Cambridge Assessment International Education

Cambridge International AS & A Level

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5615097519

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2024**

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.
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- 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 Oxygen is needed for aerobic respiration in cells.

In eukaryotic cells, the mitochondrion is the organelle used for aerobic respiration.

(a) Fig. 1.1 shows a transmission electron micrograph of a mitochondrion.



Fig. 1.1

Table 1.1 lists the four stages of aerobic respiration.

With reference to Fig. 1.1, complete Table 1.1 using the letters **A–D** to show where each stage occurs.

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

Table 1.1

stage of respiration	letter
glycolysis	……
link reaction	……
Krebs cycle	……
oxidative phosphorylation	……

[3]

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(b) In anaerobic conditions, no ATP can be synthesised by oxidative phosphorylation because the process stops.

Explain why ATP synthesis by oxidative phosphorylation stops in anaerobic conditions.

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(c) Up to 60% of the ATP that is produced in cancer cells comes from lactate fermentation of glucose, even though oxygen is present.

Scientists are developing cancer treatments to inhibit the enzyme that catalyses the last step of lactate fermentation.

Explain how the inhibition of this enzyme reduces the production of ATP in cancer cells.

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..... [3]

[Total: 10]

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[Turn over

2 **(a)** Coordination in humans involves two main systems: the nervous system and the endocrine system. Paracrine cell signalling is a third way in which coordination occurs. In paracrine signalling, one cell secretes a chemical that diffuses a short distance to act upon cells that are very near to the secreting cell.

(i) Identify **one** similarity and **one** difference between paracrine cell signalling and cell signalling that occurs as part of the endocrine system.

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(ii) Explain why a neurotransmitter such as acetylcholine could be described as a paracrine signalling molecule.

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..... [2]

(b) Human muscle cells show paracrine signalling. After muscle cells have been exposed to a substance called palmitate they:

- produce a signalling molecule
- show an increase in the expression of genes involved in a stress response (stress genes).

Scientists carried out three experiments to investigate the signalling molecule produced by muscle cells after they have been exposed to palmitate.

Experiment A

- Muscle cells were exposed to palmitate.
- The palmitate-exposed muscle cells were removed from the medium containing palmitate and then cultured in a nutrient medium for six days.
- The palmitate-exposed cells were removed from the nutrient medium and **new** muscle cells were placed in this used nutrient medium.
- The expression of stress genes in the **new** muscle cells was measured after 24 hours.
- A **control** using cells that had **not** been exposed to palmitate was also carried out.

Experiment B

Experiment **A** was repeated but the used nutrient medium for the palmitate-exposed cells and the control was boiled and then cooled before adding the new muscle cells.

Experiment C

Experiment **A** was repeated but the used nutrient medium from the palmitate-exposed cells and the control was treated to separate the lipid part. This lipid part was added to a new nutrient medium to culture the new muscle cells.

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The results are shown in Fig. 2.1.

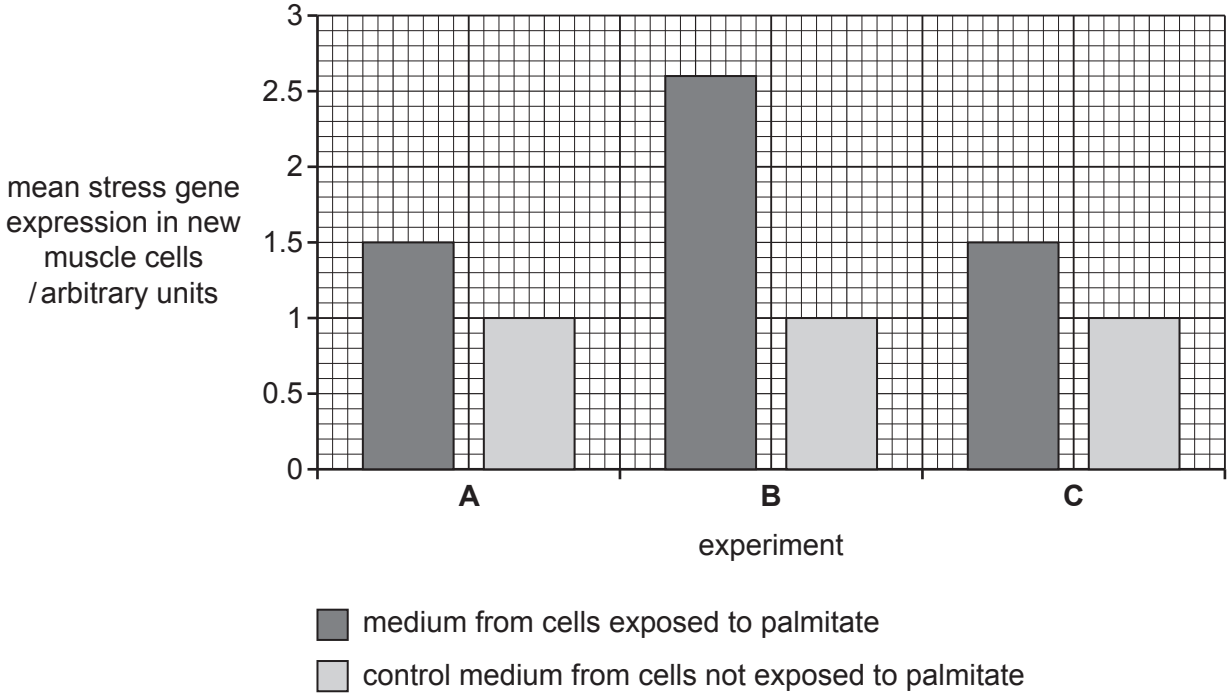


Fig. 2.1

With reference to Fig. 2.1, outline the conclusions that can be drawn about the cell signalling molecule involved in human muscle cell paracrine signalling in response to palmitate.

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(c) The process of protein translation is inhibited in developing muscle cells when stress genes are expressed.

Suggest how developing muscle cells that express stress genes will differ in structure from normal muscle cells.

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[Total: 10]

3 Stomata in leaves respond to changes in environmental conditions by opening and closing. This regulates carbon dioxide uptake and water loss.

(a) Describe the mechanism by which stomata open in sunlight.

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(b) Stomatal conductance is a measure of the rate of water vapour loss from the intercellular air spaces of leaves to the atmosphere through the stomata.

A student investigated the effect of different concentrations of abscisic acid (ABA) on stomatal conductance in *Helianthus annuus*, the common sunflower.

The student treated the roots of 15 sunflower plants with different concentrations of ABA solution. The plants were left in standardised conditions for 24 hours.

After 24 hours, the student measured:

- the concentration of ABA in the xylem sap of each plant
- the stomatal conductance of the leaves of each plant.

The results are shown in Fig. 3.1.

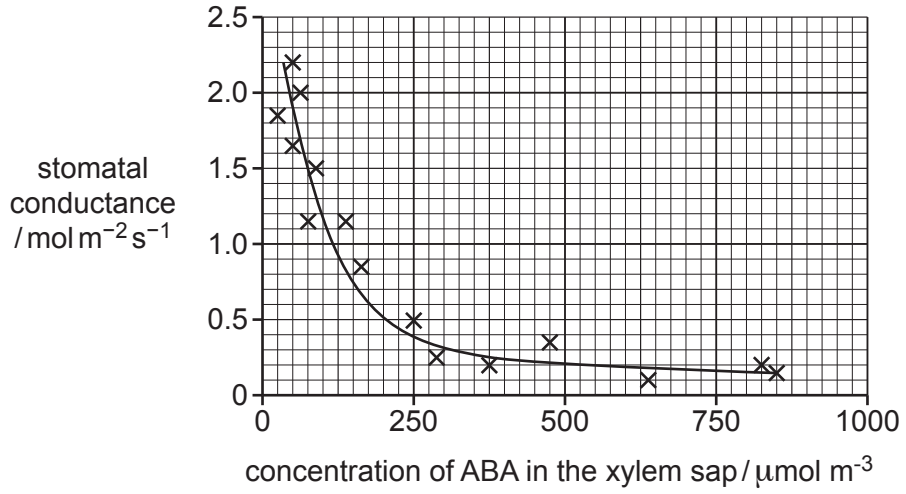


Fig. 3.1

(i) With reference to Fig. 3.1, describe the relationship between the concentration of ABA in the xylem sap and stomatal conductance.

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..... [2]

(ii) Suggest explanations for the results shown in Fig. 3.1.

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..... [4]

(c) Some transcription factors increase the rate of transcription of genes involved in the closure of stomata.

State where transcription factors bind to cause an increase in the rate of transcription.

..... [1]

[Total: 11]

4 White-clawed crayfish*, Austropotamobius pallipes*, live in rivers and lakes in Europe.
In the 1850s, the North American signal crayfish, *Pacifastacus leniusculus*, was introduced to Europe. The introduced species carried a pathogen that causes a disease known as crayfish plague. This disease kills *A. pallipes*.
Since 1850, the population size of *A. pallipes* has reduced in many areas of Europe due to the spread of crayfish plague.

(a) North American *P. leniusculus* can carry the crayfish plague pathogen without showing symptoms because they have evolved resistance to it.

Explain how *P. leniusculus* could have evolved resistance to the crayfish plague pathogen.

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..... [4]

(b) It is difficult to locate crayfish because they live underwater.
After an outbreak of crayfish plague in one country in Europe, researchers used an environmental DNA technique to find the locations in a river where populations of *A. pallipes* were still surviving.
Water samples were taken from locations along the river. Each water sample was filtered to obtain any cells or DNA that had been released by organisms into the water. The polymerase chain reaction (PCR) was carried out on this DNA using primers specific to *A. pallipes* DNA.

(i) Outline **and** explain the steps that occur in PCR.

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..... [4]

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(ii) Suggest how the researchers were able to discover suitable sequences for the primers.

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..... [1]

(c) The PCR technique used in this research is quantitative. A fluorescent dye binds to the DNA and the fluorescence is monitored throughout the process, showing the quantity of DNA present.

Fig. 4.1 shows standard curves for four known concentrations of DNA, **A**, **B**, **C** and **D**, and the result obtained for *A. pallipes* DNA at one location along the river (dotted line).

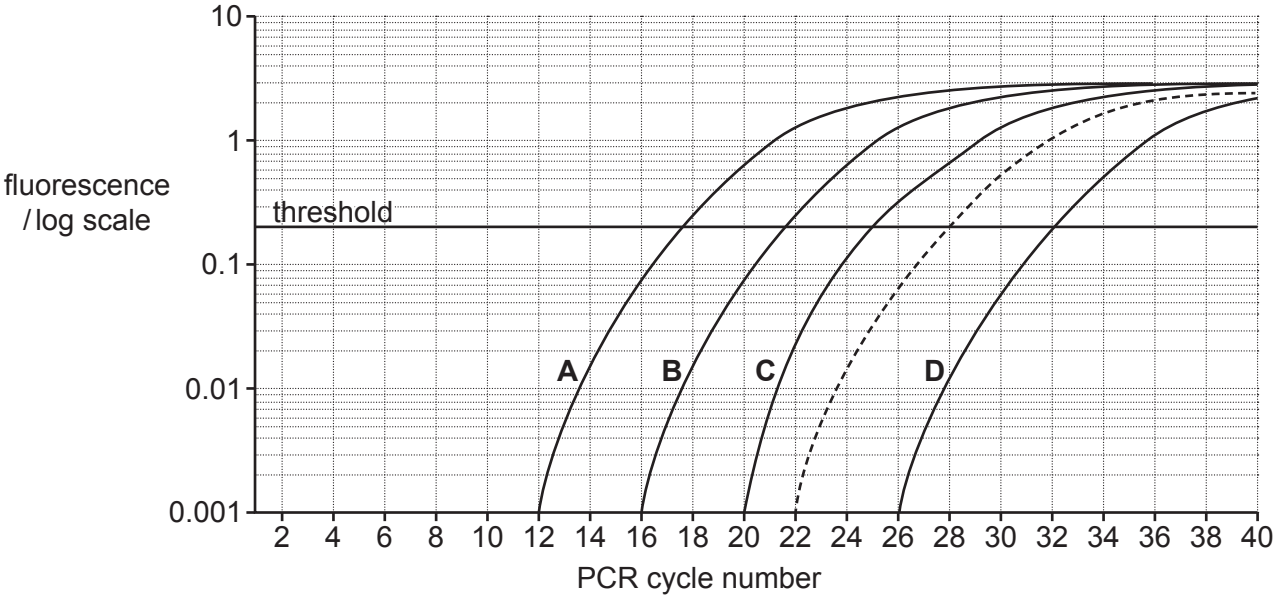


Fig. 4.1

(i) State the letter of the curve with the highest starting concentration of DNA.

..... [1]

(ii) The quantity of *A. pallipes* DNA reaches a threshold (marked as a horizontal line on Fig. 4.1) at 28 cycles. The DNA in curve **C** reaches the threshold after 25 cycles. In one cycle of PCR the concentration of DNA doubles.

Calculate the relative difference in the starting concentrations of *A. pallipes* DNA and the DNA in curve **C**.

..... [1]

(d) Fluorescent molecules have other uses in gene technology.

Fig. 4.2 shows an agar plate with normal bacteria and genetically modified bacteria. The genetically modified bacteria make a green fluorescent protein.

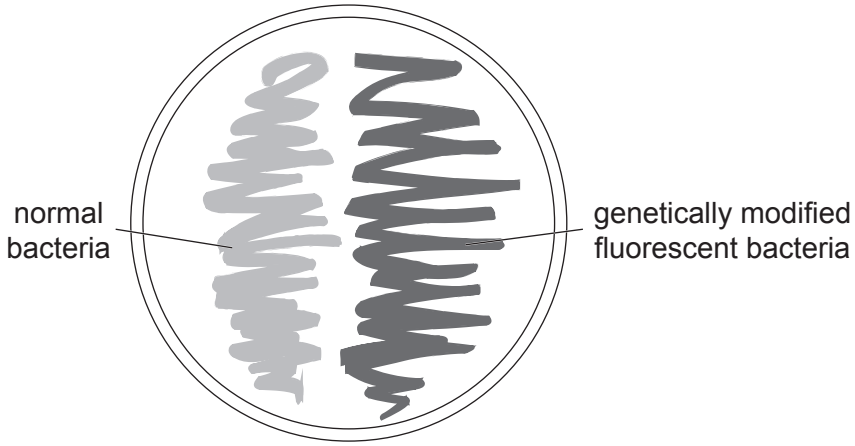


Fig. 4.2

(i) Identify the component that is taken up by normal bacteria to produce the genetically modified bacteria in Fig. 4.2 **and** state what this component contains to allow the bacteria to make green fluorescent protein.

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..... [3]

(ii) Suggest why the gene for green fluorescent protein is sometimes transferred in addition to the desired gene in genetic engineering.

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..... [1]

[Total: 15]

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5 Photosynthesis is the energy transfer process that occurs in chloroplasts.

Fig. 5.1 shows some biochemical events that occur in a chloroplast during the light-dependent stage of photosynthesis. Photosystems I and II (PSI and PSII) and some associated proteins of the thylakoid membrane are shown.

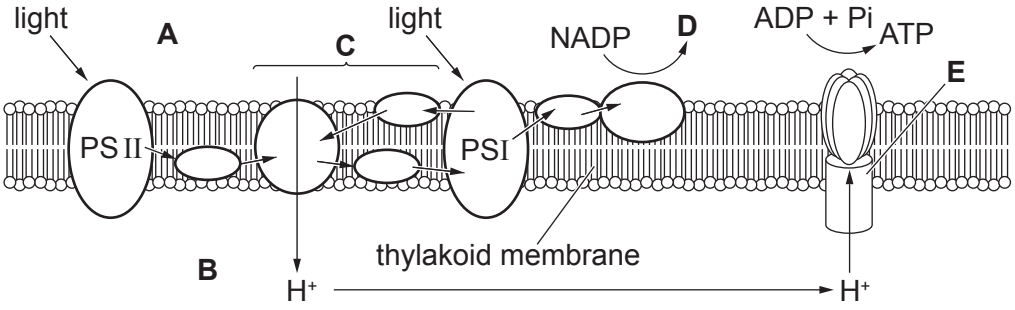


Fig. 5.1

(a) (i) **A** and **B** are areas of the chloroplast. Name areas **A** and **B**.

A .....

B .....
[2]

(ii) The group of proteins labelled **C**, PSI and the protein labelled **E** are involved in a specific biochemical process during the light-dependent stage of photosynthesis.

Name this specific biochemical process and the protein labelled **E**.

process .....

E .....
[2]

(iii) Product **D** is used during the Calvin cycle.

Identify product **D and** describe its specific role in the Calvin cycle.

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..... [3]

(b) The rate at which plants use photosynthesis to transfer light energy into chemical energy that is stored in plant biomass can be measured in megajoules per square metre per year ($MJ\,m^{-2}\,yr^{-1}$).

Fig. 5.2 compares the rates of energy transfer for different ecosystems.

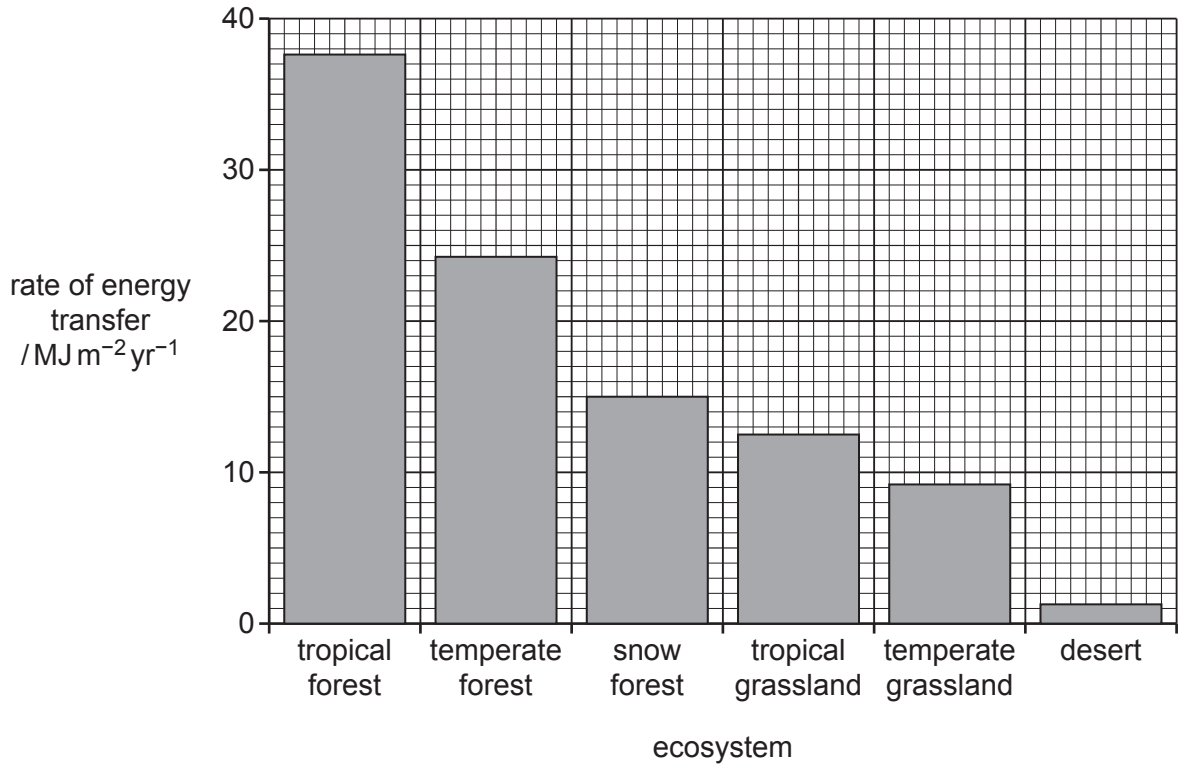


Fig. 5.2

(i) Limiting factors affect the rate of photosynthesis.

Describe **and** suggest how the results for tropical forest, temperate forest and snow forest in Fig. 5.2 show the effect of limiting factors on photosynthesis.

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..... [3]

(ii) Suggest reasons why grasslands and desert have a lower rate of energy transfer by photosynthesis than forests.

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[Total: 13]

6 Many different genes are involved in the production of pigments in mammals. One example is the *TYR* gene.

(a) In humans the *TYR* gene is located on chromosome 11.

Fig. 6.1 shows the homologous pair for chromosome 11.

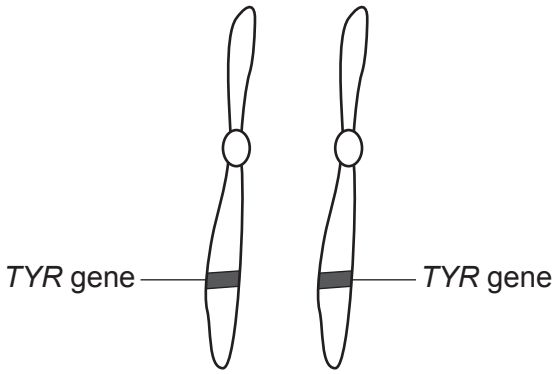


Fig. 6.1

(i) Homologous chromosomes have the same genes located at the same loci.

State one **other** feature shared by homologous chromosomes.

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..... [1]

(ii) Albinism in humans can be caused by recessive mutations of the *TYR* gene.

Explain why a person who is homozygous recessive for the *TYR* gene shows albinism.

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..... [3]

(b) Fur colour in rabbits involves a number of different genes. Some of these genes interact.

Gene 1 has two alleles, **B** and **b**.

- The dominant allele, **B**, results in black fur.
- The recessive allele, **b**, results in brown fur.

Gene 2 has two alleles, **F** and **f**.

- The dominant allele, **F**, codes for a protein that allows the expression of gene 1.
- The recessive allele, **f**, codes for a protein that does not allow the expression of gene 1, resulting in white fur.

The two genes are on different pairs of autosomes.

Complete the genetic diagram for a cross between two black rabbits that are heterozygous for both genes and show the ratio of possible offspring phenotypes.

parental phenotypes black × black

parental genotypes BbFf × BbFf

Punnett square

ratio of offspring phenotypes:

..... [4]

[Total: 8]

7 It has been hypothesised that the mutation rate of an animal species may affect how fast animals of that species age and how long they live (lifespan).

Table 7.1 compares the mutation rate and lifespan of five species of mammal.

Table 7.1

species	mutation rate per million base pairs per year	mean lifespan /years
cattle	0.08	20
ferret	0.20	8
horse	0.05	30
human	0.02	75
house mouse	0.28	3.6

(a) (i) Describe the relationship shown in Table 7.1.

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..... [1]

(ii) Use Table 7.1 to explain how these species may differ in the rate at which they can adapt if environmental selection pressures change.

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..... [3]

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(b) (i) Compare the timescales needed for selective breeding and genetic engineering to increase the frequency of a rare allele in cattle. Give a reason for your answer.

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..... [2]

(ii) Genetic engineering could be used to improve farmed animals, such as dairy cattle.

State **two** features of dairy cattle that could be improved by genetic engineering.

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..... [2]

[Total: 8]

8 Bears are several species of mammal in the family Ursidae.

Climate change and loss of habitats due to human activity have reduced the size of some bear populations in recent years.

(a) The International Union for Conservation of Nature (IUCN) has a role in the conservation of species, such as species of bear.

Outline the role of the IUCN in the conservation of species.

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..... [3]

(b) Grizzly bears, *Ursus arctos horribilis*, and polar bears, *Ursus maritimus*, are found in North America.

Fig. 8.1 shows a grizzly bear and a polar bear.



grizzly bear



polar bear

Fig. 8.1

Grizzly bears have:

- a varied diet that includes grasses, roots, berries, nuts, rodents, insects and fish
- a habitat of woodland or grassland
- a maximum mass of 270 kg.

Polar bears have:

- a diet that consists of other animals, such as seals
- a habitat of land and sea ice
- a maximum mass of 450 kg.

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Climate change has caused populations of grizzly bears to spread further north and populations of polar bears to spread further south. In some areas there is habitat overlap and, on rare occasions, breeding between grizzly bears and polar bears has occurred.

The offspring of grizzly bears and polar bears are known as pizzly bears.

Pizzly bears can breed together in the wild.

Fig. 8.2 shows a pizzly bear.



Fig. 8.2

With reference to **three** different species concepts, discuss whether grizzly bears and polar bears should be classified as separate species.

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..... [6]

(c) (i) Human activity has disturbed the habitat of many populations of spectacled bear, *Tremarctos ornatus*. The spectacled bear feeds on a variety of plant and animal species.

Scientists compared the diversity of the food eaten by two populations of spectacled bear by analysing their faeces. One population lived in an undisturbed habitat and the other population lived in a habitat that had been disturbed by road building.

The scientists analysed the faeces from 60 bears in each population. They identified the species present and the number of individuals of each species in the faeces.

The scientists calculated the diversity of species in the faeces of the two populations using Simpson's Index of Diversity.

The formula for Simpson's Index of Diversity is:

$$D = 1 - \left(\sum \left(\frac{n}{N}\right)^2\right)$$

n = number of individuals of each species present in the sample
N = total number of all individuals of all species

Table 8.1 shows the results and some of the steps for calculating the *D* value for the disturbed population.

Table 8.1

species eaten by bear	**number of individuals**	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
Gracilinanus aceramarcae	3	0.048	0.002
Oligorizomys sp.	5	0.081	0.007
Hesperomeles cuneata	4	0.065	0.004
Puya atra	28	0.452	0.204
Vaccinium floribundum	2	0.032	0.001
Pernettya prostrata	8	0.129	0.017
Gaultheria hapalotricha	12	.....	.....
total	62		.....

Calculate Simpson's Index of Diversity by completing Table 8.1 in the spaces provided.

Write the value for Simpson's Index of Diversity on the dotted line.

Simpson's Index of Diversity (*D*) = ... [3]

(ii) The scientists calculated a *D* value of 0.833 for the undisturbed population.

Explain what is shown by the difference in the *D* values between the two populations of bear.

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..... [1]

[Total: 13]

9 The harlequin ladybird, *Harmonia axyridis*, is an insect that shows discontinuous variation in colour pattern and continuous variation in body size.

(a) Within a species, the variation that is observed for a particular characteristic can be described as discontinuous or continuous.
Discontinuous variation has a different genetic basis from continuous variation.

State **two** differences between discontinuous variation and continuous variation, **other than** having a different genetic basis.

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..... [2]

(b) Fig. 9.1 shows three of the colour patterns seen in *H. axyridis* and the percentage of each in a population.

colour pattern	 *conspicua*	 *spectabilis*	 *succinea*
percentage	5	13	82

Fig. 9.1

Suggest the genetic basis of the variation in colour pattern in *H. axyridis*.

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..... [2]

(c) The body size of adult *H. axyridis* varies from 5 mm to 8 mm. Adult ladybirds do **not** grow or change size. Adults develop from larvae that hatch from eggs.

State **two** environmental factors that may affect adult body size in *H. axyridis*.

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..... [2]

[Total: 6]

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10 Humans detect the sweet taste of sucrose sugar using chemoreceptor cells in taste buds on the tongue. The red admiral butterfly, *Vanessa atalanta*, detects sucrose using chemoreceptor cells located on its antennae and on its tarsi (feet). The mode of action of the chemoreceptors in *V. atalanta* is similar to that in humans.

Fig. 10.1 shows the locations of the chemoreceptor cells on *V. atalanta.*



Fig. 10.1

Describe how the presence of sucrose causes an action potential in the sensory neurone associated with a chemoreceptor cell in *V. atalanta*.

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[Total: 6]

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BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **May/June 2024**

2 hours

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[Turn over

1 Osmoregulation is the control of the water potential of body fluids such as blood.

(a) Osmoreceptors and antidiuretic hormone (ADH) have an important role in osmoregulation.

(i) Name the location of osmoreceptors.

..... [1]

(ii) State the stimulus that is detected by osmoreceptors.

..... [1]

(iii) Name the structure that secretes ADH into the blood.

..... [1]

(b) ADH acts on the cells of the collecting duct, resulting in changes in the volume and concentration of urine.

Fig. 1.1 shows the relationship between the concentration of ADH in the blood and the rate of production of urine by the kidneys.

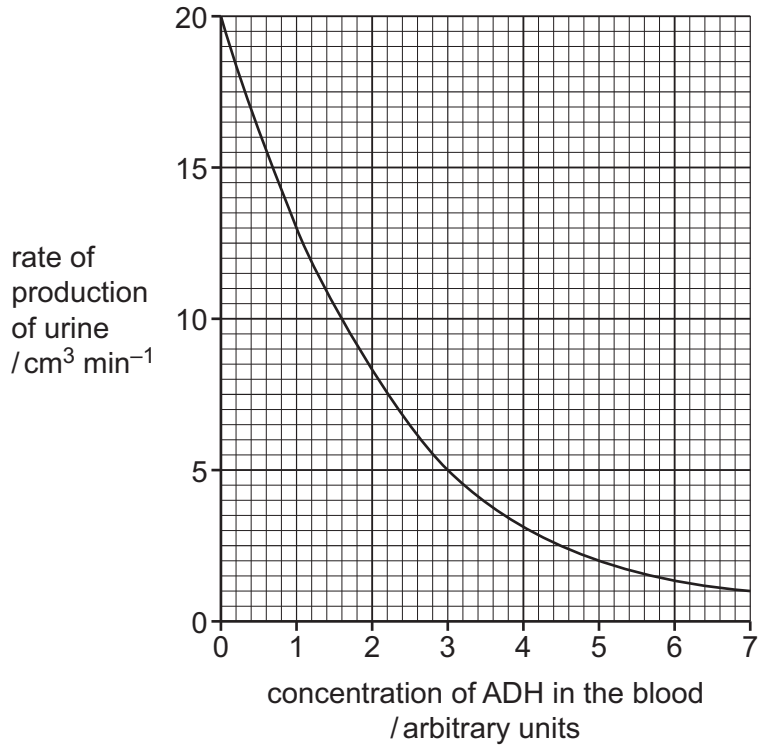


Fig. 1.1

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(i) As the concentration of ADH in the blood increases, the rate of production of urine decreases.

Using Fig. 1.1, calculate the percentage decrease in the rate of production of urine between ADH concentrations of 1 and 3 arbitrary units.

Show your working.

Give your answer to **one** decimal place.

answer = ... [2]

(ii) Explain the relationship shown in Fig. 1.1.

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[Total: 8]

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2 Variation exists in populations of a species and this may provide the opportunity for evolution to occur.

(a) Phenotypic variation exists in many forms and has a number of possible causes.

Describe the main factors that are the cause of phenotypic variation.

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(b) **(i)** Outline the theory of evolution.

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(ii) The theory of evolution is supported by DNA sequence data.

Explain how DNA sequences are used to show evolutionary relationships between species.

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[Total: 9]

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Question 3 starts on page 6.

3 The tortoise beetle, *Chelymorpha alternans*, is an insect found in Panama that has several different colour patterns. Fig. 3.1 shows a tortoise beetle.

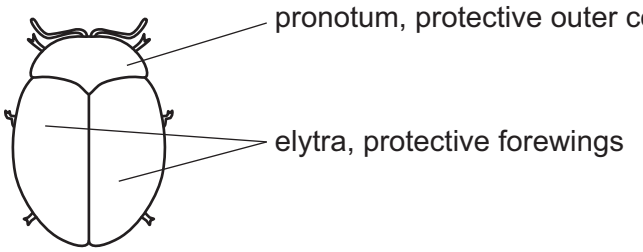
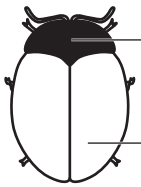
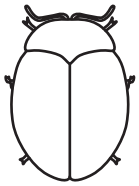


Fig. 3.1

Researchers have identified a gene, ***L***, that controls colour pattern in the pronotum and elytra. Gene ***L*** has four different alleles: $\mathbf{L^V}$, $\mathbf{L^T}$, $\mathbf{L^R}$ and $\mathbf{L^r}$.

Table 3.1 shows five different colour pattern phenotypes of tortoise beetles and their genotypes.

Table 3.1

phenotype		genotypes
rufipennis	 black; red	$\mathbf{L^R\ L^R}$ $\mathbf{L^R\ L^V}$ $\mathbf{L^R\ L^r}$
darien f. militaris-a (**dfm-a**)	 black and red striped	$\mathbf{L^T\ L^T}$ $\mathbf{L^T\ L^V}$ $\mathbf{L^T\ L^r}$
darien f. militaris-b (**dfm-b**)	 black; black and red striped	$\mathbf{L^T\ L^R}$
veraguensis	 red	$\mathbf{L^V\ L^V}$ $\mathbf{L^V\ L^r}$
metallic	 metallic and red striped	$\mathbf{L^r\ L^r}$

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(a) Explain why the inheritance of colour pattern in tortoise beetles can be described as involving multiple alleles.

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..... [1]

(b) A tortoise beetle with **dfm-b** phenotype was crossed with another tortoise beetle with **dfm-b** phenotype.

Construct a genetic diagram to show the results of this cross, including the ratio of offspring phenotypes.

parental phenotypes: **dfm-b** × **dfm-b**

parental genotypes:

gametes:

offspring genotypes:

offspring phenotypes:

ratio of offspring phenotypes:

[4]

(c) Colour pattern phenotype involves alleles that show codominance. There is also an order of dominance of alleles (dominance hierarchy).

Use the information in Table 3.1 to:

- identify the codominant alleles
- list the dominance hierarchy with alleles from the most dominant to the least dominant.

codominant alleles .....

dominance hierarchy .....

[2]

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(d) Researchers carried out two crosses.

Cross 1: female veraguensis tortoise beetles were crossed with male metallic tortoise beetles.

The results are shown in Table 3.2.

Table 3.2

number of observed offspring phenotypes				ratio of observed colour pattern phenotypes
male veraguensis	female veraguensis	male metallic	female metallic	
139	153	136	140	1.06 : 1

Cross 2: female veraguensis tortoise beetles were crossed with male veraguensis tortoise beetles.

The results are shown in Table 3.3.

Table 3.3

number of observed offspring phenotypes				ratio of observed colour pattern phenotypes
male veraguensis	female veraguensis	male metallic	female metallic	
693	592	237	213	2.9 : 1

(i) Using Table 3.1, deduce the genotypes of **each** of the parental beetles used in cross 1 and cross 2.

cross 1 .....

cross 2 .....

[2]

(ii) An assumption was made that female tortoise beetles have XX chromosomes and males have XY chromosomes. Gene ***L*** is **not** located on the X chromosome. It was concluded that colour pattern phenotype followed autosomal inheritance.

Explain how the evidence in Table 3.3 supports this conclusion.

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..... [1]

(iii) Name a statistical test that can be used to determine whether the ratio of observed phenotypes is significantly different from the expected ratio.

..... [1]

[Total: 11]

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4 Genes have a role in determining the overall phenotype of an organism.

(a) Using haemophilia as an example, explain the relationship between a gene, a protein and a phenotype.

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(b) In the pea plant, *Pisum sativum*, the genotype ***lele*** results in plants with short stems (dwarf plants).

Explain how the ***lele*** genotype and its gene product results in dwarf plants.

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(c) Dwarf plants also occur if the genes controlling growth are not activated (switched on).

Explain how DELLA proteins act as repressors preventing gene expression.

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[Total: 11]

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5 The gene *BRCA1* is expressed in breast tissue and in several other tissues of the body. *BRCA1* codes for a tumour suppressor protein. This protein is involved in either repairing damaged DNA, or in triggering the death of a cell if DNA cannot be repaired.

Some mutations in *BRCA1* are associated with an increased risk of developing breast cancer.

(a) State **one** reason why a doctor would recommend that a person has genetic testing for a mutation in the gene *BRCA1* **and** explain why this mutation would put the person at a greater risk of breast cancer.

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(b) DNA sequencing is one method used to test for mutations in *BRCA1*. Before DNA sequencing occurs, the DNA sample goes through the polymerase chain reaction (PCR).

Suggest why PCR is used for testing for mutations in *BRCA1*.

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(c) Genetic screening shows that in the UK:

- 1 in 400 females have a mutated allele of *BRCA1*
- 70% of females with a mutated allele of *BRCA1* will develop breast cancer by the time they are 80 years old.

In 2022, the population of females in the UK was 3.5×10^7.

Calculate the number of females in the UK population in 2022 who it is estimated will develop breast cancer by the age of 80 years old. Give your answer in standard form.

Show your working.

number of females = ... [2]

(d) One advantage of genetic screening is to determine which drugs should be selected to treat cancer.

A study was carried out on women with breast cancer who had been treated with a DNA-damaging drug that kills tumour cells.

The women had all been tested for *BRCA1* mutations. One group had a *BRCA1* mutation and the other group did **not** have a *BRCA1* mutation.

The researchers used data to assess the probability of survival for the women in each group of the study after treatment with the drug.

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Fig. 5.1 shows the probability of survival for a time period of up to 180 months.

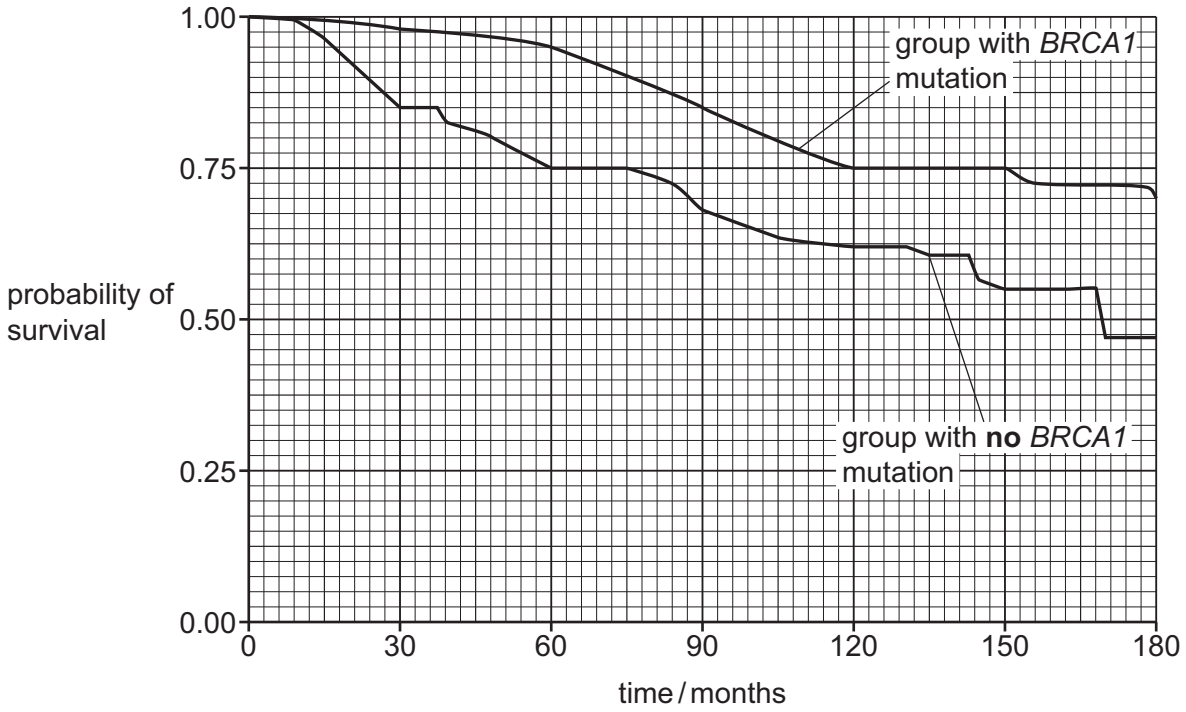


Fig. 5.1

The researchers suggested the hypothesis that the DNA-damaging drug is more effective in women with a *BRCA1* mutation.

Discuss whether the results in Fig. 5.1 support the hypothesis suggested by the researchers.

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6 **(a)** Fig. 6.1 is a diagram of part of a mitochondrion.

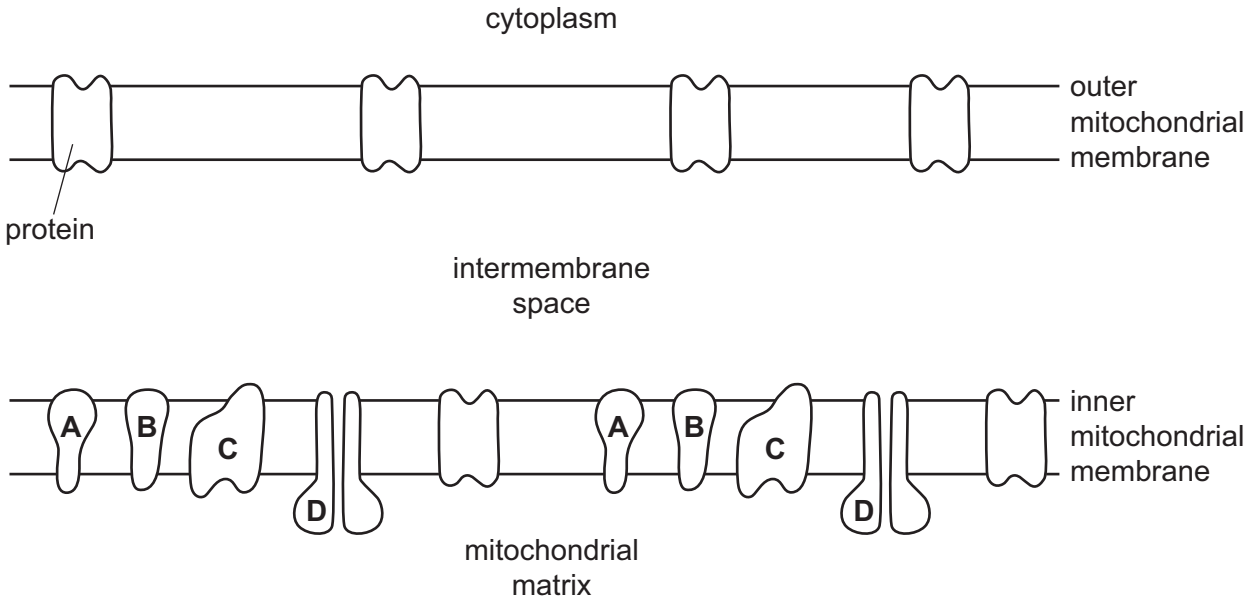


Fig. 6.1

On Fig. 6.1, use arrows to show the route taken by oxygen from the cytoplasm into the mitochondrial matrix. [1]

(b) Identify protein **D** and the group of proteins represented by **A**, **B** and **C and** describe their roles in oxidative phosphorylation.

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(c) The matrix of a mitochondrion contains small circular DNA. In the cells of humans, the mitochondria have circular DNA that contains 37 genes.

Suggest functions for these mitochondrial genes.

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[Total: 11]

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7 **(a)** A student investigated the effect of temperature on the rate of photosynthesis at two different light intensities. The rate of photosynthesis was determined by measuring the rate of oxygen production of the plant.

Fig. 7.1 shows the result of the investigation.

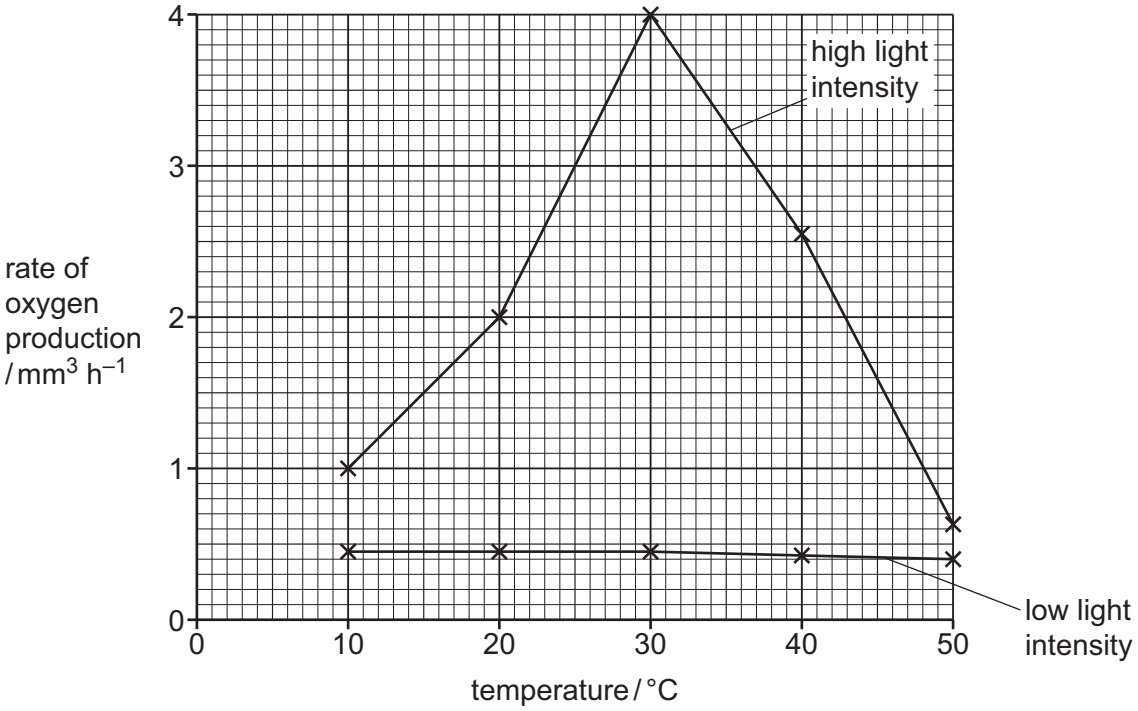


Fig. 7.1

(i) With reference to Fig. 7.1, describe **and** explain the results of the investigation for the plant in **low** light intensity.

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(ii) With reference to Fig. 7.1, describe **and** explain the results of the investigation for the plant in **high** light intensity **above** 30 °C.

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(b) Describe the process that produces oxygen during non-cyclic photophosphorylation.

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8 **(a)** Fig. 8.1 is a diagram of a sensory neurone.

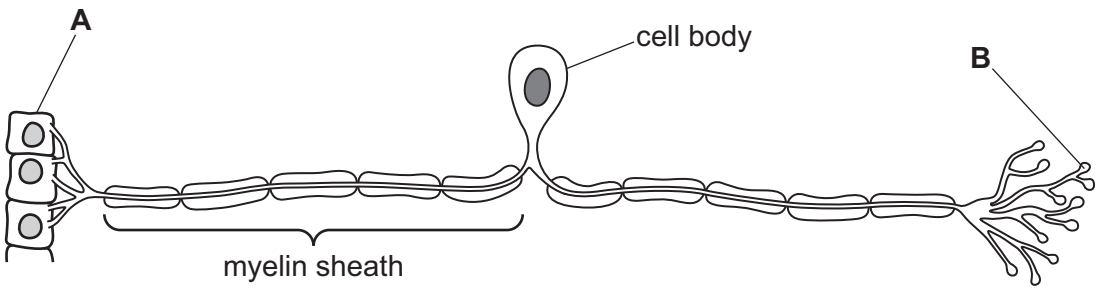


Fig. 8.1

(i) Name the type of cell represented by cell **A**.

..... [1]

(ii) Name a type of cell that forms a synapse with structure **B**.

..... [1]

(iii) Name the cells that form the myelin sheath.

..... [1]

(b) State **and** explain the differences in the transmission of impulses between myelinated and unmyelinated neurones.

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(c) Opioids are therapeutic drugs that are used to relieve pain. Morphine is an example of an opioid. It affects the functioning of synapses.

Fig. 8.2 is a diagram of a cholinergic synapse.

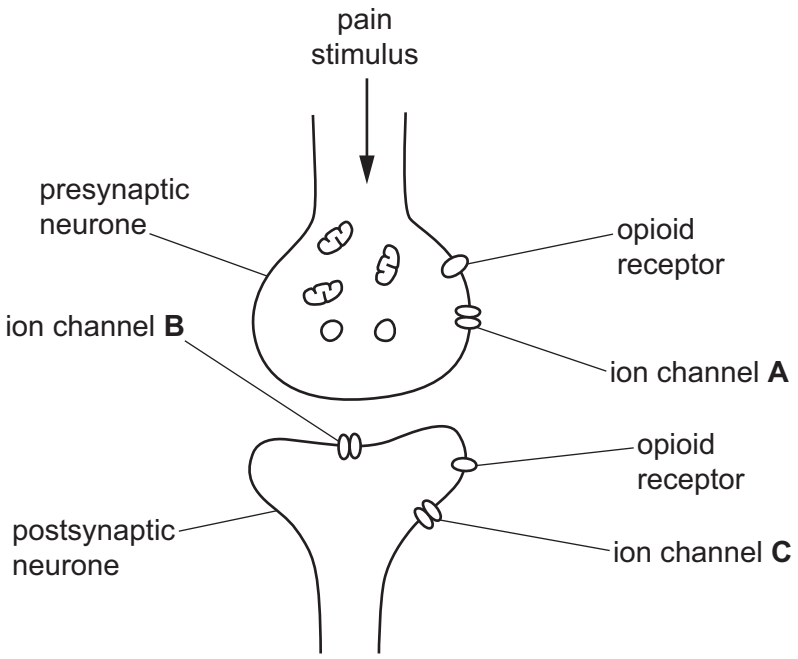


Fig. 8.2

(i) With reference to Fig. 8.2, describe the differences between ion channel **A** and ion channel **B**.

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(ii) Morphine binds to the opioid receptor in the presynaptic membrane. This stops the ion channel **A** from opening.

Suggest **and** describe the effects of the binding of morphine to this opioid receptor on the functioning of the cholinergic synapse.

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(iii) Morphine also binds to the opioid receptor in the postsynaptic membrane. This results in the opening of ion channel **C**, allowing potassium ions to diffuse out of the cell.

Suggest how this would affect the synapse.

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9 **(a)** The Asian common toad, *Duttaphrynus melanostictus*, arrived accidentally in eastern Madagascar in 2010 on a ship.

Fig. 9.1 shows an Asian common toad.



Fig. 9.1

The Asian common toad is now regarded as an invasive alien species because:

- it breeds fast in the warm, wet conditions of eastern Madagascar
- it can travel up to 2.5 km per year
- its skin contains poison, which is highly toxic to humans and predators.

Suggest ways in which the Asian common toad may affect the ecosystem of eastern Madagascar.

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..... [4]

(b) Zoos work with local groups around the world to help conserve endangered species.
One example of this is the use of assisted reproduction, such as IVF, with endangered mammals such as the eastern black rhino.

Outline the process of IVF.

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10 (a) In mammals, blood glucose concentration is maintained around a set point so that the mammal can function efficiently. This is an example of homeostasis.

Name the mechanism that maintains blood glucose concentration around a set point.

..... [1]

(b) Fig. 10.1 shows how the blood glucose concentration varies before, during and after a period of exercise.

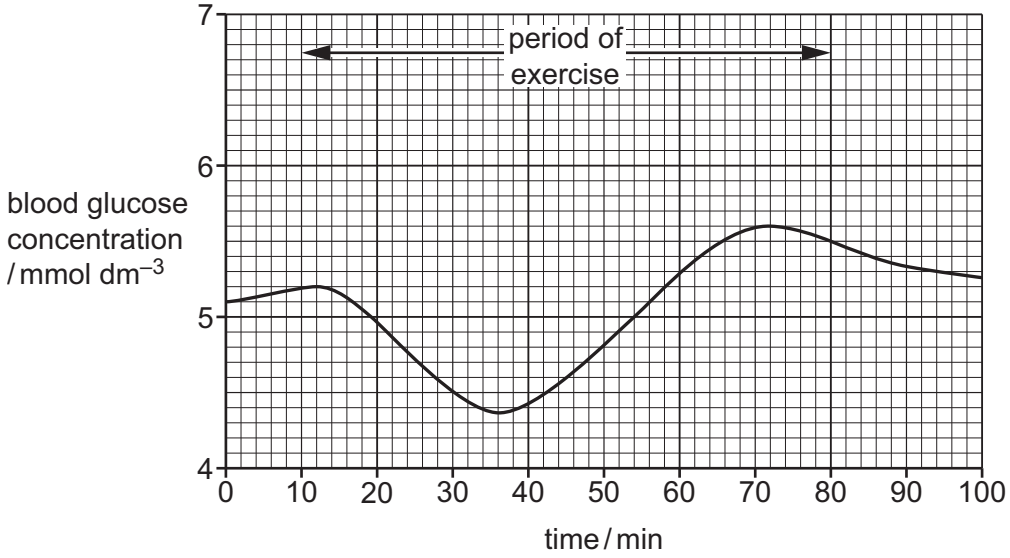


Fig. 10.1

Explain the results shown in Fig. 10.1 between 15 minutes and 70 minutes.

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(c) Type 1 diabetes in humans is a condition where the pancreas does not produce enough insulin to control blood glucose concentration.

Test strips are used to measure the concentration of glucose in a sample of urine. Two reactions take place on the test strip and a colour change occurs if glucose is present in the urine.

The equations for these reactions are:

$$\text{glucose} + \text{oxygen} \xrightarrow{\text{glucose oxidase}} \mathbf{A} + \text{hydrogen peroxide}$$

$$\text{hydrogen peroxide} + \mathbf{B} \xrightarrow{\text{peroxidase}} \text{oxidised } \mathbf{B} + \text{water}$$

(i) Identify compound **A** and the type of substrate represented by **B**.

A .....

B .....

[2]

(ii) Most people with diabetes mellitus use a biosensor to obtain their blood glucose concentration.

Suggest the advantages of using a biosensor rather than test strips.

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..... [2]

[Total: 8]

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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

7360030883

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 2024**

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 Fig. 1.1 outlines the effect of antidiuretic hormone (ADH) on the cells of the collecting duct. The cell-signalling mechanism of ADH is similar to that of glucagon on liver cells.

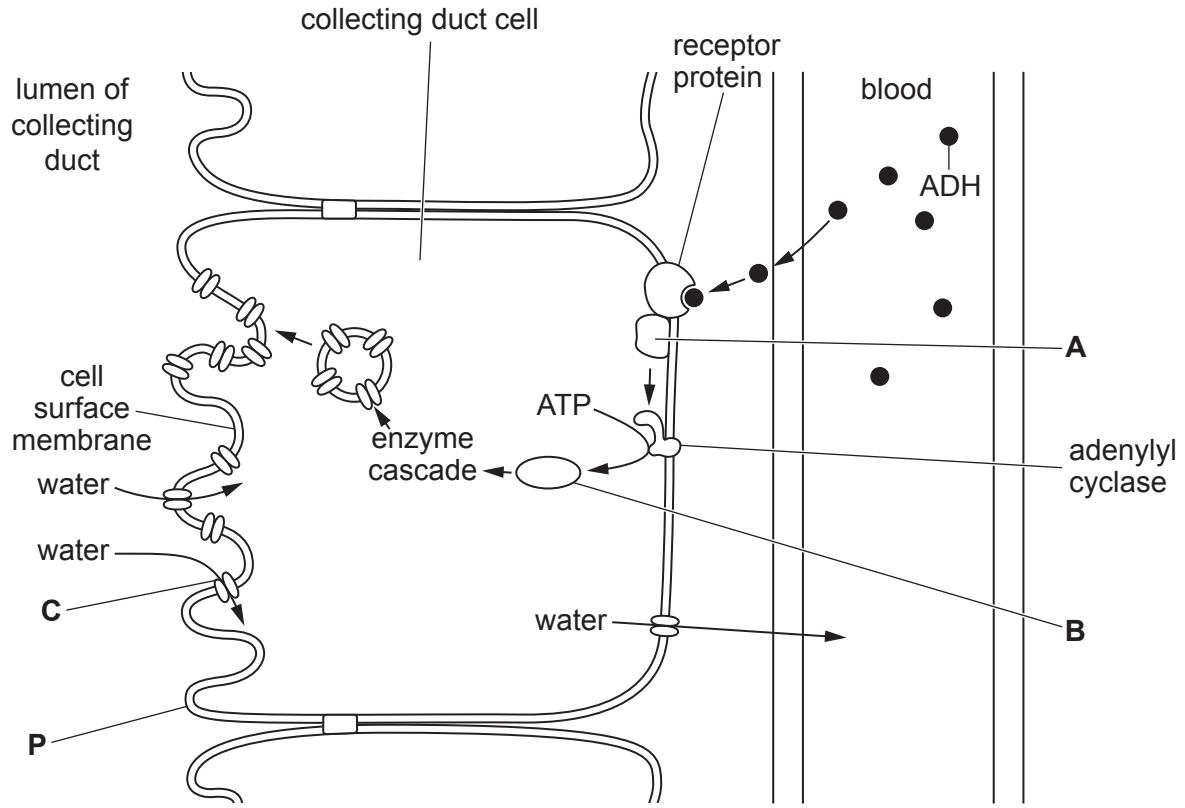


Fig. 1.1

(a) Name structures **A**, **B** and **C**.

A .....

B .....

C .....

[3]

(b) ADH is secreted by the posterior pituitary gland when the water potential of the blood decreases.

Suggest reasons why the water potential of the blood may decrease.

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(c) Diabetes insipidus is a condition affecting osmoregulation by the kidney. One form of diabetes insipidus is caused by a tumour in the pituitary gland, which results in a decreased secretion of ADH.

Suggest the symptoms that would occur in a person with diabetes insipidus.

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..... [2]

(d) Neurogenic diabetes insipidus (NDI) is another form of diabetes insipidus. In NDI, ADH molecules cannot bind to the receptor proteins located in the cell surface membranes of the cells of the collecting duct.

With reference to Fig. 1.1, explain the effect on the cell surface membrane labelled **P** if ADH cannot bind to the receptor proteins.

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..... [2]

(e) NDI is caused by a recessive allele of the gene coding for the receptor protein. The gene is located on the X chromosome.

Explain why a man with NDI could **not** have inherited the condition from his father.

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[Total: 12]

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2 Phenotypic variation exists in many forms.

(a) Some examples of phenotypic variation in plants and animals are described in Table 2.1.

Complete Table 2.1 by stating whether the cause of variation for each described example is likely to be due to:

- genetic factors, V_G
- environmental factors, V_E
- a combination of genetic and environmental factors, $V_G + V_E$.

Table 2.1

description of phenotypic variation	cause of variation
Tomato plants grown in a glasshouse and grown outside vary in the yield of tomatoes they produce. Seventeen genes associated with tomato yield have been identified.	
New strawberry plants from the variety called Sweet Ann are made by asexual reproduction. The new plants grow to different sizes and produce different numbers of fruit.	
The domestic cat has a blood group system with three possible blood types: A, B and AB. The blood types are determined by antigens present on the cell surface membrane of red blood cells.	
Over 50 genes have variants that are associated with excessive weight gain in humans. Other risk factors for excessive weight gain include diet and exercise.	
Resting heart rate in humans varies between different individuals. Some factors that influence resting heart rate include: biological sex, family history of heart disease, number of cigarettes smoked, medication taken.	

[3]

(b) Name a spontaneous, random event occurring in cells that can be a source of phenotypic variation.

..... [1]

(c) Other than the event named in **(b)**, describe the features of sexual reproduction that contribute to the production of genetically different offspring.

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[Total: 7]

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[Turn over

3 In plants and humans, the phenotype of an organism is determined by the genotype and the environment.

(a) Plants from the genus *Primula* have different petal colours. The presence of the pigment malvidin results in blue petals.

The metabolic pathway for malvidin synthesis is controlled by gene ***T***/***t***. The presence of the dominant allele **T** results in blue petals.

Another gene, gene ***D***/***d***, at a different locus, also influences the malvidin synthesis pathway. When the dominant allele **D** is present, its gene product suppresses the malvidin synthesis pathway. This is summarised in Fig. 3.1.

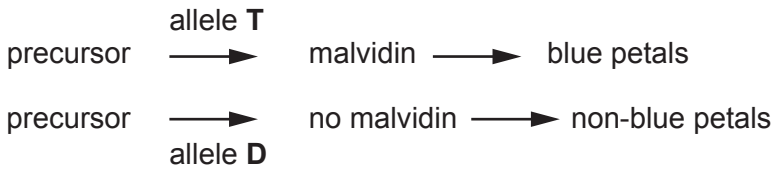


Fig. 3.1

A genetic cross was carried out between two plants heterozygous at both gene loci. The resulting offspring genotypes are shown in a Punnett square in Fig. 3.2.

	TD	**Td**	**tD**	**td**
TD	TTDD	TTDd	TtDD	TtDd
Td	TTDd	TTdd	TtDd	Ttdd
tD	TtDD	TtDd	ttDD	ttDd
td	TtDd	Ttdd	ttDd	ttdd

Fig. 3.2

(i) State which of the genotypes shown in Fig. 3.2 have blue petals.

.....

..... [1]

(ii) State the ratio of non-blue to blue petals for the cross shown in Fig. 3.2.

..... [1]

(iii) Name the type of gene interaction that has caused the offspring ratio you have stated in **(a)(ii)**.

..... [1]

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(iv) Gene ***T***/***t*** and gene ***D***/***d*** code for proteins that are involved in the control of the production of malvidin.

Discuss the possible roles of the proteins coded for by gene ***T***/***t*** and gene ***D***/***d*** in the control of the production of malvidin.

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..... [5]

(b) Some humans have the inherited condition haemophilia.

Explain the relationship between the ***F8*** gene, factor VIII and the condition haemophilia.

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[Total: 12]

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4 Genetic engineering is a technique used to modify the genetic material of a specific organism to change a characteristic.

(a) (i) Genetic engineering uses specific enzymes and commonly involves the use of plasmids for the transfer of genes into an organism.

Four enzymes that are used in genetic engineering techniques involving plasmids are:

- restriction endonuclease
- DNA ligase
- DNA polymerase
- reverse transcriptase.

Outline the role of these enzymes in genetic engineering involving plasmids.

restriction endonuclease .....

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DNA ligase .....

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DNA polymerase .....

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reverse transcriptase .....

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[4]

(ii) Explain why a promoter, as well as the desired gene, is often transferred into an organism.

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..... [3]

(b) The production of insulin by genetic engineering involves the use of plasmids and the bacterium *Escherichia coli*.

Multiple copies of a gene that codes for an insulin polypeptide are mixed with cut plasmids.

During the process, only some of the plasmids that are taken up by host bacteria will lead to the expression of insulin polypeptides.

Fig. 4.1 shows:

- a cut plasmid and the gene coding for the insulin polypeptide
- three different plasmids that have been formed as part of the genetic engineering process.

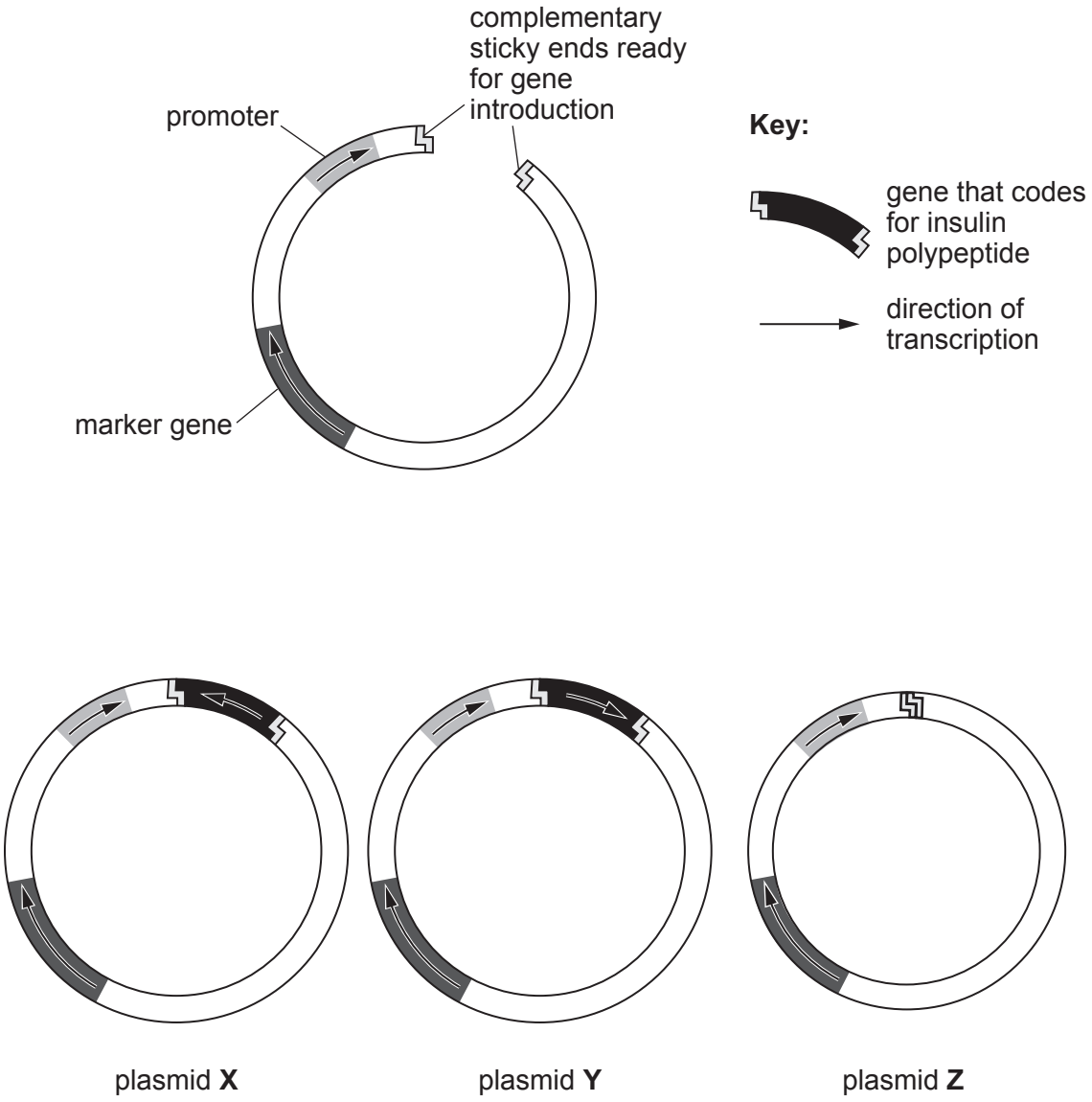


Fig. 4.1

Comment on whether a bacterium will produce the insulin polypeptide if it has either plasmid **X** or plasmid **Y** or plasmid **Z and** explain the reason for your choice.

plasmid **X** .....

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plasmid **Y** .....

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plasmid **Z** .....

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[3]

[Total: 10]

5 *BRCA2* is a tumour-suppressor gene. Its gene product, BRCA2, is involved in DNA repair. If the DNA cannot be repaired, BRCA2 has a role in causing the cell to die. BRCA2 is found in cells of breast tissue.

When a mutation occurs in *BRCA2*, damaged DNA may not be repaired and this increases the risk of breast cancer.

When a double-stranded piece of DNA breaks, BRCA2 binds to the damaged DNA directly and interacts with the enzyme RAD51 to repair the damage.

Repairing DNA prevents other mutations and gene rearrangements from occurring which could otherwise lead to breast cancer.

(a) Double-stranded DNA breaks occur naturally during meiosis.

State the event that is initiated as a result of double-stranded breaks during meiosis.

..... [1]

(b) Scientists have identified hundreds of mutations in *BRCA2*, but not all of these mutations will increase the risk of cancer. One specific mutation in *BRCA2*, known as 999del5, is found in 0.6% of the general global population.

Iceland is an island country in the North Atlantic Ocean. The ancestors of most of the current population are people who arrived to settle in Iceland in AD 874.

In the Icelandic population, mutation 999del5 is the cause of 7–8% of breast cancer cases in women and 40% of breast cancer cases in men. This is much higher than the percentage of breast cancer cases in the general global population.

(i) Suggest **and** explain how mutation 999del5 accounts for a very high percentage of breast cancer cases in Iceland compared with the general global population.

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(ii) One of the largest global genetic screening programmes for breast cancer involves identifying people with mutations in *BRCA2*.

Outline the advantages of genetic screening for mutations in *BRCA2*.

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..... [3]

(iii) Suggest **one** advantage to a country of a genetic screening programme for breast cancer that screens for specific mutations in *BRCA2* in the population.

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..... [1]

(c) *Lipocalin 2* (*Lcn2*) is a cancer-promoting gene (oncogene). When *Lcn2* is expressed, it can result in breast cancer.

Research is being carried out to see if gene editing of *Lcn2* could be used to treat breast cancer.

Gene editing was used to treat human cancer cells that had been implanted into mice to form a tumour. The treatment stopped *Lcn2* from being expressed in the cancer cells and resulted in a significant reduction in the growth of the tumour. There was no negative effect in normal tissues.

(i) Suggest how DNA editing stopped *Lcn2* from being expressed in cancer cells.

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(ii) Suggest why the expression of **only** *Lcn2* was affected.

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..... [1]

[Total: 11]

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6 **(a)** In plants, stomata open and close in response to changes in environmental conditions.

Explain why stomata need to open and close according to environmental conditions.

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..... [3]

(b) Describe the mechanism occurring in guard cells that leads to the opening of a stoma.

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[Total: 9]

7 **(a)** Experiments were carried out to determine the effect of light intensity on the rate of photosynthesis of a species of the unicellular protoctist, *Chlorella*. A cell suspension of *Chlorella* was used.

Carbon dioxide uptake was used as a measure of the rate of photosynthesis.

- The suspension of *Chlorella* was illuminated at a light intensity of 3 lux for 20 seconds.
- The carbon dioxide uptake by *Chlorella* was measured at the end of the 20 second period of illumination.
- The experiment was repeated at 6 lux, 9 lux, 12 lux and in a dark room.
- The suspension was maintained at a temperature of 20 °C.

Table 7.1 shows the results of the experiments.

Table 7.1

light intensity / lux	**total CO_2 uptake after 20 seconds / μmol**	**rate of photosynthesis / μmol s^{-1}**
0	0	0.0
3	20	1.0
6	44	.....
9	72	3.6
12	80	4.0

(i) Use Table 7.1 to calculate the rate of photosynthesis at a light intensity of 6 lux.

Complete Table 7.1 by writing your calculated value in the space provided. [1]

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(ii) Plot a graph of the data in Table 7.1 on the grid in Fig. 7.1 to show the effect of light intensity on the rate of photosynthesis.

Draw a curve **and** extend your curve to show what would happen to the rate of photosynthesis if the experiment is carried out at 18 lux.

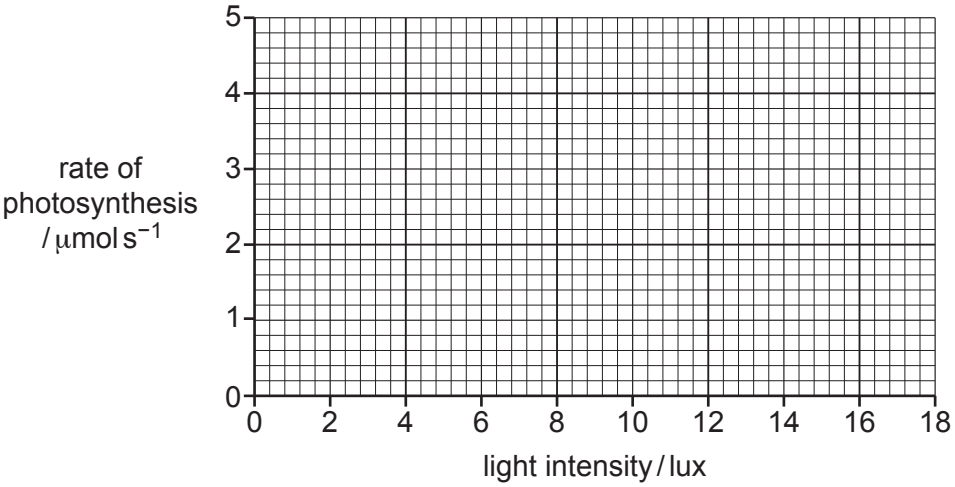


Fig. 7.1

[3]

(iii) Suggest an explanation for the shape of your curve from 12 lux to 18 lux.

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..... [2]

(b) In photophosphorylation, photoactivation of chlorophyll results in the synthesis of ATP.

Describe how photoactivation of chlorophyll results in the synthesis of ATP in photophosphorylation.

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..... [4]

[Total: 10]

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8 **(a)** Fig. 8.1 is a diagram of a mitochondrion.

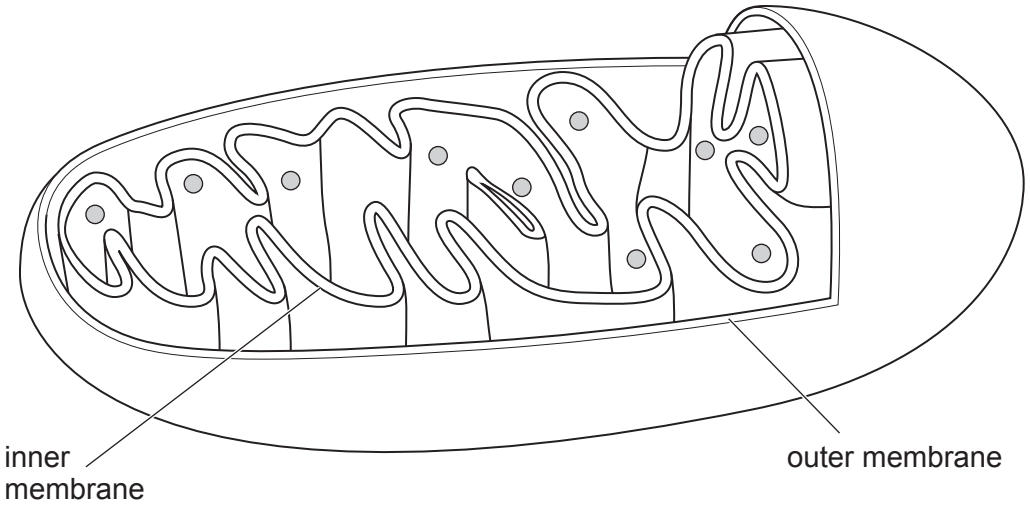


Fig. 8.1

Outline the roles played by the mitochondrial membranes in respiration.

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..... [4]

(b) The shapes and numbers of mitochondria are continually changing due to fission. Fission occurs when one mitochondrion splits to form two mitochondria.

(i) Suggest reasons why mitochondria carry out fission.

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..... [2]

(ii) Guanosine triphosphate (GTP) is a molecule that is used as a source of energy in some reactions, instead of ATP. Guanosine is composed of a purine, similar to adenine, and ribose.

Suggest why GTP can be a suitable source of energy in some reactions.

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..... [1]

(c) Old or damaged mitochondria reduce the ability of a cell to carry out aerobic respiration and produce the ATP needed for the metabolic processes of the cell.

Suggest what occurs to these mitochondria to allow the cell to maintain the same overall rate of respiration and ATP production.

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..... [2]

[Total: 9]

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9 **(a)** Fig. 9.1 shows how the mean global atmospheric carbon dioxide concentration has changed over the 800 000 (800×10^3) years leading up to the year 2020.

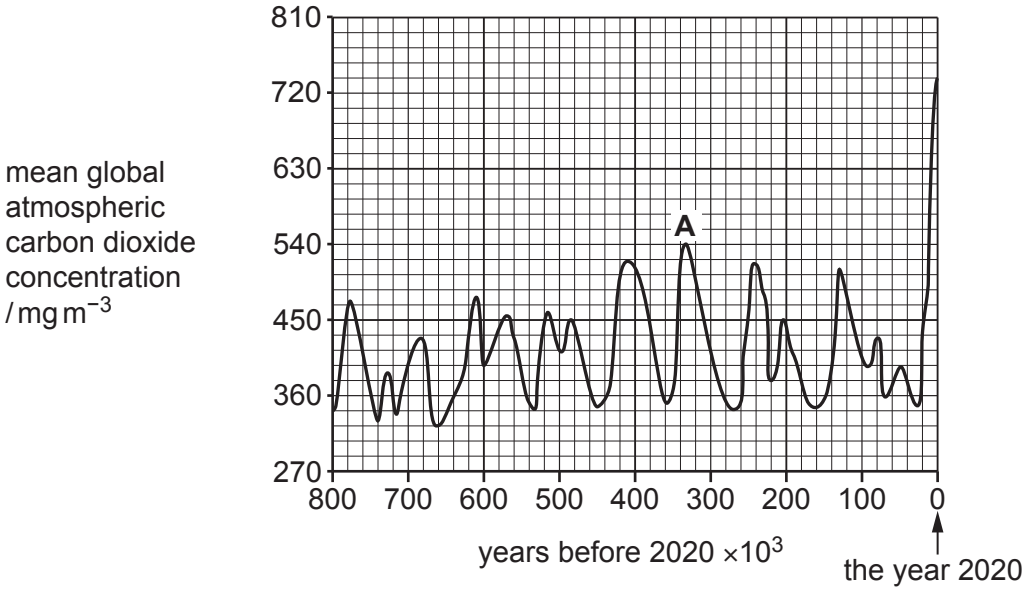


Fig. 9.1

(i) Calculate the percentage increase in carbon dioxide concentration between point **A** and the year 2020.

Show your working. Write your answer to one decimal place.

percentage increase = ...% [2]

(ii) Suggest how the changes in carbon dioxide concentration between **A** and the year 2020 may have affected the environment and biodiversity.

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(b) Outline reasons for maintaining **plant** biodiversity.

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[Total: 10]

10 **(a)** Fig. 10.1 is a diagram of part of a neurone membrane while the resting potential is maintained.

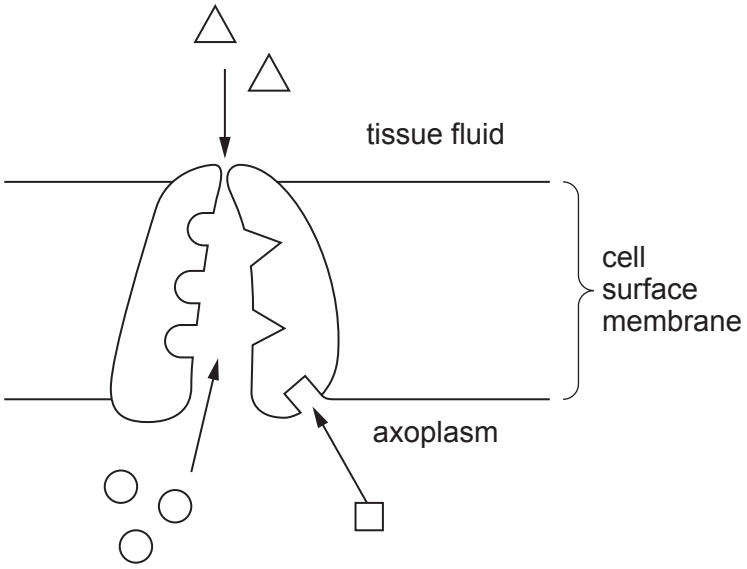


Fig. 10.1

On Fig. 10.1, use label lines and letters to label:

K – potassium ions

A – ATP.

[2]

(b) Describe the sequence of events that occur during an action potential.

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..... [4]

(c) Table 10.1 shows the axon diameter, myelination and transmission speed of impulses of motor neurones for three animals: squid, cockroach and cat.

Table 10.1

animal	axon diameter / mm	myelination	transmission speed / $m s^{-1}$
squid	1.5	no	30
cockroach	0.05	no	10
cat	0.02	yes	100

Describe **and** suggest explanations for the results shown in Table 10.1.

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..... [4]

[Total: 10]

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