Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 3

Thursday 15 November 2018 (morning)

Candidate session number

1 hour

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[35 marks]**.

Section A	Questions
Answer all questions.	1 – 3

Section B	Questions
Answer all of the questions from one of the options.	
Option A — Neurobiology and behaviour	4 – 7
Option B — Biotechnology and bioinformatics	8 – 11
Option C — Ecology and conservation	12 – 15
Option D — Human physiology	16 – 19

8818 – 6006

Section A

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

1. A variegated *Pelargonium* plant was grown outdoors in a plant pot. Figure 1 shows one leaf of the *Pelargonium*. The plant was left in the dark for 24 hours to inhibit photosynthesis. After this time, a sketch was made of the leaf to show the colours (Figure 2), then part of the leaf was covered with black card (Figure 3). Following the exposure of the plant to sunlight for six hours, the black card was removed and the leaf tested for starch (Figure 4).

Figure 1

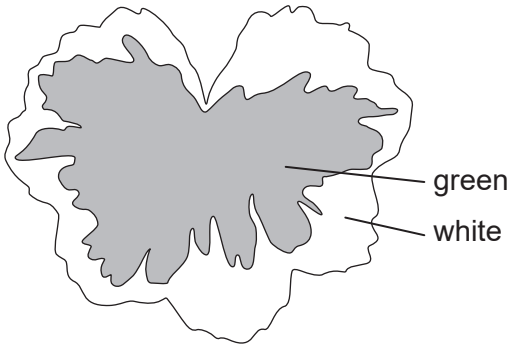


Figure 2

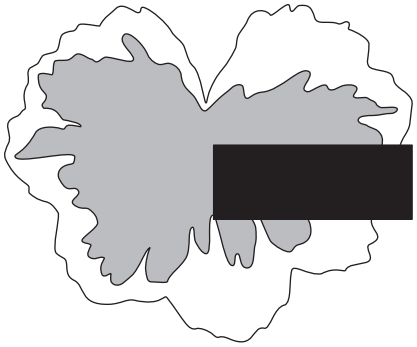


Figure 3

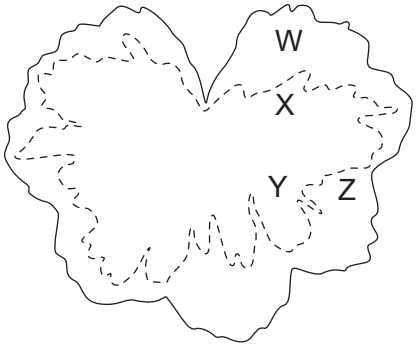


Figure 4

[Source: © International Baccalaureate Organization 2018]

(a) Outline a reason for inhibiting photosynthesis for 24 hours. [1]

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(b) (i) Identify which **two** areas, W, X, Y or Z, in Figure 4 show that light is required for photosynthesis. [1]

. . . . . .

(ii) Identify which **two** areas, W, X, Y or Z, in Figure 4 show that chlorophyll is required for photosynthesis. [1]

. . . . . .

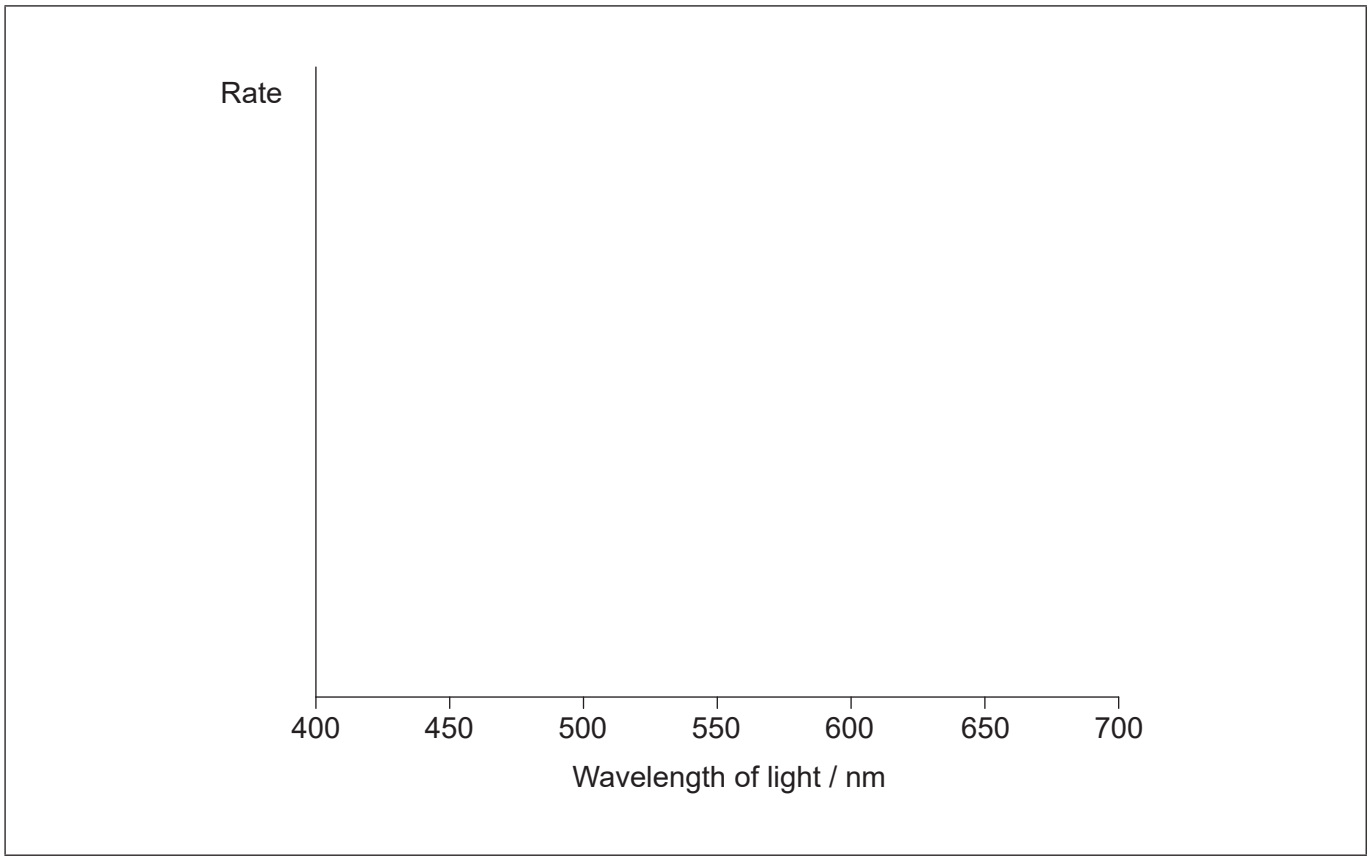
(iii) Discuss briefly whether the detection of starch in this experiment was proof that photosynthesis had occurred in the leaf. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(This question continues on the following page)

(Question 1 continued)

(c) (i) Using the axes, sketch the action spectrum for photosynthesis in the green area of the leaf in Figure 1. [1]



(ii) Predict how the action spectrum from the white areas of the leaf would differ from the green areas. [1]

. . . . . .

. . . . . .

(d) Suggest reasons that plants with variegated leaves are rarely found growing wild naturally. [1]

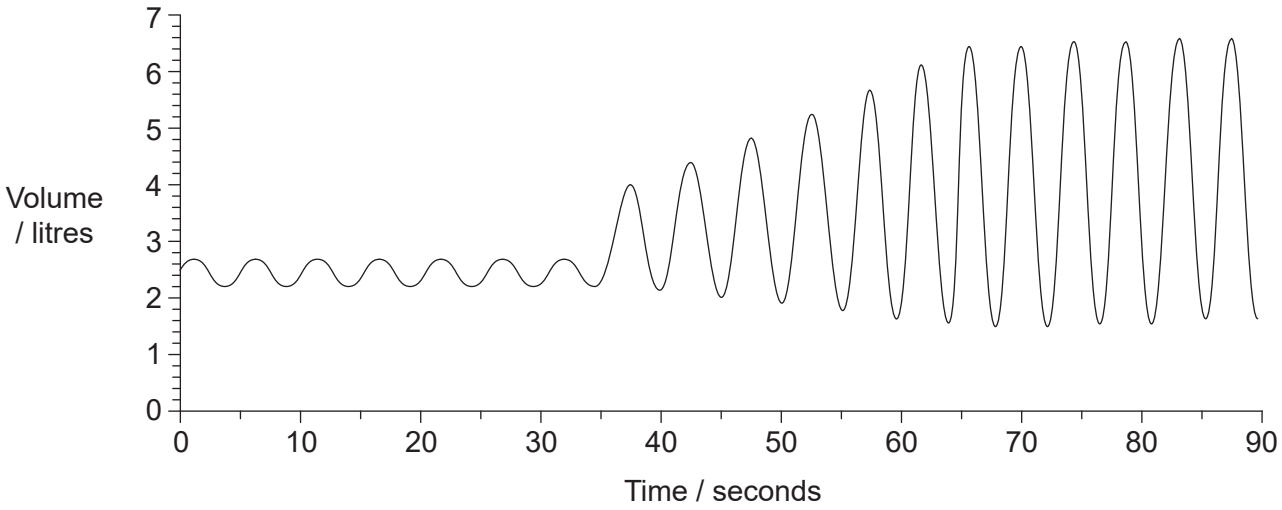
. . . . . .

. . . . . .

. . . . . .

. . . . . .

2. Measurements of the lung capacity of a student were recorded using a spirometer and displayed with a data logger. Initially the student was at rest, then changed to carrying out strenuous exercise. The results are displayed in the graph.



(a) Calculate the ventilation rate at rest, giving the units. [1]

. . . . . .

(b) Explain the changes in ventilation after 35 seconds. [2]

. . . . . .

. . . . . .

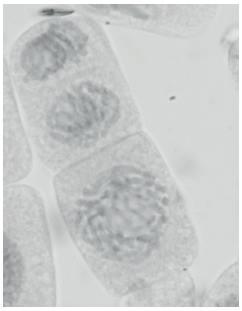
. . . . . .

. . . . . .

(c) Suggest how the total lung volume at rest would differ for a patient with emphysema. [1]

. . . . . .

3. The micrograph shows mitosis in a cell of an onion (*Allium cepa*) root tip.



[Source: Sinhyu/iStock]

(a) Deduce, with a reason, which stage of mitosis is shown. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) The cells visible in the onion root tip were classified and counted.

Interphase	63
Prophase	14
Metaphase	2
Anaphase	4
Telophase	7

Calculate the mitotic index. [1]

. . . . . .

Section B

Answer **all** of the questions from **one** of the options. Answers must be written within the answer boxes provided.

Option A — Neurobiology and behaviour

4. The energy used by the brain and skeletal muscle of a 70 kg man was measured over the period of one day.

	Mass / kg	Energy used / kJ day^{-1}
Skeletal muscle	28.0	1540
Brain	1.4	1400

(a) The metabolic rate is the energy used per kilogram of mass per day. Calculate the metabolic rate of the brain. [1]

. . . . . kJ kg^{-1} day^{-1}

(b) Using only the data in the table, distinguish between the use of energy in the brain and in skeletal muscle. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(c) Suggest **one** reason for the difference between the brain and skeletal muscle in metabolic rate. [1]

. . . . . .
. . . . . .

(Option A continues on the following page)

(Option A, question 4 continued)

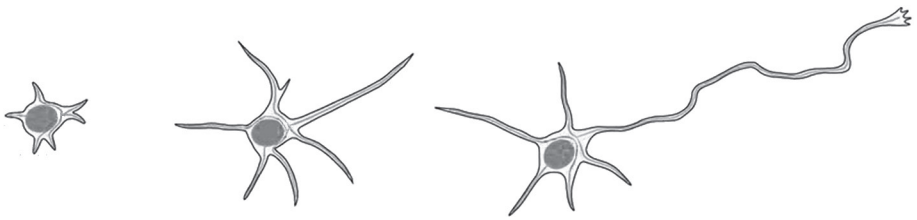
(d) Outline the role of the brain in involuntary control. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option A continues on the following page)

(Option A continued)

5. The drawings show the development of an immature neuron in a rat.



[Source: *Open Biology*, 2013 (3) 130061, 'Microtubule dynamics in neuronal morphogenesis', by Akira Sakakibara, Ryota Ando, Tamar Sapir and Teruyuki Tanaka. Published 17 July 2013.DOI: 10.1098/rsob.130061
(c) Open Biology & Akira Sakakibara, Ryota Ando, Tamar Sapir and Teruyuki Tanaka. Published 17 July (2013)
http://rsob.royalsocietypublishing.org/content/3/7/130061, Figure 2.
Licence: https://creativecommons.org/licenses/by/4.0/ Retraced by the IB and the labels removed.]

(a) Describe the process taking place. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) Outline the possible changes to this neuron that could happen during the subsequent development of the nervous system. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

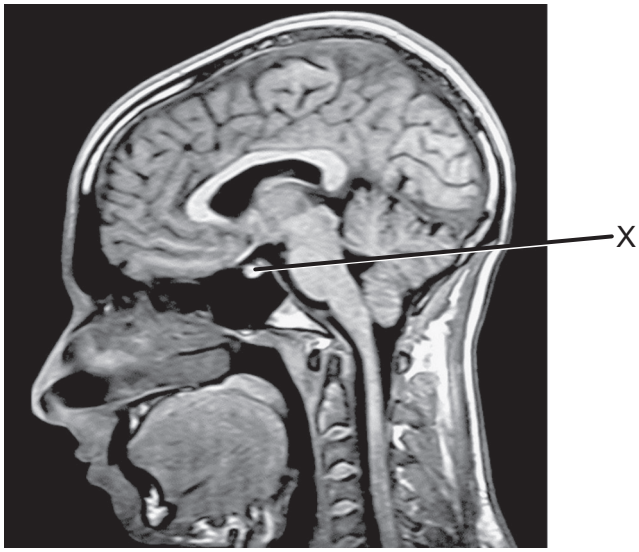
(c) Suggest how the plasticity of the brain can benefit humans. [1]

. . . . . .
. . . . . .

(Option A continues on the following page)

(Option A continued)

6. The diagram shows a magnetic resonance image (MRI) of a human brain.



[Source: http://www.fipapatients.org/ Used with permission from FIPA Patients]

(a) (i) On the diagram, label the visual cortex. [1]

(ii) Identify the structure labelled X. [1]

. . . . . .

(b) Explain how a functional MRI (fMRI) can be used to identify the function of parts of the brain. [2]

. . . . . .

. . . . . .

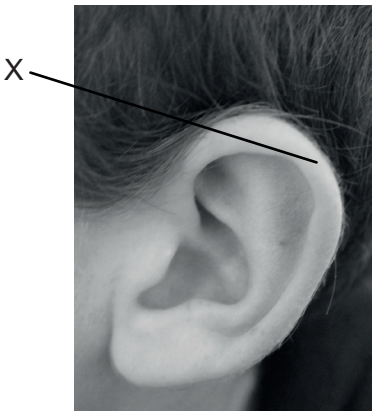
. . . . . .

. . . . . .

(Option A continues on the following page)

(Option A continued)

7. The image shows an external view of the human ear.



[https://en.wikipedia.org/wiki/Ear#/media/File:Earrr.JPG This file is licensed under the Creative Commons Attribution-Share Alike 3.0 (https://creativecommons.org/licenses/by-sa/3.0/deed.en) © 2011 Author: צביה]

(a) Identify the structure labelled X. [1]

. . . . . .

(b) Explain how sound from an outside source causes movement of the hair cells in the cochlea. [4]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

End of Option A

Option B — Biotechnology and bioinformatics

8. The leaves of rice (*Oryza sativa*) may contain some vitamin A or its precursor beta-carotene, but in the edible rice grain this nutrient is not produced due to the absence of four enzymes required in the pathway. Using *Agrobacterium tumefaciens* as a vector, scientists successfully inserted genes into the beta-carotene pathway (two genes from daffodil and one gene from a bacterium) which allowed the rice grains to produce beta-carotene. They called this genetically modified plant Golden rice.

Removed for copyright reasons

(a) Identify the protein for which Gene 1 from daffodil codes. [1]

. . . . . .

(b) Outline how the scientists would determine whether Gene 2 from daffodil had been taken up successfully by rice DNA. [1]

. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B, question 8 continued)

(c) *Agrobacterium tumefaciens* was used in the production of Golden rice varieties. Explain how this bacterium is used to produce genetically modified crop plants. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

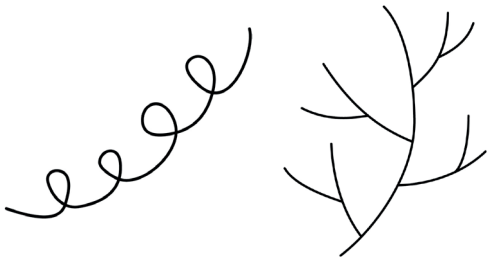
. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B continued)

9. The starch found in potato tubers (*Solanum tuberosum*) is normally a mixture of 80 % amylopectin and 20 % amylose. The Amflora potato is genetically modified to alter this ratio. The modified potato is not suitable for human consumption but is grown for industrial uses.



amylose amylopectin

[Source: © International Baccalaureate Organization 2018]

(a) Compare and contrast amylose with amylopectin. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) Outline how the composition of starch differs in the Amflora potato compared to a normal potato. [1]

. . . . . .
. . . . . .

(c) State **one** industrial use of the Amflora potato. [1]

. . . . . .

(Option B continues on the following page)

(Option B, question 9 continued)

(d) Suggest **one** reason for concerns about growing GM crop varieties such as the Amflora potato on farms. [1]

. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B continued)

10. A section of mRNA contains the start codon for translation of a polypeptide by the ribosomes.

5′ C G A U G C G A A C U A C G U G C A A C U G G C U G A C A U 3′

(a) Identify the nucleotides of the start codon for the polypeptide. [1]

. . . . . .

(b) State the chemical difference between the 5′ end and the 3′ end of a DNA strand. [1]

. . . . . .

. . . . . .

(c) Within the base sequence shown in the diagram, the sequence for the stop codon UGA appears. Explain the reasons for translation continuing beyond this point in the mRNA. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(d) Describe how bioinformatics can help identify genes within the DNA of an organism. [2]

. . . . . .

. . . . . .

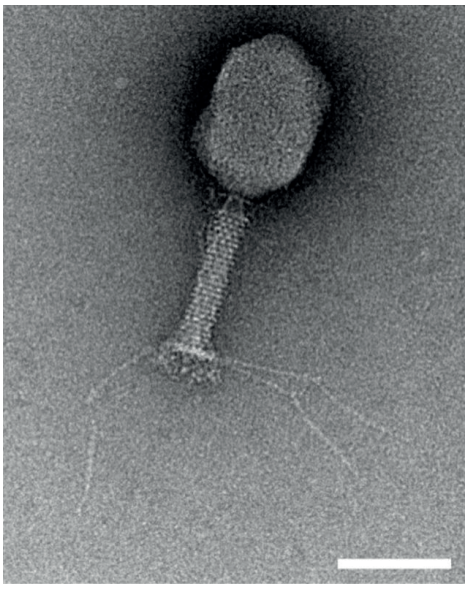
. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B continued)

11. The micrograph shows a T4 bacteriophage.



[Source: Graham Knott and Christel Genoud, 'Commentary: is EM dead?', *Journal of Cell Science* (2013), **126**: 4545–4552, reproduced with permission. http://jcs.biologists.org/content/126/20/4545.figures-only doi: 10.1242/jcs.124123]

Discuss the use of bacteriophages in water systems. [4]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

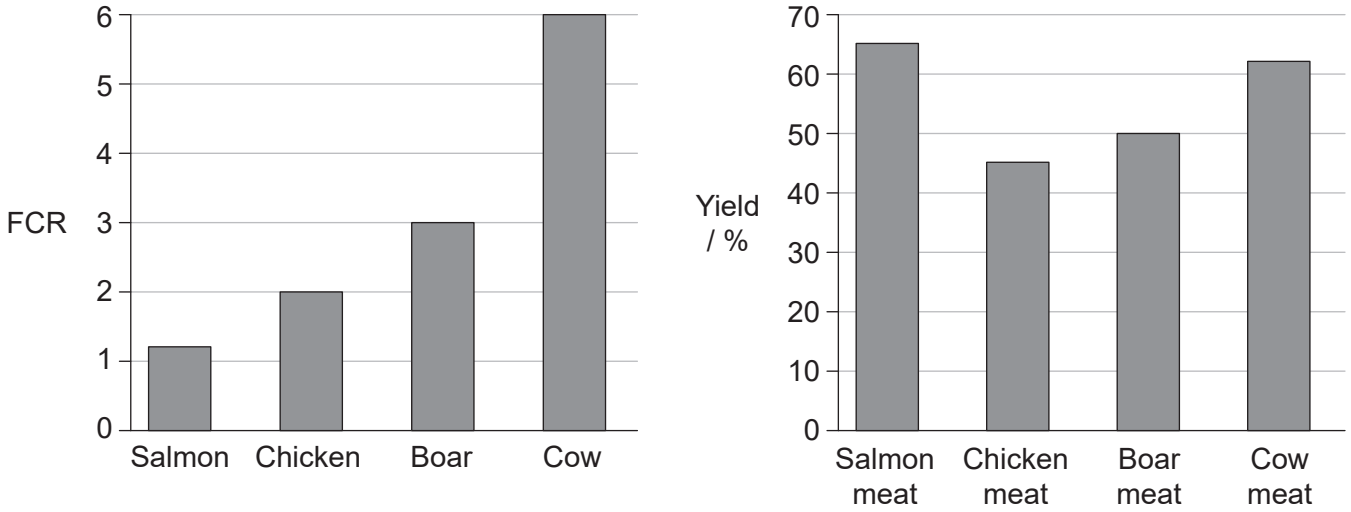
End of Option B

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

Answers written on this page
will not be marked.

Option C — Ecology and conservation

12. The food conversion ratio (FCR) is the ratio between the mass of food given to a farmed animal and its corresponding increase in mass. The first bar chart shows the FCR for four farmed animals. The second bar chart shows the percentage yield of edible meat provided by each whole animal.



[Source: © International Baccalaureate Organization 2018]

(a) Calculate the increase in mass of a cow given 6 kg of food. [1]

. . . . . kg

(b) Calculate how much food would be required to produce 20 kg of boar meat. [1]

. . . . . kg

(c) With reference to the data, discuss the farming of salmon for sustainable food production. [2]

. . . . . .

. . . . . .

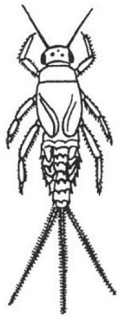
. . . . . .

. . . . . .

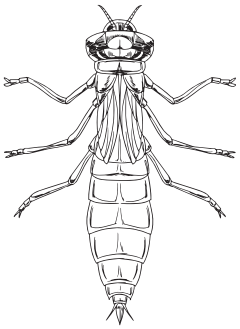
(Option C continues on the following page)

(Option C continued)

13. A biotic index allows water pollution to be monitored without the need for a large number of chemical tests. Aquatic invertebrates are assigned pollution tolerance levels and these are used to assess water quality. The amount of each invertebrate species in the water is measured and this is used to calculate the index. The tolerance level of three invertebrate species is shown.



Mayfly nymph
(intolerant to pollution)



Dragonfly nymph
(can tolerate some pollution)

Midge larva
(tolerant to pollution)

[Source: Mayfly nymph: http://www.bumblebee.org/invertebrates/Ephemeroptera.htm
Dragonfly nymph: iStock.com/blueringmedia
Midge larva: iStock.com/N. Nehring (nancynehring.com)]

(a) State which species could be found in mildly polluted water. [1]

. . . . . .

(b) State the name given to organisms whose presence or absence reflects an environmental condition. [1]

. . . . . .

(c) Distinguish between richness and evenness as components of biodiversity. [1]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(Option C continues on the following page)

(Option C, question 13 continued)

(d) Explain how edge effects can influence biodiversity in a region. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(Option C continues on the following page)

(Option C continued)

14. Wisconsin Department of Natural Resources has issued guidelines to control invasive plants within the state. One mechanical method is to cut the plants down where they occur. However the time of year the plants are cut down is important in their control. The chart shows the months when it is recommended to cut down the plants and the months when they should not be cut down.

Black swallow-wort (*Cynanchum louiseae*)
[Source: Photo by Naomi Cappuccino, used with permission.]

Cypress spurge (*Euphorbia cyparissias*)
[Source: Aelita17: Photographer, Illustrator/Vector Artist, Ukraine/ Shutterstock.com]

Japanese stiltgrass (*Microstegium vimineum*)
[Source: James H. Miller & Ted Bodner, Southern Weed Science Society, Bugwood.org - https://en.wikipedia.org/wiki/Microstegium_vimineum#/media/File:Microstegium_viminium_specimen.jpg. Under CC BY 3.0 licence: https://creativecommons.org/licenses/by/3.0/deed.en]

Plant	May		June		July		August		September		October		November	
Black swallow-wort														
Cypress spurge														
Japanese stiltgrass														

Key: cut plants do not cut plants

[Source: adapted from http://dnr.wi.gov]

(a) State which plant can be cut in August. [1]

. . . . . .

(b) Suggest a reason for not cutting invasive plants at certain times of year. [1]

. . . . . .

. . . . . .

(Option C continues on the following page)

(Option C, question 14 continued)

(c) Outline reasons for controlling invasive plants. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

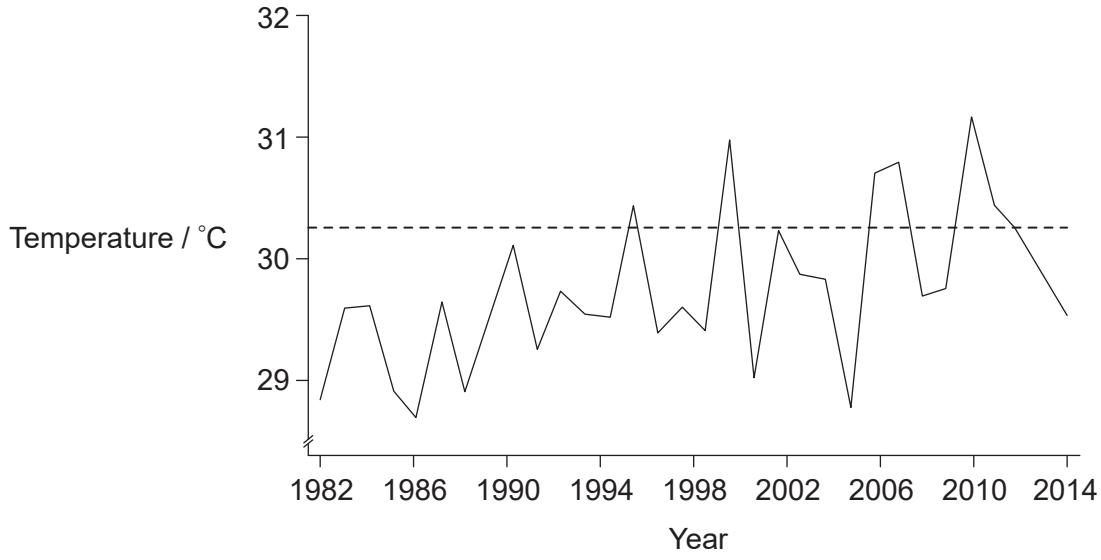
(d) Discuss what precautions should be taken before considering biological control of the invasive plants. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option C continues on the following page)

(Option C continued)

15. When water rises above a certain temperature, coral bleaching may occur. The coral expels *Zooxanthellae* algae living in its tissues, leaving the coral a white colour. The graph shows how the water temperature is changing in the coral reefs surrounding the Cayman Islands.



Key: —— sea surface temperature in September ----- coral bleaching threshold

[Source: Data from National Oceanographic Data Center, which is now incorporated into the NOAA.]

(a) State the trend in temperatures from 1982 to 2014. [1]

. . . . . .

. . . . . .

(Option C continues on the following page)

(Option C, question 15 continued)

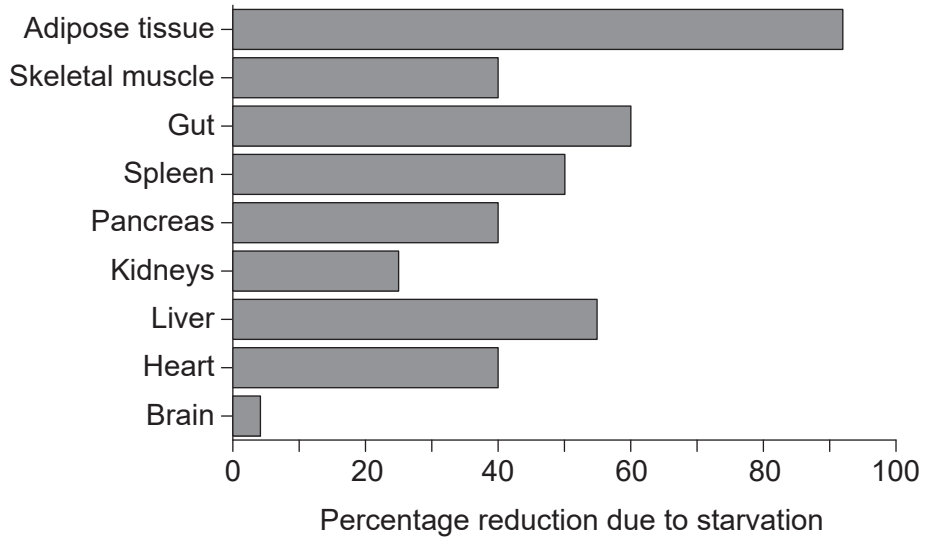
(b) Deduce the effect of bleaching on corals. [4]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

End of Option C

Option D — Human physiology

16. The bar chart shows the percentage loss of mass by various organs and tissues of the body of a person due to starvation. The overall body mass loss was 40 %.



[Source: © 2012, Company of Biologists. 'The evolution of human adiposity and obesity: where did it all go wrong?' Jonathan C. K. Wells *Disease Models & Mechanisms*, 2012(5), pp. 595--607; doi: 10.1242/dmm.009613 URL: http://dmm.biologists.org/content/5/5/595 Licence: https://creativecommons.org/licenses/by/4.0/]

(a) Outline how the data indicate that protein was being used as an energy source. [1]

. . . . . .

(b) Outline the reason for such a high percentage reduction in mass of adipose tissue. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Discuss whether the mass losses shown in the bar chart could be due to anorexia nervosa. [2]

. . . . . .

. . . . . .

. . . . . .

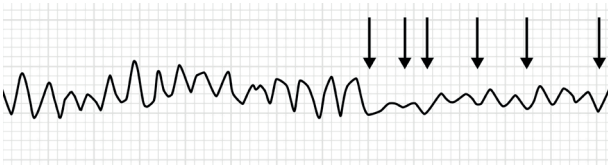
. . . . . .

(Option D continues on the following page)

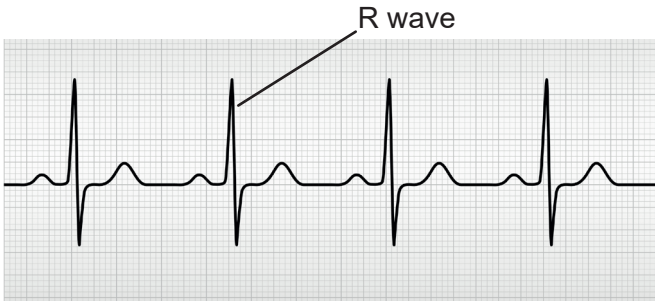
(Option D continued)

17. An electrocardiogram (ECG) records the electrical activity of the heart over a period of time using electrodes placed on the skin. The ECG shown is from a patient whose heart was beating irregularly until it was treated using a defibrillator (arrows) which restored normal electrical activity.

Before defibrillation



After defibrillation



[Source: 1st ECG: https://en.wikipedia.org/wiki/Heart_arrhythmia#/media/File:Ventricular_fibrillation.png CC BY-SA 3.0 licence, https://creativecommons.org/licenses/by-sa/3.0/ © 2012 by user: Jer5150 Cropped and reorientated by the IB in 2019
2nd ECG: linearcurves/iStock]

(a) State how many normal heartbeats are shown in the ECGs. [1]

. . . . . .

(b) Outline how a defibrillator is used to restore normal heartbeat. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Explain what is occurring in the heart during the peak of electrical activity as indicated by the R wave on the ECG. [2]

. . . . . .

. . . . . .

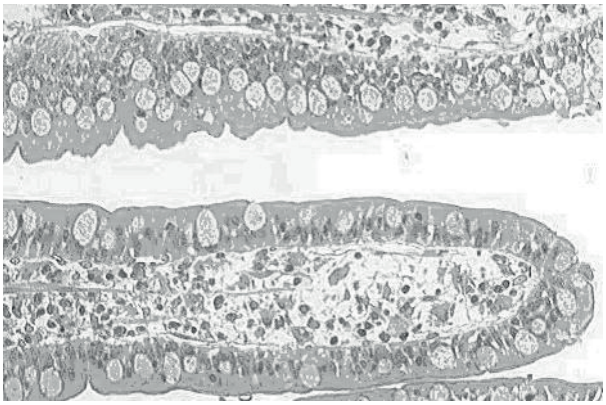
. . . . . .

. . . . . .

(Option D continues on the following page)

(Option D continued)

18. The image shows a section through the ileum as viewed under the light microscope.



[Source: https://en.wikipedia.org/wiki/Ileum#/media/File:Gobletcell.jpg © 2006 by user: Arcadian
Licence: https://creativecommons.org/licenses/by-sa/3.0/]

(a) On the diagram, label the epithelial cell layer. [1]

(b) Explain how the epithelial cells are adapted for absorption. [2]

. . . . . .

. . . . . .

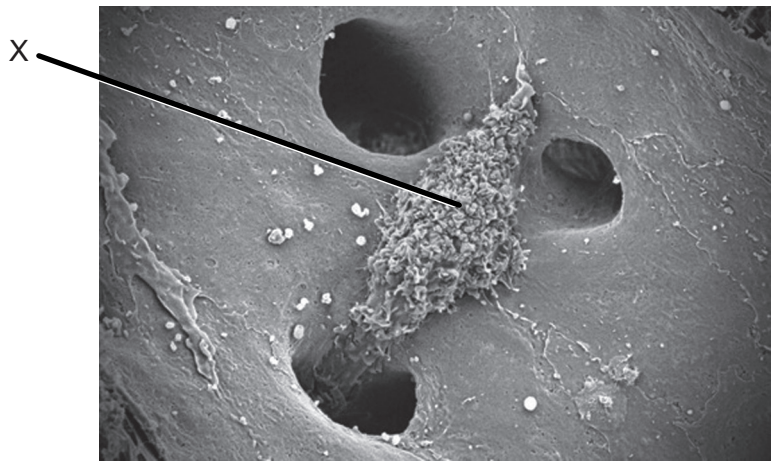
. . . . . .

. . . . . .

(Option D continues on the following page)

(Option D continued)

19. The scanning electron micrograph (SEM) shows a cell in the liver responsible for the breakdown of erythrocytes. The cells are found in the lining of the sinusoid walls.



[Source: Thomas Deerinck, NCMIR]

(a) (i) Identify cell X shown in the diagram. [1]

. . . . . .

(ii) Outline the role of the cell in recycling iron in the body. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option D continues on the following page)

(Option D, question 19 continued)

(b) Explain reasons for the dual blood supply to the liver. [4]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

End of Option D

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

Answers written on this page
will not be marked.

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

Answers written on this page
will not be marked.