

Biology
Higher level
Paper 3

Thursday 5 May 2016 (morning)

Candidate session number

1 hour 15 minutes

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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.
- Section A: answer all questions.
- Section B: answer all of the questions from one of the options.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[45 marks]**.

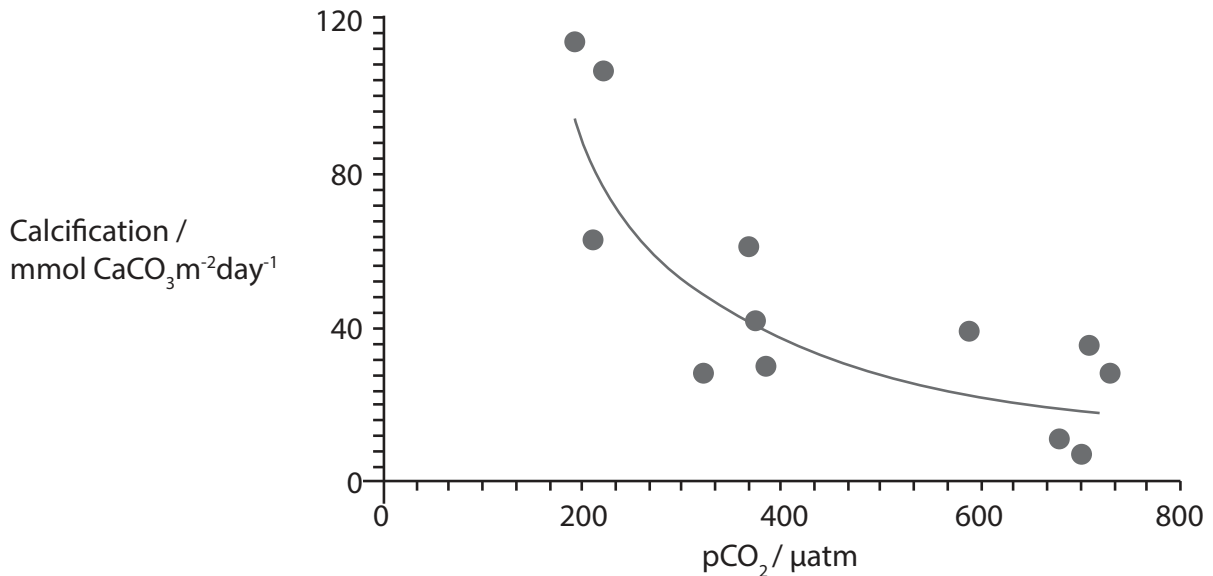
Option	Questions
Option A — Neurobiology and behaviour	4 – 8
Option B — Biotechnology and bioinformatics	9 – 13
Option C — Ecology and conservation	14 – 18
Option D — Human physiology	19 – 22



Section A

Answer **all** questions. Write your answers in the boxes provided.

1. Increasing carbon dioxide concentration in the atmosphere leads to acidification of the ocean. This in turn reduces the amount of dissolved calcium carbonate. A study was undertaken to investigate the effect of increasing the concentration of atmospheric carbon dioxide on the calcification rate of marine organisms. Calcification is the uptake of calcium into the bodies and shells of marine organisms. The study was undertaken inside Biosphere-2, a large-scale closed mesocosm. The graph shows the results of the data collection.



[Source: © International Baccalaureate Organization 2016]

- (a) State the relationship between atmospheric carbon dioxide and calcification rates. [1]

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- (b) Suggest **one** advantage of using a mesocosm in this experiment. [1]

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(This question continues on the following page)



44EP02

(Question 1 continued)

- (c) Outline **one** way in which reef-building corals are affected by increasing atmospheric carbon dioxide.

[2]

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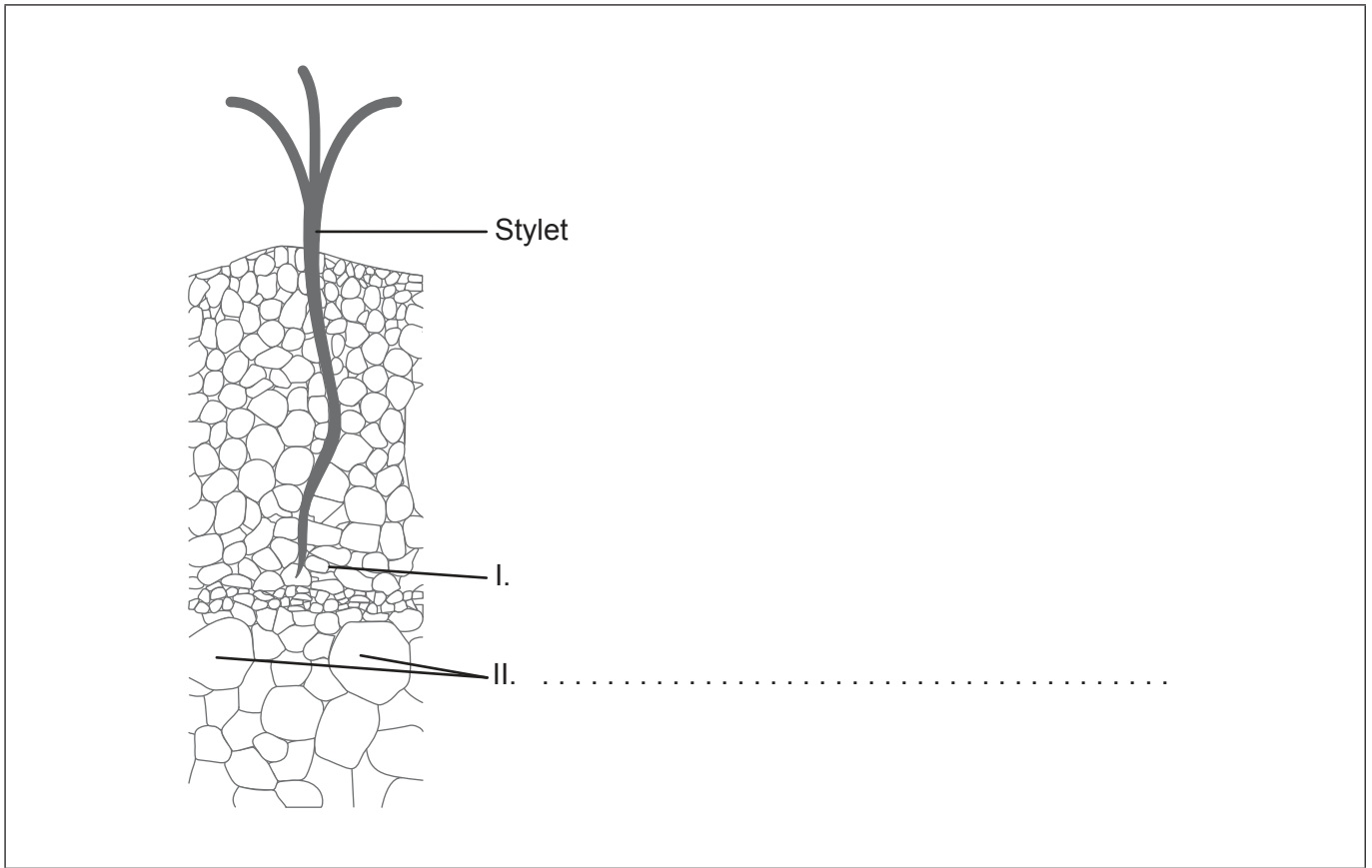
44EP03

Turn over

2. The image shows a severed aphid stylet embedded in plant tissue.

(a) Identify the tissue labelled II.

[1]



(b) Outline **one** piece of evidence that the tissue labelled I is phloem tissue.

[1]

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(This question continues on the following page)



(Question 2 continued)

(c) Explain how aphid stylets can be used to study the movement of solutes in plant tissues.

[3]

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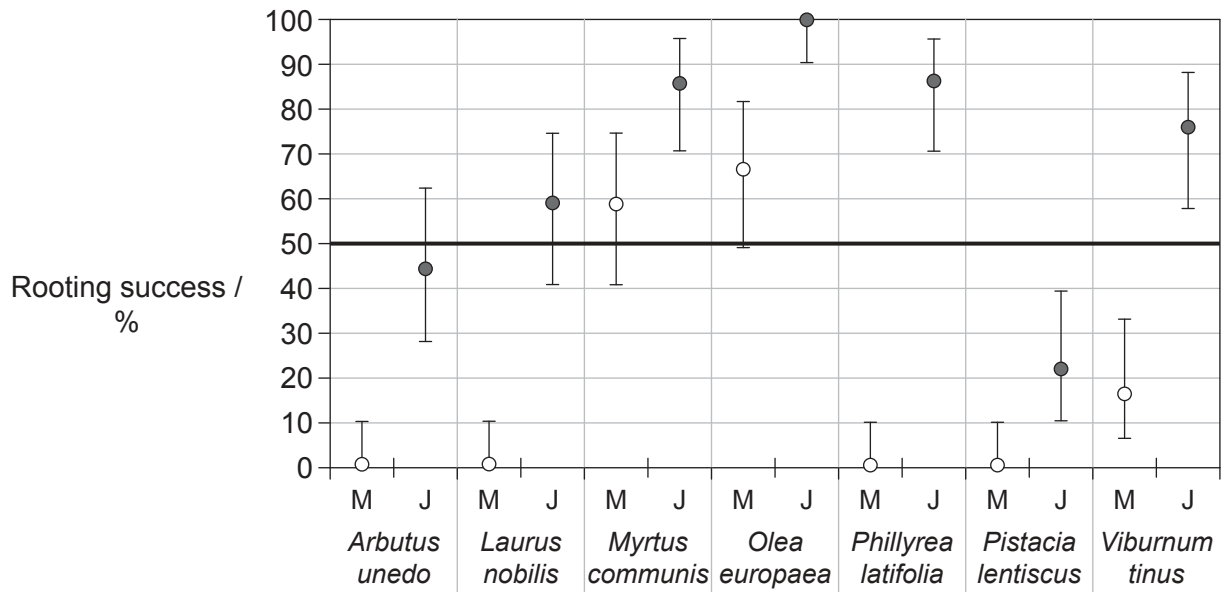
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44EP05

Turn over

3. Achieving successful rooting of cuttings is difficult in some shrub species. An experiment was undertaken to determine whether juvenile shoots (J) of shrubs root more successfully than mature shoots (M).



Key: ○ mature shoots (M) ● juvenile shoots (J)

[Source: "Effects of rejuvenation on cutting propagation of Mediterranean shrub species" by G. Pignatti and S. Crobeddu, *Forest@*, vol. 2, pp. 290-295 (Sep 2005): Figure 3. Used with permission.]

- (a) Distinguish between the rooting success of the juvenile shoots and the mature shoots. [1]

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(This question continues on the following page)



(Question 3 continued)

- (b) Suggest **one** reason for the difference in the rooting success in the juvenile shoots and the mature shoots. [1]

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- (c) Outline **one** variable that would need to be controlled in this experiment. [1]

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- (d) Auxin is a hormone that can be applied to improve the percentage success of rooting in those study plants with poor rooting success. Explain the effects of auxin on plant cells. [3]

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44EP07

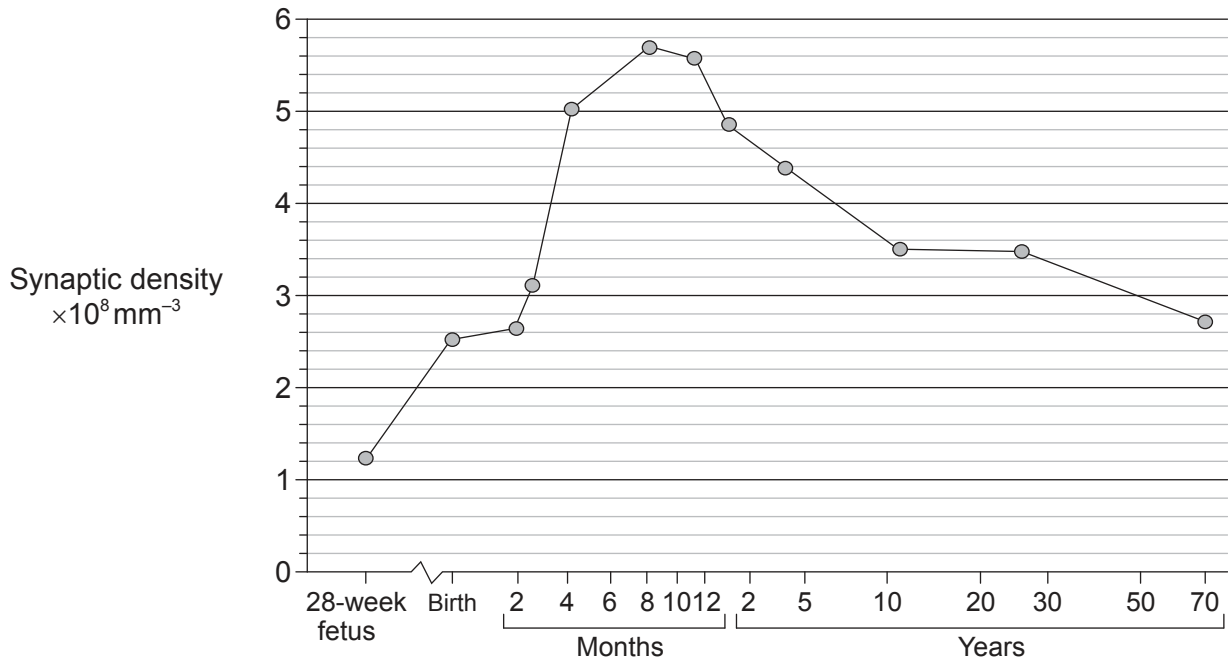
Turn over

Section B

Answer **all** of the questions from **one** of the options. Write your answers in the boxes provided.

Option A — Neurobiology and behaviour

- 4. Synaptic density is the number of synapses per unit volume. The graph shows the synaptic density for a 28-week-old fetus, and from birth to age 70.



[Source: Reprinted from *Brain Research*, 163 (2), Peter R. Huttenlocher, "Synaptic density in human frontal cortex – Developmental changes and effects of aging", pp. 195–205 © 1979, published by Elsevier. Used with permission.]

- (a) (i) Determine the age when synaptic density is highest. [1]

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- (ii) Explain how synaptic density decreases after the age determined in (a)(i). [3]

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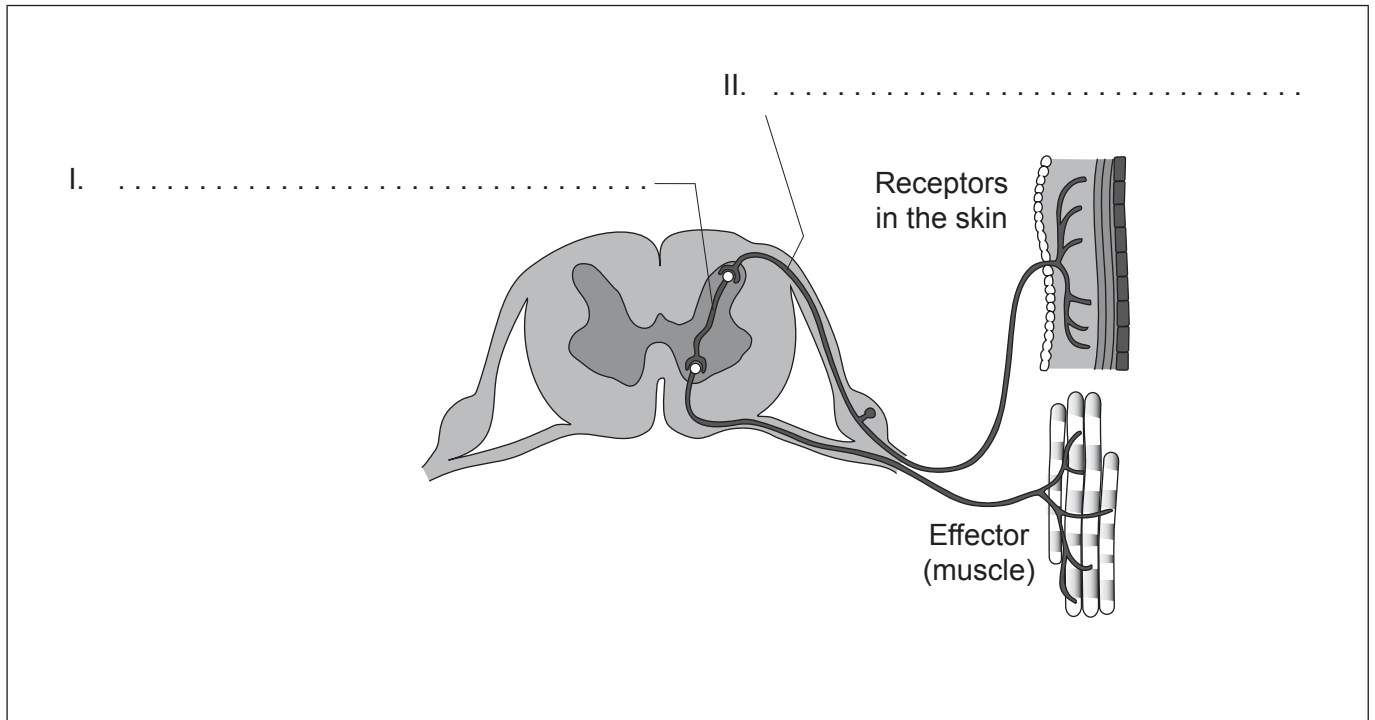
(Option A continues on the following page)



44EP08

(Option A, question 4 continued)

- (b) Label the diagram of the reflex arc with the names of the neurons indicated. [2]



[Source: adapted from <http://image.tutorvista.com>]

- (c) Draw an arrow on the diagram of the reflex arc to show the direction of impulses. [1]

(Option A continues on the following page)



44EP09

Turn over

(Option A continued)

5. The scatter graph shows the relationship between brain mass and body mass for a number of animals. Some representative animals are indicated while the dotted line represents the range of values seen for a much larger group of animals.

Graph removed for copyright reasons
Please go to: <http://cr2chicago.weebly.com/with-every-drop/behavior-and-social-interaction-in-a-wet-world-part-ii-whale-vocalizations-and-communication>

- (a) State the relationship between body mass and brain mass. [1]

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- (b) Identify the animal with the lowest brain mass. [1]

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(Option A continues on the following page)



(Option A, question 5 continued)

- (c) Discuss the evidence provided by the scatter graph for the hypothesis that humans have the largest relative brain mass to body mass ratio.

[3]

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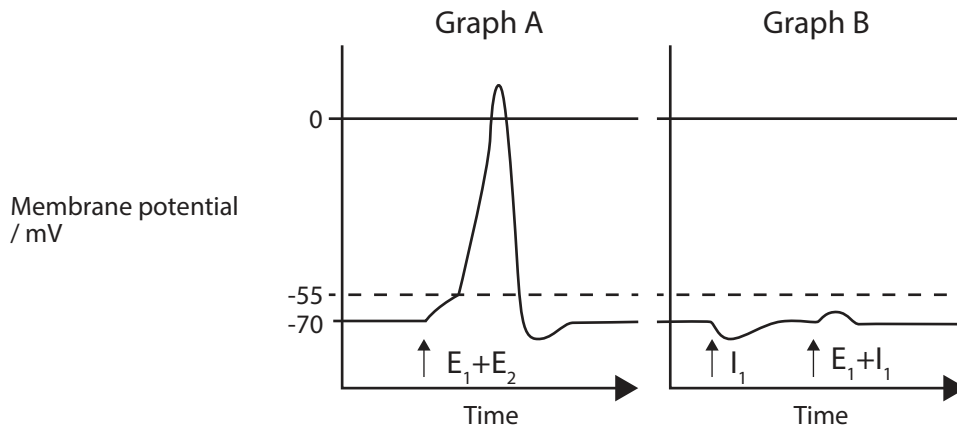


44EP11

Turn over

(Option A continued)

6. The graphs compare the changes in membrane potential that result from a combination of stimuli. Graph A shows two excitatory post-synaptic potentials (E_1 and E_2) acting on a neuron. Graph B shows one excitatory (E_1) and one inhibitory (I_1) post-synaptic potential, both acting on a neuron.



[Source: © International Baccalaureate Organization 2016]

With respect to the graphs, explain what is meant by summation.

[3]

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(Option A continues on the following page)



44EP12

(Option A continued)

7. (a) With respect to Pavlov's experiments with dogs, distinguish between the conditioned and unconditioned stimulus. [3]

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- (b) The bird known as the blackcap (*Sylvia atricapilla*) traditionally migrates from its summer breeding grounds in Central Europe to Spain and Portugal for the winter. State **two** adaptive advantages of bird migration. [2]

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- (c) Outline **one** way in which synchronized oestrus in female lions increases the chances of survival and reproduction of offspring. [2]

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(Option A continues on the following page)



44EP13

Turn over

(Option A, question 7 continued)

(d) Outline **one** way in which neurons can be altered by memory and learning. [2]

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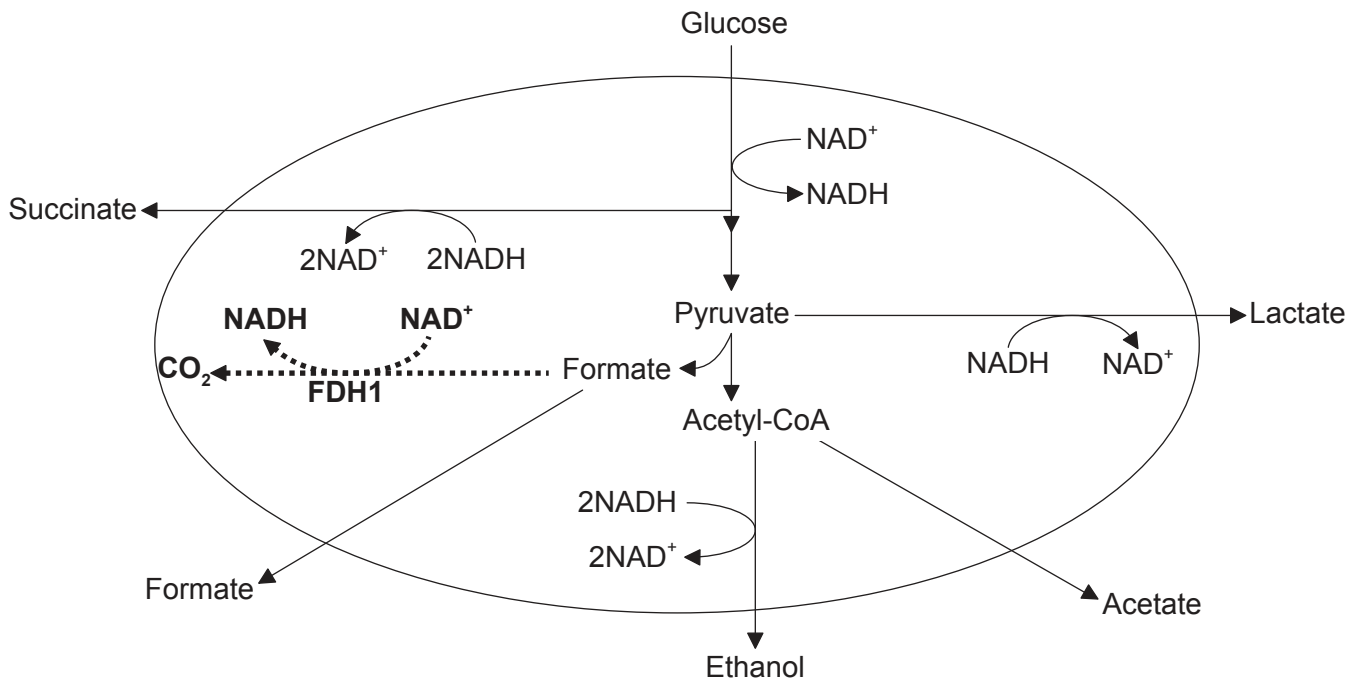
(Option A continues on the following page)



44EP14

Option B — Biotechnology and bioinformatics

9. Succinate is industrially produced by continuous fermentation. It is used as a raw material in the production of flavour enhancers, drugs and industrial chemicals. One method of increasing the production of succinate is to genetically modify *E. coli* to express high levels of formate dehydrogenase (FDH1). This results in the production of higher concentrations of NADH. The engineered pathway is shown as a bold dotted line in the image.



[Source: Ka-Yiu San, E. D. Butcher Professor of Bioengineering, Professor of Chemical Engineering, Rice University.]

- (a) Using the diagram, suggest a reason for high concentrations of NADH favouring the production of succinate.

[1]

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(Option B continues on the following page)



44EP16

(Option B, question 9 continued)

- (b) Predict **one** metabolite other than succinate that will be produced in greater amounts if the amount of NADH available is increased. [1]

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- (c) Outline the process of continuous culture fermentation. [2]

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- (d) Outline **one** reason this process, to increase the production of succinate, represents pathway engineering. [1]

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(Option B continues on the following page)

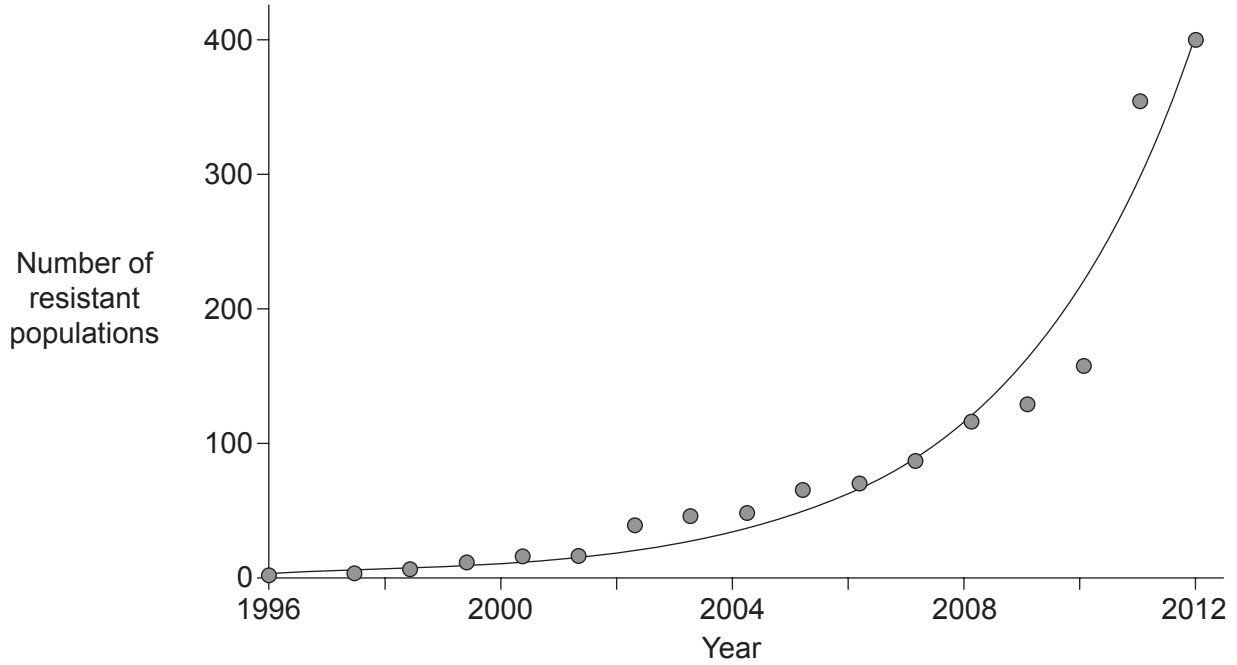


44EP17

Turn over

(Option B continued)

10. Annual ryegrass (*Lolium rigidum*) is a weed species that has been successfully controlled by the application of the herbicide glyphosate. The graph shows the number of confirmed cases of glyphosate resistant ryegrass across Australia between 1996–2012.



[Source: adapted from www.grdc.com.au]

(a) (i) Outline the pattern of change in resistant populations of ryegrass over time in Australia.

[1]

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(ii) Suggest **one** reason for the pattern.

[1]

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(Option B continues on the following page)



44EP18

(Option B, question 10 continued)

(b) State **two** environmental benefits from the use of genetically modified glyphosate resistant soybeans.

[2]

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(c) Explain the role of the *Agrobacterium tumefaciens* Ti plasmid in genetic modification.

[3]

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(Option B continues on page 21)



44EP19

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44EP20

(Option B continued from page 19)

11. The dye Reactive Black 5 (RB5) is widely used for dyeing in textile industries. Removal of the dye from factory waste-water is important not only for aesthetic reasons but also because the dye can lead to mutations that may lead to cancer. *Paenibacillus* is a bacterium that can metabolize the dye.

(a) Suggest **one** way in which organisms such as *Paenibacillus* metabolize toxic substances.

[1]

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(b) The decontamination system for the removal of the dye uses a surface to which *Paenibacillus* can attach. Suggest **one** advantage of providing a surface for attachment.

[1]

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(c) Outline another **named** example of a microorganism used in bioremediation.

[3]

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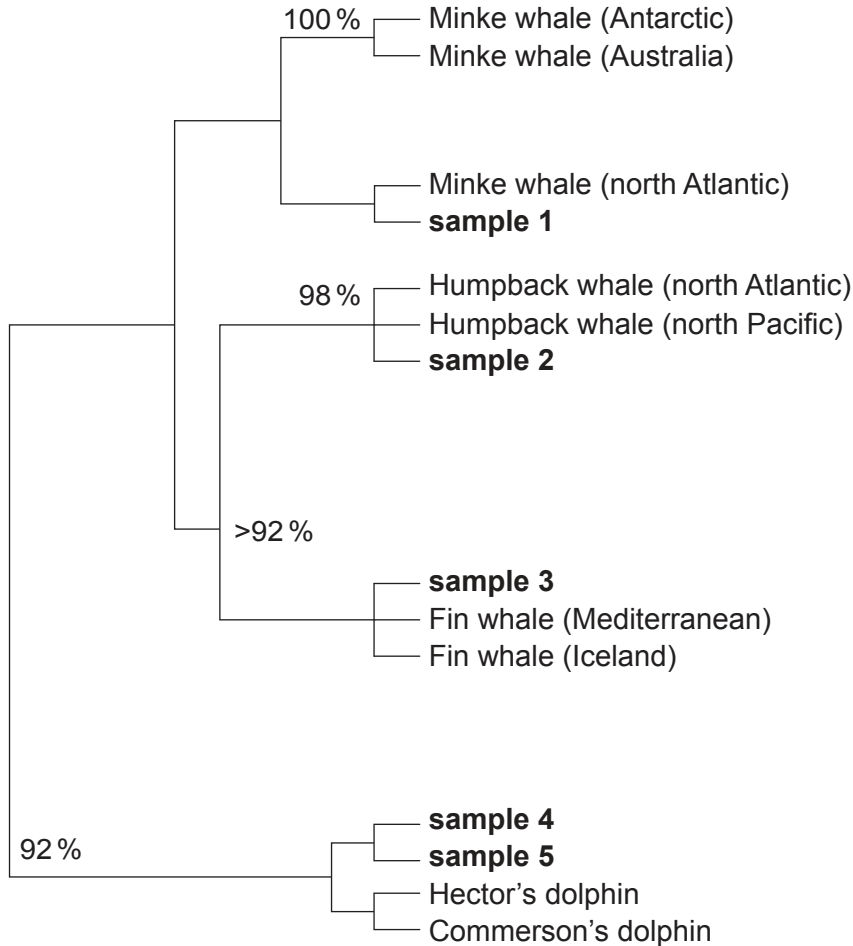


44EP21

Turn over

(Option B continued)

12. International agreement limits the hunting of whales. Only the meat of the Minke, Fin and Humpback whales from Southern Hemisphere populations is allowed to be sold on the domestic market in Japan. Scientists obtained five samples of food that were being sold as “whale meat” in a Japanese market place. They identified the species and probable geographic origin of the meat using genetic analysis. The results were used to construct the cladogram.



[Source: Adapted from C. S. Baker and S. R. Palumbi (1994), *Science*, 256 (5178), pages 1538–1539. (http://www.soest.hawaii.edu/oceanography/courses_html/OCN331/Baker%26Palumbi.pdf). Reprinted with permission from AAAS. Readers may view, browse, and/or download material for temporary copying purposes only, provided these uses are for noncommercial personal or classroom purposes. Except as provided by law, this material may not be further reproduced, distributed, transmitted, modified, adapted, performed, displayed, published, or sold in whole or in part, without prior written permission from the publisher.]

(a) Using the data in the cladogram, state the reason for sale of Sample 1 meat being illegal in Japan.

[1]

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(Option B continues on the following page)



(Option B, question 12 continued)

(b) Using the data in the cladogram, state the reason for sale of Sample 4 meat being illegal in Japan. [1]

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(c) Outline how the polymerase chain reaction (PCR) might have been used in this study. [3]

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(d) Explain how sequence alignment software might have been used in this study. [2]

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(Option B continues on the following page)



44EP23

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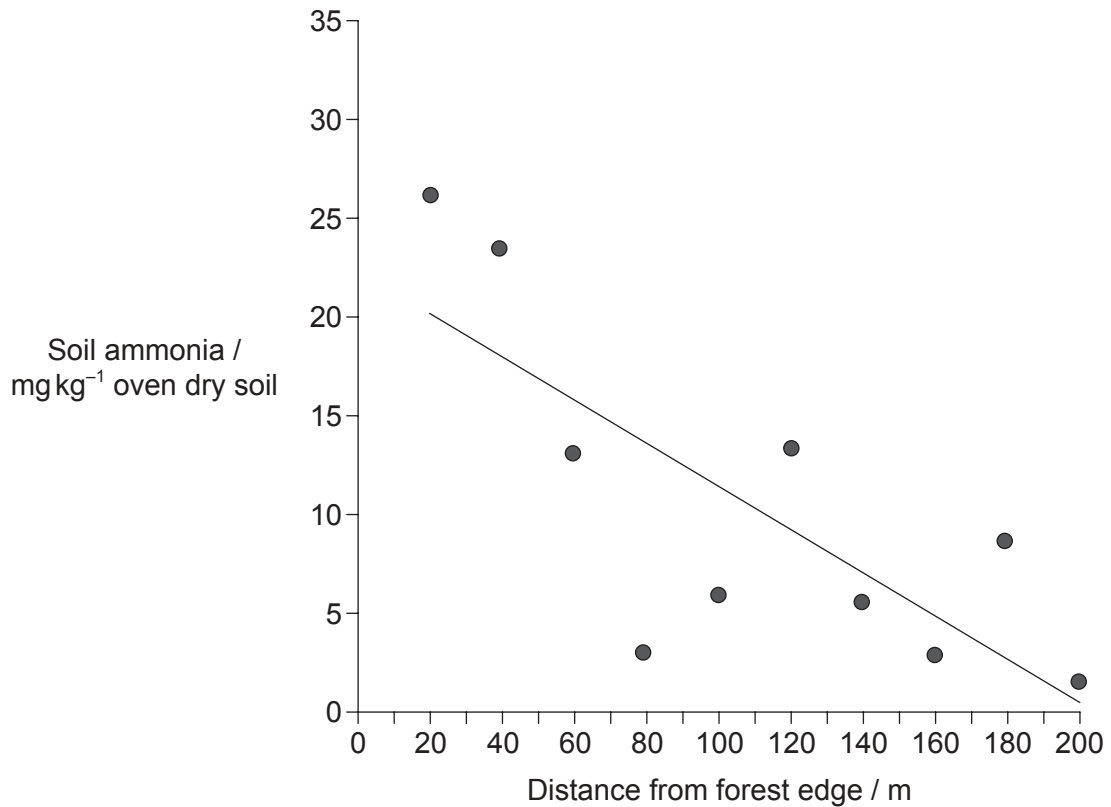


44EP25

Turn over

Option C — Ecology and conservation

14. Where high amounts of ammonium ions are present in agricultural areas, gaseous ammonia can be released into the atmosphere. This ammonia can dissolve and be carried across distances and then be deposited through precipitation. In a study of the effects of deposition of ammonium in a forest, soil samples were taken starting at the forest edge next to an open field and moving toward the centre of the forest.



[Source: "Spatial variations of nitrogen deposition and its effect on forest biochemical processes", M. A. Sutton *et al.* Crown Copyright, courtesy Forestry Commission, licensed under the Open Government Licence. <http://www.forestry.gov.uk/fr/INFD-75PJ9E#sutton2001> (accessed May 2016).]

(a) Outline the procedure that was most likely used by the researchers to decide where to take the samples. [2]

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(Option C continues on the following page)



(Option C, question 14 continued)

- (b) List **two** sources of the ammonium in the forest soils apart from deposition in rainfall. [2]

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- (c) Suggest **one** reason for ammonium levels in the interior of the forest being lower than the soil ammonium close to the edge. [1]

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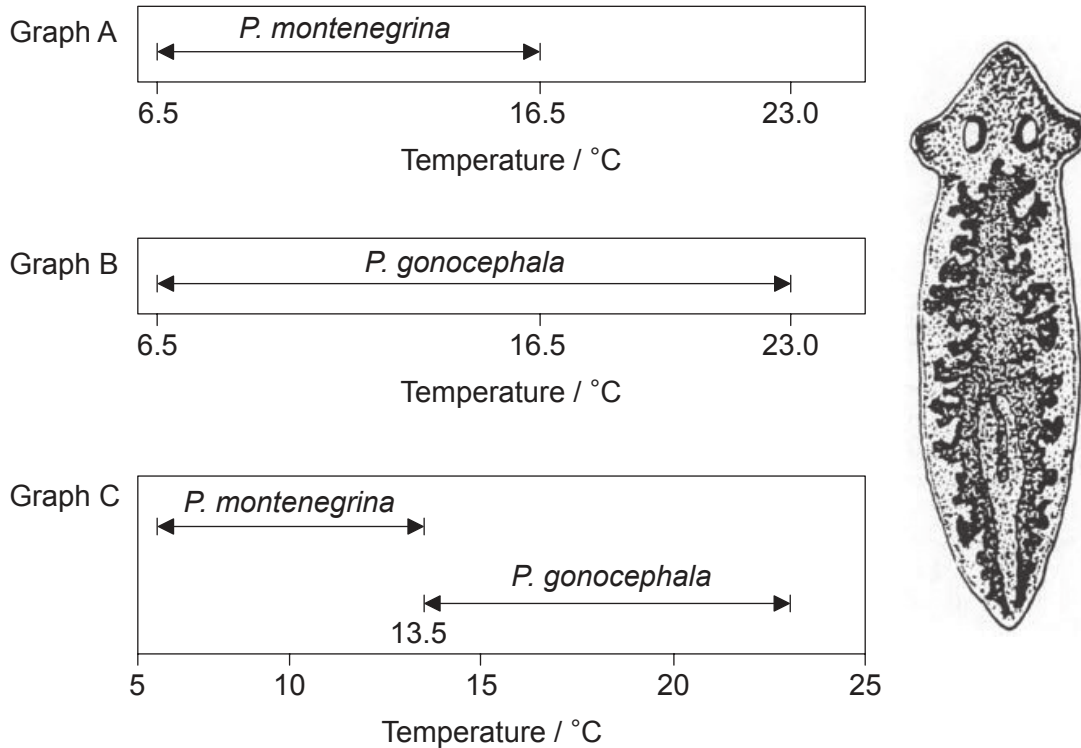


44EP27

Turn over

(Option C continued)

15. The figure shows the distribution of two species of freshwater flatworms, *Planaria gonocephala* and *Planaria montenegrina*, over a range of stream temperatures. Graph A and graph B show the distributions when each species is separate from the other. Graph C shows the distribution when they are found living together.



[Source: R. J. Putman (1994) *Community Ecology*, page 63. © Kluwer Academic Publishers Boston. Used with permission.]

- (a) Using graph A and graph B, compare and contrast the temperature ranges of the two species when they are found separately.

[2]

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(Option C continues on the following page)



44EP28

(Option C, question 15 continued)

- (b) Explain, with respect to the example of *P. montenegrina*, what is meant by realized niche.

[2]

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(Option C continues on the following page)

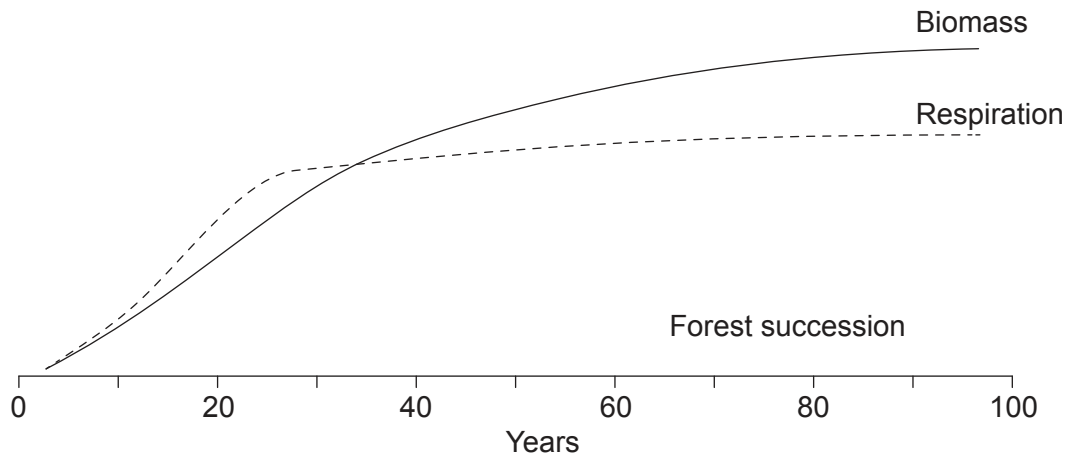


44EP29

Turn over

(Option C continued)

16. The graph is a model showing biomass and respiration levels in a field where farming stops at time zero and the abandoned land develops into forest.



[Source: From "The Strategy of Ecosystem Development" by Eugene P. Odum. *Science*, 18 Apr 1969: Vol. 164, Issue 3877, pp. 262-270. Reprinted with permission from AAAS.]

- (a) Describe the change in biomass over the 100 year period. [2]

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- (b) Outline the evidence from the graph that the area had plentiful rainfall. [2]

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(Option C continues on the following page)



44EP30

(Option C, question 16 continued)

(c) Explain the changes in biomass.

[2]

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(d) Explain why biomass continues to increase after the respiration levels plateau.

[2]

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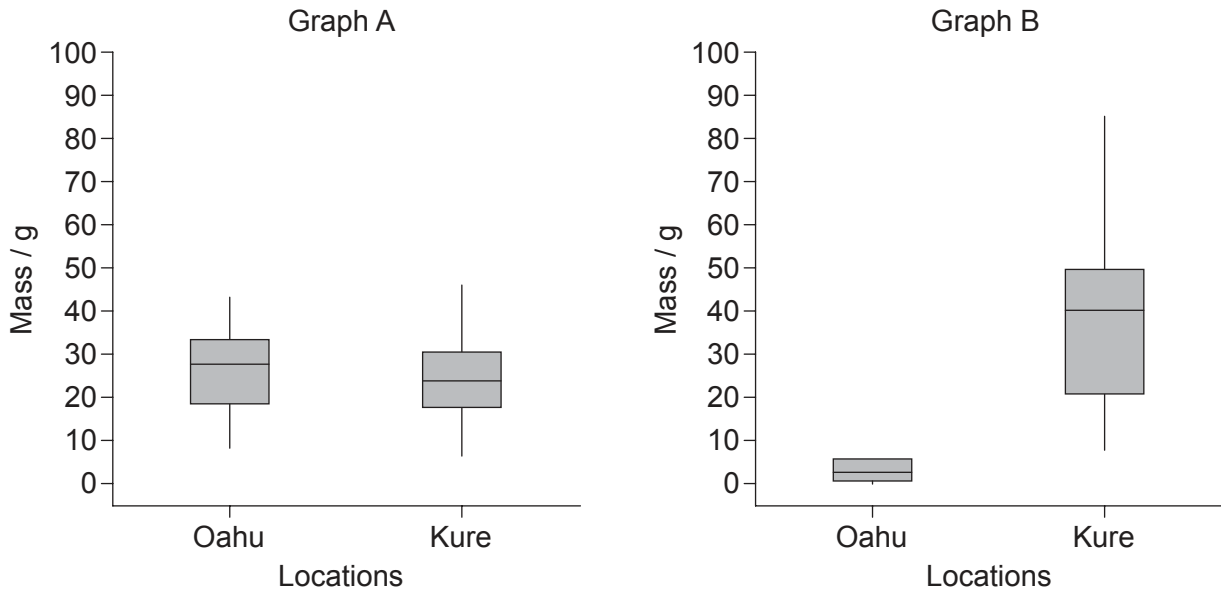


44EP31

Turn over

(Option C continued)

17. The Laysan Albatross (*Phoebastria immutabilis*) sometimes ingests plastic. A bolus is a pellet made of material that the albatross cannot digest, so brings it back up from its stomach to its mouth and then ejects the indigestible matter. Graph A indicates the mass of indigestible natural material, such as bones and octopus beaks, in the bolus of birds at two different locations. Graph B indicates the mass of plastic in the bolus at both locations.



[Source: Young LC, Vanderlip C, Duffy DC, Afanasyev V, Shaffer SA (2009) Bringing Home the Trash: Do Colony-Based Differences in Foraging Distribution Lead to Increased Plastic Ingestion in Laysan Albatrosses? *PLoS ONE* 4(10): e7623. doi:10.1371/journal.pone.0007623]

(a) Suggest **one** reason for the Laysan Albatross ingesting indigestible plastic. [1]

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(b) Suggest a reason for the difference in ingested plastic in the diets of the Laysan Albatross in the **two** locations. [2]

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(Option C continues on the following page)



44EP32

(Option C, question 17 continued)

(c) Outline the origin of microplastic debris in the marine environment. [2]

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(d) Using microplastics as an example, outline the concept of biomagnification. [2]

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(Option C continues on the following page)



44EP33

Turn over

Option D — Human physiology

19. The table summarizes the relative content of essential amino acids in different foods. Cysteine and tyrosine are classified as being “conditionally essential”. The quantity of each amino acid in a hen egg is set as 1.0 and all other values are relative to the hen egg standard.

	Hen egg	Human milk	Cow milk
Isoleucine	1.0	1.1	1.1
Leucine	1.0	1.4	1.3
Valine	1.0	1.0	1.0
Threonine	1.0	1.0	0.9
Methionine and Cysteine	1.0	1.1	0.7
Tryptophan	1.0	1.6	1.3
Lysine	1.0	1.0	1.3
Phenylalanine and Tyrosine	1.0	1.0	0.9
Histidine	1.0	0.9	1.1

[Source: Data obtained from Robert McGilvery, *Biochemistry: A Functional Approach*, 1970, W. B. Saunders.]

(a) Outline what is meant by the term essential amino acid.

[2]

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(Option D continues on the following page)

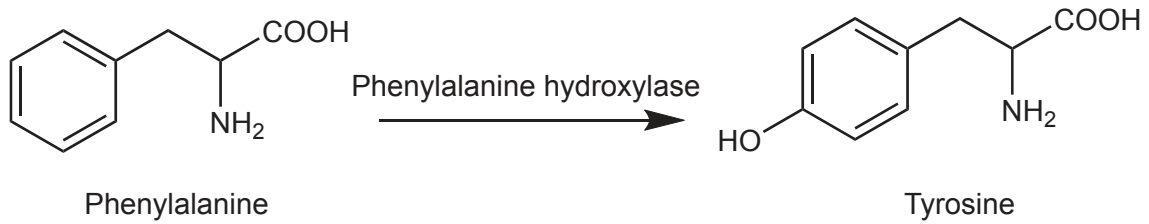


44EP35

Turn over

(Option D, question 19 continued)

(b) Phenylalanine is converted to tyrosine by the enzyme phenylalanine hydroxylase.



(i) Deduce the reason that tyrosine is considered to be a conditionally essential amino acid. [1]

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(ii) When infants with the condition phenylketonuria (PKU) are left untreated, they have a build-up of phenylalanine in the blood and high levels of phenylalanine in the urine. State the cause of this condition. [1]

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(c) Evaluate human milk as an overall source of essential amino acids. [2]

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(Option D continues on the following page)



44EP36

(Option D, question 19 continued)

(d) Outline the control of milk secretion by oxytocin and prolactin.

[3]

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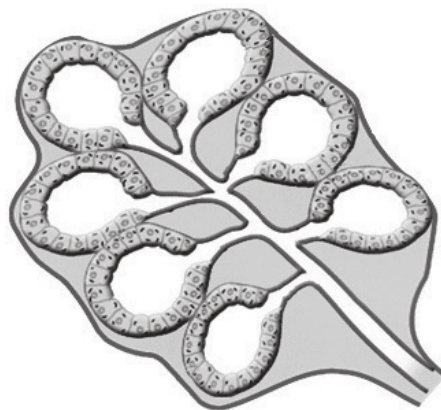
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(e) The diagram represents a lobule from a mammary gland. The mammary gland is an example of an exocrine gland.



[Source: Luis A Bate, Professor of Physiology and Ethology, University of Prince Edward Island. Used with permission.]

Identify **two** features of an exocrine gland visible in the diagram.

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(Option D continues on the following page)

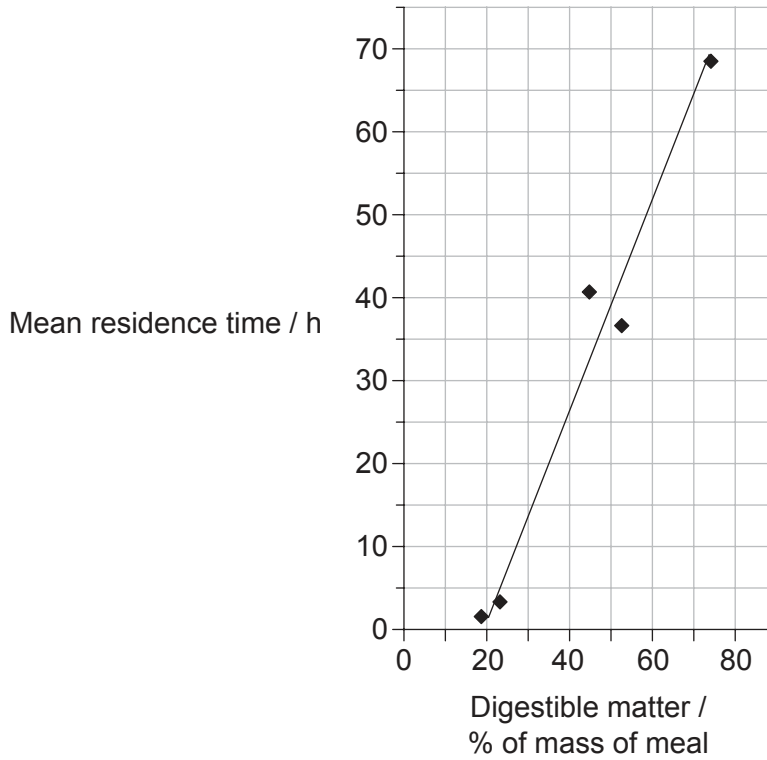


44EP37

Turn over

(Option D continued)

20. The graph shows the length of time that the content of a meal takes to pass through the gut as a function of digestible matter content. The more digestible matter present in the meal, the lower the dietary fibre content.



[Source: © International Baccalaureate Organization 2016]

- (a) Estimate the mean residence time of a meal with 50 % digestible matter.

[1]

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(Option D continues on the following page)



44EP38

(Option D, question 20 continued)

- (b) Explain the relationship between percentage of digestible matter and mean residence time.

[3]

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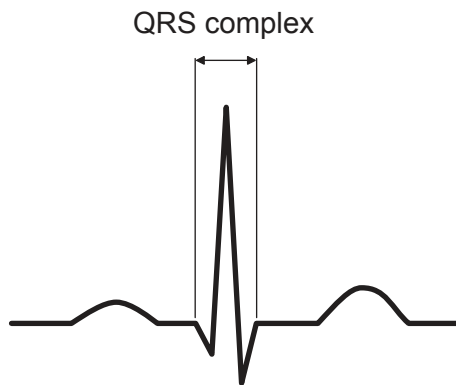


44EP39

Turn over

(Option D continued)

21. The diagram shows an ECG trace with the QRS complex indicated.



(a) Outline the events of the cardiac cycle that are occurring during this QRS interval. [2]

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(b) Heart rate is affected by the hormone epinephrine. The action of epinephrine is mediated by a chemical called a second messenger. Explain the mechanism of action of a second messenger. [3]

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(Option D continues on the following page)



(Option D, question 21 continued)

- (c) During cardiac arrest, the ventricles of the heart might begin to contract in an uncoordinated fashion. Outline the treatment used for this condition. [1]

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- (d) Explain the role of chemoreceptors in the regulation of ventilation rate. [3]

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44EP41

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44EP44