Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

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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.

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

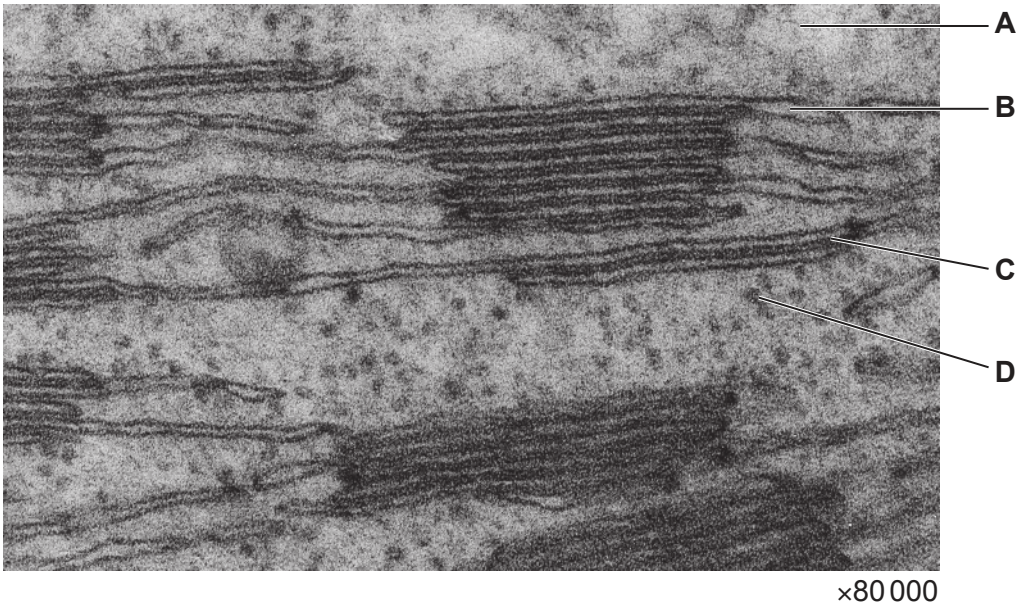


Fig. 1.1

(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**.

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..... [4]

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

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..... [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

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..... [2]

(ii) niche

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..... [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]

(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.

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..... [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**.

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..... [2]

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(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.

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..... [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.

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..... [2]

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

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..... [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.

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..... [3]

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

Explain how auxin affects the growth of rice stems.

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..... [3]

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(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.

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..... [3]

[Total: 12]

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

(i) Define the term recombinant DNA.

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..... [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.

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..... [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.

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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.

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(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.

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..... [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.

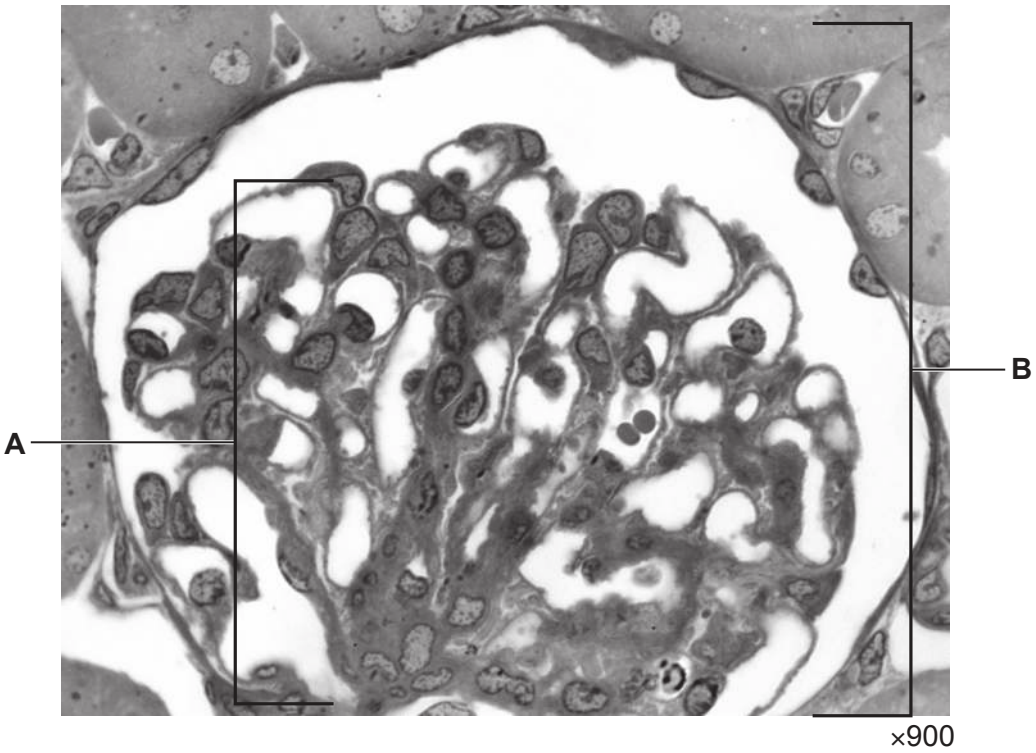


Fig. 5.1

(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.

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..... [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.

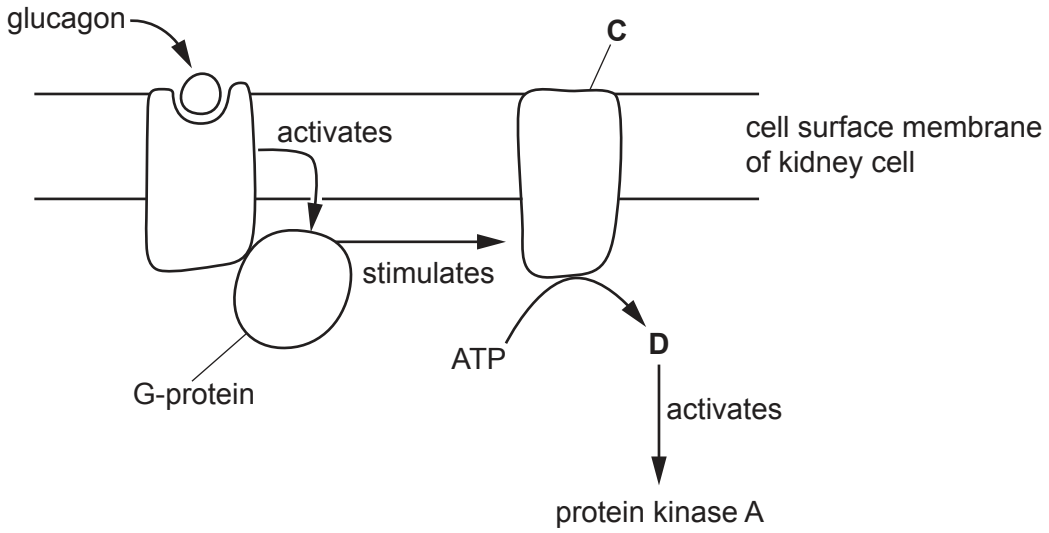


Fig. 5.2

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.

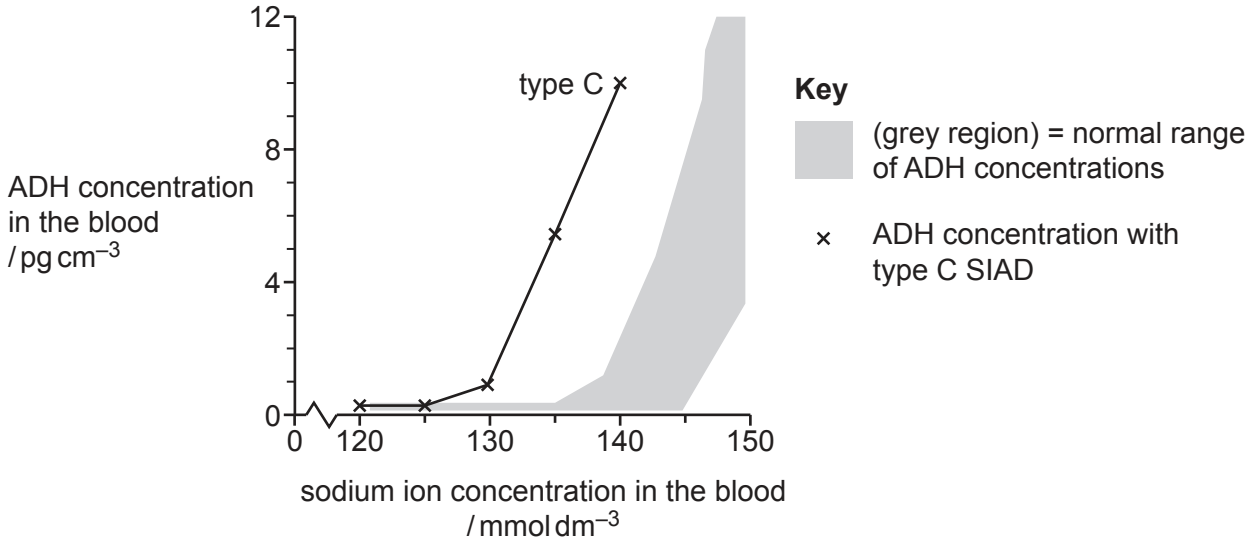


Fig. 5.3

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

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..... [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.

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..... [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]

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(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.

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..... [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]

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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.

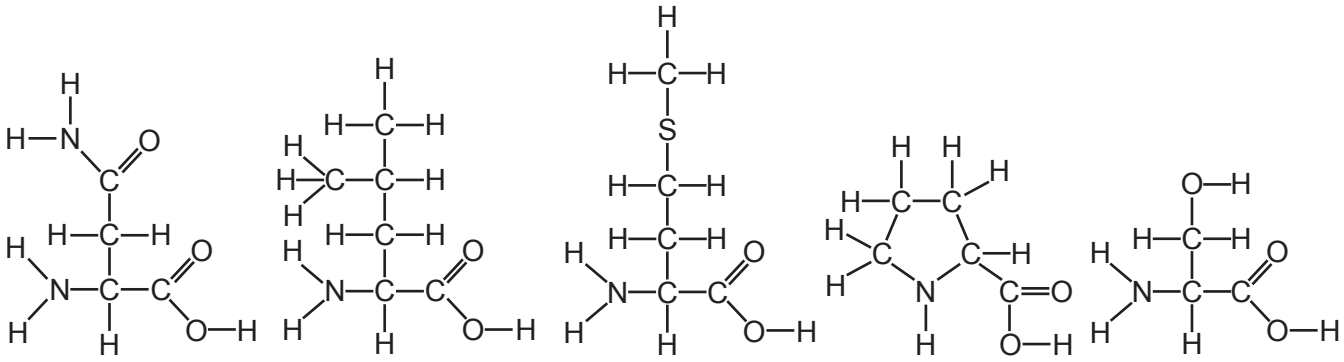


Fig. 7.1

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.

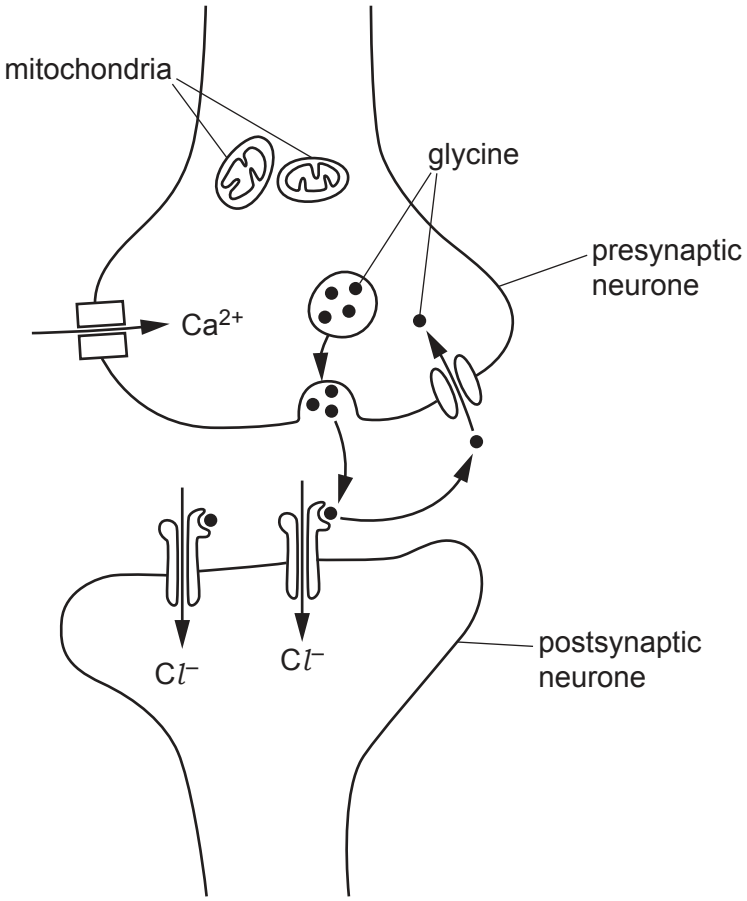


Fig. 7.2

(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.

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..... [2]

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(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.

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..... [2]

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

Describe how a neurone maintains a resting potential.

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..... [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.

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[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.

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..... [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.

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[Total: 6]

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