UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER



**BIOLOGY** **9700/42**

Paper 4 A2 Structured Questions **May/June 2012**

**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.
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 **23** printed pages, **3** lined pages and **2** blank pages.

## Section A

Answer **all** the questions.

For Examiner's Use

**1** The seahorse, *Hippocampus,* is an unusual small fish. It gives birth to live young and it is the male rather than the female that becomes pregnant.

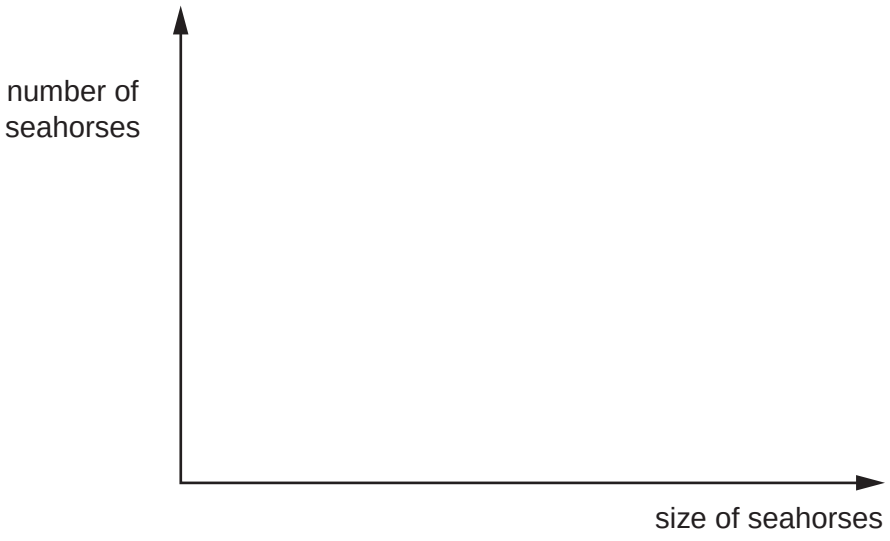
Fig. 1.1 shows a seahorse.

**Fig. 1.1**

**(a)** In one species of seahorse, a type of natural selection called disruptive selection occurs. This is where the extreme phenotypes are more likely to survive and reproduce than the intermediate phenotypes.

- Within a population, large females mate with large males and small females mate with small males.
- Few intermediate-sized individuals are produced and they have a low survival rate.

**(i)** Sketch a graph on the axes below to show the distribution in size of seahorses as a result of disruptive selection.




[2]

**(ii)** Explain how disruptive selection has been maintained in this species of seahorse.

*For Examiner's Use*

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**(iii)** State the term given to the type of selection where variation in a characteristic is maintained in its existing form over time.

.....[1]

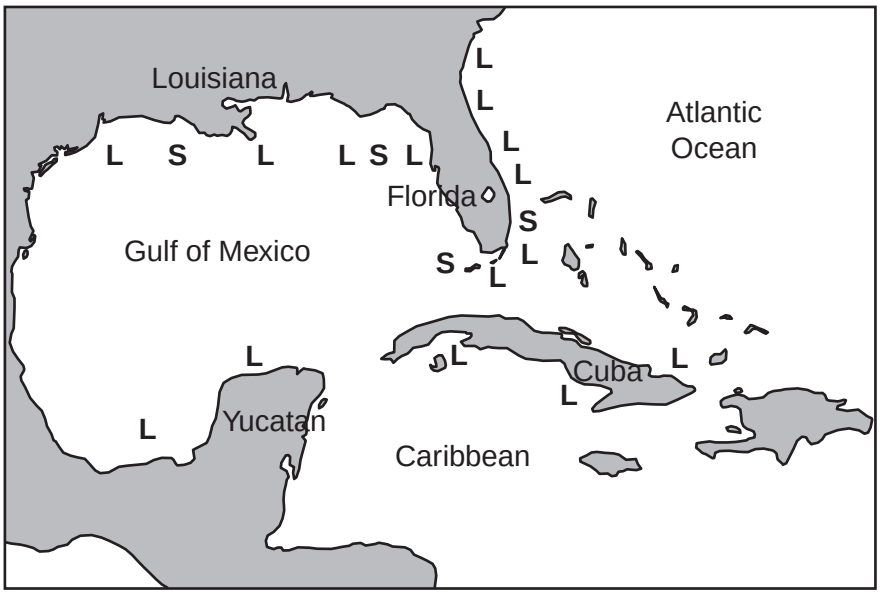




**[Turn over**

**(b)** Two different species of seahorse are found in the coastal waters shown in Fig. 1.2.

*For Examiner's Use*




**Key: L** = large seahorse *H. erectus* **S** = small seahorse *H. zosterae*

**Fig. 1.2**

Suggest how these two different species of *Hippocampus* could have arisen.

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.....[2]

[Total: 8]

**2** The bacterium, *Treponema pallidum*, causes the sexually-transmitted infectious disease, syphilis. If left untreated, the disease can be fatal, but early diagnosis can lead to successful treatment. One of the difficulties of diagnosing this disease in its early stages is the problem of recognising *T. pallidum* among the other species belonging to the genus *Treponema* that live in humans. These other treponemes are harmless.

*For Examiner's Use*

A mouse was injected with some cells of *T. pallidum*.

**(a)** Outline the steps that would then be necessary to produce a clone of hybridoma cells secreting an antibody against this bacterium.

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.....[4]

**(b)** A monoclonal antibody, H9-1, has been developed that is specific to a surface protein on *T. pallidum*, but which is not present on four other species of treponemes found in humans.

Each molecule of H9-1 carries a fluorescent yellow marker.

One of the first visible signs of syphilis is a painless sore.

Suggest how H9-1 is used in the diagnosis of syphilis, using a sample taken from a sore and placed on a microscope slide.

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**[Turn over**

**(c)** Before the development of H9-1, two tests for the presence of *T. pallidum* were commonly used:

- dark-field microscopy (in which treponemes could be seen moving against a dark background)
- testing for the presence of anti-treponemal antibodies in the blood plasma.

Suggest why, in the **early** stages of an infection, the presence of *T. pallidum* might not be detected by either of these tests.

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**(d)** The accuracy of the diagnosis of infection by *T. pallidum* using H9-1 was compared with that using dark-field microscopy and with blood testing. The results are shown in Table 2.1.

A positive test result indicated that *T. pallidum* is present and a negative test result that it is absent.

**Table 2.1**

| test | test results of 30 people later confirmed to have the infection | test results of 31 people later confirmed not to have the infection |
|---|---|---|
| H9-1 | all positive | all negative |
| dark-field microscopy | one negative | two positive |
| blood test | three negative | two positive |

With reference to Table 2.1:

*For Examiner's Use*

**(i)** compare the accuracy of diagnosis of the presence of *T. pallidum* using the different tests

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**(ii)** suggest why blood testing for anti-treponemal antibodies gave two positive results in patients later found not to have the infection.

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**(e)** Describe briefly **one** use of a monoclonal antibody in the **treatment** of disease.

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.....[2]

[Total: 15]

**3** In order to sequence the DNA of a gene, it is first denatured to separate its two strands.

Then, in the presence of a large supply of each of the four nucleotides, the single-stranded DNA is replicated by DNA polymerase.

**(a)** Explain what determines the sequence of nucleotides in the newly replicated strand of DNA.

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.....[2]

**(b)** A low concentration of specially prepared nucleotides is also present. Once added to the chain, these nucleotides do **not** allow the chain to continue growing.

Each special nucleotide is labelled with a fluorescent dye, using a different colour for each of the four bases.

Fig. 3.1 shows a replicated DNA chain ending with one of the special nucleotides.

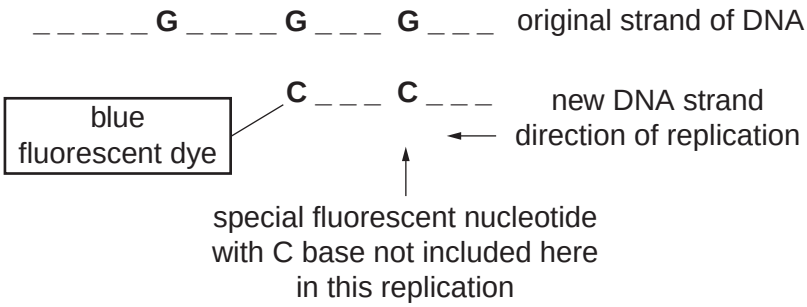


**Fig. 3.1**

With reference to Fig. 3.1 and to the information given, suggest why a special nucleotide with a C base was **not** included by DNA polymerase at the first site requiring a C nucleotide.

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.....[2]

**(c)** This method of sequencing a gene produces as many DNA fragments as there are nucleotides in the gene, each fragment differing in length by one nucleotide.

Fig. 3.2 shows part of a set of such fragments.

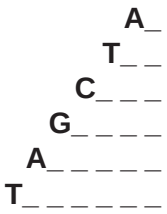


**Fig. 3.2**

These fragments are loaded onto a sequencing gel, shown in Fig. 3.3, and separated by electrophoresis.

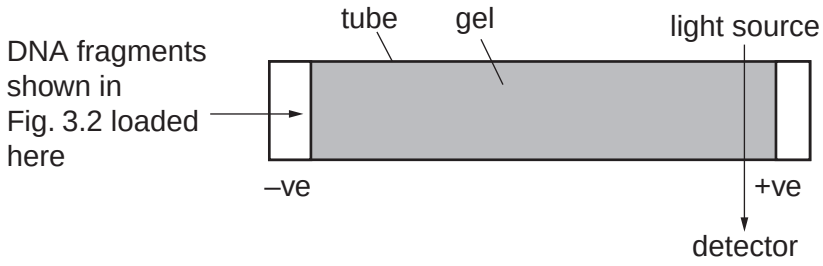


**Fig. 3.3**

**(i)** In what order will the fragments shown in Fig. 3.2 reach the light source and detector shown in Fig. 3.3?

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..... [1]

**(ii)** Explain how gel electrophoresis separates these fragments of DNA.

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..... [3]

[Total: 8]

**4** Golden Rice™ is a genetically modified form of rice that produces relatively large amounts of β carotene in the endosperm. β carotene is metabolised in the human body to produce vitamin A.

**(a)** Explain why rice has been genetically modified to produce extra β carotene.

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.....[2]

**(b)** The first types of Golden Rice™ produced only a very low mass of β carotene per gram of rice. Research continued to try to increase this.

Fig. 4.1 shows the metabolic pathway by which β carotene is synthesised in plants, and the enzymes that catalyse each step of the pathway.

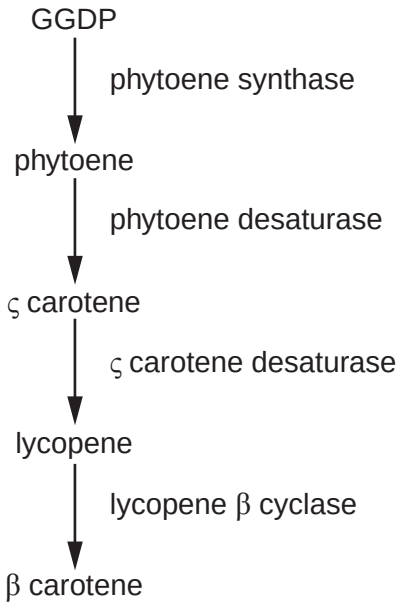


**Fig. 4.1**

The first types of Golden Rice™ contained a phytoene synthase gene, *psy*, from daffodils and a gene *crtI*, which produced the two desaturase enzymes, from the bacterium *Erwinia uredovora.*

Measurements of the quantities of intermediates in this metabolic pathway in rice endosperm showed that there was always a large amount of GGDP present, and that no phytoene accumulated in the tissues.

Explain how this suggests it was **not** the enzymes produced by the *crtI* gene that were limiting the production of β carotene.

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.....[2]

**(c)** Investigations were carried out to see if *psy* genes taken from species other than daffodils would enable rice endosperm to produce greater quantities of β carotene than the first types of Golden Rice™.

- *Psy* genes were isolated from the DNA of maize, tomatoes, peppers and daffodils. The genes were inserted into different plasmids.
- The promoter *Ubi* 1, and *crtI* genes from *E. uredovora*, were also inserted into all of the plasmids.
- The four types of genetically modified plasmids were then inserted into different cultures of rice cells.
- The quantity of β carotene produced by these rice cells was measured.

The results are shown in Table 4.1.

**Table 4.1**

| **source of *psy* gene** | **total β carotene content of rice cells / arbitrary units** |
|---|---|
| maize | 14 |
| pepper | 4 |
| tomato | 6 |
| daffodil | 1 |

**(i)** Name the type of enzyme that would have been used to cut the *psy* gene out of the DNA of the plant cells.

.....[1]

**(ii)** Explain why a promoter was inserted into the plasmids.

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.....[2]

**(iii)** Explain whether or not these results support the hypothesis that the *psy* gene, not the *crtI* gene, was limiting the production of β carotene in genetically modified rice.

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.....[2]

**(d)** The original choice of a *psy* gene from daffodils was made because daffodils produce large amounts of β carotene in their yellow petals, and because they are monocotyledonous plants, like rice.

Suggest explanations for the much lower production of β carotene in rice containing the *psy* gene from daffodils than in rice containing the *psy* gene from maize.

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.....[2]

**(e)** Describe the possible disadvantages of growing Golden Rice™.

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.....[3]

[Total: 14]

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**Question 5 starts on page 14**

**5** **(a)** Outline the biological basis of the effect of the contraceptive pill.

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..... [2]

**(b)** In Uganda, many children are infected with HIV from their mothers. This is called vertical HIV transmission.

Uganda has used two ways of trying to reduce vertical HIV transmission. These methods are

- to increase the use of antiretroviral drugs (ARVs) by HIV-infected pregnant women
- to reduce, through contraception, the numbers of unwanted pregnancies.

Table 5.1 shows the percentage reductions in the number of children born with HIV infections and the number of pregnancies in HIV-infected women, that were brought about as a result of the use of ARVs and contraception in 2007.

Table 5.1 also shows the predicted reductions in 2012 if usage of ARVs and contraception increase as expected.

**Table 5.1**

| | **percentage reduction caused** | | | |
|---|---|---|---|---|
| | **by use of ARVs** | | **by contraception** | |
| | in 2007 | predicted in 2012 | in 2007 | predicted in 2012 |
| pregnancies in HIV-infected women | 0 | 0 | 21.7 | 34.0 |
| births of HIV-infected children | 8.1 | 18.1 | 21.6 | 32.9 |

**(i)** It is estimated that if no ARVs had been used in 2007, 27 000 children would have been born with HIV infection.

Calculate the actual number of children born with HIV infection in 2007.

Show your working.

answer .....[2]

**(ii)** With reference to Table 5.1, explain the difference between the effects of ARVs and contraception on the numbers of pregnancies in HIV-infected women.

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.....[2]

**(iii)** There is only a limited amount of money to spend on HIV prevention in Uganda.

With reference to Table 5.1, suggest arguments for spending at least as much money on increasing access to contraception as on providing ARVs to HIV-infected pregnant women.

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.....[3]

[Total: 9]





**[Turn over**

*For Examiner's Use*

**6** **(a)** The Millennium Seed Bank is located in the UK. So far it has successfully stored seeds from 10% of the world's wild plant species.

**(i)** Suggest the benefits to humans of conserving plant species.

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.....[3]

**(ii)** In the wild, seeds may be subjected to conditions that can be hostile to successful germination and growth.

Suggest how the seeds should be stored in the seed bank to keep them viable for future use.

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.....[1]

**(b)** Plant biodiversity varies throughout the world and is dependent on many factors, particularly climate.

*For Examiner's Use*

Fig. 6.1 shows the relationship between the number of plant genera and the mean annual rainfall in seven countries.

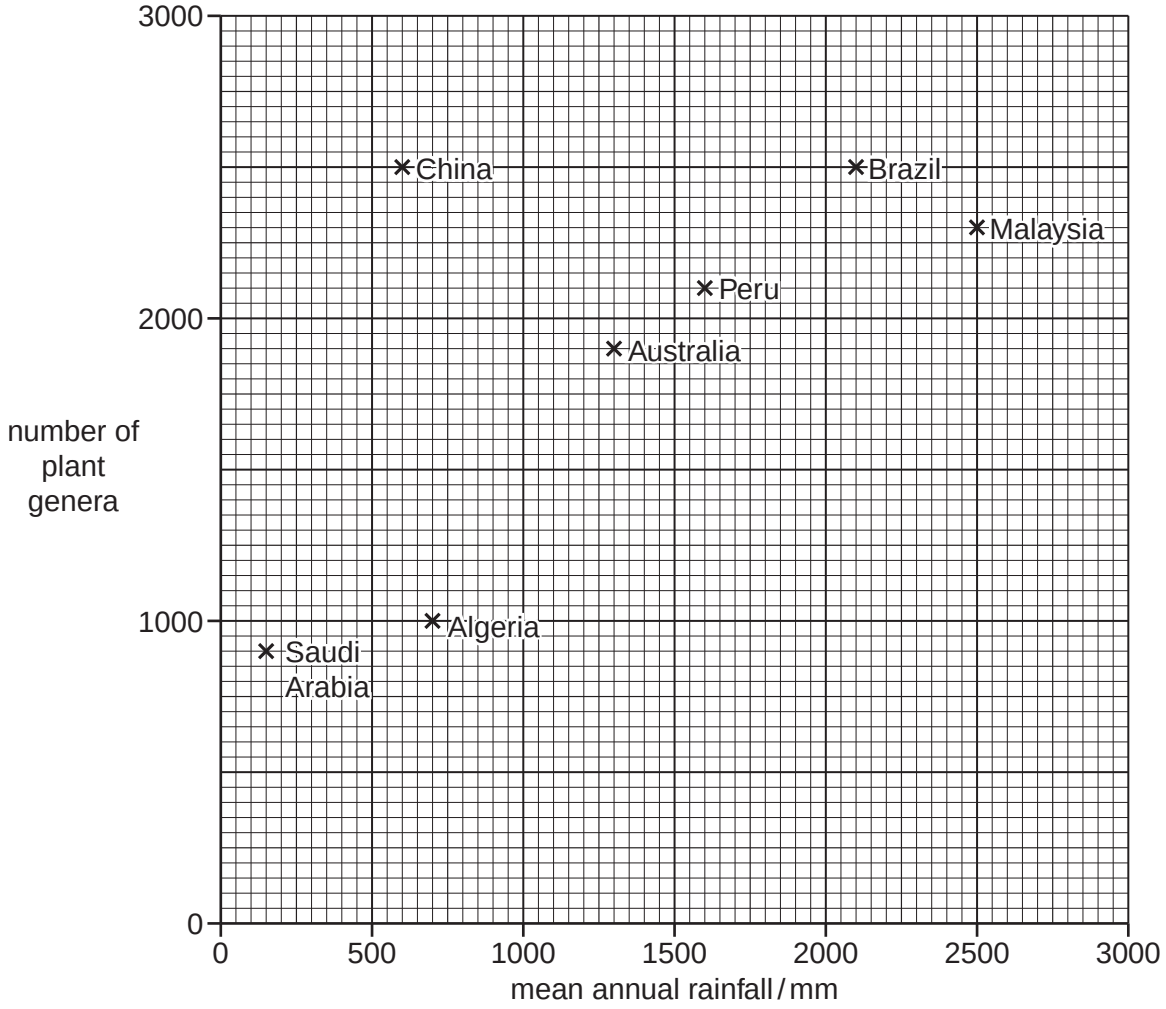


**Fig. 6.1**

**(i)** Describe the relationship between the number of plant genera and the mean annual rainfall in these seven countries.

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.....[2]

**(ii)** Suggest what other climatic factors, apart from rainfall, affect plant biodiversity.

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.....[2]

[Total: 8]

**7** **(a)** Explain what is meant by the term *heterozygous genotype*.

*heterozygous* .....

.....

*genotype* .....

.....[2]

**(b)** The budgerigar, *Melopsittacus undulatus*, is a small type of parrot that is native to Australia.

Fig. 7.1 shows a budgerigar.

**Fig. 7.1**

A budgerigar can have blue, green, yellow or white feathers.

Two genes, **A**/**a** and **D**/**d**, are involved in the inheritance of feather colour in budgerigars.

- A bird which has at least one dominant allele **A** but is homozygous for **d** has blue feathers.
- A bird which has at least one dominant allele **D** but is homozygous for **a** has yellow feathers.
- A bird with at least one dominant **A** allele **and** one dominant **D** allele has green feathers.
- A bird that is homozygous for **a** and **d** has white feathers.

**(c)** Two green-feathered budgerigars, heterozygous at both gene loci, were crossed.

Draw a genetic diagram of this cross to show the probability of producing offspring with yellow feathers.

*For Examiner's Use*

[6]

[Total: 8]

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**Question 8 starts on page 21**

**8** Fig. 8.1 shows a diagram of a stoma, its guard cells and adjacent epidermal cells.

*For Examiner's Use*

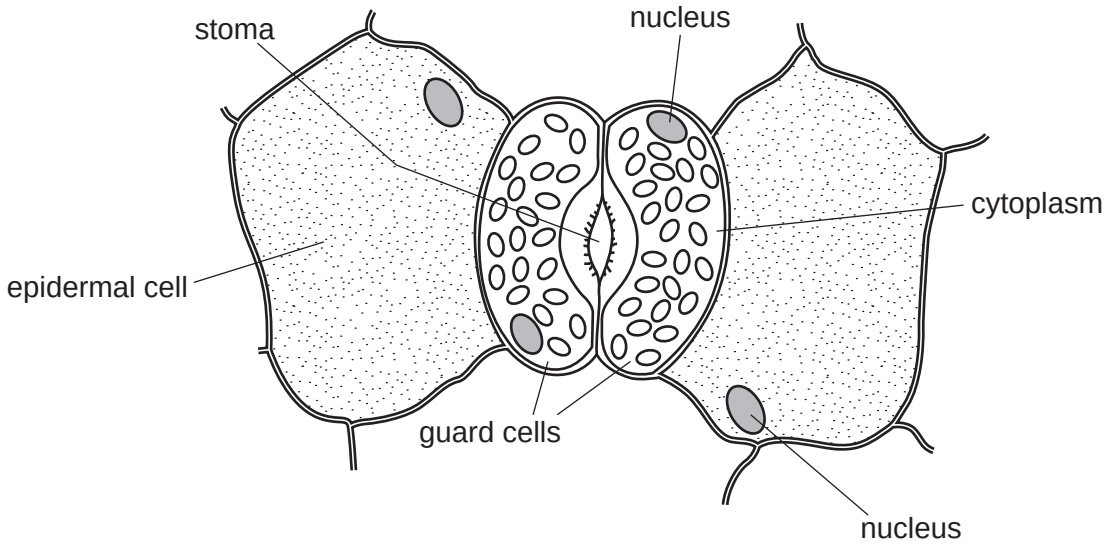


**Fig. 8.1**

**(a)** Guard cells have chloroplasts while epidermal cells do not have chloroplasts.

State **one other** difference, visible in Fig. 8.1, between guard cells and epidermal cells.

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.....[1]

**(b)** During stomatal closure:

**(i)** state precisely where abscisic acid (ABA) binds

.....[1]

**(ii)** identify the ion that diffuses from the guard cells to epidermal cells

.....[1]

**(iii)** compare the relative water potential of the guard cells with that of epidermal cells

.....[1]

**(iv)** describe the change in volume of the guard cells.

.....[1]

**(c)** The following experiment was carried out to investigate the effect of light intensity on the rate of photosynthesis of a water plant, *Elodea.*

*For Examiner's Use*

- *Elodea* was cut into three pieces, each 10 cm long.
- Each piece of *Elodea* was placed in a glass tube, containing 0.5% sodium hydrogencarbonate solution, which was then sealed with a bung.
- Tube **A** was placed 10 cm away from a lamp.
- Tube **B** was placed 5 cm away from a lamp.
- Tube **C** was placed in a dark room.
- An oxygen sensor was used to measure the percentage of oxygen in the solutions at the start of the experiment and again at 5, 10 and 20 minutes.

The results are shown in Fig. 8.2.

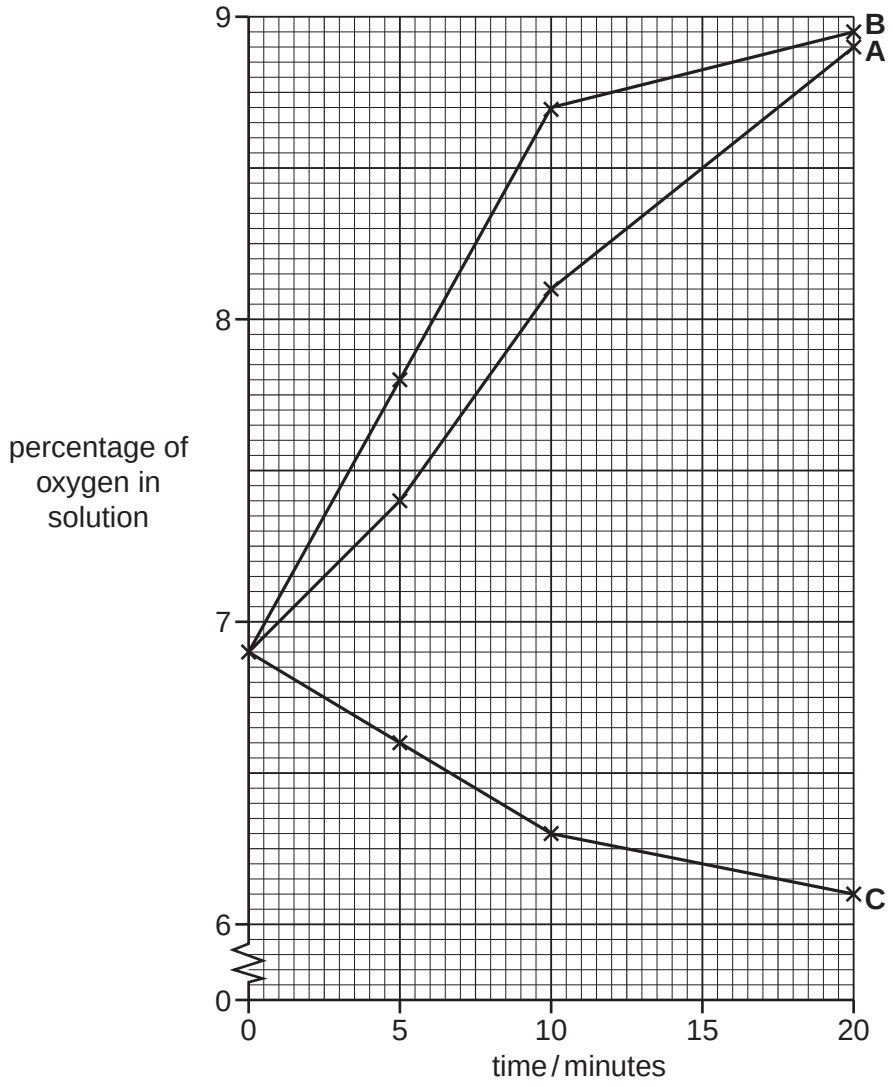


**Fig. 8.2**

**(i)** State why sodium hydrogencarbonate solution was used.

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.....[1]

**(ii)** Calculate the mean rate of oxygen production for tube **A** for the 20 minutes of the experiment.

Show your working.

answer .....[2]

**(iii)** Compare the results for tubes **A** and **B**.

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.....[2]

**(iv)** Explain the results for tube **C**.

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.....[2]

**(v)** Suggest what factor, which may have an effect on the rate of photosynthesis, was **not** taken into account in this experiment.

.....[1]





**[Turn over**

**(d)** Fig. 8.3 shows the relationship between the light-dependent and light-independent reactions in a chloroplast.

*For Examiner's Use*

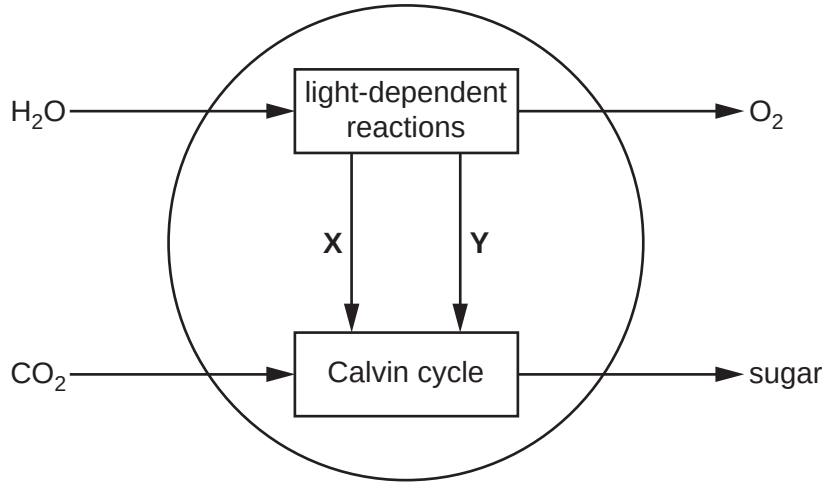


**Fig. 8.3**

Name the substances **X** and **Y** in Fig. 8.3.

**X** .....

**Y** ..... [2]

[Total: 15]

## Section B

Answer **one** question.

*For Examiner's Use*

**9** **(a)** Explain the role of ATP in active transport of ions **and** in named anabolic reactions. [7]

**(b)** Outline the process of anaerobic respiration in both mammal and yeast cells. [8]

[Total: 15]

**10** **(a)** Outline, with reference to blood glucose concentration, the principles of homeostasis in mammals. [6]

**(b)** Describe the roles of the endocrine and nervous systems in control and coordination in mammals. [9]

[Total: 15]

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For Examiner's Use

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