



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022

Centre Number

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Candidate Number

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Biology

StemUp Model Solution

Assessment Unit AS 2

assessing

Organisms and Biodiversity



[SBY21]

SBY21

MONDAY 30 MAY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all seven** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.

Section A carries 60 marks. Section B carries 15 marks.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

Use accurate scientific terminology in all answers.

You should spend approximately **20 minutes** on Section B.

You are expected to answer Section B in continuous prose.

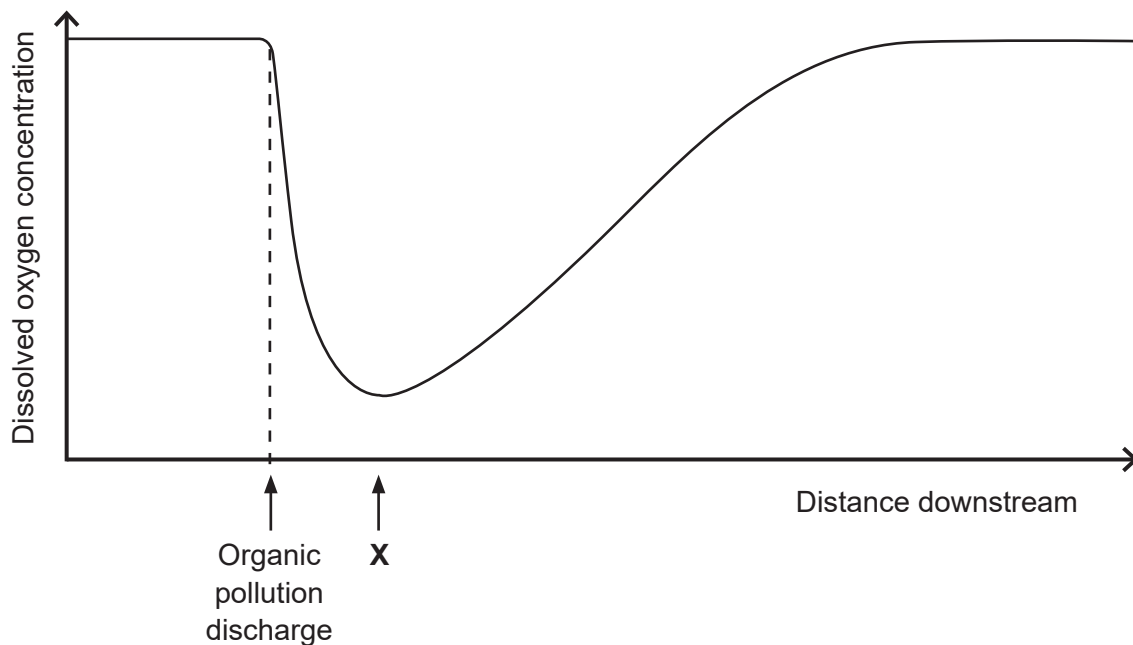
Quality of written communication will be assessed in Section B.

13154



Section A

- 1 Organic matter can pollute waterways. The graph below represents the concentration of dissolved oxygen in the water upstream and downstream from an organic pollution discharge.



Source: Chief Examiner

- (a) State **one** source of organic pollution.

Sewage (or slurry / silage effluent)

[1]

- (b) Explain the low dissolved oxygen concentration at X.

The organic pollutant is decomposed (broken down) by bacteria, as it provides nutrients for them, so the bacterial population increases.

These are aerobic bacteria which use oxygen in respiration, so oxygen is used up (high BOD) and the dissolved oxygen concentration falls.

[2]



(c) Describe **one** way in which organic pollution differs from eutrophication.

Organic pollution involves organic matter and is a sudden incident, whereas eutrophication is nutrient enrichment by nitrates and phosphates, a gradual long-term process causing an algal bloom before decomposition.

[1]

(d) Describe **one** way in which water pollution can be reduced.

Do not apply fertiliser when rain is forecast or on land close to waterways (and have adequate storage facilities for slurry).

[1]

[Turn over]



- 2 (a) Taxonomy involves classifying organisms according to presumed ancestral relationships. Systems of classification involve the organisation of species into increasingly large groups.

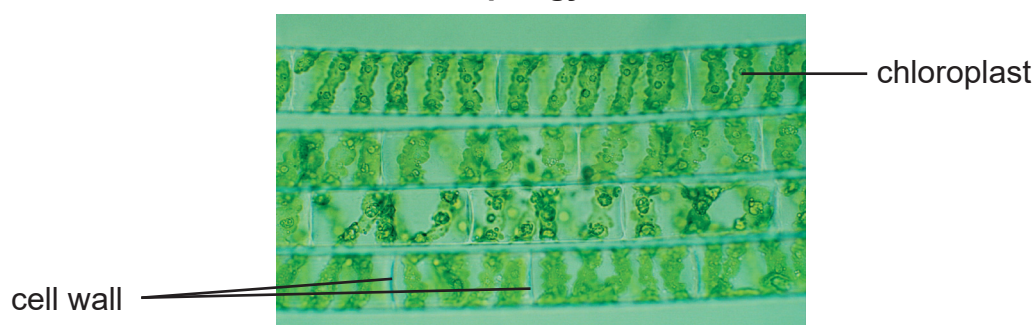
Complete the table below using the most appropriate terms.

Species
<i>Genus</i>
<i>Family</i>
<i>Order</i>
Class
<i>Phylum</i>
Kingdom

[2]

- (b) This five-kingdom classification system includes the Kingdom Protocista. The photomicrographs below show two examples of organisms classified in Kingdom Protocista.

Spirogyra



© Dennis Kunkel Microscopy / Science Photo Library

Amoeba



© Marek Mis / Science Photo Library



(i) State **two** features common to all members of Kingdom Protoctista.

1. Eukaryotic (have membrane-bound organelles).

2. Unicellular, or multicellular with limited tissue differentiation.

[2]

(ii) Members of Kingdom Protoctista may be heterotrophic or autotrophic.

Using the photomicrographs, suggest which of the two organisms shown is autotrophic.

Explain your answer.

Organism Spirogyra

Explanation Spirogyra has chloroplasts containing chlorophyll (green pigment), so it can photosynthesise.

[2]

(c) Using the photomicrograph, state **one** reason why Amoeba is not classified in Kingdom Prokaryotae.

Amoeba has a nucleus (and membrane-bound organelles such as food vacuoles).

[1]

[Turn over



- 3 (a) For gas exchange to occur at a sufficient rate, an organism's gas exchange surfaces must be adapted for the process. A moist surface is one of these adaptations.

Explain the importance of this adaptation and suggest how this is achieved in mammals.

A layer of moisture allows the gases to dissolve, increasing the rate of diffusion across the surface.

In mammals the alveoli are deep inside the body to reduce water loss by evaporation, and surfactant is produced to reduce surface tension.

[2]

- (b) Scientists discovered that plants growing in air with abnormally high levels of CO_2 have more cells in their spongy mesophyll than plants growing in normal air. This increased density of cells in the spongy mesophyll tissue leads to a reduced rate of photosynthesis.

- (i) Suggest why photosynthesis rate is reduced if there is an increased number (density) of cells in the spongy mesophyll layer.

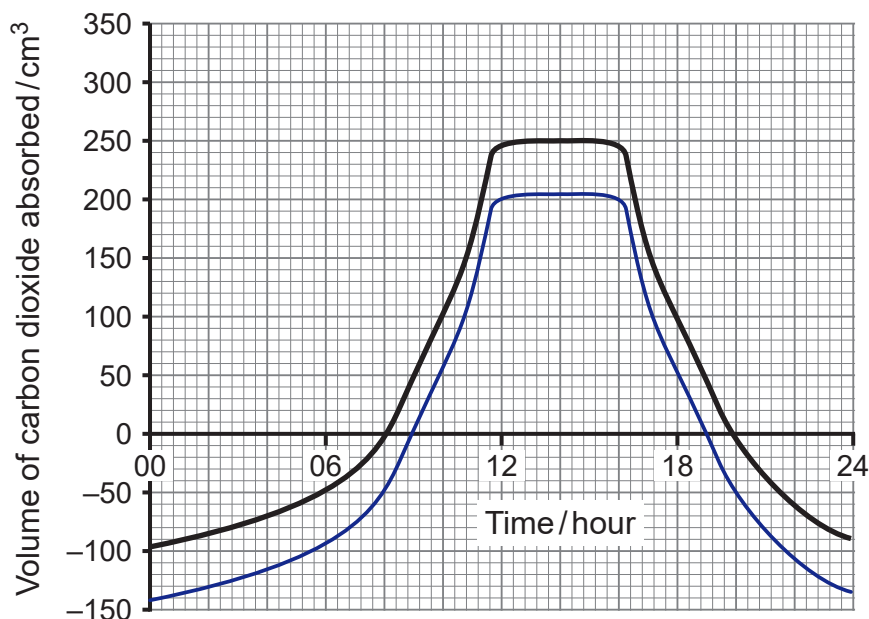
There are fewer, smaller air spaces, so there is less space for diffusion of gases and fewer pathways through the mesophyll.

There is a greater diffusion distance, so less CO_2 gets to the palisade layer.

[2]



The graph below shows the net volume of carbon dioxide absorbed by a **normal** plant over a 24-hour period.



Source: Chief Examiner

- (ii) On the graph, sketch a line to show the carbon dioxide absorbed when a plant with increased cell density in its spongy mesophyll was studied. [2]
- (iii) Twice a day, the volume of carbon dioxide absorbed is 0 cm^3 .

State the term used to describe this and explain precisely what is happening at these times.

Compensation point.

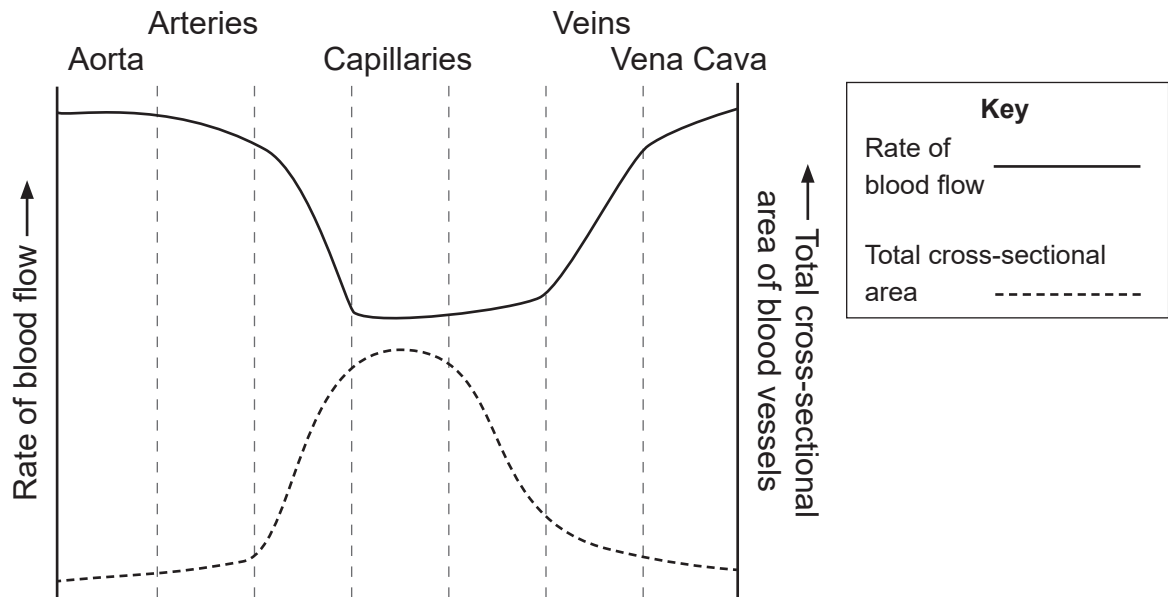
The volume of carbon dioxide absorbed in photosynthesis is the same as the volume of carbon dioxide produced in respiration, so there is no net uptake.

[2]

[Turn over



- 4 (a) The graph below represents the total cross-sectional area of blood vessels within the body and the rate of blood flow through them.



- (i) Using the graph and your knowledge, describe and explain the relationship between total cross-sectional area and rate of blood flow.

As the total cross-sectional area of the blood vessels increases, the rate of blood flow decreases (and vice versa).

This is due to increased friction (resistance) to blood flow, as the individual vessels have narrower lumens, and a decrease in blood pressure.

[2]



- (ii) Capillaries have a very small diameter (approximately $0.5\mu\text{m}$) in comparison to arteries and veins (4–5mm). However, the graph shows that capillaries have a greater total cross-sectional area.

Suggest an explanation for this.

There is a very large number of capillaries (an extensive network), so their combined total cross-sectional area is greater.

[1]

- (b) An artery may become partially blocked by an atheroma.

Describe the role of each of the following in the formation and development of an atheroma.

High blood pressure

Exerts a greater force on the artery wall, damaging the endothelium lining.

Cholesterol

Builds up underneath the endothelium in the artery wall.

Macrophages

Move from the blood into the artery wall, contributing to accumulation of cholesterol.

Plaque

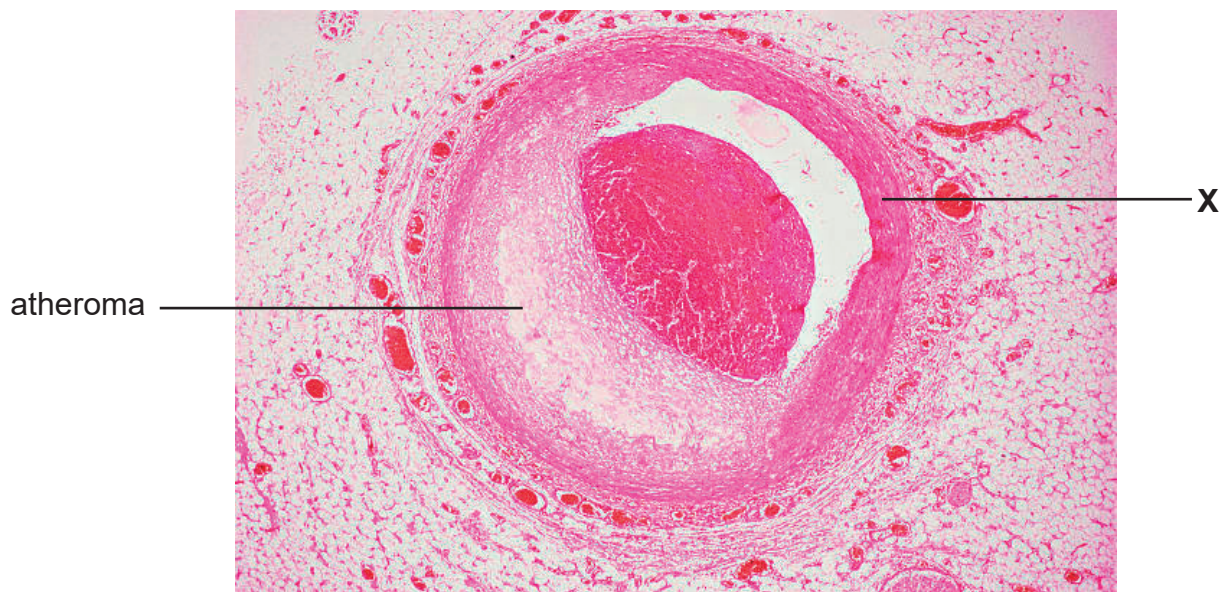
Hardened atheroma which bulges into the lumen, narrowing it and restricting blood flow.

[4]

[Turn over]



(c) The photomicrograph below shows an atheroma in a coronary artery.



© Getty Images

(i) Name the **two** main components of the artery wall at position X.

Elastic tissue and smooth muscle [1]

(ii) Explain the role of each of these components in an artery.

Elastic tissue allows the artery wall to stretch and recoil as the
blood pulses through it.

Smooth muscle provides support and can constrict or dilate the
artery, regulating blood flow to organs.

[2]



The presence of an atheroma slows the blood flow in the artery. The rate of blood flow can be calculated as follows:

$$\text{rate of blood flow} = \text{cross-sectional area of vessel lumen} \times \text{velocity of blood}$$

The following results were recorded during an investigation into the effect of an atheroma on blood flow in coronary arteries.

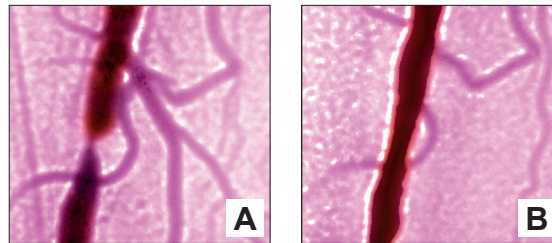
	Cross-sectional area of vessel lumen / mm ²	Velocity of blood / mm s ⁻¹	Rate of blood flow / <u>mm³ s⁻¹</u>
Normal coronary artery	4.1	640	2624
Coronary artery with atheroma	2.4	410	2.4×410 $= 984$

- (iii) Using the formula above, calculate the rate of blood flow for the artery with atheroma **and** write your answer and the units of blood flow in the table above. [2]

[Turn over



- (d) The images below show an artery of a person suffering from atherosclerosis. The narrowing of the artery can be seen in image **A**. Image **B** shows the same artery following treatment for the condition.



© James Cavallini / Science Photo Library

- (i) Name the medical imaging technique which would have been used to see this artery.

Angiography (angiogram)

[1]

- (ii) Suggest how the narrowing of the artery has been reduced (image **B**).

A stent has been fitted (angioplasty), pushing the atheroma to the sides to widen the lumen.

[1]

- (iii) In one patient treated in this way, the value for the rate of blood flow was found to be 1872.

Compare this to the rate of blood flow in a normal artery and suggest an explanation for the difference.

The blood flow (1872) is less than in the normal artery (2624).

Some of the atheroma is still present narrowing the lumen, the stent provides some resistance, or elasticity has been lost from the wall due to the previous atheroma.

[2]



- 5 Rathlin Island is a large inhabited island 4 km off the coast of Co. Antrim. Vehicle access is restricted, although each year thousands of tourists visit the island.

Rathlin has high sea cliffs which provide nesting sites for a variety of seabird species. There are three species of seabird whose numbers reach internationally important levels. Some uncommon and rare plant species are also present on the island.

The island has been designated as both SAC and ASSI. The SAC designation means certain species present in the area must be left undisturbed. The ASSI is awarded to areas with high conservation value, the aim being to manage them in a way that promotes high biodiversity.

- (a) (i) Using the information provided, state **one** reason why Rathlin Island has been awarded the SAC designation.

Uncommon and rare plant species are present there.

[1]

- (ii) Maintaining the standards required for an SAC/ASSI designation can be difficult in some circumstances.

Suggest a reason why this may be the case on Rathlin Island and describe **one** practice put in place which is helping conservation on the island.

Many thousands of tourists travel to the island each year (a large tourist industry), which can disturb species.

Vehicle access is restricted, reducing disturbance and damage to habitats.

[2]

[Turn over]



Corncrakes (*Crex crex*) are small birds which hide in tall vegetation. They have a very distinctive call and arrive in the UK from Africa in the summer. The corncrake's breeding habitat is grassland, particularly meadow. They build a nest of leaves in a hollow in the ground.

The corncrake is in steep decline across much of the UK due to modern farming practices. As a ground-nesting bird, the corncrake is also vulnerable to predators such as rats and stoats. The Royal Society for the Protection of Birds (RSPB) has 'red-listed' the corncrake which means it is of high conservation concern.

- (b) Suggest **one** way in which modern farming practices have contributed to the decline of the corncrake in the UK.

Grass cutting (mowing) reduces hiding places and nesting sites, increases vulnerability to predators and kills birds in the nest.

[1]



In 2019, two corncrake pairs were recorded on Rathlin Island, which is the only place in Northern Ireland where they still survive. In order to help increase the population, a bird protection organisation planted nettles and brambles around field margins.

- (c) Using the information provided, describe and explain how planting vegetation around field margins can help increase the corncrake population.

*Tall vegetation gives the birds somewhere to hide, undisturbed by mowing,
so they are protected from predators such as rats and stoats.*

*It provides nest material and places to nest and breed (and attracts more
species the corncrake can use as food).*

[2]

[Turn over]



(d) Corncrakes can lay eggs twice in one year, producing a first and second 'clutch' of eggs. On average they lay 12 eggs in the first clutch and 8 in the second.

(i) In some circumstances, 50% of the first clutch and 60% of the second clutch do not survive. Calculate how many chicks are likely to survive if these losses occur.

(Show your working.)

First clutch survivors: 50% of 12 = 6

Second clutch survivors: 40% of 8 = 3.2

Total = 6 + 3.2 = 9.2 (about 9 chicks)

9.2 [2]

(ii) Suggest **two** reasons why fewer chicks survive in the second clutch than in the first.

1. More competition from the first clutch of chicks, so less food available.

2. Greater number of predators later in the season (and colder, wetter weather). [2]





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(Questions continue overleaf)



- 6 (a) Define the term 'transpiration'.

The evaporation of water from the mesophyll cells and diffusion of water vapour out through the stomata.

[1]

- (b) An investigation was carried out into the effect of some environmental factors on the rate of transpiration. The effects of increased wind, heat and light were investigated and the results, along with the normal rate of transpiration for the plants, are shown in the table below. Five plant species were used.

Plant species	Rate of transpiration / cm ³ min ⁻¹			
	Normal	Increased wind	Increased heat	Increased light
Arrowhead	3.6	7.5	6.6	4.0
Devil's Ivy	2.9	4.1	4.6	3.0
Geranium	1.2	4.7	5.8	2.4
Weeping Fig	3.3	6.1	4.9	3.3
Zebra Plant	4.2	7.6	6.1	4.2



- (i) Summarise the results of the investigation.

Increased wind and increased heat increase the transpiration rate in all species compared to normal.

Increased light has the least effect, and only affects some species (Arrowhead, Devil's Ivy, Geranium).

The species were not all affected to the same degree by the environmental factors, and under normal conditions the transpiration rate is not the same in all species.

[3]

- (ii) Explain the effect of increased wind on the rate of transpiration.

Wind blows the diffusion shells of humid air away from the leaf surface, increasing the rate of diffusion of water vapour out of the leaf.

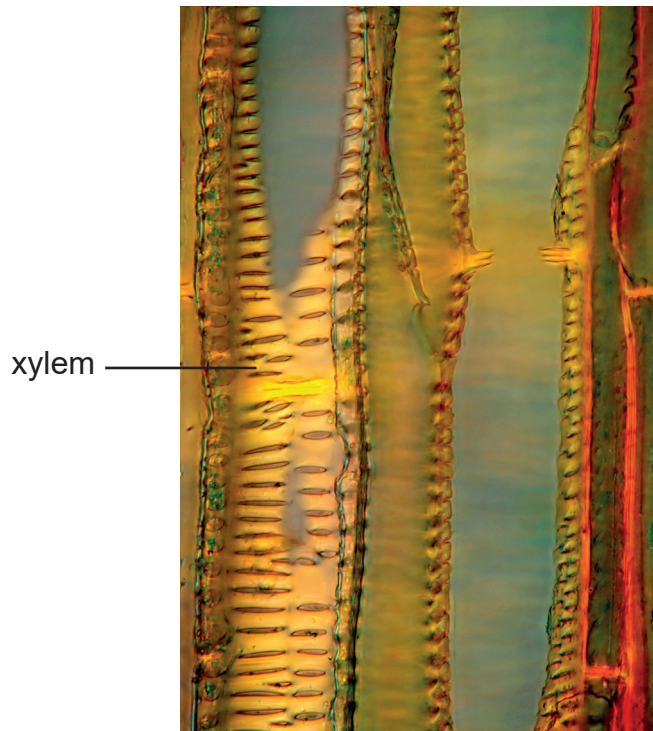
This maintains a steep water potential (concentration) gradient.

[2]

[Turn over]



- (c) Xylem vessels transport water from the roots to the leaves in a plant. The photomicrograph below shows a longitudinal section from part of a stem. A xylem vessel has been labelled.



© Marek Mis / Science Photo Library

- (i) Identify the type of lignification shown on the xylem in the photomicrograph and state what this suggests about the age of the vessel.

Scalariform lignification.

This suggests the vessel is older (mature) tissue, as more lignin has been produced.

[2]



(ii) Water moves up through the plant's xylem in an unbroken column.

Explain how this occurs.

Water evaporates from the spongy mesophyll cells in the leaf, which creates a negative pressure (tension) in the xylem, pulling water up.

Water molecules form hydrogen bonds between one another, so cohesion holds them together as a continuous column.

Adhesion between water molecules and the xylem walls also helps water move up the xylem by capillarity.

[3]



(d) Phloem tissue transports organic solutes.

- (i) Describe **one** feature which would allow phloem tissue to be identified in a photomicrograph.

Sieve plates present between sieve tube elements, with companion cells alongside.

[1]

An experiment was carried out to determine the effect of potassium cyanide, which inhibits respiration, on the rate of translocation in pea plants. It was found that as the level of potassium cyanide increased, the rate of translocation decreased and eventually stopped.

- (ii) Suggest an explanation for this.

Potassium cyanide inhibits respiration, so less ATP (energy) is released.

Translocation is an active process requiring ATP (to load sucrose into the sieve tubes), so it slows and eventually stops.

[2]



Section B

Quality of written communication will be assessed in this section.

7 Oxygen is transported by haemoglobin in red blood cells.

(a) Describe and explain how the structure of haemoglobin and the partial pressure of oxygen affect how oxygen is absorbed, transported and released to the tissues. [9]

(b) Increased carbon dioxide levels and altitude can both affect the carriage of oxygen by haemoglobin. Describe how these two factors affect the carriage of oxygen and the adaptations that are found in organisms that live at high altitudes. [6]

(a) Describe and explain how the structure of haemoglobin and the partial pressure of oxygen affect how oxygen is absorbed, transported and released to the tissues.

Haemoglobin is a conjugated protein with a quaternary structure of four

polypeptide chains, two alpha and two beta chains. Each polypeptide has a haem group as its prosthetic group, giving four haem groups in total.

Oxygen binds to the iron in the haem group to form oxyhaemoglobin.

Each haem group can combine with one oxygen molecule, so each

haemoglobin molecule can carry four oxygen molecules.

The binding of the first oxygen molecule distorts the shape of the

haemoglobin (a conformational change). This makes it easier for the other oxygen molecules to bind, which is called co-operative loading, and gives

the S-shaped (sigmoid) oxygen dissociation curve.

The concentration of oxygen in the environment is measured as the partial

[Turn over]



pressure of oxygen (ppO_2). At high ppO_2 haemoglobin has a high affinity for oxygen, so oxyhaemoglobin is readily formed. In the lungs the ppO_2 is high, so oxygen associates with (is loaded onto) haemoglobin in the alveolar capillaries.

The oxyhaemoglobin is then transported in red blood cells to the respiring tissues. Here the ppO_2 is low because oxygen is used in respiration, so haemoglobin has a low affinity for oxygen and oxygen dissociates (is released) readily to the tissues.

The loading tension is the ppO_2 at which haemoglobin is 95% saturated with oxygen, and the unloading tension is the ppO_2 at which haemoglobin is 50% saturated with oxygen. A small fall in ppO_2 on the steep part of the curve releases a large amount of oxygen to the tissues.



- When respiration is high, for example in active muscle, the partial pressure of carbon dioxide ($ppCO_2$) increases. At high $ppCO_2$ haemoglobin has a reduced affinity for oxygen, so oxygen is released to the tissues more readily. The oxygen dissociation curve moves to the right, which is called the Bohr effect. This supplies extra oxygen to respiring muscle and helps to offset anaerobic respiration during strenuous exercise.

[Turn over

to load onto haemoglobin in the lungs. Organisms that live at high altitude, such as the llama, have haemoglobin which combines with oxygen more readily (has an increased affinity), so their oxygen dissociation curve is moved to the left and the haemoglobin is still highly saturated at low ppO_2 .

Other adaptations include an increase in the number of red blood cells, allowing more efficient transport of oxygen, and increased ventilation with a larger lung volume and gas exchange surface, giving deeper breathing. They also have greater amounts of myoglobin in their muscles, which acts as a store of oxygen.





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2	
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Examiner Number

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