UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

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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.

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.

Section A

Answer **all** the questions.

For Examiner's Use

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

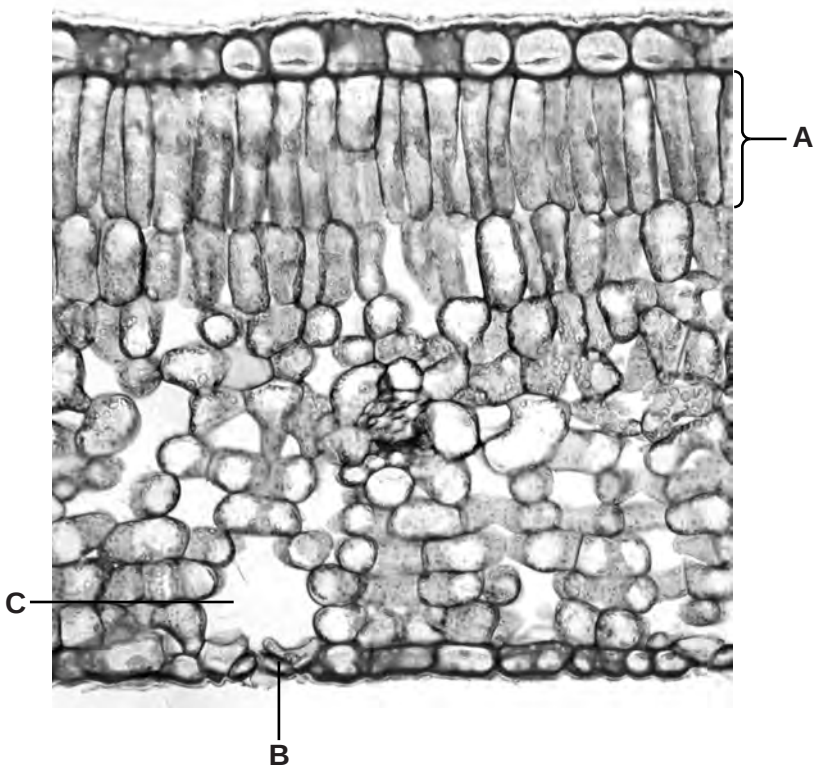

Fig. 1.1

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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(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

(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.

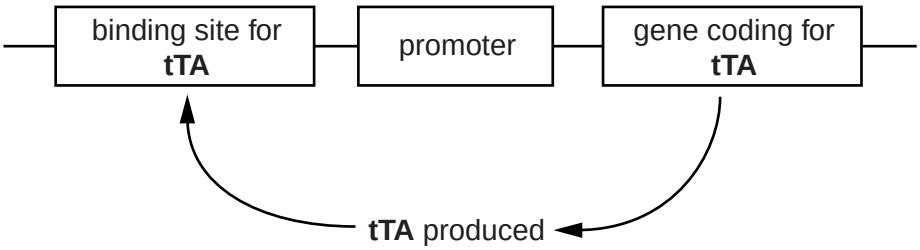

Fig. 2.1

(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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(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]

[Turn over

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.

For Examiner's Use

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

Show your working.

answer ..... [1]

[Total:7]

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.

For Examiner's Use

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.

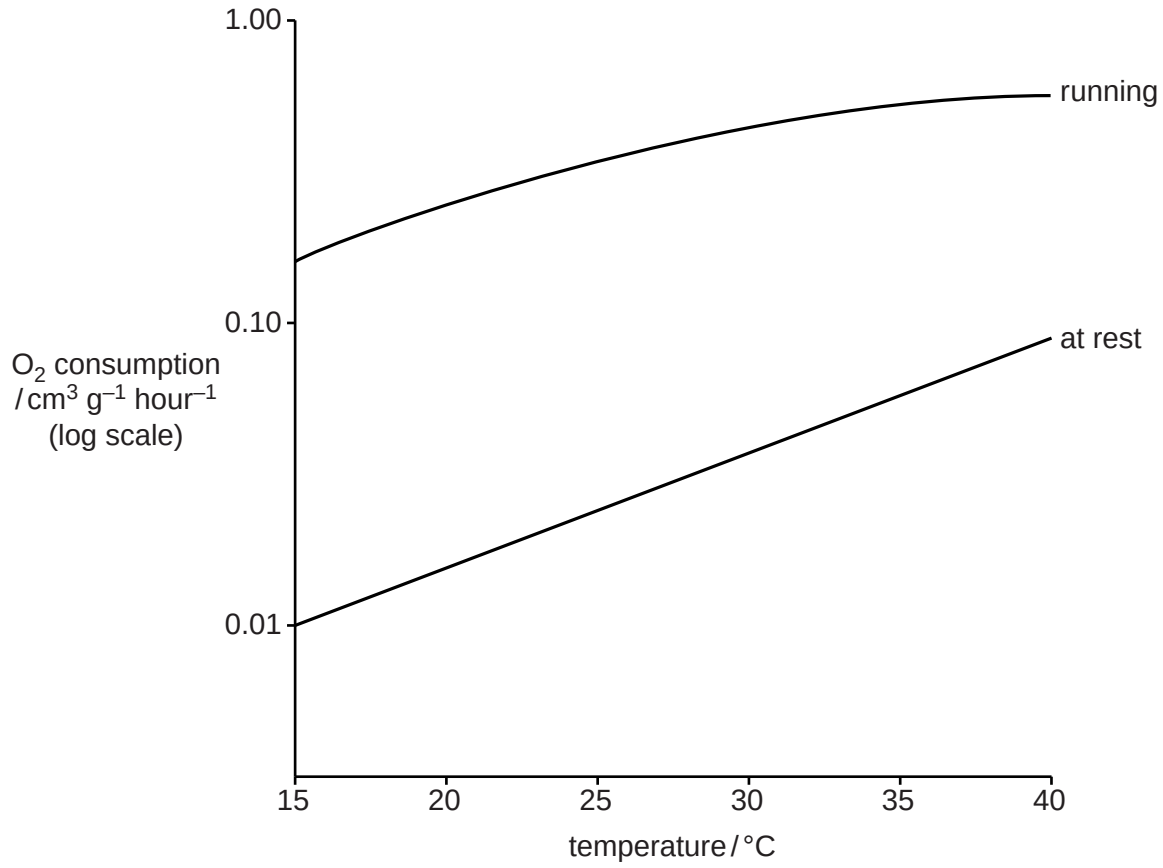

Fig. 4.1

(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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(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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(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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[Total: 17]

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.

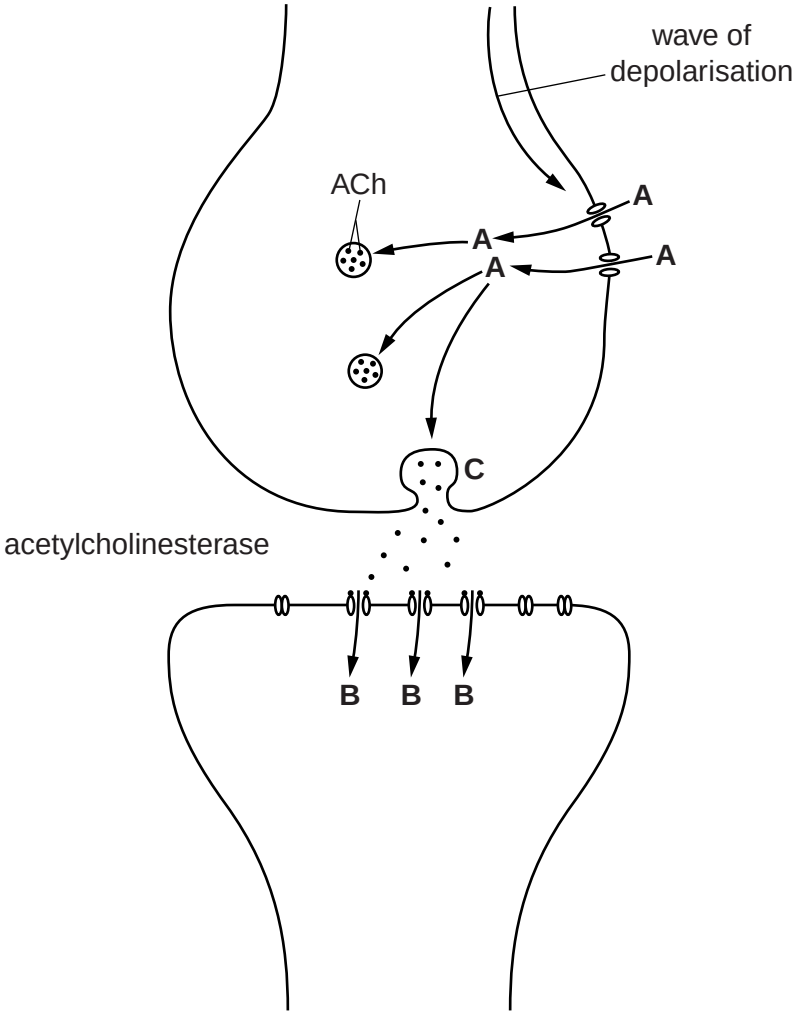

Fig. 6.1

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]

(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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[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.

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]

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 .....

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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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[Total: 8]

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]

[Turn over

Section B

For Examiner's Use

Answer **one** question.

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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For Examiner's Use

For Examiner's Use