# Module 3 - Exchange and Transport

## Section Summary

Make sure you know...

- How to work out the surface area : volume ratios of simple organisms or, e.g. by using simple known shapes.
- That single-celled organisms exchange substances with their environment by direct diffusion through their cell surface membranes, and that the rate of diffusion is quick because of the organisms' high surface area : volume ratios.
- That multicellular organisms can't exchange substances by direct diffusion across their outer membranes because it would be too slow — some cells are deep within the body, larger animals have a low surface area : volume ratio and multicellular organisms have a higher metabolic rate, so need more oxygen and glucose faster. Instead, they have specialised exchange surfaces.
- That all exchange surfaces are adapted for efficient exchange including having a large surface area (e.g. root hair cells), being thin (often only one cell thick, e.g. alveoli) and having a good blood supply and/or ventilation to maintain a steep concentration gradient (e.g. alveoli, gills).
- The structures of the mammalian gaseous exchange system.
- The functions of parts of the mammalian gaseous exchange system, including:
  - that goblet cells lining the airways secrete mucus, and cilia sweep it away from the alveoli (removing trapped microorganisms and dust),
  - that elastic fibres in the walls of the airways and the alveoli stretch and recoil to help the process of breathing out,
  - that smooth muscle allows the diameter of the airways to be controlled,
  - that cartilage provides the trachea and bronchi with support.
- How to describe the distribution of goblet cells, ciliated epithelium, elastic fibres, smooth muscle and cartilage in the mammalian gaseous exchange system.
- How the ribcage, diaphragm and intercostal muscles (internal and external) all work together during ventilation.
- That tidal volume is the volume of air in each breath, vital capacity is the maximum volume of air that can be breathed in or out, breathing rate is how many breaths are taken per unit time (e.g. per minute) and oxygen uptake is the rate at which a person uses up oxygen.
- How a spirometer can be used to measure tidal volume, vital capacity, breathing rate and oxygen uptake, and how a data logger can be used to capture the information.
- How to interpret data from a spirometer trace.
- How gas exchange in bony fish works, including the structure of gills (gill filaments and gill plates) and the counter-current system (where blood flows through the gill plates in one direction and water flows over the gill plates in the opposite direction, to maintain a steep concentration gradient of oxygen between the water and blood).
- How ventilation works in bony fish — the changes in volume and pressure in the buccal cavity which cause water to be sucked in and then forced out, and the role of the operculum.
- How gas exchange works in insects — that air enters tracheae through spiracles and oxygen travels down its concentration gradient towards the cells, and carbon dioxide travels down its concentration gradient towards the spiracles.
- How insects use rhythmic abdominal movements and/or their wing movements during flying to change the volume of their bodies and pump air in and out for ventilation.
- How to carry out dissections of gaseous exchange systems in fish and insects and make labelled diagrams of your observations.
- How to observe dissected insect gaseous exchange systems under a light microscope, using a wet mount microscope slide.

Module 3 - Exchange and Transport

# Exam-style Questions

**1** Breathing involves the processes of inspiration (breathing in) and expiration (breathing out).

**(a)** Use the most appropriate terms to complete the passage on inspiration below.

During inspiration, the diaphragm and external .......................... muscles .......................... . This causes the .......................... to move upwards and outwards and the diaphragm to flatten, increasing the .......................... of the thorax.

As this happens, lung .......................... decreases to below that of the atmosphere, causing air to flow into the lungs.

*(5 marks)*

**(b)** The volume of air in each breath is known as the tidal volume.
What is the **maximum volume** of air that can be breathed in or out known as?

*(1 mark)*

**(c)** A spirometer is a machine used to investigate breathing.
A spirometer trace of a person at rest is shown in **Fig. 1.1**.

**(i)** What happened between points A and B?

*(1 mark)*

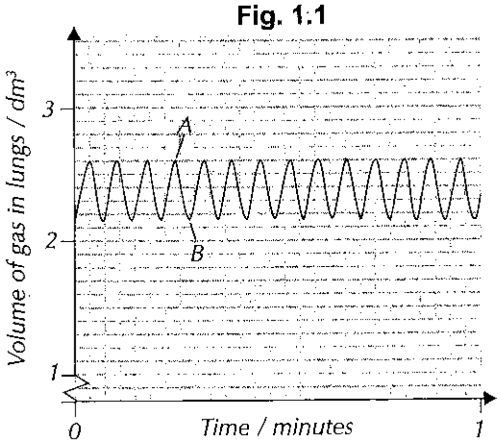
**(ii)** Use **Fig. 1.1** to work out the person's breathing rate.

*(1 mark)*

**(iii)** Suggest how the appearance of this trace would differ if the volume of gas in the spirometer was recorded instead of the volume of gas in the lungs. Explain your answer.

*(4 marks)*

**Fig. 1.1**




**(d)** Suggest **one** thing that could be done to obtain a more **precise** measurement of the person's tidal volume.

*(1 mark)*

**2** **Fig. 2.1** shows a spherical bacterium with a radius of 0.7 µm.

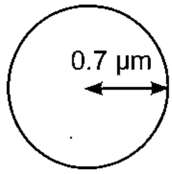
**(a)** Calculate the surface area to volume ratio of this bacterium.

*(2 marks)*

**(b)** Explain why this bacterium doesn't have a gaseous exchange system.

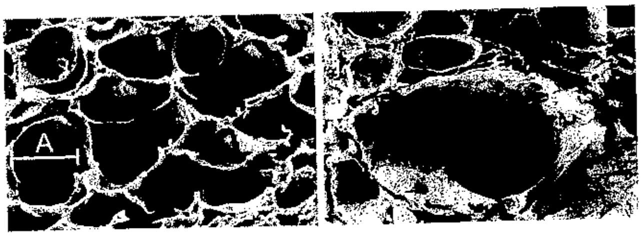
*(3 marks)*

**Fig. 2.1**



**3** **Fig. 3.1** shows a scanning electron micrograph of alveoli in a healthy human lung (left) and in a diseased lung (right). The magnification is x 60.

**Fig. 3.1**




**(a)** Calculate the actual width of the labelled alveolus, A.
Give your answer in µm.

*(2 marks)*

**(b)** Describe **one** difference between the healthy alveoli and the diseased alveoli, and explain what effect this would have on gaseous exchange in the alveoli.

*(3 marks)*

**(c)** Oxygen tents contain a higher percentage of oxygen than normal air.
Suggest how being in an oxygen tent might benefit a patient with emphysema.

*(2 marks)*

**4** **Fig. 4.1** shows a cross section of the mammalian trachea.

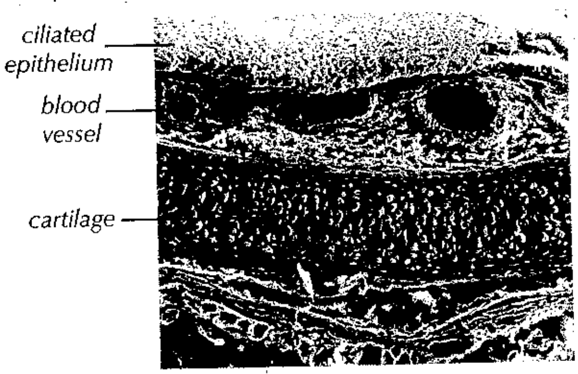



**Fig. 4.1**

**(a)** Describe the function of the cilia on ciliated epithelial cells.

*(1 mark)*

**(b) (i)** Give **one** function of cartilage in the trachea.

*(1 mark)*

**(ii)** Where else in the mammalian gaseous exchange system is cartilage found?

*(1 mark)*

**(c)** Give **one** other feature of the trachea **not** labelled in **Fig 4.1** and describe its function.

*(2 marks)*

# Module 3 - Exchange and Transport - Answers

1 a) intercostal *(1 mark)*, contract *(1 mark)*, ribcage *(1 mark)*, volume *(1 mark)*, pressure *(1 mark)*

b) vital capacity *(1 mark)*

c) i) The person breathed out/expired *(1 mark)*.

*Watch out here — the spirometer trace shows the volume of gas in the lungs, not the volume of gas in the spirometer. The volume of gas in the lungs will decrease when the person breathes out.*

ii) 14 breaths / minute *(1 mark)*

*If the question doesn't tell you what units to give your answer in, just pick sensible ones.*

iii) The trace would slope downwards *(1 mark)*. This is because the volume of gas in the spirometer would decrease over time *(1 mark)*, as oxygen would be used up in respiration *(1 mark)* and carbon dioxide would be absorbed by the soda lime in the spirometer *(1 mark)*.

d) E.g. repeat the measurement several/at least three times and find the mean of the results *(1 mark)*.

*There are lots of possible answers here — just use your common sense. (See Module 1 for more on precise results.)*

2 a) surface area $= 4\pi r^2$

$= 4 \times \pi \times 0.7^2$

$= 6\ \mu m^2$ (1 s.f.)

volume $= \frac{4}{3}\pi r^3$

$= \frac{4}{3}\pi \times 0.7^3$

$= 1\ \mu m^3$ (1 s.f.)

surface area : volume = **6 : 1**

***(2 marks for the correct ratio. 1 mark for either 6 or 1.)***

b) Because it is a single-celled organism with a short diffusion pathway *(1 mark)* and a large surface area to volume ratio *(1 mark)*. This means it can exchange substances quickly across its outer surface *(1 mark)*.

*To help you answer this question, think about why multicellular organisms do have a gaseous exchange system — it's because the diffusion pathway is too big, they have a small surface area : volume ratio and their rate of metabolism is higher, so they use up glucose and oxygen quicker. These characteristics mean that diffusion would be too slow.*

3 a) width of alveolus = width of image ÷ magnification

= 9 mm ÷ 60

= 0.15 mm × 1000 (to convert to micrometres)

= **150 µm**

***(1 mark for correct calculation, 2 marks for correct answer)***

*The question tells you to give your answer in µm, so you need to remember to convert your answer from mm to µm. If you're a bit rusty on this, check out p. 39.*

b) E.g. the walls of the alveoli have been destroyed in the diseased alveoli *(1 mark)*. Destruction of the alveolar walls reduces the surface area of the alveoli *(1 mark)*, so the rate of gaseous exchange would decrease *(1 mark)*.

c) There would be a steeper concentration gradient of oxygen between the alveoli and the capillaries *(1 mark)*. This would increase the rate of diffusion of oxygen into the blood *(1 mark)*.

4 a) To beat mucus (plus trapped dust and microorganisms) away from the alveoli *(1 mark)*.

b) i) Any one from, e.g. to support the trachea *(1 mark)*. / To stop the trachea from collapsing *(1 mark)*.

ii) the bronchi *(1 mark)*

c) Any one from, e.g. goblet cells *(1 mark)* — to secrete mucus *(1 mark)*. / Smooth muscle *(1 mark)* — to control the trachea's diameter *(1 mark)*. / Elastic fibres *(1 mark)* — to recoil and push air out of the lungs whilst breathing out/expiring *(1 mark)*.

# Module 3 - Transport in Animals

## Section Summary

Make sure you know...

- That due to their large size, high metabolic rate and small surface area to volume ratio, multicellular organisms need a transport system to supply their cells with useful substances and to take away waste.
- That fish have a single circulatory system (blood only passes through the heart once for each complete circuit of the body) and that mammals have a double circulatory system (blood passes through the heart twice for each complete circuit of the body).
- That fish and mammals have a closed circulatory system (the blood is enclosed inside blood vessels) and that insects have an open circulatory system (the blood isn't always enclosed in blood vessels).
- The structures of arteries, arterioles, capillaries, venules and veins including the distribution of different tissues within the walls of the vessels.
- That the function of arteries and arterioles is to carry blood away from the heart (under high pressure), that capillaries are the site for the exchange of substances between the cells and the blood, and that venules and veins carry blood back to the heart under low pressure.
- How tissue fluid is formed — high hydrostatic pressure at the arteriole end of the capillary bed forces water and small molecules out of the capillaries into the spaces around the tissues.
- That the high oncotic pressure (and low water potential) at the venule end of the capillary bed causes some water to be reabsorbed back into the capillaries from the tissue fluid.
- That tissue fluid is formed from blood, and lymph is formed from tissue fluid, and the differences in the composition of blood, tissue fluid and lymph.
- The external and internal structure of the heart, including the superior and inferior vena cava, pulmonary artery, aorta, pulmonary vein, right atrium, left atrium, semi-lunar valves, atrioventricular valves, cords, right ventricle, left ventricle and coronary artery.
- The stages of the cardiac cycle, including the roles of the semi-lunar and atrioventricular valves and the pressure changes that occur in the heart and associated vessels during the cycle.
- How to safely dissect and examine a mammalian heart and draw the external and internal structure.
- That cardiac muscle is myogenic and the roles of the following structures in controlling the heartbeat: sino-atrial node (sets the heartbeat rhythm), atrioventricular node (passes on the waves of electrical activity to the bundle of His), bundle of His (passes on the waves of electrical activity to the Purkyne tissue), Purkyne tissue (passes on the waves of electrical activity to the muscular walls of the right and left ventricles).
- How to interpret and explain electrocardiogram (ECG) traces of normal and abnormal heart activity, such as tachycardia, bradycardia, ectopic heartbeat and fibrillation.
- That the role of haemoglobin is to carry oxygen around the body.
- That oxygen binds reversibly with haemoglobin forming oxyhaemoglobin.
- That a dissociation curve shows how saturated haemoglobin is at any given partial pressure.
- That the fetal dissociation curve is shifted left from the adult dissociation curve — fetal haemoglobin has a higher affinity for oxygen than adult haemoglobin, allowing it to pick up the oxygen from adult oxyhaemoglobin at the placenta.
- That an increase in carbon dioxide concentration ($pCO_2$) increases the rate of oxygen unloading and the dissociation curve shifts right — this is called the Bohr effect.
- That some of the $CO_2$ that enters red blood cells is transported to the lungs by haemoglobin.
- The explanation behind the Bohr effect — $CO_2$ in red blood cells is converted to carbonic acid by carbonic anhydrase, carbonic acid splits into hydrogen ions ($H^+$) and hydrogencarbonate ions ($HCO_3^-$), and this increase in hydrogen ions causes oxyhaemoglobin to unload oxygen so that haemoglobin can take up the hydrogen ions (forming haemoglobinic acid).
- That the chloride shift is the movement of chloride ions ($Cl^-$) from the plasma into red blood cells to compensate for the loss of $HCO_3^-$.

Module 3 – Transport in Animals

# Exam-style Questions

**1** Which of the following statements about ECG traces is/are correct?

**Statement 1:** A longer QRS complex may indicate a problem with the Purkyne tissue.

**Statement 2:** A higher P wave indicates a stronger contraction of the atria.

**Statement 3:** The T wave is caused by contraction of the ventricles.

**A** 1, 2 and 3 **C** Only 2 and 3

**B** Only 1 and 2 **D** Only 1

*(1 mark)*

**2** **Fig. 2.1** is a diagram of the internal structure of the mammalian heart. The valves are shown but not labelled.

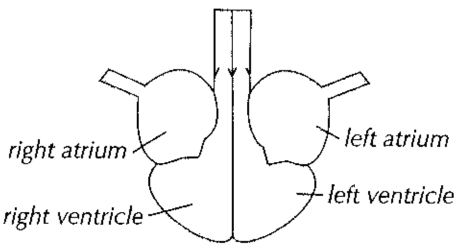



**Fig. 2.1**

**(a)** Describe and explain where the blood is flowing **into** in **Fig. 2.1**.

*(3 marks)*

**(b)** Name the valves that connect the atria to the ventricles and describe their function.

*(2 marks)*

**(c)** Mammals have a double circulatory system, which is why the heart is divided down the middle.

**(i)** Explain what is meant by a double circulatory system.

*(1 mark)*

**(ii)** Describe how the mammalian double circulatory system works and suggest the advantage to mammals of having this system.

*(3 marks)*

**3** **Fig. 3.1** shows two oxygen dissociation curves for the same man.

One curve was produced based on blood tests when he was watching television and the other was produced based on blood tests immediately after a bike ride.

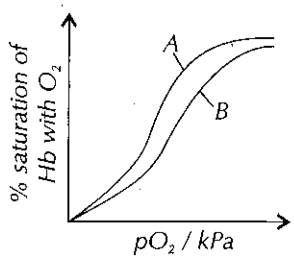



**Fig. 3.1**

**(a)** Which curve was produced after the bike ride? Explain your answer.

*(2 marks)*

**(b)** What name is given to the effect shown on the graph?

*(1 mark)*

**(c)** Explain why more $HCO_3^-$ ions would have been released from the man's red blood cells following his bike ride compared to when he was watching television.

*(3 marks)*

**4** Some people suffer from a disease called third-degree atrioventricular block — the waves of electrical activity from the sino-atrial node (SAN) are not relayed to the atrioventricular node (AVN). A pacemaker can be fitted to take over this role. **Fig. 4.1** shows a heart with a pacemaker attached.

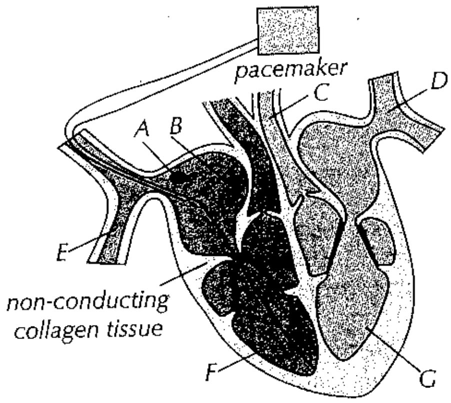



**Fig. 4.1**

**(a)** From **Fig. 4.1**, identify which labels correspond to the following structures by writing a letter from A to G in the table.

| | |
|---|---|
| AVN | |
| Right ventricle | |
| Pulmonary vein | |

*(3 marks)*

**(b)** What is the purpose of the non-conducting collagen tissue shown on the diagram? *(1 mark)*

**(c)** Explain why the pacemaker must be programmed to have a delay between receiving waves of electrical activity from the SAN and activating the AVN. *(1 mark)*

**(d)** Describe the passage of the waves of electrical activity from the AVN to rest of the heart, causing the ventricles to contract. *(3 marks)*

**5** **Fig 5.1** shows part of the circulatory system of a mammal. The arrows show the direction of blood flow.

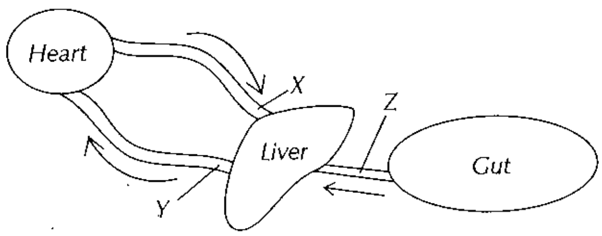



**Fig. 5.1**

**(a) (i)** Which vessel in **Fig 5.1**, **X**, **Y** or **Z**, transports blood at the highest pressure? Explain your answer. *(1 mark)*

**(ii)** State **three** ways in which the structure of blood vessel **X** differs from the structure of blood vessel **Y**. *(3 marks)*

**(b)** The liver is surrounded by a capillary bed and tissue fluid. Describe how tissue fluid is formed. *(2 marks)*

**(c)** State **two** ways in which blood is different from lymph. *(2 marks)*

# Module 3 - Transport in Animals - answers

1 B *(1 mark)*
The QRS complex is caused by contraction of the ventricles. The Purkyne tissue carries the electrical activity to the walls of both ventricles to make them contract simultaneously. The P wave is caused by contraction of the atria and a higher wave indicates more electrical charge is passing through the heart, which results in a stronger contraction. The T wave is due to relaxation (repolarisation) of the ventricles.

2 a) The semi-lunar valves are open ***(1 mark)*** so the pressure must be higher in the ventricles than the pulmonary artery/aorta ***(1 mark)***. This means the blood is moving (from the ventricles) into the pulmonary artery/aorta ***(1 mark)***.
If you get a diagram of the heart in your exam that looks a bit different from this, just look to see where the valves are and whether they're open or closed — then you should be able to answer the question.

b) Atrioventricular valves / AV valves ***(1 mark)***. They prevent the back-flow of blood into the atria when the ventricles contract ***(1 mark)***.

c) i) A double circulatory system means that blood passes through the heart twice for each complete circuit of the body ***(1 mark)***.

ii) One circuit sends deoxygenated blood from the heart to the lungs, then returns the blood to the heart after it has picked up oxygen ***(1 mark)***. This oxygenated blood is then sent out from the heart round the rest of the body in the second circuit ***(1 mark)***. The advantage of this system is that by returning to the heart to be pumped again, oxygenated blood travels to the rest of the body more quickly than if it was to travel directly from the lungs ***(1 mark)***.

3 a) B. During the bike ride the man's respiration rate would have increased, raising the $pCO_2$ ***(1 mark)***. This would have increased the rate of oxygen unloading, so the dissociation curve would have shifted to the right ***(1 mark)***.

b) The Bohr effect ***(1 mark)***.

c) The increased rate of respiration during the bike ride would have caused more carbon dioxide to be produced, most of which would have been converted in the red blood cells into carbonic acid ***(1 mark)*** by the enzyme carbonic anhydrase ***(1 mark)***. The carbonic acid would then split to give hydrogen ions/$H^+$ and hydrogencarbonate ions/$HCO_3^-$, which would diffuse out of the red blood cells and into the plasma ***(1 mark)***.

4 a) AVN — B ***(1 mark)***, right ventricle — F ***(1 mark)***, pulmonary vein — D ***(1 mark)***

b) It prevents the waves of electrical activity from being passed directly from the atria to the ventricles ***(1 mark)***.

c) There must be a delay so that the atria empty before the ventricles contract ***(1 mark)***.

d) The atrioventricular valve/AVN passes the waves of electrical activity onto the bundle of His ***(1 mark)***. The bundle of His conducts the waves of electrical activity to the Purkyne tissue ***(1 mark)***. The Purkyne tissue carries the waves of electrical activity into the muscular walls of the right and left ventricles ***(1 mark)***.

5 a) i) X because it's an artery ***(1 mark)***.
As the blood travels round the circulatory system the pressure of the blood gradually decreases and it is returned to the heart at low pressure via the veins.

ii) E.g. vessel Y contains valves, vessel X doesn't ***(1 mark)***. Vessel X contains more elastic tissue than vessel Y ***(1 mark)***. Vessel X contains a thicker muscle layer than vessel Y ***(1 mark)***.

b) At the start of the capillary bed the hydrostatic pressure inside the capillaries is higher than the pressure in the tissue fluid ***(1 mark)***. The difference in pressure forces fluid out of the capillaries and into the spaces around the cells, forming tissue fluid ***(1 mark)***.

c) E.g. blood contains red blood cells, lymph doesn't ***(1 mark)***. Blood contains platelets, lymph doesn't ***(1 mark)***.

# Module 3 – Transport in Plants

## Section Summary

Make sure you know...

- That plants are multicellular, have a small surface area to volume ratio and have a relatively high metabolic rate, so they need a transport system to move substances to and from individual cells — direct diffusion would be too slow to support their metabolic rate.
- That plants have two transport systems — the xylem (which transports water and mineral ions) and the phloem (which mainly transports sugars) and how they are distributed in the roots, stems and leaves of a plant.
- How xylem vessels are adapted for transporting water and mineral ions — they're made up of cells with no end walls (so water can easily pass up through the middle), the cells are dead (so they contain no cytoplasm), their walls are lignified (which helps to support the xylem walls and give flexibility) and they contain pits (which is how other types of cell are supplied with water).
- How sieve tube elements in phloem tissue are adapted for transporting solutes — they're joined end to end (to form sieve tubes), they have no nucleus, a thin layer of cytoplasm and few organelles, and they contain sieve plates with holes (which allow solutes to pass through from one cell to another).
- That companion cells in the phloem carry out the living functions for themselves and the sieve cells.
- How to examine and draw stained sections of plant tissue, showing the distribution of xylem and phloem.
- How to dissect stems, both longitudinally and transversely, and examine them to locate the position and structure of xylem vessels.
- That water is transported into, around and out of a plant by moving down a water potential gradient — from an area of high water potential in the soil surrounding the roots to an area of lower water potential in air surrounding the leaves.
- How water moves through a plant following the symplast pathway (via the cytoplasm of cells) and the apoplast pathway (via the cell walls).
- How water passes out of the leaves to the surrounding air — down a water potential gradient through the stomata.
- That the transpiration stream is the movement of water from roots to leaves and how cohesion and tension, and adhesion move water up the xylem.
- That transpiration is the evaporation of water from a plant's surface and occurs as a result of gas exchange — as stomata open to let carbon dioxide in, water is let out.
- How transpiration rate is affected by light, temperature, humidity and wind.
- How to use a potometer to estimate transpiration rates.
- How xerophytic plants (e.g. cacti and marram grass) are adapted to living in dry climates — cacti have a thick, waxy layer on the epidermis, spines instead of leaves and close their stomata at the hottest times of the day. Marram grass has stomata that are sunk in pits, a layer of hairs on the epidermis, can roll its leaves in hot or windy conditions and has a thick, waxy layer on the epidermis.
- How hydrophytes (e.g. water lilies) are adapted to live in aquatic habitats and cope with low oxygen levels — they have air spaces in their tissues, stomata on the upper surface of their leaves and flexible leaves and stems.
- That translocation is the movement of assimilates (e.g. sucrose) in a plant, from their source (where they're produced) to their sink (where they're used up).
- The mechanism of translocation — solutes are actively loaded into the sieve tubes at the source and diffuse out of the sieve tubes at the sink. This addition and removal of solutes affects the water potential inside the sieve tubes, which results in a pressure gradient from source to sink — this gradient pushes assimilates along the sieve tubes to where they're needed.
- How solutes are actively loaded from surrounding tissue cells into the phloem at the source — the process involves the active transport of $H^+$ ions and then the co-transport of $H^+$ ions and solutes.

# Module 3 - Transport in Plants

# Exam-style Questions

1 **Fig 1.1** shows the passage of water through part of a plant's root. Which of the following statements about **Fig. 1.1** is correct?

**A** ATP is required for the transport of water through the cells shown.

**B** The water travels via the symplast pathway until it is stopped by the Casparian strip.

**C** The rate of the water movement will decrease as it gets darker.

**D** The cells shown have a lower water potential than cells in the leaves.

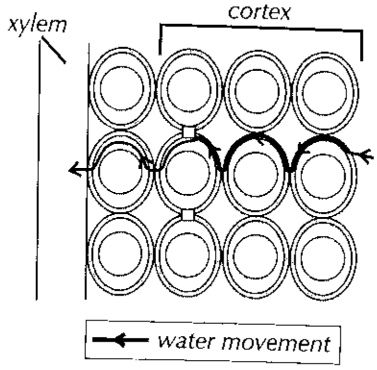



**Fig. 1.1**

*(1 mark)*

2 **Fig. 2.1** and **Fig 2.2** show transverse cross-sections through two different plants. One is from *Potamogeton*, a plant found in ponds, and the other is from *Clematis*, a common garden plant.

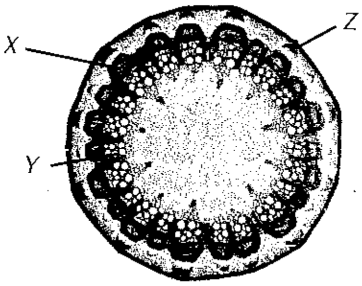



**Fig. 2.1**

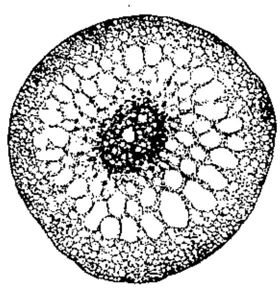


**Fig. 2.2**

(a) Which letter (X, Y or Z) on **Fig. 2.1** shows xylem tissue?

*(1 mark)*

(b) From which region of the plant has the section shown in **Fig 2.1** been taken from? Give a reason for your answer.

*(1 mark)*

(c) A longitudinal cross-section of the stem of a *Clematis* plant would reveal the presence of lignin. Explain the function of this substance in a plant stem.

*(2 marks)*

(d) Which cross-section (**Fig 2.1** or **Fig 2.2**) shows the *Potamogeton*? Give a reason for your answer.

*(1 mark)*

(e) Other than features that can be identified on the cross-section, suggest **one** way in which *Potamogeton* may be adapted to its environment.

*(1 mark)*

**3** A student used a potometer to investigate the effect of light intensity on transpiration rate. Her results are shown in **Fig. 3.1**.

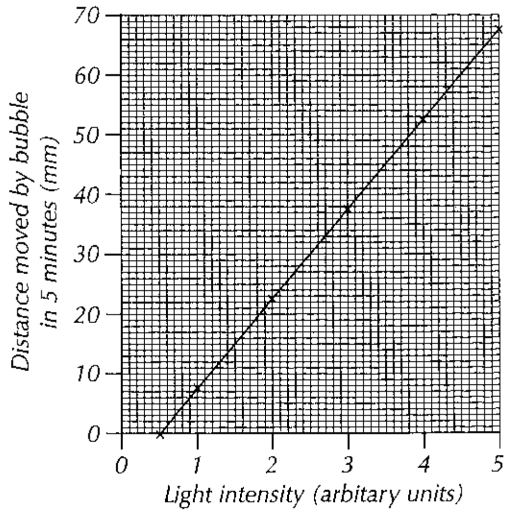



**Fig. 3.1**

**(a) (i)** Using **Fig 3.1**, work out the rate of bubble movement for a light intensity of **1.5 arbitrary units**. Give your answer in mm $min^{-1}$.

*(2 marks)*

**(ii)** Using your knowledge of cohesion and tension, explain the results shown by the graph.

*(4 marks)*

**(b)** Suggest what negative control should be used for this investigation.

*(1 mark)*

**(c)** Explain how and why transpiration occurs.

*(2 marks)*

**(d)** The experiment was repeated in a more humid environment. Suggest how this would affect the results. Explain your answer.

*(2 marks)*

**4** **Fig 4.1** shows a section of the phloem in a plant.

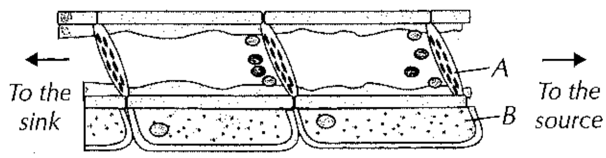



**Fig. 4.1**

**(a) (i)** Name structure **A** and describe its function.

*(2 marks)*

**(ii)** Describe and explain the function of cell **B**.

*(2 marks)*

**(b)** Explain why lots of ATP is needed at the source end of the phloem.

*(1 mark)*

**(c)** Give **two** parts of plants that are common sinks.

*(2 marks)*

**(d)*** The mass flow hypothesis is the best supported theory to describe the mechanism of translocation.

Based on this mechanism, determine whether the pressure inside the phloem's sieve tubes would be greatest at the sink end or at the source end and explain the reason for the difference in pressure.

*(6 marks)*

*The quality of your response will be assessed in this question.

# Module 3 – Transport in Plants – Answers

1 C *(1 mark)*

The rate of water movement will decrease as it gets darker because the rate of transpiration will decrease (as the stomata close). Water is transported towards the xylem via osmosis, which is a passive process (so ATP is not needed). The water is moving by the apoplast pathway through the cell walls until it reaches the Casparian strip in the endodermis. Then it takes the symplast pathway through the cytoplasm. Water moves from an area of high water potential (in the roots) to an area of relatively lower water potential (in the leaves).

2 a) Y ***(1 mark)***

b) The stem because, e.g. the xylem and phloem are distributed in a ring around the outside of the cross-section ***(1 mark)***.

c) It helps support the walls of the xylem and stops them collapsing inwards ***(1 mark)***. The spiral/ring pattern allows flexibility and prevents the stem from breaking ***(1 mark)***.

d) Fig. 2.2 because there are lots of air spaces ***(1 mark)***.

e) Any one from: e.g. stomata may only be present on the upper surface of floating leaves ***(1 mark)***. / It may have flexible leaves/stems ***(1 mark)***.

3 a) i) Reading off graph, distance moved by bubble in 5 minutes at 1.5 arbitrary units of light intensity = 15 mm

$15 \div 5 =$ **3 mm min$^{-1}$**

***(2 marks for the correct answer, otherwise 1 mark for showing a calculation of 'distance ÷ time')***

ii) The lighter it gets, the wider stomata open ***(1 mark)***. This increases the rate at which water evaporates from the leaves, which creates more tension ***(1 mark)***. The whole column of water moves up the xylem because water molecules are cohesive ***(1 mark)***. The increased tension causes the water to move faster, meaning that the bubble moves further in a shorter amount of time ***(1 mark)***.

b) E.g. the experiment should be repeated with a light intensity of zero ***(1 mark)***.

c) E.g. when the stomata in a plant open to let carbon dioxide in / when stomata open for gas exchange ***(1 mark)*** this lets water move out down its water potential gradient ***(1 mark)***.

d) The transpiration rate would not be as fast ***(1 mark)*** because with more water in the air, the water potential gradient between the air and the leaf would be lower ***(1 mark)***.

4 a) i) Sieve plate ***(1 mark)*** — it allows sugars to pass from one sieve tube element to another / it connects cell cytoplasms ***(1 mark)***.

ii) Cell B/the companion cell carries out the living functions for both itself and its sieve tube element ***(1 mark)*** because the sieve tube element can't survive on its own, e.g. it has no nucleus ***(1 mark)***.

b) ATP is needed for the active loading of solutes/ assimilates ***(1 mark)***.

c) E.g. food storage organs ***(1 mark)*** / meristems/growth areas ***(1 mark)***

d) ***5-6 marks***

The answer identifies the pressure as being greater at the source end and explains the mechanism of translocation fully with correct reference to active loading, pressure gradients, water potential and osmosis.
The answer has a clear and logical structure. The information given is relevant and detailed.

***3-4 marks***

The answer identifies the pressure as being greater at the source end and partially explains the mechanism of translocation with some reference to active loading, pressure gradients, water potential and osmosis.
The answer has some structure. Most of the information given is relevant and there is some detail involved.

***1-2 marks***

The answer may identify the pressure as being greater at the source end and attempts to explain one aspect of the mechanism of translocation with partial reference to either active loading, pressure gradients, water potential or osmosis.
The answer has no clear structure. The information given is basic and lacking in detail. It may not all be relevant.

***0 marks***

No relevant information is given.

***Here are some points your answer may include:***

The pressure will be greatest at the source end. Active transport is used to actively load the solutes/assimilates into the sieve tubes of the phloem at the source end. Solutes/assimilates moving into the sieve tubes lowers the water potential inside the sieve tubes, so water enters the tubes from the xylem by osmosis. Water entering the sieve tubes creates a high pressure inside the sieve tubes at the source end of the phloem.
At the sink end, solutes/assimilates diffuse out of the phloem to be used up. The removal of solutes/ assimilates increases the water potential inside the sieve tubes, so water leaves the tubes by osmosis. Water leaving the sieve tubes lowers the pressure inside the sieve tubes at the sink end. The result is a pressure gradient in the sieve tubes from the source to the sink end.