Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

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.

This document consists of **26** printed pages and **2** blank pages.

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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.

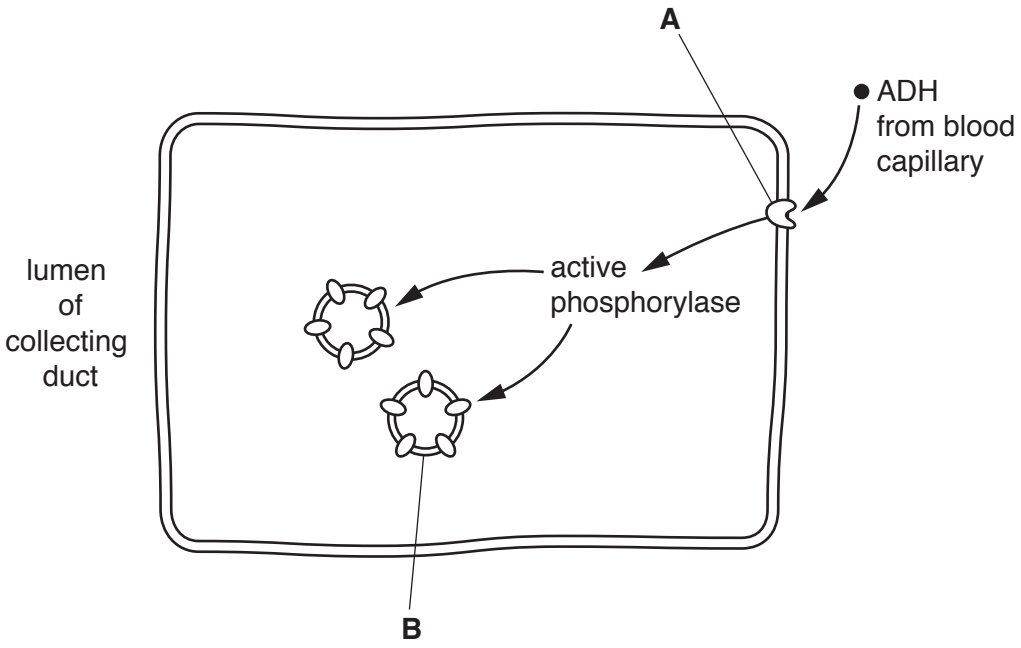
(i) State **one** change in the internal environment of a mammal that leads to the release of ADH.

..... [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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..... [2]

(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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[Total: 8]

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**
human	Cys	Gly	Asn	Leu	Ser	Thr	Cys	Met	Leu	Gly	Thr	Tyr	Thr	Gln	Asp	Phe
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]

(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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[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.

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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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[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.

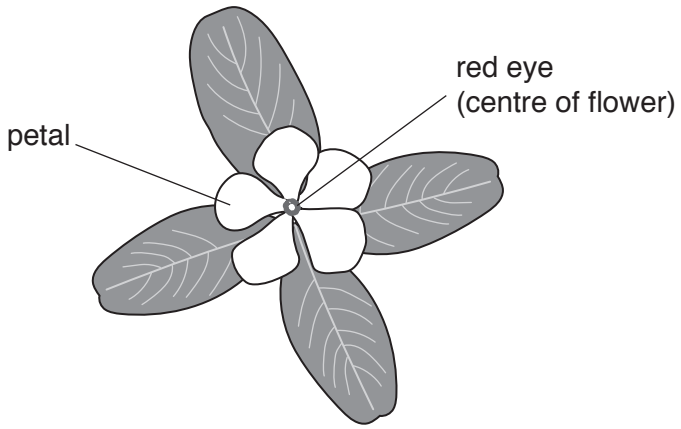


Fig. 4.1

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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..... [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.

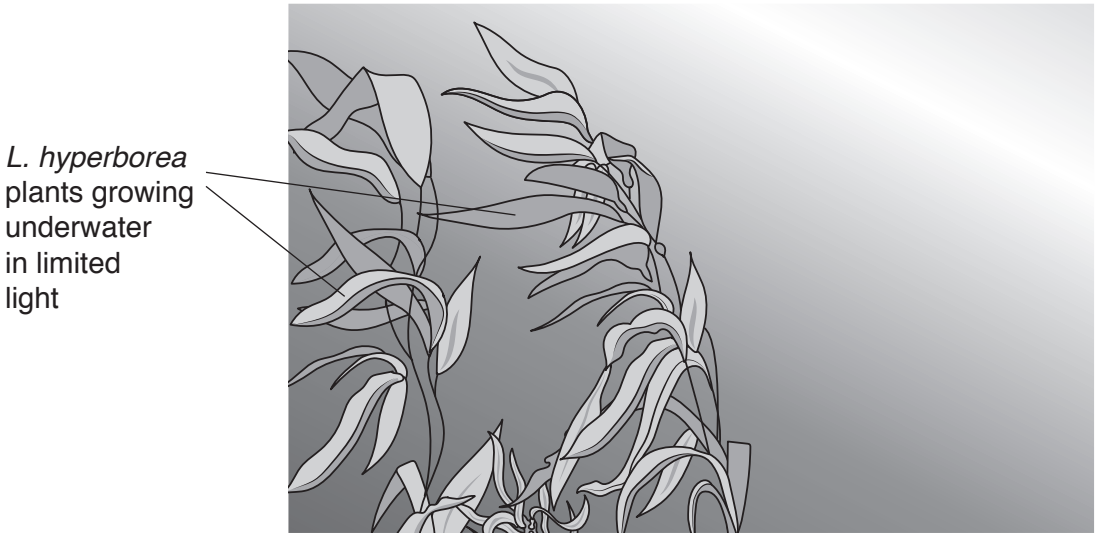


Fig. 5.1

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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(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.

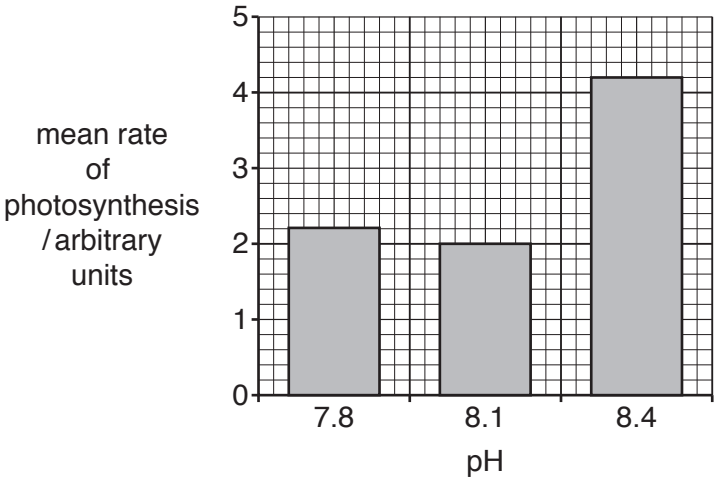


Fig. 5.2

(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]

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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.

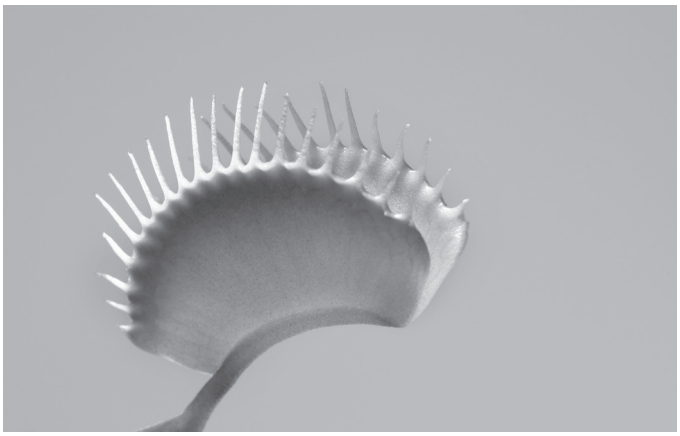


Fig. 7.1

(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.

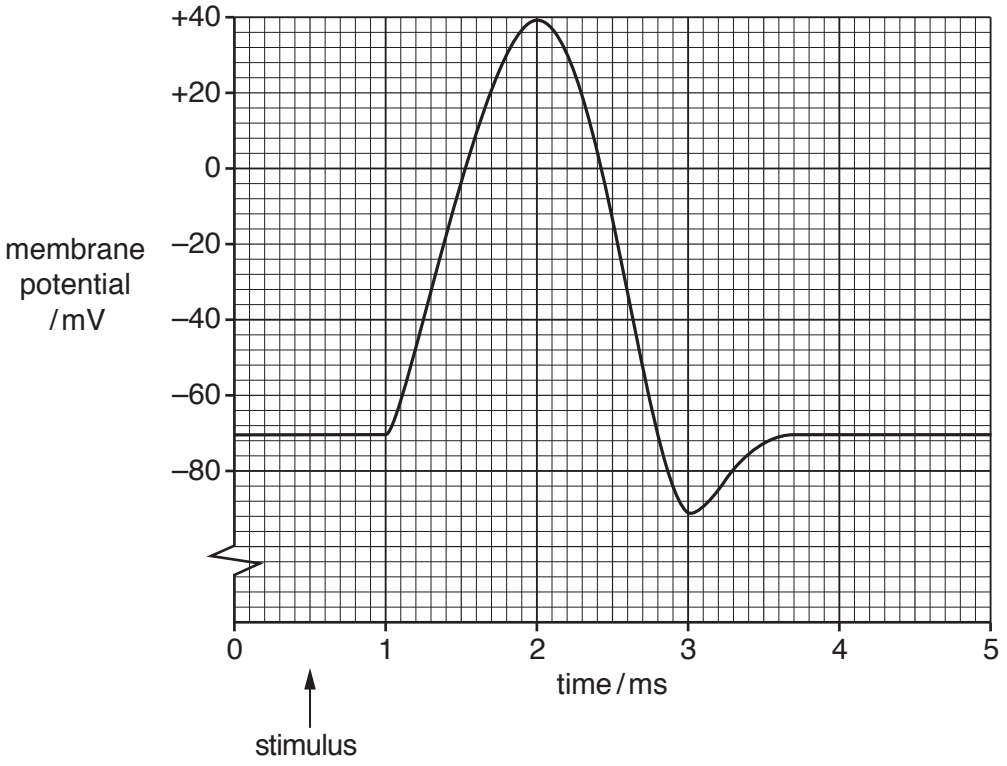


Fig. 7.2

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

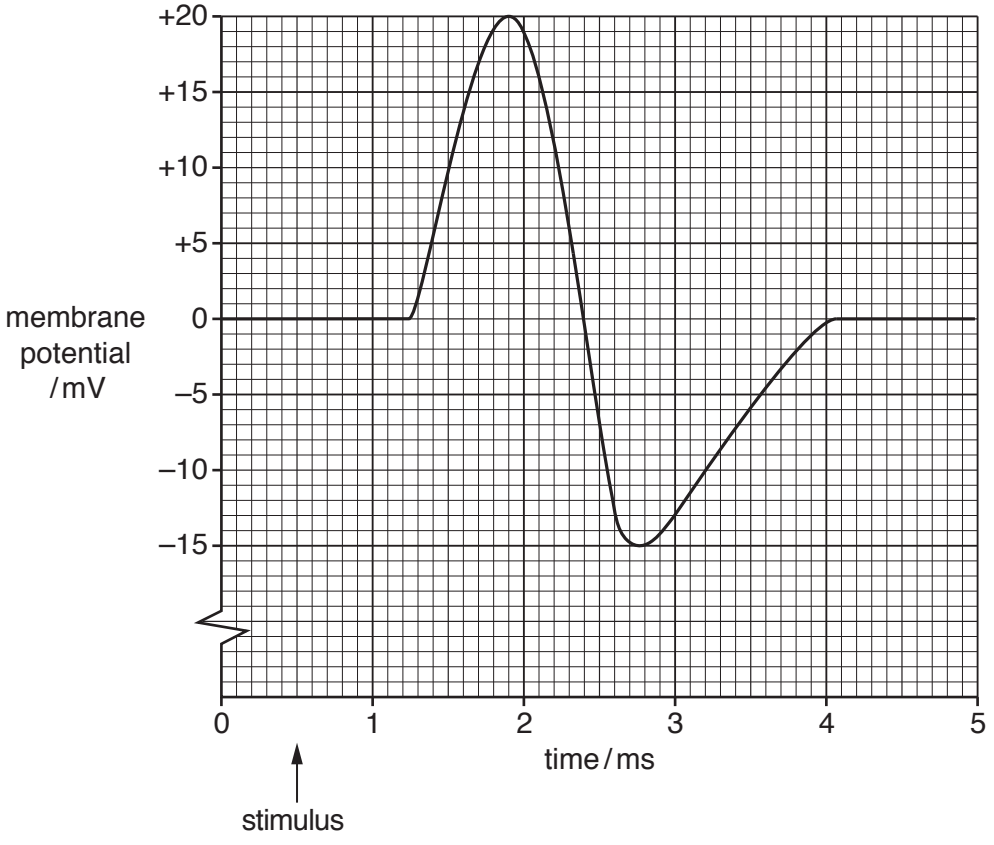


Fig. 7.3

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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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