Cambridge Assessment International Education

Cambridge International AS & A Level

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8251875797

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **October/November 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.

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1 The wild Bactrian camel, *Camelus ferus*, lives only in the desert regions of Mongolia and northern China.

Fig. 1.1 shows a wild Bactrian camel.



Fig. 1.1

(a) The wild Bactrian camel is at risk of extinction in the wild and is categorised as critically endangered by the International Union for Conservation of Nature (IUCN). There are only 950 wild Bactrian camels left in their natural habitat.

Suggest reasons why the wild Bactrian camel has become critically endangered.

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(b) Outline the role of the IUCN.

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(c) Some zoos use assisted reproduction techniques, such as embryo transfer, in their captive breeding programmes for endangered species. Embryo transfer has resulted in domesticated dromedary camels giving birth to wild Bactrian camel calves.

Describe the procedure of embryo transfer in a mammal such as a camel.

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[Total: 9]

2 Photosynthesis is an important energy transfer process.

(a) Name **one** chloroplast pigment.

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(b) Explain the relationship between the **absorption** spectrum of the main chloroplast pigments in a species of plant and the **action** spectrum for photosynthesis for that species.

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(c) Explain why temperature can be a limiting factor of photosynthesis.

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(d) Outline how the light-independent stage of photosynthesis leads to the production of carbohydrates such as starch in plant leaves.

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[Total: 9]

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3 **(a)** The results of investigations carried out on mitochondria show how the structure of a mitochondrion is related to its role in aerobic respiration.

- Intact mitochondria (not damaged) were removed from cells.
- A technique was used to remove the outer mitochondrial membrane, leaving the inner membrane intact.
- The inner mitochondrial membrane was separated from the contents of the matrix so that both could be analysed.

(i) The removal of the outer membranes of mitochondria involves placing the organelles in pure water. This results in the rupture (bursting) of the outer membrane. The inner mitochondrial membrane does not rupture and remains intact.

Suggest **and** explain why the inner membrane of a mitochondrion remains intact when the organelle is placed in pure water.

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(ii) Name **three** molecules, other than coenzymes, that are found in the mitochondrial matrix **and** explain their role in aerobic respiration.

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(iii) The inner membrane contains a very high proportion of the molecule cardiolipin. Cardiolipin makes the membrane impermeable to some ions.

Suggest why the inner membrane contains a very high proportion of cardiolipin.

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..... [1]

(b) In further experiments it was found that, in an intact mitochondrion:

- there is a membrane potential across the inner mitochondrial membrane, with the matrix having a negative charge
- the transport of ATP, ADP and inorganic phosphate (P_i) is driven by the membrane potential across the inner membrane.

Fig. 3.1 shows the location of some inner membrane carrier proteins.

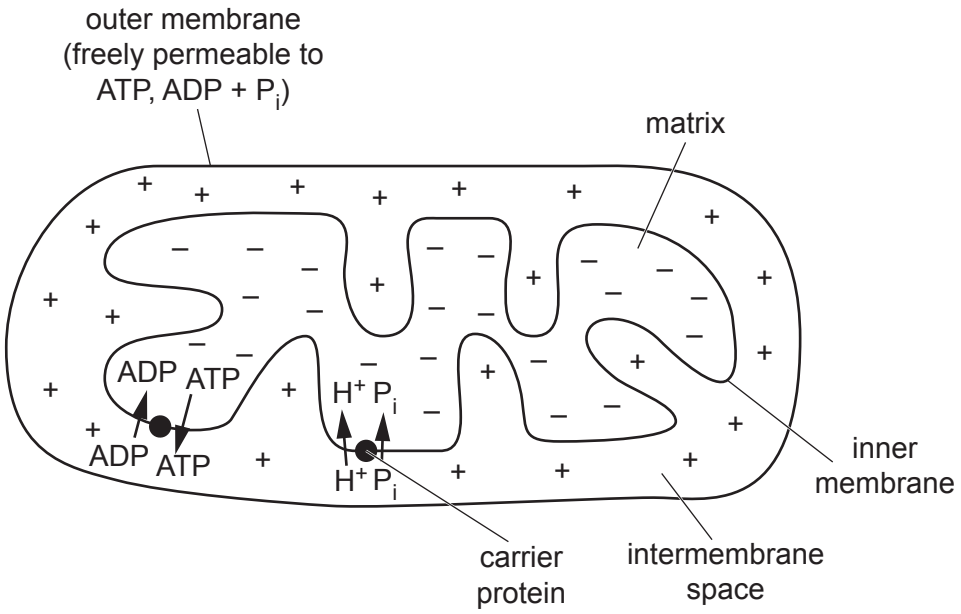


Fig. 3.1

(i) Reduced NAD and reduced FAD transfer hydrogen atoms to carriers located in the inner mitochondrial membrane.

Explain how hydrogen atoms from reduced NAD and reduced FAD lead to a membrane potential forming across the inner mitochondrial membrane during oxidative phosphorylation.

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(ii) Suggest **and** explain how P_i is transported across the inner membrane of the mitochondrion into the matrix.

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(iii) Suggest the advantages of linking ATP transport to ADP transport across the inner membrane of the mitochondrion.

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[Total: 14]

4 Adenosine deaminase (ADA) deficiency is an immune system disorder caused by a recessive autosomal mutation.

Severe combined immunodeficiency caused by a lack of ADA is called ADA-SCID.

(a) Genetic engineering is used to make a recombinant human protein to treat people with ADA-SCID.

Outline the principles of genetic engineering.

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(b) In 2016 gene therapy to cure ADA-SCID was approved in Europe. The gene therapy involves three main steps.

- Blood (haematopoietic) stem cells are taken from the bone marrow of the person with ADA-SCID.
- The functional gene and its promoter are inserted into the blood stem cells.
- A single infusion (injection) of the gene-corrected cells is given to the patient.

(i) Explain why a single infusion of gene-corrected stem cells is enough to cure the disease.

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(ii) Explain why a promoter has to be transferred as well as the desired gene.

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(iii) A modified retrovirus is used to insert the new gene into the DNA of the blood stem cells.

State **two** ethical considerations of using a retrovirus for gene therapy.

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(c) The gene therapy technique used to cure ADA-SCID is **not** suitable for treating the genetic disease called Huntington's disease. A newer technique called gene editing could potentially be used instead to cure Huntington's disease.

Explain why gene editing is more suitable as a potential cure for Huntington's disease.

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[Total: 13]

5 A large number of alpine plant species grow in the mountains of New Zealand's South Island. Alpine plants are defined as plants that live above the treeline, which is the height above which trees cannot grow. The current treeline for most of South Island is 1200 m.

(a) The alpine areas nearest to South Island are 1500–2000 km away across the sea. Many of South Island's alpine species live nowhere else in the world.

Explain how a large number of alpine plant species developed on South Island.

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(b) Fig. 5.1 shows two aspects of the history of South Island over the last 3.9 million years.

- The dashed line shows how the mean height of mountains in the Clyde region of South Island increased over time. The mountains in this range have a mean height of 2400 m at the present time.
- The solid line models the height of the treeline over time based on geological climate data. The treeline was higher when the climate was warmer, and the treeline was lower when the climate was colder, during ice ages.

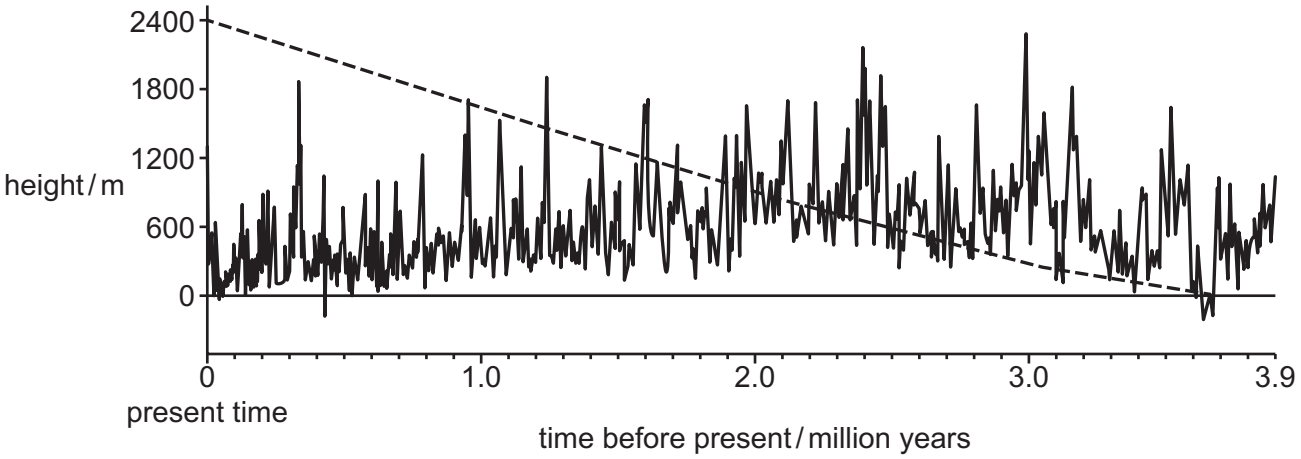


Fig. 5.1

(i) With reference to Fig. 5.1, identify with reasons the time period when South Island's alpine plant species developed.

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(ii) Suggest how DNA sequence data could be used to confirm the time period you identified in **(i)**.

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[Total: 10]

6 Selective breeding has been used to improve the characteristics of crop plants, including maize and rice.

(a) Outline how vigorous, uniform varieties of maize were developed by selective breeding.

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(b) IR8 is a variety of rice plant that was developed in the 1960s.

IR8 was developed by breeding together two different varieties of rice:

- PETA, which produces a high yield
- DGWG, which is a dwarf variety.

Fig. 6.1 is a diagram showing the three varieties of rice.

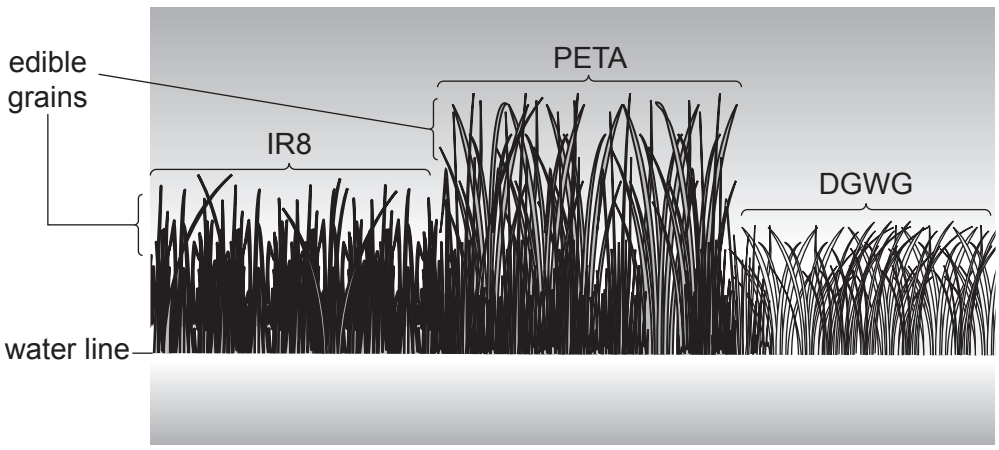


Fig. 6.1

(i) Suggest why IR8 is an improvement on the PETA variety of rice.

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..... [1]

(ii) In 2009, scientists produced a new variety of rice, IR64-Sub1, by breeding together:

- FR13A, a variety which has a low yield but has an allele for flood tolerance
- IR64, a variety which produces a high yield.

The scientists sequenced the DNA of these three rice varieties.

Suggest the benefit of sequencing the DNA of IR64-Sub1.

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..... [1]

(iii) After a few generations of breeding, the scientists crossed IR64-Sub1 with IR64.

Explain why the scientists crossed IR64-Sub1 with IR64.

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..... [1]

(c) Thale cress, *Arabidopsis thaliana*, is another plant that has dwarf varieties.

Scientists treated three varieties of *A. thaliana* with gibberellin:

- the wild type (normal, non-dwarf variety)
- dwarf variety **A**
- dwarf variety **B**.

Fig. 6.2 shows the responses of the three varieties to treatment with gibberellin.

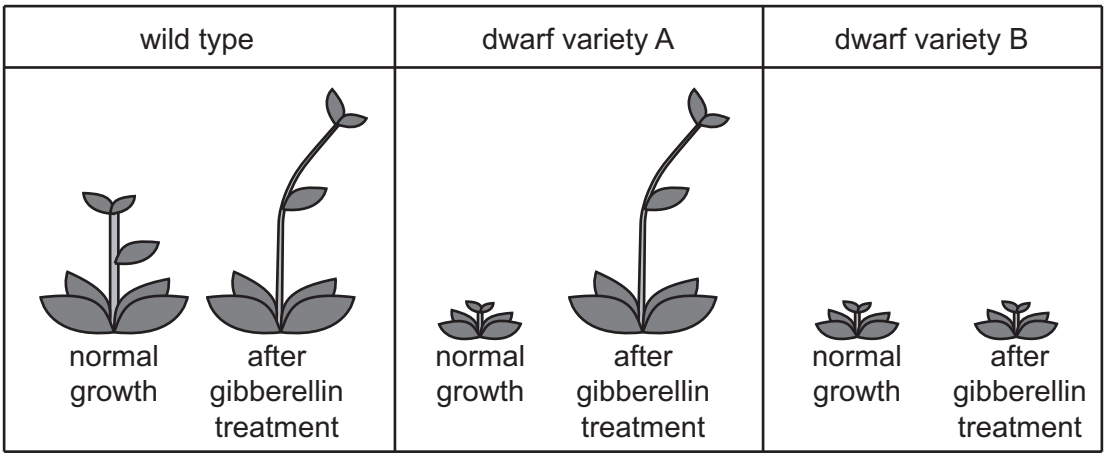


Fig. 6.2

(i) With reference to Fig. 6.2, suggest explanations for the different responses to gibberellin shown by dwarf variety **A** and dwarf variety **B**.

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(ii) BZR1 is a transcription factor that helps to regulate growth and development in *A. thaliana*.

Outline the features of a transcription factor such as BZR1.

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[Total: 13]

7 **(a)** In some varieties of domestic cats the gene for fur colour is located on the **X** chromosome. This gene has two alleles. One allele codes for black fur and the other allele codes for ginger fur. The two alleles are codominant so a heterozygous cat will have fur with patches of black and ginger colours. A cat with fur of two colours is known as a tortoiseshell.

Using appropriate symbols, construct a genetic diagram to show the results of a cross between a female tortoiseshell cat and a male ginger cat.

symbols

parent phenotypes tortoiseshell female ginger male

parent genotypes

gametes

offspring genotypes

offspring phenotypes

[5]

(b) In humans the *TYR* gene is involved in the production of a dark pigment, melanin, in some cells.

Describe how the expression of the *TYR* gene leads to the production of melanin.

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[Total: 8]

8 **(a)** Fig. 8.1 is a diagram of a kidney nephron.

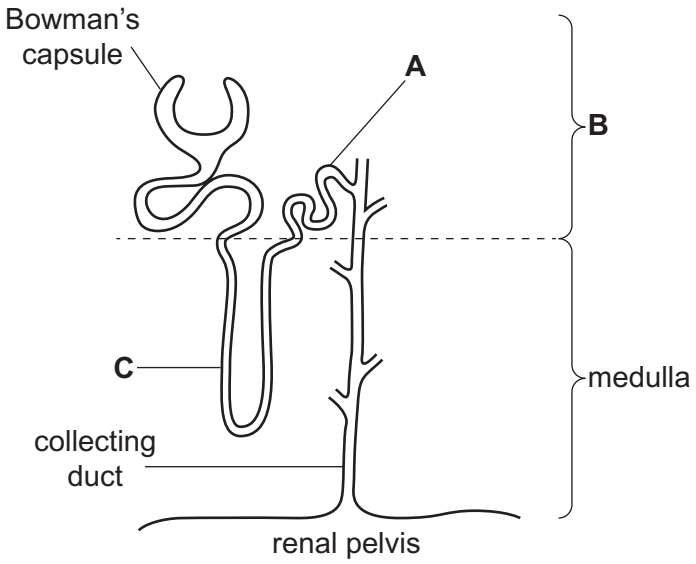


Fig. 8.1

With reference to Fig. 8.1, name **A**, **B** and **C**.

A .....

B .....

C .....

[3]

(b) Antidiuretic hormone (ADH) is involved in the maintenance of the water potential of the blood.

Fig. 8.2 shows the relationship between blood ADH concentration, urine concentration and the flow rate of urine.

The flow rate of urine is the rate of production of urine by the kidneys.

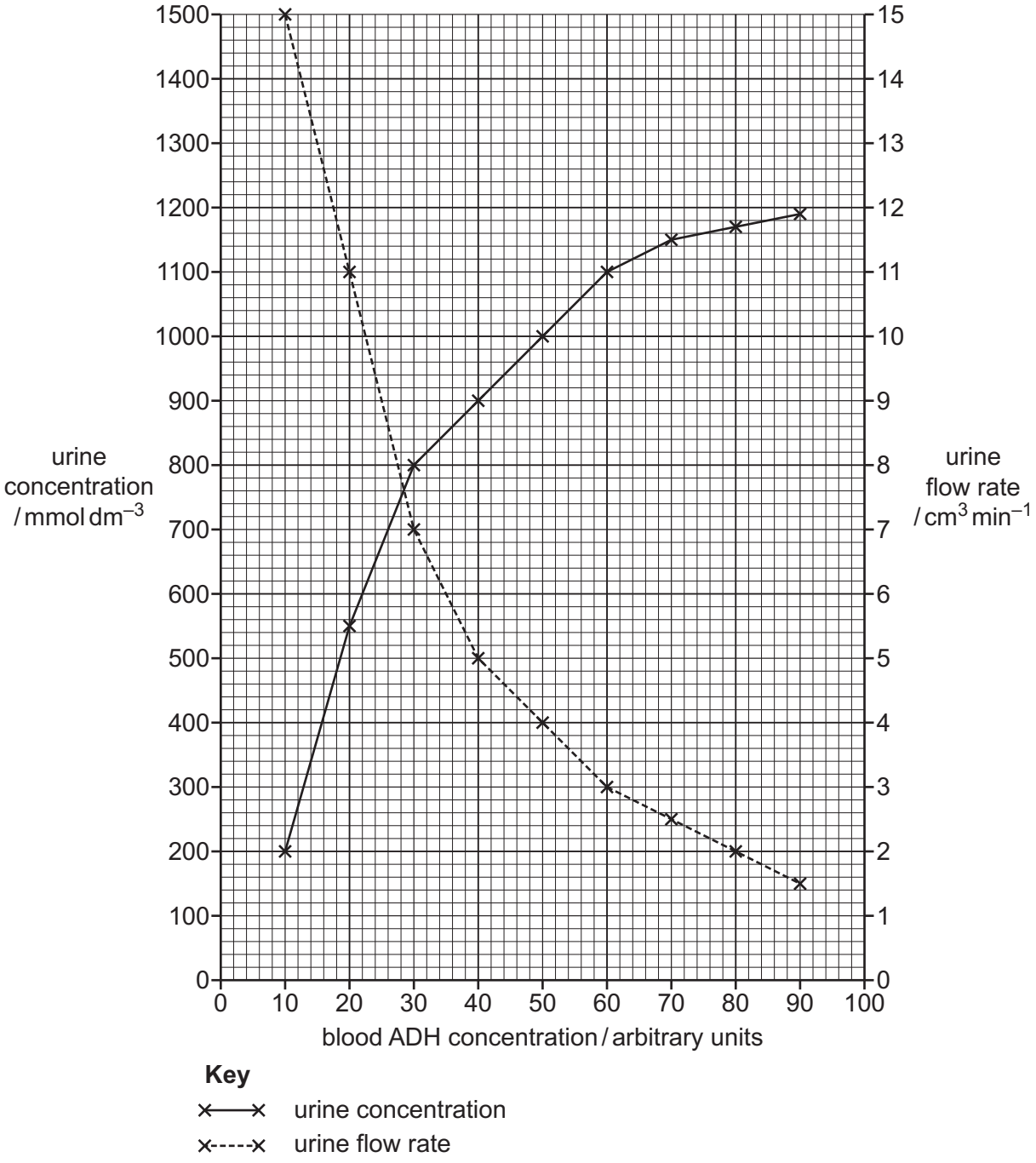


Fig. 8.2

Describe the relationships shown in Fig. 8.2.

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(c) Describe **and** explain the action of ADH on the cells of the collecting duct when the water potential of the blood decreases.

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[Total: 11]

9 **(a)** A neuromuscular junction allows the transmission of an action potential from a motor neurone to a striated muscle fibre, causing it to contract.

Fig. 9.1 is a graph of an action potential in a motor neurone.

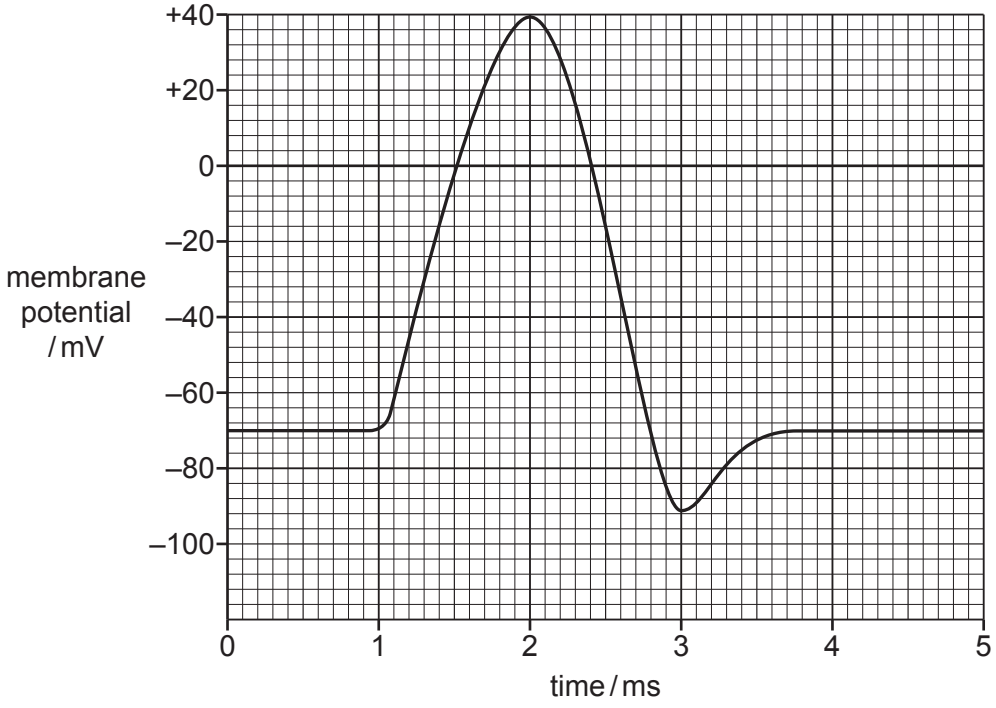


Fig. 9.1

Fig. 9.2 is a graph of an action potential in a striated muscle fibre.

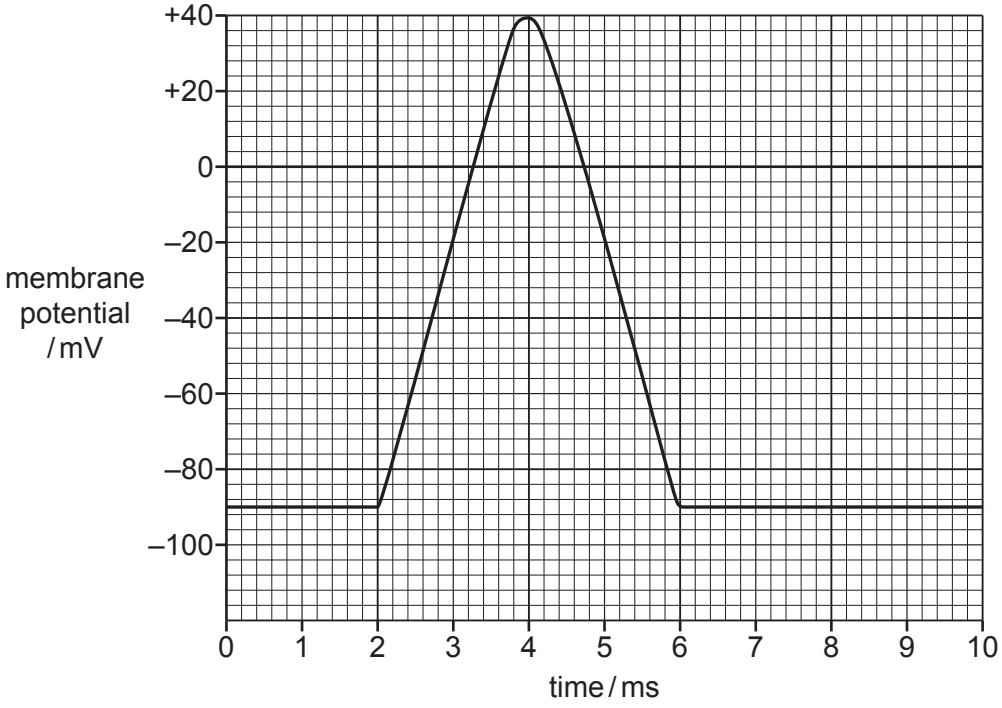


Fig. 9.2

With reference to Fig. 9.1 and Fig. 9.2, describe the differences between the action potential in a motor neurone and the action potential in a striated muscle fibre.

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(b) There are three phases in the contraction of a striated muscle: latent phase, contraction phase and relaxation phase.

The tension in a muscle represents the degree of contraction of its fibres.

Fig. 9.3 is a graph of the tension in a striated muscle during the three phases of contraction.

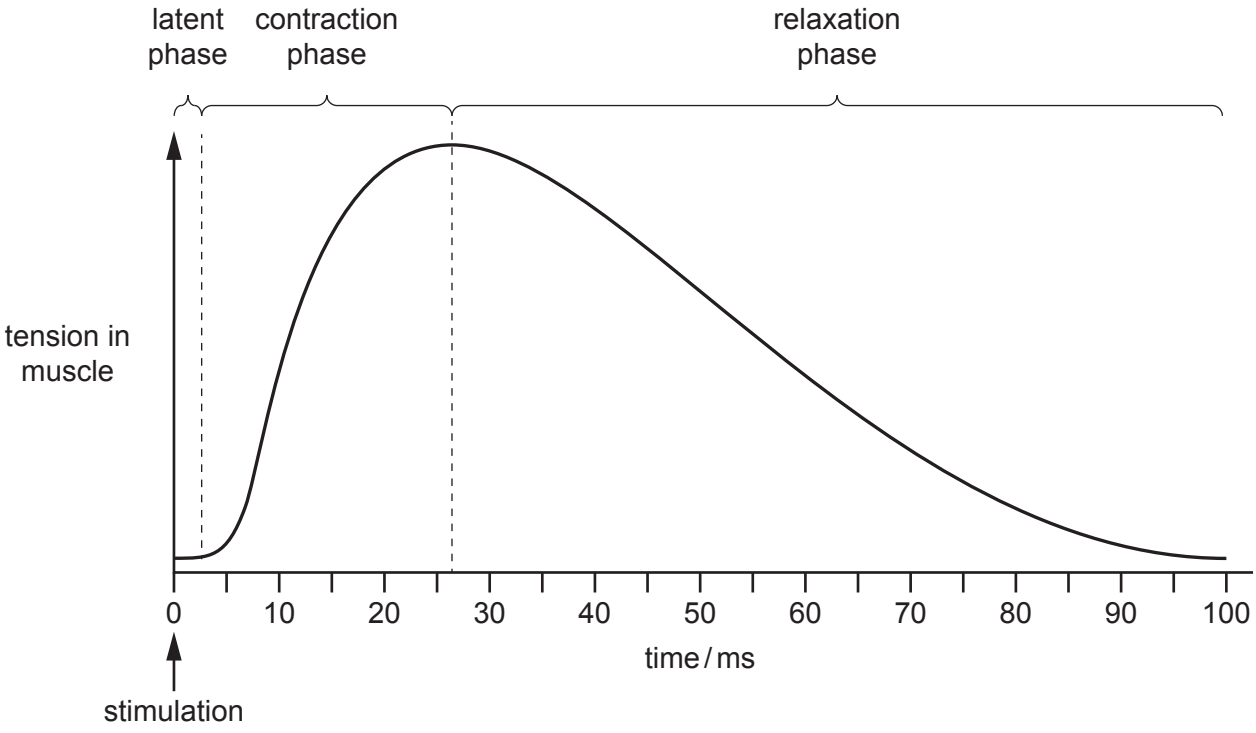


Fig. 9.3

(i) With reference to Fig. 9.3, explain what is happening in the striated muscle fibre during the latent phase.

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..... [3]

(ii) Suggest why the relaxation phase shows a gradual decrease in muscle tension.

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..... [1]

[Total: 8]

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10 The passage below outlines homeostasis.

Complete the passage by using the most appropriate scientific terms.

Homeostasis, in mammals, is the process of keeping the ..... environment of the body in optimum conditions so that cells can function efficiently. Blood water potential, core temperature and blood glucose concentration are all factors that need to be kept at optimum values or set-point.

When a condition deviates from its set-point, a corrective mechanism is triggered. An increase in blood glucose concentration triggers processes to decrease it and vice versa. This corrective mechanism is called ..... .

The pancreas is involved in the control of blood glucose concentration. Glucose binds to ..... on the cell surface membrane of pancreatic cells. These are ..... cells, which secrete hormones such as insulin and glucagon. The two hormones have opposite effects on the blood glucose concentration. For example the action of one hormone stimulates the uptake of glucose by cells for respiration and the action of the other hormone stimulates the breakdown of ..... to glucose in the liver.

[Total: 5]

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0566161817

BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **October/November 2022**

2 hours

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No additional materials are needed.

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1 The Asiatic lion, *Panthera leo persica*, is found only in the Gir Forest National Park in the Gujarat region of western India.

Fig. 1.1 shows a female Asiatic lion.



Fig. 1.1

(a) The Asiatic lion is at risk of extinction in the wild and is categorised as endangered by the International Union for Conservation of Nature (IUCN).

Outline the role of the IUCN.

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..... [3]

(b) The Maldhari community is a tribe of herdsmen that lives in the Gir Forest. The Maldhari have co-existed with the Asiatic lions for thousands of years. The Maldhari place old and weak cattle at the edges of their cattle enclosures.

Suggest why the Maldhari place old and weak cattle at the edges of their cattle enclosures.

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..... [2]

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(c) Some zoos use assisted reproduction techniques, such as IVF, in their captive breeding programmes for endangered species.

Describe how IVF can be used with an endangered species such as the Asiatic lion.

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..... [4]

[Total: 9]

2 Yeast cells can respire in anaerobic conditions.

(a) (i) Outline how yeast carries out respiration in anaerobic conditions.

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(ii) Explain why respiration in anaerobic conditions is an advantage to yeast.

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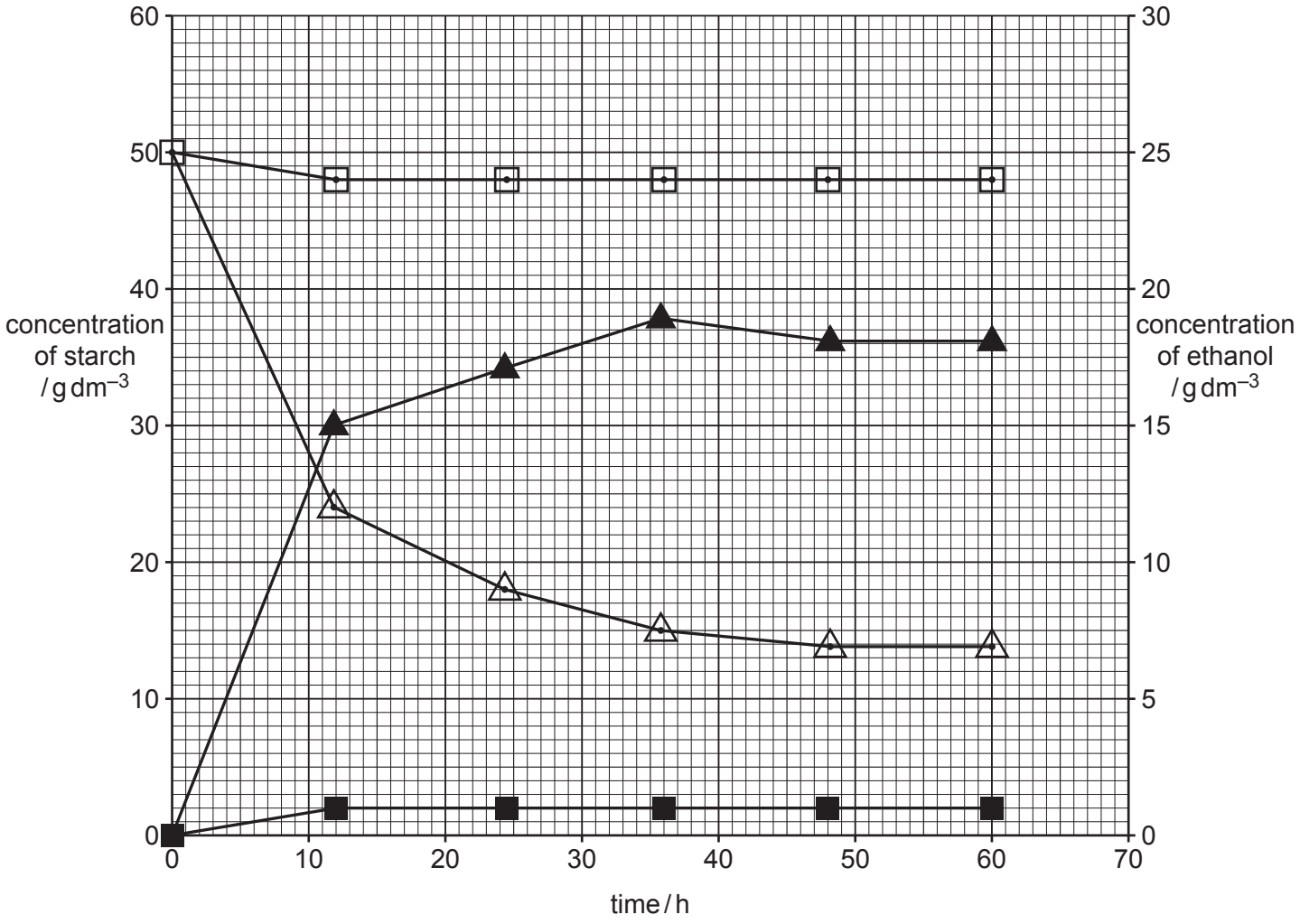
Bioethanol is a type of biofuel produced from maize starch on an industrial scale. In the high temperature method, heating to 120 °C is used to break apart starch molecules. The enzymes α-amylase and glucoamylase are added to the resulting starch suspension once it has cooled down. These enzymes hydrolyse the starch to glucose. Yeast cells are then added and maintained in anaerobic conditions to produce ethanol.

The high temperature method is expensive to carry out, so a new method has been developed which heats starch to a lower temperature of 80 °C.

In the lower temperature method, enzymes catalysing the hydrolysis of starch do **not** need to be added to the starch suspension. A genetically modified (GM) strain of the same yeast species is used. The GM strain of yeast has genes that allow the cell to produce α-amylase and glucoamylase and to attach these enzymes to the external surface of the cell surface membrane. The GM yeast cells are added to the starch that was heated to 80 °C and are maintained in anaerobic conditions to produce ethanol.

(b) An investigation was carried out to compare the GM strain of yeast with the yeast that had **not** been genetically modified (non-GM strain).
In this investigation, the starch suspension produced after heating to 80 °C was allowed to cool to 30 °C before adding yeast cells.

The results are shown in Fig. 2.1.



Key

■ ethanol concentration using non-GM strain

□ starch concentration using non-GM strain

▲ ethanol concentration using GM strain

△ starch concentration using GM strain

Fig. 2.1

With reference to Fig. 2.1, describe the trends in the data for **ethanol** production by the GM strain compared to the non-GM strain.

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(c) The rate of ethanol production is similar for the lower temperature method and the higher temperature method.

Suggest why using the lower temperature method has a similar rate of production of ethanol to the higher temperature method.

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(d) Suggest **one** reason why the high temperature method is expensive to carry out.

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[Total: 11]

3 **(a)** Photosynthesis is an energy transfer process that takes place in chloroplasts of plant cells.

(i) Fig. 3.1 shows a diagram of a chloroplast.

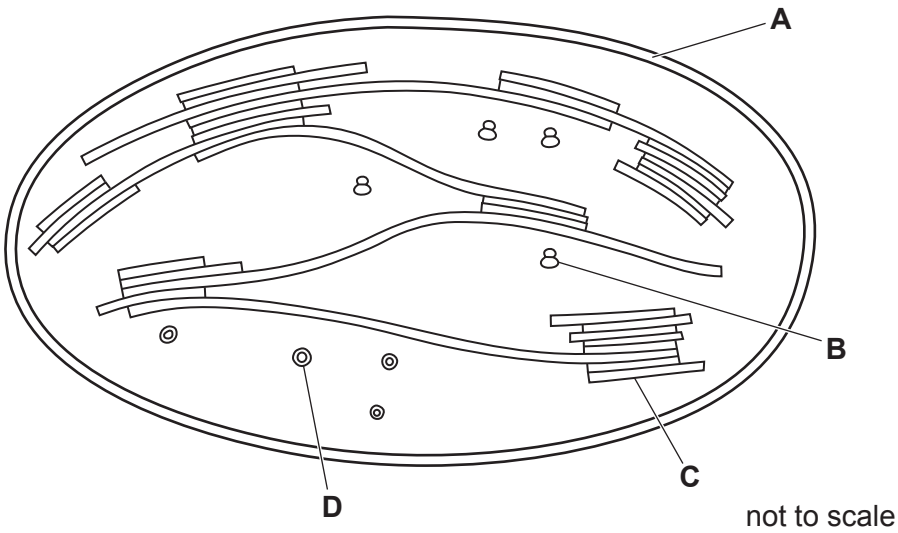


Fig. 3.1

Using the letters **A**, **B**, **C** or **D**, identify the structure that:

- contains genes that code for some of the enzymes used in photosynthesis

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- is the site of synthesis of some of the enzymes used in photosynthesis.

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[2]

(ii) Explain how grana are adapted for their specific role in photosynthesis.

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..... [4]

(b) An experiment was carried out to investigate the effect of changing light conditions on the pH of the chloroplast stroma. Scientists followed pH changes in chloroplast stroma using fluorescent chemicals that can be used as pH indicators.

- Chloroplasts were isolated from cells.
- A suspension of chloroplasts was prepared and kept in the dark for 180 seconds.
- The chloroplasts were exposed to a period of light of fixed intensity for 240 seconds, then returned to dark conditions.
- The pH of chloroplast stroma was continuously measured and recorded.

Fig. 3.2 shows the results of this experiment.

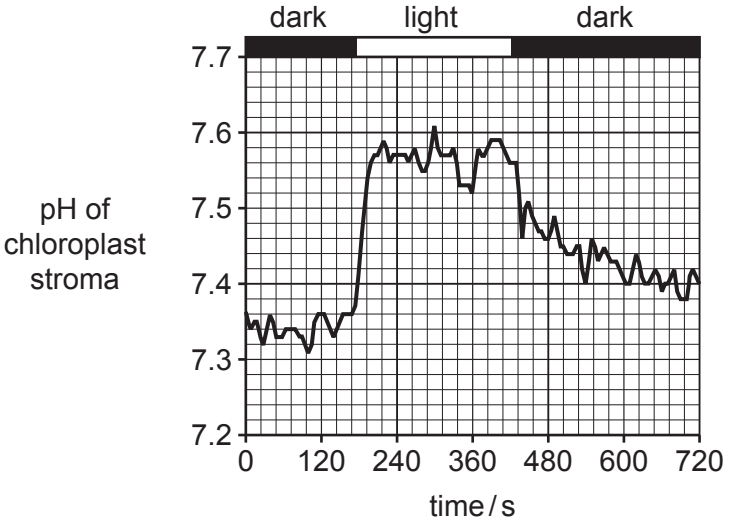


Fig. 3.2

(i) Describe the results shown in Fig. 3.2.

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(ii) Discuss how the results in Fig. 3.2 support that chemiosmosis occurs during photophosphorylation.

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..... [3]

[Total: 12]

4 Haemophilia is a blood clotting disorder in humans caused by a mutant allele on the X chromosome.

Table 4.1 compares two forms of haemophilia: haemophilia A and haemophilia B.

Table 4.1

	haemophilia A	**haemophilia B**
gene	*F8*	*F9*
clotting factor protein	factor VIII	factor IX
proportion of males born with haemophilia	1 in 5000	1 in 30 000
length of functional gene (exons only) / kilobase pairs	7.0	1.6

(a) Genetic engineering is used to make recombinant human proteins to treat people with haemophilia A and haemophilia B.

Outline the principles of genetic engineering.

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..... [4]

(b) Scientists are working towards a goal of treating haemophilia by gene therapy. They plan to use a common, harmless virus to introduce the functional gene. The virus has a genome that is 4.7 kilobase pairs long.

(i) With reference to Table 4.1 and the introduction to **(a)**, assess:
- which form of haemophilia, A or B, scientists should try to treat first
- whether they should attempt to treat haemophilia with gene therapy at all.

Explain your reasoning.

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..... [3]

(ii) In gene therapy trials to treat haemophilia, the gene coding for the clotting factor needs to be introduced together with a promoter.

Explain why a promoter has to be introduced as well as the desired gene.

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..... [2]

(iii) Some individuals taking part in gene therapy trials have been naturally exposed to the virus carrying the functional gene, so that their blood already contains antibodies to the virus.

Predict how this will affect the success of the gene therapy treatment.

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..... [2]

(c) Gene editing is a newer technique for modifying DNA. Some scientists are researching the use of gene editing, instead of introducing a functional gene, to treat haemophilia.

State **two** possible advantages of using gene editing as a method of treating haemophilia.

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..... [2]

[Total: 13]

5 *Myosotis* is a genus of small flowering plants. Many different *Myosotis* species grow on the islands of New Zealand, which are an important site of *Myosotis* evolution. Lowland *Myosotis* species grow at low altitude while alpine *Myosotis* species grow at high altitude at the tops of mountains.

(a) Scientists wanted to obtain molecular data to determine the evolutionary relationships of New Zealand's *Myosotis* species. They extracted DNA from individuals of *Myosotis* species collected from three different islands in New Zealand.

To carry out a polymerase chain reaction before DNA sequencing, the DNA samples were mixed with primers, deoxynucleotides and *Taq* polymerase and put through 35 cycles of treatment. Each treatment cycle involved one minute at 95 °C, followed by one minute at 50 °C and then four minutes at 72 °C.

Describe what happened to the DNA at each temperature.

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..... [3]

(b) Fig. 5.1 shows the three largest New Zealand islands.

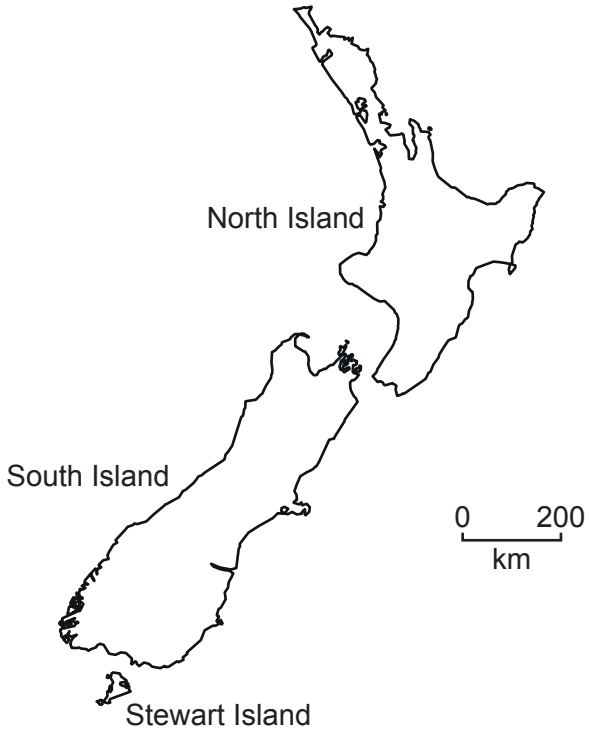


Fig. 5.1

North Island has mostly lowland habitat. South Island and Stewart Island have mountains with alpine habitats that are above the tree line.

DNA sequence data for three *Myosotis* species were compared. The results are described in the bullet points.

- In the alpine species *M. pygmaea*, individuals on South Island showed genetic differences from individuals of *M. pygmaea* on Stewart Island.
- In the alpine species *M. pulvinaris*, individuals from different mountains on South Island showed genetic differences.
- In the lowland species *M. pottsiana*, individuals from different areas of North Island showed overall genetic similarity.

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Discuss reasons for the results in the three species.

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..... [5]

(c) State **two** factors, other than natural selection, that could drive genetic changes in populations of *Myosotis*.

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..... [2]

[Total: 10]

6 **(a)** The *lac* operon of prokaryotes contains a group of structural genes that are under the same control and are transcribed together.

Another operon found in prokaryotes is the *trp* operon.

Fig. 6.1 summarises the structure and control of the *trp* operon.

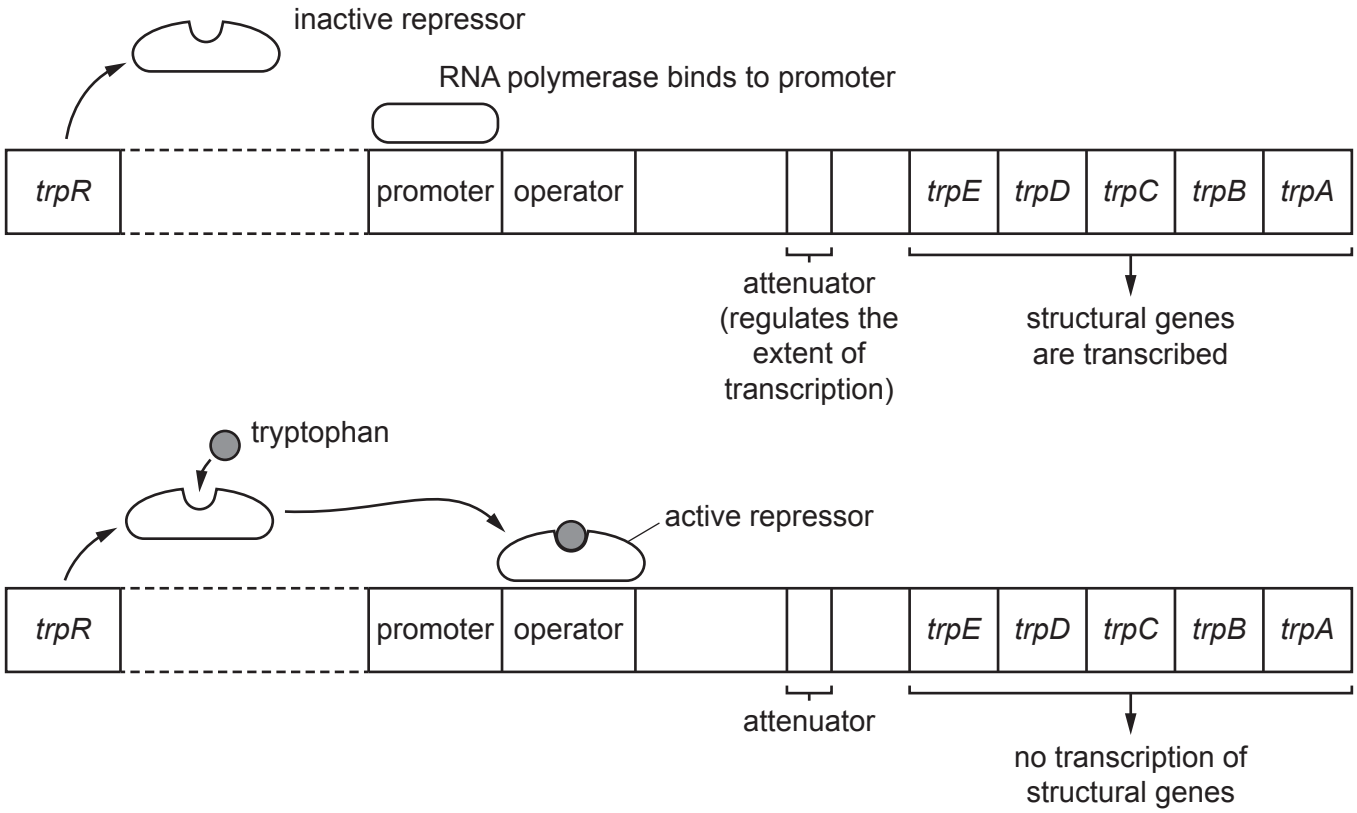


Fig. 6.1

(i) Describe the differences in structure **and** control between the *lac* operon and the *trp* operon.

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..... [3]

(ii) Suggest why structural genes in operons are transcribed together.

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..... [1]

(iii) *trpA* is an example of a structural gene and *trpR* is an example of a regulatory gene.

Describe the differences between the functions of structural genes and regulatory genes.

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..... [2]

(iv) *trpA* codes for the enzyme tryptophan synthase.

Tryptophan synthase catalyses the formation of the amino acid tryptophan.

Explain why tryptophan synthase is an example of a repressible enzyme.

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..... [2]

(b) Control of gene expression in eukaryotes is more complex than in prokaryotes.

In plants, the control of gene expression can involve plant hormones, such as gibberellin, and proteins known as JAZ and MYC.

(i) Describe how gibberellin activates genes in plant cells.

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..... [4]

(ii) Transcription of some plant genes is prevented when JAZ proteins bind to other proteins known as MYC.

When JAZ proteins are broken down, MYC proteins are free to bind to DNA. This allows transcription to begin.

State the term that is used to describe proteins such as MYC proteins.

..... [1]

[Total: 13]

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Turn over for Question 7.

7 The determination of sex in domestic turkeys is different from that in humans. The sex chromosomes in turkeys are named **Z** and **W**. Male turkeys are **ZZ** and female turkeys are **ZW**.

The gene for feather colour is located only on the **Z** chromosome.

- The dominant allele codes for bronze feathers.
- The recessive allele codes for brown feathers.

(a) Define the terms dominant and recessive.

dominant .....

.....

recessive .....

.....

[2]

(b) Using suitable symbols, construct a genetic diagram to show the results of a cross between a heterozygous bronze male turkey and a brown female turkey.

symbols

parent phenotypes bronze male brown female

parent genotypes

gametes

offspring genotypes

offspring phenotypes

[5]

(c) Explain how you would carry out a test cross to determine the genotype of a bronze male turkey.

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..... [3]

[Total: 10]

8 **(a)** Selective reabsorption takes place in the proximal convoluted tubule of a kidney nephron.

Fig. 8.1 is a diagram of two cells of the proximal convoluted tubule and part of the adjacent blood capillary.

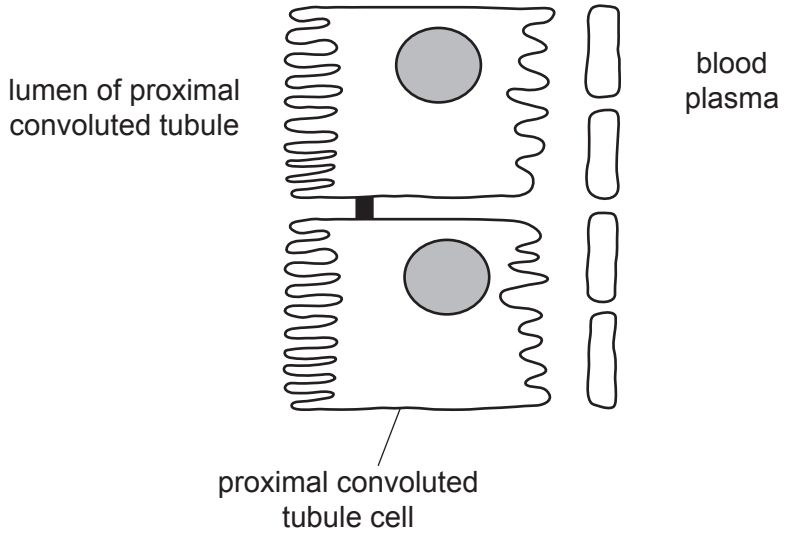


Fig. 8.1

The cells of the proximal convoluted tubule are adapted to carry out selective reabsorption.

On Fig. 8.1, use label lines and letters to indicate:

- **C**, where cotransporter proteins are located
- **P**, where sodium-potassium pumps are located. [2]

(b) Explain how the cells of the proximal convoluted tubule are adapted to carry out selective reabsorption.

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..... [5]

(c) The plasma, the glomerular filtrate and urine are composed of various substances.

Table 8.1 shows the percentage composition of plasma, the glomerular filtrate and urine.

Table 8.1

substance	percentage composition		
	plasma	**glomerular filtrate**	**urine**
water	90.00	90.00	94.00
glucose	0.10	0.10	0.00
amino acids	0.05	0.05	0.00
plasma proteins	8.00	0.00	0.00
urea	0.03	0.03	2.00
other substances	1.82	9.82	4.00

As a result of the action of the cells of the proximal convoluted tubule, glucose and amino acids have been reabsorbed by the blood, whereas only some of the urea has been reabsorbed.

Calculate how many times the percentage composition of urea has increased in the urine compared with the glomerular filtrate.

Show your working and give your answer to the nearest whole number.

answer ..... [2]

[Total: 9]

9 **(a)** Voltage-gated channels are involved in the generation of an action potential.

Fig. 9.1 is a diagram of the voltage-gated channels of sodium ions and potassium ions in the membrane of an axon. The channels are shown in three different states, **1**, **2** and **3**.

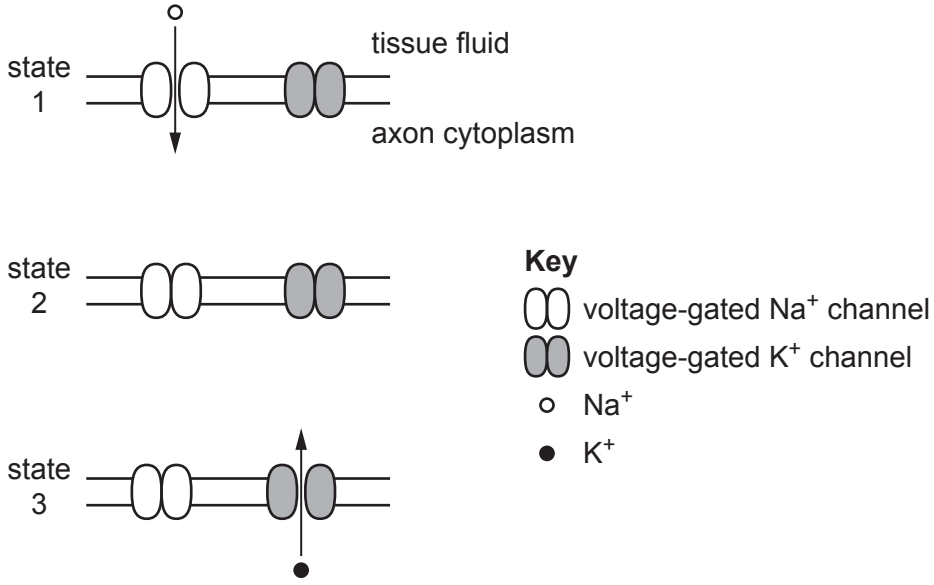


Fig. 9.1

Fig. 9.2 is a diagram of different phases of an action potential in an axon. The phases are labelled **A**, **B**, **C**, **D**, **E**, **F** and **G**.

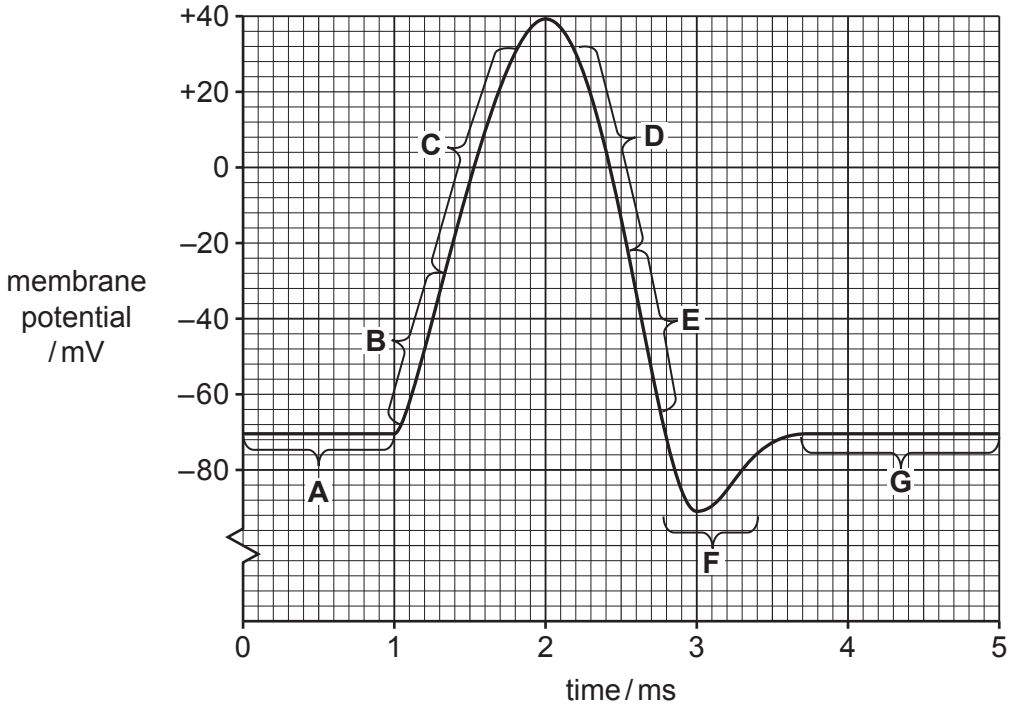


Fig. 9.2

Complete Table 9.1 to match each of the listed phases of the action potential with the appropriate state of the voltage-gated channels: **1**, **2** or **3**.

Table 9.1

phase of action potential	state of voltage-gated channels
A	.....
C	.....
E	.....
F	.....
G	.....

[3]

(b) Many neurones are surrounded by myelin sheaths.

Describe **and** explain the role of the myelin sheath in the transmission of an action potential.

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..... [3]

[Total: 6]

10 (a) Glucagon has a role in the maintenance of blood glucose concentration.

Fig. 10.1 shows the relationship between blood glucose concentration and blood glucagon concentration, measured over 90 minutes in a healthy person. The person did not have any food in the three hours before the measurements were taken.

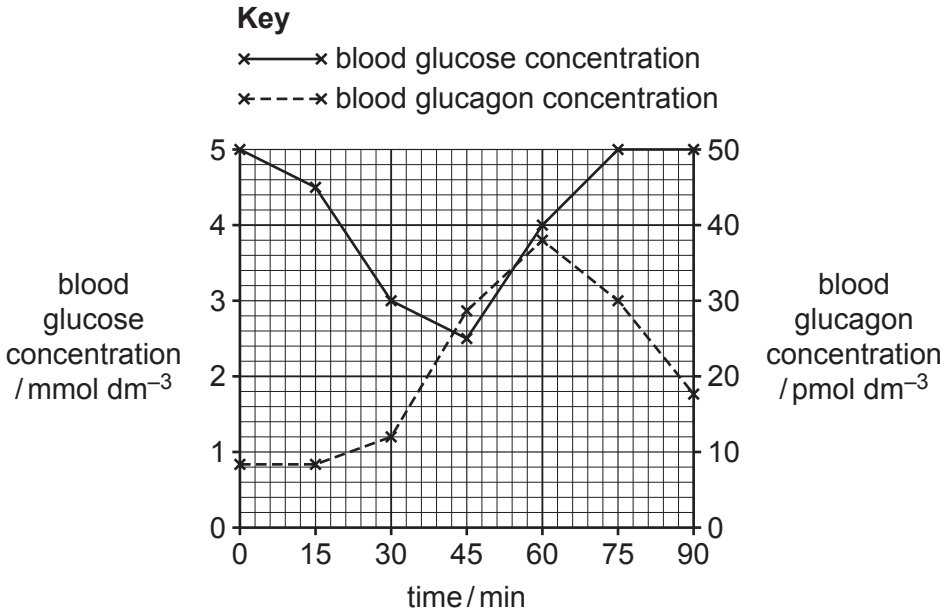


Fig. 10.1

Explain the relationship shown in Fig. 10.1.

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..... [4]

(b) The passage below outlines cell signalling.

Complete the passage by using the most appropriate scientific terms.

Cells need to interact with their environment and other cells around them. This is called cell signalling. Cells in mammals are involved in a complex system of communication with each other. For example, liver cells detect signals using receptors in their cell surface membranes. Glucagon binds to the receptors because its shape is ..... . This binding activates a ..... , leading to stimulation of the enzyme ..... . [3]

[Total: 7]

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BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **October/November 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.

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1 The wild Bactrian camel, *Camelus ferus*, lives only in the desert regions of Mongolia and northern China.

Fig. 1.1 shows a wild Bactrian camel.



Fig. 1.1

(a) The wild Bactrian camel is at risk of extinction in the wild and is categorised as critically endangered by the International Union for Conservation of Nature (IUCN). There are only 950 wild Bactrian camels left in their natural habitat.

Suggest reasons why the wild Bactrian camel has become critically endangered.

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..... [2]

(b) Outline the role of the IUCN.

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..... [3]

(c) Some zoos use assisted reproduction techniques, such as embryo transfer, in their captive breeding programmes for endangered species. Embryo transfer has resulted in domesticated dromedary camels giving birth to wild Bactrian camel calves.

Describe the procedure of embryo transfer in a mammal such as a camel.

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..... [4]

[Total: 9]

2 Photosynthesis is an important energy transfer process.

(a) Name **one** chloroplast pigment.

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..... [1]

(b) Explain the relationship between the **absorption** spectrum of the main chloroplast pigments in a species of plant and the **action** spectrum for photosynthesis for that species.

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..... [2]

(c) Explain why temperature can be a limiting factor of photosynthesis.

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..... [3]

(d) Outline how the light-independent stage of photosynthesis leads to the production of carbohydrates such as starch in plant leaves.

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..... [3]

[Total: 9]

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3 **(a)** The results of investigations carried out on mitochondria show how the structure of a mitochondrion is related to its role in aerobic respiration.

- Intact mitochondria (not damaged) were removed from cells.
- A technique was used to remove the outer mitochondrial membrane, leaving the inner membrane intact.
- The inner mitochondrial membrane was separated from the contents of the matrix so that both could be analysed.

(i) The removal of the outer membranes of mitochondria involves placing the organelles in pure water. This results in the rupture (bursting) of the outer membrane. The inner mitochondrial membrane does not rupture and remains intact.

Suggest **and** explain why the inner membrane of a mitochondrion remains intact when the organelle is placed in pure water.

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..... [2]

(ii) Name **three** molecules, other than coenzymes, that are found in the mitochondrial matrix **and** explain their role in aerobic respiration.

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..... [3]

(iii) The inner membrane contains a very high proportion of the molecule cardiolipin. Cardiolipin makes the membrane impermeable to some ions.

Suggest why the inner membrane contains a very high proportion of cardiolipin.

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..... [1]

(b) In further experiments it was found that, in an intact mitochondrion:

- there is a membrane potential across the inner mitochondrial membrane, with the matrix having a negative charge
- the transport of ATP, ADP and inorganic phosphate (P_i) is driven by the membrane potential across the inner membrane.

Fig. 3.1 shows the location of some inner membrane carrier proteins.

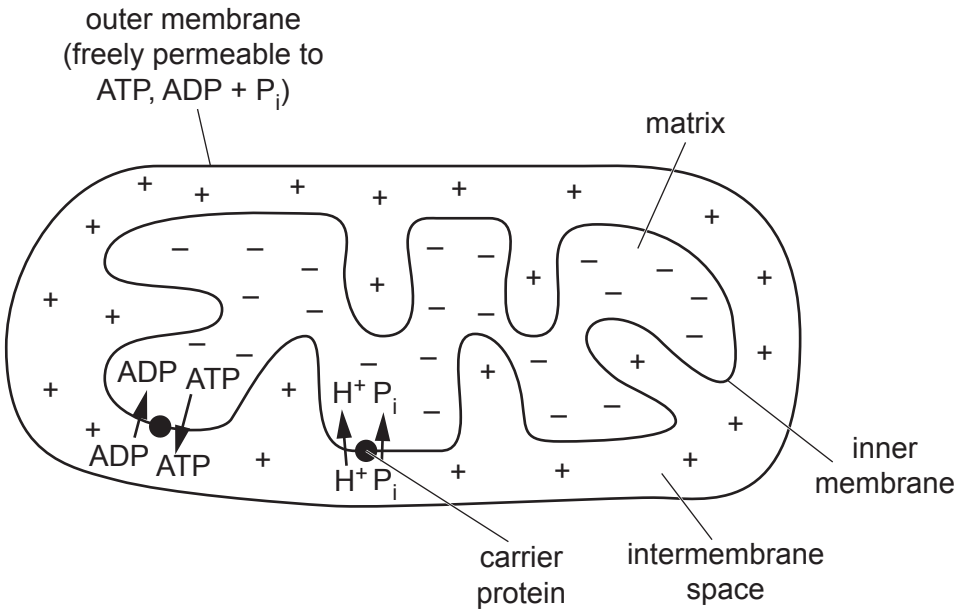


Fig. 3.1

(i) Reduced NAD and reduced FAD transfer hydrogen atoms to carriers located in the inner mitochondrial membrane.

Explain how hydrogen atoms from reduced NAD and reduced FAD lead to a membrane potential forming across the inner mitochondrial membrane during oxidative phosphorylation.

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..... [4]

(ii) Suggest **and** explain how P_i is transported across the inner membrane of the mitochondrion into the matrix.

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..... [2]

(iii) Suggest the advantages of linking ATP transport to ADP transport across the inner membrane of the mitochondrion.

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..... [2]

[Total: 14]

4 Adenosine deaminase (ADA) deficiency is an immune system disorder caused by a recessive autosomal mutation.

Severe combined immunodeficiency caused by a lack of ADA is called ADA-SCID.

(a) Genetic engineering is used to make a recombinant human protein to treat people with ADA-SCID.

Outline the principles of genetic engineering.

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..... [4]

(b) In 2016 gene therapy to cure ADA-SCID was approved in Europe. The gene therapy involves three main steps.

- Blood (haematopoietic) stem cells are taken from the bone marrow of the person with ADA-SCID.
- The functional gene and its promoter are inserted into the blood stem cells.
- A single infusion (injection) of the gene-corrected cells is given to the patient.

(i) Explain why a single infusion of gene-corrected stem cells is enough to cure the disease.

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..... [2]

(ii) Explain why a promoter has to be transferred as well as the desired gene.

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..... [2]

(iii) A modified retrovirus is used to insert the new gene into the DNA of the blood stem cells.

State **two** ethical considerations of using a retrovirus for gene therapy.

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..... [2]

(c) The gene therapy technique used to cure ADA-SCID is **not** suitable for treating the genetic disease called Huntington's disease. A newer technique called gene editing could potentially be used instead to cure Huntington's disease.

Explain why gene editing is more suitable as a potential cure for Huntington's disease.

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..... [3]

[Total: 13]

5 A large number of alpine plant species grow in the mountains of New Zealand's South Island. Alpine plants are defined as plants that live above the treeline, which is the height above which trees cannot grow. The current treeline for most of South Island is 1200 m.

(a) The alpine areas nearest to South Island are 1500–2000 km away across the sea. Many of South Island's alpine species live nowhere else in the world.

Explain how a large number of alpine plant species developed on South Island.

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..... [5]

(b) Fig. 5.1 shows two aspects of the history of South Island over the last 3.9 million years.

- The dashed line shows how the mean height of mountains in the Clyde region of South Island increased over time. The mountains in this range have a mean height of 2400 m at the present time.
- The solid line models the height of the treeline over time based on geological climate data. The treeline was higher when the climate was warmer, and the treeline was lower when the climate was colder, during ice ages.

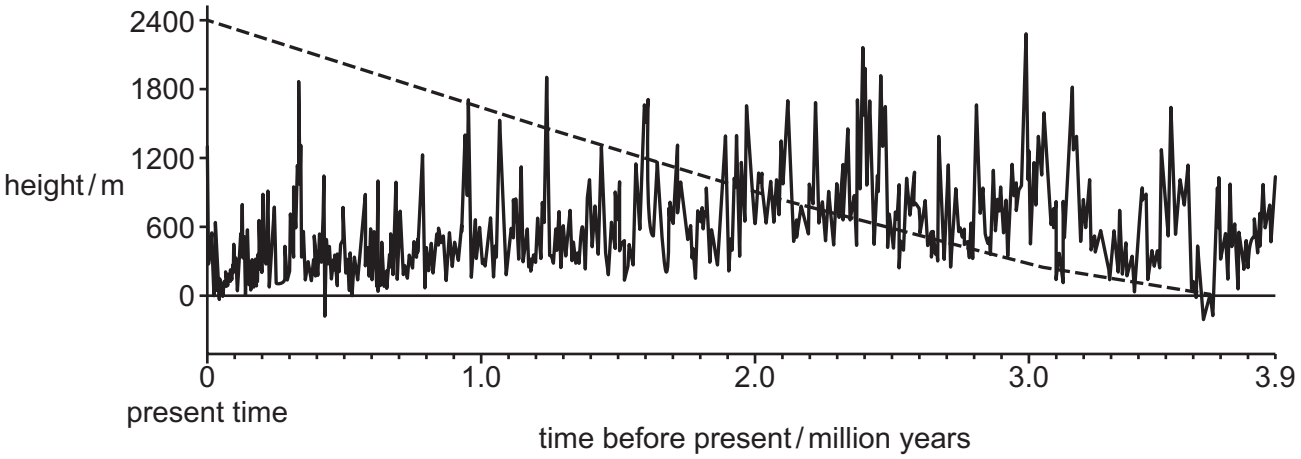


Fig. 5.1

(i) With reference to Fig. 5.1, identify with reasons the time period when South Island's alpine plant species developed.

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..... [3]

(ii) Suggest how DNA sequence data could be used to confirm the time period you identified in **(i)**.

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..... [2]

[Total: 10]

6 Selective breeding has been used to improve the characteristics of crop plants, including maize and rice.

(a) Outline how vigorous, uniform varieties of maize were developed by selective breeding.

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..... [4]

(b) IR8 is a variety of rice plant that was developed in the 1960s.

IR8 was developed by breeding together two different varieties of rice:

- PETA, which produces a high yield
- DGWG, which is a dwarf variety.

Fig. 6.1 is a diagram showing the three varieties of rice.

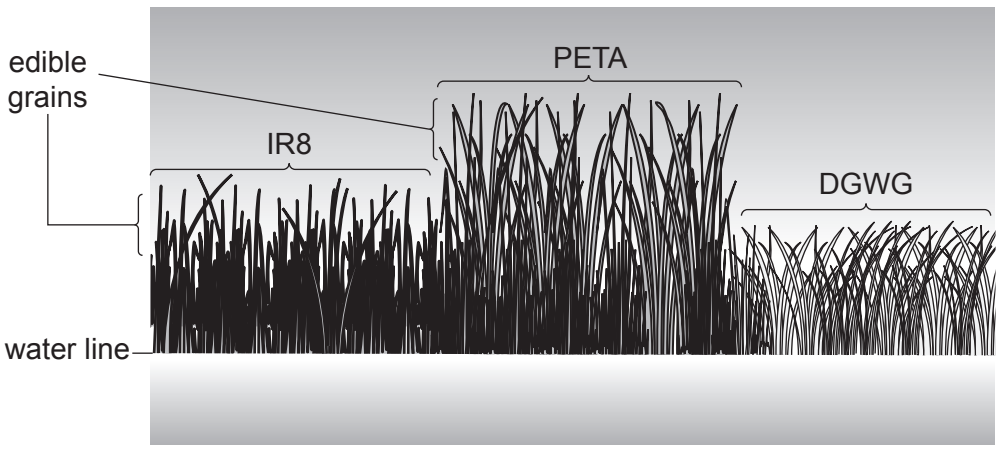


Fig. 6.1

(i) Suggest why IR8 is an improvement on the PETA variety of rice.

.....

..... [1]

(ii) In 2009, scientists produced a new variety of rice, IR64-Sub1, by breeding together:

- FR13A, a variety which has a low yield but has an allele for flood tolerance
- IR64, a variety which produces a high yield.

The scientists sequenced the DNA of these three rice varieties.

Suggest the benefit of sequencing the DNA of IR64-Sub1.

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..... [1]

(iii) After a few generations of breeding, the scientists crossed IR64-Sub1 with IR64.

Explain why the scientists crossed IR64-Sub1 with IR64.

.....

..... [1]

(c) Thale cress, *Arabidopsis thaliana*, is another plant that has dwarf varieties.

Scientists treated three varieties of *A. thaliana* with gibberellin:

- the wild type (normal, non-dwarf variety)
- dwarf variety **A**
- dwarf variety **B**.

Fig. 6.2 shows the responses of the three varieties to treatment with gibberellin.

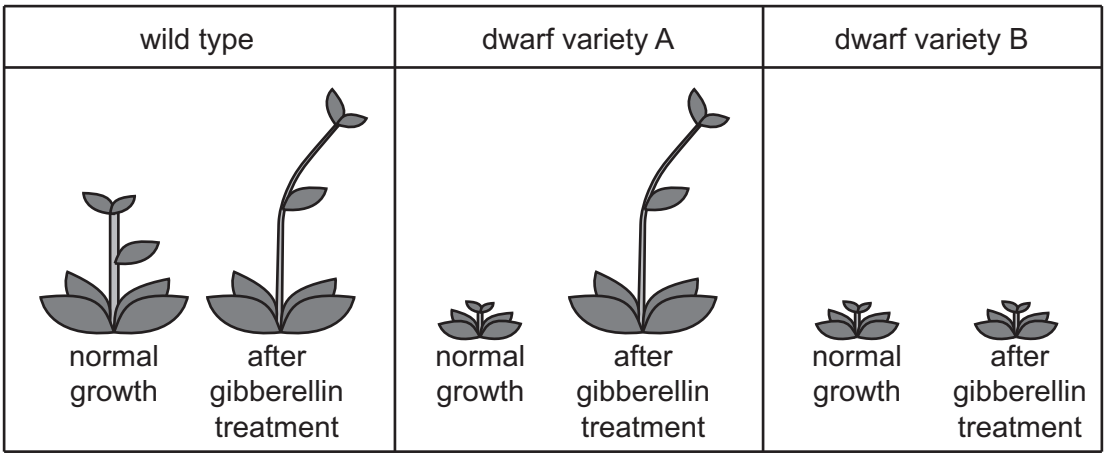


Fig. 6.2

(i) With reference to Fig. 6.2, suggest explanations for the different responses to gibberellin shown by dwarf variety **A** and dwarf variety **B**.

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..... [4]

(ii) BZR1 is a transcription factor that helps to regulate growth and development in *A. thaliana*.

Outline the features of a transcription factor such as BZR1.

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..... [2]

[Total: 13]

7 **(a)** In some varieties of domestic cats the gene for fur colour is located on the **X** chromosome. This gene has two alleles. One allele codes for black fur and the other allele codes for ginger fur. The two alleles are codominant so a heterozygous cat will have fur with patches of black and ginger colours. A cat with fur of two colours is known as a tortoiseshell.

Using appropriate symbols, construct a genetic diagram to show the results of a cross between a female tortoiseshell cat and a male ginger cat.

symbols

parent phenotypes tortoiseshell female ginger male

parent genotypes

gametes

offspring genotypes

offspring phenotypes

[5]

(b) In humans the *TYR* gene is involved in the production of a dark pigment, melanin, in some cells.

Describe how the expression of the *TYR* gene leads to the production of melanin.

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..... [3]

[Total: 8]

8 **(a)** Fig. 8.1 is a diagram of a kidney nephron.

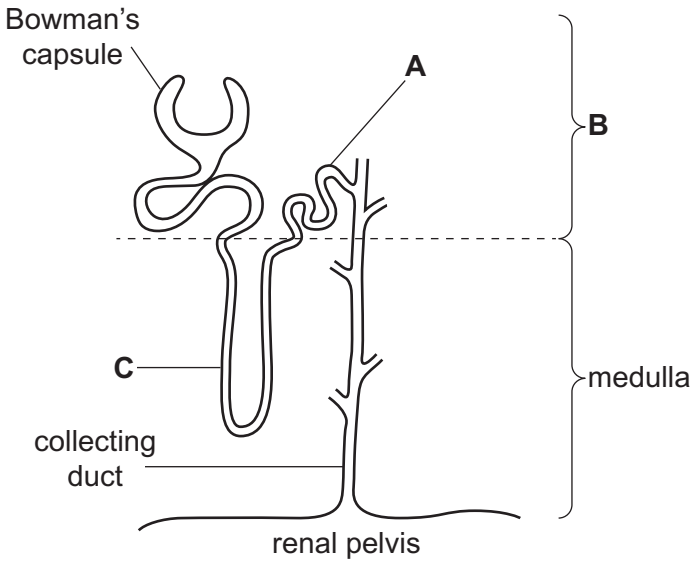


Fig. 8.1

With reference to Fig. 8.1, name **A**, **B** and **C**.

A .....

B .....

C .....

[3]

(b) Antidiuretic hormone (ADH) is involved in the maintenance of the water potential of the blood.

Fig. 8.2 shows the relationship between blood ADH concentration, urine concentration and the flow rate of urine.

The flow rate of urine is the rate of production of urine by the kidneys.

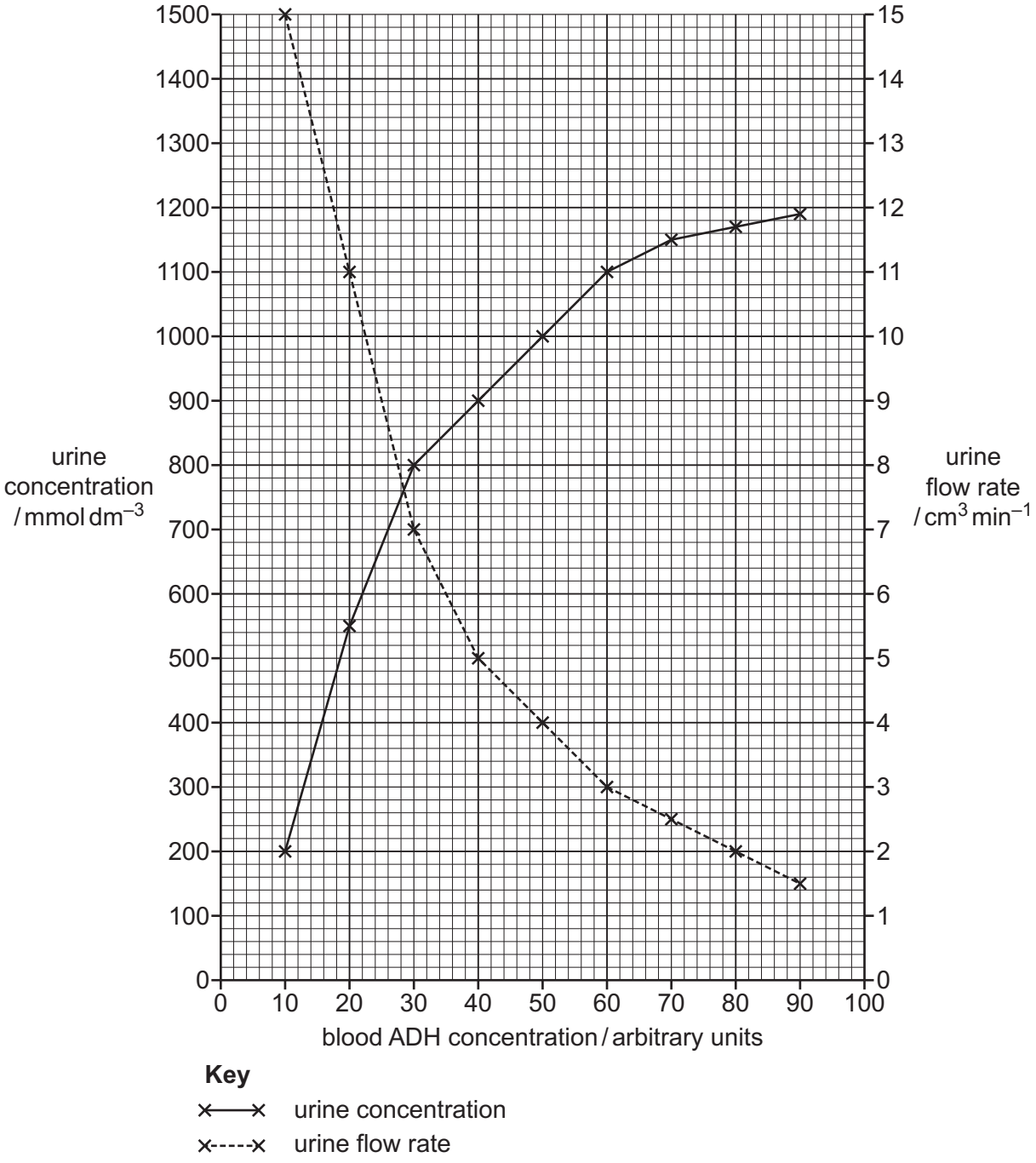


Fig. 8.2

Describe the relationships shown in Fig. 8.2.

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..... [3]

(c) Describe **and** explain the action of ADH on the cells of the collecting duct when the water potential of the blood decreases.

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..... [5]

[Total: 11]

9 **(a)** A neuromuscular junction allows the transmission of an action potential from a motor neurone to a striated muscle fibre, causing it to contract.

Fig. 9.1 is a graph of an action potential in a motor neurone.

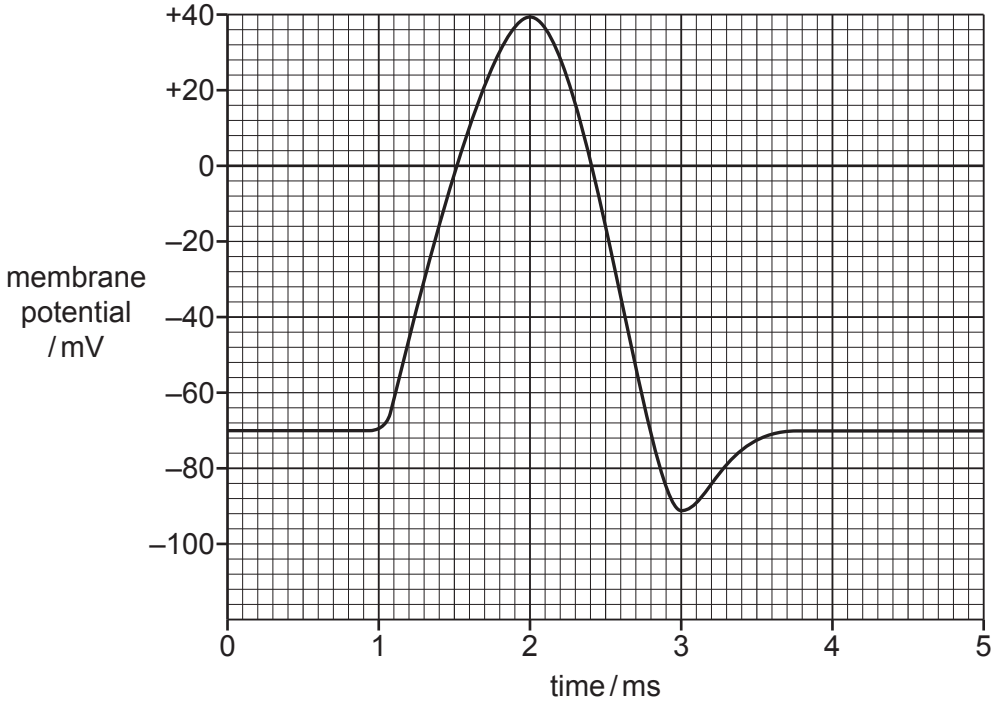


Fig. 9.1

Fig. 9.2 is a graph of an action potential in a striated muscle fibre.

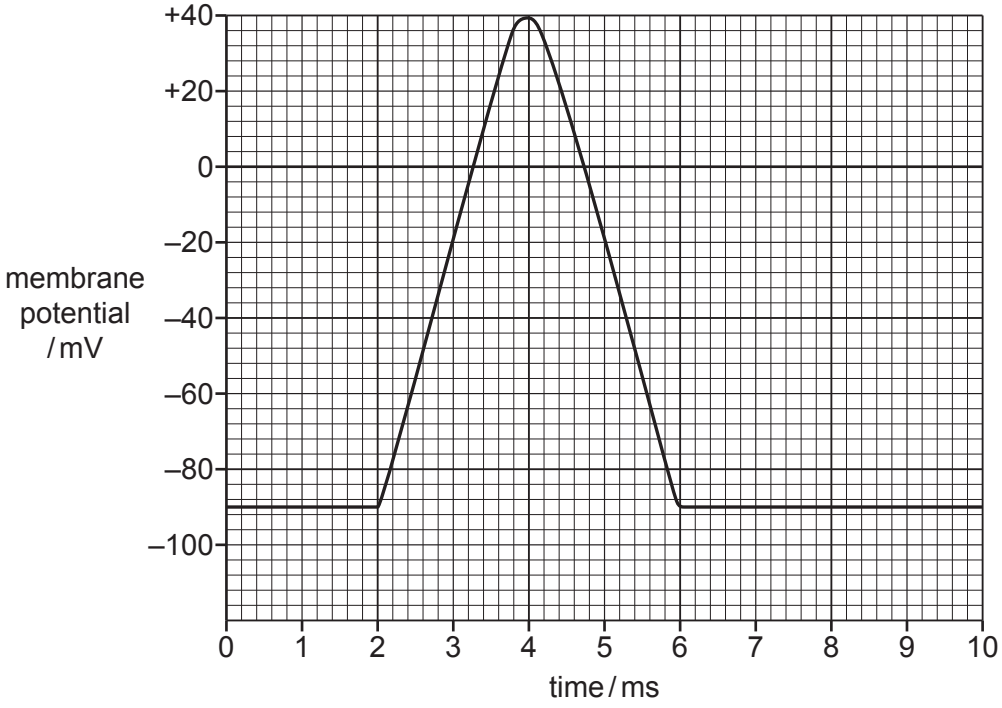


Fig. 9.2

With reference to Fig. 9.1 and Fig. 9.2, describe the differences between the action potential in a motor neurone and the action potential in a striated muscle fibre.

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..... [4]

(b) There are three phases in the contraction of a striated muscle: latent phase, contraction phase and relaxation phase.

The tension in a muscle represents the degree of contraction of its fibres.

Fig. 9.3 is a graph of the tension in a striated muscle during the three phases of contraction.

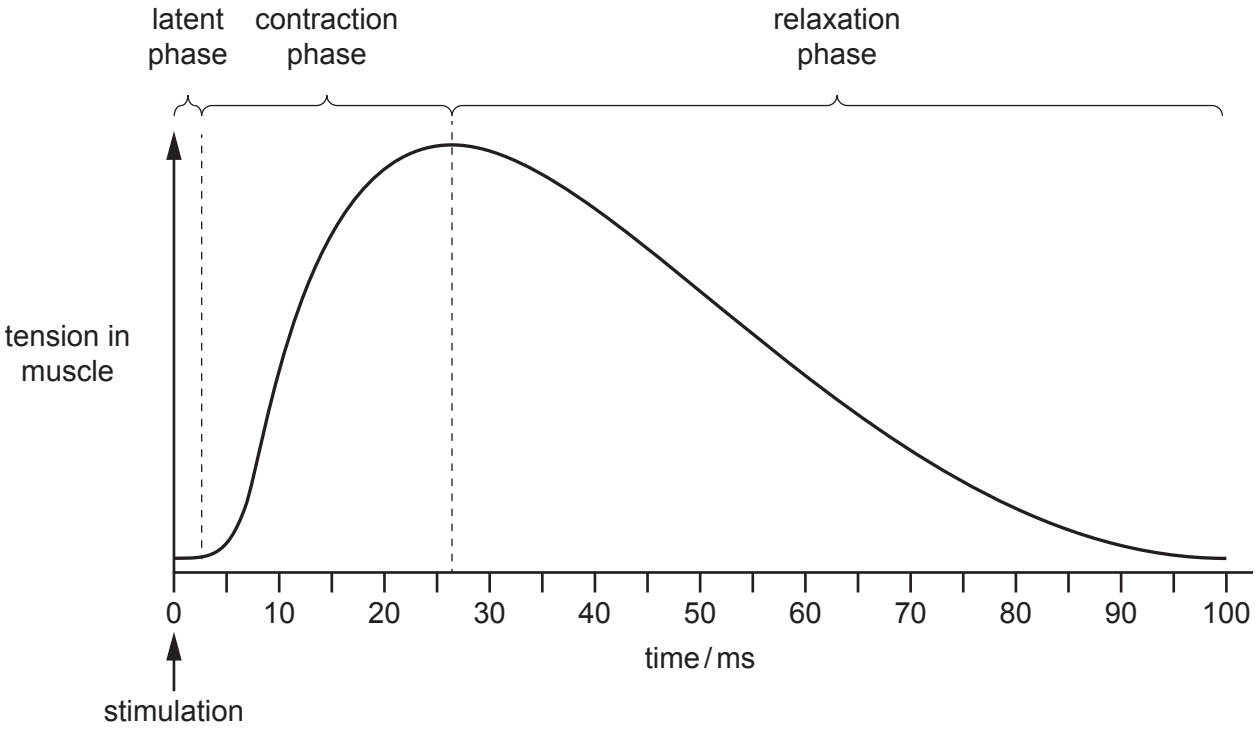


Fig. 9.3

(i) With reference to Fig. 9.3, explain what is happening in the striated muscle fibre during the latent phase.

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..... [3]

(ii) Suggest why the relaxation phase shows a gradual decrease in muscle tension.

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..... [1]

[Total: 8]

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10 The passage below outlines homeostasis.

Complete the passage by using the most appropriate scientific terms.

Homeostasis, in mammals, is the process of keeping the ..... environment of the body in optimum conditions so that cells can function efficiently. Blood water potential, core temperature and blood glucose concentration are all factors that need to be kept at optimum values or set-point.

When a condition deviates from its set-point, a corrective mechanism is triggered. An increase in blood glucose concentration triggers processes to decrease it and vice versa. This corrective mechanism is called ..... .

The pancreas is involved in the control of blood glucose concentration. Glucose binds to ..... on the cell surface membrane of pancreatic cells. These are ..... cells, which secrete hormones such as insulin and glucagon. The two hormones have opposite effects on the blood glucose concentration. For example the action of one hormone stimulates the uptake of glucose by cells for respiration and the action of the other hormone stimulates the breakdown of ..... to glucose in the liver.

[Total: 5]

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