Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

BIOLOGY **9700/41**

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 Organisms need a source of energy for many cellular processes. Respiration involves the release of energy from energy-rich molecules for the synthesis of ATP molecules. ATP is described as the energy currency of cells.

(a) Name **two** energy-rich molecules that enter the respiration pathway to synthesise ATP.

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..... [2]

(b) Fig. 1.1 shows a molecule of ATP.

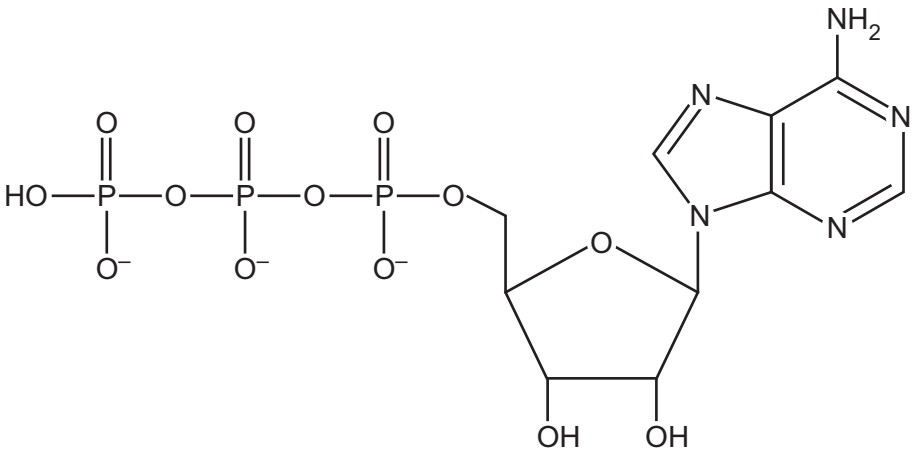

Fig. 1.1

Explain the features of ATP that make it suitable to be the universal energy currency of cells.

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..... [4]

(c) Identify the type of phosphorylation reaction to synthesise ATP that occurs during glycolysis and the Krebs cycle.

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(d) (i) Pyruvate moves into the matrix of the mitochondrion only when a particular inorganic molecule is present.

Name the inorganic molecule that must be present in the cell for pyruvate to enter the matrix of the mitochondrion.

..... [1]

(ii) Explain how the presence of the inorganic molecule named in **(d)(i)** affects the ATP yield from respiration.

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..... [3]

[Total: 11]

2 A respirometer can be used to investigate how temperature affects the rate of respiration of woodlice.

Woodlice are small invertebrate animals. Fig. 2.1 shows a single woodlouse.

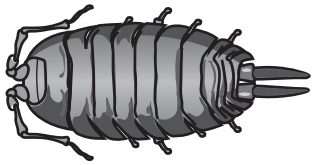

Fig. 2.1

Fig. 2.2 shows a simple respirometer.

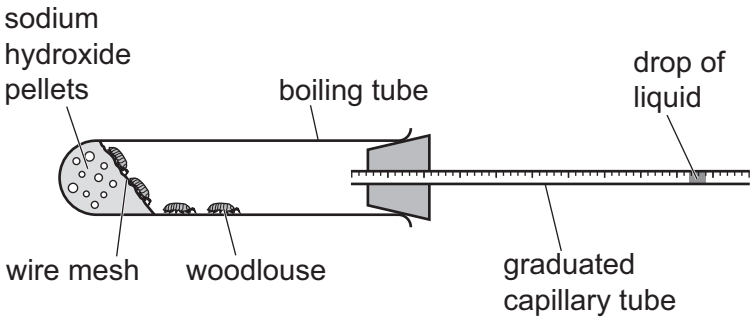

Fig. 2.2

(a) Explain how the experimental set-up in Fig. 2.2 allows the rate of respiration of woodlice to be determined.

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(b) A student determined the rate of respiration of woodlice at a temperature of 5 °C and at a temperature of 20 °C.

Predict **and** explain how the rate of respiration of woodlice differs at 5 °C compared to 20 °C.

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..... [1]

[Total: 5]

3 Porphyria is a group of rare genetic diseases in which molecules called porphyrins accumulate in the body.

Three examples of porphyria are:

- X-linked protoporphyria
- variegate porphyria
- congenital erythropoietic porphyria (CEP).

(a) X-linked protoporphyria is caused by a mutant allele located on the X chromosome.

Fig. 3.1 shows the pattern of inheritance of X-linked protoporphyria in one family.

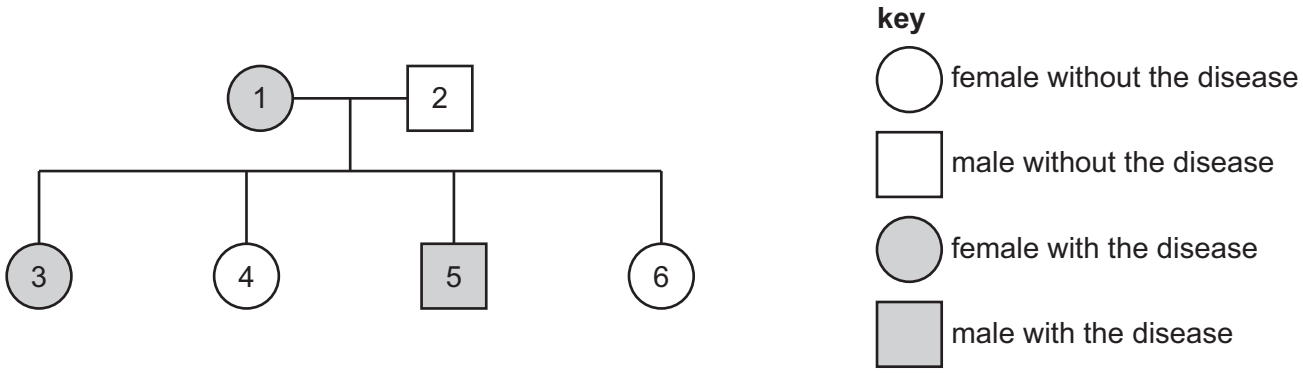

Fig. 3.1

X-linked protoporphyria is described as a sex-linked disease.

Use the information in Fig. 3.1 to make **one** other conclusion about the pattern of inheritance of X-linked protoporphyria.

Give evidence to support your conclusion.

conclusion .....

evidence .....

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[2]

(b) Variegate porphyria occurs in 1 in 100 000 people in Europe.

In the 1600s, approximately 100 Dutch people migrated from Europe to South Africa.

The population of people of Dutch descent in South Africa is now 2.5 million. Variegate porphyria occurs in 1 in 1000 people in this population.

Suggest **and** explain why variegate porphyria is more common among people of Dutch descent in South Africa than among people in Europe.

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(c) Microarrays can be used to detect various forms of porphyria caused by mutant alleles.

Describe how microarrays can be used to detect a disease by analysing gene expression.

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(d) The nucleotide sequences of alleles that cause rare genetic diseases, such as the various forms of porphyria, are stored in a database.

State **one** benefit of having a database of nucleotide sequences for alleles that cause rare diseases.

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..... [1]

(e) Congenital erythropoietic porphyria (CEP) is caused by a substitution mutation in a gene coding for an enzyme.

The mutant CEP allele codes for an enzyme with little or no function.

Scientists used gene editing in the laboratory to correct the nucleotide sequence of the mutant allele in cultured human cells.

The scientists introduced three molecules to the cells:

- an enzyme called Cas9 that causes breaks in DNA strands
- guide RNA (gRNA), attached to Cas9, that is complementary to the mutant CEP allele
- a short length of DNA, known as template DNA, that can replace the section of the allele where the substitution mutation has occurred.

The repair mechanism within the cell allows the template DNA to be inserted so that the mutation is corrected.

Fig. 3.2 shows part of the nucleotide sequence in the mutated CEP allele before and after the gene editing procedure.

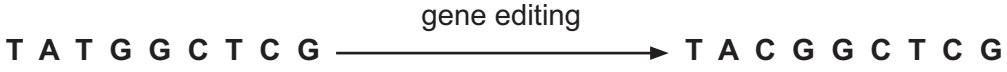

Fig. 3.2

In the future, this gene editing procedure may be used in a person with CEP to prevent the accumulation of porphyrins in the body.

Suggest **and** explain how this gene editing procedure will prevent the accumulation of porphyrins in a person with CEP without damaging other genes.

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..... [3]

[Total: 13]

4 Scientists have invented a way of producing food by artificial photosynthesis.

- Solar panels convert sunlight energy into electricity.
- The electricity powers an electrolysis reaction between carbon dioxide gas and water to form the organic product acetate.
- The single-celled alga *Chlamydomonas*, a protoctist, can use acetate to grow and reproduce in the dark, instead of photosynthesising in the light.
- The algae can be processed to make a food product.

Fig. 4.1 shows an outline of the artificial photosynthesis process.

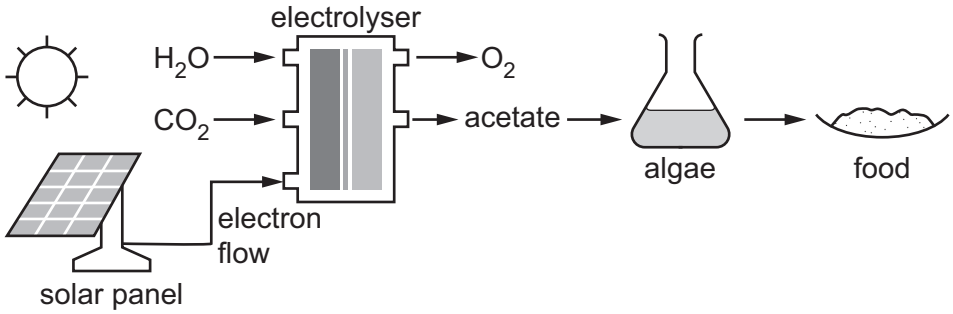

Fig. 4.1

(a) Identify **three** similarities between the artificial photosynthesis process shown in Fig. 4.1 and the normal process of photosynthesis.

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(b) Fig. 4.2 shows the single-celled alga *Chlamydomonas*. It contains a large, cup-shaped chloroplast for photosynthesis.

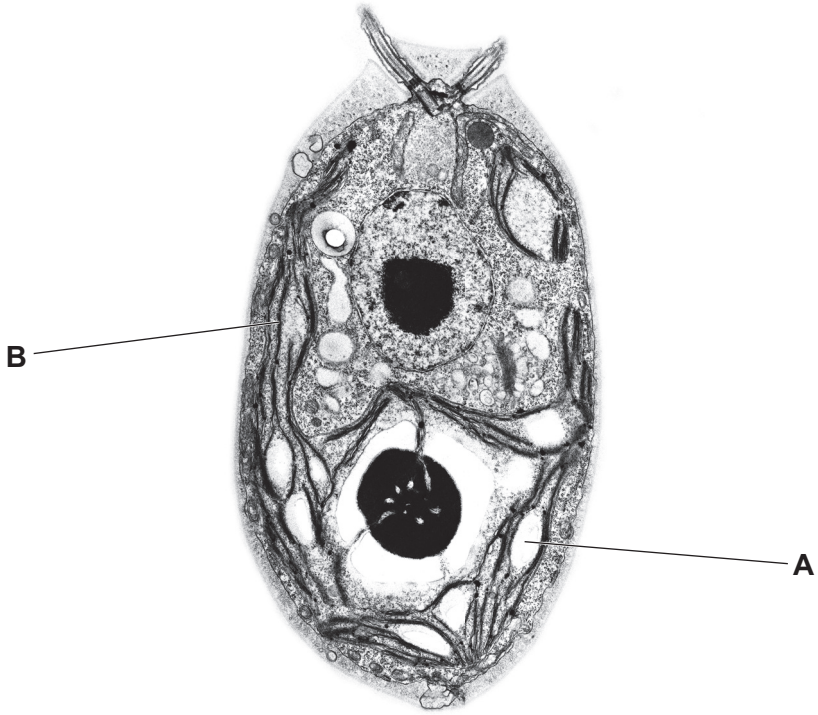

Fig. 4.2

Structures **A** and **B** in Fig. 4.2 are found within the chloroplast.

Name structures **A** and **B**.

A .....

B .....

[2]

(c) Thylakoid membranes are the site of the light-dependent stage of photosynthesis.

(i) Name the products of the light-dependent stage of photosynthesis.

..... [1]

(ii) Some of the protein components of the thylakoid membrane have a role in the light-dependent stage of photosynthesis.

Explain the roles of the different proteins that function in the light-dependent stage of photosynthesis.

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(d) The products of the light-dependent stage of photosynthesis are used in the Calvin cycle. Calvin cycle intermediates are used to produce amino acids, carbohydrates and lipids.

Name the Calvin cycle intermediate that can be used to produce starch.

..... [1]

(e) Scientists claim that the artificial photosynthesis process shown in Fig. 4.1 is more efficient at converting light energy into food than normal photosynthesis by crop plants.

Give reasons why this claim may or may **not** be true.

true .....

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not true .....

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[3]

[Total: 14]

5 The Galápagos is a group of islands with a high biodiversity.

(a) *Geospiza fortis* is one of the many species of finch that live on the Galápagos islands. On one of the Galápagos islands, Daphne Major, scientists measured the bill size (length, width and depth) of individuals in a population of *G. fortis* over several years.

Fig. 5.1 shows a *G. fortis* female.

Fig. 5.1

G. fortis feed on seeds. Seed size and bill size vary. It is easier for *G. fortis* with smaller bills to eat small seeds and for *G. fortis* with larger bills to eat large seeds.

In 1977, a drought occurred on Daphne Major, which resulted in a large decrease in the availability of seeds, particularly small seeds.

Scientists observed an increase in the mean bill size in the *G. fortis* population on Daphne Major after the drought.

(i) State the type of natural selection that occurred in the *G. fortis* population on Daphne Major as a result of the drought.

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(ii) Fig. 5.2 shows the distribution of bill size in the *G. fortis* population before the drought in 1977.

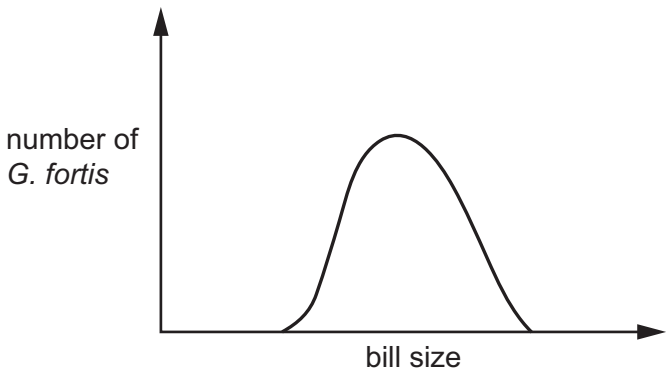

Fig. 5.2

Sketch a new curve on Fig. 5.2 to show the distribution of bill size in the *G. fortis* population after the drought.

[1]

(b) *G. fortis* also lives on Santa Cruz, another island in the Galápagos.

Most of the seeds available for *G. fortis* to eat on Santa Cruz are either small or large. There are few intermediate sizes of seed.

Fig. 5.3 shows the distribution of bill size in the *G. fortis* population on Santa Cruz.

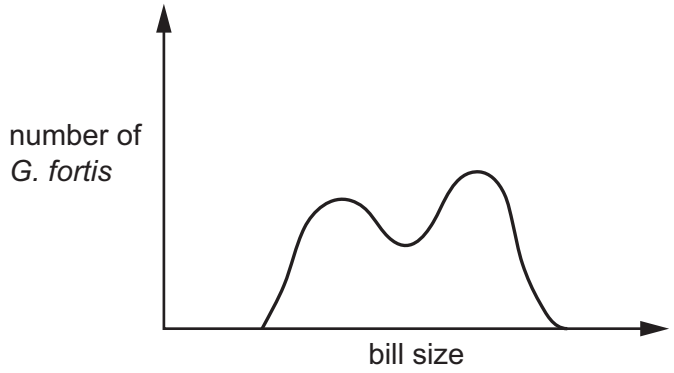

Fig. 5.3

Explain how natural selection in the *G. fortis* population on Santa Cruz has resulted in the distribution in bill size shown in Fig. 5.3.

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(c) Scientists studied the effect of an increase in the number of tourists each year on the number of invasive alien species present in the Galápagos islands.

The scientists recorded the number of invasive alien species present each year in the Galápagos islands over many years. The scientists also recorded the number of tourists visiting the islands each year.

Fig. 5.4 shows a graph of the data for five different years during the study.

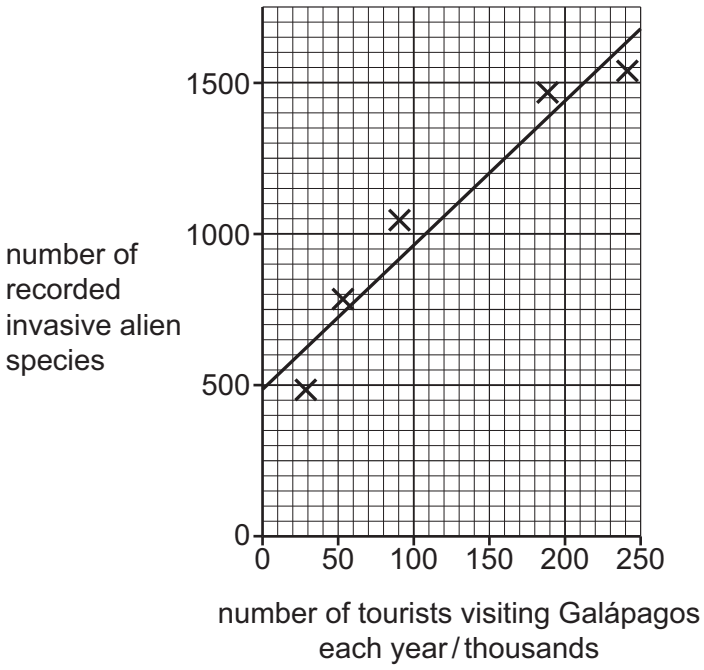

Fig. 5.4

(i) The scientists carried out a Pearson's linear correlation calculation for the data in Fig. 5.4.

The scientists calculated an ***r*** value of 0.930.

The scientists concluded that there is a significant correlation between the number of tourists visiting the Galápagos islands each year and the number of invasive alien species present.

Table 5.1 shows a probability table of critical values for Pearson's linear correlation.

Table 5.1

number of observations	probability level (*p*)	
	0.05	**0.01**
3	0.997	1.000
4	0.950	0.990
5	0.878	0.959
6	0.811	0.917
7	0.754	0.875

With reference to Table 5.1, explain why the ***r*** value of 0.930 indicates that there is a significant correlation between the number of tourists and the number of invasive alien species.

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..... [2]

(ii) Invasive alien species are thought to have contributed to extinctions recorded in the Galápagos islands.

Discuss the negative effects of introducing invasive alien species to an ecosystem.

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(iii) State **two** factors, other than competition and the introduction of invasive alien species, that can cause extinction.

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[2]

[Total: 14]

6 **(a)** In the kidney, various molecules move between the blood and the kidney nephron.

Table 6.1 describes the movements of molecules at three regions of the nephron, **P**, **Q** and **R**.

Table 6.1

region of nephron	molecule(s)	direction of movement
P	amino acids, glucose and water	from nephron to blood
Q	water	from nephron to blood in the presence of antidiuretic hormone (ADH)
R	water and molecules with a molecular mass of less than 68,000	from blood to nephron

(i) Name the processes, **other than** diffusion, osmosis and active transport, that are occurring at **P**, **Q** and **R**.

P .....

Q .....

R .....

[3]

(ii) Identify the regions of the nephron represented by **P**, **Q** and **R**.

P .....

Q .....

R .....

[3]

(b) A student cut a fresh kidney lengthways and placed one half in the freezer. After 24 hours, the student examined the kidney section and tested its firmness with a mounted needle.

Sodium chloride concentration affects the freezing point of a solution.

The student drew the diagram in Fig. 6.1 to show an area that had frozen hard and an area that was softer and less frozen.

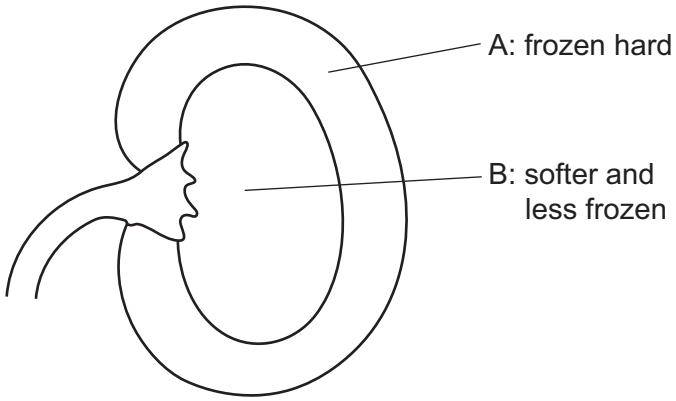

Fig. 6.1

Suggest an explanation for the observations in Fig. 6.1 made by the student.

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[Total: 8]

7 Insulin is an example of a cell-signalling molecule of the endocrine system.

(a) Outline why insulin can be described as an example of a cell-signalling molecule of the endocrine system.

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..... [4]

(b) Researchers compared the effect of two types of meal on the mean blood glucose concentration and the mean blood insulin concentration of twelve volunteers. The measurements were made for three hours after the meal.

Meal A contained 55% carbohydrate, 27% fat and 18% protein.
Meal B contained 3% carbohydrate, 90% fat and 7% protein.

Fig. 7.1 shows the results.

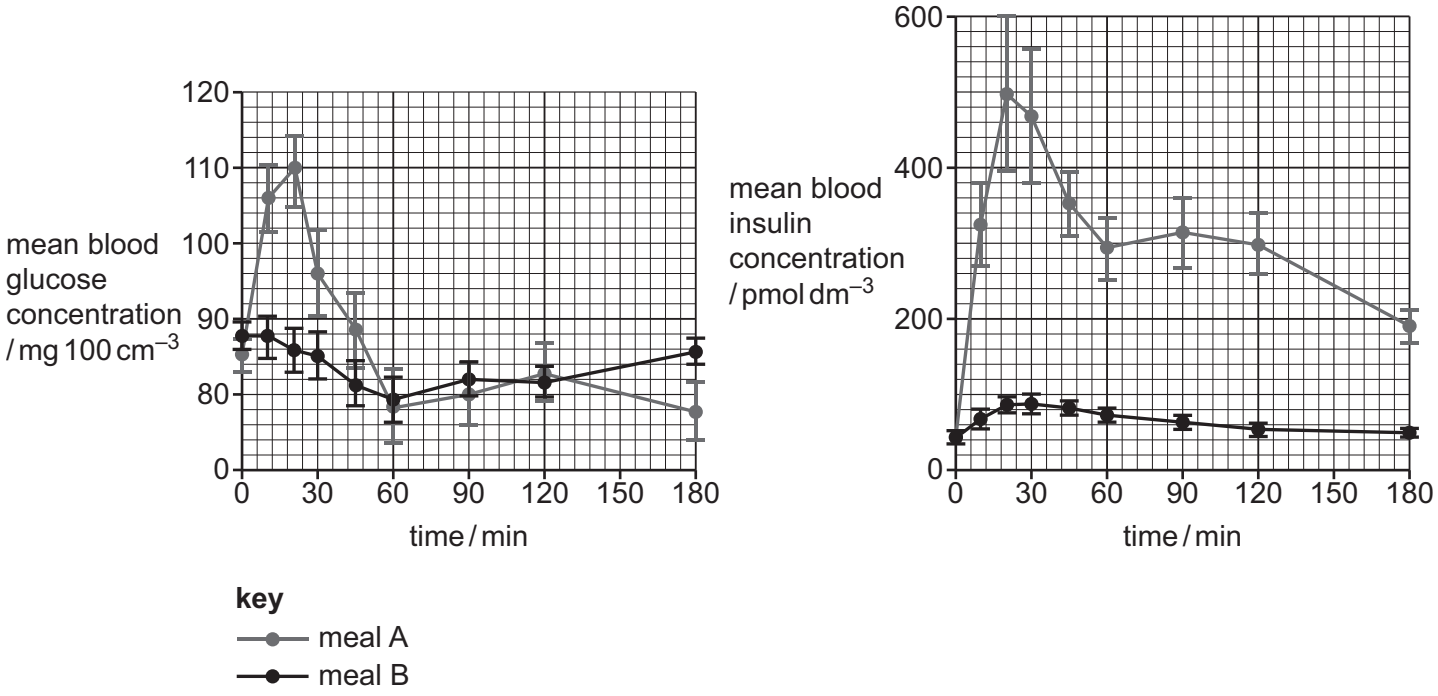

Fig. 7.1

(i) With reference to Fig. 7.1, explain how negative feedback operates to control mean blood glucose concentration in the volunteers who ate meal A.

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(ii) Suggest explanations for the changes in mean blood glucose concentration of the volunteers who ate meal B.

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[Total: 11]

8 The presence of gibberellins in a plant cell leads to the expression of genes involved in stem elongation.

Describe how gibberellin causes stem elongation in plants.

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[Total: 6]

9 A species is classified into one of three domains.

(a) Two of the domains contain only prokaryotic species.

With reference to the two prokaryotic domains, describe the features used to classify prokaryotic species into two different domains.

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..... [3]

(b) Tigers are large mammals that live in many parts of Asia.

Fig. 9.1 shows a tiger, *Panthera tigris*.

Fig. 9.1

Complete Table 9.1 by writing the domain, kingdom and genus in which tigers are classified.

Table 9.1

taxon	name
domain	
kingdom	
phylum	Chordata
class	Mammalia
order	Carnivora
family	Felidae
genus	

[3]

[Total: 6]

10 During the course of an action potential, the potential difference across a neurone membrane changes.

Table 10.1 shows the potential difference across the neurone membrane at three sequential time points, **X**, **Y** and **Z**, just before and during an action potential.

Table 10.1

time point	potential difference / mV
X	–70
Y	+40
Z	–90

(a) Describe the events that cause each of the potential differences at points **X**, **Y** and **Z**.

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(b) Suggest how one action potential causes an action potential in an adjacent section of the axon of an unmyelinated neurone.

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(c) Vertebrate animals generally have a myelin sheath around the axons of motor neurones.

Explain why the presence of a myelin sheath around a motor neurone axon is an advantage.

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..... [3]

[Total: 12]

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