

© 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**

8 November 2023

**Zone A** morning | **Zone B** morning | **Zone C** 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 – 8
Option B — Biotechnology and bioinformatics	9 – 12
Option C — Ecology and conservation	13 – 17
Option D — Human physiology	18 – 22



## Section A

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

- The image was obtained with a mobile phone camera pointing down the eyepiece tube of a light microscope. It shows onion (*Allium cepa*) epidermal cells after immersion in a hypertonic salt solution during an experiment on osmosis.



- (a) State the names of structures I and II on the image.

[2]

- I. ....
- II. ....

(This question continues on the following page)



**(Question 1 continued)**

- (b) (i) Identify what is found in the region labelled X. [1]

.....  
.....

- (ii) Explain the effect of the salt solution on these cells. [2]

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

- (c) The length of one onion epidermal cell in the micrograph measured by the line Y–Z is 24 mm. Calculate the actual length of this cell in micrometres. [1]

.....  $\mu\text{m}$

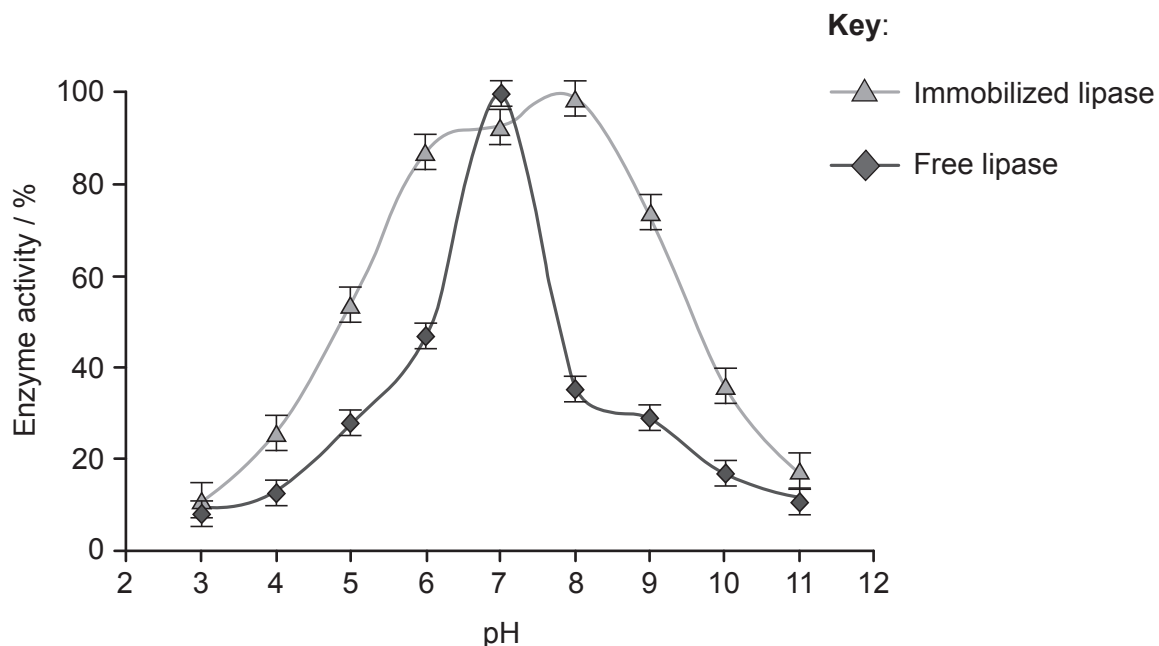


Please **do not** write on this page.

Answers written on this page  
will not be marked.



2. Immobilized enzymes are often used in industrial processes. The enzyme lipase was obtained from the fungus *Aspergillus niger*. The relative activity of immobilized and free lipase was investigated at different pH values.



- (a) Compare and contrast the effect of pH on the activity of free lipase and immobilized lipase.

[3]

.....

.....

.....

.....

.....

.....

- (b) State **one** variable which must be kept constant in this experiment.

[1]

.....

.....

- (c) State **one** application of immobilized enzymes.

[1]

.....

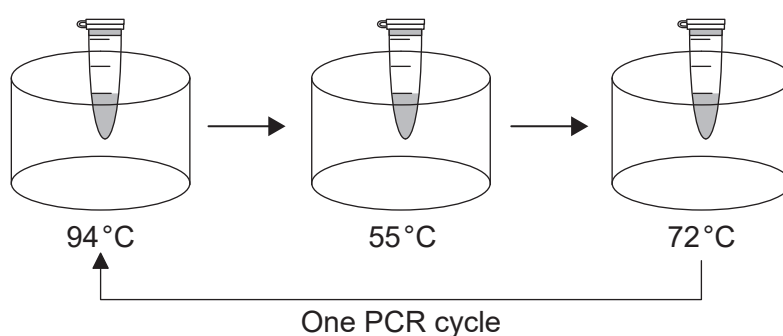
.....



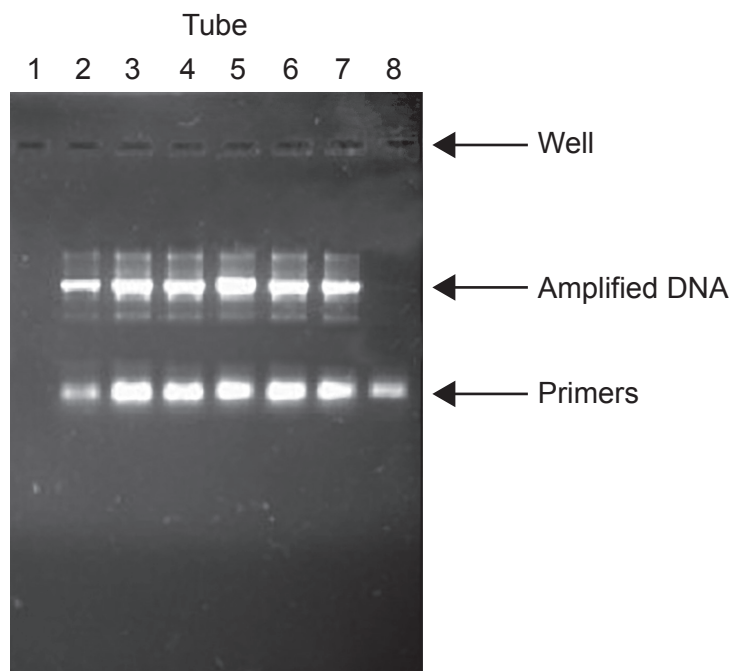
3. A polymerase chain reaction (PCR) was performed to amplify a small amount of DNA. Eight tubes were prepared as shown in the table.

	Mix of nucleotides, salts, buffer and polymerase	DNA	Primers
Control	✓	✓	✗
Control	✓	✗	✓
Six tubes	✓	✓	✓

The tubes were placed in a thermal cycler with the temperatures shown in the diagram and run for 25 cycles.



The image shows the result of gel electrophoresis on the eight samples.



(This question continues on the following page)



**(Question 3 continued)**

(a) State the number of the tube used as a control without DNA.

[1]

.....  
.....

(b) Explain the reason for changing the temperature during each cycle.

[2]

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

(c) Predict the result that would be obtained if fewer cycles were used in this PCR process.

[1]

.....  
.....



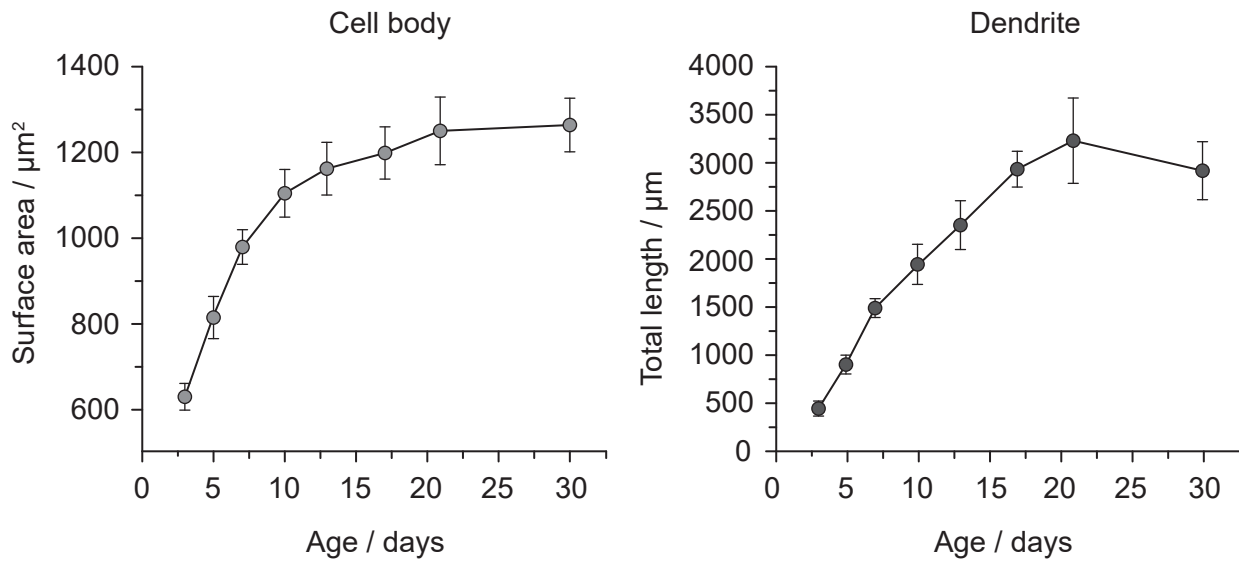


## Section B

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. During early development, there are changes to the structure of neurons and to synaptic transmission. Changes in surface area of cell bodies and length of dendrites of neurons located in the cerebral cortex were examined in rats between 3 and 30 days after birth.



- (a) Describe the changes observed in the cerebral cortex neurons of rats between 3 and 30 days after birth.

[2]

.....

.....

.....

.....

- (b) State the site of origin of neurons.

[1]

.....

.....

(Option A continues on the following page)



**(Option A, question 4 continued)**

- (c) The outer surface of the cerebral cortex is smooth in rats and folded in humans.  
Explain this difference.

[2]

.....

.....

.....

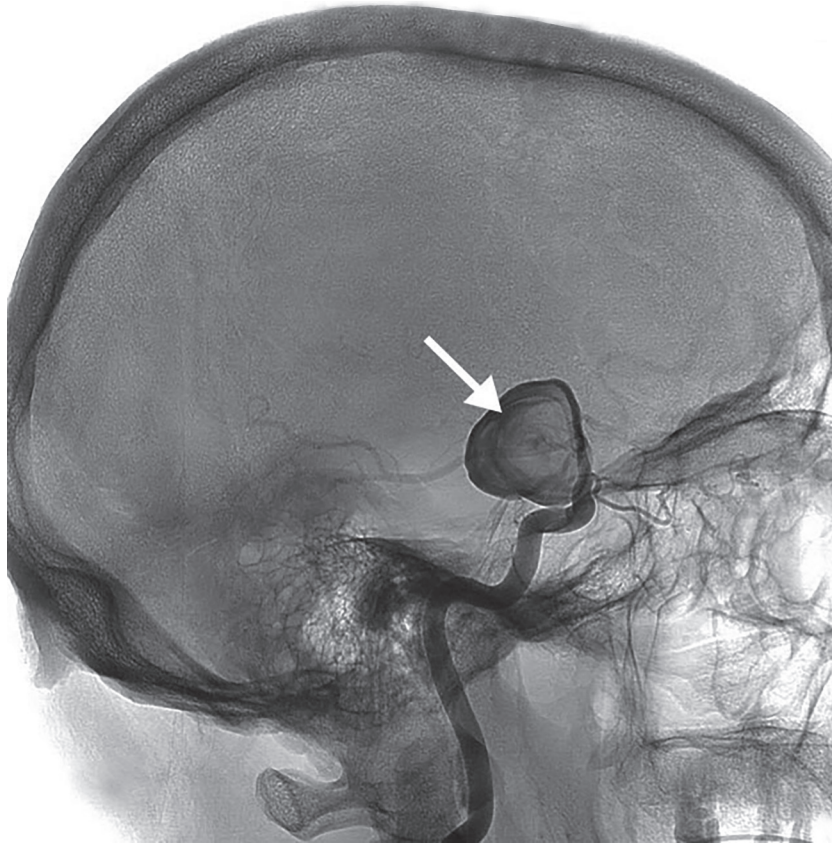
.....

**(Option A continues on the following page)**



**(Option A continued)**

5. The image shows an angiogram (X-ray with a dye) of blood vessels in the brain of a patient who has suffered a stroke in Broca's area. The arrow shows the exact location where the stroke has occurred.



- (a) Outline how a stroke may have occurred.

[1]

.....  
.....

- (b) Explain the likely consequences of a stroke in Broca's area.

[2]

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

**(Option A continues on the following page)**



**(Option A, question 5 continued)**

(c) Explain the change in the brain which could lead to recovery from a stroke.

[2]

.....

.....

.....

.....

**(Option A continues on the following page)**



36EP11

**Turn over**

(Option A continued)

6. Electroretinography measures the electrical response of the light-sensitive cells in the eyes. It is used to diagnose some acquired and inherited diseases of the retina.



- (a) (i) State **one** example of an inherited retinal disease.

[1]

.....  
.....

- (ii) State which cells in the retina are sensitive to some but not all wavelengths of light.

[1]

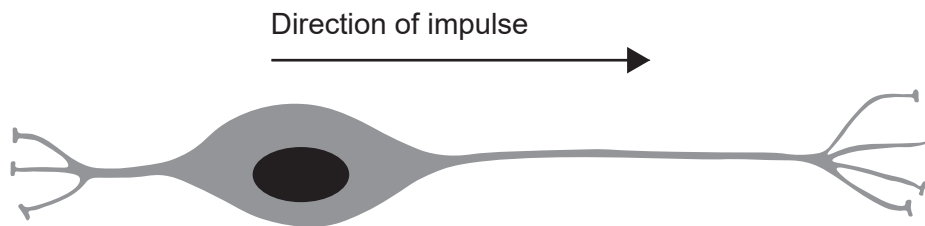
.....  
.....

(Option A continues on the following page)



**(Option A, question 6 continued)**

- (b) The diagram shows a retinal bipolar cell and the direction of the nerve impulse.



- (i) Three light-sensitive cells form synapses with this bipolar cell. State the name of these light-sensitive cells. [1]

.....  
.....

- (ii) State the type of cell that conveys signals from bipolar cells to the brain. [1]

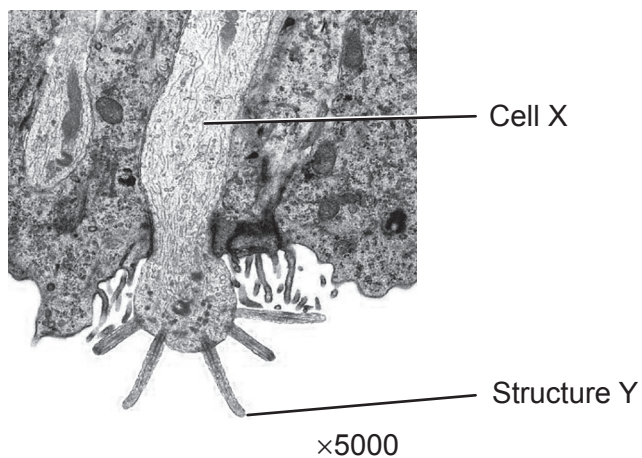
.....  
.....

**(Option A continues on the following page)**



**(Option A continued)**

7. The micrograph shows a section of the epithelium that lines the nasal cavity.



- (a) Identify cell X.

[1]

.....  
.....

- (b) State the function of structure Y.

[1]

.....  
.....

**(Option A continues on the following page)**



8. Explain how the roles of different parts of the brain can be identified.

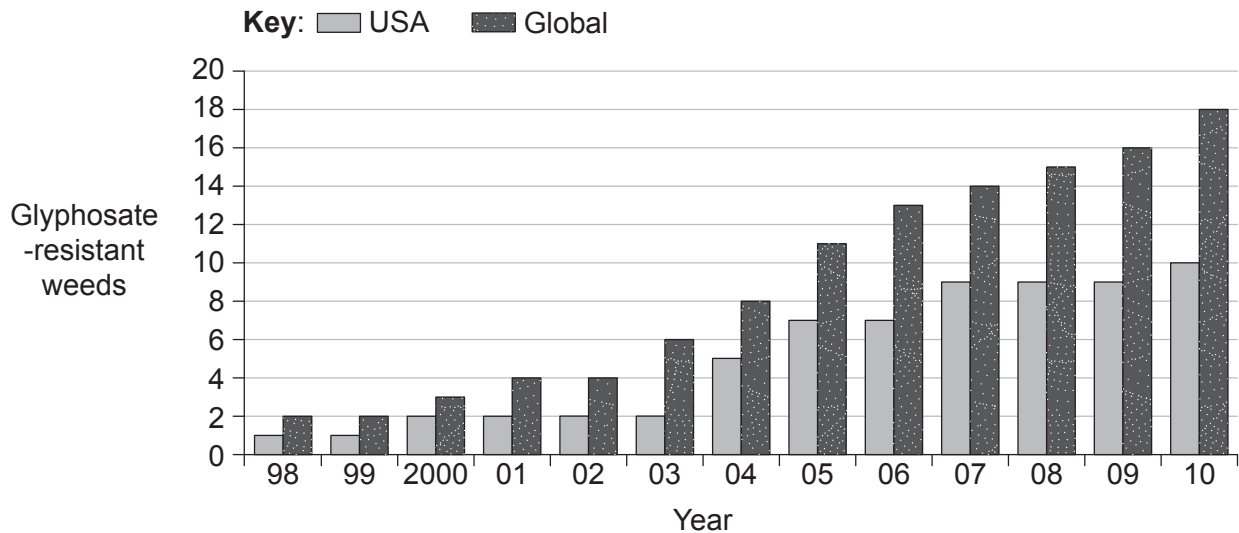


**Turn over**



**Option B — Biotechnology and bioinformatics**

9. Crops such as soybean (*Glycine max*) have been genetically modified to become glyphosate-tolerant, allowing the use of glyphosate-containing herbicides to kill weeds without affecting crops. The graph shows global trends and US trends in the number of weed species that have become resistant to glyphosate.



- (a) (i) Identify the year with the greatest number of **new** glyphosate-resistant weed species globally.

[1]

.....  
 .....

- (ii) Suggest, giving a reason, **one** consequence of glyphosate-resistant weeds to agriculture.

[1]

.....  
 .....

- (iii) During genetic modification, soybean cells are exposed to bacteria carrying plasmids with the glyphosate-resistance gene. Suggest a method used by scientists to distinguish soybean cells which have taken up the gene from those which have not.

[1]

.....  
 .....

(Option B continues on the following page)



**(Option B, question 9 continued)**

- (b) (i) State the name given to DNA containing genes from two unrelated species. [1]

.....  
.....

- (ii) Describe electroporation as a method of genetic transformation. [2]

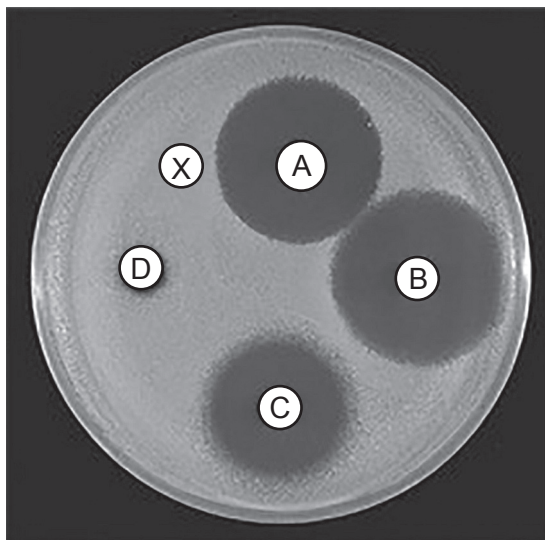
.....  
.....  
.....  
.....

**(Option B continues on the following page)**



**(Option B continued)**

10. *Actinomyces viscosus*, a Gram-positive bacterium which causes tooth decay, was spread onto an agar plate. A control disc (X) and four paper discs, each containing an antibacterial agent (A, B, C, D) were placed onto the agar plate. The photograph shows the plate after incubation at 25 °C for 36 hours.



- (a) (i) Analyse the effect of the antibacterial agents on *A. viscosus*. [2]

.....

.....

.....

.....

- (ii) Outline a reason for incubating the agar plate for 36 hours. [1]

.....

.....

- (b) Distinguish between Gram-positive bacteria and Gram-negative bacteria. [2]

Feature	Gram-positive	Gram-negative
Colour after Gram staining		
Cell wall structure		

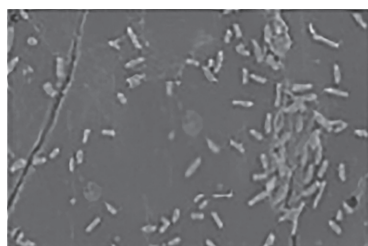
**(Option B continues on the following page)**



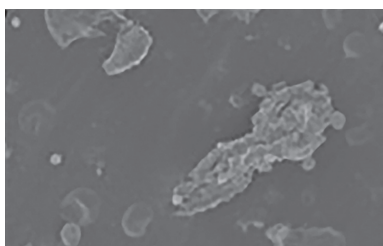
(Option B continued)

11. Microbial pathogens may grow during harvesting and processing of seafood, posing health risks to consumers. The bacterium *Vibrio parahaemolyticus* is one of the pathogens which forms biofilms on food and on food contact surfaces during processing. *V. parahaemolyticus* biofilm formation was investigated at different surface textures provided by stainless steel (smooth), shrimp shell (slightly rough) and crab shell (very rough).

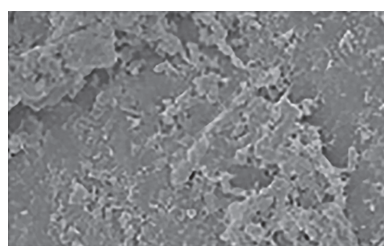
Stainless steel



Shrimp shell



Crab shell



×10 000

- (a) Discuss whether the results support the hypothesis that rough surfaces encourage biofilm adhesion and development.

[2]

.....

.....

.....

.....

- (b) (i) State **one** emergent property of biofilms.

[1]

.....

.....

- (ii) Outline **one** beneficial use of biofilms.

[2]

.....

.....

.....

.....

(Option B continues on page 21)



36EP19

Turn over

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

Answers written on this page  
will not be marked.



12. The fungus *Penicillium notatum* is used to produce penicillin. Explain how large-scale production of penicillin is carried out.



**Turn over**

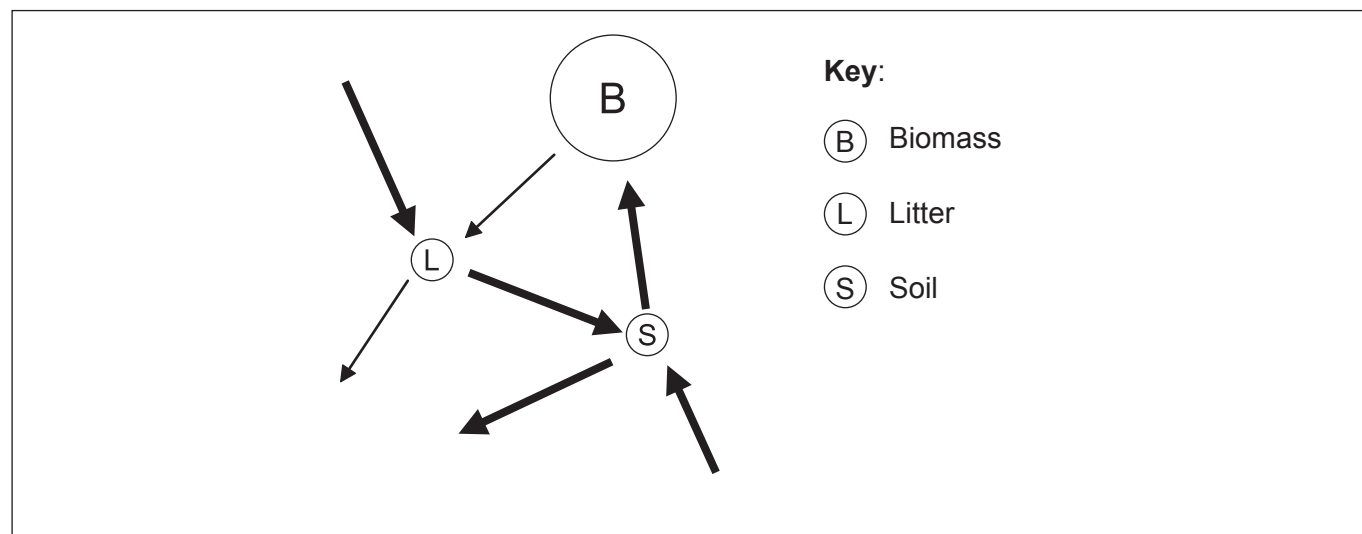
Please **do not** write on this page.

Answers written on this page  
will not be marked.



**Option C — Ecology and conservation**

13. The Gersmehl diagram shows the interrelationships between nutrient stores and nutrient flows in the tropical rainforest ecosystem.



- (a) (i) State the name of a process that decreases the soil nutrient store. [1]

.....

.....

- (ii) Breakdown of rock (weathering) can add nutrients to the ecosystem. On the diagram, label with the letter X the arrow that shows the flow of nutrients released by weathering. [1]

- (b) The Gersmehl diagram shows a large flow of nutrients from litter to soil in a tropical rainforest ecosystem. Explain this large flow. [2]

.....

.....

.....

.....

(Option C continues on the following page)





(Option C continued)

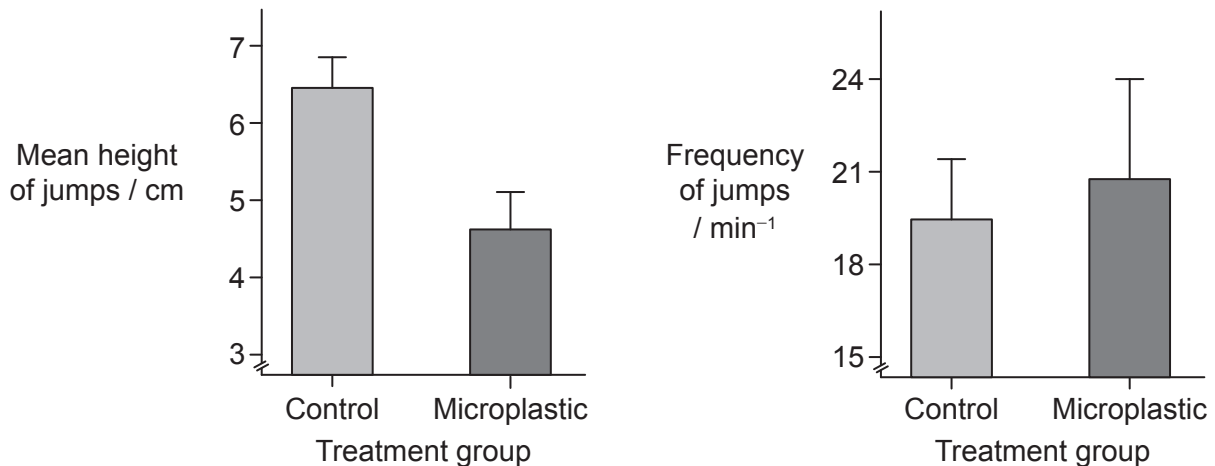
14. The impact of microplastics on the ecology of coastal biota was assessed using beach hoppers (*Platorchestia platensis*), small marine crustaceans which feed on marine sediments. These crustaceans have the ability to jump, which allows them to escape from predators.



Scientists investigated the possible effects of microplastics on their behaviour and survival, by observing the height and frequency of jumps in two groups of beach hoppers:

- experimental group: fed on marine sediments contaminated with microplastics
- control group: fed on uncontaminated marine sediments.

The graphs show the results.



[Source: Tosetto, L, Brown, C & Williamson, JE. Microplastics on beaches: ingestion and behavioural consequences for beachhoppers. *Marine Biology* 163, 199 (2016). Reproduced with permission from Springer Nature. <https://doi.org/10.1007/s00227-016-2973-0>.]

- (a) Using the data, discuss the effect that ingestion of microplastic will have on the success of beach hoppers in escaping from predators in their natural environment. [2]

.....

.....

.....

.....

(Option C continues on the following page)



**(Option C, question 14 continued)**

- (b) Macroplastics also affect the survival of other marine organisms. Outline how this may happen.

[2]

.....

.....

.....

.....

**(Option C continues on page 27)**



36EP25

**Turn over**

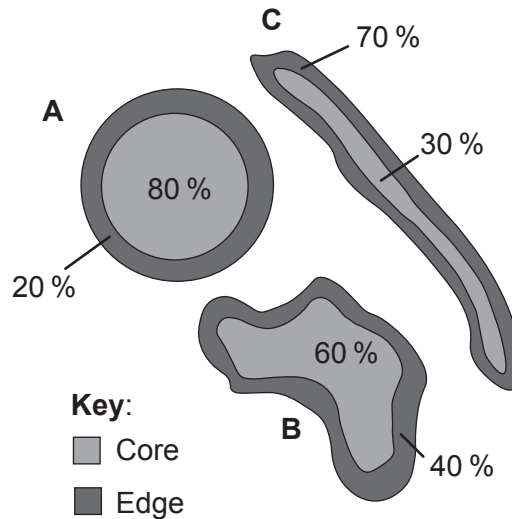
Please **do not** write on this page.

Answers written on this page  
will not be marked.



(Option C continued)

15. The diagrams show three remaining areas of forest with different shapes after clearance for agriculture or human development. They all have the same total area but differ in the proportions of core and edge areas.



- (a) Predict with a reason which forest would preserve the highest number of bird species native to the forest.

[1]

.....  
 .....

- (b) Outline the role of wildlife corridors between nearby nature reserves in preserving biodiversity.

[3]

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

(Option C continues on the following page)

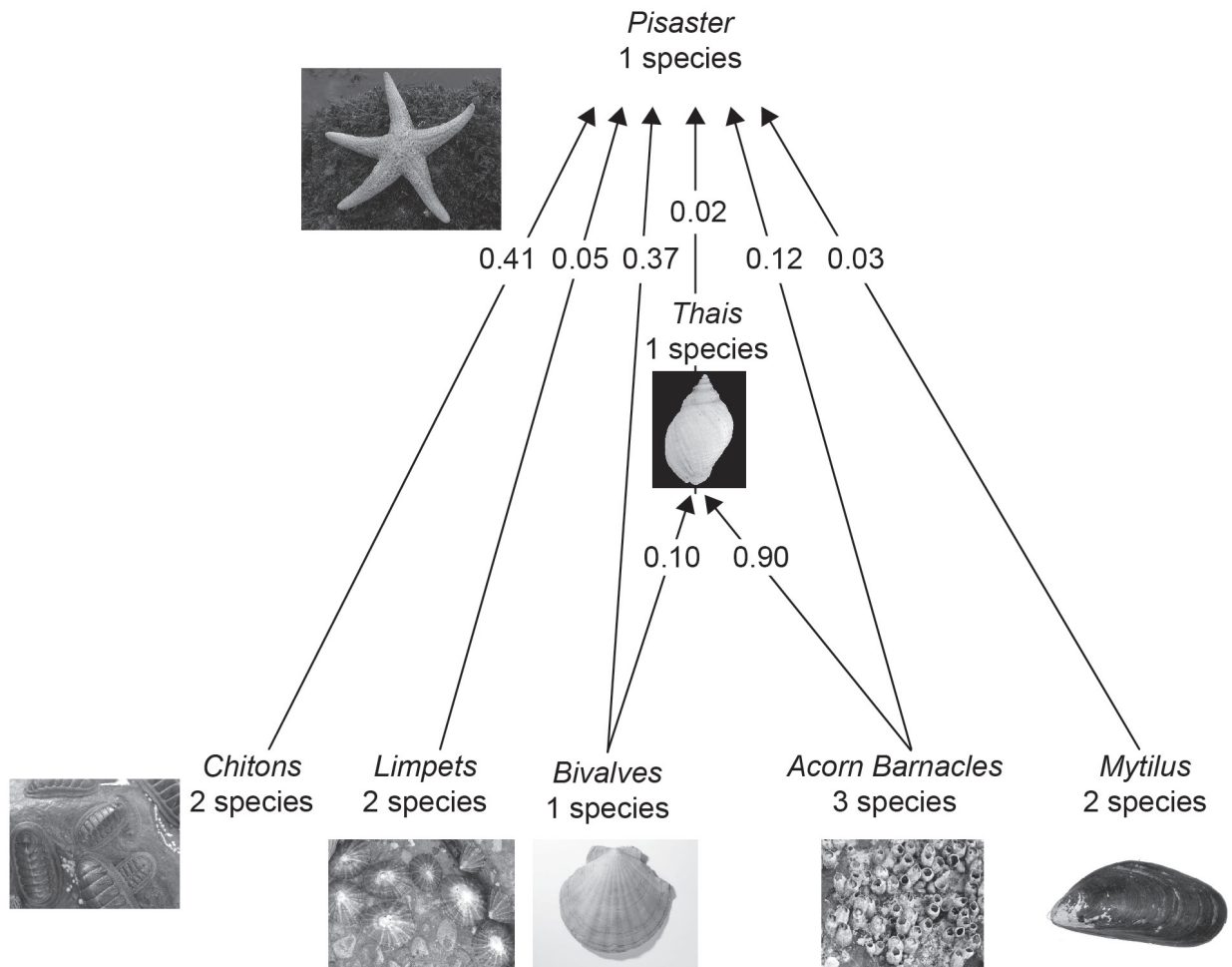


36EP27

Turn over

(Option C continued)

16. Feeding relationships between organisms on rocky shores along the Pacific Coast of North America were studied. The food web shows the proportions of the total energy consumed by the two carnivorous species, a starfish (*Pisaster ochraceus*) and a small gastropod (*Thais emarginata*).



(Option C continues on the following page)



(Option C, question 16 continued)

- (a) Identify the main source of energy of *Thais*. [1]

.....  
.....

- (b) Limpets feed on photosynthetic algae. Identify the trophic level of limpets. [1]

.....  
.....

- (c) *Pisaster* is considered a keystone species. Explain the effects of *Pisaster* on this community. [2]

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

(Option C continues on the following page)



17. Explain how *ex situ* conservation can help in the preservation of endangered species.



**Option D — Human physiology**

18. L-gulonolactone oxidase (GLO) is an enzyme that catalyses the production of ascorbic acid (vitamin C) in the body of some animals. Animals having a mutated form of the gene that codes for the enzyme GLO cannot synthesize ascorbic acid.

Daily production of ascorbic acid in animals	
Animal	mg kg <sup>-1</sup> body mass day <sup>-1</sup>
Mouse	275
Guinea pig	0
Dog	40
Human	0
Snake	10
Rabbit	226
Goat	150

- (a) (i) Identify **one** animal from the table for whom ascorbic acid is not an essential nutrient.

[1]

.....

- (ii) State **one** role of ascorbic acid in humans.

[1]

.....

.....

- (b) The appetite control centre in the brain is stimulated by several hormones. Identify **two** of these hormones and the structures that secrete them.

[2]

Hormone	Secreted by

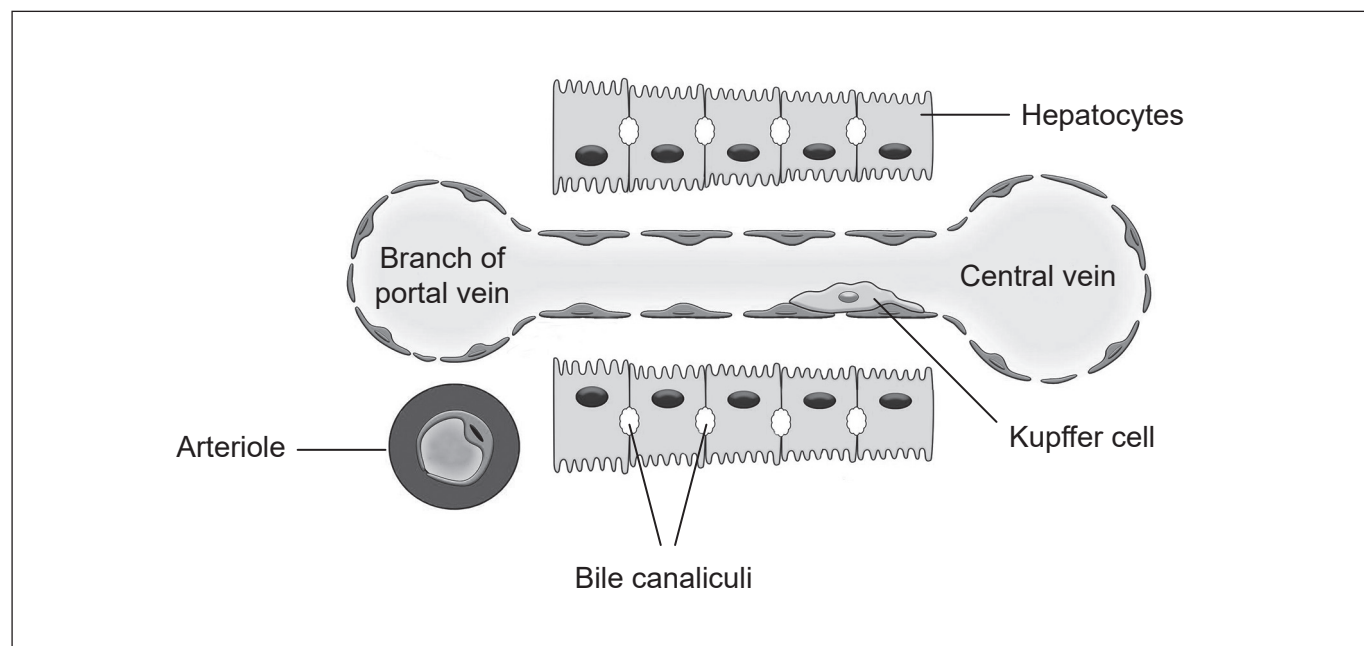
(Option D continues on the following page)





(Option D continued)

19. The diagram shows a detail of the internal structure of the sinusoid of the liver.



(a) On the diagram, draw arrows to show the direction of movement of

(i) oxygen supplied to hepatocytes

[1]

(ii) toxins after detoxification.

[1]

(b) Outline the function of hepatocytes in the regulation of nutrient levels.

[2]

.....

.....

.....

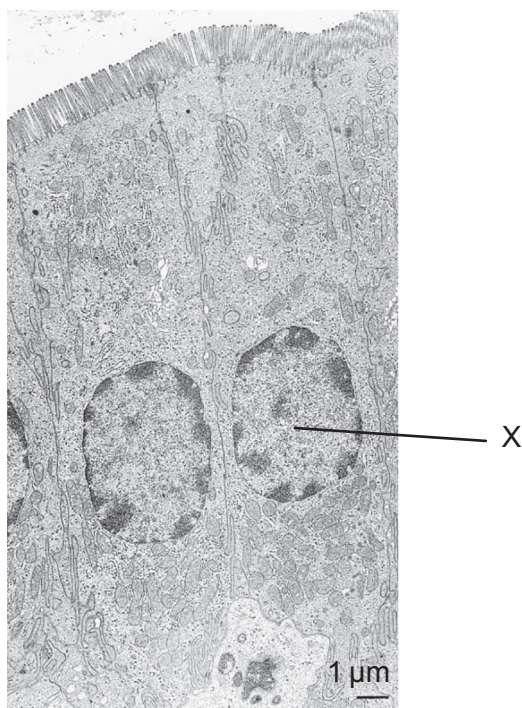
.....

(Option D continues on the following page)



(Option D continued)

20. The electron micrograph shows details of the inner lining of the small intestine.



(a) State the name of the cell labelled X on the image.

[1]

.....  
.....

(b) Explain adaptations of this cell to its function.

[3]

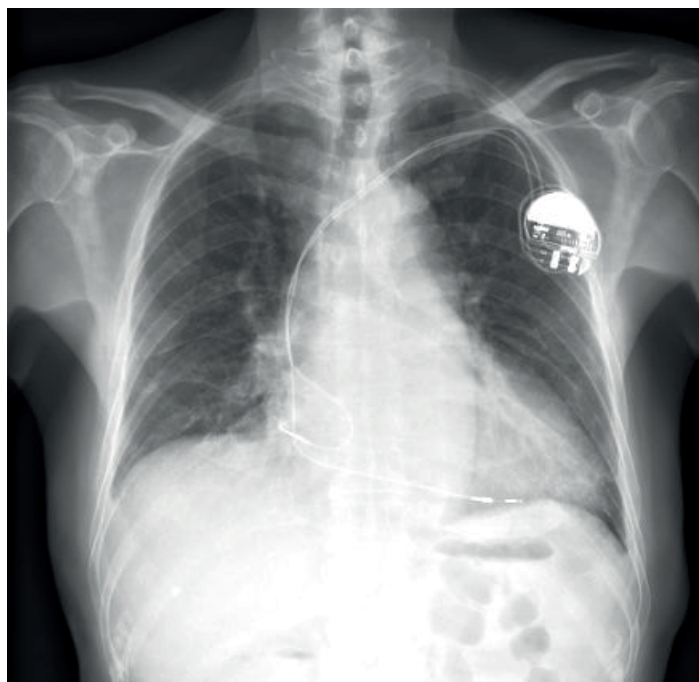
.....  
.....  
.....  
.....  
.....  
.....

(Option D continues on the following page)



(Option D continued)

21. The X-ray was taken of a patient who has an artificial pacemaker implanted under the skin.



(a) (i) State the function of an artificial pacemaker.

[1]

.....  
 .....

(ii) State the apparatus used by doctors to detect that a patient needs an artificial pacemaker.

[1]

.....  
 .....

(b) Explain the role of the atrioventricular node in the cardiac cycle.

[2]

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

(Option D continues on the following page)



**22.** Discuss the concept of malnutrition and its consequences on health.

[illegible]

### 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. Zdarta, Jakub, et al. "Chitin-Lignin Material as a Novel Matrix for Enzyme Immobilization." *Marine Drugs*, vol. 13, no. 4, 2015, pp. 2424–2446, <https://doi.org/10.3390/md13042424>. Open access.
4. Zhang, Z-w, 2004. Maturation of Layer V Pyramidal Neurons in the Rat Prefrontal Cortex: Intrinsic Properties and Synaptic Function. *Journal of Neurophysiology*, 91(3), pp. 1171–1182.
5. Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.
6. Dra. Teresa Lluch, Neurofisióloga Clínica. <http://www.neurofisiologiamurcia.es>.
7. STEVE GSCHMEISSNER / SCIENCE PHOTO LIBRARY.
9. Heap, I. The International Herbicide-Resistant Weed Database.
11. Reprinted from *Food Control*, Vol 70, Noori Han, Md. Furkanur Rahaman Mizan, Iqbal Kabir Jahid, Sang-Do Ha, Biofilm formation by *Vibrio parahaemolyticus* on food and food contact surfaces increases with rise in temperature, Pages No. 161–166, Copyright (2016), with permission from Elsevier.
14. Image: Iowa State University, Department of Entomology, n.d. *Platorchestia platensis*. [image online] Available at: <https://bugguide.net/node/view/1130911/bgimage> [Accessed 1 April 2020].  
Graphs: Tosetto, L, Brown, C & Williamson, JE. Microplastics on beaches: ingestion and behavioural consequences for beachhoppers. *Marine Biology* 163, 199 (2016). Reproduced with permission from Springer Nature. <https://doi.org/10.1007/s00227-016-2973-0>.
15. *Forest shape determines the amount of core habitat*, 3rd edition, 2013 © Government of Canada. Reproduced with the permission of Library and Archives Canada (2023). Source: Library and Archives Canada/OCCLC 855461470, page 72.
16. Food web: Used with permission of University of Chicago Press - Journals, from *The American Naturalist*, Essex Institute, American Society of Naturalists, Vol 100, No 910, 1966; permission conveyed through Copyright Clearance Center, Inc.  
*Pisaster* image: jkirkhart35, CC BY 2.0 <https://creativecommons.org/licenses/by/2.0>, via Wikimedia Commons.  
*Thais* image: H. Zell, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons.  
Chitons image: Ryan Wick. <https://flic.kr/p/5CRYNs>. Licensed under CC BY 2.0 <https://creativecommons.org/licenses/by/2.0/>.  
Limpets image: EllaGervaise. <https://flic.kr/p/5MQENM>. Licensed under CC BY 2.0 <https://creativecommons.org/licenses/by/2.0/>. Image adapted.  
Bivalves image: Oxford University Museum of Natural History.  
Acorn barnacles image: Kandukuru Nagarjun. <https://flic.kr/p/Q9FUGa>. Licensed under CC BY 2.0 <https://creativecommons.org/licenses/by/2.0/>.  
*Mytilus* image: Dentren at English Wikipedia, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons.
19. Xu J, Liu X, Koyama Y, Wang P, Lan T, Kim I-G, Kim IH, Ma H-Y and Kisseleva T (2014) The types of hepatic myofibroblasts contributing to liver fibrosis of different etiologies. *Front. Pharmacol.* 5:167.
20. Used with permission of Rockefeller University Press, from "In vivo, villin is required for Ca<sup>2+</sup>-dependent F-actin disruption in intestinal brush borders.", ROCKEFELLER INSTITUTE, AMERICAN SOCIETY FOR CELL BIOLOGY, Vol 146, Issue 4. 1999; permission conveyed through Copyright Clearance Center, Inc.
21. CardioNetworks: Drj, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons.

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

