

Biology
Higher level
Paper 3

Monday 7 November 2016 (morning)

Candidate session number

1 hour 15 minutes

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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.
- Write your answers in the 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

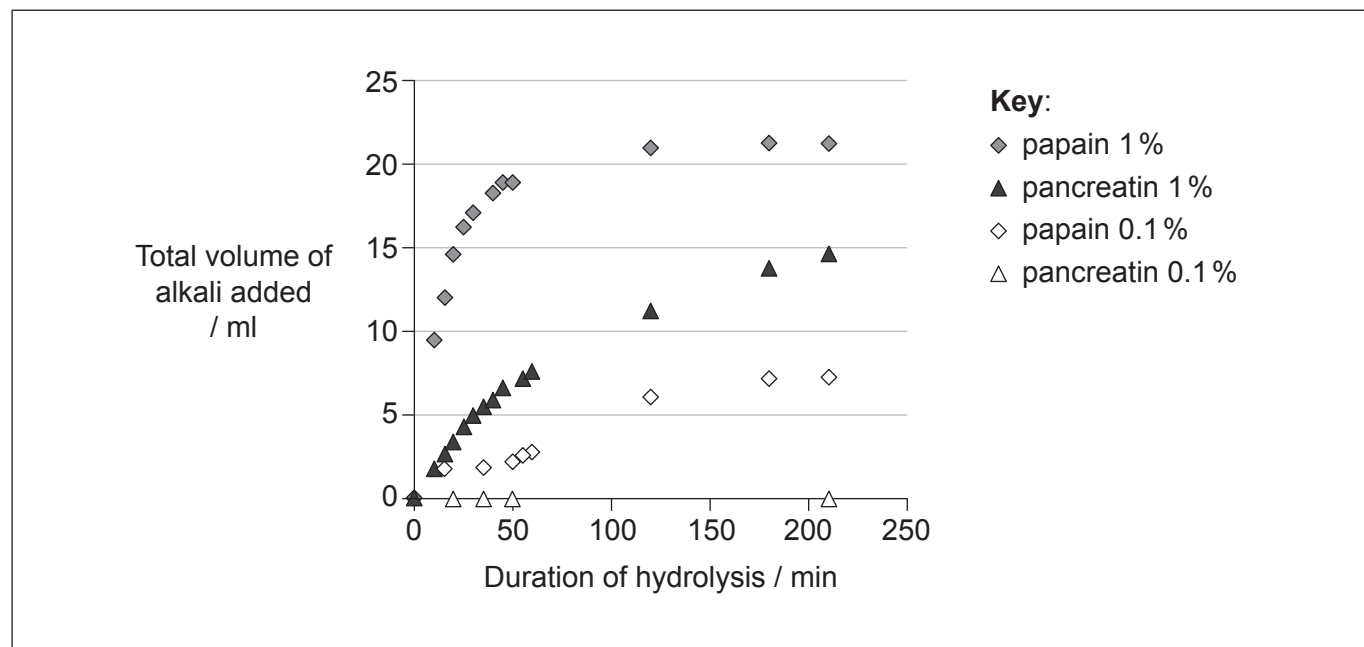
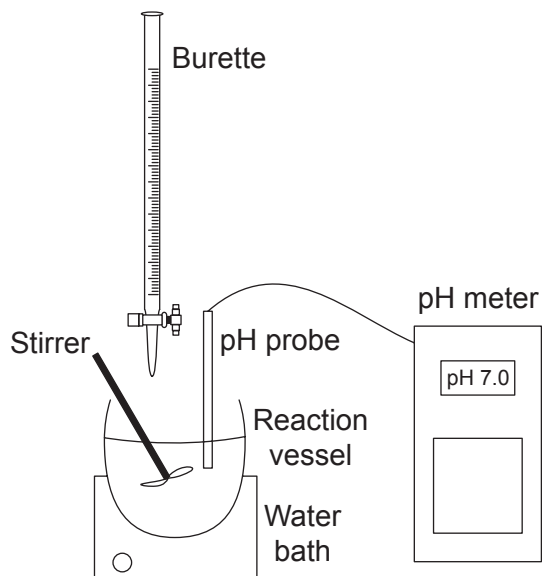
Section B	Questions
Answer all of the questions from one of the options.	
Option A — Neurobiology and behaviour	4 – 8
Option B — Biotechnology and bioinformatics	9 – 13
Option C — Ecology and conservation	14 – 18
Option D — Human physiology	19 – 23



Section A

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

- The rate of hydrolysis of fish proteins using the enzymes papain and pancreatin was monitored using the apparatus shown. The pH decreased with the progress of hydrolysis, so alkali in the burette was added as necessary in order for the hydrolysis to proceed at constant pH. The rate of protein hydrolysis was measured as the amount of alkali added. Measurements were taken at constant conditions of temperature and pH for two enzyme concentrations, 1% and 0.1%.



[Source: adapted from "A Study of the Enzymatic Hydrolysis of Fish Frames Using Model Systems", written by Aristotelis T. Himonides, Anthony K. D. Taylor, Anne J. Morris, published by *Food and Nutrition Sciences*, Vol. 2 No. 6, 2011. Copyright © 2011 SciRes.]

(This question continues on the following page)



(Question 1 continued)

- (a) State the effect of enzyme concentration on the hydrolysis of proteins. [1]

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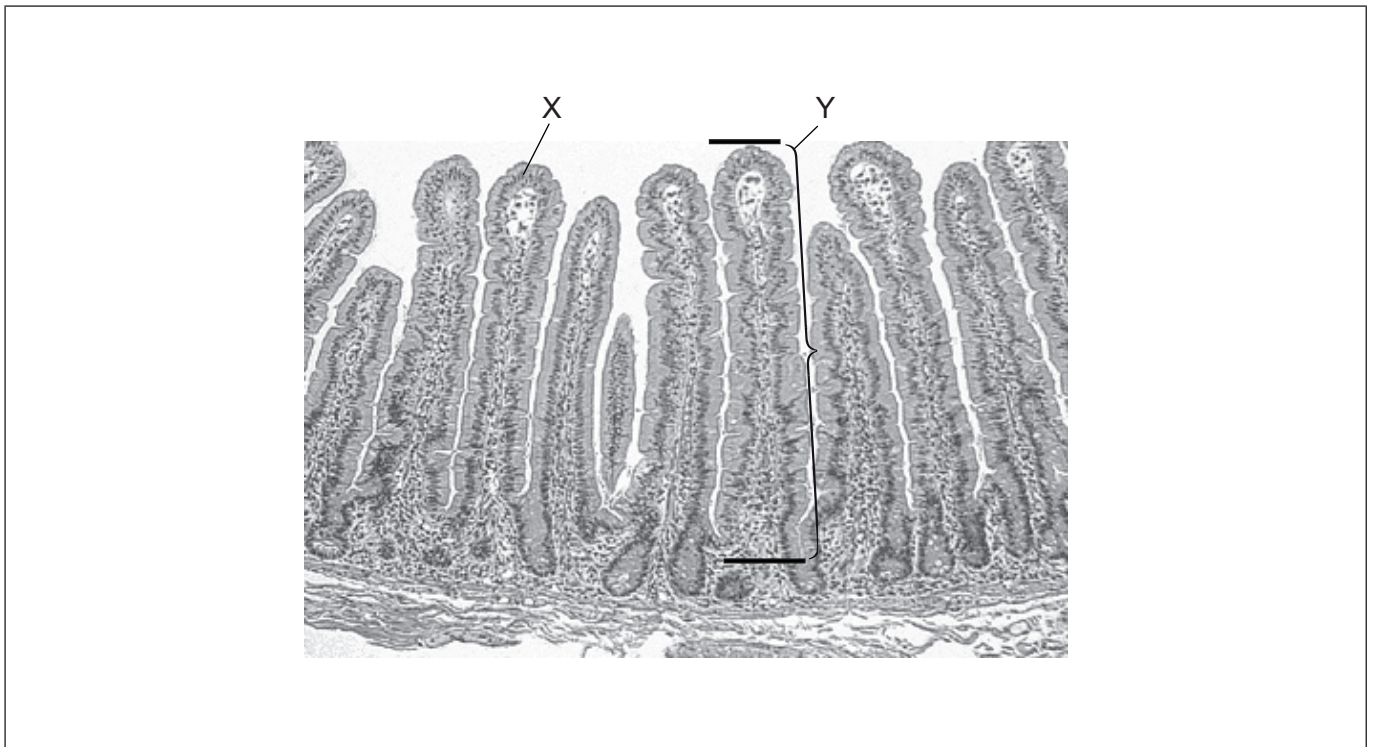
- (b) Sketch on the graph the curve expected if the hydrolysis were performed using papain 0.5%. [1]

- (c) Explain what would happen to fish protein hydrolysis if no alkali were added to the reaction vessel. [3]

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2. The micrograph shows a section of an organ in the human body.



[Source: adapted from Stacey E. Mills (ed.), *Histology for Pathologists*, 3rd Edition, Copyright ©2007, Lippincott Williams & Wilkins.]

(a) State from which organ the section was taken. [1]

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(b) Identify the layer of tissue found at X. [1]

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(This question continues on the following page)



(Question 2 continued)

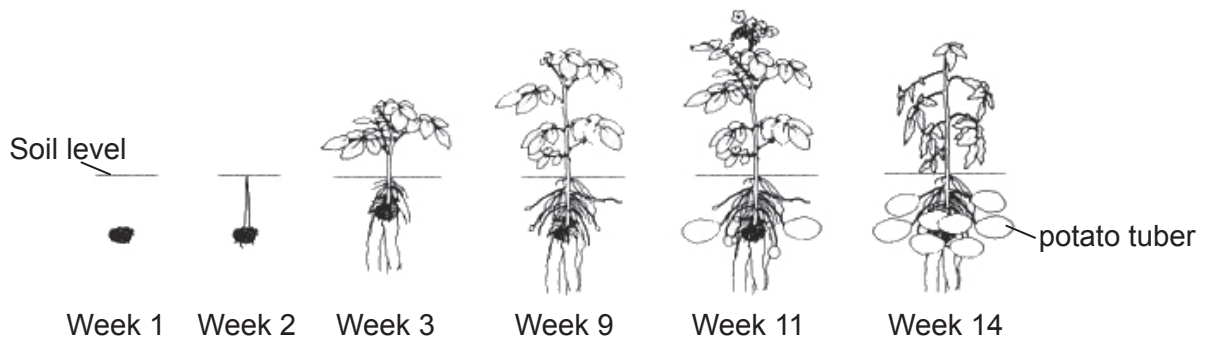
- (c) The actual length of the structure labelled Y is 0.8 mm between the two black lines. Calculate the magnification of the micrograph. Working should be shown. [2]

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- (d) One of the functions of this organ is absorption. On the micrograph, draw an arrow showing the direction of absorption. [1]

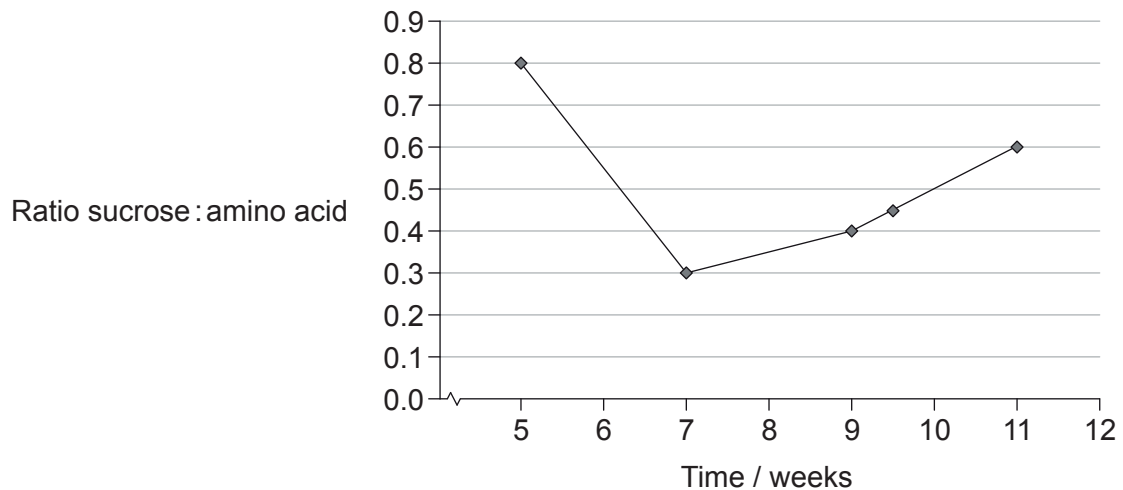


3. The diagram shows the development of potato plants (*Solanum tuberosum*) over 14 weeks. New tubers start growing from week 9. These are modified underground stems serving as a starch reserve and bearing buds from which new plants arise.



[Source: adapted from <http://humanitiespotato.weebly.com/potato-production.html>]

Scientists planted several potato plants in a greenhouse. The sucrose and amino acids in potato plant phloem exudates were measured during several weeks.



[Source: adapted from A. J. Karley, A. E. Douglas, W. E. Parker, Amino acid composition and nutritional quality of potato leaf phloem sap for aphids. *Journal of Experimental Biology* 2002 205: 3009-3018. © The Company of Biologists Limited 2002.]

- (a) Describe briefly how scientists obtained leaf phloem sap from the potato plants. [2]

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(This question continues on the following page)



(Question 3 continued)

- (b) Suggest reasons for different amounts of sucrose in the leaf phloem sap of the potato plants.

[3]

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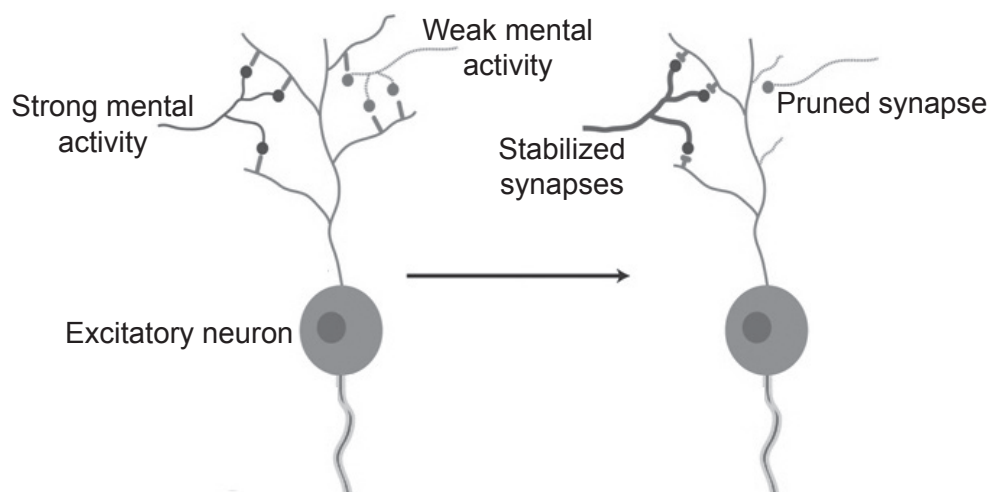
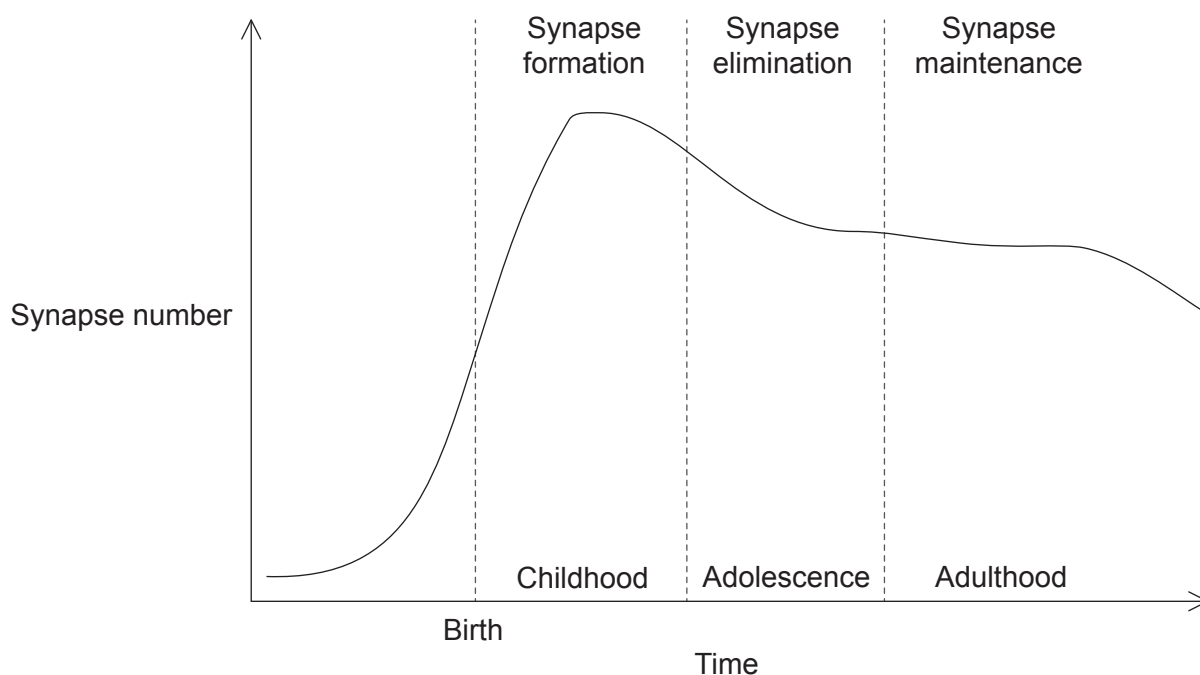


Section B

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

Option A — Neurobiology and behaviour

4. Defects in the formation of synapses could be the cause of neurological disorders such as Alzheimer’s disease that affects the ability to think and remember clearly. It is more frequent in people older than 65 years of age. The graph shows the changes in synapse number over time. The diagram shows activity-related neural development.



[Source: adapted from Doll, C. A. and Broadie, K. (2014), Impaired activity-dependent neural circuit assembly and refinement in autism spectrum disorder genetic models. *Frontiers in Cellular Neuroscience* 8: 30. doi: 10.3389/fncel.2014.00030. Copyright © 2014 Doll and Broadie.]

(Option A continues on the following page)



(Option A, question 4 continued)

(a) State what happens to unused neurons. [1]

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(b) Predict how mental activity might delay the onset of Alzheimer’s disease. [2]

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(c) Autism appears early in life and affects how a person communicates and relates to others. There is evidence that autism could be caused by a surplus of synapses. Using all of the information provided, suggest **two** possible causes of a surplus of synapses in people with autism. [2]

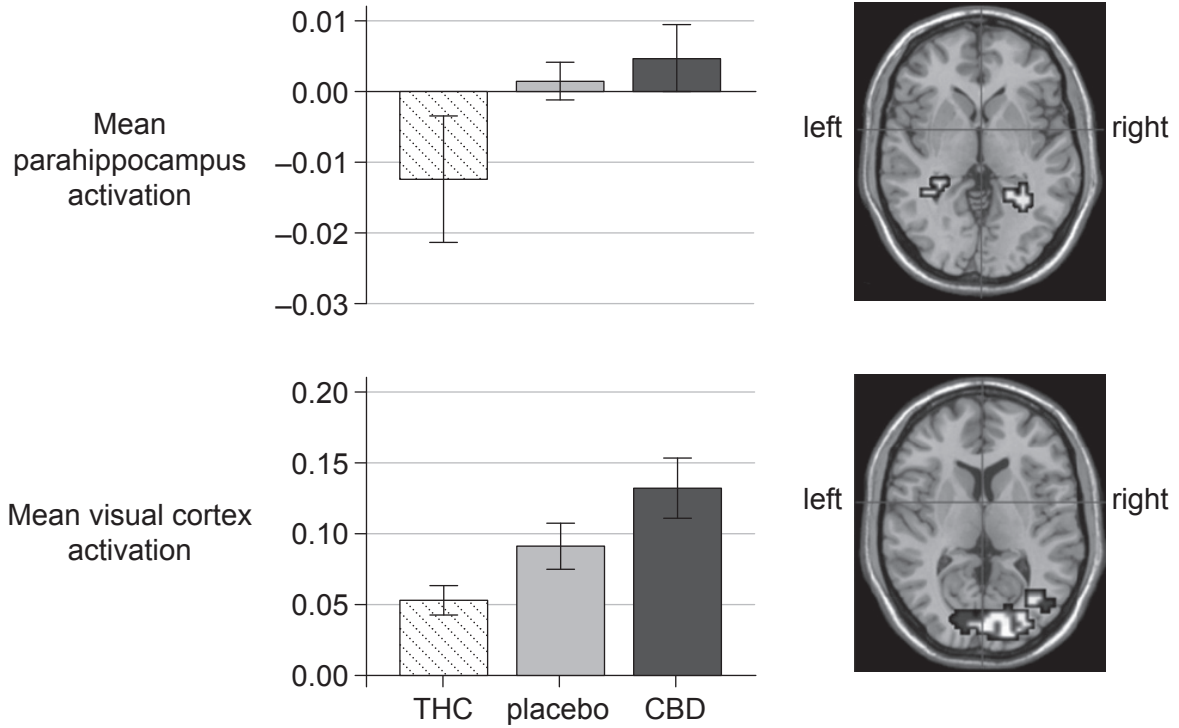
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(Option A continues on the following page)



(Option A continued)

5. D-9-tetrahydrocannabinol (THC) and cannabidiol (CBD), the two main psychoactive ingredients of the *Cannabis sativa* plant, have distinct symptomatic and behavioural effects. Functional magnetic resonance imaging (fMRI) was used in healthy volunteers to examine their effects on the parahippocampus, an area of the brain related to emotions and on the visual cortex. The effects are as shown.



[Source: adapted from S. Bhattacharyya et al. (2010), "Opposite effects of delta-9-tetrahydrocannabinol and cannabidiol on human brain function and psychopathology." *Neuropsychopharmacology*, 35:3, pages 764–774. Copyright © 2010 American College of Neuropsychopharmacology]

(a) Outline the benefits of using fMRI in this experiment. [2]

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(Option A continues on the following page)



(Option A, question 5 continued)

(b) Compare and contrast the effects of THC and CBD on the areas of the brain studied. [3]

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(c) State the function of the visual cortex. [1]

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(Option A continues on the following page)



(Option A continued)

6. (a) Outline the neural control of the process of swallowing. [3]

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(b) Describe an example of learned behaviour. [3]

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(Option A continues on the following page)



(Option A continued)

7. (a) The diagram shows the human ear. Label parts I, II and III. [3]



(b) State the function of the bones in the middle ear. [1]

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(c) Explain the role of the hair cells in the cochlea. [3]

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(Option A continues on the following page)



Option B — Biotechnology and bioinformatics

9. Lipid A is a phospholipid that makes up the external layer of the outer membranes of most Gram-negative bacteria. LpxC is an enzyme involved in the biosynthesis of lipid A. In this experiment, a lawn of the Gram-negative bacterium *Escherichia coli* was grown on a nutrient agar plate. Shortly after inoculation, before the lawn is formed, discs containing different test compounds were placed on top. The Petri dish shows the results after 24 hours incubation.



Key:

- disc 1: LpxC inhibitor
- disc 2: mutated LpxC inhibitor
- disc 3: ampicillin
- disc 4: control

[Source: © International Baccalaureate Organization 2016]

(a) Outline the effect of disc 3 on the bacterial lawn. [2]

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(b) Outline the effect of mutating the LpxC inhibitor. [1]

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(c) Predict the results obtained with disc 1 in a Gram-positive bacterial lawn. [1]

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(Option B continues on the following page)

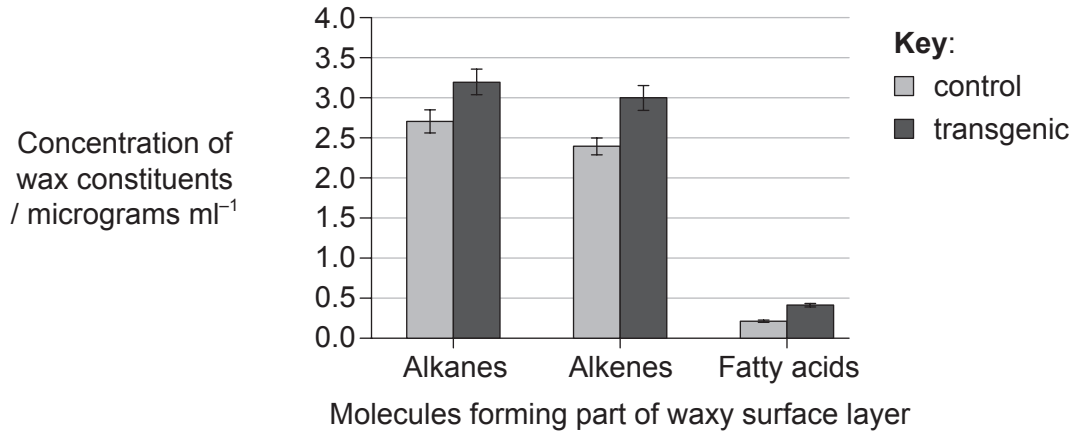


36EP15

Turn over

(Option B continued)

10. Crop genetic engineering was performed to improve drought tolerance in tomato plants (*Solanum lycopersicum*) by adding a gene from an edible fungus (*Flammulina velutipes*). The cotyledons of tomato plants were cut and co-cultivated with *Agrobacterium tumefaciens* containing the transgenic Ti plasmid. Plates containing kanamycin were used to select for transgenic cotyledons. The graph shows concentrations of three constituents of the wax that coats wild type plants (control) and transgenic tomato plants.



[Source: Reprinted by permission of Nature Publishing Group. (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3517979/>) Reprinted by permission from Macmillan Publishers Ltd: *Nature*, 'Expression of a fungal sterol desaturase improves tomato drought tolerance, pathogen resistance and nutritional quality' by Ayushi Kamthan *et al.* 2, p. 951. (2012).]

(a) Outline the use of kanamycin in the selection of transgenic cotyledons. [2]

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(b) State how the sequence of the target gene from the fungus could be identified using a bioinformatics tool. [1]

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(Option B continues on the following page)



(Option B, question 10 continued)

- (c) Suggest whether the results of this experiment show that these transgenic tomato plants are more resistant to drought. [2]

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- (d) One method of inserting new genes into plants is by gene gun.



[Source: adapted from www.genomicon.com]

Outline how a gene gun inserts genes into plants.

[2]

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(Option B continues on page 19)



36EP17

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will not be marked.



(Option B continued from page 17)

11. (a) Metabolites that indicate disease can be detected in urine. State a metabolite found in urine and the disease it could indicate. [2]

Metabolite: Disease indicated:

- (b) Discuss the implications of biopharming using a specific example. [4]

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(Option B continues on the following page)



(Option B continued)

12. The genetic code is the information encoded within the mRNA sequence that is translated into proteins by living cells. The codon table is shown.

		Second position									
		U		C		A		G			
First position	U	UUU	Phe (F)	UCU	Ser (S)	UAU	Tyr (Y)	UGU	Cys (C)	U	
		UUC		UCC		UAC		UGC		C	
		UUA	Leu (L)	UCA		UAA	STOP	UGA	STOP	A	
		UUG		UCG		UAG		UGG	Trp (W)	G	
	C	CUU	Leu (L)	CCU	Pro (P)	CAU	His (H)	CGU	Arg (R)	U	
		CUC		CCC		CAC		CGC		C	
		CUA		CCA		CAA	Gln (Q)	CGA		A	
		CUG		CCG		CAG		CGG		G	
	A	AUU	Ile (I)	ACU	Thr (T)	AAU	Asn (N)	AGU	Ser (S)	U	
		AUC		ACC		AAC		AGC		C	
		AUA		ACA		AAA	Lys (K)	AGA	Arg (R)	A	
		AUG	Met (M)	ACG		AAG		AGG		G	
	G	GUU	Val (V)	GCU	Ala (A)	GAU	Asp (D)	GGU	Gly (G)	U	
		GUC		GCC		GAC		GGC		C	
		GUA		GCA		GAA	Glu (E)	GGA		A	
		GUG		GCG		GAG		GGG		G	
		Third position									

The first part of the cytochrome c protein sequence alignment of mold fungus (*Neurospora*), horse (*Equus*), human (*Homo*), corn (*Zea*) and rice (*Oryza*) is shown using the amino acids as a one letter code.

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Neurospora  ----MGFSAGDSKKGANLFKTRCAQCHTLEEGGGNKIGPALHGLFGRKTGSVDGYAYTDA
Equus       -----MGDVEKGKKIFVQKCAQCHTVEKGGKHKHTGPNLHGLFGRKTGQAPGFSYTDA
Homo        -----MGDVEKGKKIFIMKCSQCHTVEKGGKHKHTGPNLHGLFGRKTGQAPGYSYTAA
Zea         MASFSEAPPGNPKAGEKIFKTKCAQCHTVDKGAGHKQGPNLNGLFGRQSGTTAGYSYSAG
Oryza       MASFSEAPPGNPKAGEKIFKTKCAQCHTVDKGAGHKQGPNLNGLFGRQSGTTTPGYSYSTA
            * : : * : : * . : * * * * : : : * . : * * * : * * * * : : * . * : : * : .
    
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[Source: © International Baccalaureate Organization 2016]

(a) State the bioinformatics tool used to obtain the alignment. [1]

(b) State the meaning of the dash (–) in the alignment. [1]

(Option B continues on the following page)



(Option B, question 12 continued)

- (c) (i) Identify the longest amino acid sequence where there are no differences amongst the five genera. [1]

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- (ii) Suggest, with a reason, whether the DNA coding for the amino acid sequence identified in (c)(i) must be identical for the five genera. [1]

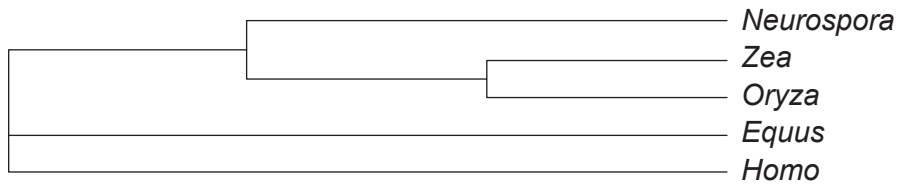
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The alignment was used to obtain a cladogram of these organisms.



- (d) Describe briefly how the cladogram was obtained. [2]

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- (e) Determine which **two** genera are most closely related according to their cytochrome c protein sequence. [1]

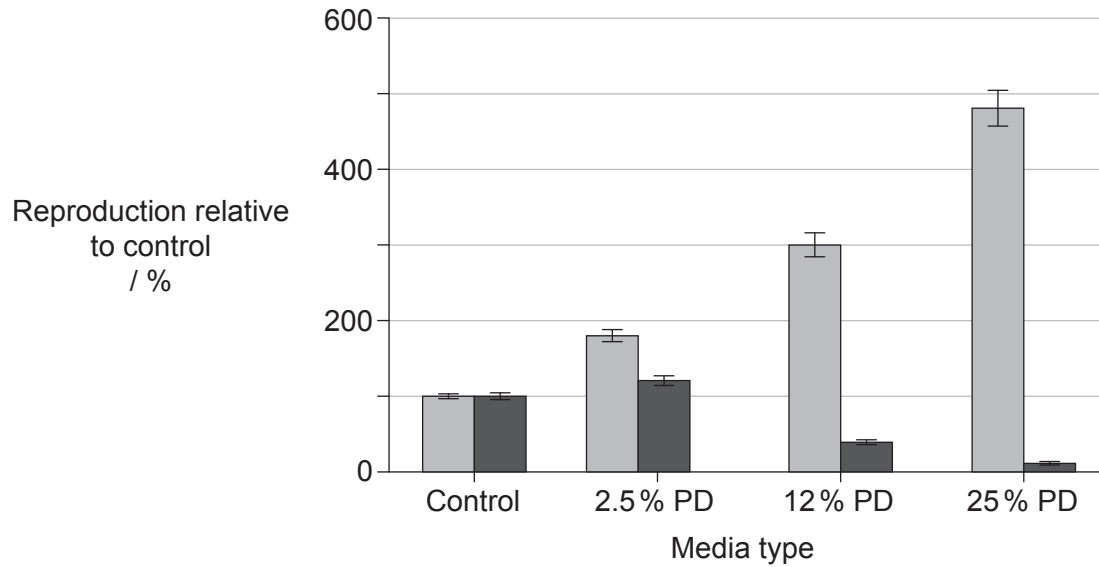
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(Option B continues on the following page)



Option C — Ecology and conservation

14. *Cryptococcus neoformans* and the closely related species *Cryptococcus gattii* are human fungal pathogens. The reproduction of these yeast species on increasing concentrations of pigeon droppings (PD) was examined to determine whether they occupy the same or different ecological niches. The results for reproduction are expressed as a percentage relative to the control.



Key: ■ *Cryptococcus neoformans* ■ *Cryptococcus gattii*

[Source: adapted from K. Nielsen et al. (2007), “*Cryptococcus neoformans* Mates on Pigeon Guano: Implications for the Realized Ecological Niche and Globalization”. *Eukaryotic Cell*, vol. 6, pp. 949–959, DOI: 10.1128/EC.00097-07. Amended with permission from American Society for Microbiology]

Suggest how this experiment shows that pigeon droppings represent a realized ecological niche for *C. neoformans* and a fundamental (but not a realized) niche for *C. gattii*.

[3]

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(Option C continues on the following page)

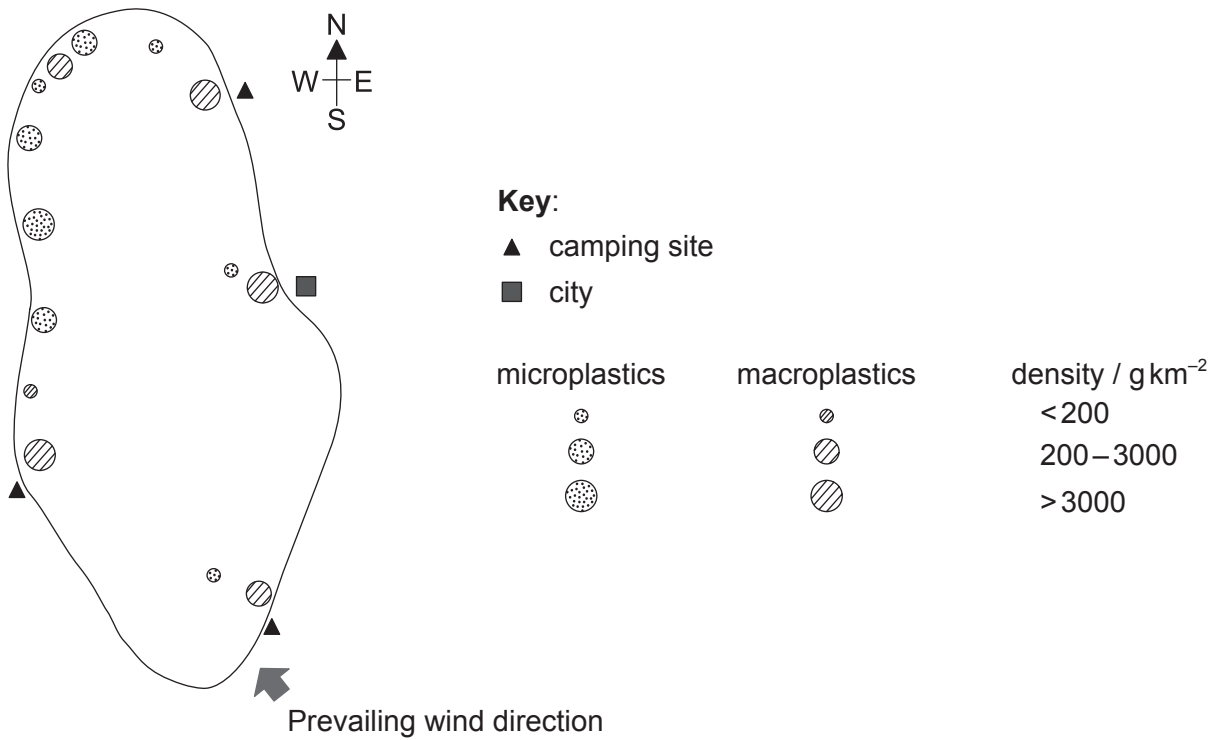


36EP23

Turn over

(Option C continued)

15. The sketched map shows the density of microplastics and macroplastics found in a lake within a national park.



[Source: © International Baccalaureate Organization 2016]

(a) Predict **one** example of macroplastic pollution that is likely to be found in this lake. [1]

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(b) State **two** possible effects on organisms of microplastic pollution. [2]

1.

2.

(Option C continues on the following page)



(Option C, question 15 continued)

- (c) Outline the effect of wind on the distribution of plastic pollution in this lake. [2]

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- (d) Suggest changes in the management of the national park that could reduce the amount of macroplastic pollution. [3]

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(Option C continues on the following page)



(Option C continued)

16. Forest fires are very common in the Amazon forest. A study was performed to see the relationship between forest fragmentation, fire and management.

(a) Describe **one** method that could have been used to estimate the population size of a given tree in a forest after fire damage had occurred. [3]

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(b) Outline how the edge effect can affect diversity in forests. [3]

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(Option C continues on the following page)



(Option C, question 16 continued)

(c) The number of plants in two fields of approximately the same size was counted.

Type of plant	Field 1	Field 2
Daisy (<i>Bellis perennis</i>)	307	18
Dandelion (<i>Taraxacum officinale</i>)	332	48
Buttercup (<i>Ranunculus repens</i>)	361	934
Total	1000	1000

Compare and contrast the richness and the evenness of the two fields.

[2]

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(Option C continues on the following page)



36EP27

Turn over

(Option C continued)

17. (a) State **two** bottom-up factors affecting algal blooms. [2]

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2.

(b) Explain how top-down factors control algal blooms. [3]

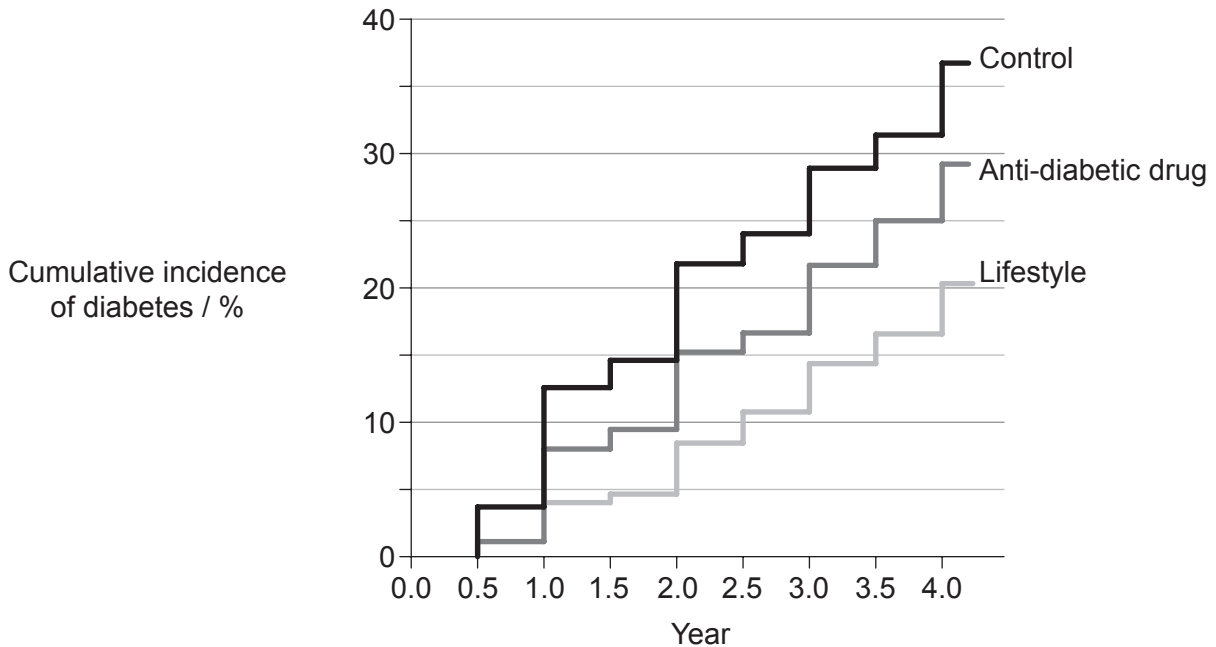
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(Option C continues on the following page)



Option D — Human physiology

19. A study was undertaken to determine the most effective method to delay the onset of type II diabetes in high-risk patients. Three groups were given either a placebo (control), a medicine that suppresses glucose production by the liver (anti-diabetic drug) or a lifestyle-modification program (lifestyle). The results for four years are shown in the graph.



[Source: adapted from Berry, Colin, Jean-Claude Tardif, and Martial G. Bourassa. "Coronary Heart Disease in Patients With Diabetes." *Journal of the American College of Cardiology* 49.6 (2007): 631-642. Web. 19 Jan. 2017.]

(a) Analyse the use of the anti-diabetic drug in delaying the onset of type II diabetes. [2]

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(b) List features that would increase a person's risk of developing diabetes. [2]

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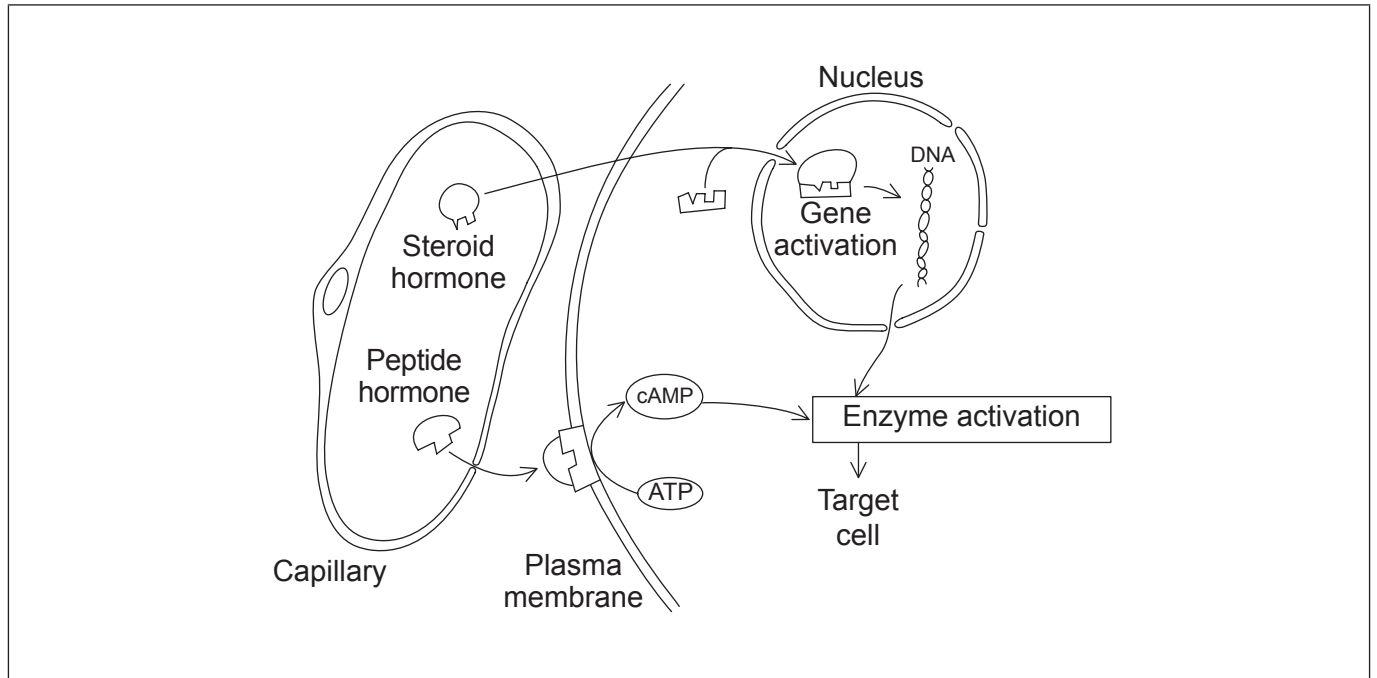
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(Option D continued)

20. The diagram demonstrates the action of steroid and peptide hormones in a section of cell and adjacent capillary.



[Source: © International Baccalaureate Organization 2016]

- (a) On the diagram, label a
 - (i) second messenger. [1]
 - (ii) gene regulatory protein. [1]
- (b) Outline **one** characteristic of steroid hormones that allows them to readily diffuse through cell membranes. [1]

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- (c) Compare and contrast the mechanisms of action of peptide and steroid hormones. [2]

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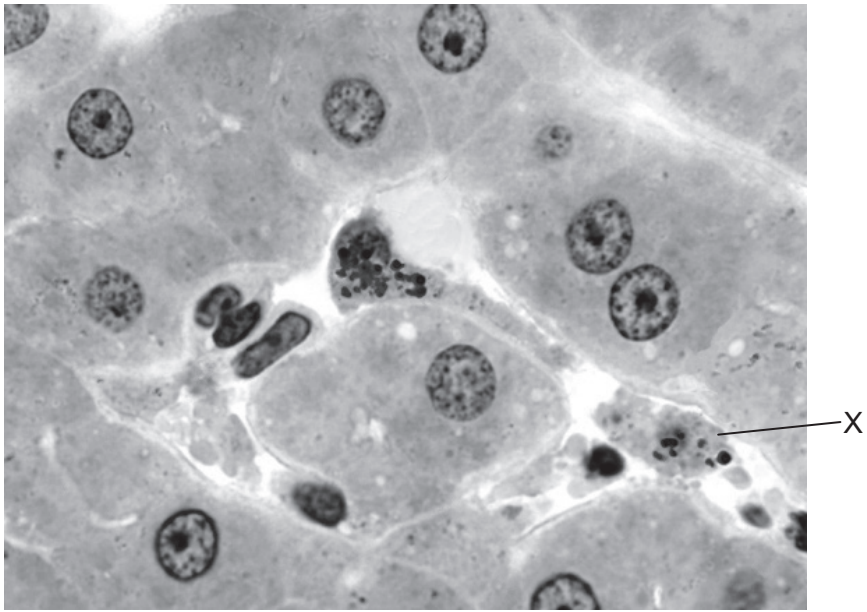
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Turn over

(Option D continued)

21. The micrograph shows a section through the human liver.



[Source: Dr Thomas Caceci, Virginia Tech/Carilion School of Medicine.]

(a) The cell labelled X is only found in the liver and is associated with the wall of a sinusoid.

(i) Identify cell X. [1]

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(ii) Outline the function of cell X. [2]

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(Option D continues on the following page)



(Option D, question 21 continued)

(b) Describe how the liver regulates nutrient levels.

[3]

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(c) Explain the importance of bilirubin in the onset of jaundice.

[4]

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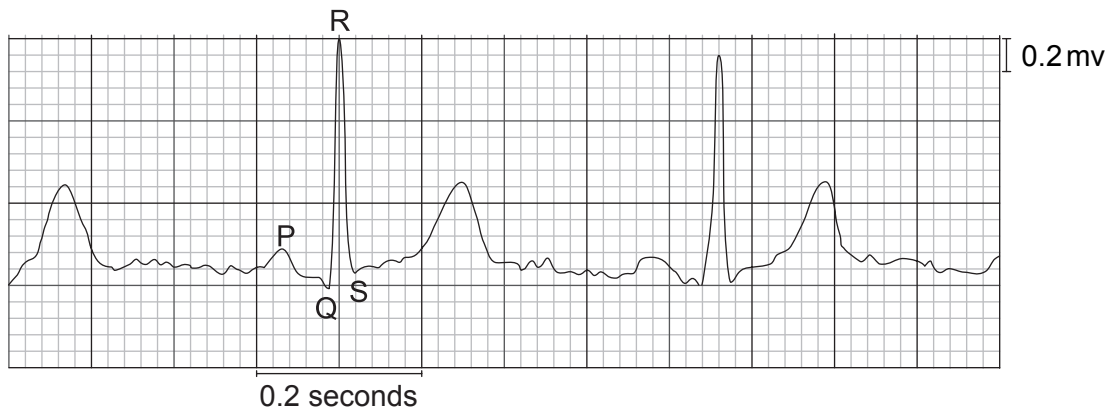


36EP33

Turn over

(Option D continued)

22. The electrocardiogram (ECG) of a normal patient after exercise is shown.



[Source: © International Baccalaureate Organization 2016]

- (a) Using the R–R interval in this ECG, calculate the heart beats per minute (bpm) of this patient. Show your working. [2]

..... bpm

- (b) Describe the electrical activity that occurs in the heart during the P wave. [1]

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- (c) Explain why the QRS wave has a larger amplitude than a P wave. [2]

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(Option D continues on the following page)



(Option D continued)

- 23.** Explain, using an oxygen dissociation curve, how hemoglobin supplies oxygen to respiring tissues and how the Bohr shift increases the supply.

[6]

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End of Option D



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36EP36