Surname	StemUp Model Solution	Centre Number	Candidate Number
Other Names			2

GCE AS

B400U20-1

S19-B400U20-1

BIOLOGY – AS component 2
Biodiversity and Physiology of Body Systems

FRIDAY, 24 MAY 2019 – MORNING

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**12**	
2.	**10**	
3.	**11**	
4.	**16**	
5.	**17**	
6.	**9**	
Total	**75**	

B400U201
01

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(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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Answer **all** *questions.*

1. The mammalian circulatory system is comprised of the pulmonary and systemic circulations. The table below shows the maximum and minimum blood pressure in different parts of the circulatory system of a mammal.

Part of the circulatory system	Blood pressure / kPa	
	Maximum	Minimum
Left ventricle	16.00	0.00
Right ventricle	3.33	0.00
Aorta	16.00	10.67
Pulmonary artery	3.33	1.07
Muscle capillary	2.00	1.60
Lung capillary	1.08	0.67
Pulmonary vein	0.67	0.27
Vein in forelimb	0.67	0.67
Artery in forelimb	12.57	8.62

(a) (i) Calculate the mean pressure in the lung capillary. [1]

(1.08 + 0.67) ÷ 2 = 1.75 ÷ 2

Mean pressure = 0.88 kPa

(ii) The mean pressure in the muscle capillary is 1.80 kPa. Explain the cause of the difference between this and the mean pressure in the lung capillary. [1]

The left ventricle has a thicker, more muscular wall than the right ventricle, so it produces a higher pressure.

(iii) Suggest and explain **one** advantage for the lower mean pressure in the lung capillary. [2]

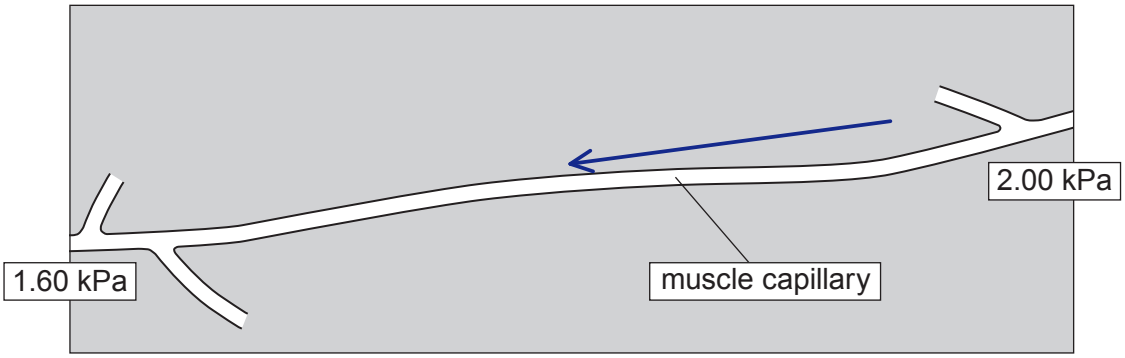
The reduced flow rate allows more time for gas exchange (diffusion) and less tissue fluid is produced in the lungs.

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(b) The diagram below shows a muscle capillary transporting blood through a tissue. It also shows where the maximum and minimum pressures occur.



(i) **Draw an arrow** on the diagram to indicate the direction of blood flow. [1]

(ii) Account for the difference between the maximum and minimum pressures in the muscle capillary. [3]

The pressure is higher at the arterial end, due to ventricular systole.

Capillaries are very numerous, so the total cross-sectional area increases,

and there is friction with the capillary walls, reducing the pressure.

Fluid is lost from the capillary as tissue fluid is formed at the arterial

end, so the pressure falls.

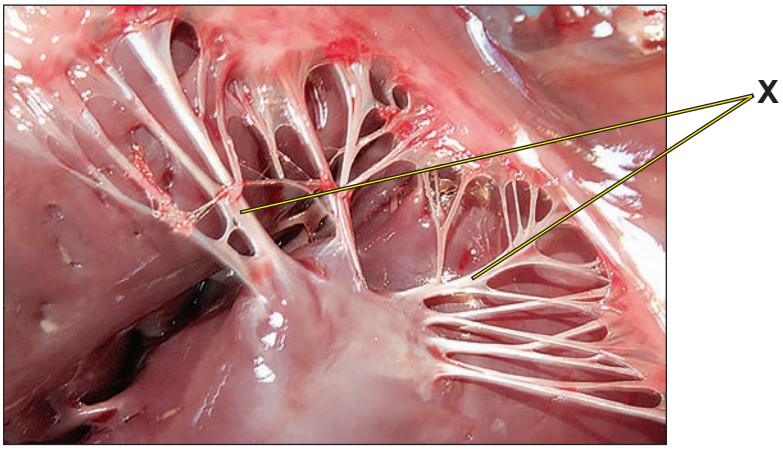
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(c) The photograph below shows the detail of the interior of the ventricle of a dissected mammalian heart.



(i) Name the structures labelled **X** in the diagram which are attached to the bicuspid valve. [1]

Tendons (chordae tendineae)

(ii) Explain the function of the structures labelled **X**. [2]

They prevent inversion of the bicuspid valve (stop it turning inside out into the atrium), so blood cannot flow back into the left atrium, during contraction of the left ventricle (ventricular systole).

(d) State **one** ethical issue which should be considered when using animals for dissection. [1]

Ensure that the animals are treated humanely and that no animals are killed needlessly.

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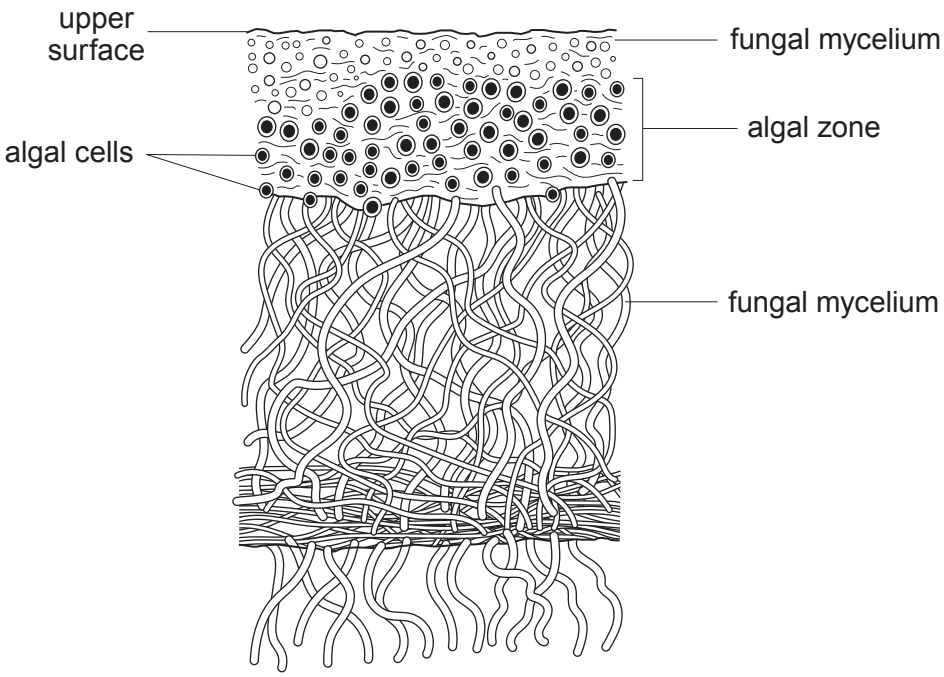
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2. Lichens are found growing on many surfaces such as buildings, rocks and tree trunks. They are composed of two organisms, a fungus and a single-celled, photosynthetic alga. The two organisms co-exist in a relationship where both benefit. The main part of the lichen is known as a thallus. The diagram below shows a cross section through a lichen thallus.



(a) Fungi are classed as saprotrophs. Define the term *saprotroph*. [2]

An organism that secretes digestive enzymes onto its food, so the food is digested externally (extracellular digestion), and then absorbs the soluble products of digestion into its cells.

(b) Name **one** inorganic ion the algae would require for growth and explain why it cannot grow without this inorganic ion. [2]

Magnesium ions (Mg^{2+}).

Magnesium is required to synthesise chlorophyll, so without it the algae could not photosynthesise and so could not grow.

(c) Explain the position and distribution of the algae within the lichen thallus. [2]

The algae are near the upper surface to capture sunlight for photosynthesis, in a thin layer because light will not penetrate deeper into the thallus. The fungal mycelium above them prevents dehydration of the algae.

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(d) Evidence shows that the fungus is able to absorb and transport inorganic ions dissolved in rainwater which the algae then use for growth.

With reference to the modes of nutrition of the two organisms within the lichen suggest the benefit of the association with the algae to the fungus. [2]

The algae are autotrophic and make sugars, which the heterotrophic fungus (unable to make its own organic molecules) uses.

Algae also give oxygen for the fungus's aerobic respiration: mutualism.

(e) A scientist extracted samples of DNA from the algae in lichen from two different locations with similar environmental conditions. Describe how the DNA samples could be used to determine whether the algae within the two lichens were the same species or not. [2]

Compare the base sequence of the DNA from both algae by DNA sequencing (or genetic fingerprinting).

If the sequences of bases (or the banding patterns) from the two algae are the same or very similar, they are the same species; if they are significantly different, they are different species.

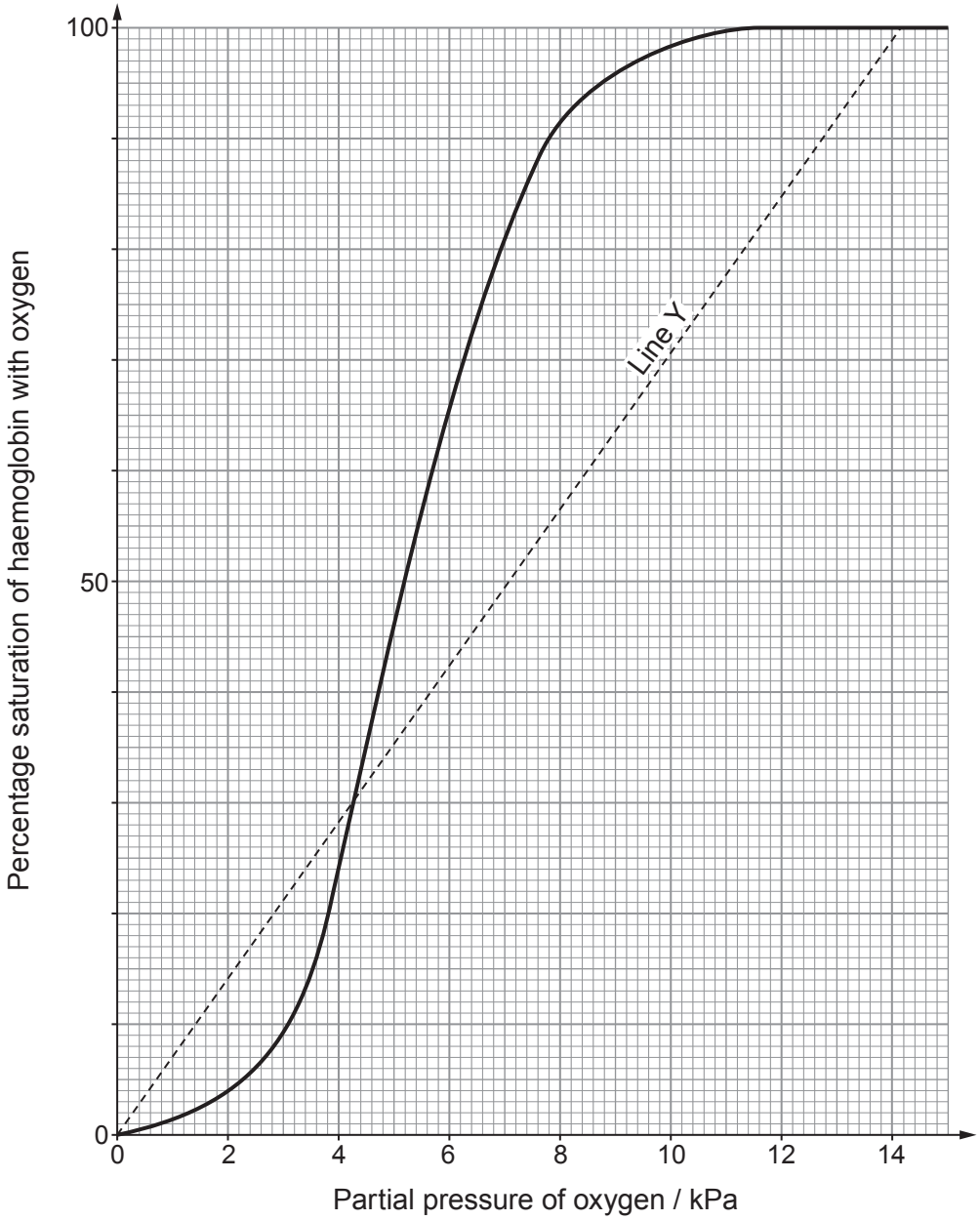
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3. The diagram below shows the oxygen dissociation curve for adult human haemoglobin.



(a) The curve shows a sigmoid (S-shaped) relationship between partial pressure of oxygen and saturation of haemoglobin with oxygen. Line Y shows the theoretical linear relationship.

(i) Using the sigmoid curve the percentage decrease in the haemoglobin saturation between 6 kPa and 2 kPa is 15.5 % per kPa.

Calculate the equivalent **percentage decrease per kPa** for the linear relationship shown in the graph. [2]

Line Y: at 6 kPa = 42.5 %, at 2 kPa = 14.2 %

Decrease = (42.5 − 14.2) ÷ (6 − 2) = 28.3 ÷ 4 = 7.08

Decrease = 7.1 % per kPa

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(ii) Explain why the sigmoid curve is more efficient for a respiratory pigment than the linear relationship. [2]

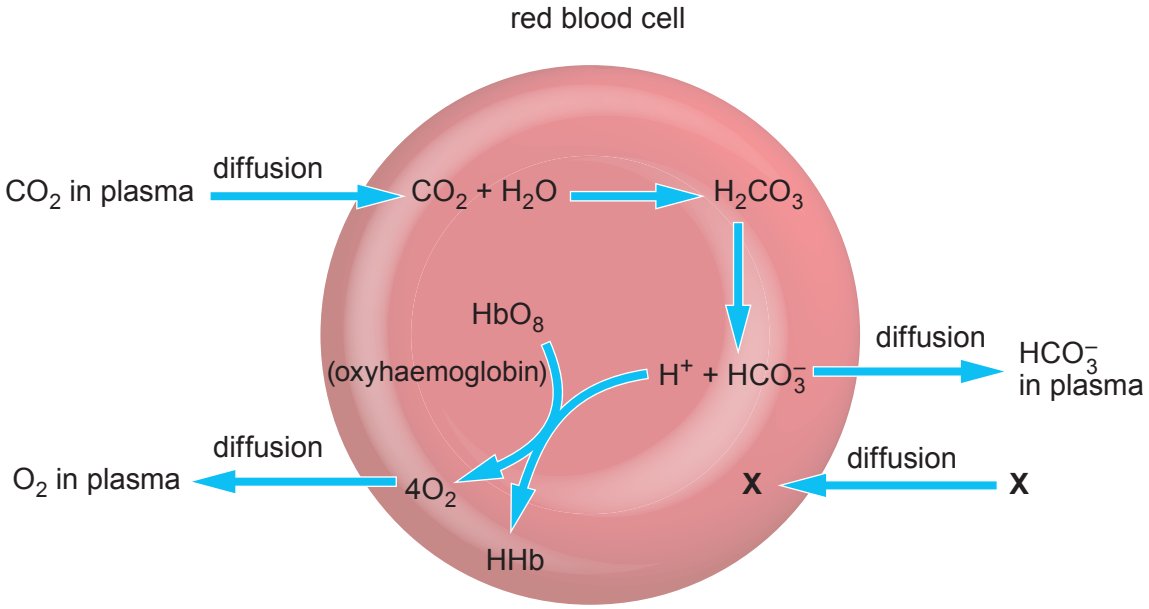
On the steep part of the sigmoid curve, a small decrease in partial pressure of oxygen results in a large decrease in percentage saturation of haemoglobin, so there is more efficient unloading of oxygen to respiring tissues; haemoglobin also reaches full saturation at lower partial pressures (in the lungs).

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(b) The diagram below shows the process by which a red blood cell located in a capillary of actively respiring tissue is involved in the transport of carbon dioxide.



(i) Carbon dioxide normally dissolves slowly in water.

Explain why carbon dioxide dissolves much more quickly within red blood cells. [1]

Red blood cells contain the enzyme carbonic anhydrase, which catalyses the combination of carbon dioxide with water.

(ii) Name ion **X** and explain why it enters red blood cells. [2]

Chloride ions (Cl^-), which diffuse in to replace the HCO_3^- ions that diffuse out, maintaining electrochemical neutrality (the chloride shift).

(iii) Use the diagram to explain why an increase in the rate of respiration would lead to more oxygen being released from oxyhaemoglobin. [4]

An increased rate of respiration leads to more carbon dioxide being produced, so more carbon dioxide diffuses into the red blood cells. Carbonic anhydrase converts it to carbonic acid (H_2CO_3), increasing the carbonic acid concentration, which dissociates into H^+ and HCO_3^-. This increases the H^+ concentration (increased acidity). The H^+ ions combine with haemoglobin to form HHb, decreasing the affinity of haemoglobin for oxygen, so more oxygen is released from oxyhaemoglobin. This is the Bohr effect.

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4. An investigation was carried out to determine the effect of sheep grazing on the plant biodiversity of an upland heath. An area of previously grazed land was fenced off to exclude the sheep and the plant biodiversity was immediately calculated and then recalculated after 5 years. Each calculation of plant biodiversity involved taking a large number of random samples at the site.

(a) (i) Define the term *biodiversity*. [1]

The number of different species (species richness) and the number of individuals of each species (species evenness) in an area.

(ii) Describe a suitable method which could be used to collect the data needed to estimate plant biodiversity in this investigation. [4]

Place two tape measures at right angles to form the axes of a grid across the site.

Use a calculator (random number generator) to generate random coordinates.

Place the corner of a quadrat (e.g. 0.5 m × 0.5 m) at the point indicated on the grid.

Identify each plant species and count the number of individuals of each species within the quadrat.

Repeat for many quadrats and calculate a mean for each species, then use the data to calculate Simpson's index.

(iii) Explain the importance of taking a **large number** of **random** samples. [2]

A large number of random samples ensures the samples are representative of the whole area and avoids bias, and ensures the results are reliable (anomalies have less effect on the mean).

(iv) Suggest a suitable control for this investigation. [2]

Sample an area next to the site where grazing by sheep has not been excluded (still grazed), ensuring the environmental conditions (e.g. soil type, altitude, light, rainfall) are the same for both areas.

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The table below shows the results of the investigation.

Species	Number of individuals	
	Immediately after fencing	Five years after fencing
Erica cinerea (height: 20 cm – 60 cm)	34	18
Calluna vulgaris (height: 20 cm – 60 cm)	26	10
Carex binervis (height: 15 cm – 120 cm)	24	53
Galium saxatile (height: 5 cm – 20 cm)	43	0
Potentilla erecta (height: 10 cm – 30 cm)	53	12
Sorbus aucuparia (height: up to 10 m)	0	2
Diversity (Simpson's index)	0.79	

(b) (i) Use the formula given below to calculate the Diversity index for the experimental site after grazing was excluded for 5 years. **Give your answer to 2 decimal places.** [3]

$$\text{Diversity} = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

N = total number of individual plants
n = number of individuals per species
$\sum$ = sum of

Species	n	$(n-1)$	$n(n-1)$
Erica cinerea	18	17	306
Calluna vulgaris	10	9	90
Carex binervis	53	52	2756
Galium saxatile	0	−1	0
Potentilla erecta	12	11	132
Sorbus aucuparia	2	1	2
	N = 95		$\sum n(n-1)$ = 3286
	$(N-1)$ = 94		

$N(N-1)$ = 95 × 94 = 8930

1 − (3286 ÷ 8930) = 1 − 0.368 = 0.632

Diversity index = 0.63

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(ii) State the conclusion you can make about the effect of excluding grazing on the biodiversity of the site. [1]

Excluding grazing resulted in a reduction in biodiversity (Simpson's index fell from 0.79 to 0.63).

(c) After grazing had been excluded for 5 years the percentage ground cover by *Erica cinerea* had increased from 33 % to 67 %.

Use this information and the information given in the table on page 12 to suggest how this change could have affected the overall biodiversity at the site. [3]

E. cinerea grows up to 60 cm in height, whereas G. saxatile only grows up to 20 cm.

The increased cover of taller heather prevents light reaching the smaller plants, so fewer small plants grow due to competition.

This reduces numbers of some species and species richness (G. saxatile eliminated), so biodiversity falls.

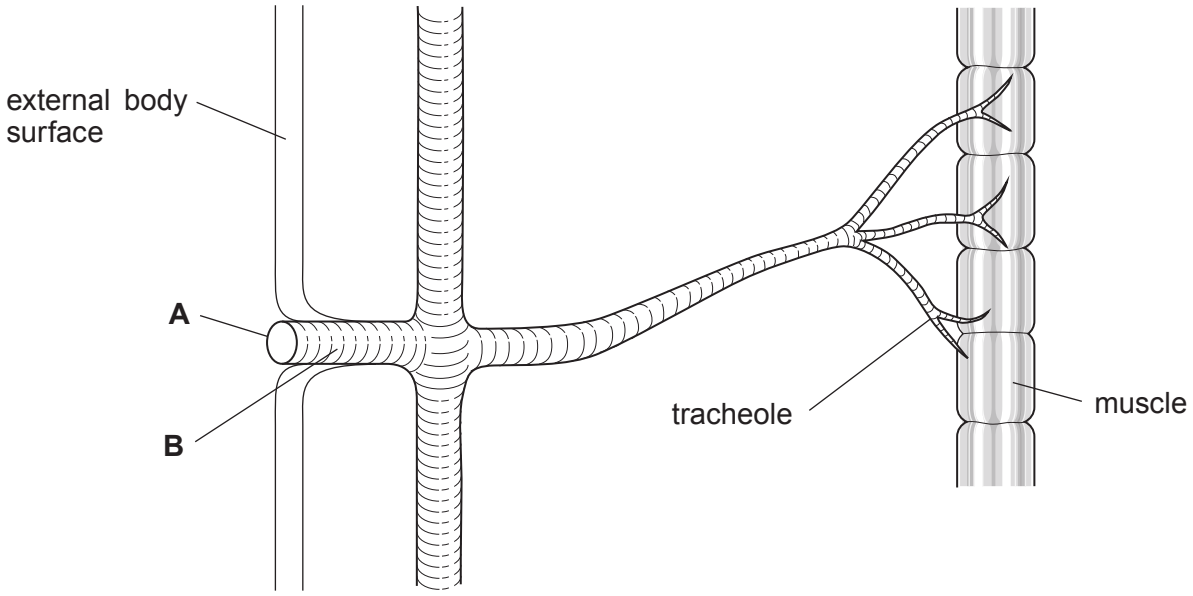
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5. Insects have evolved an internal gas exchange system as an adaptation to a terrestrial environment. The diagram below shows part of an insect's gas exchange system.



(a) Name the structures labelled **A** and **B**. [1]

A: Spiracle

B: Trachea

(b) Many small animals such as earthworms have a circulatory system with a respiratory pigment such as haemoglobin.

(i) Explain why earthworms need a respiratory pigment, but insects do not. [2]

The earthworm's gas exchange surface (skin) is not in contact with all its cells, so it needs haemoglobin to transport oxygen to them. In insects the gas exchange surface (tracheoles) is in direct contact with the muscle cells, so no transport of oxygen in blood is needed.

(ii) Suggest why having the type of gas exchange system shown in the diagram means that insects are not able to grow as large as animals which have a circulatory system and haemoglobin. [1]

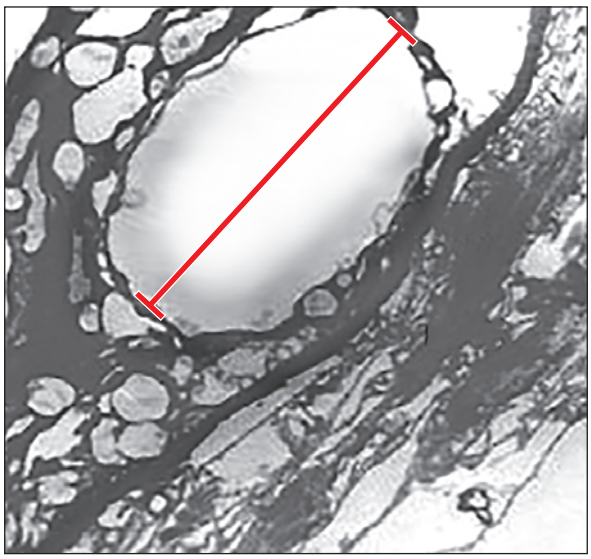
To grow larger the tracheae and tracheoles would need to be longer, so the diffusion distance to respiring cells would be too great and diffusion would be too slow to supply enough oxygen.

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The electron micrograph below shows a transverse section of an insect tracheole.



(c) Using the line provided on the electron micrograph, calculate the diameter of the insect tracheole in the electron micrograph, given that the magnification of the image is × 10 000.

Give your answer in µm to 2 significant figures. [2]

Length of line = 50 mm = 50 000 µm

Actual size = image size ÷ magnification

= 50 000 ÷ 10 000 = 5.0 µm

Diameter = *5.0* µm

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Albacore tuna (*Thunnus alalonga*) is a fast-swimming predatory fish which can swim at speeds of up to 80 km hr^{-1} and often performs very deep dives into colder water in pursuit of prey. The tuna has a very high rate of respiration and has several adaptations which help it maximise its rate of gas exchange:

- gills have a surface area up to 30 times greater than other fish of comparable size
- gas exchange surface is much thinner than that of other fish
- higher blood pressure than other fish
- counter-current flow in its gills

However, it has lost the ability to pump water over its gill surface, relying instead on a process known as ram ventilation. In this process, the fish keeps its mouth open as it swims and water is forced over the gill surface as it moves through the water.



(d) (i) Explain how a thin gas exchange surface and high blood pressure help a tuna to maximise its rate of gas exchange. [3]

A thin gas exchange surface reduces the diffusion distance.

High blood pressure increases the flow rate of blood through the gills, so oxygenated blood is carried away quickly to maintain a steep concentration gradient.

Both increase the rate of diffusion of oxygen into the blood.

(ii) Tuna must swim continuously. Explain why this is essential. [3]

The tuna is unable to pump water over its gills, so it must force water over the gills by swimming with its mouth open (ram ventilation).

This maintains a constant flow of water and so maintains the concentration gradient of oxygen across the gills,

so that sufficient oxygen is absorbed to maintain the high rate of respiration (ATP production for muscle contraction).

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Another adaptation found in tuna is that they are able to maintain a core body temperature several degrees above that of the surrounding water. They achieve this by means of a counter-current heat exchanger located deep within their muscle. Cool blood in arteries from the gills passes very close to warm blood in the veins flowing in the opposite direction. This allows heat from the warm blood to raise the temperature of the cooler blood before it reaches the muscle capillaries.

(e) The tuna's heat exchanger employs a counter-current flow mechanism. Explain how such an arrangement helps to maximise the rate of heat exchange. [2]

A temperature gradient (difference) is maintained between the warm blood and the cool blood, so equilibrium is never reached, across the whole length of the heat exchanger.

(f) Suggest why it is particularly important to the tuna to raise the temperature of blood before it reaches the muscle capillaries. [3]

Warmer blood gives oxygen molecules higher kinetic energy, so oxygen diffuses more quickly into the muscle.
It maintains a higher rate of metabolism in the muscle, closer to the optimum temperature for enzymes, so there is a higher rate of ATP production.
So the tuna can remain active and hunt for food in deeper, colder water.

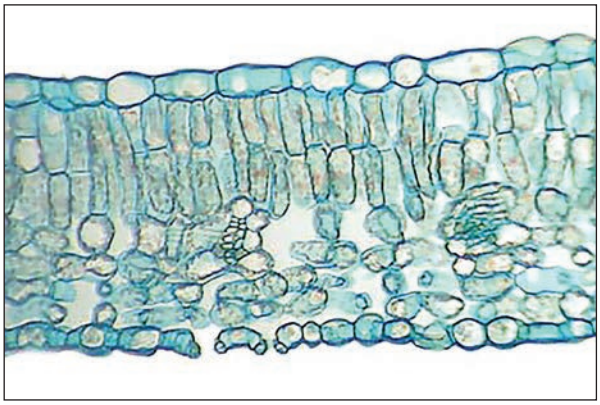
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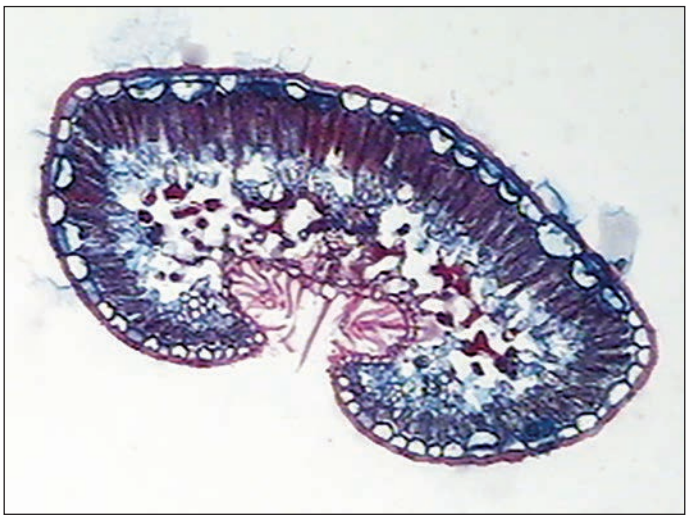
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6. The three photomicrographs below show three types of angiosperm leaf adapted to different environmental conditions.

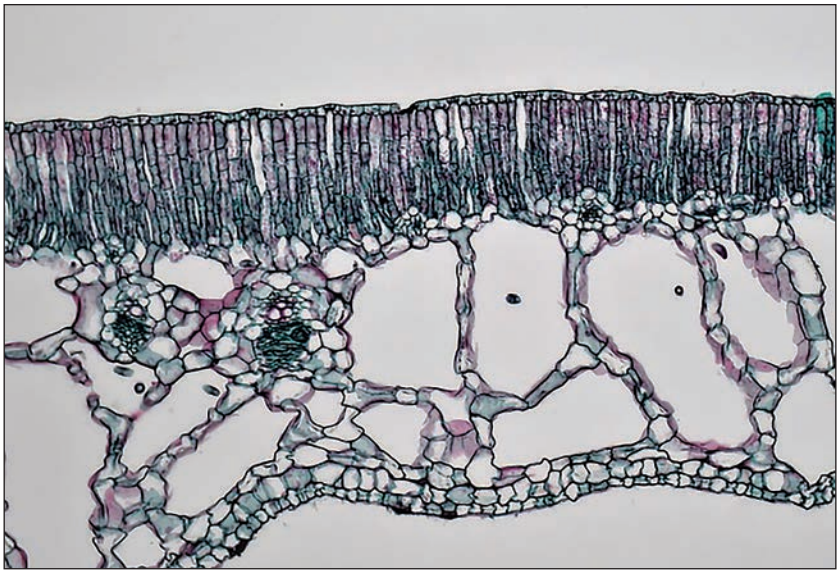
Photomicrograph **A**



Photomicrograph **B**



Photomicrograph **C**



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Describe how the structures present in the leaf in photomicrograph **A** allow the plant to carry out photosynthesis and explain how the adaptations in the leaves in photomicrographs **B** and **C** enable the plants to survive in different environmental conditions. [9 QER]

Leaf A (a mesophyte): the upper epidermis is a single layer of transparent (clear) cells with no chloroplasts, which allows light to penetrate through to the mesophyll below. A thin waxy cuticle covers it to reduce water loss. Below it is the palisade mesophyll, a layer of tall, closely packed cells containing many chloroplasts. This is the main site of photosynthesis. The palisade cells are orientated with their long axis at right angles to the leaf surface, so light passes through fewer cell walls and the chloroplasts can absorb the maximum amount of light; the chloroplasts can also move within the cells towards the light.

The spongy mesophyll has loosely packed cells with large air spaces, allowing gas exchange: carbon dioxide diffuses to the photosynthesising cells and oxygen diffuses away. The lower epidermis has stomata (opened and closed by guard cells) that allow carbon dioxide to diffuse into the leaf and oxygen out. Xylem in the vascular bundles transports water to the leaf for photosynthesis, and phloem transports the sugars produced away.

Leaf B is a xerophyte, which lives in dry conditions (e.g. marram grass), so its adaptations reduce water loss by transpiration. The leaf is rolled, with the stomata on the inner surface, which reduces air movement and traps moist air, lowering the water potential gradient between the leaf and the air.

Hairs on the inner surface trap moist air around the stomata, and the stomata are sunken in pits, so humid air is trapped and less water vapour diffuses out. A thick waxy cuticle on the outer surface reduces water loss by evaporation. These adaptations allow the plant to survive where water is scarce.

Leaf C is a hydrophyte, which lives in water (e.g. a water lily leaf floating on the surface). It has very large air spaces in the spongy mesophyll, which provide buoyancy so the leaf floats on the surface to receive maximum light,

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and they also store gases for photosynthesis and respiration.

The stomata are on the upper surface, to allow gases to diffuse from the air, as the lower surface is immersed in water. The waxy cuticle is thin or absent, as water loss is not an issue, and there is little xylem or support tissue because the water supports the leaf.

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