

PEARSON EDEXCEL A-LEVEL BIOLOGY A • 9BN0

BIOLOGY



EXAM QUESTION PACK

TOPIC 4: BIODIVERSITY AND NATURAL RESOURCES

SCORE

/430

PERCENTAGE

%

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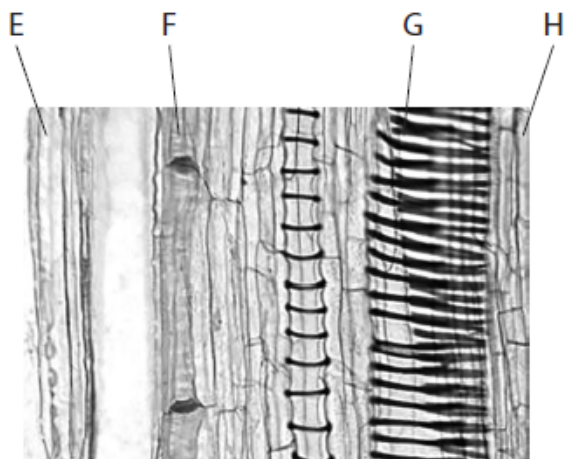
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Q1.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The stems of plants contain tissues involved in transport and in support.

The photograph shows a longitudinal section through one plant stem.



Cell image library - image ID 38928

(i) Which labelled structure in the photograph contains lignin?

(1)

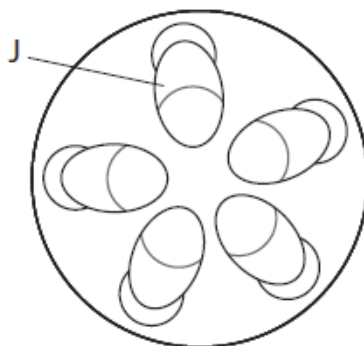
☒ **A** E

☒ **B** F

☒ **C** G

☒ **D** H

(ii) The diagram shows a transverse section through a plant stem.



Which of the labelled structures in the photograph is located in the area labelled J in the diagram?

(1)

☒ **A** E

☐ **B** F

☐ **C** G

☐ **D** H

(Total for question = 2 marks)

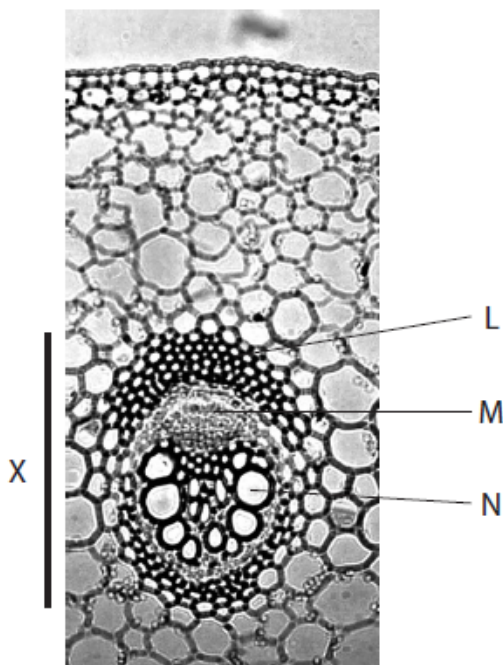
Q2.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The stems of plants contain tissues involved in transport and in support.

The photograph shows a cross section of part of the stem of a plant.

Fibres can be extracted from stems similar to this one and used instead of fibres produced from oil-based plastics.



John Bebbington FRPS Science and Plants for schools – <https://www.saps.org.uk>

(i) The part of the stem labelled L contains

(1)

☐ **A** phloem that transports organic solutes

☐ **B** sclerenchyma fibres that provide support

- ☐ **C** sieve tubes that transport water
- ☐ **D** xylem vessels that transport water and mineral ions

(ii) The part of the stem labelled M contains

(1)

- ☐ **A** phloem that transports organic solutes
- ☐ **B** sclerenchyma fibres that transport water
- ☐ **C** sieve tubes that synthesise organic solutes
- ☐ **D** xylem vessels that transport water and mineral ions

(iii) The structure labelled N is a

(1)

- ☐ **A** part of the phloem that transports water
- ☐ **B** sclerenchyma fibre that provides support
- ☐ **C** sieve tube that transports organic solutes
- ☐ **D** xylem vessel that transports water and mineral ions

(iv) The line labelled X on the photograph represents the width of the vascular bundle.

The actual width of the vascular bundle is 320 μm .

Calculate the magnification of the image.

(3)

Answer

(Total for question = 6 marks)

Q3.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Electron microscopes have enabled scientists to view the ultrastructure of cells.

(i) Which of the following structures is found in animal cells?

(1)

- ☐ **A** amyloplast
- ☐ **B** chloroplast
- ☐ **C** mesosome
- ☐ **D** ribosome

(ii) Which of the following structures is found only in plant cells?

(1)

- ☐ **A** amyloplast
- ☐ **B** Golgi apparatus
- ☐ **C** mesosome
- ☐ **D** vacuole

(iii) Which of the following structures is found in both animal and plant cells?

(1)

- ☐ **A** amyloplast
- ☐ **B** cell wall
- ☐ **C** pili
- ☐ **D** smooth endoplasmic reticulum

(Total for question = 3 marks)

Q4.

The arctic ground squirrel (*Spermophilus parryii*) lives in Alaska. It has small ears, a cylindrical body and a shorter tail than other species of ground squirrel.

The arctic ground squirrel can survive cold winters by hibernating for up to eight months per year. When hibernating, arctic ground squirrels use stored fat supplies as an energy source.



www.sciencephoto.com

Which combination of adaptations shown by the arctic ground squirrel have been described?

(1)

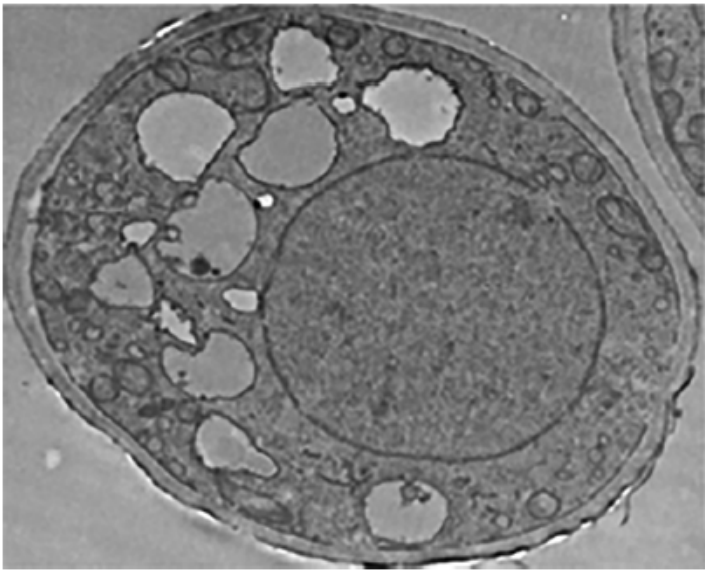
- ☐ **A** anatomical and behavioural only
- ☐ **B** anatomical and physiological only
- ☐ **C** anatomical, behavioural and physiological
- ☐ **D** behavioural and physiological only

(Total for question = 1 mark)

Q5.

Hymenoscyphus fraxineus (*H. fraxineus*) is the fungus that causes ash dieback. This disease usually kills all the ash trees that it infects.

The electron micrograph shows a section through a fungal cell.



Magnification $\times 1000$

To which group do fungi belong?

(1)

- ☐ **A** Archaea
- ☐ **B** Eukaryota
- ☐ **C** Prokaryota
- ☐ **D** Viruses

(Total for question = 1 mark)

Q6.

Plants can respond to and use light.

The photograph shows a seedling starting to grow from a germinating seed.



(a) Explain why the seedling needs a supply of magnesium ions.

(2)

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(Total for question = 2 marks)

Q7.

The scientific article you have studied is adapted from *The Biologist*.

Use the information from the scientific article and your own knowledge to answer the following question.

Human cells can be grown in monolayers using tissue culture (Figure 1).

Devise a procedure to investigate the effect of temperature on the growth rate of a monolayer of human cells.

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(Total for question = 5 marks)

Q8.

Wildlife conservation can involve keeping animals in zoos as well as protecting habitats.

Describe the roles that zoos play in animal conservation.

(3)

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(Total for question = 3 marks)

Q9.

An experiment was carried out to investigate mineral deficiencies on the growth of seedlings.

The effects of two mineral deficiencies on two different species of plant were investigated.

Test tubes were half filled with an aqueous gel containing a mineral solution without calcium ions. Seeds of rice or fenugreek were placed separately in these test tubes.

These test tubes were placed by a window for two weeks to allow the seeds to germinate and the seedlings to grow.

This was repeated using test tubes containing mineral solution without magnesium ions.

A control should have been used in this investigation.

(i) Which of the following would be a suitable control?

(1)

- ☐ **A** complete mineral ion solution
- ☐ **B** distilled water
- ☐ **C** dry gel
- ☐ **D** tap water

(ii) In this investigation a control would have improved

(1)

- ☐ **A** accuracy
- ☐ **B** precision
- ☐

C repeatability

☒ **D** validity

(iii) The table gives some properties of rice seeds and fenugreek seeds.

Property of seeds	Rice	Fenugreek
Number per g	200	500
Calcium ion content / mg 100g ⁻¹	21	176
Magnesium ion content / mg 100g ⁻¹	177	191

The calcium content of one fenugreek seed was calculated to be 3.52 µg.

Calculate the calcium content of one rice seed.

(3)

Answer µg

(iv) After two weeks, the seedlings of both rice and fenugreek grown in both solutions had green leaves.

The rice seedlings grown in mineral ion solution without calcium ions were shorter than the rice seedlings grown in mineral solution without magnesium ions.

The fenugreek seedlings grown in mineral ions solution without calcium ions grew to normal height.

Explain what is shown by these observations.

(3)

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Q10.

Mineral ions are required for plant growth.

(i) Nitrate ions are required for the synthesis of

(1)

☐ **A** amino acids

☐ **B** cellulose

☐ **C** starch

☐ **D** sucrose

(ii) Phosphate ions are required for the synthesis of

(1)

☐ **A** cellulose

☐ **B** chlorophyll

☐ **C** nucleic acids

☐ **D** sucrose

(iii) Magnesium ions are present in the structure of

(1)

☐ **A** amino acids

☐ **B** cellulose

☐ **C** chlorophyll

☐ **D** starch

(Total for question = 3 marks)

Q11.

During the civil war in Mozambique, from 1977 to 1992, 90% of the African elephants were killed for the ivory in their tusks.

Since 1992, the elephant population in Mozambique has increased.

The photograph shows a group of elephants in Mozambique.



© ALEXANDER JOE/Staff/Getty Images

A study of an elephant population in Mozambique was carried out in 2017.

The elephants studied were all born before 1992.

The table shows the number of elephants with and without tusks.

Elephants	Number of elephants
with tusks	98
without tusks	102

In most African elephant populations, 2% to 4% of elephants do not grow tusks.

(i) Explain why the percentage of elephants without tusks in Mozambique will probably increase in the future.

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(ii) Describe how the Hardy-Weinberg equation can be used to provide evidence for changes in the elephant population in Mozambique.

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(Total for question = 5 marks)

Q12.

The modern bread wheat plant (*Triticum aestivum*) has been developed from other plant species that have different genomes.

Three species of plant and their genomes are shown in the images.



Triticum aestivum
Genomes A, B and D

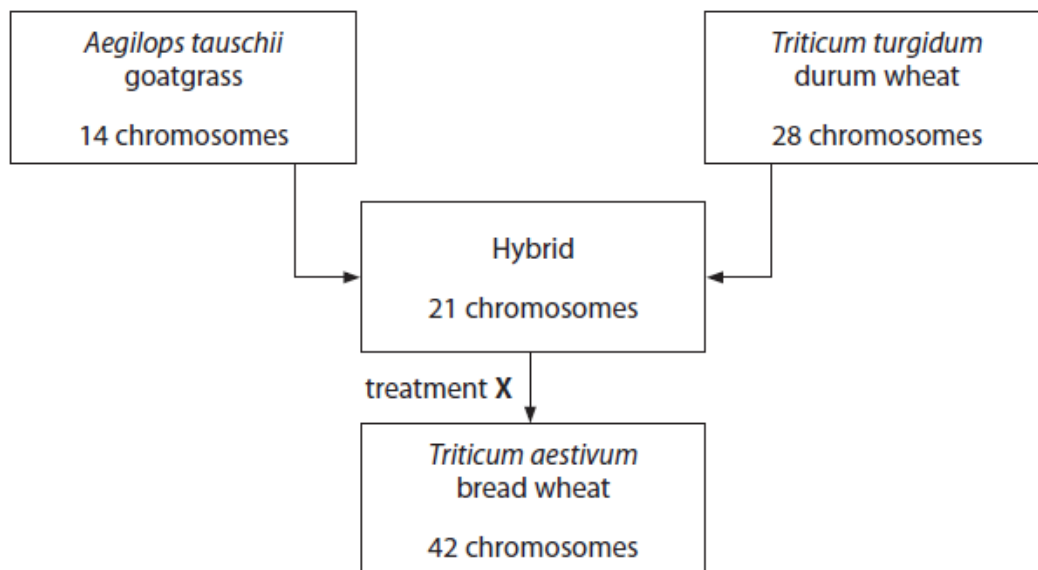


Triticum turgidum
Genomes A and B



Aegilops tauschii
Genome D

The diagram shows how chromosomes from different species have combined to produce the bread wheat species used to produce flour.



Which row in the table shows the number of chromosomes in cells from these different plant species?

(1)

	<i>A. tauschii</i> gamete	<i>T. turgidum</i> leaf cell	<i>T. aestivum</i> gamete
☒ A	7	14	42
☒ B	7	28	21
☒ C	14	28	42
☒ D	14	14	21

(Total for question = 1 mark)

The polar bear, *Ursus maritimus*, preys on seals and fish. Polar bears are adapted to live in cold Arctic regions.



Polar bear
Magnification $\times 0.04$

A recent study has shown that all polar bears are descended from populations that diverged from the Irish brown bear, *Ursus arctos*, approximately 120 000 years ago.

In this study, DNA from modern polar bears, the remains of historic polar bears and the remains of Irish brown bears was analysed.

(a) The first part of the study involved the amplification of DNA to give large enough samples for analysis.

(i) Describe how small samples of DNA can be amplified.

(4)

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(ii) Name **one** technique that could be used to analyse the amplified DNA samples.

(1)

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(b) Suggest how the scientists who conducted the study had their results accepted by other scientists.

(2)

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(c) Suggest how each of the following may have contributed towards the divergence of polar bears and Irish brown bears into two separate species.

(i) Separation of the Arctic and Irish regions by sea

(2)

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(ii) Genetic mutation

(2)

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(Total for question = 11 marks)

Q14.

Wasps are insects that live in groups.

One species of wasp (*Vespula germanica*) has been shown to knock its body repeatedly against

a hard surface. This signals the presence and quality of food to other wasps.

When threatened by another animal, it may use its stinger to inject a venom to protect itself.



bugguide.net

Phospholipase in the venom of wasps can cause allergic reactions.
Phospholipase can affect the Golgi apparatus in cells.

(i) Give two functions of the Golgi apparatus.

(2)

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(ii) A three-phase protocol will be used when developing the phospholipase inhibitor as a new drug.

Explain the purpose of each phase of this protocol for a phospholipase inhibitor.

(3)

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(Total for question = 5 marks)

Q15.

The photograph shows a glacier at the top of a mountain.
Glaciers in many areas of the world are retreating (reducing in size).
The line on the photograph shows the position of the front edge of the glacier in 1985.



Bare rock is exposed as the glacier retreats. Two hundred years ago, bare rock was exposed after a glacier retreated. A study has been made of the long-term changes in vegetation on that area of rock after the retreat of the glacier.

Plants such as lupin are often found in the early stages of glacial retreat. Lupin plants have nodules on their roots containing nitrogen-fixing bacteria that convert atmospheric nitrogen to ammonium ions. Plants can use ammonium ions as a source of nitrogen.

Explain why lupin plants are able to grow in the early stages of glacial retreat.

(3)

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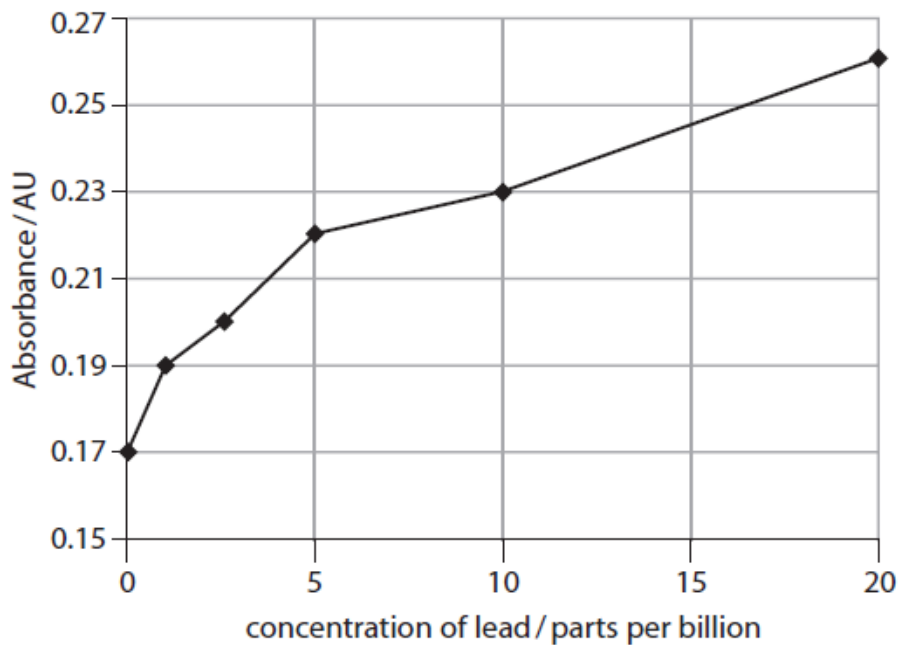
(Total for question = 3 marks)

Q16.

Lead is a toxic metal that can affect the structure of proteins. Lead affects protein in a similar way to changing pH.

Beetroot vacuoles contain a pigment. The absorbance of a solution is proportional to the concentration of the pigment in the solution.

The graph shows the results of a scientific investigation to study the effect of increasing lead concentration on the permeability of the membranes of beetroot cells.



(a) State the name of the membrane that surrounds the vacuole in beetroot cells.

(1)

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(b) Calculate the difference in percentage increase in absorbance between the lead concentration of 0-10 parts per billion and 10-20 parts per billion.

(3)

Answer %

(c) (i) Explain the effect of lead on membrane permeability in beetroot cells.

(2)

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(ii) Devise an investigation to determine whether pH has a similar effect to lead on the permeability of the membranes of beetroot cells.

(4)

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(Total for question = 10 marks)

Q17.

There are two main types of woodland in the UK. One consists of broadleaved deciduous trees, the other contains coniferous trees that have needle-like leaves.

The table shows some of the species of plant growing underneath the trees in a deciduous woodland.

Species	Number of individuals of each species (n)	$n(n - 1)$
Woodrush	2	
Holly	8	
Bramble	1	
Yorkshire fog	9	
Sedge	3	

(i) Complete the table to show $n(n - 1)$ for each species of plant.

(1)

(ii) Calculate the diversity index (D) using the data in the table.

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

(2)

Answer

(Total for question = 3 marks)

Q18.

A student carried out an investigation to compare the antibacterial effect of a garlic extract with that of three antibiotics, all at the same concentration.

(a) (i) To obtain the extract, a clove of garlic was cut into lots of small pieces and soaked in 0.1% ethanol for a long time.

Explain why this is an effective method of extraction.

(2)

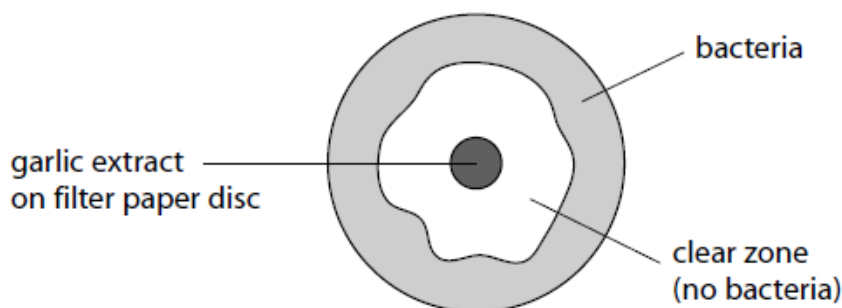
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(ii) The diagram shows the effect of the garlic extract on bacteria growing on an agar plate.



The area of the clear zone was calculated by assuming it is a circle and estimating the diameter. The estimate made was 4.3 cm.

Calculate the estimated area of the clear zone.

(2)

Answer

(b) The results of the investigation are shown in the table.

Sample number	Estimated area of clear zone / mm ²			
	Antibiotics			Plant extract
	Chloramphenicol	Tetracycline	Streptomycin	Garlic
1	28	16	15	20
2	26	19	13	28
3	29	11	14	18
4	28	21	12	25
5	26	7	14	27
6	29	11	15	26
7	22	8	9	25
8	25	21	14	25
9	29	10	12	29
Mean	27	14	13	25
Standard deviation	2.37	5.54	1.90	3.60

These data were analysed using *t*-tests.

(i) Several statistical tests were available to the student to analyse these data, including the *t*-test, Chi squared and the correlation coefficient.

Explain why the *t*-test was chosen to analyse these data, rather than the other two tests.

(3)

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(ii) Calculate the *t* value for the data to compare garlic with chloramphenicol, using the formula:

$$t = \frac{|\bar{x}^1 - \bar{x}^2|}{\sqrt{\left(\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}\right)}}$$

(3)

Answer

(iii) The table shows the critical values of t with 16 degrees of freedom.

Significance level (p)	0.20	0.10	0.05	0.01	0.001
Critical value of t	1.34	1.75	2.12	2.92	4.02

Use your value of t to test the validity of a stated null hypothesis.

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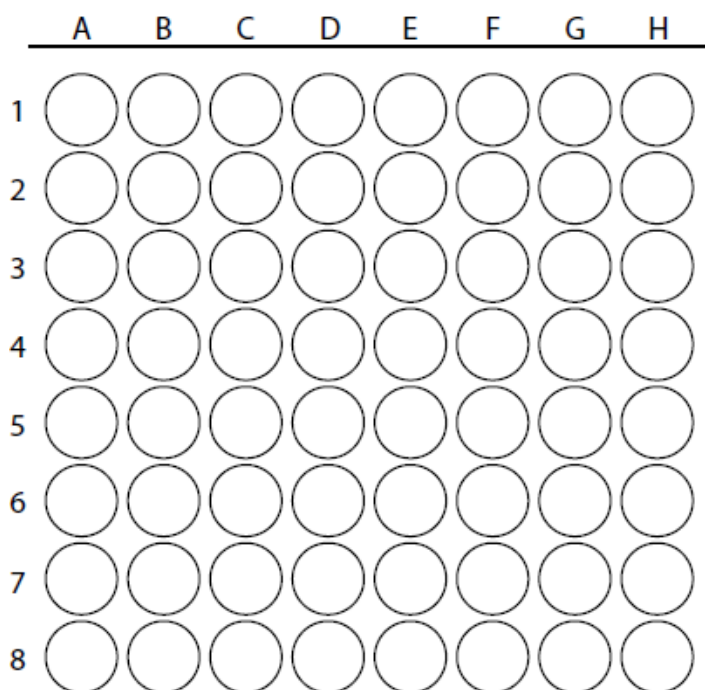
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(c) The size of the clear zone depends on variables other than the antibacterial properties of the substances used, such as size and solubility of the antimicrobial molecules in the extract.

A new method was developed in which the minimum concentration of extract that causes inhibition of bacterial growth (Minimum Inhibitory Concentration, MIC), was found.

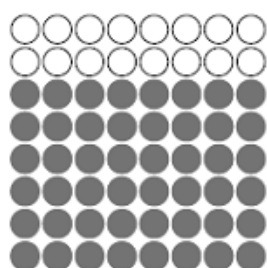
Samples of extract, bacteria (*E. coli*) and a respiration indicator were placed in a micro-titre tray.



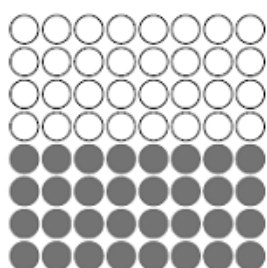
1 = 4%
 2 = 2%
 3 = 1%
 4 = 0.5%
 5 = 0.25%
 6 = 0.125%
 7 = 0.0625%
 8 = 0.0%

concentration of extract

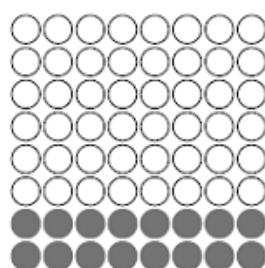
The diagrams show the results obtained. The tubes are black when respiration occurs and clear when no respiration occurs.



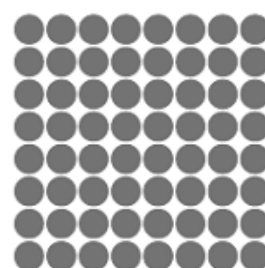
rosemary



geranium



garlic



cedar

(i) Analyse the data to explain the results of this experiment.

(2)

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(ii) Give **two** changes that can be made to the procedure to get a more accurate measure of MIC.

(2)

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(iii) It was concluded that plant extracts inhibit respiration of bacteria. This conclusion may not be valid because the investigation has limitations.

Describe how the investigation could be modified to reduce the effect of two named limitations.

(2)

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(Total for question = 20 marks)

Q19.

A number of seed banks have been set up around the world.

When a seed bank receives new seeds, it processes them in several ways.
The processes can include the following stages:

- washing the seeds with disinfectant
- allowing the seeds to dry.

Explain the advantages of these two stages.

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(Total for question = 3 marks)

Q20.

A number of seed banks have been set up around the world.

The processed seeds are stored at minus 20 °C. At intervals, samples of seeds are removed from storage and tested for viability.

If at least 75% of the seeds in the sample germinate, the remaining seeds are described as viable.

The diagram shows a container with many seeds in it.



Sunflower Seeds
mass of 1000 seeds = 50 g

A sample of 3 g of seeds was removed from this container. These seeds were given optimum conditions for germination.

However, only 48 seeds germinated.

Determine whether the remaining seeds in the container are viable or not.

(3)

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(Total for question = 3 marks)

Q21. The group of birds, known as warblers, contains many species which are very similar in external appearance.

Two of these species, the chiffchaff, *Phylloscopus collybita*, and the willow warbler, *Phylloscopus trochilus*, are so similar that many experts can identify them only by listening to their individually-characteristic songs.

These songs are used during breeding to mark territory and attract mates.

The photographs below show these two warblers.



Chiffchaff



Willow warbler

Magnification $\times 0.75$

(a) Although chiffchaffs and willow warblers are often found at the same time in the same woodlands, they do not interbreed.

(i) Suggest why successful interbreeding between chiffchaffs and willow warblers would make some scientists doubt their classification as separate species.

(3)

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(ii) Suggest reasons why the two species do not interbreed.

(3)

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(b) Records show that very little change in the appearance of chiffchaffs and willow warblers has occurred during the last two hundred years.

Suggest why the rate of change in the appearance of these two species is relatively slow.

(3)

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(Total for Question = 9 marks)

Q22. The group of birds, known as warblers, contains many species which are very similar in external appearance.

The chiffchaff, *Phylloscopus collybita*, and the willow warbler, *Phylloscopus trochilus* are two species of warbler.

These warblers are so similar that many experts can identify them only by listening to their characteristic songs. Their songs are used during breeding to mark territory and attract mates.

The photographs below show these two warblers.

(5)

(Total for question = 6 marks)

A study of the genetics of grass snakes has led to the identification of a new species

of grass snake in the UK.

The barred grass snake was thought to be a variation of the common grass snake, *Natrix natrix*.

However, the barred grass snake, *Natrix helvetica*, has been found to be a different species.

Both types of grass snake are normally found in lowland regions in the south of England. The snakes can be more than a metre long, are found near water and eat mainly amphibians such as frogs and newts.

The common grass snake is olive green with a bright yellow collar.

The barred grass snake, shown in the photograph, is grey with black markings.



State what is meant by the term species.

(1)

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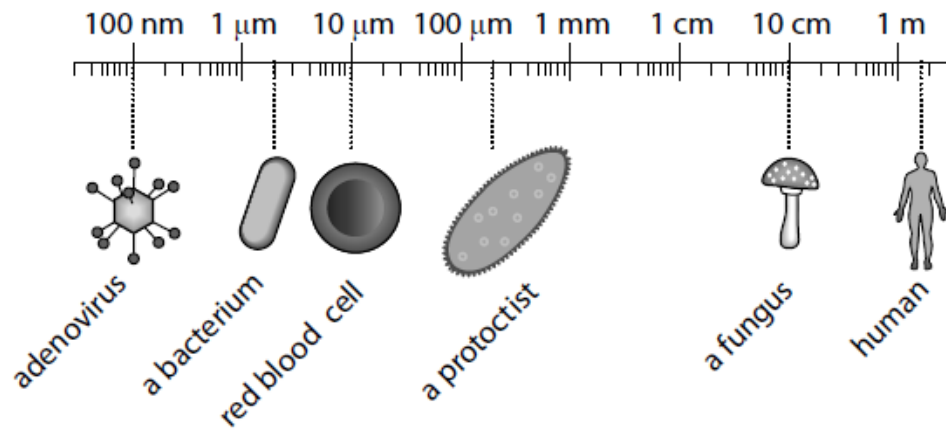
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(Total for question = 1 mark)

Q25.

The diagram compares the size of some microbes with that of a human and a human cell.



© Society for General Microbiology

(a) Which of the following belong to the domain Eukaryota?

(1)

- ☐ **A** adenovirus, bacterium and protist
- ☐ **B** human, bacterium and red blood cell
- ☐ **C** human, red blood cell and protist
- ☐ **D** adenovirus, fungus and human

(b) Which of the following do **not** have a nucleus?

(1)

- ☐ **A** bacterium and protist
- ☐ **B** bacterium and red blood cell
- ☐ **C** fungus and adenovirus
- ☐ **D** protist and adenovirus

(c) Which of the following shows how many times bigger the bacterium is than the adenovirus?

(1)

- ☐ **A** 45 times
- ☐ **B** 22 times
- ☐ **C** 2 times
- ☐ **D** 10 times

(d) State **one** way in which the structure of a virus is different from that of a bacterium.

(1)

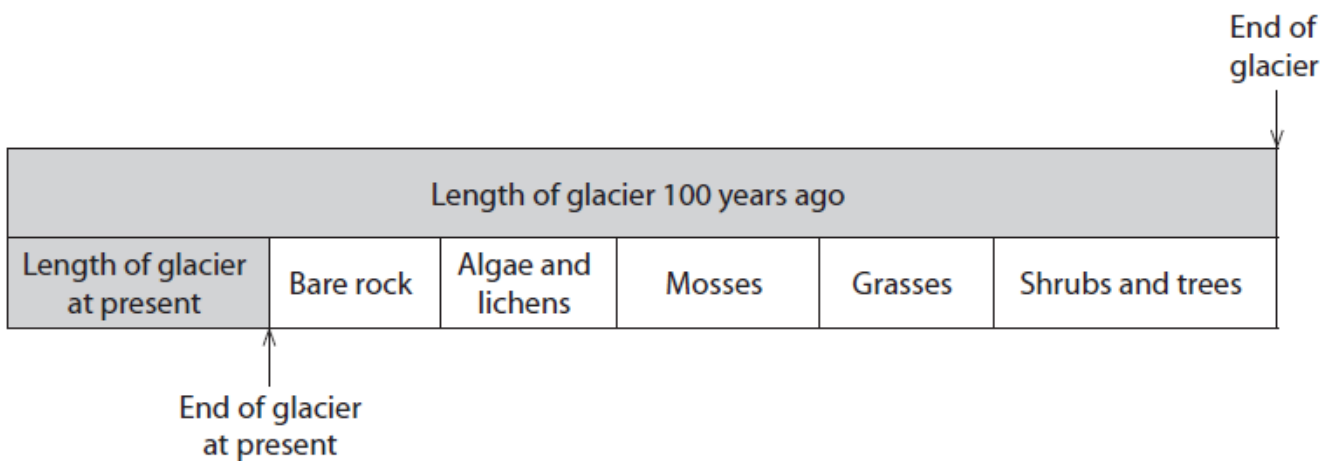
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(Total for question = 4 marks)

Q26.

Glaciers are long, large masses of ice that formed thousands of years ago. As a result of warmer climates, more ice is melting. This is reducing the length of the glaciers. As a result, bare rock that was once covered by the glacier becomes exposed.

The diagram below shows the length of a glacier 100 years ago and the glacier at present. It also shows what is now found in a transect taken from where the front edge of the glacier is at present.



(a) Using the information in the diagram, describe and explain the changes in the distribution of organisms with distance from the front edge of this glacier.

(3)

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(b) *Epilobium latifolium* is a plant that occupies a niche in an area once covered by this glacier. It is a short flowering plant that grows in clumps.

The photograph below shows three clumps of *Epilobium latifolium*.



} Clump of *Epilobium latifolium*

Magnification $\times 0.2$

(i) Explain what is meant by the term **niche**, using the plant *Epilobium latifolium* as an example.

(3)

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(ii) Describe how to carry out a study of the distribution of *Epilobium latifolium* from the front edge of this glacier.

(4)

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(iii) Suggest **one** abiotic factor that might affect the abundance of *Epilobium latifolium* and describe how this factor could be measured.

(3)

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(Total for question = 13 marks)

Q27.

Frogs are ectothermic animals. This means that their body temperature will vary as the environmental temperature varies.

(a) Explain why body temperature affects the rate of development of animals.

(3)

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(b) Several species of the frog genus, *Rana*, can be found in North America. Many of these

species inhabit areas within a range of latitudes from the colder north to the warmer south.

The table below shows data for four of these species, *R. clamitans*, *R. palustris*, *R. pipiens* and *R. sylvatica*.

Species	Body temperature of frog / °C			
	Lower lethal, below which frog dies	Minimum to start development	Maximum to complete development	Upper lethal, above which frog dies
<i>R. clamitans</i>	10.0	11.0	35.0	37.0
<i>R. palustris</i>	5.0	7.0	30.0	31.0
<i>R. pipiens</i>	3.0	6.0	28.0	30.0
<i>R. sylvatica</i>	0.0	2.0	24.0	25.0

Using the information, suggest why the lower and upper lethal temperatures limit the range of latitudes inhabited by each species of frog.

(2)

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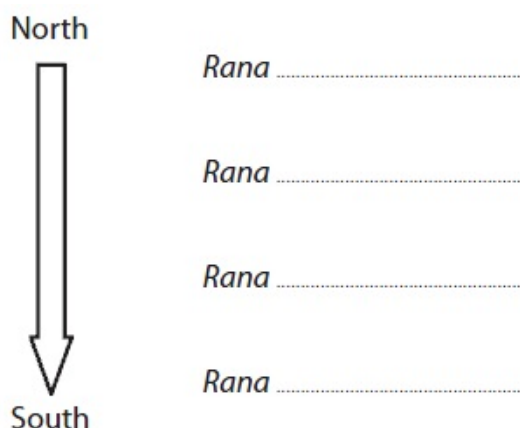
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(c) Complete the species names in the diagram below to show the most likely distribution of *Rana* from north to south.

(2)



(d) Populations of the different species overlap on the boundaries of each latitude range.

Suggest why interbreeding does not take place between these populations.

(3)

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(e) Suggest how global warming may affect the distribution of these species of Rana in North America.

(3)

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(Total for question = 13 marks)

Q28.

Plant fibres and oil-based plastics have both been used to make ropes.

Ropes used in climbing need to have high tensile strength.

State what is meant by the term **tensile strength**.

(1)

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(Total for question = 1 mark)

Q29.

There are many reasons why humans may lose muscle mass.

Two known causes are hip replacement surgery and some genetically inherited conditions.

Muscular dystrophy (MD) is a range of genetically inherited conditions in which a loss of muscle mass can occur.

Limb-girdle muscular dystrophy (LGMD2A) is a rare type of MD. Only six people per million have this recessive condition.

In 2018 there were 66.5 million people in the UK.

(i) Calculate the number of people in the UK who are carriers of LGMD2A using the Hardy-Weinberg equation.

(3)

$$p^2 + 2pq + q^2 = 1$$

Answer

(ii) In the human population, the frequency of the allele for LGMD2A may change from one generation to the next.

Explain why the frequency of this allele may change from one generation to the next.

(3)

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(Total for question = 6 marks)

Q30.

Plant fibres and oil-based plastics have both been used to make ropes.

Tissues that contain lignin provide strength to plant fibres.

Describe the positions in the stem of those tissues that contain lignin.

(2)

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(Total for question = 2 marks)

Mark Scheme

Q1.

Question Number	Answer	Mark
(i)	The only correct answer is C G (which is the xylem) <i>A is not correct because E does not contain lignin</i> <i>B is not correct because F, which is phloem, does not contain lignin</i> <i>D is not correct because H is not xylem</i>	(1)

Question Number	Answer	Mark
(ii)	The only correct answer is B F (this is phloem) <i>A is not correct because E is not phloem</i> <i>C is not correct because G is not phloem</i> <i>D is not correct because H is not phloem</i>	(1)

Q2.

Question Number	Answer	Mark
(i)	The only correct answer is B - sclerenchyma fibres provide support <i>A is not correct because it is not phloem</i> <i>B is not correct because it is not sieve tubes</i> <i>D is not correct because it is not xylem</i>	(1)

Question Number	Answer	Mark
(ii)	The only correct answer is A - phloem that transports organic solutes <i>B is not correct because sclerenchyma does not transport water</i> <i>C is not correct because sieve tubes do not synthesise organic solutes</i> <i>D is not correct because it is not xylem</i>	(1)

Question Number	Answer	Mark
(iii)	The only correct answer is D - xylem vessel that transports water and mineral ions <i>A is not correct because it is not phloem</i> <i>B is not correct because it is not a sclerenchyma fibre</i> <i>C is not correct because it is not a sieve tube</i>	(1)

Question Number	Answer	Additional guidance	Mark
(iv)	An answer that makes reference to the following - length of line correctly measured (1) - correct conversion to μm (1) - image size divided by actual size to give magnification (1)	Example of calculation 36mm ALLOW 37mm 36000 ALLOW 37000 $36000/320 = 112.5$ OR $37000/320 = 115.6$ Correct answer without working gains full marks	(3)

Q3.

Question Number	Answer	Mark
(i)	The only correct answer is D - ribosome <i>A is not correct because amyloplasts are only found in plant cells</i> <i>B is not correct because chloroplasts are only found in plant cells</i> <i>C is not correct because mesosomes are only found in bacterial cells</i>	(1)

Question Number	Answer	Mark
(ii)	The only correct answer is A-amyloplast <i>B is not correct because Golgi apparatus is found in plant and animal cells</i> <i>C is not correct because mesosomes are found only in bacterial cells</i> <i>D is not correct because some animal cells also have a vacuole</i>	(1)

Question Number	Answer	Mark
(iii)	The only correct answer is D-smooth endoplasmic reticulum <i>A is not correct because amyloplasts are only found in plant cells</i> <i>B is not correct because animal cells do not have a cell wall</i> <i>C is not correct because pili are only found in bacterial cells</i>	(1)

Q4.

Question Number	Answer	Mark
	C - anatomical, behavioural and physiological <i>The only correct answer is C</i> A is incorrect because there is also a physiological adaptation B is incorrect because there is also a behavioural adaptation D is incorrect because there is also an anatomical adaptation	(1)

Q5.

Question Number	Answer	Mark
	B - Eukaryota <i>The only correct answer is B</i> A is incorrect because the electron micrograph has a nucleus and other membrane bound organelles so must be a eukaryote C is incorrect because the electron micrograph has a nucleus and other membrane bound organelles so must be a eukaryote D is incorrect because the electron micrograph has a nucleus and other membrane bound organelles so must be a eukaryote	(1)

Q6.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • magnesium is needed to make chlorophyll (1) • because chlorophyll is required for photosynthesis (1) • because shoots need (chlorophyll) to carry out photosynthesis to grow (1)	ALLOW required to replace organic molecules stored in seed that have been used up	Choose an item. (2)

Q7.

Question Number	Answer	Additional guidance	Mark
	An answer the makes reference to five of the following: • description of how temperature will be controlled (1) • identification of another appropriate abiotic factor to control (1) • provide nutrients (for cells) (1) • use of aseptic technique (to prevent contamination of cell culture) (1) • culture for a stated period of time (1) • description of method of measuring growth (1)	e.g. set temperatures using a {water bath / incubator} e.g. pH / humidity/ carbon dioxide concentration / oxygen concentration ALLOW description of aseptic technique ALLOW times greater than 2 hours ALLOW culture at each temperature for the same period of time ALLOW e.g. measure {mass / number / area} of cells at beginning and end of culture	(5)

Q8.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to three of the following: • description of role in protection (1) • description of role in repopulation (1) • description of role in education (1) • description of role in research (1)	E.g. protection from poachers, hunting, vet care, administering medicines E.g. increase numbers, breeding programmes, release back into the wild E.g. conservation E.g. Improving health, discovering better nutrition, breeding cycles, developing a genetic database	(3)

Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	A (complete mineral ion solution)		(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	D (validity)		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	• Mass of one seed correctly calculated (1) • Calcium ion content for one seed calculated (1) • Correct answer (1)	<u>Example of Calculation:</u> $1 \div 200 = 0.005(\text{g})$ $(21 \times 0.005) \div 100$ or 0.00105 $= 1.05 (\mu\text{g})$ Allow full marks for correct answer with no working	(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iv)	An explanation that makes reference to the following: - seedlings not deficient in magnesium ions, chlorophyll production not affected (1) - seedlings of rice deficient in calcium ions were shorter due to less calcium ions stored in the seed (1) - seedlings of fenugreek did not suffer calcium ion deficiency due to the greater content of calcium ions in the seed (1)		(3)

Q10.

Question Number	Answer	Mark
(i)	The only correct answer is –A <i>amino acids</i> B is incorrect because nitrates are not found in cellulose C is incorrect because nitrates are not found in starch D is incorrect because nitrates are not found in sucrose	Computer (1)

Question Number	Answer	Mark
(ii)	The only correct answer is –C <i>nucleic acids</i> A is incorrect because phosphate is not found in cellulose B is incorrect because phosphate is not found in chlorophyll D is incorrect because phosphate is not found in sucrose	Computer (1)

Question Number	Answer	Mark
(iii)	The only correct answer is – C <i>chlorophyll</i> A is incorrect because magnesium is not found in amino acids B is incorrect because magnesium is not found in cellulose D is incorrect because magnesium is not found in starch	Computer (1)

Q11.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to three of the following - many of the elephants with tusks were killed (for their ivory) / large percentage of population do not have tusks (1) - elephants without tusks were more likely to survive and breed (1) - therefore passing on alleles for not having tusks (1) - increasing the frequency of homozygous recessives in the population (1)	ALLOW converse	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	A description that makes reference to the following - calculate the {allele frequencies/ number of dominant and recessive alleles} (in the population in Mozambique) (1) (regular) sampling over a period of time (1)		(2)

Q12.

Question number	Answer	Mark			
	The only correct answer is B - <table border="1"> <tr> <td>7</td><td>28</td><td>21</td></tr> </table> A is not correct because column 2 shows the number for a gamete and column three for a normal cell C is not correct because columns one and three show numbers for normal cells D is not correct because column one shows the number for a normal cell and column two shows the number for a gamete	7	28	21	(1)
7	28	21			

Q13.

Question Number	Answer	Additional guidance	Mark
(a)(i)	- reference to {polymerase chain reaction / PCR} ; - polymerase (enzyme) {added / eq} ; - idea of need for primers and nucleotides ; {90-98} (°C) → {50-65} (°C) → {70-75} (°C) ; - idea that cycle needs to be repeated {several times / to make several copies of DNA / eq} ;	1. Accept as a ref to PCR machine	(4)

Question Number	Answer	Additional guidance	Mark
(a)(ii)	(DNA) {profiling / fingerprinting / (gel) electrophoresis} ;	Ignore Southern blotting, PCR Accept DNA profile / DNA fingerprint	(1)

Question Number	Answer	Additional guidance	Mark
(b)	1. idea of work appearing in a (Scientific) journal or being presented at a conference ; 2. idea that validity or reliability is considered ; 3. by other scientists / ref to peer review ;	1. Accept publishing a paper, scientific meeting	(2)

Question Number	Answer	Additional guidance	Mark
(c)(i)	1. reference to different {conditions / environments /eq} (in each region) ; 2. idea of different selection pressures ; 3. idea of {restricted gene flow / separate gene pools} ; 4. reference to reproductive isolation;	1. Accept appropriate named factor e.g. temperature 3. Ignore different allele frequency	(2)

Question Number	Answer	Additional guidance	Mark
(c)(ii)	1. idea of different {alleles/ gene pool} ; 2. idea that this leads to {new / different} phenotypes ; 3. idea of new {allele / gene} can be {advantage / disadvantage} ; 4. reference to (advantageous) {(mutated) gene / (new) allele} passed onto offspring ;	1. Ignore allele frequency 2. Accept traits / characteristics / features	(2)

Q14.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to two of the following: - modifies proteins (1) - forms vesicles (1) - removes (some) water from the protein / concentrates the { protein / glycoprotein } (1)	e.g. addition of carbohydrate to protein / formation of glycoprotein ALLOW processes protein IGNORE folds protein e.g. lysosomes / secretory vesicle / vesicle in synaptic knob ALLOW packages proteins into vesicles	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: (for phase 1) – to make sure the phospholipase inhibitor is not harmful (1) (for phase 2) – to see if it is effective in { treating the condition / preventing allergic reactions to wasp venom } (1) (for phase 3) – to gather much data / data for statistical tests / to look for rare side effects (1) - to test for side effects in { phase 1 / phase 2 } (1)	ALLOW finding safe dosage ALLOW reference to how the drug is absorbed / metabolised ALLOW double blind trials to compare effectiveness with a placebo / previous drug	(3)

Q15.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following (in the early stages of glacial retreat) the soil may lack nitrates (1) (however) lupin plants can use the { ammonium ions / source of nitrogen } produced by the bacteria (1) (therefore can) synthesise { amino acids / chlorophyll / nucleic acids / nitrogenous bases } (1)	ALLOW other sources of nitrogen lacking ALLOW produce for synthesise ALLOW protein	(3)

Q16.

Biology A (Salters-Nuffield) Advanced Paper 3 (9BN0/03)

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	Tonoplast		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	• selection of correct points from the graph (1) • calculation of percentage (1) • difference in percentage (1)	0.17 AU , 0.23 AU , 0.26 AU <u>Example of calculation:</u> $35.3\% \div 13.0\%$ $= 22.3\%$ Allow full marks for correct answer with no working	(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(i)	An explanation that makes reference to the following: • interferes with { tertiary / 3-D } shape of the channel proteins (1) • therefore causes channel proteins to		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(ii)	An answer that makes reference to four of the following: • solutions with a range of pH values (1) • pieces of beetroot of same surface area (1) • control of other named relevant variables (1) • measurement of absorbance of solution using colorimeter (1) • repeats at each pH value to calculate mean (1)	e.g. temperature / volume of solution / time left in solution /	(4)

Q17.

Question Number	Answer	Additional guidance	Mark						
(i)	Correct completion of the table <table><tr><td>n(n-1)</td></tr><tr><td>2</td></tr><tr><td>56</td></tr><tr><td>0</td></tr><tr><td>72</td></tr><tr><td>6</td></tr></table>	n(n-1)	2	56	0	72	6	All figures need to be correct	(1)
n(n-1)									
2									
56									
0									
72									
6									

Question Number	Answer	Additional guidance	Mark
(ii)	• correct calculation of $N(N-1)$ (1) • correct calculation of D (1)	<u>Example of calculation</u> $N(N-1) = 23 \times 22 = 506$ $\Sigma n(n-1) = 136 \quad 506 \div 136$ $D = 3.72$ ALLOW 3.7 ALLOW ecf from 7(a)(i) Correct answer without working gains full marks	(2)

Q18.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(i)	An explanation that makes reference to the following: • (small pieces) provides large surface area to volume ratio (1) • (use of ethanol for a long time means) the antibacterial substance is soluble in ethanol and more will be extracted (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(ii)	$\pi 2.15^2$ (1) 14.5 cm ² (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(i)	An explanation that makes reference to the following: • the <i>t</i>-test assess the significance of the difference between the means of the two treatments (1) • Chi squared not appropriate because there are no expected values (1) • correlation coefficient not appropriate because the independent variable is discontinuous / not continuous (1)		(3)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(ii)	$2.37^2 \div 9 = 0.62$ and $3.60^2 \div 9 = 1.44$ (1) $\sqrt{0.62 + 1.44} = 1.44$ (1) $(27 - 25) \div 1.44 = t = 1.39$ (1)	Correct answer gains full marks	(3)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(iii)	An answer that makes reference to the following: • there is no significant difference between the clear area caused by garlic compared with that caused by chloramphenicol (1) • $p > 0.05$ (1) • difference due to chance (1) • therefore accept null hypothesis (1)	Allow marking points for the calculated value of <i>t</i> from the candidate	(4)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)(i)	An explanation that makes reference to the following: - suggests cedar wood oil has no anti-microbial effect on <i>E. coli</i> and all other oils do (1) - quoting at least two values from: rosemary 2%, geranium 0.5%, garlic 0.125% / manipulation of data to show relative effects (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)(ii)	An answer that makes reference to the following: - for cedar wood oil try concentrations above 4% (1) - for all the others, try concentrations below 0.0625% (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)(iii)	A description that makes reference to the following: - only one tray per species – need repeated measurements (1) - species – only used one species of bacteria / only used extracts from four plant species (1)		(2)

Q19.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: - washing with disinfectant will kill any microorganisms (1) - drying to { reduce chance of germination / decrease enzyme action } (1) - therefore preventing { decay / infection / damage } to the seeds (1)	ALLOW bacteria and / or fungi ALLOW: for long term storage	(3)

Q20.

Question Number	Answer	Additional Guidance	Mark
	- correct calculation of number of seeds in the sample (1) - correct calculation of percentage that germinated (1) - therefore the remaining seeds are viable (as germination was greater than 75%) (1)	Example of calculation $(1000 \div 50) \times 3 = 60$ seeds (1g = 20 seeds) $(48 \div 60) \times 100 = 80\%$ (80% without working gains 2 marks)	(3)

Q21.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	(successful interbreeding) produces offspring; (same species produce) fertile (offspring); - credit reason why offspring of different species might be infertile ;	Accept converse throughout Ignore viable eg genetic incompatibility, different number of chromosomes, poor quality gametes , low number of gametes	(3)

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	- reference to reproductive isolation ; - different breeding times; - do not recognise {courtship displays / songs / eq} ; - physically incompatible eg genitalia ;		(3)

Question Number	Answer	Additional Guidance	Mark
(b)	- idea that the two species share the same habitat ; - idea that the two species experience the same environmental conditions ; (therefore) the same selection pressures ; - idea that they are both well-adapted (to their environment) ; - idea that no mutations have happened that {improve / change} their {phenotypes / survival}; {no / few} changes in allele frequency / gene pool is stable ; - idea that there has been very little change in environment (over the years) ;	Accept similar NB this needs to be in the context of both species being subjected to the same selection pressures Accept similar	(3)

Q22.

Question Number	Answer	Additional Guidance	Mark
(a)	idea of organisms that breed to produce fertile offspring ;	Ignore reproductively isolated Ignore viable	(1)

Question Number	Answer	Additional Guidance	Mark
(b)	1. idea of geographical isolation ; 2. idea of different {environmental conditions / habitats / eq} ; 3. reference to different selection pressures ; 4. idea that mutation resulted in {adaptation / increased survival} ; 5. idea of {decrease in gene flow / different alleles} ; 6. ref to reproductive isolation ; 7. credit suitable example e.g. different songs, incompatible genitals ;		(4)

Question Number	Answer	Additional Guidance	Mark
(c)	1. idea of descending from common ancestor ; 2. idea of living in similar habitats ; 3. idea of similar (environmental) {conditions / factors} ; 4. idea of similar selection pressures ; 5. idea that both well-adapted ; 6. idea that mutations have not changed appearance ; 7. idea of similar gene pool ;	Accept same for similar throughout 2. Accept place / environment / area	(3)

Q23.

Question Number	Answer	Mark
(i)	The only correct answer is B the number of different species in one area <i>A is incorrect because species richness does not measure alleles</i> <i>C is incorrect because it is not the number of individuals of one species</i> <i>D is incorrect because it is not the number of individuals of one species and it is not different habitats</i>	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to five of the following • random sampling in each woodland using suitable method of generating co-ordinates (1) • use of a quadrat to sample at least 10 times in each woodland (1) • count the number of different species in each quadrat (1) • take measures to ensure validity of investigation / measure named abiotic variables (1) • for each woodland, calculate { the total number of species present / number of species / given area } (1) • use a suitable statistical test to compare the data from the two woodlands (1)	e.g. random number tables e.g. carry out the investigation at the same time of year / forests in similar locations / same climate / measure temperature/pH e.g. mean and standard deviation for each woodland / t-test ALLOW Mann-Whitney U test DO NOT ALLOW diversity index	(5)

Q24.

Question Number	Answer	Additional guidance	Mark
	a group of organisms that can interbreed to produce fertile offspring	ALLOW 'breed', 'reproduce', 'mate' for 'interbreed'	(1)

Q25.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	C		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	B		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	B		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(d)	An answer that makes reference to one of the following points: - virus has a non-cellular structure whereas bacteria has a cellular structure (1) - a virus has a protein capsid whereas a bacterium has a polysaccharide cell wall (1) - viruses have one type of nucleic acid whereas a bacterium has two (1)		(1)

Q26.

Question Number	Answer	Additional Guidance	Mark
(a)	- idea that as the {distance from the front edge of the glacier / time} increases, the {complexity / biodiversity / size / eq} of the organisms increases ; - reference to (primary) succession ; - idea that {algae / lichens / pioneer species} are (the first) organisms to colonise bare rock / eq; - idea that {algae / lichen / pioneer species} improve conditions for plants ; - idea of competition (limiting species present) ;	- ACCEPT idea that climax community only reached at distance from glacier edge - NOT secondary succession - including e.g. change rock into soil / increase humus content of soil / increase water content - e.g. newer species outcompete previous species	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	- the {role / interaction / eq} of an { <i>Epilobium latifolium</i> / organism / species} within its { ecosystem / habitat / environment } ; (<i>Epilobium latifolium</i>) is a producer ; - idea that <i>Epilobium latifolium</i> provides {food / energy} for other organisms (herbivores / primary consumers / decomposers) ; - idea that <i>Epilobium latifolium</i> improves soil e.g. holds soil structure together, increases nutrients ; - idea that <i>Epilobium latifolium</i> provides {shelter / (micro) habitat} for organisms ;	- IGNORE community - NOT prey - IGNORE food in soil ACCEPT adds organic matter, humus - ACCEPT named organism e.g. insects	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	1. idea of using a transect (from front edge of glacier); 2. credit method of sampling (along transect) ; 3. credit appropriate method of selecting sample sites (along transect) ; 4. description of estimate of abundance e.g. number of plants, percentage cover ; 5. idea of using more than one transect ; 6. credit appropriate method of recording quantitative data ;	2. e.g. clumps touching transect, quadrat (on transect), number of plants along perpendicular 3. e.g. set distance, regular, systematic, flip-flop quadrats NOT random 5. IGNORE references to repeating investigation 6. e.g. tally chart, table, graph	(4)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	1. credit appropriate named abiotic factor; 2. credit appropriate method of measurement of factor ; 3. credit appropriate description of where reading should be taken ; 4. idea of taking several readings and getting an average / eq ;	1. e.g. light, soil pH, water content, mineral content, temperature, salinity, wind IGNORE CO₂, O₂, rainfall, humidity 2. CE applied e.g. light {probe / sensor / meter / data logger}, {water gauge / drying out soil samples} 3. CE applied e.g. reading taken at height of plant, soil sample around roots, quadrat	(3)

Question Number	Answer	Additional guidance	Mark
(a)	- reference to increase in {metabolic rate / enzyme activity / eq} as temperature rises ; - reference to increase in {kinetic / eq} energy of molecules (as temperature rises) / eq ; - reference to increase in {enzyme-substrate complexes / energy of collisions / eq} (as temperature rises) ; - idea of {inactivation at lower temperatures/ denaturation at higher temperatures} of enzymes ; - idea that temperature affects {differentiation / growth /division / eq} ;	1. Accept converse argument for mp 1 – 3 2. Accept movement 4.Accept the idea that enzyme-substrate complexes cannot be made if denaturing	(3)

Question Number	Answer	Additional guidance	Mark
(b)	- idea that temperature affects {survival / development / growth / metabolism / cell division / eq} ; - idea that enzymes affect {development / growth / metabolism / cell division/ eq} ; - idea that temperature affects enzymes ; - idea that different frogs have different enzymes ;		(2)

Question Number	Answer	Additional guidance	Mark
(c)	<i>sylvatica,</i> <i>pipiens,</i> <i>palustris,</i> <i>clamitans</i> ; ;	if order correct but reversed = 1 mark	(2)

Question Number	Answer	Additional guidance	Mark
(d)	1. idea that different species are reproductively isolated ; 2. idea of different breeding {times / seasons / eq} ; 3. idea of different {breeding / courtship / eq} {behaviour / rituals / displays / colour / songs / croaks / eq} ; 4. idea that population at {northerly / southerly} limit of range may not develop (to adulthood) ; 5. idea that breeding between different species results in infertile offspring ;	3. Accept idea of incompatible {genitalia / gametes}	(3)

Question Number	Answer	Additional guidance	Mark
(e)	1. idea that global warming will increase the temperature (at the latitudes) ; 2. idea that temperatures (at these latitudes) may become too high for any of the species ; 3. idea that new temperature may be above the maximum to complete development or above the upper lethal limit ; 4. idea that species move {north / to cooler regions / eq} ; 5. ref to change in {food source / predators / competition / eq} ;	2.Accept become extinct	(3)

Q28.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: the (pulling) force the fibre can withstand before breaking (1)	ALLOW mass or weight instead of force	(1)

Q29.

Question Number	Answer	Additional Guidance	Mark
(i)	- correct values for p and q (1) - value for $2pq$ calculated (1) - correct number of people calculated (1)	Example of calculation $p = 0.9975$ and $q = 0.0025$ OR $p = 0.9976$ and $q = 0.0024$ ALLOW opposite values for p and q $2pq = 0.0048$ to 0.0050 319 200 to 332 500 Correct answer with no working gains full marks	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: - because the allele for LGMD2A may undergo mutation (1) - because gene flow may cause alleles to be lost or gained from the population (1) - due to { natural selection / (changed) selection pressure } (1) - because people with the condition may not have children (1)	ALLOW random mutations to allele ALLOW: immigration / emigration ALLOW confers an advantage / disadvantage	(3)

Q30.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference the following: • sclerenchyma (fibres) on the outer side of the {vascular bundle / phloem} (1) • xylem (vessels) on the {inner side / inside} of the vascular bundle (1)	ALLOW correctly labelled diagram ALLOW sclerenchyma outside vascular bundle ALLOW xylem in the vascular bundle	(2)

Q1.

Tropical rainforests play a role in maintaining biodiversity and in storing carbon.

Information on biodiversity has been collected from various rainforest habitats in Madagascar.

(i) Describe what needs to be measured in order to compare the biodiversity of two rainforests.

(2)

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(ii) The biodiversity of the land area of Earth has been estimated.

The table shows information on the number of species of plants and vertebrate animals in the rainforests of Madagascar and for the land area of Earth.

Region	Plants		Vertebrate animals		Land area / km ²
	Number of known species	Number of known endemic species	Number of known species	Number of known endemic species	
Madagascar	12 000	9704	987	771	59 300
Land area of the Earth	300 000	300 000	27 300	27 300	149 000 000

Analyse the data to determine the importance of the rainforests of Madagascar in maintaining biodiversity on Earth.

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(Total for question = 5 marks)

Q2.

The decomposition of leaves depends on the content of the leaves, the presence of certain microorganisms and a number of abiotic factors.

Leaves consist of a number of organic molecules, including lignin and cellulose.

(a) Place a cross ☐ in the box next to the groups of microorganisms that all cause decomposition.

(1)

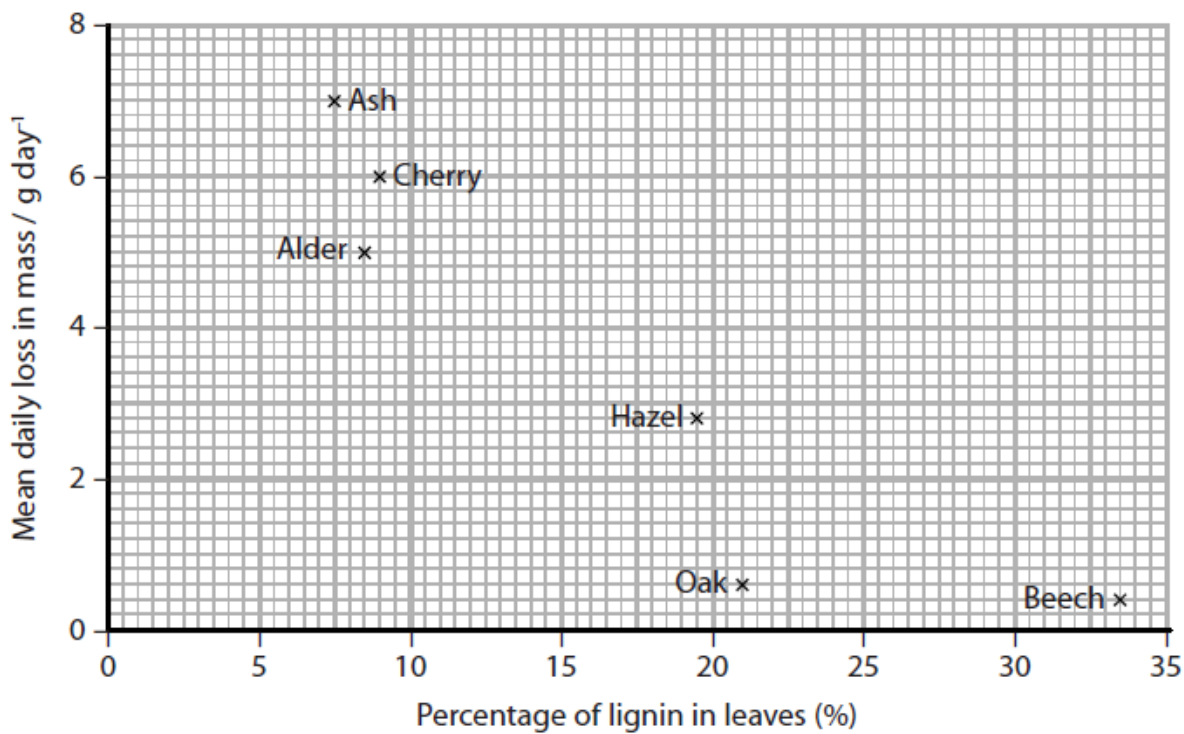
- ☐ **A** bacteria and fungi
- ☐ **B** bacteria and viruses
- ☐ **C** fungi and viruses
- ☐ **D** bacteria, fungi and viruses

(b) An investigation was carried out into the effect of lignin content on the decomposition of leaves from different types of tree.

The lignin content of leaves from an ash tree was determined. A pile of ash leaves was collected and weighed. The leaves were left for 40 days and reweighed. The mean daily loss in mass was calculated.

This was repeated for leaves from five other species of tree. All six piles of leaves had the same starting mass.

The results of this investigation are shown in the graph below.



(i) A student made the following conclusions from the data.

Beech leaves decompose faster than cherry leaves.

Microorganisms are needed for the decomposition of these leaves.

There is a causal relationship between lignin content and decomposition.

Place a cross ☒ in the box next to the number of correct conclusions made by the student.

(1)

- ☒ **A** none
- ☐ **B** one
- ☐ **C** two
- ☐ **D** three

(ii) Place a cross ☒ in the box next to the term that completes the following statement.

Each pile of leaves had the same mass to ensure the investigation was

(1)

- ☒ **A** accurate
- ☐ **B** precise
- ☐ **C** reliable
- ☐ **D** valid

(iii) Suggest what happens to the cellulose in these leaves during decomposition.

(4)

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(iv) The student repeated this investigation on sycamore leaves.

Explain why it would be necessary to keep the temperature of this investigation the same as the original.

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(Total for question = 11 marks)

Q3.

Anabolic steroids and testosterone have been used as performance-enhancing drugs by some athletes. These drugs can increase muscle mass and strength.

An investigation was carried out to assess the effect of doses of testosterone on muscle size.

A group of men was randomised into four groups: A, B, C and D. Groups A and B were given a placebo. Groups C and D were both given doses of testosterone. Groups A and C had no exercise training. Groups B and D were given exercise training.

The cross-sectional area of the triceps muscle of each individual was measured at the start of the investigation and after 10 weeks.

The results are shown in the table.

Muscle	Mean cross-sectional area of muscle / mm ² ± SD			
	Group A Placebo without exercise	Group B Placebo with exercise	Group C Testosterone without exercise	Group D Testosterone with exercise
Triceps – at the start	3621 ± 213	4052 ± 262	3579 ± 260	3483 ± 217
Triceps after 10 weeks	3539 ± 226	4109 ± 230	4003 ± 229	3984 ± 239

(i) Deduce the effect of testosterone on the size of the triceps muscle.

(2)

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(ii) The purpose of the placebo is to

(1)

- ☐ **A** increase the accuracy of the measurements
- ☐ **B** increase the reproducibility of the data
- ☐ **C** show that exercise has an effect
- ☐ **D** show that testosterone has an effect

(Total for question = 3 marks)

Q4.

The scientific article you have studied is adapted from *National Geographic*.

Use the information from the scientific article and your own knowledge to answer the following questions.

State what is meant by the term endemic (paragraph 35).

(1)

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(Total for question = 1 mark)

Q5.

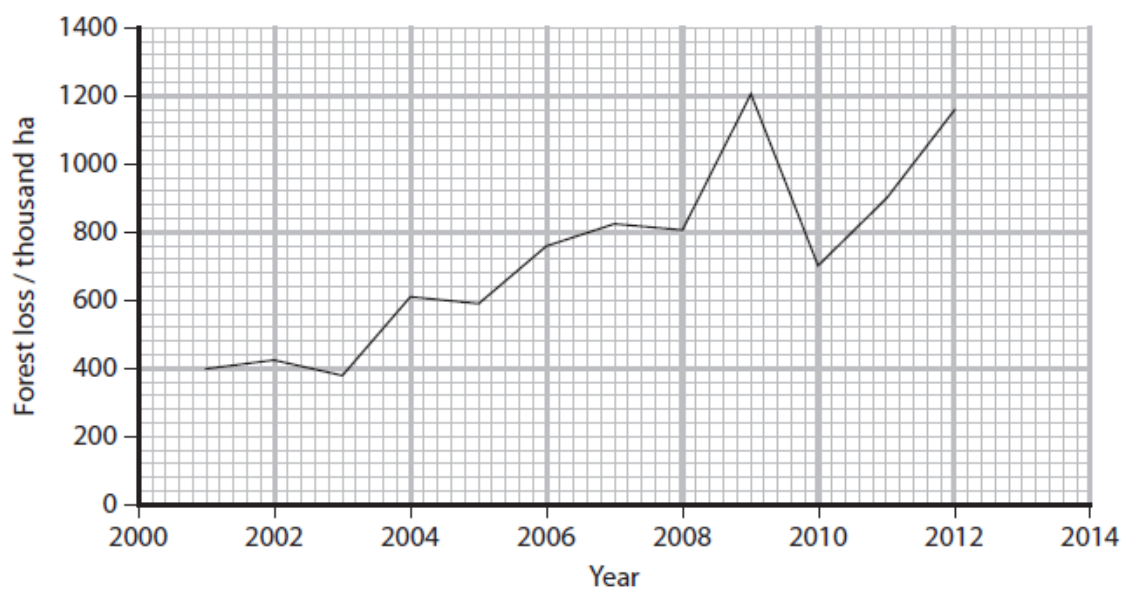
The photograph shows an orangutan. These animals inhabit the forests of Borneo and Sumatra.



The orangutan population in Borneo decreased by 60% between 1950 and 2010.

This has been linked to loss of habitat. Deforestation has resulted in the loss of natural habitat.

The graph shows the area of forest loss in Borneo from 2001 to 2012.



(2)

(i) Calculate the mean rate at which forest was lost between 2010 and 2012.

Answer

*(ii) Land use has changed over time in Borneo, with areas of forest being removed due to logging. The land may then be used for planting oil palms, which are not a suitable habitat for orangutans.

The following comments refer to other issues concerning the conservation of orangutans in Borneo.

- Over the past 100 years, 80% of suitable habitat for orangutans has been lost.
- Only 2% of the remaining forest suitable as orangutan habitat is protected.
- From 1999 to 2015, the orangutan population decreased by 50%.
- Captive-bred orangutans may spread human diseases into wild populations.
- When captive-bred orangutans are released, their offspring often die young because the

- females have not learnt parenting behaviour from older individuals.
- Large numbers of orangutans are hunted in Borneo, even though they are a protected animal.

- females have not learnt parenting behaviour from older individuals.
- Large numbers of orangutans are hunted in Borneo, even though they are a protected animal.

It has been stated that habitat protection is more important than captive breeding programmes for the conservation of orangutans in Borneo.

Evaluate this statement.

(6)

This image shows a full page of a document template designed for handwritten notes or answers. It features approximately 28 horizontal dashed lines spaced evenly down the page, providing a guide for line placement while allowing for free-form handwriting. The background is plain white, and there are no margins, headers, or footers present.

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(Total for question = 8 marks)

Q6.

Photosynthesis is a process that occurs in all green plants.

Describe how starch is formed from the products of the light-independent reactions of photosynthesis.

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(Total for question = 4 marks)

Q7.

The largest blood vessels in the body are the aorta and the vena cava.

In some individuals, the wall of the aorta splits. This can result in rapid blood loss and death.

It has been suggested that this splitting is a result of a loss of tensile strength in the wall of the aorta.

Describe how the tensile strength of the aorta wall can be determined.

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(Total for question = 3 marks)

Q8.

The effects of these plant extracts were tested on pathogenic bacteria. It was found that each extract had an effect on its own, but the effect was greater when used together.

Devise a procedure that scientists may have used to measure the effects of these extracts on pathogenic bacteria.

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(Total for question = 4 marks)

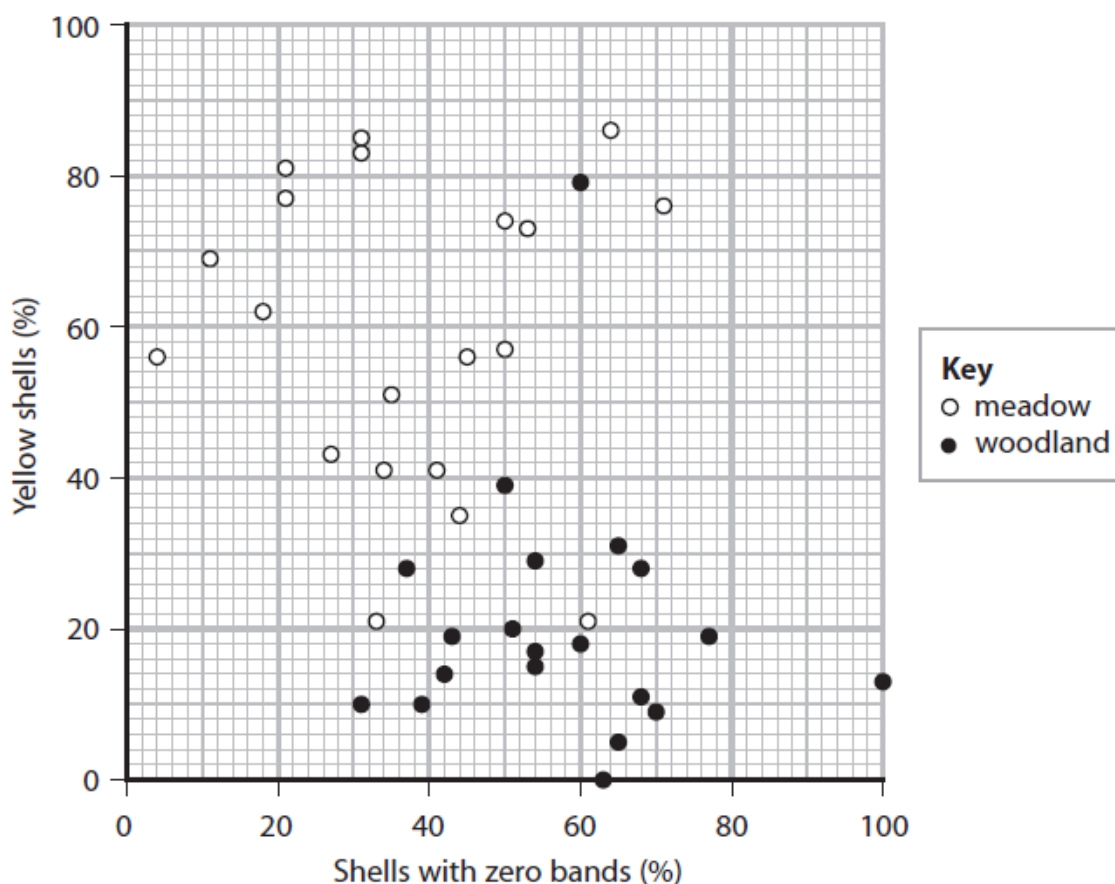
Q9.

The shells of the banded snail can have from zero to five black bands.

The populations of banded snails in 20 meadow habitats and 20 woodland

habitats were investigated.

At each location the percentage of snails with yellow shells was recorded. The percentage of snails with shells with zero bands was also recorded.



(i) Explain the importance of the different shell patterns in these two habitats.

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(ii) Explain how a statistical test could be used to determine if the number of shells with zero bands is significantly different in these two habitats.

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(Total for question = 5 marks)

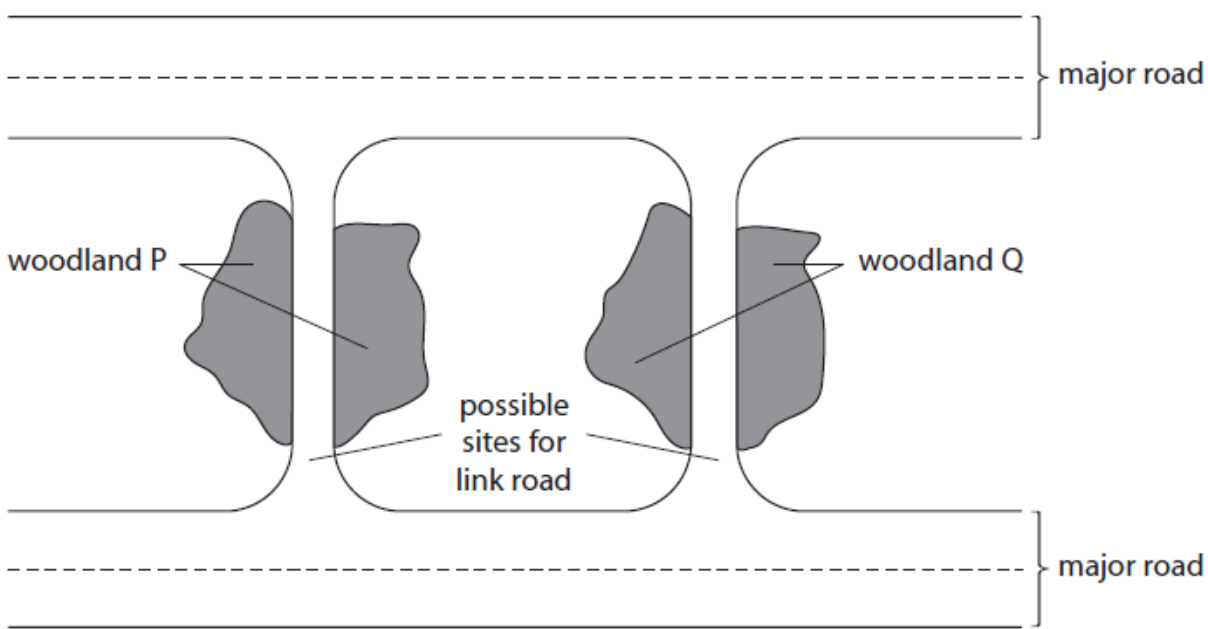
Q10.

Wildlife conservation can involve keeping animals in zoos as well as protecting habitats.

Habitats can be destroyed by road building.

A link road is planned to connect two major roads.

The diagram shows the two possible sites for the link road and two woodland habitats.



(1)

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(ii) To decide which of the two link roads should be built, studies of the biodiversity of woodlands P and Q need to be carried out.

Discuss what information needs to be collected from the two woodlands to make a decision about the site of the link road.

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(Total for question = 5 marks)

Q11.

Plant fibres and oil-based plastics have both been used to make ropes.

Climbing ropes can be made from manila (a plant fibre) or nylon (an oil-based plastic). Various factors affect the tensile strength of these ropes, including diameter and storage conditions.

The table shows the effect of rope diameter on tensile strength.

Diameter of rope / mm	Tensile strength / kN	
	Manila rope	Nylon rope
6	2.4	7.5
8	4.2	12.1
10	5.7	16.3
12	10.6	28.4

It is claimed that the ideal storage conditions for rope are 18 °C and 60% relative humidity.

Devise a valid investigation to determine the effect of storage temperature on the tensile strength of manila rope and nylon rope.

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(Total for question = 4 marks)

Q12.

A population of white-tailed deer *Odocoileus virginianus* was introduced from North America into Finland in 1934. There were four females and one male. The population has since increased rapidly.

A study in 2012 compared the genetic diversity of the population in Finland with the population in North America.

The table shows the heterozygosity index for each population of white-tailed deer.

Heterozygosity index for Finland population	Heterozygosity index for North American population
0.692	0.742

Climate change may affect the habitat of both populations of deer.

Explain which population is more likely to adapt to changing conditions.

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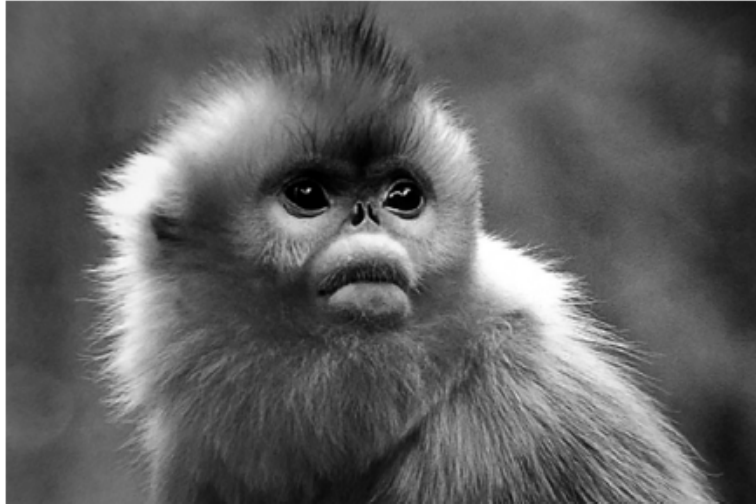
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(Total for question = 4 marks)

Q13.

The golden snub-nosed monkey (*Rhinopithecus roxellana*) is endemic to high mountainous regions of China.

This endangered species of monkey feeds on seeds.



State what is meant by the term endemic.

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(Total for question = 1 mark)

Q14.

Some marine snails produce chemicals called conotoxins. These chemicals paralyse the prey of these snails by interfering with the conduction of nerve impulses to muscles.

Conotoxins can be modified to produce painkillers.

The effects of conotoxins on the nervous system were first demonstrated in experiments involving animals.

These experiments were involved in the development of painkillers from conotoxins.

(i) Describe the ethical issues concerning the use of animals in this research.

(2)

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(ii) After testing on animals, painkillers undergo three-phased testing.

In an investigation testing the effectiveness of a painkiller produced from conotoxin, the new painkiller was tested on a group of healthy volunteers.

Explain the reasons for this stage in the testing of the painkiller.

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Q15.

Seed banks store seeds to conserve different varieties of plants.

Seeds are stored for long periods of time in conditions that allow them to be germinated when required.

An investigation was carried out to study the effect of storage time on wheat seeds of two different varieties.

Wheat seeds of one variety, P, were collected and divided into six groups, each with the same number of seeds. Each group of seeds was stored in an atmosphere of 80% humidity at a temperature of 42 °C.

Each group was stored in these conditions for different lengths of time. One group of seeds was germinated immediately after collection. This was the control group.

After storage, the seeds were planted in suitable conditions to allow germination. The number of seeds that germinated was found and the mean percentage germination calculated.

This was repeated using wheat seeds of a different variety, Q.

All other variables were kept constant.

The results are shown in the table.

Storage time / hours	Mean percentage germination (%)	
	Wheat variety P	Wheat variety Q
0 (control)	97	99
24	96	99
48	95	98
72	94	81
96	60	66
120	57	63

(i) Describe the effect of storage time on the germination of seeds for these two varieties of wheat.

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(ii) Explain how the results for the control were useful in this investigation.

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(Total for question = 5 marks)

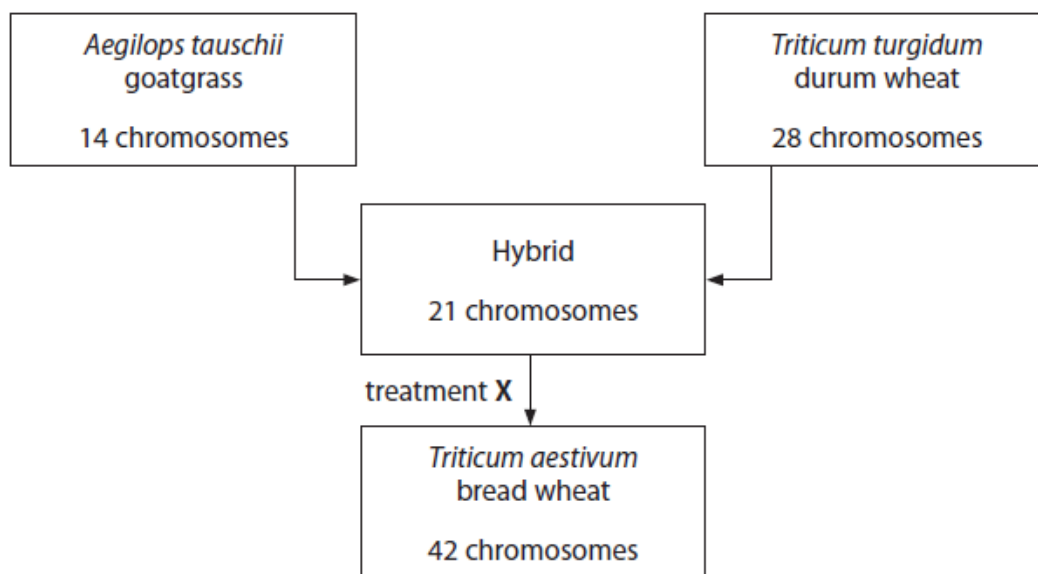
Q16.

The modern bread wheat plant (*Triticum aestivum*) has been developed from other plant species that have different genomes.

Three species of plant and their genomes are shown in the images.



The diagram shows how chromosomes from different species have combined to produce the bread wheat species used to produce flour.



* New varieties of plants with desirable combinations of characteristics can be produced using the methods shown in the table.

Method	Example
Formation of hybrids	In wheat, genome D includes genes for a tolerance of harsh conditions and genome A promotes large starch stores in seeds.
Genetic modification	Production of specific molecules in plant cells.
Selective breeding	Plants with desired characteristics can be used for breeding to produce plants with combinations of desired characteristics.

Evaluate the risks and benefits of producing varieties of plants using these methods.

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(Total for question = 6 marks)

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(Total for question = 5 marks)

Q18.

The scientific article you have studied is adapted from *National Geographic*.

Use the information from the scientific article and your own knowledge to answer the following questions.

Dengue is a disease caused by a virus carried by *Aedes aegypti*.

Using CRISPR and a gene drive, it may be possible to stop the reproduction of *Aedes aegypti* mosquitoes (paragraphs 20 and 21).

Explain why stopping the reproduction of this species of mosquito might not stop the spread of this disease.

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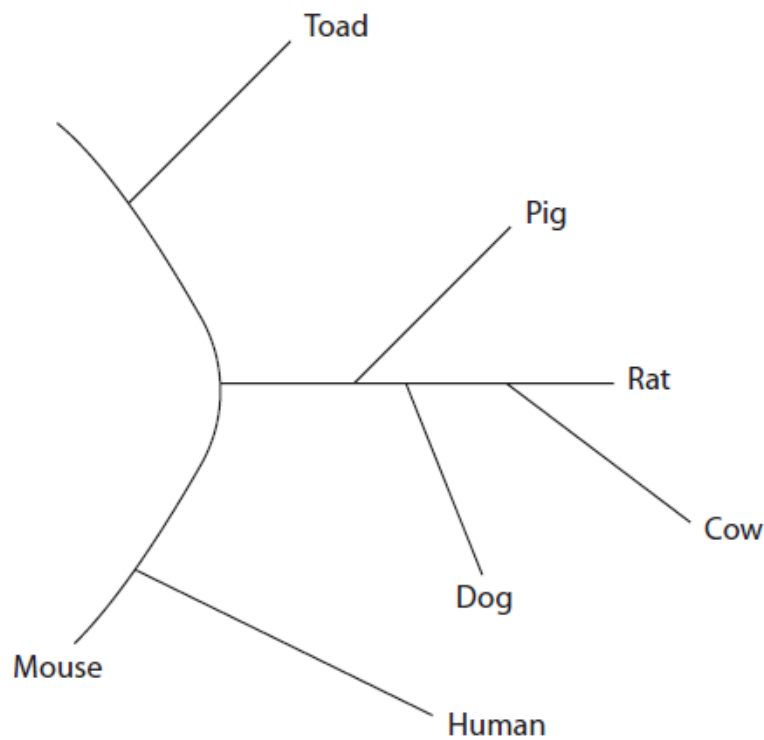
Q19.

Trypsin is an enzyme found in many groups of living organisms.

Trypsin specifically acts on a polypeptide to form amino acids.

The primary structures of trypsin molecules from different species have been used to produce a phylogenetic tree for trypsin.

Each branch of the following phylogenetic diagram represents trypsin from a different species.



Explain how the primary structure of trypsin molecules can be used to produce a phylogenetic tree.

(3)

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(Total for question = 3 marks)

Q20.

Explain how these two species of snake could have arisen from a common ancestor.

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(Total for question = 4 marks)

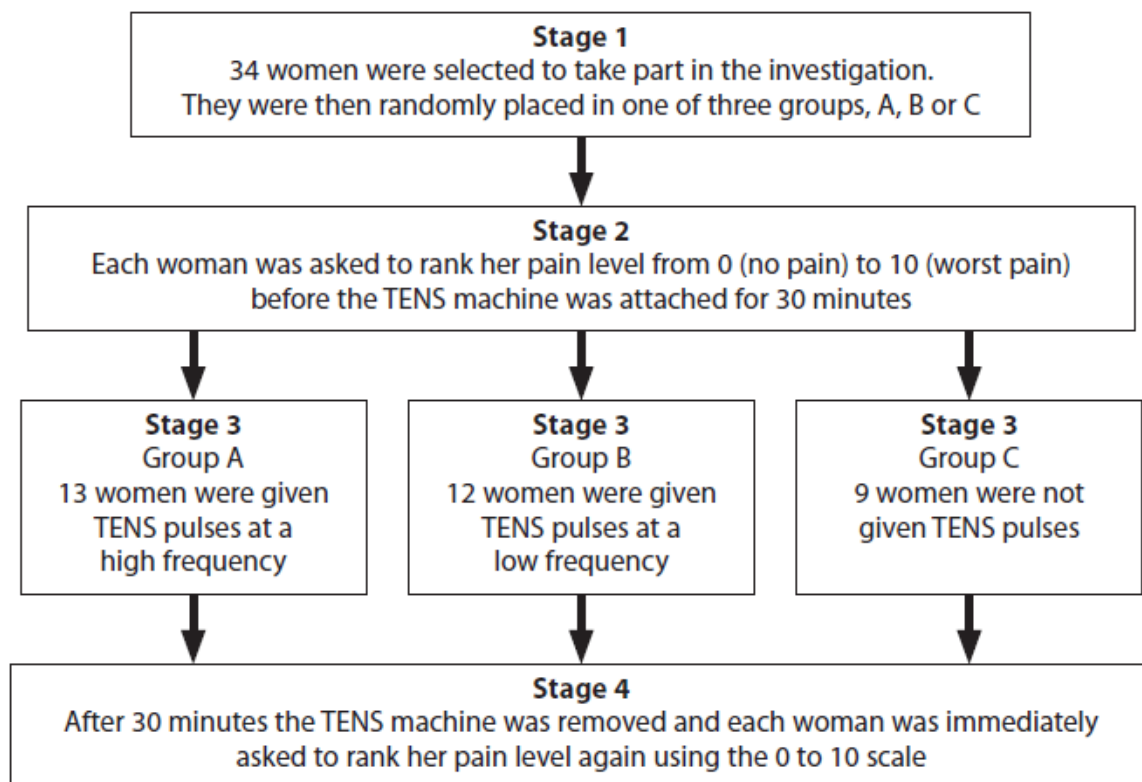
Q21.

Some women need to have surgery to aid childbirth. This can lead to pain after surgery.

A TENS (transcutaneous electrical nerve stimulation) machine releases regular pulses of electricity onto the skin surface and can be used in pain relief.

An investigation was carried out to study whether the frequency of the pulses from a TENS machine could help these women with their pain relief.

The diagram shows how the investigation was carried out.



Explain why group C was included in this investigation.

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(Total for question = 2 marks)

Q22.

Sepsis is a bacterial infection in the bloodstream. Sepsis can cause tissue death in limbs. This may require parts of a limb to be removed (amputation).

Open wounds can become infected by bacteria, leading to sepsis.

Explain why bacteria are able to multiply in the bloodstream when they enter the body.

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(Total for question = 3 marks)

Q23.

The scientific article you have studied is adapted from several sources.

Use the information from the scientific article and your own knowledge to answer the following questions.

Explain why genetically modified bacteria delivering drugs 'to the exact tissue in the body where they're needed and nowhere else' would decrease side effects (paragraph 34).

(2)

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(Total for question = 2 marks)

Q24.

The modern bread wheat plant (*Triticum aestivum*) has been developed from other plant species that have different genomes.

Three species of plant and their genomes are shown in the images.



Triticum aestivum
Genomes A, B and D

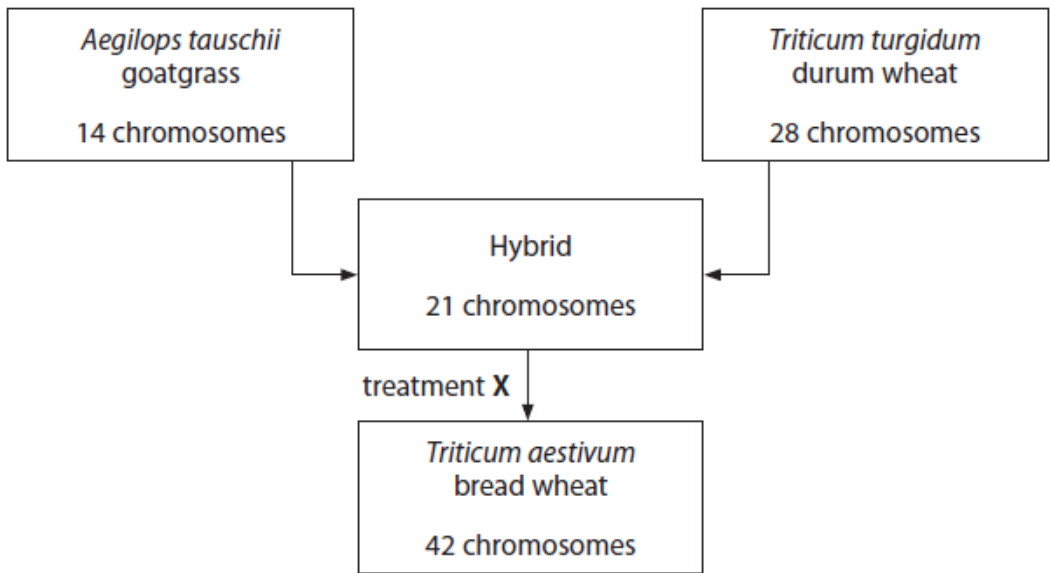


Triticum turgidum
Genomes A and B



Aegilops tauschii
Genome D

The diagram shows how chromosomes from different species have combined to produce the bread wheat species used to produce flour.



Explain why the hybrid plant cannot produce haploid gametes.

(2)

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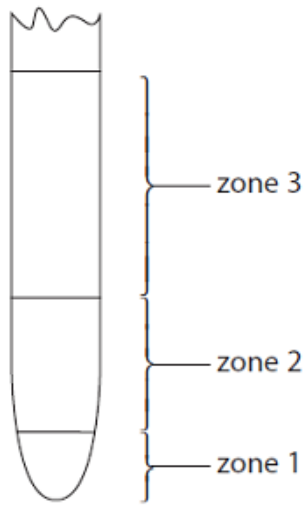
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(Total for question = 2 marks)

Q25.

The diagram shows three different zones found in a plant root.



In zone 3, some of the cells differentiate to give rise to phloem sieve tube elements and others differentiate into phloem companion cells.

(i) Explain how genetically identical cells in zone 3 can differentiate to give rise to different tissues. (3)

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(ii) The student also hypothesised that the cells in zone 1 would be smaller in size than the cells that had differentiated into xylem vessels in zone 3.

The student prepared microscope slides of sections from zones 1 and 3.

Explain how the student could compare the sizes of cells in zone 1 with the sizes of xylem vessels in zone 3.

(3)

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(Total for question = 6 marks)

Q26.

A new species of mosquito has evolved in the tunnels of the London Underground. These mosquitoes are believed to be the descendants of bird-biting mosquitoes which colonised the tunnels 100 hundred years ago. The mosquitoes now feed on rats, mice and human beings instead of birds.

(a) Place a cross in the box next to the best definition of a species.

(1)

- ☐ **A** individuals can interbreed to produce fertile offspring
- ☐ **B** individuals can interbreed to produce hybrid offspring
- ☐ **C** individuals can interbreed to produce sterile offspring
- ☐ **D** individuals can interbreed to produce offspring

(b) Explain how this species of mosquito may have evolved.

(5)

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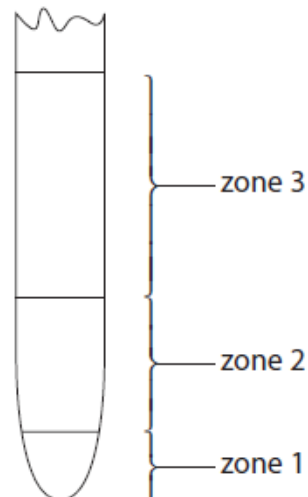
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(Total for question = 6 marks)

Q27.

The diagram shows three different zones found in a plant root.



In zone 2, the plant cells elongate due to a change in their cellulose cell walls.

(i) Cellulose and amylopectin are polymers of hexose sugars.

State one difference between the hexose in cellulose and the hexose in amylopectin.

(1)

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(ii) The cellulose molecules form microfibrils.

Name the bond between adjacent cellulose molecules in a cellulose microfibril.

(1)

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Q28.

A population of white-tailed deer *Odocoileus virginianus* was introduced from North America into Finland in 1934. There were four females and one male. The population has since increased rapidly.

A study in 2012 compared the genetic diversity of the population in Finland with the population in North America.

Ten genes were compared from 72 deer in each population. The allele richness (number of alleles in the population) of each gene was measured.

A χ^2 test was carried out to compare the two populations.

(i) The null hypothesis for this investigation is

(1)

- ☐ **A** the allele richness in the population from Finland is higher than the USA.
- ☐ **B** the allele richness in the population from the USA is higher than Finland.
- ☐ **C** the population in the USA is more genetically diverse than the population in Finland.
- ☐ **D** there is no difference in allele richness between the two populations.

(ii) The values from the population in the USA can be taken as the expected values and a χ^2 test can be carried out.

Gene	Allele richness (Finland population) X (observed)	Allele richness (USA population) Y (expected)	X – Y	(X – Y) ²	(X – Y) ² / Y
1	6	14	8	64	4.57
2	4	5	1	1	0.2
3	7	13	6	36	2.77
4	7	15	8	64	4.27
5	6	6	0	0	0
6	8	12	4	16	1.33
7	2	3	1	1	0.33
8	4	4	0	0	0
9	4	9			
10	3	4			

Complete the table to calculate the χ^2 value, using the formula

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

(3)

Answer

(iii) The table shows the critical values of chi-squared at different levels of probability.

Degrees of freedom	Probability	
	p=0.10	p=0.05
1	2.706	3.841
2	4.605	5.991
3	6.251	7.815
4	7.779	9.488
5	9.236	11.070
6	10.645	12.592
7	12.017	14.067
8	13.362	15.507
9	14.684	16.919
10	15.987	18.307

Deduce the effect of a small founder population on the allele richness in the population of white-tailed deer in Finland.

(3)

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(Total for question = 7 marks)

Q29.

During the civil war in Mozambique, from 1977 to 1992, 90% of the African elephants were killed for the ivory in their tusks.

Since 1992, the elephant population in Mozambique has increased.

The photograph shows a group of elephants in Mozambique.



© ALEXANDER JOE/Staff/Getty Images

A study of an elephant population in Mozambique was carried out in 2017.

The elephants studied were all born before 1992.

The table shows the number of elephants with and without tusks.

Elephants	Number of elephants
with tusks	98
without tusks	102

The presence of tusks is controlled by a single gene. The allele for tusks is known to be dominant.

The frequency of alleles in a population can be determined using the Hardy-Weinberg equation.

Calculate the frequency of the dominant and recessive alleles in this population.

Give your answer to 2 decimal places.

(3)

Frequency of the dominant allele

Frequency of the recessive allele

(Total for question = 3 marks)

Q30.

The scientific article you have studied is adapted from *National Geographic*.

Use the information from the scientific article and your own knowledge to answer the following question.

Explain how two populations of mosquito could be shown to belong to different species (paragraph 4).

(2)

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(Total for question = 2 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to (counting) the number of different species (1) (counting) number of individual per species (1)	ALLOW measure species richness ALLOW determined population sizes	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to - appropriate calculation e.g. - percentage of world {plants / vertebrates / total} found in Madagascar - or - percentage of {plants / vertebrate } in Madagascar that are endemic to Madagascar e.g. - or - percentage of world {plant / vertebrates / total} endemic to Madagascar - or - density of {plant / vertebrates / total} on {Madagascar / Earth} - species density of {animals / plants} in Madagascar is higher than for the Earth - many of the species found in Madagascar are not found anywhere else	4% of plants, 3.6% of vertebrates or 4% of the combined total 80.9% plants 78.1% of vertebrates endemic 3.2% of plants, 2.8% of vertebrates or 3.2% of the combined total ALLOW a large number of species relative to the area	(3)

Q2.

Question Number	Answer	Mark
(a)	A bacteria and fungi	(1)

Question Number	Answer	Mark
(b)(i)	A none	(1)

Question Number	Answer	Mark
(b)(ii)	D validity	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	1. 2. ref to hydrolysis ; 3. by {enzymes / cellulase} / eq ; 4. produced by microorganisms / eq ; 5. into(β) glucose ; 6. uptake of glucose into microorganisms / eq ; 7. idea that glucose is used in {respiration / fermentation} ; 8. releasing carbon dioxide into the atmosphere / eq ; 9. idea that some of glucose (solution) soaks into ground ;		(4)

Question Number	Answer	Additional Guidance	Mark
(b)(iv)	1. to make investigation valid ; 2. idea that {temperature / heat energy} affects {rate of enzyme reactions / enzyme activity / rate of decomposition} ; 3. increase in {heat / kinetic} energy results in more {collisions / energetic collision / enzyme-substrate complexes / eq} ; 4. idea that high temperature results in enzyme {denaturing / becoming denatured} ; 5. (so) decomposition would stop / eq ;	4. ACCEPT bacteria killed / eq	(4)

Q3.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to two of the following: • increase in cross sectional area with testosterone (and not with placebo) • greatest increase with testosterone and exercise • significant difference for {testosterone plus exercise / group D } as the SDs (for start and after 10 weeks) do not overlap	ALLOW increase in size (of triceps muscle)	(2)

Question Number	Answer	Mark
(ii)	D - show that testosterone has an effect <i>The only correct answer is D</i> A is incorrect because a placebo does not make measurements more accurate B is incorrect because placebos do not make data more reproducible C is incorrect because the placebo does not show that exercise has an effect	(1)

Q4.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: (species) found only in one particular location (1)		Choose an item. (1)

Q5.

Question Number	Answer	Additional guidance	Mark
(i)	- correct calculation of loss of area from 2010 to 2012 (1) - correct calculation of rate with relevant units (1)	<u>Example of calculation</u> $1160 - 700 = 460$ $(460 \div 2) \times 1000$ $= 230\,000 \text{ Ha yr}^{-1}$ ALLOW Ha per year Correct answer without working gains full marks ALLOW ECF(1) eg $1160 - 680 = 240\,000 \text{ Ha yr}^{-1}$ (1) $1160 - 690 = 235\,000 \text{ Ha yr}^{-1}$ (1) $1160 - 710 = 225\,000 \text{ Ha yr}^{-1}$ (1) $1160 - 720 = 240\,000 \text{ Ha yr}^{-1}$ (1) $220\,000$ to $240\,000 \text{ Ha yr}^{-1}$ with no working gains 1 mark	(2)

Question number	Answer	Mark
*(ii)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content Basic information • captive breeding will increase population size • deforestation is reducing the habitat • captive animals will be protected from hunters Evidence of linkages • orangutan numbers are declining and captive breeding will increase population size • as loss of habitat is a major reason for the decline, animals should be released into areas of forest in protected areas • more of the forest needs to be protected to reduce the rate at which habitat is being lost • captive bred animals show behaviour that may make them unable to compete in the wild • loss of habitat would lead to increased competition due to reduced food availability Evidence of sustained scientific reasoning • it is important to restrict passage of disease from humans to the wild population by minimising contact and releasing animals away from wild populations • if deforestation is not reduced – or protected areas increased – there will not be enough habitat left in which to release captive-bred orangutans • judgement on relative importance of captive breeding and habitat protection taking into account rate of deforestation and loss of suitable habitat • releasing animals if there is insufficient habitat could lead to an increased vulnerability to predation and poaching	(6)

Level 0	Marks	No awardable content	
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Captive breeding will increase numbers of orangutans Habitat loss is increasing
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Discussion of benefits of both captive breeding and habitat protection. Separate discussions of habitat loss and captive breeding. Linkages made for each aspect but not compared.
Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	Conclusion that without habitat protection, captive breeding is limited as there is less suitable habitat in which to release the animals Comparative evaluation of the benefits of habitat protection and captive breeding. Reference made to the data.

Q6.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to the following: - two GALP used to produce a glucose molecule (glucose molecules are) joined together by glycosidic bonds to form starch - by condensation reactions - producing amylose and amylopectin	ALLOW triose phosphate instead of GALP ALLOW maltose / polysaccharide	(4)

Q7.

Question Number	Answer	Additional guidance	Mark
	A description that makes reference to three of the following: - cut a {strip / ring} of aorta (1) - record thickness of the piece of aorta (1) - hang masses on the (strip / ring) until aorta splits (1) - tensile strength determined by dividing force by cross sectional area (1)	ALLOW 'take a section of aorta' ALLOW repeats with same dimensions, e.g. length and { width / thickness} ALLOW 'breaks' or 'snaps' for 'splits' ALLOW 'weights' for 'masses'	(3)

Q8.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to four of the following: - description of production of agar plates with bacteria (1) - description of method used to add plant extract to plates (1) - extracts used separately and in combination (1) - incubate for at 37 °C for an appropriate period of time (1) - measure and compare the sizes of zones of inhibition (1)	ALLOW plates { inoculated / seeded} with bacteria, production of bacterial lawn or streak plates e.g. on filter paper discs or in wells ALLOW time from 24 to 72h and a temperature from 35-38°C e.g. diameter or area ALLOW comparative statements such as the larger the area, the more effective the antimicrobial properties	(4)

Q9.

Question number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to three of the following: - the frequency of the different shell patterns in different habitats is an example of adaptation (1) - provides camouflage (appropriate to the habitat) (1) - reducing predation (in different habitats) / providing protection from predators (1) - therefore increasing the chance of (surviving to) reproduce (1)	ALLOW other reasonable suggestions e.g. temperature regulation IGNORE increasing survival rate	(3)

Question number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to the following: - use a statistical test such as the (Student) t-test (1) - if the test value is greater than the {critical / table} value at $p=0.05$ the difference is significant (1)	ALLOW using a critical value of $p = 0.05$ and a suitable number of degrees of freedom	(2)

Q10.

Question Number	Answer	Additional Guidance	Mark
(i)	A answer that makes reference to the following: the area inhabited by a particular { species / organism } (1)		(1)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to the following: • biodiversity {measured / compared} using a diversity index (1) • species richness (assessed) (1) • genetic diversity of {populations / species} (1) • presence of any {endemic / rare} species (1)	ALLOW count the number of different species in an area ALLOW endangered species / species at risk of extinction	(4)

Q11.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to four of the following: • pieces of rope of same length and {width / diameter } (1) • (stored at) a range of temperatures above and below 18°C (1) • humidity at 60% / ropes stored for same period of time (1) • {masses / force / weights} applied until rope breaks (1) • calculate change in tensile strength (1)		(4)

Q12.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following • North American population is more genetically diverse (therefore more likely to adapt) (1) • (more different alleles) therefore more likely to have an allele that gives advantage (1) • the individuals with an advantageous allele are more likely to survive and breed (1) • the frequency of that allele will increase (1)		Expert (4)

Q13.

Question Number	Answer	Additional guidance	Mark
	• found only in one geographical location(1)	ALLOW one area of the world	(1)

Q14.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	A description that makes reference to the following: - utilitarian argument, better to test on animals than on humans (1) - the benefits to humans must outweigh harm done to other animals (1)		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following: - to determine safe dose (1) - to determine side effects (1) - to determine how the drug is metabolised (1)		(2)

Q15.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to three of the following: - percentage germination decreases as length of time stored increases (for both varieties) (1) - correct calculation of decrease for both varieties (1) { little change / 1 or 2 % } in percentage germination when stored for up to 48 hours for both varieties (1) - greatest decrease in percentage germination occurred { later for P than Q / from 72 hours for P and from 48 hours for Q } (1)	ALLOW correct reference to negative correlation e.g. (from 0 to 120 hours) 40% decrease for P and a 36% decrease for Q	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following: - allowed a comparison between { the two varieties / stored seeds and seeds that had not been stored }(1) - to see the effect of seeds being stored at { 80% humidity / 42°C } (1) - data showed that the percentage germination success was { high / not 100% } in the control seeds (1)	ALLOW wheat seeds were viable or suitable for this investigation	(2)

Q16.

Question number	Answer
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. <u>Indicative content:</u> <u>Benefits</u> Described: • crops have increased yield due to pest control or resistance to disease • reduced need to use pesticides • crops can be grown in a wider range of conditions, e.g. harsh conditions, drought etc Discussed: • hybridisation could allow crop plants to have genes for tolerance to harsh conditions from genome D • crops have higher nutrient content, or produce a greater range of useful chemicals e.g. pharmaceutical products • genetic modification can be beneficial if crops are resistant to herbicides - crops can be sprayed with herbicide without { being harmed / causing reduction in yield } <u>Risks</u> Hybridisation: • hybridisation can lead to pest species which have ability to grow in wide range of conditions • hybridisation could allow genes for tolerance to harsh conditions from genome D to enter pest species GM: • genetic modification may result in genes entering pest species, making control difficult or into food chains • GM can introduce antibiotic resistant genes to other species Selective breeding • selective breeding reduces { genetic diversity / size of gene pool }, or causes genetic drift • leading to loss of useful alleles / reducing the ability of the crops to adapt to environmental change

Level	Mark	Descriptor	Additional Guidance
0	0	No awardable content	
1	1-2	Limited scientific judgement made with a focus on one side of the argument only. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Only considered one benefit or one risk without further explanation beyond a brief description.
2	3-4	A scientific judgement is made through the application of relevant evidence to both sides of the argument. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Considers at least one risk and one benefit with some discussion.
3	5-6	A scientific judgement is made, which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	Benefits generally described and specific risks discussed. Conclusions described for each of the three methods – hybrids, GM and selective breeding.

Q17.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to five of the following: • as a result of a mutation (1) • (cyanobacteria) produce proteins containing the amino acid cysteine (1) • (cysteine rich proteins) produce {heat stable enzymes / proteins resistant to unfolding} (1) • other adaptations such as {enzymes with large hydrophobic cores / simpler protein folds / amino acids that do not bond to metal ions } (1) • high temperatures act as a selection pressure (1) • allowing them to {survive / replicate} and pass advantageous allele to next generation (1)	ALLOW 'pass alleles for heat tolerance to next generation'	(5)

Q18.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: • <i>Aedes aegypti</i> mosquito occupies its own niche (1) • if this species is eliminated the niche it occupied will become vacant (1) • other species (of mosquito) may evolve to occupy the niche (1) • these species may carry the virus (1)	ALLOW each species ALLOW other organisms / insects ALLOW <i>Aedes aegypti</i> is a vector / is not the disease causing organism	Choose an item. (3)

Q19.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to - determine the sequence of amino acids (for trypsin) - determine the number of {differences / similarities} in sequences (of amino acids) between species - the greater the number of differences the less closely related the species are	ALLOW differences and similarities in primary structure ALLOW more similarities more closely related ALLOW greater difference in sequence longer the time from a common ancestor	(3)

Q20.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to four of the following: - mutation leads to { variation within the population of grass snakes / (snakes with) different colour or markings } (1) (natural selection led to) those snakes which were better camouflaged surviving to reproduce (1) (therefore) giving rise to two populations with differing allele frequency (1) (as the result of natural selection) the two populations became reproductively isolated (1) - sympatric speciation (in the context of new species developing in the same habitat) (1)	ALLOW separate gene pools develop or a change in allele frequency ALLOW can no longer breed with each other	(4)

Q21.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: {control / placebo} (1) - to allow a comparison with {A and B / the other groups} (1)		(2)

Q22.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: { warm conditions / water / glucose / amino acids / ideal pH } available Plus 2 of the following: - suitable { temperature / pH } for bacterial enzymes (1) - glucose used for {respiration / energy} - amino acids used for growth	ALLOW 37°C ALLOW optimum	(3)

Q23.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: - drugs not delivered to { other / healthy } tissues (1) - overall dosage needed is less (1)	ALLOW drug does not {affect / reach} other tissues, drug not delivered to the whole body ALLOW converse ALLOW {higher concentration / more of the drug} delivered to area where needed	(2)

Q24.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to two of the following points: - there is an odd number of chromosomes (1) - therefore it does not have homologous pairs of chromosomes (1) - therefore meiosis cannot take place / meiosis requires chromosome pairs (1)	ALLOW uneven number ALLOW non-homologous chromosomes	(2)

Q25.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to three of the following: - presence of different stimuli (1) (therefore resulting in) different genes being { activated / deactivated / transcribed / expressed } (1) - so different proteins are made (1) - proteins produced determine { structure / function } of cells (1)	e.g. transcription factors, chemical stimulus ALLOW different genes are switched {on / off} ALLOW 'tissues' for 'cells'	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: • xylem identified as { hollow / thick-walled / lacking cytoplasm } / stain used to identify { xylem tissue / lignin } (1) • sizes of cells measured using { eye piece graticule / stage micrometer } (1) • {length / width} of cells from both areas measured / several measurements made and then the means compared (1) • correct calculation by dividing image size by magnification (1)	e.g. stained with toluidine blue, safranin or phloroglucinol	(3)

Q26.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	A		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	An explanation that makes reference to the following: • mosquitoes are geographically isolated in the tunnels (1) • random genetic mutations cause variation in the population which allows some individuals to feed on rats, mice and humans (1) • these individuals {will be selected for / are more likely to survive and reproduce} (1) • the proportion of individuals in the population with this mutation will change over time (1) • over many generations these populations become genetically distinct from the above ground population (1)		(5)

Q27.

Question Number	Answer	Additional Guidance	Mark
(i)	amylopectin contains alpha glucose and cellulose contains beta glucose (1)	ALLOW { α / a } glucose and { β / b } glucose OR H and OH have been reversed on carbon 1	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	hydrogen / H (bond)		(1)

Q28.

Question Number	Answer	Mark
(i)	The only correct answer is D <i>there is no significant difference in allele richness between the two populations.</i> A is not correct because it should not state that allele richness in Finland is higher B is not correct because it should not state that allele richness in the USA is higher C is not correct because the null hypothesis does not concern genetic diversity	Computer (1)

Question Number	Answer	Additional guidance	Mark
(ii)	- correct completion of table (1) - correct substitution into the equation (1) - correct calculation of chi- squared value (1)	5 / 25 / 2.78 1 / 1 / 0.25 16.50 / 16.5 Correct answer with no working gains full marks ALLOW ecf for 2 marks 16.49 if 2.77, if 2.8 16.52, 16.42 if 2.7 in the table	Expert (3)

Question Number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to three of the following • {little / no} effect of small founder population on allele richness (1) • degrees of freedom value is 9 / critical value is 16.919 (1) • therefore stated chi-squared value is below the critical value (16.919) (1) • therefore { there is no significant difference in allele richness between the two populations/ null hypothesis can be accepted} at 0.05 probability (1)	ALLOW converse answer for a stated chi-squared value above the cv if incorrectly calculated ALLOW there is a significant difference at 0.10 probability	Expert (3)

Q29.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to the following • Hardy-Weinberg equation stated (1) • correct calculation of frequency of homozygous recessive individuals (1) • correct calculation of frequency of dominant and recessive alleles (1)	Example of calculation $p^2 + 2pq + q^2 = 1.0$ $q^2 = 102 \div 200 = 0.51$ Dominant allele = 0.29 Recessive allele = 0.71 Correct answer with no working gains full marks	(3)

Q30.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • mate {males and females / individuals} from different populations (1) • if they do not produce fertile offspring the parents are different species (1)	ALLOW converse argument ALLOW they cannot breed together to produce fertile offspring gets both marks	Choose an item. (2)

Q1.

Wasps are insects that live in groups.

One species of wasp (*Vespula germanica*) has been shown to knock its body repeatedly against a hard surface. This signals the presence and quality of food to other wasps.

When threatened by another animal, it may use its stinger to inject a venom to protect itself.



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Complete the table by giving the name of the type of adaptation.

(2)

Description of adaptation	Type of adaptation shown by the wasp
knocking its body to signal food	
the stinger	

(Total for question = 2 marks)

Q2.

Plant fibres and oil-based plastics have both been used to make ropes.

Describe one advantage and one disadvantage of using ropes made from plant fibres rather than ropes made from oil-based plastics.

(2)

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(Total for question = 2 marks)

Q3.

In the 18th century, William Withering trialled the use of an extract of foxglove plants to treat a heart condition.

Give **four** reasons why a contemporary drug testing protocol is an improvement on the trial used by William Withering.

(4)

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(Total for question = 4 marks)

Q4.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Moving a limb involves the interaction of muscles, tendons and ligaments.

Tendons and ligaments are important structures in elbow and knee joints.

(i) Which of the following identifies the structures that join bones to bones in an elbow joint?

(1)

- ☐ **A** ligaments only
- ☐ **B** ligaments and tendons
- ☐ **C** tendons only
- ☐ **D** neither ligaments nor tendons

(ii) One type of joint injury is a torn ligament. This may be treated by adding a piece of tendon to the ligament. This is because after a period of time, the tendon tissue changes and responds in the same way as a ligament.

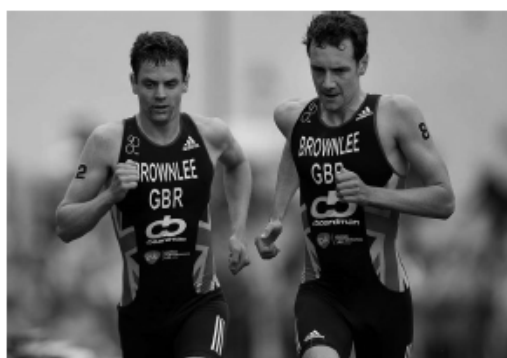
Which of the rows in the table correctly describe the changes in this piece of tendon?

(1)

Row	Piece of tendon shows a change in its	The change is
1	genotype	an anatomical adaptation
2	genotype	a physiological adaptation
3	phenotype	an anatomical adaptation
4	phenotype	a physiological adaptation

- ☐ **A** row 1 only
- ☐ **B** row 3 only
- ☐ **C** rows 1 and 2
- ☐ **D** rows 3 and 4

*(iii) The photograph shows athletes competing in the modern triathlon.



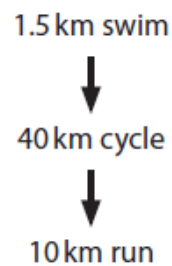
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The modern triathlon involves three sports: swimming, cycling and running.

An investigation was carried out to compare the level of demand on the body of these three sports during a triathlon.

The investigation involved 12 athletes who were all males of the same age.

Each athlete carried out the triathlon as shown in the flow diagram. There was no rest period between each sport.



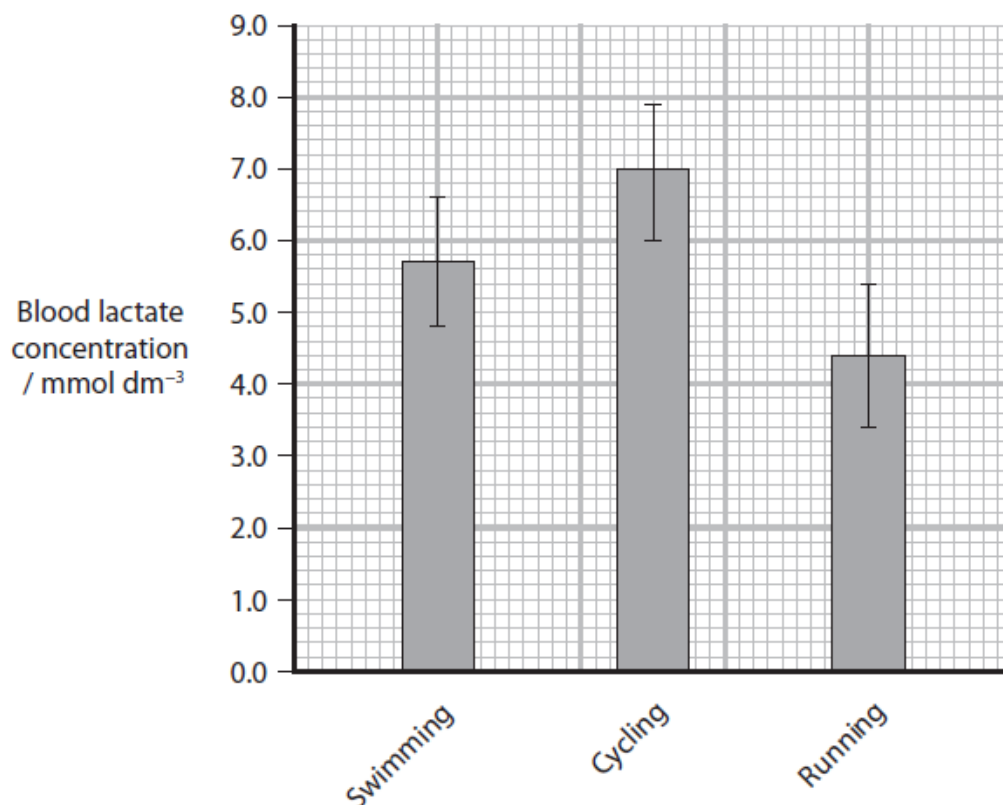
The heart rate for each athlete was measured as they completed each sport.

The mean heart rate for each sport was then calculated and is shown in the table.

Sport	Mean heart rate / bpm
Swimming	163
Cycling	165
Running	159

The blood lactate level for each athlete was also measured as they completed each sport. Means for lactate level after each sport were calculated.

The results are shown in the graph.



It was concluded that cycling was the most demanding of the three triathlon sports. This was followed by swimming and then running.

Evaluate the validity of this conclusion.

(6)

(Total for question = 8 marks)

Q5.

Anabolic steroids stimulate muscle development.

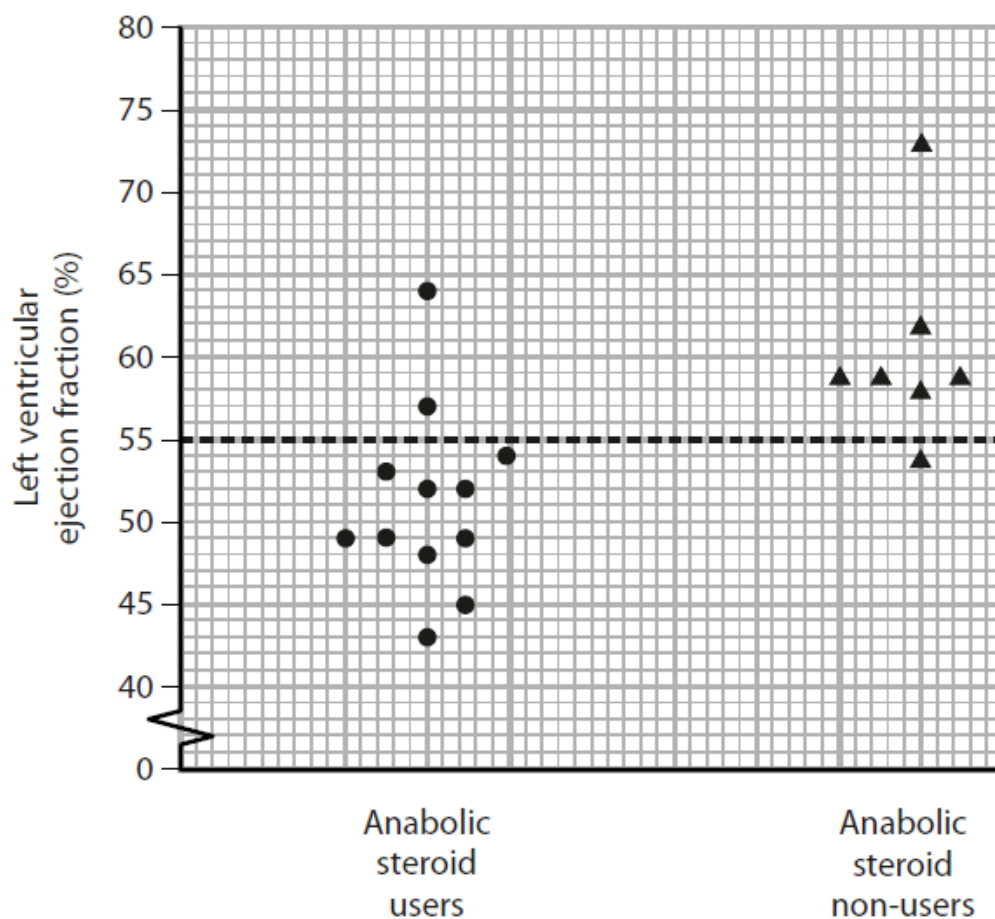
Some athletes use anabolic steroids in an attempt to improve their performance.

The effect of long-term anabolic steroid use on heart function has been investigated.

The left ventricular ejection fraction is the percentage of blood that leaves the left ventricle when it contracts.

The left ventricular ejection fraction for a healthy heart should be greater than 55%.

The results of a small study are shown in the graph.



(i) Analyse the data to determine the effect of anabolic steroid use on heart function.

(2)

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(ii) Some drugs used to treat cancer have also been shown to reduce the ventricular ejection fraction.

Describe how the safe dose of a cancer drug could be determined.

(3)

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(Total for question = 5 marks)

Q6.

The genomes of some species of cichlid fish have been sequenced and analysed.

The data collected included:

- the rate at which genes have been duplicated to produce additional copies of genes on a

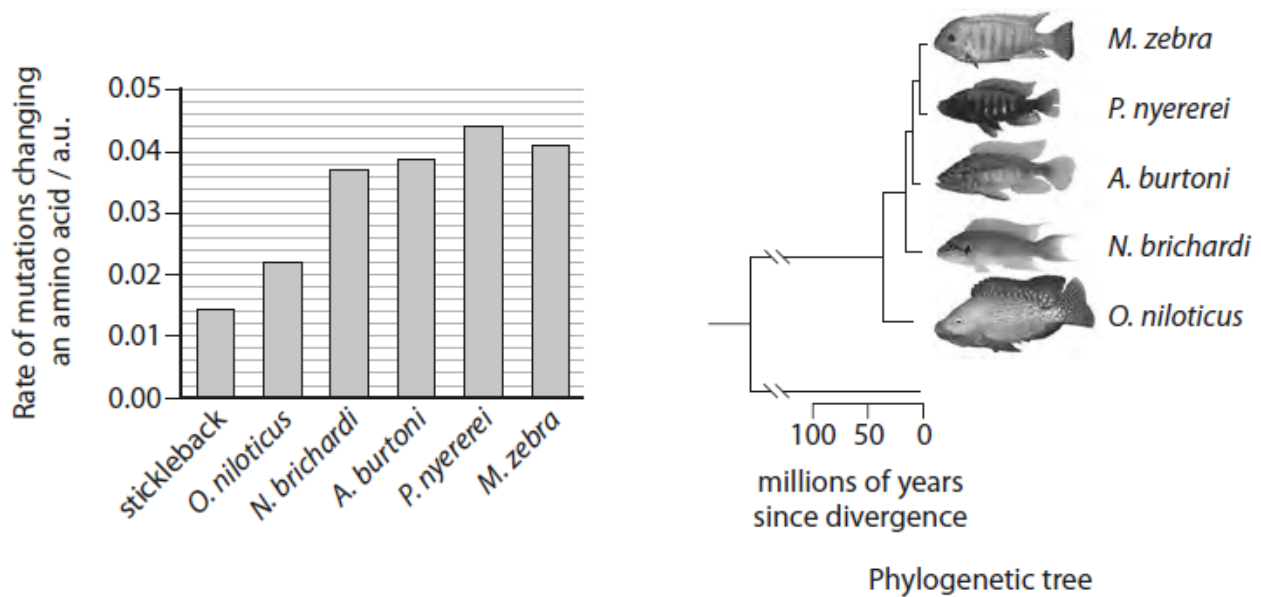
chromosome

- the frequency of mutations in transcription factor binding sites
- the rate of mutations that result in a change of an amino acid in a protein.

This information was used to produce a phylogenetic tree.

A comparison was made with a stickleback, which is a slowly evolving fish.

Speed of evolution	Fish	Rate of gene duplication / a.u.	Number of mutations in transcription factor binding sites (compared to <i>O. niloticus</i>)
Rapidly evolving cichlid fish	<i>O. niloticus</i>	45	0
	<i>N. brichardi</i>	45	214
	<i>A. burtoni</i>	55	140
	<i>P. nyererei</i>	45	129
	<i>M. zebra</i>	60	142
Slowly evolving fish	stickleback	10	0



Analyse all the data provided to discuss how several species of cichlid fish have evolved over a short period of time.

(9)

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[illegible]

(Total for question = 9 marks)

Q7.

Tuberculosis (TB) is an infectious disease caused by mycobacteria.

Individuals infected with *M. tuberculosis* can be treated with antibiotics.

Four of the antibiotics used to treat TB are shown in the table.

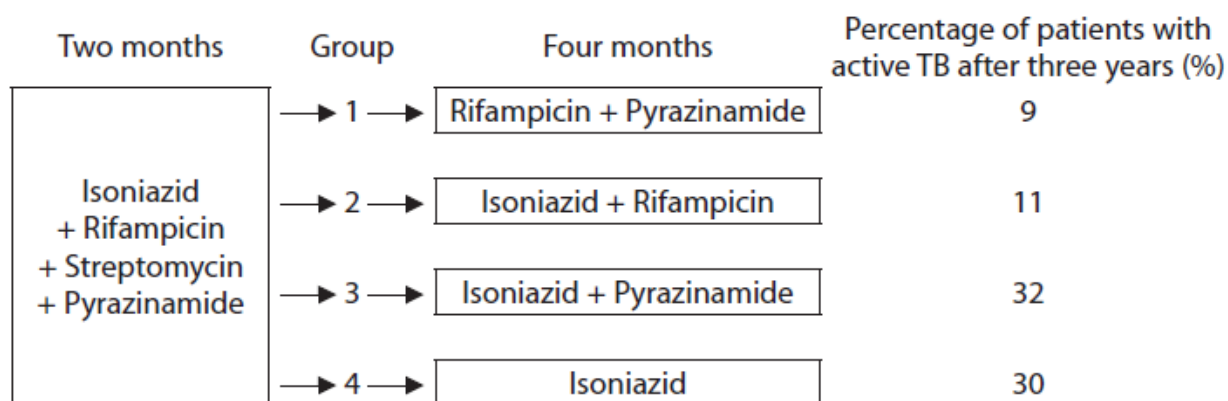
Antibiotic	Mechanism of action
Isoniazid	Inhibits the synthesis of a fatty acid needed to make bacterial cell walls
Rifampicin	Inhibits bacterial RNA polymerase
Streptomycin	Binds to bacterial ribosomes to prevent the binding of tRNA
Pyrazinamide	Not yet known, but not the same mechanisms as the other three antibiotics

In one clinical trial lasting six months, the effect of treating TB with these antibiotics was investigated.

All patients were treated with all four antibiotics for two months. Then they were treated with different pairs of antibiotics or isoniazid alone for a further four months.

All patients were free of any signs of active TB at the end of the clinical trial.

The design of the trial and the percentage of these patients with TB three years after the trial ended are shown in the diagram.



Analyse the data to comment on the effectiveness of these antibiotics for the treatment of TB.

(6)

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(Total for question = 6 marks)

Q8.

In a drug trial, people with a heart condition were given one of three drug treatments. The table shows the recorded improvement in their condition for each of the three treatments.

Treatment	Concentration of drug / mg	Recorded improvement / arbitrary units
1	0	18.8
2	400	24.8
3	600	30.9

It was concluded that the drug treatment improved the condition of the patients.

Analyse the data to comment on this conclusion.

(3)

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Q9.

Extracts of the plant St John's wort have also been used to treat depression.

A double blind trial compared the effectiveness of treating depression using a SSRI, an extract of St John's wort, and a placebo.

Depression was measured using the Hamilton Rating Scale for Depression (HRSD). The higher the HRSD score the greater the depression.

The table shows the results of this trial.

Time / weeks	HRSD score		
	SSRI	St John's wort	Placebo
0	16	16	17
1	14	15	15
2	13	14	12
3	12	13	12
4	10	13	12
5	9	12	11
6	8	12	11
7	7	11	12
8	6	12	12

(i) State what is meant by the term **double blind**.

(1)

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(ii) Analyse the data in the table to compare the effectiveness of these three treatments for depression.

(3)

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(iii) Double blind trials give scientists confidence in the results collected.

Explain **two** ways the design of this trial could be improved in order to increase confidence in the results.

(4)

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(Total for question = 8 marks)

Q10.

The photograph shows a plant called lantana (*Lantana camara*).



(Source: © Peter Vrabel/Alamy Stock Photo)

The leaves of lantana contain chemicals known to have antimicrobial properties.

The antimicrobial activity of lantana leaf extracts prepared using three different solvents, A, B and C, was compared.

Fresh lantana leaves were dried and powdered. The dried leaf material was mixed with the solvent and then the extract was purified and dried.

The mass of extract obtained from 5 g of powdered leaf, using each solvent, was measured.

Solvent used	Mean mass of extract $\pm$ SD / μg
A	501.3 $\pm$ 3.5
B	721.3 $\pm$ 1.5
C	245.6 $\pm$ 4.0

The mass of dried and powdered lantana leaves is 10.5% of the mass of fresh leaves.

Calculate the mass of fresh leaves needed to produce 1 mg of extract using solvent A.

Give your answer to three significant figures.

(2)

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(Total for question = 2 marks)

Q11.

The photograph shows a plant called lantana (*Lantana camara*).



(Source: © Peter Vrabel/Alamy Stock Photo)

The leaves of lantana contain chemicals known to have antimicrobial properties.

The antimicrobial activity of lantana leaf extracts prepared using three different solvents, A, B and C, was compared.

Fresh lantana leaves were dried and powdered. The dried leaf material was mixed with the solvent and then the extract was purified and dried.

The mass of extract obtained from 5 g of powdered leaf, using each solvent, was measured.

Solvent used	Mean mass of extract $\pm$ SD / μg
A	501.3 $\pm$ 3.5
B	721.3 $\pm$ 1.5
C	245.6 $\pm$ 4.0

The antimicrobial properties of the extracts produced using these solvents are shown in the table.

Solvent used to prepare extract	Dry mass of extract / μg	Bacteria tested	
		<i>Klebsiella pneumoniae</i> (Gram negative)	<i>Micrococcus luteus</i> (Gram positive)
		Mean diameter of the zone of inhibition / mm	
A	5.0	8.3	7.1
	10.0	10.5	7.0
B	5.0	14.5	12.2
	10.0	18.1	18.0

(i) Deduce the effect of using different solvents on the effectiveness of the extracts against these two bacteria.

(2)

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(ii) Devise a method that could be used to collect the data in the table.

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(Total for question = 6 marks)

Q12.

Lipids and carbohydrates are found in both plants and animals.

The carbohydrate content of vegetables ranges from 3 to 35%. However, meat contains little to no carbohydrate. Milk is the only food source from animals that contains a significant amount of carbohydrate.

Although plant material contains a higher proportion of carbohydrate than animal tissues, it has been claimed that carbohydrates are more important to animals than they are to plants.

Assess the relative importance of carbohydrates to plants and animals.

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(Total for question = 9 marks)

STEMUP.CO.UK

All known organisms can be placed into one of the three domains of life.

The table shows some information about the three different domains.

Feature	Archaea	Bacteria	Eukaryota
DNA is circular	Yes	Yes	No
DNA is single-stranded	No		No
Growth inhibited by the antibiotic streptomycin	No	Yes	No
Name of the link between fatty acids and glycerol in lipids	Ether	Ester	Ester
Presence of cell wall	Some	Yes	
Methionine required for starting protein synthesis	Yes	No	Yes
Transcription factors required for transcription	Yes	No	Yes

Complete the table to show the features in Bacteria and in Eukaryota.

(2)

(Total for question = 2 marks)

Q14.

Scientists have studied behavioural, anatomical and genetic variation in elephants.

The table shows some information about two populations of African elephants.

Population	Location	Feeding behaviour	Anatomical differences
Forest elephant	tropical forest of central and West Africa	feeds on leaves and fruits of high-growing plants such as shrubs and trees	• lower jaw longer and narrower • tusks straighter and downward facing • overall a much smaller size
Savannah elephant	African savannah	feeds on grass and leaves of low-growing shrubs	• lower jaw shorter and wider • tusks more curved and upward facing • overall a larger size

The photographs show elephants from the two populations.



Forest elephant



Savannah elephant

DNA samples were collected from these two populations of elephants.

One of the genes showing variation was the GBA gene. The table shows the frequency of the alleles of the GBA gene in the two populations.

GBA allele	Frequency of allele in the elephant population	
	Savannah elephant	Forest elephant
J	0.05	0.43
K	0.00	0.57
L	0.95	0.00

(i) State what is meant by the term **allele**.

(1)

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(ii) Use the Hardy-Weinberg equation to show that more than 50% of the forest elephant population are homozygous for the GBA gene.

(3)

Answer

(Total for question = 4 marks)

Q15.

Madagascar is an island rich in biodiversity.

Lemurs are a diverse group of primates endemic to Madagascar.

Scientists suggest there may be as many as 100 different species of lemur.

(i) State what is meant by the term **endemic**.

(1)

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(ii) Describe what is meant by **biodiversity**.

(2)

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(iii) Explain how the biodiversity of lemurs in two different parts of Madagascar could be compared.

(3)

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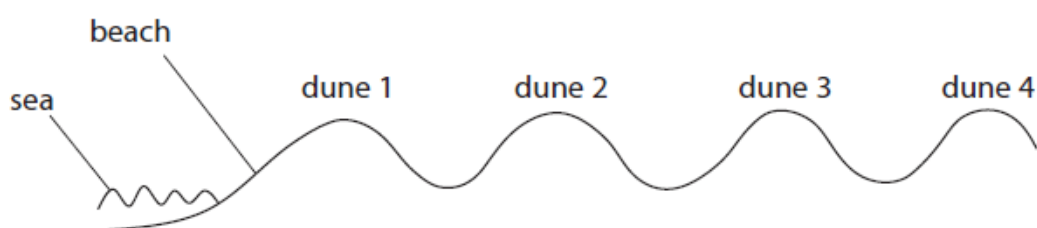
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Q16.

Sand dunes are a habitat that can often be found by the edge of the sea.

An investigation was carried out to study the variety of plant species found on sand dunes.

Four adjacent sand dunes from the sea to further inland were selected, as shown in the diagram.



Each species of plant present on dune 1 was recorded along with the total number of each species of plant present. This was repeated for dunes 2, 3 and 4 and the results are shown in the table.

Plant species	Number of each plant species present			
	dune 1	dune 2	dune 3	dune 4
A	169	9	0	0
B	5	123	19	0
C	0	0	126	182
D	1	44	0	0
E	0	0	5	2
F	0	0	20	10
G	0	0	86	35
H	0	0	0	62
I	0	0	32	17
J	0	0	0	119

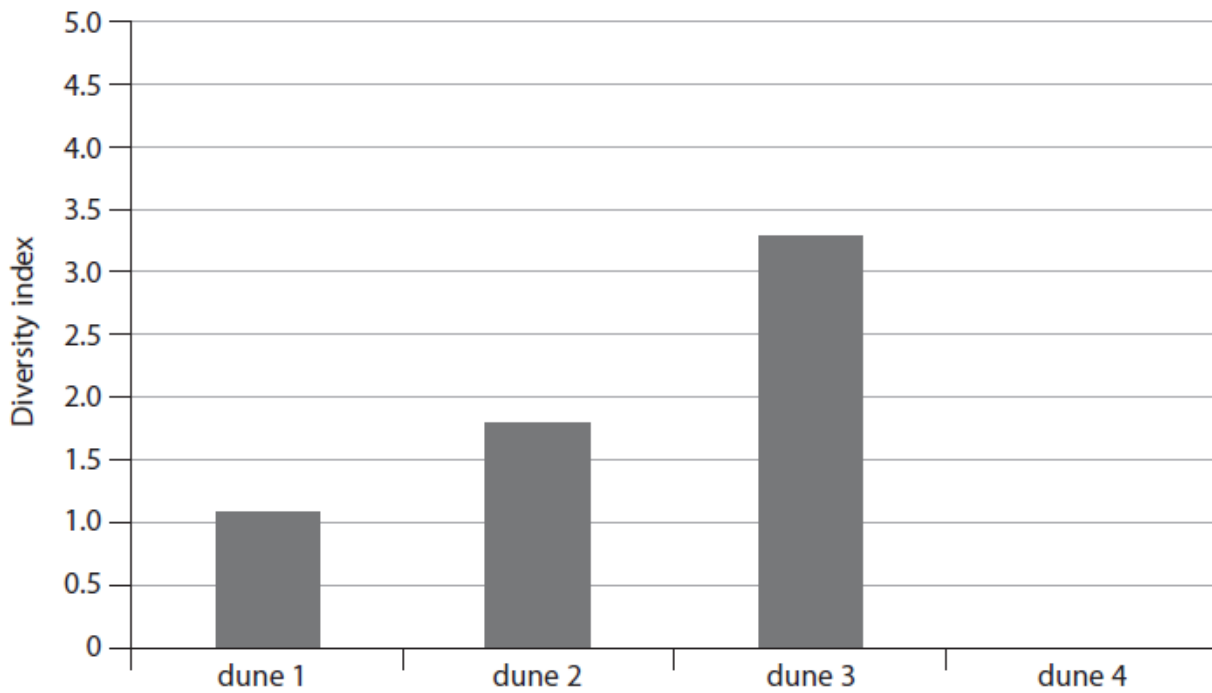
(i) The diversity index was calculated for dunes 1, 2 and 3 using this equation.

$$\text{Diversity index } (D) = \frac{N(N-1)}{\sum n(n-1)}$$

Where N is the total number of all individuals of all species in each dune. Use the table and diversity index equation to calculate the diversity index for dune 4.

Plot your answer on the bar chart.

(3)



(ii) Explain how the data demonstrate the process of succession.

(5)

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Q17.

A biodiversity hotspot is a region that is both highly diverse and threatened with destruction.

Biodiversity hotspots have at least 1500 endemic plant species.

These hotspots have lost at least 70% of their natural vegetation.

Explain how protection of these hotspots can affect global biodiversity.

(2)

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(Total for question = 2 marks)

Q18.

Biofuels are being developed to reduce the effect of greenhouse gases on global warming.

(a) The list below shows some of the gases found in the atmosphere:

- carbon dioxide
- helium
- methane
- nitrogen
- oxygen

Place a cross ☐ in the box next to the number of greenhouse gases in this list.

(1)

☐ **A** 1

☐ **B** 2

☐ **C** 3

☐ **D** 4

(b) Biofuels are produced from crop plants.

Bioethanols are produced from carbohydrates, such as corn starch and sugar.

Biodiesels are produced from lipids, such as soybean oil and rapeseed oil.

(i) Describe the structure of lipids.

(2)

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(ii) The table below gives some information about the **production** of biofuels from four different crop plants.

Crop plant	Carbon dioxide emissions from the production of biofuels / kg per MJ of energy produced	Level of resources used in production of biofuels		
		water	fertilisers	pesticides
Corn	81 to 85	High	High	High
Sugar cane	4 to 12	Medium to low	High	Medium
Soy	49	High	Low to medium	Medium
Rape	37	High	Medium	Medium

Using the information in the table, discuss the advantages of producing biodiesels instead of bioethanols.

(3)

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(iii) Fertilisers contain inorganic ions. Name **three** inorganic ions that could be contained in the

fertilisers and explain how these would improve the yield of the crop plants.

(4)

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(Total for question = 10 marks)

Q19.

*Biological farming aims to reduce the use of fertilisers to add minerals to the soil.

The following is some information on biological farming.

- Biological farming makes use of products containing fungi that can be added to soil to improve soil life.
- Soil life is essential for converting nutrients into a plant-available form.
- Fungi form a network around the roots of plants to trap water and aid absorption of mineral ions.
- Some fungi provide protection from pathogens.

Devise a procedure, using wheat seedlings, to compare the effects of a biological farming product with the use of a chemical fertiliser on the growth of plants.

(Total for question = 6 marks)

Q20.

A biodiversity hotspot is a region that is both highly diverse and threatened with destruction.

Biodiversity can be measured by the number of

(1)

- ☐ **A** different genes in a population.
- ☐ **B** different species in a habitat.
- ☐ **C** homozygotes in a habitat.
- ☐ **D** individuals in a population.

(Total for question = 1 mark)

Q21.

Forests are important habitats.

The effect of cutting down trees on the number of bird species observed in two different forest habitats was investigated.

(i) Give two biotic factors, other than cutting down trees, that could affect the number of bird species observed in a forest.

(2)

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(ii) Some of the results of the investigation are shown in the table.

Forest	Number of bird species in areas of the forest where no trees are cut down	Number of bird species in areas of the forest where some trees are cut down
A	35	19
B	16	10

Calculate the Chi-squared value (χ^2) for forest B using the formula shown.

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

(3)

Answer

(iii) The table gives some critical values for the Chi-squared test.

Probability level	Critical value
0.05	3.84
0.01	6.64
0.001	10.83

The Chi-squared value for forest A is 4.74.

Deduce the effect of some trees being cut down on the number of species of birds in these two forests.

(2)

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(Total for question = 7 marks)

Q22.

The photograph shows an orangutan. These animals inhabit the forests of Borneo and Sumatra.



They are critically endangered, largely due to habitat loss and hunting.

Managed breeding programmes in zoos are an important factor in the conservation of the orangutan.

Explain how breeding programmes in zoos maintain the genetic diversity of captive populations.

(3)

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(Total for question = 3 marks)

Q23.

All mammals have an internal skeleton that includes bone and cartilage. Bones contain calcium ions.

In humans, calcium ions are important for structure as part of bone material. These ions are also involved in physiological processes in soft tissue. Soft tissue is non-bony material.

The table shows some data relating to humans.

mean mass of an adult	80 kg
mean percentage of body mass that is bone	4%
mean mass of calcium ions per adult	1000 g
mean percentage of calcium ions present in soft tissue	1%

(i) Calculate the calcium ion concentration in the soft tissue of a human.

(3)

..... $\mu\text{g g}^{-1}$

*(ii) Calcium ions are also found in the tissue of plants.

The calcium ion concentration in one species of plant has been measured.

It was found to be $170 \mu\text{g g}^{-1}$ of plant tissue.

A student made the conclusion that:

Calcium ions are more important in the tissue of plants than in animals.

Evaluate this conclusion.

(6)

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(Total for question = 9 marks)

Q24.

Cystic fibrosis is a genetically inherited condition.

A couple who are both carriers for the condition have a 25% chance of having a baby with cystic fibrosis. In the UK, 1 in 2500 babies born have cystic fibrosis.

Use the Hardy-Weinberg equation to calculate the probability of babies born in the UK being carriers for cystic fibrosis.

(3)

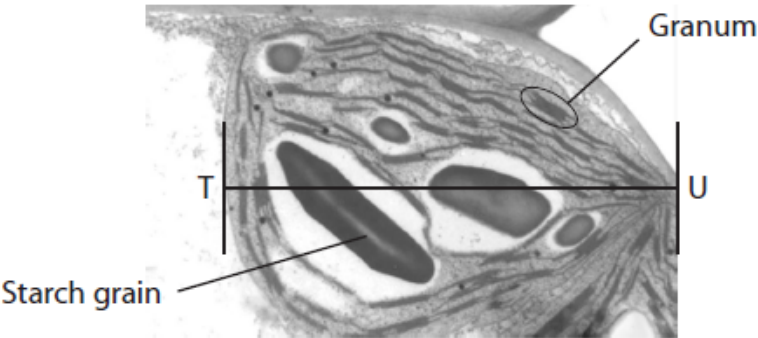
Answer

(Total for question = 3 marks)

Q25.

Photosynthesis is a process that occurs in all green plants.

The electron micrograph shows part of a chloroplast in a plant cell.



(i) The labelled starch grain in the chloroplast is 2.2 μm long.

Calculate the width of this chloroplast between T and U.

(2)

..... μm

(ii) Explain the relationship between the structure and functions of a granum in photosynthesis.

(3)

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(Total for question = 5 marks)

(i) A study compared the diversity of species at different places on a shore. On the upper shore the following data were obtained.

Species	Number of individuals found
<i>Pelvetia canaliculata</i>	10
<i>Enteromorpha</i> sp.	3
<i>Patella vulgata</i>	3
<i>Littorina littorea</i>	15
<i>Gibbula</i> sp.	14
Lichens	15

Calculate an index of diversity (D) for this site using the formula below.

(3)

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

n = total number of organisms of a particular species

N = total number of organisms of all species

Answer

(ii) On the middle shore the index was found to be 7.74 with a total individual count of 37.

Comment on the relationship between diversity and the total number of individuals on these two parts of the shore.

(2)

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(Total for question = 5 marks)

Q27.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer

with a cross ☒.

Farmers grow wheat plants to produce grain that is used to make flour. Farmers can use modern technology to monitor the mass and the moisture content of the grain in a field. Wheat can be sold at a higher price when it has a lower moisture content.

The table shows some data recorded from a field of wheat.

Plot number	Moisture content of grains (%)	Mass of wheat grains / tonnes per Ha
1	0.57	0.759
2	0.58	0.523
3	0.67	4.243
4	0.94	1.954
5	1.64	1.417
6	1.93	1.170
7	2.27	1.321
8	2.53	6.289
9	4.96	3.809
10	10.36	3.404
mean		2.489

(i) Which of the following describes the relationship between the mass of wheat grain and the moisture content of the wheat grain?

(1)

- ☐ **A** inverse correlation
- ☐ **B** negative correlation
- ☐ **C** no correlation
- ☐ **D** positive correlation

(ii) Calculate the standard deviation for the mass of wheat using the formula

$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

(3)

Answer

(Total for question = 4 marks)

Q28.

All known organisms can be placed into one of the three domains of life.

The table shows some information about the three different domains.

Feature	Archaea	Bacteria	Eukaryota
DNA is circular	Yes	Yes	No
DNA is single-stranded	No		No
Growth inhibited by the antibiotic streptomycin	No	Yes	No
Name of the link between fatty acids and glycerol in lipids	Ether	Ester	Ester
Presence of cell wall	Some	Yes	
Methionine required for starting protein synthesis	Yes	No	Yes
Transcription factors required for transcription	Yes	No	Yes

Explain how the information in the table can be used to show that the Archaea are more closely related to the Eukaryota than to the Bacteria.

(3)

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(Total for question = 3 marks)

Q29.

Ebola virus disease (EVD) is a rare and deadly disease most commonly found in Africa. Following a severe outbreak in 2014, in which 11 000 people died, work has been underway to develop a vaccine.

The vaccine is still undergoing clinical trials, but was given approval for use in recent Ebola outbreaks.

(i) Describe how clinical trials of a vaccine would be conducted.

(3)

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(ii) The Ebola vaccine was given to health workers and immediate family of those with the disease.

Justify the use of this vaccine, even though the clinical trials had not been completed.

(4)

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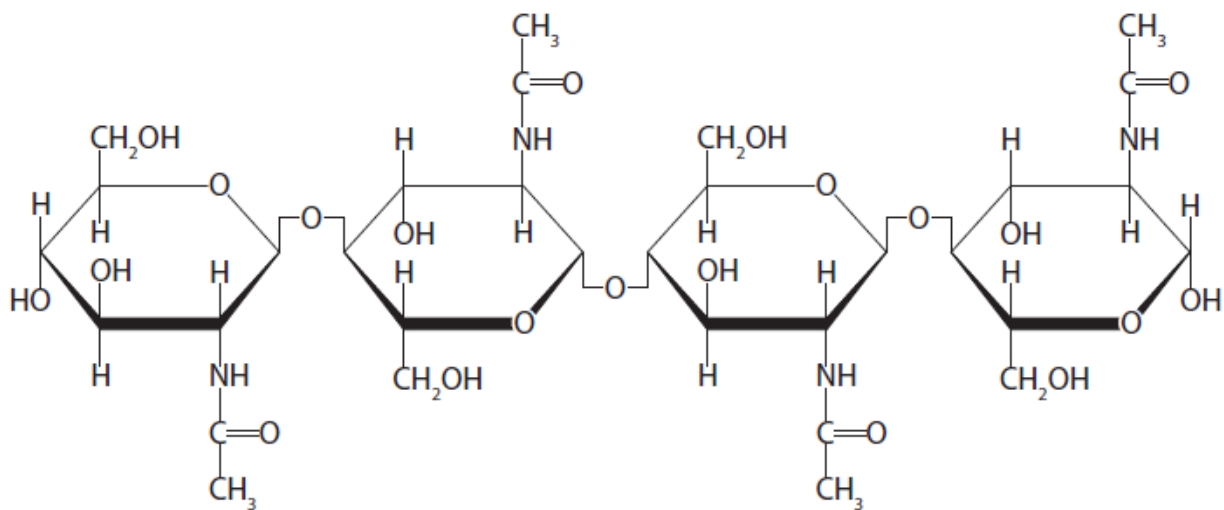
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(Total for question = 7 marks)

Q30.

The diagram shows part of a molecule of chitin, a modified polysaccharide found in fungal cell walls.



Compare and contrast the structure of chitin with that of a cellulose molecule.

(3)

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(Total for question = 3 marks)

Mark Scheme

Q1.

Question Number	Answer		Additional Guidance	Mark
	Description of adaptation	Type of adaptation shown by the wasp		(2)
	(knocking its body to signal food)	Behavioural (1)		
	(the stinger)	Anatomical (1)		

Q2.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to the following: • Advantage – being sustainable / {can decompose / is biodegradable} (1) • Disadvantage – less strong / {can decompose/ is biodegradable } (1)	Biodegradable / can decompose must be qualified if given as both an advantage and a disadvantage ALLOW renewable or more plants can be grown	(2)

Q3.

Question Number	Acceptable Answer	Additional guidance	Mark
	An answer that makes reference to four of the following: (Safer) - because pure drug used rather than extract (1) - due to pre-testing on {cells / animals} before testing on humans (1) - because regulated by legislation (1) (More valid) - because a placebo is used as a comparison (1) - because modern testing may involve double-blind trials (1) - because controlling {factors / variables / eq} tested cohort e.g. age, lifestyle (1) (More reliable) - because more people are tested (1) - because results are analysed statistically (1)	No marks awarded for safer, more valid or more reliable	(4)

Q4.

Question Number	Answer	Mark
(i)	The only correct answer is A - ligaments only <i>B is not correct because the tendons do not join bones to bones in the elbow joint</i> <i>C is not correct because the tendons do not join bones to bones in the elbow joint</i> <i>D is not correct because the ligaments do join bones to bones in the elbow joint</i>	(1)

Question Number	Answer	Mark
(ii)	The only correct answer is D rows 3 and 4 <i>A is not correct because the tendons showing a change is not a change in genotype</i> <i>B is not correct because the tendons also show a physiological adaptation</i> <i>C is not correct because the tendons showing a change is not a change in genotype</i>	(1)

Question Number	Answer	
* (iii)	Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant. Indicative content Valid because: • {sufficient replicates / 12 individuals} used and a mean calculated • All same gender • Means of both heart rate and blood lactate agree with conclusion • Spread of data (standard deviation / error bars) between cycling and running does not overlap Not valid because: • Insufficient / only 12 individuals involved • Insufficient detail relating to the athletes e.g. they maybe athletes that focus on different sports/have done more than one previous triathlon / more experienced • The three disciplines are always done in the same order / different distances covered • Spread of cycling data (standard deviation / error bars) for blood lactate overlaps with swimming • As no time allowed to recover between sports, some of blood lactate shown for cycling could have been produced during swimming • Agree or not agree with conclusion	(6)

			Additional Guidance
Level 0	Marks	No awardable content	
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Considers one area only e.g. comparing mean data or spread of data only Conclusion based on only one set of data or only one sport considered e.g. cycling is most demanding
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Considers both a valid and an invalid aspect e.g. relevance of spread of data for lactate concentrations overlap in some cases or elements of the study Conclusion given that takes both valid and invalid aspects into account
Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	Considers both a range of valid and invalid aspects A conclusion based on a range of considered evidence

Q5.

Question Number	Answer	Additional guidance	Mark
(i)	An answer that makes reference to the following: (use of anabolic steroids) reduces {ventricular fraction / ejection fraction / stroke volume / cardiac output} (1) {83 % / 10 out of 12} of users have ventricular fraction below {55% / the healthy value} (1)	ALLOW less blood leaving the ventricle when it contracts ALLOW more users of anabolic steroids have a ventricular fraction below 55% than non-users ALLOW other valid quantitative values e.g. comparing mean values for each group 51.25 and 60.6%	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer the makes reference to the following: - test the drug on { healthy individuals / animals / cell cultures } (1) (then) test on group of individuals with cancer (1) (gradually increasing the dose) to determine dose that does not reduce ventricular ejection fraction (1)	ALLOW test on a group of patients ALLOW to determine the dose that does not cause side effects	(3)

Q6.

Question Number	Indicative content
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Section of relevant data - higher rate of mutations than in {slowly evolving fish / sticklebacks} - relatively high rate of mutations that change amino acids compared to slowly evolving fish - low rate of gene duplication in slowly evolving fish / high rate of gene duplication in cichlid fish - higher rate of mutations in regulatory sequences in cichlid fish - variety of habitats available providing different selection pressures Consequences of data described - more {amino acid changes / gene duplications} the greater number of alleles in gene pool - altered amino acids result in altered protein function - changes in regulatory sequences allow for different gene expression in tissues etc - duplicated genes can be used for new functions without loss of original function / polygenic phenotypes - variety of habitats provide a number of niches suitable for cichlid fish with different adaptations to exploit Linkages made to rate of evolution - example of an altered protein function e.g. enzymes that work at different pH / temperature tolerance - development of new phenotypes {new enzymes/ different mouth shapes} allow new food types to be exploited - changes in {pigmentation / mouth shape} allow speciation

Level	Mark	Descriptor	Additional guidance
Level 0	Marks	No awardable content	
Level 1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.	At least one relevant piece of data described e.g. higher mutation rate. A consequence described for the data – e.g. linking mutations to protein structure Basic clear conclusion attempted e.g. different proteins are produced
Level 2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.	At least two pieces of relevant data referred to. Consequences of at least two pieces of data explained Linkages made to evolution of the fish e.g. changes in phenotype

Level 3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	At least three pieces of relevant data referred to Consequences of each piece of data explained Linkages to evolution discussed, e.g. the types of adaptations that may arise due to mutations
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Q7.

Question Number	Indicative content
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Basic information • All the treatment combinations were effective at treating TB • All treatments had some { relapses / individuals with TB } 3 years after treatment • { Group 1 / Groups 1 and 2 / Rifampicin + Pyrazinamide / Rifampicin + Isoniazid } had the lowest number of patients with TB (3 years later) Evidence for linkages made • Percentage relapse varies depending on second part of treatment • Combinations involving Rifampicin most effective • The antibiotics tested act on different targets in bacteria • Gaps in information - not all combinations tested, other combinations might be more effective • Other time scales may have been more effective Evidence for sustained scientific reasoning • Could be other reasons for infections with TB 3 years later not due to the antibiotic treatment • No information about dormant TB (only percentage of active cases) • Bacterial RNA polymerase possibly the best target for antibiotics • Antibiotics targeting synthesis of cell wall fatty acids least effective in terms of relapses • Idea of combination of antibiotics with different mode of activity most effective

Level	Mark	Descriptor	
Level 0	Marks	No awardable content	
Level 1	1-2	An answer may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The answer will contain basic information with some attempt made to link knowledge and understanding to the given context.	Reference to effectiveness of different combinations of antibiotics.
Level 2	3-4	An answer will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The answer shows some linkages and lines of scientific reasoning with some structure.	Reasons for differences in effectiveness considered.
Level 3	5-6	An answer is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The answer shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Information about action of antibiotics related to effectiveness. Evaluation of study design considered.

Q8.

Question Number	Acceptable Answer	Additional guidance	Mark
	An answer that makes reference to the following: - the drug did improve the condition of the patients more than the placebo but it was only 6 au with a concentration of 400 mg so not much of an improvement (1) - increasing the dosage by a further 200 mg doubled the improvement over the placebo (1) Plus one from: - therefore to be effective higher doses of the drug would be required (1) - statistical tests would be required in order to comment further (1)		(3)

Q9.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	neither patients nor {doctors /scientists / eq} know which treatment the patients were given (1)		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to three of the following: - idea that SSRI works best (1) - placebo works faster than SJW (1) - SJW and placebo effect {wear off / level / end at 12 / same final score / fall then rise / eq} (1) - correct comparative manipulation of figures to support analysis (1)		(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to two of the following pairs: - use more patients / increase sample size / repeat the trial (1) - to increase reliability (1) and/or - consider sample selection to use same age / gender / ethnicity / lifestyle / health of patients (1) - to control biotic variables (1) and/or - extension of time for trial (1) - to ensure SSRIs continue to reduce HRSD score or not / SJW continue to decrease HRSD score or not (1) and/or - use of statistical analysis (1) - to see if the differences are significant (1)		(4)

Q10.

Question number	Answer	Additional guidance	Mark
	- mass of dry powdered leaf (1) - mass of wet leaf (1)	Example of calculation $5000 \div 501.3 = 9.97$ $(9.974 \div 0.105) = 95.0 \text{ (g)}$ ALLOW 1 mark only for correct figures but to incorrect d.p. e.g. 9.50 ALLOW 1 mark only for 47.6 Correct answer with no working gains both marks	Expert (2)

Q11.

Question number	Answer	Additional guidance	Mark
(i)	An answer that makes reference to the following: - solvent B (extract) has greatest (antimicrobial) activity / solvent A (extract) has the least (antimicrobial) activity (1) {Gram negative bacteria / <i>Klebsiella</i>} are more sensitive (to both the solvent extracts) (1)	ALLOW solvent B {is more effective / increases the effectiveness} solvent A {is less effective / reduces the effectiveness} ALLOW both extracts more effective against {Gram negative bacteria / <i>Klebsiella</i>}	Expert (2)

Question number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to the following: • prepare an agar plate with a bacterial lawn (1) • description of how extract can be added to the (agar plate) (1) • incubate at a stated temperature between 20 °C and 37 °C (1) • measure the diameter of the zones of inhibition after a (suitable) stated time (1)	ALLOW adding bacteria to agar / seeding agar plate with bacteria e.g. added to wells / on paper disks IGNORE at room temperature ALLOW time periods between 1 day and 1 week ALLOW calculate diameter	Expert (4)

Q12.

Question Number	Indicative content
*	Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant. Give examples of relevant biological knowledge and understanding: Evidence of isolated elements of biological knowledge: • glucose for respiration in both • starch for energy storage in plants / glycogen for energy storage in animals • cellulose for cell walls in plants Evidence of adequate biological knowledge with linkages made • starch composed of amylose and amylopectin in plants • sucrose as a transport sugar in phloem in plants, glucose in animals • lactose in milk for energy • a judgement on the importance of carbohydrates in plants and animals is made e.g. cellulose as a structural carbohydrate in plants therefore a greater proportion of carbohydrate in plants than animals or animals require more energy, therefore need more carbohydrate Evidence for comprehensive biological knowledge and understanding with sustained linkages • pentose sugars ribose and deoxyribose { in nucleic acids / DNA/ RNA / ATP } in both • ribulose as part of the Calvin cycle in plants • glycoprotein in { mucus / receptors on cell surface membranes / antibodies } • glycolipids in cell membranes • a supported judgement on the relative importance of carbohydrates in plants and animals is given e.g. animals store more energy in lipids than carbohydrate, therefore carbohydrate more important as a storage molecule in plants or the idea of carbohydrates as part of complex molecules or the proportion of carbohydrates present is not the same as importance

Level	Mark	Descriptor	Additional guidance
0	0	No awardable content	
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Glucose for respiration Polysaccharides for energy storage Cellulose for plant cell walls Simple conclusion made
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Branched storage molecules for rapid energy release in starch Roles of sucrose, lactose A judgement on the importance of carbohydrates in plants and animals is made
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	All of the above plus discussion of carbohydrates as part of complex molecules A supported judgement on the relative importance of carbohydrates in plants and animals

Q13.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to: - no (in row two) (1) - some (in row five) (1)		(2)

Q14.

Question Number	Answer	Additional Guidance	Mark
(i)	A answer that makes reference to the following: {alternative form / different form / version / variation} of a gene (1)	IGNORE type of gene	1

Question Number	Answer	Additional Guidance	Mark
(ii)	- correct use of Hardy-Weinberg equation (1) - correct calculation of probability of each homozygote (1) - correct answer (1)	<u>Example of calculation</u> $p^2 + 2pq + q^2 = 1$ $p^2 =$ either 0.185 or 0.325 $q^2 =$ either 0.325 or 0.185 or $2pq = 0.43 \times 0.57 \times 2 = 0.4902$ frequency = 50.98 % / 51% (which is greater than 50%) Correct answer with no working gains full marks	3

Q15.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	species found only in one geographical location		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	A description that makes reference to the following: - the variety of species (in an ecosystem / community / habitat) (1) - the variety of alleles in a { gene pool / population / species } (1)		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to three of the following: record the number of species of lemur and the (1)		(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
	number of individuals of each species - calculate the diversity index (for each location) (1) - so the higher the index, the greater the biodiversity (1) - DNA profiling / gel electrophoresis / molecular phylogeny / proteomics (1)		

Q16.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	- correct calculation of numerator (1) - correct calculation of denominator (1) - correct calculation of diversity index / correctly plotted on the graph (1)	<u>Example of calculation:</u> $(N(N-1) = 427 \times 426 = 181\,902)$ $\div (\sum n(n-1) =) 52\,320)$ $= 3.48 ;$ Allow full marks for correct answer with no working	(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: - succession is the sequence of { species / communities } replacing each other with time (1) - dune 4 is older than dune 1 (1) - no species of plant inhabits all 4 dunes /example from table quoted to show one species inhabiting no more than 3 dunes (1) - plant diversity increases with time (1) - description of increasing diversity index from dune 1 to dune 4 (1)	e.g. species G only found on dunes 3 and 4	(5)

Q17.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to two of the following • endemic (species) that are only found in that one location (1) • protection of hotspots prevents extinction (of endemic species) (1) • the loss of these species will (significantly) reduce global biodiversity (1)		Expert (2)

Q18.

Question Number	Answer	Mark
(a)	B 2	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	1. (only) contain hydrogen, carbon and oxygen ; 2. reference to fatty acids and glycerol {joined by / eq} ester{bonds / eq} ; 3. idea of saturated and unsaturated (fatty acids / lipids);		(2)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	1. uses less fertiliser / eq ; 2. idea of not using more pesticides / eq ; 3. idea that greenhouse gas emissions are not that different ; 4. credit manipulation of figures to support marking point 3 ;	1. & 2. IGNORE comparisons between the different crops 3. ACCEPT less than corn but more than sugar cane	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	1. credit three correctly named ions ; 2. nitrates for {protein / amino acids / nucleic acids / named nucleic acid} ; 3. proteins used for growth ; 4. calcium ions for {other nutrients uptake / promotes cell elongation / strengthen cell walls / enzyme function / protection against heat stress / protection against diseases / eq} ; 5. magnesium ions for chlorophyll production ; 6. for photosynthesis ;	1. e.g. nitrates, calcium ions, magnesium ions, sulphates, potassium ions, phosphates ACCEPT Sulphates for amino acids Potassium ions for stomata function	(4)

Q19.

Question Number	Answer	
*expert	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Basic information • measure growth of plants e.g. length of leaves, mass of plants, etc. • grow wheat seedlings with either biological farming product or chemical fertiliser, several plants in each. • Control of one relevant abiotic variable e.g. temperature, soil and light. Evidence of linkages • measure growth of plants at standardised time intervals. • measure after growing the plants for a sensible period of time- reference to rate of growth • grow wheat seedlings from the same batch of seed. • same mass / volume / concentration of chemical fertiliser and biological farming product • plants grown in standardised conditions, e.g. light / humidity / temperature Evidence of sustained scientific reasoning • compare health of plants e.g. development of disease • calculate mean and SD to compare the results • statistical comparison of results • use of sterilised soil so that there are no fungi in the soil for the chemical fertiliser • analyse the soil at the end of the experiment to determine moisture and mineral content	(6)

Level	Marks		Additional Guidance ?
0	0	No awardable content	
1	1-2	An explanation of how the investigation should be modified may be attempted but with limited analysis, interpretation and/or evaluation of the scientific information. Generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Use of chemical fertiliser and biological farming product A number of seedlings used Growth of plants measured Control of one abiotic variable
2	3-4	An explanation of how the investigation should be modified will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Description of how growth will be measured eg height of plant, number of leaves Measured at regular intervals/after a specific time interval Wheat seedlings from the same batch of seeds Explanation of control of abiotic variables Same volume/concentration of chemical fertiliser and biological farming product
3	5-6	An explanation of how the investigation should be modified is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured.	Named statistical analysis of results Consideration of health of plants/soil analysis

Q20.

Question Number	Answer	Mark
	The only correct answer is B <i>the number of different species in a habitat</i> A is not correct because it is not the number of different genes in a population C is not correct because it is not the number of homozygotes in a population D is not correct because it is not the number of individuals in a population	Computer (1)

Q21.

Question number	Answer	Additional guidance	Mark
(i)	An answer that makes reference to two of the following: • food availability (1) • interspecific competition (1) • predation (1) • disease (1)	IGNORE time of year / availability of resources ALLOW grazing / migration IGNORE competition unqualified or competition between birds	Choose an item. (2)

Question number	Answer	Additional guidance	Mark
(ii)	• correct expected value (1) • correct values for observed minus expected squared (1) • correct answer (1)	$26 \div 2 = 13$ $(16 - 13)^2 = 9$ and $(10 - 13)^2 = 9$ 1.38 ECF for incorrect expected value ALLOW one mark for 2.25 / 3.6	Choose an item. (3)

Question number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to the following: • cutting down trees decreases the number of bird species in both forests (1) • the decrease is significant (at $p=0.05$) in forest A (1) • the decrease was not significant (at $p=0.05$) in forest B (1)	ALLOW decreases species richness ALLOW less than {5% / 0.05 probability} reduction in forest A due to chance ALLOW more than {5% / 0.05 probability} reduction in forest B due to chance ALLOW 1 mark chi squared value was {greater than the critical value for forest A / less than critical value for forest B} with no reference to p value or significance	Choose an item. (2)

Q22.

Question Number	Answer	Additional guidance	Mark
	A description that makes reference to three of the following • animals are selected to prevent { breeding between closely related individuals / inbreeding depression } (1) • a stud book is used to { select individuals for mating / keep a record of all breeding events } (1) • exchange of { animals / gametes } between zoos (1)	ALLOW use of studbook to prevent inbreeding	(3)

Q23.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to: • calculate mass of calcium ions in total soft tissue (1) • calculate the mean mass of soft tissue in a human (1) • calculate mass of calcium per gram of soft tissue (human) (1)	Example of calculation: 1% of 1000 g = 10 g 96 % of 80 kg = 76.8 kg or 76 800g 130.21 ($\mu\text{g g}^{-1}$) ALLOW 130.2 / 130 Correct answer with no working gains full marks.	(3) Exp

Question Number	Answer	Mark
(ii)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content Relating to the data - Data compared in humans and one plant species - Idea that concentration is not same as importance	(6) Exp
	- No evidence that more than one plant used Roles of calcium ions in plants and animals - Used for plant cell walls - Detail of how used in plant cell walls: calcium pectate - In humans used at synapse, muscle contraction, blood clotting, bone tissue - Details of how used in synapse, muscle contraction, blood clotting Comments on study - Only one plant species used / this plant species may not be representative of all plant species - Humans not necessarily representative of all animals	

Level 0	Marks	No awardable content	Additional Guidance
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths / weaknesses identified.	Basic description of role of calcium ions in plants and in animals. OR Basic conclusion or a comment on the data.
		A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Details provided for roles of calcium ions in both animals and plants Comparison of data e.g. more calcium ions in plant tissue than human tissue. Only one species of plant considered

Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	Details of roles of calcium ions in animals and plants. Data compared. Higher concentration – but calculated value for humans was for soft tissue and not bones. Evaluation of data provided – only from humans, not all animals. Data compared. Higher concentration – but calculated value for humans was for soft tissue and did not include bones. Idea that concentration is not the same as importance.
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Q24.

Question Number	Answer	Additional Guidance	Mark
	• correct use of Hardy-Weinberg equation (1) • correct calculation of allele frequencies (1) • correct probability of heterozygote frequency calculated (1)	<u>Example of calculation</u> $p^2 + 2pq + q^2 = 1$ $q = 0.020 \text{ and } p = 0.980$ $2pq = 2 \times (0.98 \times 0.02)$ $3.92\% / 3.9\% / 0.0392 / 0.039$ ALLOW $\frac{49}{1250}$ as a fraction for probability Correct answer with no working gains full marks ALLOW 2 marks for correct allele frequencies alone	(3)

Q25.

Question Number	Answer	Additional Guidance	Mark
(i)	- correct measurements from the photograph (1) - correct answer	<u>Example of calculation</u> Starch grain 27mm and width of chloroplast 60mm $27000 \div 22 = 12\,273$ $60000 \div 12\,273 = 4.889\,(\mu\text{m})$ ALLOW 4.9 / 4.89 / 4.8 recurring (μm) (ALLOW one mark for correct calculation from different measurements)	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: (granum) is formed from many layers of thylakoid membranes to increase surface area (for absorbing light) - thylakoid membranes contain chlorophyll to absorb light - electron carrier molecules in thylakoid membrane involved in ATP production	ALLOW stacks of thylakoids provide a large surface area ALLOW photosystems / photosynthetic pigments in place of chlorophyll ALLOW for light dependent reaction in place of absorb light ALLOW ATP synthase / photophosphorylation	(3)

Q26.

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(i)	$N(N-1) = 3540$ (1) $\sum n(n-1) = 704$ (1) $= 3540 \div 704 = 5.028 / 5.03$ (1)		(3)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(ii)	An answer that makes reference to the following: - middle shore has higher diversity (1) - even though there are fewer individuals (1)	Allow converse argument.	(2)

Q27.

Question Number	Answer	Additional guidance	Mark
(i)	The only correct answer is C – no correlation <i>A is incorrect because it is not inverse</i> <i>B is incorrect because it is not negative</i> <i>D is incorrect because it is not positive</i>		(1)

Question Number	Answer	Additional guidance	Mark
(ii)	• correct calculation of $\sum (x - \bar{x})^2$ (1) • value divided by n-1 (1) • correct calculation of SD (1)	<u>Example of calculation</u> $\sum (x - \bar{x})^2 = 31.49$ $\div 9 = 3.499$ Answer = $(\pm) 1.87$ Correct answer without working gains full marks	(3)

Q28.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: • (because) there are {more similarities / fewer differences} between the Archaea and the Eukaryota (1) • (because) there are {fewer similarities / more differences} between the Archaea and the Bacteria (1) • two similarities between Archaea and Eukaryota (from table) described (1) • (so) the more recently they have evolved from a common ancestor (1)	ALLOW correct number of similarities / differences for Archaea and Eukaryota ALLOW correct number of similarities / differences for Archaea and Bacteria e.g. not inhibited by streptomycin/ methionine required for starting protein synthesis / transcription factors required for transcription	(3)

Q29.

Question Number	Answer	Additional guidance	Mark
(i)	A description that makes reference to three of the following • (small groups of) healthy volunteers are given the vaccine to test for side effects (1) • (healthy volunteers) tested for presence of antibodies to the virus (following vaccination) (1) • a group of people at risk of contracting the disease is given the vaccine (1) • the number of people who develop the viral disease (following vaccination) are monitored (1)		(3)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to four of the following • large numbers of people died from the disease (1) • health workers are in close contact with people suffering from the disease (1) • the side effects of the vaccine will not be worse than contracting Ebola (1) • vaccinating immediate family will help to reduce the spread of disease (1) • if health workers were vaccinated they could care for more people (1)	ALLOW disease is (usually) fatal ALLOW health workers and family most likely to be exposed to the virus ALLOW risk from the disease is much greater than the risk from the vaccine	(4)

Q30.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to three of the following: <u>Similarities</u> - both have glycosidic bonds (1) - description of every other monomer being inverted (1) <u>Differences</u> (the monomers of) chitin have eight carbon atoms whereas in cellulose there are six carbon atoms (1) - chitin { has an additional side chain / contains nitrogen but cellulose does not } (1)	IGNORE 1,4 and 1,6 ALLOW every other glucose ALLOW only chitin contains nitrogen / chitin has an amide group	(3)