Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

0567776311

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2021**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **one** question.
- 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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Section A

Answer **all** questions.

1 **(a)** Photosynthesis is a complex process involving the transfer of light energy into chemical energy.

(i) Describe the role of photosynthetic pigments.

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.....

.....

..... [2]

(ii) Name the precise location in a chloroplast of photosynthetic pigments.

..... [1]

(iii) Name a practical technique to separate photosynthetic pigments.

..... [1]

(b) The rate of photosynthesis is affected by many environmental factors.

A student carried out an experiment to investigate the relationship between the concentration of carbon dioxide available to an aquatic plant, *Cabomba caroliniana*, and its rate of photosynthesis.

Fig. 1.1 shows the experimental set-up for this investigation.

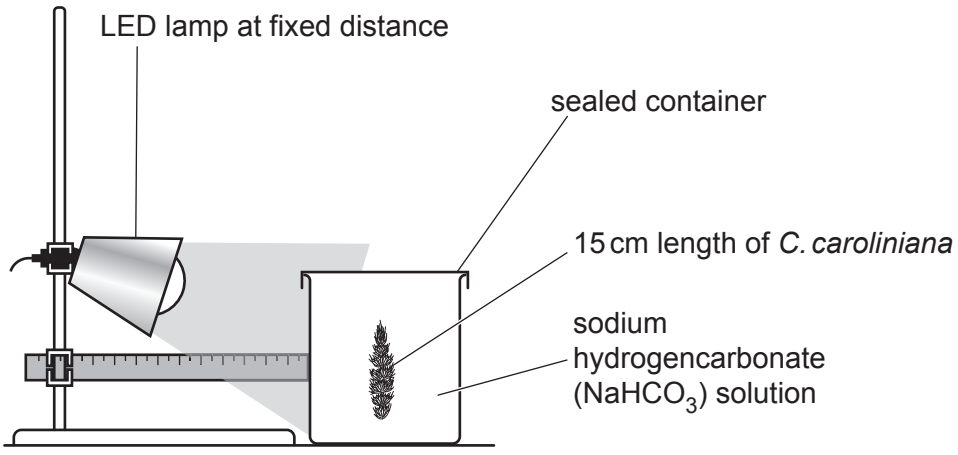


Fig. 1.1

- Sodium hydrogencarbonate solution was used as a source of carbon dioxide.
- The concentration of carbon dioxide was varied using six different concentrations of sodium hydrogencarbonate solution.
- All *C. caroliniana* plants were kept in the dark before the light was switched on at the start of the experiment.
- Five replicates were carried out at each concentration.
- The rate of photosynthesis was obtained by calculating the percentage change in dissolved oxygen concentration in the solution over five minutes.

Fig. 1.2 shows the results of the investigation.

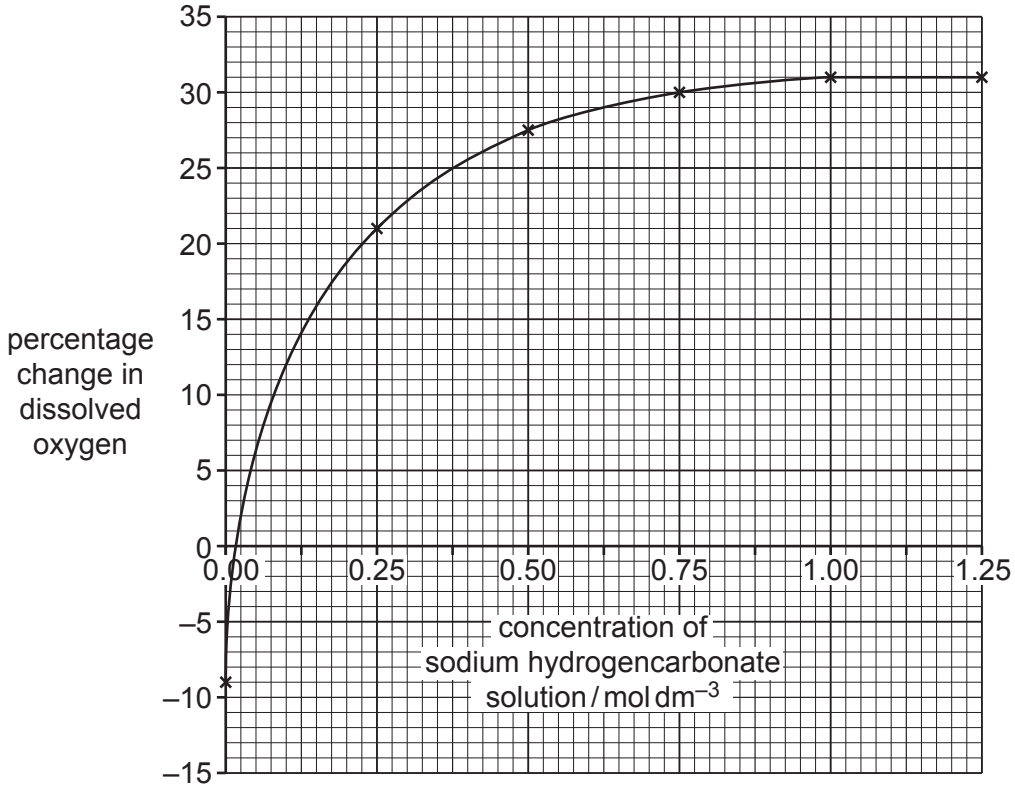


Fig. 1.2

(i) With reference to Fig. 1.2, explain the pattern of results obtained between 0.25 mol dm^{-3} and 1.25 mol dm^{-3} of sodium hydrogencarbonate solution.

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..... [3]

(ii) The percentage change in dissolved oxygen for *C. caroliniana* at 0.00 mol dm^{-3} of sodium hydrogencarbonate solution is negative.

Suggest reasons for this negative value.

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..... [2]

(iii) To minimise temperature changes, the student decided to use an LED lamp as a light source. LED lamps release very little heat energy.

Explain the importance of minimising temperature changes in this experiment.

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..... [3]

[Total: 12]

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2 **(a)** All organisms respire to release energy from energy-rich molecules such as glucose.

(i) Anabolic reactions **use** energy.

State **two** examples of anabolic reactions occurring in living organisms.

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..... [2]

(ii) Describe **and** explain the use of ATP in glycolysis.

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..... [3]

(b) Some factory workers in the early 20th century were exposed to chemical X and experienced serious side-effects.

Some of the effects of exposure to chemical X are:

- decreased production of ATP
- increased lipid metabolism, with weight loss
- increased production of pyruvate and lactate
- excess heat energy release, causing an increase in body temperature, which can be fatal.

Chemical X increases the permeability of the inner mitochondrial membrane to protons (hydrogen ions), causing some protons to leak out into the matrix.

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(i) Explain why people exposed to chemical X show:

- decreased production of ATP
- increased lipid metabolism.

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..... [3]

(ii) Suggest **and** explain why chemical X causes increased production of pyruvate and lactate.

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..... [2]

(iii) Suggest why excess heat energy is released.

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..... [1]

[Total: 11]

3 In 2014, scientists published a phylogenetic (evolutionary) tree diagram showing how and when different groups of insects developed from ancestral groups.

To construct the diagram, the scientists compared nucleotide **and** amino acid sequence data for 1478 genes from each of 103 different insect species. The 103 species represented all 32 orders of the class Insecta.

The data were used to arrange the species in related groups according to their degree of molecular similarity and to track how sequences changed over time.

(a) (i) Outline **three** ways in which the members of a species are similar.

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..... [3]

(ii) Organisms are classified in a hierarchical system of taxonomic units.

Name the domain and kingdom to which insects belong.

domain .....

kingdom .....

[2]

(iii) Explain why a phylogenetic tree diagram is useful for classifying insect species.

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..... [2]

(b) For this study, new software for processing large quantities of data was developed.

(i) Calculate the total number of sequences that were compared, considering both the nucleotide and amino acid sequences for each gene.

..... [1]

(ii) Explain why this study needs to make use of bioinformatic techniques.

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[Total: 11]

4 **(a)** Genetic engineering involves the manipulation of naturally occurring enzymes and processes.

List the enzymes used in genetic engineering (genetic modification) **and** outline their roles in natural processes.

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..... [5]

(b) Genetically modified organisms (GMOs) include crop plants. Genetically modified (GM) crop plants have been grown in North America in increasing quantities since 1996. They are now grown in many areas of the world and are eaten by millions of people and farm animals.

Table 4.1 compares the area of land used to grow GM crop plants on six continents in 2013.

Table 4.1

continent	**area of land used to grow GM crop plants / million hectares**	**edible GM crop plants grown**
Africa	3.5	maize, soybean
Asia	19.1	maize, papaya, tomato
Australasia	0.6	canola
Europe	0.2	maize
North America	81.1	canola, maize, papaya, soybean, squash, sugar beet
South America	70.9	canola, maize, soybean

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(i) Suggest how North America and South America benefit from growing large areas of GM crop plants rather than non-GM crop plants.

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..... [3]

(ii) Only a small area of land is used to grow GM crop plants in Europe. This is mainly because most of Europe uses a 'precautionary principle'. The precautionary principle prevents GM crop plants being grown if there is a possible risk of harm to human health or to the environment, even if there is no proof of harm.

Many European citizens have concerns about the safety of eating GM food, but Europe imports large quantities of GM maize and GM soybean to feed farm animals.

Use this information and Table 4.1 to deduce two arguments **in favour of** growing more GM crop plants in Europe.

1 .....

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2 .....

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[2]

(iii) Explain why the data in Table 4.1 are not enough to calculate the extent to which different continents have replaced traditional crop plants with GM versions.

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..... [2]

[Total: 12]

5 **(a)** Nerves consist of bundles of different types of neurones.

Fig. 5.1 shows the mean transmission speed of impulses for three types of sensory neurone, **C**, **A$^{\delta}$** and **A$^{\beta}$**.

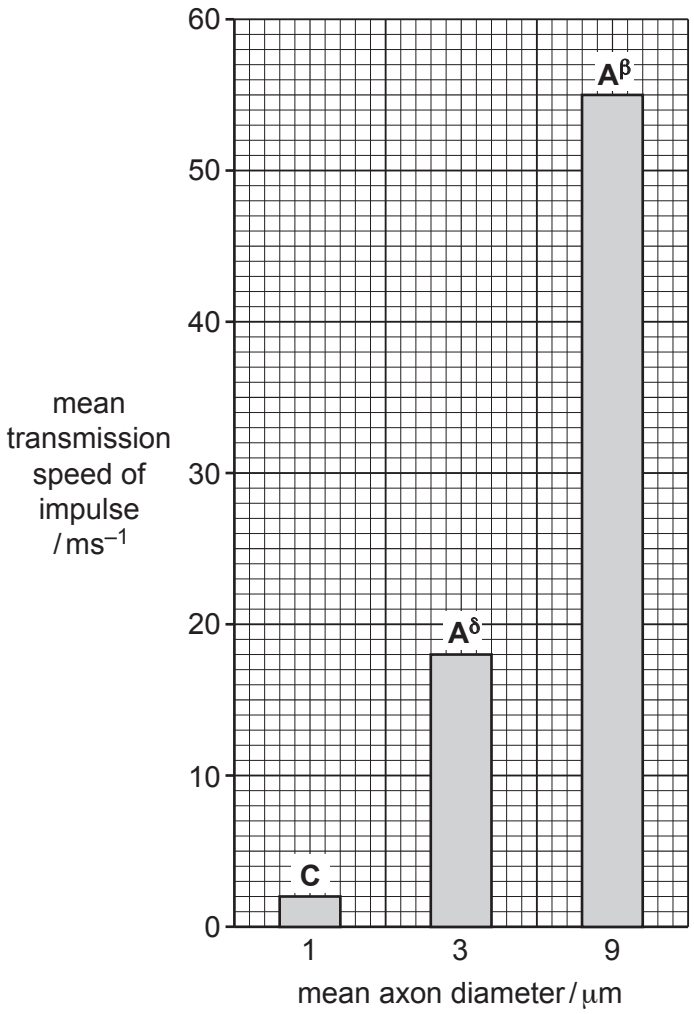


Fig. 5.1

- Impulses from pain receptors in the skin are sent along sensory neurones **C** and **A$^{\delta}$**.
- Sensory neurones **C** and **A$^{\delta}$** synapse in the spinal cord with relay neurones known as projection neurones.
- Projection neurones send impulses to the part of the brain that perceives pain.

- Impulses from touch receptors in the skin pass along sensory neurones **A$^{\beta}$**, which can also synapse with the projection neurones in the spinal cord.

- Sensory neurones **A$^{\delta}$** and **A$^{\beta}$** are myelinated.
- Sensory neurones **C** are unmyelinated.

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(i) Describe the results shown in Fig. 5.1 **and** suggest explanations for these results.

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..... [3]

(ii) Gently rubbing a damaged area of skin can reduce the perception of pain.

Suggest an explanation for this.

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..... [1]

(b) Back pain in humans can be reduced by using a transcutaneous electrical nerve stimulation (TENS) machine.

A TENS machine uses electrical impulses to stimulate nerve endings near the site of the pain.

It is thought that TENS triggers the release of natural painkillers called endorphins at synapses.

Fig. 5.2 shows synapses in a pain pathway.

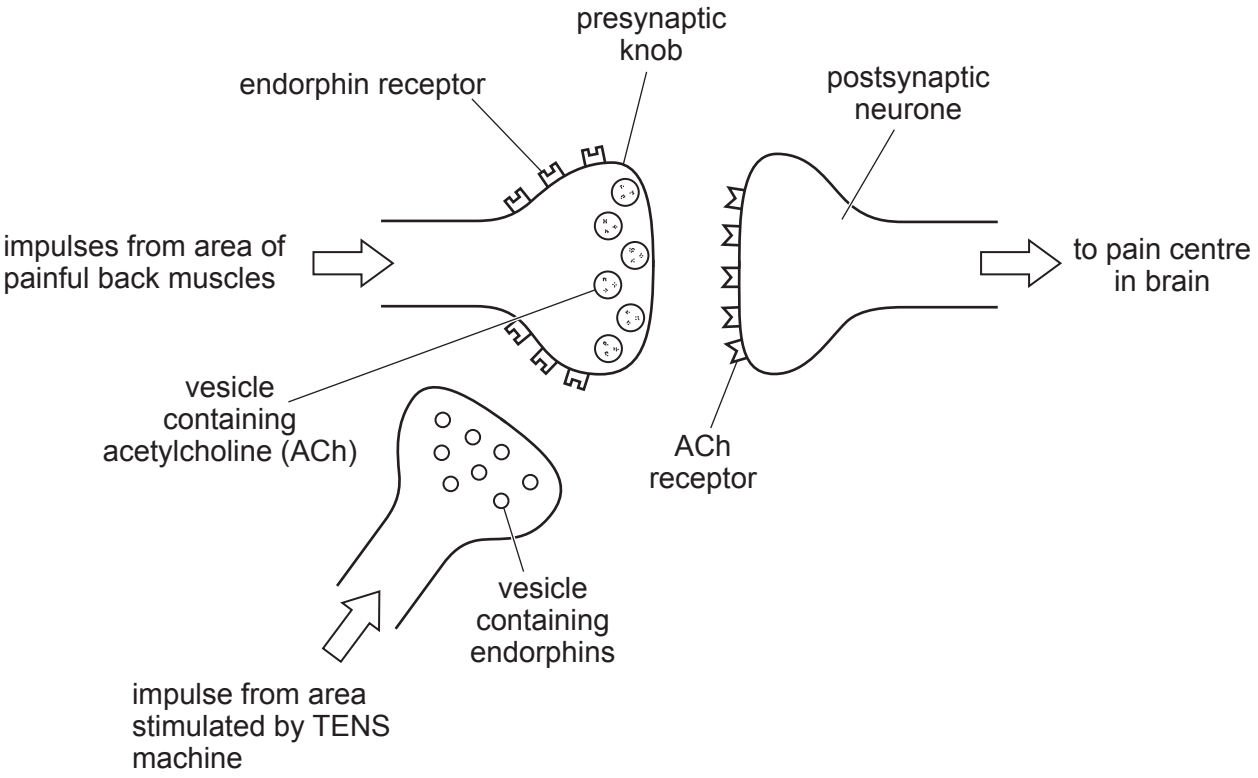


Fig. 5.2

(i) Suggest **and** explain how endorphins may act to reduce pain.

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..... [4]

(ii) Suggest **one disadvantage** of using pharmaceutical drugs for reducing pain compared to using TENS.

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..... [1]

[Total: 9]

6 **(a)** Thermoregulation is the control of the core temperature of the body.

Thermoreceptors send information about a change in core temperature to the hypothalamus. The hypothalamus controls the core temperature by sending impulses to activate several physiological responses.

Table 6.1 lists physiological responses to a **decrease** in core temperature.

Complete Table 6.1 to explain how each response contributes to maintaining a core temperature within narrow limits.

Table 6.1

response	explanation
blood vessels near the surface of the skin constrict (narrow)	....
shivering occurs	....
hairs rise	....
reduction in the production of sweat	....

[4]

(b) Animals can also use behaviour to adapt to temperature changes.

Suggest why some animals curl up their bodies in cold weather.

.....

..... [1]

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(c) The Sitatunga deer, *Tragelaphus spekii*, and the Nile monitor lizard, *Varanus niloticus*, live in Africa.

Fig. 6.1 shows a Sitatunga and Fig. 6.2 shows a Nile monitor.



Fig. 6.1



Fig. 6.2

An investigation was carried out to measure the core temperature of the Sitatunga and the Nile monitor as the environmental temperature was increased.

The results are shown in Fig. 6.3.

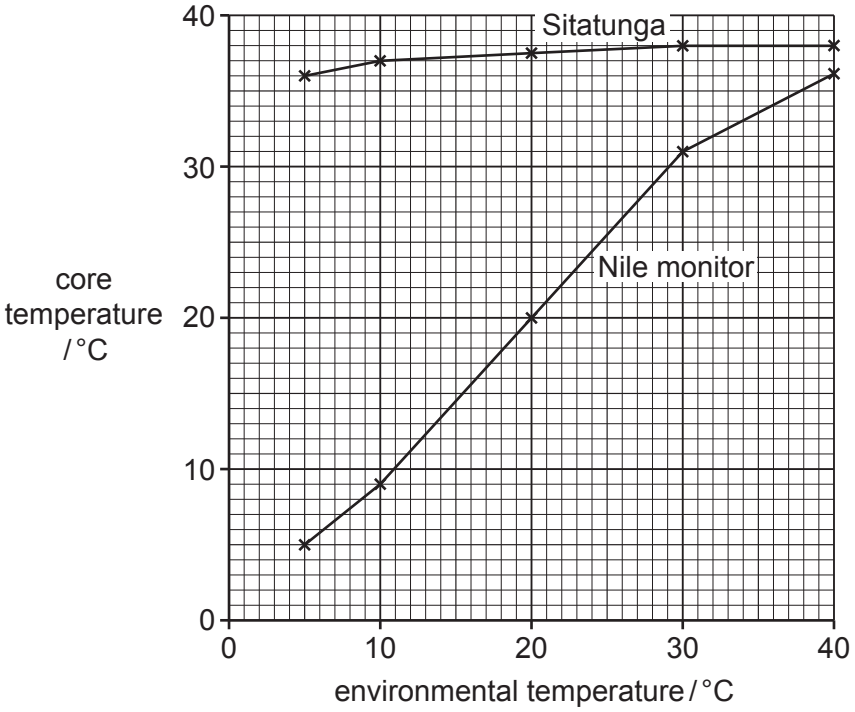


Fig. 6.3

(i) Describe the results shown in Fig. 6.3.

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..... [3]

(ii) When the environmental temperature is low, Nile monitors are relatively inactive.

Suggest **one** disadvantage to the Nile monitor of being inactive.

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..... [1]

(d) Thermoregulation relies on negative feedback.

Explain what is meant by negative feedback.

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..... [3]

[Total: 12]

7 People vary in which molecules are present on the surface of their red blood cells. For example, in the ABO blood group system, people may be categorised into one of four blood groups: A, B, AB and O.

A single gene, ***I***, with three alleles, determines these blood groups. Gene ***I*** is an example of a gene with multiple alleles.

- Alleles $\mathbf{I^A}$ and $\mathbf{I^B}$ are codominant.
- Allele $\mathbf{I^o}$ is recessive to alleles $\mathbf{I^A}$ and $\mathbf{I^B}$.

(a) Explain what is meant by codominant and recessive.

codominant .....

.....

recessive .....

.....

[3]

(b) Table 7.1 shows a cross between a person with blood group A and a person with blood group B.

Complete Table 7.1.

Table 7.1

parental phenotype (blood group)	A		B	
parental genotype	$\mathbf{I^A I^o}$		$\mathbf{I^B I^o}$	
gametes	.....	.....	.....	.....
offspring genotype	.....	.....	.....	.....
offspring phenotype (blood group)	.....	.....	.....	.....

[3]

(c) Haemophilia is a blood condition where bleeding continues for a long period of time after a blood vessel has been damaged.

A person with haemophilia has a mutation in a gene on the X chromosome, which results in the lack of a blood clotting factor.

Explain why a man who has haemophilia cannot pass the condition to his male offspring.

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..... [3]

[Total: 9]

8 **(a)** Humans use selective breeding to improve the features of crop plants and domestic animals.

(i) State another term for selective breeding.

..... [1]

(ii) Describe how selective breeding can be used to improve the milk yield of dairy cattle.

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..... [5]

(b) Explain what is meant by disruptive selection.

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..... [3]

[Total: 9]

Section B

Answer **one** question.

9 **(a)** Describe how you would carry out an investigation to calculate the effect of substrate concentration on the rate of respiration of yeast in anaerobic conditions using a redox indicator, such as DCPIP or methylene blue. [8]

(b) Compare respiration in anaerobic conditions in mammalian tissue and in yeast cells. [7]

[Total: 15]

10 **(a)** Explain how speciation can occur due to geographical separation. [8]

(b) Using examples, explain why species may become extinct. [7]

[Total: 15]

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[Turn over

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BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **May/June 2021**

2 hours

You must answer on the question paper.

No additional materials are needed.

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INFORMATION

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Section A

Answer **all** questions.

1 **(a)** Fig. 1.1 is a diagram of part of a neurone membrane at resting potential.

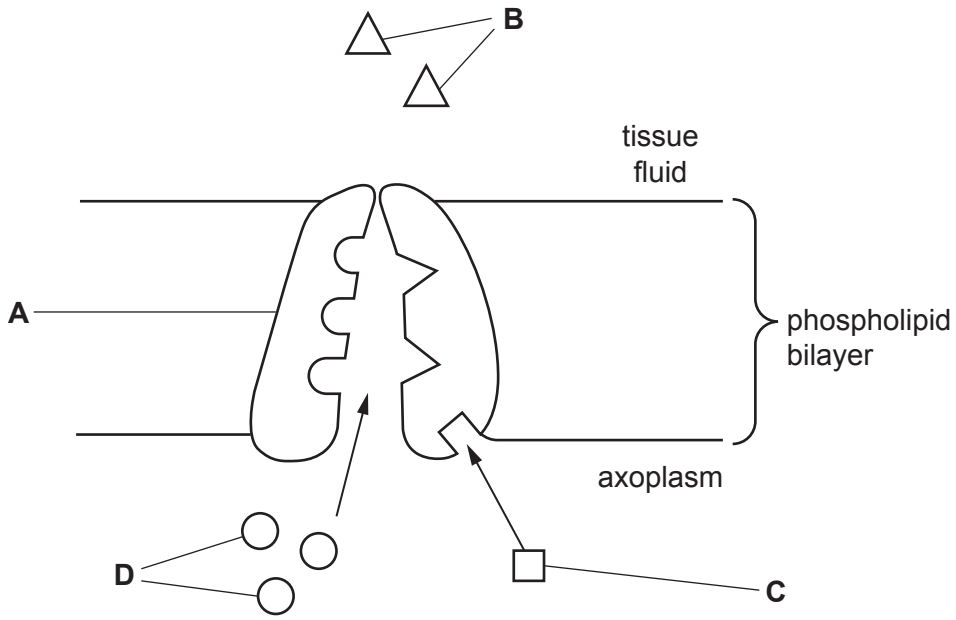


Fig. 1.1

(i) With reference to Fig. 1.1, name **A**, **B**, and **D**.

A .....

B .....

D ..... [3]

(ii) Substance **C** is required to make structure **A** function.

Name substance **C**.

..... [1]

(b) Some drugs can affect the functioning of neuromuscular junctions or cholinergic synapses.

Table 1.1 lists three drugs and describes their action on neuromuscular junctions or cholinergic synapses.

Table 1.1

drug	action of drug
curare	blocks muscle cell membrane receptors at neuromuscular junctions
nerve gas	inhibits acetylcholinesterase function in synapses
alcohol	inhibits exocytosis of neurotransmitters in synapses

Suggest **and** describe the immediate consequence of the action of each drug on a neuromuscular junction or cholinergic synapse.

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..... [5]

[Total: 9]

2 **(a)** All organisms respire. The ATP produced as a result of respiration is used as the energy currency of the cell.

(i) Outline **two** examples of movement in cells that use ATP.

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.....

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.....

..... [2]

(ii) ATP cannot be stored in cells so it has to be continually re-synthesised to meet the demands of an organism.

A person with a total quantity of 0.2 moles of ATP needs to hydrolyse 150 moles of ATP per day.

Calculate how many times the total quantity of 0.2 moles of ATP has to be re-synthesised per hour to meet the demand of 150 moles per day.

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

answer = ... [2]

(iii) Name the stages in which chemiosmosis occurs in respiration and in photosynthesis.

respiration .....

photosynthesis .....
[2]

(b) Fur seals are mammals that are adapted to live in cold temperatures. Fur seals have large quantities of a type of fat tissue known as brown adipose tissue. Brown adipose cells contain many mitochondria. These mitochondria contain a transport protein called thermogenin.

Fig. 2.1 shows the role of thermogenin in a mitochondrion of a brown adipose cell when external temperatures are cold.

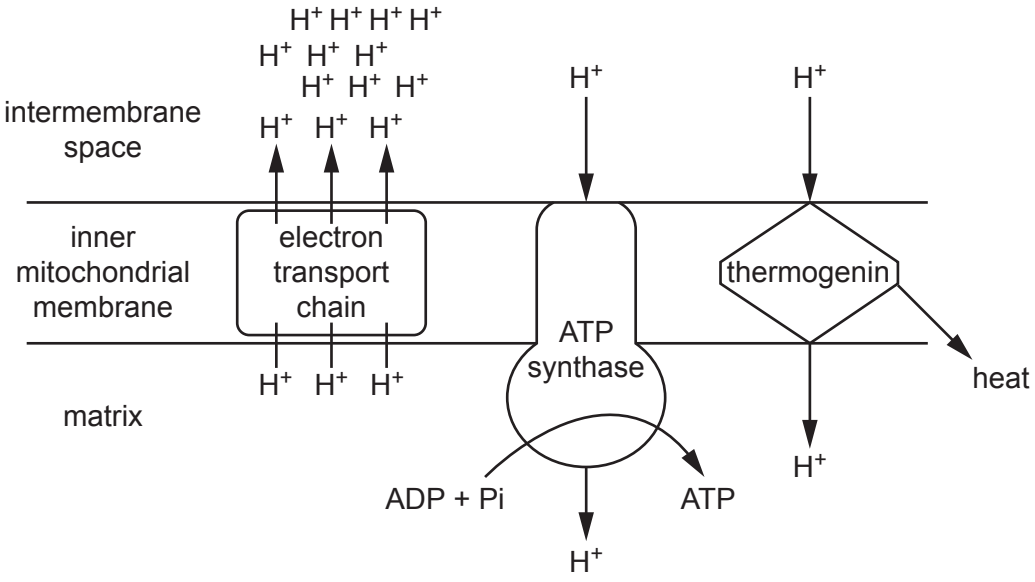


Fig. 2.1

(i) With reference to Fig. 2.1, describe **and** explain the effect of thermogenin on ATP synthesis.

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..... [3]

(ii) When the external temperature is warm, thermogenin cannot function.

When the external temperature becomes cold, thermogenin is able to function as a result of cell signalling:

- adrenaline is released
- adrenaline acts on brown adipose cells
- a sequence of events is triggered that results in the activation of the enzyme lipase
- lipase hydrolyses triglycerides in the cells into fatty acids
- fatty acids enter the mitochondrion
- thermogenin starts to function.

Outline the stages of cell signalling that trigger the functioning of thermogenin.

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..... [3]

[Total: 12]

Question 3 starts on page 8.

3 **(a)** One way to measure global biodiversity is to count the number of species of organisms.

Table 3.1 shows estimates for 2009 of the number of species in some taxa of animals.

The numbers in brackets are the numbers that were updated in 2019 from the International Union for Conservation of Nature and Natural Resources (IUCN) for three intensively studied taxa.

Table 3.1

number of species in each taxon		
kingdom	**phylum**	**class**
animals 1 438 805	arthropods 1 191 770	arachnids 102 248
		crustaceans 47 000
		myriapods 16 072
		insects 1 024 945
		other arthropod classes 1505
	chordates 63 543	fish 31 269
		amphibians 6515 (6722)
		birds 9990 (11 126)
		reptiles 8734
		mammals 5487 (5692)
	molluscs 85 000	
	other animal phyla 98 492	

(i) List **three** features shared by **animal** species.

1 .....

2 .....

3 .....

[3]

(ii) Explain how the classification of species into a taxonomic hierarchy assists the work of conservation bodies such as the IUCN.

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..... [3]

(iii) Table 3.1 shows that the number of species of amphibians, birds and mammals has increased between 2009 and 2019.

Discuss whether the increase in numbers means that these classes of chordate are being successfully conserved.

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..... [2]

(iv) With reference to Table 3.1, identify the class of animals that is most diverse then calculate the percentage of animal species that belongs to this class.

Show your working and give your answer to two significant figures.

answer = ... % [2]

(b) An analysis in 2019 concluded that twice as many insect species have populations that are decreasing in size compared with chordate species. This analysis focused on developed countries that have large human populations.

(i) Outline **two** factors that may cause populations of insects to decrease in size in developed countries that have large human populations.

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..... [2]

(ii) Explain how the introduction of crops that are genetically modified to express the Bt toxin can benefit biodiversity.

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..... [2]

[Total: 14]

4 **(a)** Genetic technology involving the creation of recombinant DNA can be used to treat different human diseases. These include diseases such as diabetes that may have multiple causes and inherited disorders that are caused by a single gene.

Outline **two different** ways of using recombinant DNA technology to treat these diseases.

diabetes .....

.....

.....

single gene disorder .....

.....

.....

[2]

(b) A new application of recombinant DNA technology uses the genetic modification of a plant to prevent disease. It aims to prevent the most common source of food-borne disease, which is caused by eating food contaminated with pathogenic *Escherichia coli* bacteria.

Scientists genetically modified edible spinach plants to produce colicins. Colicins are antimicrobial proteins that can kill pathogenic *E.coli*. Colicins are normally made by other bacteria.

An experiment was carried out to test this application by spraying an extract of genetically modified (GM) spinach in buffer solution onto raw meat contaminated with pathogenic *E.coli*. The meat was stored at 10 °C for varying lengths of time before the numbers of viable (living) pathogenic *E.coli* bacteria were counted. Fig. 4.1 shows the results.

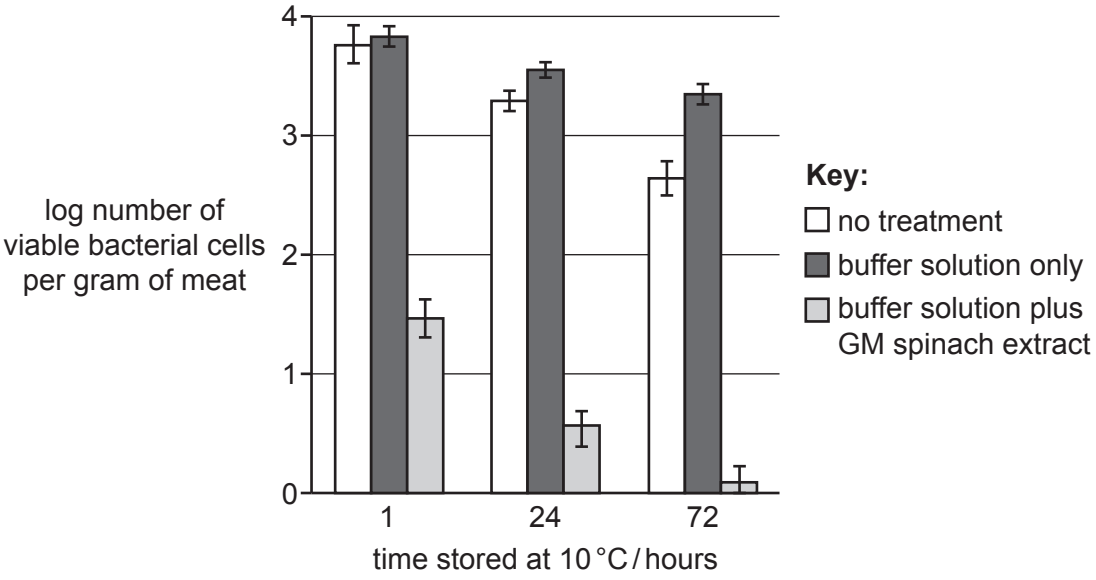


Fig. 4.1

(i) With reference to Fig. 4.1, evaluate the effectiveness of using GM spinach spray on raw meat to prevent food-borne disease.

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..... [4]

(ii) Regulatory authorities may not approve the use of GM spinach spray on raw meat to protect consumers.

Discuss the concerns that may stop regulatory authorities approving this application of recombinant DNA technology.

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..... [3]

[Total: 9]

5 **(a)** Photosynthesis is a complex process involving a light dependent stage and a light independent stage.

(i) Name the products of the light dependent stage that are needed in the light independent stage.

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..... [2]

(ii) Describe the role of chlorophyll b in photosynthesis.

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..... [2]

A student carried out an experiment to investigate the effect of light intensity and light wavelength on the rate of photosynthesis.

- An aquatic plant, *Elodea canadensis,* was put into a beaker containing sodium hydrogencarbonate solution as a source of carbon dioxide.
- To minimise changes in temperature, an LED lamp was used as a source of light.
- The lamp was switched on and the number of bubbles released by the aquatic plant in 1 minute was counted.
- The lamp was placed at seven different distances from the beaker to change light intensity.
- Five replicates were carried out at each lamp distance.
- All other variables were controlled.

(b) The student calculated the light intensity for each distance (d) using $\frac{1}{d^2}$.

Table 5.1 shows the calculated light intensities for each distance.

Table 5.1

distance between plant and lamp / m	light intensity / $\frac{1}{d^2}$
0.025	1600
0.050	400
0.100	
0.150	44
0.200	25
0.250	16
0.300	11

Complete Table 5.1 by calculating the light intensity for distance 0.100 m. [1]

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(c) At each distance from the lamp, the experiment was repeated using a red filter in front of the lamp to give a different wavelength of light. The experiment was repeated using a blue filter and then using a green filter. Each filter transmitted the same light intensity.

The student calculated the mean rate of bubble production as a measure of the rate of photosynthesis.

Fig. 5.1 shows a graph of the results.

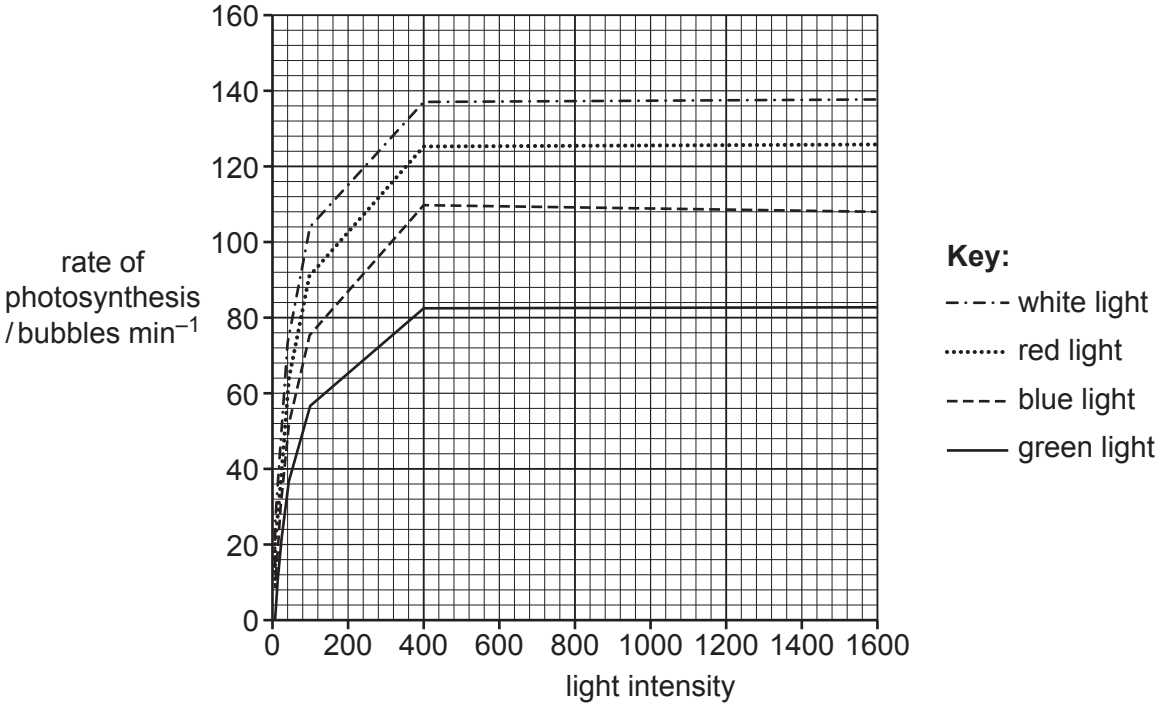


Fig. 5.1

(i) With reference to Fig. 5.1:

- state the range over which light intensity is the limiting factor
- explain why light intensity above this range is not limiting the rate of photosynthesis.

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(ii) At a light intensity of 1600, explain why different colour filters result in different rates of photosynthesis.

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..... [3]

[Total: 11]

6 Glucagon-like peptide-1 (GLP-1) is a hormone consisting of 31 amino acids. It is secreted by specialised intestinal epithelial cells known as L cells.

Fig. 6.1 outlines the secretion of GLP-1 and its effects on the pancreas, brain and stomach.

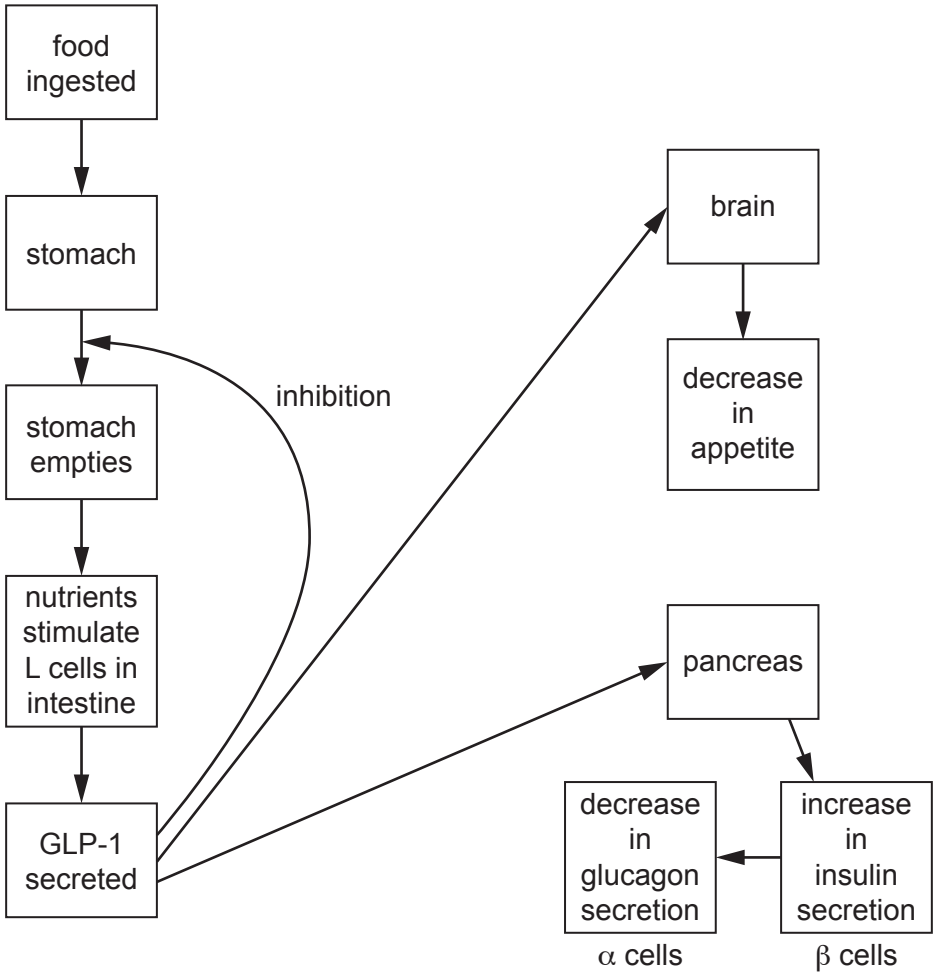


Fig. 6.1

(a) GLP-1 binds to receptors on cell surface membranes of β cells in the pancreas. These cells secrete insulin.

(i) Name the type of membrane component that forms a receptor in the cell surface membrane.

..... [1]

(ii) State how GLP-1 is transported to the pancreas.

..... [1]

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(b) GLP-1 inhibits the secretion of glucagon by α cells in the pancreas.

Describe **two** processes in the liver that are stimulated by glucagon.

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..... [2]

(c) Suggest **one** reason why GLP-1 causes a decrease in appetite.

..... [1]

(d) GLP-1 inhibits the emptying of the stomach. This is an example of negative feedback.

Explain what is meant by negative feedback.

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..... [3]

(e) A transcription factor is involved in the production of GLP-1. An insertion mutation in the gene that codes for the transcription factor can affect the production of GLP-1.

Outline the effect of an insertion mutation on the production of GLP-1.

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..... [3]

[Total: 11]

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7 (a) The fruit fly, *Drosophila melanogaster*, feeds on sugars found in damaged fruits.

A fruit fly with normal features is described as wild type. It has red eyes and its wings are longer than its abdomen. There are mutant variations such as purple eyes or short (vestigial) wings.

Fig. 7.1 shows a wild type fruit fly and a mutant fruit fly with purple eyes and vestigial wings.

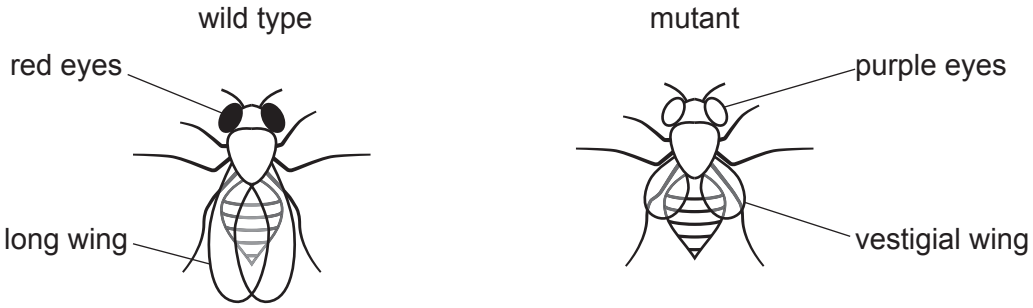


Fig. 7.1

- The genes coding for eye colour and wing length are located on the same chromosome.
- Allele **R** for red eyes is dominant to allele **r** for purple eyes.
- Allele **N** for long wings is dominant to allele **n** for vestigial wings.

Explain what is meant by the terms allele and dominant.

allele .....

dominant .....

.....

[2]

(b) A wild type fruit fly, heterozygous for both genes, was crossed with a fruit fly that was homozygous recessive for both genes.

(i) Table 7.1 is a summary of the cross.

Complete Table 7.1.

Table 7.1

	wild type parent		**double homozygous recessive parent**	
parental phenotype	.....		..... **x**	
parental genotype	.....		**x**	
offspring				
offspring phenotype	....	....	....	....
offspring genotype	.....	.....	.....	.....
number of offspring	1339	1195	151	154

[5]

(ii) Explain why the four offspring phenotypes are not present in a 1:1:1:1 ratio.

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..... [3]

[Total: 10]

8 **(a)** In continuous variation, a population shows a range of phenotypes between two extremes with no distinct groups. Height and mass are examples of phenotypic traits that show continuous variation.

Describe the genetic basis for continuous variation.

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..... [3]

(b) Environmental factors can contribute to continuous variation.

Suggest **two** environmental factors that may affect the body mass of an animal.

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..... [2]

(c) Humans have used selective breeding (artificial selection) for thousands of years to improve the quality of livestock.

Outline the principles of selective breeding in livestock.

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..... [4]

[Total: 9]

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Section B

Answer **one** question.

9 **(a)** Describe how the structure of a mitochondrion is related to its function. [9]

(b) Explain how rice is adapted to grow with its roots submerged in water. [6]

[Total: 15]

10 **(a)** Explain how different types of gene mutation can affect the phenotype **and** outline the effects of the mutant alleles that cause Huntington's disease on the phenotype of a person. [9]

(b) Explain how gibberellin acts on DELLA proteins to stimulate the production of amylase in a germinating seed. [6]

[Total: 15]

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BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 2021**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **one** question.
- 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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Section A

Answer **all** questions.

1 **(a)** Fig. 1.1 is a diagram of a part of a sarcomere in striated muscle.

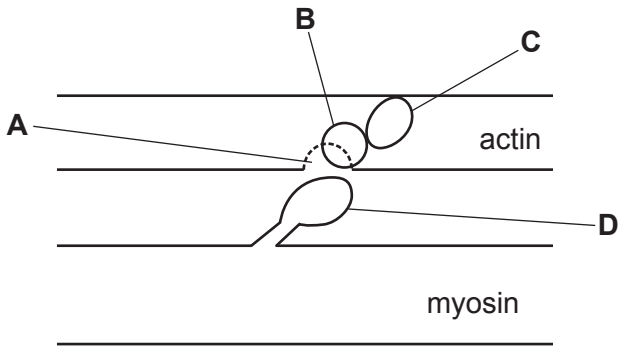


Fig. 1.1

With reference to Fig. 1.1, name **A**, **B**, **C** and **D**.

A .....

B .....

C .....

D .....

[4]

(b) When a muscle cell is stimulated, calcium ions are released from the sarcoplasmic reticulum.

With reference to Fig. 1.1, describe the role of calcium ions in the contraction of the sarcomere.

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..... [4]

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(c) When a mammal dies, aerobic respiration stops. The striated muscles contract and remain contracted for a few hours after death.

Suggest why the muscles remain contracted for a few hours.

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.....

.....

..... [2]

[Total: 10]

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2 **(a)** During respiration, respiratory substrates such as glucose are used as a source of energy to produce ATP molecules.

(i) Cells can maintain a different concentration of ions within the cell compared with the extracellular environment.

It is estimated that animals may use 50% of ATP made from respiration to maintain higher concentrations of some ions inside cells.

Name the mechanism that can maintain a higher concentration of ions inside a cell.

..... [1]

(ii) Only a proportion of energy released by the respiration of glucose is used to make ATP.

- The energy yield from the respiration of glucose in aerobic conditions is 2870 kJ mol^{-1}.
- When ATP is hydrolysed to ADP, it releases 30.5 kJ mol^{-1} of energy.
- It is estimated that 31 moles of ATP are made per mole of glucose respired.

Calculate the percentage efficiency of glucose respiration.

Show your working.

..... % [2]

(iii) The energy that is **not** converted to ATP during respiration is released as heat energy.

State **one** homeostatic use of this heat energy in mammals.

..... [1]

(iv) State the term used to describe the reaction that results in the production of ATP during the Krebs cycle.

..... [1]

(b) When a person exercises, power is generated.

Power is measured in joules per second ($J\,s^{-1}$).

The power generated when a person exercises will vary depending on the type and intensity of exercise. More power is generated when the intensity of exercise increases.

An experiment was carried out to determine whether increasing the intensity of exercise in a healthy human male caused a change in the value of the respiratory quotient (RQ).

- The man had a balanced diet.
- The RQ was calculated at rest.
- He carried out exercise for the same length of time on four separate days.
- The intensity of exercise was increased over the four days, generating different powers.
- The RQ was calculated for the four different powers generated.

The results are shown in Fig. 2.1.

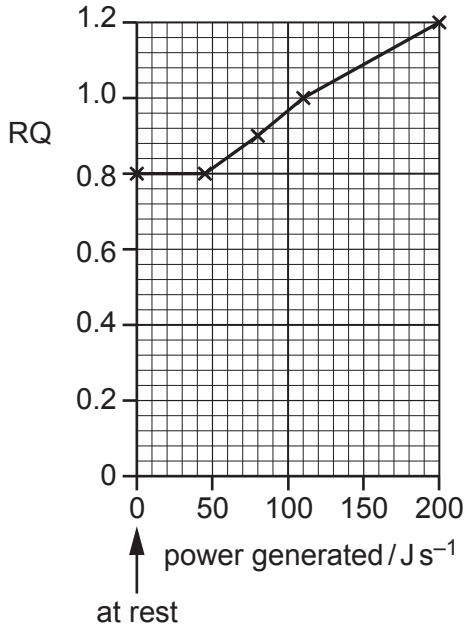


Fig. 2.1

With reference to Fig. 2.1, suggest what can be deduced from:

the RQ at rest

.....

.....

the RQ when the power generated is $110\,J\,s^{-1}$

.....

.....

the RQ when the power generated is $200\,J\,s^{-1}$.

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[4]

(c) Explain why a person continues to breathe deeply and at a higher rate for some time after the person has stopped exercising.

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..... [3]

[Total: 12]

3 Fruit flies of the genus *Bactrocera* are pests that damage fruit crops.

Table 3.1 gives the names and geographical ranges of *Bactrocera* fruit flies that were classified as four separate species.

Table 3.1

name	geographical range
B. dorsalis	China, India, Thailand
B. invadens	Africa, India
B. papayae	Indonesia, Malaysia
B. philippinensis	Philippine Islands, Borneo

In 2014, the classification of these flies was changed. All four species were recognised as belonging to a single species, *B. dorsalis*.

(a) (i) Suggest reasons why the four species were originally classified as separate species.

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..... [2]

(ii) Some students decided to investigate whether the flies were members of one species or four separate species.

Suggest a simple investigation that the students could carry out.

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..... [2]

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(b) Female *B. dorsalis* lay their eggs in different types of fruits, such as avocados, bananas, mangos and papayas. The eggs hatch into larvae that eat the fruit. The actions of the female flies and larvae allow microorganisms to enter the fruit. The microorganisms feed by secreting extracellular enzymes, causing the fruit to rot.

Name **two** kingdoms that include organisms that could spoil fruit by secreting extracellular enzymes.

1 .....

2 .....

[2]

Before the four *Bactrocera* species were reclassified as a single species in 2014, some governments in Asia banned fruit imports from African countries to avoid introducing *B. invadens* as an alien species.

(c) Explain why the introduction of alien species should be avoided.

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..... [4]

(d) Suggest how reclassifying *B. invadens* as *B. dorsalis* will benefit fruit-producing countries in Africa.

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..... [2]

[Total: 12]

4 **(a)** Bt maize has been genetically engineered to resist insect attack. In 2019, Bt maize formed 83% of the maize grown in the USA.

Outline how the genetic engineering process produced Bt maize plants with resistance to insect attack.

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..... [5]

(b) A proposed conservation benefit of Bt maize is that, unlike chemical insecticide sprays, it should not harm non-target insects.

When Bt maize was first grown in the USA, scientists were concerned that maize pollen containing the Bt toxin might be deposited by the wind on wild plants such as milkweeds, *Asclepias* spp. Milkweed leaves are the food source of caterpillars (larvae) of the monarch butterfly, *Danaus plexippus*.

In 1999, a laboratory experiment tested the effects of feeding milkweed leaves treated in different ways to the caterpillars of monarch butterflies. Each group of caterpillars was provided with milkweed leaves to eat throughout the experiment. The three different treatments were:

- leaves with no pollen
- leaves dusted with pollen from non-Bt maize
- leaves dusted with pollen from Bt maize.

Fig. 4.1 shows the results of this laboratory experiment.

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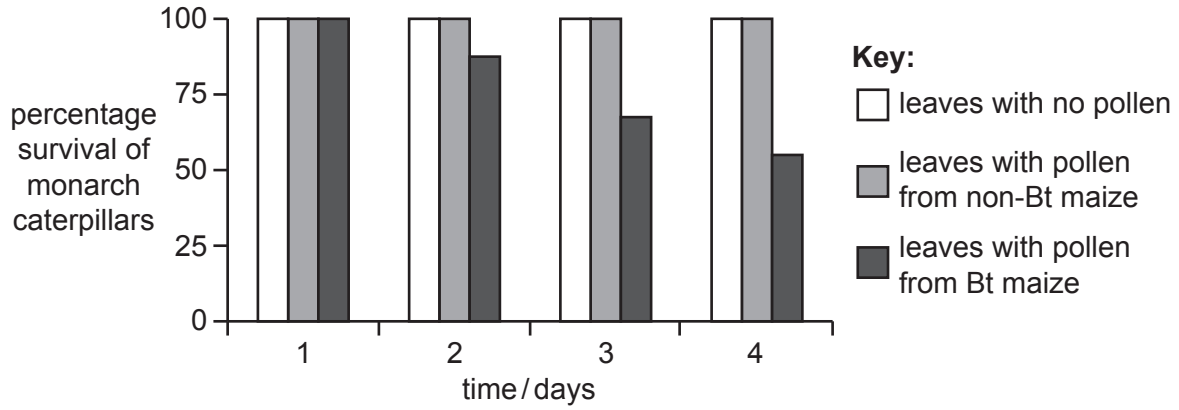


Fig. 4.1

(i) State what can be concluded from Fig. 4.1.

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..... [2]

(ii) Laboratory results are not always useful in predicting what will happen in real ecosystems.

- Some scientists predicted that increasing the area of Bt maize in the USA would decrease the number of monarch butterflies, based on the results in Fig. 4.1.
- More monarch butterflies were counted in 2019 than in 1999, even though the quantity of Bt maize grown more than tripled.

Suggest reasons why the predicted decrease in the number of monarch butterflies did not occur in the real ecosystem.

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..... [4]

[Total: 11]

5 Photosynthesis is a process that results in the synthesis of complex organic molecules.

Respiration is a process that involves the breakdown of complex organic molecules.

(a) The light dependent stage of photosynthesis involves cyclic and non-cyclic photophosphorylation.

Describe **two** differences between cyclic and non-cyclic photophosphorylation.

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.....

..... [2]

(b) Biochemical processes involving carbon dioxide change the external environment of the aquatic plant, *Elodea canadensis*, and the pond snail, *Lymnaea stagnalis*. Carbon dioxide dissolves in water to form carbonic acid.

A student set up 8 test-tubes. Each test-tube contained 30 cm^3 of distilled water containing a pH indicator, bromothymol blue.

Fig. 5.1 shows the experimental set up for these 8 test-tubes.

The test-tubes were left for 12 hours.

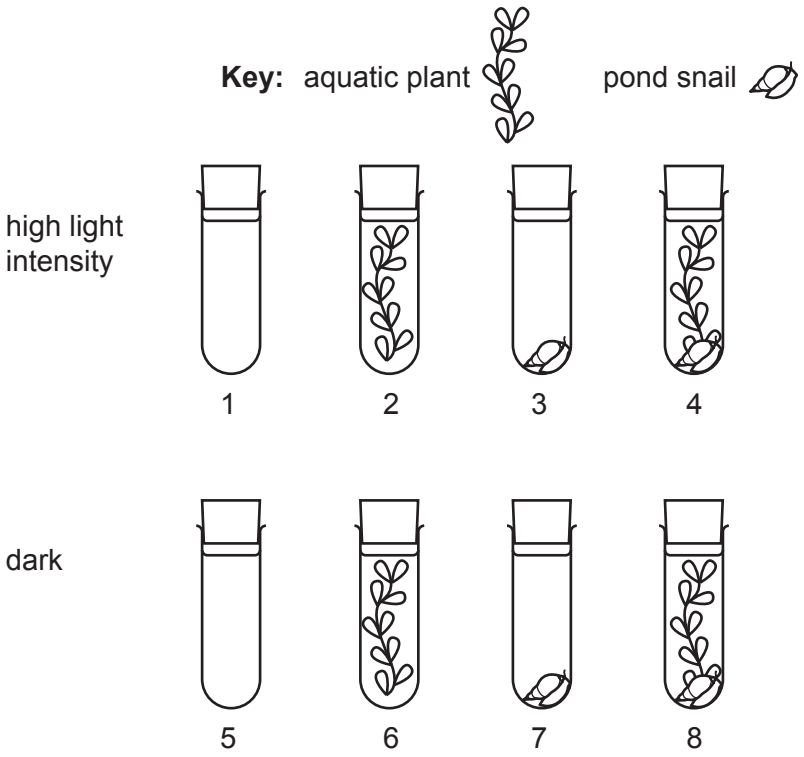


Fig. 5.1

Fig. 5.2 shows how the colour of bromothymol blue changes with pH.

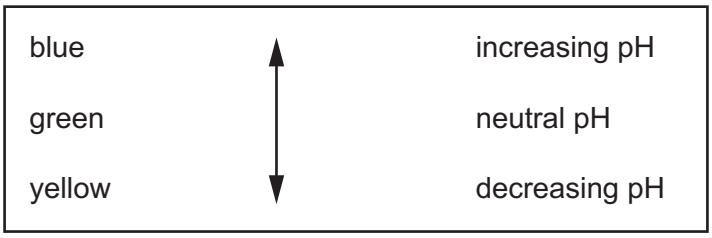


Fig. 5.2

All tubes were green at the start of the experiment.

The results of the experiment are shown in Table 5.1.

Table 5.1

test-tube	colour after 12 hours
1	green
2	blue
3	yellow
4	green
5	green
6	yellow-green
7	yellow
8	yellow

(i) Explain the purpose of test-tube 1 and test-tube 5.

.....

..... [1]

(ii) Explain the results of test-tubes 2, 3 and 4.

test-tube 2 .....

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test-tube 3 .....

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test-tube 4 .....

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[5]

(iii) Explain the colour change in test-tube 6.

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..... [3]

[Total: 11]

6 **(a)** The bottlenose dolphin, *Tursiops truncatus*, is an aquatic mammal. It has adaptations to conserve heat when swimming in cold water.

Fig. 6.1 shows a bottlenose dolphin.

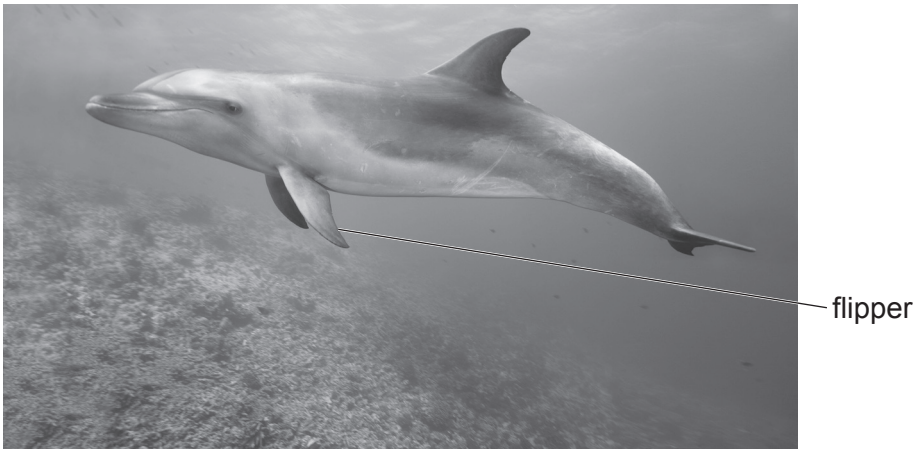


Fig. 6.1

(i) The arteries in the bottlenose dolphin that carry blood to the flippers are surrounded by veins bringing blood back to the rest of the body.

Outline how this arrangement of blood vessels is an adaptation to conserve body heat.

.....

..... [1]

(ii) When a dolphin has exercised for a long time, it may need to lose excess heat. Unlike humans, dolphins do **not** produce sweat.

Suggest how a dolphin may lose excess heat.

.....

..... [1]

(b) The control of blood glucose concentration in dolphins is the same as in most mammals.

A study was carried out to investigate the concentration of insulin in the blood of dolphins that were provided with a diet of fish, supplemented with glucose.

- One group of dolphins ate fish with 3 g of glucose for every kg of fish.
- Another group ate fish with 11 g of glucose for every kg of fish.

The concentration of insulin in the blood was measured 60 minutes before being fed, at the time of being fed and at regular intervals afterwards.

Measurements were also taken for a third group of dolphins, at the same time intervals, that were not fed any fish (fasting).

The results of the study are shown in Fig. 6.2.

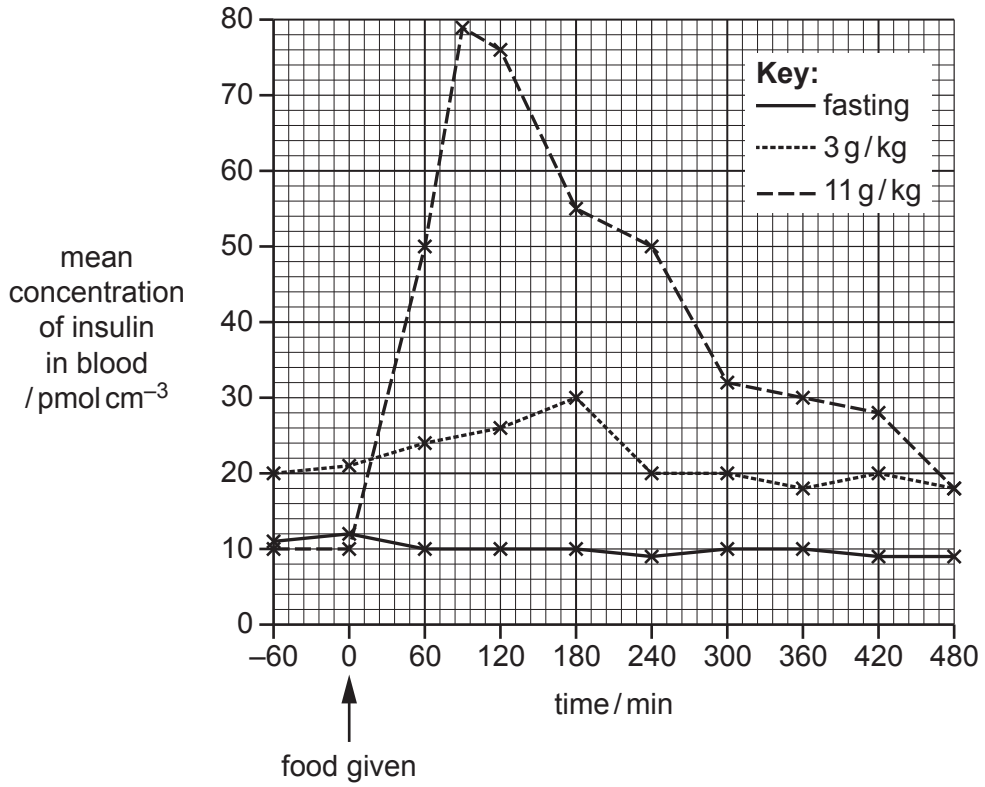


Fig. 6.2

(i) Describe the trends shown in Fig. 6.2.

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..... [4]

(ii) The mean concentration of insulin in the blood changes over time for the dolphins that were fed fish with 11 g of glucose per kg of fish.

Calculate the rate of change in the mean concentration of insulin in this group of dolphins from the time of being fed until the concentration reaches its maximum.

Show your working.

..... $pmol\,cm^{-3}\,min^{-1}$ [2]

(c) Blood glucose concentration is regulated by negative feedback.

Explain what is meant by negative feedback.

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..... [3]

[Total: 11]

7 **(a)** Haemoglobin is made of two α-globin chains and two β-globin chains.

A person may have a mutation in the gene coding for β-globin. This is due to a base substitution and leads to the production of abnormal β-globin and therefore abnormal haemoglobin.

A person who is homozygous for the mutant allele will have a condition called sickle cell anaemia.

Outline the phenotypic effects of having abnormal haemoglobin in a person with sickle cell anaemia.

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..... [4]

(b) $\mathbf{Hb^A}$ is the allele coding for normal β-globin.

$\mathbf{Hb^S}$ is the allele coding for abnormal β-globin.

The alleles are codominant.

(i) Explain what is meant by the alleles being codominant.

.....

..... [1]

(ii) A person who is heterozygous will have sickle cell trait but may not experience the symptoms of sickle cell anaemia.

Suggest why a person with sickle cell trait may not show the symptoms of sickle cell anaemia.

.....

..... [1]

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(iii) Construct a genetic diagram to show the possible offspring for a man and a woman who both have sickle cell trait.

parental phenotype	sickle cell trait	×	sickle cell trait
parental genotype			
gametes			
offspring genotypes			
offspring phenotypes			

[3]

[Total: 9]

8 **(a)** Explain what is meant by stabilising selection.

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..... [3]

(b) Fig. 8.1 shows the distribution of fur colour in a population of mice.

The colour of the soil where the mice lived was mid-brown.

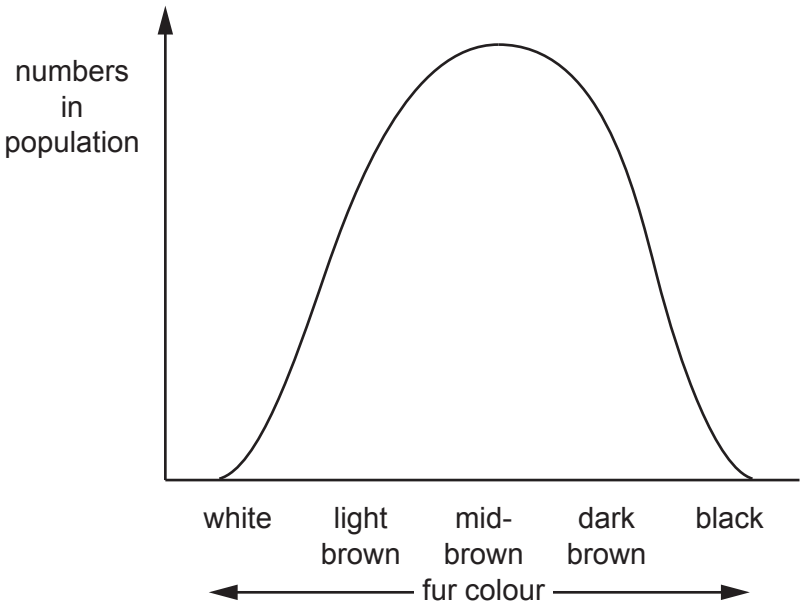


Fig. 8.1

(i) Suggest why mice with white fur and mice with black fur were present in the lowest numbers in Fig. 8.1.

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..... [2]

(ii) An environmental event caused the colour of the soil to change to dark brown.

On Fig. 8.1, sketch a curve to show the distribution of fur colour in the mouse population after many generations. [2]

(c) Explain what is meant by genetic drift.

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..... [2]

[Total: 9]

Section B

Answer **one** question.

9 **(a)** Explain the use of genes for fluorescence as markers in gene technology. [6]

(b) Discuss the **social** implications of using genetically modified organisms in food production. [9]

[Total: 15]

10 **(a)** Describe the roles of sodium ions in selective reabsorption in the nephron **and** calcium ions in the functioning of a cholinergic synapse. [7]

(b) Compare the endocrine and nervous systems in control and co-ordination in mammals. [8]

[Total: 15]

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