

© International Baccalaureate Organization 2023

All rights reserved. No part of this product may be reproduced in any form or by any electronic or mechanical means, including information storage and retrieval systems, without the prior written permission from the IB. Additionally, the license tied with this product prohibits use of any selected files or extracts from this product. Use by third parties, including but not limited to publishers, private teachers, tutoring or study services, preparatory schools, vendors operating curriculum mapping services or teacher resource digital platforms and app developers, whether fee-covered or not, is prohibited and is a criminal offense.

More information on how to request written permission in the form of a license can be obtained from <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

© Organisation du Baccalauréat International 2023

Tous droits réservés. Aucune partie de ce produit ne peut être reproduite sous quelque forme ni par quelque moyen que ce soit, électronique ou mécanique, y compris des systèmes de stockage et de récupération d'informations, sans l'autorisation écrite préalable de l'IB. De plus, la licence associée à ce produit interdit toute utilisation de tout fichier ou extrait sélectionné dans ce produit. L'utilisation par des tiers, y compris, sans toutefois s'y limiter, des éditeurs, des professeurs particuliers, des services de tutorat ou d'aide aux études, des établissements de préparation à l'enseignement supérieur, des fournisseurs de services de planification des programmes d'études, des gestionnaires de plateformes pédagogiques en ligne, et des développeurs d'applications, moyennant paiement ou non, est interdite et constitue une infraction pénale.

Pour plus d'informations sur la procédure à suivre pour obtenir une autorisation écrite sous la forme d'une licence, rendez-vous à l'adresse <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

© Organización del Bachillerato Internacional, 2023

Todos los derechos reservados. No se podrá reproducir ninguna parte de este producto de ninguna forma ni por ningún medio electrónico o mecánico, incluidos los sistemas de almacenamiento y recuperación de información, sin la previa autorización por escrito del IB. Además, la licencia vinculada a este producto prohíbe el uso de todo archivo o fragmento seleccionado de este producto. El uso por parte de terceros —lo que incluye, a título enunciativo, editoriales, profesores particulares, servicios de apoyo académico o ayuda para el estudio, colegios preparatorios, desarrolladores de aplicaciones y entidades que presten servicios de planificación curricular u ofrezcan recursos para docentes mediante plataformas digitales—, ya sea incluido en tasas o no, está prohibido y constituye un delito.

En este enlace encontrará más información sobre cómo solicitar una autorización por escrito en forma de licencia: <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

Biology
Standard level
Paper 3

17 May 2023

Zone A afternoon | **Zone B** morning | **Zone C** afternoon

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

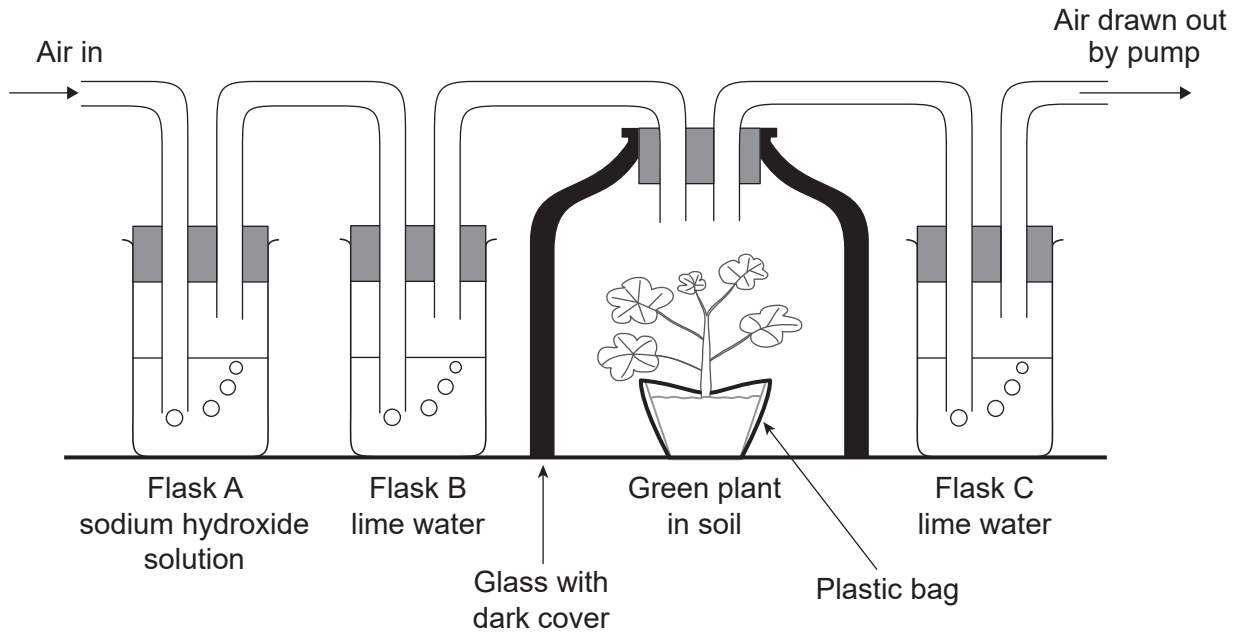
Section B	Questions
Answer all of the questions from one of the options.	
Option A — Neurobiology and behaviour	4 – 7
Option B — Biotechnology and bioinformatics	8 – 11
Option C — Ecology and conservation	12 – 15
Option D — Human physiology	16 – 19



Section A

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

1. An experiment on aerobic respiration was performed using a plant in a pot containing fertile soil. The apparatus was set up as shown in the diagram. Sodium hydroxide and limewater (calcium hydroxide) are both alkaline solutions. Limewater goes cloudy when carbon dioxide is bubbled into it.



- (a) State the purpose of lime water in flask B. [1]

.....
.....

- (b) Suggest a reason that the pot was covered with a plastic bag. [1]

.....
.....

- (c) Suggest a suitable control for this experiment. [1]

.....
.....

(This question continues on the following page)



(Question 1 continued)

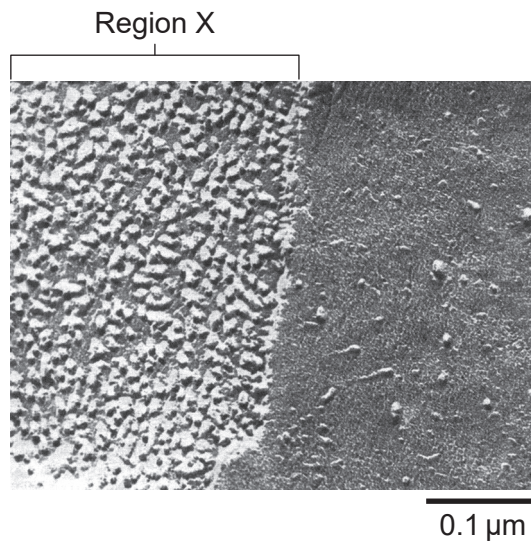
- (d) The same apparatus was used in another experiment, but the potted plant was exposed to light. Predict with a reason the results for lime water in flask C after one hour. [1]

.....

.....



2. The electron micrograph shows the surface membrane of an animal cell.



(a) State the technique used to obtain this electron micrograph. [1]

.....
.....

(b) Using the scale, calculate the magnification of the image. [1]

.....
.....

(c) Identify the type of molecule that can be seen at region X. [1]

.....
.....

(d) Outline the reason that images such as this falsified the Davson-Danielli model. [1]

.....
.....

(This question continues on the following page)



(Question 2 continued)

- (e) Explain the reason that animal cells and tissues under investigation must be maintained in solutions with the same osmolarity.

[3]

.....

.....

.....

.....

.....

.....

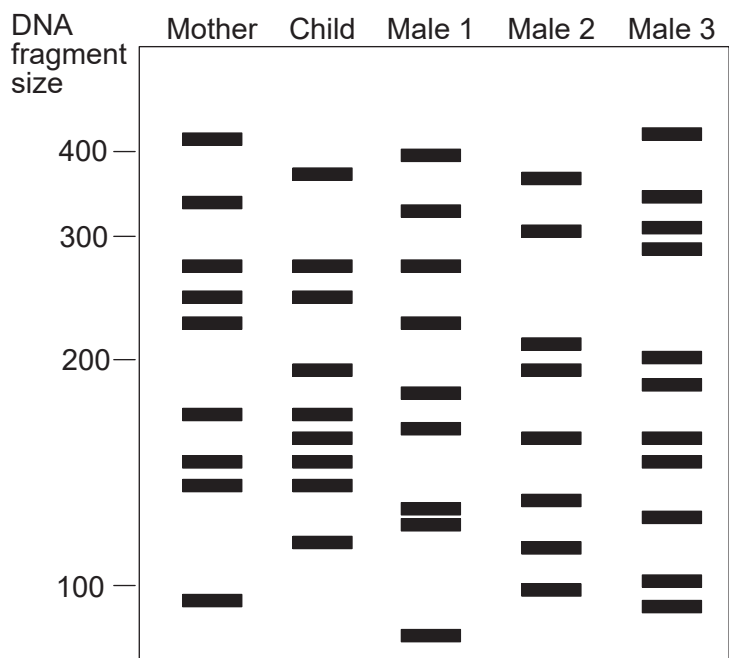


Please **do not** write on this page.

Answers written on this page
will not be marked.



3. DNA samples of a child, his mother and three males were studied in order to determine paternity. The diagram is a simplified version of the DNA profiles obtained in the study.



(a) State

(i) where the DNA of each individual could be taken from.

[1]

.....
.....

(ii) how the DNA is amplified.

[1]

.....
.....

(b) Deduce with a reason the identity of the father.

[2]

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



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. Scientists studied the potential use of stem cell therapy to maximize recovery of brain function after a stroke. A brain stroke was induced in small mammals. Two months after the stroke, the brains of one group of mammals received a transplant of stem cells from their own bone marrow and a control group did not receive a transplant. The graph shows the level of neurological damage in the mammals, measured before and after the transplant.

Graph and questions (a) and (b)
removed for copyright reasons

(a)

[1]

.....
.....

(b)

[1]

.....
.....

(Option A continues on the following page)



(Option A, question 4 continued)

(c) Suggest an advantage of using animal experiments to identify the role of brain parts. [1]

.....
.....

(d) Describe how fMRI can be used to assess brain function. [2]

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

(Option A continues on the following page)

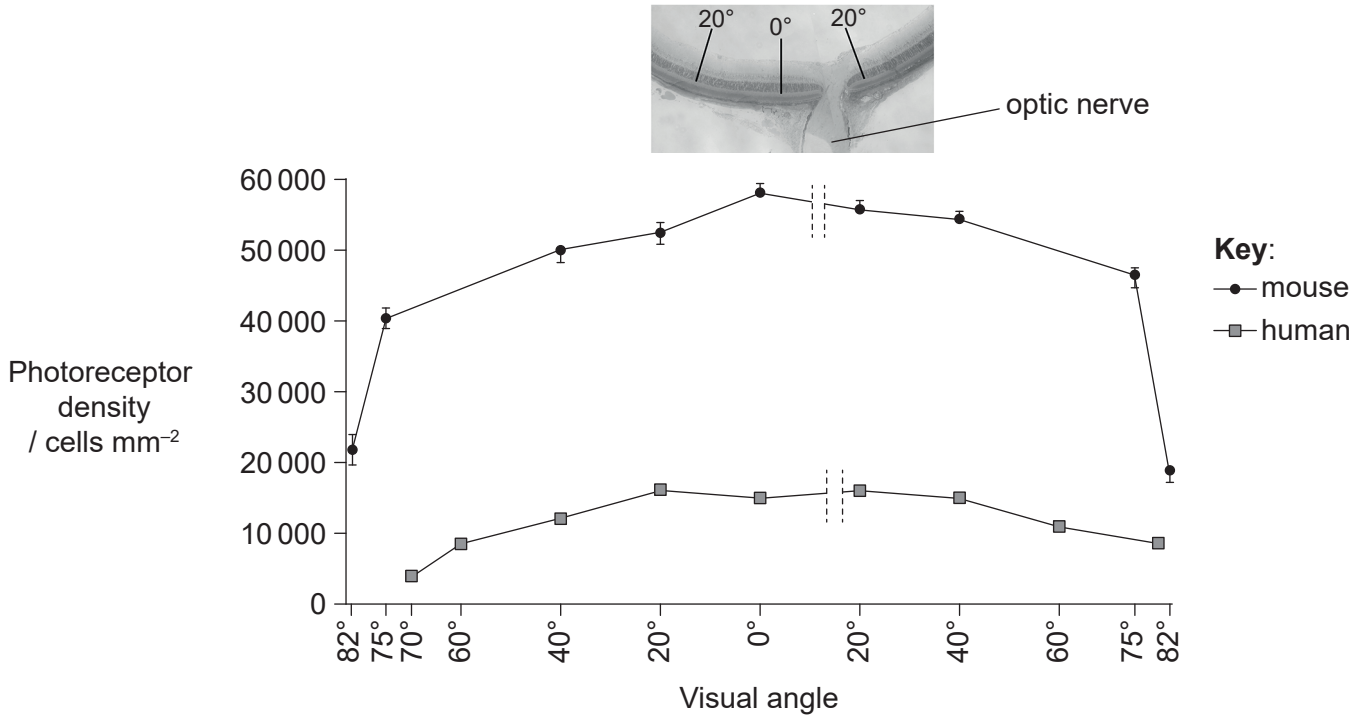


28EP09

Turn over

(Option A continued)

5. The graph shows the distribution of photoreceptors in the retinas of humans and mice. Distances from the centre of the retina (0°) are expressed as visual angles. The image shows the position of the optic nerve.



- (a) Outline **one** reason that no data is shown at the position of the optic nerve. [1]

.....

.....

- (b) Suggest whether the data in the graph shows that mice have better colour vision than humans. [2]

.....

.....

.....

.....

(Option A continues on the following page)



(Option A, question 5 continued)

- (c) Outline the role of bipolar cells in the retina. [2]

.....

.....

.....

.....

- (d) Distinguish between chemoreceptors and mechanoreceptors, including an example of each. [2]

.....

.....

.....

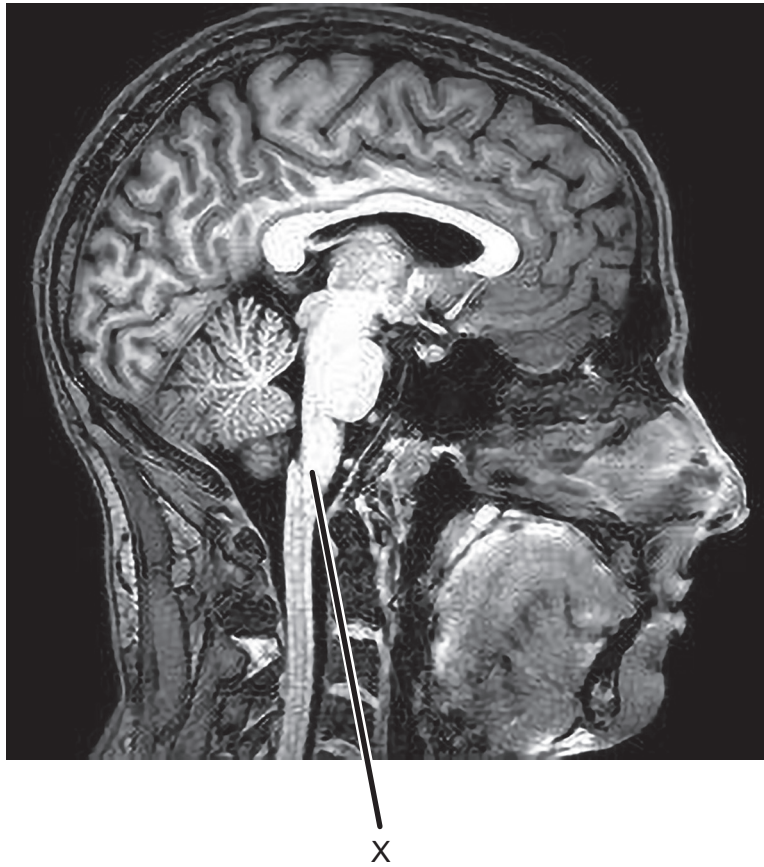
.....

(Option A continues on the following page)



(Option A continued)

6. The fMRI scan shows a human brain.



- (a) On the diagram, label the cerebellum. [1]
- (b) Explain control of breathing rate by the structure labelled X. [3]

.....

.....

.....

.....

.....

.....

(Option A continues on the following page)



(Option A continued)

7. Explain how neurons develop in embryonic tissue to allow communication.

[4]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

End of Option A

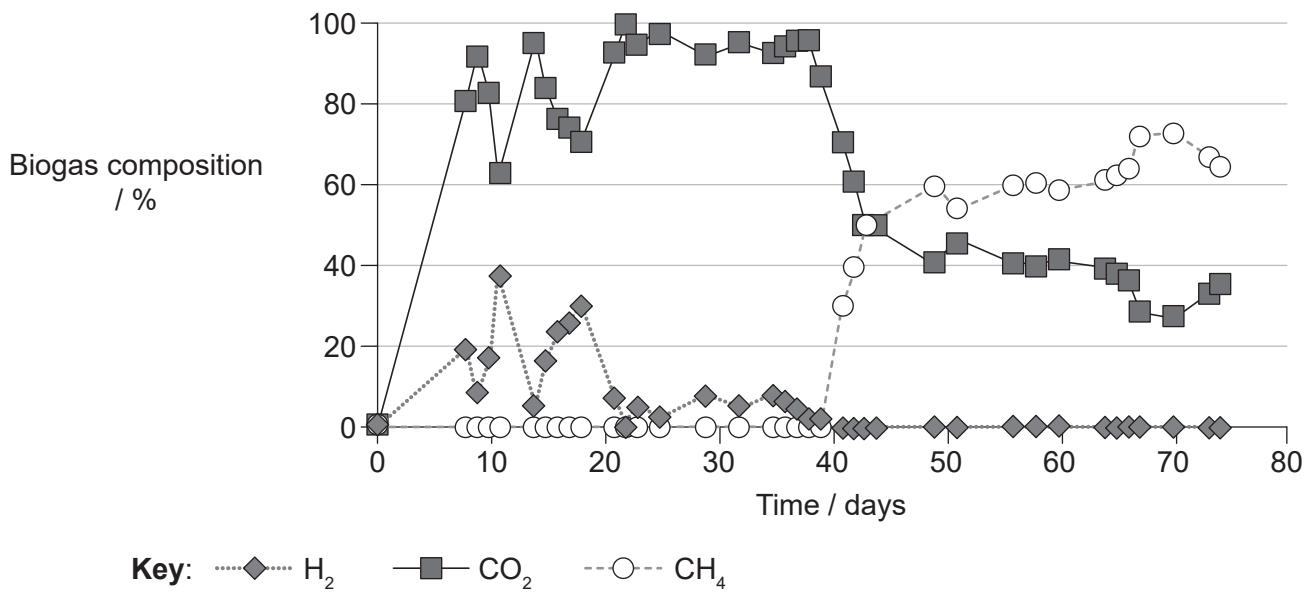


28EP13

Turn over

Option B — Biotechnology and bioinformatics

8. The graph shows the changes in the composition of biogas inside a fermenter.



(a) Explain the changes in biogas composition from day 40. [3]

.....

.....

.....

.....

.....

.....

(b) State **one** source of organic matter that can be used to produce biogas. [1]

.....

(c) Solid and liquid waste are generated during biogas production. State how this waste can be used. [1]

.....

.....

(Option B continues on the following page)

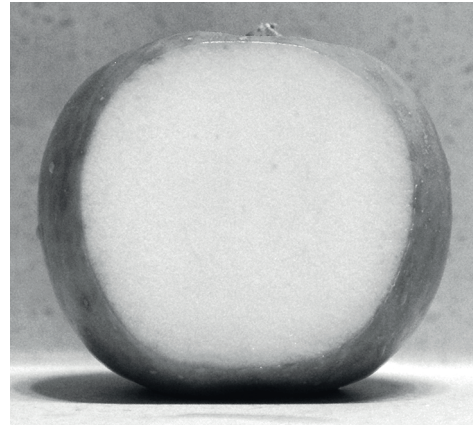


(Option B continued)

9. When apples are damaged or cut, exposure to oxygen causes the enzyme polyphenol oxidase (PPO) to oxidize polyphenols in the apple, a reaction that leads to the flesh becoming brown. Scientists have developed transgenic apples in which browning does not occur.



Normal apple



Transgenic apple

- (a) Suggest a reason for browning not occurring in the transgenic apple. [1]

.....
.....

- (b) A marker gene in transgenic apples produces a protein called NPTII. Outline the role of marker genes. [1]

.....
.....

- (c) Describe how electroporation can be used to produce transgenic plants. [2]

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

(Option B continues on the following page)



(Option B, question 9 continued)

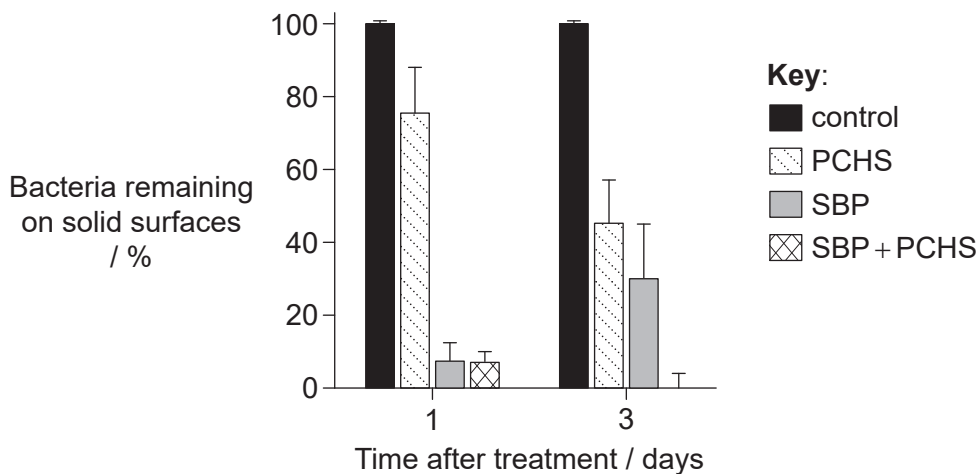
- (d) Herbicide-resistant GM crops have been blamed for causing several environmental problems in the last few decades. Some weeds now have tolerance to herbicides. Suggest how this might have occurred. [1]

.....

.....

10. The effectiveness of three different treatments for killing the pathogenic bacterium *Staphylococcus aureus* found on solid surfaces was assessed. Each treatment contained a probiotic cleaning hygiene system (PCHS), specific bacteriophages alone (SBP), or a combination of both (SBP+PCHS). A control was set up using water.

The bar chart shows the percentage of *S. aureus* remaining on solid surfaces at two different times after applying the treatments and the control.



- (a) Deduce with a reason the most efficient treatment to eliminate *S. aureus* from solid surfaces. [1]

.....

.....

(Option B continues on the following page)



(Option B, question 10 continued)

- (b) *S. aureus* often forms biofilms in water systems together with *Pseudomonas aeruginosa*. Outline the benefits of using bacteriophages rather than chemicals to eliminate biofilms from water systems. [2]

.....

.....

.....

.....

- (c) Describe how *Pseudomonas* can be used to reduce pollution caused by methyl mercury. [3]

.....

.....

.....

.....

.....

.....

- 11. Microorganisms are used in industry for making a range of products. Explain the reasons that conditions must be carefully controlled inside fermenters for optimal production. [4]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

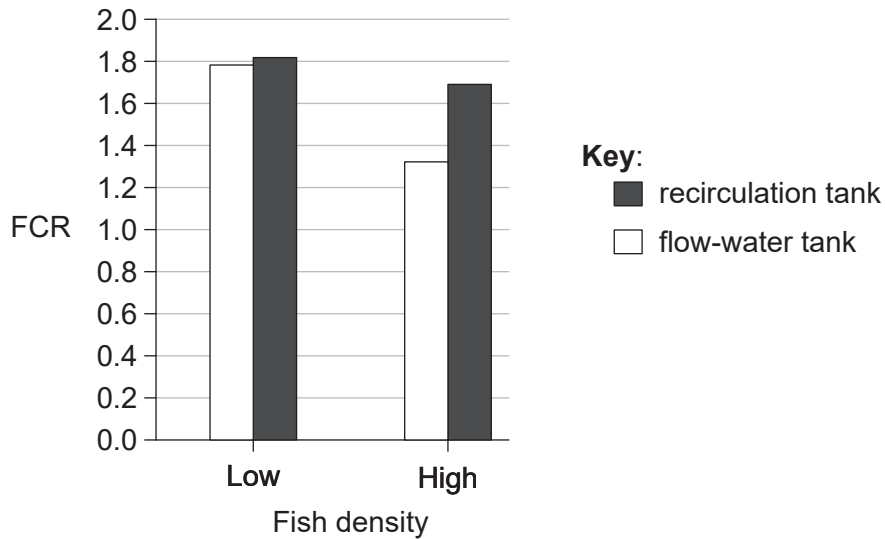
.....

End of Option B



Option C — Ecology and conservation

12. The feed conversion ratio (FCR) of grouper fish, *Epinephelus coioides*, was compared at two different fish densities in two types of tanks over a period of 10 weeks. The recirculation tank reused the same water, which was constantly purified. The flow-water tank had a continuous flow of clean water.



(a) State the effect of increasing fish density on feed conversion ratios. [1]

.....

.....

(b) Evaluate the rearing of grouper fish as food for humans at high density using recirculation tanks rather than water-flow tanks. [3]

.....

.....

.....

.....

.....

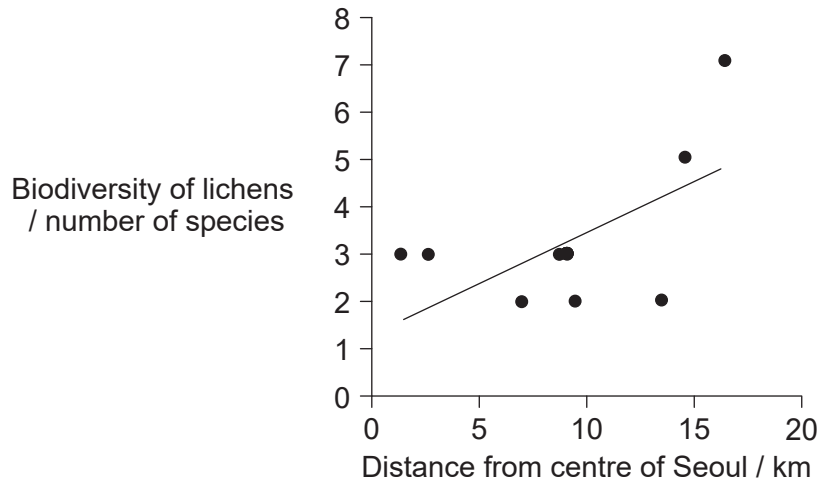
.....

(Option C continues on the following page)



(Option C continued)

13. Scientists examined the distribution of lichen species in Seoul, South Korea. The line graph shows the number of lichen species found on the bark of trees in green areas at different distances from the city centre.



- (a) Describe the trend in the distribution of lichen species. [1]

.....

.....

- (b) Explain how lichens can be used as indicator species. [3]

.....

.....

.....

.....

.....

.....

(Option C continues on the following page)



(Option C, question 13 continued)

- (c) Describe a method that can be used to measure the diversity of herbaceous plants in one of the green areas at different distances from the main road. [3]

.....

.....

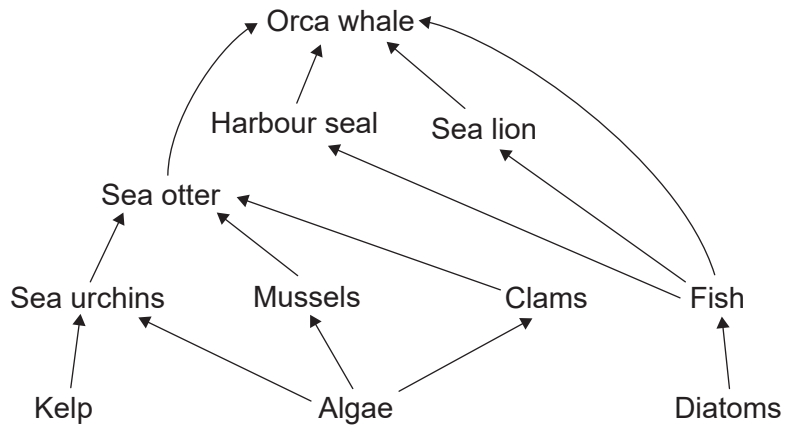
.....

.....

.....

.....

14. The diagram shows a simplified marine food web in an area of the North Pacific Ocean.



(a) Identify the

- (i) trophic level of sea lions. [1]

.....

.....

- (ii) type of interspecific relationship between orca whales and sea otters. [1]

.....

.....

(Option C continues on the following page)



(Option C, question 14 continued)

- (b) *Ex situ* conservation measures are being introduced due to a rapid decline in sea otter populations. Describe the advantages of *ex situ* conservation. [2]

.....

.....

.....

.....

- (c) A pyramid of energy can be constructed to show energy flows in this food web. Outline **one** limitation of these pyramids. [1]

.....

.....

- 15. Explain the consequences of plastic pollution in marine environments. [4]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

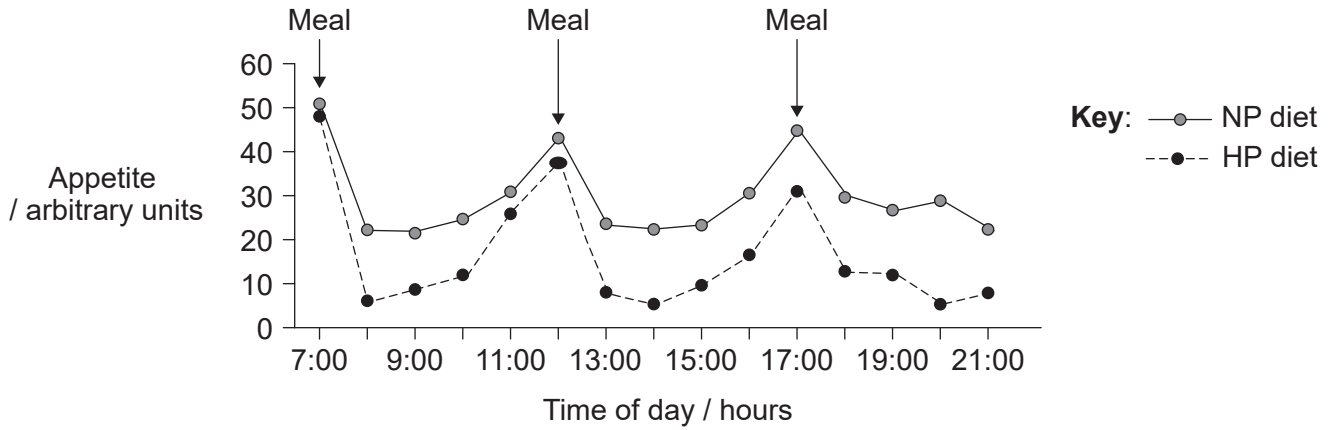
.....

End of Option C



Option D — Human physiology

16. Doctors investigated the effect of diets with different protein content on appetite for food in overweight males. One group followed a diet with normal protein (NP group) and a second group followed a diet with high protein (HP group). Participants were asked to record their perceptions of appetite every hour during 15 waking hours.



(a) Identify the effect on appetite of changing from an NP diet to an HP diet. [1]

.....

.....

(b) Outline the control of appetite by the brain. [2]

.....

.....

.....

.....

(Option D continues on the following page)



(Option D, question 16 continued)

- (c) Explain the reason that a protein-rich diet would not be recommended to obese adults suffering from phenylketonuria (PKU).

[3]

.....

.....

.....

.....

.....

.....

(Option D continues on the following page)

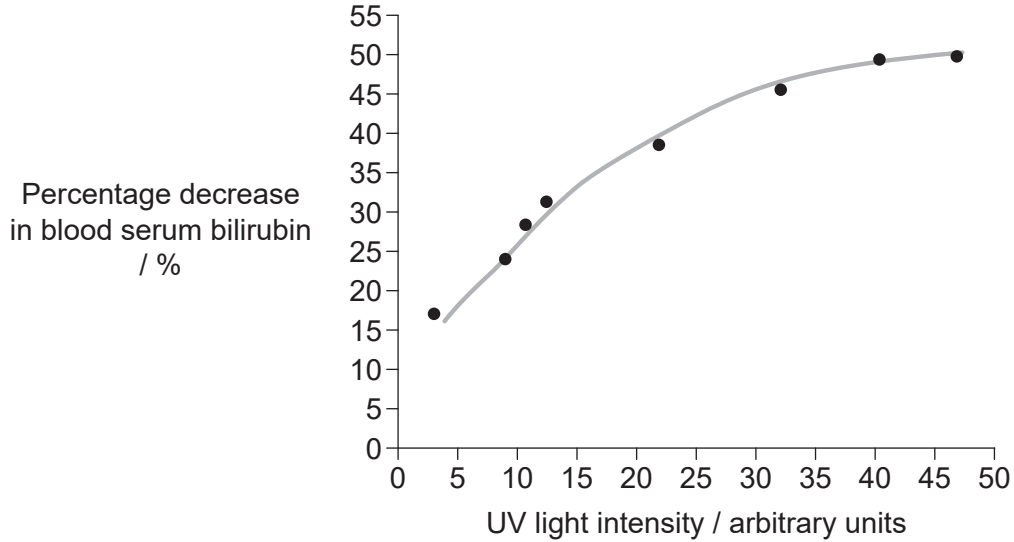


28EP23

Turn over

(Option D continued)

17. Newborn babies showing signs of jaundice can be treated with ultraviolet (UV) light. The graph shows the percentage decrease in blood serum bilirubin levels in these babies after 24-hour exposure to different ultraviolet (UV) light intensities.



- (a) Deduce the relationship between blood serum bilirubin levels and UV light intensity. [1]

.....
.....

- (b) State **one** long-term consequence of jaundice in newborn babies if this condition is not treated. [1]

.....

- (c) Outline **two** ways in which blood nutrient levels are regulated by the liver. [2]

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

(Option D continues on the following page)



(Option D, question 17 continued)

(d) Distinguish between liver sinusoids and capillaries.

[1]

.....

.....

(Option D continues on the following page)

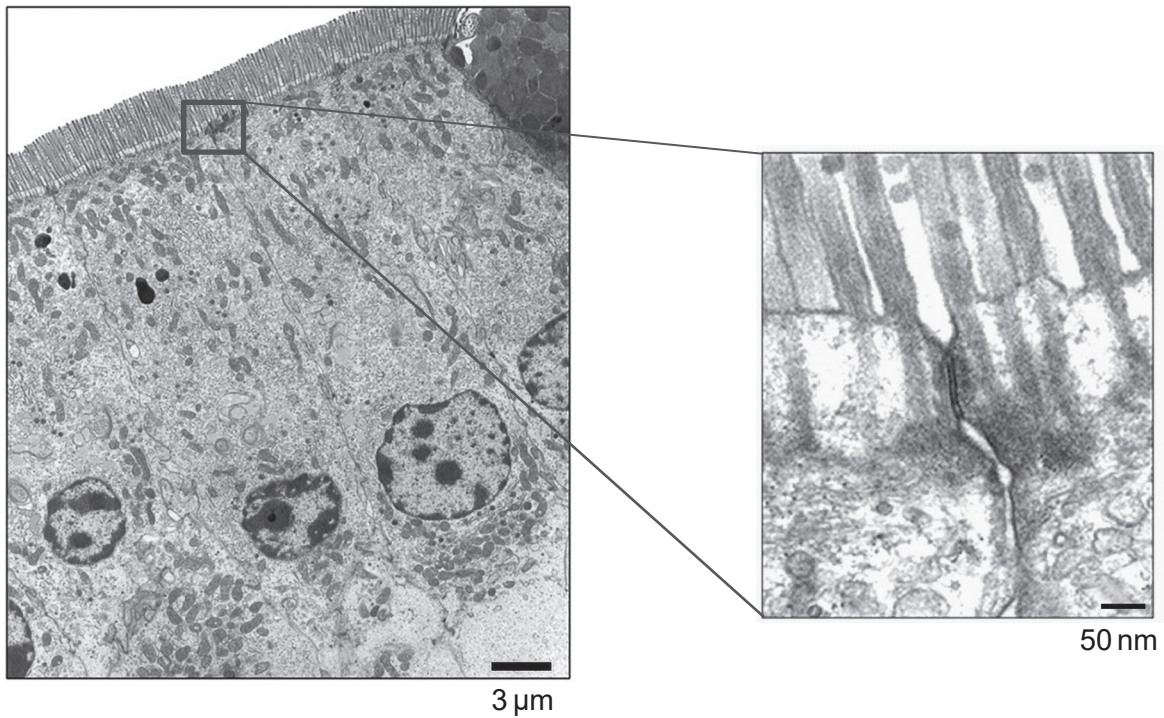


28EP25

Turn over

(Option D continued)

18. Intestinal villi are highly specialized for the absorption of digested nutrients. The micrographs show some epithelial cells on the surface of the villi and a detail of two of these cells.



- (a) Outline **one** reason for the large number of mitochondria observed in these cells. [1]

.....
.....

- (b) Using the images, identify another structure that adapts these cells to their function. [1]

.....

(Option D continues on the following page)



(Option D, question 18 continued)

- (c) Explain how infection of these cells by the bacterium *Vibrio cholerae* can lead to diarrhoea.

[3]

.....

.....

.....

.....

.....

.....

- 19. Ventricular contraction is coordinated to pump as much blood as possible into the arteries. Explain how this is achieved.

[4]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

End of Option D



Disclaimer:

Content used in IB assessments is taken from authentic, third-party sources. The views expressed within them belong to their individual authors and/or publishers and do not necessarily reflect the views of the IB.

References:

2. Dunant, Y., Garcia-Segura, L.M., Muller, D. and Parducz, A., 1989. Momentary alteration of the postsynaptic membrane during transmission of a single nerve impulse. *Proceedings of the National Academy of Sciences of the United States of America*, [e-journal] 86(5), pp. 1717–1720. <https://doi.org/10.1073/pnas.86.5.1717>.
5. Volland, S., Esteve-Rudd, J., Hoo, J., Yee, C. and Williams, D.S., 2015. A Comparison of Some Organizational Characteristics of the Mouse Central Retina and the Human Macula. *PLOS ONE*, [e-journal] 10(4), e0125631. <https://doi.org/10.1371/journal.pone.0125631>. Open access.
6. DrOONeil, 2014. fMRI Brain Scan. [image online] Available at: https://commons.wikimedia.org/wiki/File:FMRI_Brain_Scan.jpg [Accessed 26 January 2022]. Public domain.
8. Náthia-Neves, G., de Alencar Neves, T., Berni, M., Dragone, G., Mussatto, S., Forster-Carneiro, T., 2018. Start-up phase of a two-stage anaerobic co-digestion process: hydrogen and methane production from food waste and vinasse from ethanol industry. *Biofuel Research Journal*, [e-journal] 5(2), pp. 813–820. <https://dx.doi.org/10.18331/BRJ2018.5.2.5>.
10. D'Accolti, M., Soffritti, I., Piffanelli, M., Bisi, M., Mazzacane, S. and Caselli, E., 2018. Efficient removal of hospital pathogens from hard surfaces by a combined use of bacteriophages and probiotics: potential as sanitizing agents. *Infection and Drug Resistance*, [e-journal] 11, pp. 1015–1026. <https://doi.org/10.2147/IDR.S170071>. Open access.
12. Samad, A., Nan, F.-H. and Lee, M., 2014. Effects of stocking density on growth and feed utilization of grouper (*Epinephelus coioides*) reared in recirculation and flow-through water system. *African Journal of Agricultural Research*, [e-journal] 9(9), pp. 812–822. <https://doi.org/10.5897/AJAR2013.7888>. Open access.
13. Ahn, C., Chang, E. and Kang, H., 2011. Epiphytic macro lichens in Seoul: 35 years after the first lichen study in Seoul. *Journal of Ecology and Field Biology*, [e-journal] 34(4), pp. 381–391. <https://doi.org/10.5141/JEFB.2011.040>.
16. Reproduced from Leidy, H.J., Tang, M., Armstrong, C.L., Martin, C.B., Campbell, W.W., 2011. The effects of consuming frequent, higher protein meals on appetite and satiety during weight loss in overweight/obese men. *Obesity*, 19(4), pp. 818–824, with permission from Wiley.
17. Reproduced with permission from *Pediatrics*, Vol. 114, Pages 297–316, Copyright © 2004 by the AAP.
18. Nighot, P.K. and Blikslager, A.T., 2010. *AJP. Gastrointestinal and Liver Physiology*, [e-journal] 299(2), pp. 449–456. <https://doi.org/10.1152/ajpgi.00520.2009>.

All other texts, graphics and illustrations © International Baccalaureate Organization 2023



28EP28