Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 3

Tuesday 2 May 2017 (morning)

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 – 7
Option B — Biotechnology and bioinformatics	8 – 12
Option C — Ecology and conservation	13 – 17
Option D — Human physiology	18 – 22

2217 – 6009

40 pages

Section A

Answer **all** questions. Write your answers in the boxes provided.

1. A study was carried out to explore the impact of various sports on pulmonary functions in professional athletes.

The forced vital capacity (FVC) is the maximum volume of air a person can expel from the lungs after full inspiration. Forced expiratory volume in one second (FEV) is the volume of air that can forcibly be blown out in one second, after full inspiration.

The table below summarizes the mean results for the different sports including the standard deviation.

Removed for copyright reasons

(a) (i) State **one** type of apparatus that could be used to measure lung capacity. [1]

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(ii) Outline how the FVC could be measured using the apparatus in (a)(i). [2]

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(This question continues on the following page)

(Question 1 continued)

(b) Using the information in the table, suggest the likely impact of long distance running on the pulmonary functions of professional athletes. [1]

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(c) 147 professional athletes and 30 non-athletes were included in the study. State **one** variable that had to be controlled in this experiment. [1]

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2. The image below shows freely-growing aerial rhizoids of the bryophyte *Homalothecium sericeum* near a shoot apex.

Removed for copyright reasons

(a) Calculate the magnification of this image. [1]

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(b) Outline the procedure for focusing a light microscope. [3]

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(This question continues on the following page)

(Question 2 continued)

(c) State **one** advantage of using a light microscope compared to an electron microscope. [1]

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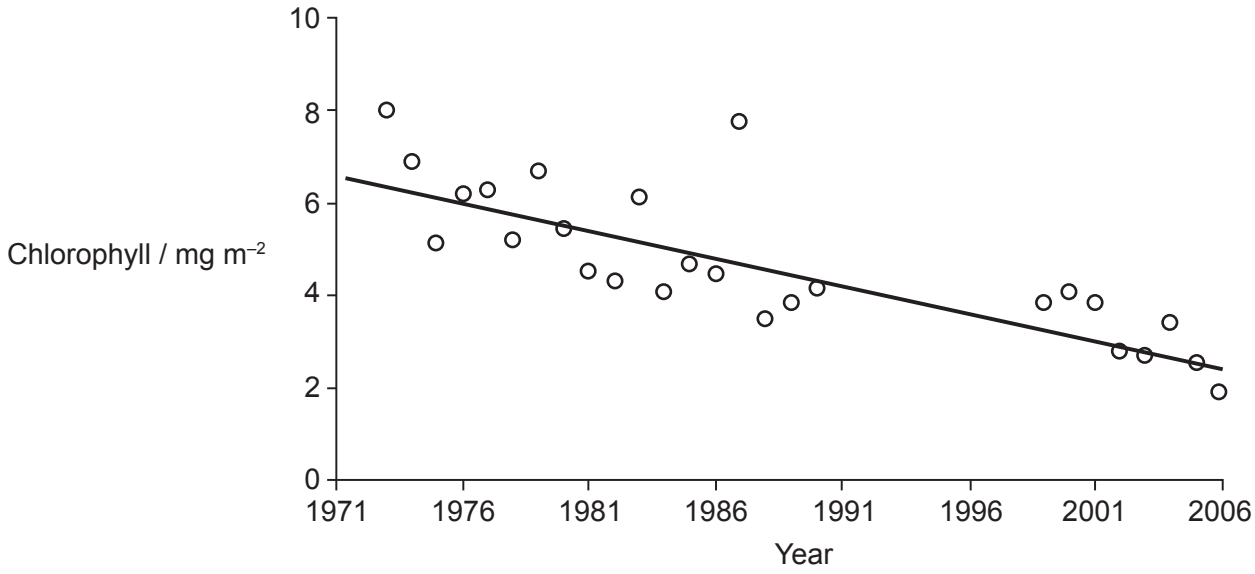
3. Mean annual chlorophyll concentration was measured in surface water of Narragansett Bay along the Atlantic coast of the USA, from 1971 to 2006. Field data of chlorophyll concentrations are shown below.



[Source: Reprinted by permission from Macmillan Publishers Ltd: *Nature*, Vol. 448, R. W. Fulweiler, S. W. Nixon, B. A. Buckley and S. L. Granger, Reversal of the net dinitrogen flux in coastal marine sediments, copyright (2007)]

(a) Suggest a hypothesis for the trend in the graph. [2]

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(b) Mesocosm experiments using water from Narragansett Bay were completed in the laboratory during a six month period. Discuss advantages and limitations of carrying out mesocosm investigations. [3]

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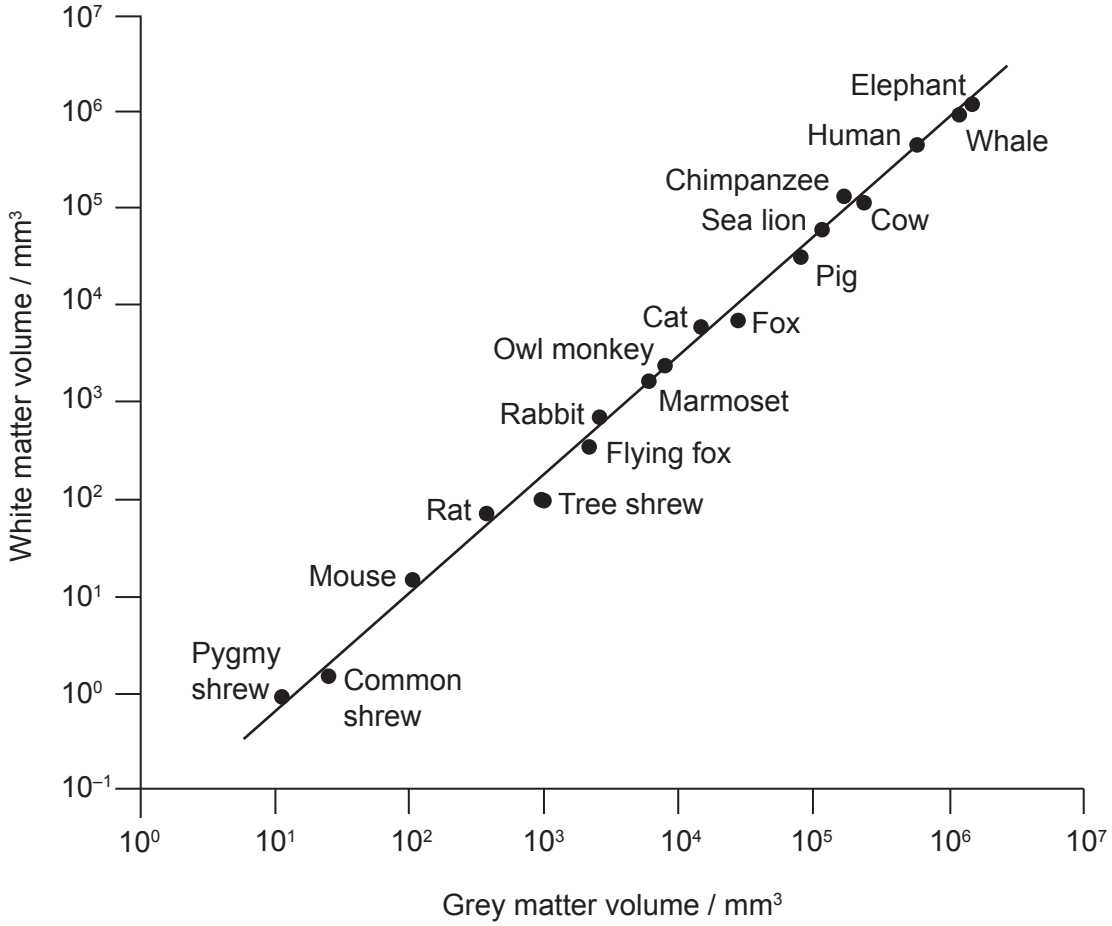
Section B

Answer **all** of the questions from **one** of the options. Write your answers in the boxes provided.

Option A — Neurobiology and behaviour

4. In a study of brain organization, several factors were investigated. The relationship between the volumes of grey and white matter across mammalian species was compared.



[Source: E. Bullmore and O. Sporns (2012) *Nature Reviews, Neuroscience* Vol. 3, pages 336–349. Reprinted by permission from Macmillan Publishers Ltd. http://www.nature.com/nrn/index.html]

(a) Describe the relationship between the volume of white matter and grey matter. [1]

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(Option A continues on the following page)

(Option A, question 4 continued)

(b) Outline the development of axons in immature neurons. [2]

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(c) Outline the organization of the human cerebral cortex with regard to structure and function. [3]

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(d) Outline **one** reason for the large energy requirement of the brain. [1]

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(e) State **one** activity controlled by the medulla oblongata. [1]

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(Option A continues on page 11)

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will not be marked.

(Option A continued)

5. (a) Approximately 350 000 people worldwide have received cochlear implants. Outline the use of cochlear implants in patients with hearing problems. [3]

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(b) State the part of the ear that is responsible for detecting movement of the head. [1]

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(c) Describe the role of bipolar cells in the eye. [3]

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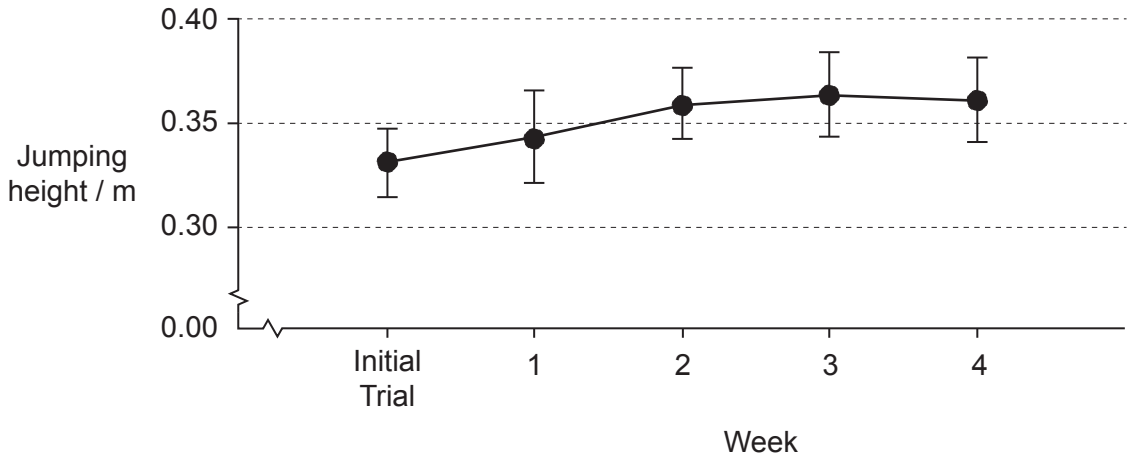
(Option A continues on the following page)

(Option A continued)

6. A study examined the effects of four weeks of intensive training in athletes on vertical jumping performance and neuromuscular learning. The graph shows the results for jumping height.



[Source: Tine Alkjaer, Jacob Meyland, Peter C. Raffalt, Jesper Lundbye-Jensen and Erik B. Simonsen (2013) Neuromuscular adaptations to 4 weeks of intensive drop jump training in well-trained athletes. *Physiological Reports*, Volume 1, Issue 5, 2013, e00099, doi: 10.1002/phy2.99.]

(a) Outline the effect of training on jumping performance. [2]

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(b) List the different types of neurons involved in a reflex arc. [2]

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(Option A continues on the following page)

(Option A, question 6 continued)

(c) Predict whether an animal such as a laboratory rat could be encouraged to learn a new behaviour pattern. [2]

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(d) Using an example, describe how innate behaviour may increase the chances of survival of a species. [3]

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(Option A continues on the following page)

(Option A continued)

7. Explain, using examples, the neurological effects of inhibitory psychoactive drugs. [6]

End of Option A

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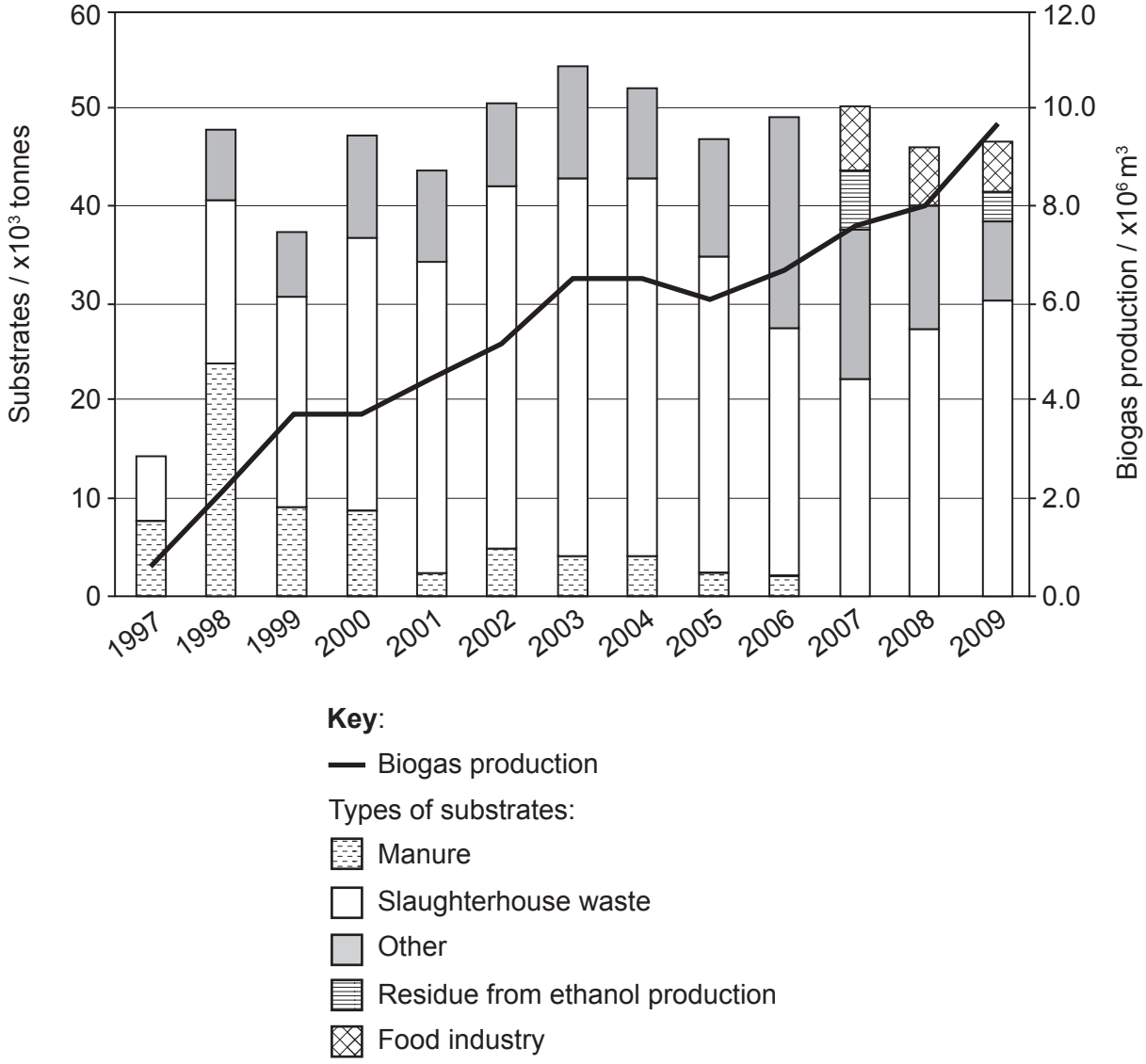
Option B — Biotechnology and bioinformatics

8. The graph shows the development of biogas production and substrate utilization at Svensk Biogas (Sweden) from 1997 to 2009.



[Source: L Vallin, (2012), Svensk Biogas AB]

(a) (i) Biogas production in a fermenter requires a substrate. State another requirement for this process. [1]

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(Option B continues on the following page)

(Option B, question 8 continued)

(ii) Suggest reasons based on the data in the graph for increases in biogas production at Svensk Biogas. [2]

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(b) Outline the principles of fermentation by continuous culture. [3]

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(c) Distinguish between the structure of Gram-positive and Gram-negative bacteria. [1]

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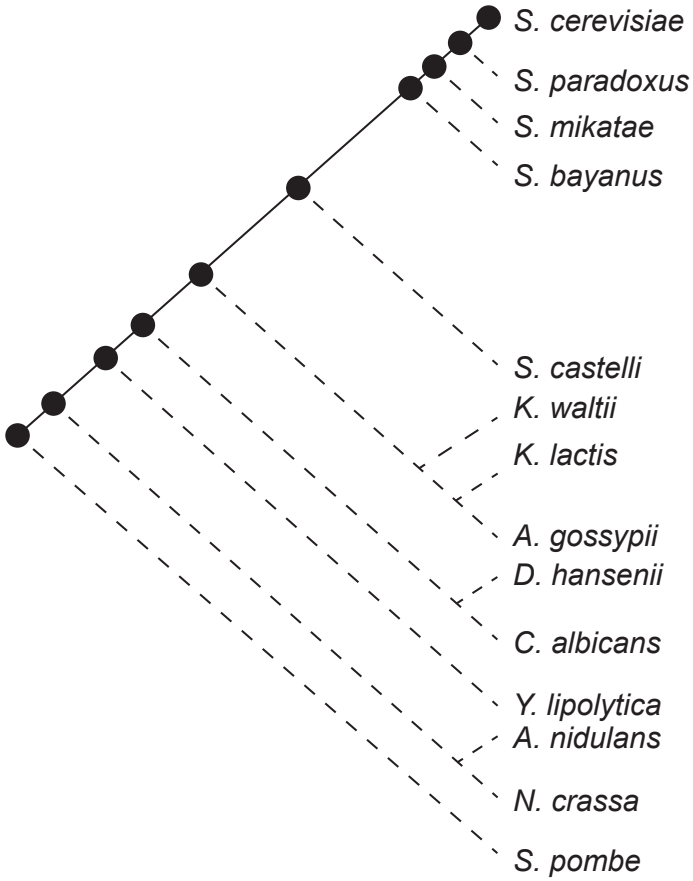
(Option B continues on the following page)

(Option B continued)

9. The cladogram is based on a comparison of open reading frames in DNA taken from fungi. It is an example of how open reading frames can be used in phylogenetic studies.



[Source: Reprinted by permission from Macmillan Publishers Ltd: *Nature*, Vol. 487, Anne-Ruxandra Carvunis *et al*. Proto-genes and de novo gene birth, pp. 370–374, copyright (2012), http://www.nature.com/]

(a) Outline how open reading frames are identified in DNA. [2]

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(b) Explain what the branching off points represent in the cladogram of these fungi. [1]

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(Option B continues on the following page)

(Option B, question 9 continued)

(c) There are several methods of introducing DNA into a cell in the laboratory. Outline the introduction of recombinant DNA in plant cell protoplasts. [2]

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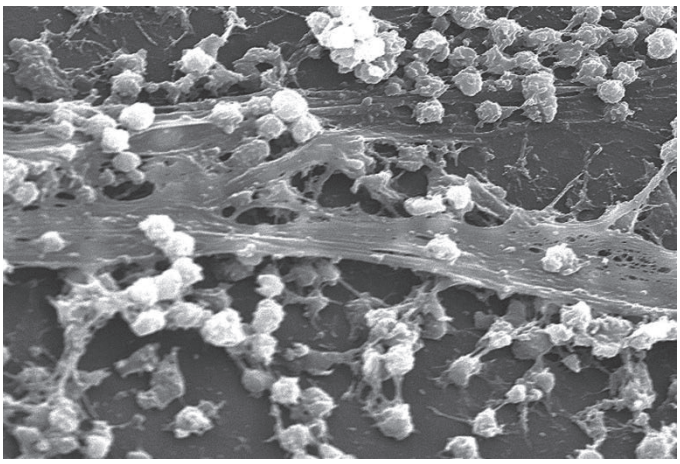
(Option B continues on the following page)

(Option B continued)

10. The micrograph below shows an example of a biofilm including *Staphylococcus aureus*.



[Source: https://en.wikipedia.org/wiki/Biofilm#/media/File:Staphylococcus_aureus_biofilm_01.jpg]

Biofilms can be formed in many different environments.

(a) State **one** example of an environment where biofilms can be formed. [1]

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(b) Discuss the emergent properties of biofilms. [3]

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(Option B continues on the following page)

(Option B continued)

11. (a) (i) Outline what is meant by the term genetic markers. [1]

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(ii) Outline **two** uses of genetic markers. [2]

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(b) Evaluate the use of viral vectors in gene therapy. [2]

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(c) Outline the use of microarrays to test for genetic disease. [3]

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(Option B continues on the following page)

(Option B continued)

12. Explain how BLAST searches are carried out and the applications of different types of these searches. [6]

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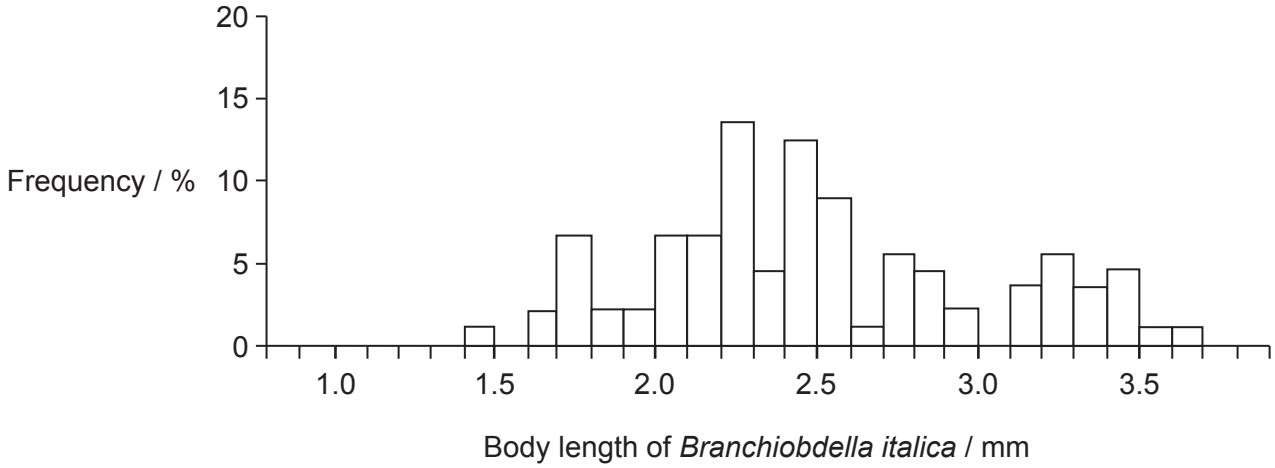
End of Option B

Option C — Ecology and conservation

13. The worm *Branchiobdella italica* lives on the external surface of the freshwater crayfish *Austropotamobius pallipes*. A study was carried out in a river in central Liguria, north-western Italy, of the range of sizes of *B. italica* found on adult *A. pallipes*.



[Source: M Mori, *et al*., (2001), *Journal of Limnology*, 60(2), pages 208–210]

(a) Describe the body length frequency of the *B. italica* worms collected in this study. [1]

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The relationship between *A. pallipes* and *B. italica* is mutualistic.

(b) *A. pallipes* feeds on algae and another worm, *B. exodonta*, lives inside *A. pallipes* as a parasite. State the trophic level of *B. exodonta* in this food chain. [1]

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(c) Distinguish between mutualism and parasitism, providing another example of mutualism and another example of parasitism. [2]

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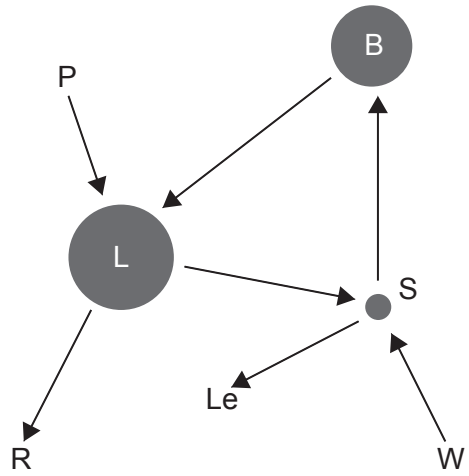
(Option C continues on the following page)

(Option C continued)

14. The Gersmehl diagram below shows the movement and storage of nutrients in a taiga ecosystem.



Key:
B – biomass
L – litter
S – soil
Le – leaching
P – precipitation
R – run off
W – weathering

[Source: Adapted from: http://www.slideshare.net/ecumene/ecosystems-3-nutrient-cycle-presentation]

(a) Predict the possible effect of global warming on the nutrient flow in a taiga ecosystem. [2]

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(b) Define indicator species. [1]

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(Option C continues on the following page)

(Option C, question 14 continued)

(c) Indicator species may be affected by biomagnification. Discuss biomagnification using a **named** example of a pollutant. [3]

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(d) Outline **one** consequence of introducing an alien species into an ecosystem. [2]

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(e) Determine whether islands are open or closed ecosystems. [1]

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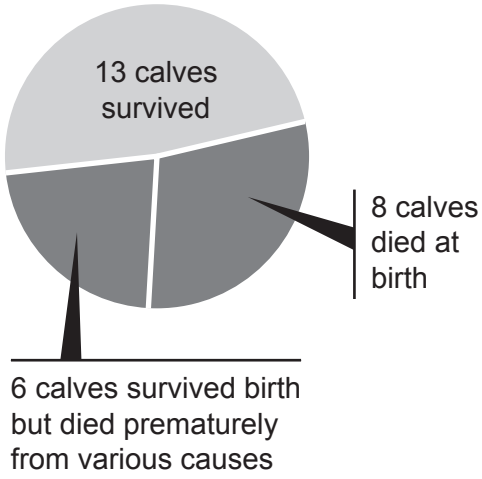
(Option C continues on the following page)

(Option C continued)

15. Zoos devote much effort to preserving and breeding elephants in captivity. Data for births resulting from artificial insemination in zoos in the United States from 1960 to 2012 are shown below.



[Source: Association of Zoos and Aquariums, http://seattletimes.com]

54 % of successful artificial inseminations have resulted in miscarriages, stillborn births or premature deaths.

(a) Evaluate the success rate of breeding elephants by artificial insemination using these data. [1]

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(b) Discuss **two** advantages of *ex situ* conservation measures. [2]

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(Option C continues on the following page)

(Option C, question 15 continued)

(c) State the **two** components needed to calculate the biodiversity of an area. [2]

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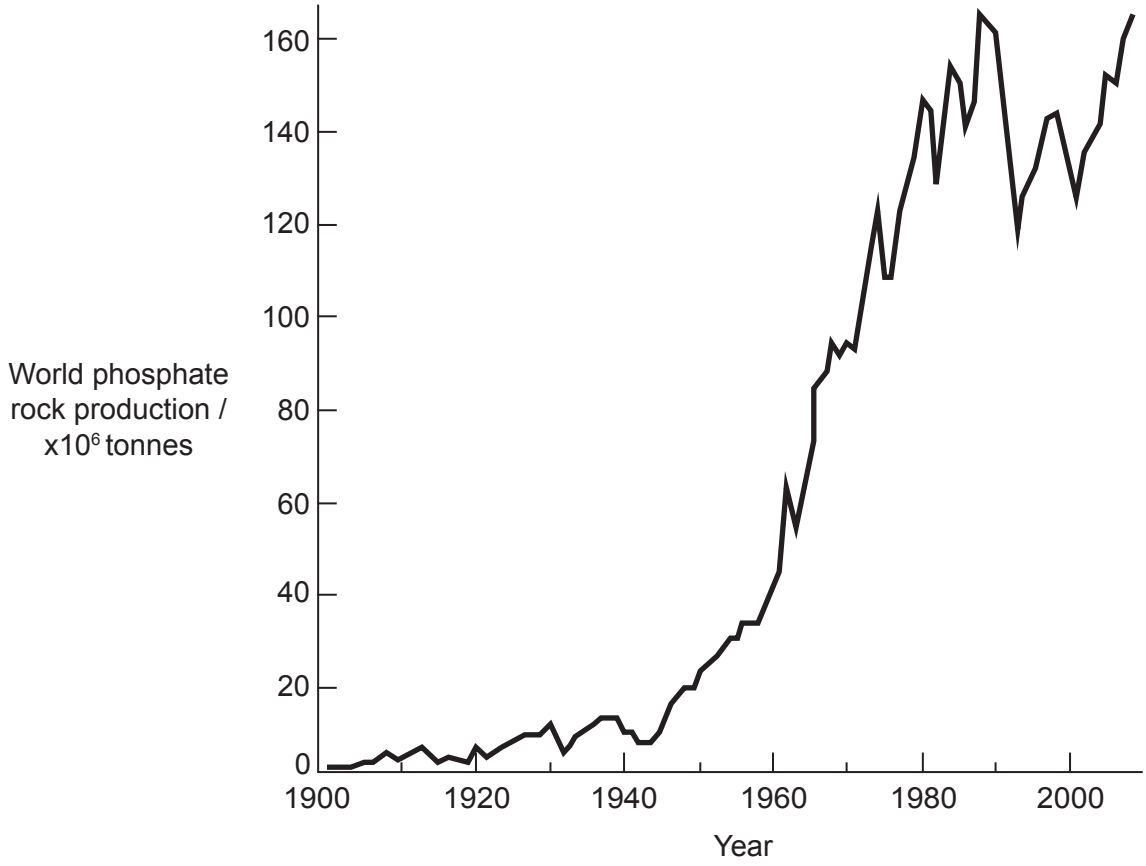
(Option C continues on the following page)

(Option C continued)

16. The predominant source of phosphorus is rock containing phosphate (phosphate rock). The graph below shows the world production between 1900 and 2009.



[Source: From the US Geological Survey, http://minerals.usgs.gov/ds/2005/140/#phosphate), redrawn by the IB]

(a) Some scientists estimate that available phosphorus reserves in the Earth will be completely depleted within approximately 100 years. Discuss the implications of these estimates. [2]

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(Option C continues on the following page)

(Option C, question 16 continued)

(b) The percentage of phosphorus in an ecosystem that is recycled per year is in most cases very small, and far smaller than the percentage of nitrogen that is recycled. Suggest reasons for this difference. [2]

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(c) Nitrates (NO_3^-) are components of the nitrogen cycle. Outline the possible conversions of NO_3^- in the nitrogen cycle. [2]

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(Option C continues on the following page)

(Option C continued)

17. Discuss the factors affecting population growth that can result in an exponential growth curve. [6]

End of Option C

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

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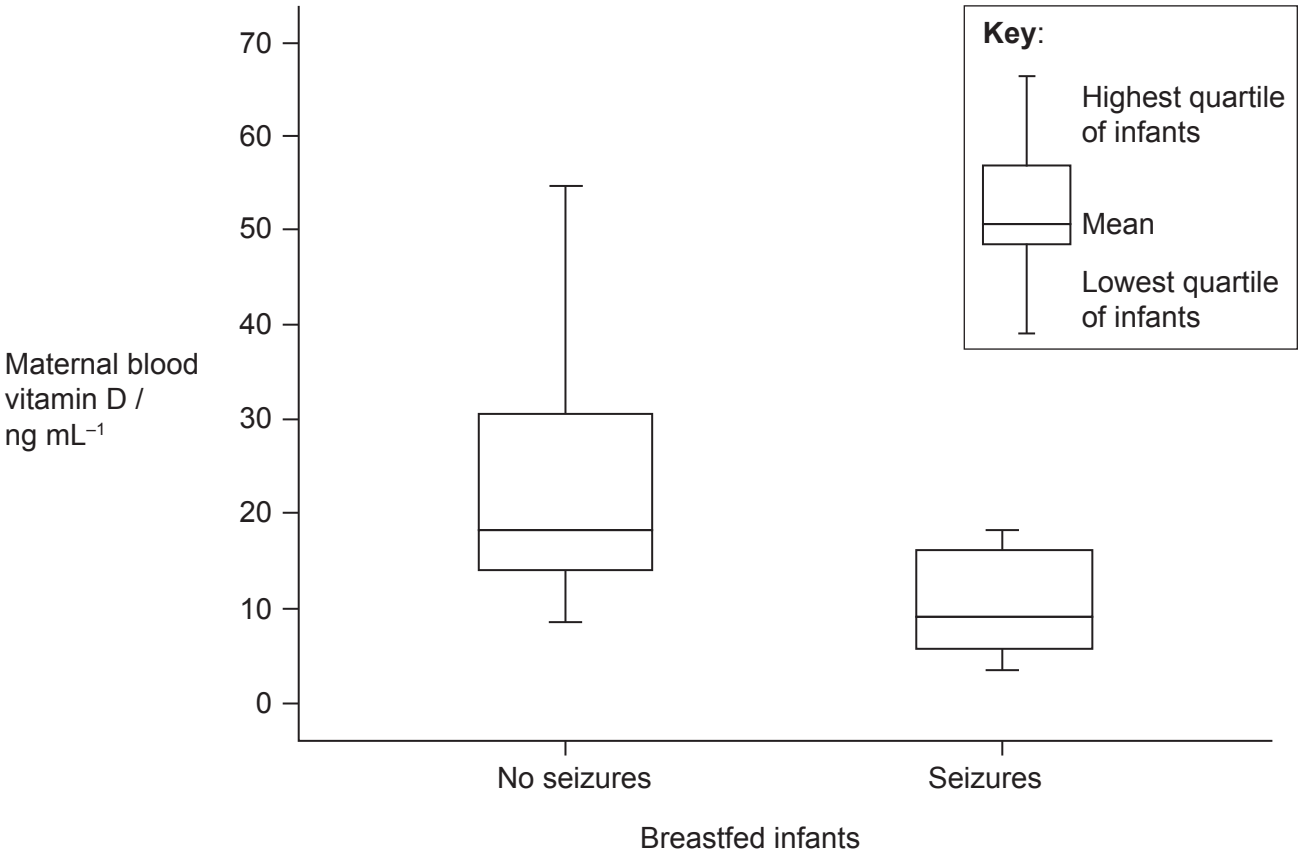
will not be marked.

Option D — Human physiology

18. Breastfed infants with rickets sometimes have seizures due to low blood calcium levels. A study was carried out to investigate the relationship between maternal blood vitamin D levels and the incidence of these infant seizures.



[Source: Mostafa M. Salam and Abeer S. El-Sakka (2010) Hypocalcemic seizures in breastfed infants with Rickets secondary to severe maternal vitamin D deficiency. *Pakistan Journal of Biological Sciences*, 13(9): 437–472]

(a) (i) Describe the relationship between the maternal blood vitamin D levels and the incidence of seizures. [1]

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(ii) Deduce the reason for rickets in these infants. [1]

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(Option D continues on the following page)

(Option D, question 18 continued)

(b) Identify the reason for vitamin D not being considered to be a typical vitamin. [1]

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(c) Outline the reason for some amino acids being classified as essential amino acids. [1]

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(d) Cells on the surface of intestinal villi have microvilli, which provide a large surface area for absorption. State another structural characteristic of these villus cells that adapts them to the absorption of nutrients. [1]

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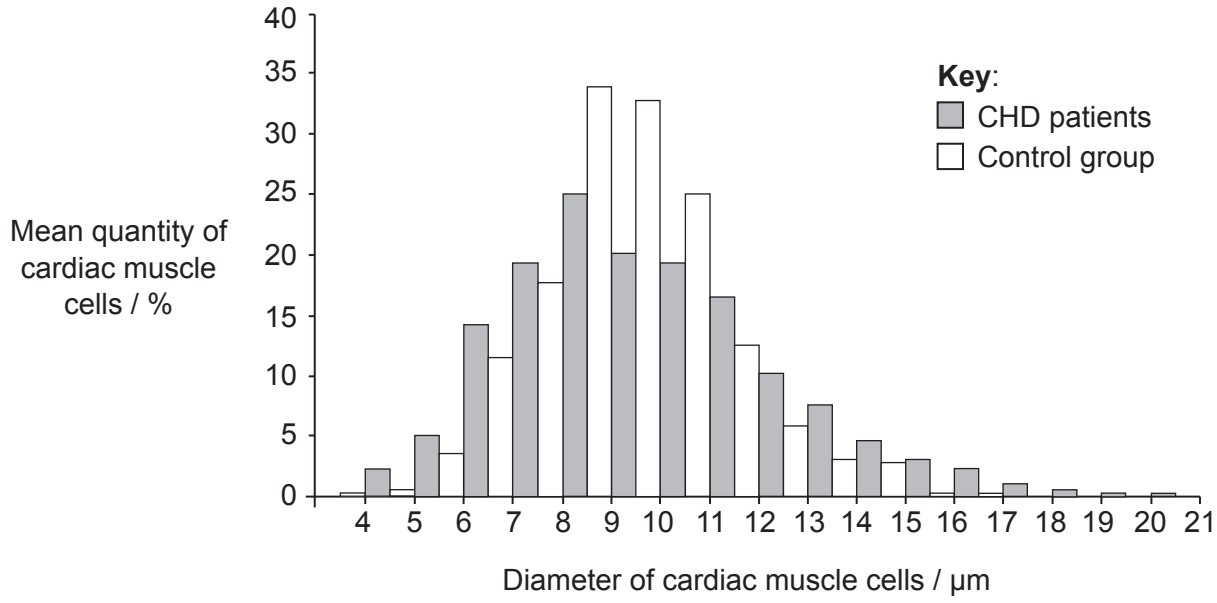
(Option D continues on the following page)

(Option D continued)

19. Samples from cardiac muscle were taken during autopsies from individuals who had coronary heart disease (CHD) and a control group. The histogram shows the relationship between the quantity of cardiac muscle cells and their diameter in the left ventricle in the two groups.



[Source: A Karaskov, *et al*., (2011), *Health 3*, pages 263–270]

(a) Distinguish between the distribution of cardiac muscle cell diameters in the CHD and control groups. [1]

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(b) Describe how the structure of cardiac muscle cells allows them to transmit impulses. [3]

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(Option D continues on the following page)

(Option D, question 19 continued)

(c) Explain the reason for the delay between contractions of the atria and of the ventricles. [2]

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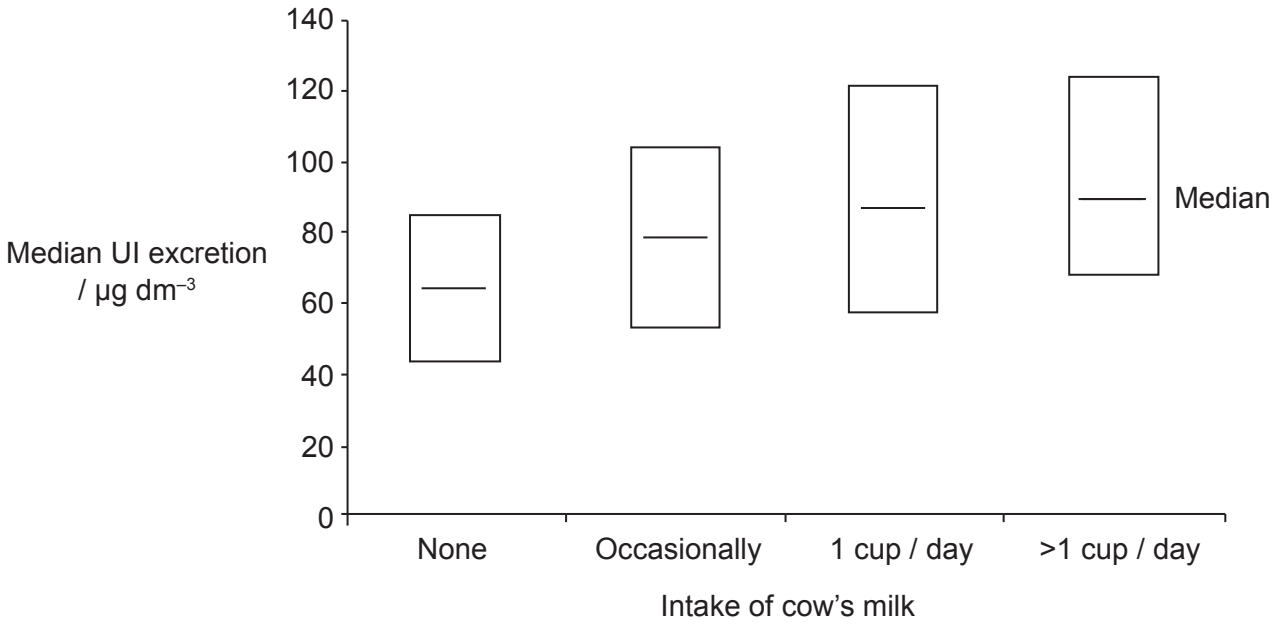
(Option D continues on the following page)

(Option D continued)

20. A good marker of dietary intake of iodine is the urinary iodine level (UI). A study was carried out in the UK to establish urinary iodine levels and milk intake in schoolgirls aged 14–15 years.



[Source: M Vanderpump (2014) *Clinical Medicine* 2014, Vol 14, No 6, Royal College of Physicians, pages 7–11. Reproduced with permission of ROYAL COLLEGE OF PHYSICIANS, via Copyright Clearance Center.]

(a) Urinary iodine values from 50 to 99 μg dm^{-3} are considered to be mild iodine deficiency. Deduce the effect of milk intake on the iodine status of schoolgirls in the UK. [2]

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(b) Outline the need for iodine in the endocrine system. [2]

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(Option D continues on the following page)

(Option D, question 20 continued)

(c) Growth hormones are examples of peptide hormones. Explain the mechanism of action of peptide hormones. [3]

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(Option D continues on the following page)

(Option D continued)

21. (a) (i) Outline the main changes in the lungs that occur in patients with emphysema. [2]

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(ii) State a treatment for emphysema. [1]

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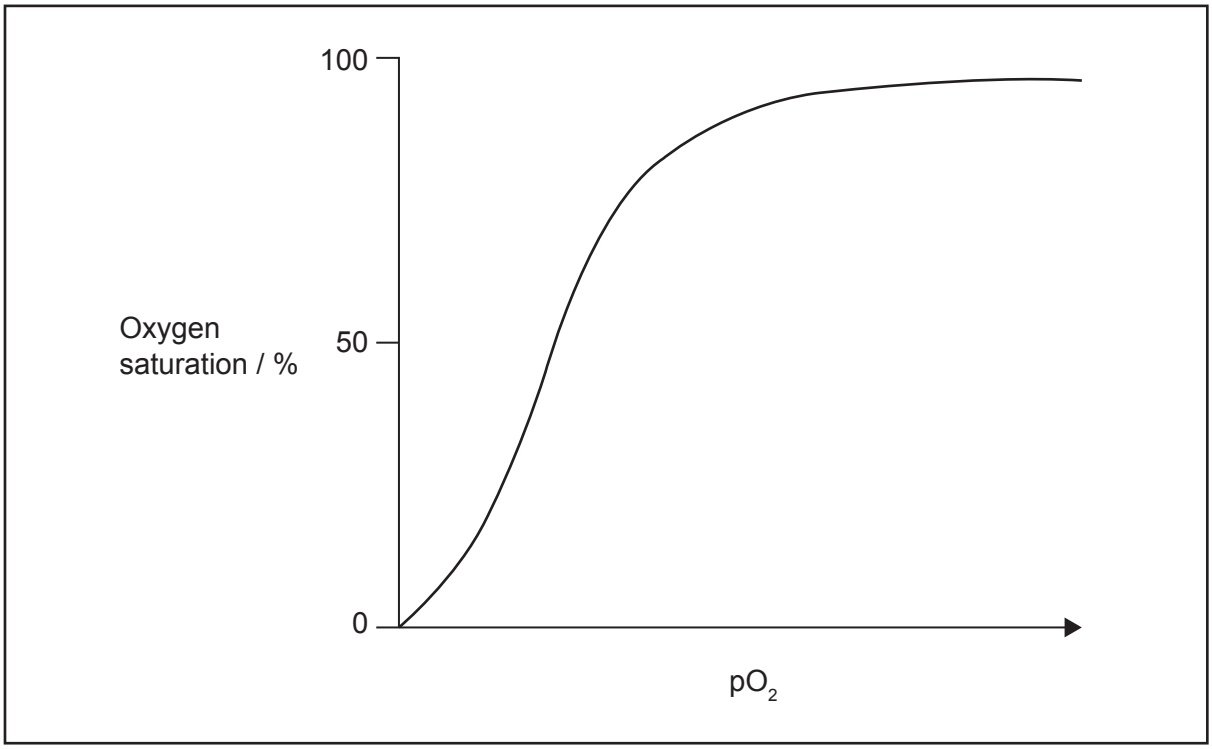
(Option D continues on the following page)

(Option D, question 21 continued)

(b) The graph below shows the oxygen dissociation curve at a low CO_2 concentration.



(i) An increase in metabolic activity results in greater release of CO_2 into the blood. On the graph, draw the oxygen dissociation curve during intense exercise when the CO_2 concentration of the blood is high. [1]

(ii) Explain how the increase in CO_2 concentration affects the release of oxygen to respiring cells. [2]

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(Option D continues on the following page)

(Option D continued)

22. Explain the process of erythrocyte and hemoglobin breakdown in the liver. [6]

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End of Option D