Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 3

Thursday 5 May 2016 (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.
- Section A: answer all questions.
- Section B: answer all of the questions from one of the options.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[35 marks]**.

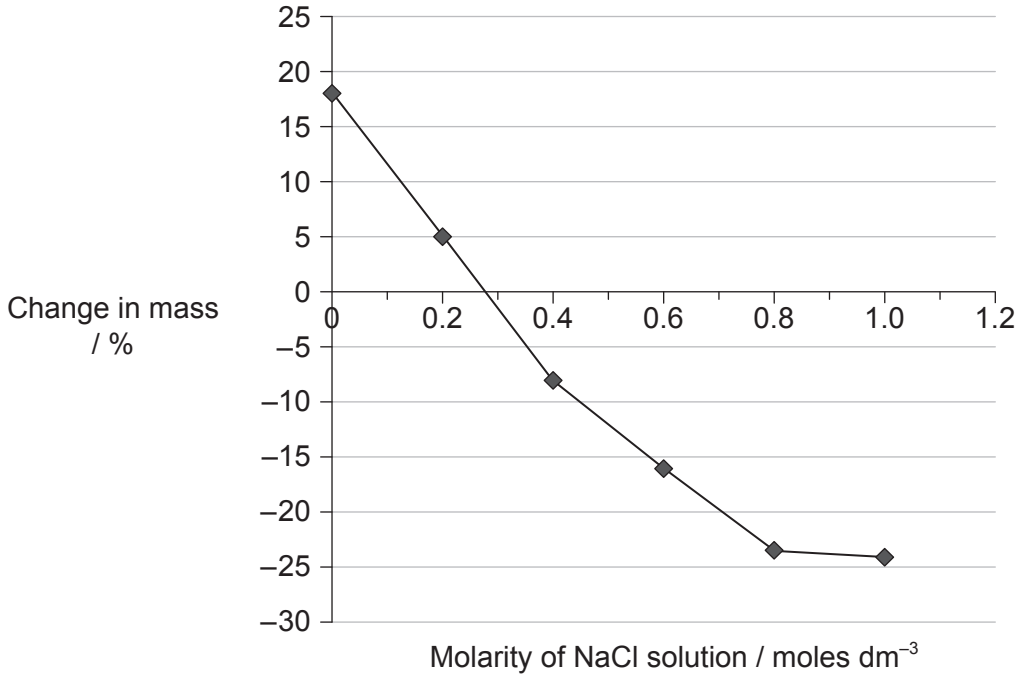
Option	Questions
Option A — Neurobiology and behaviour	4 – 8
Option B — Biotechnology and bioinformatics	9 – 12
Option C — Ecology and conservation	13 – 16
Option D — Human physiology	17 – 20

2216 – 6006

Section A

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

1. Solutions of ions, for example NaCl dissolved in water, can be used to investigate the concentration of solutes in plant tissues. After immersion in solutions of varying concentration, the percentage changes in mass of potato samples were measured. The graph shows the results.



(a) (i) Estimate the osmolarity of the plant tissue. [1]

. . . . . moles dm^{-3}

(ii) Identify which part of the graph represents samples measured in a hypotonic solution. [1]

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(This question continues on the following page)

(Question 1 continued)

(iii) State **one** possible source of error when collecting data during this experiment. [1]

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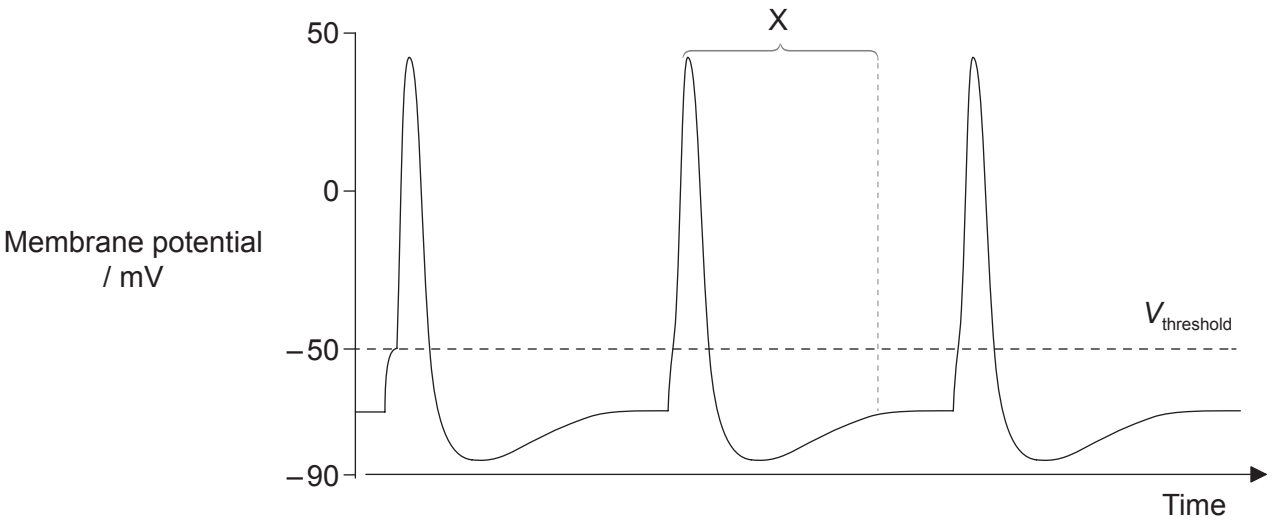
(b) Ions move across the plasma membrane of a neuron during an action potential. The oscilloscope trace shows voltage changes generated in a neuron during three action potentials.



Explain the movement of ions which causes the voltage changes observed during the interval labelled X on the graph. [3]

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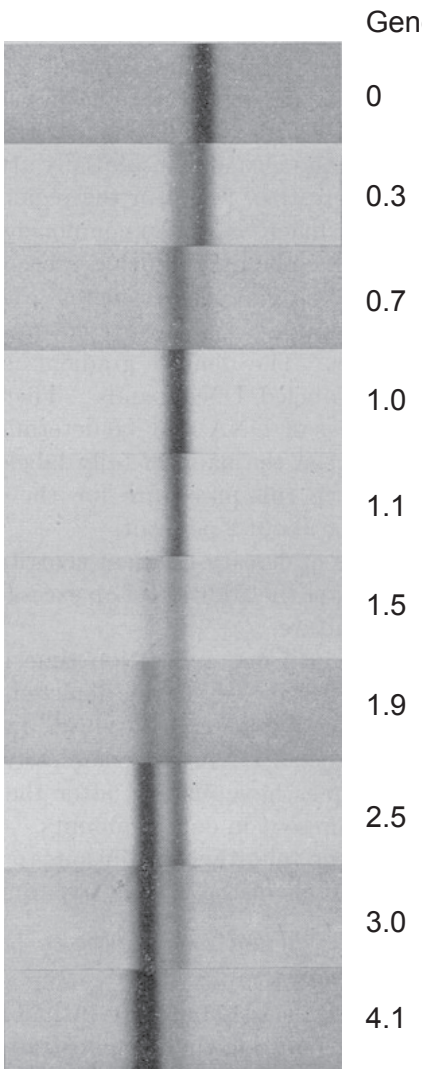
2. Over 50 years ago, Meselson and Stahl investigated the mechanism of DNA replication. They transferred a rapidly growing population of *Escherichia coli* from a growth medium containing only ^{15}N to a growth medium with only ^{14}N. DNA samples were centrifuged at high speed in a salt density gradient. In the original published research, DNA molecules of the same density appear as a band in the UV absorption photographs as shown.



[Source: M. Meselson and F. W. Stahl (1958) 'The Replication of DNA in Escherichia coli.' *PNAS*, 44, pp. 671–682, Figure 4a. Used with the authors' permission.]

(a) The density of the DNA band at generation 0 is 1.724 and the density of the dark band of DNA at generation 4.1 is 1.710. Estimate the density of the DNA band at generation 1.0. [1]

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(This question continues on the following page)

(Question 2 continued)

(b) Describe the nitrogen composition of the DNA band in the *E. coli* at generation 1.0. [1]

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(c) Explain the pattern shown in generation 3.0. [3]

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(d) This experiment was designed to demonstrate whether replication was semi-conservative or conservative. Distinguish between semi-conservative replication and conservative replication. [2]

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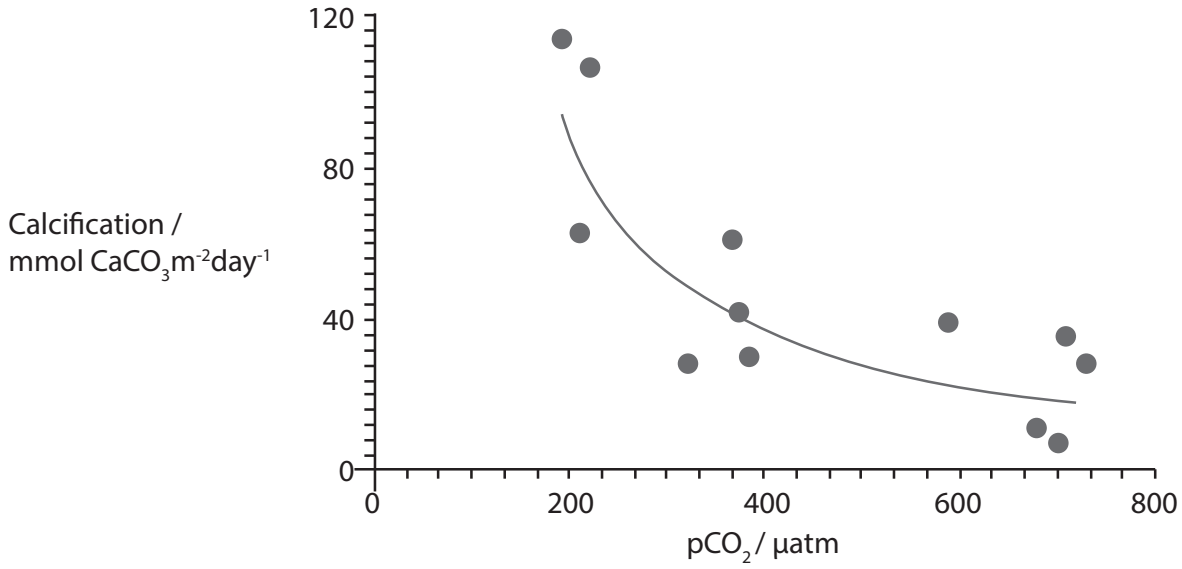
3. Increasing carbon dioxide concentration in the atmosphere leads to acidification of the ocean. This in turn reduces the amount of dissolved calcium carbonate. A study was undertaken to investigate the effect of increasing the concentration of atmospheric carbon dioxide on the calcification rate of marine organisms. Calcification is the uptake of calcium into the bodies and shells of marine organisms. The study was undertaken inside Biosphere-2, a large-scale closed mesocosm. The graph shows the results of the data collection.



[Source: © International Baccalaureate Organization 2016]

(a) State the relationship between atmospheric carbon dioxide and calcification rates. [1]

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(b) Distinguish between the exchange of matter and energy with the surroundings in a closed mesocosm. [1]

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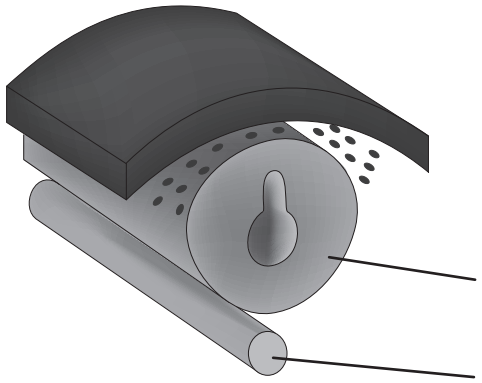
Section B

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

Option A — Neurobiology and behaviour

4. The diagram shows an advanced stage during neurulation in humans or chicks.



[Source: Diagram © UCLA, P.E. Phelps. Used with permission.]

(a) Label structures I and II. [2]

(b) State the process by by which neurons are initially produced in the embryo. [1]

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(c) Outline the plasticity of the nervous system. [2]

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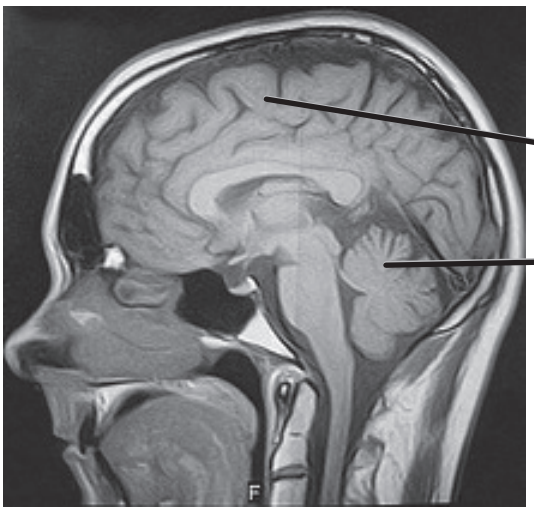
(Option A continues on the following page)

(Option A continued)

5. This image shows an MRI (magnetic resonance image) human brain scan.

(a) Identify the parts labelled I and II. [2]



I. . . . . .

II. . . . . .

[Source: "Humans may have a brain-deep aversion to income inequality", Paul Raven, 03-03-2010. http://futurismic.com/?s=mri+brain.]

(b) Outline the source of visual sensory input to the right cerebral hemisphere. [1]

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(Option A continues on the following page)

(Option A continued)

6. Explain the functioning of hair cells in the semicircular canals of the inner ear. [3]

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(Option A continues on the following page)

(Option A continued)

7. The scatter graph shows the relationship between brain mass and body mass for a number of animals. Some representative animals are indicated while the dotted line represents the range of values seen for a much larger group of animals.

Graph removed for copyright reasons
Please go to: http://cr2chicago.weebly.com/with-every-drop/behavior-and-social-interaction-in-a-wet-world-part-ii-whale-vocalizations-and-communication

(a) State the relationship between body mass and brain mass. [1]

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(b) Determine the brain mass to body mass ratio for an African elephant. [1]

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(Option A continues on the following page)

(Option A, question 7 continued)

(c) Discuss the evidence provided by the scatter graph for the hypothesis that humans have the largest relative brain mass to body mass ratio. [3]

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(Option A continues on the following page)

(Option A continued)

8. Outline the nervous system processes involved in reading and responding to this question. [4]

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End of Option A

Option B — Biotechnology and bioinformatics

9. The photograph shows apparatus used to culture microorganisms in order to produce a metabolite.

[Source: adapted from www.medicalexpo.com]

(a) State the general term for the reaction, involving microorganisms, that takes place in the apparatus shown. [1]

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(b) Other than temperature and pH, state **one** variable that should be monitored during continuous culture in the apparatus shown. [1]

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(c) State the binomial name of an organism used in continuous culturing to produce citric acid used as a preservative. [1]

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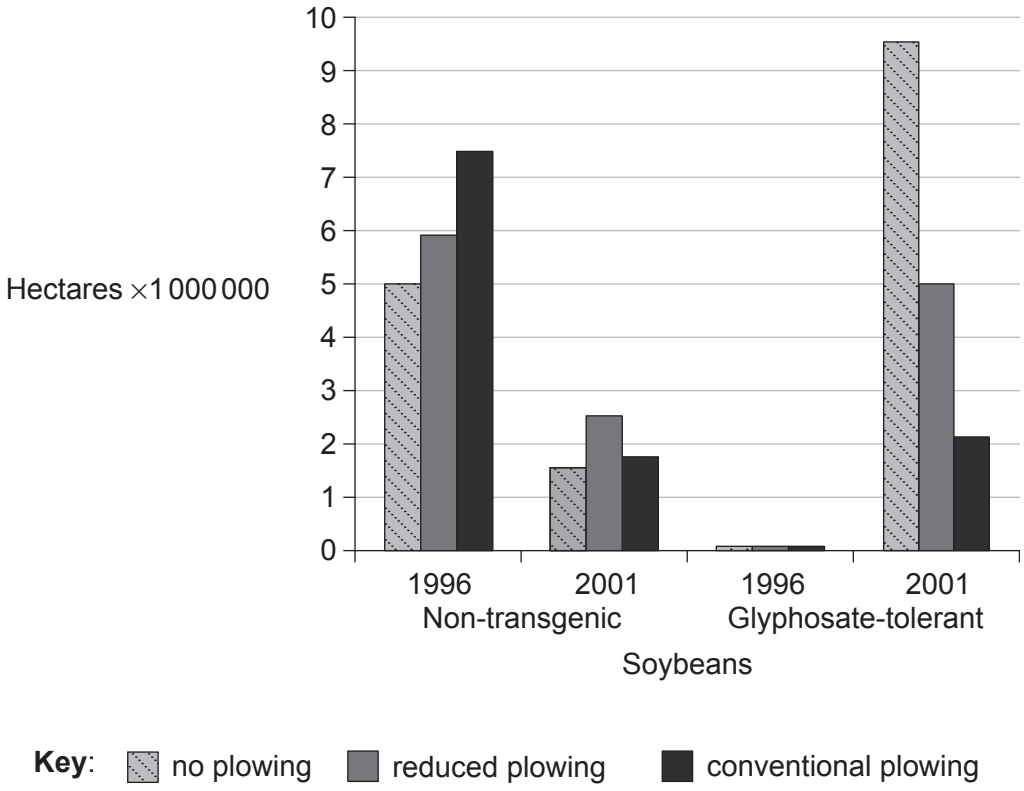
(Option B continues on the following page)

(Option B continued)

10. Before planting their crops, farmers have traditionally plowed their land to suppress weed growth. Unfortunately, plowing causes the loss of valuable topsoil. Modern farming is shifting toward the use of chemical weed killers such as glyphosate in combination with genetically modified glyphosate-tolerant (GT) crops. The graph shows the area of plowed land in the USA for soybeans in 1996 and 2001. During that period GT soybean planting increased from a few percent to about 70 %.



[Source: adapted from A. Cerdeira and S. Duke (2006) *Journal of Environmental Quality*, 35, pages 1633–1658. Reprinted by Permission, ASA, CSSA, SSSA]

(a) Evaluate the hypothesis that increased planting of glyphosate-tolerant crops has resulted in the reduction of plowing. [2]

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(Option B continues on the following page)

(Option B, question 10 continued)

(b) Explain the role of bioinformatics in the determination of the function of an unknown target gene. [2]

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(c) Outline what is meant by open reading frame (ORF). [1]

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(d) Genetic engineers sometimes use physical methods to transform cells. Describe the method of biolistics. [2]

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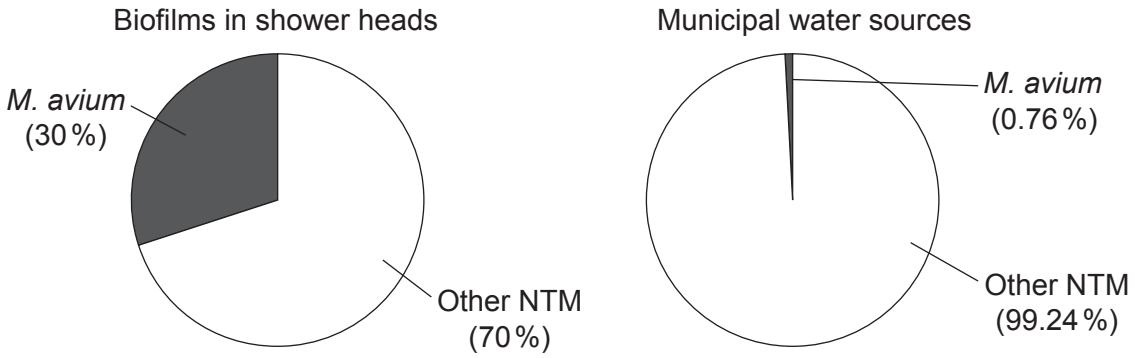
(Option B continues on the following page)

(Option B continued)

11. Many people around the world wash themselves under a warm shower. This personal hygiene may expose individuals to harmful microorganisms such as *Mycobacterium avium* through inhalation of water droplets from the shower head and direct water contact. Samples taken from biofilms inside shower heads and municipal water sources were analysed. Proportions of other non-tuberculous mycobacteria (NTM) were also analysed. The results are shown in the pie charts.



[Source: L. M. Feazel *et al*. (2009) 'Opportunistic pathogens enriched in showerhead biofilms.' *PNAS*, 106 (38), pages 16393–16399, Figure 3 (pie charts B & C).]

(a) List **two** properties of biofilms. [2]

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(b) Distinguish between the data for shower head biofilms and municipal water sources. [1]

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(Option B continues on the following page)

(Option B, question 11 continued)

(c) Suggest reasons for biofilms developing inside shower heads. [3]

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12. Explain, with reference to **one** example, how a polluted ecosystem can be restored through bioremediation. [4]

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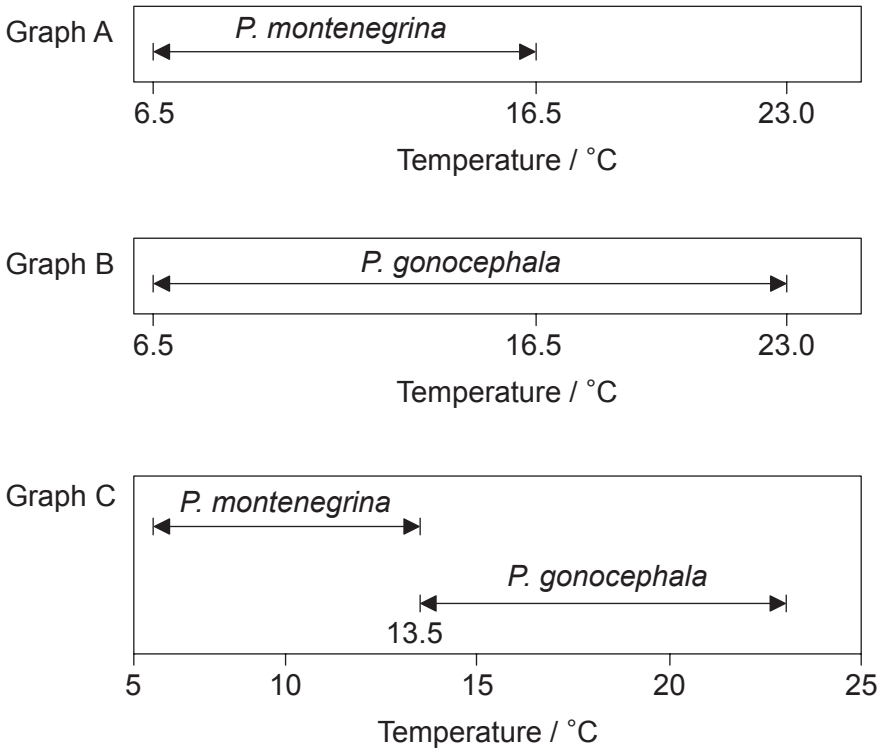
End of Option B

Option C — Ecology and conservation

13. The figure shows the distribution of two species of freshwater flatworms, *Planaria gonocephala* and *Planaria montenegrina*, over a range of stream temperatures. Graph A and graph B show the distributions when each species is separate from the other. Graph C shows the distribution when they are found living together.



[Source: R. J. Putman (1994) *Community Ecology*, page 63 © Kluwer Academic Publishers Boston. Used with permission.]

(a) Using graph A and graph B, compare and contrast the temperature ranges of the two species when they are found separately. [2]

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(Option C continues on the following page)

(Option C, question 13 continued)

(b) Explain, with respect to the example of *P. montenegrina*, what is meant by realized niche. [2]

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14. Primary plant succession has been observed in sand dunes adjacent to the northern end of Lake Michigan, one of the Great Lakes in North America. The youngest sand dunes have beach grass (*Ammophila breviligulata*) and prairie bunch grass (*Schizachyrium scoparium*). The oldest dunes have coniferous trees (*Pinus strobus* and *Pinus resinosa*).

(a) Predict the differences in the soil characteristics between the youngest and oldest sand dunes. [3]

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(b) Outline how the type of stable ecosystem that will develop in an area can be predicted based on climate. [3]

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(Option C continues on the following page)

(Option C continued)

15. The images show three predator–prey relationships.

Sparrowhawk
(*Accipiter nisus*)
preys on song birds

[Source: https://en.wikipedia.org/wiki/Eurasian_sparrowhawk#/media/File:Accnis_edit.jpg]

Buzzard
(*Buteo buteo*)
preys on small rodents

[Source: https://upload.wikimedia.org/wikipedia/commons/c/cd/Buteo_buteo_-Netherlands-8.jpg]

Swift fox
(*Vulpes velox*)
preys on small rodents

[Source: https://en.wikipedia.org/wiki/Swift_fox#/media/File:Swift_Fox.jpg]

Biomagnification of two groups of organic pollutants was investigated in three predator–prey relationships. BDEs and PCBs are broadly used in industry. The biomagnification factor is a ratio of the amount of pollutant in predator tissue compared to the amount of pollutant in prey tissue.

	Mean biomagnification factor		
	sparrowhawk–song bird	buzzard–rodent	fox–rodent
Pollutant	mean	mean	mean
BDE 47	10	12	<1
BDE 100	25	17	<1
BDE 99	20	14	<1
BDE 153	21	22	<1
BDE 183	29	12	<1
PCB 153	19	45	2
PCB 138/163	21	49	2
PCB 180	20	36	5

[Source: Reprinted from *Journal of Environmental Sciences*, 23 (1), Ziaofei Qin *et al*, "Polybrominated diphenyl ethers in chicken tissues and eggs from an electronic waste recycling area in southeast China", pp. 133–138, © 2011, with permission from Elsevier.]

(Option C continues on the following page)

(Option C, question 15 continued)

(a) Outline how biomagnification occurs. [2]

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(b) (i) Identify the predator with the **least** biomagnification of pollutants. [1]

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(ii) Suggest a reason for the species identified in (b)(i) having the **lowest** biomagnification factor. [1]

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(c) Deduce **two** conclusions about PCBs that are supported by the data. [2]

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(Option C continues on the following page)

(Option C continued)

16. Explain how alien species can affect community structure in an ecosystem. [4]

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End of Option C

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Option D — Human physiology

17. Numerous health benefits are associated with diets that include omega-6 fatty acids and omega-3 fatty acids in a ratio between 1 : 1 and 4 : 1. When consumed in excess, omega-6 inhibits uptake of omega-3. Many people in developed countries eat large amounts of processed foods and oils, so they consume omega-6 fatty acids and omega-3 fatty acids at a ratio of between 10 : 1 and 25 : 1. Such high ratios are associated with many chronic diseases.

Oils	Ratio of omega-6 to omega-3
Flaxseed oil	0.24 : 1
Canola oil	2 : 1
Walnut oil	5 : 1
Olive oil	13 : 1
Sunflower oil	19 : 1
Corn oil	46 : 1
Sesame oil	138 : 1
Grapeseed oil	696 : 1

[Source: © International Baccalaureate Organization 2016]

(a) Deduce with reasons which **two** oils would be the best sources of fatty acids for a healthy diet. [2]

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(b) Outline the meaning of the term essential when used to describe some fatty acids. [2]

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(Option D continues on the following page)

(Option D, question 17 continued)

(c) (i) State the name of the part of the brain where appetite is controlled. [1]

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(ii) State the role of the vagus nerve. [1]

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18. (a) Outline the importance of acid conditions in the stomach. [2]

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(Option D continues on the following page)

(Option D, question 18 continued)

(b) In the 1880s, roller mills began to replace stone mills for grinding cereal grain. This resulted in the production and widespread use of refined flour with a low fibre content. The dietary changes that followed correlated with a sharp rise in many noninfectious gastrointestinal conditions such as appendicitis, diverticulitis, colon cancer and hemorrhoids. These problems persist in the 21st century. The effects of diets ranging from high-fibre (unrefined) to low-fibre (refined) were studied in different groups. Materials that are not absorbed during digestion and are then egested are called stools.

Chart removed for copyright reasons

Using the data in the chart, analyse the effect of diet on the digestive system. [2]

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(c) Suggest **one** reason for a correlation between a low-fibre diet and a higher incidence of gastrointestinal problems. [1]

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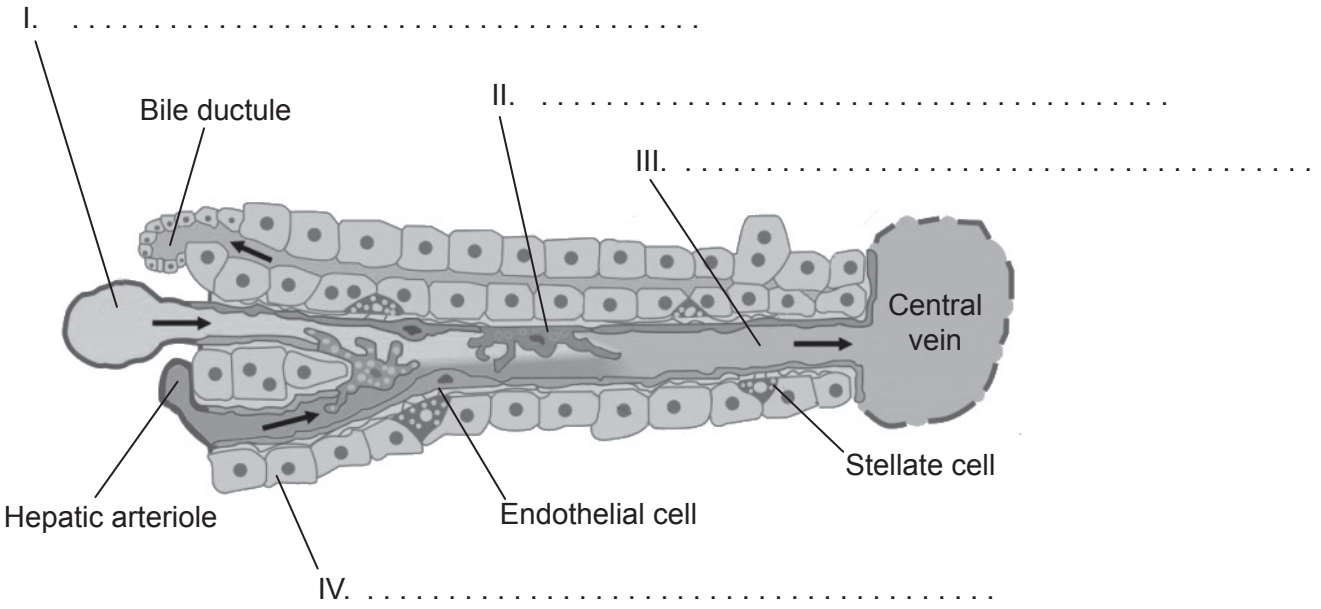
(Option D continues on the following page)

(Option D continued)

19. The liver's unique blood supply and system of ducts allow proper functioning of its hepatocytes and Kupffer cells. These cells are found throughout the liver in functional units called liver lobules. The image shows a cross section of the blood and bile paths in a liver lobule.



[Source: Ute Frevert, Sabine Engelmann, Sergine Zougbédé, Jörg Stange, Bruce Ng, Kai Matuschewski, Leonard Liebes, Herman Yee. Intravital observation of Plasmodium berghei sporozoite infection of the liver. *PLoS Biol.*: 2005, 3(6);e192 PubMed 15901208]

(a) Label the structures I, II, III and IV. [2]

(b) Outline functions of hepatocytes that involve changing the chemical composition of the plasma. [2]

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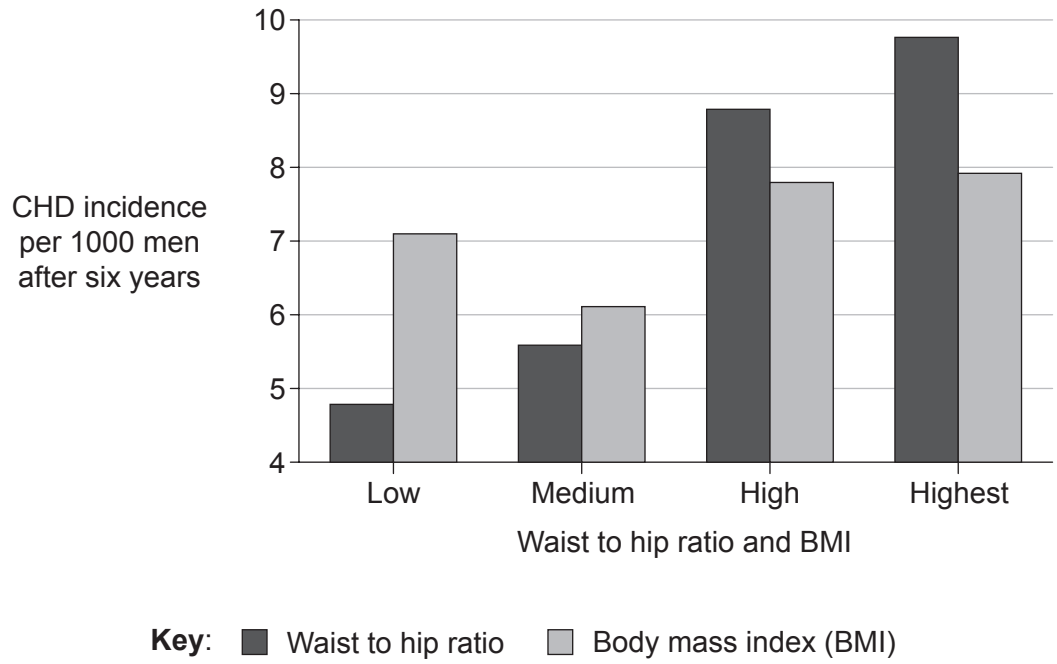
(Option D continues on the following page)

(Option D continued)

20. The incidence of coronary heart disease (CHD) was investigated among 14 000 people. Baseline measurements of the waist to hip ratio and body mass index (BMI) were collected from the participants. After six years, evidence of CHD was identified in follow-up interviews. The bar chart shows the results for the men only.



[Source: adapted from AR Folsom, *et al.*, (1998), *American Journal of Epidemiology*, **148** (12), pages 1187–1194, by permission of Oxford University Press]

(a) Deduce with a reason whether the waist to hip ratio **or** the BMI most clearly correlates to incidence of CHD. [1]

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(Option D continues on the following page)

(Option D, question 20 continued)

(b) Explain how electrical signalling in the heart leads to ventricular contraction. [4]

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End of Option D

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