Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 3

17 May 2023

Zone A afternoon | **Zone B** morning | **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 – 24

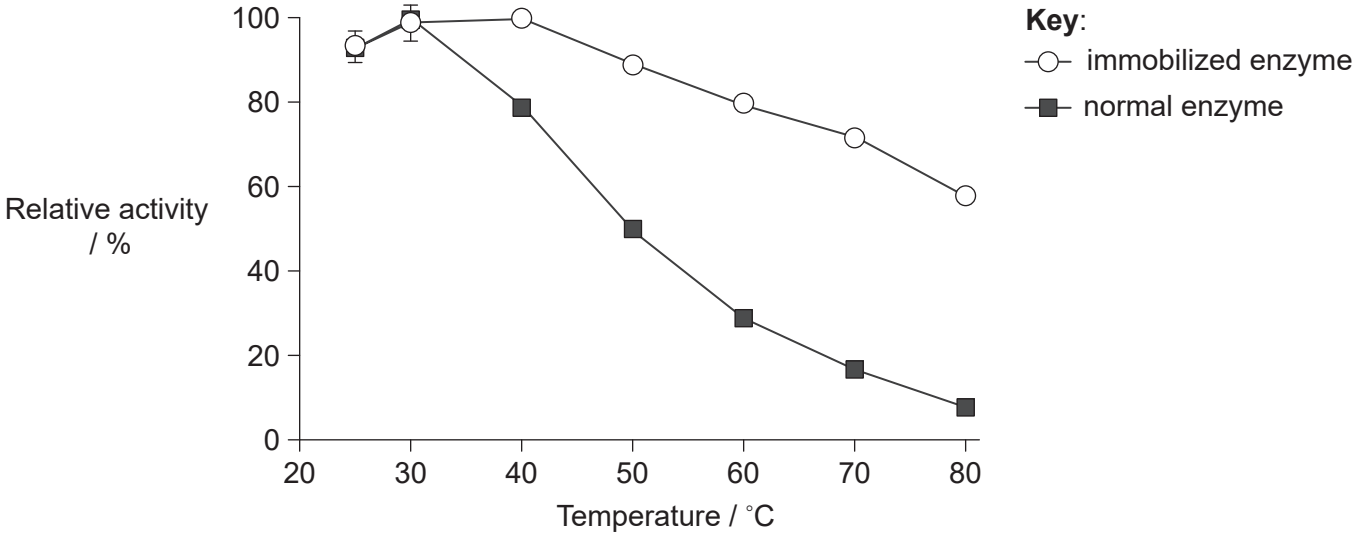
2223 – 6009

38 pages

Section A

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

1. Peroxidase enzyme (HRP) in horseradish (*Armoracia rusticana*) plants is used to break down hydrogen peroxide into water and oxygen. The extracted enzyme also has industrial uses when immobilized in ferrosoferric oxide (Fe_3O_4) and embedded in a polymer matrix. The graph shows the relative activity of HRP in both its free and immobilized forms at different temperatures. The results are a mean of three trials.



(a) State the effect that immobilizing the enzyme had on the relative activity of the enzyme. [1]

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(b) Identify **one** variable that should be kept constant while measuring enzyme activity at all temperatures. [1]

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(c) Evaluate the reliability of the results. [1]

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(This question continues on the following page)

(Question 1 continued)

(d) Using the information in the graph, describe how the experiment could be extended to determine the optimum temperature for immobilized HRP. [2]

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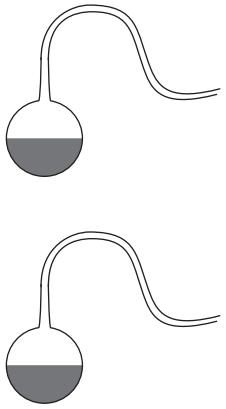
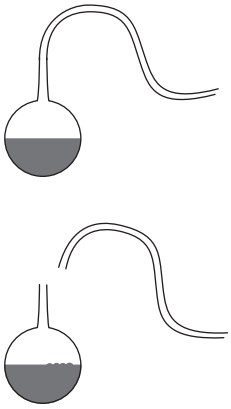
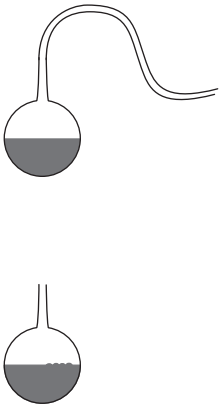
Please **do not** write on this page.

Answers written on this page
will not be marked.

2. Between 1860 and 1862, Pasteur carried out a series of experiments focusing on the development of microbes. The illustrations show Pasteur's diagrams and procedure for one experiment.

Stage 1	Stage 2	Stage 3
		
Nutrient broth is added to both flasks which are then heated until boiling	Flasks allowed to cool. One flask has glass neck broken off	Flasks left for several days

(a) Outline the reason for boiling the broth in Stage 1. [1]

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(b) Describe how Pasteur included a control in his experiment. [1]

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(c) Explain Pasteur's conclusions from his observations at Stage 3 of this experiment. [2]

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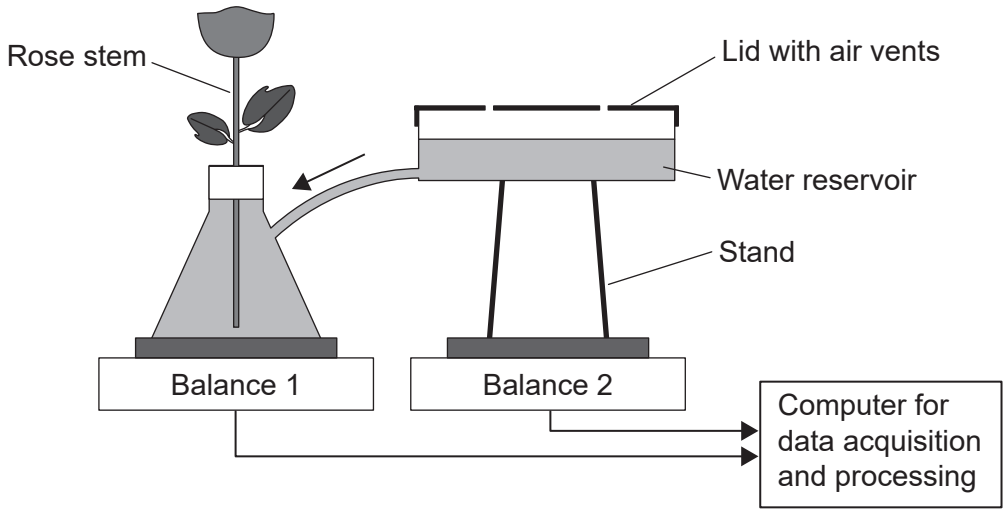
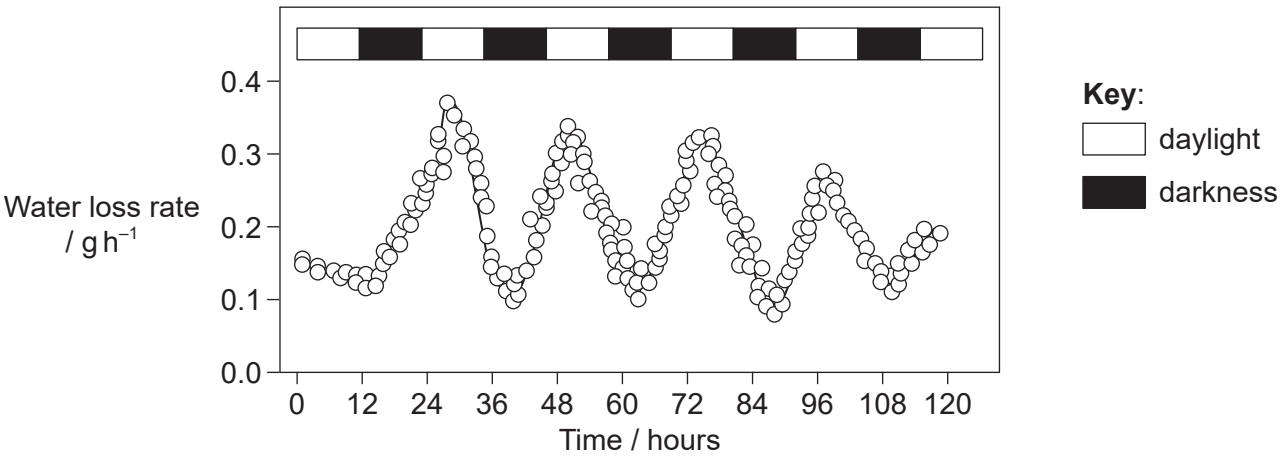
3. Researchers set up apparatus that continuously monitored the rates of water uptake and loss from cut flowers. A rose shoot was inserted into a flask of water placed on a balance. The flask was kept full by a water supply from a reservoir. The graph shows the results over five days.





(a) Suggest a reason for including a lid with vents above the water reservoir. [1]

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(This question continues on the following page)

(Question 3 continued)

(b) Explain the differences in the water loss rate in dark and light conditions. [2]

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(c) Describe how the rose shoot could be treated to show what part of the plant loses water. [1]

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(d) A standard potometer only measures water uptake. Explain how this apparatus measures the amount of water lost by the shoot as well as uptake. [2]

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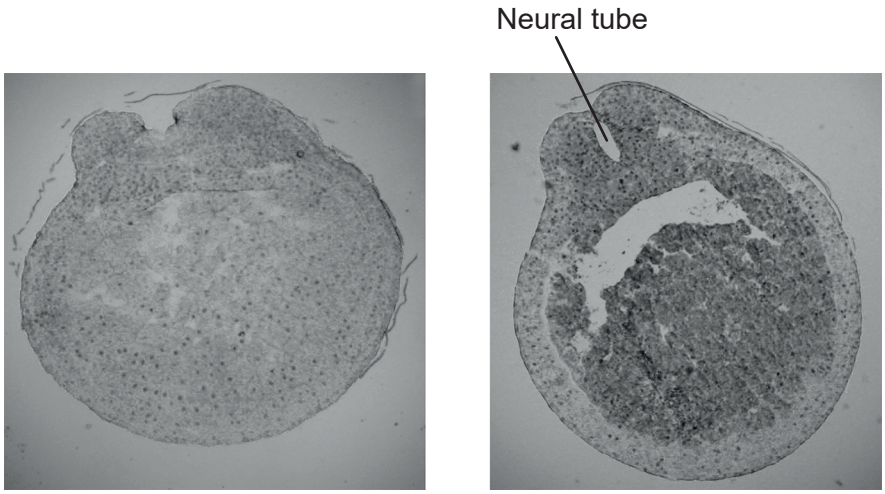
Section B

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 images show cross sections through the embryo of the African clawed frog *Xenopus laevis* at 19 and 24 hours after fertilization.



19 hours after fertilization

24 hours after fertilization

(a) Describe the formation of the neural tube between 19 and 24 hours after fertilization. [2]

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(b) Explain how development of the nervous system in the frog would continue after 24 hours. [3]

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(Option A continues on the following page)

(Option A, question 4 continued)

(c) Suggest an advantage of using animal experiments to identify the role of brain parts. [1]

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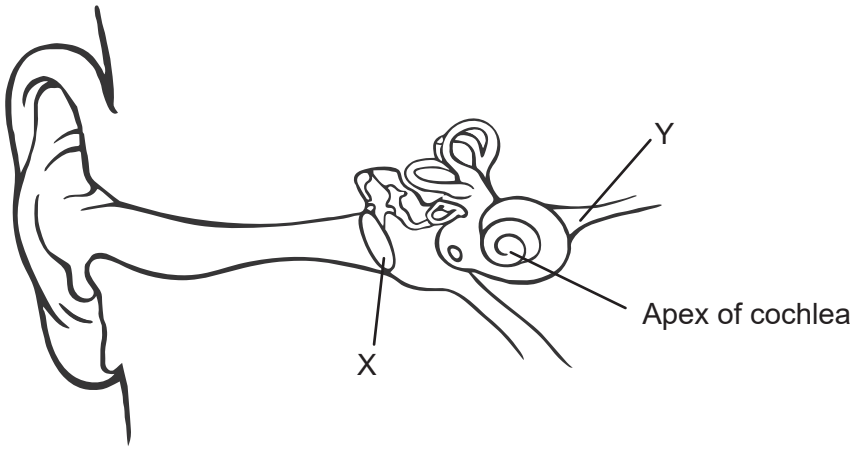
(Option A continues on the following page)

(Option A continued)

5. The diagram shows a section through the ear.



(a) Identify structures X and Y. [2]

X: . . . . . .

Y: . . . . . .

(b) State how sound waves are changed by bones in the middle ear. [1]

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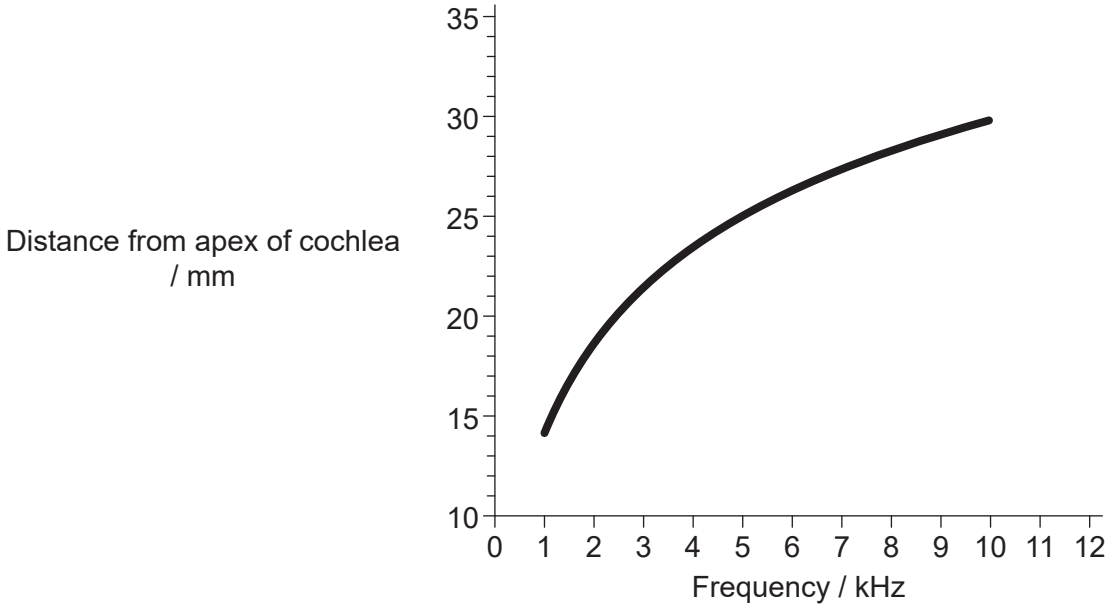
(Option A continues on the following page)

(Option A, question 5 continued)

(c) The graph shows the distance from the apex of the cochlea to the region where different frequencies of sound wave are interpreted.



Explain how high frequency and low frequency sounds are distinguished. [3]

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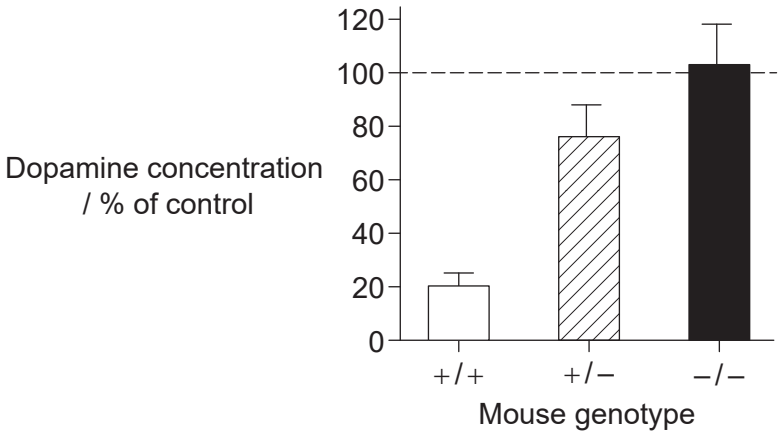
(Option A continues on the following page)

(Option A continued)

6. Dopamine transporter protein (DAT) is involved in the reabsorption of dopamine in presynaptic neurons. Mice can be homozygous (+/+) or heterozygous (+/–), or they can lack the gene (–/–) to produce DAT. Mice were given four injections of the stimulant methamphetamine, each given two hours apart, and the level of dopamine in synapses in the brain was recorded after two days. The data is presented as percentages of dopamine levels in saline controls.



(a) Using the data in the graph, state the effect of DAT on dopamine concentration in synapses. [1]

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(b) Describe the effect of stimulants on the nervous system. [3]

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(Option A continues on the following page)

(Option A, question 6 continued)

(c) Sedatives are a group of drugs that relax the central nervous system. State **one** example of a sedative drug. [1]

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(d) Outline how social environment can contribute to drug addiction. [2]

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(Option A continues on the following page)

(Option A continued)

7. The willie wagtail (*Rhipidura leucophrys*) is a common species of bird found in New Guinea and Australia. It feeds by foraging for a diverse selection of prey, including arthropods and lizards. When a willie wagtail catches prey, it either eats it or flies back to the nest to feed a young nestling bird. Researchers studied the feces of the birds to determine the size of prey eaten by the adults and the nestlings. The results are shown in the chart.

Chart removed for copyright reasons

(a) State the range of prey size most frequently eaten by adults, giving the units. [1]

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(b) Suggest a reason for the differences between prey size eaten by adults and fed to nestlings. [1]

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(c) Adults eat some prey larger than 30 mm but none between 16 and 30 mm. Suggest a reason for this difference. [1]

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(Option A continues on the following page)

(Option A, question 7 continued)

(d) Explain how the foraging behaviour shown in the graph could have evolved in willie wagtails. [2]

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8. Explain how breathing is controlled by the brain. [6]

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End of Option A

Option B — Biotechnology and bioinformatics

9. The diagrams show three types of fermenters. The arrows show where substances are added to or removed from the fermenters. The curves on the graph represent the quantity of product obtained from each fermenter at a given time.

Removed for copyright reasons

(a) Identify the curve for the product obtained from the batch fermenter. [1]

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(b) State **one** condition that should be kept constant in the fermenters to maximize output. [1]

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(Option B continues on the following page)

(Option B, question 9 continued)

(c) Explain reasons that the amount of product obtained from the fed-batch and the continuous fermenter differs. [2]

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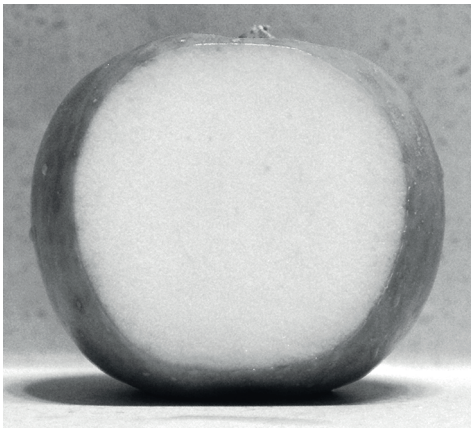
(Option B continues on the following page)

(Option B continued)

10. When apples are damaged or cut, exposure to oxygen causes the enzyme polyphenol oxidase (PPO) to oxidize polyphenols in the apple, a reaction that leads to the flesh becoming brown. Scientists have developed transgenic apples in which browning does not occur.

Normal apple



Transgenic apple

(a) Suggest a reason for browning not occurring in the transgenic apple. [1]

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(b) A marker gene in transgenic apples produces a protein called NPTII. Outline the role of marker genes. [1]

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(c) Describe how calcium chloride can be used in genetic modification. [2]

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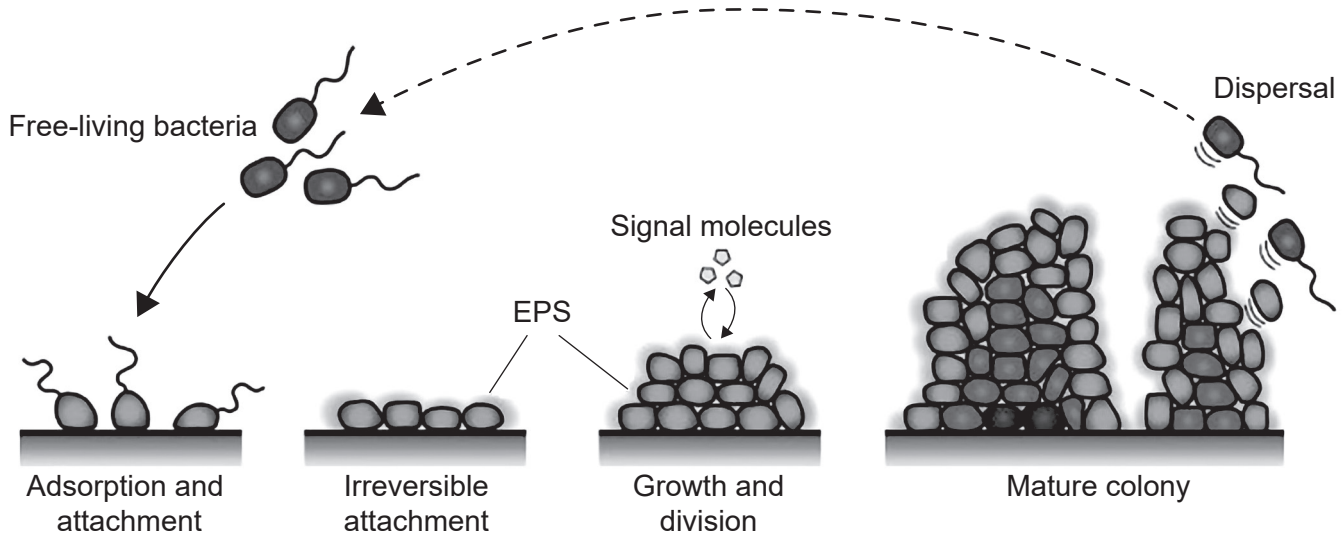
(Option B continues on the following page)

(Option B continued)

11. The image shows the life cycle of a biofilm.



(a) State **one** function of biopolymers (EPS) in the biofilm. [1]

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(b) Describe emergent properties in mature colonies of biofilms, other than EPS production. [2]

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

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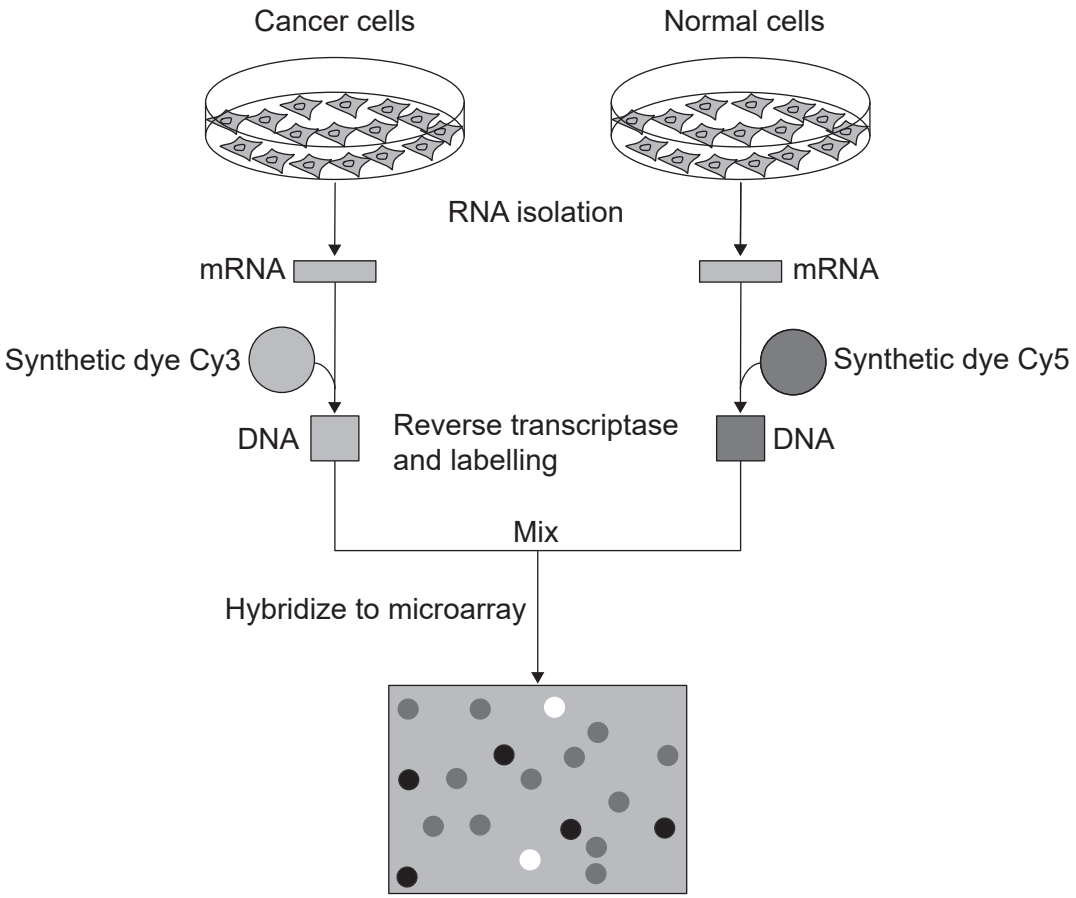
(Option B continues on the following page)

(Option B continued)

12. The diagram shows the steps in preparing a DNA microarray to detect cancer in a patient.



(a) Outline the reason that DNA is labelled with synthetic dyes Cy3 and Cy5. [1]

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(b) State the type of DNA produced by reverse transcriptase. [1]

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(Option B continues on the following page)

(Option B, question 12 continued)

(c) Explain how a microarray detects gene expression. [3]

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(Option B continues on the following page)

(Option B continued)

13. The data shows the amino acids found in a section of histone protein from various mammals. The lighter columns show differences in the amino acid sequence between the mammals.

Histone H1 (resides 120–180)

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Human KKASKPKKAASKAPTKKPKATPVKKAKKKLAATPKKAKKPKTVKAKPVKASKPKKAKPVK
Chimp KKASKPKKAASKAPTKKPKATPVKKAKKKLAATPKKAKKPKTVKAKPVKASKPKKAKPVK
Mouse KKAAKPKKAASKAPSKKPKATPVKKAKKKPAATPKKAKKPKVVKVKPVKASKPKKAKTVK
  Rat KKAAKPKKAASKAPSKKPKATPVKKAKKKPAATPKKAKKPKIVKVKPVKASKPKKAKPVK
  Cow KKAAKPKKAASKAPSKKPKATPVKKAKKKPAATPKKTKKPKTVKAKPVKASKPKKTKPVK
      *** : ********** : ************** ****** : **** ** . ********** : * **
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(a) State the name of the software which could be used to obtain the data. [1]

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(b) Suggest how the nucleotide sequence for this section of the protein may show more differences than the amino acid sequence. [1]

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(c) Describe with reference to the data how multiple sequence alignment can be used to trace evolutionary relationships between humans and other species. [3]

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(Option B continues on the following page)

(Option B continued)

14. Explain how bacteria of the genus *Pseudomonas* can be used in bioremediation of aquatic environments. [6]

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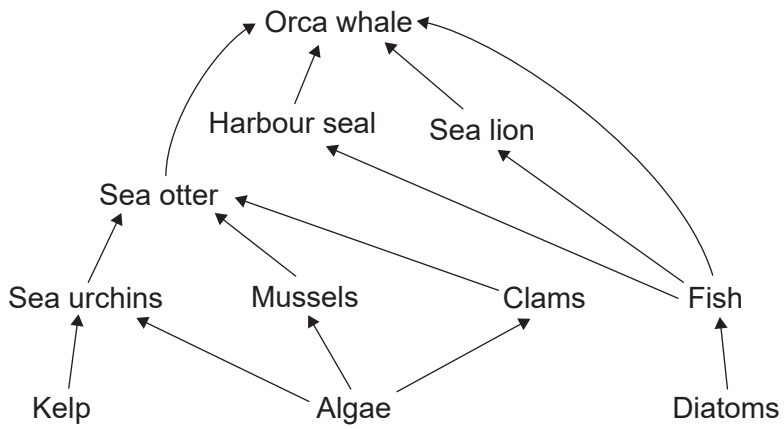
End of Option B

Option C — Ecology and conservation

15. The diagram shows a simplified marine food web in an area of the North Pacific Ocean.



(a) Identify the trophic level of sea lions. [1]

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(b) Outline the additional information that would be required to convert the food web into a pyramid of energy. [2]

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(c) Outline a reason that the orca whale would be difficult to represent in a pyramid of energy. [1]

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(Option C continues on the following page)

(Option C, question 15 continued)

(d) Explain reasons for the feed conversion ratio in fish being lower than in cattle. [2]

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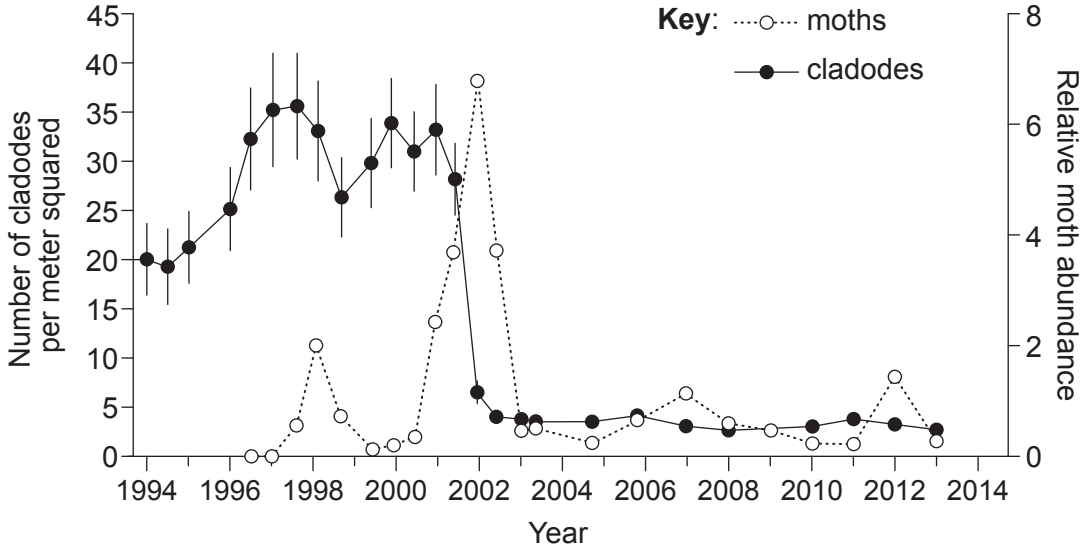
(Option C continues on the following page)

(Option C continued)

16. The prickly pear cactus (*Opuntia stricta*) was first recorded in Kruger National Park, South Africa, in 1950. It spread rapidly, mainly through seeds being dispersed by baboons and elephants.

In 1997, the cactus moth (*Cactoblastis cactorum*) from South America was introduced into the area as a biological control. The larvae of the moth feed on the cactus. The graph shows the number of cladodes (flattened stem sections) of cactus found per m^2 in the years before and after the introduction of the cactus moth.



Catus moth larvae feeding on a cactus cladode

(a) Outline how the prickly pear cactus may become an ecological problem in Kruger National Park. [2]

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(b) Explain the change in numbers of the cactus moth throughout the study period. [2]

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(Option C continues on the following page)

(Option C, question 16 continued)

(c) Discuss the possible benefits and risks of introducing a biological control into an ecosystem. [2]

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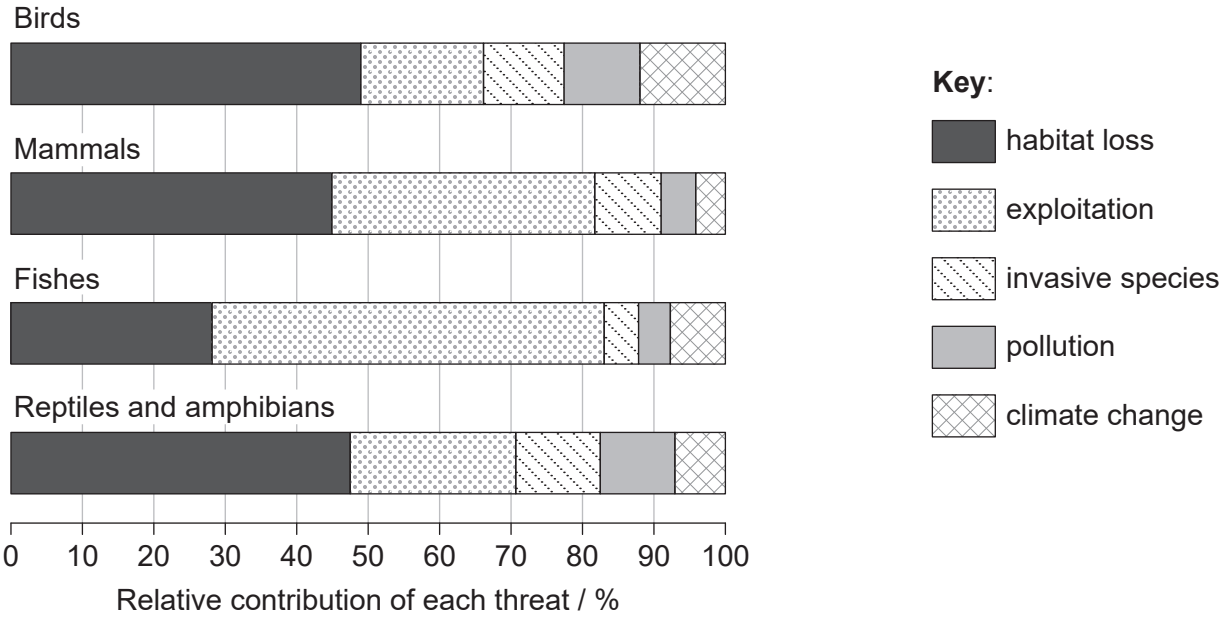
(Option C continues on the following page)

(Option C continued)

17. The Living Planet Index published by the World Wildlife Fund (WWF) tracks the state of global biodiversity by measuring the population sizes of thousands of vertebrate species around the world. The 2018 index shows an overall decline of 60 % in population size between 1970 and 2014. The chart shows the main threats to each taxonomic group in 2018.



(a) Suggest a reason for the loss of bird habitats. [1]

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(b) Outline how *in situ* conservation may help preserve populations of amphibians. [2]

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(c) Distinguish between species richness and evenness as components of biodiversity. [1]

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(Option C continues on the following page)

(Option C, question 17 continued)

(d) Explain how an indicator species may help monitor pollution. [2]

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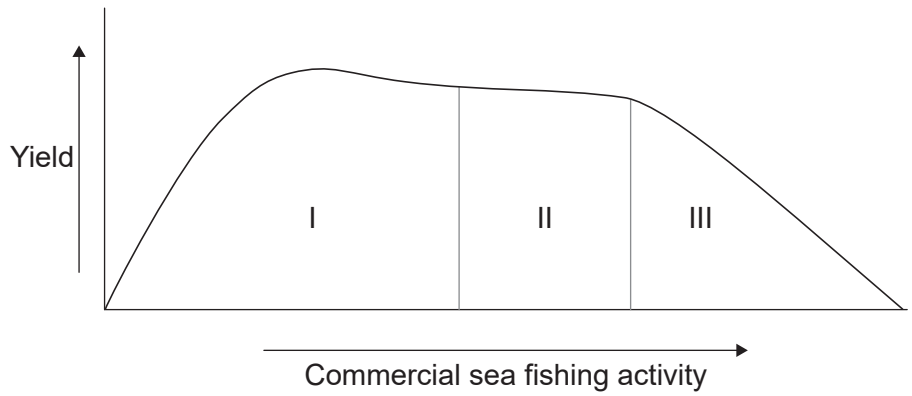
(Option C continues on the following page)

(Option C continued)

18. The diagram shows the relationship between commercial sea fishing activity and yield, and how this affects sustainability.



Key:
I. Sustainable
II. At risk of overfishing
III. Overfishing

(a) Label with a P on the x-axis the level of commercial sea fishing activity that would result in maximum sustainability. [1]

(b) Outline the reason for the change in yield in region III of the diagram. [1]

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(c) Suggest a reason that it is difficult to keep global commercial sea fishing activity at a sustainable level. [1]

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(Option C continues on the following page)

(Option C, question 18 continued)

(d) Explain how the population of fish in a pond could be estimated using the capture-mark-release-recapture method. [3]

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19. Explain the role of bacteria in the nitrogen cycle. [6]

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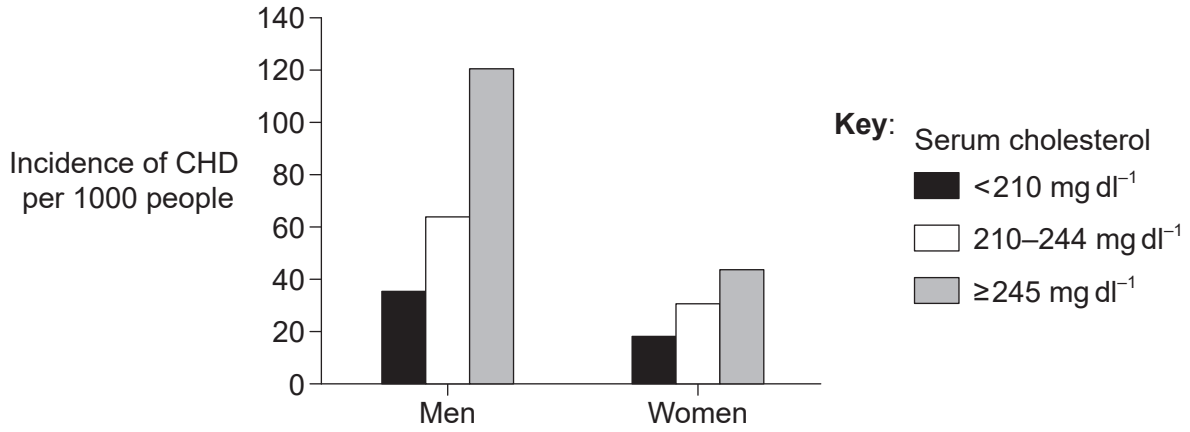
End of Option C

Option D — Human physiology

20. The level of cholesterol in blood can be used as an indicator of the risk of cardiovascular disease. The chart shows the incidence of coronary heart disease (CHD) per 1000 people aged between 40 and 59 years according to their serum cholesterol level.



(a) Compare and contrast the effect on men and women of an increase in serum cholesterol. [2]

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(b) Suggest a reason for high total serum cholesterol not always being an indicator of CHD risk. [1]

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(Option D continues on the following page)

(Option D, question 20 continued)

(c) Describe the reactions that occur in the liver, leading to the production of bile. [3]

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(d) State **one** long-term consequence of jaundice in newborn babies if this condition is not treated. [1]

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(Option D continues on the following page)

(Option D continued)

21. The diagram shows how the bacterium *Vibrio cholerae* can cause dehydration in humans.

Removed for copyright reasons

(a) State where in the digestive system *Vibrio cholerae* acts, leading to dehydration. [1]

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(b) Explain how cholera toxin causes dehydration. [3]

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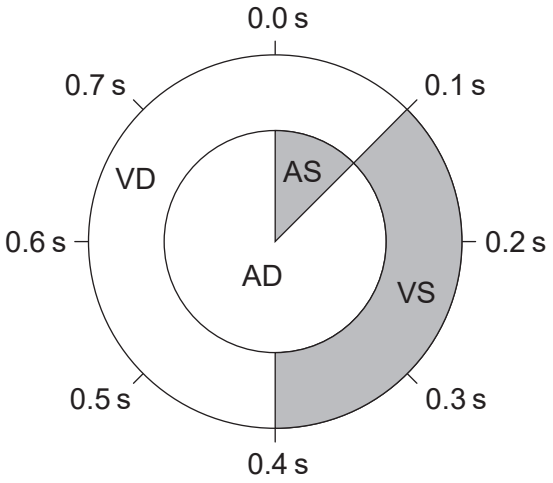
(Option D continues on the following page)

(Option D continued)

22. The diagram indicates the condition of the heart chambers during a heart cycle of duration 0.8 s, beginning with atrial systole.



Key:
AS = Atrial systole
AD = Atrial diastole
VS = Ventricular systole
VD = Ventricular diastole

(a) Calculate how long all the heart chambers are in diastole at the same time. [1]

. . . . . .

(b) State the letter on an ECG corresponding with the events from 0.0 to 0.1 s. [1]

. . . . . .

(c) Describe the state of the heart valves at 0.3 s. [2]

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(Option D continues on the following page)

(Option D, question 22 continued)

(d) Explain how cardiac muscle is adapted to its function. [3]

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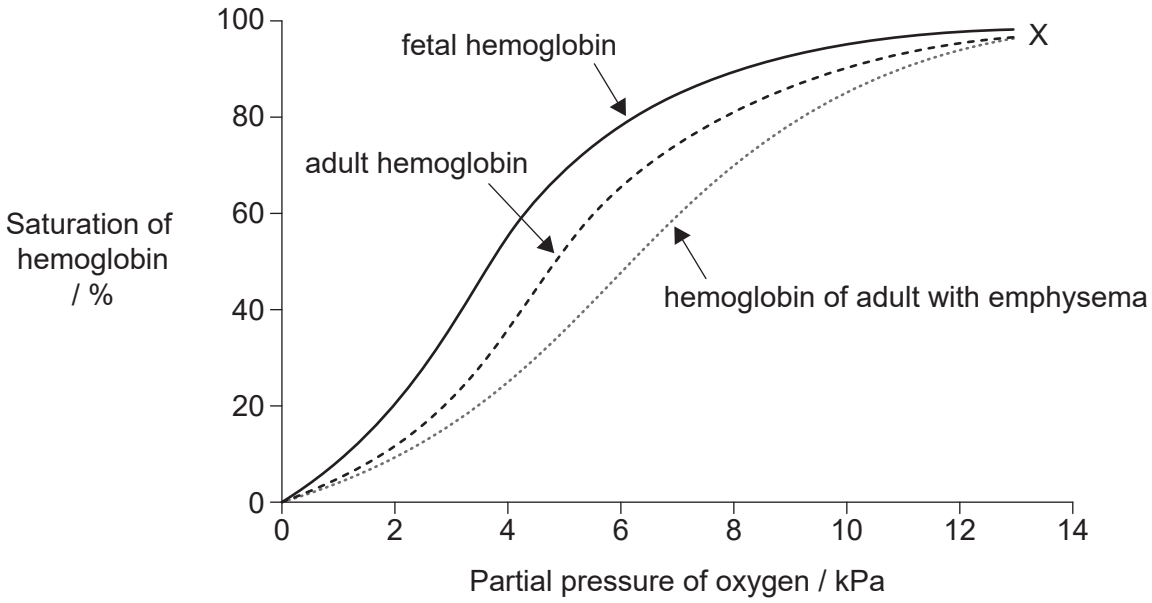
23. The graph shows the oxygen dissociation curves for hemoglobin in a fetus, a healthy adult and an adult with emphysema.



(a) State where in the body the blood would be flowing at point X on the graph. [1]

. . . . . .

(Option D continues on the following page)

(Option D, question 23 continued)

(b) Outline the reason that the curve for fetal hemoglobin is to the left of normal adult hemoglobin. [1]

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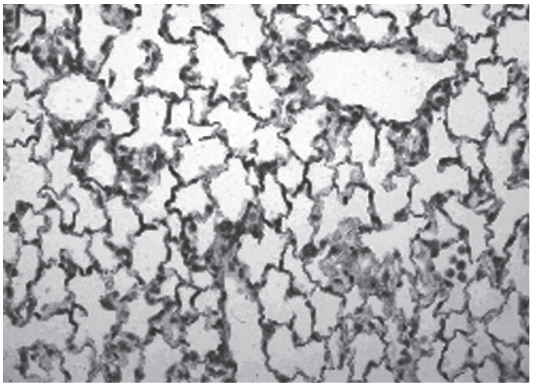
. . . . . .

(c) State where the curve for myoglobin would be drawn on the diagram. [1]

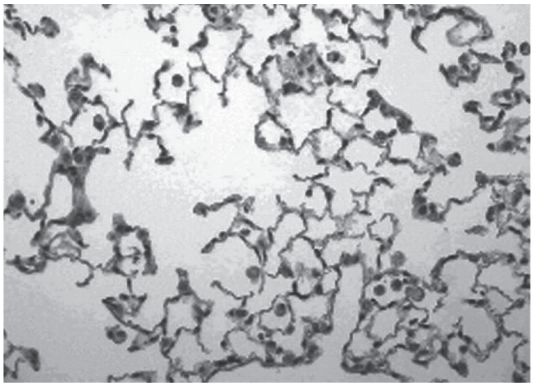
. . . . . .

. . . . . .

(d) The micrographs show mammalian lung tissue in its healthy condition and with emphysema.



Healthy



With emphysema

Explain how emphysema is treated. [3]

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(Option D continues on the following page)

(Option D continued)

24. Athletes may take growth hormone to build muscle mass and improve performance. Explain the action of peptide hormones, using growth hormone as an example. [6]

End of Option D

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