Cambridge Assessment International Education

Cambridge International AS & A Level

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BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 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 [ ].

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1 **(a)** The golden mantella, *Mantella aurantiaca*, is a small terrestrial frog found in Madagascar.

Fig. 1.1 shows a golden mantella.



Fig. 1.1

(i) Name the domain and kingdom to which the golden mantella belongs.

domain .....

kingdom .....
[2]

(ii) The skin of the golden mantella is brightly coloured and contains a toxin.

Suggest a benefit to the frog of being brightly coloured.

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..... [1]

(b) The toxin in the skin of the golden mantella affects the action of the sarcomeres in muscle fibres (muscle cells) of mammalian striated muscle. The toxin inhibits a protein, Ca^{2+}ATPase, found in the membrane of the sarcoplasmic reticulum.

Ca^{2+}ATPase pumps calcium ions from the cytoplasm into the sarcoplasmic reticulum when the fibre is no longer stimulated.

Suggest the consequences to the sarcomere of the action of the golden mantella toxin.

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(c) Describe the role of calcium ions in a cholinergic synapse.

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..... [3]

[Total: 9]

2 **(a)** In eukaryotes, the cells of plants and photosynthetic protoctists contain chloroplasts.

Describe the relationship between the function of a chloroplast and its structure.

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(b) Outline the main features of cyclic photophosphorylation.

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(c) Red algae are aquatic protoctists that are multicellular. The cells of red algae have chloroplasts containing photosynthetic pigments. Many red algae live in deep water.

Two of the accessory pigments of red algae chloroplasts are:
- phycoerythrin (appears red), often present in large concentrations
- phycocyanin (appears blue).

The first few metres of water nearest the surface absorb the red wavelengths of light. If the water also contains particles of organic material it absorbs blue wavelengths.

Fig. 2.1 shows absorption spectra of some pigments in red algae chloroplasts.

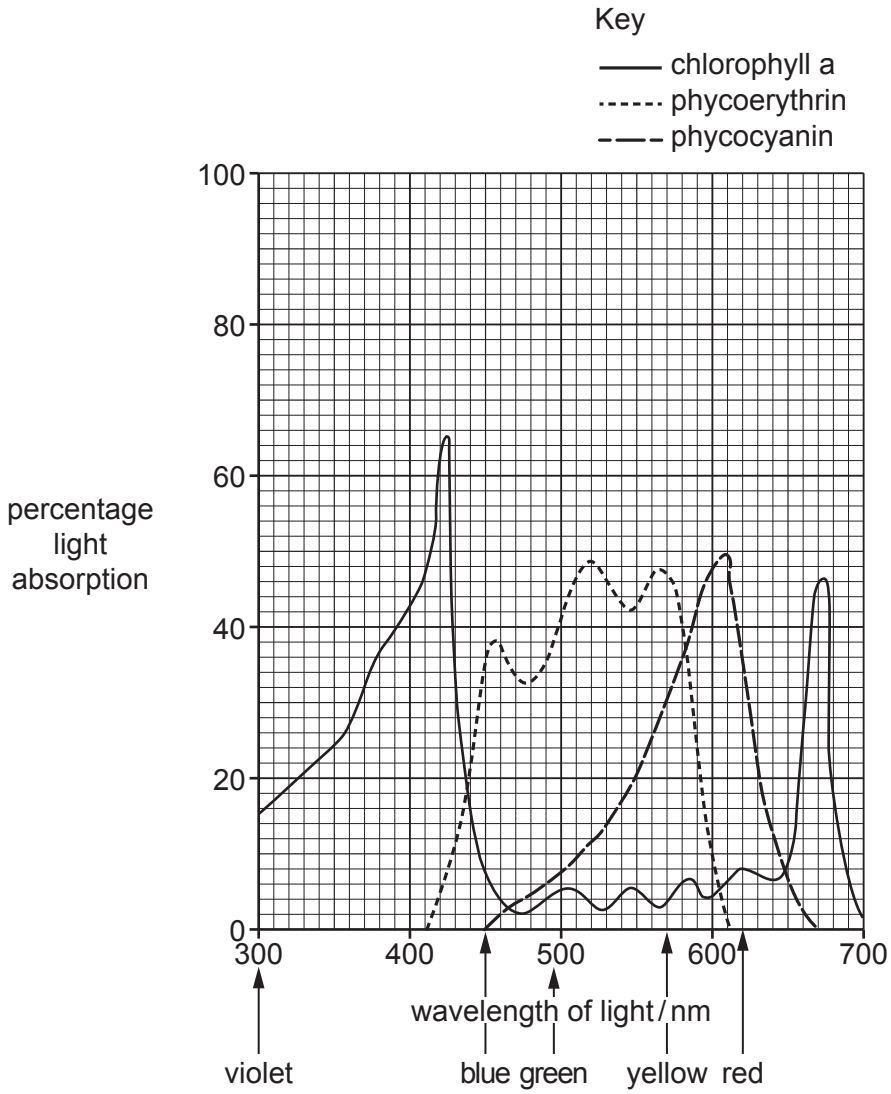


Fig. 2.1

Describe the differences in the absorption spectra of the three photosynthetic pigments shown in Fig. 2.1 **and** explain how these differences help red algae to survive in deep water.

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[Total: 14]

3 Respiration is a process that results in the synthesis of ATP. The ATP can be used within the cell for energy-requiring reactions and processes.

There are four stages in aerobic respiration: glycolysis, the link reaction, the Krebs cycle and oxidative phosphorylation.

(a) The ATP synthesised in respiration can be used to make larger and more complex biological molecules from smaller molecules.

Name the type of reaction that occurs when larger more complex biological molecules are made from smaller molecules.

..... [1]

(b) The first part of glycolysis uses ATP.

Explain why ATP is needed in the first part of glycolysis.

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..... [2]

(c) State the precise locations of substrate-linked phosphorylation reactions in aerobic respiration.

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..... [1]

(d) Explain what happens to pyruvate in the link reaction in aerobic respiration.

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..... [2]

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(e) Chemiosmosis is a process that occurs in mitochondria during aerobic respiration and in chloroplasts during photosynthesis.

Describe the differences between the process of chemiosmosis in mitochondria and the process of chemiosmosis in chloroplasts.

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..... [3]

[Total: 9]

4 In 1973 a technique for genetic engineering was used for the first time. Recombinant DNA was made using a plasmid and this was successfully transferred into an organism.

In 2012 a new technique for genetic engineering, called gene editing, was developed.

(a) Table 4.1 lists some statements about the two genetic engineering techniques.

Complete Table 4.1 to compare the original genetic engineering technique using a plasmid vector with the newer technique of gene editing. For each row, place a tick (✓) in the correct column if the statement applies and leave a blank if the statement does not apply.

Table 4.1

statement	genetic engineering using a plasmid	gene editing
It can produce a transgenic organism.		
It can modify the characteristics of an organism.		
It can delete unwanted DNA.		
It uses an enzyme that cuts DNA.		
It can use RNA to precisely locate the target gene.		

[5]

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(b) Orange trees, *Citrus sinensis*, produce fruits that are an important food crop. The functional leaf area of orange trees may be reduced by the growth of citrus canker bacteria. These bacteria cause citrus canker disease.

Scientists used gene editing to develop two types of orange tree with different mutations (changes to the DNA). The mutant orange tree leaves showed resistance to citrus canker disease.

Fig. 4.1 shows the area of leaf with citrus canker disease in wild type (not gene edited) and gene edited orange tree leaves after they have been exposed to citrus canker bacteria.

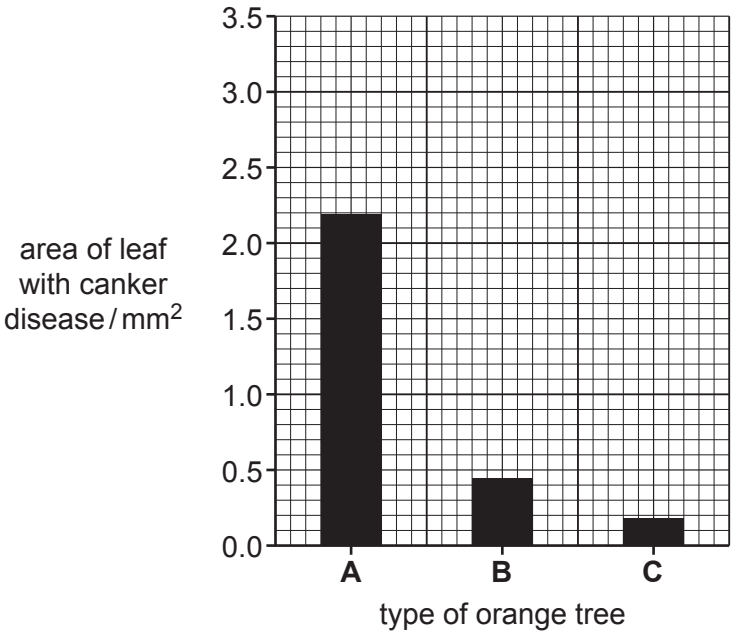


Fig. 4.1

(i) Identify the letter that represents the wild type orange trees on Fig. 4.1.

..... [1]

(ii) Explain the social benefits of this example of gene editing.

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[Total: 9]

5 Two subspecies of reindeer, *Rangifer tarandus*, live in North America. Members of the different subspecies belong to the same species but have some morphological differences and are found in different geographical locations.

Fig. 5.1 shows a reindeer.



Fig. 5.1

Table 5.1 compares the features of the two North American reindeer subspecies.

Table 5.1

feature	**woodland subspecies, *R. tarandus caribou***	**barren ground subspecies, *R. tarandus groenlandicus***
habitat	southern woodland (warmer)	northern tundra (colder)
type of food	tree leaves, grass	lichens, moss
summer and winter feeding grounds overlap	yes	no
carry out long migrations	no	yes
body size	large	small
colour of fur	dark	light

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(a) During the last ice age an ice sheet separated southern and northern populations of *R. tarandus* in North America.

Explain how this ice sheet affected the evolution of *R. tarandus* to result in the two different subspecies.

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..... [4]

(b) Assess the relative importance of natural selection and genetic drift in producing:

(i) the different colours of fur of the two subspecies of reindeer

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..... [2]

(ii) the different body sizes of the two subspecies of reindeer.

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..... [2]

(c) Hybridisation has occurred between individuals of the two subspecies which now live in the area previously covered by the ice sheet.

Comment on how the hybrid populations compare to the pure subspecies in terms of genetic variation and potential to adapt to climate change.

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(d) Outline how practical techniques could be used to test the hypothesis that migratory behaviour in reindeer has a genetic basis.

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[Total: 14]

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6 **(a)** In mammals, the blood glucose concentration must be maintained within narrow limits so that the body cells can function efficiently.

Name the mechanism by which the blood glucose concentration is maintained within narrow limits.

..... [1]

(b) Glucagon is released by the alpha (α) cells of the pancreas when the blood glucose concentration decreases below the set point.

Fig. 6.1 outlines the response of liver cells to glucagon.

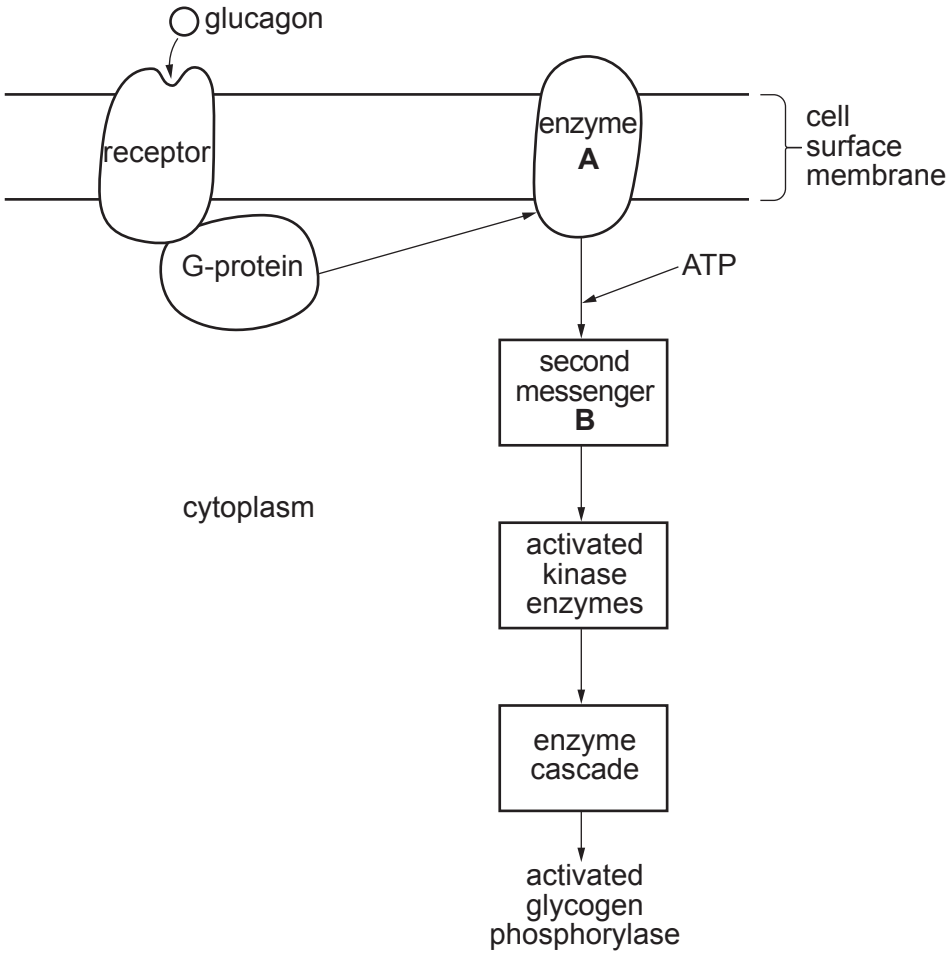


Fig. 6.1

(i) State how glucagon reaches the liver cells.

..... [1]

(ii) With reference to Fig. 6.1, name enzyme **A** and second messenger **B**.

A .....

B .....
[2]

(iii) State the role of the enzyme cascade.

.....

..... [1]

(iv) State the function of the final enzyme in the pathway, glycogen phosphorylase.

..... [1]

(c) A biosensor is used to measure blood glucose concentration to check that it is within the normal range.

Describe how a glucose biosensor works.

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..... [4]

[Total: 10]

7 **(a)** The fruit fly, *Drosophila melanogaster*, usually has red eyes. A gene for eye colour has four alleles: red, apricot, honey and white.

Define the terms *gene* and *allele*.

gene .....

.....

allele .....

.....

[2]

(b)
- The allele for red eyes, $\mathbf{C^R}$, is dominant to the other three alleles.
- The allele for apricot eyes, $\mathbf{C^A}$, is dominant to the allele for honey eyes, $\mathbf{C^H}$.
- The allele for white eyes, $\mathbf{C^W}$, is recessive to the other three alleles.

Construct a genetic diagram to show the genotypes, phenotypes and ratio of the offspring from a cross between a fruit fly with red eyes, $\mathbf{C^RC^H}$, and a fruit fly with apricot eyes, $\mathbf{C^AC^W}$.

parents phenotypes	red eyes	apricot eyes
parents genotypes	$\mathbf{C^RC^H}$	$\mathbf{C^AC^W}$
gametes		
offspring genotypes		
offspring phenotypes		
ratio		

[3]

(c) Describe how you would carry out a test cross **and** use it to determine the genotype of a red-eyed fruit fly.

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..... [3]

[Total: 8]

8 **(a)** Over the past 200 years, many species of animals and plants have become extinct.

Fig. 8.1 shows the changes between the years 1800 and 2000 in:
- the number of species becoming extinct
- the size of the world human population.

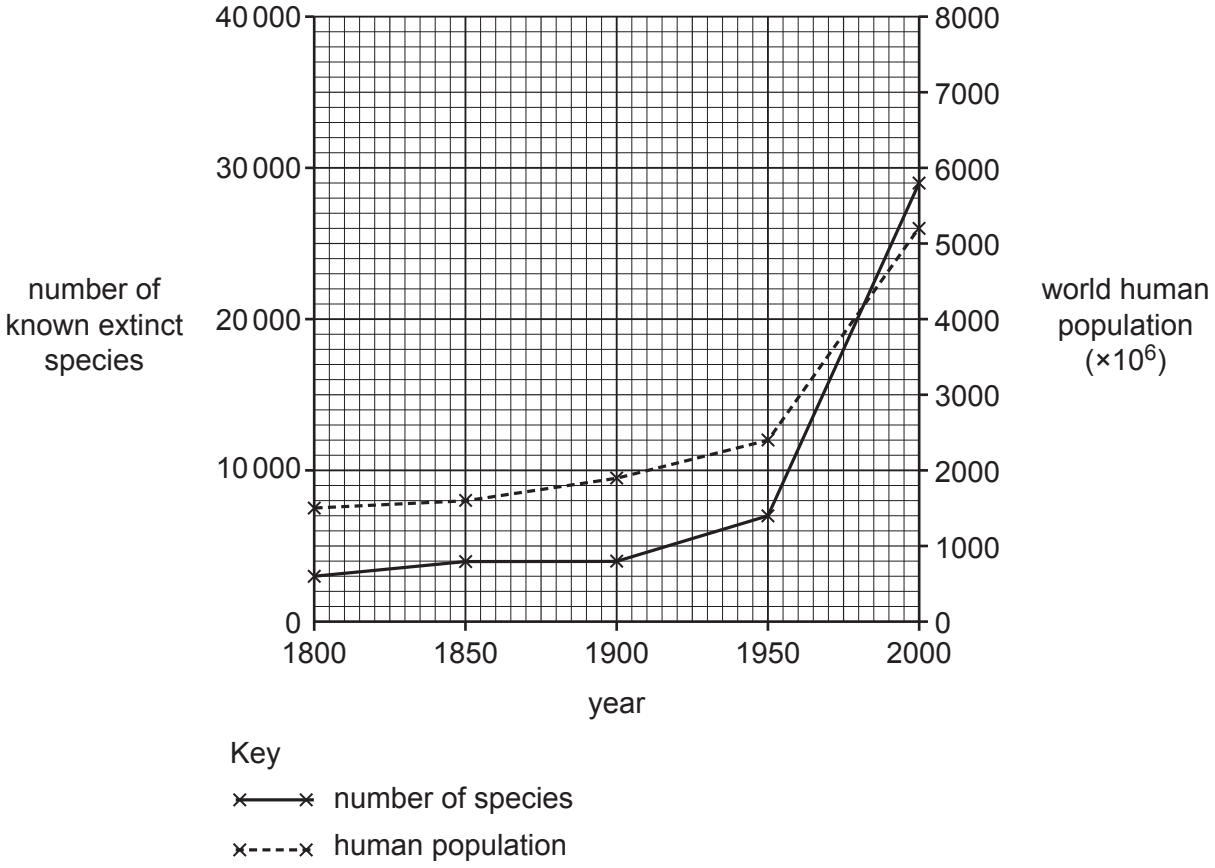


Fig. 8.1

(i) It has been suggested that there is a correlation between the number of species becoming extinct and the size of the world human population.

Suggest reasons for this possible correlation.

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..... [3]

(ii) Calculate the rate of species extinction per year between 1950 and 2000.

Show your working.

answer = ... [2]

(b) Extinction of animal and plant species reduces biodiversity.

Explain why it is important to maintain biodiversity.

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..... [7]

[Total:12]

9 (a) Stomata are involved in both transpiration and photosynthesis in plants.

Fig. 9.1 is a diagram of an open stoma, its guard cells and surrounding epidermal cells.

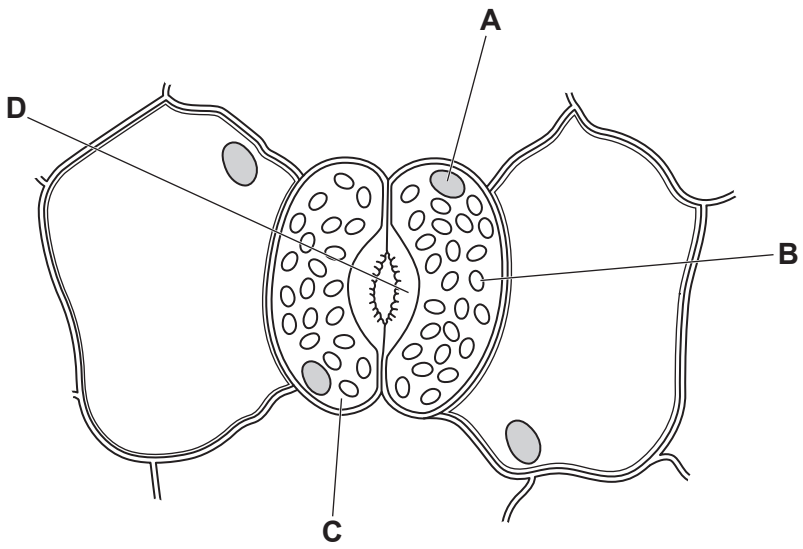


Fig. 9.1

Complete Table 9.1 by choosing the correct letter from Fig. 9.1 to match the feature stated in Table 9.1.

Each letter may be used once, more than once or not at all.

Table 9.1

letter	feature
.....	location of Calvin cycle
.....	made mainly of cellulose

[2]

(b) The opening and closing of stomata are due to changes in environmental conditions. Hydrogen ions (H^+) and potassium ions (K^+) are involved in the opening of stomata.

Describe how hydrogen ions and potassium ions are involved in the opening of a stoma.

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..... [4]

[Total: 6]

10 (a) Motor neurones and sensory neurones have different roles in nervous coordination.

Contrast the structure **and** function of sensory neurones and motor neurones.

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..... [3]

(b) Mammals have many types of neurones, which vary in axon diameter and myelination.

Table 10.1 shows the axon diameter and mean impulse transmission speed of four different types of mammalian neurone.

Table 10.1

neurone type	myelination	mean axon diameter / μm	mean impulse transmission speed / m s^{-1}
motor α	✓	13.0–20.0	80–120
motor β	✓	6.0–12.0	35–75
motor δ	✓	1.0–5.0	5–35
motor C	✗	0.2–1.5	0.5–2.0

Using the data shown in Table 10.1, comment on the relationship between:
- myelination and mean impulse transmission speed
- axon diameter and mean impulse transmission speed.

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..... [3]

(c) Fig. 10.1 is a graph of an action potential in a mammalian neurone.

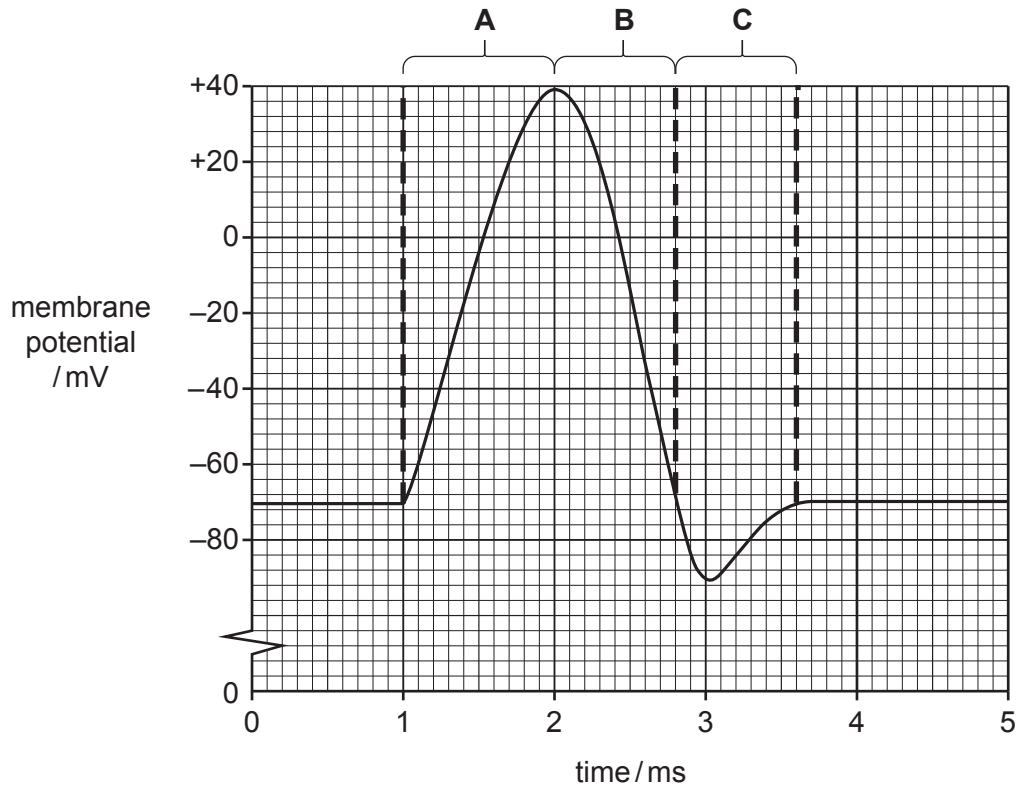


Fig. 10.1

With reference to Fig. 10.1 suggest why:

- no further action potential can occur during **A** and **B**
- it is difficult for a further action potential to occur during **C**.

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..... [3]

[Total: 9]

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BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **May/June 2022**

2 hours

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INFORMATION

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[Turn over

1 The jaguar, *Panthera onca*, is a large cat that lives mainly in South America. The majority of jaguars have light brown fur with black spots, as shown in Fig. 1.1. Some jaguars have completely black fur, as shown in Fig. 1.2.

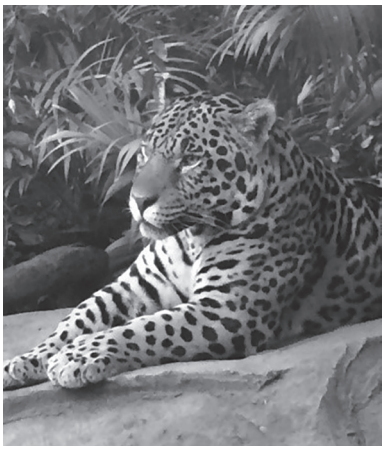


Fig. 1.1



Fig. 1.2

(a) The pigments involved in fur colour are produced as a result of biochemical pathways that take place in cells called melanocytes. These pathways are similar to those that occur in human melanocytes.

The melanocortin 1 receptor (MC1R) is located on the cell surface membrane of melanocytes and is coded for by the *MC1R* gene.

Fig. 1.3 outlines the processes that occur in jaguar melanocytes.

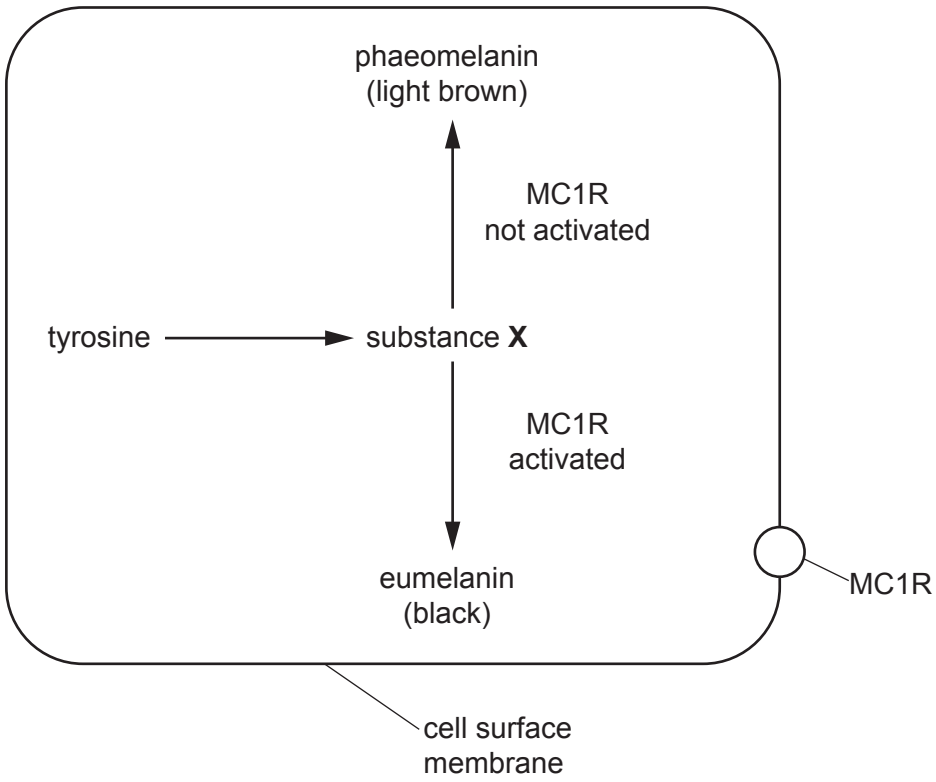


Fig. 1.3

(i) Name the substance represented by **X**.

..... [1]

(ii) When MC1R is activated a second messenger is produced in the cell.

Give an example of a second messenger.

..... [1]

(iii) Substance **X** is also produced in humans, but a mutation of the *TYR* gene can result in substance **X** not being produced.

Describe the phenotype of a person with this mutation.

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..... [2]

(b) The *MC1R* gene has two alleles and is located on an autosome.

- When two jaguars with light brown fur mate all the offspring have light brown fur.
- When two jaguars with black fur mate either all the offspring will have black fur or some offspring will have black fur and some will have light brown fur.

Using symbols, construct a genetic diagram to show how two jaguars with black fur can produce some offspring with black fur and some offspring with light brown fur.

[4]

[Total: 8]

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2 **(a)** Photosynthesis is affected by many environmental factors.

(i) Explain why light intensity can be a limiting factor in photosynthesis.

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..... [2]

(ii) The concentration of carbon dioxide (CO_2) can also be a limiting factor. It has an effect on the Calvin cycle in the light-independent stage of photosynthesis.

Ribulose bisphosphate (RuBP), triose phosphate (TP) and glycerate 3-phosphate (GP) are three important molecules in the Calvin cycle.

Fig. 2.1 shows how the concentration of GP changes when the concentration of CO_2 is reduced from 0.04% (atmospheric) to 0.008%.

Complete Fig. 2.1 by sketching the lines for RuBP and TP when the concentration of CO_2 is reduced from 0.04% to 0.008%.

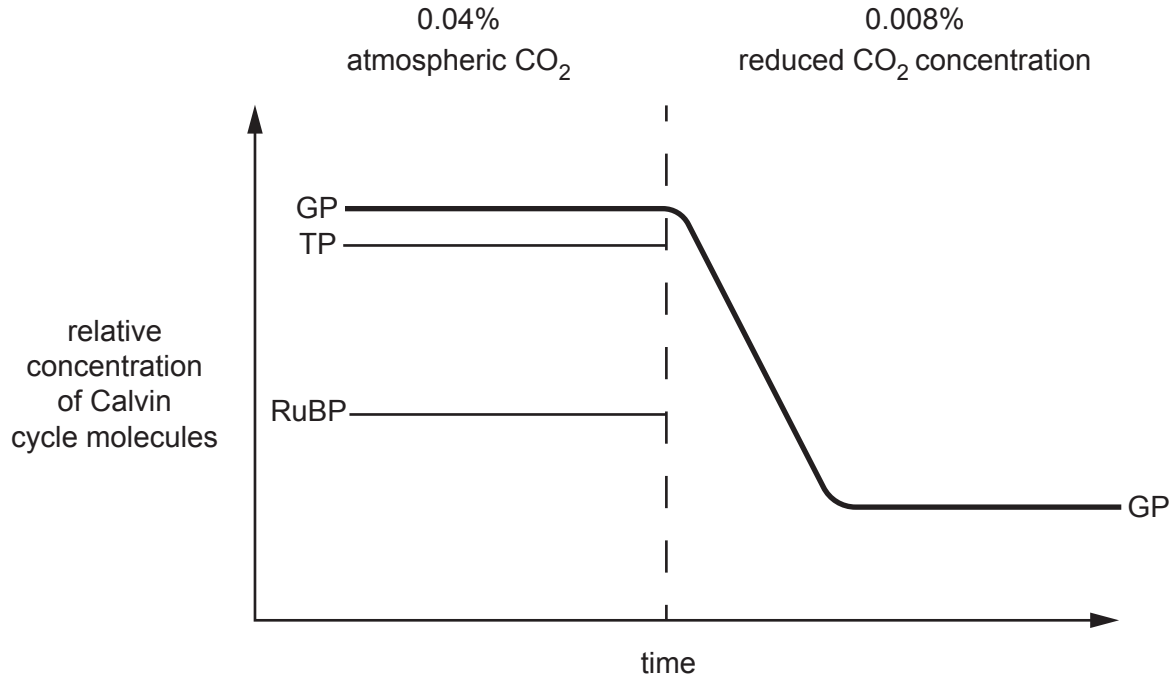


Fig. 2.1 [2]

(iii) In very dry conditions, CO_2 concentration can become the main limiting factor of photosynthesis in plants.

Explain how very dry conditions cause CO_2 concentration to become the main limiting factor of photosynthesis in plants.

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..... [3]

(b) A factor that can limit the rate of photosynthesis is the rate of regeneration of RuBP.

Sedoheptulose-1,7-bisphosphatase (SBPase) is an enzyme in the Calvin cycle that controls the rate of regeneration of RuBP. SBPase is coded for by the gene *SBPase*.

In an experiment, wheat plants were genetically modified to make more SBPase by introducing the *SBPase* gene from another grass species, *Brachypodium distachyon*. The resulting GM wheat plants were named Sox4.

- Wild type plants (not GM) and Sox4 plants were grown in a greenhouse.
- Light intensity, CO_2 concentration and temperature were kept constant.
- Mature plants were removed and dried to measure the biomass.

Fig. 2.2 shows the mean plant biomass for the wild type plants and GM Sox4 plants.

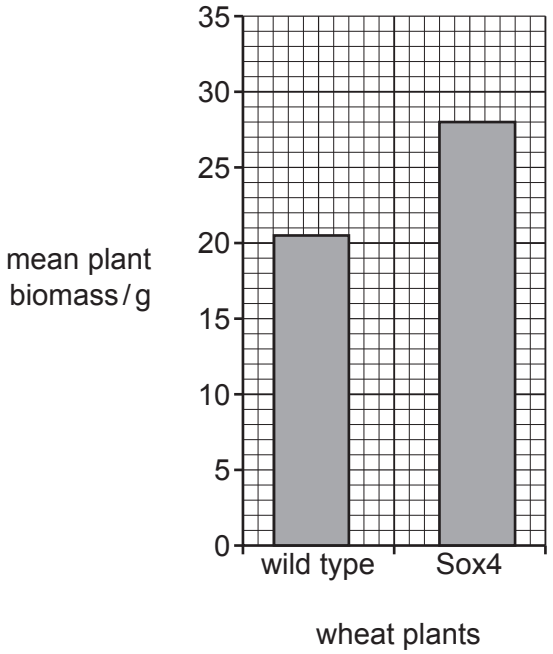


Fig. 2.2

(i) Calculate the percentage change in mean plant biomass when Sox4 plants are grown compared to wild type plants.

Show your working.

percentage change = ... % [2]

(ii) Suggest **and** explain why Sox4 plants have a different mean plant biomass than wild type plants.

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..... [4]

(iii) Some soils may be deficient in nitrates.

Suggest how nitrate deficiency could limit the quantity of SBPase made by Sox4 plants.

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..... [2]

[Total: 15]

3 Aerobic respiration occurs when oxygen is available. A much greater energy yield is obtained from aerobic respiration than from respiration in anaerobic conditions.

(a) Explain why the link reaction only occurs when oxygen is available.

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..... [4]

(b) Outline the stage of aerobic respiration that occurs in the cytoplasm of eukaryotic cells.

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..... [5]

[Total: 9]

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4 In 1973, a technique for genetic engineering was used for the first time. Recombinant DNA was made using a plasmid and this was successfully transferred into an organism.

In 2012, a new technique for genetic engineering, called gene editing, was developed.

(a) Table 4.1 lists some statements about the two genetic engineering techniques.

Complete Table 4.1 to compare the original genetic engineering technique using a plasmid vector with the newer technique of gene editing. For each row, place a tick (✓) in the correct column if the statement applies and leave a blank if the statement does not apply.

Table 4.1

statement	genetic engineering using a plasmid	gene editing
It may cause the organism to produce a different protein.		
It may cause a single base pair in a gene to be changed.		
The success of the technique can be evaluated using marker genes.		
It may use the CRISPR system.		
It uses DNA ligase.		

[5]

(b) Cassava plants, *Manihot esculenta*, produce roots that have a high starch content. These roots are an important food source in tropical regions. The growth of cassava plants is reduced by competition from weeds.

Scientists used gene editing to develop two types of cassava plant with different mutations (changes to the DNA). The gene edited cassava plants showed resistance to the herbicide glyphosate. In susceptible plants, glyphosate prevents synthesis of three amino acids from a precursor molecule called shikimate.

Fig. 4.1 shows the concentration of shikimate in the wild type (not gene edited) and the two types of gene edited cassava plant after they were exposed to three different concentrations of glyphosate.

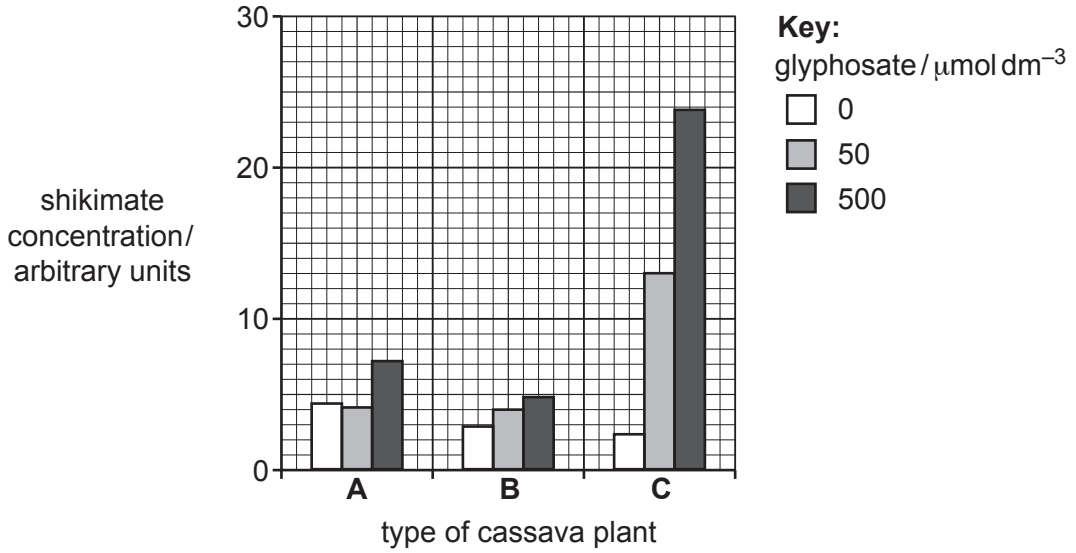


Fig. 4.1

(i) Identify the letter in Fig. 4.1 that represents the wild type cassava plant.

..... [1]

(ii) Explain the social benefit of this example of gene editing.

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..... [3]

[Total: 9]

5 Bison are a type of large wild cattle. Ancestors of modern bison appeared in Asia 2.5 million years ago. This ancestral bison species increased its range into Europe and North America.

While the ancestral species is now extinct, its descendants include *Bison bonasus*, the European bison, and *Bison bison*, the American bison.

Fig. 5.1 shows an American bison.



Fig. 5.1

(a) After the end of the last ice age, populations of the ancestral bison were separated by sea and by forests that were not suitable as habitats. The separation resulted in the evolution of the European bison and the American bison.

Explain how this separation resulted in the evolution of the two bison species.

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..... [4]

(b) Table 5.1 compares features of European bison and American bison.

Table 5.1

feature	European bison, *B. bonasus*	American bison, *B. bison*
type of food	grass and higher vegetation such as leaves of bushes and trees	grass and low vegetation
height / m	2.1	2.0
maximum mass / kg	1000	1270

Assess the relative importance of natural selection and genetic drift in producing the different heights and masses of the two species of bison.

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..... [3]

(c) The European bison has a nuclear genome that is very similar to that of the American bison. The European bison has a mitochondrial genome that is more similar to that of wild cattle of the genus *Bos* than to the American bison.

Discuss what this implies about the evolutionary history of the European bison.

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..... [3]

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(d) Outline how practical techniques could be used to test the hypothesis that farmed cattle are closely related to European bison.

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..... [4]

[Total: 14]

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6 **(a)** Gibberellin is a plant hormone that has an important role in seed germination.

Fig. 6.1 is a diagram of a section through a barley seed (grain).

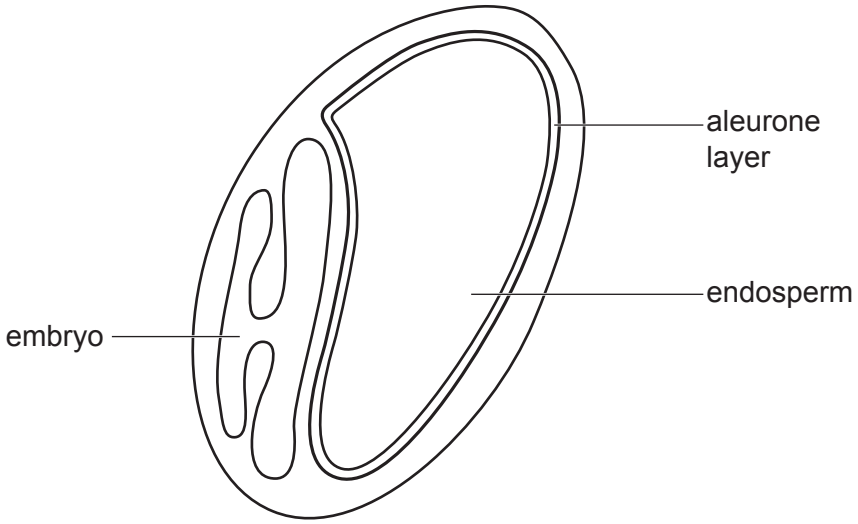


Fig. 6.1

On Fig. 6.1:

- Draw **one** arrow, labelled **G**, to show the movement of gibberellin during germination.
- Draw **one** arrow, labelled **A**, to show the movement of amylase during germination.

[2]

(b) Outline the role of amylase in seed germination.

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..... [3]

(c) The germination of three groups of seeds of the plant *Penstemon digitalis* was investigated.

The seeds were soaked for 24 hours in distilled water or in a solution of gibberellin. They were then sown on filter paper in dishes and kept moist for 10 days.

Fig. 6.2 shows the results for each group.

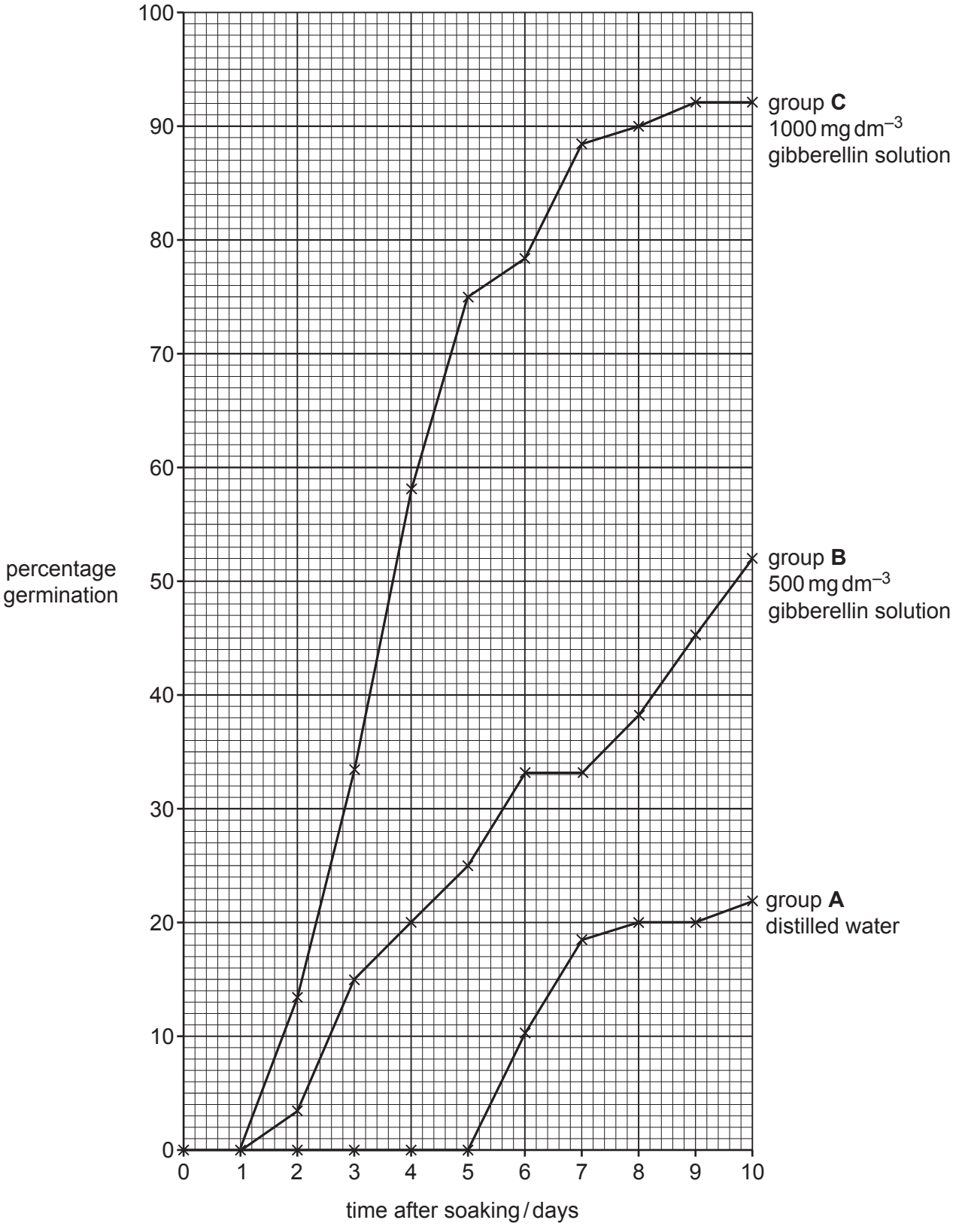


Fig. 6.2

Describe the results shown in Fig. 6.2.

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..... [4]

[Total: 9]

7 The bacterium, *Escherichia coli*, can use glucose or disaccharides, such as lactose, in its metabolism. Lactose needs to be hydrolysed by the enzyme β-galactosidase to form glucose and galactose, which can then be used by *E. coli*.

The production of β-galactosidase is controlled by a length of DNA called the *lac* operon.

(a) Fig. 7.1 shows the *lac* operon when lactose is **absent**.

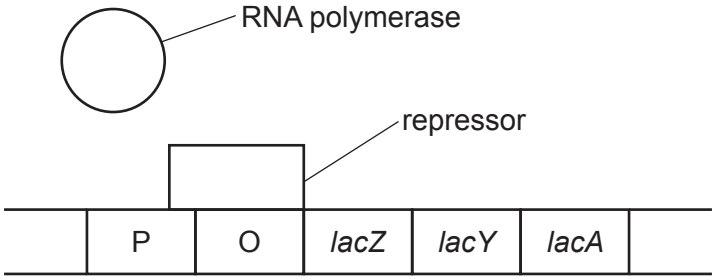


Fig. 7.1

On Fig. 7.2, draw the positions of RNA polymerase and the repressor molecule when lactose is **present**.

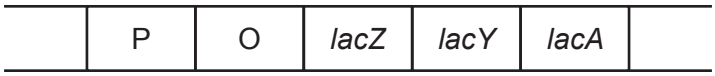


Fig. 7.2 [2]

(b) The protein coded for by *lacY* is not involved in the control of gene expression.

(i) Name the type of gene represented by *lacY*.

..... [1]

(ii) Name the protein product coded for by *lacY* **and** state the precise role of this protein.

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..... [2]

(c) In an investigation into the growth of *E. coli*, a sample of the bacterium was grown in a medium that contained limited concentrations of glucose and lactose. The population size of *E. coli* was measured at regular intervals.

Fig. 7.3 shows the population growth curve obtained for this investigation.

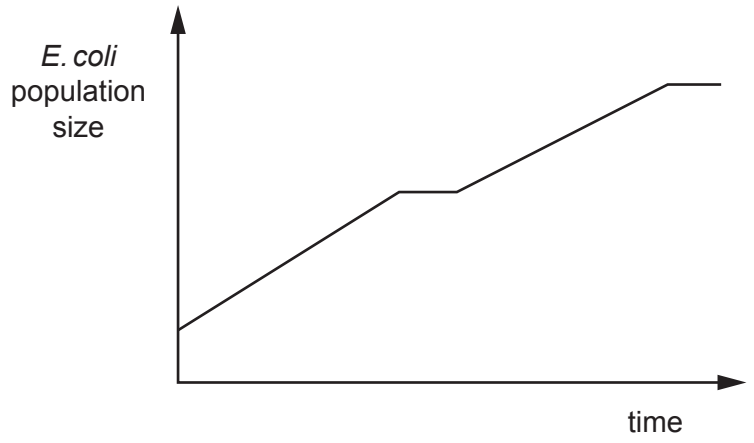


Fig. 7.3

Describe **and** suggest explanations for the population growth curve shown in Fig. 7.3.

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..... [4]

[Total: 9]

8 The role of sensory receptor cells in mammals is to detect stimuli and generate action potentials in sensory neurones.

Human taste buds on the tongue contain chemoreceptor cells. Different chemoreceptor cells respond to different chemical stimuli.

Fig. 8.1 is a diagram of chemoreceptor cells in a taste bud.

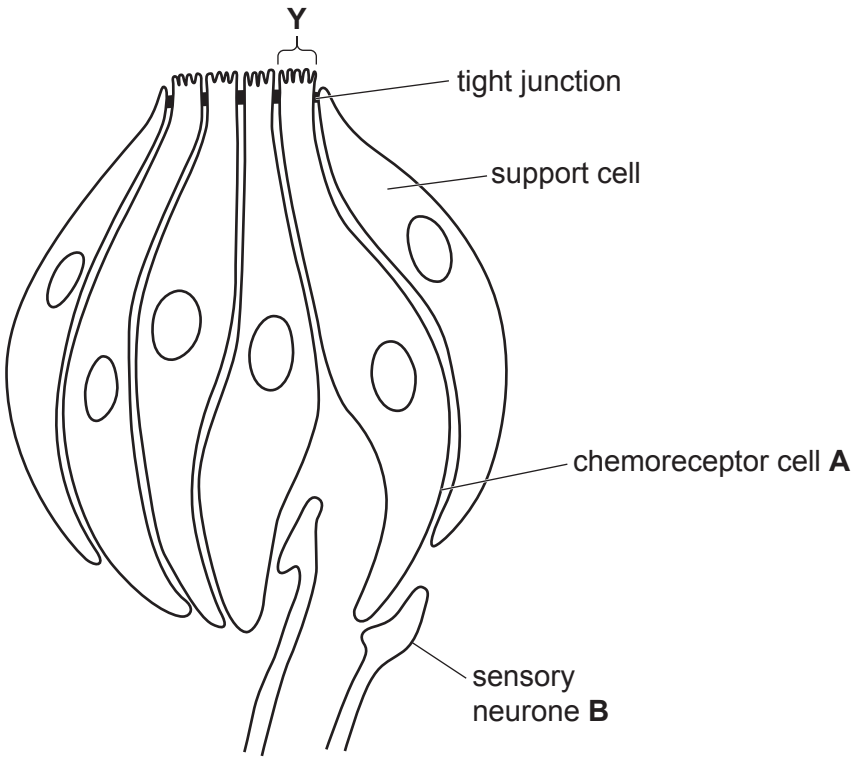


Fig. 8.1

(a) Name the structures in the region **Y**.

..... [1]

(b) Suggest a reason for the tight junctions between the chemoreceptor cells.

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..... [1]

(c) Chemoreceptor cell **A** responds to sodium ions (Na^+) in salt.

Describe how the contact of cell **A** with Na^+ can result in an action potential in sensory neurone **B**.

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[Total: 9]

9 **(a)** Ultrafiltration in the kidney takes place between the glomerulus and the Bowman's capsule. The afferent blood vessel carrying blood to the glomerulus has a wider lumen than the efferent blood vessel.

Explain why the lumen of the afferent blood vessel needs to be wider than the lumen of the efferent blood vessel.

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(b) Fig. 9.1 is a diagram of part of the glomerulus and Bowman's capsule.

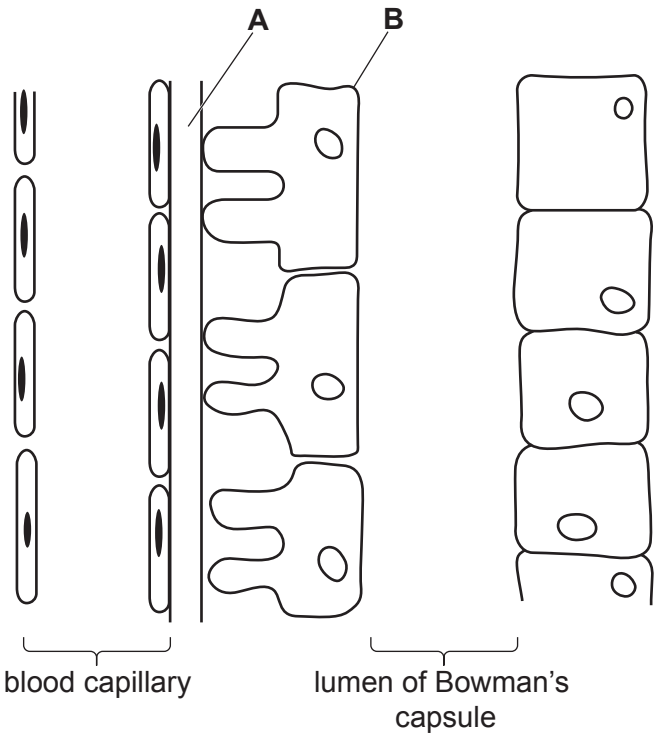


Fig. 9.1

(i) Name **A** and **B**.

A .....

B .....
[2]

(ii) Describe the roles of **A** and **B** in the formation of the glomerular filtrate.

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..... [3]

[Total: 7]

10 The African penguin, *Spheniscus demersus*, lives along the coast of South Africa.

Fig. 10.1 shows two African penguins.



Fig. 10.1

(a) One way of estimating the size of a population of African penguins is to use the mark-release-recapture method.

Suggest **three** assumptions that must be made for the mark-release-recapture method to be valid.

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..... [3]

(b) The International Union for the Conservation of Nature (IUCN) Red List of Threatened Species has categorised the African penguin as endangered and could become extinct.

Suggest reasons why the African penguin has become endangered and could become extinct.

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..... [3]

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(c) Fig. 10.2 shows the estimated numbers of African penguins in the years of 1800, 1900 and 2000.

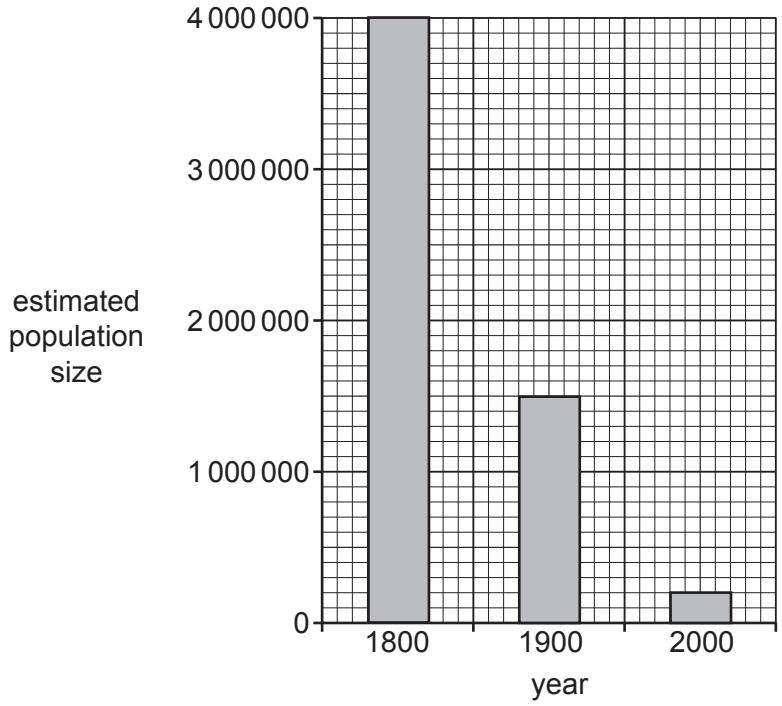


Fig. 10.2

Calculate the mean yearly decrease in population size of the African penguin between 1900 and 2000.

answer = ... yr^{-1} [1]

(d) The African penguin is a member of the kingdom Animalia.

Outline the characteristic features of the kingdom Animalia.

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..... [4]

[Total: 11]

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BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 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 **(a)** The water potential of mammalian blood needs to be maintained within narrow limits so that cells function efficiently. This process is called osmoregulation.

The relative medullary thickness (RMT) indicates the proportion of a kidney that is composed of medullary tissue.

$$\text{RMT} = \frac{\text{thickness of medulla}}{\text{kidney size}} \times 10$$

Table 1.1 shows the relationship between the RMT and the concentration of urine produced by four mammals from different habitats.

Table 1.1

mammal	habitat	RMT	urine concentration / arbitrary units
beaver	rivers and lakes	1.4	0.90
warthog	savannah	2.8	2.35
human	variable	3.2	2.50
kangaroo rat	desert	8.6	10.50

(i) Name the parts of the nephron that are located in the medulla.

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..... [2]

(ii) Name a hormone involved in osmoregulation.

..... [1]

(iii) Describe the relationship between the RMT and the concentration of urine produced **and** explain the differences between the data for the beaver and the kangaroo rat.

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..... [4]

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(b) The warthog, *Phacochoerus africanus*, is a member of the pig family. The warthog lives in dry savannah areas of sub-Saharan Africa.

Fig. 1.1 shows a warthog.



Fig. 1.1

A warthog and a human have similar values of RMT and concentration of urine. A human can survive only a few days without drinking water, whereas a warthog can live for several months without drinking water.

Suggest how a warthog is able to survive several months without drinking water.

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..... [2]

[Total: 9]

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2 Photosynthesis is an energy transfer process that results in the production of carbohydrate. It has two stages: the light-dependent stage and the light-independent stage.

Cyclic photophosphorylation and non-cyclic photophosphorylation are essential pathways in photosynthesis that occur in the light-dependent stage.

(a) (i) Describe the similarities and differences between cyclic photophosphorylation and non-cyclic photophosphorylation.

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..... [4]

(ii) Explain why herbicides that prevent cyclic photophosphorylation and non-cyclic photophosphorylation stop carbohydrate being produced in the chloroplast.

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..... [2]

(b) The rate of regeneration of RuBP in the Calvin cycle is known to limit the rate of photosynthesis.

Sedoheptulose-1,7-bisphosphatase (SBPase) is an enzyme in the Calvin cycle that controls the rate of regeneration of RuBP. SBPase is coded for by the gene *SBPase*.

In an experiment, wheat plants were genetically modified to make more SBPase by introducing the *SBPase* gene from another grass species, *Brachypodium distachyon*. The resulting GM wheat plants were named Sox4.

- Wild type plants (not GM) and Sox4 plants were grown.
- A leaf from the wild type plant was placed in a sealed glass vessel.
- The carbon dioxide (CO_2) concentration in the vessel was increased so that the intercellular air spaces also had an increase in CO_2 concentration.
- The other environmental conditions were kept constant.
- The rate of fixation of CO_2 was measured for the leaf.
- The experiment was repeated with a leaf from a Sox4 plant.

Fig. 2.1 shows the rate of fixation of CO_2 by the leaves of wild type plants and Sox4 plants when the intercellular air space CO_2 concentration was increased.

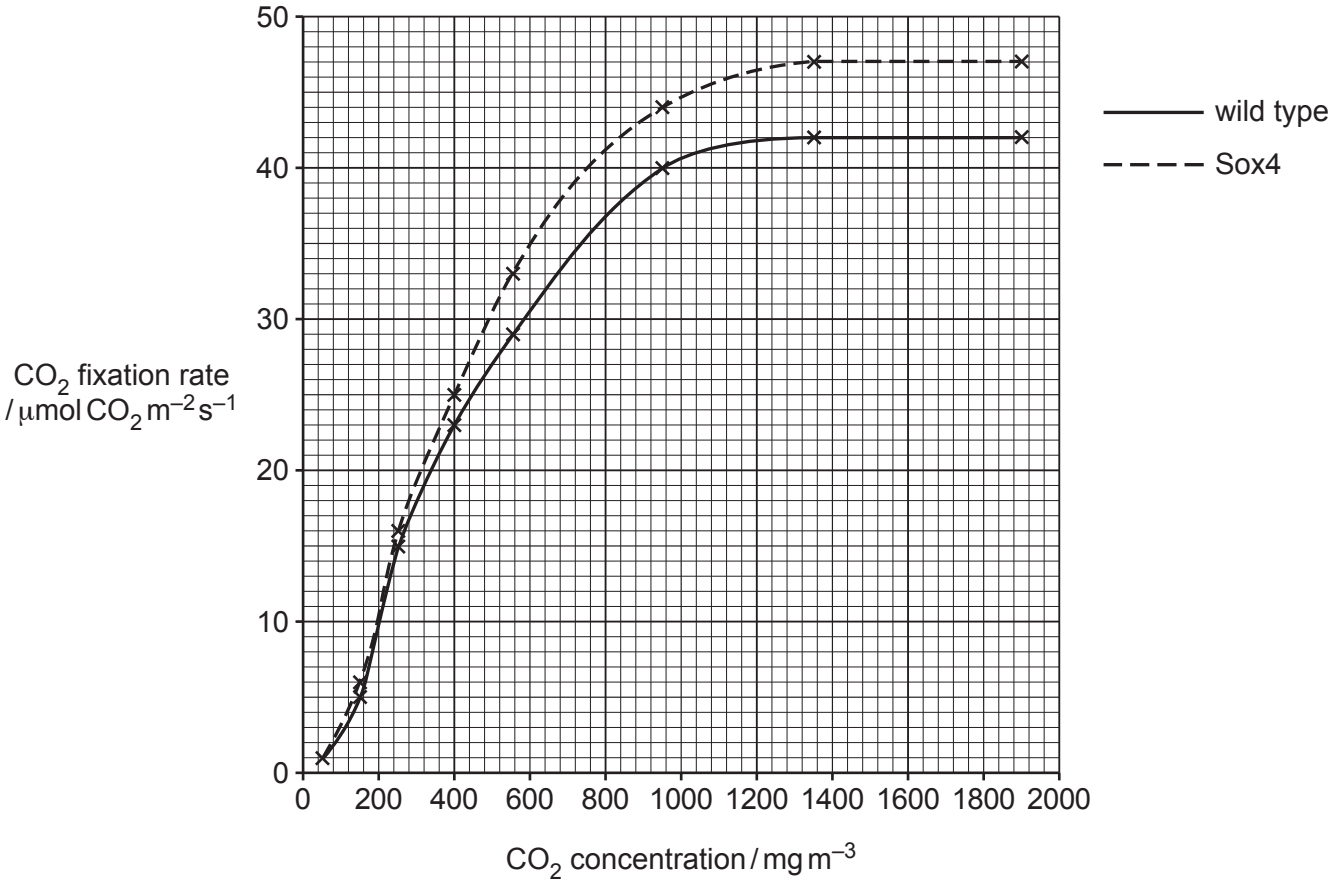


Fig. 2.1

(i) With reference to Fig. 2.1, describe **and** explain the results shown by the **wild type** plants.

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..... [4]

(ii) With reference to Fig. 2.1, describe **and** suggest explanations for the differences in the rate of fixation of CO_2 between wild type plants and Sox4 plants.

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..... [3]

[Total: 13]

3 **(a)** ATP is synthesised from ADP and P_i in a phosphorylation reaction.

State the **two** different ways in which this phosphorylation reaction occurs in aerobic respiration.

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..... [2]

(b) Coenzymes are important in all four stages of aerobic respiration.

Describe **and** explain the role of the coenzymes NAD and FAD in aerobic respiration.

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..... [6]

(c) The enzyme pyruvate dehydrogenase catalyses the link reaction. Pyruvate dehydrogenase is inhibited when the ratio of acetyl coenzyme A to coenzyme A increases.

Suggest the importance of this inhibition to the functioning of the cell.

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..... [2]

[Total: 10]

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4 In 1973, a technique for genetic engineering was used for the first time. Recombinant DNA was made using a plasmid and this was successfully transferred into an organism.

In 2012, a new technique for genetic engineering, called gene editing, was developed.

(a) Table 4.1 lists some statements about the two genetic engineering techniques.

Complete Table 4.1 to compare the original genetic engineering technique using a plasmid vector with the newer technique of gene editing.
For each row, place a tick (✓) in the correct column if the statement applies and leave a blank if the statement does not apply.

Table 4.1

statement	genetic engineering using a plasmid	gene editing
It can add a new phenotypic characteristic to an organism.		
It can change an A–T base pair to C–G.		
It can inactivate a desired selected gene in an organism.		
It may change DNA in a way that cannot be distinguished from a natural mutation.		
It requires a DNA donor and a recipient.		

[5]

(b) *Camelina sativa* is a fast-growing plant with oil-rich seeds.

C. sativa grows in dry and poor soils and so it may be important as a food crop in the future. The oil from its seeds has a high content of polyunsaturated fatty acids. This shortens the time that the oil can be stored for, which is a disadvantage.

Scientists used gene editing to develop two types of *C. sativa* with different genetic changes. The gene edited *C. sativa* seeds produced oil with longer storage times.

Fig. 4.1 shows the percentage composition of fatty acids in the oil extracted from seeds of gene edited and wild type (not gene edited) *C. sativa*.

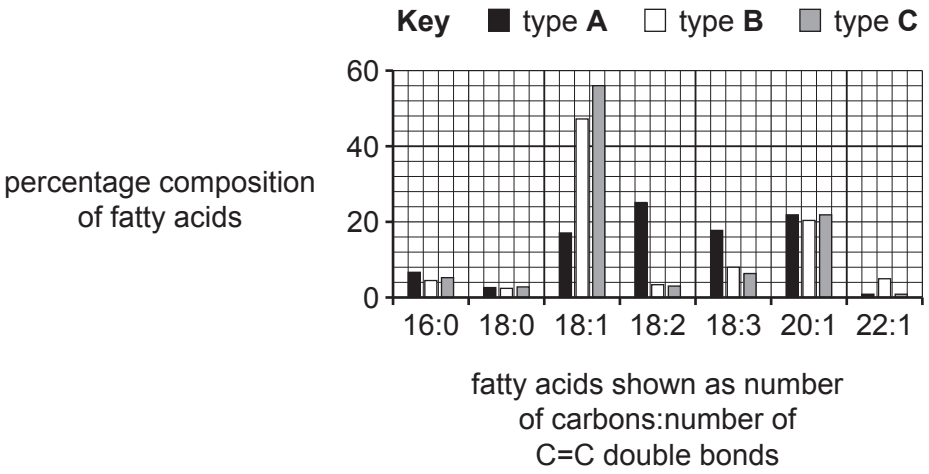


Fig. 4.1

(i) Identify the letter that represents the oil of the wild type *C. sativa* on Fig. 4.1.

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(ii) With reference to Fig. 4.1, discuss the social benefits of this example of gene editing.

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..... [3]

[Total: 9]

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5 The puma, *Puma concolor*, lives in North and South America.

Fig. 5.1 shows a puma.

Fig 5.2 shows the distribution of the puma species.

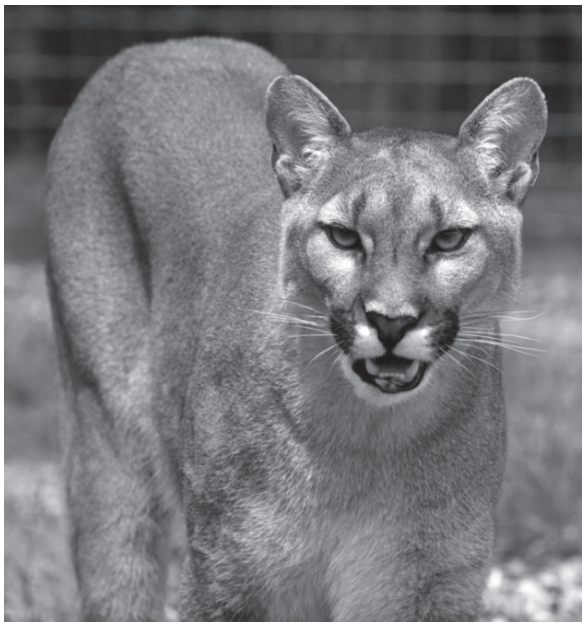


Fig. 5.1

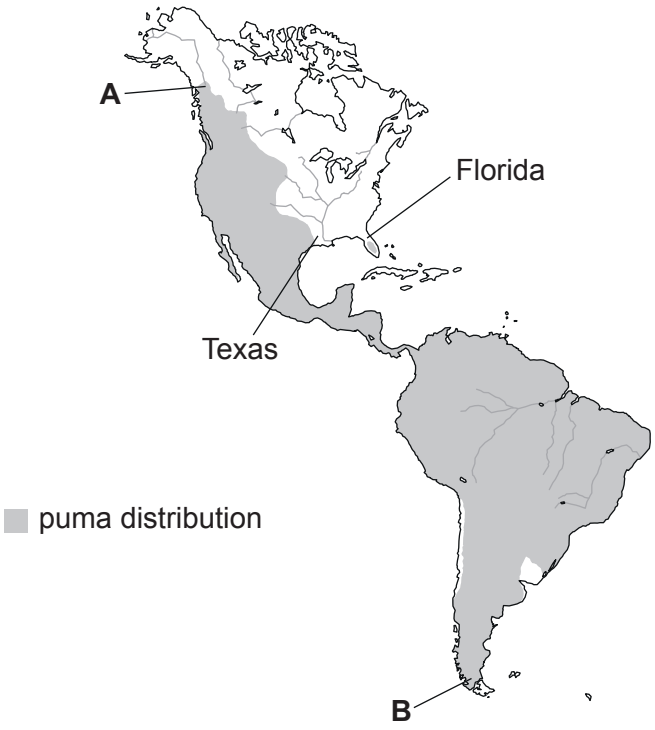


Fig. 5.2

(a) Members of different subspecies belong to the same species but have some morphological differences and are found in different geographical locations.

In the past the puma has been divided into 32 subspecies. The subspecies of puma varied in body size, coat colour and behaviour to adapt each population to its environment.

Explain how the different subspecies of puma evolved.

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..... [4]

In 2016, genetic analysis concluded that there are only two genetically distinct subspecies of puma, one in North and Central America and one in South America.

(b) Outline how practical techniques could be used to conduct a genetic analysis of the puma species.

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(c) Fig. 5.2 shows the location of an isolated puma population in Florida. In 1990, the size of this population was very small, with fewer than 30 individuals.

Three phenotypic features that vary in pumas are the shape of the tail, the pattern of hair growth on the back and the position of the testes in male pumas.

Variant forms of these phenotypic features that are normally rare occur at a high frequency in the small Florida population. These variant forms are:

- bent tail
- abnormal pattern of hair growth on the back
- testes remain in abdomen (undescended) in some male pumas.

(i) Predict, with reasons, whether these phenotypic features show a continuous or a discontinuous pattern of variation.

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..... [2]

(ii) Explain how the small size of the Florida population resulted in a high frequency of these normally rare variant forms.

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..... [3]

(iii) In 1995, eight puma females from Texas were introduced to Florida to increase the breeding success and future size of the puma population in Florida. In the next 20 years the population grew substantially.

Suggest why the introduced females were taken from Texas and not from points **A** or **B** on Fig. 5.2.

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..... [2]

[Total: 14]

6 The role of sensory receptor cells in mammals is to detect stimuli and generate action potentials in sensory neurones.

Human taste buds on the tongue contain chemoreceptor cells. Different chemoreceptor cells respond to different chemical stimuli.

Fig. 6.1 is a diagram of chemoreceptor cells in a taste bud.

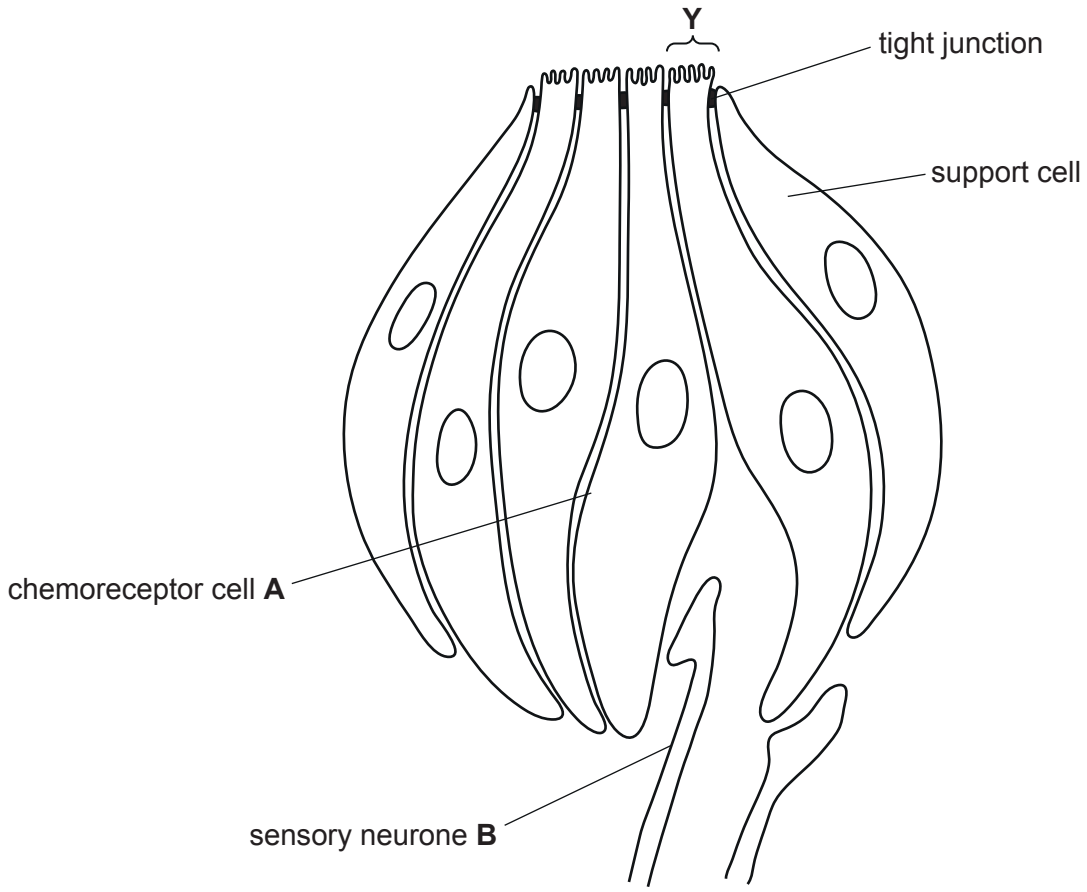


Fig. 6.1

(a) Name the structures in the region **Y and** describe their function in a chemoreceptor cell.

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..... [3]

(b) When a sugar molecule binds to a receptor protein on the cell surface membrane of cell **A**, calcium ions are released into the cytoplasm of the cell by the endoplasmic reticulum.

Explain how the release of calcium ions will lead to an action potential being generated in sensory neurone **B**.

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..... [6]

[Total: 9]

7 **(a)** Epistasis occurs when a gene at one locus can affect the expression of a gene at another locus.

Define the terms gene and locus.

gene .....

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locus .....

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[2]

(b) Fur colour in mice, *Mus musculus*, is determined by a number of genes. One example is the result of epistatic interaction between two genes, **A** and **B**.

- Allele **A** codes for the production of pigment in the fur.
- Allele **a** does not code for the production of pigment and results in white fur (albino).

- Allele **B** codes for the production of brown fur.
- Allele **b** codes for the production of black fur.

Construct a genetic diagram to show the results, including the ratio, of a cross between two mice heterozygous for both genes.

parent genotypes **AaBb** **x** **AaBb**

parent phenotypes

gametes

ratio..... [6]

(c) White fur is due to a mutation of the *TYR* gene. This is called albinism.

Explain how a mutation of the *TYR* gene can result in albinism.

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..... [3]

[Total: 11]

8 **(a)** The Malayan tapir, *Tapirus indicus*, lives in the rainforest of South East Asia.

Fig. 8.1 shows a Malayan tapir and her calf.

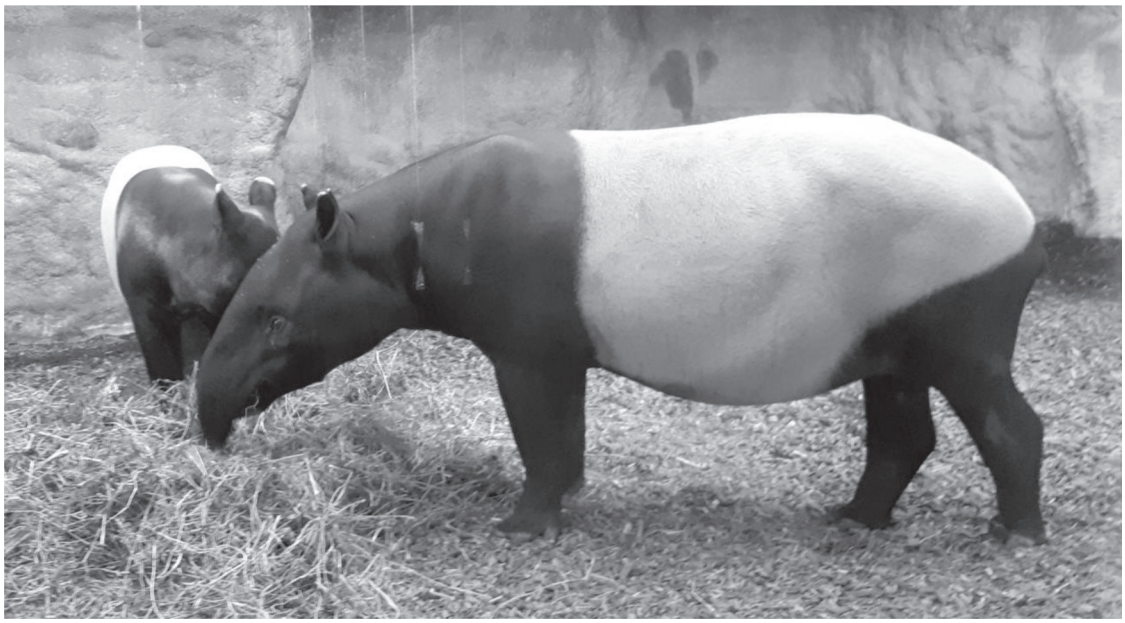


Fig. 8.1

On the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species, the Malayan tapir is categorised as endangered and could become extinct. One problem is the illegal trade in the Malayan tapir.

Apart from illegal trading, suggest **and** explain reasons why the Malayan tapir has become endangered and could become extinct.

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..... [2]

(b) The trade in Malayan tapirs is regulated by the Convention on International Trade in Endangered Species (CITES).

Suggest ways by which CITES attempts to regulate the trade in wild fauna and flora.

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..... [3]

(c) Many endangered species, such as the Malayan tapir, are protected in zoos.

Outline the role of zoos in the conservation of endangered species.

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..... [4]

[Total: 9]

9 **(a)** Fig. 9.1 shows a cross-section through a myelinated neurone.

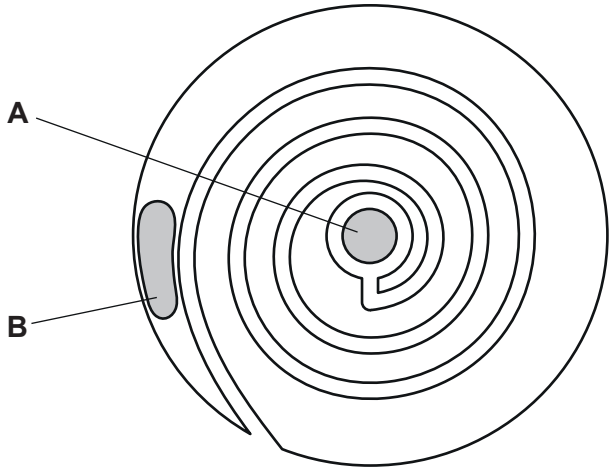


Fig. 9.1

Identify structures **A** and **B**.

A .....

B .....
[2]

(b) With reference to voltage-gated sodium ion channels, explain the difference in speed of transmission of an action potential along a myelinated neurone and a non-myelinated neurone.

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[Total: 6]

10 (a) Insulin has an important role in the maintenance of blood glucose concentration.

An investigation measured how blood glucose concentration and blood insulin concentration changed after a glucose-rich meal had been eaten.

The results are shown in Fig. 10.1.

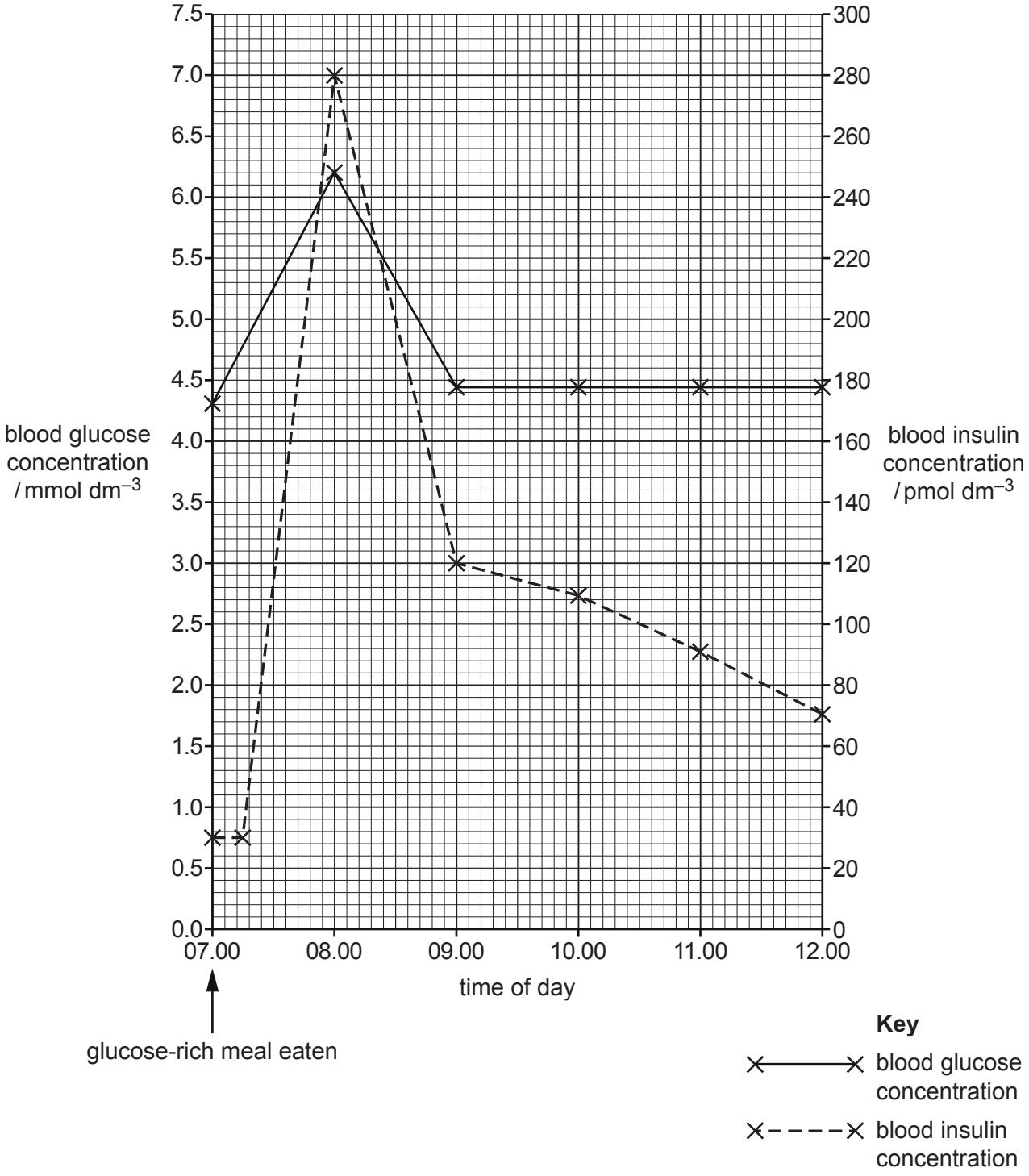


Fig. 10.1

(i) Describe **and** explain how the results shown in Fig. 10.1 indicate a relationship between blood glucose concentration and blood insulin concentration after the consumption of a glucose-rich meal.

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..... [3]

(ii) Suggest **and** explain how the results shown in Fig. 10.1 would change if the meal was mostly starch rather than glucose.

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..... [3]

(b) Glucagon is synthesised by cells in the pancreas known as alpha (α) cells. Glucagon binds to G-protein-coupled receptors in the cell surface membrane of liver cells. This results in the activation of G-proteins.

Outline the sequence of events occurring within the cell after the activation of G-proteins that helps to restore the blood glucose concentration to its set point.

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[Total: 10]

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