



# Cambridge International AS & A Level

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**BIOLOGY**

**9700/42**

Paper 4 A Level Structured Questions

**May/June 2023**

**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) Glycolysis is a biochemical pathway that occurs in the cytoplasm of cells.

In glycolysis, a molecule of glucose is metabolised to two molecules of pyruvate. The process is outlined in Fig. 1.1.

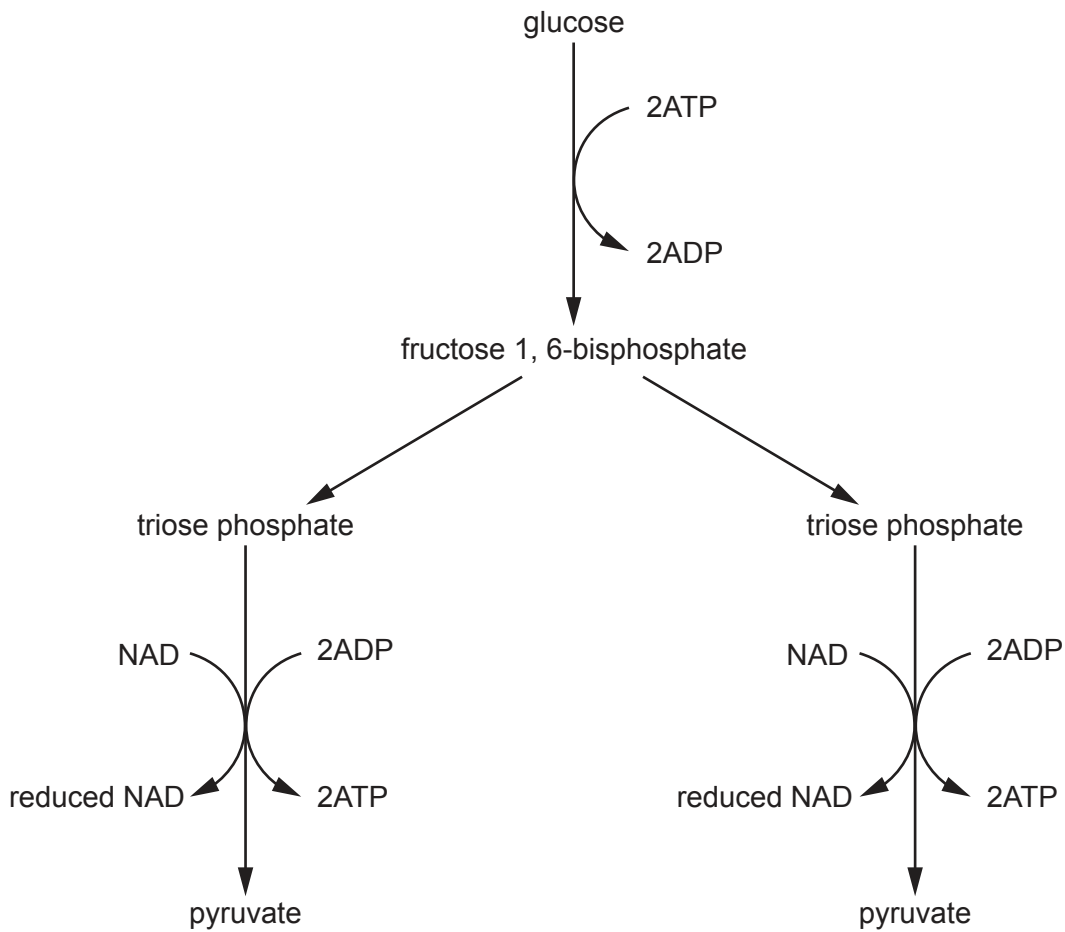


Fig. 1.1

(i) Explain why glucose is phosphorylated at the beginning of glycolysis.

.....  
 ..... [1]

(ii) Suggest **one** use of the reduced NAD that is produced in glycolysis.

.....  
 ..... [1]

(iii) Name the type of phosphorylation reaction by which ATP is made during glycolysis.

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 ..... [1]

(b) Pyruvate can enter the mitochondrion by active transport.

Describe the main conditions that are required for pyruvate to enter the mitochondrion by active transport.

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..... [3]

(c) Pyruvate is involved in the link reaction in the matrix of the mitochondrion.

Describe the link reaction.

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..... [3]

[Total: 9]

2 (a) In sexual reproduction, meiosis occurs to produce haploid gametes from a diploid cell.

Explain the meaning of the terms haploid **and** diploid.

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..... [2]

(b) Describe the behaviour of **chromosomes** during the main stages of meiosis I in animal cells.

prophase I .....

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metaphase I .....

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anaphase I .....

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telophase I .....

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[4]

(c) The production of haploid gametes by meiosis also involves division of the cytoplasm.

State the term used to describe this division of the cytoplasm.

..... [1]

[Total: 7]

- 3 (a) The sea blush, *Plectritis congesta*, is a flowering plant that grows on the west coast of North America.

Individual sea blush plants produce fruit that is either winged or wingless. Investigations have shown that this characteristic is controlled by a single gene with two alleles:

- a dominant winged fruit allele
- a recessive wingless fruit allele.

Fig. 3.1 shows the difference in structure between winged fruit and wingless fruit phenotypes.

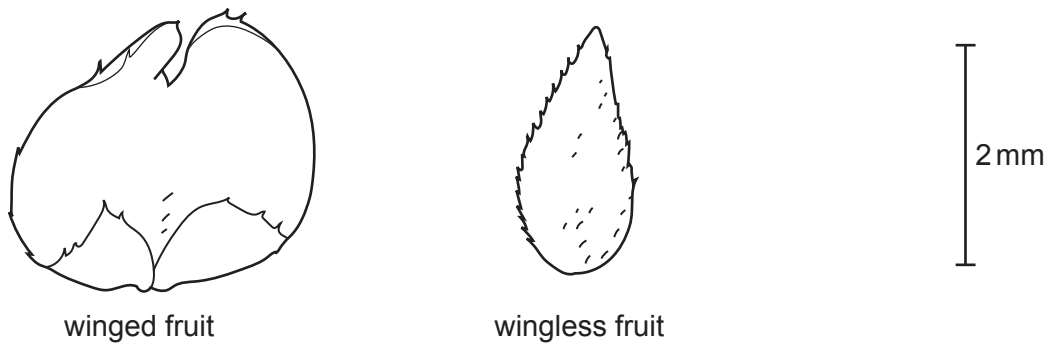


Fig. 3.1

- (i) A large sample of sea blush fruits was collected and their fruit-wing characteristic was recorded.

Name the type of variation that is shown for the fruit-wing characteristic of the sea blush.

..... [1]

- (ii) Different sea blush plants can have fruit with different colours.

Suggest **two** ways in which a new fruit colour could naturally occur in a sea blush population.

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..... [2]



4 Genetic technology uses many different enzymes and techniques.

- (a) Restriction endonucleases are used in genetic modification. These enzymes occur naturally in prokaryotic cells. More than 3500 different restriction endonucleases have been identified and it is thought there are many more to discover.

Name **two** domains that are a source of restriction endonucleases.

.....  
..... [1]

- (b) Originally, the method used to obtain a restriction endonuclease was to:
  - grow large numbers of the specific prokaryotic cells that are the source of the enzyme
  - break open the cells and extract and purify the restriction endonuclease.

This original method produced only a small quantity of restriction endonuclease and was **not** economical.

The newer method for large-scale production is to:

- obtain the gene coding for a specific restriction endonuclease
- introduce the gene into *Escherichia coli*, with a promoter that allows the gene to be expressed continuously.

The newer method increases the quantity of specific restriction endonuclease produced.

Suggest **and** explain the steps needed to carry out the newer method for large-scale production of a specific restriction endonuclease.

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- 5 (a) Warfarin is a poison used to kill rats. Some rats are resistant to warfarin and can survive the effects of the poison. Warfarin resistance is due to a mutant dominant allele at a single gene locus.

Researchers investigated the population of brown rats on a large island where there are no predators of rats. On this island, warfarin is used to try to control the rat population.

The researchers found that 40% of the population of rats was resistant to warfarin.

- (i) Use Hardy–Weinberg equation 1 and equation 2 to calculate the percentage of the population of rats on the island that is heterozygous for warfarin resistance.

equation 1  $p + q = 1$

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

Show your working.

answer ..... % [3]

- (ii) In natural populations, it is usual to find that only some of the conditions of the Hardy–Weinberg principle are met.

Suggest **and** explain which of the conditions of the Hardy–Weinberg principle are most likely to be met for the island population of brown rats.

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..... [4]

(b) Dominant advantageous alleles and recessive advantageous alleles both naturally occur in populations.

Explain why, when a new **dominant** advantageous allele occurs, its frequency increases more quickly in the population than when a new **recessive** advantageous allele occurs.

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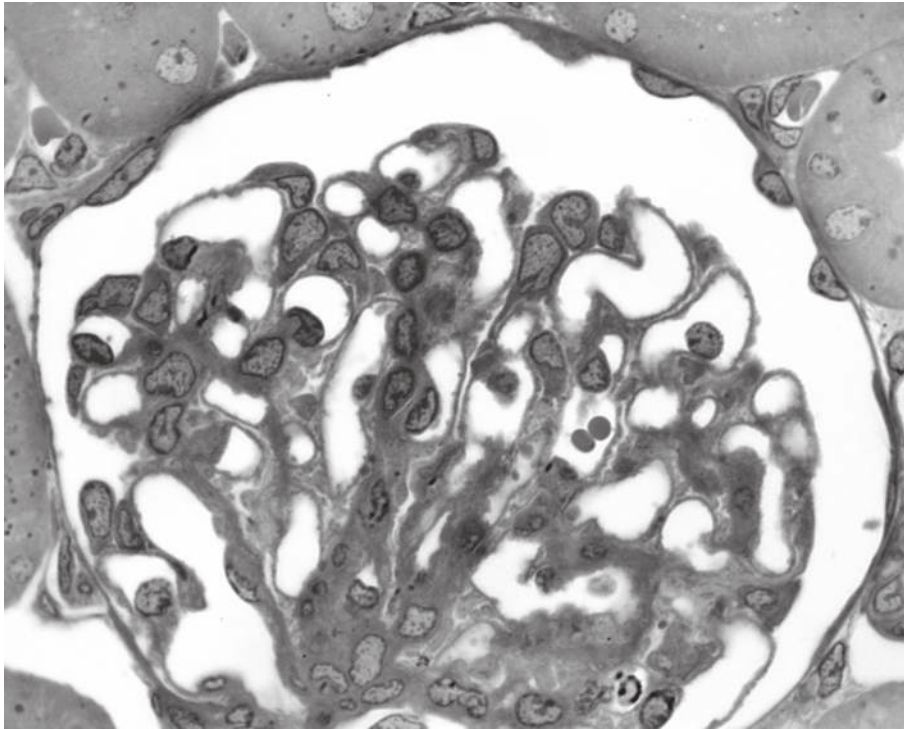
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..... [3]

[Total: 10]

- 6 (a) Fig. 6.1 is a photomicrograph of a section through a Bowman's capsule and a glomerulus.



**Fig. 6.1**

On Fig. 6.1, use label lines and letters to label:

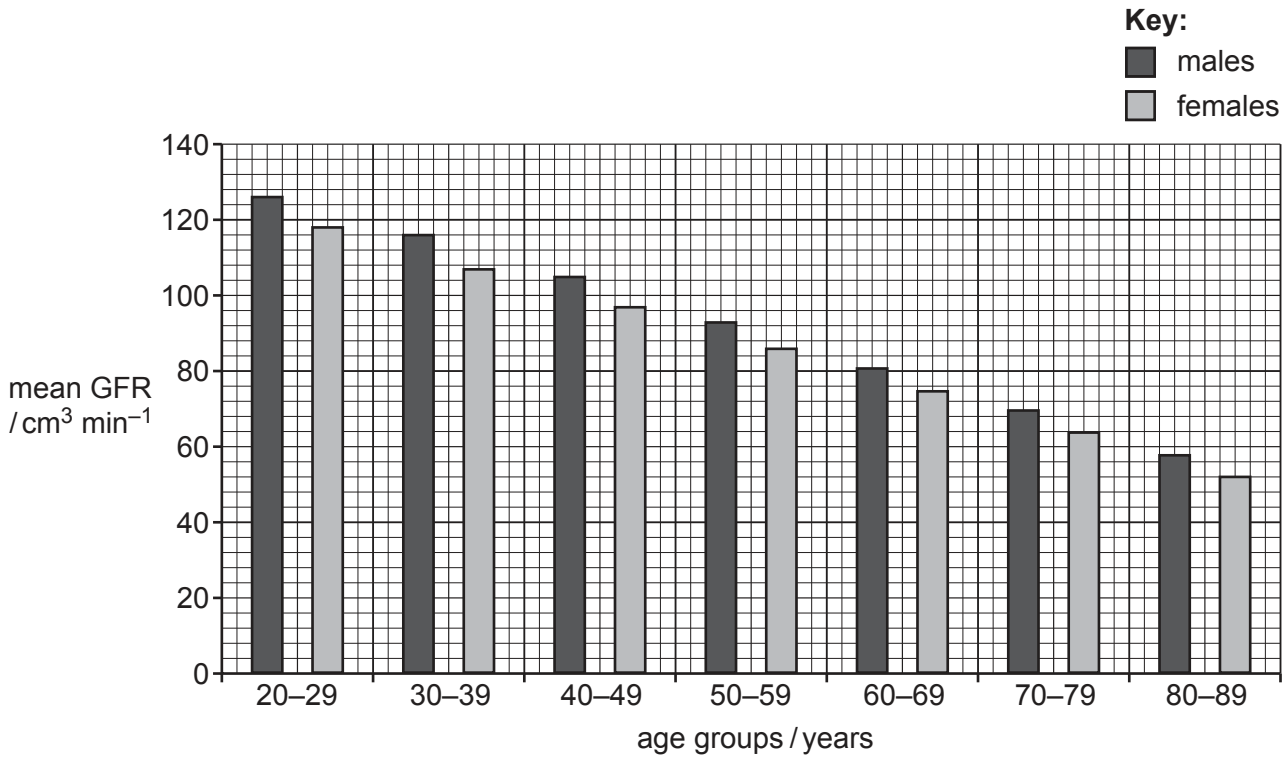
**F** – the location of the glomerular filtrate

**P** – the location of the blood plasma.

[2]

(b) The glomerular filtration rate (GFR) is the rate at which fluid filters from the blood in the glomerulus into the Bowman’s capsule.

Fig. 6.2 shows the mean GFR values for healthy males and females of different age groups.



**Fig. 6.2**

(i) Use Fig. 6.2 to calculate the yearly rate of decrease in mean GFR from the 20–29 age group to the 80–89 age group for **females**.

Show your working.

Give your answer to **one** decimal place and include units.

answer ..... [3]





- (b) The greater blue-ringed octopus, *Hapalochlaena lunulata*, produces tetrodotoxin (TTX). TTX is a neurotoxin. If a mammal is bitten by this octopus, the effect of TTX can cause the death of the mammal.

Fig. 7.1 shows a greater blue-ringed octopus.



Fig. 7.1

TTX binds to voltage-gated sodium ion channels in the axon of a neurone and changes the tertiary structure of the channel protein.

Suggest how TTX may affect the functioning of a motor neurone.

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..... [3]

[Total: 7]

- 8 (a) In plants such as rice, *Oryza sativa*, rubisco has a low rate of activity, which in turn affects the rate of photosynthesis. The cereal crop sorghum, *Sorghum bicolor*, has a high rate of activity of rubisco.

A genetically modified (GM) variety of rice was produced. Parts of the quaternary structure of rubisco in rice were altered to be the same as the rubisco in sorghum.

The rate of activity of rubisco in non-GM rice and GM rice was measured at different concentrations of atmospheric carbon dioxide (CO<sub>2</sub>).

The results are shown in Fig. 8.1.

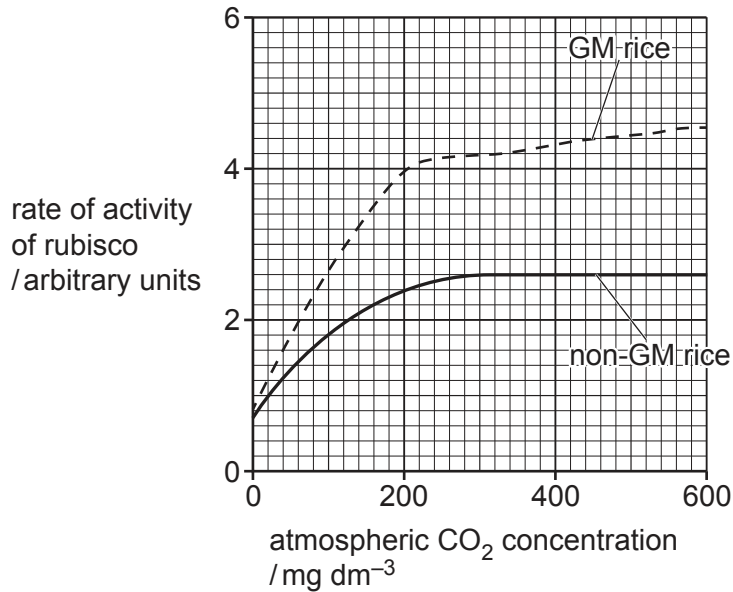


Fig. 8.1

- (i) Compare the two curves shown in Fig. 8.1 and explain why the curve for non-GM rice levels off.

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..... [3]

- (ii) Suggest which part of the rubisco molecule was altered to produce the GM variety of rice.

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..... [1]



(b) Fig. 8.2 shows an outline of the Calvin cycle.

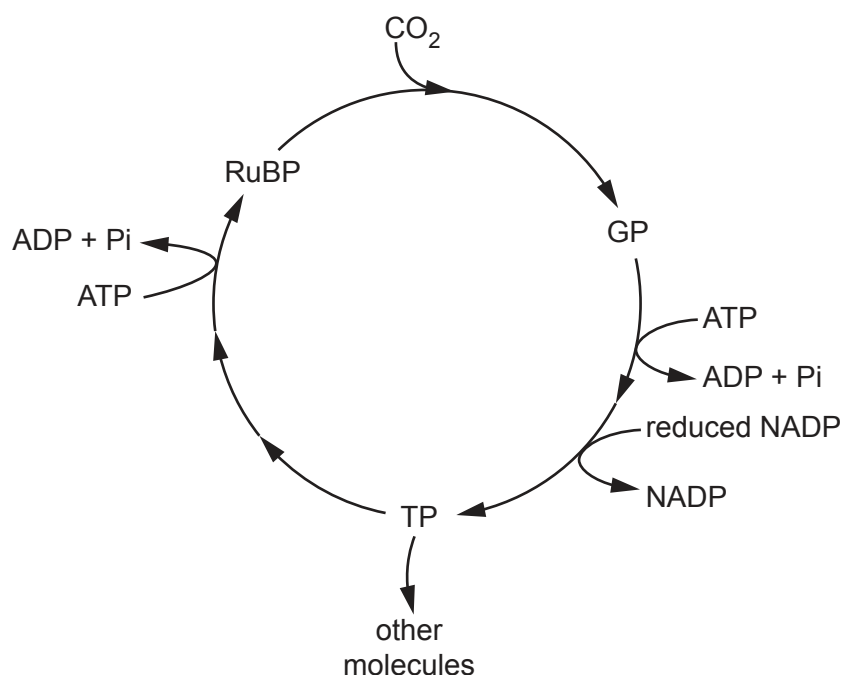


Fig. 8.2

(i) Name the process that involves the enzyme rubisco.

..... [1]

(ii) State the type of reaction that occurs when GP is converted to TP.

..... [1]

(iii) RuBP is regenerated from molecules of TP.

State how many molecules of RuBP are produced from 10 molecules of TP.

..... [1]

(iv) TP molecules that are **not** involved in the regeneration of RuBP can be used in the synthesis of other molecules.

State **two** molecules that can be produced from these TP molecules.

.....  
 ..... [2]

[Total: 9]

- 9 (a) The passage outlines the endocrine system.

Complete the passage by using the most appropriate scientific terms.

The endocrine system consists of tissues and ..... , which secrete hormones such as insulin, glucagon and antidiuretic hormone (ADH). Glucagon only affects target cells that have complementary receptors, which are located on the ..... . Glucagon binds to these receptors and this leads to the production of a ..... , which transfers the signal throughout the cytoplasm. The target cells for insulin are in the liver, ..... and adipose tissue. The target cells for ADH are those of the distal convoluted tubule and the ..... of the kidney nephron. These hormones are involved in ..... , which is the maintenance of a constant internal environment. [6]

- (b) The blood glucose concentration of a person was measured at regular intervals after the ingestion of a meal rich in glucose.

Fig. 9.1 shows the results of this investigation.

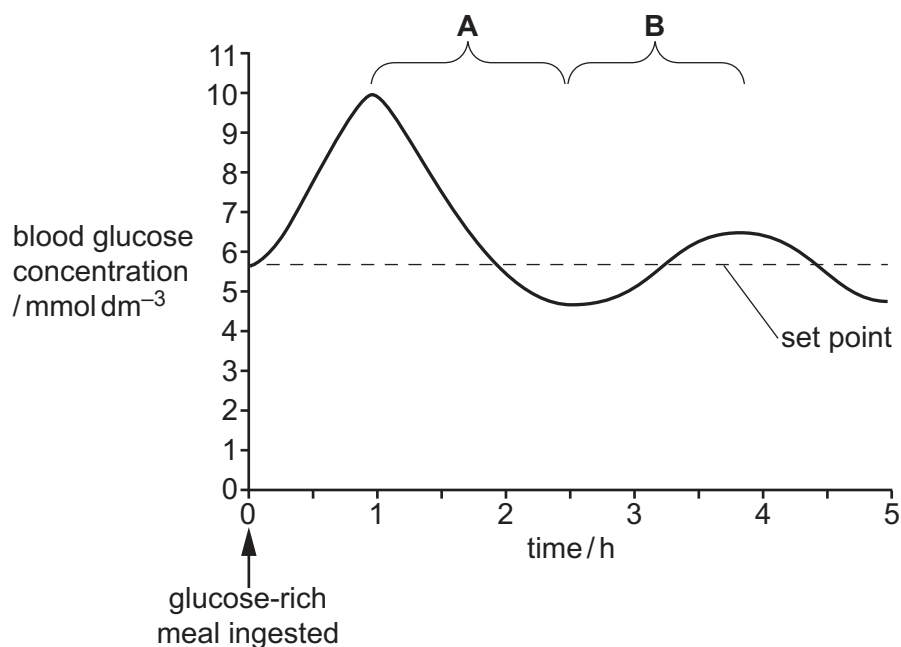


Fig. 9.1

(i) Explain how the blood glucose concentration is reduced during phase **A** of the curve.

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..... [3]

(ii) Suggest why the blood glucose concentration increases again during phase **B**.

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..... [1]

[Total: 10]

- 10 (a) Many zoos around the world are involved in captive breeding programmes for endangered species.

Outline the role of zoos in the conservation of endangered species, **other than** captive breeding programmes.

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