Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 3

Thursday 21 November 2019 (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 – 8
Option B — Biotechnology and bioinformatics	9 – 13
Option C — Ecology and conservation	14 – 18
Option D — Human physiology	19 – 23

8819 – 6003

38 pages

Section A

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

1. Scientists have constructed systems to reproduce the conditions of natural wetlands. The mesocosms below were used to study nutrient removal from water flowing through.

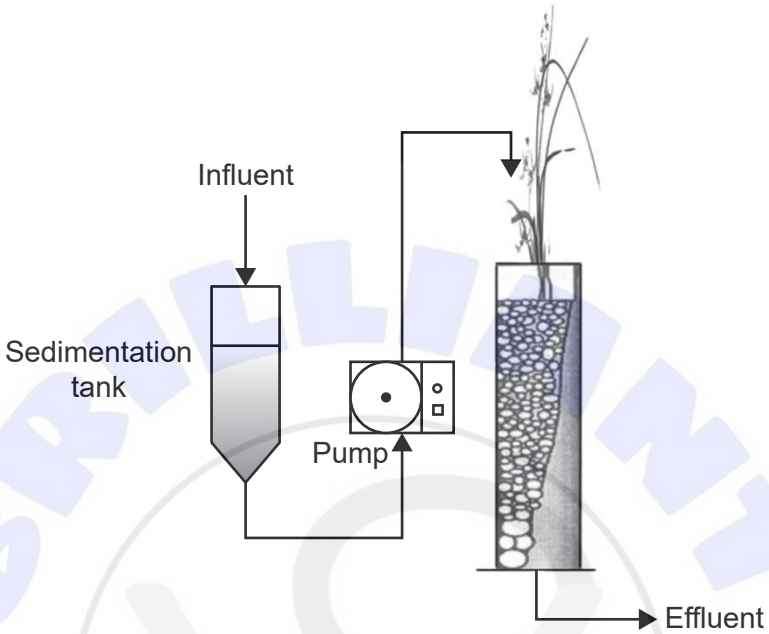

Figure A: Vertical flow

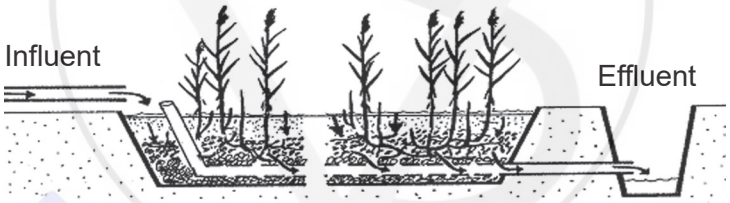

Figure B: Horizontal flow

[Source: © 2013. Silviya Lavrova and Bogdana Koumanova (October 2nd 2013). Nutrients and Organic Matter Removal in a Vertical-Flow Constructed Wetland, Applied Bioremediation – Active and Passive Approaches, Yogesh B. Patil and Prakash Rao, IntechOpen, DOI: 10.5772/56245. Available from: https://www.intechopen.com/books/applied-bioremediation-active-and-passive-approaches/nutrients-and-organic-matter-removal-in-a-vertical-flow-constructed-wetland]

(a) Compare and contrast the design of both mesocosms (vertical flow and horizontal flow). [2]

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(This question continues on the following page)

(Question 1 continued)

(b) Suggest with a reason which system best reproduces the conditions of the natural environment. [1]

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(c) State **two** variables other than temperature and light that should be controlled in this experiment, in order to discover which system is more effective at removing nutrients from water. [2]

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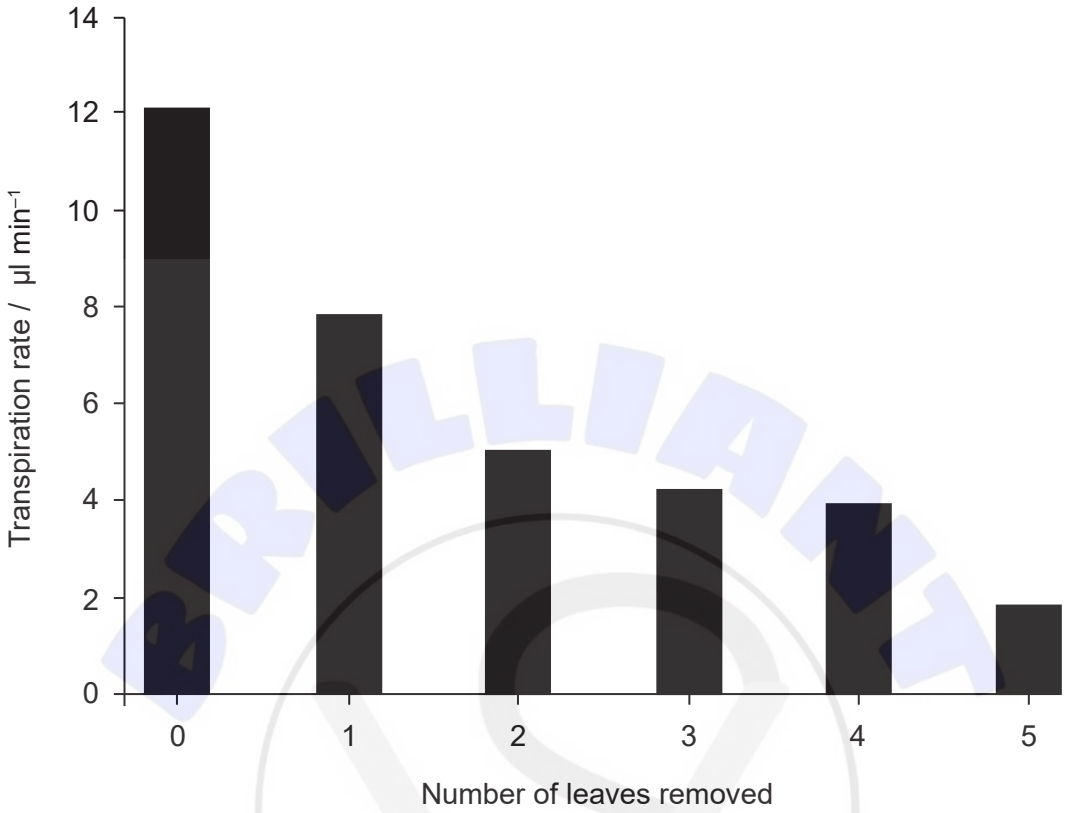
2. A student designed an experiment to study the transpiration through the leaves of a tomato plant (*Solanum lycopersicum*). Measurements were taken in the initial conditions with five leaves on a tomato shoot and then again after each of the five leaves was removed.



[Source: R. C. Hodson and J. Acuff. 2006. Water transport in plants: anatomy and physiology in *Tested Studies for Laboratory Teaching*, Volume **27** pp 163–183]

(a) (i) Describe the trend in the data. [1]

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(ii) Transpiration continued after the fifth leaf had been removed. Suggest what can be concluded. [1]

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(This question continues on the following page)

(Question 2 continued)

(b) State the independent variable in this investigation. [1]

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(c) Explain how the results in the graph could have been obtained. [2]

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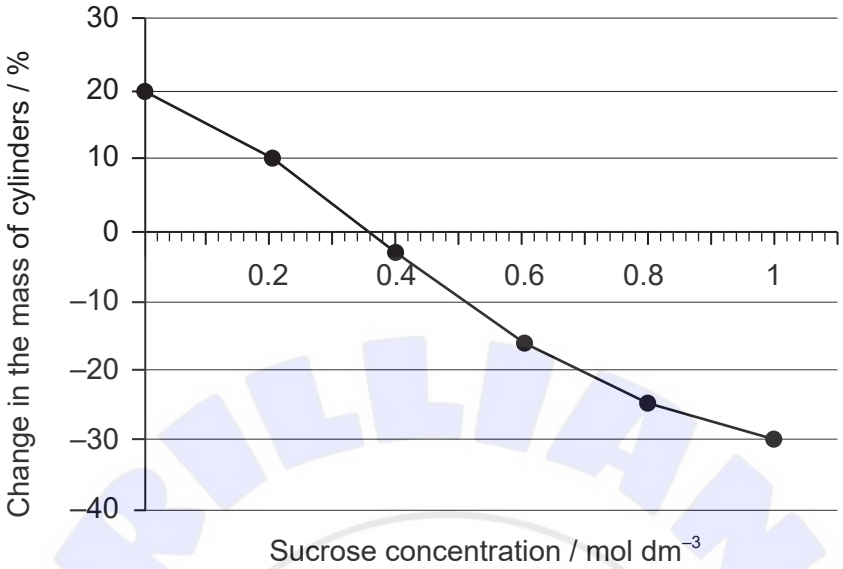
3. An experiment was carried out to study osmosis in plant cells. Small cylinders of zucchini (*Cucurbita pepo*) were cut and placed in different sucrose solutions at 25 °C. The figure shows the percentage changes in mass after 24 hours.



(a) Estimate the solute concentration of the zucchini cells. [1]

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(b) If a zucchini is allowed to dry in the open air, predict how the osmolarity of the zucchini cells would change. [1]

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(c) Explain **one** reason for calculating the percentage changes in mass. [2]

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(This question continues on the following page)

(Question 3 continued)

(d) Predict what would happen to a red blood cell placed in distilled water. [1]

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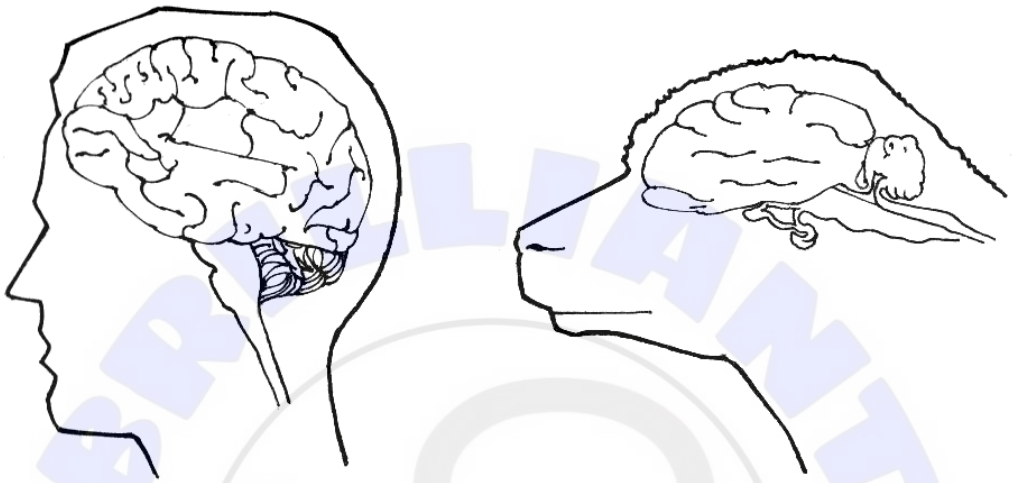
Section B

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 figures below show a human and a sheep brain.



Human brain Sheep brain

[Source: Pearson Scott Foresman, donated to the Wikimedia Foundation, https://commons.wikimedia.org/wiki/File:Convolution_he_-_sheep_and_human_brain.png]

(a) The human brain is larger than the brain of many animals. Identify **one** other difference between the human brain and the brain of a sheep. [1]

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(b) Outline the main feature of neural pruning. [1]

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(c) State the name of the part of the brain that controls breathing rate. [1]

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(Option A continues on the following page)

(Option A, question 4 continued)

(d) Explain the need for the adult human brain to be supplied continuously with a relatively large supply of blood. [3]

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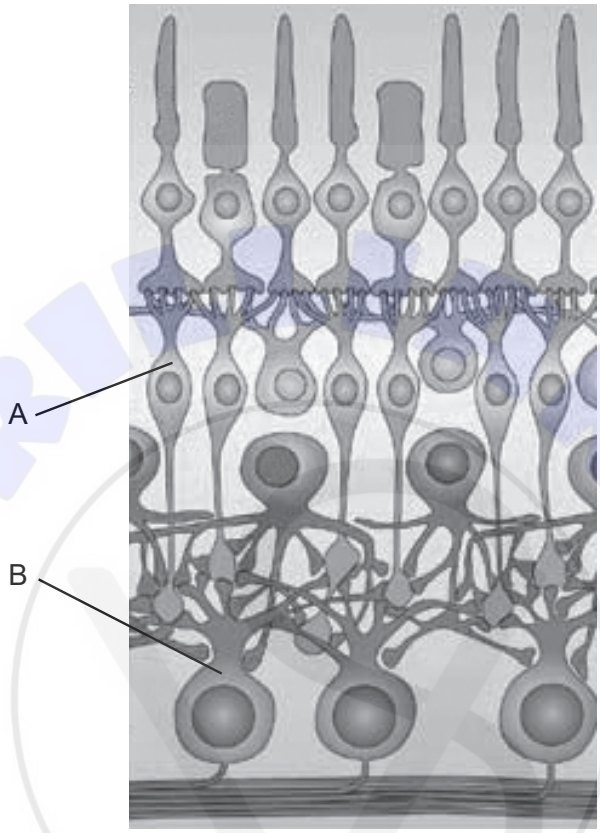
(Option A continues on the following page)

(Option A continued)

5. The diagram shows part of a human retina.



[Source: reprinted by permission from Springer Nature: Nature Reviews Neuroscience Parallel processing in the mammalian retina, Heinz Wässle, 2004, *Nat Rev Neurosci* **5**, 747–757 (2004) doi:10.1038/nrn1497]

(a) On the diagram, draw an arrow showing the direction of the light. [1]

(b) Identify the cells labelled A and B. [1]

A: . . . . . .

B: . . . . . .

(Option A continues on the following page)

(Option A, question 5 continued)

(c) Photoreceptors in the retina sense light. State the name of another type of receptor with an example of the stimulus it detects. [1]

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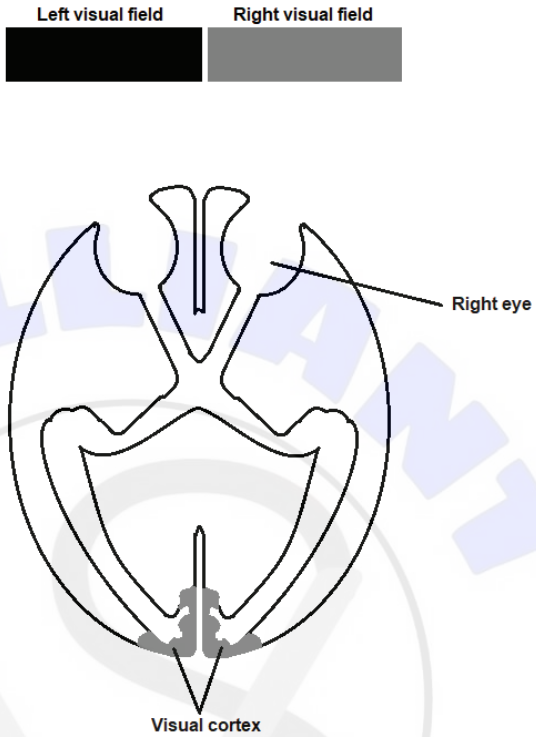
(Option A continues on the following page)

(Option A, question 5 continued)

(d) Explain, using the diagram, how the visual stimuli from the right eye reach the visual cortex of the brain. [3]



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(Option A continues on the following page)

(Option A continued)

6. Prior to the 1840s, doctors and dentists did not routinely use anesthesia when operating on patients. However, advances in the knowledge of neurotransmitters have assisted the use of anesthesia.

(a) Define neurotransmitter. [1]

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(b) Describe how local anesthetics act on the nervous system. [3]

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(c) Describe the main role of slow-acting neurotransmitters in memory and learning. [2]

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(Option A continues on the following page)

(Option A continued)

7. Many animals have a unique technique for courting their mate. The male peacocks (*Pavo cristatus*) spread their brightly-coloured tails to impress the females (peahens).

[Source: cocoparisienne/Pixabay]

(a) Courtship behaviour leads to mate selection. Describe innate behaviour. [1]

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(b) Explain the implications of courtship behaviour in natural selection. [3]

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(Option A continues on the following page)

(Option A, question 7 continued)

(c) Outline operant conditioning, giving an example. [2]

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(Option A continues on the following page)

(Option A continued)

8. Explain the effect of a **named** stimulant drug on the nervous system. [6]

End of Option A

Option B — Biotechnology and bioinformatics

9. The figure represents a section of DNA.

5’ 3’
ATGCCCAAGTTGAGGACGATGTAACCG

(a) Identify the first triplet of nucleotides of each of the three reading frames in the 5’ to 3’ direction. [1]

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(b) Open reading frames have start and stop codons. State **one** other characteristic of open reading frames. [1]

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(c) Explain how marker genes are used in genetic modification. [3]

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(d) State **one** physical method that could be used to introduce a gene into a plant. [1]

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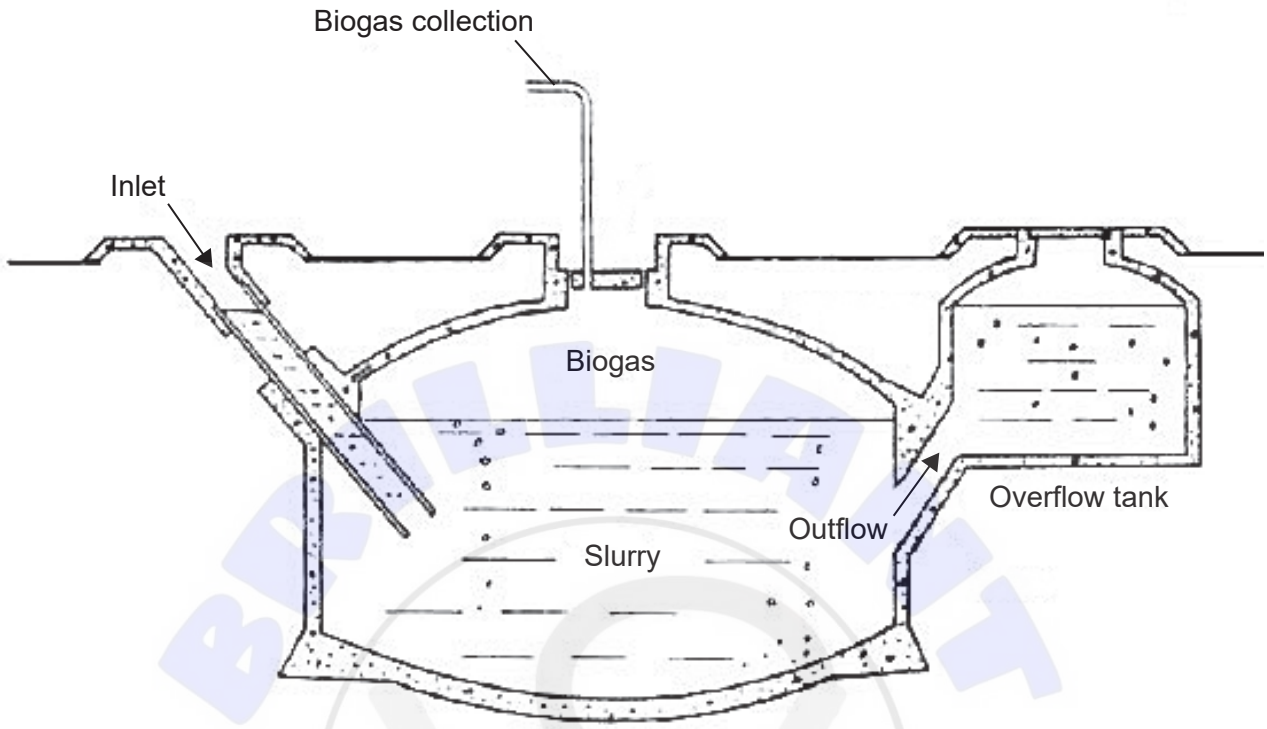
(Option B continues on the following page)

(Option B continued)

10. The diagram below represents a small-scale biogas fermenter.



[Source: © Science in Society. http://www.i-sis.org.uk/BiogasChina.php]

(a) Suggest **one** material that could be loaded into the biogas fermenter from which biogas can be produced. [1]

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(b) Identify the ideal temperature and oxygen conditions inside the fermenter for efficient biogas production. [1]

Temperature: . . . . . .

Oxygen: . . . . . .

(Option B continues on the following page)

(Option B, question 10 continued)

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

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(d) Explain how conditions in the fermenters are maintained to maximize penicillin production. [2]

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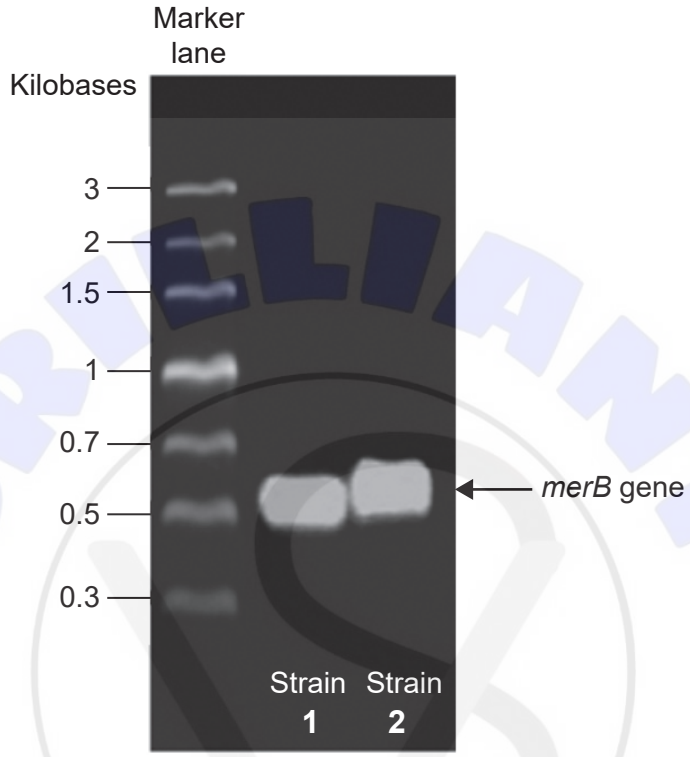
(Option B continues on the following page)

(Option B continued)

11. *Cupriavidus metallidurans* CH34 is a heavy metal-resistant bacterium that was genetically modified to be used for bioremediation. The *merB* gene that controls the conversion of organic mercury into inorganic mercury was introduced in the bacterium. The gel electrophoresis image below shows the presence of the *merB* gene in two strains after 70 generations.



[Source: Copyright © 2011 Rojas LA, Yáñez C, González M, Lobos S, Smalla K, Seeger M (2011) Characterization of the Metabolically Modified Heavy Metal-Resistant Cupriavidus metallidurans Strain MSR33 Generated for Mercury Bioremediation. *PLoS ONE* **6**(3): e17555. https://doi.org/10.1371/journal.pone.0017555]

(a) Outline the aims and methods of bioremediation. [2]

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(Option B continues on the following page)

(Option B, question 11 continued)

(b) The generation time of *C. metallidurans* is a few hours. Two strains of the bacterium were tested for the presence of the *merB* gene 70 generations after the genetic modification. Suggest **one** reason for carrying out these tests after 70 generations of the transgenic bacterium. [1]

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(c) Explain the use of *Pseudomonas* in bioremediation. [3]

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(Option B continues on the following page)

(Option B continued)

12. Corn (*Zea mays*) is by far the most widely used biopharming plant, followed by soybeans, tobacco and rice. Around the world approximately 400 biopharming products are in open-air field trials.

(a) State **one** possible application of biopharming. [1]

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(b) Explain the use of a viral vector in gene therapy. [3]

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(c) Outline the main principles of the Enzyme-Linked Immunosorbent Assays (ELISA) test. [2]

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(Option B continues on the following page)

(Option B continued)

13. Explain the use of DNA microarrays in genetic testing or diagnosis. [6]

End of Option B

Option C — Ecology and conservation

14. (a) Feed conversion ratio (FCR) is the mass of animal feed in kilograms required for farmed animals to produce one kilogram of edible mass. For example, the FCR for salmon is 1.2 and for chicken is 2.2. Deduce the implication of these ratios for sustainability. [2]

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(b) Models are used as representations of the real world. Evaluate the use of food webs to represent ecological communities. [2]

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(c) Explain why some biologists think protecting keystone species would help preserve biological diversity in an ecosystem. [1]

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(d) Outline what is meant by the niche concept. [2]

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(Option C continues on the following page)

(Option C continued)

15. The table below summarizes the number and percentage of marine species worldwide with at least one documented record of becoming entangled and at least one record of ingesting marine debris, such as plastics and fishing nets.

	Total species worldwide / number	**Percentage of species with at least one record of becoming entangled / %**	**Percentage of species with at least one record of ingesting marine debris / %**
Baleen whales	10	60	20
Penguins	16	38	6
Seals	19	42	5
Sea turtles	7	86	86

[Source: Küehn *et al.* 2015 (http://edepot.wur.nl/344861)]

(a) Compare and contrast the information provided for baleen whales and sea turtles. [2]

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(b) Outline how plastic ingestion may lead to biomagnification in these marine species. [1]

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(c) Describe the use of indicator species in monitoring environmental change. [3]

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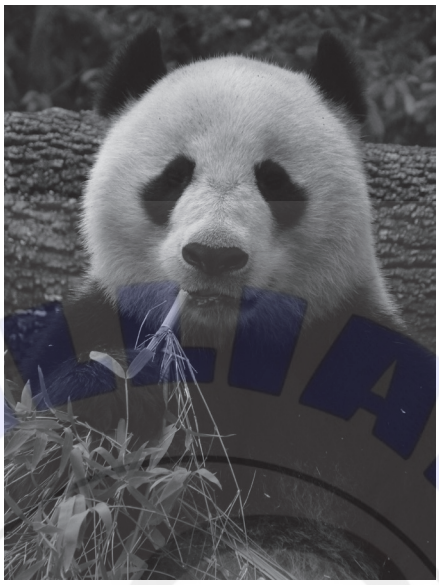
(Option C continues on the following page)

(Option C continued)

16. By mid-2005, the Chinese government had established over 50 panda reserves. These protect more than 10 400 km^2 and over 45 % of remaining panda habitat. There are also efforts to ensure the existence of natural corridors between panda populations.



[Source: Manyman/ https://commons.wikimedia.org/wiki/Ailuropoda_melanoleuca#/media/File:Giant_Panda_eating_Bamboo.JPG, licensed under CC BY-SA 3.0]

(a) State **one** advantage of this *in situ* conservation method. [1]

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(b) Suggest **one** reason for leaving natural corridors between different natural reserves. [1]

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(c) State what a high value of Simpson's reciprocal index of diversity suggests about an ecosystem. [1]

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(Option C continues on the following page)

(Option C, question 16 continued)

(d) Explain how the shape and size of a protected area may influence its success in protecting the organisms and ecosystems within it. [3]

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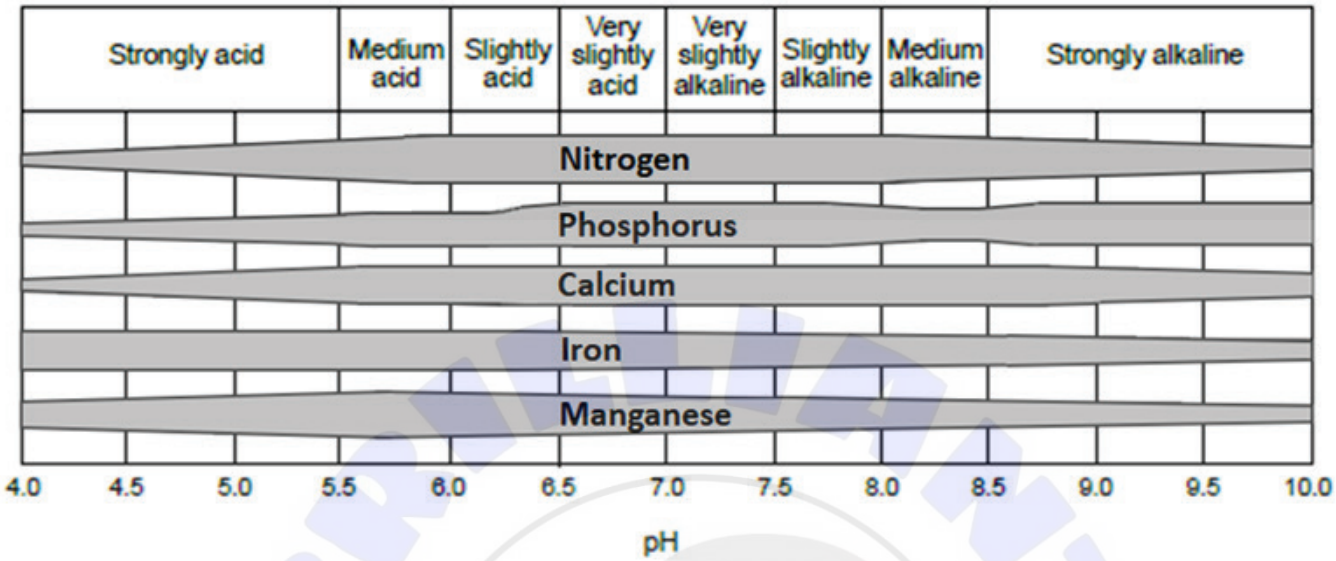
(Option C continues on the following page)

(Option C continued)

17. The figure below shows the effects of soil pH on nutrient availability. Thicker bars indicate higher nutrient availability.



[Source: diagram drawn from Emil Truog, 1947, The Liming of Soils, USDA Yearbook of Agriculture 1943–1947, and N.A. Pettinger, 1935, A Useful Chart for Teaching the Relation of Soil Reaction to the Availability of Plant Nutrients to Crops, Virginia Cooperative Extension, Virginia Tech, and Virginia State University]

(a) Identify which element is more available in strongly acid conditions. [1]

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(b) Outline the roles of *Rhizobium* bacteria in the nitrogen cycle. [2]

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(Option C continues on the following page)

(Option C, question 17 continued)

(c) Describe the major characteristics of a eutrophic lake. [2]

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(Option C continues on page 31)

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(Option C continued)

18. Explain the technique used to estimate the population size of a **named** species of organism that is able to move. [6]

End of Option C

Option D — Human physiology

19. The table below summarizes the distribution of the amino acids lysine and tryptophan in four food items.

	Lysine / mg g^{-1} of protein	**Tryptophan** / mg g^{-1} of protein
Beef	203	213
Milk	158	417
Rice	86	224
Wheat	57	217

The table below shows the average content of lysine and tryptophan in diets of the UK and India. The Indian diet is mainly vegetarian.

	Lysine / mg g^{-1} of protein	**Tryptophan** / mg g^{-1} of protein
UK diet	140	211
Indian diet	87	293

[Source: reprinted from Protein and amino acid requirements in human nutrition. Copyright (2007). https://www.who.int/nutrition/publications/nutrientrequirements/WHO_TRS_935/en/]

(a) Distinguish between essential and non-essential amino acids. [1]

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(b) Using the data from the tables, suggest a reason for the differences in lysine concentration in the diets from the UK and India. [1]

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(Option D continues on the following page)

(Option D, question 19 continued)

(c) Explain the consequences of protein deficiency malnutrition. [2]

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(d) List **two** dietary sources of vitamin D. [1]

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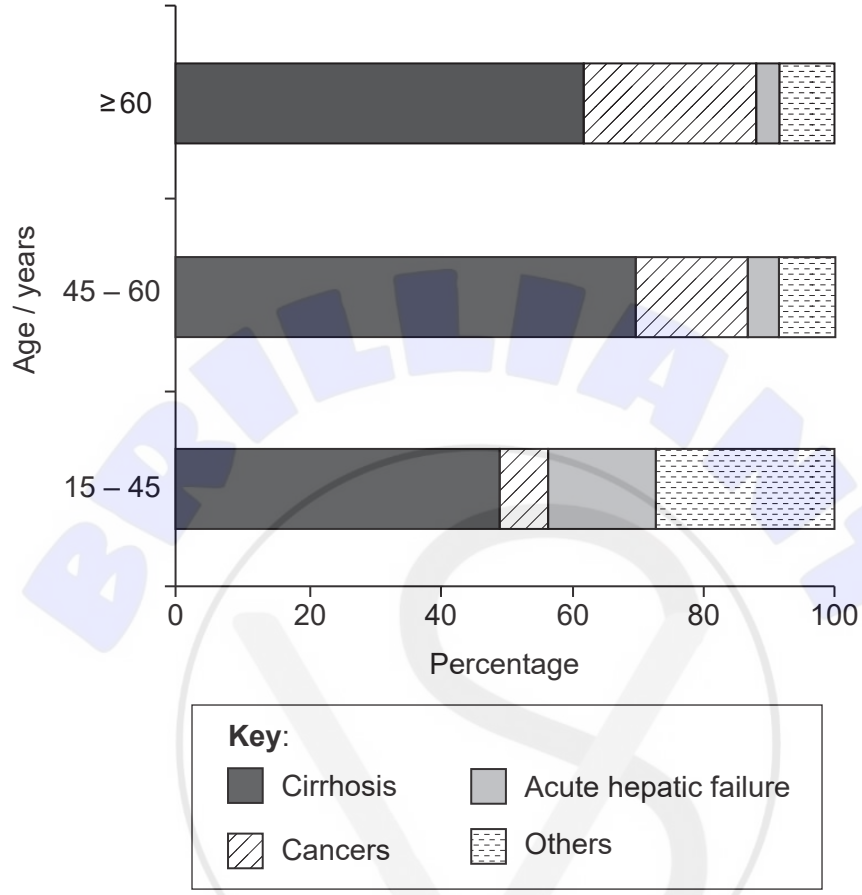
(e) State **one** possible cause and **one** symptom of type II diabetes. [1]

Cause: . . . . . .
Symptom: . . . . . .

(Option D continues on the following page)

(Option D continued)

20. Liver transplantation is a viable treatment option for end-stage liver disease and acute hepatic failure. The graph below shows the main diseases leading to liver transplants, in three age groups.



[Source: European Liver Transplant Registry. http://www.eltr.org/Overall-indication-and-results.html]

(a) Describe the relationship between age and liver transplants due to cancers. [1]

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(Option D continues on the following page)

(Option D, question 20 continued)

(b) One of the functions of the liver is to break down hemoglobin.

(i) Describe the breakdown of hemoglobin in the liver. [3]

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(ii) Outline **one** other function of the liver. [1]

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(c) State **one** material **not** produced by the human body that is egested from the digestive system. [1]

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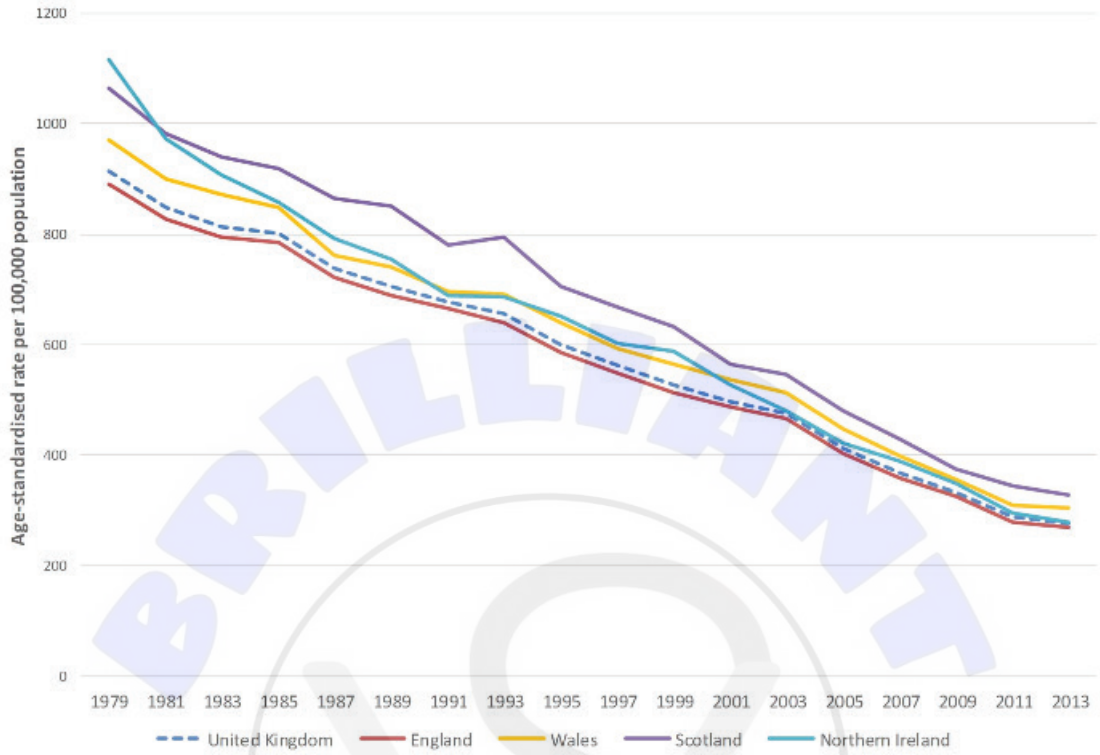
(Option D continues on the following page)

(Option D continued)

21. The figure below shows the average death rates from coronary heart disease in the UK.



[Source: Bhatnagar P, Wickramasinghe K, Wilkins E, *et al*, Trends in the epidemiology of cardiovascular disease in the UK, *Heart* 2016; **102**: 1945–1952.]

(a) Suggest **one** reason for the general decrease in the incidence of coronary heart disease. [1]

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(b) Outline the use of a defibrillator. [2]

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(Option D continues on the following page)

(Option D, question 21 continued)

(c) Explain the heart sounds. [3]

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22. (a) Athletes taking growth hormones show an increase in their sprinting capacity. This is not maintained after discontinuing the drug. Suggest **one** reason for the disappearance of the effect. [1]

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(b) Distinguish between the mode of action of steroid hormones and peptide hormones. [3]

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(c) Identify with reasons whether the pituitary gland is an exocrine or endocrine gland. [2]

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(Option D continues on the following page)

(Option D continued)

23. Explain how ventilation rate is changed during vigorous physical exercise. [6]

End of Option D

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