Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

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9694844746

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **October/November 2019**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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[Turn over

Section A

Answer **all** questions.

1 **(a)** ADH is a hormone that is released into the blood of a mammal when changes occur in the internal environment.

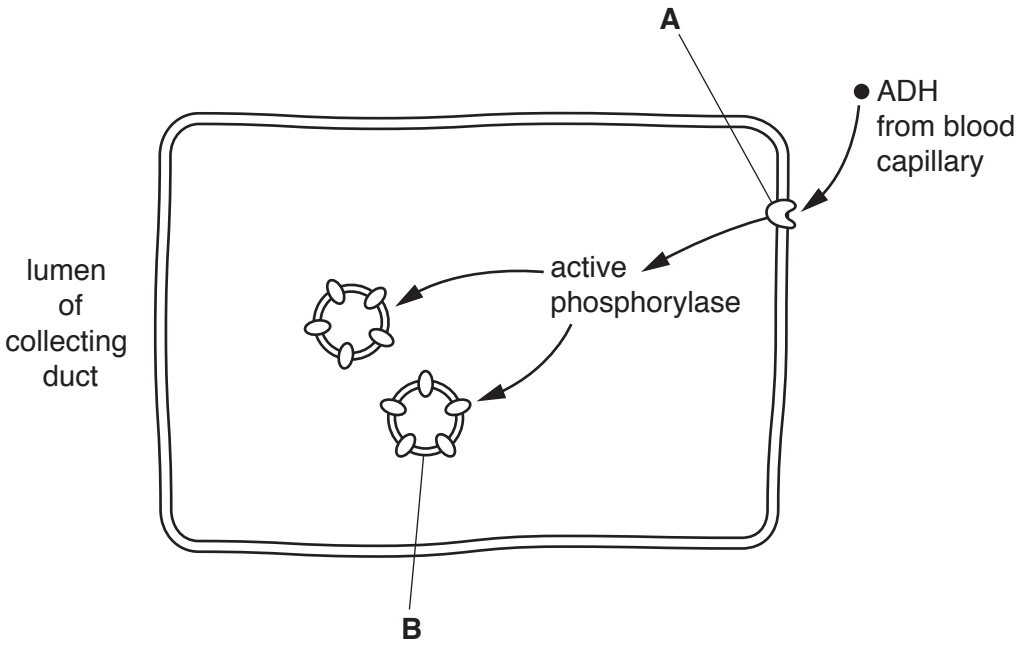
(i) State **one** change in the internal environment of a mammal that leads to the release of ADH.

..... [1]

(ii) Name the part of the body that releases ADH into the blood.

..... [1]

(b) Fig. 1.1 shows a cell of one of the collecting ducts of the kidney.



not to scale

Fig. 1.1

Name membrane protein **A** and cell structure **B**.

A .....

B ..... [2]

(c) The phosphorylase enzyme stimulates structure **B**.

Describe the response of structure **B** to this stimulation **and** describe the consequences of this response.

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..... [4]

[Total: 8]

2 The stickleback fish, *Gasterosteus aculeatus*, has two distinct forms, the saltwater form and the freshwater form. The larger, freshwater form is thought to have evolved from the smaller, saltwater form. Both forms have armour plating on each side of the body. The plates are made of bone and contain a high proportion of calcium.

The ectodysplasin gene, *EDA*, codes for a protein involved in the development of armour plates. The *EDA* gene has two alleles, low armour and high armour.

Three main morphs of armour plating have been described.

Complete morph armour plating:

- is found mainly in the saltwater form
- has many plates from head to tail to cover most of the body
- provides defence against large, predatory fish
- limits the growth of the fish.

Partial morph armour plating:

- is found mainly in the freshwater form
- has a reduced number of plates to cover only part of the body.

Low morph armour plating:

- is found mainly in the freshwater form
- has very few, undeveloped plates and no body cover.

(a) Explain why the variation in armour plating in stickleback fish can be described as discontinuous.

.....

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(b) In 1982, at Loberg Lake in Southern Alaska, the entire freshwater stickleback fish population was accidentally destroyed by humans.

In 1990, a new population of stickleback fish was found in the lake. Most of these fish had armour plates from head to tail on each side.

Suggest why these new stickleback fish have armour plates from head to tail on each side, despite living in freshwater.

.....

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..... [1]

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(c) From 1990, annual sampling took place in the lake.

Each year showed a reduction in the number of individuals with complete morph armour plating (from head to tail on each side). This change took place in a relatively short period of time.

- In 1990, 96% of the stickleback fish population had complete morph armour plating.
- In 1993, 39% of the stickleback fish population had complete morph armour plating.

Explain how natural selection has occurred in this new stickleback fish population.

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3 Therapeutic proteins are used to treat disease. The first purified therapeutic protein used was insulin, in 1922. The insulin was extracted from animal pancreases. Since 1982 most insulin has been made by recombinant DNA technology.

(a) Explain the advantages of producing human therapeutic proteins, such as insulin, by recombinant DNA technology.

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Calcitonin is a small protein hormone consisting of 32 amino acids. One of its functions is to inhibit the activity of cells, called osteoclasts, that break down bone tissue.

Calcitonin has been used as a therapeutic protein to treat osteoporosis. In osteoporosis too much breakdown of bone tissue in older people leads to reduced bone density and a risk of breaking bones.

(b) Fig. 3.1 shows the amino acid sequences of human calcitonin and calcitonin from the salmon fish, *Salmo salar*.

position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
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salmon	Cys	Ser	Asn	Leu	Ser	Thr	Cys	Val	Leu	Gly	Lys	Leu	Ser	Gln	Glu	Leu

position	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
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salmon	His	Lys	Leu	Gln	Thr	Tyr	Pro	Arg	Thr	Asn	Thr	Gly	Ser	Gly	Thr	Pro

Fig. 3.1

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(i) The two amino acid sequences shown in Fig. 3.1 can be compared. The number of amino acids that occur at the same position in both sequences can be counted and expressed as a percentage of the total number of amino acids present in one sequence. This is called the percentage sequence similarity.

Use Fig. 3.1 to calculate the percentage sequence similarity of human and salmon calcitonin.

Show your working.

..... % [2]

(ii) Compared to human calcitonin, salmon calcitonin is more biologically active. It remains active in the human body for longer and binds to calcitonin receptors more readily.

Bioinformatics was used to identify this more biologically active form of calcitonin to treat osteoporosis.

Explain how bioinformatics helped identify salmon calcitonin as a suitable form of calcitonin to treat human osteoporosis.

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..... [2]

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[Turn over

(c) Salmon calcitonin to treat osteoporosis is made by genetically engineered *Escherichia coli* bacteria. To produce these bacteria, a plasmid was cut and joined to the new gene to form a recombinant plasmid. The recombinant plasmid was then introduced into the bacterial cells.

(i) Name an enzyme that can:

- cut plasmid DNA

.....

- join the salmon calcitonin gene with plasmid DNA.

..... [2]

(ii) Identify **and** explain two properties of plasmids that allow them to be used as vectors in gene cloning.

1 .....

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(d) The gene coding for salmon calcitonin is introduced into bacteria in a specially designed plasmid called an expression vector. An expression vector must contain a prokaryotic promoter, such as the *lac* promoter.

Explain why differences in the control of gene expression in prokaryotes and eukaryotes mean that expression vector plasmids must contain a prokaryotic promoter.

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[Total: 14]

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4 **(a)** Meiosis has an important role in sexual reproduction. Meiosis occurs during gametogenesis in humans and during the formation of pollen grains and embryo sacs in plants.

(i) Complete Table 4.1 to compare meiosis with mitosis.

For both columns, put a tick (✓) in the box if the statement is correct and put a cross (✗) in the box if the statement is incorrect.

Each box must contain either a tick or a cross.

Table 4.1

statement	meiosis	mitosis
chromosome number is maintained		
homologous chromosomes pair up		
sister chromatids separate		
occurs in prokaryotes		

[2]

(ii) Compare the role of meiosis in gametogenesis to produce sperm cells in humans with the role of meiosis in gametogenesis in producing pollen grains in flowering plants.

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(b) Flower colour is important in sexual reproduction of insect-pollinated plants.

In the rosy periwinkle, *Catharanthus roseus*, flower colour is controlled by three genes, **R/r**, **D/d** and **P/p**, which interact together to control flower colour.

Fig. 4.1 is a drawing of a rosy periwinkle.

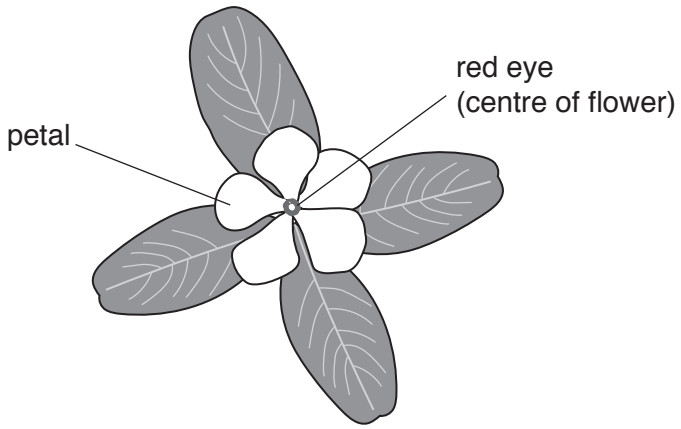


Fig. 4.1

The presence of the **R** allele results in a red pigment in the centre of the flower (red eye).

The **D** allele and the **P** allele are only expressed when the **R** allele is present.

- When the **D** allele and the **R** allele are present, the flower has dark pink petals with a red eye.
- When the **P** allele and the **R** allele are present, the flower has pale pink petals with a red eye.
- When the **D** allele, the **P** allele and the **R** allele are all present, the flower has dark pink petals with a red eye.
- The recessive alleles **r**, **d** and **p** result in no pigments being produced and the flower has white petals and no red eye.

(i) Deduce the phenotypes of these rosy periwinkle genotypes.

RR dd PP .....

Rr Dd Pp .....

rr Dd Pp .....

RR dd pp ..... [4]

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(ii) The pigments causing flower colour in the rosy periwinkle are formed by a biosynthetic pathway.

The **R** allele mutated to produce the **r** allele.

The **r** allele codes for a non-functional protein.

Explain how the mutation that changes **R** to **r** results in no red pigment being synthesised in the flower of rosy periwinkle.

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(iii) One mutation that changes the flower colour of rosy periwinkle occurs in a region of the DNA that does not code for a polypeptide.

Suggest what function this region of DNA might perform.

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[Total: 15]

5 **(a)** Fig. 5.1 shows the seaweed *Laminaria hyperborea*. This is a photosynthetic protoctist found in the coastal waters around Norway.

The seaweed is grown commercially to obtain the glucose polysaccharide called alginate. This is used in certain food products.

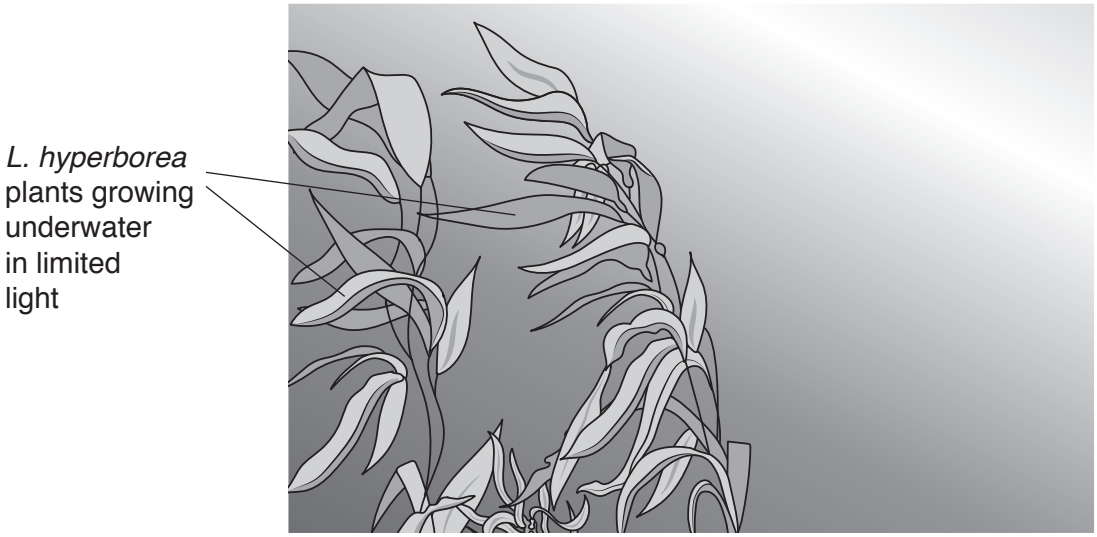


Fig. 5.1

An increase in carbon dioxide concentration in the atmosphere has resulted in higher concentrations of carbon dioxide in the ocean. This has caused a decrease in the pH of the ocean and has resulted in ocean acidification.

Scientists are studying seaweeds such as *L. hyperborea* because they absorb a large quantity of carbon dioxide during photosynthesis. This may help to increase the pH of the ocean and reverse ocean acidification.

(i) State where light absorption occurs in the chloroplasts of *L. hyperborea*.

..... [1]

(ii) Name **one** product of the light dependent stage of photosynthesis.

..... [1]

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(iii) Outline the reactions occurring in the stroma that lead to the production of a polysaccharide, such as alginate.

The first sentence has been completed for you.

Carbon dioxide binds to RuBP.

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(b) Laboratory experiments were carried out to investigate the effect of day length on the rate of photosynthesis in another marine autotroph, *Zostera marina*.

- The temperature was controlled at 4 °C.
- A low concentration of carbon dioxide dissolved in the water was used.
- The light exposure period (day length) was different for five groups of *Z. marina*.
- This was maintained for 10 days to allow *Z. marina* to adapt to these conditions.
- After 10 days, the rate of photosynthesis was measured for each group under the **same** controlled conditions.
- The experiment was repeated using five groups of *Z. marina* with a high concentration of carbon dioxide dissolved in water.

Table 5.1 shows the rate of photosynthesis for each group.

Table 5.1

day length /hours	rate of photosynthesis /arbitrary units	
	low carbon dioxide concentration	high carbon dioxide concentration
12	2.0	2.5
14	3.0	5.0
16	4.0	7.0
18	5.5	11.0
20	7.5	18.0

(i) With reference to Table 5.1, explain the difference in the rate of photosynthesis at high carbon dioxide concentration compared to low carbon dioxide concentration.

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..... [2]

(ii) With reference to Table 5.1, describe **and** explain the effect of increasing day length on the rate of photosynthesis for the *Z. marina* in high carbon dioxide concentration.

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..... [3]

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(c) In the laboratory, a seaweed was grown in water with different pH values. All other variables, including temperature and light, were standardised.

The mean rate of photosynthesis was calculated over a 24 hour period for each pH value.

The results are shown in Fig 5.2.

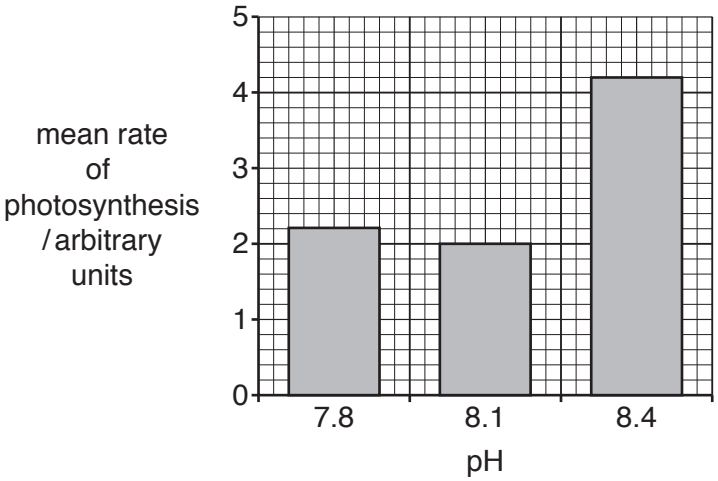


Fig. 5.2

(i) With reference to Fig. 5.2, explain the effect on the rate of photosynthesis when the pH increases from 8.1 to 8.4.

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..... [2]

(ii) The lower pH values on Fig. 5.2 represent ocean acidification.

Suggest why the results for the lower pH values do **not** fully support the idea that seaweeds can help to reduce ocean acidification.

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..... [1]

[Total: 14]

6 The genus *Heliconius* contains more than 40 species of brightly patterned butterflies.

Researchers have investigated in the laboratory how one species, *Heliconius heurippa*, could have developed as a separate species. The phenotype of *H. heurippa* is intermediate between that of two other species, *H. cydno* and *H. melpomene*.

Laboratory breeding experiments showed that:

- matings between *H. cydno* and *H. melpomene* (parent species) produce fertile hybrid offspring
- controlled matings of the hybrids produces individuals identical in appearance to *H. heurippa* within three generations
- hybrid butterflies prefer to mate with each other, rather than with individuals of either of the parent species.

The researchers concluded that the *H. heurippa* species could contain DNA from the two parent species as a result of hybridisation.

(a) (i) Suggest, with reasons, **one** prediction that can be made about the chromosome numbers of *H. cydno* and *H. melpomene*.

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..... [2]

(ii) The researchers thought that, because the hybrid butterflies preferred to mate with each other, this could make speciation more likely to occur.

Give reasons why the researchers thought that this made speciation more likely.

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(b) *Heliconius* butterflies taste unpleasant to predators such as birds. The bright colours on the wings of the butterflies act as warnings so that birds avoid eating them.

Individual birds have to learn which patterns to avoid. If one *Heliconius* species is abundant, or if it has a pattern shared with another similar species, predators learn to avoid this pattern faster. Therefore this pattern provides a selective advantage.

In the wild, *Heliconius* hybrids occur in small numbers and have patterns that do not resemble the established warning pattern of either parent species. These hybrids have a selective disadvantage.

This is an example of a post-zygotic isolating mechanism.

Explain how selection against hybrids can act as a post-zygotic isolating mechanism.

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..... [2]

[Total: 8]

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[Turn over

7 The Venus fly trap, *Dionaea muscipula*, is a carnivorous plant, native to wetlands of the East Coast of the USA. Mineral ions from decayed organisms are often washed away in these wetlands.

Fig. 7.1 shows a Venus fly trap leaf.

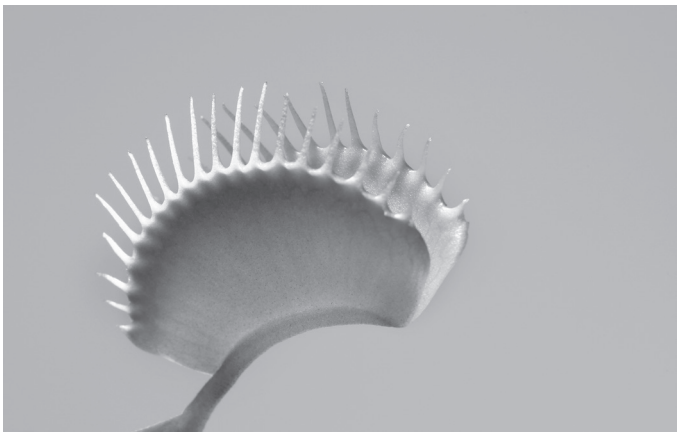


Fig. 7.1

(a) Suggest why a Venus fly trap benefits from catching insects in these wetlands.

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..... [2]

(b) **(i)** The leaves of the Venus fly trap will close if stimulated by an insect.

State which part of the leaf detects the stimulus.

..... [1]

(ii) Explain how the plant does not waste energy by closing when it does not need to, such as when a large drop of rain touches the receptor.

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..... [1]

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Question 7 continues on page 20.

(c) Fig. 7.2 is a graph of an action potential in a human neurone.

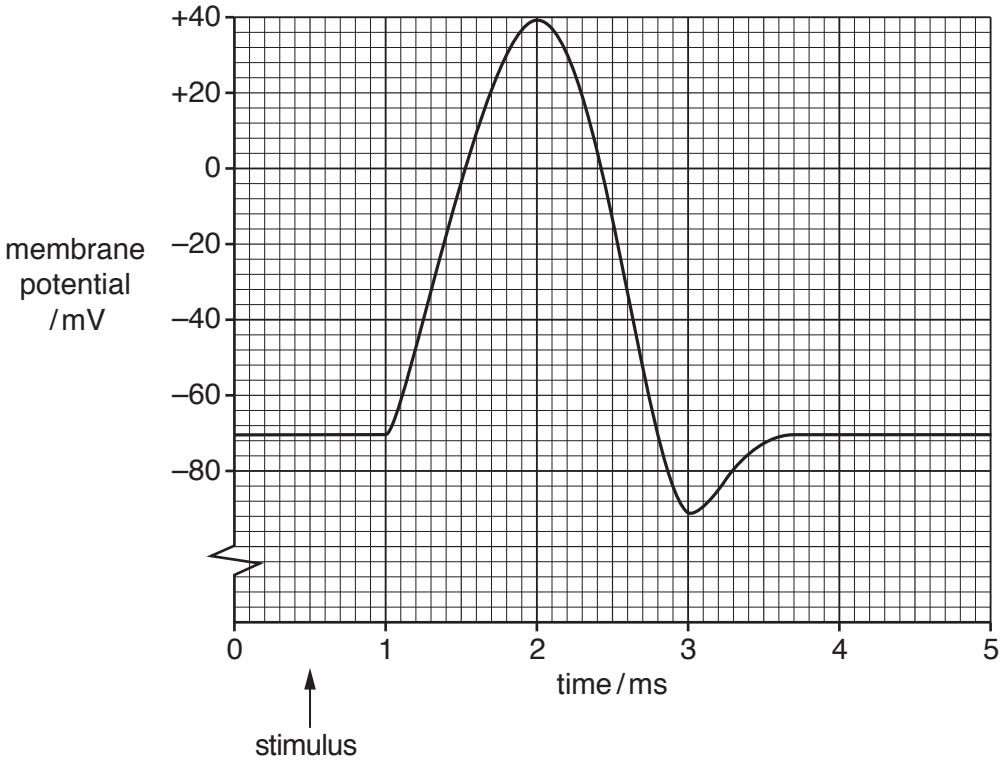


Fig. 7.2

Fig. 7.3 is a graph of an action potential in leaf cells of a Venus fly trap.

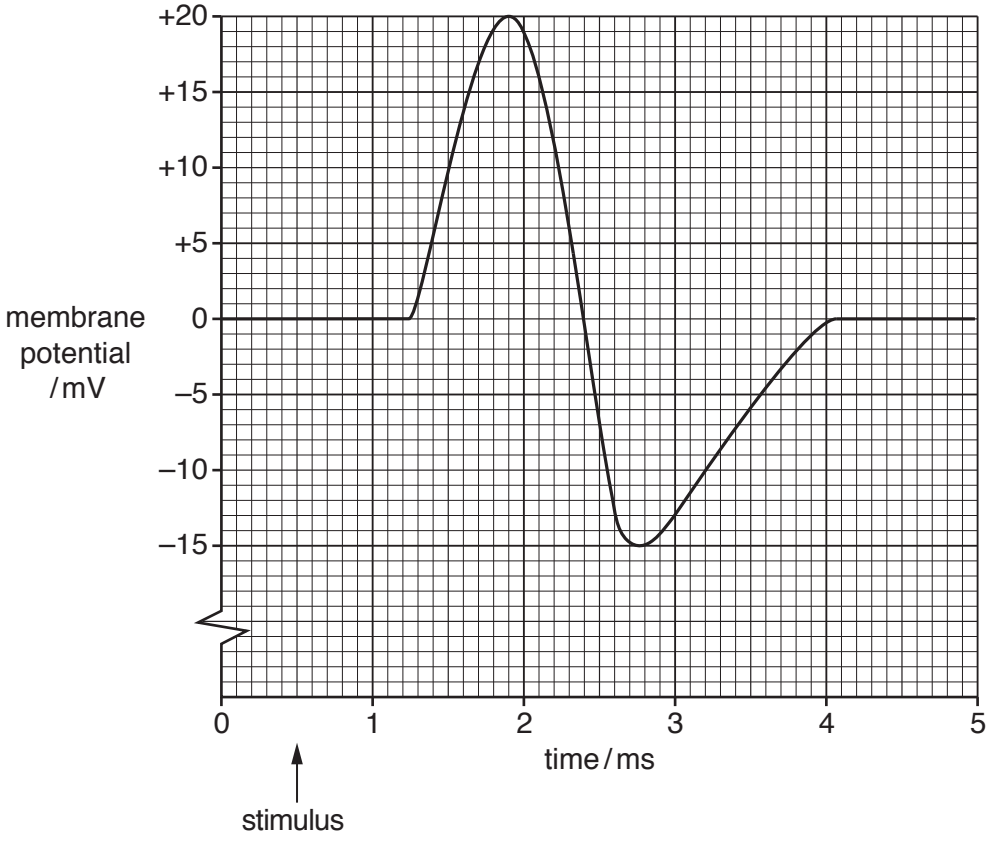


Fig. 7.3

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With reference to Fig. 7.2 and Fig. 7.3, describe how the action potential of the Venus fly trap differs from that of a human.

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(d) Describe how the production of action potentials in the leaf cells of the Venus fly trap can result in the leaves closing and trapping an insect.

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[Total: 12]

8 The passage below outlines the process of oxidative phosphorylation in mitochondria.

Complete the passage by using the most appropriate scientific terms.

Reduced ..... releases hydrogen atoms to cytochrome carriers.

Hydrogen atoms split into protons and electrons and the electrons are passed from carrier to carrier. Energy from electron transfer is used to pump protons into the

..... , so that a proton gradient is set up across the

..... .

Protons ..... through the channel protein known as

..... , into the matrix, producing ATP. The protons combine with electrons and ..... atoms to form water.

[Total: 6]

Section B

Answer **one** question.

9 **(a)** Compare the characteristic features of members of the kingdoms Fungi and Animalia. [7]

(b) Discuss the methods used in breeding programmes for endangered mammal species **and** outline the problems that may occur with these programmes. [8]

[Total: 15]

10 **(a)** Describe the features of ATP that make it suitable for its role as the universal energy currency of cells. [6]

(b) Describe how you would carry out an investigation on the effect of temperature on the rate of respiration of yeast in anaerobic conditions using a redox indicator, such as methylene blue. [9]

[Total: 15]

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Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

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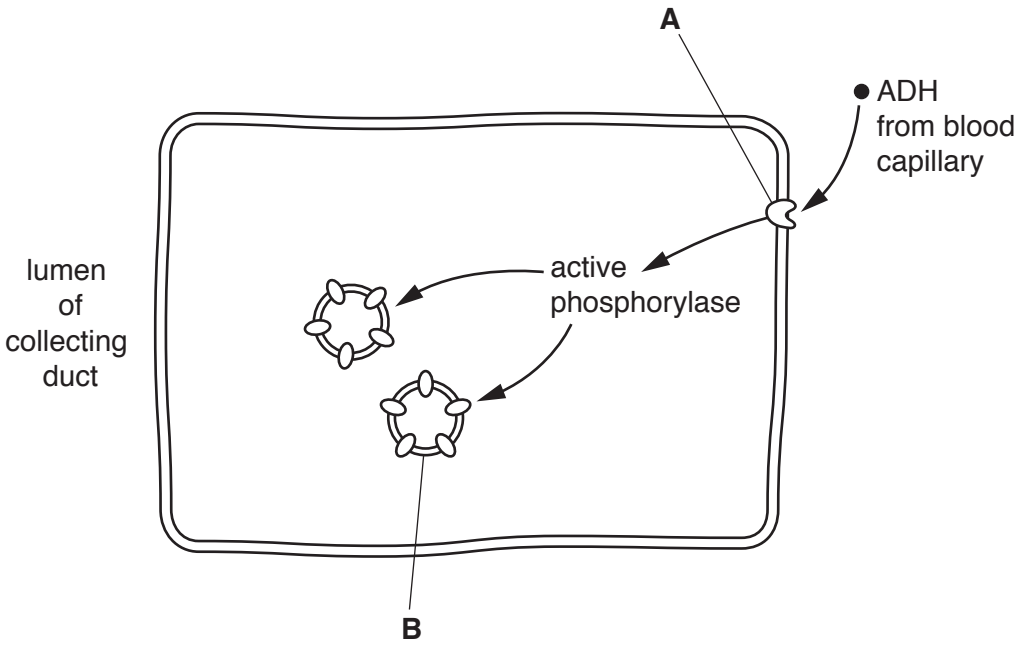
(i) State **one** change in the internal environment of a mammal that leads to the release of ADH.

..... [1]

(ii) Name the part of the body that releases ADH into the blood.

..... [1]

(b) Fig. 1.1 shows a cell of one of the collecting ducts of the kidney.



not to scale

Fig. 1.1

Name membrane protein **A** and cell structure **B**.

A .....

B ..... [2]

(c) The phosphorylase enzyme stimulates structure **B**.

Describe the response of structure **B** to this stimulation **and** describe the consequences of this response.

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.....

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(b) In 1982, at Loberg Lake in Southern Alaska, the entire freshwater stickleback fish population was accidentally destroyed by humans.

In 1990, a new population of stickleback fish was found in the lake. Most of these fish had armour plates from head to tail on each side.

Suggest why these new stickleback fish have armour plates from head to tail on each side, despite living in freshwater.

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..... [1]

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(c) From 1990, annual sampling took place in the lake.

Each year showed a reduction in the number of individuals with complete morph armour plating (from head to tail on each side). This change took place in a relatively short period of time.

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salmon	Cys	Ser	Asn	Leu	Ser	Thr	Cys	Val	Leu	Gly	Lys	Leu	Ser	Gln	Glu	Leu

position	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
human	Asn	Lys	Phe	His	Thr	Phe	Pro	Gln	Thr	Ala	Ile	Gly	Val	Gly	Ala	Pro
salmon	His	Lys	Leu	Gln	Thr	Tyr	Pro	Arg	Thr	Asn	Thr	Gly	Ser	Gly	Thr	Pro

Fig. 3.1

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(i) The two amino acid sequences shown in Fig. 3.1 can be compared. The number of amino acids that occur at the same position in both sequences can be counted and expressed as a percentage of the total number of amino acids present in one sequence. This is called the percentage sequence similarity.

Use Fig. 3.1 to calculate the percentage sequence similarity of human and salmon calcitonin.

Show your working.

..... % [2]

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Explain how bioinformatics helped identify salmon calcitonin as a suitable form of calcitonin to treat human osteoporosis.

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..... [2]

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[Turn over

(c) Salmon calcitonin to treat osteoporosis is made by genetically engineered *Escherichia coli* bacteria. To produce these bacteria, a plasmid was cut and joined to the new gene to form a recombinant plasmid. The recombinant plasmid was then introduced into the bacterial cells.

(i) Name an enzyme that can:

- cut plasmid DNA

.....

- join the salmon calcitonin gene with plasmid DNA.

..... [2]

(ii) Identify **and** explain two properties of plasmids that allow them to be used as vectors in gene cloning.

1 .....

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2 .....

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..... [2]

(d) The gene coding for salmon calcitonin is introduced into bacteria in a specially designed plasmid called an expression vector. An expression vector must contain a prokaryotic promoter, such as the *lac* promoter.

Explain why differences in the control of gene expression in prokaryotes and eukaryotes mean that expression vector plasmids must contain a prokaryotic promoter.

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..... [2]

[Total: 14]

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4 **(a)** Meiosis has an important role in sexual reproduction. Meiosis occurs during gametogenesis in humans and during the formation of pollen grains and embryo sacs in plants.

(i) Complete Table 4.1 to compare meiosis with mitosis.

For both columns, put a tick (✓) in the box if the statement is correct and put a cross (✗) in the box if the statement is incorrect.

Each box must contain either a tick or a cross.

Table 4.1

statement	meiosis	mitosis
chromosome number is maintained		
homologous chromosomes pair up		
sister chromatids separate		
occurs in prokaryotes		

[2]

(ii) Compare the role of meiosis in gametogenesis to produce sperm cells in humans with the role of meiosis in gametogenesis in producing pollen grains in flowering plants.

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..... [4]

(b) Flower colour is important in sexual reproduction of insect-pollinated plants.

In the rosy periwinkle, *Catharanthus roseus*, flower colour is controlled by three genes, **R/r**, **D/d** and **P/p**, which interact together to control flower colour.

Fig. 4.1 is a drawing of a rosy periwinkle.

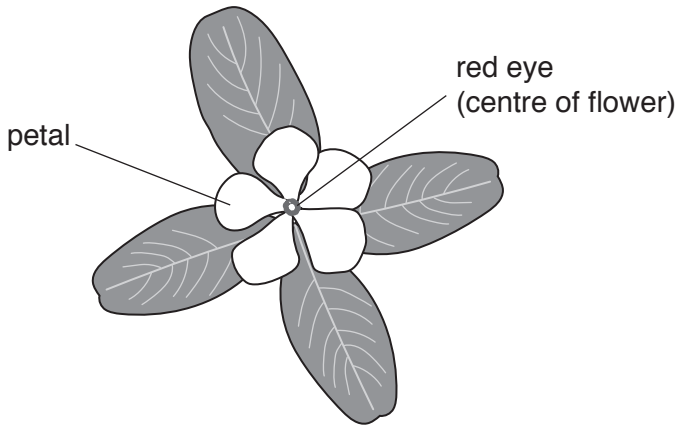


Fig. 4.1

The presence of the **R** allele results in a red pigment in the centre of the flower (red eye).

The **D** allele and the **P** allele are only expressed when the **R** allele is present.

- When the **D** allele and the **R** allele are present, the flower has dark pink petals with a red eye.
- When the **P** allele and the **R** allele are present, the flower has pale pink petals with a red eye.
- When the **D** allele, the **P** allele and the **R** allele are all present, the flower has dark pink petals with a red eye.
- The recessive alleles **r**, **d** and **p** result in no pigments being produced and the flower has white petals and no red eye.

(i) Deduce the phenotypes of these rosy periwinkle genotypes.

RR dd PP .....

Rr Dd Pp .....

rr Dd Pp .....

RR dd pp ..... [4]

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(ii) The pigments causing flower colour in the rosy periwinkle are formed by a biosynthetic pathway.

The **R** allele mutated to produce the **r** allele.

The **r** allele codes for a non-functional protein.

Explain how the mutation that changes **R** to **r** results in no red pigment being synthesised in the flower of rosy periwinkle.

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..... [4]

(iii) One mutation that changes the flower colour of rosy periwinkle occurs in a region of the DNA that does not code for a polypeptide.

Suggest what function this region of DNA might perform.

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..... [1]

[Total: 15]

5 **(a)** Fig. 5.1 shows the seaweed *Laminaria hyperborea*. This is a photosynthetic protoctist found in the coastal waters around Norway.

The seaweed is grown commercially to obtain the glucose polysaccharide called alginate. This is used in certain food products.

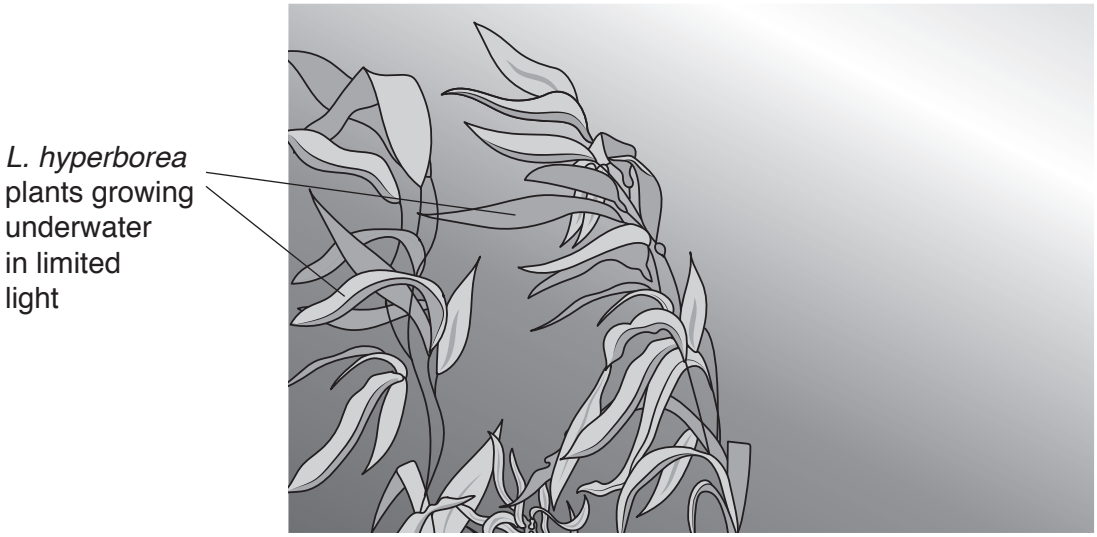


Fig. 5.1

An increase in carbon dioxide concentration in the atmosphere has resulted in higher concentrations of carbon dioxide in the ocean. This has caused a decrease in the pH of the ocean and has resulted in ocean acidification.

Scientists are studying seaweeds such as *L. hyperborea* because they absorb a large quantity of carbon dioxide during photosynthesis. This may help to increase the pH of the ocean and reverse ocean acidification.

(i) State where light absorption occurs in the chloroplasts of *L. hyperborea*.

..... [1]

(ii) Name **one** product of the light dependent stage of photosynthesis.

..... [1]

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(iii) Outline the reactions occurring in the stroma that lead to the production of a polysaccharide, such as alginate.

The first sentence has been completed for you.

Carbon dioxide binds to RuBP.

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..... [4]

(b) Laboratory experiments were carried out to investigate the effect of day length on the rate of photosynthesis in another marine autotroph, *Zostera marina*.

- The temperature was controlled at 4 °C.
- A low concentration of carbon dioxide dissolved in the water was used.
- The light exposure period (day length) was different for five groups of *Z. marina*.
- This was maintained for 10 days to allow *Z. marina* to adapt to these conditions.
- After 10 days, the rate of photosynthesis was measured for each group under the **same** controlled conditions.
- The experiment was repeated using five groups of *Z. marina* with a high concentration of carbon dioxide dissolved in water.

Table 5.1 shows the rate of photosynthesis for each group.

Table 5.1

day length /hours	rate of photosynthesis /arbitrary units	
	low carbon dioxide concentration	high carbon dioxide concentration
12	2.0	2.5
14	3.0	5.0
16	4.0	7.0
18	5.5	11.0
20	7.5	18.0

(i) With reference to Table 5.1, explain the difference in the rate of photosynthesis at high carbon dioxide concentration compared to low carbon dioxide concentration.

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..... [2]

(ii) With reference to Table 5.1, describe **and** explain the effect of increasing day length on the rate of photosynthesis for the *Z. marina* in high carbon dioxide concentration.

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..... [3]

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(c) In the laboratory, a seaweed was grown in water with different pH values. All other variables, including temperature and light, were standardised.

The mean rate of photosynthesis was calculated over a 24 hour period for each pH value.

The results are shown in Fig 5.2.

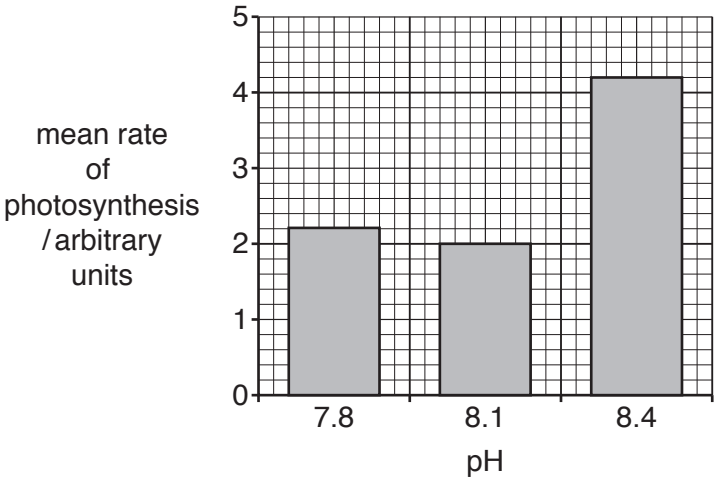


Fig. 5.2

(i) With reference to Fig. 5.2, explain the effect on the rate of photosynthesis when the pH increases from 8.1 to 8.4.

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..... [2]

(ii) The lower pH values on Fig. 5.2 represent ocean acidification.

Suggest why the results for the lower pH values do **not** fully support the idea that seaweeds can help to reduce ocean acidification.

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..... [1]

[Total: 14]

6 The genus *Heliconius* contains more than 40 species of brightly patterned butterflies.

Researchers have investigated in the laboratory how one species, *Heliconius heurippa*, could have developed as a separate species. The phenotype of *H. heurippa* is intermediate between that of two other species, *H. cydno* and *H. melpomene*.

Laboratory breeding experiments showed that:

- matings between *H. cydno* and *H. melpomene* (parent species) produce fertile hybrid offspring
- controlled matings of the hybrids produces individuals identical in appearance to *H. heurippa* within three generations
- hybrid butterflies prefer to mate with each other, rather than with individuals of either of the parent species.

The researchers concluded that the *H. heurippa* species could contain DNA from the two parent species as a result of hybridisation.

(a) (i) Suggest, with reasons, **one** prediction that can be made about the chromosome numbers of *H. cydno* and *H. melpomene*.

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..... [2]

(ii) The researchers thought that, because the hybrid butterflies preferred to mate with each other, this could make speciation more likely to occur.

Give reasons why the researchers thought that this made speciation more likely.

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..... [4]

(b) *Heliconius* butterflies taste unpleasant to predators such as birds. The bright colours on the wings of the butterflies act as warnings so that birds avoid eating them.

Individual birds have to learn which patterns to avoid. If one *Heliconius* species is abundant, or if it has a pattern shared with another similar species, predators learn to avoid this pattern faster. Therefore this pattern provides a selective advantage.

In the wild, *Heliconius* hybrids occur in small numbers and have patterns that do not resemble the established warning pattern of either parent species. These hybrids have a selective disadvantage.

This is an example of a post-zygotic isolating mechanism.

Explain how selection against hybrids can act as a post-zygotic isolating mechanism.

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..... [2]

[Total: 8]

7 The Venus fly trap, *Dionaea muscipula*, is a carnivorous plant, native to wetlands of the East Coast of the USA. Mineral ions from decayed organisms are often washed away in these wetlands.

Fig. 7.1 shows a Venus fly trap leaf.

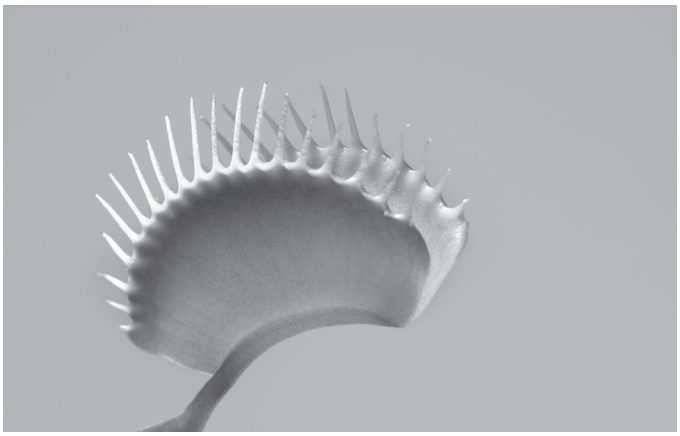


Fig. 7.1

(a) Suggest why a Venus fly trap benefits from catching insects in these wetlands.

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.....

.....

..... [2]

(b) **(i)** The leaves of the Venus fly trap will close if stimulated by an insect.

State which part of the leaf detects the stimulus.

..... [1]

(ii) Explain how the plant does not waste energy by closing when it does not need to, such as when a large drop of rain touches the receptor.

.....

..... [1]

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Question 7 continues on page 20.

(c) Fig. 7.2 is a graph of an action potential in a human neurone.

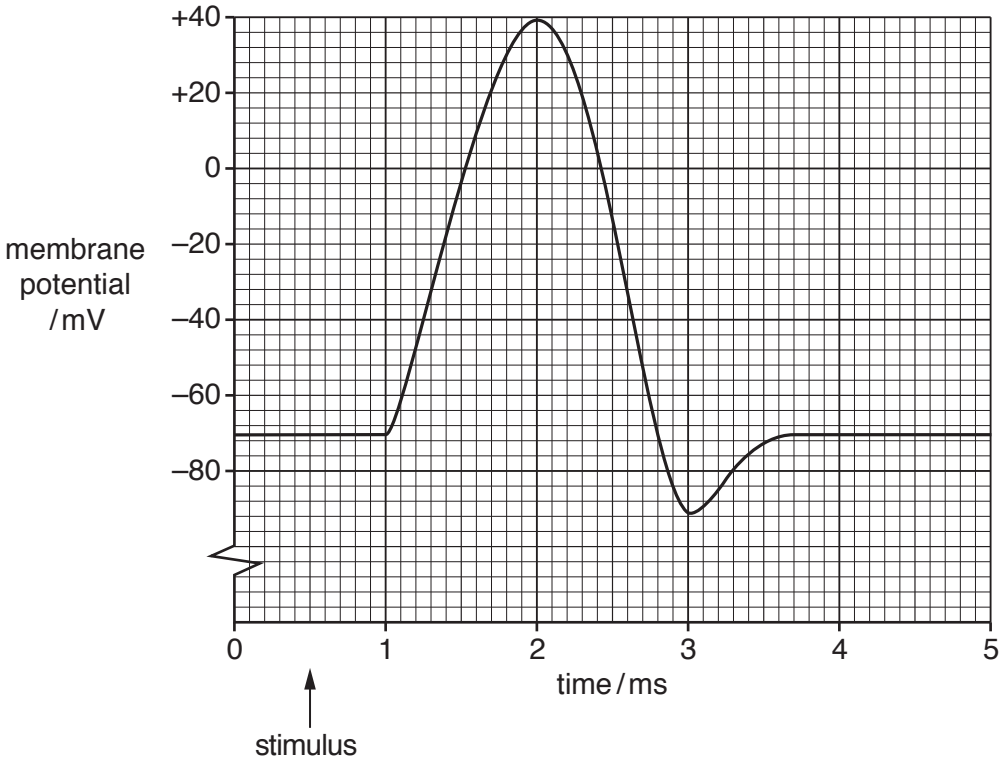


Fig. 7.2

Fig. 7.3 is a graph of an action potential in leaf cells of a Venus fly trap.

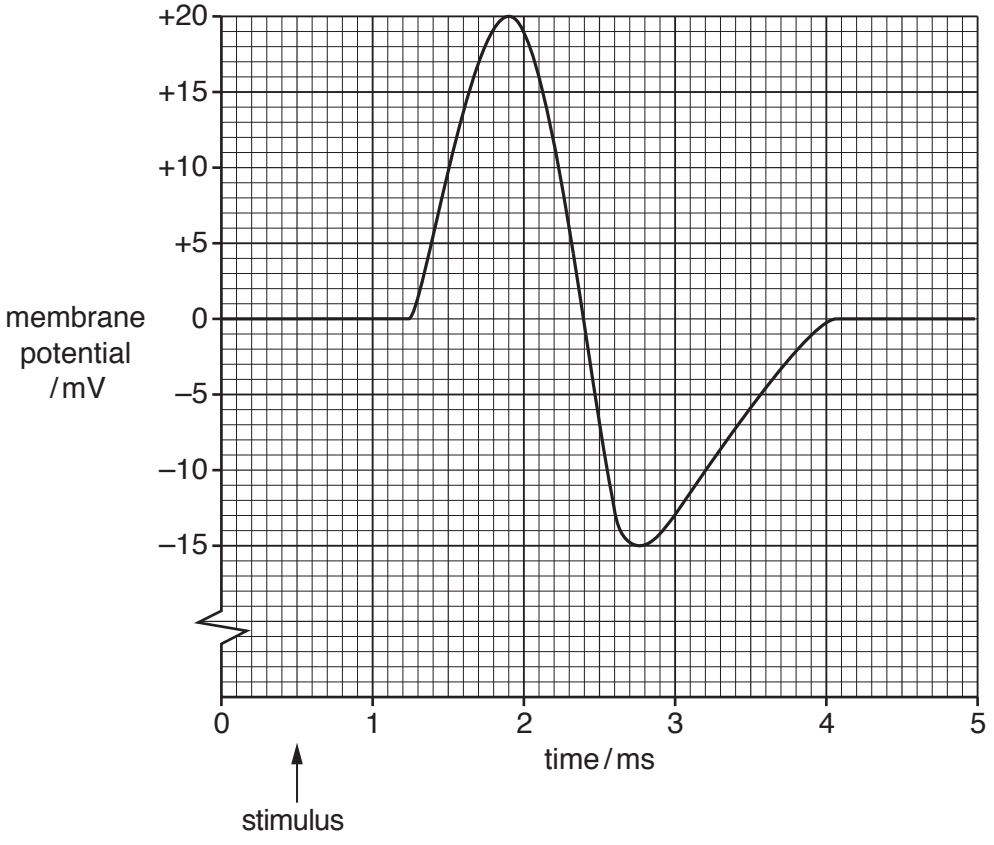


Fig. 7.3

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With reference to Fig. 7.2 and Fig. 7.3, describe how the action potential of the Venus fly trap differs from that of a human.

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..... [3]

(d) Describe how the production of action potentials in the leaf cells of the Venus fly trap can result in the leaves closing and trapping an insect.

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..... [5]

[Total: 12]

8 The passage below outlines the process of oxidative phosphorylation in mitochondria.

Complete the passage by using the most appropriate scientific terms.

Reduced ..... releases hydrogen atoms to cytochrome carriers.

Hydrogen atoms split into protons and electrons and the electrons are passed from carrier to carrier. Energy from electron transfer is used to pump protons into the

..... , so that a proton gradient is set up across the

..... .

Protons ..... through the channel protein known as

..... , into the matrix, producing ATP. The protons combine with electrons and ..... atoms to form water.

[Total: 6]

Section B

Answer **one** question.

9 **(a)** Compare the characteristic features of members of the kingdoms Fungi and Animalia. [7]

(b) Discuss the methods used in breeding programmes for endangered mammal species **and** outline the problems that may occur with these programmes. [8]

[Total: 15]

10 **(a)** Describe the features of ATP that make it suitable for its role as the universal energy currency of cells. [6]

(b) Describe how you would carry out an investigation on the effect of temperature on the rate of respiration of yeast in anaerobic conditions using a redox indicator, such as methylene blue. [9]

[Total: 15]

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[Turn over

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BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **October/November 2019**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **24** printed pages.

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Section A

Answer **all** questions.

1 **(a)** Fig. 1.1 shows part of a guard cell.

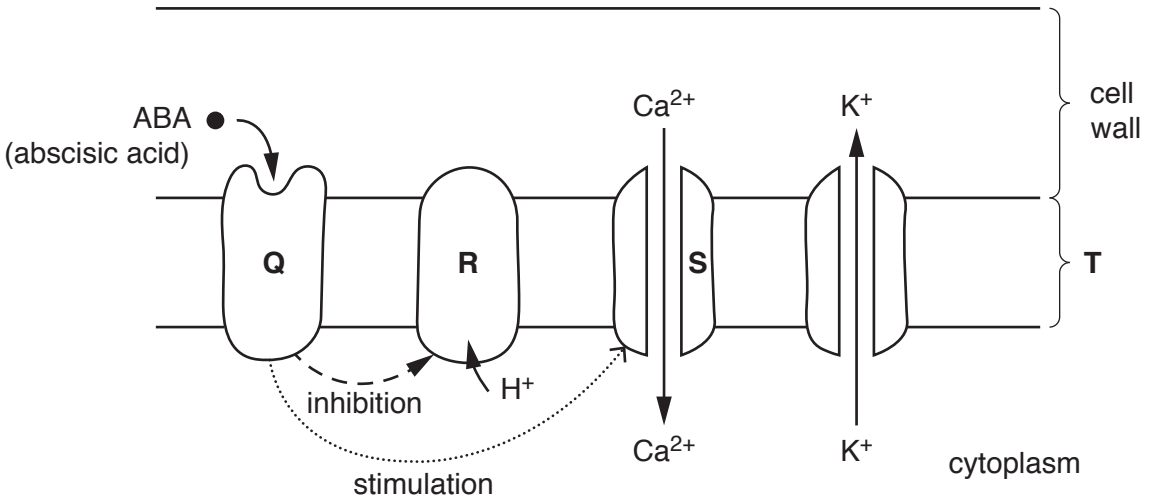


Fig. 1.1

(i) State the **type** of protein represented by **Q**.

..... [1]

(ii) Proteins **R** and **S** are transport proteins.

Identify **R** and **S**.

R.....

S..... [2]

(iii) Name cell structure **T**.

..... [1]

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(b) With reference to Fig. 1.1, outline the events that occur in a guard cell during times of water stress.

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..... [5]

[Total: 9]

2 **(a)** The house mouse, *Mus musculus*, has a diploid number of 40 chromosomes.

Fig. 2.1 shows 6 of these chromosomes.

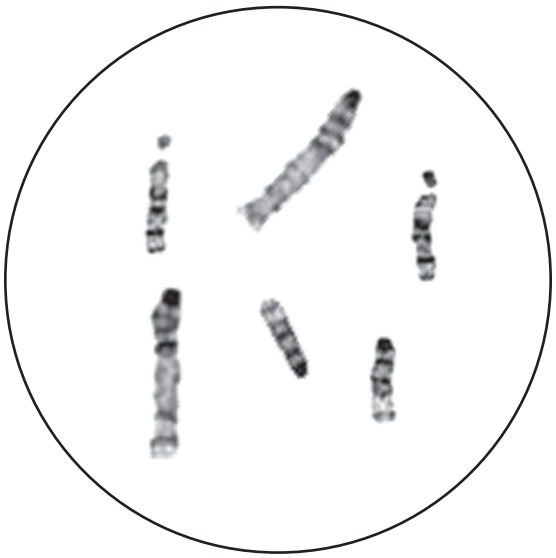


Fig. 2.1

Identify **one** pair of homologous chromosomes on Fig. 2.1 by drawing circles around **two** chromosomes. [1]

(b) Fig. 2.2 shows the banding pattern of chromosome pair 11 of *M. musculus*. The banding pattern is obtained by staining.

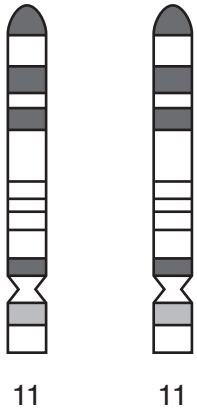


Fig. 2.2

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(i) Explain why chromosomes, such as those in Fig. 2.2, are described as a homologous pair.

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..... [3]

(ii) State the number of chromosomes that are present in *M. musculus* spermatozoa.

..... [1]

(c) *M. musculus* produces gametes by meiosis. These gametes are genetically different.

There is random fusion of gametes at fertilisation.

(i) Explain why meiosis is important in the life cycle of *M. musculus*, **apart from** producing genetically different gametes.

.....

.....

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..... [2]

(ii) Explain how the random fusion of gametes leads to the expression of rare, recessive alleles.

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..... [2]

(d) A mutation causing coats of mice to be woolly in appearance is in a gene located on chromosome 11. The mutation causes a very shortened polypeptide product. Mice with the woolly coat phenotype have longer fur than mice with normal coats.

(i) Explain how a base substitution mutation can lead to a very shortened polypeptide product.

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..... [2]

(ii) The inheritance of the woolly coat characteristic was investigated.

Draw a genetic diagram to show a cross between two heterozygous parents with normal coats.

Use the symbols **A** and **a** for the alleles.

parental genotypes

gametes

offspring genotypes

offspring phenotypes

[3]

[Total: 14]

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3 Therapeutic proteins are used to treat disease. One example of a therapeutic protein is human growth hormone (hGH).

hGH has important roles in growth during childhood and in regulation of metabolism in adulthood.

Children described as hGH-deficient do not produce enough hGH and grow more slowly than other children. People who were hGH-deficient when they were children have a mean adult height that is 32 cm shorter than the population mean.

Daily injections of hGH are a treatment for hGH-deficient children that can increase growth rate, resulting in an increased adult height.

(a) The growth rate of three children was measured.

- The growth rate of the hGH-deficient child who did **not** receive daily hGH injections was 2.5 cm $year^{-1}$.
- The growth rate of the hGH-deficient child who received daily hGH injections was 10.0 cm $year^{-1}$ in the first year after starting treatment.
- The growth rate of the child who is **not** hGH-deficient was 5.0 cm $year^{-1}$.

Calculate the percentage increase in growth rate of the hGH-deficient child treated with hGH injections compared to the child who is **not** hGH-deficient.

Show your working.

..... % [2]

When this form of treatment started in 1958, hGH could only be obtained from the pituitary glands of people who had died.

In 1981, a plasmid containing hGH cDNA was constructed and inserted into *Escherichia coli* bacteria. This allowed recombinant hGH protein to be produced by the bacteria.

(b) Name the type of enzyme that:

- cuts plasmid DNA

  .....

- makes cDNA from hGH mRNA.

  ..... [2]

(c) Identify **and** explain **two** properties of plasmids that allow them to be used as vectors of hGH cDNA into cells of *Escherichia coli*.

1.....

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2.....

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..... [2]

(d) In 1985, several cases of a rare brain disease were discovered in people who had been treated many years previously with hGH obtained from pituitary glands. It was decided, from 1985 onwards, that only recombinant hGH should be used to treat patients.

Explain the advantages of producing human therapeutic proteins, such as hGH, by recombinant DNA technology.

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..... [4]

(e) hGH is one of many proteins in the body whose secretion or production is controlled by a person's sleep-wake pattern.

The sleep-wake pattern describes when, during a 24 hour day, a person is asleep and when they are awake. For example:

- pattern 1 – asleep during the night and awake during the day (normal)
- pattern 2 – asleep during the day and awake during the night.

Researchers used microarray analysis to identify which genes have their expression changed by a person's sleep-wake pattern. They collected mRNA from:

- a group of people with sleep-wake pattern 1
- the same group of people whose sleep-wake pattern was changed to pattern 2.

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A summary of the results is shown in Table 3.1.

Table 3.1

sleep-wake pattern	number of genes with increased expression		
	during the day	during the night	all the time
pattern 1	661	733	108
pattern 2	134	95	8

(i) Describe how changing the sleep-wake pattern from pattern 1 to pattern 2 affects the number of genes expressed.

.....

..... [1]

(ii) Explain how eukaryotic genes can be switched on and off, for example, at certain times of day.

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..... [2]

(iii) Explain how bioinformatics can help to identify whether the genes whose expression is changed by moving from pattern 1 to pattern 2 are important to health.

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..... [2]

[Total: 15]

4 A 28-year study of Magellanic penguins, *Spheniscus magellanicus*, found in Argentina, provides evidence of natural selection.
Magellanic penguins lay their eggs in nests. They use their bills (beaks) to catch prey and feed their chicks (offspring) in the nest. Each breeding pair of penguins uses the same nest each year.

A Magellanic penguin is shown in Fig. 4.1.



Fig. 4.1

- Data were collected for bill size every year from 1983 to 2010.
- Bill size was calculated using the length and depth of the bill.
- Bill size showed variation between the individuals.
- In 1983 all the penguins in one area were tagged.
- All tagged penguins were measured each year and their new chicks were tagged and measured.
- For each year of the study, an estimate of food availability was made.
- A statistical analysis was conducted to quantify whether selection had taken place.

(a) Explain why bill size is an example of continuous variation.

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..... [2]

(b) Statistical analysis of the data showed that selection was **not** significant in most years of the study. However, a significant increase in bill size occurred in four years of the study.

(i) Name the type of selection that occurred in these four years.

..... [1]

(ii) In these same four years, food availability was low.

Explain how the data for bill size and food availability supports the idea of the 'struggle for existence' seen in natural selection.

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..... [2]

(c) Further investigation showed that, in some years, larger bill sizes of adult males correlated with higher reproductive success.

Reproductive success was measured by the number of chicks that survived per adult each year.

Suggest why larger bill size of adult males correlated with higher reproductive success.

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..... [1]

[Total: 6]

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[Turn over

5 *Mimulus* is a plant genus containing a diverse range of species that have colourful flowers to attract pollinators, such as bees and hummingbirds. Pollinators transfer pollen between flowers for plant sexual reproduction.

Table 5.1 compares some features of two closely-related species of *Mimulus* that both grow in the same region of North America.

The features in which they differ are:

- the altitude at which the two species grow
- their flower characteristics, including petal colour and the distance from the opening of the flower to the nectar on which the pollinators feed
- the percentages of pollinator visits that they receive from bees or from hummingbirds.

Table 5.1

species of *Mimulus*	altitude / m	petal colour	distance to nectar / mm	percentage of visits from pollinator type	
				bee	hummingbird
M. lewisii	1600 – 3000	pink	14	100	0
M. cardinalis	0 – 2000	red	27	3	97

(a) With reference to the data in Table 5.1, explain the isolating mechanisms that prevent gene flow between *M. lewisii* and *M. cardinalis* populations.

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..... [5]

(b) Breeding experiments in the laboratory show that *M. lewisii* and *M. cardinalis* can breed together and produce offspring. The F1 hybrid offspring are fertile.

(i) Suggest, with reasons, what prediction can be made about the chromosome numbers of *M. lewisii* and *M. cardinalis*.

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..... [2]

(ii) The F1 hybrids produce 50% fewer seeds than either of the two parent species.

Explain how the reduced production of seeds by the inter-species (F1) hybrids can act as a post-zygotic isolating mechanism.

.....

.....

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.....

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..... [2]

[Total: 9]

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[Turn over

6 Mining may result in the release of heavy metal ions, causing pollution of lakes and rivers.

High concentrations of these heavy metal ions, such as cadmium (Cd^{2+}) and copper (Cu^{2+}), decrease the rate of photosynthesis in plants.

(a) Cadmium ions disrupt the function of photosystem II in chloroplasts.

(i) Name the part of the chloroplast where photosystem II is located.

..... [1]

(ii) Describe the role of photosystem II in the absorption of light.

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..... [3]

(b) An investigation was carried out into the effect of cadmium ion concentration on the aquatic, single-celled, photosynthetic protoctist, *Chlamydomonas reinhardtii*.

The activity of photosystem II was measured at different concentrations of cadmium ions.

- Four different concentrations of cadmium ions were used, 0, 1, 10 and 100 $\mu mol\,dm^{-3}$.
- *C. reinhardtii* was allowed to acclimatise in the dark before the experiment started.
- At time 0 min the light was switched on and the cadmium ions were added.
- At each concentration, the activity of photosystem II was measured over a period of 60 minutes.
- Each experiment was carried out under the same controlled conditions.

The results are shown in Fig. 6.1.

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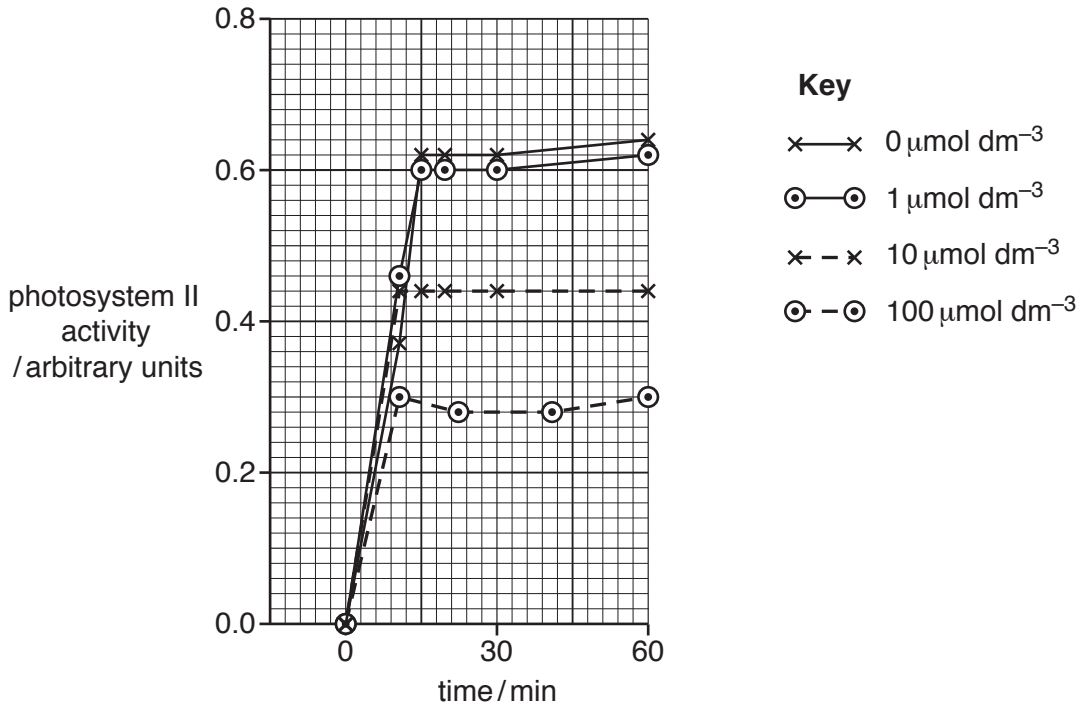


Fig. 6.1

Describe the effects of cadmium ion concentration on the activity of photosystem II, as shown in Fig. 6.1.

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..... [2]

(c) Copper(II) ions (Cu^{2+}) inhibit the function of a proportion of the chlorophyll a present in single-celled, photosynthetic protoctists.

The concentration of functional chlorophyll a in these organisms was measured in two different months of the same year in an unpolluted lake and in a lake polluted with copper ions.

The results are shown in Table 6.1.

Table 6.1

lake	concentration of functional chlorophyll a / $\mu g\ dm^{-3}$	
	month **A**	month **B**
unpolluted	3.45	0.24
polluted with copper ions	1.79	0.24

(i) Describe **and** suggest explanations for the results shown in Table 6.1.

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..... [4]

(ii) Copper ions can replace other metal ions present in organic molecules.

Suggest how copper ions change the structure of chlorophyll a.

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..... [1]

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(d) Chromatography is a method that can be used to separate and identify different photosynthetic pigments in a chloroplast extract.

Describe how chromatography is used to identify chlorophyll a in an extract from chloroplasts.

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..... [4]

[Total: 15]

7 (a) Gibberellin is involved in the germination of barley seeds.

In an investigation, aleurone layers from barley seeds were extracted. One sample was treated with gibberellin and the other sample was given no gibberellin treatment. The rate of production of amylase enzyme by the aleurone layers was measured over 15 hours.

The results are shown in Fig. 7.1.

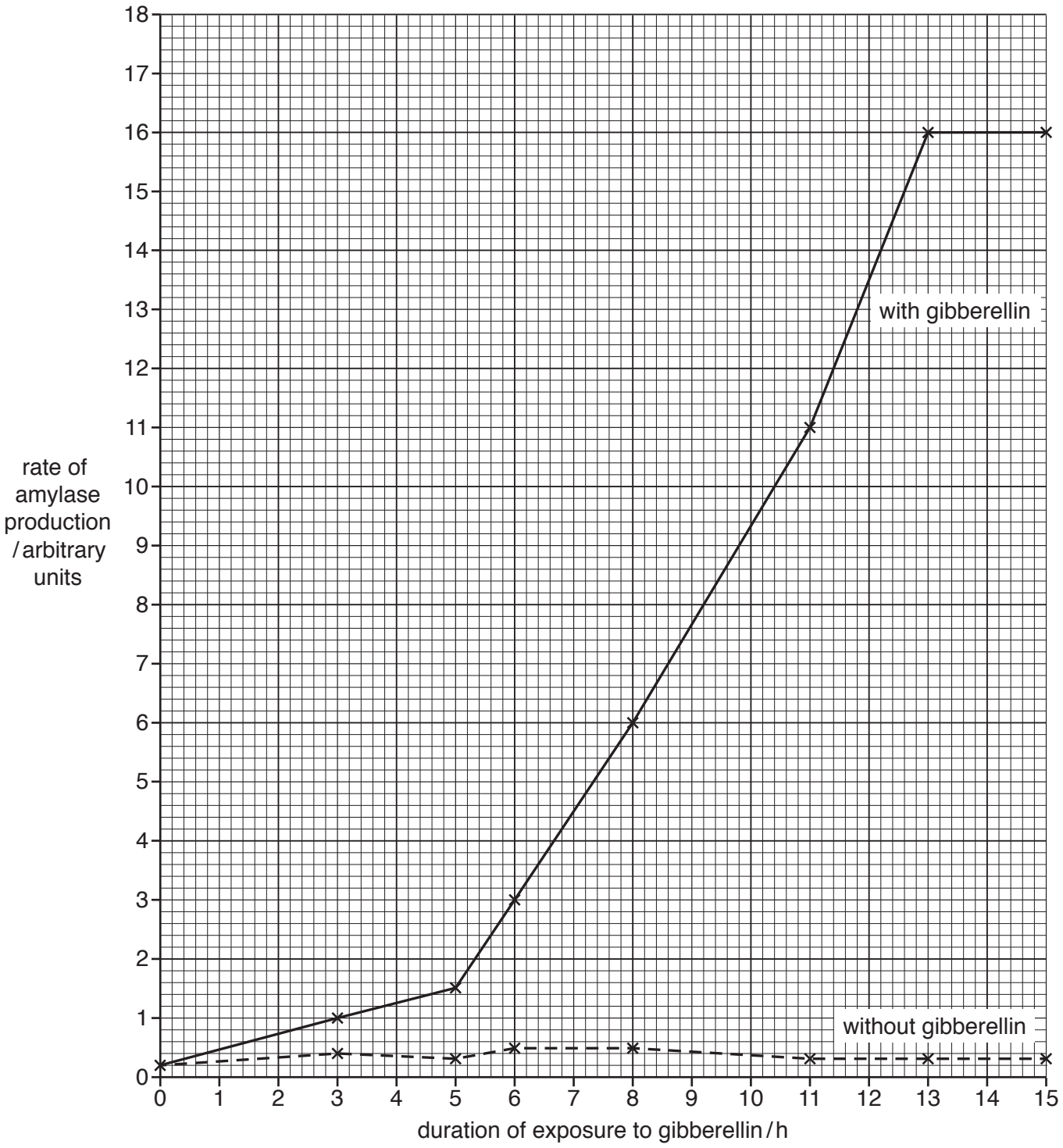


Fig. 7.1

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Describe the results shown in Fig. 7.1.

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..... [3]

(b) Explain why the aleurone layers of barley seeds need to produce amylase during germination.

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..... [3]

(c) The height of some plants is partly controlled by their genes. Height in pea plants is affected by a gene with two alleles. The dominant allele results in the production of active gibberellin, which stimulates stem elongation.

(i) State the symbol that represents the dominant allele.

..... [1]

(ii) Explain how this dominant allele results in the production of active gibberellin.

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..... [2]

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(iii) Active gibberellin stimulates stem elongation by causing the breakdown of DELLA protein repressors so that growth genes can be expressed.

Suggest the effects of the expression of these growth genes.

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..... [2]

[Total: 11]

8 The passage below outlines the structure of the mitochondrion.

Complete the passage by using the most appropriate scientific term(s).

The mitochondrion is found in eukaryotic cells. It is bound by a double membrane.

The outer membrane is permeable to pyruvate, which is the main product of

..... .

The inner membrane is folded to form ..... ,

which increase the surface area of the membrane. Embedded in the inner membrane are the carrier proteins of the electron transport chain and the protein complex responsible for ATP production, known as ..... .

Electron flow leads to the build-up of a large concentration of ..... in the intermembrane space due to the activity of the electron transport chain. The

..... of the mitochondrion, which contains enzymes, is the site of the link reaction and the ..... .

[6]

Section B

Answer **one** question.

9 **(a)** Viruses are not included in the three domain classification system as they have different features from most organisms.

Describe the features of viruses. [8]

(b) Non-governmental organisations play a role in **global** conservation.

Discuss how **two** global non-governmental organisations contribute to conservation. [7]

[Total: 15]

10 **(a)** Describe the roles of the neuromuscular junction, transverse system tubules (T-tubules) and the sarcoplasmic reticulum in stimulating contraction in striated muscle. [7]

(b) Outline the effects of mutant alleles on the phenotype in Huntington's disease. [8]

[Total: 15]

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