APOLLO

Biology
SL Workbook

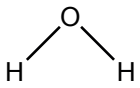
First assessment 2025
Whole questions arranged by syllabus topic.
Original question and scheme crops preserve source diagrams.

APOLLO

Water

6 questions

1. Which symbol indicates the polarity of the oxygen atom in the water molecule?



A. $\delta +$

B. $\delta -$

C. $+$

D. $-$

1. What describes bonding within a water molecule?

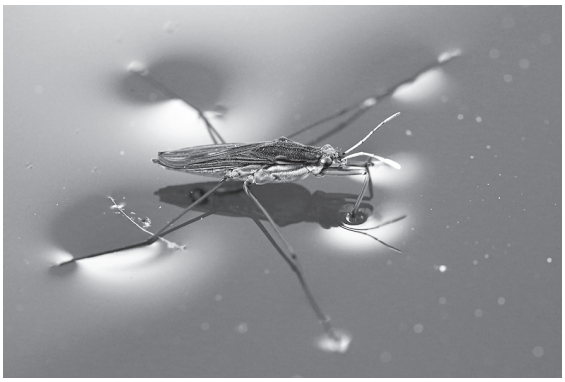
A. Hydrogen bonding due to transfer of electrons

B. Double bonds due to equal sharing of electrons

C. Non-polar covalent bonding due to equal sharing of electrons

D. Polar covalent bonding due to unequal sharing of electrons

1. The photograph shows a pond skater.



Which property of water allows the insect to walk on water?

A. Adhesion

B. Capillarity

C. Surface tension

D. Transparency

1. Which of the following is a consequence of the adhesive properties of water?

A. Stable temperatures of aquatic environments

B. Water movement by capillary action in soil

C. Transport of dissolved nutrients in blood plasma

D. Cooling effect of sweating

Section B

Answer **one** question. One additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

7. Albert Szent-Gyorgi, the Nobel Prize winner for Physiology or Medicine in 1937, said, "There is no life without water."

(a) Draw a labelled diagram to show how two water molecules interact with each other. [4]

(b) Outline the effects of immersing animal and plant cells in pure water. [4]

(c) Explain the process of transpiration and how xylem vessels are adapted for the transport of water from roots to leaves. [7]

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. Any trademarks™ or registered® trademarks included are used for illustrative purposes only, and use does not imply any affiliation with or endorsement by the International Baccalaureate.

References:

1.a Francis, L., McCluskey, D., Ganier, C. Jiang, T., Du-Harpur, X., Gabriel, J., Dhami, P., Kamra, Y., Visvanathan, S., Barker, J.N., Smith, C.H., Capon, F. and Mahil, S.K., 2024. *Nature Communications*, [e-journal] 15(913), [online] Available at: https://doi.org/10.1038/s41467-024-44994-w. Reference redacted. Source adapted.

1.d Francis, L., McCluskey, D., Ganier, C. Jiang, T., Du-Harpur, X., Gabriel, J., Dhami, P., Kamra, Y., Visvanathan, S., Barker, J.N., Smith, C.H., Capon, F. and Mahil, S.K., 2024. *Nature Communications*, [e-journal] 15(913), [online] Available at: https://doi.org/10.1038/s41467-024-44994-w. Reference redacted. Source adapted.

4. paveugra, 2015. *Respiratory system*. [image online] Available at: https://www.gettyimages.co.uk/detail/illustration/respiratory-system-royalty-free-illustration/489734346 [Accessed 29 October 2024]. Source adapted.

5. Bastian, C., 2022. *Three cows black and white group together in a field*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/three-cows-black-and-white-group-together-in-a-royalty-free-image/1440057213?phrase=cattle+in+field&adppopup=true [Accessed 4 December 2024]. Source adapted.

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

Answers written on this page
will not be marked.

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

Answers written on this page
will not be marked.

Question 7 - working space

2. What is a consequence of the ability of water to form many intermolecular hydrogen bonds?

A. Ice has a higher density than water and floats, providing habitats for fish-eating mammals.

B. Light can pass through water, so algae can photosynthesise.

C. Some small invertebrates can walk on water surfaces.

D. Small amounts of energy are needed to change water from one state to another, so that evaporation rates and condensation rates are rapid.

APOLLO

Nucleic acids

9 questions

2. What allows DNA to store very large amounts of data?

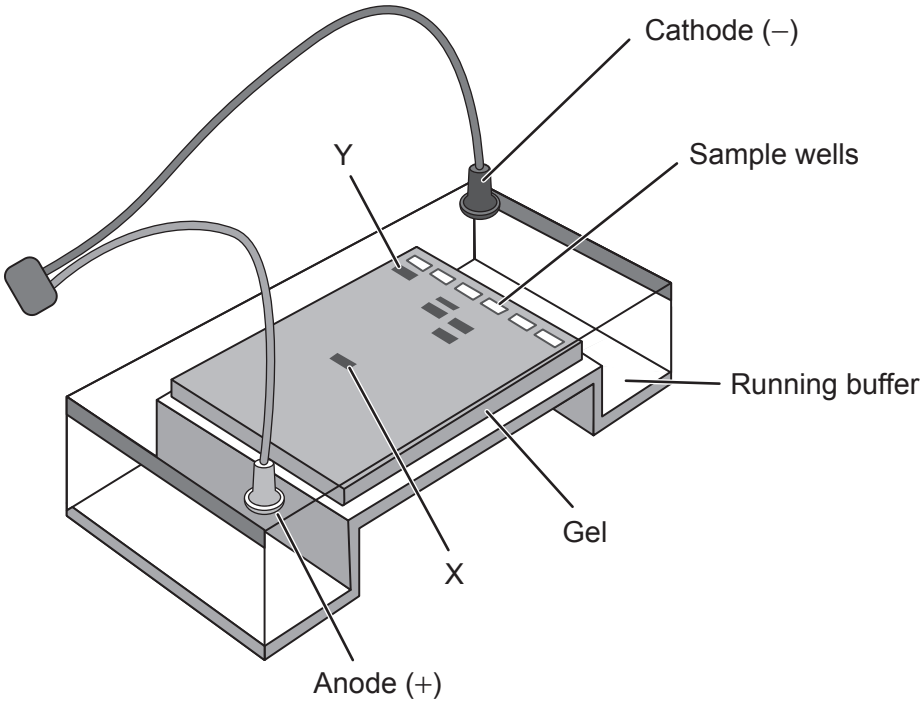
A. Two strands of DNA

B. Base sequence

C. Complementary base pairing

D. Sugar–phosphate backbone

7. The diagram shows a gel electrophoresis apparatus.



What can be deduced from the diagram?

A. X is the smallest fragment.

B. Y is positively charged.

C. X is moving towards the cathode.

D. Y travels at the greatest rate.

4. The table shows the nuclear DNA content of some plant and animal species.

Species scientific name	**Common name**	**Chromosome number**	**Genome size / DNA million base pairs**
Apis mellifera	honey bee	16	215
Homo sapiens	human	46	3080
Ailurus fulgens	red panda	36	2340
Pinus sylvestris	Scots pine	22	20 000
Paris japonica	canopy plant	40	150 000

(a) Suggest, giving a reason, whether gametes or somatic cells have been used to provide the information in the table. [1]

. . . . . .

. . . . . .

(b) State **one** way in which chromosomes are classified to construct the karyotype of an individual. [1]

. . . . . .

. . . . . .

(c) Outline the role of histones in plant and animal chromosomes. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 4 continued)

(d) Using the data provided in the table, discuss whether genome size positively correlates to organism complexity. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

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:

1. tonaquatic, 2021. [*Leaf epidermis under light microscope view*]. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/the-leaf-epidermis-under-light-microscope-view-has-royalty-free-image/1323853398 [Accessed 14 June 2024]. Reference redacted. Source adapted.

2. Golemansky, V. and Todorov, M., 2006. New Data to the Shell Ultrastructure and the Biometry of the Marine Interstitial Testate Amoebae (Rhizopoda: Testaceafilosia). *Acta Protozoologica* 45(3), pp. 301–312. Source adapted.

3. Drakesmith, M., Harms, R., Rudrapatna, U., Parker, G. D., Evans, J. and Jones, D. K., 2019. Estimating axon conduction velocity in vivo from microstructural MRI. *NeuroImage* 203, 116186. https://doi.org/10.1016/j.neuroimage.2019.116186. Source adapted. Licensed under CC BY 4.0: https://creativecommons.org/licenses/by/4.0/.

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

Answers written on this page
will not be marked.

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

Answers written on this page
will not be marked.

Question 4 - working space

1. Whole genome sequencing has allowed scientists to compare the genetic content of different organisms. The table shows the genome sizes of some plants and animals.

Organism	Scientific name	Genome size in million base pairs (mbp)
Nematode worm	*Caenorhabditis elegans*	100
Thale cress plant	*Arabidopsis thaliana*	160
Fruit fly	*Drosophila melanogaster*	180
Tiger pufferfish	*Takifugu rubripes*	400
Rice plant	*Oryza sativa*	490

(a) There are 64 million adenine–thymine base pairs in the genome of the nematode worm. Deduce the number of cytosine–guanine base pairs in the genome. [1]

. . . . . .

(b) State **one** organelle in which a base pair could be found. [1]

. . . . . .

(c) Discuss the current and potential future uses of whole genome sequencing. [3]

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

Question 1 - working space

Section A

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

5. Watson and Crick's discovery of the double helical structure of DNA gave rise to our current understanding of genes.

(a) State the name of the monomers that make up DNA. [1]

. . . . . .

. . . . . .

(b) Distinguish between the structure of DNA and RNA. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) From experiments, it was concluded that pea (*Pisum sativum*) plants have a recessive allele (t) for short stems. Explain the reason that recessive alleles are not always expressed in the phenotype. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 5 - working space

Section A

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

2. The percentage of cytosine in the genome of the common octopus (*Octopus vulgaris*) is 17.6 %.

(a) Explain the reasons for expecting a thymine percentage of 32.4 %. [2]

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

Scientists can amplify DNA molecules and separate mixtures of DNA molecules in the laboratory for analysis.

(b) State the laboratory method used to amplify DNA. [1]

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

(c) Distinguish between the structure of the nucleotides in DNA and RNA. [2]

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

Question 2 - working space

14. What is a function of histones?

A. Supercoiling of DNA during binary fission in prokaryotes

B. Synthesis of proteins

C. Formation of microtubules during mitosis

D. Condensation of DNA

16. Which term describes the whole of the genetic information of an organism?

A. Genome

B. DNA

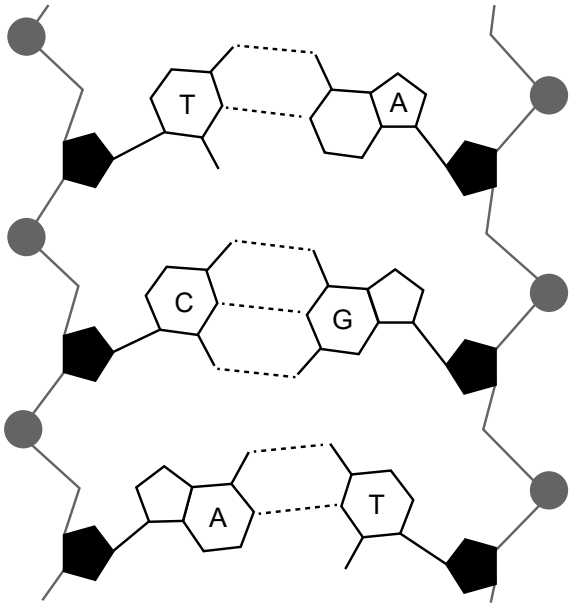
C. Gene pool

D. Allele frequency

Section A

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

3. The diagram shows a short stretch of DNA with complementary base pairing.



(a) Identify **two** features of DNA shown in this diagram that distinguish it from RNA. [2]

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

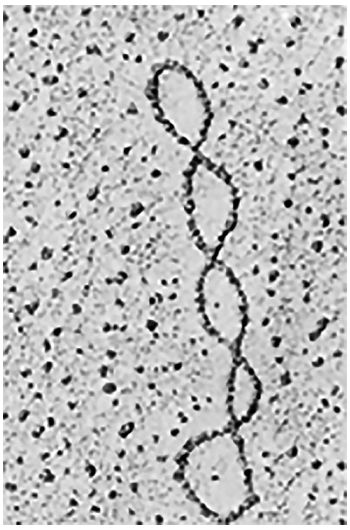
(b) Explain the significance of complementary base pairing in DNA. [3]

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

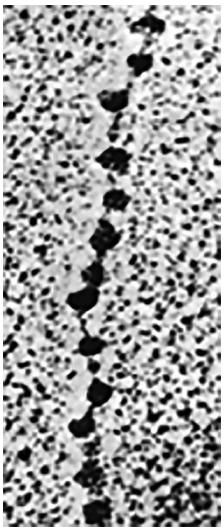
(This question continues on the following page)

(Question 3 continued)

The images are electron micrographs of DNA from a prokaryote and from a eukaryote.



Prokaryote DNA



Eukaryote DNA

(c) Distinguish between the structure of DNA in prokaryotes and eukaryotes. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 3 - working space

APOLLO

Cell structure

5 questions

9. Which cell organelle is common to all prokaryotic and eukaryotic cells?

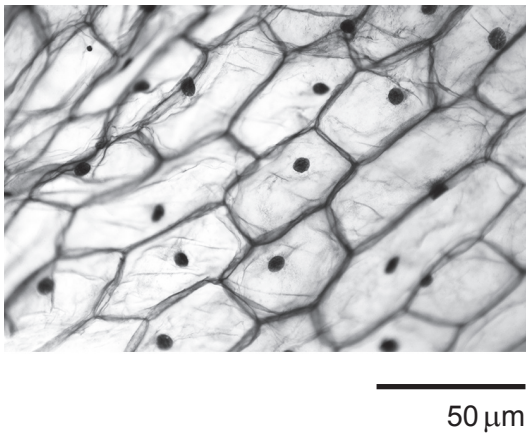
A. Nucleus

B. Cell wall

C. Vesicle

D. Ribosome

1. The image shows epidermis tissue from a bulb of the onion plant (*Allium cepa*) viewed using a light microscope.



(a) Calculate the magnification of the image. [1]

. . . . . .

(b) State the item of equipment that a student could use to accurately measure the length of an onion cell viewed using a light microscope. [1]

. . . . . .

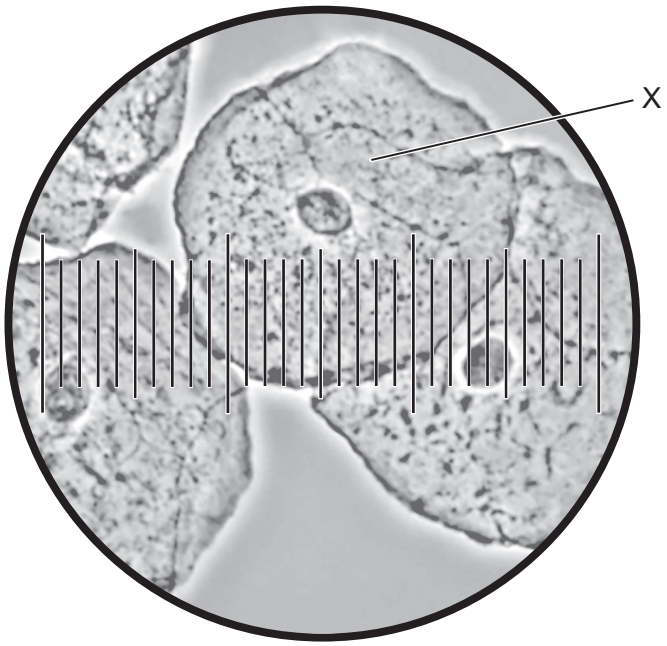
(This question continues on the following page)

(Question 1 continued)

(c) Draw a labelled diagram of a nucleus from a eukaryotic cell, such as an onion epidermis cell, as seen using an **electron** microscope. [3]

Question 1 - working space

1. The micrograph is an image of human cheek cells viewed with a light microscope.



(a) Identify the piece of equipment that is used together with the microscope to measure the size of the cells. [1]

. . . . . .

. . . . . .

(b) Each small division of the scale in the micrograph is equivalent to 2.5µm.

(i) Calculate the diameter of the cell labelled X. [1]

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(ii) Calculate the magnification of the image. [1]

. . . . . .

(c) Compare and contrast the cell components of eukaryotic and prokaryotic cells. [2]

. . . . . .

. . . . . .

. . . . . .

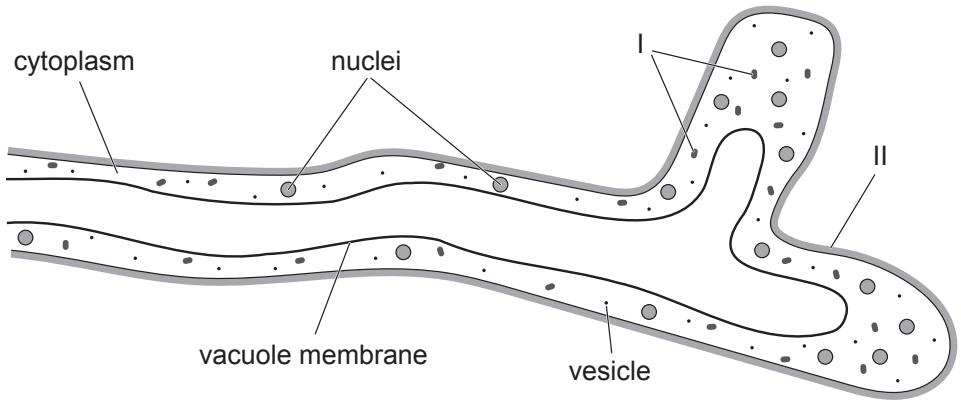
. . . . . .

Question 1 - working space

Section A

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

3. The diagram shows the structure of part of a fungus.



(a) The structures labelled I are membrane-bound organelles. Deduce, giving a reason, what these organelles could be. [2]

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

(b) State with a reason whether the fungus is prokaryotic or eukaryotic. [1]

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

(c) The structure labelled II is the outer part of the fungus. State the main component of this structure. [1]

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

(This question continues on the following page)

(Question 3 continued)

(d) Identify **one** feature of the fungus that is atypical of cell structure. [1]

. . . . . .

. . . . . .

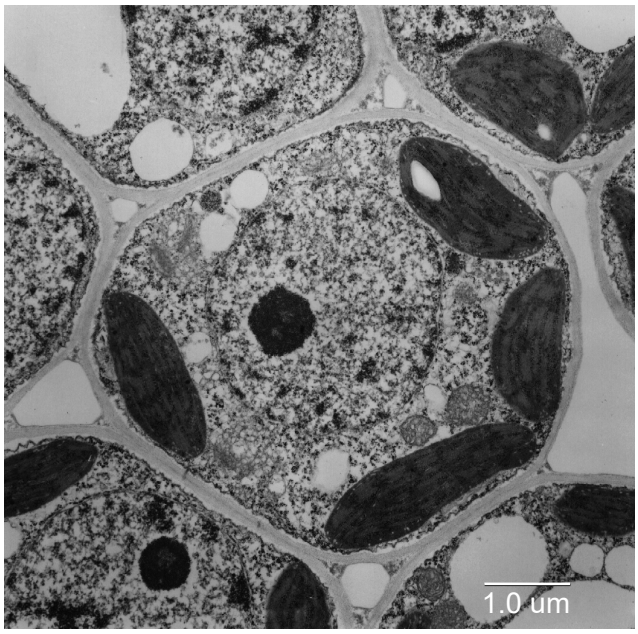
. . . . . .

. . . . . .

(e) Water is the main component of vacuoles and cytoplasm in fungi. Draw a diagram to show the structure of a water molecule. [2]

Question 3 - working space

11. What can be identified in the electron micrograph?



A. Plant cells with cell walls, nuclei and chloroplasts

B. Plant cells with chloroplasts and large central vacuoles containing nuclei

C. Several prokaryotes with cell walls and cytoplasm

D. Animal cells with prominent mitochondria

Turn over

APOLLO

Diversity of organisms

6 questions

8. The table shows features of three types of cells (X, Y and Z).

Feature	**Cell**		
	X	**Y**	**Z**
Cell wall	absent	present	present
Centrioles	present	absent	absent
Large vacuole	absent	present	present
Plastids	absent	present	absent

To which kingdom do each of the cells belong?

	X	**Y**	**Z**
A.	Animal	Fungi	Plant
B.	Fungi	Animal	Protist
C.	Animal	Plant	Fungi
D.	Protist	Animal	Plant

25. The image shows *Prorocentrum*, a coastal dinoflagellate that obtains energy from sunlight and from other organisms.



What best describes the mode of nutrition of *Prorocentrum*?

A. Mixotrophic

B. Autotrophic

C. Holozoic

D. Heterotrophic

Section A

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

2. There can be much variation within a single species, such as dogs (*Canis familiaris*).



(a) Define species. [1]

. . . . . .

. . . . . .

(b) Describe how karyotyping can be used to decide if all these dogs are of the same species or not. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 2 - working space

13. The table shows the binomial naming of four species.

Organism	Genus	Species
W	*Felis*	*catus*
X	*Conus*	*catus*
Y	*Ameiurus*	*catus*
Z	*Felis*	*silvestris*

What can be concluded?

A. W, X and Y are the most closely related.

B. X and Y are the most closely related.

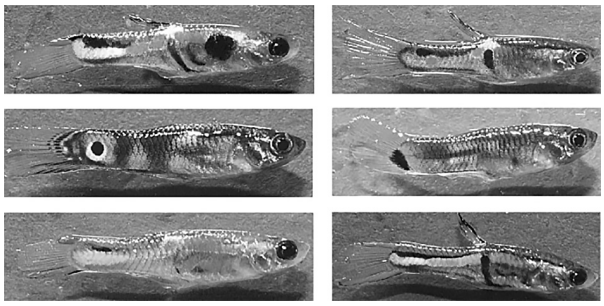
C. W and Z are the most closely related.

D. W is equally related to all the other species.

25. What describes holozoic nutrition?

	Nutrition type	Digestion
A.	chemoautotrophic	none
B.	photoautotrophic	none
C.	saprotrophic	external
D.	heterotrophic	internal

4. The images show examples of adult male guppies (*Poecilia reticulata*).



(a) State the name of the genus to which the guppy belongs. [1]

. . . . . .

. . . . . .

(b) Outline Linnaeus's morphological concept of species. [1]

. . . . . .

. . . . . .

(c) (i) Two alternative hypotheses were suggested:

- the guppies were from a single interbreeding population
- the guppies were not from a single interbreeding population.

Explain, with a reason, which hypothesis is stronger. [1]

. . . . . .

. . . . . .

(ii) Suggest how additional evidence could be used to further test which hypothesis is supported. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 4 continued)

(d) Suggest an adaptive advantage for these guppies of having striking colour patterns. [1]

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

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:

1. Jamieson, J.D. and Palade, G.E., 1967. Intracellular transport of secretory proteins in the pancreatic exocrine cell. *Journal of Cell Biology*, 34, pp.597–615.

2. Houseman, J. and Ford, M., 2014. *Dicot leaf L*. [image online] Available at: <https://commons.wikimedia.org/wiki/File:Dicot_leaf_L.jpg> [Accessed 28 July 2020].

3. *Lemna minor*, 2015. [image online] Available at: <https://www.semanticscholar.org/paper/Darwin-Wallace-Demons%3A-survival-of-the-fastest-in-Kutschera-Niklas/a2e3531fa8c1920d2bd4d04871bfeb19ed2143f0> [Accessed 8 December 2020].

4. Jones, J.C., Gunter, H.M. and Meyer, A., 2008. Will he still look good with the lights on? Spectral tuning of visual pigments in fish. *Journal of Biology*, [e-journal] 7(26). Available at: <https://jbiol.biomedcentral.com/articles/10.1186/jbiol86> [Accessed 28 July 2020].

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

Answers written on this page
will not be marked.

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

Answers written on this page
will not be marked.

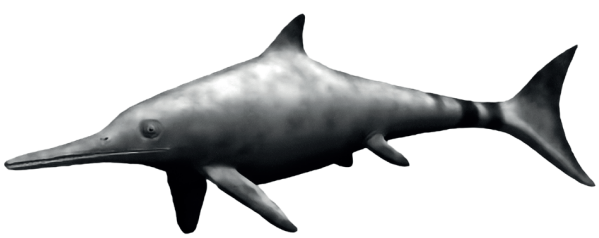
Question 4 - working space

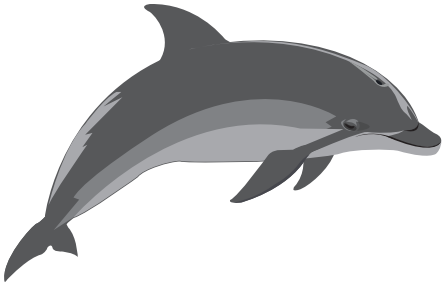
APOLLO

Evolution and speciation

10 questions

22. The images show an ichthyosaurus and a dolphin. Ichthyosaurus is an extinct aquatic reptile, known only from fossil remains. Dolphins are mammals.





How have these species evolved?

A. Their streamlined bodies show divergent evolution.

B. Their streamlined bodies are analogous structures.

C. Their pentadactyl limbs are an example of convergent evolution.

D. Their pentadactyl limbs are analogous structures.

Turn over

22. What describes analogous structures?

A. They are formed from divergent evolution.

B. They share a common ancestor.

C. They came from different evolutionary origins.

D. They have the same structure but different functions.

Turn over

14. The salamander genus *Ensatina* from California, USA, has evolved several different forms, depending on location. Two such forms are shown.



What determines if these forms are members of the same species?

A. Have similar appearance

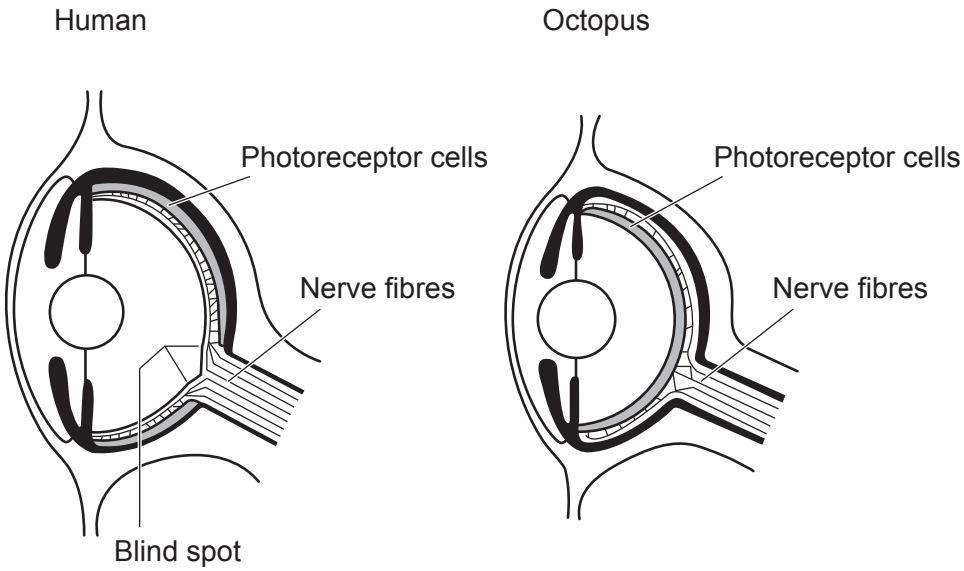
B. Populations mix freely

C. Produce fertile offspring

D. Can interbreed

Turn over

23. Human and octopus eyes have a similar structure and function but humans and octopuses have a different evolutionary origin.



What explains the similar structure of these eyes?

	Type of evolution	Relationship of structures
A.	convergent	analogous
B.	convergent	homologous
C.	divergent	homologous
D.	divergent	analogous

Turn over

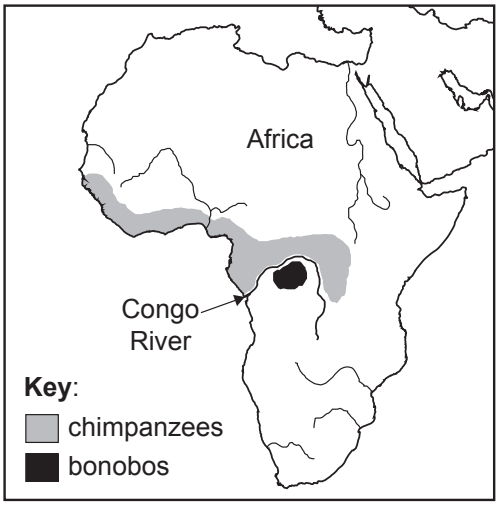
Section A

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

3. (a) Describe the role of the EDGE of Existence programme. [2]

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

Chimpanzees and bonobos are different species of primate. It is thought that neither species can swim. The map shows the relative locations of chimpanzees and bonobos in Africa.



Evidence suggests that the level of the Congo River was lower during one period in the past. At this time, chimpanzees could have migrated across.

(b) Explain how bonobos could have evolved from chimpanzees by speciation. [3]

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

Question 3 - working space

22. Bonobos (*Pan paniscus*) and chimpanzees (*Pan troglodytes*) are primates.



Bonobo (*Pan paniscus*)



Chimpanzee (*Pan troglodytes*)

Separation by the Congo River allowed these two species to be formed. What was a consequence of the separation?

A. Natural selection

B. Reproductive isolation

C. Selective breeding

D. Analogous structures

24. What is evidence for evolution?

I. Homologous structures such as pentadactyl limbs
II. Domestication of dogs from wolves
III. Inheritance of acquired characteristics

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

13. According to the biological species concept, which of the following indicates that two organisms belong to the same species?

I. They occupy the same ecological niche.

II. They share morphological features.

III. They can crossbreed and produce fertile offspring.

A. I only

B. I and II

C. II and III

D. III only

23. What can lead to the emergence of analogous structures?

A. Divergent evolution from a recent common ancestor

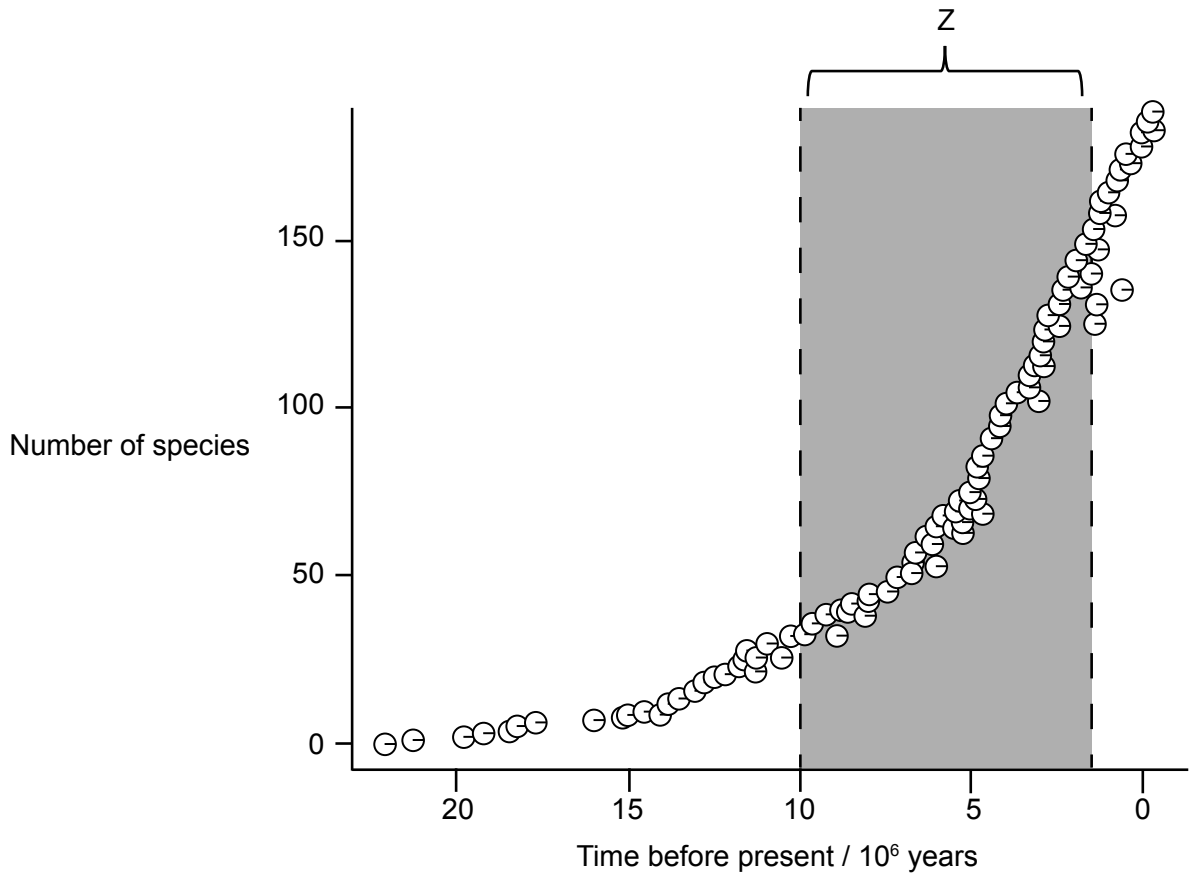
B. Convergent evolution of unrelated species

C. Splits in the fundamental niche of a species

D. Splits in the realized niche of a species

Turn over

24. The number of hummingbird species in South America has increased continuously as shown in the graph.



What could be a reason for the increase in the number of hummingbird species during the period labelled Z?

A. Food and shelter are plentiful and there is little intraspecific competition.

B. Closely related species can coexist indefinitely in the same niche.

C. A wide range of unoccupied potential niches exists, leading to adaptive radiation.

D. There are few limiting factors on the population size of hummingbirds.

APOLLO

Conservation of biodiversity

6 questions

23. The North Island giant moa (*Dinornis novaezealandiae*) went extinct some time between the arrival of humans in New Zealand and the 1800s.



What do scientists believe to be the cause of this extinction?

A. Deforestation

B. New diseases

C. Competition with other megafauna

D. Overhunting

23. What are causes for a global reduction in biodiversity?

I. Increase in size of towns and cities
II. Reclamation of degraded ecosystems
III. Clearance of land for agriculture

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

29. Which action is part of the rewilding of ecosystems?

A. Applying fertilizer

B. Removal of apex predators

C. Reintroduction of keystone species

D. Restricting size for easier management

Turn over

23. What could minimize the loss of biodiversity?

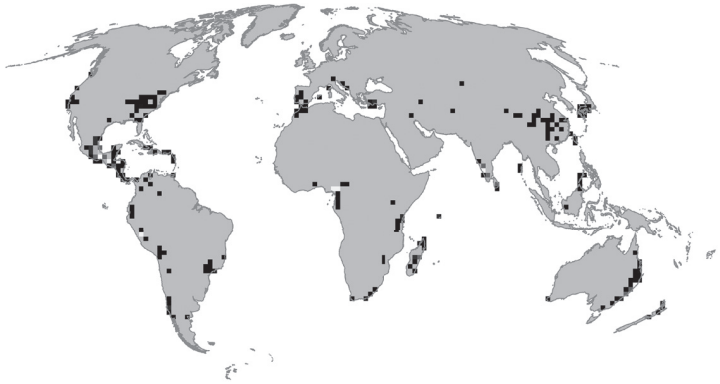
A. Increase the rate of deforestation

B. Introduce species into new environments to control predation

C. Reduce the use of renewable energy

D. Rewilding of degraded ecosystems

22. The dark areas of the map show the distribution of some species included in the EDGE of Existence programme.



What is the reason these species have been included in the EDGE of Existence programme?

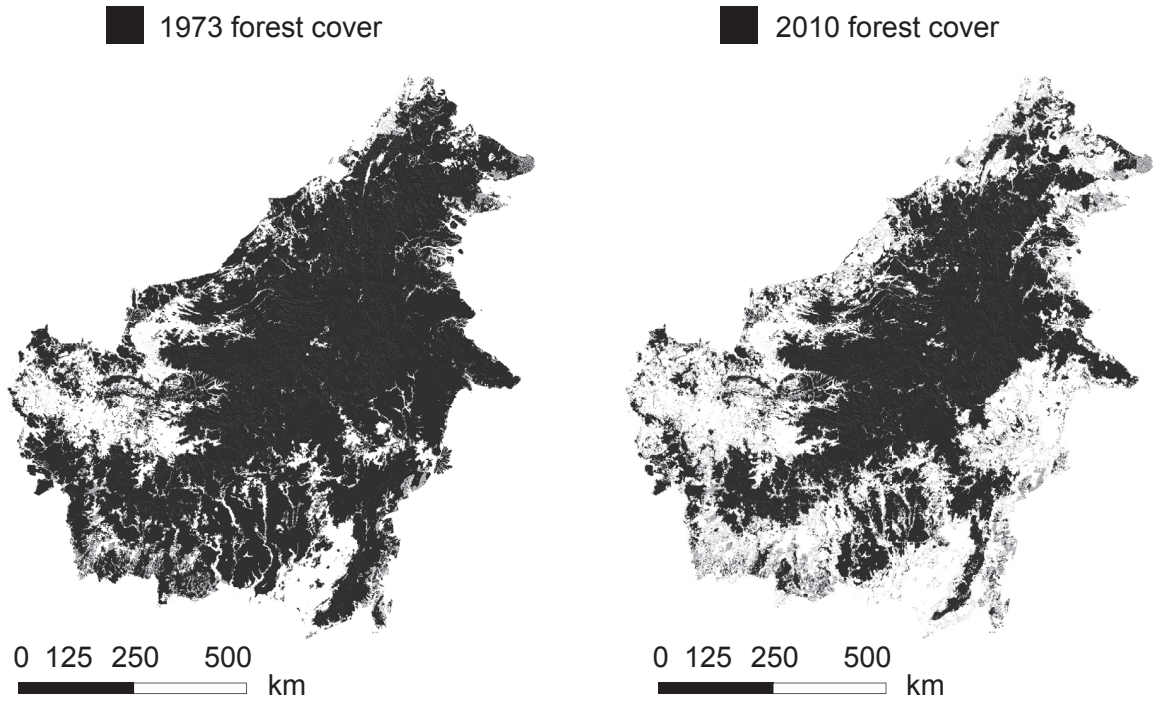
A. They occupy similar niches threatened by invasive species.

B. Their risk of extinction is higher as they live at the edge of ecosystems.

C. Their populations are decreasing and there are few or no closely related species.

D. They are keystone species in their ecosystems.

23. The satellite images show changes in the area covered by forest, much of which is mixed dipterocarp forest, on the island of Borneo in Southeast Asia.



Which human activities are most likely to have caused the changes shown in the map?

A. Logging and palm oil plantation

B. Logging and rewilding

C. Mining and afforestation

D. Afforestation and palm oil plantation

Turn over

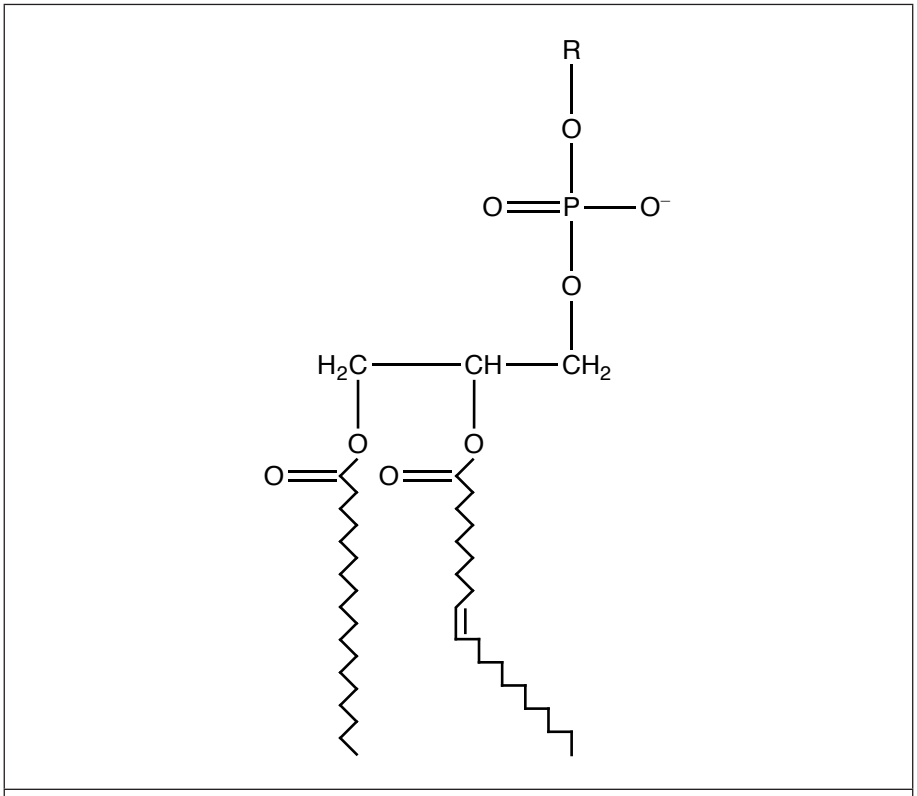
APOLLO

Carbohydrates and lipids

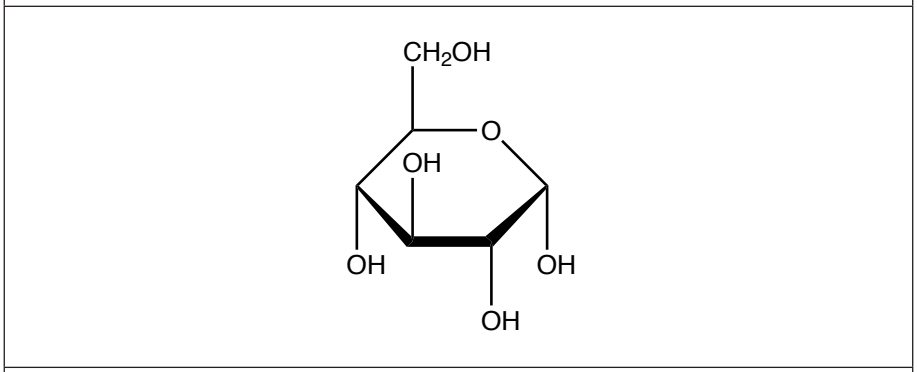
10 questions

2. Which of these molecules is amphipathic?

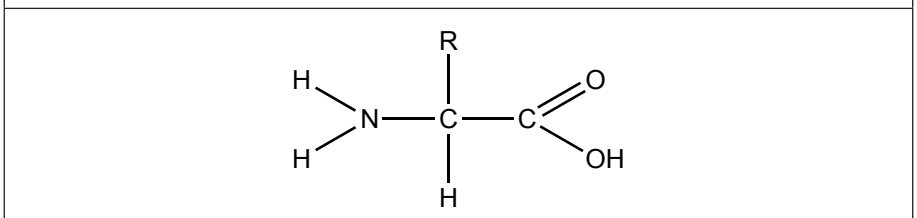
A.



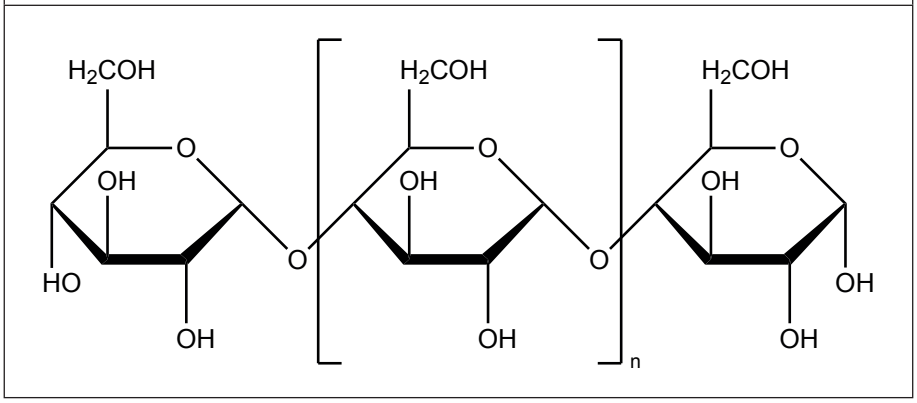
B.



C.



D.



Turn over

3. What describes the structure of cellulose?

A. Branched with bonds between alpha-glucose and beta-glucose molecules

B. Branched with bonds between alpha-glucose molecules

C. Linear with bonds between alpha-glucose molecules

D. Linear with bonds between beta-glucose molecules

2. What is the function of cellulose in plant cells?

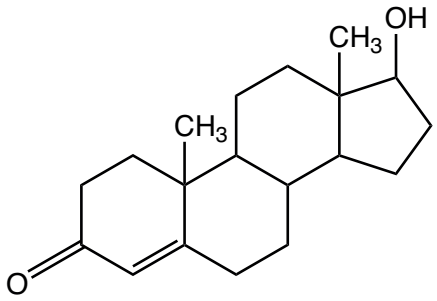
A. It increases the strength of cell walls.

B. It is a source of energy for plants.

C. It maintains the structure of the vacuole.

D. It increases the permeability of the cell membranes.

3. A simplified diagram of molecule X is shown.



What describes molecule X?

A. Lipid able to pass through the bilayer of membranes

B. Lipid used for energy storage in mammals

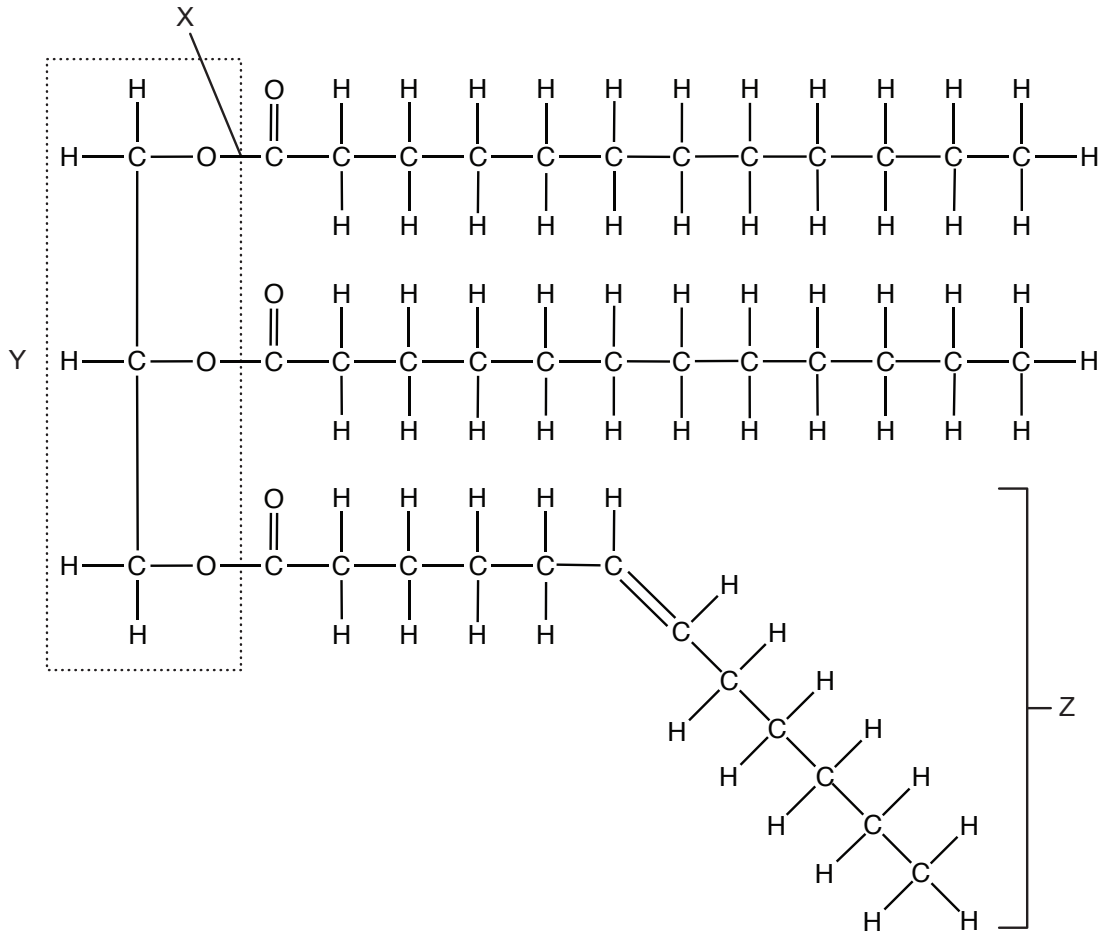
C. Carbohydrate transported in the blood

D. Carbohydrate used for energy storage in plants

Section A

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

2. The diagram shows the structure of a triglyceride.



(a) Identify the type of reaction used to form the covalent bond indicated by X. [1]

. . . . . .

(b) Identify the molecule that was used to form part Y of the triglyceride. [1]

. . . . . .

(This question continues on the following page)

(Question 2 continued)

(c) State the type of fatty acid shown as Z. [1]

. . . . . .

(d) Explain how the properties of triglycerides make them suitable for energy storage. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

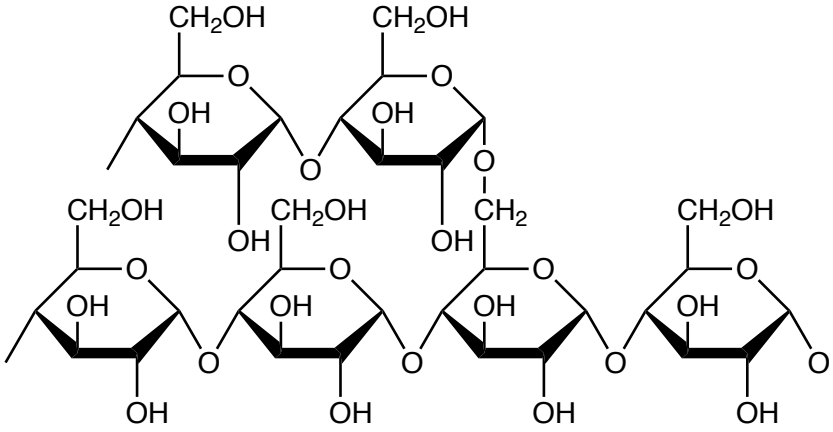
Please **do not** write on this page.

Answers written on this page
will not be marked.

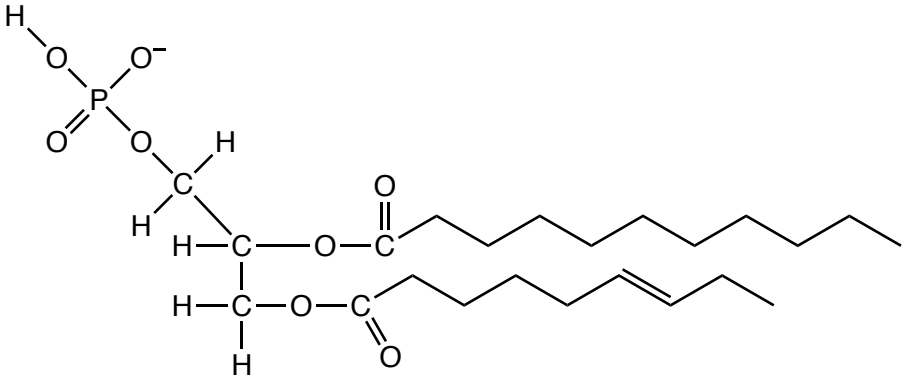
Question 2 - working space

2. Which molecular diagram shows a phospholipid molecule?

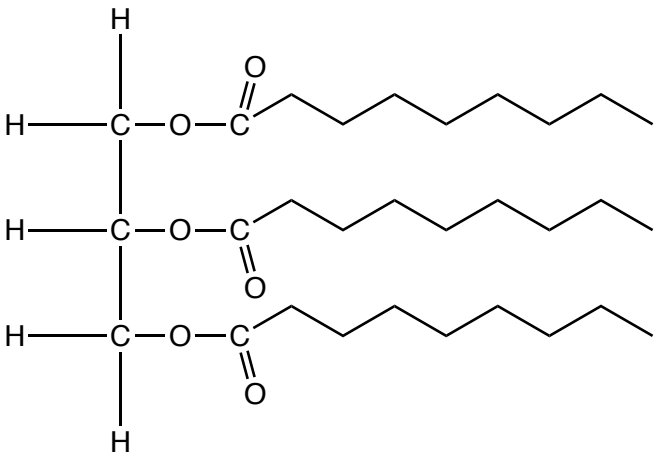
A.



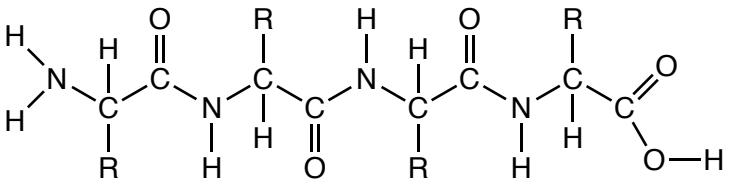
B.



C.

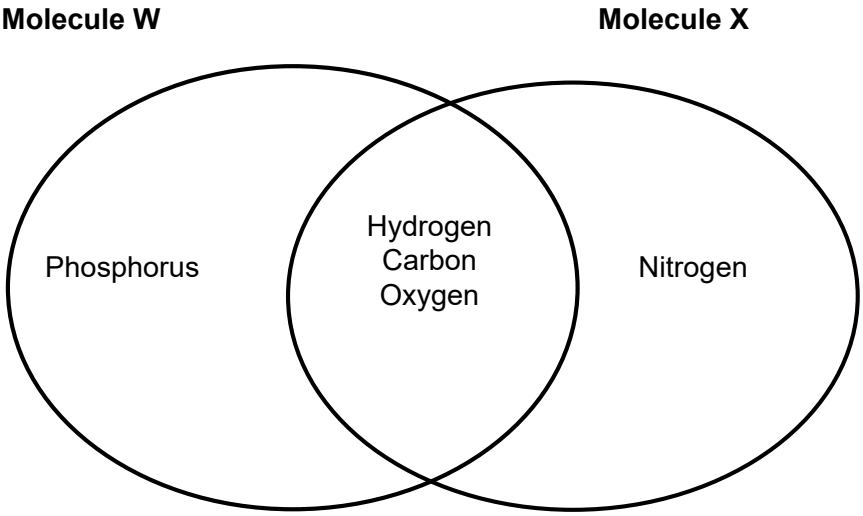


D.



Turn over

1. The diagram shows the elements present in two organic molecules, W and X.
Which molecules could W and X be?



	Molecule W	Molecule X
A.	monosaccharide	amino acid
B.	nucleic acid	triglyceride
C.	phospholipid	protein
D.	triglyceride	fatty acid

3. Which molecules are produced during the hydrolysis of a triglyceride molecule?

A. Water and glycerol

B. Fatty acids and glycerol

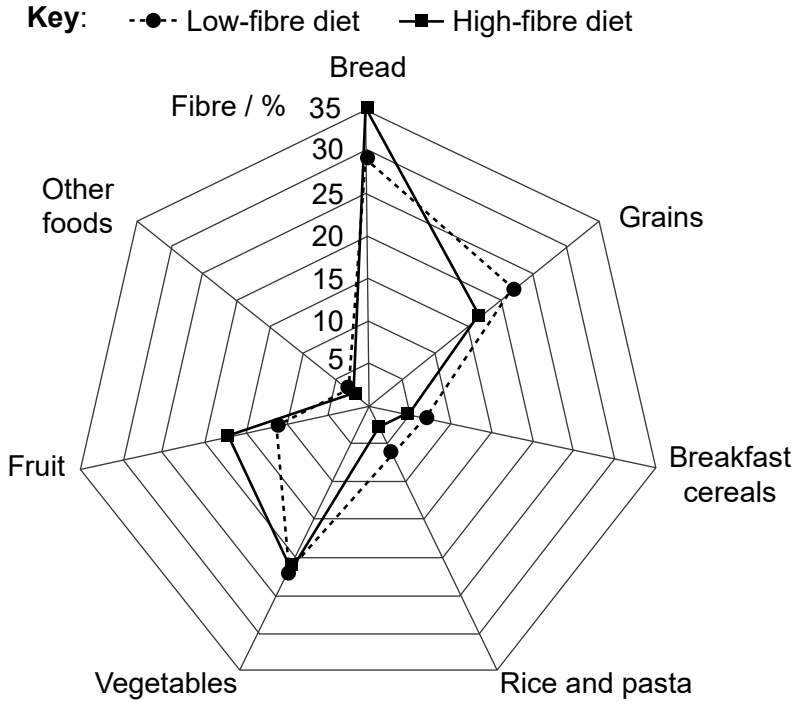
C. Water and fatty acids

D. Water and lipids

Section A

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

1. A long-term study looked at the effect of diets with differing fibre content in 543 children between the ages of 8 months and 9 years. The children were divided into groups according to the amount of fibre in their diet. The chart shows the sources of fibre for the 9-year-olds as a percentage of the total fibre intake.



[Source: adapted from Ruottinen, S., Lagström, H.K., Niinikoski, H., Rönnemaa, T., Saarinen, M., Pahkala, K.A., Hakanen, M., Viikari, J.S.A. and Simell, O., 2010. *The American Journal of Clinical Nutrition*, 91(3), pp.651–661. REDACTED.]

(a) (i) State the source of fibre that provides 5 % of the fibre intake for those in the high-fibre group. [1]

. . . . . .

. . . . . .

(ii) State the percentage of the daily fibre intake obtained from fruit by the low-fibre group. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(b) Compare and contrast the fibre intake of the two groups. [2]

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

(c) Explain whether it is possible to determine from the data which group eats the most grains in a day. [2]

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

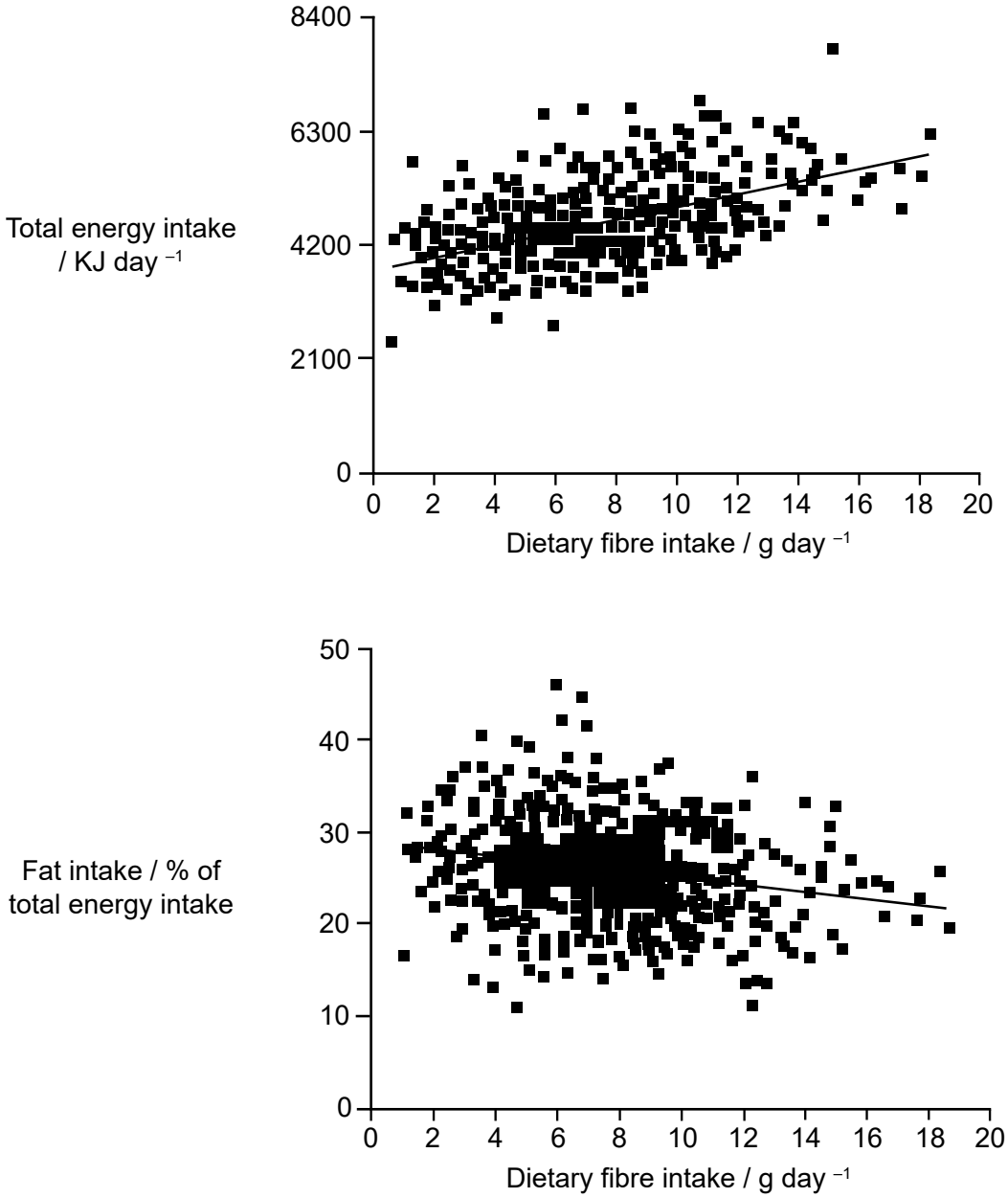
(d) Suggest with a reason, based on the data in the chart, **one** food that should be increased for children on the low-fibre diet. [2]

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

(This question continues on the following page)

(Question 1 continued)

The graphs show how the energy intake of the 13-month-old children varied with the daily intake of fibre and the percentage of this energy that came from fat.



[Source: adapted from Ruottinen, S., Lagström, H.K., Niinikoski, H., Rönnemaa, T., Saarinen, M., Pahkala, K.A., Hakanen, M., Viikari, J.S.A. and Simell, O., 2010. *The American Journal of Clinical Nutrition*, 91(3), pp.651–661. REDACTED.]

(This question continues on the following page)

(Question 1 continued)

(e) Compare the effect of increasing daily dietary fibre intake on total energy intake and percentage of total energy from fat. [1]

. . . . . .

. . . . . .

(f) Fibre is known to have no energy value. Suggest a reason for the relationship between dietary fibre intake and total energy intake. [1]

. . . . . .

. . . . . .

(g) Discuss whether the study supports the hypothesis that high-fibre diets are healthy for children. [1]

. . . . . .

. . . . . .

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

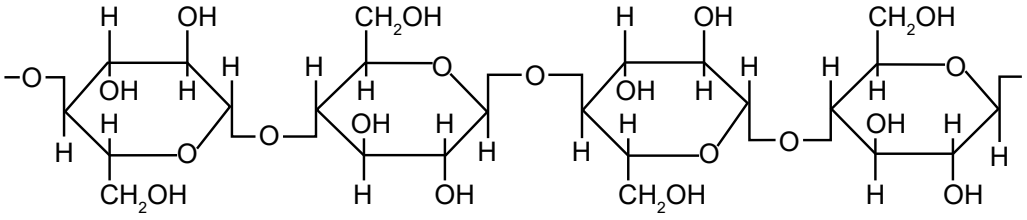
Answers written on this page
will not be marked.

Question 1 - working space

Section A

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

4. The structure of part of a cellulose molecule is shown.



(a) Identify the monomer from which cellulose is composed. [1]

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

(b) Explain how the structure of cellulose is related to its function. [3]

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

Question 4 - working space

APOLLO

Proteins

4 questions

3. How are amino acids joined together to form a dipeptide?

A. Single bond between a carbon and a hydrogen

B. Hydrolysis reaction forming a hydrogen bond

C. Anabolism forming a double bond

D. Condensation reaction forming a peptide bond

4. What must vegans ensure when they plan their diet?

A. Higher protein consumption than meat-eaters

B. Sufficient quantities of all essential amino acids are consumed

C. Only proteins with all 20 amino acids are consumed

D. Higher fat consumption than meat-eaters

Turn over

3. The table shows some essential and non-essential amino acids.

Essential amino acids	Non-essential amino acids
valine	alanine
lysine	glycine

What is a valid conclusion for an amino acid in the table?

A. Lysine is synthesized by the human body.

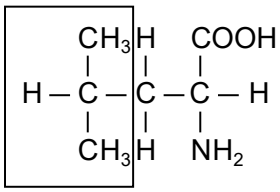
B. Alanine can only be obtained from food.

C. Glycine is not used in the human body.

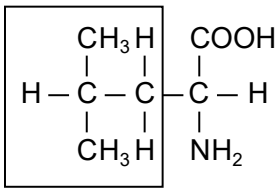
D. Valine must be supplied in the diet.

4. The diagrams show the structure of leucine, an essential amino acid. Which diagram highlights the part of leucine that distinguishes it from other amino acids?

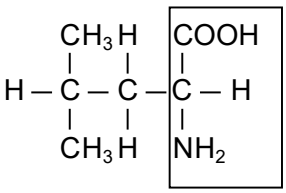
A.



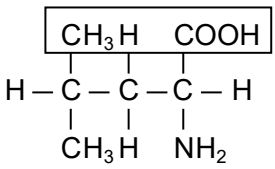
B.



C.



D.

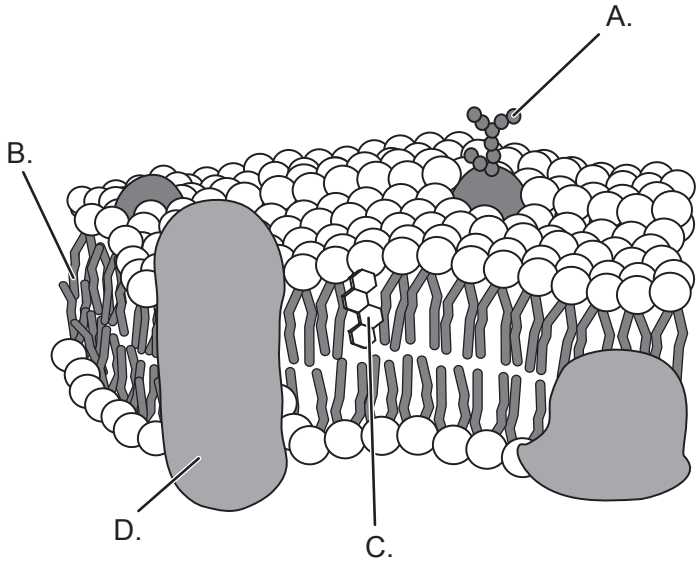


APOLLO

Membranes and membrane transport

10 questions

9. Which part of the membrane allows cell recognition?



9. The table shows concentrations of potassium ions and sodium ions maintained inside and outside human cells.

	Concentration of ions / 10^{-3} mol dm^{-3}	
Ions	**Intracellular**	**Extracellular**
Potassium	135	4
Sodium	10	145

What explains these concentrations?

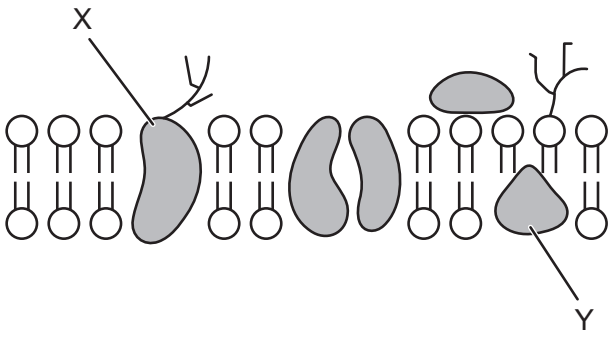
A. Active transport using a protein pump

B. Facilitated diffusion using a vesicle

C. Simple diffusion using a protein channel

D. Osmosis using an aquaporin

10. The diagram shows a portion of fluid mosaic membrane.



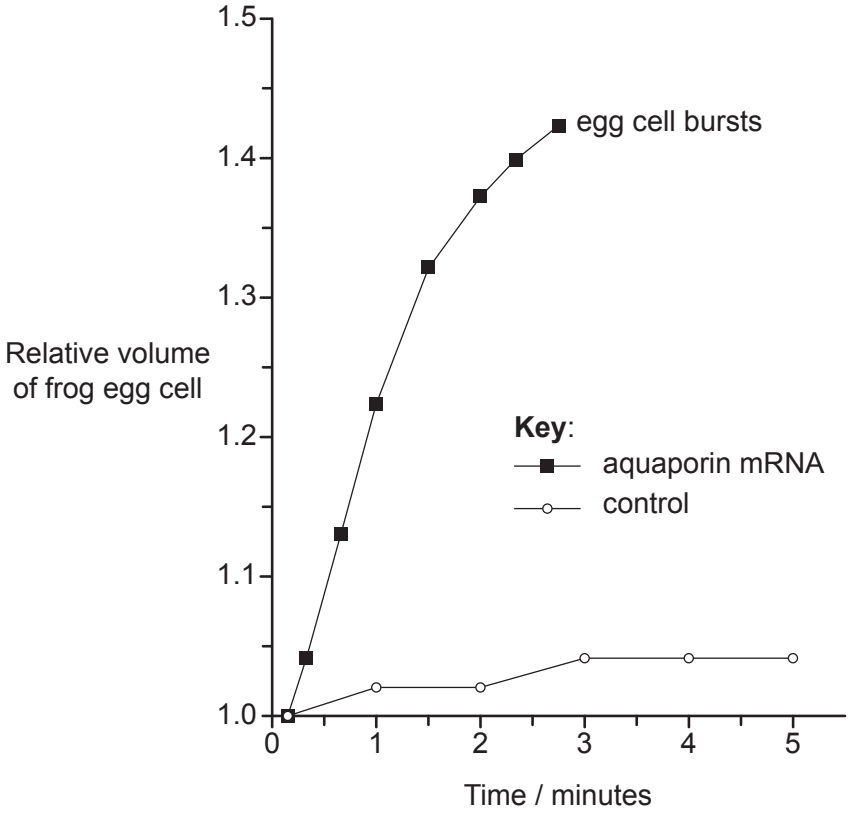
What are the membrane structures X and Y?

	X	Y
A.	glycoprotein	integral protein
B.	integral protein	peripheral protein
C.	channel protein	integral protein
D.	glycoprotein	peripheral protein

2. In the early 1990s, investigations involving egg cells from the African clawed frog (*Xenopus laevis*) led to the discovery of membrane channel proteins called aquaporins.

In one investigation, scientists injected 10 frog egg cells with a solution containing mRNA encoding for an aquaporin, and another 10 frog egg cells with distilled water (control cells). All the frog egg cells were then incubated in a hypotonic solution. The volume of the frog egg cells was then measured during a period of five minutes.

The graph shows the mean results of the investigation.



(a) State the direction of net movement of water across the plasma membrane of all the frog egg cells between 0 and 3 minutes. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 2 continued)

(b) (i) Distinguish between the results shown for the frog egg cells with aquaporin mRNA and the control egg cells. [2]

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

(ii) Explain the role of aquaporins in the movement of water across cell membranes. [2]

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

(c) Outline the reason that the results are displayed as mean relative volumes rather than mean volumes. [1]

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

(d) Comment on the reliability of the results of this investigation. [1]

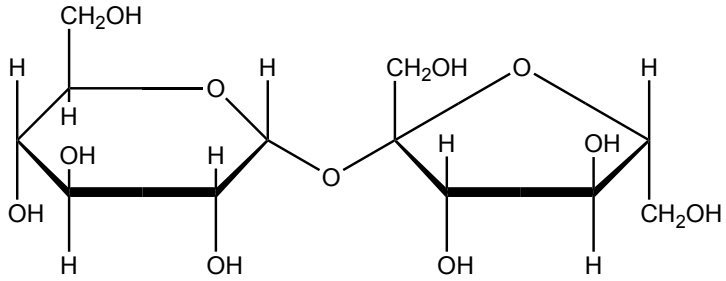
. . . . . .
. . . . . .

Question 2 - working space

Section A

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

4. The image shows the molecular structure of sucrose, which the body digests in order to absorb the monosaccharides glucose and fructose.



Sucrose

(a) State the type of reaction that produces monosaccharides from disaccharides. [1]

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

(b) Describe how capillaries are adapted for exchange of monosaccharides. [2]

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

(c) Outline how fructose could be transported by facilitated diffusion across cell membranes. [2]

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

Question 4 - working space

3. Which molecule is paired with the component of the cell membrane that allows it to pass through the membrane?

	Molecule	Component of the cell membrane
A.	insulin	aquaporin
B.	glycogen	channel protein
C.	oestradiol	phospholipid bilayer
D.	carbon dioxide	pump protein

9. Which type of protein uses energy from ATP to transfer particles across membranes against a concentration gradient?

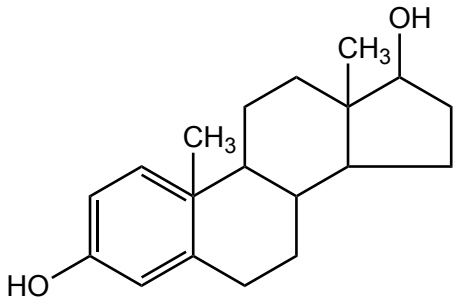
A. Glycoprotein

B. Pump protein

C. Aquaporin

D. Channel protein

2. Oestradiol is a steroid hormone.



How does oestradiol cross plasma membranes?

A. It can move between phospholipids because it is non-polar.

B. It can pass either between phospholipids or through channel proteins because it is amphipathic.

C. It can only pass through hydrophilic pores as its polar ends can form H bonds.

D. It must pass through channel proteins due to its large size.

Section A

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

3. Cell membranes have a fluid mosaic structure.

(a) Outline the reason the structure is described as a mosaic. [1]

. . . . . .

. . . . . .

(b) Phospholipids are the most common molecules in cell membranes. Draw a diagram of the simplified structure of a phospholipid and label its amphipathic properties. [2]

(c) Explain how the rate of diffusion of oxygen into a cell is affected by the concentration of oxygen outside of the cell. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

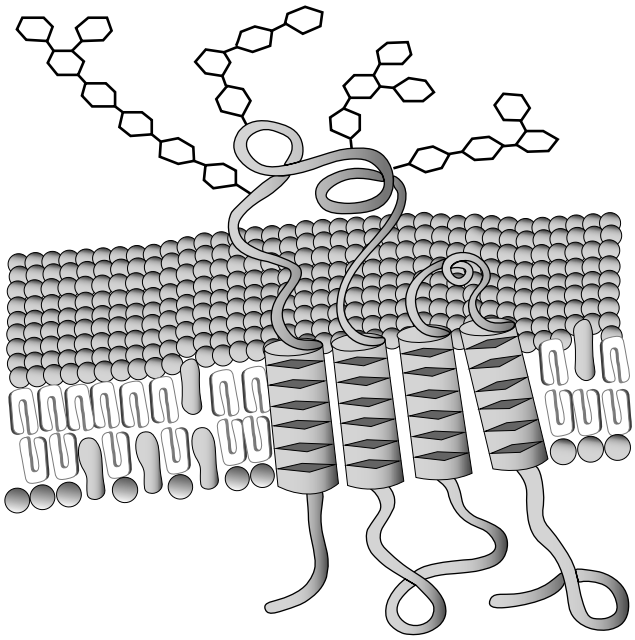
. . . . . .

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

Answers written on this page
will not be marked.

Question 3 - working space

12. The image shows a glycoprotein embedded in the phospholipid bilayer of a cell membrane.



Which features of this glycoprotein can be deduced from the image?

A. It is a peripheral protein that allows attachment to neighbouring cells.

B. It is a channel protein that provides hydrophilic channels for carbohydrate transport.

C. It is an integral protein that may be involved in cell recognition.

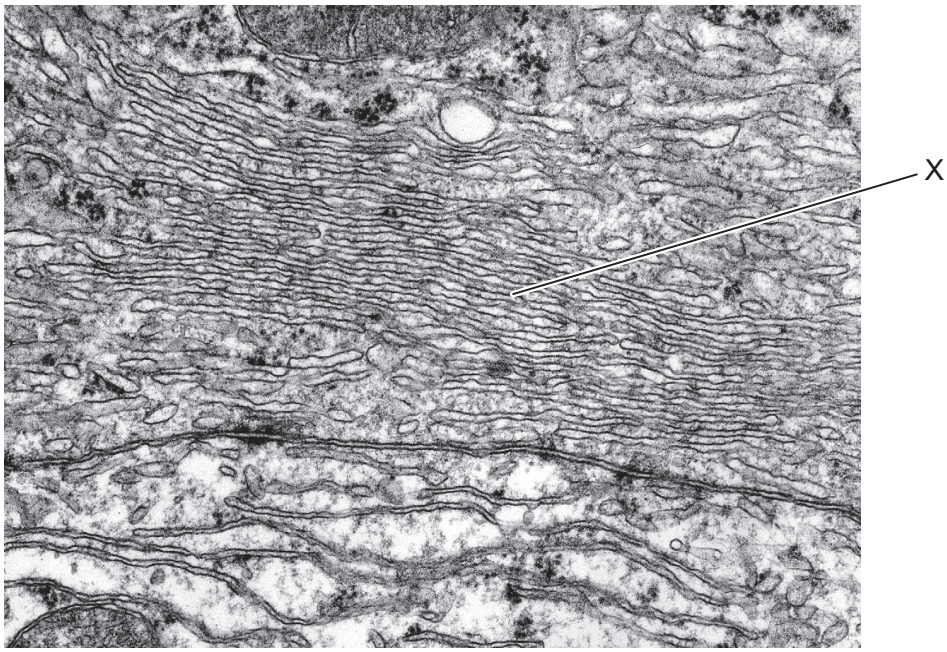
D. It is a transport protein that increases the permeability of the membrane to glucose.

APOLLO

Organelles and compartmentalization

3 questions

8. The electron micrograph shows part of a eukaryotic cell.



What is the organelle labelled X?

A. Mitochondrion

B. Smooth endoplasmic reticulum

C. Lysosome

D. Nucleus

10. Which of the following is considered a cell organelle?

A. Cell wall

B. Lysosome

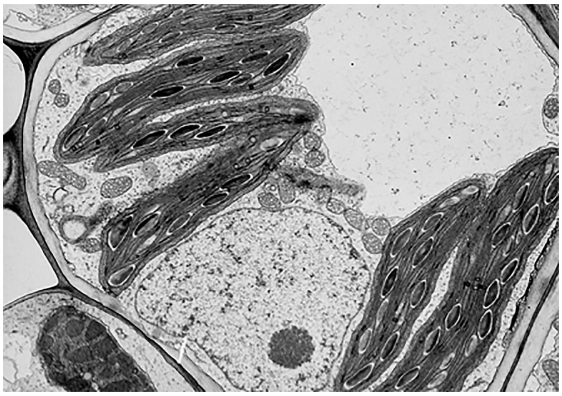
C. Cytoskeleton

D. Cytoplasm

Section A

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

2. The cytoplasm in eukaryotic cells is compartmentalized into membrane-bound organelles, as seen in this electron micrograph of a plant cell.



(a) State **two** membrane-bound organelles that are common to both plant and animal cells. [2]

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

(b) (i) State **one** organelle that is found in a plant cell but not in an animal cell. [1]

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

(ii) State **one** organelle that is common to prokaryotic and eukaryotic cells. [1]

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

Question 2 - working space

APOLLO

Cell specialization

9 questions

10. Which term describes very early-stage embryonic stem cells in a mouse?

A. Totipotent

B. Pluripotent

C. Multipotent

D. Unipotent

Turn over

10. What results from an unspecialized cell experiencing gradients of signalling chemicals?

A. Cell differentiation

B. Meiosis

C. Saltatory conduction

D. DNA replication

Turn over

11. Which is a description of stem cells?

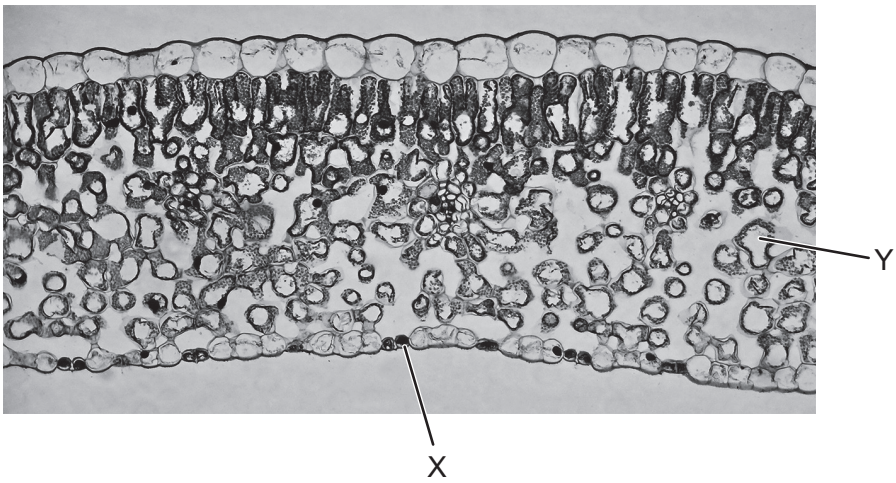
A. Hair follicle stem cells are pluripotent.

B. Stem cells in bone marrow are multipotent.

C. Very early embryo stem cells are pluripotent.

D. Late embryo stem cells are totipotent.

15. A cross section of a lily leaf (*Lilium spp.*) is shown.



Which leaf structures are represented by labels X and Y?

	X	Y
A.	palisade mesophyll cell	phloem cell
B.	epidermal cell	palisade mesophyll cell
C.	spongy mesophyll cell	guard cell
D.	guard cell	spongy mesophyll cell

10. Which specialized cell has the largest volume?

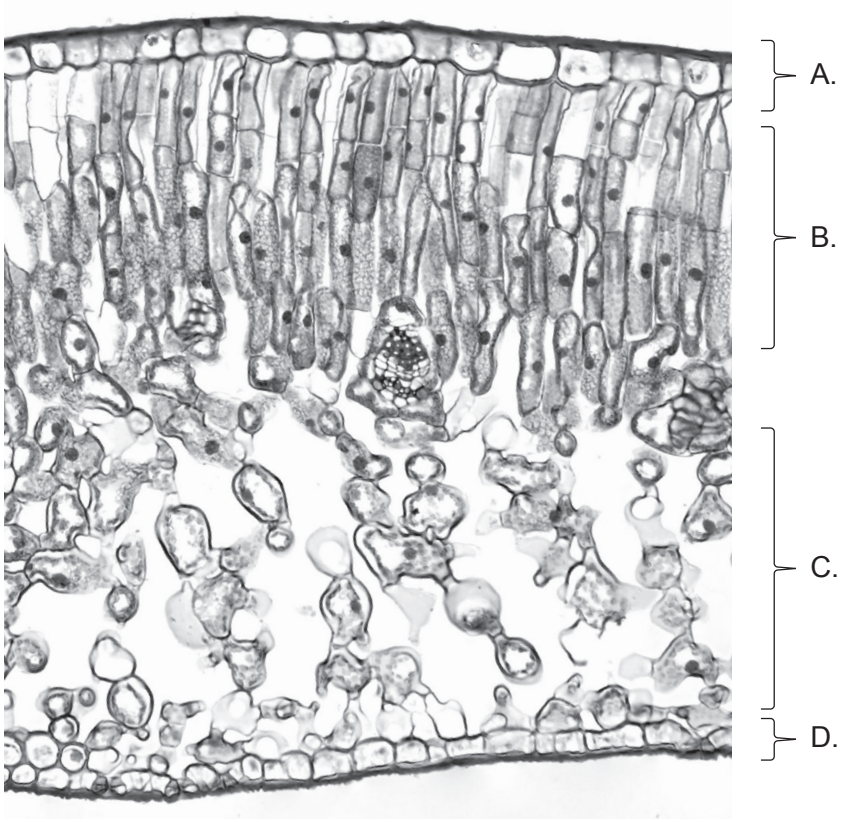
A. Egg cell

B. Sperm cell

C. Red blood cell

D. White blood cell

14. The image shows the transverse section of a leaf. Which letter identifies the palisade mesophyll?



8. What is a reason that both phloem sieve tube elements and human red blood cells are considered atypical?

A. They have no cytoplasm

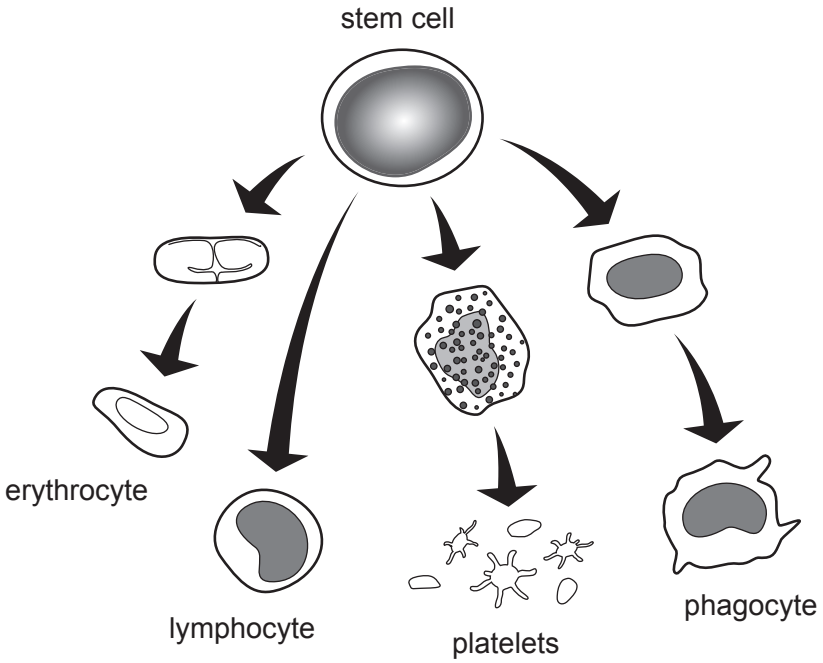
B. Their DNA is free in the cytoplasm

C. They do not have a nucleus

D. All membrane-bound organelles are missing

Turn over

9. Stem cells can differentiate to produce a variety of cell types in the adult human body.



Which description corresponds to the stem cell in the diagram?

	Type	Location
A.	totipotent	bone marrow
B.	multipotent	bone marrow
C.	totipotent	blood
D.	multipotent	blood

10. Which is a feature of phloem sieve tube cells?

A. Numerous chloroplasts

B. No nucleus

C. Lignified walls

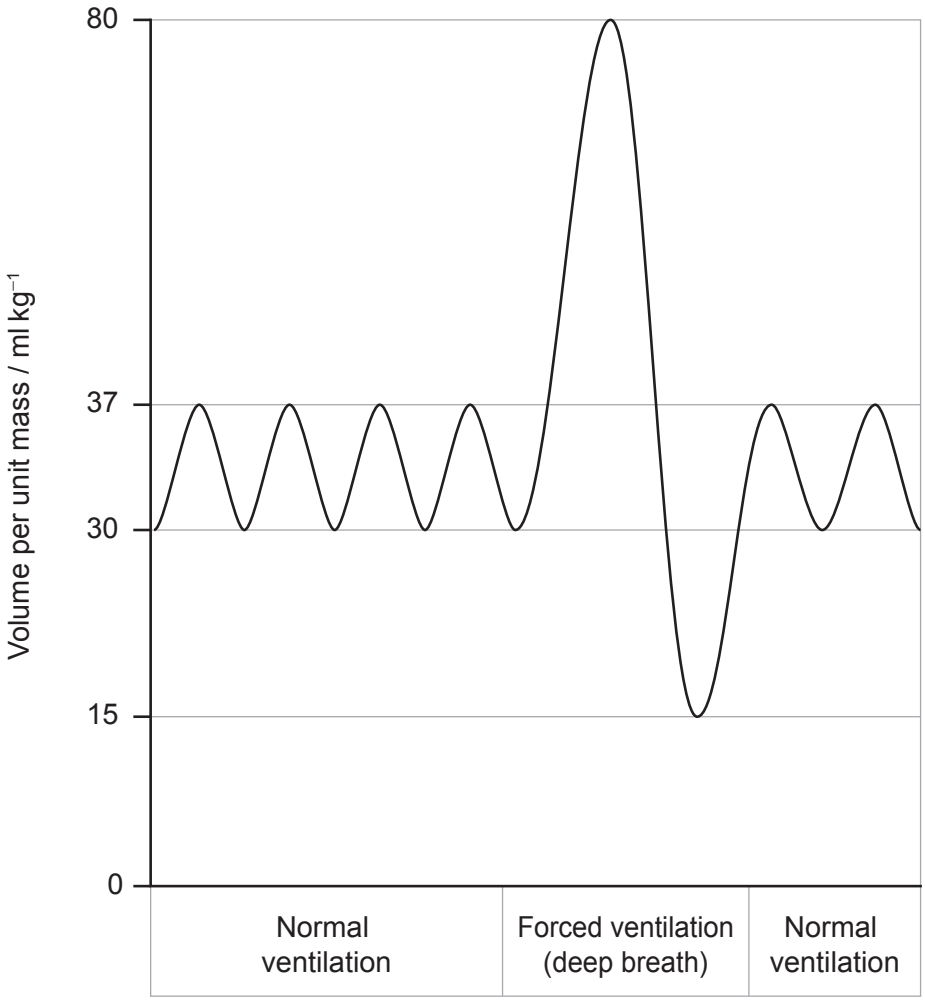
D. No cytoplasm

APOLLO

Gas exchange

5 questions

14. The graph shows changes in lung volume during normal ventilation and forced ventilation (taking a deep breath).



What is the vital capacity?

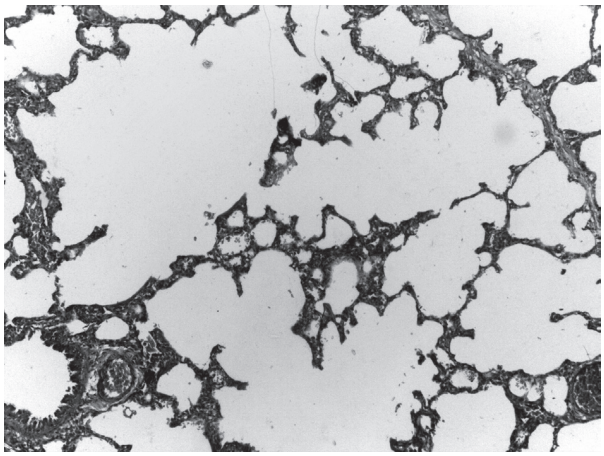
A. $7\,ml\,kg^{-1}$

B. $37\,ml\,kg^{-1}$

C. $65\,ml\,kg^{-1}$

D. $80\,ml\,kg^{-1}$

13. Emphysema is a condition where the alveoli of the lungs are destroyed, resulting in patients feeling out of breath. The micrograph shows air pockets resulting from emphysema.



What is a direct consequence of the destruction of alveoli?

A. Decrease in surface area for gas exchange

B. Increased blood flow to the lungs

C. Increase in pulmonary surfactant production

D. Decrease in ventilation rate

16. What happens in humans to cause inhalation of air?

A. The diaphragm contracts, causing pressure in the thorax to decrease.

B. Abdominal muscles contract, causing pressure in the thorax to decrease.

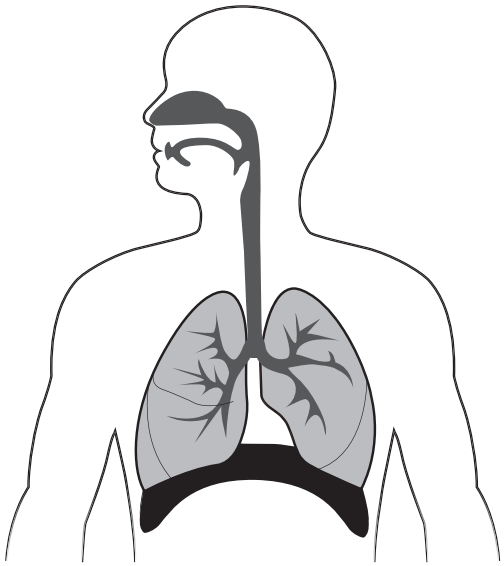
C. The diaphragm contracts, causing pressure in the thorax to increase.

D. Intercostal muscles contract, causing pressure in the thorax to increase.

Section A

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

4. The image shows the location of the lungs and diaphragm in a human.



(a) Explain how contraction of the diaphragm causes air to enter the lungs. [2]

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

(b) State another muscle group that causes inspiration when it contracts. [1]

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

(c) Outline the role of surfactant in the mammalian lung. [2]

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

Question 4 - working space

17. What occurs at gas exchange surfaces in the lungs of mammals?

I. Gases diffuse across a moist surface.
II. Concentration gradients are maintained by ventilation.
III. Water is lost.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

APOLLO

Transport

7 questions

15. What are features of veins?

	Valves	**Wall**
A.	present	thick
B.	absent	thick
C.	absent	thin
D.	present	thin

14. Which environmental condition(s) would increase the rate of transpiration in plants?

I. Increased carbon dioxide concentration in the atmosphere
II. Increased temperature of the atmosphere
III. Decreased humidity of the atmosphere relative to the inside of the leaf

A. I and II only

B. III only

C. II and III only

D. I and III only

Turn over

Section B

Answer **one** question. Up to one additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

7. Mitosis produces genetically identical cells, which become specialized by expressing specific genes. This ensures that tissues and organs are adapted to their functions.

(a) Outline how the behaviour of chromosomes during mitosis ensures the production of genetically identical cells. [4]

(b) Describe how mRNA is produced in the nucleus. [4]

(c) Explain how the structures of arteries and veins are adapted to their functions. [7]

Question 7 - working space

15. What is a property of veins?

A. Flexible to allow compression

B. Elastic to maintain blood pressure

C. Fenestrations for rapid exchange

D. Narrow lumen to carry deoxygenated blood

14. The micrograph shows a transverse section of blood vessels in a human leg muscle.



Which is the main contributor to the movement of blood along vessel X?

A. The smooth surface of the inner lining

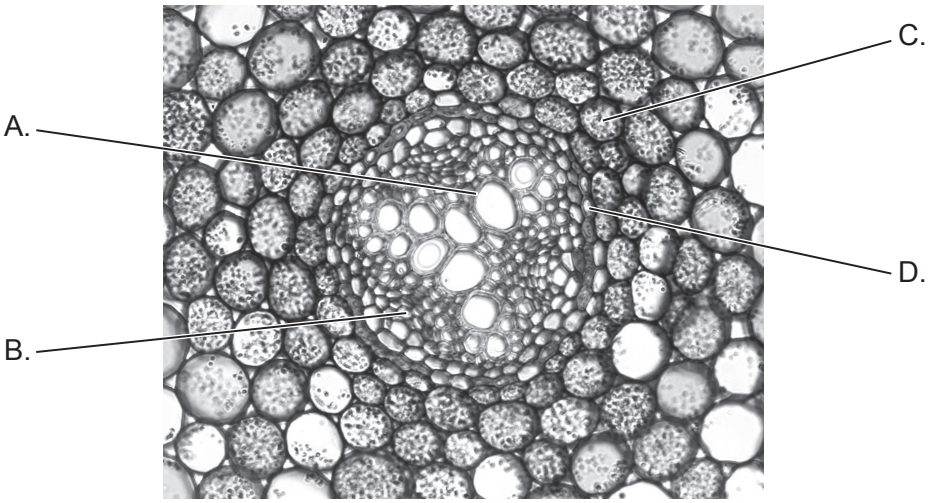
B. Stretching and recoiling of the vessel walls

C. Differences in plasma solute concentration

D. Contraction of muscles adjacent to the vessel

15. The micrograph of a transverse section of buttercup (*Ranunculus sp.*) root shows the stele (central part) and surrounding cortex cells.

Where is lignin found?



18. What is always a consequence of the evaporation of water from mesophyll cells in leaves of a healthy plant?

A. Plasmolysis occurs in mesophyll cells.

B. Photosynthesis stops.

C. Stomata close to reduce transpiration.

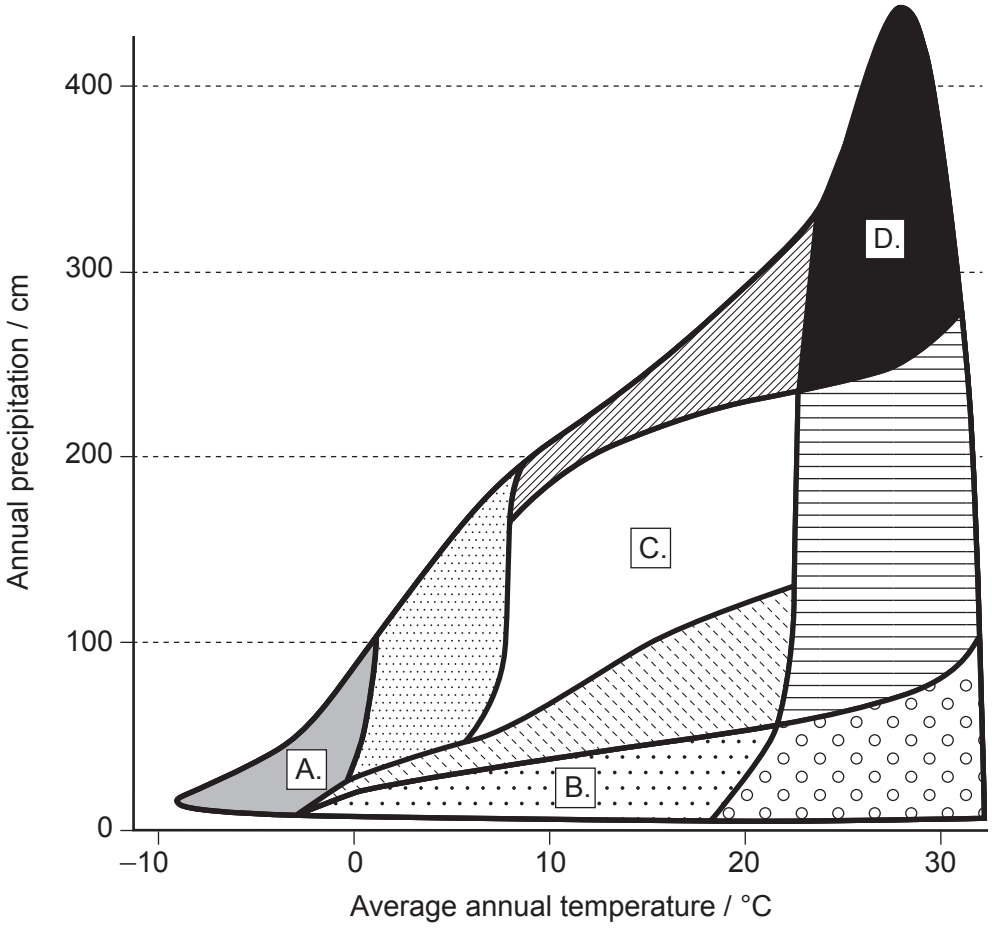
D. Water moves up the stem in the xylem.

APOLLO

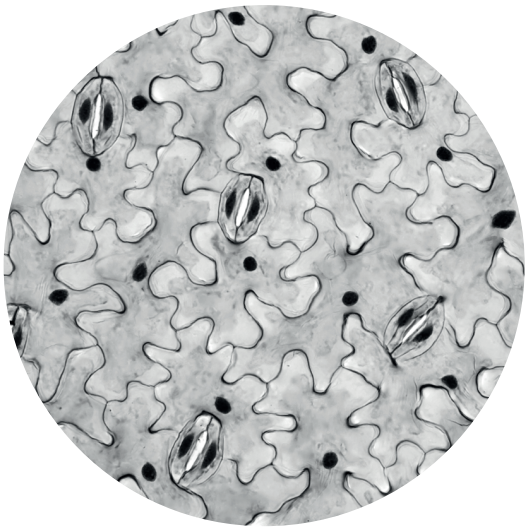
Adaptation to environment

7 questions

24. A graph of abiotic factors needed for biomes to develop is shown. Which label identifies temperate forest?



1. The image shows a cast of the lower surface of a leaf from a busy Lizzie (*Impatiens walleriana*) plant as seen under a light microscope with a magnification of 600×.



(a) On the image, label a guard cell. [1]

(b) State how the magnification of the microscope was calculated. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(c) (i) Outline how stomatal density in busy Lizzie leaves can be estimated within a known field of view. [1]

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

(ii) Suggest how this estimate can be made more reliable. [1]

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

(d) Explain **one** feature of tree roots that help trees to survive in mangrove swamps. [2]

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

Question 1 - working space

1. Which characteristic of the ringed seal (*Pusa hispida*) is a consequence of the thermal conductivity of water?

A. Streamlined body

B. Sharp teeth

C. Blubber (layer of fat)

D. Lungs

21. Scientists incubated larvae of the moth *Utetheisa ornatrix* at either 15 °C or 22 °C until they hatched. They found the hatched moths had different wing colour patterns due to phenotypic plasticity.

Moth from larvae incubated at 15 °C



Moth from larvae incubated at 22 °C



Which of the following explains the observed differences in wing colour?

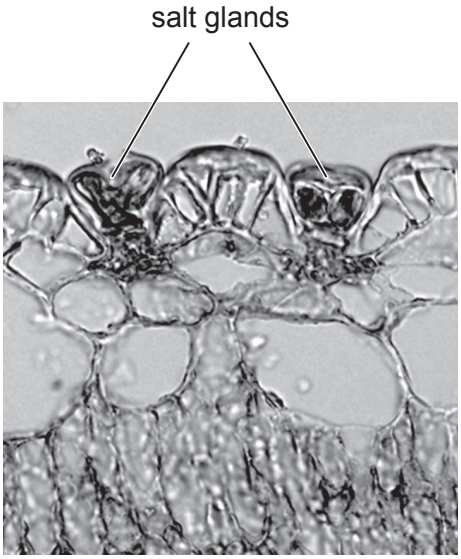
A. Colder temperatures induce mutations in genes for wing colour.

B. The expression of genes for wing colour is affected by temperature.

C. A mutation makes moths less visible to predators in cold climates.

D. Wing colour is the result of polygenic inheritance.

24. *Avicennia officinalis* is a tree species that is adapted to live in mangrove swamps. Salt glands can be seen in the micrograph of a transverse section of an *A. officinalis* leaf.



How does *A. officinalis* benefit from this adaptation?

A. The glands provide nitrates for amino acid synthesis as mangrove soils are nitrogen-deficient.

B. The salt in the leaves attracts predators to eat the leaves.

C. A high concentration of salt in the glands allows absorption of water into the leaf cells.

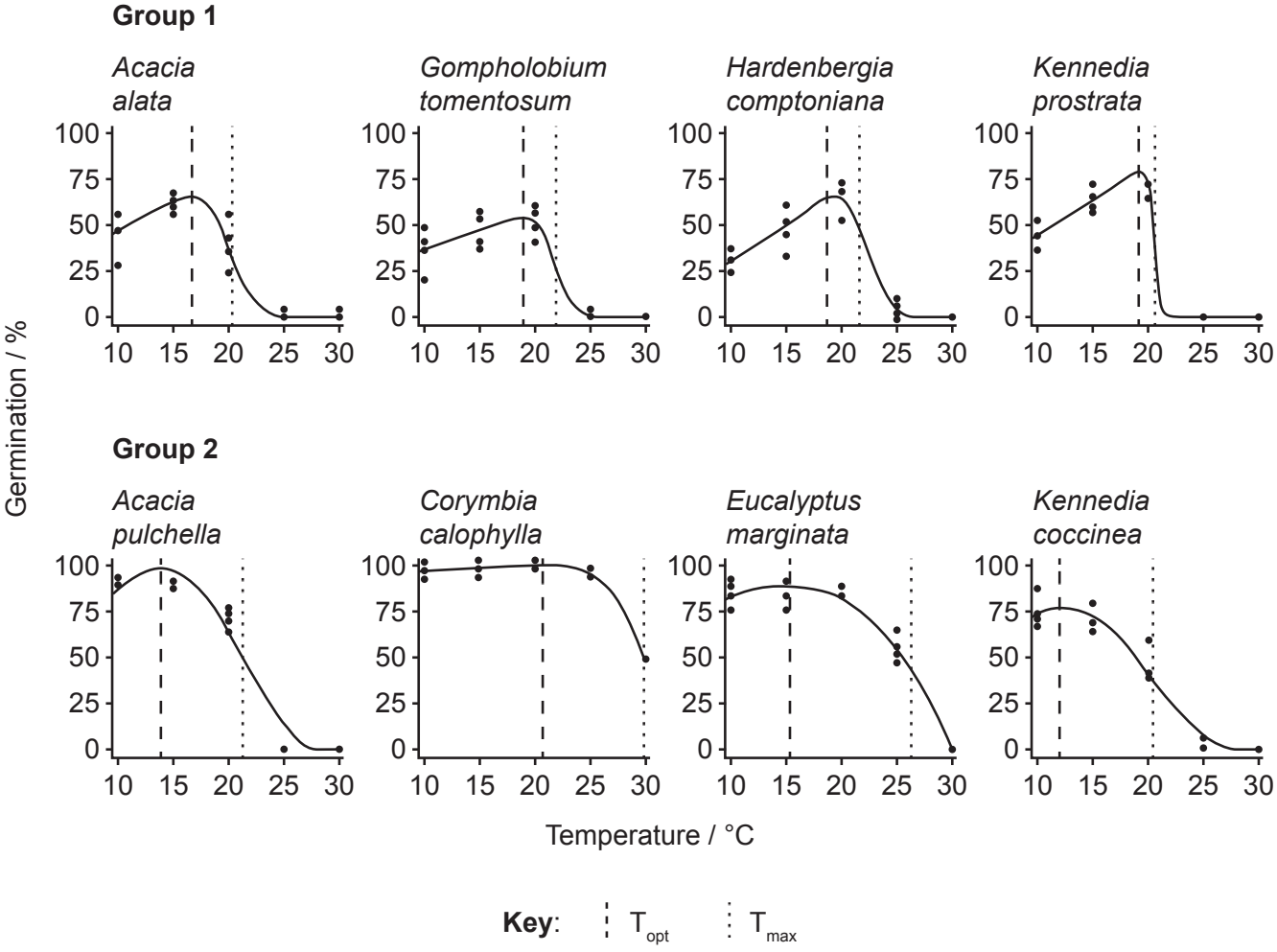
D. The glands secrete salt to keep cytoplasmic concentration suitable for metabolic processes.

Section A

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

1. Fires are a natural phenomenon in some forest ecosystems, so plants evolve to become fire-adapted. The Northern Jarrah Forest in southwest Australia is an example. The seeds of many species germinate after forest fires, when there is less competition for resources from existing plants.

The effect of temperature on germination was measured in species that occur commonly in the Northern Jarrah Forest. The graphs show results for eight species across the range of soil temperatures expected in this ecosystem. Four replicates of 25 seeds were sown at each temperature. Statistical modelling was used to predict the overall relationship between temperature and germination, and to estimate the optimum temperature (T_{opt}) and maximum temperature (T_{max}) at which germination commonly occurs. The eight species were then divided into two groups according to the effects of temperature on germination.



(This question continues on the following page)

(Question 1 continued)

(a) Identify the species in which T_{opt} is lowest. [1]

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

(b) Calculate the range for T_{max} among the eight species. [1]

. . . . . .

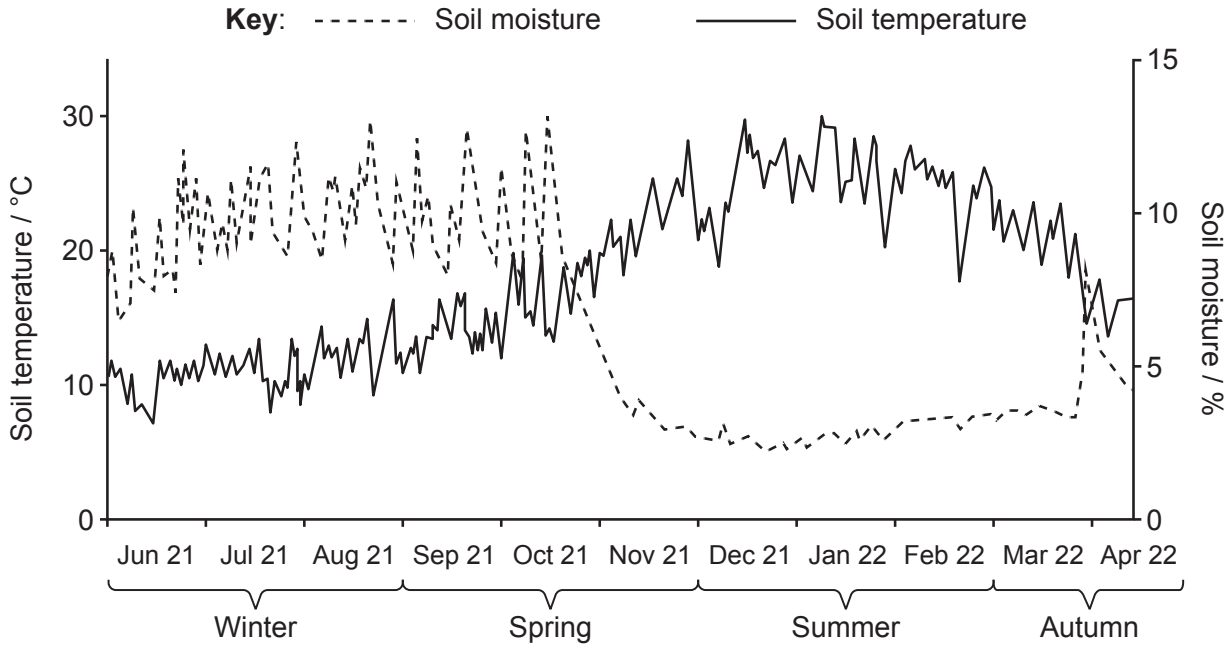
(c) Analyse the graphs to find the key difference between species in Group 1 and Group 2. [1]

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

(This question continues on the following page)

(Question 1 continued)

To investigate the seasonality of germination, soil temperature and soil moisture were monitored at sites in Korung National Park, which is part of the Northern Jarrah Forest. The graph shows the results.



(d) (i) Distinguish between soil moisture in winter and in summer. [2]

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

(ii) Suggest reasons for the differences. [2]

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

(This question continues on the following page)

(Question 1 continued)

(e) Predict, giving reasons, when germination would start in *Kennedia prostrata*, following a forest fire at the start of summer. [3]

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

(f) Using the data in the graphs, discuss whether species in Group 1 or Group 2 are more likely to be adversely affected by increases in soil temperature due to global warming. [2]

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

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

Answers written on this page
will not be marked.

Question 1 - working space

Section B

Answer **one** question. One additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

7. Convergent evolution increases similarities, despite differences in origins.

(a) Explain how analogous structures can evolve. [4]

(b) Describe adaptations that are typical of plants growing in hot deserts throughout the world. [7]

(c) Suggest examples of adaptations in herbivores for feeding on plants. [4]

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. Any trademarks™ or registered® trademarks included are used for illustrative purposes only, and use does not imply any affiliation with or endorsement by the International Baccalaureate.

References:

1.a and d Ryan, C., Callow, J.N., Lewandrowski, W. and Tangney, R., 2023. *Conserv Physiol* 11(1): coad093. https://doi.org/10.1093/conphys/coad093. Reference redacted. Source adapted.

2. Christinelmiller. https://en.wikipedia.org/wiki/File:Multiple_Ribosomes_Translation_Protein_Synthesis.png. CC BY-SA 4.0. https://creativecommons.org/licenses/by-sa/4.0, image adapted.

5. Used with permission of University of Chicago Press - Journals, from *Retinal Circuitry and Clinical Ophthalmology*, MARINE BIOLOGICAL LABORATORY (WOODS HOLE, MASS.), volume 168, issue 3, 1985; permission conveyed through Copyright Clearance Center, Inc.

All other texts, graphics and illustrations © International Baccalaureate Organization 2025

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

Answers written on this page
will not be marked.

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

Answers written on this page
will not be marked.



Question 7 - working space

APOLLO

Ecological niches

4 questions

25. What occurs during competitive exclusion between two species?

I. They compete for the same resources so cannot coexist in the same niche.
II. Competing species are regulated by predators in the ecosystem.
III. Both species are restricted to a part of their fundamental niche.

A. I and II only

B. I and III only

C. III only

D. I, II and III

Turn over

27. The paradise tree (*Ailanthus altissima*) produces a chemical called ailanthone which inhibits the growth of other plants. What is this process?

A. Allelopathy

B. Endemism

C. Mutualism

D. Herbivory

2. The distribution of native grasses in a temperate arid region of Mendoza, Argentina, was studied in six habitats (I to VI) at different altitudes. The table shows the presence (+) or absence (–) of the species in each habitat.

Species \ Habitats	I	II	III	IV	V	VI
Bromus araucanus	–	–	–	–	–	+
Bromus brevis	–	–	–	+	+	+
Bromus sp.	–	–	–	–	+	+
Cortaderia rudiuscula	–	–	+	–	–	–
Elymus erianthus	–	–	+	+	+	–
Elytrigia attenuata	–	–	–	–	–	+
Elytrigia mendocina	–	–	–	–	–	+
Festuca rubra	–	–	–	–	–	+
Koeleria mendocinensis	–	–	–	–	–	+
Melica andina	–	–	–	–	+	+
Piptochaetium napostaense	–	–	+	+	+	+
Poa lanuginosa	–	–	–	–	+	+
Poa resinulosa	–	–	–	–	+	+
Poa ligularis	–	–	+	–	+	+
Polypogon monspeliensis	–	–	+	–	+	+
Schismus barbatus	–	–	–	–	+	–
Stipa debilis	–	–	+	–	+	–
Stipa ichu	+	–	+	+	+	+
Stipa paramilloensis	–	–	–	–	+	+
Stipa plumosa	–	+	+	+	+	–
Stipa psittacorum	–	–	+	–	+	–
Stipa sanluisensis	–	–	+	+	+	–
Stipa scirpea	–	–	+	–	+	+
Stipa tenuis	–	–	+	+	+	–
Stipa tenuissima	–	–	+	–	+	+
Stipa vaginata	–	–	+	+	+	+
Total species present	1	1	14	8	20	18

(This question continues on the following page)

(Question 2 continued)

(a) Suggest **one** abiotic factor, other than altitude, that could be affecting the distribution of species in the different habitats. [1]

. . . . . .

. . . . . .

(b) Define habitat. [1]

. . . . . .

. . . . . .

(c) Explain how the number of organisms of each species could be determined experimentally. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 2 - working space

25. The preferred temperature ranges for three species of trout that are found together in freshwater lakes in North America are shown.



Lake trout (*Salvelinus namaycush*)	Rainbow trout (*Oncorhynchus mykiss*)	Brown trout (*Salmo trutta*)
6–13 °C	12–18 °C	11–23 °C

What can be deduced from this information?

I. The niches for all three species overlap.
II. Brown trout have the most specialized niche.
III. Lake trout can avoid competition by living in colder water.

A. I only

B. II only

C. I and III only

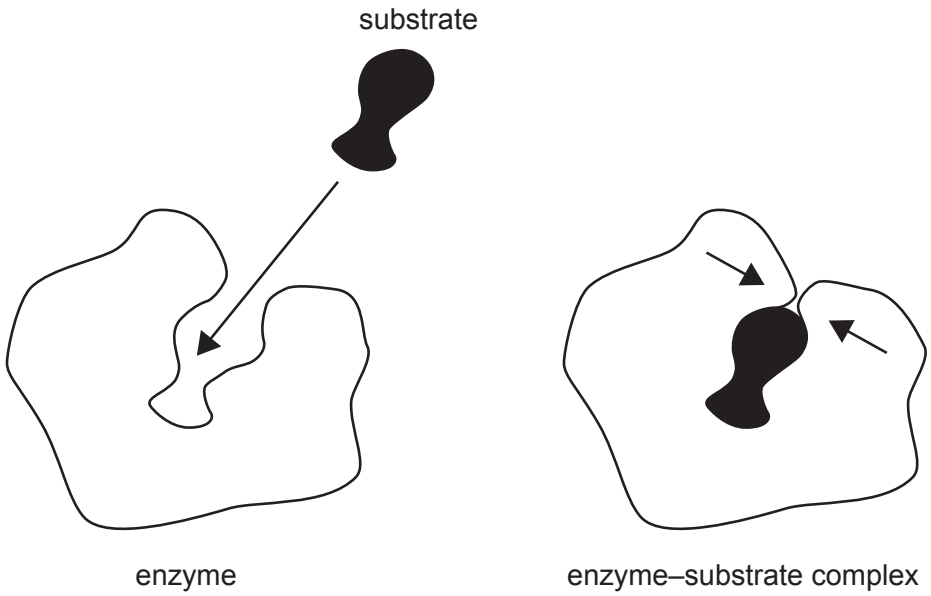
D. I, II and III

APOLLO

Enzymes and metabolism

7 questions

5. The diagram shows the formation of an enzyme–substrate complex.



What describes the process shown in the diagram?

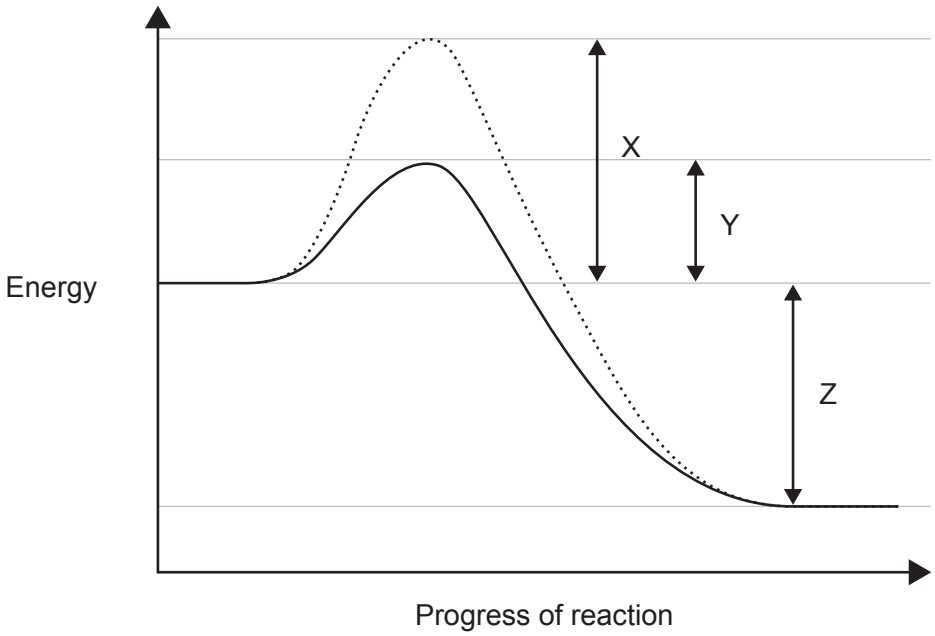
A. The lock and key hypothesis, as the substrate is complementary to the enzyme.

B. The substrate permanently alters the shape of the enzyme's active site.

C. The substrate and the active site have the same shape.

D. The active site changes shape to accommodate the substrate in the induced-fit model.

5. The graph shows energy changes during a reaction both with and without an enzyme present.



Which statement correctly identifies two of the regions labelled X, Y and Z in the graph?

A. X is the activation energy with an enzyme and Z is the net energy released from the reaction.

B. X is the energy released from the reaction and Y is the activation energy with an enzyme.

C. Y is the energy released with an enzyme and Z is the energy released when bonds are broken.

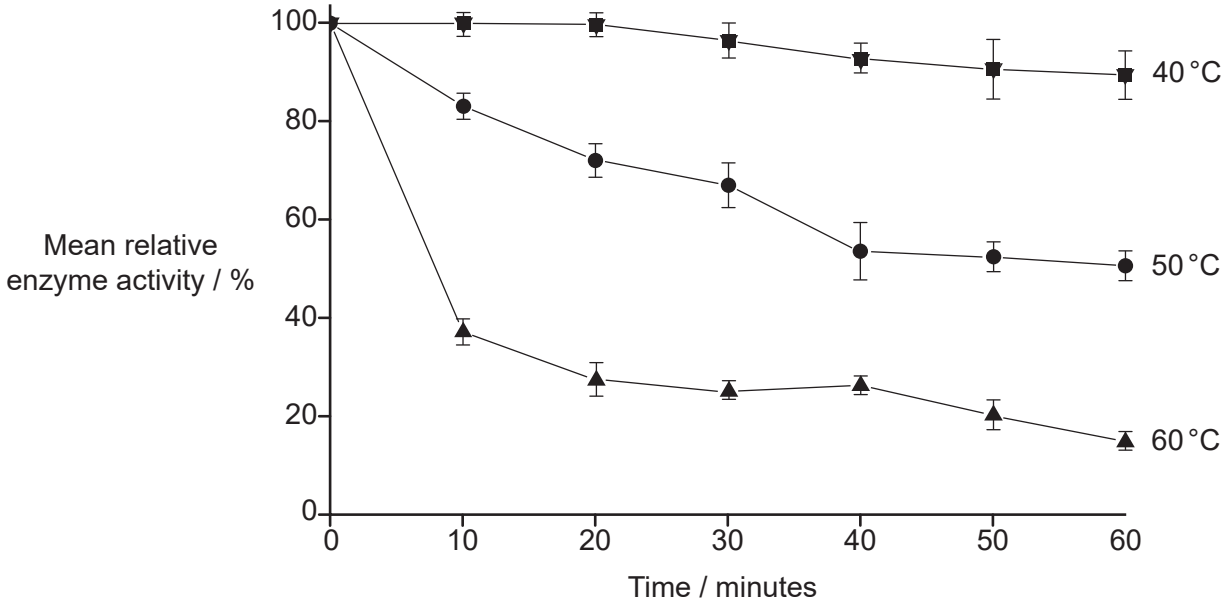
D. Y is the activation energy with an enzyme and Z is the net energy released.

4. A scientist investigated the effect of storage temperature on the activity of an enzyme.

The scientist incubated three lipase solutions for one hour at three different storage temperatures (40 °C, 50 °C or 60 °C).

At every 10-minute interval, a sample of lipase solution was taken and immediately used to catalyse the digestion of a small volume of oil. The values were then compared to the results obtained at the optimum temperature for lipase (37 °C). Relative enzyme activity values were determined.

The graph shows the mean results of the investigation.



(a) Identify the independent variable in this investigation. [1]

. . . . . .

. . . . . .

(b) Identify **one** factor that needs to be controlled in this investigation. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 4 continued)

(c) Explain the relationship shown between storage temperature and relative enzyme activity. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(d) Describe how the reliability of the results obtained in this investigation is indicated on the graph. [1]

. . . . . .

. . . . . .

(e) When oils are digested, fatty acids are produced. These reduce the pH of the reaction mixture. Explain how the rate of reaction could be measured in this investigation. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

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:

1. PeterHermesFurian, 2017. *Onion epidermis with large cells under light microscope*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/onion-epidermis-with-large-cells-under-light-royalty-free-image/655178448 [Accessed 29 April 2024]. Source adapted.

2. Reproduced from Gregory M. Preston et al., Appearance of Water Channels in Xenopus Oocytes Expressing Red Cell CHIP28 Protein, DOI: 10.1126/science.256.5055.385. 1992, AAAS.

3. Lezh, 2008. *Ixodid tick*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/ixodid-tick-royalty-free-image/157332347 [Accessed 30 April 2024]. Source adapted.

4. Zheng, C., 2021. Study on enzymatic activity and lipase catalysis by lipase high-yield strain. Conf. Ser.: Earth Environ. Sci. 632 032016. https://doi.org/10.1088/1755-1315/632/3/032016. Source adapted.

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

Answers written on this page
will not be marked.

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

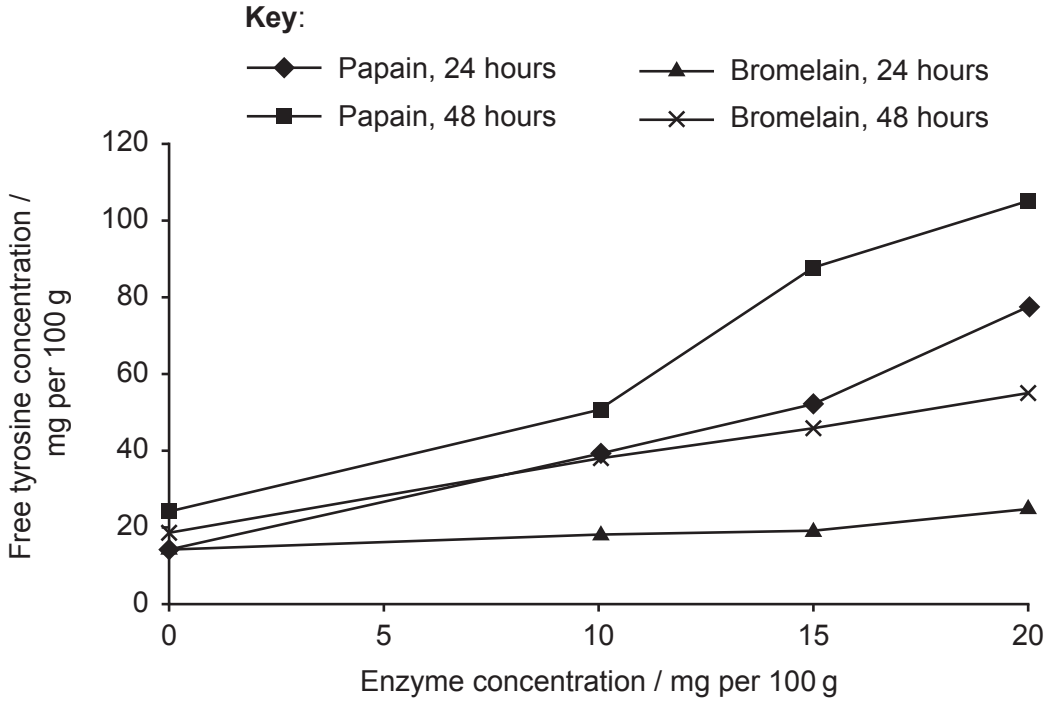
Answers written on this page
will not be marked.

Question 4 - working space

4. Which are examples of anabolic and catabolic reactions?

	Anabolic reaction	Catabolic reaction
A.	hydrolysis of macromolecules into monomers	oxidation of substrates in respiration
B.	glycogen formation	hydrolysis of macromolecules into monomers
C.	oxidation of substrates in respiration	protein synthesis
D.	protein synthesis	glycogen formation

3. Protease enzymes break down (degrade) protein. The catalytic activity of the protease enzymes papain and bromelain on meat tenderization was evaluated by injecting the enzymes at different concentrations into beef. Meat tenderization was assessed by measuring the concentration of the amino acid tyrosine, which is released from proteins as they become degraded. The graph shows the effect of enzyme concentration after 24 and 48 hours.



(a) State an independent variable in this experiment. [1]

. . . . . .

. . . . . .

(b) Outline the effect of increasing the papain concentration on the free tyrosine concentration. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 3 continued)

(c) Distinguish between the results for bromelain activity at 24 hours and at 48 hours. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(d) Justify the use of the concentration of amino acids, such as tyrosine, to assess protease enzyme activity. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 3 - working space

5. What is a common feature of enzymes?

A. They all react with substrates.

B. They all decrease the rate of reaction.

C. They are all secreted from cells in vesicles.

D. They all bind to the active site of their substrate.

7. What is a reason that Taq polymerase is a suitable enzyme for use in the polymerase chain reaction (PCR)?

A. It can work at a wide range of pH.

B. It works at higher temperatures than most enzymes.

C. It can separate two strands of DNA.

D. It allows DNA to be replicated without the use of primers.

APOLLO

Cell respiration

7 questions

4. Which process is an example of catabolism?

A. Protein synthesis

B. Photosynthesis

C. Oxidation of substrates in respiration

D. Glycogen formation

6. What are the product(s) and site of anaerobic respiration in human cells?

	Product	Site of anaerobic respiration
A.	lactate	mitochondria
B.	carbon dioxide + water	mitochondria
C.	lactate	cytoplasm
D.	carbon dioxide + water	cytoplasm

Section B

Answer **one** question. One additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

7. All living organisms require energy to survive.

(a) Outline **three** characteristics of polysaccharides that make them efficient compounds to store energy in organisms. [3]

(b) Describe how energy passes through a food chain. [4]

(c) Explain the need for energy in cells and how energy is released through cell respiration. [8]

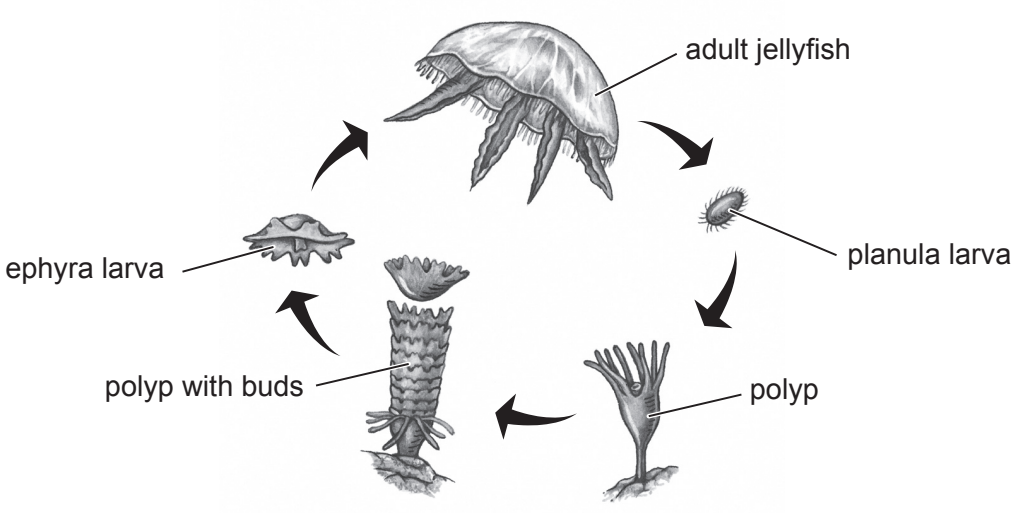
Question 7 - working space

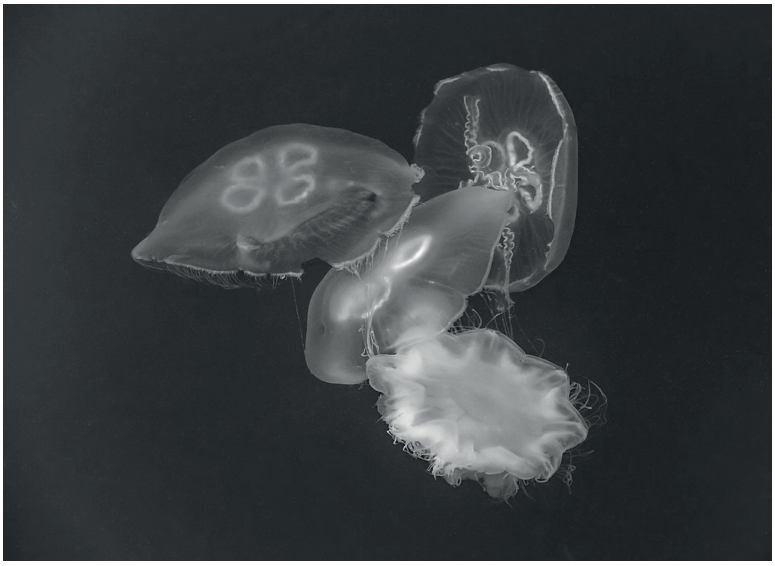
4. What are the waste products of aerobic and anaerobic respiration in humans?

	Aerobic respiration	Anaerobic respiration
A.	carbon dioxide only	lactate and carbon dioxide
B.	carbon dioxide and water	lactate and carbon dioxide
C.	carbon dioxide and water	lactate only
D.	carbon dioxide only	lactate only

Turn over

3. The diagram shows the life cycle of a jellyfish. At one stage in the cycle, polyps attach to rocks. The photograph shows adult free-swimming *Aurelia* jellyfish.

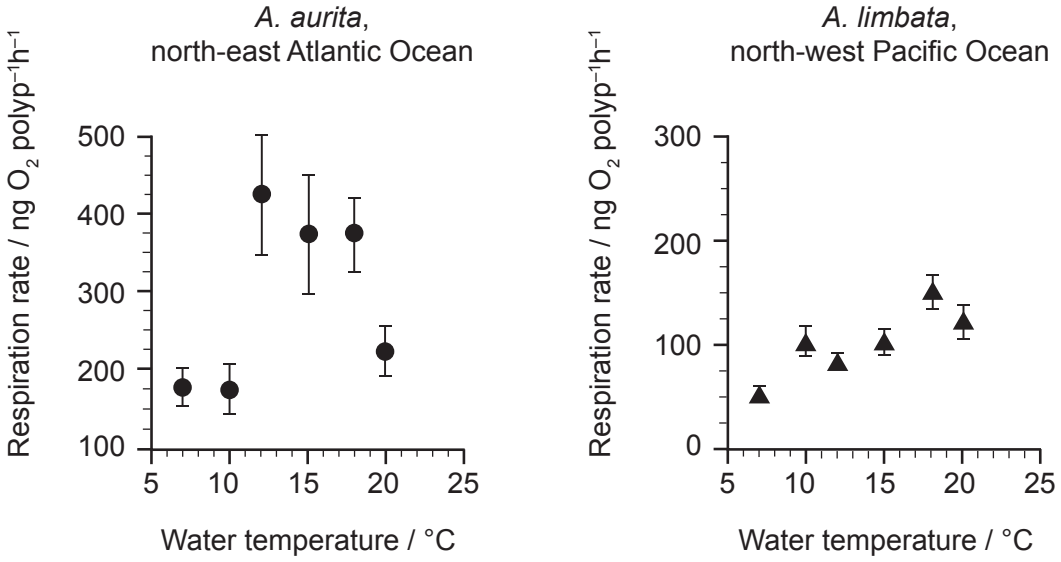




(This question continues on the following page)

(Question 3 continued)

Waters in the north-east Atlantic Ocean and north-west Pacific Ocean have a similar annual temperature range of 9–13 °C. The mean respiration rate of polyps from two jellyfish species (*Aurelia aurita* and *Aurelia limbata*), collected from the two regions, were measured at different temperatures in the laboratory.



(a) State the instrument that was used to enable calculation of respiration rate. [1]

. . . . . .

. . . . . .

(b) Suggest an alternative measurement that could be taken to calculate the respiration rate. [1]

. . . . . .

. . . . . .

(c) Calculate the difference between the temperature at which the maximum respiration rate occurs in the two species. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 3 continued)

(d) A jellyfish bloom is a rapid increase in jellyfish population size. Discuss, using only the data, which species is more likely to form a bloom if the ocean temperature rises 5 °C above its usual range due to global warming. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(e) Jellyfish have a network of neurons that can transmit impulses in the form of action potentials. Outline how adenosine triphosphate (ATP) from respiration is used to generate the resting potential in neurons. [2]

. . . . . .

. . . . . .

. . . . . .

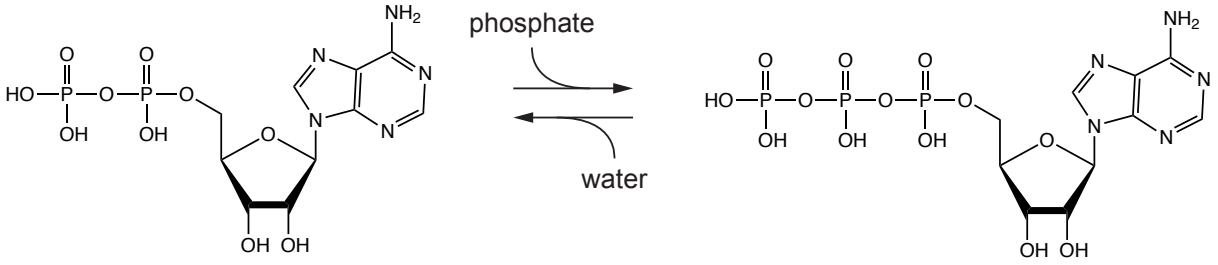
. . . . . .

Question 3 - working space

Section A

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

4. The equation shows a reversible reaction that happens in all living cells.



ADP (adenosine diphosphate) ATP (adenosine triphosphate)

(a) State **two** processes in cells that are supplied with energy by converting ATP to ADP. [2]

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

(b) Outline how ATP is produced in cells. [3]

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

Question 4 - working space

6. What distinguishes aerobic respiration from anaerobic respiration in humans?

A. Mitochondria are only used in anaerobic respiration.

B. Aerobic respiration yields lower quantities of ATP.

C. Only aerobic respiration can use glucose as a starting substrate.

D. Only aerobic respiration produces carbon dioxide.

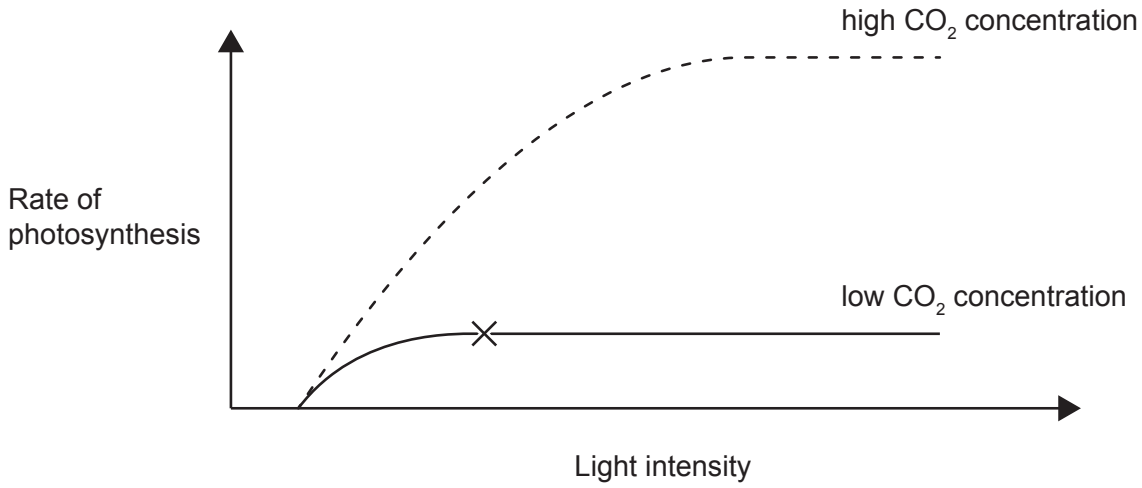
Turn over

APOLLO

Photosynthesis

6 questions

4. The graph shows the effect of light intensity on the rate of photosynthesis of a green plant at different CO_2 concentrations. The temperature is kept constant at 25 °C.



What is the limiting factor at ×?

A. Chlorophyll

B. CO_2 concentration

C. Temperature

D. Light intensity

5. Bromothymol blue is an indicator that is initially blue and turns yellow when CO_2 is present. Tests were carried out varying the presence of a plant (*Elodea canadensis*) and a snail (*Marisa cornuarietis*) in an aquatic environment. What condition would produce a blue colour after sampling the water?

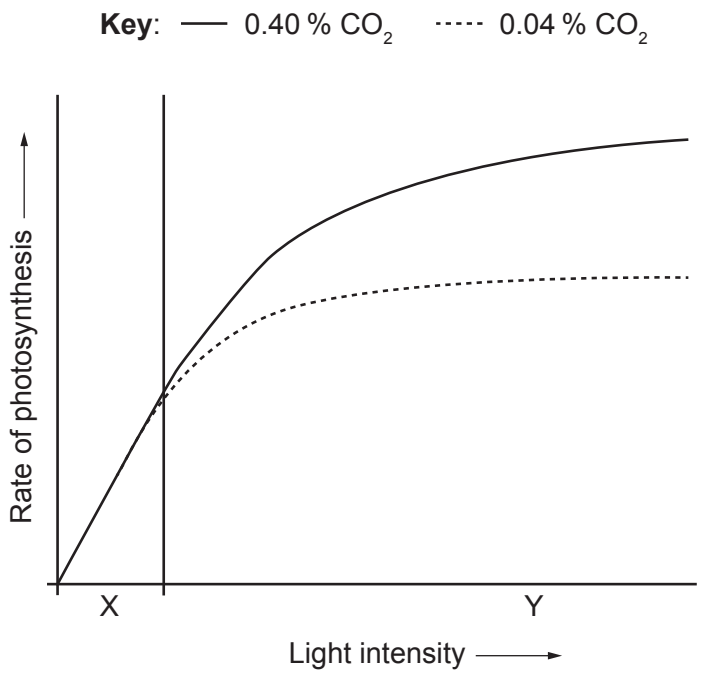
A. Plant kept in the dark without snail

B. Plant and snail kept in the dark

C. Plant kept in the light without snail

D. Snail with no plant

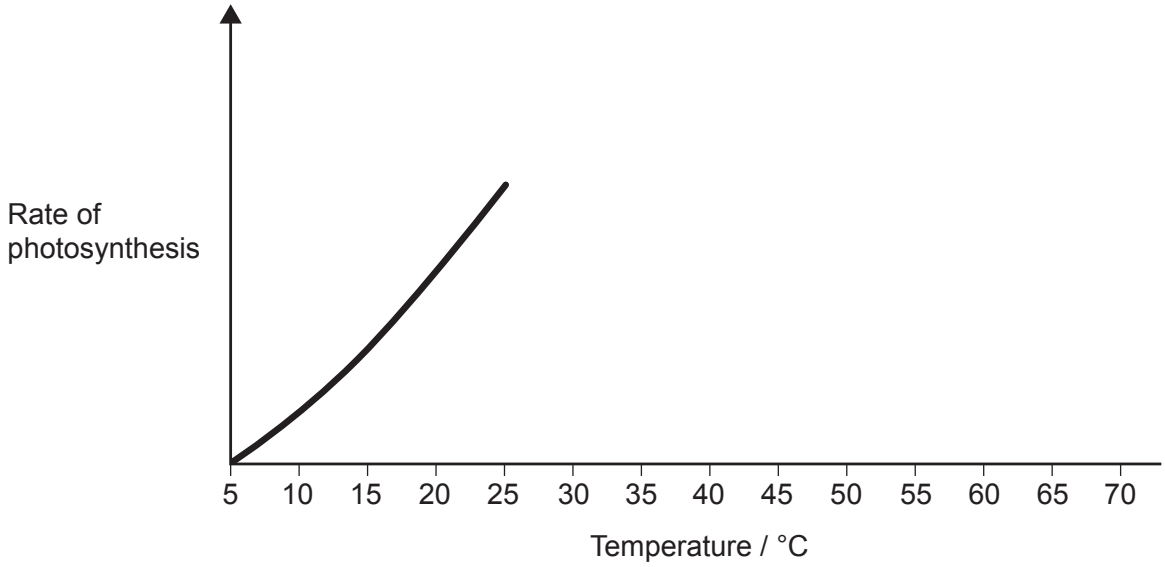
5. The graph shows the rate of photosynthesis as light intensity increases at two different carbon dioxide (CO_2) concentrations.



What are the limiting factors of photosynthesis at regions X and Y on the graph?

	X	Y
A.	CO_2 concentration	light intensity
B.	temperature	light intensity
C.	light intensity	CO_2 concentration
D.	light intensity	temperature

5. An experiment investigated the effect of temperature on the rate of photosynthesis of a plant. Results are shown for temperatures between 5 °C and 25 °C.



How would further increases in temperature, up to 70 °C, affect the rate of photosynthesis?

A. It would decrease between 25 °C and 35 °C and then increase between 35 °C and 70 °C.

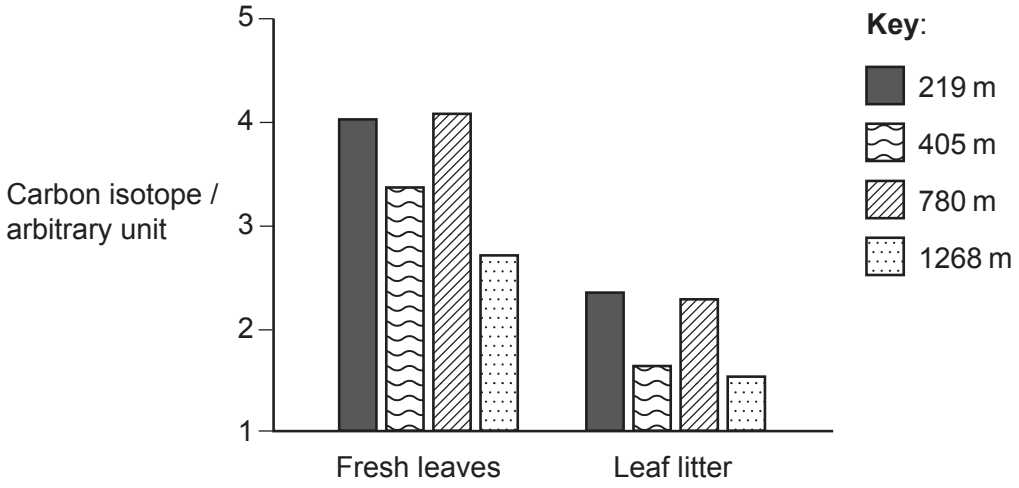
B. It would continue increasing as temperature increases.

C. It would increase to a maximum of between 30 °C and 40 °C and then decrease.

D. It would peak above 25 °C and then remain constant.

2. A study was conducted on the presence of a form (isotope) of carbon, carbon-13 (^{13}C), in trees at four different altitudes of Lushan, a mountain in central subtropical China.

Samples of fresh leaves and leaf litter (dead leaves on the ground) were taken from altitudes between 219 m and 1268 m. The carbon isotope in the leaves was measured in each sample. Presence of the carbon isotope was measured to indicate the relative uptake of carbon dioxide in photosynthesis.



(a) State the method that is used to measure changes in the distribution of organisms and abiotic factors across a specific distance. [1]

. . . . . .

. . . . . .

(b) Compare and contrast the data for fresh leaves with the data for leaf litter. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 2 continued)

(c) Suggest **one** abiotic variable that would affect the carbon isotope content of the fresh leaves at high altitudes. [1]

. . . . . .

. . . . . .

(d) Carbon enters a plant as carbon dioxide from the air. Outline the route that the gas takes to reach chloroplasts in a dicotyledonous plant. [2]

. . . . . .

. . . . . .

. . . . . .

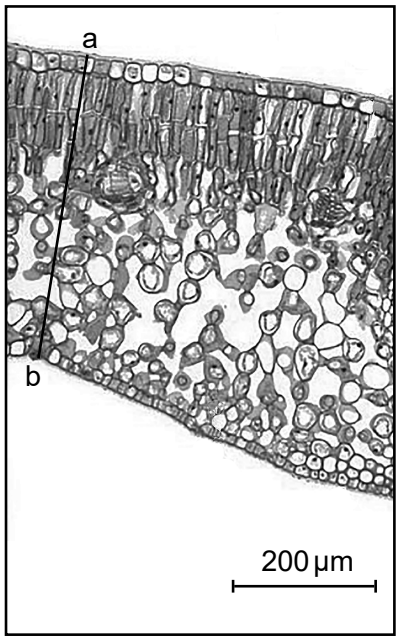
. . . . . .

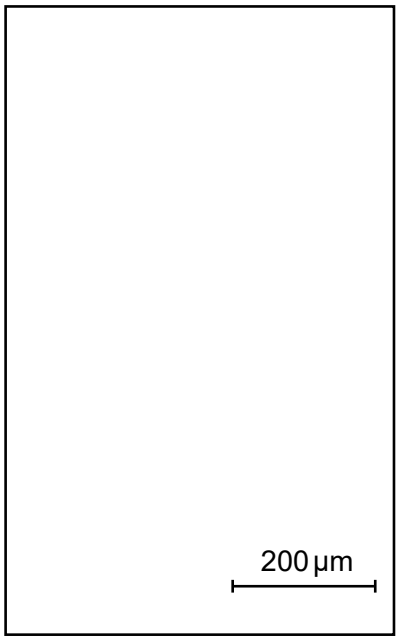
Please **do not** write on this page.

Answers written on this page
will not be marked.

Question 2 - working space

2. The micrograph shows a transverse section of a leaf from a flowering plant.





(a) Draw a plan diagram in the right-hand box with labels to show the distribution of tissues in this transverse section of a leaf. [3]

(b) Calculate the actual thickness of the leaf, from upper to lower surface along the line a–b, showing your working. [2]

. . . . . .

(This question continues on the following page)

(Question 2 continued)

(c) Suggest a reason for using a lower power objective lens when first focusing on a slide under the microscope. [1]

. . . . . .

. . . . . .

(d) Identify **one** adaptation of the leaf for the absorption of light visible in this micrograph. [1]

. . . . . .

. . . . . .

Question 2 - working space

APOLLO

Neural signalling

11 questions

17. Which of these structures is most likely to be the effector in a pain reflex arc?

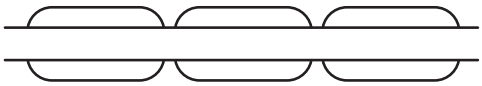
A. Grey matter

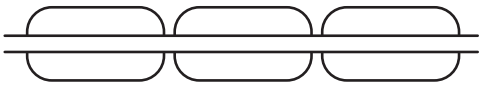
B. Skeletal muscle

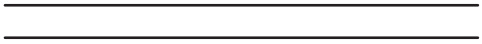
C. Motor neuron

D. Pineal gland

12. The diagrams represent sections through different axons. Which axon has the slowest speed of impulse?

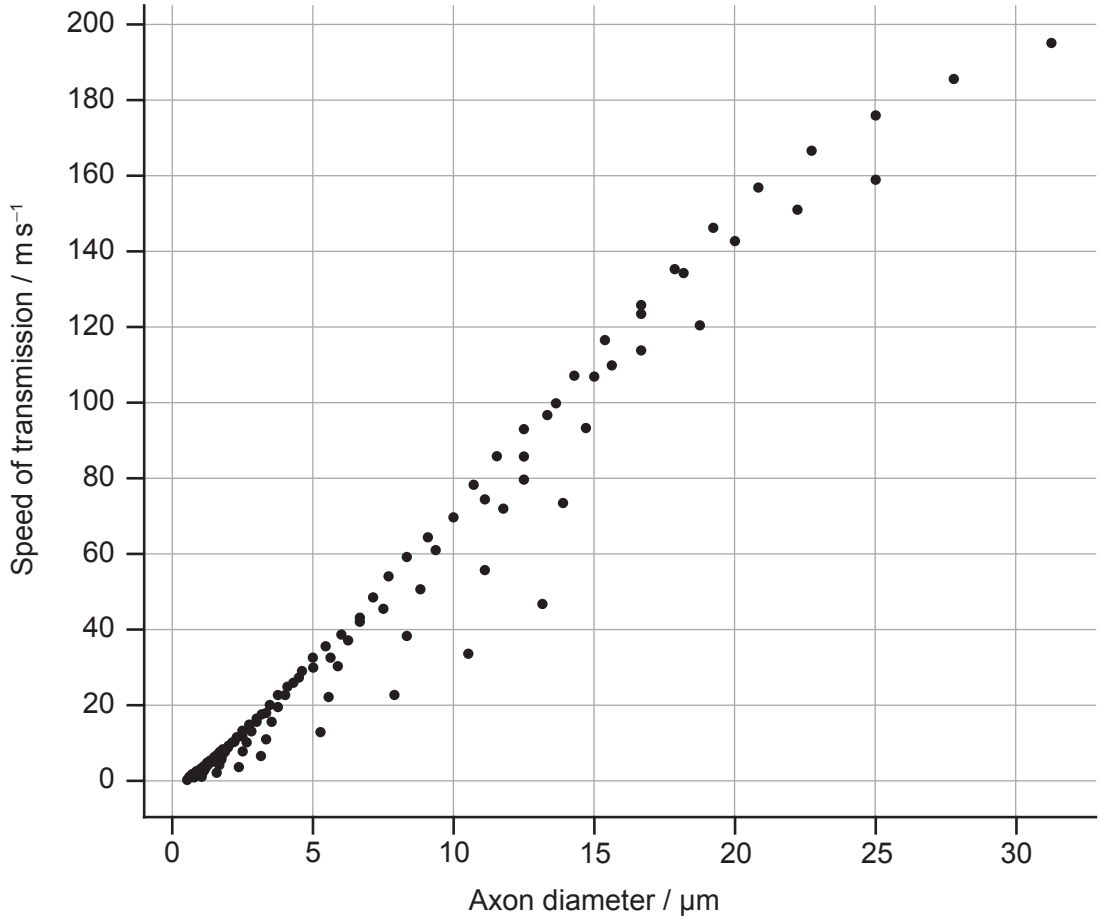
A. 

B. 

C. 

D. 

3. Scientists used MRI to calculate the speed of transmission of nerve impulses along axons of brain neurons.



(a) (i) Describe the relationship between speed of transmission and axon diameter. [1]

. . . . . .

. . . . . .

(ii) In a similar experiment, scientists determined an R^2 value of 0.92.
Comment on this result. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 3 continued)

(b) Distinguish between the functions of sensory and motor neurons. [1]

. . . . . .

. . . . . .

(c) The transmission of nerve impulses along axons relies on a supply of energy. Explain how ATP is adapted to perform this function. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

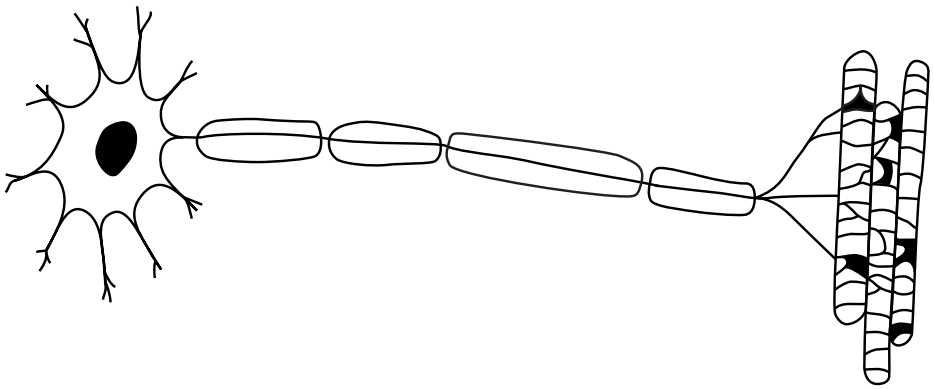
. . . . . .

Question 3 - working space

Section A

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

3. The neuron is a specialized cell that exhibits a structure important to its function. The diagram shows a neuron interacting with a muscle cell.



(a) Determine, with a reason, whether this neuron is insulated. [1]

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

(b) List **two** structures that neurons have in common with prokaryotic cells. [2]

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

(c) Describe how neurotransmitters are released from a presynaptic neuron membrane. [3]

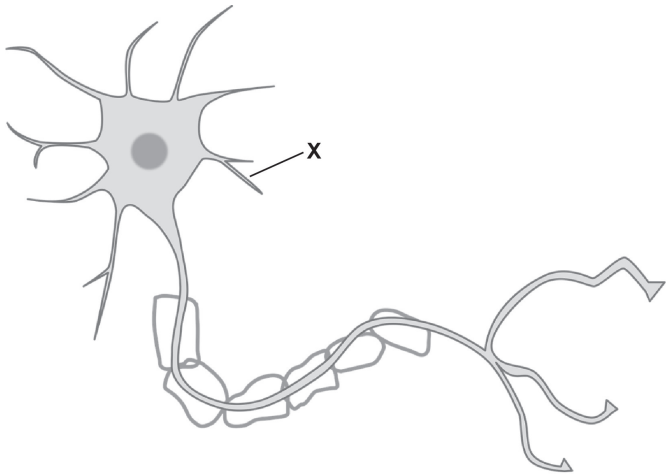
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

Question 3 - working space

Section A

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

6. The diagram shows a neuron.



(a) Identify the structure and function for the part of the neuron labelled X. [2]

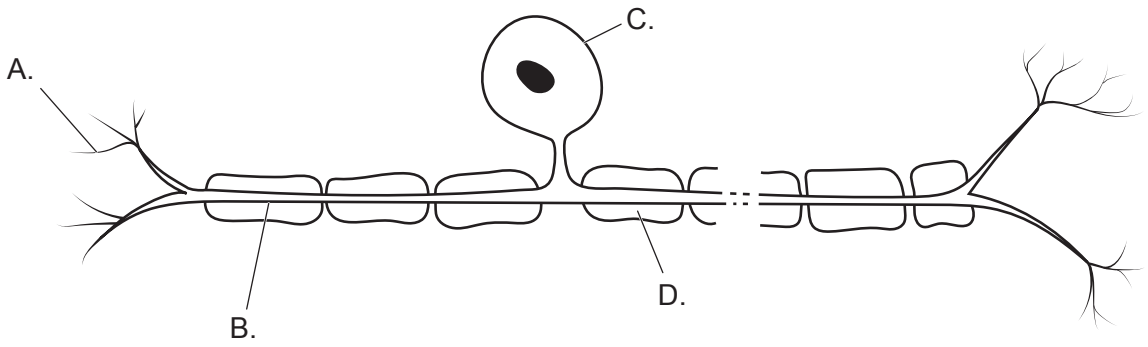
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) Describe how an excitatory postsynaptic potential is generated. [3]

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

Question 6 - working space

11. The image shows a neuron. Which letter shows a dendrite?



Turn over

16. Which is the receptor in a pain reflex arc?

A. Skeletal muscle

B. Grey matter of spinal cord

C. Pituitary gland

D. Sensory nerve ending

Turn over

11. The conduction velocity of electrical impulses was measured in different myelinated nerve fibres.

Type of nerve fibre	Conduction velocity / m s^{-1}
P	3–10
Q	30–70
R	80–110

Which hypothesis would explain the higher conduction velocity of nerve fibre R, compared to nerve fibres P and Q?

A. It is the longest.

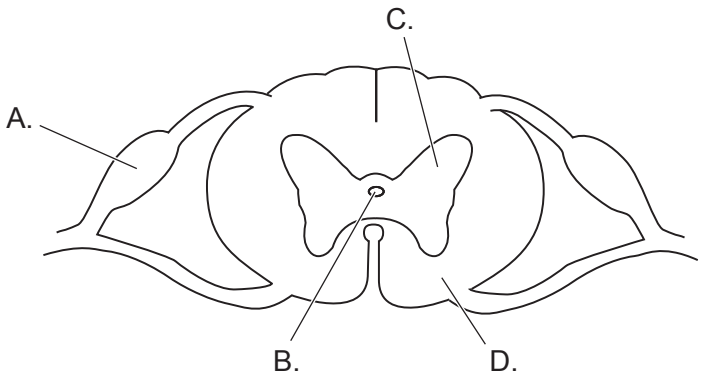
B. It has the thinnest myelin sheath.

C. It has the largest diameter.

D. It has the greatest number of mitochondria.

17. The spinal cord is involved in the coordination of involuntary actions such as the pain reflex.

Where are synapses between sensory neurons and interneurons found?

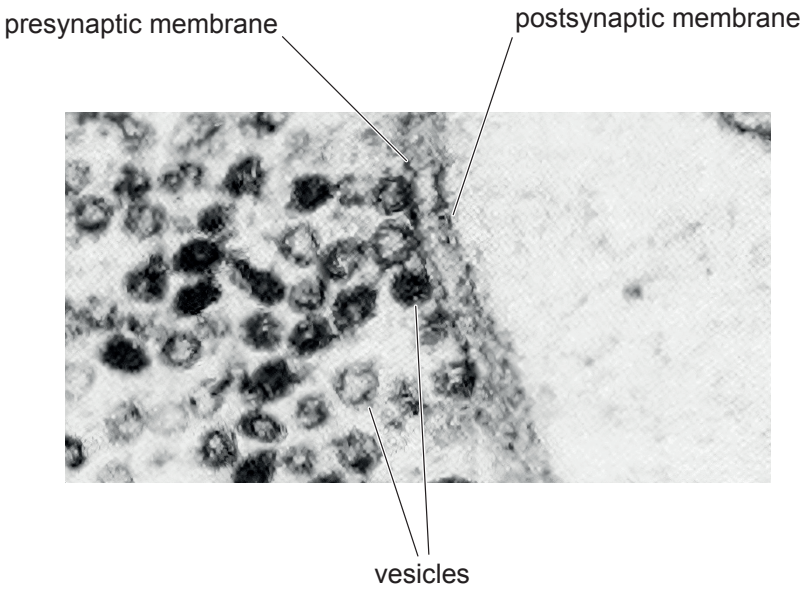


Turn over

Section A

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

5. The electron micrograph shows part of a synapse between two neurons.



(a) Deduce what type of substance the vesicles contain. [1]

. . . . . .

. . . . . .

(b) Distinguish between the presynaptic and postsynaptic membranes by giving **two** differences. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) The gap between the presynaptic and postsynaptic membranes is very narrow. Suggest an advantage of this. [1]

. . . . . .

. . . . . .

Question 5 - working space

13. How is the Na/K ion ratio established during the resting potential phase of neuron activity?

	Na ions	K ions
A.	Actively transferred in	Actively transferred out
B.	Actively transferred out	Actively transferred in
C.	Passively diffused in	Passively diffused out
D.	Passively diffused out	Passively diffused in

APOLLO

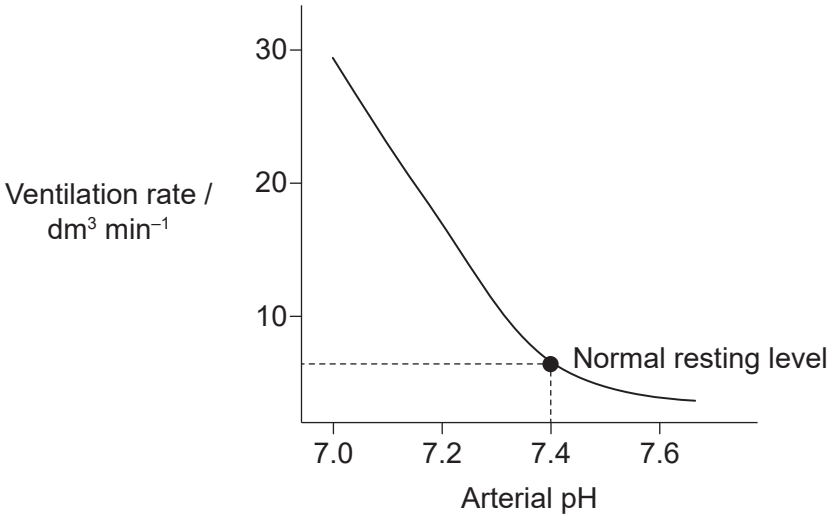
Integration of body systems

6 questions

16. Which row has the correct information regarding the endocrine system?

	Gland	**Hormone**	**Action**
A.	pineal	melatonin	controls circadian rhythm
B.	adrenal	Epinephrine (adrenaline)	controls circadian rhythm
C.	adrenal	melatonin	prepares the body for vigorous activity
D.	pineal	Epinephrine (adrenaline)	prepares the body for vigorous activity

15. The graph shows ventilation rate as a result of change in arterial pH. Blood is normally maintained at approximately pH 7.4 in response to changes detected by receptors.



What is happening in the blood below pH 7.4?

A. Transmembrane receptors detect increased O_2 concentration.

B. Baroreceptors detect increased CO_2 concentration.

C. Thermoreceptors detect increased O_2 concentration.

D. Chemoreceptors detect increased CO_2 concentration.

16. What describes the control mechanisms for peristalsis that ensure coordinated passage of material through the digestive system?

A. Voluntary control by the central nervous system

B. Involuntary control by the enteric nervous system

C. Involuntary control by the central nervous system

D. Voluntary control by the enteric nervous system

17. What describes the control mechanisms for peristalsis that ensure coordinated passage of material through the digestive system?

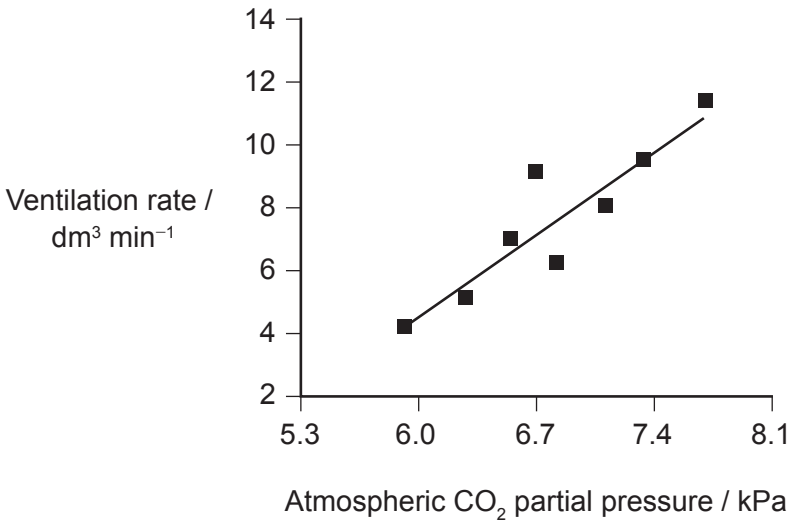
A. Voluntary control by the central nervous system

B. Involuntary control by the enteric nervous system

C. Involuntary control by the central nervous system

D. Voluntary control by the enteric nervous system

18. The graph shows the effect of atmospheric carbon dioxide (CO_2) concentration (measured as partial pressure) on the ventilation rate (measured as total volume of air breathed in and out from the lungs in one minute) of a mammal.



Which of the following explains the results obtained at high atmospheric CO_2 concentration?

A. The brainstem stimulates increased contraction of the diaphragm and intercostal muscles when chemoreceptors detect a drop in blood pH.

B. Stretch receptors in the brainstem send impulses to the lungs to increase ventilation rate.

C. Baroreceptors sense a build-up of CO_2 and send signals to the diaphragm and intercostal muscles.

D. The pituitary gland stimulates the brainstem when blood plasma becomes more acidic.

19. What conveys messages from the central nervous system to an endocrine gland?

A. Sensory neurons

B. Hormones

C. Interneurons

D. Motor neurons

APOLLO

Defence against disease

9 questions

18. Which cell type is part of the innate immune system?

A. Phagocytes

B. B-lymphocytes

C. T-lymphocytes

D. Helper T-cells

Turn over

18. What do rabies, tuberculosis and Japanese encephalitis have in common?

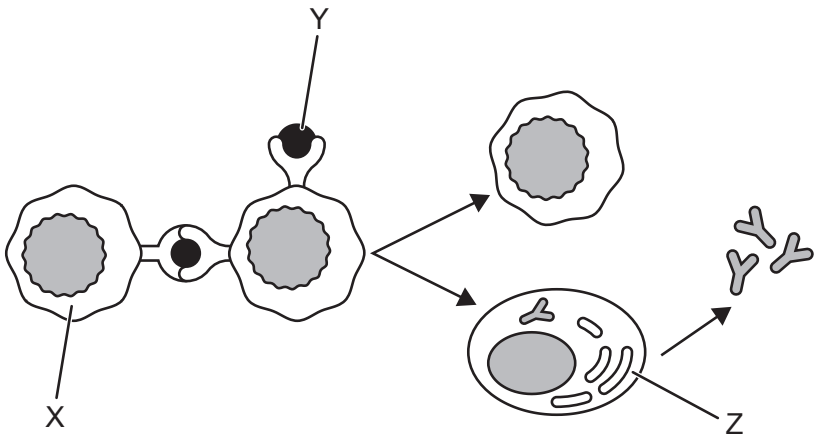
A. They are all infectious diseases caused by bacteria.

B. They are all infectious diseases caused by viruses.

C. They are all zoonoses.

D. They are all infecting red blood cells.

18. The diagram shows stages in an immune response.



What is represented by labels X, Y and Z?

	X	Y	Z
A.	helper T-cell	antibody	plasma cell
B.	B-cell	antigen	memory B-cell
C.	helper T-cell	antigen	plasma cell
D.	B-cell	antibody	memory B-cell

19. Which illness is an example of a zoonosis?

A. Common cold

B. Rabies

C. Cholera

D. Coronary heart disease

Turn over

17. Which function is primarily associated with helper T-cells in the immune system?

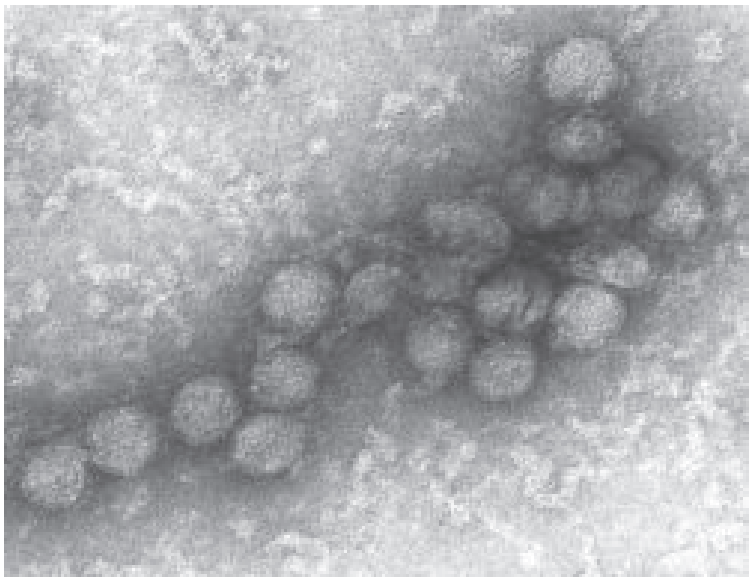
A. Phagocytosis of pathogens

B. Activation of other cells in the immune system

C. Antibody production

D. Retention as memory cells

18. The electron micrograph shows the Japanese encephalitis virus.



Why are some diseases, such as Japanese encephalitis, known as zoonoses?

A. They can be directly transferred from an animal to humans.

B. They are transferred from human to human.

C. They are only found in animals in captivity (zoos).

D. They can directly transfer antigens into animal cells.

16. Which of the following will cause the production of antibodies during an infection?

A. Conversion of fibrinogen to fibrin by thrombin

B. B-cell activation by helper T-cells and antigens

C. Plasma cell activation by platelets

D. Activation of phagocytes by infected body cells

Section A

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

1. Psoriasis is a disorder characterized by inflammation of the skin. It causes the formation of red patches (lesional skin), which often have flaky, silver–white surfaces (skin plaques).

Some drugs are available to treat psoriasis. During treatment, the changes in psoriasis severity can be measured by taking daily photographs of the affected region(s) of the body.

In one study, five males of a similar age and with similar psoriasis severity were provided with the same dose of a medicinal drug for seven days. The skin maps show the change in psoriasis severity on the back of **one** of the males during this study.



(a) Distinguish between the appearance of the skin of this male on Day 0 and Day 7 of treatment. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(b) Explain how quantitative data could be obtained from all males to assess the success of the treatment. [2]

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

(c) Comment on the reliability of this investigation. [1]

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

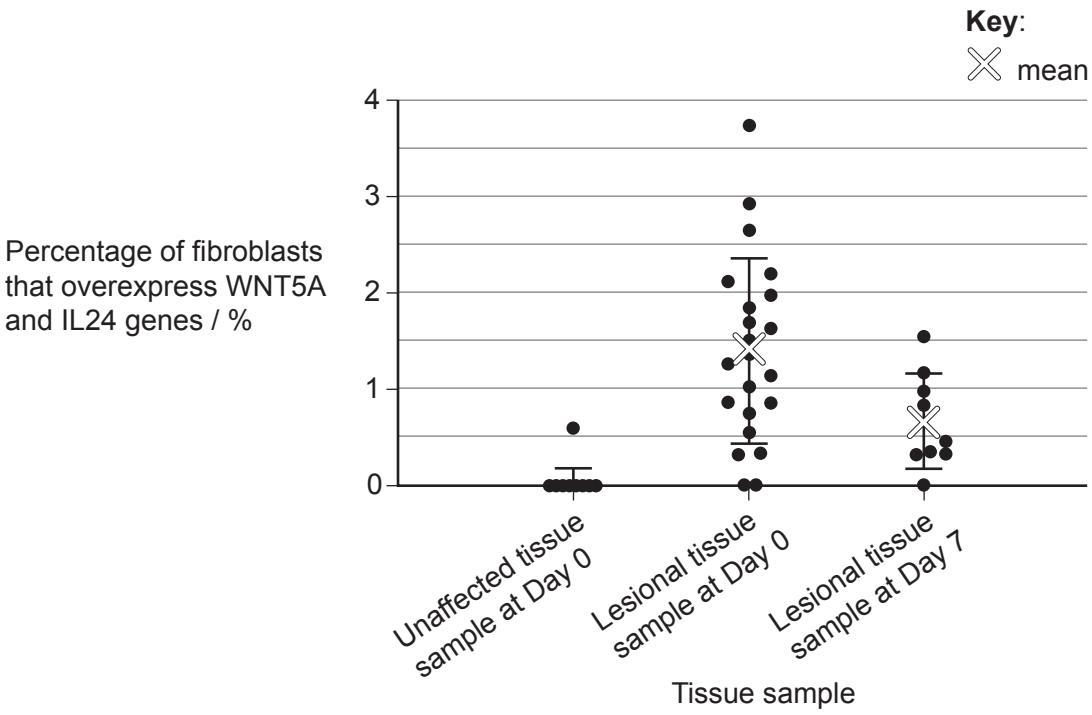
(This question continues on the following page)

(Question 1 continued)

One drug commonly used to treat psoriasis is called guselkumab. It reduces inflammation in affected regions of skin.

Tissue samples of lesional skin were taken from people with psoriasis before treatment with guselkumab (Day 0) and after one week of treatment (Day 7). Tissue samples of unaffected skin were also taken from these people before treatment with guselkumab. The numbers of samples were different for the three groups.

Skin cells called fibroblasts were extracted from all tissue samples. The scientists measured the expression of two genes that are known to cause inflammation, WNT5A and IL24. They calculated the percentage of fibroblasts that overexpress (express more than normal) **both** the WNT5A and IL24 genes. The graph shows the data. The crosses on the graph represent mean percentages.



Statistical significance levels

Unaffected tissue sample at Day 0	Lesional tissue sample at Day 0
$p < 0.001$	

Lesional tissue sample at Day 0	Lesional tissue sample at Day 7
$p < 0.05$	

(This question continues on the following page)

(Question 1 continued)

(d) State the highest percentage of fibroblasts that overexpress WNT5A and IL24 in the lesional tissue sample at Day 0. [1]

. . . . . .

. . . . . .

(e) Calculate the decrease in the mean percentage of fibroblasts in lesional tissue that overexpress WNT5A and IL24 after treatment with guselkumab. [1]

. . . . . .

(f) Suggest the reason for including unaffected tissue samples in this investigation. [1]

. . . . . .

. . . . . .

(g) Explain the conclusions that can be drawn from the data in the graph. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 1 - working space

20. Which cell is a component of the innate immune system?

A. T lymphocyte

B. Phagocyte

C. B lymphocyte

D. B memory cell

APOLLO

Populations and communities

12 questions

24. What is an abiotic factor in an ecosystem?

A. The mutualistic relationship between zooxanthellae and coral

B. The predator–prey relationship between wolves and elk

C. The salinity surrounding marram grass on a sand dune

D. An infectious disease affecting a population of rabbits

26. A capture–mark–release–recapture experiment was used, together with the Lincoln index formula (population size estimate = M × N/R), to estimate the population size of common periwinkles (*Littorina littorea*) on a rocky shore. The table shows the data collected.



Individuals captured and marked initially	100
Individuals recaptured	50
Marked individuals recaptured	10

What is the estimated size of the population?

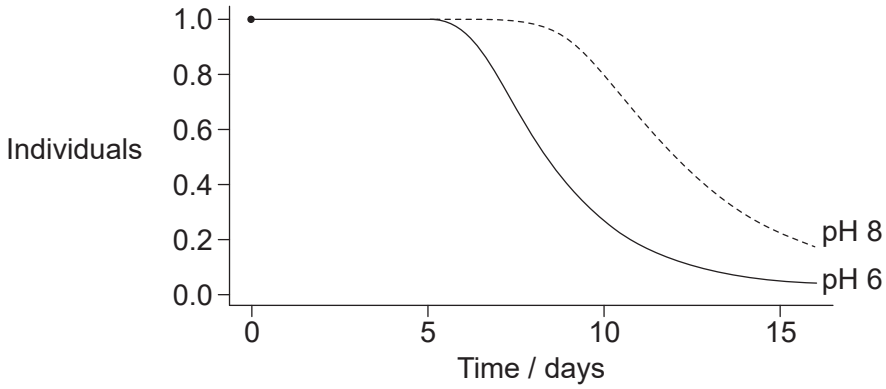
A. 160

B. 500

C. 1000

D. 5000

25. The life cycle of the mosquito (*Aedes aegypti*) starts as a larva, then moves to the pupa stage, after which it moves to the adult stage. The influence of pH on mosquito larval development was measured. On the graph, 1.0 indicates that all individuals are at the larval stage and 0 indicates that all are pupae.



What can be concluded about the effect of pH on larval development from this graph?

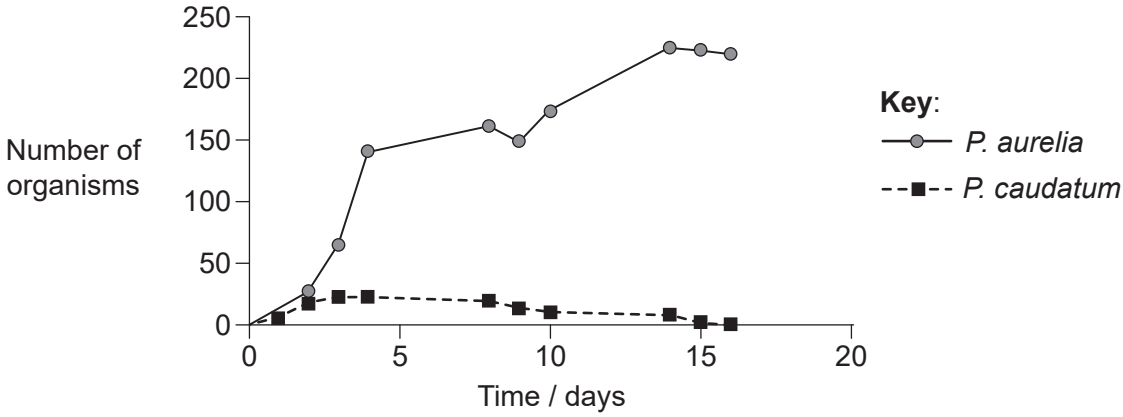
A. All mosquito larvae developed into pupae by day 15 at both pH values.

B. pH has no effect on larval development of the mosquito.

C. On day 10, there are more pupae at pH 8 than at pH 6.

D. Mosquito larvae developed faster at pH 6.

27. *Paramecium aurelia* and *Paramecium caudatum* are two species of paramecium that grow well individually. Scientists grew these two species of paramecium together, and the result is shown in the graph.



What could be deduced from this data?

A. Predation results in *P. caudatum* consuming *P. aurelia*.

B. Allelopathy results in *P. caudatum* outcompeting *P. aurelia*.

C. Interspecific competition results in *P. aurelia* outcompeting *P. caudatum*.

D. Intraspecific competition results in *P. aurelia* eliminating *P. caudatum*.

26. *Bifidobacteria* living in human intestines can synthesise several B vitamins, such as folate and riboflavin. What is the type of interspecific relationship between these bacteria and humans?

A. Pathogenicity

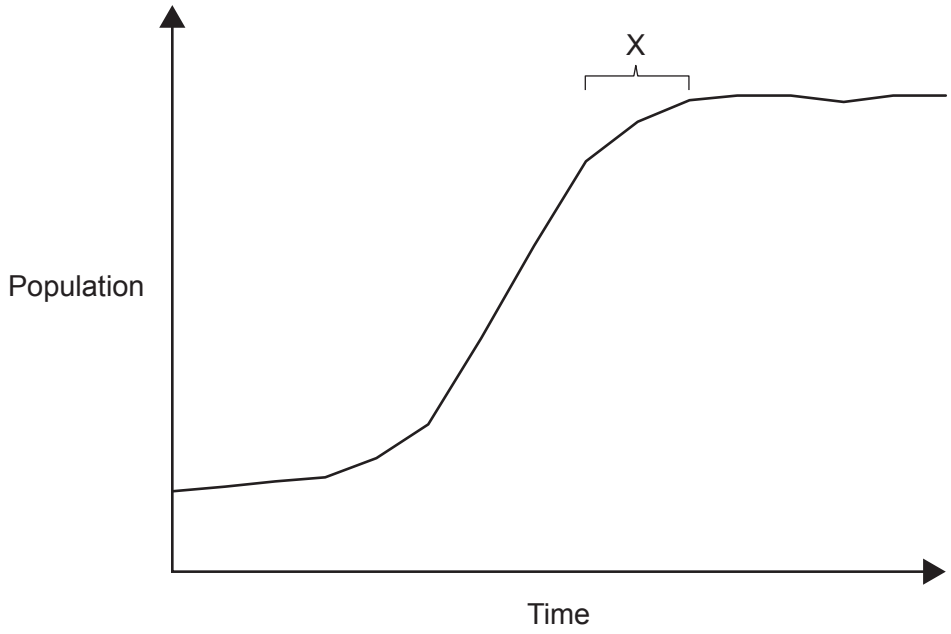
B. Predation

C. Parasitism

D. Mutualism

Turn over

27. The graph shows a population growth curve.



What factor could cause the part of the graph indicated by X?

A. Increased food supply

B. Increased disease

C. Reduced predation

D. Reduced competition

26. Which interspecific relationship has a negative impact on both individuals?

A. Competition

B. Mutualism

C. Parasitism

D. Pathogenicity

Turn over

27. Root nodules in a plant of the Fabaceae (legume) family is an example of a type of interspecific relationship that involves bacteria.



Which of the following explains the relationship between the species?

A. It is mutualistic, as bacteria obtain oxygen for respiration and provide carbon dioxide for plant photosynthesis.

B. It is mutualistic, as the plant supplies bacteria with sugars and obtains ammonium for protein synthesis.

C. It is parasitic, as bacteria take nutrients from the plant causing poor plant growth.

D. It is parasitic, as bacteria obtain water from roots, which reduces plant photosynthesis.

Turn over

28. Black walnut (*Juglans nigra*) secretes the chemical juglone into the soil surrounding its roots. Juglone inhibits cell respiration in other species of plants. What does this example illustrate?

A. Mutualism

B. Intraspecific competition

C. Allelopathy

D. Parasitism

29. Which is a density-independent limiting factor for a kangaroo?

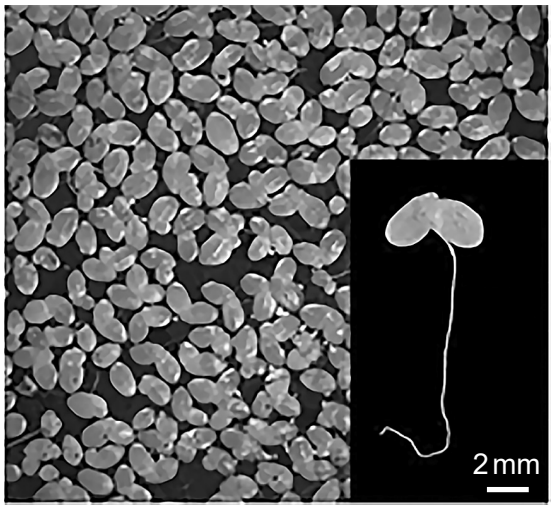
A. A forest fire

B. Predation

C. Climate change

D. Eutrophication

3. Duckweed (*Lemna minor*) is a small flowering plant that floats on water. Duckweed can reproduce rapidly using asexual reproduction, giving rise to dense populations.



A group of students investigated the effect of temperature on the rate of population growth of duckweed. They set up three culture dishes using 500ml of filtered pond water with a pH of 7.0. The culture dishes were given a small starting population of plants and each dish was incubated at a fixed temperature (15, 20 or 25 °C).

The number of duckweed plants in each dish was counted over several weeks. The data are summarized in the table.

Time / weeks	**Number of plants at a given temperature**		
	15 °C ± 1 °C	**20 °C ± 1 °C**	**25 °C ± 1 °C**
0	5	5	5
1	10	14	15
2	31	37	50
3	38	76	80
4	24	115	117
5	23	168	177

(a) Outline what indicates that temperature is the independent variable in this experiment. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 3 continued)

(b) Identify the temperature that gives the highest overall population growth rate over the experimental period. [1]

. . . . . .

. . . . . .

(c) Explain how temperature can influence population growth in a species such as *Lemna minor*. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(d) Suggest how the reliability of this investigation could be improved. [1]

. . . . . .

. . . . . .

Question 3 - working space

Section A

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

5. Many flowering plants require an animal pollinator in order to transfer pollen from one flower to another.



(a) Explain the type of ecological relationship between the hummingbird and the flower on which it feeds. [2]

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

(b) State **one** way that plants attract animal pollinators. [1]

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

(c) Hummingbirds have few natural predators. Suggest **one** type of behaviour that an animal such as a hummingbird can display to reduce the risk of predation while it is feeding. [1]

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

Question 5 - working space

APOLLO

Transfers of energy and matter

18 questions

28. Which organisms use oxidation of simple inorganic substances as an energy source?

A. Photoautotrophs

B. Heterotrophs

C. Chemoautotrophs

D. Saprotrophs

30. What directly causes oxygen levels to drop during eutrophication in aquatic ecosystems?

A. Increased photosynthesis by aquatic plants

B. Enhanced respiration by fish

C. More decomposition of organic matter by bacteria

D. Lower levels of nitrogen in the water

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:

5. Olson, K., 2012. *Induced Fit Enzyme Catalyst*. [image online] Available at: https://commons.wikimedia.org/wiki/File:InducedFit_Enzyme_Catalyst.png. Public domain. Source adapted.

7. Helixitta, 2017. DNA paternity testing en. [image online] Available at: https://commons.wikimedia.org/wiki/File:DNA_paternity_testing_en.svg [Accessed 3 June 2024]. Source adapted. Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license: https://creativecommons.org/licenses/by-sa/3.0/deed.en.

9. LadyofHats, 2007. Cell membrane detailed diagram. [image online] Available at: https://commons.wikimedia.org/wiki/File:Cell_membrane_detailed_diagram_en.svg [Accessed 26 July 2024]. Source adapted. Public domain.

11. Natalierussell77, 2023. Mitosis in Onion Root - various stages. [image online] Available at: https://commons.wikimedia.org/wiki/File:Mitosis_in_Onion_Root_-_various_stages_(Anaphase_and_Interphase).jpg. Licensed under the Creative Commons Attribution-Share Alike 4.0 International license: https://creativecommons.org/licenses/by-sa/4.0/deed.en. Source adapted.

14. LungVolume, 2011. [image online] Available at: https://commons.wikimedia.org/wiki/File:Lungvolumes.svg [Accessed 4 June 2024]. Source adapted. This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license: https://creativecommons.org/licenses/by-sa/3.0/deed.en.

22. Nobu Tamura, 2009. *Ichthyosaurus BW*. [image online] Available at: https://commons.wikimedia.org/wiki/File:Ichthyosaurus_BW.jpg. Licensed under the Creative Commons Attribution 3.0 Unported license: https://creativecommons.org/licenses/by/3.0/deed.en [Accessed 5 June 2024]. Source adapted.

DataBase Center for Life Science (DBCLS), 2019. 201905 BottlenoseDolphin. [image online] Available at: https://commons.wikimedia.org/wiki/File:201905_BottlenoseDolphin.svg. Licensed under the Creative Commons Attribution 4.0 International license: https://creativecommons.org/licenses/by/4.0/deed.en. [Accessed 5 June 2024]. Source adapted.

23. Frohawk, F.W., 1907. Dinornis novaezealandiae. [image online] Available at: https://commons.wikimedia.org/wiki/File:Dinornis_novaezealandiae.png. Public domain. [Accessed 5 June 2024]. Source adapted.

26. Richard Villalonundefined undefined, 2021. A periwinkle. Available at: https://www.gettyimages.co.uk/detail/photo/periwinkle-royalty-free-image/1334118471?phrase=mollusc%20on%20rock%20littorina%20littorea&searchscope=image%2Cfilm&adppopup=true. [Accessed 11 June 2025]. Source adapted.

29. Deacon, A.E., Shimadzu, H., Dornelas, M., Ramnarine, I.W. and Magurran, A.E., 2015. From species to communities: the signature of recreational use on a tropical river ecosystem. *Ecology & Evolution* 5(23), pp. 5561–5572. https://doi.org/10.1002/ece3.1800.

All other texts, graphics and illustrations © International Baccalaureate Organization 2025

24. Dry rot fungus (*Serpula lacrymans*) secretes digestive enzymes to externally digest dead wood.



What type of nutrition is used by dry rot fungus?

A. Holozoic

B. Saprotrophic

C. Mixotrophic

D. Autotrophic

26. What is the energy source of photoautotrophs and chemoautotrophs?

A. They both use light only.

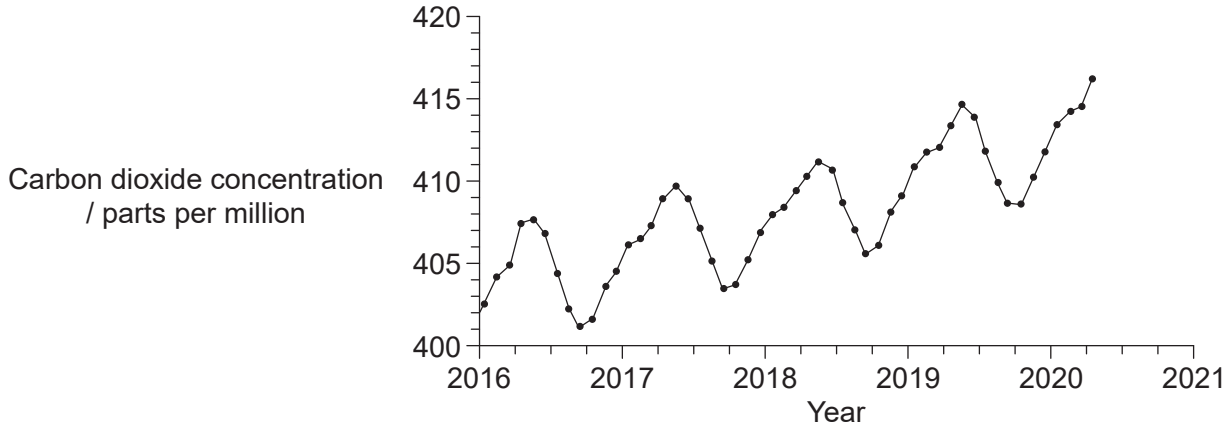
B. They both use oxidation reactions only as an external energy source.

C. Photoautotrophs use oxidation reactions, while chemoautotrophs use light.

D. Photoautotrophs use light, while chemoautotrophs use oxidation reactions.

Turn over

28. The graph shows annual fluctuations of atmospheric carbon dioxide in the Northern Hemisphere. There is a relative increase in carbon dioxide concentration during winters.



Which reason might explain this increase during winters?

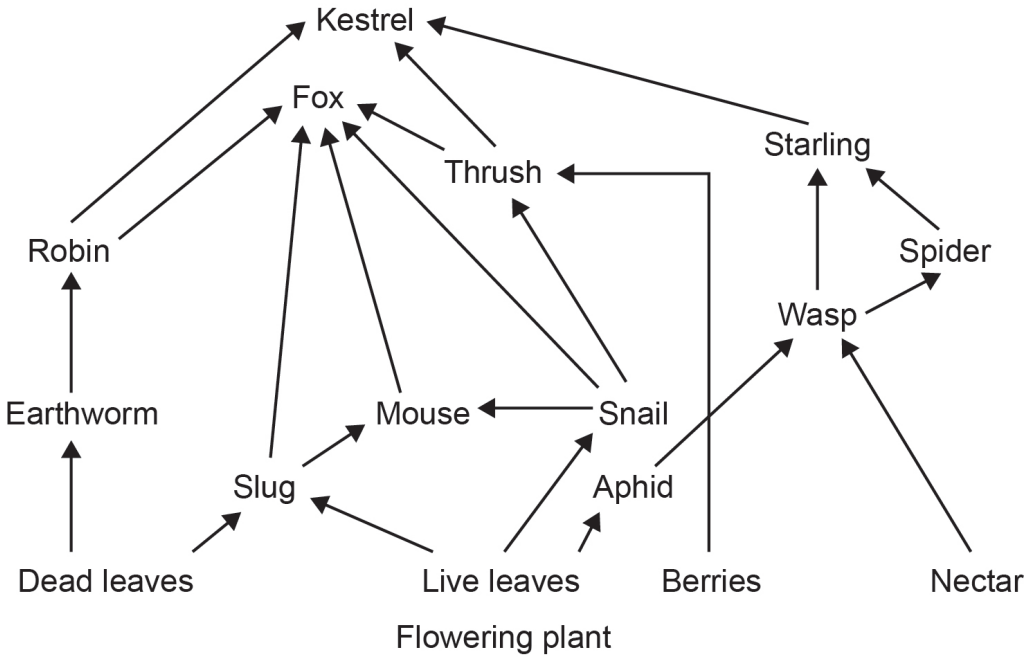
A. Increase in atmosphere–ocean diffusion

B. Decrease in photosynthesis of plants

C. Increase in respiration of all organisms

D. Decrease in combustion from wildfires

28. A terrestrial food web is shown.



How many species in the food web are **only** primary consumers?

A. 3

B. 4

C. 5

D. 6

30. Which action will decrease carbon sequestration?

A. Afforestation

B. Primary production

C. Deforestation

D. Rewetting peatlands

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:

1. Malsam, L., 2020. *Macro of Gerris lacustris or common pond skater.* [image online] Available at: https://www.gettyimages.co.uk/detail/photo/macro-of-gerris-lacustris-or-common-pond-skater-royalty-free-image/1225103683?phrase=pond+skater&adppopup=true [Accessed 13 May 2024]. Source adapted.

14. Devitt, T.J., Baird, S.J.E. and Moritz, C., 2011. *Ensatina eschscholtzii ring species*. [image online] Available at: https://commons.wikimedia.org/wiki/File:Ensatina_eschscholtzii_ring_species.jpg [Accessed 18 April 2024]. Source adapted. This file is licensed under the Creative Commons Attribution 2.0 Generic license: https://creativecommons.org/licenses/by/2.0/deed.en.

15. Lazaj, D., 2021. *Lily leaf c.s. under microscope*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/lily-leaf-c-s-under-microscope-royalty-free-image/1335686572 [Accessed 13 May 2024]. Source adapted.

18. VectorMine. 2018. https://www.gettyimages.co.uk/detail/illustration/cells-and-t-cells-schematic-diagram-vector-royalty-free-illustration/907993572?phrase=Vectormine%20immune%20response&adppopup=true. Source adapted.

23. Philcha, 2008. *Vertebrate n octopus eyes*. [image online] Available at: https://commons.wikimedia.org/wiki/File:Vertebrate_n_octopus_eyes.png [Accessed 23 April 2024]. Source adapted. Public domain.

24. Navarras, 2017. *Climate influence on terrestrial biome*. [online] Available at: https://commons.wikimedia.org/wiki/File:Climate_influence_on_terrestrial_biome.svg [Accessed 24 April 2024]. Source adapted. This file is made available under the Creative Commons CC0 1.0 Universal Public Domain Dedication: https://creativecommons.org/publicdomain/zero/1.0/deed.en.

25. Minami Himemiya. https://commons.wikimedia.org/wiki/File:Prorocentrum_micans.jpg. Licensed under CC BY-SA 3.0. https://creativecommons.org/licenses/by-sa/3.0.

All other texts, graphics and illustrations © International Baccalaureate Organization 2025

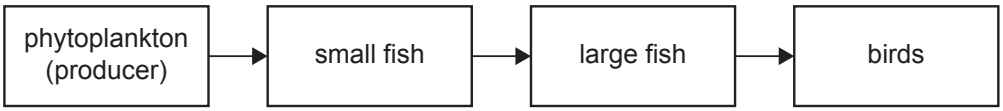
Section A

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

5. (a) Broad-spectrum insecticides kill many different species of insect. Narrow-spectrum insecticides only target a specific species of insect. Suggest **one** disadvantage of using a broad-spectrum insecticide. [1]

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

(b) The diagram shows the concentration of an insecticide, in parts per million (ppm), at different trophic levels of an aquatic food chain.



(i) Identify the trophic level of the large fish. [1]

. . . . . .

(ii) Explain the high concentration of insecticide in birds. [3]

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

Question 5 - working space

Section B

Answer **one** question. Up to one additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

8. Cycles play an important role both within and outside the body.

(a) Outline the roles of progesterone in the menstrual cycle. [4]

(b) Describe the polymerase chain reaction (PCR). [4]

(c) Explain how carbon is recycled in a terrestrial ecosystem. [7]

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:

1.a From *The New England Journal of Medicine*, Mark A. Mintun, Albert C.Lo, Cynthia Duggan Evans, Donanemab in Early Alzheimer's Disease. 384(18), pp. 1691–1704. Copyright © 2021 Massachusetts Medical Society. Reprinted with permission from Massachusetts Medical Society.

1.d Öhrfelt, A., Brinkmalm, A., Dumurgier, J., et al., 2019. A Novel ELISA for the Measurement of Cerebrospinal Fluid SNAP-25 in Patients with Alzheimer's Disease. *Neuroscience* 420, pp. 136–144. https://doi.org/10.1016/j.neuroscience.2018.11.038. Source adapted.

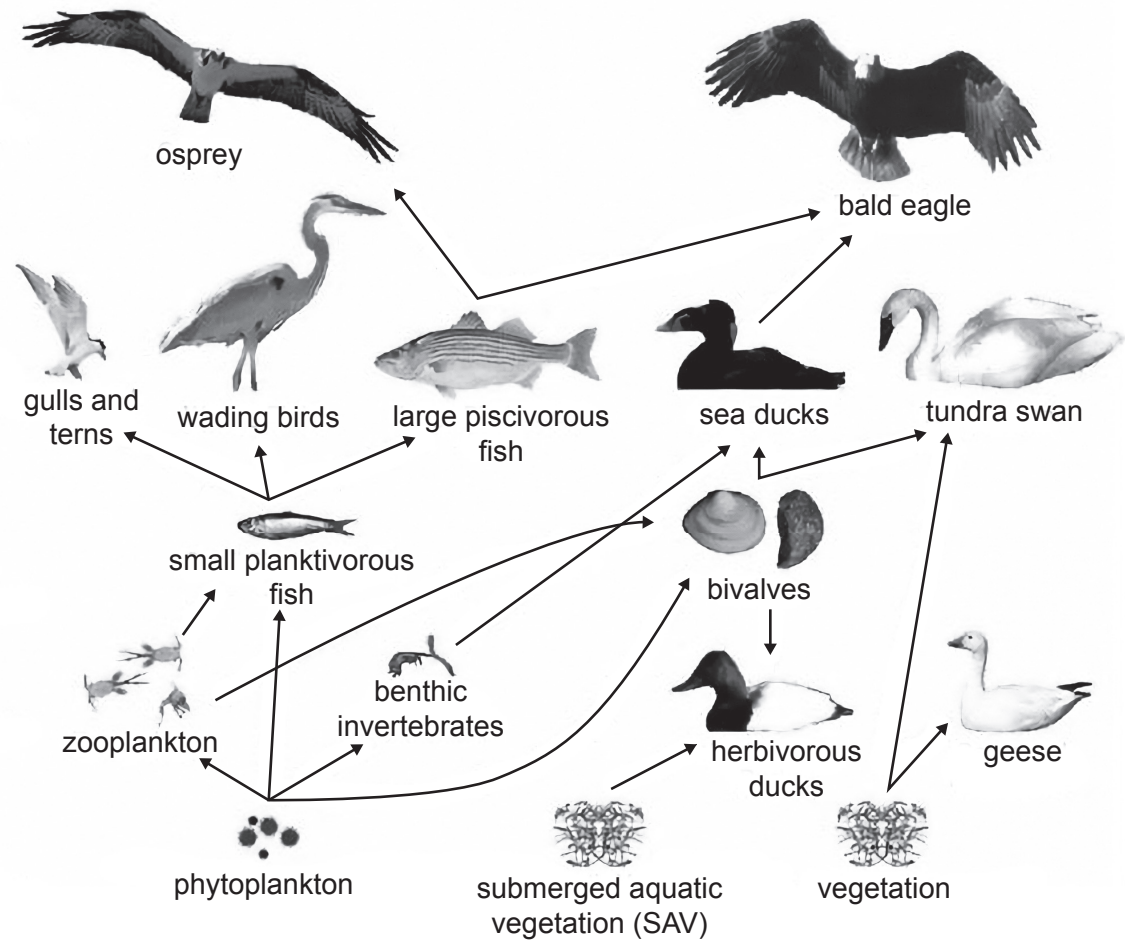
3. *The regions of Africa where the chimpanzee and the bonobo are found*, n.d. [online] Available at: https://www.chrismadden.co.uk/where-are-we/chapters/chapter-16.html [Accessed 1 May 2024]. Source adapted.

6. Image by OpenClipart-Vectors from Pixabay. Source adapted

All other texts, graphics and illustrations © International Baccalaureate Organization 2025

Question 8 - working space

27. The image shows a food web from Chesapeake Bay, USA.



Which organisms are tertiary consumers in at least one food chain?

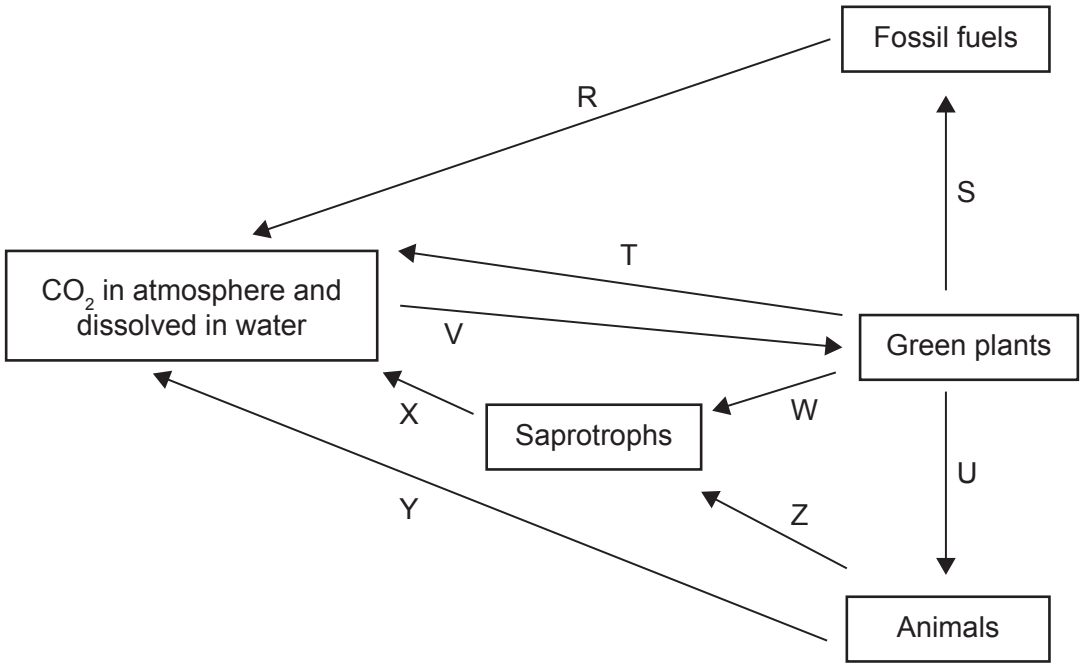
A. Small planktivorous fish and tundra swans

B. Herbivorous ducks and bald eagles

C. Wading birds and geese

D. Ospreys and benthic invertebrates

28. The diagram represents the carbon cycle.



Which arrows represent respiration?

A. R and V

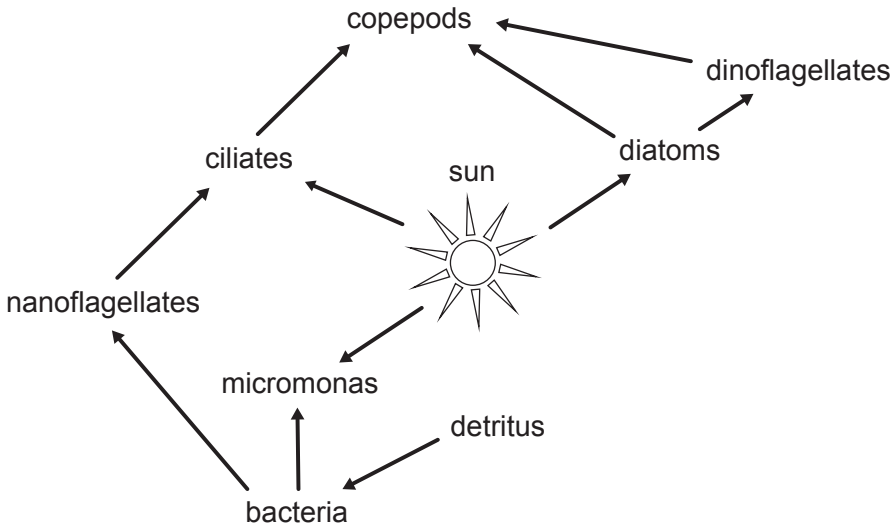
B. T and Y

C. U and Z

D. W and X

Turn over

25. The diagram shows the flow of energy between some Arctic species.



Which organism is a mixotroph?

A. Bacteria

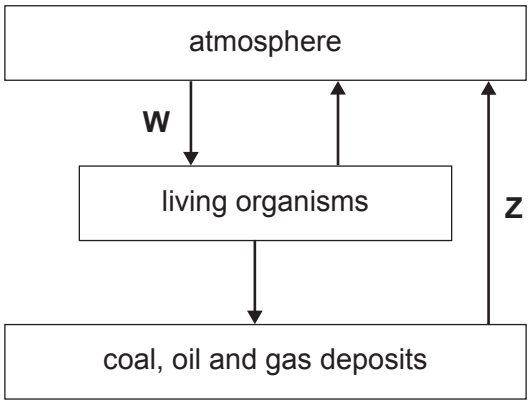
B. Nanoflagellates

C. Micromonas

D. Copepods

Turn over

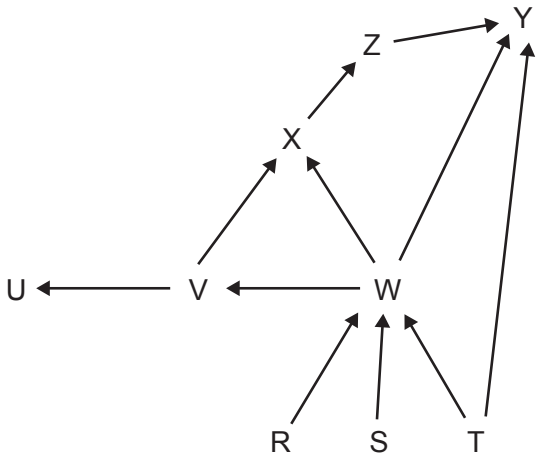
26. The diagram shows a simplified carbon cycle.



Which processes are taking place at W and Z?

	W	Z
A.	respiration	combustion
B.	photosynthesis	decomposition
C.	respiration	decomposition
D.	photosynthesis	combustion

28. The diagram shows a food web for an aquatic ecosystem in which the letters R–Z represent individual species.



Which organism is both a secondary and tertiary consumer?

A. Organism T

B. Organism X

C. Organism Y

D. Organism Z

Section A

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

5. Food chains combine to form food webs in an ecosystem.

(a) Define the term autotroph. [1]

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

(b) Describe the role of decomposers in ecosystems. [2]

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

(c) The efficiency of energy transfer along the various food chains in a food web varies. Suggest reasons for the differences. [3]

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

(This question continues on the following page)

(Question 5 continued)

There are estimated to be over 940 million cattle in the world.



(d) Suggest how increases in cattle farming are affecting climate patterns worldwide. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 5 - working space

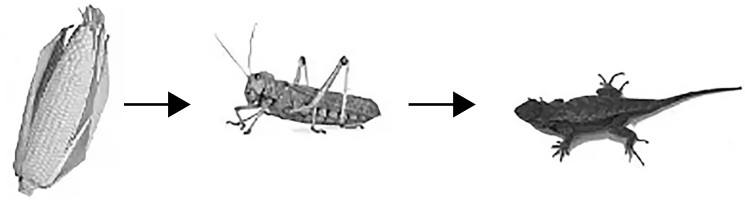
26. Which row of the table describes a type of nutrition?

	Type of nutrition	Source of energy	Source of carbon	Method of acquiring energy
A.	**Autotrophic**	sunlight	organic molecules containing carbon	respiration
B.	**Heterotrophic**	sunlight	carbon dioxide	photosynthesis
C.	**Mixotrophic**	sunlight and energy-rich organic molecules	carbon dioxide and organic molecules containing carbon	photosynthesis and ingestion
D.	**Consumer**	energy-rich organic molecules	organic molecules containing carbon	photosynthesis and respiration

Turn over

Blank page

27. With respect to the food chain shown in the image, what is the role of the locust?



maize locust lizard

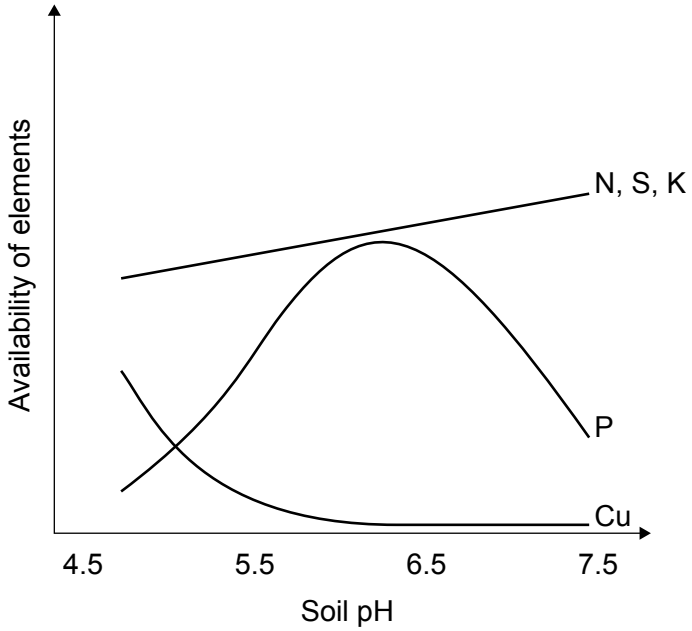
A. Secondary consumer

B. Parasite

C. Chemoautotroph

D. Herbivore

1. The addition of some forms of nitrogen fertilizer to soil can lead to acidification. As a strategy to combat this, farmers will often undertake 'liming' to combat acidification. This involves adding lime to return the pH to neutral.



Certain soil pH levels are associated with copper (Cu) deficiency in cattle.

(a) Explain how a copper deficiency in soil could lead to a copper deficiency in a cow. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Deduce with a reason which action (fertilizing or liming) could lead to a copper deficiency in a cow. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(c) Copper-deficient cows are more susceptible to infections and do not respond as well to vaccinations. Suggest a role for copper in cows. [1]

. . . . . .

. . . . . .

(d) Phosphorous deficiency leads to poor growth of plants.

(i) State an example of a soil pH where phosphorous deficiency might result. [1]

. . . . . .

. . . . . .

(ii) List two biochemicals important to life that have phosphorous as a raw material. [1]

. . . . . .

. . . . . .

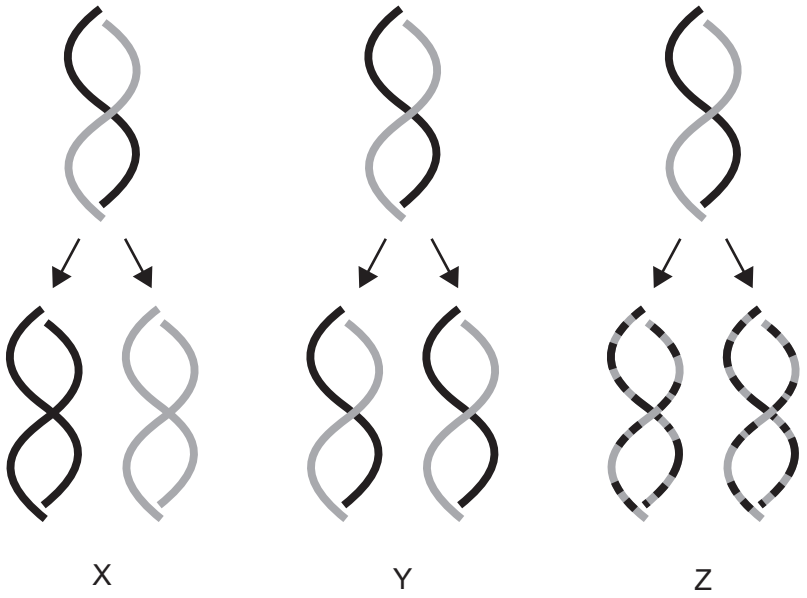
Question 1 - working space

APOLLO

DNA replication

2 questions

6. Which diagram(s) illustrate(s) semi-conservative replication of DNA?



A. X only

B. Y only

C. Z only

D. X and Y only

Turn over

7. What bonds do the enzymes DNA polymerase and helicase form or break during DNA replication?

	DNA polymerase	Helicase
A.	forms sugar–phosphate bonds	breaks hydrogen bonds
B.	forms hydrogen bonds	breaks sugar–phosphate bonds
C.	forms hydrogen bonds	forms sugar–phosphate bonds
D.	forms sugar–phosphate bonds	forms hydrogen bonds

APOLLO

Protein synthesis

5 questions

6. What occurs during translation?

I. Polypeptides synthesised on ribosomes
II. RNA polymerase catalyses polypeptide synthesis
III. Complementary base pairing between codons and anticodons

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Turn over

7. The table shows the genetic code.

1st base in codon	2nd base in codon: U	C	A	G	3rd base in codon
U	Phe	Ser	Tyr	Cys	**U**
	Phe	Ser	Tyr	Cys	**C**
	Leu	Ser	**STOP**	**STOP**	**A**
	Leu	Ser	**STOP**	Trp	**G**
C	Leu	Pro	His	Arg	**U**
	Leu	Pro	His	Arg	**C**
	Leu	Pro	Gln	Arg	**A**
	Leu	Pro	Gln	Arg	**G**
A	Ile	Thr	Asn	Ser	**U**
	Ile	Thr	Asn	Ser	**C**
	Ile	Thr	Lys	Arg	**A**
	Met	Thr	Lys	Arg	**G**
G	Val	Ala	Asp	Gly	**U**
	Val	Ala	Asp	Gly	**C**
	Val	Ala	Glu	Gly	**A**
	Val	Ala	Glu	Gly	**G**

Which mRNA could code for the sequence Ser-Leu-Arg-Phe?

A. UCA UCG UGG UUU

B. UCC ACC AGA UUC

C. UCU CCC AGA UUU

D. UCG CUG AGG UUC

6. The table shows information on the genetic code of four different mRNA sequences. Which sequence demonstrates degeneracy in the genetic code?

	mRNA sequence	Amino acids
A.	UUU UUA UCU	Phe Leu Ser
B.	CUU CCU CUU	Leu Pro Leu
C.	AUG ACG AAG	Met Thr Lys
D.	GUU GGU GUG	Val Gly Val

Turn over

6. Which of the following is a consequence of the degeneracy of the genetic code?

A. Codons affected by mutagens always code for non-functional proteins.

B. There are variations in the amino acid sequences for the same protein.

C. Some base mutations cause no changes in protein structure.

D. A codon may code for more than one amino acid in response to environmental changes.

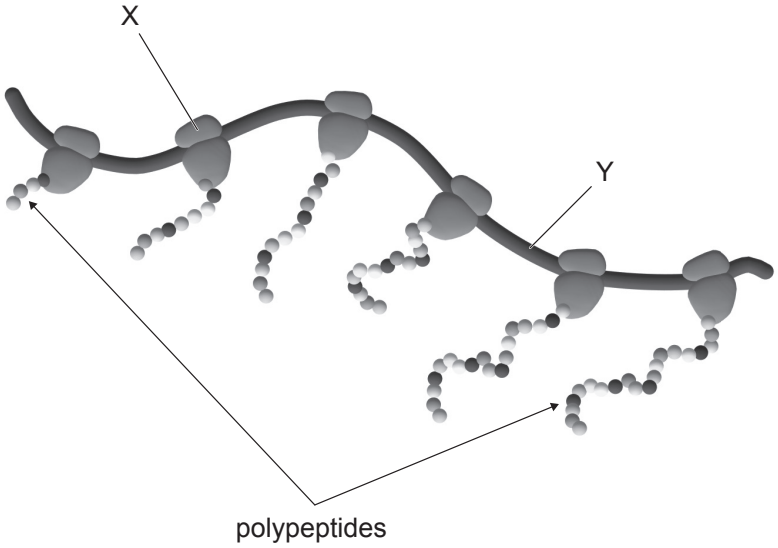
Section A

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

2. (a) Some of the twenty amino acids that are linked together to make polypeptides in human cells are essential in the diet and others are not. Distinguish between essential and non-essential amino acids. [2]

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

The diagram represents the synthesis of proteins in the cytoplasm of a cell.



(b) Identify X and Y. [2]

X: . . . . . .

Y: . . . . . .

(c) Six polypeptides are shown in the diagram. Explain the different lengths of these polypeptides. [2]

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

Question 2 - working space

APOLLO

Mutation and gene editing

7 questions

17. Azithromycin is an antibiotic commonly used to treat pneumonia, an infection of the lungs caused by *Streptococcus pneumoniae*. A patient was diagnosed for the second time with pneumonia, but the same antibiotic was ineffective this time. What biological explanation might there be for this?

A. *S. pneumoniae* had mutated.

B. *S. pneumoniae* had developed antibodies for the antibiotic.

C. The patient was immune to the antibiotic.

D. The patient had antibiotic remaining from the first treatment.

29. Mutations and sexual reproduction both play a role in generating variation, upon which natural selection acts. What describes how variation is generated?

I. Mutations generate new alleles.

II. Mutations generate new combinations of alleles.

III. Sexual reproduction generates new alleles.

A. I only

B. III only

C. II and III only

D. I and III only

Turn over

8. What is a feature of mutations?

A. They occur randomly.

B. They only occur in germ cells.

C. The frequency cannot be increased by external factors.

D. They only occur in certain base sequences of the genome.

Turn over

7. A mutation in which type of cell could be inherited?

A. Beta cell in the pancreas

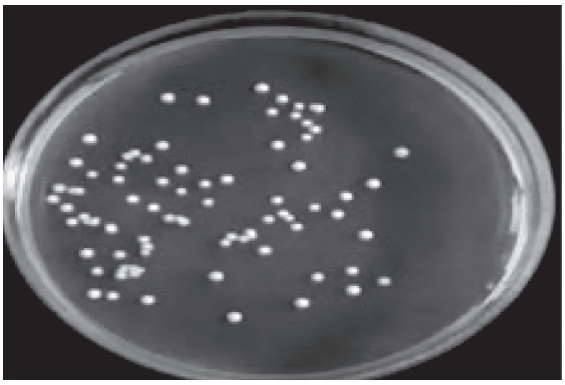
B. T-cell in the lymph

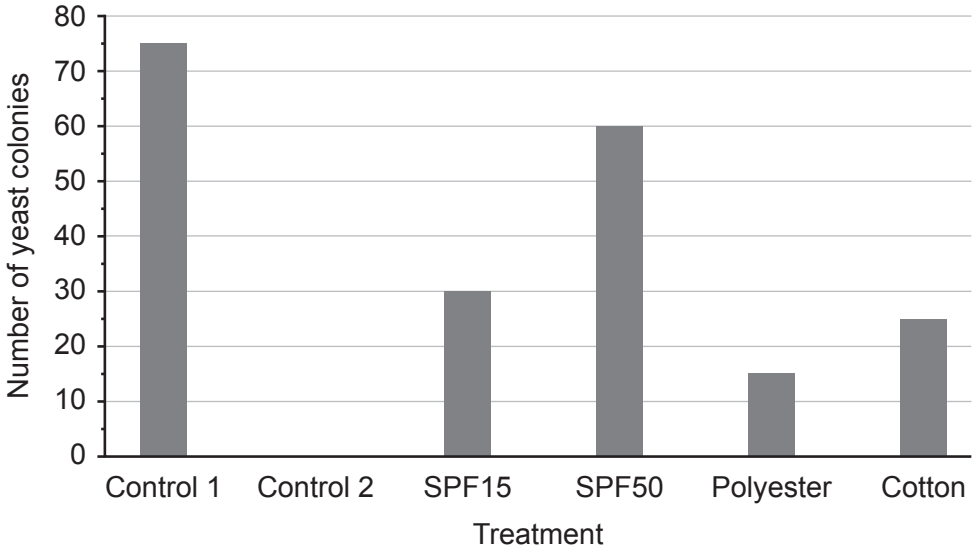
C. Sperm cell in the testis

D. Skeletal muscle cell in the diaphragm

4. Ultraviolet (UV) light can penetrate cells, causing DNA damage. This effect can be reduced by using sunscreens or covering skin with clothing.

In an experiment to look at the effect of different treatments to reduce UV damage to DNA, yeast fungus (*Saccharomyces cerevisiae*) was used as the test organism. Six Petri dishes with agar were inoculated with yeast in sucrose solution. The Petri dishes were labelled according to the treatment applied to the lid, with sunscreen (Sun Protection Factors SPF15 or SPF50), cloth (polyester or cotton) or control (no treatment). Control 1 was placed in the dark and all the other Petri dishes were placed in direct sunlight for 6 hours. The dishes were then incubated for three days. The image shows yeast colonies that grew on the agar in one of the Petri dishes. The bar graph shows the number of yeast colonies present per Petri dish.





(a) Describe how yeast cells reproduce. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 4 continued)

(b) Identify **one** type of mutation that can be induced by UV light. [1]

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

(c) State **one** role of sucrose in this experiment. [1]

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

(d) Suggest a possible reason for the difference in number of yeast colonies

(i) between Control 1 and Control 2. [1]

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

(ii) between SPF15 and SPF50. [1]

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

(e) Using the experimental results, evaluate the use of cotton clothing instead of polyester in humans. [2]

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

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. Any trademarks™ or registered® trademarks included are used for illustrative purposes only, and use does not imply any affiliation with or endorsement by the International Baccalaureate.

References:

1. Lucas, M. and Wallace, I., 1973. Chromosomes of *Gorilla gorilla gorilla J. Zool.* 169, pp. 403–407. Available at: https://zslpublications.onlinelibrary.wiley.com/doi/abs/10.1111/j.1469-7998.1973.tb04565.x. Source adapted.

2. Cavagnaro, J.B., 1988. Distribution of C_3 and C_4 grasses at different altitudes in a temperate arid region of Argentina. *Oecologia* 76(2), pp. 273–277. https://doi.org/10.1007/bf00379962. Source adapted.

3. Ionescu, A., Aprodu, I. and Pascaru, G., 2008. Effect of papain and bromelain on muscle and collagen proteins in beef meat. *The annals of the University Dunarea de Jos of Galati. Fascicle VI- Food Technology*, Year II (XXXI), pp. 9–16. Source adapted.

4. Alhamdy, T. and Al-Sowayan, N.S., 2020. The Effect of Sunscreens on Yeast to Prevent Ultraviolet Damage. *Advances in Bioscience and Biotechnology* 11, pp. 111–122. https://doi.org/10.4236/abb.2020.114009. Licensed under the Creative Commons Attribution 4.0 International Deed license: https://creativecommons.org/licenses/by/4.0/deed.en.

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

Answers written on this page
will not be marked.

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

Answers written on this page
will not be marked.

Question 4 - working space

8. A strand of DNA containing four codons with base sequence ACT GTA CTC TAC mutates, changing the base sequence to ACT ATG CTC TAC. What type of mutation has occurred?

A. Insertion

B. Substitution

C. Deletion

D. Degeneracy

Section B

Answer **one** question. One additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

7. Mutations have a range of consequences for organisms.

(a) Outline how mutation can lead to cancer. [4]

(b) Outline **one** example of a human disease caused by an autosomal recessive allele. [4]

(c) Explain the role of mutations in evolution. [7]

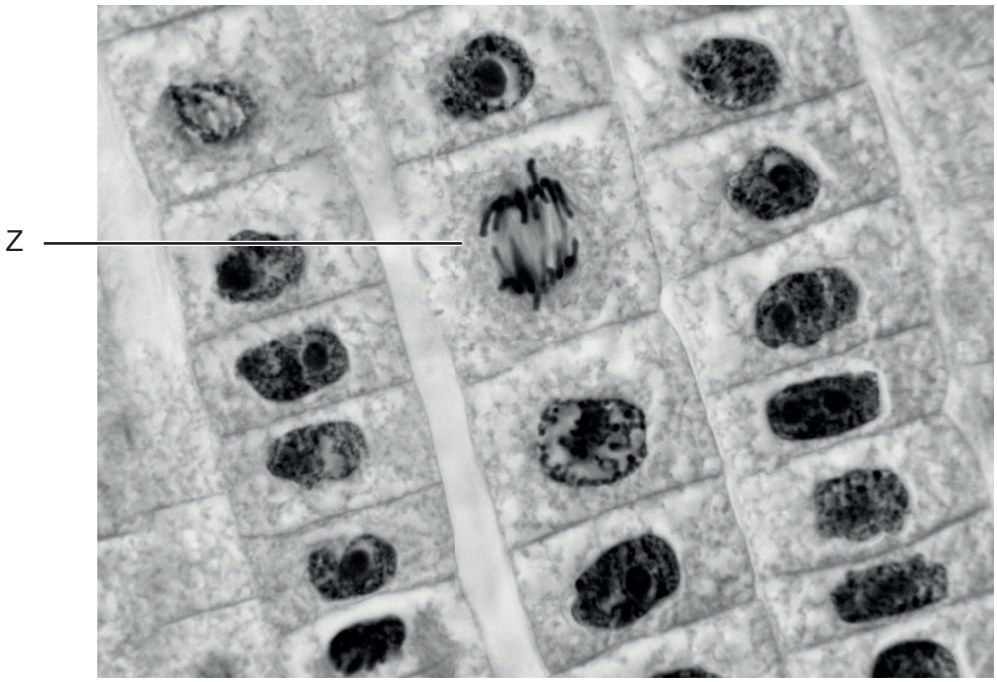
Question 7 - working space

APOLLO

Cell and nuclear division

6 questions

11. The micrograph shows onion (*Allium cepa*) root tip cells dividing by mitosis.



In which phase is cell Z?

A. Interphase

B. Prophase

C. Metaphase

D. Anaphase

12. What occurs in cell division during both mitosis and meiosis?

A. Condensation of DNA by supercoiling in telophase

B. Movement of microtubules to move chromatids in anaphase

C. Pairing of homologous chromosomes in prophase

D. Crossing over between chromosomes in metaphase

13. What occurs during both mitosis and meiosis?

A. Chromatids are held together by microtubules.

B. Homologous chromosomes are separated.

C. Crossing over occurs.

D. Chromatids are separated.

12. Daughter cells usually receive equal amounts of cytoplasm as parent cells undergo cytokinesis. Which of the following is an exception?

A. Asexual reproduction by budding in yeast

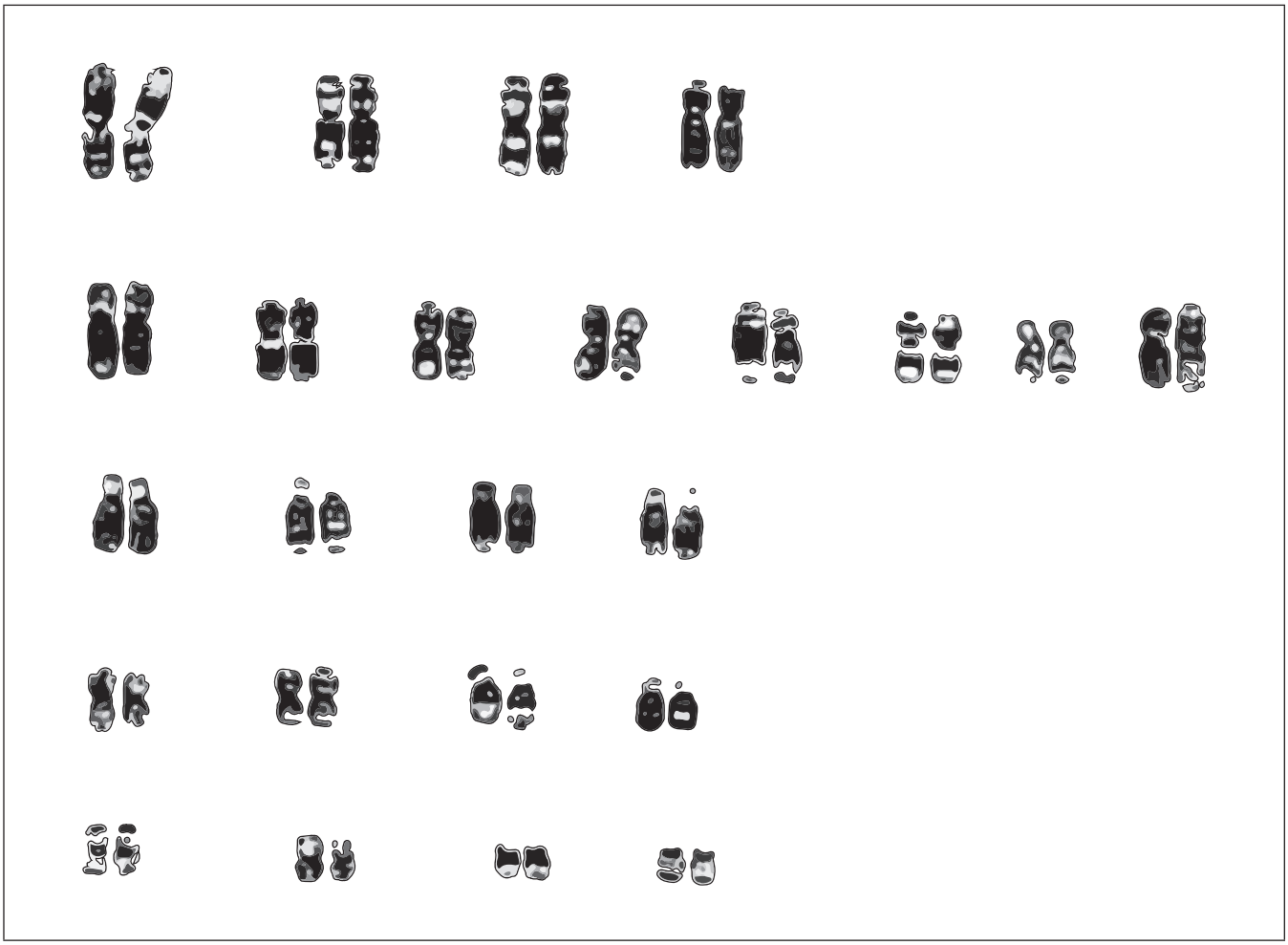
B. Bacterial cell division

C. Cloning of lymphocytes during an immune response

D. Formation of a zygote during fertilization

Turn over

1. The western gorilla (*Gorilla gorilla*) is the largest primate. Sex determination in gorillas is the same as in humans. The image shows a karyogram of a gorilla.



(a) (i) Acrocentric chromosomes have a centromere near one end of the chromosome. Draw a circle around the row on the karyogram that contains all acrocentric chromosomes. [1]

(ii) State the chromosome number in this gorilla. [1]

. . . . . .

(b) Deduce with a reason the sex of this gorilla. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(c) Describe how a karyogram is constructed. [2]

. . . . . .

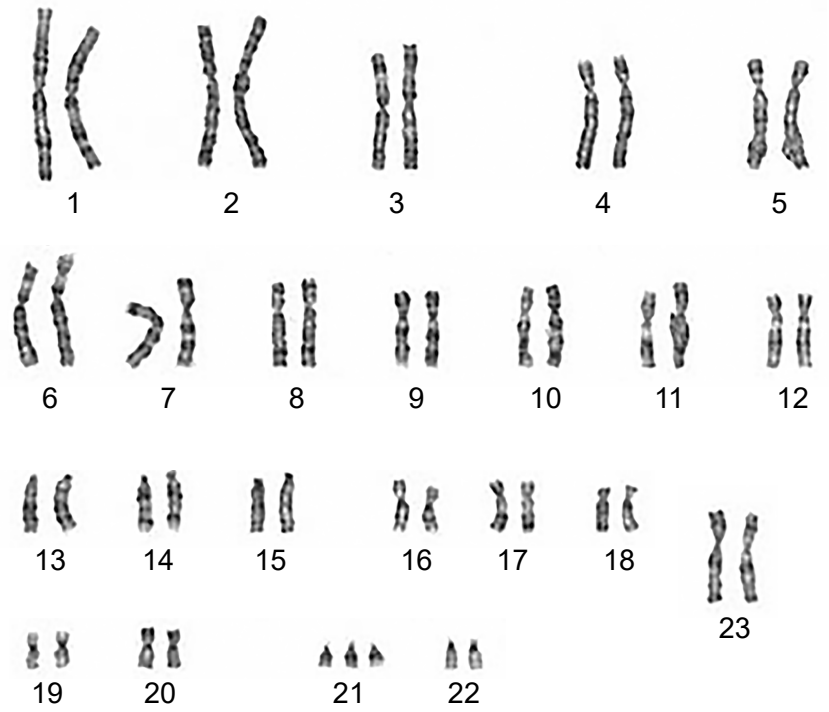
. . . . . .

. . . . . .

. . . . . .

Question 1 - working space

15. The karyogram shows a chromosome abnormality in a human female.



What could cause the abnormality to arise?

A. Failure of homologous chromosomes to separate during gamete formation

B. Chromosome 21 replicating after fertilization

C. A gene mutation of the mother's chromosomes during cell division

D. Polyploidy occurring during anaphase I of meiosis in both parents

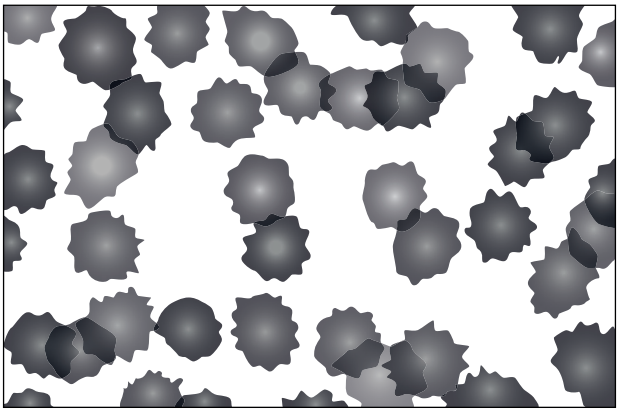
Turn over

APOLLO

Water potential

3 questions

12. The image shows human blood cells immersed in a solution.



What can be deduced from the image?

A. The solution is hypotonic as the cells are crenated.

B. The solution is hypotonic as the cells are turgid.

C. The solution is hypertonic as the cells are crenated.

D. The solution is hypertonic as the cells are turgid.

Section B

Answer **one** question. One additional mark is available for the construction of your answer.
Answers must be written within the answer boxes provided.

6. Water is one of the most abundant molecules on Earth. Living organisms must maintain homeostatic levels of water to survive.

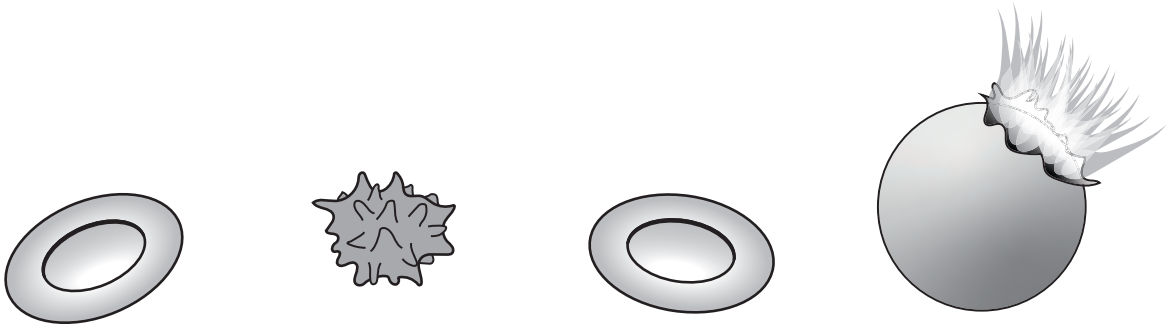
(a) Outline how the cohesive properties of water benefit living organisms. [4]

(b) Outline how environmental factors affect the rate of transpiration in plants. [4]

(c) Explain the process of osmosis with reference to its effects on plant cells. [7]

Question 6 - working space

12. Red blood cells were transferred from solution 1 to solution 2, 3 or 4. The images show the effects on these cells.



Solution 1 Solution 2 Solution 3 Solution 4

What can be concluded about the concentrations of the solutions?

A. Solution 1 is hypotonic to solution 4.

B. Solution 2 is hypotonic to solution 1.

C. Solution 3 is hypertonic to solution 4.

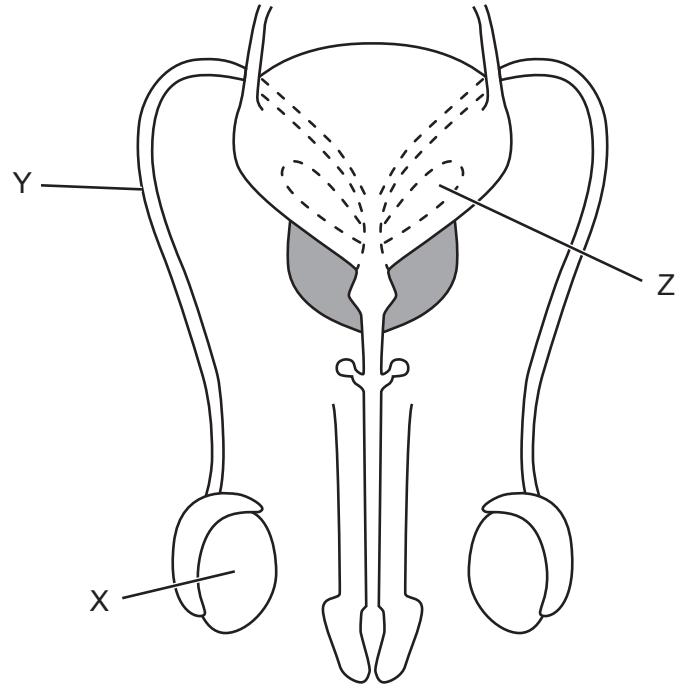
D. Solution 4 is hypertonic to solution 2.

APOLLO

Reproduction

7 questions

19. The diagram shows the male reproductive system in front view.



Which structures are indicated by the letters X, Y and Z?

	X	**Y**	**Z**
A.	testis	sperm duct	seminal vesicle
B.	epididymis	sperm duct	prostate gland
C.	testis	urethra	prostate gland
D.	epididymis	urethra	seminal vesicle

19. Cherry trees (*Prunus avium*) have two self-incompatibility alleles. What benefit do self-incompatibility alleles have?

A. They decrease genetic variation.

B. They prevent inbreeding.

C. They decrease the chances of mutations taking place within the gametes.

D. They prevent the plant from releasing pollen at certain times of the year.

Turn over

20. What happens during fertilization in humans?

A. The nuclear membranes of sperm and egg break down.

B. The sperm enters the egg.

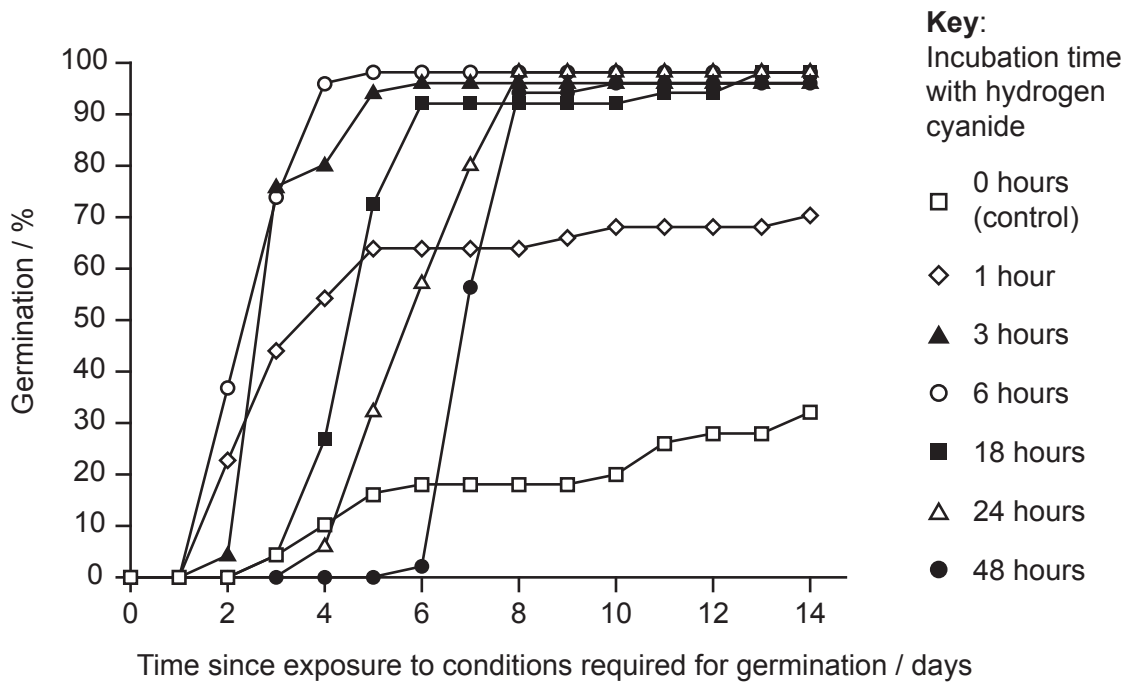
C. The chromosomes undergo joint meiosis.

D. Mitochondria in the zygote come from sperm and egg.

Section A

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

1. Cyanide, a chemical found in all living organisms, is known to stimulate seed germination in many plant species. Cyanide is also known to be an inhibitor of cellular respiration. Freshly harvested sunflower (*Helianthus annuus*) seeds were incubated with hydrogen cyanide for different periods of time and then exposed to the conditions required for germination. The graph shows the percentage of seeds that had germinated over fourteen days.



(a) State the percentage of seeds that had germinated after 10 days with no hydrogen cyanide incubation time. [1]

. . . . . .

. . . . . .

(b) Sketch a line on the graph to show what the results for seeds incubated for 60 hours in hydrogen cyanide might look like. [2]

(This question continues on the following page)

(Question 1 continued)

(c) Compare and contrast the results for seeds incubated for 18 hours with those for the control seeds over the period of the experiment. [2]

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

(d) Cyanide is also known to inhibit respiration. Suggest how this is shown in the graph. [1]

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

(e) Evaluate the hypothesis that 6 hours incubation with hydrogen cyanide is the optimum time for seed germination. [2]

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

(This question continues on the following page)

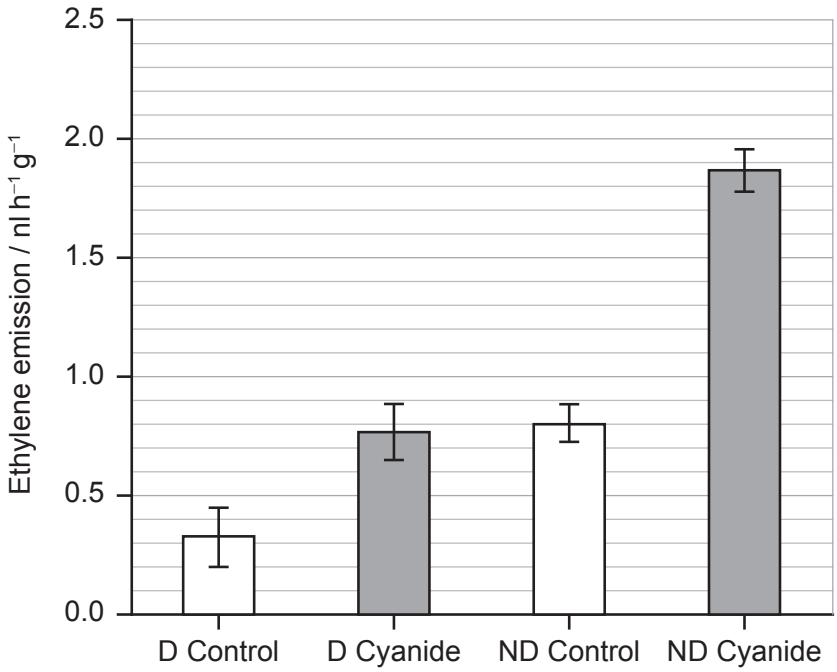
(Question 1 continued)

Ethylene is a chemical that promotes germination in sunflower seeds. Cyanide is known to activate ethylene production.

Four groups of sunflower seed embryos were treated as follows:

- D Control: dormant (not yet able to germinate) seed embryos not incubated with cyanide
- D Cyanide: dormant (not yet able to germinate) seed embryos incubated with cyanide for 3 hours
- ND Control: non-dormant (able to germinate) seed embryos not incubated with cyanide
- ND Cyanide: non-dormant (able to germinate) seed embryos incubated with cyanide for 3 hours

The graph shows the mean volume of ethylene emission by the four groups of seed embryos measured over a period of 5 hours at 20 °C.



(f) State the mean increase in ethylene emission in the dormant sunflower seed embryos due to the presence of cyanide. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(g) Calculate the percentage change in the ethylene emission in the non-dormant sunflower seed embryos due to the presence of cyanide. [1]

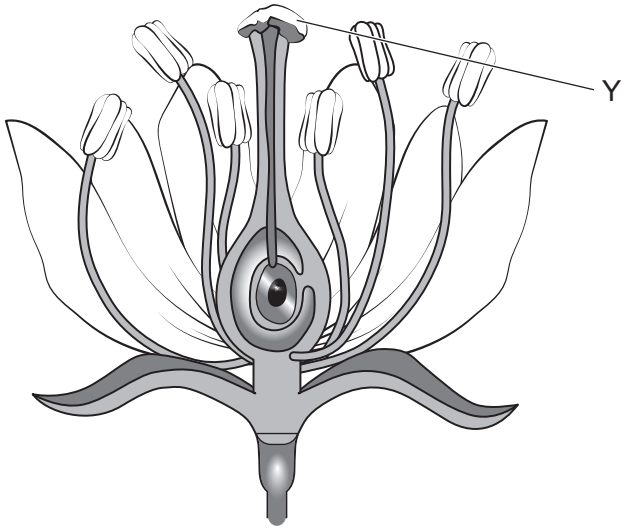
. . . . . %

(h) Compare and contrast the effects of cyanide incubation on mean ethylene production for dormant (D) and non-dormant (ND) seed embryos. [2]

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

Question 1 - working space

19. A cross-section of a flower is shown.



What is structure Y?

A. Anther

B. Nectary

C. Style

D. Stigma

19. Flowering plants can use either self-pollination or cross-pollination when they carry out sexual reproduction. Which plants are most likely to cross-pollinate?

A. Plants that are hermaphrodites

B. Plants whose anthers and stigmas mature at the same time

C. Plants with flowers that have much longer stamens than stigmas

D. Plants that are either male or female

22. The first day of the menstrual cycle is when menstruation begins. What occurs around day 15 of the cycle?

A. Formation of a corpus luteum

B. The placenta starts to secrete progesterone

C. The end of menstruation

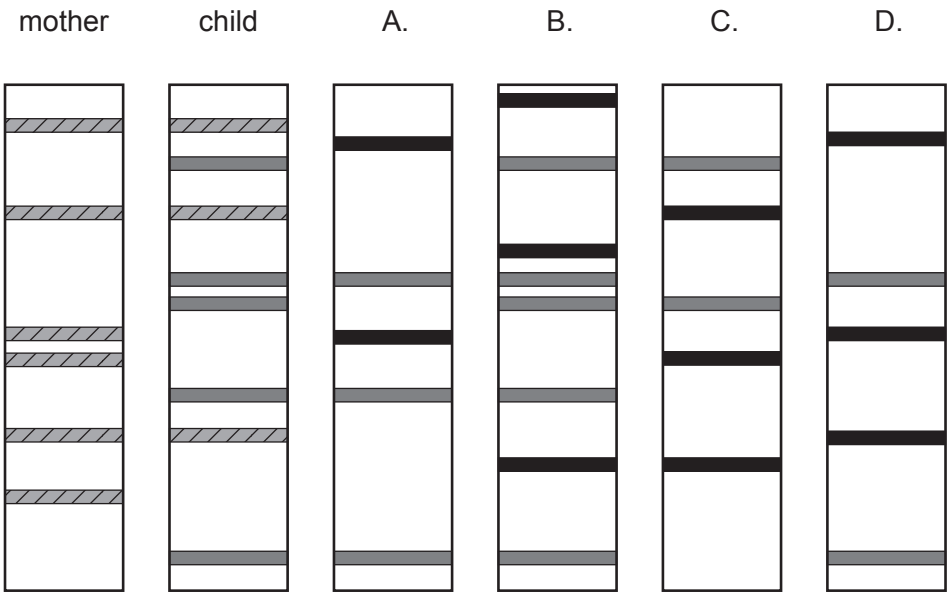
D. Blood progesterone concentration reaches its maximum

APOLLO

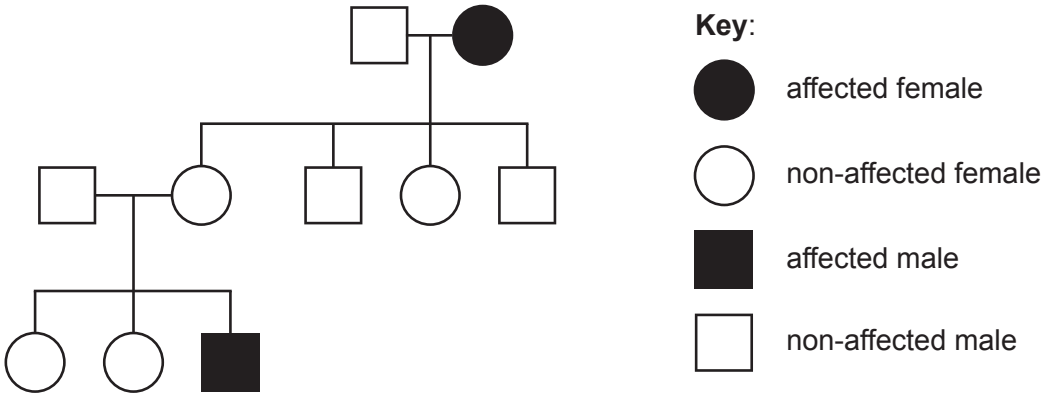
Inheritance

10 questions

7. The DNA profile from a paternity test shows six profiles. Who is the child's father?



13. A pedigree chart is shown.



What is the most likely pattern of inheritance?

A. Sex-linked recessive

B. Sex-linked dominant

C. Autosomal recessive

D. Autosomal dominant

Turn over

20. A *Mirabilis jalapa* plant with red flowers was crossed with one with white flowers. All plants in the F1 generation had pink flowers. What phenotype ratio would be expected in the F2 generation?

A. 100 % pink

B. 50 % red and 50 % white

C. 25 % white, 50 % pink and 25 % red

D. 75 % red and 25 % white

20. Pink flowers arise from the incomplete dominance between red and white flowers in the four o'clock flower (*Mirabilis jalapa*). A pink-flowering variety is crossed with a white-flowering variety.



What could be the possible phenotypes of the offspring?

A. White flowers only

B. Pink and white flowers

C. Red and white flowers

D. Pink flowers only

21. When white flowers of the species *Mirabilis jalapa* are fertilized by pollen from red flowers, the resulting plants produce pink flowers. What is the pattern of inheritance and the reason for this?

	Inheritance	Reason
A.	incomplete dominance	offspring show both parental phenotypes
B.	codominance	offspring show both parental phenotypes
C.	incomplete dominance	offspring show a blended phenotype of the parents'
D.	codominance	offspring show a blended phenotype of the parents'

Section B

Answer **one** question. One additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

8. Hereditary information is stored in nucleic acids and passed on to offspring.

(a) Outline how mitosis allows for the same hereditary information to be passed on to new cells. [3]

(b) Describe the importance of DNA in speciation. [4]

(c) Explain the genetic basis of inheritance patterns in organisms that reproduce sexually. [8]

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:

1. Image Asian shore crab: Silver, C., 2019. *Creature Feature – Asian Shore Crab*. [online] Available at: https://www.blueoceansociety.org/blog/creature-feature-asian-shore-crab/ [Accessed 13 March 2024]. Source adapted.

Image amphipod: Brutto SL, Iaciofano D. A taxonomic revision helps to clarify differences between the Atlantic invasive *Ptilohyale littoralis* and the Mediterranean endemic *Parhyale plumicornis* (*Crustacea*, *Amphipoda*). *Zookeys*. 2018 Apr 30; (754): 47–62. doi: 10.3897/zookeys.754.22884. PMID: 29740225; PMCID: PMC5938321.

Image blue mussel: Emőke Dénes. https://commons.wikimedia.org/wiki/File:Broadstairs_-_Mytilus_edulis_2.jpg. CC BY-SA 4.0 https://creativecommons.org/licenses/by-sa/4.0.

Graphs: Spilmont, N. and Seuront, L., 2023. Aliens eating aliens: an introduced amphipod as a potential prey of an invasive rocky shore crab in laboratory experiments. *Aquatic Invasions* 18(2), pp. 163–177. https:// doi.org/10.3391/ai.2023.18.2.106252. Source adapted.

2. Image by macrovector on Freepik. https://www.freepik.com/free-vector/colored-purebred-dogs-icon-set_4329617.htm#fromView=search&page=1&position=2&uuid=afab0859-2246-4637-abc5-a733503d42d3&query=%40macrovector+dogs.

3. Adobe Stock / Andrea Danti.

4. Nils Tirén/reproduced by Ola Myrin/Malmö museum.

5. Image by brgfx on Freepik. https://www.freepik.com/free-vector/diagram-showing-stem-root-cell_18973458.htm#fromView=search&page=1&position=16&uuid=26e1a0ae-56b5-4aab-ae64-64cf6e2b7928&query=plant+vascular+xylem. Source adapted.

6. Holly Cheng. https://commons.wikimedia.org/wiki/File:Sylvilagus_audubonii_2.jpg. Licensed under CC BY-SA 3.0 https://creativecommons.org/licenses/by-sa/3.0. Source adapted.

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

Answers written on this page
will not be marked.

Question 8 - working space

Section A

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

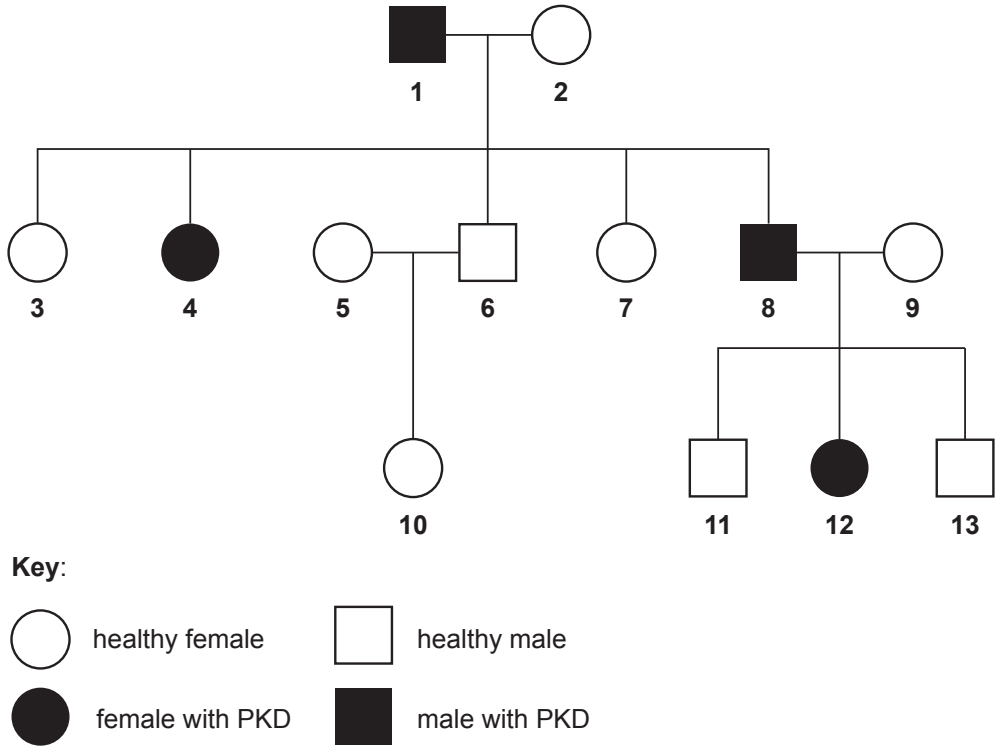
4. (a) Define the term genotype. [1]

. . . . . .

. . . . . .

PKD (polycystic kidney disease) is an inherited disorder that causes the kidneys to become enlarged and lose function over time. PKD is caused by a dominant allele, **D**, which is **not** sex-linked.

The pedigree chart shows the inheritance of PKD in a family.



(This question continues on the following page)

(Question 4 continued)

(b) (i) Calculate the probability of individuals **1** and **2** having a child with PKD. [1]

. . . . . .

(ii) Explain how the pedigree chart shows that the dominant allele causing PKD is **not** on the X chromosome. [2]

. . . . . .

. . . . . .

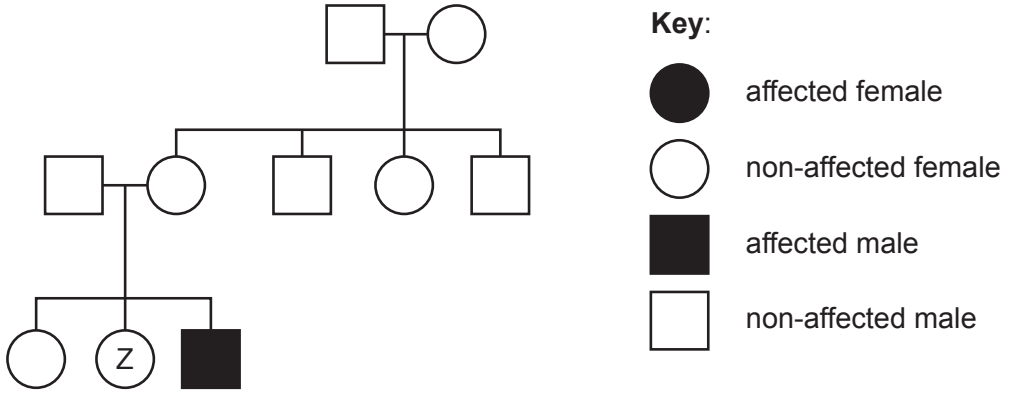
. . . . . .

. . . . . .

. . . . . .

Question 4 - working space

20. The pedigree chart shows the incidence of colour blindness in three generations of a family. Colour blindness is caused by a sex-linked recessive allele.



What could the genotype of individual Z be?

A. X^BX^B only

B. X^BX^b only

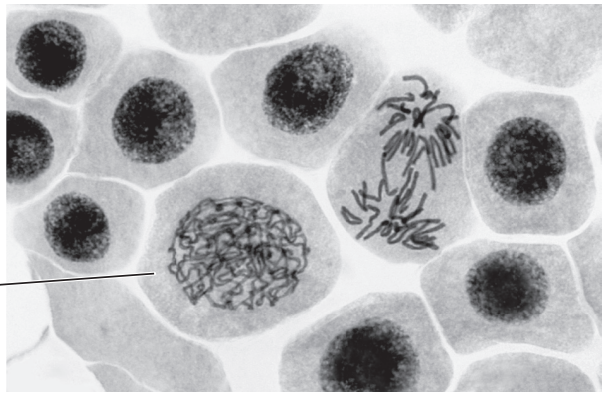
C. X^BX^B or X^BX^b

D. X^bX^b or X^BX^b

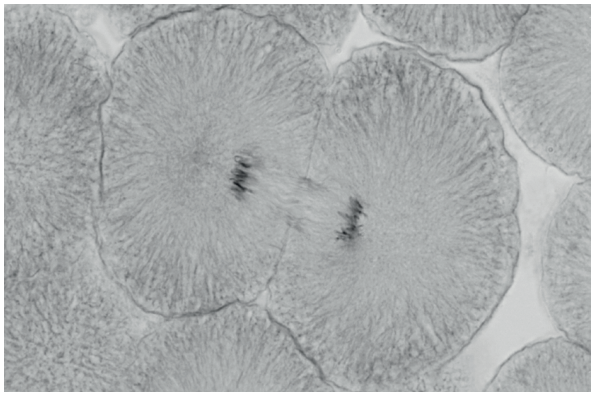
4. Both the genome and the environment of an organism affect its growth and development. Variation between individuals of a species can be continuous or discrete (discontinuous). Mitosis produces identical cells for growth and meiosis allows for variation.

The micrographs show onion and whitefish cells in mitosis.

Onion (*Allium cepa*)



Whitefish (*Coregonus lavaretus*)



(a) Identify the phase of mitosis labelled X. [1]

. . . . . .

. . . . . .

(b) The process of cytokinesis is occurring in the whitefish embryo cells. Explain how cytokinesis occurs in this animal cell. [2]

. . . . . .

. . . . . .

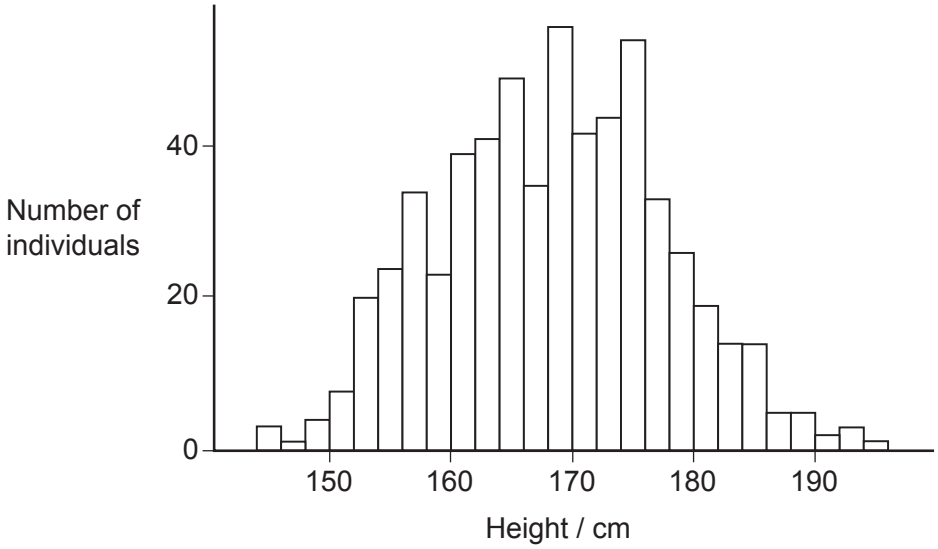
. . . . . .

. . . . . .

(This question continues on the following page)

(Question 4 continued)

The National Health and Nutrition Examination Survey in the USA measured heights of individuals aged 21–79. Height is an example of continuous variation.



(c) State the range of heights that is the mode. [1]

. . . . . .

. . . . . .

(d) Blood group in humans is an example of discrete (discontinuous) variation. Explain the inheritance of ABO blood groups in humans. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

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. Any trademarks™ or registered® trademarks included are used for illustrative purposes only, and use does not imply any affiliation with or endorsement by the International Baccalaureate.

References:

1.a Nikon's MicroscopyU, n.d. *Buccal epithelial cells*. [image online] Available at: https://www.microscopyu.com/gallery-images/buccal-epithelial-cells [Accessed 23 October 2024]. Source adapted.

2.a Du, B., Liu, C., Kang, H., Zhu, P., Yin, S., Shen, G., Hou, J. and Ilvesniemi, H., 2014. *Figure 2.* [image online] Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0086440 [Accessed 23 October 2024]. Reference redacted. Source adapted.

3. Antoniou, E., 2010. *Illustration of life cycle of jellyfish*. [image online] Available at: https://www.gettyimages.co.uk/detail/illustration/illustration-of-life-cycle-of-jellyfish-royalty-free-illustration/95644630?searchscope=image%2Cfilm&adppopup=true [Accessed 23 October 2024]. Source adapted.

W.carter, 2020. *Three moon jellyfishes captured by a lion's mane jellyfish 1*. [image online] Available at: https://en.wikipedia.org/wiki/File:Three_moon_jellyfishes_captured_by_a_lion%27s_mane_jellyfish_1.jpg Licensed under the Creative Commons CC BY-SA 4.0 license: https://creativecommons.org/licenses/by-sa/4.0/. [Accessed 6 November 2025]. Source adapted.

Reprinted from *Journal of Experimental Marine Biology and Ecology*, Volume 459, 2014, by Gambill, M. and Peck, M.A., Respiration rates of the polyps of four jellyfish species: Potential thermal triggers and limits, pages 17–22. Available at: https://www.sciencedirect.com/science/article/pii/S0022098114001245?ref=pdf_download&fr=RR-2&rr=8c9306260f77cdaf [Accessed 23 October 2024]. Source adapted.

4.a Reischig, J., 2014. *Mitosis (261 14)*. [image online] Available at: https://commons.wikimedia.org/wiki/File:Mitosis_(261_14)_Pressed;_root_meristem_of_onion_(cells_in_prophase,_anaphase).jpg. Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license: https://creativecommons.org/licenses/by-sa/3.0/deed.en. [Accessed 23 October 2024]. Source adapted.

Reschke, E., 2012. *Whitefish mitosis*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/whitefish-mitosis-whitefish-embryo-royalty-free-image/139814315?adppopup=true [Accessed 23 October 2024]. Reference redacted. Source adapted.

4.c National Health and Nutrition Examination Survey, 2017. *Height of NHANES subjects ages 2179*. [image online] Available at: https://thomaselove.github.io/431notes-2017/dataviz.html [Accessed 23 October 2024]. Source adapted.

Question 4 - working space

Section A

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

6. In humans, sex is determined genetically and human populations have approximately equal numbers of males and females in each generation.

(a) Outline how sex is determined in humans. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Explain how sexual reproduction gives rise to genetic variation. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 6 - working space

APOLLO

Homeostasis

8 questions

21. What is the body's response to an increase in environmental temperature?

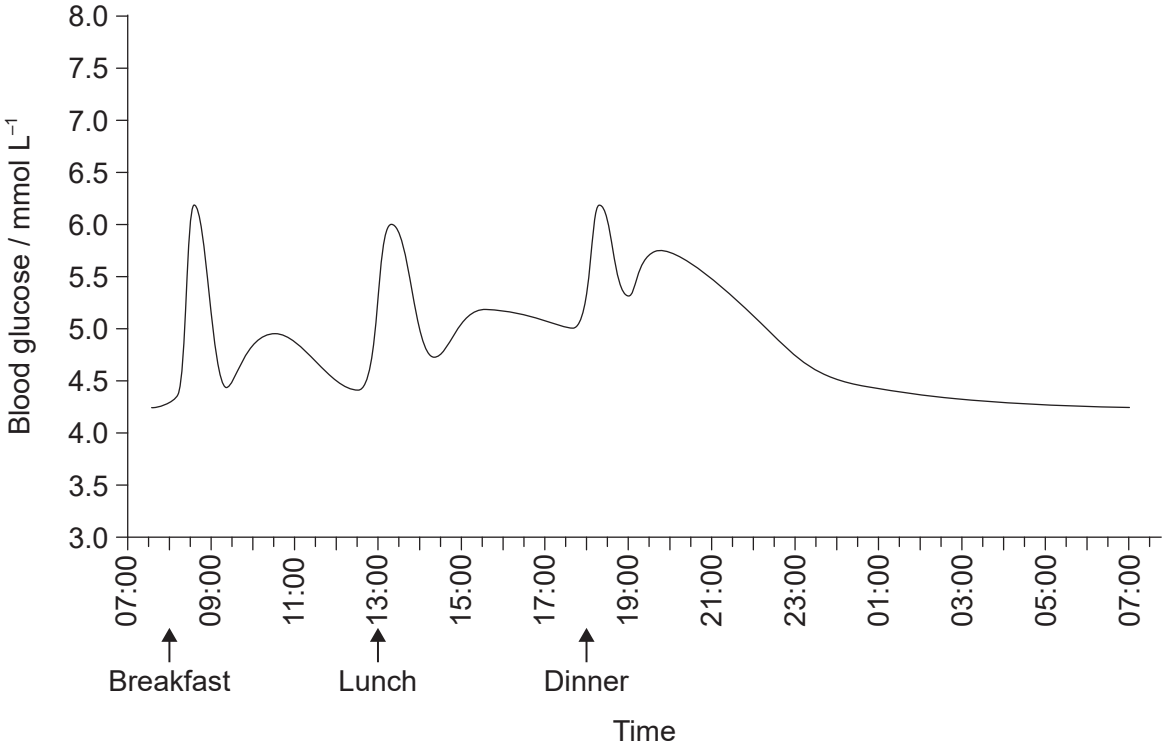
A. Uncoupled respiration in brown adipose tissue

B. Vasodilation

C. Vasoconstriction

D. Shivering

21. The graph shows blood glucose levels over the course of a day.



What could explain the trend in glucose levels between 20:00 and 23:00?

A. Increasing insulin concentration forming glycogen from glucose

B. Decreasing insulin concentration forming glucose from glycogen

C. Increasing glucagon concentration forming glycogen from glucose

D. Decreasing glucagon concentration forming glucose from glycogen

22. What occurs if human body temperature decreases?

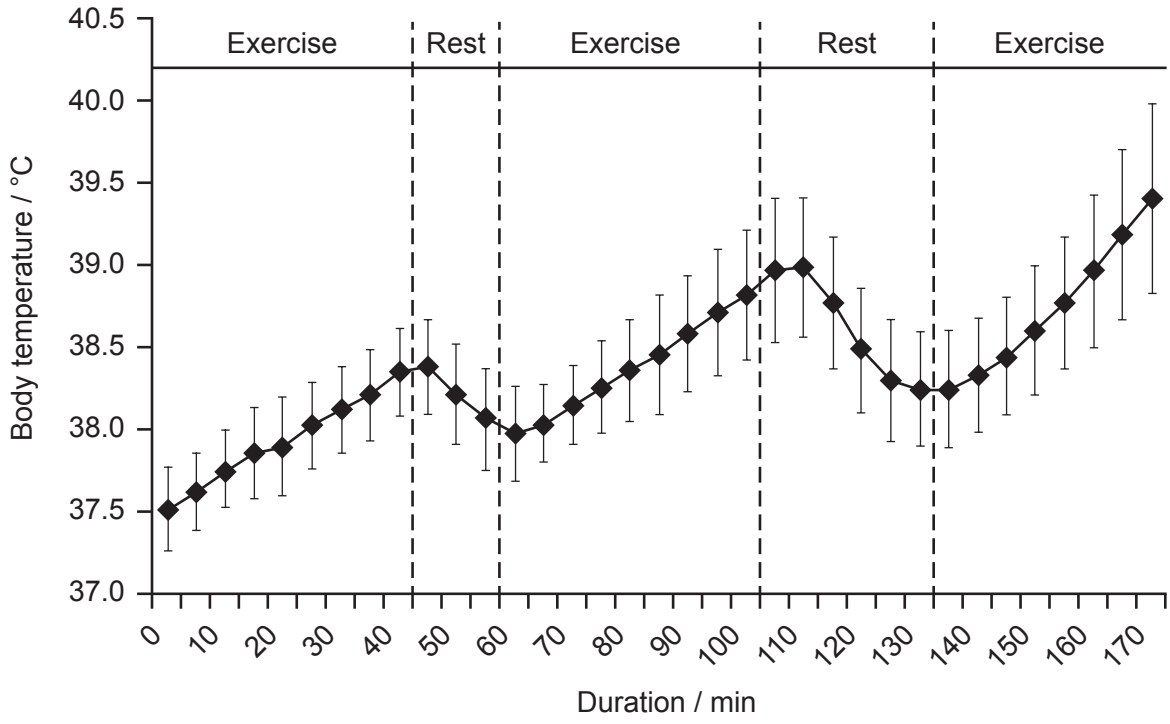
A. Thyroxin secretion decreases

B. Vasodilation of skin arterioles

C. Sweating increases

D. Shivering increases

21. These results were obtained by measuring the body temperature of people exercising on a hot and humid day.



What mechanism could result in the changes seen during rest periods?

A. Shivering

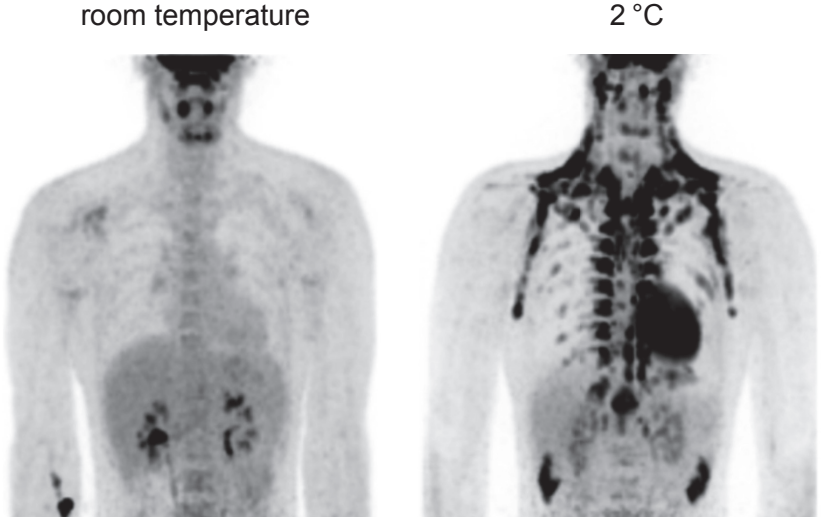
B. Uncoupled respiration in brown adipose tissue

C. Vasodilation in the skin

D. Hair erection

Turn over

20. The dark areas in the PET/CT scanning images show the activity of brown adipose tissue in an adult human at room temperature (20 °C) and 2 °C.



How does brown adipose tissue contribute to regulating body temperature at 2 °C?

A. It provides adenosine triphosphate (ATP) for muscle contraction when shivering.

B. It further insulates the body so that internal heat is not lost.

C. It turns into thick layers of white adipose tissue to prevent hypothermia.

D. It breaks down fat to generate heat but not ATP.

Turn over

Section B

Answer **one** question. One additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

6. Feedback control is used to regulate the levels of variables in the blood system.

(a) Discuss the use of positive and negative feedback to control levels of variables. [4]

(b) Describe the mechanisms used to keep blood glucose levels within narrow limits in humans. [7]

(c) Explain the changes that would occur in the body if blood pH decreased below the optimum level. [4]

Question 6 - working space

21. How would the body respond to a rise above normal body temperature?

	Type of feedback	Response
A.	positive	increased secretion from sweat glands
B.	positive	spread limbs to increase surface area
C.	negative	vasodilation of skin blood vessels
D.	negative	shivering

Section B

Answer **one** question. One additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

8. Biological systems are sensitive to temperature changes, so they have mechanisms to resist temperature changes.

(a) Explain the mechanisms involved in thermoregulation in humans. [7]

(b) Explain the relationship between temperature and the activity of enzymes. [4]

(c) Distinguish between the thermal properties of air and water as they relate to the habitat of animals. [4]

References:

2. *Electron micrograph of cells from the leaf of a corn plant*, n.d. [image online] Available at: <http://innolearn.weebly.com/bio-cell.html> [Accessed 9 December 2020].

3c. Left image:
Polder, L., 1992. [*Prokaryote DNA*]. [image online] Available at: <http://www.siumed.edu/~bbartholomew/images/chapter29/F29-17.jpg> [Accessed 9 December 2020].

Right image:
[*Eukaryote DNA*], n.d. [image online] Available at: <http://www.mun.ca/biology/desmid/brian/BIOL2060/BIOL2060-18/18_22.jpg> [Accessed 9 December 2020].

5. UC Davis School of Veterinary Medicine, n.d. [*Hummingbird*]. [image online] Available at: <https://hummingbirds.vetmed.ucdavis.edu/help-us-protect-hummingbirds> [Accessed 30 July 2020].

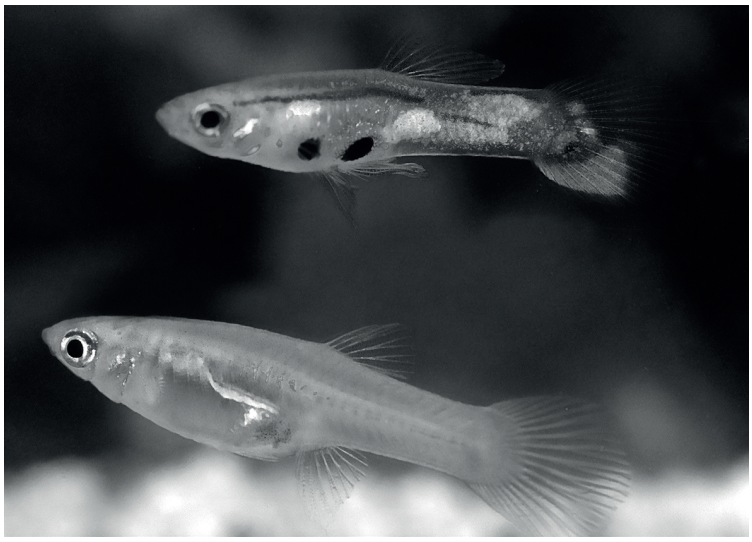
Question 8 - working space

APOLLO

Natural selection

5 questions

29. John Endler's experiments modelled sexual and natural selection in Trinidadian guppies (*Poecilia reticulata*) by controlling selection pressures.



What did the experiments of John Endler demonstrate?

A. Guppies have no predators in their natural habitat.

B. Male guppies prefer dull-coloured females for mating.

C. Predation influences the colour of guppies in different environments.

D. Guppies are not affected by the presence of other fish species.

Turn over

Section A

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

2. Populations evolve by natural selection due to interactions with the environment and other species within the ecosystem.

(a) Identify **one** source of genetic variation in a population. [1]

. . . . . .

. . . . . .

(b) Explain how natural selection is influenced by changes in the environment. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Explain how the loss of a keystone species affects an ecosystem. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 2 - working space

29. A bird of paradise (*Ptiloris victoriae*) has very showy plumage and demonstrates a unique dance.



What type of selection pressure could have caused this plumage to evolve?

A. Interspecific competition

B. Abiotic factors

C. Paradigm shift

D. Sexual selection

Section B

Answer **one** question. One additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

6. Insect pollinators are vital to maintaining the biodiversity of ecosystems, but they are threatened by some human actions. Some pollinators, such as honey bees (*Apis mellifera*), produce honey, which is rich in glucose.

(a) Outline how the properties of glucose are linked to their uses in organisms. [5]

(b) List human actions that could threaten populations of insect pollinators such as bees. [3]

(c) Explain how a plant species may evolve by natural selection over a long period to produce insect-pollinated flowers. [7]

Question 6 - working space

30. What is an outcome of natural selection?

A. Evolution

B. Mutations

C. Reproductive isolation

D. Variation

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:

9. LeavingBio, n.d. [*Unicellular organisms*]. [image online] Available at: <http://leavingbio.net/amoeba/> [Accessed 28 July 2020].

11. Miami University, n.d. [*Electron micrograph*]. [image online] Available at: <http://www.cas.miamioh.edu/~meicenrd/ANATOMY/Ch2_Ultrastructure/Tempcell.htm> [Accessed 28 July 2020].

12. University of Delaware, n.d. [*Model 2*]. [image online] Available at: <http://www1.udel.edu/chem/white/C527/TransmembraneProteins.pdf> [Accessed 28 July 2020].

15. Hill, M.A., 2020. *Embryology Trisomy 21*. [image online] Available at: <https://embryology.med.unsw.edu.au/embryology/index.php/Trisomy_21> [Accessed 28 July 2020].

24. McGuire, J.A., Witt, C.C., Remsen Jr., J.V., Corl, A., Rabosky, D.L., Altshuler, D.L. and Dudley, R., 2014. Molecular Phylogenetics and the Diversification of Hummingbirds. *Current Biology*, 24(8), pp.910–916.

25. Mepps.com Staff, n.d. *Favored temperature range*. [image online] Available at: <https://www.mepps.com/mepps-tactics/article/how-water-temperature-and-oxygen-affect-fishing/418> [Accessed 8 December 2020].

27. *Food chain*, 2019. [image online] Available at: <https://www.tuttee.co/blog/biol-food-chain-and-food-web> [Accessed 8 December 2020].

APOLLO

Stability and change

1 questions

30. Increased leaching of nitrogen fertilizers disrupts the stability of aquatic ecosystems such as lakes. What change is expected if nitrogen leaches into a lake over time?

A. Wilting of surface plants

B. Increased biochemical oxygen demand (BOD)

C. Weakened mollusc shells

D. Bioaccumulation of pollutants at higher trophic levels

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. Any trademarks™ or registered® trademarks included are used for illustrative purposes only, and use does not imply any affiliation with or endorsement by the International Baccalaureate.

References:

14. Calvo, J.L., 2018. *Muscular artery, vein and nerve bundles surrounded by adipose tissue, near a lymph node*. Available at: https://www.shutterstock.com/image-photo/muscular-artery-vein-nerve-bundles-surrounded-785176687?dd_referrer=. Source adapted.

15. olikim, 2006. *Microscopic image of a buttercup plant*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/microscopic-image-of-a-buttercup-plant-royalty-free-image/184098803 [Accessed 4 December 2024]. Source adapted.

18. Reproduced with permission of the © ERS 2025. Dempsey JA, Smith CA. Pathophysiology of human ventilatory control. *Eur Respir J* 2014; 44: 495–512 DOI:10.1183/09031936.00048514. [Accessed 17 October 2024]. Source adapted.

20. From *The New England Journal of Medicine* [online], Lichtenbelt, W.D. van M., Vanhommerig, J.W., Smulders, N.M., Drossaerts, J., Kemerink, G.J., Bouvy, N.D., Schrauwen, P. and Teule, G.J.J., Cold-Activated Brown Adipose Tissue in Healthy Men, Vol. 360., No. 15, Figure 1, © 2009 Massachusetts Medical Society. Reprinted with permission from Massachusetts Medical Society. Available at: https://www.nejm.org/doi/full/10.1056/nejmoa0808718 [Accessed 22 October 2024]. Source adapted.

21. Sourakov, A., 2015. Temperature-dependent phenotypic plasticity in wing pattern of *Utetheisa ornatrix bella* (*Erebidae*, *Arctiinae*). *Tropical Lepidoptera Research*, June 2015, Vol. 25, No. 1. Available at: https://journals.flvc.org/troplep/article/view/89750 [Accessed 14 November 2025]. Source adapted.

22. Safi K, Armour-Marshall K, Baillie JEM, Isaac NJB (2013) Global Patterns of Evolutionary Distinct and Globally Endangered Amphibians and Mammals. *PLoS ONE* 8(5): e63582. https://doi.org/10.1371/journal.pone.0063582.

23. Gaveau, D.L.A., Sloan, S., Molidena, E., Yaen, H., Sheil, D., Abram, N.K., Ancrenaz, M., Nasi, R., Quinones, M., Wielaard, N. and Meijaard, E., 2014. *Figure 3*. [image online] Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0101654#pone-0101654-g003 [Accessed 6 December 2024]. Reference redacted. Source adapted.

24. Tan W-K, Lim T-K, Loh C-S, Kumar P, Lin Q (2015) Proteomic Characterisation of the Salt Gland-Enriched Tissues of the Mangrove Tree Species *Avicennia officinalis*. *PLoS ONE* 10(7): e0133386. https://doi.org/10.1371/journal.pone.0133386. Licensed under the Creative Commons Attribution 4.0 International license: https://creativecommons.org/licenses/by/4.0/ [Accessed 17 October 2024]. Source adapted.

27. Tomasz Klejdysz, 2024. *Rhizobium root nodules on the roots of a soybeans for nitrogen fixation*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/rhizobium-root-nodules-on-the-roots-of-a-soybeans-royalty-free-image/2184787169?phrase=soybean%20root&searchscope=image%2Cfilm&adppopup=true. [Accessed 6 November 2024]. Source adapted.

All other texts, graphics and illustrations © International Baccalaureate Organization 2025

APOLLO

Climate change

4 questions

30. What results from global warming?

A. An increase in absorption of solar radiation decreases poleward shift of temperate species.

B. Release of carbon dioxide from the deep ocean causes decreased rates of decomposition.

C. Release of methane from melting permafrost causes a decrease in absorption of solar radiation.

D. Loss of snow and ice causes an increase in absorption of solar radiation.

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:

13. Department of Pathology, Calicut Medical College, 2015. *Emphysema Lung*. [image online] Available at: https://commons.wikimedia.org/wiki/File:Emphysema_Lung_10x.jpg [Accessed 18 March 2024]. Source adapted. Licensed under CC Attribution-Share Alike 4.0 International: https://creativecommons.org/licenses/by-sa/4.0/deed.en.

15. Nascari, D. and Sved, A., 2019. *Impact of arterial blood gases on alveolar ventilation*. [graph online] Available at: https://commons.wikimedia.org/wiki/File:Impact_of_arterial_blood_gases_on_alveolar_ventilation.png [Accessed 18 March 2024]. Source adapted. Licensed under Creative Commons Attribution-Share Alike 4.0: https://creativecommons.org/licenses/by-sa/4.0/deed.en.

20. Buhl, V., 2009. *Wunderblume, Four oclock flower, Mirabilis jalapa*. [image online] Available at: https://commons.wikimedia.org/wiki/File:2009-09-26_(2)_Wunderblume,_Four_oclock_flower,_Mirabilis_jalapa.JPG. [Accessed 18 March 2024]. Source adapted. Licensed under CC Attribution-Share Alike 3.0 Unported license: https://creativecommons.org/licenses/by-sa/3.0/deed.en.

21. Suckale, J. and Solimena, M., 2011. *Glucose-day-english*. [graph online] Available at: https://commons.wikimedia.org/wiki/File:Glucose-day-english.svg [Accessed 18 March 2024]. Source adapted. Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license: https://creativecommons.org/licenses/by-sa/3.0/deed.en.

24. Sachverständigenbüro für Zimmerei und Holzbau Lutz Weidner, 2005. *Serpula lacrimans* [sic]. [image online] Available at: https://commons.wikimedia.org/wiki/File:Serpula_lacrimans.jpg [Accessed 18 March 2024]. Source adapted. Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license: https://creativecommons.org/licenses/by-sa/3.0/deed.en.

25. Torres, P., Baldinotti, H., Costa, D., Miranda, C. and Cardoso, A., 2022. Influence of pH, light, food concentration and temperature in *Aedes aegypti* Linnaeus (Diptera: Culicidae) larval development. *EntomoBrasilis* 15, e999. https://doi.org/10.12741/ebrasilis.v15.e999. Source adapted.

27. CNX OpenStax, 2016. [Both species grown together.] [graph online] Available at: https://commons.m.wikimedia.org/wiki/File:Graph_of_competitive_exclusion_principle.jpg [Accessed 18 March 2024]. Licensed under CC Attribution 4.0 International. https://creativecommons.org/licenses/by/4.0/deed.en, https://openstax.org/license.

28. Burger, B.J., 2020. *Carbon-dioxide-keeling-curve-2020*. [graph online] Available at: https://commons.wikimedia.org/wiki/File:Carbon-dioxide-keeling-curve-2020.gif [Accessed 18 March 2024]. Source adapted. Licensed under the Creative Commons Attribution-Share Alike 4.0 International license: https://creativecommons.org/licenses/by-sa/4.0/deed.en.

All other texts, graphics and illustrations © International Baccalaureate Organization 2025

Section B

Answer **one** question. One additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

7. Carbon is an essential element for life on Earth and must be distributed and recycled within ecosystems.

(a) Outline the chemical properties of carbon that allow it to form diverse compounds. [4]

(b) Describe the processes involved in the transfer of carbon in an ecosystem. [4]

(c) Explain the impact of anthropogenic activity on climate change. [7]

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:

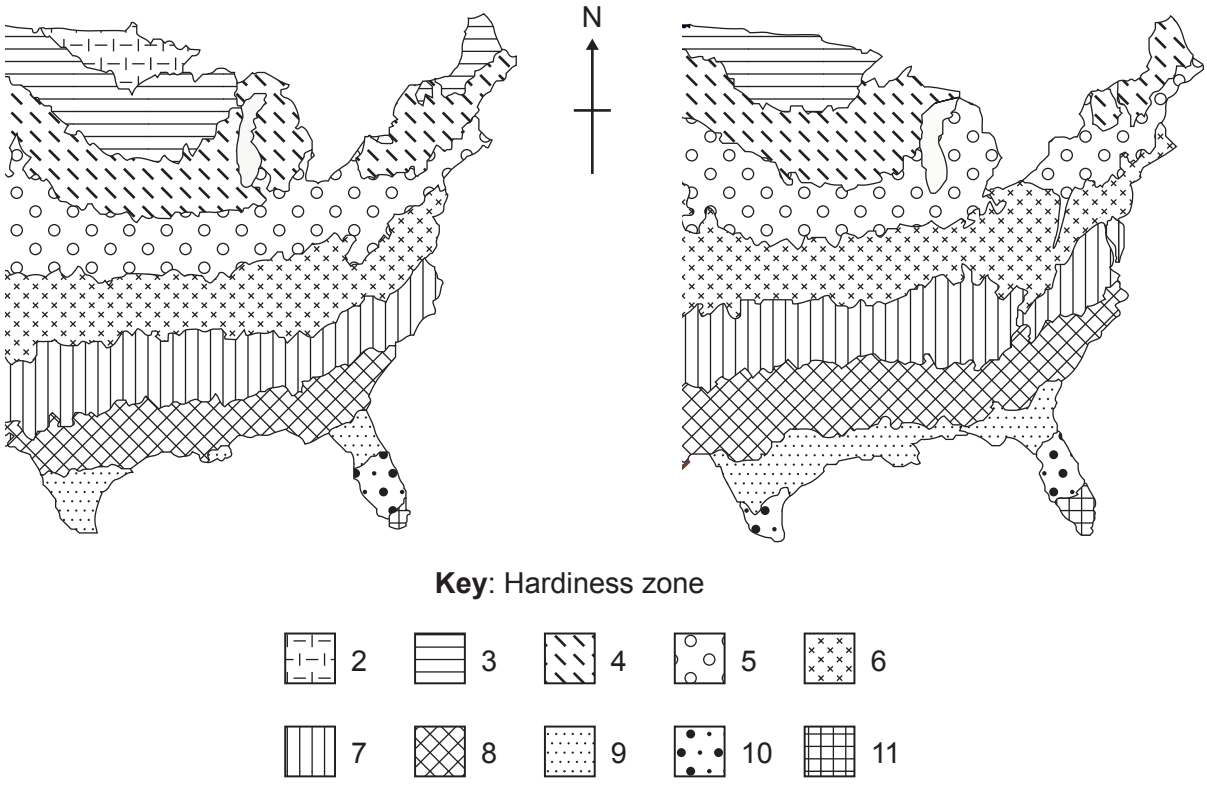
1. Used with permission of Oxford University Press - Journals, from *Journal of Experimental Botany*, Society for Experimental Biology (Great Britain), Federation of European Societies of Plant Physiology, Vol. 59, Issue 8, 2008. Permission conveyed through Copyright Clearance Center, Inc.

3. Sunshineconnelly at English Wikibooks. https://commons.wikimedia.org/wiki/File:Anatomy_and_physiology_of_animals_motor_neuron.jpg. Licensed under CC BY 2.5 https://creativecommons.org/licenses/by/2.5.

Question 7 - working space

30. The data shows how the hardiness zones in part of North America are predicted to change over the next 25 years. A hardiness zone is an area that has a certain average annual minimum temperature, a factor relevant to the survival of many plants. The lower the number, the more cold-resistant the plants must be.

Hardiness zones 1960–1990 Hardiness zones 2050



What is a likely consequence of this change for tree species?

A. Tree species will spread northwards as climate changes.

B. Tree species that are not cold-resistant will decline.

C. There will be no change in the distribution of the tree species.

D. Tree species that currently live in the north will outcompete other tree species.

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. Any trademarks™ or registered® trademarks included are used for illustrative purposes only, and use does not imply any affiliation with or endorsement by the International Baccalaureate.

References:

8. Medcell/Yale University, n.d. [*Micrograph*]. [online] Available at: https://medcell.org/histology/cell_lab/smooth_endoplasmic_reticulum_em.php. [Accessed 24 September 2024].

14. tonaquatic, 2021. *Cross section leaf of plant under the light microscope view for botany education*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/cross-section-leaf-of-plant-under-the-light-royalty-free-image/1323832648?adppopup=true [Accessed 27 September 2024]. Source adapted.

18. Mamiossa, 2016. *Japanese encephalitis virus*. [image online] Available at: https://species.wikimedia.org/wiki/Japanese_encephalitis_virus#/media/File:Encefalitis_japonesa_01.jpg. Licensed under the Creative Commons Attribution BY-SA 4.0 International Deed license: https://creativecommons.org/licenses/by-sa/4.0/. [Accessed 3 December 2025]. Source adapted.

19. srle7777, 2014. *Cross-section of Flower*. [image online] Available at: https://www.istockphoto.com/photo/cross-section-of-flower-gm480193817-36441870 [Accessed 27 September 2024]. Source adapted.

21. Lim, C.L., Byrne, C. and Lee, J.K., 2008. [*measurement of body temperature in exercise and clinical settings*]. [online] Available at: https://doi.org/10.47102/annals-acadmedsg.V37N4p347 [Accessed 25 September 2024]. Reference redacted. Source adapted.

22. Bonobo: van Dieren, M., 2017. *Bonobo plankendaal*. [image online] Available at: https://commons.wikimedia.org/wiki/File:Bonobo_plankendaal.jpg. Licensed under the Creative Commons CC0 1.0 Universal Public Domain Dedication license: https://creativecommons.org/publicdomain/zero/1.0/deed.en. [Accessed 27 September 2024]. Source adapted.

Chimpanzee: Hillewaert, H., 2011. *Pan troglodytes (male)*. [image online] Available at: https://commons.wikimedia.org/wiki/File:Pan_troglodytes_(male).jpg. Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license: https://creativecommons.org/licenses/by-sa/3.0/deed.en. [Accessed 27 September 2024]. Source adapted.

27. U.S. Geological Survey/illustration by Auer, T., 2017. Figure 14.1 from *Circular 1316*. [image online] Available at: https://www.usgs.gov/media/images/chesapeake-bay-waterbird-food-web-illustration-circular-1316 [Accessed 25 September 2024]. Source adapted.

29. DirkKotze1, 2021. *Victoria's Riflebird courtship display*. [image online] Available at: https://www.gettyimages.co.uk [Accessed 27 September 2024]. Reference redacted. Source adapted.

30. Bradley, B., 2011. [*Hardiness zones*]. [online] *Frontiers in Ecology and the Environment*, 10: 20–28. https://doi.org/10.1890/110145. Available at: https://esajournals.onlinelibrary.wiley.com/doi/10.1890/110145?utm_source=researchgate [Accessed 3 November 2025]. Source adapted.

All other texts, graphics and illustrations © International Baccalaureate Organization 2025

29. Which of the following may contribute to a positive feedback cycle in global warming?

A. The release of methane from thawing ice caps

B. The uptake of carbon dioxide by a reforested area

C. Higher temperatures increasing photosynthesis rates

D. The accumulation of peat in swamps