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# Biology

## Standard level

### Paper 3

8 November 2023

**Zone A** morning | **Zone B** morning | **Zone C** morning

Candidate session number

1 hour

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#### Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[35 marks]**.

Section A	Questions
Answer all questions.	1 – 3

Section B	Questions
Answer all of the questions from one of the options.	
Option A — Neurobiology and behaviour	4 – 7
Option B — Biotechnology and bioinformatics	8 – 10
Option C — Ecology and conservation	11 – 14
Option D — Human physiology	15 – 18



## Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

1. The image shows a section through a specialised plant cell.

Removed for copyright reasons

- (a) Identify structure X. [1]

.....

- (b) State **one** function of structure X. [1]

.....

- (c) Calculate the magnification of the image. [1]

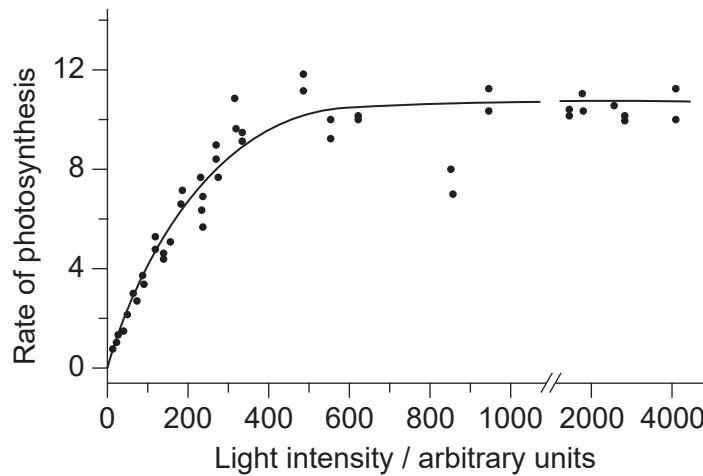
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- (d) The image was obtained using a transmission electron microscope. Outline how the invention of the electron microscope has contributed to understanding of cell structure. [1]

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2. The cells of a cnidarian, *Acropora*, contain single-celled, photosynthetic algae belonging to the genus *Symbiodinium*. The graph shows the effect of light intensity on the rate of photosynthesis by *Symbiodinium*. A line of best fit is shown on the graph.



- (a) Explain the shape of the curve using the concept of limiting factors.

[3]

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- (b) State **one** factor that would need to be controlled in an experiment to test the effect of light intensity on rates of photosynthesis by the algae.

[1]

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- (c) Experimental studies have also shown that an increase in the rate of photosynthesis by *Symbiodinium* in the cells of *Acropora* is associated with an increase in pH. Suggest an explanation for the increase in pH.

[2]

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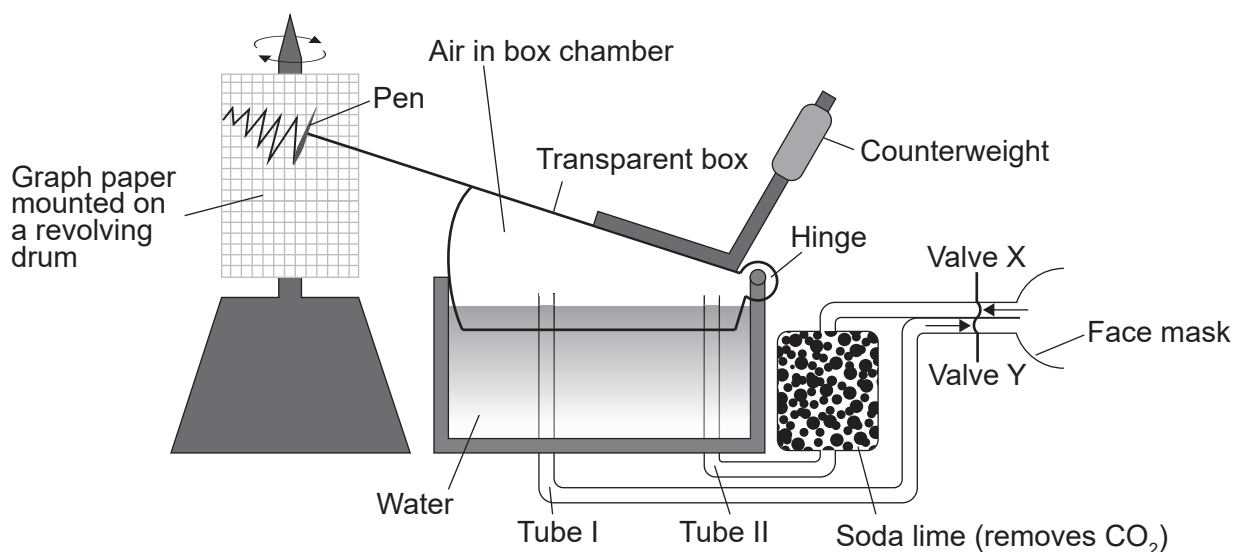
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3. In the spirometer shown in the diagram, a box chamber suspended over the water in the tank is filled with air at the start of the investigation. The subject inspires air from the chamber and expires air out into the chamber through two tubes attached to a sealed face mask. The box chamber falls during inspiration and rises during expiration.



- (a) State **one** function of valve X.

[1]

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- (b) Describe the trace left by the pen on the graph paper as the subject inspires air from the chamber.

[1]

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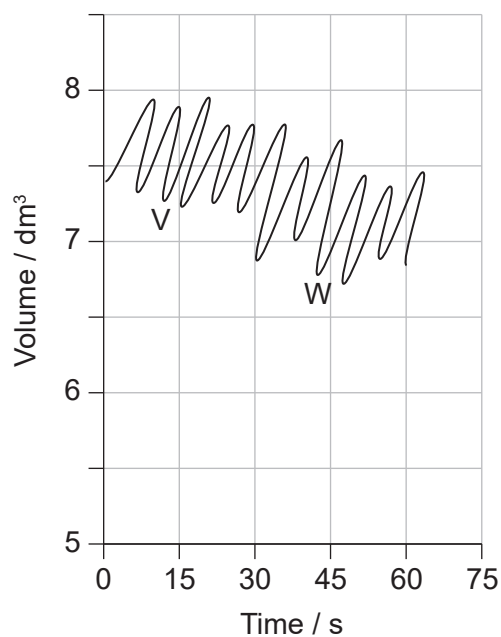
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**(Question 3 continued)**

- (c) The image shows the trace created by a subject at rest and breathing normally into the apparatus.



Explain the reason that the trace slopes downwards as it moves across the paper from left to right between V and W.

[3]

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Please **do not** write on this page.

Answers written on this page  
will not be marked.

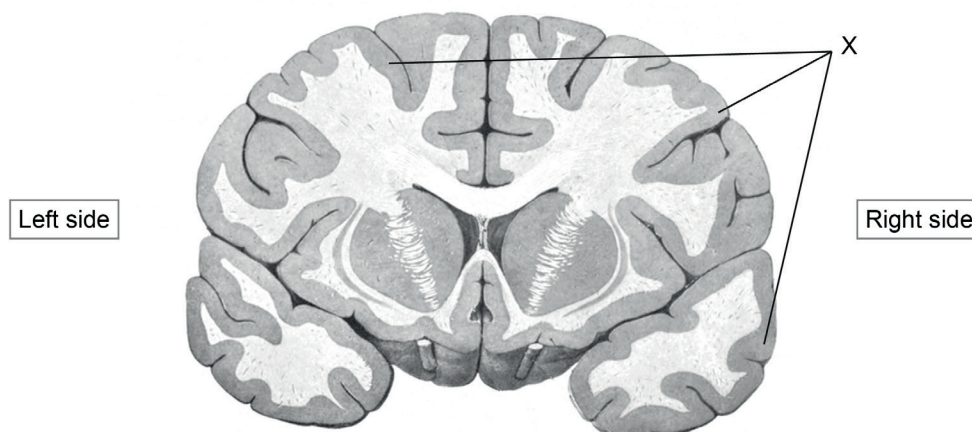


## Section B

Answer **all** of the questions from **one** of the options. Answers must be written within the answer boxes provided.

### Option A — Neurobiology and behaviour

4. The image shows a section through the brain.



- (a) State **one** function that can be performed by structure X.

[1]

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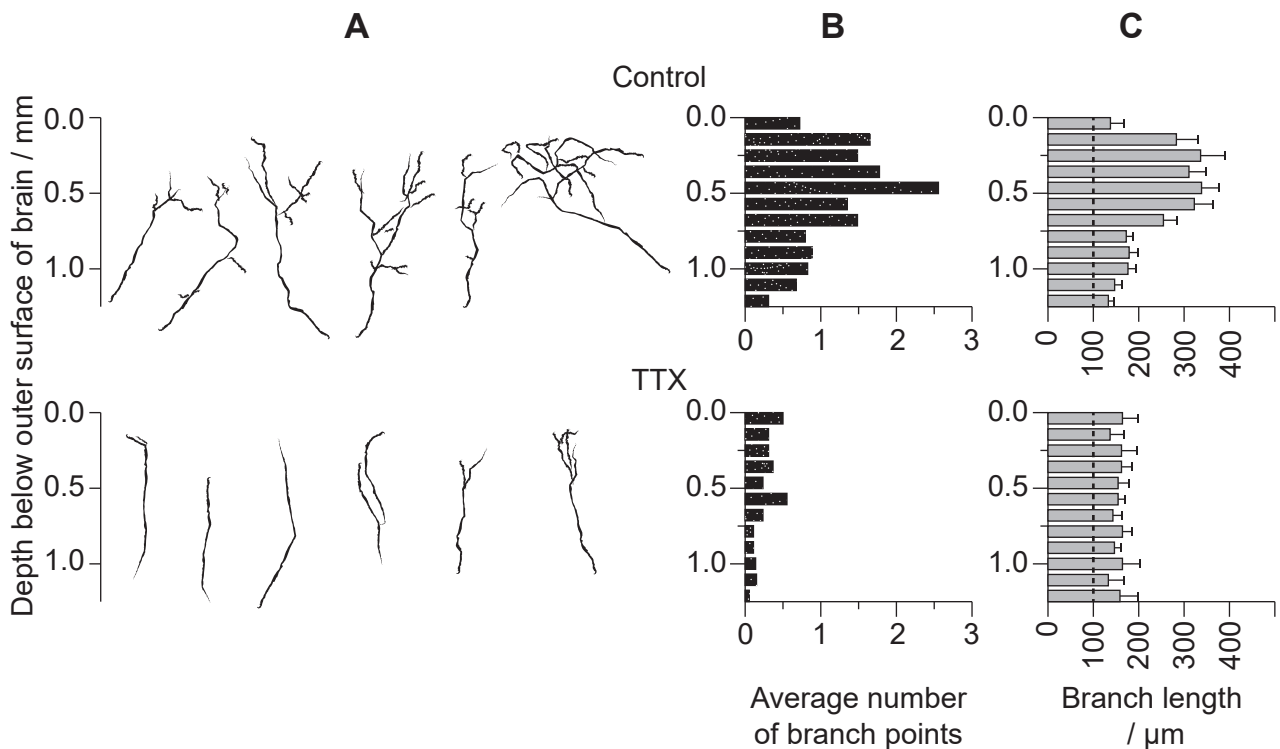
(Option A continues on the following page)





(Option A, question 4 continued)

- (b) Blocks of tissue removed from the brains of young rats were exposed to tetrodotoxin (TTX), a drug that prevents postsynaptic neurons from responding to signals from presynaptic neurons. The growth of axons in cultures containing TTX was compared with growth in control cultures without TTX over a two-week period. The image shows the pattern of branching in representative axons (A), the average number of branch points per axon (B) and the average length of branches (C) at different depths below the surface of the tissue.



- (i) Identify the depth at which the highest average number of branch points was recorded in the control culture.

[1]

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- (ii) Describe the effect of TTX on axons in the brain tissue.

[2]

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(Option A continues on the following page)



**(Option A, question 4 continued)**

- (c) Explain how the nervous system adapts to change throughout the lifetime of the organism.

[3]

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**(Option A continues on the following page)**



32EP09

**Turn over**

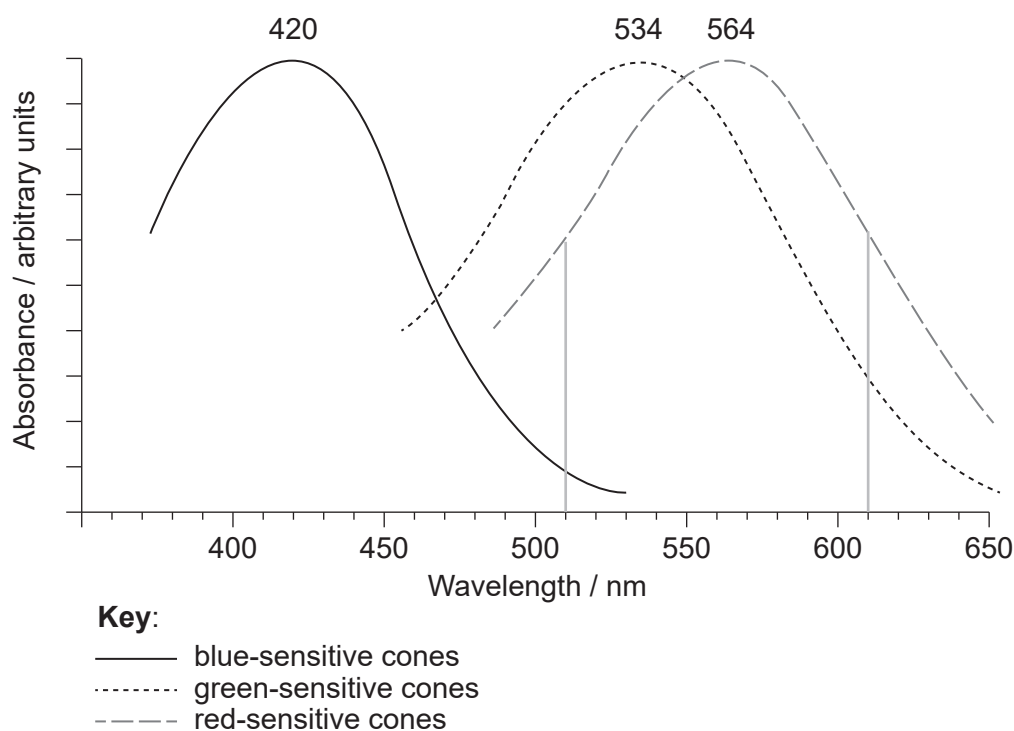
**(Option A continued)**

5. (a) State the location of rods and cones in the human eye.

[1]

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- (b) The graph shows the absorbance of light by cones in the human eye with curves for blue-sensitive, green-sensitive and red-sensitive cones. The numbers represent the wavelength that is absorbed most strongly by each type of cone.



- (i) Identify the range of wavelengths absorbed by green-sensitive cones in the graph. [1]

.....

**(Option A continues on the following page)**



**(Option A continued)**

- (ii) Light with wavelength 510 nm is perceived by our brain as blue-green in colour, while light with wavelength 610 nm is perceived as orange. Explain how our brain is able to perceive the two different wavelengths of light as different colours when both are absorbed equally by the red-sensitive cones. [2]

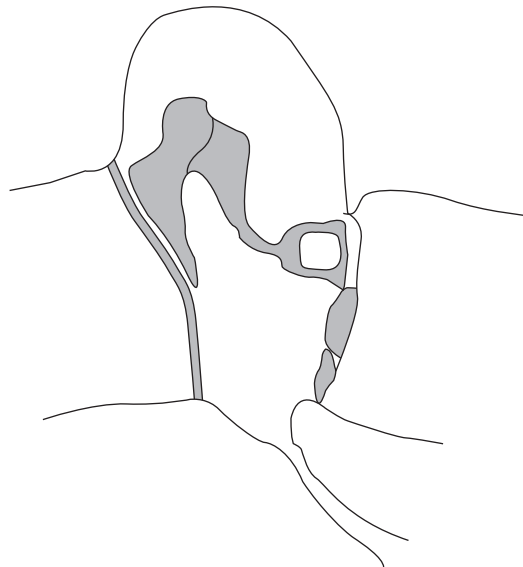
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6. The diagram shows structures that form part of the middle ear.



- (a) Label the eardrum. [1]
- (b) Explain how sound is modified as it passes through the middle ear. [1]

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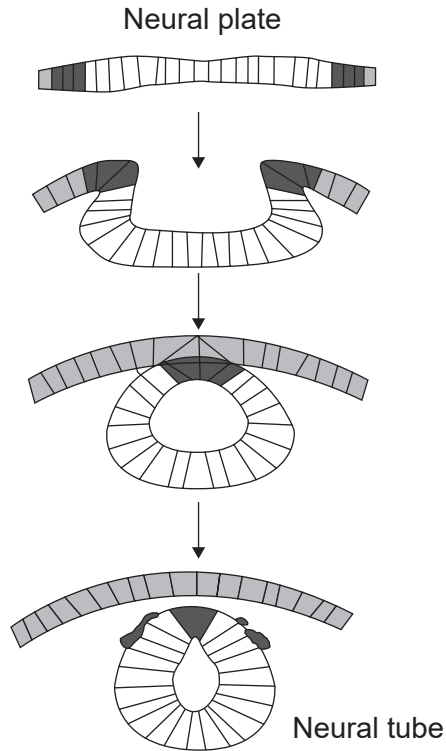
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**(Option A continues on the following page)**



**(Option A continued)**

7. The diagram shows changes in the neural plate during neurulation in a vertebrate embryo. The neural tube forms the central nervous system, which is made up of the brain and spinal cord.



[Source: Clare Baker, Neural Crest and Cranial Ectodermal Placodes, In: Rao, MS, Jacobson†, M (eds), *Developmental Neurobiology*, 2005, Springer Nature. Reproduced with permission from Springer Nature. [https://link.springer.com/chapter/10.1007/0-387-28117-7\\_4](https://link.springer.com/chapter/10.1007/0-387-28117-7_4).]

(a) Describe neurulation.

[3]

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**(Option A continues on the following page)**



**(Option A, question 7 continued)**

- (b) Compare and contrast the functions of the right and left cerebral hemispheres of the brain.

[4]

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**End of Option A**

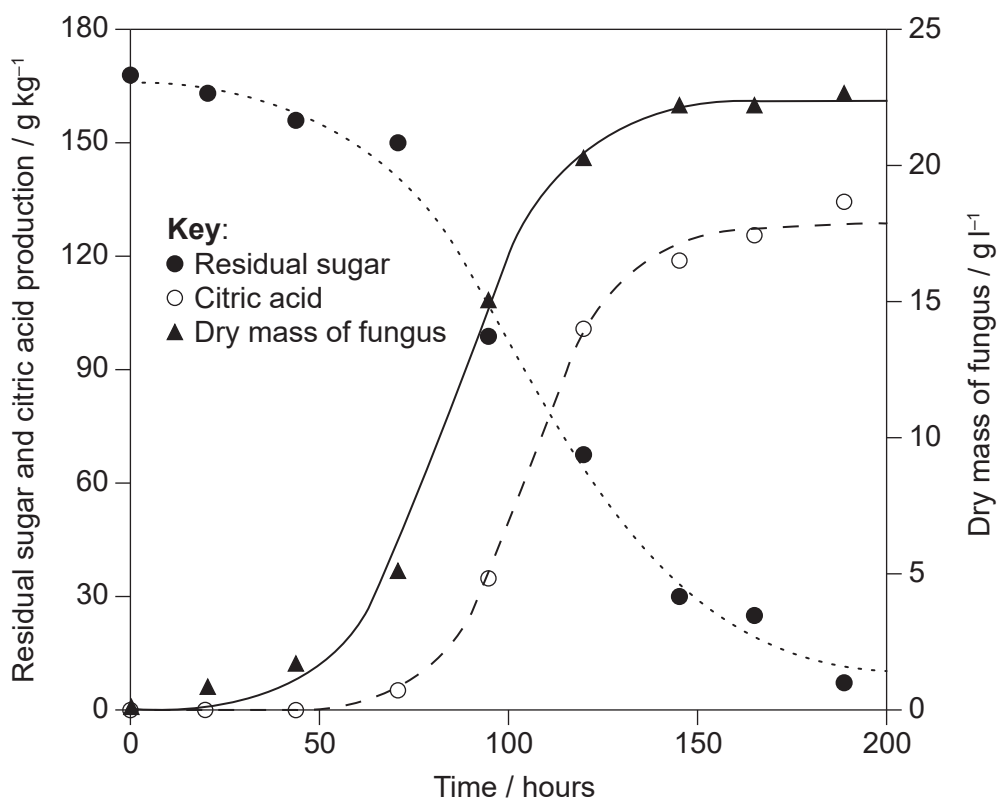


32EP13

**Turn over**

**Option B — Biotechnology and bioinformatics**

8. The graph shows the results of a study of citric acid fermentation by *Aspergillus niger* grown on sugar in apple waste.



- (a) Citric acid fermentation by *Aspergillus niger* is widely used in industry. List **two** reasons for this. [2]

1. ....
2. ....

- (b) The activities of microorganisms can change conditions in fermenters, with harmful effects for the microorganisms. Outline how this is prevented for **one** condition that could change. [1]

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.....

(Option B continues on the following page)



**(Option B, question 8 continued)**

- (c) Compare and contrast the use of batch and continuous fermentation methods in industry. [2]

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9. Glyphosate is a broad-spectrum systemic herbicide incorporated into a wide range of herbicide products.

- (a) Crop plants that were genetically engineered to resist the effects of glyphosate were introduced in 1996. Describe the process used to produce glyphosate-resistant crop plants. [3]

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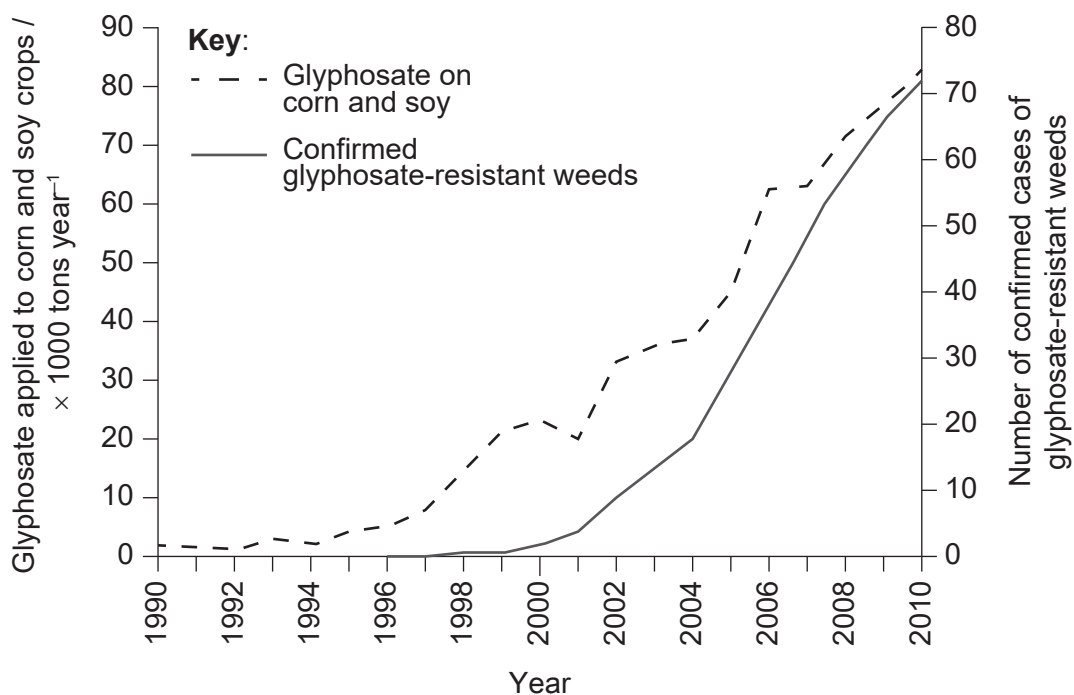
**(Option B continues on the following page)**





(Option B, question 9 continued)

- (b) The graph shows trends in the application of glyphosate to corn and soy plants based on data from annual surveys of major crop-producing states in the United States between 1990 and 2010.



The introduction of glyphosate-resistant crop species is also associated with a dramatic increase in the incidence of glyphosate-resistant weeds, which have spread rapidly over millions of hectares of agricultural land. Suggest **one** reason for the increase in the incidence of glyphosate-resistant weeds.

[1]

(Option B continues on the following page)



**(Option B, question 9 continued)**

- (c) Data obtained from a large number of hospitals in the United States between 1990 and 2010 has shown strong correlations between trends in the application of glyphosate and trends in the frequency of specific disorders in humans, especially newborns. The correlation coefficient (R) is a measure of the strength of the relationship between two variables, with a higher value reflecting a stronger relationship.

Type of disorder	Correlation coefficient (R value)
Head and face abnormalities in newborns	0.95
Newborn eye disorders	0.92
Newborn skin disorders	0.96
Congenital heart conditions in newborns	0.98
Newborn lung problems	0.95
Newborn metabolic disorders	0.95
Newborn genital and urinary disorders	0.96
Liver cancer in all age groups except newborn	0.93

Using the data in the table, evaluate the evidence for the hypothesis that glyphosate is toxic to humans.

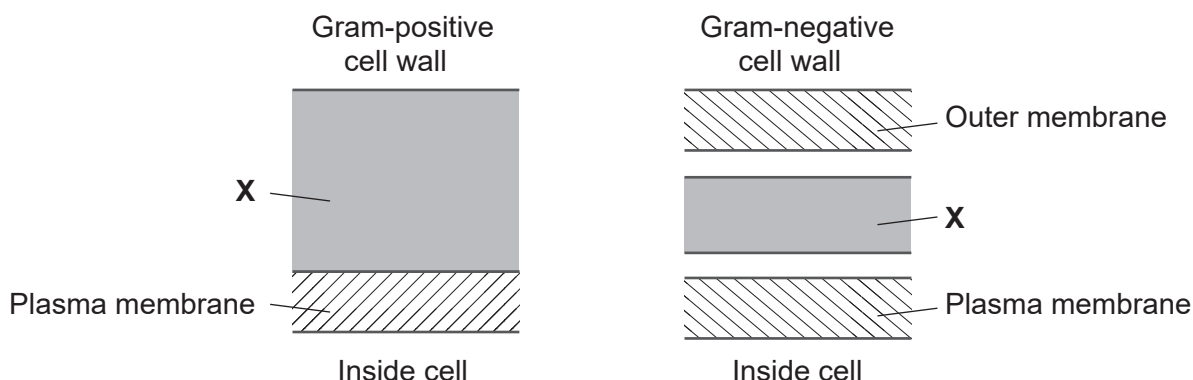
[3]

**(Option B continues on the following page)**



(Option B continued)

10. (a) The diagram shows sections through the cell wall of Gram-positive and Gram-negative bacteria.



The layer labelled X is composed of a polymer consisting of amino acids and sugars. State the name of the polymer.

[1]

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- (b) The production of oil in marine environments results in the accumulation of large volumes of salt water contaminated with benzene and other hydrocarbons. Outline the use of the halophilic Gram-negative bacterium *Marinobacter hydrocarbonoclasticus* in bioremediation of wastewater from the production of oil.

[3]

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(Option B continues on the following page)



**(Option B, question 10 continued)**

- (c) *M. hydrocarbonoclasticus* forms biofilms on the surface of a variety of hydrocarbon substrates. Explain how bacteria form biofilms.

[4]

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**End of Option B**

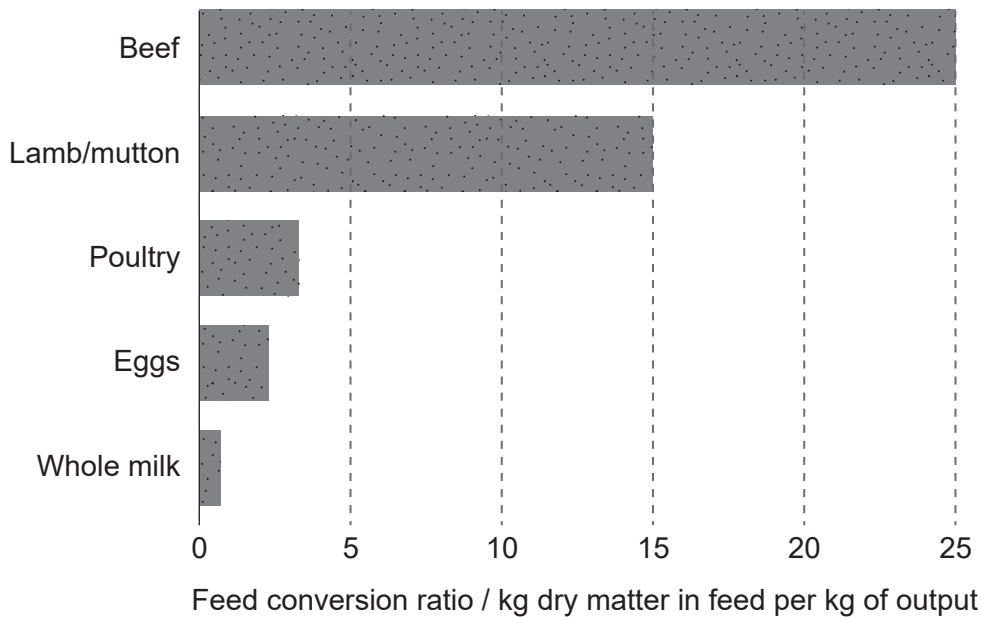


32EP19

**Turn over**

**Option C — Ecology and conservation**

11. The bar chart shows the mass of animal feed required to produce one kilogram of meat, egg or milk (kg dry matter in feed per kg of output).



- (a) Distinguish between the energy efficiency of beef and poultry production.

[1]

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 .....

- (b) Suggest a reason for the difference between the energy efficiency of beef and poultry production.

[1]

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 .....

- (c) Outline **two** ways in which agricultural production of animals may change the cycling of nutrients (for example phosphorous or nitrogen) in ecological systems.

[2]

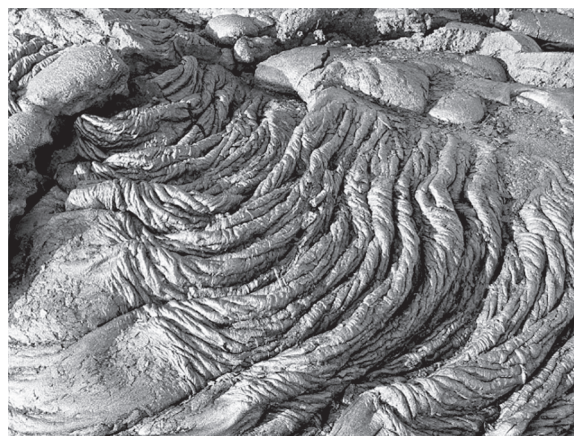
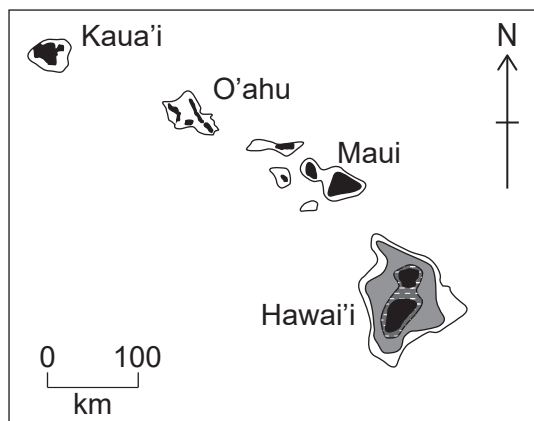
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(Option C continues on the following page)



(Option C continued)

12. The Hawaiian Islands are the exposed peaks of a great undersea mountain range formed by volcanic activity over a hotspot in the Earth's mantle. They are located about 3000 km from the nearest continent. The map shows the Hawaiian archipelago and the photograph shows an example of a cooled lava flow.



- (a) Predict, with a reason, which island will have the greatest biodiversity. [1]

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- (b) The process leading to the establishment of mature ecological communities on a lava flow is called primary succession. Outline the processes involved in primary succession on lava flows. [2]

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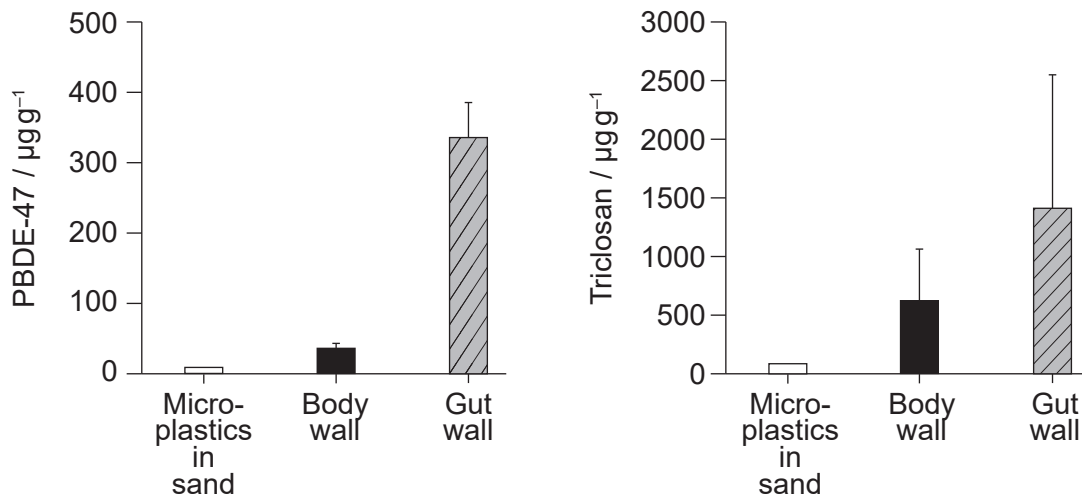
(Option C continues on the following page)



(Option C continued)

13. PBDE-47 (a fire-retardant) and triclosan (an antimicrobial agent) are chemical additives used to reduce the flammability of plastics and growth of microorganisms on their surfaces.

Marine organisms living on the ocean floor are at risk of absorbing these chemicals into their tissues from microplastics in sand. The concentrations of PBDE-47 and triclosan in sand containing microplastics were compared with concentrations in the body wall (external body surface) and gut wall of bottom-dwelling marine worms *Arenicola marina*.



- (a) Identify the chemical that was most highly concentrated in each tissue.

[2]

Body wall: .....

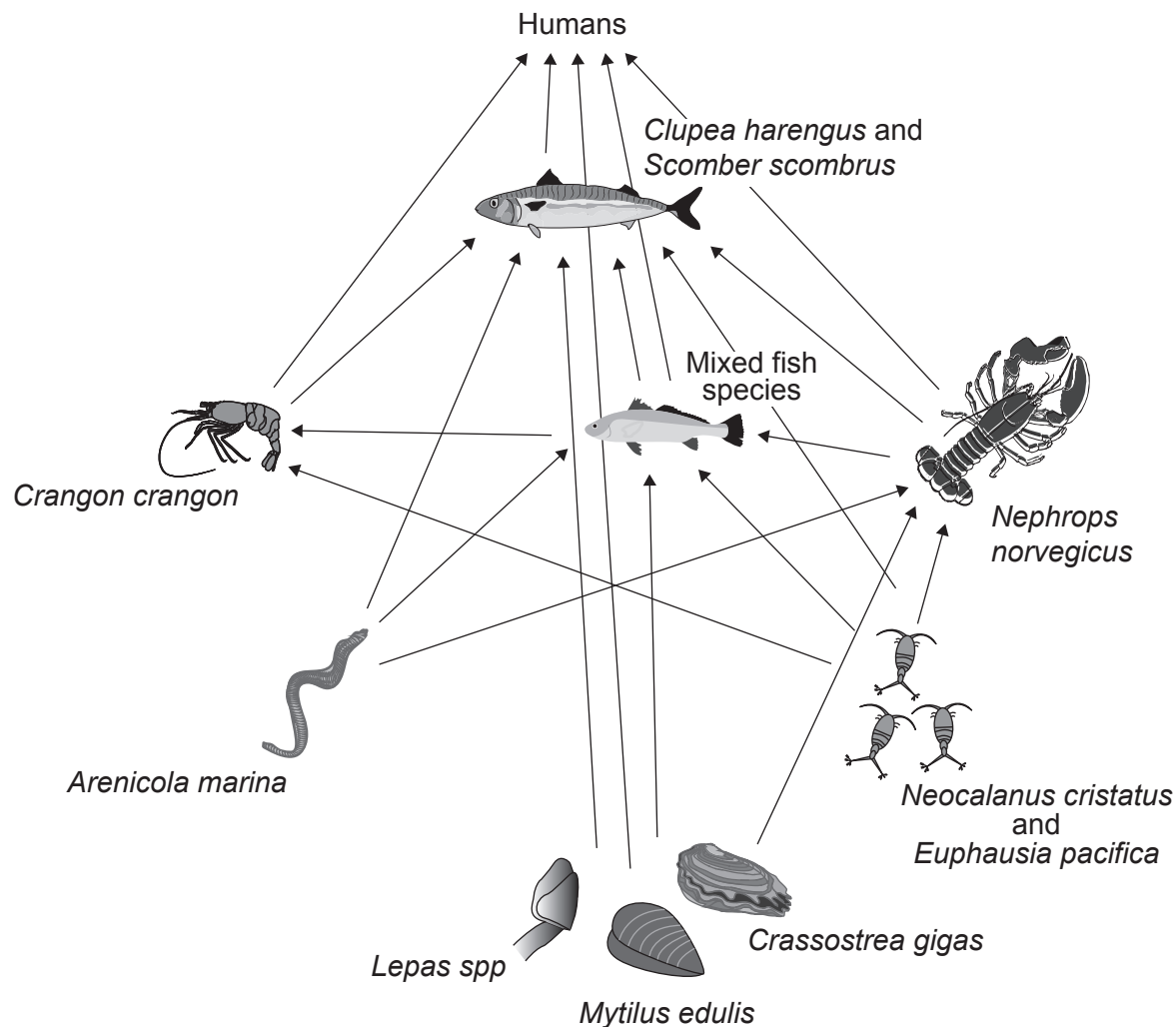
Gut wall: .....

(Option C continues on the following page)



(Option C, question 13 continued)

- (b) Triclosan has been shown to have adverse effects on the health of living organisms. This has led to concerns about the consequences of biomagnification of triclosan within ecosystems. A marine foodweb is shown.



Using the information in the food web, explain how biomagnification of triclosan could cause problems for human health.

[3]

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(Option C continues on the following page)



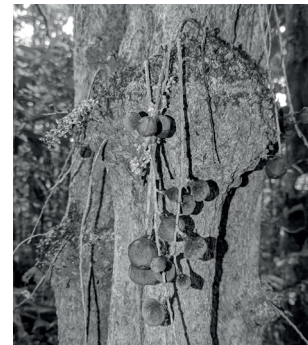
32EP23

Turn over



(Option C continued)

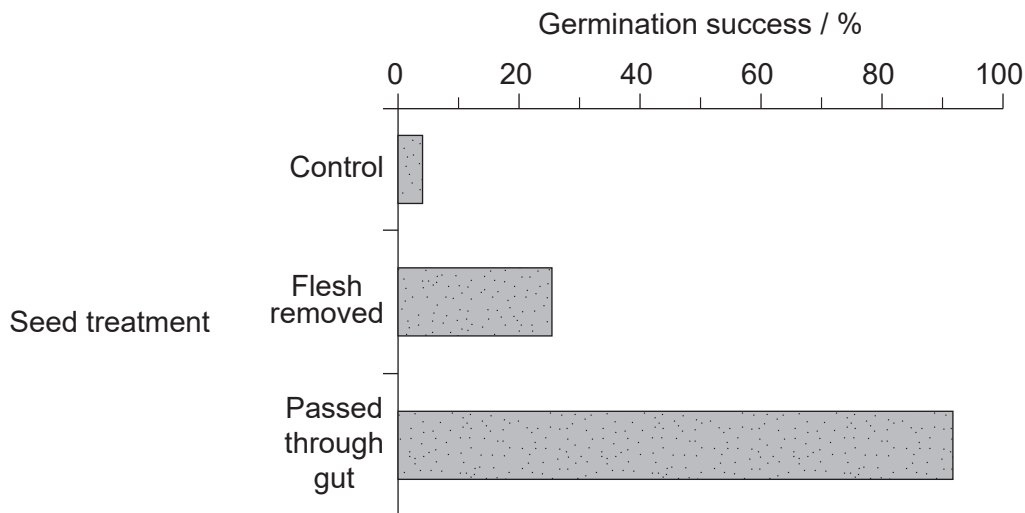
14. The images show a southern cassowary (*Casuarius casuarius johnsonii*) and the fruit of *Ryparosa kurrangii*. The fruit grow suspended from the main trunk of the tree on long stems.



The southern cassowary is a large, flightless bird found in New Guinea and Queensland, Australia, which feeds on the fruits of rainforest trees. Many of these tree species contain large seeds that are stripped of their flesh as they pass along the cassowary gut, and may be transported long distances before being ejected in fecal material.

The graph shows the results of an investigation in which seeds of the rainforest tree species *Ryparosa kurrangii* were exposed to one of three conditions before being transferred to soil to assess the effects of consumption by the cassowary on seed germination:

- seeds left intact inside the fruit (control)
- some flesh roughly removed
- seeds consumed by cassowaries and passed through their gut.



- (a) Calculate the increase in germination success of seeds that passed through the gut of the cassowaries compared to seeds that had flesh removed.

[1]

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(Option C continues on the following page)



(b) Populations of the southern cassowary are experiencing serious decline as a result of collision with road vehicles which kills many adults, wild dogs which kill chicks and juveniles, and wild pigs which destroy cassowary habitat. Deduce **two** effects of this decline on *R. kurrangii*.

1. ....
2. ....

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.....

This image shows a full page of white paper with horizontal dotted lines, typical of primary school handwriting practice paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.



**Option D — Human physiology**

- 15.** The table shows the results of a survey of 4171 women aged 18 years and over in the Republic of Ireland in 2007. Data on the prevalence of chronic diseases was categorized by BMI categories (normal weight, overweight and obese).

Females (n=4171)			
Percentage of women with chronic disease / %			
Chronic condition	Normal weight	Overweight	Obese
Lower back pain	14.3	18.2	24.3
Osteoarthritis	4.2	8.5	9.7
Diabetes	1.5	3.6	6.9
Cardiovascular disease	1.8	3.7	2.0
Raised cholesterol	15.6	20.2	24.8

- (a) Using the data in the table, evaluate the evidence that BMI is positively correlated with the incidence of chronic disease.

[3]

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- (b) Outline the mechanisms in the body that help to regulate appetite.

[2]

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(Option D continues on the following page)



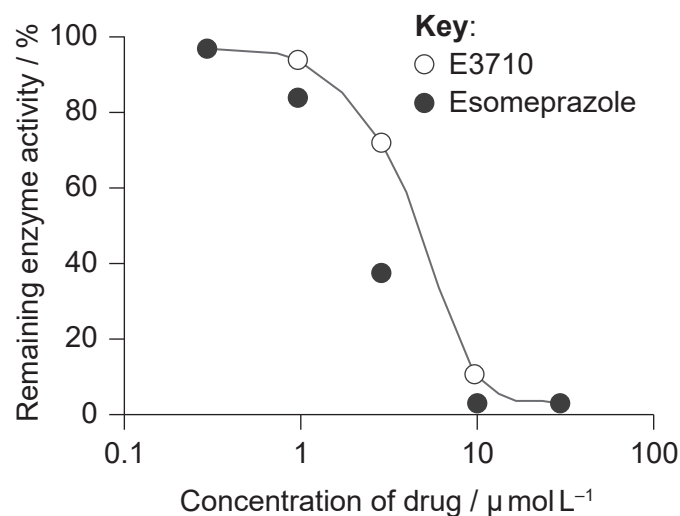
(Option D, question 15 continued)

- (c) State **one** enzyme produced by exocrine gland cells of the pancreas.

[1]

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16. The membrane protein  $H^+/K^+$  ATPase lowers the pH of the stomach by exchanging two protons in the cytoplasm of the parietal cells for two potassium ions in the lumen of the stomach. The graph shows the effects of two drugs, E3710 and esomeprazole on the activity of  $H^+/K^+$  ATPase.



- (a) Deduce the effect of esomeprazole and E3710 on the pH of the stomach.

[1]

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- (b) Explain how hydrochloric acid (HCl) contributes to the breakdown of proteins in the stomach.

[2]

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(Option D continues on the following page)



32EP27

Turn over

**(Option D continued)**

17. The images show a Kupffer cell (KC) in a sinusoid of the liver (image I) and a hepatocyte in the tissue surrounding a sinusoid (image II).

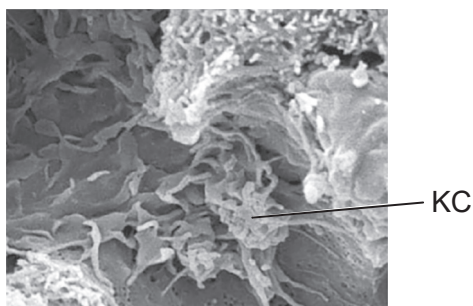


Image I

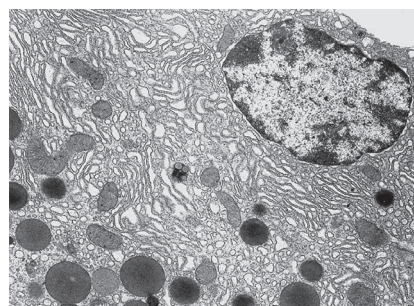


Image II

- (a) Describe the role of Kupffer cells in the breakdown of red blood cells.

[3]

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- (b) The hepatocytes surrounding the sinusoids contain extensive networks of endoplasmic reticulum. Suggest a reason for this.

[1]

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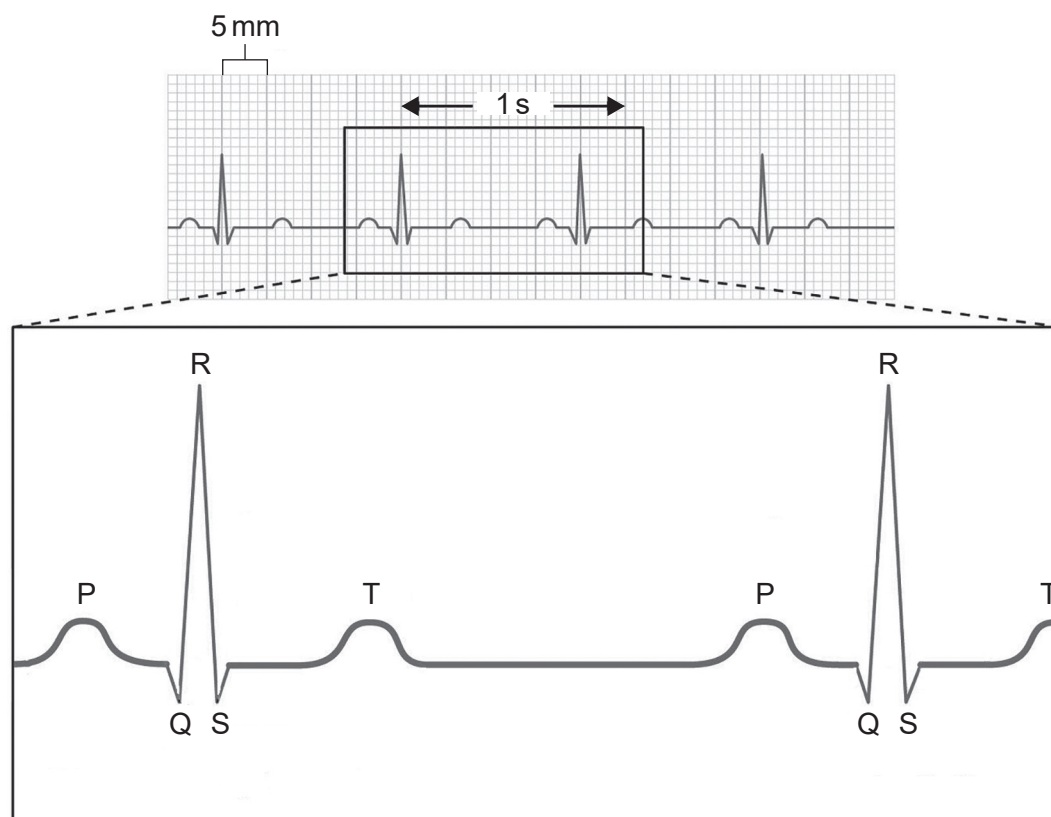
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**(Option D continues on the following page)**



(Option D continued)

18. The diagram illustrates the pattern of electrical activity during the cardiac cycle.



(a) State what happens in the heart during the T wave.

[1]

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(b) Describe **one** structural feature of cardiac muscle cells that allows them to function effectively in the conduction of electrical impulses.

[2]

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(Option D continues on the following page)



32EP29

Turn over

(Option D, question 18 continued)

- (c) Explain how the cardiac cycle is controlled by electrical signals in the walls of the heart. [4]

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**End of Option D**

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#### References:

2. Kuhl M, Cohen Y, Dalsgaard T, Jorgensen BB, Revsbech NP. "Microenvironment and Photosynthesis of Zooxanthellae in Scleractinian Corals Studied with Microsensors for O<sub>2</sub>, PH and Light". *Mar Ecol Prog Ser* 117: 159172." *MARINE ECOLOGY PROGRESS SERIES*, vol. 117, 1 Feb. 1995, pp. 159–172, <https://doi.org/10.3354/meps117159>. Open access.
4. Dr Johannes Sobotta, [https://commons.wikimedia.org/wiki/File:Sobo\\_1911\\_643.png](https://commons.wikimedia.org/wiki/File:Sobo_1911_643.png). Source adapted. Public domain.
4. (b) Uesaka, N, Hayano, Y, Yamada, A and Yamamoto, N, 2007. Interplay between Laminar Specificity and Activity-Dependent Mechanisms of Thalamocortical Axon Branching. *The Journal of Neuroscience*, 27, pp. 5215–5223 Copyright 2007 Society for Neuroscience.
5. (b) Bowmaker, JK, Dartnall, HJ, (1980), Visual pigments of rods and cones in a human retina. *The Journal of Physiology*, 298 doi: 10.1113/jphysiol.1980.sp013097. John Wiley and Sons.
6. Gopalan, MK and Menon, UK, 2016. Construction of a 3D Model of Epitympanic Folds and Space. *Journal of Biocommunication*, [e-journal] 40(1). Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9139137/> [Accessed 3 January 2020].
7. Clare Baker, Neural Crest and Cranial Ectodermal Placodes, In: Rao, MS, Jacobson†, M (eds), *Developmental Neurobiology*, 2005, Springer Nature. Reproduced with permission from Springer Nature. [https://link.springer.com/chapter/10.1007/0-387-28117-7\\_4](https://link.springer.com/chapter/10.1007/0-387-28117-7_4).
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