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 – 6
Option B — Biotechnology and bioinformatics	7 – 10
Option C — Ecology and conservation	11 – 14
Option D — Human physiology	15 – 19

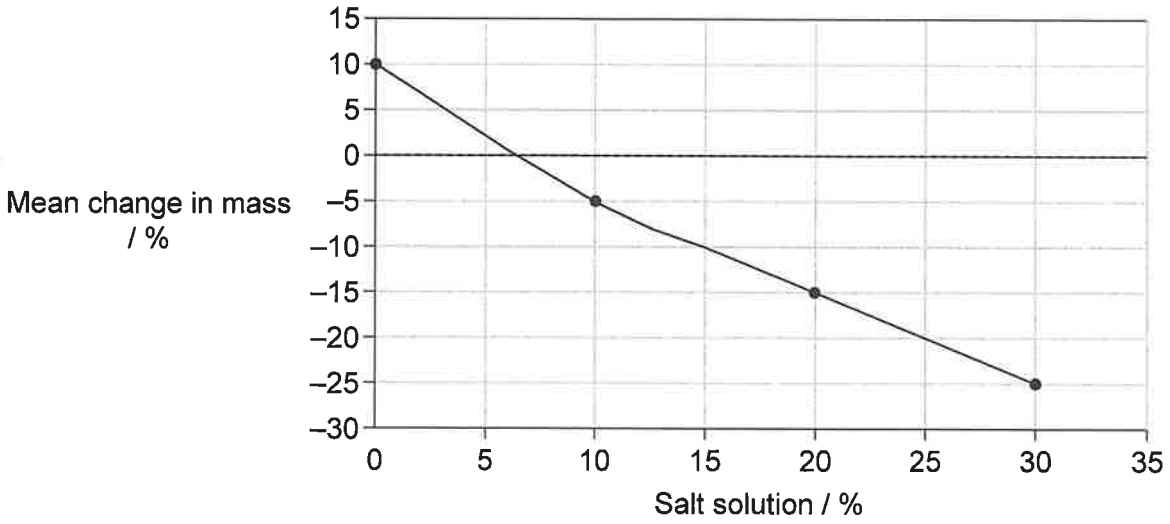
2224–6012

27 pages

Section A

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

1. An experiment was carried out to measure the osmolarity of cantaloupe (fruit of *Cucumis melo*) tissue by placing pieces in salt solutions of different concentrations. The results are shown in the graph.



(a) (i) Define osmolarity. [1]

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(ii) Identify the concentration of salt solution with an osmolarity equal to that of the cantaloupe tissue. [1]

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(This question continues on the following page)

(Question 1 continued)

(b) Using the graph, explain what happened when the pieces of tissue were placed in a hypertonic salt solution. [1]

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(c) Describe **two** factors that should be kept constant in this experiment in order to obtain an accurate measurement of the osmolarity of the cantaloupe tissue. [2]

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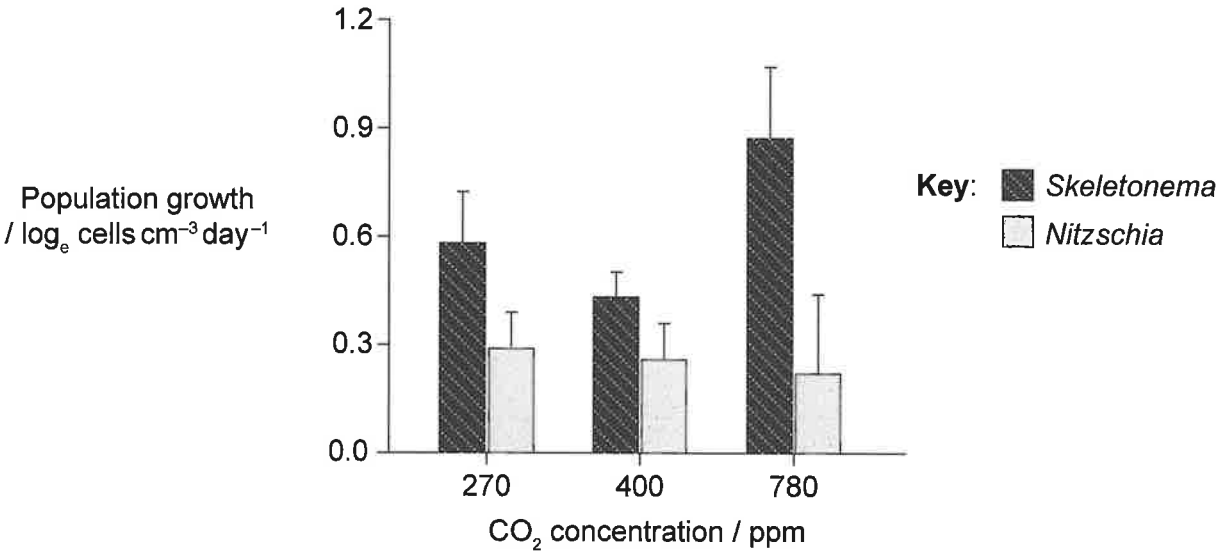
2. Three different seawater mesocosms were set up to measure the effect of variations in the concentration of carbon dioxide (CO_2) on the growth rate of two genera of phytoplankton over a 14-day period. CO_2 concentration was measured in parts per million (ppm).

Three concentrations of CO_2 were chosen to simulate atmospheres of the pre-industrial age (270 ppm), the present day (400 ppm) and predictions for the year 2100 (780 ppm). Growth rate was determined by recording the cell counts each day and calculating the increase in the number of cells per cubic centimetre per day. The graphs show the growth rate of *Skeletonema* and *Nitzschia* in the three different mesocosms.



(a) State what the error bars on the graphs signify. [1]

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(b) Distinguish between the results of the two genera shown in the bar chart. [2]

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(This question continues on the following page)

(Question 2 continued)

(c) On the basis of the data in the graph, suggest changes that might result from an increase in carbon dioxide concentration to 780 ppm in the ecosystem where these phytoplankton occur. [2]

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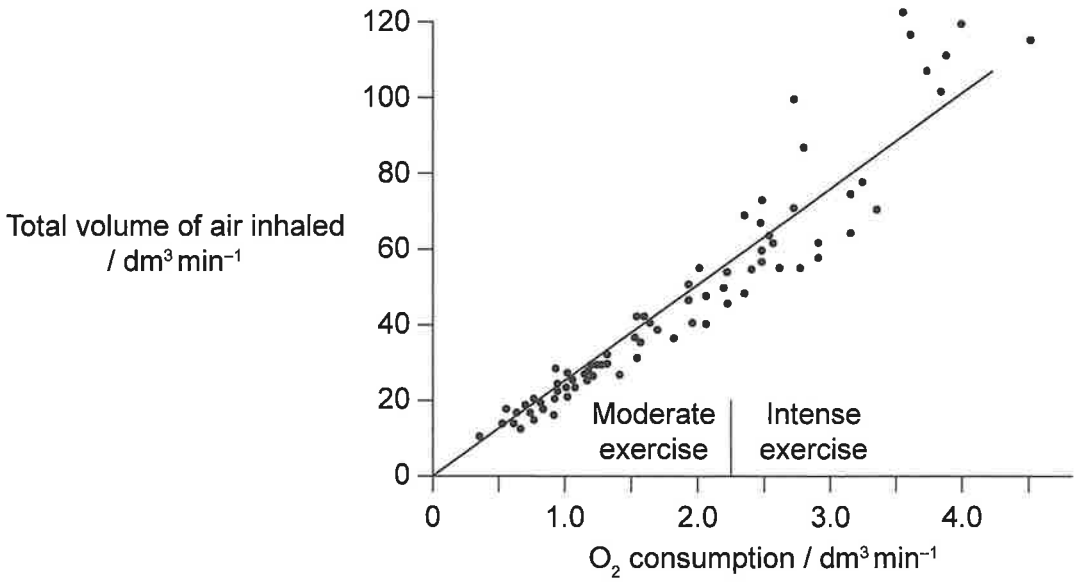
3. In a study of the effects of exercise on ventilation, tidal volume and ventilation rate were measured at different intensities of exercise. The tidal volumes and ventilation rates were multiplied together, to obtain the total volume of air taken into and then expelled out of the lungs per minute. Oxygen consumption at the different intensities of exercise was also measured. The results are shown in the scattergraph.



(a) Describe the relationships of exercise intensity with O_2 consumption **and** with total volume of air inhaled per minute. [1]

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(b) Explain how the increase in exercise causes a change in the total volume of air inhaled. [2]

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(This question continues on the following page)

(Question 3 continued)

(c) Predict the effect of emphysema on a person's response to moderate exercise. [2]

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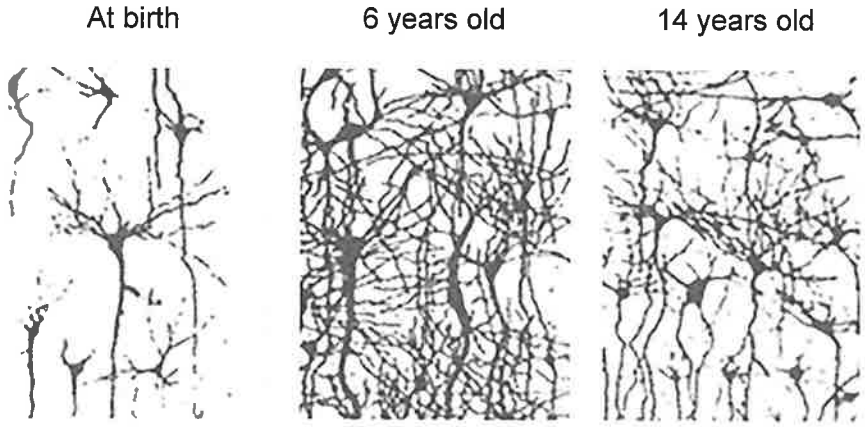
Section B

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. (a) The diagrams show the development of neural tissues in the brain of a child.



(i) State the major changes that occur in neural tissues from birth to 6 years old, as shown in the images. [2]

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(ii) Outline the main process that occurs in the brain between 6 years old and 14 years old, as shown in the images. [1]

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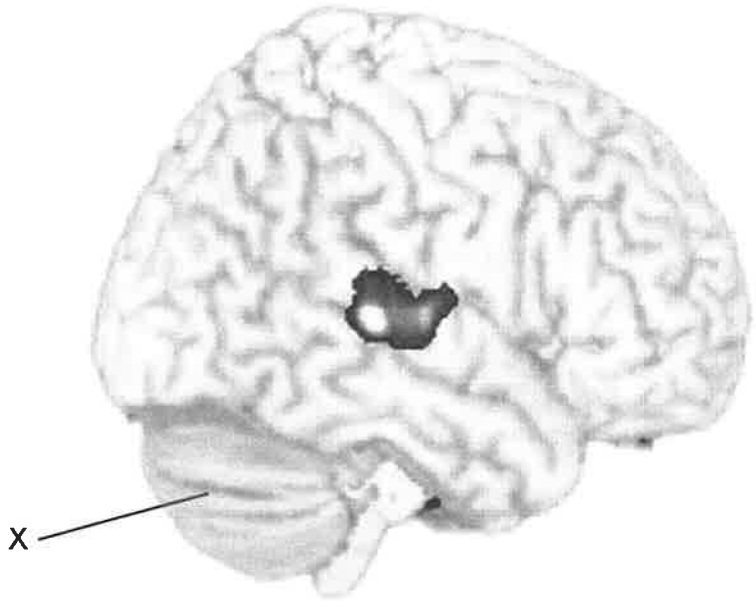
(Option A continues on the following page)

(Option A, question 4 continued)

(b) The image shows the human brain.



(i) Identify the name and function of X indicated in the image. [2]

Name: .....

Function: .....

(ii) The brain has a very high rate of metabolism. Suggest its major source of energy. [1]

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(iii) Broca's area is active in the fMRI section of the image shown. Predict what the person was doing when the scan was taken. [1]

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(Option A continues on the following page)

(Option A continued)

5. (a) Olfactory receptors detect different odours. Describe **two** characteristics all olfactory receptor cells must have in common. [2]

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(b) Suggest **two** types of behaviour in mammals that could be affected by the detection of particular odours. [2]

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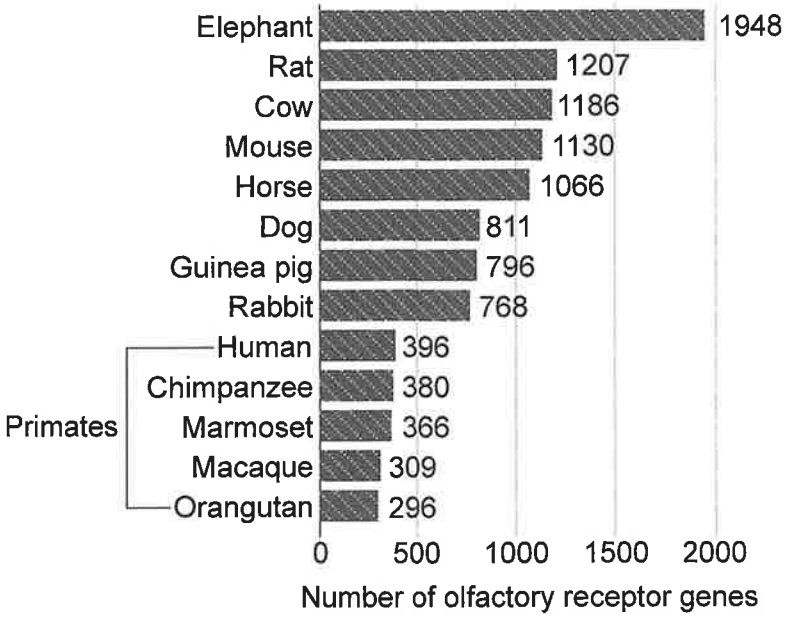
(Option A continues on the following page)

(Option A, question 5 continued)

(c) Researchers studied 13 placental mammals to identify the number of genes involved in the sense of smell. The results are given in the chart below.



Suggest **two** reasons for primates having fewer genes for olfactory receptors than the other placental mammals. [2]

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(Option A continues on the following page)

(Option A continued)

6. (a) Using a specific example, describe the learning processes involved in imprinting. [2]

(b) Define memory. [1]

(c) Explain the processes that contribute to the development of song in a young bird. [4]

End of Option A

Option B — Biotechnology and bioinformatics

7. (a) State **one** advantage of using microorganisms in industry. [1]

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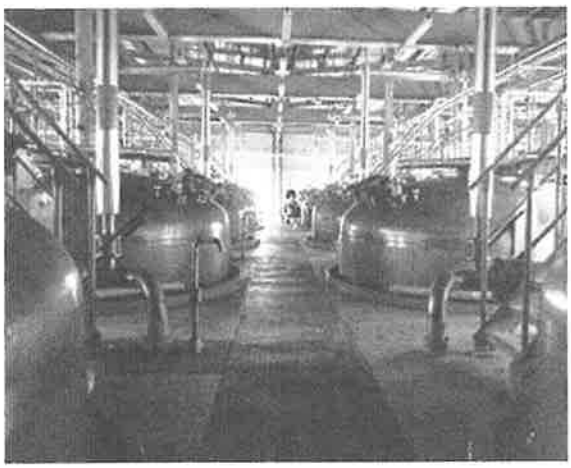
(b) Citric acid can be produced in fermenters by continuous culture.



(i) State the name of the microorganism that is used industrially to produce citric acid. [1]

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(ii) Outline **one** condition required for optimal production of citric acid in the continuous fermenter. [1]

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(c) Outline how pathway engineering is used in industrial fermentation. [2]

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(Option B continues on the following page)

(Option B continued)

8. (a) The Amflora potato is a genetically modified organism (GMO).

(i) State how Amflora potatoes are used in industry. [1]

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(ii) Distinguish between the types of starch molecules produced in this GMO potato and in a normal potato. [1]

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(iii) Outline the genetic modification used in a GMO, such as this potato. [2]

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(Option B continues on the following page)

(Option B, question 8 continued)

(b) Soybeans have been genetically modified to be resistant to glyphosate.

(i) State the name of the organism used to introduce the glyphosate resistance into soybeans. [1]

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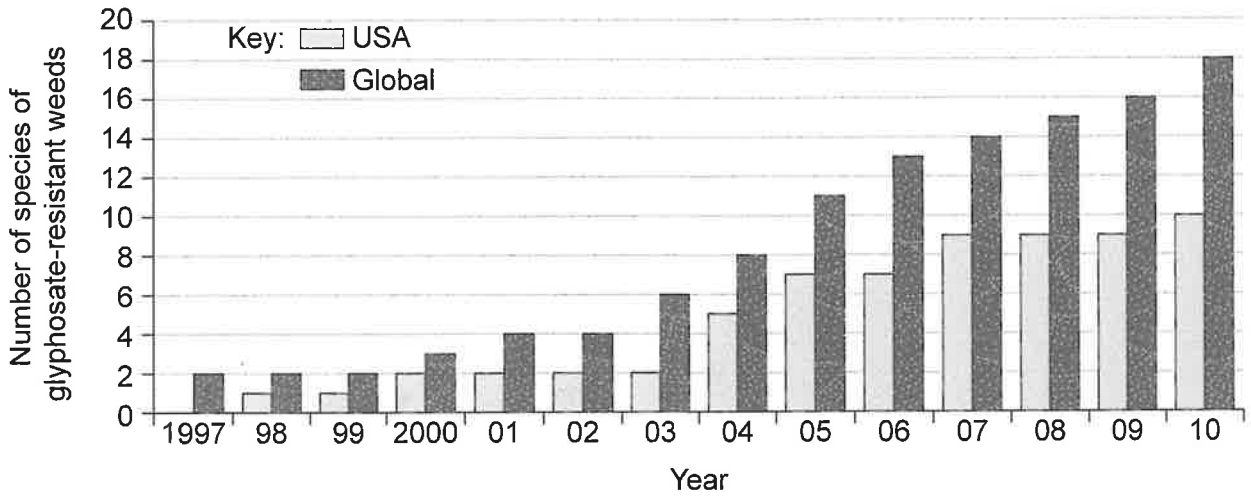
(ii) Data has been recorded on the number of species of glyphosate-resistant weeds between 1997 and 2010.



Suggest how the change in the number of species of glyphosate-resistant weeds could cause environmental problems. [2]

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(Option B continues on the following page)

(Option B continued)

9. A developing technology in wastewater treatment is membrane-based separation. However, biofilms can develop on the membranes and prevent them from filtering waste.

(a) Describe a biofilm. [1]

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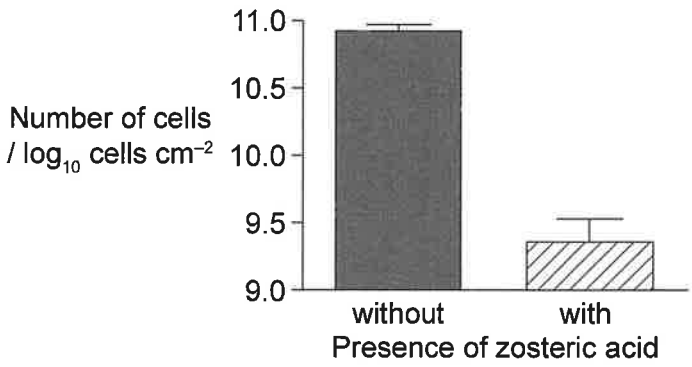
(b) Biofilms on filter membranes in wastewater treatment plants were found to be dominated by the bacterium *Pseudomonas putida*. Zosteric acid (an organic acid) was tested as a possible control of the growth of *P. putida* biofilms.



(i) Evaluate the use of zosteric acid as a possible control of the formation of biofilms by *P. putida*. [2]

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(ii) Suggest a reason for the effect of zosteric acid on the growth of *P. putida*. [1]

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(Option B continues on the following page)

(Option B continued)

10. Explain briefly how genes are introduced into plants by electroporation and by using calcium chloride. [4]

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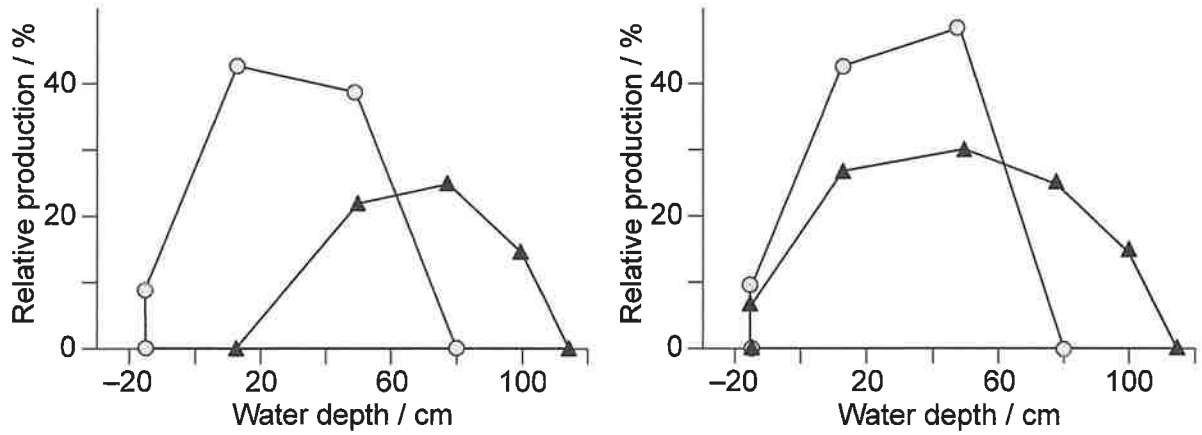
End of Option B

Option C — Ecology and conservation

11. Cattails or bulrushes (*Typha*) are plants found in wetlands in many parts of the world.

The distribution of two species of *Typha* was studied in ponds at different depths of water. The relative production (%) was calculated from the mean total dry biomass of each species at each depth. The negative values of water depth indicate that the plants were growing at the edge of the ponds with their bases above the water level.

Both species grown together **Each species grown separately**



Key: ○ *T. latifolia* ▲ *T. angustifolia*

(a) Identify the specific type of niche that each graph illustrates. [2]

Both species grown together: .....

Each species grown separately: .....

(Option C continues on the following page)

(Option C, question 11 continued)

(b) Distinguish between the distributions of the two species in the two graphs according to water depth. [2]

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(c) Describe **two** environmental factors, other than water depth, that could affect the distribution of the two species, giving a reason for each. [2]

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(Option C continues on the following page)

(Option C continued)

12. (a) Not all of the energy ingested by animals in their food is ultimately converted to energy in the biomass of the animal's body.

(i) State **one** factor that affects the percentage of ingested energy converted to biomass. [1]

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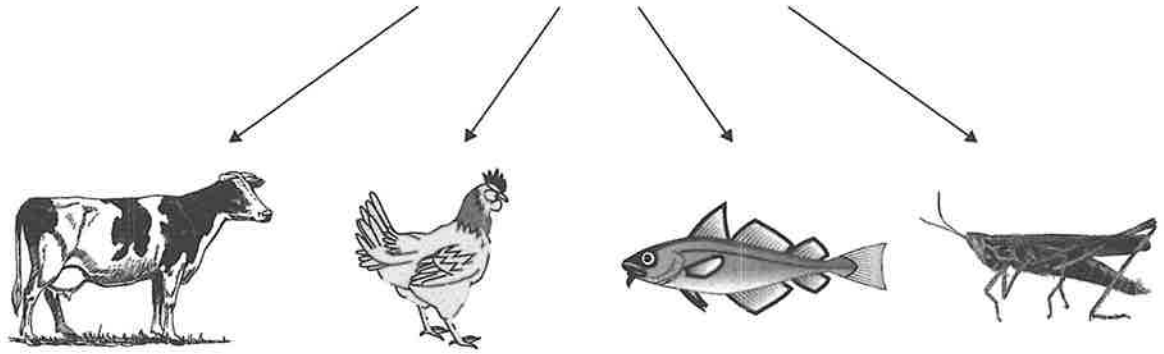
(ii) The diagram shows the conversion ratios of four animals when fed 100 kg of feed.

100 kg feed



Cow
5 kg edible parts

Chicken
22 kg edible parts

Fish
65 kg edible parts

Cricket
80 kg edible parts

Discuss the differences in the conversion ratios of the cow and fish. [2]

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(Option C continues on the following page)

(Option C, question 12 continued)

(iii) Crickets are said to be the food of the future. Using the data, deduce an advantage for crickets as a food source for humans. [1]

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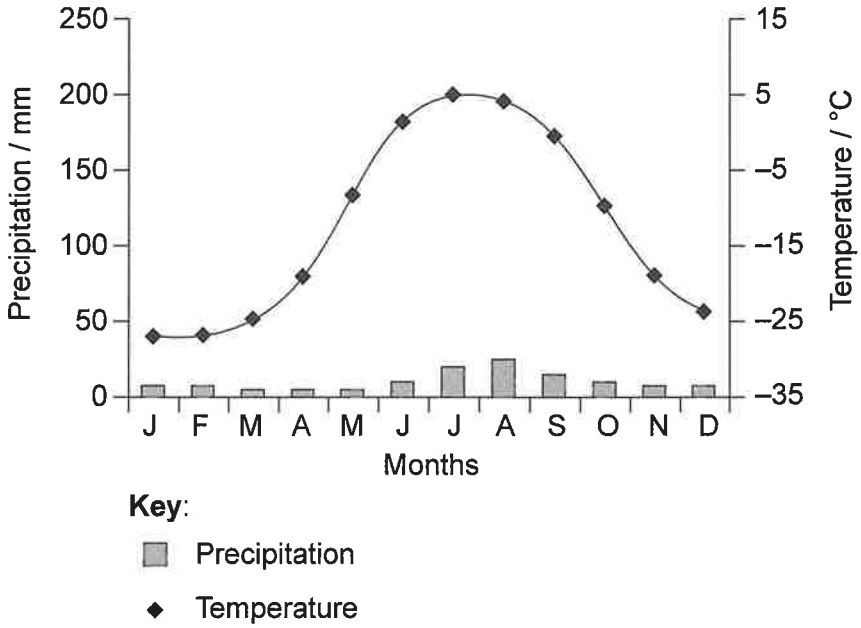
(b) A climograph for an ecosystem is shown.



Identify the ecosystem shown in the climograph. [1]

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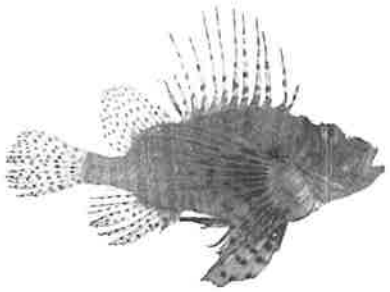
(Option C continues on the following page)

(Option C continued)

13. (a) The red lionfish (*Pterois volitans*) is an aggressive predator that inhabits coral reefs. It is native to the Indo-Pacific ocean but has recently been found in Florida, the Gulf of Mexico and the Caribbean and is considered to be an invasive species.



Discuss the impact that the presence of this fish could have in the Gulf of Mexico. [3]

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(b) Outline the effect of DDT on the environment. [2]

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(Option C continues on the following page)

(Option C continued)

14. Entire communities need to be conserved in order to preserve biodiversity. Suggest different quantitative methods to measure changes in biodiversity in a community over time. [4]

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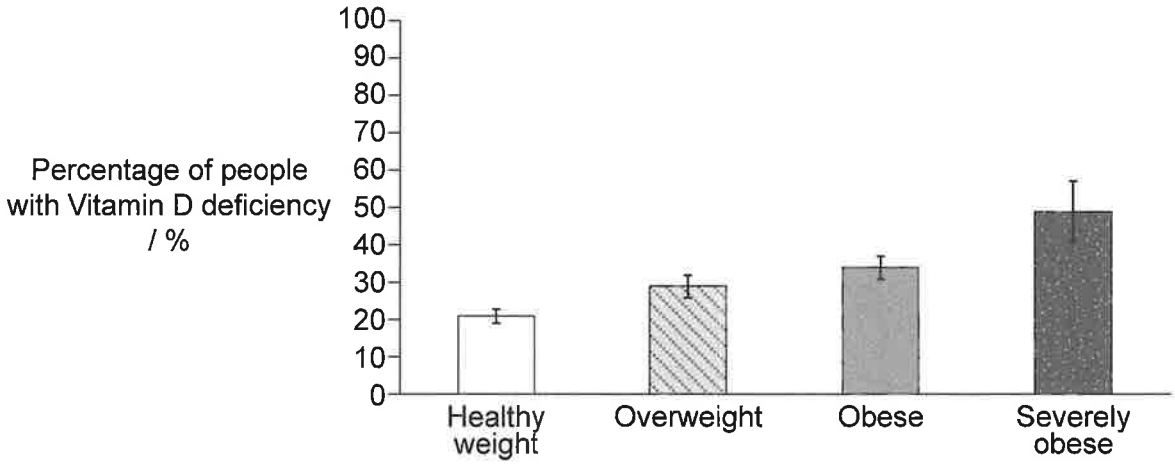
End of Option C

Option D — Human physiology

15. There are many studies that show that overweight and obese people have greater health risks. The graph shows the relationship between body mass and Vitamin D deficiency.



(a) (i) Outline the relationship shown between body mass and Vitamin D deficiency. [1]

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(ii) State **one** effect of Vitamin D deficiency. [1]

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(iii) People who are obese have an increased risk of hypertension. Outline the consequences of hypertension. [2]

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(b) State the cause of scurvy. [1]

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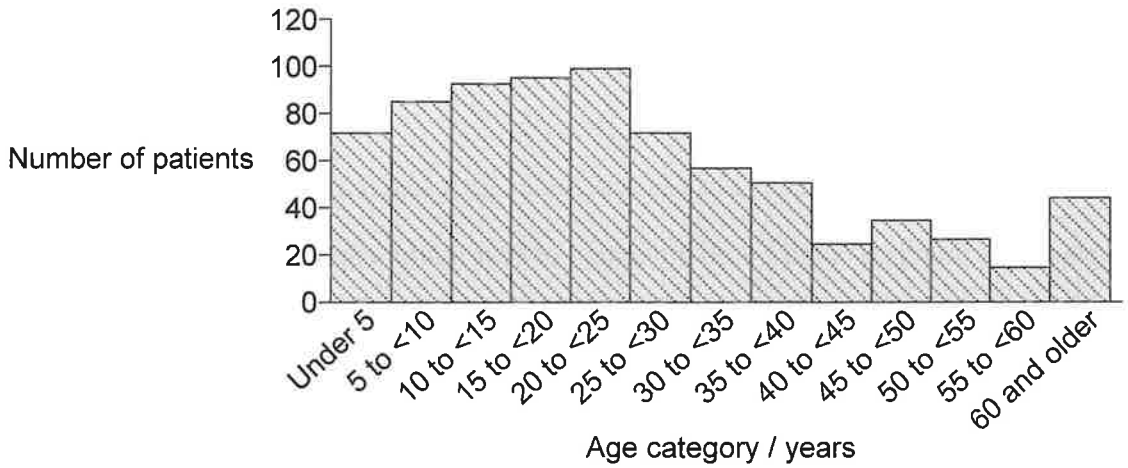
(Option D continues on the following page)

(Option D continued)

16. In 2012, Sierra Leone suffered a nationwide cholera epidemic. The graph shows the number of people admitted to cholera wards during a two-month period.



(a) State the main symptom of cholera that would have resulted in admission to hospital. [1]

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(b) Suggest **one** reason for the age distribution of patients admitted to cholera wards. [1]

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(c) Outline the processes that occur in the large intestine of a healthy person. [2]

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(Option D continues on the following page)

(Option D continued)

17. (a) Identify **one** structural difference between sinusoids and capillaries of the liver. [1]

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(b) Explain how jaundice could be an indication of liver malfunction. [2]

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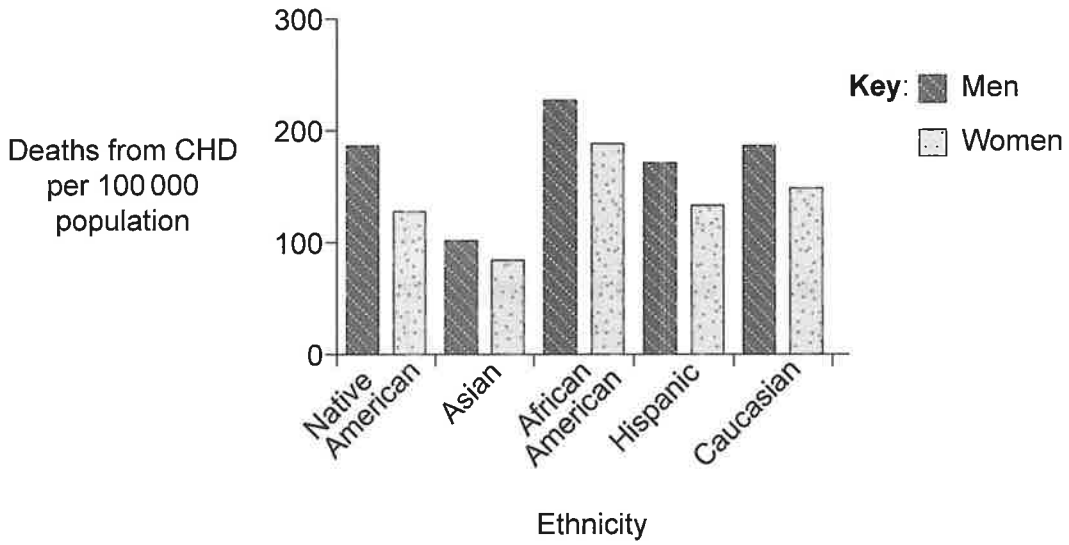
18. The bar chart shows the prevalence of coronary heart disease (CHD) deaths in New Mexico, USA, between 2014–2016, according to ethnicity and sex.



(a) Distinguish between male and female death rates due to CHD. [1]

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(Option D continues on the following page)

(Option D, question 18 continued)

(b) Suggest **one** reason for the differences between the sexes in death rate from CHD. [1]

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(c) Explain the reasons for separating the population of New Mexico into ethnic groups in this research. [2]

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19. Explain how signals from the sinoatrial node (SAN) pass to other parts of the heart, so that the beating of the heart is coordinated. [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:

1. [*How concentration of salt solution affects the average % change in mass of cantaloupe pieces*], 2008. [graph online] Available at: <http://science.halleyhosting.com/sci/ibbio/cells/labs/osmosisinq/graph2.gif> [Accessed: 8 April 2019].

2. Kim, J., et al., 2006. *Fig. 6. The effects of varying pCO^2 concentrations on the mean growth rates of (a) S. costatum, and (b) Nitzschia spp. during the bloom period.* [graph] (*Limnol. Oceanogr.*, 51(4), p.1634).

3. Guyton, A.C. and Hall, J.E., 2006. *Figure 41–8. Effect of exercise on oxygen consumption and ventilatory rate.* [graph] (T*extbook of Medical Physiology*, 11th edition, p.520).

4. (a) [*Neural tissues*], 1997. [images online] Available at: <https://shareitforward.files.wordpress.com/2012/06/data-to-action-kamsack-june-2011.pdf> [Accessed: 8 April 2019].

4. (b)(i) Marslen-Wilson, W.D. and Tyler, L.K., 2007. *Figure 7.* [image] (*Philosophical Transactions of the Royal Society B*, 362(1481)).

5. (c) Niimura, Y., et al., 2014. [*Genes involved in sense of smell*] [chart online] Available at: <http://www.genome.org/cgi/doi/10.1101/gr.169532.113> [Accessed: 9 April 2019].

7. (b)(i) [*Citric acid plant in Czech Republic*], n.d. [image online] Available at: <http://www.kasel.com/citric-acid-plant-in-czech-republic/> [Accessed: 8 April 2019].

8. (a). [*Amflora potato*], 2011. [image online] Available at: <https://www.basf.com> [Accessed: 8 April 2019]. REFERENCE REDACTED.

8. (b)(ii) National Research Council, 2010. *FIGURE 2-6 Number of weeds with evolved glyphosate resistance.* [graph] *(The Impact of Genetically Engineered Crops on Farm Sustainability in the United States*. Washington, DC: The National Academies Press, p.78).

9. (b)(i) Polo, A., et al., 2014. *Figure 4. Effect of zosteric acid on the amount of P. putida sessile cells.* [graph] (*International Journal of Molecular Sciences*, 15(6), p.9504).

11. [*Flowers of Common Cattail*], n.d. [image online] Available at: <https://extension.umass.edu/landscape/weeds/typha-latifolia> [Accessed: 8 April 2019].

11. (a) Grace, J.B. and Wetzel, R.G., 1981. *The American Naturalist*, 118(4), pp.463–474.

12. (a)(ii) [*Four animals when fed 100 kg of feed*]. [images online] Available at: <https://pixabay.com> [Accessed: 8 April 2019].

12. (b) [*Climograph*], 2018. [climograph online] Available at: <https://www.earthonlinemedia.com> [Accessed 9 April 2019]. REFERENCE REDACTED.

13. (a) [*Pterois volitans*], 2013. [image online] Available at: <http://fishesofaustralia.net.au/Images/Image/PteroisVolitansNORFANZ.jpg> [Accessed: 8 April 2019].

15. Turer, C.B., et al., 2013. *Fig. 1A. The prevalence of vitamin D deficiency.* [graph] (*Pediatrics*, 131(1), p.e155).

16. Blacklock, A., et al., 2014. *Fig. 2 Age distribution of total patient population admitted to the cholera wards.* [graph] (Global Health Action, 8(1)).

18. [*Deaths from CHD per 100000 population*], n.d. [graph online] Available at: <https://ibis.health.state.nm.us/indicator/complete_profile/CardioVasDiseaseHeartDeath.html> [Accessed: 8 April 2019].