Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3500389226

BIOLOGY **9700/43**

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

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions.

Section B
Answer **one** question.

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

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

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

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Section A

Answer **all** questions.

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

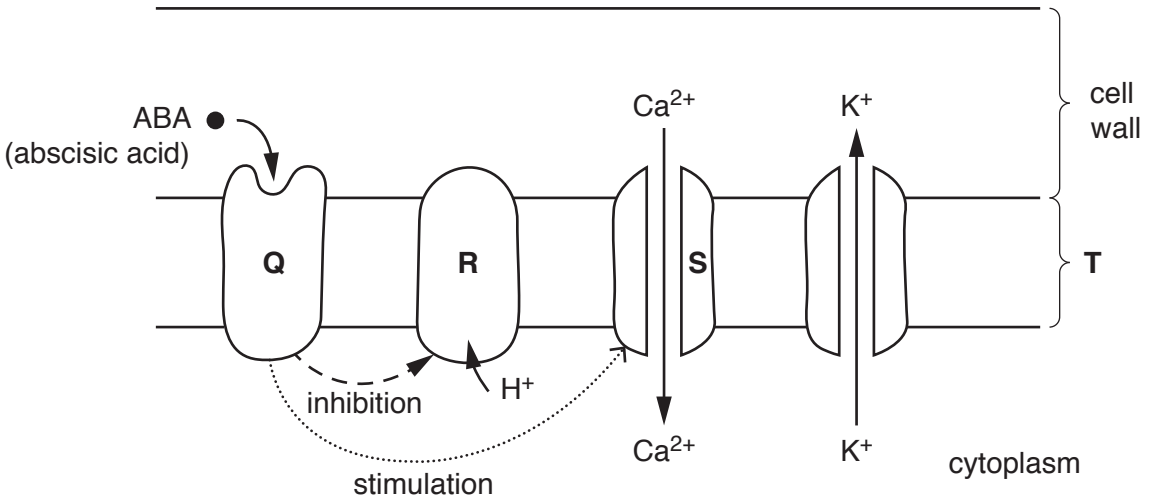


Fig. 1.1

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

..... [1]

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

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

R.....

S..... [2]

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

..... [1]

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

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..... [5]

[Total: 9]

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

Fig. 2.1 shows 6 of these chromosomes.

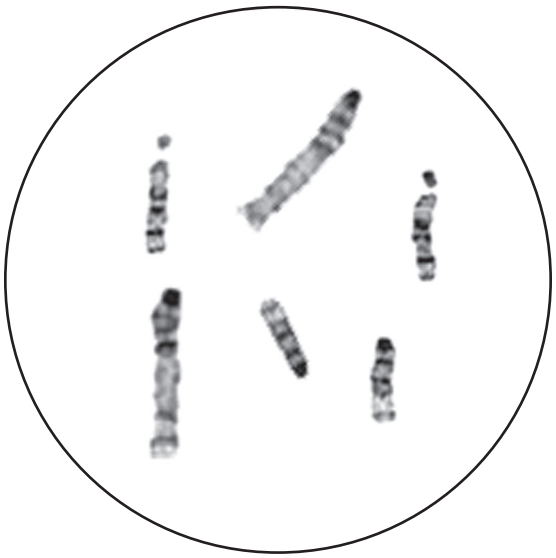


Fig. 2.1

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

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

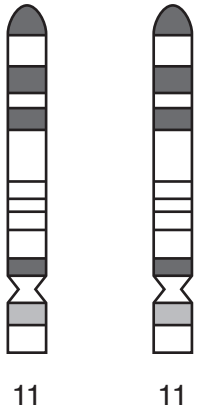


Fig. 2.2

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

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..... [3]

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

..... [1]

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

There is random fusion of gametes at fertilisation.

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

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..... [2]

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

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..... [2]

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

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

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..... [2]

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

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

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

parental genotypes

gametes

offspring genotypes

offspring phenotypes

[3]

[Total: 14]

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

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

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

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

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

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

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

Show your working.

..... % [2]

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

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

(b) Name the type of enzyme that:

- cuts plasmid DNA

  .....

- makes cDNA from hGH mRNA.

  ..... [2]

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

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..... [2]

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

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

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..... [4]

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

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

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

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

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

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A summary of the results is shown in Table 3.1.

Table 3.1

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

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

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..... [1]

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

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..... [2]

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

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..... [2]

[Total: 15]

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

A Magellanic penguin is shown in Fig. 4.1.



Fig. 4.1

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

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

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..... [2]

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

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

..... [1]

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

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

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..... [2]

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

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

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

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..... [1]

[Total: 6]

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[Turn over

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

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

The features in which they differ are:

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

Table 5.1

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

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

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

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

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..... [2]

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

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

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..... [2]

[Total: 9]

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[Turn over

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

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

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

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

..... [1]

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

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..... [3]

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

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

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

The results are shown in Fig. 6.1.

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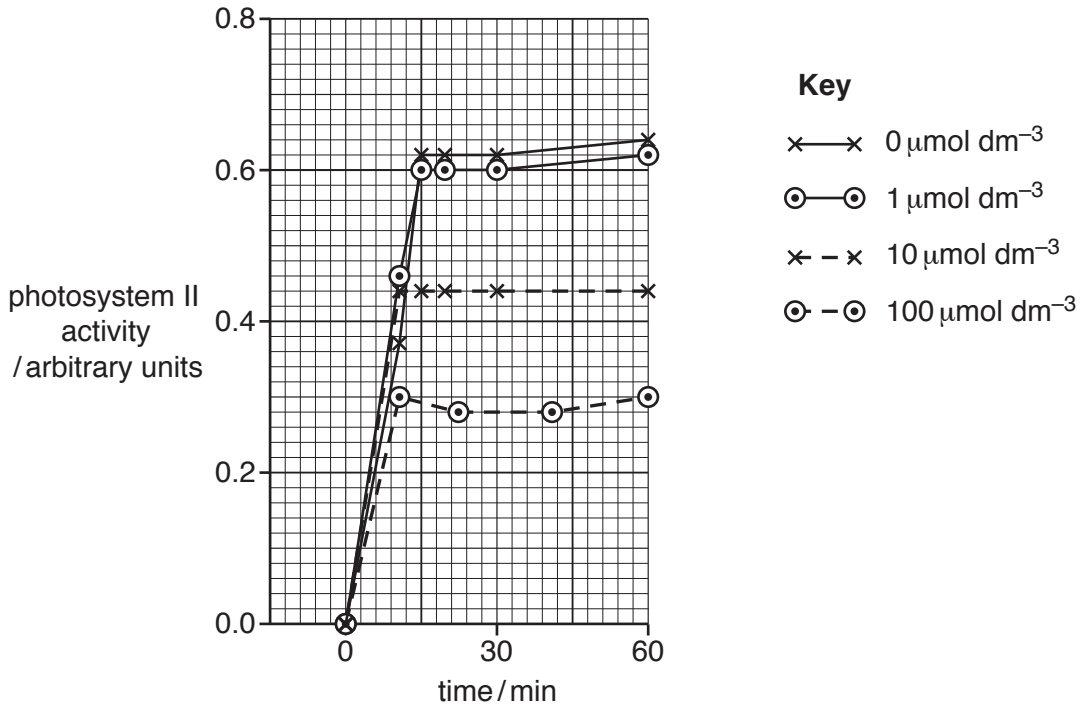


Fig. 6.1

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

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..... [2]

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

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

The results are shown in Table 6.1.

Table 6.1

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

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

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..... [4]

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

Suggest how copper ions change the structure of chlorophyll a.

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..... [1]

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

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

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..... [4]

[Total: 15]

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

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

The results are shown in Fig. 7.1.

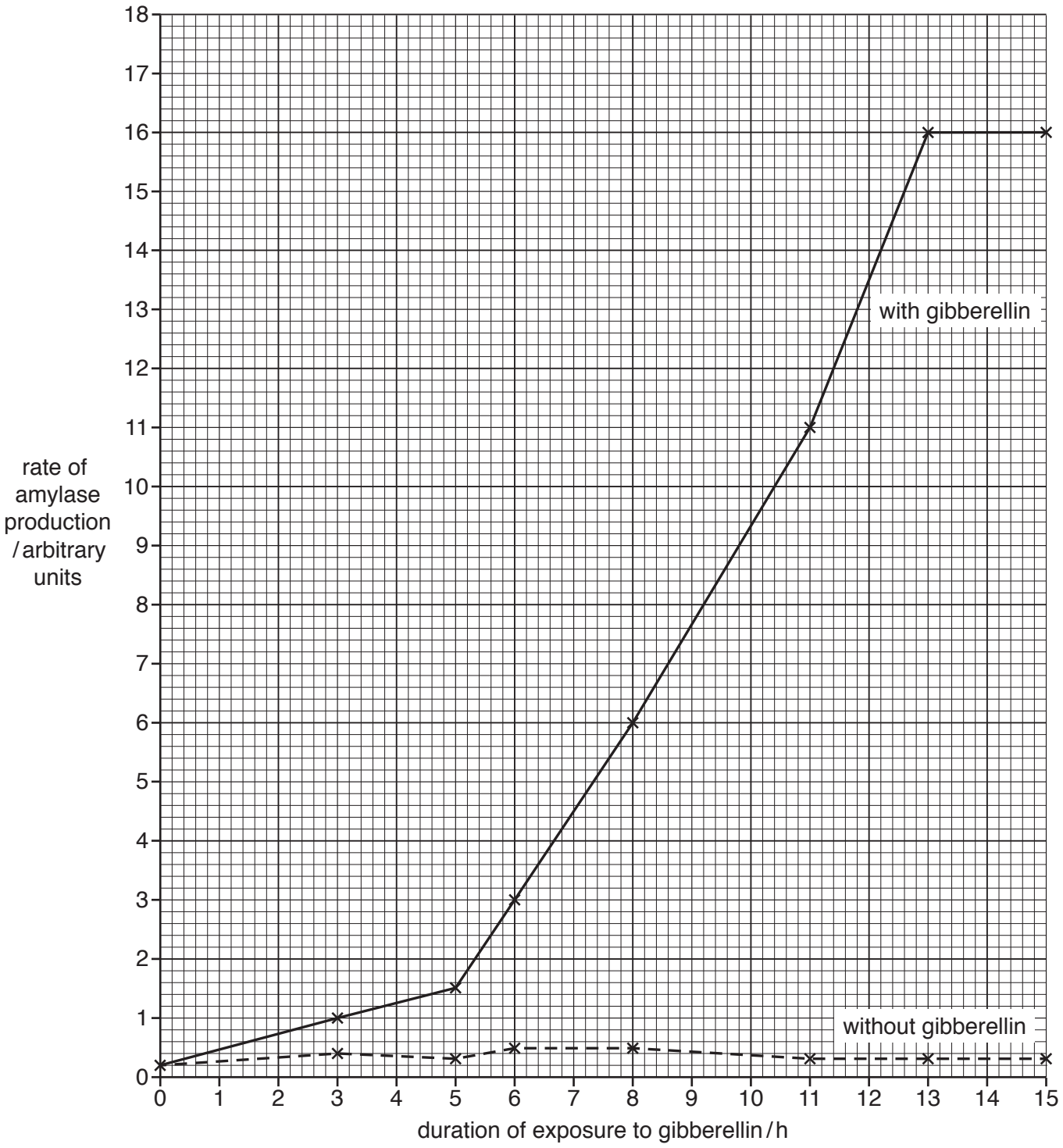


Fig. 7.1

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Describe the results shown in Fig. 7.1.

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..... [3]

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

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..... [3]

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

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

..... [1]

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

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..... [2]

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[Turn over

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

Suggest the effects of the expression of these growth genes.

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..... [2]

[Total: 11]

8 The passage below outlines the structure of the mitochondrion.

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

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

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

..... .

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

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

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

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

[6]

Section B

Answer **one** question.

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

Describe the features of viruses. [8]

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

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

[Total: 15]

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

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

[Total: 15]

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