Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 3

13 May 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

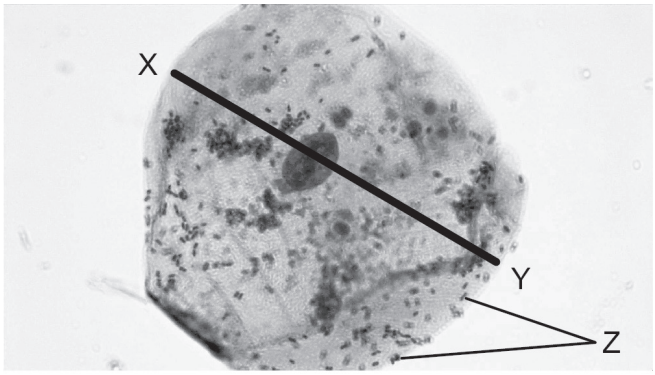
2224 – 6006

25 pages

Section A

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

1. The micrograph shows a human cheek cell magnified with a light microscope.



1000×

(a) Calculate the width of the cheek cell from X to Y. [1]

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(b) Explain what causes the irregular shape of the cheek cells rather than the uniform shape of plant cells. [2]

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(c) Describe what would happen to the cheek cell if it was placed in a hypertonic salt solution. [1]

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(This question continues on the following page)

(Question 1 continued)

(d) In addition to the cheek cell, the micrograph shows smaller single cells. Two of these cells are labelled Z. Predict with a reason what the single cells could be. [1]

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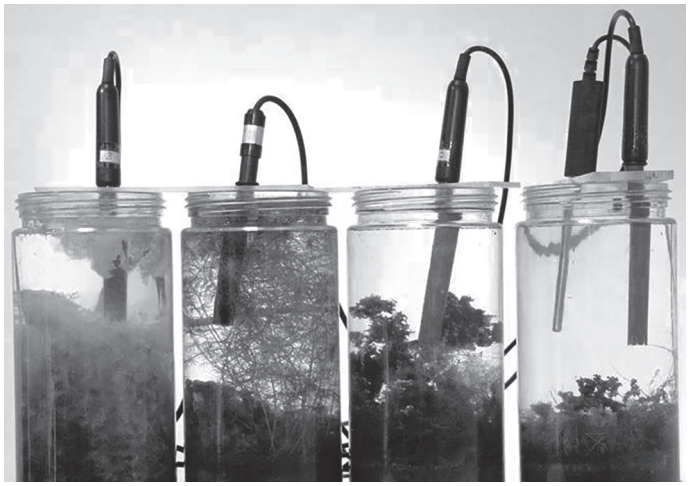
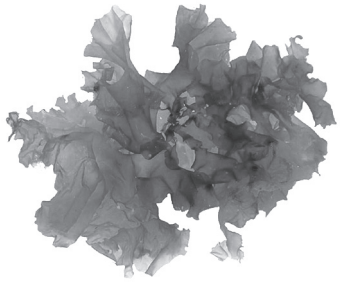
2. Draw the internal structures of a prokaryotic cell within the diagram. [3]

3. Growth rates of marine algae can be investigated using experimental mesocosms such as those shown.

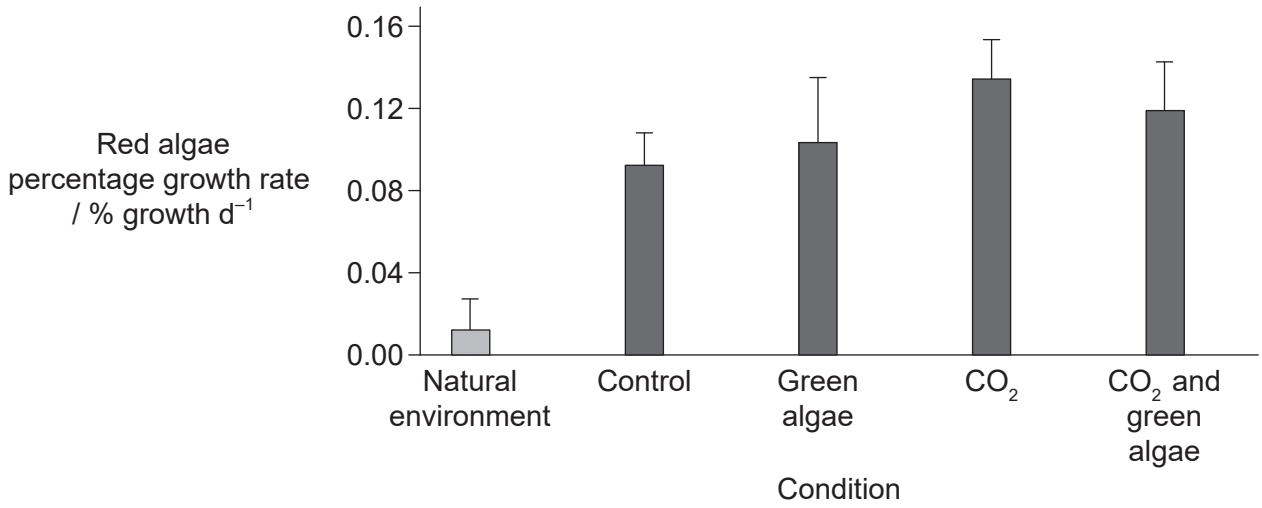


Gracilaria, a red alga



Ulva, a green alga

Data are shown for percentage growth rates of red algae, grown in their natural environment and using mesocosms. The conditions investigated included competition from green algae and from elevated CO_2, as well as competition from green algae combined with elevated CO_2.



(This question continues on the following page)

(Question 3 continued)

(a) Outline the effect of elevated CO_2 on the percentage growth rate of the red algae. [2]

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(b) Suggest a possible reason for the elevated percentage growth rates of red algae in the mesocosms compared with the percentage growth rate in their natural environment. [1]

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(c) State **one** advantage of conducting research using mesocosms. [1]

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(d) Explain how to set up a mesocosm in a sealed container. [3]

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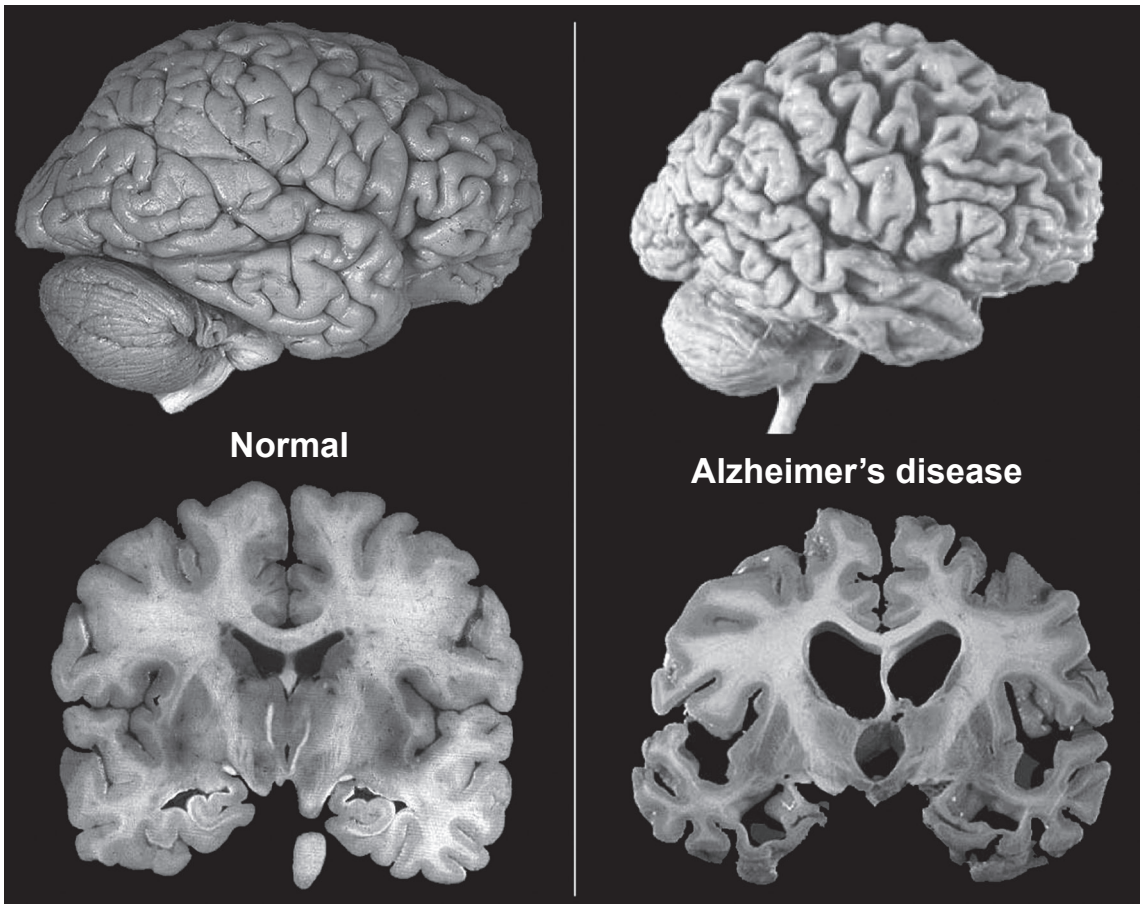
Section B

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. Alzheimer's disease is a condition associated with ageing, in which there are changes to the structure of the brain. The images show the side view and cross section of a normal brain and a brain with advanced Alzheimer's disease. All the images are at the same scale.



(a) Distinguish between the normal brain and the brain with Alzheimer's disease shown in the images. [2]

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(Option A continues on the following page)

(Option A, question 4 continued)

(b) Brain-imaging tests may be used to confirm Alzheimer's disease. However, there are behavioural changes that may be observed before diagnosis, including changes in higher-order functions.

(i) State the brain structure responsible for higher-order functions. [1]

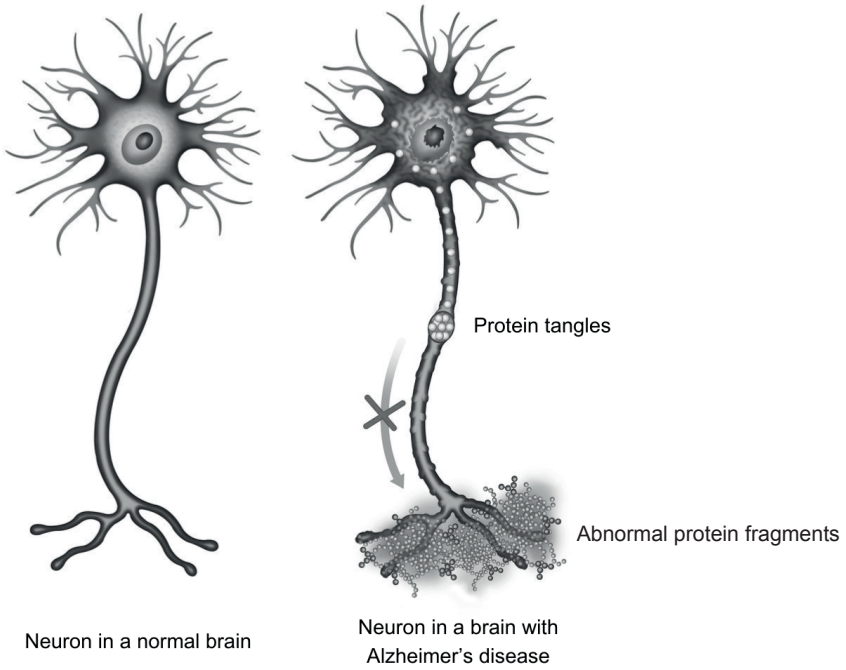
. . . . . .

(ii) State **two** higher-order functions. [2]

1. . . . . .

2. . . . . .

(c) The brain of a person with Alzheimer's disease contains abnormal protein fragments that build up between the neurons. Another protein causes tangles within the neuron. The image shows a neuron from a normal brain and a neuron from a brain with Alzheimer's disease.



Predict **one** effect of Alzheimer's disease on neuron function. [1]

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(Option A continues on the following page)

(Option A continued)

5. Modifications of the neurons start in the earliest stages of embryogenesis.

(a) Explain the formation of the neural tube during neurulation. [3]

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(b) State how neurons are initially produced. [1]

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(c) Spina bifida is a birth defect that may occur during neurulation. Describe how this condition occurs. [1]

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(Option A continues on the following page)

(Option A continued)

6. The autonomic nervous system is one part of the peripheral nervous system.

(a) Outline the role of the autonomic nervous system. [1]

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(b) Identify the control centre for the autonomic nervous system. [1]

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(c) Outline the pupil reflex. [3]

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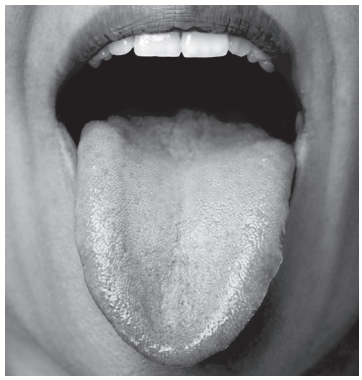
(Option A continues on the following page)

(Option A continued)

7. The lips and tongue contain a high concentration of sensory receptors.



Explain how different types of sensory receptors in the mouth and lips are used to sense food. [4]

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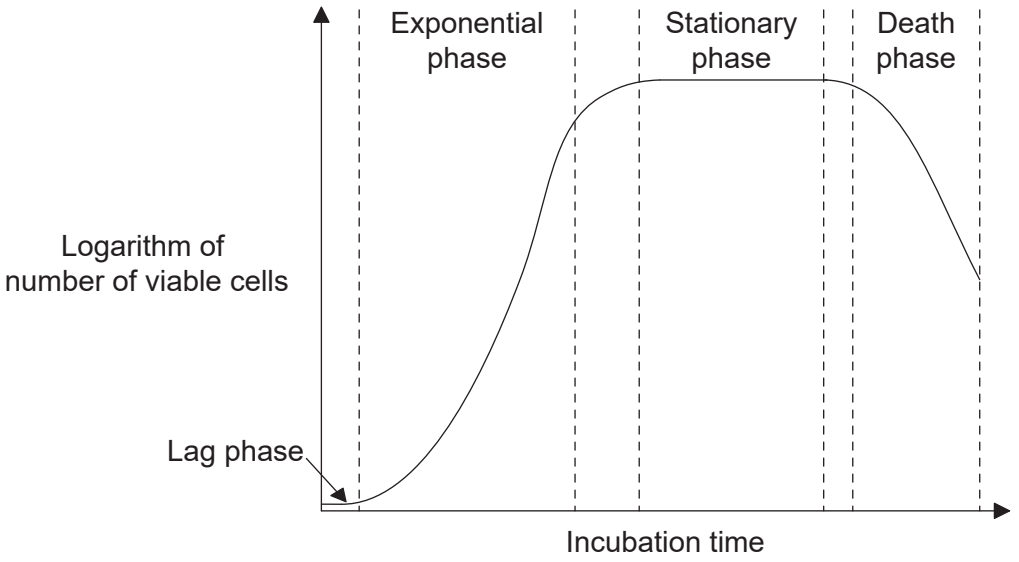
End of Option A

Option B — Biotechnology and bioinformatics

8. The graph shows the expected growth curve of microorganisms in **batch** cultures.



(a) (i) When growing in continuous culture (rather than in batch culture), state the growth phase where most of the microorganisms would be found. [1]

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(ii) Outline **one** advantage of maintaining the microorganisms in this growth phase. [1]

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(b) Identify **two** conditions that must be constantly monitored to help maintain optimal conditions within a continuous fermenter. [2]

1. . . . . .

2. . . . . .

(c) State **one** industrial application of a continuous fermenter. [1]

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(Option B continues on the following page)

(Option B continued)

9. Glyphosate is a powerful herbicide that is rapidly broken down by soil bacteria. In 1996, genetically engineered glyphosate-resistant soybeans were made commercially available.

(a) Describe how glyphosate resistance is introduced into soybean crops by genetic engineering. [3]

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(b) Explain **two** advantages of using glyphosate-resistant soybeans. [2]

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2. . . . . .

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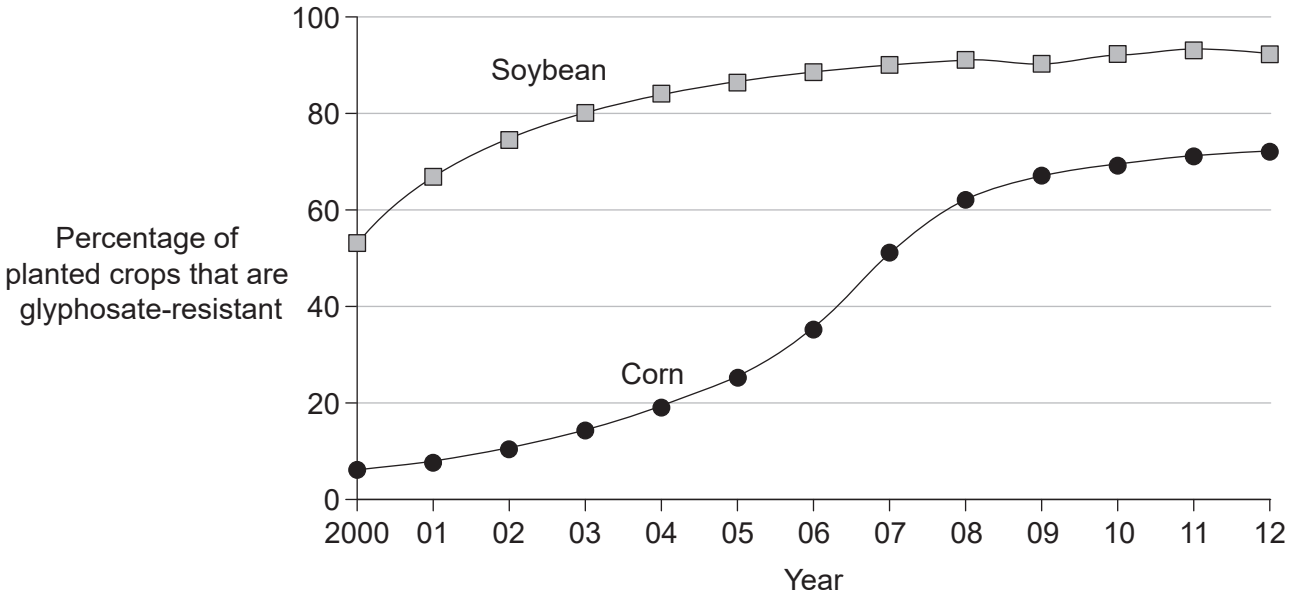
(Option B continues on the following page)

(Option B, question 9 continued)

(c) The graph shows the percentage of soybean (*Glycine max*) and corn (*Zea mays*) crops with glyphosate resistance planted in the United States.



(i) Identify the first year when planting of glyphosate-resistant soybeans declines. [1]

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(ii) Suggest **one** possible reason for glyphosate-resistant crops not reaching 100 % of plantings. [1]

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(Option B continues on the following page)

(Option B continued)

10. Many of the bacterial species that live in the mouth form biofilms that are responsible for tooth decay. Bacteriophages are a promising treatment for control of these oral biofilms.

(a) (i) The mouth often contains large numbers of bacteria. Suggest **one** reason for this. [1]

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(ii) Outline how bacteria form biofilms. [1]

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(b) Discuss whether bacteriophages might be an effective treatment for tooth decay. [2]

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(Option B continues on the following page)

(Option B continued)

11. Many countries are considering the use of biofuels to reduce their dependence on fossil fuels. Discuss the production of biogas. [4]

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End of Option B

Option C — Ecology and conservation

12. American crows (*Corvus brachyrhynchos*) and Common ravens (*Corvus corax*) belong to the same genus but are separate species. Both are found in North America and compete for similar resources, but the larger-bodied ravens are mostly found in rural habitats while crows have taken over the urban areas.

American crow (*Corvus brachyrhynchos*)

Common raven (*Corvus corax*)

(a) Outline **two** factors that may cause crows and ravens to occupy separate habitats. [2]

1. . . . . .
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2. . . . . .
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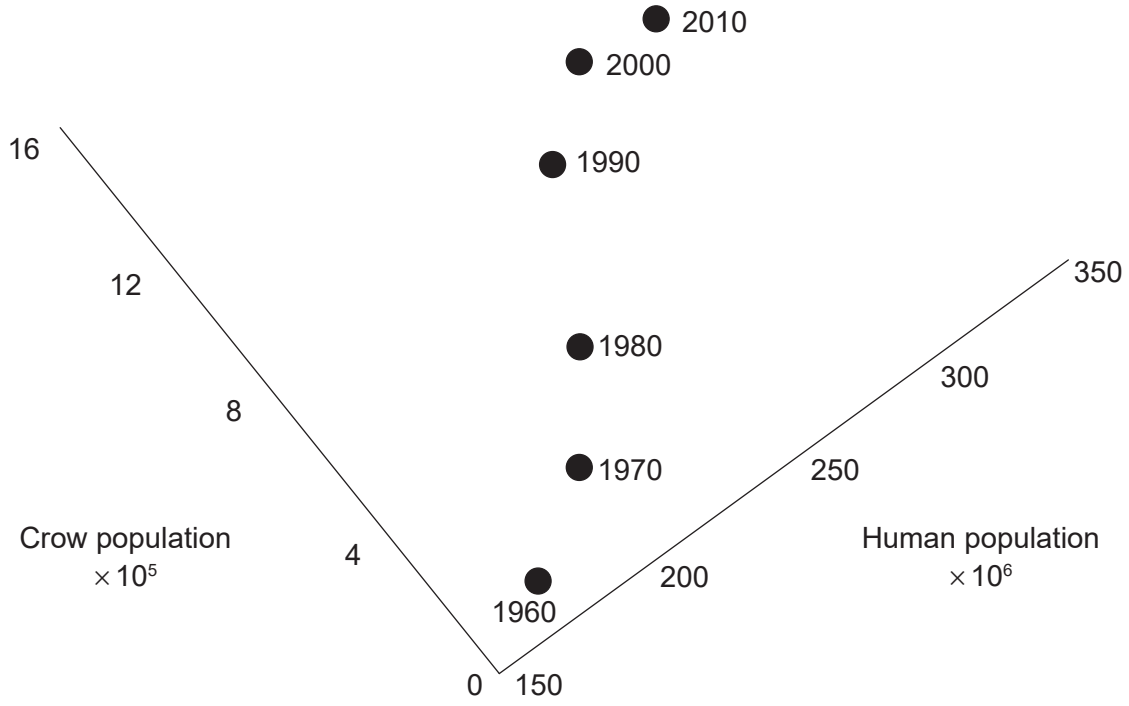
(Option C continues on the following page)

(Option C, question 12 continued)

(b) The graph shows the population of humans and crows in the United States between 1960 and 2010.



Deduce whether the data in the graph show that increases in the human population cause increases in the crow population. [2]

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(c) List **three** factors that affect the distribution of animal species. [3]

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2. . . . . .

3. . . . . .

(Option C continues on the following page)

(Option C continued)

13. Wildfires affect more land area than any other natural disturbance. A significant consequence of forest fire is the potential for soil erosion.

(a) After wildfires, the process of ecological succession usually occurs. State the meaning of ecological succession. [1]

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(b) Outline how wildfires increase the risk of erosion. [2]

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(Option C continues on the following page)

(Option C, question 13 continued)

(c) In order to investigate the status of ecological succession, suggest **two** factors that could be monitored after a wildfire. [2]

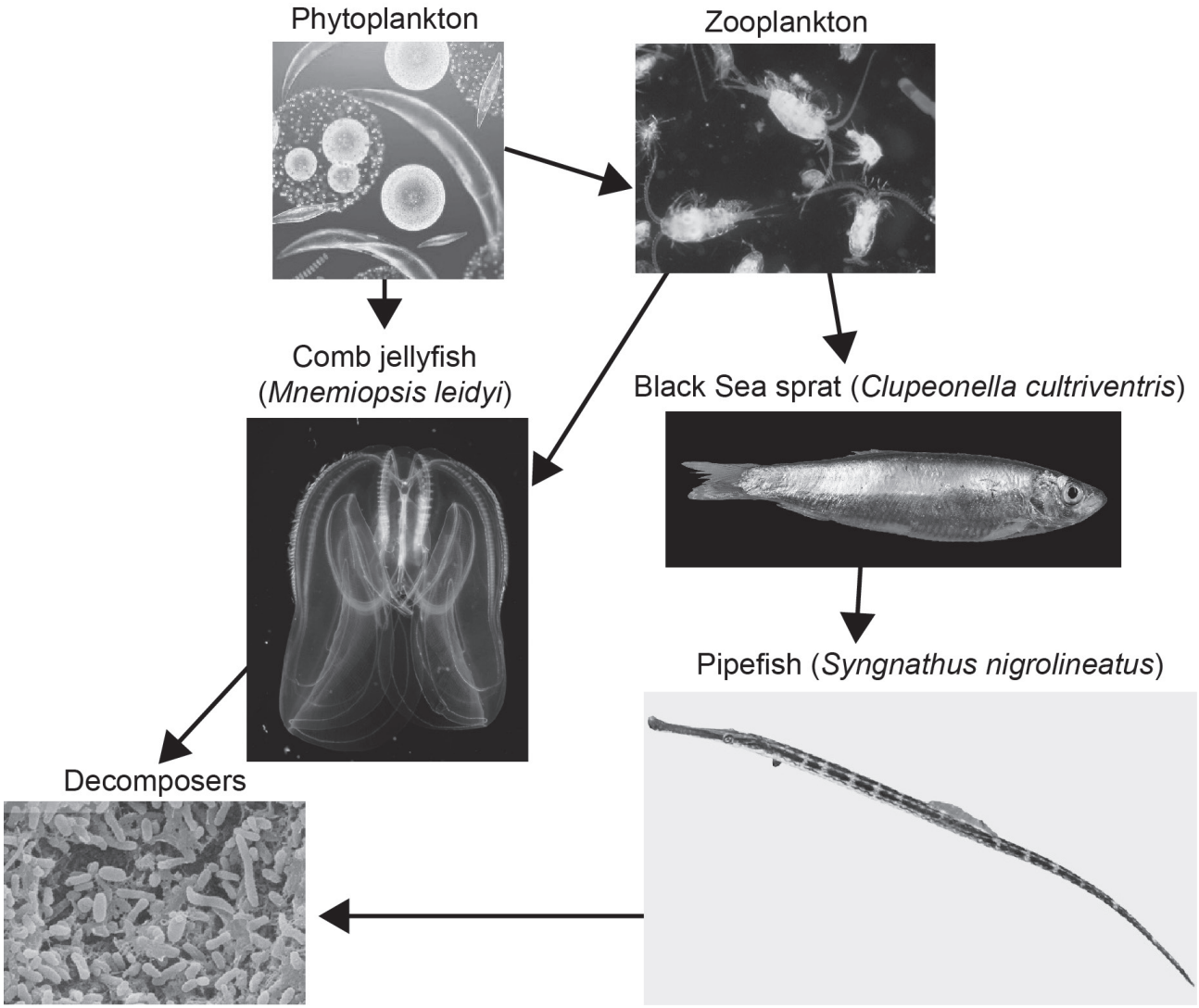
1. . . . . .

2. . . . . .

(Option C continues on the following page)

(Option C continued)

14. The diagram shows a simplified Black Sea food web.



(a) Identify **two** primary consumers from the food web. [1]

1. . . . . .

2. . . . . .

(Option C continues on the following page)

(Option C, question 14 continued)

(b) In the Black Sea, invasive comb jellies, *Mnemiopsis leidyi*, have been blamed for a significant disruption in the food web. The accidental introduction of *Beroe ovata*, a different species of comb jelly, drastically reduced the population of *M. leidyi*. Discuss whether biological control measures, such as introducing *B. ovata* into the Black Sea ecosystem, should be used. [3]

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15. Discuss *in situ* and *ex situ* conservation of endangered species. [4]

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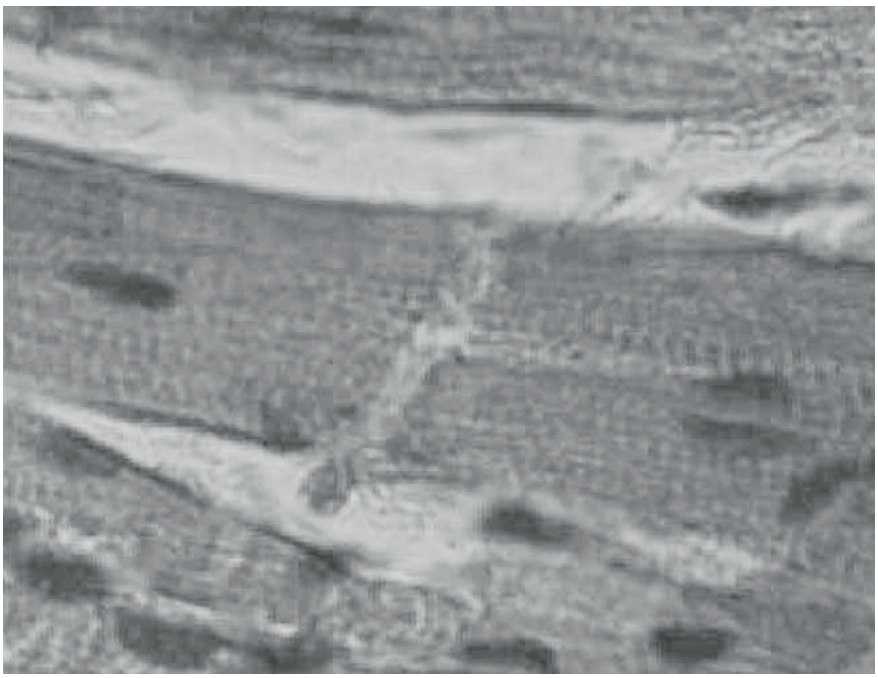
End of Option C

Option D — Human physiology

16. Intercalated discs are found in cardiac muscle.

(a) On the micrograph of cardiac muscle, label an intercalated disc. [1]



(b) Outline **two** functions of intercalated discs. [2]

1. . . . . .
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2. . . . . .
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(c) The first cardiac pacemaker was developed by a Canadian scientist in 1950. Describe how an artificial pacemaker maintains a normal heartbeat. [2]

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(Option D continues on the following page)

(Option D continued)

17. Cholera is an acute intestinal disease caused by the bacterium *Vibrio cholerae*. It is transmitted in contaminated drinking water or food.

(a) Explain how *V. cholerae* causes diarrhea. [3]

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(b) State how cholera can cause death. [1]

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18. Early scientists established the role of gastric acid while observing the process of digestion through an open gunshot wound.

(a) Describe the control of gastric acid secretion in the stomach. [2]

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(b) Suggest **two** reasons that people who are on proton pump inhibitor drugs may be more at risk for some bacterial infections. [2]

1. . . . . .

2. . . . . .

(Option D continues on the following page)

(Option D continued)

19. The table shows the daily minimum and maximum sodium intakes for healthy individuals recommended by the Canadian government.

Age / years	Minimum sodium intake / mg day^{-1}	Maximum sodium intake / mg day^{-1}
1 – 3	1000	1500
4 – 8	1200	1900
9 – 13	1500	2200
14 – 50	1500	2300
51 – 70	1300	2300

The nutrition label may be found on a bag of potato chips.

Nutrition Label

Per 27 chips (50 g)

	Amount
Energy	1130 kJ
Fat	17 g
Saturated 1.5 g	
Trans 0 g	
Cholesterol	0 g
Sodium	270 mg
Carbohydrates	27 g
Fibre 1 g	
Sugars 3 g	
Protein	3 g
Vitamin A*	2 %
Vitamin C*	15 %
Calcium*	2 %
Iron*	4 %

* *Percentage daily values based on 8400 kJ diet*

(Option D continues on the following page)

(Option D, question 19 continued)

(a) (i) Calculate the percentage of the recommended daily maximum sodium intake for an individual aged 14–50 years who consumes 54 potato chips. [1]

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(ii) Outline **one** reason for concern about the nutrition of a child who consumes a large quantity of potato chips. [1]

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(b) State a health risk that is associated with excessive sodium intake. [1]

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20. A 30-year-old female has a yellow discolouration of her skin and the whites of her eyes. She is diagnosed with jaundice. Explain the possible causes and consequences of jaundice. [4]

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End of Option D

Disclaimer:

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References:

1. Fox, E. (2022, February 12). Micrograph human cheek epithelial cells methylene blue 1000X p000018. OER Commons. https://oercommons.org/courseware/lesson/89980.

3. Mosley, L., Reid, R., 2015. Figure 9. [image online] Available at: https://www.researchgate.net/figure/Variation-in-mesocosmplant-composition-and-probes-for-continuous-monitoring-of-pH-Eh_fig5_328661328.

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4. Guo, H., & Zhang, Y. (2020). Resting State fMRI and Improved Deep Learning Algorithm for Earlier Detection of Alzheimer's Disease. *IEEE Access*, 8, 115383–115392.

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7. Image by kues1 on Freepik. https://www.freepik.com/free-photo/young-cool-woman-joke-close-up_1012294.htm.

9. https://www.pioneer.com/ca-en/agronomy/weed_mgmt_era_glyphosate_resistance.html#:~:text=Plant%20into%20weed%2Dfree%20fields,most%20prone%20to%20herbicide%20resistance.

12. crow: Ian Routley/Macaulay Library.

raven: Common Raven by Kyle Lima, Cornell Lab of Ornithology | Macaulay Library.

12. (b) Wilson, S., Teasley, E., Pereira, M. and Smith, T., n.d. *Human vs. American Crow Population*. [online] Available at: https://researchnature.files.wordpress.com/2012/10/ecology-crow-vs-human.pdf [Accessed 1 May 2019].

13. Raymond Gehman / https://raymondgehman.com.

14. Phytoplankton: © Richard Kirby.

Zooplankton: Zingone, A., D'Alelio, D., Mazzocchi, M. G., Montresor, M., Sarno, D., & team, L. (3 C.E.). Time series and beyond: multifaceted plankton research at a marine Mediterranean LTER site. *NC*, 34, 273310. https://doi.org/10.3897/natureconservation.34.30789. Licensed under the Creative Commons Attribution-Share Alike 4.0 International license https://creativecommons.org/licenses/by-sa/4.0/deed.en.

Black Sea sprat: Hans Hillewaert. https://commons.wikimedia.org/wiki/File:Sprattus_sprattus.jpg. Creative Commons Attribution-Share Alike 4.0 International license. hhttps://creativecommons.org/licenses/by-sa/4.0/deed.en. Image adapted.

Comb jellyfish: Bruno C. Vellutini. https://commons.wikimedia.org/wiki/File:Comb_jelly.tif. Licensed under CC BY-SA 3.0 https://creativecommons.org/licenses/by-sa/3.0. Image adapted.

Decomposers: Omura, T., Isobe, N., Miura, T. et al. Microbial decomposition of biodegradable plastics on the deep-sea floor. *Nat Commun* 15, 568 (2024). https://doi.org/10.1038/s41467-023-44368-8.

Pipefish: ID 33229999. © Serg_dibrova. Dreamstime.com.

16. Dr. S. Girod, Anton Becker, CC BY-SA 3.0 http://creativecommons.org/licenses/by-sa/3.0/, via Wikimedia Commons. Source adapted.

19. Government of Canada, n.d. Sodium in Canada. [online] Available at: https://www150.statcan.gc.ca/n1/pub/82-003-x/2006004/article/sodium/4148995-eng.htm#1 and https://www150.statcan.gc.ca/n1/pub/82-003-x/2006004/article/sodium/c-g/4148991-eng.htm.

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

Answers written on this page
will not be marked.