

Biology

Higher level

Paper 3

Tuesday 15 May 2018 (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.
- 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



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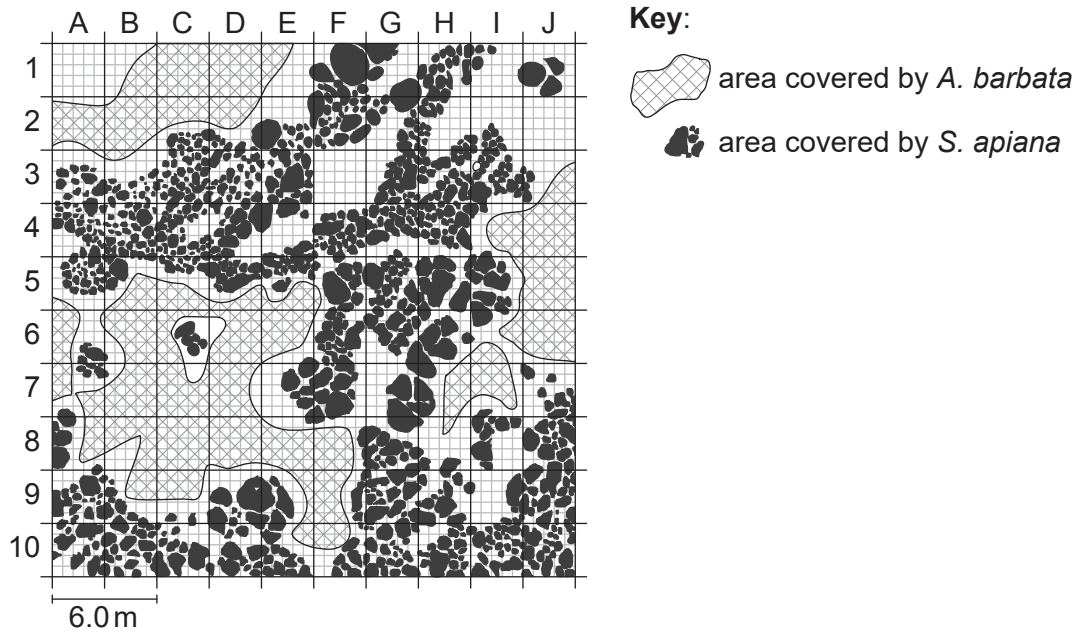
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will not be marked.



Section A

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

- White sage (*Salvia apiana*) is a native Californian shrub. Slender oat (*Avena barbata*) is a grass, originally from the Mediterranean, which was introduced to California. The map shows the distribution of the two species in relation to one another in an area near Santa Ynez, California.



[Source: Adapted from <http://web.csulb.edu>. Reproduced with permission from Christine M. Rodrigue, Ph.D.]

- Using the scale bar, determine the area of quadrat A1, giving the units. [1]

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- Outline how chi-squared can be used to test for an association between the distributions of the two species. [3]

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2. Egg white or albumin solutions can be used in enzyme activity experiments. The influence of different ions on the activity of a peptidase was determined at 55°C and at pH 6.5. The concentration of each ion studied was the same.

Removed for copyright reasons

- (a) Determine the ion that inhibits enzyme activity the most. [1]

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- (b) Predict, with reasons, the difference in peptidase activity if the experiment were repeated at pH 5. [3]

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(Question 2 continued)

(c) Describe an experimental method that can be used to measure the activity of an enzyme.

[2]

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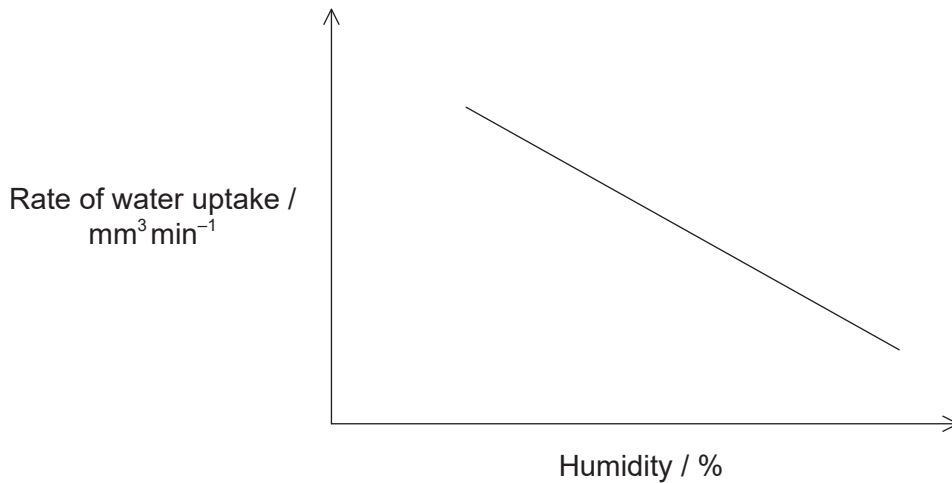
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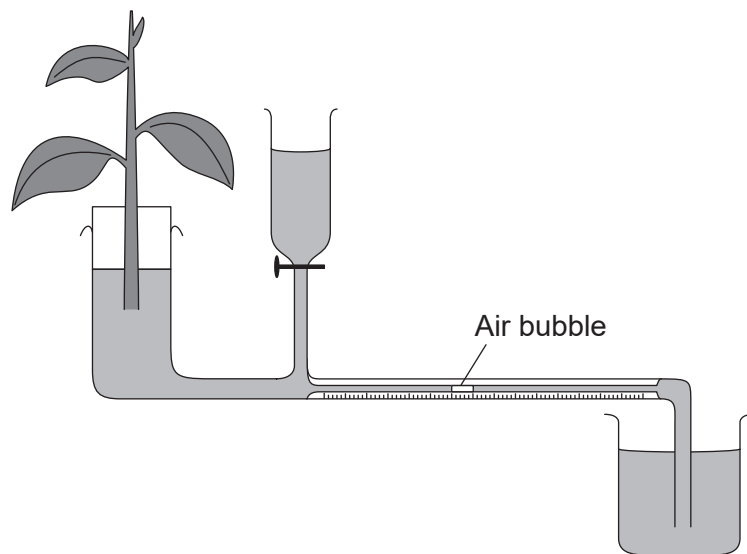
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3. The graph shows the effect of relative humidity on the transpiration rate in Chinese privet (*Ligustrum sinense*).



[Source: Reprinted from *Procedia Environmental Sciences*, 13, T F Chen and X S Wange, A correlation model on plant water consumption and vegetation index in Mu Us Desert, in China, 1517-1526, Copyright (2012), with permission from Elsevier]

The rate of water uptake was measured using the potometer shown in the diagram. The diameter of the capillary tube is 1 mm.



[Source: Reprinted from *Procedia Environmental Sciences*, 13, T F Chen and X S Wange, A correlation model on plant water consumption and vegetation index in Mu Us Desert, in China, 1517-1526, Copyright (2012), with permission from Elsevier]

- (a) Outline how the rate of water uptake is recorded in this potometer. [2]

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(Question 3 continued)

(b) State a variable that needs to be controlled in this experiment. [1]

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(c) Explain the effect of relative humidity on the rate of water uptake. [2]

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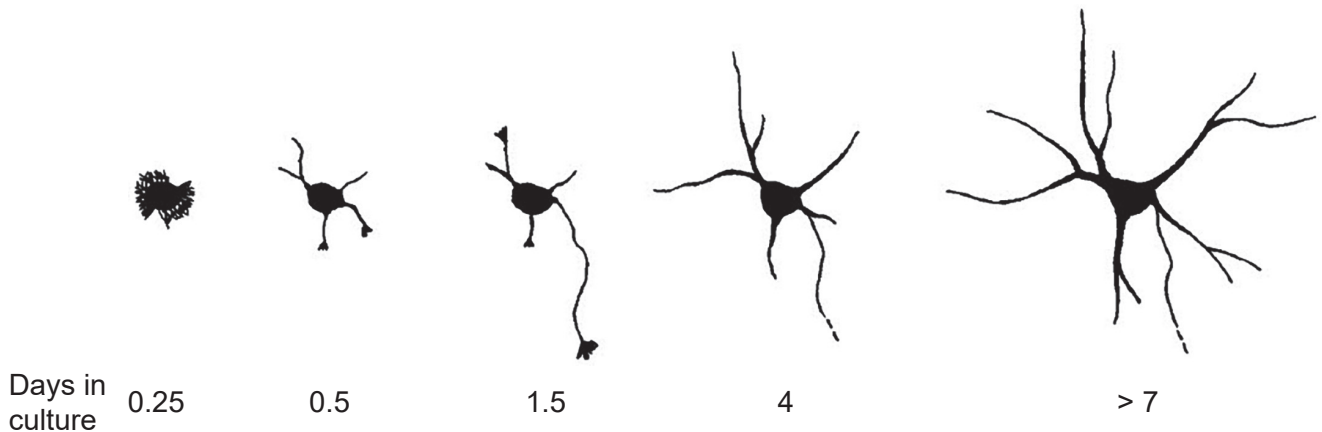


Section B

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. Modification of neurons starts in the earliest stages of embryo development and continues to the final years of life. The image shows changes occurring in mice brain neurons at an early stage in life.



[Source: Republished with permission of Society of Neuroscience, from The establishment of polarity by hippocampal neurons in culture, CG Dotti, CA Sullivan and GA Banker, 8(4) 1988; permission conveyed through Copyright Clearance Center, Inc]

- (a) Outline how an immature neuron develops an axon. [2]

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- (b) Explain neuroplasticity in terms of the developing neurons. [3]

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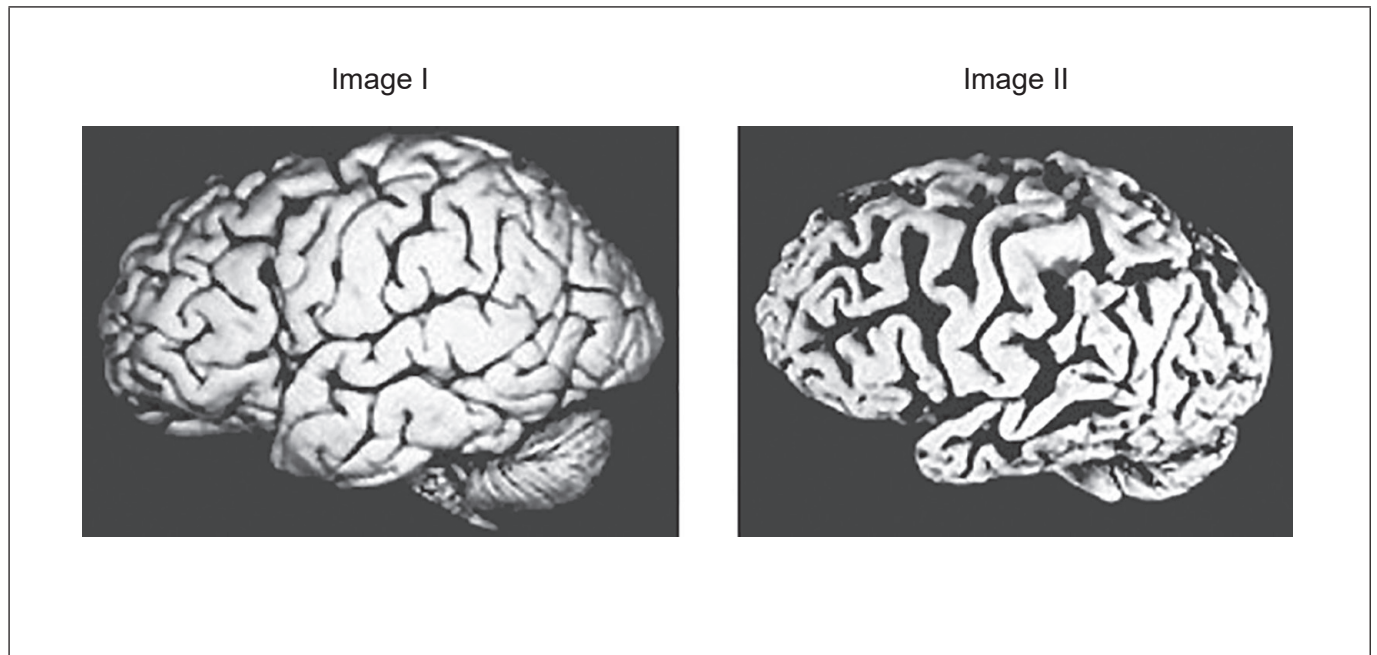
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(Option A continued)

- 5. The images show differences in structure between the brain of a person without Alzheimer’s disease (image I) and the brain of a patient with Alzheimer’s disease (image II).



[Source: Reprinted by permission from Springer Nature: *Nature*, Pathways towards and away from Alzheimer’s disease, Mark P. Mattson, © 2004]

- (a) (i) Label the cerebellum on image I. [1]
- (ii) State **one** function of the cerebellum. [1]

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- (b) State the difference in the cerebral cortex between the two images of the brain. [1]

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(Option A, question 5 continued)

- (c) A person with Alzheimer’s disease typically has a reduced nucleus accumbens. Predict how this will affect the person.

[2]

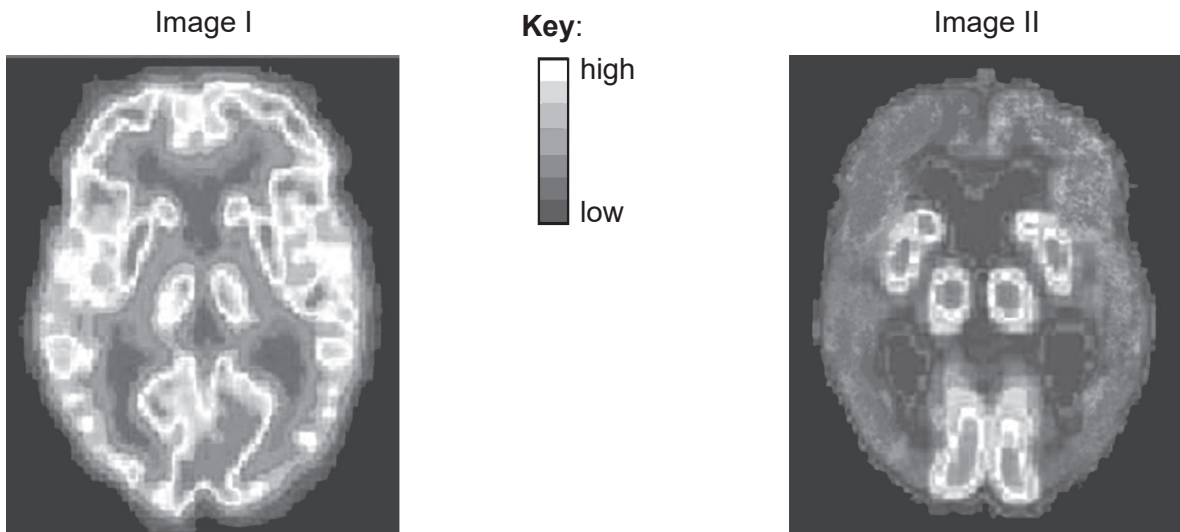
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- (d) The images show the differences in glucose uptake between the brain of a person without Alzheimer’s disease (image I) and the brain of a patient with Alzheimer’s disease (image II). The key indicates the levels of glucose uptake.



[Source: Reprinted by permission from Springer Nature: *Nature*, Pathways towards and away from Alzheimer’s disease, Mark P. Mattson, © 2004]

Deduce the implications of reduced glucose uptake in the brain of a patient with Alzheimer’s disease.

[2]

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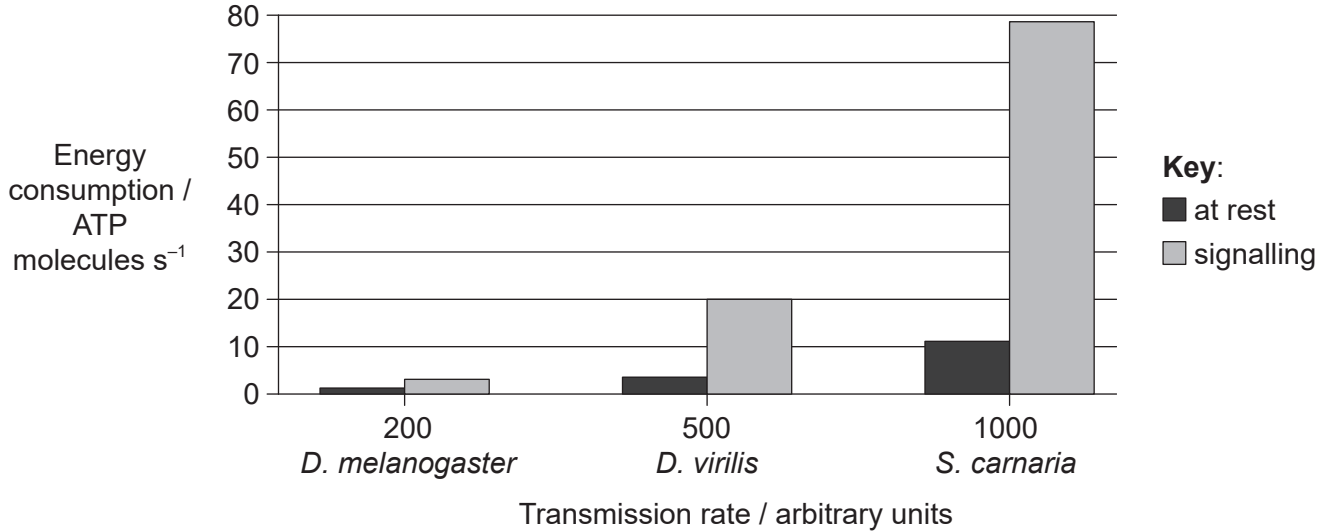
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(Option A continued)

- 6. The graph shows the energy consumption of photoreceptors in three different species of fly (*Drosophila melanogaster*, *Drosophila virilis* and *Sarcophaga carnaria*) at the mean of the highest transmission rate for each species at rest and while sending a nerve signal (signalling).



[Source: Adapted with permission of J E Niven and S B Laughlin (2008), *Journal of Experimental Biology*, 211, pp 1792–1804]

- (a) Explain how neurons at rest still consume energy. [2]

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- (b) Identify the species with photoreceptors that have the fastest signalling transmission rate. [1]

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- (c) Describe the relationship between energy consumption and transmission rate. [2]

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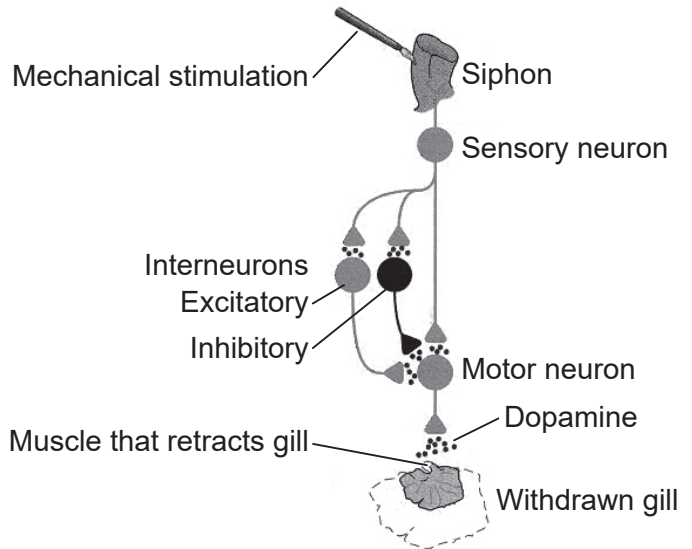
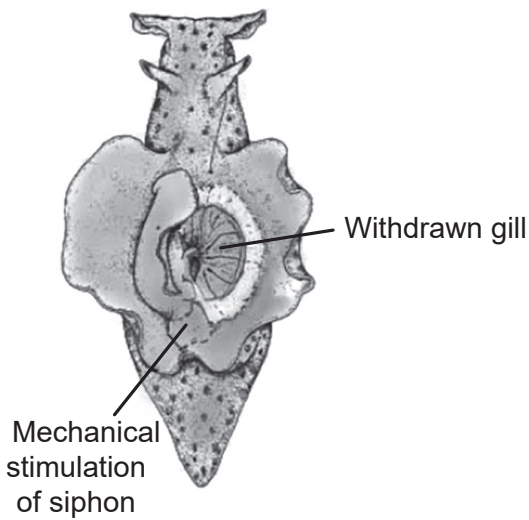
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(Option A continued)

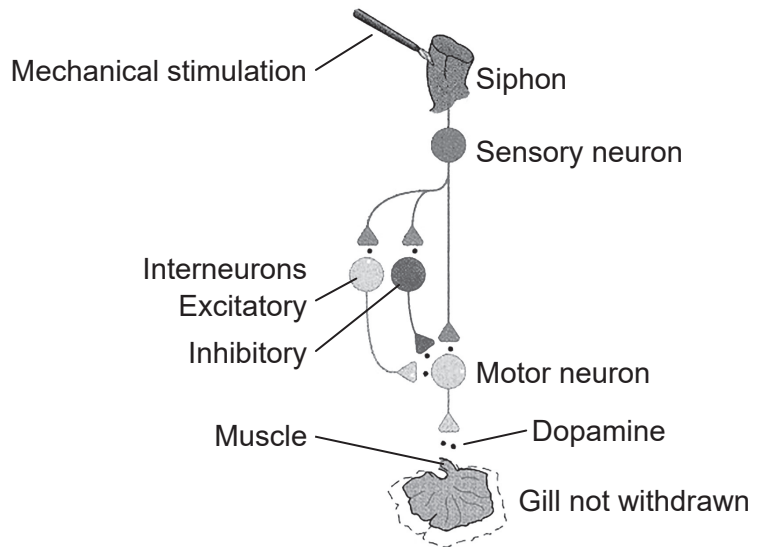
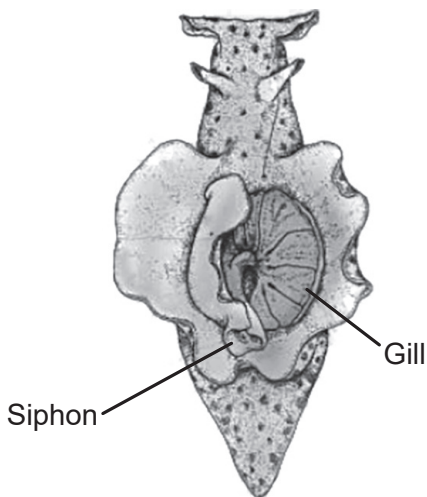
7. An organism's diminished response to a repeated stimulus is referred to as habituation. The diagrams show the experiments performed on habituation to a stimulus in a sea slug (*Aplysia californica*). The sea slug is a mollusc that has an external gill for gas exchange. If the siphon of the sea slug is stimulated mechanically, it withdraws the gill in a simple reflex action.

Control



With repeated stimulus (habituation), the sea slug no longer withdraws the gill.

Habituated



[Source: Eric R Kandel's address to the Nobel Foundation, December 2000 and Eric R Kandel, J H Schwartz and T M Jessell 2000 *Principles of Neural Science* © McGraw-Hill Education]

(Option A continues on the following page)



(Option A, question 7 continued)

- (a) State the effector in this reflex arc. [1]

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- (b) With reference to the experiments on habituation, state the effect of repeated stimulation on the level of neurotransmitter in the synapses. [1]

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- (c) With reference to the withdrawal of the siphon in *Aplysia californica*, explain the concept of summation. [2]

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- (d) Amphetamines act on synapses that use dopamine as a neurotransmitter by increasing the release of dopamine into the synaptic cleft. Outline the effect this would have on human synaptic transmission. [3]

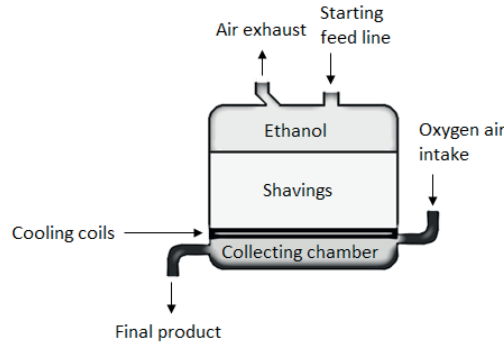
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Option B — Biotechnology and bioinformatics

- 9. In the generator method of ethanoic acid fermentation, *Acetobacter aceti* are grown over wood shavings in a fermenter to the point where they form a biofilm.



[Source: © International Baccalaureate Organization 2018]

At the base of the fermenter oxygen is bubbled in, which then rises through the wood shavings. Ethanol drips through the wood shavings. At a suitable temperature the ethanol is converted to ethanoic acid, which is withdrawn from the bottom of the fermenter, and new ethanol is added at the top.

- (a) List **two** abiotic variables that would need to be monitored during this fermentation process.

[2]

1.
2.

- (b) Describe **one** way in which microorganisms in this fermenter could be limited by their own activities.

[2]

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(Option B continues on the following page)

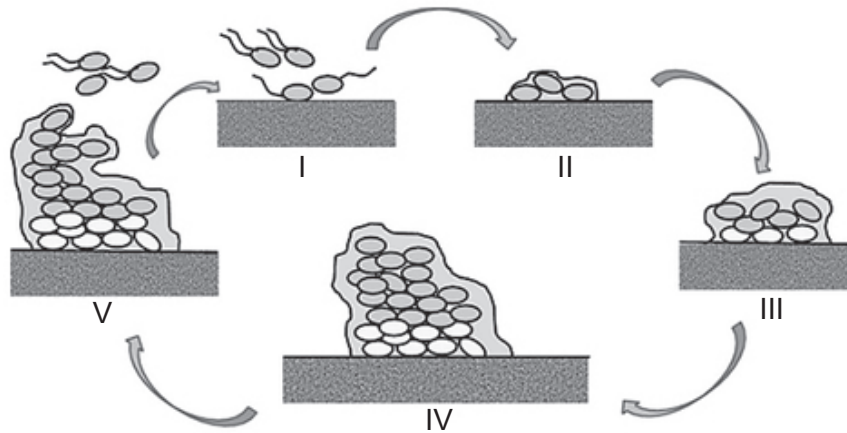


36EP15

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(Option B continued)

10. Bacterial biofilms play an important role in urinary tract infections. They can be responsible for persistence of infections. The diagram shows biofilm formation.



[Source: Sara M. Soto, "Importance of Biofilms in Urinary Tract Infections: New Therapeutic Approaches," *Advances in Biology*, vol. 2014, Article ID 543974, 13 pages, 2014. <https://doi.org/10.1155/2014/543974>.]

- (a) Identify the step where the extracellular matrix first appears. [1]

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- (b) Explain the persistence of urinary tract infections, if bacterial biofilms are formed. [3]

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- (c) *Escherichia coli*, a Gram-negative bacterium, is a common cause of urinary tract infections. State the colour of *E. coli* bacteria after Gram staining. [1]

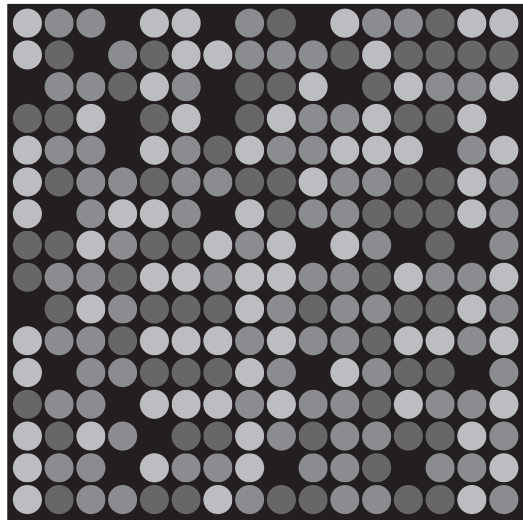
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(Option B continues on the following page)



(Option B continued)

11. A DNA microarray chip was prepared as a collection of microscopic DNA strands from human genes attached to a solid surface. The diagram shows part of the microarray chip after hybridization with cDNA produced from normal cells and from cancer cells. cDNA of normal cells was labelled with green fluorescent dye and cDNA from cancer cells was labelled with red fluorescent dye. Both sets of labelled cDNA were then allowed to bind to the microarray.



Key:

- (red fluorescence) cancer
- (green fluorescence) normal
- (yellow fluorescence) both cancer and normal

[Source: This figure was published in the *eJIFCC - electronic Journal of the International Federation of Clinical Chemistry and Laboratory Medicine*, 2005, 1(2), Global approach to biomedicine: Functional genomics and proteomics, K Pavelic *et al.* Copyright IFCC]

(a) Explain the reason that only cDNA from expressed genes binds to the DNA on the chip. [2]

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(b) Explain how the information obtained in this microarray accounts for the differences between normal cells and cancer cells. [3]

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(Option B continues on the following page)



36EP17

Turn over

(Option B continued)

12. A protein expressed by the gene carotene desaturase (CTP1) was introduced into Golden rice (*Oryza sativa*) through genetic engineering. Bioinformatics were used to determine if the protein sequence matched any allergenic proteins (proteins that trigger an allergic reaction). The table shows the results from the alignment of the CTP1 protein with proteins from moth, soybean and dust mite that are known to be allergenic.

Organism	Number of amino acids in protein	Percentage identity (exact match)	Amino acid alignment
Moth (<i>Plodia interpunctella</i>)	705	25.9	108
Soybean (<i>Glycine max</i>)	131	24.7	89
House dust mite (<i>Dermatophagoides farinae</i>)	145	44.4	36

[Source: *Food Allergy Research and Resource Program*. Used with permission from Richard E Goodman, PhD FA AAAI]

(a) (i) State a bioinformatic search tool that could be used to perform the alignment. [1]

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(ii) Outline how the similar protein sequences were found. [1]

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(b) Regulations say that a protein is considered allergenic and unsafe for human consumption if at least 80 amino acids are aligned and there is greater than 35% identity with any known allergen. Analyse the data provided to consider whether CTP1 is safe for human consumption. [3]

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(Option B continues on the following page)



(Option B, question 12 continued)

- (c) Genes such as the one coding for CTP1 can be located by searching for open reading frames. Outline how open reading frames are identified. [3]

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- (d) Physical and chemical methods can be used to genetically modify crop plants by inserting new genes. List a physical and a chemical method that could have been used to introduce the gene coding for CTP1 into the rice plants. [2]

Physical:

Chemical:

(Option B continues on the following page)



Option C — Ecology and conservation

14. The pyramid shows energy losses from a harvested wheat crop in tropical Africa.



(a) Distinguish between the efficiency of ingested energy conversion to biomass by *Tribolium* beetle and by bacteria.

[2]

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(b) Explain how the energy is lost between trophic levels.

[3]

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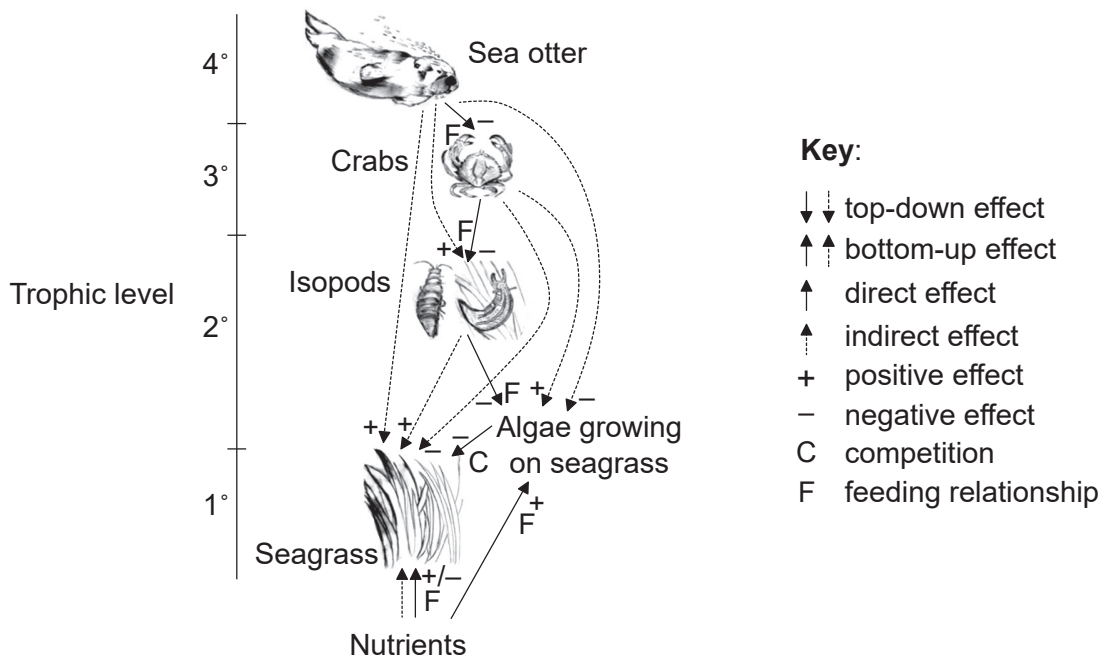


36EP21

Turn over

(Option C continued)

15. The interaction web shows top-down and bottom-up effects in a seagrass study system.



[Source: Adapted from Sea otters mediate eutrophic effects on seagrass, Brent B. Hughes, Ron Eby, Eric Van Dyke, M. Tim Tinker, Corina I. Marks, Kenneth S. Johnson, Kerstin Wasson, *Proceedings of the National Academy of Sciences* Sep 2013, 110 (38) 15313-15318; DOI: 10.1073/pnas.1302805110]

(a) Identify which of the types of interaction shown in the key occur between crabs and seagrass. [2]

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(b) Describe how the sea otter indirectly affects seagrass. [2]

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(Option C continues on the following page)



(Option C, question 15 continued)

(c) Explain how nutrients can have a positive or negative bottom-up effect on seagrass. [3]

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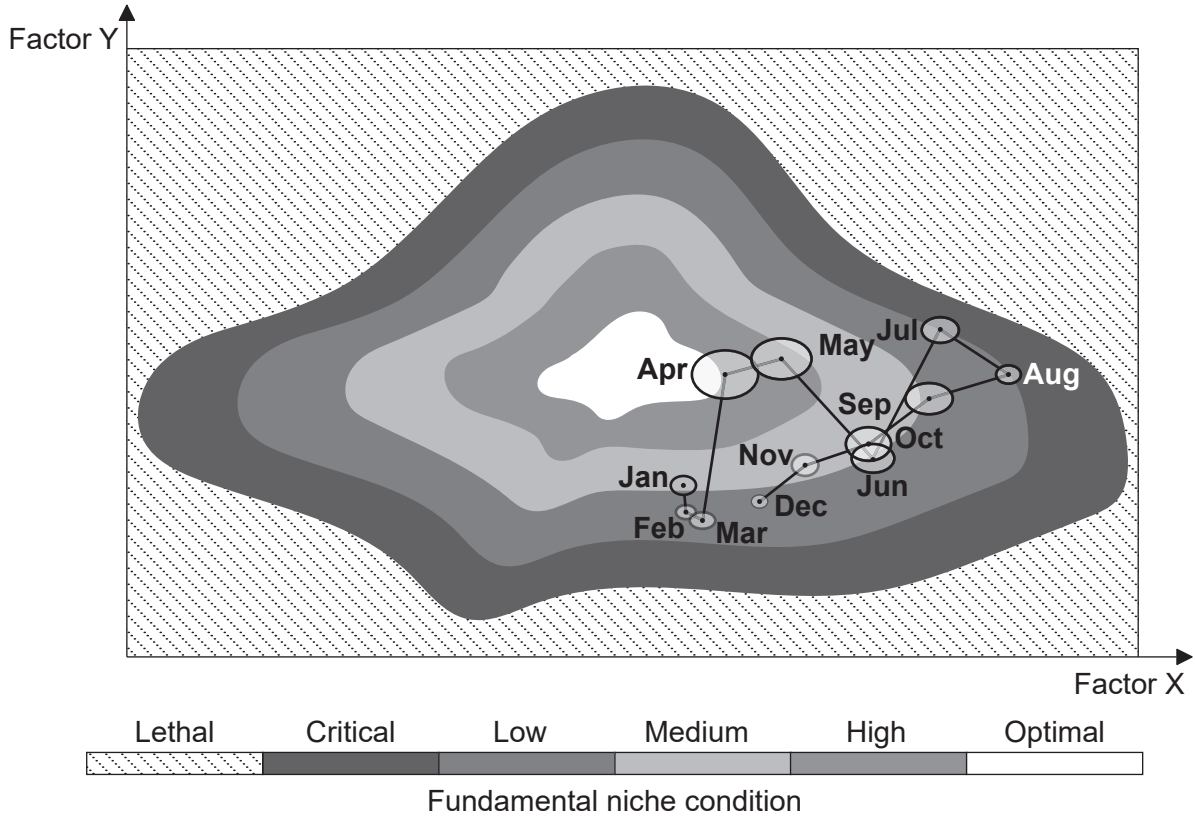


36EP23

Turn over

(Option C continued)

- 16. The model describes the fundamental and realized niches of a species of microscopic marine arthropod in the Northern hemisphere with respect to two different factors (X and Y). The abundance of the species is shown over twelve months. The fundamental niche is separated into five zones ranging from critical to optimal conditions. The population of the species in its realized niche each month is represented by an oval. The size of each oval shows the population abundance.



[Source: Adapted from P Helaouet *et al* (2013), Marine Ecosystem Response to the Atlantic Multidecadal Oscillation, *PLoS ONE*, 8(11). © P Helaouet *et al*]

- (a) Distinguish between fundamental niche and realized niche. [1]

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- (b) State the month where the population reaches its maximum. [1]

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(Option C continues on the following page)



(Option C, question 16 continued)

(c) (i) Outline how factor Y affects the species from January to April. [2]

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(ii) Suggest, with a reason, what factor Y could be. [2]

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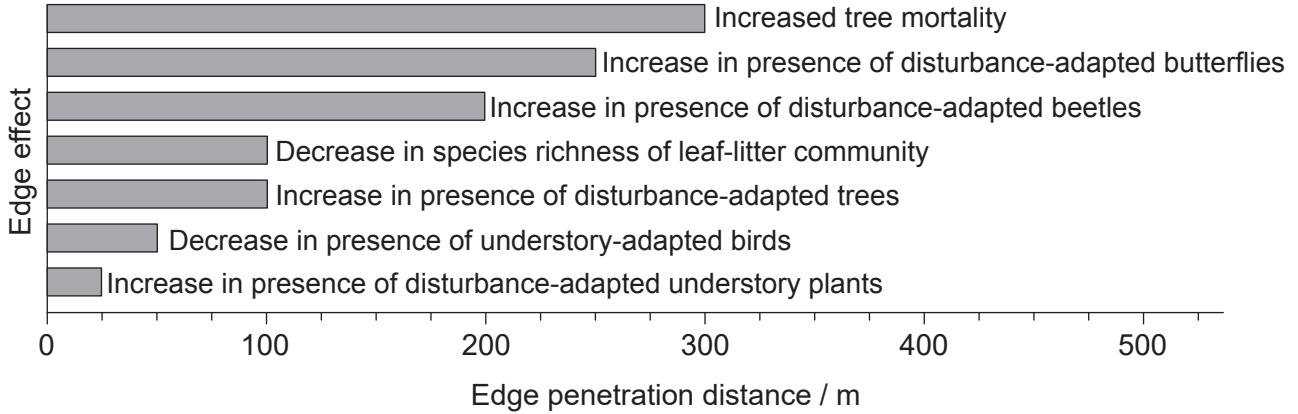


36EP25

Turn over

(Option C continued)

17. One challenge associated with establishing nature reserves is concerns about edge effects. The graph shows that some edge effects in the Amazon rainforest are detected quite far in from the edge.



[Source: Reprinted from *Biological Conservation*, 141, William F Laurance, Theory meets reality: How habitat fragmentation research has transcended island biogeographic theory, 1731, Copyright (2008), with permission from Elsevier]

(a) Determine how far from the forest edge an increase in disturbance-adapted beetles would be detected. [1]

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(b) With respect to the example of disturbance-adapted beetles, explain what is meant by an indicator species. [2]

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(Option C continues on the following page)



(Option C, question 17 continued)

(c) Outline how reserve size and shape can impact edge effects.

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(Option C continues on page 29)



36EP27

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(Option C continued)

18. Evaluate the impact of the introduction of a **named** invasive alien species into an environment.

[6]

Dotted response area for writing the answer to Question 18.

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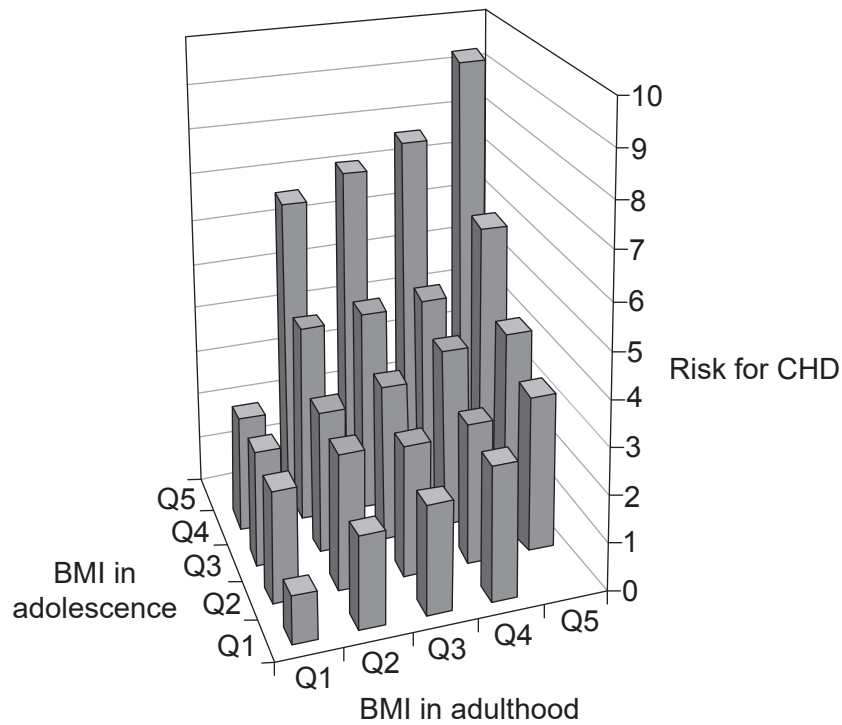


36EP29

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Option D — Human physiology

19. A long term study followed nearly 40 000 apparently healthy young men for coronary heart disease (CHD) from adolescence through adulthood. The results show how the body mass index (BMI) at adolescence and adulthood affect the risk of CHD. The BMIs are divided into five groups (quintiles), Q1 being the lowest BMI and Q5 the highest. A risk factor of 2 or less is desirable.



[Source: From *The New England Journal of Medicine*, A Tirosh *et al.*, Adolescent BMI Trajectory and Risk of Diabetes versus Coronary Disease, 364, 1315. Copyright © (2011) Massachusetts Medical Society. Reprinted with permission from Massachusetts Medical Society]

- (a) Using the graph, discuss the hypothesis that a high BMI in adolescence is more dangerous than a high BMI in adulthood.

[2]

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(Option D continues on the following page)



(Option D, question 19 continued)

(b) State **one** factor, other than BMI, that increases the risk of CHD. [1]

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20. (a) State the disease caused by *Helicobacter pylori*. [1]

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(b) Outline how gastric acid is produced in the stomach. [2]

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(c) Explain why proton pump inhibitors alleviate the symptoms of *H. pylori* infections. [2]

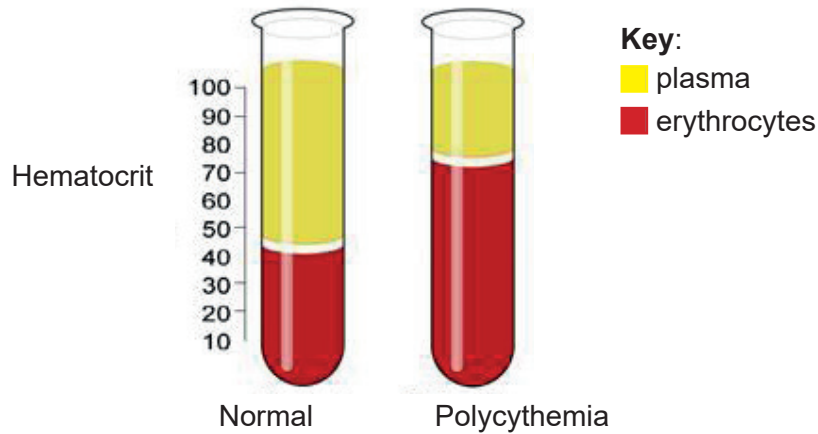
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(Option D continued)

21. The hematocrit is the volume percentage fraction of erythrocytes in blood.



[Source: Adapted from KnuteKnudsen/Wikipedia]

(a) From the diagram, deduce the effect of the disease polycythemia on the proportion of erythrocytes in total blood volume. [1]

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(b) Suggest how high altitude could lead to polycythemia. [2]

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(Option D continues on the following page)



(Option D, question 21 continued)

(c) Suggest how changes in hemoglobin could help humans become better adapted to living at high altitude.

[3]

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(d) Outline the stages involved in the recycling of erythrocytes by the liver.

[3]

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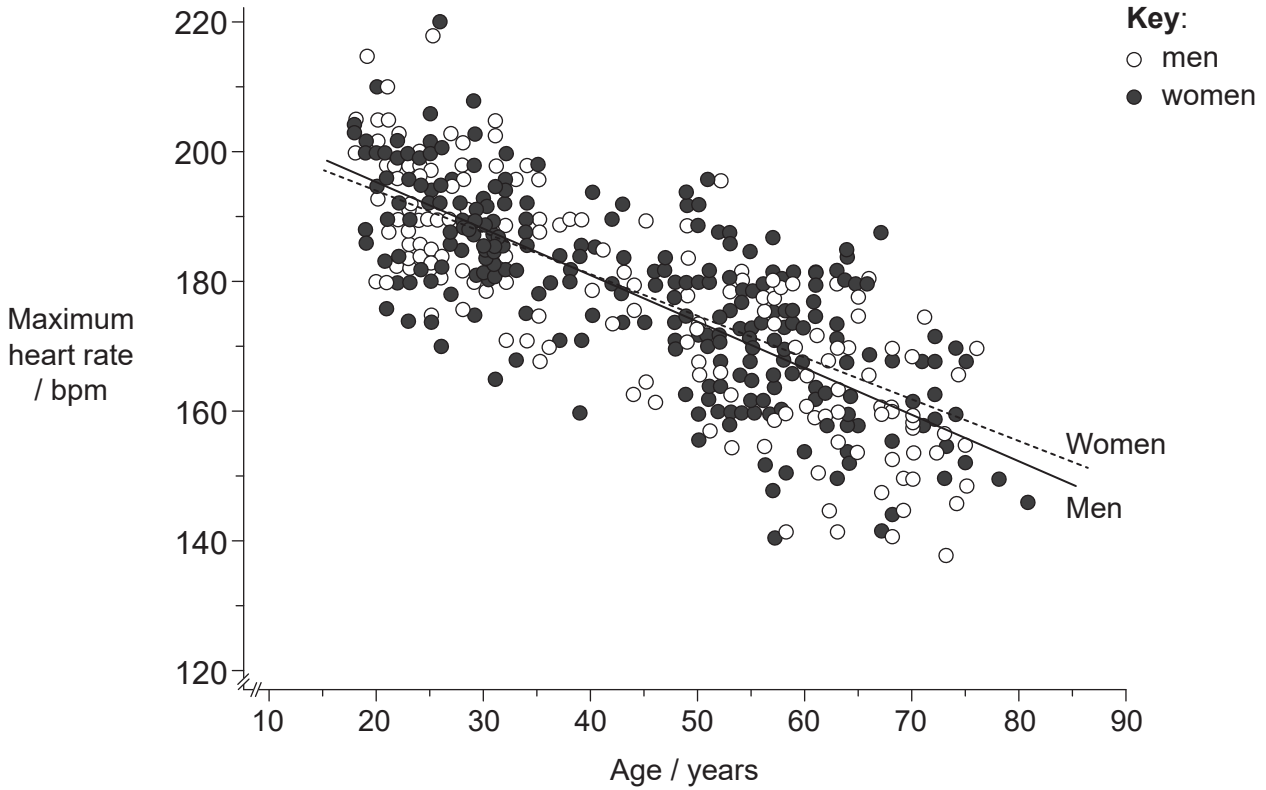


36EP33

Turn over

(Option D continued)

22. The graph shows the relationship between the maximum heart rate during exercise and a person's age.



[Source: Reprinted from *Journal of the American College of Cardiology*, 37, H Tanaka, K D Monahan and D R Seals, Age-predicted maximal heart rate revisited, 153, Copyright (2001), with permission from Elsevier]

(a) Outline **one** method that the researchers could have used to measure heart rate in this study. [2]

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(b) Suggest reasons for the change in maximum heart rate with increasing age. [2]

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(Option D continues on the following page)



(Option D, question 22 continued)

- (c) Outline the use of defibrillation to treat life-threatening cardiac conditions. [3]

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(Option D continues on the following page)



36EP35

Turn over

(Option D continued)

23. Compare and contrast steroid and peptide hormone action.

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End of Option D

