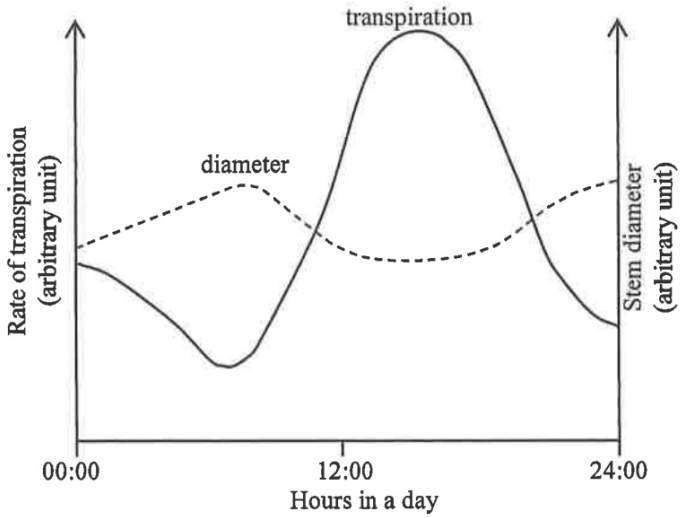
Examiner's comment (source page(s) 3)

Do not draw individual cells in a low-power plan. Pith is not cortex. The comparison of support must refer to the proportions of different tissues shown in the photograph, rather than merely recalling general facts about plant support.

Marking reference: HKDSE Biology 2014 Paper 1B Q4, official marking scheme, source page(s) 2, 3.

Example 3 [HKDSE Biology 2019 Paper 1B Q10]

The graph below shows the change in the rate of transpiration and the change in stem diameter of a plant over 24 hours:



(a) **Describe the relationship between the rate of transpiration and stem diameter.** (1 mark)

(b) **It is known that the change in stem diameter is related to the diameter of the xylem vessels. With reference to the way in which water is transported along the stem, explain the relationship between the rate of transpiration and stem diameter described in (a).** (2 marks)

(c) **Describe and explain *two* adaptive features of xylem vessels as a structure for water transport.** (4 marks)

Solution a; original allocation: 1 mark(s)

Stem diameter decreases as the transpiration rate rises, and increases again as transpiration slows.

First describe the opposing trends of the two curves. Transpiration is represented by the solid line and stem diameter by the dashed line. Each has its own vertical axis, so their heights cannot be compared as quantities with the same units.

Method: Identify tissue position, then trace transport or support.

b; original allocation: 2 mark(s)

Transpiration pulls the xylem water column upwards, increasing its tension or negative pressure. This inward pull slightly reduces the diameter of the vessels and the stem.

Water evaporates from the leaves, and the continuous water column transmits the pull down the stem. Greater transpiration produces greater tension and a stronger inward pull on vessel walls, reducing the overall stem diameter. Xylem does not contract actively like a muscle, nor do roots pump water upwards with each change.

c; original allocation: 4 mark(s)

Mature vessels are hollow and lack cell contents, offering little resistance to water flow. Their thickened, lignified walls withstand the negative pressure produced by transpiration and resist collapse.

Match each structure to a function. A hollow interior provides a continuous, unobstructed passage for the upward movement of large quantities of water. Thickening and lignification provide mechanical strength, keeping the passage open under tension. Describing both features only as allowing faster water transport is insufficient.

Examiner's comment (source page(s) 6, 7)

The decrease in stem diameter is not simply due to tissue losing water: increased transpiration pull lowers the pressure inside xylem vessels and pulls their walls inwards. Hollow vessels reduce resistance to water flow, while lignified walls resist collapse under negative internal pressure. Explain how each structure assists water transport.

Marking reference: HKDSE Biology 2019 Paper 1B Q10, official marking scheme, source page(s) 5.

Practice

1. [HKDSE Biology 2012 Paper 1A Q3]

Hint: Identify tissue position, then trace transport or support.

Which of the following is the major cause that accounts for the ascent of water in trees?

A. the loss of water from leaves
B. the absorption of water in roots
C. the thickness of tree trunks
D. the diameter of xylem vessels

2. [HKDSE Biology 2015 Paper 1A Q19]

Hint: Identify tissue position, then trace transport or support.

Which of the following can be the functions of roots in flowering plants?

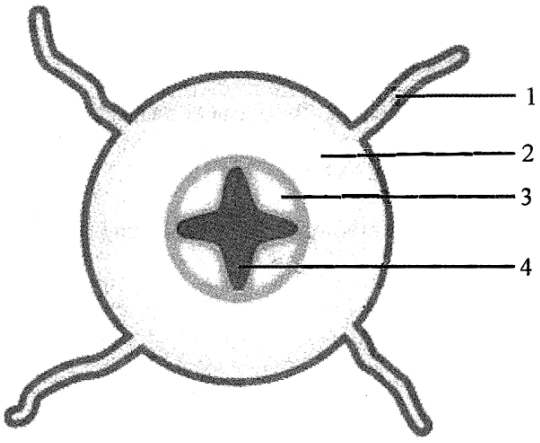
(1) anchorage
(2) absorption
(3) vegetative propagation

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

3. [HKDSE Biology 2016 Paper 1A Q21]

Hint: Identify tissue position, then trace transport or support.

Directions: Questions 21 to 23 refer to the diagram below, which shows the cross section of a young dicotyledonous root:

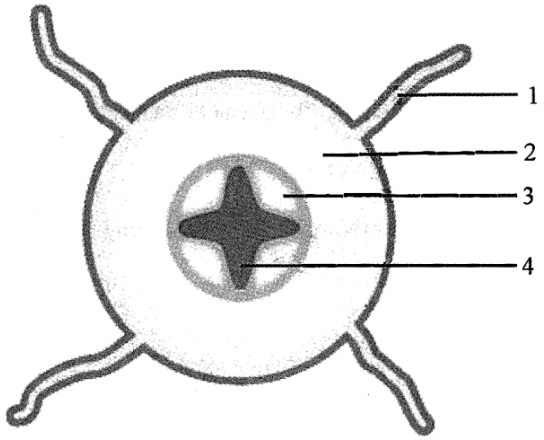


Which of the following parts provides rigidity to support the plant?

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

4. [HKDSE Biology 2016 Paper 1A Q22]
Hint: Identify tissue position, then trace transport or support.

Directions: Questions 21 to 23 refer to the diagram below, which shows the cross section of a young dicotyledonous root:



Which of the following parts is responsible for the transport of food?

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

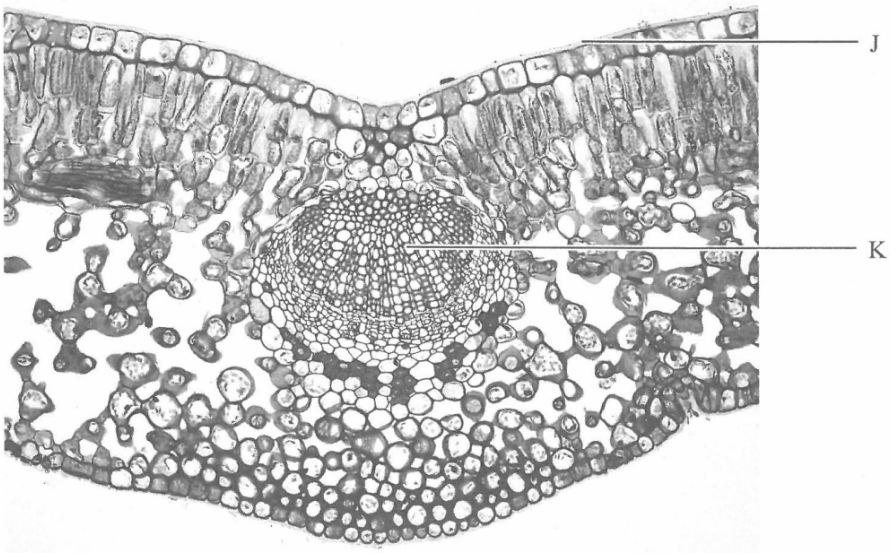
5. [HKDSE Biology 2020 Paper 1A Q26]
Hint: Identify tissue position, then trace transport or support.

On which of the following parts of the root can root hairs be found?

A. root cap
B. region of elongation
C. region of cell division
D. region of differentiation

6. [HKDSE Biology 2022 Paper 1A Q29]
Hint: Identify tissue position, then trace transport or support.

Directions: Questions 28 and 29 refer to the photomicrograph below, which shows a section of a leaf:



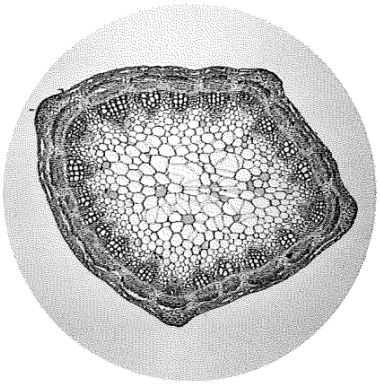
Which of the following substances will move out of the leaf through stomata from cell K in the daytime?

A. water
B. oxygen
C. mineral
D. carbon dioxide

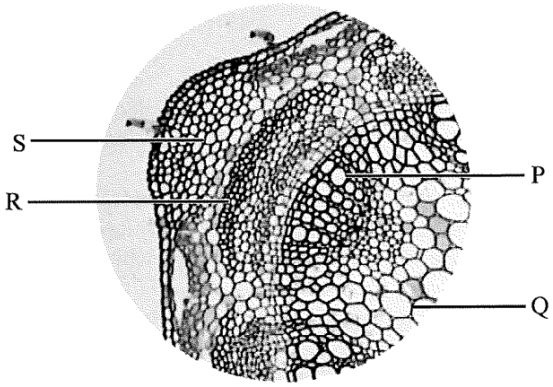
7. [HKDSE Biology 2023 Paper 1A Q14]
Hint: Identify tissue position, then trace transport or support.

Directions: Questions 12 to 14 refer to the photomicrographs below, which show the images of the cross section of a certain part of plant viewed under different magnifications:

Low magnification



High magnification

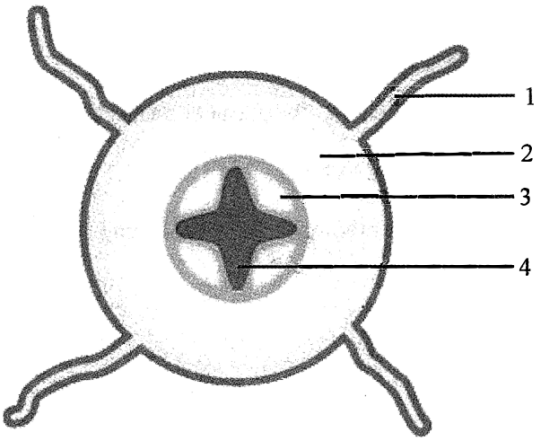


Which of the labelled tissues is responsible for the transport of water?

A. P
B. Q
C. R
D. S

8. [HKDSE Biology 2016 Paper 1A Q23]
Hint: Identify tissue position, then trace transport or support.

Directions: Questions 21 to 23 refer to the diagram below, which shows the cross section of a young dicotyledonous root:



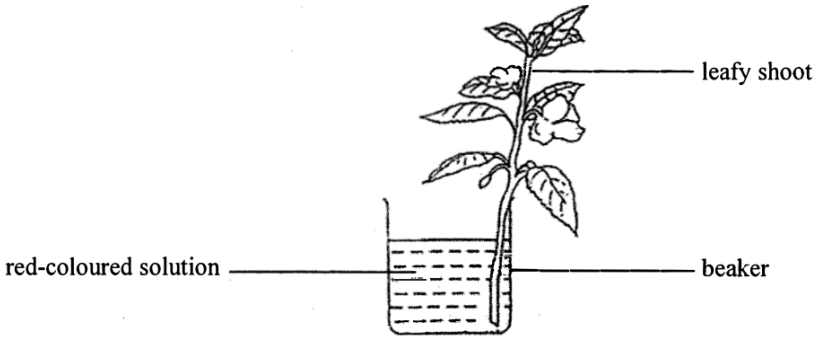
Which of the following parts is most likely to have more mitochondria?

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

9. [HKDSE Biology 2017 Paper 1A Q16]

Hint: Identify tissue position, then trace transport or support.

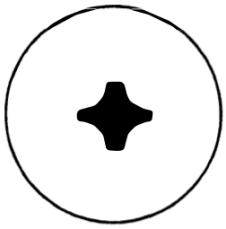
Directions: Questions 14 to 16 refer to the set-up below, which is used to investigate the effect of environmental factors on the transpiration rate of a leafy shoot. The leafy shoot was put into a beaker of red-coloured solution. After five hours, cross-sections of the shoot were cut starting from the top until red colour appeared in the cut section. The length of the remaining shoot was then measured.



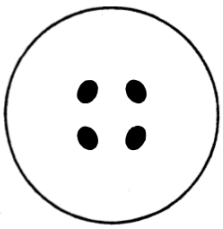
A section of the remaining shoot was observed under a microscope. Which of the following diagrams correctly shows the appearance of the shoot section?

Key: ■ Stained red

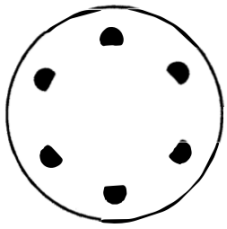
A.



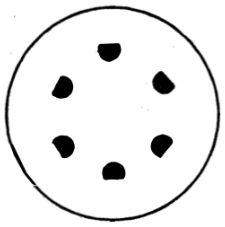
B.



C.



D.



10. [HKDSE Biology 2017 Paper 1A Q17]

Hint: Identify tissue position, then trace transport or support.

Which of the following cell types contribute(s) to the support of a leaf in a woody flowering plant?

(1) guard cells
(2) xylem vessels
(3) mesophyll cells

A. (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

11. [HKDSE Biology 2018 Paper 1A Q24]
Hint: Identify tissue position, then trace transport or support.

The following photograph shows a tree with roots covered by concrete:



Four students have expressed their views about this:


John: Don't worry! Oxygen produced in the leaves can be transported to the root for respiration!


Mary: Oh, no! The concrete blocks gas exchange in roots, leading to poor absorption of minerals in roots.


Tom: How come? Water absorbed cannot be transported to the leaves because the concrete will block the xylem.

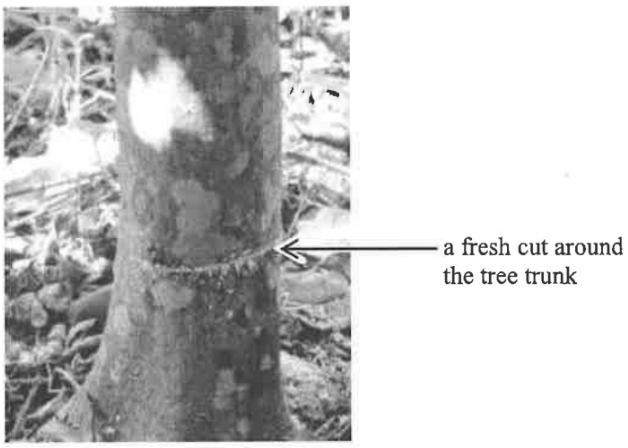

Susan: Good! The concrete can provide mechanical support and keep the tree upright.

Whose view is correct?

A. John's view
B. Mary's view
C. Tom's view
D. Susan's view

12. [HKDSE Biology 2019 Paper 1A Q32]
Hint: Identify tissue position, then trace transport or support.

The photograph below shows a fresh cut around the trunk near the bottom of a tree:



The tree eventually died. Which of the following is the most likely reason for the death of the tree?

A. Water could not be transported to the leaves for transpiration.
B. Water could not be transported to the leaves for photosynthesis.
C. Minerals could not be transported upward for protein synthesis.
D. Photosynthetic products could not be transported to the roots for respiration.

13. [HKDSE Biology 2020 Paper 1A Q23]
Hint: Identify tissue position, then trace transport or support.

Directions: Questions 22 to 24 refer to the photomicrographs below, which show the stem section of a plant observed under a microscope. Diagram Y shows a higher magnification of the vascular bundle (Vb) in Diagram X:

Diagram X

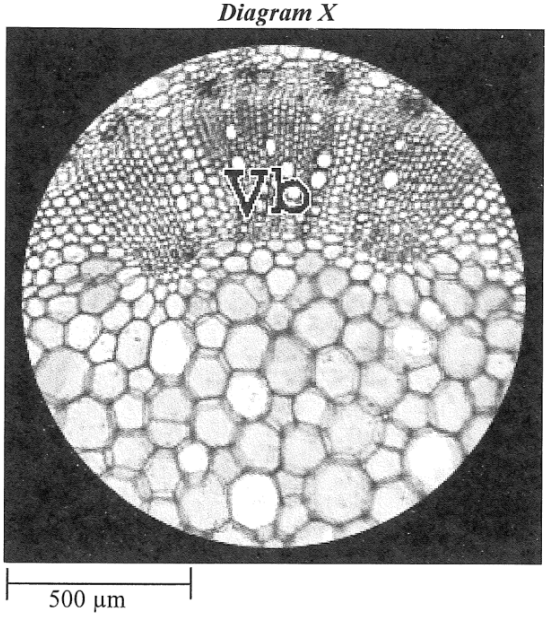
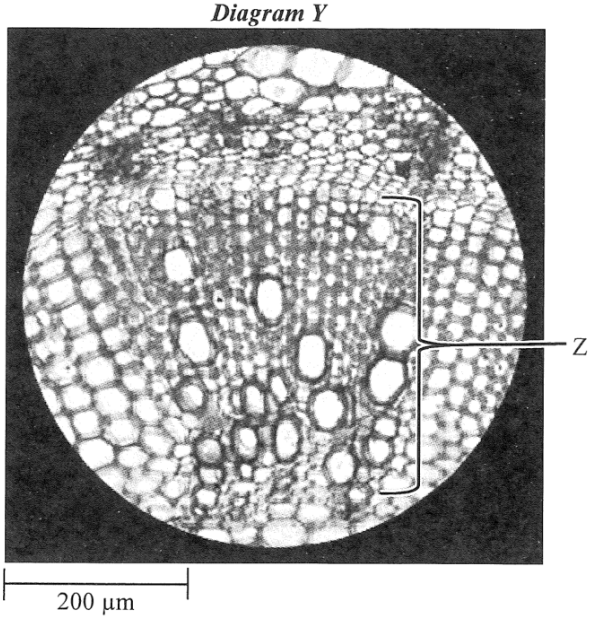


Diagram Y



Key: Vb = vascular bundle

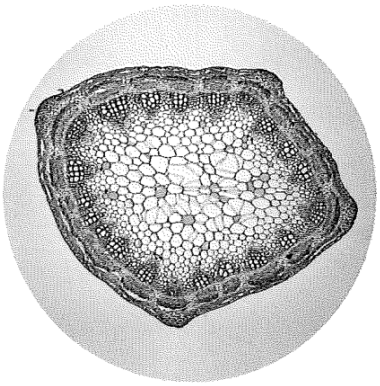
Which of the following descriptions of the function of tissue Z shown in Diagram Y is correct?

A. It transports proteins upwards.
B. It transports minerals upwards.
C. It transports water downwards.
D. It transports sugars downwards.

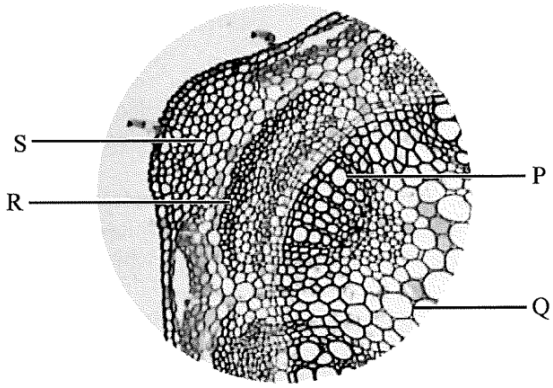
14. [HKDSE Biology 2023 Paper 1A Q12]
Hint: Identify tissue position, then trace transport or support.

Directions: Questions 12 to 14 refer to the photomicrographs below, which show the images of the cross section of a certain part of plant viewed under different magnifications:

Low magnification



High magnification



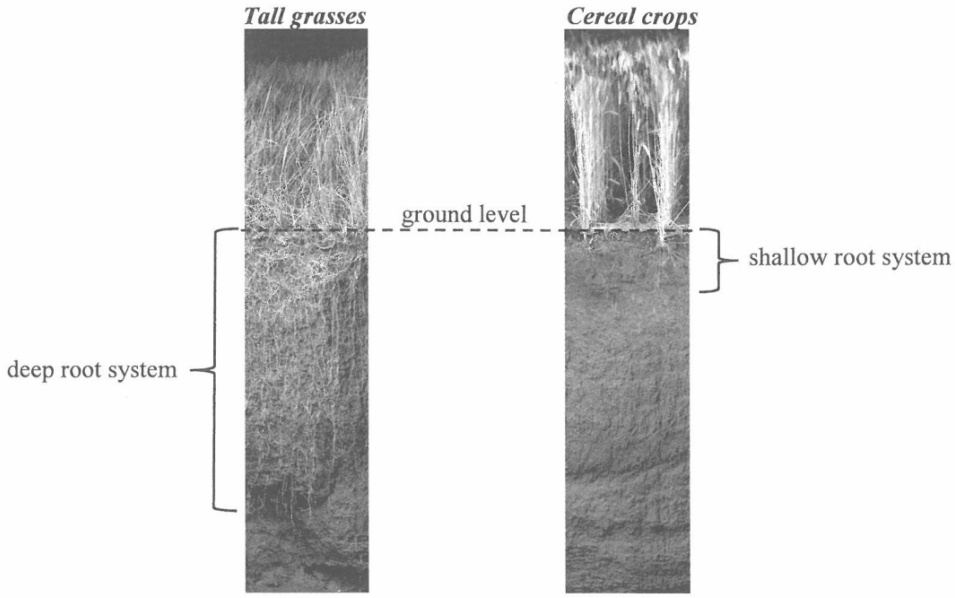
Which of the following combinations correctly matches the part of the plant where the section was taken from and the supporting evidence from the photomicrograph?

	Part of the plant	***Evidence***
A.	root	presence of hairs on the epidermis
B.	root	with thin-walled cells at the centre
C.	stem	presence of cuticle on the epidermis
D.	stem	with vascular bundles at the periphery

15. [HKDSE Biology 2022 Paper 1B Q8]

Hint: Identify tissue position, then trace transport or support.

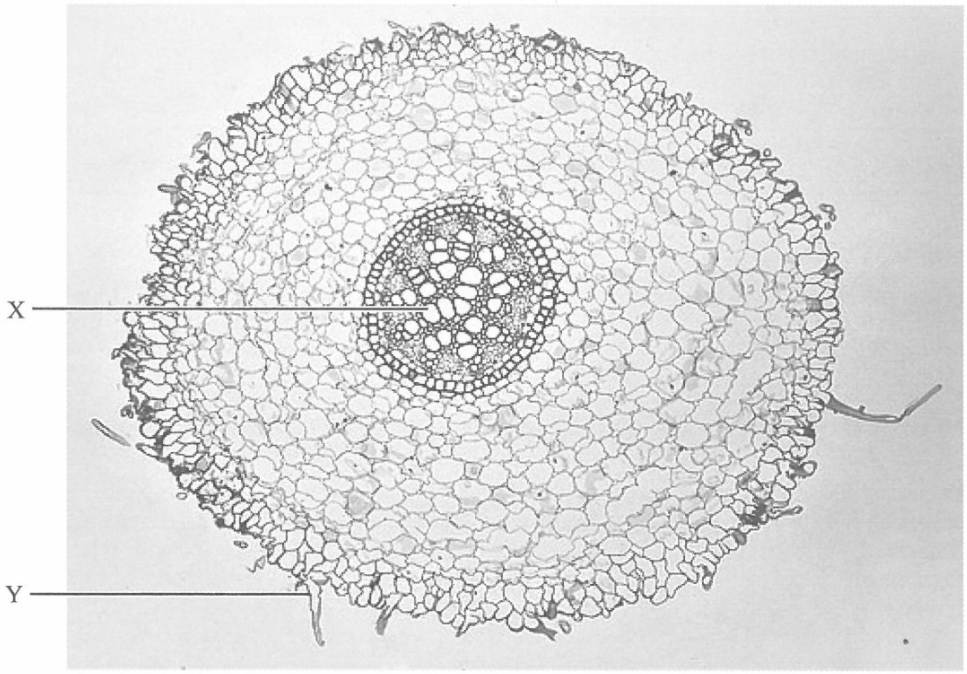
Tall grasses and cereal crops belong to the same family and share a common ancestor. Cereal crops have been artificially selected for agriculture and their seeds harvested as food. The roots of the tall grasses in grasslands range in depth from 1.5 m to 4.5 m while those of cereal crops rarely exceed 1 m. The photographs below show the root depths of tall grasses and cereal crops under the same magnification:



(a) (i) Grassland is a region of treeless plain which is mainly occupied by tall grasses. It is usually found in regions with moderate rainfall. The tall grasses have evolved with a deep root system. What is the selection pressure involved in this evolutionary process? What is the advantage of the greater root depth in tall grasses? (2 marks)

(ii) In terms of energy usage of the plant, explain why having a shallow root system for cereal crops is considered an advantage to farmers. (2 marks)

(b) The photomicrograph below shows the cross-section of the root of a cereal crop:



(i) Complete the table below to show how an observable feature of the structures X and Y is related to its function. (4 marks)

	Observable feature	Function
X		
Y		

(ii) Explain how water is transported from structure Y to structure X. (3 marks)

Type 2 Investigate plant nutrition using cultures, tracers and growth data

Degree of integration ★★★☆☆

Key ideas

① Magnesium deficiency can reduce chlorophyll, impair light absorption and consequently affect organic-substance production. This indirect effect does not mean that glucose contains magnesium. In mineral-deficiency comparisons, keep light, temperature and other nutrients the same.

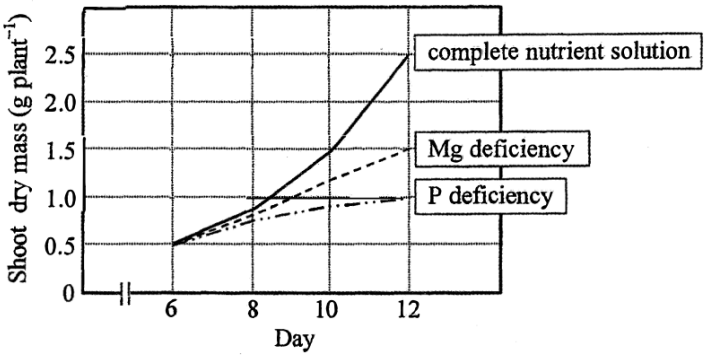
② With radioactive-carbon tracing, follow where labelled carbon first enters organic substances and where it travels next. The order in which labels appear is more informative than a list of organs.

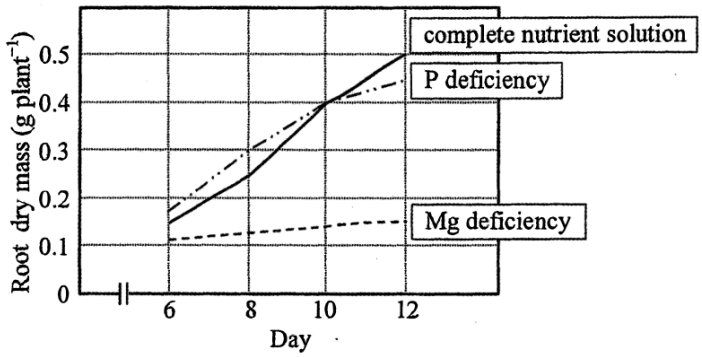
How to recognise the problem For culture solutions, identify the omitted component and control. For tracers, follow the labelled atom. For growth, distinguish dry mass, fresh mass and rate.

Example 1 [HKDSE Biology 2016 Paper 1B Q9]

To study the effect of mineral deficiency on shoot and root dry masses, bean plants were grown in a complete nutrient solution (a solution containing all essential nutrients for growth) or a nutrient solution without either phosphorus (P) or magnesium (Mg) for 12 days respectively. The dry masses of shoot and root were then measured. The results are shown in the graphs below:

Key: ——— complete nutrient solution
—·—·— P deficiency
- - - - - - - Mg deficiency





(a) Briefly describe how the dry mass of a plant can be determined. (2 marks)

(b) The leaves of the bean plants grown under Mg deficient conditions appeared yellow.

(i) Why did the leaves appear yellow? (1 mark)

(ii) Use this phenomenon to explain the results of the shoot dry mass and root dry mass of the bean plants under Mg deficient conditions. (3 marks)

(c) (i) Explain the difference in the overall dry mass of the plant grown under P deficient conditions and that in the complete nutrient solution. (2 marks)

(ii) It was hypothesized that P inhibits the export of photosynthetic products from leaves to roots. Use this hypothesis to explain the results of the shoot dry mass and root dry mass of the bean plants under P deficient conditions. (3 marks)

Solution (a); original allocation: 2 mark(s)

Harvest the plants, dry them at about 100°C, allow them to cool and weigh them. Repeat drying and weighing until their mass no longer changes.

Method: Distinguish the changed condition, labelled atom and measurement.

Dry mass excludes the effect of water. A single weighing cannot establish that all water has been removed, so drying 'to constant mass' is essential. Repeated measurements are made on the same harvested sample; fresh masses of different plants measured on successive days are not dry masses.

(b)(i); original allocation: 1 mark(s)

Magnesium deficiency prevents normal chlorophyll formation, reducing the green colour so the leaves appear yellow.

Magnesium is a constituent of chlorophyll. When it is deficient, the colours of other pigments become more visible. Minerals themselves are neither plant food nor yellow pigments.

(b)(ii); original allocation: 3 mark(s)

Less chlorophyll reduces photosynthesis and the production of organic nutrients. Both shoot and root dry masses are therefore lower than in the complete nutrient solution.

Follow the causal chain through both plant parts shown: insufficient magnesium → insufficient chlorophyll → fewer photosynthetic products → less material for shoot growth and fewer nutrients transported to roots. Thus the magnesium-deficient curves are lower in both graphs.

(c)(i); original allocation: 2 mark(s)

Phosphorus-deficient plants have a lower total dry mass. Phosphorus is required for substances including nucleic acids, ATP and phospholipids, so deficiency limits growth.

Total dry mass is the sum of shoot and root masses; the root graph alone cannot represent the whole plant. On day 12, the complete-solution group has about 2.5 + 0.5 = 3.0 g, compared with about 1.0 + 0.45 = 1.45 g in the phosphorus-deficient group, which is clearly lower. Phosphorus is not an obligatory constituent of proteins in general, so nucleic acids and ATP provide more accurate examples.

(c)(ii); original allocation: 3 mark(s)

According to the hypothesis, phosphorus deficiency reduces inhibition of photosynthate export, allowing more photosynthetic products to move from leaves to roots. Shoot dry mass is therefore much lower, while root dry mass remains close to that of the complete-solution group.

This subpart specifically requires the hypothesis to explain the different magnitudes of change in the graphs. Phosphorus deficiency limits whole-plant growth but also changes resource allocation, directing more of the limited products towards roots. Shoots are markedly reduced while roots remain broadly maintained. Similar root dry masses do not mean that the whole plant is unaffected.

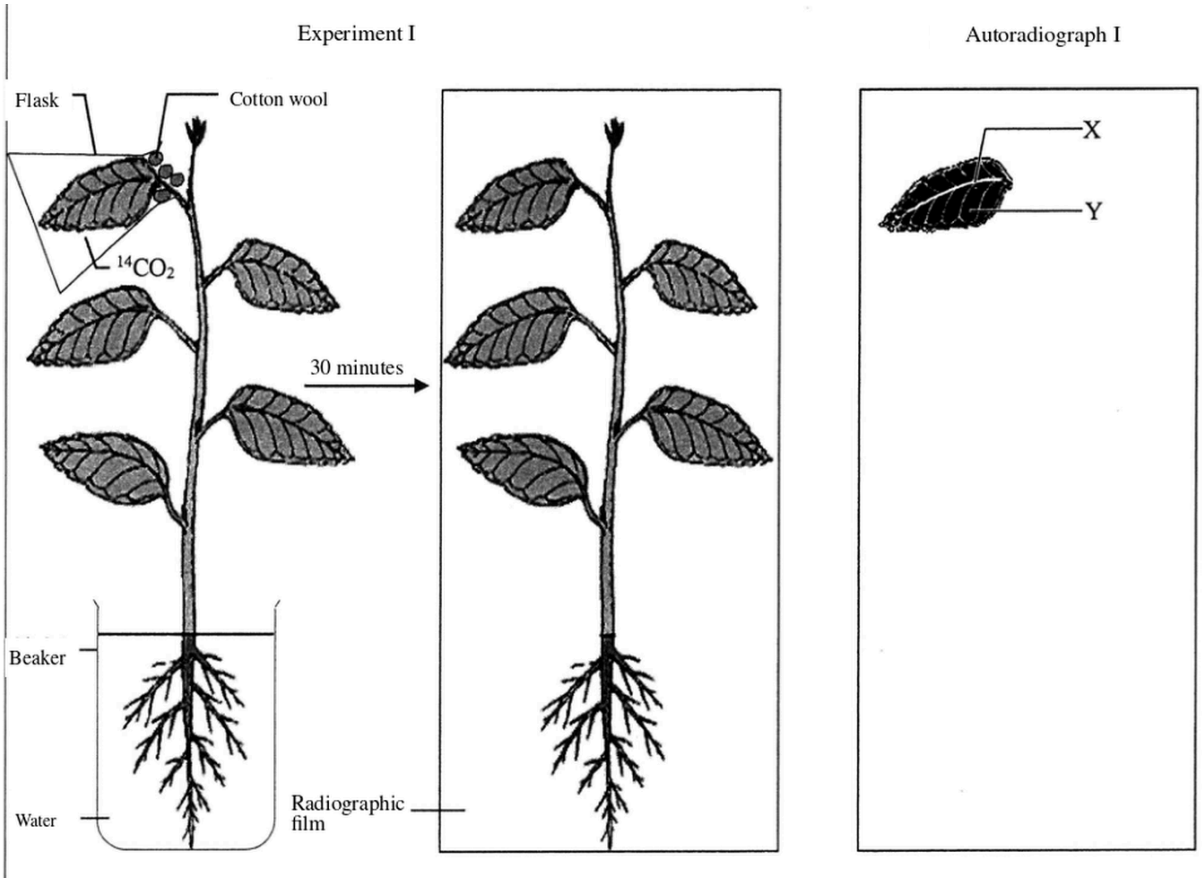
Examiner's comment (source page(s) 3)

Determine dry mass by drying to constant mass. Compare mineral-deficiency effects with the complete nutrient-solution control. Differences in dry mass are not direct measurements of photosynthetic rate.

Marking reference: HKDSE Biology 2016 Paper 1B Q9, official marking scheme, source page(s) 4, 5.

Example 2 [HKDSE Biology 2025 Paper 1B Q7 (English translation)]

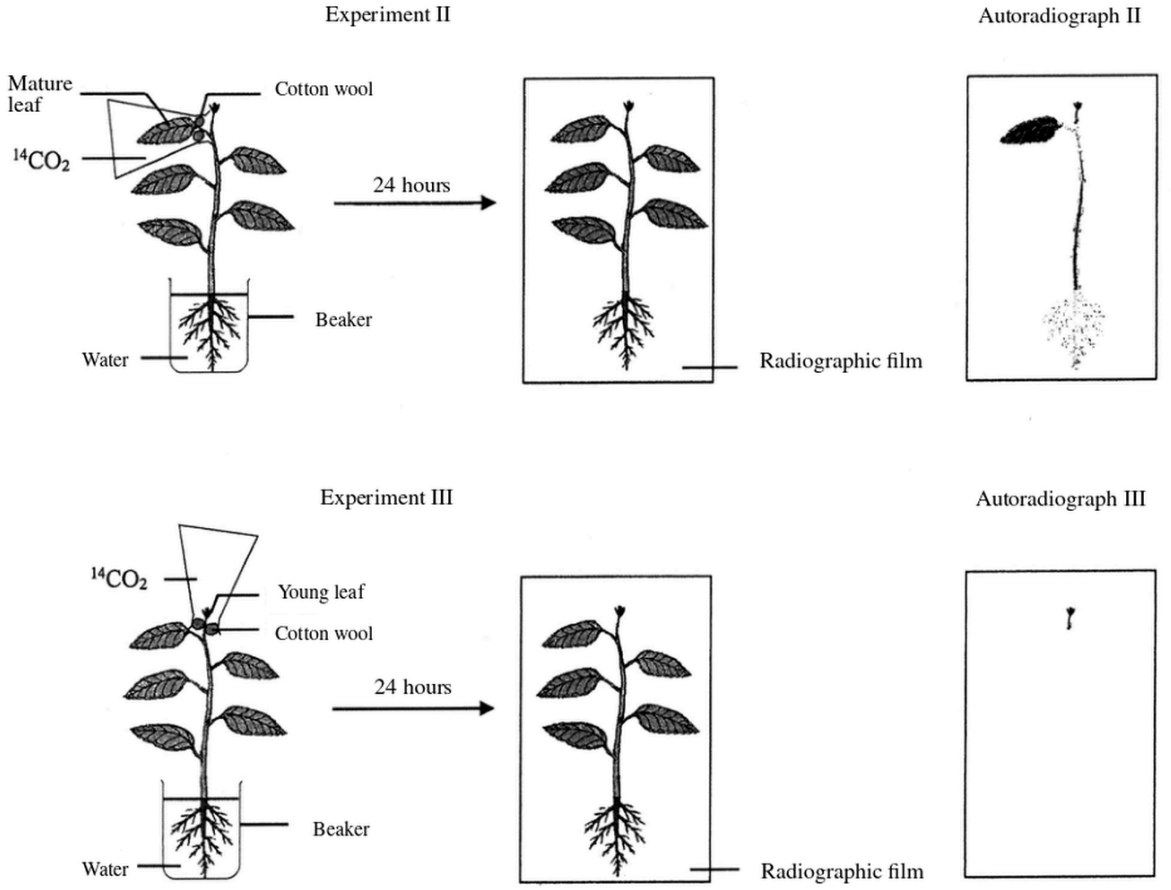
(a) In experiment I, a leaf is enclosed in a flask containing carbon dioxide labelled with radioactive ^{14}C ($^{14}CO_2$) for 30 minutes. The plant is then placed on radiographic film. In autoradiograph I, different shades of black indicate radioactivity: a darker shade indicates stronger ^{14}C radioactivity.



(i) Explain why radioactivity appears in the leaf. (1 mark)

(ii) Explain the distribution of radioactivity in the different tissues (X and Y) of the leaf shown in autoradiograph I. (3 marks)

(b) In the following two experiments, a mature leaf (experiment II) and a young leaf (experiment III) are exposed to $^{14}CO_2$. After 24 hours, each whole plant is placed on radiographic film, and the radioactivity shown in autoradiographs II and III is analysed separately.



(i) Autoradiograph II shows radioactivity in parts of the plant that were not exposed to $^{14}CO_2$. Explain this observation. (2 marks)

(ii) Suggest one reason why radioactivity in autoradiograph III is confined to the young leaf. (1 mark)

Solution **(a)(i); original allocation: 1 mark(s)**

Method: Distinguish the changed condition, labelled atom and measurement.

The leaf carries out photosynthesis, fixing carbon from $^{14}CO_2$ into organic products such as carbohydrates.

The label is in the carbon atoms. Once these enter photosynthetic products, autoradiography can reveal those products. Dark regions cannot be explained merely as carbon dioxide adhering to the surface.

(a)(ii); original allocation: 3 mark(s)

Y is more radioactive than X. X consists mainly of vascular tissue; xylem and phloem cells have no chloroplasts or relatively few. Y contains more mesophyll cells with numerous chloroplasts, carrying out more photosynthesis and fixing more labelled carbon.

First compare the actual light and dark regions in the photograph, then explain X and Y separately. The ability of leaf veins to transport sugars does not mean that after 30 minutes of exposure to $^{14}CO_2$ they must be more strongly labelled than the mesophyll producing photosynthates.

(b)(i); original allocation: 2 mark(s)

Labelled carbohydrates synthesised in mature leaves are translocated as sucrose through the phloem to roots, young leaves or buds. Parts not directly exposed to $^{14}CO_2$ therefore also become radioactive.

The two marks require translocation of photosynthetic products and identification of phloem as the conducting tissue. Carbon dioxide itself is not transported directly to roots through phloem.

(b)(ii); original allocation: 1 mark(s)

Young leaves are growing and retain photosynthetic products for their own respiration, assimilation and growth, leaving insufficient surplus carbohydrate for export.

Mature leaves are often sources of sugar, whereas young leaves mainly use sugar. Even if both photosynthesise, their export and the distribution of the label throughout the plant can differ.

Examiner's comment (source page(s) 73)

Radioactive carbon first enters organic compounds through photosynthesis and is then translocated as organic nutrients. Carbon dioxide does not flow along the phloem. Young leaves retain nutrients to support rapid growth; 'young leaves have no sieve tubes' is not a valid reason.

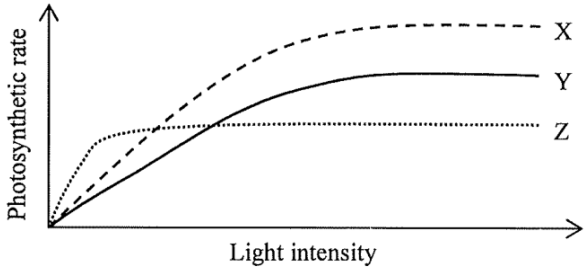
Marking reference: HKDSE Biology 2025 Paper 1B Q7, official marking scheme, source page(s) 56.

Practice

1. [HKDSE Biology 2023 Paper 1A Q10]

Hint: Distinguish the changed condition, labelled atom and measurement.

The graph below shows the photosynthetic rates of three plant species X, Y and Z in response to the change of light intensity. The three plant species are in the same habitat.



Which of the following can be deduced from the above graph?

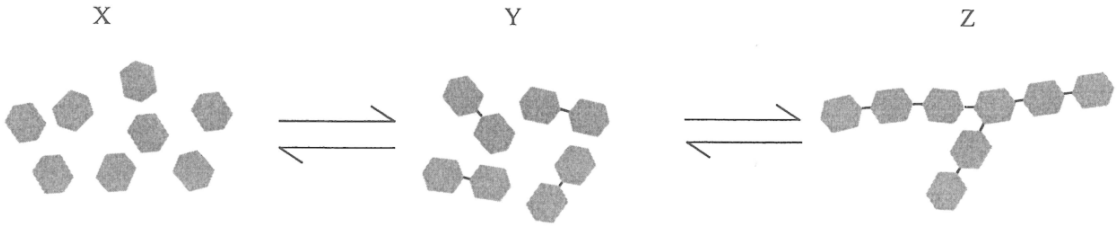
A. Species Y is the tallest among the three species.
B. Species Z is most competitive in shady condition.
C. Species Y will outcompete species X in all light conditions.
D. Removal of species Z will increase the photosynthetic rate of species X.

2. [HKDSE Biology 2024 Paper 1A Q19]

Hint: Distinguish the changed condition, labelled atom and measurement.

Directions: Questions 19 and 20 refer to the diagram below, which shows interconversion of three types of compounds catalysed by enzymes in a living organism:

Key: ⬢ six-carbon sugars



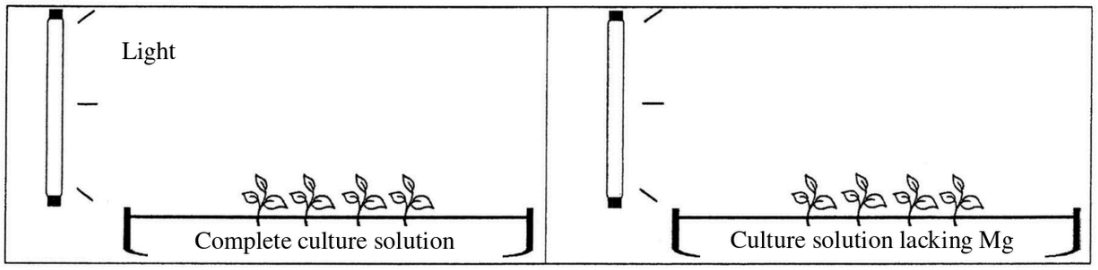
If the organism is a plant, which of the following statements is ***incorrect***?

A. X is the major form of carbohydrate transported through phloem
B. The conversion of Z to X takes place in a germinating seed.
C. X can be the raw materials for synthesis of cell wall.
D. The conversion of X to Z takes place in chloroplast.

3. [HKDSE Biology 2025 Paper 1A Q21 (English translation)]

Hint: Distinguish the changed condition, labelled atom and measurement.

Directions: Refer to the following investigation of the effect of magnesium on plant growth to answer Questions 21 and 22. Two groups of seedlings are supplied with two different culture solutions, as shown below:



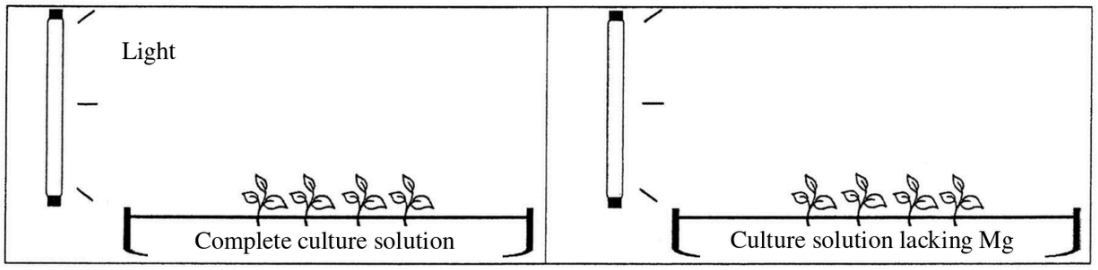
After one month, the amounts of biological molecules in the seedlings in the two set-ups are analysed. Which of the following biological molecules are present in smaller amounts in seedlings grown in the culture solution lacking magnesium?

(1) Chlorophyll
(2) Lipids
(3) Starch

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

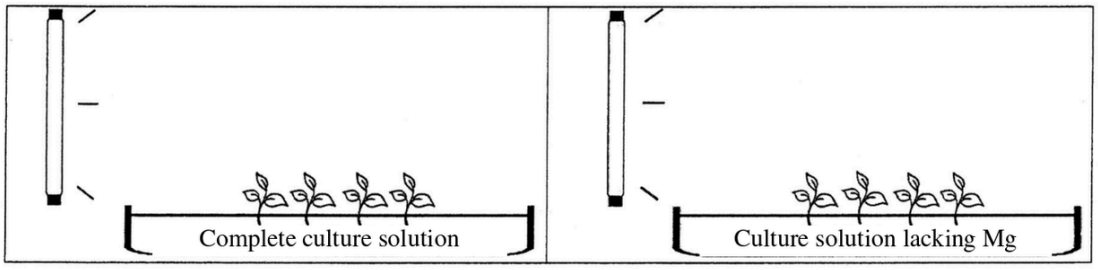
4. [HKDSE Biology 2025 Paper 1A Q22 (English translation)]
Hint: Distinguish the changed condition, labelled atom and measurement.

Directions: Refer to the following investigation of the effect of magnesium on plant growth to answer Questions 21 and 22. Two groups of seedlings are supplied with two different culture solutions, as shown below:

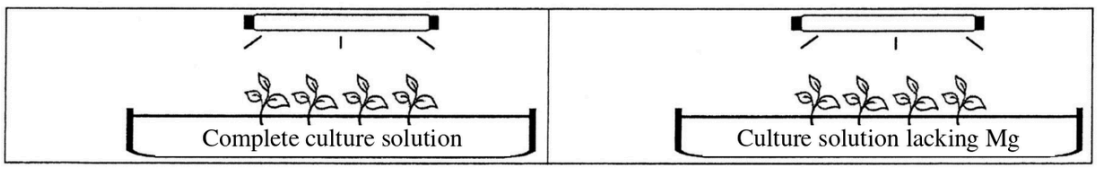


Two students disagree about the position of the light source. Student P proposes placing it to the left of the seedlings (method I), while student Q thinks it should be placed above the seedlings (method II):

Method I



Method II



Which of the following statements about the methods is correct?

A. Method I is preferable because it simulates a natural environment in which some plants are closer to the light source.
B. Methods I and II are equally preferable because both groups contain the same number of seedlings.
C. Methods I and II are equally preferable because both groups are part of a fair test.
D. Method II is preferable because it reduces the environmental differences experienced by the four seedlings within each group.

5. [HKDSE Biology Sample Paper Paper 1B Q12]
Hint: Distinguish the changed condition, labelled atom and measurement.

Hydrogen and nitrogen are essential components of proteins. Compare and contrast the processes by which non-leguminous plants acquire these two elements from the environment and describe how they can be incorporated together to form proteins in mesophyll cells. (11 marks)

Type 3 Explain plant water loss using potometers and environmental data

Degree of integration ★★★☆☆

Key ideas

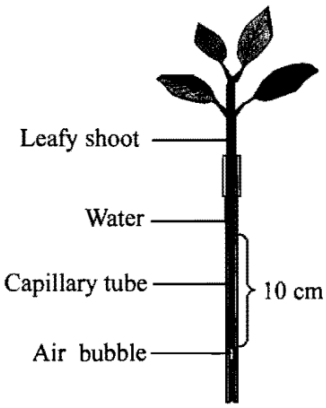
① A potometer directly measures water uptake, which can approximate water loss under comparable conditions. Wind removes humid air near the leaf, increasing the water-vapour gradient; higher humidity reduces it.

② Even with water in the soil at midday, water loss may temporarily exceed uptake, lowering cell turgor. When measuring leaf water loss, account for each group's initial mass, leaf area and time.

How to recognise the problem Identify whether uptake or loss is measured, then explain using stomata, gradients, wind, temperature and surface area. Bubble distance is not directly another unmeasured quantity.

Example 1 [HKDSE Biology 2012 Paper 1A Q10]

Directions: Questions 10 and 11 refer to the following set-up, which is used to investigate the effect of different environmental conditions on the rate of water loss from a leafy shoot:



It is important to cut the leafy shoot under water at the beginning of the experiment because this

A. allows the leafy shoot to adjust to the new environment.
B. prevents the drying up of the cut end of the leafy shoot.
C. avoids the forming of air bubbles in the xylem of the leafy shoot.
D. makes sure that there is no water loss from the leafy shoot before the experiment.

Solution Answer: C

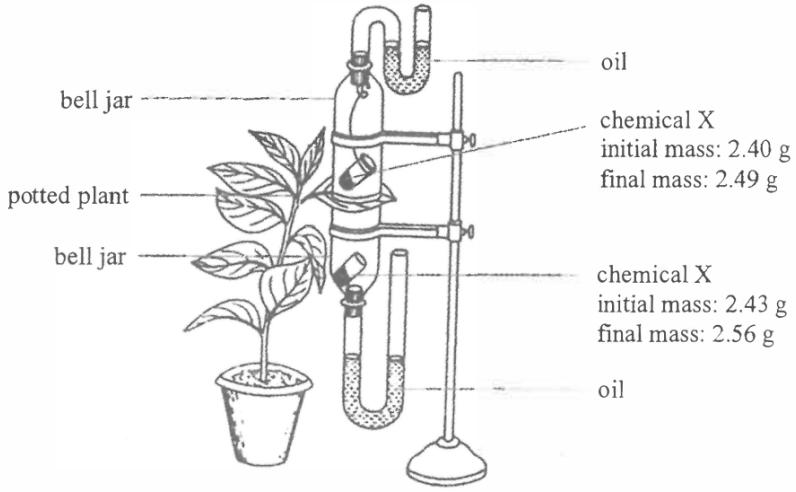
Cutting the shoot under water prevents air from entering xylem vessels and maintains a continuous water column. Air bubbles would break the column, making movement of the measuring bubble an unreliable indicator of water uptake. This procedure neither stops all water loss nor merely keeps the cut surface moist.

Method: Distinguish water uptake from water loss, then use gradients to explain changes.

Marking reference: HKDSE Biology 2012 Paper 1A Q10, official marking scheme, source page(s) 1.

Example 2 [HKDSE Biology 2018 Paper 1A Q30]

Directions: Questions 30 and 31 refer to the set-up below. The set-up consists of two bell jars placed one above the other with the leaf of a potted plant in between. Chemical X was placed into the jars to absorb water vapour. The whole set-up was made air-tight. The masses of chemical X in the two jars were measured at the beginning and after five hours.



The change in mass of chemical X was mainly caused by

A. water uptake by the plant.
B. water loss in transpiration.
C. water produced in respiration.
D. water consumed by photosynthesis.

Solution Reading the question and choosing a method

Method: Distinguish water uptake from water loss, then use gradients to explain changes.

The water-absorbing chemical is in a sealed space outside the leaf, so follow water vapour entering that space.

Answer: B

Water evaporates within the leaf and passes from the leaf surface into the surrounding space as vapour. Chemical X absorbs it and increases in mass. The apparatus therefore directly reflects water lost from the leaf by transpiration, matching B. Root uptake replenishes water in the plant, but it is not the process measured directly by X outside the leaf. Water consumption in photosynthesis also cannot directly explain the increased mass of an external water absorber. Therefore, choose B.

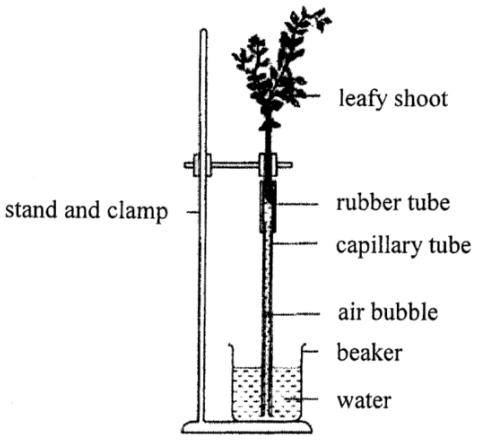
Common error

Confusing the source of replacement water with the process actually measured by the apparatus.

Marking reference: HKDSE Biology 2018 Paper 1A Q30, official marking scheme, source page(s) 1.

Example 3 [HKDSE Biology 2013 Paper 1B Q6]

The following set-up can be used to determine the transpiration rate of a leafy shoot:



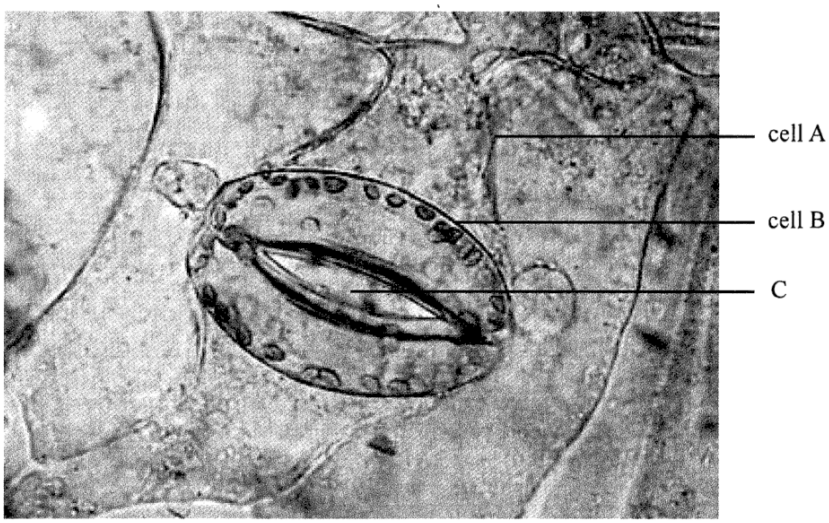
(a) In setting up this experiment, the lower end of the shoot should be cut under water. Why? (1 mark)

(b) Give ***one*** assumption for using this set-up to measure the transpiration rate. (1 mark)

(c) Explain how the transpiration rate will change if the fan placed near the shoot is switched on. (4 marks)

Answers written in the margins will not be marked.

(d) The photomicrograph below shows the appearance of the surface of a leaf during daytime:



(i) In terms of sub-cellular structure, state ***two*** differences between cell A and cell B. (2 marks)

(ii) What will happen to the size of C at night? Discuss the functional significance of this change. (3 marks)

Solution a; original allocation: 1 mark(s)

Method: Distinguish water uptake from water loss, then use gradients to explain changes.

Cut the shoot under water to prevent air entering the xylem and forming bubbles that interrupt the continuous water column.

The apparatus requires continuous water uptake through xylem. If air enters the cut end, resistance from bubbles means the measured uptake rate no longer represents the shoot's normal condition.

b; original allocation: 1 mark(s)

Assume that almost all absorbed water is used to replace transpiration losses, so water uptake rate approximately equals the rate of water loss by transpiration.

A potometer measures water uptake directly; it does not directly collect water vapour. This approximation is required to estimate transpiration rate from bubble movement.

c; original allocation: 4 mark(s)

Turning on the fan increases transpiration. Moving air removes water vapour near the leaf, lowering the external water-vapour concentration. This steepens the concentration gradient between the leaf air spaces and surrounding air, increasing outward diffusion through stomata.

Do not merely state that wind 'sucks water away'. Explain how wind changes humidity at the leaf surface and how this affects diffusion.

d(i); original allocation: 2 mark(s)

B contains chloroplasts but A does not. B has unevenly thickened walls, thicker on the side facing the pore, whereas A has walls of more uniform thickness.

B is a guard cell and A an ordinary epidermal cell. The question specifies subcellular structures, so simply describing one cell as curved and the other as not curved is insufficient.

d(ii); original allocation: 3 mark(s)

Stoma C becomes narrower or closes at night, reducing water loss through transpiration. With no photosynthesis at night, the demand for carbon-dioxide uptake falls, so water can be conserved without maintaining unnecessarily high gas exchange.

Plants still respire at night, so do not state that they require no gas exchange at all. The key is the coordination of reduced photosynthetic demand with water conservation.

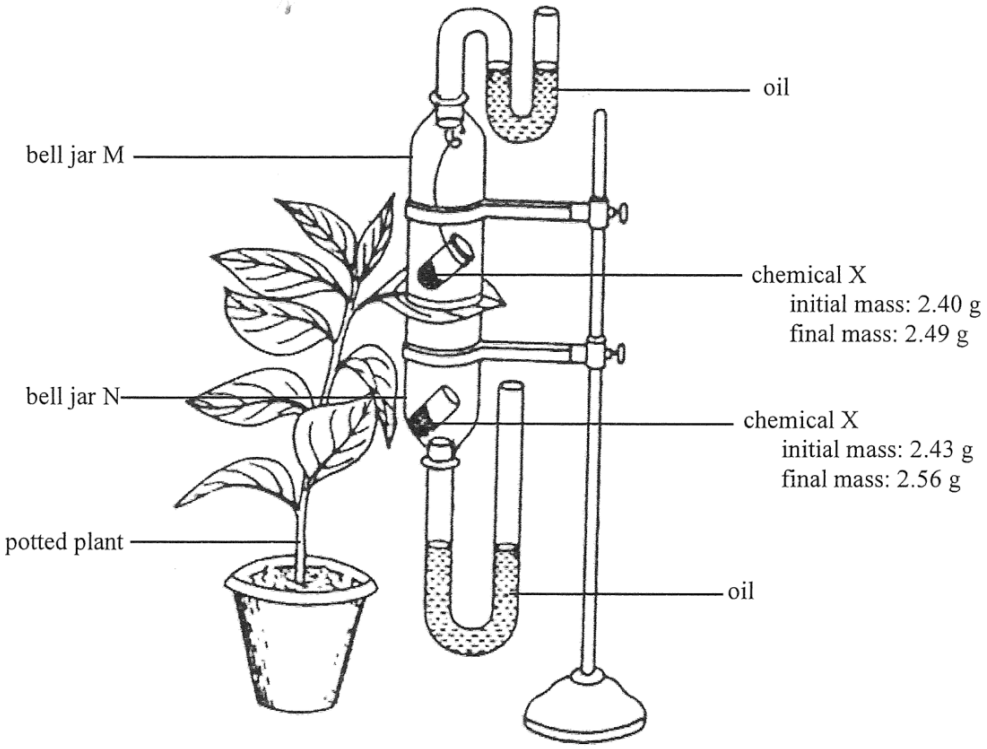
Examiner's comment (source page(s) 3)

Water lost through transpiration is water vapour, and the relevant process is diffusion in the gas phase. A chloroplast is an organelle, whereas chlorophyll is a pigment; do not confuse them.

Marking reference: HKDSE Biology 2013 Paper 1B Q6, official marking scheme, source page(s) 4.

Example 4 [HKDSE Biology 2020 Paper 1B Q5]

The diagram below shows an experimental set-up used to compare the transpiration rates of the upper and lower epidermis of the leaf of a potted plant. The set-up consists of two identical bell jars placed one above the other with the leaf of a potted plant in between. Chemical X was placed into the jars to absorb water vapour. The whole set-up was made air-tight. The masses of the chemical X in the jars were measured at the beginning and after five hours.



(a) (i) Which of the following parameters is used to measure the transpiration rate of the plant in this investigation? Put a '✓' in the appropriate box to indicate your choice. (1 mark)

☐ amount of water lost by the leaf

☐ amount of water absorbed by the leaf

(ii) How can the above set-up measure the parameter chosen in (a) (i)? (2 marks)

(b) List ***two*** variables which have been controlled by this set-up during the investigation. (2 marks)

(c) (i) Compare the changes in the mass of chemical X in bell jars M and N. What conclusion can you draw? (2 marks)

(ii) Suggest ***one*** possible explanation for the conclusion. (1 mark)

(iii) Propose ***one*** workable method to test your hypothesis in (c) (ii). (2 marks)

Solution a(i); original allocation: 1 mark(s)

The amount of water lost from the leaf.

Chemical X is outside the leaf and contacts water vapour released from its surface. The apparatus does not measure root water uptake, so select water loss. Measuring loss over a fixed time interval then allows comparison of transpiration rates.

✓ Method: Distinguish water uptake from water loss, then use gradients to explain changes.

a(ii); original allocation: 2 mark(s)

During transpiration, water leaves the leaf surface as vapour and is absorbed by chemical X. The increase in X's mass therefore reflects water loss from that epidermis.

Connect the reading to the process: water evaporates within the leaf, moves into air inside the cover, and is absorbed by X. The airtight apparatus limits entry of external vapour. Therefore, leaf water loss is the increase in X's mass, after subtracting its initial mass, rather than its entire final mass.

b; original allocation: 2 mark(s)

Leaf type is the same because both surfaces belong to the same leaf. The enclosed areas of upper and lower epidermis are equal because the two bell jars are identical.

The question asks which variables the apparatus already controls, so identify conditions confirmed by the diagram and text. Identical jars also control air-space volume, and the enclosed spaces limit differences in wind speed. Do not simply list familiar variables such as temperature and light intensity without explaining how this apparatus controls them.

c(i); original allocation: 2 mark(s)

X gains more mass in N, indicating a higher transpiration rate from the lower epidermis.

Subtract the initial masses separately:

Mass gain in M = 2.49 – 2.40 = 0.09 g.

Mass gain in N = 2.56 – 2.43 = 0.13 g.

Both measurements span 5 hours, giving average water-loss rates of 0.018 g/h and 0.026 g/h respectively. Comparing only the final values, 2.49 and 2.56, is insufficient. Rates are determined from increases over the same time.

c(ii); original allocation: 1 mark(s)

The lower epidermis may have a higher stomatal density.

Stomata are important routes of water-vapour loss. More stomata per unit area could allow greater vapour loss under otherwise similar conditions. This is a testable hypothesis inferred from the result, not a structural fact established by water-loss measurements alone.

c(iii); original allocation: 2 mark(s)

Take nail-varnish impressions of both epidermises and count stomata in equal areas under a microscope. Repeat at several positions and compare mean stomatal densities.

The test must follow the preceding hypothesis. If the claim is higher stomatal density, measure stomata per unit area directly. Merely looking at leaves under a microscope, or repeating the water-loss experiment, does not measure that density. A different hypothesis about cuticle thickness would require measurements in transverse sections.

Marking reference: HKDSE Biology 2020 Paper 1B Q5, official marking scheme, source page(s) 4.

Practice

1. [HKDSE Biology 2014 Paper 1A Q22]

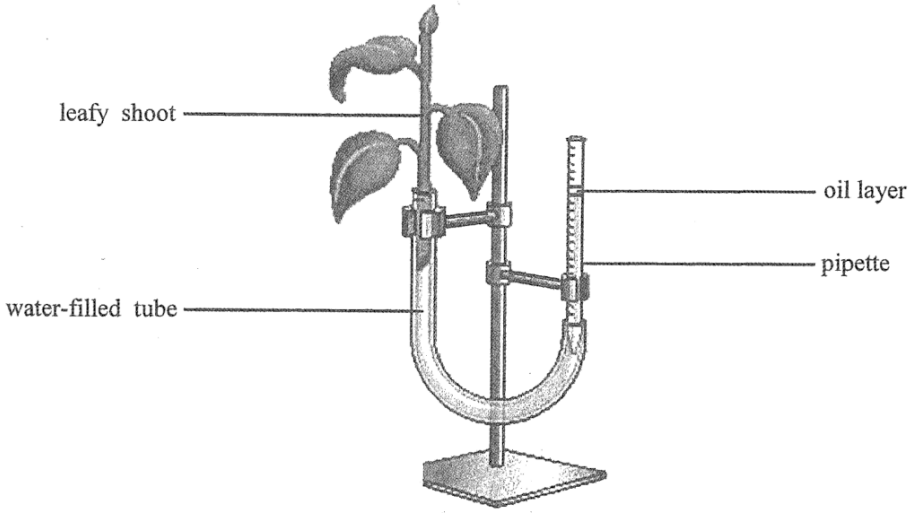
← Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

The transpiration rate of a tree is much higher than that of a herbaceous plant because the tree

A. is much taller than the herbaceous plant.
B. has many more roots than the herbaceous plant.
C. has many more leaves than the herbaceous plant.
D. has much more xylem than the herbaceous plant.

2. [HKDSE Biology 2015 Paper 1A Q18]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 17 and 18 refer to the set-up below, which is used to measure the rate of transpiration of a leafy shoot:



Which of the following variables has the greatest influence on the rate of transpiration of the leafy shoot?

A. the area of the leaves
B. the thickness of the leaves
C. the length of the leafy shoot
D. the number of xylem vessels

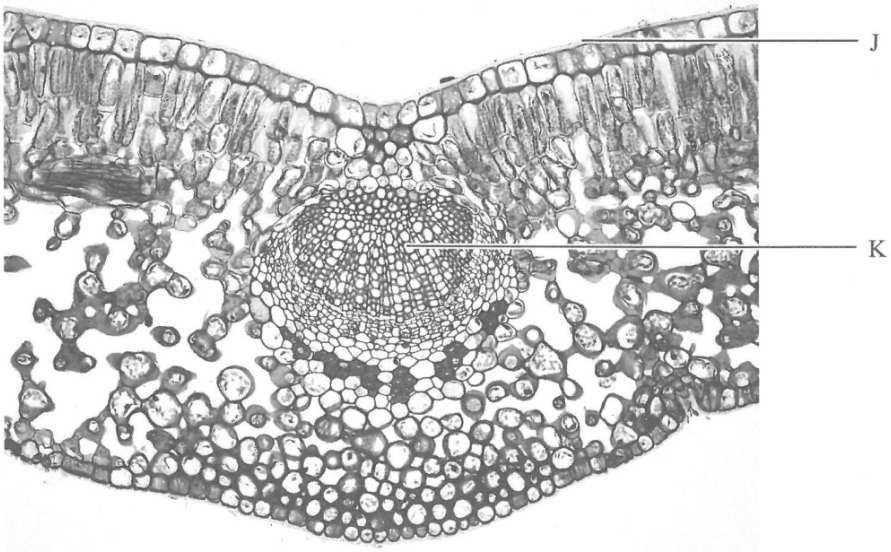
3. [HKDSE Biology 2017 Paper 1A Q13]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Water absorbed by trees is mostly used

A. to replenish water loss.
B. for storage in vacuoles.
C. as a raw material in photosynthesis.
D. as a medium for reactions to take place.

4. [HKDSE Biology 2022 Paper 1A Q28]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 28 and 29 refer to the photomicrograph below, which shows a section of a leaf:

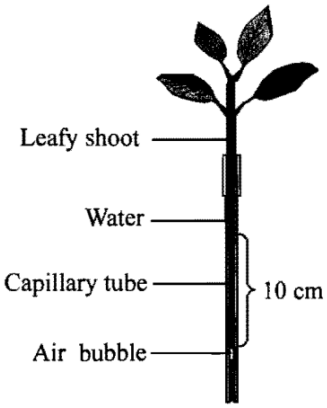


Which of the following correctly describes the major function of layer J?

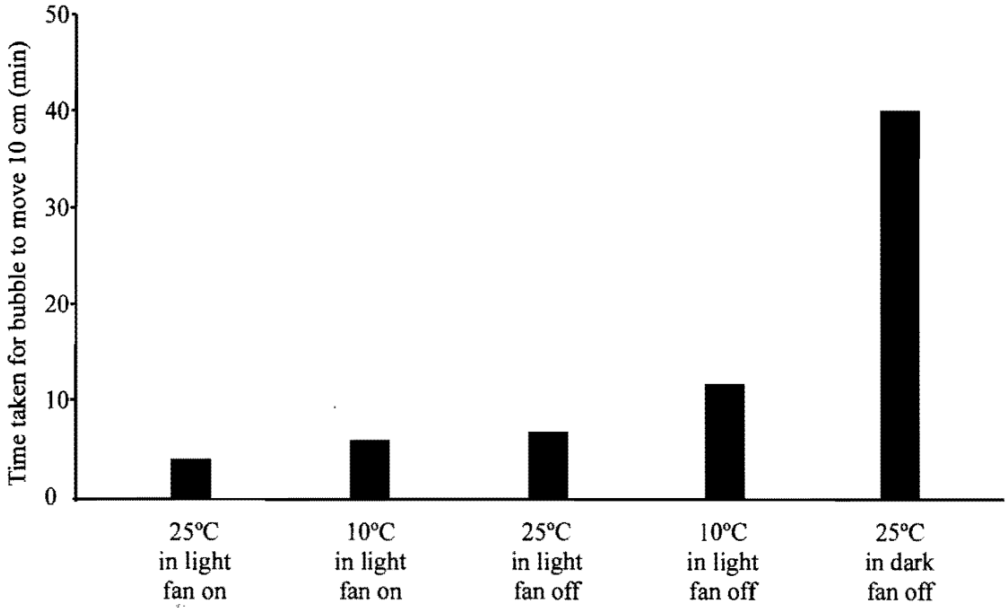
A. It reduces water loss.
B. It allows light to pass through.
C. It protects the leaf from infection.
D. It increases the photosynthetic rate.

5. [HKDSE Biology 2012 Paper 1A Q11]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 10 and 11 refer to the following set-up, which is used to investigate the effect of different environmental conditions on the rate of water loss from a leafy shoot:



The results of the experiment conducted under different environmental conditions are shown in the bar chart below:



Which of the following changes in conditions results in the greatest decrease in water loss from the leafy shoot?

A. switching off the light
B. switching off the fan
C. increasing the temperature from 10°C to 25°C
D. decreasing the temperature from 25°C to 10°C

6. [HKDSE Biology 2012 Paper 1A Q12]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Leaves were taken from four different plants and the number of stomata was counted. The results are shown in the following table:

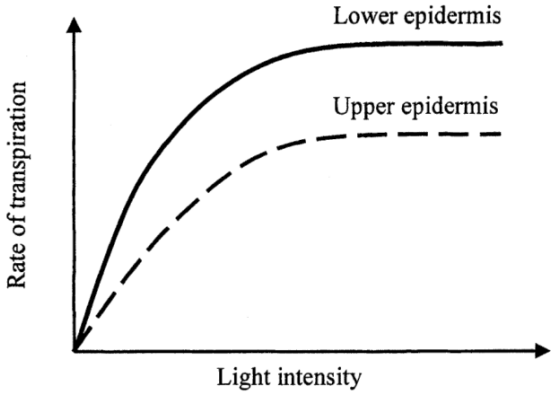
Plant	*Mean number of stomata per cm²*	
	Upper surface of the leaf	*Lower surface of the leaf*
P	4 000	28 000
Q	0	800
R	8 500	15 000
S	8 000	26 000

Which plant will wilt first when it is grown in a very dry region?

A. P
B. Q
C. R
D. S

7. [HKDSE Biology 2014 Paper 1A Q20]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 20 and 21 refer to the graph below, which shows how the transpiration rates through the upper and lower epidermis of a leaf vary with light intensity:

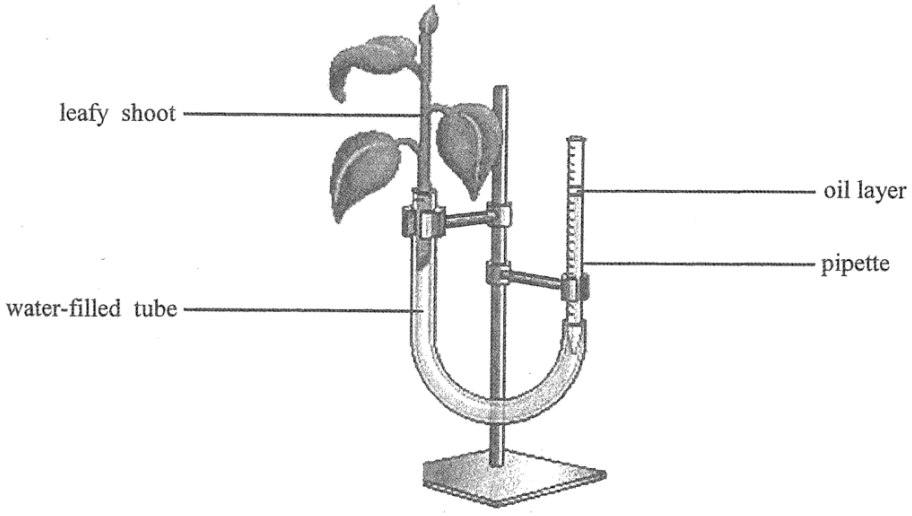


Which of the following accounts for the difference in the transpiration rates through the upper and lower epidermis shown above?

A. The mesophyll layer near the lower epidermis has more air spaces.
B. The upper epidermis is more exposed to light.
C. The air temperature below the leaf is lower.
D. The upper epidermis has fewer stomata.

8. [HKDSE Biology 2015 Paper 1A Q17]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 17 and 18 refer to the set-up below, which is used to measure the rate of transpiration of a leafy shoot:

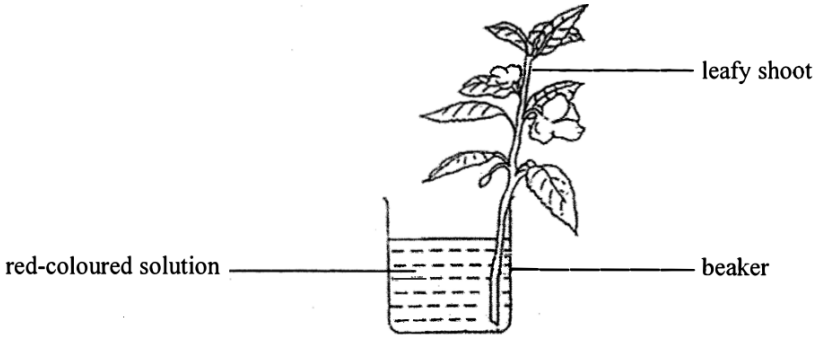


The assumption behind the use of this set-up for measuring the rate of transpiration is that

A. the connections in the set-up are sealed off.
B. the rate of water uptake is equal to that of water loss.
C. the stomata of the leaves remain open throughout the experiment.
D. the cutting of the shoot does not introduce air bubbles into the xylem vessels.

9. [HKDSE Biology 2017 Paper 1A Q15]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 14 to 16 refer to the set-up below, which is used to investigate the effect of environmental factors on the transpiration rate of a leafy shoot. The leafy shoot was put into a beaker of red-coloured solution. After five hours, cross-sections of the shoot were cut starting from the top until red colour appeared in the cut section. The length of the remaining shoot was then measured.



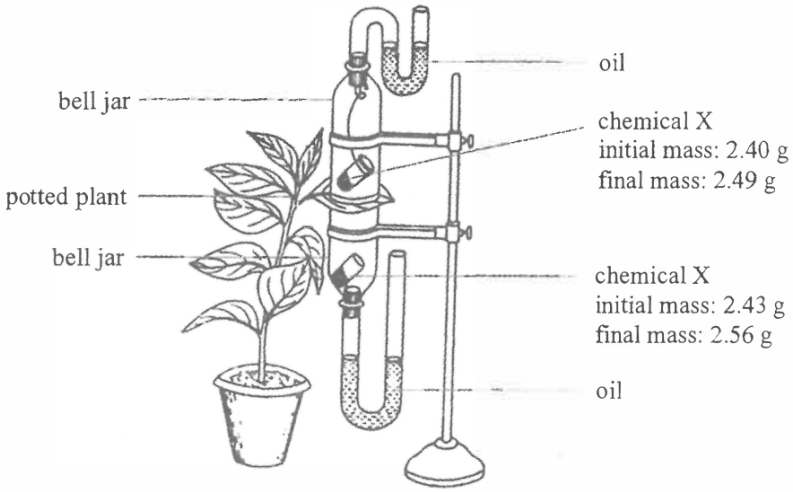
The length of the remaining shoot will be the longest if the experiment is conducted in

A. hot and bright conditions.
B. hot and humid conditions.
C. cold and bright conditions.
D. cold and humid conditions.

10. [HKDSE Biology 2018 Paper 1A Q31]

Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 30 and 31 refer to the set-up below. The set-up consists of two bell jars placed one above the other with the leaf of a potted plant in between. Chemical X was placed into the jars to absorb water vapour. The whole set-up was made air-tight. The masses of chemical X in the two jars were measured at the beginning and after five hours.



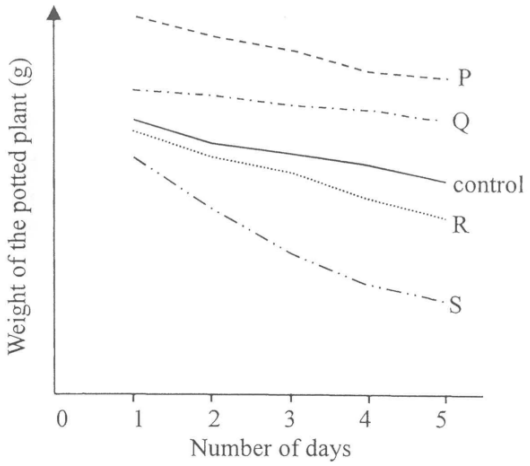
Which of the following conclusions can be drawn from the results?

A. Water absorption by the root is mainly driven by the lower epidermis of the leaf.
B. There are more stomata at the lower epidermis than the upper epidermis of the leaf.
C. The respiration rate is higher than the photosynthetic rate during the experiment.
D. The photosynthetic rate of the upper layer of the leaf is higher than that of the lower layer.

11. [HKDSE Biology 2021 Paper 1A Q30]

Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 30 and 31 refer to the graph below, which shows the effect of environmental conditions on the transpiration rate of a potted plant placed in a small room. The weight of the potted plant was recorded daily at noon for five consecutive days (control experiment). The experiment was repeated by changing one of the environmental conditions: increased light intensity, increased air current, increased relative humidity, or increased temperature.



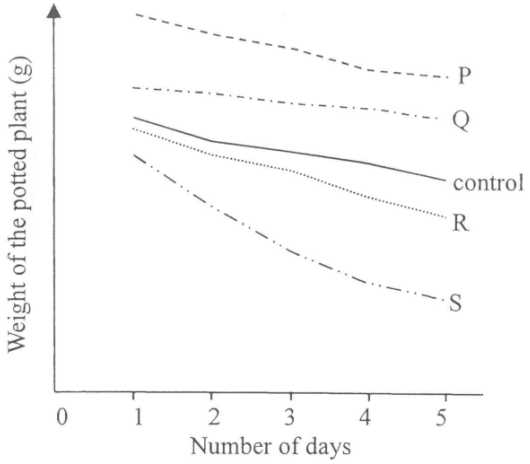
Which of the following lines represents the results with an increased relative humidity?

A. P
B. Q
C. R
D. S

12. [HKDSE Biology 2021 Paper 1A Q31]

Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 30 and 31 refer to the graph below, which shows the effect of environmental conditions on the transpiration rate of a potted plant placed in a small room. The weight of the potted plant was recorded daily at noon for five consecutive days (control experiment). The experiment was repeated by changing one of the environmental conditions: increased light intensity, increased air current, increased relative humidity, or increased temperature.



In the above study, which of the following steps is necessary?

A. Remove any fallen leaves.
B. Wrap the pot with a plastic bag.
C. Water the plant every day in the morning.
D. Smear vaseline on the lower epidermis of the leaves.

13. [HKDSE Biology 2022 Paper 1A Q30]

Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 30 and 31 refer to the investigation below. Diagram I shows a set-up for measuring the transpiration rate of a leafy shoot under different environmental conditions. For each treatment, the experiment was conducted for three hours. Table II shows the initial and final readings of the water level in different treatments.

Diagram I

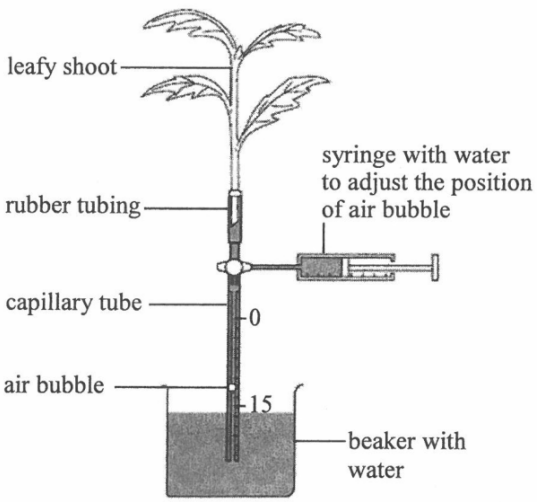


Table II

Treatment	Environmental conditions		Initial reading (cm)	Final reading (cm)
	Light intensity	Humidity		
1	Low	Low	14	7.4
2	Low	High	15	12.5
3	High	Low	15	5.6
4	High	High	14	10.6

In which treatment does the leafy shoot have the highest transpiration rate?

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

14. [HKDSE Biology 2024 Paper 1B Q9]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Hormone X is a plant hormone which is produced in leaves of plant P when water supply is inadequate. A student detached some leaves from plant P and placed them in either water or a 10 μM solution of hormone X. After two hours, the student examined the lower epidermis of the leaves under a light microscope. The photomicrographs below show the images obtained:

Water



10 μM hormone X



(a) Based on the above information, explain the importance of hormone X to the drought tolerance in plant P. (2 marks)

(b) In nature, there are varieties of plant P which produce different amounts of plant hormone X in response to drought stress. The student measured the fresh leaf masses of two different varieties (A and B) of plant P after drought treatment for two weeks. The results are shown in the table below:

Plant variety	*Treatment*	*Leaf fresh mass (g)*
A	Control	0.20
	Drought	0.18
B	Control	0.21
	Drought	0.08

Which variety will have a higher level of hormone X produced? Explain your answer. (3 marks)

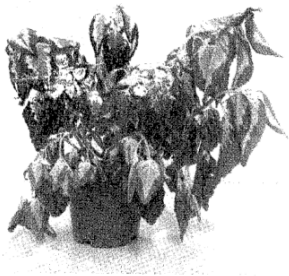
15. [HKDSE Biology 2015 Paper 1B Q9]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

The photographs below show the appearance of the leaves of a well-watered potted plant at 9 am and 1 pm on a sunny day in summer.

Photograph X (9 am)



Photograph Y (1 pm)



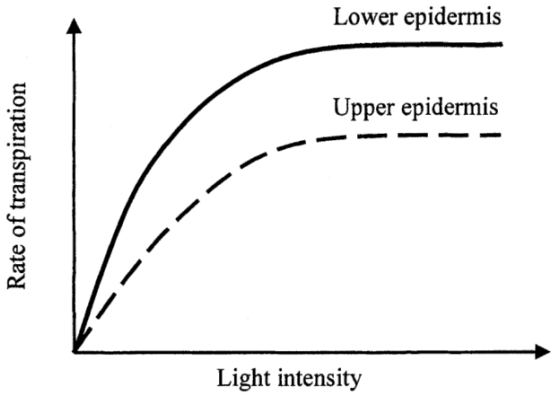
(a) Briefly describe how the appearance of the leaves shown in photograph X is maintained. (2 marks)

(b) Suggest an explanation for the appearance of the leaves at 1 pm (Photograph Y). (3 marks)

(c) With reference to the appearance of the leaves in the two photographs, which one is more effective for photosynthesis? Explain your answer. (4 marks)

16. [HKDSE Biology 2014 Paper 1A Q21]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 20 and 21 refer to the graph below, which shows how the transpiration rates through the upper and lower epidermis of a leaf vary with light intensity:

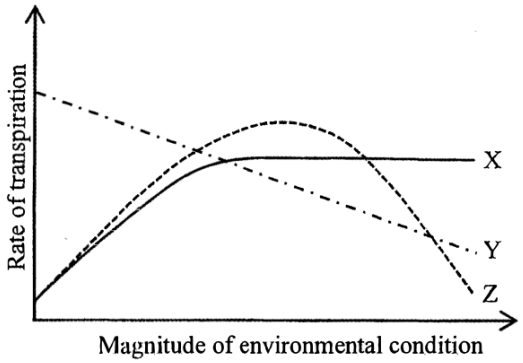


Which of the following methods can be used to measure the rate of transpiration through the upper and lower epidermis of the leaf?

A. Peel the upper epidermis of the leaf and count the number of stomata under a microscope, and then repeat with the lower epidermis.
B. Put the leaf into warm water and then count the number of bubbles that appear on each side of the leaf in a fixed period of time.
C. Shine light on the upper epidermis of the leaf and measure the rate of water absorbed using a bubble potometer, and then repeat with the lower epidermis.
D. Smear the upper epidermis of the leaf with vaseline and measure the rate of water loss using a weight potometer, and then repeat with the lower epidermis.

17. [HKDSE Biology 2016 Paper 1A Q11]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

... The graph below shows the changes of the transpiration rate of a plant under different environmental conditions:



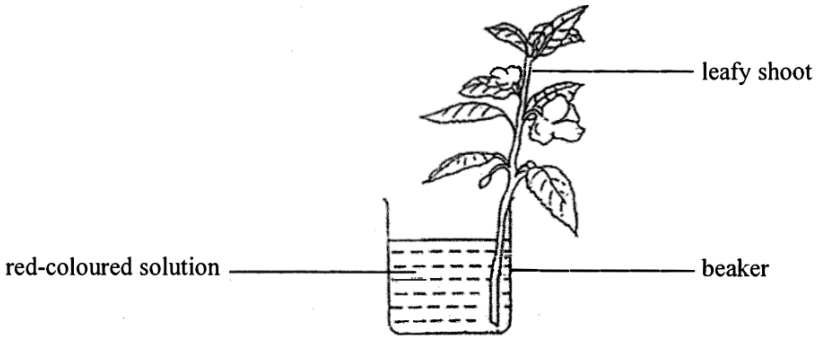
Which of the following correctly matches the environmental conditions represented by X, Y and Z?

	X	***Y***	***Z***
A.	light intensity	wind speed	relative humidity
B.	wind speed	light intensity	relative humidity
C.	relative humidity	light intensity	wind speed
D.	light intensity	relative humidity	wind speed

18. [HKDSE Biology 2017 Paper 1A Q14]

Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 14 to 16 refer to the set-up below, which is used to investigate the effect of environmental factors on the transpiration rate of a leafy shoot. The leafy shoot was put into a beaker of red-coloured solution. After five hours, cross-sections of the shoot were cut starting from the top until red colour appeared in the cut section. The length of the remaining shoot was then measured.



Which of the following step(s) is / are necessary when preparing the set-up?

(1) Smear vaseline onto the lower surface of the leaves.
(2) Add a layer of oil on the surface of the red-coloured solution.
(3) Cut the lower end of the leafy shoot under the red-coloured solution.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

19. [HKDSE Biology 2022 Paper 1A Q31]

Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

Directions: Questions 30 and 31 refer to the investigation below. Diagram I shows a set-up for measuring the transpiration rate of a leafy shoot under different environmental conditions. For each treatment, the experiment was conducted for three hours. Table II shows the initial and final readings of the water level in different treatments.

Diagram I

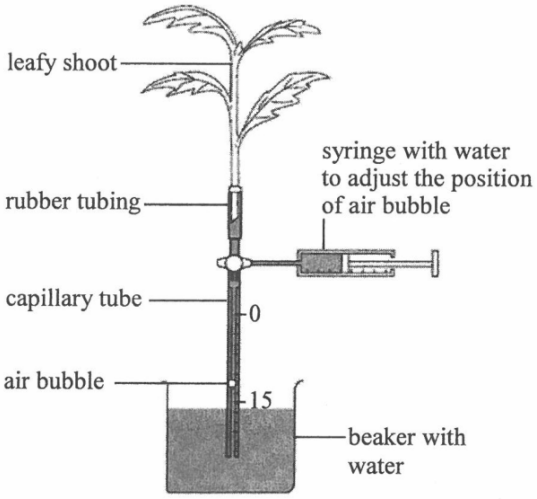


Table II

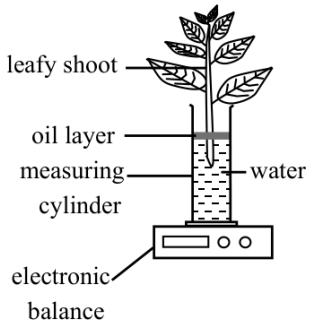
Treatment	Environmental conditions		Initial reading (cm)	Final reading (cm)
	Light intensity	Humidity		
1	Low	Low	14	7.4
2	Low	High	15	12.5
3	High	Low	15	5.6
4	High	High	14	10.6

According to the results of the investigation, which of the following changes in environmental conditions will lead to a greater reduction in the transpiration rate of the leafy shoot?

A. At low humidity condition, adjust the light intensity from high to low.
B. At high humidity condition, adjust the light intensity from high to low.
C. At low light intensity, adjust the humidity from low to high.
D. At high light intensity, adjust the humidity from low to high.

20. [HKDSE Biology Practice Paper Paper 1A Q27]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

The diagram below shows a weight potometer used in an experiment. The leafy shoot was left in the laboratory for 3 hours. The change in the reading of the electronic balance and the change in the volume of water in the measuring cylinder were recorded. The experiment was then repeated under the same environmental conditions with the upper surface of all the leaves of the shoot smeared with vaseline. The results are shown in the following table:



Treatment	Change in the reading of the balance (g)	Change in the volume of water in the measuring cylinder (mL)
(I) Leaves **not** smeared with vaseline	*p*	*r*
(II) Upper surface of all leaves smeared with vaseline	*q*	*s*

Note:
1. *p*, *q*, *r* and *s* are numerical values
2. mass of 1 mL of water = 1 g

From the results of the experiment, we can calculate the amount of

A. water absorbed by the shoot in Treatment (I) from $p - r$.
B. water transpired by the shoot in Treatment (II) from $r - s$.
C. water retained by the shoot in Treatment (II) from $s - q$.
D. water transpired by the lower surface of the leaves of the shoot in 3 hours from $p - q$.

21. [HKDSE Biology Practice Paper Paper 1A Q28]
Hint: Distinguish water uptake from water loss, then use gradients to explain changes.

The photographs below show the appearances of a flower at different times of a day:


8:00 am


2:00 pm

With reference to the appearances of the flower at the times shown, which of the following can be concluded?

(1) The major support in the flower stalk is provided by the turgidity of the cells.
(2) The rate of water uptake of the flower is higher than its rate of transpiration at 8:00 am.
(3) The rate of water uptake of the flower is lower than its rate of transpiration at 2:00 pm.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

III.b Essential life processes in animals

First read the explanations and diagrams in Concept III.b, then work through the question types in this section. Each worked example retains the complete original question and explanation. The subsequent exercises require progressively more integration of information, based on the demands of the whole question.

Type 1 Calculate energy balance from nutrient composition

Degree of integration ★★☆☆☆

Key ideas

① If a food portion contains 10 g carbohydrate and 4 g fat, supplying 17 and 37 kJ per gram respectively, its energy is 10 × 17 + 4 × 37 = 318 kJ. Use the same portion size or per-100-g basis when comparing foods.

② An increase in body stores depends on the long-term difference between intake and expenditure. Dietary fibre's functions cannot all be converted into absorbable, energy-supplying nutrients.

How to recognise the problem Identify per portion, per 100 g or per gram. Make units consistent, multiply each contribution and add them, then compare with activity expenditure.

Example 1 [HKDSE Biology 2022 Paper 1B Q1]

The following are some life processes in humans:

Egestion (A)
Excretion (B)
Feeding (C)
Growth (D)
Respiration (E)

(a) Use the letters to construct an equation showing the relationship of these processes in energy flow. (1 mark)

□ = □ − □ − □ − □

(b) In terms of the energy value of each process, explain why the D/C ratio for vegetarians is lower than that for non-vegetarians. (3 marks)

Solution a; original allocation: 1 mark(s)

D = C − A − B − E.

C is energy taken in with food. Subtract energy lost in faeces through egestion, A; in metabolic wastes through excretion, B; and used or lost through respiration, E. The remainder is available for growth, D. The three subtractions can be written in any order.

b; original allocation: 3 mark(s)

A vegetarian diet contains more indigestible dietary fibre, so more ingested energy leaves in faeces and the fraction available for growth, D/C, is lower.

Humans cannot digest cellulose. Dietary fibre such as cellulose in plant foods is not fully digested and absorbed but is removed by egestion. For the same ingested energy C, a greater fraction is lost through A, leaving a smaller fraction D for growth. Link more fibre to indigestibility and energy lost in faeces to explain D/C fully.

Examiner's comment (source page(s) 3)

Compare dietary-fibre content and energy lost through egestion in the two diets when discussing D/C. Vegetarians are not producers, and simply stating that vegetarian food supplies less energy is insufficient.

Marking reference: HKDSE Biology 2022 Paper 1B Q1, official marking scheme, source page(s) 3.

Method: Use a consistent per-portion or per-gram basis, then calculate each energy contribution.

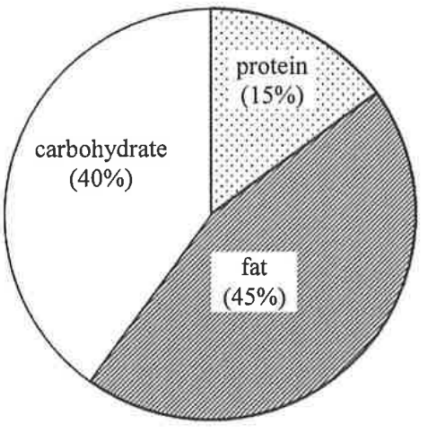
Practice

1. [HKDSE Biology 2019 Paper 1A Q26]

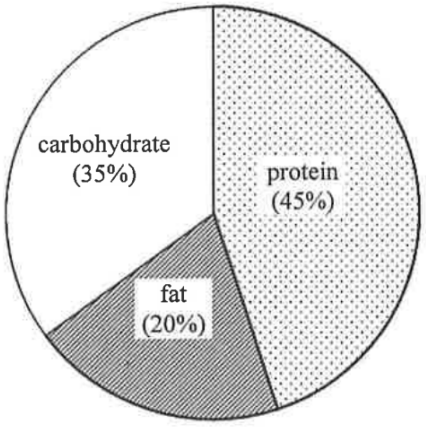
Hint: Use a consistent per-portion or per-gram basis, then calculate each energy contribution.

The following charts show the composition of four different foodstuffs. Which foodstuff yields the highest amount of energy per gram?

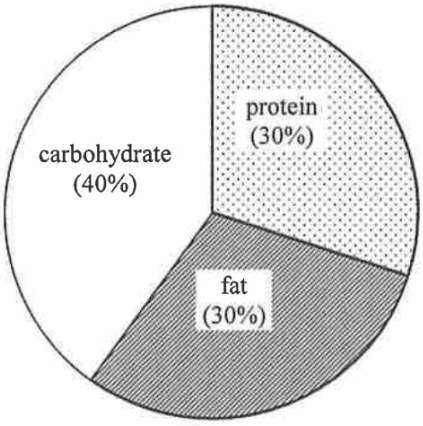
A.



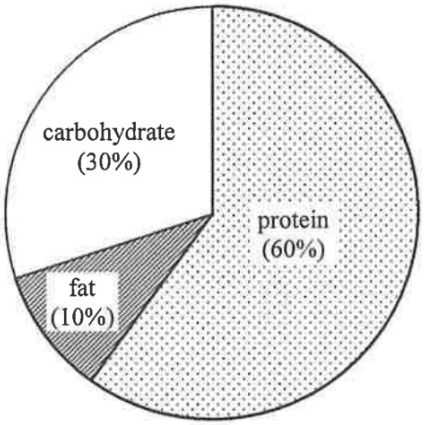
B.



C.



D.



2. [HKDSE Biology 2016 Paper 1A Q5]

Hint: Use a consistent per-portion or per-gram basis, then calculate each energy contribution.

Directions: Questions 5 and 6 refer to the diagram below, which shows the nutrition label of a food product:

Nutrition Information	Per serving
Energy	62 Kcal
Protein	3.1 g
Total fat	3.5 g
- Saturated fat	2.4 g
- Trans fat	0 g
Total carbohydrate	4.6 g
- Dietary fibre	0 g
- Sugars	4.6 g
Sodium	44 mg
Calcium	110 mg

Which of the following food substances provides most of the energy content in this food product?

A. fat
B. protein
C. sodium
D. carbohydrate

3. [HKDSE Biology 2016 Paper 1A Q6]
Hint: Use a consistent per-portion or per-gram basis, then calculate each energy contribution.

Directions: Questions 5 and 6 refer to the diagram below, which shows the nutrition label of a food product:

Nutrition Information	Per serving
Energy	62 Kcal
Protein	3.1 g
Total fat	3.5 g
- Saturated fat	2.4 g
- Trans fat	0 g
Total carbohydrate	4.6 g
- Dietary fibre	0 g
- Sugars	4.6 g
Sodium	44 mg
Calcium	110 mg

The food product bearing this nutrition label is most likely to be

A. milk.
B. bread.
C. sausages.
D. potato chips.

Type 2 Explain physical digestion using dentition and mouth structure

Degree of integration ★★☆☆☆

Key ideas

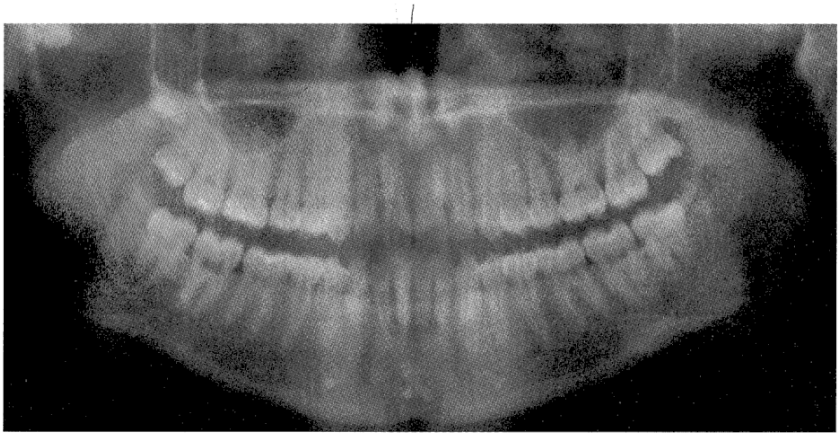
① A dental formula usually gives the numbers of each tooth type on one side of the upper and lower jaws. Account for both sides when calculating the whole mouth, according to the notation given. Chewing reduces food size and increases the total surface area accessible to digestive enzymes; it does not directly hydrolyse starch molecules.

② The outer and inner parts of a tooth differ in composition and activity. Hard enamel does not imply that the entire tooth lacks living tissue.

How to recognise the problem Check whether the diagram shows deciduous or permanent teeth and which sides are included, then count. For chewing, connect size, surface area and enzyme contact.

Example 1 [HKDSE Biology 2014 Paper 1A Q24]

Which of the following dental formulae best represents the dentition shown in the photograph of the X-ray?



A. $\frac{2123}{2123}$

B. $\frac{2132}{2132}$

C. $\frac{3212}{3212}$

D. $\frac{2312}{2312}$

Solution Answer: A

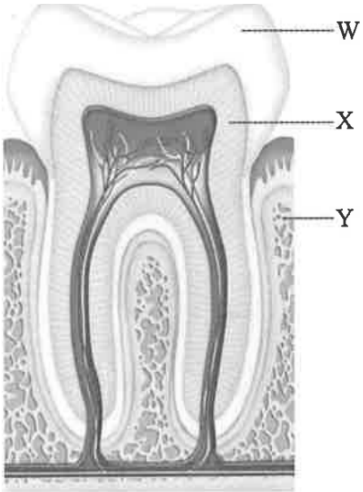
The photograph shows adult dentition. Each half of the upper and lower jaws contains, in order, 2 incisors, 1 canine, 2 premolars and 3 molars, giving the dental formula 2123/2123. A dental formula records only half of each jaw, not the total number in the whole upper jaw.

Method: Confirm the dental formula's scope before counting or explaining chewing.

Marking reference: HKDSE Biology 2014 Paper 1A Q24, official marking scheme, source page(s) 1.

Example 2 [HKDSE Biology 2019 Paper 1A Q23]

Directions: Questions 23 and 24 refer to the diagram below, which shows a section of one type of tooth and its associated structures:



Which of the following are living tissues that contain a large amount of calcium salt?

A. W and X
B. W and Y
C. X and Y
D. W, X and Y

Solution **Answer: C**

X is dentine and Y is jawbone. Both are living tissues containing calcium salts. W, enamel, contains abundant minerals but is not living tissue. Therefore, choose X and Y, giving C.

Marking reference: HKDSE Biology 2019 Paper 1A Q23, official marking scheme, source page(s) 1.

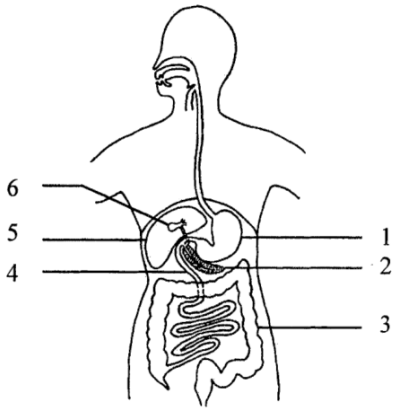
✓ *Method: Confirm the dental formula's scope before counting or explaining chewing.*

Practice

1. [HKDSE Biology 2014 Paper 1A Q25]

⟵ *Hint: Confirm the dental formula's scope before counting or explaining chewing.*

Directions: Questions 25 and 26 refer to the diagram below, which shows the human digestive system:



Physical digestion takes place at

A. 1 and 3.
B. 1 and 4.
C. 3 and 4.
D. 1, 3 and 4.

2. [HKDSE Biology 2018 Paper 1A Q18]

⟵ *Hint: Confirm the dental formula's scope before counting or explaining chewing.*

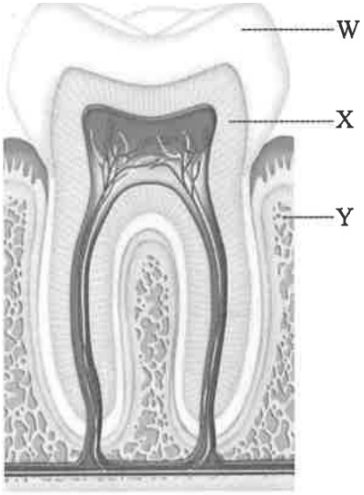
Some people claim that we should chew food for a longer time before swallowing. Which of the following statements about this claim is ***incorrect***?

A. This stimulates the secretion of saliva.
B. This moistens the food for easier swallowing.
C. This provides enough time for digestion of starch into glucose.
D. This increases the surface area of the food for chemical digestion.

3. [HKDSE Biology 2019 Paper 1A Q24]

⟵ *Hint: Confirm the dental formula's scope before counting or explaining chewing.*

Directions: Questions 23 and 24 refer to the diagram below, which shows a section of one type of tooth and its associated structures:

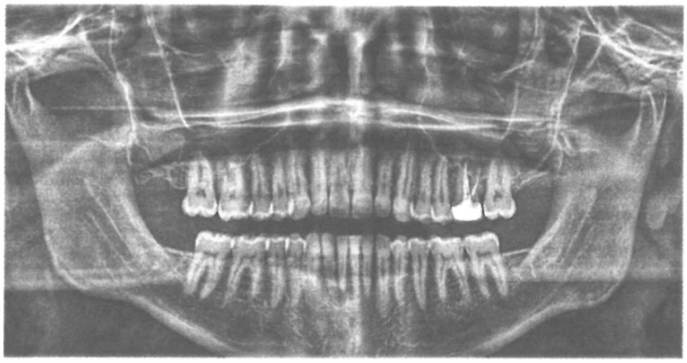


The number of this type of tooth in the milk dentition is

A. 0.
B. 4.
C. 8.
D. 12.

4. [HKDSE Biology 2018 Paper 1A Q23]
Hint: Confirm the dental formula's scope before counting or explaining chewing.

The following picture shows an X-ray photograph of the dentition of a person:



Which of the following dental formulae correctly describes the dentition in the above photograph?

A. $\frac{2212}{2212}$
B. $\frac{2122}{2122}$
C. $\frac{2131}{2131}$
D. $\frac{2113}{2113}$

Type 3 Match digestive juices, organs and chemical digestion

Degree of integration ★★★☆☆

Key ideas

① The liver makes bile and the gall bladder stores it. Bile disperses large fat droplets, increasing the surface area for lipase. It contains no enzyme catalysing fat hydrolysis. Digestive enzymes secreted by the pancreas enter the small intestine, so an enzyme's production and action sites may differ.

② Use any pH or food-test information to check the conditions in which a substrate is broken down.

How to recognise the problem List substrate, products, catalyst, secretion source and site of action. With a blocked duct, trace which fluid cannot reach its destination.

Example 1 [HKDSE Biology 2016 Paper 1A Q7]

Which of the following organs produces digestive juice that ***does not*** contain enzymes?

A. liver
B. mouth
C. stomach
D. pancreas

Solution **Answer: A**

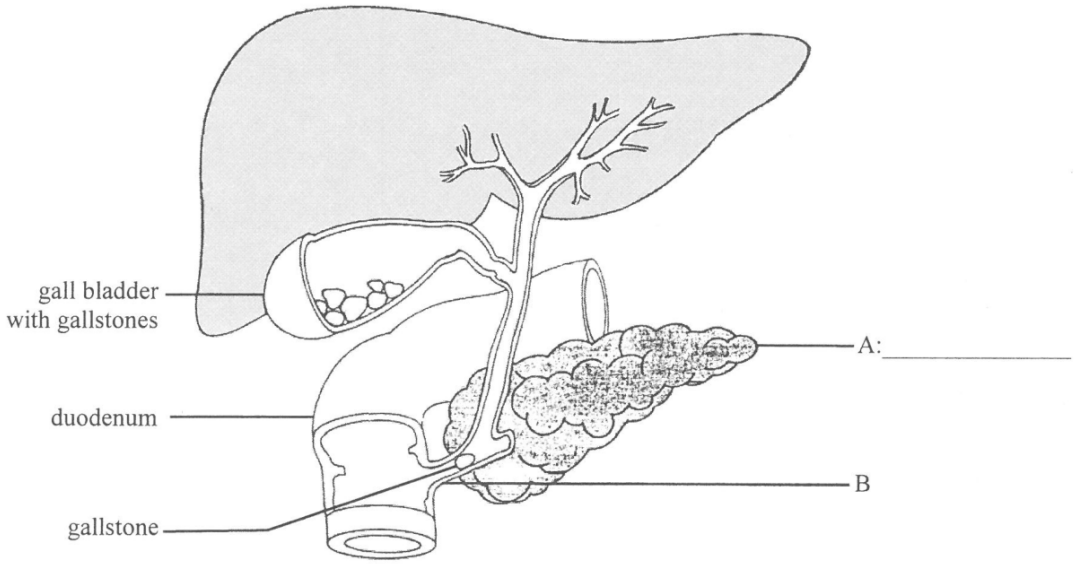
The liver produces bile. Bile salts emulsify large fat droplets into small ones, increasing the total surface area available for lipase, but bile itself contains no digestive enzymes. Choose A. The relevant secretions in the mouth, stomach and pancreas contain amylase, pepsin and various digestive enzymes respectively.

Marking reference: HKDSE Biology 2016 Paper 1A Q7, official marking scheme, source page(s) 1.

Method: Match substrates, products, digestive juices and locations.

Example 2 [HKDSE Biology 2021 Paper 1B Q1]

The diagram below shows the presence of gallstones in some parts of the human digestive system:



(a) Label structure A. (1 mark)

(b) With reference to ***two*** components of the secretion released from duct B, explain how the condition shown in the above diagram would lead to a decrease in the rate of fat digestion. (4 marks)

Solution a; original allocation: 1 mark(s)

A is the pancreas.

Follow the label line to the digestive gland behind the stomach that drains into the duodenum. Do not mistake the associated gall bladder for A.

b; original allocation: 4 mark(s)

Less bile salt supply reduces fat emulsification. Less lipase supply reduces the rate of chemical digestion of fat.

B lies at the common outlet after the bile and pancreatic ducts join, so blockage affects both secretions. Bile salts disperse fat into small droplets, increasing the total surface area accessible to lipase; fewer bile salts weaken this step. Less pancreatic lipase reaches the small intestine, reducing the enzyme available to catalyse fat hydrolysis. Sodium hydrogencarbonate is another acceptable component: reduced supply makes it harder to maintain a suitable intestinal pH for digestive enzymes, also slowing fat digestion. Each component must be linked to its effect on digestion.

✓ Method: Match substrates, products, digestive juices and locations.

Examiner's comment (source page(s) 3)

Bile and pancreatic juice are names of secretions. If components are requested, specify bile salts, hydrogencarbonate or lipase, and connect them to emulsification, acid neutralisation or fat digestion. 'Bile' cannot replace a specific component.

Marking reference: HKDSE Biology 2021 Paper 1B Q1, official marking scheme, source page(s) 2.

Example 3 [HKDSE Biology 2012 Paper 1B Q10]

Average initial body weight (kg)	4.90	4.46	4.65	4.52
Average final body weight (kg)	7.15	7.36	7.81	7.92
Average dry weight of fat in the faeces (%)	6.52	5.81	4.65	3.78

(a) How do bile salts help with fat digestion? (2 marks)

(b) What was the effect of bile supplementation on fat digestion in the above investigation? Explain your answer. (2 marks)

(c) Suggest why it is important to monitor the body weight of the piglets in this investigation. (1 mark)

(d) Suggest an *in vitro* experimental method that allows a direct measurement of the digestion of fat in a laboratory. (3 marks)

Solution a; original allocation: 2 mark(s)

Method: Match substrates, products, digestive juices and locations.

Bile salts emulsify large fat globules into small droplets, increasing the total surface area in contact with lipase and allowing faster digestion.

Emulsification is physical dispersion, not hydrolysis of fat molecules. Lipase performs the hydrolysis. Write the connection: smaller droplets → larger total surface area → greater access for the enzyme.

b; original allocation: 2 mark(s)

As bile supplementation increases from 0 to 0.45%, the percentage of fat in faecal dry mass falls from 6.52% to 3.78%, supporting greater fat digestion and absorption in the alimentary canal.

State the direction of change or quote the values before explaining their biological meaning. Less faecal fat does not mean that bile has been converted to fat; it means less fat remains unabsorbed and is eventually egested.

c; original allocation: 1 mark(s)

Measuring body mass checks whether added bile impairs growth or is associated with improved growth and nutrient absorption.

This gives the whole animal's growth outcome, supplementing the digestive outcome indicated by faecal fat. Account for initial body mass by calculating each group's mass gain.

d; original allocation: 3 mark(s)

Add equal amounts of lipase to equal volumes of fat emulsion. Compare a group with bile salts against one without, keeping temperature and initial pH constant. Use a pH probe or indicator to measure how quickly pH falls. A faster fall in the bile-salt group supports faster fat digestion.

Hydrolysis releases fatty acids, so decreasing pH can indicate the digestion rate. The experiment needs a fat substrate, enzyme, measurable dependent variable and predicted result. Merely observing whether digestion is 'good' is insufficient. The main credited points are a suitable digestion system, pH measurement and its connection to fatty-acid production.

Examiner's comment (source page(s) 2)

An explanation of emulsification must mention formation of small fat droplets. An in-vitro experiment should not continue to use a whole piglet or intestine as the test system, and should specify a quantitative indicator.

Marking reference: HKDSE Biology 2012 Paper 1B Q10, official marking scheme, source page(s) 4, 5.

Practice

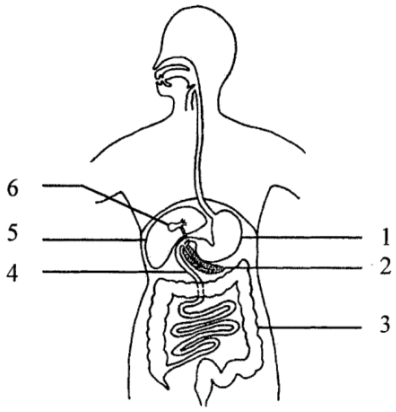
1. [HKDSE Biology 2012 Paper 1A Q34]
⟵ *Hint: Match substrates, products, digestive juices and locations.*

After consuming a boiled egg, chemical digestion begins in the

A. mouth.
B. oesophagus.
C. stomach.
D. small intestine.

2. [HKDSE Biology 2014 Paper 1A Q26]
⟵ *Hint: Match substrates, products, digestive juices and locations.*

Directions: Questions 25 and 26 refer to the diagram below, which shows the human digestive system:



Which of the following structures are responsible for producing digestive juices that help the digestion of fat?

A. 2 and 5
B. 2 and 6
C. 5 and 6
D. 2, 5 and 6

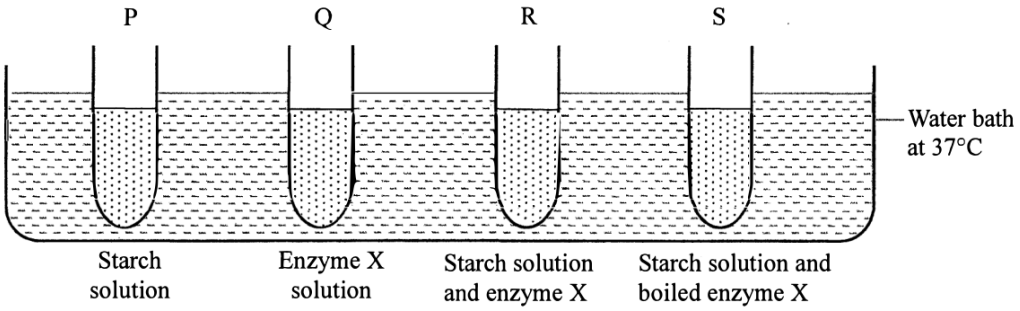
3. [HKDSE Biology 2015 Paper 1A Q8]
⟵ *Hint: Match substrates, products, digestive juices and locations.*

After eating a hamburger, chemical digestion begins in the

A. mouth cavity.
B. oesophagus.
C. stomach.
D. small intestine.

4. [HKDSE Biology 2017 Paper 1A Q2]
⟵ Hint: Match substrates, products, digestive juices and locations.

Directions: Questions 2 to 4 refer to the diagram below, which shows four test tubes prepared by a student to investigate the action of a starch-digesting enzyme X:



In which of the following regions of the human alimentary canal can enzyme X be found?

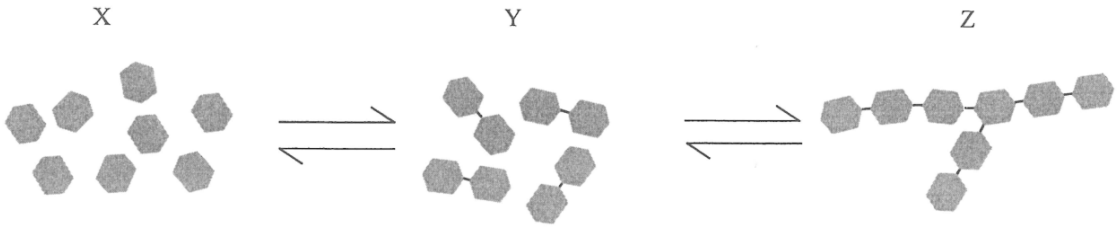
(1) mouth cavity
(2) stomach
(3) small intestine

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

5. [HKDSE Biology 2024 Paper 1A Q20]
⟵ Hint: Match substrates, products, digestive juices and locations.

Directions: Questions 19 and 20 refer to the diagram below, which shows interconversion of three types of compounds catalysed by enzymes in a living organism:

Key: ⬢ six-carbon sugars



If the organism is a human, which of the following statements are correct?

(1) Conversion of Z to Y takes place in the stomach.
(2) Conversion of X to Z takes place in the liver.
(3) Z is present in muscle.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

6. [HKDSE Biology 2024 Paper 1A Q21]
⟵ Hint: Match substrates, products, digestive juices and locations.

Patients who have had their gall bladder removed should eat less oily food. This is because they are ***unable*** to

A. store bile.
B. store lipase.
C. produce bile.
D. produce lipase.

7. [HKDSE Biology Sample Paper Paper 1A Q12]
← Hint: Match substrates, products, digestive juices and locations.

Which of the following secretions are alkaline and contain digestive enzymes?

A. bile and saliva
B. saliva and gastric juice
C. bile and pancreatic juice
D. pancreatic juice and intestinal juice

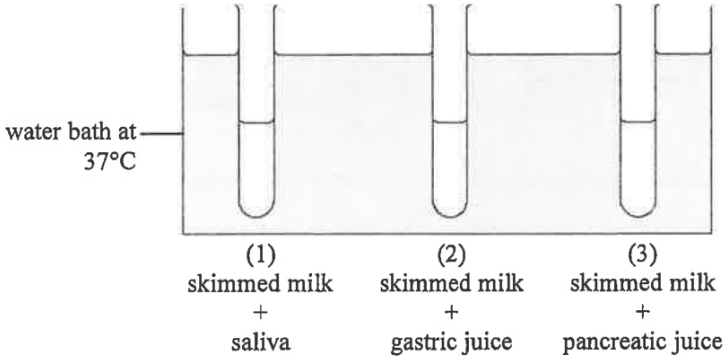
8. [HKDSE Biology 2015 Paper 1A Q7]
← Hint: Match substrates, products, digestive juices and locations.

Which of the following combinations correctly matches the gland, the enzyme secreted and the optimum pH of the enzyme?

	Gland	*Enzyme*	*Optimum pH*
A.	gastric gland	carbohydrase	2
B.	liver	lipase	8
C.	salivary gland	amylase	11
D.	pancreas	protease	11

9. [HKDSE Biology 2019 Paper 1A Q25]
← Hint: Match substrates, products, digestive juices and locations.

The diagram below shows a water bath with three test-tubes containing different mixtures:

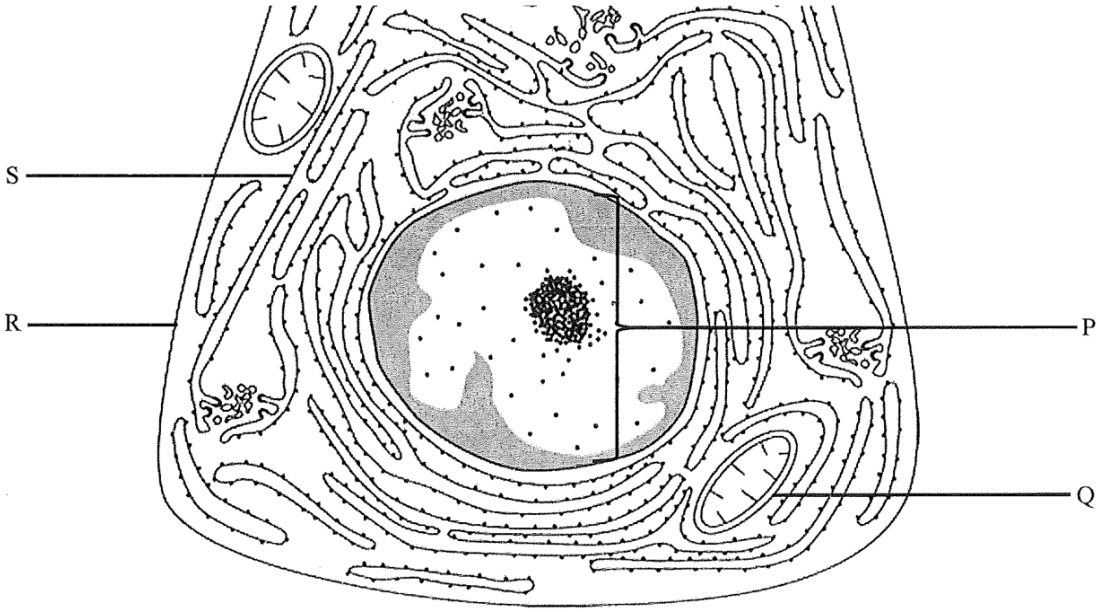


Chemical digestion of food takes place in test-tubes

A. (1) and (2) only.
B. (1) and (3) only.
C. (2) and (3) only.
D. (1), (2) and (3).

10. [HKDSE Biology 2023 Paper 1A Q3]
Hint: Match substrates, products, digestive juices and locations.

Directions: Questions 1 to 3 refer to the schematic diagram below, which shows part of a pancreas cell:



The radioactivity is later detected in the content of the small intestine. Which of the following substances is / are responsible for the presence of the radioactivity?

(1) protease
(2) glucagon
(3) sodium hydrogencarbonate

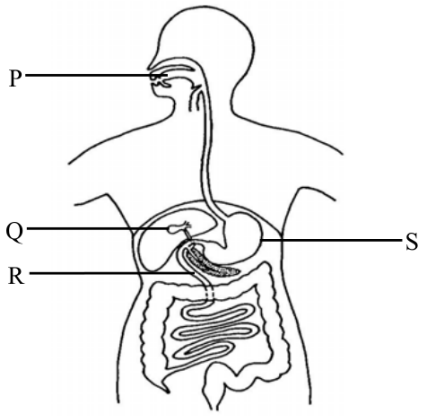
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

11. [HKDSE Biology Practice Paper Paper 1A Q34]
Hint: Match substrates, products, digestive juices and locations.

The following shows a table listing the results of the food tests for a piece of food and a diagram of the human digestive system:

Food test	Result
Albustix paper	+
Benedict's test	+
Iodine test	−
Grease spot test	+

Key:
\+ positive result
− negative result



In which of the labelled parts will this food be chemically digested?

A. P and S only
B. Q and R only
C. R and S only
D. Q, R and S only

12. [HKDSE Biology 2021 Paper 1B Q10]
Hint: Match substrates, products, digestive juices and locations.

In humans, breast milk provides not only nutrients but also protective effects to infants. Recently, scientists discovered a new constituent of breast milk: short RNA fragments enclosed in vesicles. Scientists have very diverse views about the roles of these short RNA fragments. The following are two of the hypotheses:

Hypothesis 1: the short RNA fragments serve as food particles
Hypothesis 2: the short RNA fragments regulate gene expression in infants

(a) To test Hypothesis 1, scientists performed an experiment of *in vitro* digestion of breast milk. The method is shown below:

Method of *in vitro* digestion with 20 mL of fresh breast milk

Step 1	Addition of hydrochloric acid solution
Step 2	Addition of enzyme mixture 1
Step 3	Incubation at 37°C for 20 minutes
Step 4	Addition of sodium hydrogen carbonate solution
Step 5	Addition of enzyme mixture 2
Step 6	Incubation at 37°C for 30 minutes
Step 7	Incubation at 85°C for 3 minutes
Step 8	Measurement of the level of short RNA fragments and nucleotides

(i) With reference to the digestion in the human body, what is the importance of Step 1 and Step 4 to the experimental design of this *in vitro* experiment? (3 marks)

(ii) What is the purpose of Step 7? (1 mark)

(iii) After the *in vitro* digestion, the level of short RNA fragments in the reaction mixture was similar to that of fresh breast milk and no nucleotides were detected. Explain why the results disprove Hypothesis 1. (2 marks)

(b) Scientists will ask scientific questions when designing experiments to test Hypothesis 2. Suggest ***one*** example of these scientific questions. (1 mark)

Type 4 Track nutrient absorption using adaptations of the small intestine

Degree of integration ★★☆☆☆

Key ideas

① Villi and microvilli increase absorptive area. Thin epithelium reduces travel distance, while blood or lymph flow carries absorbed substances away. Glucose and amino acids mainly enter the blood. Products of long-chain lipid digestion are processed again in epithelial cells and mainly leave through lacteals.

② The small intestine absorbs the most water, while the large intestine still has a water-absorption function; both statements can be true.

How to recognise the problem Identify the nutrient before choosing the capillary or lacteal route. Connect adaptations to surface area, distance or maintenance of a gradient.

Example 1 [HKDSE Biology 2013 Paper 1B Q3]

Figure A shows a section of part of the human alimentary canal. Figure B shows another section of the same part with blood vessels stained.

Figure A

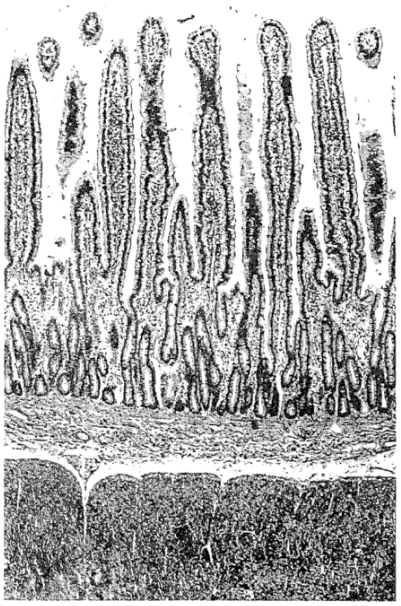
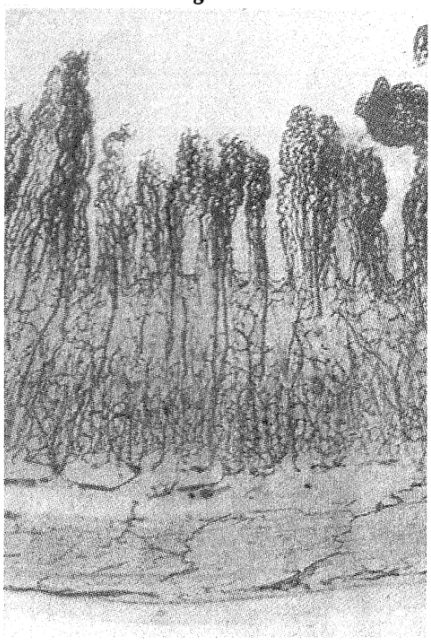


Figure B



(a) Which part of the alimentary canal is shown in the figures? Support your answer with evidence. (2 marks)

(b) For each of the above figures, describe ***one*** observable feature and explain how it is related to the functioning of this part of the alimentary canal.

Figure A: (2 marks)

Figure B: (3 marks)

Solution a; original allocation: 2 mark(s)

The small intestine, or ileum, because the inner lining bears numerous villi.

Give both the location and visible photographic evidence. Do not confuse intestinal villi with gastric glands or respiratory cilia.

b, Figure A; original allocation: 2 mark(s)

Numerous finger-like villi on the inner lining increase the surface area for absorption of digested nutrients.

Method: Identify the nutrient, then trace absorption and transport.

Describe the visible form before linking it to absorption. The image is not magnified enough to identify microvilli, so do not replace visible evidence with a structure that is not shown.

b, Figure B; original allocation: 3 mark(s)

A dense capillary network in each villus rapidly carries absorbed nutrients away, maintaining a steep concentration gradient between the intestinal lumen and blood and allowing continued absorption.

The three linked steps are abundant blood vessels, rapid removal and maintenance of the gradient. 'A good blood supply improves absorption' does not fully explain the mechanism.

Examiner's comment (source page(s) 2)

Link the dense capillary network to rapid removal of nutrients to explain maintenance of a steep concentration gradient.

Marking reference: HKDSE Biology 2013 Paper 1B Q3, official marking scheme, source page(s) 3.

Example 2 [HKDSE Biology 2015 Paper 1A Q10]

After absorption in the small intestine, most fat is first transported to the

A. large intestine.
B. pancreas.
C. heart.
D. liver.

Solution Answer: C

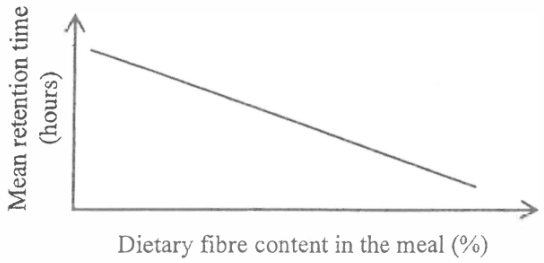
Most fat digestion products are reassembled into fat within the small-intestinal epithelium, packaged and passed into lacteals. They then return through lymph to venous blood and travel towards the heart. This differs from the route of most glucose, which first reaches the liver through the hepatic portal vein. Choose C.

Method: Identify the nutrient, then trace absorption and transport.

Marking reference: HKDSE Biology 2015 Paper 1A Q10, official marking scheme, source page(s) 1.

Example 3 [HKDSE Biology 2018 Paper 1A Q25]

The graph below shows the relationship between the dietary fibre content of a meal and the mean retention time (i.e. the duration for which the undigested materials stay in the large intestine) in the human body:



Which of the following can be deduced from the graph?

A. Meals with more dietary fibre can increase the bulk of the faeces.
B. Meals with more dietary fibre can hold more water, and so soften faeces better.
C. Meals with less dietary fibre have more nutrients and a longer time is required for complete absorption.
D. Meals with less dietary fibre result in harder faeces due to an increased time for water absorption.

Solution Reading the question and choosing a method

State the relationship actually shown, then connect it to the known function of the organ.

Method: Identify the nutrient, then trace absorption and transport.

Answer: D

The graph shows that a lower proportion of dietary fibre is associated with a longer average residence time of undigested material in the large intestine. The large intestine absorbs water, so a longer stay allows more time for absorption, producing drier, harder faeces. This matches D. Faecal volume and the water-retaining effect of fibre in A and B are not variables measured directly in this graph. C treats the residence time of undigested material as the time needed for nutrient absorption, failing to connect the result to water absorption in the large intestine. Choose D.

Common error

Selecting a generally plausible health statement without using the relationship between the variables shown in the graph.

Marking reference: HKDSE Biology 2018 Paper 1A Q25, official marking scheme, source page(s) 1.

Practice

1. [HKDSE Biology 2013 Paper 1A Q26]

Hint: Identify the nutrient, then trace absorption and transport.

Which of the following nutrients enter the epithelial cells of the small intestine mainly by simple diffusion?

A. amino acids
B. fatty acids
C. monosaccharides
D. nucleotides

2. [HKDSE Biology 2021 Paper 1A Q19]

Hint: Identify the nutrient, then trace absorption and transport.

Which of the following segments of the alimentary canal absorbs the largest amount of water?

A. the oesophagus
B. the stomach
C. the small intestine
D. the large intestine

3. [HKDSE Biology 2023 Paper 1A Q18]

Hint: Identify the nutrient, then trace absorption and transport.

Which of the following features of the small intestine allow it to be the major site of food absorption?

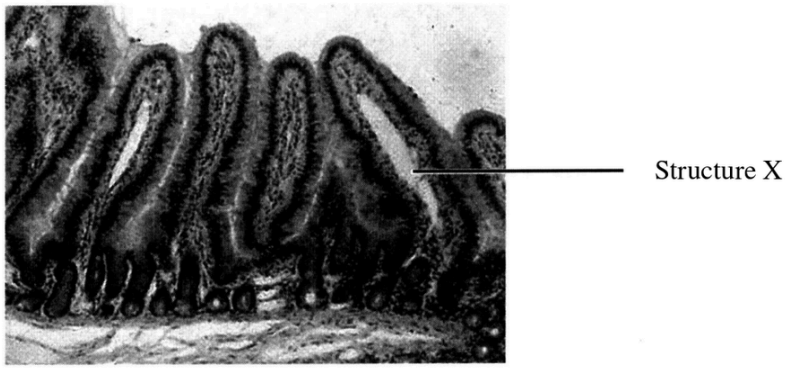
(1) It is long.
(2) Its inner wall is highly folded.
(3) It secretes different kinds of enzymes.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

4. [HKDSE Biology 2025 Paper 1A Q5 (English translation)]

Hint: Identify the nutrient, then trace absorption and transport.

Directions: Refer to the photomicrograph below to answer Questions 5 and 6. It shows a section of the inner wall of the human alimentary canal.



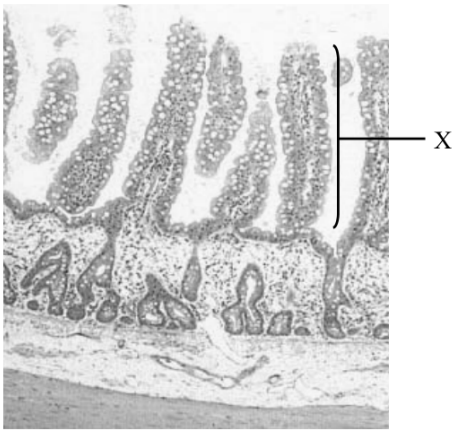
In which part(s) of the alimentary canal can the section above be found?

(1) Colon
(2) Duodenum
(3) Ileum

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

5. [HKDSE Biology Practice Paper Paper 1A Q29]
Hint: Identify the nutrient, then trace absorption and transport.

The following photograph shows a section of a part of the human intestine:



Which of the following is/are the function(s) of X?

(1) to move the food along the intestine by peristalsis
(2) to secrete enzymes for fat digestion
(3) to absorb digested food

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

6. [HKDSE Biology 2015 Paper 1A Q9]
Hint: Identify the nutrient, then trace absorption and transport.

Which of the following combinations correctly describes the absorption of water in the alimentary canal?

	Occurs mostly in	*Major reason*
A.	ileum	it is the longest part of the digestive tract
B.	ileum	most digested food is absorbed in this region
C.	large intestine	its function is water absorption
D.	large intestine	absorption of food has completed in this region

7. [HKDSE Biology 2021 Paper 1A Q7]
Hint: Identify the nutrient, then trace absorption and transport.

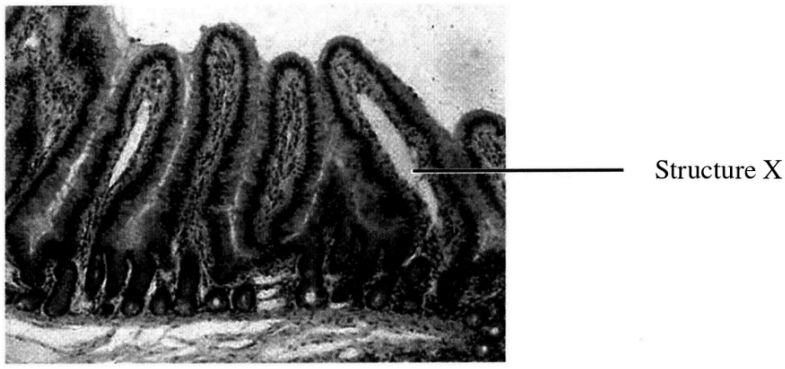
Which of the following correctly describe the absorption of amino acids in the small intestine?

(1) Amino acids are absorbed into lacteals.
(2) The absorption is assisted by membrane proteins.
(3) Amino acids can move along or against a concentration gradient.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

8. [HKDSE Biology 2025 Paper 1A Q6 (English translation)]
⟵ Hint: Identify the nutrient, then trace absorption and transport.

Directions: Refer to the photomicrograph below to answer Questions 5 and 6. It shows a section of the inner wall of the human alimentary canal.



Which of the following substances can be absorbed directly into structure X?

A. Amino acids
B. Glycerol
C. Vitamin A
D. Vitamin C

9. [HKDSE Biology 2025 Paper 1A Q7 (English translation)]
⟵ Hint: Identify the nutrient, then trace absorption and transport.

Radioactive fatty acids are introduced into the lumen of a person's small intestine. Which of the following correctly shows the order in which radioactivity appears from the small intestine to the heart?

A. Capillaries in villi → lymphatic vessels → vena cava → right atrium
B. Capillaries in villi → hepatic portal vein → liver → hepatic vein → vena cava → right atrium
C. Lacteals in villi → lymphatic vessels → vena cava → right atrium
D. Lacteals in villi → hepatic portal vein → liver → hepatic vein → vena cava → right atrium

Type 5 Connect blood vessels, tissue fluid and lymph in exchange pathways

Degree of integration ★★★★☆

Key ideas

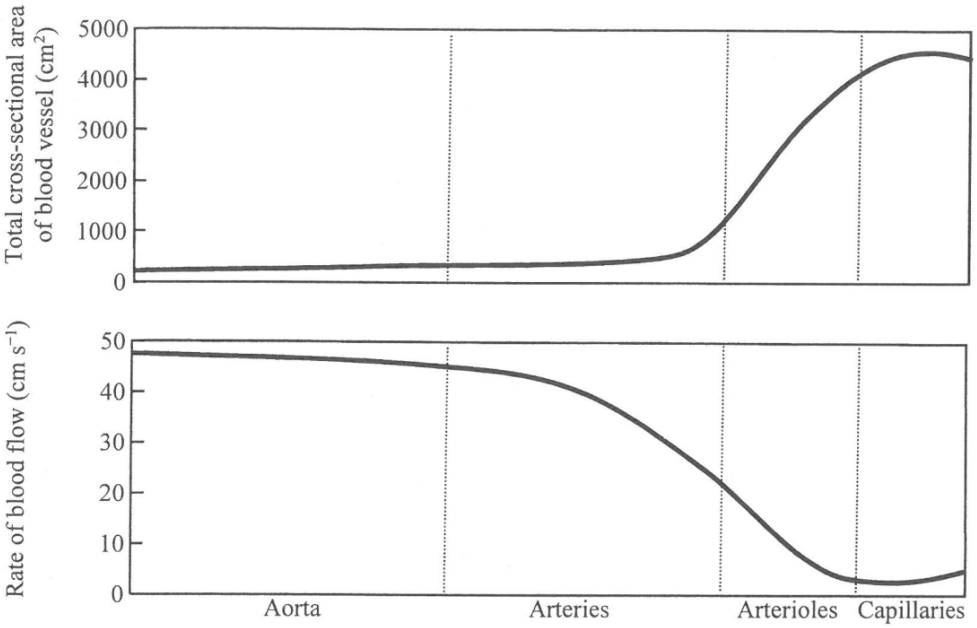
① Higher hydrostatic pressure at the arterial end of capillaries can drive fluid out to form tissue fluid. Some returns, while the remainder enters lymph vessels and eventually returns to veins. A capillary bed contains many parallel vessels with a large total cross-sectional area, allowing slower blood flow. The small lumen of one vessel alone does not explain the velocity throughout this region.

② Lymphatic valves and compression by surrounding muscles assist one-way return.

How to recognise the problem Label blood, tissue fluid and lymph separately, then explain pressure, exchange surfaces and return for each arrow. When assessing claims, check for actual changes in fat or energy balance.

Example 1 [HKDSE Biology 2021 Paper 1B Q3]

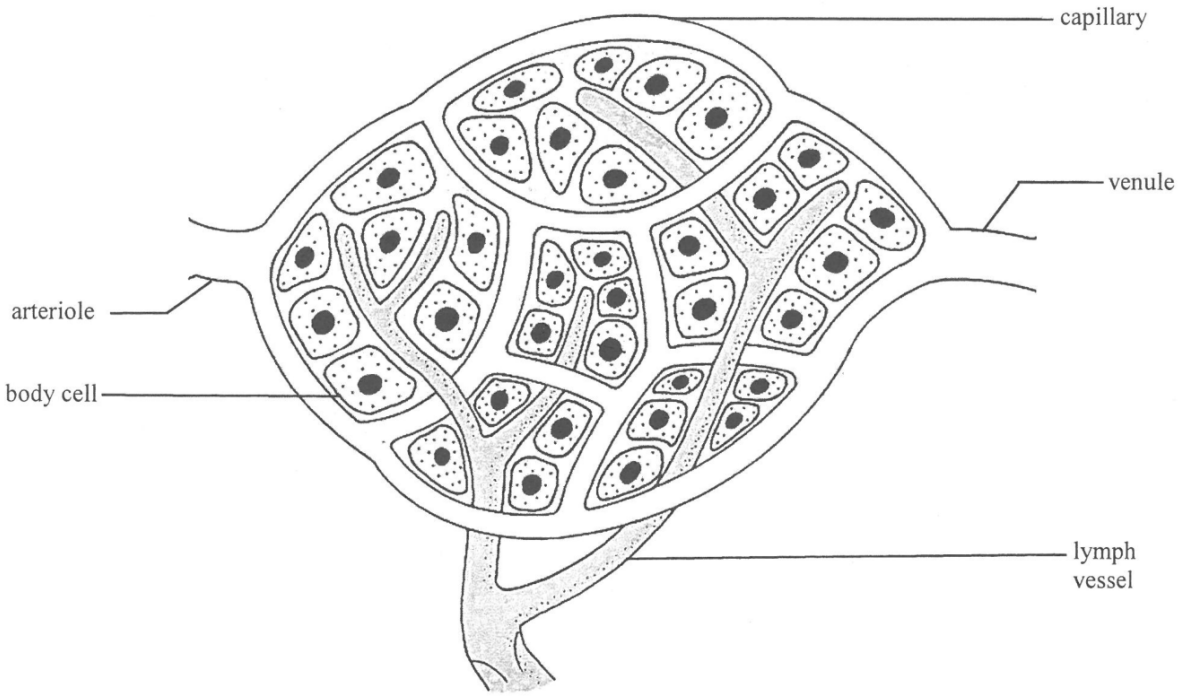
(a) The graph below shows the total cross-sectional area and the rate of blood flow of different types of blood vessels:



(i) Describe the overall relationship between the total cross-sectional area of blood vessels and the rate of blood flow. (1 mark)

(ii) Explain how the relationship described in (i) can facilitate the material exchange that takes place in the capillaries. (2 marks)

(b) The following schematic diagram illustrates a capillary network and the associated structures:



With reference to ***two*** features of the capillary network illustrated in the above diagram, explain the importance of these features to the material exchange in the capillary network. (4 marks)

Features illustrated in the diagram	*Importance to the material exchange*

Solution a(i); original allocation: 1 mark(s)

Overall, blood-flow velocity is lower where the total cross-sectional area is greater.

Compare the corresponding vessel type in both graphs. The narrow lumen of one capillary does not imply a small total cross-sectional area for all capillaries.

Method: Distinguish blood, tissue fluid and lymph before tracing exchange.

a(ii); original allocation: 2 mark(s)

Slow blood flow in capillaries gives more time for exchange between blood and tissues.

Many capillaries in parallel create a large total cross-sectional area. Slower flow gives oxygen and nutrients more time to leave the blood, and carbon dioxide and other substances more time to enter it.

b; original allocation: 4 mark(s)

Extensive branching forms a dense capillary network, increasing the exchange surface area.

Capillaries penetrate tissues and lie close to most cells, shortening diffusion distances.

Begin each point with a feature visible in the diagram and link it to an exchange advantage.

Wall thickness is not shown, so 'one cell thick' cannot replace one of the two features the question requires you to identify from this figure.

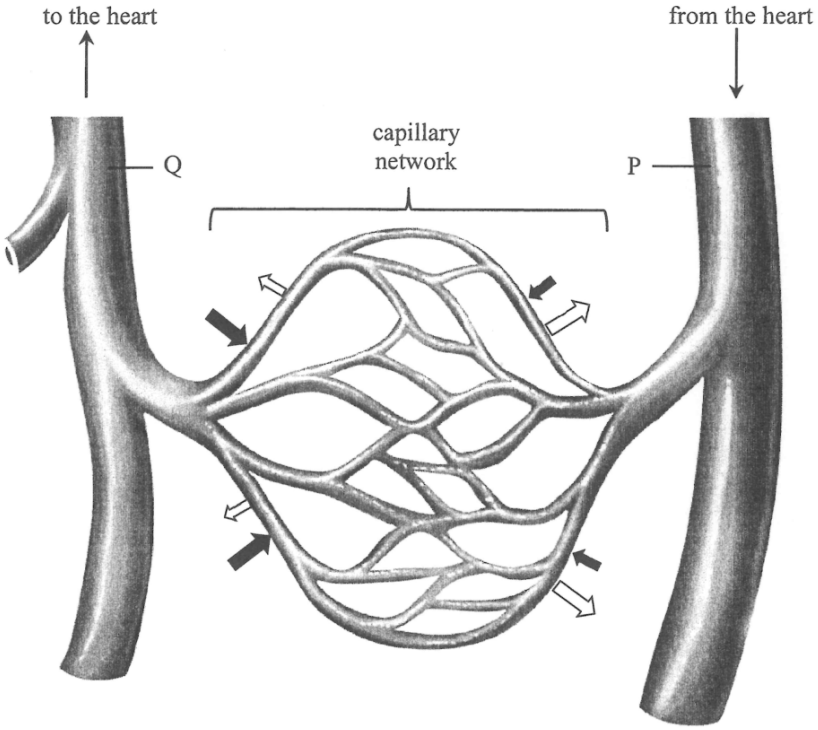
Examiner's comment (source page(s) 4)

When asked about features of the capillary network, explain how extensive branching produces a large total cross-sectional area and slow flow. A thin wall is a different adaptation.

Marking reference: HKDSE Biology 2021 Paper 1B Q3, official marking scheme, source page(s) 2.

Example 2 [HKDSE Biology 2024 Paper 1B Q4]

The schematic diagram below shows the arrangements of some blood vessels:



(a) The two types of arrows (black and white) represent two factors which govern the movement of fluid into or out of the capillary network. Identify these two factors. (2 marks)

➡ :

⇨ :

(b) The sizes of the arrows in the above diagram represent the magnitudes of the factors. Explain the change in the factors denoted by ⇨ as the blood flows from P to Q. (3 marks)

(c) The capillary network is the location where exchange of materials occurs between the blood and tissue fluid. When the blood flows through the capillary network of a particular organ, some substances will be taken up into the blood.

Complete the table below to show the organ where the capillary network is found. Provide your explanation. (3 marks)

	Organ	*Substance taken up into the blood*	*Explanation*
(i)		insulin	Insulin is secreted from the organ in response to the change of the blood glucose level.
(ii)		urea	

Solution a; original allocation: 2 mark(s)

Black arrows: the water-potential difference between blood and tissue fluid. White arrows: the hydrostatic-pressure difference between them.

✓ Method: Distinguish blood, tissue fluid and lymph before tracing exchange.

Black arrows point into the capillary. Plasma proteins lower blood water potential, tending to draw water into the blood by osmosis. White arrows point outwards, indicating that higher hydrostatic pressure inside the capillary pushes fluid into tissue spaces.

b; original allocation: 3 mark(s)

From P to Q, the hydrostatic-pressure difference represented by the white arrows decreases. P is the arterial end, where initially high blood hydrostatic pressure pushes water and small molecules out. As fluid leaves, blood volume and pressure within the capillary fall, reducing the outward pressure difference. Accordingly, the white arrows become smaller towards Q.

c(i); original allocation: 1 mark(s)

The pancreas.

Cells in the pancreatic islets detect blood-glucose changes and release insulin into nearby capillaries for transport to target tissues.

c(ii); original allocation: 2 mark(s)

The liver. Excess amino acids are deaminated there, and their nitrogen-containing component is converted into urea, which enters the blood.

Distinguish the site of production from the site of removal: the liver processes excess amino acids and forms urea; kidneys remove urea from blood and excrete it in urine. Blood obtaining urea from an organ therefore identifies the liver, not a kidney.

Examiner's comment (source page(s) 69, 70)

Tissue-fluid exchange depends on water-potential and hydrostatic-pressure differences between blood and tissue fluid, not the water potential at just one location. Explain falling pressure from P to Q through filtration reducing blood volume, rather than merely greater distance from the heart. Urea is produced by the liver and excreted by kidneys.

Marking reference: HKDSE Biology 2024 Paper 1B Q4, official marking scheme, source page(s) 52.

Example 3 [HKDSE Biology 2017 Paper 1B Q11]

For the following question, candidates are required to present their answer in essay form. Criteria for marking will include relevant content, logical presentation and clarity of expression.

Some natural therapists claim that applying pressure along one's limbs toward the body trunk can improve the circulation of lymph and result in reduced body weight. However, the effects of this treatment are controversial. Briefly describe how lymph is formed from blood and returned to the blood circulatory system. For each of the claims above, discuss whether it is scientifically valid. (11 marks)

Solution **Essay; original allocation: 11 mark(s)**

✓ *Method: Distinguish blood, tissue fluid and lymph before tracing exchange.*

Lymph comes from tissue fluid that has not returned directly to the blood. Lymphatic vessels collect it and return it to veins. Appropriate compression along these vessels may assist flow, but returning fluid to the blood does not itself reduce body mass or fat.

In the capillary-exchange model used in this question, higher hydrostatic pressure at the arteriolar end filters some plasma water and small molecules into tissue spaces, forming tissue fluid. Blood cells and most large plasma proteins remain inside vessels. Some water returns to the blood at the venous end because of a water-potential difference; remaining tissue fluid is called lymph once it enters lymphatic vessels.

Valves in lymphatic vessels prevent backflow. Contraction of nearby skeletal muscles compresses the vessels and pushes lymph towards the trunk. Large lymphatic vessels eventually drain into veins, returning it to blood circulation. Pressure applied in an appropriate direction can therefore plausibly assist local fluid movement. This mechanism alone does not establish that every advertised treatment has the claimed effect.

Regarding weight loss, movement of lymph from limbs to blood simply redistributes fluid within the body; it does not remove it. Less local tissue-fluid accumulation may temporarily make an area look slimmer, without reducing body mass or fat. Fluid redistribution also does

not directly change energy intake, expenditure or fat breakdown. Improved return therefore does not imply inevitable weight loss.

The official scheme allows up to 5 marks for formation and return, 1 for the circulation claim and 2 for the weight-loss claim, with another 3 for expression and organisation. Establish the circulation mechanism first, then evaluate the two claims separately. A bare judgement of 'effective' or 'ineffective' does not replace evidence.

Examiner's comment (source page(s) 4)

Lymph forms when tissue fluid enters lymphatic vessels, and flow is assisted by skeletal-muscle compression and valves. Evaluate claims about lymphatic drainage and body mass by connecting the manipulation, tissue fluid and fat or energy balance explicitly.

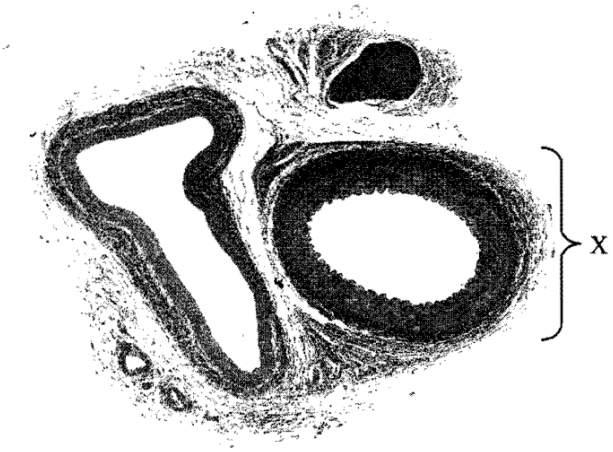
Marking reference: HKDSE Biology 2017 Paper 1B Q11, official marking scheme, source page(s) 6, 7.

Practice

1. [HKDSE Biology 2012 Paper 1A Q31]

⟵ *Hint: Distinguish blood, tissue fluid and lymph before tracing exchange.*

Directions: Questions 31 and 32 refer to the photomicrograph below, which shows some blood vessels found in the human body:

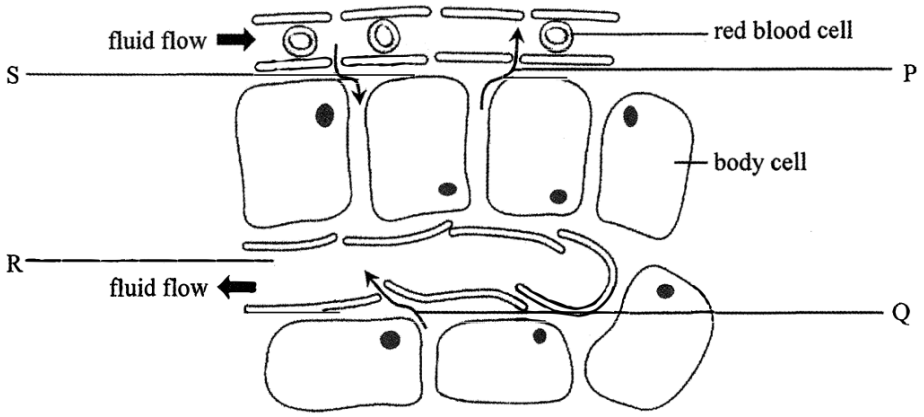


Blood vessel X is an artery because it has a

A. thick muscular wall to withstand high blood pressure.
B. thick muscular wall to generate high blood pressure.
C. large lumen to slow down the blood flow.
D. large lumen to accommodate more blood.

2. [HKDSE Biology 2016 Paper 1A Q29]
Hint: Distinguish blood, tissue fluid and lymph before tracing exchange.

Directions: Questions 28 and 29 refer to the diagram below, which shows the cells and the associated vessels in a tissue:



Fluid in R eventually returns to the heart at the

A. left atrium.
B. right atrium.
C. left ventricle.
D. right ventricle.

3. [HKDSE Biology 2017 Paper 1A Q18]
Hint: Distinguish blood, tissue fluid and lymph before tracing exchange.

Which of the following descriptions of the circulatory system is correct?

A. Veins have a large lumen because the blood pressure inside them is low.
B. Arteries have a thick layer of elastic tissue because they have smaller lumen.
C. The aorta has the highest blood pressure because it supplies blood to the whole body.
D. The capillary network is a suitable site for material exchange because capillaries have the thinnest walls.

4. [HKDSE Biology 2020 Paper 1A Q14]
Hint: Distinguish blood, tissue fluid and lymph before tracing exchange.

Which of the following combinations correctly matches the water movement in the human body with its major driving force?

	Water movement	*Major driving force*
A.	water in tissue fluid enters lymph vessels	osmosis
B.	water in blood leaves capillaries at the arterial end	hydrostatic pressure
C.	water in tissue fluid enters capillaries at the venous end	active transport
D.	water enters capillaries from the lumen of the small intestine	diffusion

5. [HKDSE Biology 2025 Paper 1A Q15 (English translation)]
Hint: Distinguish blood, tissue fluid and lymph before tracing exchange.

Read the following two statements carefully:

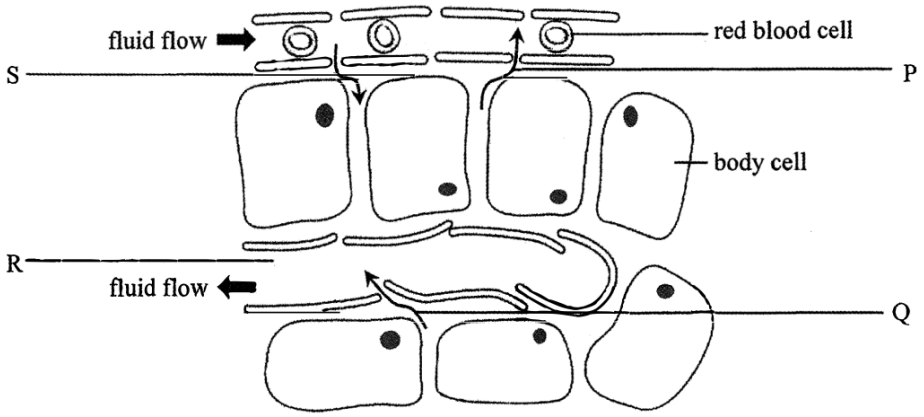
I: Blood flows slowly through capillary beds.
II: Capillaries have narrow lumens.

Which of the following descriptions of the two statements is correct?

A. I and II are both correct, and II correctly explains I.
B. I and II are both correct, but II does not explain I.
C. I is correct, but II is incorrect.
D. I is incorrect, but II is correct.

6. [HKDSE Biology 2016 Paper 1A Q28]
Hint: Distinguish blood, tissue fluid and lymph before tracing exchange.

Directions: Questions 28 and 29 refer to the diagram below, which shows the cells and the associated vessels in a tissue:



Which of the following combinations correctly identifies the major causes of fluid flow represented by P, Q and S?

	P	*Q*	*S*
A.	osmosis	diffusion	hydrostatic pressure
B.	hydrostatic pressure	hydrostatic pressure	diffusion
C.	osmosis	hydrostatic pressure	hydrostatic pressure
D.	diffusion	diffusion	osmosis

7. [HKDSE Biology 2015 Paper 1B Q11]
Hint: Distinguish blood, tissue fluid and lymph before tracing exchange.

For the following question, candidates are required to present their answer in essay form. Criteria for marking will include relevant content, logical presentation and clarity of expression.

Although both arteries and veins are blood vessels, they are very different in their structure. Discuss how their structural differences are related to the different ways of maintaining blood flow inside the blood vessels. (11 marks)

8. [HKDSE Biology 2020 Paper 1B Q11]
Hint: Distinguish blood, tissue fluid and lymph before tracing exchange.

You are required to present your answer to the following question in essay form. Criteria for marking will include relevant content, logical presentation and clarity of expression.

Our body systems are highly specialised at various levels of organisation to facilitate the functioning of each system. Discuss how the adaptive features of the human blood and circulatory system facilitate the transport of oxygen. Your discussion should cover adaptive features at cellular, tissue and organ levels. (11 marks)

(Note: Details of the different types of blood vessels are not required.)

Type 6 Explain ventilation and gas exchange through pressure and surfaces

Degree of integration ★★★★☆

Key ideas

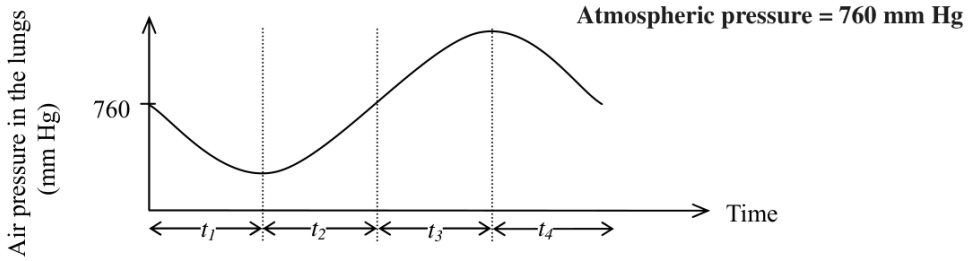
① During inhalation, the relevant muscles contract, thoracic volume increases and pressure in the lungs falls, allowing air to enter. Alveolar gas exchange is a separate process: oxygen and carbon dioxide diffuse down their respective gradients across thin, moist exchange surfaces.

② Tracheal cilia and mucus help remove foreign material; they are not the main oxygen-exchange surface. Distinguish ventilation, gas exchange and cellular respiration.

How to recognise the problem Use the causal chain muscles → volume → pressure → airflow direction. Explain exchange-surface adaptations through area, distance and gradients.

Example 1 [HKDSE Biology Practice Paper Paper 1A Q30]

The following graph shows the change in the air pressure inside the lungs within a period of time:



Which of the following correctly describes what happens at the specified time period?

A. During t_1, air leaves the lungs.
B. During t_2, the intercostal muscles contract.
C. During t_3, the diaphragm is pulled flat.
D. During t_4, the rib cage is moved upwards and outwards.

Solution Answer: B

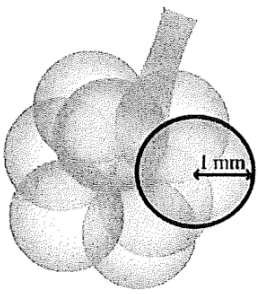
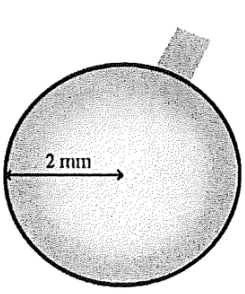
Method: Explain in the order muscles, volume, pressure and airflow.

During t_2, lung pressure remains below atmospheric pressure, 760 mmHg, so air continues to enter. Inspiration is occurring and the external intercostal muscles contract, giving B. A rising curve alone does not indicate expiration; compare lung pressure with atmospheric pressure.

Marking reference: HKDSE Biology Practice Paper Paper 1A Q30, official marking scheme, source page(s) 2.

Example 2 [HKDSE Biology 2023 Paper 1B Q1]

The spheres shown in the diagram below represent the air sacs of different sizes in the lung. The total volume of the eight small spheres with a radius of 1 mm each is equal to the volume of one large sphere with a radius of 2 mm.

		
surface area of one sphere (mm^2)	12.6	50.3

(a) Calculate the total surface area of eight small spheres. (1 mark)

(b) With reference to the answer in (a), explain why having smaller air sacs in the lungs is more efficient than bigger air sacs for gas exchange. (2 marks)

(c) Apart from (b), explain how air sacs are specialised at tissue level for gas exchange. (1 mark)

Solution a; original allocation: 1 mark(s)

Method: Explain in the order muscles, volume, pressure and airflow.

100.8 mm^2.

Each small sphere has a surface area of 12.6 mm², so eight have 8 × 12.6 = 100.8 mm². The single-sphere area is already given; there is no need to recalculate it from the sphere formula.

b; original allocation: 2 mark(s)

At the same total volume, eight small alveoli have about twice the total surface area of one large alveolus, allowing faster gas diffusion.

The eight small spheres and one large sphere have equal total volumes, but surface areas of 100.8 and 50.3 mm² respectively. Greater surface area or surface-area-to-volume ratio provides more sites for simultaneous gas movement, improving exchange per unit volume of lung tissue.

c; original allocation: 1 mark(s)

An alveolar wall consists of one layer of thin cells, shortening the gas diffusion distance.

The question asks for a tissue-level adaptation. A thin wall gives oxygen and carbon dioxide a short path between alveolar air and blood. Another acceptable answer is a moist inner surface that allows gases to dissolve first.

Examiner's comment (source page(s) 4)

After identifying greater total surface area, explain that diffusion is faster. When a tissue-level adaptation of the alveolus is requested, a surrounding capillary network alone does not directly describe the alveolar wall.

Marking reference: HKDSE Biology 2023 Paper 1B Q1, official marking scheme, source page(s) 3.

Example 3 [HKDSE Biology 2017 Paper 1B Q5]

(a) Briefly describe the breathing actions that bring air into the lungs. (4 marks)

(b) In the following diagrams, Diagram I shows some structures of a human lung while Diagram II shows a collapsed lung if it is ruptured at location Y:

Diagram I

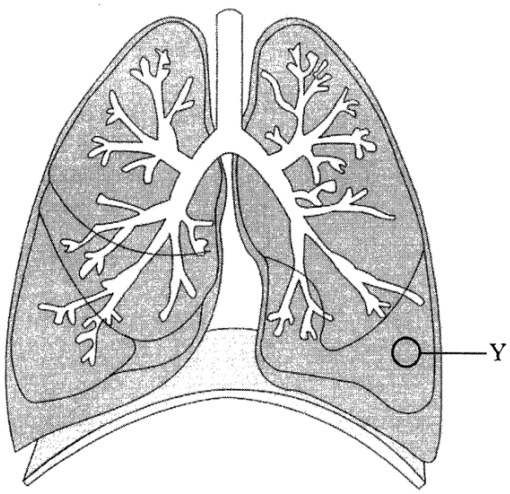
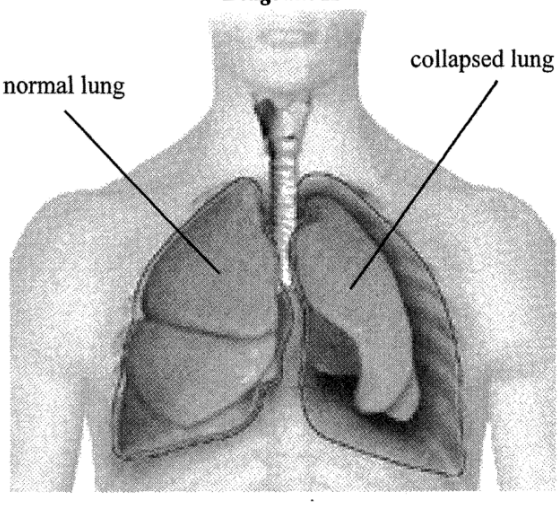


Diagram II



Explain why the lung collapses if it is ruptured at location Y. (2 marks)

Solution (a); original allocation: 4 mark(s)

External intercostal muscles contract, moving the ribs upwards and outwards. The diaphragm contracts and flattens. Thoracic volume increases, lung pressure falls below atmospheric pressure, and air enters the lungs.

Use the sequence muscle → rib cage or diaphragm → volume → pressure → airflow. Lungs do not actively grab air; air flows in down a pressure gradient. Include both rib and diaphragm movements.

✓ Method: Explain in the order muscles, volume, pressure and airflow.

(b); original allocation: 2 mark(s)

Air enters the pleural cavity through the opening, eliminating the pressure difference that keeps the lung expanded. The lung collapses through its own elastic recoil.

Normally, pleural pressure is below pressure inside the lungs, and mechanical coupling to the chest wall makes the lungs expand with the thorax. Rupture at Y admits air into the pleural cavity and disrupts this condition, allowing inward recoil. Do not explain the collapse as the lung containing no air at all.

Examiner's comment (source page(s) 3)

The causal order in ventilation is muscle contraction, change in thoracic volume, change in lung pressure, then airflow. Lung collapse also requires consideration of elastic recoil and pleural pressure.

Marking reference: HKDSE Biology 2017 Paper 1B Q5, official marking scheme, source page(s) 3.

Example 4 [HKDSE Biology 2016 Paper 1B Q11]

For the following question, candidates are required to present their answer in essay form. Criteria for marking will include relevant content, logical presentation and clarity of expression.

Gas exchange in organisms relies very much on diffusion. To be an effective organ for gas exchange, the leaves in plants and the lungs in humans share some common principles in their structural adaptations. Discuss how their structures are adapted to fulfil these common principles. Despite these similarities, explain why the operation of the breathing system in human is more effective. (11 marks)

Solution Essay; original allocation: 11 mark(s)

Method: Explain in the order muscles, volume, pressure and airflow.

Leaves and lungs both promote gas exchange through a large surface area, moist surfaces and short diffusion distances. Humans additionally maintain concentration gradients through active ventilation and blood flow.

Gas exchange depends on diffusion. A larger surface allows more gas to exchange in the same time. Numerous alveoli provide a large surface in human lungs. Plants have many leaves, and extensive air spaces among spongy mesophyll cells expose a large mesophyll surface to air.

Gases first dissolve in water before passing readily across cell membranes. Alveoli have a thin film of water on their inner surface, while moist mesophyll cell surfaces also allow oxygen and carbon dioxide to dissolve. Diffusion distances must be short: alveolar walls and adjacent capillary walls are each only one cell thick. Leaves are thin, and stomata and internal air spaces allow gases to reach mesophyll cells quickly over short distances.

Human breathing actively draws in and expels air, renewing alveolar gases. The extensive capillary supply continually carries absorbed oxygen away and delivers carbon dioxide. Together, ventilation and blood flow maintain steep gradients between alveoli and blood, supporting rapid, continuous diffusion. Leaves mainly renew air-space gases by passive diffusion and lack a comparable respiratory pump. In the operating mechanisms compared by the question, the human respiratory system can therefore maintain effective exchange more actively.

The official scheme allows up to 5 marks for shared adaptations and 3 for mechanisms making human exchange more effective, plus 3 for expression and organisation. Pair each principle with specific features in both organs, rather than listing only alveolar or only leaf adaptations.

Examiner's comment (source page(s) 3)

Gas exchange in leaves occurs at mesophyll cell surfaces; stomata are entry and exit routes. A moist surface means a thin water film, not water filling the intercellular air spaces. Connect each structure to its effect on diffusion distance.

Marking reference: HKDSE Biology 2016 Paper 1B Q11, official marking scheme, source page(s) 6.

Practice

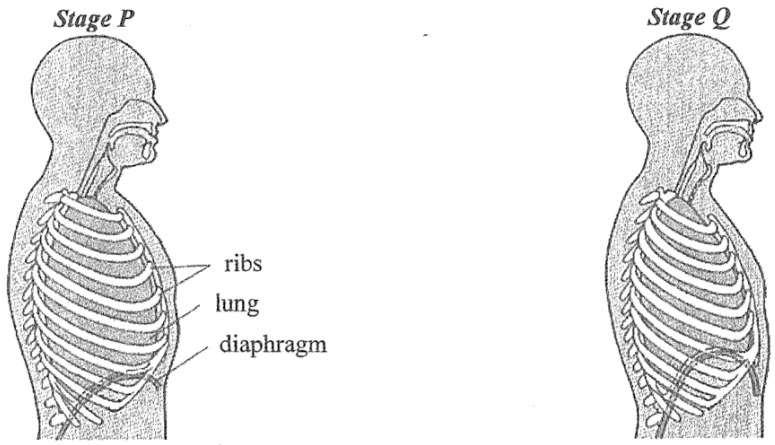
1. [HKDSE Biology 2012 Paper 1A Q22]
Hint: Explain in the order muscles, volume, pressure and airflow.

Which of the following descriptions about the function of the cilia lining the trachea is correct?

A. to warm the incoming air
B. to moisten the incoming air
C. to move mucus away from the trachea
D. to produce mucus to protect the trachea

2. [HKDSE Biology 2015 Paper 1A Q15]
Hint: Explain in the order muscles, volume, pressure and airflow.

The diagrams below show the relative positions of the human respiratory system and its associated structures in two different breathing stages:



Which of the following statements correctly describes the change that takes place from stage P to stage Q?

A. Pressure inside the lungs is increasing.
B. Diaphragm muscle is contracting.
C. Volume of the lungs is increasing.
D. Rib cage is moving upward.

3. [HKDSE Biology 2020 Paper 1A Q11]
Hint: Explain in the order muscles, volume, pressure and airflow.

Which of the following descriptions of breathing is correct?

A. The air rushes in to expand the lungs.
B. The trachea expands to draw in more air.
C. Pressure in the lungs decreases to draw in air.
D. The expansion of the lungs pushes the diaphragm downward.

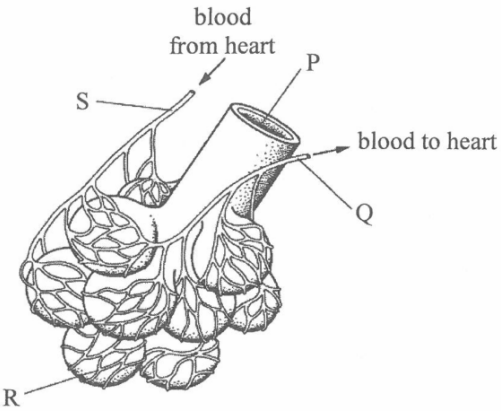
4. [HKDSE Biology 2020 Paper 1A Q13]
Hint: Explain in the order muscles, volume, pressure and airflow.

Both the villi of the small intestine and the air sacs of the lung are sites for material exchange. Which of the following is an adaptive feature common to the epithelium of both structures?

A. The epithelium is one cell thick.
B. There is a water film on the surface of the epithelium.
C. The epithelial cells contain a large number of mitochondria.
D. The epithelial cells have a modified cell membrane to increase surface area.

5. [HKDSE Biology 2022 Paper 1A Q15]
⟵ Hint: Explain in the order muscles, volume, pressure and airflow.

Directions: Questions 15 and 16 refer to the diagram below, which shows the end of the respiratory tract and the associated blood vessels in humans:



Which labelled part has the highest concentration of carbon dioxide?

A. P
B. Q
C. R
D. S

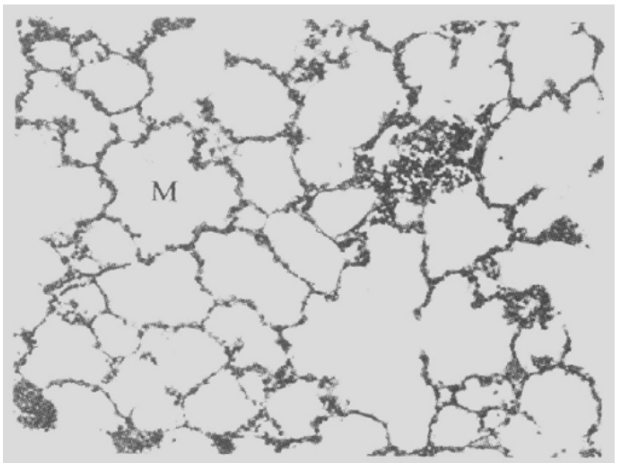
6. [HKDSE Biology 2023 Paper 1A Q9]
⟵ Hint: Explain in the order muscles, volume, pressure and airflow.

When we breathe out, some air will be left inside the air sacs in the lungs. Which of the following correctly shows the gas composition of the remaining air inside the air sacs?

	Oxygen	***Carbon dioxide***
A.	16%	0.04%
B.	16%	4%
C.	21%	0.04%
D.	21%	4%

7. [HKDSE Biology Sample Paper Paper 1A Q15]
⟵ Hint: Explain in the order muscles, volume, pressure and airflow.

Directions: Questions 15 to 17 refers to the photomicrograph below which shows a section of the human lung:



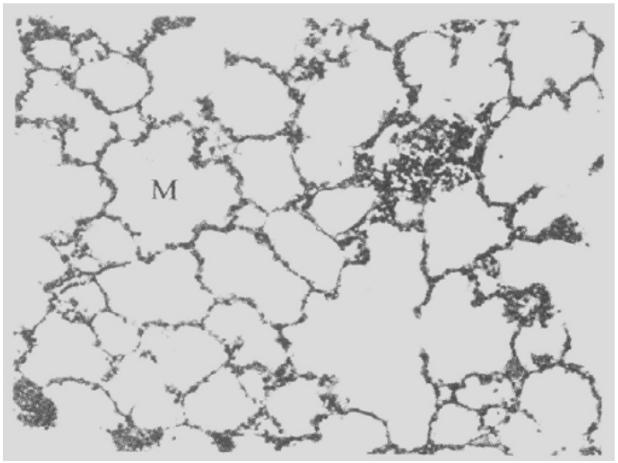
Which of the following features allow structures M to adapt to their function?

(1) folded surface
(2) thin and ciliated wall
(3) rich supply of blood capillaries

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

8. [HKDSE Biology Sample Paper Paper 1A Q16]
⟵ Hint: Explain in the order muscles, volume, pressure and airflow.

Directions: Questions 15 to 17 refers to the photomicrograph below which shows a section of the human lung:

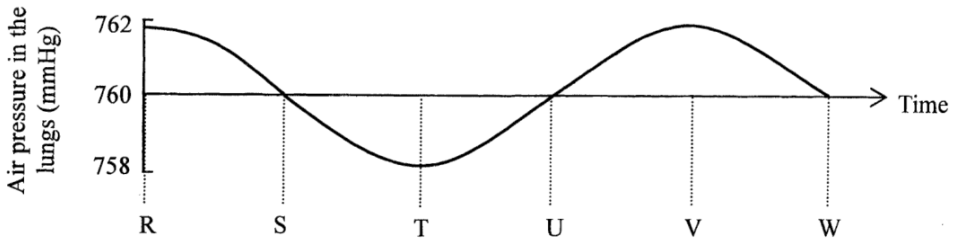


The air in structure M consists mostly of

A. nitrogen.
B. oxygen.
C. water vapour.
D. carbon dioxide.

9. [HKDSE Biology 2014 Paper 1A Q27]
⟵ Hint: Explain in the order muscles, volume, pressure and airflow.

The graph below shows the change in air pressure in the lungs of a man:



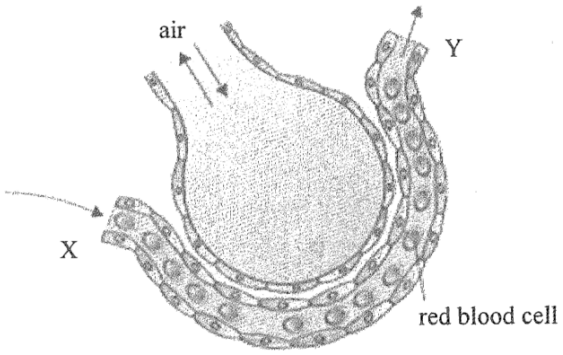
Atmospheric pressure = 760 mm Hg

His diaphragm muscles are in a state of contraction during the period

A. RT.
B. SU.
C. TV.
D. UW.

10. [HKDSE Biology 2015 Paper 1A Q13]
Hint: Explain in the order muscles, volume, pressure and airflow.

Directions: Questions 13 and 14 refer to the diagram below, which shows a section of an air sac and its associated blood capillary in humans:



Which of the following combinations correctly describes the changes in blood composition when blood flows from X to Y?

	Oxygen content	*Glucose content*	*Urea content*
A.	increases	remains unchanged	increases
B.	increases	decreases	remains unchanged
C.	remains unchanged	decreases	remains unchanged
D.	remains unchanged	remains unchanged	increases

11. [HKDSE Biology 2018 Paper 1A Q8]
Hint: Explain in the order muscles, volume, pressure and airflow.

The photomicrograph below shows a section of human lung:



With reference to the structures shown in the photomicrograph, which of the following are adaptive features for gas exchange?

(1) presence of water film
(2) short diffusion distance
(3) rich supply of blood capillaries

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

12. [HKDSE Biology 2020 Paper 1A Q10]
← Hint: Explain in the order muscles, volume, pressure and airflow.

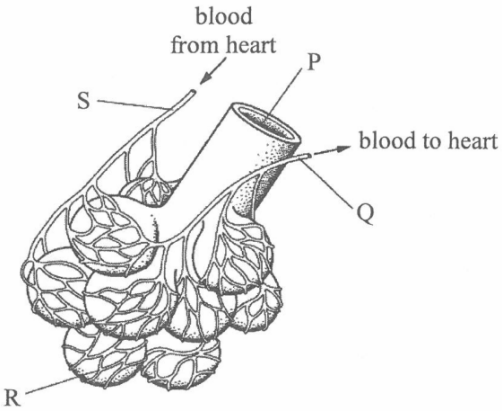
Which of the following explain why a person cannot swallow food and talk at the same time?

(1) The epiglottis covers the opening of the trachea during swallowing.
(2) Swallowing is a reflex action while speaking is a voluntary action.
(3) Air must flow through the larynx to produce sounds.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

13. [HKDSE Biology 2022 Paper 1A Q16]
← Hint: Explain in the order muscles, volume, pressure and airflow.

Directions: Questions 15 and 16 refer to the diagram below, which shows the end of the respiratory tract and the associated blood vessels in humans:



Which of the following adaptive features for gas exchange can be illustrated in the above diagram?

(1) The respiratory tract ends in numerous spherical structures.
(2) The end of the respiratory tract has a thin wall.
(3) The end of the respiratory tract is covered with blood vessels.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

14. [HKDSE Biology 2022 Paper 1A Q17]
← Hint: Explain in the order muscles, volume, pressure and airflow.

Directions: Questions 17 and 18 refer to the diagrams below. Diagram I shows a device which is used to monitor the breathing pattern of a person. It consists of an elastic band strapped around a person's chest and a sensor which detects the tension of the elastic band. Diagram II shows the change in the tension of the elastic band during breathing.

Diagram I

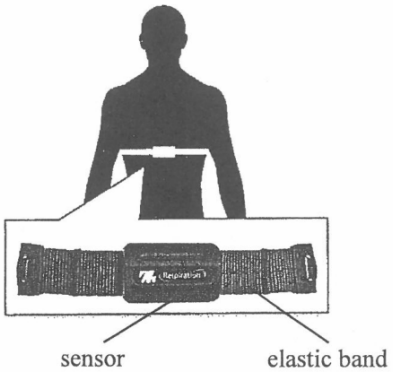
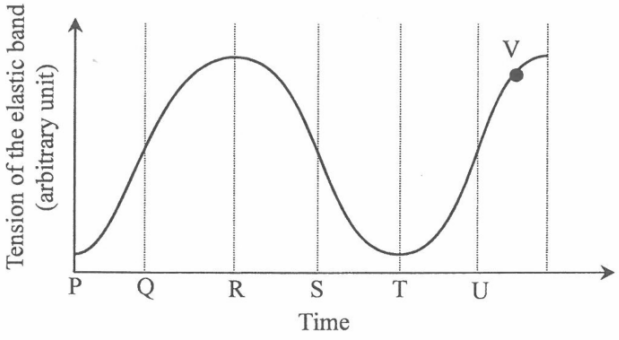


Diagram II



Exhalation takes place during period

A. PR.
B. QS.
C. RT.
D. SU.

15. [HKDSE Biology 2022 Paper 1A Q18]
Hint: Explain in the order muscles, volume, pressure and airflow.

Directions: Questions 17 and 18 refer to the diagrams below. Diagram I shows a device which is used to monitor the breathing pattern of a person. It consists of an elastic band strapped around a person's chest and a sensor which detects the tension of the elastic band. Diagram II shows the change in the tension of the elastic band during breathing.

Diagram I

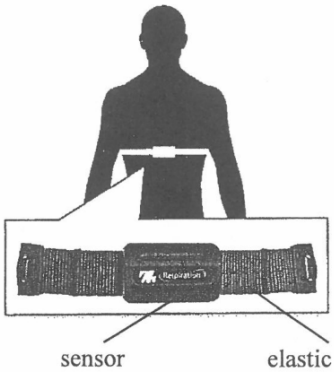
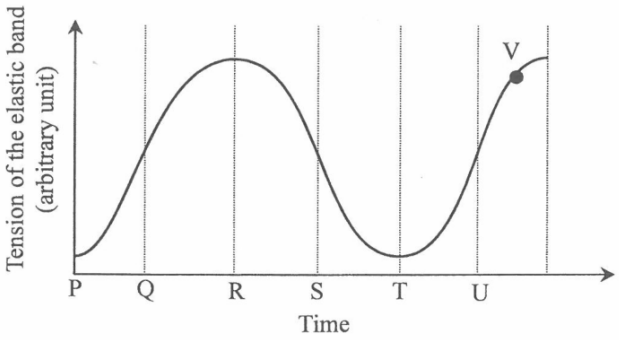


Diagram II



Which of the following interpretations about Diagram II is/are correct?

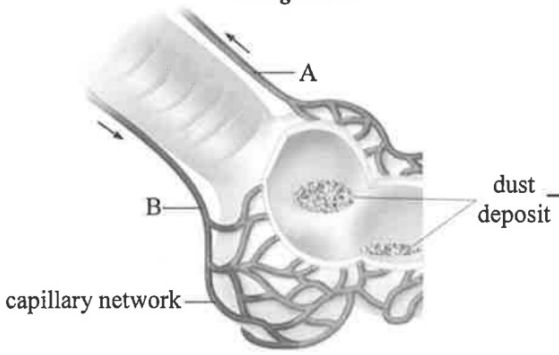
(1) The diaphragm is contracting during period QR.
(2) Air pressure inside the lungs increases during period TU.
(3) Air pressure inside the lungs is greater than atmospheric pressure at point V.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

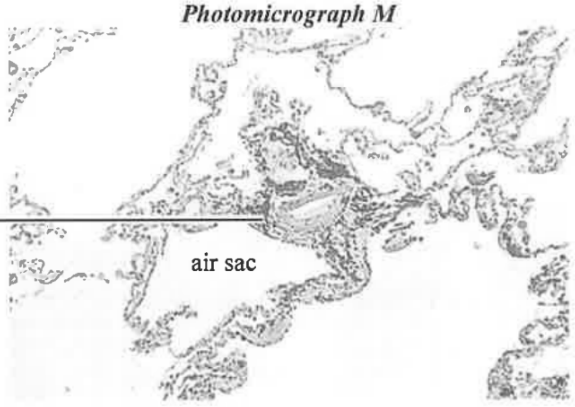
16. [HKDSE Biology 2019 Paper 1B Q5]
Hint: Explain in the order muscles, volume, pressure and airflow.

Diagram L below shows part of the lung in a patient suffering from a certain lung disease. A hardened layer of dust deposit was found on the respiratory surface of the air sacs. Photomicrograph M shows the lung tissue taken from the patient.

Diagram L



Photomicrograph M

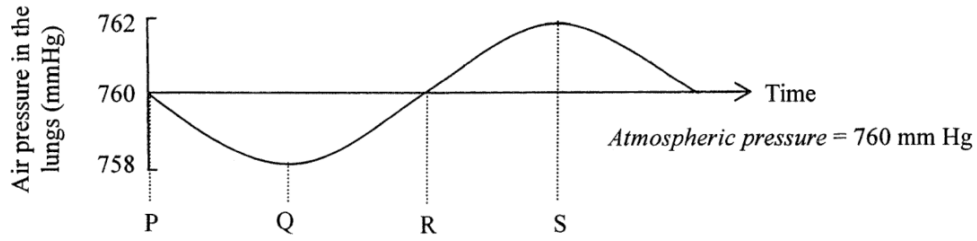


(a) Compare the oxygen and glucose content of the blood in vessels A and B. Explain your answer. (4 marks)

(b) With reference to the above information about the lung disease, suggest ***two*** possible ways in which the disease adversely affects gas exchange in the patient. (4 marks)

17. [HKDSE Biology 2013 Paper 1A Q30]
Hint: Explain in the order muscles, volume, pressure and airflow.

The graph below shows the change in air pressure in the lungs of a person:



At which point of time on the graph is the volume of the lung the largest?

A. P
B. Q
C. R
D. S

Type 7 Track blood, substances and pressure through circulation

Degree of integration ★★★☆☆

Key ideas

① Blood returning from the body passes through the right atrium, right ventricle and pulmonary artery to the lungs, then through the pulmonary veins, left atrium and left ventricle into the systemic circulation. Valves open and close passively according to pressure differences. Oxygen content alone does not distinguish arteries from veins.

② Comparing a substance in different vessels also requires considering uptake, production or release by the organs traversed, such as glucose regulation and urea formation by the liver.

How to recognise the problem Draw the complete directional pathway, then add each organ's effect on substances. For heart-chamber diagrams, use wall thickness, valves and connected vessels together.

Example 1 [HKDSE Biology 2012 Paper 1B Q1]

For each type of the blood cells listed in column 1, select from column 2 ***one*** phrase that correctly describes its functon. Put the appropriate letter in the space provided. (3 marks)

Column 1		***Column 2***	
Lymphocytes	_____	A.	Involved in blood clotting
Blood platelets	_____	B.	Involved in oxygen transport
Red blood cells	_____	C.	Involved in antibody production
		D.	Involved in phagocytosis
		E.	Involved in transporting hormones

Solution Matching; original allocation: 3 mark(s)

Lymphocytes: C; platelets: A; red blood cells: B.

Lymphocytes participate in specific defence; B lymphocytes can differentiate into antibody-producing cells. Platelets promote clotting and blood-clot formation. Haemoglobin in red blood cells binds and transports oxygen. Phagocytosis is mainly performed by phagocytes, and hormones are mainly carried in plasma; neither matches the three components listed. Each correct match earns 1 mark.

Method: Draw blood-flow directions, then add the organs' effects on substances.

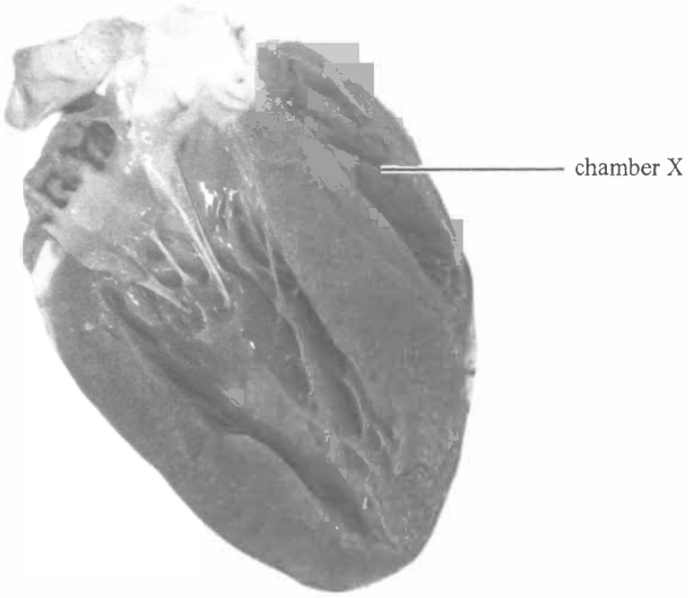
Examiner's comment (source page(s) 1)

Do not confuse the functions of lymphocytes and phagocytes.

Marking reference: HKDSE Biology 2012 Paper 1B Q1, official marking scheme, source page(s) 2.

Example 2 [HKDSE Biology 2018 Paper 1A Q35]

The following photograph shows a dissected pig heart:



Which of the following descriptions about chamber X is correct?

A. It receives blood from the pulmonary vein.
B. It pumps out blood to the aorta.
C. It receives blood from the vena cava.
D. It pumps out blood to the pulmonary artery.

Solution **Reading the question and choosing a method**

Method: Draw blood-flow directions, then add the organs' effects on substances.

Left and right in a dissection photograph need not correspond to the body's left and right. First locate the thicker muscular wall of the left ventricle.

Answer: D

The left ventricle pumps into the systemic circulation and has a thicker wall. The right ventricle pumps into the pulmonary circulation and has a relatively thinner wall. X is the right ventricle and pumps into the pulmonary artery, giving D. Pulmonary veins bring blood to the left atrium, while venae cavae bring it to the right atrium. Vessels entering atria must not be treated as entering ventricles directly. Choose D.

Common error

Identifying ventricles by their positions on the page, or confusing vessel connections of the right atrium and right ventricle.

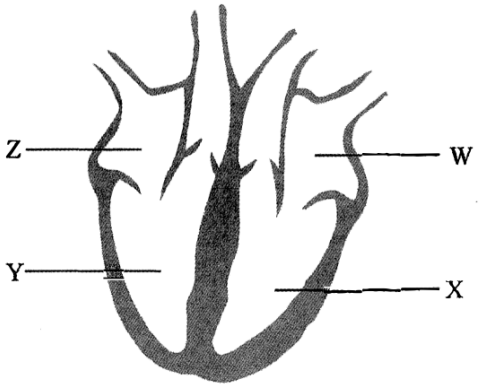
Examiner's comment (source page(s) 2)

Identify ventricles from muscle thickness and the interventricular septum, then follow vessel connections. X is the right ventricle and pumps blood into the pulmonary artery.

Marking reference: HKDSE Biology 2018 Paper 1A Q35, official marking scheme, source page(s) 1.

Example 3 [HKDSE Biology 2016 Paper 1A Q17]

Directions: Questions 16 and 17 refer to the diagram below, which shows a section of the heart:



Which of the following statements about the heart is correct?

A. Z receives oxygenated blood from the lungs.
B. Y and Z pump out same volume of blood.
C. Blood in Z has higher glucose content than that of W.
D. Blood pumped out from Y travels a longer distance than that of X before returning to the heart.

Solution Answer: C

Z is the right atrium and W the left atrium. Blood passes from the right heart through the lungs to the left heart. Lung-cell respiration consumes glucose, so in the comparison given, Z has more glucose than W. Choose C. The right atrium receives deoxygenated systemic blood. The right ventricle sends blood along the shorter pulmonary route compared with the left ventricle's systemic route. The volume ejected by a ventricle cannot simply be equated with the volume pushed in by active atrial contraction.

Method: Draw blood-flow directions, then add the organs' effects on substances.

Marking reference: HKDSE Biology 2016 Paper 1A Q17, official marking scheme, source page(s) 1.

Example 4 [HKDSE Biology 2022 Paper 1A Q20]

Some babies are born with a heart defect which is a hole in the septum separating the left and right ventricles. When the ventricles contract at the same time, some blood flow will deviate from the normal route. Which of the following is most likely the deviated route?

A. left ventricle → right ventricle → aorta
B. left ventricle → right ventricle → pulmonary artery
C. right ventricle → left ventricle → aorta
D. right ventricle → left ventricle → pulmonary artery

Solution Answer: B

The thicker left-ventricular wall generates greater pressure during contraction than the right ventricle. A hole between them therefore tends to allow flow from left to right and subsequently into the pulmonary artery. Compare pressures first to determine the shunt direction.

Method: Draw blood-flow directions, then add the organs' effects on substances.

Marking reference: HKDSE Biology 2022 Paper 1A Q20, official marking scheme, source page(s) 1.

Practice

1. [HKDSE Biology 2012 Paper 1A Q20]

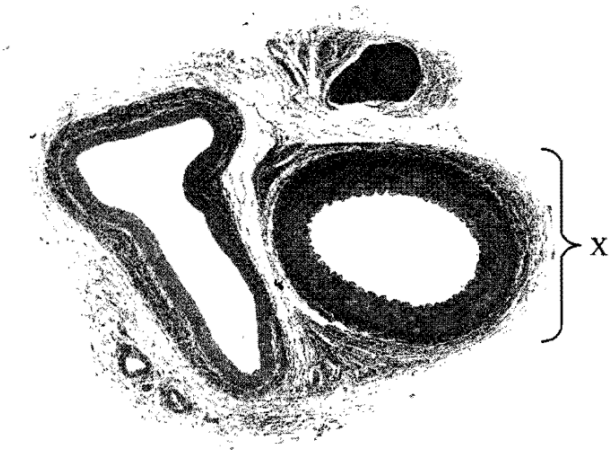
Hint: Draw blood-flow directions, then add the organs' effects on substances.

Which of the following descriptions about the function of the liver is correct?

A. detects blood glucose level
B. breaks down red blood cells
C. secretes glucagon into the blood
D. secretes enzymes into the small intestine

2. [HKDSE Biology 2012 Paper 1A Q32]
← Hint: Draw blood-flow directions, then add the organs' effects on substances.

Directions: Questions 31 and 32 refer to the photomicrograph below, which shows some blood vessels found in the human body:



If blood vessel X is connected with the lung, it carries

A. oxygenated blood towards the heart.
B. oxygenated blood towards the lungs.
C. deoxygenated blood towards the heart.
D. deoxygenated blood towards the lungs.

3. [HKDSE Biology 2012 Paper 1A Q33]
← Hint: Draw blood-flow directions, then add the organs' effects on substances.

In the circulatory system, the highest blood pressure is developed in the

A. left atrium.
B. right atrium.
C. left ventricle.
D. right ventricle.

4. [HKDSE Biology 2013 Paper 1A Q31]
← Hint: Draw blood-flow directions, then add the organs' effects on substances.

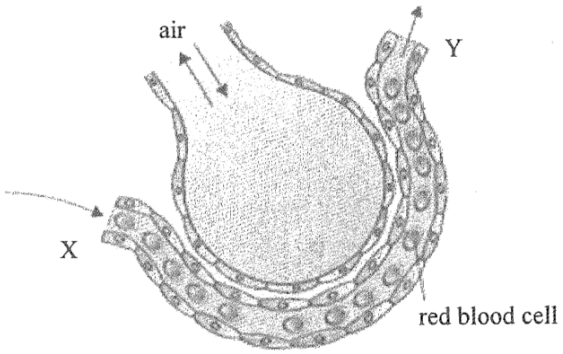
Muscles are found in

(1) arterioles.
(2) capillaries.
(3) veins.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

5. [HKDSE Biology 2015 Paper 1A Q14]
← Hint: Draw blood-flow directions, then add the organs' effects on substances.

Directions: Questions 13 and 14 refer to the diagram below, which shows a section of an air sac and its associated blood capillary in humans:



As the blood in the capillary continues to flow, the red blood cell will first return to the

A. left atrium.
B. right atrium.
C. left ventricle.
D. right ventricle.

6. [HKDSE Biology 2024 Paper 1A Q10]
← Hint: Draw blood-flow directions, then add the organs' effects on substances.

Lactic acid is produced during the anaerobic respiration in humans. Which of the following combinations correctly describes the metabolism of the lactic acid produced?

	the location where lactic acid is broken down	*the period involved*
A.	muscle	during vigorous exercise
B.	muscle	after vigorous exercise
C.	the liver	during vigorous exercise
D.	the liver	after vigorous exercise

7. [HKDSE Biology 2012 Paper 1A Q21]
← Hint: Draw blood-flow directions, then add the organs' effects on substances.

A red blood cell leaves the aorta, travels through the body and arrives at the capillaries of the air sacs. The correct sequence of organs through which the red blood cell may have travelled is

A. liver, lungs, small intestine and heart.
B. lungs, heart, small intestine and liver.
C. small intestine, heart, liver and lungs.
D. small intestine, liver, heart and lungs.

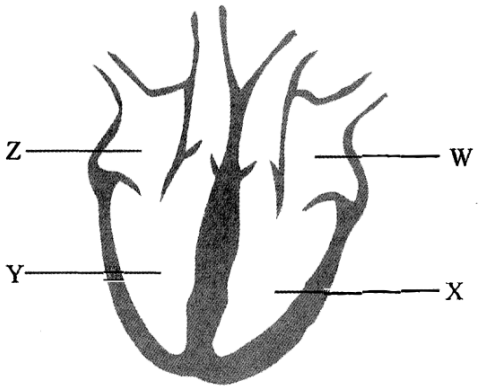
8. [HKDSE Biology 2016 Paper 1A Q13]
← Hint: Draw blood-flow directions, then add the organs' effects on substances.

Of the following blood vessels, which one contains blood with the highest urea content?

A. renal vein
B. hepatic vein
C. pulmonary vein
D. hepatic portal vein

9. [HKDSE Biology 2016 Paper 1A Q16]
Hint: Draw blood-flow directions, then add the organs' effects on substances.

Directions: Questions 16 and 17 refer to the diagram below, which shows a section of the heart:



When W contracts, which of the following combinations about the conditions of the valves is correct?

	Semi-lunar valve	***Bicuspid valve***
A.	open	open
B.	open	closed
C.	closed	open
D.	closed	closed

10. [HKDSE Biology 2018 Paper 1A Q34]
Hint: Draw blood-flow directions, then add the organs' effects on substances.

Which of the following contribute to the continuous blood flow in the aorta?

(1) pumping action of the heart
(2) elastic nature of the wall of the aorta
(3) contraction and relaxation of muscle wall of the aorta

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

11. [HKDSE Biology 2019 Paper 1A Q22]
Hint: Draw blood-flow directions, then add the organs' effects on substances.

When ventricles contract, the valves between ventricles and atria close. Which of the following is the cause of the valve closure?

A. The heart tendons hold the valves in position.
B. The refilling of blood at the atria pushes the valves so that they close.
C. The closure of valves prevents the blood from flowing back to the atria.
D. The higher blood pressure resulting from ventricular contraction pushes the valves so that they close.

12. [HKDSE Biology 2020 Paper 1A Q12]
Hint: Draw blood-flow directions, then add the organs' effects on substances.

Which of the following descriptions of the hepatic portal vein is correct?

A. It carries blood away from the liver.
B. It carries blood with lower oxygen content than that in the hepatic vein.
C. It carries blood with lower amino acid content than that in the hepatic artery after meals.
D. It carries blood with lower glucose content than that in the hepatic vein when one is hungry.

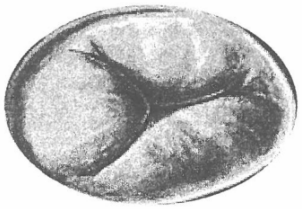
13. [HKDSE Biology 2021 Paper 1A Q20]
Hint: Draw blood-flow directions, then add the organs' effects on substances.

Carbon dioxide produced in the small intestine is passed to the lungs for gas exchange. Which of the following correctly shows the transport route of the carbon dioxide?

A. small intestine → lungs
B. small intestine → liver → lungs
C. small intestine → heart → lungs
D. small intestine → liver → heart → lungs

14. [HKDSE Biology 2022 Paper 1A Q19]
⟵ Hint: Draw blood-flow directions, then add the organs' effects on substances.

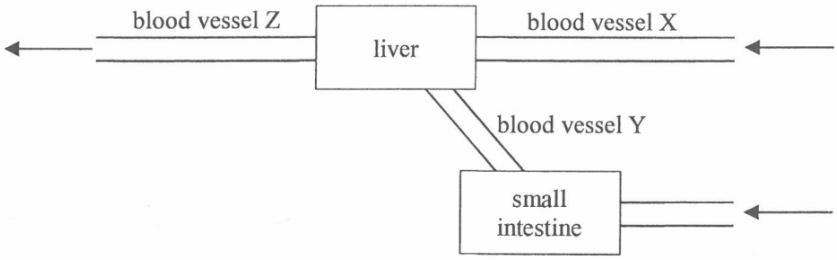
Imagine that you were a red blood cell travelling along a blood vessel and had reached the heart. After passing through the 'gate' shown in the diagram below, there was another 'gate' ahead. Which heart chamber were you situated now?



A. left atrium
B. left ventricle
C. right atrium
D. right ventricle

15. [HKDSE Biology 2022 Paper 1A Q22]
⟵ Hint: Draw blood-flow directions, then add the organs' effects on substances.

Directions: Questions 21 and 22 refer to the diagram below, which shows part of the human circulatory system and the associated organs:



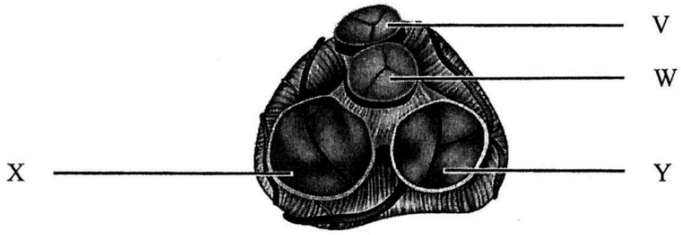
Which of the following descriptions about blood vessel Y are correct?

(1) It transports hormones.
(2) It carries deoxygenated blood.
(3) It has capillary networks at both ends.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

16. [HKDSE Biology 2025 Paper 1A Q8 (English translation)]
⟵ Hint: Draw blood-flow directions, then add the organs' effects on substances.

The diagram below shows the interior of a mammalian heart:

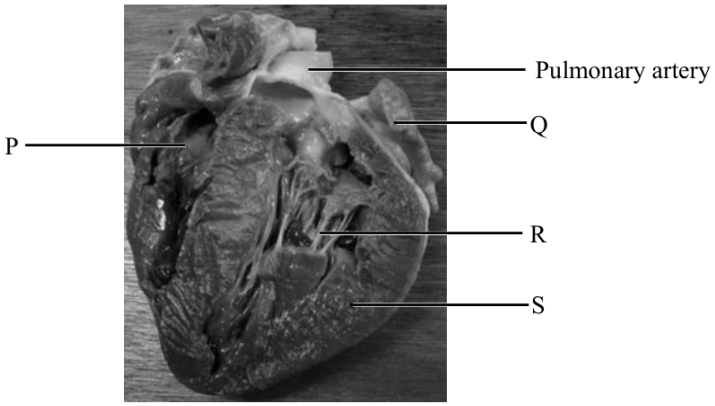


Which valves close to prevent backflow of blood from the aorta and pulmonary artery?

A. W and V
B. W and Y
C. X and V
D. X and Y

17. [HKDSE Biology Practice Paper Paper 1A Q31]
Hint: Draw blood-flow directions, then add the organs' effects on substances.

The following photograph shows a dissected pig's heart:

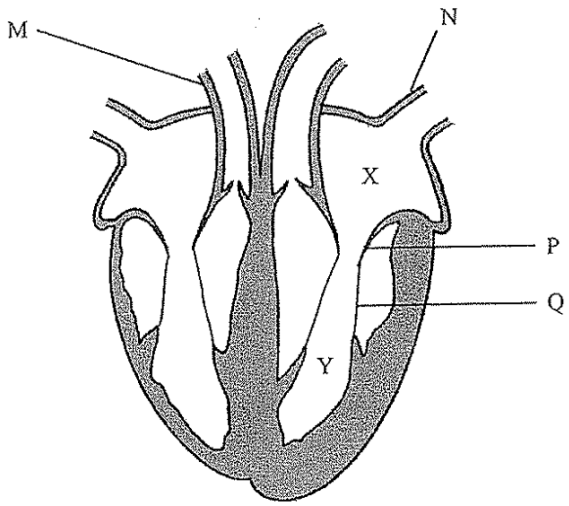


Which of the following descriptions of the labelled structures is correct?

A. Structure P contracts to deliver blood to various parts of the body except the lungs.
B. Structure Q receives blood from the pulmonary veins.
C. Structure R controls the opening and closing of the valve.
D. Structure S contracts to force the blood out of the heart through the pulmonary artery.

18. [HKDSE Biology Sample Paper Paper 1A Q13]
Hint: Draw blood-flow directions, then add the organs' effects on substances.

Directions: Questions 13 and 14 refer to the diagram below, which shows a section of the heart:



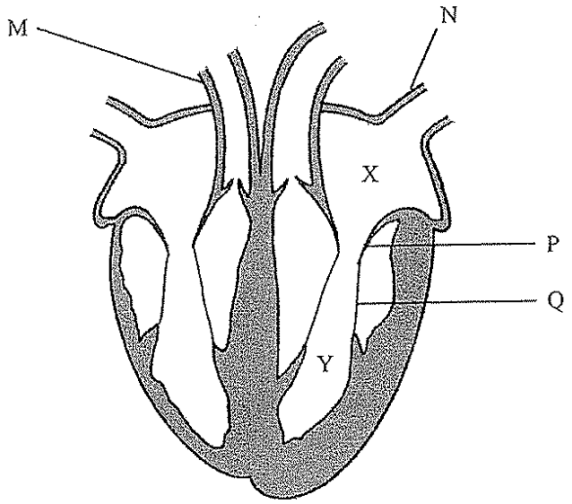
Which of the following comparisons of blood vessels M and N is correct?

	Blood vessel M	***Blood vessel N***
A.	thicker wall	thinner wall
B.	carbon dioxide present	carbon dioxide absent
C.	lower blood pressure	higher blood pressure
D.	lower urea content	higher urea content

19. [HKDSE Biology Sample Paper Paper 1A Q14]

Hint: Draw blood-flow directions, then add the organs' effects on substances.

Directions: Questions 13 and 14 refer to the diagram below, which shows a section of the heart:



Which of the following causes the closure of structure P?

A. increase in tension of structure Q
B. decrease in tension of structure Q
C. decrease in pressure of chamber X
D. increase in pressure of chamber Y

20. [HKDSE Biology 2018 Paper 1B Q6]

Hint: Draw blood-flow directions, then add the organs' effects on substances.

Hong Kong Red Cross Blood Transfusion Service keeps stocks of different blood groups to ensure that there is enough blood supply for transfusion in hospitals.

(a) Of all the blood groups, blood group O is in greatest demand in the Accident and Emergency Departments of hospitals. Suggest why the demand for blood group O is the greatest. (3 marks)

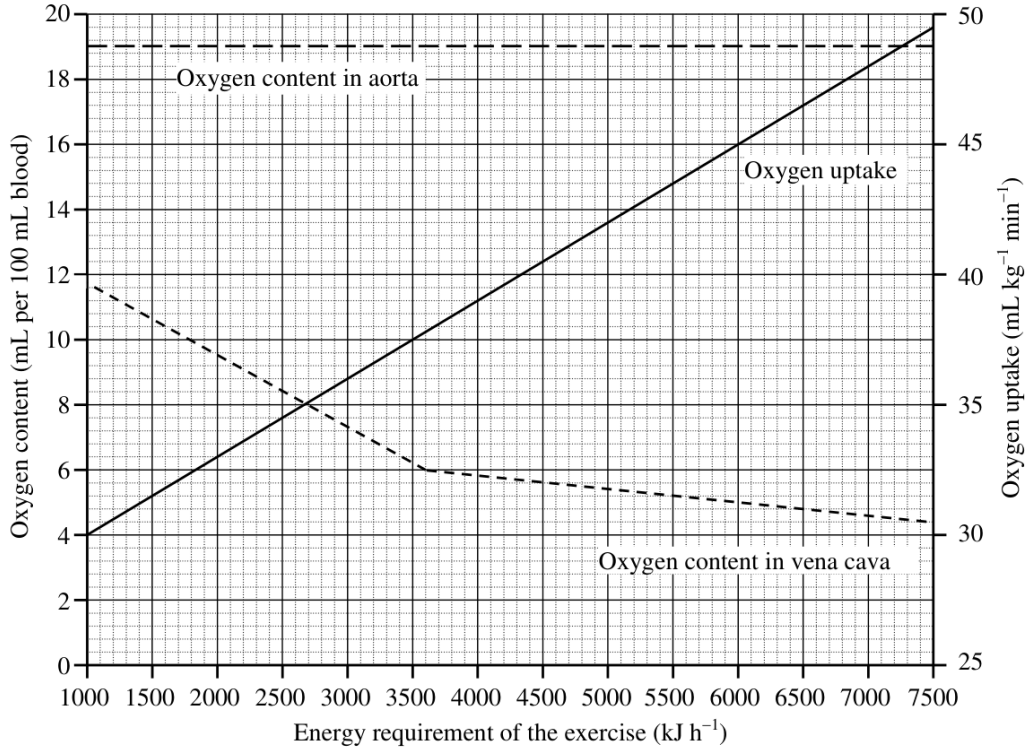
(b) The table below shows some recommendations for adult female and male donors:

	Female donors	Male donors
Maximum number of donations in a year	4	5
Interval between donations	No less than 105 days	No less than 75 days

Suggest why there are different recommendations for female and male donors. (3 marks)

21. [HKDSE Biology Sample Paper Paper 1B Q8]
Hint: Draw blood-flow directions, then add the organs' effects on substances.

The graph below shows the oxygen content of blood in the aorta and that in the vena cava, and the oxygen uptake of a person performing exercise of different intensities. The intensity of exercise is expressed as the energy requirement of the exercise.



(a) The energy requirements for running and leisurely cycling are 3600 kJ h^{-1} and 1800 kJ h^{-1} respectively. Calculate the difference in the blood oxygen content between the aorta and the vena cava for each type of exercise. (2 marks)

Running :

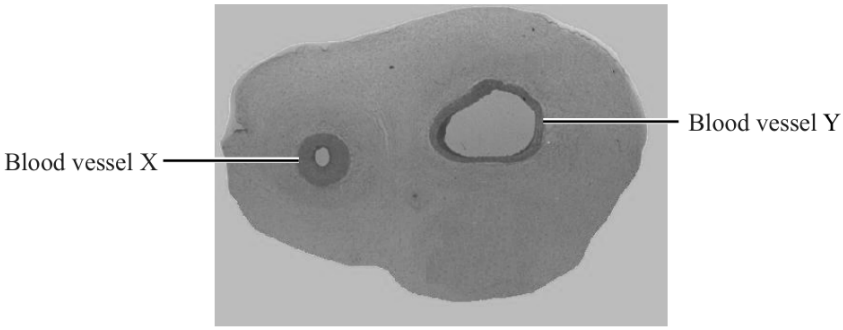
Cycling :

(b) How does the difference in blood oxygen content between the two blood vessels change with the intensity of exercise? Account for this change. (4 marks)

(c) How does the oxygen uptake of the person change with the intensity of exercise? Suggest a physiological response that leads to this change. (2 marks)

22. [HKDSE Biology Practice Paper Paper 1A Q32]
Hint: Draw blood-flow directions, then add the organs' effects on substances.

The photograph below shows the cross section of the umbilical cord of a foetus:



Which of the following descriptions about blood vessels X and Y are correct?

(1) The blood pressure in blood vessel Y is lower than that in blood vessel X.
(2) There are valves along the length of blood vessel Y but not in blood vessel X.
(3) The blood in blood vessel Y has a lower oxygen content than that in blood vessel X.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

III.c Reproduction, growth and development

First read the explanations and diagrams in Concept III.c, then work through the question types in this section. Each worked example retains the complete original question and explanation. The subsequent exercises require progressively more integration of information, based on the demands of the whole question.

Type 1 Follow pollination and fertilisation from flower to fruit

Degree of integration ★★☆☆☆

Key ideas

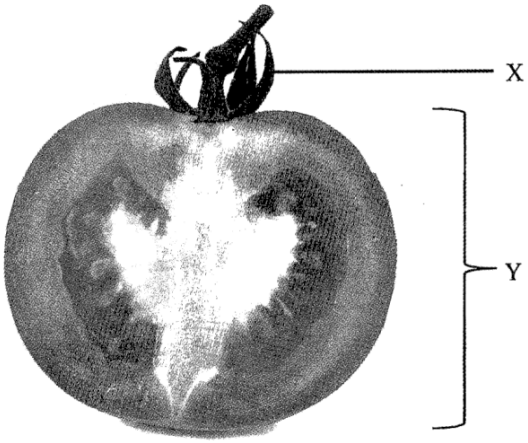
① Pollination brings pollen grains to the stigma. A pollen tube subsequently grows, allowing male gametes to reach the ovule. Fertilisation is the fusion of male and female gamete nuclei. The ovary wall becomes the pericarp, the ovule becomes the seed and the zygote forms the embryo.

② Pericarp and seed coat are maternal in origin, whereas the embryo has a genetic combination formed through fertilisation. Do not assign every cell in the whole fruit the same genetic origin.

How to recognise the problem Distinguish organs, pollen grains and gametes, then trace what each develops into. Dispersal and pollination transport different objects.

Example 1 [HKDSE Biology 2016 Paper 1A Q31]

Directions: Questions 31 and 32 refer to the diagram below, which shows the section of a fruit:



Which of the following combinations correctly shows the floral parts that develop into structures X and Y?

	X	***Y***
A.	carpel	petal
B.	carpel	ovary
C.	sepal	petal
D.	sepal	ovary

Solution **Answer: D**

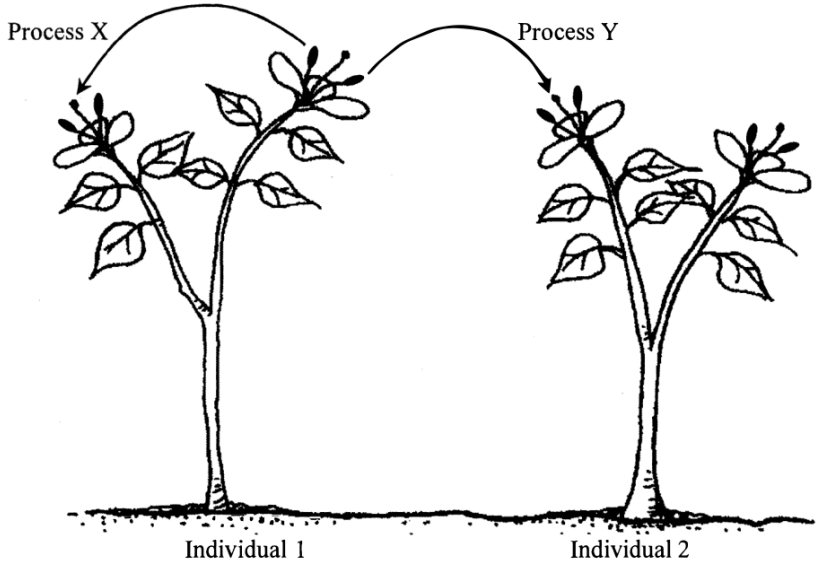
X, remaining at the top of the fruit, is a sepal. The whole fruit Y surrounding the seeds develops from the ovary, so D is correct. The ovary wall forms the fruit wall and ovules form seeds. Distinguish the whole fruit from its wall to avoid replacing the ovary with another flower part.

Method: Distinguish organs, pollen and gametes before tracing development.

Marking reference: HKDSE Biology 2016 Paper 1A Q31, official marking scheme, source page(s) 1.

Example 2 [HKDSE Biology 2017 Paper 1B Q3]

The diagram below shows certain processes occurring in a species of flowering plant:



(a) What is process Y? (1 mark)

(b) Describe the sequence of events leading to fertilisation after process Y has completed. (4 marks)

(c) Explain briefly why process Y is better than process X in terms of evolution. (2 marks)

Solution (a); original allocation: 1 mark(s)

Cross-pollination.

Y transfers pollen from individual 1 to the stigma of individual 2, meeting the definition of pollination between individuals. X transfers pollen within one plant; different flowers alone do not necessarily mean cross-pollination.

Method: Distinguish organs, pollen and gametes before tracing development.

(b); original allocation: 4 mark(s)

Pollen germinates on the stigma and forms a pollen tube. The tube grows down the style towards the ovary and ovule, carrying male gametes. A male gamete is released and fuses with the female gamete inside the ovule.

Distinguish pollen from a male gamete. Pollen forms the tube and transports gametes; the male gamete itself fuses with the egg. Follow the route stigma → style → ovule within the ovary, then fertilisation. 'Pollen falls into the ovary' omits the transport mechanism.

(c); original allocation: 2 mark(s)

Y combines genes from two individuals, generally producing more genetic combinations and more heritable variation for natural selection.

With greater variation, some offspring are more likely to have favourable traits and reproduce if the environment changes. The benefit is a diversity of potentially useful traits, not a guarantee that every offspring is stronger or that every cross-pollination immediately creates a new species.

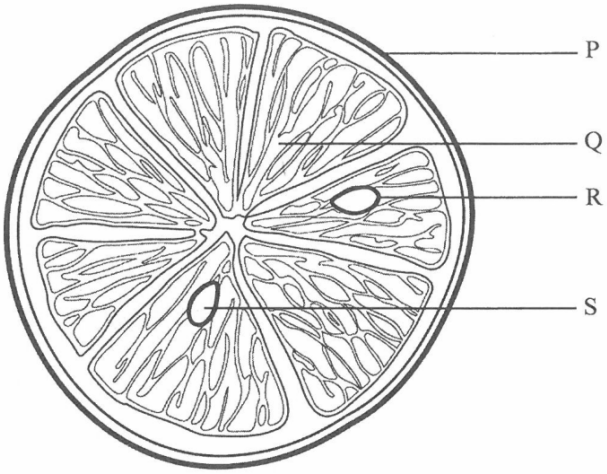
Examiner's comment (source page(s) 2)

A pollen grain is not a male gamete, and an ovule is not a female gamete. The tube grows from the pollen grain and allows male gametes to reach the ovule. Cross-pollination increases variation; it does not guarantee better adaptation of every offspring to every environment.

Marking reference: HKDSE Biology 2017 Paper 1B Q3, official marking scheme, source page(s) 3.

Example 3 [HKDSE Biology 2022 Paper 1A Q33]

Directions: Questions 32 to 34 refer to the following diagram which shows a section of a fruit:



Which of the following pairs of structures have the same genetic composition?

(1) P and Q
(2) Q and R
(3) R and S

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

Solution Answer: C

P, Q and R develop from existing maternal somatic tissues through mitosis and therefore have the same genetic constitution. S is the embryo derived from a zygote and contains genetic material from both parents, so it need not match the mother. P and Q, and Q and R, match: select (1) and (2).

Method: Distinguish organs, pollen and gametes before tracing development.

Marking reference: HKDSE Biology 2022 Paper 1A Q33, official marking scheme, source page(s) 1.

Practice

1. [HKDSE Biology 2012 Paper 1A Q24]

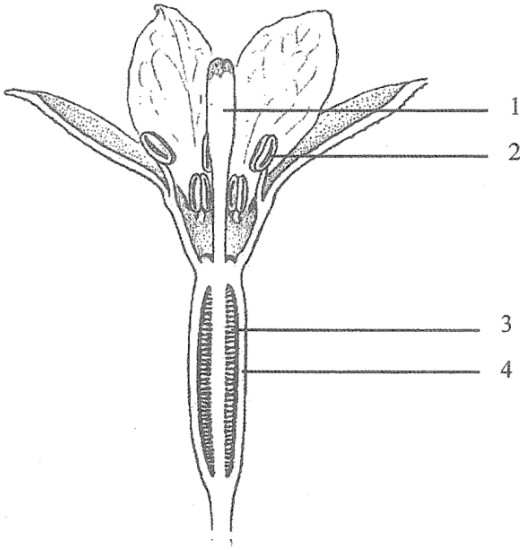
Hint: Distinguish organs, pollen and gametes before tracing development.

Which of the following descriptions about pollen grains is correct?

A. Pollen grains are the male gametes of a plant.
B. Pollen grains can produce nectar to attract insects.
C. Pollen grains germinate when they land on the stigma of the same species.
D. Pollen grains of insect-pollinated flowers are usually smaller than those of wind-pollinated flowers.

2. [HKDSE Biology 2015 Paper 1A Q24]
← Hint: Distinguish organs, pollen and gametes before tracing development.

Directions: Questions 24 and 25 refer to the diagram below, which shows the structures of a flower:



Which structure will develop into the fruit wall?

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

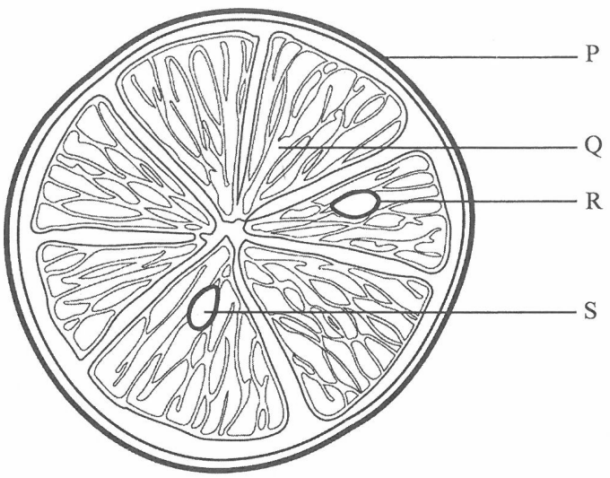
3. [HKDSE Biology 2020 Paper 1A Q25]
← Hint: Distinguish organs, pollen and gametes before tracing development.

Which of the following descriptions of floral structures is correct?

A. The ovule forms seeds.
B. The ovary forms seed coats.
C. Pollen grains are male gametes.
D. The filament contains pollen grains.

4. [HKDSE Biology 2022 Paper 1A Q32]
← Hint: Distinguish organs, pollen and gametes before tracing development.

Directions: Questions 32 to 34 refer to the following diagram which shows a section of a fruit:

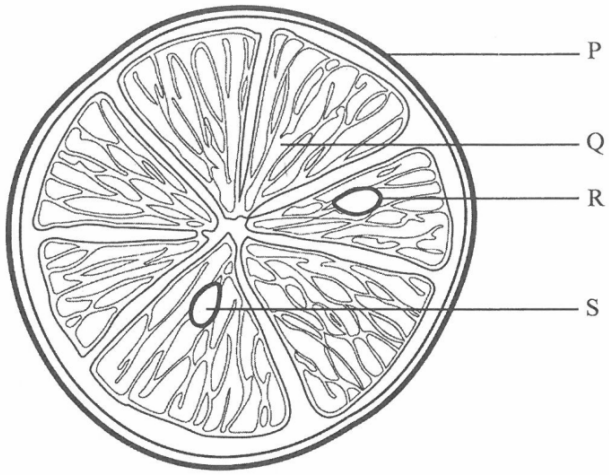


Which of the following structures is developed from the ovum?

A. P
B. Q
C. R
D. S

5. [HKDSE Biology 2022 Paper 1A Q34]
Hint: Distinguish organs, pollen and gametes before tracing development.

Directions: Questions 32 to 34 refer to the following diagram which shows a section of a fruit:



Which of the following statements correctly describes the major role of Q?

A. It protects the seeds by acting as a cushion.
B. It provides nutrients to the seeds for germination.
C. It helps seed dispersal by attracting animals to eat the fruit.
D. It allows the seeds to survive through adverse conditions by storing food.

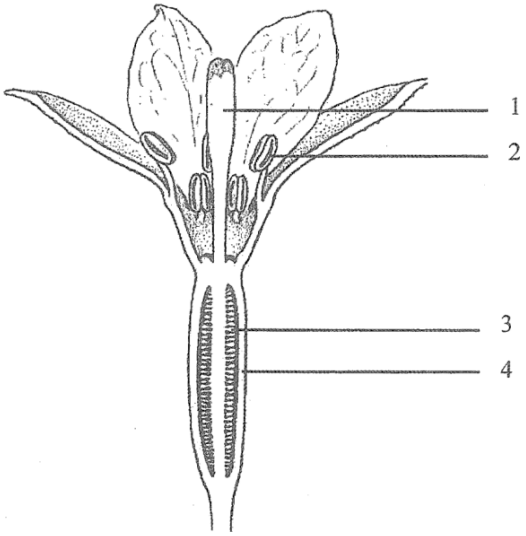
6. [HKDSE Biology 2012 Paper 1A Q28]
Hint: Distinguish organs, pollen and gametes before tracing development.

Which of the following pairs of reproductive structures in humans and flowering plants have the same function?

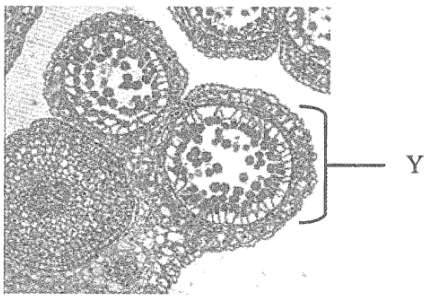
	Humans	***Flowering plants***
A.	sperm	anther
B.	penis	pollen tube
C.	uterus	carpel
D.	vagina	petal

7. [HKDSE Biology 2015 Paper 1A Q25]
Hint: Distinguish organs, pollen and gametes before tracing development.

Directions: Questions 24 and 25 refer to the diagram below, which shows the structures of a flower:



The photograph below shows the cross section of structure 2.

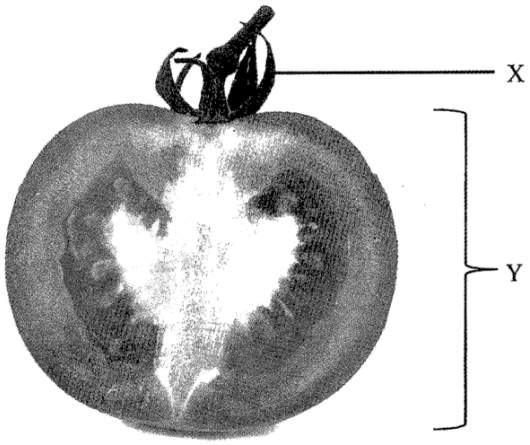


Which of the following parts of the human reproductive system serves a function similar to that of Y?

A. ovum
B. sperm
C. testis
D. ovary

8. [HKDSE Biology 2016 Paper 1A Q32]
Hint: Distinguish organs, pollen and gametes before tracing development.

Directions: Questions 31 and 32 refer to the diagram below, which shows the section of a fruit:



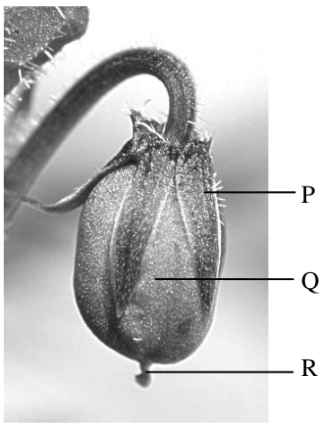
Structure Y serves as

(1) food store for seed germination.
(2) attraction to animals for seed dispersal.
(3) cushion to protect the seed during falling.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

9. [HKDSE Biology Sample Paper Paper 1A Q31]
Hint: Distinguish organs, pollen and gametes before tracing development.

The photograph below shows the fruit of a plant:



Which of the following statements about the fruit is correct?

(1) Structure P is formed from the petal.
(2) Structure Q is developed from the fertilized ovule.
(3) Structure R is the remains of the style.

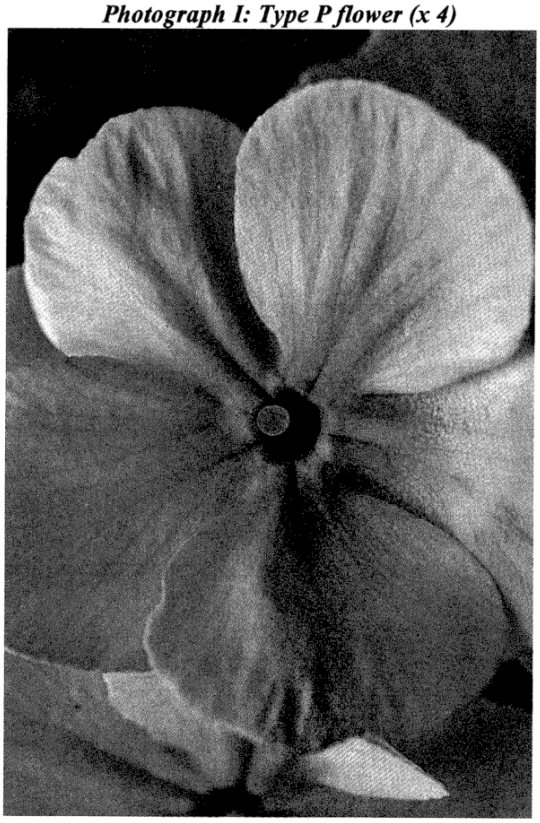
A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

10. [HKDSE Biology 2014 Paper 1B Q8]

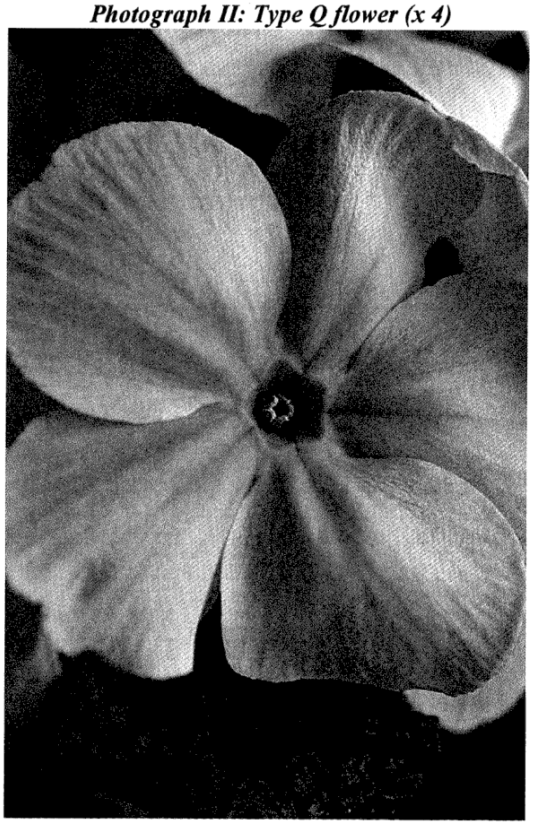
Hint: Distinguish organs, pollen and gametes before tracing development.

A primrose plant is a flowering plant that has two different types of flowers. Photograph I and Photograph II show the appearances of the two types of flowers (P and Q) and Photograph III and Photograph IV show the sections of the flowers respectively. Each primrose plant produces either type P flowers or type Q flowers.

Photograph I: Type P flower (x 4)



Photograph II: Type Q flower (x 4)



Photograph III: Section of type P flower (x 4)



Photograph IV: Section of type Q flower (x 4)



nectary

(a) Apart from the presence of nectaries, give ***two*** observable features of type P flowers which support the claim that the primrose is an insect-pollinated plant. (2 marks)

(b) Butterflies collect nectar from flowers using a mouth structure in the form of a long sucking tube.

(i) When a butterfly visits a type P flower, which part of the sucking tube will the pollen grains stick to? (1 mark)

(ii) When the same butterfly visits another flower, which type of flower will be more readily pollinated? Why? (2 marks)

(iii) What is the advantage of having the different positioning of anthers and stigmas in the primrose? (2 marks)

Type 2 Compare genetic outcomes of sexual and vegetative reproduction

Degree of integration ★★☆☆☆

Key ideas

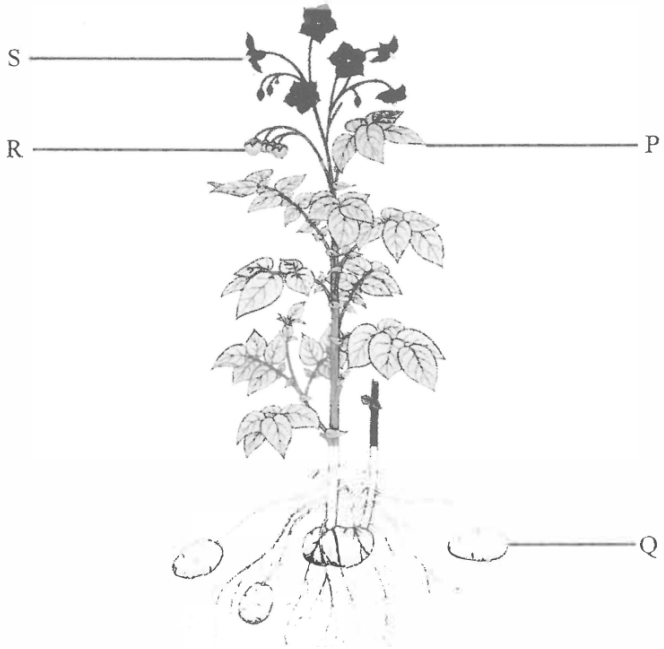
① Growing a new plant from a potato tuber or shoot allows reproduction without gamete fusion, and offspring usually retain the original genetic combination. Gamete fusion defines sexual reproduction; the two gametes need not come from different individuals.

② Many similar offspring preserve suitable traits, but may lack different combinations capable of surviving a shared adverse condition.

How to recognise the problem Identify sexual reproduction by gamete fusion, not simply one versus two parents. Assess cultivation uses through uniformity and variation.

Example 1 [HKDSE Biology 2018 Paper 1A Q15]

Directions: Questions 15 to 17 refer to the following diagram, which shows the structures of a potato plant:



Which of the following labelled structure(s) is / are involved in the reproduction of this potato plant?

A. Q only
B. S only
C. R and S only
D. Q, R and S only

Solution **Reading the question and choosing a method**

Method: Check for gamete fusion, then compare genetic consequences.

Reproduction in the diagram includes both seed formation and formation of new plants from vegetative organs.

Answer: D

Buds on the underground potato tuber Q can grow into new plants through vegetative propagation. Fruit R contains seeds, and flower S contains structures involved in sexual reproduction. Q, R and S all relate to reproduction. Do not regard only flowers as reproductive structures or mistake a potato tuber for a root or bulb. Choose D.

Common error

Excluding asexual reproduction from the meaning of 'reproduction'.

Marking reference: HKDSE Biology 2018 Paper 1A Q15, official marking scheme, source page(s) 1.

Example 2 [HKDSE Biology 2025 Paper 1A Q16 (English translation)]

Read the following two statements carefully:

I: Compared with asexual reproduction, sexual reproduction produces offspring with greater genetic variation.
II: Sexual reproduction always involves two parent individuals, whereas asexual reproduction involves only one parent individual.

Which of the following descriptions of the two statements is correct?

A. I and II are both correct, and II correctly explains I.
B. I and II are both correct, but II does not explain I.
C. I is correct, but II is incorrect.
D. I is incorrect, but II is correct.

Solution **Answer: C**

Method: Check for gamete fusion, then compare genetic consequences.

Compared with asexual reproduction, sexual reproduction generally produces greater genetic variation, so assertion I is true. One individual may supply both kinds of gamete, as in self-fertilisation in plants. Assertion II incorrectly restricts sexual reproduction to two parental individuals. I is true and II false, giving C. A and B treat II as true, while D treats I as false.

Key knowledge

Sexual reproduction involves formation and fusion of gametes. 'Two gametes' cannot be rewritten as 'two different parental individuals are always required'.

Common error

Self-fertilisation remains sexual reproduction; the involvement of only one individual does not make it asexual.

Marking reference: HKDSE Biology 2025 Paper 1A Q16, official marking scheme, source page(s) 51.

Practice

1. [HKDSE Biology 2013 Paper 1A Q14]

Hint: Check for gamete fusion, then compare genetic consequences.

Which of the following consists of individuals that are genetically different from each other?

A. seeds of the same fruit
B. stigmas of the same flower
C. petals of the same plant
D. buds of the same tuber

* The item intended to test whether candidates can identify which of the three options are products of photochemical reactions. In the live paper, the word 'compounds' was used instead of 'substances'. However, oxygen is an element instead of a compound. Hence, the item might not be able to effectively assess candidates' ability and had been deleted. The question in this Examination Report and Question papers has been rectified.

2. [HKDSE Biology 2018 Paper 1A Q17]
Hint: Check for gamete fusion, then compare genetic consequences.

Directions: Questions 15 to 17 refer to the following diagram, which shows the structures of a potato plant:



Farmers usually grow potato plants by vegetative propagation. This is probably because vegetative propagation

A. produces tubers for harvesting.
B. does not involve seed dispersal.
C. takes a shorter time to reproduce.
D. allows rapid colonisation of an area.

3. [HKDSE Biology 2020 Paper 1A Q21]
Hint: Check for gamete fusion, then compare genetic consequences.

In flowering plants, asexual reproduction is considered less favourable than sexual reproduction in terms of natural selection because offspring produced from asexual reproduction

A. are genetically identical to each other.
B. have keen competition with each other.
C. cannot invade and colonise new environments.
D. can grow rapidly only in favourable conditions.

Type 3 Analyse growth, germination and flowering with measurements and experiments

Degree of integration ★★★☆☆

Key ideas

① Compare growth rates using increases over the same period, not only final size. Repeated measurements of one plant cannot use destructive dry-mass measurement; choose a suitable non-destructive indicator such as height or leaf area and explain its limitations.

② Germination experiments also require links among hormones, enzyme production, hydrolysis of stored substances and embryo growth. Each control should isolate one possible explanation.

How to recognise the problem Identify whether the quantity measured is body mass, length, dry mass or rate, then select suitable intervals and controls. Do not treat different indicators as equivalent.

Example 1 [HKDSE Biology 2015 Paper 1A Q28]

Which of the following parameters is best for measuring the growth of the broad bean after germination?

A. the length of the shoot
B. the area of the leaves
C. the weight of the embryo
D. the volume of the cotyledon

Solution Answer: A

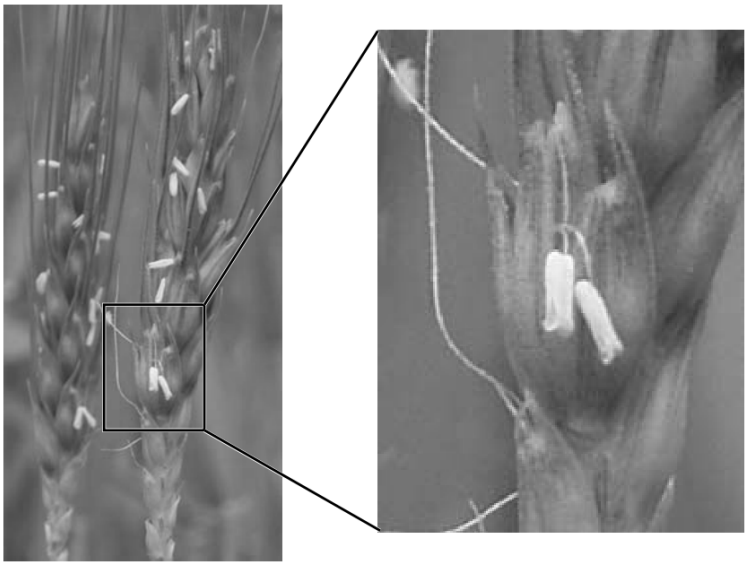
Method: Identify the growth indicator, then compare time, rate and controls.

Shoot length after germination is directly measurable and increases as the seedling elongates, making it the suitable growth indicator among the options. Cotyledons supply stored nutrients and may shrink. Embryo mass alone is affected by water content and consumption of reserves. Choose A.

Marking reference: HKDSE Biology 2015 Paper 1A Q28, official marking scheme, source page(s) 1.

Example 2 [HKDSE Biology Practice Paper Paper 1B Q10]

(a) Photograph 1 shows two groups of wheat flowers and Photograph 2 shows an enlarged wheat flower:



Photograph 1 **Photograph 2**

Suggest the agent for pollination of the wheat. Support your answer with reference to an observable feature in the above photographs. (2 marks)

(b) Explain the importance of soaking wheat grains in water for germination. (2 marks)

(c) When wheat grains are sown on a piece of farmland which has been frequently sprayed with a pesticide X, the germination rate is poor. Design an experiment to investigate whether pesticide X affects germination of the wheat grains. (4 marks)

Solution a; original allocation: 2 mark(s)

Method: Identify the growth indicator, then compare time, rate and controls.

Wind. The photograph shows anthers hanging outside the flower, allowing pollen to be released readily into the air.

Use visible structures as evidence, rather than pollen quantity or scent that the photograph does not show.

b; original allocation: 2 mark(s)

Water activates enzymes required for germination, allowing stored food to be hydrolysed for the embryo's respiration and growth. It also provides a transport medium carrying soluble nutrients to growing regions.

Any two distinct roles can earn credit; softening the seed coat after water uptake is another possibility. Water itself is not the main chemical-energy source during germination.

c; original allocation: 4 mark(s)

Randomly divide an adequate number of similar-sized wheat grains from the same batch into two groups, for example 50 per group. Treat the experimental group with water containing insecticide X and the control with an equal amount of water without X. Keep temperature, light, water availability and duration the same. Count grains with emerged radicles and calculate germination percentage = germinated grains / total grains × 100%. Compare the groups and repeat the experiment.

The four main points are adequate sample size, a control without X, identical other conditions, and quantified comparison of germination percentages. Using new seeds in one group and old seeds in the other confounds insecticide treatment with seed quality.

Marking reference: HKDSE Biology Practice Paper Paper 1B Q10, official marking scheme, source page(s) 6.

Example 3 [HKDSE Biology 2025 Paper 1B Q8 (English translation)]

An experiment was carried out to investigate the effect of salinity on seed germination. Two groups of seeds were sterilised and then placed in plates containing distilled water or sodium chloride (NaCl) solution to germinate. After several days, the germination percentage and the level of plant hormone X in the seeds were measured for the two treatments. The results are shown below:

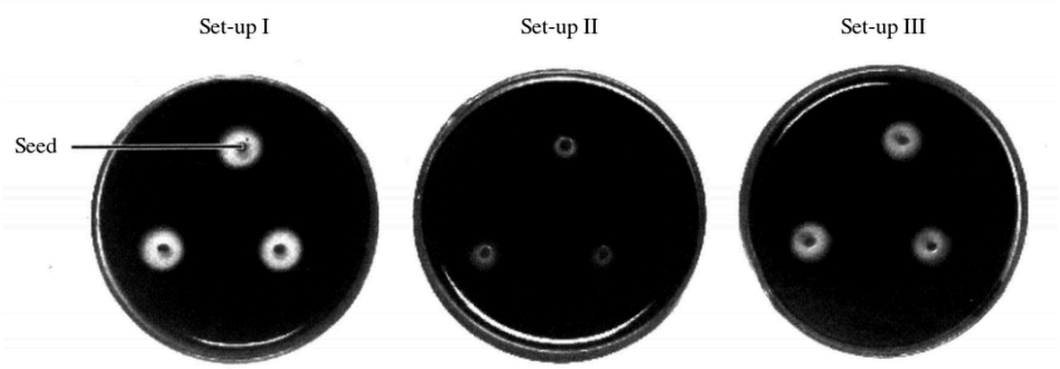
Treatment	Germination percentage (%)	Level of plant hormone X (arbitrary units)
Soaked in distilled water	98	0.9
Soaked in NaCl solution	73	0.3

(a) Complete the table below to show what conclusions can be drawn about the effects of NaCl solution on seed germination percentage and the level of plant hormone X in the seeds. (4 marks)

Effect of NaCl solution on	Comparison of results	Conclusion
Germination percentage		
Level of plant hormone X		

(b) Another experiment was carried out to investigate the function of plant hormone X in seeds. The seeds were divided into three groups, cut transversely and placed on the following three starch-agar plates containing different ingredients:
Set-up I: starch agar and distilled water
Set-up II: starch agar and NaCl solution
Set-up III: starch agar, NaCl solution and plant hormone X solution

After incubation at 28 °C for 48 hours, the plates were flooded with iodine solution. The reaction between starch and iodine turned the agar plates dark blue, while clear zones appeared around the positions of the seeds, as shown below:



(i) Explain why clear zones appear in the agar plates. (2 marks)

(ii) Based on the results above, suggest the function of hormone X and explain why this hormone is important for seed germination. (3 marks)

Solution (a): germination percentage; original allocation: 2 mark(s)

Method: Identify the growth indicator, then compare time, rate and controls.

The NaCl-treated group has 73% germination, below the distilled-water group's 98%. NaCl treatment inhibits germination.

State the direct 73% versus 98% comparison before concluding inhibition. The results support lower germination under these experimental conditions, not death of every seed.

(a): hormone X level; original allocation: 2 mark(s)

Hormone X is 0.3 arbitrary units in the NaCl group, below 0.9 in the distilled-water group. NaCl reduces the X level, possibly by inhibiting synthesis or promoting breakdown.

This is a separately measured outcome. Germination changes cannot substitute for hormone data, and simultaneous decreases alone do not establish the entire causal link without further experiments.

(b)(i); original allocation: 2 mark(s)

The seeds produce and release starch-hydrolysing enzymes. Starch around them is hydrolysed, so a clear zone remains after iodine solution is added.

The clear zone is not caused by seeds absorbing iodine. Identify hydrolysis first, then explain the colour through absence of the original starch.

(b)(ii); original allocation: 3 mark(s)

Hormone X promotes amylase synthesis. Starch is hydrolysed into soluble sugars such as maltose, whose digestion products supply respiration with substrates for energy release or provide materials for synthesis, supporting germination.

Compare set-ups II and III: the salt-treatment background is the same, but adding X increases the clear zone, supporting a connection between X and hydrolytic-enzyme action.

The question calls it hormone X; there is no need to assign an additional name not supplied.

Examiner's comment (source page(s) 74)

Distinguish describing results from drawing conclusions, and germination from general growth. A clear zone indicates hydrolysis by enzymes released from seeds, not seeds directly eating starch from the plate. Hydrolysis itself is not equivalent to respiratory energy release.

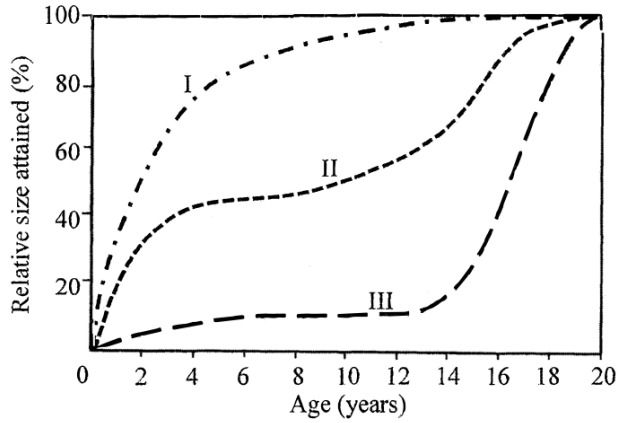
Marking reference: HKDSE Biology 2025 Paper 1B Q8, official marking scheme, source page(s) 57.

Practice

1. [HKDSE Biology 2017 Paper 1A Q24]

Hint: Identify the growth indicator, then compare time, rate and controls.

The graph below shows the growth curves of the head, reproductive system and whole body in humans:



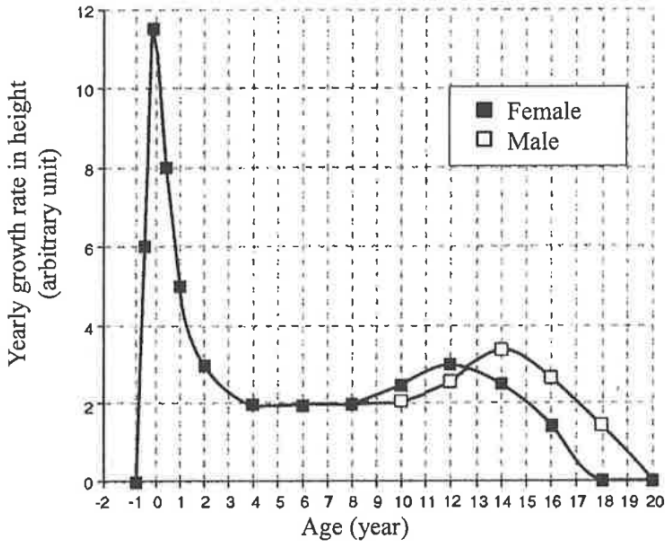
Which of the following combinations correctly identifies curves I, II and III?

	I	*II*	*III*
A.	whole body	reproductive system	head
B.	head	reproductive system	whole body
C.	head	whole body	reproductive system
D.	reproductive system	whole body	head

2. [HKDSE Biology 2019 Paper 1A Q31]

Hint: Identify the growth indicator, then compare time, rate and controls.

The graph below shows the growth rate of humans:

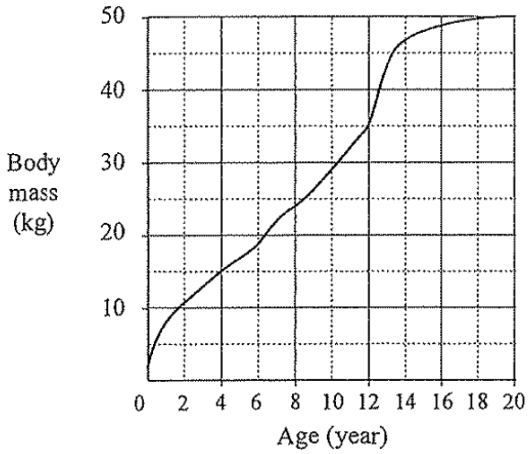


Which of the following can be deduced from the graph?

A. The brain grows rapidly from age 0 to age 4.
B. There is no more change in growth for males after age 20.
C. The duration of adolescence is the same in males and females
D. Growth of the reproductive organs begins at age 10 in females.

3. [HKDSE Biology Sample Paper Paper 1A Q32]
⟵ Hint: Identify the growth indicator, then compare time, rate and controls.

The graph below shows the average growth curve of the first 20 years of a girl's life:



Based on the curve, girls grow fastest between the ages of

A. 0 – 2.
B. 6 – 8.
C. 12 – 14.
D. 18 – 20.

4. [HKDSE Biology 2019 Paper 1A Q30]
⟵ Hint: Identify the growth indicator, then compare time, rate and controls.

Which of the following parameters is best used for recording the growth of a potted germinating seedling over a period of time?

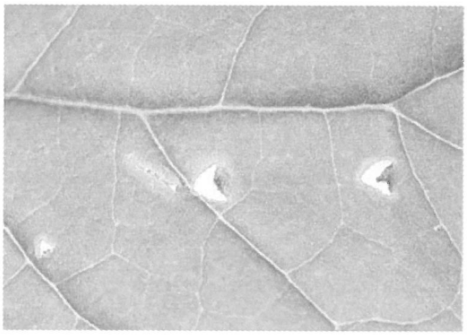
A. the dry mass of the seedling
B. the fresh mass of the seedling
C. the total surface area of the seedling's leaves
D. the time taken for the seedling's first leaf to appear

5. [HKDSE Biology 2021 Paper 1B Q7]
Hint: Identify the growth indicator, then compare time, rate and controls.

(a) In flowering plants, environmental stress (i.e. under adverse conditions) in general can induce flowering. Explain why this flowering response can increase the chance of survival of flowering plants. (3 marks)

(b) Recently, scientists observed that bees cut tiny holes in leaves with their mouthparts (as shown in the photographs below) but did not consume or transport the leaf fragments:





It has been hypothesised that bees induce flowering by imposing a mechanical stress on the flowering plants. To test this hypothesis, three groups of tomato plants at the same developmental stage (without floral buds) were subjected to the following treatments respectively:

1. Bees cut tiny holes in leaves (bee damage)
2. Similar holes in leaves were cut by using forceps (mechanical damage)
3. Intact leaves without treatment (no damage)

The time taken for flowering of each group of these tomato plants after the respective the treatment was recorded.

(i) If the above hypothesis is correct, what would be the predicted results? (1 mark)

(ii) The table below shows the time taken for flowering of these tomato plants after the treatments:

	Bee damage	Mechanical damage	No damage
Average time taken for flowering after the treatment (days)	38	56	70

With reference to the data shown in the table, discuss if the data support the hypothesis that bees induce flowering by imposing a mechanical stress on the flowering plants. (4 marks)

(c) When bees establish a new colony, they will inflict more leaf damage to the surrounding flowering plants if the colony is in an area with insufficient supply of pollen. What is the advantage of this behaviour to the bees? (1 mark)

Type 4 Track gametes, fertilisation, embryos and maternal–fetal exchange

Degree of integration ★★★☆☆

Key ideas

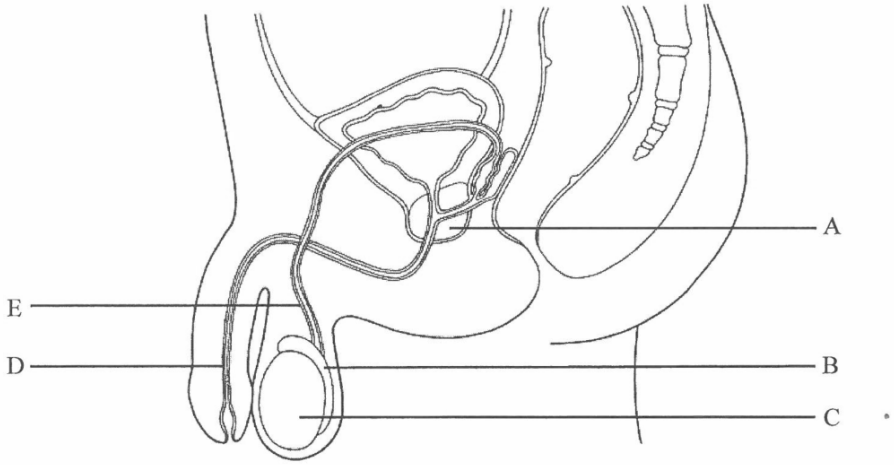
① Sperm are produced in the testes and transported through sperm ducts. Secretions from accessory glands contribute to semen. Fertilisation normally occurs in an oviduct, and the early embryo divides before implanting in the uterine lining.

② The placenta allows maternal–fetal exchange, but the two blood supplies normally do not mix directly. Umbilical arteries and veins are named by their direction relative to the fetal heart; ordinary oxygen-content shortcuts do not apply.

How to recognise the problem Locate production → transport → fertilisation → implantation. For ligation or blockage, identify the interrupted pathway and distinguish gamete transport from hormone transport.

Example 1 [HKDSE Biology 2022 Paper 1B Q2]

The diagram below shows the human male reproductive system and its associated structures:



(a) In which structure does meiosis take place? Give your answer using the letters in the diagram. (1 mark)

(b) State the functions of structures A and B respectively. (2 marks)

(c) Vasectomy is an operation for achieving permanent contraception in males.

(i) Using the letters in the diagram, state the structure which is affected in this contraceptive method. (1 mark)

(ii) What is the biological basis of this contraceptive method? (2 marks)

Solution a; original allocation: 1 mark(s)

C.

C is a testis, where germ cells undergo meiosis to produce haploid sperm.

b; original allocation: 2 mark(s)

A produces the fluid component of semen, supplying nutrients for sperm. B stores and protects sperm and allows them to mature.

A is an accessory gland whose secretion mixes with sperm to form semen. B is the epididymis, where sperm are stored and mature after leaving the testis. Do not confuse maturation in the epididymis with sperm production.

c(i); original allocation: 1 mark(s)

E.

E is the sperm duct, carrying sperm from the epididymis towards the urethra. Vasectomy interrupts this route.

c(ii); original allocation: 2 mark(s)

Ejaculated semen contains no sperm, so an egg cannot be fertilised.

The operation prevents sperm entering the ejaculate and therefore prevents their fusion with an egg. Accessory glands can still secrete fluid. Failure of fertilisation results from absence of sperm, not necessarily absence of ejaculation.

Examiner's comment (source page(s) 3, 4)

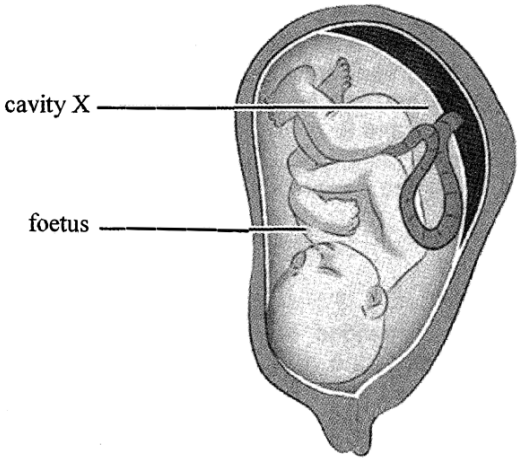
A supplies seminal fluid, while B is the epididymal site of sperm storage and maturation. Do not interchange them. The direct consequence of sperm-duct surgery is semen without sperm, from which failure of fertilisation follows.

Marking reference: HKDSE Biology 2022 Paper 1B Q2, official marking scheme, source page(s) 3.

Method: Trace locations from gamete production through fertilisation to implantation.

Example 2 [HKDSE Biology 2016 Paper 1B Q2]

The following diagram shows a foetus and the associated structures inside the uterus:



(a) What is the fluid found in cavity X? (1 mark)

(b) On the diagram, label the structure where the exchange of materials between the foetal blood and maternal blood takes place. (1 mark)

(c) Give ***two*** reasons why foetal blood has to be separated from maternal blood. (2 marks)

Solution (a); original allocation: 1 mark(s)

Amniotic fluid.

X is the amniotic cavity surrounding the fetus. Its fluid cushions external shocks and provides a liquid environment. The question asks for the fluid, not the membrane.

(b); original allocation: 1 mark(s)

The placenta: the disc-like region where the umbilical cord joins the uterine wall.

Follow the cord from the fetal abdomen towards the uterine wall; its attachment is the placenta. The diagram below labels that region. Do not label the entire cord or amnion as the placenta.

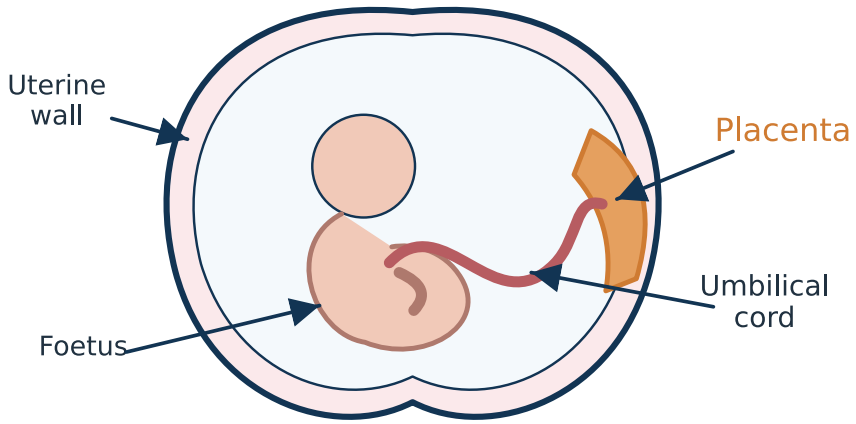
(c); original allocation: 2 mark(s)

Prevent agglutination when blood groups are incompatible, and prevent higher maternal blood pressure being transmitted directly and damaging fetal vessels.

Maternal and fetal blood are separated by an exchange barrier. Small molecules can cross without directly joining the two bloodstreams. Their blood groups may differ, so separation reduces the risk of agglutination from direct contact between incompatible antigens and antibodies. Fetal vessels can also maintain a suitably lower pressure. The barrier blocks some pathogens, but not every virus or drug.

Method: Trace locations from gamete production through fertilisation to implantation.

The placenta attaches to the uterine wall; the umbilical cord connects the foetus to it



The placenta and umbilical cord are distinct structures. Maternal and foetal blood normally do not mix directly.

Diagram answer corresponding to the original question

Examiner's comment (source page(s) 3)

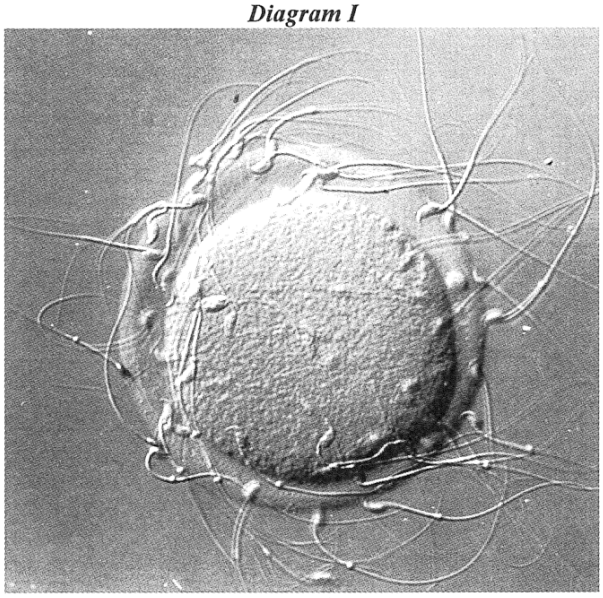
The placenta lies on the uterine wall, and the cord connects fetus and placenta; they are not interchangeable. Direct entry of high-pressure maternal blood could damage fetal vessels. The reaction to incompatible antigens is agglutination.

Marking reference: HKDSE Biology 2016 Paper 1B Q2, official marking scheme, source page(s) 2.

Example 3 [HKDSE Biology 2020 Paper 1B Q10]

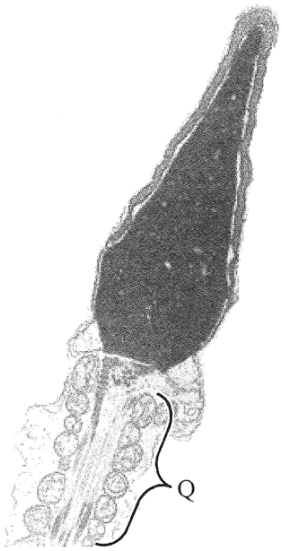
Diagram I shows a photomicrograph of human sperm and a human ovum during fertilisation while Diagram II shows an electron micrograph of an enlarged view of human sperm.

Diagram I



(700X)

Diagram II



(30 000X)

(a) Under normal circumstances, in which structure of the female reproductive system does the process shown in Diagram I take place? (1 mark)

(b) With reference to Diagram II, what is the significance of organelles Q to the sperm's function? (1 mark)

(c) (i) Explain the significance of the chromosome number of the sperm and ovum to sexual reproduction. (2 marks)

(ii) Briefly describe how identical twins may arise after fertilisation. (2 marks)

Solution a; original allocation: 1 mark(s)

Method: Trace locations from gamete production through fertilisation to implantation.

The oviduct.

Figure I shows fertilisation, involving sperm–egg contact, which normally occurs in a human oviduct. The ovary develops and releases eggs, while the uterus is the main site of later implantation and development.

b; original allocation: 1 mark(s)

Mitochondria in Q provide ATP for sperm swimming.

Q is concentrated in the sperm midpiece and supplies energy through cellular respiration for flagellar movement. 'Provides energy' alone does not explain the functional benefit; connect it to swimming and reaching the egg.

c(i); original allocation: 2 mark(s)

Both sperm and egg are haploid. Their chromosome sets unite at fertilisation, restoring diploidy and keeping chromosome number stable between generations.

In humans, 23 sperm chromosomes and 23 egg chromosomes produce 46. If gametes retained the somatic diploid number, each fertilisation would double it again. Halving before fusion allows inheritance from both parents while maintaining the species' chromosome number.

c(ii); original allocation: 2 mark(s)

One zygote first divides by mitosis to form an early embryo. At an early stage, the embryo separates into two parts, which develop into identical twins.

Mitosis produces cells with the same genetic constitution, and both embryos originate from one zygote, so their genetic constitutions are very similar. Ordinary first cleavage does not automatically produce two independent babies. Two eggs fertilised separately instead produce non-identical twins.

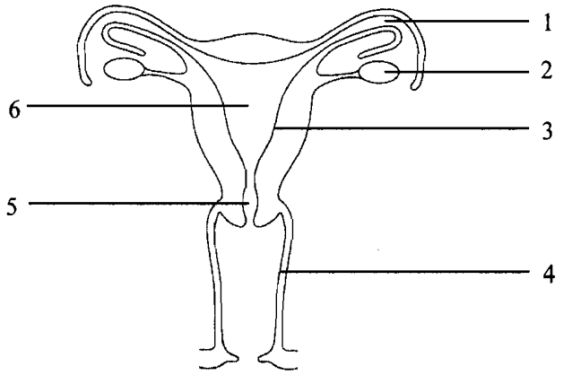
Marking reference: HKDSE Biology 2020 Paper 1B Q10, official marking scheme, source page(s) 7.

Practice

1. [HKDSE Biology 2012 Paper 1A Q25]

Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 25 and 26 refer to the following diagram, which shows part of the female reproductive system:



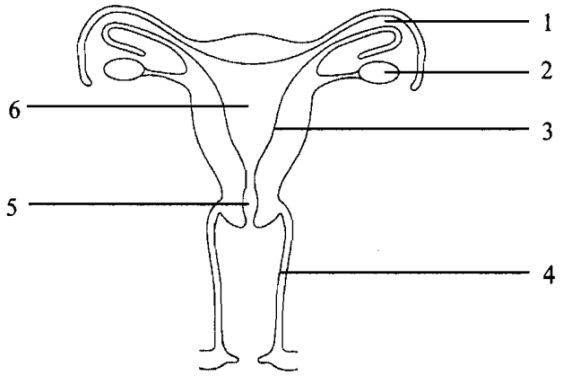
Which of the following structures undergo periodic changes?

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

2. [HKDSE Biology 2012 Paper 1A Q26]

Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 25 and 26 refer to the following diagram, which shows part of the female reproductive system:



In which of the following structures does implantation normally take place?

A. 1
B. 3
C. 5
D. 6

3. [HKDSE Biology 2012 Paper 1A Q27]

Hint: Trace locations from gamete production through fertilisation to implantation.

Which of the following contraceptive methods prevents the formation of mature gametes?

A. using diaphragm
B. using rhythm method
C. intake of contraceptive pills
D. using intrauterine device

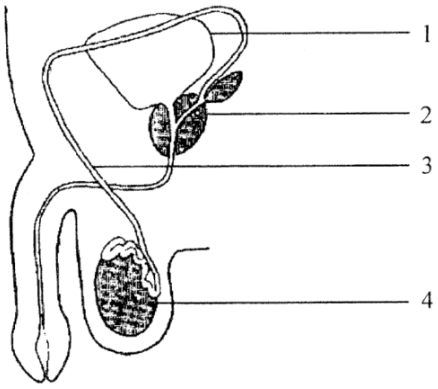
4. [HKDSE Biology 2012 Paper 1A Q29]
Hint: Trace locations from gamete production through fertilisation to implantation.

Which of the following is ***not*** a secondary sexual characteristic of a man?

A. growth of beard
B. production of sperms
C. broadening of shoulders
D. enlargement of larynx

5. [HKDSE Biology 2013 Paper 1A Q35]
Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 35 and 36 refer to the diagram below, which shows the reproductive system of a man:



Which of the following structures are involved in the production of the content of semen?

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

6. [HKDSE Biology 2014 Paper 1A Q29]
Hint: Trace locations from gamete production through fertilisation to implantation.

During foetal development, the placenta has functional roles similar to

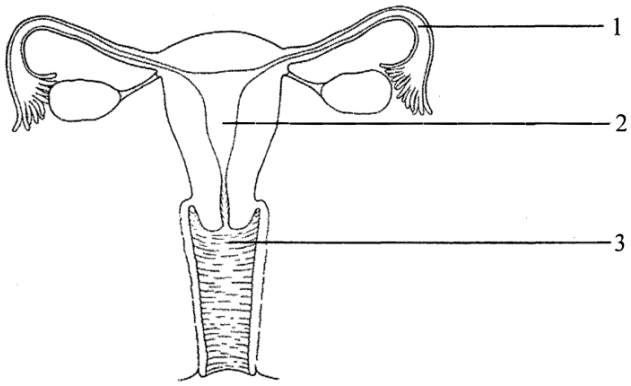
(1) the bone.
(2) the lungs.
(3) the small intestine.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

7. [HKDSE Biology 2017 Paper 1A Q19]

Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 19 and 20 refer to the diagram below, which shows some structures of the female reproductive system in humans:



Which of the following combinations correctly shows the location where fertilisation and discharge of semen normally take place?

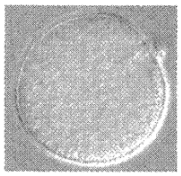
	Fertilisation	***Discharge of semen***
A.	1	2
B.	1	3
C.	2	2
D.	2	3

8. [HKDSE Biology 2017 Paper 1A Q23]

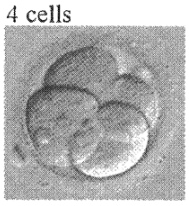
Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 21 to 23 refer to the following photomicrographs of the same magnification. The photomicrographs show some early stages of embryo development:

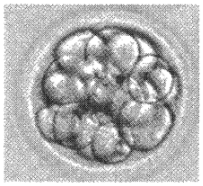
I. 1 cell



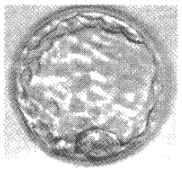
II. 4 cells



III. 16 cells



IV. More than 100 cells



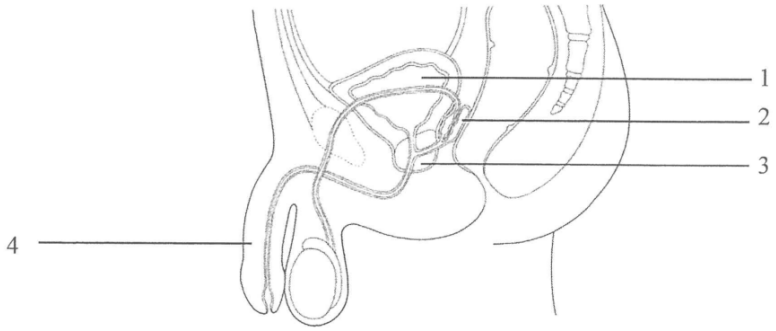
Which of the following stages is ready for implantation?

A. I
B. II
C. III
D. IV

9. [HKDSE Biology 2021 Paper 1A Q21]

Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 21 and 22 refer to the diagram below, which shows the male reproductive system and its associated structures:



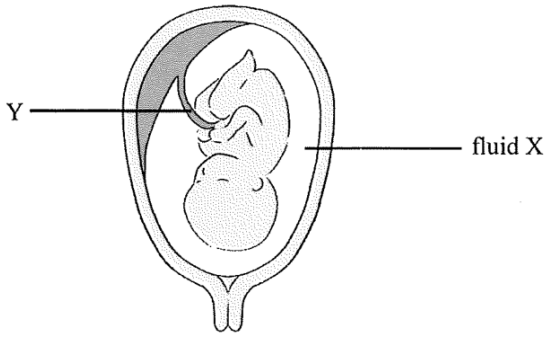
Which of the labelled structures are responsible for producing seminal fluid?

A. 1 and 2 only
B. 1 and 3 only
C. 2 and 3 only
D. 1, 2 and 3

10. [HKDSE Biology 2023 Paper 1A Q34]

Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 34 and 35 refer to the diagram below, which shows a foetus and the associated structures inside the uterus:



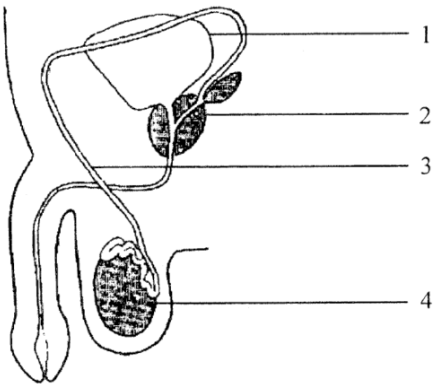
Which of the following statements about fluid X is correct?

A. It is secreted by the uterus.
B. It provides antibodies to the foetus.
C. It is a medium for material exchange.
D. It provides a stable environment for the foetus.

11. [HKDSE Biology 2013 Paper 1A Q36]

Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 35 and 36 refer to the diagram below, which shows the reproductive system of a man:



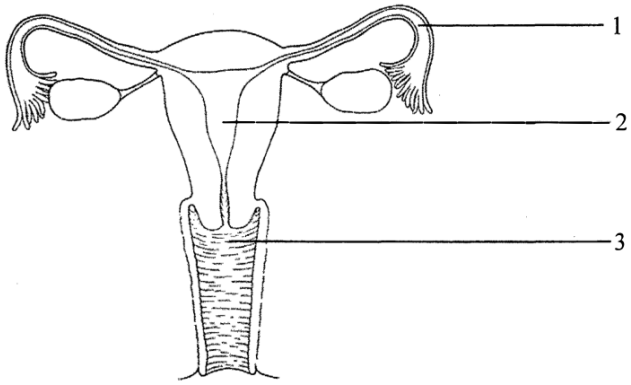
Which of the following may still occur after structure 3 on both sides of the body has been tied up and cut?

(1) production of sperms
(2) erection of penis
(3) ejaculation

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

12. [HKDSE Biology 2017 Paper 1A Q20]
Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 19 and 20 refer to the diagram below, which shows some structures of the female reproductive system in humans:



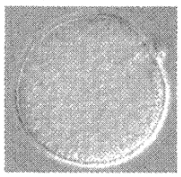
If location 1 is blocked in a 14-year-old girl, which of the following is most likely to occur?

A. There is no ovulation.
B. Her fertility decreases.
C. There is no menstruation.
D. Her breasts fail to develop.

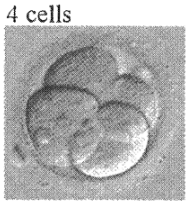
13. [HKDSE Biology 2017 Paper 1A Q21]
Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 21 to 23 refer to the following photomicrographs of the same magnification. The photomicrographs show some early stages of embryo development:

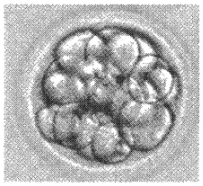
I. 1 cell



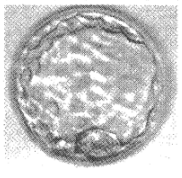
II. 4 cells



III. 16 cells



IV. More than 100 cells



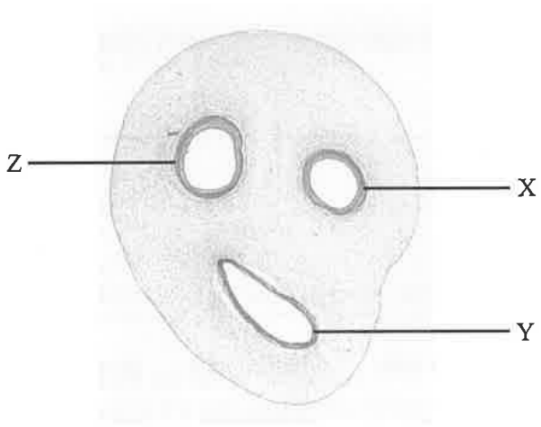
Which of the following processes are taking place from stage I to stage IV?

(1) cell division
(2) cell enlargement
(3) cell differentiation

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

14. [HKDSE Biology 2019 Paper 1A Q27]
Hint: Trace locations from gamete production through fertilisation to implantation.

The photomicrograph below shows a section of a human umbilical cord with three blood vessels:

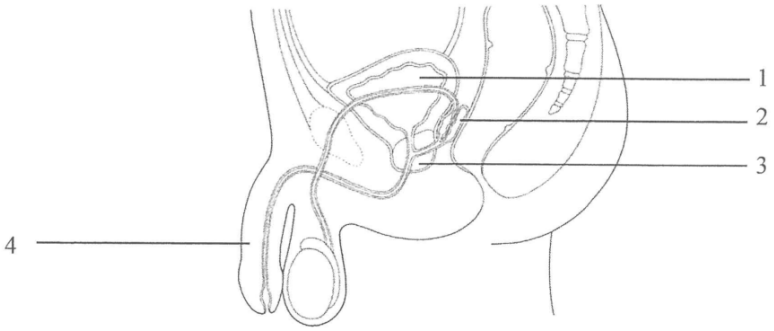


Which of the following comparisons of the content of the blood vessels is correct?

A. The blood in vessel X has a higher oxygen content than that in vessel Y.
B. The blood in vessel Z has a higher glucose content than that in vessel X.
C. The blood in vessel Y has a higher amino acid content than that in vessel X.
D. The blood in vessel Y has a higher carbon dioxide content than that in vessel Z.

15. [HKDSE Biology 2021 Paper 1A Q22]
Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 21 and 22 refer to the diagram below, which shows the male reproductive system and its associated structures:

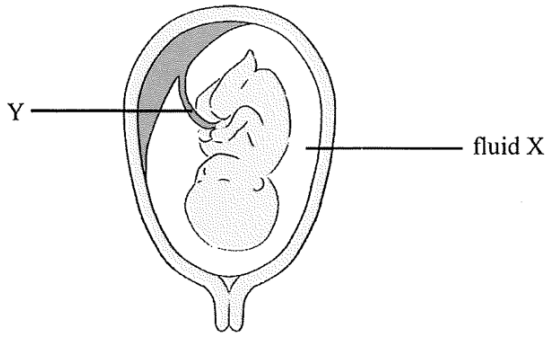


With reference to structure 4 above, which of the following structures of flowering plants has a similar function?

A. style
B. anther
C. filament
D. pollen tube

16. [HKDSE Biology 2023 Paper 1A Q35]
Hint: Trace locations from gamete production through fertilisation to implantation.

Directions: Questions 34 and 35 refer to the diagram below, which shows a foetus and the associated structures inside the uterus:



Which of the following combinations correctly compares the blood vessels inside structure Y?

	Artery inside Y	*Vein inside Y*
A.	has a larger lumen	has a smaller lumen
B.	carries oxygenated blood	carries deoxygenated blood
C.	has less glucose in its blood	has more glucose in its blood
D.	blood flows towards foetus' heart	blood flows towards placenta

17. [HKDSE Biology 2024 Paper 1A Q29]
Hint: Trace locations from gamete production through fertilisation to implantation.

Study the following two statements:

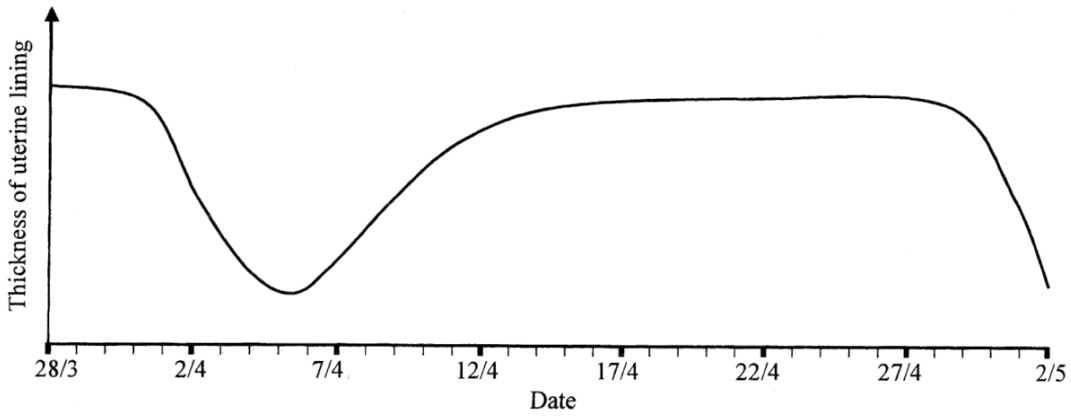
I: Not all copulations lead to fertilisation and pregnancy.
II: Fertilisation occurs when a sperm enters the ovum at the oviduct.

Which of the following descriptions about the two statements is correct?

A. Both I and II are correct and II correctly explains I.
B. Both I and II are correct but II does not explain I.
C. I is correct but II is incorrect.
D. I is incorrect but II is correct.

18. [HKDSE Biology 2014 Paper 1A Q28]
Hint: Trace locations from gamete production through fertilisation to implantation.

The diagram below shows the changes in the uterine lining of a woman:



During which of the following periods would the woman most likely get pregnant after copulation?

A. 28/3 to 1/4
B. 4/4 to 8/4
C. 11/4 to 15/4
D. 18/4 to 21/4

III.d Coordination and response

First read the explanations and diagrams in Concept III.d, then work through the question types in this section. Each worked example retains the complete original question and explanation. The subsequent exercises require progressively more integration of information, based on the demands of the whole question.

Type 1 Trace hearing through vibrations and nerve impulses

Degree of integration ★★☆☆☆

Key ideas

① Sound waves vibrate the eardrum. The ossicles transmit vibrations to the inner ear, where fluid movement in the cochlea stimulates sensory hair cells. Nerve signals then travel to the brain. The first part transmits mechanical vibration; only the later part transmits nerve impulses.

② The Eustachian tube equalises air pressure across the eardrum. Semicircular canals mainly contribute to balance and are not interchangeable with the cochlea merely because both lie in the inner ear.

How to recognise the problem Identify whether damage affects a sound-transmitting structure, sensory cell or nerve, then locate the blocked step.

Example 1 [HKDSE Biology 2015 Paper 1B Q1]

For each of the ear parts listed in column 1, select from column 2 one phrase that matches it. Put the appropriate letter in the space provided. (3 marks)

Column 1		Column 2	
Ear bones	.....	A.	Transmitting vibrations
Eustachian tube	.....	B.	Transmitting sound waves
Cochlea	.....	C.	Converting sound waves to vibrations
		D.	Converting vibrations to nerve impulses
		E.	Equalizing the air pressure on either side of the ear drum

Solution **This subpart; original allocation: 3 mark(s)**

Method: Trace vibration to nerve signals to find the interrupted step.

Ear ossicles: A; Eustachian tube: E; cochlea: D.

Sound first makes the eardrum vibrate, and the ossicles transmit these vibrations to the inner ear. The Eustachian tube connects the middle ear to the pharynx, balancing pressure across the eardrum so a pressure difference does not hinder its vibration. Receptor cells in the cochlea respond to vibration and convert mechanical changes into nerve signals. The three structures therefore serve transmission, pressure equalisation and sensory transduction respectively.

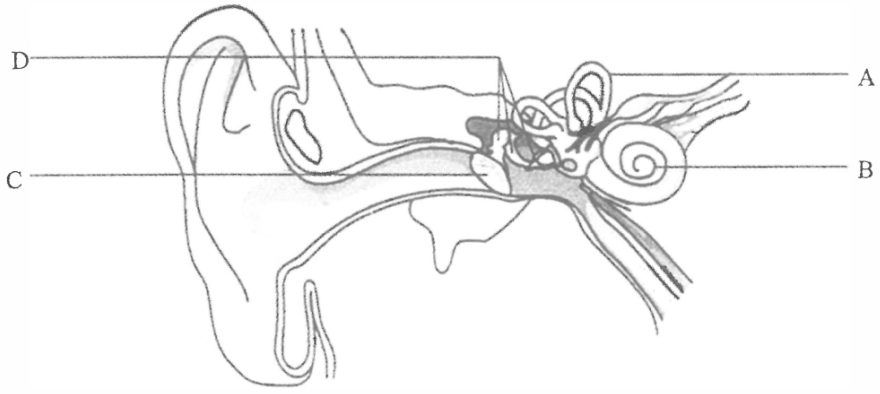
Examiner's comment (source page(s) 2)

The Eustachian tube balances pressure across the eardrum; ossicles transmit and amplify vibrations already produced. Sound waves make the eardrum vibrate. Do not claim that ossicles are where sound is first converted into vibration.

Marking reference: HKDSE Biology 2015 Paper 1B Q1, official marking scheme, source page(s) 2.

Example 2 [HKDSE Biology 2018 Paper 1B Q1]

The diagram below shows the human ear and its associated structures:



(a) The table below lists two types of hearing loss. Using the label(s) in the above diagram, indicate which structure(s) is / are most likely to be defective in each case. (2 marks)

	Type of hearing loss	Structure
X	Damage to sensory hair cells	
Y	Failure of sound conduction	

(b) Ludwig van Beethoven, a famous 18th century composer, suffered from type Y hearing loss in his 20s and became deaf in his 40s. Some records say that he could hear music through his jawbone and skull by biting on a metal rod attached to his piano. Based on the structures and functions of human ears, complete the following flow chart to show the major steps involved in his method of hearing music. (4 marks)

(i) _____ of the metal rod

↓

transmission through bones to reach (ii) _____

↓

detection of (iii) _____ movement by sensory hair cells

↓

generation and transmission of nerve impulses through (iv) _____

↓

interpretation at the sensory area of the cerebrum

Answers written in the margins will not be marked.

Solution **Reading the question and choosing a method**

Method: Trace vibration to nerve signals to find the interrupted step.

Distinguish transmission of mechanical vibration, detection by hair cells and transmission of nerve impulses.

a; original allocation: 2 mark(s)

X: B; Y: C and D.

B is the cochlea, containing sensory hair cells that convert mechanical stimuli into nerve signals. Hair-cell damage therefore belongs to category X. C is the eardrum and D the ossicles. Both transmit sound-induced vibrations towards the inner ear. Damage can impair

sound conduction, placing them in category Y. Giving only one of these structures leaves that row incomplete.

b; original allocation: 4 mark(s)

i: vibrations

ii: oval window or cochlea

iii: fluid or lymph

iv: auditory nerve

The piano makes the metal rod vibrate. Vibrations pass through the teeth and skull to the inner ear. This bone-conduction pathway can bypass some outer- and middle-ear conducting structures, but not cochlear hair cells or the auditory nerve. Movement of inner-ear fluid stimulates hair cells, which convert the stimulus into neural signals. The auditory nerve then carries impulses to the brain, where hearing results. The first part transmits mechanical vibrations and the second nerve impulses; do not call both sound waves.

Examiner's comment (source page(s) 3)

Bone conduction transmits mechanical vibration. Sensory hair cells in the cochlea convert the stimulus to neural signals. Sensory nerves carry impulses towards the brain; sensory neurones do not 'produce sound'.

Marking reference: HKDSE Biology 2018 Paper 1B Q1, official marking scheme, source page(s) 2.

Practice

1. [HKDSE Biology 2013 Paper 1A Q29]

← *Hint: Trace vibration to nerve signals to find the interrupted step.*

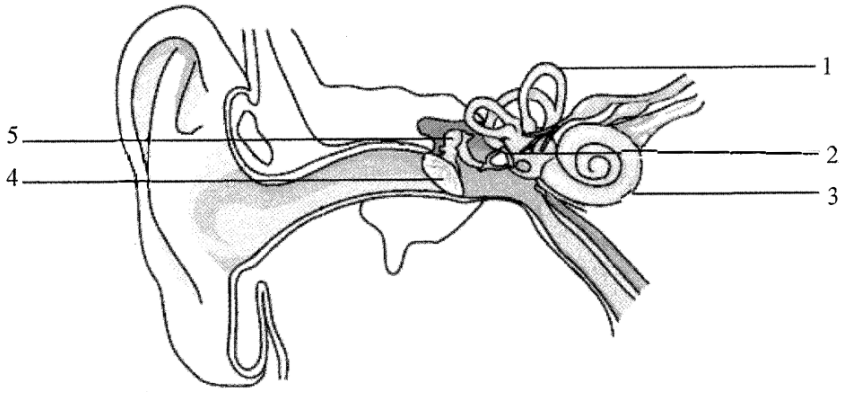
Which of the following combinations correctly matches the structure of the human ear and its function?

	Structure	*Function*
A.	ear flap	protecting the ear
B.	ear drum	amplifying sound waves
C.	ear bones	transmitting vibrations
D.	round window	setting the endolymph in motion

2. [HKDSE Biology 2017 Paper 1A Q25]

← *Hint: Trace vibration to nerve signals to find the interrupted step.*

Directions: Questions 25 and 26 refer to the diagram below, which shows the structures of a human ear:



Which of the following structures is ***not*** involved in hearing?

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

3. [HKDSE Biology 2023 Paper 1A Q19]

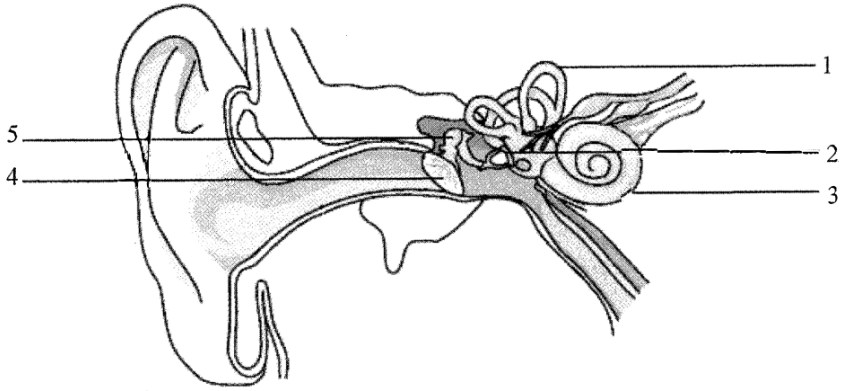
← *Hint: Trace vibration to nerve signals to find the interrupted step.*

Blockage of the Eustachian tube will directly affect the functioning of the

A. cochlea.
B. eardrum.
C. ear bones.
D. oval window.

4. [HKDSE Biology 2017 Paper 1A Q26]
Hint: Trace vibration to nerve signals to find the interrupted step.

Directions: Questions 25 and 26 refer to the diagram below, which shows the structures of a human ear:



Which of the following structures will vibrate when there are sound waves?

A. 1 and 3 only
B. 2 and 3 only
C. 2, 3 and 4 only
D. 2, 4 and 5 only

Type 2 Explain vision through image formation, accommodation and the retina

Degree of integration ★★☆☆☆

Key ideas

① For near vision, ciliary muscles contract, tension in suspensory ligaments decreases and the lens becomes thicker with greater refractive power. This differs from iris control of pupil size.

② In short-sightedness, distant images form in front of the retina; a concave lens first diverges the light. Photoreceptor distribution varies across the retina, with a high cone density at the yellow spot. The blind spot has no photoreceptors, so an image falling there cannot generate a visual signal.

How to recognise the problem Separate image position, lens accommodation, the pupil reflex and photoreceptors into four question types. Avoid mixing the actions of different muscles.

Example 1 [HKDSE Biology 2015 Paper 1A Q27]

Which of the following combinations correctly shows the conditions of different parts of the eyes when a person is looking at an object moving towards him?

	Lens	*Suspensory ligament*
A.	becoming thinner	slackening
B.	becoming thinner	tightening
C.	becoming thicker	slackening
D.	becoming thicker	tightening

Solution Answer: C

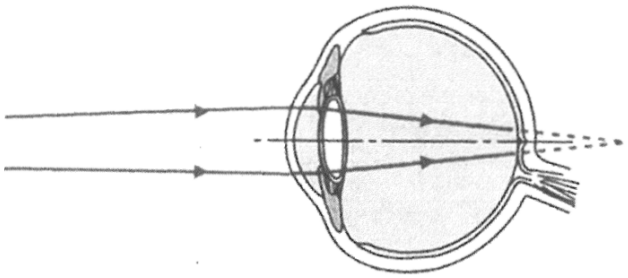
As an object approaches, incoming rays diverge more and require greater refractive power. Ciliary muscles contract, relaxing the suspensory ligaments. The lens becomes thicker and more convex through its own elasticity, increasing convergence. The correct pairing is a thicker lens and relaxed suspensory ligaments, giving C.

Method: Distinguish imaging, accommodation, pupil control and photoreception.

Marking reference: HKDSE Biology 2015 Paper 1A Q27, official marking scheme, source page(s) 1.

Example 2 [HKDSE Biology 2018 Paper 1A Q7]

Below is a ray diagram of a common eye defect:



Which of the following combinations correctly identifies the eye defect and type of lens to be worn to remedy it?

	Eye defect	*Type of lens*
A.	Long-sightedness	Convex lens
B.	Long-sightedness	Concave lens
C.	Short-sightedness	Convex lens
D.	Short-sightedness	Concave lens

Solution Reading the question and choosing a method

Method: Distinguish imaging, accommodation, pupil control and photoreception.

Follow the incident rays to their focus and determine whether it lies in front of or behind the retina.

Answer: A

The rays focus behind the retina, showing that they have not converged sufficiently when they reach it. This is long-sightedness and requires greater convergence of incoming light. A convex lens converges rays before they enter the eye, bringing the image onto the retina. Long-sightedness paired with a convex lens is therefore correct. A concave lens would increase divergence and cannot correct this diagram. Choose A.

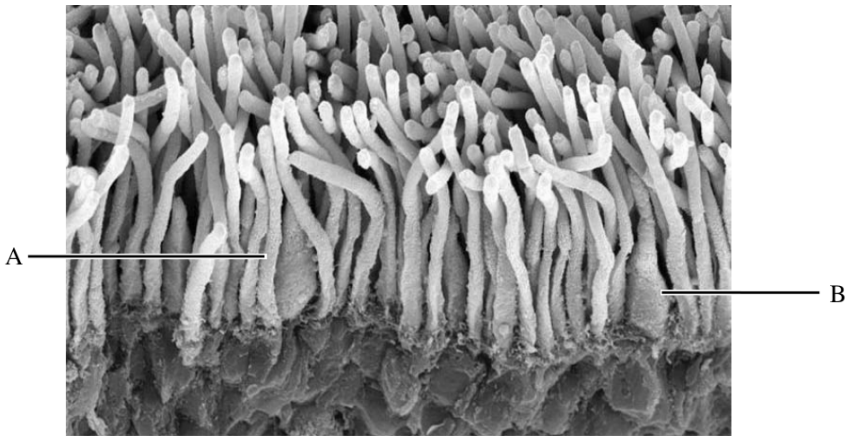
Common error

Recalling a rule about eyeball length without checking the focus actually shown.

Marking reference: HKDSE Biology 2018 Paper 1A Q7, official marking scheme, source page(s) 1.

Example 3 [HKDSE Biology Practice Paper Paper 1B Q3]

The electronmicrograph below shows two types of photoreceptors in the human eye:



(a) Name the part of the human eye where the photoreceptors are found. (1 mark)

(b) A coloured object is perceived as being more colourful in bright light than in dim light. Explain this with respect to the functioning of photoreceptors A and B. (4 marks)

Solution a; original allocation: 1 mark(s)

Method: Distinguish imaging, accommodation, pupil control and photoreception.

The retina.

Photoreceptors are specialised retinal cells, not cells of the cornea or iris.

b; original allocation: 4 mark(s)

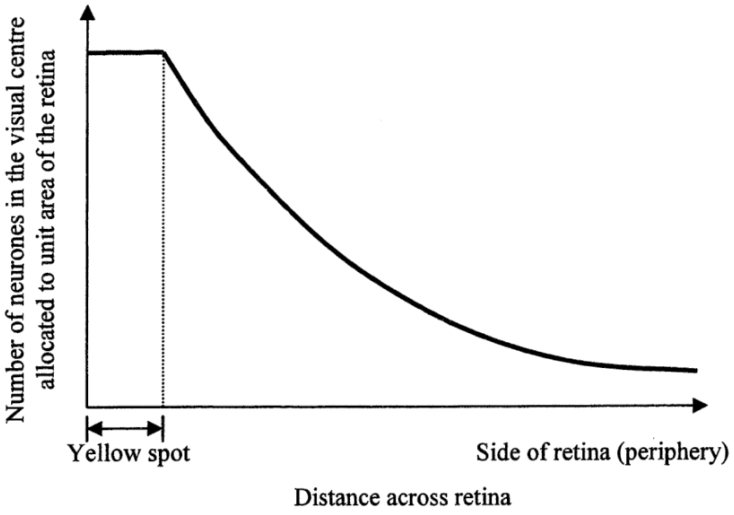
A represents rods, which do not distinguish colours. B represents cones, which contribute to colour vision. Cones are less light-sensitive and require stronger light for substantial stimulation. More cones respond in bright light, making colours appear more vivid. In dim light, vision relies more on rods, so colour discrimination is poorer.

The four links are no colour vision in A, colour vision in B, stronger light required by B, and more B cells stimulated by bright light. Illumination is not changing the object's pigments.

Marking reference: HKDSE Biology Practice Paper Paper 1B Q3, official marking scheme, source page(s) 4.

Example 4 [HKDSE Biology 2014 Paper 1B Q10]

The visual centre of the brain is responsible for processing nerve impulses from the retina. The number of neurones in the visual centre allocated to receiving impulses from a unit area of the retina is shown below (only half of the retina is shown):



(a) **With reference to the types of photoreceptor cells and their distribution on the retina, explain why more neurones in the visual centre are allocated to unit area of the yellow spot.** (4 marks)

(b) **After the perception of what we 'see', what it means to us depends on other parts of the brain. Explain how this works.** (2 marks)

Solution a; original allocation: 4 mark(s)

Method: Distinguish imaging, accommodation, pupil control and photoreception.

The yellow spot has densely packed cones. Different cone types are most sensitive to different wavelengths and provide colour information. This region supplies abundant detailed visual signals, requiring more visual-cortex neurones to process them, so it occupies a larger cortical representation.

'It sees clearly, so more brain is needed' is insufficient. Connect receptor density, colour and fine detail, and processing demand step by step.

b; original allocation: 2 mark(s)

Association areas further integrate and interpret signals from the visual cortex and compare them with stored memories, enabling recognition of objects and their meaning.

The visual cortex initially processes signals; association areas connect features such as shape and colour with previous experience. Reception of light by the eye is not itself understanding of the object.

Examiner's comment (source page(s) 3)

The horizontal-axis mapping concerns distribution of visual-cortex neurones, not retinal receptors. Association areas compare signals with stored memories to give images meaning.

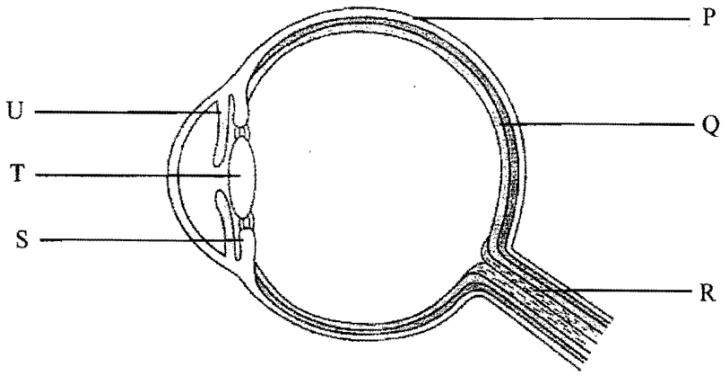
Marking reference: HKDSE Biology 2014 Paper 1B Q10, official marking scheme, source page(s) 5.

Practice

1. [HKDSE Biology 2012 Paper 1A Q8]

Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Directions: Questions 8 and 9 refer to the diagram below, which shows a section of the human eye:



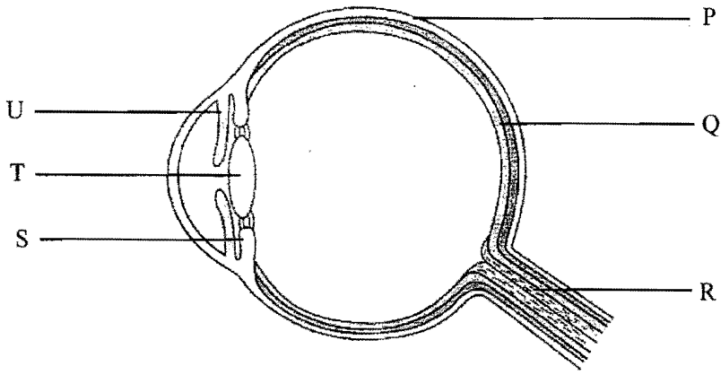
Which part of the eye is tough and white in colour?

A. P
B. Q
C. R
D. S

2. [HKDSE Biology 2012 Paper 1A Q9]

Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Directions: Questions 8 and 9 refer to the diagram below, which shows a section of the human eye:



Which of the following parts are made of muscle?

A. P and S
B. Q and R
C. R and T
D. S and U

3. [HKDSE Biology 2017 Paper 1A Q27]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Which of the following combinations correctly matches the problem of short sightedness and its correction?

	Problem	***Correction***
A.	image focussed behind the retina	wear concave lens
B.	image focussed behind the retina	wear convex lens
C.	image focussed in front of the retina	wear concave lens
D.	image focussed in front of the retina	wear convex lens

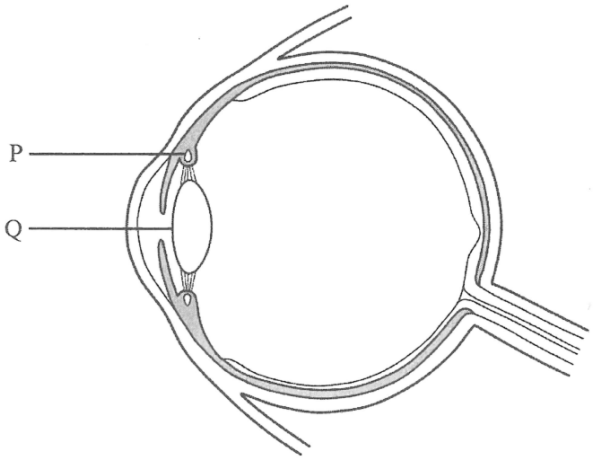
4. [HKDSE Biology 2019 Paper 1A Q17]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Wearing contact lenses for too long will have an adverse effect on the eyes because this decreases the amount of oxygen reaching the eyes. Which of the following eye structures is most affected in this case?

A. iris
B. lens
C. cornea
D. sclera

5. [HKDSE Biology 2024 Paper 1A Q27]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Directions: Questions 27 and 28 refer to the diagram below, which shows a section of a human eyeball:

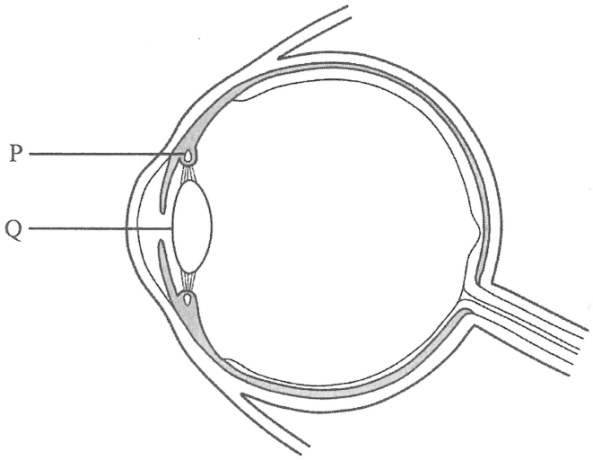


Ken and Jane are looking at a bird flying away from them. Which of the following combinations correctly describes the conditions of structures P and Q of their eyeball?

	Structure P	***Structure Q***
A.	relaxing	becoming thinner
B.	relaxing	becoming thicker
C.	contracting	becoming thinner
D.	contracting	becoming thicker

6. [HKDSE Biology 2024 Paper 1A Q28]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Directions: Questions 27 and 28 refer to the diagram below, which shows a section of a human eyeball:



When the bird flies away to a certain distance, Ken can still see it clearly but Jane cannot. Ken has normal eyesight. Which of the following combinations correctly describes Jane's condition?

	Eyeball	***Position of image***
A.	too long	focused behind the retina
B.	too long	focused in front of the retina
C.	too short	focused behind the retina
D.	too short	focused in front of the retina

7. [HKDSE Biology 2025 Paper 1A Q17 (English translation)]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Before an eye examination, special eye drops are applied to a patient's eye. The photograph below shows the appearance 30 minutes after the drops were applied to the left eye:

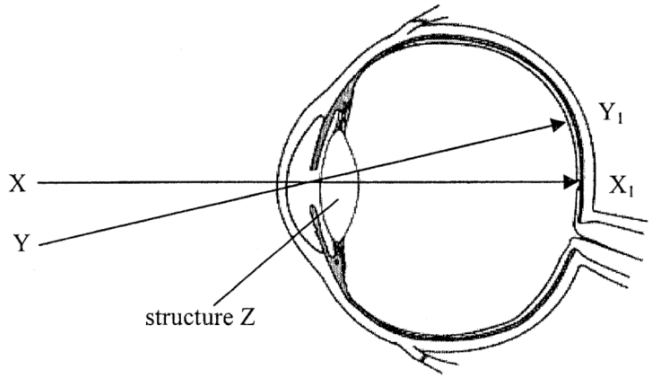
Right eye  Left eye

Which structure in the left eye is relaxed?

A. Ciliary muscle
B. Circular muscles of the iris
C. Pupil
D. Radial muscles of the iris

8. [HKDSE Biology 2013 Paper 1A Q27]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Directions: Questions 27 and 28 refer to the diagram below, which shows a section of the human eye and the positions X_1 and Y_1 where the images of two coloured objects X and Y are formed respectively on the retina:

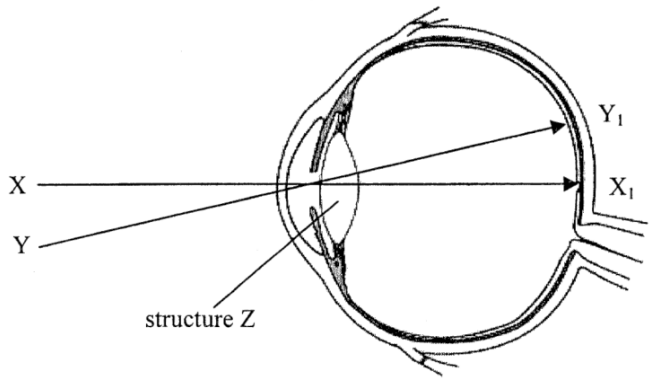


Which of the following correctly describes a person's visual perception in day time?

A. X appears brighter because cone cells are found at position X_1.
B. X appears sharper because cone cells are found at position X_1.
C. Y appears black and white because rod cells are found at position Y_1.
D. Y appears blurred because rod cells are found at position Y_1.

9. [HKDSE Biology 2013 Paper 1A Q28]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Directions: Questions 27 and 28 refer to the diagram below, which shows a section of the human eye and the positions X_1 and Y_1 where the images of two coloured objects X and Y are formed respectively on the retina:



When a person ages, structure Z becomes less elastic. When this happens, a person will probably have difficulty focusing on

A. a nearby object because structure Z cannot be thickened fully.
B. a nearby object because structure Z cannot be pulled thin fully.
C. a distant object because structure Z cannot be thickened fully.
D. a distant object because structure Z cannot be pulled thin fully.

10. [HKDSE Biology 2017 Paper 1A Q28]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Which of the following correctly explains why our eyes feel tired if we have been reading a book for a long time?

A. The ciliary body has contracted for a long time.
B. The photosensitive cells have been over-stimulated.
C. The lens has maintained a curved state for a long time.
D. The suspensory ligament has been under tension for a long time.

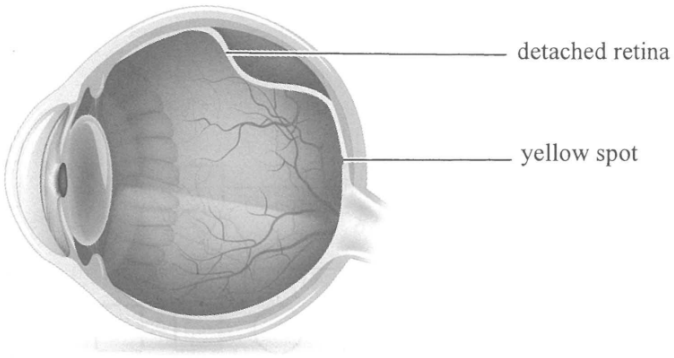
11. [HKDSE Biology 2019 Paper 1A Q16]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Peter wanted to throw a crumpled paper into the rubbish bin in a dim room. He found that he could see the bin more clearly if he tried to focus on objects right next to the bin. Which of the following statements about the image formation of the bin is correct?

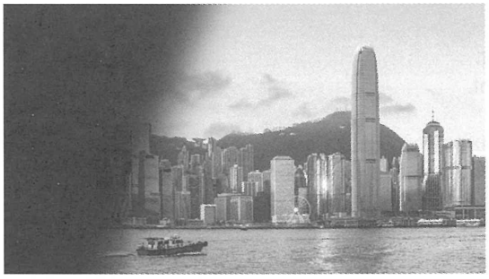
A. Image of the bin is formed on the yellow spot where there are cone cells only.
B. Image of the bin is formed on the yellow spot where there are more cone cells than rod cells.
C. Image of the bin is formed on the periphery of the retina where there are rod cells only.
D. Image of the bin is formed on the periphery of the retina where there are more rod cells than cone cells.

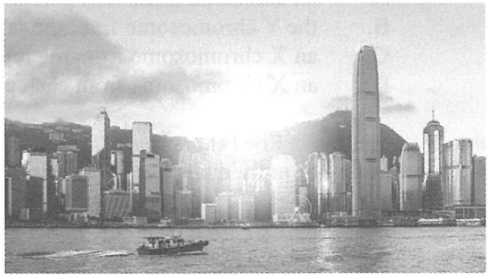
12. [HKDSE Biology 2021 Paper 1A Q18]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

The diagram below shows an early stage of an eye defect:

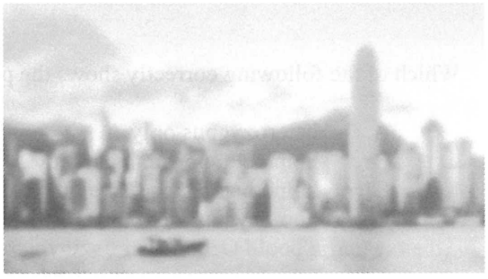


If a person suffers from this eye defect, which of the following diagrams is the most likely vision perceived by this person?

A.


B.


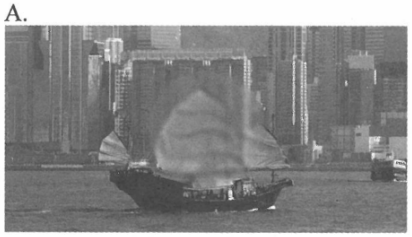
C.


D.


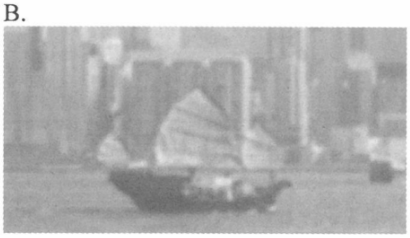
13. [HKDSE Biology 2022 Paper 1A Q24]
← Hint: Distinguish imaging, accommodation, pupil control and photoreception.

During aging, some people may suffer from an eye defect which is caused by the degeneration of light-sensitive cells in the yellow spot. Which of the following diagrams is the most likely vision perceived by a person suffering from this eye defect?

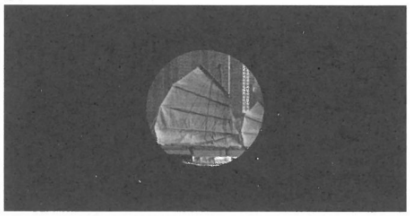
A.



B.



C.

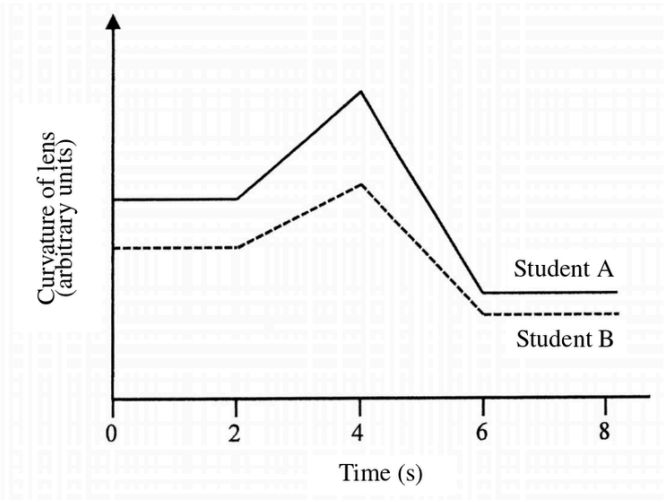


D.



14. [HKDSE Biology 2025 Paper 1A Q18 (English translation)]
← Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Two students stand at the same position and look at the same moving object for 8 seconds. The graph below shows the changes in the curvature of their lenses during this period.

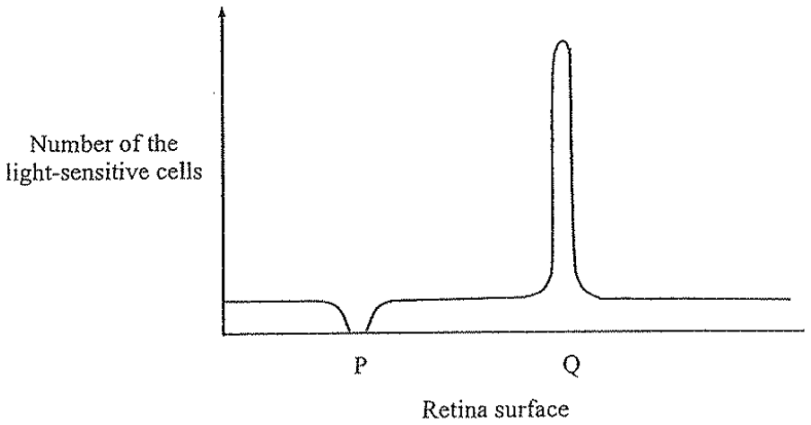


Which of the following interpretations of the graph is correct?

A. Student A is short-sighted.
B. Student A's lens is more elastic than student B's.
C. From 2 to 4 seconds, the images of the object are formed in front of the retinas of both students.
D. From 4 to 6 seconds, the object moves towards the two students.

15. [HKDSE Biology Sample Paper Paper 1A Q21]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Directions: Questions 21 and 22 refer to the diagram below which shows the distribution of a type of light-sensitive cells on the surface of the retina:

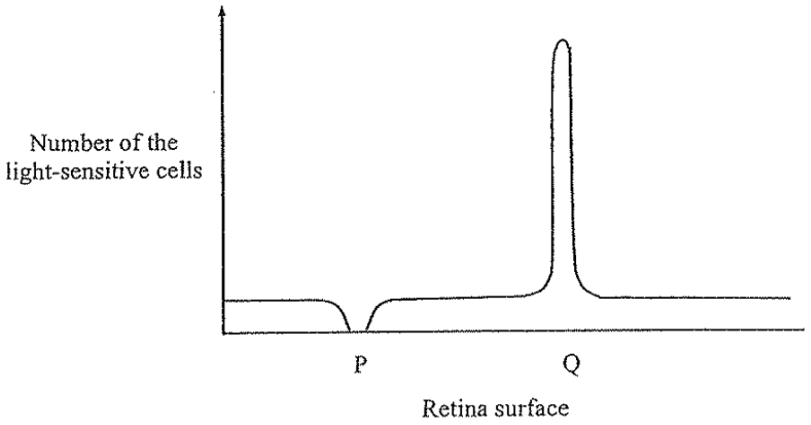


Which of the following correctly identifies the type of light-sensitive cells and region Q?

	Type of light-sensitive cells	***Region Q***
A.	rods	blind spot
B.	rods	yellow spot
C.	cones	blind spot
D.	cones	yellow spot

16. [HKDSE Biology Sample Paper Paper 1A Q22]
Hint: Distinguish imaging, accommodation, pupil control and photoreception.

Directions: Questions 21 and 22 refer to the diagram below which shows the distribution of a type of light-sensitive cells on the surface of the retina:



Which of the following will occur when light is focussed on region P?

A. no image will be formed
B. no vision will be generated
C. only black and white vision will be generated
D. colour vision will be generated

Type 3 Relate joints, tendons and antagonistic muscles to movement

Degree of integration ★★☆☆☆

Key ideas

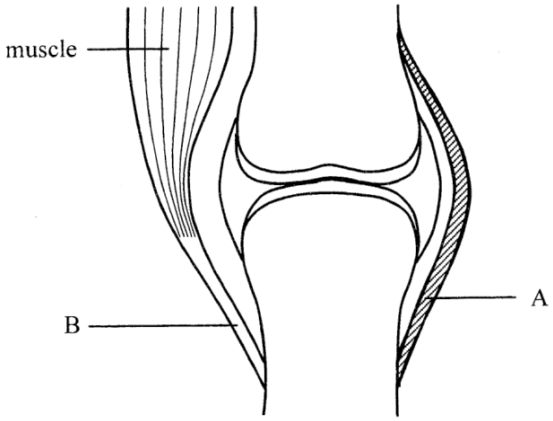
① A contracting muscle pulls a bone through a tendon, rotating the bone about a joint. Muscles mainly produce movement by pulling, so opposite movements require antagonistic muscles. Ligaments connect bone to bone and help stabilise joints.

② Cartilage reduces friction and absorbs shocks. If a question links a neuromuscular junction to movement, explain how the chemical signal causes contraction before describing bone displacement.

How to recognise the problem Identify the structures at both ends of each connection. Infer movement from the pulling direction and joint pivot, rather than assuming straightening always means relaxation of a particular muscle.

Example 1 [HKDSE Biology 2013 Paper 1B Q2]

The diagram below shows the structures of a joint.



(a) Name the type of joint shown and suggest an example of such a joint in the body. (2 marks)

Type of joint: .....

Example in the body: .....

(b) Briefly describe how A and B work together to bring about movement at the joint shown. (4 marks)

.....

.....

Solution a; original allocation: 2 mark(s)

A hinge joint, for example the elbow joint or knee joint.

These mainly permit flexion and extension in one plane. The joint type and a suitable human example earn 1 mark each.

Method: Identify both ends of the connection, then infer movement from the pulling direction.

b; original allocation: 4 mark(s)

A is a ligament connecting bone to bone and preventing dislocation during movement. B is a tendon connecting muscle to bone and transmitting the pull from muscle contraction, rotating the bone about the joint.

Identify the connected structures at both ends: A spans two bones, while B continues from muscle to bone. A tendon does not actively contract to generate the pull; the muscle contracts. The two connections and their functions together earn 4 marks.

Examiner's comment (source page(s) 2)

Specify an elbow joint or knee joint, not merely an elbow or knee. Explain how A and B work together rather than only naming them.

Marking reference: HKDSE Biology 2013 Paper 1B Q2, official marking scheme, source page(s) 3.

Example 2 [HKDSE Biology 2023 Paper 1B Q3]

Diagram I below shows the right leg with the associated joints and muscles. Diagram II shows a series of motions during running with the right leg highlighted in grey.

Diagram I

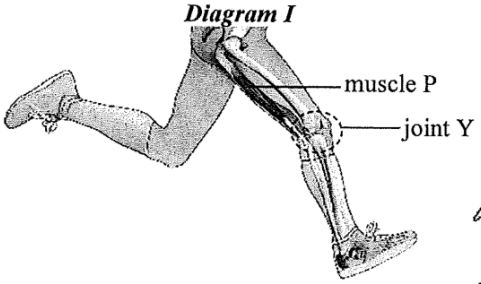
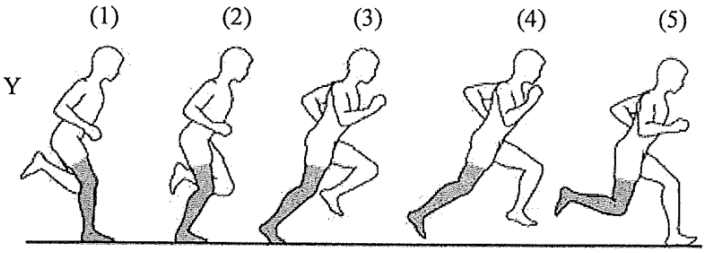


Diagram II



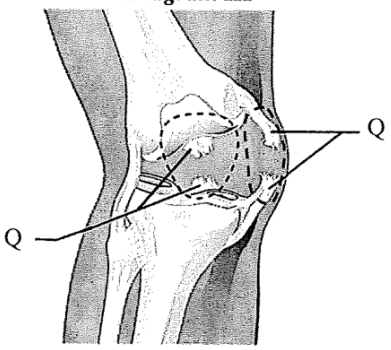
(a) In order to bring about the changes in motion from (3) to (5), what is the change of state of muscle P?
(1 mark)

(b) With respect to the answer in (a), state the role of muscle P by circling the following choices in (i) and complete the sentence in space (ii).
(1 mark)

Muscle P is a (i) flexor / extensor because (ii) _____

(c) A person injured his knee while running. Diagram III shows the condition of joint Y after the injury:

Diagram III



Structure Q was torn. How would this affect joint Y and its functioning? (2 marks)

Solution a; original allocation: 1 mark(s)

P contracts.

From movement (3) to (5), the right knee changes from a relatively extended position to flexion. P pulls the lower leg backwards and upwards and must contract to generate this pull.

Method: Identify both ends of the connection, then infer movement from the pulling direction.

b; original allocation: 1 mark(s)

A flexor. Contraction of P reduces the angle at joint Y and flexes the knee.

Name a muscle by the movement its contraction produces. Flexors bend a joint and extensors straighten it. Do not guess solely from the side on which the muscle lies.

c; original allocation: 2 mark(s)

Tearing Q weakens the stable bone-to-bone connection. The knee becomes unstable or displaced, making lower-limb movement difficult.

Q is a ligament normally constraining bone positions and joint range. A tear permits abnormal movement or dislocation, impairing stable weight-bearing and normal running.

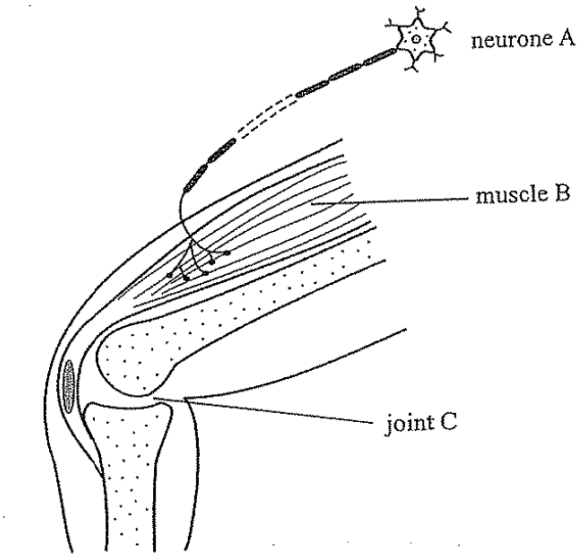
Examiner's comment (source page(s) 4)

Muscle contraction causes flexion; do not reverse the causal order. Ligaments connect bone to bone, tendons muscle to bone. A torn ligament mainly destabilises a joint rather than directly removing a muscle.

Marking reference: HKDSE Biology 2023 Paper 1B Q3, official marking scheme, source page(s) 3.

Example 3 [HKDSE Biology Sample Paper Paper 1B Q6]

The diagram below shows some structures of the leg and a neurone supplying the leg muscle:



(a) Outline how the arrival of nerve impulses at the nerve endings of neurone A leads to the contraction of muscle B. (3 marks)

(b) Describe the role of joint C in the movement of the leg. (2 marks)

Solution a; original allocation: 3 mark(s)

A nerve impulse reaches the terminal of A and triggers neurotransmitter release. The transmitter diffuses across the gap between nerve and muscle fibre, stimulating the muscle-cell membrane and initiating contraction.

A and B do not share continuous cytoplasm. The signal travels along the neurone as an impulse, becomes a chemical message at the junction, crosses the gap, and triggers a muscle response. Write the sequence arrival → release → diffusion → muscle-membrane stimulation to explain transmission to a different cell type.

b; original allocation: 2 mark(s)

Joint C acts as a fulcrum, allowing adjacent bones to move relative to each other under muscular pull and forming a lever system.

Contracting muscle supplies the force, bone acts as the lever, and the joint determines its pivot. The joint does not actively generate pulling force. Without a movable pivot, muscle shortening would not flex and extend the leg in the way shown.

Marking reference: HKDSE Biology Sample Paper Paper 1B Q6, official marking scheme, source page(s) 3.

Method: Identify both ends of the connection, then infer movement from the pulling direction.

Practice

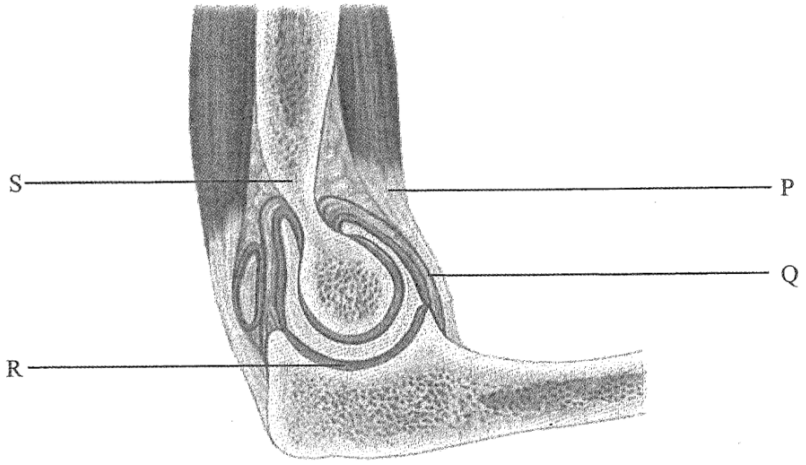
1. [HKDSE Biology 2012 Paper 1A Q7]
   ← *Hint: Identify both ends of the connection, then infer movement from the pulling direction.*

In a movable joint, the tissue holding the bones together is called

A. ligament.
B. cartilage.
C. muscle.
D. tendon.

2. [HKDSE Biology 2015 Paper 1A Q20]
   ← *Hint: Identify both ends of the connection, then infer movement from the pulling direction.*

Directions: Questions 20 and 21 refer to the diagram below, which shows an elbow joint and its associated structures:

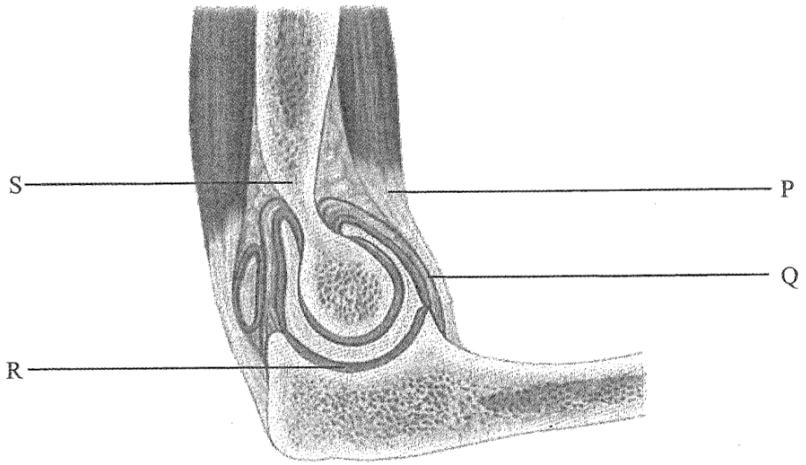


Which of the above structures are elastic?

A. P and R only
B. P and S only
C. Q and R only
D. Q and S only

3. [HKDSE Biology 2015 Paper 1A Q21]
   ← *Hint: Identify both ends of the connection, then infer movement from the pulling direction.*

Directions: Questions 20 and 21 refer to the diagram below, which shows an elbow joint and its associated structures:



Structure S is able to

(1) carry out respiration.
(2) store minerals.
(3) produce blood cells.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

4. [HKDSE Biology 2016 Paper 1A Q33]
Hint: Identify both ends of the connection, then infer movement from the pulling direction.

Which of the following organs are protected by the rib cage?

(1) lung
(2) liver
(3) heart

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

5. [HKDSE Biology 2019 Paper 1A Q19]
Hint: Identify both ends of the connection, then infer movement from the pulling direction.

Directions: Questions 19 and 20 refer to Diagram I and Diagram II below. Diagram I shows a leg and its associated muscles while Diagram II shows a woman practising yoga.

Diagram I

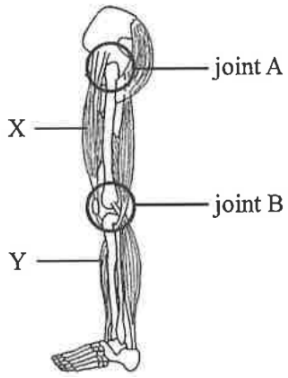


Diagram II



Which of the following combinations correctly identifies joints A and B in Diagram I?

	Joint A	***Joint B***
A.	Hinge joint	Hinge joint
B.	Hinge joint	Ball and socket joint
C.	Ball and socket joint	Ball and socket joint
D.	Ball and socket joint	Hinge joint

6. [HKDSE Biology 2021 Paper 1A Q23]
Hint: Identify both ends of the connection, then infer movement from the pulling direction.

Which of the following correctly describe the functions of the intervertebral disc?

(1) It prevents the wearing of the vertebrae.
(2) It encloses the spinal cord.
(3) It allows the bending of the vertebral column during movement.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

7. [HKDSE Biology 2022 Paper 1A Q23]
Hint: Identify both ends of the connection, then infer movement from the pulling direction.

Which of the following structures are the components of a joint?

(1) bone
(2) tendon
(3) ligament

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

8. [HKDSE Biology 2017 Paper 1B Q1]
Hint: Identify both ends of the connection, then infer movement from the pulling direction.

For each of the components of the musculoskeletal system listed in Column I, select from Column II one phrase that correctly describes it. Put the letter in the space provided. (3 marks)

Column I		***Column II***
Ligament	.....	A. Inelastic tissue found at the two ends of a skeletal muscle
Tendon	.....	B. Elastic tissue found at the two ends of a long bone
Cartilage	.....	C. Inelastic tissue that surrounds a joint
		D. Elastic tissue that binds bones together

9. [HKDSE Biology 2014 Paper 1A Q34]
Hint: Identify both ends of the connection, then infer movement from the pulling direction.

Directions: Questions 34 and 35 refer to Diagram I and Diagram II below. Diagram I shows a yoga instructor in a yoga posture. Diagram II shows some of the muscles associated with her left leg.

Diagram I

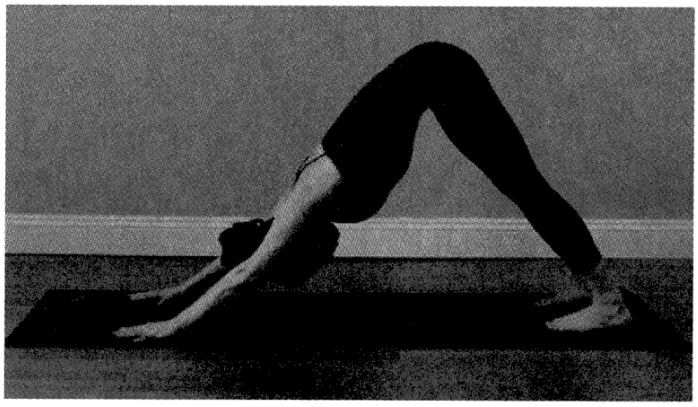
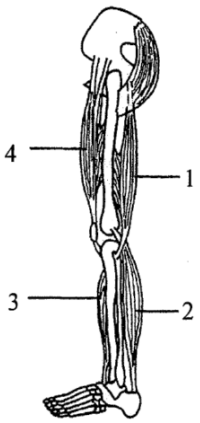


Diagram II



Which muscles of the left leg of the yoga instructor are contracting when she maintains the posture shown in diagram I?

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

10. [HKDSE Biology 2014 Paper 1A Q35]
Hint: Identify both ends of the connection, then infer movement from the pulling direction.

Directions: Questions 34 and 35 refer to Diagram I and Diagram II below. Diagram I shows a yoga instructor in a yoga posture. Diagram II shows some of the muscles associated with her left leg.

Diagram I

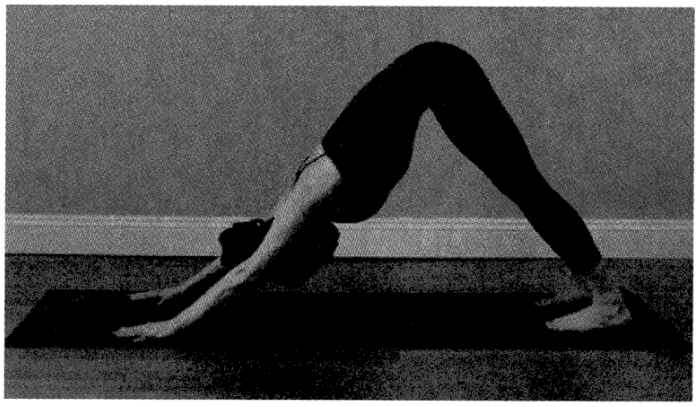
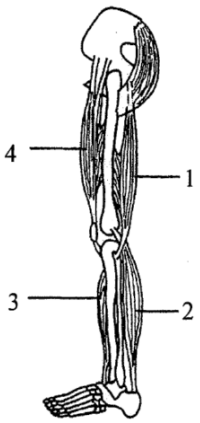


Diagram II



Which muscles of the left leg are flexors?

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

11. [HKDSE Biology 2019 Paper 1A Q20]
Hint: Identify both ends of the connection, then infer movement from the pulling direction.

Directions: Questions 19 and 20 refer to Diagram I and Diagram II below. Diagram I shows a leg and its associated muscles while Diagram II shows a woman practising yoga.

Diagram I

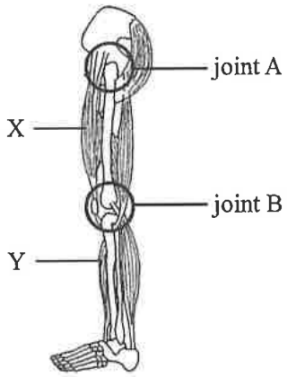


Diagram II



Which of the following combinations correctly indicates the state of muscles X and Y when the woman is maintaining the yoga posture shown in Diagram II?

	X	*Y*
A.	contracted	contracted
B.	contracted	relaxed
C.	relaxed	contracted
D.	relaxed	relaxed

Type 4 Investigate auxin using barriers, controls and curves

Degree of integration ★★★★☆

Key ideas

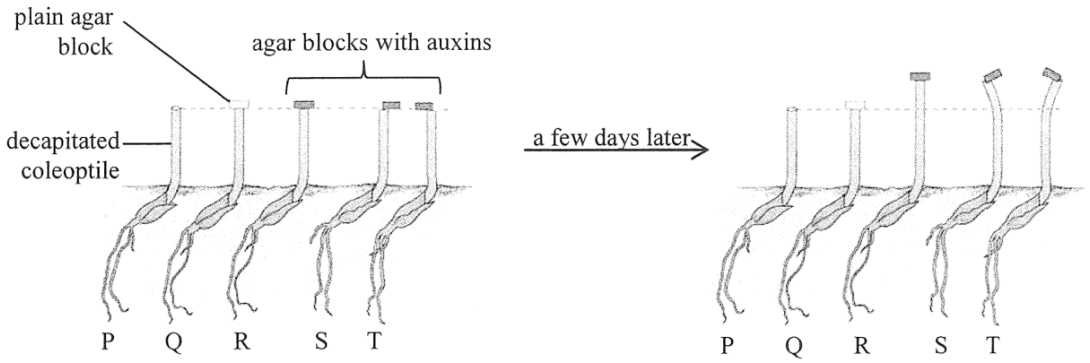
① Auxin produced in a coleoptile tip can affect elongation of cells below it. Under unilateral illumination, unequal growth on the two sides causes bending. Merely stating growth towards light does not explain the mechanism.

② In partition experiments, locate the signal movement being blocked. Promotion or inhibition on a concentration-response curve must be compared with the zero-concentration control. Positive growth can still represent relative inhibition.

How to recognise the problem Separate light detection at the tip, signal movement and elongation below it. Use partition positions or control curves to test explanations at each step.

Example 1 [HKDSE Biology 2020 Paper 1A Q28]

Directions: Questions 27 and 28 refer to the diagram below, which shows an investigation into the effect of auxins on the growth of plant shoots:



28. Which of the following conclusions can be drawn based on the results of the investigation?

A. The tip of the coleoptile produces auxins.
B. Auxins stimulate the growth of coleoptiles.
C. The coleoptile shows positive phototropism.
D. Coleoptiles stop growing when the tip is removed.

Solution Answer: B

Method: Separate light detection, signal movement and elongation, then examine the control.

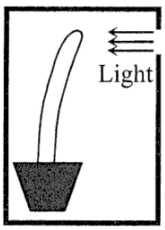
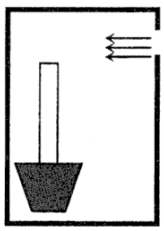
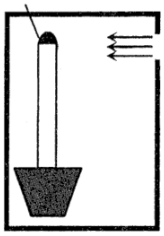
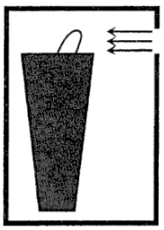
After receiving agar containing auxin, R, S and T elongate more than P and Q, which receive no auxin. This supports the conclusion that auxin stimulates coleoptile growth, so B is correct. Placing auxin to one side causes unequal elongation on the two sides, explaining the curvature.

The experiment does not compare different light directions or intensities, so curvature alone does not demonstrate phototropism. Nor does it directly trace auxin production in the tip, so A and C go beyond the evidence. D claims that growth stops after removal of the tip, which also fails to explain the elongation that occurs after auxin is added.

Marking reference: HKDSE Biology 2020 Paper 1A Q28, official marking scheme, source page(s) 1.

Example 2 [HKDSE Biology 2013 Paper 1B Q7]

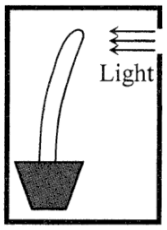
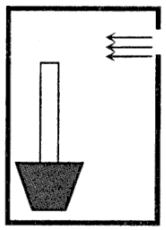
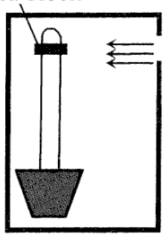
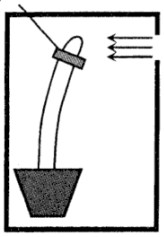
In 1880, Darwin conducted an experiment to investigate the phototropism of plants. He placed some coleoptiles in dark boxes, each with a hole at one side to allow light to pass through. The results after various treatments of coleoptiles are shown in the diagrams below:

Set-up	I	II	III	IV
Treatment of the coleoptile	Intact coleoptile	Tip removed	Opaque cap placed on the tip	Buried in soil with tip exposed
Result	 Growth with bending	 No growth and no bending	 Growth without bending	 Growth with bending

(a) From the results of the experiment, which part of the coleoptile is responsible for detecting unilateral light? Support your answer with reasons. (3 marks)

(b) Explain why it is necessary to have set-up III in the experiment. (1 mark)

(c) In 1913, Boysen-Jensen performed some other experiments to study the nature of the signal transmission involved in phototropism. The diagram below shows his experimental set-ups:

Set-up	A	B	C	D
Treatment of the coleoptile	Intact coleoptile	Tip removed	Cut tip placed on a mica block	Cut tip placed on an agar block
Result	 Growth with bending	 No growth and no bending	 No growth and no bending	 Growth with bending

What conclusion can be drawn from Boysen-Jensen's experiment? (3 marks)

(d) Which of the following statements about the nature of science are demonstrated in the above historical events? Put a '✓' in the space next to the statement and provide an explanation. The first one is an example for your reference. (4 marks)

Statement		*Evidence from the historical events*
Doing science requires creativity and imagination.	✓	Both Darwin and Boysen-Jensen used innovation and imagination to design their experiments.
Science is socially and culturally embedded.		
Science is based on evidence.		
Science knowledge is tentative and dynamic.		

Solution a; original allocation: 3 mark(s)

The tip detects unilateral light. Removing the tip or preventing light from reaching it with an opaque cap prevents bending towards the light. However, burying the lower part while exposing only the tip to light still allows bending.

To locate the light-sensitive region, use both types of result: those in which light cannot reach the tip and those in which only the tip receives light. The fact that an intact coleoptile bends towards light is insufficient on its own.

b; original allocation: 1 mark(s)

In set-up III, the tip is not cut or damaged, yet no bending occurs. This shows that the lack of bending in set-up II cannot be attributed solely to damage caused by cutting off the tip. III retains its capacity for growth but has its tip shaded. This allows the researcher to distinguish the effect of preventing light detection from the possible confounding effect of cutting damage.

✓ Method: Separate light detection, signal movement and elongation, then examine the control.

c; original allocation: 3 mark(s)

The tip produces a substance that promotes growth. This substance can diffuse through agar and reach the lower part of the coleoptile, where it causes growth and bending. A mica sheet blocks this transmission.

These results support the conclusion that the signal is a diffusible substance. The four treatments in the historical experiment alone cannot establish the chemical identity of the substance, so state precisely what the evidence supports.

d; original allocation: 4 mark(s)

Tick 'Science is based on evidence': both researchers proposed explanations of phototropism based on experimental observations. Tick 'Scientific knowledge is tentative and dynamic': later experiments built on Darwin's discovery of the light-sensitive region by further explaining how the signal is transmitted. The historical account provides no direct evidence for 'Science is influenced by society and culture', so do not tick that statement.

The question is not asking whether these statements about the nature of science are generally true. It asks which aspects are actually illustrated by the historical evidence supplied. Support each tick with the corresponding historical evidence.

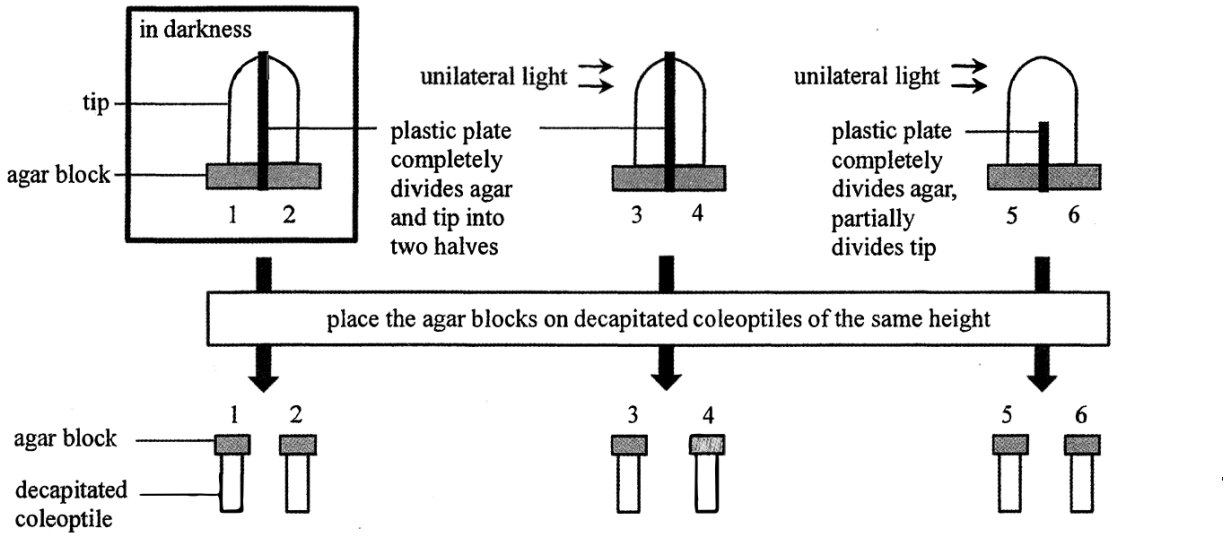
Examiner's comment (source page(s) 3)

Use set-up III to rule out cutting damage as the explanation, and IV to support light detection by the tip. Historical questions require an explanation of the nature of science based on evidence, rather than merely retelling the story.

Marking reference: HKDSE Biology 2013 Paper 1B Q7, official marking scheme, source page(s) 4.

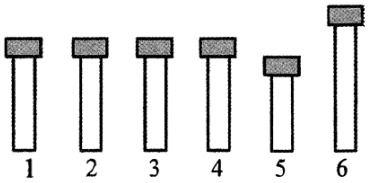
Example 3 [HKDSE Biology 2016 Paper 1A Q35]

Directions: Questions 35 and 36 refer to the diagram below, which shows an experiment that collects auxins from the tip of coleoptiles under different conditions. After that, the agar blocks are placed on decapitated coleoptiles of the same height:

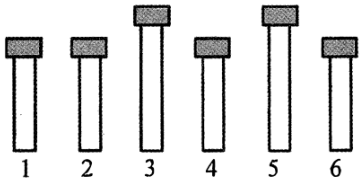


Which of the following correctly shows the growth response of the decapitated coleoptiles?

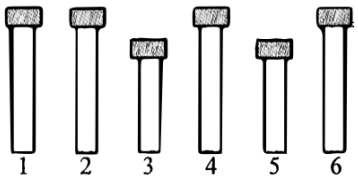
A.



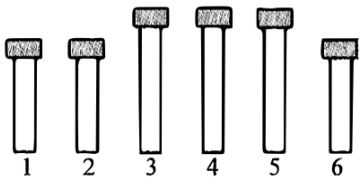
B.



C.



D.



Solution **Answer: A**

First compare the positions of the partitions. In darkness, 1 and 2 receive equal amounts of auxin. Under unilateral light, a partition that completely divides the tip prevents auxin transfer between 3 and 4, so their amounts remain similar to those in 1 and 2. The partition between 5 and 6 divides only the lower part of the tip, allowing auxin to move in the upper part from the illuminated side to the shaded side. Thus, 5 receives less and 6 receives more. When transferred to identical decapitated coleoptiles, 1–4 produce similar growth, 5 produces a shorter coleoptile and 6 a longer one. Choose A.

Method: Separate light detection, signal movement and elongation, then examine the control.

Marking reference: HKDSE Biology 2016 Paper 1A Q35, official marking scheme, source page(s) 1.

Example 4 [HKDSE Biology Practice Paper Paper 1B Q12]

For question 12, candidates are required to present their answers in essay form. 7 marks will be allocated to biological knowledge, and 3 marks to logical presentation and clarity of expression.

Being able to respond to external stimuli is very important for the survival of organisms. Illustrate this with reference to **one** tropic response in flowering plants. Contrast the nature and process of this type of response with that involved in reflex action in humans. (10 marks)

Solution **Complete essay; original allocation: 10 mark(s)**

When a shoot receives light from one side, it gradually bends towards the light source. This is positive phototropism. It helps the leaves receive more light, increasing their opportunities for photosynthesis and thus helping the plant obtain the organic substances needed for growth. During this response, the direction of light affects the distribution of auxin. Cells on the two sides of the shoot elongate to different extents; the shaded side elongates more rapidly, causing the shoot to bend towards the light.

A tropism is a growth response whose direction depends on the direction of the stimulus. It usually involves chemical signals regulating cell growth, so it is relatively slow and changes the pattern of growth. A human reflex, in contrast, is a rapid, stereotyped response to a stimulus that does not require a prior conscious decision, such as immediately withdrawing a hand after touching a very hot object. A receptor converts the stimulus into a nerve signal, which travels along a sensory neurone to the central nervous system and then along a motor neurone to a muscle, causing contraction. This response is not produced by unequal growth on the two sides of a muscle.

The same type of directional stimulus can also cause different plant organs to grow in opposite directions. For example, roots and shoots show different tropic responses to gravity. The response in a particular human reflex is determined by its specific reflex pathway. Both types of response therefore enable organisms to respond to their environment, but they differ in whether growth is involved, their relationship to the direction of the stimulus, their means of signal transmission and their speed.

Method: Separate light detection, signal movement and elongation, then examine the control.

There are 7 content marks: 2 marks for a specific example of a tropism and its survival value, and up to 5 marks for comparisons such as the nature of the response, hormonal versus nervous control, and speed. A further 3 marks are awarded for clear and coherent expression. The original question asks for one tropism and a comparison with a reflex; there is no need to list every function of plant hormones or the entire nervous system.

Marking reference: HKDSE Biology Practice Paper Paper 1B Q12, official marking scheme, source page(s) 7, 8.

Practice

1. [HKDSE Biology 2012 Paper 1A Q30]

Hint: Separate light detection, signal movement and elongation, then examine the control.

Which of the following correctly describe the importance of phototropism to plants?

(1) It ensures that the root can get water from the soil.
(2) It ensures that the root can anchor to the soil for support.
(3) It allows the shoot to reach a position where there is sunlight.

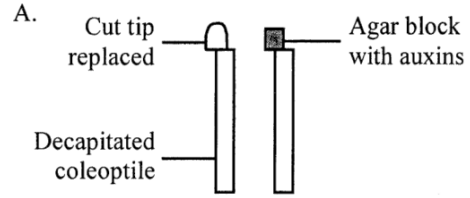
A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

2. [HKDSE Biology 2014 Paper 1A Q36]

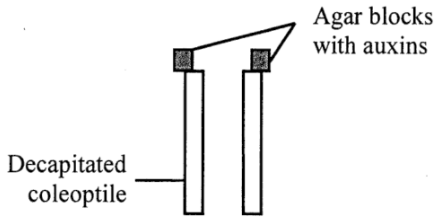
Hint: Separate light detection, signal movement and elongation, then examine the control.

Which of the following pairs of set-ups can be used to test the hypothesis that auxins are growth-promoting substances in oat coleoptiles?

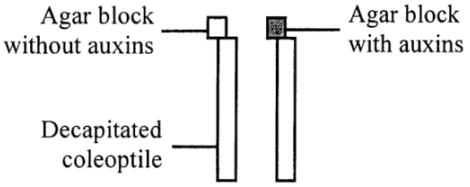
A.



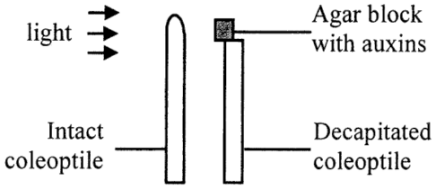
B.



C.

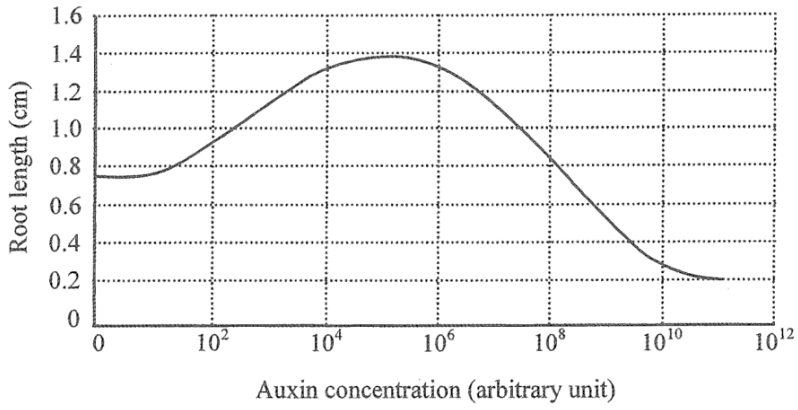


D.



3. [HKDSE Biology 2015 Paper 1A Q29]
Hint: Separate light detection, signal movement and elongation, then examine the control.

The graph below shows the average root length of germinating seeds irrigated with different auxin concentrations:

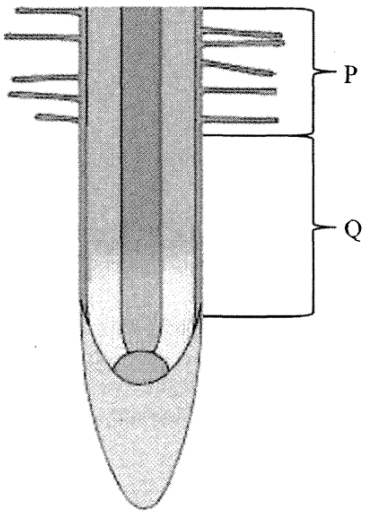


Which of the following can be deduced from the above graph?

A. Auxins promote the elongation of the root.
B. Auxins promote cell division that results in the elongation of the root.
C. Auxins promote water absorption that results in the elongation of the root.
D. Different concentrations of auxins result in differences in the extent of root elongation.

4. [HKDSE Biology 2017 Paper 1A Q31]
Hint: Separate light detection, signal movement and elongation, then examine the control.

The diagram below shows a low power drawing of the cut section of a root:

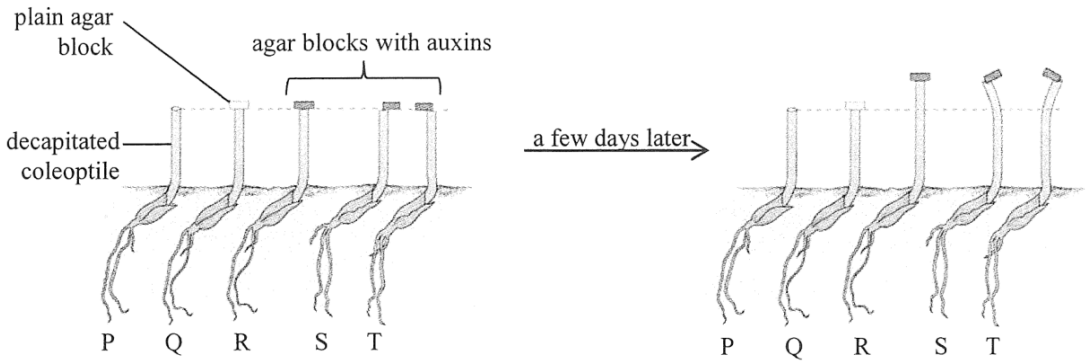


Which of the following correctly describes the relationship of auxin and different regions of the root?

A. It affects cell division at P.
B. It affects cell division at Q.
C. It affects cell elongation at P.
D. It affects cell elongation at Q.

5. [HKDSE Biology 2020 Paper 1A Q27]
← Hint: Separate light detection, signal movement and elongation, then examine the control.

Directions: Questions 27 and 28 refer to the diagram below, which shows an investigation into the effect of auxins on the growth of plant shoots:

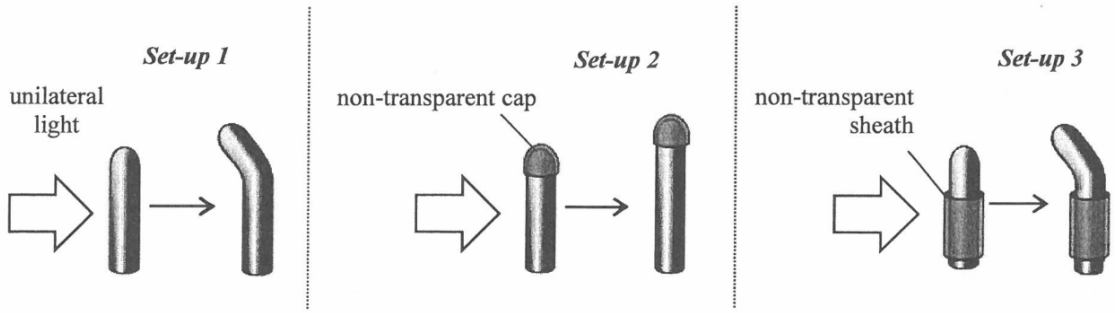


Which of the following serve(s) as the control set-up(s) in this investigation?

A. P only
B. R only
C. P and Q only
D. Q and R only

6. [HKDSE Biology 2022 Paper 1A Q25]
← Hint: Separate light detection, signal movement and elongation, then examine the control.

Darwin performed some experiments on the study of the phototropic response of coleoptiles of young seedlings. The coleoptile in each set-up was exposed to a unilateral light source and the appearance of the coleoptiles after three days are shown below:



Which of the following can be deduced from Darwin's experiment?

(1) Auxins is produced from the tip of the coleoptile.
(2) The coleoptiles show positive phototropic response.
(3) The tip of the coleoptile detects the direction of light.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

7. [HKDSE Biology 2024 Paper 1A Q30]
Hint: Separate light detection, signal movement and elongation, then examine the control.

Directions: Questions 30 and 31 refer to an investigation about the effects of auxins on the growth of shoots. 10 mm sections of shoots were obtained from a number of seedlings. Auxin solutions of different concentrations were prepared. Three shoot sections were put into each solution for two days. The results are shown in the table below:

Auxin concentration (ppm)	*Length of the shoot section after 2 days (mm)*		
	Shoot 1	*Shoot 2*	*Shoot 3*
0	15.0	14.5	15.1
0.1	32.5	32.4	32.2
1	37.1	37.2	10.1
10	24.0	23.9	23.8
100	12.5	12.5	13.0
1000	10.0	9.8	10.3

Based on the above results, which of the following is the lowest auxin concentration that inhibits the growth of the shoots?

A. 0.1 ppm
B. 10 ppm
C. 100 ppm
D. 1000 ppm

8. [HKDSE Biology 2024 Paper 1A Q31]
Hint: Separate light detection, signal movement and elongation, then examine the control.

Directions: Questions 30 and 31 refer to an investigation about the effects of auxins on the growth of shoots. 10 mm sections of shoots were obtained from a number of seedlings. Auxin solutions of different concentrations were prepared. Three shoot sections were put into each solution for two days. The results are shown in the table below:

Auxin concentration (ppm)	*Length of the shoot section after 2 days (mm)*		
	Shoot 1	*Shoot 2*	*Shoot 3*
0	15.0	14.5	15.1
0.1	32.5	32.4	32.2
1	37.1	37.2	10.1
10	24.0	23.9	23.8
100	12.5	12.5	13.0
1000	10.0	9.8	10.3

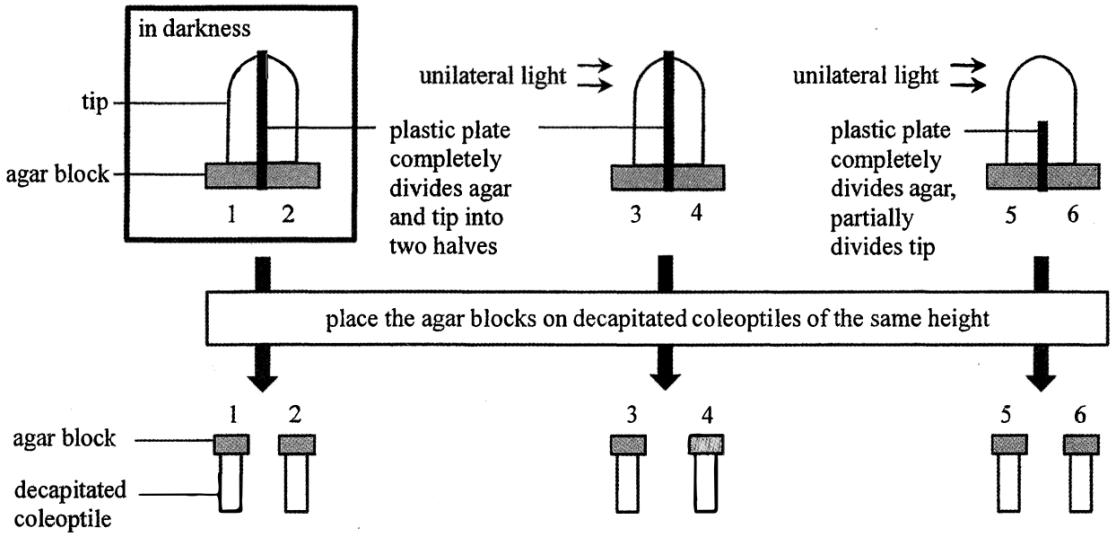
Which of the following best explains the result of Shoot 3 in 1 ppm auxin concentration solution?

A. This datum is anomalous.
B. It is an error which should be deleted.
C. It is due to variations in individual differences.
D. The shoot section is likely taken from the region of cell differentiation.

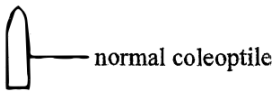
9. [HKDSE Biology 2016 Paper 1A Q36]

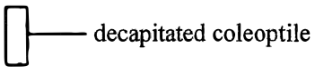
Hint: Separate light detection, signal movement and elongation, then examine the control.

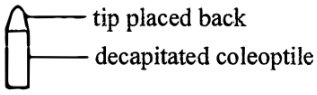
Directions: Questions 35 and 36 refer to the diagram below, which shows an experiment that collects auxins from the tip of coleoptiles under different conditions. After that, the agar blocks are placed on decapitated coleoptiles of the same height:

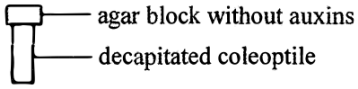


Which of the following can be used as a control set-up for the above experiment?

A. 

B. 

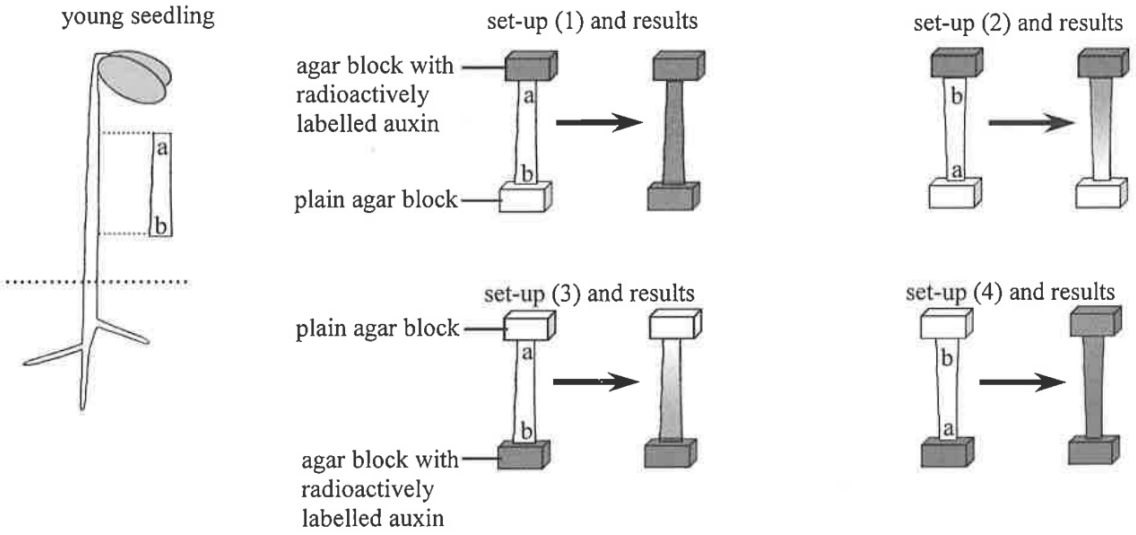
C. 

D. 

10. [HKDSE Biology 2019 Paper 1A Q28]

Hint: Separate light detection, signal movement and elongation, then examine the control.

To investigate the transport of auxins in the stem of a young seedling, a plain agar block and an agar block soaked in radioactively labelled auxins were prepared and placed at different ends of a cut stem, as shown in the diagram below. The relative amounts of radioactivity in different parts are shown as different intensities of shaded area.



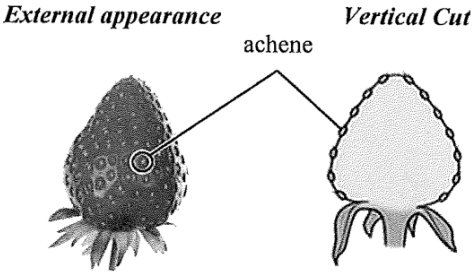
Which of the following conclusions can be drawn from the above results?

(1) Transport of auxins in the stem is not affected by gravity.
(2) Transport of auxins in the stem involves an active process.
(3) Transport of auxins in the stem mainly takes place from a to b.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

11. [HKDSE Biology 2023 Paper 1B Q9]
Hint: Separate light detection, signal movement and elongation, then examine the control.

The diagram below shows the external appearance of a strawberry and its vertical cut. The achenes found on the surface of the strawberry are the fruits:



(a) An investigation into the role of achenes in the development of a strawberry was carried out as shown below:

Treatment	Relative size and appearance of the strawberry	
	Day 1	Day 20
1. Achenes remained intact.		
2. All achenes were removed on Day 1.		
3. All achenes were removed on Day 1 and the strawberry was then regularly sprayed with auxins.		

2 versus 3	
1 versus 3	

(ii) Based on the results, suggest ***one*** hypothesis for the enlargement of the strawberry. (1 mark)

(iii) Study another treatment as follows:

Treatment	Relative size and appearance of the strawberry	
	Day 1	Day 20
4. Achenes were removed from the lower part of the strawberry on Day 1.	Achenes remained on the upper part  Achenes removed from the lower part	

In terms of experimental design, what is the advantage of Treatment 4 as compared to Treatments 1 and 2? (1 mark)

(b) Give ***one*** example of a growth response induced by auxins and state its significance to plants. (2 marks)

Type 5 Track information through neurones, synapses and reflex arcs

Degree of integration ★★☆☆☆

Key ideas

① A receptor converts a stimulus into a signal, which travels along a sensory neurone to the central nervous system and then along a motor neurone to an effector. Presynaptic vesicles release neurotransmitter, whose molecules diffuse and bind postsynaptic receptors. The locations of release and receptors give chemical transmission its direction.

② A reflex does not require a prior conscious judgement, although information can also travel to the brain to produce sensation.

How to recognise the problem Use signal direction to identify sensory and motor neurones. For a blockage, remove only the affected step, not every function of the whole cell.

Example 1 [HKDSE Biology 2016 Paper 1B Q1]

The table below shows the condition which may result from damage to a certain part of the brain. Complete the table by filling in either the condition or the structural part of the brain affected. (3 marks)

Condition	***Structural part of the brain***
difficulty in breathing	
	cerebellum
difficulty in speech and vision	

Solution **Table; original allocation: 3 mark(s)**

Difficulty breathing: medulla oblongata (brain stem). Damage to the cerebellum: difficulty with balance and coordination during movement or walking. Difficulties with speech and vision: cerebrum (cerebral cortex).

For each cell, first identify the key functional term. The medulla oblongata helps control involuntary activities such as breathing. The cerebellum coordinates muscular activity and maintains balance. The cerebral cortex is responsible for higher functions such as visual processing and speech. Do not confuse the ability to contract muscles with the ability to coordinate movements. Each of the three cells carries 1 mark.

Method: Follow signal direction to locate neurones, synapses and the blockage.

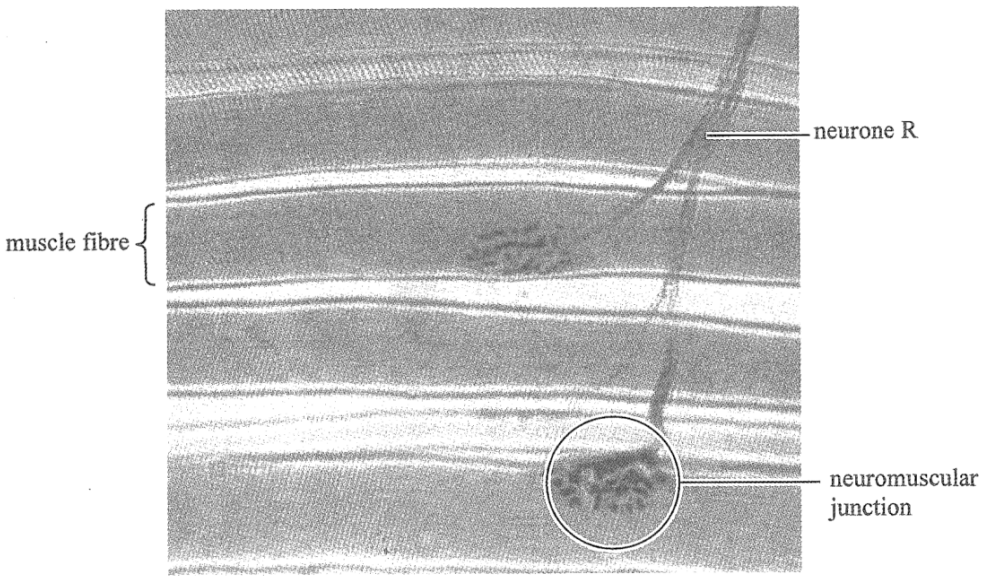
Examiner's comment (source page(s) 2)

The question asks about the effects of damage. State specifically how the function changes, rather than simply listing the brain region's normal function.

Marking reference: HKDSE Biology 2016 Paper 1B Q1, official marking scheme, source page(s) 2.

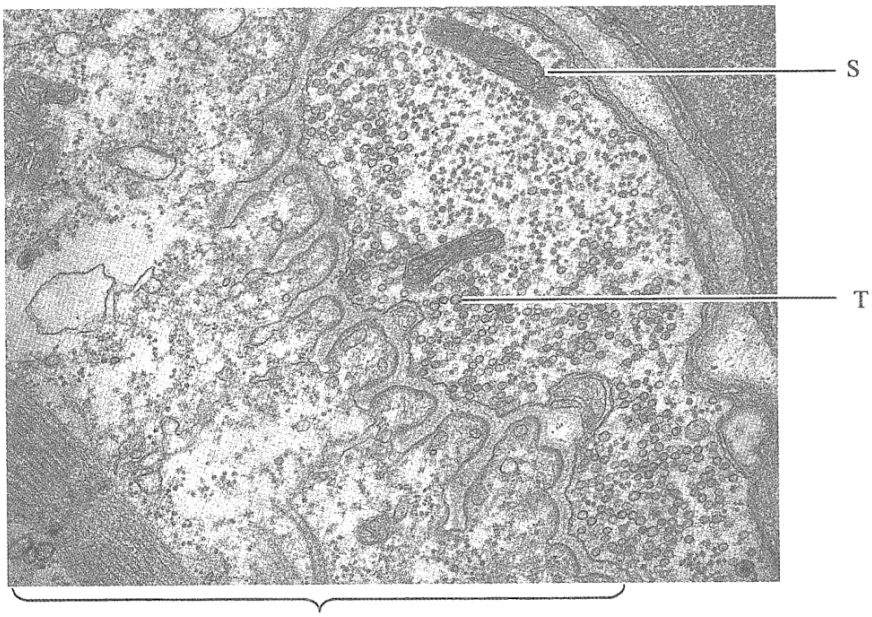
Example 2 [HKDSE Biology 2015 Paper 1B Q5]

Photograph P



(x 400)

Photograph Q



(x 4500) part of muscle fibre

On the opposite page, Photograph P shows several muscle fibres associated with the terminal parts of neurone R and Photograph Q shows the detailed structure of a neuromuscular junction.

(a) Which type of neurones does R belong to? Give a reason for your answer. (2 marks)

(b) What is the functional relationship between S and T shown in Photograph Q? (2 marks)

(c) Describe how nerve impulses can be transmitted across the neuromuscular junction leading to muscle contraction. (3 marks)

Solution (a); original allocation: 2 mark(s)

It is a motor neurone because its terminal connects to muscle fibres, which act as effectors. The structure to which a neurone connects provides direct evidence of its type. The terminal of P forms a junction with muscle, indicating that information passes from the nervous system to an effector rather than inwards from a receptor.

Method: Follow signal direction to locate neurones, synapses and the blockage.

(b); original allocation: 2 mark(s)

S is a mitochondrion. It supplies energy for synthesising, storing or releasing the neurotransmitter contained in vesicles T.

T stores a chemical messenger, and releasing this messenger requires an energy supply. ATP produced by respiration in S supports these activities. Connect the two structures within the same functional process instead of giving two unrelated names.

(c); original allocation: 3 mark(s)

A nerve impulse reaches the terminal, causing neurotransmitter to be released at the junction. The neurotransmitter diffuses across the synaptic cleft and binds to receptors on the muscle fibre membrane, triggering a response and contraction of the muscle.

The electrical signal is converted into a chemical signal at the nerve terminal. The chemical messenger crosses the gap between the two cells and then triggers a response at the muscle membrane. This continuous sequence explains how the signal crosses the junction. The nerve fibre does not extend directly into the muscle and pull it.

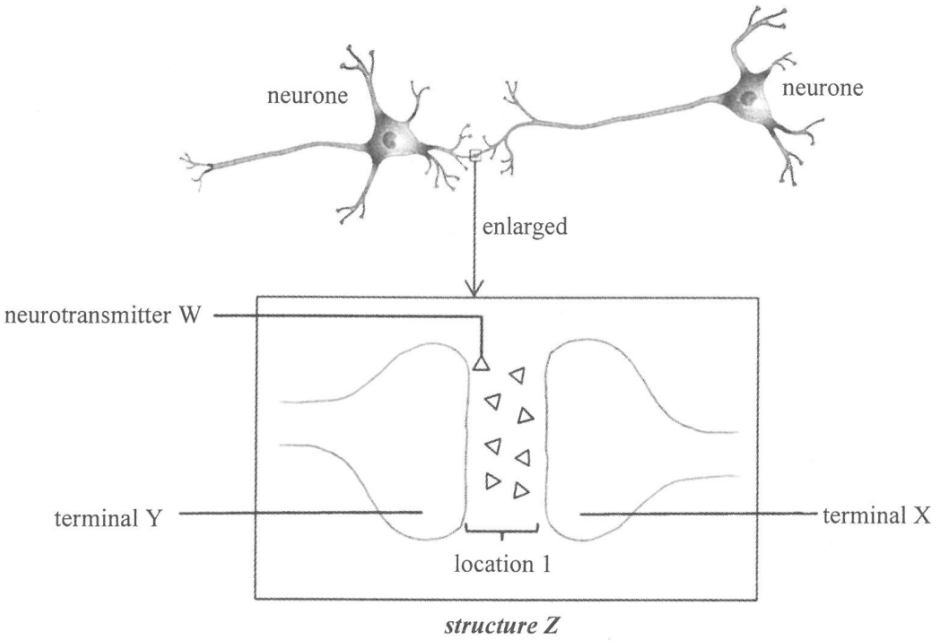
Examiner's comment (source page(s) 3)

Identify the motor neurone using the visible evidence that it connects to muscle. Mitochondria in the presynaptic terminal supply energy for vesicles to release neurotransmitter. A chemical substance diffuses across the synaptic cleft; the nerve impulse itself does not.

Marking reference: HKDSE Biology 2015 Paper 1B Q5, official marking scheme, source page(s) 3.

Example 3 [HKDSE Biology 2021 Paper 1B Q2]

The diagram below shows two adjacent neurones. When a nerve impulse arrives at structure Z, the amount of neurotransmitter W at location 1 increases.



structure Z

(a) Name structure Z. (1 mark)

(b) (i) Neurotransmitter W at location 1 is released from one of the terminals of structure Z. Which terminal (X or Y) releases neurotransmitter W? (1 mark)

(ii) Describe how the neurotransmitter W at location 1 can bring about the transmission of nerve impulses at structure Z. (2 marks)

(c) What is the significance of the process in (b) to the transmission of nerve impulses? (1 mark)

Solution a; original allocation: 1 mark(s)

Z is a synapse.

It is a junction at which information is transmitted between two neurones. Position 1 in the diagram is the gap between their membranes.

Method: Follow signal direction to locate neurones, synapses and the blockage.

b(i); original allocation: 1 mark(s)

Terminal X.

Tracing the structure of the neurones shown above, the axon of the neurone on the right transmits information to the neurone on the left. X, on the right, is therefore the presynaptic terminal that releases neurotransmitter.

b(ii); original allocation: 2 mark(s)

W diffuses to the membrane of terminal Y and binds to its receptors, stimulating Y to produce a nerve impulse.

When the electrical signal reaches X, W is released into position 1. W crosses the gap by molecular diffusion; the original electrical impulse does not pass directly through the gap. Stimulation of the receptors then causes the next neurone to generate a new electrical signal.

c; original allocation: 1 mark(s)

It ensures that nerve signals are transmitted in only one direction.

The structures that release and receive neurotransmitter are on opposite sides, so normal transmission proceeds from X to Y.

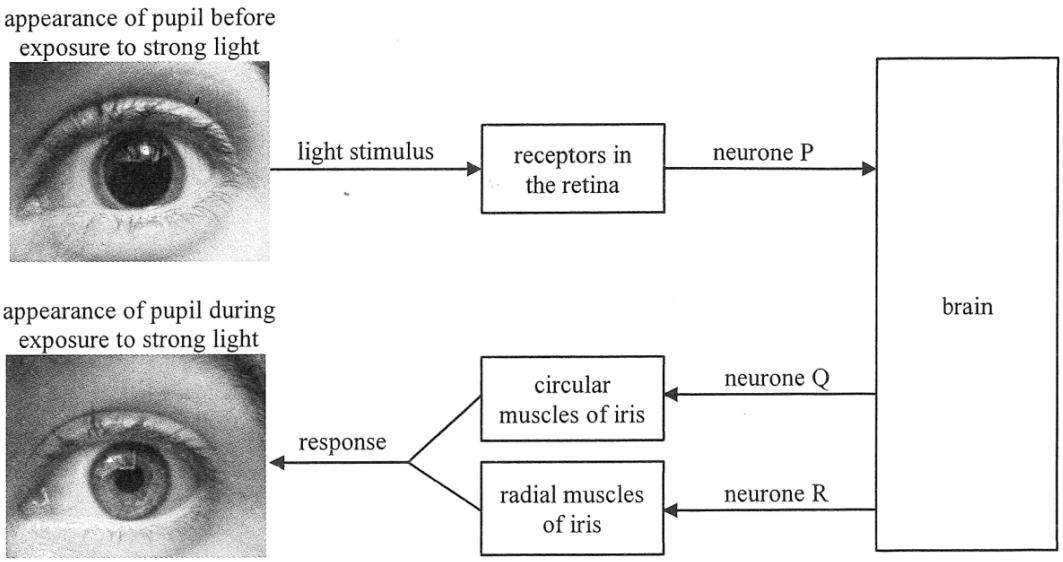
Examiner's comment (source page(s) 3, 4)

The complete sequence of synaptic transmission includes diffusion of neurotransmitter, binding to receptors on the next neurone's membrane and initiation of a new nerve impulse. Merely stating that the neurotransmitter crosses the gap omits a key step.

Marking reference: HKDSE Biology 2021 Paper 1B Q2, official marking scheme, source page(s) 2.

Example 4 [HKDSE Biology 2020 Paper 1B Q3]

The diagram below shows a neural pathway involved in the coordination of pupil size when a human eye is exposed to strong light:



(a) With reference to the above neural pathway,

(i) state the ***two*** types of receptors located in the retina. (1 mark)

(ii) state the type of neurone represented by Q and R. (1 mark)

(b) Describe how the two sets of iris muscles work together to bring about the change in the pupil size shown above. State the significance of this response. (4 marks)

(c) If someone falls unconscious, the response of the above neural pathway will be assessed to confirm if this pathway is still functioning. What does this assessment tell you about the nature of this neural coordination? (1 mark)

Solution a(i); original allocation: 1 mark(s)

Rod cells and cone cells.

The question asks for the two types of receptor in the retina, so give the actual cell names. 'Photoreceptors' is their shared category and does not identify the two types. The iris muscles are effectors that carry out a response; both their location and function are different.

Method: Follow signal direction to locate neurones, synapses and the blockage.

a(ii); original allocation: 1 mark(s)

Motor neurones.

The arrows for Q and R point from the brain towards the iris muscles. Information passes from the central nervous system to effectors, so these are functionally motor neurones. P, from the retina to the brain, carries sensory information inwards.

b; original allocation: 4 mark(s)

Bright light causes the circular muscles of the iris to contract and the radial muscles to relax. The pupil becomes smaller, reducing the amount of light entering the eye and preventing excessive stimulation of the rod and cone cells.

The circular muscles form a ring around the pupil. Their contraction makes the central opening smaller, while the antagonistic radial muscles relax. The pupil itself is an opening: say that it becomes smaller. It is the muscles that contract. Linking this action to the amount of light entering and the receptors being protected connects the structural action, the visible response and its biological significance.

c; original allocation: 1 mark(s)

This is an involuntary, innate reflex that does not require a conscious decision before it occurs.

An unconscious person cannot consciously constrict the pupils on command. However, if the reflex pathway still functions, a light stimulus can still trigger the response. This examination therefore uses the automatic nature of a reflex. Passing through the brain does not necessarily mean that a conscious decision by the cerebrum is required.

Marking reference: HKDSE Biology 2020 Paper 1B Q3, official marking scheme, source page(s) 3.

Practice

1. [HKDSE Biology 2012 Paper 1A Q4]

Hint: Follow signal direction to locate neurones, synapses and the blockage.

Which of the following gives the correct direction of impulse transmission in a neurone?

A. axon → cell body → dendrites
B. dendrites → cell body → axon
C. cell body → axon → dendrites
D. dendrites → axon → cell body

2. [HKDSE Biology 2012 Paper 1A Q5]

Hint: Follow signal direction to locate neurones, synapses and the blockage.

Chemicals released at the synapse are responsible for the impulse transmission from

(1) sensory neurone to interneurone.
(2) interneurone to motor neurone.
(3) motor neurone to muscle.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

3. [HKDSE Biology 2012 Paper 1A Q6]

Hint: Follow signal direction to locate neurones, synapses and the blockage.

Which of the following activities is coordinated by the cerebellum?

A. muscular movements during dancing
B. breathing movements during sleeping
C. secretion of digestive juices when one is hungry
D. withdrawal of hand when one touches a hot object

4. [HKDSE Biology 2015 Paper 1A Q22]

Hint: Follow signal direction to locate neurones, synapses and the blockage.

Toys are often used to develop children's fine motor skills. Which of the following parts is trained when children play with toys?

A. cerebellum
B. spinal cord
C. pituitary
D. medulla oblongata

5. [HKDSE Biology 2015 Paper 1A Q23]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

Which of the following correctly compares reflex actions and voluntary actions?

	Reflex actions	*Voluntary actions*
A.	responses may vary	responses are always the same
B.	stimulus is optional	stimulus is required
C.	initiated by receptors	initiated in the brain
D.	effectors must be muscles	effectors can be muscles or glands

6. [HKDSE Biology 2017 Paper 1A Q30]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

Which of the following ***does not*** belong to the central nervous system?

A. medulla oblongata
B. spinal cord
C. cerebellum
D. eye

7. [HKDSE Biology 2018 Paper 1A Q19]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

Directions: Questions 19 to 21 refer to the diagrams below. Diagram I shows the reflex arc of the knee jerk reflex while diagram II shows three types of neurones:

Diagram I

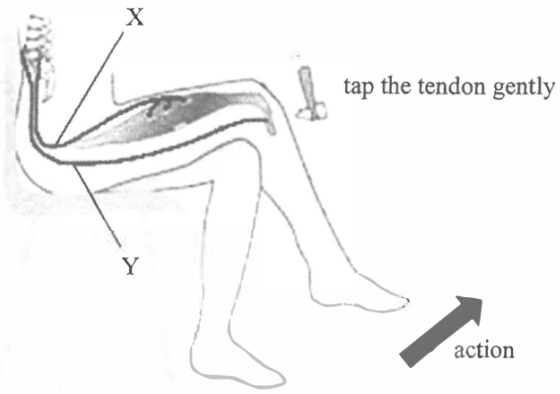


Diagram II



The effector in the reflex arc in Diagram I is

A. a flexor because its response bends the limb.
B. an extensor because its response straightens the limb.
C. a flexor because it shortens to bring about the movement.
D. an extensor because it lengthens to bring about the movement.

8. [HKDSE Biology 2018 Paper 1A Q21]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

Directions: Questions 19 to 21 refer to the diagrams below. Diagram I shows the reflex arc of the knee jerk reflex while diagram II shows three types of neurones:

Diagram I

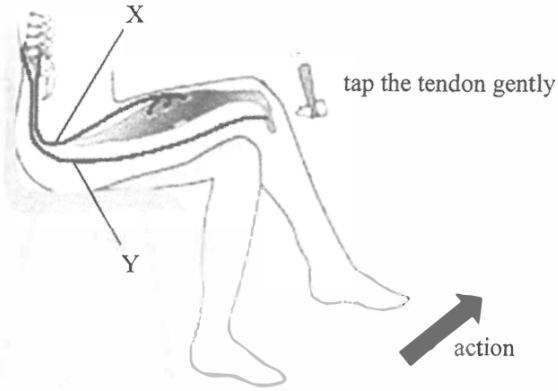


Diagram II



Another neural pathway allows the man to feel the tapping action. Which of the following parts should this pathway connect to?

A. cerebellum
B. spinal cord
C. cerebral cortex
D. medulla oblongata

9. [HKDSE Biology 2018 Paper 1A Q22]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

Which of the following combinations correctly identifies the distribution of grey matter and white matter in the cerebrum and spinal cord?

	Inner part of the cerebrum	***Inner part of the spinal cord***
A.	white matter	grey matter
B.	white matter	white matter
C.	grey matter	grey matter
D.	grey matter	white matter

10. [HKDSE Biology Sample Paper Paper 1A Q23]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

What is the role of the cerebrum and cerebellum when a person is swimming?

	Cerebrum	***Cerebellum***
A.	controls muscle contraction	coordinates muscular actions
B.	controls muscle contraction	regulates heart beat
C.	coordinates muscular actions	controls muscle contraction
D.	regulates heart beat	coordinates muscular actions

11. [HKDSE Biology 2013 Paper 1B Q1]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

For each of the brain parts listed in column 1, select from column 2 one phrase that matches it. Put the appropriate letter in the space provided. (3 marks)

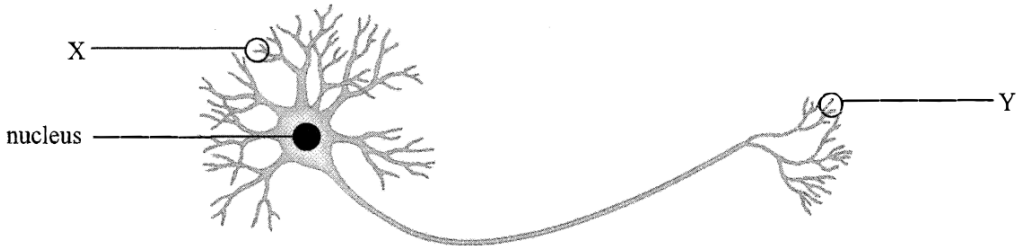
Column 1		Column 2
Cerebellum	.....	A. Damage causes inability to make decisions
Medulla oblongata	.....	B. Damage causes loss of body balance
Cerebrum	.....	C. Damage causes loss of control of breathing rate
		D. Damage causes loss of withdrawal reflex

12. [HKDSE Biology 2024 Paper 1B Q1]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

		Nervous control	*Hormonal control*
(a)	Signalling molecule		
(b)	Transmission pathway		
(c)	Comparison of the time taken to induce responses		

13. [HKDSE Biology 2017 Paper 1A Q29]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

The diagram below shows a motor neurone:



Which of the following statements correctly describes the motor neurone?

A. X is connected to a muscle fibre.
B. Electrical impulses are transmitted from Y to X.
C. Synapses can be found at the end of both X and Y.
D. Electrical impulses are sent out at Y to the next neurone.

14. [HKDSE Biology 2018 Paper 1A Q20]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

Directions: Questions 19 to 21 refer to the diagrams below. Diagram I shows the reflex arc of the knee jerk reflex while diagram II shows three types of neurones:

Diagram I

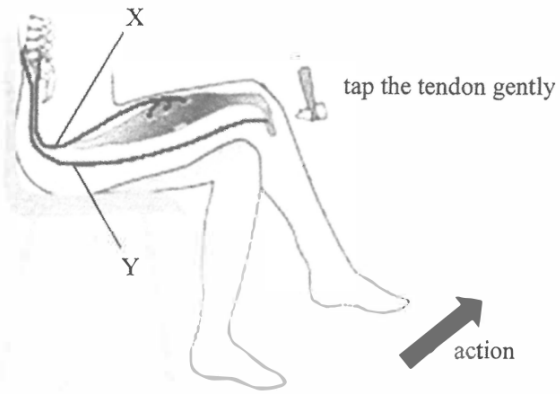
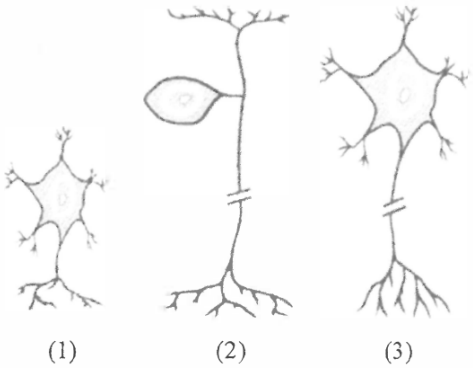


Diagram II



Which of the following combinations correctly identifies the types of neurones to which X and Y belong?

	X	*Y*
A.	(1)	(3)
B.	(2)	(1)
C.	(2)	(3)
D.	(3)	(2)

15. [HKDSE Biology 2019 Paper 1A Q21]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

Daisy is very hungry. When the waiter puts her favourite dish on the table, her saliva secretion increases. Which of the following body parts controls this response?

A. cerebrum
B. cerebellum
C. salivary gland
D. medulla oblongata

16. [HKDSE Biology 2023 Paper 1A Q20]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

Which of the following correctly explain(s) why reflex actions are usually faster than voluntary actions?

(1) Reflex actions do not involve decision making.
(2) Nerve impulses travel faster in reflex actions.
(3) Reflex actions are inborn.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

17. [HKDSE Biology 2024 Paper 1A Q22]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

Which of the following combinations correctly compares pupil reflex in humans and phototropism in plants?

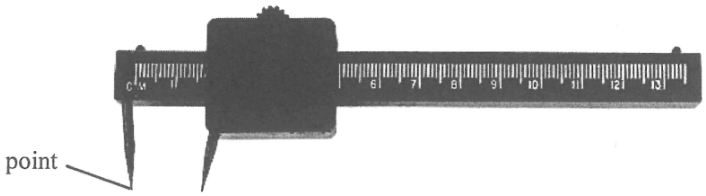
		pupil reflex	***phototropism***
(1)	stimulus	light intensity	direction of light
(2)	location of receptors	retina	shoot tip
(3)	effector	pupil	shoot

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

18. [HKDSE Biology 2024 Paper 1A Q23]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

Directions: Questions 23 to 25 refer to a two-point discrimination test on the human skin by following the procedure shown below:

1. Blindfold the subjects (tested persons).
2. Set the calipers (shown below) at a distance of 30 mm. Apply the two points of the calipers with equal pressure on the fingertip of the subject's index finger. Have the subjects identify if they feel one touch or two touches.



3. Repeat step 2 by using a progressively shorter distance (e.g. 28 mm, 26 mm, 24 mm) between the two points until the subject feels one touch. Record the distance.
4. Repeat steps 2 and 3 by touching the palm of the hand, the back of the hand and the upper arm.
5. Over the course of the experiment, randomly use the caliper set at 0 mm for every couple of trials. It is important to make sure that the subjects tell you that they only feel one touch when the caliper is set at 0 mm.

Based on the procedure given, how many independent variable(s) is/are being studied in this investigation?

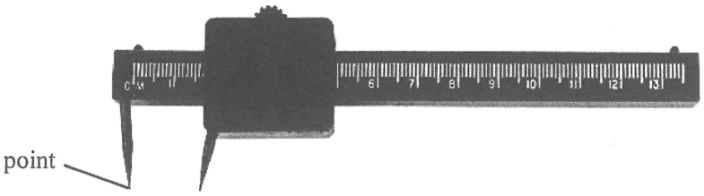
A. 1
B. 2
C. 3
D. 4

19. [HKDSE Biology 2024 Paper 1A Q24]

Hint: Follow signal direction to locate neurones, synapses and the blockage.

Directions: Questions 23 to 25 refer to a two-point discrimination test on the human skin by following the procedure shown below:

1. Blindfold the subjects (tested persons).
2. Set the calipers (shown below) at a distance of 30 mm. Apply the two points of the calipers with equal pressure on the fingertip of the subject's index finger. Have the subjects identify if they feel one touch or two touches.



3. Repeat step 2 by using a progressively shorter distance (e.g. 28 mm, 26 mm, 24 mm) between the two points until the subject feels one touch. Record the distance.
4. Repeat steps 2 and 3 by touching the palm of the hand, the back of the hand and the upper arm.
5. Over the course of the experiment, randomly use the caliper set at 0 mm for every couple of trials. It is important to make sure that the subjects tell you that they only feel one touch when the caliper is set at 0 mm.

The investigation was designed to show the density of the touch receptors of the skin. What is the assumption of this investigation?

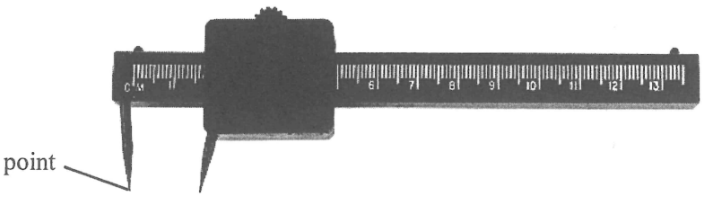
A. The subjects do not cheat by peeking out of the blindfold.
B. The fingertip is more sensitive than the other parts of the body.
C. A closer distance means that the density of the touch receptors is higher.
D. The two-touch sensations are produced by two separated touch receptors without overlapping.

20. [HKDSE Biology 2024 Paper 1A Q25]

Hint: Follow signal direction to locate neurones, synapses and the blockage.

Directions: Questions 23 to 25 refer to a two-point discrimination test on the human skin by following the procedure shown below:

1. Blindfold the subjects (tested persons).
2. Set the calipers (shown below) at a distance of 30 mm. Apply the two points of the calipers with equal pressure on the fingertip of the subject's index finger. Have the subjects identify if they feel one touch or two touches.



3. Repeat step 2 by using a progressively shorter distance (e.g. 28 mm, 26 mm, 24 mm) between the two points until the subject feels one touch. Record the distance.
4. Repeat steps 2 and 3 by touching the palm of the hand, the back of the hand and the upper arm.
5. Over the course of the experiment, randomly use the caliper set at 0 mm for every couple of trials. It is important to make sure that the subjects tell you that they only feel one touch when the caliper is set at 0 mm.

Which of the following correctly explains the importance of Step 5 in this investigation?

A. It ensures the validity of the measurement.
B. It checks the accuracy of the measurement.
C. It improves the reliability of the measurement.
D. It reduces the random error of the measurement.

21. [HKDSE Biology 2024 Paper 1A Q26]
⟵ Hint: Follow signal direction to locate neurones, synapses and the blockage.

Which of the following parts of the brain are responsible for coordination when one is speaking?

(1) cerebellum
(2) motor area
(3) sensory area
(4) association area

A. (2) and (4) only
B. (1), (2) and (3) only
C. (1), (2) and (4) only
D. (1), (3) and (4) only

22. [HKDSE Biology 2025 Paper 1A Q30 (English translation)]
⟵ Hint: Follow signal direction to locate neurones, synapses and the blockage.

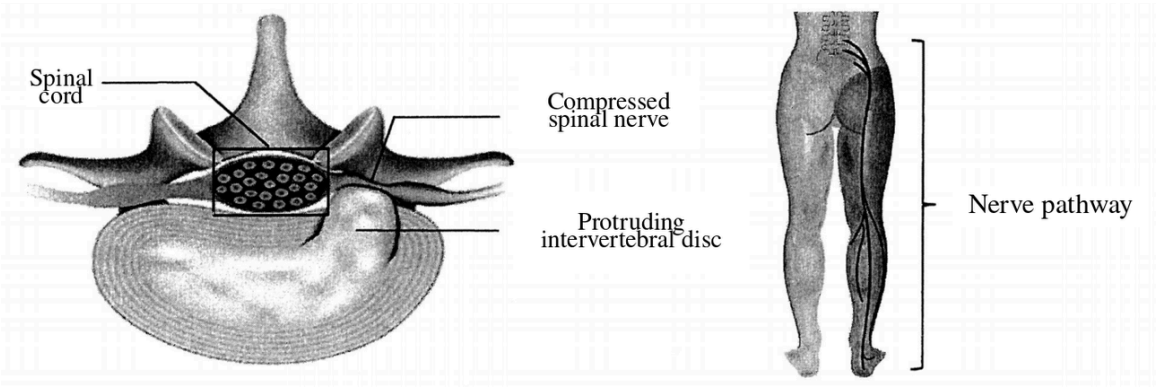
Repeated contraction of facial muscles produces wrinkles. The cosmetic industry uses injections of botulinum toxin to remove wrinkles. Botulinum toxin prevents synaptic vesicles at neuromuscular junctions from fusing with the axon terminal membrane. Which of the following processes will NOT occur after the use of botulinum toxin?

(1) Binding of neurotransmitters to receptors on facial muscle-fibre membranes
(2) Release of neurotransmitters at axon terminals
(3) Synthesis of neurotransmitters at axon terminals

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

23. [HKDSE Biology 2025 Paper 1A Q31 (English translation)]
⟵ Hint: Follow signal direction to locate neurones, synapses and the blockage.

The diagram below shows a patient whose spinal nerve is compressed by a protruding intervertebral disc as a result of frequently carrying heavy objects:



Which of the following symptoms may the patient experience?

(1) Reduced blood supply to the leg muscles
(2) Loss of sensation in the leg
(3) Reduced strength of the leg muscles

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

24. [HKDSE Biology 2019 Paper 1B Q4]
Hint: Follow signal direction to locate neurones, synapses and the blockage.

Diagrams I and II below show a person with both eyes moving right and then left. This eyeball movement is brought about by the coordination of different eye muscle pairs. Diagram III shows four of the muscles (P, Q, R, and S), all connected to motor neurones controlling eyeball movement.

Key: directions of eyeball movement

Diagram I



Diagram II

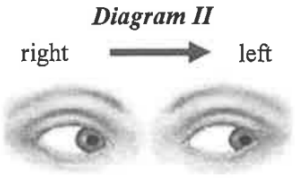
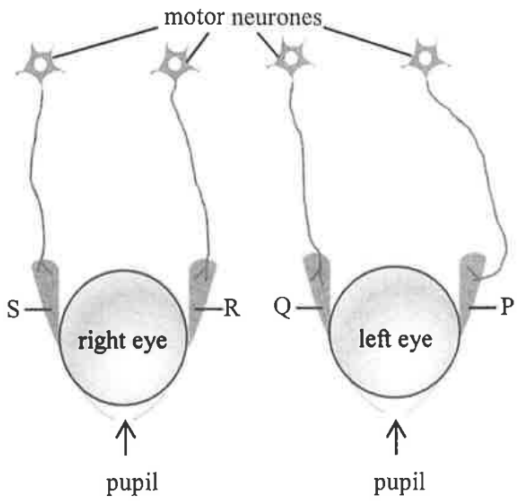


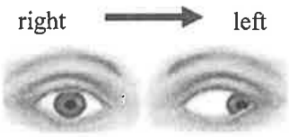
Diagram III (top view)



(a) To bring about the eyeball movement shown in Diagram I, which muscle(s) (P, Q, R, or S) contract(s)? (1 mark)

(b) A person suffers from impaired eyeball movement when turning his eyes from right to left, as shown in Diagram IV.

Diagram IV



It is found that one of his eye muscles cannot fully contract. Based on your knowledge of neurotransmission at the neuromuscular junction, suggest ***two*** possible defects that would lead to the impaired eyeball movement shown in Diagram IV. (2 marks)

III.e Homeostasis

First read the explanations and diagrams in Concept III.e, then work through the question types in this section. Each worked example retains the complete original question and explanation. The subsequent exercises require progressively more integration of information, based on the demands of the whole question.

Type 1 Explain negative feedback using blood-glucose and hormone data

Degree of integration ★★★☆☆

Key ideas

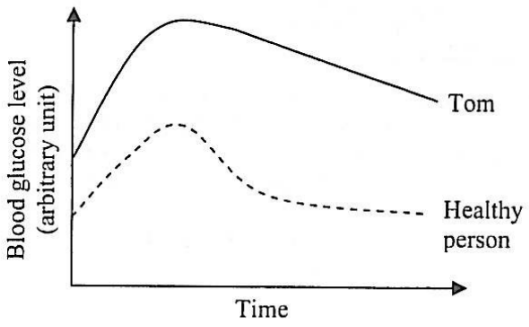
① After a meal, small-intestinal glucose absorption raises blood glucose and can increase insulin secretion. Relevant cells are stimulated to take up, use or store glucose. As blood glucose falls, the stimulus weakens. During fasting, pathways such as liver glycogen breakdown can increase to supply blood glucose.

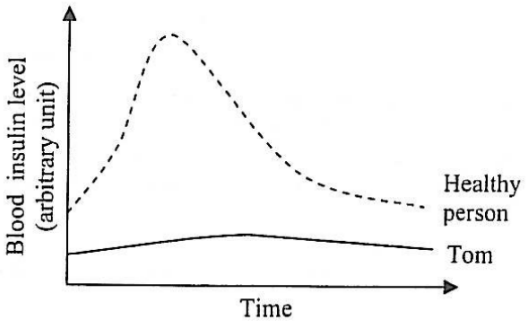
② Negative feedback reduces the original deviation; it does not require the response always to lower a value. Correcting an abnormally low quantity instead raises it.

How to recognise the problem Identify the regulated quantity, then connect stimulus, detection / secretion, target organ, effect and feedback. Compare the timing of curves, not only peak height.

Example 1 [HKDSE Biology 2012 Paper 1B Q7]

Tom suffers from diabetes. His doctor asked him to drink, after overnight fasting, a large volume of a glucose solution. After that, blood samples were taken at regular time intervals, to measure insulin and glucose contents. The following graphs show the changes in Tom's blood glucose level and blood insulin level after the test, and those of a healthy person:





(a) Which type of diabetes does Tom suffer from? Explain your answer. (4 marks)

(b) Explain the difference in blood glucose response to the oral consumption of glucose solution between Tom and the healthy person. (3 marks)

(c) What medical treatment should Tom be given? (1 mark)

Solution a; original allocation: 4 mark(s)

Method: Identify the regulated quantity, then connect stimulus, effect and feedback.

Siu Tung is a case of insulin-dependent diabetes mellitus. After he drinks glucose, his blood glucose rises markedly, but his insulin concentration remains below that of the healthy person and increases very little. This indicates that he cannot produce enough insulin.

Do not identify the type solely from high blood glucose. The second graph directly shows the secretory response: the healthy person has a clear insulin peak, whereas Siu Tung lacks a corresponding rise. This supports the conclusion that his insulin supply is insufficient.

b; original allocation: 3 mark(s)

Because insulin is insufficient, body cells take up and use blood glucose less effectively. Blood glucose therefore rises higher, falls more slowly and remains elevated for longer.

After the ingested glucose enters the blood, insulin should promote glucose uptake by certain cells and glycogen synthesis in the liver and muscles. Insufficient activity of these glucose-removing processes explains the higher peak and delayed recovery of the curve.

c; original allocation: 1 mark(s)

Insulin injection.

The direct defect in this case is an insufficient supply of insulin, so the answer is to replace insulin. Insulin is a protein and would be digested if taken orally in an ordinary formulation; this is the mechanistic explanation relevant to the examination question.

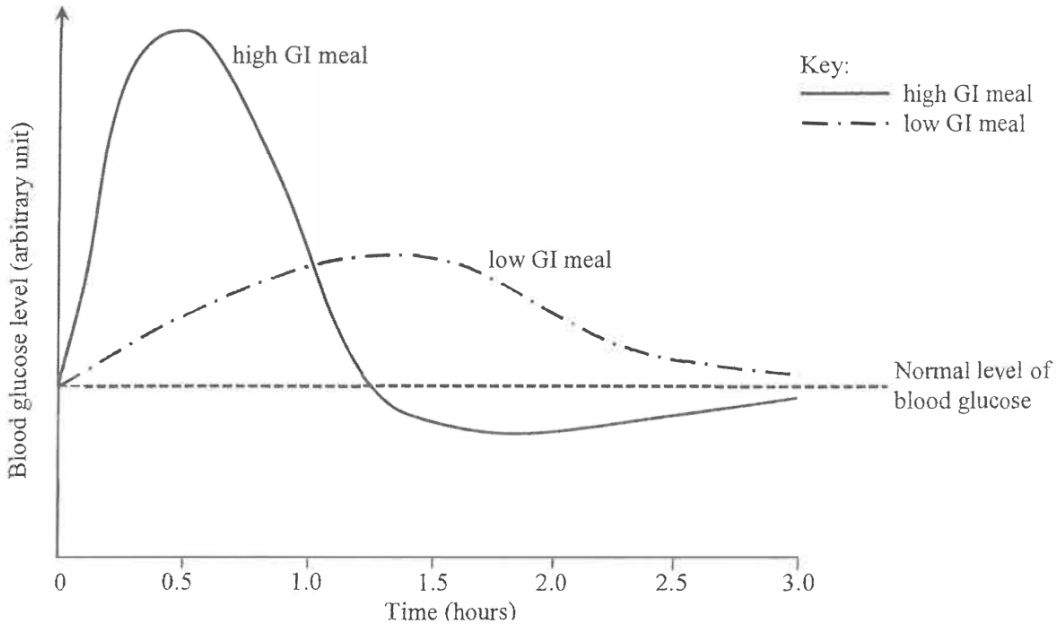
Examiner's comment (source page(s) 1)

Read both the insulin and glucose curves to identify the type of diabetes. Insulin promotes glucose processing; it is not itself an enzyme that directly converts glucose into glycogen.

Marking reference: HKDSE Biology 2012 Paper 1B Q7, official marking scheme, source page(s) 3.

Example 2 [HKDSE Biology 2018 Paper 1B Q7]

7. The glycemic Index (GI) is an indication of the effect of food on the blood glucose level. The higher the GI value of a food, the quicker is the rise in blood glucose level. The graph below shows the changes in the blood glucose level of a healthy individual after consuming the same quantity of a low GI or high GI meal over a period of three hours:



(a) Describe how the consumption of a meal leads to an increase in the blood glucose level. (2 marks)

(b) (i) Name the key hormone which lowers the blood glucose level. (1 mark)

(ii) Describe how this hormone lowers the blood glucose level. (3 marks)

(iii) On the graph on the opposite page (page 10), sketch a curve to show the change in the level of this key hormone in response to the consumption of a high GI meal by the healthy person. (2 marks)

(c) Explain why diabetic patients should consume low GI meals. (2 marks)

Solution Reading the question and choosing a method

Method: Identify the regulated quantity, then connect stimulus, effect and feedback.

Connect the changes in the blood glucose curve, in sequence, to glucose entering the blood, being used by cells and being stored.

a; original allocation: 2 mark(s)

Carbohydrates in food are digested into glucose. Glucose is absorbed from the small intestine into the blood, raising the blood glucose level.

Eating food does not mean that its glucose is already in the blood. Digestion must first convert large molecules into small, absorbable molecules, which then pass through the small intestinal epithelium before blood glucose rises.

b(i); original allocation: 1 mark(s)

Insulin.

This subpart asks for the main hormone that lowers blood glucose, not an enzyme that digests carbohydrates. Insulin is a hormone; do not answer pancreatic amylase.

b(ii); original allocation: 3 mark(s)

Insulin promotes the uptake and use of glucose by body cells, increases the use of glucose in respiration and promotes conversion of glucose into glycogen for storage in liver and muscle cells. These actions lower blood glucose.

From the perspective of the blood, a fall in glucose requires glucose to leave the blood or cease to remain as free glucose in the body fluids. Cellular uptake is the first step; after uptake, glucose may be used in respiration or converted into glycogen for storage. Glycogen

is formed and stored inside cells. Do not state that insulin directly turns blood glucose into glycogen within blood vessels. Different tissues do not respond identically to insulin; explain using the liver and muscle examples required here.

b(iii); original allocation: 2 mark(s)

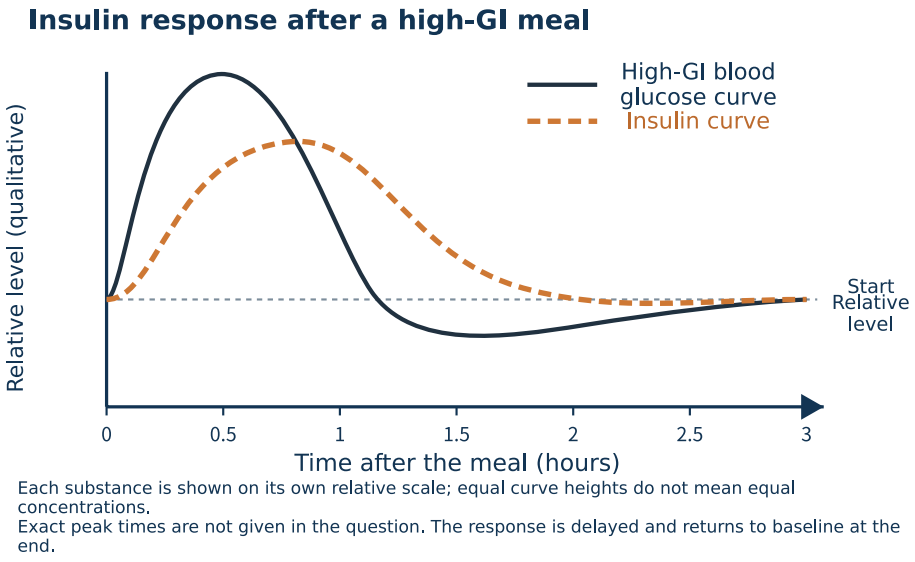
Draw a curve showing insulin rising after the meal, reaching its peak after the high-GI blood glucose peak, then falling and returning close to its starting baseline towards the end.

Insulin secretion responds to a rise in blood glucose, so it should not suddenly peak before the meal. As the glucose stimulus increases, insulin rises. As blood glucose falls, the stimulus to secretion weakens and insulin also falls. Clearly label the added curve as insulin. Do not treat the arbitrary units for blood glucose as exact hormone concentrations, or impose a particular peak height or time that the question does not specify.

c; original allocation: 2 mark(s)

According to the graph, blood glucose rises more gradually and fluctuates less after a low-GI meal. This can reduce the likelihood of excessively high blood glucose and glucose appearing in the urine.

Begin with the actual comparison in the graph: the high-GI curve rises more sharply and has a higher peak, while the low-GI curve changes more gradually. For someone whose blood glucose regulation is impaired, a more gradual entry of glucose into the blood helps reduce an excessively high peak. This explains the mechanism in the question; it does not mean that GI alone determines every aspect of an individual's diet.



Qualitative curves after a high-GI meal; the key features are the delayed response and return to baseline.

Examiner's comment (source page(s) 5)

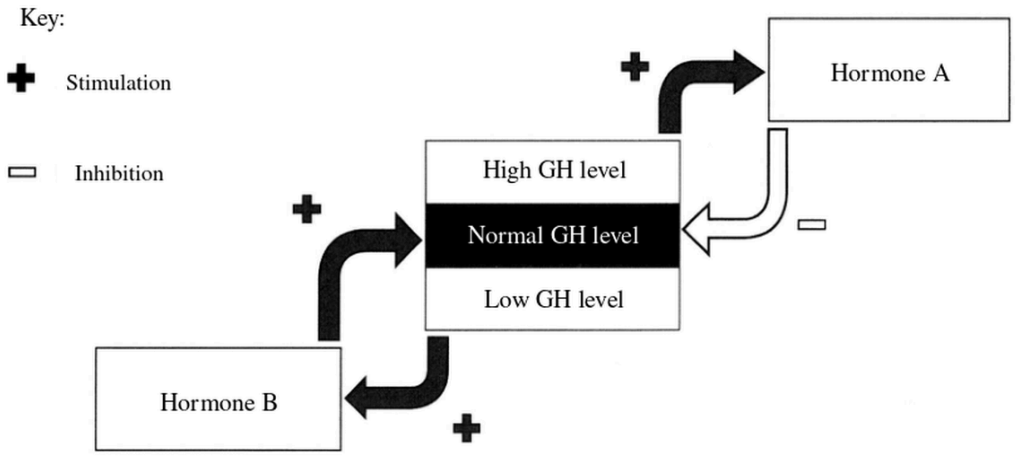
The insulin curve should lag behind the blood glucose stimulus and eventually return to its own starting level. Insulin is a hormone that regulates cellular metabolism, not a substance that directly catalyses the conversion of glucose into glycogen in the blood.

Marking reference: HKDSE Biology 2018 Paper 1B Q7, official marking scheme, source page(s) 3, 4.

Example 3 [HKDSE Biology 2025 Paper 1B Q10 (English translation)]

Human growth hormone (GH), secreted by the pituitary gland in the brain, is known to promote growth mainly in children and adolescents. Insufficient secretion of GH causes dwarfism, whereas excessive secretion causes gigantism (excessive growth and height).

The plasma concentration of GH is controlled by two hormones (A and B) secreted by the hypothalamus. The diagram below shows the relationships between these hormones:



(a) Name this form of homeostatic control. (1 mark)

(b) An 11-year-old girl is referred for medical consultation because she has gigantism. The table below shows the levels of hormones A and B and GH in her plasma:

Hormone	Level in plasma (arbitrary units)	Normal range
A	80	10–22
B	6	5–18
GH	34	0.01–6.2

Based on the diagram above and the levels of these hormones, complete the following table to infer whether her hypothalamus and pituitary gland are functioning normally. (4 marks)

Gland	Functioning normally?	Evidence
Hypothalamus	☐ Yes ☐ No	
Pituitary gland	☐ Yes ☐ No	

Solution (a); original allocation: 1 mark(s)

Negative feedback.

When GH is too high, an inhibitory response is activated; when GH is too low, a stimulatory response is activated. In both cases, the response counteracts the original deviation.

(b): hypothalamus; original allocation: 2 mark(s)

Under the model given in the question, the hypothalamus is functioning normally. GH is 34, far above the normal range of 0.01–6.2. The inhibitory hormone A is 80, also above its normal range of 10–22. This shows that the hypothalamus has responded appropriately to high GH by increasing A.

Judge an organ's function by whether it responds appropriately to its input signal. Here, elevated A is a compensatory response to high GH and is not itself evidence that the hypothalamus has failed.

(b): pituitary gland; original allocation: 2 mark(s)

Under the model given in the question, the pituitary gland is not functioning normally. A is already markedly elevated and should inhibit GH release, but GH remains very high. This shows that the pituitary has not undergone the expected inhibition.

Method: Identify the regulated quantity, then connect stimulus, effect and feedback.

Considering the existing inhibitory signal alongside the persistently high output locates the dysfunction in the controlled organ. Hormone B is 6, still within its normal range of 5–18, so there is no need to invent another abnormality.

Examiner's comment (source page(s) 74)

Answer with the relevant principle, such as negative feedback, when that concept is asked for. The broader term 'endocrine' is not an adequate substitute. Assess the organs using the hormone A data specified in the question.

Marking reference: HKDSE Biology 2025 Paper 1B Q10, official marking scheme, source page(s) 58.

Practice

1. [HKDSE Biology 2013 Paper 1A Q33]
   ⟵ *Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.*

A person has not taken any food for 24 hours. Which of the following will increase in concentration in the blood?

A. glucagon
B. glucose
C. glycogen
D. insulin

2. [HKDSE Biology 2019 Paper 1A Q18]
   ⟵ *Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.*

Which of the following organs serves both endocrine and exocrine functions?

A. pancreas
B. pituitary
C. oesophagus
D. adrenal gland

3. [HKDSE Biology Practice Paper Paper 1A Q24]
   ⟵ *Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.*

Which of the following descriptions about the regulation of the blood glucose level is correct?

A. The chemoreceptor in the liver detects changes in the blood glucose level.
B. The liver secretes more glucagon when the blood glucose level is low.
C. More glycogen is converted to glucose when more glucagon is secreted.
D. More glucose is taken up by cells when more glucagon is secreted.

4. [HKDSE Biology 2019 Paper 1A Q35]
   ⟵ *Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.*

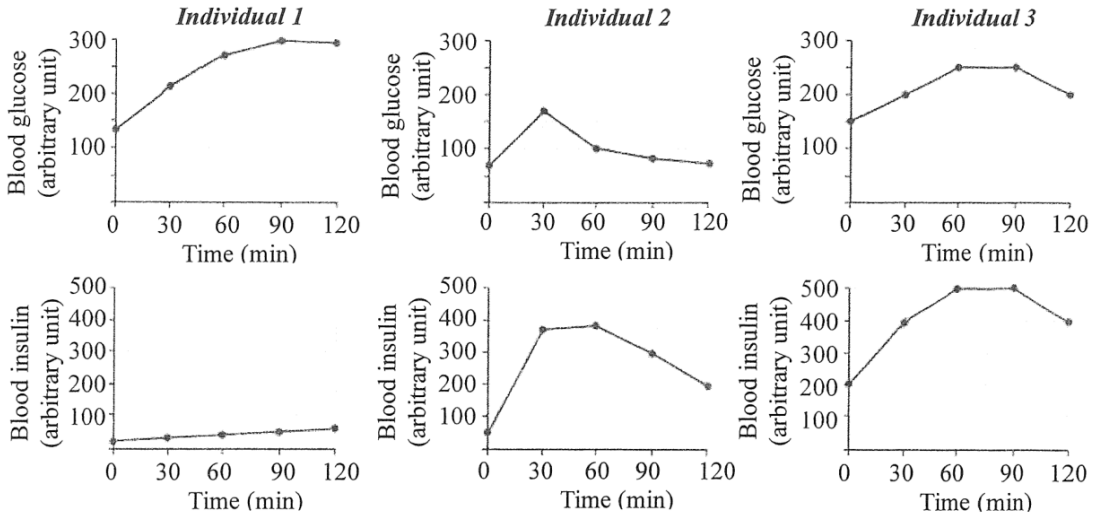
Type II diabetic patients may feel dizzy after prolonged exercise. Which of the following is the most likely explanation for this?

A. Their blood glucose level has dropped to too low a level because they do not have enough stored glycogen to replenish the glucose used.
B. Their blood glucose level has dropped to too low a level because they do not have enough glucagon to stimulate the conversion of glycogen to glucose.
C. Their blood glucose level has risen to too high a level because they keep losing water during exercise.
D. Their blood glucose level has risen to too high a level because they do not have enough insulin to stimulate the conversion of glucose to glycogen.

5. [HKDSE Biology 2020 Paper 1A Q31]

Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.

The graphs below show the changes in blood glucose level and the blood insulin level of three individuals after consuming a sugary drink:



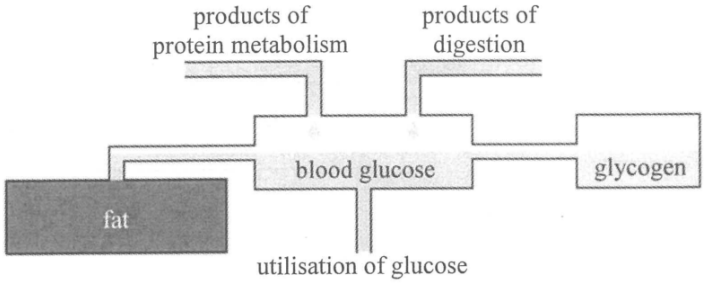
Which of the following combinations correctly shows the health conditions of these three individuals?

	Individual 1	*Individual 2*	*Individual 3*
A.	No diabetes	Type 1 diabetes	Type 2 diabetes
B.	Type 1 diabetes	Type 2 diabetes	No diabetes
C.	Type 2 diabetes	No diabetes	Type 1 diabetes
D.	Type 1 diabetes	No diabetes	Type 2 diabetes

6. [HKDSE Biology 2021 Paper 1A Q26]

Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.

Directions: Questions 26 and 27 refer to the model below, which shows the regulation of blood glucose level in humans:



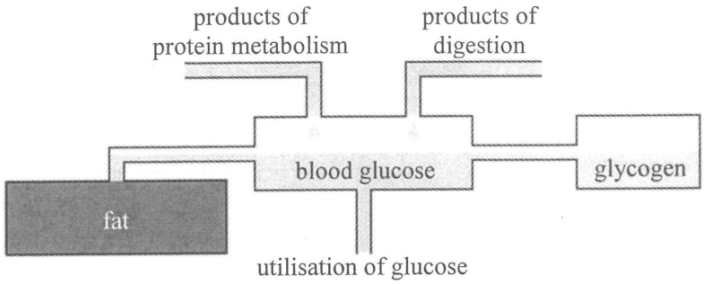
A student adds the following remarks to this model. Which remark is ***incorrect***?

A. Glycogen can be stored in muscles.
B. Insulin converts glucose to glycogen for storage.
C. The products of digestion take the form of simple sugars.
D. The products of protein metabolism come from the liver.

7. [HKDSE Biology 2021 Paper 1A Q27]

Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.

Directions: Questions 26 and 27 refer to the model below, which shows the regulation of blood glucose level in humans:



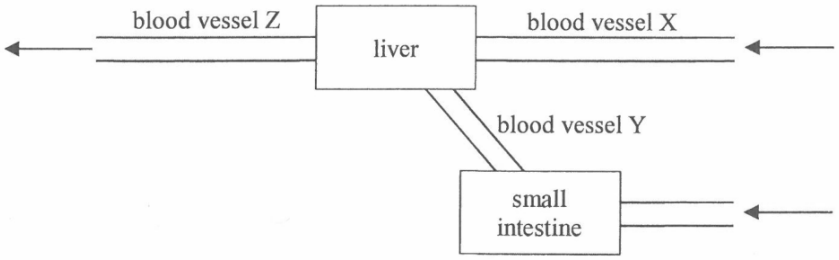
When the blood glucose level is higher than normal, which of the following changes is ***incorrect***?

A. The utilisation of glucose will increase.
B. The conversion of fat to glycogen will increase.
C. The conversion of blood glucose to fat will increase.
D. The conversion of blood glucose to glycogen will increase.

8. [HKDSE Biology 2022 Paper 1A Q21]

Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.

Directions: Questions 21 and 22 refer to the diagram below, which shows part of the human circulatory system and the associated organs:

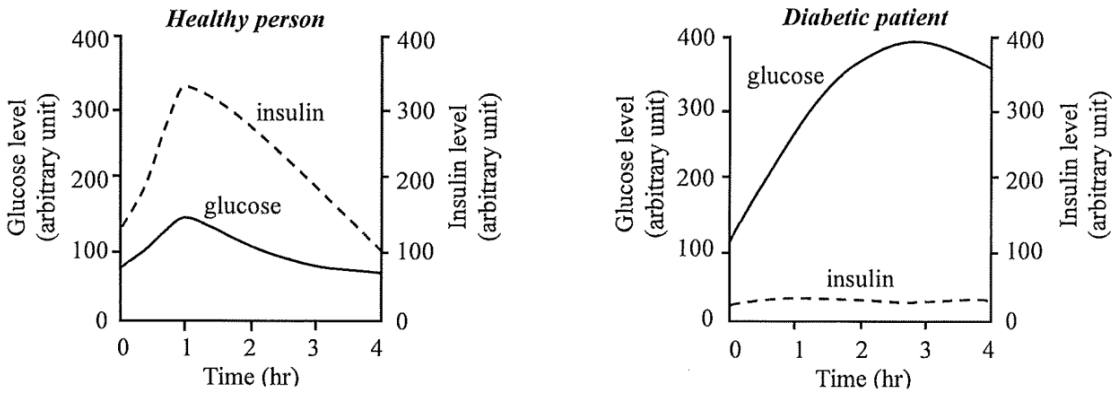


Which of the following correctly compares the blood glucose concentration in blood vessels X, Y and Z when a person is fasting?

A. X > Z > Y
B. Y > X > Z
C. Z > Y > X
D. Z > X > Y

9. [HKDSE Biology 2023 Paper 1A Q32]
Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.

Directions: Questions 32 and 33 refer to the graphs below, which show the changes in the blood glucose levels and blood insulin levels of a healthy person and a diabetic patient after consuming a sugary drink:

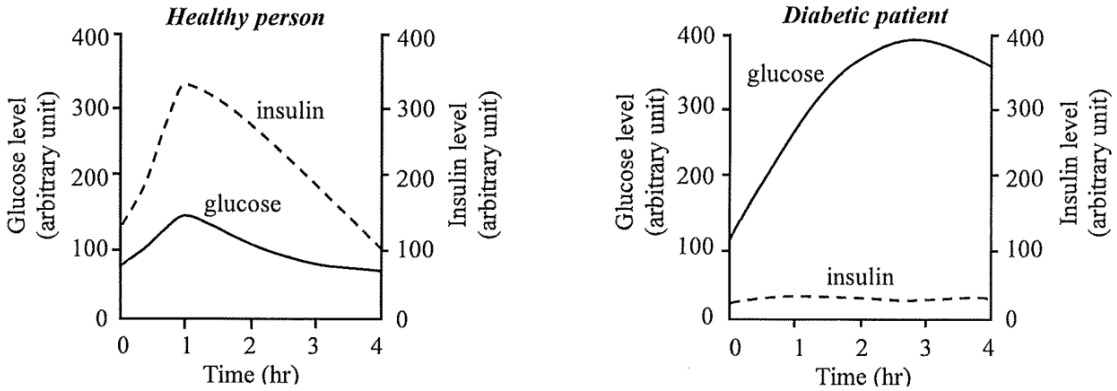


Based on the graphs, which of the following combinations correctly matches the type of diabetes the patient is suffering from and its explanation?

	Diabetes	***Explanation***
A.	type 1	blood glucose level remains high after the patient consumes a sugary drink
B.	type 1	insulin level shows no response to the rise in blood glucose level
C.	type 2	blood glucose level has a sharp rise after the patient consuming a sugary drink
D.	type 2	liver fails to convert glucose to glycogen when blood glucose level is high

10. [HKDSE Biology 2023 Paper 1A Q33]
Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.

Directions: Questions 32 and 33 refer to the graphs below, which show the changes in the blood glucose levels and blood insulin levels of a healthy person and a diabetic patient after consuming a sugary drink:



The blood glucose level of the patient eventually drops because of

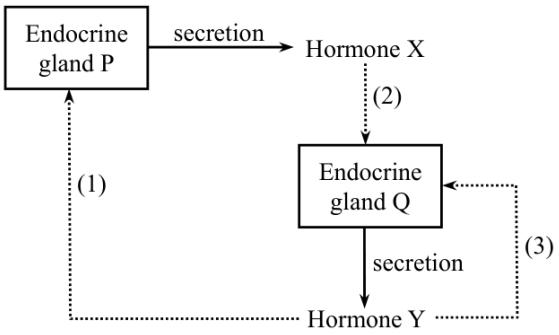
(1) the actions of glucagon.
(2) respiration of body cells.
(3) loss of glucose through urine.

A. (3) only
B. (1) and (2) only
C. (2) and (3) only
D. (1), (2) and (3)

11. [HKDSE Biology Practice Paper Paper 1A Q25]

Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.

The flow chart below shows the interaction between the two endocrine glands and the hormones they secrete:



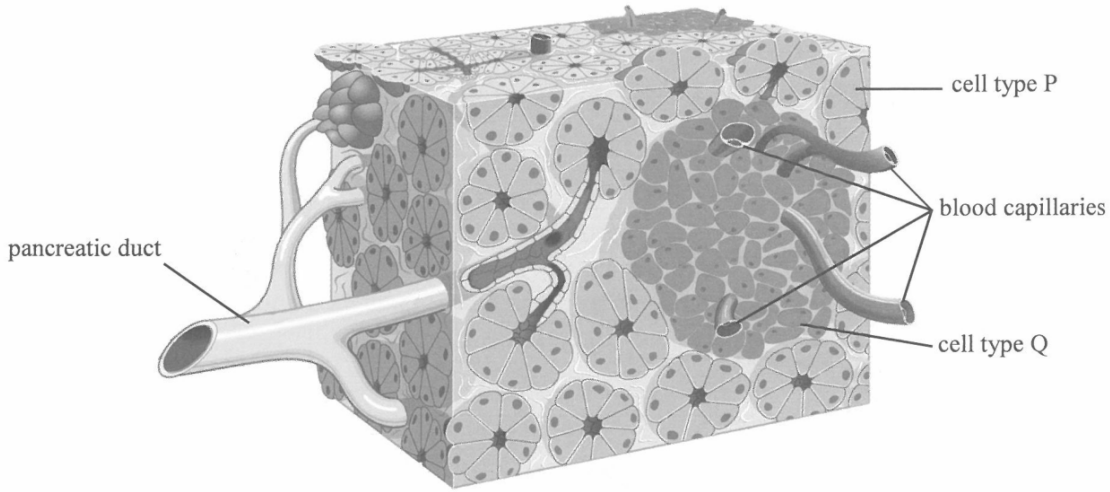
Which of the following combinations correctly shows the regulation of hormone Y by a negative feedback mechanism?

	(1)	*(2)*	*(3)*
A.	inhibition	stimulation	inhibition
B.	inhibition	inhibition	stimulation
C.	stimulation	stimulation	inhibition
D.	stimulation	inhibition	stimulation

12. [HKDSE Biology 2022 Paper 1B Q6]

Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.

The schematic diagram below illustrates the distribution of different cell types in the human pancreas:



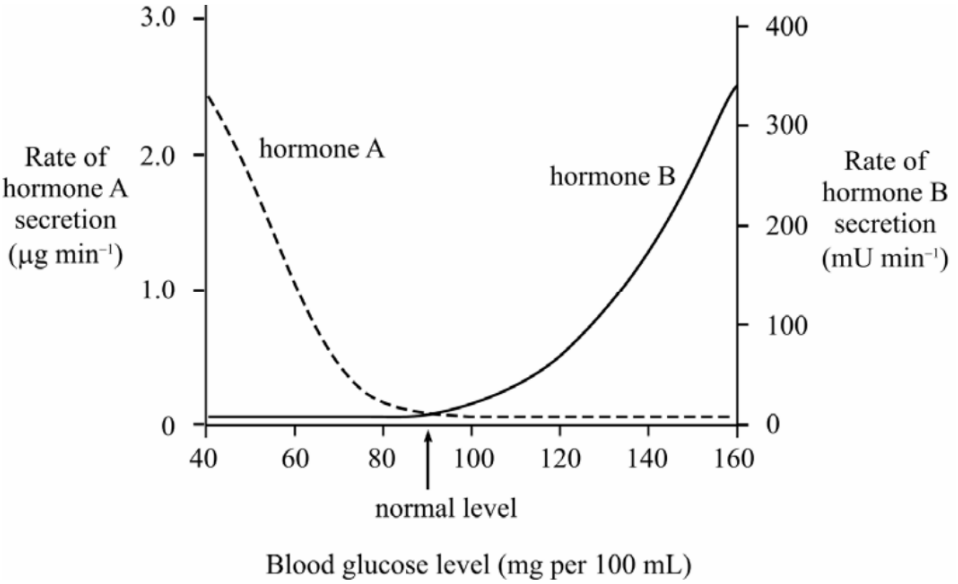
(a) Which type of cells, P or Q, secretes hormones? Support your answer with ***one*** observable feature illustrated in the diagram. (3 marks)

(b) A person jogs slowly for an hour. Describe how the hormones from the pancreas can regulate the blood glucose level of the person while jogging. (4 marks)

13. [HKDSE Biology Sample Paper Paper 1B Q11]

Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.

(a) The graph below shows changes in the rate of secretion of two pancreatic hormones, A and B, at different blood glucose levels in humans:



(i) Which hormone will play an active role in the homeostatic control of blood glucose level when it drops from the normal level to 40 mg per 100 mL? Give evidence from the graph to support your answer. (3 marks)

(ii) Name hormone A and state how this hormone contributes to the homeostatic control of blood glucose level. (3 marks)

(b) John suffers from a certain type of diabetes because his body cells fail to respond to one of the pancreatic hormones. If you were a doctor, give ***two*** pieces of advice to John for controlling the severity of his disease. (2 marks)

14. [HKDSE Biology 2017 Paper 1A Q36]

Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.

Which of the following combinations correctly matches the type of diabetes with its description?

	Type of diabetes	***Description***
A.	Insulin-dependent (type I)	Heredity is the major cause.
B.	Insulin-dependent (type I)	Blood insulin level remains high.
C.	Non-insulin-dependent (type II)	Blood insulin level remains low even after meal.
D.	Non-insulin-dependent (type II)	Blood glucose level will drop significantly after insulin injection.

15. [HKDSE Biology 2015 Paper 1B Q8]
Hint: Identify the regulated quantity, then connect stimulus, effect and feedback.

Tests	Results	Normal range	Units
Blood glucose	8.4	4-6	mmol L^{-1}
Insulin	0.2	3-32	μU mL^{-1}
Glucagon	130	20-100	μg L^{-1}

(a) State the type of diabetes Lisa is suffering from. (1 mark)

(b) With reference to the production and actions of the two hormones, account for the results of Lisa's blood tests.

(i) Insulin (3 marks)

(ii) Glucagon (3 marks)

(c) Suggest *two* dietary habits that Lisa should establish. (2 marks)

III.f Ecosystems

First read the explanations and diagrams in Concept III.f, then work through the question types in this section. Each worked example retains the complete original question and explanation. The subsequent exercises require progressively more integration of information, based on the demands of the whole question.

Type 1 Track carbon and nitrogen through cycle diagrams

Degree of integration ★★★☆☆

Key ideas

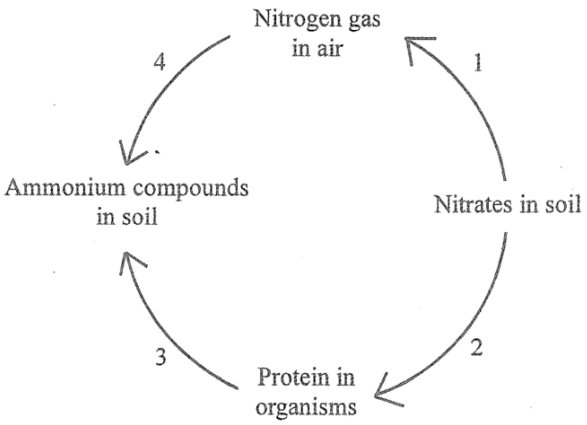
① Carbon moves between carbon dioxide and organic substances: photosynthesis fixes it, while respiration and decomposition return it to the environment. In the nitrogen cycle, fixation introduces atmospheric nitrogen into usable nitrogen-containing substances. Nitrification converts ammonium ions stepwise into nitrate, plants assimilate nitrogen into organic substances, and denitrification can return nitrogen to the atmosphere.

② Pair every process name with its starting substances and products rather than only memorising bacterial names.

How to recognise the problem Read the substances at both ends of each arrow before naming the process and organisms. For percentage tables, check denominators and row–column correspondence.

Example 1 [HKDSE Biology 2015 Paper 1A Q30]

Directions: Questions 30 and 31 refer to the diagram below, which shows the conversion of some nitrogen-containing substances in nature:



Process 3 is

A. nitrification.
B. denitrification.
C. decomposition.
D. nitrogen fixation.

Solution Answer: C

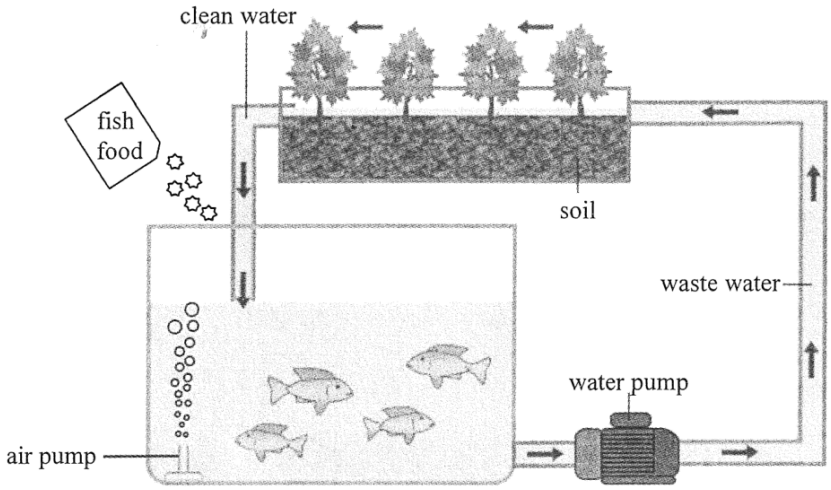
Process 3 points from proteins in organisms to ammonium compounds in the soil. It represents decomposers breaking down organic nitrogen-containing substances and releasing ammonium. Identify the process by first reading the two ends of the arrow, not merely by its position in the cycle. Choose C.

Method: Read the substances at both ends of the arrow, then name the conversion.

Marking reference: HKDSE Biology 2015 Paper 1A Q30, official marking scheme, source page(s) 1.

Example 2 [HKDSE Biology 2020 Paper 1B Q6]

The diagram below shows a mini-ecosystem in which waste water from a fish tank is used as a source of nutrients for plant growth by making use of the interaction among fish, microorganisms and plants. Adding fertilisers and periodic change of water are not necessary. This is an eco-friendly way to grow vegetables and raise fish for human consumption.



(a) Ammonia, a toxic substance, is the major waste product excreted by fish. Ammonia in waste water from the fish tank can be converted to nitrate, which is required by plants for growth.

(i) Name the bacteria involved in the conversion. (1 mark)

(ii) Describe how plants can obtain nitrate from waste water and make use of it for protein synthesis in their leaves. (3 marks)

(b) The air pump performs some important functions in this system. Describe these functions. (2 marks)

(1) .....

(2) .....

(c) If double the amount of fish food is added accidentally, some fish will die a few days later. Based on your knowledge of the cycling of materials, suggest an explanation for this phenomenon. (4 marks)

Solution a(i); original allocation: 1 mark(s)

Nitrifying bacteria.

The conversion described is from ammonia to nitrate: nitrification. Nitrogen-fixing bacteria convert nitrogen gas into usable nitrogen-containing substances, whereas denitrifying bacteria convert nitrate towards nitrogen gas. The three processes have different starting and ending substances. Do not interchange their names merely because all belong to the nitrogen cycle.

Method: Read the substances at both ends of the arrow, then name the conversion.

a(ii); original allocation: 3 mark(s)

Roots absorb nitrate and deliver it into the xylem. Nitrate travels upwards in the transpiration stream to the leaves. Its nitrogen is combined with carbon skeletons derived from photosynthesis to synthesise amino acids and then proteins.

Begin with nitrate entering the plant from the wastewater; do not repeat the bacterial conversion in the preceding subpart. Diffusion can occur when the concentration conditions inside and outside the root allow it. If uptake must occur against the concentration gradient, root cells obtain nitrate by active transport. The xylem then provides long-distance upward transport, with the pulling force on the water column linked to leaf transpiration. Finally, nitrate supplies nitrogen and photosynthesis supplies the organic carbon source, allowing

leaf cells to make amino acids and proteins. Nitrate does not turn into a complete protein on its own. Nor do plants convert nitrate into nitrogen gas to synthesise proteins.

b; original allocation: 2 mark(s)

The air pump supplies oxygen for aerobic respiration in fish, plant roots and other organisms. It also supplies oxygen for nitrification by nitrifying bacteria.

The first role maintains the organisms' own energy supply; the second maintains the conversion of ammonia into nitrate in the material cycle. These are different functions. An answer may also refer to decomposers requiring oxygen to break down organic waste. However, supplying oxygen to one fish and supplying it to another fish do not count as two different functions.

c; original allocation: 4 mark(s)

Excess fish food causes fish to ingest more nitrogen-containing substances and excrete more ammonia. Nitrifying bacteria cannot convert all the ammonia into nitrate quickly enough, so ammonia accumulates in the water, reaches toxic levels and kills the fish.

This explanation uses the question's stated conditions that ammonia is toxic and that materials are recycled. Increasing input does not automatically double nitrification capacity immediately. Even with continuous water circulation, ammonia production can exceed its removal. Another complete explanation is: more uneaten food → decomposers break down organic nitrogen-containing substances and release ammonia → ammonia accumulates → fish are poisoned. If using the uneaten-food explanation, include decomposition. Do not state that uneaten food directly becomes nitrate, or discuss only oxygen depletion due to eutrophication while ignoring the ammonia central to this question.

Marking reference: HKDSE Biology 2020 Paper 1B Q6, official marking scheme, source page(s) 5.

Example 3 [HKDSE Biology 2018 Paper 1B Q11]

For the following question, candidates are required to present their answer in essay form. Criteria for marking will include relevant content, logical presentation and clarity of expression.

Sharon was told that she might be breathing out carbon dioxide containing carbon which was once a part of the body of a dinosaur, buried underground for millions of years. Use your biological knowledge to describe the journey of the carbon. The journey should include how it is possible for the carbon derived from a dinosaur buried underground to go through millions of years and appear in the form of carbon dioxide in Sharon's breath. (11 marks)

Solution Reading the question and choosing a method

Track the same carbon atom at every step, identifying the substance containing it, its location and the process that transfers it.

Method: Read the substances at both ends of the arrow, then name the conversion.

Essay; original allocation: 11 mark(s)

The carbon atom was once part of organic matter in a dinosaur's remains. As the remains decomposed, microorganisms used this organic matter and could release its carbon as carbon dioxide during respiration. Once the carbon dioxide containing this atom entered the atmosphere, plants could absorb it and fix it into organic substances such as carbohydrates through photosynthesis. When an animal ate a plant, the carbon atom could enter the animal along a food chain. Respiration by plants, animals or decomposers could release it again as carbon dioxide. Over long periods, the same carbon atom could move repeatedly between the atmosphere, organisms and other carbon stores. There is no need to assume that the same carbon dioxide molecule remained intact for millions of years. Later, the carbon atom became incorporated into food eaten by Siu Ling. The relevant organic substances in the food were digested into small, absorbable molecules and then absorbed into the body through the small intestine. Carbon-containing nutrients were carried by the circulatory system to tissues, taken up by cells and used in respiration. Their carbon formed carbon dioxide during these reactions. This carbon dioxide entered the blood from the tissues and was transported by the circulation to the lungs. It then diffused from the blood into the alveoli and finally left the body during exhalation. Thus, the carbon in a carbon dioxide molecule exhaled by Siu Ling could once have been part of the material in a dinosaur's body. The first paragraph explains how carbon leaves the remains; the second connects this to cycling in ecosystems; the third explains how food enters the human body; and the fourth explains how cells produce carbon dioxide and how it is excreted. These paragraphs form one continuous journey, rather than four disconnected definitions. Atoms can be conserved through chemical reactions, while molecules change. Do not state that carbon becomes energy, or that respiration occurs only in the lungs. The lungs carry out gas exchange; cellular respiration is an important process producing carbon dioxide from nutrients. The question asks for a possible pathway. It does not require proof that a particular exhaled carbon atom actually came from a dinosaur. Nor should all fossil fuels be described as having formed from dinosaur remains. The marking reference allocates content marks as follows: carbon leaving dinosaur remains, up to 1 mark; the carbon cycle before entry into Siu Ling, up to 3 marks; entry into Siu Ling's body, up to 2 marks; and transport and excretion within the body, up to 2 marks. There are a further 3 marks for expression and organisation. This is the allocation for the whole essay; the same sentence should not be credited repeatedly.

Examiner's comment (source page(s) 7, 12)

Organise the whole essay around the journey of the same carbon atom. Plants obtain the carbon needed to synthesise organic substances mainly from carbon dioxide. Describing roots as absorbing carbon salts from the soil, or omitting digestion, transport, respiration and excretion in the human body, breaks the pathway.

Marking reference: HKDSE Biology 2018 Paper 1B Q11, official marking scheme, source page(s) 5.

Practice

1. [HKDSE Biology 2014 Paper 1A Q33]

Hint: Read the substances at both ends of the arrow, then name the conversion.

Which of the following processes releases nitrogen-containing compounds from organisms back into the environment?

A. Nitrification
B. Decomposition
C. Denitrification
D. Nitrogen fixation

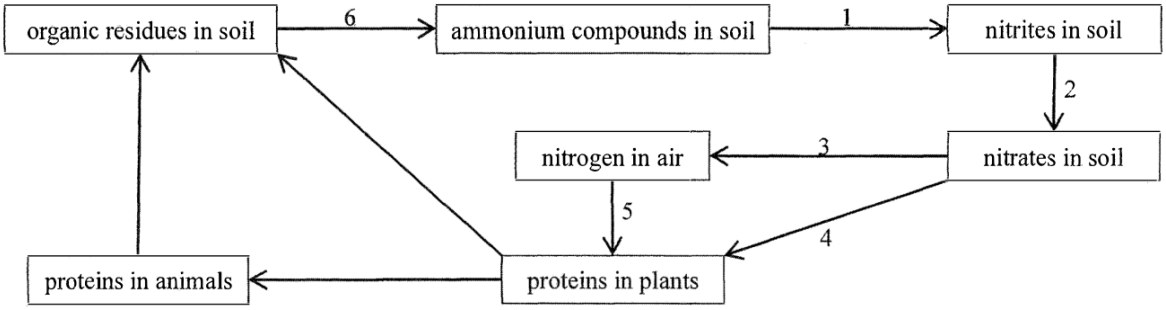
2. [HKDSE Biology 2016 Paper 1A Q34]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Symbiotic bacteria found in the root nodules of bean plants are able to convert

A. nitrite ions to nitrate ions.
B. nitrogen gas to nitrate ions.
C. organic nitrogenous compounds to nitrate ions.
D. nitrogen gas to ammonium ions.

3. [HKDSE Biology 2017 Paper 1A Q33]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 32 and 33 refer to the diagram below, which shows some processes in the nitrogen cycle in nature:

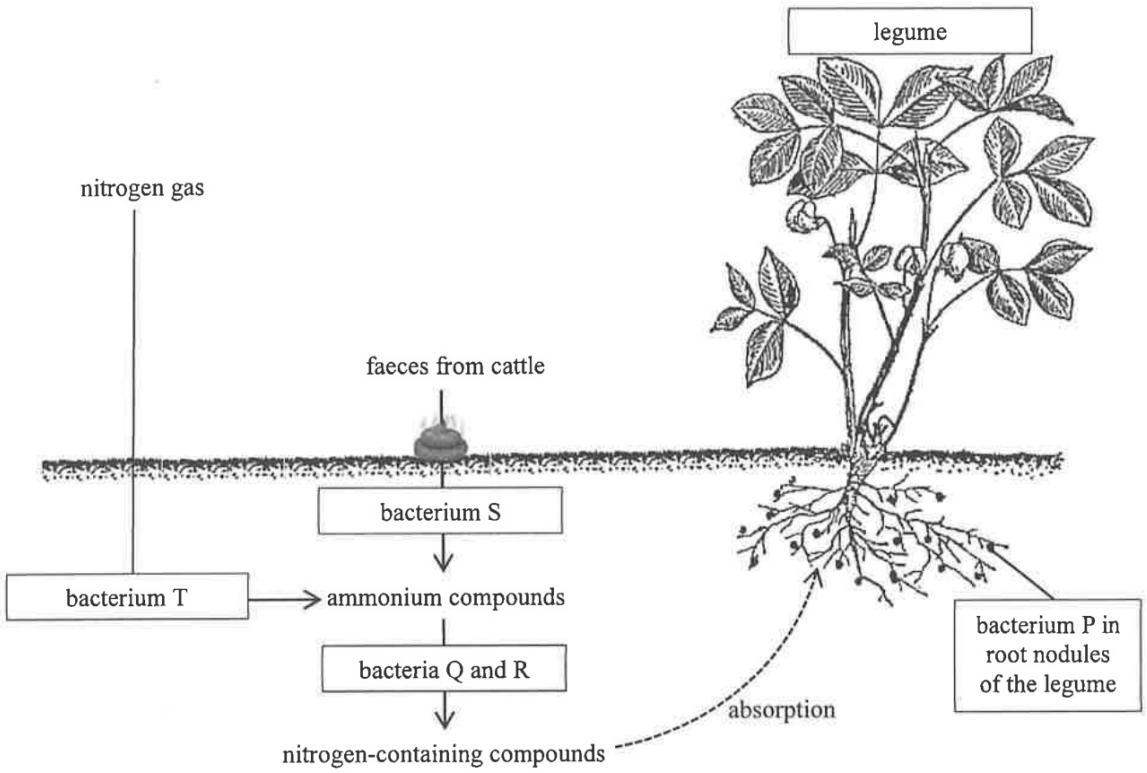


Which of the following processes ***does not*** require the action of bacteria?

A. 1
B. 2
C. 4
D. 5

4. [HKDSE Biology 2019 Paper 1A Q34]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 33 and 34 refer to the diagram below, which shows some processes of the nitrogen cycle:

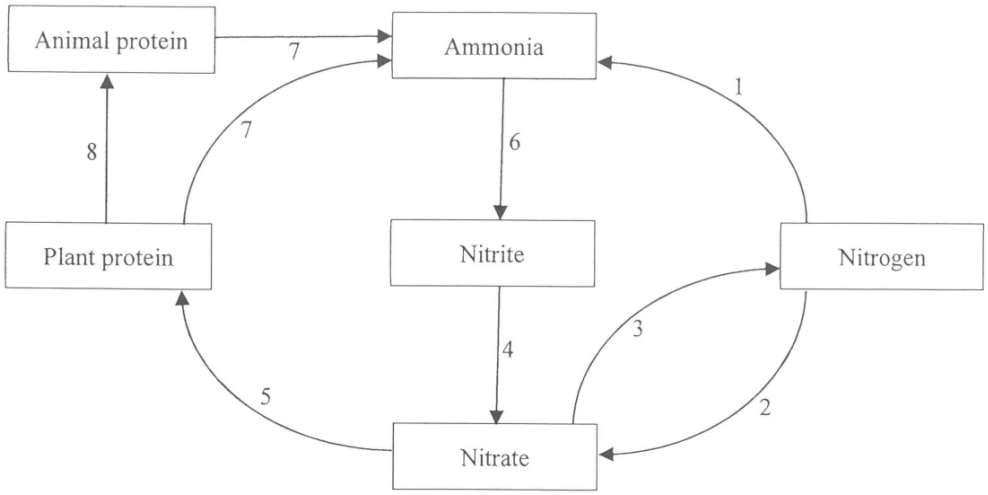


Which of the following bacteria has a similar role to fungi in the cycling of materials?

A. Q
B. R
C. S
D. T

5. [HKDSE Biology 2021 Paper 1A Q35]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 35 and 36 refers to the diagram below, which shows some natural processes involved in the nitrogen cycle:



Process 2 refers to

A. lightning.
B. nitrification.
C. denitrification.
D. nitrogen fixation.

6. [HKDSE Biology 2022 Paper 1A Q8]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Decomposers can speed up the process of ecological succession because they

A. break down rocks into soil particles.
B. remove dead organic matter from the soil.
C. release carbon back into the atmosphere in the form of carbon dioxide.
D. release nitrogen back into the soil in the form of ammonium compounds.

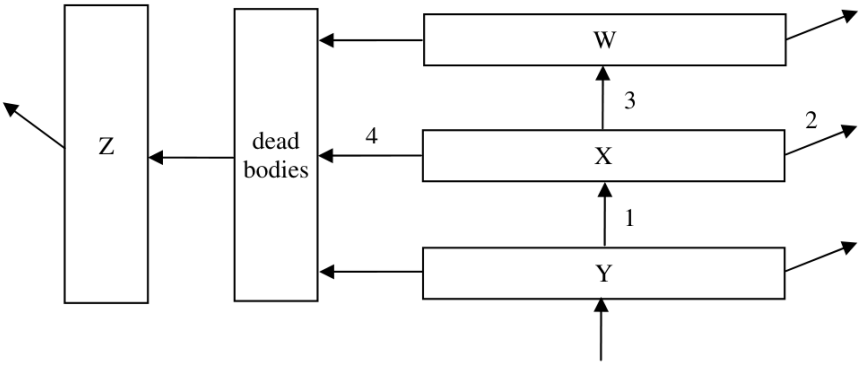
7. [HKDSE Biology 2023 Paper 1A Q21]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Kitchen wastes can be converted to fertilisers. Which of the following processes are essential for this conversion?

A. nitrification and decomposition
B. nitrification and nitrogen fixation
C. denitrification and decomposition
D. denitrification and nitrogen fixation

8. [HKDSE Biology Sample Paper Paper 1A Q25]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 25 to 27 refer to the diagram below, which shows the flow of energy in an ecosystem. W, X and Y represent different trophic levels and Z represents another group of organisms in the ecosystem.



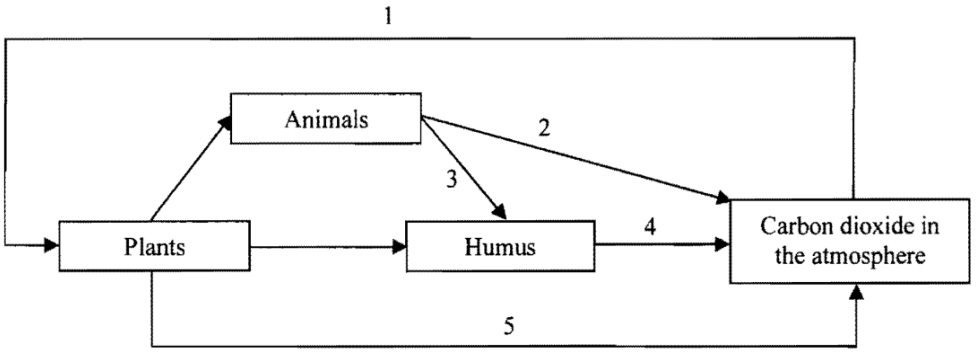
Key: ⟶ direction of energy flow

Organisms Z are

A. predators.
B. pathogens.
C. parasites.
D. decomposers.

9. [HKDSE Biology 2012 Paper 1A Q16]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 16 and 17 refer to the following diagram, which shows the flow of carbon in an ecosystem:

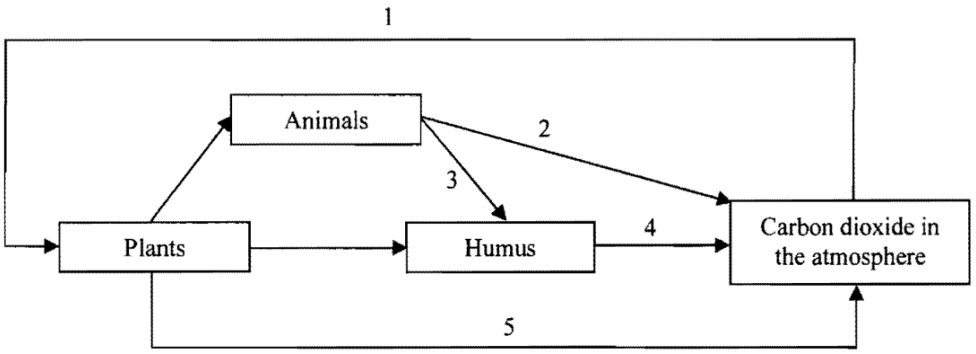


Which of the following combinations correctly shows the processes indicated by labels 1, 4 and 5?

	1	*4*	*5*
A.	respiration	photosynthesis	decomposition
B.	photosynthesis	respiration	decomposition
C.	photosynthesis	decomposition	respiration
D.	decomposition	photosynthesis	respiration

10. [HKDSE Biology 2012 Paper 1A Q17]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 16 and 17 refer to the following diagram, which shows the flow of carbon in an ecosystem:

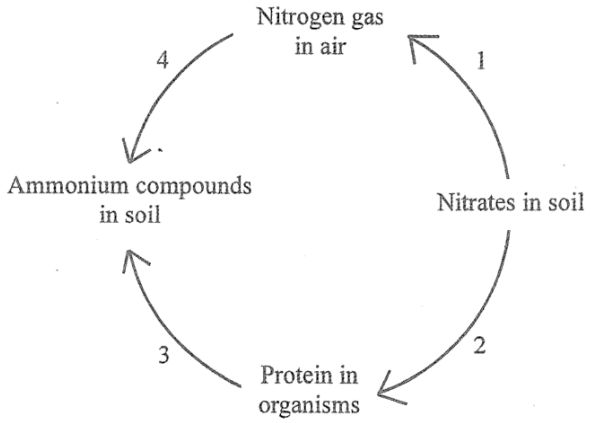


Saprophytes are involved in process

A. 1.
B. 2.
C. 3.
D. 5.

11. [HKDSE Biology 2015 Paper 1A Q31]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 30 and 31 refer to the diagram below, which shows the conversion of some nitrogen-containing substances in nature:



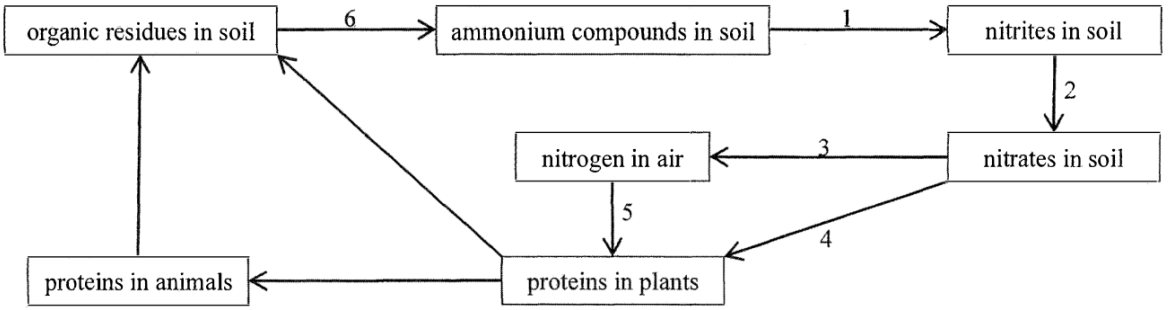
Which of the following processes does ***not*** require the action of bacteria?

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

12. [HKDSE Biology 2017 Paper 1A Q32]

Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 32 and 33 refer to the diagram below, which shows some processes in the nitrogen cycle in nature:



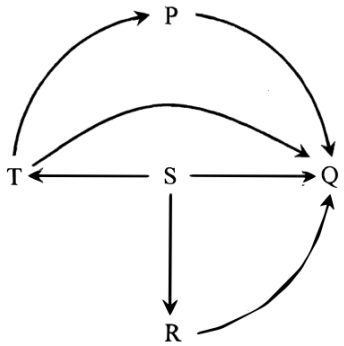
Which of the following combinations correctly matches the microorganism involved in processes 3 and 6?

	3	***6***
A.	denitrifying bacteria	nitrogen-fixing bacteria
B.	nitrogen-fixing bacteria	fungi
C.	fungi	denitrifying bacteria
D.	denitrifying bacteria	fungi

13. [HKDSE Biology 2017 Paper 1A Q35]

Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 34 and 35 refer to the diagram below, which shows the flow of energy among organisms found in a grassland:

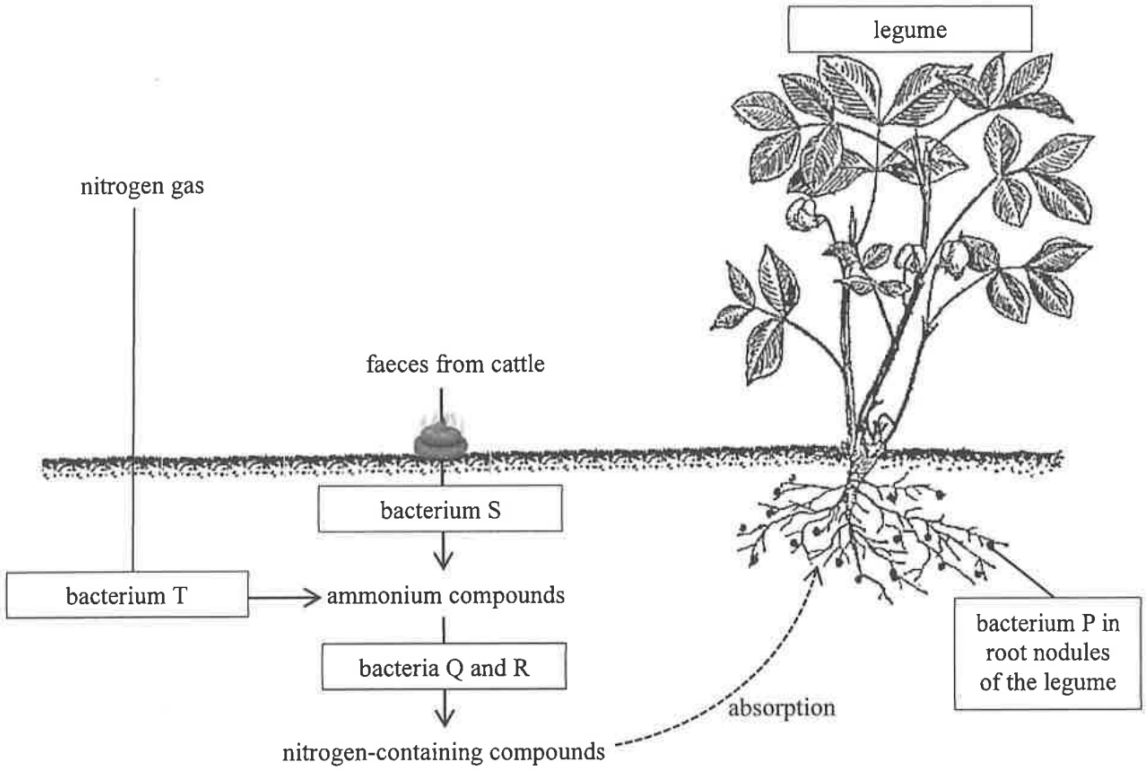


If there is a decomposer in this group of organisms, it is most likely to be

A. Q.
B. R.
C. S.
D. T.

14. [HKDSE Biology 2019 Paper 1A Q33]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 33 and 34 refer to the diagram below, which shows some processes of the nitrogen cycle:

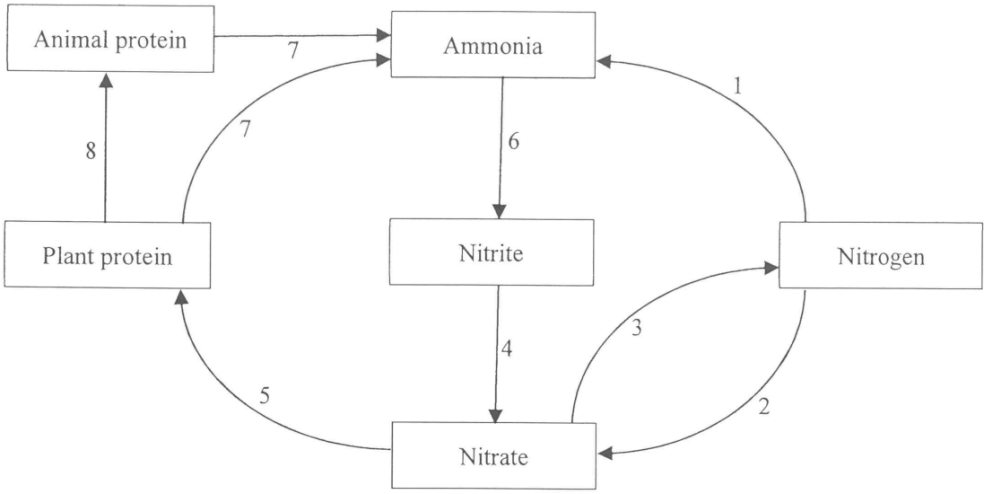


Which of the following statements about the bacteria shown in the diagram is correct?

A. P belongs to parasitic bacteria.
B. Q belongs to nitrifying bacteria.
C. R belongs to nitrogen-fixing bacteria.
D. S belongs to denitrifying bacteria.

15. [HKDSE Biology 2021 Paper 1A Q36]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 35 and 36 refers to the diagram below, which shows some natural processes involved in the nitrogen cycle:



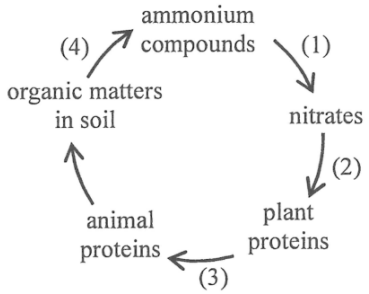
Which of the following pairs of processes involves the action of bacteria?

A. 1 and 5
B. 2 and 6
C. 3 and 7
D. 4 and 8

END OF SECTION A
Go on to Question-Answer Book B for questions on Section B

16. [HKDSE Biology 2024 Paper 1A Q32]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 32 and 33 refer to the diagram below, which shows the conversion of some nitrogenous compounds in nature:

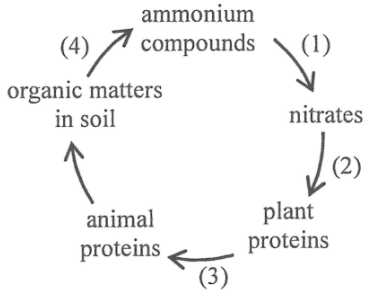


Which of the following statements about the conversions is correct?

A. Process (1) involves nitrogen fixing bacteria.
B. Process (2) is anabolic in nature.
C. Process (3) is catabolic in nature.
D. Process (4) involves denitrifying bacteria.

17. [HKDSE Biology 2024 Paper 1A Q33]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Directions: Questions 32 and 33 refer to the diagram below, which shows the conversion of some nitrogenous compounds in nature:

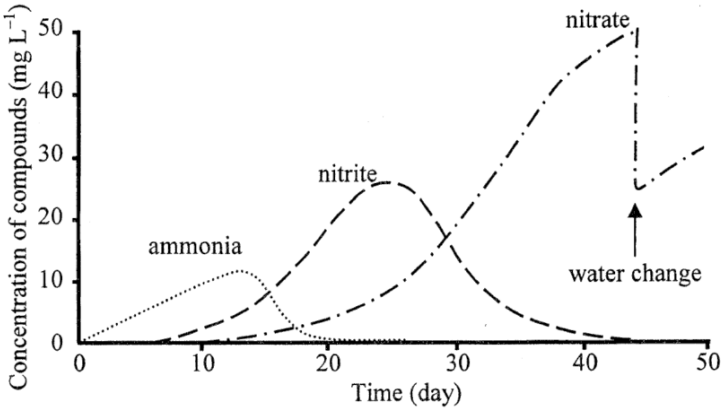


Which of the following process(es) involve(s) assimilation?

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

18. [HKDSE Biology 2013 Paper 1B Q5]
Hint: Read the substances at both ends of the arrow, then name the conversion.

Knowing that the nitrogen cycle is important to the healthy growth of fish, Tom purchased testing kits to monitor the levels of ammonia, nitrite and nitrate in his aquarium. He kept the aquarium aerated with an air pump. The graph below shows the changes in the concentrations of the three compounds over 50 days:



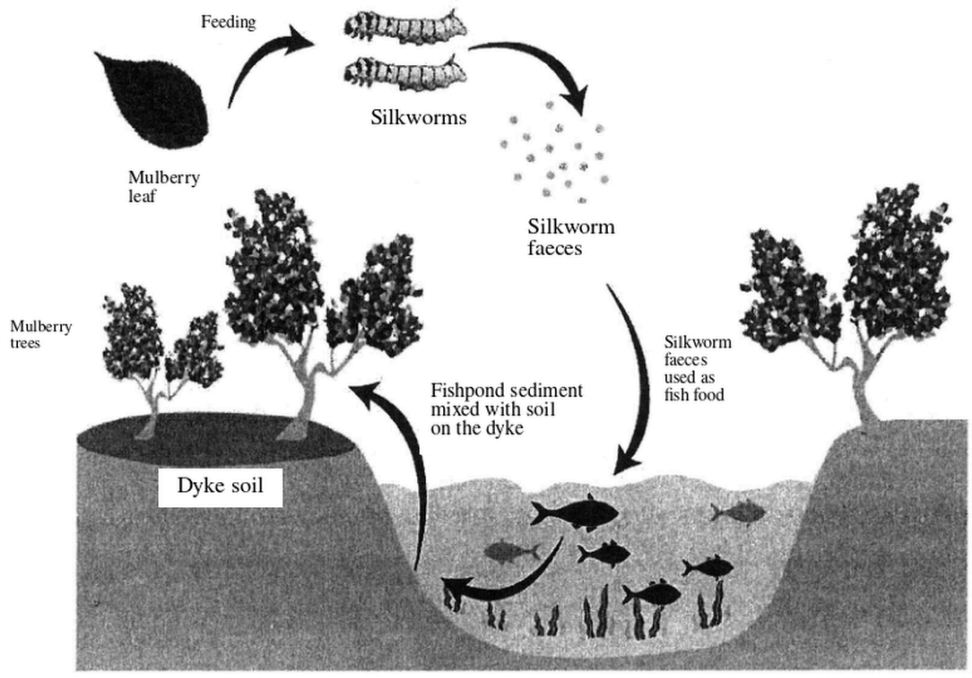
(a) Name the process that led to the changes shown in the graph. (1 mark)

(b) After three weeks, Tom observed a high concentration of nitrite in the water and the fish were showing symptoms of nitrite poisoning. Therefore, Tom added a suspension of a bacterial culture to the water to lower the nitrite concentration. Suggest the type of bacteria he added and explain how it lowered the nitrite concentration. (2 marks)

(c) To prevent the accumulation of nitrate, Tom regularly replaced some water in the aquarium with fresh water. What else could Tom do to lower the nitrate concentration? (2 marks)

19. [HKDSE Biology 2025 Paper 1B Q9 (English translation)]
Hint: Read the substances at both ends of the arrow, then name the conversion.

The mulberry-dyke–fishpond system in Huzhou, Zhejiang, has a history of 2,500 years. In 2017, it was officially recognised as a Globally Important Agricultural Heritage System by the Food and Agriculture Organization of the United Nations. The diagram below shows how the system operates:



This system is self-sustaining. The silk obtained from silkworms provides substantial economic returns with zero pollution to the environment.

The nitrogen cycle is important in this system. The table below shows the chemical composition of fishpond sediment, the original soil on the dyke, and the soil on the dyke one year after mixing with fishpond sediment:

Sample	Total nitrogen (mg kg^{-1})	Total organic nitrogen (mg kg^{-1})	Ammonium compounds (mg kg^{-1})	Nitrate compounds (mg kg^{-1})
Fishpond sediment	3500	3395	37.2	2.1
Original soil on the dyke	2800	2460	14.8	2.8
Soil on the dyke one year after mixing with fishpond sediment	3000	2200	325.0	431.1

(a) (i) Compare the percentages of total nitrogen present as organic nitrogen in the fishpond sediment and the original soil on the dyke. Show your calculations. (2 marks)

(ii) With reference to the nitrogen cycle, suggest an explanation for the difference in (i). (3 marks)

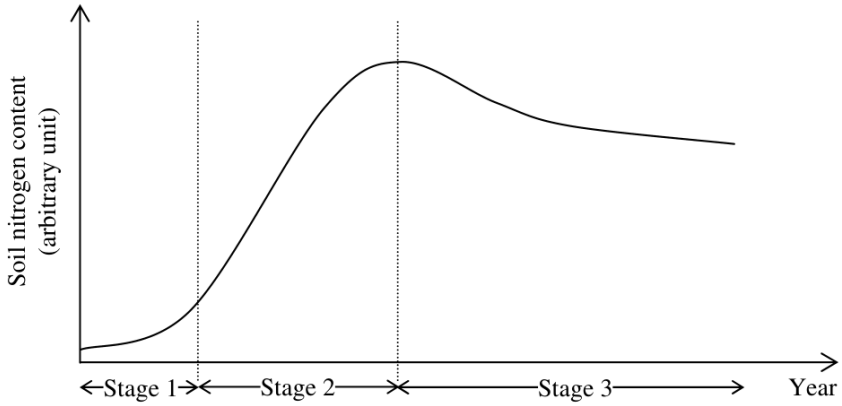
(b) With reference to the data, suggest why mixing fishpond sediment with the soil on the dyke is beneficial for growing mulberry trees. (2 marks)

(c) Describe how ammonium compounds and nitrate compounds in the soil on the dyke are converted into silk by silkworms. (4 marks)

20. [HKDSE Biology Practice Paper Paper 1B Q8]

Hint: Read the substances at both ends of the arrow, then name the conversion.

Graph 1 shows the change in the soil nitrogen content in an area over 200 years. At the beginning of Stage 1, the area was without vegetation. Table 1 shows the relative abundance of three plant species found in this area at the different stages:



Graph 1

Plant species	Relative abundance of the plant species at the end of each stage (%)		
	Stage 1	Stage 2	Stage 3
A	95	10	5
B	5	85	20
C	0	5	65

Table 1

(a) With reference to Table 1, state the process that accounts for the change in the relative abundance of the plant species in this area. (1 mark)

(b) (i) The bacteria living symbiotically with plant species A and species B played an important role in causing the increase in the soil nitrogen content in Stages 1 and 2.

(1) Name the symbiotic bacteria living in plant species A and B. (1 mark)

(2) Describe how the symbiotic bacteria and the two plant species caused the increase in the soil nitrogen content in Stages 1 and 2. (3 marks)

(ii) Species C was absent in Stage 1 but became the dominant species in Stage 3. Explain the change in its relative abundance from Stage 1 to Stage 3. (3 marks)

Type 2 Analyse energy transfer using food webs and pyramids

Degree of integration ★★★☆☆

Key ideas

① Food-web arrows usually point from food to consumer, indicating transfer of matter and energy. Each trophic level uses energy in respiration, while some material is not eaten or digested by the next level, leaving less energy available to it.

② Numbers, standing biomass and energy flow over a period are different measures. Aquatic producers can turn over rapidly and support consumers despite having a smaller standing biomass.

③ For dietary carbon-footprint comparisons, first draw plant → human and plant → livestock → human.

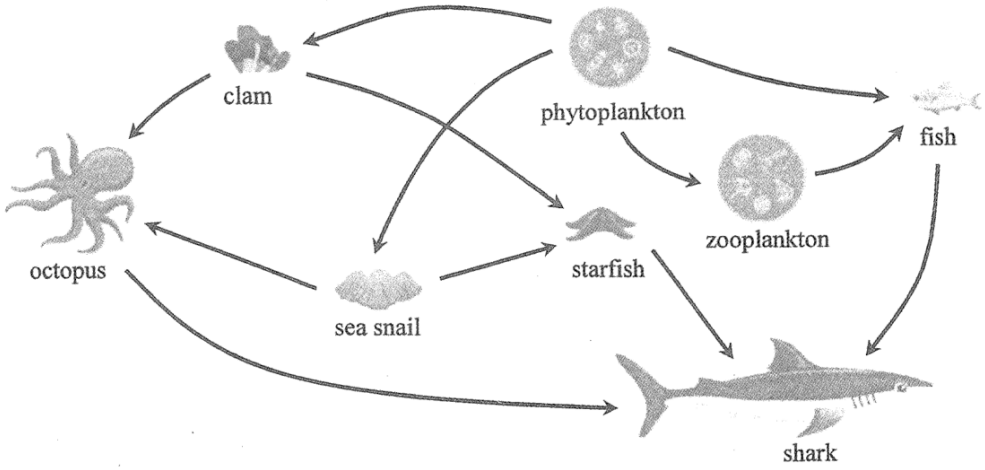
④ An additional trophic level adds emissions from respiration during rearing and waste decomposition. Lower energy-transfer efficiency also increases feed requirements. Microorganisms in ruminant digestive tracts can produce methane. A carbon footprint includes direct and indirect greenhouse-gas emissions. Do not claim that plants do not respire or that food cultivation and transport cause no emissions.

⑤ For personal emission-reduction actions, connect transport or electricity use to fuel combustion and carbon dioxide emissions.

How to recognise the problem Check whether a pyramid measures numbers, mass or energy. For diets, draw the food chains and link life processes at each additional trophic level to energy losses and carbon emissions.

Example 1 [HKDSE Biology 2015 Paper 1B Q3]

The diagram below shows the feeding relationships among some organisms in a marine ecosystem:



(a) Write down the shortest food chain found in the diagram. (1 mark)

(b) In the space provided below, draw the pyramid of numbers for the food chain in (a). (2 marks)

(c) Explain the shape of the pyramid of numbers drawn in (b). (3 marks)

(d) Suggest *two* practical methods that allow you to confirm the feeding relationships among various organisms in this ecosystem. (2 marks)

Solution (a); original allocation: 1 mark(s)

Phytoplankton → fish → shark.

Arrows point from the organism eaten to its consumer, showing the transfer of matter and energy through feeding. Following the arrows from phytoplankton to fish and then to shark requires only two transfers and is the shortest route shown.

Method: Identify trophic levels and the measured quantity, then trace energy destinations.

(b); original allocation: 2 mark(s)

Label the levels from bottom to top as phytoplankton, fish and shark. Make the bars progressively narrower upwards.

The width of each level in a pyramid of numbers represents the number of individuals at that trophic level. Place the producers at the bottom and clearly label each of the three levels with the corresponding organism. Do not draw three unlabelled rectangles.

(c); original allocation: 3 mark(s)

Energy is lost as it passes from a lower to a higher trophic level. Individuals at the lower levels of this food chain are also smaller, so a larger number of lower-level individuals is needed to support a smaller number of higher-level individuals.

Phytoplankton are small, and a fish must consume many individuals from a lower trophic level. The fish also uses some energy in respiration and other activities, so it cannot provide all the energy to the shark. Both energy transfer losses and the individual sizes in this chain are needed to explain why its pyramid of numbers becomes narrower upwards.

(d); original allocation: 2 mark(s)

Observe in the field which organisms prey on which others. Examine the contents of predators' alimentary canals to identify their prey.

Both methods seek direct feeding evidence: the first records behaviour, and the second records food already ingested. Give two different feasible methods. Merely observing two species together does not establish a predator–prey relationship.

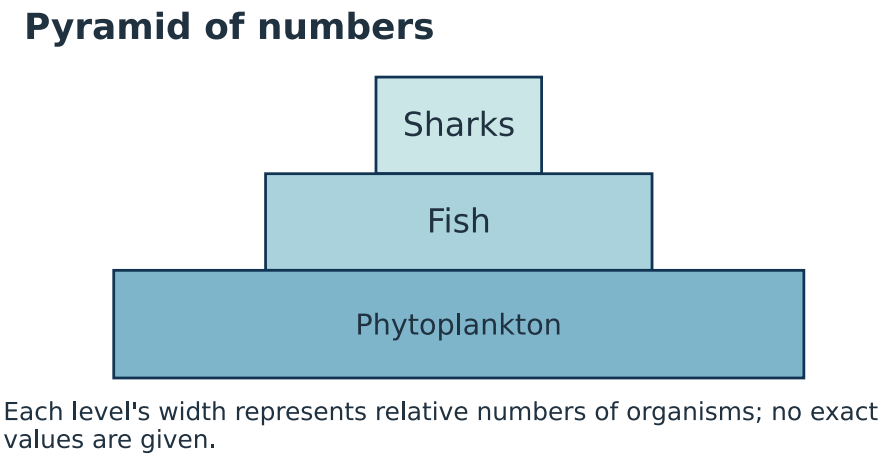


Diagram answer corresponding to the original question

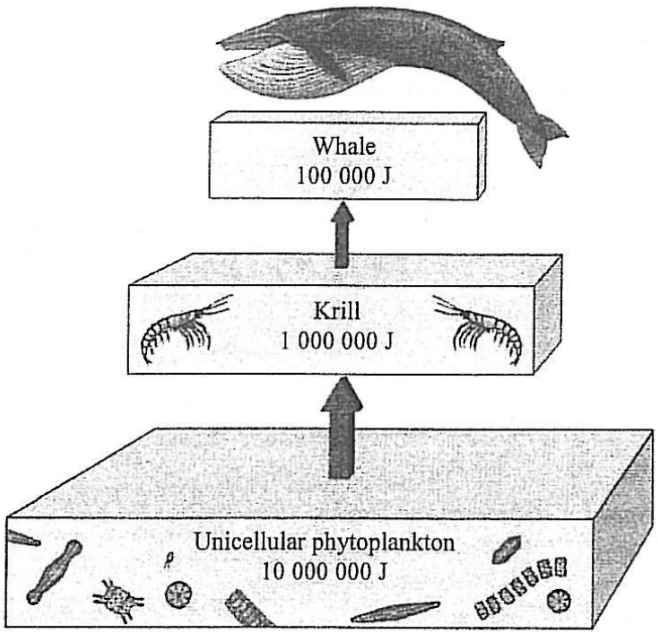
Examiner's comment (source page(s) 3)

Label the trophic levels in a pyramid of numbers. Link energy loss to less energy being available to the next trophic level. This question also requires consideration of the larger size of individual predators. Investigating feeding relationships requires evidence of what is eaten; simply counting species is insufficient to establish a food chain.

Marking reference: HKDSE Biology 2015 Paper 1B Q3, official marking scheme, source page(s) 2.

Example 2 [HKDSE Biology 2012 Paper 1B Q6]

The diagram below shows a food chain in an ocean. The energy content of each trophic level is shown in the boxes:



(a) In the space below, calculate the percentage decrease in energy content from unicellular phytoplankton to krill. (2 marks)

(b) Give *two* reasons why there is a decrease in energy content from a lower trophic level to a higher one. (2 marks)

(c) In another food chain, the producer is tree and the primary consumer is caterpillar. Would the percentage decrease in energy content be greater or smaller than the value found in (a)? Explain your answer. (2 marks)

Solution a; original allocation: 2 mark(s)

Percentage energy loss = (10 000 000 − 1 000 000) ÷ 10 000 000 × 100% = 90%.

The denominator is the energy in the starting trophic level, phytoplankton, not the energy in krill. First calculate the loss of 9 000 000 J, then divide by the original 10 000 000 J. The calculation and correct percentage each earn 1 mark.

Method: Identify trophic levels and the measured quantity, then trace energy destinations.

b; original allocation: 2 mark(s)

Some phytoplankton are not eaten by krill, or are eaten but not digested and are egested in faeces. Energy is also lost as heat during respiration.

The question asks for two routes by which energy fails to reach the next level. Failure to be consumed / assimilated is one category; energy used in metabolism and dissipated as heat after assimilation is another. Do not state that energy is recycled.

c; original allocation: 2 mark(s)

The percentage energy loss from trees to caterpillars is greater because caterpillars mainly eat leaves, leaving most of the tree's biomass uneaten.

A unicellular phytoplankton organism can be ingested whole. A tree, however, has large amounts of woody stem, roots and other parts that do not enter the caterpillars' food. Thus, a smaller proportion of the starting energy reaches the caterpillars.

Examiner's comment (source page(s) 1)

Use the starting trophic level as the denominator when calculating percentage energy loss. When discussing respiratory losses, identify the relevant organism / trophic level rather than referring to respiration only in general terms.

Marking reference: HKDSE Biology 2012 Paper 1B Q6, official marking scheme, source page(s) 3.

Example 3 [HKDSE Biology Sample Paper Paper 1B Q2]

A piece of agricultural land can be used for growing crops, or for growing grass to raise cattle for meat. Explain why crop-growing can provide more food for human consumption than cattle-raising. (4 marks)

Solution Whole question; original allocation: 4 mark(s)

When humans eat crops directly, energy passes through fewer trophic levels. If cattle first eat grass and humans then eat beef, energy passes through an additional trophic level. More energy is lost through the cattle's life processes and in material not eaten. The same land can therefore usually provide more food energy for humans by growing edible crops.

Compare the routes explicitly: crops become human food directly, whereas grass is first consumed by cattle and only part of it becomes edible cattle tissue. Cattle respire and lose energy as heat, egest undigested material, and have tissues that humans do not eat. Therefore, not all energy originally fixed by plants reaches humans, and an additional trophic level adds another transfer loss. This is a comparison of energy transfer in food chains; saying only that crops grow faster does not explain where the energy goes.

✓ Method: Identify trophic levels and the measured quantity, then trace energy destinations.

Marking reference: HKDSE Biology Sample Paper Paper 1B Q2, official marking scheme, source page(s) 2.

Example 4 [HKDSE Biology 2014 Paper 1A Q30]

Some environmental protection groups claim that the vegetarian diet is good for our environment. This is probably because

A. vegetables grow faster than animals.
B. it protects endangered species as less animals are killed for food.
C. growing vegetables can produce oxygen but rearing animals only consumes oxygen.
D. it reduces the emission of carbon dioxide associated with rearing animals for food.

Solution Answer: D

Reducing the number of animals raised for food can reduce carbon dioxide emissions associated with their rearing. D therefore supports the environmental benefit of a vegetarian diet in this question. Do not claim that all livestock are endangered species, or use plants' oxygen production to overlook the fact that plants also respire.

✓ Method: Identify trophic levels and the measured quantity, then trace energy destinations.

Marking reference: HKDSE Biology 2014 Paper 1A Q30, official marking scheme, source page(s) 1.

Practice

1. [HKDSE Biology 2018 Paper 1A Q6]

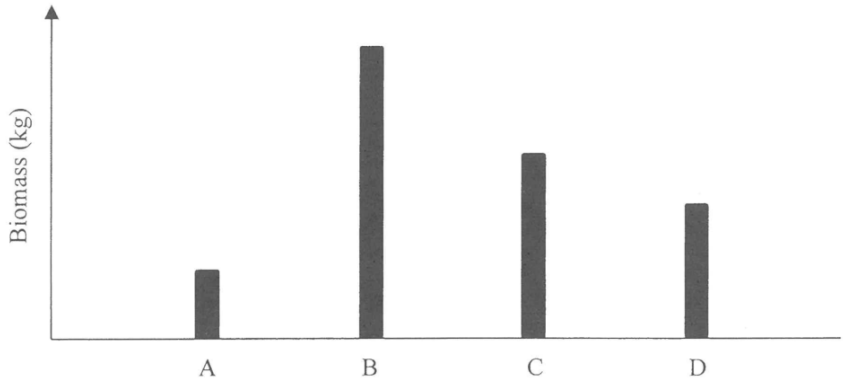
← Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

Protecting sharks in the wild is important for maintaining the ecological balance of the marine ecosystem because

A. sharks are an endangered species.
B. shark fin is a popular dish for banquets.
C. the dead bodies of sharks are an important food source for decomposers.
D. sharks are top predators that regulate the population sizes of other consumers.

2. [HKDSE Biology 2021 Paper 1A Q33]
Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

Directions: Questions 33 and 34 refer to the following graph, which shows the biomasses of four populations forming a food chain in a terrestrial habitat:

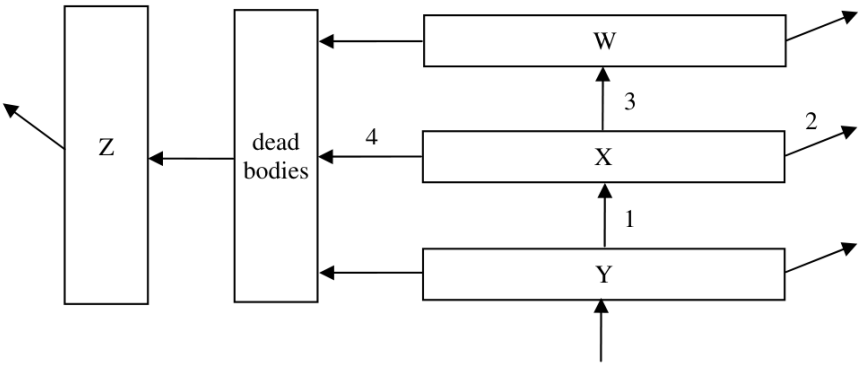


Which population is most likely the autotrophs in this habitat?

A. A
B. B
C. C
D. D

3. [HKDSE Biology Sample Paper Paper 1A Q26]
Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

Directions: Questions 25 to 27 refer to the diagram below, which shows the flow of energy in an ecosystem. W, X and Y represent different trophic levels and Z represents another group of organisms in the ecosystem.



Key: ⟶ direction of energy flow

Energy is lost from the ecosystem through process 2. What is this process?

A. excretion
B. respiration
C. transpiration
D. decomposition

4. [HKDSE Biology 2018 Paper 1A Q5]
Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

The diagrams below show the pyramids of numbers and biomass of a food chain:

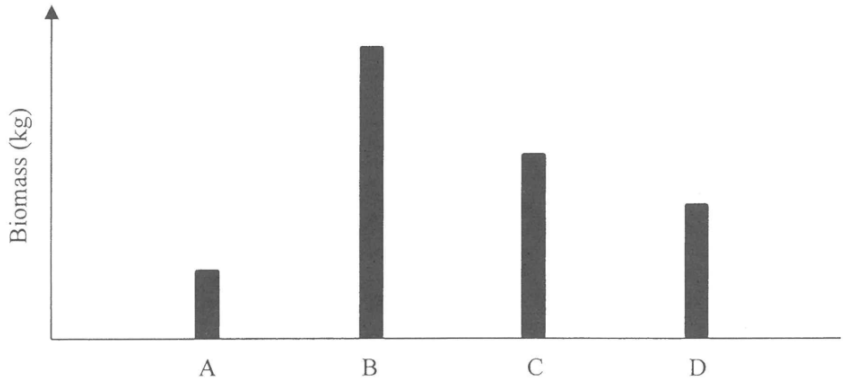


Which of the following is most likely to be the producer in this food chain?

A. rice
B. trees
C. grass
D. phytoplankton

5. [HKDSE Biology 2021 Paper 1A Q34]
Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

Directions: Questions 33 and 34 refer to the following graph, which shows the biomasses of four populations forming a food chain in a terrestrial habitat:



What would you expect to happen if the number of individuals in population D decreased?

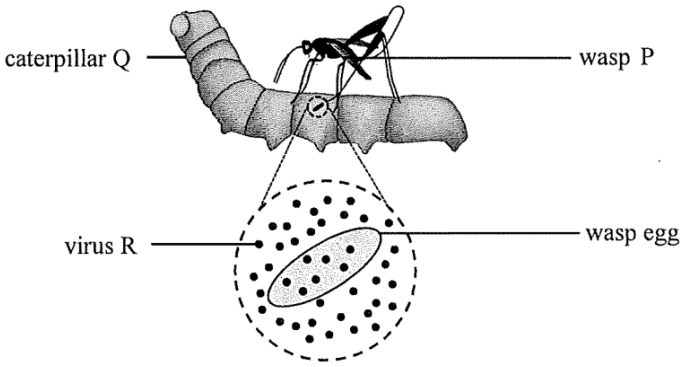
A. The number of individuals in population A would increase.
B. The number of individuals in population C would decrease.
C. The amount of energy passed to population A would decrease.
D. The amount of energy passed to population C would increase.

6. [HKDSE Biology 2023 Paper 1A Q22]
Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

Directions: Questions 22 and 23 refer to the following information about the interactions of wasp P, caterpillar Q and virus R.

Wasp P lays eggs inside the caterpillar Q. When the eggs hatch, the wasp larvae feed on the body tissues of the caterpillars and kill them eventually.

Recent research showed that these wasps are the host of virus R. The viral DNA becomes part of the wasp genome and passes to the wasp's offspring. The wasps inject their eggs along with virus R into the caterpillars. Virus R protect the eggs by suppressing the caterpillars' body defence mechanism.

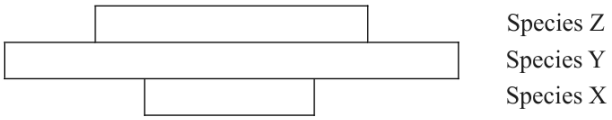


Which of the following correctly describes their feeding roles?

A. The virus is the top consumer.
B. The caterpillar is the producer.
C. The wasp adult is the primary consumer.
D. The wasp larva is the secondary consumer.

7. [HKDSE Biology Practice Paper Paper 1A Q18]
Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

In an aquatic ecosystem, species X, Y and Z form a food chain. The following diagram shows the pyramid of biomass of this ecosystem:



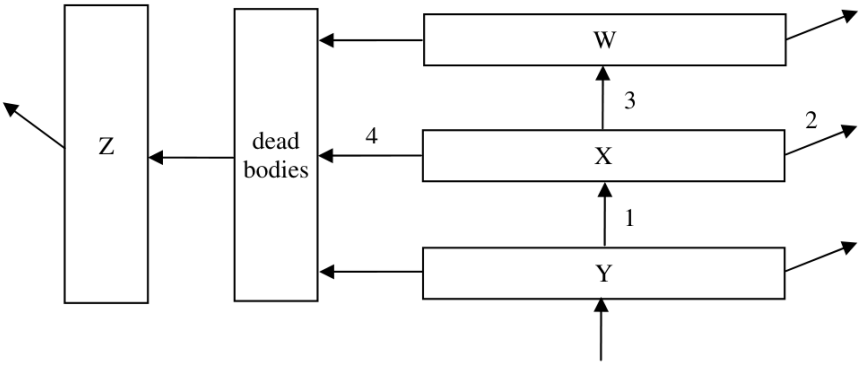
With reference to the above pyramid of biomass, which of the following statements are correct?

(1) Species Z is the secondary consumer in this food chain.
(2) The body size of species X is larger than that of species Y.
(3) There is an energy loss when energy flows from species Y to species Z.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

8. [HKDSE Biology Sample Paper Paper 1A Q27]
Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

Directions: Questions 25 to 27 refer to the diagram below, which shows the flow of energy in an ecosystem. W, X and Y represent different trophic levels and Z represents another group of organisms in the ecosystem.



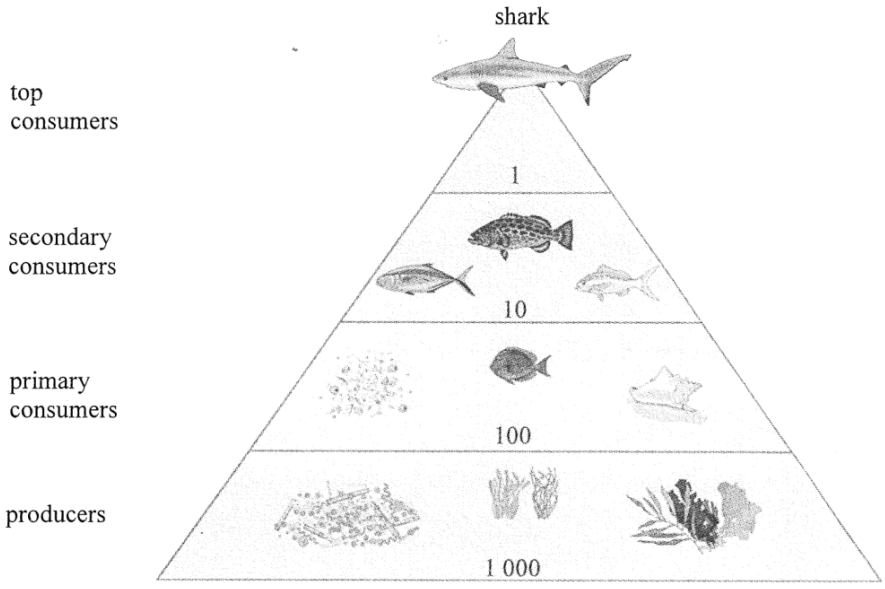
Key: ⟶ direction of energy flow

With reference to trophic level X, the largest amount of energy flow occurs in

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

9. [HKDSE Biology 2020 Paper 1B Q2]
Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

The diagram below shows the total biomass (arbitrary unit) at each trophic level in a marine ecosystem:



(a) As the trophic level becomes higher, the total biomass of each level decreases. Give ***two*** reasons for this phenomenon. (2 marks)

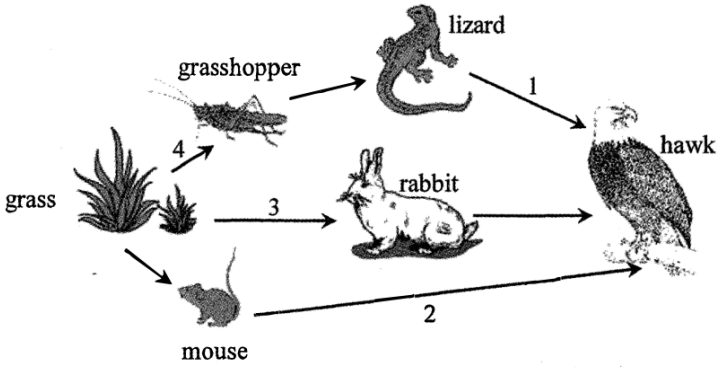
Reason 1: .....

Reason 2: .....

(b) Sharks, being the top consumers in the ocean, play an important role in keeping the populations of other marine organisms under control. It is predicted that the extinction of sharks would result in overpopulation of producers. Explain how this would happen. (3 marks)

10. [HKDSE Biology 2016 Paper 1A Q30]
Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

The following is a food web found in grassland:

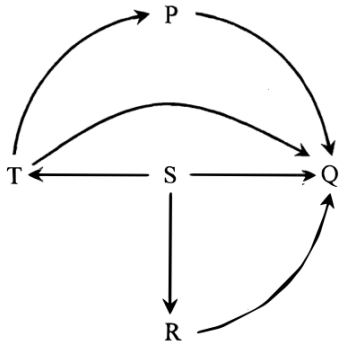


If the energy input for each food chain is the same, the transfer of energy between two trophic levels is the smallest in

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

11. [HKDSE Biology 2017 Paper 1A Q34]
Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

Directions: Questions 34 and 35 refer to the diagram below, which shows the flow of energy among organisms found in a grassland:



Which of the following statements correctly describe(s) the above organisms?

(1) S is a heterotroph.
(2) P is the secondary consumer.
(3) Q has the largest total biomass.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

12. [HKDSE Biology 2024 Paper 1B Q11]
Hint: Identify trophic levels and the measured quantity, then trace energy destinations.

You are required to present your answer to the following question in essay form. Criteria for marking will include relevant content, logical presentation and clarity of expression.

Carbon footprint is an estimation of the total amount of greenhouse gases (including carbon dioxide and methane) generated by our actions, e.g. our choice of food. For instance, skipping meat one day per week will help to reduce the carbon footprint.

Discuss why the practice of eating a vegetarian diet rather than a mixed diet can reduce your personal carbon footprint by referring to the biological aspects of the practice. Briefly discuss ***two*** other personal actions that you can do to reduce your carbon footprint from other perspectives. (11 marks)

Type 3 Explain species interactions through benefits, harm and niches

Degree of integration ★★★☆☆

Key ideas

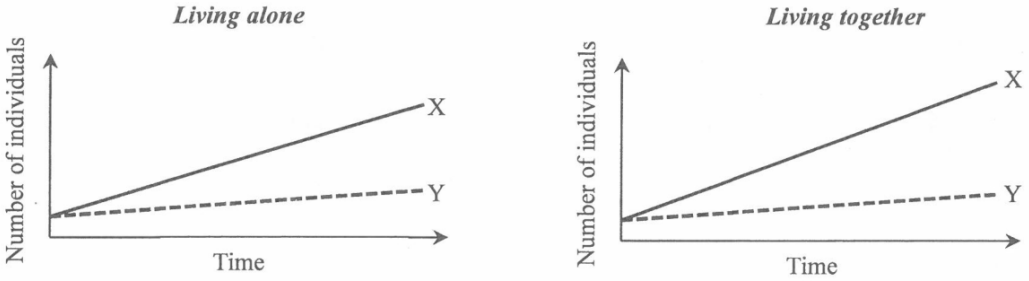
① Coexistence does not necessarily mean mutualism. Assess benefit, harm or no clear effect for each species separately. Comparing separate and mixed cultures tests their effects on each other. Different resource use may limit competition even within the same habitat.

② An introduced species' threat to native species requires evidence about resource use, reproduction or survival. Non-native status alone does not establish harm.

How to recognise the problem State the effect on A and on B separately, then use controls to support the relationship. To move from populations to the community, add the causal links through competition and resources.

Example 1 [HKDSE Biology 2022 Paper 1A Q10]

The graphs below show the changes in the population sizes of organisms X and Y over a period of time when they are living alone or living together.



Which of the following correctly describes the ecological relationship of X and Y?

A. predation
B. mutualism
C. competition
D. commensalism

Solution Answer: D

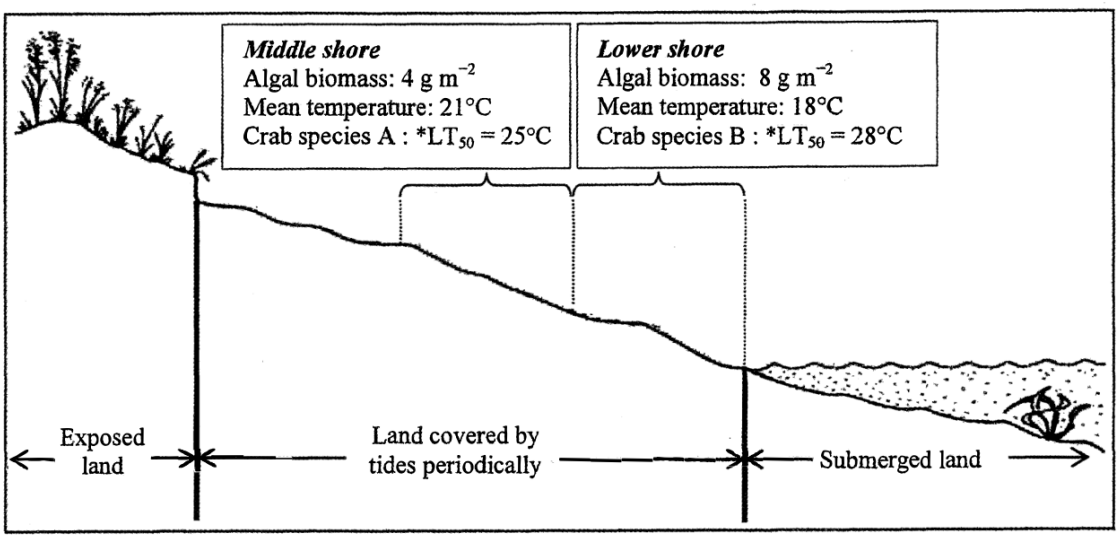
Compare each species in mixed culture with its separate culture. X increases in abundance when living with Y, indicating a benefit to X. Y shows no clear change, indicating no apparent benefit or harm. This is commensalism. Mutualism requires both parties to benefit, while parasitism or predation harms one party.

Method: State the effect on each species separately and support it with controls.

Marking reference: HKDSE Biology 2022 Paper 1A Q10, official marking scheme, source page(s) 1.

Example 2 [HKDSE Biology 2016 Paper 1B Q5]

The diagram below shows some biotic and abiotic factors of a rocky shore, the distribution of two crab species and their temperature tolerance:



* Median lethal temperature (LT_{50}): When a species is exposed to that temperature for 24 hours, half of the individuals die.

(a) The two species coexist on a rocky shore and feed on the same species of alga. When the two crab species are kept in a simulated habitat with the algal species, they will fight against each other. According to the information given in the diagram, deduce which crab species, A or B, would be a stronger competitor. (3 marks)

(b) Deduce whether temperature tolerance is a determining factor for the distribution of these crab species. (4 marks)

(c) Explain why quadrats are unsuitable for studying the abundance of crabs on the rocky shore. (2 marks)

Solution (a); original allocation: 3 mark(s)

Species B is the stronger competitor. Algal biomass is greater on the lower shore, and B occupies this more favourable feeding environment.

First use the data to assess the habitat: algal biomass is 8 g m^{-2} on the lower shore, compared with 4 g m^{-2} on the middle shore. The two crabs feed on the same alga and compete through mutual aggression. B, occupying the food-rich area, is therefore more likely the stronger competitor. Include the species, the habitat advantage and the competitive inference.

Method: State the effect on each species separately and support it with controls.

(b); original allocation: 4 mark(s)

Heat tolerance is not the sole or main factor determining their distribution.

A has an LT_{50} of 25°C and B of 28°C, so A is less heat-tolerant. If heat tolerance determined distribution, the lower shore, averaging 18°C, should be more favourable to A than the middle shore, averaging 21°C. Yet A occupies the warmer middle shore rather than the cooler lower shore. Other factors, such as competition, therefore also influence distribution. Comparing the two LT_{50} values alone is insufficient to predict the location.

(c); original allocation: 2 mark(s)

Crabs move rapidly, making reliable counts in fixed quadrats difficult.

Quadrat estimation assumes that organisms remain within the defined area during the survey and is more suitable for plants or very slow-moving organisms. Crabs can enter or leave while a quadrat is being placed or counted, causing double counting or omissions. Quadrat sampling is therefore unsuitable for estimating their abundance.

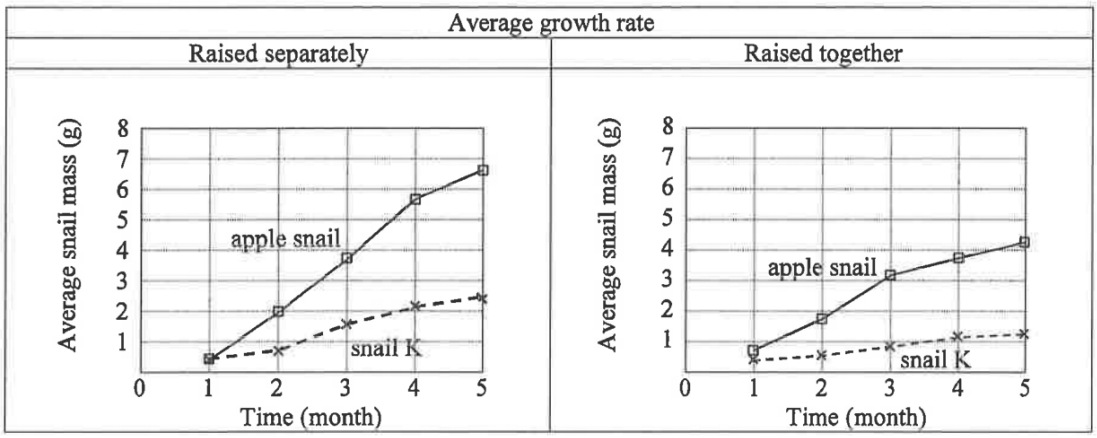
Examiner's comment (source page(s) 3)

The median lethal temperature indicates a tolerance limit, not the optimum growth temperature. A stronger competitor may occupy a habitat with more food or more favourable conditions. Crab movement also affects the reliability of quadrat sampling.

Marking reference: HKDSE Biology 2016 Paper 1B Q5, official marking scheme, source page(s) 3.

Example 3 [HKDSE Biology 2019 Paper 1B Q9]

The apple snail originates from South Africa. It was first imported to Asian countries for human consumption. However, it escaped to the local wetland habitat. Below are data regarding the average growth rates of apple snail and a local snail species K when they were raised separately and raised together:



(a) With reference to the above data, what would happen to the population of snail K in the wetland habitat once the apple snails have escaped to this habitat? Support your answer with data from the graphs above. (4 marks)

(b) It has been noted that apple snails consume wetland plants at a high rate, especially buds and young leaves. Suggest why the feeding habits of apple snails may have an adverse effect on the community of local wetland habitats. (3 marks)

(c) Apart from the above, suggest another biotic factor which may explain why an imported species would turn into an invasive or dominant species. (1 mark)

(d) Suggest ***one*** human activity which might lead to an invasion of imported species in Hong Kong. (1 mark)

Solution a; original allocation: 4 mark(s)

Method: State the effect on each species separately and support it with controls.

The population of snail K is expected to decline. Its growth is inhibited when kept with apple snails, supporting competition from apple snails.

First compare snail K with itself: at month 5, its mass is about 2.5 g when kept separately but only about 1.3 g when kept together. Apple snail growth also decreases, indicating competition for shared resources. Snail K is markedly inhibited, potentially making it harder to reach maturity and reproduce and increasing the likelihood of death, ultimately reducing its population. The graph measures individual mass; population decline is inferred through effects on survival and reproduction.

b; original allocation: 3 mark(s)

Consumption of many seedlings and young leaves inhibits plant growth, regeneration and reproduction, reducing plant abundance or biomass and the food and habitats available to other organisms.

Seedlings are the starting point for the establishment of new plants, while young leaves carry out photosynthesis. Persistent feeding may destroy plants before maturity. A decline in producers also affects animals that depend on plants for food, shelter or habitat, so the effects spread through community relationships.

c; original allocation: 1 mark(s)

The local habitat may lack natural predators of apple snails.

An introduced organism escaping the natural enemies that controlled its abundance in its native range experiences less mortality, allowing more individuals to survive and reproduce. Other reasonable biological factors, such as a higher reproductive rate, may also be proposed.

d; original allocation: 1 mark(s)

For example, releasing unwanted non-native pets into natural habitats.

This directly introduces non-native organisms previously kept under human control into the local environment. If they survive and reproduce, they may establish a non-native population.

Examiner's comment (source page(s) 6)

To infer population effects from reduced mean mass, explain the causal chain from competition to slower growth and effects on maturity and reproduction. Consumption of plant seedlings should be linked to community establishment and opportunities for reproduction. Biological factors such as predators must be explained in the context specified; a high reproductive rate of the snail itself is not a substitute.

Marking reference: HKDSE Biology 2019 Paper 1B Q9, official marking scheme, source page(s) 5.

Practice

1. [HKDSE Biology 2018 Paper 1A Q14]

← *Hint: State the effect on each species separately and support it with controls.*

Caterpillar fungus is a kind of Chinese herbal medicine. When the spores of this fungus land on the larvae of moths, the spores will germinate inside the body of the larvae and grow out of their heads, as shown in the photograph below:



Which of the following best describes the role of this fungus?

A. parasite
B. predator
C. producer
D. consumer

2. [HKDSE Biology Practice Paper Paper 1A Q20]
Hint: State the effect on each species separately and support it with controls.

In the table below, P and Q represent two types of relationships between different species of organisms. The effect of each type of relationship on the species concerned is represented by the following symbols:

\+ = gaining benefits
— = being harmed

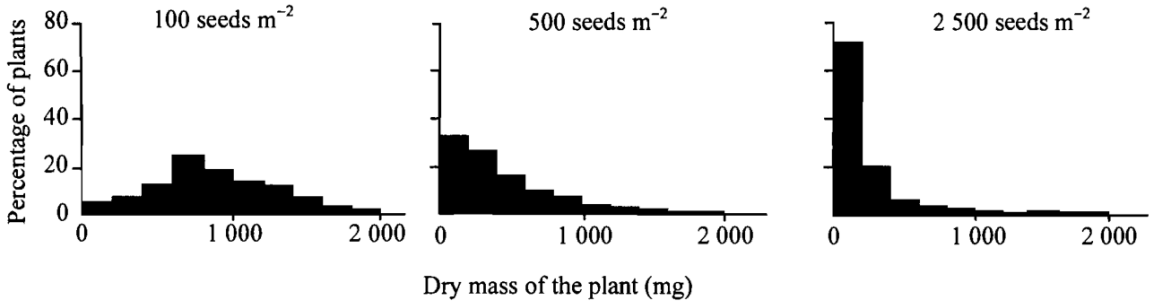
Type of relationship between species	Effect of the relationship on the species	
	Species 1	Species 2
P	+	+
Q	—	+

Which of the following combinations correctly shows the types of relationships represented by P and Q?

	P	*Q*
A.	competition	commensalism
B.	mutualism	competition
C.	commensalism	parasitism
D.	mutualism	predation

3. [HKDSE Biology 2012 Paper 1A Q13]
Hint: State the effect on each species separately and support it with controls.

Directions: Questions 13 and 14 refer to an investigation described below. Pots were planted with seeds at densities of 100, 500 and 2 500 m^{-2} respectively. The soil, water and lighting conditions were similar for each pot. The dry masses of mature plants are shown in the following graphs:

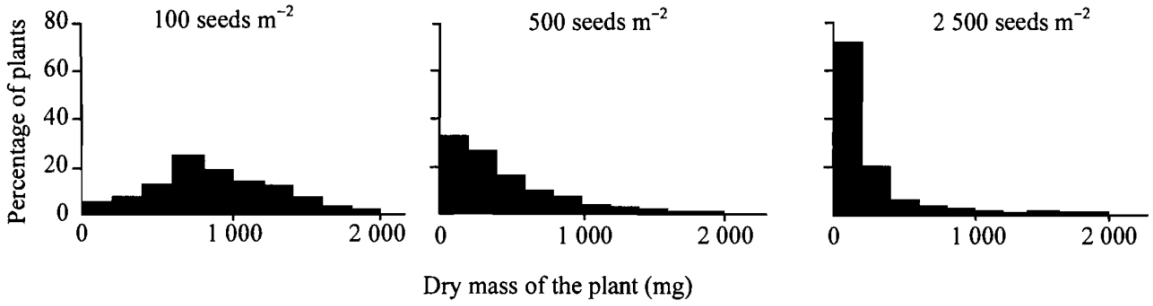


The investigation was most likely performed to study

A. the effect of symbiosis.
B. the effect of competition.
C. the success rate of seed germination.
D. the optimum density for seed germination.

4. [HKDSE Biology 2012 Paper 1A Q14]
Hint: State the effect on each species separately and support it with controls.

Directions: Questions 13 and 14 refer to an investigation described below. Pots were planted with seeds at densities of 100, 500 and 2 500 m^{-2} respectively. The soil, water and lighting conditions were similar for each pot. The dry masses of mature plants are shown in the following graphs:

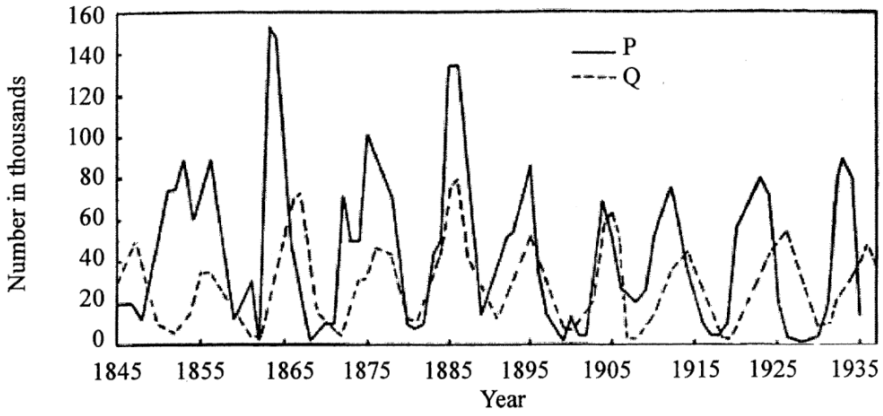


Which of the following best describes the effect on the plants as the density of seeds planted increases?

A. biomass of individual plants is reduced
B. genetic variability of the plants is increased
C. dry masses of plants are normally distributed
D. leaves become smaller and stems get thinner

5. [HKDSE Biology 2014 Paper 1A Q31]
Hint: State the effect on each species separately and support it with controls.

The graph below shows the changes in the populations of two organisms that exhibit a predator-prey relationship in a habitat:



Which of the following statements about the identity of the organism is correct?

A. P is the predator because its number fluctuates more than that of Q.
B. P is the predator because its lowest number is lower than that of Q.
C. Q is the predator because its number fluctuates less than that of P.
D. Q is the predator because its highest number is lower than that of P.

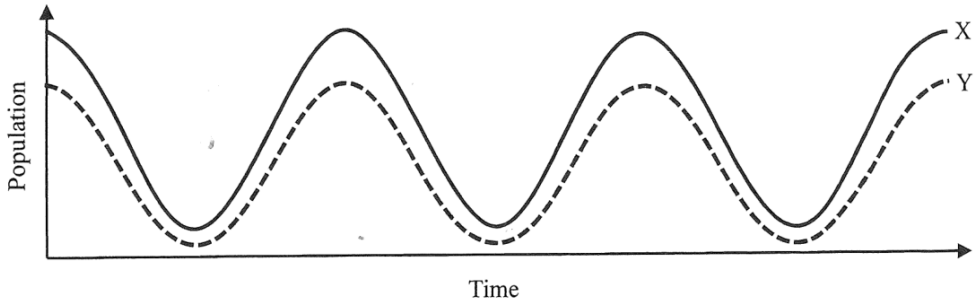
6. [HKDSE Biology 2018 Paper 1A Q32]
Hint: State the effect on each species separately and support it with controls.

Organisms P and Q are found in the same local habitat. Their population sizes have continued to grow in the last few years. Which of the following statements best describes organisms P and Q?

A. They are heterotrophs.
B. They are top predators.
C. They have different niches.
D. They have different predators.

7. [HKDSE Biology 2020 Paper 1A Q32]
Hint: State the effect on each species separately and support it with controls.

The following graph shows the change in the populations of organisms X and Y living in the same habitat:

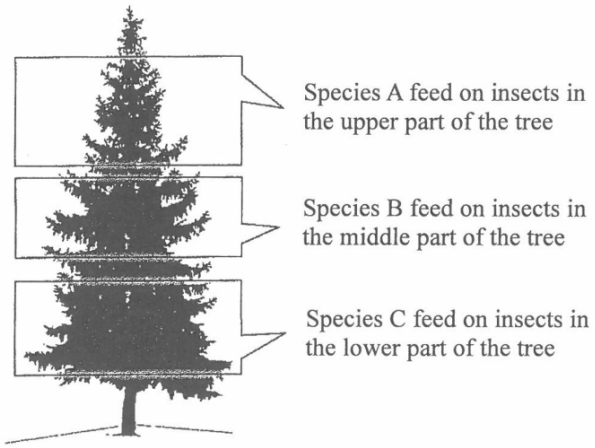


Which of the following is the most likely ecological relationship between organisms X and Y?

A. predation
B. mutualism
C. competition
D. commensalism

8. [HKDSE Biology 2022 Paper 1A Q9]
Hint: State the effect on each species separately and support it with controls.

Three bird species are living on the same tree species for years. They feed on the insects found at different regions of the tree as shown in the diagram below:



Which of the following can be deduced from the above phenomenon?

(1) The insects are evenly distributed on the tree.
(2) Birds species A, B and C have different ecological niches.
(3) There is less interspecific competition among bird species A, B and C.

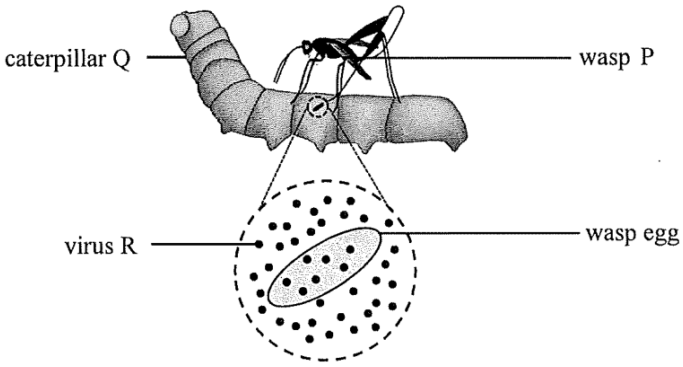
A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

9. [HKDSE Biology 2023 Paper 1A Q23]
Hint: State the effect on each species separately and support it with controls.

Directions: Questions 22 and 23 refer to the following information about the interactions of wasp P, caterpillar Q and virus R.

Wasp P lays eggs inside the caterpillar Q. When the eggs hatch, the wasp larvae feed on the body tissues of the caterpillars and kill them eventually.

Recent research showed that these wasps are the host of virus R. The viral DNA becomes part of the wasp genome and passes to the wasp's offspring. The wasps inject their eggs along with virus R into the caterpillars. Virus R protect the eggs by suppressing the caterpillars' body defence mechanism.

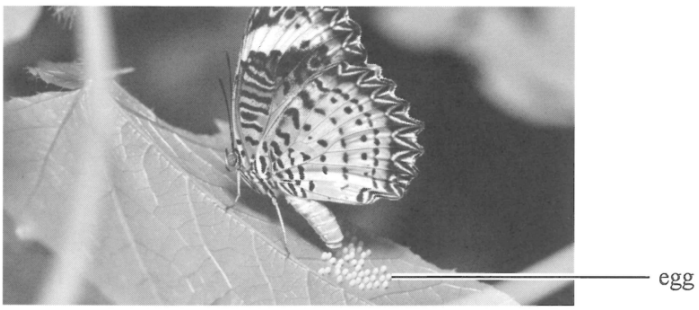


Which of the following correctly shows the relationship between the wasp and the virus?

A. parasitism
B. mutualism
C. competition
D. commensalism

10. [HKDSE Biology 2024 Paper 1A Q34]
Hint: State the effect on each species separately and support it with controls.

Directions: Questions 34 and 35 refer to some information about the interaction among three organisms: butterflies, plant species X and ants. Butterflies lay eggs on the leaf surfaces of plant species X. When caterpillars hatch from the eggs, they feed on the leaves. Plant species X secretes a sugary solution on their leaves. Ants are attracted to feed on the sugary solution and the eggs.



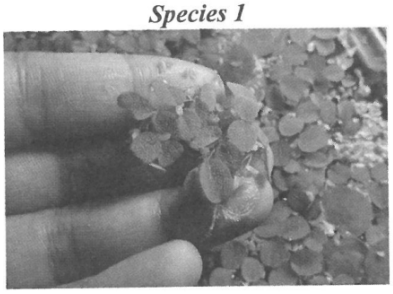
Which of the following combinations correctly describes the relationship between the organisms mentioned?

	Plant species X and ant	*Ant and butterfly*
A.	mutualism	competition
B.	mutualism	predation
C.	commensalism	competition
D.	commensalism	predation

11. [HKDSE Biology 2021 Paper 1B Q9]
Hint: State the effect on each species separately and support it with controls.

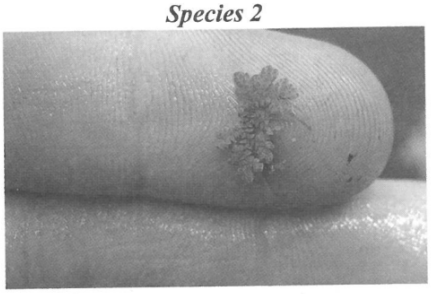
The photographs below show the appearances of two species of free-floating, freshwater plants, Species 1 and Species 2:

Species 1



(0.58 X)

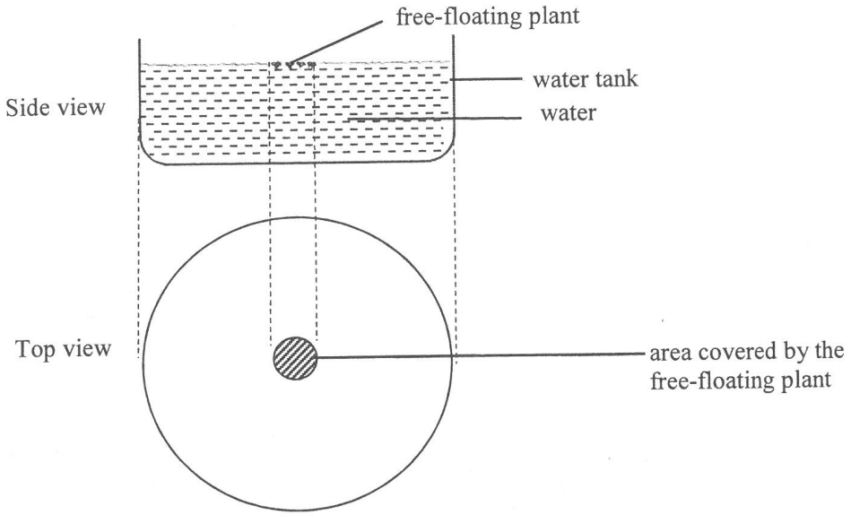
Species 2



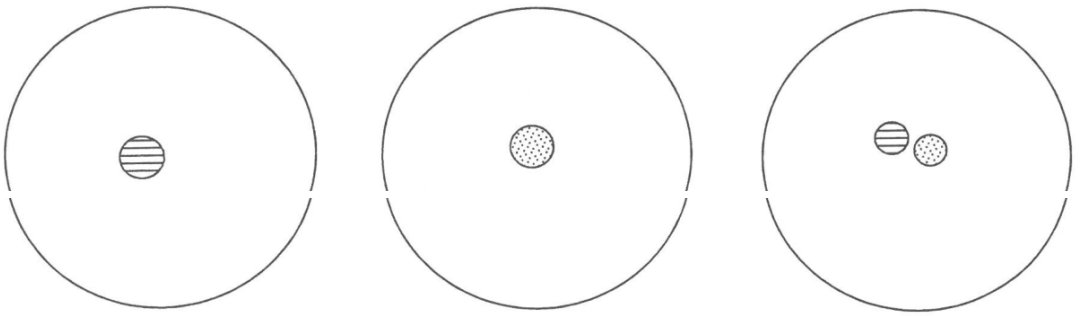
(1.5 X)

To study the interaction between these two plant species, each species was grown either alone or together with another species in a water tank for 50 days. Each species covered 10% of the area of water surface at the beginning of the experiment. The experimental set-up and design are shown in the following diagrams:

Experimental set-up:

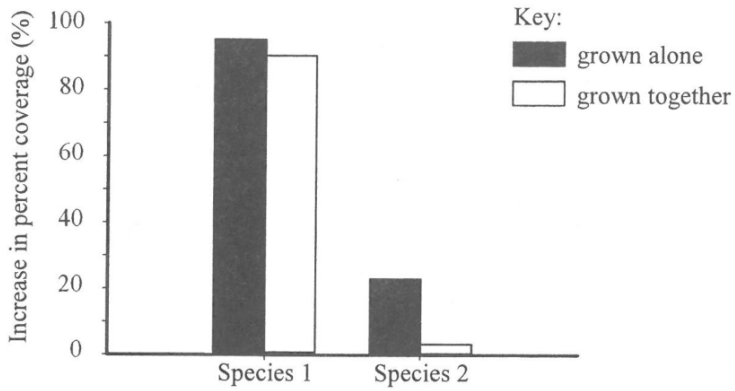


Experimental design (top view):



Species 1 grown alone | Species 2 grown alone | Species 1 and 2 grown together

The percent coverage of each plant species was measured at the beginning and at the end of the experiment. The increases in the percent coverage are shown below:



(a) With reference to the aim of the experiment, what conclusions can be drawn about the interaction between Species 1 and 2? Explain your answer. (4 marks)

Conclusion 1:

Conclusion 2:

(b) With reference to the photographs of Species 1 and 2, suggest an explanation for the difference in the percent coverage of the two plant species when they were grown together. (2 marks)

(c) The table below shows two other methods of measuring plant growth and whether these methods would be feasible in this experiment. Complete the table by giving justifications for the feasibility of the methods. (2 marks)

Method	*Feasibility*	*Justifications*
Fresh weight	Feasible	
Number of leaves	Not feasible	

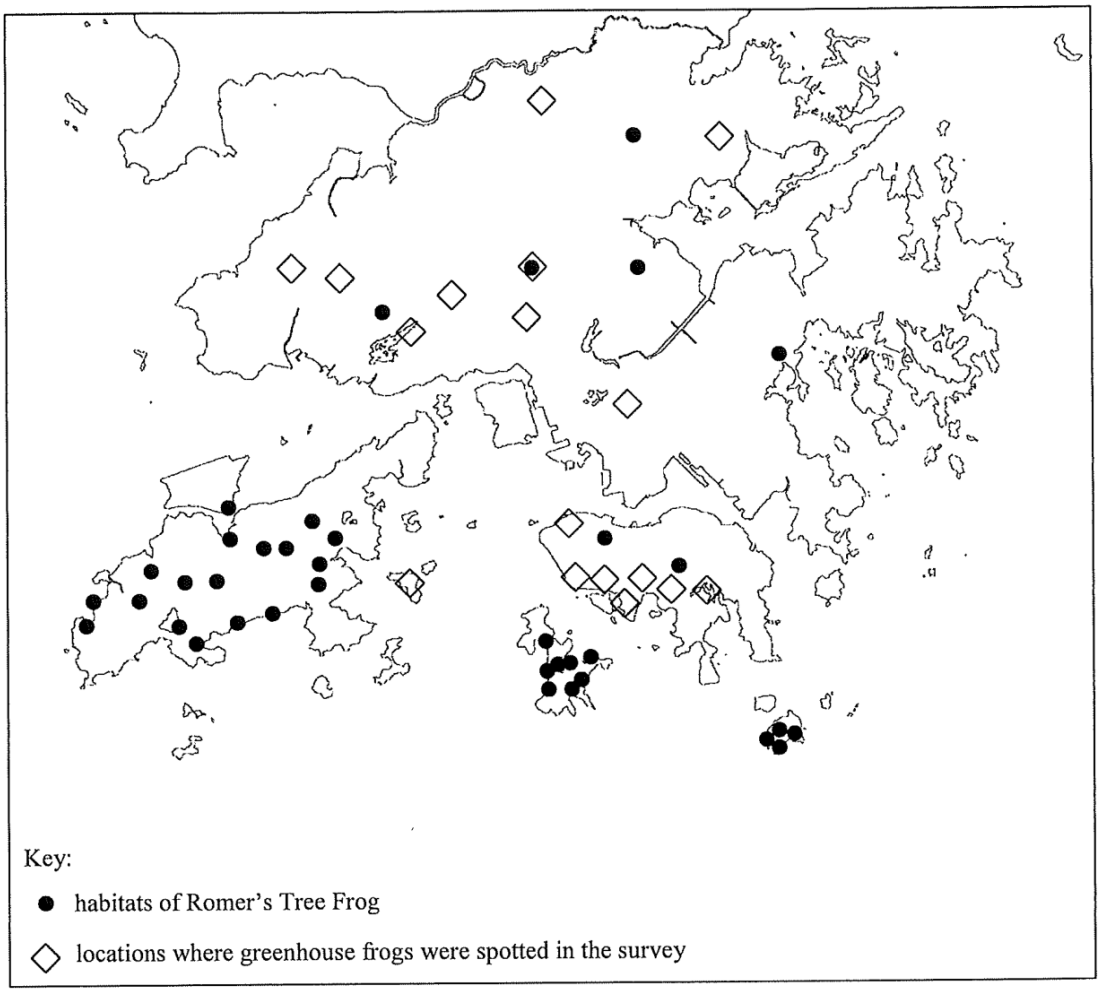
12. [HKDSE Biology 2023 Paper 1B Q7]

Hint: State the effect on each species separately and support it with controls.

Name	Romer's Tree Frog	Greenhouse Frog
Size	1.5-2.5 cm	1.2-3.0 cm
Breeding site and habitat	Wetland, small and temporary water bodies; woodland; shrubland; plantations	Woodland; shrubland; agricultural field; urban park
Food	Small insects	Small insects and snails

By comparing the ecological niche of the two frog species, give ***two*** pieces of evidence that support the possibility of the greenhouse frog posing a threat to the Romer's Tree Frog. Explain your answer. (3 marks)

(b) The map below shows the distribution of the two frog species in Hong Kong:



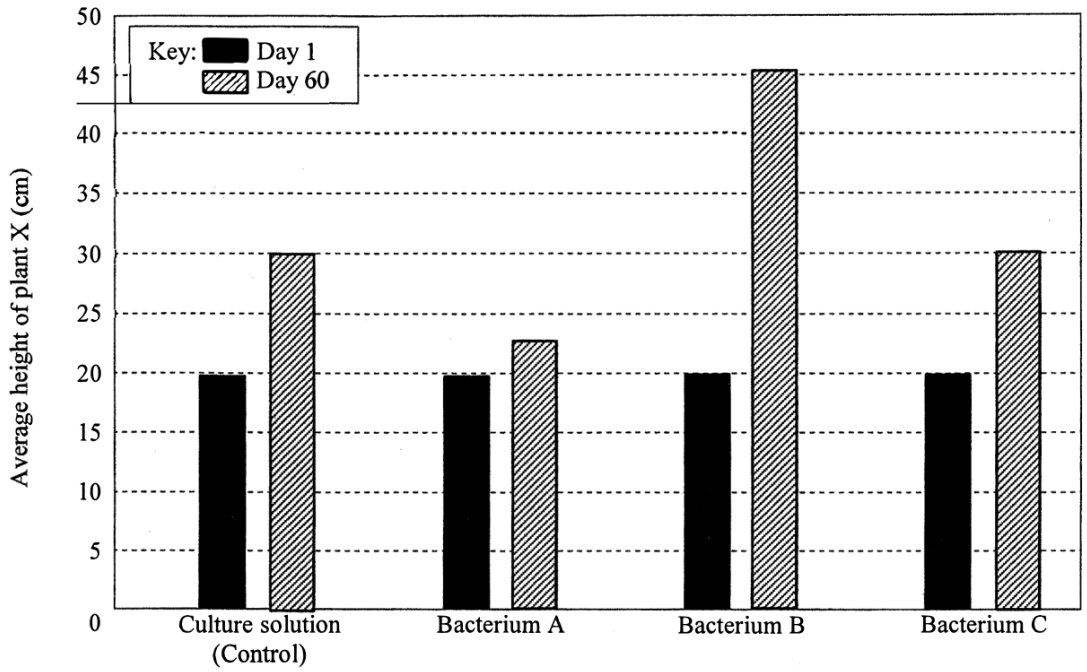
Suggest why the information above ***cannot*** prove that the Romer's Tree Frog is facing a real threat from the greenhouse frogs. (1 mark)

(c) Suggest how you could collect data to show if Romer's Tree Frogs are facing a real threat from greenhouse frogs. (2 marks)

13. [HKDSE Biology 2017 Paper 1B Q8]

Hint: State the effect on each species separately and support it with controls.

In an investigation about the effect of soil bacteria on the growth of plant X, three types of soil bacteria (A, B and C) were grown separately in one type of culture solution. After this, each bacterial culture was added to the soil of separate pots of plant X. A control was prepared by adding the culture solution only. The average height of plant X was recorded at day 1 and day 60 of the experiment. The results are shown in the chart below:



(a) With reference to the above results, state the effect of each type of bacterium on the growth of plant X. (3 marks)

Bacterium A: _____

Bacterium B: _____

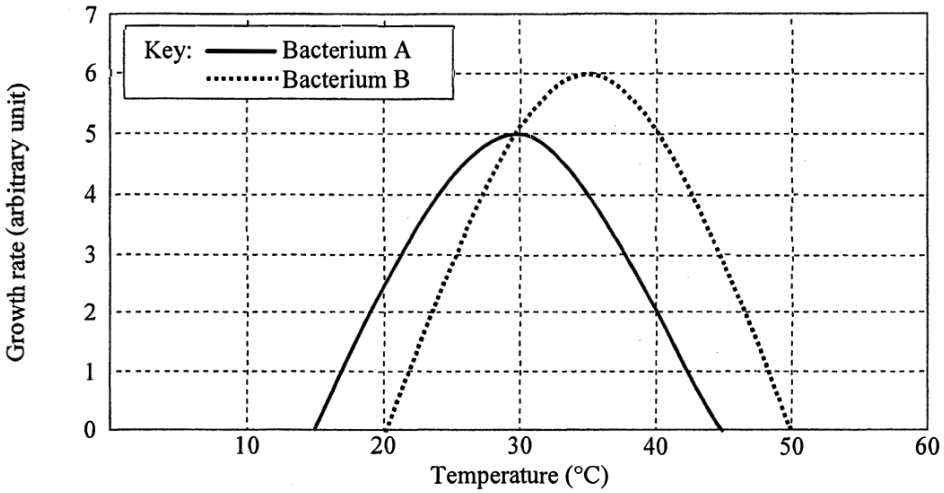
Bacterium C: _____

(b) It is known that both bacteria A and B are able to colonise the root of plant X and obtain nutrients from the root for growth. Suggest the possible ecological relationships between each type of bacterium and plant X. (2 marks)

Bacterium A: _____

Bacterium B: _____

(c) In a subsequent experiment, the effect of temperature on the growth of bacteria A and B was tested and the results are shown in the graph below:



(i) Indicate the optimum temperature for the growth of bacteria A and B respectively. (1 mark)

Bacterium A: _____

Bacterium B: _____

(ii) Normal soil temperature in Hong Kong is around 30°C in summer. Global warming has led to an increase in soil temperature within 2°C. With reference to the above graph, predict the changes in the population sizes of bacteria A and B in soil in summer. (2 marks)

(d) Plant X is a foreign species that is more competitive than the native plant species in Hong Kong. With reference to your answers in (a) and (c)(ii), suggest a possible impact of global warming on the native plant community. Explain your answer. (2 marks)

Type 4 Study distribution using quadrats and transects

Degree of integration ★★★☆☆

Key ideas

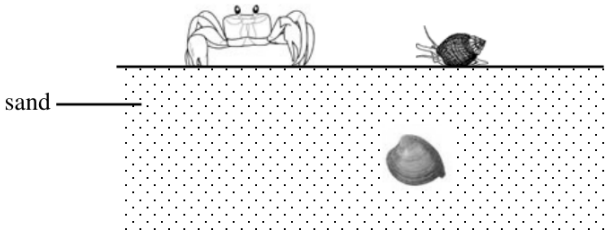
① Random quadrat placement reduces subjective site-selection bias. Transects along tidal heights or other environmental gradients show how species change with conditions. Sampled area, replication and organism mobility affect estimate reliability.

② A correlation between distribution and temperature does not directly exclude competition, drying or other factors.

How to recognise the problem Decide whether the aim is a site-wide average or a change along a gradient, then choose random sampling or transects. Explain which bias each improvement reduces.

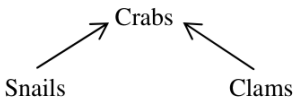
Example 1 [HKDSE Biology Practice Paper Paper 1B Q5]

A sandy shore community has three species: a burrowing clam, a snail, and a crab.



(a) To determine the relative abundance of these species, a student placed a quadrat on the shore and collected all the individuals on the sediment surface inside the quadrat. After counting the number of individuals of each species collected from this quadrat, he determined their relative abundance. Give **three** reasons why the student's sampling method may not reflect the actual relative abundance of these organisms. (3 marks)

(b) The feeding relationship of these three species is shown below:



Suggest the effect on the population of crabs if a large number of clams are harvested by visitors to the shore. Explain your answer. (2 marks)
(Assume that the crabs have the same preference for snails and clams.)

Solution a; original allocation: 3 mark(s)

Only one quadrat is sampled, giving insufficient replication and potentially an unrepresentative result. Collecting animals only from the sand surface misses burrowing clams. Crabs can move, so a single quadrat collection may not accurately represent their population.

Another possible point is that non-random quadrat placement introduces site-selection bias.

Give three distinct sources of distortion rather than rephrasing 'too few samples' three times.

Method: Decide between estimating an average and investigating a gradient, then select the sampling method.

b; original allocation: 2 mark(s)

If snails adequately replace the lost clams as food, crabs can eat more snails and their population may remain approximately unchanged. If snails cannot compensate, the crabs' food supply falls and their population may decline.

The official scheme accepts either direction when supported by a causal explanation. Snail abundance is not provided, so do not assert that crabs must increase or all starve. Each acceptable answer must connect food substitution to the population outcome.

Marking reference: HKDSE Biology Practice Paper Paper 1B Q5, official marking scheme, source page(s) 4.

Example 2 [HKDSE Biology 2013 Paper 1B Q8]

A study was carried out to investigate the distribution and abundance of animal species A and B on a rocky shore. The table below shows the results obtained from the back of the shore to the waterfront:

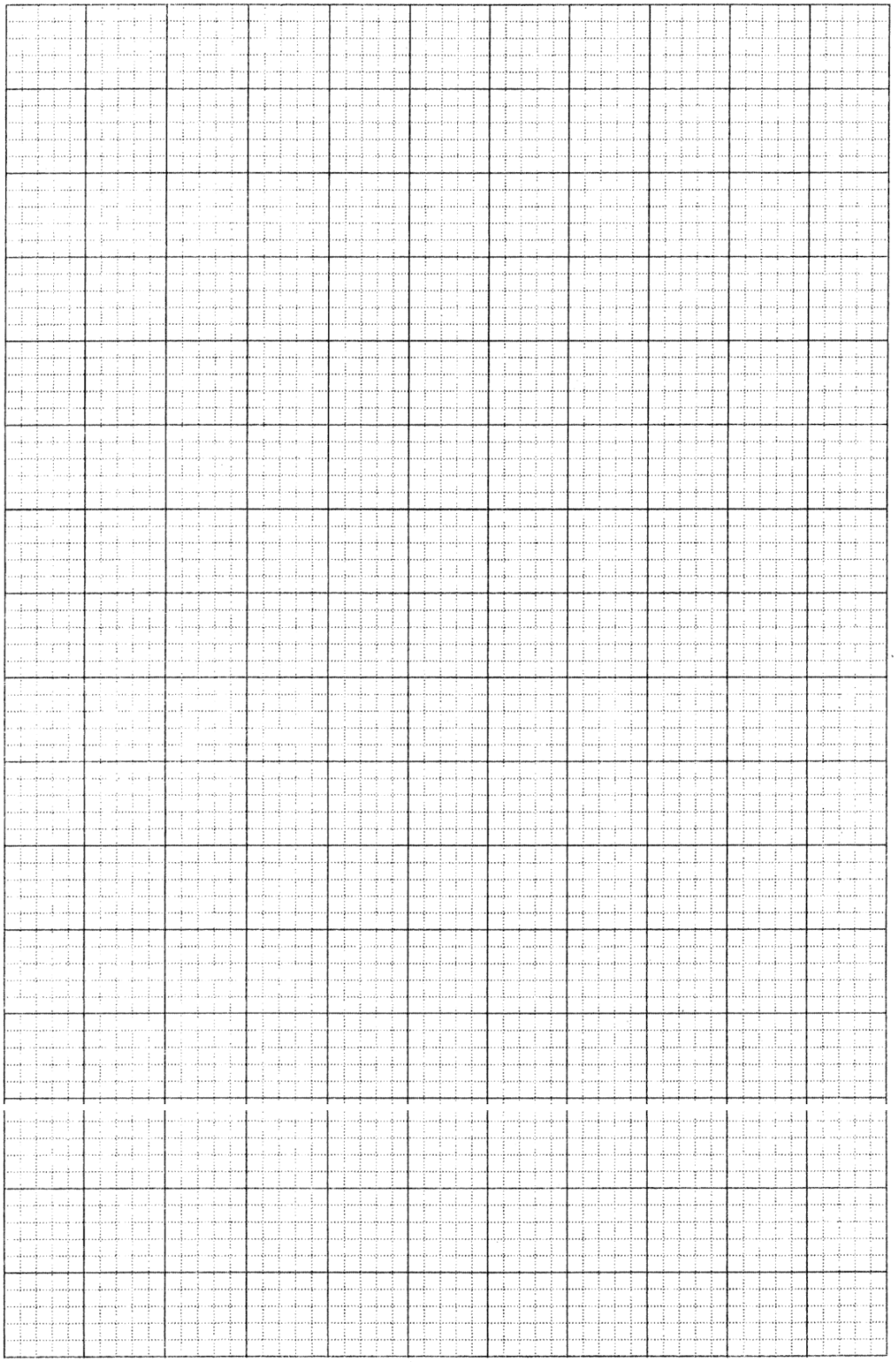
Distance from the back of the shore (m)	Abundance (number of individuals m^{-2})	
	Species A	Species B
1	10	0
2	25	2
3	40	8
4	38	10
5	20	20
6	18	35
7	15	33
8 (waterfront)	11	28

(a) Using the graph paper on the opposite page, plot a graph to show the results. (5 marks)

(b) Based on the information in the graph, suggest which species would have a higher tolerance to desiccation. Explain your answer. (4 marks)

(c) Briefly describe the sampling procedure used to obtain the above data. (3 marks)

Answers written in the margins will not be marked.



Solution a; original allocation: 5 mark(s)

Use distance from the back of the rocky shore (m), from 1 to 8, on the horizontal axis and abundance (number of individuals m^{-2}) on the vertical axis. Plot A as 10, 25, 40, 38, 20, 18, 15, 11 and B as 0, 2, 8, 10, 20, 35, 33, 28. Join the points for each species, and add a key and a suitable title.

The horizontal coordinate of each point is its distance along the same transect. Do not use the two species as categories on the horizontal axis. The title, axis choice, labels and units, and accurate plotting of the two lines together carry 5 marks. The completed graph is included with this solution.

Method: Decide between estimating an average and investigating a gradient, then select the sampling method.

b; original allocation: 4 mark(s)

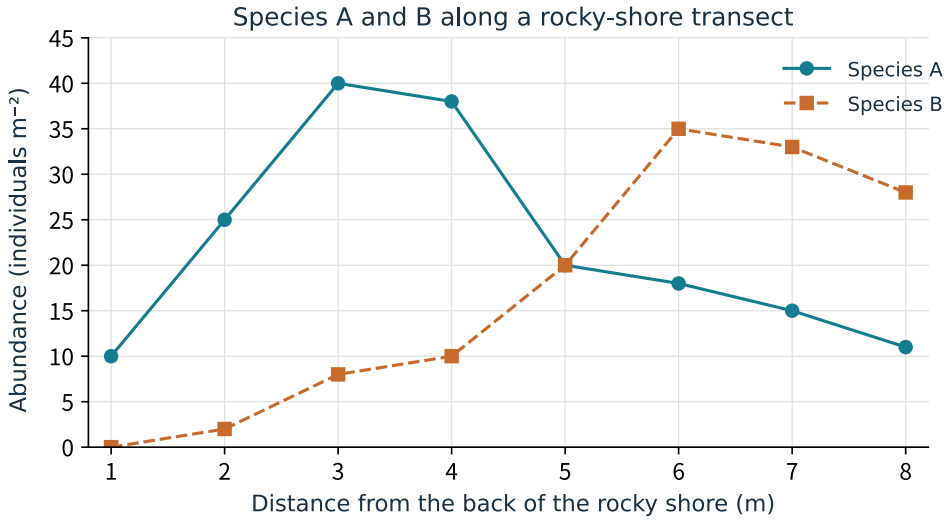
A is more tolerant of desiccation. Near the back of the rocky shore, A is more abundant than B. This area is covered by seawater less often or for shorter periods, leaving organisms exposed to air and desiccation for longer. A can therefore maintain greater abundance in the drier area.

Inferring tolerance from distribution requires the intervening environmental explanation. Do not directly equate A's greater maximum abundance with desiccation tolerance while ignoring the location of its peak.

c; original allocation: 3 mark(s)

Lay a transect line from the back of the rocky shore towards the water's edge. Place quadrats at fixed intervals along it. Count A and B separately in each quadrat, record the locations and convert the counts into abundance per square metre.

This is systematic sampling along an environmental gradient. The transect establishes direction, fixed intervals determine locations and quadrats provide a consistent area. Repeat with several transects to improve representativeness.



Plotted from all 16 data points in the original table; neither line is arbitrarily extended to the origin.

Examiner's comment (source page(s) 3)

Join the given data points and include a title and units. The origin (0,0) is not a data point in the table, so do not extend lines to it without justification. Compare the two species at the same locations when assessing desiccation tolerance.

Marking reference: HKDSE Biology 2013 Paper 1B Q8, official marking scheme, source page(s) 5.

Practice

1. [HKDSE Biology 2019 Paper 1A Q29]

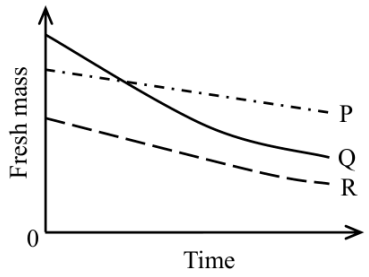
Hint: Decide between estimating an average and investigating a gradient, then select the sampling method.

If a student wants to find out whether the distribution of plant species is affected by the slope of a hillside, which of the following sampling methods should be used?

A. Set up a line transect along the hillside and record the plant species that touch the line.
B. Set up a line transect around the hillside and record the plant species that touch the line.
C. Randomly place quadrats along the hillside and record the plant species within the quadrat.
D. Randomly place quadrats around the hillside and record the plant species within the quadrat.

2. [HKDSE Biology Practice Paper Paper 1A Q19]
Hint: Decide between estimating an average and investigating a gradient, then select the sampling method.

Three types of seaweeds, P, Q and R, were collected from the intertidal zone (the zone between the high tide mark and the low tide mark) of a rocky shore. The distribution of these seaweeds in the intertidal zone is related to their ability to withstand exposure to air. The graph below shows the changes in the fresh mass of these seaweeds when they are left to dry in the laboratory:



Which of the following shows the most likely distribution of these seaweeds from the lower shore to the upper shore?

A. P, Q, R
B. P, R, Q
C. Q, R, P
D. R, Q, P

3. [HKDSE Biology 2024 Paper 1B Q7]
Hint: Decide between estimating an average and investigating a gradient, then select the sampling method.

The following photograph was generated by an artificial intelligence programme using the following sentence:

'A photograph capturing Hong Kong students on a field trip to a rocky shore, studying the distribution and abundance of organisms along the shore.'

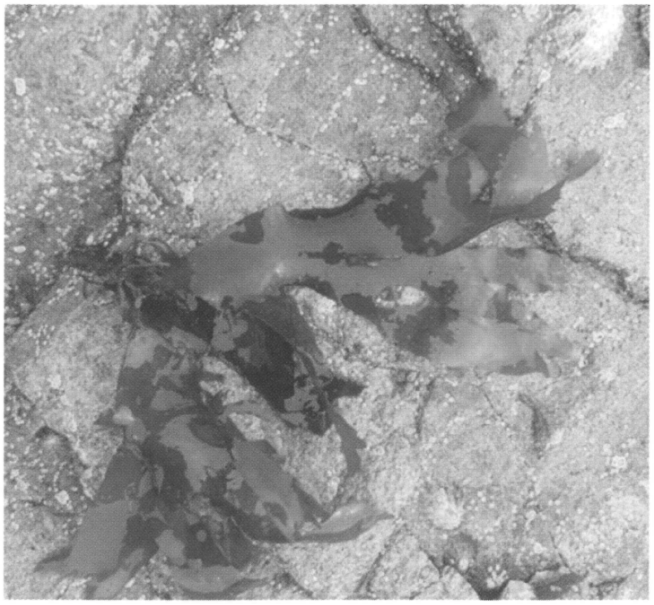


(a) The photograph does not truly reflect the requirement in the sentence because two pieces of essential equipment are missing.

(i) List the ***two*** pieces of essential equipment for the study. (1 mark)

(ii) How could you use the equipment listed in (i) to collect the data needed for the study? (2 marks)

(b) In a field trip to a rocky shore, a student found a thin brown sheet lying on a rock. The student suspected that it was an alga. A small piece of the sample was taken back to school for further study.



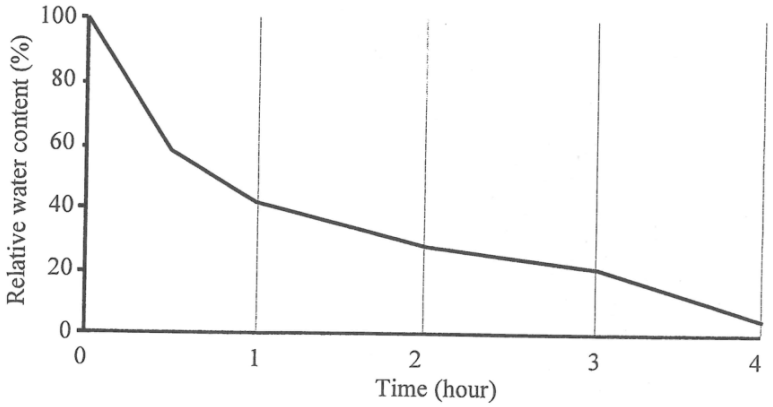
Using apparatus and reagents available in a school laboratory, design a set-up which can be used to show whether the sample of this thin sheet can undergo respiration. In the space below, draw a simple labelled diagram of this set-up. (3 marks)

Title: A set-up for demonstrating if respiration occurs in the sample

(c) Under normal circumstances, the level of free radicals in algal tissues is kept at a certain level as a result of homeostasis. In response to dehydration, algal tissues will be stimulated to produce free radicals which can cause damage to the cell components if there is an accumulation.

Graph I shows the change in relative water content of algal tissue samples during a period of four hours of dehydration:

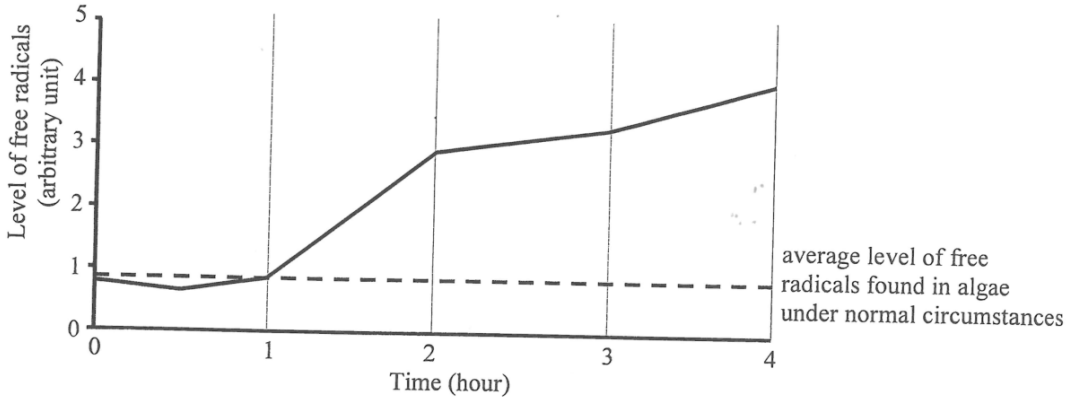
Graph I



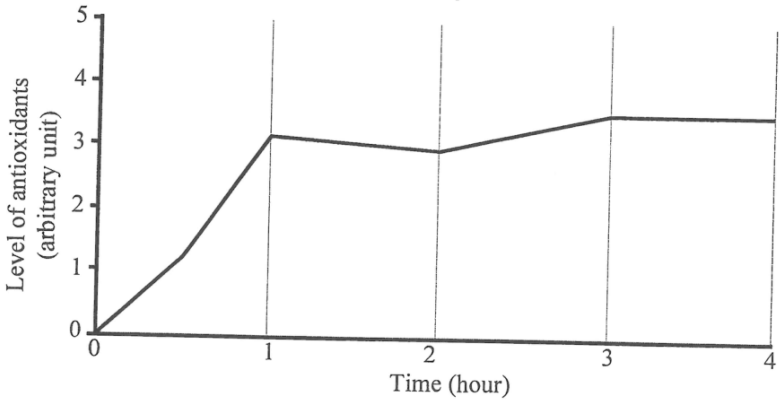
With reference to Graph I, what would be the expected change in the level of free radicals found in the algal tissue samples during the four hours of dehydration? (1 mark)

(d) Graph II and Graph III respectively show the actual change in the level of free radicals and the change in the level of antioxidants found in the algal tissue samples of the alga during the same period of dehydration:

Graph II



Graph III



Based on your answer in (c) and the data shown in Graph II and Graph III, suggest the role of antioxidants in helping the algae to cope with the dehydration. Give ***two*** pieces of evidence from the data shown.
(3 marks)

Type 5 Explain succession using starting conditions, soil and community data

Degree of integration ★★★☆☆

Key ideas

① Community establishment on bare rock without pre-existing soil differs from recovery after disturbance of vegetation where soil remains. Pioneer organisms can alter conditions, and later competition and resource use further change the community.

② The presence of trees does not establish that every site develops towards one fixed endpoint. Answer using the stated starting conditions and actual data.

How to recognise the problem Identify what remains after disturbance, then connect soil, nutrients, shading and species replacement over time.

Example 1 [HKDSE Biology 2018 Paper 1A Q33]

Which of the following statements about primary succession and secondary succession is correct?

A. Primary succession is always followed by secondary succession.
B. Primary succession always starts with a barren area while secondary succession does not.
C. Secondary succession always ends with a climax community while primary succession does not.
D. Secondary succession always ends with a climax community while primary succession ends with a pioneer community.

Solution Reading the question and choosing a method

Method: Identify remaining soil and organisms, then trace replacement.

First check whether soil and remnants of a previous community are already present at the start of succession.

Answer: B

Primary succession begins on exposed sites without pre-existing soil or a mature community, such as newly exposed rock. Secondary succession follows disturbance of an existing community, usually with soil or other biological remnants retained. This difference in starting conditions corresponds to B. Primary succession does not necessarily follow immediately after secondary succession. Continued disturbance may also prevent a community from reaching a stable state, so neither type should be described as inevitably reaching a climax community. Choose B.

Common error

Interpreting primary and secondary literally as the first and second stages of one necessarily continuous process.

Marking reference: HKDSE Biology 2018 Paper 1A Q33, official marking scheme, source page(s) 1.

Example 2 [HKDSE Biology 2014 Paper 1B Q5]

In a study, a plot of land was burnt by fire. After this, the vegetation on this land, classified into herbs and woody plants, was monitored for 8 years. The percentage cover of each type of vegetation is shown in the graph below:



(a) Which type of succession is shown in the above case? Explain your answer. (2 marks)

(b) (i) Describe briefly how the dominant community of vegetation changes with time after the fire. (2 marks)

(ii) Explain the changes in the dominant community described in (i). (4 marks)

Solution a; original allocation: 2 mark(s)

Method: Identify remaining soil and organisms, then trace replacement.

Secondary succession. A community previously existed here and is recovering at the same site after fire damage, rather than beginning on bare ground entirely without soil and life. Fire alone is not the defining feature. The key is that a community existed beforehand and some soil, seeds or underground organs remain.

b(i); original allocation: 2 mark(s)

Herbaceous plants dominate from 0 to about 3 years after the fire; woody plants dominate from about 3 to 8 years.

Compare the percentage cover of the two curves; they intersect at about year 3. Do not confuse when each plant type first appears with when dominance changes.

b(ii); original allocation: 4 mark(s)

Seeds and underground organs may remain in the soil after the fire. Herbaceous plants germinate and grow faster, rapidly occupying space and giving greater cover initially. Woody plants subsequently continue growing taller and expanding their canopies, shading herbaceous plants and gradually replacing their dominance through competition.

Explain the sequence: regrowth is possible; herbaceous plants increase rapidly first; woody plants grow taller later; and shading creates competition. Woody plants do not feed on herbaceous plants.

Examiner's comment (source page(s) 3)

This is secondary succession, so do not apply the bare-rock-to-soil sequence of primary succession. Include surviving seeds / underground organs and later shading of herbaceous plants by woody plants.

Marking reference: HKDSE Biology 2014 Paper 1B Q5, official marking scheme, source page(s) 3.

Example 3 [HKDSE Biology 2019 Paper 1B Q7]

The table below shows the changes in soil nitrogen content and the number of species of herbaceous plants and woody plants before and after a landslide on a hillside:

	Soil nitrogen content ($mg\ g^{-1}$)	Number of plant species	
		Herbaceous plants (e.g. grass)	Woody plants (e.g. shrubs and trees)
Before landslide	6	10	15
2 years after landslide	1	17	2
20 years after landslide	3	14	9

(a) What type of ecological succession occurred on the hillside after the landslide? Explain your answer. (2 marks)

(b) (i) Explain the change in the soil nitrogen content shown in the above table. (3 marks)

(ii) With reference to the change in soil nitrogen content, explain the change in the plant composition after the landslide in terms of the number of species of herbaceous and woody plants. (3 marks)

Solution a; original allocation: 2 mark(s)

Method: Identify remaining soil and organisms, then trace replacement.

Secondary succession: a community re-establishes where soil and vegetation previously existed.

Distinguish primary and secondary succession by their starting conditions. This slope already had vegetation and soil and was disturbed by a landslide; it is not starting from bare rock entirely without soil.

b(i); original allocation: 3 mark(s)

Soil nitrogen falls from 6 to 1 $mg\ g^{-1}$, then recovers to 3 $mg\ g^{-1}$.

Initially, the landslide removes nitrogen-containing topsoil, and early plants also absorb nitrogen from the soil, lowering its nitrogen content. Later, nitrogen-fixing bacteria in root nodules convert atmospheric nitrogen into usable nitrogen-containing substances. Fallen

leaves and remains of the new vegetation also decompose and release nitrogen-containing substances, allowing soil nitrogen to accumulate gradually.

b(ii); original allocation: 3 mark(s)

In year 2, there are 17 herbaceous species but only 2 woody species. After soil nitrogen recovers, the number of woody species increases to 9 by year 20.

Early soil nitrogen is low. Herbaceous plants generally have lower nutrient requirements and can establish more readily under these conditions, while woody growth is more restricted. As nitrogen rises from 1 to 3 mg g^{-1}, more woody plants can grow, increasing the number of species from 2 to 9. This explains species composition; do not confuse species number with individual abundance.

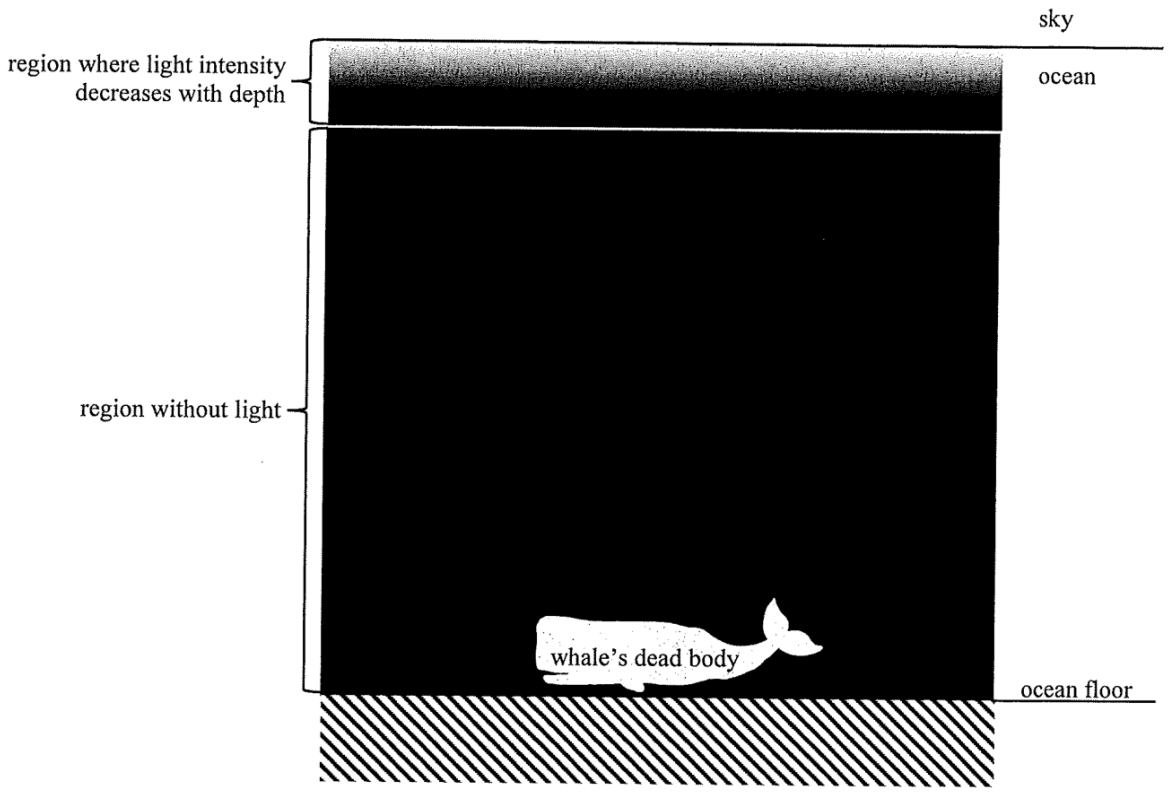
Examiner's comment (source page(s) 5, 6)

Explain recovery of soil nitrogen through decomposition of organic matter and nitrogen fixation, rather than indiscriminately listing every nitrogen-cycle process. More woody species and a lower proportion of herbaceous plants merely describe the data. Improved soil conditions and later competition through shading are needed to explain succession.

Marking reference: HKDSE Biology 2019 Paper 1B Q7, official marking scheme, source page(s) 3, 4.

Example 4 [HKDSE Biology 2023 Paper 1B Q8]

When whales die, their dead bodies sink to the bottom of the ocean. The whale carcasses support a unique community known as whale fall community. The diagram below shows different regions of the ocean and the location of a whale's dead body:

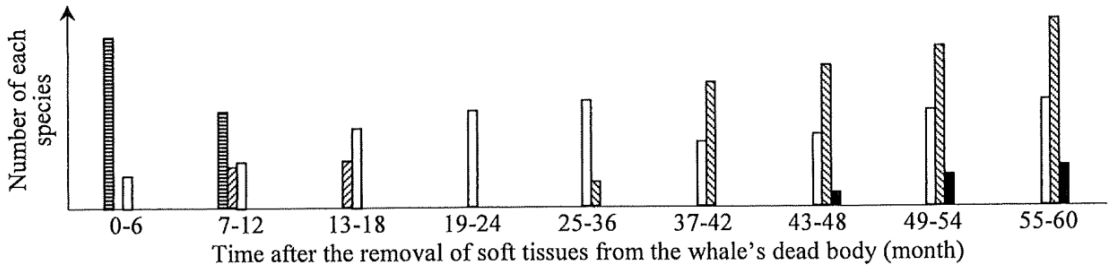


(a) (i) With reference to the energy flow in the ecosystem, what is the ultimate source of the energy stored inside the whale's dead body? (1 mark)

(ii) With reference to the above diagram, explain the importance of the whale's dead body to the whale fall community on the ocean floor. (2 marks)

(b) What is the role of the organisms that feed on the soft tissues of the whale's dead body in the cycling of materials? (1 mark)

(c) After the soft tissues of the whale's dead body have been consumed, another group of organisms start to feed on the remaining nutrients from the skeleton. For an average-sized whale, it could have 2 000 – 3 000 kg lipid stored inside its skeleton. The bar chart below shows the abundance of different species that feed on the skeleton of the whale over time:



Key:

- species P
- species Q
- species R
- species S
- species T

Complete the following table with evidence from the bar chart to support that the above case is an example of ecological succession. (4 marks)

Characteristics of ecological succession	Evidence from the bar chart
(i)	
(ii)	

Solution a(i); original allocation: 1 mark(s)

Light energy from the Sun.

Organic substances in the whale originate from a food chain. Producers near the sea surface first fix solar energy through photosynthesis, and feeding transfers it through successive levels into whale tissues. The ultimate source is therefore the Sun.

Method: Identify remaining soil and organisms, then trace replacement.

a(ii); original allocation: 2 mark(s)

There is no light at the seabed, so the local community cannot rely on photosynthetic producers. The whale carcass supplies large quantities of stored organic matter and energy, supporting the whale-fall community.

The diagram places the carcass in the aphotic zone. Energy originally fixed by photosynthesis in upper waters and accumulated through the food chain reaches the seabed with the sinking carcass. Local organisms can use this food without photosynthesis occurring locally.

b; original allocation: 1 mark(s)

They help decompose organic matter, recycling its materials into reusable inorganic substances.

Feeding and subsequent decomposition and metabolism gradually convert the carcass's organic matter back into carbon dioxide, water and inorganic nitrogen-containing substances, promoting material cycling. The answer concerns their decomposing role in material recycling.

c(i); original allocation: 2 mark(s)

The dominant species is replaced over time: P dominates during months 0–12, R during months 13–36 and S during months 37–60.

Find the tallest bar in each interval to identify successive dominant species. The community is not a fixed set of species surviving in unchanged proportions. This directional replacement of dominance is evidence of succession.

c(ii); original allocation: 2 mark(s)

Community species composition changes: P and R occur during months 0–6, Q is added during months 7–12, and S and T appear later while P and Q disappear.

Examine not only bar heights but also which species appear or disappear. As available resources and the habitat at the carcass change, the suitable combination of organisms changes. This is another line of evidence for succession, distinct from replacement of the dominant species.

Examiner's comment (source page(s) 6)

Trace the ultimate energy source to the Sun; chemical energy in the carcass is only an intermediate storage form. Answers about succession must pair a specific feature with bar-chart evidence. Merely stating that new species appear is insufficient.

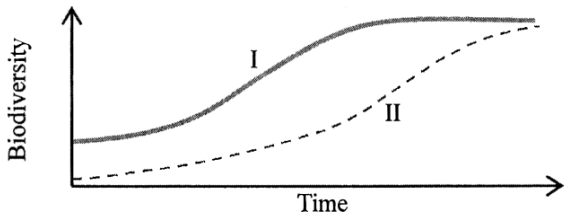
Marking reference: HKDSE Biology 2023 Paper 1B Q8, official marking scheme, source page(s) 6, 7.

Practice

1. [HKDSE Biology 2017 Paper 1A Q12]

Hint: Identify remaining soil and organisms, then trace replacement.

The following graph shows the predicted change in biodiversity during the processes of primary and secondary succession in an ecosystem:



Which of the following combinations is correct?

	Type of succession	*Explanation*
A.	I is primary succession.	A climax community is reached in I.
B.	I is secondary succession.	I has a higher biodiversity than II at the beginning.
C.	II is primary succession.	Pioneer community is involved in II.
D.	II is secondary succession.	II shows a slow increase in biodiversity.

2. [HKDSE Biology 2021 Paper 1A Q32]
Hint: Identify remaining soil and organisms, then trace replacement.

During primary succession in a terrestrial habitat, which of the following descriptions about the ecosystem is ***incorrect***?

A. The nutrient level of the soil decreases.
B. The complexity of the food web increases.
C. The abundance of non-vascular plants decreases.
D. The energy available to the community increases.

3. [HKDSE Biology Sample Paper Paper 1A Q24]
Hint: Identify remaining soil and organisms, then trace replacement.

Which of the following is an example of primary succession?

A. succession occurring on an abandoned farmland
B. succession after a volcanic eruption
C. succession after deforestation
D. succession after a flood

4. [HKDSE Biology 2019 Paper 1B Q8]
Hint: Identify remaining soil and organisms, then trace replacement.

(a) Bats are night-time animals. The mystery of how bats avoid obstacles in darkness has puzzled scientists for centuries. Below shows some major events in the research on how bats use ultrasound to navigate as they fly:

Time	Scientist	Event
Late 18th Century	Spallanzani	He noted that blind bats could avoid obstacles.
	Jurine	He plugged the ears of bats with wax; the bats collided with obstacles.
Next 140 years	Various scientists	Despite the work of Spallanzani and Jurine, scientists continued to explore the possible use of other senses for navigation in bats.
1930s	Pierce	He developed an apparatus that could detect ultrasound.
1938	Griffin	He used Pierce's apparatus to show that bats emitted ultrasound.
	Griffin and Galambos	They worked out how bats used the ultrasound they produced in navigation.

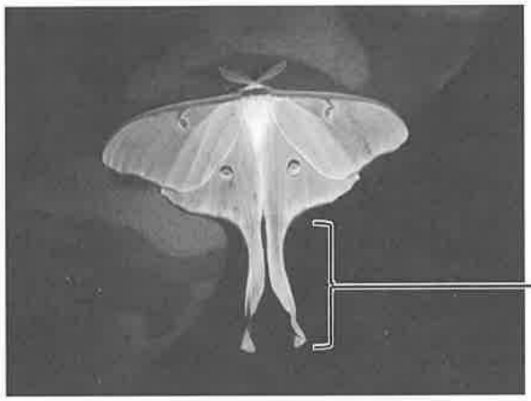
(i) With regard to the observation of Spallanzani, what conclusion can you draw about bats' ability to avoid obstacles? (1 mark)

(ii) Below are some aspects of the nature of science which can be demonstrated by the discovery of ultrasound navigation of bats. Choose any ***two*** aspects of nature of science and elaborate on how these are demonstrated in the above events. (2 marks)
(Note: Only the first two will be marked if you give more than two aspects.)

Nature of Science	Elaboration
Science is based on evidence from experiments	
Scientists build on the work of other scientists	

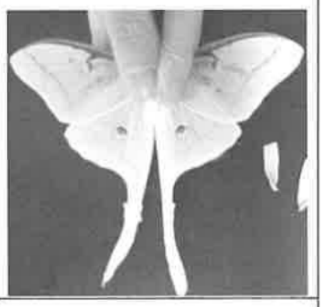
Technology has impacts on the development of science	

(b) Bats prey on moths. The photograph below shows a type of moth which has long wing tails:



After the discovery of ultrasound navigation in bats, scientists hypothesised that the wing tails of the moths may disturb the ultrasound emitted by bats and thus help moths to escape from a bat attack.

To test this hypothesis, scientists manipulated the wing tail length of the moths and then determined their rate of successful escape from bat attacks. The treatments of the wing tails and the results are shown below:

Treatment of wing tails	A: No treatment	B: Cut and glued back	C: Cut	D: Elongated
				
Wing tail length (cm)	5	5	2	6
Successful rate of escape (%)	57	57	26	65

(i) What can you conclude from the results of treatment A and B? What is the purpose of treatment B in the experimental design of this study? (2 marks)

Treatment	Conclusion
A and C	
A and D	

(iii) What is the overall conclusion of this study? (1 mark)

(c) With reference to the hypothesis stated in (b), describe how the long wing tail could have evolved in the moths. (4 marks)

Chapter 10

Health and disease: question types and practice

IV.a Personal health

First read the explanations and diagrams in Concept IV.a, then work through the question types in this section. Each worked example retains the complete original question and explanation. The subsequent exercises require progressively more integration of information, based on the demands of the whole question.

Type 1 Evaluate diet, exercise and health risks using data

Degree of integration ★★★☆☆

Key ideas

① Two people eating the same food need not have the same risk; genetic predisposition, activity and other lifestyle factors may differ. Dietary comparisons must control other conditions such as total energy. An observed association between diet and disease alone does not establish causation.

② Evaluate health in terms of nutritional adequacy, energy balance and the population to which the evidence applies.

How to recognise the problem State what the data actually compare, then propose the corresponding physiological mechanism. Assess controls, grouping, other variables and the scope of conclusions.

Example 1 [HKDSE Biology 2015 Paper 1A Q34]

Directions: Questions 34 and 35 refer to the list of factors shown below.

(1) Smoking
(2) Family history
(3) Overweight
(4) Radiation

Which of the above factors can be controlled by lifestyle adjustment?

A. (1) and (3) only
B. (2) and (4) only
C. (1), (2) and (3) only
D. (1), (3) and (4) only

Solution Answer: D

Stopping smoking, adjusting diet and activity to control body weight, and avoiding unnecessary radiation exposure can all reduce risk through behavioural or lifestyle changes. Family history is the existing history of disease among relatives; lifestyle changes cannot erase it. Therefore, the choices are (1), (3) and (4), giving D.

Method: State the comparison, then explain its mechanism and limits.

Marking reference: HKDSE Biology 2015 Paper 1A Q34, official marking scheme, source page(s) 1.

Example 2 [HKDSE Biology 2016 Paper 1B Q6]

(a) Kitty and Karen are identical twins. Kitty has preferred meats to vegetables in her diet since her childhood. Kitty suffered from colon cancer at age 35 while Karen had the same disease 10 years later.

(i) Why did both sisters suffer from colon cancer? (1 mark)

(ii) Why did the disease occur at different ages? (1 mark)

(b) Give *two* other lifestyles that increase the risk of suffering from cancer. (2 marks)

Solution (a)(i); original allocation: 1 mark(s)

Method: State the comparison, then explain its mechanism and limits.

Identical twin sisters have the same genetic constitution and therefore the same genetic susceptibility.

Identical twins develop from the same zygote and have extremely similar genetic constitutions compared with non-identical twins. If a genetic variant increases colorectal cancer risk, both may carry it. This explains their shared risk, not a certainty that someone with the relevant genes will develop cancer.

(a)(ii); original allocation: 1 mark(s)

Kit Ting's preference for meat and low vegetable intake may have contributed to the earlier onset of disease.

Genes confer susceptibility, while lifestyle can also affect the risk and timing of cancer development. The question specifically provides a dietary difference, so connect it to age at onset. This case alone does not prove that one food was necessarily the sole cause.

(b); original allocation: 2 mark(s)

Smoking; excessive alcohol consumption.

Give two distinct lifestyle factors, each worth 1 mark. Lack of exercise is another acceptable example. Do not count 'smoking tobacco' and 'smoking cigarettes' separately, or classify inherited family factors outside a person's choice as lifestyle.

Examiner's comment (source page(s) 3)

Identical twin sisters share the same genetic constitution, so different ages at onset suggest the influence of factors beyond genes. Link lifestyle factors to the actual mechanism of disease.

Marking reference: HKDSE Biology 2016 Paper 1B Q6, official marking scheme, source page(s) 3.

Example 3 [HKDSE Biology 2022 Paper 1B Q11]

You are required to present your answer to the following question in essay form. Criteria for marking will include relevant content, logical presentation and clarity of expression.

Recently, the use of the ketogenic diet for achieving weight loss is becoming popular. In fact, this high-fat, moderate-protein and very-low-carbohydrate diet has been used as an approach to control the blood glucose level in diabetics. However, the effectiveness of this diet in achieving weight loss is still controversial.

Describe how a ketogenic diet can be used to control the blood glucose level in diabetics. Evaluate the possibility of using this diet for weight loss and discuss the health concerns of adopting such a diet for healthy persons. (12 marks)

Solution Essay; original allocation: 12 mark(s)

Method: State the comparison, then explain its mechanism and limits.

Low carbohydrate intake can reduce glucose entering the blood after meals. Weight loss still depends on an overall energy deficit. High fat intake and inadequate glucose and glycogen supplies can have health costs.

A ketogenic diet contains very little carbohydrate. Less glucose is produced from carbohydrate digestion, so less glucose is absorbed from the small intestine into the blood after a meal and the rise in blood glucose is smaller. People with diabetes have insufficient insulin secretion or an inadequate response to insulin in target cells, making it difficult to return elevated post-meal glucose rapidly to normal. Reducing glucose input can help maintain blood glucose at a more manageable level.

The basic requirement for weight loss remains that daily energy intake is below energy expenditure. When carbohydrate is scarce, the body first uses stored glycogen. As glycogen becomes insufficient, fat use for energy increases, so a ketogenic diet may promote body-fat use. However, eating less carbohydrate does not itself mean taking in less energy: fat supplies more energy per gram than carbohydrate or protein, and this diet has a high fat proportion. If total energy intake still exceeds expenditure, weight loss cannot be guaranteed.

In terms of health, a high-fat diet containing more saturated fat, for example, may raise blood lipid and cholesterol levels and increase the risk of arterial blockage and cardiovascular disease. Very low carbohydrate intake may also reduce glucose supply and glycogen reserves, causing fatigue or affecting activities requiring a steady energy supply. Evaluation should therefore consider reduced glucose input, overall energy balance and health costs of the dietary composition together. Its effects cannot be judged solely by whether ketosis occurs.

Examiner's comment (source page(s) 7, 8)

Low carbohydrate intake does not guarantee low total energy intake. Evaluating weight loss requires consideration of both the high energy content of fat and use of the body's energy reserves. Dietary fibre differs from digestible carbohydrate, so a low-carbohydrate diet does not automatically imply insufficient fibre.

Marking reference: HKDSE Biology 2022 Paper 1B Q11, official marking scheme, source page(s) 7, 8.

Practice

1. [HKDSE Biology 2015 Paper 1A Q35]

⟵ *Hint: State the comparison, then explain its mechanism and limits.*

Directions: Questions 34 and 35 refer to the list of factors shown below.

(1) Smoking
(2) Family history
(3) Overweight
(4) Radiation

Which of the above are risk factors for coronary heart disease?

A. (1) and (3) only
B. (1), (2) and (3) only
C. (1), (2) and (4) only
D. (2), (3) and (4) only

2. [HKDSE Biology Sample Paper Paper 1A Q18]

⟵ *Hint: State the comparison, then explain its mechanism and limits.*

Of the following groups of people, which group may have the highest risk of liver cancer?

A. people suffering from alcoholism
B. people suffering from diabetes
C. people with smoking habits
D. people with weight problems

3. [HKDSE Biology Practice Paper Paper 1A Q36]

⟵ *Hint: State the comparison, then explain its mechanism and limits.*

Directions: Questions 35 and 36 refer to the following description of an experiment, which was carried out in the 1880s by a scientist, Christiaan Eijkman, for identifying the cause of the disease beriberi:

Group	Experimental conditions	Result after 5 weeks
I	chickens with beriberi and healthy chickens kept together; fed with unpolished rice	chickens with beriberi recovered, others remained healthy
II	healthy chickens injected with bacteria taken from chickens with beriberi; fed with unpolished rice	all chickens remained healthy
III	healthy chickens; fed with polished rice	all chickens developed beriberi
IV	healthy chickens; fed with unpolished rice	all chickens remained healthy

In light of the results of this experiment, Eijkman used prisoners for testing whether the same cause led to beriberi in humans. Which of the following should have been included in the experimental design so that he could make a valid conclusion?

(1) The test should have been performed on healthy prisoners.
(2) The controlled variables should have included the sex, age and body mass of the prisoners.
(3) The prisoners chosen for the test should have been randomly assigned to the experimental and control groups.

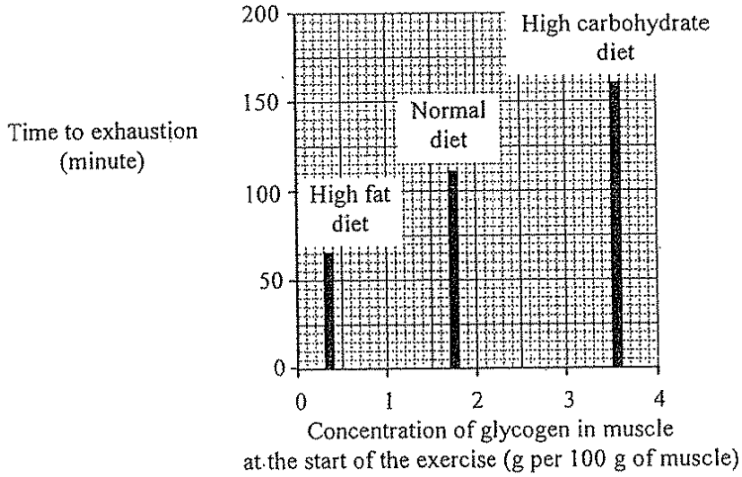
A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

END OF SECTION A

Go on to Question-Answer Book B for questions on Section B

4. [HKDSE Biology Sample Paper Paper 1A Q10]
Hint: State the comparison, then explain its mechanism and limits.

Directions: Questions 10 and 11 refer to an investigation to study the effect of diet on the performance of athletes. Three groups of athletes were each fed on a different diet for three days. The concentration of glycogen in their leg muscles was then measured. The athletes then exercised on a cycling machine at maximum level until they were exhausted. The results of the investigation are shown in the bar chart below:

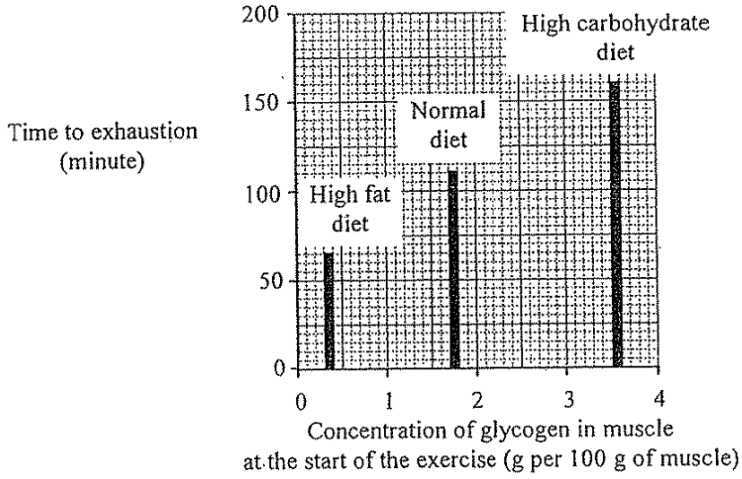


In order to make a valid comparison of the investigation results, the amount of proteins, vitamins and minerals in the diets have to be the same. Apart from these substances, what other parameter of the diets has to be identical?

A. mass of the food intake
B. water content of the diet
C. energy content of the diet
D. proportion of dietary fibre in the diet

5. [HKDSE Biology Sample Paper Paper 1A Q11]
⟵ Hint: State the comparison, then explain its mechanism and limits.

Directions: Questions 10 and 11 refer to an investigation to study the effect of diet on the performance of athletes. Three groups of athletes were each fed on a different diet for three days. The concentration of glycogen in their leg muscles was then measured. The athletes then exercised on a cycling machine at maximum level until they were exhausted. The results of the investigation are shown in the bar chart below:

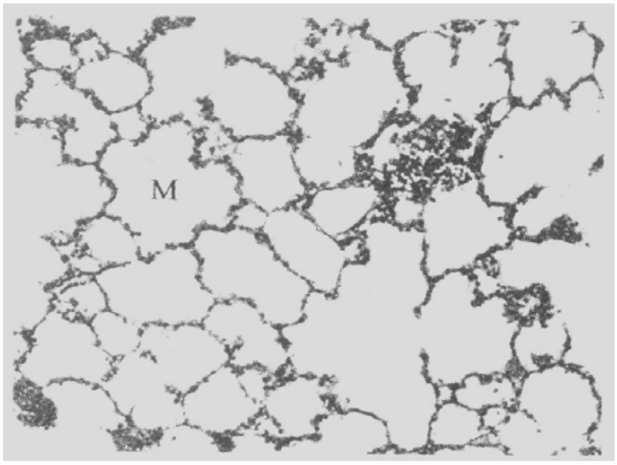


With reference to the bar chart, what conclusion can be drawn from the results of the investigation?

A. A high-fat diet has a higher energy content than a high-carbohydrate diet.
B. The amount of fat stored in the leg muscles is smaller than the amount of glycogen stored.
C. The leg muscles undergo anaerobic respiration more readily when the athletes have a high-fat diet.
D. The more the glycogen stored, the longer the athlete can carry out vigorous exercise.

6. [HKDSE Biology Sample Paper Paper 1A Q17]
⟵ Hint: State the comparison, then explain its mechanism and limits.

Directions: Questions 15 to 17 refers to the photomicrograph below which shows a section of the human lung:



What is the long-term effect of cigarette smoking on structure M?

A. The size of structure M decreases.
B. The number of structure M decreases.
C. The wall of structure M becomes more folded.
D. The lumen of structure M becomes filled with blood.

7. [HKDSE Biology 2014 Paper 1B Q11]
Hint: State the comparison, then explain its mechanism and limits.

For the following question, candidates are required to present their answer in essay form. Criteria for marking will include relevant content, logical presentation and clarity of expression.

Recently, some people have adopted a diet rich in lean meat in order to lose weight and build muscle. They may be able to achieve these aims but there are some health problems associated with this diet. Discuss the pros and cons of this controversial diet with regard to the nutritional needs of our body and protein metabolism. (12 marks)

8. [HKDSE Biology 2014 Paper 1B Q9]
Hint: State the comparison, then explain its mechanism and limits.

Table I shows the number of deaths in Hong Kong caused by certain diseases. The deaths are categorised according to sex and age.

Table I

Cause of death	Sex	Age Group						
		All ages	0	1-4	5-14	15-44	45-64	≥65
Heart disease	Male	3352	1	2	2	104	679	2564
	Female	2981	2	2	0	20	146	2811
Diabetes mellitus	Male	213	0	0	0	2	43	168
	Female	246	0	0	0	10	19	217
Colon cancer	Male	725	0	0	0	16	177	532
	Female	627	0	0	0	8	131	488

(a) Rank the diseases in the descending order of mortality (death rate). (1 mark)

(b) From the data above, generalize a trend of mortality that is exhibited by all the diseases. (1 mark)

(c) Table II shows the relative proportions of males and females in the above table who had particular lifestyles:

Table II

Lifestyle	Male	Female
Smoking daily	78.9%	21.1%
Never smoked	36.9%	63.1%
≥4 servings of processed meat per week	57.7%	42.3%

For the following diseases, explain how these lifestyles of the males and females are related to the number of deaths in Table I.

Heart disease: (3 marks)

Colon cancer: (3 marks)

9. [HKDSE Biology 2023 Paper 1B Q10]
Hint: State the comparison, then explain its mechanism and limits.

Cassava is a crop which grows in areas with poor soil and a low rainfall. It produces starchy root tubers which serve as a major food source in Africa.

(a) Give the location(s) where the chemical digestion of starch takes place in the human digestive tract. (1 mark)

(b) Table I below shows some nutritional information of cassava while Table II lists the daily energy and protein requirements recommended for boys at age 16:

Table I

Fresh weight (g) from which 100 g dry weight is yielded	250
Energy (kJ per 100 g dry weight)	2 675
Protein (g per 100 g dry weight)	3.5

Table II

	Daily requirement
Energy (kJ)	11 100
Protein (g)	52

In Africa, some low-income families may rely only on cassava for food for a long period.

(i) A 16-year-old boy relies only on cassava for food. Calculate the fresh weight of cassava he needs to consume so as to meet the recommended daily energy requirement. (1 mark)

(ii) After consuming cassava only for a period of time, this boy develops swollen feet due to the accumulation of tissue fluid.

(1) How much protein can he obtain from the amount of cassava consumed in (i)? (1 mark)

(2) According to Table II, predict the difference of the blood protein level of this boy when compared with that of normal healthy boys of the same age. Explain your answer. (2 marks)

(3) Based on your answer in (2), explain why this would lead to the accumulation of tissue fluid in his feet. (2 marks)

(ii) A man accidentally consumed some raw cassava. How will his blood lactate level change? Explain your answer. (3 marks)

IV.b Diseases and prevention

First read the explanations and diagrams in Concept IV.b, then work through the question types in this section. Each worked example retains the complete original question and explanation. The subsequent exercises require progressively more integration of information, based on the demands of the whole question.

Type 1 Choose prevention and control measures from transmission routes

Degree of integration ★★☆☆☆

Key ideas

① A pathogen must reach a susceptible person from its source. Mosquito-vector control can reduce breeding sites or opportunities for bites; safe drinking water targets a different route.

② Antibiotics act against suitable bacteria. Influenza being infectious does not mean that antibiotics directly kill its virus. Genetic disease differs from pathogen transmission, and improved hygiene cannot prevent every disease.

③ In the comparable inhibition tests specified in the questions, antibiotics diffuse outwards from filter-paper discs. Clear zones show where bacterial growth is inhibited. Compare zone sizes while considering disc size, culture conditions, bacterial species and drug diffusion. Absence of a clear zone shows only that inhibition was not observed under those test conditions.

④ If prolonged drug use increases resistance, explain pre-existing or newly arising heritable differences, selective survival, transmission through reproduction and an increased resistant proportion. This connects to the natural-selection method in II.c.

How to recognise the problem Identify the cause, pathogen and vector, then state which transmission step a measure interrupts. For inhibition tests, check comparability. For resistance, connect heritable variation, selection and reproduction over generations.

Example 1 [HKDSE Biology Practice Paper Paper 1B Q1]

For each of the infectious diseases listed in Column 1, select **one** of the methods listed in Column 2 that helps to protect people from contracting the disease. Put the appropriate letter in the space provided. (2 marks)

Column 1		Column 2
Cholera	.....	A. using serving chopsticks and spoons at meal times
		B. boiling water before drinking
Dengue fever	.....	C. wrapping up rubbish properly before disposal
		D. wearing a face mask in crowded places
		E. getting rid of stagnant water

Solution **Matching; original allocation: 2 mark(s)**

Cholera: B, boil water before drinking. Dengue fever: E, remove stagnant water.

Cholera can spread through contaminated drinking water; boiling kills the pathogens. Dengue is mosquito-borne; removing stagnant water reduces mosquito larval breeding. The measures target different links in transmission.

Method: Identify the target, then state which step the control measure interrupts.

Marking reference: HKDSE Biology Practice Paper Paper 1B Q1, official marking scheme, source page(s) 4.

Example 2 [HKDSE Biology 2012 Paper 1B Q2]

Dengue Fever is a vector borne disease transmitted by mosquitoes. The table below shows two methods adopted by the Government to break the transmission link of this disease. Complete the table below to show how each method works and comment on its advantage ***or*** disadvantage. (4 marks)

Method	*How it works*	*Comment (advantage or disadvantage)*
Spraying of pesticides or larvicidal oil around mosquito's habitat		
Clearance of accumulated water in a neighbourhood		

Solution **Insecticide / oil; original allocation: 2 mark(s)**

Kill mosquitoes or their larvae to reduce the vector population. This can reduce mosquito numbers quickly, but insecticides may pollute the environment or select for resistant mosquitoes.

Method: Identify the target, then state which step the control measure interrupts.

Dengue is transmitted by mosquitoes, so mosquito control can interrupt pathogen transmission from one host to another. Award 1 mark for the mechanism and 1 for a relevant advantage or disadvantage. If using an oil film, explain that it prevents aquatic larvae from breathing at the water surface. Do not claim that oil directly kills all viruses.

Removing stagnant water; original allocation: 2 mark(s)

Remove mosquito breeding sites so that mosquitoes cannot lay eggs and complete larval development in that water. This avoids adding pollutants, although removing every source of stagnant water is difficult in practice.

The method targets the mosquito life cycle: aquatic larvae lack suitable habitats, reducing the source of adult mosquitoes. Award 1 mark for the mechanism and 1 for an appropriate advantage or limitation.

Examiner's comment (source page(s) 1)

Explain the control method's mechanism and evaluate advantages and disadvantages. Merely repeating how to spray insecticide or remove stagnant water is insufficient.

Marking reference: HKDSE Biology 2012 Paper 1B Q2, official marking scheme, source page(s) 2.

Example 3 [HKDSE Biology Sample Paper Paper 1B Q10]

Influenza (abbreviated flu) is a common infection of the respiratory tract. The pathogens that cause flu are divided into types A, B and C. Each type differs slightly with regard to the antigens carried on the surface of the pathogens. In Hong Kong, the common types of flu are types A and B. If infected, most healthy people will recover by themselves within a week. Antibiotics are not recommended for treating flu. For protection against flu, people can have a vaccination before the onset of the flu season. Each year, the World Health Organization (WHO) will review the composition of the flu vaccines and recommend the type of flu vaccines to be used in the coming flu season.

(a) How is flu transmitted? (1 mark)

(b) Give ***two*** reasons why antibiotics are not recommended for treating flu. (2 marks)

(c) Suggest why the composition of the flu vaccines has to be reviewed each year. (2 marks)

(d) In a class of students, one of them got flu. Some of his neighbouring classmates became infected while some did not. Besides vaccination, suggest ***two*** other reasons why some of his neighbouring classmates were not infected by flu. (2 marks)

Solution a; original allocation: 1 mark(s)

Through respiratory droplets or airborne particles carrying influenza virus.

An infected person can release virus-containing respiratory secretions into the air when breathing, speaking, coughing or sneezing. Others may become infected after inhaling them. Since the question asks for a route, explain how the virus passes from one person to another, not merely proximity to a patient.

Method: Identify the target, then state which step the control measure interrupts.

b; original allocation: 2 mark(s)

Influenza is caused by a virus, which antibiotics cannot directly eliminate. Inappropriate antibiotic use also increases the chance of selecting antibiotic-resistant bacteria.

Antibiotics commonly target bacterial cell walls, ribosomes or metabolic pathways. Viruses lack the same independent cellular structures and metabolism, so antibiotics cannot directly

treat the virus itself. During antibiotic use, susceptible bacteria are inhibited, while bacteria already resistant or acquiring resistance genes are more likely to survive and reproduce. Do not say that influenza viruses consequently become antibiotic-resistant bacteria.

c; original allocation: 2 mark(s)

Influenza viruses can mutate, changing their surface antigens. The strains circulating in different seasons also vary, so vaccine antigens must be reviewed against the strains expected to circulate.

Antibody–antigen binding is specific. If a new strain has differently shaped antigens, previous antibodies may recognise them less effectively, so vaccine design must take circulating strains into account. This is not because people replace all their immune cells annually or because every virus necessarily mutates on the same day.

d; original allocation: 2 mark(s)

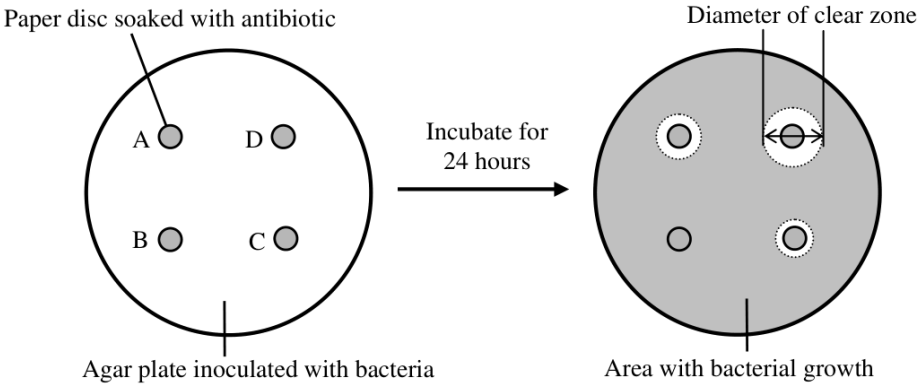
They may maintain better personal hygiene, reducing exposure to the virus, or may previously have been infected with influenza viruses bearing the same or similar antigens, giving immune memory that responds more rapidly.

Sitting nearby indicates proximity, not equal exposure to the same quantity of virus. Avoiding contact of contaminated hands with the mouth and nose can reduce exposure, while memory cells from a previous infection can accelerate the specific response. These explanations address reduced entry and faster clearance after entry, respectively. Do not use vaccination, which the question excludes.

Marking reference: HKDSE Biology Sample Paper Paper 1B Q10, official marking scheme, source page(s) 4.

Example 4 [HKDSE Biology Practice Paper Paper 1B Q6]

A test was carried out to investigate the effects of four antibiotics against a species of bacteria isolated from a patient. The bacteria were inoculated on the surface of an agar plate. Four filter-paper discs (each with a diameter of 5 mm) soaked with different antibiotics A, B, C and D were placed on the surface of the agar. The agar plate was then incubated to allow the growth of the bacteria. If bacterial growth is inhibited by an antibiotic, a clear zone surrounding the filter-paper disc soaked with the antibiotic will be observed after 24 hours. The results of the test are shown below:



The following table shows the diameter of the clear zone measured in each of the filter-paper discs:

Antibiotic	Diameter of the clear zone (mm)
A	13
B	5
C	10
D	21

(a) Explain why the agar plate should be incubated at 37 °C. (1 mark)

(b) (i) Based on the results, arrange the four antibiotics in descending order of effectiveness at inhibiting bacterial growth. (1 mark)

(ii) Explain your reasoning in determining the order in (i). (3 marks)

(c) Antibiotic B has been commonly used. It was the most effective antibiotic against the same bacteria a few years ago. Explain the result of antibiotic B in this test. (4 marks)

Solution a; original allocation: 1 mark(s)

Method: Identify the target, then state which step the control measure interrupts.

The bacteria come from the human body. Incubation at 37°C, close to body temperature, provides suitable growth conditions for these bacteria.

This explains the professional testing conditions in the question; it is not a general procedure recommended for culturing environmental bacteria in classrooms.

b(i); original allocation: 1 mark(s)

D > A > C > B.

The clear-zone diameters are 21, 13, 10 and 5 mm, respectively. B's 5 mm equals the filter-paper diameter, so there is no visible inhibition zone beyond the disc.

b(ii); original allocation: 3 mark(s)

Antibiotic diffuses outwards from the filter paper, with concentration decreasing as distance from the paper increases. A larger clear zone indicates that bacterial growth is still inhibited at a lower local concentration, so effectiveness is ranked by inhibition-zone size.

This explanation follows the question's assumption of comparable tests. Drug diffusion properties and standard concentrations also affect actual clinical interpretation. Any two unknown drugs cannot be selected for treatment solely by comparing which has the larger zone.

c; original allocation: 4 mark(s)

The bacterial population originally contained heritable variation conferring resistance to B. During prolonged use of B, susceptible bacteria were more readily inhibited or eliminated, while resistant bacteria survived and reproduced, passing resistance to their offspring. The resistant proportion increased over generations, so B now produces almost no inhibition zone.

The antibiotic is a selection pressure; it does not purposefully teach bacteria to resist it. Connect all four stages: variation, selective survival, inheritance through reproduction and an increasing proportion of resistant bacteria.

Marking reference: HKDSE Biology Practice Paper Paper 1B Q6, official marking scheme, source page(s) 5.

Practice

1. [HKDSE Biology 2013 Paper 1A Q32]

Hint: Identify the target, then state which step the control measure interrupts.

Which of the following descriptions about antibiotics is correct?

A. Antibiotics can engulf pathogens.
B. Antibiotics can be produced by fungi.
C. Antibiotics can bind to specific antigens.
D. Antibiotics can be produced by lymphocytes.

2. [HKDSE Biology 2015 Paper 1A Q33]

Hint: Identify the target, then state which step the control measure interrupts.

Directions: Questions 32 and 33 refer to the table below, which shows the results of blood tests for the presence of antigens and antibodies of hepatitis B in four individuals:

	Individual 1	Individual 2	Individual 3	Individual 4
Antigens of hepatitis B	Negative	Positive	Negative	Positive
Antibodies of hepatitis B	Negative	Negative	Positive	Positive

Hepatitis B is transmitted through

A. insects.
B. droplets.
C. body fluid.
D. skin contact.

3. [HKDSE Biology 2020 Paper 1A Q29]
Hint: Identify the target, then state which step the control measure interrupts.

Which of the following combinations of causative agents and ways of transmission of infectious diseases is correct?

	Infectious disease	*Causative agent*	*Way of transmission*
A.	cholera	virus	food
B.	cholera	bacterium	body fluid
C.	hepatitis B	virus	body fluid
D.	hepatitis B	bacterium	food

4. [HKDSE Biology Sample Paper Paper 1A Q34]
Hint: Identify the target, then state which step the control measure interrupts.

Which of the following diseases ***cannot*** be prevented by good personal hygiene?

A. cholera
B. haemophilia
C. tuberculosis
D. athlete's foot

5. [HKDSE Biology Practice Paper Paper 1A Q35]
Hint: Identify the target, then state which step the control measure interrupts.

Directions: Questions 35 and 36 refer to the following description of an experiment, which was carried out in the 1880s by a scientist, Christiaan Eijkman, for identifying the cause of the disease beriberi:

Group	Experimental conditions	Result after 5 weeks
I	chickens with beriberi and healthy chickens kept together; fed with unpolished rice	chickens with beriberi recovered, others remained healthy
II	healthy chickens injected with bacteria taken from chickens with beriberi; fed with unpolished rice	all chickens remained healthy
III	healthy chickens; fed with polished rice	all chickens developed beriberi
IV	healthy chickens; fed with unpolished rice	all chickens remained healthy

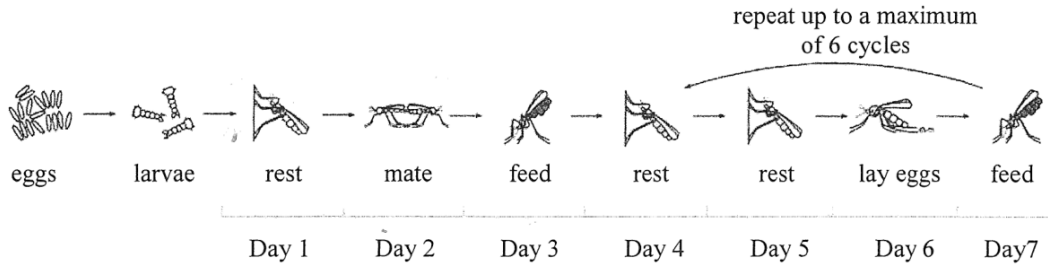
Which of the following can be concluded from this experiment?

(1) Beriberi is not caused by the bacteria taken from chickens with beriberi.
(2) Beriberi is most likely non-infectious.
(3) Eating unpolished rice can prevent beriberi in healthy chickens.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

6. [HKDSE Biology 2020 Paper 1B Q7]
Hint: Identify the target, then state which step the control measure interrupts.

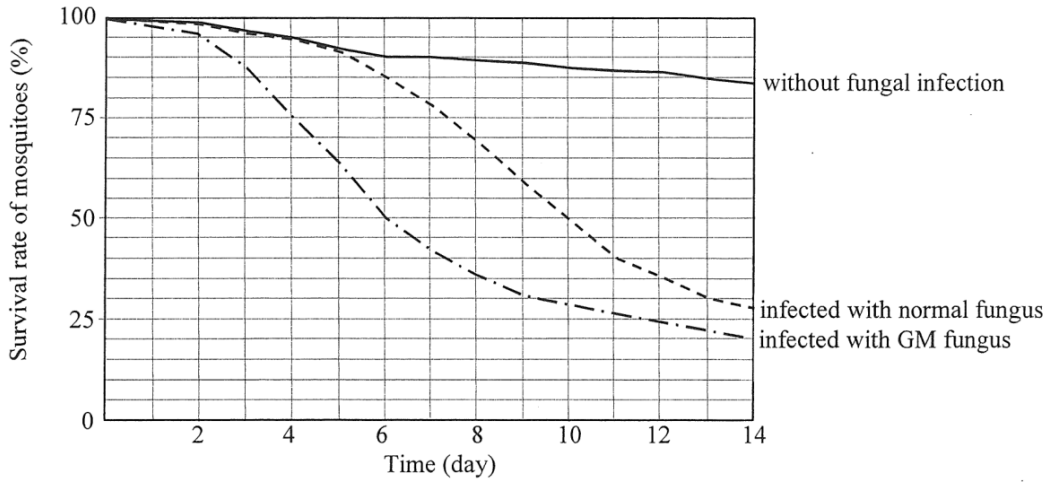
The diagram below shows the life cycle of mosquitoes:



(a) Give ***one*** example of a mosquito-borne disease. (1 mark)

(b) The Food and Environmental Hygiene Department introduced a fungal species to control the mosquito population in Hong Kong. Mosquitoes will die in a few days if they are infected with the fungus. What is the ecological relationship between mosquitoes and this fungal species? (1 mark)

(c) To make this fungal species more deadly to mosquitoes, researchers produced a genetically-modified (GM) fungus which can produce a toxin in the mosquitoes. The effectiveness of this biological control was examined by measuring the survival rate of adult mosquitoes over 14 days. The results are shown below:



(i) Using the data from the graph, complete the following table. (1 mark)

	Without fungal infection	Infected with normal fungus	Infected with GM fungus
Survival rate on Day 6 (%)			

(ii) The GM fungus but not the normal fungus was able to 'wipe out' the mosquito population after several generations. With reference to the mosquito's life cycle and the answer in (c) (i), explain this phenomenon. (3 marks)

Type 2 Connect organ damage, symptoms and disease data

Degree of integration ★★★☆☆

Key ideas

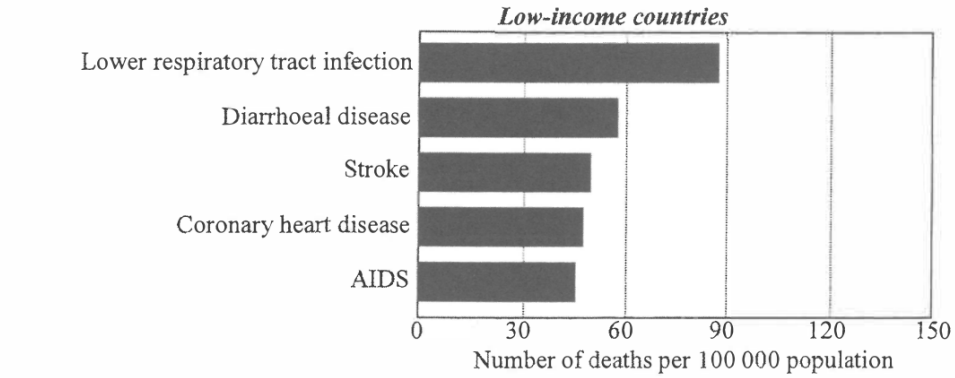
① Coronary-artery narrowing reduces blood supplied to cardiac muscle; insufficient oxygen then impairs its activity. Alveolar damage affects exchange area or diffusion distance, so oxygen deficiency requires a different explanation.

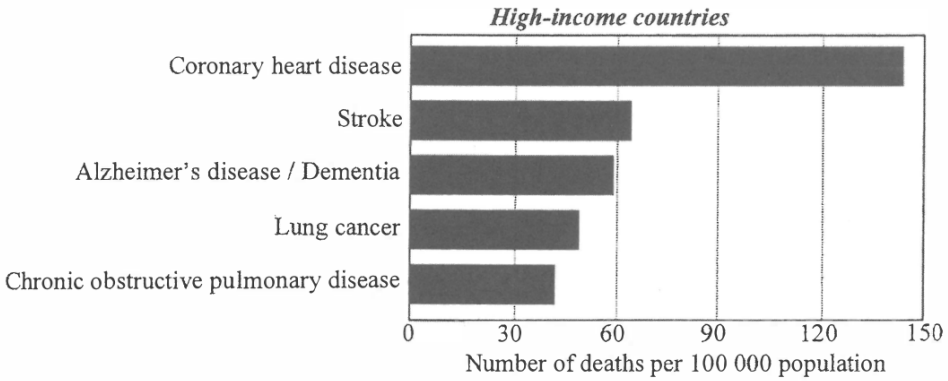
② Total death counts are not incidence rates, because population size and age structure may differ. Interpret a positive screening result according to the test's nature.

How to recognise the problem For symptoms, write structure → function → whole-body effect. For statistics, check denominator, time and population before comparing risk.

Example 1 [HKDSE Biology 2018 Paper 1B Q4]

The bar charts below show the top five diseases that caused death in low-income countries and high-income countries respectively in the year 2015:





(a) With reference to the bar charts, which countries (low-income or high-income) have more infectious diseases as the top five diseases that caused death? (1 mark)

(b) Suggest ***two*** reasons to account for the phenomenon stated in (a). (2 marks)

(c) Coronary heart disease is the top cause of death in high-income countries. Explain how ***one*** of the lifestyle habits in high-income countries is related to coronary heart disease. (4 marks)

Solution Reading the question and choosing a method

Method: Infer function from pathology, then check data denominators and populations.

Classify only the five diseases listed in each chart. Do not extend a partial ranking into a complete disease profile for the whole population.

a; original allocation: 1 mark(s)

Low-income countries.

Among their five listed conditions are infectious diseases such as lower respiratory infections, diarrhoeal diseases and AIDS. The conditions listed for high-income countries are mainly non-infectious. Thus, more of the five listed conditions in low-income countries are infectious.

b; original allocation: 2 mark(s)

Poorer public sanitation or personal hygiene can promote pathogen transmission. Insufficient healthcare resources or unaffordable treatment can prevent timely access to effective care.

The first reason connects sanitary conditions with transmission. For example, inadequate clean-water supply and sewage treatment can increase pathogen exposure. The second connects access to healthcare with disease outcomes. Limited services or unaffordable

treatment can delay care. Explain distinct pathways affecting infection or death rather than repeating poverty twice.

c; original allocation: 4 mark(s)

Prolonged excessive consumption of high-fat foods can increase the risk of lipid plaque formation in coronary arteries. Plaques narrow or block the lumen, reducing blood flow to the heart muscle. The cardiac muscle receives insufficient oxygen and respiratory substrates, impairing its normal activity and potentially causing coronary heart disease.

Choose one lifestyle factor and complete its causal chain. Here, start with a high-fat diet, then describe changes to the vessel wall, lumen and blood flow, and inadequate supply to cardiac muscle. Coronary arteries supply the heart muscle itself; they do not move blood directly from the left ventricular cavity into the muscle. Nor does every person eating high-fat foods inevitably develop disease. The question asks for a risk mechanism.

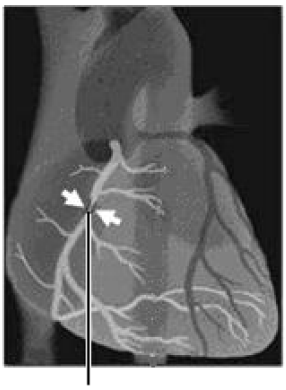
Examiner's comment (source page(s) 4)

Specify coronary arteries and cardiac muscle when explaining coronary heart disease. Merely stating blocked vessels and reduced blood supply to the heart omits the pathway supplying the muscle.

Marking reference: HKDSE Biology 2018 Paper 1B Q4, official marking scheme, source page(s) 2.

Example 2 [HKDSE Biology Practice Paper Paper 1B Q7]

Mr. Chan has been a smoker for more than 25 years. He has excessive rapid breathing and experiences chest pain during vigorous exercise. When consulting the doctor, he was advised to undertake an imaging of his heart for diagnosis. The image taken is shown below:



Narrowed artery X

(a) (i) Identify artery X. (1 mark)

(ii) Based on the condition shown in the above image, explain why Mr. Chan may suffer from a heart attack during vigorous exercise. (3 marks)

(b) The doctor advised Mr. Chan to quit smoking and to adopt a low-fat diet. With reference to Mr. Chan's health condition, give a reason for each piece of advice. (2 marks)

(i) Quitting smoking

(ii) Adopting a low-fat diet

Solution a(i); original allocation: 1 mark(s)

Coronary artery.

It runs over the heart's surface and supplies the cardiac muscle itself. It is not the pulmonary artery carrying blood from a ventricle to the lungs.

Method: Infer function from pathology, then check data denominators and populations.

a(ii); original allocation: 3 mark(s)

During vigorous exercise, cardiac workload and energy demand increase. A narrowed coronary artery limits blood flow, supplying insufficient oxygen and glucose to the heart muscle. Severe ischaemia can damage or kill some cardiac muscle cells and cause a heart attack.

Compare increased demand with restricted supply. The problem is not an absence of blood inside the heart chambers.

b(i); original allocation: 1 mark(s)

Stopping smoking reduces carbon monoxide binding to haemoglobin, improving the blood's oxygen-carrying capacity and benefiting heart muscle with an already restricted blood supply.

Connect the measure to this person's oxygen supply to cardiac muscle, rather than referring generally to lung cancer prevention.

b(ii); original allocation: 1 mark(s)

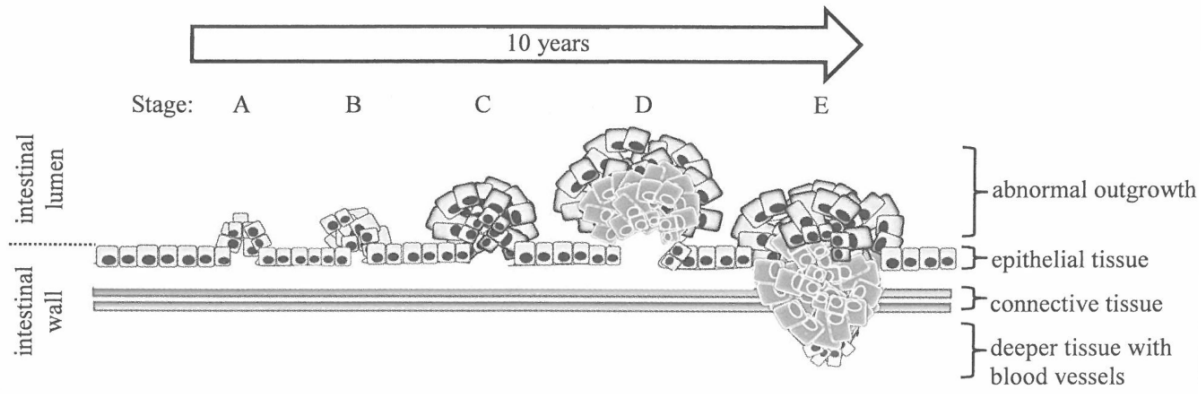
Reducing an inappropriate high-fat diet can help lower the risk of lipid deposition associated with atherosclerosis and prevent further narrowing of coronary arteries.

The original question uses the shorthand 'low fat'. The biological focus is atherosclerosis and blood supply, not an assumption that all fats are identical.

Marking reference: HKDSE Biology Practice Paper Paper 1B Q7, official marking scheme, source page(s) 5.

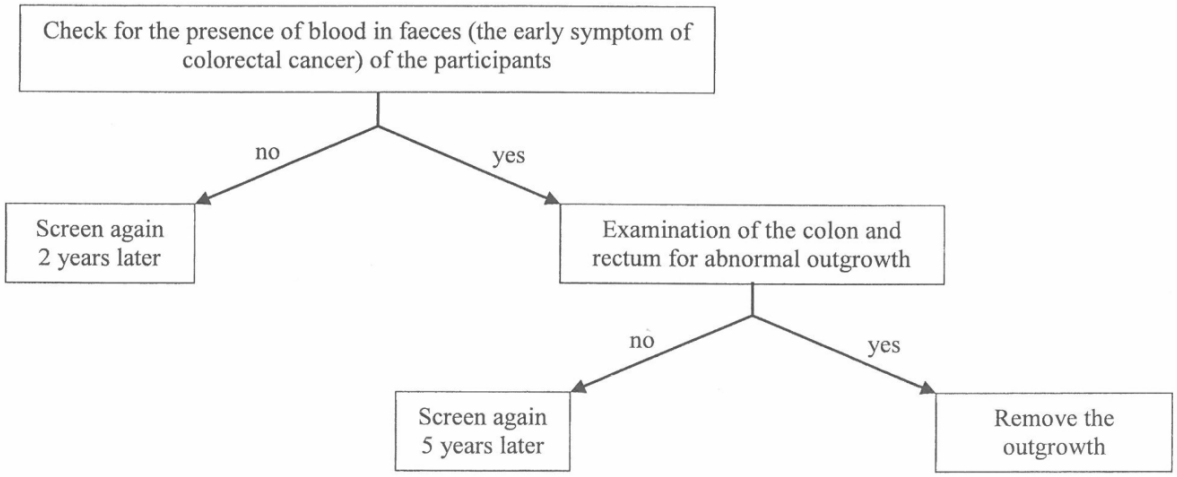
Example 3 [HKDSE Biology 2022 Paper 1B Q7]

Colorectal cancer is one of the most common cancers in Hong Kong. The schematic diagram below shows the developmental stages of colorectal cancer over time:



(a) Which stage of colorectal cancer has a high risk of spreading? Explain your answer. (2 marks)

(b) The Department of Health in Hong Kong has launched a regular screening programme for the prevention of colorectal cancer. The flowchart below illustrates the screening programme:



(i) The screening programme is recommended for people aged 50 or above. Give ***two*** reasons why this group of people is more susceptible to colorectal cancer. (2 marks)

(ii) If there is no abnormal outgrowth of the epithelium of the large intestine, the next screening can be conducted 5 years later. With reference to the developmental stages of colorectal cancer, explain this practice. (1 mark)

(iii) Recently, there is a growing trend of people diagnosed with colorectal cancer at a younger age. Suggest ***two*** eating habits which may lead to this growing trend. (2 marks)

Solution a; original allocation: 2 mark(s)

E; tumour cells have invaded deeper tissue containing blood vessels and can spread through the bloodstream.

Compare the positions from A to E. Only E clearly crosses the epithelial and connective-tissue boundary. Once cancer cells contact or enter blood vessels, they can be transported elsewhere and form metastases, giving E the highest risk of spread.

Method: Infer function from pathology, then check data denominators and populations.

b(i); original allocation: 2 mark(s)

Older people have had longer to accumulate gene mutations. Their cellular repair or immune surveillance may also be less effective.

Cancer often involves several progressively accumulated changes. With increasing age, there are more cumulative opportunities for cell division and exposure to mutagens. Reduced repair allows abnormalities to persist more readily. The two explanations concern production of abnormalities and failure to eliminate them, respectively.

b(ii); original allocation: 1 mark(s)

Progression from a small projection to a malignant stage capable of spreading usually takes many years.

The diagram gives about ten years for the whole progression. If no abnormal projection is found, a further check five years later can still detect a lesion before it reaches the high-risk stage. Explain using the development time shown.

b(iii); original allocation: 2 mark(s)

Insufficient dietary fibre; frequent consumption of large amounts of processed meat.

Insufficient fibre may prolong the time intestinal contents remain in the intestine, while processed meat can involve exposure to carcinogens. Both are dietary habits, as requested. Stress or lack of exercise are not dietary answers.

Examiner's comment (source page(s) 5)

Explain the greater susceptibility of older people through age-related accumulation of mutations or changes in repair capacity. List dietary factors only for the dietary subpart. The screening interval relates to the many years needed for progression to malignancy.

Marking reference: HKDSE Biology 2022 Paper 1B Q7, official marking scheme, source page(s) 5.

Practice

1. [HKDSE Biology 2013 Paper 1A Q34]

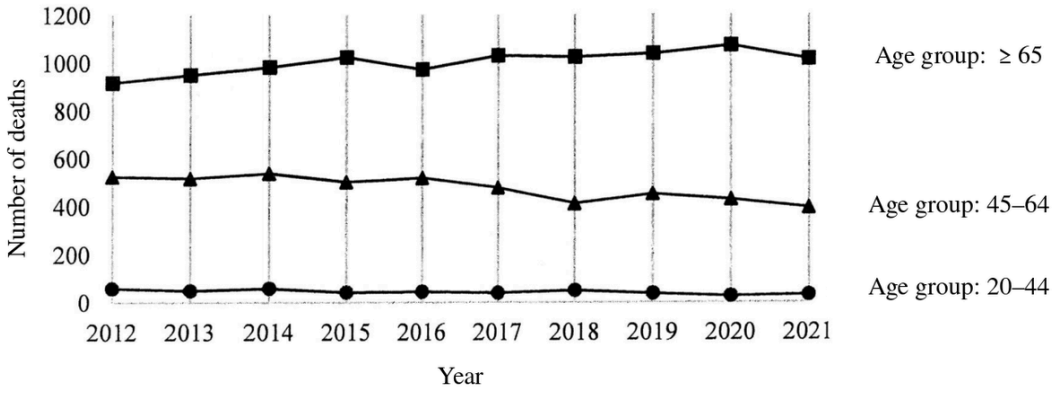
Hint: Infer function from pathology, then check data denominators and populations.

Which of the following information concerning the characteristics of insulin-dependent diabetes and non-insulin-dependent diabetes is correct?

	Insulin-dependent diabetes	***Non-insulin-dependent diabetes***
A.	accounts for the majority of diabetic cases	accounts for a small portion of diabetic cases
B.	is mainly due to an unhealthy lifestyle	is mainly due to hereditary factors
C.	requires regular injections of insulin	may be controlled through proper diet
D.	body fails to respond to insulin	body produces a low level of insulin

2. [HKDSE Biology 2025 Paper 1A Q32 (English translation)]
⟵ *Hint: Infer function from pathology, then check data denominators and populations.*

The graph below shows the numbers of deaths from liver cancer in different age groups in Hong Kong from 2012 to 2021:



Which of the following conclusions can be drawn from the graph?

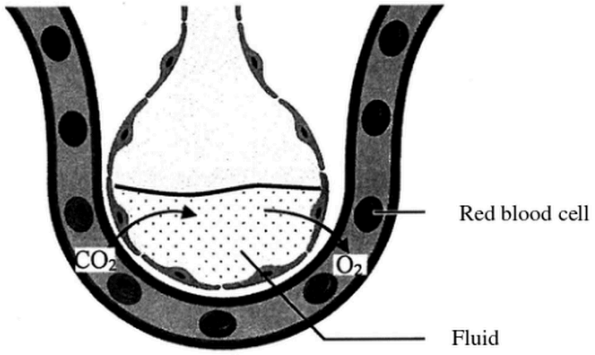
A. People under 20 do not develop liver cancer.
B. People over 45 are more susceptible to infection by viruses that cause liver cancer.
C. People over 65 have been exposed to carcinogens for a longer time.
D. Older age groups have more deaths from liver cancer.

3. [HKDSE Biology 2025 Paper 1B Q6 (English translation)]
⟵ *Hint: Infer function from pathology, then check data denominators and populations.*

Electronic cigarettes were initially regarded as a useful means of stopping conventional cigarette smoking. In fact, an electronic cigarette contains a heating device and a container holding a volatile liquid with various chemicals. The heating device vaporises the liquid into vapour that can be inhaled. The inhaled vapour passes through the respiratory tract to the lungs, damaging different parts of the respiratory tract along the way.

(a) Some chemicals in the volatile liquid have been found to damage ciliated epithelial cells in the respiratory tract. Explain how this leads to severe coughing. (2 marks)

(b) An electronic-cigarette user develops inflammation in his lungs after inhaling these chemicals. The diagram below shows an alveolus in his lungs:



(i) Explain why fluid accumulates in the inflamed alveolus. (3 marks)

(ii) Explain how the fluid accumulation affects the oxygen content of the patient's blood. (4 marks)

IV.c Body defence mechanisms

First read the explanations and diagrams in Concept IV.c, then work through the question types in this section. Each worked example retains the complete original question and explanation. The subsequent exercises require progressively more integration of information, based on the demands of the whole question.

Type 1 Connect barriers, phagocytosis and inflammation in defence

Degree of integration ★★★☆☆

Key ideas

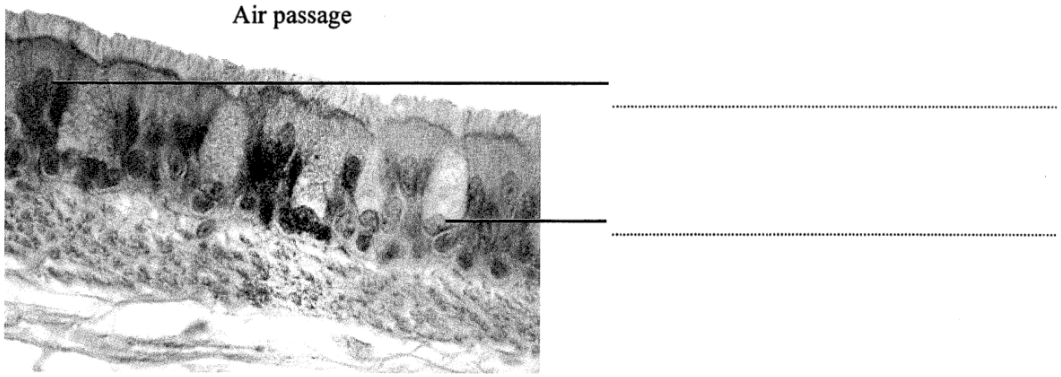
① Skin and mucous membranes first reduce pathogen entry. If tissue is damaged, inflammation changes local blood flow and permeability, allowing white blood cells to reach the infection site. Arteriolar dilation helps explain redness and warmth, while fluid entering tissues explains swelling.

② Phagocytes engulf and digest pathogens, and antibody binding can assist recognition. This does not make an antibody a type of cell.

How to recognise the problem Distinguish a surface barrier from an internal response. Give each symptom its direct mechanism rather than repeatedly stating that white blood cells increase.

Example 1 [HKDSE Biology 2014 Paper 1B Q2]

The photomicrograph below shows a section of the inner wall of the human trachea:



(x 400)

(a) In the spaces provided, label the cells shown in the photomicrograph. **(2 marks)**

(b) With reference to the features of the inner wall shown in the photomicrograph, describe how the inner wall of the trachea can protect our body against bacterial invasion. **(3 marks)**

Solution a; original allocation: 2 mark(s)

Upper: ciliated epithelial cell. Lower: mucus-secreting cell (goblet cell).

Identify them from the surface cilia and intracellular mucus in the photograph. Each earns 1 mark.

Method: Distinguish surface and internal defences, then explain their mechanisms.

b; original allocation: 3 mark(s)

Goblet cells secrete mucus, trapping inhaled bacteria. Cilia beat towards the pharynx, moving bacteria-containing mucus there to be swallowed or coughed out. Closely packed epithelial cells form a physical barrier preventing bacteria from entering internal tissues.

Connect the two cell types into a trapping-and-removal defence, then add the barrier formed by the epithelium itself. Cilia are not phagocytes and do not engulf bacteria.

Examiner's comment (source page(s) 2)

Use accurate cell names. Cilia sweep mucus towards the pharynx, after which it is swallowed or coughed out. Avoid a vague statement that cilia move material, and include the physical barrier of closely packed epithelium.

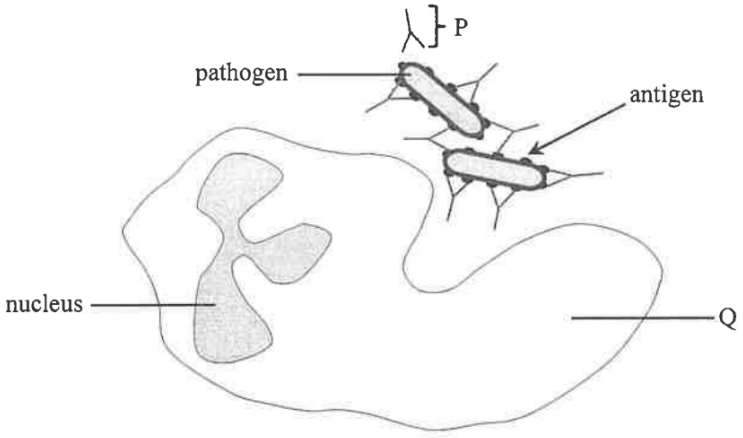
Marking reference: HKDSE Biology 2014 Paper 1B Q2, official marking scheme, source page(s) 2.

Example 2 [HKDSE Biology 2019 Paper 1B Q1]

(a) Physical and chemical barriers are the first line of defence in the human body. Select from Column II ***all*** correct example(s) that belong(s) to the two types of barriers in Column I and put the letter(s) in the spaces provided. (2 marks)

Column I		*Column II*	
(i)	physical barrier _____	A.	skin
		B.	tear
(ii)	chemical barrier _____	C.	antibody
		D.	blood clot
		E.	gastric juice

(b) The diagram below shows the process of phagocytosis. Q is a phagocyte while P is a protein molecule produced by a type of lymphocyte.



Describe the function of P in phagocytosis. (3 marks)

Solution a(i); original allocation: 1 mark(s)

A and D: skin and a blood clot.

Physical barriers prevent pathogen entry through their structure. Intact skin separates internal tissues from the surroundings, while a blood clot seals an opening at a wound.

a(ii); original allocation: 1 mark(s)

B and E: tears and gastric juice.

Tears contain lysozyme, and the acidic conditions of gastric juice can inhibit or kill many pathogens. Antibody C is a chemical substance, but it belongs to specific defence rather than the first-line chemical barriers asked for.

b; original allocation: 3 mark(s)

P is an antibody. It binds to antigens on pathogens and links several pathogens into clumps, making them easier for Q to engulf.

Antibody binding sites fit specific antigens and can link different pathogens, forming larger agglutinated clumps that facilitate ingestion and digestion by phagocyte Q. An antibody is a protein, not a cell that feeds by itself. Q performs the actual phagocytosis.

Examiner's comment (source page(s) 3)

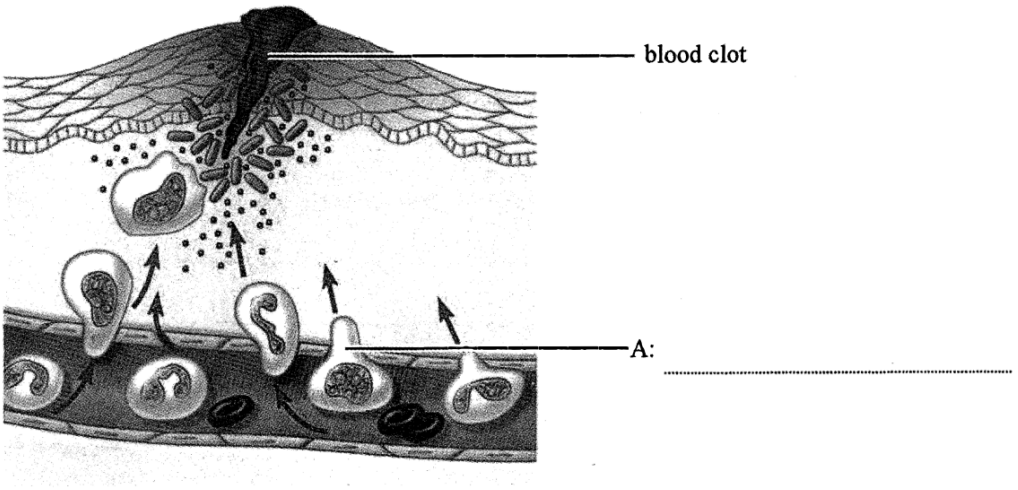
A clot covering a wound is also a physical barrier. Phagocytosis of pathogens that have already entered is not a first-line chemical barrier. P is an antibody: explain binding to pathogens, aggregation and facilitation of phagocytosis. Do not confuse antibody, antigen and pathogen.

Marking reference: HKDSE Biology 2019 Paper 1B Q1, official marking scheme, source page(s) 2.

✓ *Method: Distinguish surface and internal defences, then explain their mechanisms.*

Example 3 [HKDSE Biology 2016 Paper 1B Q7]

The diagram below shows a site of injured skin exhibiting an inflammatory response:



(a) Label the type of white blood cell represented by cell A in the above diagram. (1 mark)

(b) Explain why the tissue exhibiting the inflammatory response usually shows symptoms such as redness, swelling and pain. (3 marks)

(c) Cell A will present the antigens of the invading pathogens to the lymphocytes. Describe what will happen subsequently. (3 marks)

Solution (a); original allocation: 1 mark(s)

Phagocyte.

A moves from a blood vessel towards injured tissue and surrounds invading pathogens. Its main function is phagocytosis, so label it with the functional name 'phagocyte'.

(b); original allocation: 3 mark(s)

Arteriolar dilation increases local blood flow, causing redness. Increased capillary permeability increases tissue fluid, causing swelling. Swollen tissue stimulates or compresses nerve endings, causing pain.

For each symptom, state change → consequence → symptom. Increased blood flow explains redness; fluid filtration and accumulation explain swelling; stimulation of pain receptors explains pain. Do not replace all three explanations with a single statement about more white blood cells.

(c); original allocation: 3 mark(s)

Activated B lymphocytes differentiate and produce antibodies against the antigen. T lymphocytes help destroy infected cells. Memory cells form, allowing a faster response on reinfection.

Antigen presentation after phagocytosis links non-specific defence to an immune response directed against the pathogen. Antibodies act on the corresponding antigen, while cytotoxic T cells target infected cells. Some lymphocytes become long-lived memory cells. These are three distinct marking points.

Examiner's comment (source page(s) 3)

During inflammation, dilation of arterioles mainly increases local blood flow. Capillary walls themselves lack muscle for active dilation or contraction. Link swelling to fluid moving from blood vessels into tissues.

Marking reference: HKDSE Biology 2016 Paper 1B Q7, official marking scheme, source page(s) 3, 4.

Method: Distinguish surface and internal defences, then explain their mechanisms.

Practice

1. [HKDSE Biology 2012 Paper 1A Q36]
Hint: Distinguish surface and internal defences, then explain their mechanisms.

After injury, the wound usually becomes swollen due to

A. accumulation of bacteria at the wound.
B. accumulation of tissue fluid at the wound.
C. increased phagocytosis at the wound.
D. increased blood flow to the capillaries around the wound.

2. [HKDSE Biology 2021 Paper 1A Q24]
Hint: Distinguish surface and internal defences, then explain their mechanisms.

Which of the following types of cells can be found in the tissue fluid?

(1) B cell
(2) T cell
(3) phagocyte

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

3. [HKDSE Biology 2021 Paper 1A Q25]
Hint: Distinguish surface and internal defences, then explain their mechanisms.

Which of the following is ***not*** the first line of defence against the invasion of pathogens in humans?

A. saliva
B. sweat
C. mucus
D. lymph

4. [HKDSE Biology 2024 Paper 1A Q36]
Hint: Distinguish surface and internal defences, then explain their mechanisms.

Which of the following are examples of non-specific defence in humans?

(1) tear glands
(2) phagocytes
(3) epithelial tissue

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

5. [HKDSE Biology Practice Paper Paper 1A Q26]
Hint: Distinguish surface and internal defences, then explain their mechanisms.

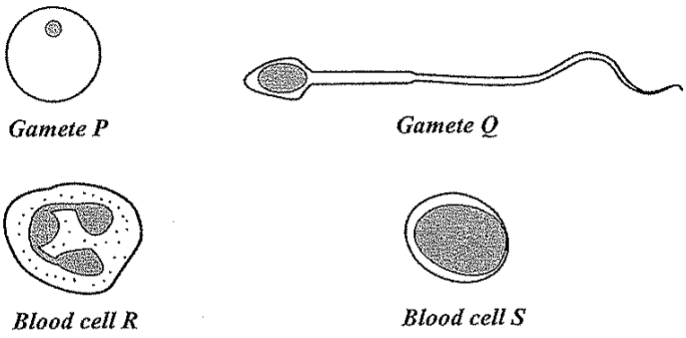
Which of the following parts of the human skin are responsible for preventing us from microbial infections?

(1) sebaceous gland
(2) epidermis
(3) hair

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

6. [HKDSE Biology Sample Paper Paper 1A Q20]
⟵ Hint: Distinguish surface and internal defences, then explain their mechanisms.

Directions: Questions 19 and 20 refer to the diagrams below, which show four different types of cells found in humans:



Key: ▒ nucleus

Which of the following comparisons between the functions of blood cells R and S is correct?

	Blood cell R	***Blood cell S***
A.	produces antitoxins	for blood clotting
B.	engulfs bacteria	for blood clotting
C.	produces antitoxins	produces antibodies
D.	engulfs bacteria	produces antibodies

7. [HKDSE Biology Sample Paper Paper 1A Q33]
⟵ Hint: Distinguish surface and internal defences, then explain their mechanisms.

When the skin is infected by bacteria, the infected area will become swollen because

A. a lot of bacteria are killed.
B. the blood capillaries dilate.
C. there is an accumulation of tissue fluid.
D. the concentration of antibodies increases.

8. [HKDSE Biology 2015 Paper 1A Q36]
⟵ Hint: Distinguish surface and internal defences, then explain their mechanisms.

Which of the following components of blood are involved in forming a blood clot?

(1) Blood platelets
(2) Red blood cells
(3) White blood cells

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

END OF SECTION A
Go on to Question-Answer Book B for questions on Section B

9. [HKDSE Biology 2025 Paper 1A Q36 (English translation)]
⟵ Hint: Distinguish surface and internal defences, then explain their mechanisms.

Directions: Refer to the table below to answer Questions 35 and 36. It shows the growth of bacterium X, which can infect human wounds, in three different media:

Medium	Time required for the number of bacteria X to double (min)	Percentage change in the amount of protein P used for respiration in bacteria X (%)	Percentage change in the amount of protein Q used for translation in bacteria X (%)
Culture medium + tea tree oil M	80	−20	−20
Culture medium + tea tree oil N	30	−5	0
Culture medium	30	0	0

To investigate the effect of tea tree oil N on wounds, people whose wounds are infected with bacteria X are divided into two groups. Their wounds are treated in different ways:

Group	Treatment	Result
I	Cover the wound with a sterile dressing coated with tea tree oil N.	No redness or swelling around the wound.
II	Cover the wound with a sterile dressing without tea tree oil N.	Redness and swelling around the wound.

Which of the following is the most likely effect of tea tree oil N on wounds?

A. It increases the permeability of capillaries near the wound.
B. It inhibits the release of histamine at the wound.
C. It kills bacteria X infecting the wound.
D. It increases blood flow to the wound.

Type 2 Explain vaccination and immune memory using antibody curves

Degree of integration ★★★☆☆

Key ideas

① After first exposure to the corresponding antigen, some lymphocytes differentiate into effector cells and memory cells also form. Re-exposure to the same antigen usually gives a faster, stronger response. Direct acquisition of antibodies can immediately provide passive protection, but does not mean the recipient has established corresponding immune memory.

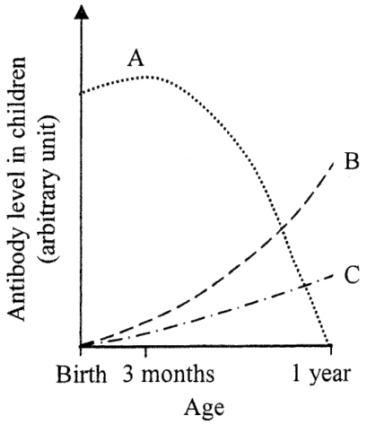
② Read the onset of the rise, peak and duration of curves rather than one isolated point.

How to recognise the problem Identify whether antibodies are externally supplied or produced by the body, then distinguish primary from secondary responses. Align a vaccine's protection threshold with the entire period requiring protection.

Example 1 [HKDSE Biology 2013 Paper 1B Q9]

(a) The following graph shows the change in levels of antibodies in children's bodies:

(A) antibodies from mother
(B) children's own antibodies with vaccination
(C) children's own antibodies without vaccination



(i) State the types of immunity resulting from A, B and C. (3 marks)

A: .....

B: .....

C: .....

(ii) Suggest ***two*** possible ways that newborns can acquire antibodies from their mother. (2 marks)

(b) Explain why children who have been vaccinated against diseases are better protected than those who have not. (4 marks)

Solution a(i); original allocation: 3 mark(s)

A: passive immunity; B: active immunity; C: active immunity.

In A, antibodies made by the mother are transferred to the infant, giving passive immunity. In B, vaccination stimulates the infant's own antibody production. In C, natural exposure to antigens stimulates its own production. B and C are both active immunity.

a(ii); original allocation: 2 mark(s)

During pregnancy, some maternal antibodies cross the placenta into the fetal blood. After birth, the infant can obtain maternal antibodies through breast milk.

These are routes before and after birth, respectively. Passive transfer supplies ready-made antibodies, not all of the mother's memory cells.

b; original allocation: 4 mark(s)

A vaccine contains antigens that stimulate formation of corresponding memory cells. On later exposure to the same antigen, memory cells proliferate rapidly and lead to production of large amounts of the corresponding antibodies. The response is faster and stronger, providing better protection.

Vaccination does more than inject a small amount of ready-made antibody: it establishes a specific response that can be activated again later. Connect four points: antigen, memory cells, re-exposure and abundant antibody production.

Method: Identify the antibody source, then align response and protection periods.

Examiner's comment (source page(s) 3)

Types of immunity and types of immune response are not the same classification. Antigen stimulation produces memory cells; do not assume that memory for a vaccine is innately present at birth.

Marking reference: HKDSE Biology 2013 Paper 1B Q9, official marking scheme, source page(s) 5.

Example 2 [HKDSE Biology 2018 Paper 1A Q10]

Which of the following statements best explains why vaccination against flu is administered annually?

A. The flu virus is constantly mutating.
B. The antibodies against flu virus only last for one year.
C. The flu vaccine is not very effective because it is made from a weakened virus.
D. When memory cells encounter the flu vaccine again, a secondary response is triggered.

Solution Reading the question and choosing a method

Method: Identify the antibody source, then align response and protection periods.

Link changes in the virus to whether existing antibodies and memory cells can recognise its antigens effectively.

Answer: A

Antibody binding is specific. The genetic material of influenza viruses can change, potentially altering their surface antigens. The existing immune response may therefore fail to recognise newly appearing antigens as effectively. This is the reason in A. Do not assign all antibodies an exact one-year period of effectiveness or claim that a vaccine must be ineffective because it uses weakened or inactivated material. Choose A.

Common error

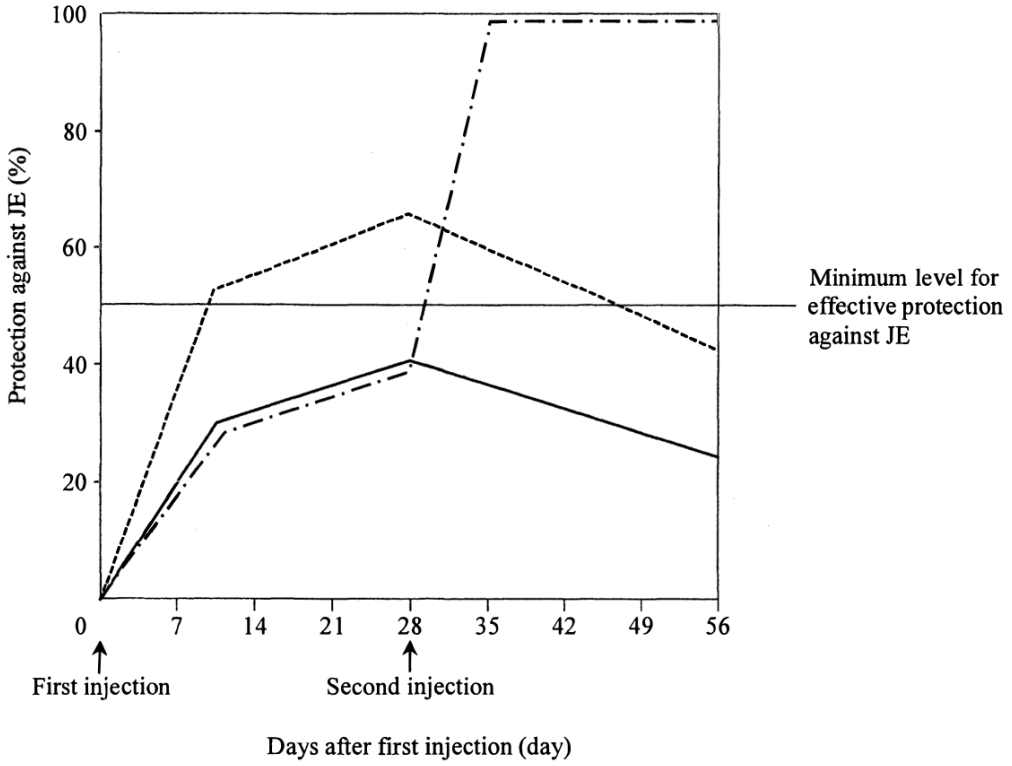
Treating immune protection as a switch with a fixed expiry date while ignoring changes in pathogen antigens.

Marking reference: HKDSE Biology 2018 Paper 1A Q10, official marking scheme, source page(s) 1.

Example 3 [HKDSE Biology 2017 Paper 1B Q9]

Japanese encephalitis (JE) is an inflammation of the brain caused by a viral infection. Scientists have developed a vaccine against the JE virus. In a study of the effectiveness of the vaccine, three groups of healthy people received different vaccination treatments and the level of protection against JE was monitored over a period of time. The results are shown in the graph below:

Key:
——— Treatment A: one injection of 6 μg vaccine on day 0
---------- Treatment B: one injection of 12 μg vaccine on day 0
—·—·— Treatment C: two injections of 6 μg vaccine each on day 0 and day 28 respectively



(a) What is the vector for transmitting the JE virus? (1 mark)

(b) For treatment C, explain why there is a sharp rise in protection against JE from day 28 to day 35. (4 marks)

(c) Give ***one*** more benefit of treatment C. (1 mark)

(d) Mathew plans to visit a country with many JE cases in 10 days and will stay there for 15 days.

(i) With reference to the graph, which vaccination treatment (A, B or C) should he receive at this moment? Explain your answer. (2 marks)

(ii) As a responsible citizen, Mathew will continue to use insect repellant as a precaution for two weeks after he is back from that country. Suggest a rationale for this precaution. (1 mark)

Solution (a); original allocation: 1 mark(s)

Mosquitoes.

Japanese encephalitis virus is transmitted to humans by bites from infected mosquitoes. The mosquito is the vector, while the virus is the pathogen. These terms are not interchangeable.

✓ Method: Identify the antibody source, then align response and protection periods.

(b); original allocation: 4 mark(s)

The first vaccination forms memory cells. After re-exposure to the same antigen on day 28, memory cells rapidly proliferate and differentiate, producing abundant specific effector responses within a short time. Protective effectiveness rises sharply.

In method C, the second injection is on day 28. Memory B cells left by the first response rapidly form more plasma cells on restimulation, producing more antibodies. Corresponding memory T cells can also rapidly form effector cells. The secondary response is therefore faster and stronger. Do not say that the vaccine itself consists of large amounts of antibodies.

(c); original allocation: 1 mark(s)

From days 35 to 56, protective effectiveness remains high without an obvious decline.

Read duration as well as magnitude: method C approaches a plateau in the latter part of the graph. State only that protection stays high during the observed period; a 56-day graph cannot establish lifelong effectiveness.

(d)(i); original allocation: 2 mark(s)

Method B. It remains above the effective-protection line from about days 10 to 47, covering the entire journey from days 10 to 25.

Place the itinerary on the horizontal axis: departure after 10 days and a 15-day stay give a risk period of approximately days 10–25. B remains above the minimum protection threshold throughout. A is insufficient, while C rises rapidly only after its second injection on day 28, too late. This answer compares only the schedules in the original graph and is not current clinical vaccination advice.

(d)(ii); original allocation: 1 mark(s)

The original marking reference expects avoidance of mosquito bites to reduce the risk of passing infection to others. This reasoning has a scientific limitation, explained below.

Separate historical marking from disease biology. The original reference interprets the measure as preventing human → mosquito → another human transmission. However, humans are generally dead-end hosts for Japanese encephalitis: the amount and duration of virus in their blood are usually insufficient to infect mosquitoes. The statement must therefore not be treated as a common Japanese encephalitis transmission route. Mosquito precautions do prevent bites, but this subpart's specific reasoning about transmission after returning home should not be generalised. This scientific correction is based on CDC information on Japanese encephalitis transmission.

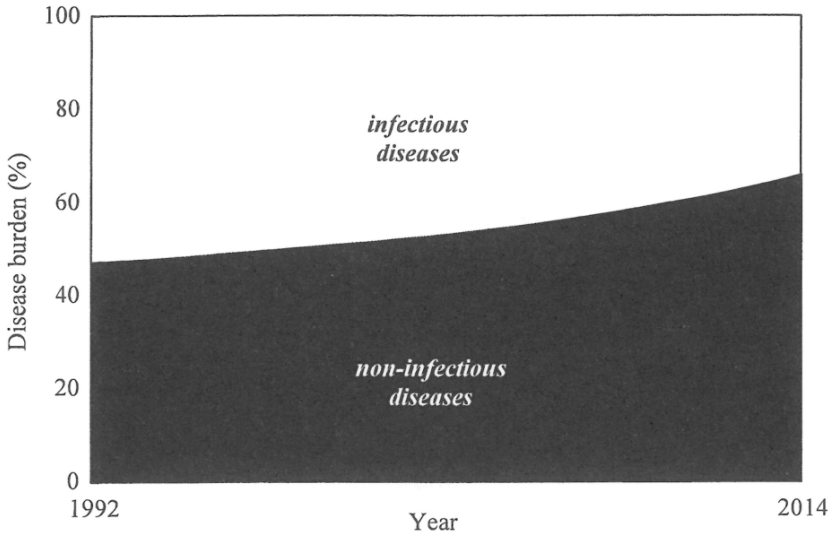
Examiner's comment (source page(s) 3)

After the first vaccination, some lymphocytes differentiate into memory cells. On re-exposure to the antigen, large numbers of effector cells and antibodies are produced more rapidly. Choosing a vaccination schedule requires comparison of the whole journey with the effective-protection threshold.

Marking reference: HKDSE Biology 2017 Paper 1B Q9, official marking scheme, source page(s) 5.

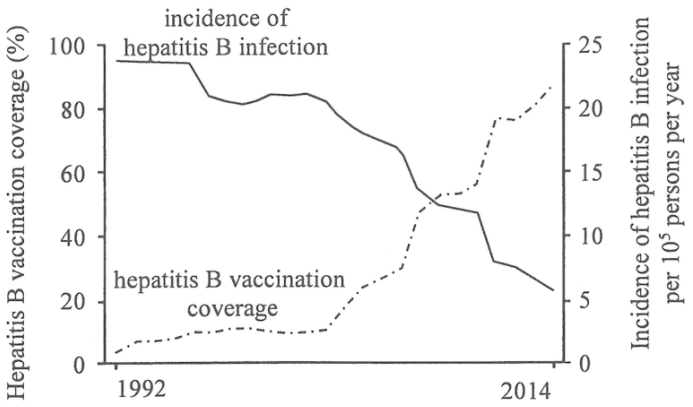
Example 4 [HKDSE Biology 2024 Paper 1B Q8]

Disease burden is a measure of population health that aims to quantify the potential loss of lifespan and health outcomes due to illness as compared to the ideal of living to a ripe old age and in good health. The graph below shows the percentage share of disease burden caused by infectious diseases and non-infectious diseases in Country X from 1992 to 2014:



(a) Describe the change in the percentage shares of the disease burden of Country X from 1992 to 2014.
(1 mark)

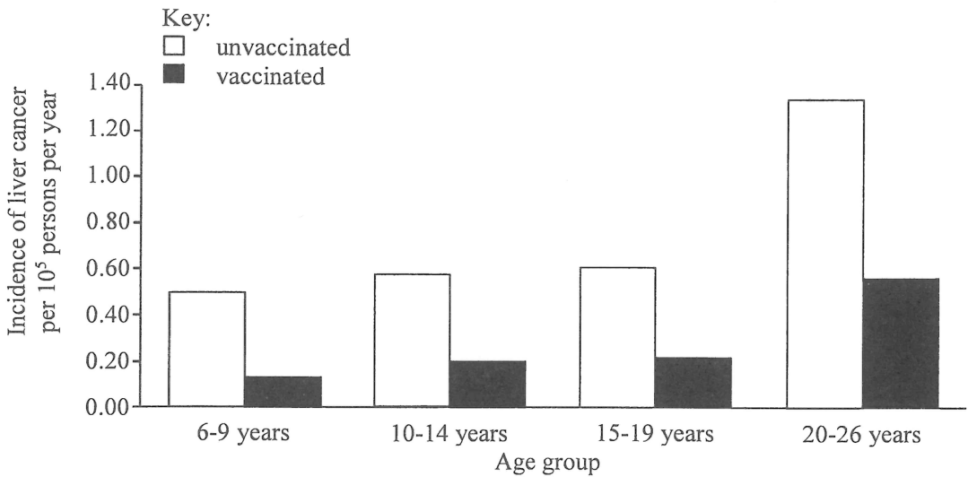
(b) The graph below shows the impact of hepatitis B vaccination on the incidence of hepatitis B infection in Country X from 1992 to 2014:



With reference to the principle of vaccination, explain the relationship shown in the above graph.
(4 marks)

(c) With reference to the information from (a) and (b), suggest the role of vaccination in the change of disease burden in Country X. (1 mark)

(d) The graph below shows the incidence of liver cancer among different age groups who have or have not been vaccinated against hepatitis B in Country X:



What can you conclude about the relationship between hepatitis B and liver cancer? Support your answer with evidence from the graph. (2 marks)

Solution a; original allocation: 1 mark(s)

Method: Identify the antibody source, then align response and protection periods.

The proportion of disease burden due to infectious diseases decreases, while the proportion due to non-infectious diseases increases.

First recognise the stacked-area chart: the darker lower area represents non-infectious diseases and rises from about 42% to about 59%. The infectious-disease proportion above it therefore falls from about 58% to about 41%. These are proportions; do not directly claim that the absolute case numbers decrease and increase, respectively.

b; original allocation: 4 mark(s)

As vaccination coverage increases, hepatitis B incidence decreases. Vaccination establishes memory cells that produce a faster and stronger immune response on later exposure to the virus.

The vaccine first exposes the immune system to hepatitis B viral antigens, activating corresponding lymphocytes and forming long-lived memory cells. When the same antigen later enters the body, memory cells proliferate rapidly and produce more effector cells and antibodies. Earlier viral clearance reduces the chance of infection and disease. As more people gain this protection, overall incidence falls.

c; original allocation: 1 mark(s)

Vaccination reduces the proportion of susceptible people and the incidence of infectious disease, lowering the disease burden caused by infectious diseases.

Connect the protection against a particular disease in (b) with the population-health indicator in (a): fewer infections, illnesses and transmission events reduce losses of life and health.

d; original allocation: 2 mark(s)

Hepatitis B is a risk factor for liver cancer. In every age group, liver cancer incidence is higher among unvaccinated than vaccinated people.

The vaccine targets hepatitis B, and vaccinated people have lower liver cancer incidence in every age group. This supports the conclusion that reducing hepatitis B can lower liver cancer risk. The conclusion concerns increased risk, not an inevitability that every person with hepatitis B develops liver cancer. Do not cite only one age group while ignoring the consistent overall pattern.

Examiner's comment (source page(s) 72)

Corresponding memory cells form on first antigen exposure; they do not wait until reinfection to arise. The liver cancer results support hepatitis B increasing risk. Liver cancer still occurs after vaccination, so hepatitis B cannot be inferred to be its only cause.

Marking reference: HKDSE Biology 2024 Paper 1B Q8, official marking scheme, source page(s) 56.

Practice

1. [HKDSE Biology 2012 Paper 1A Q35]
Hint: Identify the antibody source, then align response and protection periods.

Which of the following belongs to humoral immune response?

A. blood clotting
B. production of antibodies
C. phagocytosis of pathogens
D. production of memory T cells

2. [HKDSE Biology 2014 Paper 1A Q32]
Hint: Identify the antibody source, then align response and protection periods.

Infants can obtain antibodies from breast feeding. Which of the following combinations correctly describes this type of immunity in infants?

	Type of immunity	*Explanation*
A.	active	the antibodies are produced from white blood cells
B.	active	the antibodies attack pathogens bearing foreign antigens
C.	passive	the antibodies do not trigger the production of memory cells
D.	passive	the antibodies work only when there is re-entry of the same pathogen

3. [HKDSE Biology 2019 Paper 1A Q36]
Hint: Identify the antibody source, then align response and protection periods.

Antibodies are produced by

A. memory B cells.
B. memory T cells.
C. specialised B cells.
D. specialised T cells.

END OF SECTION A
Go on to Question-Answer Book B for questions on Section B

4. [HKDSE Biology 2020 Paper 1A Q30]
Hint: Identify the antibody source, then align response and protection periods.

Which of the following provides immunity to the human body?

A. phagocytosis
B. inflammation
C. memory cell
D. formation of blood clots

5. [HKDSE Biology Sample Paper Paper 1A Q35]
Hint: Identify the antibody source, then align response and protection periods.

Antibodies

A. act on specific antigens.
B. are produced by T lymphocytes.
C. are made up of proteins and fats.
D. can develop a memory for pathogens.

6. [HKDSE Biology 2015 Paper 1A Q32]
Hint: Identify the antibody source, then align response and protection periods.

Directions: Questions 32 and 33 refer to the table below, which shows the results of blood tests for the presence of antigens and antibodies of hepatitis B in four individuals:

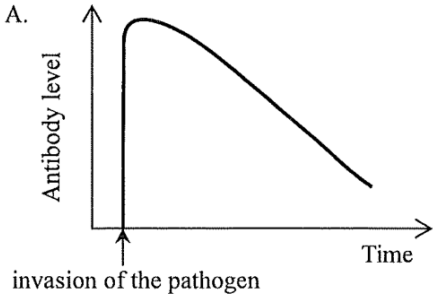
	Individual 1	Individual 2	Individual 3	Individual 4
Antigens of hepatitis B	Negative	Positive	Negative	Positive
Antibodies of hepatitis B	Negative	Negative	Positive	Positive

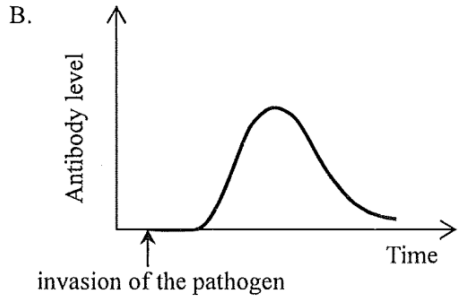
Which individual(s) would you recommend for vaccination against hepatitis B?

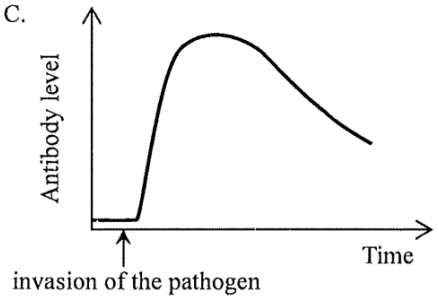
A. 1 only
B. 4 only
C. 1 and 2 only
D. 1 and 3 only

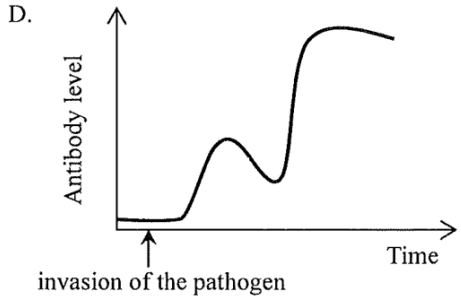
7. [HKDSE Biology 2023 Paper 1A Q36]
Hint: Identify the antibody source, then align response and protection periods.

A person is successfully vaccinated against infectious disease P. Which of the following graphs correctly shows the change in the antibody level of this person when he is invaded by the pathogen of disease P?

A.


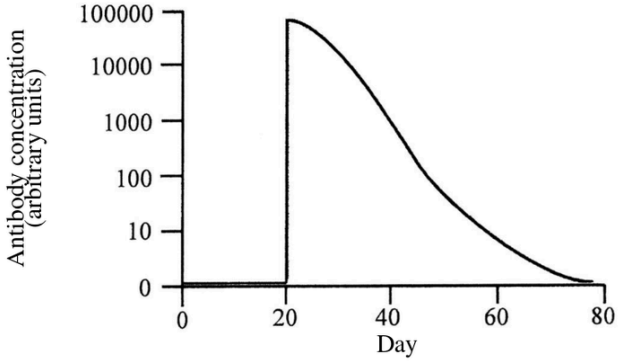
B.


C.


D.


8. [HKDSE Biology 2025 Paper 1A Q33 (English translation)]
Hint: Identify the antibody source, then align response and protection periods.

Directions: Refer to the graph below to answer Questions 33 and 34. It shows changes in the concentration of antibodies against a particular virus in a woman's body over 80 days:

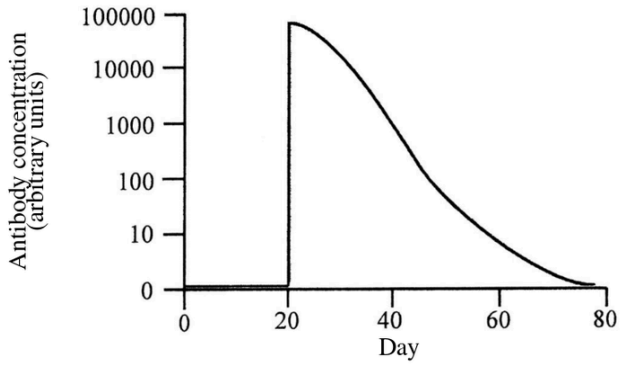


Which of the following events may have occurred on day 20?

A. She received a booster dose of a vaccine against the virus.
B. She received antibiotics.
C. She received antibodies against the virus.
D. She was infected by the virus.

9. [HKDSE Biology 2025 Paper 1A Q34 (English translation)]
Hint: Identify the antibody source, then align response and protection periods.

Directions: Refer to the graph below to answer Questions 33 and 34. It shows changes in the concentration of antibodies against a particular virus in a woman's body over 80 days:



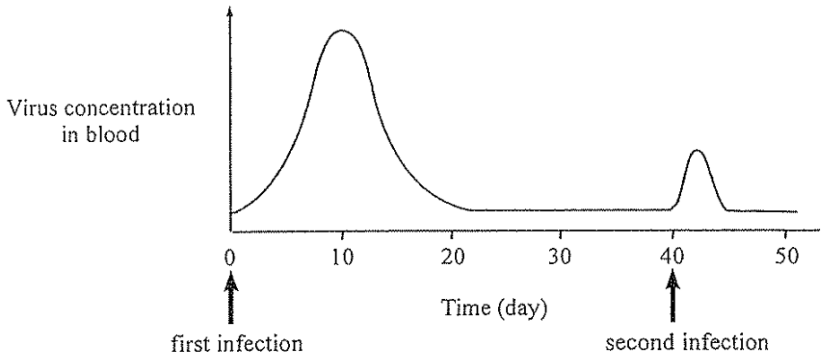
Where in the woman's body can these antibodies be found?

(1) Breast milk
(2) Cerebrospinal fluid
(3) Saliva

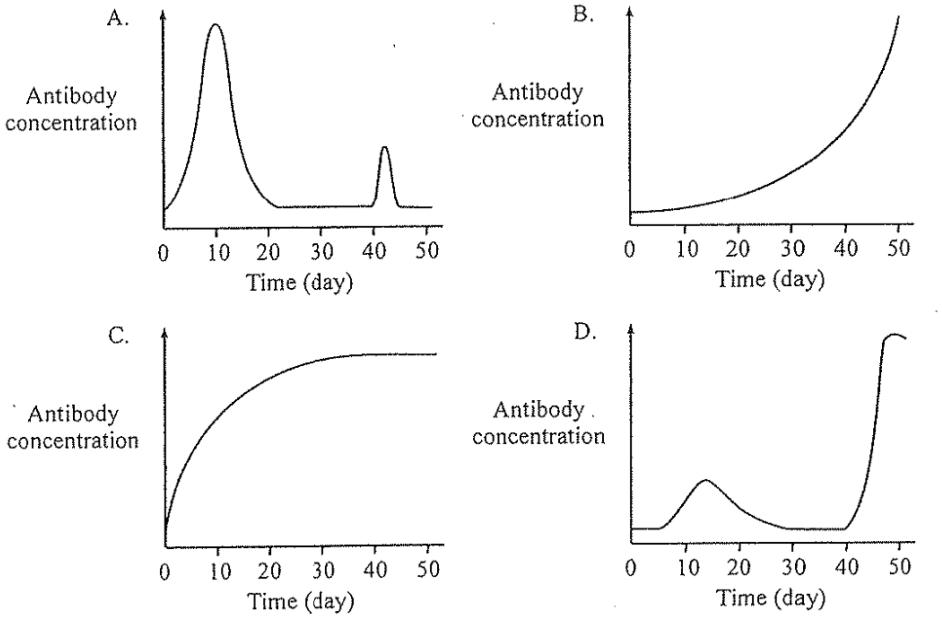
A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

10. [HKDSE Biology Sample Paper Paper 1A Q36]
Hint: Identify the antibody source, then align response and protection periods.

A person was infected by a virus. Forty days later, he was infected again by the same virus. Blood samples were taken from the person at regular intervals and the concentration of the virus was determined. The results are shown in the graph below:



Which of the following graphs best represents the changes in concentration of antibody in the blood?

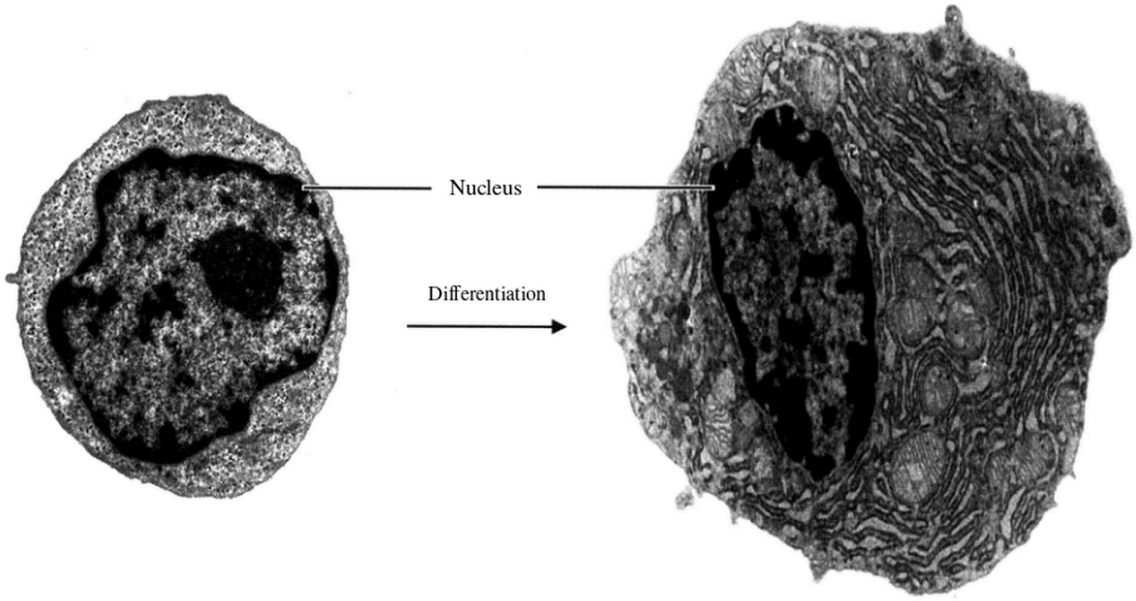


END OF SECTION A

Go on to Question-Answer Book B for questions on Section B

11. [HKDSE Biology 2025 Paper 1B Q1 (English translation)]
Hint: Identify the antibody source, then align response and protection periods.

The following electron micrographs show the appearance of a B lymphocyte before and after differentiation:



(a) State one stimulus that triggers this differentiation. (1 mark)

(b) (i) Apart from the nucleus, state two observable structural changes during this differentiation that are important for the function of the differentiated B lymphocyte. (2 marks)

(ii) Explain how the two structures mentioned in (i) work together to enable the differentiated B lymphocyte to perform its function. (1 mark)

12. [HKDSE Biology 2023 Paper 1B Q4]

Hint: Identify the antibody source, then align response and protection periods.

Dengue fever is an infection caused by the dengue viruses (DENV). It is an endemic illness in many countries in tropical and sub-tropical regions. DENV encompasses four different subtypes. Each subtype can lead to dengue fever.

(a) What is the way of transmission for dengue fever? (1 mark)

(b) Suggest ***two*** environmental factors in tropical and subtropical regions which lead to a higher risk of contracting dengue fever for people living in these regions. Explain your answer. (3 marks)

(c) Patients infected with a particular subtype of DENV for the first time can recover on their own after about a week without any treatment.

(i) Give ***three*** types of white blood cells that aid the recovery and describe each of their actions. (3 marks)

(ii) Explain why people who have recovered from infection with a particular subtype of DENV can still be infected with other subtypes of DENV in the future. (2 marks)

(d) Suggest ***one*** preventive measure against the spreading of dengue fever. (1 mark)

13. [HKDSE Biology 2021 Paper 1B Q6]

Hint: Identify the antibody source, then align response and protection periods.

Pathogen X is a pathogen that infects humans. Research has discovered an antigen Y present on the surface of pathogen X. Using recombinant DNA technology, antigen Y can be produced and serves as a vaccine to induce immunity against pathogen X.

(a) Explain how the injection of antigen Y can induce immunity against pathogen X. (4 marks)

(b) Other than the use of recombinant DNA technology, suggest another way to produce a vaccine. (1 mark)

(c) Refer to the codon table below, answer the questions that follow:

UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys
UUC		UCC		UAC		UGC	
UUA	Leu	UCA		UAA	STOP codon	UGA	STOP codon
UUG		UCG		UAG		UGG	Trp
CUU	Leu	CCU	Pro	CAU	His	CGU	Arg
CUC		CCC		CAC		CGC	
CUA		CCA		CAA	Gln	CGA	
CUG		CCG		CAG		CGG	
AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser
AUC		ACC		AAC		AGC	
AUA		ACA		AAA	Lys	AGA	Arg
AUG	Met	ACG		AAG		AGG	
GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly
GUC		GCC		GAC		GGC	
GUA		GCA		GAA	Glu	GGA	
GUG		GCG		GAG		GGG	

(i) The starting sequence of the coding strand of the gene which encodes antigen Y is shown below:

ATG GCC ATA AAT TGC TGT … … …

Referring to the codon table, write the corresponding amino acid sequence of the coding strand shown above. (2 marks)

(ii) Over the years, mutation has occurred in the gene encoding antigen Y in different strains of pathogen X. The variations in the starting sequence of this gene are shown below:

original strain:	ATG GCC ATA AAT TGC TGT … … …
strain P:	ATG GCC ATA AAT TGC TGC … … …
strain Q:	ATG GCC ATA AAT TGA TGT … … …
strain R:	ATG GCT ATA AAC TGC TGT … … …

One of these strains has the ability to infect people who have been injected with the vaccine containing antigen Y. With reference to the codon table, which strain (P, Q or R) will that be? Explain your answer. (4 marks)

14. [HKDSE Biology 2020 Paper 1B Q8]
Hint: Identify the antibody source, then align response and protection periods.

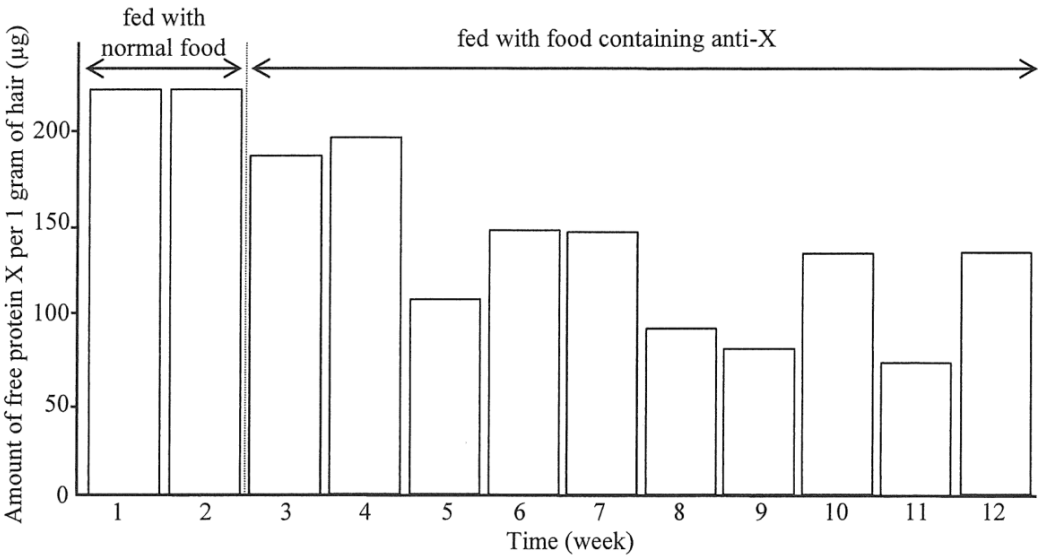
Some people suffer from sneezing and coughing when there are cats nearby. These unwanted immune responses, known as allergies, are caused by a protein X secreted by cats' salivary and sebaceous glands. When cats lick their body surface, this protein X is spread to their hair. Protein X can accumulate in their living environment over time.

(a) Recent research shows that the amount of free protein X on cats' hair can be reduced by adding antibodies against protein X (anti-X) to cat food.

(i) Why can anti-X reduce the amount of free protein X on cats' hair? (1 mark)

(ii) There are no proteases in the saliva of cats. Explain why this is important for the success of this method of reducing free protein X. (1 mark)

(b) In the research, a group of domestic cats were fed with normal cat food for 2 weeks, followed by cat food containing anti-X for 10 weeks. The amount of free protein X found on their hair during the research is shown in the bar chart below:



(i) Research team member A thought anti-X was effective in reducing the amount of free protein X on cats' hair while team member B thought anti-X was not effective. Based on the bar chart, give ***one*** reason to support team member A and ***another*** reason to support team member B. (2 marks)

Supporting reason for team member A:

Supporting reason for team member B:

(ii) How would you modify the research to confirm whether anti-X in cat food is effective in reducing the amount of free protein X on cats' hair? (2 marks)

(c) Based on the information in the introductory paragraph of this question, suggest ***two*** limitations of this approach to reducing allergies caused by cats. (2 marks)

Chapter 11

Sources of questions, marking references and images

Sources Curriculum and questions

Curriculum basis: the Education Bureau and Hong Kong Examinations and Assessment Authority, Biology Curriculum and Assessment Guide (Secondary 4–6), updated 2015, with reference also to the 2026 HKDSE Biology assessment information. Question text, marking references and candidate-performance information are checked against the original papers and question collections for each year. Sample and practice papers supplement the examination questions and are labelled separately from examination years.

The year, paper section and original question number appear beside each question. Solutions also identify pages in the official marking reference. 'Source page' refers to the page sequence in the cited PDF; printed page numbers may differ between combined and standalone files. Each book has its own question-source index linking original questions to book pages.

The knowledge sections explain concrete examples before introducing terminology, symbols and diagrams. Interpret process arrows and numerical illustrations together with the text. Typical cell or organ diagrams are not complete records of every specimen. Original question figures are retained with their questions.

Education Bureau: Biology Curriculum and Assessment Guide

HKEAA: 2026 Biology assessment information

The original structural diagrams of the eye, ear and intestinal villi are by Servier Medical Art, supplied through Bioicons under CC BY 3.0. This edition retains the structural forms and adds English labels, leader lines, function tables and captions. The villus diagram's original text has been replaced with corresponding labels.

- Eye cross-section: Servier Medical Art / Bioicons
- Ear: Servier Medical Art / Bioicons
- Intestinal villi: Servier Medical Art / Bioicons

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plasmid: EmilyADaniel; cc-0 Image source and licence
HKDSE Biology 2024 Paper 1B Q3: Wikimedia Commons: Mitochondria, mammalian lung - TEM.jpg
HKDSE Biology 2024 Paper 1B Q7: original paper image: Pixlr; seaweed images: Foras na Mara Marine Institute, Explorers Wild About Wildlife on the Seashore: Seaweed Information Sheets
HKDSE Biology 2024 Paper 1B Q9: Microscopy of Nature: Stomata
HKDSE Biology 2024 Paper 2 Q2: The Conservancy Association: The Ecology of Long Valley