* 0000800000001 *

Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

* 9 3 4 0 3 6 5 7 3 3 *

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **October/November 2024**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION
- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **24** pages.

DC (PB/CGW) 336399/4

1 Different species of animal have neurones with different characteristics.

(a) Fig. 1.1 is a diagram of a motor neurone of a rat and a motor neurone of a snail.

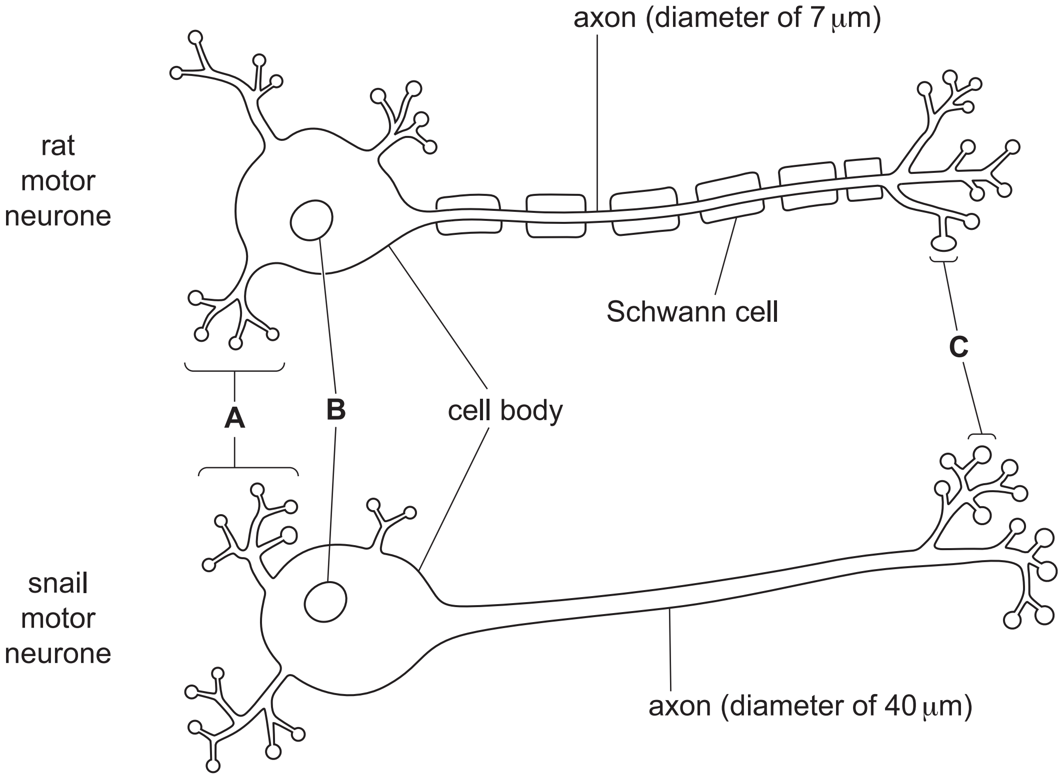

Fig. 1.1

(i) Name the structures labelled **A**, **B** and **C** on Fig. 1.1.

A ....

B ....

C ....
[3]

(ii) The rat motor neurone has an impulse transmission speed of $50\,m\,s^{-1}$. The snail motor neurone has an impulse transmission speed of $8\,m\,s^{-1}$.

Explain why the rat motor neurone has a faster impulse transmission speed than the snail motor neurone.

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(b) Fig. 1.2 shows an action potential in a rat neurone and Fig. 1.3 shows an action potential in a snail neurone.

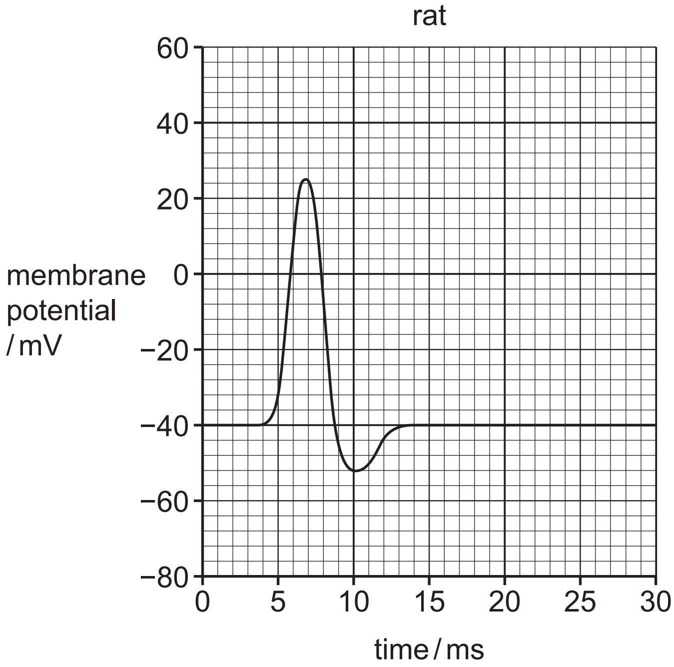

Fig. 1.2

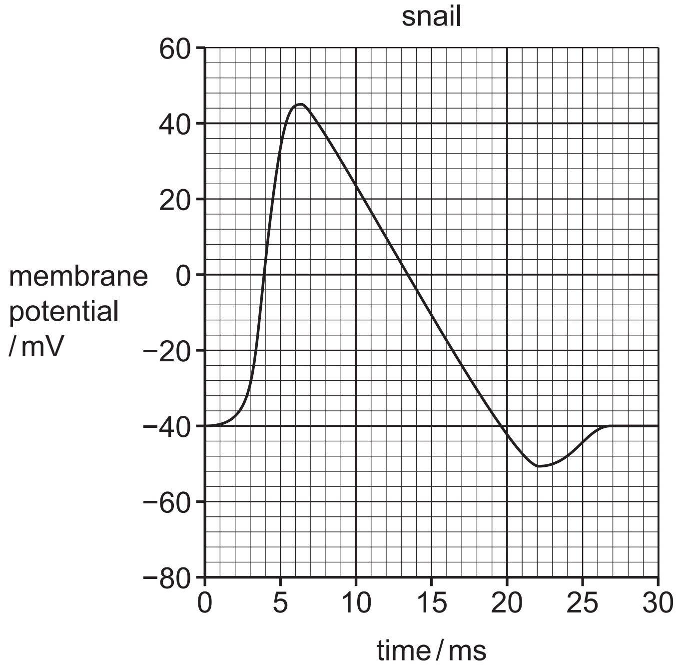

Fig. 1.3

Contrast the two action potentials shown in Fig. 1.2 and Fig. 1.3.

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.... [3]

[Total: 8]

2 The leaves of many plants have stomata that show a regular daily rhythm of opening and closing over a period of 24 hours.

(a) Explain why it is important for plants to open and close their stomata in a daily rhythm.

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.... [3]

(b) Fig. 2.1 shows the results of an experiment to monitor this rhythm over three days and nights for the plant *Arabidopsis thaliana*. The percentage of open stomata is shown. Each day consisted of 14 hours of light (white bar) and each night consisted of 10 hours of darkness (black bar).

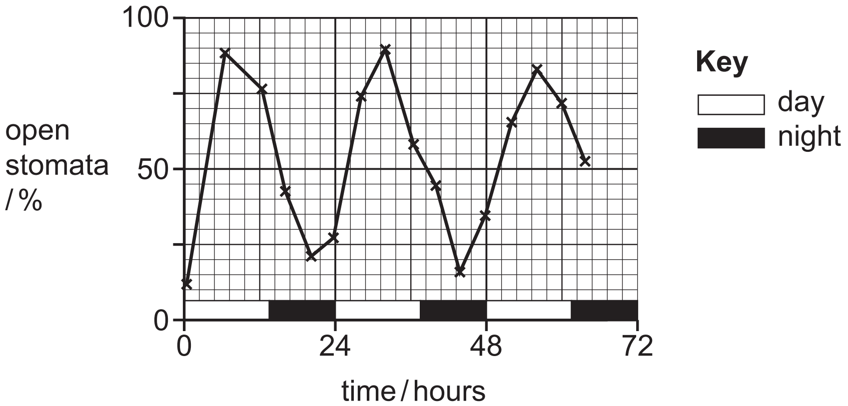

Fig. 2.1

Fig. 2.1 shows that the percentage of open stomata increases in the first seven hours of the experiment. Describe the sequence of changes that occurs in the guard cells that leads to the stomata opening.

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(c) The experiment was repeated with *A. thaliana* plants that were left in darkness from 14 to 96 hours. The results are shown in Fig. 2.2.

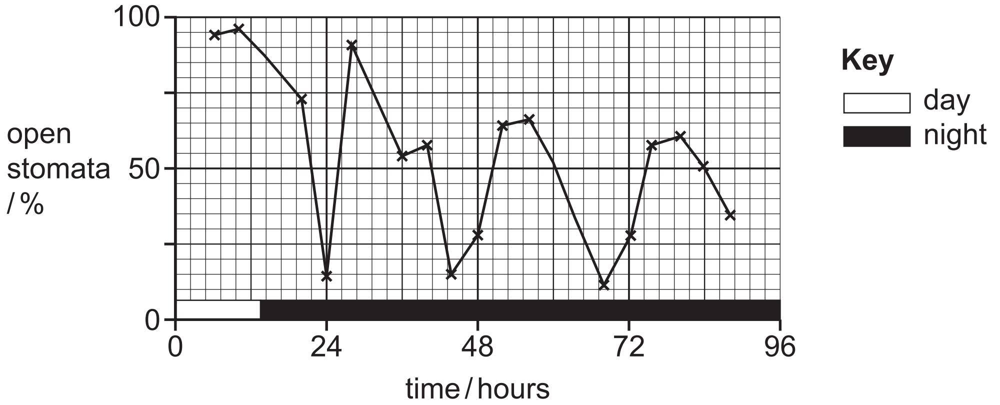

Fig. 2.2

With reference to Fig. 2.1, explain what Fig. 2.2 shows about the role of genes and the role of the environment in controlling the rhythm of stomatal opening and closing in *A. thaliana*.

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.... [2]

[Total: 11]

3 During aerobic respiration, cells respire substrates such as glucose to produce ATP.

Some events that occur during aerobic respiration are:

- The respiratory substrate breaks down into smaller and smaller molecules. These series of reactions are described as catabolism.
- Coenzymes take part in various reactions. In some reactions, coenzymes are reduced or oxidised.
- Carbon dioxide is released.

(a) Aerobic respiration occurs in four successive stages: glycolysis (**G**), link reaction (**LR**), Krebs cycle (**KC**) and oxidative phosphorylation (**OP**).

Complete Table 3.1 to show which events occur in each stage of aerobic respiration. Use a tick (✓) to show that the event does occur or a cross (✗) to show that the event does **not** occur.

Table 3.1

event	stage			
	G	**LR**	**KC**	**OP**
catabolism				
coenzyme is reduced or oxidised				
a coenzyme forms a covalent bond with a respiratory intermediate				
carbon dioxide is released				

[4]

(b) A new hand-held technological device shows the main type of respiratory substrate being used in the cells of a person.

The device consists of a carbon dioxide sensor and air-flow meter. The person inhales through the device for a fixed time and then exhales into it.

The device calculates the respiratory quotient (RQ) value to show whether the cells are mainly respiring carbohydrates or lipids.

(i) Explain how the device calculates the RQ value **and** how this shows whether the cells are mainly respiring carbohydrates or lipids.

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(ii) State the difference in the relative energy values of carbohydrates and lipids as respiratory substrates, **and** explain the reasons for the difference.

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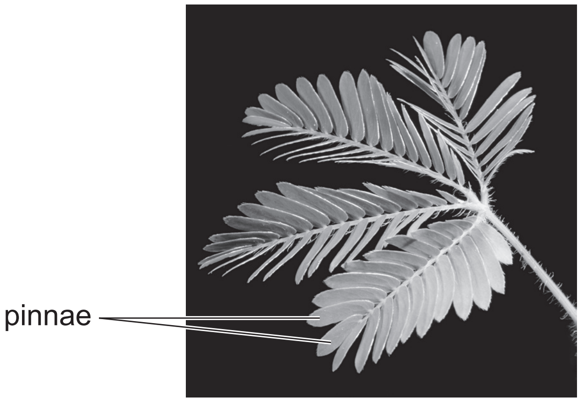
[Total: 11]

4 The leaves of *Mimosa pudica* plants are made of a number of structures known as pinnae. The pinnae fold when the leaf is touched. This closes the leaf.

Fig. 4.1 shows an open leaf of *M. pudica* before it is touched. Fig. 4.2 shows the same leaf that has closed after being touched.



A open (not touched)

Fig. 4.1

B closed (touched)

Fig. 4.2

(a) A touch stimulus to an *M. pudica* leaf causes an action potential to be generated.

The action potential results in changes in cells, which cause the leaf to close.

Fig. 4.3 shows the mechanism in *M. pudica* cells that causes the leaf to close.

action potential after touch stimulus ⇨ protons pumped into extensor cells ⇨ Cl^- and K^+ ions move out of cells ⇨ water moves out of cells by osmosis ⇨ cells become flaccid

Fig. 4.3

The leaves of *M. pudica* and the leaves of Venus fly traps move in response to touch stimuli, but the mechanisms that cause the responses are different.

Describe the differences between the mechanism shown in Fig. 4.3 and the mechanism that causes the closure of the modified leaves in Venus fly traps.

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.... [3]

(b) The rate of photosynthesis decreases by 40% when the leaves of *M. pudica* close.

Explain why the rate of photosynthesis decreases when the leaves of *M. pudica* close.

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(c) Plants can carry out cyclic photophosphorylation and non-cyclic photophosphorylation during the light-dependent stage of photosynthesis. These processes occur at the grana of chloroplasts.

Outline the similarities **and** differences between cyclic photophosphorylation and non-cyclic photophosphorylation.

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[Total: 11]

5 *Lunularia cruciata* is a primitive plant. Its body consists of a flattened sheet of photosynthetic tissue called a thallus.

Fig. 5.1 shows *L. cruciata* with two different types of reproductive structure, labelled **A** and **B**, on its surface.

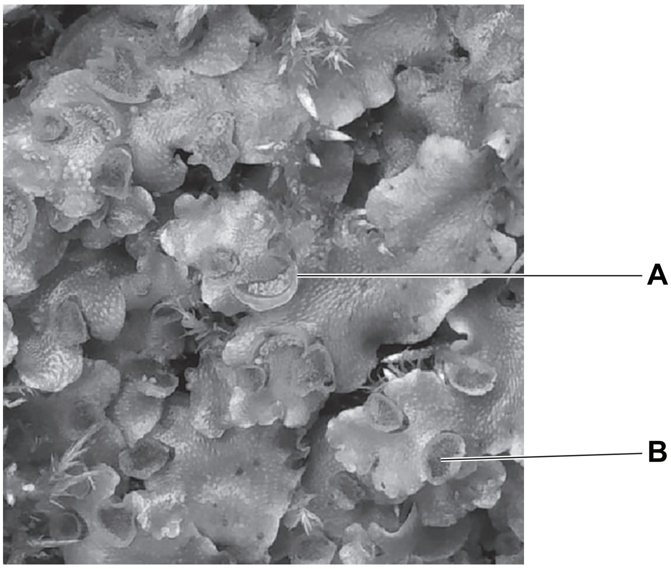

Fig. 5.1

(a) Structures **A** and **B** and the thallus of *L. cruciata* are haploid.

Explain what is meant by haploid.

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.... [2]

(b) Structure **A** contains pale discs of tissue, **C**, that can germinate into new *L. cruciata.* The new plants that develop from **C** are genetically identical to the parent plant in Fig. 5.1.

Structure **B** contains male sperm that are chemically attracted to swim to female eggs on a neighbouring parent plant. When the egg and sperm fuse, they form structure **D**. Structure **D** develops to produce spores that grow into new plants that are genetically different from the two parent plants.

Identify which of the structures **A**, **B**, **C** and **D** are:

associated with sexual reproduction ....

produced by mitosis ....

the site of meiosis ....

Each letter may be used once, more than once, or not at all. [3]

(c) Fig. 5.2 shows a horse, *Equus caballus*. Horses are diploid animals that reproduce sexually. Male and female horses produce gametes, which fuse to form genetically different offspring.

Fig. 5.2

Explain the need for a reduction division during meiosis in the production of gametes in animals such as horses.

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.... [3]

[Total: 8]

6 The mammalian kidney is responsible for:

- the excretion of urea
- osmoregulation (the homeostatic control of the water potential of the blood).

(a) **(i)** Outline how **and** where the excretory product urea is made in the body.

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.... [2]

(ii) Homeostatic control of the water potential of blood includes receptors, effectors and target cells.

Identify the names **and** locations of these components of homeostatic control in osmoregulation.

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.... [3]

(b) The glomerulus and Bowman's capsule of the nephron are important in the formation of urine.

Outline the role of the glomerulus and Bowman's capsule in the formation of urine.

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.... [3]

(c) Concentrated urine contains a high concentration of solutes and a small volume of water. Different species of mammals vary in their ability to produce urine with a high solute concentration.

Table 6.1 compares the ratio of the solute concentration of urine (U) to the solute concentration of blood plasma (P) in some mammal species. The habitats of the mammal species are also shown.

Table 6.1

mammal species	maximum ratio of solute concentration of urine to solute concentration of blood plasma (U : P)	habitat
beaver	1.7 : 1	rivers and lakes
human	4.5 : 1	variable
camel	8.0 : 1	desert
rat	9.0 : 1	variable
kangaroo rat	16.0 : 1	desert

With reference to Table 6.1, suggest what the different values of U : P show about the ability of these mammal species to tolerate a shortage of water in their environment.

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.... [3]

[Total: 11]

7 *Spea multiplicata* is one of several species of American spadefoot toad.

(a) Young spadefoot toads are called tadpoles and live in water in ponds.

S. multiplicata tadpoles show three different phenotypes due to genetic variation. The three phenotypes are: detritus feeder, intermediate and carnivore.

Detritus feeders are small, and carnivores are large. Intermediates vary in size between the two extremes.

A detritus feeder and a carnivore are shown in Fig. 7.1.

Fig. 7.1

Detritus feeders:

- eat detritus (small pieces of dead organic matter) and algae (photosynthetic protoctists)
- have smooth mouthparts, small jaw muscles and long intestines.

Intermediates:

- can eat all available food (detritus, algae and fairy shrimps)
- have teeth-like mouthparts, medium-sized jaw muscles and medium-sized intestines.

Carnivores:

- eat fairy shrimps and other small animals
- have teeth-like mouthparts, large jaw muscles and short intestines.

Scientists counted the number of each type of tadpole in two different ponds: pond 1 and pond 2.

(i) In pond 1, the scientists observed:

- a high density of tadpoles
- a low abundance of food
- that most of the tadpoles they counted were either detritus feeders or carnivores, with very few intermediates present.

Describe **and** suggest explanations for the type of natural selection that appears to be acting in pond 1.

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.... [3]

(ii) In pond 2, the scientists observed:

- a low density of tadpoles
- sufficient food availability for all tadpoles
- that most of the tadpoles they counted were intermediates, with fewer detritus feeders or carnivores.

Describe **and** suggest explanations for the type of natural selection that appears to be acting in pond 2.

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(iii) The intestine length of *S. multiplicata* tadpoles shows continuous variation.

Sketch a curve on Fig. 7.2 to show how intestine length varies in the tadpole population in **pond 2**.

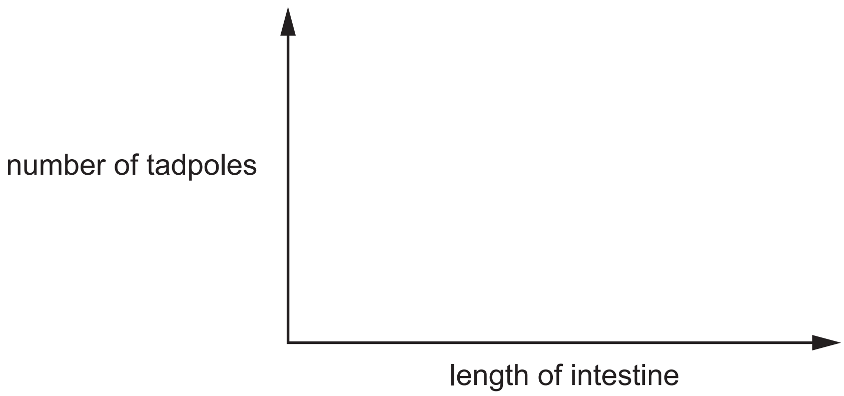

Fig. 7.2

[1]

(iv) A student suggested that the variation in *S. multiplicata* tadpoles could lead to sympatric speciation in some populations.

Outline the features of sympatric speciation.

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(b) Fig. 7.3 shows the evolutionary relationships between three species of American spadefoot toad.

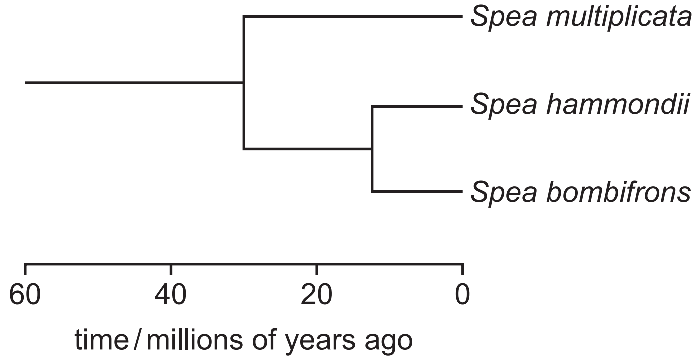

Fig. 7.3

Explain how analysis of DNA allowed the evolutionary relationships shown in Fig. 7.3 to be determined.

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[Total: 12]

8 Scientists use many different techniques in genetic engineering.

(a) Sometimes the gene for genetic engineering cannot be extracted from the donor organism. Instead, the gene is synthesised using one of two different methods.

Outline the **two** methods for synthesising a gene for use in genetic engineering.

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.... [3]

(b) DNA ligase and DNA polymerase are two enzymes that are used in genetic engineering.

Complete Table 8.1 to show the roles of DNA ligase and DNA polymerase in genetic engineering.

Use a tick (✓) if the enzyme has the role or a cross (✗) if the enzyme does **not** have the role.

Table 8.1

role in genetic engineering	DNA ligase	DNA polymerase
joins two sections of sugar phosphate backbone in DNA		
adds a gene to a plasmid		
adds free activated DNA nucleotides to a polynucleotide		

[3]

(c) The polymerase chain reaction (PCR) is used to make many copies of a gene.

Three temperatures are used in a PCR cycle.

State the three temperatures that are used, **and** outline what happens at each temperature during a PCR cycle.

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.... [3]

[Total: 9]

9 Lichens are found growing on trees, walls, rocks and soil.

Fig. 9.1 shows a lichen of the genus *Usnea*. *Usnea* can tolerate only low concentrations of sulfur dioxide and does not grow in places where the air is polluted with sulfur dioxide.

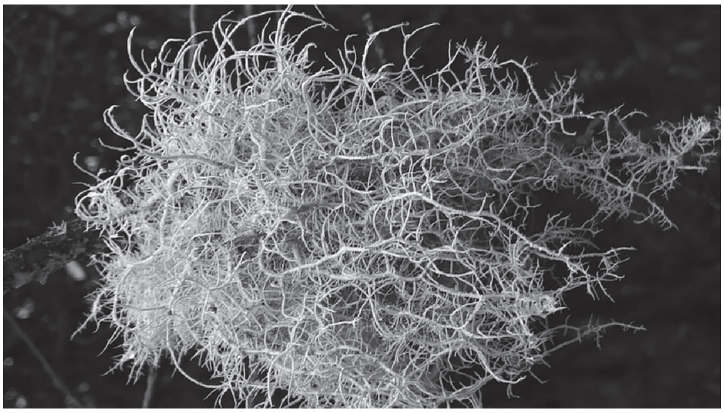

Fig. 9.1

Usnea is composed of a mixture of two types of cell:

- photosynthetic cells that are classified in the kingdom Protoctista
- fungal cells that are classified in the kingdom Fungi.

(a) Outline the characteristic features of the kingdoms Protoctista and Fungi.

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.... [4]

(b) *Xanthoria* is a lichen that can grow in places where there is a high concentration of sulfur dioxide in the air, for example in towns where homes, factories and vehicles burn fuels.

Fig. 9.2 shows a lichen of the genus *Xanthoria*.

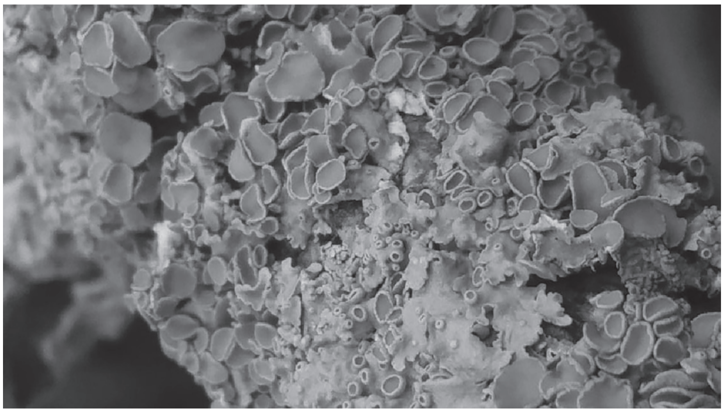

Fig. 9.2

(i) A student planned a method to measure the relative abundance of *Usnea* and *Xanthoria* on trees along a transect from the town centre at 0 km to unpolluted countryside at 4 km.

Suggest why measuring the relative abundance of the two types of lichen gives information that is useful for conservation.

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(ii) Although a large biodiversity of lichens can be found in a range of habitats, most people ignore them.

Outline why forms of life that are usually ignored, such as lichens, should be conserved.

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.... [2]

[Total: 9]

10 Populations of the moth *Biston betularia* live in Europe and in North America. The most common phenotype on both continents is a pale wing colour with light-grey shading (the typical form).

A moth phenotype with dark wing colour (the melanic form) also occurs on both continents.

Fig. 10.1 shows the typical form of the moth.

Fig. 10.2 shows the melanic form of the moth.

Fig. 10.1

Fig. 10.2

(a) Two melanic European moths were crossed together. The wing colours of the offspring were 15 typical and 41 melanic.

Construct a genetic diagram to explain these results. You may use the symbols **A** and **a** to represent the alleles.

[3]

(b) In a similar experiment, two melanic North American moths were crossed together. The colours of the offspring were 10 typical and 31 melanic.

What can be concluded about the allele that causes the melanic form in the moth populations in **both** continents?

.... [1]

(c) Researchers did not know if the allele causing the melanic form in European moths occurred at the same locus as the allele causing the melanic form in North American moths. To find out, they carried out the following crosses:

- Cross 1: European moths that were heterozygous at the European melanic locus only were crossed with North American moths that were heterozygous at the North American melanic locus only.
- Cross 2: The melanic and the typical offspring of cross 1 were mated together.

(i) Explain why cross 2 is a test cross.

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.... [1]

(ii) Complete Table 10.1 to show the predicted results if:

- the European and North American melanic alleles are on **the same locus (A/a)**
- the European and North American melanic alleles are on two **different loci (A/a and B/b)**.

Table 10.1

	same locus (A/a)	**different loci (A/a and B/b)**
genotypes of **melanic** moths from cross 1		
proportion of test crosses (cross 2) giving 100% melanic offspring		

[3]

(d) A light trap was used to estimate the total size of a population of *B. betularia* in a woodland. On night one, 24 moths were captured. These were marked with a small spot of harmless paint. On night two, 29 moths were captured, and 8 of these showed a spot of paint.

Use the Lincoln index formula provided to calculate the size of the population.

Show your working.

$$N = \frac{n_1 \times n_2}{m_2}$$

Key to symbols:
N = estimate of population size
n_1 = number of individuals captured in first sample
n_2 = number of individuals (both marked and unmarked) captured in second sample
m_2 = number of marked individuals recaptured in second sample

population size = ... [2]

[Total: 10]