Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 3

13 May 2024

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

Candidate session number

1 hour 15 minutes

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 **[45 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 – 8
Option B — Biotechnology and bioinformatics	9 – 14
Option C — Ecology and conservation	15 – 19
Option D — Human physiology	20 – 25

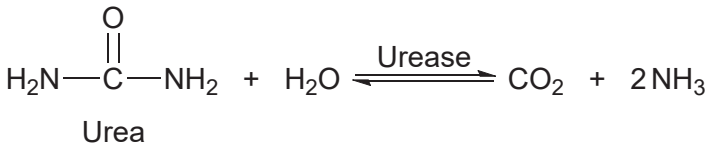
2224 – 6003

34 pages

Section A

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

1. Urease is an enzyme found in soybeans (*Glycine max*) that catalyses the hydrolysis of urea into ammonia and carbon dioxide. The reaction can be summarized as shown.



In order to investigate the effect of temperature on the activity of urease, a student placed 0.50 g samples of urease powder into 10.0 ml of 1.0 % aqueous urea solutions in five separate test tubes. Each test tube was held at a different temperature and the change in pH in the samples was measured after 20 minutes. Ammonia is a weak base and its formation causes the pH of the reaction mixture to increase. The results are summarized in the table.

Test tube	Temperature / °C	Starting pH	Final pH	Change in pH
1	10	7.05	7.09	0.04
2	20	7.05	7.89	0.84
3	40	7.05	8.90	1.85
4	60	7.05	7.42	0.37
5	80	7.05	7.14	0.09

(a) Identify the independent variable in this investigation. [1]

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(b) Identify **two** controlled variables in this investigation. [2]

1. . . . . .

2. . . . . .

(This question continues on the following page)

(Question 1 continued)

(c) Explain **two** ways in which the investigation can be improved. [2]

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

Answers written on this page
will not be marked.

2. A wearable monitor can be used to measure heart rate before and after exercise on an aerobic stepper. A student asked 100 female classmates of approximately 14 years of age to take part in the investigation.

monitor

stepper

(a) (i) Suggest a research question that the student could investigate using this equipment. [1]

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(ii) The student plans to conduct the investigation in the school. Identify **two** variables that should be controlled in this investigation. [2]

1. . . . . .

2. . . . . .

(b) Discuss how the student can ensure that the investigation is conducted in a safe and ethical way. [2]

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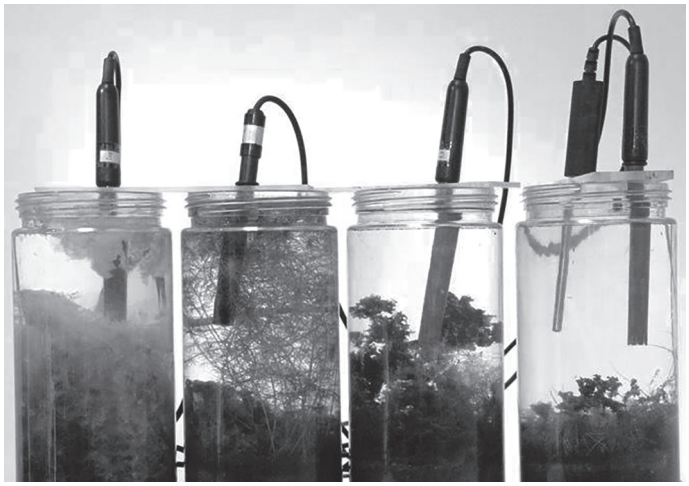
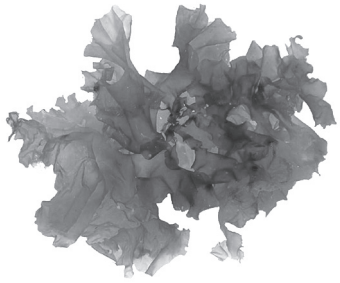
3. Growth rates of marine algae can be investigated using experimental mesocosms such as those shown.

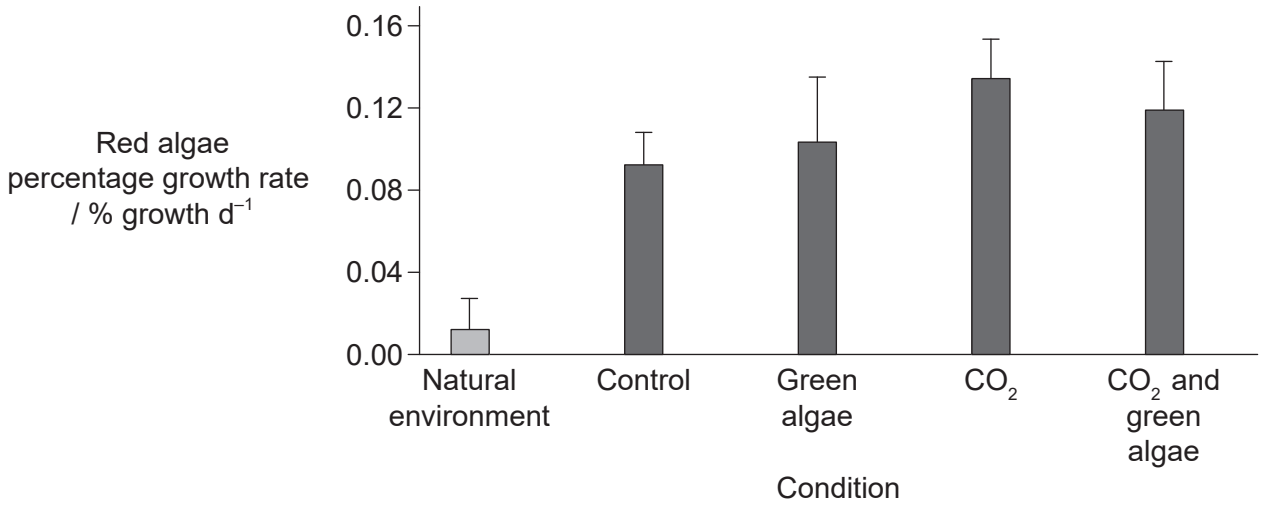


Gracilaria, a red alga



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) Describe how the photosynthetic pigments in the algae can be identified. [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

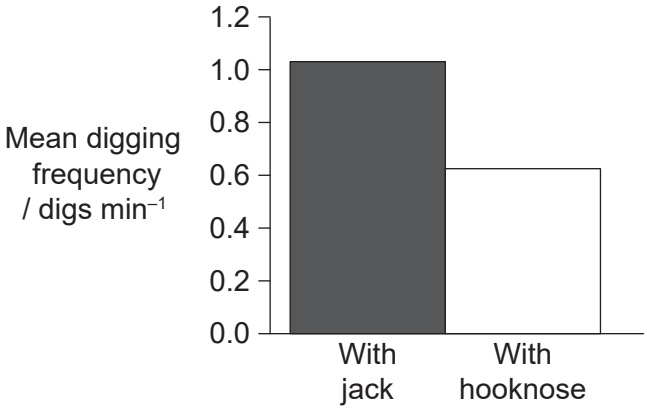
4. Coho salmon, *Oncorhynchus kisutch,* displays two distinct male phenotypes commonly referred to as "jack" and "hooknose". Females will spawn with both male phenotypes. Hooknose males are larger, have greater fat reserves and have more strongly developed secondary sex characteristics.

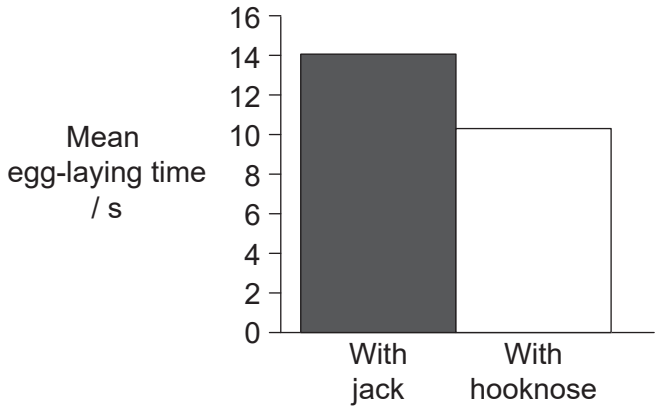
jack male

hooknose male

The reproductive behaviour of the two phenotypes is different. Jack males prefer a less aggressive approach to females while hooknose males display a more threatening, aggressive approach.

In the presence of a male (hooknose or jack), females display digging and egg-laying behaviour. Digging involves making one or more holes in the riverbed to receive the eggs. The occurrence of digging behaviour and the time spent laying eggs were recorded over two mating seasons.





(Option A continues on the following page)

(Option A, question 4 continued)

(a) Compare and contrast the female behaviour in the presence of each male phenotype. [3]

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(b) Suggest a possible advantage of the jack behavioural strategy. [1]

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(c) Suggest an evolutionary advantage for the presence of stable populations of jack and hooknose males in coho salmon populations. [1]

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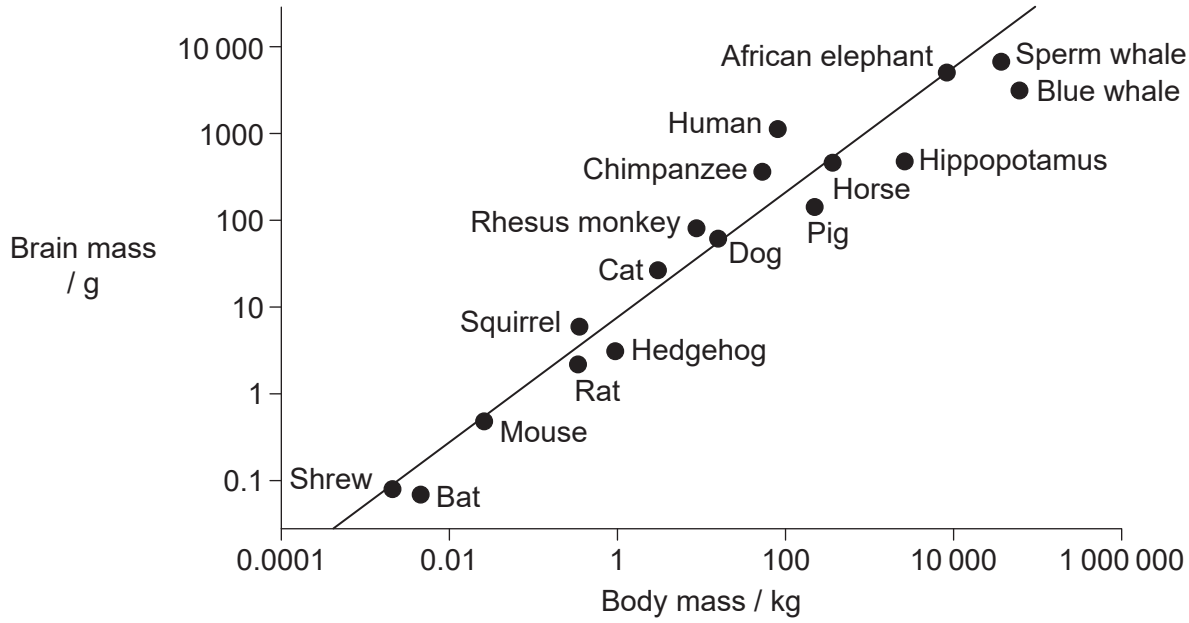
(Option A continues on the following page)

(Option A continued)

5. Brain mass and body mass are shown for a range of mammals.



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

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(b) State **two** functions of the cerebral hemispheres of the brain. [2]

1. . . . . .

2. . . . . .

(c) Outline the features of the cerebral cortex of humans that make it more developed than in other mammals. [2]

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(Option A continues on the following page)

(Option A, question 5 continued)

(d) Outline the relationship between learning and memory. [2]

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(e) Outline neural plasticity. [2]

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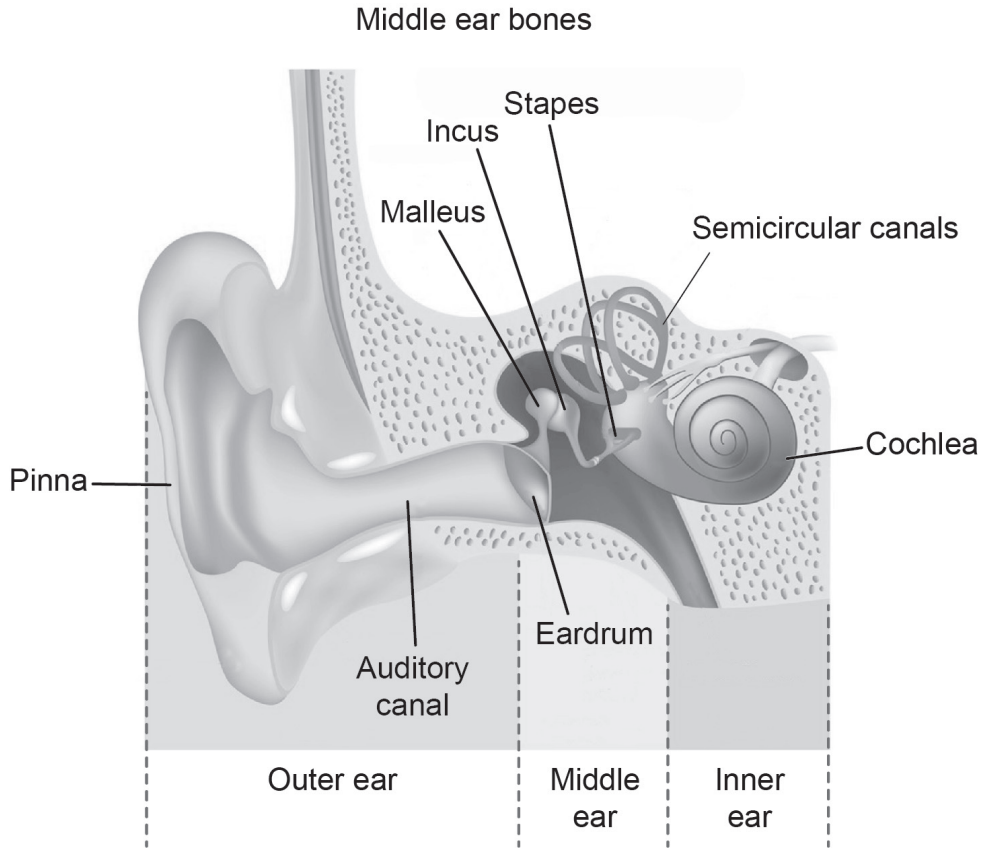
(Option A continues on the following page)

(Option A continued)

6. The image shows the anatomy of the human ear.



(a) State the function of the bones of the middle ear. [1]

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(b) Explain how sound waves arriving at the inner ear are processed. [3]

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(Option A continues on the following page)

(Option A, question 6 continued)

(c) Outline how the inner ear controls balance in humans. [2]

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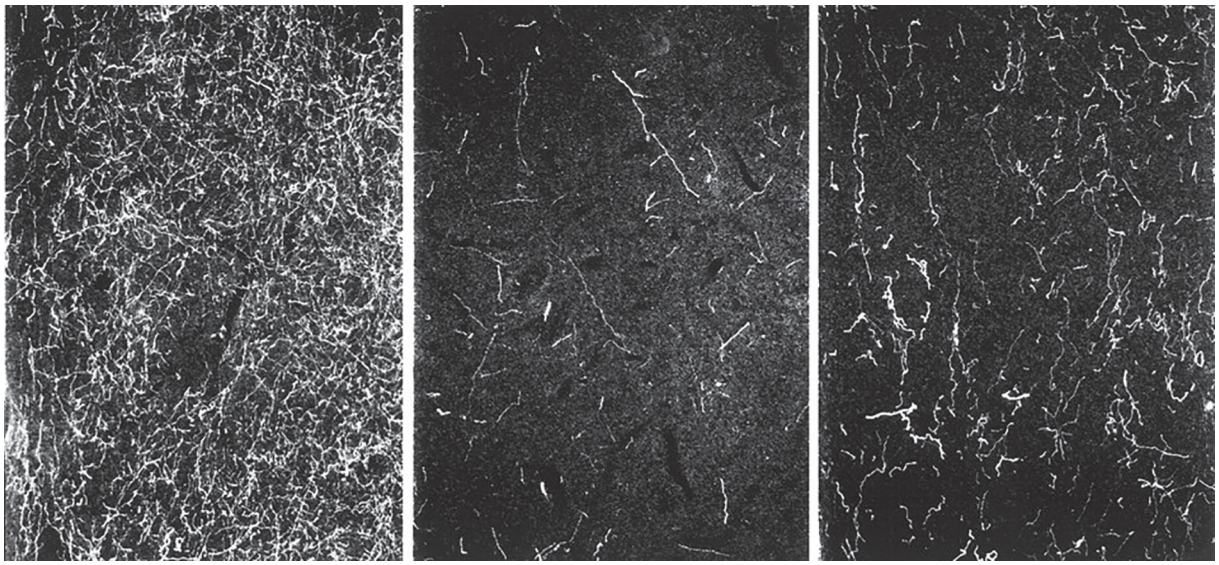
(Option A continues on the following page)

(Option A continued)

7. The images show axons in the brains of squirrel monkeys, *Saimiri sciureus,* that have been exposed once to MDMA (ecstasy). Axons of serotonin-producing neurons appear light against the dark background. Image A shows axons from the forebrain in an untreated control (no MDMA). Image B shows the forebrain two weeks after MDMA treatment and image C shows this region seven years after MDMA treatment.

A Untreated control (no MDMA)	B Two weeks after MDMA treatment	C Seven years after MDMA treatment



(a) Outline the conclusions that can be drawn from these images. [2]

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(b) Outline **one** physiological impact and **one** behavioural impact of MDMA. [2]

Behavioural impact: . . . . . .

Physiological impact: . . . . . .

(Option A continues on the following page)

(Option A continued)

8. Explain the mechanisms involved in the transmission of impulses between neurons. [6]

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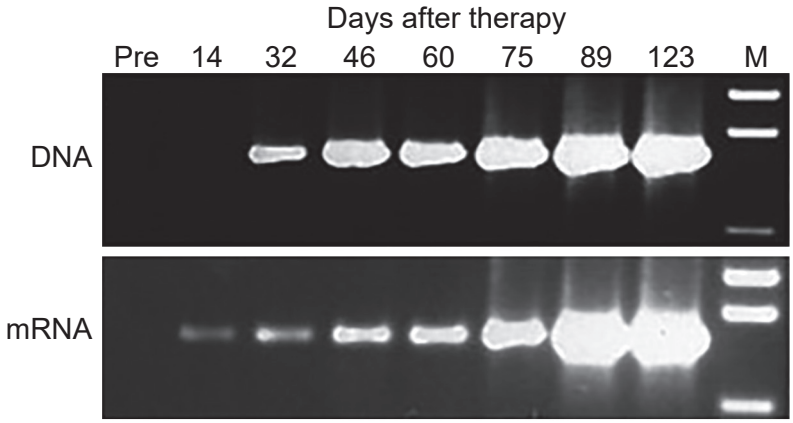
End of Option A

Option B — Biotechnology and bioinformatics

9. Severe combined immunodeficiency disease (SCID) is linked to a mutation in a peptide chain of a T-cell surface protein. A viral vector was used to genetically modify the T-cells of a SCID patient with a gene encoding a normal human cell surface protein. Gene transfer was performed *in vitro* and the modified cells returned to the patient by blood transfusion.

Gel electrophoresis performed on samples from the patient's T-cells showed the presence of viral DNA and the mRNA transcribed from this DNA.



Key:
Pre: pre-treatment sample
M: molecular mass marker (standard-sized DNA)

(a) Outline the evidence that the gene transfer has been successful. [3]

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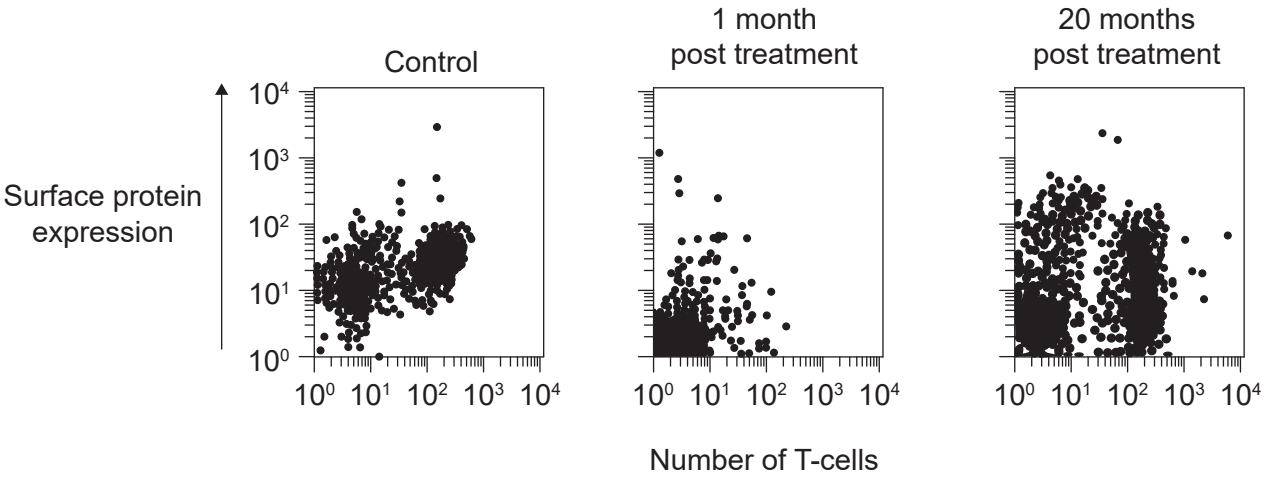
(Option B continues on the following page)

(Option B, question 9 continued)

(b) The proportions of T-cells producing the surface protein in a control sample from a healthy patient and two samples from the SCID patient one month and 20 months post treatment are shown in a series of graphs.



Evaluate the evidence from these graphs that the treatment has been successful over the 20-month period. [2]

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(c) Outline how a viral vector can genetically modify a target host cell. [2]

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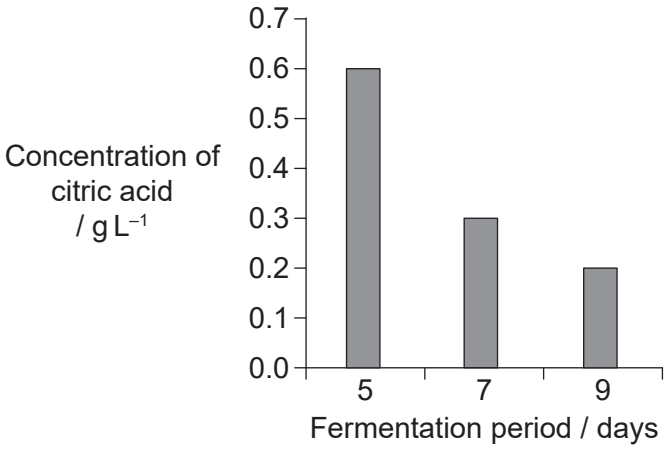
(Option B continues on the following page)

(Option B continued)

10. Citric acid can be produced from fruit pulp using *Aspergillus niger* as the active microorganism. Fermenters can be operated either on a continuous or a batch basis. The image shows a typical batch fermenter and the bar chart shows concentrations of citric acid in such a fermenter.

Citric acid fermenter



(a) At the start of batch fermentation, measured amounts of *A. niger* and fruit pulp are added to the fermenter. Identify **one** variable that should be controlled during batch fermentation of citric acid. [1]

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(b) Explain what may cause the changes in citric acid concentration seen in the bar chart. [2]

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(Option B continues on the following page)

(Option B, question 10 continued)

(c) Distinguish between batch fermentation and continuous fermentation. [2]

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11. Genetically modified plants, including agricultural crops, are widely grown around the world.

(a) Using a **named** example, outline the advantages that can be achieved through genetic modification of plants. [2]

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(b) Explain how biolistics is used to transfer DNA into plants. [4]

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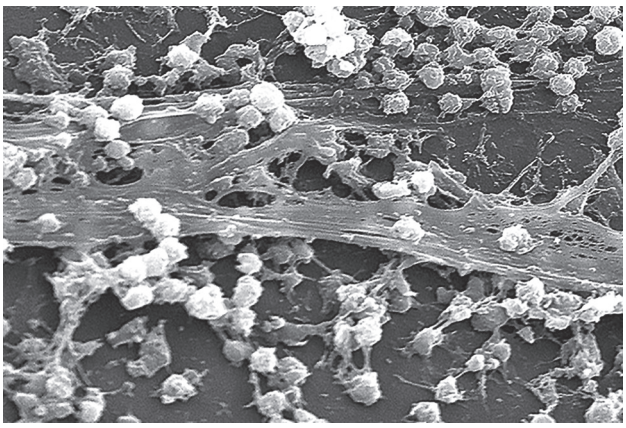
(Option B continues on the following page)

(Option B continued)

12. Bacterial biofilms have important consequences in technology and medicine. The image shows a biofilm on medical equipment.



(a) Outline the properties of biofilms. [2]

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(b) Explain how sewage treatment plants make use of biofilms. [2]

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13. The symptoms of some genetic diseases only become apparent in later life. Outline how a genetic disease can be diagnosed in adults. [2]

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(Option B continues on the following page)

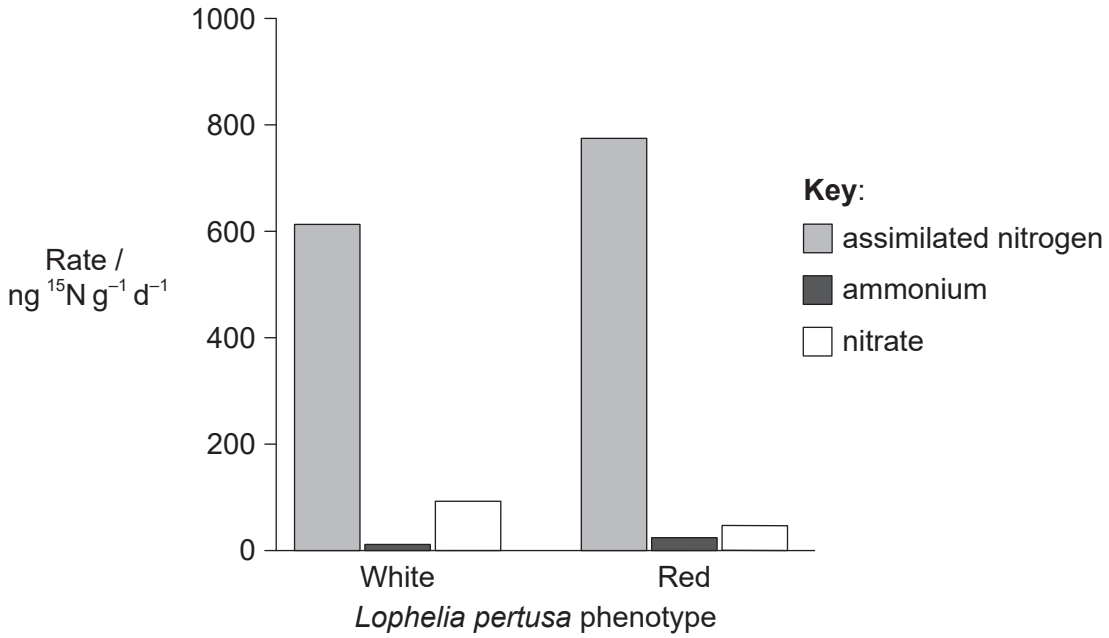
(Option B continued)

14. Explain how online databases can be used to investigate the functions of a newly discovered protein. [6]

End of Option B

Option C — Ecology and conservation

15. *Lophelia pertusa* is a cold-water marine coral that forms reefs at depths of fifty metres or more, where little light is available. In this environment, nutrients are scarce and must be cycled efficiently. The efficiency of nitrogen cycling was investigated using an ^{15}N tracer isotope. The rate at which ^{15}N is assimilated into organic compounds in the coral tissues was measured for two phenotypes of *L. pertusa*. The rate at which ^{15}N is released into the surrounding water as ammonium and nitrate was also measured.



(a) List **two** types of molecule that could contain ^{15}N assimilated into the tissues of *L. pertusa*. [1]

1. . . . . .

2. . . . . .

(b) Compare and contrast the contributions of the red and white phenotypes to nitrogen cycling. [2]

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(Option C continues on the following page)

(Option C, question 15 continued)

(c) Some of the ^{15}N supplied to the corals is later found in the surrounding water in the form of nitrate. Outline the process of denitrification which helps to retain this nitrogen in the ecosystem. [2]

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(d) *L. pertusa* lives in a symbiotic relationship with nitrogen-fixing bacteria. Suggest why nitrogen fixation is important for *L. pertusa*. [1]

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(Option C continues on the following page)

(Option C continued)

16. *Aedes japonicus* and *Aedes albopictus* are invasive mosquito species that have recently become established in Western Europe. *A. japonicus* is more suited to the cooler regions in central Europe, while *A. albopictus* is adapted to warmer temperatures of the Mediterranean regions.

A. japonicus

A. albopictus

(a) Outline **two** other ways, apart from preferred climate, in which the niches of these species may differ. [2]

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(b) Suggest a possible impact of increasing mean temperatures in Europe on the distribution of *A. albopictus*. [1]

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(c) Predict possible outcomes for the two species in regions of Europe where the niches overlap. [2]

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(Option C continues on the following page)

(Option C, question 16 continued)

(d) Discuss the benefits and risks of using DDT to control mosquitoes. [3]

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(e) Outline the environmental concerns surrounding marine macroplastic pollution. [2]

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(Option C continues on the following page)

(Option C continued)

17. Farmed fish are a rich source of protein. Feed conversion ratio is a measure of the proportion of feed that is converted into fish biomass.

(a) Describe the flow of energy in a fish farm. [3]

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(b) Suggest **two** possible harmful consequences of supplying excess feed, leaving some uneaten by the farmed fish. [2]

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(Option C continues on the following page)

(Option C continued)

18. Outline how *ex situ* strategies are used in conservation. [3]

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(Option C continues on the following page)

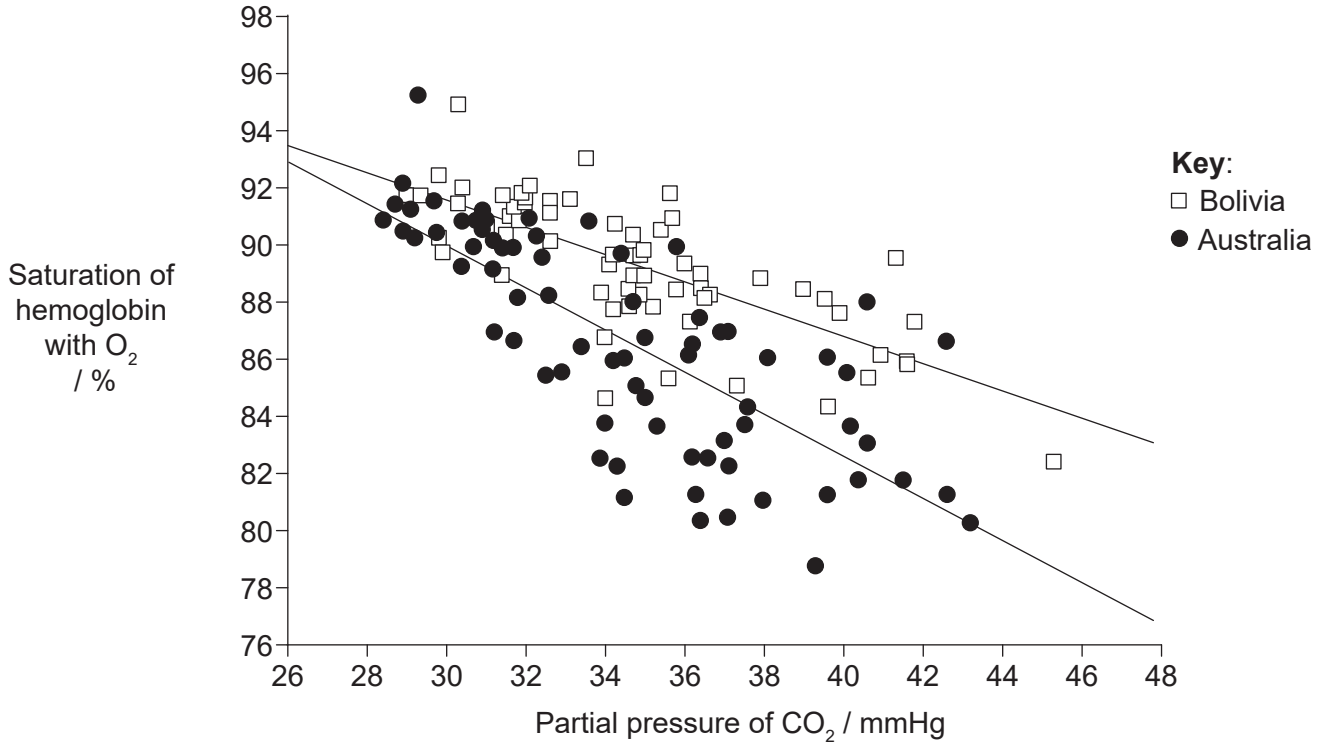
(Option C continued)

19. Discuss how wild fish populations are assessed to ensure sustainable fishing practices. [6]

End of Option C

Option D — Human physiology

20. The effects of altitude on athletic performance were investigated in teams of soccer players while they were acclimatizing to an altitude of 3600 m above sea level. The study group consisted of players from Bolivia who normally lived at high altitude and players from Australia who normally lived at sea level. O_2 and CO_2 concentrations in arterial blood were measured daily over a 12-day period. O_2 concentrations were measured as the percentage saturation of hemoglobin and CO_2 concentrations were measured as partial pressure.



(a) Compare and contrast the results for the two teams. [2]

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(Option D continues on the following page)

(Option D, question 20 continued)

(b) The concentration of CO_2 in arterial blood changed in athletes from both teams as they acclimatized to the high altitude. Outline how CO_2 is transported in blood. [2]

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(c) In the Australian players, the rate of ventilation increases initially with altitude. Explain how the rate of ventilation is controlled in humans. [2]

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21. Many mammals, including cats and dogs, can biosynthesize ascorbic acid (vitamin C), while in humans and other primates, ascorbic acid is an essential nutrient.

(a) Identify **two** groups of essential nutrients, other than vitamins, in the human diet. [2]

1. . . . . .

2. . . . . .

(b) Outline the role of a **named** essential nutrient, other than vitamin C, in the human diet. [2]

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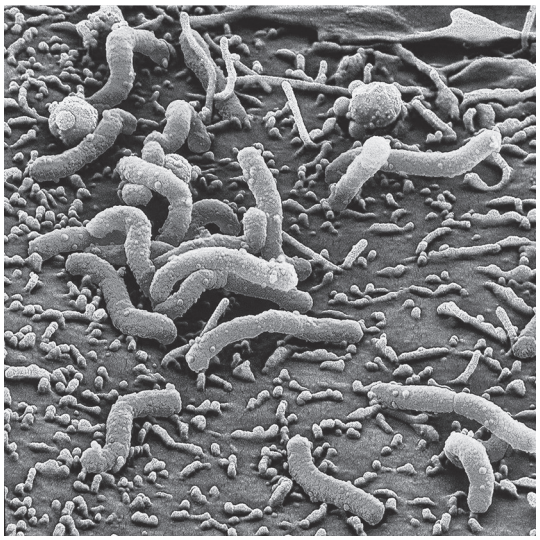
(Option D continues on the following page)

(Option D continued)

22. Stomach ulcers are often caused by *Helicobacter pylori* infection. These bacteria attach to the cells of the stomach wall using flagella. They secrete ammonia that neutralizes the acid in the immediate vicinity of the bacterial cells.



(a) Outline the importance of stomach acid for digestion. [2]

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(b) Describe the mechanisms involved in controlling the secretion of digestive juices. [2]

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(Option D continues on the following page)

(Option D, question 22 continued)

(c) The liver is a large, complex organ with many metabolic functions. Outline the role of the liver in regulating the levels of nutrients in the blood. [3]

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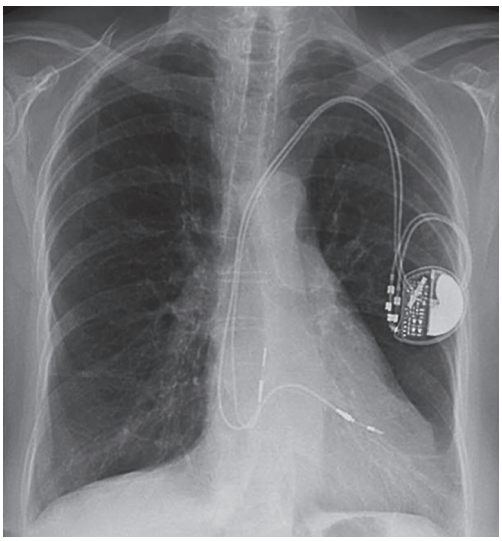
23. The image shows a cardiac pacemaker that has been implanted in the chest of a patient.



(a) State the function of a pacemaker. [1]

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(b) Describe the causes of the heart sound in humans when the ventricles are relaxing. [1]

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(Option D continues on the following page)

(Option D, question 23 continued)

(c) Explain how the atria and ventricles of the heart are stimulated to contract. [3]

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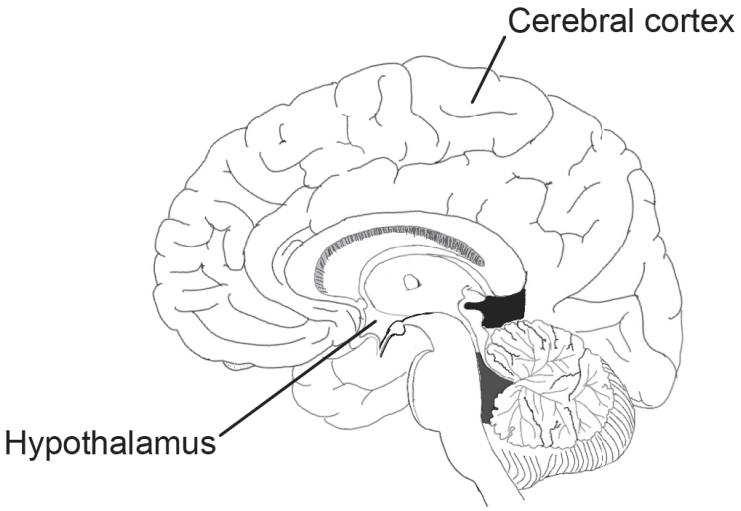
24. The hypothalamus is a region of the brain with a wide range of regulatory functions.



Outline **two** regulatory functions of the hypothalamus. [2]

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2. . . . . .

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(Option D continues on the following page)

(Option D continued)

25. Compare and contrast the mode of action of peptide hormones and steroid hormones. [6]

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:

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