22106012

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

BIOLOGY
STANDARD LEVEL
PAPER 3

Tuesday 18 May 2010 (morning)

1 hour

Candidate session number

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INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

0129

Option A — Human nutrition and health

A1. A study was made to look at the effect of breastfeeding on infant health. The infants studied were all healthy at birth. They were classified as never breastfed, partially breastfed or only breastfed, based on their feeding status in the first three months of life. The frequency of health care use was assessed for each of these groups, for three illnesses (lower respiratory infection, middle ear infection and gastroenteritis).

The table below indicates the frequency of initial and follow-up visits to the doctor, prescription of medication and hospitalizations during the first year of life. Follow-up visits and medication were seldom needed for gastroenteritis.

	Mean frequency of healthcare use per child in the first year of life		
	Never breastfed	**Partially breastfed**	**Only breastfed**
Lower respiratory infection			
Mean number of visits to doctor	0.46	0.44	0.40
Follow-up visits	0.07	0.01	0.02
Medications	0.27	0.21	0.19
Hospitalization	0.02	0.02	0.01
Middle ear infection			
Mean number of visits to doctor	2.04	1.88	1.51
Follow-up visits	1.02	1.44	0.76
Medications	2.04	1.88	1.51
Gastroenteritis			
Mean number of visits to doctor	1.50	0.94	0.45
Hospitalizations	0.11	0.11	0.04

[Source: Reproduced with permission from *Pediatrics*, Vol 103, pages 870-876, Copyright 1999 by the AAP.]

(a) Using the data, identify the illness

(i) that causes the greatest healthcare use in the first year of life. *[1]*

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(ii) for which breastfeeding causes the greatest reduction in visits to the doctor. *[1]*

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(This question continues on the following page)

(Question A1 continued)

(b) Compare the health effects of only breastfeeding with partial breastfeeding, using the data in the table. *[2]*

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(c) Suggest how the composition of breast milk and artificial milk may have contributed to these results. *[2]*

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A2. (a) State the energy content of 100 g of carbohydrate, fat and protein. *[1]*

Carbohydrate: . . . . . .

Fat: . . . . . .

Protein: . . . . . .

(b) Explain the possible health consequences of diets rich in fats. *[3]*

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(Question A2 continued)

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

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A3. (a) List **two** dietary sources of vitamin D. *[1]*

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(b) Discuss exposure to sunlight as a source of vitamin D. *[3]*

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A4. Outline the concept of food miles. *[2]*

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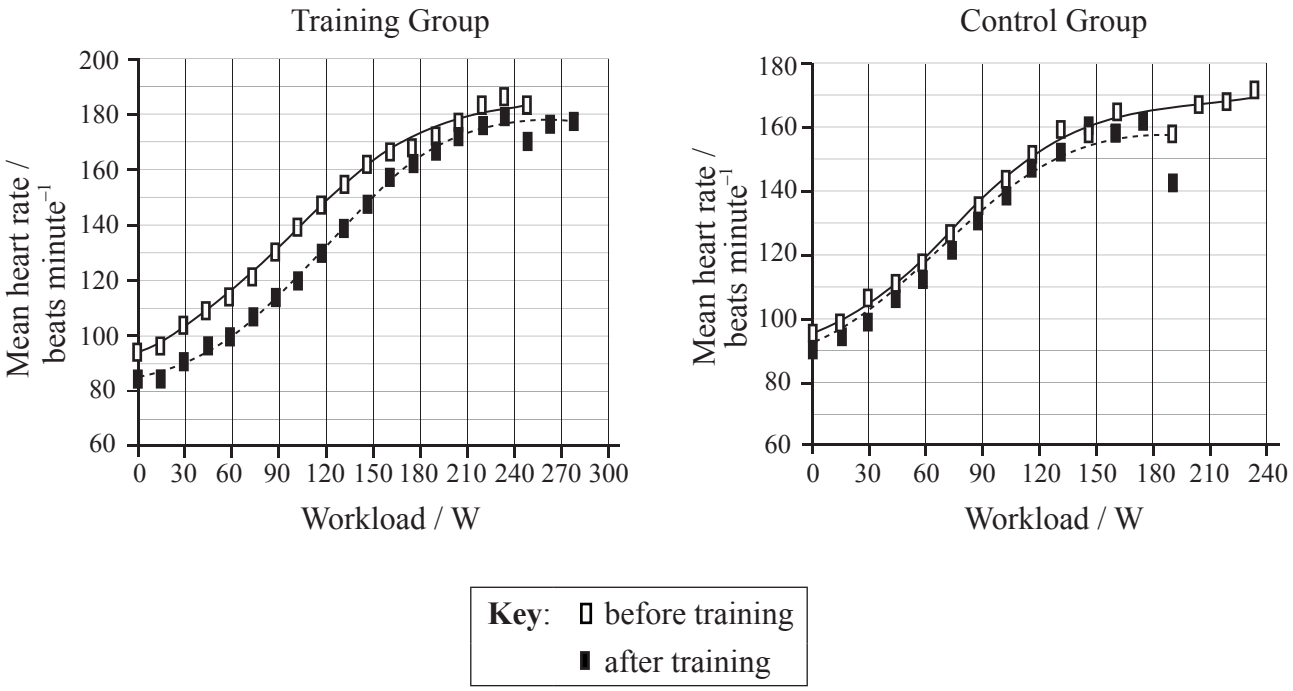
Option B — Physiology of exercise

B1. A study was carried out to assess the effects of high-intensity interval training on heart rate. 20 subjects were randomly assigned to two groups: training and control. They underwent a test in which the exercise became harder and harder until they reached the point of exhaustion (progressive incremental test). The training group then performed nine sessions of high intensity interval training on a cycle ergometer during three weeks (1 minute at 130 % of maximal aerobic work rate with 1 minute rest intervals until they felt they were at the point of exhaustion). The control group did not do any training. Both groups then repeated the progressive incremental test.

The graphs below show the mean heart rate curves during progressive incremental tests before and after training.



[Source: L Fronchetti, *et al*., "Effects of High Intensity Interval Training on Heart Rate Variability During Exercise", *Journal of Exercise Physiology*, (2007), **10** (4) August, pages 1–9. Reprinted with permission.]

(This question continues on the following page)

(Question B1 continued)

(a) State **three** factors that would have to be considered when selecting the subjects used in this study. *[1]*

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(b) Describe the relationship between workload and heart rate shown by the graphs. *[2]*

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(c) (i) Calculate the change in mean heart rate at a workload of 90 W in the training group before and after three weeks of training. *[1]*

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(ii) Deduce the effect of training on heart rate. *[2]*

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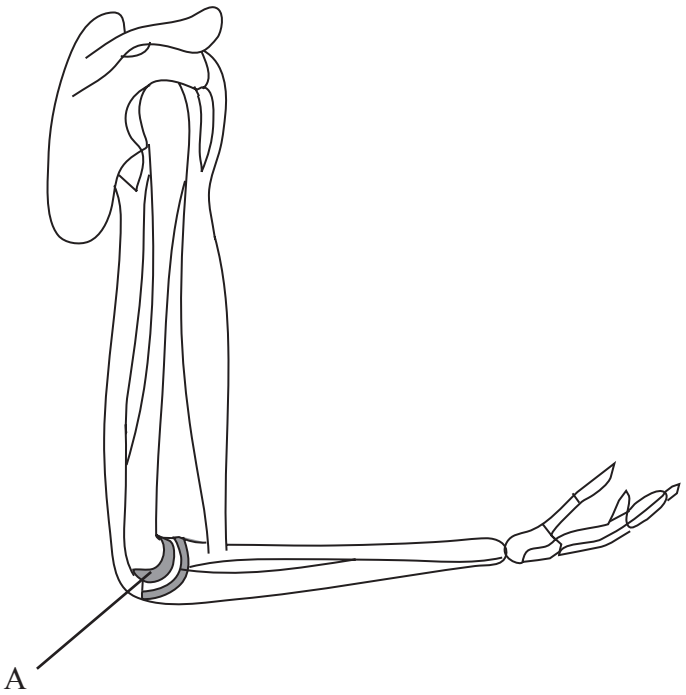
B2. (a) The diagram below shows an elbow joint.



(i) On the diagram, label a pair of antagonistic muscles. *[1]*

(ii) State the function of the structure labelled A. *[1]*

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(b) Explain the role of ATP in the contraction of skeletal muscle. *[3]*

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B3. (a) Define *tidal volume*. *[1]*

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(b) Outline the effects of training on the pulmonary system. *[3]*

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B4. Discuss the need for warm-up routines. *[3]*

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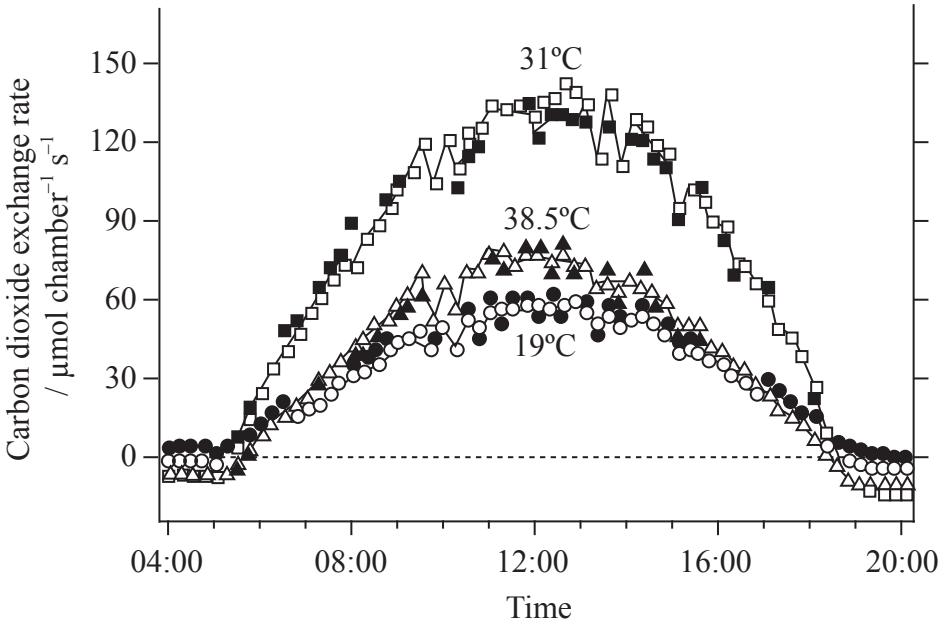
Option C — Cells and energy

C1. Global atmospheric carbon dioxide levels are rising. A study was carried out to test if the temperature dependence of photosynthesis was altered by elevated atmospheric CO_2. Maize plants were grown in natural sunlight in controlled environmental chambers at different temperatures using current atmospheric and doubled CO_2 levels.

The graph below shows daily patterns of CO_2 exchange at three different temperatures. Open shapes (○, △, □) represent current atmospheric CO_2 levels and closed shapes (●, ▲, ■) represent elevated CO_2 levels.



[Source: Reprinted from **61** (3), *Environmental and Experimental Botany*, S H Kim, *et al*., "Temperature dependence of growth, development, and photosynthesis in maize under elevated CO2", pages 224-236, copyright (2007) with permission from Environmental and Experimental Botany.]

(a) (i) State the time at which carbon dioxide exchange rate is maximal. *[1]*

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(ii) Explain the reasons for maximum carbon dioxide exchange rate at this time. *[2]*

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(This question continues on the following page)

(Question C1 continued)

(b) State the temperature that resulted in the highest rate of photosynthesis under current atmospheric conditions. *[1]*

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(c) Using the data in the graph, discuss whether rising carbon dioxide levels in the atmosphere will increase growth rates in maize. *[2]*

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C2. (a) State **two** functions of proteins, giving a **named** example of each. *[2]*

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(b) Explain the significance of polar and non-polar amino acids. *[3]*

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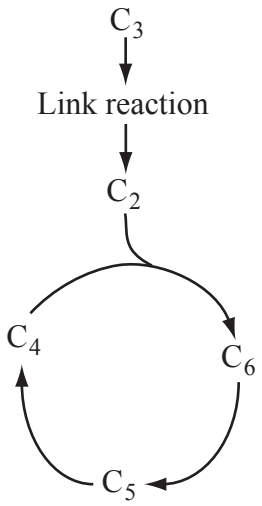
C3. The diagram below shows part of the respiratory pathway. The number of carbon atoms in each molecule is indicated.



(a) (i) Label pyruvate and acetyl coenzyme A on the diagram above. *[1]*

(ii) Indicate **two** places where decarboxylation occurs on the diagram. *[1]*

(iii) List **one** product other than carbon dioxide formed in this stage of respiration. *[1]*

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(b) State precisely where in a cell this stage of respiration is occurring. *[1]*

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C4. Explain the control of metabolic pathways. *[3]*

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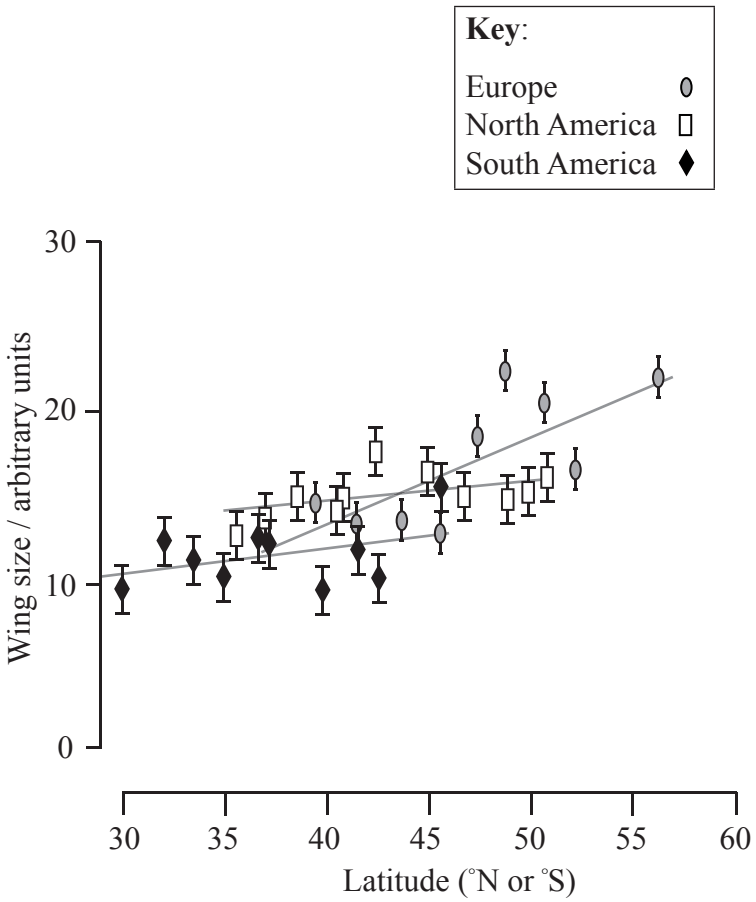
Option D — Evolution

D1. *Drosophila subobscura* (shown in photograph below) is a species of fruit fly native to Europe. The sample on the left is from Spain, latitude 39°, and the one on the right is from Denmark, latitude 56°. The species was introduced into both South America and North America approximately 20 years ago. The graph below shows the wing size in arbitrary units of *D. subobscura* at different latitudes in the three locations.

Photograph by George W. Gilchrist



[Source: G W Gilchrist, *et al*., "A time series of evolution in action: a latitudinal cline in wing size in South American Drosophila subobscura" (2004), *Evolution*, **58** (4), pages 768–780. Used with the permission of Wiley-Blackwell.]

(a) Identify the relationship between wing size and latitude shown by *D. subobscura* in Europe. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(b) (i) Compare the data for wing size of *D. subobscura* in North and South America with wing size in Europe. *[2]*

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(ii) Suggest **one** reason for the differences. *[1]*

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(c) Predict, with a reason, what might happen to *D. subobscura* in the future as a result of its introduction to new areas. *[2]*

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D2. (a) State **two** processes needed for the spontaneous origin of life on Earth. *[2]*

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(b) Outline the properties of RNA that may have allowed it to play a role in the origin of life. *[2]*

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D3. (a) Outline a method for dating fossils using ^{14}C. *[2]*

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(b) Outline the trends illustrated by the fossils of *Ardipithecus* and *Australopithecus*. *[3]*

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D4. Compare convergent and divergent evolution. *[3]*

Convergent evolution	Divergent evolution

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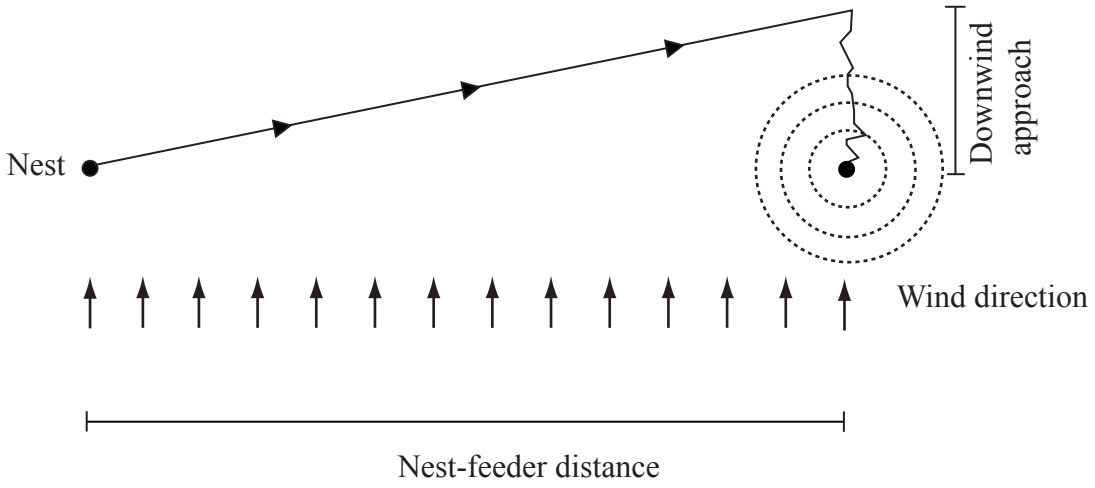
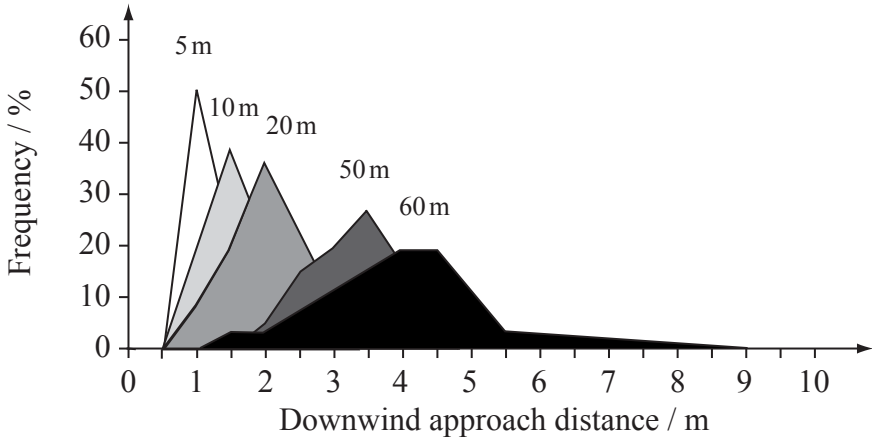
Option E — Neurobiology and behaviour

E1. Desert ants (*Cataglyphis fortis*) use odour to help find their food. When a constant wind is blowing, the ants do not approach food directly. Instead, they walk downwind of the food source and then, when they detect the odour of the food, they follow the odour trail upwind until they reach the food, as shown in the figure below.



[Source: Harald Wolf and Rudiger Wehner, "Desert Ants Compensate for Navigation Uncertainty", *Journal of Experimental Biology*, **208** (22), Nov. 2005, pages 4223-4230: Figures 1 and 4. Adapted with permission.]

To investigate this behaviour pattern, feeders were established at distances of 5 m to 60 m away from the nest. Each feeder consisted of a Petri dish filled with biscuit crumbs. The graph below shows the distribution of downwind approach distances for each different nest-feeder distance.



[Source: Harald Wolf and Rudiger Wehner, "Desert Ants Compensate for Navigation Uncertainty", *Journal of Experimental Biology*, **208** (22), Nov. 2005, pages 4223-4230: Figures 1 and 4. Adapted with permission.]

(This question continues on the following page)

(Question E1 continued)

(a) Outline the relationship between the downwind approach distance and the nest-feeder distance. *[1]*

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(b) Compare the results observed when the feeders were located at 5 m with the feeders at 60 m. *[3]*

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(c) Suggest **one** possible source of uncertainties or errors in these experiments. *[1]*

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(d) Deduce, with a reason, what type of behaviour pattern is shown by the ants in the experiment. *[2]*

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E2. (a) Define *reflex*. *[1]*

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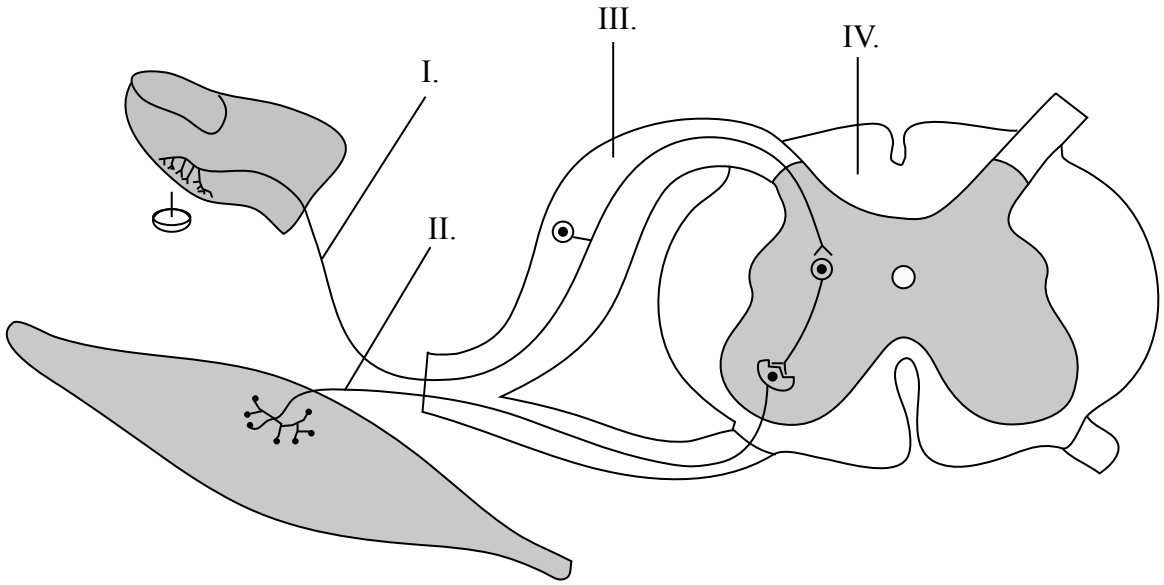
(b) Below is a diagram of a relex arc for a pain withdrawal reflex.



(i) Label the parts indicated by the letters I–IV. *[2]*

I. . . . . .

II. . . . . .

III. . . . . .

IV. . . . . .

(ii) Explain the role of parts I and II in a pain withdrawal reflex. *[2]*

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E3. (a) (i) State the type of receptor cells that detect sound. *[1]*

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(ii) State an example of these receptors in humans. *[1]*

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(b) Outline the role of inheritance and learning in the development of birdsong in young birds. *[2]*

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E4. Explain the effects of cocaine in terms of action at synapses in the brain. *[2]*

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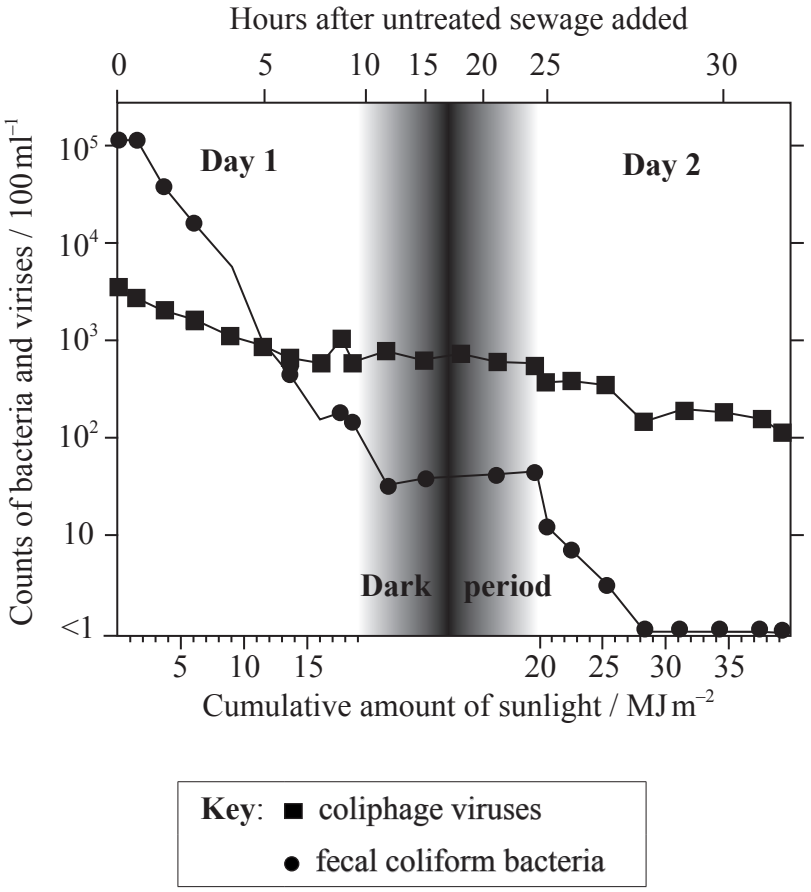
Option F — Microbes and biotechnology

F1. Release of sewage in marine waters is a common practice but it can cause water contamination with pathogens. A series of experiments were conducted to compare inactivation rates of two different groups of microbes with different sunlight exposures. One group were fecal coliform bacteria and the other were coliphage viruses. Experiments were conducted outdoors using 300-litre mixtures of sewage-seawater in open-top tanks.

A two-day experiment was carried out with untreated sewage added to seawater. Both days were sunny with no clouds. The figure below shows the inactivation of the microbes in seawater as a function of the cumulative amount of sunlight and time. The survival curves of the two microbes are plotted against sunlight exposure (lower x axis) during daylight periods and against time during the overnight period (upper x axis). The y axis gives counts of bacteria and viruses per 100 ml.



[Source: adapted from L W Sinton, *et al*., (1999), *Applied and Environmental Microbiology*, **65** (8), pages 3605–3613]

(This question continues on the following page)

(Question F1 continued)

(a) Identify the time at which fecal coliform bacteria counts fell below 1 unit per 100 ml. *[1]*

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(b) Deduce, using the data in the graph, the effect of sunlight on

(i) fecal coliform bacteria. *[2]*

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(ii) coliphage viruses. *[2]*

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(c) For an accidental sewage spill, suggest, giving a reason, which of the two microbes may be most useful as a fecal indicator two days after the spill. *[1]*

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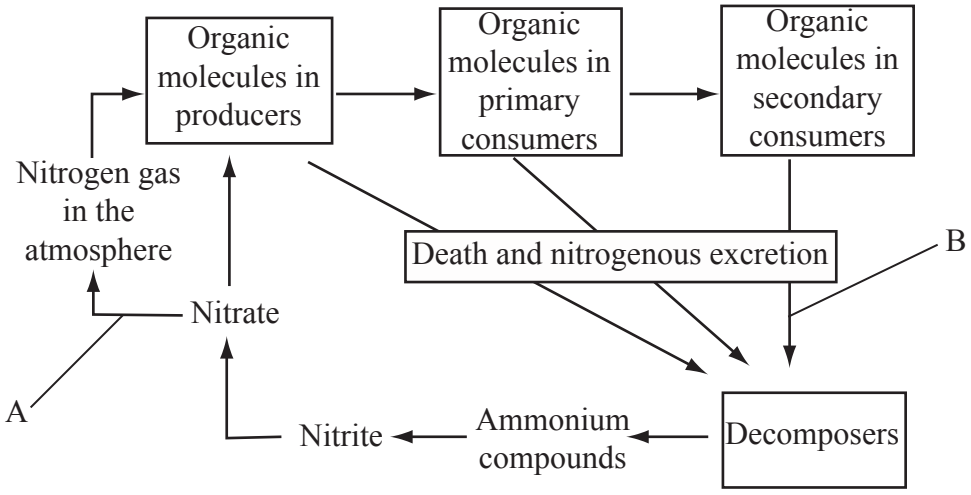
F2. Below is a diagram of the nitrogen cycle.



(a) Indicate the processes occurring at A and B. *[1]*

A: . . . . . .

B: . . . . . .

(b) (i) Draw an arrow to indicate where in the cycle *Azotobacter* plays a role. *[1]*

(ii) State the role of *Nitrobacter* in this cycle. *[1]*

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(c) Outline the consequences of releasing nitrate fertilizer into rivers. *[2]*

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F3. (a) Outline the production of soy sauce. *[2]*

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(b) Explain the use of high sugar **or** salt concentration in food preservation. *[2]*

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F4. Explain how reverse transcriptase is used in molecular biology. *[3]*

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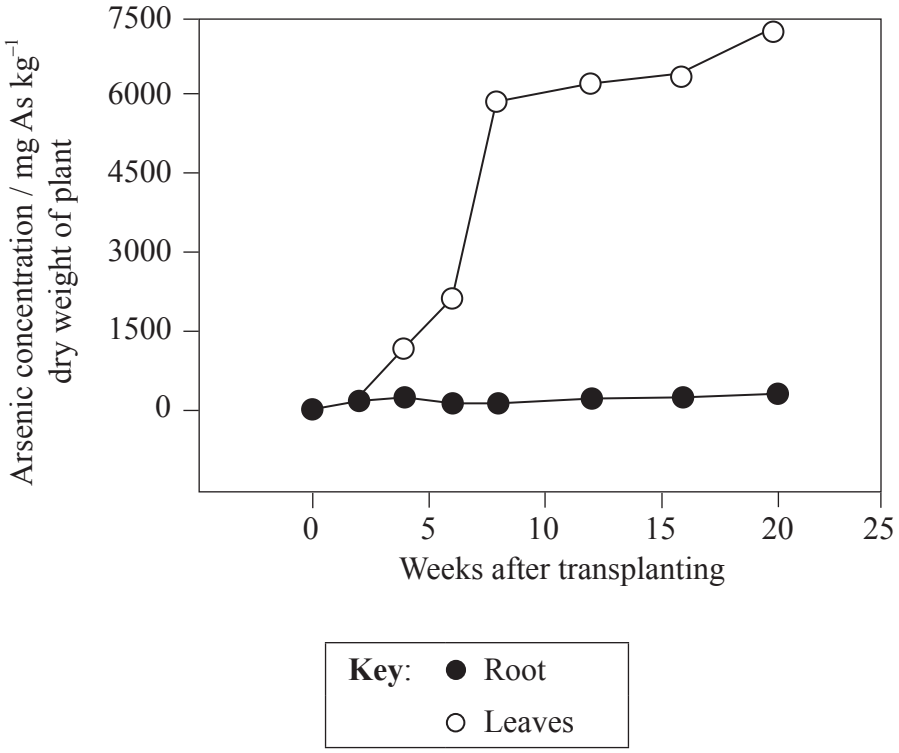
Option G — Ecology and conservation

G1. The element arsenic (As) is not needed for plant growth and development. The accumulation of arsenic in the Chinese brake fern (*Pteris vittata*) was studied. Young ferns with five or six leaves were transplanted to soil contaminated with arsenic and were grown for 20 weeks in a greenhouse.

The graph below shows the arsenic concentrations in leaves and roots of the Chinese brake fern during the 20 weeks after transplanting. Arsenic concentration is expressed as mg As kg^{-1} dry weight of plant.



[Source: C Tu, *et al*., "Arsenic Accumulation in the Hyperaccumulator Chinese Brake and its Utilization Potential for Phytoremediation", (2002), *Journal of Environmental Quality*, **31** (5), pages 1671–1675: Figure 2 (adapted). Reprinted with permission.]

(a) Using the data in the graph, describe the accumulation of arsenic in the Chinese brake fern. *[3]*

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(This question continues on the following page)

(Question G1 continued)

The table below shows the total amount of arsenic accumulated by the Chinese brake fern, expressed as a concentration in the plant tissue and as a percentage of the arsenic originally in the soil.

Time / weeks	Arsenic concentration in fern / mg As kg^{-1}	Percentage of original soil arsenic absorbed by fern
0	2	0.00
2	66	0.05
4	221	0.15
6	408	0.28
8	1300	0.88
12	5390	3.68
16	13 800	9.43
20	37 900	25.90

[Source: C Tu, *et al*., "Arsenic Accumulation in the Hyperaccumulator Chinese Brake and its Utilization Potential for Phytoremediation", (2002), *Journal of Environmental Quality*, **31** (5), pages 1671–1675: Figure 2 (adapted). Reprinted with permission.]

(b) (i) Assuming the mean rate of arsenic accumulation over the first 20 weeks continued, calculate how long it would take to remove all the arsenic from the soil. *[1]*

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(ii) Using the data in the table, discuss the potential of using Chinese brake fern to remove all arsenic from contaminated soil. *[2]*

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(c) Suggest **one** possible consequence of arsenic accumulation in plants for other organisms in the community. *[1]*

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G2. (a) Outline **three** factors that affect plant distribution. *[3]*

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(b) Outline a method used to correlate the distribution of plant species with an abiotic factor. *[2]*

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G3. (a) State **one** example of the accidental release of an alien species that has had a significant impact on an ecosystem. *[1]*

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(b) Discuss the impact of alien species on ecosystems. *[3]*

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G4. Describe the distribution of tundra in the world today. *[2]*

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