Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

1285409528

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **October/November 2025**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **20** pages. Any blank pages are indicated.

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1 Guinea pigs, *Cavia porcellus*, vary in the length and colour of their fur.

Fig. 1.1 shows a guinea pig with short black fur.



Fig. 1.1

Two genes that determine the length and colour of the fur occur at the **A**/**a** locus and the **B**/**b** locus. These two gene loci are on separate autosomal chromosomes.

- The allele **A** results in short fur.
- The allele **a** results in long fur.
- **A** is dominant to **a**.

- The allele **B** results in black fur.
- The allele **b** results in chocolate fur.
- **B** is dominant to **b**.

(a) (i) List **all** the possible genotypes of a guinea pig with short black fur.

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..... [2]

(ii) A test cross could be used to determine the genotype of a female guinea pig with short black fur.

Describe the **phenotype** of the male guinea pig that could be used to carry out this test cross.

..... [1]

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(b) A black guinea pig with long fur that was homozygous at both loci was crossed with a chocolate guinea pig with short fur that was homozygous at both loci. The F1 offspring of this cross had short black fur. F1 offspring were mated together to produce the F2 offspring.

Complete the Punnett square to:
- show the cross between the F1 offspring
- predict the F2 offspring genotypes.

You should include the gametes in your answer.

State the ratio of F2 offspring phenotypes. You should include a key to link phenotypes to genotypes.

ratio of F2 offspring phenotypes:

[4]

(c) Some genes in guinea pigs are structural genes and some are regulatory genes.

Describe the difference between a structural gene and a regulatory gene.

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[Total: 9]

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2 *Exserohilum turcicum* is a fungal pathogen. The growth of the mycelium of the fungus damages the leaves of maize plants, *Zea mays*. Leaf damage reduces crop yield.

(a) (i) Complete Table 2.1 to show **one** structural difference and **one** functional difference between *E. turcicum* and *Z. mays*.

Table 2.1

	E. turcicum	***Z. mays***
structural difference		
functional difference		

[2]

(ii) Describe the principles by which organisms such as *E. turcicum* and *Z. mays* are classified in the taxonomic hierarchy.

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(b) Two inbred varieties of maize, SKV50 and CML153, were crossed. The resulting F1 hybrids were self-crossed to produce F2 offspring. The F2 plants were grown, and the percentage area of leaf damage caused by *E. turcicum* was measured.

Fig. 2.1 shows the results for the F2 generation. The arrows show the mean percentage area of leaf damage for the two parent varieties.

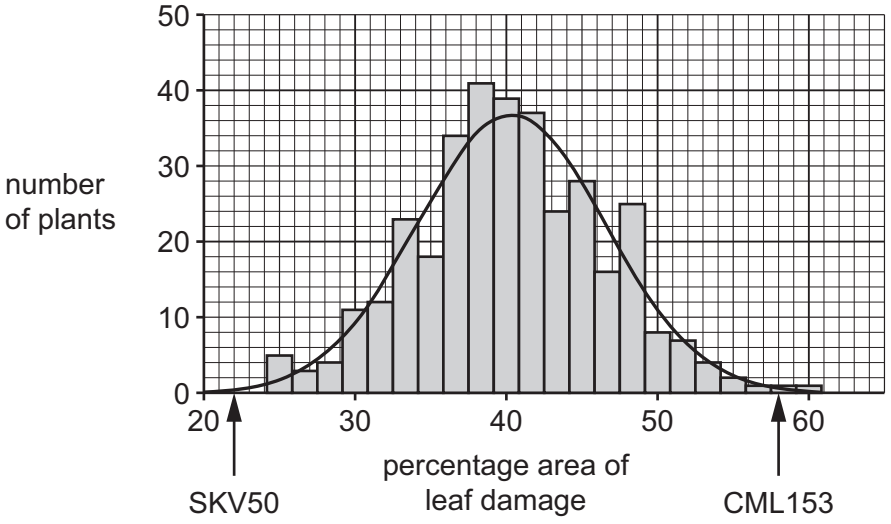


Fig. 2.1

(i) Explain how Fig. 2.1 can be used to determine which parent maize variety shows the greatest resistance to infection by *E. turcicum*.

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..... [2]

(ii) State the name of the type of variation shown by the maize F2 generation in Fig. 2.1.

..... [1]

(iii) Explain the **genetic** basis of the type of variation shown by the maize F2 generation.

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[Total: 13]

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3 Plants have several different photosynthetic pigments in their chloroplasts.

(a) A student separated and identified the chloroplast pigments present in a leaf extract from a spinach plant using two slightly different methods.

Method **A**

- A type of chromatography known as thin layer chromatography (TLC) was used to separate the pigments.
- A mixture of ether and cyclohexane was used as a solvent in TLC.

Method **B**

- The student repeated TLC but treated the spinach leaf extract with a chemical. The chemical causes a magnesium ion in a pigment to be replaced by two hydrogen ions.
- The student used a leaf from the same spinach plant, and used the same solvent as in method **A**.

The student calculated R_f values and compared these to reference values to identify the pigments.

Fig. 3.1 shows the results for method **A** and method **B**.

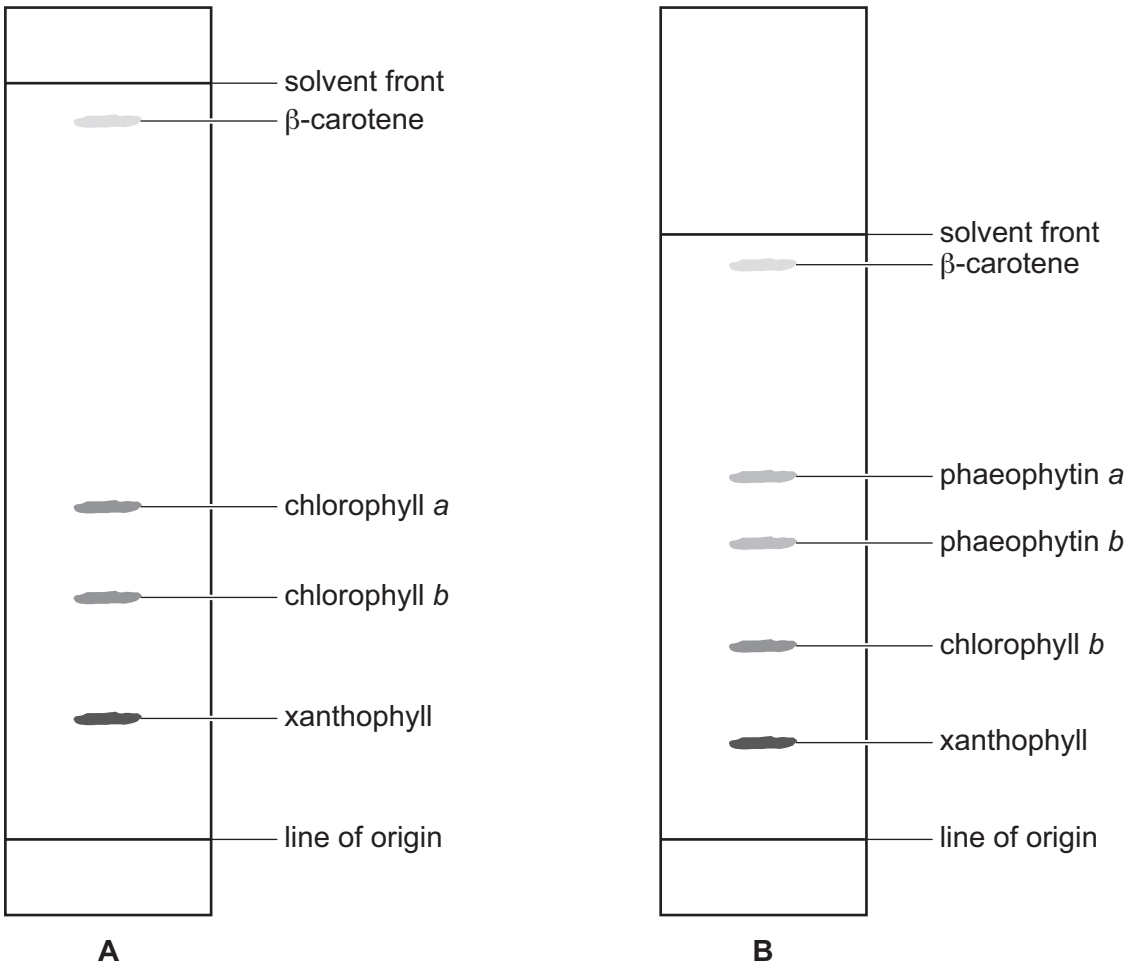


Fig. 3.1

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(i) Calculate the R_f value of β-carotene in Fig. 3.1.

R_f = ...
[2]

(ii) Suggest **two** explanations for the differences in appearance of chromatograms **A** and **B** in Fig. 3.1.

1 .....

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2 .....

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[2]

(iii) The student found some different R_f values for the chloroplast pigments of spinach in a scientific paper.

The values in the scientific paper were different from the reference values that the student originally used to identify the pigments on chromatograms **A** and **B** in Fig. 3.1.

Suggest **one** reason, other than measurement error, for the different R_f values.

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(b) Fig. 3.2 shows the absorption spectra of some chloroplast pigments.

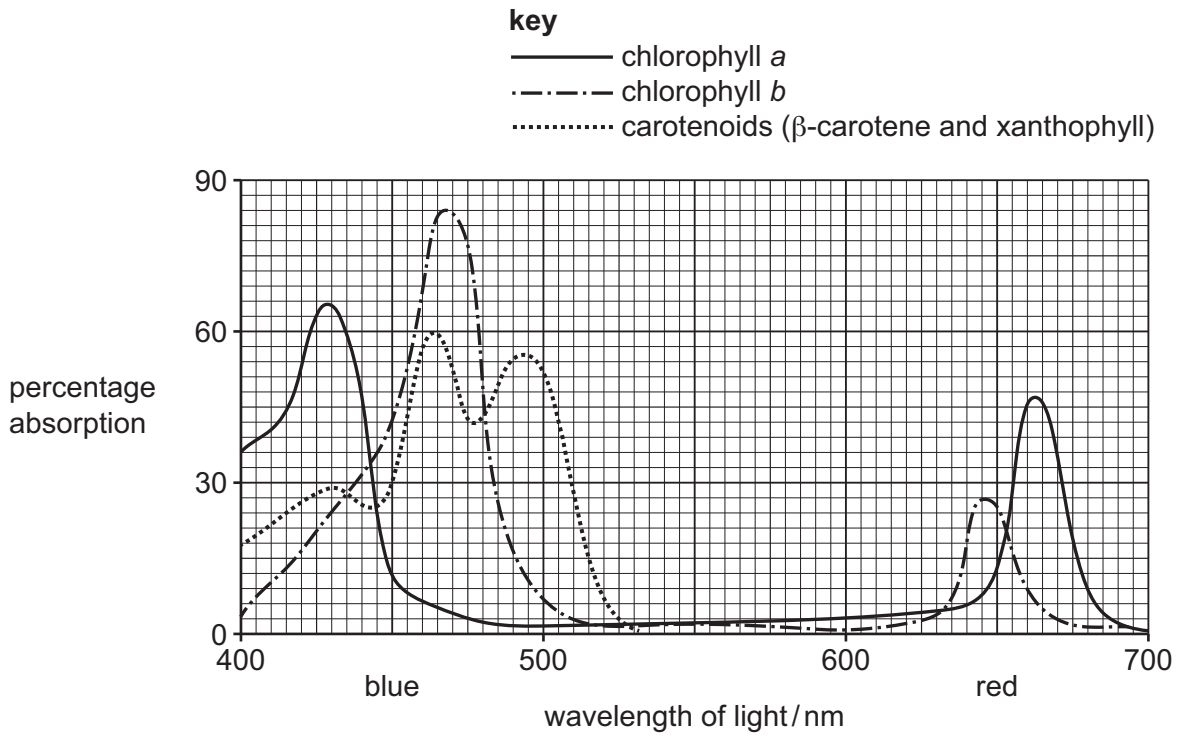


Fig. 3.2

Use Fig. 3.2 to compare the similarities and differences between the absorption spectra of chlorophyll *a* and carotenoids.

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(c) In some species of plant, the absorption of light stimulates seed germination.

The absorption of light increases the production of gibberellin in the embryo of a seed.

Describe the role of gibberellin in the germination of a seed.

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4 The wolf, *Canis lupus*, lives in North America. Wolves may have a grey or a black coat colour. The colour of an individual wolf depends on the DNA it inherits at the *CPD103* gene locus.

- Wolves inherit two copies of *CPD103*, one from each parent.
- Wolves that inherit one copy of the black form of the *CPD103* gene have a black coat.

(a) State the term used to describe:

- an organism that has two copies of each gene .....
- a form of a gene .....
- a form of a gene that gives a phenotypic effect in a heterozygote. .....

[3]

In addition to producing black coat colour, the protein coded for by the *CPD103* gene also defends against infectious lung disease.

Canine distemper virus (CDV) causes serious lung disease in wolves. Wolves that have been previously infected by CDV have antibodies against CDV (anti-CDV antibodies) in their blood.

(b) CDV can be passed from domestic dogs to wolves.

- Domestic dogs are more numerous in the southern part of the area occupied by wolves.
- Domestic dogs are less numerous in the northern part of the area occupied by wolves.
- The relative frequency of black wolves compared to grey wolves increases from the north to the south of the area they occupy.

Explain how natural selection causes this trend in the distribution of black wolves.

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(c) Several different populations of wolves were compared.

Fig. 4.1 shows the relationship between the percentage of wolves in a population that have anti-CDV antibodies in their blood and the percentage of wolves in that population that are black. The line of best fit was calculated after comparing the different populations of wolves.

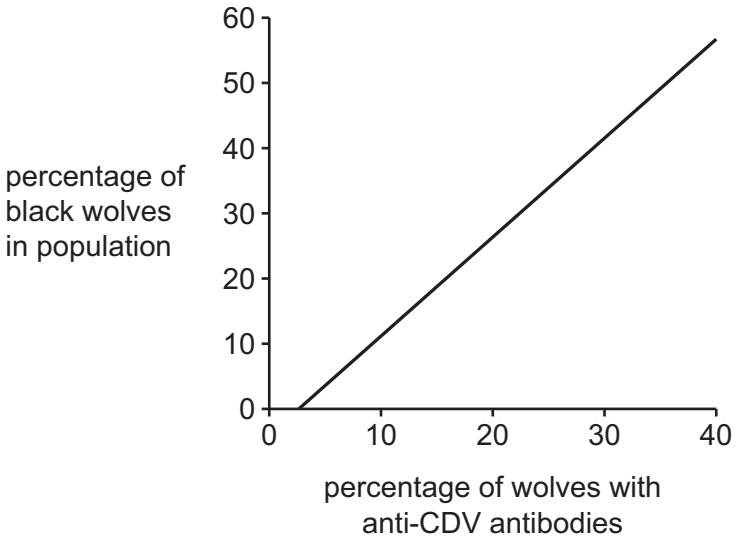


Fig. 4.1

With reference to Fig. 4.1, state the relationship between the percentage of wolves with anti-CDV antibodies and wolf coat colour, **and** suggest reasons for this relationship.

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5 The endocrine system and the nervous system both coordinate responses in mammals.

(a) Complete Table 5.1 to show the features of three cell-signalling molecules of the endocrine system: antidiuretic hormone (ADH), glucagon and insulin.

Use a tick (✓) if the molecule has the feature and a cross (✗) if the molecule does **not** have the feature.

Put a tick (✓) or a cross (✗) in every box.

Table 5.1

feature	ADH	glucagon	insulin
binds to receptors on cell surface membranes			
results in molecules moving from cells into the blood			
is secreted as a result of detection by osmoreceptors			

[3]

(b) The endocrine system has a slower transmission speed than the nervous system.

Describe **other** ways in which the endocrine system and the nervous system differ.

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(c) The endocrine system and the nervous system can affect muscle function.

Fig. 5.1 shows a transmission electron micrograph of a longitudinal section of striated muscle tissue that is in a relaxed state.

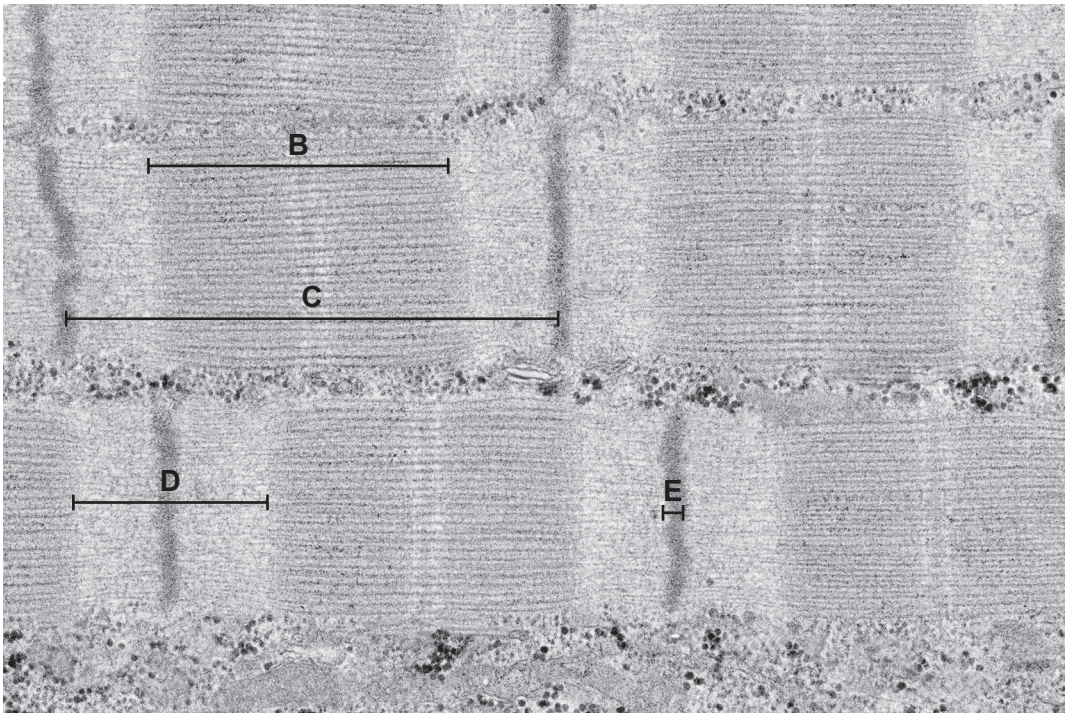


Fig. 5.1

(i) State the letter on Fig. 5.1 that indicates the length of a sarcomere.

..... [1]

(ii) State the letter on Fig. 5.1 that indicates a region where actin and myosin overlap.

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(iii) Describe **and** explain how the region labelled **D** on Fig. 5.1 changes during muscle contraction.

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[Total: 13]

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6 The distribution of the large blue butterfly, *Phengaris arion*, extends across Europe and Asia. It is assessed by the International Union for Conservation of Nature (IUCN) on the Red List™ as 'Near Threatened' globally and 'Endangered' in Europe.

In Europe, *P. arion* became extinct in the Netherlands in 1964 and in the United Kingdom in 1979.

Fig. 6.1 lists the conservation status categories in the IUCN Red List™.

conservation status	
Extinct (EX)	↑
Extinct in the Wild (EW)	↑
Critically Endangered (CR)	↑
Endangered (EN)	**increasing risk of extinction**
Vulnerable (VU)	↑
Near Threatened (NT)	↑
Least Concern (LC)	↑

Fig. 6.1

Fig. 6.2 shows *P. arion*.



Fig. 6.2

(a) (i) Explain how IUCN Red List™ assessments help to conserve biodiversity.

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(ii) With reference to Fig. 6.1 and the IUCN assessments for *P. arion*, suggest how the abundance of the butterfly differs across its distribution.

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(b) *P. arion* has been successfully re-introduced in the United Kingdom at 12 sites. These sites were restored to flower-rich grassland.

The conservation management actions designed for *P. arion* also resulted in the re-establishment or increase of other species at the restored sites. These included 12 species of flowering plant, 8 other butterfly species and 4 species of other insects.

(i) Use the information given to suggest why *P. arion* went extinct in the United Kingdom in 1979.

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(ii) Outline the advantages of restoring habitats for endangered species.

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[Total: 11]

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7 In aerobic respiration, most ATP is produced by oxidative phosphorylation.

(a) Outline the features of ATP that make it suitable as the universal energy currency.

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..... [3]

(b) Rotenone is a compound that affects oxidative phosphorylation.

Rotenone disrupts the first carrier in the electron transport chain by stopping the transfer of electrons from this carrier.

Suggest **and** explain how rotenone reduces the production of ATP **and** water in aerobic respiration.

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8 LibertyLink® soybean is a genetically modified crop. It was first grown in 1996 and used in food products from 1998. It has been grown in 6 countries and used in food products in 21 countries.

Table 8.1 summarises the modifications made to the soybean plant to produce LibertyLink® soybean.

Table 8.1

name of introduced gene	gene donor organism	gene product	function of gene product
pat	*Streptomyces viridochromogenes*	phosphinothricin *N*-acetyltransferase	stops action of glufosinate, a herbicide

(a) Explain how the modification made to produce LibertyLink® soybean may help to solve the global demand for food.

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(b) **(i)** Name the type of enzyme that could be used to cut out the *pat* gene from *S. viridochromogenes*.

..... [1]

(ii) Name the enzyme that could be used to join the *pat* gene to a plasmid by forming phosphodiester bonds.

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(c) Suggest reasons why LibertyLink® soybean is used in food products in 21 countries but only grown in 6 countries.

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[Total: 9]

9 **(a)** Fig. 9.1 shows a longitudinal section of a human kidney.

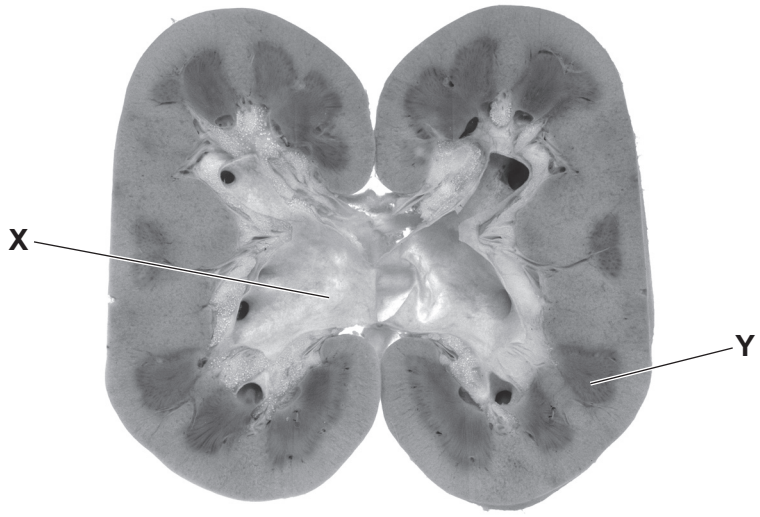


Fig. 9.1

Name the regions of the kidney labelled **X** and **Y** in Fig. 9.1.

X .....

Y .....

[2]

(b) A biosensor can be used to measure the concentration of glucose in urine.

Outline how a biosensor measures the concentration of glucose in urine.

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[Total: 6]

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10 Explain the relationship between genes, proteins and phenotype, with reference to **two** examples of genetic diseases in humans.

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7252330661

BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **October/November 2025**

2 hours

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1 Rice, *Oryza sativa*, is a crop plant that has adapted to grow in flooded fields.

Fig. 1.1 outlines the effects on rice plants of growing in flooded fields.

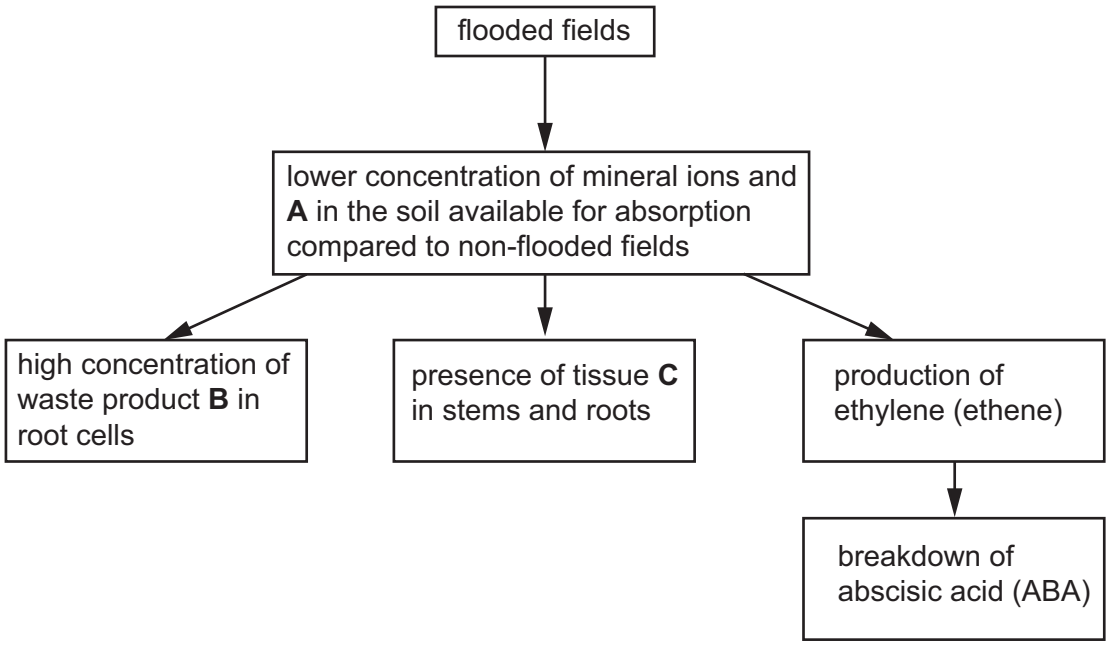


Fig. 1.1

(a) With reference to Fig. 1.1, name:

substance **A** .....

substance **B** .....

tissue **C** .....

[3]

(b) Describe how root cells respond to a high concentration of substance **B**.

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(c) Gibberellin is involved in the growth of stems in rice plants.

Fig. 1.2 shows the effect of gibberellin concentration on the length of stems in rice plants.

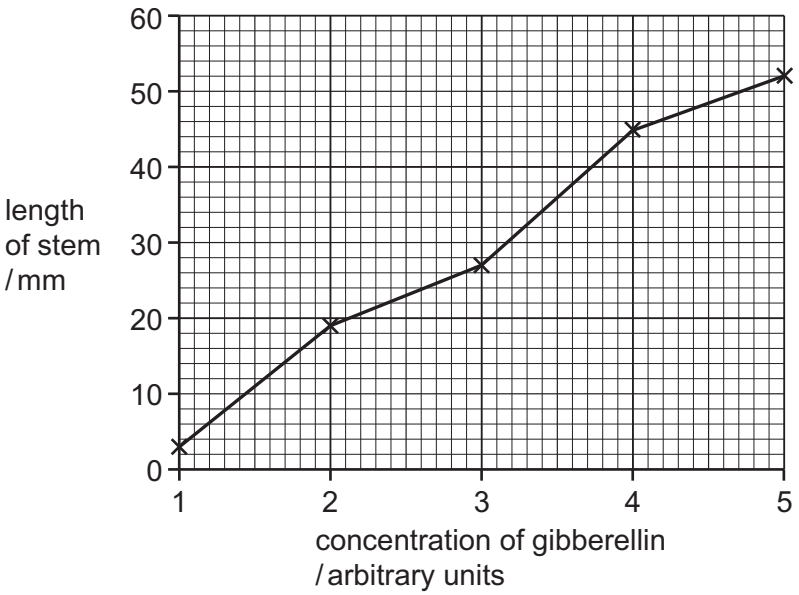


Fig. 1.2

(i) Describe the relationship shown in Fig. 1.2.

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(ii) ABA in rice plant cells inhibits the action of gibberellin.

With reference to Fig. 1.1 and Fig. 1.2, explain the importance of ethylene production for the growth of rice plants in flooded fields.

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[Total: 9]

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2 **(a)** Explain the terms gene, genotype and phenotype.

gene .....

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genotype .....

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phenotype .....

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[3]

(b) A monohybrid genetic cross can be carried out to produce an F1 and an F2 generation.

- Outline how a monohybrid genetic cross is carried out.
- State the expected percentage of each of the different offspring **genotypes** in the F2 generation.

Assume that the inheritance pattern is for autosomal dominant and recessive alleles.

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Question 3 starts on page 6.

3 The *lac* operon is present in the genome of the bacterium *Escherichia coli*.

When glucose is **not** available, the presence of lactose in the extracellular environment leads to the expression of the genes of the *lac* operon. This leads to an increase in the uptake and metabolism of lactose.

When glucose **and** lactose are available in the extracellular medium, lactose is prevented from entering the bacterial cell.

Fig. 3.1 shows what happens when glucose enters a bacterial cell.

- Glucose enters the bacterial cell using a transport protein, **A**.
- **B** is an enzyme found in the cytoplasm of the bacterial cell.
- **B** catalyses the phosphorylation of glucose to produce glucose 6-phosphate.

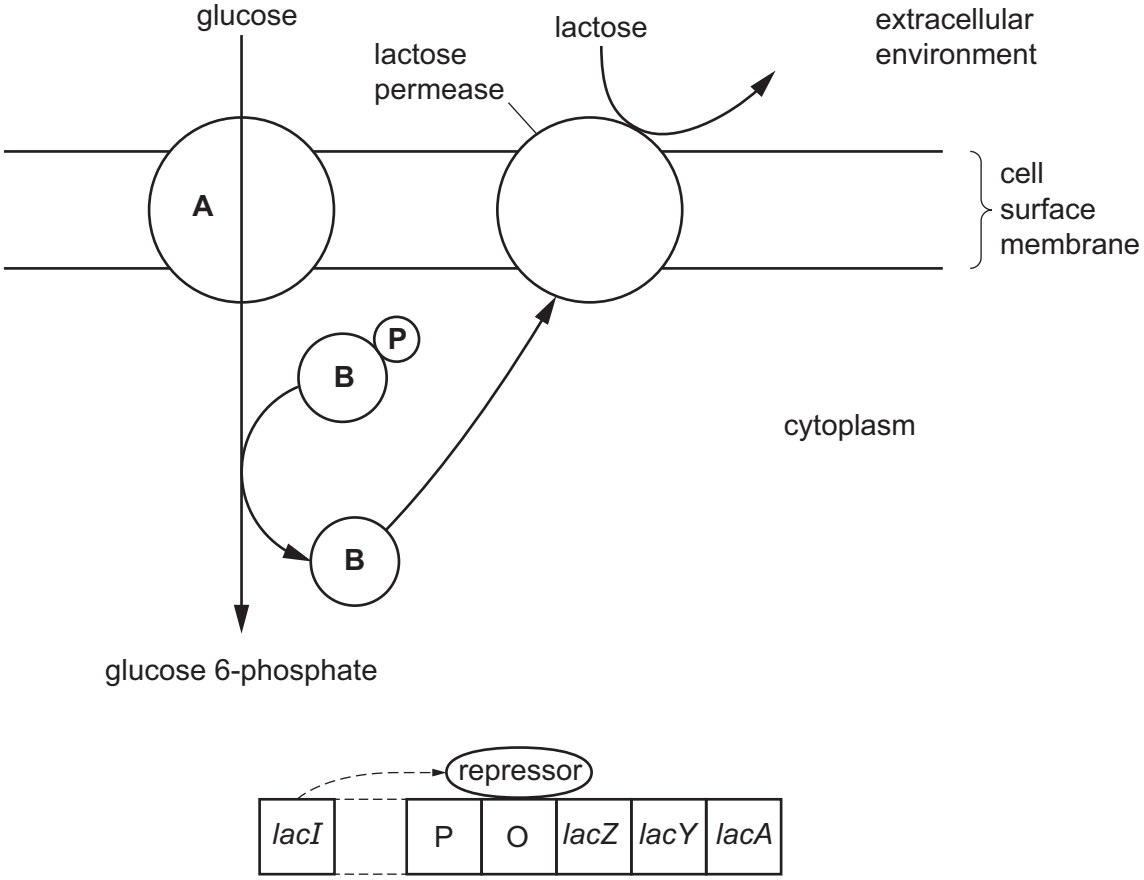


Fig. 3.1

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(a) (i) With reference to Fig. 3.1, suggest **and** explain how the presence of glucose in the extracellular environment prevents lactose entering the bacterial cell.

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..... [3]

(ii) Suggest the advantages for the bacterial cell in preventing the entry of lactose when glucose is present in the extracellular environment.

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..... [2]

(iii) The glucose 6-phosphate in the cytoplasm of the bacterial cell is used to produce fructose 1,6-bisphosphate.

Fructose 1,6-bisphosphate is used in glycolysis.

Outline the events that occur in glycolysis following the production of fructose 1,6-bisphosphate.

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(b) *E. coli* is present in the gut (intestines) of young mammals.

The diet of young mammals contains lactose which is present in the milk they consume.

Scientists carried out an experiment using *E. coli* with a *lac* operon (lac^+ *E. coli*) and *E. coli* without a *lac* operon (lac^- *E. coli*).

The experiment was carried out to determine whether the presence of a *lac* operon gives *E. coli* a selective advantage.

- Equal numbers of lac^+ *E. coli* and lac^- *E. coli* were given to 8 mice to allow the bacteria to colonise the gut.
- On day 0, 50% of the *E. coli* in the gut of each mouse were lac^+ *E. coli.*
- 4 mice were fed a standard diet that included lactose.
- 4 mice were fed a standard diet without lactose.
- The percentage of lac^+ *E. coli* that were in the gut of each mouse was determined every day for 6 days.

The results are shown in Fig. 3.2.

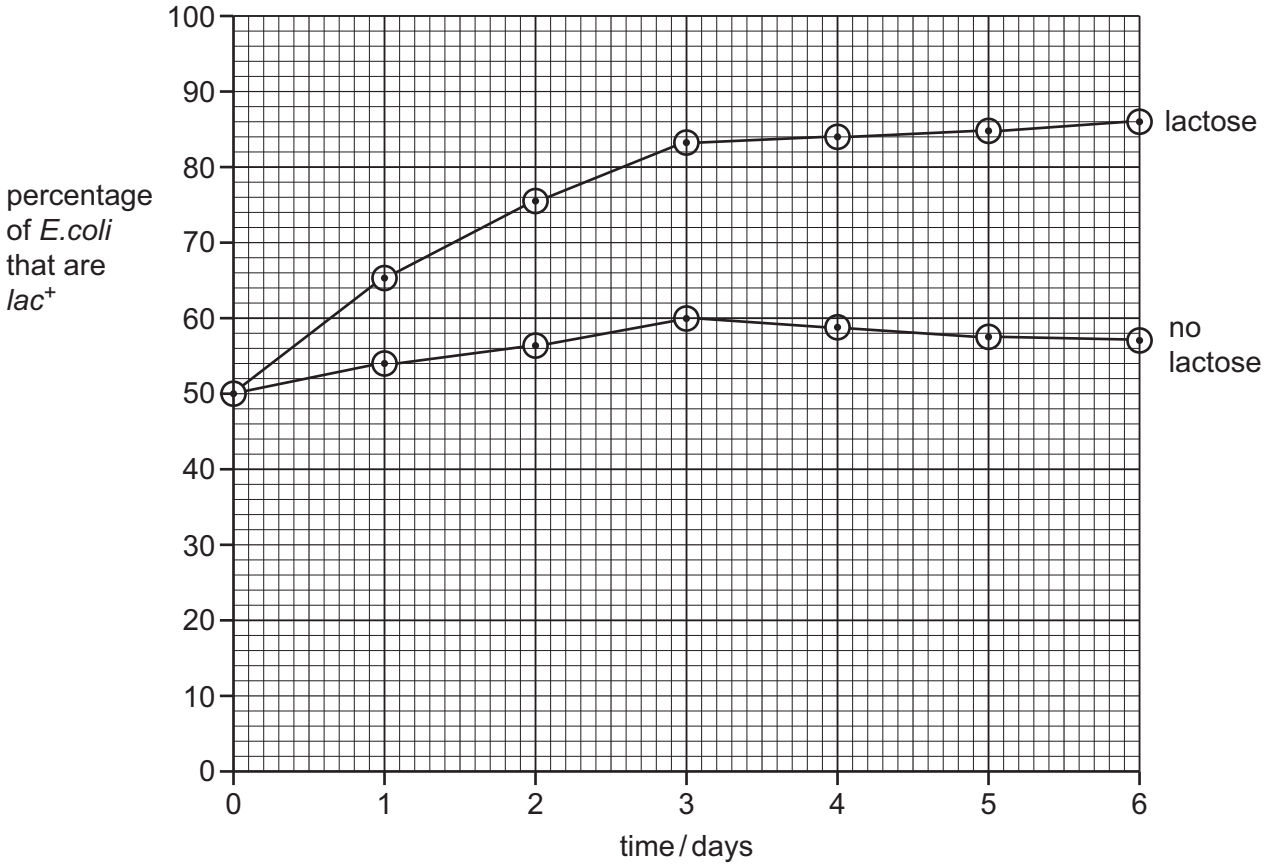


Fig. 3.2

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(i) With reference to Fig. 3.2, describe the effect of the different diets on the percentage of *E. coli* that are *lac*$^+$.

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..... [2]

(ii) The scientists concluded that *lac*$^+$ *E. coli* had a selective advantage when colonising the gut, but only in the presence of lactose.

Suggest why the presence of lactose caused *lac*$^+$ *E. coli* to have a selective advantage.

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[Total: 12]

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4 The evolution of antibiotic resistance in bacteria has occurred as a result of natural selection.

(a) Name **two** ways in which a bacterium can become resistant to an antibiotic.

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..... [2]

(b) The World Health Organisation regularly analyses bacterial DNA sequence data.

Suggest **one** way in which this contributes to solving the problem of antibiotic resistance in bacteria.

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..... [1]

(c) Some infectious bacterial diseases are treated with the antibiotic streptomycin.

If a person does **not** finish the prescribed course of streptomycin, bacteria are more likely to become resistant to the antibiotic.

Explain why a streptomycin-resistant strain of bacteria is more likely to develop as a result of natural selection when a person does **not** complete the prescribed course of antibiotics.

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Question 5 starts on page 12.

5 Metachromatic leukodystrophy (MLD) is a genetic disease that affects the nervous system.

MLD is caused by mutations in the *ARSA* gene located on chromosome 22. The *ARSA* gene, which is 3150 base pairs (bp) in length, includes 8 exons and is shown in Fig. 5.1.

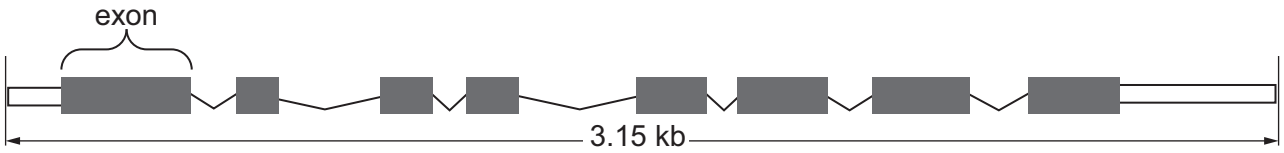


Fig. 5.1

A genetic test using DNA sequencing is available to identify mutations associated with MLD in the *ARSA* gene. The sequencing method can only work if a DNA fragment size is less than 1000 bp.

The test involves a number of different stages:

- Genomic DNA is extracted from a blood sample.
- Polymerase chain reaction (PCR) using 5 pairs of primers selects 5 different DNA fragments of the *ARSA* gene.
- Gel electrophoresis is carried out on the DNA fragments.
- The DNA fragments are sequenced and analysed for mutations.

Table 5.1 shows the length of the DNA fragments and the exons present in each DNA fragment.

Table 5.1

fragment number	DNA fragment length / bp	exons in DNA fragment
1	405	1
2	737	1-2
3	706	2-4
4	860	5-7
5	916	7-8

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(a) Genomic DNA and primers are added to the PCR machine.

Name **two** other substances that are added to the PCR machine, **and** explain why each substance is added.

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(b) Gel electrophoresis is carried out on the 5 different DNA fragments produced as a result of PCR. Each DNA fragment is put into a loading well on the gel.

The final lane on the electrophoresis gel contains a DNA ladder of known lengths of DNA.

Fig. 5.2 shows the results of the gel electrophoresis.

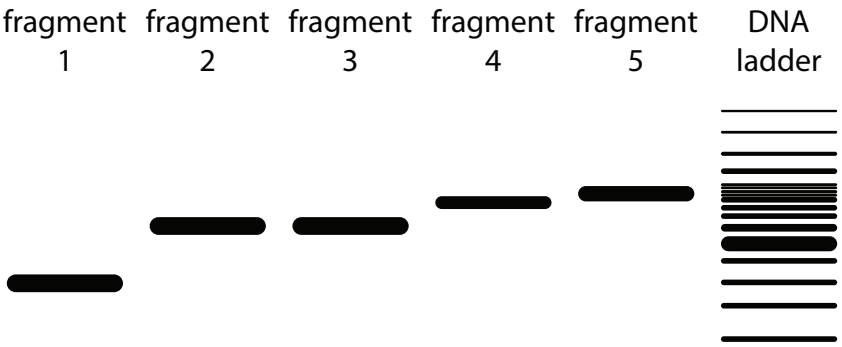


Fig. 5.2

(i) Suggest the role of the DNA ladder.

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(ii) In the genetic test for MLD, PCR and gel electrophoresis are carried out before DNA sequencing.

Suggest **and** explain reasons why PCR and gel electrophoresis are carried out before DNA sequencing.

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(c) Calculate the number of copies of DNA that are obtained if PCR is run for 35 cycles.

Assume that there is only 1 copy of DNA at the start of PCR.

Give your answer in standard form to **two** significant figures.

number of copies .....

[1]

(d) MLD is a rare autosomal recessive disease. It is estimated that there is one case of MLD in every 40 000 births worldwide. Children with MLD have a reduced life expectancy.

- MLD is a degenerative disease that causes severe disability.
- Before 2022, there was no known cure for MLD and the only treatment for symptoms was to provide pain relief.

A new gene therapy treatment known as Libmeldy® became available in a number of countries in 2022. The treatment must start before symptoms are present. Although the treatment may provide a cure for MLD, a single dose is extremely expensive.

Blood samples from newborn babies are screened for a number of rare genetic diseases (neonatal screening) in most countries of the world, but none include screening for MLD.

Discuss the social and ethical considerations of including screening for MLD when carrying out neonatal screening in a country where gene therapy for MLD is available.

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[Total: 14]

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6 **(a)** Phosphoinositide 3-kinase (PI3K) and protein kinase B (PKB) are enzymes involved in the regulation of blood glucose concentration.

Fig. 6.1 shows a cell-signalling pathway involving insulin, PI3K and PKB in a muscle cell.

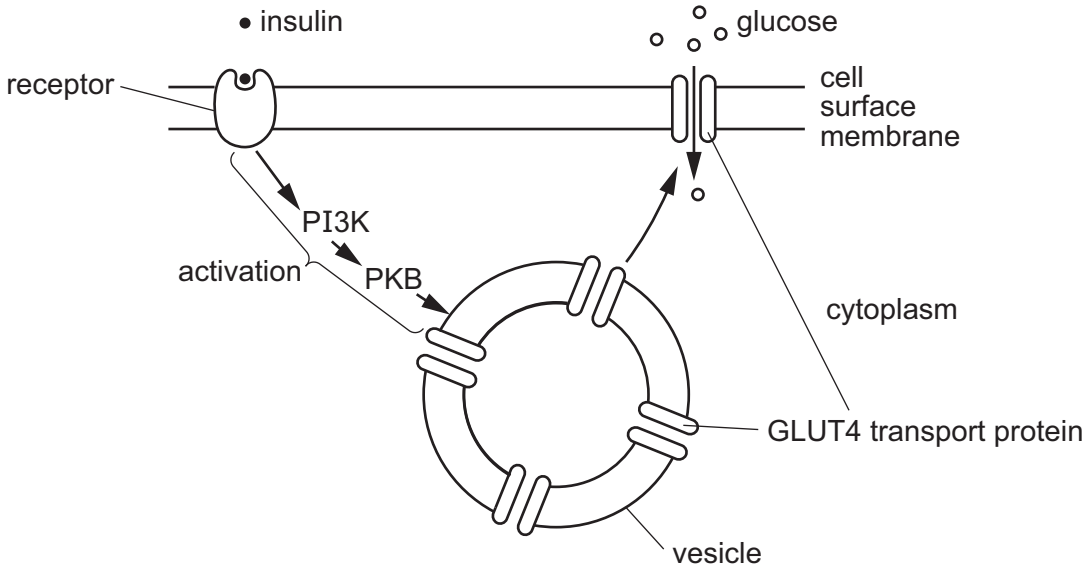


Fig. 6.1

Type 2 diabetes mellitus is a common disease. Some people with type 2 diabetes have a low concentration of PI3K in their muscle cells and cannot maintain their blood glucose concentration within normal limits.

With reference to Fig. 6.1, suggest why a low concentration of PI3K can lead to type 2 diabetes.

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(b) Describe how a biosensor can be used to measure blood glucose concentration.

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7 **(a)** The Venus fly trap, *Dionaea muscipula*, is a plant that can capture insects. Each leaf of a Venus fly trap is modified to form 2 lobes.

Fig. 7.1 shows how the leaf of a Venus fly trap appears folded (closed) when an insect has been captured.



Fig. 7.1

(i) Suggest a reason why the Venus fly trap needs to capture insects, even though it carries out photosynthesis.

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..... [1]

(ii) The leaves are specialised to form 2 lobes. The lobes are red on the upper surface.

Suggest why the lobes are red.

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..... [1]

(iii) The lobes have sensory hairs. Touching 1 sensory hair will **not** cause a response by the leaf. At least 2 sensory hairs need to be touched within 20 seconds to cause a response in the leaves.

State the advantage to the plant of producing a response only when 2 sensory hairs are touched within 20 seconds.

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(iv) When an insect has been trapped, the leaves have to remain closed for a number of days.

Suggest why this needs to happen.

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(b) Action potentials are produced by the Venus fly trap during the closure of a leaf. Each action potential is also associated with a refractory period. This is similar to the action potential and refractory period observed in a mammalian neurone during nerve impulse transmission.

Explain the role played by the refractory period in the transmission of an impulse in a mammalian neurone.

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[Total: 7]

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8 **(a)** Palm oil is the most widely used vegetable oil. It is obtained from the African oil palm, *Elaeis guineensis*. Oil palms are the highest yielding vegetable oil crop, needing only 10% of the land area required by other crops to produce the same quantity of oil.

On the island of Borneo, tropical rainforests are cut down and cleared to create oil palm plantations. This has a large effect on biodiversity.

The Bornean orangutan, *Pongo pygmaeus,* is only found on the island of Borneo and is classified as critically endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species™.

Fig. 8.1 shows Bornean orangutans.



Fig. 8.1

Suggest ways in which the Bornean orangutan may be conserved.

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(b) Biodiversity can be assessed at different levels.

Outline the main levels at which biodiversity can be assessed.

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(c) The biodiversity of a habitat can be measured by calculating Simpson's index of diversity (*D*).

The formula for Simpson's index of diversity (*D*) is:

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

Key to symbols:

n = number of individuals of each type present in the sample

N = the total number of all individuals of all types present in the sample

A survey of shrubs and trees in a temperate woodland was carried out. The results are shown in Table 8.1.

Table 8.1

common name	n	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
maple	807	0.196	0.0384
alder	6	0.001	0.0000
hazel	1856	0.451	.....
hawthorn	82	0.020	0.0004
blackthorn	40	0.010	0.0001
willow	101	0.025	0.0006
birch	78	0.019	0.0004
wild rose	84	0.020	0.0004
oak	1036	0.252	0.0635
dogwood	29	0.007	0.0000
N =	4119	Total =	.....

(i) Complete Table 8.1. [2]

(ii) Calculate the value for Simpson's index of diversity (*D*).

D = ...
[1]

(iii) Using your value for *D*, comment on the biodiversity of this temperate woodland.

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[Total: 12]

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9 **(a)** Fig. 9.1 shows an absorption spectrum for chlorophyll *a* and the corresponding action spectrum for a species of plant.

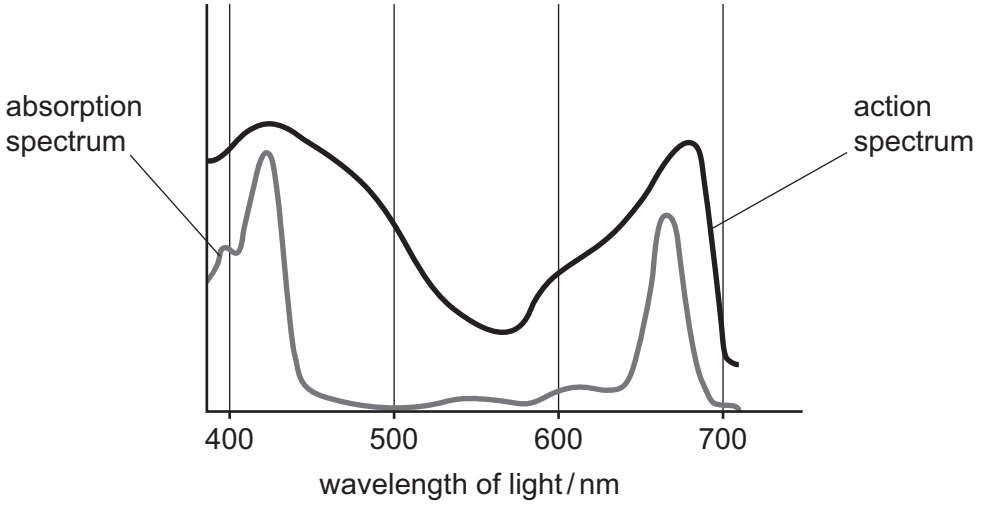


Fig. 9.1

(i) Explain what is meant by an absorption spectrum and an action spectrum.

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(ii) Suggest **and** explain why the curve shown in Fig. 9.1 for the absorption spectrum is different from the curve for the action spectrum for wavelengths of light between 450 nm and 550 nm.

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(b) Scientists investigated the effect of temperature on the rate of photosynthesis **and** the rate of respiration of the trailing azalea, *Kalmia procumbens*, at a high light intensity.

Fig. 9.2 shows the results of this investigation.

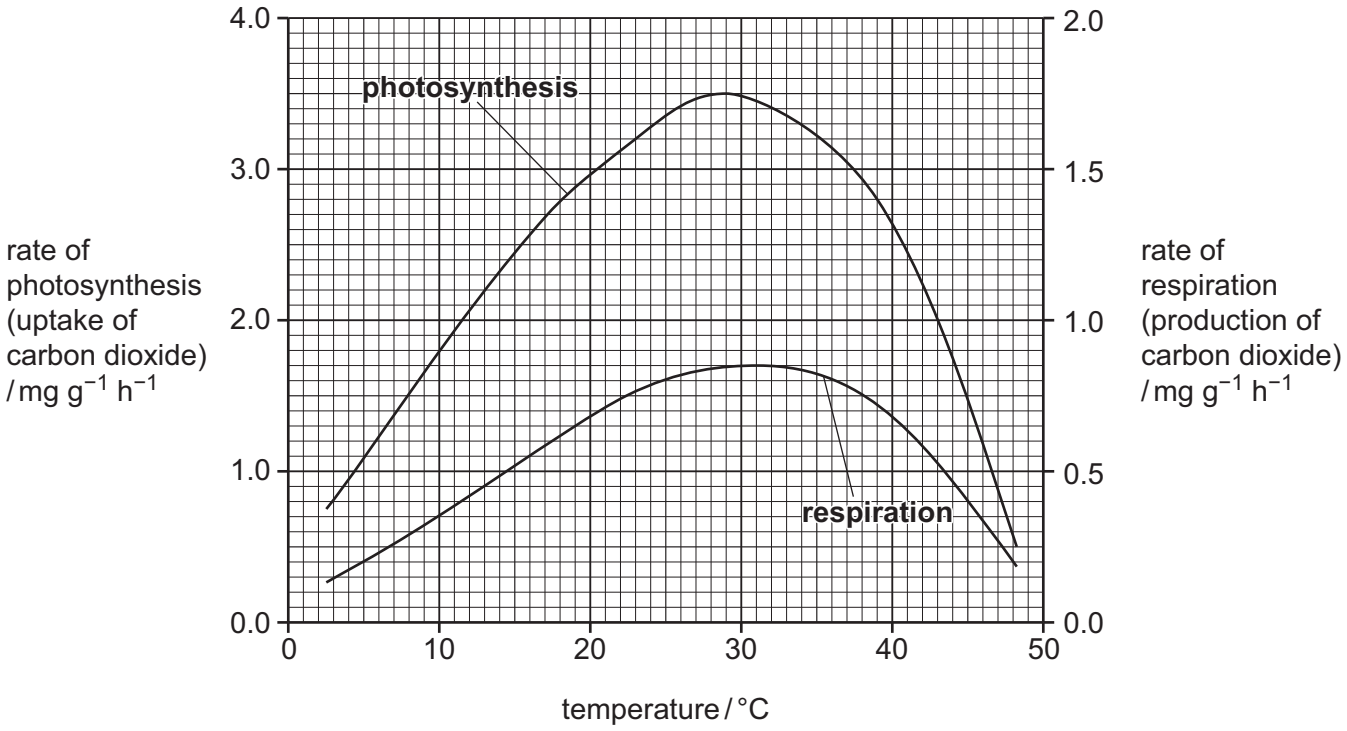


Fig. 9.2

(i) With reference to Fig. 9.2, describe **and** explain the effect of temperature on the rate of **photosynthesis** for *K. procumbens*.

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(ii) The rate of photosynthesis in this investigation was obtained by measuring the uptake of carbon dioxide from the atmosphere. It did **not** take into account the use of carbon dioxide produced by respiration.

Using Fig. 9.2, calculate the rate of photosynthesis at 20 °C when the carbon dioxide produced by respiration is taken into account.

rate of photosynthesis .....
[2]

[Total: 11]

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10 (a) Nerve impulses can be transmitted along a myelinated motor neurone to a neuromuscular junction at fast speeds of up to $100\,m\,s^{-1}$.

Outline how a transmission speed of $100\,m\,s^{-1}$ is achieved by the neurone.

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..... [3]

(b) When a nerve impulse reaches the neuromuscular junction, acetylcholine is released and diffuses to the sarcolemma.

Describe how the release of acetylcholine can result in the binding of calcium ions to troponin in the sarcomere.

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(c) Muscle contraction can be affected by a low blood glucose concentration.

Suggest how a low blood glucose concentration would affect the functioning of the sarcomere.

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CENTRE NUMBER

CANDIDATE NUMBER

9790368818

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **October/November 2025**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **20** pages. Any blank pages are indicated.

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[Turn over

1 Guinea pigs, *Cavia porcellus*, vary in the length and colour of their fur.

Fig. 1.1 shows a guinea pig with short black fur.



Fig. 1.1

Two genes that determine the length and colour of the fur occur at the **A**/**a** locus and the **B**/**b** locus. These two gene loci are on separate autosomal chromosomes.

- The allele **A** results in short fur.
- The allele **a** results in long fur.
- **A** is dominant to **a**.

- The allele **B** results in black fur.
- The allele **b** results in chocolate fur.
- **B** is dominant to **b**.

(a) (i) List **all** the possible genotypes of a guinea pig with short black fur.

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..... [2]

(ii) A test cross could be used to determine the genotype of a female guinea pig with short black fur.

Describe the **phenotype** of the male guinea pig that could be used to carry out this test cross.

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(b) A black guinea pig with long fur that was homozygous at both loci was crossed with a chocolate guinea pig with short fur that was homozygous at both loci. The F1 offspring of this cross had short black fur. F1 offspring were mated together to produce the F2 offspring.

Complete the Punnett square to:
- show the cross between the F1 offspring
- predict the F2 offspring genotypes.

You should include the gametes in your answer.

State the ratio of F2 offspring phenotypes. You should include a key to link phenotypes to genotypes.

ratio of F2 offspring phenotypes:

[4]

(c) Some genes in guinea pigs are structural genes and some are regulatory genes.

Describe the difference between a structural gene and a regulatory gene.

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[Total: 9]

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2 *Exserohilum turcicum* is a fungal pathogen. The growth of the mycelium of the fungus damages the leaves of maize plants, *Zea mays*. Leaf damage reduces crop yield.

(a) (i) Complete Table 2.1 to show **one** structural difference and **one** functional difference between *E. turcicum* and *Z. mays*.

Table 2.1

	E. turcicum	***Z. mays***
structural difference		
functional difference		

[2]

(ii) Describe the principles by which organisms such as *E. turcicum* and *Z. mays* are classified in the taxonomic hierarchy.

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(b) Two inbred varieties of maize, SKV50 and CML153, were crossed. The resulting F1 hybrids were self-crossed to produce F2 offspring. The F2 plants were grown, and the percentage area of leaf damage caused by *E. turcicum* was measured.

Fig. 2.1 shows the results for the F2 generation. The arrows show the mean percentage area of leaf damage for the two parent varieties.

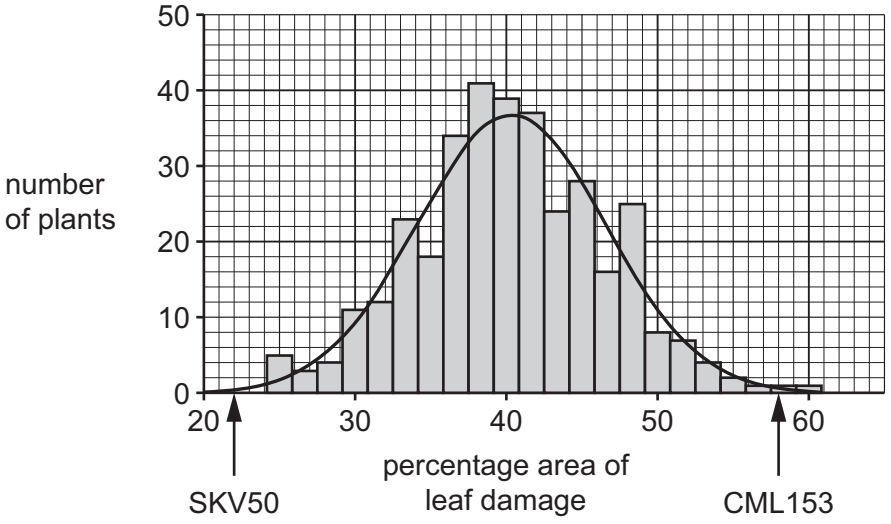


Fig. 2.1

(i) Explain how Fig. 2.1 can be used to determine which parent maize variety shows the greatest resistance to infection by *E. turcicum*.

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..... [2]

(ii) State the name of the type of variation shown by the maize F2 generation in Fig. 2.1.

..... [1]

(iii) Explain the **genetic** basis of the type of variation shown by the maize F2 generation.

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3 Plants have several different photosynthetic pigments in their chloroplasts.

(a) A student separated and identified the chloroplast pigments present in a leaf extract from a spinach plant using two slightly different methods.

Method **A**

- A type of chromatography known as thin layer chromatography (TLC) was used to separate the pigments.
- A mixture of ether and cyclohexane was used as a solvent in TLC.

Method **B**

- The student repeated TLC but treated the spinach leaf extract with a chemical. The chemical causes a magnesium ion in a pigment to be replaced by two hydrogen ions.
- The student used a leaf from the same spinach plant, and used the same solvent as in method **A**.

The student calculated R_f values and compared these to reference values to identify the pigments.

Fig. 3.1 shows the results for method **A** and method **B**.

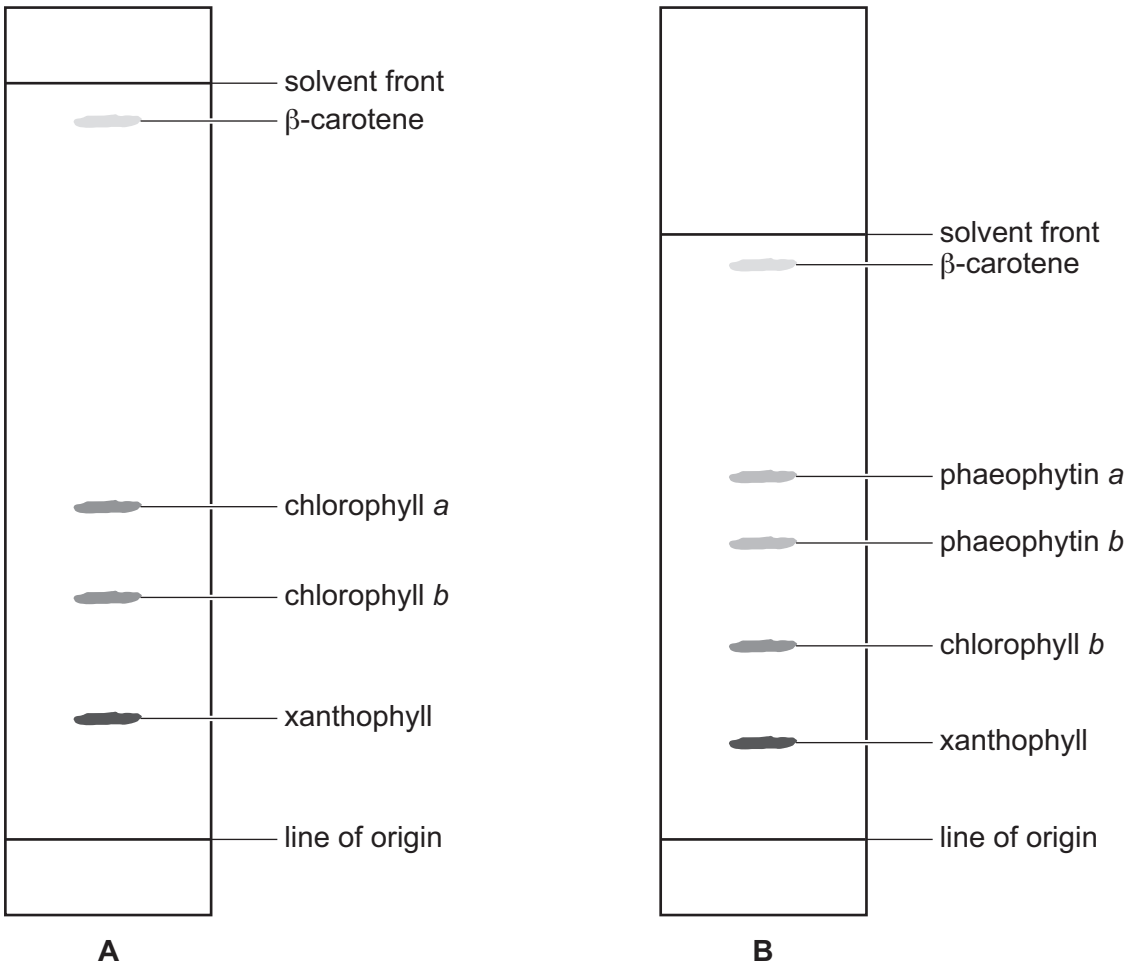


Fig. 3.1

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(i) Calculate the R_f value of β-carotene in Fig. 3.1.

R_f = ...
[2]

(ii) Suggest **two** explanations for the differences in appearance of chromatograms **A** and **B** in Fig. 3.1.

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[2]

(iii) The student found some different R_f values for the chloroplast pigments of spinach in a scientific paper.

The values in the scientific paper were different from the reference values that the student originally used to identify the pigments on chromatograms **A** and **B** in Fig. 3.1.

Suggest **one** reason, other than measurement error, for the different R_f values.

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(b) Fig. 3.2 shows the absorption spectra of some chloroplast pigments.

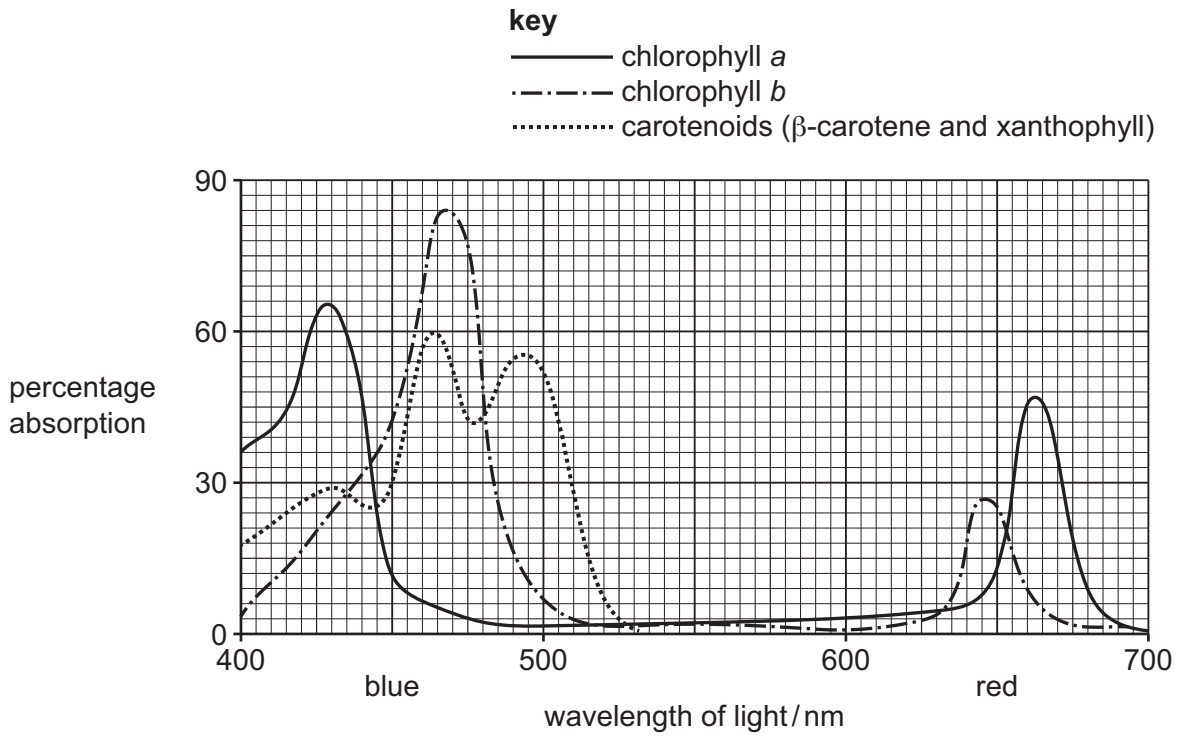


Fig. 3.2

Use Fig. 3.2 to compare the similarities and differences between the absorption spectra of chlorophyll *a* and carotenoids.

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(c) In some species of plant, the absorption of light stimulates seed germination.

The absorption of light increases the production of gibberellin in the embryo of a seed.

Describe the role of gibberellin in the germination of a seed.

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4 The wolf, *Canis lupus*, lives in North America. Wolves may have a grey or a black coat colour. The colour of an individual wolf depends on the DNA it inherits at the *CPD103* gene locus.

- Wolves inherit two copies of *CPD103*, one from each parent.
- Wolves that inherit one copy of the black form of the *CPD103* gene have a black coat.

(a) State the term used to describe:

- an organism that has two copies of each gene .....
- a form of a gene .....
- a form of a gene that gives a phenotypic effect in a heterozygote. .....

[3]

In addition to producing black coat colour, the protein coded for by the *CPD103* gene also defends against infectious lung disease.

Canine distemper virus (CDV) causes serious lung disease in wolves. Wolves that have been previously infected by CDV have antibodies against CDV (anti-CDV antibodies) in their blood.

(b) CDV can be passed from domestic dogs to wolves.

- Domestic dogs are more numerous in the southern part of the area occupied by wolves.
- Domestic dogs are less numerous in the northern part of the area occupied by wolves.
- The relative frequency of black wolves compared to grey wolves increases from the north to the south of the area they occupy.

Explain how natural selection causes this trend in the distribution of black wolves.

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(c) Several different populations of wolves were compared.

Fig. 4.1 shows the relationship between the percentage of wolves in a population that have anti-CDV antibodies in their blood and the percentage of wolves in that population that are black. The line of best fit was calculated after comparing the different populations of wolves.

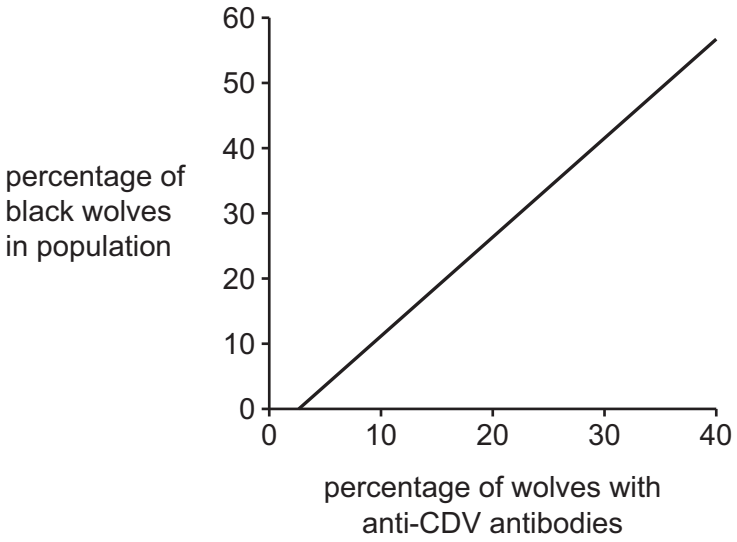


Fig. 4.1

With reference to Fig. 4.1, state the relationship between the percentage of wolves with anti-CDV antibodies and wolf coat colour, **and** suggest reasons for this relationship.

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5 The endocrine system and the nervous system both coordinate responses in mammals.

(a) Complete Table 5.1 to show the features of three cell-signalling molecules of the endocrine system: antidiuretic hormone (ADH), glucagon and insulin.

Use a tick (✓) if the molecule has the feature and a cross (✗) if the molecule does **not** have the feature.

Put a tick (✓) or a cross (✗) in every box.

Table 5.1

feature	ADH	glucagon	insulin
binds to receptors on cell surface membranes			
results in molecules moving from cells into the blood			
is secreted as a result of detection by osmoreceptors			

[3]

(b) The endocrine system has a slower transmission speed than the nervous system.

Describe **other** ways in which the endocrine system and the nervous system differ.

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(c) The endocrine system and the nervous system can affect muscle function.

Fig. 5.1 shows a transmission electron micrograph of a longitudinal section of striated muscle tissue that is in a relaxed state.

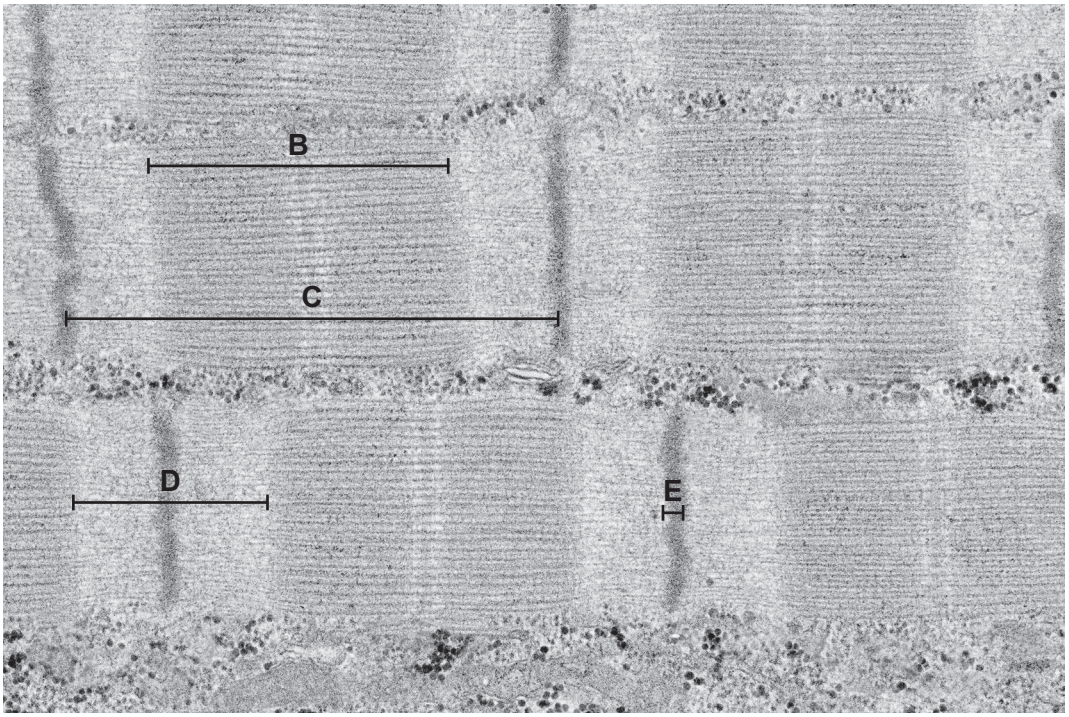


Fig. 5.1

(i) State the letter on Fig. 5.1 that indicates the length of a sarcomere.

..... [1]

(ii) State the letter on Fig. 5.1 that indicates a region where actin and myosin overlap.

..... [1]

(iii) Describe **and** explain how the region labelled **D** on Fig. 5.1 changes during muscle contraction.

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6 The distribution of the large blue butterfly, *Phengaris arion*, extends across Europe and Asia. It is assessed by the International Union for Conservation of Nature (IUCN) on the Red List™ as 'Near Threatened' globally and 'Endangered' in Europe.

In Europe, *P. arion* became extinct in the Netherlands in 1964 and in the United Kingdom in 1979.

Fig. 6.1 lists the conservation status categories in the IUCN Red List™.

conservation status

Extinct (EX)

Extinct in the Wild (EW)

Critically Endangered (CR)

Endangered (EN)

Vulnerable (VU)

Near Threatened (NT)

Least Concern (LC)

increasing risk of extinction

Fig. 6.1

Fig. 6.2 shows *P. arion*.



Fig. 6.2

(a) (i) Explain how IUCN Red List™ assessments help to conserve biodiversity.

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(ii) With reference to Fig. 6.1 and the IUCN assessments for *P. arion*, suggest how the abundance of the butterfly differs across its distribution.

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(b) *P. arion* has been successfully re-introduced in the United Kingdom at 12 sites. These sites were restored to flower-rich grassland.

The conservation management actions designed for *P. arion* also resulted in the re-establishment or increase of other species at the restored sites. These included 12 species of flowering plant, 8 other butterfly species and 4 species of other insects.

(i) Use the information given to suggest why *P. arion* went extinct in the United Kingdom in 1979.

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(ii) Outline the advantages of restoring habitats for endangered species.

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[Total: 11]

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7 In aerobic respiration, most ATP is produced by oxidative phosphorylation.

(a) Outline the features of ATP that make it suitable as the universal energy currency.

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..... [3]

(b) Rotenone is a compound that affects oxidative phosphorylation.

Rotenone disrupts the first carrier in the electron transport chain by stopping the transfer of electrons from this carrier.

Suggest **and** explain how rotenone reduces the production of ATP **and** water in aerobic respiration.

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8 LibertyLink® soybean is a genetically modified crop. It was first grown in 1996 and used in food products from 1998. It has been grown in 6 countries and used in food products in 21 countries.

Table 8.1 summarises the modifications made to the soybean plant to produce LibertyLink® soybean.

Table 8.1

name of introduced gene	gene donor organism	gene product	function of gene product
pat	*Streptomyces viridochromogenes*	phosphinothricin *N*-acetyltransferase	stops action of glufosinate, a herbicide

(a) Explain how the modification made to produce LibertyLink® soybean may help to solve the global demand for food.

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(b) **(i)** Name the type of enzyme that could be used to cut out the *pat* gene from *S. viridochromogenes*.

..... [1]

(ii) Name the enzyme that could be used to join the *pat* gene to a plasmid by forming phosphodiester bonds.

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(c) Suggest reasons why LibertyLink® soybean is used in food products in 21 countries but only grown in 6 countries.

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9 **(a)** Fig. 9.1 shows a longitudinal section of a human kidney.

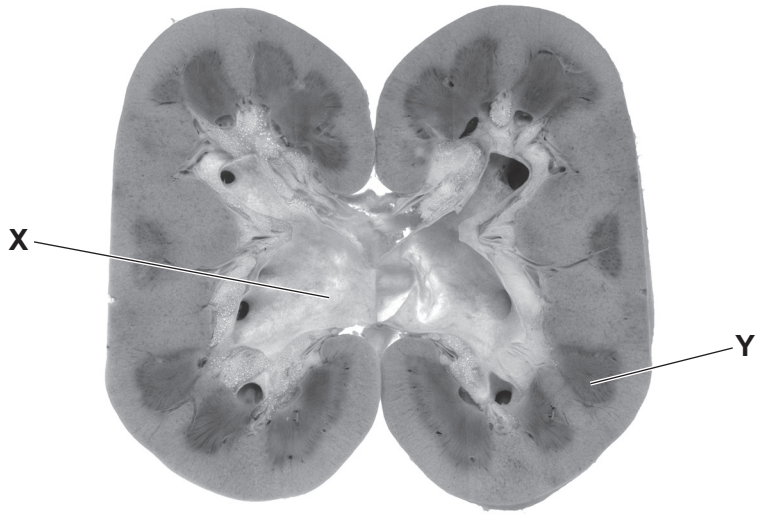


Fig. 9.1

Name the regions of the kidney labelled **X** and **Y** in Fig. 9.1.

X .....

Y .....

[2]

(b) A biosensor can be used to measure the concentration of glucose in urine.

Outline how a biosensor measures the concentration of glucose in urine.

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10 Explain the relationship between genes, proteins and phenotype, with reference to **two** examples of genetic diseases in humans.

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CENTRE NUMBER

CANDIDATE NUMBER

2176246435

BIOLOGY **9700/44**

Paper 4 A Level Structured Questions **October/November 2025**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **28** pages. Any blank pages are indicated.

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1 **(a)** Fig. 1.1 is a diagram of a sensory neurone.

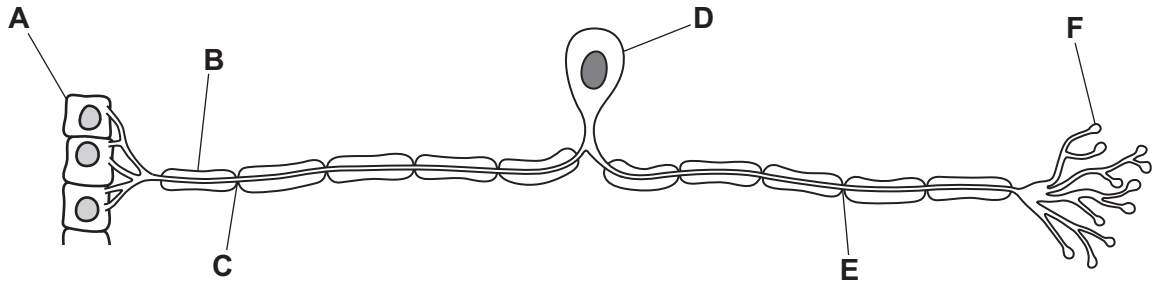


Fig. 1.1

Use the letters **A**–**F** in Fig. 1.1 to identify:

a receptor cell .....

an area where dendron membrane depolarisation occurs .....

a structure that forms a synapse with an intermediate neurone .....

a structure that allows rapid transmission of impulses .....

[4]

(b) Opioid drugs can bind to opioid receptors in the presynaptic membrane of a cholinergic synapse.

Fig. 1.2 is a diagram of a presynaptic membrane with an opioid receptor.

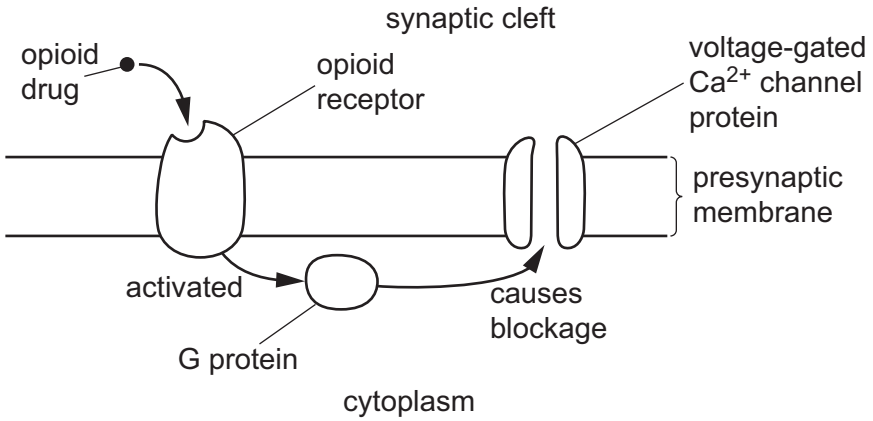


Fig. 1.2

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Opioid drugs have an effect on the normal events that occur at a cholinergic synapse.

Suggest **and** explain the effect that an opioid drug will have on the normal events that occur at a cholinergic synapse.

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2 **(a)** Meiosis and cytokinesis occur in the male reproductive organs (anthers) of plants to make pollen grains. Cells which carry out meiosis are known as pollen mother cells.

Fig. 2.1 shows five stages of meiosis in a pollen mother cell.

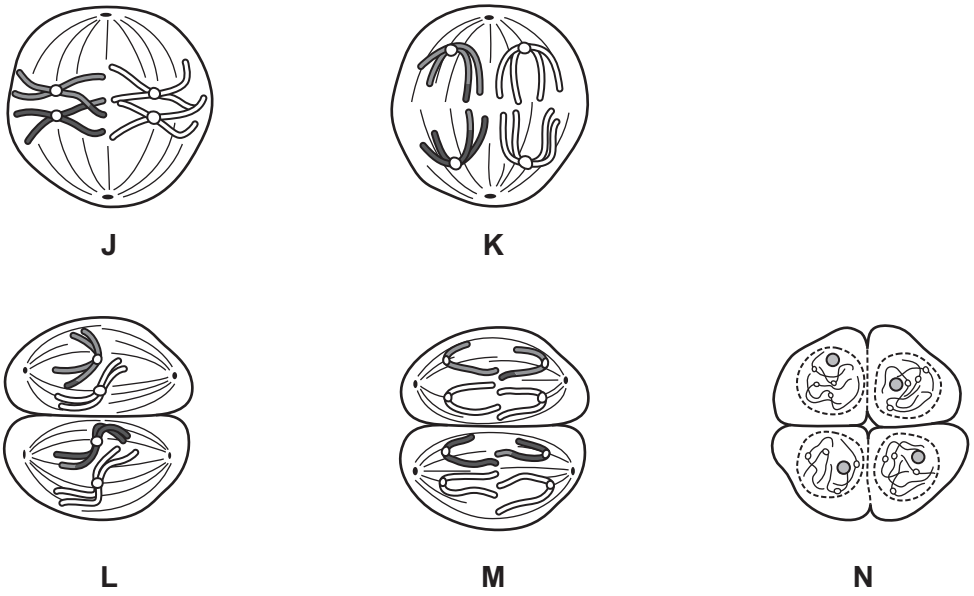


Fig. 2.1

Use the letters **J**–**N** in Fig. 2.1 to state **all** the stages that show:

anaphase .....

cells containing pairs of homologous chromosomes .....

crossing over .....

haploid cells .....

[4]

(b) Maize plants have male and female reproductive organs on the same plant. The male anthers are located on structures known as tassels. When selective breeding is carried out to create an F1 hybrid, the tassels are removed.

Suggest why the tassels are removed when selective breeding is carried out to create an F1 hybrid.

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(c) Outline how selective breeding is used to produce vigorous, uniform varieties of maize.

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3 **(a)** Genetic engineering is a modern method for producing crop plants with improved characteristics.

One example of a crop plant with improved characteristics is soybean, *Glycine max*, which has been genetically modified to make it resistant to a herbicide. This genetically modified soybean is called GM soybean.

To create GM soybean, a bacterial gene and a section of regulatory DNA were introduced into soybean cells.

Outline the roles of enzymes and a section of regulatory DNA in the creation of genetically modified organisms such as GM soybean.

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(b) In 2018, an area of 123.5 million hectares was used to grow soybean crops worldwide. GM soybean was grown in 73% of this area.

In 2018, soybeans accounted for 50% of the total GM crop area worldwide.

Calculate the total area used to grow GM crops worldwide in 2018.

Show your working.

..... hectares [2]

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(c) Discuss the social implications of growing GM crops.

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4 Alleles are alternative forms of a gene. For example, there may be a dominant allele, **T**, and a recessive allele, **t**, at the same gene locus.

The relative frequency of each allele of a gene in a population can change over time due to factors such as selection, genetic drift and the bottleneck effect.

(a) Fig. 4.1 shows the relative frequency of the **T** allele in a population of 50 individuals over 20 generations.

At generation 0, the number of **T** alleles and the number of **t** alleles in the population was equal, so the relative frequency of each allele was 0.5. The relative frequencies of the two alleles of the gene add up to 1.

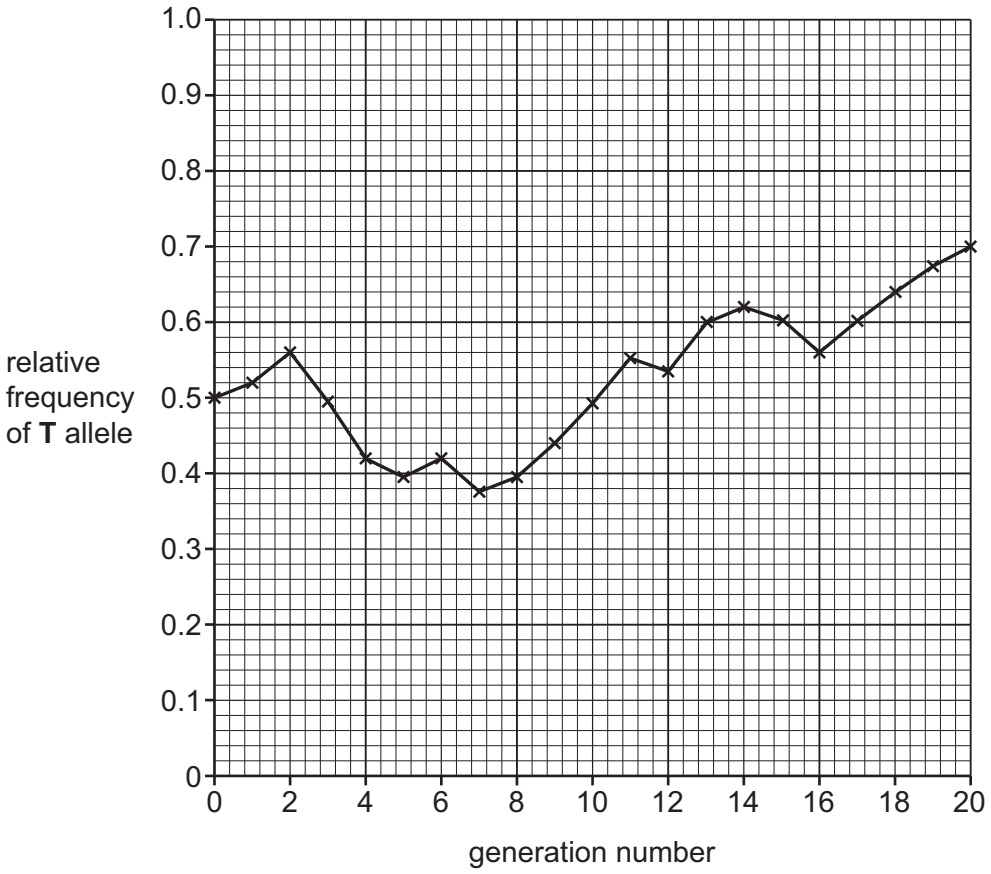


Fig. 4.1

(i) With reference to Fig. 4.1, state the relative frequency of the **t** allele after 20 generations.

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(ii) Suggest possible explanations for the change in the relative frequency of the **T** allele between generation 0 and generation 13.

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(b) The relative frequency of the **T** allele in a population of only 10 individuals was determined over 20 generations. The environmental conditions remained the same throughout the experiment.

Fig. 4.2 shows the results.

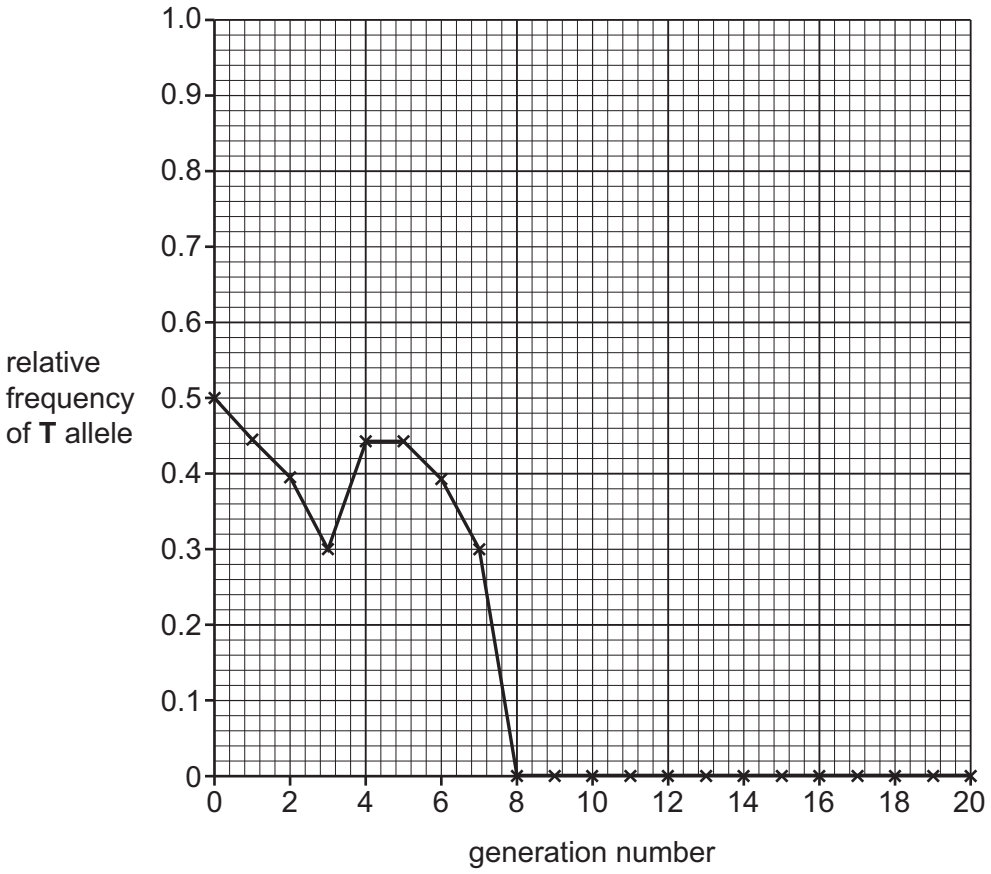


Fig. 4.2

Explain why Fig. 4.2 shows a different result from Fig. 4.1.

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(c) State the name of the principle that can be used to calculate relative frequencies of two alleles by counting the numbers of organisms in the population showing dominant and recessive phenotypes.

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5 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 a grey body and its wings are longer than its abdomen. The genes for body colour and wing length are located on different chromosomes.

A fruit fly with mutations in these two genes has a black body and short wings.

Fig. 5.1 shows a wild type fruit fly and a mutant fruit fly.

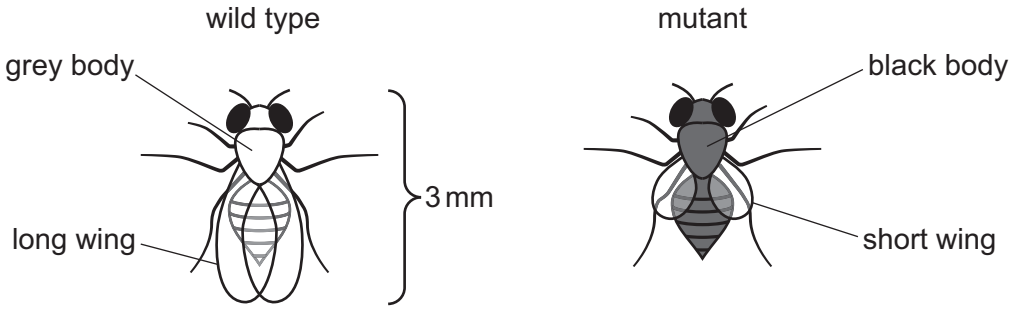


Fig. 5.1

(a) Fruit flies were first used for genetic crosses by Thomas Morgan in 1908. They are one of the most studied animals in current genetic research.

- Male fruit flies are easily distinguished from female fruit flies.
- Fruit flies have a short life cycle and a female can lay hundreds of eggs in a few days.
- Some genes for development and cell signalling in fruit flies are similar to those of humans.

Suggest why fruit flies are still used in genetic crosses.

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(b) When a wild type fruit fly was crossed with a mutant fruit fly with a black body and short wings, all the F1 offspring had grey bodies and long wings.

Using appropriate symbols, complete Fig. 5.2 to show the expected results of a cross between two of these **F1** fruit flies.

symbols:

F1 phenotypes: grey body long wing × grey body long wing

F1 genotypes:

Punnett square

offspring phenotypes:

phenotypic ratio .....

Fig. 5.2

[6]

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(c) Describe how you would determine the genotype of an F2 fruit fly with a grey body and long wings.

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6 Some people can develop a condition called type 2 diabetes. In people with type 2 diabetes, glucose uptake from the blood is decreased. In some cases, the pancreas cannot make enough insulin to keep blood glucose concentration within a healthy range.

(a) A person with type 2 diabetes and a person without type 2 diabetes were given a glucose drink. The blood glucose concentration of each person was measured at regular intervals for 120 minutes.

The results are shown in Fig. 6.1.

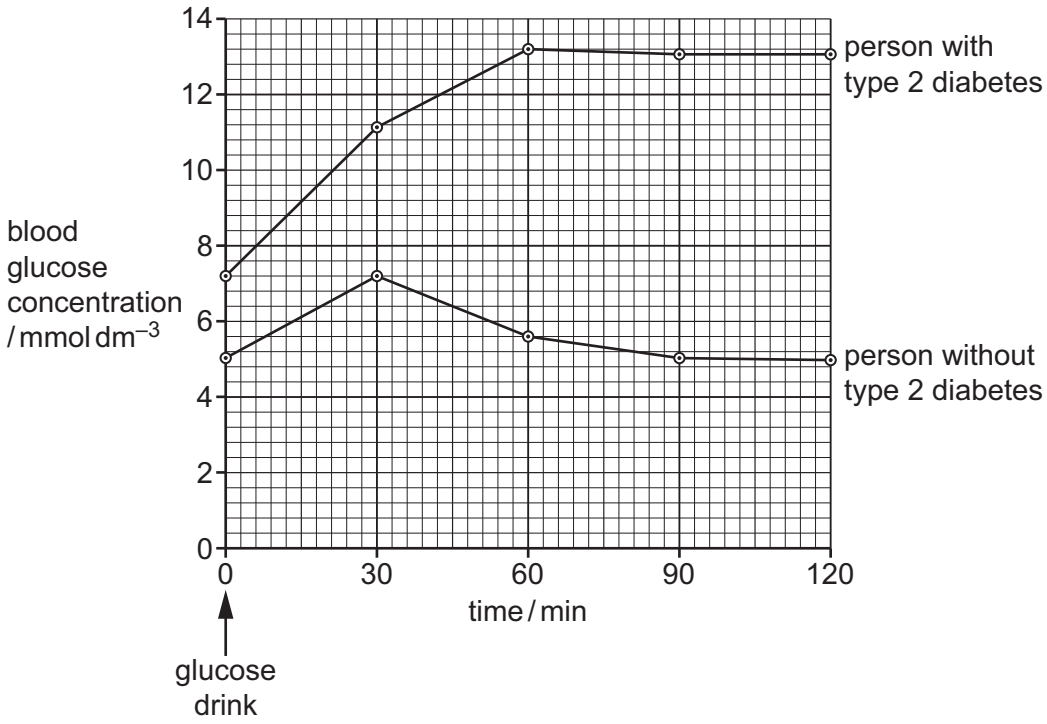


Fig. 6.1

(i) Describe the curve for the person **without** type 2 diabetes.

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(ii) Calculate the percentage increase in blood glucose concentration, between 0 and 60 minutes, for the person **with** type 2 diabetes.

answer ..... [2]

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(iii) Suggest ways in which people with type 2 diabetes can help to control their condition.

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(b) Glucagon has a role in the control of blood glucose concentration.

Describe the cell signalling pathway involving glucagon, and describe how this pathway leads to a change in the blood glucose concentration.

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[Total: 13]

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7 The kakapo, *Strigops habroptila*, is a species of large, nocturnal (active at night) parrot and is found only in New Zealand. The bird does not fly and lives on the ground.

The kakapo is classified as critically endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species™.

Fig. 7.1 shows a kakapo.



Fig. 7.1

(a) Complete Table 7.1 to show the classification of the kakapo.

Table 7.1

taxonomic group	name
domain	Eukarya
kingdom	Animalia
.....	Chordata
class	Aves
.....	Psittaciformes
family	Strigopidae
genus	.....

[3]

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(b) The kakapo was widely distributed before humans arrived in New Zealand. The Kakapo Recovery Programme started in 1995. Birds were moved to protected areas. In 2024 they were only found in these protected areas.

This is shown in Fig. 7.2.

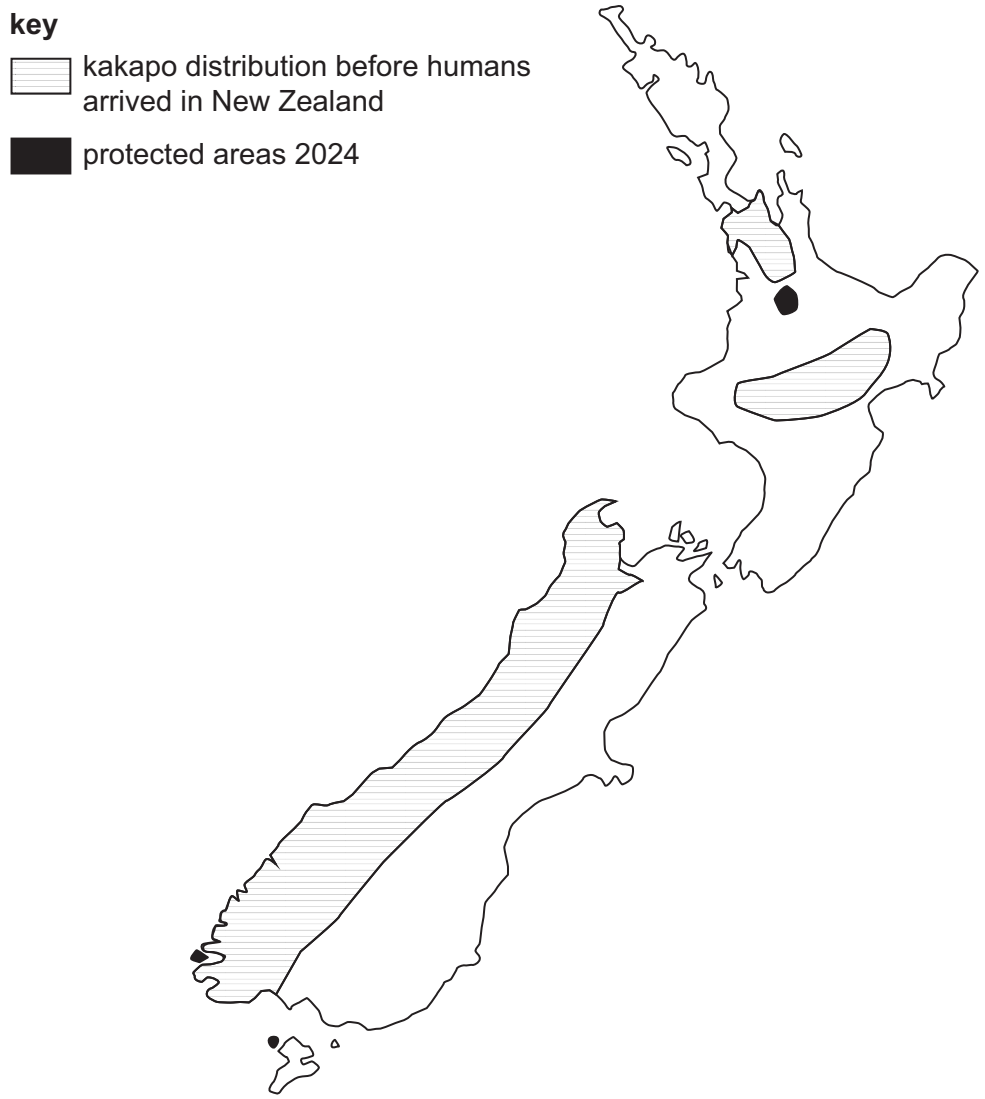


Fig. 7.2

Suggest the ideal features of a protected area for the kakapo.

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(c) DNA has shown that the kakapo population may have gone through one or more genetic bottlenecks after the arrival of humans in New Zealand.

Suggest the consequences of a genetic bottleneck to the kakapo population in New Zealand.

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8 **(a)** When the water supply to a plant is reduced, the concentration of abscisic acid (ABA) in the leaves increases.

ABA binds to receptors in the cell surface membranes of guard cells. This triggers a series of events in the cells, which results in stomatal closure.

Fig. 8.1 is a diagram of part of a guard cell showing some of the events that occur when ABA binds to its receptor.

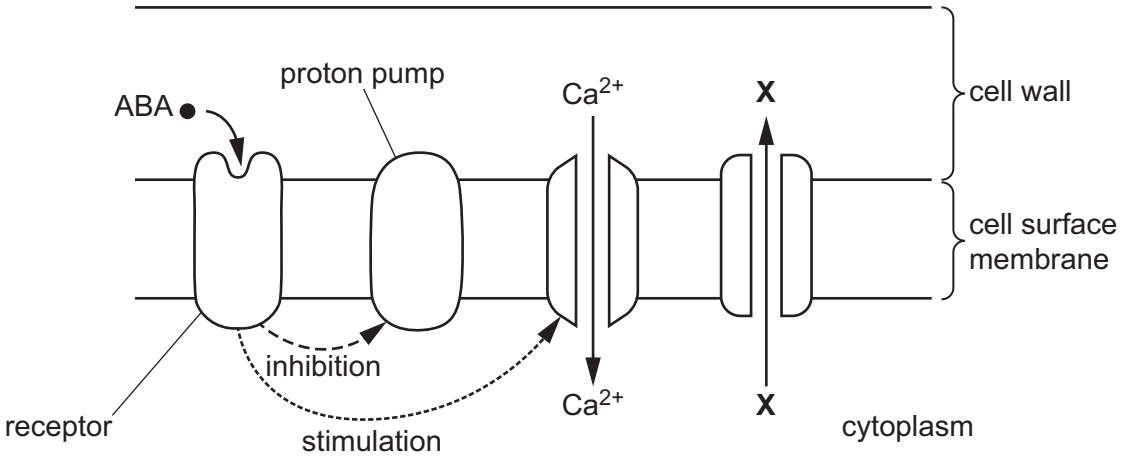


Fig. 8.1

Fig. 8.1 shows that calcium ions are involved in the events within a guard cell that result in stomatal closure.

Outline the role of calcium ions in the response of the guard cell to a reduced water supply **and** explain how this response results in stomatal closure.

Identify **X** in your answer.

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(b) Explain, using examples, why the homeostatic control involving the opening and closing of stomata is important for the efficient functioning of plants.

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9 **(a)** In aerobic conditions, pyruvate that has formed during glycolysis enters the mitochondrion and takes part in the link reaction.

Name the **two** coenzymes involved in the link reaction.

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[2]

(b) Enzymes play an important role in the functioning of the Krebs cycle.

The enzymes in the Krebs cycle can be affected by the presence of hydrogen peroxide. Hydrogen peroxide is a product of some of the reactions that occur within the mitochondrion.

An investigation was carried out to measure the effect of two different concentrations of hydrogen peroxide on an enzyme of the Krebs cycle. The activity of the enzyme was measured over 10 minutes when exposed to the two different concentrations of hydrogen peroxide.

The results are shown in Fig. 9.1.

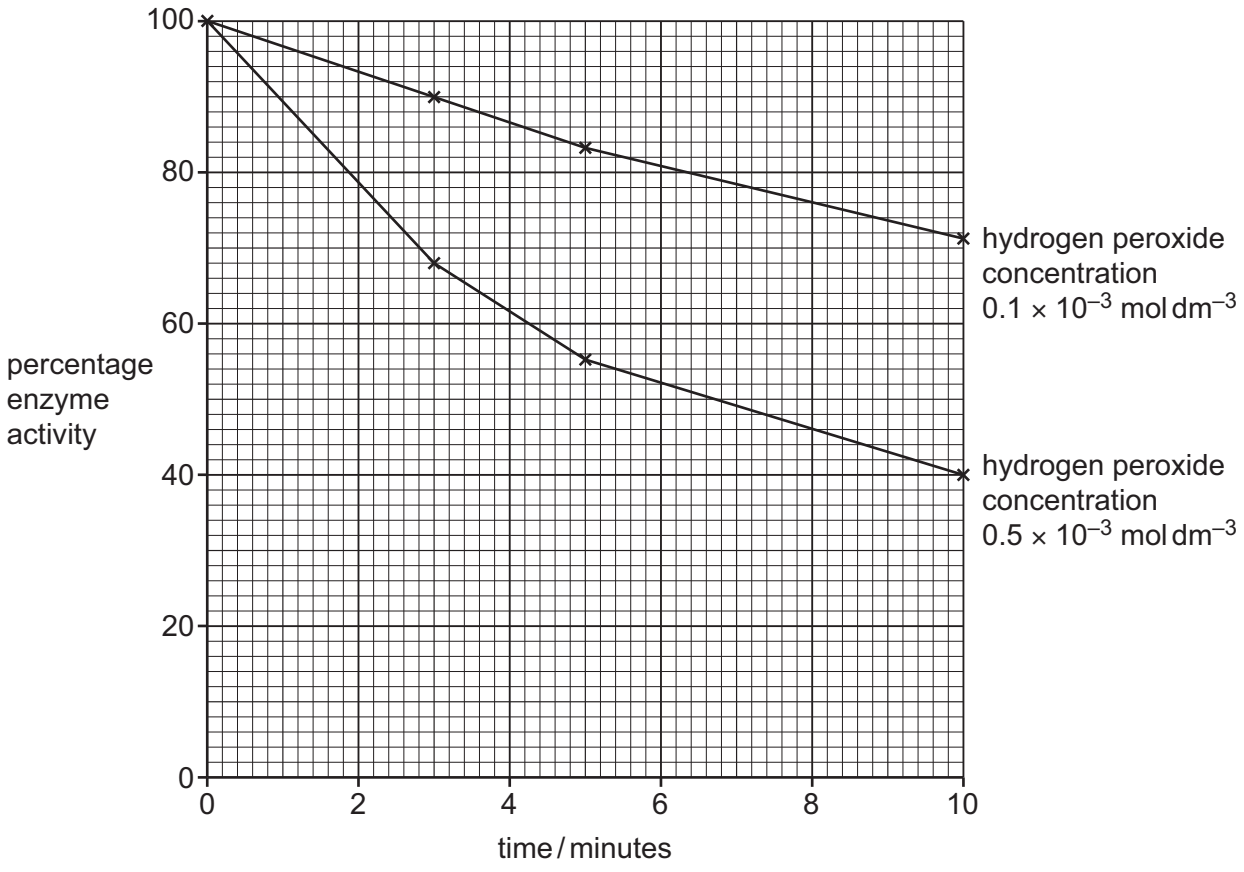


Fig. 9.1

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Describe the effect shown in Fig. 9.1 of hydrogen peroxide concentration on the activity of the Krebs cycle enzyme.

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(c) Reduced NAD and reduced FAD are produced during the Krebs cycle. They carry hydrogen to the inner mitochondrial membrane where oxidative phosphorylation occurs.

The first two steps in oxidative phosphorylation are:

1. Hydrogen atoms split into protons and electrons.
2. Electrons move along the electron transport chain, releasing energy.

Outline the steps that occur to complete oxidative phosphorylation.

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(d) Fig. 9.2 shows the oxygen consumption of a person who is carrying out a fast-running exercise.

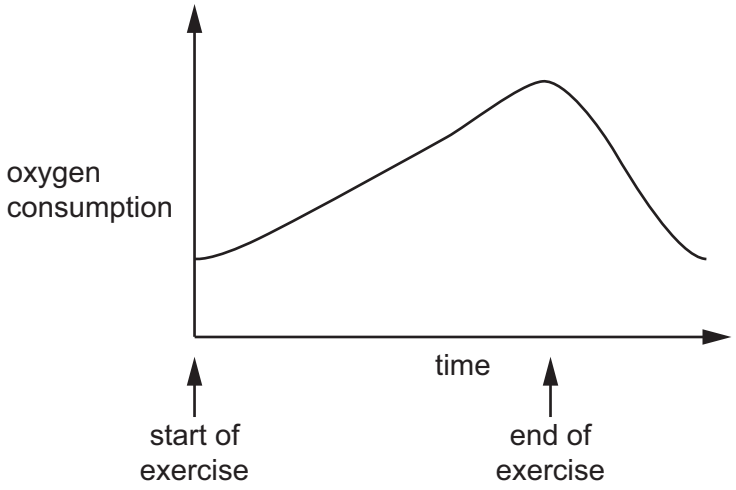


Fig. 9.2

Suggest why the oxygen consumption takes time to return to normal after exercise.

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10 (a) Cyclic photophosphorylation and non-cyclic photophosphorylation occur during the light-dependent stage of photosynthesis.

Outline the **differences** between cyclic photophosphorylation and non-cyclic photophosphorylation.

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(b) Complete the passage about the Calvin cycle using the most appropriate word or words.

A molecule of ..... combines with a five-carbon molecule, ribulose bisphosphate (RuBP), catalysed by the enzyme ..... . This reaction produces a six-carbon compound that splits into two molecules of a three-carbon compound, glycerate 3-phosphate (GP).

ATP and ..... are used to convert GP molecules into molecules of a three-carbon sugar, triose phosphate (TP).

Some TP molecules are used to make ....., while others are recycled to regenerate RuBP using ATP.

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