Surname	StemUp Model Solution	Centre Number	Candidate Number
Other Names			2

GCE AS

B400U20-1

S18-B400U20-1

BIOLOGY – AS component 2
Biodiversity and Physiology of Body Systems

MONDAY, 4 JUNE 2018 – AFTERNOON

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**11**	
2.	**10**	
3.	**13**	
4.	**15**	
5.	**17**	
6.	**9**	
Total	**75**	

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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

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 continuation page 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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Answer **all** *questions.*

1. Organisms display a wide range of feeding mechanisms. For example, *Amoeba* are holozoic and feed by ingesting food particles which are digested intracellularly, whereas fungi are saprotrophic.

(a) Define the term *saprotrophic*. [1]

Enzymes are secreted outside the body (extracellular digestion) and the soluble products of digestion are then absorbed.

(b) The parasitic tapeworm *Taenia solium* is an endoparasite that completes its life cycle in two different species of animal, humans and pigs. As an adult, *T. solium* lives in the human intestine. The tapeworm has no mouth or alimentary canal and relies on anaerobic respiration to provide energy.

(i) Describe how the tapeworm is adapted to resist peristalsis in the human intestine. [1]

It has a scolex with hooks and suckers to attach to the gut wall.

(ii) Explain why the tapeworm does not need a mouth or alimentary canal. [2]

Nutrients are absorbed through its body surface (no mouth needed).

Food is pre-digested by the host (no alimentary canal needed).

(iii) Suggest why the tapeworm relies on anaerobic respiration for its metabolism. [1]

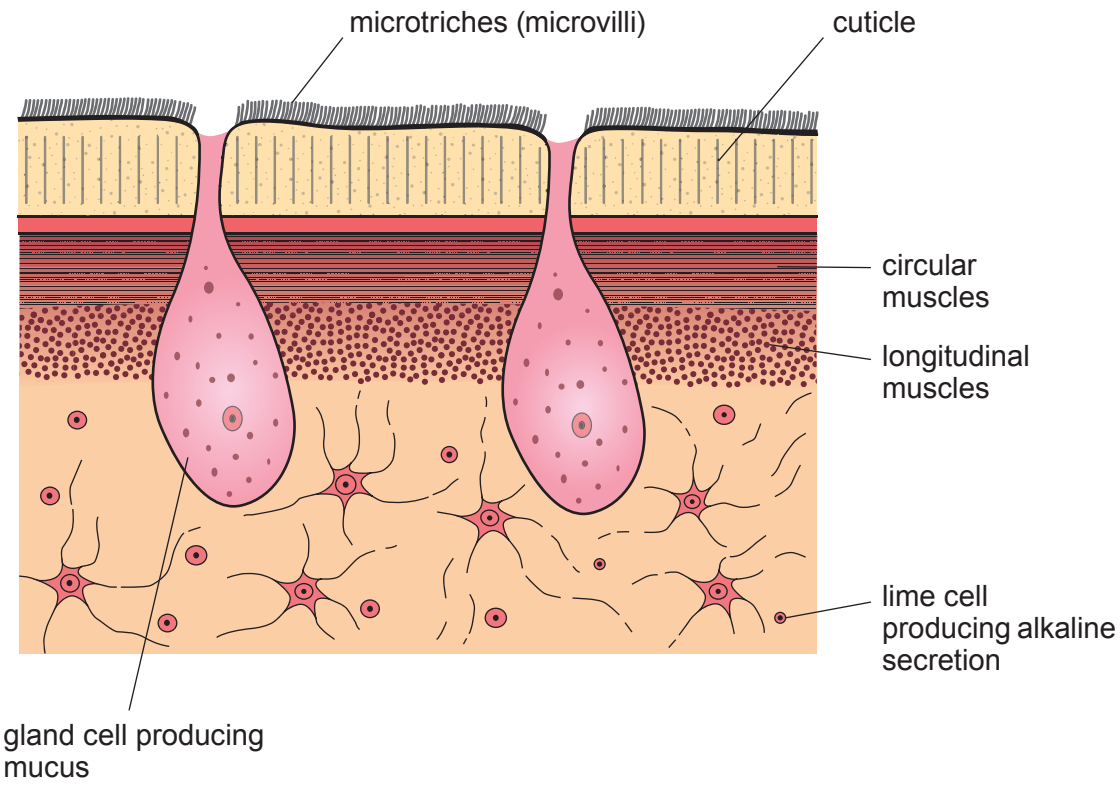
Oxygen levels in the intestine are too low for aerobic respiration (and it has a low metabolic rate as it does not move much).

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(c) The diagram below shows a section of the tapeworm's body wall.



(i) Describe and explain how the adaptations visible in the diagram enable the tapeworm to survive in the environment within the host. [4]

Thick cuticle protects the worm from the host's acids and enzymes.

Lime cell alkaline secretion neutralises acid.

Microtriches (microvilli) increase the surface area for absorption of digested food.

Glands secrete mucus to protect the worm from digestive enzymes.

Muscles allow the tapeworm to increase contact with digested food.

(ii) Body wall cells of *T. solium* have been observed to contain transmembrane proteins involved in active transport mechanisms. Suggest how these mechanisms aid the survival of the parasite within its host. [2]

They enable the worm to absorb ions, amino acids and glucose (products of digestion) from the host's gut contents.

This can occur against a concentration gradient, so it can take up nutrients even when they are scarce.

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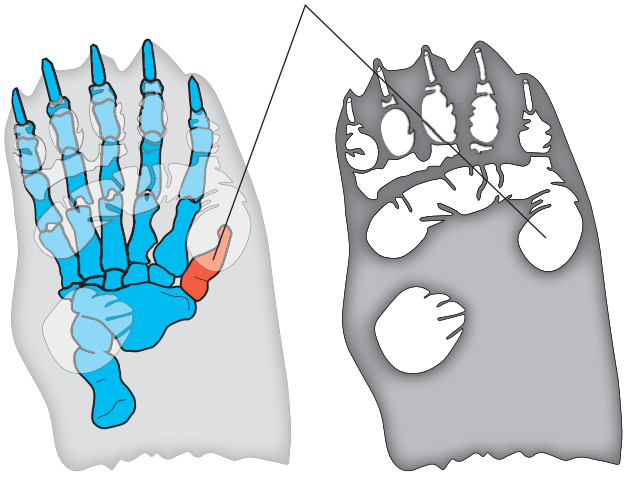
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2. Giant pandas, *Ailuropoda melanoleuca* and red pandas, *Ailurus fulgens* are both mammals which are native to China. It was long believed that giant pandas and red pandas were close evolutionary relatives and there is much evidence to support this hypothesis:

- both animals live in similar habitats,
- both have digestive systems similarly adapted to their bamboo diet,
- both have a sixth digit, known as a pseudo-thumb, which they use to grip and shred bamboo shoots.





With the advent of DNA sequencing techniques, it has been possible to compare the DNA of different species to confirm how closely related they are to each other.
The table below shows mitochondrial DNA sequences from four species of mammal including giant panda and red panda.

Species	Mitochondrial DNA (mtDNA) codes
Black bear	……ATTGGAGCAGACTTA……
Giant panda	……ATTGGCACTAATCTA……
Red panda	……ATTGGAACTAATCTT……
Raccoon	……ATCGGAACTAATCTT……

(a) Use the table to identify which of the species is most closely related to the red panda. Explain your answer. [2]

Raccoon.

There is only 1 base difference between the red panda and the raccoon (more bases in common), whereas there are more differences between the red panda and the giant panda (2) and the black bear (6).

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(b) In the study, mitochondrial DNA base pairs were analysed.
The following number of differences were found between giant panda DNA and that of the other species analysed:

Red panda	17
Black bear	12
Raccoon	21

One estimate of the mutation rate for the mitochondrial DNA sequence analysed is 3.95×10^{-7} mutations yr^{-1}.

Estimate how many years ago the giant panda and the red panda last shared a common ancestor. **Give your answer in standard form to two significant figures.** [3]

time = 17 differences ÷ 3.95×10^{-7} mutations yr^{-1}

= 43 037 974.68 years

= 43 000 000 years (2 s.f.)

Answer: 4.3×10^{7} years

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(c) There has been some debate as to whether the pseudo-thumb in red pandas and giant pandas are examples of analogous or homologous structures. Distinguish between analogous and homologous structures. Explain why analogous features are not considered evidence of common ancestry. [3]

Analogous structures evolve separately: they are different structures (different origin) that perform a similar function, e.g. wings of insects and birds.

Homologous structures evolve from a common ancestor: they have a similar basic structure but may perform different functions, e.g. the pentadactyl limb.

Analogous structures arise through convergent evolution (similar selection pressures), so they do not indicate common ancestry.

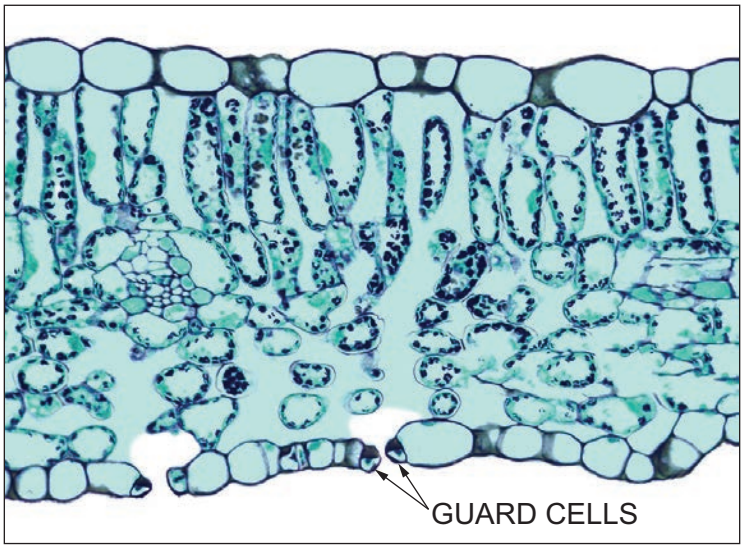
(d) In 1977, Carl Woese proposed the three domain system based on analysis of differences in the nucleotide sequences of 16S rRNA genes. Identify the domain to which the giant panda would belong. Give a reason for your answer. [2]

Eukaryota, as its cells contain membrane-bound organelles and DNA enclosed in a nuclear envelope.

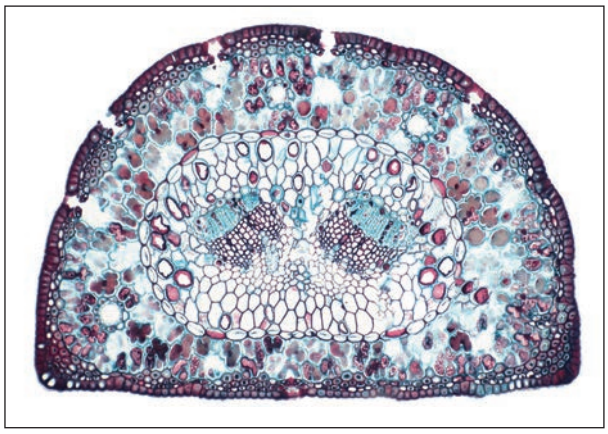
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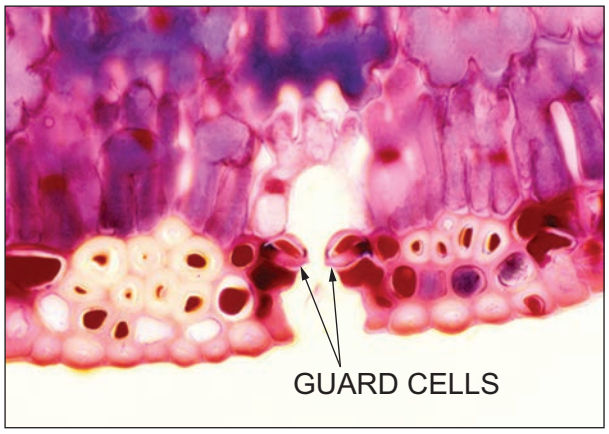
3. There is a wide variation in the rate of water loss from different plant species. Such variation is often due to structural features of the leaf. The photomicrographs below show transverse sections of a leaf of privet *(Ligustrum sp.)* and a leaf of pine *(Pinus sp.)*.



Ligustrum sp. T.S. leaf



Pinus sp. T.S. leaf



detail of stoma of *Pinus sp.*

(a) Use the photomicrographs to explain why less water vapour is lost through the stomata of *Pinus sp.* than through the stomata of *Ligustrum sp.* . [3]

Pinus has sunken stomata, in pits, so water vapour builds up in the pits.

This reduces the diffusion (water potential) gradient, so the rate of

transpiration is reduced.

Ligustrum has no pits (stomata nearer the surface), so moving air can easily

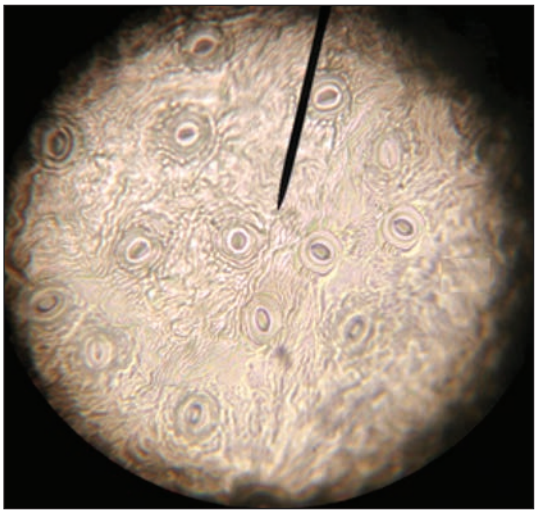
disrupt the diffusion shells and blow away the water vapour.

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(b) An investigation was carried out into the distribution of stomata on the lower surface of leaves of *Ligustrum*. The image below shows the view through a microscope showing an impression of the lower epidermis of a *Ligustrum* leaf.



(i) Describe how the investigation would have been carried out. [4]

Paint clear nail varnish (or PVA) onto the lower epidermis of the leaf, allow it to dry and peel it off with clear sticky tape to obtain an impression.

Prepare a slide using the impression and observe it under a light microscope.

Count the number of stomata in a field of view of known area.

Repeat for several fields of view (and leaves) to obtain a mean.

(ii) Calculate the stomatal density of this part of the leaf. The diameter of the field of view of the microscope is 1mm. **Give the answer to two decimal places.** [3]

Use the formula πr^2 where $\pi = 3.142$

14 stomata in the field of view; $r = 0.5$ mm

area = $3.142 \times 0.5^2 = 0.7855$ mm^2

density = $14 \div 0.7855 = 17.8230...$

Stomatal density = 17.82 mm^{-2}

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(iii) Suggest why the method used would not be suitable for calculating the stomatal density of *Pinus* leaves. [1]

The stomata of Pinus are sunken in pits, so they would not show up on the impression.

(c) The table below shows the mean number of stomata on the upper and lower surface of leaves from two species of plant.

Species	Mean number of stomata / cm^2	
	Upper surface	Lower surface
A	850	2651
B	5800	6100

Which of the two species in the table is likely to live in the driest environment? Explain your answer. [2]

Species A, as it has the lowest stomatal density (fewer stomata, especially on the upper surface).

So it has a lower rate of water loss (transpiration).

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4. The photomicrograph below shows a transverse section (T.S.) of the trachea and oesophagus of a mammal.



5 mm

(a) (i) Calculate the magnification of the photograph. [2]

scale bar length = 27 mm, actual length = 5 mm

magnification = image ÷ actual = 27 ÷ 5

Magnification = *x 5.4*

(ii) Explain how a feature visible in the photograph ensures that the trachea can function effectively during inspiration. [2]

Rings of cartilage (C-shaped) in the trachea wall.

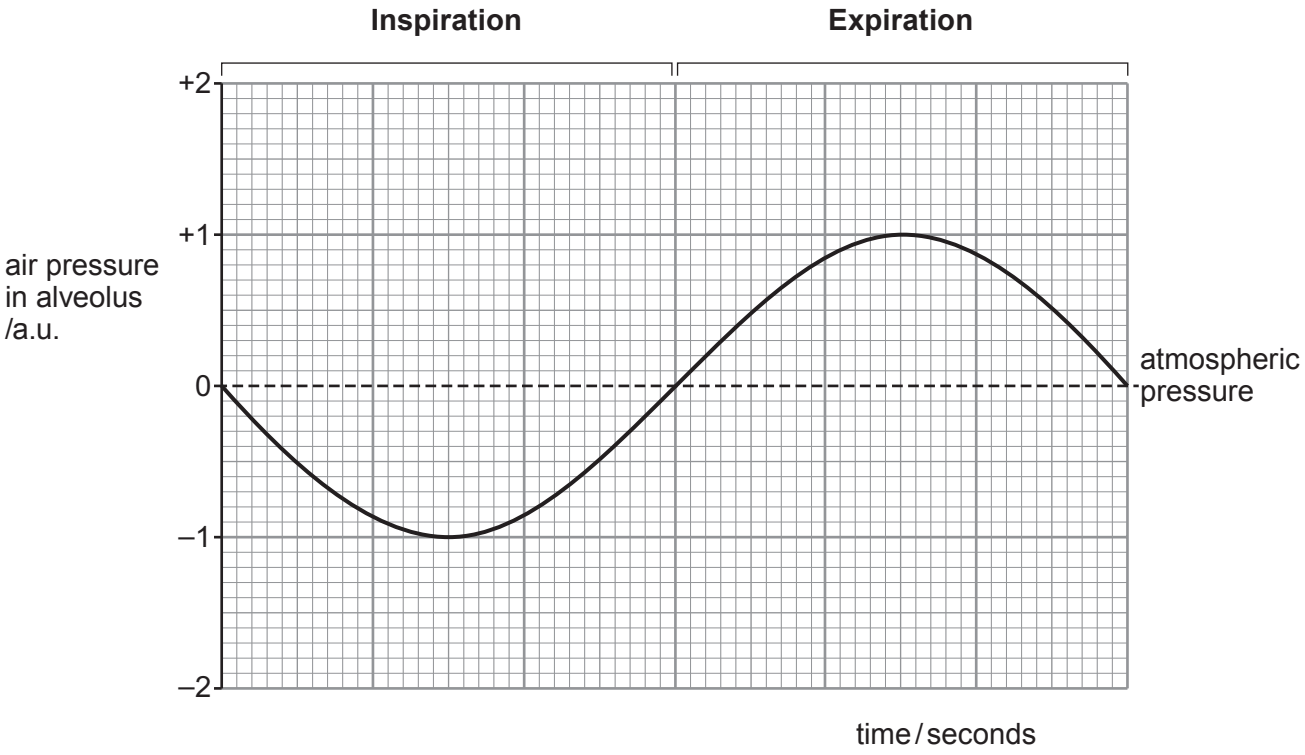
They support the trachea and prevent it from collapsing due to the decrease in air pressure during inspiration.

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(b) The graph below shows how the air pressure changes in the alveoli during ventilation of the lungs.



With reference to the graph explain how the muscles involved in the process of inspiration bring about the changes in pressure shown. [3]

The external intercostal muscles contract, moving the ribs up and out, and the diaphragm contracts and flattens.

The pleural membranes link the lungs to the thorax wall, so the lungs expand with it.

The volume of the thorax increases, therefore the pressure decreases.

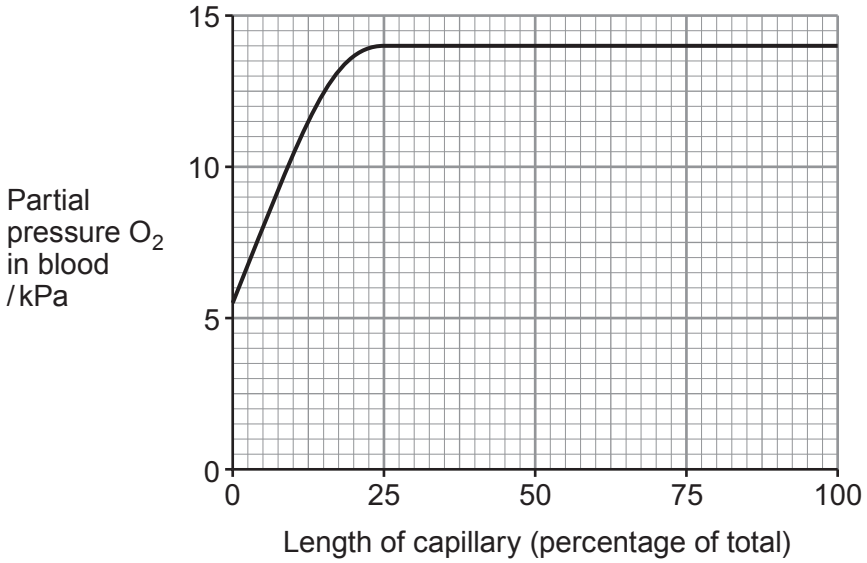
The air pressure in the alveolus falls to −1 a.u., below atmospheric pressure, so air rushes in.

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(c) The graph below shows how the partial pressure of oxygen in blood changes as blood flows through the pulmonary capillaries.



(i) I. Describe and explain the change in the partial pressure of oxygen in the blood as it passes along the pulmonary capillaries. [2]

pO_2 rises from 5.5 kPa to 14 kPa, as there is initially a large concentration gradient so oxygen diffuses into the blood; it then plateaus as equilibrium is reached at 14 kPa.

II. What conclusion could be reached about the minimum partial pressure of oxygen in the air in the alveoli? Explain your answer. [1]

14 kPa

14 kPa, because equilibrium has been reached between the pO_2 in the alveoli and the capillary.

(ii) Describe the features of the capillaries that allow this change to take place. [2]

Thin walls, only one cell thick (short diffusion path).

A dense network of capillaries giving a large total surface area.

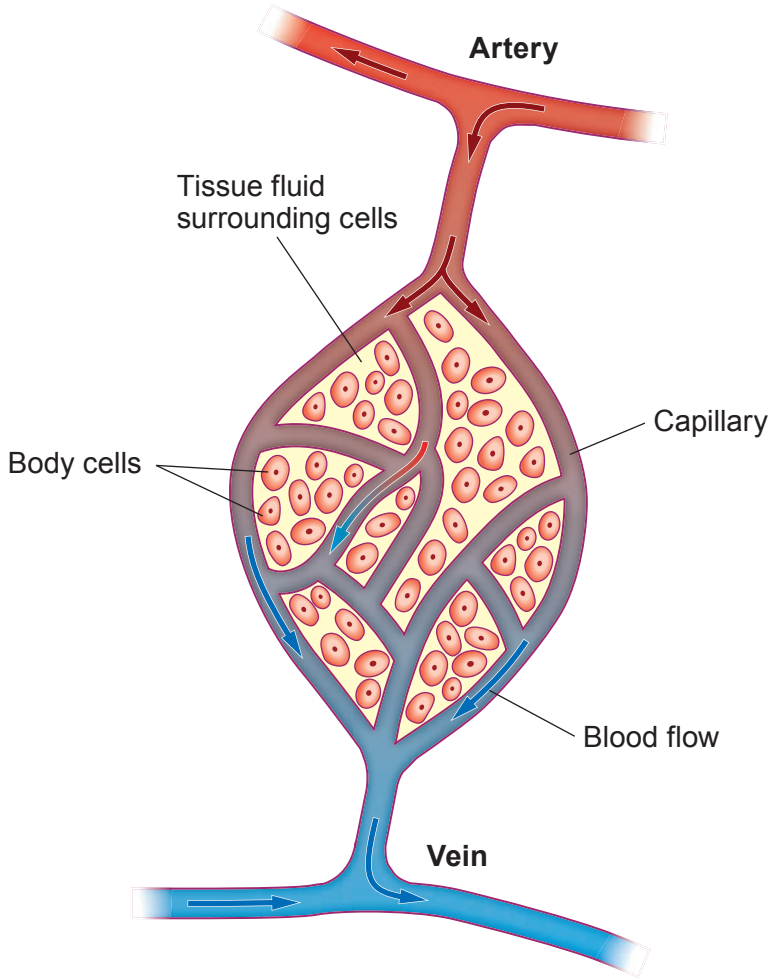
Small diameter, so low velocity of blood (more time for diffusion).

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The diagram below shows the arrangement of blood vessels in a capillary bed.



(d) With reference to the diagram, describe how tissue fluid is formed. [3]

At the arterial end of the capillary the hydrostatic (blood) pressure is higher than the osmotic pressure (solute potential effect of plasma proteins). This forces water and small soluble molecules (e.g. glucose, ions, amino acids) out of the capillary into the spaces around the body cells as tissue fluid. Blood cells and larger protein molecules are too large, so they are retained in the capillary.

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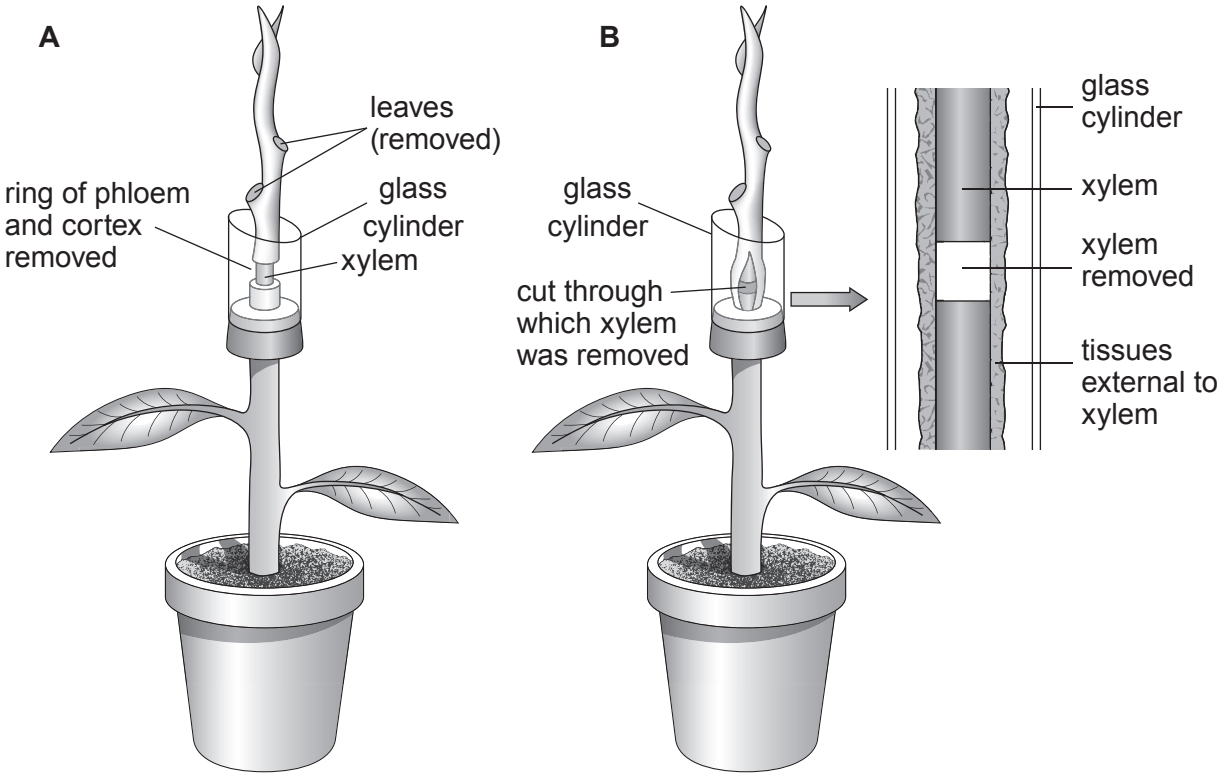
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5. An investigation was carried out into the transport of sugars in the stems of actively growing woody shoots. The leaves were removed from the shoots above the region to be investigated and the shoots were divided into three experimental groups.

- **Plant A** had all the tissues (phloem and cortex) outside the xylem removed in a ring at the base of the region from which the leaves had been removed.
- In **plant B** the xylem was removed from the centre of the stem at the base of the region with the leaves removed. This left the phloem and cortex intact except for the cut through which the xylem was removed (see diagram below).
- **Plant C** – control (not shown).

Each stem was enclosed in a clear glass cylinder. The cylinders were filled with distilled water which was changed daily. No sugars were detected in the water at any point during the investigation.



(a) Suggest how Plant **C** was set up as a control for the experiment. [2]

Keep all other conditions the same as the experimental plants (leaves removed and enclosed in a glass cylinder of distilled water, with a cut made), but do not remove any vascular tissue.

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(b) (i) Explain why the leaves were removed above the region to be investigated. [2]

Removal of leaves above the cut reduces photosynthesis, reducing sugar production above the experimental region.

(ii) Suggest why:

I. Each stem was enclosed in a glass cylinder containing distilled water. [1]

The cylinder of water prevents the exposed region from drying out.

II. The water was changed daily. [1]

Replenishing the water stops the build-up of chemicals and bacteria, and replenishes oxygen.

Question continued on next page.

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(c) The results after running the experiment for six days are shown in the table below.

Plant	Increase in length of stem / mm	Total sugar in stem above cut region / mg
A	8.3	0.08
B	48.7	5.28
C	68.2	3.21

Explain the difference in the results:

(i) between **A** and **B** [3]

Phloem translocates sugar. Removal of phloem in A almost completely stopped upward transport of sugars past the cut (0.08 mg, B 5.28 mg). Growth is reduced in A (8.3 mm) due to reduced supply of sugars.

(ii) between **B** and **C** [2]

Removal of xylem in B prevents the transport of water up the plant, which reduces growth of B (48.7 compared with 68.2 mm). Less growth, so less respiration (energy) needed, therefore more sugar remains in B (5.28 mg).

(d) (i) With reference to the results table, suggest how the reliability of the results might have been improved. [1]

Repeat the experiment with several plants in each group and calculate the mean increase in stem length.

(ii) State **two** variables which should have been controlled in this experiment. [1]

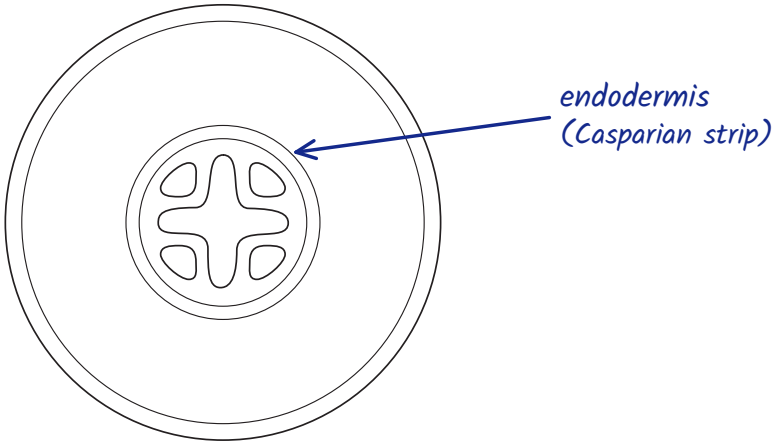
Temperature and light intensity.

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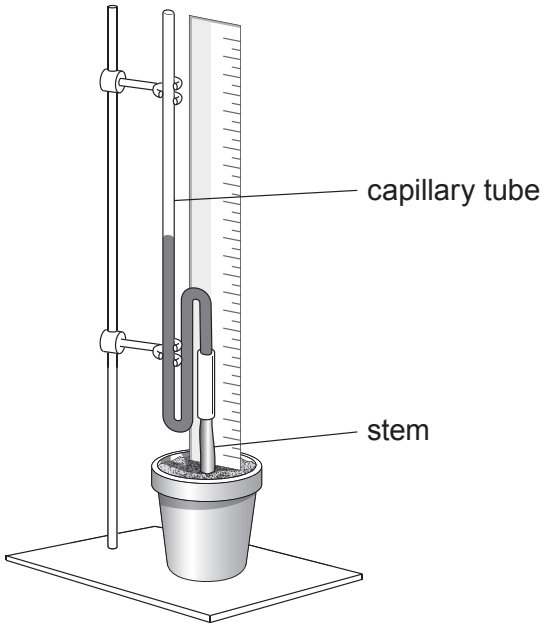
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The diagram below shows a cross section of a root from one of the plants used in the experiment.



(e) **Indicate with an arrow on the diagram** where you would expect to find the Casparian strip. [1]

The apparatus below can be used to demonstrate the formation of root pressure in a plant under certain conditions.



When cyanide solution was added to the soil in the pot the root pressure was observed to fall significantly.

(f) With reference to the role of the Casparian strip, explain how cyanide would result in the reduction in root pressure observed. [3]

Casparian strip stops the apoplast pathway, forcing ions into the symplast;

ions move into the xylem by active transport.

Cyanide is a respiratory inhibitor, so stops ATP synthesis.

Lower water potential gradient (less osmosis into xylem) reduces root pressure.

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6. Domestic dogs evolved from wolves between 10 000 and 30 000 years ago. Both are adapted to feed mainly on a carnivore diet. Recent studies into dogs and wolves have shown that the ancestors of domesticated dogs produced enzymes involved in starch digestion which are not produced by wolves. It has been proposed that dogs might have developed the ability to digest starch **after** they were domesticated by humans.

Explain how wolves and dogs are both adapted to feed mainly on a carnivore diet. Describe the process of starch digestion and suggest the advantage to domesticated dogs of being able to digest starch. [9 QER]

Wolves and dogs both have carnivore dentition. Sharp, chisel-shaped incisors are used for gripping and tearing flesh from bone, and long, pointed canines are used to seize, hold and kill prey. The carnassial teeth (the last upper premolar and first lower molar) slide past each other like scissors, shearing through flesh, bone, ligaments and tendons. The jaw only moves up and down (vertical, hinge-like movement), so chewing is limited and food is swallowed in large pieces. They have a relatively short gut adapted for protein digestion, since protein is easily digested and no cellulose has to be broken down.

Starch digestion begins in the mouth. Salivary amylase hydrolyses starch (breaking glycosidic bonds) into maltose. The optimum pH (about 7) for amylase is maintained by mineral salts (hydrogencarbonate buffers) in saliva. In the acidic stomach amylase is denatured, so starch digestion stops. It resumes in the duodenum, where pancreatic amylase, secreted in pancreatic juice, hydrolyses the remaining starch to maltose; alkaline bile and pancreatic juice neutralise the acid. Maltose is then hydrolysed to glucose by the enzyme maltase, bound to the membranes of the epithelial cells of the small intestine (ileum), and the glucose is absorbed into the blood.

Domesticated dogs lived alongside humans and were fed on human food waste, which contained large amounts of starch (e.g. from cereal crops). Due to variation (mutation), some dogs were better at digesting starch than others because they produced more amylase. These dogs could obtain more energy (glucose) from human food waste, so they were more likely to survive, breed and pass on the alleles for starch digestion to their offspring: natural selection.

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Over many generations the frequency of these alleles increased in domestic dogs. Wolves (wild dogs) feed on prey and cannot digest starch well, because there is no selective advantage for them in producing amylase.

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