

© 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

## Higher level

### Paper 1

8 November 2023

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

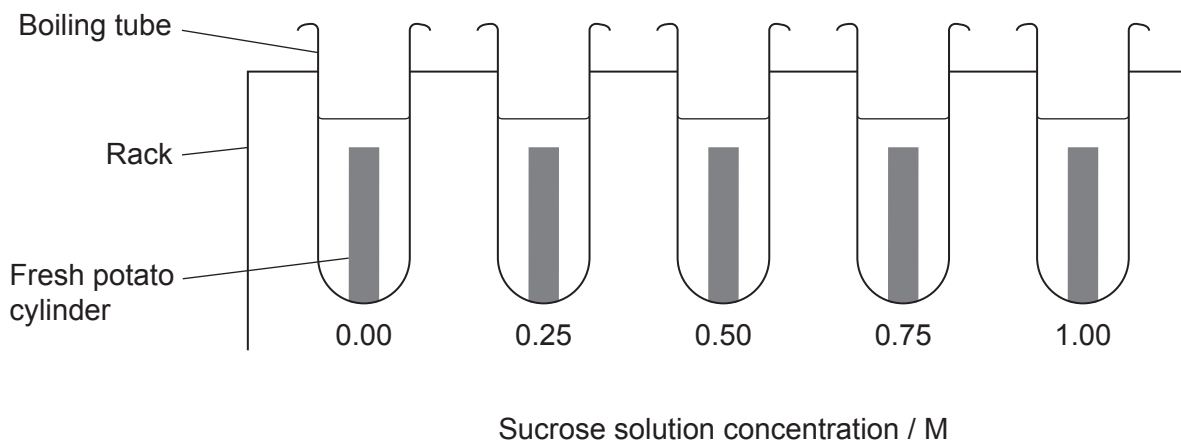
1 hour

---

#### Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The maximum mark for this examination paper is **[40 marks]**.

1. Stargardt's is an inherited disease caused by the mutation of a gene associated with vitamin A processing in the eye. It results in degeneration of receptor cells and loss of vision. For what reason are stem cells suitable to treat this disease?
  - A. They can be taken from the eye of an embryo and transplanted into a patient.
  - B. They can produce vitamin A in newborn babies.
  - C. They can develop into receptor cells and prevent blindness.
  - D. They can be removed from an embryo to detect early onset of the disease.
2. What is a function of cholesterol in the cell membrane?
  - A. To regulate fluidity
  - B. To store energy
  - C. To provide a channel for transport
  - D. To hold adjacent cells together
3. In an experiment, a student placed five fresh potato cylinders of equal size in solutions of varying sucrose concentrations.



On completion of the experiment, the student concluded that the concentration of sucrose isotonic with the potato was 0.30 M. In how many of the solutions did the potato cylinders lose mass?

- A. 1
- B. 2
- C. 3
- D. 4

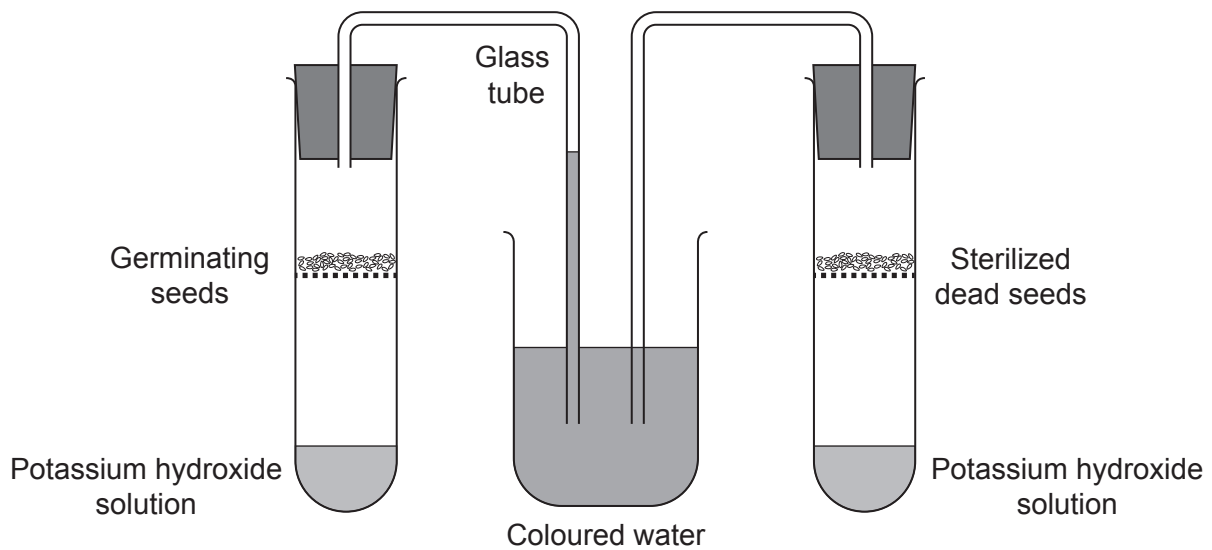
4. Water striders of the Gerridae family of insects have areas of their legs covered with a hydrophobic substance.



What property of water makes it possible for them to walk on its surface?

- A. Adhesion of water molecules
  - B. Cohesion of water molecules
  - C. High specific heat capacity
  - D. High density
5. What is the function of the primers in the polymerase chain reaction (PCR)?
- A. To separate the two strands of DNA
  - B. To bind to the complementary strands of DNA
  - C. To determine the region of DNA that will be copied
  - D. To activate the *Taq* DNA polymerase

6. The diagram shows the arrangement of the apparatus used to carry out an experiment with germinating seeds. The levels of coloured water in the glass tubes show the results at the end of the experiment. Initially, the levels of coloured water in the glass tubes were equal.



What does the experiment show?

- A. Potassium hydroxide has absorbed the oxygen produced by photosynthesis.
  - B. Anaerobic respiration takes place during seed germination.
  - C. Oxygen has been absorbed by the seeds in aerobic respiration.
  - D. Heat is produced by germinating seeds during respiration.
7. How does the study of rock deposition provide evidence of when organisms first started to photosynthesise?
- A. Fossils of leaves were found from the first plants to photosynthesise.
  - B. Analysis of the rocks for magnesium indicate when chlorophyll could be synthesised.
  - C. The carbon content of rock indicates the amount of carbon dioxide in the atmosphere.
  - D. Rocks of a different colour were deposited when oxygen was released by photosynthesis.

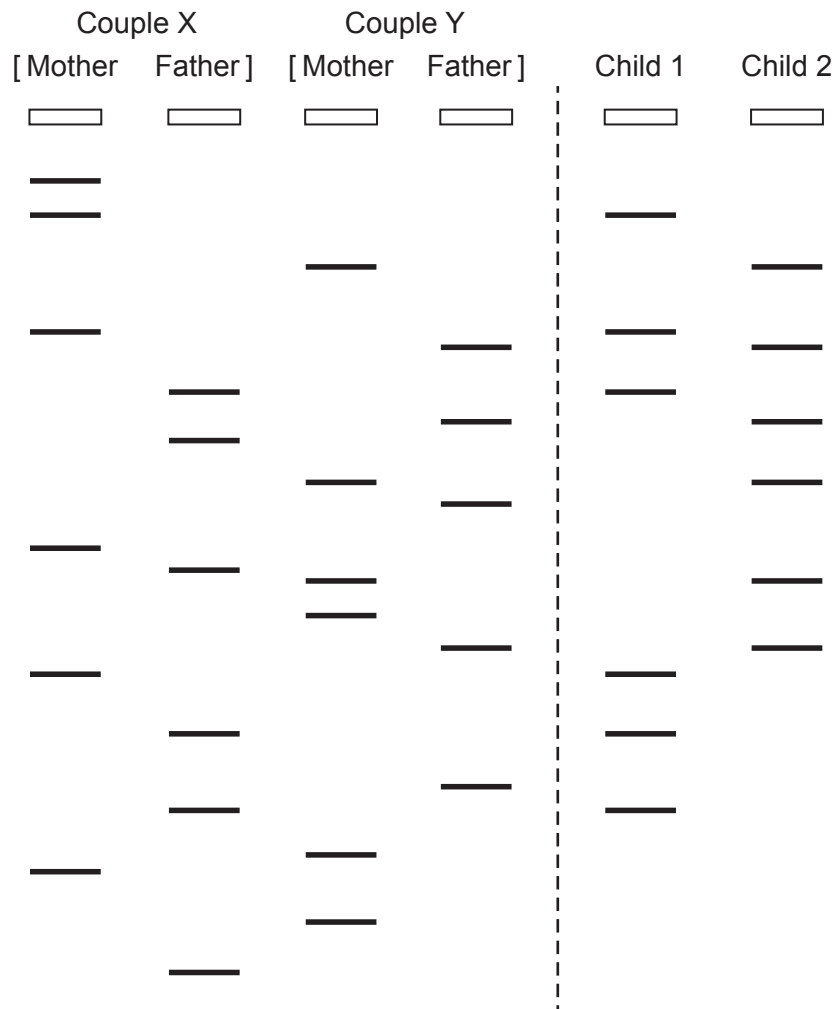
8. The table shows the approximate genome size of four species of organisms.

Species	Type of organism	Genome size / bp $\times 10^6$
<i>Escherichia coli</i>	Bacterium	5
<i>Drosophila melanogaster</i>	Insect	140
<i>Homo sapiens</i>	Mammal	3000
<i>Paris japonica</i>	Plant	150 000

What can be deduced from this information?

- A. Plants have more chromosomes than humans.
  - B. The genetic code is universal.
  - C. The amount of functional DNA varies between organisms.
  - D. The genome size does not always indicate the complexity of the organism.
9. What occurs during the first division of meiosis?
- A. Replication of DNA
  - B. Separation of chromatids
  - C. Halving of the chromosome number
  - D. Production of two identical cells

10. The diagram shows the DNA profile of two couples and two children.



What is the most probable relationship between them?

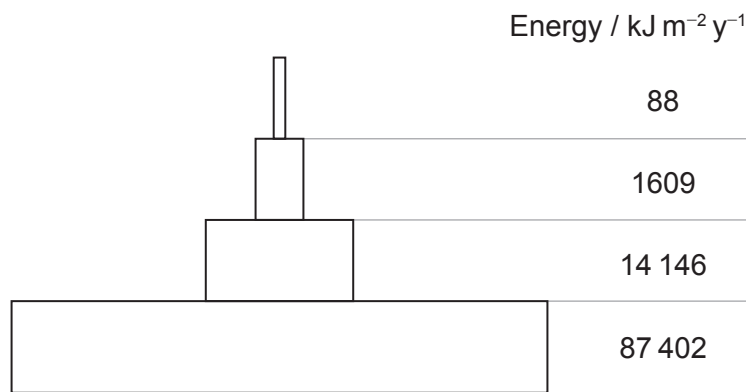
- A. Couple X are the parents of child 1 and couple Y are the parents of child 2.
- B. Couple X are the parents of child 2 and couple Y are the parents of child 1.
- C. Couple X are the parents of both children.
- D. Couple Y are the parents of both children.

11. Which factor(s) would be expected to vary in a closed terrestrial mesocosm?

- I. Carbon content
- II. Temperature
- III. Biomass

- A. I only
- B. I and II only
- C. II and III only
- D. I, II and III

12. The pyramid of energy shows the annual gross productivity for each trophic level in the Silver Springs ecosystem in Florida.

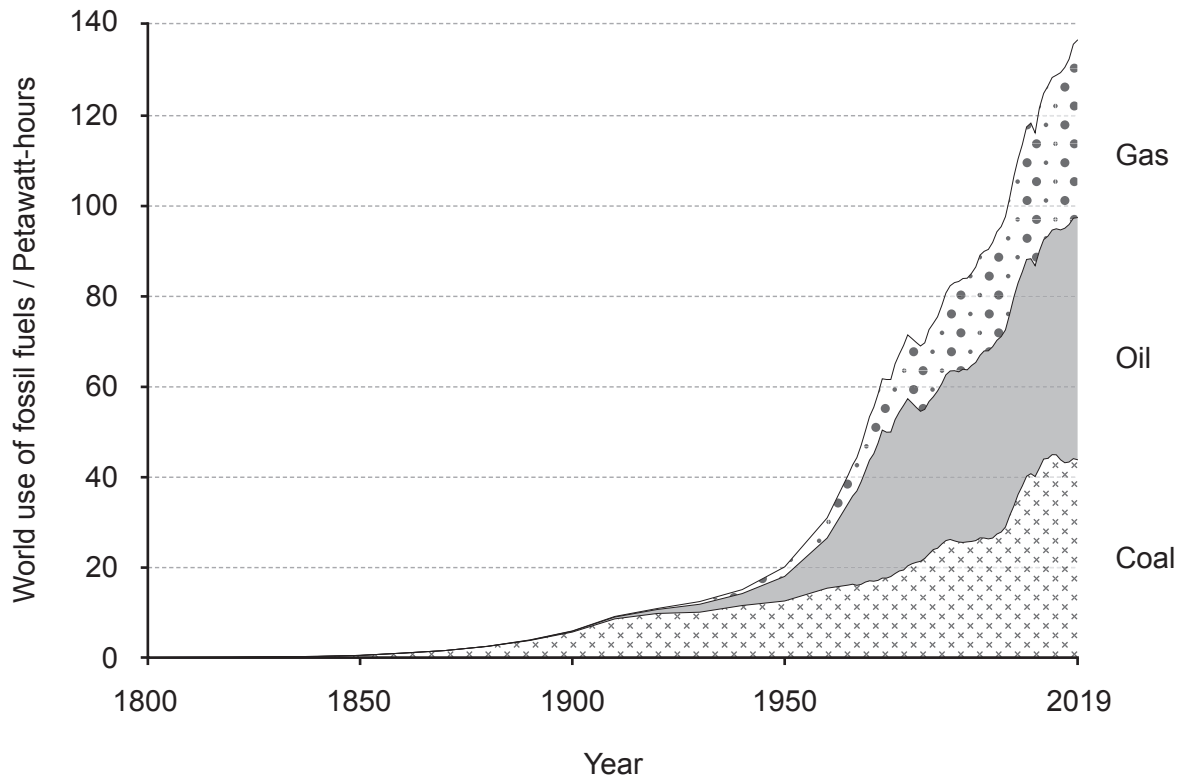


What does the pyramid show?

- A. Most energy is lost by the autotrophs.
- B. There are a larger number of herbivores than carnivores.
- C. The biggest loss of energy is when sunlight reflects from plants.
- D. The energy in the trophic levels is affected by seasonal changes.



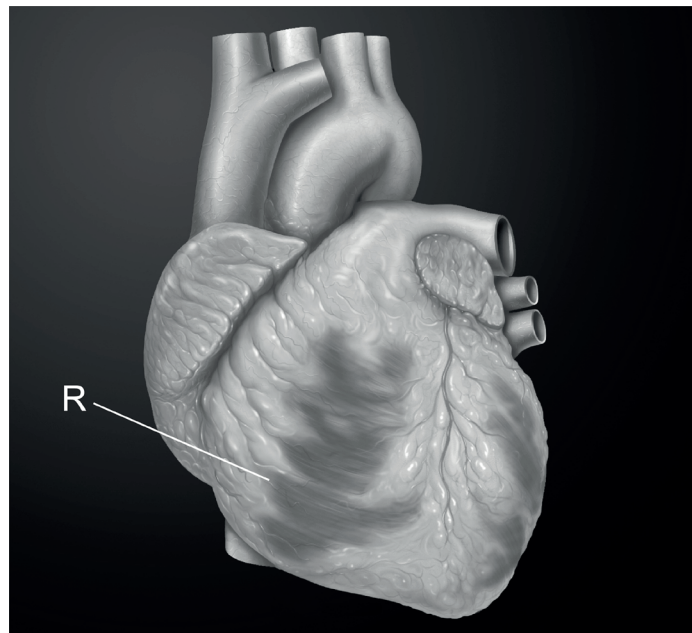
13. The graph shows how the worldwide use of fossil fuels has increased from 1800 to 2019.



How has the increased combustion of fossil fuels contributed significantly to global warming?

- A. The heat released raises the temperature of the air.
  - B. Combustion causes ozone depletion, which enhances the greenhouse effect.
  - C. Carbon dioxide produced by combustion prevents radiation from the Sun reaching Earth.
  - D. The products of combustion absorb long wave radiation.
14. Dogs are descended from the grey wolf, *Canis lupus*, by selective breeding and are thought to be first domesticated about 30 000 years ago. What is a result of this selective breeding?
- A. Many different species of dogs exist.
  - B. The legs of different breeds of dogs show discrete variation.
  - C. Dogs have a variety of phenotypes.
  - D. The tails of dogs are analogous structures.

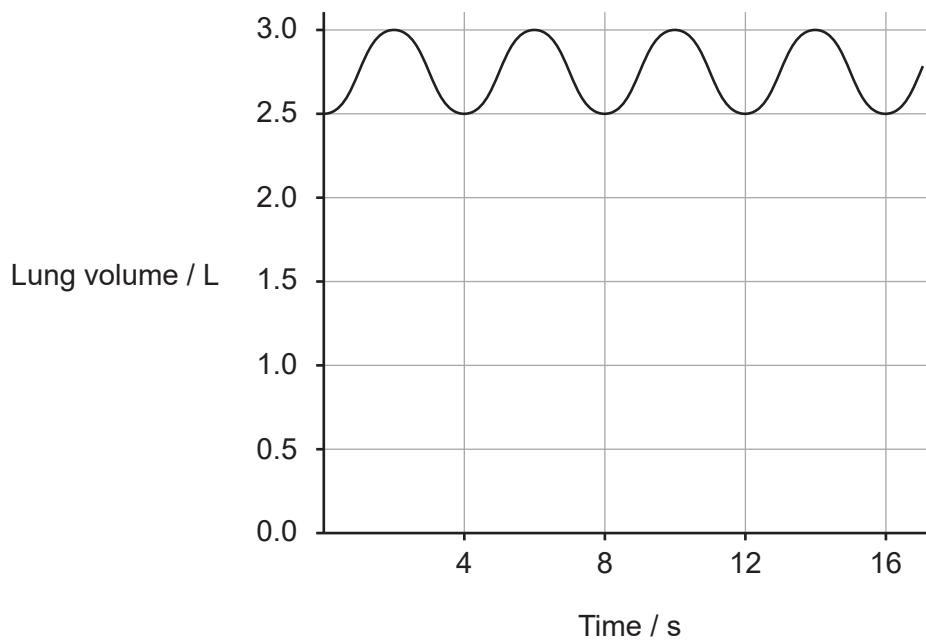
15. How does overuse of antibiotics make them less effective?
- A. It makes patients develop antibiotic resistance.
  - B. It can cause a mutation in bacteria.
  - C. It causes antibiotics to change due to natural selection.
  - D. It increases the number of bacteria better adapted for survival.
16. The starry thyme-moss (*Mnium stellare*) and the badge moss (*Plagiomnium insignne*) are both bryophytes in the order Bryales. What must they have in common?
- A. They are classified into the same class.
  - B. They are classified into the same genus.
  - C. They have vascular tissue to transport water.
  - D. They reproduce by producing seeds.
17. The image shows a model of a human heart with one chamber labelled R.



Which statement is most accurate?

- A. When the pressure in R increases the semilunar valve closes.
- B. R contains the sinoatrial node, which initiates heartbeat.
- C. Blood passes from R into the pulmonary artery.
- D. Deoxygenated blood in the vena cava flows directly into R.

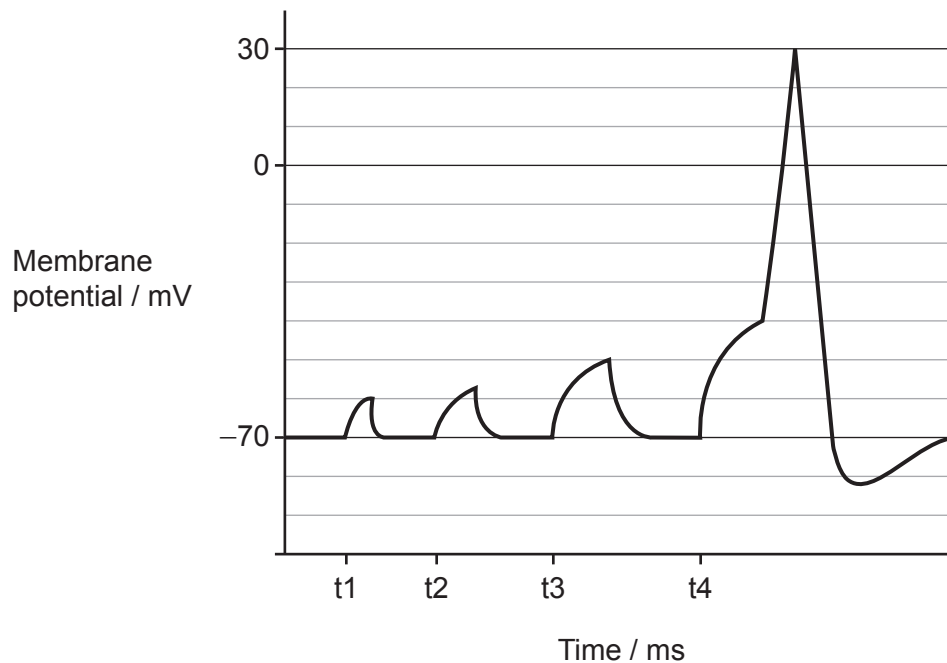
18. The spirometer reading shows the change of volume of the lungs during normal breathing.



What are the tidal volume and the ventilation rate?

	<b>Tidal volume / L</b>	<b>Ventilation rate / breaths min<sup>-1</sup></b>
A.	3.0	4
B.	3.0	15
C.	0.5	4
D.	0.5	15

19. Four electrical stimuli of increasing size are applied to a neuron at times  $t_1$  to  $t_4$ . The graph shows the effects of each electrical stimulus on the membrane potential of the neuron at the point where the stimulus is applied.



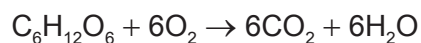
What can be concluded from the graph?

- A. The stronger the stimulus, the greater the action potential.
  - B. Only the stimulus at  $t_4$  causes a change in membrane potential.
  - C. The stimulus at  $t_4$  caused a total increase of membrane potential of 30 mV.
  - D. The threshold potential is approximately  $-40$  mV.
20. The hormone leptin has been tested on patients with clinical obesity to try to treat the disease. From where is leptin secreted, where does it act and what is its function?

	Secreted from	Acts on	Function
A.	adipose tissue	hypothalamus	inhibits appetite
B.	hypothalamus	adipose tissue	inhibits appetite
C.	hypothalamus	small intestine	inhibits absorption
D.	adipose tissue	small intestine	inhibits absorption

- 21.** What enzyme removes the RNA primers and replaces them with DNA during DNA replication?
- A. DNA polymerase I
  - B. DNA polymerase III
  - C. DNA gyrase
  - D. DNA primase
- 22.** Sanger sequencing uses nucleotides containing dideoxyribose instead of deoxyribose. How do these nucleotides block DNA replication?
- A. They inhibit DNA polymerase.
  - B. They prevent the formation of base pairs.
  - C. They prevent the formation of sugar–phosphate bonds.
  - D. They hold the two DNA strands together.
- 23.** What happens to mRNA after transcription in eukaryotic cells?
- A. Binding to the large subunit of the ribosome
  - B. Removal of introns
  - C. Addition of exons
  - D. Attachment of an amino acid
- 24.** What is a feature of enzyme inhibition?
- A. In the pathway that converts threonine to isoleucine, end-product inhibition occurs when isoleucine binds to threonine.
  - B. Increasing the amount of substrate will increase the amount of product when a reaction is inhibited by non-competitive inhibitors.
  - C. Competitive inhibitors prevent catalysis by binding to an allosteric site.
  - D. Non-competitive inhibitors are a different shape from the substrate.

25. Aerobic cell respiration using glucose can be summarized with an equation.

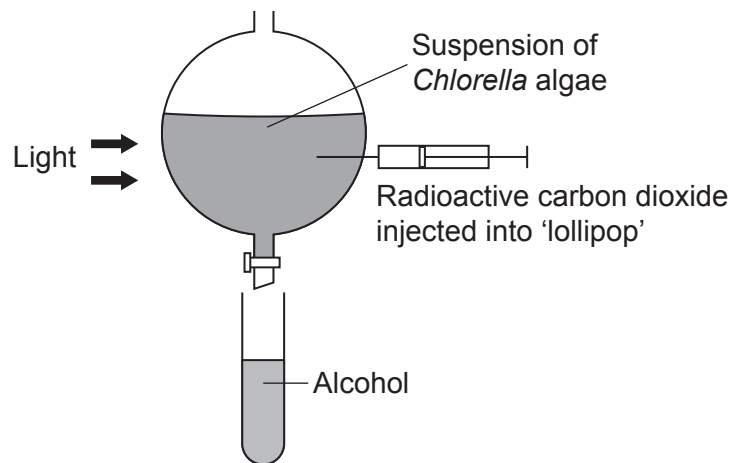


At what stage(s) is carbon dioxide produced?

	<b>Glycolysis</b>	<b>Link reaction and Krebs cycle</b>	<b>Electron transport chain</b>
A.		✓	
B.	✓		✓
C.		✓	✓
D.	✓	✓	

26. Scientists discovered from an electron tomogram of a mitochondrion that the inner membrane of a mitochondrion invaginates to form cristae through narrow tubes. How does an image produced by tomography differ from an image produced by conventional electron microscopy?
- A. Organelles can be viewed in colour.
  - B. Tomography provides greater magnification.
  - C. Three-dimensional images can be produced.
  - D. Live tissue can be observed.

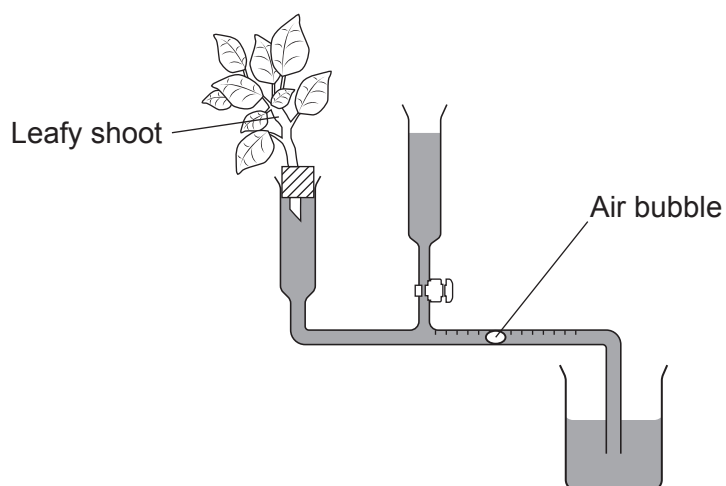
27. The diagram shows the apparatus used by Calvin in his experiments to determine the biochemical details of photosynthesis.



In what compound(s) was radioactive carbon found?

- I. Ribulose biphosphate
  - II. Glycerate 3-phosphate
  - III. Glucose
- A. I only
  - B. III only
  - C. I and III only
  - D. I, II and III

28. The diagram shows a potometer.

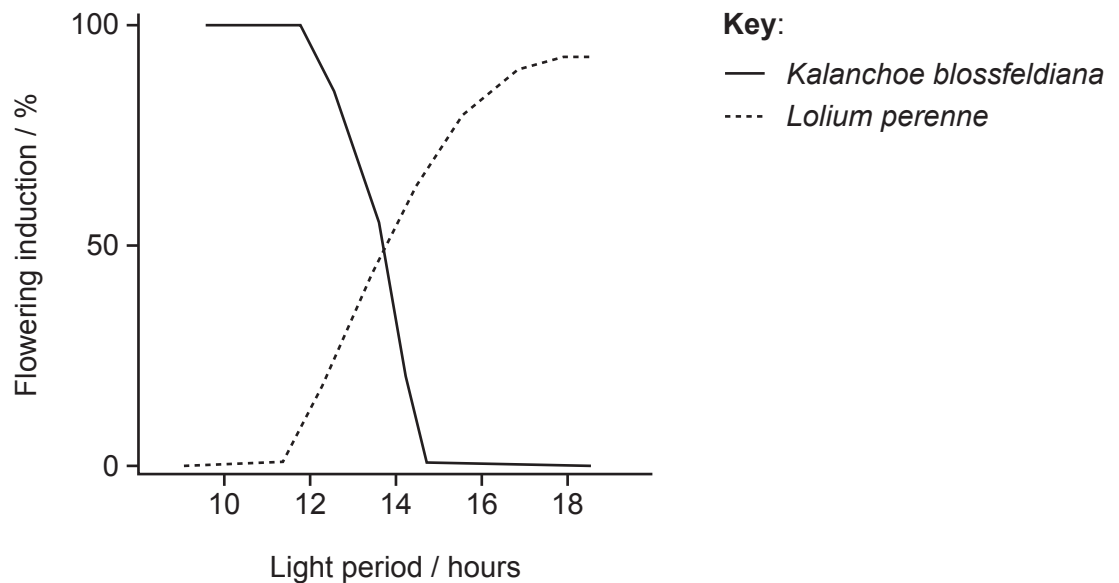


Under what weather conditions would the air bubble move fastest towards the shoot?

- A. Warm and humid
  - B. Warm and dry
  - C. Cold and humid
  - D. Cold and dry
29. What happens in the transport of organic compounds in plants?
- A. High hydrostatic pressure is created at the source.
  - B. Organic compounds are loaded into phloem sieve tubes by diffusion.
  - C. A raised hydrostatic pressure at the sink causes a flow of solutes.
  - D. Mass flow occurs from an area of low to an area of high pressure.
30. What is an advantage of micropropagation?
- A. Production of plants without application of hormones
  - B. Genetically modified plants are obtained
  - C. Allows development of hybrids
  - D. Production of virus-free plant strains



31. The graph shows the percentage of plants that flower according to the period of light for two different plant species, *Kalanchoe blossfeldiana* and *Lolium perenne*, one of which is a short-day plant.



Which plant would be described as a short-day plant?

- A. *Kalanchoe blossfeldiana*, as flowering is stimulated by long nights
  - B. *Kalanchoe blossfeldiana*, as flowering is stimulated by short days
  - C. *Lolium perenne*, as flowering is stimulated by long nights
  - D. *Lolium perenne*, as flowering is stimulated by short days
32. How do cells at the end of meiosis I differ from cells at the end of meiosis II?
- A. DNA at the end of meiosis I differs from DNA at the end of meiosis II due to crossing over.
  - B. There is less DNA at the end of meiosis I, due to separation of homologous chromosomes.
  - C. The cells are diploid at the end of meiosis I and haploid at the end of meiosis II.
  - D. There are more chromatids per cell at the end of meiosis I than at the end of meiosis II.

33. Mendel crossed pea plants with round yellow seeds with pea plants with wrinkled green seeds and found that all the pea plants in the F1 generation had round yellow seeds. In the F2 generation, 556 pea plants were produced. Assuming independent assortment, what is the most probable number of round green seeds produced?
- A. 0
  - B. 32
  - C. 101
  - D. 556
34. Some species could potentially hybridize but never do in the wild. What could be an example of temporal isolation?
- A. Different song patterns by grasshoppers of the genus *Chorthippus*
  - B. Sage plants *Salvia apiana* and *Salvia mellifera*, pollinated by different species of insects
  - C. Cicadas *Magicicada tredecim* become sexually mature every 13 years and *Magicicada septedecim* every 17 years
  - D. Pygmy three-toed sloths (*Bradypus pygmaeus*), isolated on the island of Escudo de Veraguas from mainland sloths
35. Allergic conjunctivitis can be stimulated by exposure to pollen and leads to watery, itchy and red eyes. What is the cause of this condition?
- A. White blood cells release antihistamines in response to allergens.
  - B. Allergens in pollen stimulate the release of histamines.
  - C. White blood cells produce antibodies to destroy pollen.
  - D. There is a similar structure between the antigens of pollen and pathogens.

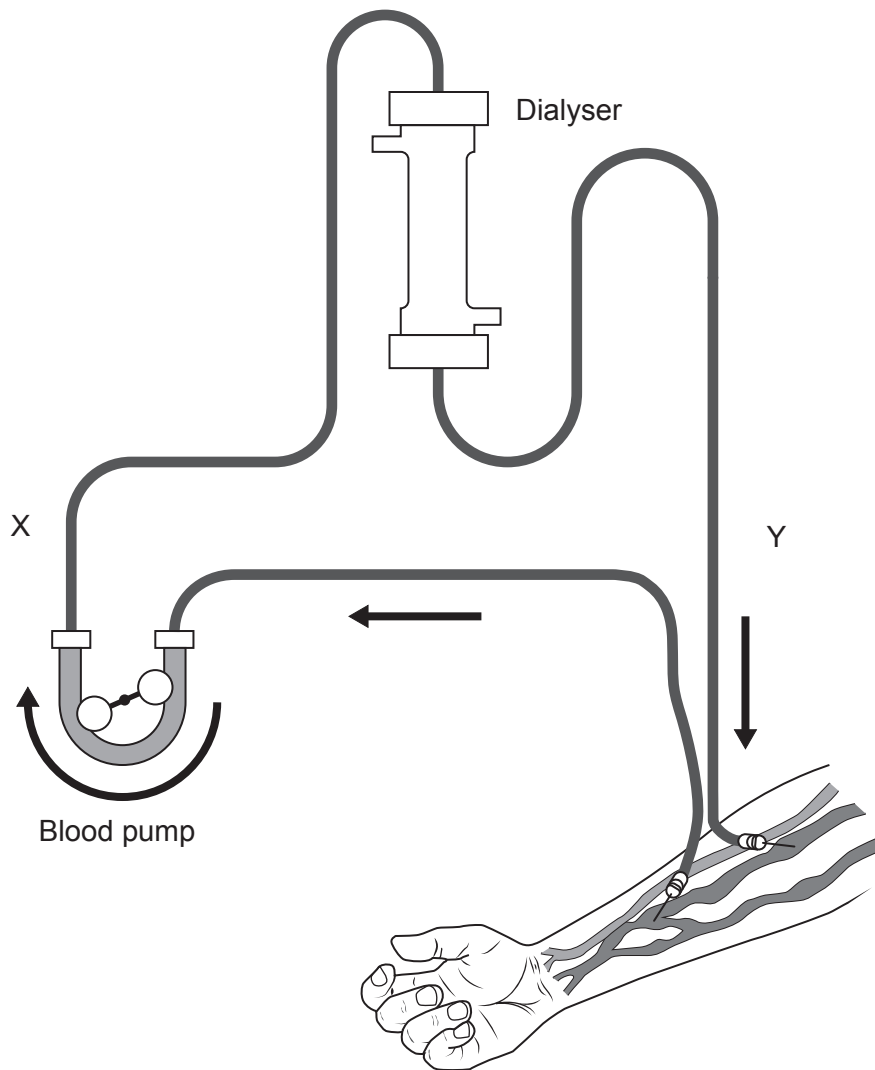
- 36.** Blood groups depend on the presence and absence of antigens on the surface of red blood cells. Antibodies in blood plasma react against foreign antigens, causing agglutination. The table shows the antigens and antibodies present in each blood group.

<b>Blood group</b>	A	B	AB	O
<b>Antigens</b>	A	B	A and B	none
<b>Antibodies</b>	anti-B	anti-A	none	anti-A and anti-B

What deductions can be made?

- A. A person of blood group O can receive blood of any blood type.
  - B. A person of blood group B can receive O blood.
  - C. A child whose parents are blood groups AB and O will have two types of antibodies.
  - D. A child whose parents are both blood group A can only produce anti-B antibodies.
- 37.** What occurs during skeletal muscle contraction?
- A. Myosin and actin filaments decrease in length.
  - B. Calcium ions bind to troponin.
  - C. ATP binds to actin heads.
  - D. The dark band gets shorter.

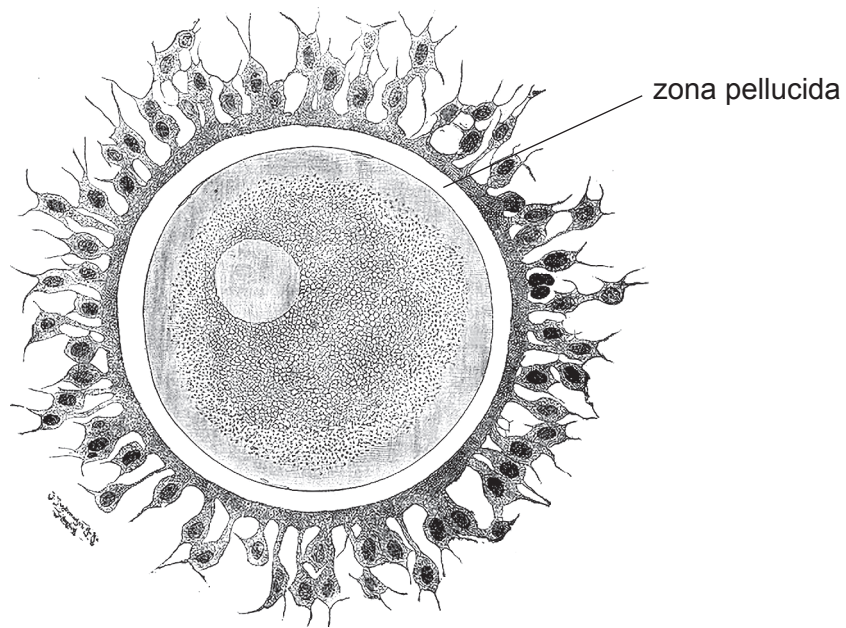
38. The diagram shows blood flowing through a hemodialyser to treat kidney failure. The arrows show the direction of blood flow.



Which statement describes what happens in blood during hemodialysis?

- A. Useful substances are selectively reabsorbed.
- B. More urea will be found in the blood at Y than at X.
- C. Hemodialysis removes all salts from the blood.
- D. Glucose can diffuse into or out of the blood during hemodialysis.

39. What stage of spermatogenesis produces haploid cells from diploid cells?
- A. Spermatogonia to primary spermatocytes
  - B. Primary spermatocytes to secondary spermatocytes
  - C. Secondary spermatocytes to spermatids
  - D. Spermatids to sperm cells
40. The diagram shows the location of the zona pellucida, a layer of glycoproteins on the human ovum.



What is the main function of the zona pellucida?

- A. To prevent polyspermy
  - B. To form polar bodies
  - C. To provide amino acids
  - D. To release FSH
-

**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:**

4. Pérez, Nicolás. [https://commons.wikimedia.org/wiki/File:02\\_Villaverde\\_de\\_Pontones\\_Rio\\_Aguanaz\\_Gerris\\_lacustris\\_Ni.jpg](https://commons.wikimedia.org/wiki/File:02_Villaverde_de_Pontones_Rio_Aguanaz_Gerris_lacustris_Ni.jpg). Licensed under CC BY-SA 4.0 DEED <https://creativecommons.org/licenses/by-sa/4.0/deed.en>. Image adapted.
10. Barral, M, 2020. *The Birth of Genetic Fingerprinting, an Invaluable Tool for CSI*. [online] Available at: <https://www.bbvaopenmind.com/en/science/scientific-insights/the-birth-of-genetic-fingerprinting-an-invaluable-tool-for-csi/> [Accessed 1 September 2022]. Source adapted.
13. Hannah Ritchie and Pablo Rosado (2017) – “Fossil Fuels” Published online at OurWorldInData.org. Retrieved from: <https://ourworldindata.org/fossil-fuels> [Online Resource]. Data source: Energy Institute Statistical Review of World Energy (2023). CC BY 4.0 DEED.
17. Patrick J Lynch; illustrator; C Carl Jaffe; MD; cardiologist Yale University Center for Advanced Instructional Media Medical Illustrations by Patrick Lynch, generated for multimedia teaching projects by the Yale University School of Medicine, Center for Advanced Instructional Media, 1987–2000. Accessed at: [https://commons.wikimedia.org/wiki/File:Heart\\_anterior\\_exterior\\_view.jpg](https://commons.wikimedia.org/wiki/File:Heart_anterior_exterior_view.jpg) Licensed under CC BY 2.5 DEED: <https://creativecommons.org/licenses/by/2.5/>. Image adapted.
28. Wikibooks, 2020. *School Science/Potometer*. [online] Available at: [https://en.wikibooks.org/wiki/School\\_Science/Potometer](https://en.wikibooks.org/wiki/School_Science/Potometer) [Accessed 12 September 2022]. Drawn by Theresa Knott and Rachel Knott. CC BY-SA 3.0.
31. Engelmann, W, 2015. Photoperiodism: The Calendar of Plants. In: Mancuso, S and Shabala, S (eds) *Rhythms in Plants*. Springer, Cham. [https://doi.org/10.1007/978-3-319-20517-5\\_8](https://doi.org/10.1007/978-3-319-20517-5_8). Source adapted.
40. Vandyke Carter, H and Gray, H, 1918. *Human ovum*. [online] Available at: [https://en.wikipedia.org/wiki/Egg\\_cell](https://en.wikipedia.org/wiki/Egg_cell) [Accessed 12 September 2022]. Source adapted.

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