills; to diffusion only being able to take place in water, and to the presence of carbon dioxide being essential for the diffusion of oxygen.
- (b) Successful responses to this part of the question usually referred to photosynthesis or to the diffusion of oxygen from the higher concentration in the air. There were many answers, however, that involved fanciful ideas about generation of oxygen at depth and this bubbling to the surface, or incorporated the concept of need, such as that there was less oxygen at depth because the toadfish did not need it.
- (c) This answer illustrated a common failing among less able candidates in answering questions that involve application of knowledge. They were often inclined to rely on recall and, while most were able to indicate that the toadfish environment was low in oxygen, they not infrequently related this to high altitude. There was also a tendency to give answers that were too brief, omitting reference to the context of low partial pressure when describing the high affinity of toadfish haemoglobin for oxygen.
- (d) Answers to this question tended to fall into two categories. Either candidates gave very good answers that made the points in the mark scheme succinctly, or they

wrote at length about the three organisms without ever quite answering the question. However, it was encouraging to see many excellent answers to a question set in a context which is new to the specification.

Q40.

- (a) Most candidates gained credit for their answers to this part of the question.
- (b) There were many incorrect responses to this straightforward calculation. The answers to this part, and to others within this question, suggested a very limited understanding of the concept of percentages.
- (c) Most candidates correctly recognised the positive correlation between the percentage of frogs with deformed legs and the mean number of parasitic worms per frog but some, despite the length of their answers, were unable to progress beyond this point. Many, however, pointed out that correlation does not necessarily mean causation and supported their answers with references to the involvement of other factors, or to the fact that there were frogs with deformed legs in ponds where there were no parasitic worms.
- (d) Most responses to part (i) recognised that very few ponds meant that the sample was small but then went no further than to rewrite the question and explain that this meant that the scientists involved could not draw reliable conclusions. Answers to part (ii) were generally better, and most were able to suggest that there would be factors that might apply specifically to mountainous areas. Only the better candidates pointed out the need to compare like with like before valid conclusions could be drawn. Among less able candidates there was concern about the risk to biologists working in mountainous regions and much philosophical discussion over whether a pond that was studied by a biologist could be said to be free of human influence.
- (e) One of the purposes of this question was to help candidates to understand the complex table. Very few were able to describe the information in the shaded box in terms of the column and row headings. There were two particularly disconcerting approaches. Many candidates saw the figure as representing an anomaly, even going as far as to suggest that the scientists shaded the box to show that the figure was anomalous. Many of the candidates who approached the question in the right way failed to note that this figure was a percentage and referred to 27 frogs having deformed limbs.
- (f) This question was targeted at the more able candidates and, in view of this, it was extremely encouraging to note that many of those whose ability was more limited were able to make a number of pertinent observations for which they gained credit. The weakest candidates, however, made little progress, usually because they failed to note that this was a properly designed investigation. They resorted to a stock answer that would have been more appropriate in answering part (c). There was, however, widespread recognition that the parasites caused deformities and most candidates were able to support this with appropriate evidence. Better candidates also recognised the role of run-off in increasing this problem. Candidates were awarded credit for supporting their statements with calculations based on the data provided. It was disturbing to note the number who treated percentages in a totally inappropriate way, totalling the figures or calculating means.

Q41.

Many weaker candidates produced vague responses, simply suggesting that by using tomatoes of the same size, it would be a fair test. These answers were not credited. Better

candidates were aware that variation in size would affect the amount that tomatoes flattened. However, relatively few mentioned that this would enable a comparison to be made.

Q42.

Candidates were not always selective in choosing the material to answer this question. They sometimes wrote at length about succession in part (a) (which concerned diversity), and then found they had nothing new to say in part (b), which did concern succession.

- (a) Good candidates were able to state, clearly and unequivocally, that an increase in the index of diversity means that the number of species has increased, as has the number of individuals within each species. Weaker candidates sometimes wrote all they knew about succession here or sometimes just wrote about “an increase in the organisms”, failing to distinguish between new species and existing species.
- (b) Most candidates were able to describe the role of pioneer species in colonising a harsh environment and the ways in which they might change this environment. Better candidates then went on to say that these changes allowed new species to become established with the creation of new habitats for still other species. However, too many could not resist following the development right through to the climax and describing the nature of this condition. Clearly, given the question, this was not necessary and could have wasted valuable time for some candidates.

Q43.

- (a) Nearly all candidates knew that habitats would be lost, and a good number also knew that this would reduce the number of species in the area.
- (b) Better candidates realised that both potassium nitrate and ammonium nitrate would release nitrate ions into the soil immediately, and that the ammonium ions in ammonium nitrate could be nitrified by nitrifying bacteria to provide a secondary release of nitrates. Many candidates, however, just did not apply their knowledge to the problem and merely recited chunks of the nitrogen cycle, with some confusion between nitrifying and nitrogen-fixing bacteria.

Q44.

- (a) In this section, candidates often concentrated on either the method of achieving randomness in the sampling or on how other variables might have been controlled: both aspects were required for a complete answer.
- (b) Most realised that mayfly nymphs belonging to the family Caenidae and living in the deep water showed the greatest variation as this sample had the highest standard deviation. Some were less specific.
- (c) A simple definition in terms of an organism's role in the ecosystem or community was required to explain the meaning of the term *ecological niche*. Some candidates' answers could equally well have been applied to the term 'habitat'. However, there were few problems in recognising that one family of mayfly nymphs living mainly in deep water and the other in shallow water indicated that they occupied different ecological niches. Also, most candidates appreciated that the occupancy of different niches would result in reduced competition for some environmental resource (food being the most common correct suggestion), although some should have thought more carefully about the given situation before suggesting competition for 'light' or for 'mates' (the two groups of mayflies were from different families). Some confused *intraspecific* and *interspecific* competition – only the latter being applicable here.

Q45.

- (a) Most candidates were able to substitute the data in the formula and calculate the index of diversity correctly. There were occasional arithmetical errors. Many appreciated that the numbers of individuals had been used in the calculation of the index of diversity, or pointed out that the influence of rare species would be minimised. Weaker candidates frequently thought the index of diversity was good for comparing two areas (although why this should be an advance on just comparing the numbers of species present was not made apparent).
- (b) Some candidates were confused and seemed to regard the results as having been derived *in situ* on the shore rather than being produced using a balance in a laboratory. Many confused cause and effect and ignored information provided earlier in the question, insisting that *Fucus spiralis* must have been located on the lower shore as it lost less water due to having been exposed for a shorter time. Those who did realise that *Fucus spiralis* in fact lost less water because it was better adapted to life on the upper shore, very rarely went on to suggest that living in this location (seemingly rather hostile) would result in reduced competition between it and the other species.

Q46.

- (a) Most candidates clearly appreciated that the samples would best be obtained by using random numbers to determine co-ordinates, although they were not always specific as to how these numbers would be generated. There were, however, frequent references to “throwing” a quadrat, a technique which does not give rise to a genuinely random distribution.
- (b) In part (i), candidates revealed considerable difficulty in recognising the trend of a decrease followed by stabilisation from a depth of around 200 cm. The most frequent response was to ignore the change in gradient and refer simply to the population falling. Where a genuine attempt was made to offer an explanation for the difference in numbers in part (ii), answers were usually correctly related to the decreasing concentration of oxygen available for respiration.
- (c) There was obvious confusion in the minds of some between the concepts of ecological succession and natural selection. While some of those who made this distinction produced excellent answers, others lost their way in rambling anthropomorphic accounts of bacteria “not finding conditions to their liking” or being “happier” with conditions at other depths. There were also many general references to “bacteria”. These lacked the necessary precision to gain significant credit.
- (d) Part (i) was generally well answered and there were many accounts based on correct references to the surface layers being the only ones where numbers of aerobic bacteria increased. Part (ii) also produced some sound responses although candidates were inclined to embellish their answers with irrelevant detail relating to the anticipated change with time. Once again, a failure to gain marks most commonly stemmed from imprecise use of the word “bacteria”. In both parts (c) and (d) there was a need to refer them as being either aerobic or anaerobic.
- (e) There was encouraging evidence of a good understanding of standard error and many candidates were able to show some appreciation of this demanding concept. However, answers were seldom targeted at explaining what the error bars revealed about the difference in activity at the times given. In spite of the wording of the last sentence of the question, the terms probability and chance were seldom incorporated into the explanation.
- (f) The most frequent approach to this part of the question was to produce a mass of

figures supporting a complex but inappropriate calculation. With these data the best approach was to construct a graph and draw a line of best fit. The likely number of bacteria could then have been established by reading off the appropriate value from the curve.

Q47.

Although only a few candidates obtained maximum marks on this question, most candidates were able to gain between two and four marks.

- (a) Most candidates correctly filled in phylum, class and order, however, weaker candidates often put common names such as cat or cheetah in the species box.
- (b) Approximately half the candidates gained this mark. Most candidates who did not, either provided definitions which were too vague or referred to 'different sizes' of organisms.
- (c)
 - (i) Most candidates obtained this mark by referring to the breeding of organisms to produce fertile offspring.
 - (ii) Very few candidates gained two marks with the majority simply referring to different diets, colours or behaviour. Correct answers usually referred to fossils, evolutionary history or biochemical differences.

Q48.

Many good answers were seen to both parts of this question. The topics covered were obviously familiar to many candidates. Where marks were not gained, it was usually because of omissions rather than errors. The full range of marks was seen and the question discriminated well.

- (a) Almost all of the candidates obtained a mark for noting that cyanogenic plants might die in areas with very low mean January temperatures. Many went on to obtain a second mark for identifying the positive advantage that cyanogenic plants have in warmer areas, because they deter herbivores. Only the better candidates wrote about the impact of these different selection pressures on allele frequencies in different clover populations. It was encouraging to note that 'rote answers', unrelated to this example were absent. Some weaker candidates did fail to score marks because they wrote in general terms about factors affecting natural selection and evolution but with no reference to the specific factors given in this example.
- (b) The vast majority of candidates were familiar with the use of quadrats. Many were also able to describe a suitable method for placing these at random locations in the study areas. Some candidates suggested the use of transects and this suggestion was rejected; unless they suggested the use of very large numbers of transects along randomly chosen lines. Many candidates scored one mark for suggesting the use of large numbers of quadrats. A surprising number failed to get this mark, either because they made no reference to sample size, or because they wrote vaguely about 'several' quadrats being used. The majority of candidates obtained a mark for what a quadrat might be used to measure. A large number of candidates made reference to the use of statistics but often that was all they said. The examiners were looking for the use of a statistical test to determine whether or not there was a significant difference in the number of clover plants in the two areas.

Q49.

Most candidates had little difficulty obtaining at least half the available marks for this question.

- (a) The vast majority of candidates gained both marks, almost invariably for indicating that organisms of the same species would breed together to produce fertile offspring. A few weaker candidates referred to DNA but these answers were only credited when a specific method of comparing the DNA, e.g. DNA sequencing, was mentioned.
- (b) Most candidates were able to gain at least one or two marks, often for referring to variation being present in each population and the different selection pressures in the different environments. Better candidates had little difficulty obtaining maximum marks by explaining that organisms with favourable alleles would survive and pass these alleles on to future generations, resulting in a change in the frequency of alleles. However, some weaker candidates provided descriptions akin to Lamarckism, although these were not as prevalent as in previous years.
- (c) Unfortunately, a significant number of candidates considered colour and camouflage rather than colour and mate selection. However, candidates making the correct link usually obtained both marking points.

Q50.

- (a) Often not well done and answers were generally poorly expressed. Many candidates did not answer the question set and just described the classification system involving Kingdom, Phylum, etc. or gave the definition of a species. Often there was no mention of putting organisms into groups with similar characteristics. Those who did mention characteristics often did not mention the standard methods and chose any characteristic which could be different such as method of feeding. References to cell or anatomical differences were often vague.
- (b) About half the candidates gave the correct two answers. Many candidates just listed the groups at the top of the tree and many included Protoctists in their answer.
- (c) Most candidates stated that fungi and insects had a common ancestor, but only a few were able to give a full answer. Many stated that insects had evolved from fungi, or were closely related.
- (d) There were many unclear answers which used poor language. Although many put organisms with similar sequences in the same branch, they did not develop their answer any further. There were many references to protein or DNA structure instead of amino acid sequences.
- (e) This was often poorly answered, although many scored the marks relating to eukaryotes/prokaryotes.

Q51.

- (a) (i) Few gained credit, as most candidates incorrectly focused on transects which would only sample a small number of plants or suggested that it would be too difficult practically. They frequently missed the point that the transect would

miss out representative areas.

- (ii) It was pleasing to see that most candidates could describe a random method of selecting plants to prevent bias, with thankfully very few candidates describing techniques involving throwing a quadrat over their shoulders. However, few mentioned the need to carry out the method many times in order for it to be representative.
- (b) (i) Most candidates were able to describe the meaning of standard deviation with only the weaker candidates referring vaguely to it as a range from minimum height to maximum height with no reference to the mean.
- (ii) Many recognised that the mean plant height decreased with altitude but only the better candidates recognised that the standard deviation was also lower at higher altitudes. Very few supported their answers by using data from the diagrams.
- (iii) A relatively small proportion of candidates used the information given in the stem of the question, that the seeds were not grown at different altitudes but in a laboratory under the same environmental conditions.

Q52.

- (a) Candidates gave variable answers. Only the better candidates were able to apply their knowledge and score high marks. Candidates failed to gain credit for vague answers lacking scientific rigour with poor use of terminology.
- (b) (i) A pleasing number of candidates understood how to work out probability. Common mistakes included incorporating 0.5 into the calculation and adding up the figures.
- (ii) Most candidates gained the first mark. Only the better candidates referred to the absence of scissor wings for the second mark, most candidates simply quoting the difference in probabilities.
- (c) Reticence to use the term 'sign stimulus' prevented many candidates from gaining both marks.

Q53.

- (a) This question proved a good discriminator with a surprising range of answers being produced. Candidates appeared not fully to appreciate the question, with many having difficulty applying a standard technique to an unfamiliar situation. A number of candidates described setting up transects without reference to the random nature of the sample to be obtained, references to counting were common and many failed to suggest a sufficient number of quadrats. A few resorted to throwing the quadrats over their shoulder, some doing so even after describing how to produce random co-ordinates.
- (b) This question was generally well answered with most candidates gaining two marks. Weaker answers confused the data with probability values.
- (c) (i) This was generally poorly answered. Most gained a mark for linking the foot or aperture size with grip but few answers were clearly expressed, with only the best candidates discussing both aperture and shell size. There were confused ideas attributing smaller shell size to erosion by waves.

- (ii) Answers to this question were disappointing with few candidates being able to amplify their understanding of standard deviation. Only the better candidates recognised the point of the question and were able to appreciate the effect of wave action on limiting the range of sizes. The idea of size being age-related and linked to situation was rarely given.

Q54.

- (a) The vast majority of candidates answered this question correctly.
- (b)
 - (i) Many candidates answered this question correctly by stating similarities between genes or DNA. Few considered recent ancestry. A significant number referred only to phenotypic similarities or they used a definition of species to suggest that the organisms would fail to produce fertile offspring.
 - (ii) Most candidates picked up marks for referring to mutations and for an understanding of variation, although a significant proportion stated that the mutation occurred in the structure of the protein, or implied that cytochrome was an organism. Unfortunately, most candidates failed to link their answer to cytochrome c and relied on generalisations about 'natural selection' and 'survival' without focusing on why differences in the protein would be the basis of evolutionary change. Also, very few candidates either considered time or multiple generations in their explanation about a change in allele frequency; in many answers, evolution occurred in a single step.

Q55.

This question tended to be centre-based in terms of the marks awarded. There were some very good answers indicating a clear understanding of the statistics while in other cases a lack of appreciation of the outcome of the statistical test was apparent.

- (a) Few candidates gained full marks. The most common omission was to appreciate the need for a large sample. Very few were able to explain how to obtain the mean population density, often suggesting the determination of percentage cover or simply counting the daisies to produce the data.
- (b) Most gave a satisfactory answer to gain the mark.
- (c) This produced a complete range of answers from no marks for a lack of any reference to significance to very good discussions on relative significance and explanations of the p values. Many simply described the results in the table with no reference to p values. A common mistake was to confuse the p values of 0.05 and 0.5 or not appreciate the value at which data are statistically significant and to assign significance of the plantain data.

Q56.

- (a) The majority of candidates showed that they were aware of what is meant by an abiotic factor and many correctly identified all three.
- (b) Candidates showed little evidence of having actually carried out fieldwork. Several misread the question and simply gave the standard answer relating to the random positioning of quadrats. Few could give a reasonable description of how to obtain a measure of the percentage cover. Better answers suggested subdividing the large quadrat into smaller squares, or counting whether vegetation was present at a large number of points. Several candidates merely subdivided the quadrat into 10 small squares, and candidates then recorded presence or absence of vegetation, which

clearly could only at best give a value to the nearest 10%.

- (c) Most candidates were aware that the correlation was unlikely to be due to chance, and several expanded their answer to point out there was only a 1 in 20 probability of its being a chance result. Some, however, stated that the result showed that moisture in the soil caused the increase in vegetation, or vice versa.
- (d) Most could suggest some factor that might change, such as increase in humus, but few gave a clear explanation of how the physical environment would be changed as a consequence.