Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 3

Friday 10 May 2019 (morning)

Candidate session number

1 hour

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 – 11
Option C — Ecology and conservation	12 – 15
Option D — Human physiology	16 – 19

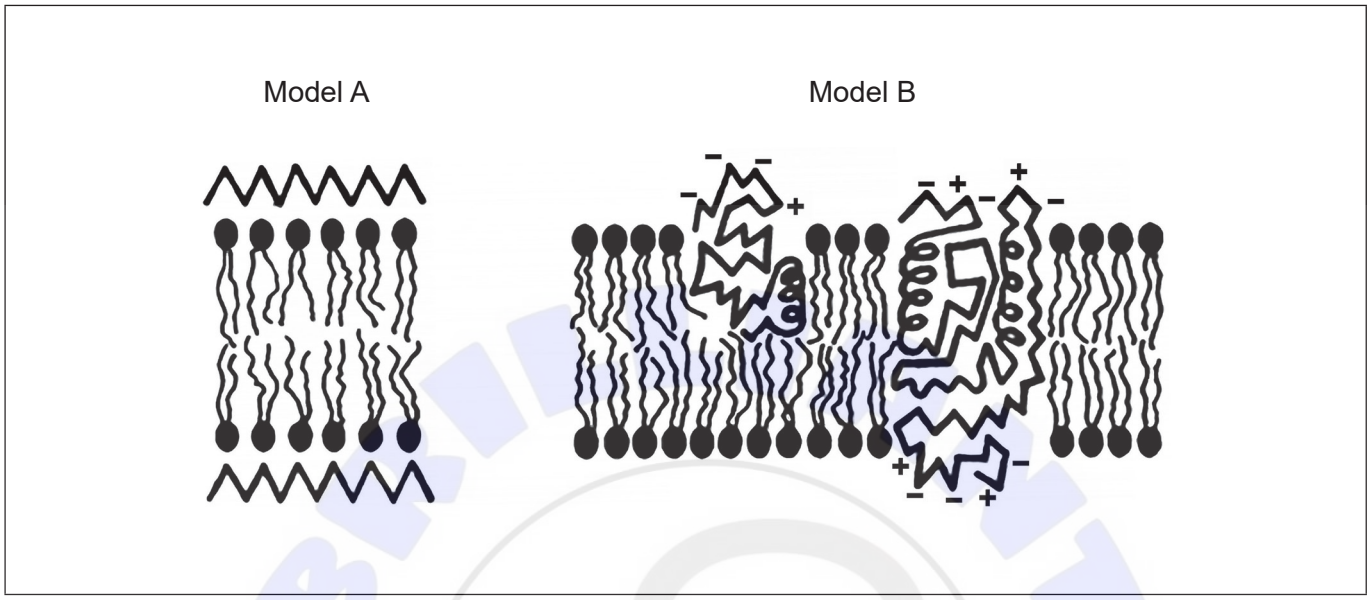
2219 – 6018

31 pages

Section A

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

1. Two models of plasma membrane structure are shown.



[Source: diagram from article published in *The American Journal of Pathology*, **65**, J Singer and G Nicolson, The structure and chemistry of mammalian cell membranes, 427–437, Copyright Elsevier (1971)]

(a) State the scientists who proposed model A. [1]

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(b) (i) Label the model A diagram to show a region of protein. [1]

(ii) Label the model B diagram to show a phospholipid. [1]

(This question continues on the following page)

(Question 1 continued)

(c) Phospholipase C is an enzyme that digests the polar heads of phospholipids. Scientists used phospholipase C to test these models of membrane structure. They found that the enzyme could digest the heads of phospholipids in the plasma membranes of red blood cells.

(i) Deduce **one** conclusion about the structure of the plasma membrane reached by the scientists from their results. [1]

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(ii) Suggest **one** reason for maintaining a pH of 7.5 throughout the experiment. [2]

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(d) State **one** technological improvement, other than enzymatic digestion, that led to the falsification of previous models to determine the current model of membrane structure. [1]

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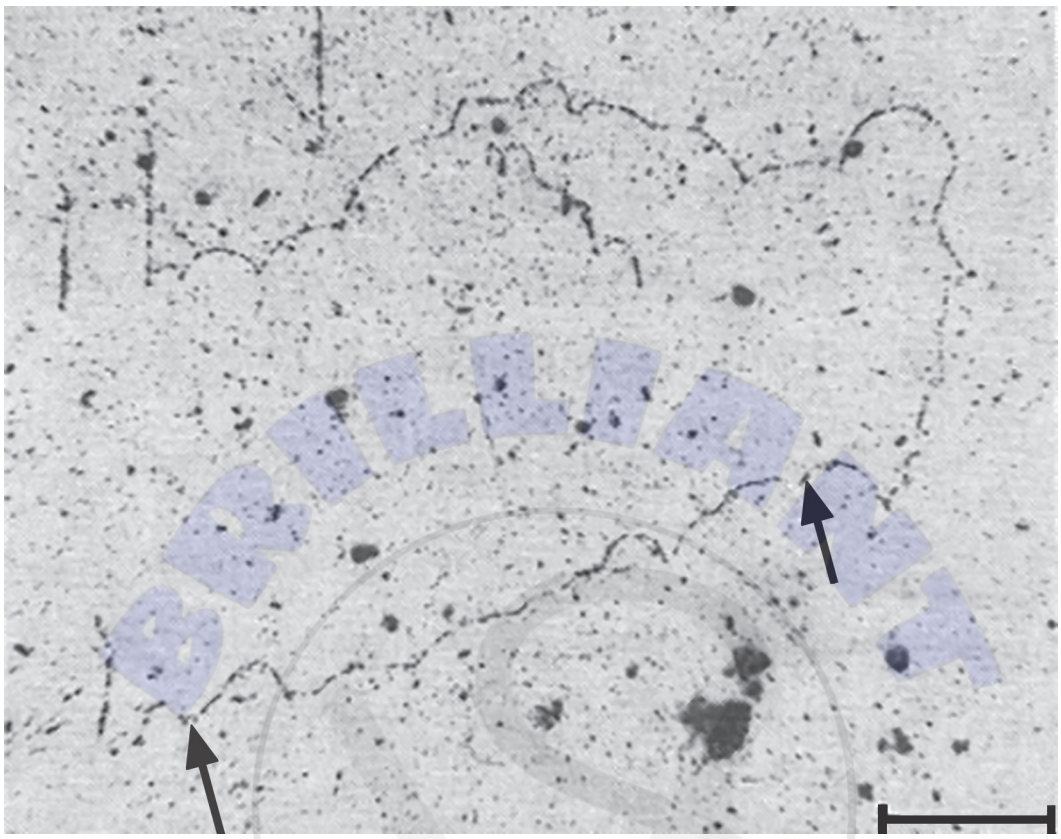
will not be marked.

2. Cairns' technique was used in an experiment to measure the length of DNA in the Chinese hamster (*Cricetulus griseus*). Fibroblast cells were grown with radioactive nucleotides. The DNA autoradiogram obtained is shown.



[Source: © Joel A. Huberman and Arthur D. Riggs]

(a) Estimate the length of the molecule of DNA shown in the autoradiogram between the two arrows. [1]

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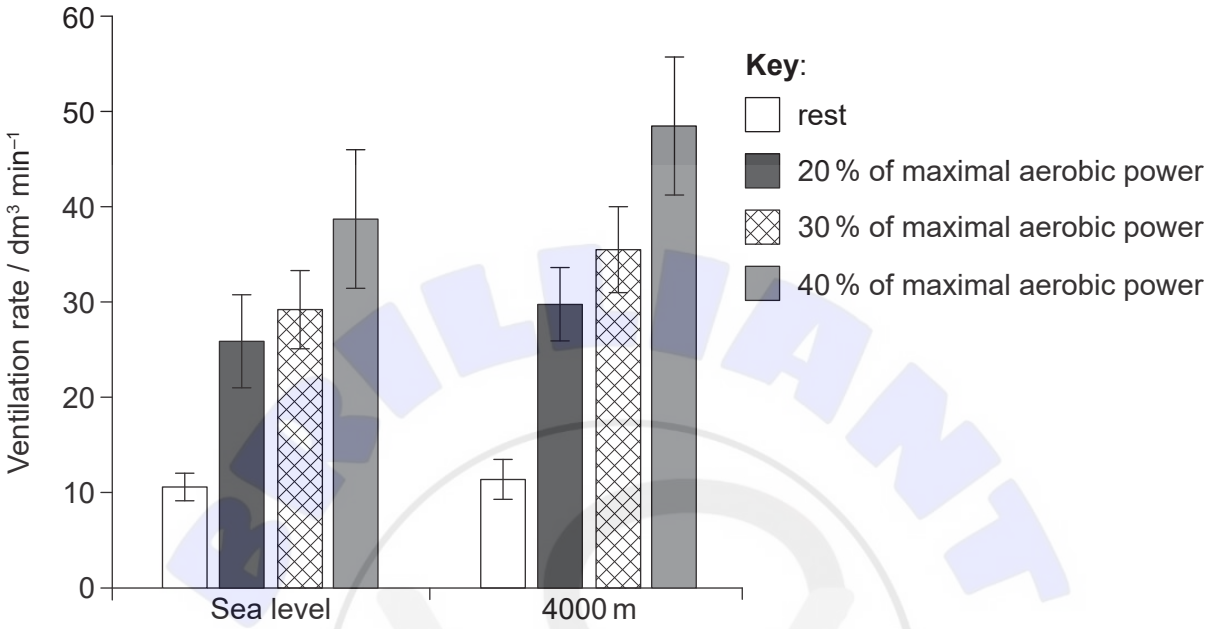
(b) Determine, with a reason, the nucleotide base that was marked with radioactivity. [2]

Base: . . . . . .

Reason: . . . . . .

3. A study was conducted on 25 healthy, non-smoking males to look at the effect of exercise and altitude on ventilation rate. Subjects were first asked to rest in a sitting position for six minutes. They then pedalled for three periods of six minutes at increasing exercise intensity: at 20 %, 30 % and 40 % of their maximal aerobic power. The entire study was conducted either in normal sea level oxygen conditions or in lower oxygen conditions simulating an altitude of 4000 m. The results are shown in the bar chart.



[Source: E Hermand, *et al.*, (2015), Periodic breathing in healthy humans at exercise in hypoxia, *Journal of Applied Physiology*, **118**, pages 115–123. https://doi.org/10.1152/japplphysiol.00832.2014]

(a) State **one** other variable that should have been controlled in this study. [1]

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(b) Compare and contrast the effect of increasing exercise intensity at sea level and at an altitude of 4000 m. [2]

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(This question continues on the following page)

(Question 3 continued)

(c) Outline how ventilation rate could have been monitored in this study. [2]

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Section B

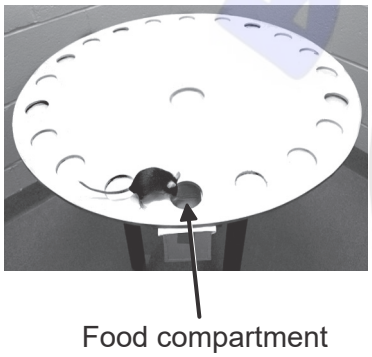
Answer **all** of the questions from **one** of the options. Answers must be written within the answer boxes provided.

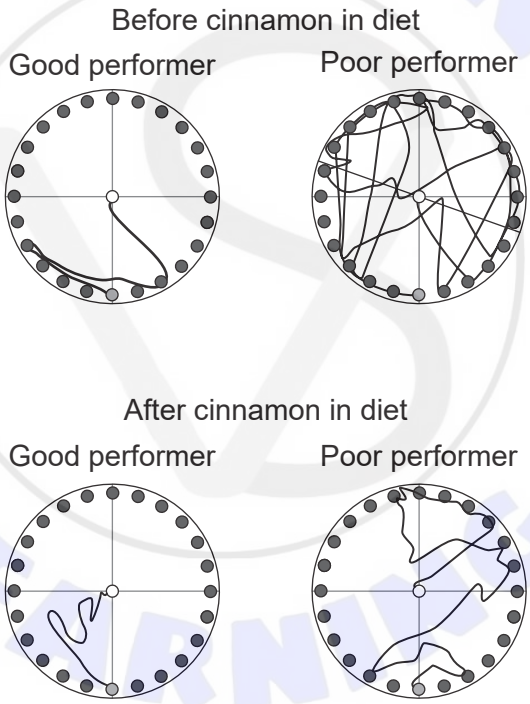
Option A — Neurobiology and behaviour

4. The performance of mice on a Barnes maze, shown in the photograph, was used to test the effect of cinnamon on learning.

Mice were trained for three days to find a compartment in the maze containing food. Their ability to find the compartment was tested by placing the mice at the centre and recording their movement. The mice were divided into two groups according to the route taken: good performers and poor performers. After this all the mice were fed a small amount of cinnamon in their diet for 30 days. They were then trained for three days and retested on the maze.

The diagrams show the movements of a typical good performer and a typical poor performer before and after cinnamon was included in their diet.





Key:
- ○ starting position
- ● wrong hole
- ● correct hole

[Source: reprinted by permission from: Springer Natures, *Journal of NeuroImmune Pharmacology*, Cinnamon Converts Poor Learning Mice to Good Learners: Implications for Memory Improvement, Khushbu K.Modi *et al*, copyright 2016]

(Option A continues on the following page)

(Option A, question 4 continued)

(a) Describe how the use of cinnamon changes mouse performance on the Barnes maze. [2]

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(b) Scientists demonstrated that cinnamon increased neural plasticity in some parts of mouse brains. Explain how neural plasticity could have affected learning in poor performer mice. [3]

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(c) It has been suggested that cinnamon might be of benefit to patients who are recovering from a stroke. Suggest **one** advantage of adding cinnamon to the diet of a patient who has suffered a stroke. [1]

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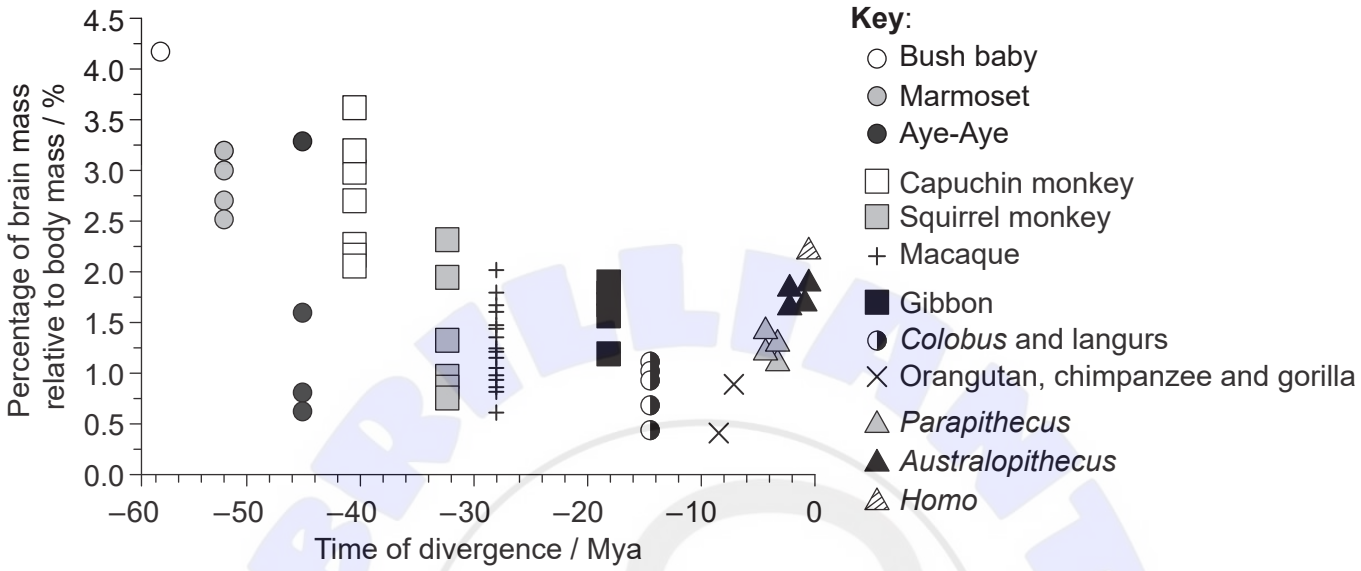
(Option A continues on the following page)

(Option A continued)

5. Scientists investigated how relative brain mass varied in primate evolution. The graph shows the relative brain mass for species belonging to different primate groups against time of divergence from the common ancestor of modern humans in million years ago (Mya), 0 being the present era.



[Source: S Herculano-Houzel and J H Kaas, (2011), *Brain, Behavior and Evolution*, **77**, pages 33–44.
© 2011 Karger Publishers, Basel, Switzerland]

(a) State the trend in relative brain mass in primates other than humans according to their time of divergence from humans. [1]

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(b) Suggest **one** reason that the relative brain mass of *Homo* is different from *Parapithecus* and *Australopithecus*. [1]

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(Option A continues on the following page)

(Option A, question 5 continued)

(c) Deduce, with a reason, whether the relative brain mass is a good indicator of brain development. [1]

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(d) Primates belong to the phylum chordata. The neural tube of chordates is formed by the infolding of the ectoderm followed by the elongation of the tube. Outline the process of formation of neurons from this neural tube in primates. [2]

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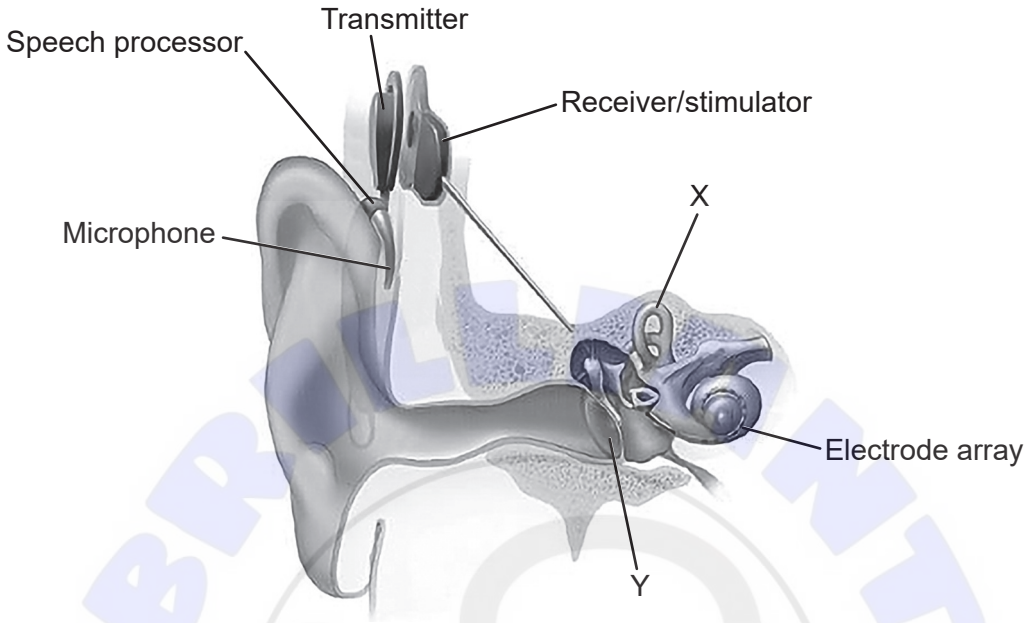
(Option A continues on the following page)

(Option A continued)

6. Hearing loss can range from mild to severe. Cochlear implants have been used in those with profound hearing loss such as children who are born deaf. The image shows a cross section of the ear with a cochlear implant.



[Source: NIDCD (www.nidcd.nih.gov/health/cochlear-implants)]

(a) Identify the parts of the ear labelled X and Y. [2]

X: . . . . . .

Y: . . . . . .

(b) Describe the use of cochlear implants in deaf patients. [3]

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(Option A continues on the following page)

(Option A continued)

7. Explain the autonomic control of the pupil of the eye and how the pupil reflex is used to determine brain damage. [4]

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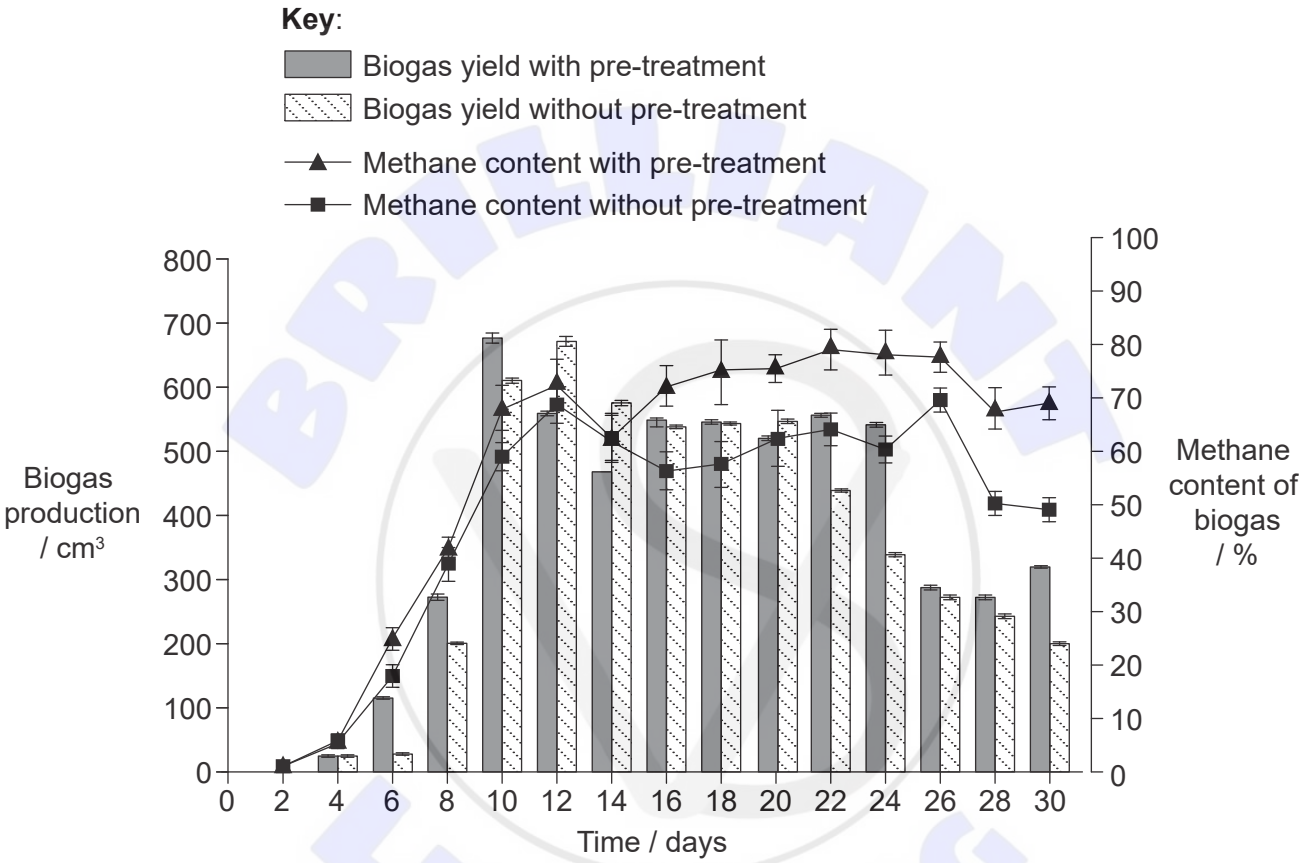
End of Option A

Option B — Biotechnology and bioinformatics

8. Rice straw waste can be used to produce biogas, but it contains cellulose that is difficult to digest. Bacteria capable of digesting cellulose are found in the cow's digestive system. Rice straw waste was pre-treated in a batch fermenter with liquid cow manure. A control was kept under the same conditions without the liquid cow manure.

The resultant products of each culture were placed in two separate continuous biogas fermentation tanks with anaerobic bacteria for 30 days under the same conditions. The graph shows the differences in biogas production and amount of methane produced.



[Source: reprinted from *Bioresource Technology*, **111**, Lei Yan *et al*, Diversity of a mesophilic lignocellulolytic microbial consortium which is useful for enhancement of biogas production, 49–54, Copyright 2012, with permission from Elsevier]

(a) Suggest reasons for the use of a batch culture for the first fermentation and a continuous fermenter for the second fermentation. [2]

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(Option B continues on the following page)

(Option B, question 8 continued)

(b) Using the graph, explain the trend in biogas production over time in the fermenter without pre-treatment. [3]

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(c) Suggest **one** reason for the higher methane content in biogas in pre-treated rice straw waste. [1]

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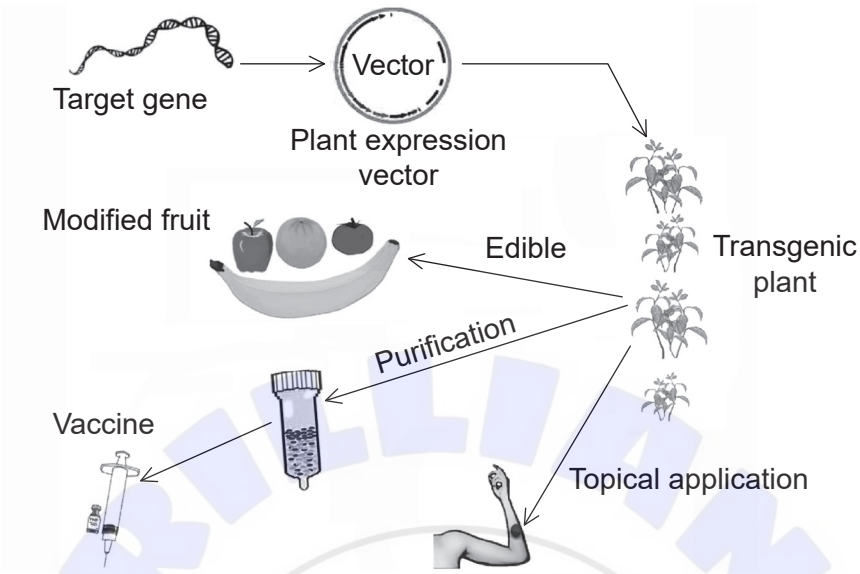
(Option B continues on the following page)

(Option B continued)

9. The diagram shows a method of production of transgenic plants and some of their uses.



[Source: Jian Yao, *et al.*, (2015), *International Journal of Molecular Science*, 2015, **16**(12), 28549–28565; https://doi.org/10.3390/ijms161226122]

(a) Outline how the target gene is found using bioinformatics. [2]

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(Option B continues on the following page)

(Option B, question 9 continued)

(b) In this method of producing transgenic plants, state

(i) the name of the vector. [1]

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(ii) how to detect successful uptake of the gene. [1]

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(iii) **one** method used to introduce the vector into a plant. [1]

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(c) Another method of plant transformation can be used to produce the hepatitis B vaccine. Outline the production of hepatitis B vaccine in tobacco plants. [2]

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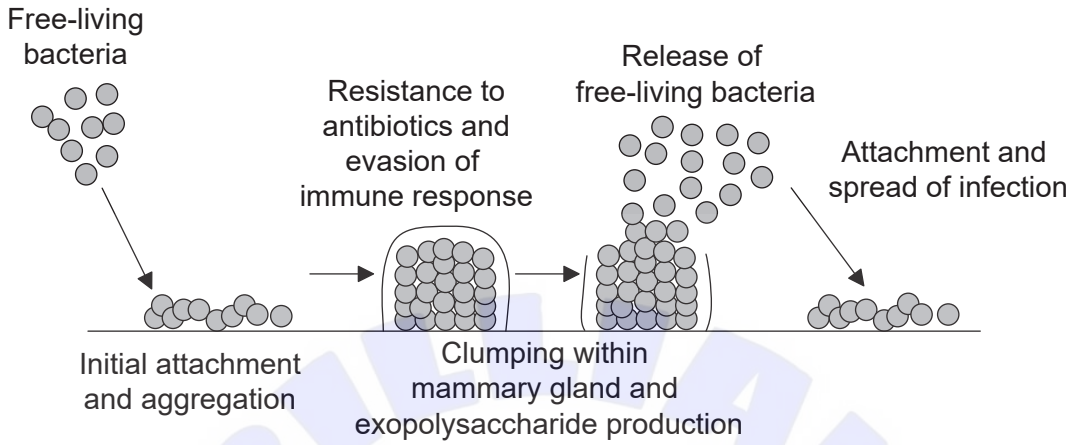
(Option B continues on the following page)

(Option B continued)

10. The diagram shows the formation of a biofilm in a mammary gland, producing a mastitis infection.



[Source: © International Baccalaureate Organization 2019]

(a) Outline the process of quorum sensing in bacteria forming a biofilm. [2]

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(b) Suggest **one** reason, other than quorum sensing, for the resistance to antibiotics of a biofilm. [1]

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(Option B continues on the following page)

(Option B continued)

11. Explain the use of **two named** bacteria in response to pollution incidents. [4]

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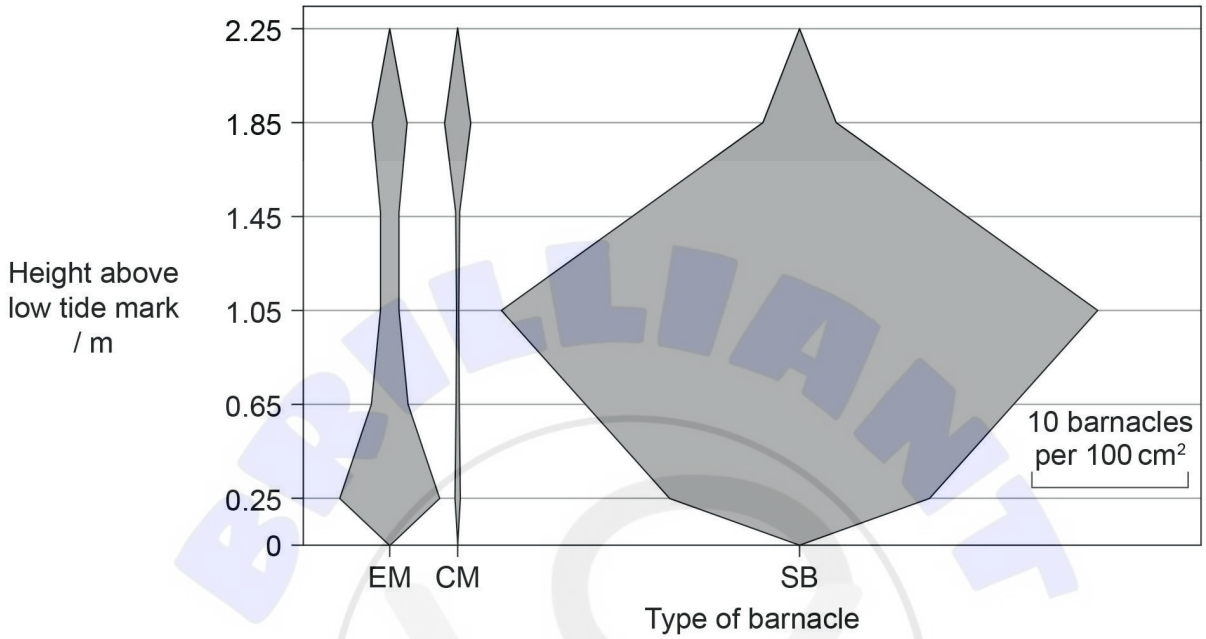
End of Option B

Option C — Ecology and conservation

12. A survey was made of the intertidal zone at Butter Lump Bay, Great Cumbrae, Scotland. The three species of barnacle found were *Elminius modestus* (EM), *Chthamalus montagui* (CM) and *Semibalanus balanoides* (SB). The kite diagram shows the vertical distribution of these three species from the low tide mark at 0 m to 2.25 m above low tide.



[Source: reprinted from *Estuarine Coastal and Shelf Science*, **152**, M C Gallagher, *et al.*, The invasive barnacle species, Austrominius modestus: Its status and competition with indigenous barnacles on the Isle of Cumbrae, Scotland, pages 134–141, 2014 with permission from Elsevier]

(a) Outline how the data could have been obtained. [2]

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(Option C continues on the following page)

(Option C, question 12 continued)

(b) Describe the distribution of *C. montagui* and *S. balanoides* barnacles in Butter Lump Bay. [2]

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(c) *E. modestus* is an invasive barnacle while the others are native species. Analyse the data to show how it supports this statement. [2]

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(d) State **one** abiotic factor that could have determined the distribution of barnacles. [1]

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(e) Barnacles are sensitive to pollution. Outline how it might be possible to use these organisms as indicator species. [2]

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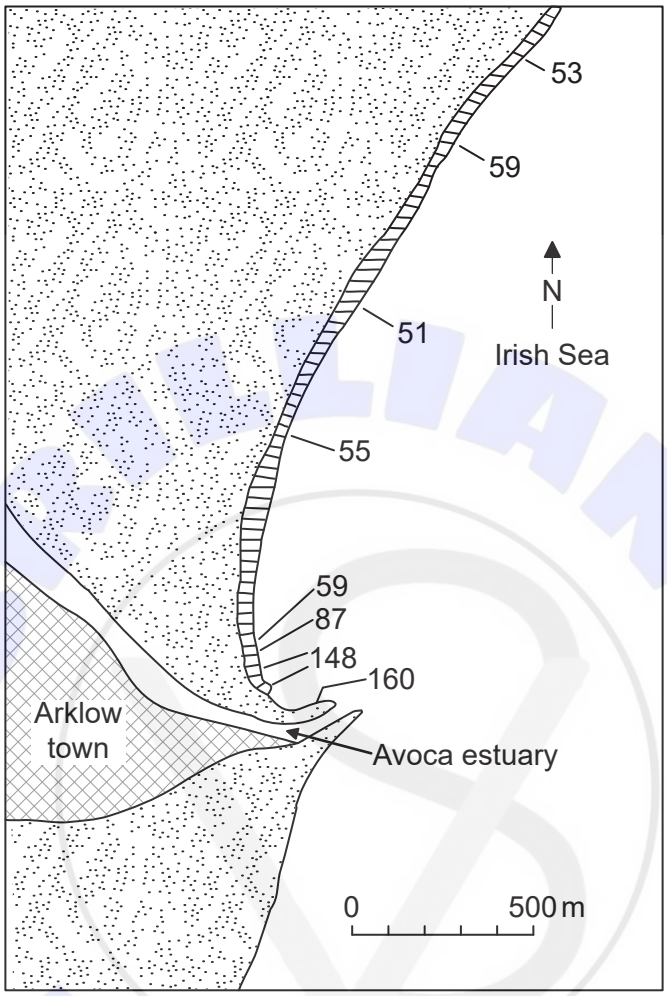
(Option C continues on the following page)

(Option C continued)

13. The diagram shows the copper concentration ($\mu g\ g^{-1}$) in the seaweed *Porphyra umbilicalis* collected along the shoreline in Arklow, Ireland.



[Source: reprinted by permission from Springer Nature: *Helgoländer Meeresuntersuchungen*, Problems in the assessment of heavy-metal levels in estuaries and the formation of a pollution index, D L Tomlinson, *et al.*, **33**, issue 1, pages 566–575. Copyright 1980]

Explain how the copper found in these seaweeds could affect the birds living in Arklow town. [3]

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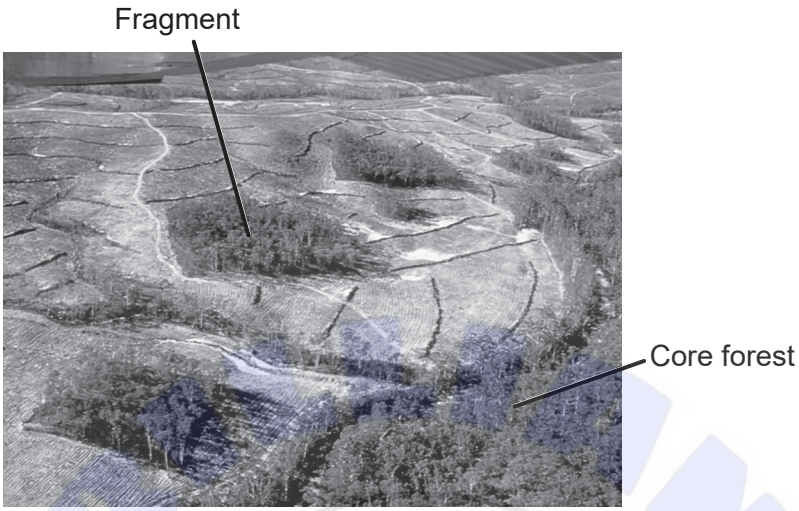
(Option C continues on the following page)

(Option C continued)

14. The photograph shows small, isolated *Eucalyptus* forest fragments in New South Wales, Australia, as part of a long-term experiment on habitat fragmentation.



[Source: Margules, C. (1992). The Wog Wog Habitat Fragmentation Experiment. *Environmental Conservation*, **19**(4), 316–325 © Foundation for Environmental Conservation 1992, published by Cambridge University Press]

(a) State **two** abiotic factors that are increased in the fragmented forest with respect to the centre of the core forest. [2]

1. . . . . .

2. . . . . .

(b) Explain the likely effects on biodiversity if a forest becomes fragmented. [2]

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(Option C continues on page 25)

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will not be marked.

(Option C continued)

15. Explain how food conversion ratios in livestock affect the amount of food for human consumption. [4]

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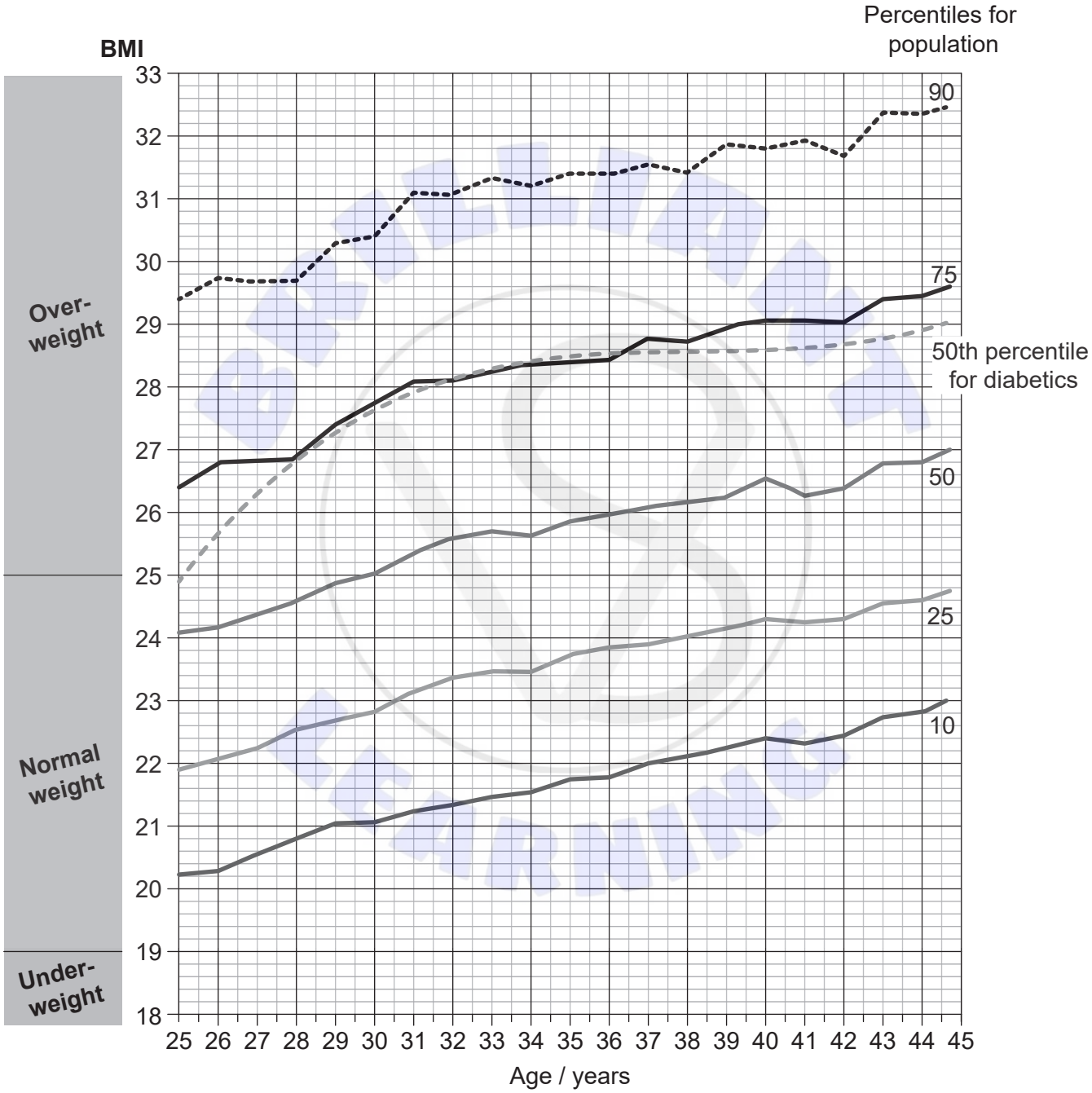
End of Option C

Option D — Human physiology

16. Body mass index (BMI) was calculated for 37 674 men over 20 years of their life, between the ages of 25 and 45. Percentile BMI values were then determined for each age and plotted on the graph. For example, along the 75th percentile, 75 % of the population at a given age will have a BMI lower than the BMI indicated by the graph and 25 % of the population will have a higher BMI. The graph also shows the 50th percentile BMI curves for the men in this study who developed diabetes.



[Source: *The New England Journal of Medicine*, A Tirosh, *et al.*, Adolescent BMI Trajectory and Risk of Diabetes versus Coronary Disease, **364** pages 1315–1325 © 2011 Massachusetts Medical Society. Reprinted with permission from Massachusetts Medical Society.]

(Option D continues on the following page)

(Option D, question 16 continued)

(a) State the relationship between BMI and age in men. [1]

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(b) Evaluate the data to assess whether a high BMI is a risk factor for the development of diabetes. [2]

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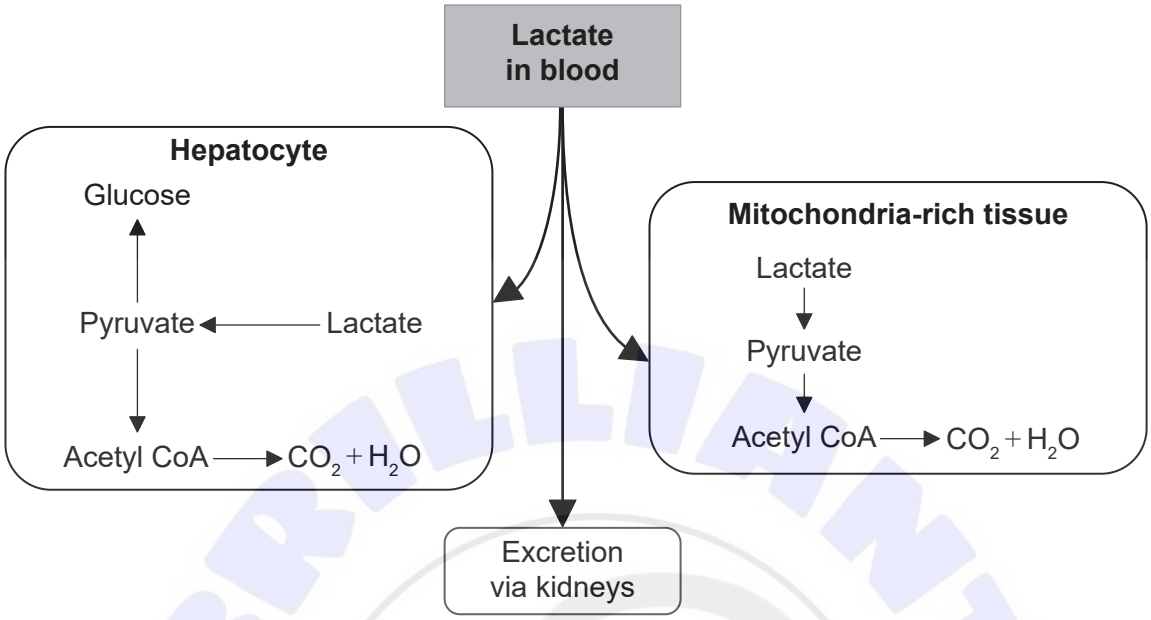
(Option D continues on the following page)

(Option D continued)

17. The diagram shows metabolic pathways for lactate in humans.



[Source: © International Baccalaureate Organization 2019]

(a) State the name of the blood vessel through which lactate from muscles reaches the liver. [1]

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(b) Compare and contrast the possible metabolic pathways for lactate in hepatocytes and in mitochondria-rich tissue. [2]

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(c) List **two** functions of hepatocytes other than regulating lactate levels in the blood. [2]

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2. . . . . .

(Option D continues on the following page)

(Option D continued)

18. (a) Describe the structure of cardiac muscle cells. [2]

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(b) State the name of the valves that prevent blood flowing from the arteries back into the heart. [1]

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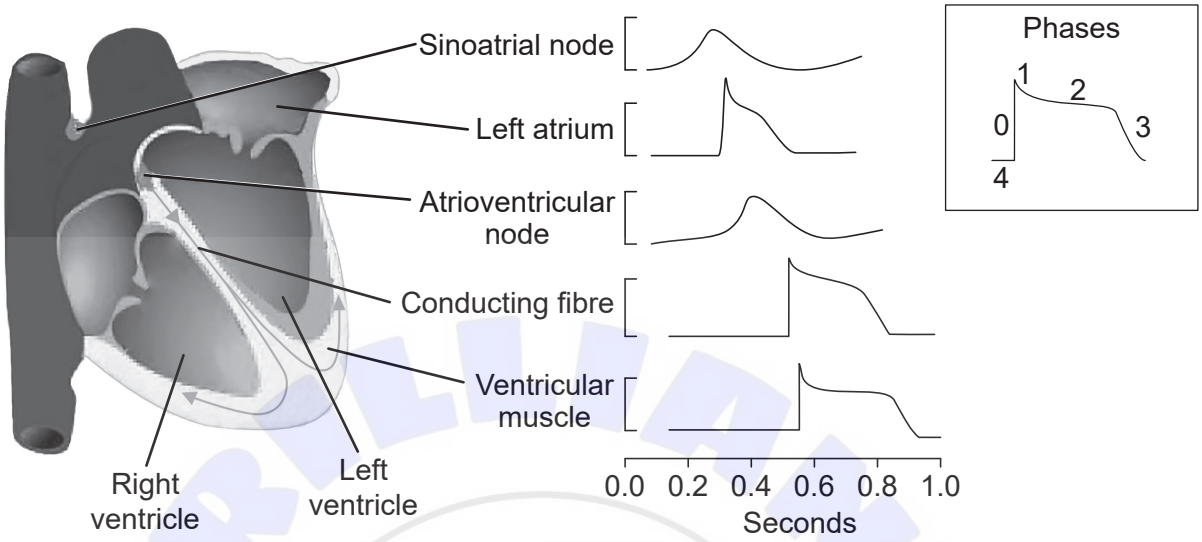
(Option D continues on the following page)

(Option D, question 18 continued)

(c) The drawing shows the typical action potential waveforms with the different phases of the cardiac cycle recorded in different regions of a human heart.



[Source: J M Nerbonne and R S Kass, (2005), *Physiological Reviews*, **85**, pages 1205–1253 doi:10.1152/physrev.00002.2005]

Distinguish between the different phases of the cardiac cycle in the atria and in the ventricular muscle. [2]

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(d) Sketch the pattern seen in a typical electrocardiogram (ECG) trace for **one** complete cardiac cycle, including labels of the main features. [3]

(Option D continues on the following page)

(Option D continued)

19. Gastric juice is secreted by the wall of the stomach. Explain how the timing of secretion is controlled, with reference to the content of the juice. [4]

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End of Option D

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