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Biology A (Salters Nuffield)

Advanced Subsidiary

Paper 2: Development, Plants and the Environment

Monday 4 June 2018 – Afternoon

Time: 1 hour 30 minutes

Paper Reference

8BN0/02

You must have:

Calculator, HB pencil, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Show your working in any calculation questions and include units in your answer where appropriate.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You may use a scientific calculator.
- In questions marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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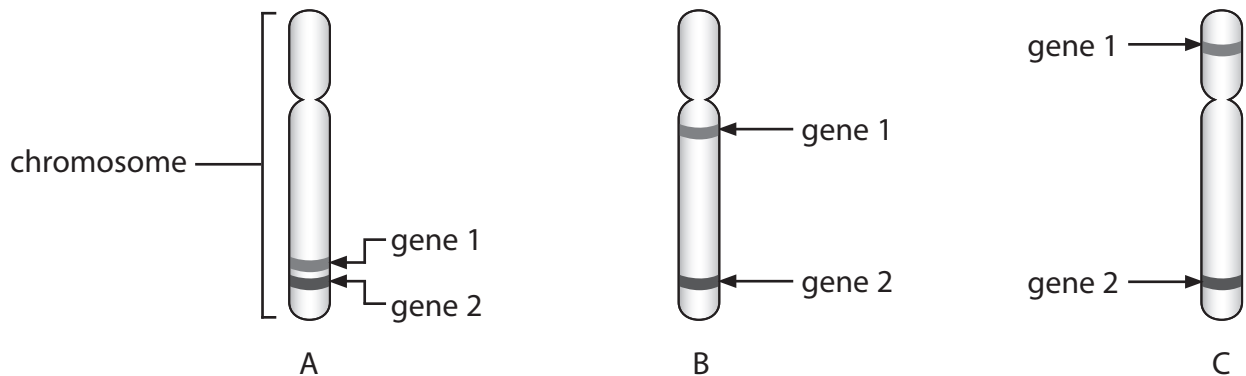
Answer ALL questions.

Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Linked genes are usually inherited together.

(a) The diagram shows the position of two genes on three chromosomes, A, B and C.



(i) Name the part of a chromosome that is occupied by a gene.

(1)

locus

(ii) Explain which chromosome shows the weakest linkage between genes 1 and 2.

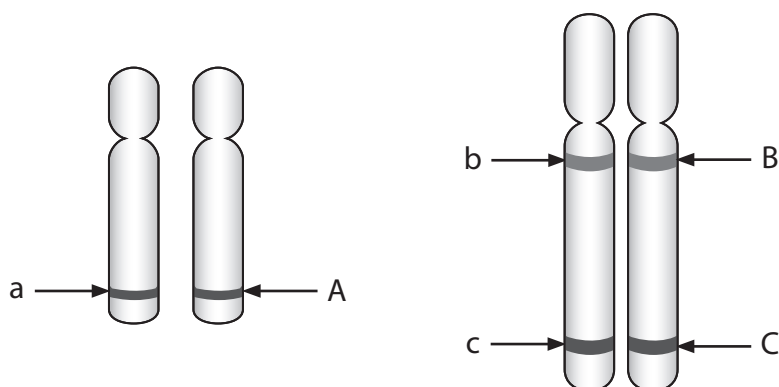
(3)

Chromosome C, because genes 1 and 2 are furthest apart on this chromosome.

So the two genes are more likely to be separated during crossing over, as chiasmata are more likely to form between the two genes.



- (b) The process of meiosis gives rise to genetic variation. Genes A, B and C are located on two different pairs of chromosomes, as shown in the diagram.



Which combination of alleles could only be present if crossing over has occurred?

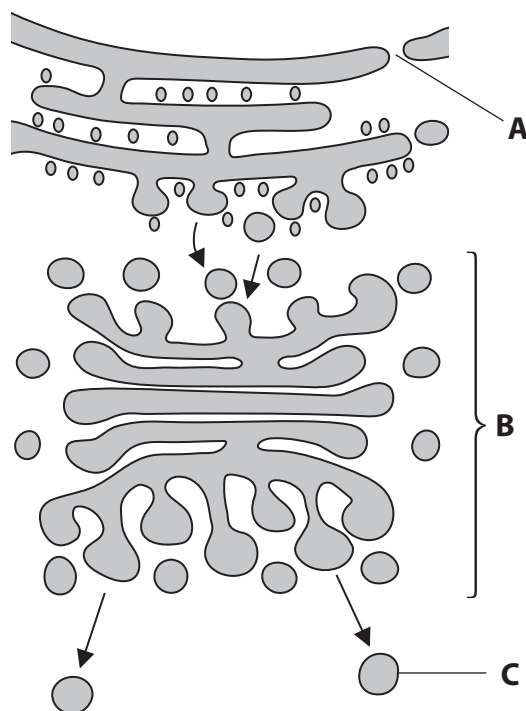
(1)

- ☐ A ABC
- ☐ B aBC
- ☒ C ABc
- ☐ D Abc

(Total for Question 1 = 5 marks)



- 2 The diagram shows some of the cell organelles involved in the formation of extracellular enzymes.



(a) Name the parts of the cell labelled **A**, **B** and **C**.

(3)

A *nuclear pore*

B *Golgi apparatus*

C *secretory vesicle*



(b) Describe the roles of parts **B** and **C** in the formation and transport of extracellular enzymes.

(4)

B: vesicles from the rough ER carrying the protein fuse with the Golgi apparatus, so the protein enters the Golgi apparatus.

Inside the Golgi apparatus the protein (enzyme) is modified, e.g. carbohydrate is added, and folded into its final form.

The protein is then packaged into secretory vesicles that bud off from the Golgi apparatus.

C: the secretory vesicles move to and fuse with the cell surface membrane, releasing the enzyme out of the cell by exocytosis.

(c) Extracellular enzymes are produced by specialised cells.

Explain how groups of cells can produce the same enzyme.

(3)

All the cells contain the same genes, but genes can be activated or deactivated (switched on or off).

These cells all receive the same stimulus, so they all have the gene for the enzyme activated (switched on).

This results in the production (transcription) of mRNA for the enzyme, which is translated, so they all make the same enzyme.



(d) Eukaryotic and prokaryotic cells both produce enzymes.

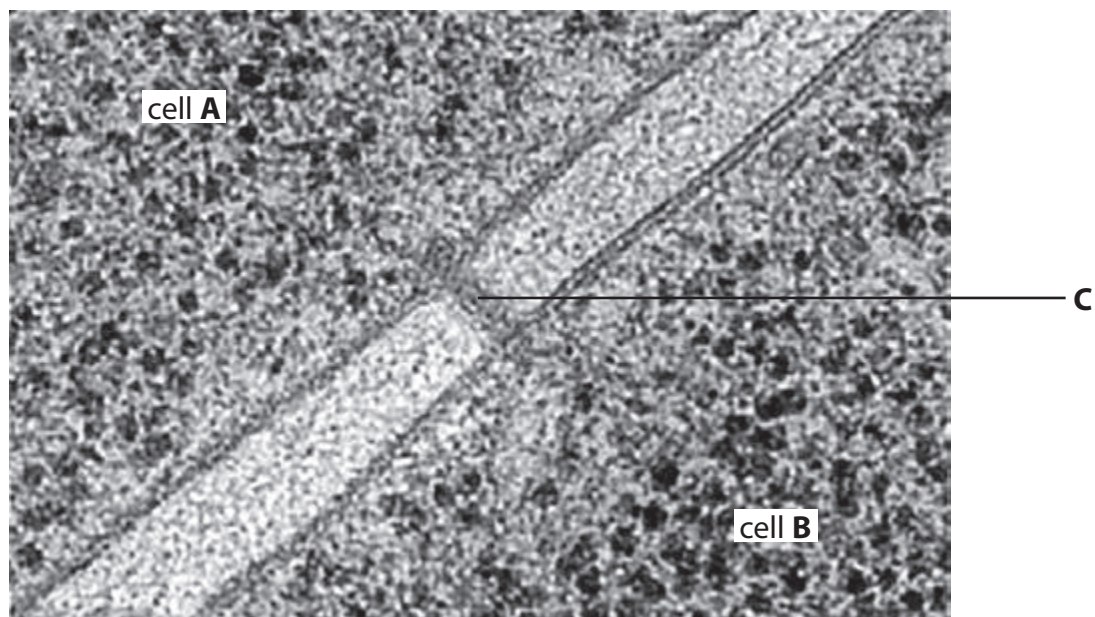
Which of the following pairs of statements is true for eukaryotic and prokaryotic cells?
(1)

	Similarity	Difference
☐ A	Both possess ribosomes	Only eukaryotic cells possess plasmids
☐ B	Both possess pili	Prokaryotic cells do not secrete enzymes
☒ C	Both possess ribosomes	Prokaryotic cells do not possess endoplasmic reticulum
☐ D	Both possess pili	Only eukaryotic cells possess ribosomes

(Total for Question 2 = 11 marks)



3 The electronmicrograph shows the junction between two plant cells, **A** and **B**.



(a) (i) Name the structure labelled **C**.

(1)

plasmodesma (plural plasmodesmata)

(ii) Explain the function of the structure labelled **C**.

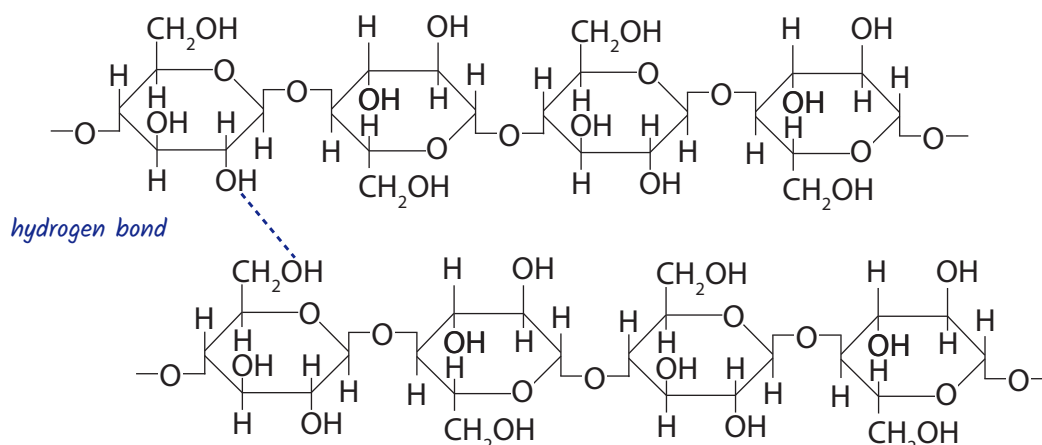
(2)

It is a cytoplasmic connection between the cells: the cytoplasm is continuous between cell A and cell B through the cell walls.

This allows transport (exchange of materials) and communication between the cells.



- (b) The cell wall consists of cellulose molecules arranged as microfibrils.
The diagram shows the partial structure of two molecules of cellulose.



- (i) Draw **one** link on the diagram that would hold these molecules together in a microfibril.

(1)

- (ii) Compare and contrast the structure of cellulose and amylopectin.

(3)

Similarities: both are polysaccharides (polymers of glucose) and both contain 1,4 glycosidic bonds.

Differences: cellulose contains β -glucose whereas amylopectin contains α -glucose, so in cellulose alternate monomers are inverted.

Cellulose is not branched (no 1,6 glycosidic bonds) whereas amylopectin is branched, with 1,6 glycosidic bonds.

- (c) Plant cells also contain structures called amyloplasts.

Amyloplasts

(1)

- ☐ A allow fluid exchange
- ☐ B consist mainly of pectin
- ☐ C are membranes surrounding the vacuole
- ☒ D store starch granules

(Total for Question 3 = 8 marks)



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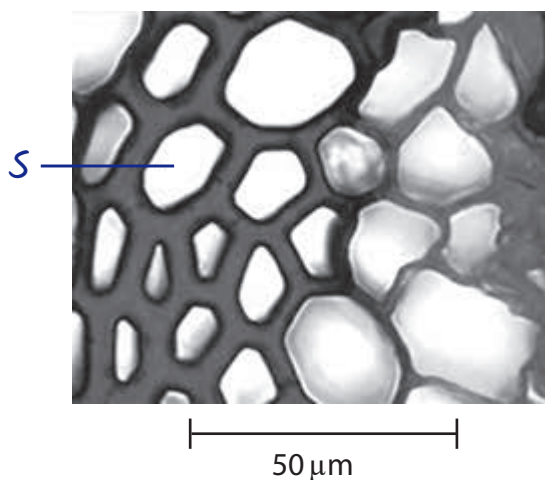
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P 5 1 7 9 4 A 0 9 2 8

- 4 The image shows a cross section of part of a plant stem examined using a light microscope.



- (a) (i) Label a sclerenchyma fibre with the letter **S**.

(1)

- (ii) Calculate the magnification of this image.

(3)

Length of scale bar = 35 mm

35 mm = 35 000 μm

Magnification = image size ÷ actual size

= 35 000 ÷ 50

= × 700

Answer... *× 700*



(b) (i) A nucleus will be found in a

(1)

- ☒ **A** companion cell
- ☐ **B** sclerenchyma fibre
- ☐ **C** sieve tube
- ☐ **D** xylem vessel

(ii) Xylem and sclerenchyma fibres both

(1)

- ☒ **A** provide support
- ☐ **B** transport glucose
- ☐ **C** transport hormones
- ☐ **D** transport mineral ions

(iii) The cell wall forms a greater percentage of the total mass of the sclerenchyma fibre than of a phloem sieve tube.

Which of the following explains this difference?

(1)

- ☐ **A** phloem sieve tubes do not contain organelles
- ☐ **B** phloem sieve tubes have thinner, lignified walls
- ☐ **C** sclerenchyma fibres contain organelles
- ☒ **D** sclerenchyma fibres have thickened, lignified cell walls

(Total for Question 4 = 7 marks)



5 Mineral ions in the soil affect the growth of the peanut plant, *Arachis hypogaea*.



The effect of mineral ions on the production of fruit by these plants was investigated.

Young peanut plants were grown in soil containing all the mineral ions required.

After one week, 10 of these plants were moved into soil without calcium ions.

Another 10 plants were moved into soil without magnesium ions.

Ten plants were left in the original soil.

After leaving the plants to grow, the mean number of flowers per plant and the percentage of these flowers that formed fruit were recorded.

The results are shown in the table.

Soil	Mean number of flowers per plant	Percentage of flowers producing fruit (%)
Containing all minerals	644	9.2
Without calcium ions	392	5.4
Without magnesium ions	583	2.3

- (a) (i) Calculate the mean reduction in the number of fruit produced by peanut plants grown in soil without calcium ions.

Give your answer to two decimal places.

All minerals: $(644 \times 9.2) \div 100 = 59.248 = 59.25$ fruit

(3)

Without calcium: $(392 \times 5.4) \div 100 = 21.168 = 21.17$ fruit

Reduction = $59.25 - 21.17 = 38.08$

Answer 38.08



(ii) Comment on the results of this investigation.

(3)

A deficiency in both calcium and magnesium ions reduces flowering and fruit formation compared with soil containing all minerals.

The number of flowers is reduced more by a deficiency in calcium than in magnesium (392 compared with 583 flowers).

Fruit production is reduced more by a deficiency in magnesium than in calcium (only 2.3% of flowers produce fruit compared with 5.4%).

(b) Devise an investigation to determine the effect of nitrate ion concentration on the growth of young peanut plants.

(5)

Use young peanut plants that are clones (same variety and same age, and similar size).

Grow them in a range of at least five different nitrate concentrations, e.g. 0, 2, 4, 6, 8 and 10 mmol dm⁻³.

Control abiotic variables: same temperature and light intensity (in a growth room), same soil pH, same volume of water given, and all other mineral ions present in the same amounts.

Grow the plants for a set period of time, e.g. 4 weeks.

Measure growth, e.g. the increase in height or (dry) mass of each plant.

Use repeats (e.g. 10 plants at each nitrate concentration) to calculate mean values.

(Total for Question 5 = 11 marks)



- 6 The saiga antelope is found in the grasslands of Eurasia. In the 1970s its population was 1 250 000. The population has decreased due to loss of habitat and a disease outbreak in 2015.

Population estimates suggest as few as 50 000 individuals remain.

Conservation efforts aim to ensure that the population recovers to previous levels.



- (a) The population may recover quickly as saiga antelopes usually produce twins.
(i) Even though both offspring are from the same father and the same mother, they may be genetically different.

Explain why the offspring may be genetically different.

(2)

Each zygote is formed from different gametes, by random fertilisation (they are not identical twins).

Each gamete contains a different combination of alleles, due to independent assortment and crossing over during meiosis.



(ii) During fertilisation, only one sperm cell can fertilise an egg cell.

Explain why a second sperm cell cannot fertilise the egg cell.

(3)

When the first sperm fuses with the egg cell, the cortical reaction occurs: cortical granules fuse with the egg cell surface membrane and release their contents.

This results in thickening and hardening of the zona pellucida.

Therefore other sperm cells cannot reach the egg cell surface membrane, so they cannot fertilise it.

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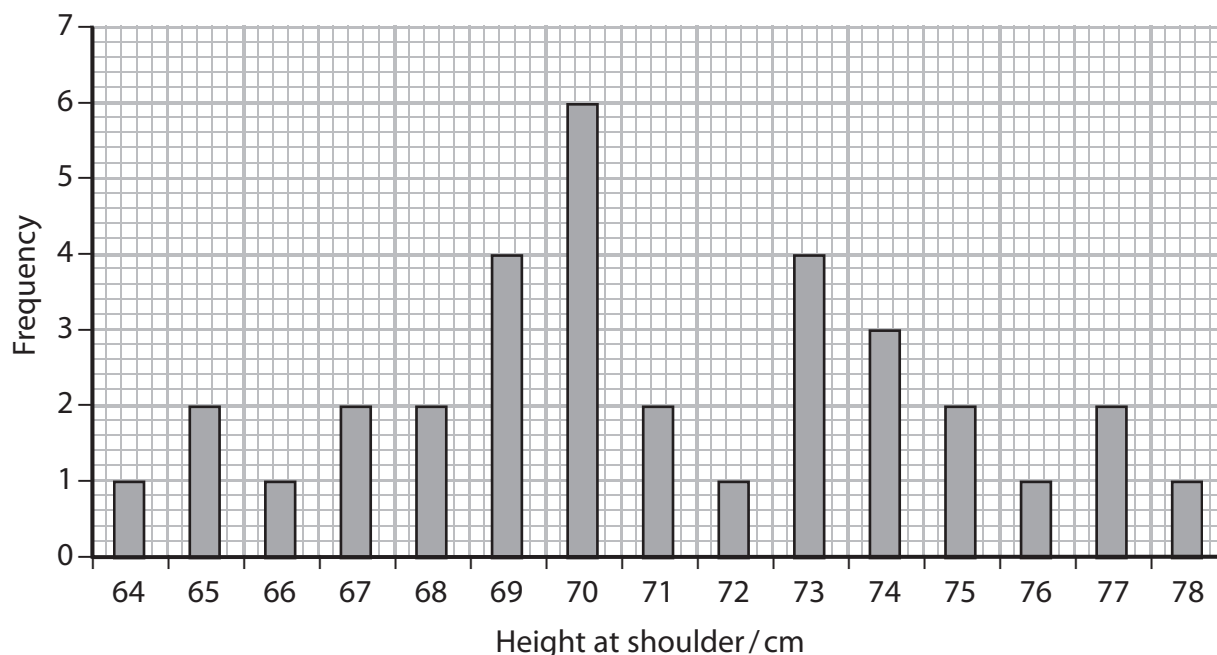
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P 5 1 7 9 4 A 0 1 5 2 8

(b) Endangered animals are monitored to determine the diversity and viability of the population.

The height of 34 saiga antelopes is shown in the graph.



- (i) State how the graph provides evidence that this characteristic shows polygenic inheritance.

(1)

The heights show continuous variation, with a range of values rather than distinct categories.

- (ii) Height in animals is determined by polygenic inheritance.

Which is a description of polygenic inheritance of height?

(1)

- ☐ A controlled by a large number of alleles of one gene
- ☒ B controlled by more than one gene
- ☐ C controlled by one gene from each parent
- ☐ D controlled by one gene and the environment

(iii) State and justify the mode for height of the saiga antelope.

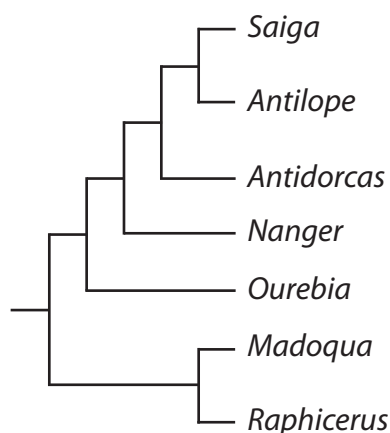
(2)

The mode is 70 cm.

This is the height with the highest frequency (6 antelopes), so it is the most common height.

(c) Saiga antelopes are related to a wide range of other species of antelope.

The diagram shows the phylogenetic relationships between some antelopes.
This diagram was produced using data from analysis of a protein.



(i) Explain how this diagram indicates that saiga antelopes are more closely related to *Antilope* than to *Antidorcas*.

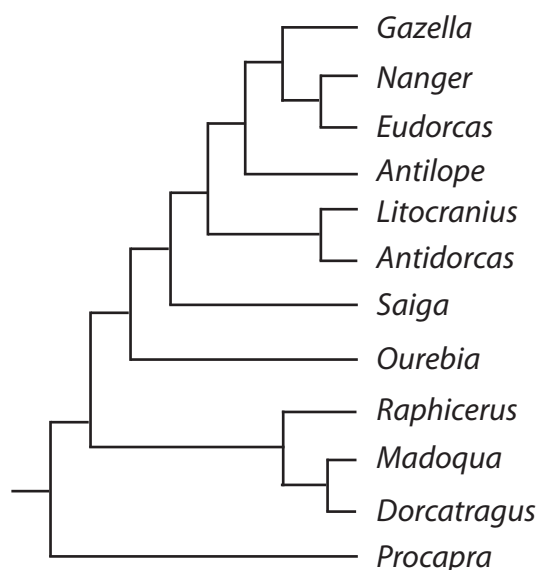
(2)

Saiga and Antilope branch from the most recent common ancestor, so they shared a common ancestor more recently than Saiga and Antidorcas.

This means there are more similarities in the protein, e.g. more similar amino acid sequences.



- (ii) This is a more recent classification diagram based on a study of the mitochondrial genomes of antelopes.



Deduce how this study led to different opinions about the relationship between *Saiga* and *Antelope*.

(3)

The new diagram shows that *Saiga* and *Antelope* are less closely related than previously thought, as *Antelope* now groups with *Nanger* and *Gazella*.

This study used DNA analysis (comparison of the mitochondrial DNA sequences) rather than a protein.

It detected more differences between the mitochondrial genomes of *Saiga* and *Antelope*, so they do not share such a recent common ancestor.

(Total for Question 6 = 14 marks)



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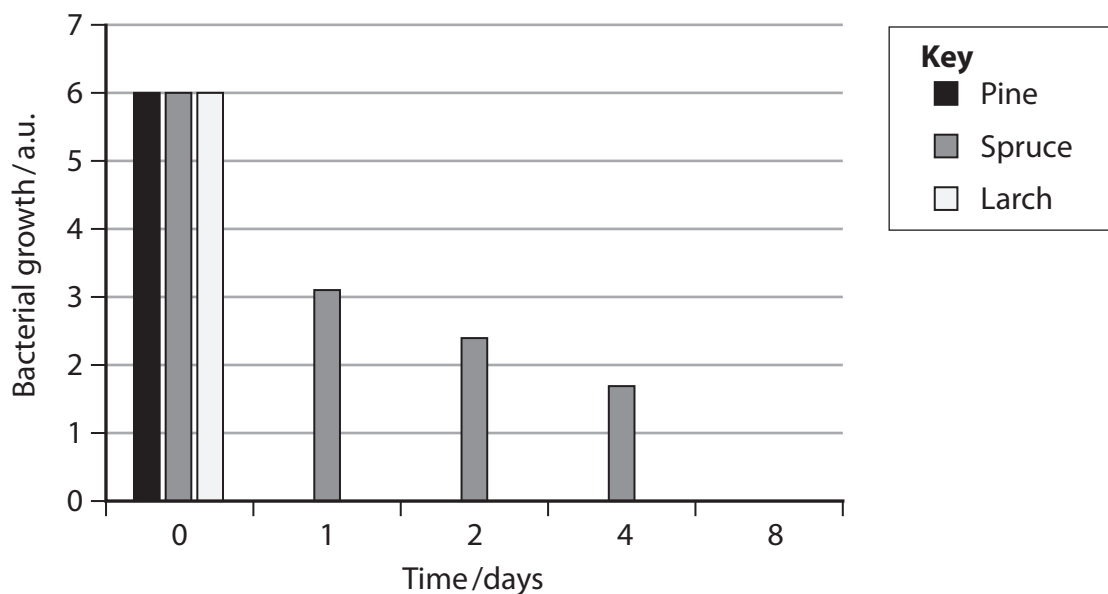
7 Many plants produce chemicals that have antimicrobial properties.

The suitability of using wood from three types of tree to make kitchen chopping boards was investigated.

In this investigation, 50 cm³ of a bacterial culture was added to 100 g of wood chippings from each of three types of tree.

The growth of bacteria was measured at the start (Day 0), and then after 1, 2, 4 and 8 days.

The results are shown in the graph.



(a) (i) Describe the antimicrobial properties of these three types of wood.

(2)

Pine and larch have greater antimicrobial properties than spruce: they act faster, with no bacterial growth after 1 day, whereas spruce still has some growth until day 4.

Pine and larch are equally effective.

- (ii) It was concluded from this investigation that spruce caused bacterial growth to decrease at a constant rate after the first day.

Criticise this conclusion.

(2)

The conclusion is not valid. Time is not shown as a continuous scale (the intervals between 0, 1, 2, 4 and 8 days are not equal).

There are no data between 4 and 8 days, so it is not known how growth changed.

- (iii) Explain how this investigation could be improved to provide additional data to determine whether pine or larch have greater antimicrobial properties.

(4)

Take measurements at shorter time intervals, e.g. hourly measurements,

between 0 and 1 day (within the first 24 hours),

because there is no bacterial growth on either pine or larch after 1 day, so the difference cannot be seen with daily readings.

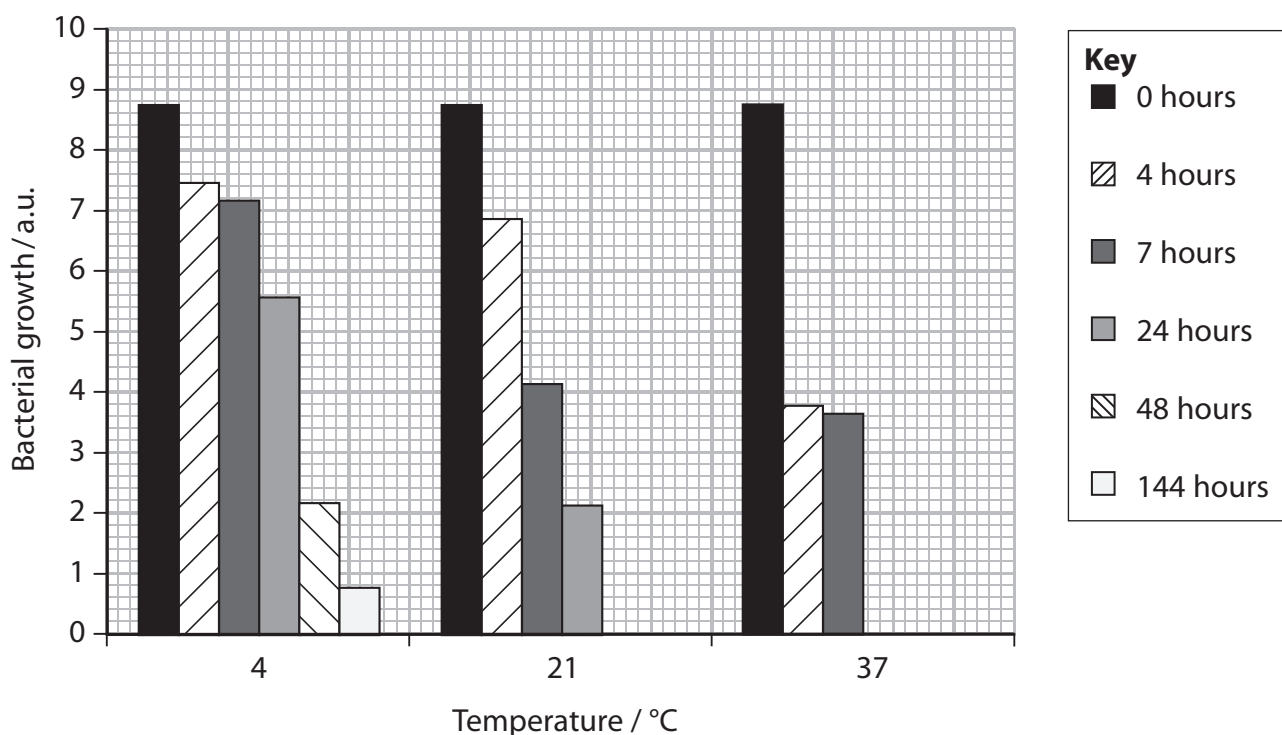
Test the woods with different bacterial cultures (different species of bacteria),

because the antimicrobial properties may vary with the type of bacteria.



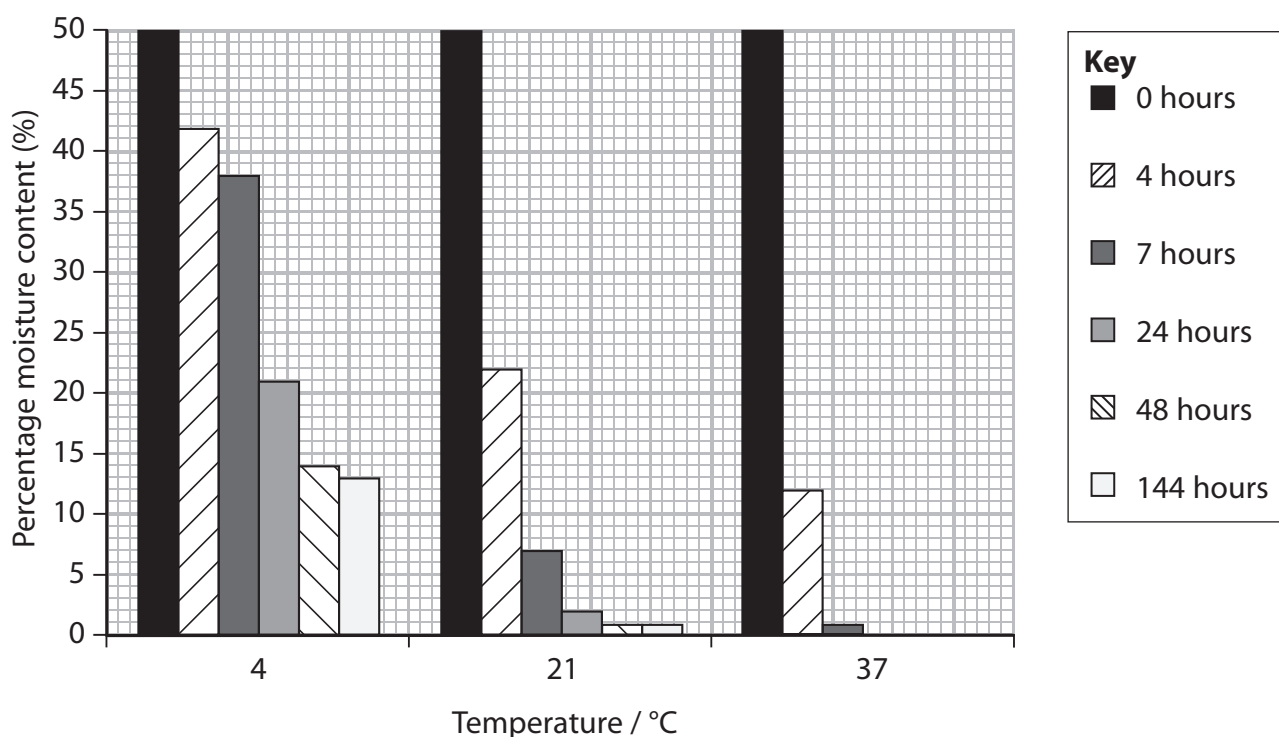
- (b) Temperature and the moisture content of wood from pine trees can affect bacterial growth.

Graph 1 shows the effect of temperature on bacterial growth.



Graph 1

Graph 2 shows the effect of temperature on the moisture content of wood.



Graph 2

Analyse the data to deduce the effects of these two factors on bacterial growth on wood from pine trees.

(4)

Graph 1 shows that bacterial growth decreases faster at higher temperatures: at 37 °C there is no growth by 24 hours, at 21 °C none by 48 hours, but at 4 °C growth is still about 0.7 a.u. after 144 hours.

Therefore the antimicrobial properties of pine are more active at higher temperatures.

Graph 2 shows that the moisture content of the wood decreases faster at higher temperatures: at 37 °C it falls to about 1% by 24 hours, but at 4 °C it is still about 13% after 144 hours.

Loss of moisture could reduce bacterial growth, as bacteria need water, or it could make the antimicrobial chemicals more concentrated.

So both higher temperature and lower moisture content reduce bacterial growth on pine wood.

(Total for Question 7 = 12 marks)



- 8 Sloths are mammals found in Central and South America.
- (a) Sloths are slow moving and use their hooked claws to hold onto branches. They sleep for over 15 hours a day. During this time, their slow metabolism processes their diet of low nutrition vegetation.



Sloths have behavioural, physiological and anatomical adaptations to their environment.

Complete the table using the information provided.

(3)

Type of adaptation	Example
Behavioural	<i>Sleeps for over 15 hours a day / slow moving</i>
Physiological	<i>Slow metabolism</i>
Anatomical	<i>Hooked claws to hold onto branches</i>



(b) Three species of sloth are described in the table.

Species	Common name	Status
<i>Bradypus pygmaeus</i>	pygmy three-toed sloth	critically endangered
<i>Choloepus didactylus</i>	Linné's two-toed sloth	least concern
<i>Choloepus hoffmanni</i>	Hoffmann's two-toed sloth	least concern

It is believed that *C. hoffmanni* and *C. didactylus* shared a common ancestor before becoming isolated on either side of the Andes mountain range.

(i) Explain why they are now classed as different species.

(2)

They are no longer able to interbreed to produce fertile offspring,

because the populations have become reproductively isolated (geographically isolated by the Andes).

(ii) Which of the following describes the term **niche** with reference to *C. hoffmanni*?

(1)

- ☐ A the area where *C. hoffmanni* is found
- ☐ B the preferred diet of *C. hoffmanni*
- ☐ C the risk of *C. hoffmanni* becoming extinct
- ☒ D the role of *C. hoffmanni* in its environment



- *(c) The map shows the distribution of two species of sloth.
There are currently two major populations of *C. hoffmanni* in South America.
B. pygmaeus is restricted to an island off the coast of Central America.
Each population occupies different habitats.



Discuss why the number of sloth species may change in the future.

(6)

The number of species may increase: the two populations of *C. hoffmanni* are geographically isolated (fragmentation of habitat), so there is no gene flow between them.

Each population occupies a different habitat, so there are different selection pressures. Natural selection favours different alleles, so different allele frequencies accumulate in the separate populations.

Over time they may become reproductively isolated, so evolution could lead to the formation of a new species (speciation).

The number of species may decrease: *B. pygmaeus* is critically endangered and there is only one population, restricted to one island.

This small population has low genetic diversity, so it is vulnerable to inbreeding depression, and at risk from a natural disaster, disease or predation, so it may become extinct.



Overall, the number of sloth species could increase if *C. hoffmanni* forms new species,
or decrease if *B. pygmaeus* becomes extinct.

(Total for Question 8 = 12 marks)

TOTAL FOR PAPER = 80 MARKS



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