Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

2714028291

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2022**

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. Any blank pages are indicated.

1 **(a)** The golden mantella, *Mantella aurantiaca*, is a small terrestrial frog found in Madagascar.

Fig. 1.1 shows a golden mantella.

Fig. 1.1

(i) Name the domain and kingdom to which the golden mantella belongs.

domain .....

kingdom .....
[2]

(ii) The skin of the golden mantella is brightly coloured and contains a toxin.

Suggest a benefit to the frog of being brightly coloured.

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..... [1]

(b) The toxin in the skin of the golden mantella affects the action of the sarcomeres in muscle fibres (muscle cells) of mammalian striated muscle. The toxin inhibits a protein, Ca^{2+}ATPase, found in the membrane of the sarcoplasmic reticulum.

Ca^{2+}ATPase pumps calcium ions from the cytoplasm into the sarcoplasmic reticulum when the fibre is no longer stimulated.

Suggest the consequences to the sarcomere of the action of the golden mantella toxin.

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(c) Describe the role of calcium ions in a cholinergic synapse.

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[Total: 9]

2 **(a)** In eukaryotes, the cells of plants and photosynthetic protoctists contain chloroplasts.

Describe the relationship between the function of a chloroplast and its structure.

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(b) Outline the main features of cyclic photophosphorylation.

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(c) Red algae are aquatic protoctists that are multicellular. The cells of red algae have chloroplasts containing photosynthetic pigments. Many red algae live in deep water.

Two of the accessory pigments of red algae chloroplasts are:
- phycoerythrin (appears red), often present in large concentrations
- phycocyanin (appears blue).

The first few metres of water nearest the surface absorb the red wavelengths of light. If the water also contains particles of organic material it absorbs blue wavelengths.

Fig. 2.1 shows absorption spectra of some pigments in red algae chloroplasts.

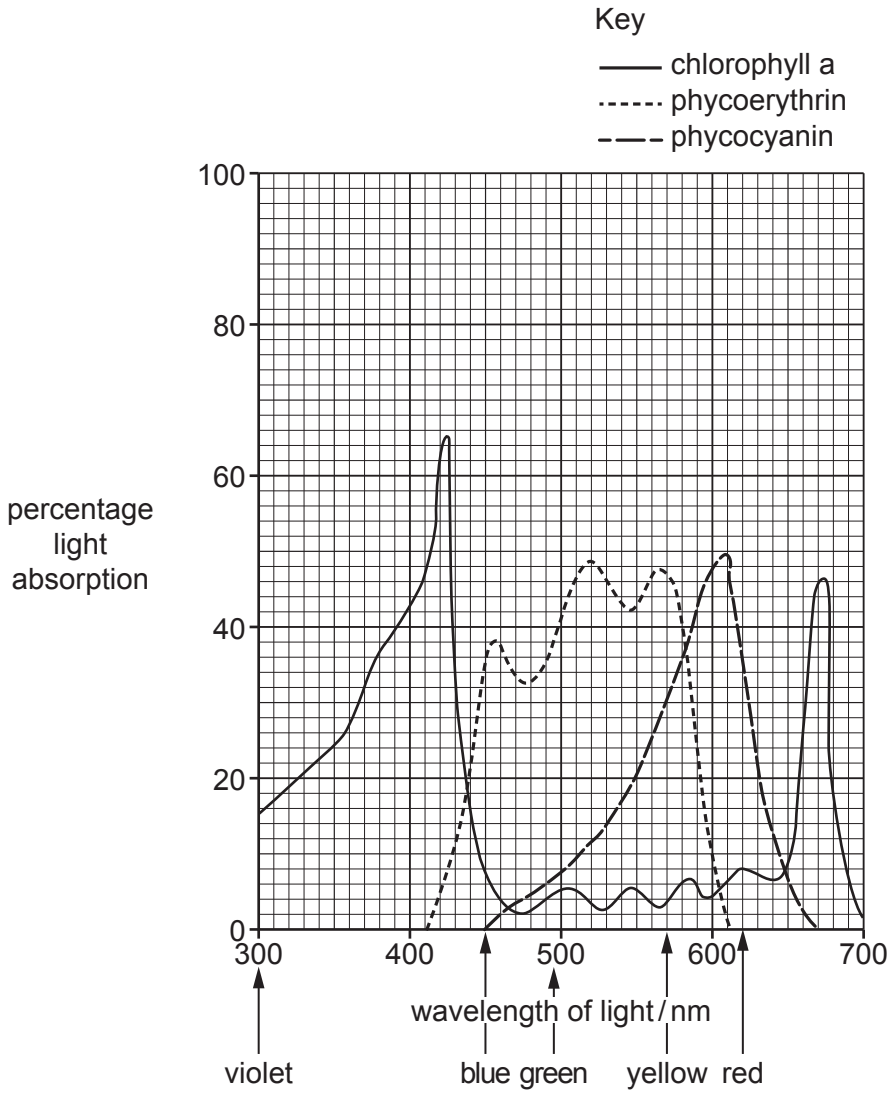

Fig. 2.1

Describe the differences in the absorption spectra of the three photosynthetic pigments shown in Fig. 2.1 **and** explain how these differences help red algae to survive in deep water.

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[Total: 14]

3 Respiration is a process that results in the synthesis of ATP. The ATP can be used within the cell for energy-requiring reactions and processes.

There are four stages in aerobic respiration: glycolysis, the link reaction, the Krebs cycle and oxidative phosphorylation.

(a) The ATP synthesised in respiration can be used to make larger and more complex biological molecules from smaller molecules.

Name the type of reaction that occurs when larger more complex biological molecules are made from smaller molecules.

..... [1]

(b) The first part of glycolysis uses ATP.

Explain why ATP is needed in the first part of glycolysis.

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..... [2]

(c) State the precise locations of substrate-linked phosphorylation reactions in aerobic respiration.

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..... [1]

(d) Explain what happens to pyruvate in the link reaction in aerobic respiration.

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..... [2]

(e) Chemiosmosis is a process that occurs in mitochondria during aerobic respiration and in chloroplasts during photosynthesis.

Describe the differences between the process of chemiosmosis in mitochondria and the process of chemiosmosis in chloroplasts.

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..... [3]

[Total: 9]

4 In 1973 a technique for genetic engineering was used for the first time. Recombinant DNA was made using a plasmid and this was successfully transferred into an organism.

In 2012 a new technique for genetic engineering, called gene editing, was developed.

(a) Table 4.1 lists some statements about the two genetic engineering techniques.

Complete Table 4.1 to compare the original genetic engineering technique using a plasmid vector with the newer technique of gene editing. For each row, place a tick (✓) in the correct column if the statement applies and leave a blank if the statement does not apply.

Table 4.1

statement	genetic engineering using a plasmid	gene editing
It can produce a transgenic organism.		
It can modify the characteristics of an organism.		
It can delete unwanted DNA.		
It uses an enzyme that cuts DNA.		
It can use RNA to precisely locate the target gene.		

[5]

(b) Orange trees, *Citrus sinensis*, produce fruits that are an important food crop. The functional leaf area of orange trees may be reduced by the growth of citrus canker bacteria. These bacteria cause citrus canker disease.

Scientists used gene editing to develop two types of orange tree with different mutations (changes to the DNA). The mutant orange tree leaves showed resistance to citrus canker disease.

Fig. 4.1 shows the area of leaf with citrus canker disease in wild type (not gene edited) and gene edited orange tree leaves after they have been exposed to citrus canker bacteria.

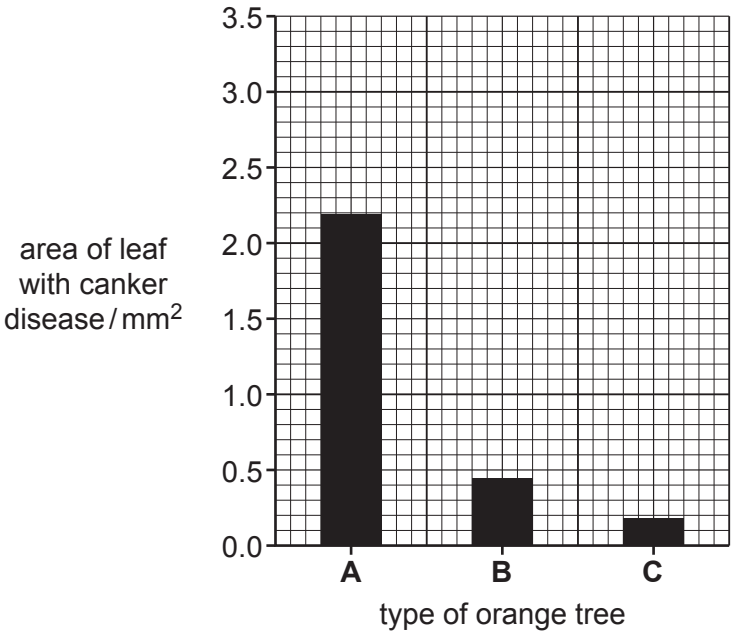

Fig. 4.1

(i) Identify the letter that represents the wild type orange trees on Fig. 4.1.

..... [1]

(ii) Explain the social benefits of this example of gene editing.

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..... [3]

[Total: 9]

5 Two subspecies of reindeer, *Rangifer tarandus*, live in North America. Members of the different subspecies belong to the same species but have some morphological differences and are found in different geographical locations.

Fig. 5.1 shows a reindeer.

Fig. 5.1

Table 5.1 compares the features of the two North American reindeer subspecies.

Table 5.1

feature	**woodland subspecies, *R. tarandus caribou***	**barren ground subspecies, *R. tarandus groenlandicus***
habitat	southern woodland (warmer)	northern tundra (colder)
type of food	tree leaves, grass	lichens, moss
summer and winter feeding grounds overlap	yes	no
carry out long migrations	no	yes
body size	large	small
colour of fur	dark	light

(a) During the last ice age an ice sheet separated southern and northern populations of *R. tarandus* in North America.

Explain how this ice sheet affected the evolution of *R. tarandus* to result in the two different subspecies.

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..... [4]

(b) Assess the relative importance of natural selection and genetic drift in producing:

(i) the different colours of fur of the two subspecies of reindeer

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..... [2]

(ii) the different body sizes of the two subspecies of reindeer.

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..... [2]

(c) Hybridisation has occurred between individuals of the two subspecies which now live in the area previously covered by the ice sheet.

Comment on how the hybrid populations compare to the pure subspecies in terms of genetic variation and potential to adapt to climate change.

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(d) Outline how practical techniques could be used to test the hypothesis that migratory behaviour in reindeer has a genetic basis.

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[Total: 14]

6 **(a)** In mammals, the blood glucose concentration must be maintained within narrow limits so that the body cells can function efficiently.

Name the mechanism by which the blood glucose concentration is maintained within narrow limits.

..... [1]

(b) Glucagon is released by the alpha (α) cells of the pancreas when the blood glucose concentration decreases below the set point.

Fig. 6.1 outlines the response of liver cells to glucagon.

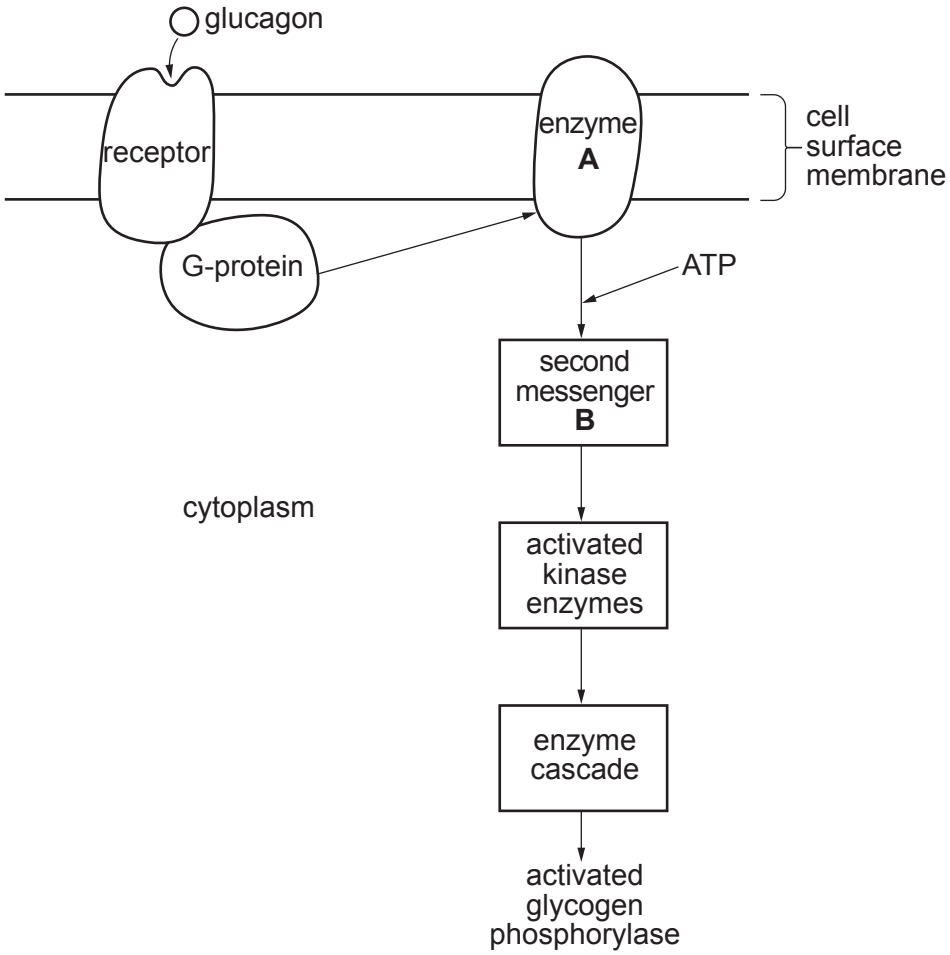

Fig. 6.1

(i) State how glucagon reaches the liver cells.

..... [1]

(ii) With reference to Fig. 6.1, name enzyme **A** and second messenger **B**.

A .....

B .....
[2]

(iii) State the role of the enzyme cascade.

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..... [1]

(iv) State the function of the final enzyme in the pathway, glycogen phosphorylase.

..... [1]

(c) A biosensor is used to measure blood glucose concentration to check that it is within the normal range.

Describe how a glucose biosensor works.

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..... [4]

[Total: 10]

7 **(a)** The fruit fly, *Drosophila melanogaster*, usually has red eyes. A gene for eye colour has four alleles: red, apricot, honey and white.

Define the terms *gene* and *allele*.

gene .....

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allele .....

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[2]

(b)
- The allele for red eyes, $\mathbf{C^R}$, is dominant to the other three alleles.
- The allele for apricot eyes, $\mathbf{C^A}$, is dominant to the allele for honey eyes, $\mathbf{C^H}$.
- The allele for white eyes, $\mathbf{C^W}$, is recessive to the other three alleles.

Construct a genetic diagram to show the genotypes, phenotypes and ratio of the offspring from a cross between a fruit fly with red eyes, $\mathbf{C^RC^H}$, and a fruit fly with apricot eyes, $\mathbf{C^AC^W}$.

parents phenotypes	red eyes	apricot eyes
parents genotypes	$\mathbf{C^RC^H}$	$\mathbf{C^AC^W}$
gametes		
offspring genotypes		
offspring phenotypes		
ratio		

[3]

(c) Describe how you would carry out a test cross **and** use it to determine the genotype of a red-eyed fruit fly.

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..... [3]

[Total: 8]

8 **(a)** Over the past 200 years, many species of animals and plants have become extinct.

Fig. 8.1 shows the changes between the years 1800 and 2000 in:
- the number of species becoming extinct
- the size of the world human population.

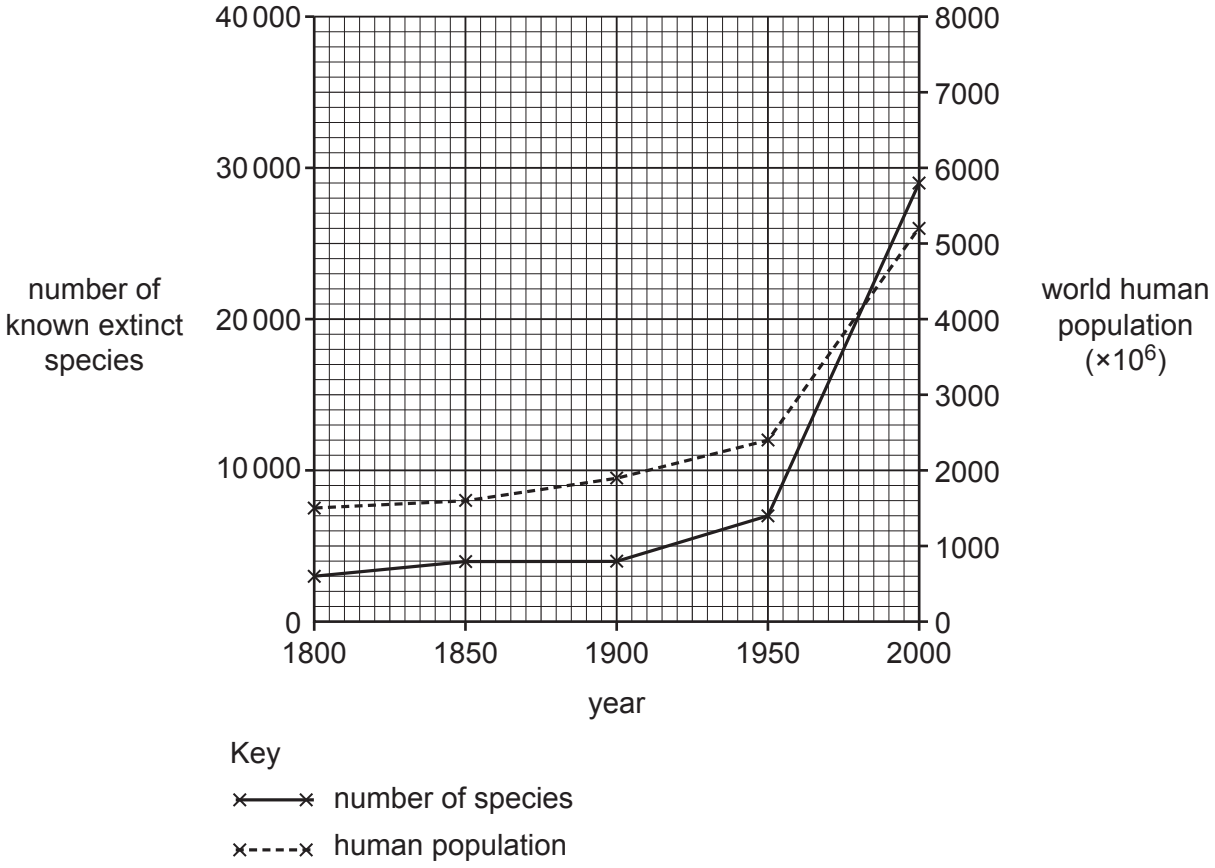

Fig. 8.1

(i) It has been suggested that there is a correlation between the number of species becoming extinct and the size of the world human population.

Suggest reasons for this possible correlation.

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(ii) Calculate the rate of species extinction per year between 1950 and 2000.

Show your working.

answer = ... [2]

(b) Extinction of animal and plant species reduces biodiversity.

Explain why it is important to maintain biodiversity.

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[Total:12]

9 (a) Stomata are involved in both transpiration and photosynthesis in plants.

Fig. 9.1 is a diagram of an open stoma, its guard cells and surrounding epidermal cells.

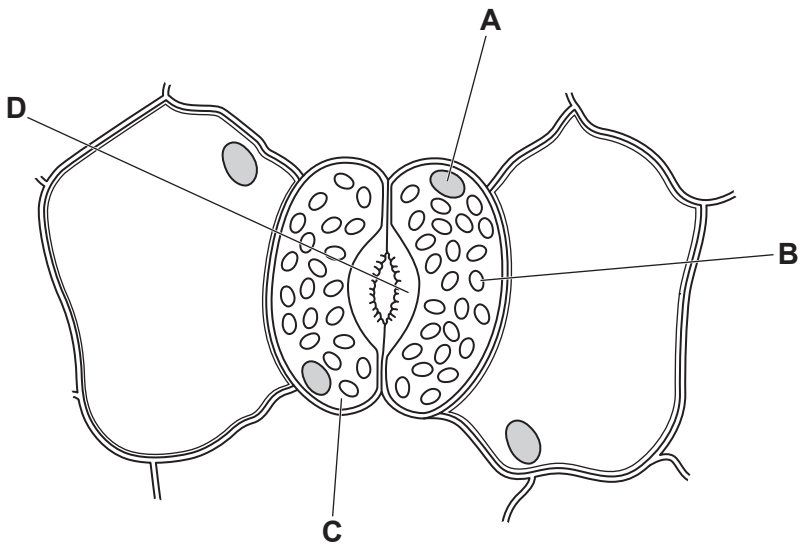

Fig. 9.1

Complete Table 9.1 by choosing the correct letter from Fig. 9.1 to match the feature stated in Table 9.1.

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

Table 9.1

letter	feature
.....	location of Calvin cycle
.....	made mainly of cellulose

[2]

(b) The opening and closing of stomata are due to changes in environmental conditions. Hydrogen ions (H^+) and potassium ions (K^+) are involved in the opening of stomata.

Describe how hydrogen ions and potassium ions are involved in the opening of a stoma.

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[Total: 6]

10 (a) Motor neurones and sensory neurones have different roles in nervous coordination.

Contrast the structure **and** function of sensory neurones and motor neurones.

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..... [3]

(b) Mammals have many types of neurones, which vary in axon diameter and myelination.

Table 10.1 shows the axon diameter and mean impulse transmission speed of four different types of mammalian neurone.

Table 10.1

neurone type	myelination	mean axon diameter / μm	mean impulse transmission speed / m s^{-1}
motor α	✓	13.0–20.0	80–120
motor β	✓	6.0–12.0	35–75
motor δ	✓	1.0–5.0	5–35
motor C	✗	0.2–1.5	0.5–2.0

Using the data shown in Table 10.1, comment on the relationship between:
- myelination and mean impulse transmission speed
- axon diameter and mean impulse transmission speed.

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(c) Fig. 10.1 is a graph of an action potential in a mammalian neurone.

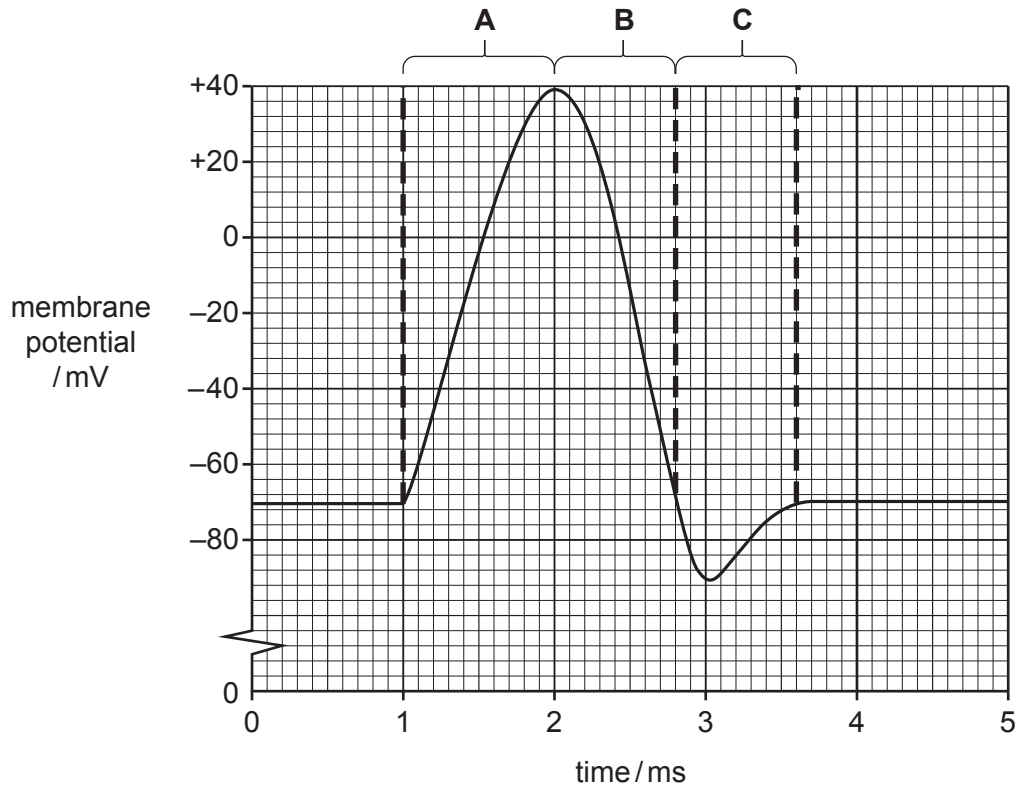

Fig. 10.1

With reference to Fig. 10.1 suggest why:

- no further action potential can occur during **A** and **B**
- it is difficult for a further action potential to occur during **C**.

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..... [3]

[Total: 9]

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