GradeMax

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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

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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.

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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.

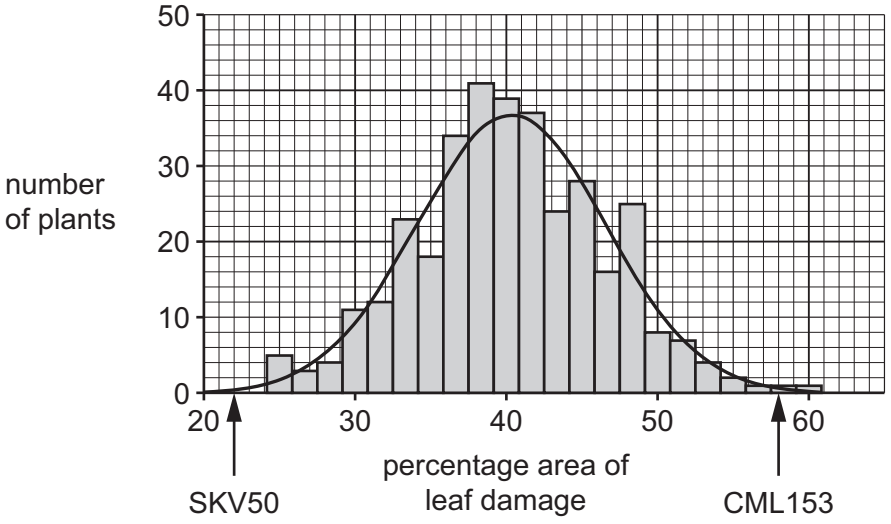


Fig. 2.1

(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.

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(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**.

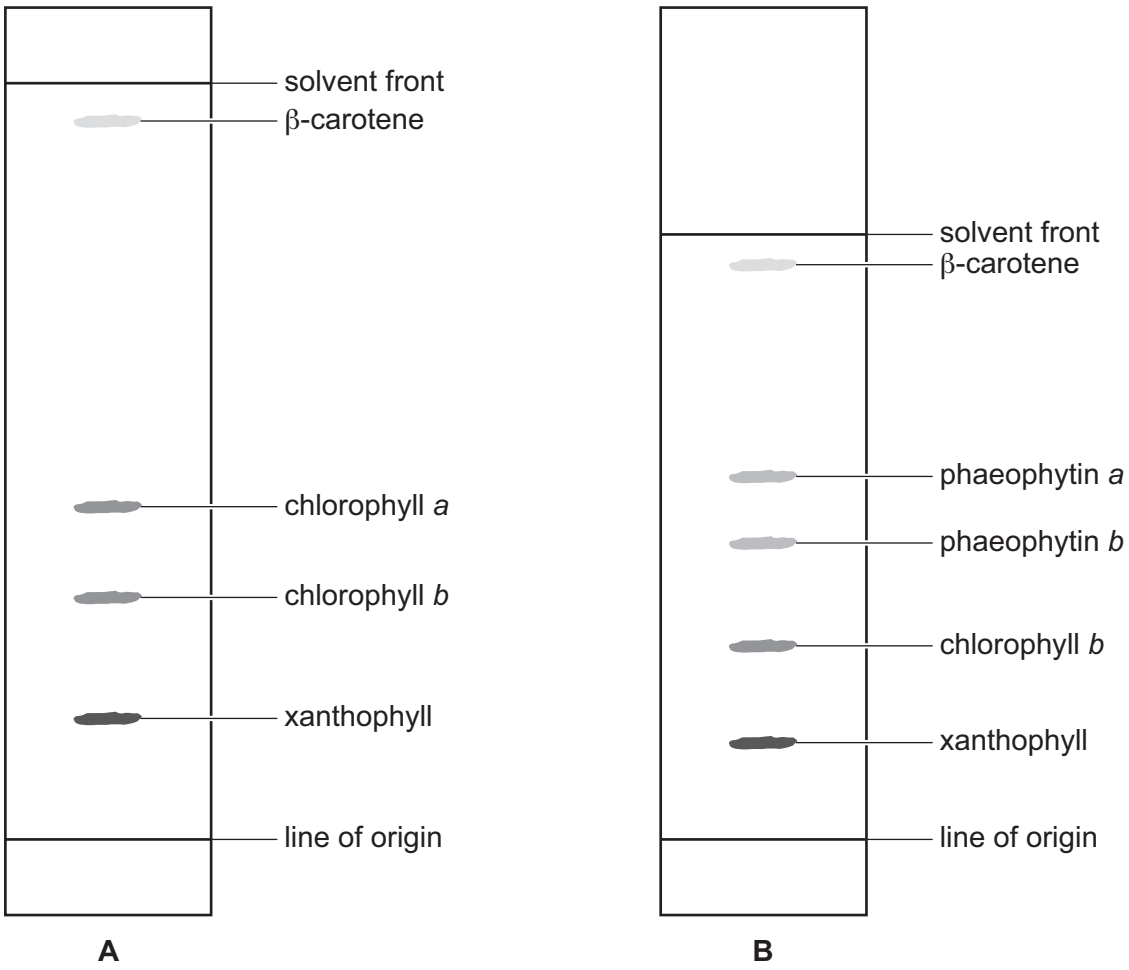


Fig. 3.1

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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.

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.

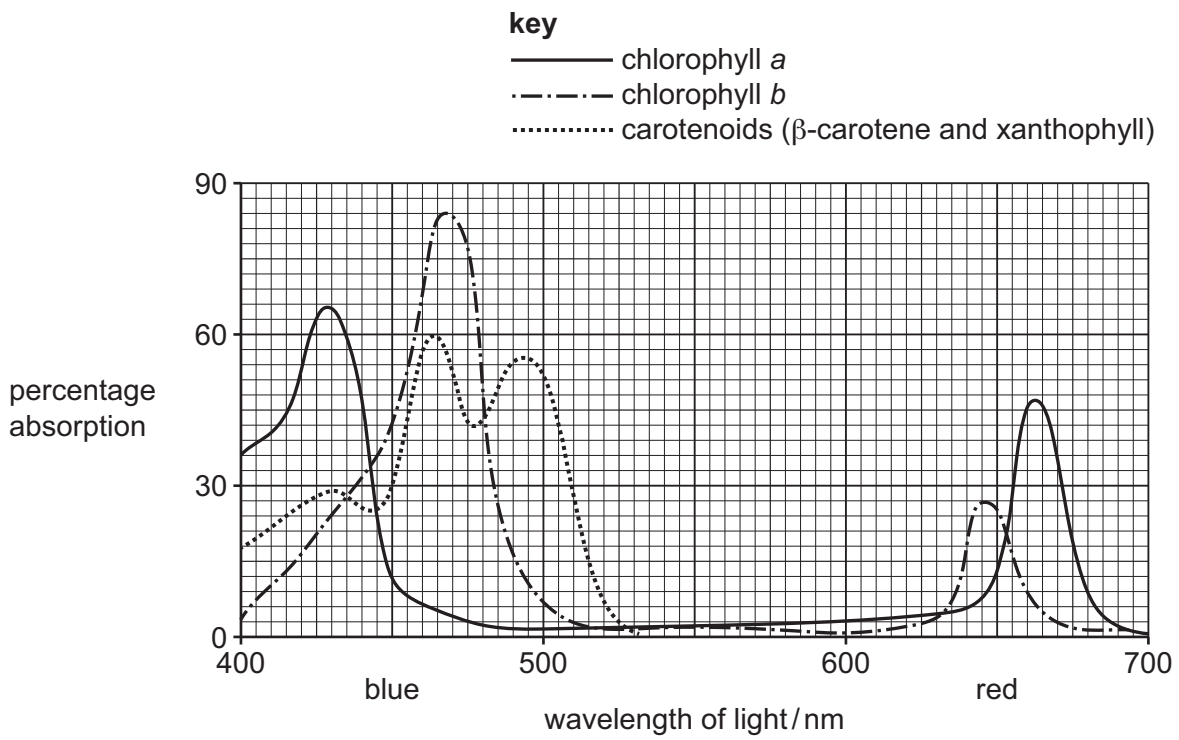


Fig. 3.2

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.

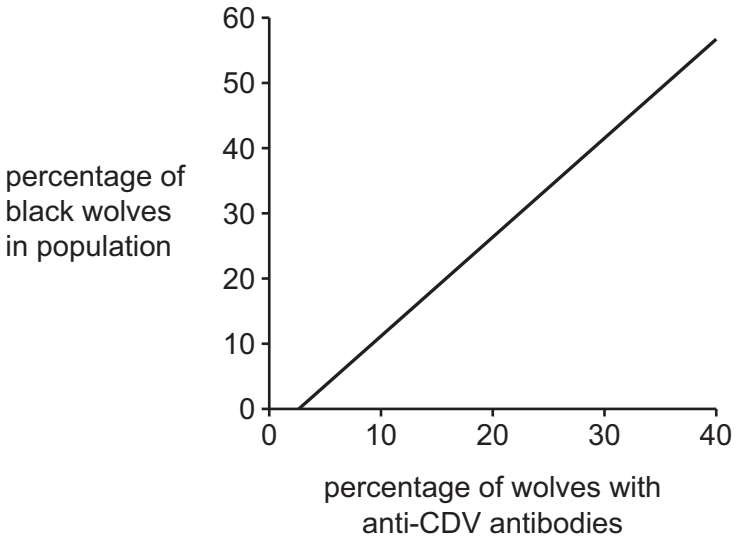


Fig. 4.1

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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[Total: 11]

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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.

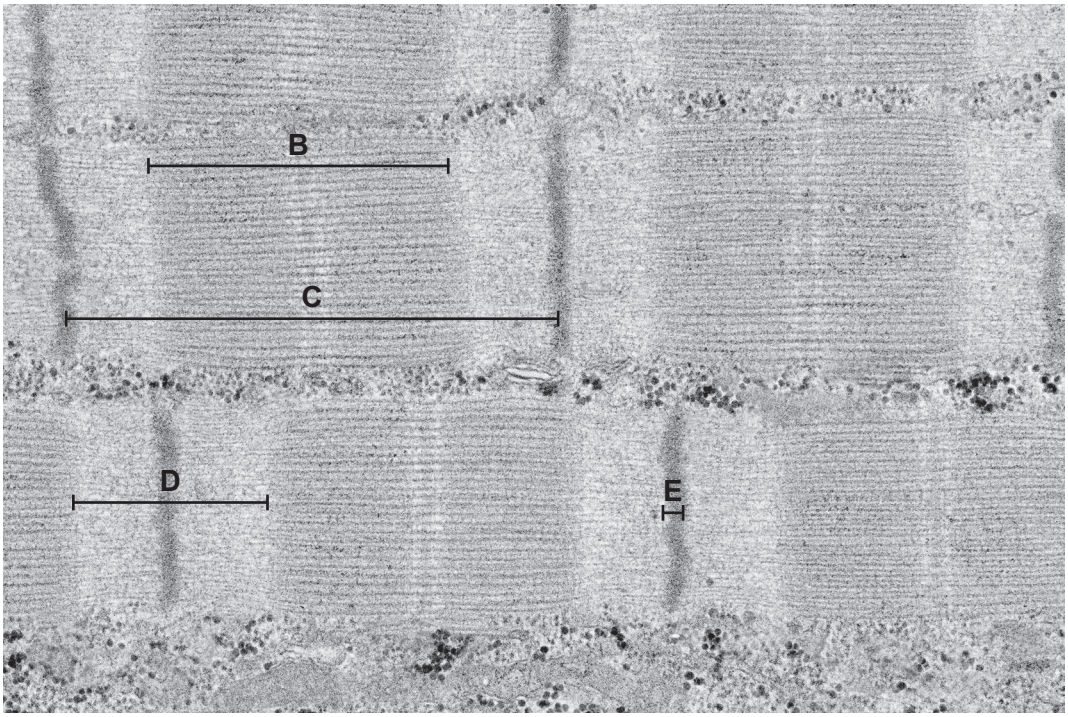


Fig. 5.1

(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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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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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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(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.

..... [1]

(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.

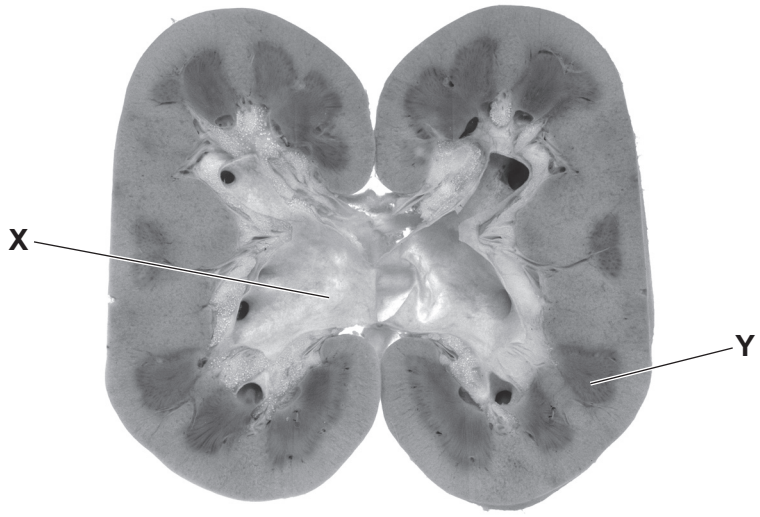


Fig. 9.1

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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