Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 3

Thursday 15 November 2018 (morning)

1 hour 15 minutes

Candidate session number

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

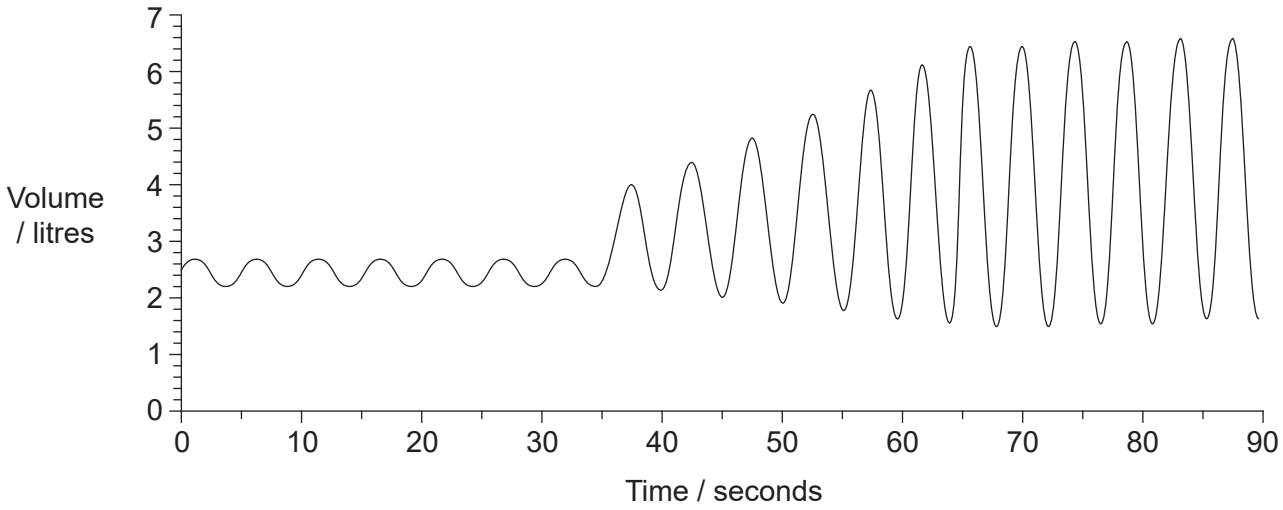
Section B	Questions
Answer all of the questions from one of the options.	
Option A — Neurobiology and behaviour	4 – 8
Option B — Biotechnology and bioinformatics	9 – 12
Option C — Ecology and conservation	13 – 17
Option D — Human physiology	18 – 21

8818–6003

Section A

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

1. 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.



[Source: © International Baccalaureate Organization 2018]

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

. . . . . .

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

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

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(This question continues on the following page)

(Question 1 continued)

(d) Outline the function of pneumocytes in the lungs. [2]

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

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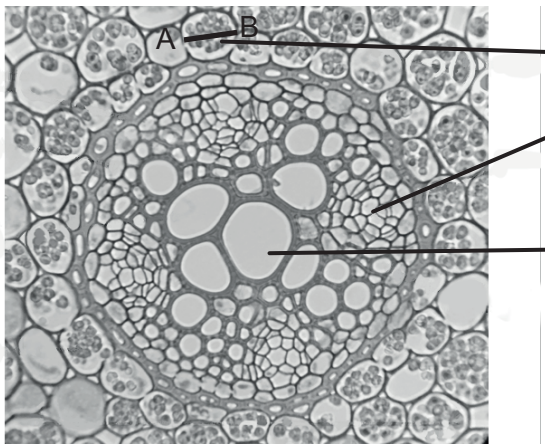
will not be marked.

2. The micrograph shows a section through the root of a dicotyledonous plant (×400).



[Source: © User: Sadierath / Wikimedia Commons / CC-BY-SA4.0
https://en.wikipedia.org/wiki/Root#/media/File:Ranunculus_Root_Cross_Section.png Relabelled by the IB]

(a) Label tissues X and Y. [2]

(b) Calculate the actual width along line A-B of the parenchyma cell shown. [1]

. . . . . μm

(c) Describe the distribution of vascular tissues in the **stem** of dicotyledonous plants. [2]

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3. 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

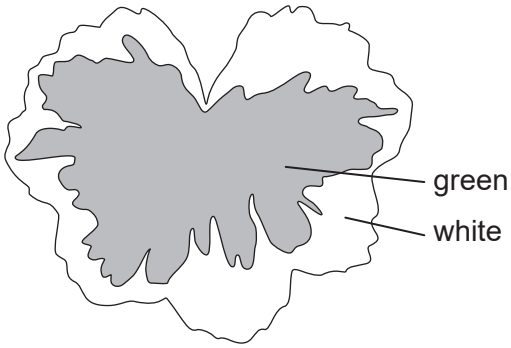

Figure 2

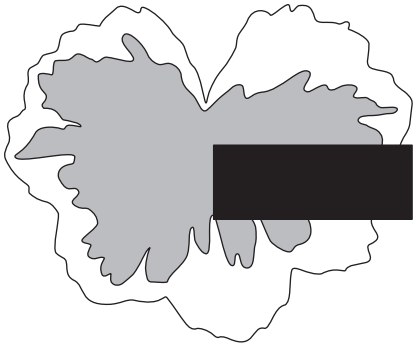

Figure 3

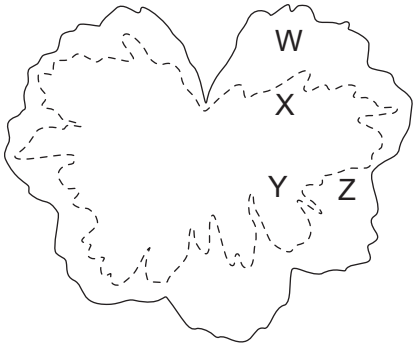

Figure 4

[Source: © International Baccalaureate Organization 2018]

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

. . . . . .

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

. . . . . .

(This question continues on the following page)

(Question 3 continued)

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

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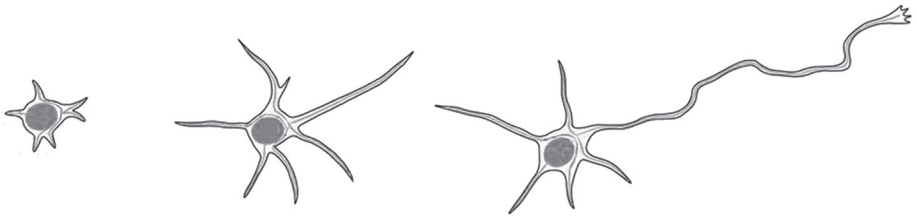
will not be marked.

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 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
© 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]

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

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

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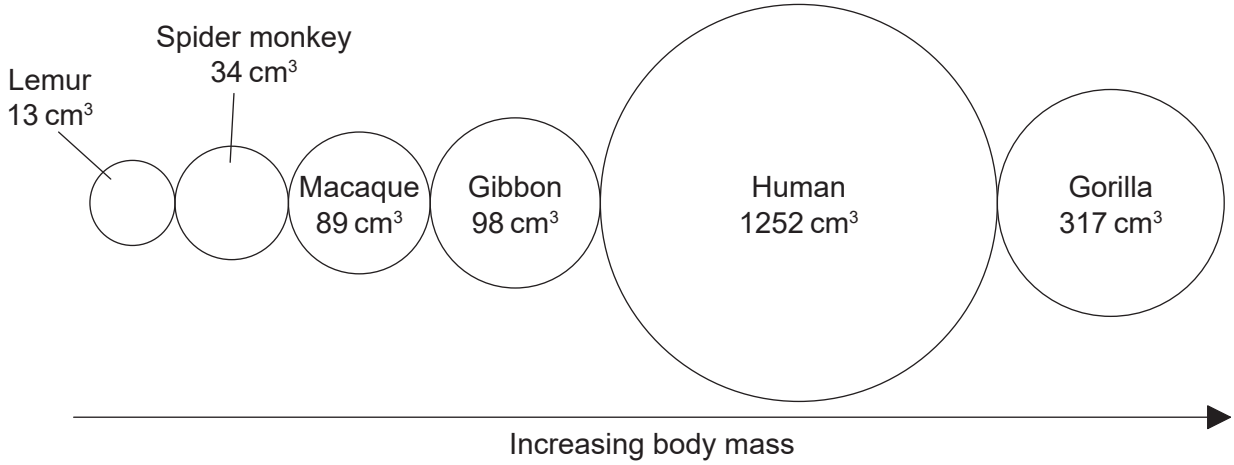
(Option A continues on the following page)

(Option A continued)

5. The diagram (not to scale) represents the average brain volume of six species of mammal. The mammals are arranged in rank order of body mass.



[Source: © International Baccalaureate Organization 2018]

(a) Compare and contrast the rank order of body mass and brain volume in the six species of mammals. [2]

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(b) Predict the difference that would be seen if the cerebral cortex of a human and a gorilla were compared. [1]

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(Option A continues on the following page)

(Option A, question 5 continued)

(c) State **one** function of each of the following areas of the brain.

(i) Broca's area [1]

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

(ii) Nucleus accumbens [1]

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

(iii) Medulla oblongata [1]

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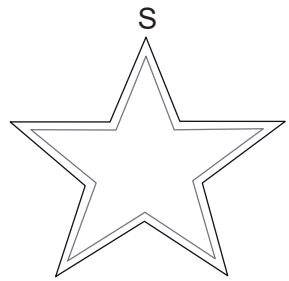
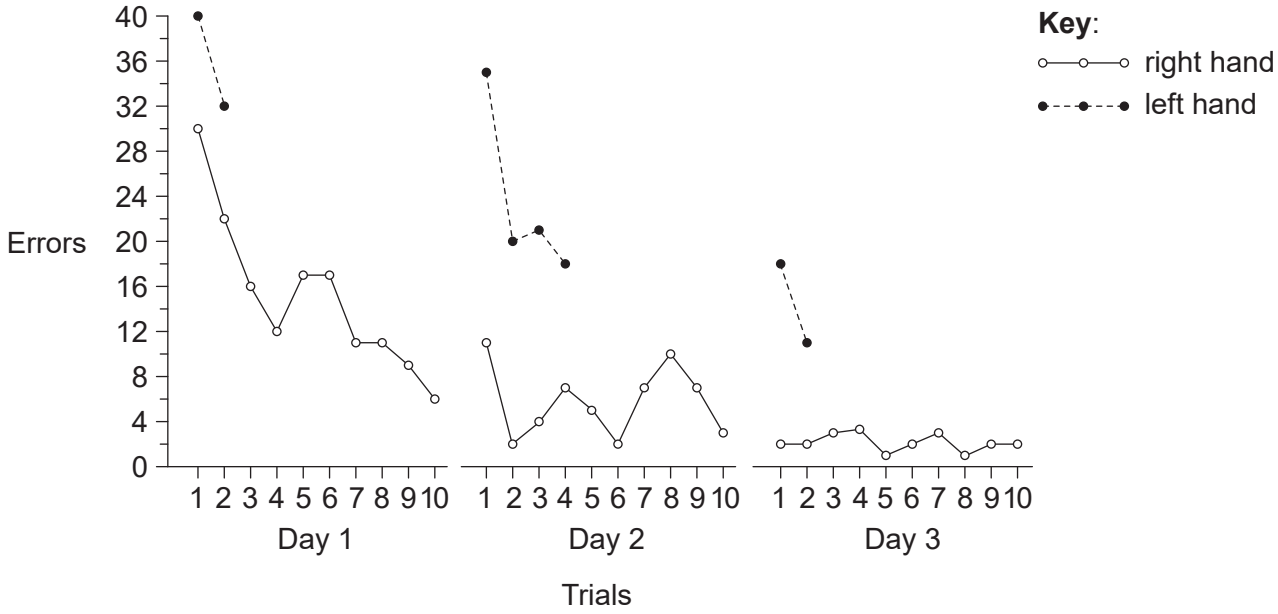
(Option A continues on the following page)

(Option A continued)

6. A patient was asked to trace a line between two guidelines of a star shape, starting at point S (see star image) while viewing the star in a mirror. The graph shows the number of times the patient strayed outside the boundaries while drawing the star in each trial for both hands.



(not drawn to full size)



[Source: Reprinted from *Neuron*, **20**(3), Brenda Milner, Larry R. Squire and Eric R. Kande, 'Cognitive neuroscience and the study of memory', pp. 445–468, Copyright (1998), with permission from Elsevier.]

(a) Outline how this experiment shows learned behaviour. [3]

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(Option A continues on the following page)

(Option A, question 6 continued)

(b) Deduce, with a reason, whether the patient is left-handed **or** right-handed. [1]

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(c) Define, with an example,

(i) operant conditioning. [2]

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

(ii) imprinting. [2]

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(d) Outline the effects of slow-acting neurotransmitters. [2]

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(Option A continues on the following page)

(Option A continued)

7. The drawing shows male and female Emperor birds of paradise (*Paradisaea guilielmi*) found in Papua New Guinea.

[Source: https://en.wikipedia.org/wiki/Emperor_bird-of-paradise#/media/File:Paradisaea_guilielmi_by_Bowdler_Sharpe.jpg
Licence: https://creativecommons.org/publicdomain/mark/1.0/deed.en]

Suggest how the external features and courtship behaviour of these birds of paradise affect reproductive success. [3]

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(Option A continues on the following page)

(Option A continued)

8. Explain how the eye detects stimuli and sends information to the brain. [6]

End of Option A

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

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will not be marked.

Option B — Biotechnology and bioinformatics

9. (a) Outline the characteristics which would indicate biofilm formation in *Bacillus subtilis*. [2]

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(b) The formation of hydrophobic concrete is an example of how biofilms can be useful. Outline **one** example where biofilms can cause environmental problems. [2]

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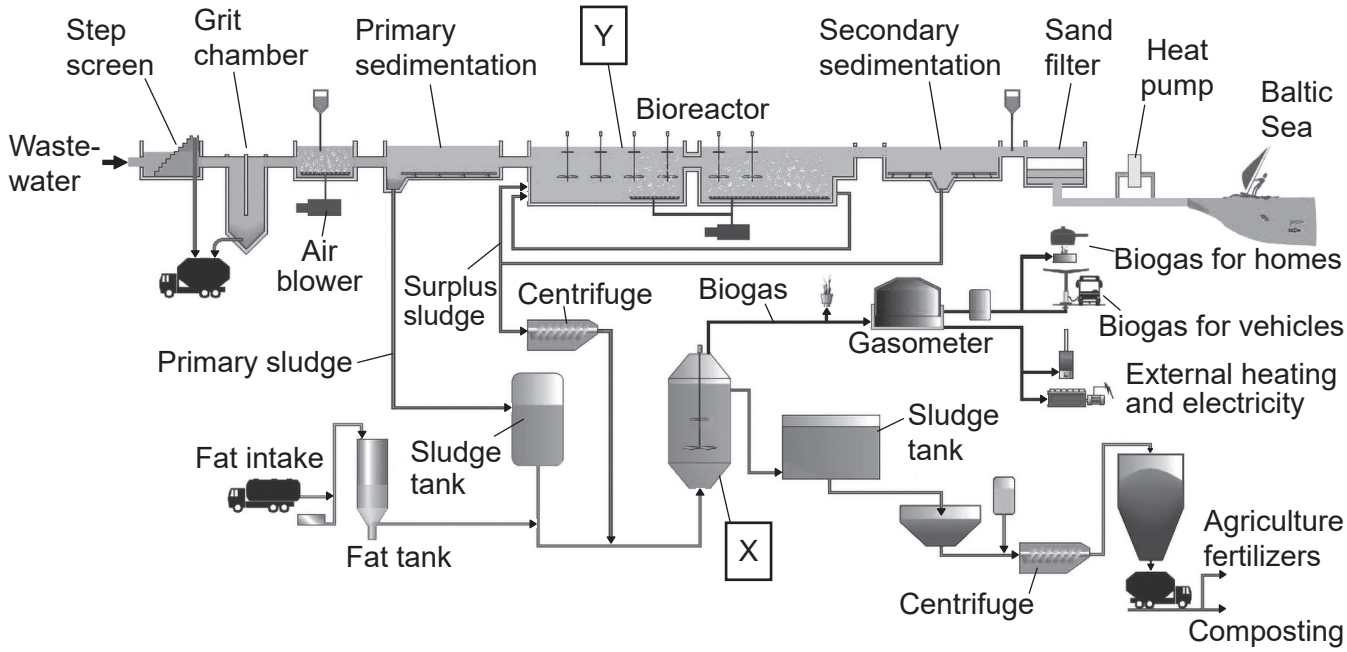
(Option B continues on the following page)

(Option B continued)

10. The diagram shows an overview of the Henriksdal wastewater treatment process in Stockholm, Sweden.



[Source: Stockholm Water Company and Dr Daniel Hellstrom: adapted from D Hellström, *et al.*, (2009), BIOGASMAX – Integrated Project No 019795, *Optimisation Activities at Stockholm Site – Status of Biogas Production at Henriksdal plant 2000–2005*, page 10]

(a) State a group of organisms that will be active in the fermenter labelled X. [1]

. . . . . .

(b) Deduce, with a reason, whether X is a continuous fermenter **or** a batch fermenter. [1]

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(Option B continues on the following page)

(Option B, question 10 continued)

(c) Probes are used to monitor significant variables within the fermenter. List **three** significant variables that should be monitored in the fermenter. [3]

1. . . . . .

2. . . . . .

3. . . . . .

(d) State the main component of biogas. [1]

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(e) Inside Y there are rotating paddles. Outline **two** reasons for these paddles being needed. [2]

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(Option B continues on the following page)

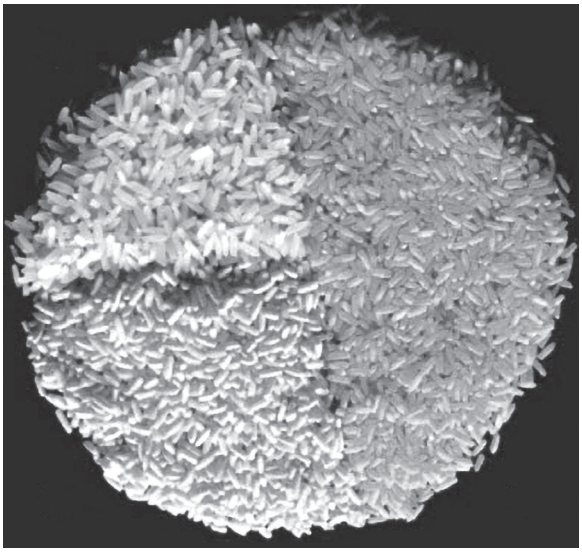
(Option B continued)

11. Golden rice (*Oryza sativa*, GR) is the generic name given to genetically modified rice that produces beta-carotene (provitamin A). Golden rice was created by transforming rice with the gene coding for the PSY protein (phytoene synthase) from daffodil (*Narcissus pseudonarcissus*) or from corn (*Zea mays*).

The picture shows variations of rice.

A White wild-type rice
B Yellow Golden rice expressing the gene coding for PSY from daffodil
C Orange Golden rice expressing the gene coding for PSY from corn

A



C

B

[Source: Reprinted from *TRENDS in Plant Science*,**10**(12), S. Al-Babili and P. Beyer, 'Golden Rice – five years on the road – five years to go?', pp. 565–573, Copyright (2005), with permission from Elsevier.]

(a) Outline how scientists would determine whether the gene coding for PSY from daffodils has been taken up successfully by rice DNA. [1]

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(Option B continues on the following page)

(Option B, question 11 continued)

(b) Discuss whether production of Golden rice is an example of biopharming. [2]

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(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]

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(Option B continues on the following page)

(Option B, question 11 continued)

(d) A bioinformatics analysis was performed on the protein PSY transcribed from the gene from corn and from daffodil to obtain the sequence alignment.

On the alignment, identify the longest part of the sequence where the consecutive amino acids are the same. [1]

```
Corn      ---MAIILVRAASP-------GLSAAD----------SISH-
Daffodil  ---MVVAILRVVSAIEIPIRLGFSEANWRFSSPKYDNLGRK
              *       *   *           *  *  *

Corn      QGTLQCSTLLKTKRPAARRWMPCSLLGLHPWEAGRP-SPAV
Daffodil  KSRLSVYSLYTTSKYA----------CVGFEAENNGKFLI
              *   *   *   *                **

Corn      YSSLPVNPAGEAVVSSEQKVYDVVLKQAALLKRQLRTP--V
Daffodil  RSSLVANPAGEATISSEQKVYDVVLKQAALVKDQTKSSRKS
            ***   *******   ******************  *  *

Corn      LDARPQDMDMPRN--GLKEAYDRCGEICEEYAKTFYLGTML
Daffodil  TDVKP-DIVLPGTVYLLKDAYDRCGEVCAEYAKTFYLGTLL
            *     *   *       **  ********  *  **********  *

Corn      MTEERRRAIWAIYVWCRRTDELVDGPNANYITPTALDRWEK
Daffodil  MTPERRRAIWAIYVWCRRTDELVDGHNASHITPSALDRWEA
          **  ************************  **   ***  ******

Corn      RLEDLFTGRPYDMLDAALSDTISRFPIDIQPFRDMIEGMRS
Daffodil  RLEDLFAGRPYDMFDAALSDTVSRFPVDIQPFMDMVEGMRM
          ******  ******  *******  ****  *****  **  ****

Corn      DLRKTRYNNFDELYMYCYYVAGTVGLMSVPVMGIATESKAT
Daffodil  DLKKSRYKNFDELYLYCYYVAGTVGLMSVPVMGIAPESLAE
          **  *  **  ******  ********************  **  *

Corn      TESVYSAALALGIANQLTNILRDVGEDARRGRIYLPQDELA
Daffodil  AESVYNAALALGIANQLTNILRDVGEDARRGRIYLPQDELA
            ****  ********************************

Corn      QAGLSDEDIFKGVVTNRWRNFMKRQIKRARMFFEEAERGVN
Daffodil  EAGLSDEDVFTGKVTDKWRSFMKRQIKRARTFFEQAEKGVT
            *******  *  *  **   **  **********  ***  **  **

Corn      ELSQASRWPVWASLLLYRQILDEIEANDYNNFTKRAYVGKG
Daffodil  ELSQASRWPVWASLLLYRQILDEIEANDYNNFTKRAYVSKV
          **********************************************  *

Corn      KKLLALPVAYGKSLLLPCSLRN---GQT
Daffodil  KRLAALPLAYGKSLLIPLSLRPPSLSKA
          *  *  ***  *******  *  ***
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[Source: © International Baccalaureate Organization 2018]

(Option B continues on the following page)

(Option B, question 11 continued)

(e) BLASTp was used to obtain the alignment of the genes coding for PSY. Outline reasons for BLASTn **not** being suitable for obtaining this alignment. [2]

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(f) In the alignment there are dashes (–) in some positions. Deduce what is indicated by these dashes. [3]

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(Option B continues on page 25)

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will not be marked.

(Option B continued)

12. Explain **two** or more laboratory tests that can be used to detect the presence of specific pathogens in patients with an infectious disease. [6]

End of Option B

Option C — Ecology and conservation

13. 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]

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(Option C continues on the following page)

(Option C, question 13 continued)

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

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

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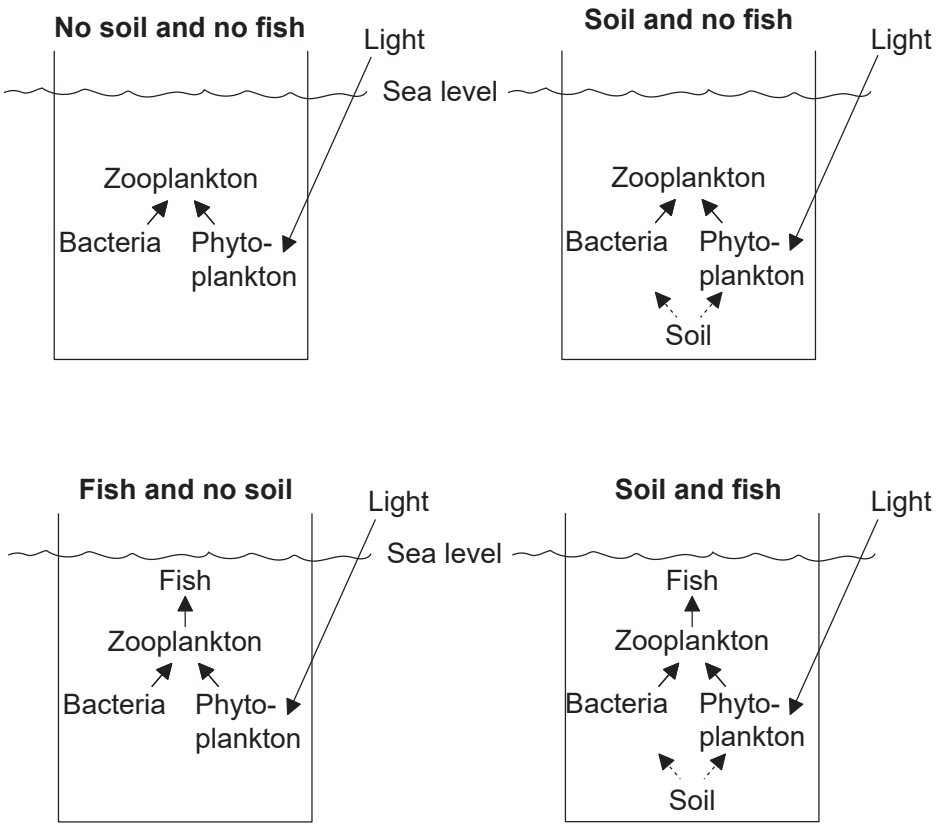
(Option C continues on the following page)

(Option C continued)

14. An investigation into food web interactions was conducted in mesocosms in the Mediterranean Sea, off the coast of France. The effects of the addition of soil and fish on bacterial populations were tested.



[Source: adapted from Junwen Guo, Project of Umeå University, Faculty of Science and Technology, Department of Ecology and Environmental Sciences (Arcum)]

(a) Each of the mesocosms is an open ecosystem. State the property that makes the mesocosms open ecosystems. [1]

. . . . . .

(b) Assuming that the populations of bacteria are under bottom-up control, identify the mesocosms in which the bacterial populations will be highest. [1]

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(Option C continues on the following page)

(Option C, question 14 continued)

(c) Outline top-down effects on the bacteria in the four mesocosms. [2]

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(d) Suggest advantages of undertaking this experiment in the sea rather than in the laboratory. [2]

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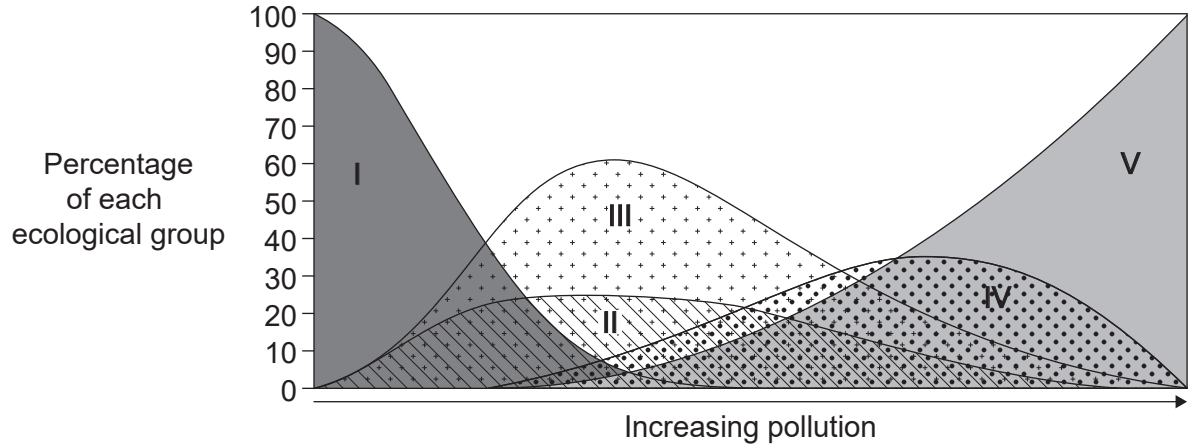
(Option C continues on the following page)

(Option C continued)

15. The graph shows a theoretical model that divides species into five ecological groups (I to V) related to the degree of tolerance to an increasing pollution gradient.



[Source: Reprinted from *Marine Pollution Bulletin*, **40**, A. Borja, J. Franco and V. Perez, 'A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments', pp. 1100–1114, Copyright (2000), with permission from Elsevier.]

(a) Identify the group that is most intolerant to pollution. [1]

. . . . . .

(b) The biotic index is calculated using the formula shown.

$$BI = \frac{\Sigma(n_i \times a_i)}{N}$$

Deduce the meaning of n_i and a_i in this formula.

(i) n_i [1]

. . . . . .

(ii) a_i [1]

. . . . . .

(Option C continues on the following page)

(Option C, question 15 continued)

(c) Outline how organisms in Group V could be used to measure pollution in an environment. [3]

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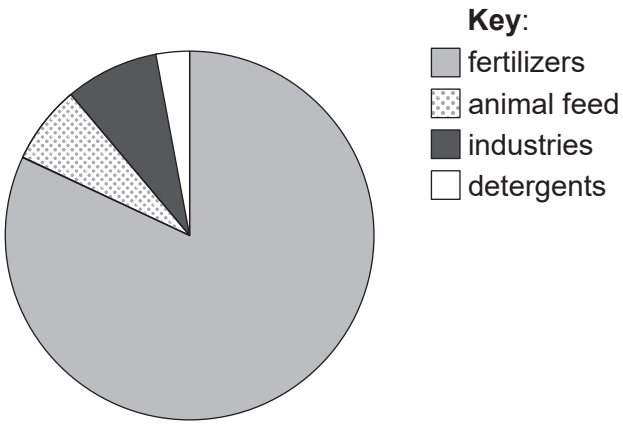
(Option C continues on the following page)

(Option C continued)

16. The pie chart shows the world demand for phosphorus in 2010. The fraction used as detergents and in industries has decreased in recent years in response to evidence that phosphate pollution of surface waters causes eutrophication.



[Source: adapted from J J Schroeder, *et al.*, (2010), EU Tender ENV.B.1/ETU/2009/0025, page 19]

(a) Describe reasons that the availability of phosphates may become limiting to agriculture in the future. [3]

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(b) Explain how eutrophication can occur from the excessive use of phosphates. [3]

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(Option C continues on the following page)

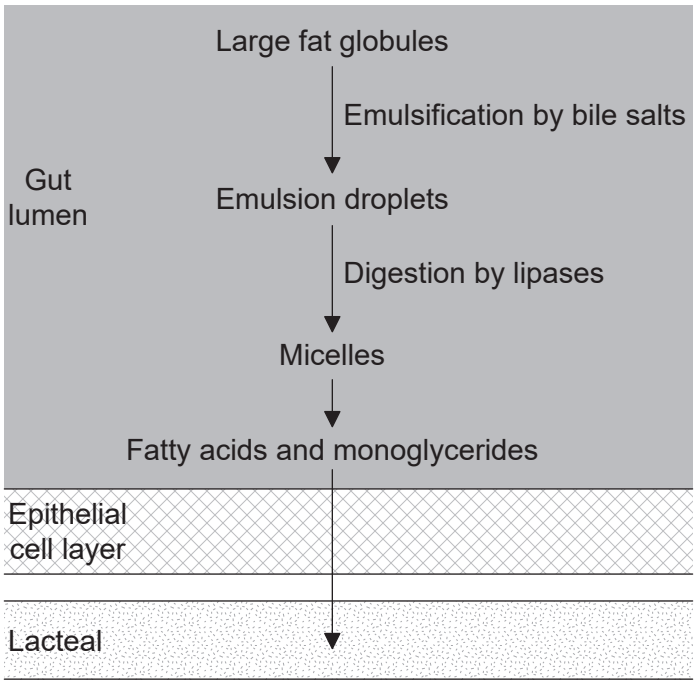
(Option C continued)

17. Explain how an ecological community structure could be affected by the removal of a keystone species. [6]

End of Option C

Option D — Human physiology

18. The diagram shows the emulsion and absorption of a fat globule in the gut.



[Source: © International Baccalaureate Organization 2018]

(a) State the organ in the digestive system where this process is taking place. [1]

. . . . . .

(b) Explain how components of bile are produced by the liver. [3]

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(Option D continues on the following page)

(Option D, question 18 continued)

(c) Outline a function of fats in the body. [1]

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. . . . . .

(d) Explain how epithelial cells in the gut are adapted for absorption. [2]

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

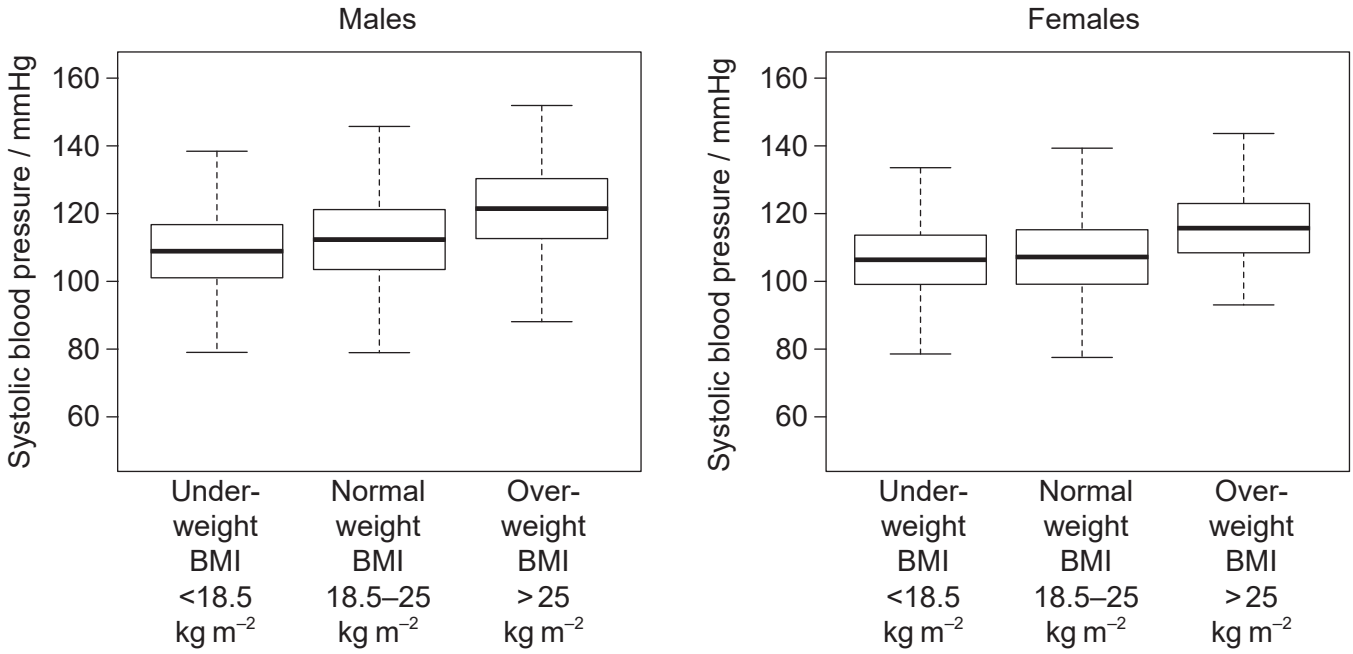
(e) In order to compare the absorption of fat and of glucose in the digestive system, state in the table, using yes **or** no, whether the processes occur. [3]

Process	Fat	Glucose
Transported in micelles		
Absorption mostly into lacteals		
Transported from gut in blood		

(Option D continues on the following page)

(Option D continued)

19. The mean systolic blood pressure and body mass index (BMI) of many individuals were measured. The results are displayed in the box plot.



[Source: Reprinted from *Obesity Research & Clinical Practice*, **9**(2), Noritaka Kawada, Kaori Nakanishi, Tohru Ohama, Makoto Nishida, Keiko Yamauchi-Takihara and Toshiki Moriyama, 'Gender differences in the relationship between blood pressure and body mass index during adolescence', pp. 141–151, Copyright (2015), with permission from Elsevier.]

(a) Compare and contrast the relationship between BMI and systolic blood pressure in males and females. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(Option D continues on the following page)

(Option D, question 19 continued)

(b) (i) Outline the relationship between systolic blood pressure and hypertension. [1]

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

(ii) State **two** effects hypertension can have on the circulatory system. [2]

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

(c) State how blood pressure and heart rate can be measured. [2]

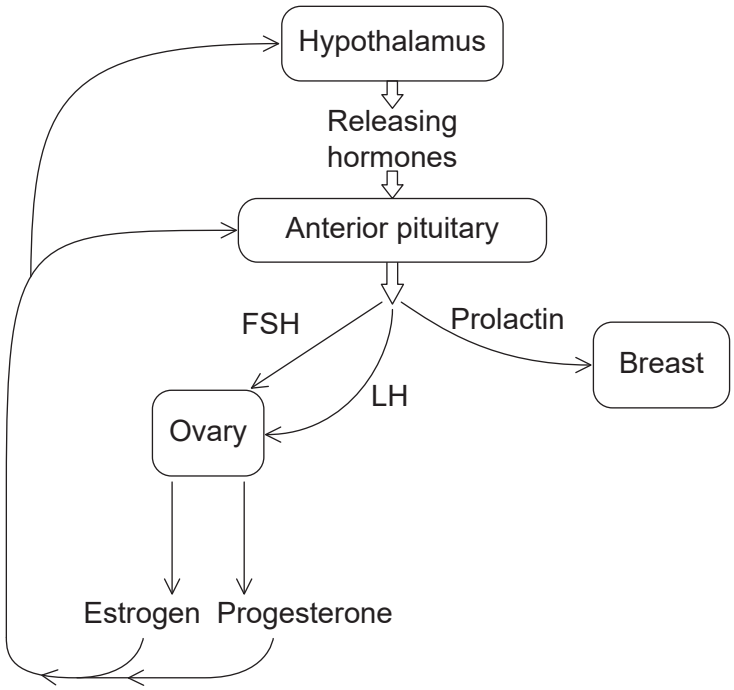
Blood pressure: . . . . . .
. . . . . .

Heart rate: . . . . . .
. . . . . .

(Option D continues on the following page)

(Option D continued)

20. The diagram shows part of the control of the pituitary gland by the hypothalamus and, at the same time, the control of secretion in the breasts and the ovary by the pituitary gland.



[Source: © International Baccalaureate Organization 2018]

(a) Using the diagram, identify

(i) an organ containing an exocrine gland. [1]

. . . . . .

(ii) a hormone involved in the development of a follicle. [1]

. . . . . .

(iii) a steroid hormone. [1]

. . . . . .

(Option D continues on the following page)

(Option D, question 20 continued)

(b) State **two** effects of prolactin. [2]

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

(c) List **two** hormones produced by the posterior pituitary gland. [2]

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

(Option D continues on the following page)

(Option D continued)

21. Explain how the pH of blood is kept constant during exercise. [6]

End of Option D