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Cambridge Assessment International Education

Cambridge International AS & A Level

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BIOLOGY **9700/41**

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

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[Turn over

1 Different species of animal have neurones with different characteristics.

(a) Fig. 1.1 is a diagram of a motor neurone of a rat and a motor neurone of a snail.

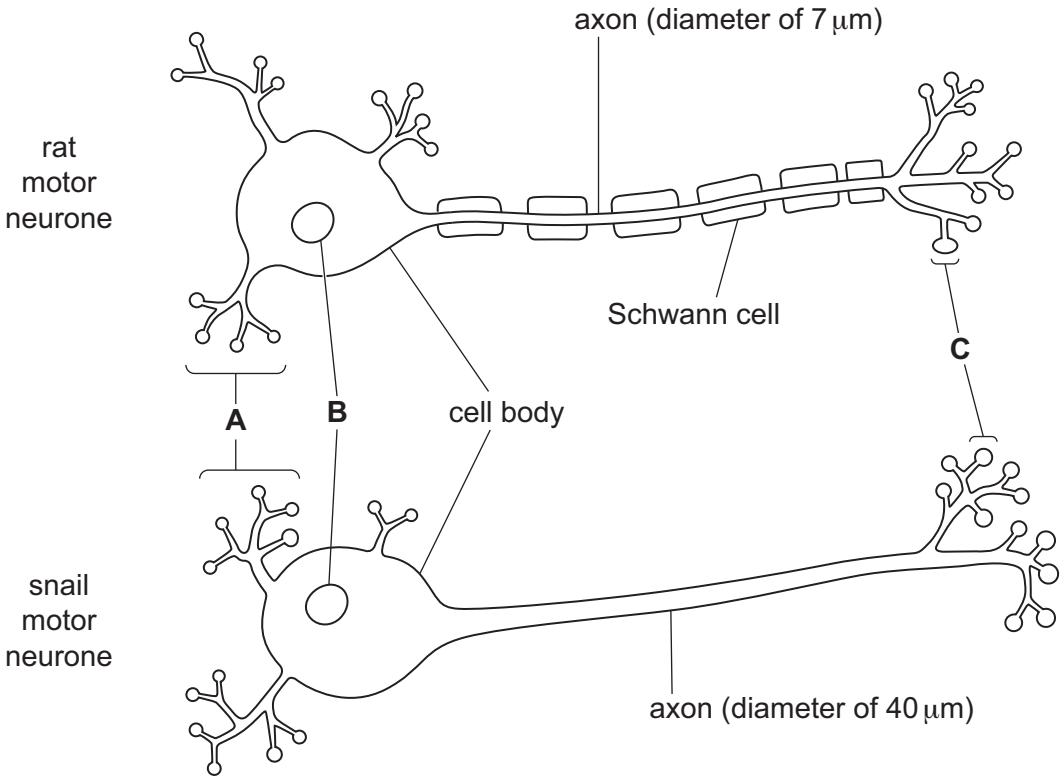


Fig. 1.1

(i) Name the structures labelled **A**, **B** and **C** on Fig. 1.1.

A .....

B .....

C .....

[3]

(ii) The rat motor neurone has an impulse transmission speed of $50\,m\,s^{-1}$. The snail motor neurone has an impulse transmission speed of $8\,m\,s^{-1}$.

Explain why the rat motor neurone has a faster impulse transmission speed than the snail motor neurone.

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(b) Fig. 1.2 shows an action potential in a rat neurone and Fig. 1.3 shows an action potential in a snail neurone.

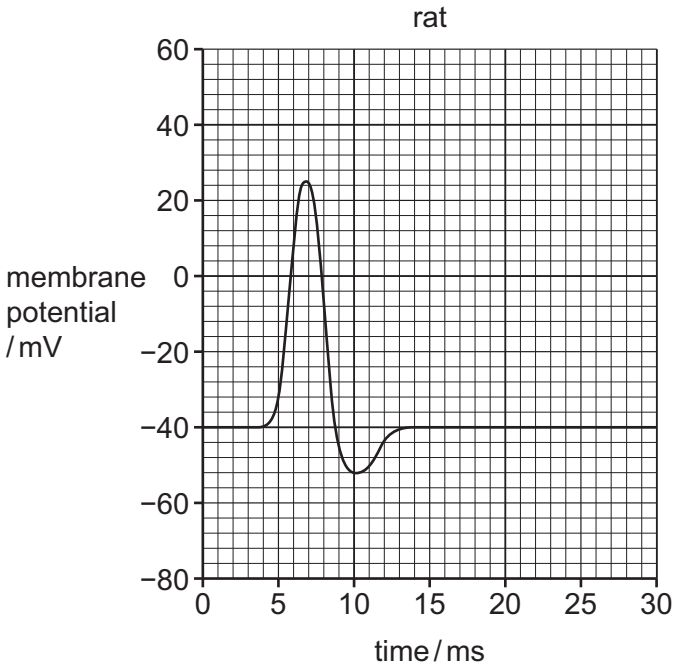


Fig. 1.2

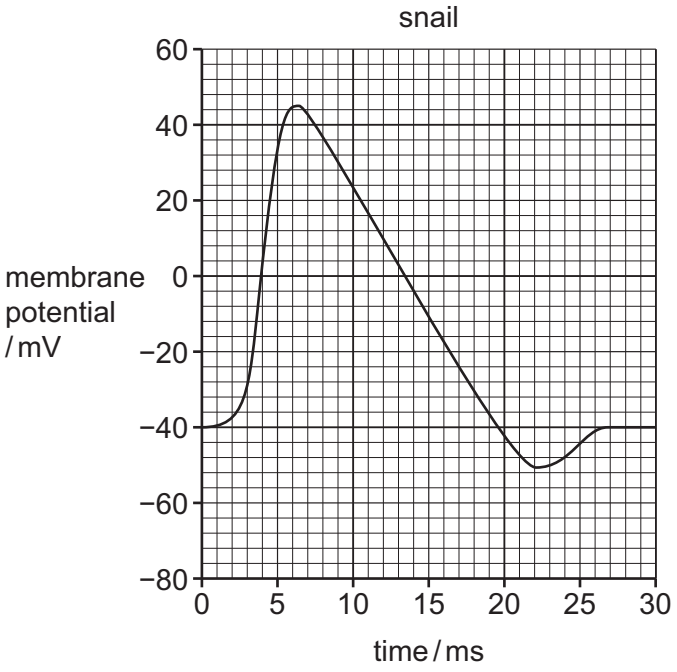


Fig. 1.3

Contrast the two action potentials shown in Fig. 1.2 and Fig. 1.3.

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2 The leaves of many plants have stomata that show a regular daily rhythm of opening and closing over a period of 24 hours.

(a) Explain why it is important for plants to open and close their stomata in a daily rhythm.

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(b) Fig. 2.1 shows the results of an experiment to monitor this rhythm over three days and nights for the plant *Arabidopsis thaliana*. The percentage of open stomata is shown. Each day consisted of 14 hours of light (white bar) and each night consisted of 10 hours of darkness (black bar).

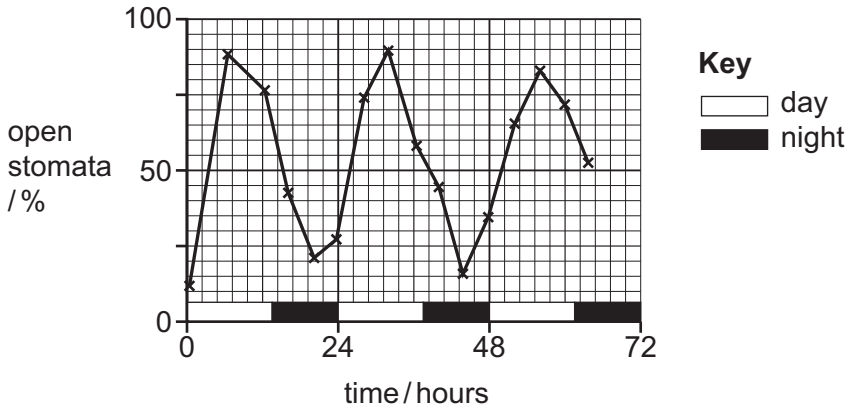


Fig. 2.1

Fig. 2.1 shows that the percentage of open stomata increases in the first seven hours of the experiment. Describe the sequence of changes that occurs in the guard cells that leads to the stomata opening.

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(c) The experiment was repeated with *A. thaliana* plants that were left in darkness from 14 to 96 hours. The results are shown in Fig. 2.2.

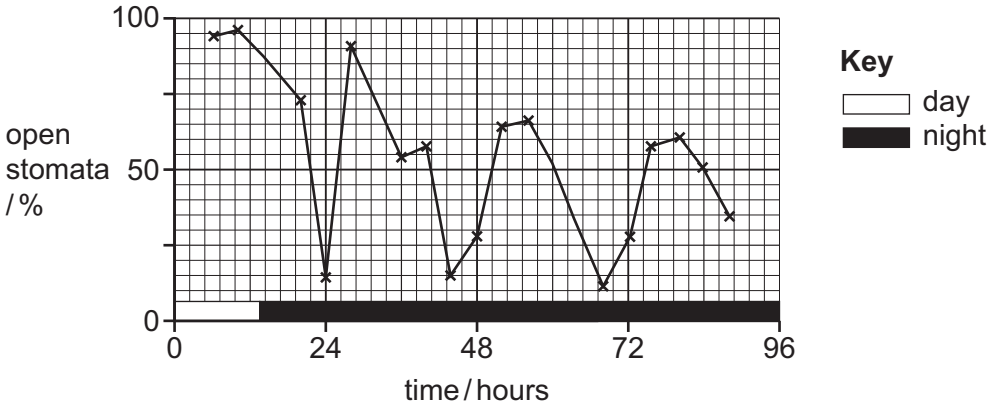


Fig. 2.2

With reference to Fig. 2.1, explain what Fig. 2.2 shows about the role of genes and the role of the environment in controlling the rhythm of stomatal opening and closing in *A. thaliana*.

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3 During aerobic respiration, cells respire substrates such as glucose to produce ATP.

Some events that occur during aerobic respiration are:

- The respiratory substrate breaks down into smaller and smaller molecules. These series of reactions are described as catabolism.
- Coenzymes take part in various reactions. In some reactions, coenzymes are reduced or oxidised.
- Carbon dioxide is released.

(a) Aerobic respiration occurs in four successive stages: glycolysis (**G**), link reaction (**LR**), Krebs cycle (**KC**) and oxidative phosphorylation (**OP**).

Complete Table 3.1 to show which events occur in each stage of aerobic respiration. Use a tick (✓) to show that the event does occur or a cross (✗) to show that the event does **not** occur.

Table 3.1

event	stage			
	G	**LR**	**KC**	**OP**
catabolism				
coenzyme is reduced or oxidised				
a coenzyme forms a covalent bond with a respiratory intermediate				
carbon dioxide is released				

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(b) A new hand-held technological device shows the main type of respiratory substrate being used in the cells of a person.

The device consists of a carbon dioxide sensor and air-flow meter. The person inhales through the device for a fixed time and then exhales into it.

The device calculates the respiratory quotient (RQ) value to show whether the cells are mainly respiring carbohydrates or lipids.

(i) Explain how the device calculates the RQ value **and** how this shows whether the cells are mainly respiring carbohydrates or lipids.

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(ii) State the difference in the relative energy values of carbohydrates and lipids as respiratory substrates, **and** explain the reasons for the difference.

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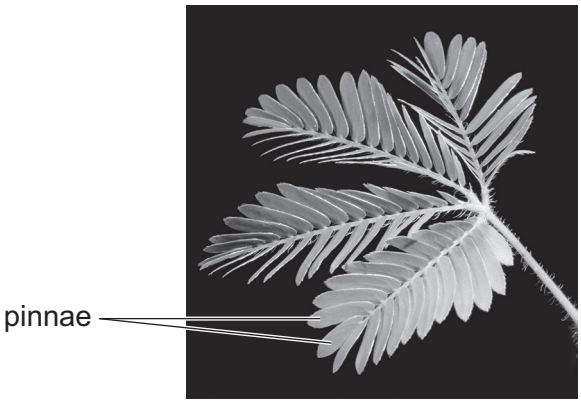
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4 The leaves of *Mimosa pudica* plants are made of a number of structures known as pinnae. The pinnae fold when the leaf is touched. This closes the leaf.

Fig. 4.1 shows an open leaf of *M. pudica* before it is touched. Fig. 4.2 shows the same leaf that has closed after being touched.



A open (not touched)

Fig. 4.1



B closed (touched)

Fig. 4.2

(a) A touch stimulus to an *M. pudica* leaf causes an action potential to be generated.

The action potential results in changes in cells, which cause the leaf to close.

Fig. 4.3 shows the mechanism in *M. pudica* cells that causes the leaf to close.

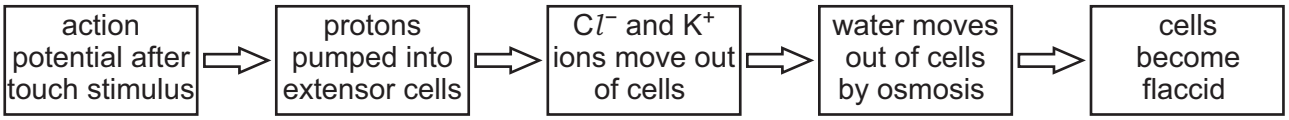


Fig. 4.3

The leaves of *M. pudica* and the leaves of Venus fly traps move in response to touch stimuli, but the mechanisms that cause the responses are different.

Describe the differences between the mechanism shown in Fig. 4.3 and the mechanism that causes the closure of the modified leaves in Venus fly traps.

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(b) The rate of photosynthesis decreases by 40% when the leaves of *M. pudica* close.

Explain why the rate of photosynthesis decreases when the leaves of *M. pudica* close.

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(c) Plants can carry out cyclic photophosphorylation and non-cyclic photophosphorylation during the light-dependent stage of photosynthesis. These processes occur at the grana of chloroplasts.

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

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[Total: 11]

5 *Lunularia cruciata* is a primitive plant. Its body consists of a flattened sheet of photosynthetic tissue called a thallus.

Fig. 5.1 shows *L. cruciata* with two different types of reproductive structure, labelled **A** and **B**, on its surface.

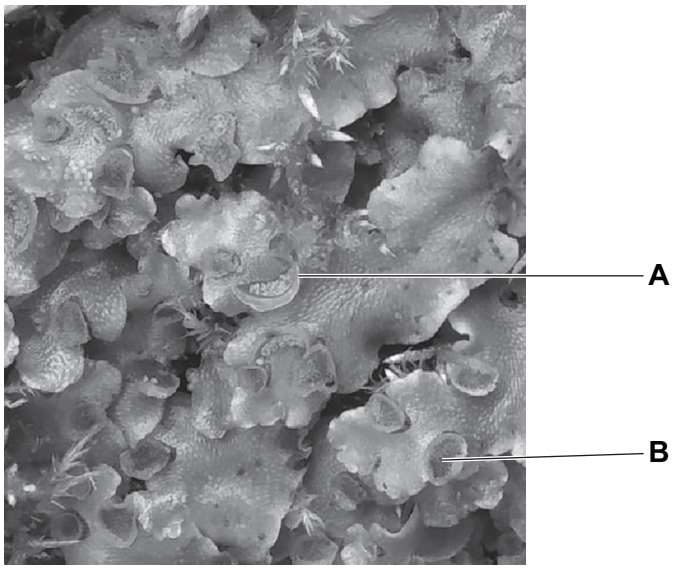


Fig. 5.1

(a) Structures **A** and **B** and the thallus of *L. cruciata* are haploid.

Explain what is meant by haploid.

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(b) Structure **A** contains pale discs of tissue, **C**, that can germinate into new *L. cruciata.* The new plants that develop from **C** are genetically identical to the parent plant in Fig. 5.1.

Structure **B** contains male sperm that are chemically attracted to swim to female eggs on a neighbouring parent plant. When the egg and sperm fuse, they form structure **D**. Structure **D** develops to produce spores that grow into new plants that are genetically different from the two parent plants.

Identify which of the structures **A**, **B**, **C** and **D** are:

associated with sexual reproduction ……

produced by mitosis ……

the site of meiosis ……

Each letter may be used once, more than once, or not at all. [3]

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(c) Fig. 5.2 shows a horse, *Equus caballus*. Horses are diploid animals that reproduce sexually. Male and female horses produce gametes, which fuse to form genetically different offspring.



Fig. 5.2

Explain the need for a reduction division during meiosis in the production of gametes in animals such as horses.

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6 The mammalian kidney is responsible for:

- the excretion of urea
- osmoregulation (the homeostatic control of the water potential of the blood).

(a) (i) Outline how **and** where the excretory product urea is made in the body.

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(ii) Homeostatic control of the water potential of blood includes receptors, effectors and target cells.

Identify the names **and** locations of these components of homeostatic control in osmoregulation.

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(b) The glomerulus and Bowman's capsule of the nephron are important in the formation of urine.

Outline the role of the glomerulus and Bowman's capsule in the formation of urine.

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(c) Concentrated urine contains a high concentration of solutes and a small volume of water. Different species of mammals vary in their ability to produce urine with a high solute concentration.

Table 6.1 compares the ratio of the solute concentration of urine (U) to the solute concentration of blood plasma (P) in some mammal species. The habitats of the mammal species are also shown.

Table 6.1

mammal species	maximum ratio of solute concentration of urine to solute concentration of blood plasma (U : P)	habitat
beaver	1.7 : 1	rivers and lakes
human	4.5 : 1	variable
camel	8.0 : 1	desert
rat	9.0 : 1	variable
kangaroo rat	16.0 : 1	desert

With reference to Table 6.1, suggest what the different values of U : P show about the ability of these mammal species to tolerate a shortage of water in their environment.

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[Total: 11]

7 *Spea multiplicata* is one of several species of American spadefoot toad.

(a) Young spadefoot toads are called tadpoles and live in water in ponds.

S. multiplicata tadpoles show three different phenotypes due to genetic variation. The three phenotypes are: detritus feeder, intermediate and carnivore.

Detritus feeders are small, and carnivores are large. Intermediates vary in size between the two extremes.

A detritus feeder and a carnivore are shown in Fig. 7.1.



Fig. 7.1

Detritus feeders:

- eat detritus (small pieces of dead organic matter) and algae (photosynthetic protoctists)
- have smooth mouthparts, small jaw muscles and long intestines.

Intermediates:

- can eat all available food (detritus, algae and fairy shrimps)
- have teeth-like mouthparts, medium-sized jaw muscles and medium-sized intestines.

Carnivores:

- eat fairy shrimps and other small animals
- have teeth-like mouthparts, large jaw muscles and short intestines.

Scientists counted the number of each type of tadpole in two different ponds: pond 1 and pond 2.

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(i) In pond 1, the scientists observed:

- a high density of tadpoles
- a low abundance of food
- that most of the tadpoles they counted were either detritus feeders or carnivores, with very few intermediates present.

Describe **and** suggest explanations for the type of natural selection that appears to be acting in pond 1.

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(ii) In pond 2, the scientists observed:

- a low density of tadpoles
- sufficient food availability for all tadpoles
- that most of the tadpoles they counted were intermediates, with fewer detritus feeders or carnivores.

Describe **and** suggest explanations for the type of natural selection that appears to be acting in pond 2.

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(iii) The intestine length of *S. multiplicata* tadpoles shows continuous variation.

Sketch a curve on Fig. 7.2 to show how intestine length varies in the tadpole population in **pond 2**.

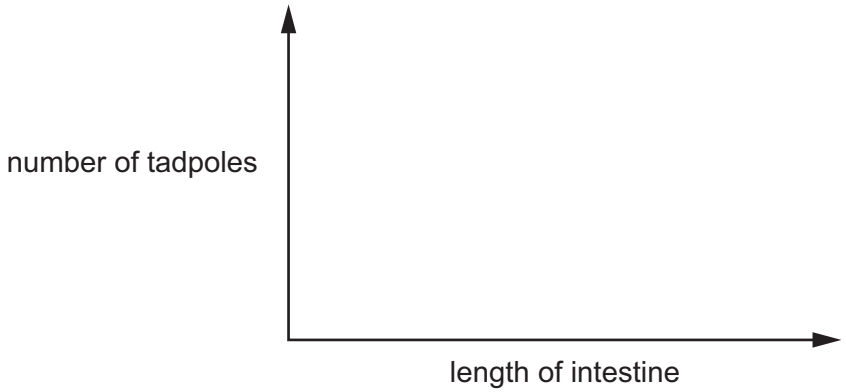


Fig. 7.2

[1]

(iv) A student suggested that the variation in *S. multiplicata* tadpoles could lead to sympatric speciation in some populations.

Outline the features of sympatric speciation.

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(b) Fig. 7.3 shows the evolutionary relationships between three species of American spadefoot toad.

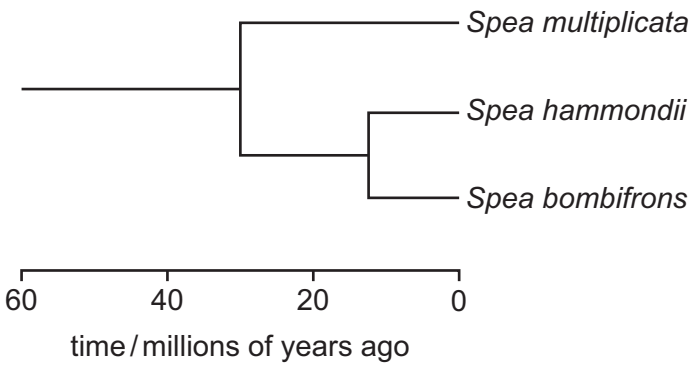


Fig. 7.3

Explain how analysis of DNA allowed the evolutionary relationships shown in Fig. 7.3 to be determined.

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8 Scientists use many different techniques in genetic engineering.

(a) Sometimes the gene for genetic engineering cannot be extracted from the donor organism. Instead, the gene is synthesised using one of two different methods.

Outline the **two** methods for synthesising a gene for use in genetic engineering.

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(b) DNA ligase and DNA polymerase are two enzymes that are used in genetic engineering.

Complete Table 8.1 to show the roles of DNA ligase and DNA polymerase in genetic engineering.

Use a tick (✓) if the enzyme has the role or a cross (✗) if the enzyme does **not** have the role.

Table 8.1

role in genetic engineering	DNA ligase	DNA polymerase
joins two sections of sugar phosphate backbone in DNA		
adds a gene to a plasmid		
adds free activated DNA nucleotides to a polynucleotide		

[3]

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(c) The polymerase chain reaction (PCR) is used to make many copies of a gene.

Three temperatures are used in a PCR cycle.

State the three temperatures that are used, **and** outline what happens at each temperature during a PCR cycle.

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9 Lichens are found growing on trees, walls, rocks and soil.

Fig. 9.1 shows a lichen of the genus *Usnea. Usnea* can tolerate only low concentrations of sulfur dioxide and does not grow in places where the air is polluted with sulfur dioxide.

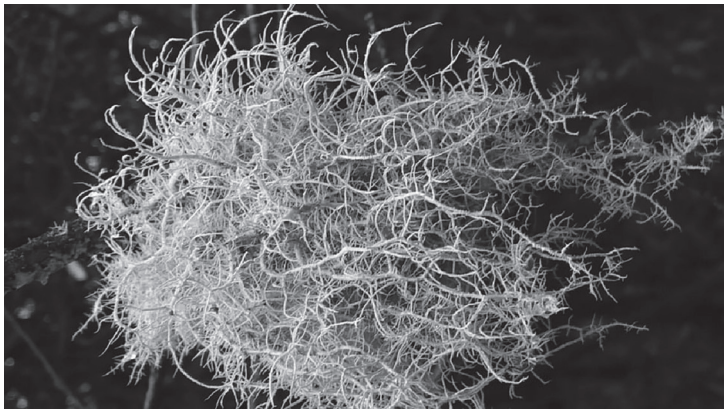


Fig. 9.1

Usnea is composed of a mixture of two types of cell:

- photosynthetic cells that are classified in the kingdom Protoctista
- fungal cells that are classified in the kingdom Fungi.

(a) Outline the characteristic features of the kingdoms Protoctista and Fungi.

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(b) *Xanthoria* is a lichen that can grow in places where there is a high concentration of sulfur dioxide in the air, for example in towns where homes, factories and vehicles burn fuels.

Fig. 9.2 shows a lichen of the genus *Xanthoria*.

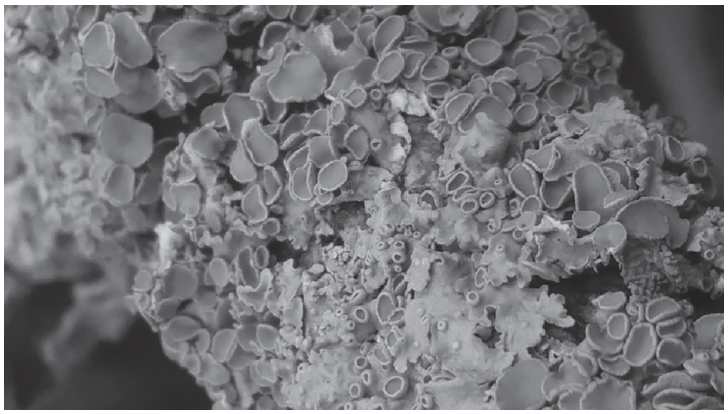


Fig. 9.2

(i) A student planned a method to measure the relative abundance of *Usnea* and *Xanthoria* on trees along a transect from the town centre at 0 km to unpolluted countryside at 4 km.

Suggest why measuring the relative abundance of the two types of lichen gives information that is useful for conservation.

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(ii) Although a large biodiversity of lichens can be found in a range of habitats, most people ignore them.

Outline why forms of life that are usually ignored, such as lichens, should be conserved.

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10 Populations of the moth *Biston betularia* live in Europe and in North America. The most common phenotype on both continents is a pale wing colour with light-grey shading (the typical form).

A moth phenotype with dark wing colour (the melanic form) also occurs on both continents.

Fig. 10.1 shows the typical form of the moth.

Fig. 10.2 shows the melanic form of the moth.



Fig. 10.1



Fig. 10.2

(a) Two melanic European moths were crossed together. The wing colours of the offspring were 15 typical and 41 melanic.

Construct a genetic diagram to explain these results. You may use the symbols **A** and **a** to represent the alleles.

[3]

(b) In a similar experiment, two melanic North American moths were crossed together. The colours of the offspring were 10 typical and 31 melanic.

What can be concluded about the allele that causes the melanic form in the moth populations in **both** continents?

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(c) Researchers did not know if the allele causing the melanic form in European moths occurred at the same locus as the allele causing the melanic form in North American moths. To find out, they carried out the following crosses:

- Cross 1: European moths that were heterozygous at the European melanic locus only were crossed with North American moths that were heterozygous at the North American melanic locus only.
- Cross 2: The melanic and the typical offspring of cross 1 were mated together.

(i) Explain why cross 2 is a test cross.

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..... [1]

(ii) Complete Table 10.1 to show the predicted results if:

- the European and North American melanic alleles are on **the same locus (A/a)**
- the European and North American melanic alleles are on two **different loci (A/a** and **B/b)**.

Table 10.1

	same locus (A/a)	**different loci (A/a and B/b)**
genotypes of **melanic** moths from cross 1		
proportion of test crosses (cross 2) giving 100% melanic offspring		

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(d) A light trap was used to estimate the total size of a population of *B. betularia* in a woodland. On night one, 24 moths were captured. These were marked with a small spot of harmless paint. On night two, 29 moths were captured, and 8 of these showed a spot of paint.

Use the Lincoln index formula provided to calculate the size of the population.

Show your working.

$$N = \frac{n_1 \times n_2}{m_2}$$

Key to symbols:
N = estimate of population size
n_1 = number of individuals captured in first sample
n_2 = number of individuals (both marked and unmarked) captured in second sample
m_2 = number of marked individuals recaptured in second sample

population size = ... [2]

[Total: 10]

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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

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BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **October/November 2024**

2 hours

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1 **(a)** Fig. 1.1 is a diagram of part of a Bowman's capsule and a glomerular capillary.

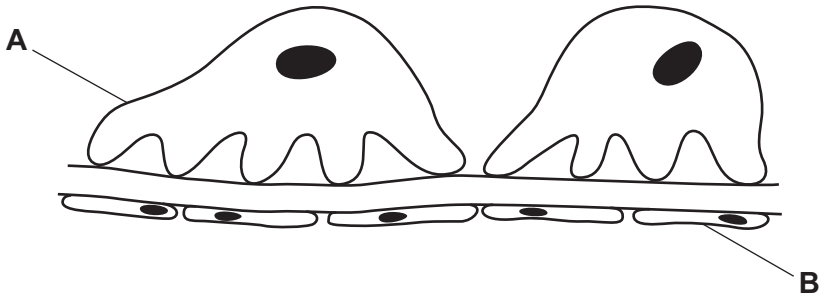


Fig. 1.1

(i) Identify structures **A** and **B**.

A .....

B .....
[2]

(ii) The glomerular filtrate is produced in the Bowman's capsule by the process of ultrafiltration.

State the conditions required for ultrafiltration.

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(b) As the newly formed glomerular filtrate passes along the proximal convoluted tubule, selective reabsorption takes place. The fluid remaining in the proximal convoluted tubule eventually forms urine.

Table 1.1 lists three of the components of blood plasma that enter the glomerulus in a healthy person.

Complete Table 1.1 by writing:

- **increased**, if the component is present and is higher in concentration than in blood plasma
- **decreased**, if the component is present and is lower in concentration than in blood plasma
- **same**, if the component is present and is of the same concentration as blood plasma
- **not present**, if the component is absent.

You may use each response once, more than once or not at all.

Table 1.1

component of blood plasma entering glomerulus	component in newly formed glomerular filtrate	component in urine
glucose		
large plasma proteins		
urea		

[3]

(c) Sweating during exercise can lead to a response in the posterior pituitary gland and in the kidney.

State the response to sweating that occurs in the posterior pituitary gland **and** the response that occurs in the kidney.

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[Total: 9]

2 Several different processes can affect allele frequencies in populations.

(a) Outline the processes that may affect allele frequencies in wildlife populations.

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(b) The process of selective breeding changes allele frequencies in a population. Plant breeders use selective breeding to improve crop plants such as maize.

Explain how selective breeding can be used to obtain a variety of maize where the plants are vigorous and of uniform height.

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3 The treatment of many diseases has been improved by the use of genetic technology in medicine.

(a) Explain what is meant by genetic engineering.

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(b) **(i)** Leber Congenital Amaurosis (LCA) is an inherited eye disease. In LCA, the photoreceptor cells in the retina die at an early age. This causes impaired vision (reduced eyesight) in children, which can progress to blindness.

Mutations in different genes cause different forms of LCA. One form of this disease, LCA2, is caused by a mutation in the *RPE65* gene. Gene therapy has been used to treat LCA2.

Outline how an inherited eye disease, such as LCA2, is treated with gene therapy.

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(ii) Suggest why the eye is a suitable organ for gene therapy.

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(c) LCA10 is a different form of LCA caused by a recessive mutation in the *CEP290* gene. This gene codes for the protein CEP290, which is involved in the correct functioning of photoreceptor cells in the retina.

The mutation in *CEP290* causes an error to be made when the primary transcript is spliced to form messenger RNA (mRNA). The abnormal mRNA that is formed has an extra sequence of RNA nucleotides, known as exon X, between exon 26 and exon 27. Exon X contains a STOP codon.

Fig. 3.1 compares the effect of the mutation in *CEP290* with the normal gene expression.

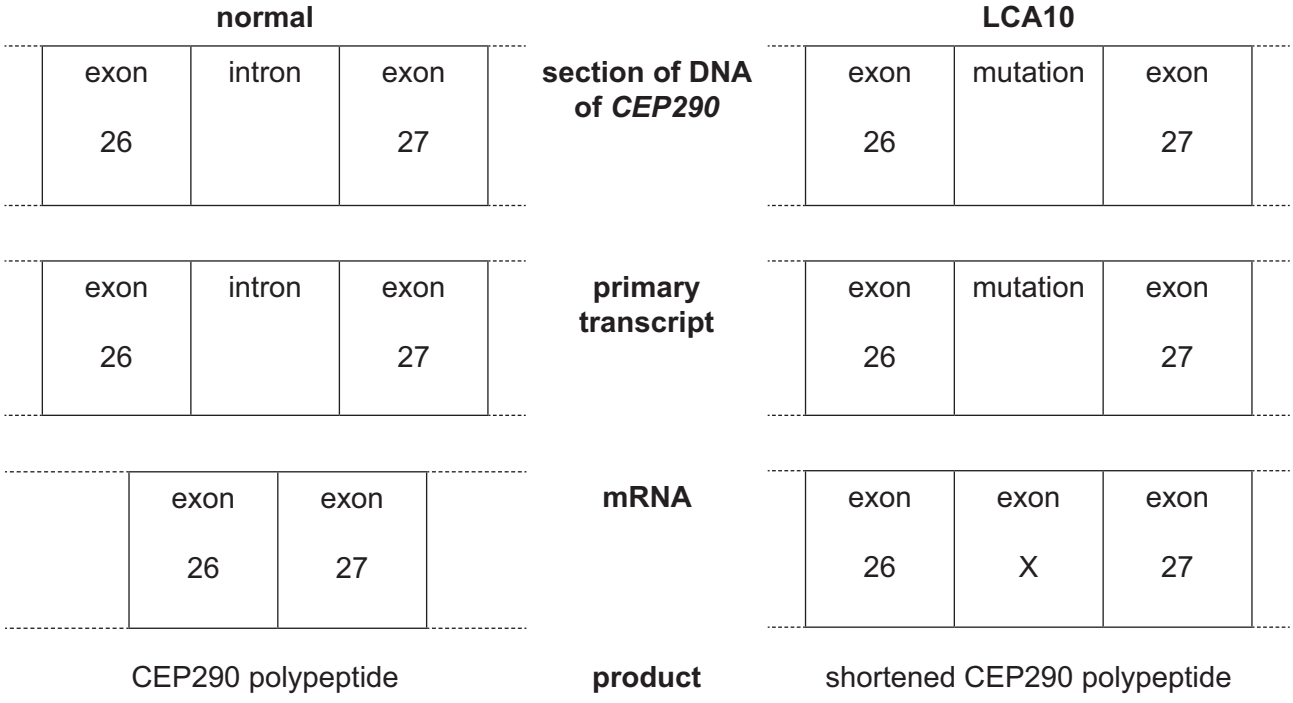


Fig. 3.1

In 2022, research was carried out into possible treatment of LCA10 using genetic technology.

(i) A human clinical trial investigated a treatment of LCA10 using a short RNA nucleotide sequence known as Sepofarsen.

Sepofarsen binds to the section of the primary transcript containing the *CEP290* mutation so that normal splicing occurs and functional CEP290 protein is synthesised.

- People in the clinical trial received regular treatment with Sepofarsen to the eye with the greatest loss of vision (treated eye) for a period of 12 months.
- Changes in the light perception (visual acuity) of both eyes were measured using a vision chart.
- A negative change in the visual acuity score shows an improvement in visual acuity.

Fig. 3.2 shows the results of the clinical trial over 12 months.

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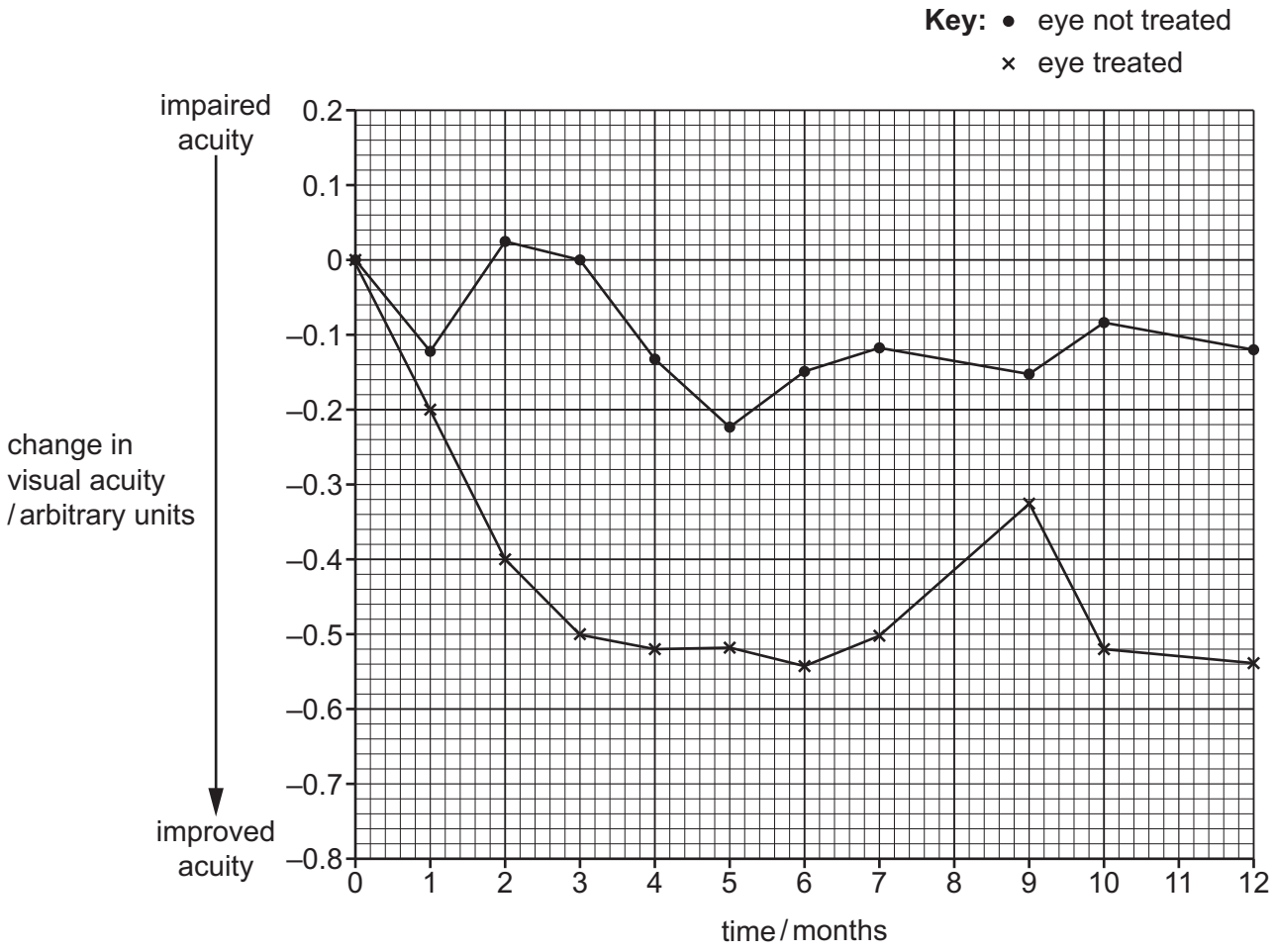


Fig. 3.2

Describe the results of the clinical trial data shown in Fig. 3.2.

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(ii) Another method being investigated to treat LCA10 is to use a gene editing tool known as the CRISPR/Cas9 system.

The CRISPR/Cas9 system uses a short length of RNA called guide RNA. Guide RNA is complementary to the target DNA and is linked to a nuclease enzyme called Cas9. Cas9 breaks phosphodiester bonds in DNA.

The cell repair mechanisms repair the cut in DNA after the modification has taken place.

- A vector delivers Cas9 and two specific guide RNAs to the photoreceptor cells.
- They act on the section of DNA which contains the mutation.
- Exon X is no longer added to the mRNA.

Explain how this method used to treat LCA10 is an example of gene editing.

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Question 4 starts on page 10

4 Genetic crosses can be used to investigate patterns of inheritance.

(a) A mutation in a gene involved in fruit colour in tomato plants, *Solanum lycopersicum*, results in the production of yellow fruits instead of red fruits.

A genetic cross was carried out between a pure breeding plant with a red fruit and a pure breeding plant with a yellow fruit to produce the F1 generation. All offspring plants produced red fruits.

The F1 plants were then crossed with each other and the seeds produced were planted to obtain the F2 generation.

Construct a genetic diagram to show the cross of the F1 generation that produced this F2 generation.

Use the symbols **R** and **r** for the alleles.

[3]

(b) A theoretical dihybrid cross involves two genes located on different autosomes. Each gene has two alleles, one dominant and one recessive.

A parent, homozygous dominant for both genes, is crossed with a parent that is homozygous recessive for both genes. This produces F1 individuals that are then crossed to produce the F2 generation.

State the phenotypic ratio of this dihybrid F2 generation **and** explain why some of these offspring phenotypes are different from the original parental phenotypes.

ratio .....

explanation .....

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[Total: 6]

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5 Phenotypic variation exists in natural populations. There are many causes of variation. Natural selection determines which phenotypes are advantageous.

(a) Variation in a particular characteristic can be described as either discontinuous or continuous.

Table 5.1 contains a list of statements that apply to discontinuous variation, continuous variation or both.

Complete both columns of Table 5.1. Put a tick (✓) in the box if the statement applies and leave the box empty if the statement does not apply.

Table 5.1

statement	discontinuous variation	continuous variation
often involves one gene only		
environmental factors may affect gene expression		
there is an additive effect of genes that contributes to the phenotype		
there are distinct differences between the various forms of a characteristic		

[4]

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(b) There is variation in the quantity of vitamin D stored in the body.

Vitamin D has an important role in keeping bones healthy. The main storage form of vitamin D in the body is serum 25-hydroxyvitamin D (serum 25-OHD).

A study was carried out on 262 healthy women to investigate if the concentration of serum 25-OHD varied between summer and winter. The women had taken no vitamin D supplements. The age range of the women in the sample was 40 to 72 years old.

Table 5.2 shows the results of the study.

Table 5.2

group	mean concentration of serum 25-OHD / ng cm^{-3}	standard deviation
sampled during summer n = 138	32.7	7.6
sampled during winter n = 124	28.5	8.3
whole sample n = 262	30.7	8.2

Additional analysis showed that there was no significant correlation between age and serum 25-OHD concentration.

(i) Explain what is meant by standard deviation.

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..... [1]

(ii) The *t*-test was used to compare the mean concentration of serum 25-OHD when sampled during the summer with the mean concentration of serum 25-OHD when sampled during the winter, as shown in Table 5.2.

Calculate the value of *t* using the formula provided.

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

key to symbols:
$\bar{x}$ = mean
s = sample standard deviation
n = sample size (number of observations)

Give your answer to **four** significant figures.

There is space for your working.

t-test value ..... [3]

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(iii) The critical value at the 0.0001 probability level is 3.773.

State the conclusion that can be made about the results of the study shown in Table 5.2 **and** explain how the result of your calculation in **(b)(ii)** can be used to support this conclusion.

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(iv) Suggest the likely **causes** of variation in quantity of vitamin D stored in the body in this sample of women.

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6 **(a)** DCPIP is an indicator and can be used to determine the rate of respiration of organisms such as yeast.

(i) State the category of indicators to which DCPIP belongs.

..... [1]

(ii) Describe the colour change that occurs in DCPIP during experiments to determine the rate of respiration.

..... [1]

(b) An investigation was carried out to determine the effect of temperature on the rate of respiration of yeast.

- A suspension of yeast cells was added to a test-tube containing glucose solution.
- A further four test-tubes were set up in the same way.
- One test-tube was placed in a water-bath at 10 °C for 5 minutes.
- DCPIP was added to the test-tube and the time taken for the DCPIP to change colour was measured.
- The experiment was repeated using the other test-tubes at 20 °C, 30 °C, 40 °C and 50 °C.

The results are shown in Fig. 6.1.

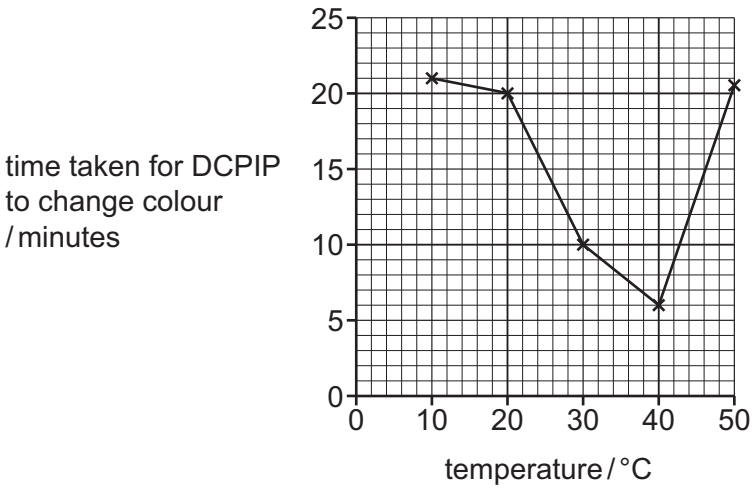


Fig. 6.1

(i) State **two** variables that need to be kept constant in this experiment.

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(ii) Explain the results shown in Fig. 6.1.

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7 **(a)** Paper chromatography is a technique that can be used to separate and identify different chloroplast pigments.

Describe how the **results** of paper chromatography can be used to identify chloroplast pigments.

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(b) Carotene and xanthophyll are chloroplast pigments.

Describe the role played by these pigments in photosynthesis.

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(c) The light-dependent stage of photosynthesis produces ATP and reduced NADP, which are used in the light-independent stage.

Describe the **light-independent** stage of photosynthesis.

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

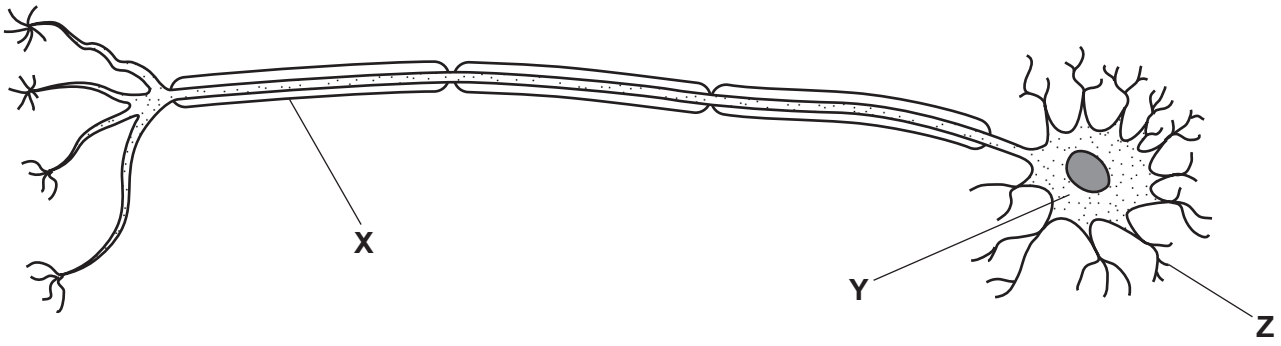


Fig. 8.1

(i) Name cell **X** and part **Y**.

X .....

Y .....

[2]

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

..... [1]

(b) Table 8.1 shows some of the events that occur during muscle contraction.

They are **not** listed in the correct order.

Table 8.1

event	description of event
A	calcium ions diffuse out of sarcoplasmic reticulum
B	myosin heads bind to actin
C	sarcolemma depolarised
D	sarcomere shortens
E	calcium ions bind to troponin
F	T-tubule system membranes depolarised
G	binding sites on actin exposed
H	myosin heads tilt
I	tropomyosin moves
J	troponin changes shape

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Complete Table 8.2 to show the correct order of the events that occur during muscle contraction. Two of the events have been completed for you.

Table 8.2

correct order	letter of event
1	.....
2	.....
3	.....
4	.....
5	**J**
6	.....
7	.....
8	.....
9	.....
10	**D**

[4]

(c) Lambert-Eaton myasthenic syndrome (LEMS) is a rare disorder of the neuromuscular junction. A person with LEMS produces antibodies that bind to the voltage-gated calcium channels on the presynaptic knob. One symptom of LEMS is weaker muscle contraction.

Suggest **and** explain why LEMS leads to weaker muscle contraction.

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9 The red ruffed lemur, *Varecia rubra*, is a mammal found only in the rainforests of the Masoala region in north east Madagascar.

Fig. 9.1 shows a red ruffed lemur.



Fig. 9.1

(a) The International Union for Conservation of Nature (IUCN) Red List of Threatened Species™ states that the red ruffed lemur is critically endangered.

Suggest why the red ruffed lemur has become critically endangered.

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(b) Many zoos around the world operate captive breeding programmes for the red ruffed lemur.

Fig. 9.2 shows the numbers of captive-born red ruffed lemurs in North American zoos from 1970 to 2020.

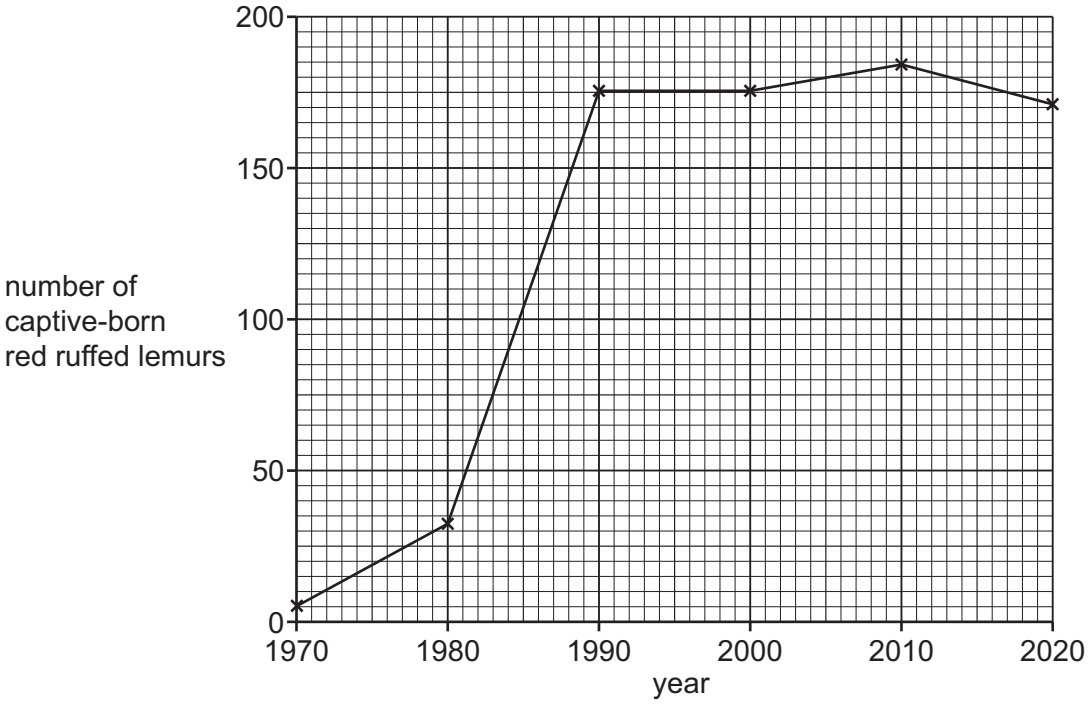


Fig. 9.2

Describe the results shown in Fig. 9.2.

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(c) Captive breeding programmes for endangered mammals such as the red ruffed lemur can vary in their success rate.

(i) Suggest problems that may affect the success of captive breeding programmes of mammals like the red ruffed lemur.

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(ii) Occasionally, wild-caught red ruffed lemurs are introduced into captive breeding programmes.

Suggest why this is done.

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10 (a) Blood glucose concentration is maintained around a set point by homeostasis.

Explain the principles of homeostasis.

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(b) Glycogen phosphorylase catalyses the conversion of glycogen to glucose in liver cells. The production of glycogen phosphorylase is coded for by the gene *PYGL*.

A mutation in *PYGL* leads to a condition called glycogen storage disease type VI (GSDVI), in which glycogen is not broken down efficiently.

Suggest **and** explain why cell signalling by glucagon is likely to be affected in the liver cells of a person with GSDVI.

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(c) Glycogen synthase catalyses the conversion of glucose to glycogen in liver cells. The production of glycogen synthase is coded for by the gene *GYS2*.

A mutation in *GYS2* leads to a condition called glycogen storage disease type 0 (GSD0) in which glycogen is not formed efficiently.

Suggest what the consequences would be if a person with GSD0 has a meal rich in glucose.

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BIOLOGY **9700/43**

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

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[Turn over

1 Different species of animal have neurones with different characteristics.

(a) Fig. 1.1 is a diagram of a motor neurone of a rat and a motor neurone of a snail.

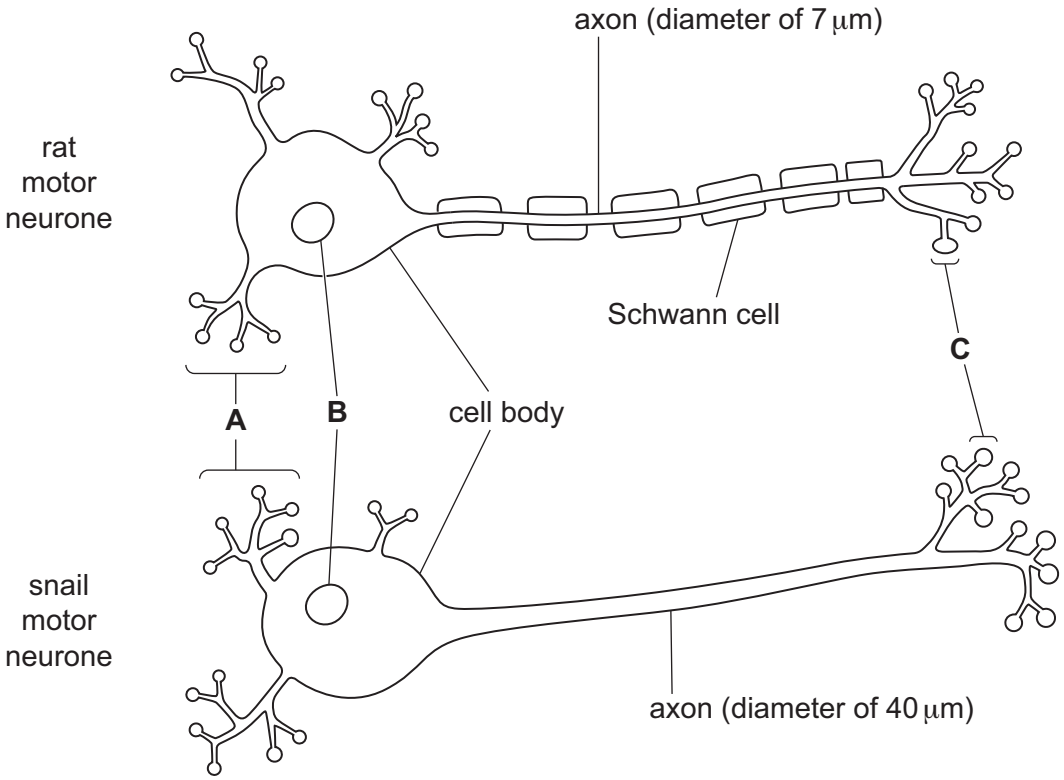


Fig. 1.1

(i) Name the structures labelled **A**, **B** and **C** on Fig. 1.1.

A .....

B .....

C .....

[3]

(ii) The rat motor neurone has an impulse transmission speed of $50\,m\,s^{-1}$. The snail motor neurone has an impulse transmission speed of $8\,m\,s^{-1}$.

Explain why the rat motor neurone has a faster impulse transmission speed than the snail motor neurone.

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(b) Fig. 1.2 shows an action potential in a rat neurone and Fig. 1.3 shows an action potential in a snail neurone.

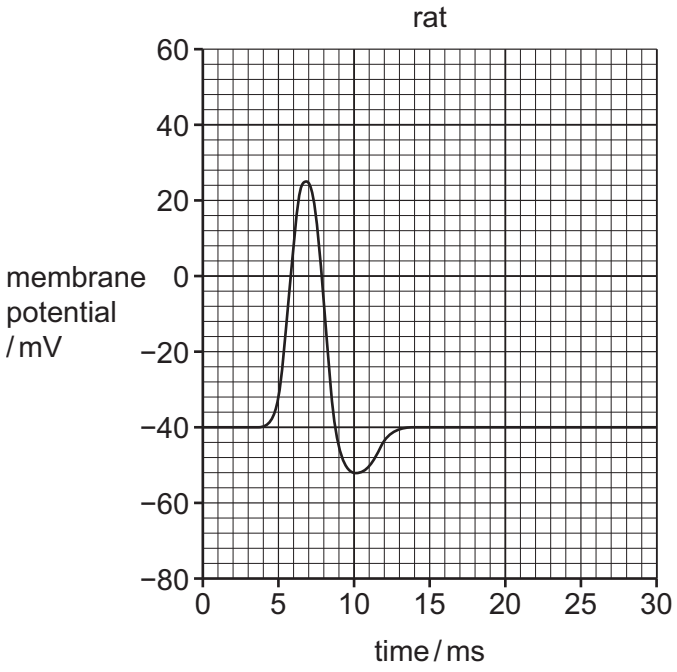


Fig. 1.2

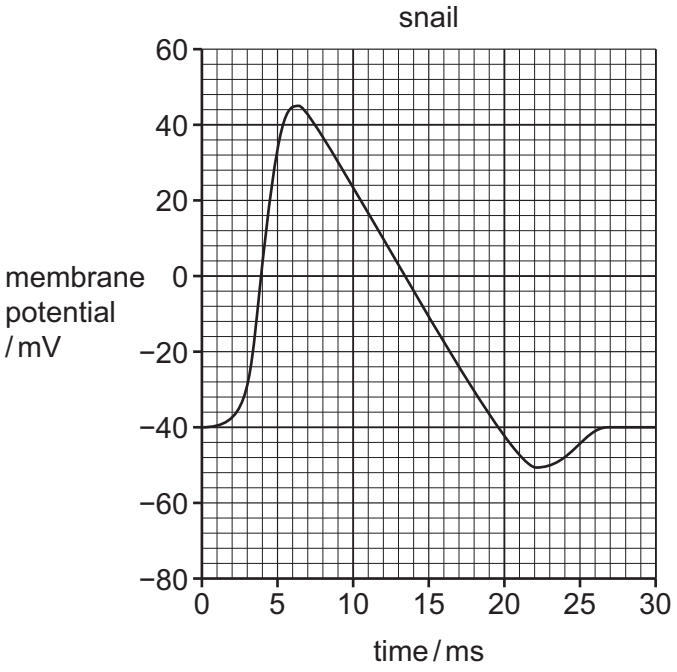


Fig. 1.3

Contrast the two action potentials shown in Fig. 1.2 and Fig. 1.3.

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2 The leaves of many plants have stomata that show a regular daily rhythm of opening and closing over a period of 24 hours.

(a) Explain why it is important for plants to open and close their stomata in a daily rhythm.

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(b) Fig. 2.1 shows the results of an experiment to monitor this rhythm over three days and nights for the plant *Arabidopsis thaliana*. The percentage of open stomata is shown. Each day consisted of 14 hours of light (white bar) and each night consisted of 10 hours of darkness (black bar).

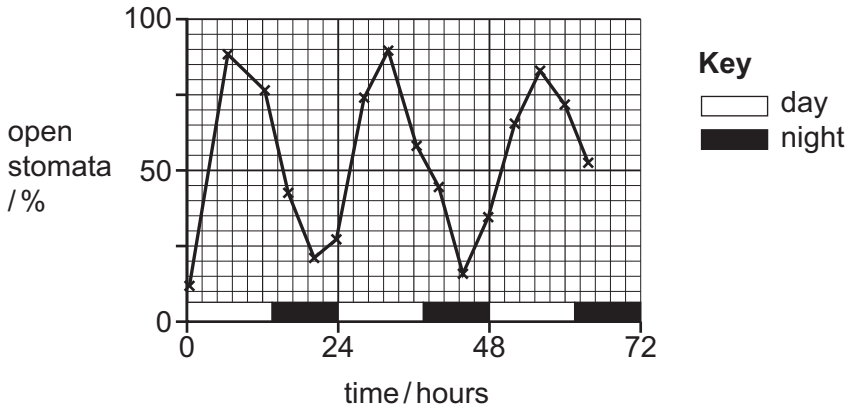


Fig. 2.1

Fig. 2.1 shows that the percentage of open stomata increases in the first seven hours of the experiment. Describe the sequence of changes that occurs in the guard cells that leads to the stomata opening.

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(c) The experiment was repeated with *A. thaliana* plants that were left in darkness from 14 to 96 hours. The results are shown in Fig. 2.2.

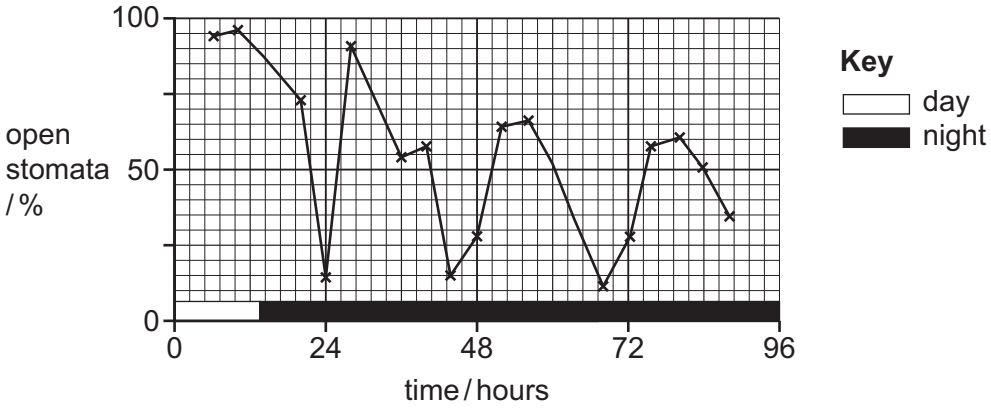


Fig. 2.2

With reference to Fig. 2.1, explain what Fig. 2.2 shows about the role of genes and the role of the environment in controlling the rhythm of stomatal opening and closing in *A. thaliana*.

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3 During aerobic respiration, cells respire substrates such as glucose to produce ATP.

Some events that occur during aerobic respiration are:

- The respiratory substrate breaks down into smaller and smaller molecules. These series of reactions are described as catabolism.
- Coenzymes take part in various reactions. In some reactions, coenzymes are reduced or oxidised.
- Carbon dioxide is released.

(a) Aerobic respiration occurs in four successive stages: glycolysis (**G**), link reaction (**LR**), Krebs cycle (**KC**) and oxidative phosphorylation (**OP**).

Complete Table 3.1 to show which events occur in each stage of aerobic respiration. Use a tick (✓) to show that the event does occur or a cross (✗) to show that the event does **not** occur.

Table 3.1

event	stage			
	G	**LR**	**KC**	**OP**
catabolism				
coenzyme is reduced or oxidised				
a coenzyme forms a covalent bond with a respiratory intermediate				
carbon dioxide is released				

[4]

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(b) A new hand-held technological device shows the main type of respiratory substrate being used in the cells of a person.

The device consists of a carbon dioxide sensor and air-flow meter. The person inhales through the device for a fixed time and then exhales into it.

The device calculates the respiratory quotient (RQ) value to show whether the cells are mainly respiring carbohydrates or lipids.

(i) Explain how the device calculates the RQ value **and** how this shows whether the cells are mainly respiring carbohydrates or lipids.

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(ii) State the difference in the relative energy values of carbohydrates and lipids as respiratory substrates, **and** explain the reasons for the difference.

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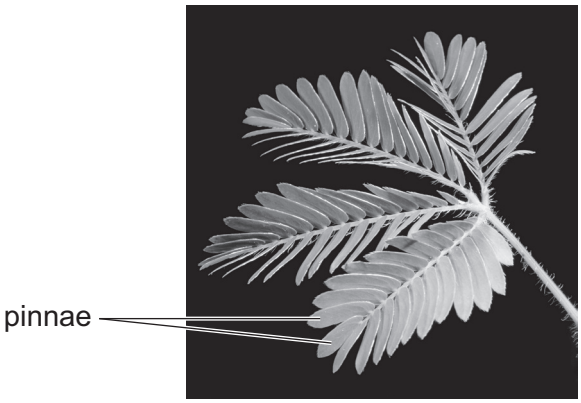
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4 The leaves of *Mimosa pudica* plants are made of a number of structures known as pinnae. The pinnae fold when the leaf is touched. This closes the leaf.

Fig. 4.1 shows an open leaf of *M. pudica* before it is touched. Fig. 4.2 shows the same leaf that has closed after being touched.



A open (not touched)

Fig. 4.1



B closed (touched)

Fig. 4.2

(a) A touch stimulus to an *M. pudica* leaf causes an action potential to be generated.

The action potential results in changes in cells, which cause the leaf to close.

Fig. 4.3 shows the mechanism in *M. pudica* cells that causes the leaf to close.

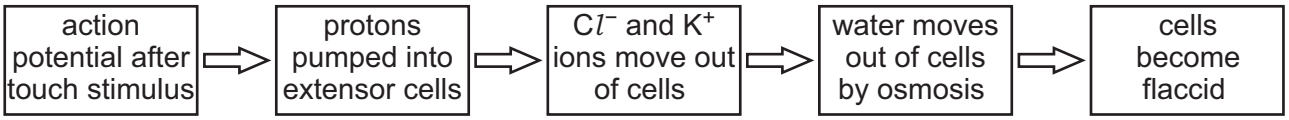


Fig. 4.3

The leaves of *M. pudica* and the leaves of Venus fly traps move in response to touch stimuli, but the mechanisms that cause the responses are different.

Describe the differences between the mechanism shown in Fig. 4.3 and the mechanism that causes the closure of the modified leaves in Venus fly traps.

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(b) The rate of photosynthesis decreases by 40% when the leaves of *M. pudica* close.

Explain why the rate of photosynthesis decreases when the leaves of *M. pudica* close.

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(c) Plants can carry out cyclic photophosphorylation and non-cyclic photophosphorylation during the light-dependent stage of photosynthesis. These processes occur at the grana of chloroplasts.

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

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5 *Lunularia cruciata* is a primitive plant. Its body consists of a flattened sheet of photosynthetic tissue called a thallus.

Fig. 5.1 shows *L. cruciata* with two different types of reproductive structure, labelled **A** and **B**, on its surface.

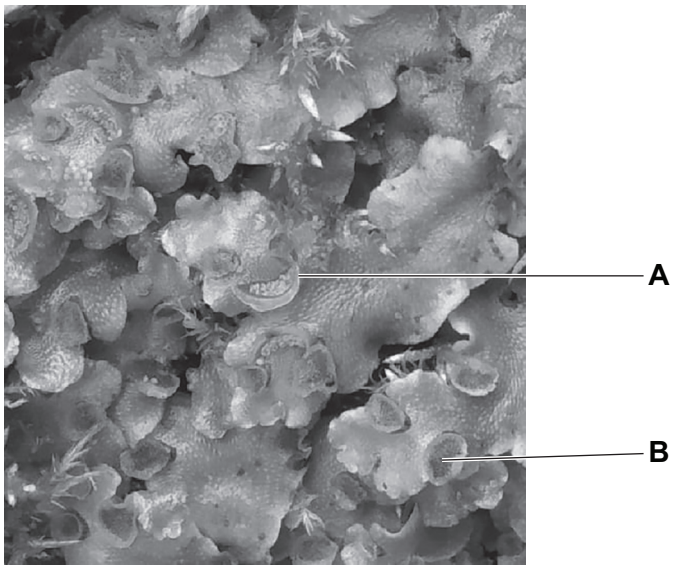


Fig. 5.1

(a) Structures **A** and **B** and the thallus of *L. cruciata* are haploid.

Explain what is meant by haploid.

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(b) Structure **A** contains pale discs of tissue, **C**, that can germinate into new *L. cruciata.* The new plants that develop from **C** are genetically identical to the parent plant in Fig. 5.1.

Structure **B** contains male sperm that are chemically attracted to swim to female eggs on a neighbouring parent plant. When the egg and sperm fuse, they form structure **D**. Structure **D** develops to produce spores that grow into new plants that are genetically different from the two parent plants.

Identify which of the structures **A**, **B**, **C** and **D** are:

associated with sexual reproduction ……

produced by mitosis ……

the site of meiosis ……

Each letter may be used once, more than once, or not at all. [3]

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(c) Fig. 5.2 shows a horse, *Equus caballus*. Horses are diploid animals that reproduce sexually. Male and female horses produce gametes, which fuse to form genetically different offspring.



Fig. 5.2

Explain the need for a reduction division during meiosis in the production of gametes in animals such as horses.

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6 The mammalian kidney is responsible for:

- the excretion of urea
- osmoregulation (the homeostatic control of the water potential of the blood).

(a) (i) Outline how **and** where the excretory product urea is made in the body.

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(ii) Homeostatic control of the water potential of blood includes receptors, effectors and target cells.

Identify the names **and** locations of these components of homeostatic control in osmoregulation.

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(b) The glomerulus and Bowman's capsule of the nephron are important in the formation of urine.

Outline the role of the glomerulus and Bowman's capsule in the formation of urine.

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(c) Concentrated urine contains a high concentration of solutes and a small volume of water. Different species of mammals vary in their ability to produce urine with a high solute concentration.

Table 6.1 compares the ratio of the solute concentration of urine (U) to the solute concentration of blood plasma (P) in some mammal species. The habitats of the mammal species are also shown.

Table 6.1

mammal species	maximum ratio of solute concentration of urine to solute concentration of blood plasma (U : P)	habitat
beaver	1.7 : 1	rivers and lakes
human	4.5 : 1	variable
camel	8.0 : 1	desert
rat	9.0 : 1	variable
kangaroo rat	16.0 : 1	desert

With reference to Table 6.1, suggest what the different values of U : P show about the ability of these mammal species to tolerate a shortage of water in their environment.

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[Total: 11]

7 *Spea multiplicata* is one of several species of American spadefoot toad.

(a) Young spadefoot toads are called tadpoles and live in water in ponds.

S. multiplicata tadpoles show three different phenotypes due to genetic variation. The three phenotypes are: detritus feeder, intermediate and carnivore.

Detritus feeders are small, and carnivores are large. Intermediates vary in size between the two extremes.

A detritus feeder and a carnivore are shown in Fig. 7.1.



Fig. 7.1

Detritus feeders:

- eat detritus (small pieces of dead organic matter) and algae (photosynthetic protoctists)
- have smooth mouthparts, small jaw muscles and long intestines.

Intermediates:

- can eat all available food (detritus, algae and fairy shrimps)
- have teeth-like mouthparts, medium-sized jaw muscles and medium-sized intestines.

Carnivores:

- eat fairy shrimps and other small animals
- have teeth-like mouthparts, large jaw muscles and short intestines.

Scientists counted the number of each type of tadpole in two different ponds: pond 1 and pond 2.

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(i) In pond 1, the scientists observed:

- a high density of tadpoles
- a low abundance of food
- that most of the tadpoles they counted were either detritus feeders or carnivores, with very few intermediates present.

Describe **and** suggest explanations for the type of natural selection that appears to be acting in pond 1.

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(ii) In pond 2, the scientists observed:

- a low density of tadpoles
- sufficient food availability for all tadpoles
- that most of the tadpoles they counted were intermediates, with fewer detritus feeders or carnivores.

Describe **and** suggest explanations for the type of natural selection that appears to be acting in pond 2.

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(iii) The intestine length of *S. multiplicata* tadpoles shows continuous variation.

Sketch a curve on Fig. 7.2 to show how intestine length varies in the tadpole population in **pond 2**.

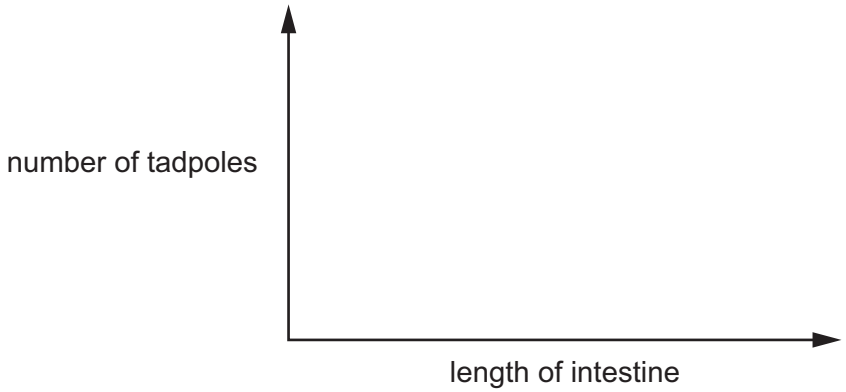


Fig. 7.2

[1]

(iv) A student suggested that the variation in *S. multiplicata* tadpoles could lead to sympatric speciation in some populations.

Outline the features of sympatric speciation.

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(b) Fig. 7.3 shows the evolutionary relationships between three species of American spadefoot toad.

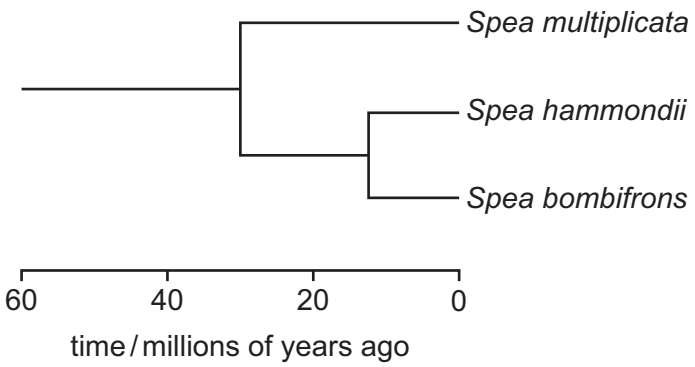


Fig. 7.3

Explain how analysis of DNA allowed the evolutionary relationships shown in Fig. 7.3 to be determined.

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8 Scientists use many different techniques in genetic engineering.

(a) Sometimes the gene for genetic engineering cannot be extracted from the donor organism. Instead, the gene is synthesised using one of two different methods.

Outline the **two** methods for synthesising a gene for use in genetic engineering.

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(b) DNA ligase and DNA polymerase are two enzymes that are used in genetic engineering.

Complete Table 8.1 to show the roles of DNA ligase and DNA polymerase in genetic engineering.

Use a tick (✓) if the enzyme has the role or a cross (✗) if the enzyme does **not** have the role.

Table 8.1

role in genetic engineering	DNA ligase	DNA polymerase
joins two sections of sugar phosphate backbone in DNA		
adds a gene to a plasmid		
adds free activated DNA nucleotides to a polynucleotide		

[3]

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(c) The polymerase chain reaction (PCR) is used to make many copies of a gene.

Three temperatures are used in a PCR cycle.

State the three temperatures that are used, **and** outline what happens at each temperature during a PCR cycle.

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9 Lichens are found growing on trees, walls, rocks and soil.

Fig. 9.1 shows a lichen of the genus *Usnea. Usnea* can tolerate only low concentrations of sulfur dioxide and does not grow in places where the air is polluted with sulfur dioxide.

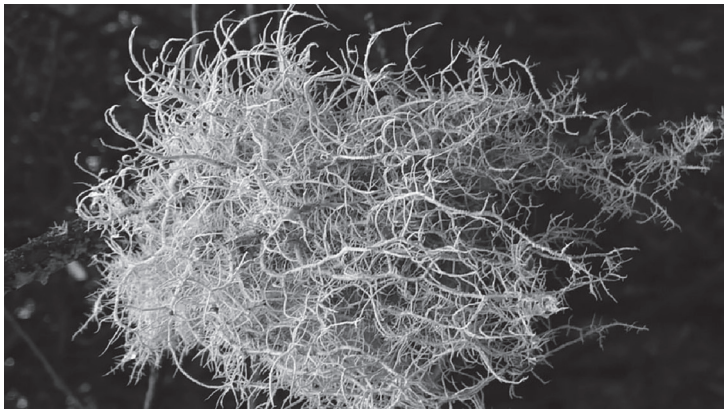


Fig. 9.1

Usnea is composed of a mixture of two types of cell:

- photosynthetic cells that are classified in the kingdom Protoctista
- fungal cells that are classified in the kingdom Fungi.

(a) Outline the characteristic features of the kingdoms Protoctista and Fungi.

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(b) *Xanthoria* is a lichen that can grow in places where there is a high concentration of sulfur dioxide in the air, for example in towns where homes, factories and vehicles burn fuels.

Fig. 9.2 shows a lichen of the genus *Xanthoria*.

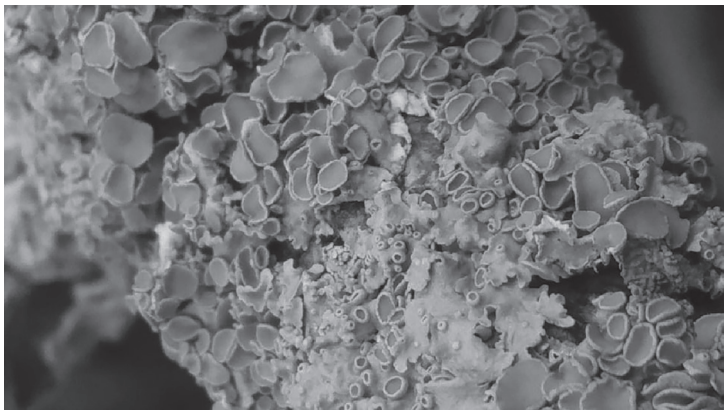


Fig. 9.2

(i) A student planned a method to measure the relative abundance of *Usnea* and *Xanthoria* on trees along a transect from the town centre at 0 km to unpolluted countryside at 4 km.

Suggest why measuring the relative abundance of the two types of lichen gives information that is useful for conservation.

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(ii) Although a large biodiversity of lichens can be found in a range of habitats, most people ignore them.

Outline why forms of life that are usually ignored, such as lichens, should be conserved.

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10 Populations of the moth *Biston betularia* live in Europe and in North America. The most common phenotype on both continents is a pale wing colour with light-grey shading (the typical form).

A moth phenotype with dark wing colour (the melanic form) also occurs on both continents.

Fig. 10.1 shows the typical form of the moth.

Fig. 10.2 shows the melanic form of the moth.



Fig. 10.1



Fig. 10.2

(a) Two melanic European moths were crossed together. The wing colours of the offspring were 15 typical and 41 melanic.

Construct a genetic diagram to explain these results. You may use the symbols **A** and **a** to represent the alleles.

[3]

(b) In a similar experiment, two melanic North American moths were crossed together. The colours of the offspring were 10 typical and 31 melanic.

What can be concluded about the allele that causes the melanic form in the moth populations in **both** continents?

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(c) Researchers did not know if the allele causing the melanic form in European moths occurred at the same locus as the allele causing the melanic form in North American moths. To find out, they carried out the following crosses:

- Cross 1: European moths that were heterozygous at the European melanic locus only were crossed with North American moths that were heterozygous at the North American melanic locus only.
- Cross 2: The melanic and the typical offspring of cross 1 were mated together.

(i) Explain why cross 2 is a test cross.

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(ii) Complete Table 10.1 to show the predicted results if:

- the European and North American melanic alleles are on **the same locus (A/a)**
- the European and North American melanic alleles are on two **different loci (A/a** and **B/b)**.

Table 10.1

	same locus (A/a)	**different loci (A/a and B/b)**
genotypes of **melanic** moths from cross 1		
proportion of test crosses (cross 2) giving 100% melanic offspring		

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(d) A light trap was used to estimate the total size of a population of *B. betularia* in a woodland. On night one, 24 moths were captured. These were marked with a small spot of harmless paint. On night two, 29 moths were captured, and 8 of these showed a spot of paint.

Use the Lincoln index formula provided to calculate the size of the population.

Show your working.

$$N = \frac{n_1 \times n_2}{m_2}$$

Key to symbols:
N = estimate of population size
n_1 = number of individuals captured in first sample
n_2 = number of individuals (both marked and unmarked) captured in second sample
m_2 = number of marked individuals recaptured in second sample

population size = ... [2]

[Total: 10]

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