Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE AS

B400U20-1

S25-B400U20-1

THURSDAY, 22 MAY 2025 – MORNING

BIOLOGY – AS component 2
Biodiversity and Physiology of Body Systems

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**16**	
2.	**12**	
3.	**11**	
4.	**14**	
5.	**13**	
6.	**9**	
Total	**75**	

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ADDITIONAL MATERIALS

A calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of quality of extended response (QER) will take place in question **6**.

The quality of written communication will affect the awarding of marks.

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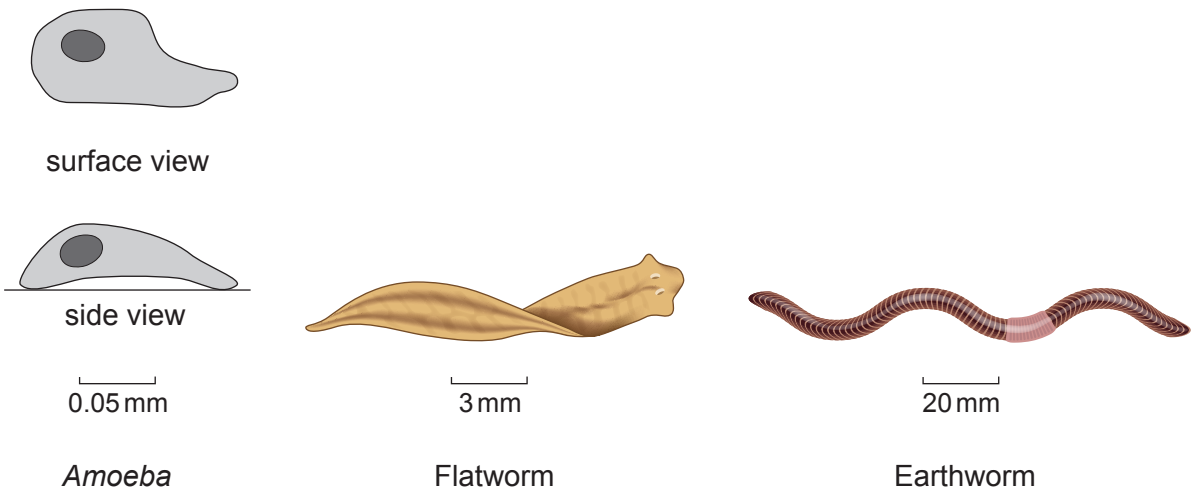
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Answer **all** questions.

1. **Image 1.1** shows outline drawings of an amoeba, a flatworm and an earthworm. Gas exchange takes place across the surface of each organism.

Image 1.1



(a) An amoeba and a flatworm have no additional structures associated with their gas exchange surfaces, whereas an earthworm has capillaries close to the surface of its body.
Explain why an amoeba and a flatworm do not need a specialised gas exchange surface or a circulatory system, but an earthworm does. [4]

The amoeba and the flatworm have a large surface area to volume ratio (larger than the earthworm), so they have sufficient gas exchange over their body surface and absorb enough oxygen. They also have a short diffusion distance, so oxygen can diffuse throughout the organism to all cells. The earthworm is larger, with a smaller SA:V ratio and a longer diffusion distance, so it needs capillaries: its blood vessels transport oxygen away from the body surface in the blood to the respiring tissues, so a concentration gradient is maintained.

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(b) Gas exchange in earthworms was investigated by measuring the percentage saturation of their blood with oxygen. They were maintained at 10 °C and were studied in three different conditions:

- in air;
- in moist soil;
- in air, following a low dose of adrenaline.

The readings are shown in **Table 1.2**.

Table 1.2

Earthworm	Percentage oxygen saturation of blood		
	In air	In moist soil	+ adrenaline
1	48	73	not tested
2	40	82	
3	41	65	
4	46	77	30
5	51	not tested	24
6	46		4
7	57		19
8	52		25
9	57		19
10	5		5
11	37		8
Mean	43.6	74.3	16.8

(i) Calculate the mean percentage oxygen saturation in the blood of earthworms treated with adrenaline.
Write your answer in Table 1.2. [2]

(ii) Explain why a mean was calculated for each condition, rather than using a single reading from one earthworm. [1]

Greater confidence in a mean than in a single reading, as it reduces the effect of variation and helps identify anomalous results.

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(iii) Explain how the readings in **Table 1.2** are consistent with the observation that earthworms are more active in moist soil than in air. [2]

Oxygen saturation of the blood is higher in moist soil (mean 74.3%) than in air (43.6%), as oxygen dissolves in the moisture before absorption. So more aerobic respiration takes place and more energy (ATP) is available for movement.

(iv) When the earthworms are treated with adrenaline, the blood vessels near the body surface become constricted.

Suggest how this might account for the effect of adrenaline on the oxygen saturation of the blood. [2]

With the vessels constricted, less blood flows near the body surface, so less oxygen is absorbed by the blood: the mean saturation falls from 43.6% in air to 16.8% with adrenaline.

(v) Use **Table 1.2** to suggest **one** limitation in the data collected in this investigation. [1]

The sample size is small: not all worms were tested in all conditions (only four in moist soil), so the sample size should be larger.

(vi) Earthworms have an optimum temperature range of 10–16 °C.

Suggest how the readings shown in **Table 1.2** might be different if the experiments had been conducted on earthworms maintained at 16 °C instead of 10 °C.

Give **one** explanation for your answer. [2]

Difference: Higher oxygen saturation of the blood.

Explanation: Oxygen diffuses faster at a higher temperature (molecules have more kinetic energy).

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(c) Bony fish use counter current flow, which increases the percentage oxygen saturation in their blood.

Describe what is meant by counter current flow. Explain how it results in higher oxygen saturation. [2]

Counter current flow means that blood in the gill lamellae and water passing over the gills flow in opposite directions. So the water always has a higher oxygen concentration than the blood it meets, maintaining a concentration gradient across the whole of the gas exchange surface: the concentrations never reach equilibrium, so oxygen keeps diffusing into the blood.

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2. Three genetically different barley seedlings were tested to determine how efficient they were at absorbing water. The observations are summarised in **Table 2.1**.

Table 2.1

Barley seedling	Root hair length	Relative efficiency of water absorption
1	normal	high
2	short	low
3	absent	very low

(a) Use **Table 2.1** to conclude the effect of root hair length on the efficiency of water absorption into roots. Explain your answer. [2]

Longer root hairs give more efficient water absorption (normal: high, short: low), as longer root hairs give more surface area (membrane) for absorption. With no root hairs only a very small amount is absorbed directly into the root.

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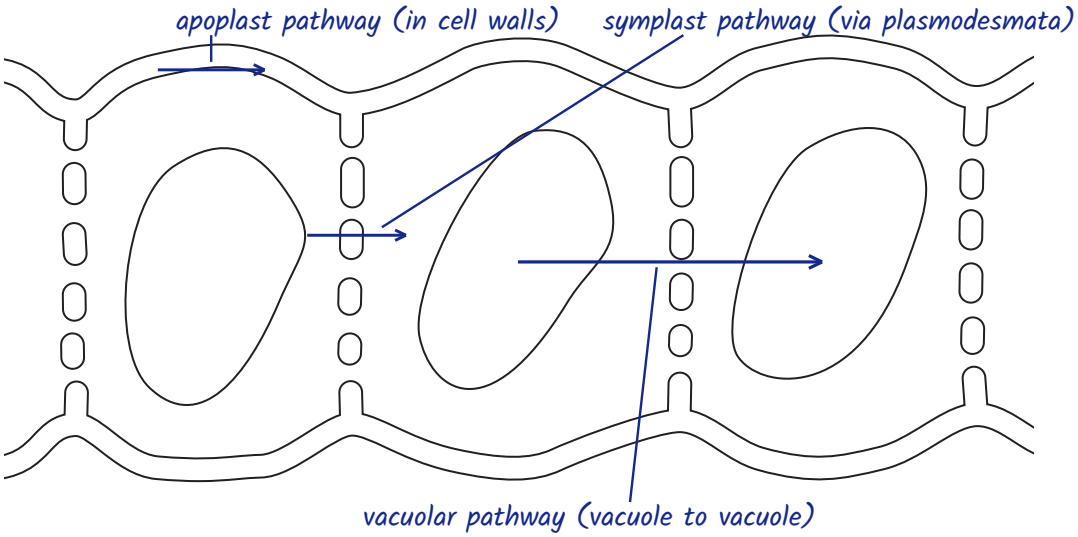
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(b) **Image 2.2** shows cells from the root cortex.

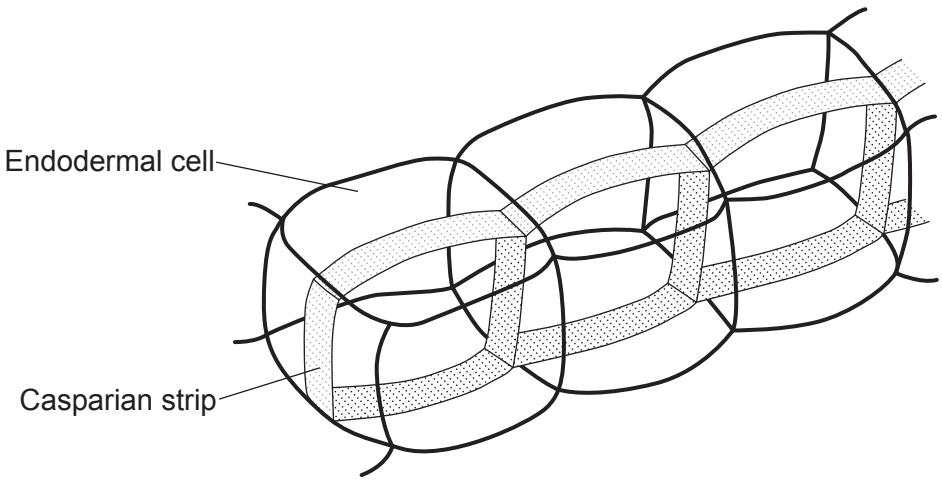
Image 2.2



(i) **Draw arrows** on **Image 2.2** to show the **three** pathways by which water moves across the root cortex. **Label your arrows** with the names of the pathways. [3]

Image 2.3 is a 3-dimensional drawing showing endodermal cells. The endodermis cell walls have a Casparian strip, which contains suberin.

Image 2.3



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(ii) Explain how the Casparian strip directs water towards the xylem of the root. [3]

The Casparian strip contains suberin, which is impermeable (hydrophobic) to water, so water cannot continue in the apoplast pathway through the cell walls. Water has to cross the cell membranes and is diverted into the cytoplasm (symplast) of the endodermal cells, which passes it on into the xylem.

(c) Root hairs also take up ions from the soil into the plant. Experiments were performed on *Arabidopsis thaliana* to assess the uptake of phosphate ions into its root hairs. The observations from this experiment are outlined in **Table 2.4**.

Table 2.4

Relative oxygen concentration in soil	Relative phosphate ion uptake into root hairs
high	high
low	low

The phosphate ion concentration in soil is 1–10 μmol dm^{-3} and in the cytoplasm of *Arabidopsis* cells, it is 60–80 μmol dm^{-3}.

Use **all** the information given to explain how phosphate ions are absorbed into *Arabidopsis* roots. [4]

The phosphate ion concentration is higher in the cells (60 to 80 μmol dm^{-3}) than in the soil (1 to 10 μmol dm^{-3}), so phosphate uptake is against a concentration gradient, by active transport using carrier proteins in the root hair membranes. At high oxygen concentration there is more aerobic respiration, so higher ATP production; more ATP (energy) means more phosphate uptake. At low oxygen there is less ATP, so less uptake.

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3. (a) In 2003, human skeletal remains were found on the island of Flores, Indonesia. Researchers proposed three possible origins for these remains:

- modern humans, *Homo sapiens*;
- a related species of early humans, *Sundanthropus floresianus*;
- a previously unknown human species. The name *Homo floresiensis* was proposed.

(i) **Complete Table 3.1** to show the taxonomy of *Homo sapiens*. [1]

Table 3.1

Taxon	Name
Domain	Eukaryota
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primates
Family	Hominidae
Genus	*Homo*
Species	*sapiens*

(ii) Use the information above and your understanding of classification to explain the term 'tentative' in relation to the classification of *Homo floresiensis*. [1]

Classification depends on the information available, so it is provisional and may change as new information (more fossils or DNA evidence) becomes available.

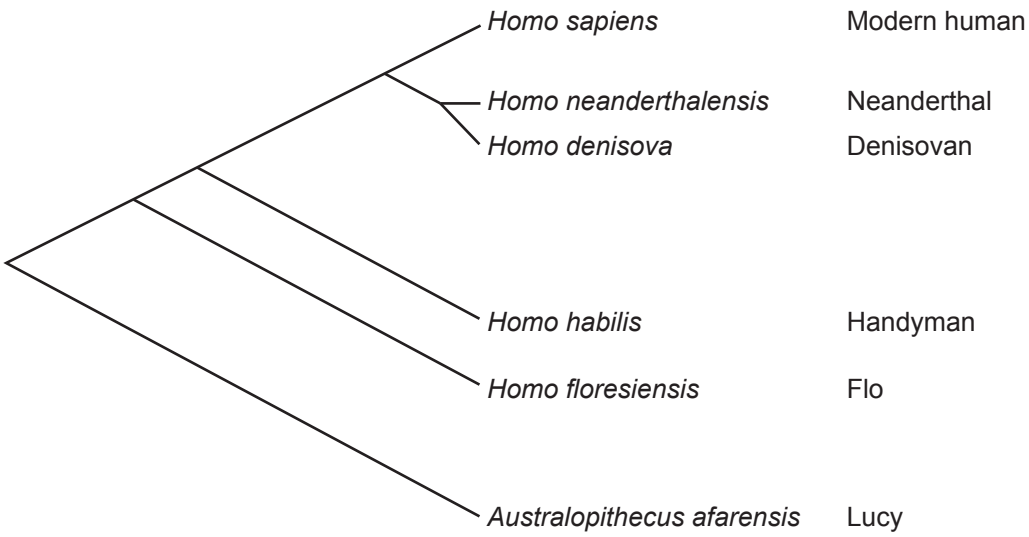
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(b) **Image 3.2** is a phylogenetic tree showing the binomial and common names of modern humans and five related species.

Image 3.2



(i) Explain why scientists prefer to use the binomial system for naming, rather than common names as shown in **Image 3.2**. [1]

Biological (binomial) names are used worldwide, whereas common names may be regional; the same genus name also shows relatedness.

(ii) Use **Image 3.2** to describe the evolutionary relationships shown between *H. sapiens*, *H. neanderthalensis* and *H. floresiensis*. Explain your answer. [2]

H. sapiens and H. neanderthalensis are more closely related to each other than either is to H. floresiensis, because they share a more recent common ancestor (a later branch point) than either has with H. floresiensis.

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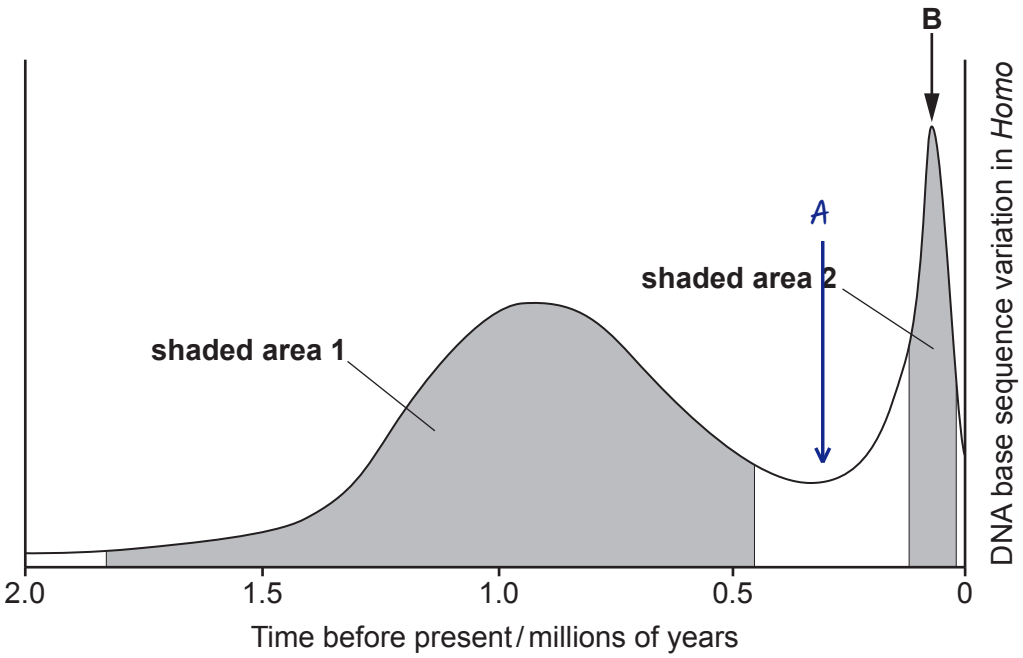
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(c) DNA from ancient bones and teeth can be extracted and sequenced. **Image 3.3** shows the variation in the base sequences of DNA from bones of members of the genus *Homo* who lived up to two million years ago.

Image 3.3



Shaded area 1 in **Image 3.3** shows the time when early species of the genus *Homo* were diverging from each other. **Shaded area 2** shows the time when *H. sapiens* and *H. neanderthalensis* both lived.

(i) On **Image 3.3**, **draw an arrow labelled A** to suggest when a common ancestor of *H. neanderthalensis* and *H. sapiens* may have lived. [1]

(ii) Explain why the position of Arrow **B** on **Image 3.3** indicates the time when the genus *Homo* had the highest genetic diversity. [1]

It is at the highest peak, showing the greatest variation in the DNA base sequence.

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(iii) DNA analysis and fossil evidence show that:

- 2% of the DNA of modern non-African *H. sapiens* comes from *H. neanderthalensis*;
- 5% of the DNA of modern South Pacific and South and East Asian *H. sapiens* comes from *H. denisova*.

Use this information to explain why *H. neanderthalensis*, *H. sapiens* and *H. denisova* should all be considered to be members of the same species. [1]

They were able to interbreed to make fertile offspring, as their DNA is found in modern H. sapiens.

(d) *H. sapiens* and *H. floresiensis* diverged from their common ancestor approximately 1 860 000 years ago.
It has been estimated that *H. sapiens* and their common ancestor differ by 5.92×10^6 mutations. An average human generation time is 22 years.

Calculate the number of mutations per generation.
Give your answer to one significant figure. [3]

Mutations per generation = $(5.92 \times 10^6 \times 22) \div 1\ 860\ 000$

$= 70.02$

$= 70$ (1 s.f.)

Number of mutations per generation = 70

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4. (a) **Image 4.1** shows a capillary bed in a body tissue.

Image 4.1

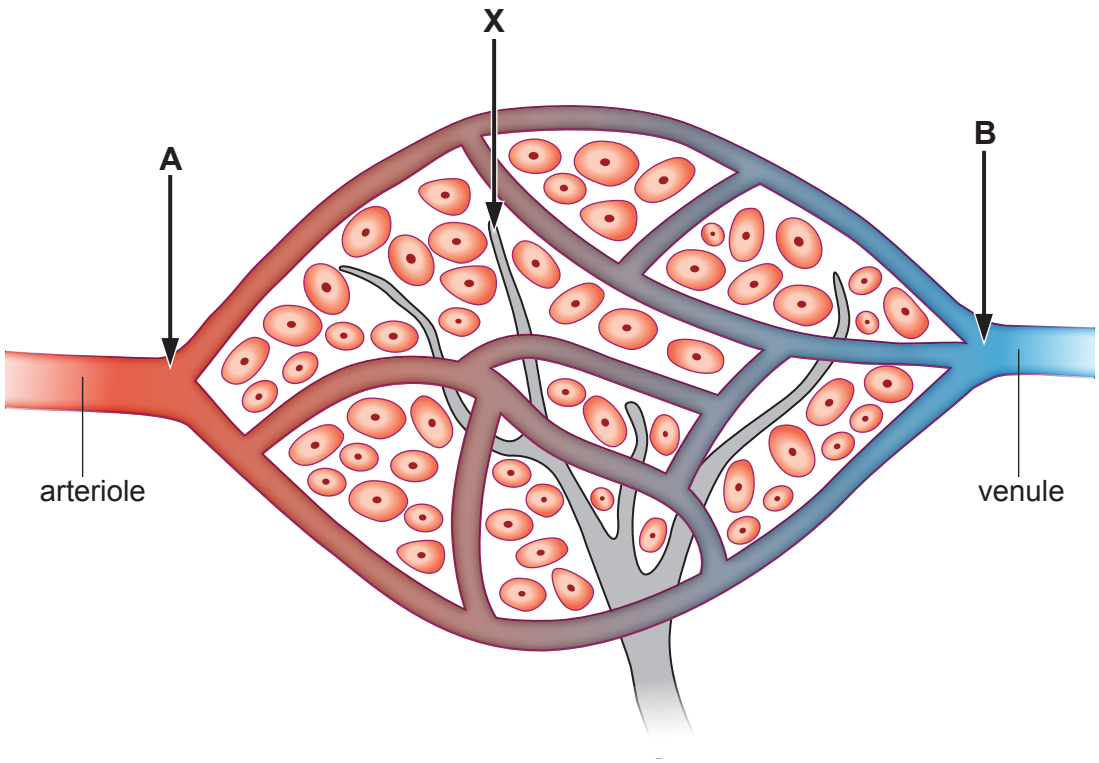


Table 4.2 shows the hydrostatic pressure and solute potential of the blood at positions **A** and **B** on **Image 4.1**.

Table 4.2

	Pressure / kPa	
	Position **A**	Position **B**
Hydrostatic pressure	5.3	1.4
Solute potential	–2.5	–2.6

The hydrostatic pressure of the blood is higher at position **A** than at position **B**.

(i) Give **two** reasons for the high hydrostatic pressure at **A**. [2]

Contraction of the ventricles (heart) pumps blood out at high pressure.

A large blood volume enters from the wide arteriole into the narrow capillaries.

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(ii) Give **two** reasons for the fall in hydrostatic pressure between positions **A** and **B**. [2]

Resistance from contact (friction) with the capillary walls.

Reduced volume of blood, as fluid has been forced out of the capillary into the tissue.

(b) (i) The resultant force on the fluid in the capillary is the combination of the hydrostatic and solute potential of the blood.
At Position **A** in **Image 4.1**, the resultant force is:

$= 5.3 + (-2.5) = +2.8\,\text{kPa}$

The resultant force is **positive** and so fluid moves **out** of the capillary.

Use **Table 4.2** to calculate the resultant force at Position **B**.
Explain the direction of fluid movement at Position **B**. [3]

Resultant force = *−1.2* kPa

Explanation

Resultant force = 1.4 + (−2.6) = −1.2 kPa. It is negative, so fluid (water) moves into the capillary by osmosis, down a water potential gradient.

(ii) Identify the structure labelled **X** in **Image 4.1** and describe its role. [2]

X is a lymph vessel (lymphatic capillary). It absorbs excess tissue fluid that is not reabsorbed into the blood capillary and returns it as lymph to the blood.

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(iii) **Image 4.3** shows part of a patient's leg, with a clinical condition called oedema. Their plasma has a very low concentration of solutes. Its solute potential is less negative (higher) than normal.

Image 4.3



State the effect of a less negative solute potential on the resultant force at position **B** in **Image 4.1**.

Explain how this might affect the movement of tissue fluid at the venous end of a capillary bed and result in oedema. [3]

The resultant force at position B becomes positive (less negative). So fluid is pushed out of, or does not move back into, the capillaries at the venous end of the capillary bed. The tissue fluid remains bathing the tissues and builds up, so the tissue swells (oedema).

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(c) Tissue fluid is formed from the blood.
Complete Table 4.4 by explaining **one** reason for each difference in the properties of blood and tissue fluid. [2]

Table 4.4

Property	Blood	Tissue fluid	Reason for difference
Colour	red	pale yellow	Blood contains red blood cells (haemoglobin) but tissue fluid does not: red blood cells are too big to pass out through the capillary walls.
Large protein molecules	present	absent	The large protein molecules are too big to pass out through the capillary walls, so they stay in the blood plasma.

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5. (a) **Image 5.1** is a photomicrograph of a transverse section of the stem of a sunflower seedling.

Image 5.1

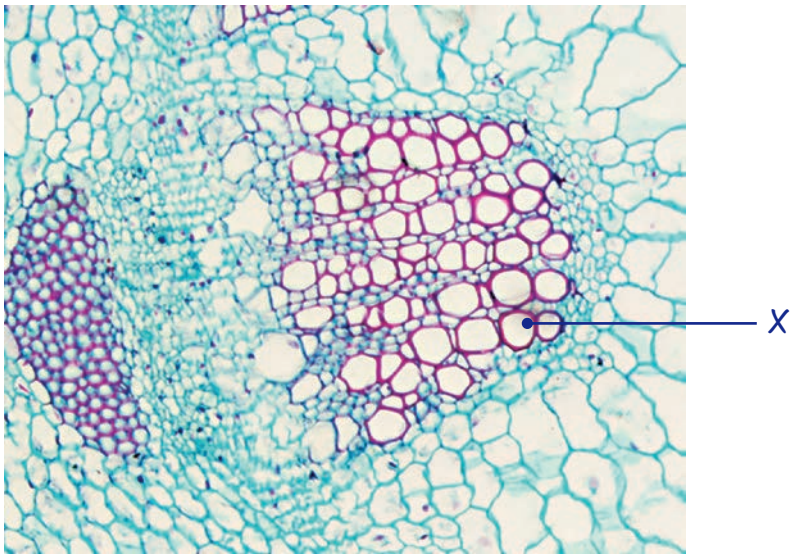


(i) State the evidence from **Image 5.1** that this section shows a stem. [1]

The vascular bundles are arranged in a ring round the periphery, not in the centre.

Image 5.2 shows a part of **Image 5.1**.

Image 5.2



(ii) On **Image 5.2**, **draw a line** labelled **X** to identify a xylem vessel. [1]

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(iii) Describe **one structural** characteristic that allowed you to identify a xylem vessel in **Image 5.2**. [1]

Xylem vessels have a large diameter (wide lumen) with thick (lignified) cell walls.

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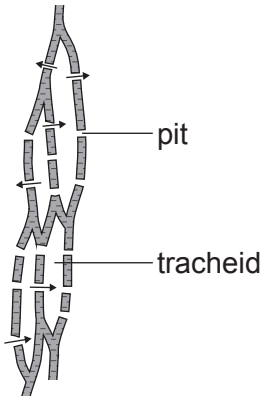
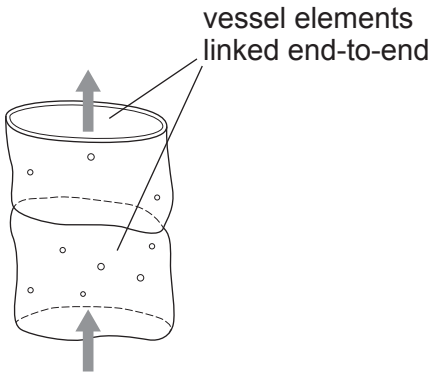
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(b) Xylem contains many types of cell, including tracheids and vessels. These are described in **Table 5.3**. The arrows show the direction of water movement.

Table 5.3

	Tracheids	Vessels
Appearance of cells		
Relative length	short	long
Relative diameter	narrow	wide
Ends of cells	end walls present	no end walls
Major direction of water movement	laterally, through pits	vertically
Resistance to water movement	high	low

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Spruce and beech are members of two major groups of plants: spruce is a gymnosperm and beech is an angiosperm. **Table 5.4** shows the types of water-conducting cells in gymnosperms and angiosperms.

Table 5.4

Plant group	Example	Specialised water conducting cells	
		Tracheids	Vessels
Gymnosperm	Spruce	present	absent
Angiosperm	Beech	present	present

Explain how the information in **Table 5.3** and **Table 5.4** supports the observation that water travels upwards faster in beech than in spruce. [4]

In spruce there are only tracheids and no vessels, so water must move laterally through the pits, not vertically, because the ends of the tracheids are closed (end walls present). This gives more resistance to flow. In beech, vessels are present, so water moves vertically (and laterally); the open ends of the vessel elements (no end walls) provide less resistance, so water travels upwards faster in beech.

(c) The rate at which liquid moves upwards in the xylem of beech trees was measured. Readings were made over 24 hours during days in summer when there was no wind and no clouds.

(i) Explain why readings were only made when there was no wind. [2]

Air movement (wind) enhances transpiration by removing water vapour from around the leaves, so the transpiration stream would be faster, changing the flow rate and making readings not comparable.

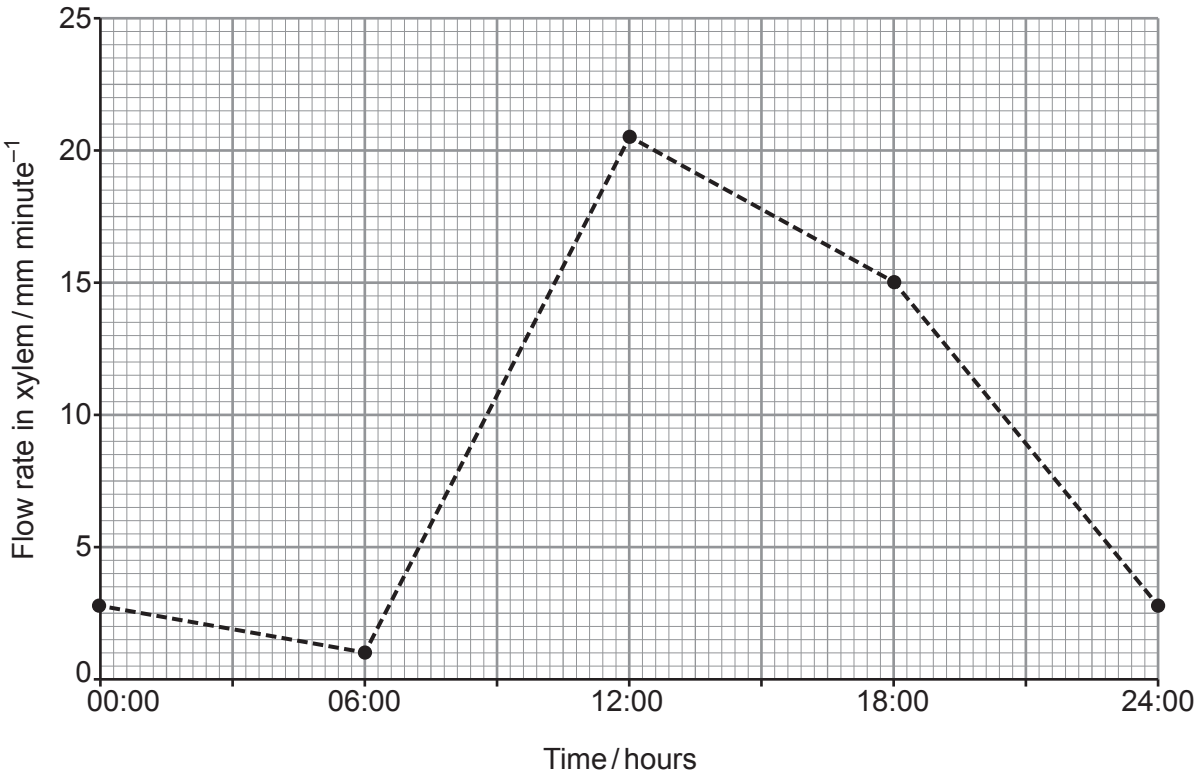
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Graph 5.5 shows the flow rate in the xylem of beech trees.

Graph 5.5



(ii) Use readings from **Graph 5.5** to calculate the rate of increase in flow rate in xylem between 06:00 hours and 12:00 hours. State the unit for your answer. [3]

Flow rate at 06:00 = 1.0, at 12:00 = 20.5 mm minute^{-1}

Increase = 20.5 − 1.0 = 19.5 mm minute^{-1}

Rate of increase = 19.5 ÷ 6 hours = 3.25

Increase in flow rate = *3.25*

Unit = *mm minute^{-1} hour^{-1}*

(iii) Explain **one** reason why the rate of transpiration increases between 06:00 and 12:00 hours. [1]

Stomata open more widely because of increased light intensity (and temperature), so more water vapour diffuses out.

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6. All plants and some prokaryotes are autotrophs. All animals are heterotrophs and may exhibit holozoic or parasitic nutrition. Fungi are also heterotrophs but have a different way of obtaining nutrients.

Explain the term 'autotroph' and describe the different categories of autotrophs.

Explain the term 'heterotroph' and state the meanings of holozoic and parasitic nutrition.

Describe how fungi obtain their nutrients. [9 QER]

An autotroph converts an external energy source into chemical energy: it makes its own food (energy-containing compounds such as glucose), building complex (large) organic molecules from simple (small) inorganic molecules such as carbon dioxide and water. There are two categories of autotroph. Photoautotrophs, such as plants and some prokaryotes, use light as their energy source in photosynthesis. Chemoautotrophs, such as some bacteria, use the energy released from chemical reactions (for example the oxidation of inorganic substances) as their energy source.

A heterotroph cannot convert an external energy source such as light into chemical energy. Instead it relies on autotrophs or other heterotrophs for energy-containing compounds (food, biological compounds) and converts the chemical energy in this food into chemical energy in its own cells. Holozoic nutrition, as in most animals, means digesting food internally: food is ingested, digested inside the body, the products are absorbed and undigested material is egested. Parasitic nutrition means living in or on another organism (the host), gaining nutrition at the expense of the host, which is harmed.

Fungi are saprotrophs (saprobionts). They feed on dead or decaying organic material. Their hyphae secrete enzymes on to the substrate, so digestion is external (extracellular). The small soluble products of digestion, such as glucose and amino acids, are then absorbed across the hyphal walls and membranes into the fungus.

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