Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

5961476185

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.

DC (CE) 315914/2
© UCLES 2023

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.

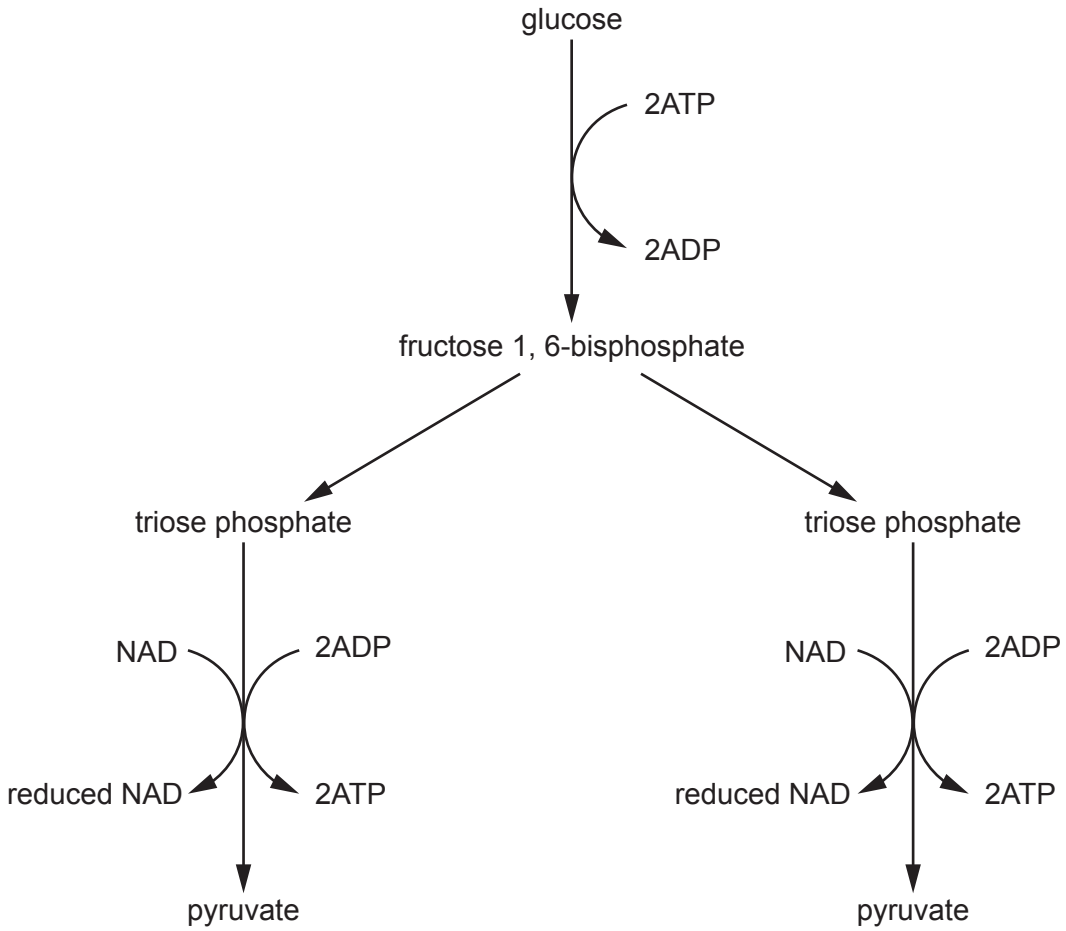

Fig. 1.1

(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.

.....

..... [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.

.....

.....

.....

.....

.....

.....

..... [3]

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

Describe the link reaction.

.....

.....

.....

.....

.....

.....

..... [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.

.....

.....

.....

..... [2]

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

prophase I .....

.....

.....

.....

metaphase I .....

.....

.....

.....

anaphase I .....

.....

.....

.....

telophase I .....

.....

.....

.....

[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]

© UCLES 2023

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.

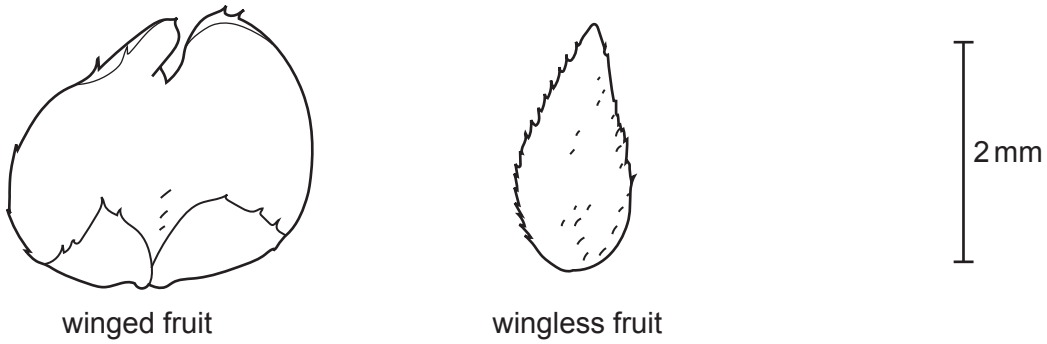

Fig. 3.1

(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.

.....

.....

.....

..... [2]

(iii) Early taxonomists classified sea blush plants with winged fruits as a different species to sea blush plants with wingless fruits.

Since this time, evidence from observations and experiments has confirmed that the plants belong to the same species.

Suggest **three** examples of the evidence obtained that helped to confirm that these sea blush plants belong to the same species.

.....

.....

.....

.....

.....

.....

..... [3]

(b) Natural selection occurs in populations, such as in populations of sea blush plants.

Explain why natural selection occurs in populations.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 11]

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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) Describe the advantages of databases for the study and use of restriction endonucleases.

.....

.....

.....

.....

.....

.....

..... [3]

(d) Electrophoresis is a technique used in genetic technology.

Paper chromatography is a technique used to investigate the photosynthetic pigments found in chloroplasts.

Compare the similarities and differences between electrophoresis and chromatography.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 12]

© UCLES 2023

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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [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.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

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

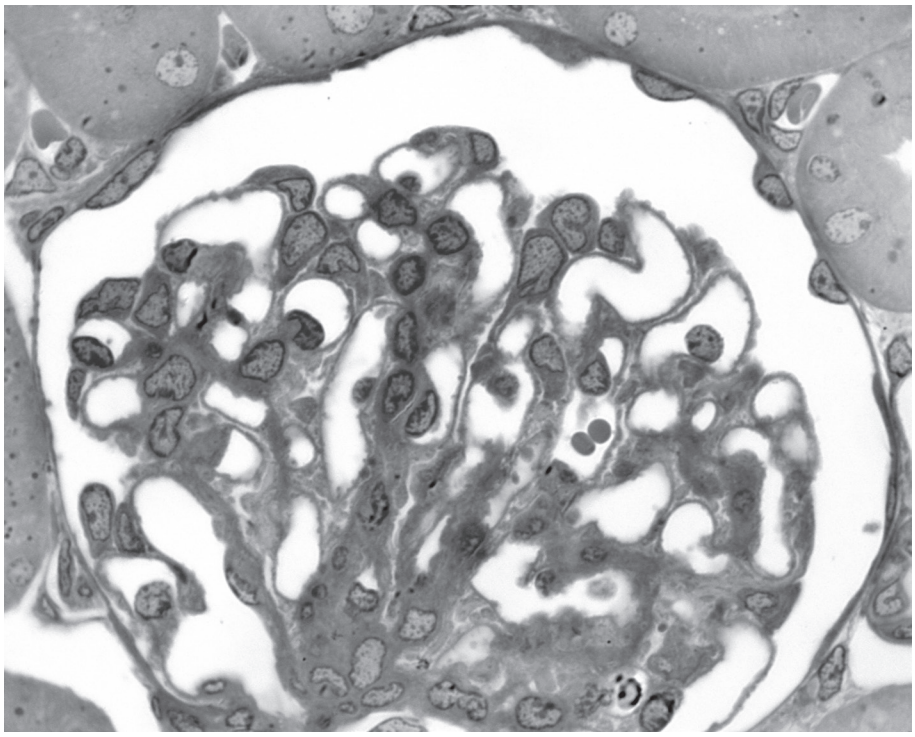

Fig. 6.1

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.

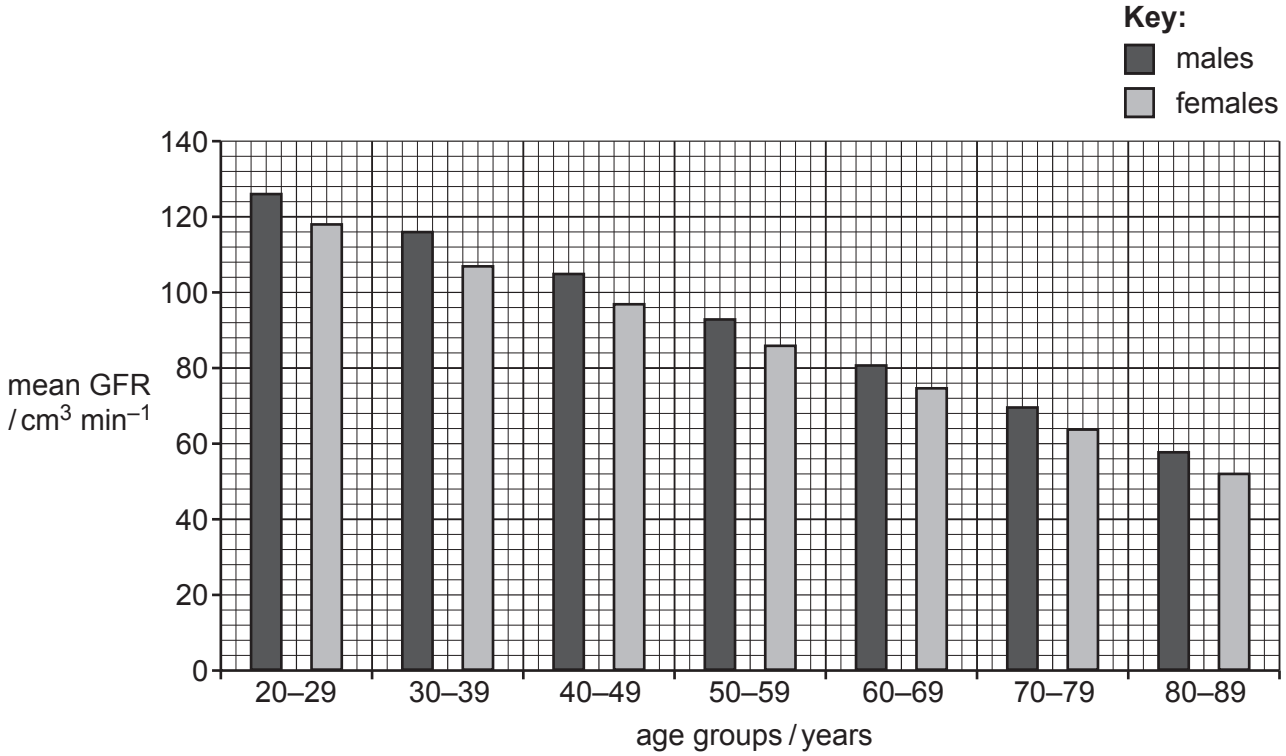

Fig. 6.2

(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]

(ii) The age of a person and whether they are male or female can affect GFR.

Suggest **and** explain other factors that can affect GFR.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(c) The glomerular filtrate passes from the Bowman's capsule to the proximal convoluted tubule, where selective reabsorption takes place.

Describe the process of selective reabsorption.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [7]

[Total: 15]

7 **(a)** A striated muscle cell (muscle fibre) will contract when stimulated by a motor neurone at a neuromuscular junction.

Air temperature can affect the temperature of striated muscle cells.

Investigations have shown that the efficiency of contraction of striated muscle cells decreases when the air temperature decreases.

Suggest reasons why a reduction in temperature can decrease the efficiency of contraction of striated muscle cells.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(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.

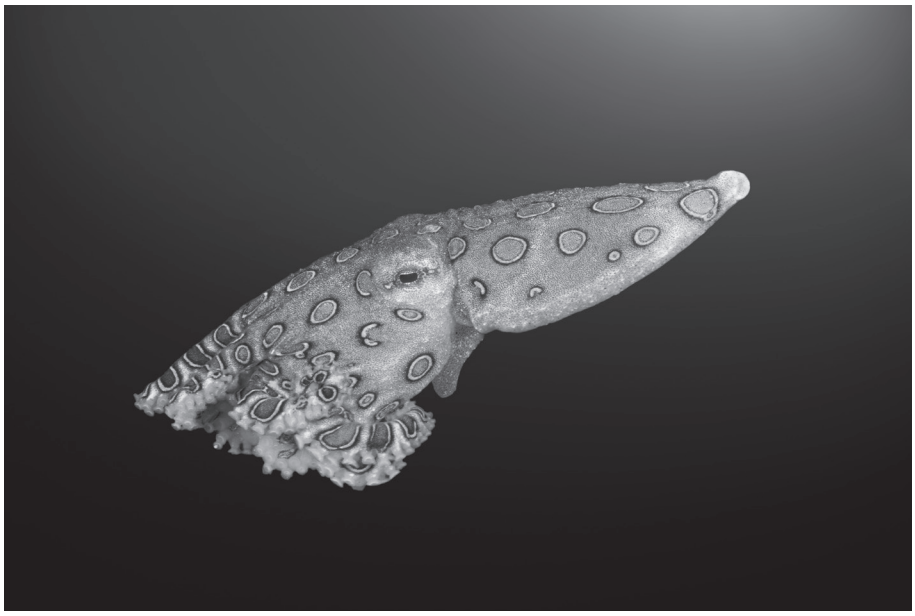

Fig. 7.1

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.

.....

.....

.....

.....

.....

.....

.....

.....

..... [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_2).

The results are shown in Fig. 8.1.

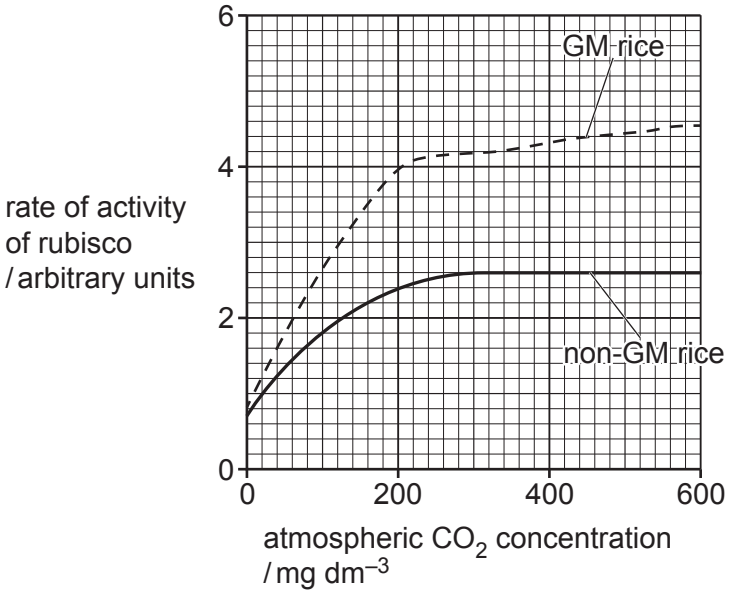

Fig. 8.1

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

.....

.....

.....

.....

.....

.....

.....

..... [3]

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

.....

..... [1]

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

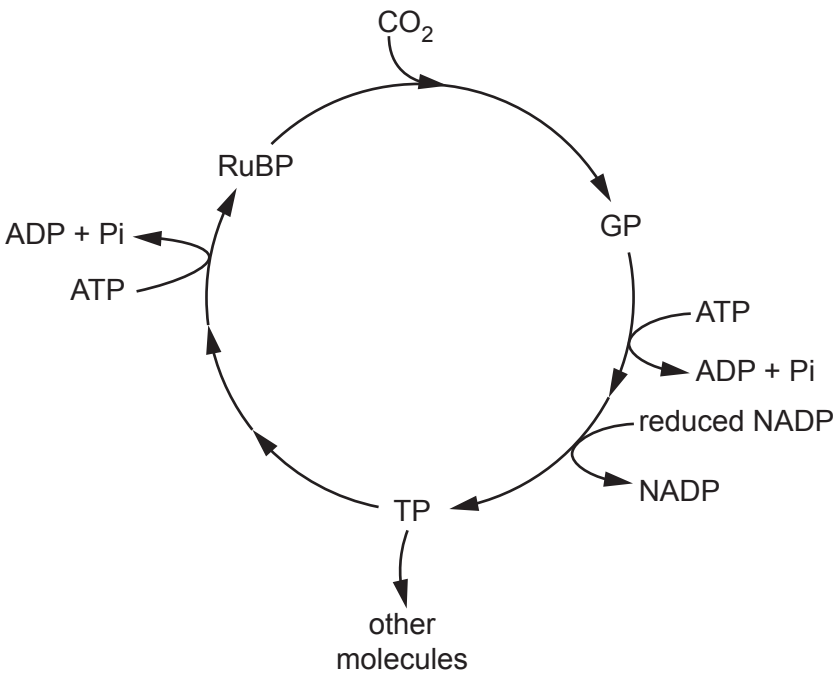

Fig. 8.2

(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.

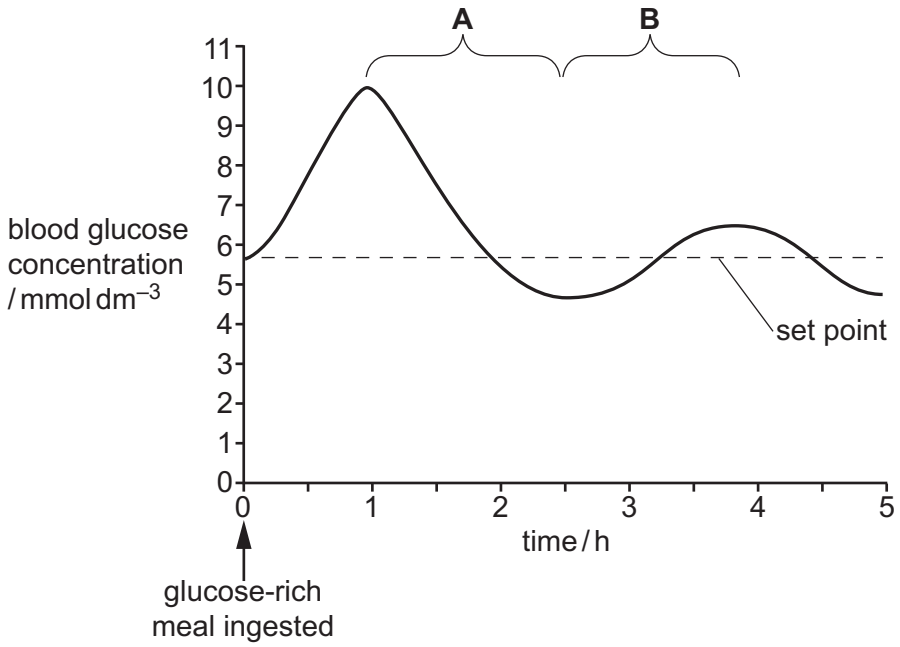

Fig. 9.1

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

.....

.....

.....

.....

.....

.....

.....

..... [3]

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

.....

.....

..... [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.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(b) Chester Zoo, in the United Kingdom, controls the European captive breeding programme for the eastern black rhinoceros, *Diceros bicornis michaeli*.

Fig. 10.1 shows an eastern black rhinoceros.

Fig. 10.1

In the captive breeding programme for the eastern black rhinoceros, 15.8% of females breed each year while in the wild 23.7% of females breed each year.

Suggest reasons why fewer females breed in captivity than in the wild.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) Sometimes assisted reproduction is used in captive breeding programmes for the eastern black rhinoceros.

Fig. 10.2 outlines the process of IVF that is used in these programmes.

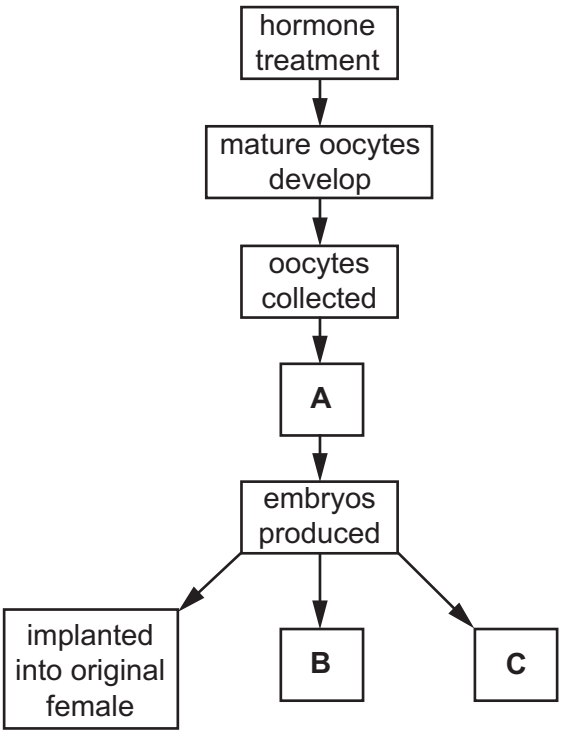

Fig. 10.2

Outline:
- the event **A** that occurs in the production of the embryos
- the **two** other possible outcomes, **B** and **C**, for the embryos that have been produced.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

BLANK PAGE

BLANK PAGE

The boundaries and names shown, the designations used and the presentation of material on any maps contained in this question paper/insert do not imply official endorsement or acceptance by Cambridge Assessment International Education concerning the legal status of any country, territory, or area or any of its authorities, or of the delimitation of its frontiers or boundaries.

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.

© UCLES 2023