UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

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4153427722

BIOLOGY **9700/41**

Paper 4 A2 Structured Questions **May/June 2013**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Answer Paper available on request.

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Write in dark blue or black ink.
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DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in Section A and **one** question from Section B.

Electronic calculators may be used.

Circle the number of the Section B question you have answered in the grid below.

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.

For Examiner's Use	
Section A	
1	
2	
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6	
7	
8	
Section B	
9 or 10	
Total	

This document consists of **21** printed pages, **2** lined pages and **1** blank page.

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Section A

Answer **all** the questions.

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1 **(a)** Fig. 1.1 shows a transverse section through a dicotyledonous leaf.

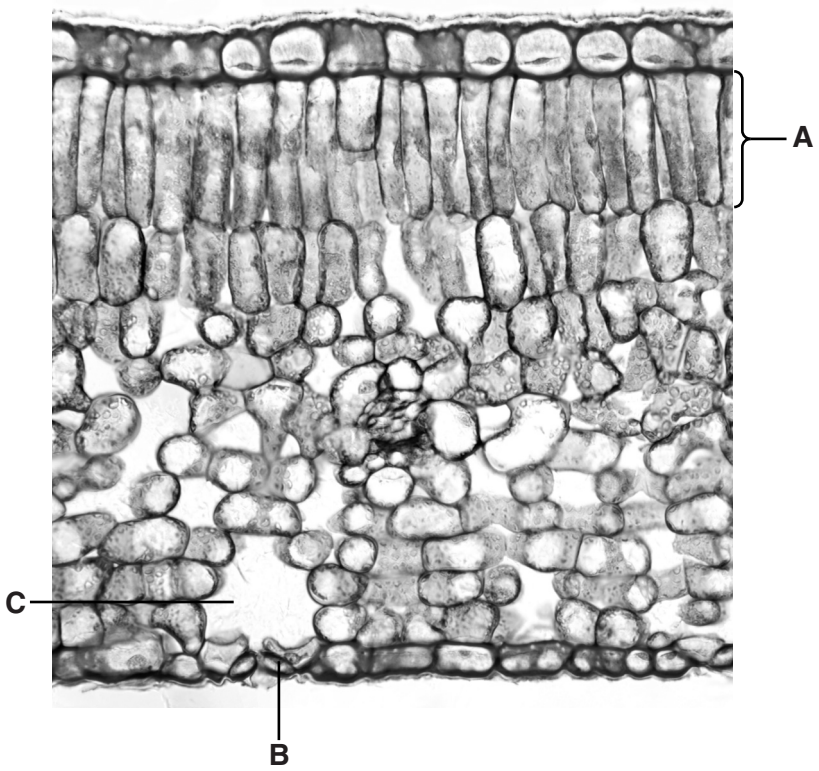


Fig. 1.1

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

A .....

B .....

C .....

[3]

(b) The leaf is the main photosynthetic organ in most plants. For the light-independent stage of photosynthesis to occur, carbon dioxide must be present.

(i) Describe how carbon dioxide enters the leaf.

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(ii) Name the compound that combines with carbon dioxide in the light-independent stage in a C3 plant.

For Examiner's Use

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(iii) Outline the role of reduced NADP in the light-independent stage.

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[Total: 8]

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2 A number of diseases, such as dengue fever, are spread by mosquitoes. The incidence of this disease has increased dramatically in recent years and this has been linked with the spread of the mosquito, *Aedes aegypti*.

For Examiner's Use

In an attempt to reduce the numbers of *A. aegypti*, genetically modified (GM) male mosquitoes were produced. One of the genes added to these mosquitoes, **when switched on**, results in the production of a protein which is toxic to mosquitoes.

In 2010, in the Cayman Islands and in Malaysia, GM male mosquitoes were released into the wild to mate with females. All the resulting offspring died in the larval stage.

(a) About 3 million GM male mosquitoes were released in the Cayman Islands.

Suggest why releasing such large numbers of male mosquitoes did not immediately increase the risk of transmission of dengue fever.

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..... [1]

(b) In Malaysia, both GM male and non-GM male mosquitoes were released in order to compare their dispersal and life span in the wild. The GM mosquitoes could be identified because they also carried a gene for green fluorescent protein (GFP).

Explain why, in many examples of gene technology, fluorescent markers are used in preference to antibiotic resistance genes.

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[Turn over

For Examiner's Use

(c) In addition to the gene for GFP, the DNA that has been added to the GM mosquitoes consists of

- a promoter
- a gene coding for a toxic protein, tTA
- a binding site for tTA.

When a GM mosquito larva hatches from an egg, the promoter induces the production of only a small amount of tTA, so that the larva does not die immediately. In a process of positive feedback, the tTA produced binds to the DNA as shown in Fig. 2.1. This increases the expression of the gene until the increased concentration of tTA kills the larva.

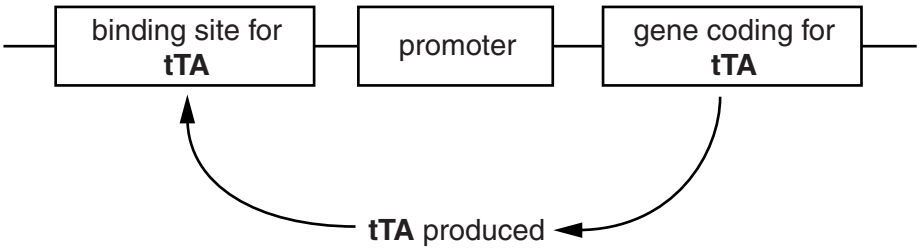


Fig. 2.1

(i) Suggest why this process is called *positive feedback*.

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(ii) Explain why, in gene technology, a promoter needs to be transferred along with the desired gene.

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For Examiner's Use

(iii) Switching on the gene coding for tTA in the mosquito larvae, rather than in the eggs, increases the effectiveness of this method of controlling mosquito numbers.

Suggest why this is so.

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(d) GM mosquitoes carrying the tTA gene can live and reproduce normally when fed on a diet containing an added chemical, **A**.

With reference to Fig. 2.1:

(i) suggest how **A** could prevent death of the GM mosquitoes

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(ii) suggest how large numbers of adult GM male mosquitoes can be produced for release into the wild, from an original stock of GM males

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(iii) suggest why there is little danger of the gene carried by these GM mosquitoes being passed to other organisms from GM mosquitoes which escape or are released into the wild.

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[Total: 15]

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[Turn over

For Examiner's Use

3 The filamentous fungus, *Fusarium venenatum*, can be grown in a fermenter and harvested as mycoprotein. It is sold as a food in a number of different countries.

The fungus is grown in continuous culture in 150 000 dm^3 airlift fermenters, in which the introduction of bubbles of compressed air both oxygenates and stirs the contents. The fungus grows as narrow, branched filaments, giving the harvested mycoprotein a naturally chewy, fibrous texture. Approximately 300 kg of fungus can be harvested per hour.

(a) Explain what is meant by the term *continuous culture*.

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(b) After about six weeks, mutants may appear in the fungal population, for example, a more highly-branched form of the fungus.

The fermenter is emptied, cleaned and repopulated with the original strain of *F. venenatum* every six weeks.

Explain why the fermentation process should be stopped before mutants appear.

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(c) Approximately 12% of the harvested fungus is protein.

Calculate the approximate mass of protein harvested in one day during continuous culture.

Show your working.

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answer ..... [1]

[Total:7]

For Examiner's Use

4 **(a)** An experiment was carried out to investigate the effect of temperature on the rate of oxygen consumption of the lizard, *Sauromalus hispidus*. The body temperature of a lizard varies with environmental temperature.

Several lizards were fitted with small, airtight masks that covered their heads. Air was supplied inside the mask through one tube, and collected through another. The differences between oxygen concentrations in the air supplied for inhalation and the exhaled air enabled the researchers to measure the rate of oxygen consumption of the lizards.

The rate of oxygen consumption of each lizard was measured when it was at rest and when it was running. Measurements were made at different temperatures ranging from 15 °C to 40 °C.

Fig. 4.1 shows the results.

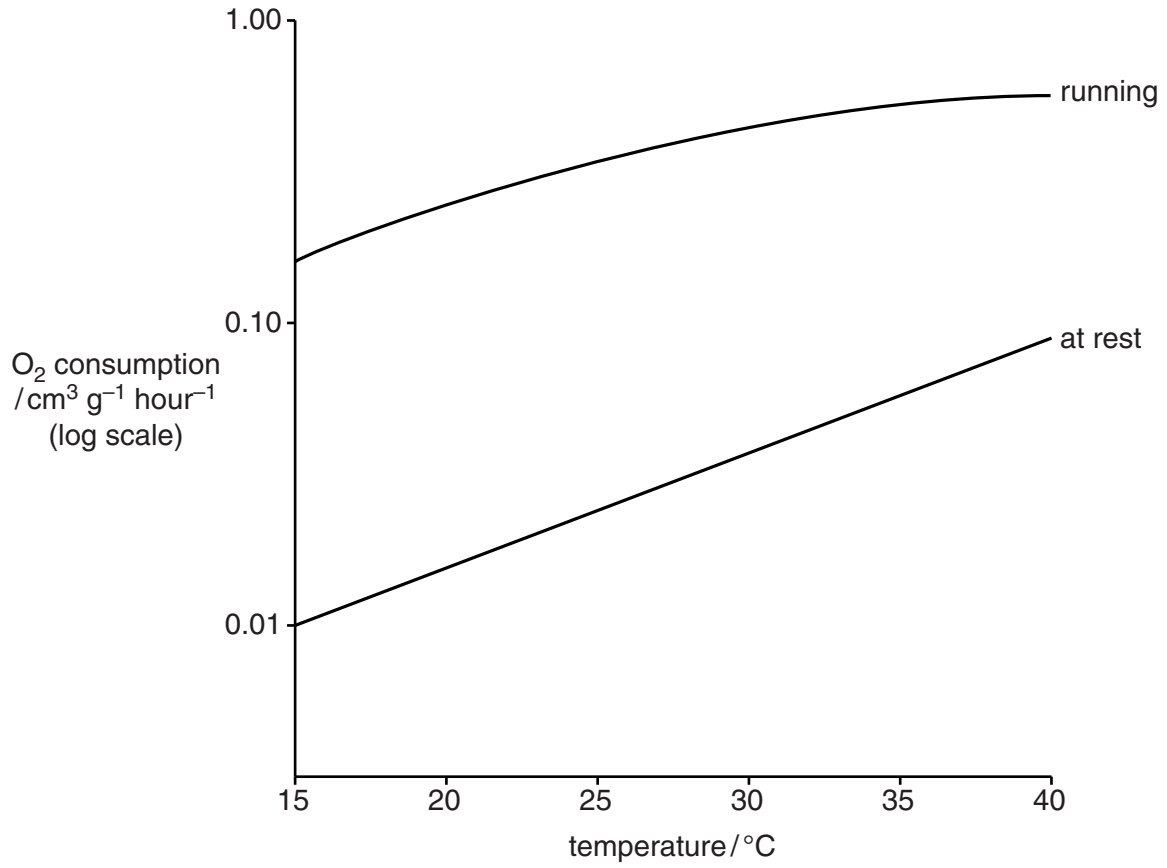


Fig. 4.1

(i) Running requires rapid use of ATP by muscle cells in the legs and heart of a lizard.

For Examiner's Use

With reference to the events occurring inside a mitochondrion, explain why a faster use of ATP requires a greater rate of oxygen consumption.

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(ii) Explain the effect of temperature on the rate of oxygen consumption in *Sauromalus* when at rest.

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For Examiner's Use

(b) The researchers also measured the oxygen debt that was built up when a lizard was running.

They measured this for two species of lizard, *Sauromalus hispidus* and *Varanus gouldi*, at six different temperatures.

The results are shown in Table 4.1.

Table 4.1

temperature / °C	**15**	**20**	**25**	**30**	**35**	**40**
***Sauromalus* oxygen debt / $cm^3 O_2 kg^{-1}$**	70.3	81.3	93.0	102.0	118.0	154.0
***Varanus* oxygen debt / $cm^3 O_2 kg^{-1}$**	62.0	72.2	78.5	87.9	96.7	102.0

(i) The oxygen debts were found by using the masks described in **(a)**.

Suggest what measurements were taken, and how these measurements were used to calculate the oxygen debt.

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(ii) Compare the oxygen debt built up by a running *Varanus* with that of a running *Sauromalus*.

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For Examiner's Use

(iii) *Varanus* is a fast-moving carnivore. *Sauromalus* is a slow-moving herbivore.

Explain how the results in Table 4.1 indicate that *Varanus* is well-adapted for its mode of life.

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(iv) Most lizards, including *Sauromalus*, have very simple lungs with no alveoli. *Varanus*, however, has lungs that are more like those of mammals, containing large numbers of air sacs similar to the alveoli of human lungs.

Suggest how this difference could account for the differences in the oxygen debts of *Sauromalus* and *Varanus* shown in Table 4.1.

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..... [2]

[Total: 17]

For Examiner's Use

5 **(a)** As part of the technique of In-vitro fertilisation (IVF), several oocytes are collected from a woman who is undergoing treatment. Each oocyte is checked under a microscope.

Explain why oocytes that have a first polar body are used in the fertilisation process.

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(b) It is possible to freeze embryos that are produced by IVF, using a solution containing sucrose and various salts. The embryos can later be thawed and implanted.

A trial was carried out to compare the success rates of freezing **oocytes** in

- solution **A**, the same solution as is used for freezing embryos
- solution **B**, a different solution containing different concentrations of sucrose and salts.

Oocytes were placed into either solution **A** or solution **B**. They were then frozen and stored at a temperature of –33 °C. Later, the oocytes were thawed and then fertilised, using intracytoplasmic sperm injection (ICSI).

(i) When the oocytes were placed into solution **A** or solution **B**, they quickly reduced in size. Explain why this happened.

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(ii) Table 5.1 shows the results of the trial.

Table 5.1

	number of oocytes frozen	number of oocytes thawed	number of oocytes that survived after thawing	number of oocytes that underwent ICSI	number of oocytes that were successfully fertilised
solution **A**	60	49	6	6	3
solution **B**	90	90	67	66	39

With reference to Table 5.1, explain which solution is the better solution to use.

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(iii) Suggest **one** advantage of being able to freeze and thaw oocytes as part of the IVF procedure.

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[Total: 7]

6 **(a)** Fig. 6.1 outlines how a cholinergic synapse works.

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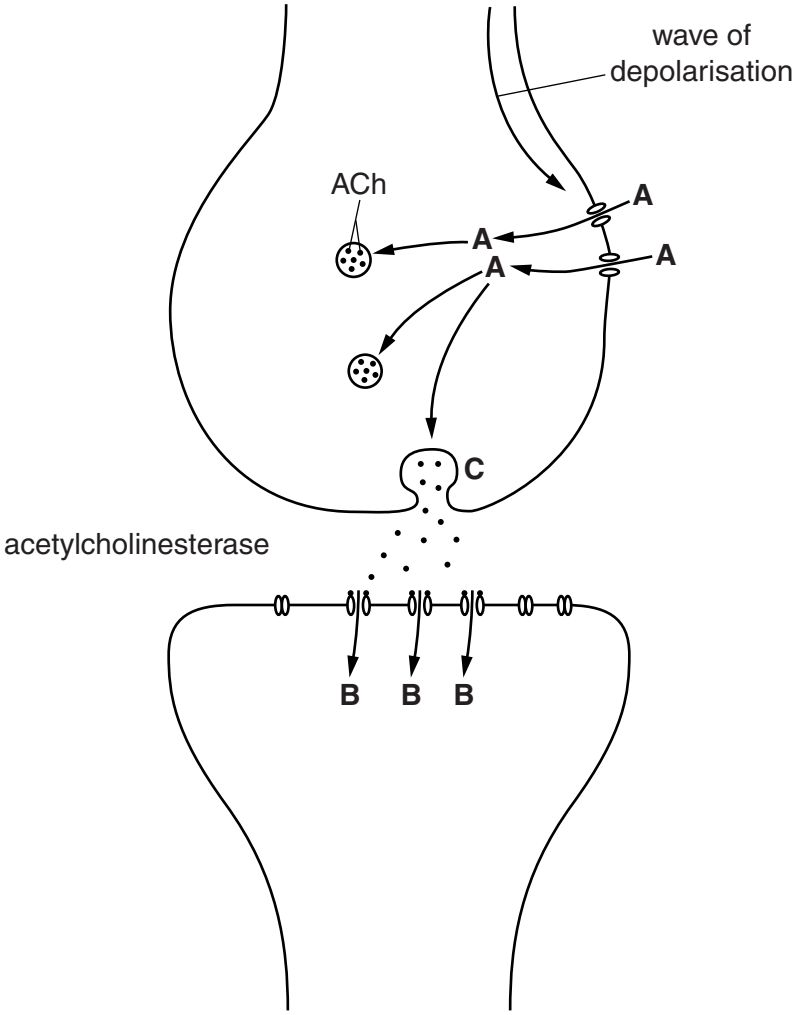


Fig. 6.1

With reference to Fig. 6.1:

(i) name **A** and **B**

A .....

B ..... [2]

(ii) name the process occurring at **C**

..... [1]

(iii) state the effect of **B** entering the post-synaptic neurone

..... [1]

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(iv) explain the role of acetylcholinesterase in the synapse.

For Examiner's Use

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(b) Some synapses in the brain use the neurotransmitter dopamine. After the postsynaptic membrane has been depolarised, dopamine leaves the receptor proteins and moves back into the presynaptic neurone through specific transporter proteins.

Schizophrenia is a condition in which there is a higher than usual concentration of dopamine in certain areas of the brain. The drug phenothiazine has a similar shape to dopamine and is used to treat schizophrenia.

Suggest and explain what occurs at the synapse when phenothiazine is used in the treatment of schizophrenia.

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(c) DRD4 is a dopamine receptor in humans. The gene coding for the DRD4 receptor has a large number of alleles, of which an individual can have only two.

For Examiner's Use

Three alleles of the DRD4 receptor gene have the following mutations:

- a single base substitution
- a 21 base-pair deletion
- a 13 base-pair deletion.

The 13 base-pair deletion has the most serious consequences for the structure of the DRD4 receptor protein. Suggest why this is so.

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(d) One allele of the DRD4 gene has been found more frequently amongst individuals whose personality is described as 'impulsive and exploratory'.

Describe the mechanism whereby an allele such as this could have become common in the human population.

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[Total: 15]

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7 Coat colour in cats is determined by a sex-linked gene with two alleles coding for black and orange.

When black cats are mated with orange cats:

- the female offspring are always tortoiseshell (black and orange patches)
- the male offspring are always the same colour as their mother.

(a) Explain what is meant by a *sex-linked gene*.

sex-linked .....

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gene .....

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(b) Using the symbols **B** for the allele for black coat and **O** for the allele for orange coat, complete the genetic diagram below.

parental phenotypes	tortoiseshell female	black male
parental genotypes		
gametes		
offspring genotypes		
offspring phenotypes		

[4]

(c) Explain why a male cat cannot have a tortoiseshell coat.

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[Total: 8]

For Examiner's Use

8 Sarawak is an area of south-east Asia that is largely covered by tropical rainforest. Logging has been allowed in large parts of the forest. A study was carried out to estimate the population size of different species of mammals living in the rainforest:

- before logging
- immediately after logging
- two years after logging
- four years after logging.

Table 8.1 shows the results of the study for six species of mammal. Where numbers were too small to measure the population density, the species were recorded as "present".

Table 8.1

	mean number of animals km^{-2}			
mammal	**before logging**	**immediately after logging**	**two years after logging**	**four years after logging**
marbled cat	present	0	0	0
small-clawed otter	present	0	0	0
giant squirrel	5	1	4	1
treeshrew	10	5	10	38
small squirrel	16	24	104	19
barking deer	3	1	10	present

(a) Calculate the percentage rise in the small squirrel population from before logging to two years after logging.

Show your working.

answer ..... % [2]

(b) Suggest why populations, such as that of the small squirrel, do not increase in size indefinitely.

For Examiner's Use

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(c) Suggest why marbled cats and small-clawed otters became extinct in this area but the other mammals did not.

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[Total: 8]

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[Turn over

Section B

Answer **one** question.

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9 **(a)** Explain the need to maintain biodiversity in an ecosystem such as a tropical rainforest. [7]

(b) Discuss the advantages and the disadvantages of captive breeding programmes for mammals. [8]

[Total: 15]

10 **(a)** Explain how the physiology of the leaves of a C4 plant, such as maize, is adapted for efficient carbon fixation at high temperatures. [7]

(b) Describe how, in photosynthesis, light energy is converted into chemical energy, in the form of ATP. [8]

[Total: 15]

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General Certificate of Education Advanced Level

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BIOLOGY **9700/42**

Paper 4 A2 Structured Questions **May/June 2013**

2 hours

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Section A	
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Section A

Answer **all** the questions.

For Examiner's Use

1 **(a)** A student investigated the effects of temperature and light intensity on the rate of photosynthesis of an aquatic plant.

Fig. 1.1 shows the results of the investigation.

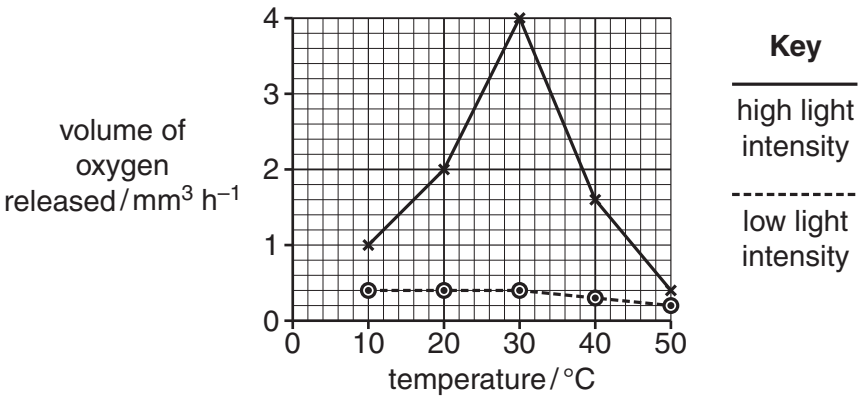


Fig. 1.1

With reference to Fig. 1.1:

(i) describe the results of the investigation

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(ii) suggest explanations for the results for high light intensity **above 30 °C**.

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For Examiner's Use

(b) (i) Name the process in the light-dependent stage of photosynthesis that produces oxygen.

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(ii) Name the photosystem involved in the production of oxygen in the light-dependent stage.

..... [1]

(iii) Explain why the volume of oxygen released from the plant does not give a true rate of photosynthesis.

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[Total: 8]

2 The pink bollworm moth, *Pectinophora gossypiella*, is a pest of cotton crops. The size of its population can be reduced by releasing large numbers of sterile male moths into cotton fields. The sterile male moths mate with wild females from the cotton fields, but no offspring are produced.

For Examiner's Use

Over a period of three years, 20 million genetically modified (GM) sterile male moths were released in the USA. Each insect contained a gene coding for a red fluorescent protein (DsRed) taken from a species of reef coral. The added DNA also included a promoter.

(a) Explain why, in gene technology:

(i) genes for fluorescent proteins such as DsRed are now more commonly used as markers than are genes for antibiotic resistance

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(ii) a promoter needs to be included when transferring a gene from a coral into an insect.

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(b) DsRed is visible at all stages of the life cycle of the moth, but the presence of the gene in a particular individual can be confirmed by genetic fingerprinting, using gel electrophoresis.

(i) Outline the principles of gel electrophoresis.

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(ii) Explain how the presence of the gene for DsRed in a moth can be confirmed once electrophoresis is complete.

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(c) DsRed allows sterile male moths to be distinguished from wild moths when caught in an insect trap in a field of cotton plants.

Suggest why it is important to be sure whether a moth caught in such a trap is a released sterile male or a wild insect.

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(d) The United States Department of Agriculture has ruled that the release of sterile males to control insect pest numbers is environmentally preferable to all other alternatives.

For Examiner's Use

Suggest what information would be needed to determine whether the release of the sterile male moths, carrying the gene for DsRed, has a damaging effect on the environment.

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..... [2]

[Total: 15]

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Question 3 starts on page 8

For Examiner's Use

3 The filamentous fungus, *Fusarium venenatum*, is grown in continuous culture in large fermenters to provide mycoprotein for human consumption.

(a) Explain what is meant by the term *continuous culture*.

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(b) In an investigation into the growth of the fungus in culture, several factors were varied including:

- temperature
- concentration of the carbon source
- concentration of the nitrogen source.

Some of the results are shown in Table 3.1.

Table 3.1

temperature /°C	concentration of carbon source / g dm^{-3}	concentration of nitrogen source / g dm^{-3}	dry mass of fungus / g dm^{-3}
25	7.0	2.9	3.1
25	14.0	3.5	4.3
30	7.0	3.5	4.8
30	14.0	2.9	4.2

(i) Describe the effect of temperature on the growth of the fungus at the different concentrations of the carbon source.

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(ii) Explain why the fungus needs sources of carbon and nitrogen.

For Examiner's Use

carbon .....

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nitrogen .....

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[Total: 8]

4 **(a)** The production of ATP by oxidative phosphorylation takes place in the electron transport chain in a mitochondrion.

(i) State the part of the mitochondrion in which the electron transport chain is found.

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(ii) Describe briefly where the electrons that are passed along the electron transport chain come from.

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(iii) Describe the role of oxygen in the process of oxidative phosphorylation.

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(b) The brain depends on a constant supply of oxygen for aerobic respiration. Anaerobic respiration is not sufficient to keep neurones in the brain alive. This is because neurones require especially large amounts of ATP. Up to 80% of the ATP is used to provide energy for the Na^+/K^+ pump.

For Examiner's Use

When a person suffers a stroke, blood flow to part of the brain is stopped, so some neurones receive no oxygen. ATP production by oxidative phosphorylation stops. Fig. 4.1 shows some of the ways in which the lack of ATP affects a neurone in the brain.

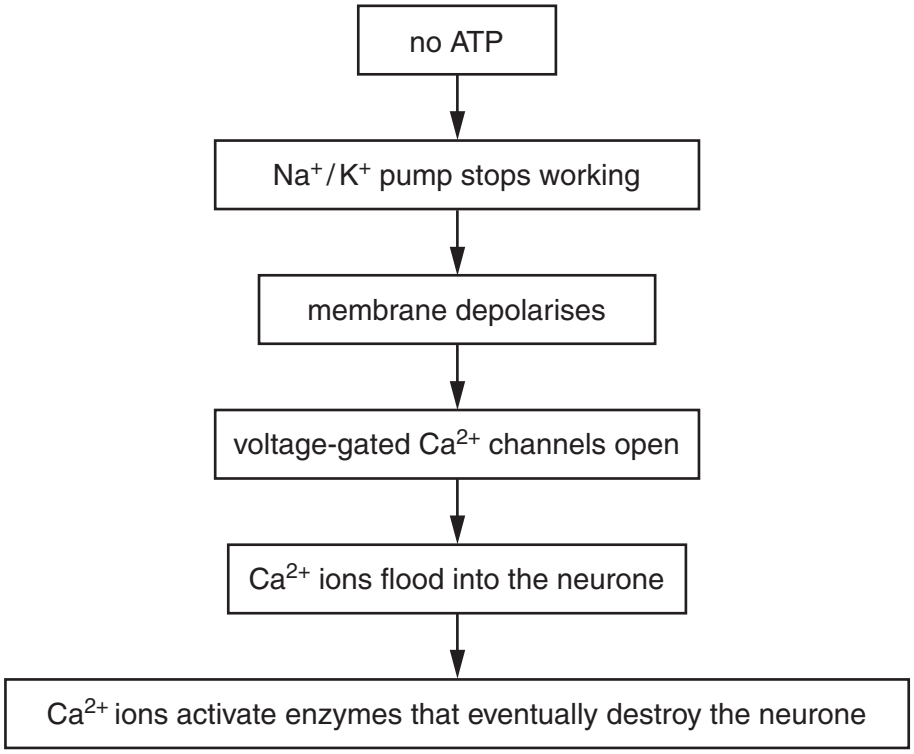


Fig. 4.1

(i) Explain why the membrane of the neurone depolarises when the Na^+/K^+ pump stops working.

For Examiner's Use

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(ii) Suggest why calcium ions flood into the neurone when the Na^+/K^+ pump stops working.

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(c) The freshwater turtle, *Trachemys scripta*, is able to survive for long periods in conditions of very low oxygen concentration. As in humans, the rate of activity of the Na^+/K^+ pump in the neurones in its brain falls sharply. However, in turtles this does not result in damage to these cells.

For Examiner's Use

A better understanding of how the neurones in the turtle's brain survive in these conditions could lead to new treatments for people who have suffered a stroke.

Experiments show that, in turtle brain neurones, in conditions of low oxygen availability:

- most ion channels in the cell surface membranes immediately close
- after about four hours, the quantity of mRNA involved in the synthesis of proteins used to build ion channels, falls to less than one fifth of normal concentrations.

(i) Suggest how the closure of ion channels in the neurones of the turtle in very low oxygen concentrations could allow the cells to survive.

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(ii) Suggest what causes the quantity of mRNA for protein channels to fall.

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[Total: 16]

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Question 5 starts on page 14

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[Turn over

5 Fig. 5.1 shows some of the steps involved in in-vitro fertilisation (IVF).

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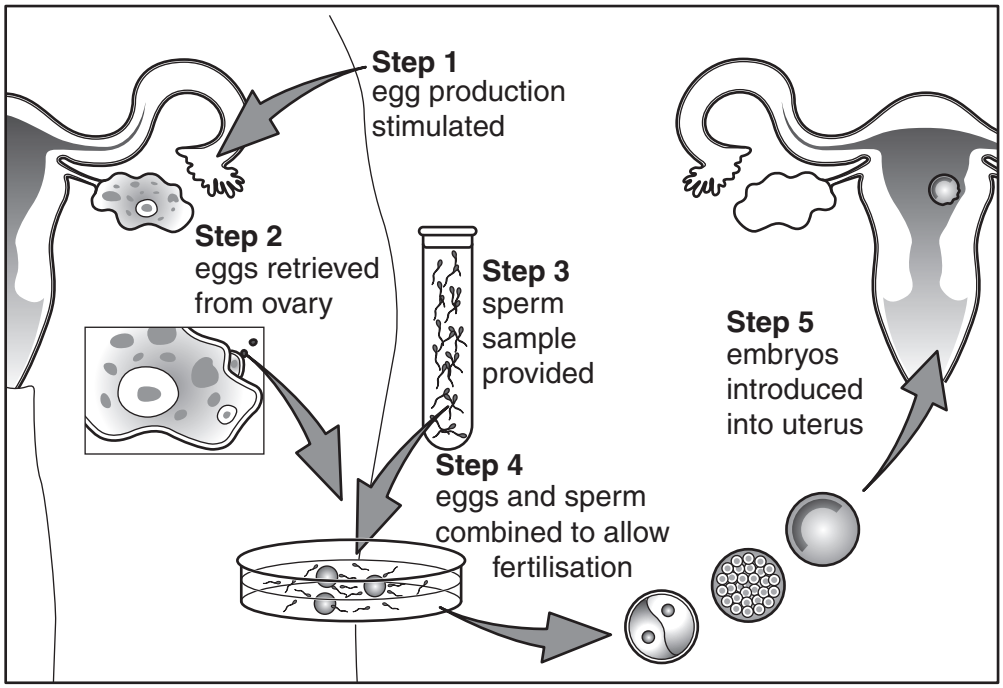


Fig. 5.1

(a) Explain how egg production is stimulated at **step 1**.

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..... [2]

(b) Following **step 3** in Fig. 5.1, the sperm sample is placed in a solution containing various nutrients and other substances, for up to one hour, before being added to the eggs.

For Examiner's Use

Explain why this is done.

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(c) In 2010, researchers found that they could predict with 93% certainty which embryos produced by in-vitro fertilisation would develop into healthy babies when implanted into the uterus.

Their technique involved the use of time-lapse microscopy. The successful embryos met three criteria:

- the first cytokinesis lasted between 0 and 33 minutes
- the time interval between the first and second cell division was between 7.8 and 14.3 hours
- the time interval between the second and third cell division was between 0 and 5.8 hours.

(i) Suggest **one** advantage of the use of this new technique in the IVF procedure.

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(ii) Suggest **one** disadvantage of the use of this technique.

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[Total: 8]

For Examiner's Use

6 **(a)** The human kidneys process 1200 cm^3 of blood every minute. This 1200 cm^3 of blood contains 700 cm^3 of plasma. As blood passes through the glomeruli of the kidneys, 125 cm^3 of fluid passes into the renal capsules (Bowman's capsules). This fluid is called the glomerular filtrate and is produced by a process called ultrafiltration.

(i) Calculate the percentage of plasma that passes into the renal capsules.

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

answer .....% [2]

(ii) Explain how the **structures** of the glomerular capillaries and the podocytes are adapted for ultrafiltration.

glomerular capillaries .....

.....

.....

.....

.....

podocytes .....

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..... [4]

(b) The glomerular filtrate then passes through the proximal convoluted tubule.

For Examiner's Use

Fig. 6.1 is a transverse section through part of the proximal convoluted tubule.

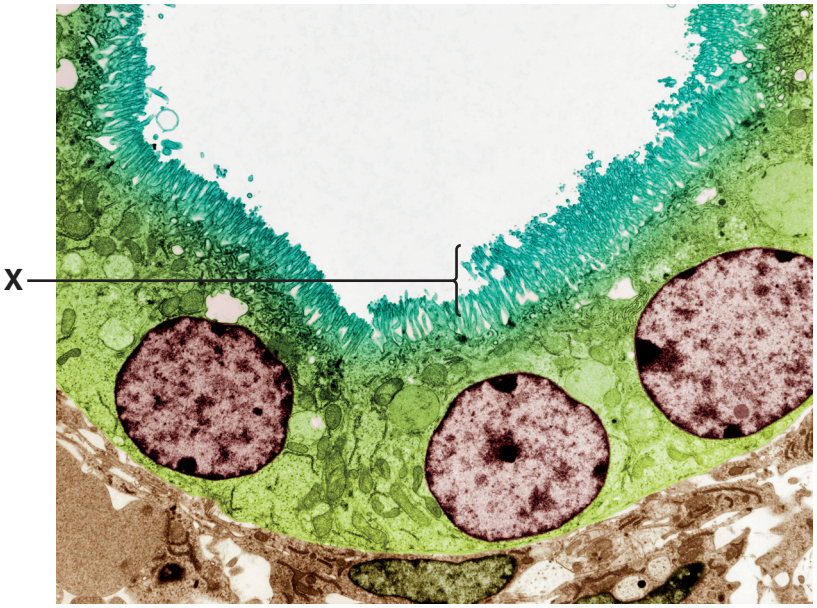


Fig. 6.1

(i) Name the structures labelled **X**.

..... [1]

(ii) Explain why the epithelial cells of the proximal convoluted tubule have many mitochondria in them.

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..... [2]

(iii) Of the 125 cm^3 of glomerular filtrate that enters the renal capsules each minute, only 45 cm^3 reaches the loops of Henlé.

Name **two** substances that are reabsorbed into the blood from the proximal convoluted tubule, **apart from water**.

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..... [2]

[Total: 11]

For Examiner's Use

7 Resistance to the poison warfarin is now extremely common in rats. Warfarin inhibits an enzyme in the liver, vitamin K epoxide reductase, that is necessary for the recycling of vitamin K. This vitamin is involved in the production of substances required for blood clotting.

- Rats susceptible to warfarin die of internal bleeding.
- Rats that are homozygous for resistance to warfarin do not suffer from internal bleeding when their diet provides more than 70 μg of vitamin K per kg body mass per day.
- Heterozygous rats are resistant to warfarin when their diet provides about 10 μg of vitamin K per kg body mass per day.

(a) Using appropriate symbols, complete the genetic diagram to show how two resistant rats can produce warfarin-susceptible offspring.

key to symbols

.....

.....

parental phenotypes	resistant male	resistant female
parental genotypes		
gametes		
offspring genotypes		
offspring phenotypes		

[3]

(b) Rats that are homozygous for warfarin resistance have a low survival rate in the wild. Suggest why this is so.

.....

..... [1]

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(c) Warfarin can be safely given to humans who are at risk of unwanted blood clots. The clotting time of the blood is measured regularly and the warfarin dose is varied accordingly.

For Examiner's Use

Suggest, giving a reason, the type of inhibition warfarin has on the enzyme vitamin K epoxide reductase.

type of inhibition .....

reason .....

..... [2]

(d) The allele for warfarin resistance may have originated by a single base substitution and resulted in a modified vitamin K epoxide reductase.

Explain how a single base substitution may affect the phenotype of an organism.

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..... [3]

[Total: 9]

For Examiner's Use

8 The Death Valley region of Nevada in the USA used to have an extensive lake system. Approximately 20 000 years ago the lakes started to dry up and now consist of isolated small pools. Four different species of the desert pupfish have been found living in these pools. Evidence indicates that over 20 000 years ago there was only one species of pupfish living in the lake system.

Fig. 8.1 shows a desert pupfish.



Fig. 8.1

(a) Explain how the change from an extensive lake system to just a few pools could have resulted in the evolution of four new species of desert pupfish.

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..... [5]

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(b) State how environmental factors can act as stabilising forces of natural selection in an isolated pool, after the initial evolution of a new species of desert pupfish.

For Examiner's Use

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..... [2]

(c) Suggest what may happen to the desert pupfish if water levels rise and the pools once more form an extensive lake system.

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..... [3]

[Total: 10]

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[Turn over

Section B

Answer **one** question.

For Examiner's Use

9 **(a)** Bacteria are members of the kingdom *Prokaryota*. Describe the main features of a bacterial cell. [8]

(b) Outline the use of bacteria in the extraction of metals from ores. [7]

[Total:15]

10 **(a)** Describe the structure of a chloroplast. [7]

(b) Explain how rice is adapted to growing in flooded fields. [8]

[Total:15]

For Examiner's Use

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

6016630360

BIOLOGY **9700/43**

Paper 4 A2 Structured Questions **May/June 2013**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Answer Paper available on request.

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 ink.
You may use a pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in Section A and **one** question from Section B.

Electronic calculators may be used.

Circle the number of the Section B question you have answered in the grid below.

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.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
6	
7	
8	
Section B	
9 or 10	
Total	

This document consists of **21** printed pages, **2** lined pages and **1** blank page.

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Section A

Answer **all** the questions.

For Examiner's Use

1 **(a)** Fig. 1.1 shows a transverse section through a dicotyledonous leaf.

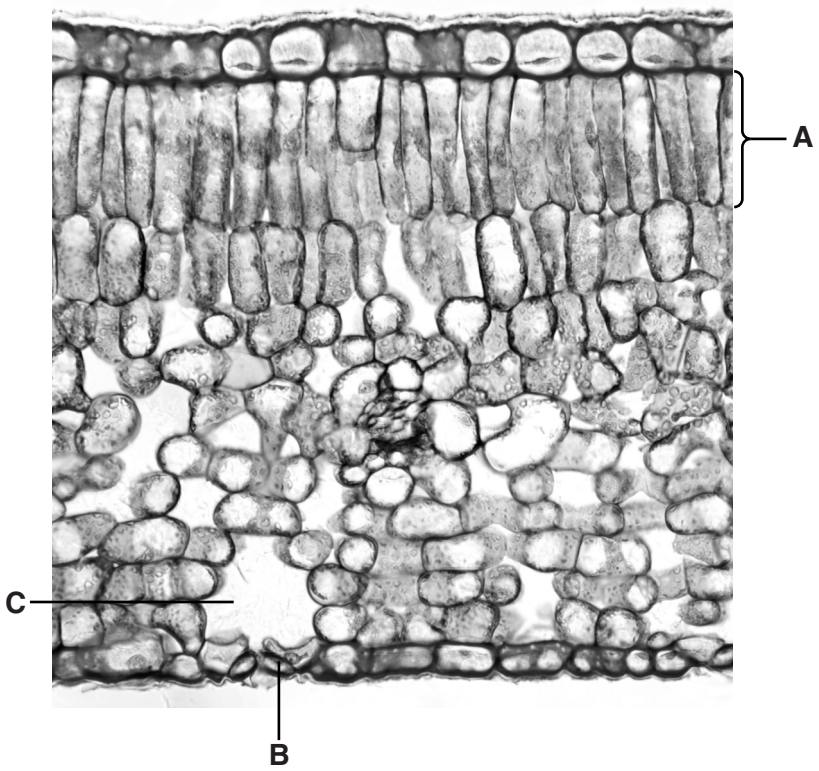


Fig. 1.1

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

A .....

B .....

C .....

[3]

(b) The leaf is the main photosynthetic organ in most plants. For the light-independent stage of photosynthesis to occur, carbon dioxide must be present.

(i) Describe how carbon dioxide enters the leaf.

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..... [2]

(ii) Name the compound that combines with carbon dioxide in the light-independent stage in a C3 plant.

For Examiner's Use

..... [1]

(iii) Outline the role of reduced NADP in the light-independent stage.

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..... [2]

[Total: 8]

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2 A number of diseases, such as dengue fever, are spread by mosquitoes. The incidence of this disease has increased dramatically in recent years and this has been linked with the spread of the mosquito, *Aedes aegypti*.

For Examiner's Use

In an attempt to reduce the numbers of *A. aegypti*, genetically modified (GM) male mosquitoes were produced. One of the genes added to these mosquitoes, **when switched on**, results in the production of a protein which is toxic to mosquitoes.

In 2010, in the Cayman Islands and in Malaysia, GM male mosquitoes were released into the wild to mate with females. All the resulting offspring died in the larval stage.

(a) About 3 million GM male mosquitoes were released in the Cayman Islands.

Suggest why releasing such large numbers of male mosquitoes did not immediately increase the risk of transmission of dengue fever.

.....

..... [1]

(b) In Malaysia, both GM male and non-GM male mosquitoes were released in order to compare their dispersal and life span in the wild. The GM mosquitoes could be identified because they also carried a gene for green fluorescent protein (GFP).

Explain why, in many examples of gene technology, fluorescent markers are used in preference to antibiotic resistance genes.

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..... [2]

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[Turn over

For Examiner's Use

(c) In addition to the gene for GFP, the DNA that has been added to the GM mosquitoes consists of

- a promoter
- a gene coding for a toxic protein, tTA
- a binding site for tTA.

When a GM mosquito larva hatches from an egg, the promoter induces the production of only a small amount of tTA, so that the larva does not die immediately. In a process of positive feedback, the tTA produced binds to the DNA as shown in Fig. 2.1. This increases the expression of the gene until the increased concentration of tTA kills the larva.

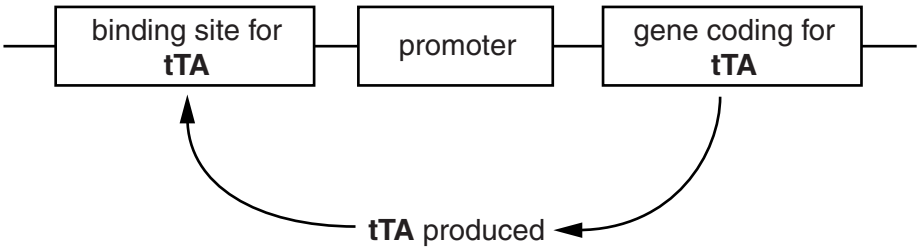


Fig. 2.1

(i) Suggest why this process is called *positive feedback*.

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..... [1]

(ii) Explain why, in gene technology, a promoter needs to be transferred along with the desired gene.

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..... [3]

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For Examiner's Use

(iii) Switching on the gene coding for tTA in the mosquito larvae, rather than in the eggs, increases the effectiveness of this method of controlling mosquito numbers.

Suggest why this is so.

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..... [2]

(d) GM mosquitoes carrying the tTA gene can live and reproduce normally when fed on a diet containing an added chemical, **A**.

With reference to Fig. 2.1:

(i) suggest how **A** could prevent death of the GM mosquitoes

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..... [2]

(ii) suggest how large numbers of adult GM male mosquitoes can be produced for release into the wild, from an original stock of GM males

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..... [2]

(iii) suggest why there is little danger of the gene carried by these GM mosquitoes being passed to other organisms from GM mosquitoes which escape or are released into the wild.

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..... [2]

[Total: 15]

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[Turn over

For Examiner's Use

3 The filamentous fungus, *Fusarium venenatum*, can be grown in a fermenter and harvested as mycoprotein. It is sold as a food in a number of different countries.

The fungus is grown in continuous culture in 150 000 dm^3 airlift fermenters, in which the introduction of bubbles of compressed air both oxygenates and stirs the contents. The fungus grows as narrow, branched filaments, giving the harvested mycoprotein a naturally chewy, fibrous texture. Approximately 300 kg of fungus can be harvested per hour.

(a) Explain what is meant by the term *continuous culture*.

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..... [2]

(b) After about six weeks, mutants may appear in the fungal population, for example, a more highly-branched form of the fungus.

The fermenter is emptied, cleaned and repopulated with the original strain of *F. venenatum* every six weeks.

Explain why the fermentation process should be stopped before mutants appear.

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..... [4]

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(c) Approximately 12% of the harvested fungus is protein.

Calculate the approximate mass of protein harvested in one day during continuous culture.

Show your working.

For Examiner's Use

answer ..... [1]

[Total:7]

For Examiner's Use

4 **(a)** An experiment was carried out to investigate the effect of temperature on the rate of oxygen consumption of the lizard, *Sauromalus hispidus*. The body temperature of a lizard varies with environmental temperature.

Several lizards were fitted with small, airtight masks that covered their heads. Air was supplied inside the mask through one tube, and collected through another. The differences between oxygen concentrations in the air supplied for inhalation and the exhaled air enabled the researchers to measure the rate of oxygen consumption of the lizards.

The rate of oxygen consumption of each lizard was measured when it was at rest and when it was running. Measurements were made at different temperatures ranging from 15 °C to 40 °C.

Fig. 4.1 shows the results.

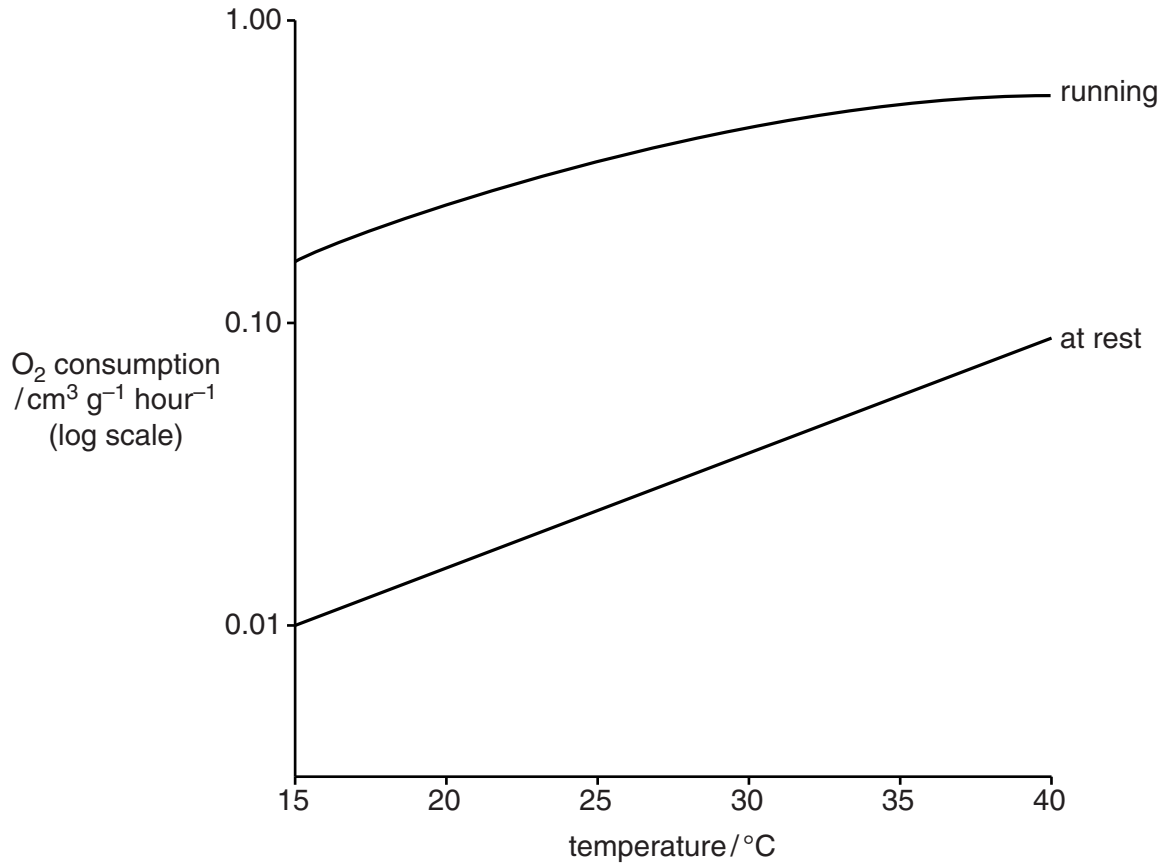


Fig. 4.1

(i) Running requires rapid use of ATP by muscle cells in the legs and heart of a lizard.

For Examiner's Use

With reference to the events occurring inside a mitochondrion, explain why a faster use of ATP requires a greater rate of oxygen consumption.

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..... [4]

(ii) Explain the effect of temperature on the rate of oxygen consumption in *Sauromalus* when at rest.

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..... [3]

For Examiner's Use

(b) The researchers also measured the oxygen debt that was built up when a lizard was running.

They measured this for two species of lizard, *Sauromalus hispidus* and *Varanus gouldi*, at six different temperatures.

The results are shown in Table 4.1.

Table 4.1

temperature / °C	**15**	**20**	**25**	**30**	**35**	**40**
***Sauromalus* oxygen debt / $cm^3 O_2 kg^{-1}$**	70.3	81.3	93.0	102.0	118.0	154.0
***Varanus* oxygen debt / $cm^3 O_2 kg^{-1}$**	62.0	72.2	78.5	87.9	96.7	102.0

(i) The oxygen debts were found by using the masks described in **(a)**.

Suggest what measurements were taken, and how these measurements were used to calculate the oxygen debt.

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..... [2]

(ii) Compare the oxygen debt built up by a running *Varanus* with that of a running *Sauromalus*.

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..... [3]

For Examiner's Use

(iii) *Varanus* is a fast-moving carnivore. *Sauromalus* is a slow-moving herbivore.

Explain how the results in Table 4.1 indicate that *Varanus* is well-adapted for its mode of life.

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..... [3]

(iv) Most lizards, including *Sauromalus*, have very simple lungs with no alveoli. *Varanus*, however, has lungs that are more like those of mammals, containing large numbers of air sacs similar to the alveoli of human lungs.

Suggest how this difference could account for the differences in the oxygen debts of *Sauromalus* and *Varanus* shown in Table 4.1.

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..... [2]

[Total: 17]

For Examiner's Use

5 **(a)** As part of the technique of In-vitro fertilisation (IVF), several oocytes are collected from a woman who is undergoing treatment. Each oocyte is checked under a microscope.

Explain why oocytes that have a first polar body are used in the fertilisation process.

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..... [2]

(b) It is possible to freeze embryos that are produced by IVF, using a solution containing sucrose and various salts. The embryos can later be thawed and implanted.

A trial was carried out to compare the success rates of freezing **oocytes** in

- solution **A**, the same solution as is used for freezing embryos
- solution **B**, a different solution containing different concentrations of sucrose and salts.

Oocytes were placed into either solution **A** or solution **B**. They were then frozen and stored at a temperature of –33 °C. Later, the oocytes were thawed and then fertilised, using intracytoplasmic sperm injection (ICSI).

(i) When the oocytes were placed into solution **A** or solution **B**, they quickly reduced in size. Explain why this happened.

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..... [2]

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(ii) Table 5.1 shows the results of the trial.

Table 5.1

	number of oocytes frozen	number of oocytes thawed	number of oocytes that survived after thawing	number of oocytes that underwent ICSI	number of oocytes that were successfully fertilised
solution **A**	60	49	6	6	3
solution **B**	90	90	67	66	39

With reference to Table 5.1, explain which solution is the better solution to use.

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..... [2]

(iii) Suggest **one** advantage of being able to freeze and thaw oocytes as part of the IVF procedure.

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..... [1]

[Total: 7]

6 **(a)** Fig. 6.1 outlines how a cholinergic synapse works.

For Examiner's Use

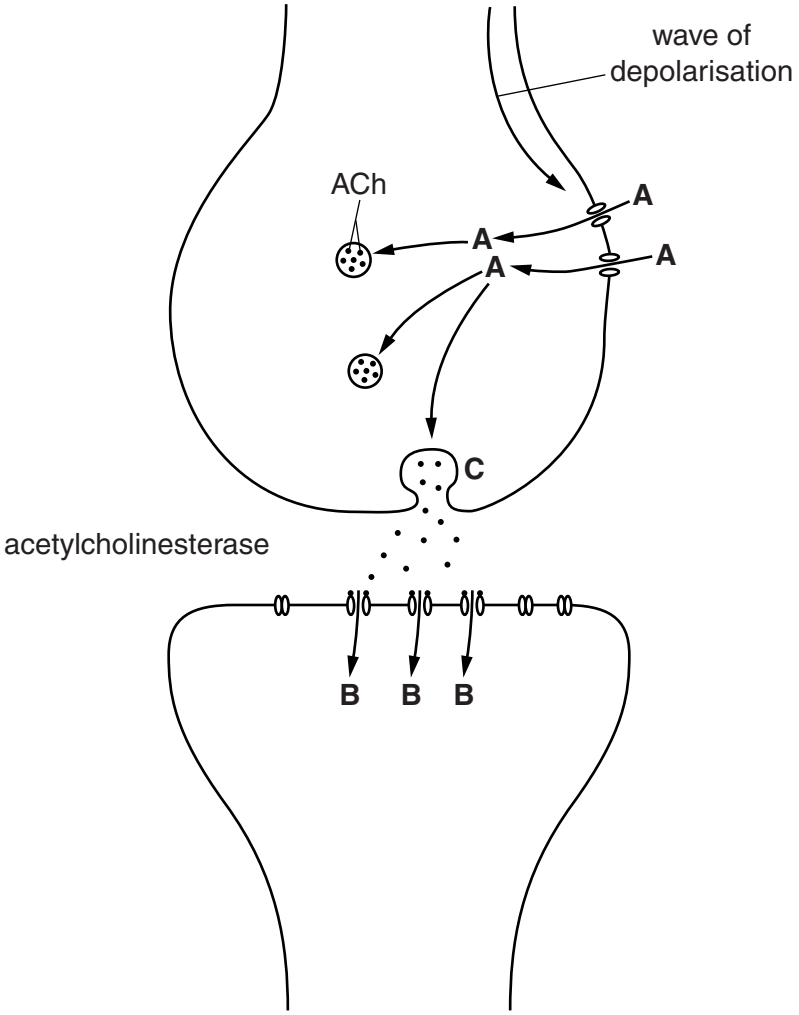


Fig. 6.1

With reference to Fig. 6.1:

(i) name **A** and **B**

A .....

B ..... [2]

(ii) name the process occurring at **C**

..... [1]

(iii) state the effect of **B** entering the post-synaptic neurone

..... [1]

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(iv) explain the role of acetylcholinesterase in the synapse.

For Examiner's Use

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..... [3]

(b) Some synapses in the brain use the neurotransmitter dopamine. After the postsynaptic membrane has been depolarised, dopamine leaves the receptor proteins and moves back into the presynaptic neurone through specific transporter proteins.

Schizophrenia is a condition in which there is a higher than usual concentration of dopamine in certain areas of the brain. The drug phenothiazine has a similar shape to dopamine and is used to treat schizophrenia.

Suggest and explain what occurs at the synapse when phenothiazine is used in the treatment of schizophrenia.

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..... [2]

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[Turn over

(c) DRD4 is a dopamine receptor in humans. The gene coding for the DRD4 receptor has a large number of alleles, of which an individual can have only two.

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Three alleles of the DRD4 receptor gene have the following mutations:

- a single base substitution
- a 21 base-pair deletion
- a 13 base-pair deletion.

The 13 base-pair deletion has the most serious consequences for the structure of the DRD4 receptor protein. Suggest why this is so.

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..... [3]

(d) One allele of the DRD4 gene has been found more frequently amongst individuals whose personality is described as 'impulsive and exploratory'.

Describe the mechanism whereby an allele such as this could have become common in the human population.

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..... [3]

[Total: 15]

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7 Coat colour in cats is determined by a sex-linked gene with two alleles coding for black and orange.

For Examiner's Use

When black cats are mated with orange cats:

- the female offspring are always tortoiseshell (black and orange patches)
- the male offspring are always the same colour as their mother.

(a) Explain what is meant by a *sex-linked gene*.

sex-linked .....

.....

gene .....

..... [2]

(b) Using the symbols **B** for the allele for black coat and **O** for the allele for orange coat, complete the genetic diagram below.

parental phenotypes	tortoiseshell female	black male
parental genotypes		
gametes		
offspring genotypes		
offspring phenotypes		

[4]

(c) Explain why a male cat cannot have a tortoiseshell coat.

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..... [2]

[Total: 8]

For Examiner's Use

8 Sarawak is an area of south-east Asia that is largely covered by tropical rainforest. Logging has been allowed in large parts of the forest. A study was carried out to estimate the population size of different species of mammals living in the rainforest:

- before logging
- immediately after logging
- two years after logging
- four years after logging.

Table 8.1 shows the results of the study for six species of mammal. Where numbers were too small to measure the population density, the species were recorded as "present".

Table 8.1

	mean number of animals km^{-2}			
mammal	**before logging**	**immediately after logging**	**two years after logging**	**four years after logging**
marbled cat	present	0	0	0
small-clawed otter	present	0	0	0
giant squirrel	5	1	4	1
treeshrew	10	5	10	38
small squirrel	16	24	104	19
barking deer	3	1	10	present

(a) Calculate the percentage rise in the small squirrel population from before logging to two years after logging.

Show your working.

answer ..... % [2]

(b) Suggest why populations, such as that of the small squirrel, do not increase in size indefinitely.

For Examiner's Use

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..... [4]

(c) Suggest why marbled cats and small-clawed otters became extinct in this area but the other mammals did not.

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..... [2]

[Total: 8]

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[Turn over

Section B

Answer **one** question.

For Examiner's Use

9 **(a)** Explain the need to maintain biodiversity in an ecosystem such as a tropical rainforest. [7]

(b) Discuss the advantages and the disadvantages of captive breeding programmes for mammals. [8]

[Total: 15]

10 **(a)** Explain how the physiology of the leaves of a C4 plant, such as maize, is adapted for efficient carbon fixation at high temperatures. [7]

(b) Describe how, in photosynthesis, light energy is converted into chemical energy, in the form of ATP. [8]

[Total: 15]

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