Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 3

Thursday 16 November 2017 (morning)

1 hour 15 minutes

Candidate session number

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 – 13
Option C — Ecology and conservation	14 – 18
Option D — Human physiology	19 – 23

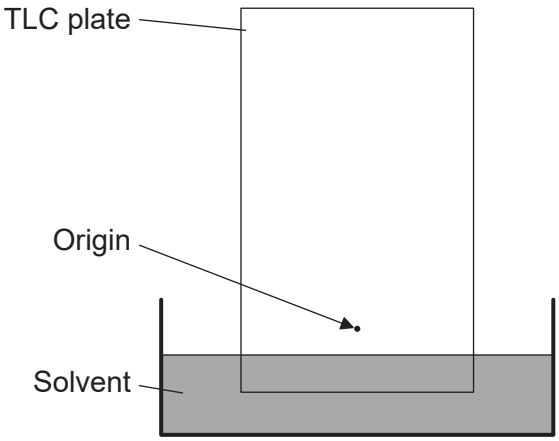
8817 – 6003

36 pages

Section A

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

1. R_f values for photosynthetic pigments may be determined using the technique of thin-layer chromatography (TLC).



(a) Outline what happens when spinach extract is spotted on a TLC plate and placed into a container of solvent. [2]

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(b) Explain what the R_f values represent in chromatography. [3]

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(This question continues on the following page)

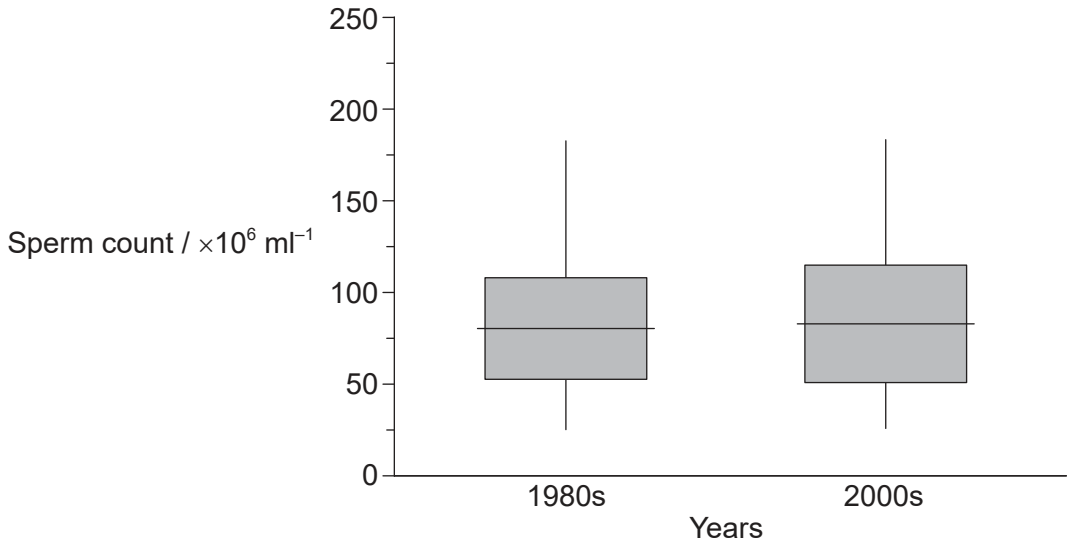
(Question 1 continued)

(c) State **two** photosynthetic pigments that could be identified using chromatography. [1]

1. . . . . .

2. . . . . .

2. Concerns have been raised about the effect of rising pollution levels on sperm production in men. To investigate the possible effects of pollution on spermatogenesis, sperm samples from men of similar ages were collected in Kolkata in the 1980s and 2000s. The box plot represents the mean and range of sperm counts in the 1980s and 2000s.



[Source: Republished with permission of Elsevier Science and Technology Journals, from 'Semen quality and age-specific changes: A study between two decades on 3729 male partners of couples with normal sperm count and attending an andrology laboratory for infertility-related problems in an Indian city', Dyutiman Mukhopadhyay, Alex C. Varghese, Manisha Pal, Sudip K. Banerjee, Asok K. Bhattacharyya, Rakesh K. Sharma, and Ashok Agarwal, *Fertility and Sterility*, 93 (7), 2009; permission conveyed through Copyright Clearance Center, Inc]

(a) A hypothesis has been suggested that pollution may have a negative effect on spermatogenesis. Evaluate whether the data support this hypothesis. [3]

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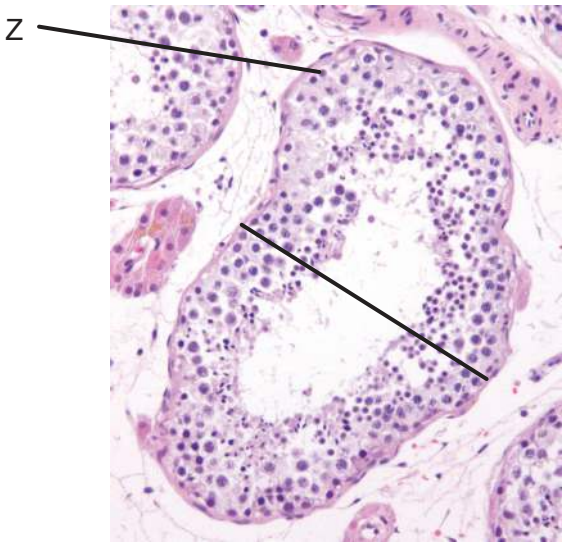
(This question continues on the following page)

(Question 2 continued)

(b) The light micrograph shows a cross section of seminiferous tubules.



x 400

[Source: Micrograph of a seminiferous tubule with sperm by Nephron (https://commons.wikimedia.org/wiki/File:Seminiferous_tubule_and_sperm_low_mag.jpg)]

(i) Calculate the actual size of the seminiferous tubule in the area indicated by the line across it, giving the units. [1]

. . . . . .

(ii) Identify the type of cell labelled Z. [1]

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

Answers written on this page
will not be marked.

3. (a) The Hershey and Chase experiment supported DNA as the hereditary material. Describe the experiment. [3]

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(b) Some regions of DNA act as telomeres or produce tRNA. State **one** other function of DNA sequences that do **not** code for protein. [1]

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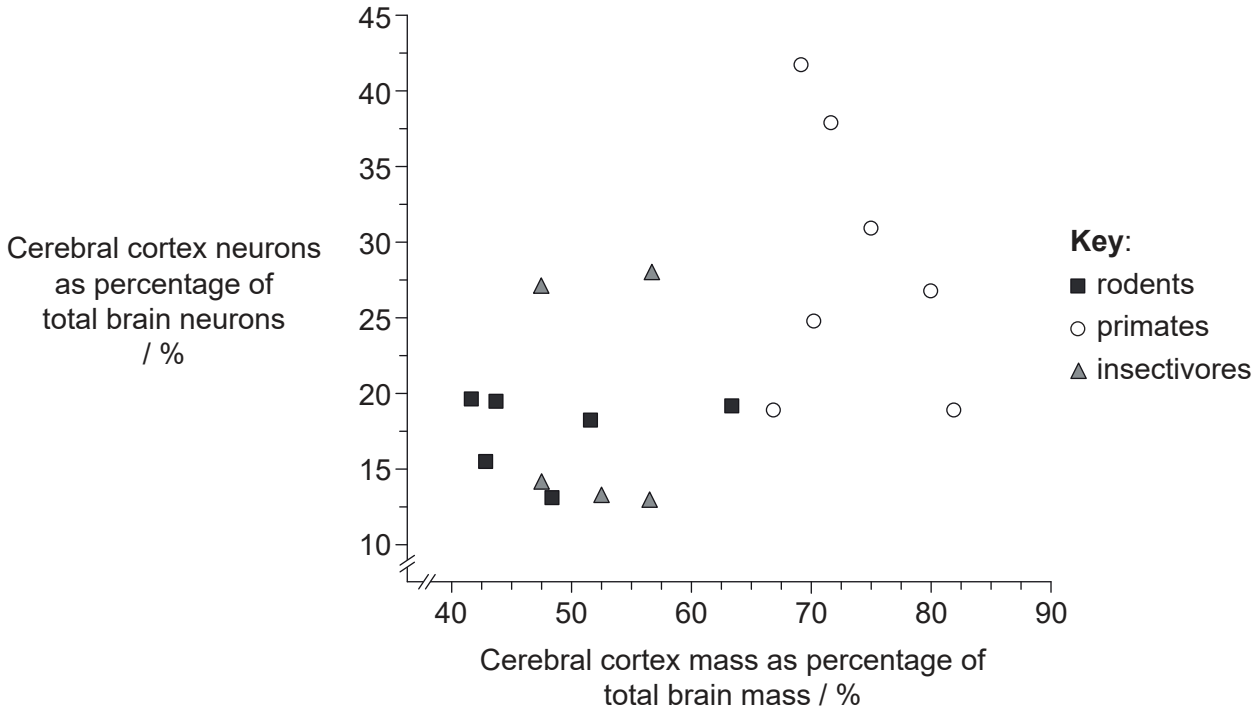
Section B

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 graph shows the correlation between the cerebral cortex mass and the number of neurons in the cerebral cortex of three groups of mammals (rodents, primates and insectivores). Each point indicates the mean number from different research studies for the species.



[Source: S Herculano-Houzel (2009) *Frontiers in Human Neuroscience*, 3, p 31, Frontiers Research Foundation http://journal.frontiersin.org/article/10.3389/neuro.09.031.2009/full]

(a) (i) State which group has the lowest percentage of cerebral cortex mass. [1]

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(ii) Suggest advantages of the cerebral cortex containing a high percentage of the brain's neurons. [2]

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(Option A continues on the following page)

(Option A, question 4 continued)

(b) Suggest a role for the cerebral cortex in rodents such as rats and mice. [1]

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(c) Explain how the cerebral cortex in humans differs from other mammals. [3]

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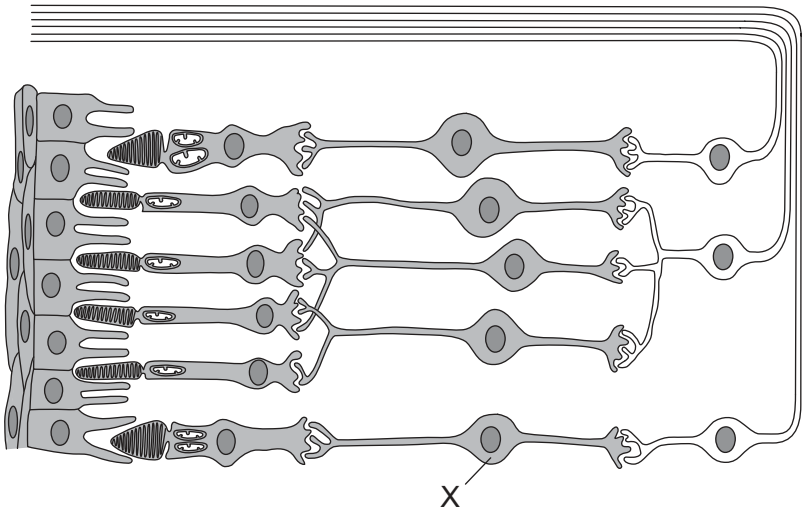
(Option A continues on the following page)

(Option A continued)

5. (a) The diagram shows part of a retina.



[Source: C. J. Clegg, *Introduction to Advanced Biology*, 2000, p. 285. Reproduced by permission of Hodder Education.]

(i) Identify the cell labelled X. [1]

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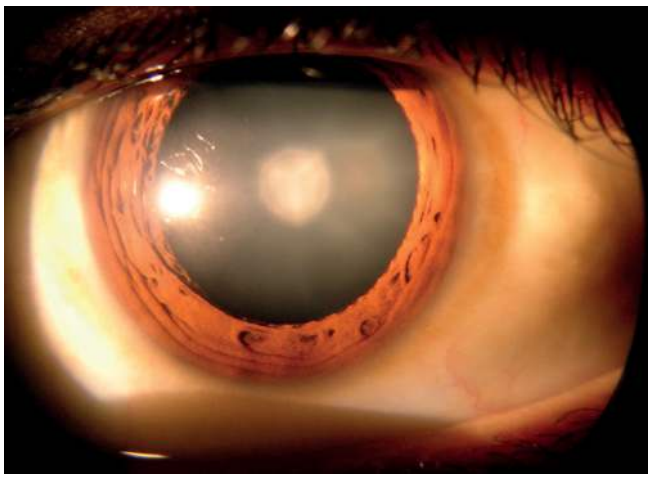
(ii) Draw an arrow to show the direction of light through the retina. [1]

(Option A continues on the following page)

(Option A, question 5 continued)

(b) A cataract is a clouding of the lens in the eye, resulting in blurred vision.



[Source: Cataract in Human Eye, Rakesh Ahuja, MD (https://en.wikipedia.org/wiki/Cataract#/media/File:Cataract_in_human_eye.png)]

Explain the use of a local anesthetic during surgery to remove the cataract. [2]

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(c) Describe red-green colour blindness. [2]

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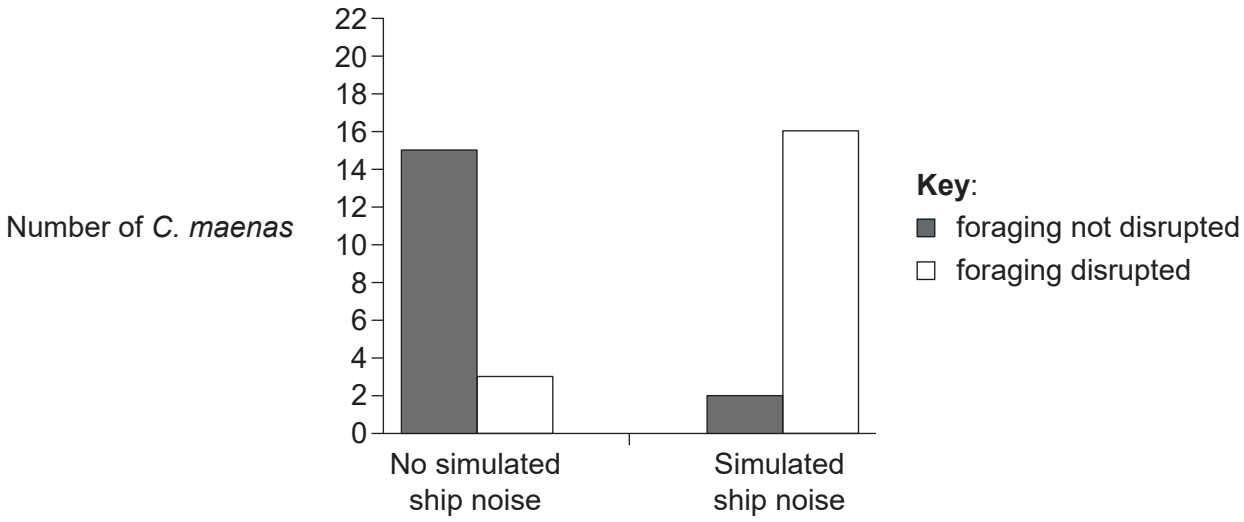
(Option A continues on the following page)

(Option A continued)

6. Noise from ships has the capacity to disrupt the foraging behaviour of shore crabs (*Carcinus maenas*). In this study, *C. maenas* were collected from Newquay Harbour in the UK and held for a maximum of 48 hours in salt-water tanks located at a neighbouring aquarium. The graph shows the effect of simulated ship noise on the time spent foraging for food by *C. maenas*.



[Source: Republished with permission of Elsevier Science and Technology Journals, from 'Noise negatively affects foraging and antipredator behaviour in shore crabs', Matthew A. Wale, Stephen D. Simpson, Andrew N. Radford, *Animal Behaviour* 86, 2013; permission conveyed through Copyright Clearance Center, Inc]

(a) State the effect of simulated ship noise on foraging behaviour. [1]

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(b) Predict the consequences on *C. maenas* of increasing noise related to human activity. [3]

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(Option A continues on the following page)

(Option A continued)

7. The diagrams illustrate changes in synapse density of the cerebral cortex from newborn to adult.

[Source: THE POSTNATAL DEVELOPMENT OF THE HUMAN CEREBRAL CORTEX, VOLUMES IVIII, by Jesse LeRoy Conel, Cambridge, Mass.: Harvard University Press, Copyright © 1939, 1941, 1947, 1951, 1955, 1959, 1963, 1967 by the President and Fellows of Harvard College. Copyright © renewed 1967, 1969, 1975, 1979, 1983, 1987, 1991]

(a) Explain the processes illustrated by the diagrams. [4]

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(Option A continues on the following page)

(Option A, question 7 continued)

(b) Outline how the human brain can reorganize itself following a stroke. [1]

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(c) State the area of the human brain that may have been damaged when the following symptoms are present.

(i) A lack of muscle control on the left side of the body [1]

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(ii) Difficulty in swallowing [1]

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(Option A continues on the following page)

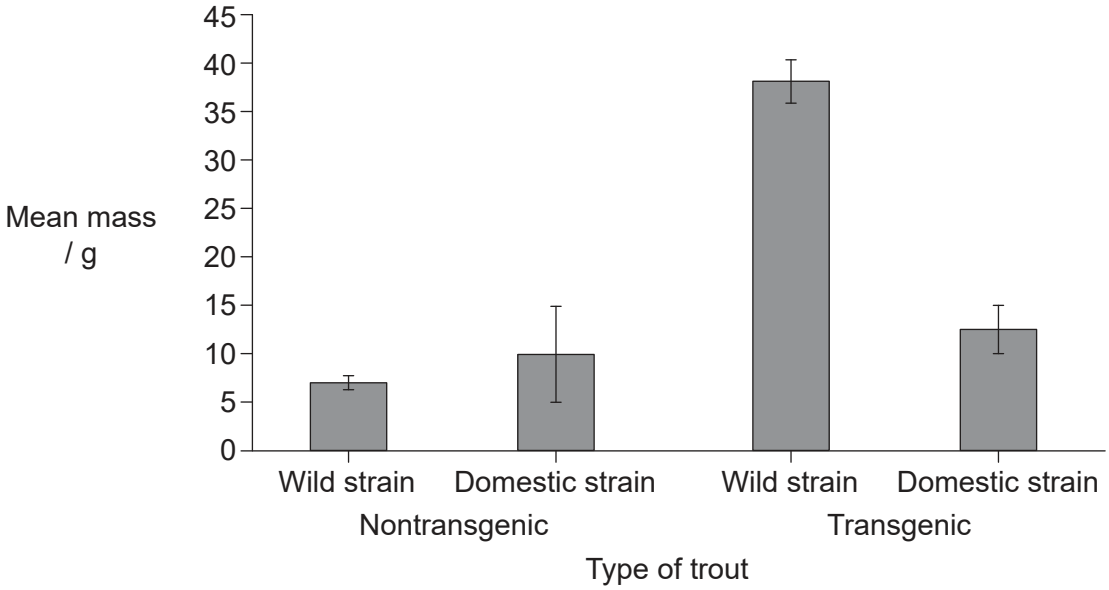
(Option A continued)

8. Outline innate and learned behaviour. [6]

End of Option A

Option B — Biotechnology and bioinformatics

9. Transgenic rainbow trout (*Oncorhynchus mykiss*) were produced from both wild strain and domestic strain trout, using a gene coding for growth hormone from coho salmon (*Oncorhynchus kisutch*). The graph shows the mean mass of the nontransgenic and transgenic trout at 8 months post-fertilization.



[Source: Reprinted by permission from Macmillan Publishers Ltd: *Nature*, 409, Growth of domesticated transgenic fish, R H Devlin *et al.*, pp. 781–782, copyright 2001]

(a) Analyse the data for the growth of nontransgenic trout and transgenic trout. [2]

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(b) Suggest a reason for the growth differences between the nontransgenic trout and transgenic trout. [1]

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(Option B continues on the following page)

(Option B, question 9 continued)

(c) Describe the use of marker genes in the development of transgenic organisms such as trout. [2]

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(d) Outline the possible environmental impact associated with the accidental release of transgenic trout. [2]

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(Option B continues on the following page)

(Option B continued)

10. The table shows a comparison of DNA base sequences in several yeast (*Saccharomyces*) genomes.

Species	Number of DNA base sequences	Percentage of coding sequences
S. paradoxus	728	88
S. cariacanus	867	88
S. mikatae	1136	84
S. bayanus	851	80
S. castellii	2290	70
S. kluyveri	2145	70
S. unisporus	2357	69

[Source: P. F. Cliften *et al.* (2001) 'Surveying Saccharomyces Genomes to Identify Functional Elements by Comparative DNA Sequence Analysis', *Genome Research*, 11, pp. 1175–1186.
]

(a) Identify the species that has the lowest percentage of coding sequences. [1]

. . . . . .

(b) State how similar nucleotide sequences can be identified. [1]

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(Option B continues on the following page)

(Option B, question 10 continued)

(c) The yeast *Saccharomyces cerevisiae* was the first eukaryotic organism to have its entire genome sequenced. Suggest reasons for the choice of yeast as a study organism. [3]

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(d) Outline possible medical applications of the polymerase chain reaction (PCR). [1]

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(Option B continues on the following page)

(Option B continued)

11. The scanning electron micrograph shows a biofilm on a metal surface from an industrial water system.

[Source: Biofilms: Survival Mechanisms of Clinically Relevant Microorganisms, Rodney M. Donlan, J. William Costerton, *Clinical Microbiology Reviews*, 2002, 15 (2), pp. 167–193. Reproduced with permission from American Society for Microbiology]

(a) Outline the emergent properties of biofilms. [3]

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(b) State a positive application of biofilms. [1]

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(Option B continues on the following page)

(Option B, question 11 continued)

(c) Suggest **two** problems that could be caused by the presence of biofilms in water systems. [2]

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12. (a) Beans contribute to flatulence. Alpha-galactosidase, derived from the fungus *Aspergillus niger*, is an enzyme that breaks down the fibre usually fermented by bacteria, reducing intestinal gas. Describe how alpha-galactosidase would be produced using *A. niger* in a continuous fermenter. [3]

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(b) Temperature is a variable that needs to be continually monitored in deep-tank batch fermentation of penicillin. List **two** other variables that need to be monitored. [2]

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(Option B continues on page 23)

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will not be marked.

(Option B continued from page 21)

13. Discuss biopharming. [6]

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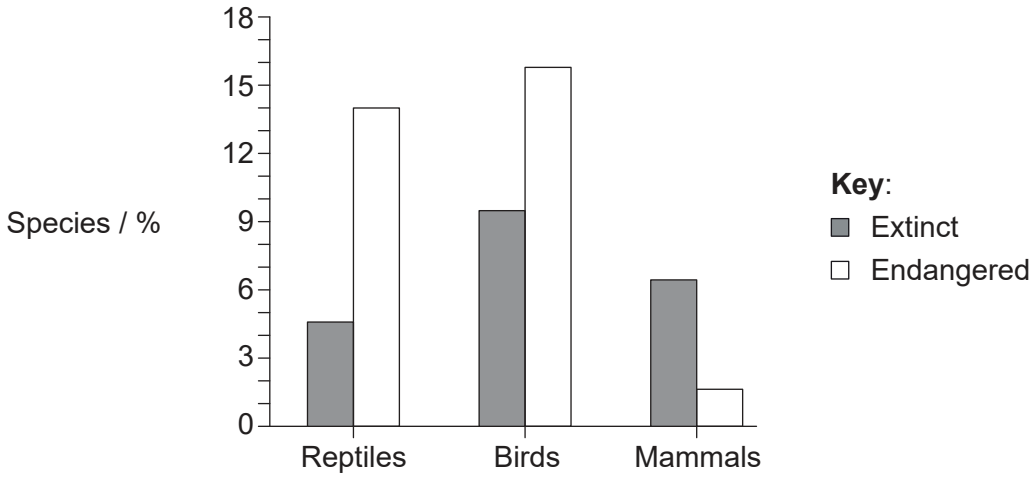
End of Option B

Option C — Ecology and conservation

14. To assess the impact of introduced cats (*Felis silvestris*) that prey on native species, a study was carried out on 120 islands around the world. The graph shows the impact of *F. silvestris* on reptiles, birds and mammals.



[Source: A global review of the impacts of invasive cats on island endangered vertebrates, F. M. Medina *et al.* (2011) *Global Change Biology*, 17, pp. 3503–3510. Reproduced with permission from John Wiley and Sons.]

(a) (i) Identify how the pattern in mammals is different from reptiles and birds. [1]

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(ii) Describe how invasive species such as *F. silvestris* can have a significant impact on native species. [2]

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(iii) Suggest a method to limit the impact of *F. silvestris* on native species. [1]

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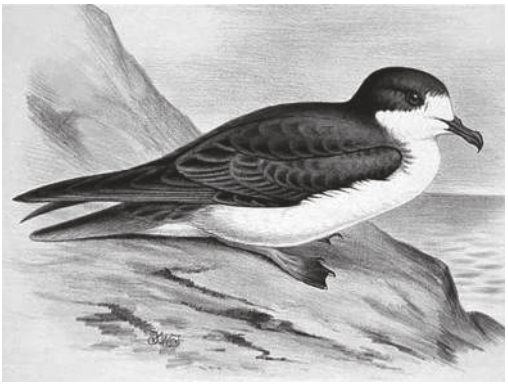
(Option C continues on the following page)

(Option C, question 14 continued)

(b) The ‘Ua‘u petrel (*Pterodroma sandwichensis*) is considered to be an indicator species in the Hawaiian Islands.



[Source: https://commons.wikimedia.org/wiki/File:Oestrelata_phaeopygia_AvesHawaiienses00Wils_0382.jpg]

(i) State the role of an indicator species. [1]

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(ii) Identify possible approaches to maintain the population of *P. sandwichensis*. [2]

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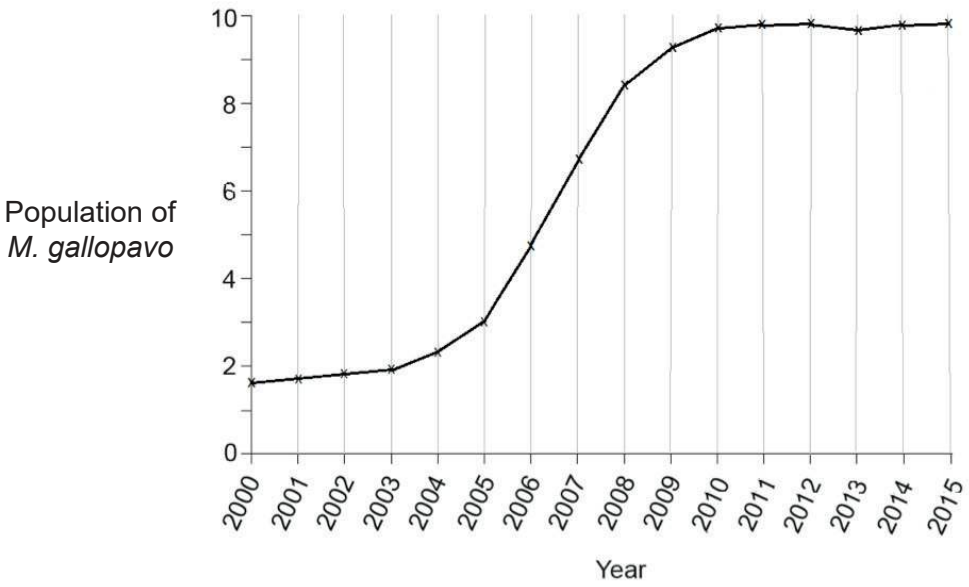
(Option C continues on the following page)

(Option C continued)

15. Wild turkeys (*Meleagris gallopavo*) once inhabited most forested areas of North America. As an important food source for early European settlers, the population of *M. gallopavo* seriously decreased. Due to recent conservation efforts, population numbers are increasing.

[Source: https://commons.wikimedia.org/wiki/File:A_wild_turkey_in_Middleboro,_Massachusetts.jpg]

The curve shows a population of *M. gallopavo* from 2000 to 2015 in Ohio in the mid-western USA.



[Source: © International Baccalaureate Organization 2017]

(Option C continues on the following page)

(Option C, question 15 continued)

(a) (i) State the range of years when exponential growth of the *M. gallopavo* population occurred. [1]

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(ii) Suggest factors that could account for the growth curve of the *M. gallopavo* population. [2]

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(b) State how the population of *M. gallopavo* may have been determined. [1]

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(c) Hunting of *M. gallopavo* is currently regulated. Predict what would happen if the hunting regulations were removed. [2]

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(Option C continues on the following page)

(Option C continued)

16. The graph shows the variation in the annual temperature and precipitation in different ecosystems.

Removed for copyright reasons

(a) Identify the ecosystem labelled X. [1]

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(b) Compare and contrast the exchange of energy with nutrient cycling in ecosystems. [3]

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(Option C continues on the following page)

(Option C, question 16 continued)

(c) Outline **three** issues arising from the release of pollutants into the environment. [3]

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17. (a) (i) Define fundamental niche. [1]

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(ii) Outline a reason for organisms seldom occupying their entire fundamental niche. [1]

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(b) Describe the relationship between *Zooxanthellae* and reef-building coral species. [2]

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(Option C continues on page 31)

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will not be marked.

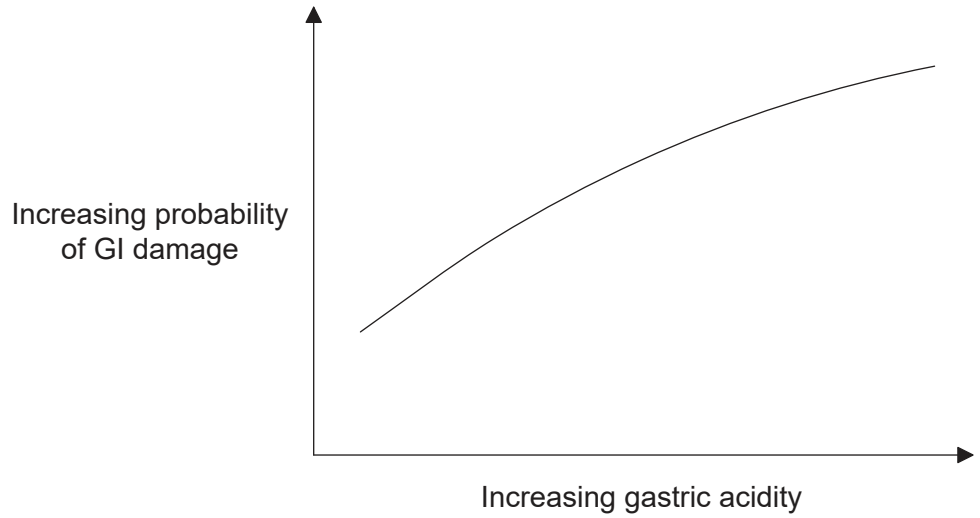
(Option C continued from page 29)

18. Discuss the causes and consequences of eutrophication. [6]

End of Option C

Option D — Human physiology

19. The graph shows the relationship between gastrointestinal (GI) damage and gastric acidity in 37 healthy human volunteers.



[Source: Republished with permission of Elsevier Science and Technology Journals, from 'Integrated gastric acidity can predict the prevention of naproxen-induced gastroduodenal pathology in normal subjects', John Plachetka, Gaetano Morelli, Carolyn Hines, Julie Borland, Alison Lyke, Diane Littlefield, Jerry D. Gardner *Gastroenterology*, Vol. 124, Issue 4, 2003; permission conveyed through Copyright Clearance Center, Inc.]

(a) State the relationship of gastric acidity and GI damage. [1]

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(b) GI damage can include ulcers. Outline the treatment of stomach ulcers. [3]

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(Option D continues on the following page)

(Option D, question 19 continued)

(c) Other than gastric acidity, state a primary cause of stomach ulcers. [1]

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20. (a) (i) Thyroxin is a hormone produced in the thyroid gland. State **one** function of thyroxin. [1]

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(ii) The action of thyroxin is similar to steroid hormones. Describe the action of steroid hormones. [3]

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(b) The World Health Organization recommends that the iodine intake should be supplemented in pregnant women due to their increased requirements. Outline the need for iodine supplementation. [2]

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(Option D continues on the following page)

(Option D continued)

21. (a) (i) Jaundice causes a yellow discolouration of the skin, mucous membranes and sclera of the eyes. State the bile pigment causing this discolouration. [1]

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(ii) Explain how the normal production of bile pigments changes with the development of jaundice. [4]

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(b) Distinguish between the structure of liver sinusoids and capillaries. [2]

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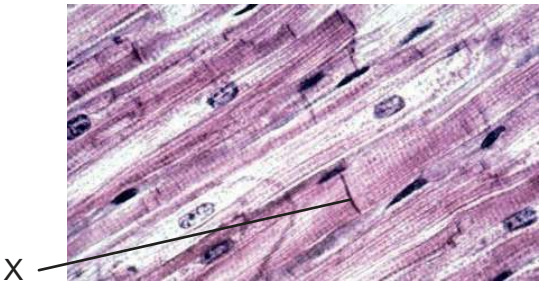
(Option D continues on the following page)

(Option D continued)

22. The micrograph shows a section of cardiac muscle.



[Source: Musculocardiaco by Goyitrina (https://commons.wikimedia.org/wiki/File:Musculocardiaco.jpg)]

(a) Identify the structure labelled X. [1]

. . . . . .

(b) Describe the unique properties of cardiac muscle cells. [4]

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(c) State an early invention that led to improved knowledge of the heart. [1]

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(Option D continues on the following page)

(Option D continued)

23. Discuss high altitude training for athletes. [6]

End of Option D