Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3066423331

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2023**

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.

© UCLES 2023

1 Fig. 1.1 shows a transmission electron micrograph of part of a chloroplast.

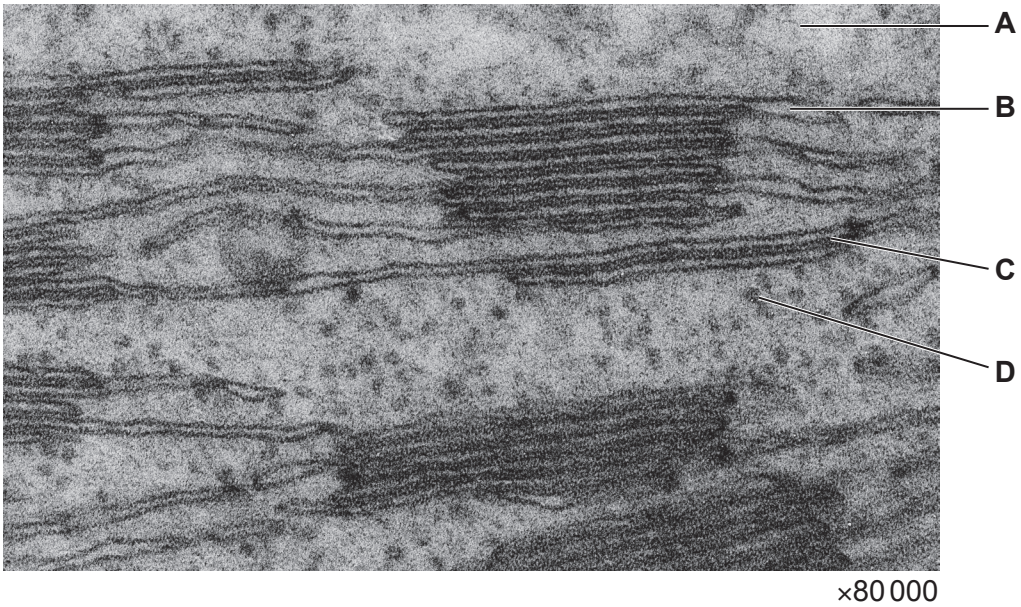


Fig. 1.1

(a) Table 1.1 describes some functions that occur in different parts of a chloroplast.

Complete Table 1.1 by identifying the letter on Fig. 1.1 that is a location matching the description. Each letter may be used once, more than once, or not at all.

Table 1.1

description	**letter**
accumulates (builds up) a high concentration of protons	
makes triose phosphate	
makes some chloroplast proteins	
pumps protons	

[4]

(b) Membranes of the type labelled **C** in Fig. 1.1 were made into a liquid extract. Chromatography was then used to separate and identify the coloured components (pigments) in this extract. The resulting chromatogram showed that these membranes contain a yellow pigment, an orange pigment, a green-brown pigment and two different green pigments.

(i) Describe how you would carry out chromatography to separate and identify the coloured pigments in the liquid extract of **C**.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(ii) Explain why membrane **C** has many different coloured pigments to function efficiently.

.....

.....

.....

.....

.....

..... [3]

[Total: 11]

2 The natural **ecosystem** on Hawadax Island in Alaska was disrupted in the 1780s when brown rats, *Rattus norvegicus*, swam to the island from a sinking ship and then rapidly increased their population size.

The rats occupied a new **niche** on the island as predators. The rats ate the eggs and chicks of birds such as the black oystercatcher, *Haematopus bachmani*, and the glaucous-winged gull, *Larus glaucescens*. These birds make nests, lay eggs and rear their chicks on the beaches of the island.

(a) Define the terms ecosystem and niche.

(i) ecosystem

.....

.....

..... [2]

(ii) niche

.....

.....

..... [1]

Conservation ecologists carried out a project to try to restore the natural ecosystem of Hawadax Island. In 2008, they removed all rats from the island.

Before removing the rats, the ecologists measured the abundance of birds, invertebrates and seaweeds on eight of the island's beaches. Seaweeds are large algae that grow attached to rocks on the beach. The ecologists repeated these measurements in 2013 and in 2019, so that they could calculate the percentage change in abundance from 2008.

(b) To measure the abundance of invertebrates and seaweeds, the ecologists used this method:

- They laid 30 m tapes from high-tide mark to low-tide mark on the beach.
- They placed quadrats at 5 metre intervals next to the tapes.
- They took a photograph of each quadrat.
- They analysed the photographs to calculate the percentage cover of seaweeds and the percentage cover of invertebrates such as mussels and sea snails.

(i) State the name of the sampling technique used.

..... [1]

© UCLES 2023

(ii) Biodiversity can be assessed at a number of different levels.

Identify the levels of biodiversity:

- that were assessed by this sampling technique
- that were **not** assessed by this sampling technique.

.....

.....

.....

.....

..... [3]

(c) Table 2.1 shows the percentage change in abundance of some of the seaweeds, invertebrates and birds found on the beaches of Hawadax Island.

Table 2.1

organism	percentage change from 2008 to 2013	percentage change from 2008 to 2019
seaweeds	+2	+49
mussel, *Mytilus*	–94	–99
sea snail, *Littorina*	–47	–91
black oystercatcher, *Haematopus bachmani*	+400	+800
glaucous-winged gull, *Larus glaucescens*	+126	+191

(i) Use Table 2.1 to state the **genus** name of **one** organism that has **increased** in abundance.

..... [1]

(ii) Seaweeds were once thought to be plants but are now classified in the kingdom Protoctista.

Outline the features of the kingdom Protoctista that are shown by **seaweeds**.

.....

.....

.....

.....

..... [2]

© UCLES 2023

(d) To evaluate the success of the Hawadax Island restoration project, the ecologists obtained data from other islands near to Hadawax Island.

- Some islands had never been occupied by rats (rat-free islands) and had a healthy ecosystem.
- Some islands were still occupied by rats (rat-occupied islands) and had a disrupted ecosystem.

Table 2.2 shows the percentage differences in the abundance of organisms in rat-free islands compared with rat-occupied islands.

Table 2.2

organism	**percentage difference in rat-free islands compared to rat-occupied islands**
seaweeds	+68
mussel, *Mytilus*	–97
sea snail, *Littorina*	–83
black oystercatcher, *Haematopus bachmani*	+883
glaucous-winged gull, *Larus glaucescens*	+914

With reference to Table 2.1 and Table 2.2, suggest **and** explain how removing rats has restored the ecosystem on Hawadax Island.

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 14]

3 *Oryza* is a genus of grass plants that includes the rice, *Oryza sativa*, a food crop.

(a) Farmers flood fields of rice because this encourages faster growth and higher yields.

(i) An adaptation of rice plants that allows them to grow in water is the development of aerenchyma.

State the function of aerenchyma.

.....

.....

.....

.....

..... [2]

(ii) State **one other** way in which the roots of rice are adapted to being submerged in water.

.....

..... [1]

(iii) Another adaptation in some varieties of rice is the fast growth of stems.

Describe how selective breeding could produce varieties of rice with fast-growing stems.

.....

.....

.....

.....

.....

..... [3]

(iv) Auxin is a plant growth hormone that affects the growth of rice stems.

Explain how auxin affects the growth of rice stems.

.....

.....

.....

.....

.....

..... [3]

© UCLES 2023

(b) *O. rufipogon* and *O. nivara* are two species of wild rice.

- *O. rufipogon* grows in places where water is always available.
- *O. nivara* grows within the same geographical range as *O. rufipogon*.
- The habitat of *O. nivara* can lack water for part of the year.
- The two species flower at different times of the year.

These two rice species may have evolved by sympatric speciation.

Explain how *O. rufipogon* and *O. nivara* may have evolved through sympatric speciation.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 12]

4 **(a)** Recombinant human proteins can be used to treat disease.

(i) Define the term recombinant DNA.

.....

..... [1]

(ii) From the 1920s until the 1970s, insulin obtained from the bodies of animals was used to treat diabetes. From the 1970s, recombinant human insulin was used instead.

Explain the advantages of using recombinant human insulin to treat people with diabetes.

.....

.....

.....

.....

..... [3]

(b) Insulin is composed of two polypeptide chains, the A chain and the B chain, that are linked by disulfide bonds.

Variations in amino acid sequence occur:

- in the insulin molecules of different animals
- in new versions of human insulin that have been engineered to control blood glucose concentration more effectively than normal recombinant human insulin. These new versions of human insulin are called analogues.

© UCLES 2023

Table 4.1 shows the amino acid positions where variation occurs in different animal and human analogue insulin molecules. The dashes indicate a missing amino acid.

Table 4.1

amino acid position	type of insulin					
	human	**cow**	**pig**	**cat**	**short-acting analogue**	**long-acting analogue**
A8	threonine	alanine	threonine	alanine	threonine	threonine
A10	isoleucine	valine	isoleucine	valine	isoleucine	isoleucine
A18	asparagine	–	asparagine	histidine	asparagine	asparagine
A21	asparagine	asparagine	asparagine	asparagine	asparagine	glycine
B3	asparagine	asparagine	asparagine	asparagine	asparagine	–
B28	proline	proline	proline	proline	lysine	proline
B29	lysine	lysine	lysine	lysine	proline	lysine
B30	threonine	alanine	alanine	alanine	threonine	threonine
B31	–	–	–	–	–	arginine
B32	–	–	–	–	–	arginine

(i) Cats with diabetes can be successfully treated with insulin injections. Cat insulin is **not** available, but vets can choose from the other types of insulin shown in Table 4.1.

Identify the type of insulin that is most suitable for treating cats.

..... [1]

(ii) Suggest ways in which analogue insulin molecules can be produced by genetic engineering techniques.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(c) Information about amino acid and nucleotide sequences is stored in computer databases.

Outline the advantages of using databases of nucleotide sequences to investigate evolutionary relationships between species.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 11]

5 The kidney is an important organ of homeostasis. One role of the kidney is osmoregulation.

(a) Fig. 5.1 is a photomicrograph of part of a kidney nephron.

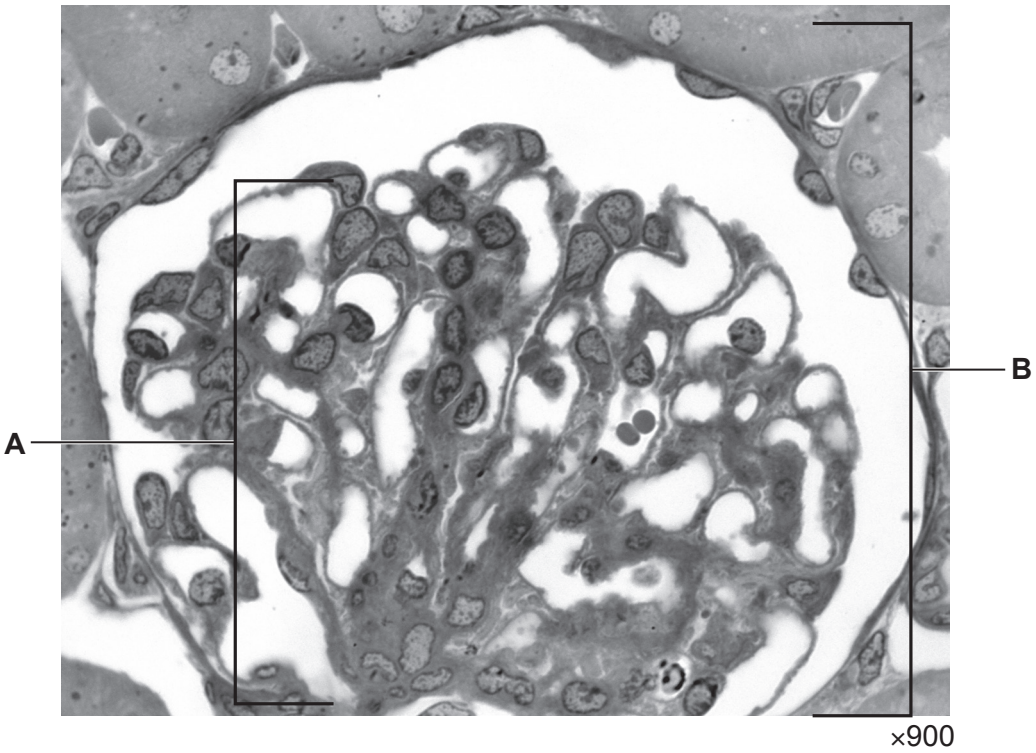


Fig. 5.1

(i) Identify the structures labelled **A** and **B** in Fig. 5.1.

A .....

B .....
[2]

(ii) Describe how blood is filtered by the part of the kidney nephron shown in Fig. 5.1.

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) The cell surface membranes of kidney cells have receptors for many molecules, including glucagon and antidiuretic hormone (ADH).

(i) Glucagon binds to G-protein-coupled receptors on kidney cells.

The binding of glucagon to kidney cells activates a cell signalling pathway that is similar to the cell signalling pathway activated when glucagon binds to liver cells.

Fig. 5.2 is an outline of the cell signalling pathway activated when glucagon binds to kidney cells.

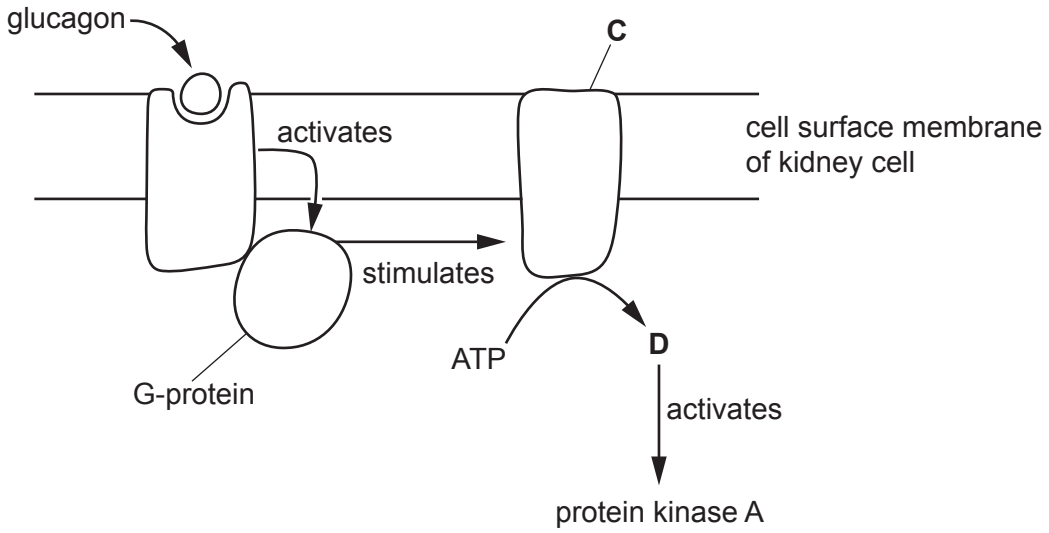


Fig. 5.2

Name the molecules labelled **C** and **D** in Fig. 5.2.

C .....

D .....
[2]

(ii) Syndrome of inappropriate antidiuresis (SIAD) is a condition that affects osmoregulation in the kidney.

Fig. 5.3 shows how sodium ion concentration in the blood affects the ADH concentration in the blood in:

- people with normal homeostasis
- people with one type of SIAD, known as type C SIAD.

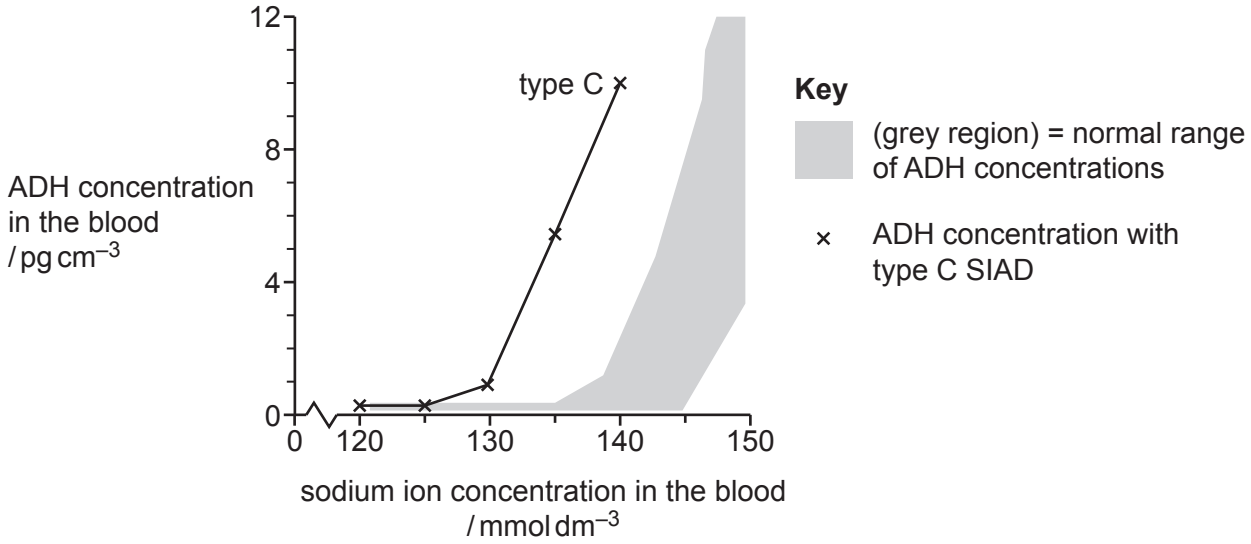


Fig. 5.3

Describe the results shown in Fig. 5.3 **and** explain the effect of type C SIAD on osmoregulation.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 12]

6 Domestic rabbits vary in the length and colour of their fur.

Fig. 6.1 shows a domestic rabbit with short fur and a fur colour pattern called Himalayan.



Fig. 6.1

The two genes that determine the length and colour of the fur of this rabbit occur at the **A / a** locus and the **B / b^h / b** locus. These two gene loci are on separate chromosomes.

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

- The allele **B** results in black fur all over the body.
- The allele **b^h** results in black fur on the nose, ears, paws and tail of the rabbit, and white fur on the rest of the body (Himalayan pattern).
- The allele **b** results in white fur all over the body (albino).
- **B** is dominant to **b^h** and **b^h** is dominant to **b**.

(a) (i) List the **four** possible genotypes of the rabbit shown in Fig. 6.1.

.....

.....

..... [2]

(ii) One phenotype of rabbit always breeds true. This means that when it is mated to a rabbit that looks the same as itself, all the offspring look the same as the parents.

Describe the **phenotype** of the rabbit that breeds true.

..... [1]

© UCLES 2023

(b) A rabbit with long, black fur all over the body that was homozygous at both loci was crossed with a rabbit with short, white fur that was homozygous at both loci. The F1 offspring had short, black fur. These F1 rabbits were mated together to become the parents of the F2 generation.

Draw a genetic diagram to predict the F2 offspring genotypes and the ratio of F2 offspring phenotypes.

F1 genotypes:

gametes:

F2 offspring genotypes:

ratio of F2 offspring phenotypes:

[5]

(c) A rabbit breeder performed multiple crosses of the type described in **(b)**. This gave enough data to test the prediction that the genes for fur length and fur colour show independent assortment.

(i) Explain why the two genes assort independently.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(ii) The rabbit breeder placed the results in a table and started to calculate the χ^2 value.

Table 6.1 shows the results and some of the calculations made.

Table 6.1

phenotype	**observed number (*O*)**	**expected number (*E*)**	$(O - E)^2$	$\frac{(O - E)^2}{E}$
short, black fur	25		4	0.148
long, black fur	11		4	0.444
short, white fur	8		1	0.111
long, white fur	4		1	0.333

Calculate the expected numbers and write them in the shaded column in Table 6.1. [1]

(iii) Use the formula provided and the figures in Table 6.1 to calculate the χ^2 value.

$$\chi^2 = \Sigma\frac{(O - E)^2}{E}$$

χ^2 = ... [1]

[Total: 13]

© UCLES 2023

7 Amino acids are the monomers that are used to produce proteins in organisms. Amino acids also have other, non-protein, roles in the body.

(a) Fig. 7.1 shows the structures of five amino acids with varying numbers and arrangements of carbon atoms.

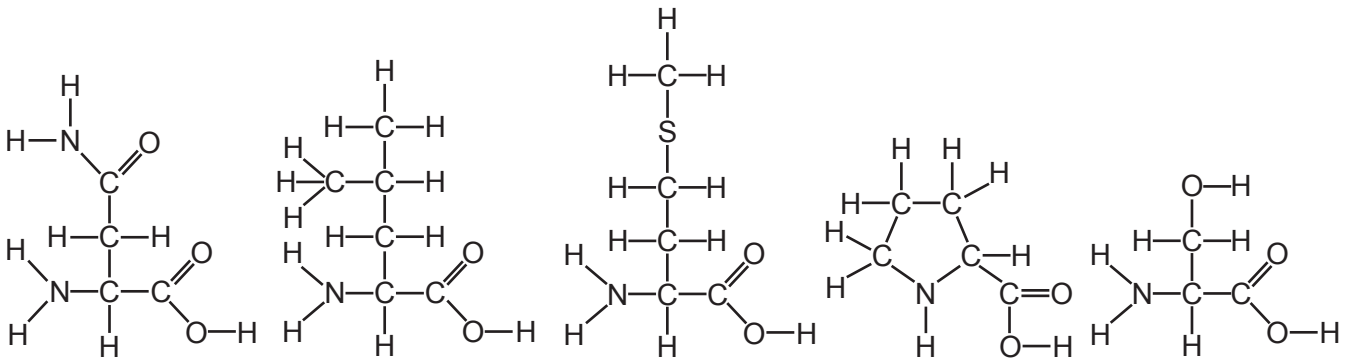


Fig. 7.1

In the liver, one of these amino acids can be converted to pyruvate and one of these amino acids can be converted to oxaloacetate.

Suggest which of the amino acids shown in Fig. 7.1 would be most directly converted to:

- pyruvate
- oxaloacetate.

amino acid converted to pyruvate .....

amino acid converted to oxaloacetate .....

[2]

(b) The amino acid glycine can act as a neurotransmitter.

A glycinergic synapse is shown in Fig. 7.2.

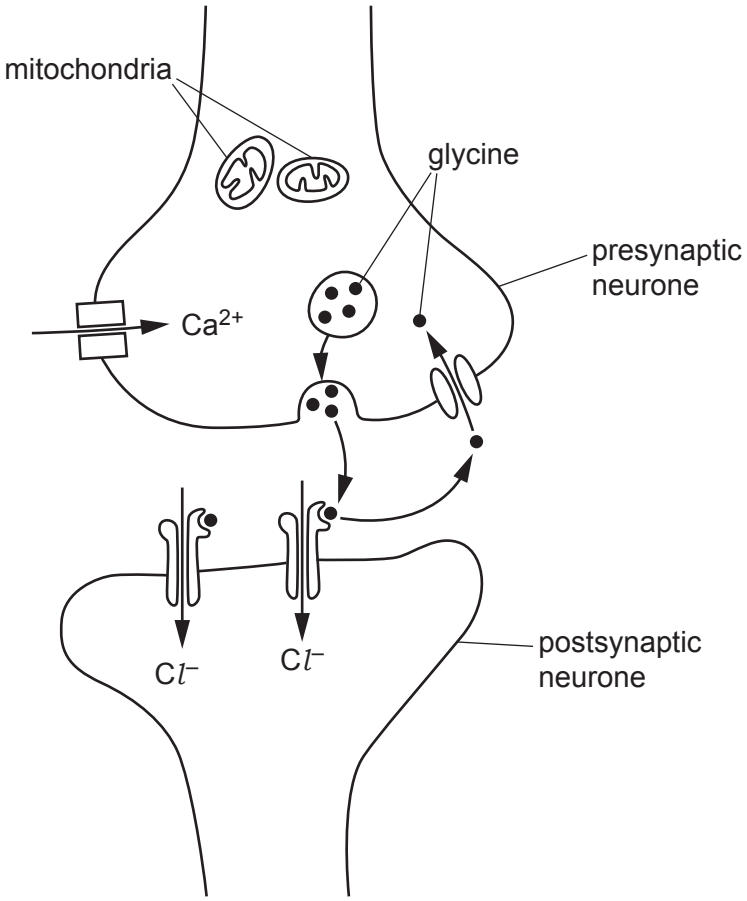


Fig. 7.2

(i) The glycinergic synapse and a cholinergic synapse use different neurotransmitters and different postsynaptic receptors.

Describe differences between the glycinergic synapse shown in Fig. 7.2 and a cholinergic synapse.

.....

.....

.....

.....

.....

..... [2]

© UCLES 2023

(ii) The binding of glycine to receptors, as shown in Fig. 7.2, makes an action potential less likely to occur in the postsynaptic neurone.

Suggest why an action potential is less likely to occur after the binding of glycine to receptors.

.....

.....

.....

.....

..... [2]

(iii) Neurones need to maintain a resting potential before an action potential can occur.

Describe how a neurone maintains a resting potential.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 10]

8 Fig. 8.1 shows a cell from the testis of a locust at the late prophase I stage of meiosis.



Fig. 8.1

Explain how the behaviour of the chromosomes in prophase I of meiosis results in the appearance shown in Fig. 8.1.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

[Total: 4]

9 Many factors affect the rate of cellular respiration.

(a) Pyruvate carboxylase (PC) deficiency is a rare disease. The rate of respiration in the cells of a person with PC deficiency is much lower than normal.

The passage describes the occurrence of PC deficiency in human populations.

Complete the passage by using the most appropriate scientific terms.

PC deficiency affects one in 250 000 people. A person either has the disease or does not, so there are no intermediate forms of the disease. PC deficiency is caused by a genetic mutation in one gene. Whether a person develops the disease is not influenced by ..... factors. The distribution of PC deficiency in human populations shows ..... variation. [2]

(b) Coenzymes are important in aerobic respiration.

Outline the roles of named coenzymes in aerobic respiration.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 7]

10 Sweet peas are garden plants that vary in height.

- Tall sweet peas grow to 200 cm in height.
- Dwarf sweet peas grow to 30 cm in height.
- Tall sweet peas contain a dominant ***Le*** allele.
- Dwarf sweet peas are homozygous for the recessive ***le*** allele.

Explain how the ***lele*** genotype results in the dwarf phenotype in sweet peas, with reference to the effect of ***lele*** on:

- enzyme synthesis
- hormone production
- the expression of genes affecting plant growth.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

[Total: 6]

The boundaries and names shown, the designations used and the presentation of material on any maps contained in this question paper/insert do not imply official endorsement or acceptance by Cambridge Assessment International Education concerning the legal status of any country, territory, or area or any of its authorities, or of the delimitation of its frontiers or boundaries.

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.

© UCLES 2023

Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

5961476185

BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **May/June 2023**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

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

INFORMATION

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

This document has **24** pages. Any blank pages are indicated.

© UCLES 2023

1 **(a)** Glycolysis is a biochemical pathway that occurs in the cytoplasm of cells.

In glycolysis, a molecule of glucose is metabolised to two molecules of pyruvate. The process is outlined in Fig. 1.1.

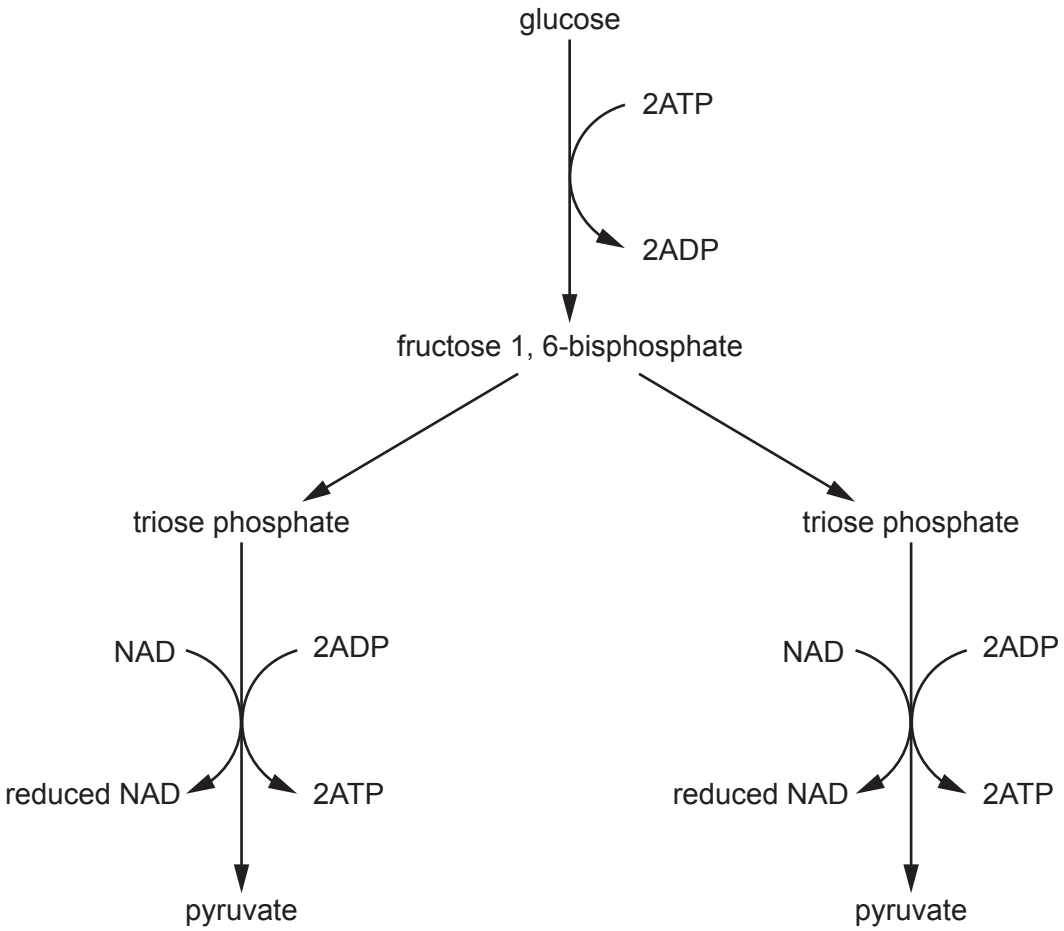


Fig. 1.1

(i) Explain why glucose is phosphorylated at the beginning of glycolysis.

.....

..... [1]

(ii) Suggest **one** use of the reduced NAD that is produced in glycolysis.

.....

..... [1]

(iii) Name the type of phosphorylation reaction by which ATP is made during glycolysis.

.....

..... [1]

© UCLES 2023

(b) Pyruvate can enter the mitochondrion by active transport.

Describe the main conditions that are required for pyruvate to enter the mitochondrion by active transport.

.....

.....

.....

.....

.....

.....

..... [3]

(c) Pyruvate is involved in the link reaction in the matrix of the mitochondrion.

Describe the link reaction.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 9]

2 **(a)** In sexual reproduction, meiosis occurs to produce haploid gametes from a diploid cell.

Explain the meaning of the terms haploid **and** diploid.

.....

.....

.....

..... [2]

(b) Describe the behaviour of **chromosomes** during the main stages of meiosis I in animal cells.

prophase I .....

.....

.....

.....

metaphase I .....

.....

.....

.....

anaphase I .....

.....

.....

.....

telophase I .....

.....

.....

.....

[4]

(c) The production of haploid gametes by meiosis also involves division of the cytoplasm.

State the term used to describe this division of the cytoplasm.

..... [1]

[Total: 7]

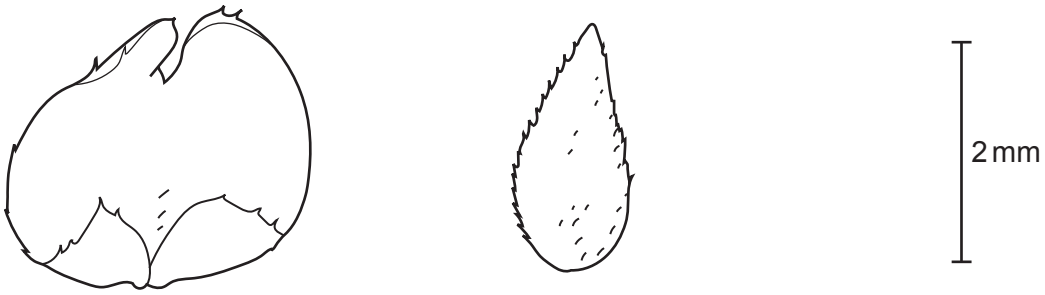
© UCLES 2023

3 **(a)** The sea blush, *Plectritis congesta*, is a flowering plant that grows on the west coast of North America.

Individual sea blush plants produce fruit that is either winged or wingless. Investigations have shown that this characteristic is controlled by a single gene with two alleles:

- a dominant winged fruit allele
- a recessive wingless fruit allele.

Fig. 3.1 shows the difference in structure between winged fruit and wingless fruit phenotypes.



winged fruit wingless fruit

Fig. 3.1

(i) A large sample of sea blush fruits was collected and their fruit-wing characteristic was recorded.

Name the type of variation that is shown for the fruit-wing characteristic of the sea blush.

..... [1]

(ii) Different sea blush plants can have fruit with different colours.

Suggest **two** ways in which a new fruit colour could naturally occur in a sea blush population.

.....

.....

.....

..... [2]

(iii) Early taxonomists classified sea blush plants with winged fruits as a different species to sea blush plants with wingless fruits.

Since this time, evidence from observations and experiments has confirmed that the plants belong to the same species.

Suggest **three** examples of the evidence obtained that helped to confirm that these sea blush plants belong to the same species.

.....

.....

.....

.....

.....

.....

..... [3]

(b) Natural selection occurs in populations, such as in populations of sea blush plants.

Explain why natural selection occurs in populations.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 11]

4 Genetic technology uses many different enzymes and techniques.

(a) Restriction endonucleases are used in genetic modification. These enzymes occur naturally in prokaryotic cells. More than 3500 different restriction endonucleases have been identified and it is thought there are many more to discover.

Name **two** domains that are a source of restriction endonucleases.

.....

..... [1]

(b) Originally, the method used to obtain a restriction endonuclease was to:
- grow large numbers of the specific prokaryotic cells that are the source of the enzyme
- break open the cells and extract and purify the restriction endonuclease.

This original method produced only a small quantity of restriction endonuclease and was **not** economical.

The newer method for large-scale production is to:
- obtain the gene coding for a specific restriction endonuclease
- introduce the gene into *Escherichia coli*, with a promoter that allows the gene to be expressed continuously.

The newer method increases the quantity of specific restriction endonuclease produced.

Suggest **and** explain the steps needed to carry out the newer method for large-scale production of a specific restriction endonuclease.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) Describe the advantages of databases for the study and use of restriction endonucleases.

.....

.....

.....

.....

.....

.....

..... [3]

(d) Electrophoresis is a technique used in genetic technology.

Paper chromatography is a technique used to investigate the photosynthetic pigments found in chloroplasts.

Compare the similarities and differences between electrophoresis and chromatography.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 12]

© UCLES 2023

5 **(a)** Warfarin is a poison used to kill rats. Some rats are resistant to warfarin and can survive the effects of the poison. Warfarin resistance is due to a mutant dominant allele at a single gene locus.

Researchers investigated the population of brown rats on a large island where there are no predators of rats. On this island, warfarin is used to try to control the rat population.

The researchers found that 40% of the population of rats was resistant to warfarin.

(i) Use Hardy–Weinberg equation 1 and equation 2 to calculate the percentage of the population of rats on the island that is heterozygous for warfarin resistance.

equation 1 $p + q = 1$

equation 2 $p^2 + 2pq + q^2 = 1$

Show your working.

answer ..... % [3]

(ii) In natural populations, it is usual to find that only some of the conditions of the Hardy–Weinberg principle are met.

Suggest **and** explain which of the conditions of the Hardy–Weinberg principle are most likely to be met for the island population of brown rats.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) Dominant advantageous alleles and recessive advantageous alleles both naturally occur in populations.

Explain why, when a new **dominant** advantageous allele occurs, its frequency increases more quickly in the population than when a new **recessive** advantageous allele occurs.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

© UCLES 2023

6 **(a)** Fig. 6.1 is a photomicrograph of a section through a Bowman's capsule and a glomerulus.

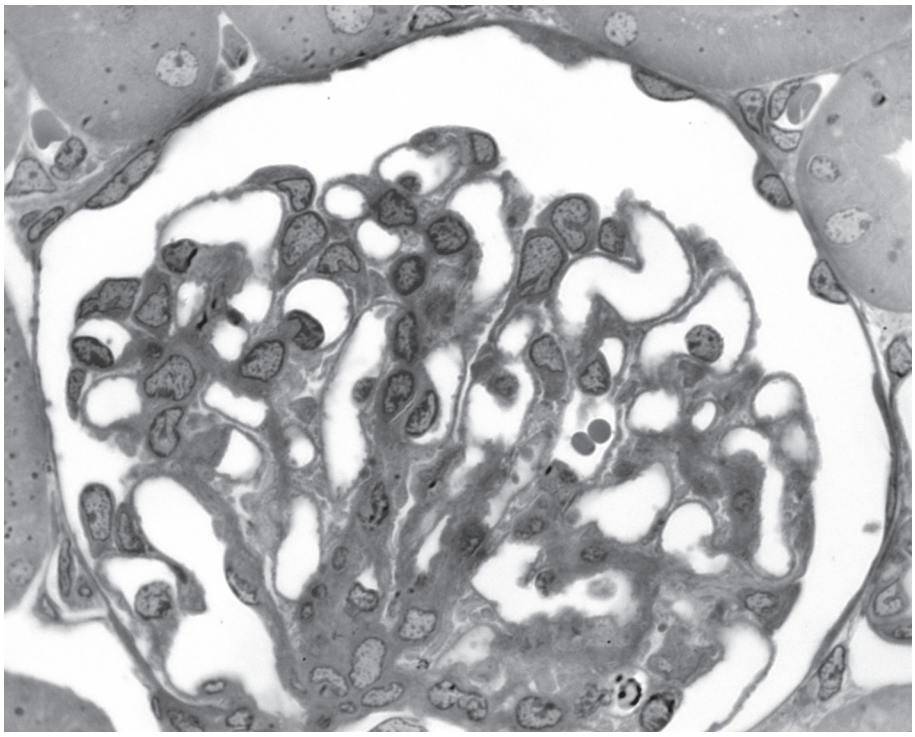


Fig. 6.1

On Fig. 6.1, use label lines and letters to label:

F – the location of the glomerular filtrate

P – the location of the blood plasma. [2]

© UCLES 2023

(b) The glomerular filtration rate (GFR) is the rate at which fluid filters from the blood in the glomerulus into the Bowman's capsule.

Fig. 6.2 shows the mean GFR values for healthy males and females of different age groups.

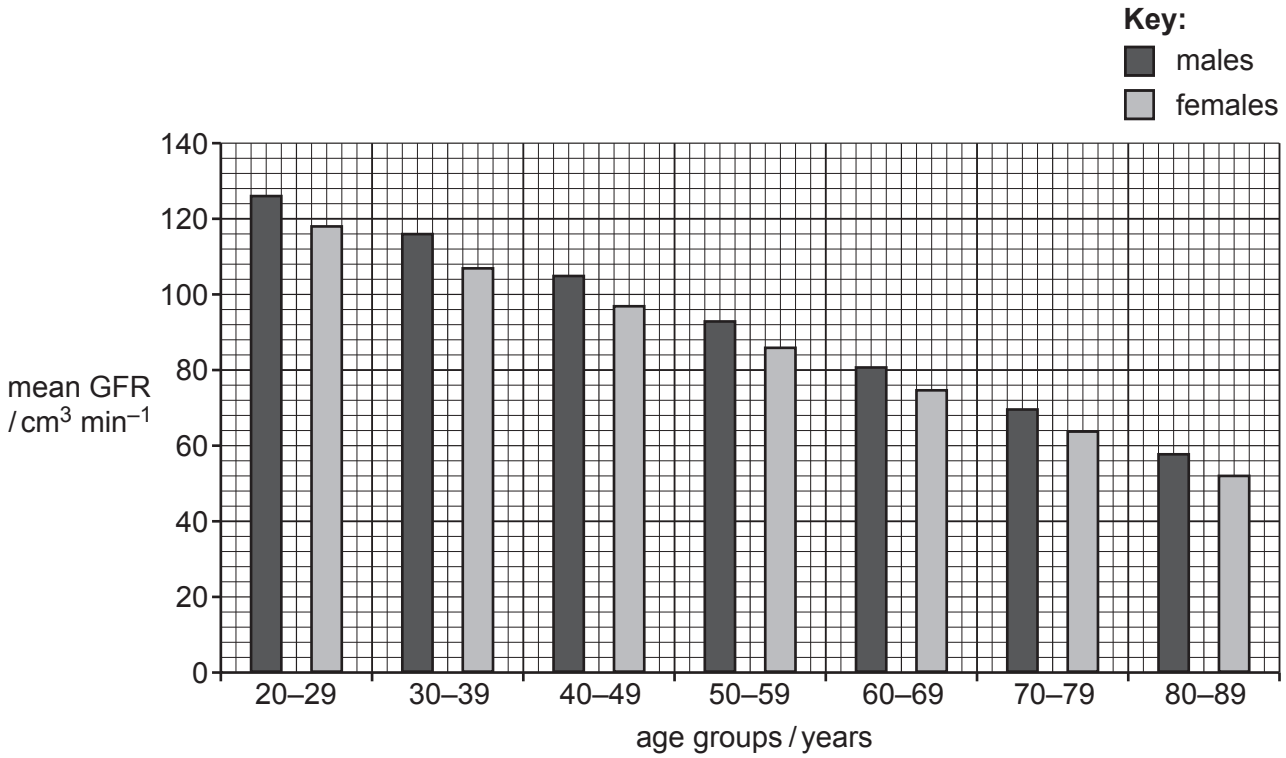


Fig. 6.2

(i) Use Fig. 6.2 to calculate the yearly rate of decrease in mean GFR from the 20–29 age group to the 80–89 age group for **females**.

Show your working.

Give your answer to **one** decimal place and include units.

answer ..... [3]

(ii) The age of a person and whether they are male or female can affect GFR.

Suggest **and** explain other factors that can affect GFR.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(c) The glomerular filtrate passes from the Bowman's capsule to the proximal convoluted tubule, where selective reabsorption takes place.

Describe the process of selective reabsorption.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [7]

[Total: 15]

7 **(a)** A striated muscle cell (muscle fibre) will contract when stimulated by a motor neurone at a neuromuscular junction.

Air temperature can affect the temperature of striated muscle cells.

Investigations have shown that the efficiency of contraction of striated muscle cells decreases when the air temperature decreases.

Suggest reasons why a reduction in temperature can decrease the efficiency of contraction of striated muscle cells.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) The greater blue-ringed octopus, *Hapalochlaena lunulata*, produces tetrodotoxin (TTX). TTX is a neurotoxin. If a mammal is bitten by this octopus, the effect of TTX can cause the death of the mammal.

Fig. 7.1 shows a greater blue-ringed octopus.

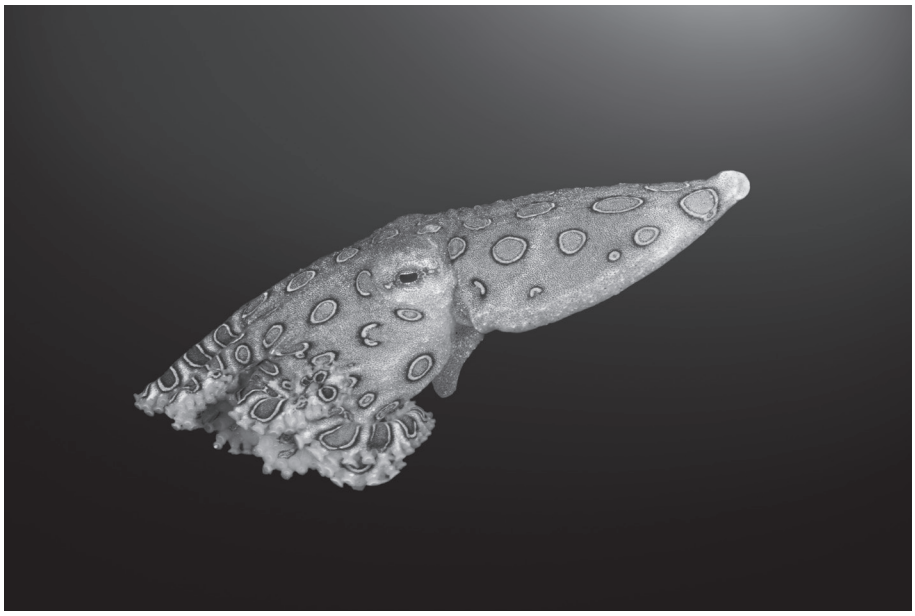


Fig. 7.1

TTX binds to voltage-gated sodium ion channels in the axon of a neurone and changes the tertiary structure of the channel protein.

Suggest how TTX may affect the functioning of a motor neurone.

.....

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 7]

8 **(a)** In plants such as rice, *Oryza sativa*, rubisco has a low rate of activity, which in turn affects the rate of photosynthesis. The cereal crop sorghum, *Sorghum bicolor*, has a high rate of activity of rubisco.

A genetically modified (GM) variety of rice was produced. Parts of the quaternary structure of rubisco in rice were altered to be the same as the rubisco in sorghum.

The rate of activity of rubisco in non-GM rice and GM rice was measured at different concentrations of atmospheric carbon dioxide (CO_2).

The results are shown in Fig. 8.1.

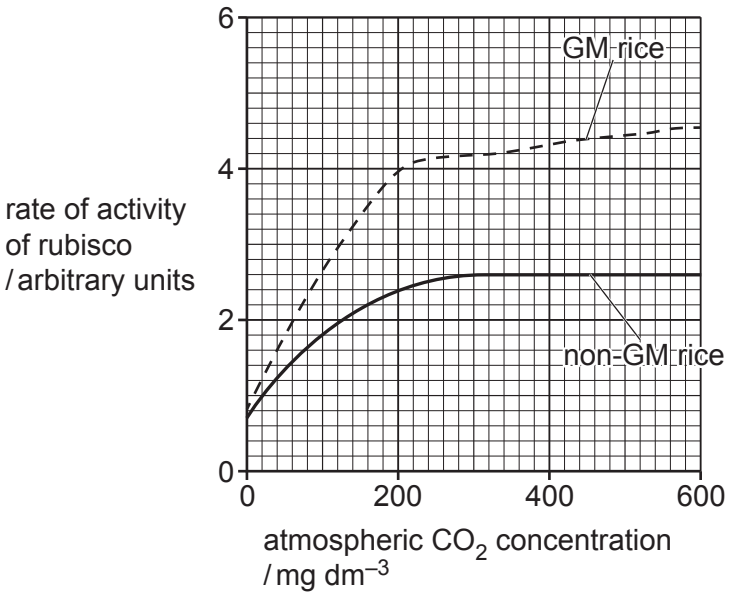


Fig. 8.1

(i) Compare the two curves shown in Fig. 8.1 **and** explain why the curve for non-GM rice levels off.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(ii) Suggest which part of the rubisco molecule was altered to produce the GM variety of rice.

.....

..... [1]

© UCLES 2023

(b) Fig. 8.2 shows an outline of the Calvin cycle.

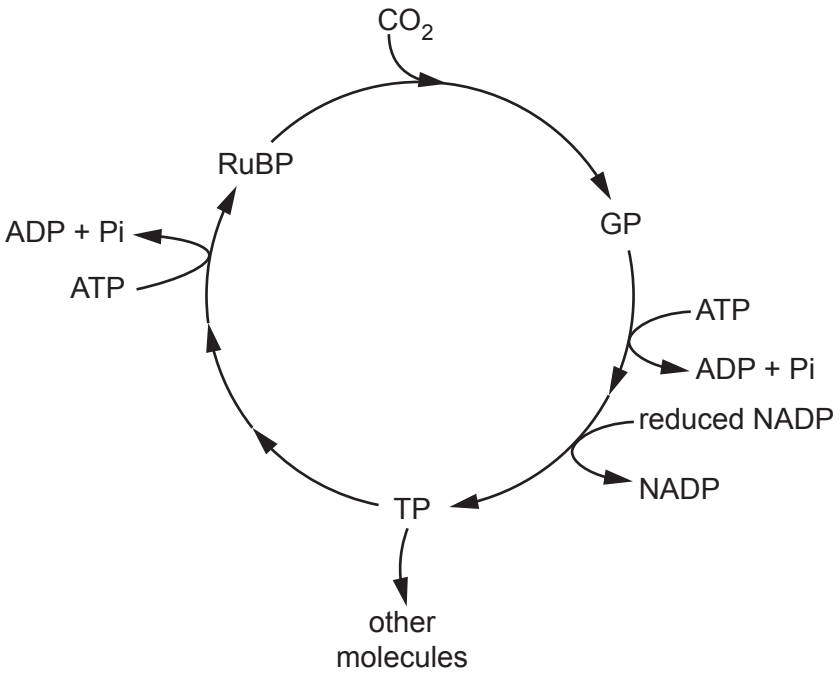


Fig. 8.2

(i) Name the process that involves the enzyme rubisco.

..... [1]

(ii) State the type of reaction that occurs when GP is converted to TP.

..... [1]

(iii) RuBP is regenerated from molecules of TP.

State how many molecules of RuBP are produced from 10 molecules of TP.

..... [1]

(iv) TP molecules that are **not** involved in the regeneration of RuBP can be used in the synthesis of other molecules.

State **two** molecules that can be produced from these TP molecules.

.....

..... [2]

[Total: 9]

9 **(a)** The passage outlines the endocrine system.

Complete the passage by using the most appropriate scientific terms.

The endocrine system consists of tissues and ..... , which secrete hormones such as insulin, glucagon and antidiuretic hormone (ADH). Glucagon only affects target cells that have complementary receptors, which are located on the ..... . Glucagon binds to these receptors and this leads to the production of a ..... , which transfers the signal throughout the cytoplasm. The target cells for insulin are in the liver, ... and adipose tissue. The target cells for ADH are those of the distal convoluted tubule and the ..... of the kidney nephron. These hormones are involved in ..... , which is the maintenance of a constant internal environment. [6]

(b) The blood glucose concentration of a person was measured at regular intervals after the ingestion of a meal rich in glucose.

Fig. 9.1 shows the results of this investigation.

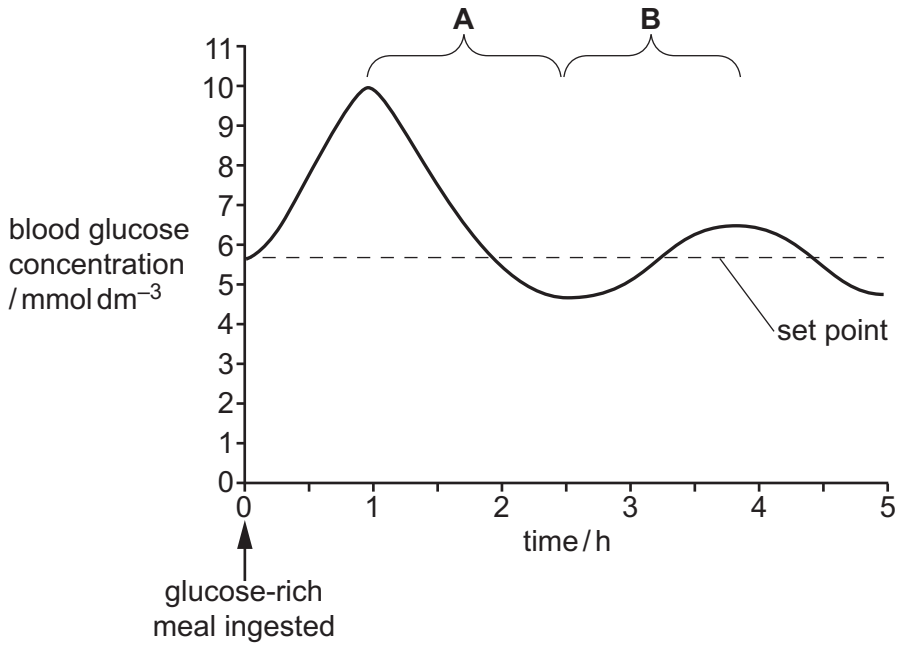


Fig. 9.1

(i) Explain how the blood glucose concentration is reduced during phase **A** of the curve.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(ii) Suggest why the blood glucose concentration increases again during phase **B**.

.....

.....

..... [1]

[Total: 10]

10 (a) Many zoos around the world are involved in captive breeding programmes for endangered species.

Outline the role of zoos in the conservation of endangered species, **other than** captive breeding programmes.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(b) Chester Zoo, in the United Kingdom, controls the European captive breeding programme for the eastern black rhinoceros, *Diceros bicornis michaeli*.

Fig. 10.1 shows an eastern black rhinoceros.



Fig. 10.1

In the captive breeding programme for the eastern black rhinoceros, 15.8% of females breed each year while in the wild 23.7% of females breed each year.

Suggest reasons why fewer females breed in captivity than in the wild.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) Sometimes assisted reproduction is used in captive breeding programmes for the eastern black rhinoceros.

Fig. 10.2 outlines the process of IVF that is used in these programmes.

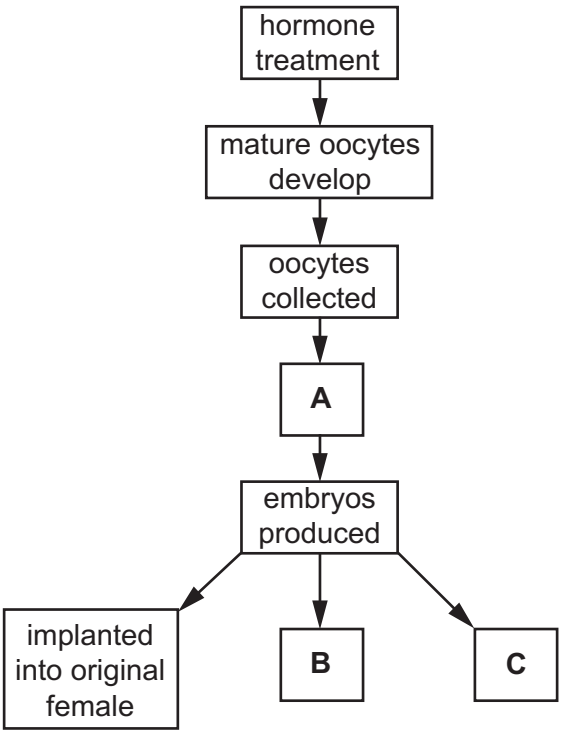


Fig. 10.2

Outline:

- the event **A** that occurs in the production of the embryos
- the **two** other possible outcomes, **B** and **C**, for the embryos that have been produced.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

BLANK PAGE

© UCLES 2023

BLANK PAGE

The boundaries and names shown, the designations used and the presentation of material on any maps contained in this question paper/insert do not imply official endorsement or acceptance by Cambridge Assessment International Education concerning the legal status of any country, territory, or area or any of its authorities, or of the delimitation of its frontiers or boundaries.

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.

© UCLES 2023

Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0796397395

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 2023**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

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

INFORMATION

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

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

© UCLES 2023

[Turn over

1 **(a)** The Krebs cycle was named after the biochemist Sir Hans Krebs, who worked out the sequence in 1937.

Fig. 1.1 is an outline of the Krebs cycle.

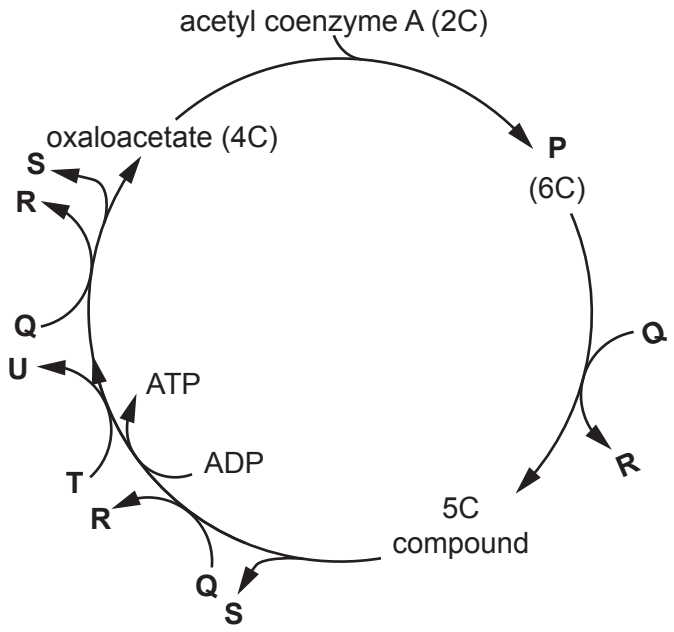


Fig. 1.1

Identify substances **P**–**U**.

P .....

Q .....

R .....

S .....

T .....

U .....

[3]

(b) Describe how ATP is produced from ADP in the Krebs cycle.

.....

.....

.....

.....

..... [2]

(c) Describe **and** explain the features of ATP that make it suitable as the universal energy currency.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 9]

2 Humans use antibiotics to treat bacterial infections. The increased use of antibiotics has led to an increase in the number of strains of bacteria that are resistant to antibiotics.

The evolution of antibiotic resistance in bacteria has resulted from natural selection.

Outline how bacteria become resistant to antibiotics.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

[Total: 7]

BLANK PAGE

3 Gene expression in a cell is controlled. When a gene is expressed (switched on), the gene is transcribed. When a gene is **not** expressed (switched off), the gene is **not** transcribed.

Environmental changes can cause some genes to be switched on or switched off.

(a) An example of control of gene expression in prokaryotes is regulation in the *lac* operon.

The *lac* operon is a length of DNA that is made up of different parts.

Fig. 3.1 shows a simple diagram representing the *lacI* (regulatory) gene and the *lac* operon.



Fig. 3.1

(i) Outline the main features of the *lac* operon.

.....

.....

.....

.....

.....

.....

..... [3]

(ii) Explain the role of the *lacI* gene in the regulation of the *lac* operon.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) The *lac* operon codes for inducible enzymes. Repressible operons code for repressible enzymes.

Suggest **and** explain why it is an advantage to a prokaryote to have a repressible operon.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

4 One cause of the genetic disease severe combined immunodeficiency (SCID) is a mutation in the *ADA* gene. This mutation results in a deficiency of the enzyme adenosine deaminase (ADA).

Although ADA is found throughout the body, it is especially active in lymphocytes. The absence of functional ADA causes the build-up of toxic metabolites that kill lymphocytes and damage organs.

Babies are often diagnosed with SCID by six months old. Treatment can greatly improve the life expectancy of children with SCID.

Some treatment options are available.

- Enzyme replacement therapy with recombinant human ADA made by genetically modified (GM) *Escherichia coli*. Weekly intra-muscular injections are given.
- Bone marrow transplant if a well-matched donor, such as a close relative, can be found.
- Gene therapy.

(a) Suggest **and** explain why it may be more appropriate to use enzyme replacement therapy to treat SCID instead of a bone marrow transplant.

.....

.....

.....

.....

.....

.....

.....

.....

..... [3]

(b) Outline the procedure used for gene therapy treatment of a person with SCID.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) Suggest the social and ethical implications of gene therapy for SCID that need to be considered before treatment is carried out.

.....

.....

.....

.....

.....

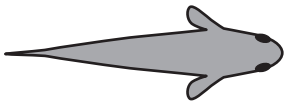
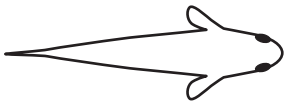
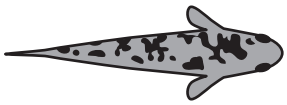
.....

..... [3]

[Total: 10]

5 A freshwater fish species, *Oryzias latipes*, has individuals with four body colour patterns, as shown in Table 5.1.

Table 5.1

phenotype	body colour pattern
red	
white	
red with black spots	
white with black spots	

Two unlinked genes determine the body colour patterns shown in Table 5.1.

One gene controls whether the body colour is red or white:
- dominant allele **R** = red
- recessive allele **r** = white.

The other gene controls whether black spots are present or **not** present:
- dominant allele **B** = with black spots
- recessive allele **b** = without black spots.

A fish that is homozygous recessive at both loci is white.

Genetic crosses were carried out to investigate the inheritance of the four different body colour patterns.

Males that were red with black spots, and homozygous at both loci, were crossed with females that were white. The F1 offspring were all red with black spots.

These F1 offspring were then crossed to produce the F2 generation.

© UCLES 2023

(a) Table 5.2 shows the observed numbers obtained of each of the four different phenotypes for the F2 generation.

Table 5.2

phenotype	**observed**	**expected**	***O–E***	$(O–E)^2$	$\frac{(O–E)^2}{E}$
red with black spots	279	281.25			
white with black spots	95	93.75	1.25	1.5625	0.017
red	96	93.75	2.25	5.0625	0.054
white	30	31.25			
				χ^2 = ...	

Table 5.2 compares the observed numbers with the numbers that would be expected in the F2 generation for a normal dihybrid ratio.

Calculate χ^2 for the F2 generation by completing Table 5.2.

The formula for χ^2 is:

$$\chi^2 = \sum \frac{(O–E)^2}{E}$$

[3]

(b) The critical value at $p = 0.05$ and 3 degrees of freedom is 7.815.

Comment on whether the null hypothesis should be accepted or rejected.

.....

.....

.....

.....

..... [2]

Further analysis of the results from the F2 generation in Table 5.2 showed that there were no white males or white males with black spots.

In *O. latipes*, females have two **X** chromosomes and males have an **X** and a **Y** chromosome.

It was deduced that, in *O. latipes*:

- the gene that controls body colour is located on the **X** chromosome **and** the **Y** chromosome
- the gene that controls whether black spots are present or **not** is located on an autosome.

(c) To produce the F2 generation, red males with black spots, $\mathbf{X^rY^RBb}$, were crossed with red females with black spots, $\mathbf{X^RX^rBb}$.

Complete the Punnett square in Fig. 5.1 to show the genotypes and phenotypes of the F2 generation.

- Use the symbols $\mathbf{X^R}$, $\mathbf{X^r}$ and $\mathbf{Y^R}$ for the alleles of the gene that controls body colour.
- Use the symbols **B** and **b** for the alleles of the gene that controls whether black spots are present or **not**.

Some of Fig. 5.1 has been completed for you.

	female gametes			
male gametes	$\mathbf{X^RB}$	$\mathbf{X^rB}$	$\mathbf{X^Rb}$	$\mathbf{X^rb}$
$\mathbf{X^rB}$	$\mathbf{X^RX^rBB}$		$\mathbf{X^RX^rBb}$	$\mathbf{X^rX^rBb}$
	female		female	female
	red + black spots		red + black spots	white + black spots
$\mathbf{Y^RB}$	$\mathbf{X^RY^RBB}$	$\mathbf{X^rY^RBB}$	$\mathbf{X^RY^RBb}$	$\mathbf{X^rY^RBb}$
	male	male	male	male
	red + black spots	red + black spots	red + black spots	red + black spots
$\mathbf{X^rb}$	$\mathbf{X^RX^rBb}$	$\mathbf{X^rX^rBb}$	$\mathbf{X^RX^rbb}$	
	female	female	female	
	red + black spots	white + black spots	red + no spots	
$\mathbf{Y^Rb}$		$\mathbf{X^rY^RBb}$		$\mathbf{X^rY^Rbb}$
		male		male
		red + black spots		red + no spots

Fig. 5.1 [4]

(d) Explain why there are no white males or males that are white with black spots in the F2 generation.

.....

.....

.....

.....

..... [2]

© UCLES 2023

(e) In another cross, red males with the genotype $\mathbf{X^rY^Rbb}$ were mated with white females with the genotype $\mathbf{X^rX^rbb}$. All the male offspring were expected to be red and all the female offspring were expected to be white.

The observed results showed that the offspring included two red females out of 253 and one white male out of 198.

Suggest an explanation for this unexpected result.

.....

.....

.....

.....

..... [2]

[Total: 13]

6 **(a)** Fig. 6.1 shows part of the Bowman's capsule of a kidney nephron.

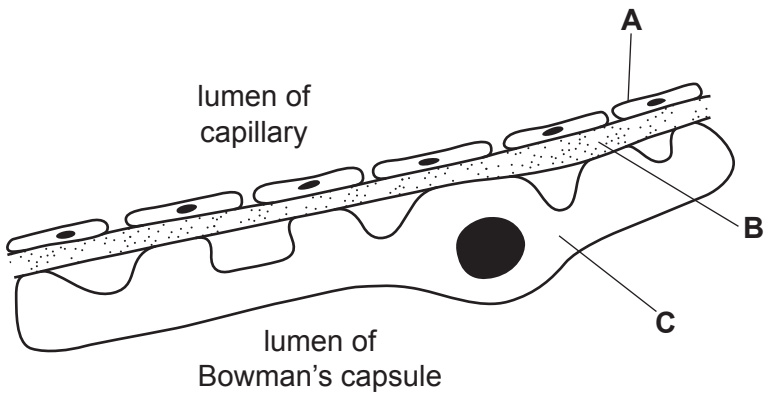


Fig. 6.1

Name structures **A**, **B** and **C**.

A .....

B .....

C .....

[3]

(b) Fluid is forced into the Bowman's capsule by ultrafiltration to form the glomerular filtrate.

Describe the role of structure **B** in ultrafiltration.

.....

.....

.....

.....

..... [2]

(c) The main component of the glomerular filtrate formed in the Bowman's capsule is water. Most of this water is reabsorbed as the filtrate passes along the nephron.

- 180 dm^3 of water forms part of the glomerular filtrate each day.
- 1.4 dm^3 of water leaves the body in urine each day.

Calculate the percentage of water in the glomerular filtrate that is reabsorbed as the glomerular filtrate passes along the nephron.

Show your working and give your answer to **one** decimal place.

answer ..... % [2]

© UCLES 2023

(d) Describe how the action of antidiuretic hormone (ADH) on the cells of the collecting duct leads to the reabsorption of water in the glomerular filtrate.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [7]

[Total: 14]

7 **(a)** Sarcomeres are the functioning units of the myofibrils of the muscle fibres (muscle cells) of striated muscle.

The arrival of an action potential at the sarcoplasmic reticulum of a striated muscle fibre can lead to the shortening of a sarcomere. This shortening occurs by the sliding filament model.

Outline the sequence of events occurring after stimulation of the sarcoplasmic reticulum that results in the shortening of a sarcomere.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) Scientists compared the diameter of samples of striated muscle fibres taken from young mice and adult mice.

The results are shown in Fig. 7.1.

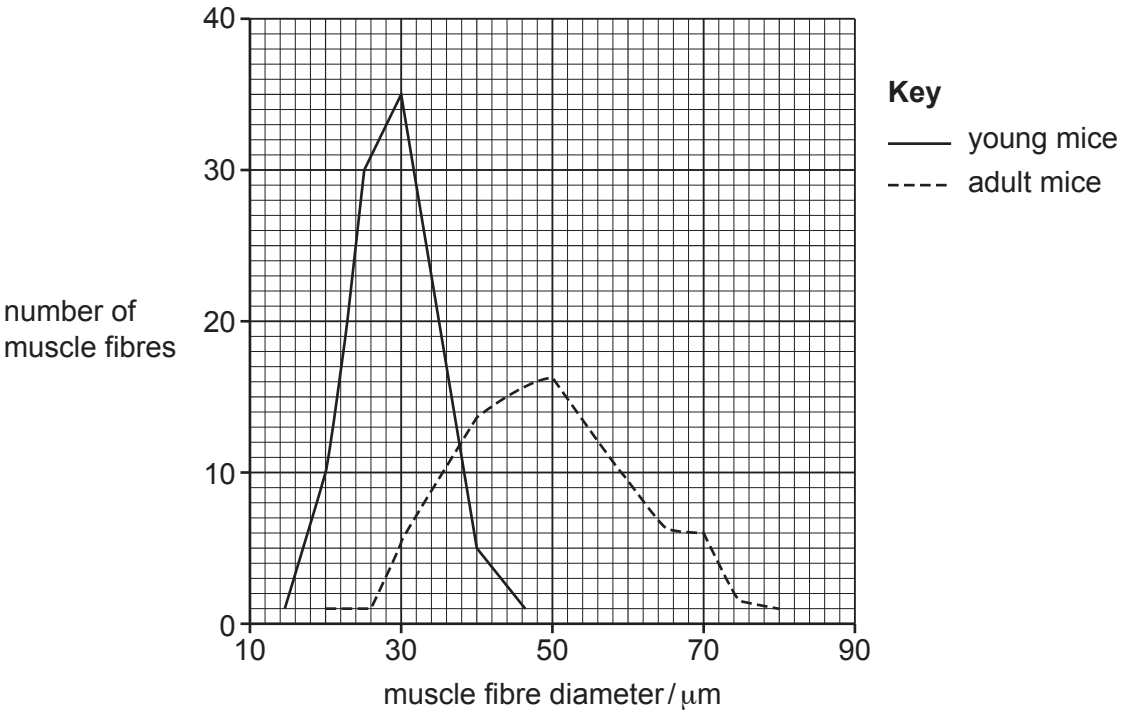


Fig. 7.1

With reference to Fig. 7.1:

- describe **two** differences between the muscle fibres of young mice and adult mice
- suggest how these differences may affect the sliding filament model.

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 8]

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

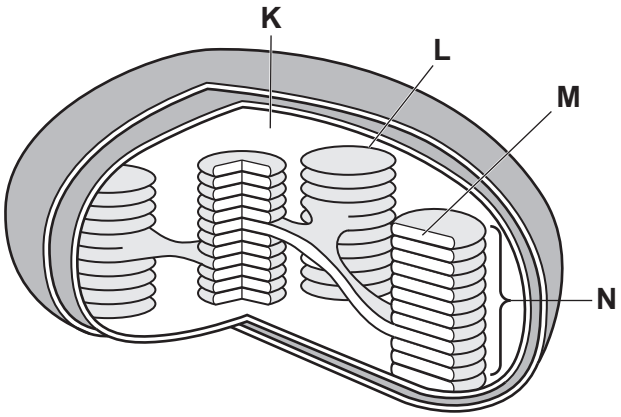


Fig. 8.1

Using the letters **K**–**N**, complete Table 8.1.

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

Table 8.1

	letter
high concentration of protons	.....
location of photosynthetic pigments	.....
site of light-independent stage	.....
site of light-dependent stage	.....

[4]

(b) Chlorophyll *a* is the main photosynthetic pigment in plants.

Describe the role of other photosynthetic pigments found in plant chloroplasts.

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

(c) The absorption of different wavelengths of light by chloroplast pigments can be represented by an absorption spectrum.

Fig. 8.2 is an absorption spectrum of an extract of chloroplast pigments and an absorption spectrum of whole chloroplasts.

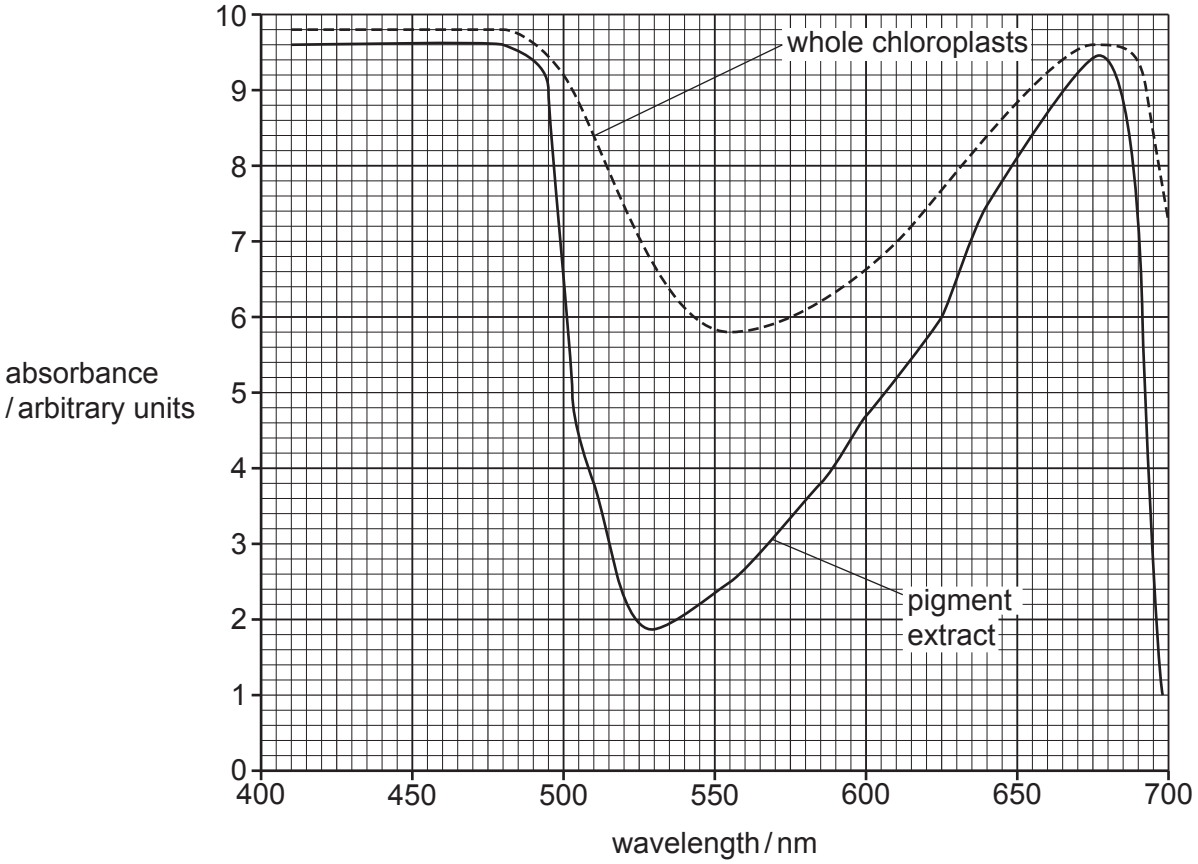


Fig. 8.2

With reference to Fig. 8.2, describe the differences between the two spectra **and** suggest explanations for the differences.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

[Total: 12]

9 **(a)** Dopamine is a neurotransmitter released in some synapses in the brain. The release and action of dopamine is similar to that of acetylcholine.

Fig. 9.1 is a diagram of a brain synapse where dopamine is the neurotransmitter.

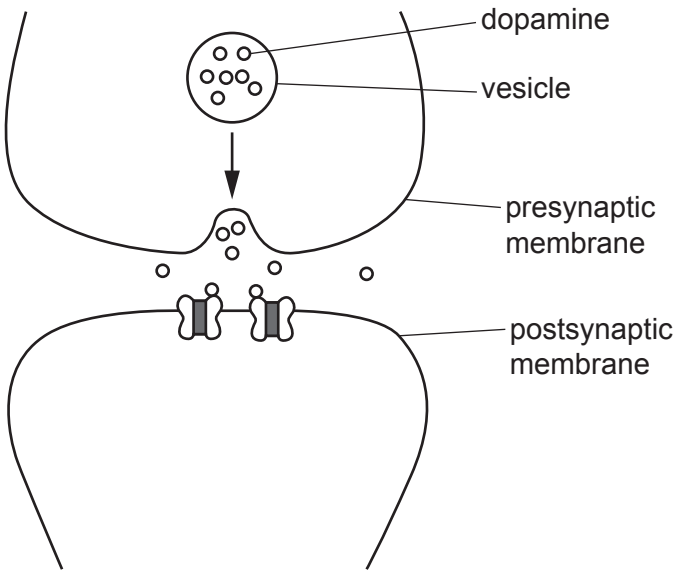


Fig. 9.1

(i) Describe how the release of dopamine from the presynaptic neurone can lead to an action potential in the postsynaptic neurone.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(ii) In brain cells, the amino acid tyrosine is changed into DOPA, which then is converted to dopamine.

Name another compound in the body produced from DOPA.

..... [1]

© UCLES 2023

(b) In some brain synapses, the neurotransmitter gamma-aminobutyric acid (GABA) is released. This results in an influx of chloride ions into the postsynaptic neurone.

Suggest **and** explain whether an action potential would be generated in the postsynaptic neurone if GABA is released into a brain synapse.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 8]

BLANK PAGE

10 (a) The moose, *Alces alces*, is a large member of the deer family. It lives in temperate forests in North America and northern Europe, where snow is present for large parts of the year.

Fig. 10.1 shows an adult male moose feeding in a lake.



Fig. 10.1

The moose feeds on a plant in the lake called watermilfoil, *Myriophyllum aquaticum*.

The moose and the watermilfoil belong to the domain Eukarya, which includes the kingdoms Animalia and Plantae.

Describe the main differences between the kingdom Animalia and the kingdom Plantae.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) Measurements of the surface temperature of land and oceans can be taken from locations around the world. The mean global surface temperature for land and ocean combined can be calculated for a fixed time period.

Scientists calculated:

- the mean global temperature for the twentieth century
- the mean global temperature for each decade (ten years) from 1880 to 2020.

The mean temperature for each decade was compared to the mean for the twentieth century. For each decade, the difference in temperature was calculated.

The calculated differences are shown in Fig. 10.2.

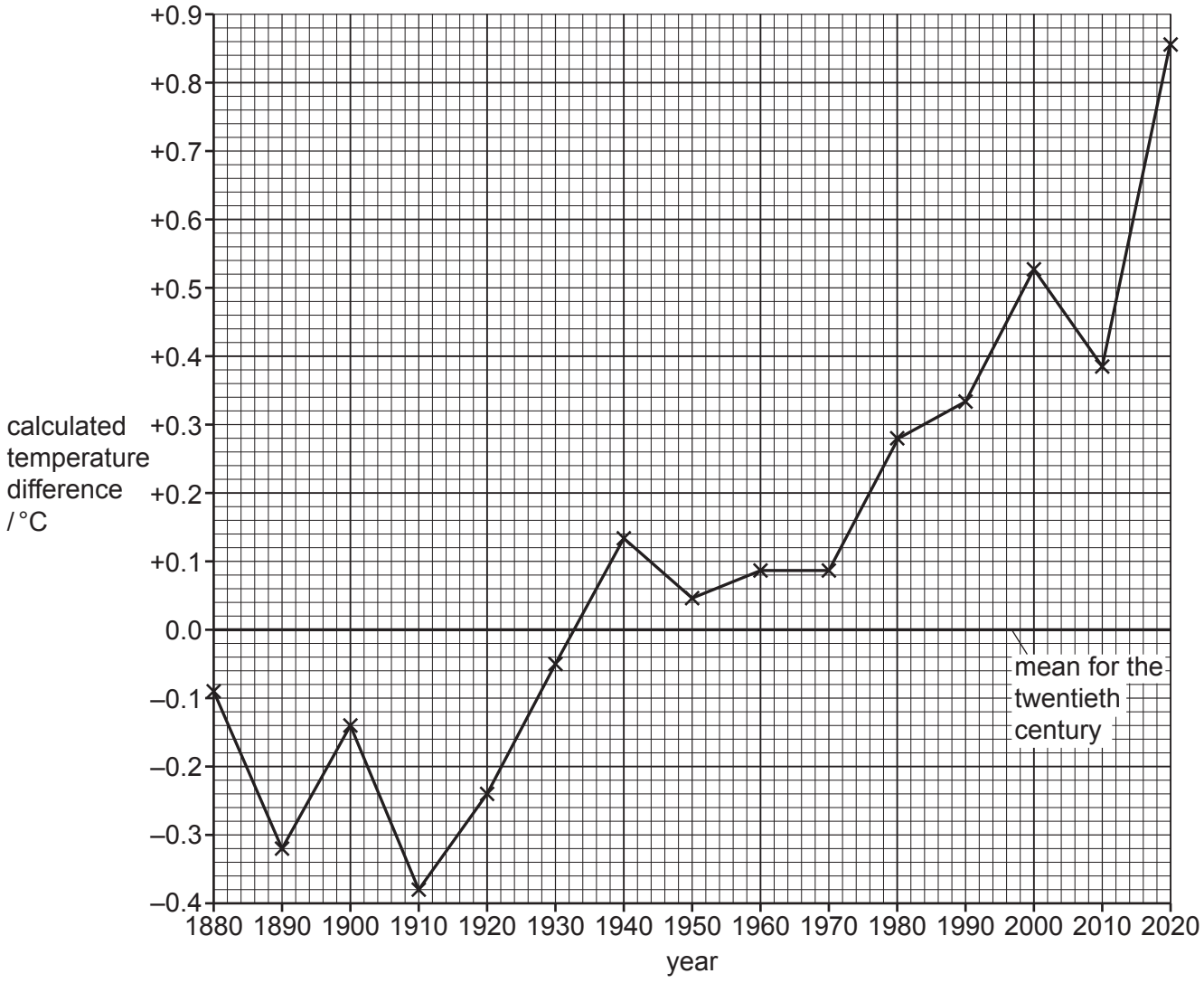


Fig. 10.2

(i) Calculate the rate of increase in temperature per **decade** between 1980 and 2020.

Show your working.

Write your answer to **two** decimal places.

answer ..... °C per decade [2]

(ii) Moose populations have decreased in North America since 1980.

Suggest **and** explain reasons for the decrease in moose populations.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 9]

BLANK PAGE

BLANK PAGE

© UCLES 2023

BLANK PAGE

The boundaries and names shown, the designations used and the presentation of material on any maps contained in this question paper/insert do not imply official endorsement or acceptance by Cambridge Assessment International Education concerning the legal status of any country, territory, or area or any of its authorities, or of the delimitation of its frontiers or boundaries.

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.

© UCLES 2023