Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 3

22 October 2024

Zone A afternoon | **Zone B** afternoon | **Zone C** afternoon

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 – 20

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Section A

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

1. An experiment was carried out to determine the change in mass due to osmosis.
Potato cubes were soaked in different concentrations of sodium chloride for 12 hours.
The table shows the mean data for the mass of potato before and after the 12-hour period.

	Mean mass / g (± 0.01 g)	
Sodium chloride concentration / mol dm^{-3}	**Original**	**Final**
0.00	1.02	1.37
0.10	1.00	1.25
0.20	1.01	1.08
0.30	1.04	1.05
0.40	0.98	0.80
0.50	1.03	0.60
0.60	1.00	0.34

(a) Outline the conditions necessary for osmosis to occur. [2]

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(b) Explain how the data may be used to determine the solute concentration of the potato tissue. [2]

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(This question continues on the following page)

(Question 1 continued)

(c) Estimate the solute concentration of the potato tissue. [1]

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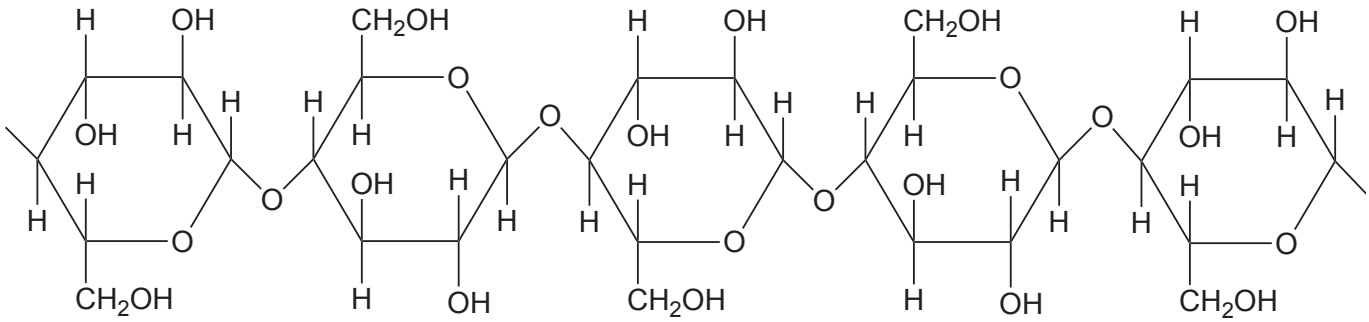
2. Monosaccharides, disaccharides and polysaccharides are three categories of carbohydrate. The structural formula for a polysaccharide is shown.



(a) (i) Identify the polysaccharide from the structural formula. [1]

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(ii) Identify the monomer that makes up this polysaccharide. [1]

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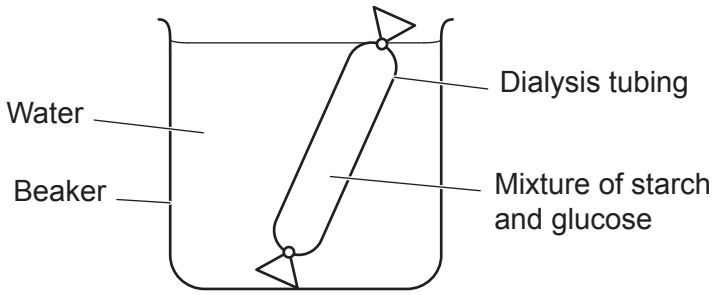
(This question continues on the following page)

(Question 2 continued)

(b) The diagram shows an experiment using dialysis tubing to model absorption in the intestine.



A sample of the water surrounding the dialysis tubing tested positive for glucose and negative for the presence of starch. Explain how absorption of digested food in the intestine is modelled in this experiment. [4]

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3. When an apple is cut, phenol molecules and polyphenol oxidase enzymes (PPO) are exposed to oxygen. This starts a series of reactions that results in the formation of a brown pigment that changes the colour of the apple. This is known as browning.

The wax apple (*Syzygium samarangense*) browns in the same way as the common apple. Researchers looking for a natural way to prevent browning covered the cut surface of wax apples with an extract of the plant *Aloe vera*, known to inhibit PPO, and left the samples exposed to air. Freshly cut wax apples had a browning index (BI) of 1.00. A higher BI indicates more browning.

Concentration of *Aloe vera* extract / %	0	25	50	75	100
Browning index (BI)	4.06	3.67	2.44	1.94	2.76

(a) State the concentration of *Aloe vera* extract shown to be the most effective at preventing browning. [1]

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(b) State **one** condition that should be kept constant for all the wax apple samples. [1]

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(This question continues on the following page)

(Question 3 continued)

(c) Various other means are used to prevent browning of apples and other fruit when cut open. Outline how the following two procedures may prevent the browning of fruit.

(i) Squeezing citric acid (from lemon juice) over the cut surface [1]

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(ii) Wrapping the cut apple with plastic film [1]

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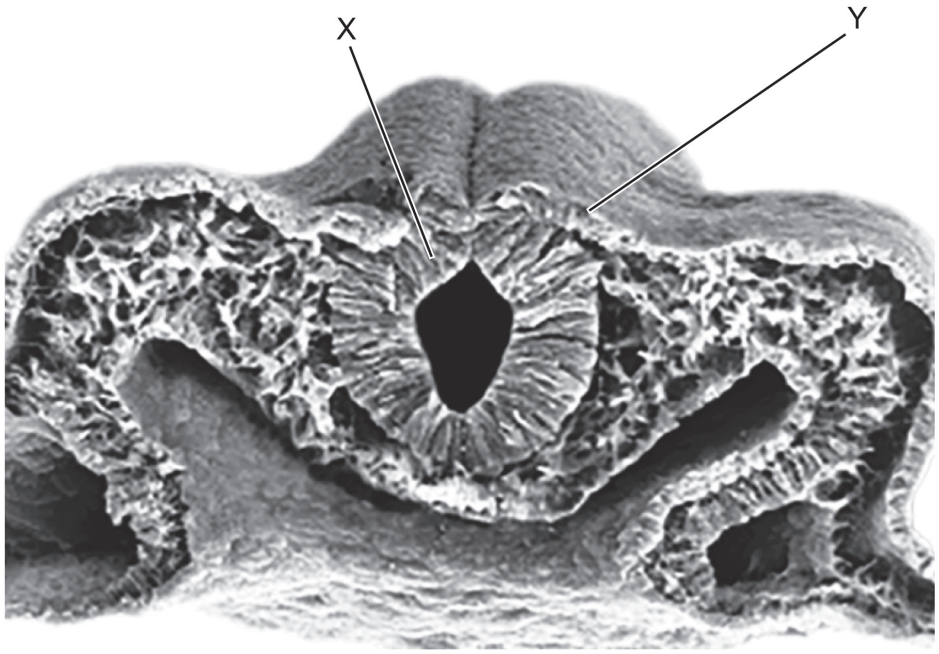
Section B

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 micrograph of a chicken embryo shows one stage in the process of neurulation.



(a) (i) Identify X and Y in the micrograph. [1]

X: . . . . . .

Y: . . . . . .

(ii) Describe the process of neurulation in chordates. [2]

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(Option A continues on the following page)

(Option A, question 4 continued)

(b) Outline how spina bifida may occur during neurulation. [1]

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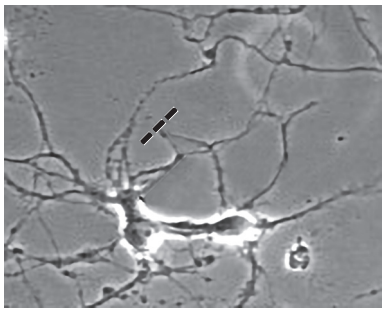
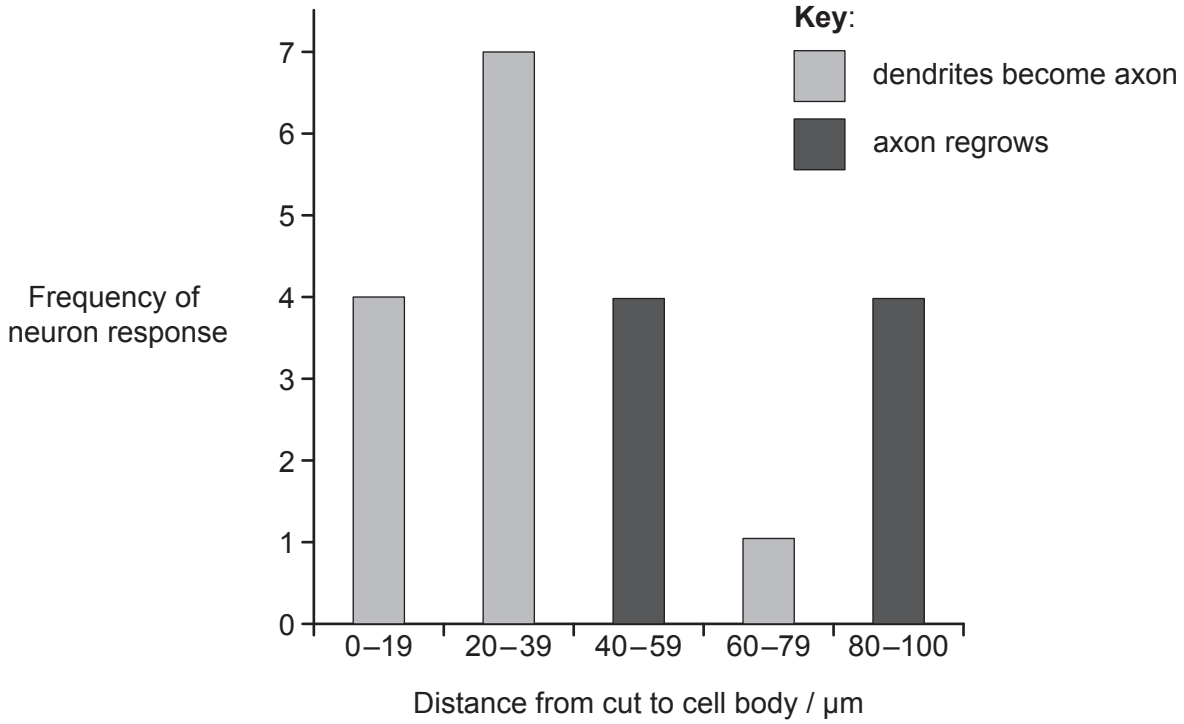
(Option A continues on the following page)

(Option A continued)

5. Neurons were removed from the cerebral hemisphere of a mature mouse (*Mus musculus*) brain. The axons were cut at different distances from the cell body. An example is shown in the micrograph.



The graph shows the results from 20 individual cell cultures.



(a) Identify the relationship between distance from cut to cell body and neuron response. [1]

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(Option A continues on the following page)

(Option A, question 5 continued)

(b) Discuss the advantages of plasticity in the nervous system. [3]

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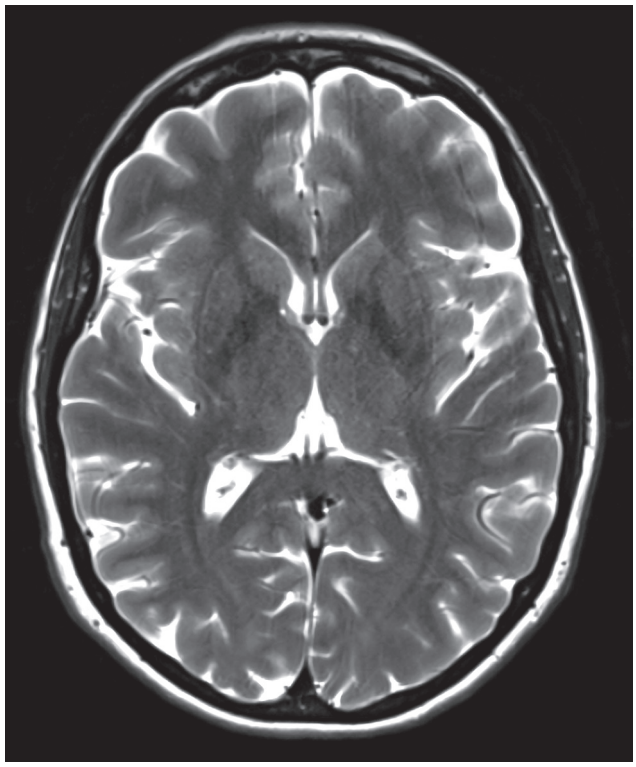
(Option A continues on the following page)

(Option A, question 5 continued)

(c) The image shows the cerebral hemispheres of the human brain.

left  right

(i) Identify the technique used to generate this image. [1]

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(ii) Compare and contrast the roles of the left and right cerebral hemispheres. [3]

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(Option A continues on the following page)

(Option A continued)

6. Swallowing is a complex coordinated process regulated by the autonomic nervous system.

(a) Describe the autonomic nervous system. [2]

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(b) State the area of the brain that coordinates swallowing. [1]

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(c) Receptors in the mouth send information to the brain about the food being chewed. Outline **one** type of sensory receptor found in the mouth that provides information to the brain when hot food is eaten. [1]

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(Option A continues on the following page)

(Option A continued)

7. Explain the role of cone cells in the colour vision of humans. [4]

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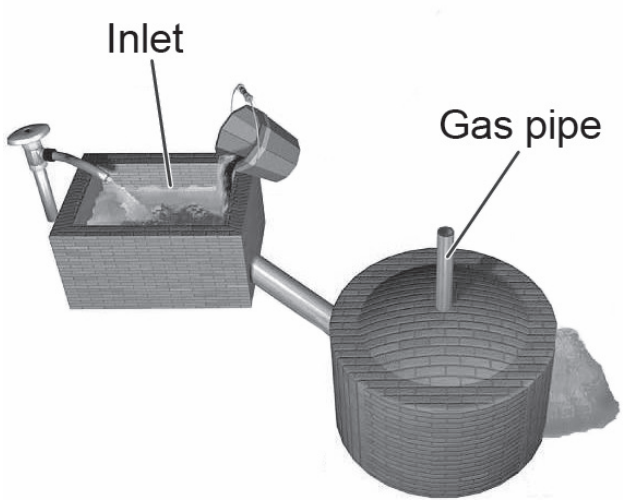
End of Option A

Option B — Biotechnology and bioinformatics

8. The photograph shows a biogas fermenter used in Pakistan. The diagram is a section showing the arrangement within the fermenter.



(a) State **one** example of a suitable material to add to the inlet of the fermenter. [1]

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(b) Identify the main combustible gas released in the gas pipe. [1]

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(c) Describe how gas is produced in the fermenter. [2]

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(Option B continues on the following page)

(Option B, question 8 continued)

(d) Distinguish between batch culture and continuous culture in a fermenter. [2]

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9. Biofilms are common on surfaces in both natural and industrial environments.

(a) Describe the characteristics of a biofilm. [3]

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(b) Explain how biofilms can be used in the treatment of sewage. [3]

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(Option B continues on the following page)

(Option B continued)

10. (a) Describe the characteristics of an open reading frame in a eukaryotic cell. [2]

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(b) Explain how open reading frames are identified. [2]

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11. In 1969, soil in northern Ontario, Canada, was polluted with mercury from industrial waste and probably remains contaminated to this day. Discuss how *Pseudomonas* could be used in the bioremediation of methyl mercury contamination. [4]

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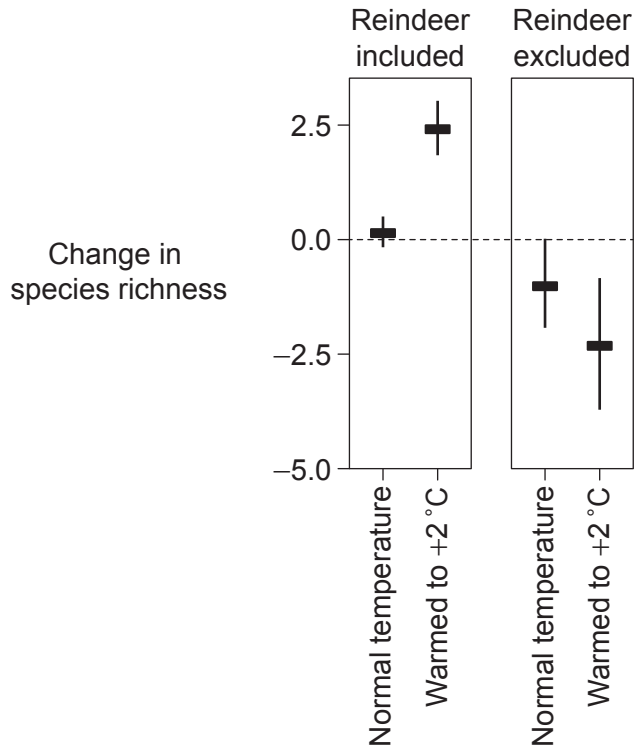
End of Option B

Option C — Ecology and conservation

12. The tundra ecosystem in Finnish Lapland has a short growing season and a mean temperature of –2.0 °C. It is also naturally grazed by herbivores such as reindeer (*Rangifer tarandus*). Different quadrats were set up to include and exclude the reindeer in both normal and warmed temperatures. Open-topped warming chambers were used to heat both the soil and air in the warmed quadrats. The graph shows the changes in plant richness over five years.



(a) State what is meant by species richness. [1]

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(b) Identify **two** abiotic limiting factors on plant growth in a tundra ecosystem. [2]

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(Option C continues on the following page)

(Option C, question 12 continued)

(c) (i) Analyse the effect of the reindeer on species richness. [2]

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(ii) Suggest possible reasons for the increase in species richness. [2]

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(d) Suggest how the results of this experiment can be used in the planning of *in situ* conservation programmes for tundra plant species. [1]

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(Option C continues on the following page)

(Option C continued)

13. Mount Saint Helens, located in the Pacific Northwest of the United States, erupted in 1980. This 2007 photograph shows the growth of vegetation on the base and sides of the volcano.

(a) Outline the process of primary succession following the eruption of a volcano like Mount Saint Helens. [3]

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(Option C continues on the following page)

(Option C, question 13 continued)

(b) In communities next to Mount Saint Helens, there is a relationship between the red squirrel (*Tamiasciurus hudsonicus*) and the Sitka spruce tree (*Picea sitchensis*). The main food source of the squirrel is the seeds found in the cones produced by the spruce trees. The squirrel buries the cones but does not always find them again to eat the seeds.

(i) Describe how the squirrel and the spruce tree benefit from the interactions between them. [2]

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(ii) Identify the trophic level of the squirrel in this food chain. [1]

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14. State what is represented by arrows in a Gersmehl diagram. [2]

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(Option C continues on page 23)

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

Answers written on this page
will not be marked.

(Option C continued)

15. Certain mercury compounds are toxic to living organisms. Health warnings have been issued against consuming large amounts of certain fish because they contain high levels of mercury. Explain how methyl mercury has reached potentially harmful concentrations in the human food supply. [4]

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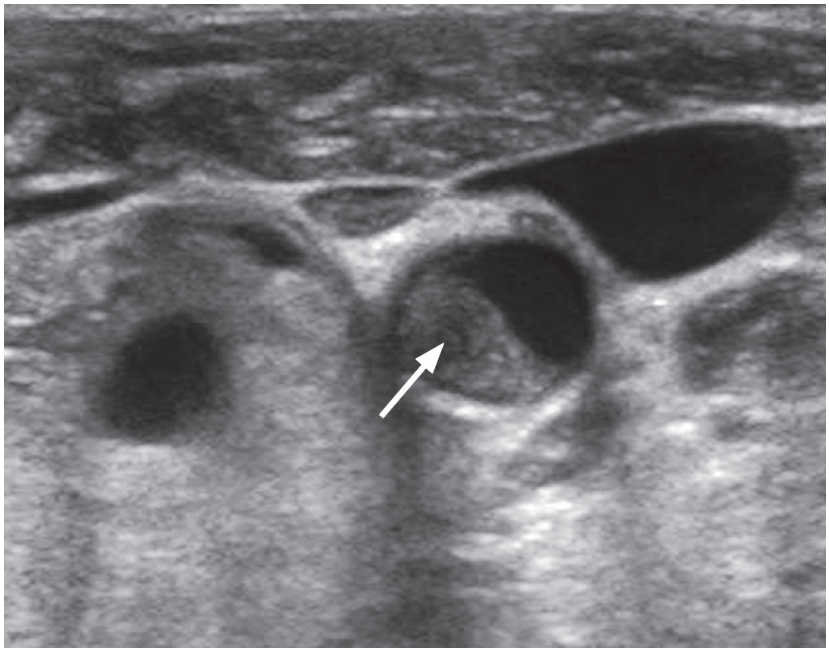
End of Option C

Option D — Human physiology

16. The ultrasound scan shows a buildup of cholesterol in the carotid artery indicated by the white arrow.



(a) Outline how high blood cholesterol may contribute to coronary heart disease. [1]

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(b) Identify **two** possible causes of high blood cholesterol. [2]

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(c) State the role of high-density lipoproteins in cholesterol transport. [1]

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(Option D continues on the following page)

(Option D, question 16 continued)

(d) Outline the disposal of excess cholesterol in the body. [2]

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17. (a) Distinguish between systolic and diastolic blood pressure. [1]

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(b) Suggest **one** short-term and **one** long-term effect of exercise on the heart, other than the blood pressures generated. [2]

Short-term: . . . . . .

Long-term: . . . . . .

18. An estimated 10–20 % of adult Canadians suffer acid reflux due to excess stomach acid production.

(a) State a class of drugs that reduce the secretion of stomach acid. [1]

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(b) Outline **two** reasons for maintaining a low pH in the stomach. [2]

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(Option D continues on the following page)

(Option D continued)

19. Vitamin and mineral supplements often include “essential” on their label.

(a) Outline what is meant by an essential nutrient. [1]

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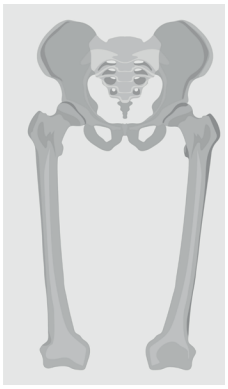
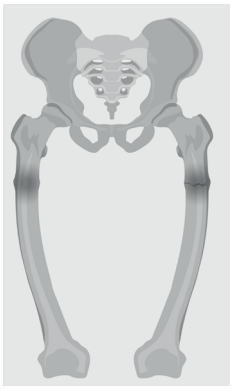
(b) The images show how lack of vitamin D can lead to abnormal bone development.



Normal bone development



Abnormal bone development

Patient with abnormally formed bones

Explain possible reasons for the abnormal bone development of patients lacking vitamin D. [3]

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(Option D continues on the following page)

(Option D continued)

20. Excess alcohol consumption may interfere with a broad range of liver functions. Suggest the effects of alcohol on liver function. [4]

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End of Option D

Disclaimer:

Content used in IB assessments is taken from authentic, third-party sources. The views expressed within them belong to their individual authors and/or publishers and do not necessarily reflect the views of the IB.

References:

3. Image: LOU63/iStock.

Table: Supapvanich, S., Mitrsang, P., Srinorkham, P., Boonyaritthongchai, P. and Wongs-Aree, C., 2016. Effects of fresh Aloe vera gel coating on browning alleviation of fresh cut wax apple (*Syzygium samarangense*) fruit cv. Taaptimjaan. *Journal of Food Science and Technology*, 53 (6), pp. 2844–2850. Springer Nature.

4. [*Section of chicken embryo*] Reproduced with the permission of UPV/EHU Press from Schoenwolf, G. (2018). Contributions of the chick embryo and experimental embryology to understanding the cellular mechanisms of neurulation. Int. J. Dev. Biol. 62, pp. 49–55. https://doi.org/10.1387/ijdb.170288gs.

5. Image: Reprinted from *Current Biology*, 18(13), Susana Gomis-Rüth, Corette J. Wierenga, Frank Bradke, Plasticity of Polarization: Changing Dendrites into Axons in Neurons Integrated in Neuronal Circuits, pp. 992–1000, Copyright 2008, with permission from Elsevier.

Graph: Reprinted from *Current Biology*, 18(13), Susana Gomis-Rüth, Corette J. Wierenga, Frank Bradke, Plasticity of Polarization: Changing Dendrites into Axons in Neurons Integrated in Neuronal Circuits, pp. 992–1000, Copyright 2008, with permission from Elsevier.

5.(c) Image: Copyright 2024 Dr Frank Gaillard. Image courtesy of Dr Frank Gaillard and Radiopaedia.org. Used under licence.

8. Image: [*Biogas plant*] Ilhador. https://commons.wikimedia.org/wiki/File:Biodigestor.JPG. Public domain. Image adapted.

Diagram: Nur Shuhada Ghazali, et al., 2013. [*Biogas fermenter*] [diagram online] Available at: https://www.semanticscholar.org/paper/Potential-of-Biogas-Power-Plant-Produced-by-of-Ghazali-Mydin/d8d289a88c2571f02c3506d34b7f14dcd69a60fa [Accessed 29 March 2019]. Source adapted.

12. Kaarlejärvi, E., Eskelinen, A. & Olofsson, J. Herbivores rescue diversity in warming tundra by modulating trait-dependent species losses and gains. *Nat Commun* 8, 419 (2017). https://doi.org/10.1038/s41467-017-00554-z. https://creativecommons.org/licenses/by/4.0/. Source adapted.

13. Curved Light USA / Alamy Stock Photo, 2009. *Regrowth in the blast plain in front of Mount St Helens volcano*. [image online] Available at: https://www.alamy.com/stock-photo-regrowth-in-the-blast-plain-in-front-of-mount-st-helens-volcano-37924867.html [Accessed 3 April 2019]. Source adapted.

16. [*Ultrasound*], n.d. [image online] Available at: https://www.e-ultrasonography.org/journal/view.php?doi=10.14366/usg.13018 [Accessed 3 April 2019]. Source adapted.

19. Photo by Supliful - Supplements On Demand on Unsplash.

19.(b) Diagrams: [*Bone development*] Double Brain/Shutterstock. n.d. Available at: https://www.shutterstock.com/image-vector/normal-bones-versus-rickets-osteomalacia-medical-1049310371.

Photo: [*Abnormally formed bones*] Al-Mosawi, A. (2020). Inadequately Treated Vitamin D-Deficiency Nutritional Rickets Complicated by Genu Varum: Correlation with High Alkaline Phosphatase. *Clinical Surgery Journal*, 3(S3), 26–28. https://doi.org/10.5281/zenodo.4322946. Image adapted.