Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3490479618

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **October/November 2021**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

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

INFORMATION

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

This document has **24** pages.

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Section A

Answer **all** questions.

1 (a) Fig. 1.1 is a diagram of a kidney nephron and some of its blood vessels.

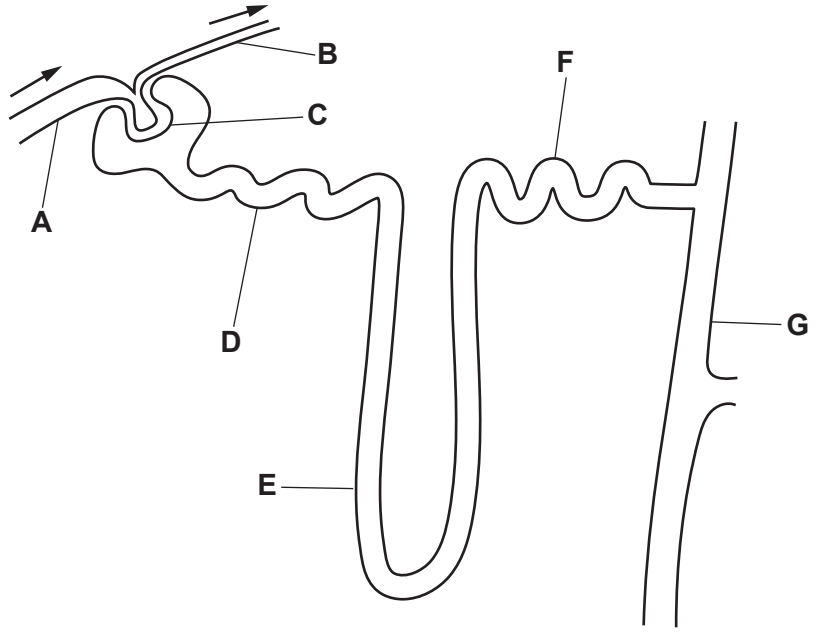


Fig. 1.1

With reference to Fig. 1.1, complete Table 1.1 using the letters **A** – **G**.

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

Table 1.1

description	letter
efferent blood vessel	.....
part of nephron containing cells that respond to ADH	.....
part of nephron where podocyte cells are located	.....
part of nephron containing cells that are located in the medulla	.....

[4]

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(b) Describe **and** explain how the cells of the proximal convoluted tubule are adapted to carry out selective reabsorption.

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..... [5]

(c) Fig. 1.2 shows the concentrations of ADH in the blood at different percentage changes in water potential of the blood.

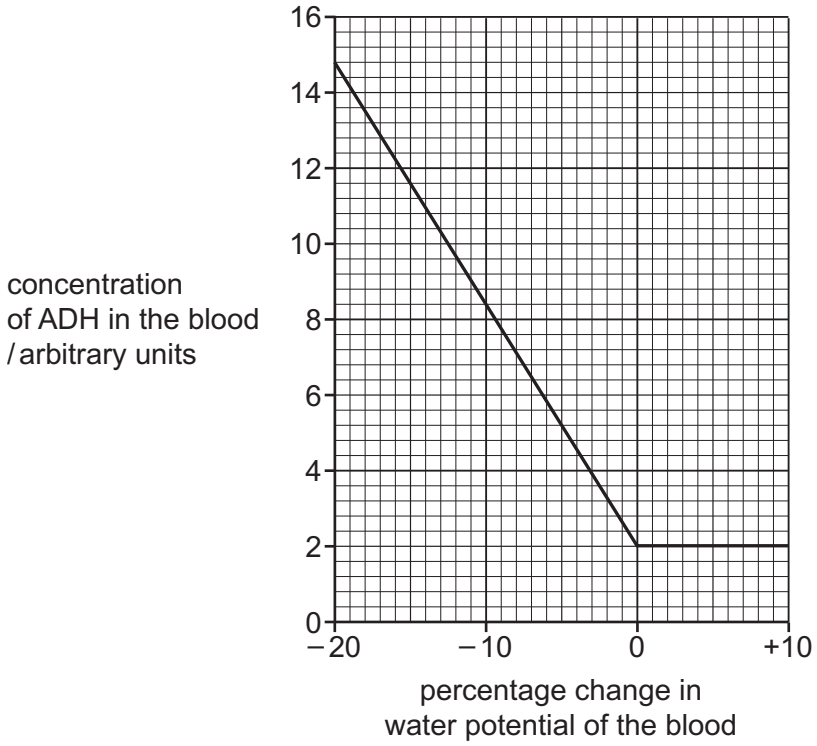


Fig. 1.2

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

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..... [2]

(ii) Sometimes a person will have a low concentration of ADH in the blood even though there is a change in the water potential.

Suggest **one** effect on the circulatory system of a low concentration of ADH in the blood.

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..... [1]

[Total: 12]

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Turn over for Question 2

2 **(a)** Cotton, *Gossypium hirsutum*, and false flax, *Camelina sativa*, are crop plants that are grown in different parts of the world.

Rubisco activase is an enzyme in the stroma of chloroplasts that is needed to maintain the activity of a second enzyme, rubisco.

Scientists measured the activity of rubisco activase in cotton and in false flax at a range of temperatures.

Fig. 2.1 shows the results.

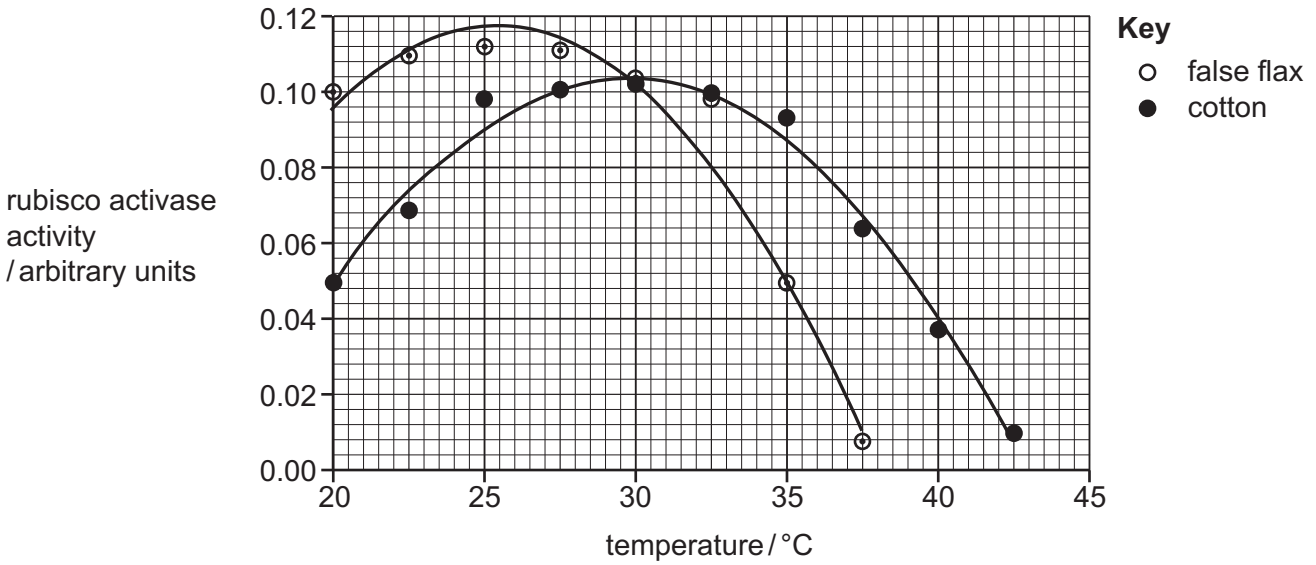


Fig. 2.1

(i) With reference to Fig. 2.1, compare the results obtained for cotton and false flax.

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..... [4]

(ii) Suggest reasons for the differences shown in Fig. 2.1.

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..... [3]

(b) Rubisco enzymes from cotton and false flax are active at temperatures up to 45 °C and will denature at 45 °C.

Explain how the Calvin cycle is affected when rubisco denatures.

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..... [3]

(c) One goal of genetic engineering is to make crops that are heat tolerant. This means that crops can grow and produce a good yield at high environmental temperatures.

Use the information given in Question 2 to suggest **and** explain a way to improve the tolerance of a crop to high temperatures.

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..... [2]

[Total: 12]

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[Turn over

3 Ecological surveys are conducted before conservation decisions are made. For example, surveys can be carried out before deciding whether to reintroduce a species to its former habitat.

(a) Outline how an ecological survey can measure the biodiversity of a terrestrial habitat.

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..... [4]

(b) Table 3.1 lists some mammal species that became extinct in Great Britain or were introduced into Great Britain in the last 12 400 years.

The reasons for each extinction or introduction and the time of each event are shown.

Table 3.1

species	number of years before present time	event	reason
arctic fox	12 400	extinction	climate change
sheep	5 400	introduction	farming
house mouse	3 500	introduction	accidental
lynx	1 500	extinction	hunting
fallow deer	900	introduction	food
South American coypu	86	introduction	fur
South American coypu	33	extinction	conservation culling

With reference to Table 3.1, state **and** explain the factors that have had a negative impact on biodiversity in Great Britain.

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..... [4]

(c) Non-governmental and government organisations are working together to reintroduce a lynx population to its former habitat in a remote part of Great Britain. Lynx are predatory big cats.

Fig. 3.1 shows a lynx.



Fig. 3.1

Suggest the factors that need to be considered by organisations to successfully reintroduce and restore a breeding population of lynx in Great Britain.

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..... [5]

[Total: 13]

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Turn over for Question 4

4 **(a)** In 1984, the geneticist Alec Jeffreys invented a DNA testing technique, known as DNA profiling, that produces a DNA banding pattern on a gel. The DNA banding pattern (profile) is unique to each individual.

DNA profiling can be used in police forensic work to catch criminals.

Since 1987, police in many countries have collected and stored DNA from crime scenes to create DNA profiles, which they try to match with the DNA profiles of criminal suspects.

(i) DNA at a crime scene may be obtained from hairs and traces of blood, semen and saliva.

Explain why PCR may be needed before DNA from a crime scene can be profiled.

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..... [2]

(ii) Explain why electrophoresis produces a DNA banding pattern on a gel.

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..... [2]

(b) GEDmatch is described as 'an open data personal genomics website'. It can be used by people who want to upload their DNA data to trace their ancestors and other relatives.

In 2018, police in the USA solved a large number of serious crimes. Some of these crimes had been unsolved for over thirty years. The police used GEDmatch to profile DNA taken from crime scenes and to look for matching DNA profiles. In many cases the police found partial matches to the relatives of criminals. This allowed the criminals to be identified and then charged on the basis of a complete DNA profile match.

(i) Suggest why the police strategy of comparing crime scene DNA with the GEDmatch database was so successful.

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..... [2]

(ii) Explain why GEDmatch is an example of bioinformatics.

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..... [2]

(iii) The first successful conviction resulting from the use of GEDmatch by the police was widely reported.

Some journalists and broadcasters thought that the GEDmatch website should not have been used by the police in this way.

In the days following the news, the number of citizens choosing to upload their DNA data to GEDmatch increased from 1500 to 5000 a day.

Comment on the social **and** ethical issues raised by this first successful conviction.

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..... [2]

[Total: 10]

5 **(a)** Gibberellin is a plant growth regulator involved in barley seed germination. Production of gibberellin is stimulated by the uptake of water.

State the location of gibberellin synthesis in a barley seed during germination.

..... [1]

(b) Barley seeds germinate when placed on blotting (absorbent) paper soaked in water.

The germination of barley seeds placed on blotting paper soaked in solutions of different water potential was investigated.

The success of germination was measured as a germination index for:

- barley seeds placed on blotting paper soaked in water
- barley seeds placed on blotting paper soaked in 5 solutions of different water potential.

The results are shown in Fig. 5.1.

The higher the germination index value, the more successful the germination of the barley seeds.

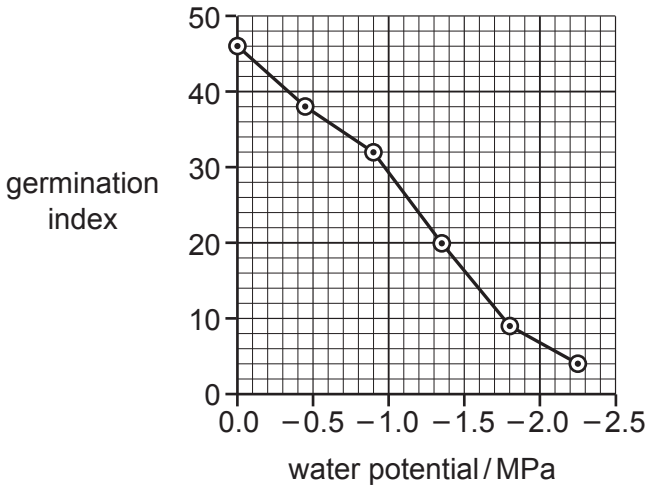


Fig. 5.1

(i) With reference to Fig. 5.1, describe the relationship between the germination index of barley seeds and water potential.

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..... [2]

(ii) Suggest explanations for the relationship shown in Fig. 5.1.

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..... [3]

(c) During barley seed germination, gibberellin stimulates the synthesis of enzymes.

State the name of one of these enzymes **and** the precise location of its synthesis.

enzyme .....

location .....
[2]

(d) Some plants are grown commercially for their flowers. Many of these plants are varieties that have short stems.

Two factors that affect the height of stems are:
- gibberellin
- the *Le*/*le* gene.

The *Le*/*le* gene has two alleles, Le and le.

(i) Suggest an advantage of growing a short-stemmed variety of a flowering plant.

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..... [1]

(ii) Explain how the *Le*/*le* gene and gibberellin are involved in affecting the height of plant stems.

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..... [3]

[Total: 12]

6 Fig. 6.1 outlines the first three stages of respiration in aerobic conditions.

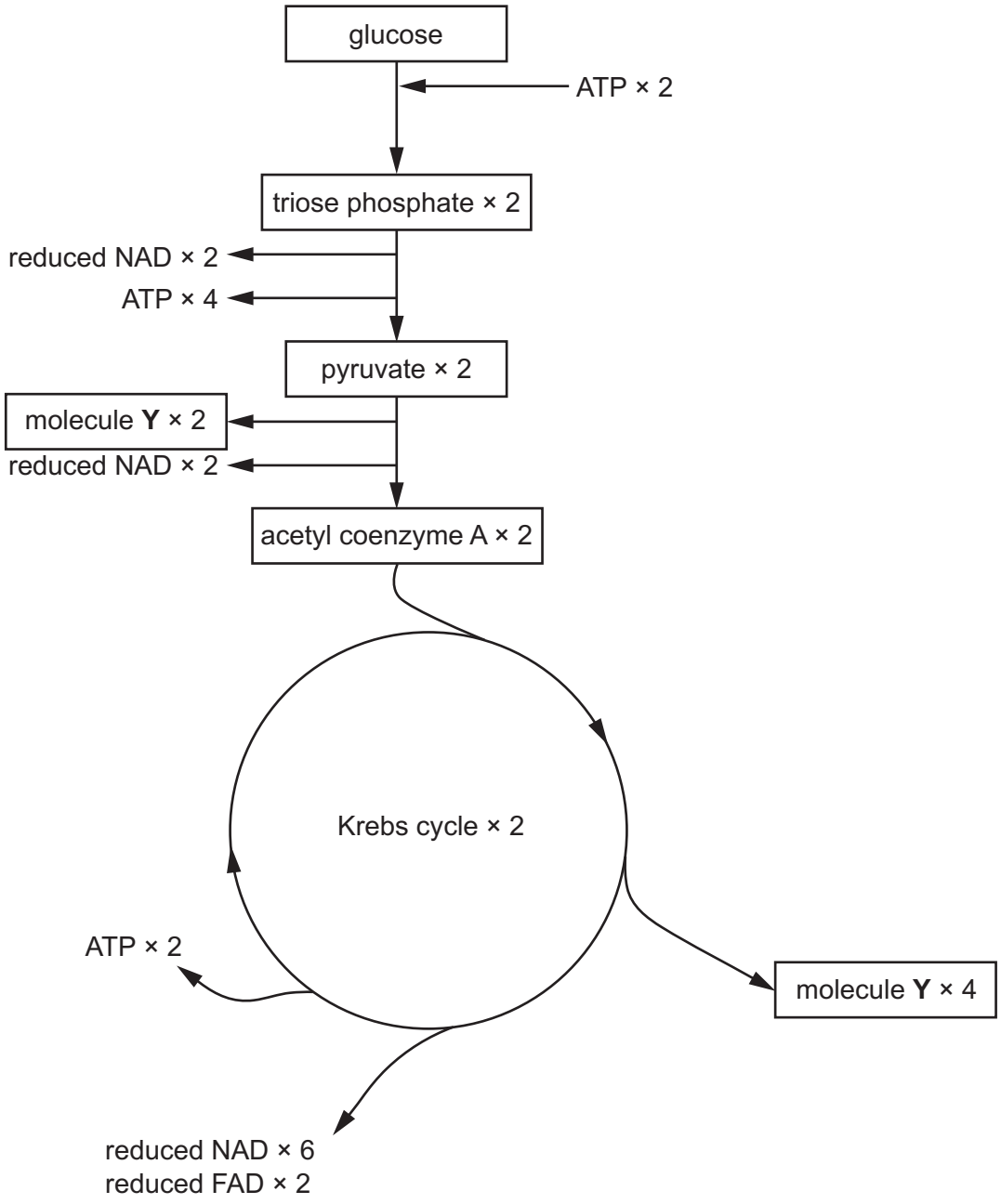


Fig. 6.1

(a) Name molecule **Y** in Fig. 6.1.

..... [1]

(b) Explain how Fig. 6.1 shows that glycolysis involves oxidation.

.....

..... [1]

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(c) At one time it was thought that the oxidative phosphorylation of:

- one molecule of reduced NAD results in the synthesis of 3 ATP molecules
- one molecule of reduced FAD results in the synthesis of 2 ATP molecules.

Using Fig. 6.1, a theoretical value for the net number of ATP molecules that are synthesised for each molecule of glucose can be calculated.

Modern research has shown that the actual net number of ATP molecules synthesised for each glucose molecule respired is much lower than this theoretical value.

(i) Using Fig. 6.1, calculate the theoretical value for the net number of ATP molecules that are synthesised for each molecule of glucose respired in **all** phosphorylation reactions.

Show your working.

answer = ... [2]

(ii) Suggest **two** reasons why the actual net number of ATP molecules synthesised is less than the theoretical number.

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..... [2]

(d) Outline the roles of NAD and FAD in aerobic respiration.

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..... [3]

(e) Rotenone is used as an insecticide. Rotenone kills insects by inhibiting the transfer of electrons in the electron transport chain of the mitochondrion.

Explain how rotenone affects ATP synthesis in the mitochondrion.

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..... [3]

[Total: 12]

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7 **(a)** The function of the enzyme iduronate 2-sulfatase is to break down certain complex molecules.

Hunter syndrome is a rare, inherited condition in humans, caused by iduronate 2-sulfatase not functioning properly or by iduronate 2-sulfatase not being produced. This will cause the complex molecules to build up, leading to progressive damage to many organs.

Explain how a gene mutation can lead to iduronate 2-sulfatase not functioning properly or not being produced.

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..... [4]

(b) Hunter syndrome is caused by a recessive allele located on the **X** chromosome.

Using appropriate symbols, draw a genetic diagram to show the probability of a normal male and a heterozygous normal female having a child with Hunter syndrome.

key

parental phenotype	normal male	×	normal female
parental genotype			
gametes			
offspring genotypes			
offspring phenotypes			

probability ..... [5]

[Total: 9]

8 California salamanders are terrestrial amphibians.

An original population of California salamanders occupied an area of forest in northern California. Approximately 10 million years ago, two separate populations, **A** and **B**, started to migrate from the original population.

- Population **A** travelled along the coast of California, to the west of the Great Central Valley.
- Population **B** travelled east of the Great Central Valley.

The two populations now live close to each other in southern California.

Fig. 8.1 outlines the migratory routes of populations **A** and **B**.

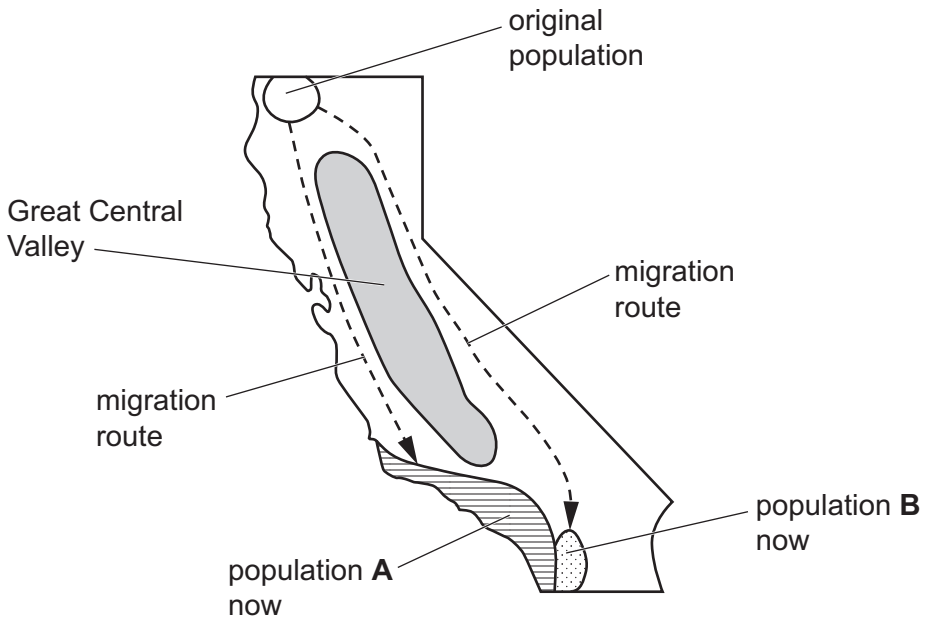


Fig. 8.1

Salamanders from population **A** rarely interbreed with salamanders of population **B**. If they do interbreed, the offspring are infertile.

Suggest **and** explain the sequence of events that have resulted in these two populations becoming reproductively isolated from each other.

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..... [5]

[Total: 5]

Section B

Answer **one** question.

9 **(a)** Describe **and** explain the mechanism by which guard cells open stomata. [7]

(b) Explain how the anatomy **and** physiology of the leaves of maize or sorghum are able to maximise carbon dioxide fixation at high temperatures. [8]

[Total: 15]

10 **(a)** Describe **and** explain the transmission of an action potential in a myelinated neurone. [9]

(b) Explain what is meant by homeostasis in a mammal **and** explain why it is important to maintain body temperature, blood glucose concentration and the water potential of blood. [6]

[Total: 15]

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[Turn over

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BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **October/November 2021**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

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INFORMATION

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- 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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Section A

Answer **all** questions.

1 (a) The Bowman's capsule of a nephron is involved in ultrafiltration.

Fig. 1.1 is a diagram of part of a Bowman's capsule and glomerulus.

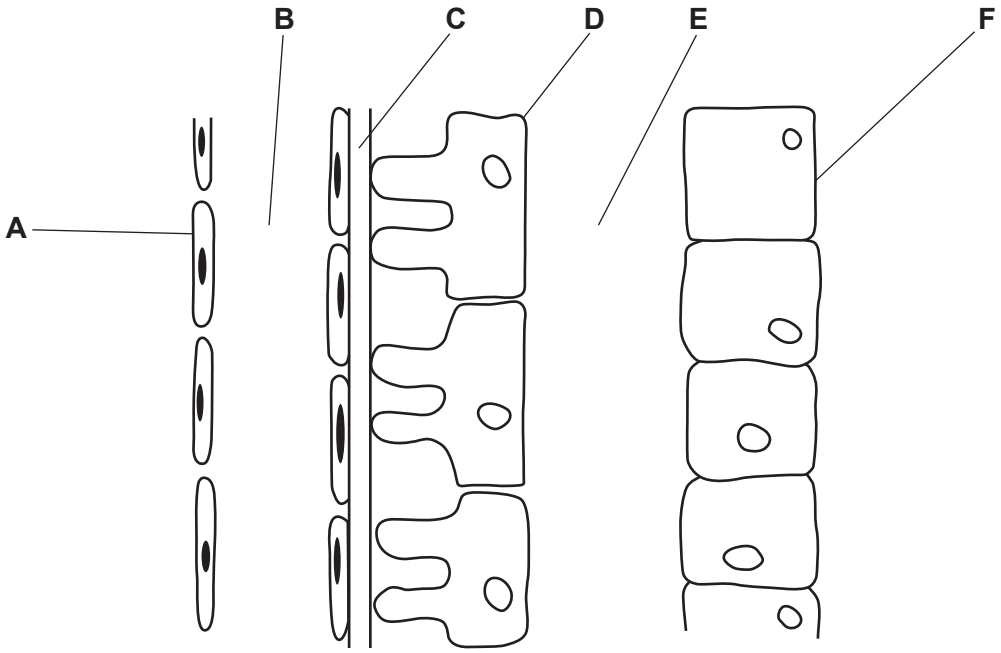


Fig. 1.1

With reference to Fig. 1.1, complete Table 1.1 using the letters **A** – **F**.

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

Table 1.1

feature	letter
glomerular filtrate	.....
basement membrane	.....
podocyte cell	.....
capillary endothelial cell	.....

[4]

(b) Describe **and** explain how the structures in the Bowman's capsule and its associated blood supply are adapted to allow ultrafiltration to take place.

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..... [5]

(c) The glomerular filtration rate (GFR) is the rate at which blood plasma is filtered in the Bowman's capsule.

Fig. 1.2 shows the relationship between GFR and mean renal arterial blood pressure.

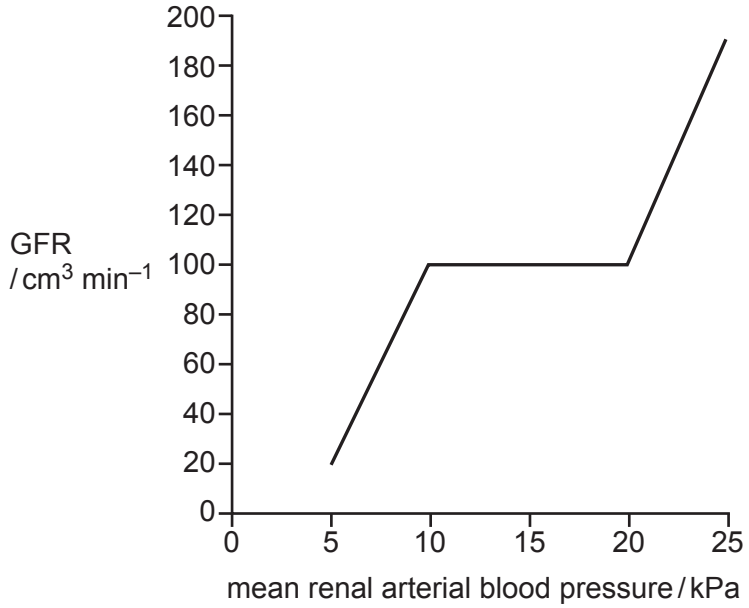


Fig. 1.2

(i) Comment on the relationship between GFR and mean renal arterial blood pressure.

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..... [2]

(ii) Suggest **one** reason why the GFR of a person might decrease.

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..... [1]

[Total: 12]

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Question 2 starts on page 6.

2 Scientists are researching new ways to reduce the global atmospheric carbon dioxide (CO_2) concentration. There are concerns that an increasing atmospheric CO_2 concentration may lead to effects that decrease biodiversity.

(a) Give **one** example of a human activity, other than deforestation, that contributes greatly to the increase in global atmospheric CO_2 concentration.

..... [1]

Algae are aquatic photosynthetic protoctists. Some researchers genetically modified the unicellular alga, *Chlorella vulgaris*, to try to increase the rate of the light independent stage of photosynthesis.

C. vulgaris was modified to increase the expression of the gene coding for aldolase. Aldolase is an enzyme that causes an increase in the concentration of rubisco.

Two cultures of *C. vulgaris*, one that was not genetically modified (unmodified) and one genetically modified, were grown under controlled conditions for 14 days. Samples were taken from the cultures at regular intervals during the 14 days to obtain measurements of dry mass.

The results are shown in Fig. 2.1.

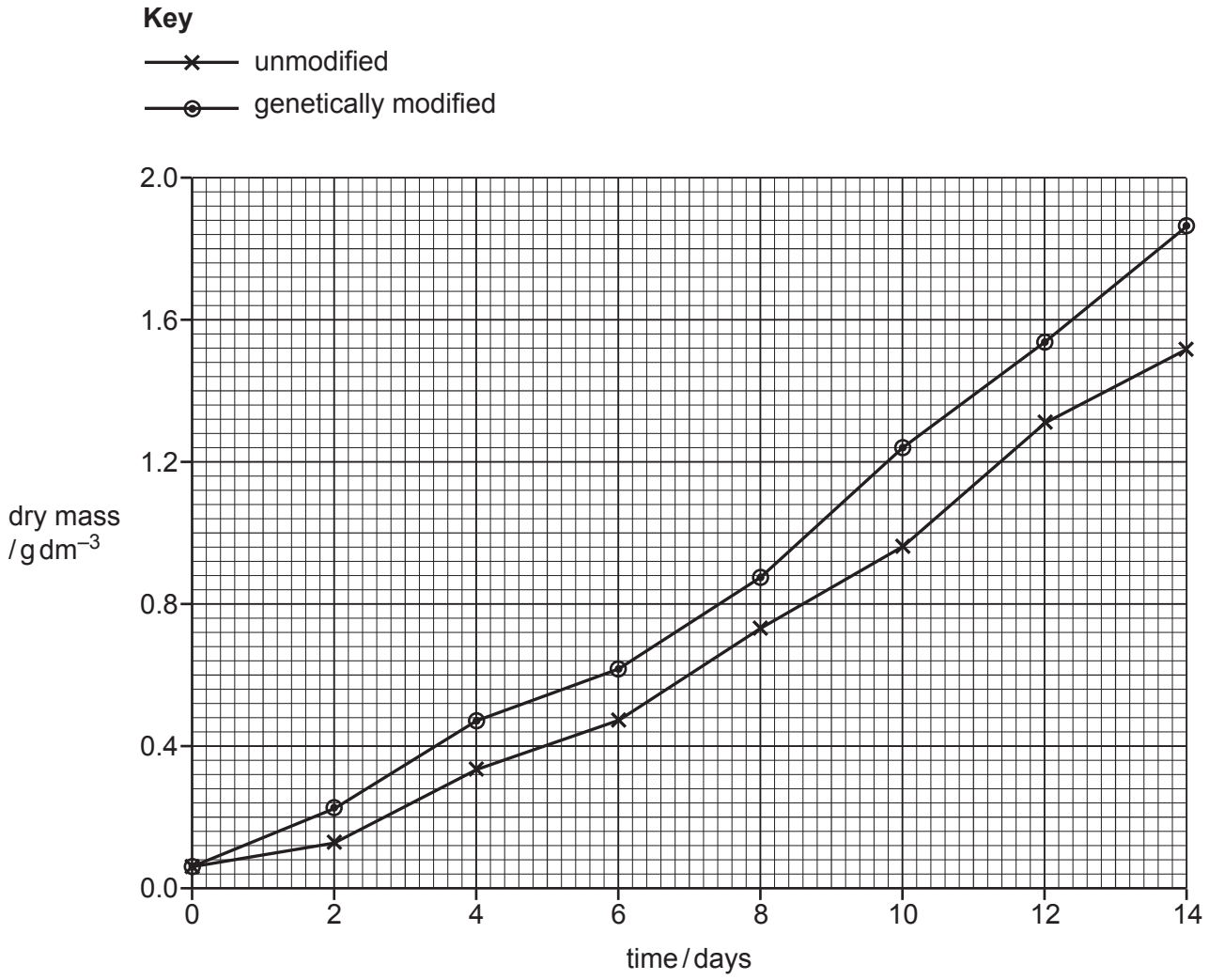


Fig. 2.1

(b) With reference to Fig. 2.1, describe the differences between the results for the two cultures.

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..... [3]

(c) Explain how the Calvin cycle was affected by the genetic modification of *C. vulgaris*.

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..... [3]

(d) Intermediate products of the Calvin cycle are needed to produce organic molecules for use by the cell.

Describe how these organic molecules are used by cells.

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..... [3]

(e) Planting large numbers of trees is one way to reduce global atmospheric CO_2 concentration. Large scale culture of genetically modified *C. vulgaris* could also reduce global atmospheric CO_2 concentration.

Suggest **one** advantage of using genetically modified *C. vulgaris* instead of trees to reduce global atmospheric CO_2 concentration.

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..... [1]

[Total: 11]

3 During the germination of barley seeds, amylase is produced.

(a) Describe the sequence of events that lead to the production of amylase during germination of barley seeds.

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..... [3]

(b) Malting is a process involved in the production of a drink called beer. During malting, barley seed germination is controlled so that the sugars produced during germination can be used in the production of beer.

Fig. 3.1 shows two features of a germinating barley seed during the first five days of malting:
- activity of the amylase enzyme
- the percentage of starch reserves remaining in the barley seed.

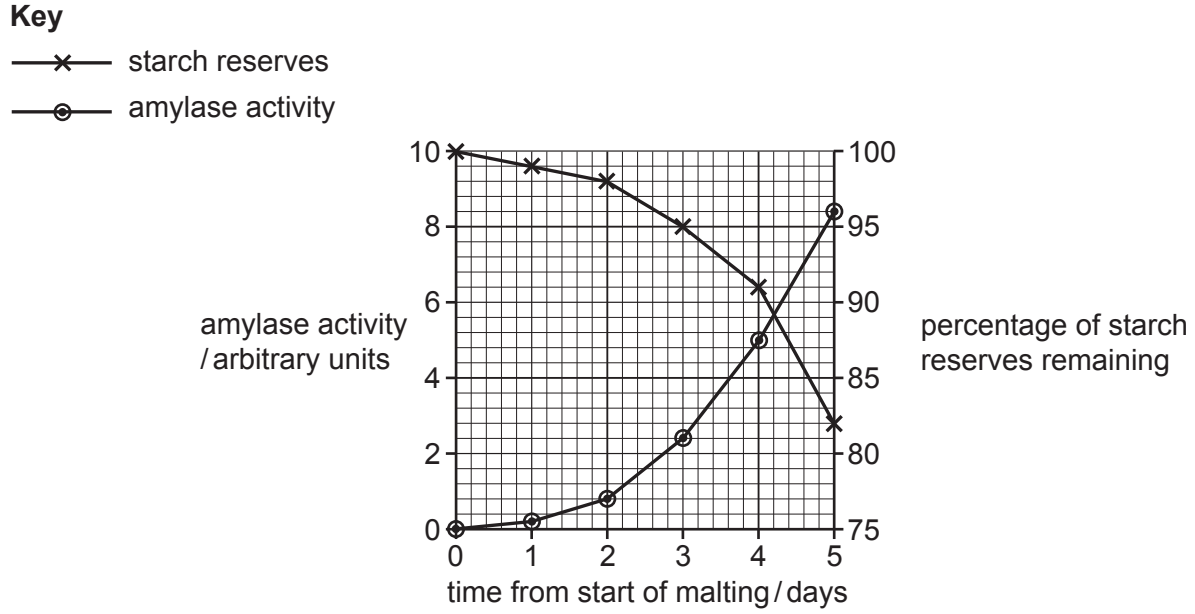


Fig. 3.1

(i) State the precise location of the starch reserves in the barley seed.

..... [1]

(ii) With reference to Fig. 3.1, describe **and** explain the effect of malting on amylase activity and the percentage of starch reserves remaining in the germinated barley seed.

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..... [4]

(c) In the malting process, germination is stopped before the concentration of sugars in the germinating barley seeds exceeds a concentration that causes shoot or root growth.

Drying the germinating barley seeds at 50 °C is one method used to stop malting.

(i) Explain how this method would stop malting.

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..... [3]

(ii) Suggest why malting is stopped before shoot or root growth occurs.

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..... [1]

[Total: 12]

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4 **(a)** Genome-wide association studies find links between single nucleotide polymorphisms (SNPs) and phenotypic features such as human diseases. SNPs are points on the DNA that vary in the population because of DNA base substitutions.

A genome-wide association study investigates the effect of genetic variation on a disease. A large number of people with the disease and a large number of healthy control individuals provide DNA. Microarray chips are used to identify the genotype of each individual at many SNPs.

The Wellcome Trust Case Control Consortium (WTCCC) study was an important genome-wide association study.

- The study used a microarray chip that identified each person's genotype at 500 000 different SNPs.
- The study looked for links between SNPs and 7 different diseases.
- For each disease, 2000 people with the disease were tested.
- Their results were compared with the results of 3000 healthy control individuals.

(i) Outline how microarrays are used in the analysis of genomes.

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..... [4]

(ii) Explain why bioinformatics was important to the WTCCC study.

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..... [2]

(b) Fig. 4.1 summarises results for three diseases in the WTCCC study. The 22 human autosomes and the X chromosome (chromosome 23) are shown.

Chromosome locations with SNPs that are associated with a disease at a statistically significant level (greater than 5 arbitrary units) are shown in black.

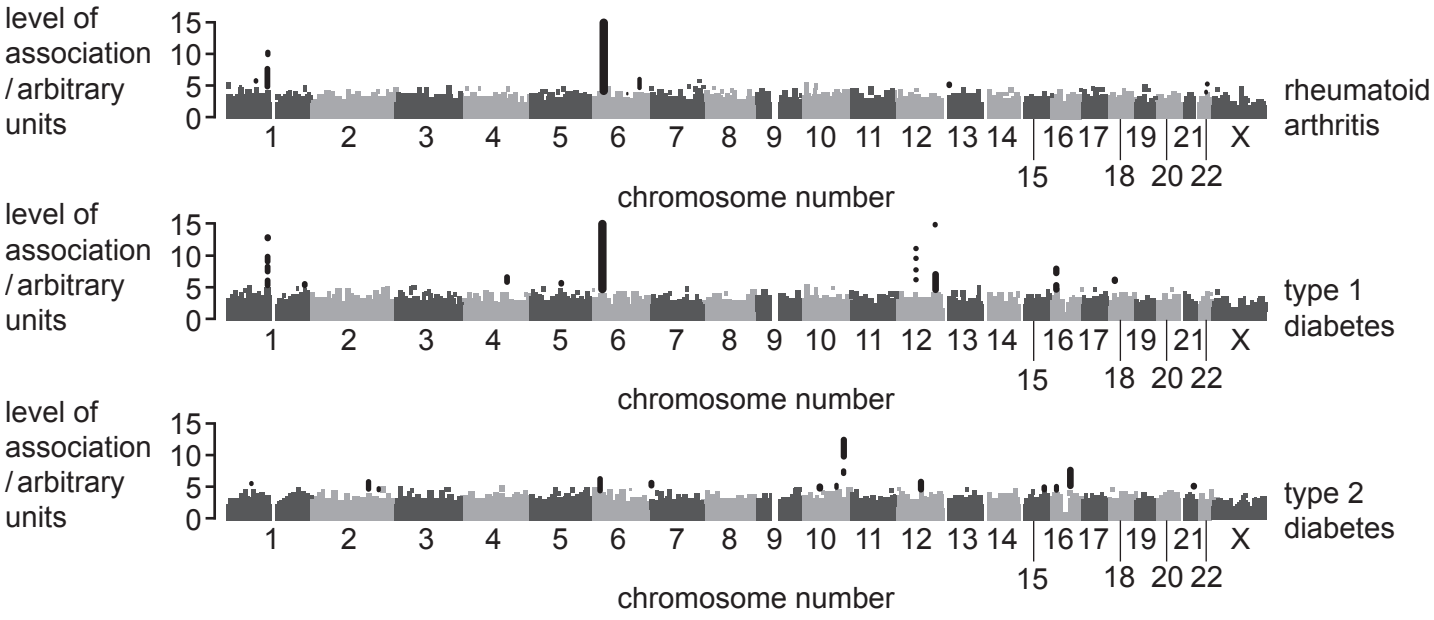


Fig. 4.1

(i) Identify the chromosomes that contain SNPs that have a high level of association with **both** rheumatoid arthritis and Type 1 diabetes.

..... [1]

(ii) With reference to Fig. 4.1, compare the genetic basis of the three diseases.

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..... [2]

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(c) Individuals can choose to have their DNA analysed on a microarray chip to predict their risk of developing different diseases.

Outline the social **and** ethical considerations of this type of DNA analysis.

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..... [3]

[Total: 12]

5 Biodiversity can be considered at three different levels.

Fig. 5.1, Fig. 5.2 and Fig. 5.3 are images that show these three different levels of biodiversity.



Fig. 5.1



Fig. 5.2



Fig. 5.3

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(a) Describe the level of biodiversity most clearly visible in each image.

Fig. 5.1 .....

Fig. 5.2 .....

Fig. 5.3 .....

[3]

(b) Prairie strips are restored habitat areas planted with native grasses and wildflowers. Prairie strips are usually located between or around the edges of fields of maize or soy bean.

Students in North America wanted to investigate biodiversity along a prairie strip.

(i) Outline how the students could measure the biodiversity of plants and insects along a prairie strip.

plants .....

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.....

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insects .....

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.....

.....

[4]

(ii) Mathematical methods and statistical tests help to summarise and compare biodiversity data.

Name the mathematical method **or** statistical test that the students can use:

to estimate the total biodiversity of a prairie strip

.....

to test whether plant biodiversity is associated with insect biodiversity.

.....

[2]

(c) Prairie strips have environmental and economic effects.

Scientists have made long-term measurements of the environmental effects of prairie strips.

The scientists found that when prairie strips formed 10% of a crop-field:
- soil erosion decreased by 95%
- mineral loss from the field decreased by 90% for phosphorus compounds
- mineral loss from the field decreased by 85% for nitrogen compounds.

Crop plants need phosphorus (P) and nitrogen (N) to grow.

Evaluate the **economic** effects of prairie strips on farming.

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..... [3]

[Total: 12]

Question 6 starts on page 18.

6 **(a)** ATP is needed for many metabolic processes in living organisms.

(i) Describe the properties of ATP that make it suitable for its role as the universal energy currency.

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..... [4]

(ii) Suggest why ATP is needed for protein synthesis.

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..... [2]

(b) Fig. 6.1 is a diagram of mitochondrion.

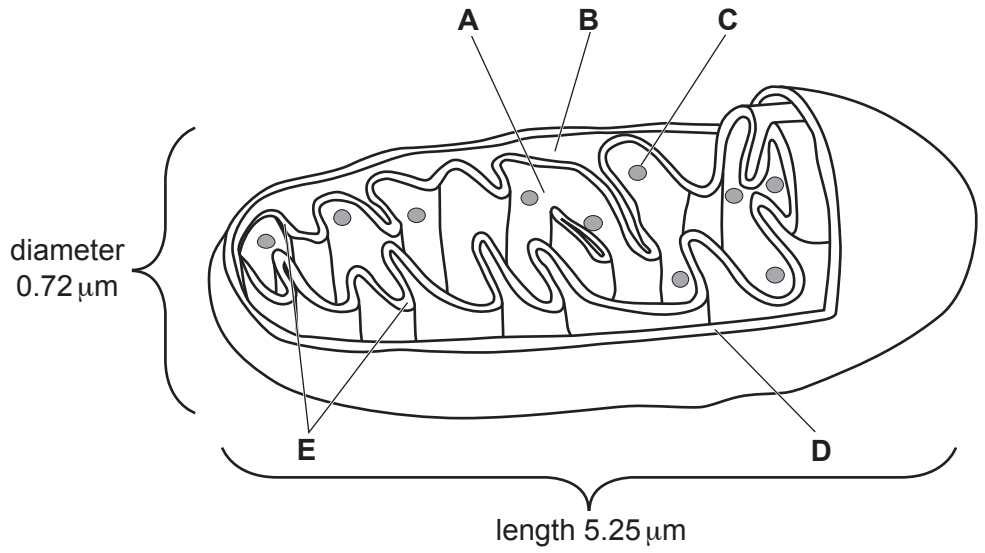


Fig. 6.1

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(i) Complete Table 6.1 using the letters **A** to **E** from Fig. 6.1.

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

Table 6.1

statement	letter
the site of the Krebs Cycle	.....
a phospholipid bilayer impermeable to H^+ ions	.....
the site of translation	.....

[2]

(ii) Assume that the mitochondrion in Fig. 6.1 is a cylinder.

Calculate the surface area of this mitochondrion.

Use the formula: Surface area of cylinder = $2\pi r^2 + 2\pi rh$

Show your working.

surface area = ... μm^2 [2]

(iii) The inner membrane of the mitochondrion has a much larger surface area than the outer membrane because of the presence of cristae.

Different cell types vary in the number of cristae present per mitochondrion. Cardiac muscle cells have mitochondria with a very large number of cristae.

Suggest **and** explain why cardiac muscle cells have mitochondria with very large numbers of cristae.

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..... [2]

[Total: 12]

7 **(a)** The Labrador is a variety of domestic dog. Labradors have fur that can be brown, black or yellow.

In Labradors, *TYRP1* is one gene that codes for fur colour. This gene has two alleles, **B** and **b**.

- The dominant allele, **B**, codes for the enzyme tyrosinase that functions in the pathway to produce melanin, leading to black fur.
- The production of melanin in Labradors is very similar to the production of melanin in humans.
- The recessive allele, **b**, codes for an enzyme that results in the production of a brown form of melanin, leading to brown fur.

Outline how melanin may be produced in Labradors to produce black fur.

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.....

..... [2]

(b) Another gene, *MC1R*, interacts with *TYRP1*.

MC1R has two alleles, **E** and **e**.

- The dominant allele, **E**, allows the alleles of *TYRP1* to be expressed.
- The recessive allele, **e**, prevents the alleles of *TYRP1* from being expressed.
- When no form of melanin is produced the Labrador will have yellow fur.

(i) Construct a genetic diagram to show the ratio of possible offspring from a cross between a black male Labrador, heterozygous for both genes, and a yellow female Labrador, heterozygous for *TYRP1*.

parental phenotype	black	×	yellow
parental genotype			
gametes			
offspring genotypes			
offspring phenotypes			

ratio .....

[6]

(ii) State the term used to describe a protein that is involved in the control of gene expression in eukaryotes.

..... [1]

[Total: 9]

8 Twenty million years ago, an ocean covered the area where the country of Panama is now located. There was a gap between the continents of North America and South America through which the waters of the Atlantic and Pacific Oceans flowed freely.

The porkfish, *Anisotremus sp*, lived in this area between North America and South America.

Fig. 8.1 shows a porkfish.



Fig. 8.1

About 3 million years ago, volcanic activity and sedimentation formed a narrow strip of land, Panama, joining North America and South America.

Fig. 8.2 shows the area 20 million years ago and now.

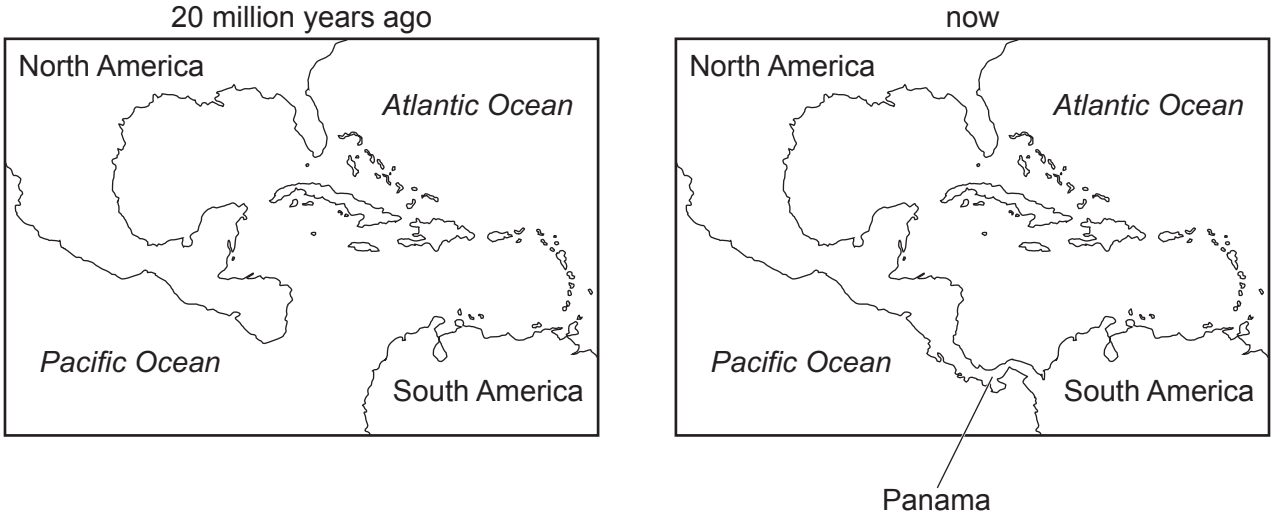


Fig. 8.2

Twenty million years ago, porkfish in the Atlantic and Pacific Oceans were able to breed successfully and produce fertile offspring.

Explain why Atlantic porkfish and Pacific porkfish are now **not** able to breed successfully to produce fertile offspring.

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..... [5]

[Total: 5]

Section B

Answer **one** question.

9 **(a)** Describe the roles of ADH **and** the collecting ducts in osmoregulation. [9]

(b) Describe the structure of a motor neurone. [6]

[Total: 15]

10 **(a)** Explain how dip sticks function to test for glucose in a sample of urine. [7]

(b) Explain the control of gibberellin synthesis **and** outline how gibberellin stimulates stem elongation. [8]

[Total: 15]

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BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **October/November 2021**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

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

INFORMATION

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

This document has **24** pages.

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Section A

Answer **all** questions.

1 (a) Fig. 1.1 is a diagram of a kidney nephron and some of its blood vessels.

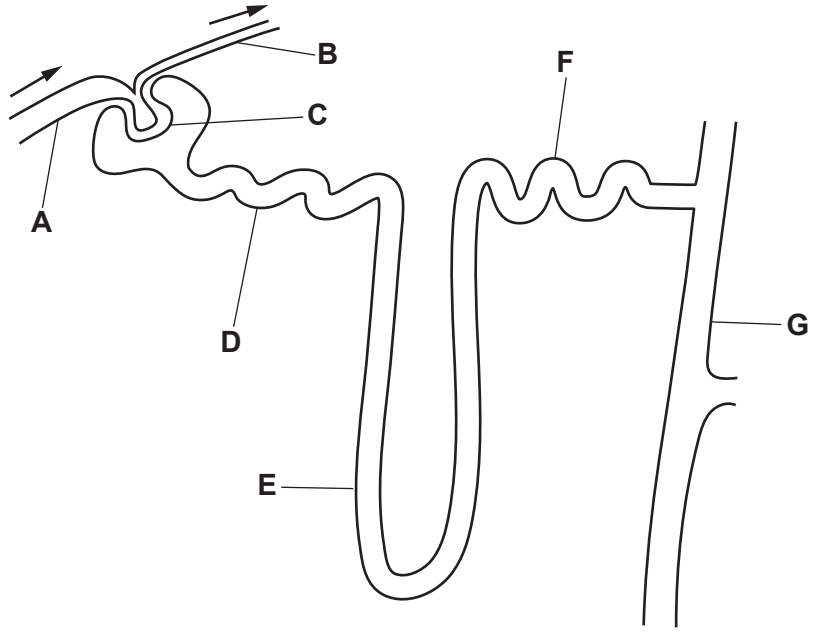


Fig. 1.1

With reference to Fig. 1.1, complete Table 1.1 using the letters **A** – **G**.

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

Table 1.1

description	letter
efferent blood vessel	.....
part of nephron containing cells that respond to ADH	.....
part of nephron where podocyte cells are located	.....
part of nephron containing cells that are located in the medulla	.....

[4]

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(b) Describe **and** explain how the cells of the proximal convoluted tubule are adapted to carry out selective reabsorption.

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..... [5]

(c) Fig. 1.2 shows the concentrations of ADH in the blood at different percentage changes in water potential of the blood.

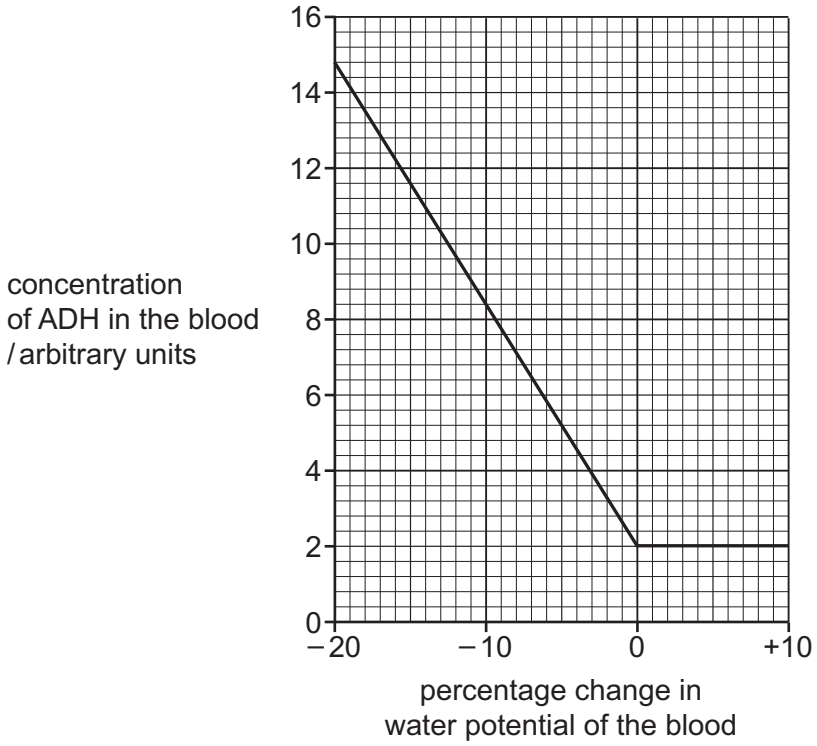


Fig. 1.2

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

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..... [2]

(ii) Sometimes a person will have a low concentration of ADH in the blood even though there is a change in the water potential.

Suggest **one** effect on the circulatory system of a low concentration of ADH in the blood.

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.....

..... [1]

[Total: 12]

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Turn over for Question 2

2 **(a)** Cotton, *Gossypium hirsutum*, and false flax, *Camelina sativa*, are crop plants that are grown in different parts of the world.

Rubisco activase is an enzyme in the stroma of chloroplasts that is needed to maintain the activity of a second enzyme, rubisco.

Scientists measured the activity of rubisco activase in cotton and in false flax at a range of temperatures.

Fig. 2.1 shows the results.

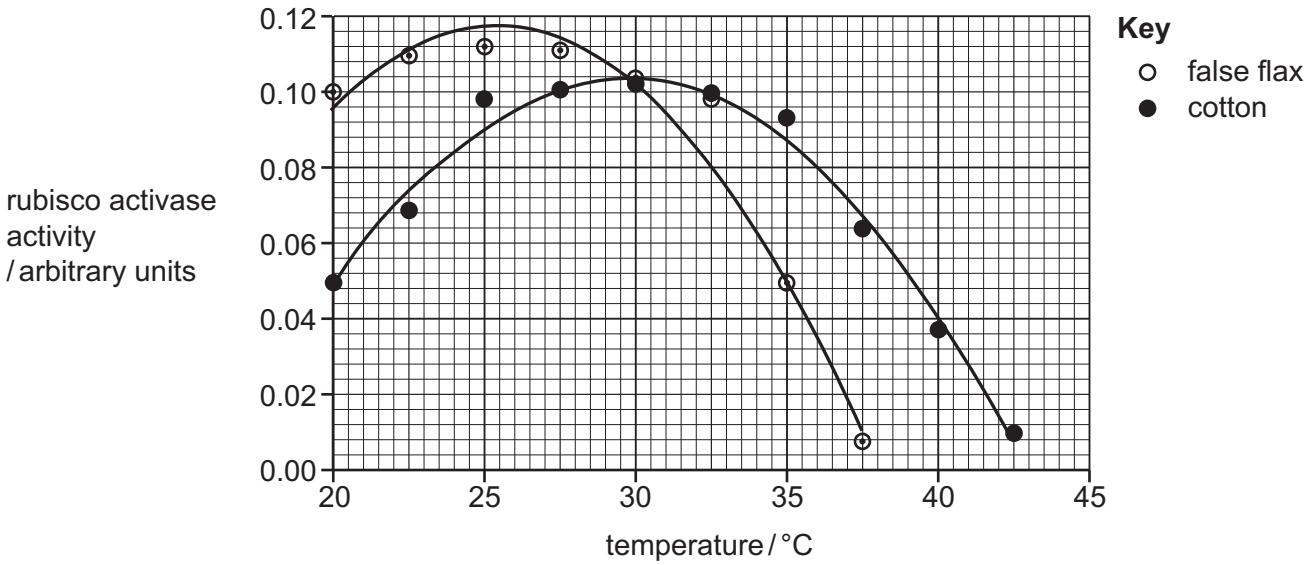


Fig. 2.1

(i) With reference to Fig. 2.1, compare the results obtained for cotton and false flax.

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..... [4]

(ii) Suggest reasons for the differences shown in Fig. 2.1.

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..... [3]

(b) Rubisco enzymes from cotton and false flax are active at temperatures up to 45 °C and will denature at 45 °C.

Explain how the Calvin cycle is affected when rubisco denatures.

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..... [3]

(c) One goal of genetic engineering is to make crops that are heat tolerant. This means that crops can grow and produce a good yield at high environmental temperatures.

Use the information given in Question 2 to suggest **and** explain a way to improve the tolerance of a crop to high temperatures.

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..... [2]

[Total: 12]

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[Turn over

3 Ecological surveys are conducted before conservation decisions are made. For example, surveys can be carried out before deciding whether to reintroduce a species to its former habitat.

(a) Outline how an ecological survey can measure the biodiversity of a terrestrial habitat.

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..... [4]

(b) Table 3.1 lists some mammal species that became extinct in Great Britain or were introduced into Great Britain in the last 12 400 years.

The reasons for each extinction or introduction and the time of each event are shown.

Table 3.1

species	number of years before present time	event	reason
arctic fox	12 400	extinction	climate change
sheep	5 400	introduction	farming
house mouse	3 500	introduction	accidental
lynx	1 500	extinction	hunting
fallow deer	900	introduction	food
South American coypu	86	introduction	fur
South American coypu	33	extinction	conservation culling

With reference to Table 3.1, state **and** explain the factors that have had a negative impact on biodiversity in Great Britain.

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..... [4]

(c) Non-governmental and government organisations are working together to reintroduce a lynx population to its former habitat in a remote part of Great Britain. Lynx are predatory big cats.

Fig. 3.1 shows a lynx.



Fig. 3.1

Suggest the factors that need to be considered by organisations to successfully reintroduce and restore a breeding population of lynx in Great Britain.

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..... [5]

[Total: 13]

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Turn over for Question 4

4 **(a)** In 1984, the geneticist Alec Jeffreys invented a DNA testing technique, known as DNA profiling, that produces a DNA banding pattern on a gel. The DNA banding pattern (profile) is unique to each individual.

DNA profiling can be used in police forensic work to catch criminals.

Since 1987, police in many countries have collected and stored DNA from crime scenes to create DNA profiles, which they try to match with the DNA profiles of criminal suspects.

(i) DNA at a crime scene may be obtained from hairs and traces of blood, semen and saliva.

Explain why PCR may be needed before DNA from a crime scene can be profiled.

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..... [2]

(ii) Explain why electrophoresis produces a DNA banding pattern on a gel.

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..... [2]

(b) GEDmatch is described as 'an open data personal genomics website'. It can be used by people who want to upload their DNA data to trace their ancestors and other relatives.

In 2018, police in the USA solved a large number of serious crimes. Some of these crimes had been unsolved for over thirty years. The police used GEDmatch to profile DNA taken from crime scenes and to look for matching DNA profiles. In many cases the police found partial matches to the relatives of criminals. This allowed the criminals to be identified and then charged on the basis of a complete DNA profile match.

(i) Suggest why the police strategy of comparing crime scene DNA with the GEDmatch database was so successful.

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..... [2]

(ii) Explain why GEDmatch is an example of bioinformatics.

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..... [2]

(iii) The first successful conviction resulting from the use of GEDmatch by the police was widely reported.

Some journalists and broadcasters thought that the GEDmatch website should not have been used by the police in this way.

In the days following the news, the number of citizens choosing to upload their DNA data to GEDmatch increased from 1500 to 5000 a day.

Comment on the social **and** ethical issues raised by this first successful conviction.

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..... [2]

[Total: 10]

5 **(a)** Gibberellin is a plant growth regulator involved in barley seed germination. Production of gibberellin is stimulated by the uptake of water.

State the location of gibberellin synthesis in a barley seed during germination.

..... [1]

(b) Barley seeds germinate when placed on blotting (absorbent) paper soaked in water.

The germination of barley seeds placed on blotting paper soaked in solutions of different water potential was investigated.

The success of germination was measured as a germination index for:

- barley seeds placed on blotting paper soaked in water
- barley seeds placed on blotting paper soaked in 5 solutions of different water potential.

The results are shown in Fig. 5.1.

The higher the germination index value, the more successful the germination of the barley seeds.

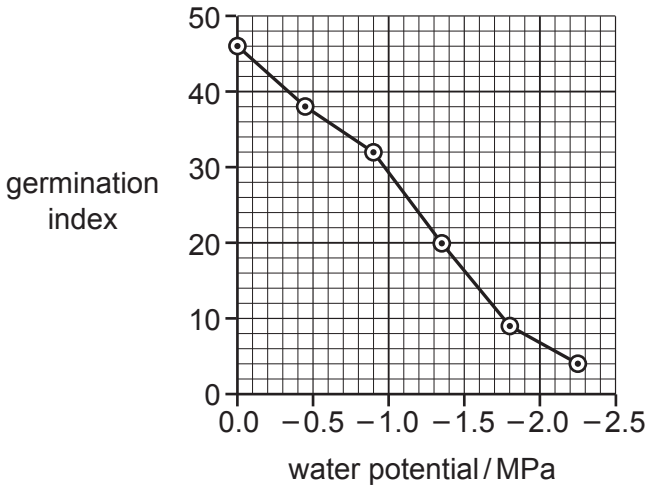


Fig. 5.1

(i) With reference to Fig. 5.1, describe the relationship between the germination index of barley seeds and water potential.

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..... [2]

(ii) Suggest explanations for the relationship shown in Fig. 5.1.

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..... [3]

(c) During barley seed germination, gibberellin stimulates the synthesis of enzymes.

State the name of one of these enzymes **and** the precise location of its synthesis.

enzyme .....

location .....
[2]

(d) Some plants are grown commercially for their flowers. Many of these plants are varieties that have short stems.

Two factors that affect the height of stems are:
- gibberellin
- the *Le*/*le* gene.

The *Le*/*le* gene has two alleles, Le and le.

(i) Suggest an advantage of growing a short-stemmed variety of a flowering plant.

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..... [1]

(ii) Explain how the *Le*/*le* gene and gibberellin are involved in affecting the height of plant stems.

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..... [3]

[Total: 12]

6 Fig. 6.1 outlines the first three stages of respiration in aerobic conditions.

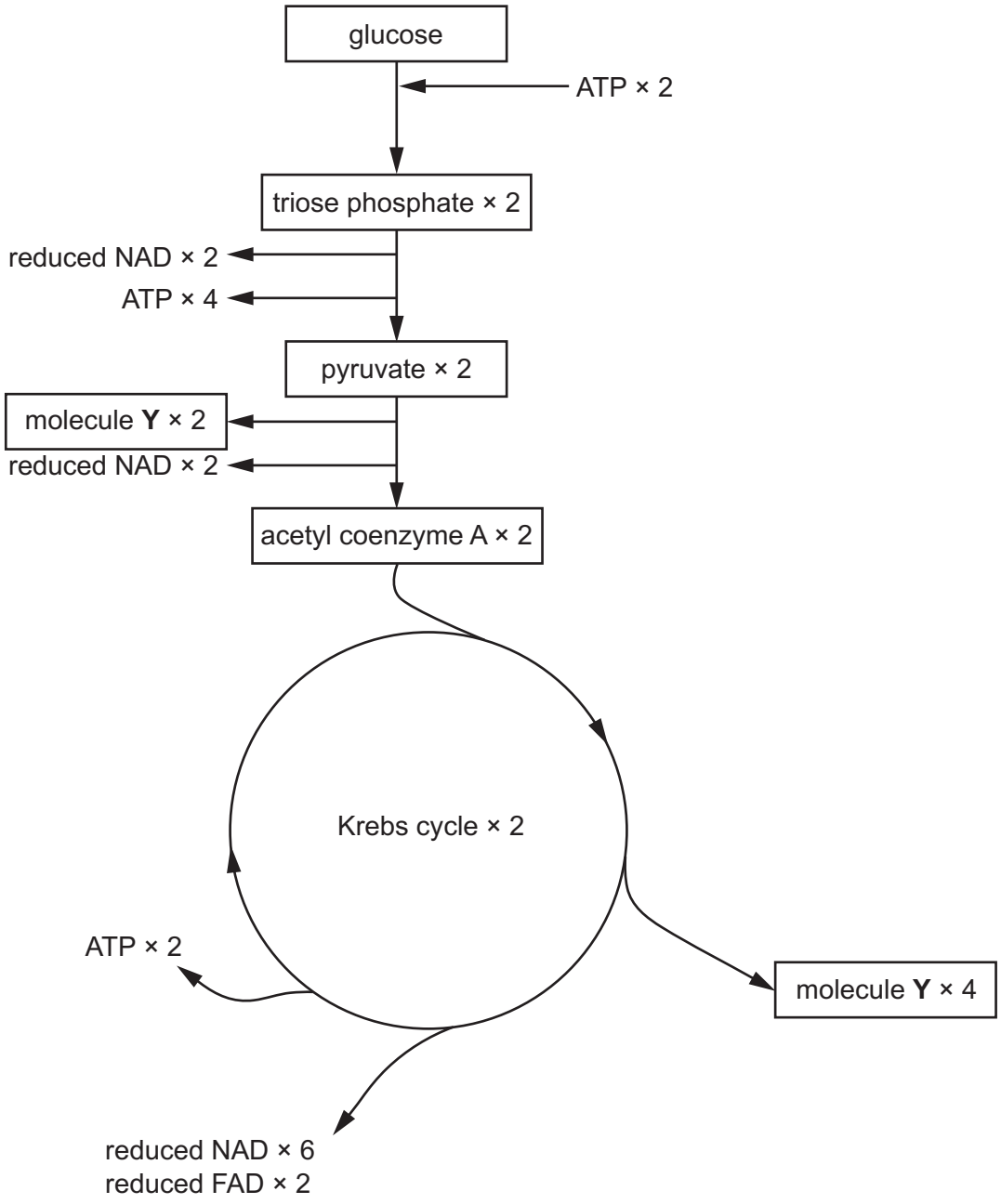


Fig. 6.1

(a) Name molecule **Y** in Fig. 6.1.

..... [1]

(b) Explain how Fig. 6.1 shows that glycolysis involves oxidation.

.....

..... [1]

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(c) At one time it was thought that the oxidative phosphorylation of:

- one molecule of reduced NAD results in the synthesis of 3 ATP molecules
- one molecule of reduced FAD results in the synthesis of 2 ATP molecules.

Using Fig. 6.1, a theoretical value for the net number of ATP molecules that are synthesised for each molecule of glucose can be calculated.

Modern research has shown that the actual net number of ATP molecules synthesised for each glucose molecule respired is much lower than this theoretical value.

(i) Using Fig. 6.1, calculate the theoretical value for the net number of ATP molecules that are synthesised for each molecule of glucose respired in **all** phosphorylation reactions.

Show your working.

answer = ... [2]

(ii) Suggest **two** reasons why the actual net number of ATP molecules synthesised is less than the theoretical number.

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..... [2]

(d) Outline the roles of NAD and FAD in aerobic respiration.

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..... [3]

(e) Rotenone is used as an insecticide. Rotenone kills insects by inhibiting the transfer of electrons in the electron transport chain of the mitochondrion.

Explain how rotenone affects ATP synthesis in the mitochondrion.

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..... [3]

[Total: 12]

7 **(a)** The function of the enzyme iduronate 2-sulfatase is to break down certain complex molecules.

Hunter syndrome is a rare, inherited condition in humans, caused by iduronate 2-sulfatase not functioning properly or by iduronate 2-sulfatase not being produced. This will cause the complex molecules to build up, leading to progressive damage to many organs.

Explain how a gene mutation can lead to iduronate 2-sulfatase not functioning properly or not being produced.

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..... [4]

(b) Hunter syndrome is caused by a recessive allele located on the **X** chromosome.

Using appropriate symbols, draw a genetic diagram to show the probability of a normal male and a heterozygous normal female having a child with Hunter syndrome.

key

parental phenotype	normal male	×	normal female
parental genotype			
gametes			
offspring genotypes			
offspring phenotypes			

probability ..... [5]

[Total: 9]

8 California salamanders are terrestrial amphibians.

An original population of California salamanders occupied an area of forest in northern California. Approximately 10 million years ago, two separate populations, **A** and **B**, started to migrate from the original population.

- Population **A** travelled along the coast of California, to the west of the Great Central Valley.
- Population **B** travelled east of the Great Central Valley.

The two populations now live close to each other in southern California.

Fig. 8.1 outlines the migratory routes of populations **A** and **B**.

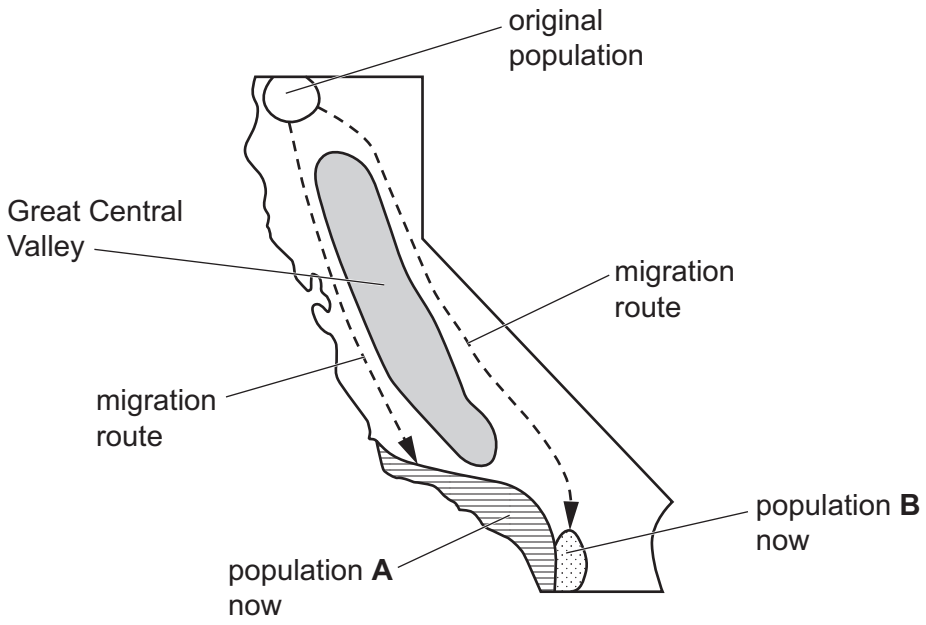


Fig. 8.1

Salamanders from population **A** rarely interbreed with salamanders of population **B**. If they do interbreed, the offspring are infertile.

Suggest **and** explain the sequence of events that have resulted in these two populations becoming reproductively isolated from each other.

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..... [5]

[Total: 5]

Section B

Answer **one** question.

9 **(a)** Describe **and** explain the mechanism by which guard cells open stomata. [7]

(b) Explain how the anatomy **and** physiology of the leaves of maize or sorghum are able to maximise carbon dioxide fixation at high temperatures. [8]

[Total: 15]

10 **(a)** Describe **and** explain the transmission of an action potential in a myelinated neurone. [9]

(b) Explain what is meant by homeostasis in a mammal **and** explain why it is important to maintain body temperature, blood glucose concentration and the water potential of blood. [6]

[Total: 15]

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