Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 2025**

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.

[Turn over

1 Fig. 1.1 is a diagram of part of a liver cell.

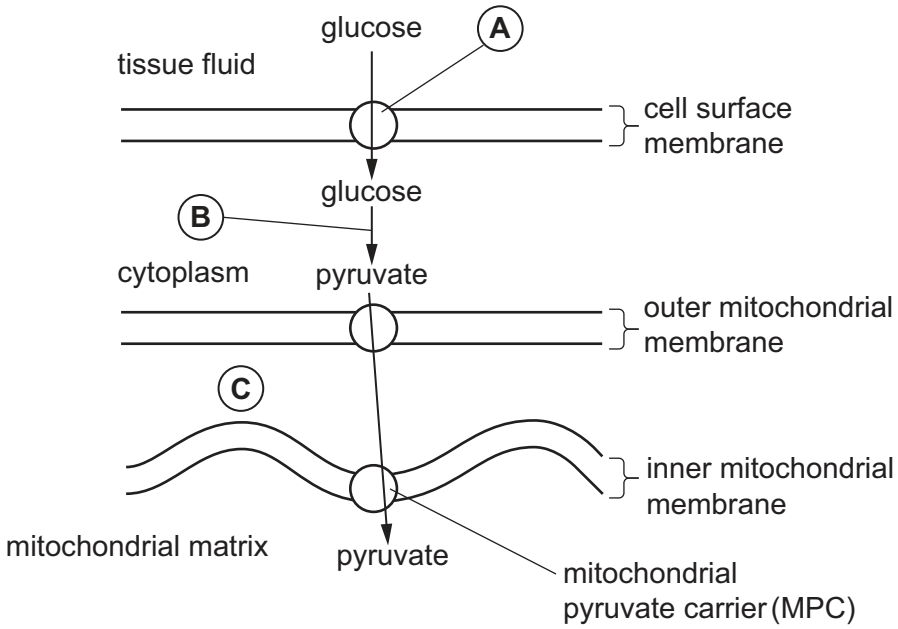

Fig. 1.1

(a) With reference to Fig. 1.1, name:

the type of membrane transport protein represented by **A** .....

process **B** .....

area **C** .....

[3]

(b) The mitochondrial pyruvate carrier (MPC), shown in Fig. 1.1, allows the passage of pyruvate into the mitochondrial matrix. When pyruvate enters the mitochondrial matrix, it takes part in the link reaction.

Describe the link reaction.

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(c) Some tumour cells have a greatly reduced ability to transport pyruvate into the matrix of the mitochondrion.

Suggest how a reduction in pyruvate transport could affect respiration in these tumour cells.

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[Total: 10]

2 Natural selection and selective breeding (artificial selection) are processes that result in changes in the gene pool of a population.

Natural selection and selective breeding have implications for humans.

(a) If a person with a bacterial infection does not finish the course of an antibiotic given, it provides the conditions for a population of bacteria to become resistant to this antibiotic.

(i) A mutation in a bacterial gene can give resistance to an antibiotic. Directional selection can occur when the antibiotic is present in the environment.

A bacterium can also gain resistance when it receives genetic material from another bacterium in a process known as horizontal gene transfer.

Outline how directional selection and horizontal gene transfer result in a new population of bacteria that is resistant to an antibiotic.

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(ii) Some bacterial diseases can be treated only with one antibiotic, because the bacterial pathogens are resistant to all other antibiotics.

A drug is being developed to help treatment.

- The drug is a small polynucleotide.
- The drug inhibits translation of the messenger RNA (mRNA) produced by transcription of the gene associated with antibiotic resistance.
- The bacteria are then susceptible to more antibiotics.

Suggest **and** explain how the drug could cause bacteria to become susceptible to more antibiotics.

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(b) (i) Outline how natural selection differs from selective breeding.

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(ii) Selective breeding is used to produce uniform varieties of maize. The maize plants in a crop ripen at the same time and are the same height. The advantage of this is that harvesting is easy and quick. The disadvantage is that farmers must buy new seeds each year.

Explain why farmers must buy new seeds each year.

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[Total: 11]

3 An operon is a section of DNA found in prokaryotes.

(a) Explain why the enzymes coded for by the *lac* operon are described as inducible enzymes.

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(b) An investigation into the induction and action of the *lac* operon was carried out using the bacterium, *Escherichia coli*, grown in a growth medium containing glucose.

When the bacteria had used all the glucose, an excess of lactose was added to the growth medium. The activity of β-galactosidase was measured from this time (0 min), as shown in Fig. 3.1.

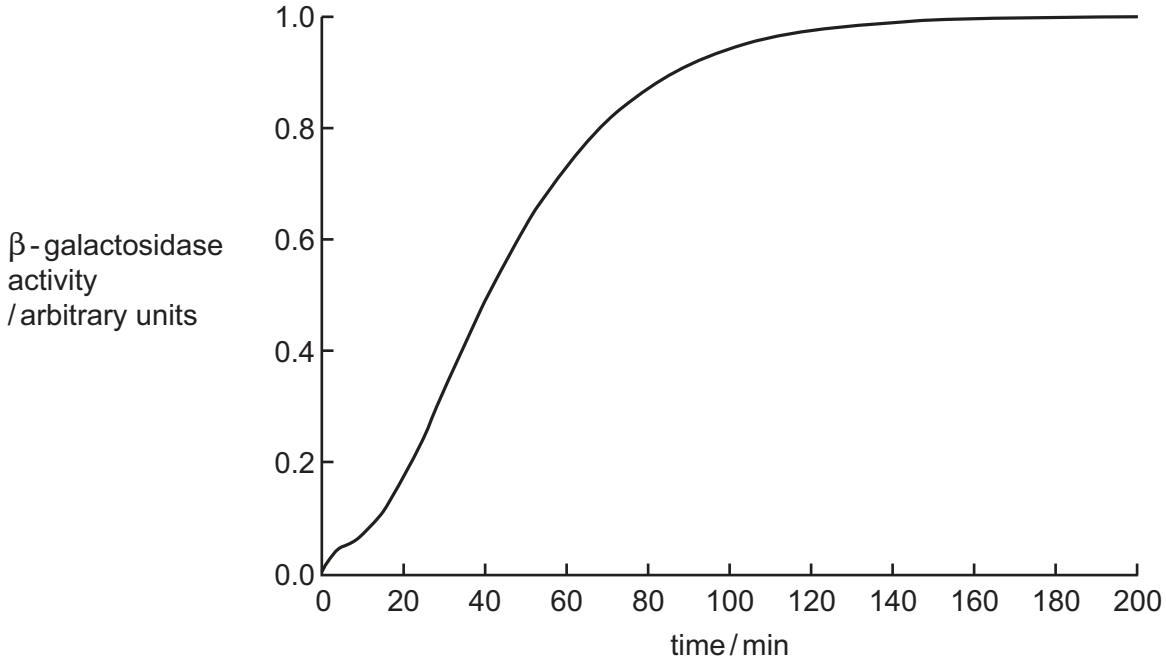

Fig. 3.1

With reference to the *lac* operon, explain the shape of the curve in Fig. 3.1.

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[Total: 9]

4 The Grand Canyon is located in Arizona, USA. It is estimated to have formed over five million years ago as the Colorado River began to create a deep channel (canyon) in the surrounding rocks.

Before the canyon formed, an ancestral species of antelope squirrel lived in the area. An antelope squirrel is a type of rodent and member of the squirrel family, Sciuridae.

It is estimated that around 3.6 million years ago, an ancestral species diverged into the two species that are present today.

- Harris's antelope squirrel, *Ammospermophilus harrisii*, has its habitat range extending from the south rim of the canyon.
- The white-tailed antelope squirrel, *Ammospermophilus leucurus*, has its habitat range extending from the north rim of the canyon.

Fig. 4.1 shows the location of the Colorado River in the Grand Canyon and the location of these species of antelope squirrel.

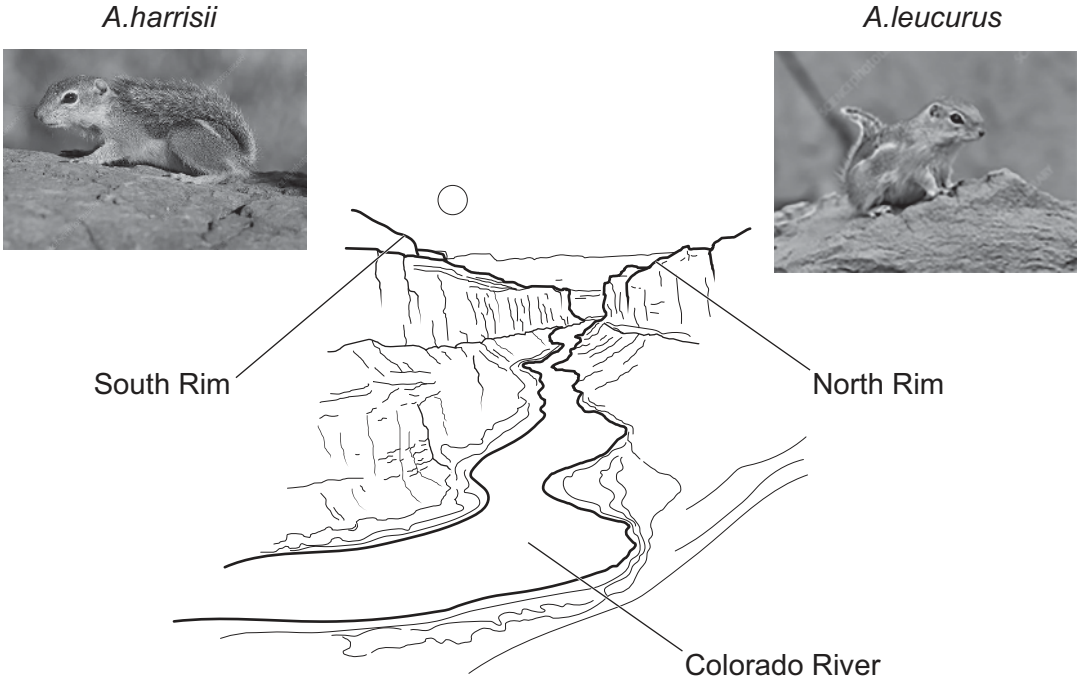

Fig. 4.1

(a) Suggest **and** explain how *A. harrisii* and *A. leucurus* evolved from an ancestral species.

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(b) Scientists investigated the evolutionary relationships of the squirrel family, Sciuridae. The scientists took samples from the current species in the family and carried out DNA sequencing and morphological analysis.

To compare current species with species from the past:
- specimens from museums were used to provide the tissue for DNA sequencing
- teeth and skulls from fossils were compared as part of the morphological analysis.

Describe the advantages of using DNA sequencing rather than morphological analysis to find out more about the evolutionary relationships of the squirrel family.

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(c) The estimate for the date that an ancestral species diverged into *A. harrisii* and *A. leucurus* is 3.58 million years ago. This estimate has a large uncertainty.

DNA sequencing, including DNA from fossils, was used to estimate this date of divergence.

Suggest a reason why there is such a large uncertainty for this date estimate.

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[Total: 8]

5 Recombinant DNA technology is used to make recombinant human proteins.

Two of the available methods to obtain the gene of interest are:
- cutting the gene out of genomic DNA using restriction enzymes
- obtaining messenger RNA (mRNA) from cells that are expressing the gene and then using reverse transcriptase to make complementary DNA (cDNA).

Plasmids can be used as vectors to transfer the gene of interest into a host organism.

(a) Recombinant human insulin is a protein that is made using recombinant DNA technology.

Bacteria can be used as host cells to express the recombinant protein.

For the human insulin gene to be successfully expressed in bacteria, one method chosen to obtain the gene is to extract mRNA from β-cells in the pancreas.

The gene coding for insulin is not expressed in the bacterial host when it has been obtained by cutting it out of genomic DNA.

Suggest **and** explain how the structural difference of cDNA and genomic DNA leads to only cDNA being expressed successfully.

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(b) Plasmids are cut using a restriction enzyme to create sticky ends. The plasmids are mixed with many copies of the desired gene and DNA ligase. The gene is inserted into many plasmids.

(i) State the role of DNA ligase in the formation of recombinant plasmids.

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(ii) Explain why a promoter, as well as the gene, may have to be transferred into the plasmid.

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(c) Explain how a marker gene coding for a fluorescent product could be used.

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(d) The unicellular fungus *Saccharomyces cerevisiae* is a species of yeast that has been used to produce human insulin. *S. cerevisiae* cells are able to take up recombinant plasmids.

Suggest advantages of using yeast compared to using bacteria for human insulin production.

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[Total: 12]

6 The kidneys have a role in excretion and in osmoregulation.

Excretion is the removal of the waste products of metabolism or the removal of substances that are in excess.

(a) (i) Name the **main** metabolic waste product excreted by the kidneys.

..... [1]

(ii) State **how** this metabolic product is made.

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(iii) State **where** this metabolic product is made.

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(b) Glomerular filtrate is formed by the process of ultrafiltration.

Describe the process of ultrafiltration.

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(c) Different mammals have different thicknesses of medulla relative to the size of the kidney.

Fig. 6.1 shows the relationship between the mean thickness of the medulla in kidneys of different mammals and concentration of urine produced by the kidneys.

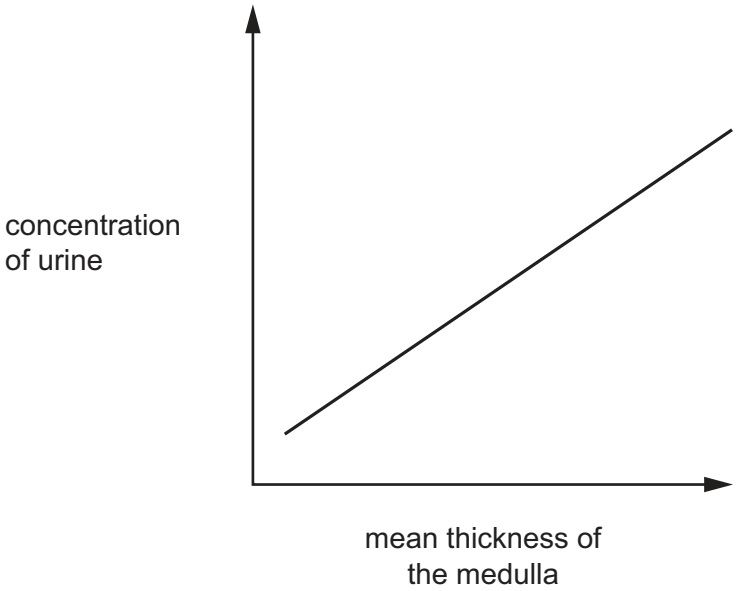

Fig. 6.1

Suggest an explanation for the relationship shown in Fig. 6.1.

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[Total: 12]

7 **(a)** A chloroplast is composed of many structures, each with a different function. Several chloroplast structures are listed.

stroma **lamellae** **thylakoid membrane** **ribosome**

thylakoid space **starch grain** **DNA** **outer membrane**

From the list:

(i) identify the structures involved in the production of rubisco

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[2]

(ii) identify the structure that contains a high concentration of protons in daylight.

…… [1]

(b) Paper chromatography is a technique that can be used to separate a mixture of four common chloroplast pigments. The pigments can be identified by calculating their R_f values.

A student carried out paper chromatography on a solution containing a mixture of chloroplast pigments.

The results are shown in Table 7.1.

Table 7.1

pigment	distance travelled by pigment from baseline / cm	distance travelled by solvent from baseline / cm	R_f
……	6.5	8.9	0.73
chlorophyll a	4.6	8.9	0.52
chlorophyll b	……..	8.9	0.38
carotene	8.2	8.9	……..

Complete Table 7.1. [3]

(c) Fig. 7.1 shows the absorption spectrum for carotene and for chlorophyll a.

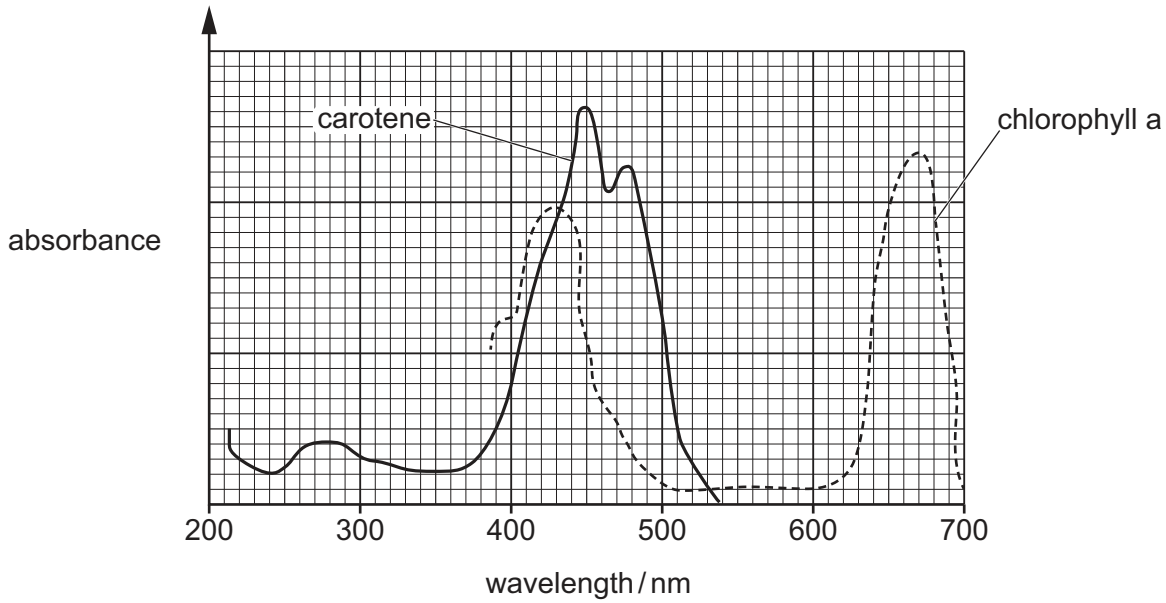

Fig. 7.1

With reference to Fig. 7.1, describe **and** explain the role of carotene in photosynthesis.

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[Total: 10]

8 **(a)** The Boelen's python, *Simalia boeleni*, is a non-venomous snake found only on the island of Papua New Guinea.

Fig. 8.1 shows a Boelen's python.

Fig. 8.1

The International Union for Conservation of Nature (IUCN) has not assessed the conservation status of *S. boeleni* because the python is very hard to detect and locate.

S. boeleni is listed in one of the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Suggest the advantages of *S. boeleni* being listed in CITES, even though it does not have an IUCN conservation status.

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(b) *S. boeleni* is a member of the kingdom Animalia.

Outline the characteristic features of the kingdom Animalia.

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[Total: 7]

9 **(a)** Most carnivorous mammals need to move to hunt their prey.

Outline why a carnivorous mammal makes more use of its nervous system, rather than its endocrine system, when it hunts.

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(b) Fig. 9.1 is a diagram of a motor neurone.

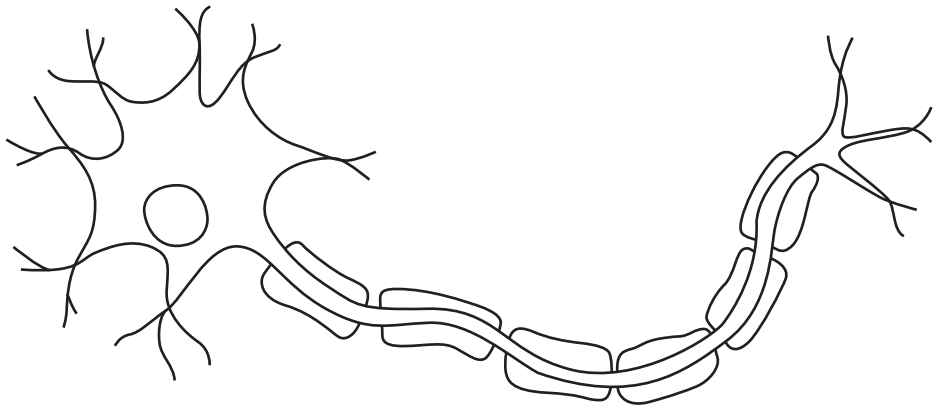

Fig. 9.1

On Fig. 9.1, add label lines and the letters **R**, **S** and **T** to label a part of the neurone that:

- can become depolarised – use the letter **R**
- contains many mitochondria – use the letter **S**
- acts as an insulator – use the letter **T**.

[3]

(c) Fig. 9.2 summarises changes that occur during the contraction of a sarcomere.

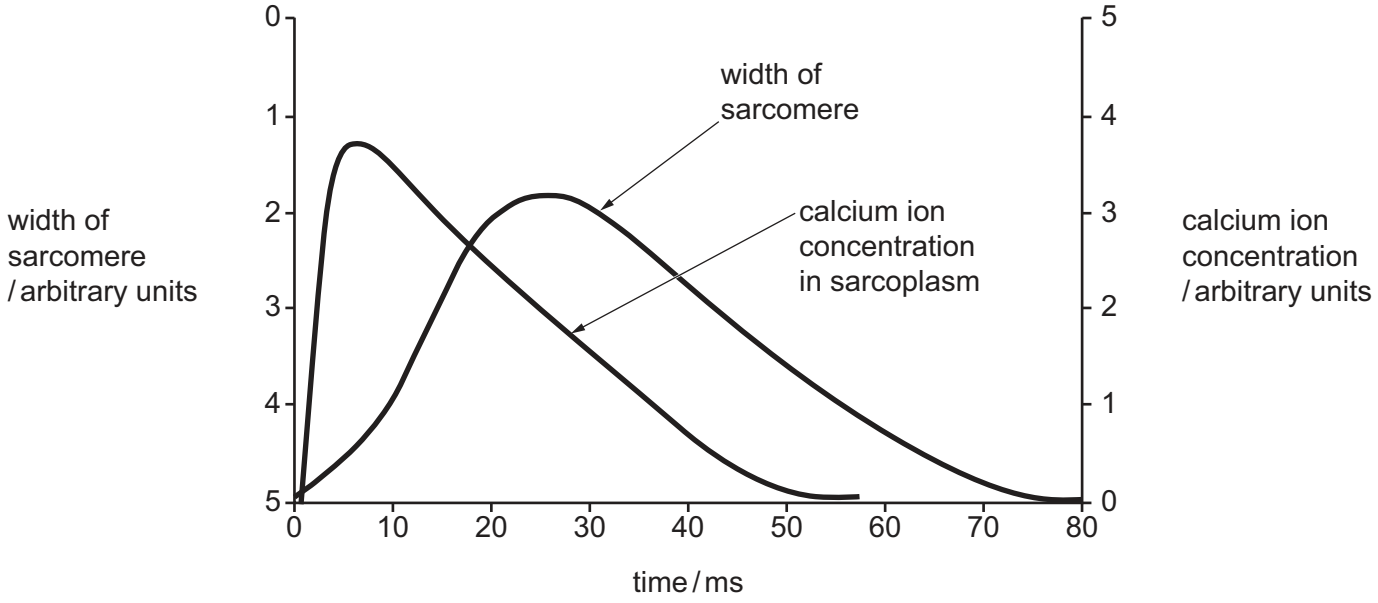

Fig. 9.2

(i) Suggest an explanation for the shape of the curve that shows changes in the width of the sarcomere.

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(ii) Suggest an explanation for the curve that shows changes in calcium ion concentration.

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[Total: 13]

10 The golden poison dart frog, *Phyllobates terribilis*, lives in the Colombian rainforest ecosystem.

Fig. 10.1 shows golden poison dart frogs.

Fig. 10.1

(a) Define the term ecosystem.

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(b) One way of estimating the size of a population of golden poison dart frogs is to use the mark-release-recapture method.

(i) Suggest the assumptions that must be made for the mark-release-recapture method to be valid.

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(ii) A first sample of 27 golden poison dart frogs was captured, marked and released. When a second sample of 33 frogs was captured, 13 had marks on them.

Use the Lincoln index to estimate the population size of the frogs.

$$\text{estimate of population size} = \frac{n_1 \times n_2}{m_2}$$

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

answer ..... [2]

[Total: 8]

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