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

GCE AS

B400U20-1

O21-B400U20-1

FRIDAY, 15 OCTOBER 2021 – 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.	**10**	
2.	**10**	
3.	**12**	
4.	**18**	
5.	**16**	
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. Do not used gel pen or correction fluid.

You may use 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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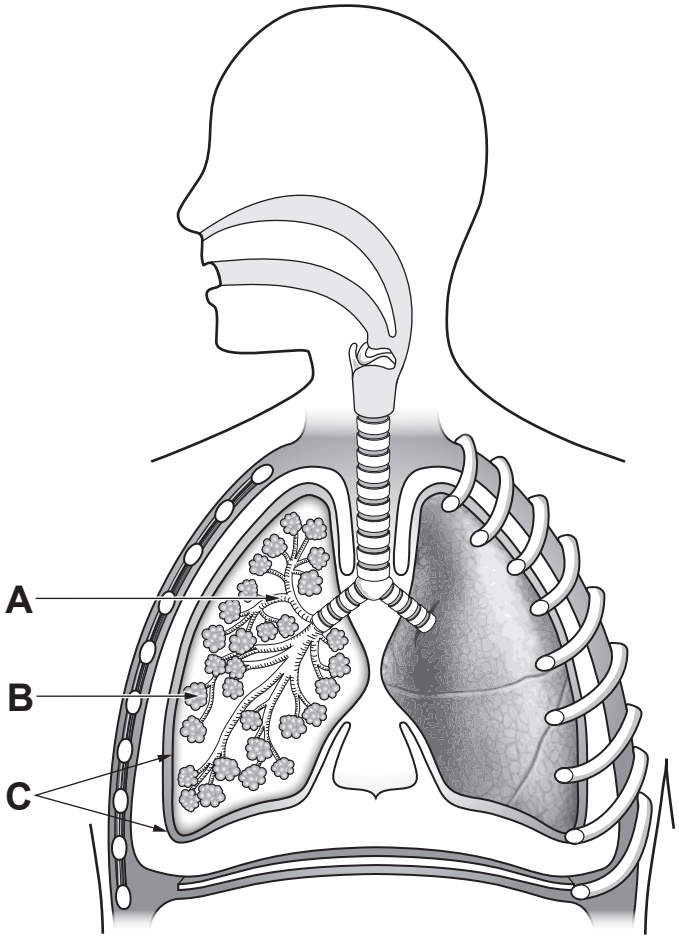
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Answer **all** *questions.*

1. **Image 1.1** shows the human respiratory system.

Image 1.1



(a) (i) Name structures **A**, **B** and **C** shown in **image 1.1**. [1]

A Bronchiole

B Alveolus (alveoli)

C Pleural membranes

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Image 1.2 shows a transverse section of a human trachea.

Image 1.2



Magnification ×8

(ii) Use the line shown in **image 1.2** to calculate the actual diameter of the trachea lumen. [2]

Length of line on image = 38 mm

actual diameter = image size ÷ magnification

= 38 ÷ 8 = 4.75 mm

Diameter = 4.75 mm

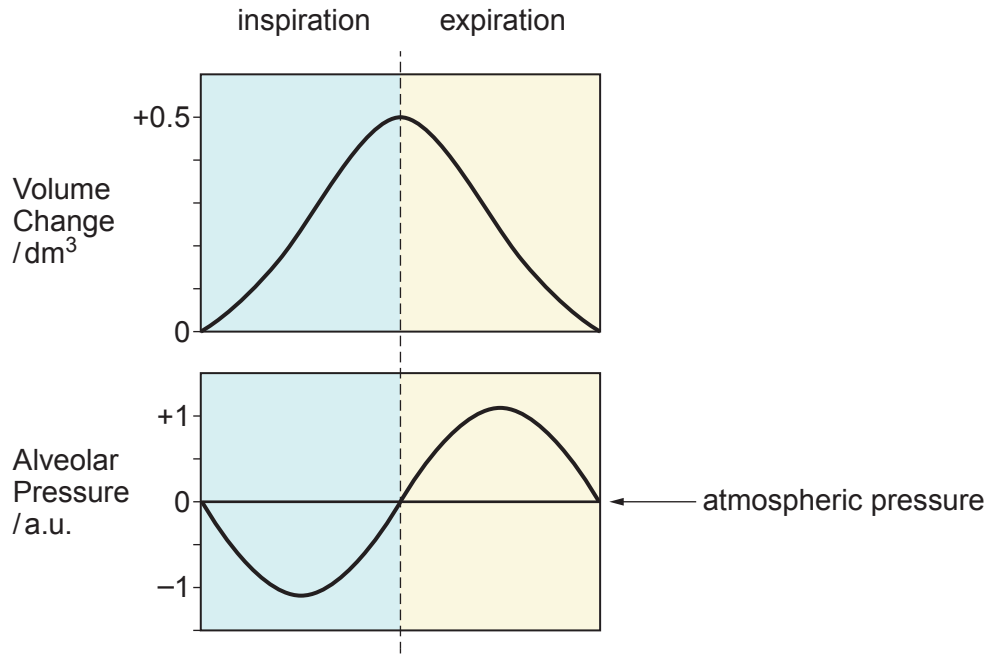
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(b) **Image 1.3** shows the changes in pressure and volume changes within the human thorax during one breath.

Image 1.3



(i) I. Explain how the volume of the thorax is changed during inspiration. [3]

External intercostal muscles contract, moving the ribcage up and outwards.

The diaphragm contracts and flattens (moves down).

The pleural membranes link the lungs to the thorax wall, so the lungs are pulled outwards too and the thorax volume increases.

II. With reference to the graphs in **image 1.3** and your own knowledge, explain the change in alveolar pressure during inspiration. [2]

As thoracic volume increases, alveolar pressure decreases below atmospheric (to −1 a.u.), so air is drawn in.

As air enters the alveoli the pressure increases back to atmospheric (0).

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(ii) During expiration there is a risk of collapse of the alveoli due to the positive pressure. Suggest how the alveoli are adapted to deal with this. [2]

The alveoli are coated (lined) with surfactant.

Surfactant reduces the surface tension of the moisture lining the alveoli,

so the alveolar walls do not stick together and collapse.

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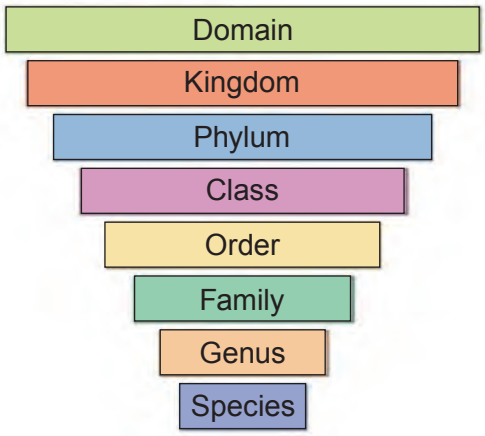
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2. **Image 2.1** shows the taxonomic groups used in the classification of living organisms.

Image 2.1



(a) Organisms in the Domain Eukaryota can be divided into Kingdoms based on common features. **Complete table 2.2**. [4]

Table 2.2

Kingdom	Feature
Plantae	• Cellulose cell wall • Photoautotrophic
Animalia	• No cell wall • Nervous coordination • Heterotrophic
Fungi	• Chitin cell wall • Hyphae / spores • Heterotrophic (saprotrophic)
Protoctista	• Single celled • If multicellular, no tissue differentiation

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(b) **Image 2.3** shows part of a coral reef, an example of a biodiversity hotspot.

Image 2.3



(i) Define the term biodiversity. [1]

The number and variety of organisms (number of species and of individuals of each species) in a specified geographical area.

(ii) Describe the process through which this biodiversity has been generated. [3]

Natural selection: there is variation within populations, and the reef has lots of different niches, so lots of different adaptations are favoured. Individuals with advantageous adaptations survive (e.g. selective predation removes others) and reproduce, passing on their alleles. Over many generations this produces many different species (speciation), each adapted to its own niche.

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(c) Scientists compared the biodiversity levels in two different ecosystems, the tropical rainforests and the arctic tundra. The location of these ecosystems are shown in **image 2.4**. **Images 2.5 and 2.6** show examples of these ecosystems.

Image 2.4

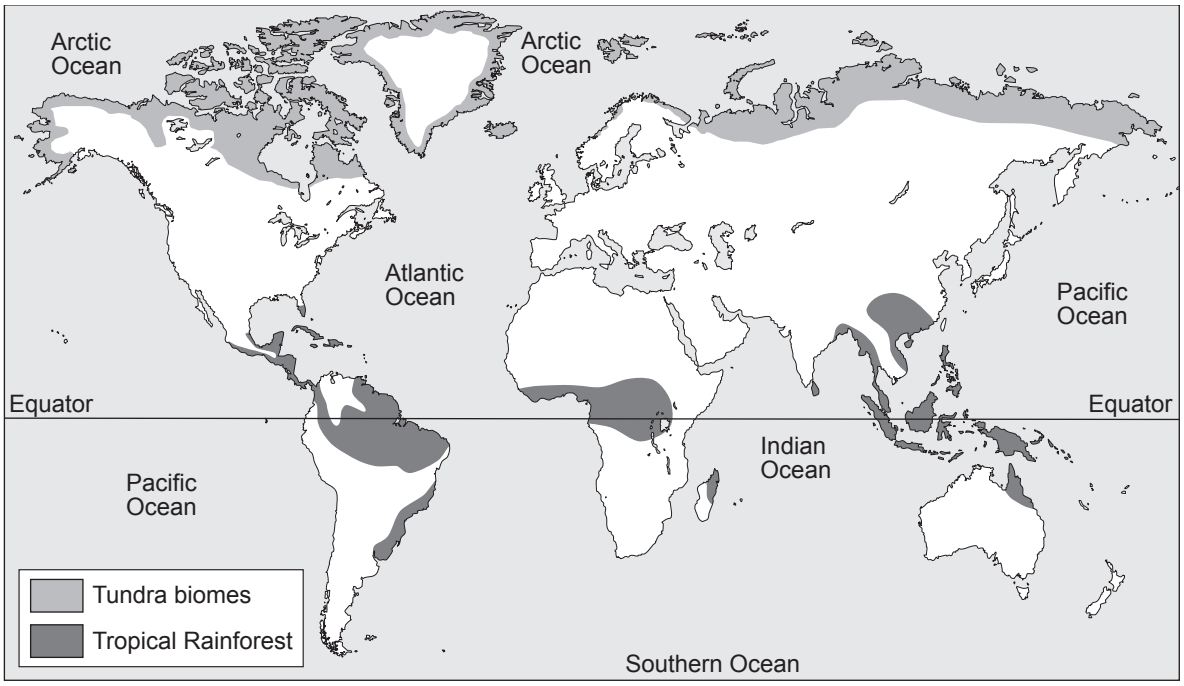


Image 2.5 – tropical rainforest



Image 2.6 – arctic tundra



Simpson's diversity index was calculated for the two ecosystems. The diversity index of the tropical rain forest was 0.96 and the tundra was 0.34. **Using the data**, conclude which ecosystem was more diverse. Suggest **one** reason for the higher biodiversity in this ecosystem. [2]

The tropical rainforest is more diverse, as its Simpson's index (0.96) is nearer to 1 than the tundra's (0.34).

Reason: the rainforest has a warmer temperature, higher rainfall and more daylight (longer days) all year.

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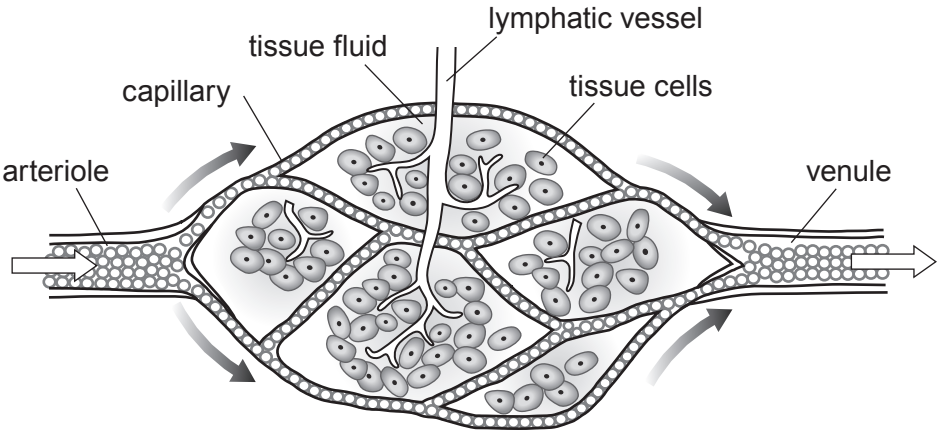
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3. Tissue fluid is where gases and nutrients are exchanged between blood and tissues. **Image 3.1** shows a capillary bed and the associated lymphatic vessels.

Image 3.1

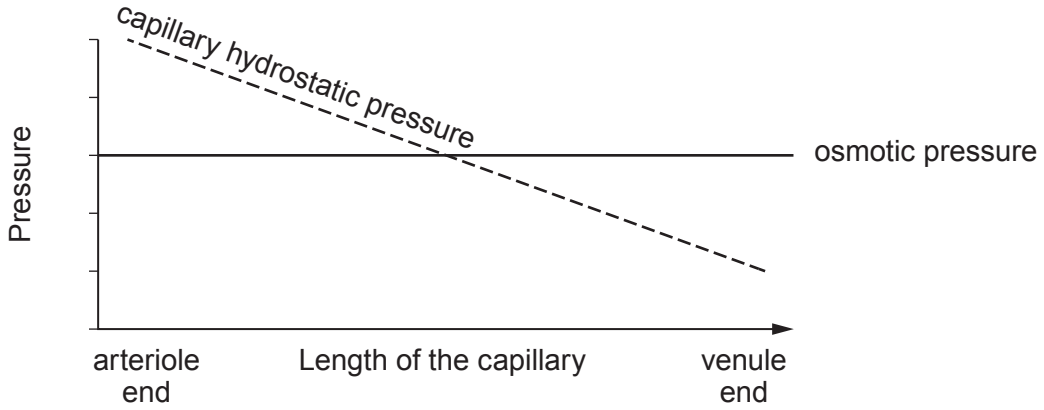


(a) (i) State **one** feature of the capillary wall which allows tissue fluid to be formed. [1]

Fenestrations (gaps / pores) between the endothelial cells.

Image 3.2 shows the changes in pressure within the capillary bed as blood moves from the arteriole to venule end.

Image 3.2



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(ii) Using **image 3.2** and your own knowledge:

I. Describe and explain the change in capillary hydrostatic pressure between the arteriole end and the venule end. [4]

The capillary hydrostatic pressure is high at the arteriole end, due to the pumping of the heart (left ventricle), as blood is close to the heart.

The hydrostatic pressure decreases along the capillary towards the venule end.

This is because fluid is lost from the capillary to form tissue fluid, which reduces the blood volume.

There is also friction (resistance) from the capillary walls, and the total cross sectional area of the capillaries is large, so pressure falls.

II. Explain why there is a net movement of water back into the capillary at the venule end. [3]

The plasma proteins are too large to leave the capillary, so they stay in the blood and maintain a low water potential (high osmotic pressure) in the blood.

At the venule end the hydrostatic pressure of the blood is lower, so it is now less than the osmotic pressure.

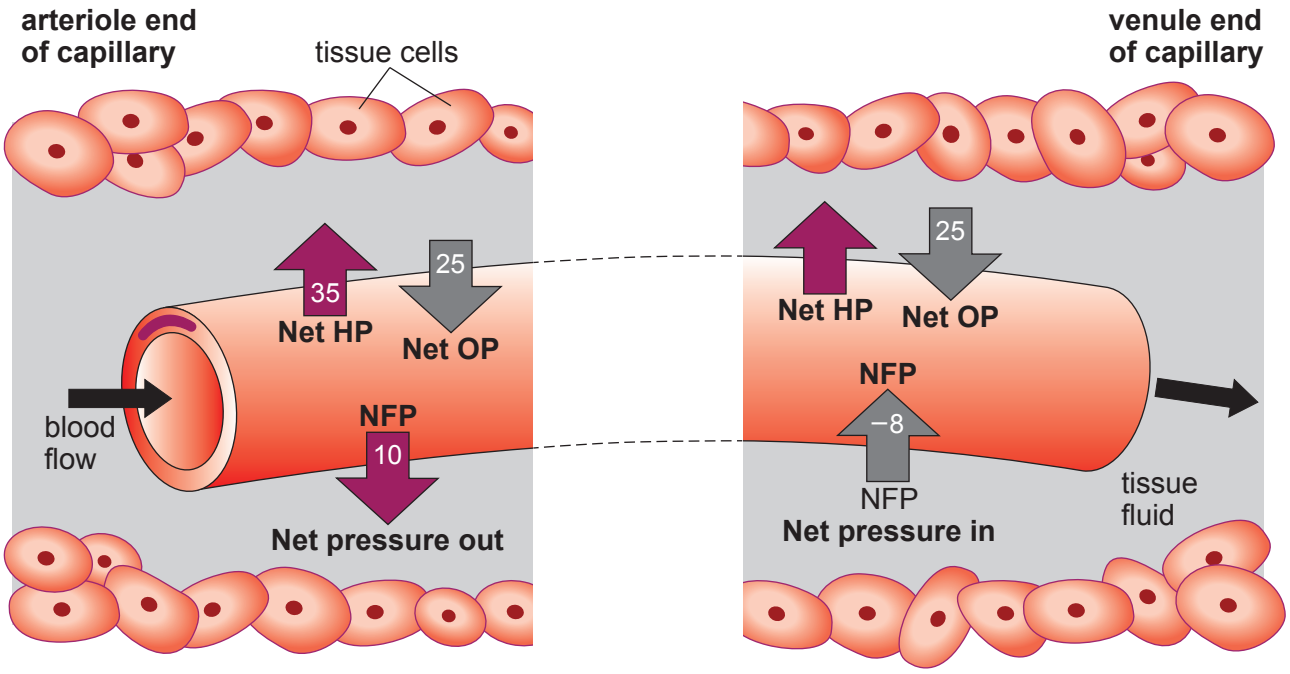
The water potential of the tissue fluid is higher than that of the blood, so water moves back into the capillary by osmosis, down the water potential gradient.

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(iii) The values of osmotic pressure (OP) and hydrostatic pressure (HP) make it possible for the Net filtration pressure (NFP) to be calculated. This is shown in **image 3.3**.

Image 3.3



Arteriole NFP = Net HP – Net OP
Arteriole NFP = 35 – 25
Arteriole NFP = + 10

Use the information in **image 3.3** and the example shown to calculate:

I. the **Net HP** at the **venule** end. [1]

Net HP = NFP + Net OP

= −8 + 25 = 17

Net HP = ...17....

II. the percentage change in **Net hydrostatic pressure (Net HP)** between the arteriole and venule end of the capillary. [2]
Space for working.

change = 35 − 17 = 18

percentage change = (35 − 17) ÷ 35 × 100

= 51.4% (decrease)

Percentage change = ...51.4% decrease....

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(b) Lymphatic filariasis is a medical condition caused by parasitic worms which block the lymphatic vessels. This can result in swelling of the legs as shown in **image 3.4**.

Image 3.4



Affected leg



Unaffected leg

Explain the appearance of the affected leg. [1]

Excess tissue fluid usually drains into the lymphatic vessels; the blocked lymph vessels cannot take away the excess, so tissue fluid builds up in the leg, causing swelling (oedema).

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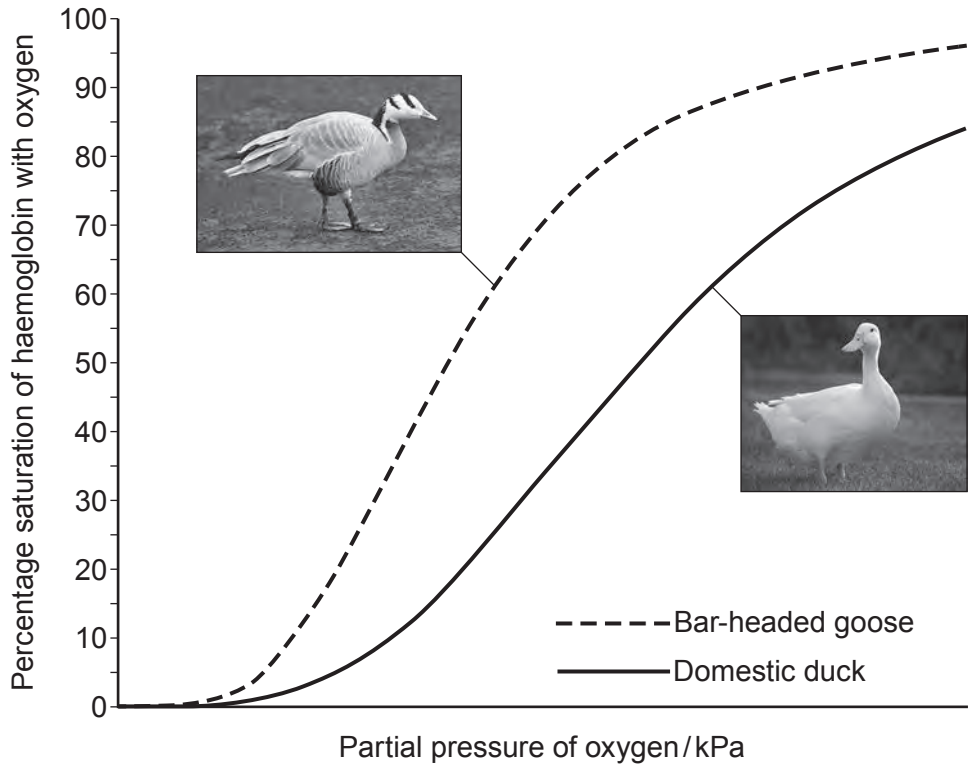
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4. Bar-headed geese fly at high altitude during their migration. A sample of blood was taken from an adult Bar-headed goose and the haemoglobin was analysed. The percentage saturation of the haemoglobin was measured when exposed to varying concentrations of oxygen. This was repeated for the haemoglobin of a domestic duck. The results are shown in **image 4.1**.

Image 4.1



(a) (i) Explain the advantage of the position of the curve for Bar-headed goose haemoglobin compared to the curve for the domestic duck haemoglobin. [3]

The goose curve is to the left of the duck curve, so goose haemoglobin has a higher affinity for oxygen.

It is more highly saturated at low partial pressures of oxygen and reaches saturation at a lower partial pressure.

It only dissociates oxygen at very low partial pressures, and a small change in partial pressure gives a larger change in saturation.

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(ii) Suggest the benefit of this to the Bar-headed goose when flying at high altitudes. [2]

At high altitude the air has a low partial pressure of oxygen (low oxygen environment).

So more oxygen can still be absorbed (loaded) from the inhaled air in the lungs, supplying the flight muscles for aerobic respiration.

(iii) The mean total blood volume for an adult Bar-headed goose is $5 \times 10^5 mm^3$. The mean total number of red blood cells in an adult Bar-headed goose is 1.46×10^{12}. Calculate the density (number per mm^3 blood) of red blood cells within an adult Bar-headed goose. **Express your answer to two significant figures.** [3]

density = $1.46 \times 10^{12} \div (5 \times 10^5)$

= 2 920 000 per mm^3

= 2.9×10^6 (to 2 s.f.)

Density = 2.9×10^6 per mm^3 blood

(iv) The red blood cell density of domestic duck blood is 1.4×10^6. Compare the red blood cell density of the domestic duck and the Bar-headed goose. Suggest a reason for this. [2]

The goose has a higher red blood cell density than the duck (2.9×10^6 compared with 1.4×10^6 per mm^3).

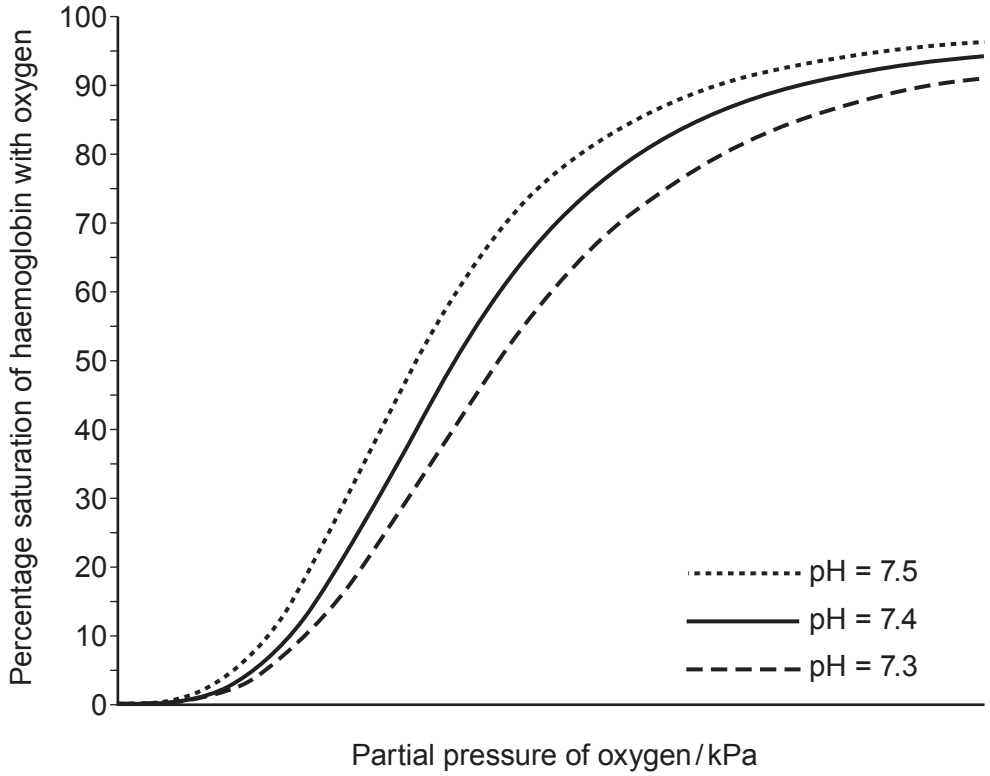
So the goose has more haemoglobin per mm^3 of blood, giving increased oxygen absorption and transport at high altitude.

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The blood sample from the goose was exposed to different pH levels. The results are shown in **image 4.2**.

Image 4.2



(b) (i) Describe the effect of changing the pH from 7.5 to 7.3 on the percentage saturation of haemoglobin with oxygen. [2]

As the pH gets lower (7.5 to 7.3) the percentage saturation of haemoglobin decreases at each partial pressure (curve shifts right), as Hb has a lower affinity for oxygen.

This is because more oxygen has dissociated from the haemoglobin.

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(ii) State the name of the effect of pH on haemoglobin saturation. Using your own knowledge, suggest how the change in pH of the goose's blood has caused this effect. [4]

This is the Bohr effect.

Respiration in the flight muscles produces more CO_2, which forms carbonic acid (carbonic anhydrase); this dissociates into H^+ and HCO_3^-, so lower pH means more H^+.

Haemoglobin has a higher affinity for H^+ than for oxygen; H^+ binds to Hb (haemoglobinic acid), decreasing its affinity for oxygen.

So oxygen is released more readily, at higher partial pressures of oxygen, to the respiring tissues.

(c) For a goose to fly, it requires a lot of energy some of which is gained from the digestion of lipids. The digestive system of a goose is similar to that of a human.
State the main site of lipase secretion and name the products of lipid digestion in the goose. [2]

Lipase (enzyme) is secreted mainly from the pancreas (into the duodenum).

Lipids (triglycerides) are hydrolysed into fatty acids and monoglycerides (and glycerol).

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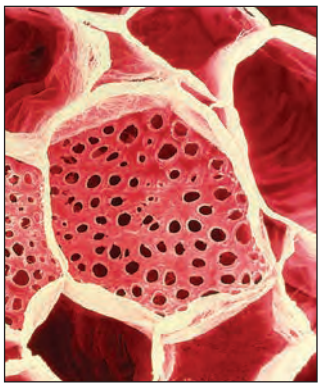
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5. **Images 5.1A** and **5.1B** show sections of the vascular tissues of a plant.

Image 5.1A



A

Image 5.1B



B

(a) (i) Complete **table 5.2** by identifying the type of tissue shown in each image and name a structure visible in each image to justify your answer. [2]

Table 5.2

	Image 5.1A	**Image 5.1B**
Tissue	*Phloem*	*Xylem*
Visible structure	*Sieve plates*	*Lignin*

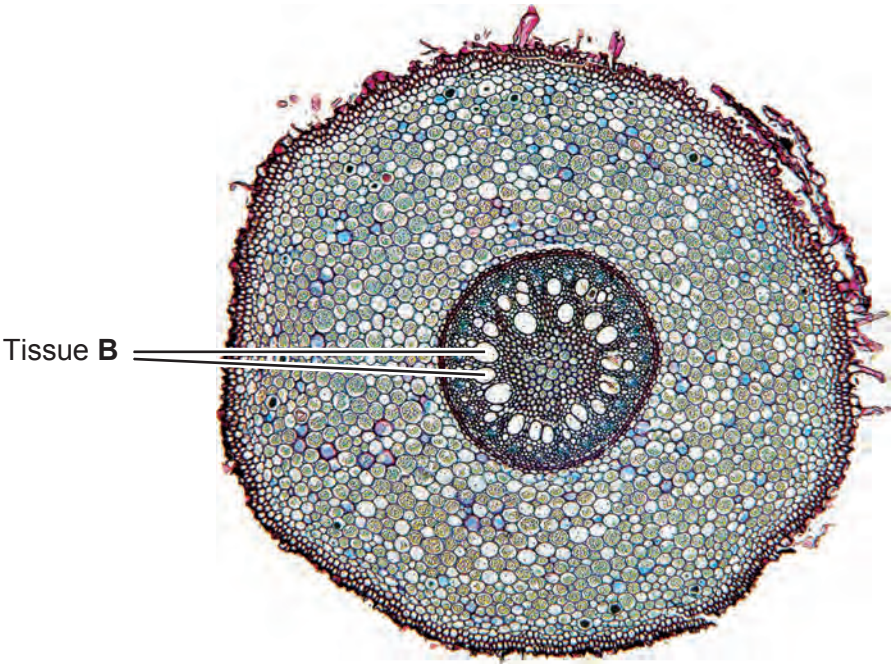
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Water is absorbed by the roots and transported in the root and stem. **Image 5.3** shows detail of the vascular tissue within the root of *Ranunculus*.

Image 5.3



(ii) Mineral ions in the soil are absorbed by root hair cells and transported to the vascular tissue of the root. Explain the movement of mineral ions from the soil into tissue **B**. [4]

Mineral ions are actively transported into root hair cells across the membrane (using ATP), so uptake is controlled.

They cross the cortex by the apoplast pathway (cell walls) until the endodermis, and by the symplast pathway (via plasmodesmata).

At the endodermis the Casparian strip, made of waterproof suberin, stops the apoplast pathway.

So ions are moved by active transport into the endodermis cells, then pass into tissue B (xylem).

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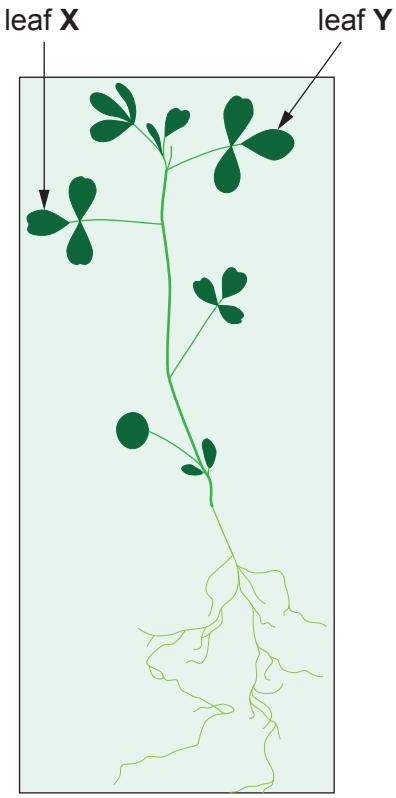
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(b) Plants like alfalfa, use light energy to make carbohydrates such as sucrose, which it then transports around the plant. Ascorbic acid (AsA) is a natural carbohydrate found in plants. AsA can be taken in by leaf cells when applied to the surface.

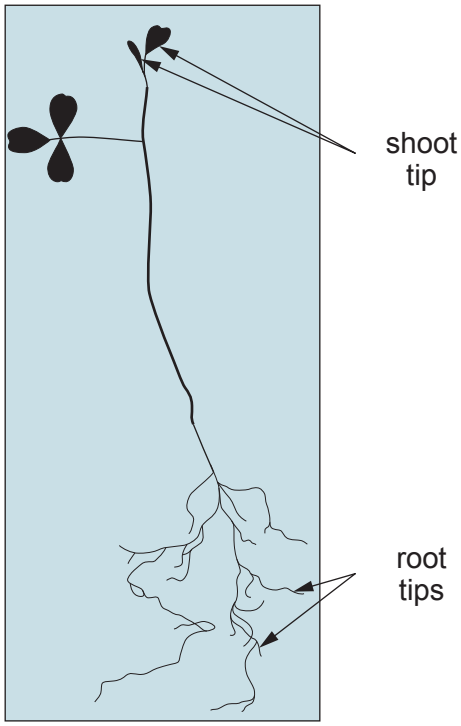
Radiolabelled ascorbic acid, ^{14}C-AsA, was applied to leaf **X** of an alfalfa plant as shown in **image 5.4A**. Autoradiography was carried out to identify where ^{14}C-AsA was located after 12 hours. The results are shown in **image 5.4B**.

Image 5.4A



Alfalfa plant

Image 5.4B



Autoradiograph of Alfalfa plant

(i) State the process by which carbohydrates are transported through a plant. [1]

Translocation (mass flow in the phloem).

(ii) ^{14}C-AsA was found in the root tips and shoot tips of the plant, but not in mature leaf **Y**. Explain these results. [3]

The root tips and shoot tips are meristems where cells are dividing and growing, so they act as sinks where ^{14}C-AsA is used.

The carbohydrate is used for respiration (ATP), cell division and growth of the tips.

Mature leaf Y is not growing (no cell division) and makes its own carbohydrate, so ^{14}C-AsA is not transported to it.

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Table 5.5 shows the levels of ^{14}C-AsA at different locations in the plant over 12 hours.

Table 5.5

Time / hr	Concentration of ^{14}C-AsA / mmol dm^3		
	Leaf	Shoot tip	Root tip
6	24	26	28
12	20	27	25

(iii) Describe the change in ^{14}C-AsA concentrations between 6 and 12 hours at the root tip. Suggest a reason for the concentrations of ^{14}C-AsA at 12 hours. [2]

^{14}C-AsA at the root tip decreased from 28 to 25 mmol dm^{-3}, as it has been used in metabolic processes (e.g. respiration) or stored as another carbohydrate.

(iv) State **two** factors that would need to be controlled to ensure confidence in the results. [1]

Temperature and light intensity (during the 12 hours).

(c) The experiment was only carried out once for 12 hours. State how this would affect the reliability of the data. Explain your answer. [1]

Limited reliability; with no repeats we cannot be sure that the readings are true, as anomalies cannot be identified.

(d) Suggest how the experiment could be modified to investigate the **rate** of transport of AsA through the plant. [2]

Apply ^{14}C-AsA to leaf X of several plants and carry out autoradiography at different times (e.g. every hour).

Measure the distance the ^{14}C-AsA has travelled from leaf X at each time.

Rate of transport = distance travelled ÷ time taken (e.g. mm h^{-1}).

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6. Using the information in **Image 6.1** and your knowledge of gas exchange in organisms, explain how *Paramecium caudatum* is adapted for gas exchange. Explain the adaptations shown by *Pseudoceros ferrugineus* and *Eisenia fetida* which have allowed their evolution into larger multicellular organisms. [9 QER]

Image 6.1

Organism	Features
Paramecium caudatum 	• Protoctista • single celled • 0.25 mm length • aquatic environment
Pseudoceros ferrugineus 	• Flatworm • multicellular • 18–48 mm length • thin • aquatic environment
Eisenia fetida 	• Annelid • multicellular • 80 mm length • terrestrial environment • contains haemoglobin • folded body surface

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Paramecium caudatum is single celled and very small (0.25 mm long), so it has a high surface area to volume ratio.

It exchanges gases by diffusion directly across its cell surface membrane (external body surface): oxygen diffuses in and carbon dioxide diffuses out.

Because it is only one cell, the diffusion path from the surface to the centre of the cell is very short.

It also has a low metabolic demand, so although water contains less oxygen than air, the rate of diffusion across the body surface is sufficient to meet its needs and no specialised gas exchange surface or transport system is needed.

As organisms became larger and multicellular, their surface area to volume ratio decreased, the diffusion distance to the inner cells increased and their metabolic demand increased because there are more cells respiring. Diffusion across the surface alone would not be enough unless they were adapted.

Pseudoceros ferrugineus (flatworm) is multicellular and much longer (18 to 48 mm), so if it were a rounded shape it would have a low surface area to volume ratio. However, it has a flattened body shape, which increases its surface area to volume ratio.

It is also thin, so no cell is far from the surface and the diffusion path is short. This allows it to still use its external body surface for gas exchange by diffusion from the surrounding water, meeting its higher metabolic demand without a transport system.

Eisenia fetida (annelid / earthworm) is larger still (80 mm) and cylindrical, so it has a lower surface area to volume ratio, and its inner cells are far from the body surface.

Gas exchange still occurs by diffusion across its external body surface, and the

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folded body surface increases the surface area for exchange.

As it lives in a terrestrial environment, the skin secretes mucus which keeps the surface moist, so oxygen dissolves in the mucus before diffusing across the body surface; this prevents the surface drying out.

To meet its high metabolic demand it has a circulatory system: blood vessels just beneath the surface carry oxygen away, maintaining a steep concentration gradient, and transport oxygen to cells far from the body surface.

The blood contains haemoglobin, which binds to oxygen and increases the amount of oxygen that can be carried to the respiring cells.

So these adaptations (flattening and thinness in the flatworm; a folded moist surface, haemoglobin and blood vessels in the annelid) overcome the decrease in surface area to volume ratio and the increase in diffusion distance, allowing the evolution of larger multicellular organisms.

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