Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8811534614

BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **February/March 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 **32** printed pages.

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Section A

Answer **all** questions.

1 **(a)** The effect of light intensity on the rate of photosynthesis can be investigated using a cut shoot of a pond plant.

The apparatus used in the investigation is shown in Fig. 1.1.

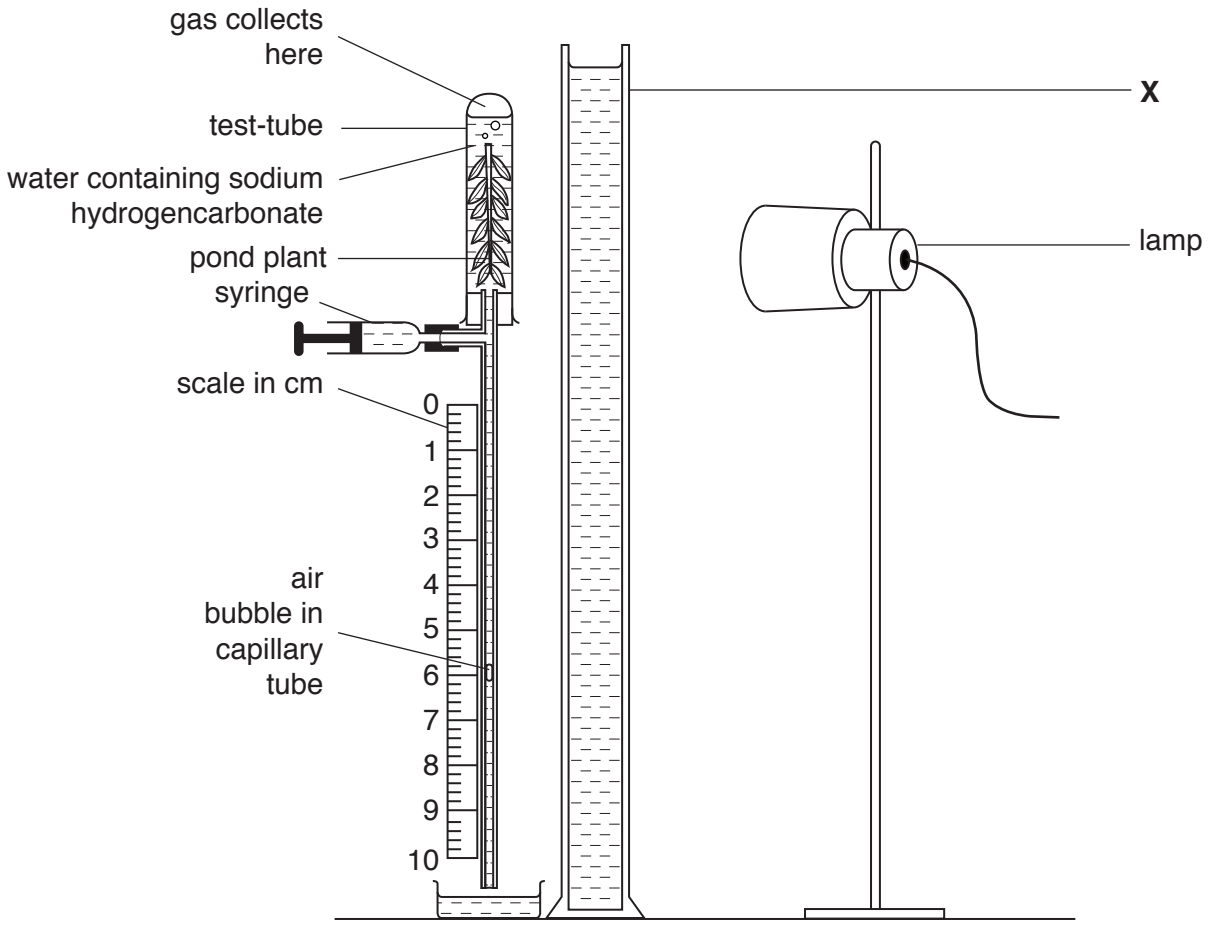


Fig. 1.1

The light intensity can be changed by placing the lamp at different distances from the pond plant.

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(i) Apparatus **X**, shown in Fig. 1.1, is a thin glass container filled with water.

Explain the function of apparatus **X**.

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..... [2]

(ii) Before completing the assembly of the apparatus shown in Fig. 1.1, sodium hydrogencarbonate is added to the water surrounding the pond plant in the test-tube.

Explain why sodium hydrogencarbonate is added to the water surrounding the pond plant in the test-tube.

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..... [1]

(iii) Name the gas collected in the test-tube.

..... [1]

(b) The investigation was carried out with the lamp at distances of 10, 20, 30, 40 and 50 cm from the pond plant. For each of these distances, the air bubble in the capillary tube was initially positioned at 0 cm on the scale and, after 5 minutes, the distance moved by the air bubble was measured. The rate of movement of the air bubble was then calculated.

The results are shown in Fig. 1.2.

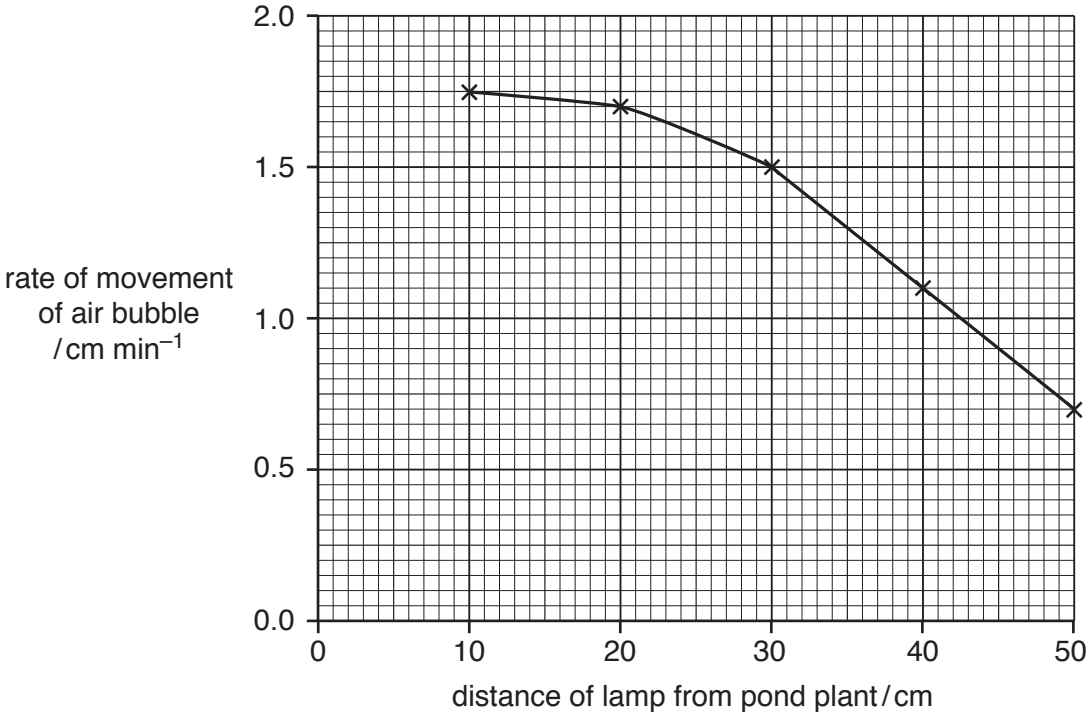


Fig. 1.2

(i) With reference to Fig. 1.2, describe the relationship between the rate of photosynthesis and **light intensity**.

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..... [2]

(ii) Further investigations showed that at distances of less than 10 cm, the rate of movement of the air bubble was the same as at 10 cm.

Explain why there was no change in the rate of movement of the air bubble at distances less than 10 cm.

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..... [2]

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(c) Some of the light energy absorbed by the pond plant is used in cyclic photophosphorylation.

Outline the process of cyclic photophosphorylation.

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..... [5]

[Total: 13]

2 **(a)** The hormone glucagon is an example of a cell signalling molecule. Table 2.1 lists the main events that occur when the blood glucose concentration decreases below the set point.

The events are **not** listed in the correct order.

Table 2.1

event	description of event
A	adenylyl cyclase enzyme is activated
B	cyclic AMP activates an enzyme cascade
C	glycogen stored in liver cells is broken down to glucose
D	blood glucose concentration increases
E	glucagon is secreted by α cells in the pancreas
F	conformational change to glucagon receptor causes G-protein activation
G	active adenylyl cyclase acts on ATP to produce second messenger
H	glucagon signal is amplified
I	glucose diffuses out of liver cells through GLUT transporter proteins
J	glucagon binds to receptors in the cell surface membranes of liver cells
K	cyclic AMP is formed

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Complete Table 2.2 to show the correct order in which these events occur.

Three of the events have already been placed in their correct order.

Table 2.2

correct order	letter of event
1	E
2	
3	
4	
5	
6	K
7	
8	
9	
10	
11	D

[4]

(b) An investigation was carried out to measure the rate at which glucose is provided for respiration from three different sources of glucose:

- a meal
- glycogenolysis – the breakdown of glycogen
- gluconeogenesis – production of glucose from non-carbohydrate molecules.

After a person ate a meal, the rates at which glucose was provided for respiration from the three different sources were measured at regular intervals over a 24-hour period. During this period, no food was eaten.

Fig. 2.1 shows the results of this investigation.

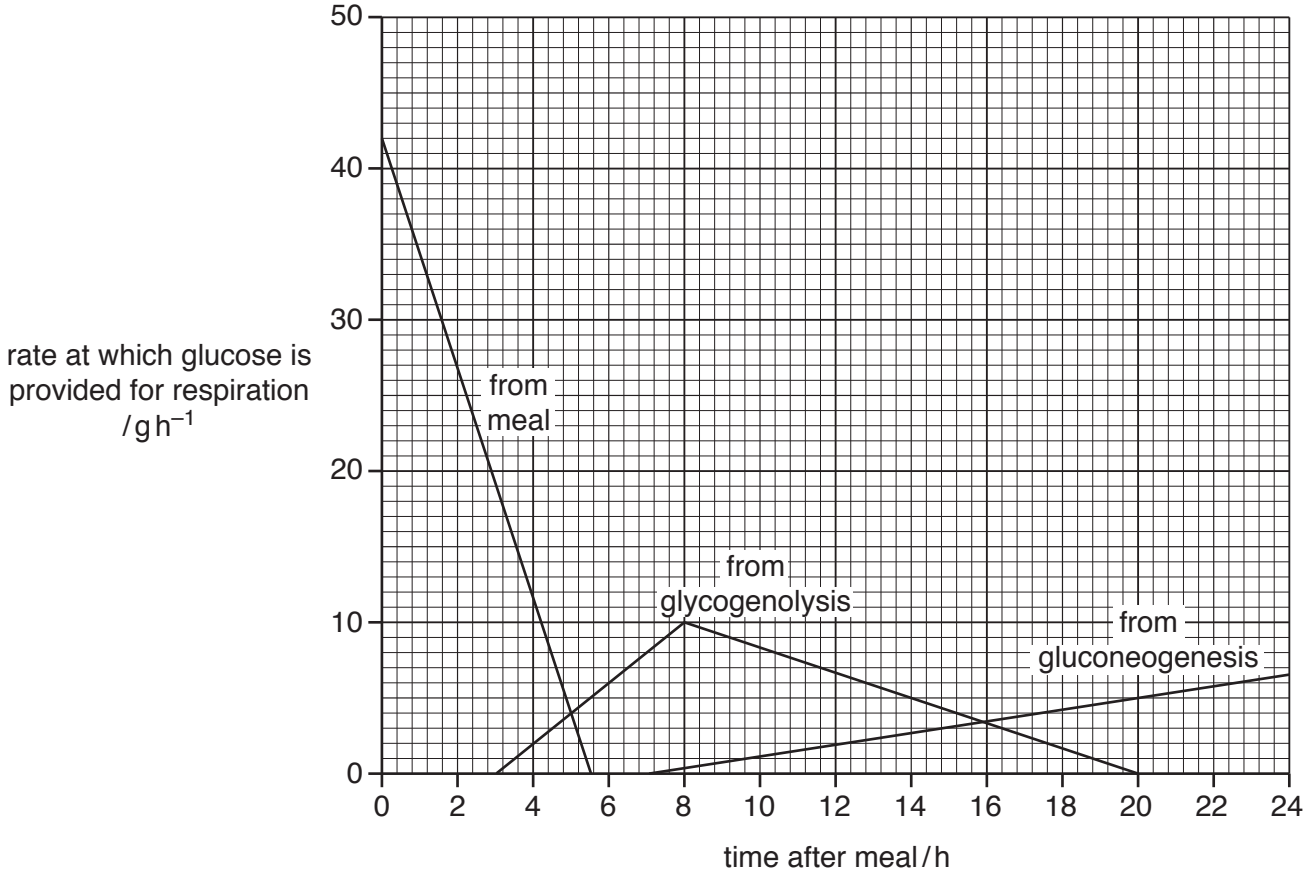


Fig. 2.1

(i) State the time after the meal when the rate at which glucose was provided from the meal for respiration was the same as the rate at which glucose was provided from glycogenolysis for respiration.

..... [1]

(ii) State the first time after the meal when **all** of the glucose for respiration was provided by gluconeogenesis.

..... [1]

(iii) Name the homeostatic mechanism by which blood glucose concentration is maintained at a set point.

..... [1]

(iv) In humans, carbohydrates such as glucose are not the only respiratory substrates.

Name **two** non-carbohydrate respiratory substrates in humans.

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..... [2]

[Total: 9]

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[Turn over

3 During an immune response, only B-lymphocytes with receptors that are specific to the antigens present are activated. Activation occurs when an antigen binds to a receptor of a B-lymphocyte.

Activated B-lymphocytes grow in size and then divide by mitosis. Many further mitotic cell divisions occur, increasing the number of B-lymphocytes with receptors specific to the antigen. Eventually, cells produced in this process will develop into either plasma cells that secrete antibodies or memory B-cells.

Fig. 3.1 is a summary of B-lymphocyte activation and the events that follow.

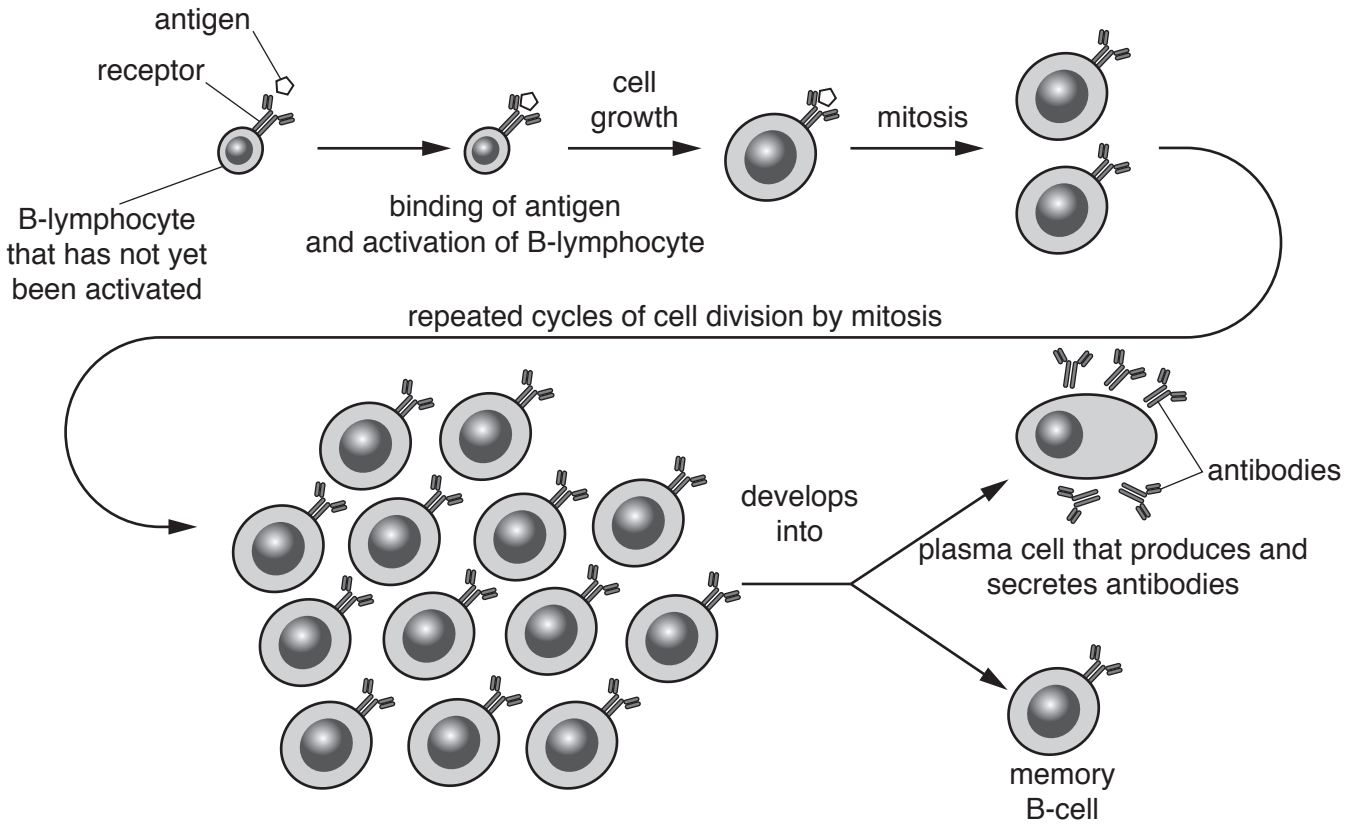


Fig. 3.1

The development of plasma cells and memory B-cells in this process depends on transcription factors.

(a) Explain the role of transcription factors in gene expression in eukaryotic cells.

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(b) Transcription factors are proteins. Genes that code for proteins can become mutated.

Describe how different types of gene mutation can cause changes in the protein that is synthesised.

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(c) BLIMP-1 is a transcription factor that is essential for the development of plasma cells and memory B-cells in the process shown in Fig. 3.1. BLIMP-1 reduces the synthesis of c-Myc in B-lymphocytes. c-Myc is a protein that is required for the mitotic cell cycle to continue.

Suggest **and** explain how a mutation in the gene coding for BLIMP-1 can prevent the development of plasma cells and memory B-cells.

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.....[3]

(d) Microarrays can be used to analyse the effect of transcription factors, such as BLIMP-1, on gene expression.

(i) Describe how a microarray is used in the study of gene expression.

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..... [4]

(ii) BCL6 is another transcription factor found in B-lymphocytes. The effect of BCL6 on gene expression was compared in two samples of B-lymphocytes.

- Sample 1 consisted of B-lymphocytes that were producing BCL6.
- Sample 2 consisted of B-lymphocytes that were **not** producing BCL6.

Suggest why a microarray is suitable for identifying the function of the transcription factor BCL6 in these two samples.

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..... [2]

[Total: 17]

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Question 4 starts on page 14

4 Mexican spadefoot toads, *Spea multiplicata*, live on land but return to ponds to breed. Eggs are laid in water and hatch into tadpoles, which feed in ponds before developing into adults.

The tadpoles can be classified into two main types: omnivore-type tadpoles and carnivore-type tadpoles. Differences between the phenotypes of these two types of tadpole are related to their different feeding behaviours.

- Omnivore-type tadpoles feed on tiny pieces of detritus (dead material from plants and animals) and algae (microscopic photosynthetic organisms) at the bottom of ponds. These tadpoles grow slowly.
- Carnivore-type tadpoles feed on small animals in the water, such as fairy shrimp and small omnivore tadpoles. These tadpoles grow quickly.

Fig. 4.1 shows two tadpoles of the same age, one of each type. A fairy shrimp is also shown. All three organisms are at the same distance from the camera.



Fig. 4.1

Between these two main types of tadpole there is a continuous range of tadpoles with intermediate body phenotypes and feeding behaviours.

For any individual tadpole, regardless of age, it is possible to calculate a phenotype score depending on the features of the tadpole. A tadpole with a phenotype score close to 3 is a typical omnivore type and a tadpole with a phenotype score close to 7 is a typical carnivore type.

The phenotype scores were determined for a large number of tadpoles sampled from two ponds. The availability of detritus and algae was high for one pond and low for the other pond. All other conditions in the two ponds were similar.

For both ponds, phenotype scores were determined shortly after the tadpoles had hatched from eggs and ten days later.

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The results are shown in Fig. 4.2.

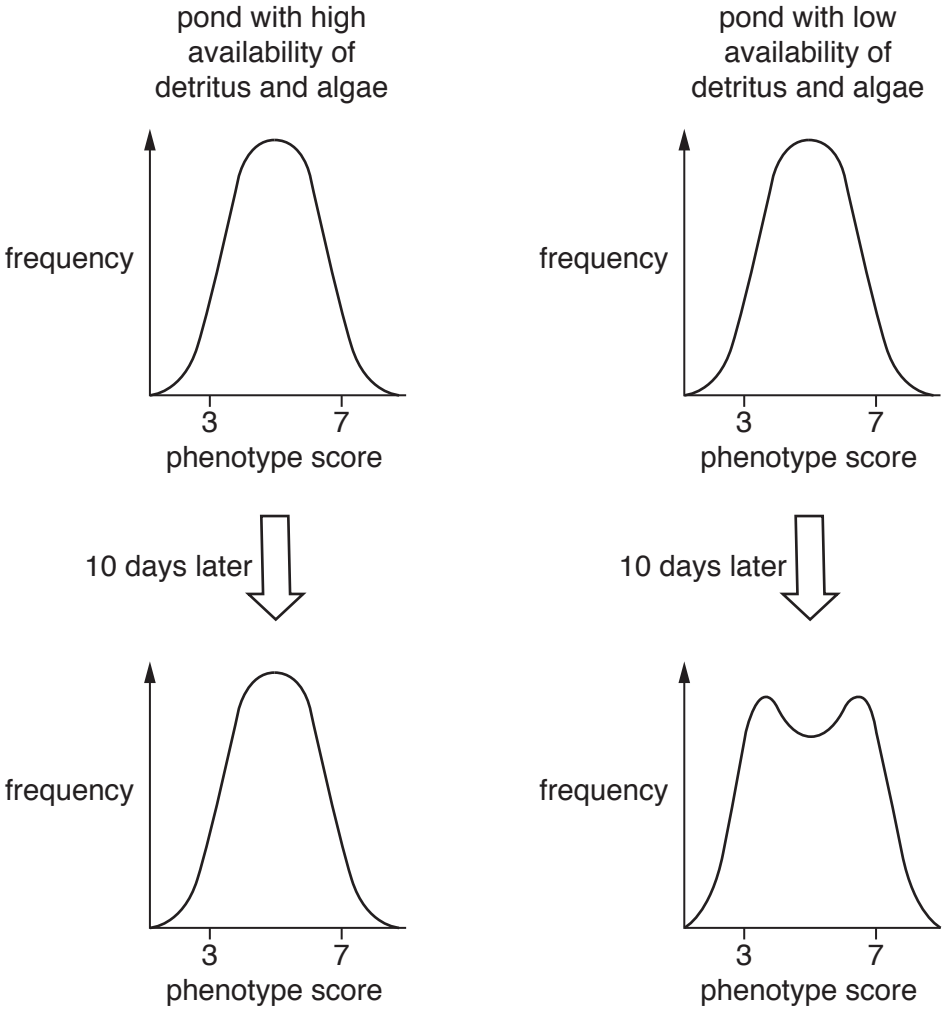


Fig. 4.2

(a) Using the results shown in Fig. 4.2, describe **and** suggest an explanation for the change in frequency of tadpole phenotypes in the pond with **low** availability of detritus and algae.

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..... [4]

(b) Eleven days after eggs had hatched, the mean body masses of omnivore-type tadpoles and carnivore-type tadpoles in the pond with low availability of detritus and algae were measured. The results are shown in Fig. 4.3.

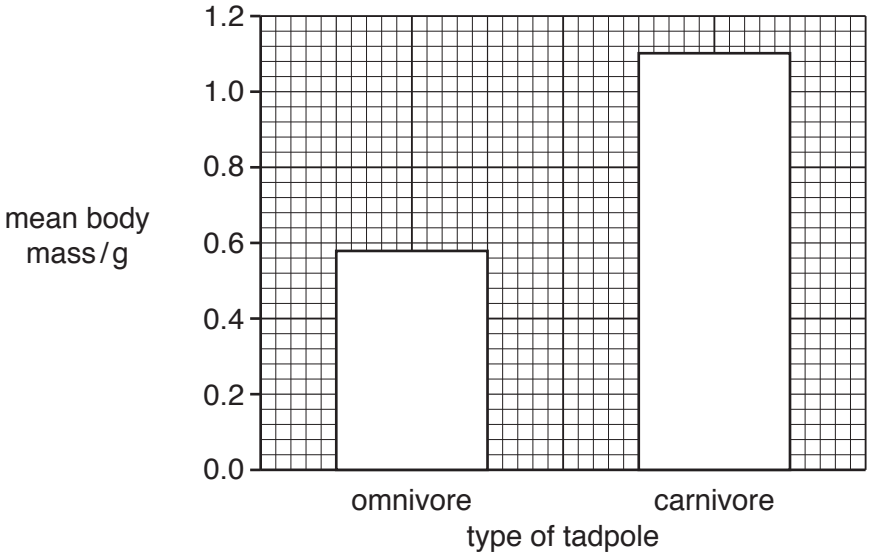


Fig. 4.3

Using the data in Fig. 4.3, calculate the mean body mass of an omnivore-type tadpole as a percentage of the mean body mass of a carnivore-type tadpole.

Show your working.

percentage = ...%
[2]

(c) The phenotype scores of a large number of tadpoles were determined in a different pond with **very low** availability of detritus and algae. All other conditions were the same as the first two ponds. As previously, measurements were taken shortly after the eggs hatched and ten days later. After ten days, nearly all of the Mexican spadefoot toad tadpoles in this pond were carnivore types.

The results are shown in Fig. 4.4.

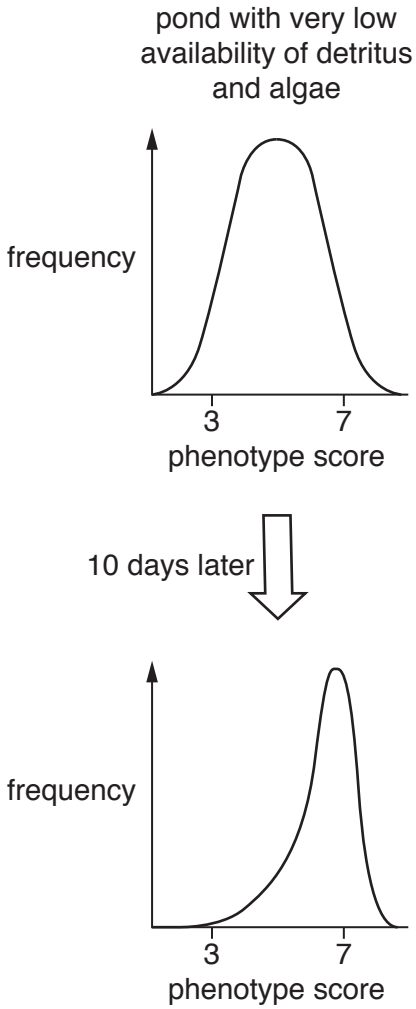


Fig. 4.4

(i) State the type of natural selection that is acting on the tadpoles in the pond with **very low** availability of detritus and algae.

..... [1]

(ii) Suggest explanations for the change in phenotype frequencies of the tadpoles in the pond with **very low** availability of detritus and algae, as shown in Fig. 4.4.

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..... [2]

(d) Mexican spadefoot toad tadpoles develop into adult toads that do not live in water.

In some years, the ponds where Mexican spadefoot toad tadpoles live, dry out quickly.

Suggest why the carnivore-type tadpoles have a selective advantage in the years when ponds dry out quickly.

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..... [1]

[Total: 10]

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Question 5 starts on page 20

5 Fig. 5.1 shows the area of land that was used to grow genetically modified (GM) crops in the USA, Brazil, India and China from 2004 to 2015.

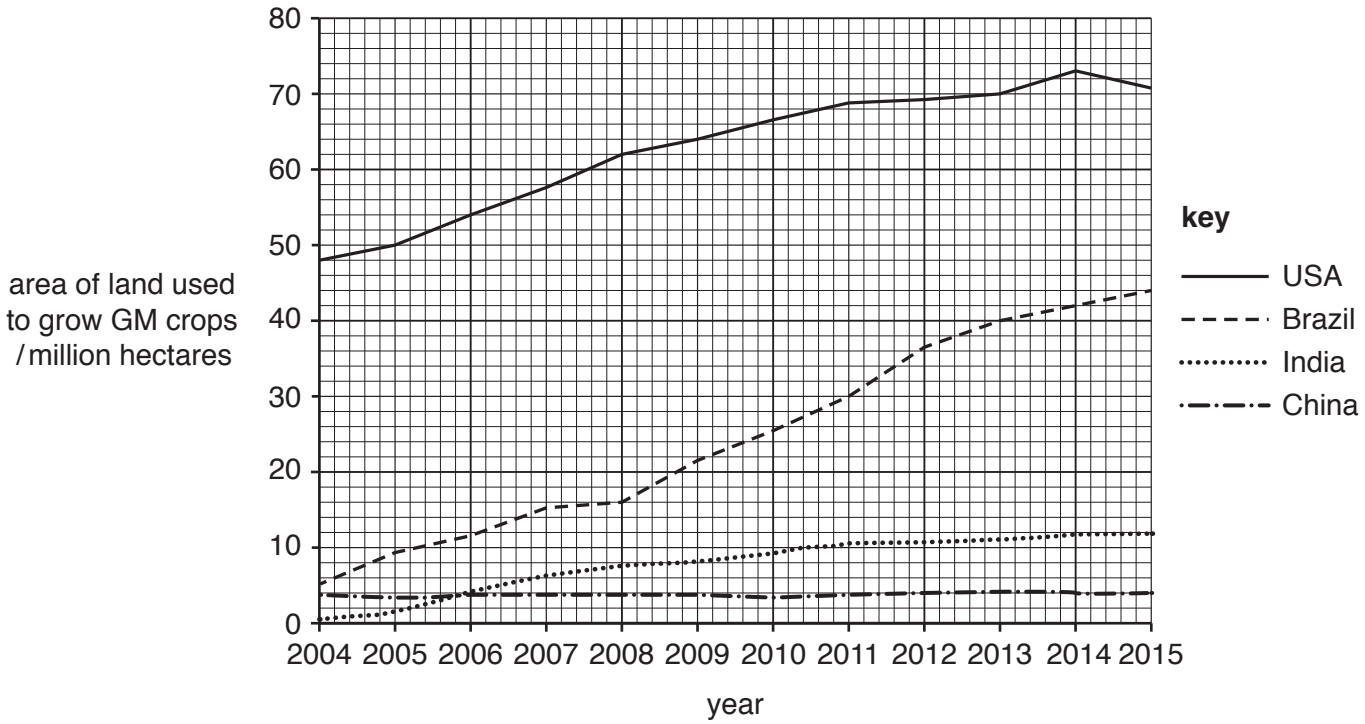


Fig. 5.1

(a) (i) Suggest reasons why the area of land used to grow GM crops in the USA is greater than the area of land used to grow GM crops in Brazil.

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(ii) Describe the differences in the area of land that was used to grow GM crops in China and the area of land that was used to grow GM crops in India, over the time shown in Fig. 5.1.

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..... [3]

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(b) (i) Genetic modifications in crops can provide resistance to insect pests. Bt maize is one type of GM crop that has been produced to be resistant to insect pests.

State **two** benefits to farmers of insect resistance in crops.

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..... [2]

(ii) Describe the difference between Bt maize and non-GM maize that explains why Bt maize is resistant to insects.

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..... [2]

(c) (i) State **two** reasons why people may have objections to the growth of insect-resistant GM crops.

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..... [2]

(ii) In 2015, the percentage of the USA population that objected to the use of GM crops was lower than in 2005.

Suggest why a smaller percentage of the USA population objected to the use of GM crops in 2015.

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..... [1]

[Total: 12]

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[Turn over

6 MELAS syndrome is an inherited disease caused by a mutation in a gene located in mitochondrial DNA (mtDNA). All mtDNA is inherited from the mother.

Fig. 6.1 shows four generations of a family where several individuals are affected by MELAS syndrome.

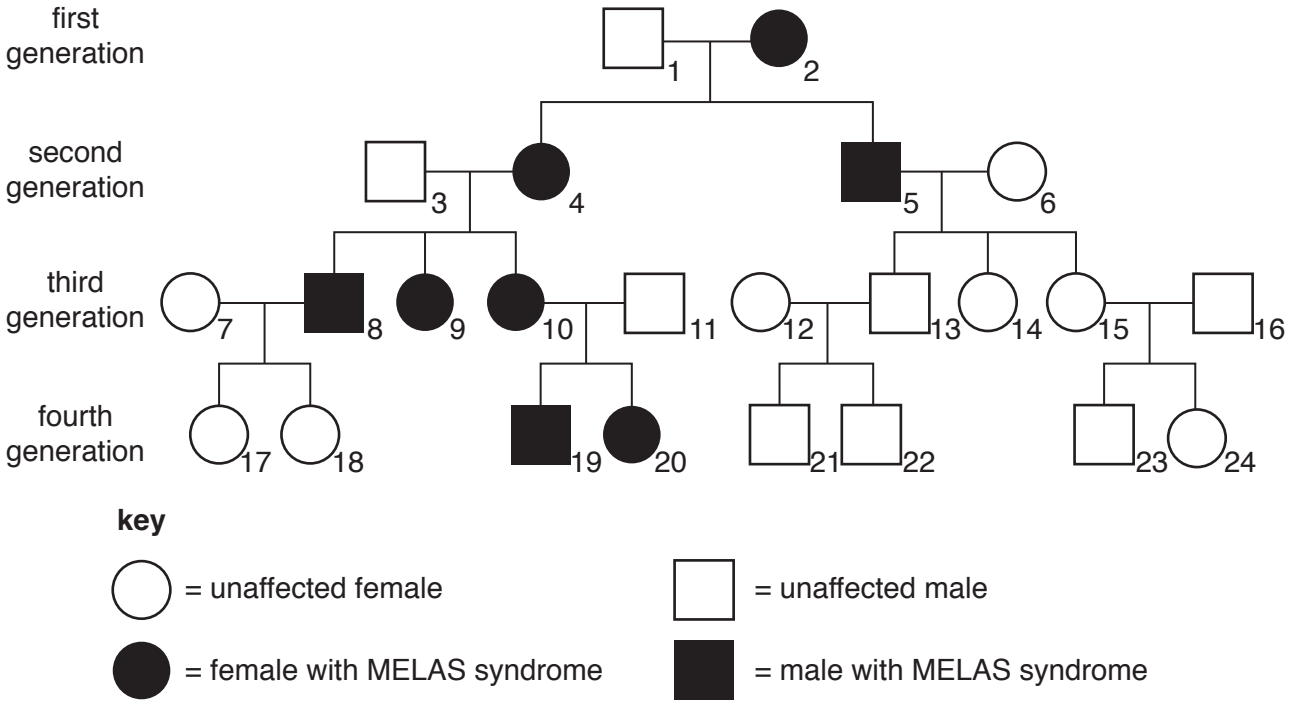


Fig. 6.1

(a) With reference to Fig. 6.1, state **and** explain the evidence that MELAS syndrome is an mtDNA disease and **not** a disease caused by a mutation in a gene on the X chromosome.

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..... [4]

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(b) Analysis of mtDNA can show how recently species have evolved from each other.

Describe the properties of mtDNA that make it suitable for the study of evolution.

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..... [3]

[Total: 7]

7 **(a)** Isolated mitochondria were used to investigate respiration.

- Mitochondria were extracted from respiring mammalian cells and incubated in a buffer solution.
- Pyruvate and inorganic phosphate (Pi) were added at time zero.
- ADP was added one minute later.
- The oxygen concentration of the buffer solution containing mitochondria was monitored throughout the investigation.

The results of the investigation are shown in Fig. 7.1.

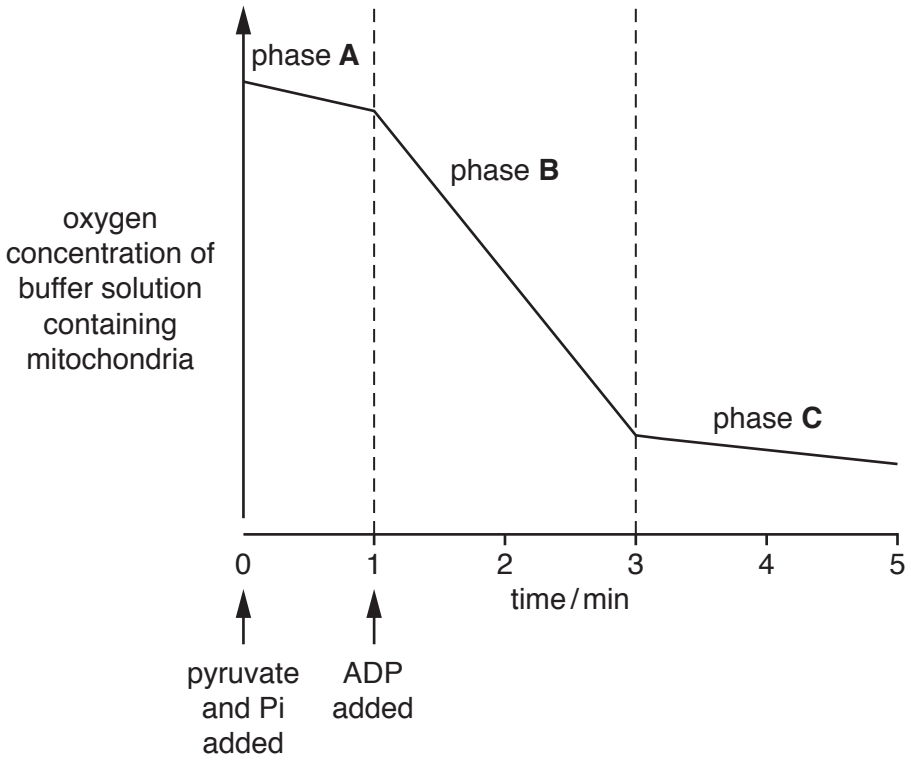


Fig. 7.1

(i) Suggest why the line of the graph in Fig. 7.1 is steeper during phase **B** than during phase **A**.

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..... [3]

(ii) Suggest why the line of the graph starts to level out in phase **C**.

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..... [1]

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(b) Some plants, such as rice, grow with their roots submerged in water.

Fig. 7.2 shows a group of rice plants.



Fig. 7.2

Explain how rice is adapted to grow with its roots submerged in water.

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..... [5]

[Total: 9]

8 **(a)** Explain what is meant by the term *biodiversity*.

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..... [3]

(b) Simpson's Index of Diversity (D) is a method of assessing biodiversity.

The formula for Simpson's Index of Diversity is:

$$D = 1 - \left(\sum \left(\frac{n}{N} \right)^2 \right)$$

n = number of individuals of each species present in the sample
N = total number of all individuals of all species

(i) In an investigation of biodiversity in a pond, samples of pond animals were removed using sampling nets. The species of each animal was identified and the number of individuals of each species was recorded.

Table 8.1 shows the results of the investigation.

Calculate Simpson's Index of Diversity by completing Table 8.1 in the spaces provided. Record your values to three decimal places.

Write the value for Simpson's Index of Diversity on the dotted line. Record your value to three decimal places.

Table 8.1

species	**number**	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
Rana temporaria	10	0.042	0.002
Leucorrhinia dubia	35	0.148	0.022
Hydrometra stagnorum	50	0.212	0.045
Lymnaea stagnalis	44	0.186	0.035
Gammarus pulex	97		
total	236		

Simpson's Index of Diversity (D) = ...
[3]

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(ii) Explain what this value for Simpson's Index of Diversity shows about the diversity of the pond.

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..... [2]

[Total: 8]

Section B

Answer **one** question.

9 **(a)** Describe the sliding filament model of muscular contraction. [7]

(b) Explain the roles of the hormones FSH, LH, oestrogen and progesterone in the human menstrual cycle. [8]

[Total: 15]

10 **(a)** State the general theory of evolution and explain the process of natural selection in evolution. [7]

(b) Explain how meiosis **and** fertilisation can result in genetic variation amongst offspring. [8]

[Total: 15]

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