Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 3

Thursday 21 November 2019 (morning)

Candidate session number

1 hour

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 **[35 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 – 11
Option C — Ecology and conservation	12 – 15
Option D — Human physiology	16 – 19

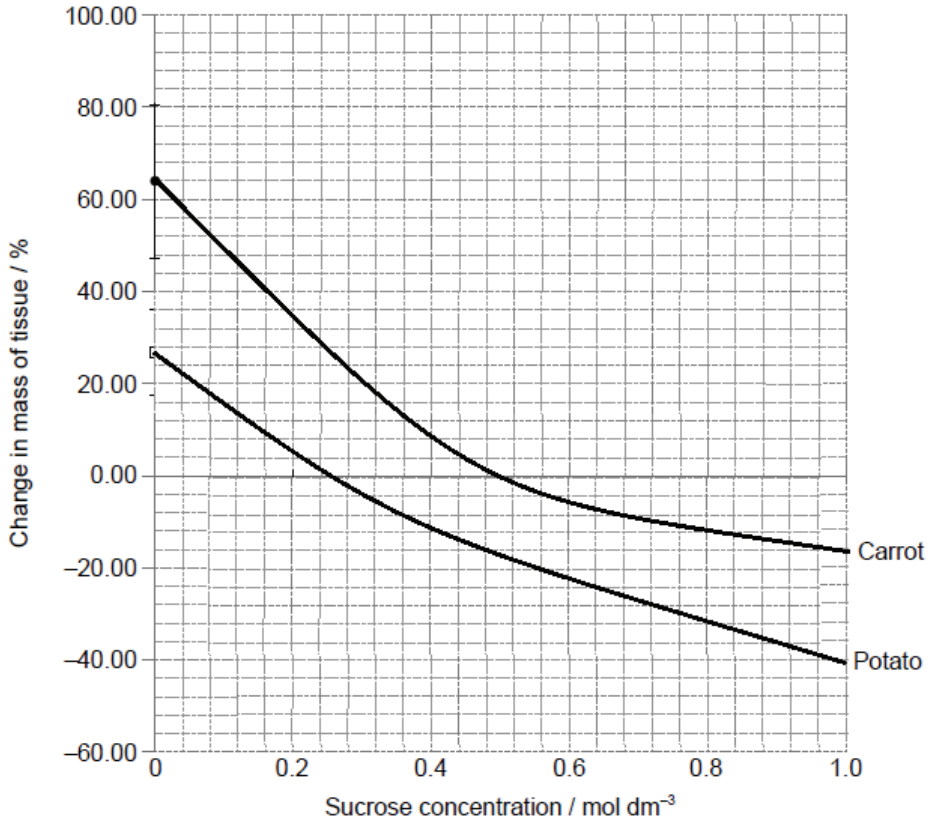
8819 – 6006

27 pages

Section A

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

1. An experiment was carried out on osmosis in carrot (*Daucus carota*) root tissue and potato (*Solanum tuberosum*) tuber tissue. Similar sized pieces of tissue were cut and soaked in different sucrose solutions for 24 hours. The results are shown in the graph below.



(a) Using the graph, estimate isotonic sucrose solutions for potato tissue and carrot tissue. [2]

Potato: . . . . . .

Carrot: . . . . . .

(This question continues on the following page)

(Question 1 continued)

(b) Suggest a reason for the difference in the isotonic points for the potato and the carrot tissues. [1]

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(c) From the evidence provided by the graph, evaluate the reliability of these data. [2]

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

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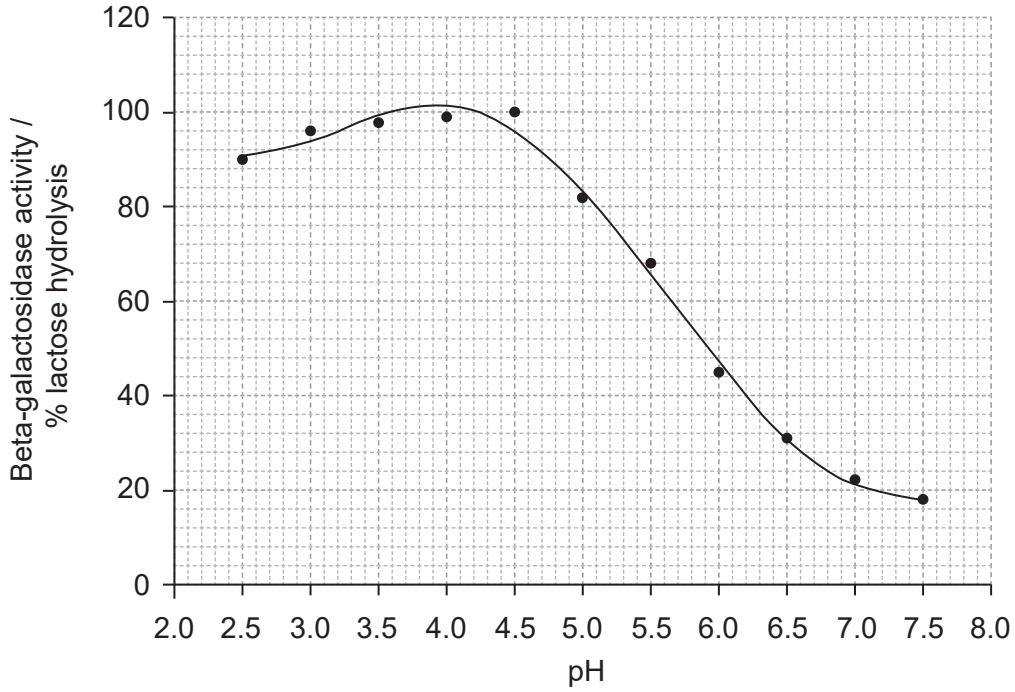
2. The enzyme beta-galactosidase hydrolyses lactose to release glucose and fructose. A study was carried out to determine how acidity affects the activity of a beta-galactosidase enzyme, extracted from the fungus *Penicillium simplicissimum*.



[Source: Cruz R, *et al.* Properties of a new fungal β-galactosidase with potential application in the dairy industry. *Revista de Microbiologia* **30**: 265–271, 1999]

(a) State another independent variable that would affect the activity of this enzyme. [1]

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(b) Outline the measurements which would need to be taken to determine the activity of the beta-galactosidase at different pH values. [2]

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3. Pigments were extracted from spinach (*Spinacia oleracea*) leaves and separated on a thin layer chromatogram.

Removed for copyright reasons

(a) Describe how the spinach leaf pigment extract should be applied to a chromatogram so that the pigment bands separate clearly. [2]

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(b) State **one** advantage of using thin layer chromatograms over paper chromatograms. [1]

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(c) The chromatogram reveals that the spinach leaves contain a variety of coloured pigments. Explain the observation that spinach leaves appear green. [2]

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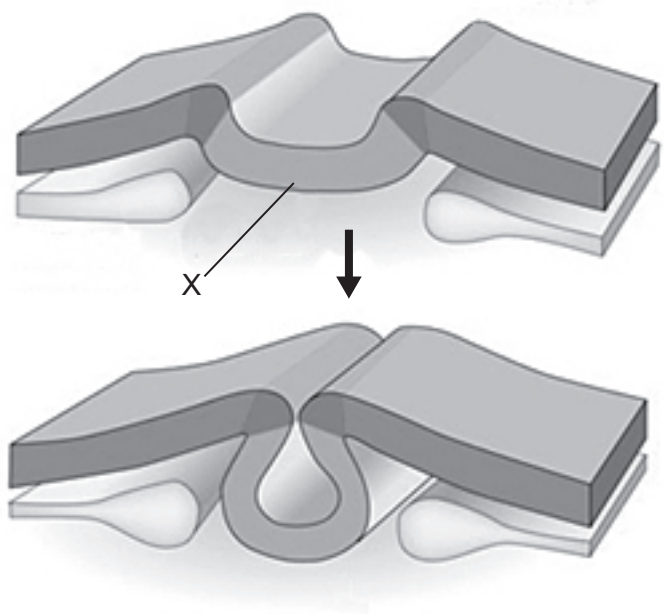
Section B

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 development of the neural tube in the frog *Xenopus* is shown in the diagram.



[Source: reprinted by permission from Nature Reviews Neuroscience, Gammill, L., Bronner-Fraser, M. Neural crest specification: migrating into genomics. *Nat Rev Neurosci* **4**, 795–805 (2003) doi:10.1038/nrn1219]

(a) State the name of the stage of embryonic development shown in the diagram. [1]

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(b) Identify the part labelled X. [1]

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(Option A continues on the following page)

(Option A, question 4 continued)

(c) State a consequence of incomplete folding of the neural tube in humans. [1]

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(d) Explain how the nervous system develops from the cells of the neural tube. [2]

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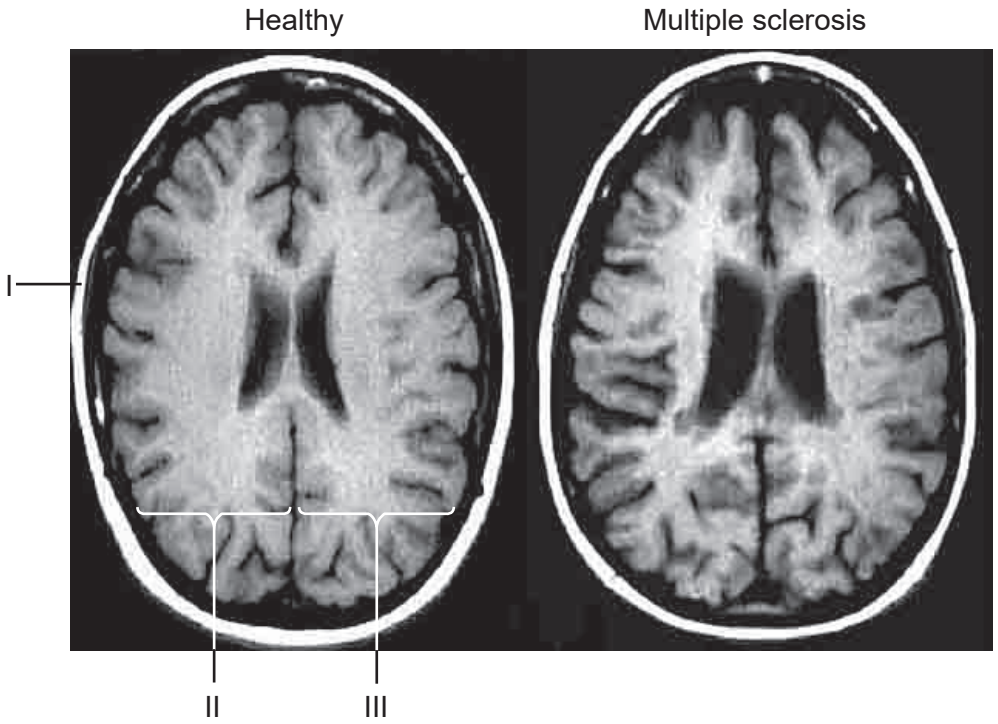
(Option A continues on the following page)

(Option A continued)

5. The MRI brain scans show the cerebral hemispheres of two people of the same age, one of whom is suffering from multiple sclerosis and has lost motor functions.



[Source: © *Frontiers in Bioscience*. Role of MRI in Multiple Sclerosis II: Brain and Spinal Cord Atrophy, Robert Zivadinov and Rohit Bakshi, **9**, 647–664, January 1, 2004]

(a) Identify the structures found at I, II and III. [2]

I: . . . . . .

II: . . . . . .

III: . . . . . .

(b) Suggest **one** way in which multiple sclerosis has affected the cerebral hemispheres of the brain. [1]

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(Option A continues on the following page)

(Option A, question 5 continued)

(c) The folding of the cerebral hemispheres is extensive and varies between different mammals. Explain briefly the importance of folding of the cerebral hemispheres in humans. [3]

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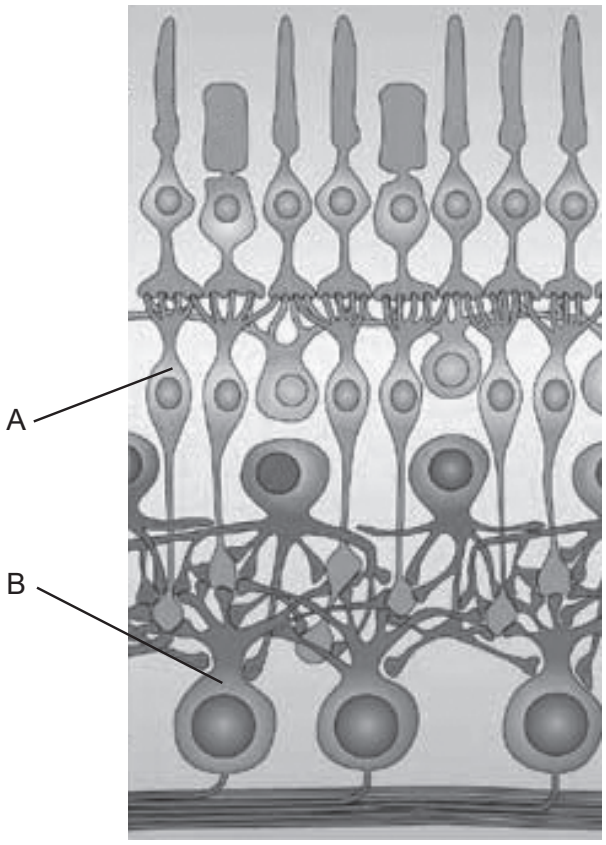
(Option A continues on the following page)

(Option A continued)

6. 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]

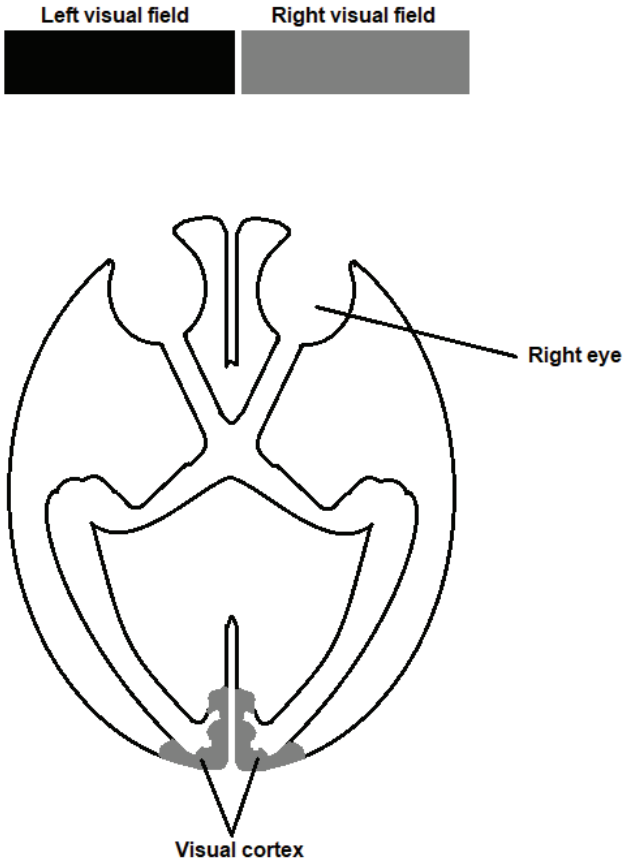
A: . . . . . .

B: . . . . . .

(Option A continues on the following page)

(Option A, question 6 continued)

(c) 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 page 13)

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

Answers written on this page will not be marked.

(Option A continued)

7. Describe how the inner ear detects audible sounds. [4]

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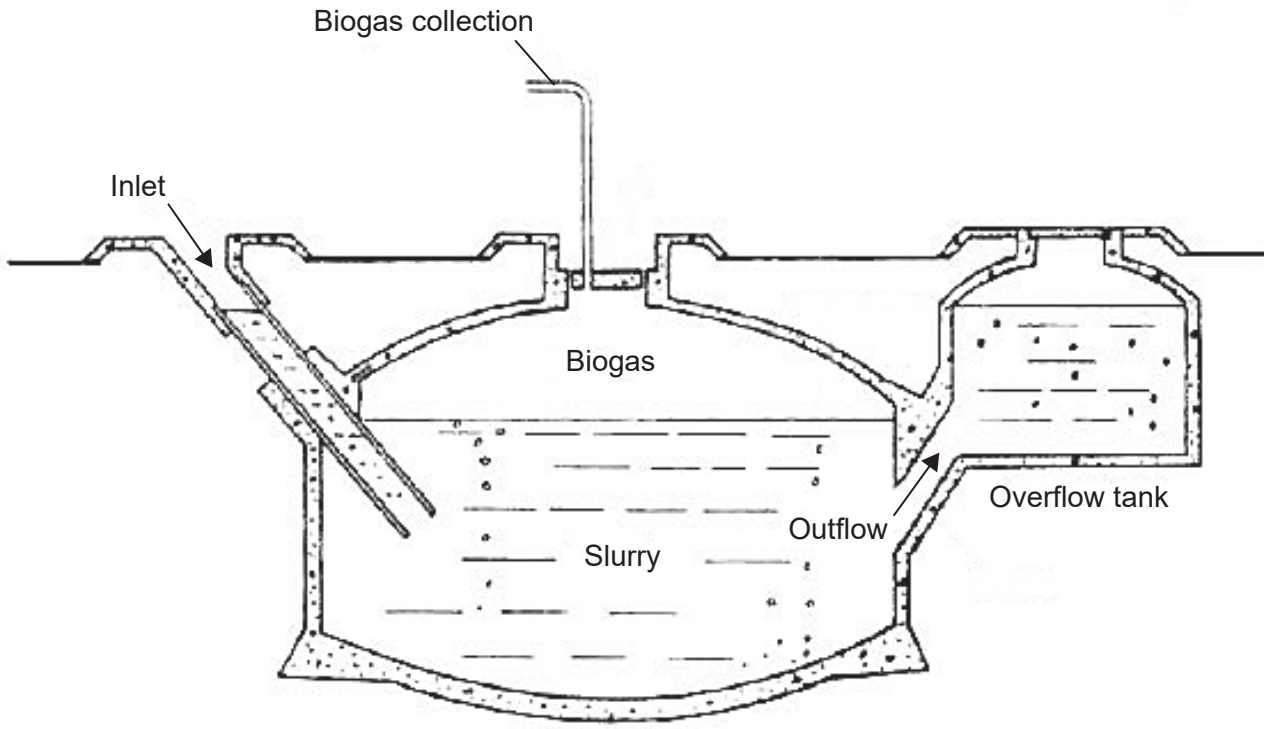
End of Option A

Option B — Biotechnology and bioinformatics

8. 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 8 continued)

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

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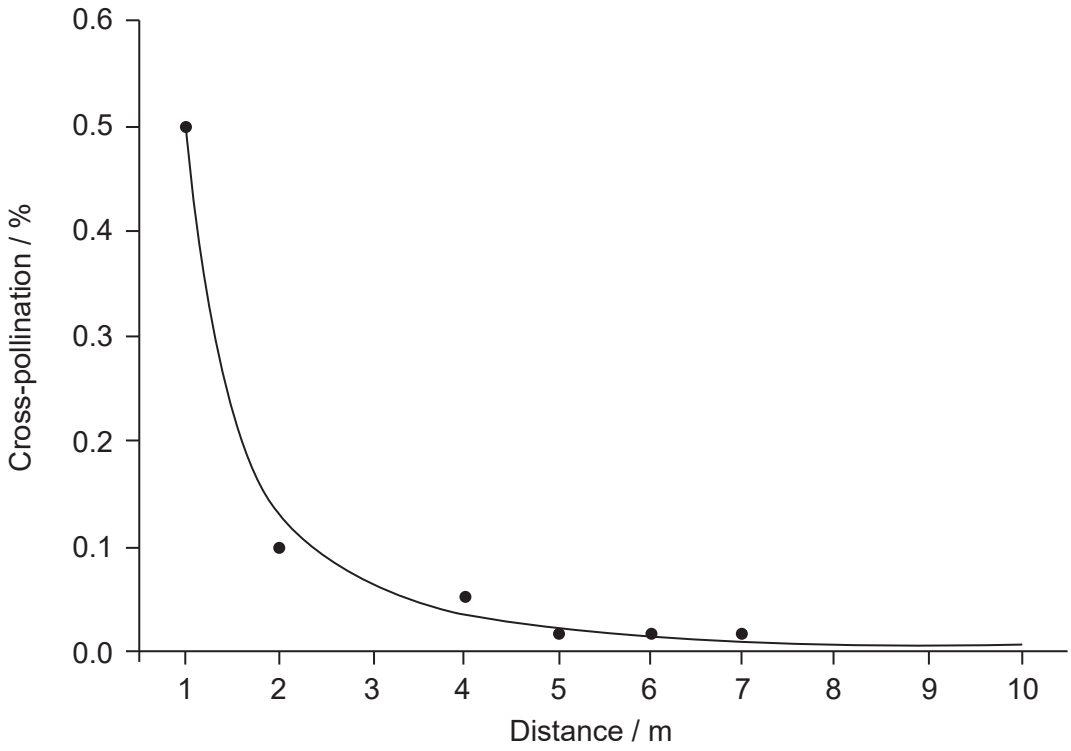
(Option B continues on the following page)

(Option B continued)

9. A study was carried out in Brazil on the transfer of pollen (cross-pollination) from transgenic strains to non-transgenic strains of soybean (*Glycine max*). The transgenic crop was resistant to the herbicide glyphosate. The graph below shows the percentage of cross-pollination between transgenic and non-transgenic crops in fields separated by different distances.



[Source: S Abud, *et al.*, (2007), Gene flow from transgenic to nontransgenic soybean plants in the Cerrado region of Brazil, *Genetics and Molecular Research*, **6** (2), pages 445–452]

(a) Suggest **one** undesirable consequence of cross-pollination involving glyphosate resistant crop plants with other plants. [1]

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(b) Using the data, suggest **one** recommendation to farmers who plant transgenic soybeans. [1]

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(Option B continues on the following page)

(Option B, question 9 continued)

(c) *Agrobacterium tumefaciens* stains pink or red with the Gram stain. Deduce from this result what type of bacterium *A. tumefaciens* is. [1]

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(d) Outline how *A. tumefaciens* is used to introduce genes into soybeans. [3]

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10. A sequence of DNA is translated in a continuous reading frame without spaces. Each triplet of nucleotides corresponds to successive amino acids in a polypeptide. The sequence given shows part of one strand of a DNA molecule.

AATGCGAGGATGCCCAAGCTGAATAGCGTAGAGGGGTTTTCATCATTTGAGGACGATGTAT

(a) Identify the first triplets of each possible reading frame for this piece of DNA. [1]

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(b) Define what is meant by an open reading frame. [1]

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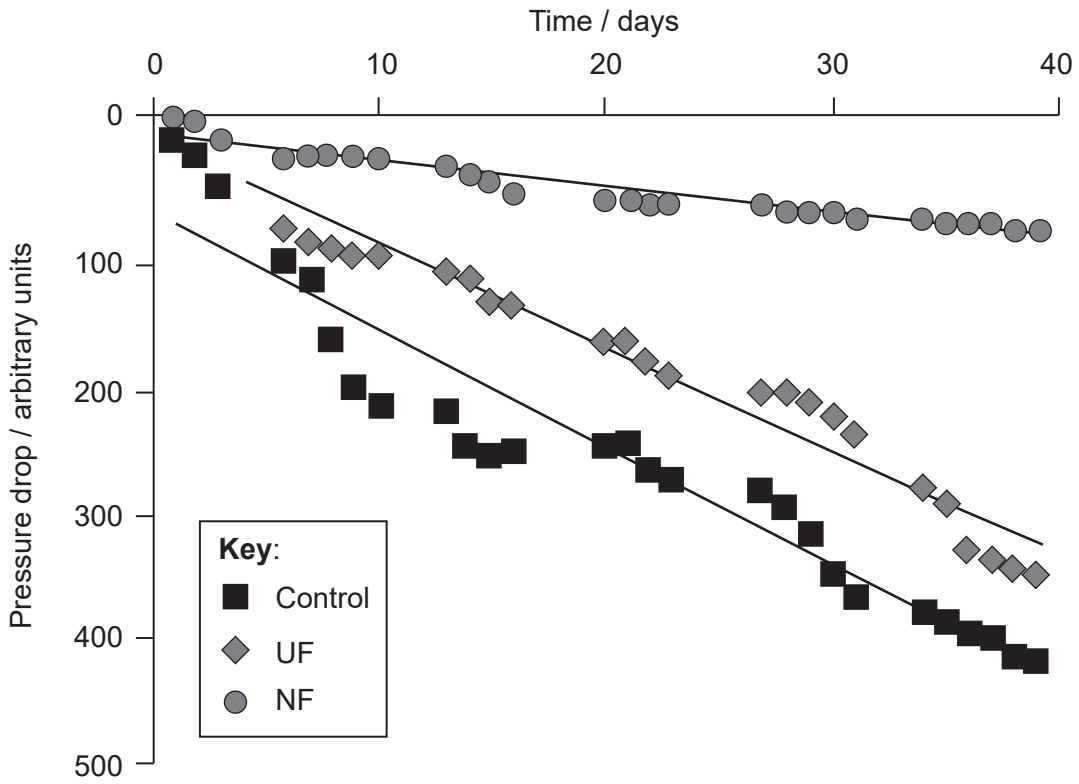
(Option B continues on the following page)

(Option B continued)

11. Ensuring the delivery of water to homes requires a pressure to be maintained in the pipes. Biofilm formation will reduce the pressure in the pipes. Three experimental water piping systems were set up and the water was treated before entering the system in one of the following three ways:

- untreated water (**Control**)
- ultrafiltration (**UF**) filters particles <500 nm
- nanofiltration (**NF**) filters particles <1 nm.

The drop in pressure of the water coming out of the tap at the end of the system compared to the pressure of water entering the system was measured.



[Source: reprinted from *Water Research*, **47**(8), G. Liu, M.C. Lut, J.Q.J.C. Verberk, J.C. Van Dijk, A comparison of additional treatment processes to limit particle accumulation and microbial growth during drinking water distribution, pp 2719–2728, Copyright (2013), with permission from Elsevier]

(Option B continues on the following page)

(Option B, question 11 continued)

(a) Compare and contrast the effect of ultrafiltration and nanofiltration on the drop in pressure. [3]

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(b) State **one** other way in which the formation of biofilms can be inhibited. [1]

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Some biological systems show emergent properties. Emergent properties arise from the interaction of the component parts of a system that are not predictable from studying the individual components.

(c) Explain how biofilms show emergent properties. [4]

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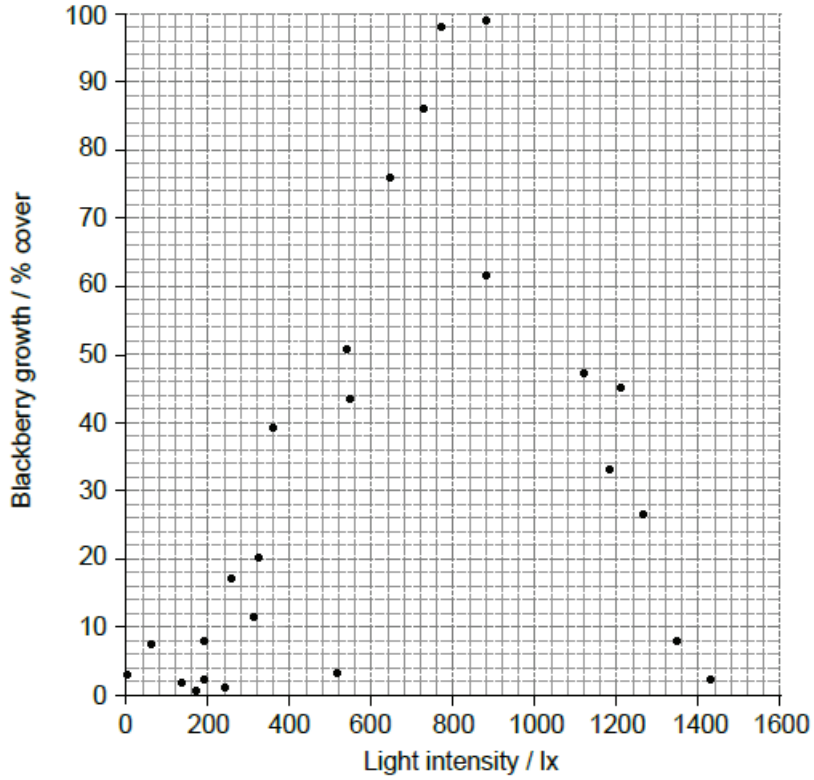
End of Option B

Option C — Ecology and conservation

12. The blackberry (*Rubus fruticosus*) is a plant that grows in deciduous woodlands in many parts of the world. A 30 m transect was laid out in a woodland to investigate the relationship between light intensity and blackberry growth. The percentage cover of blackberries and the light intensity were measured at 26 positions along this transect.



(a) Outline how these results indicate that blackberry distribution is limited by light intensity. [2]

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(b) Distinguish between the transfer of matter and energy in closed ecosystems. [1]

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(Option C continues on the following page)

(Option C, question 12 continued)

(c) A pyramid of energy represents the amount of energy taken in by each trophic level per unit time and per unit area. Discuss the advantages and disadvantages of the use of pyramids of energy as models of energy flow in an ecosystem. [4]

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

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(b) Compare and contrast fundamental and realized niche of a species. [2]

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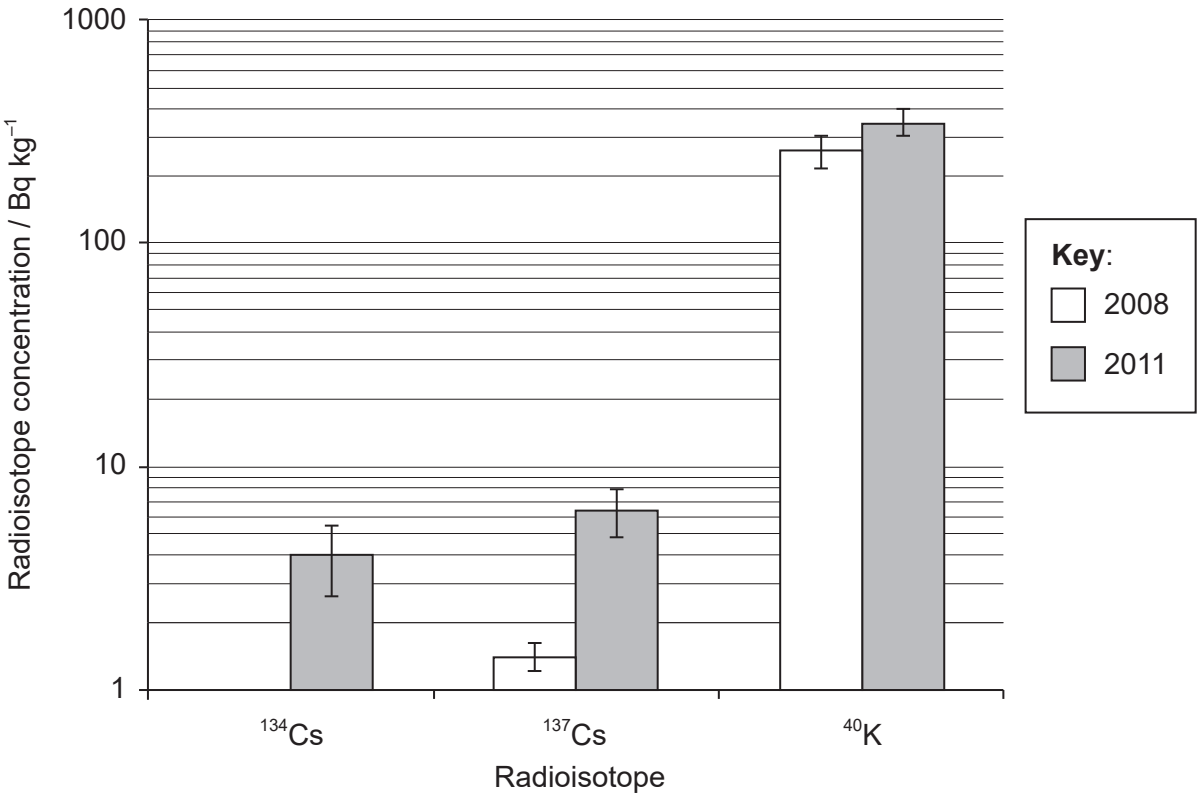
(Option C continues on the following page)

(Option C continued)

14. Blue fin tuna (*Thunnus orientalis*) are top carnivores in the marine ecosystem. Some radioisotopes of elements are produced by nuclear reactors. Following a nuclear accident at Fukushima in Japan in March 2011, the levels of certain radioisotopes were measured in the bodies of blue fin tuna caught off California in August 2011, the other side of the Pacific Ocean from Japan. The becquerel (Bq) is a measure of radioactivity.



[Source: reproduced from Pacific bluefin tuna transport Fukushima-derived radionuclides from Japan to California Daniel J. Madigan, Zofia Baumann, and Nicholas S. Fisher *PNAS* June 12, 2012 **109** (24) 9483–9486]

(a) Explain how the levels of the Caesium (Cs) radioisotopes could have accumulated in the tissues of these fish. [3]

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(Option C continues on the following page)

(Option C, question 14 continued)

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

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15. (a) State the impact of environmental disturbance on biodiversity. [1]

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(b) (i) State an example of an alien species. [1]

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(ii) Outline the impact of alien species on endemic species in ecosystems. [2]

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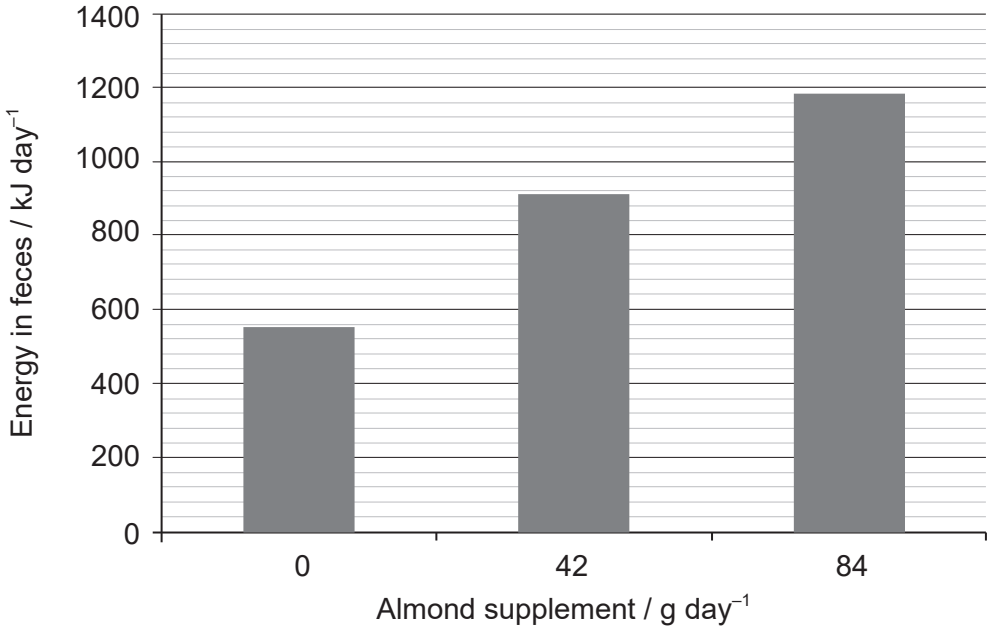
End of Option C

Option D — Human physiology

16. Three groups of human volunteers were given different amounts of almond nuts added to a controlled diet for a period of 68 days. During that period the amount of energy released in their feces was measured.



[Source: Janet A Novotny, Sarah K Gebauer, David J Baer, Discrepancy between the Atwater factor predicted and empirically measured energy values of almonds in human diets, *The American Journal of Clinical Nutrition*, Volume **96**, Issue 2, August 2012, Pages 296–301, https://doi.org/10.3945/ajcn.112.035782]

(a) Using the data, discuss the implications for the advice given by dieticians to patients. [2]

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(b) Describe how the energy content of food may be measured by combustion. [3]

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(Option D continues on the following page)

(Option D, question 16 continued)

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

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17. (a) The stomach secretes hydrochloric acid into its lumen.

(i) State **one** mechanism that controls gastric secretion. [1]

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(ii) State the type of gland that secretes juices into the digestive system. [1]

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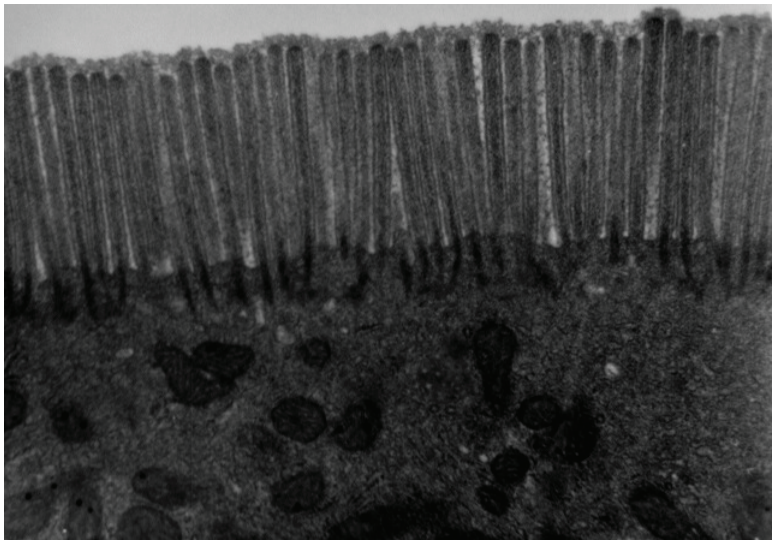
(Option D continues on the following page)

(Option D, question 17 continued)

(b) The electron micrograph below shows part of an epithelial cell from the digestive system.



[Source: Louisa Howard, Katherine Connollly – Dartmouth Electron Microscope Facility]

(i) State where this type of cell can be found in the digestive system. [1]

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(ii) Outline **two** adaptations of this cell to its function that are visible in this electron micrograph. [2]

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(Option D continues on the following page)

(Option D continued)

18. (a) Explain how materials from red blood cells are recycled by the liver. [4]

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(b) State a cause and a consequence of jaundice. [2]

Cause: . . . . . .

Consequence: . . . . . .

19. Explain the heart sounds. [3]

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End of Option D

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