15 Transport in Living Things

The transport system is made up of parts that help to transport substances around an organism. This is to ensure that nutrients reach all cells quickly and wastes are removed efficiently. Plants use a system consisting of xylem and phloem to help them transport substances. Humans use the circulatory system consisting of the heart, blood vessels and blood.

- The need for transport system (15.1)
- Transport in plants (15.2)
- Movement of substances into and out of cells (15.3)
- Factors affecting rate of transpiration (15.4)
- Transport in humans (15.5)

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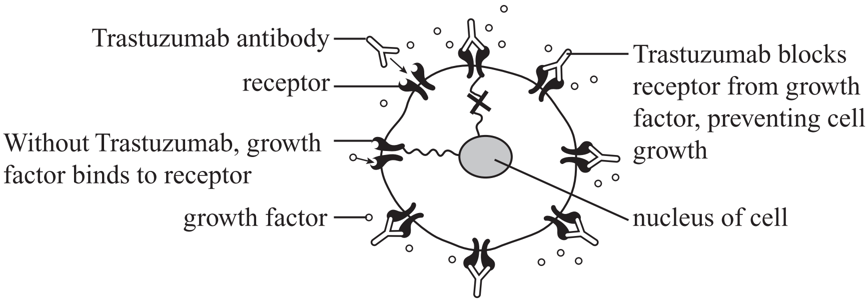
15.1 The Need for Transport System

Optional for **N(A)**

In the treatment of cancer, targeted therapy forms the foundation of precision medicine. It is a type of cancer treatment that targets proteins so as to control how cancer cells grow, divide, and spread. An in-depth understanding of the circulatory system within the human body will be essential for targeted therapy to be optimised.



Science behind Healthcare

Fig 15.1 Trastuzumab may be injected into a patient with breast or stomach cancer. This antibody drug binds to the receptors on cancer cells, preventing these receptors from sending signals to the cancer cell nucleus to divide. This is an example of targeted therapy.

1. Not all living things require a transport system. Organisms such as an amoeba or a bacterium does not have a transport system.
2. Amoebas and bacteria are single-cell organisms. Therefore, substances can move into or out of the cell and throughout the cell by cellular transport processes such as diffusion as they have a high surface area to volume ratio. (See Chapter 7 for Diffusion)
3. Other organisms such as humans, insects and plants need a transport system to survive. This is because they are multi-cellular organisms.
4. Multicellular organisms have a low surface area to volume ratio. For substances to move throughout the organism by diffusion would take a long time. Cells would not get their nutrients fast enough for cellular processes to occur.
5. A transport system is required to ensure nutrients reach all cells quickly and wastes are removed quickly as well.

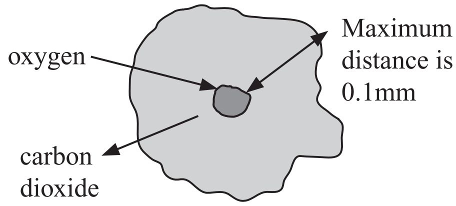
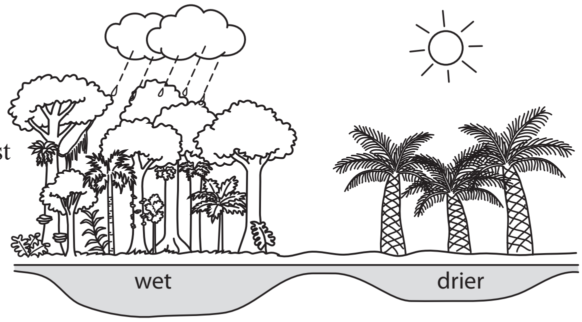


Fig 15.2 The distance in the amoeba is so small that diffusion is rapid enough for the cell to carry out respiration.

15.2 Transport in Plants

Transpiration is the evaporation of water vapour from aerial parts of the plant. This process helps to cool the plant and surrounding environment. Over a forest, large amount of transpiration can result in a significant increase in the amount of water vapour, contributing to cloud cover. This can reinforce the cooling effect.



Climate change

Fig 15.3 Since 2000, surface temperature in Sumatra has increased by 1.05 ºC as forests are destroyed to make way for palm oil plantation. This is because forests moderate local climate by providing shade and releasing moisture through transpiration. (Transpiration is an important process in the Water Cycle.)

Vascular Tissue

Optional for **N(A)**

1. The vascular tissue is a conducting tissue. The vascular tissue consists of two main types of tissues, namely the **xylem** and **phloem**. They are found in the roots, shoots and leaves of the plant.

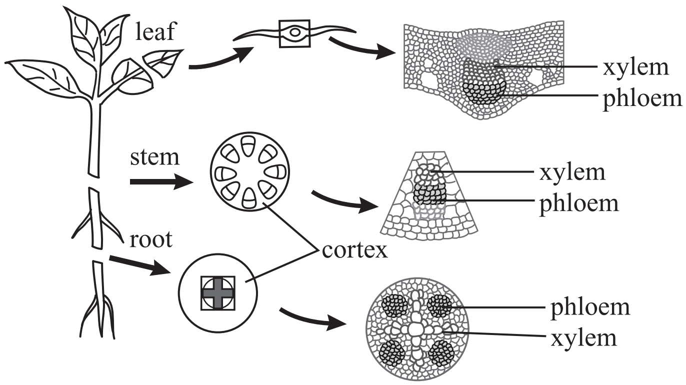


Fig 15.4 The xylem and phloem extend from the roots to the leaves.

Extra

Figure 15.4 shows the vascular bundles of a dicotyledon. The vascular bundles of a monocotyledon are scattered throughout the stem with no particular arrangement.

2. The xylem tissue is a long and thin hollow tube that comprises dead cells that are arranged vertically.
3. The walls of the xylem are thickened with lignin. Lignin helps to keep the plant upright.
4. The xylem vessels transport **water** and **mineral salts** from the roots upwards to the other parts of the plant.
5. The phloem consists of **sieve tube elements** and **companion cells**. Phloem tissues are alive.

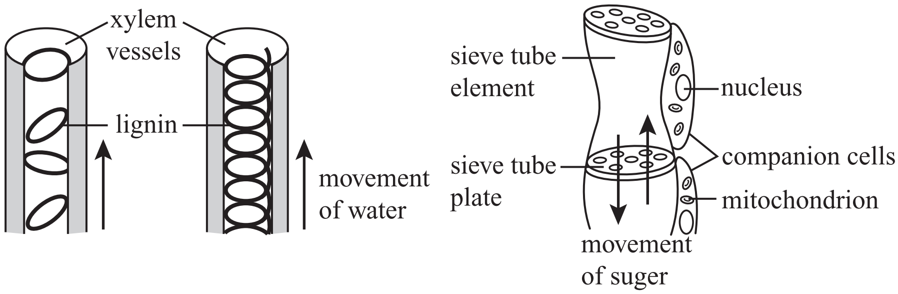


Fig 15.5 (a) The walls of xylem are strengthened by lignin. (b) In the phloem, the companion cells provide nutrients (sugar, amino acids) and energy to the sieve tubes.

6. The phloem transports **sugars** and other food materials such as amino acids from the leaves to other parts of the plant.

15.3 Movement of Substances Into and Out of Cells

In the treatment of some diseases, drugs are often administered to the patients. There are few ways for a drug to make its way through cells. They include paracellular diffusion (aqueous), intracellular diffusion (lipid), membrane diffusion (usually aqueous) and active transport / facilitated diffusion.

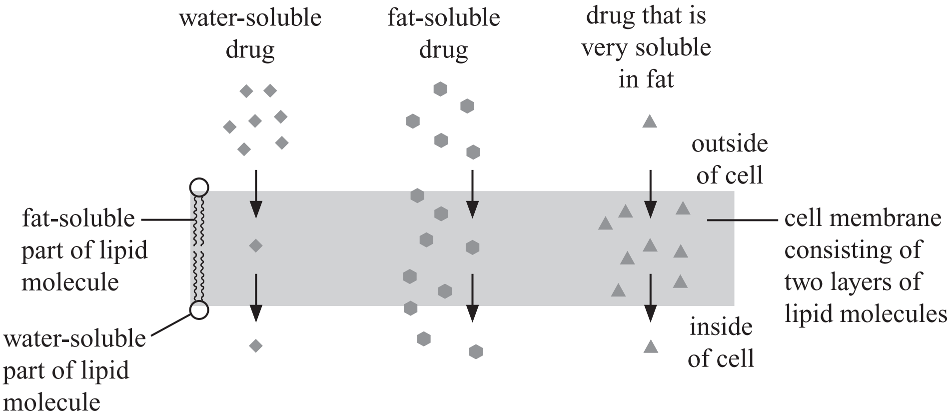


Fig 15.6 A cell membrane consists of two layers of lipid molecules. An oil-soluble drug molecule tends to pass through the cell membrane more easily than a water-soluble drug molecule.

1. **Diffusion** is the net movement of solutes from a region of higher concentration to a region of lower concentration. (See Chapter 7 for Evidence for the Particulate Model of Matter)
2. Optional for **N(A)** **Active Transport**
   Active transport is the movement of solutes from a region of **lower concentration** to a region of **higher concentration**, **using energy** in the process.
3. Optional for **N(A)** **Osmosis**
   - **Osmosis** is the net movement of water molecules from a region of higher water potential to a region of lower water potential through a partially permeable membrane.

- A **partially permeable**/selectively-permeable membrane is a membrane that allows certain particles such as molecules and ions to pass through. Osmosis requires a partially permeable membrane.
- A region of higher water potential has a lower concentration of solute particles.
- Water molecules will move from one side to the other in a random manner, according to the particulate nature of matter. However, there will be more water molecules moving from the region of higher water potential to the region of lower water potential. Therefore, the **net movement** of water molecules is towards the region of lower water potential.
- Like diffusion, osmosis is also a spontaneous process that does not require energy.

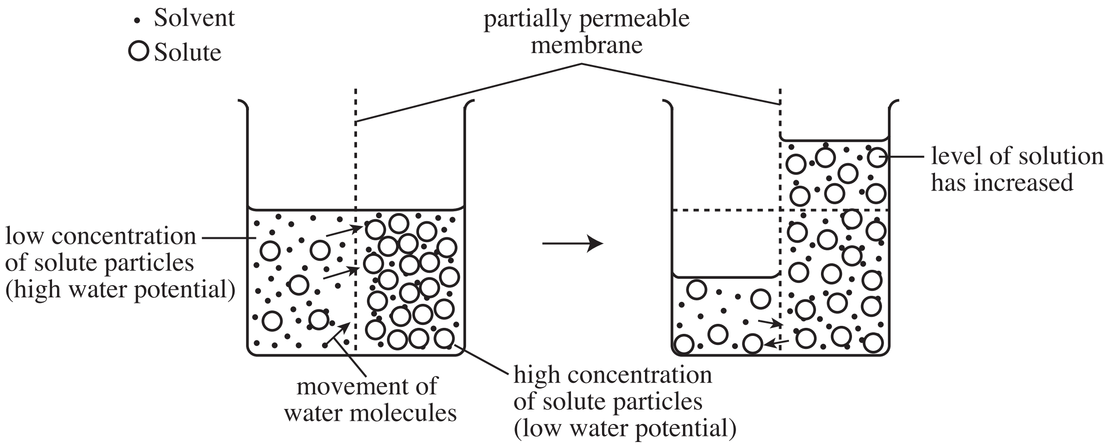


Fig 15.7 In osmosis, water molecules move through a partially permeable membrane from a region of higher water potential to a region of lower water potential.

Effects of Osmosis on Cells

Optional for **N(A)**

1. When an animal cell is placed in a dilute solution (higher water potential), there is net movement of water into the cell. The cell swells and eventually **bursts**.
2. When an animal cell is placed in a concentrated solution (lower water potential), there is net movement of water out of the cell. The cell **shrinks and crenates**.

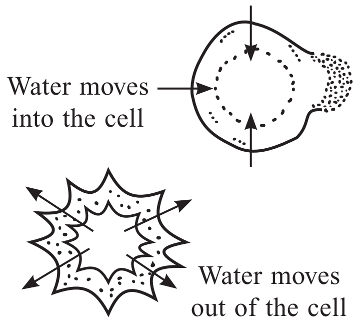


Fig 15.8 (a) In a dilute solution, the red blood cell swells and bursts. (b) In a concentrated solution, the red blood cell shrivels.

3. When a plant cell is placed in a dilute solution (higher water potential), there is net movement of water into the cell. The cytoplasm presses against the rigid cell wall. The cell becomes **turgid**.
4. When a plant cell is placed in a concentrated solution (lower water potential), there is net movement of water out of the cell. The cytoplasm pulls away from the cell wall. The cell is plasmolysed and **flaccid**.

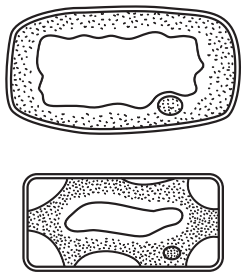


Fig 15.9 (a) In a dilute solution, the plant cell becomes turgid. (b) In a concentrated solution, the plant cell becomes flaccid.

SCIENCE AROUND US

Optional for **N(A)**

Industrial accidents can lead to workers severing their body parts, such as a finger, by machinery. When such accidents occur, it is important to soak the severed body part in cold saline solution as fast as possible. Saline solution has the same salt concentration as blood.
Explain the importance of soaking the body part in saline water. [2]

ANSWER

Saline water has the same water potential as the severed body part. Hence, the cells in the body will not crenate or burst.

Absorbing Water and Mineral Salts

Optional for **N(A)**

1. Plants absorb water through **root hair cells** by **osmosis**.
2. The root hair cell is well-adapted for absorption because its elongated structure provides a large surface area to volume ratio.
3. The large vacuole in the root hair cell contains a high concentration of solute so that water moves into the cell by osmosis.
4. The concentration of ions in the root hair cell is often greater than that in the soil so mineral salts usually cannot move into the root hair cell by diffusion.

5. The root hair cell is a living cell so it can carry out active transport to take in mineral salts from the soil. Energy is required in **active transport**.

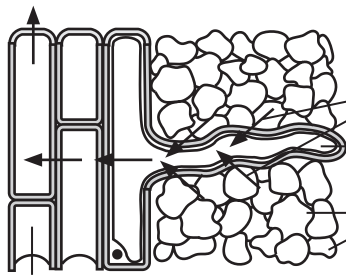


Fig 15.10 Water enters the root hair by osmosis. The water then passes from cell to cell by osmosis. The water is then drawn up by the xylem by transpiration.

6. The root hair cell is adapted to its function of absorbing water and mineral salts.

Structure	Function
Elongated structure	Increases surface area to volume ratio for faster movement of substances
Has mitochondria	Mitochondria releases energy through respiration for active transport of mineral salts
Vacuole has a high concentration of solute	Maintains a low water potential in the cell for water to move into the cell from the soil via osmosis

Table 15.1 Adaptations of the root hair cell

Movement of Water and Mineral Salts Up the Xylem

1. There are three ways that water moves up the xylem from the roots to the rest of the plant.
   (a) Root pressure
   (b) Capillary action
   (c) Transpiration pull
2. Transpiration pull is the main force that pulls water and mineral salts up the xylem.
3. Optional for **N(A)**
   Root pressure is the force that helps to drive fluids upward into the xylem due to the osmotic pressure in the cells of the roots.

4. Optional for **N(A)**

   Capillary action is the tendency of a liquid to move up against gravity when confined within a narrow tube. The effect of capillary action is greater when the tubes are narrower.

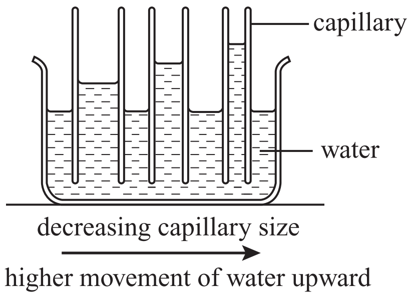


Fig 15.11 Capillary action brings water up narrow tubes such as xylem vessels but this can only 'pull' water up a small distance, after which it cannot overcome gravity.

5. **Transpiration** is the loss of water vapour from the leaves through the stomata.

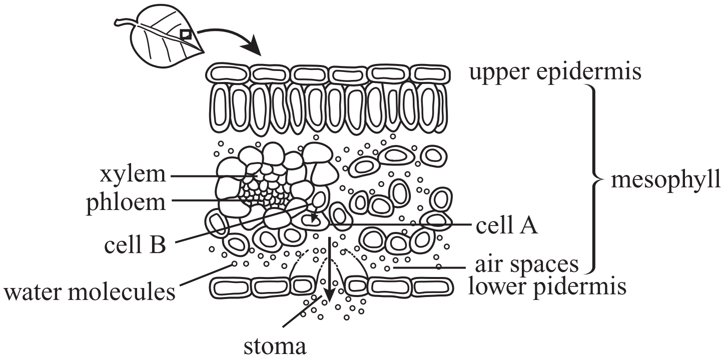


Fig 15.12 The evaporation of water from the mesophyll cells produces a negative water potential gradient, causing water to move up the xylem from the roots.

6. Normally, the air outside the stomata has less water vapour than the air in the air spaces inside the leaf.
7. Water vapour then **diffuses** from the air spaces through the stomata to the air outside the leaf. This water loss is referred to as transpiration.
8. Moisture surrounding the mesophyll cells near the air spaces (Cell A) **evaporates** into the air spaces. This draws water out of the mesophyll cells. (See Figure 15.12)
9. The mesophyll cell (Cell A) has a lower water potential compared to the surrounding mesophyll cell (Cell B). Water moves via **osmosis** from Cell B to Cell A.
10. Water potential in Cell B in turn, lowers. Cell B then draws water into it from the xylem.
11. When water leaves the xylem and moves into Cell B, a force is generated that pulls the column of water up the xylem.
12. Transpiration pull is a force that pulls water up the xylem from the roots to the leaves due to diffusion of water vapour out of the stomata (transpiration).

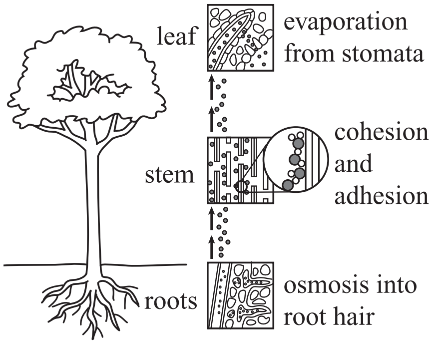


Fig 15.13 Transpiration is the water movement from the roots to out of the stomata.

13. Water moves up the xylem vessels in a continuous column due to cohesive and adhesive forces of water.
14. Cohesion is the ability of water molecules to attract one another.
15. Adhesion is the tendency of water molecules to be attracted to a surface (e.g. walls of xylem vessels).
16. Xylem structure is adapted for its function of transporting water and mineral salts.

Structure	Function
Continuous long, hollow tube with no end walls	Allows water to move in one continuous column, uninterrupted
Walls are thickened with lignin	Helps to keep the plant upright and prevents the xylem from collapsing due to high water pressure inside
Thin vessels	Allows for capillary action

Table 15.2 Adaptation of xylem

Extra

Cohesion is due to intermolecular forces, called hydrogen bonding, between water molecules. Adhesion is due to the attraction between water molecules and other types of molecules.Adhesion and cohesion are responsible for the meniscus that you observe when measuring the volume of water in a measuring cylinder.

15.4 Factors Affecting Rate of Transpiration

1. The rate of transpiration is affected by four factors:
   (a) Air movement
   (b) Temperature
   (c) Humidity
   (d) Light intensity
2. **Air Movement**
   - The faster the air movement around the leaves, the faster the rate of transpiration.
   - As water vapour near the stomata gets removed faster, there is a lower concentration of water vapour outside the leaf compared to the inside of the leaf.
3. **Temperature**
   - A higher temperature leads to a faster rate of transpiration. The rate of transpiration will reach a maximum at a certain temperature.
   - The higher the temperature, the faster the rate of evaporation from the moisture surrounding mesophyll cells.
   - Higher temperature also leads to faster rate of diffusion.

4. **Humidity**
   - The higher the humidity, the slower the rate of transpiration.
   - Humidity is the concentration of water vapour in the air. The higher the concentration of water vapour, the higher the humidity.
   - At higher humidity, the difference in water vapour concentration between the inside and outside of the leaf is less. Hence, less water vapour diffuses out of the stomata.
5. **Light intensity**
   - The higher the light intensity, the faster the rate of transpiration. The rate of transpiration will reach a maximum at a certain light intensity.
   - At higher light intensity, the rate of photosynthesis increases. As rate of photosynthesis increases, the amount of glucose within the guard cells increases.
   - This lowers the water potential of the guard cell. There is net movement of water molecules into the guard cells via osmosis, causing the guard cells to become turgid.
   - The stomata open wider, allowing faster diffusion of water vapour out of the cells.
   - When rate of transpiration is too high, too much water is lost from the plant.
   - This causes the stomata to close to prevent excessive water loss.
   - When too much water is lost, wilting occurs.

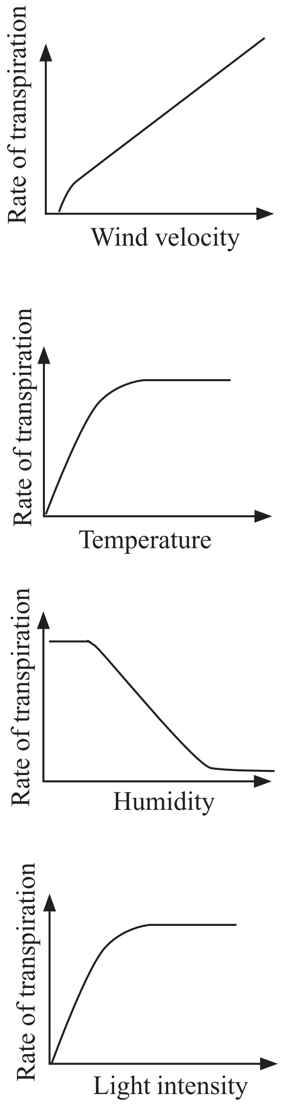


Fig 15.14 (a) Effect of wind velocity on transpiration (b) Effect of temperature on transpiration (c) Effect of humidity on transpiration (d) Effect of light intensity on transpiration

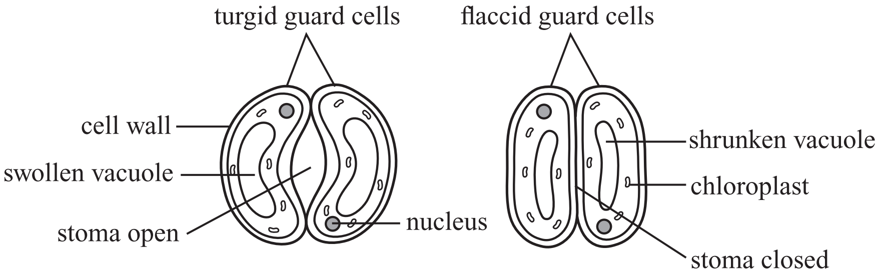


Fig 15.15 When water moves into the guard cells, the cells become turgid and the stoma opens. When water moves out of the guard cells, the cells become flaccid and the stoma closes.

SCIENCE AROUND US

A student placed his plant directly in front of a fan. After a few days, he noticed that his plant has wilted even though he has been watering it daily. Explain why his plant wilted. [3]

ANSWER

The faster air movement around the leaf increased the rate of transpiration. The water taken in by the plant was not enough to replenish the amount of water lost. The plant cells lost water and became flaccid, causing the plant to wilt.

Translocation

Optional for **N(A)**

1. Water transported to the leaves is used in photosynthesis.
2. **Translocation** is the transport of food such as sucrose and amino acids from the leaves to other parts of the plant.

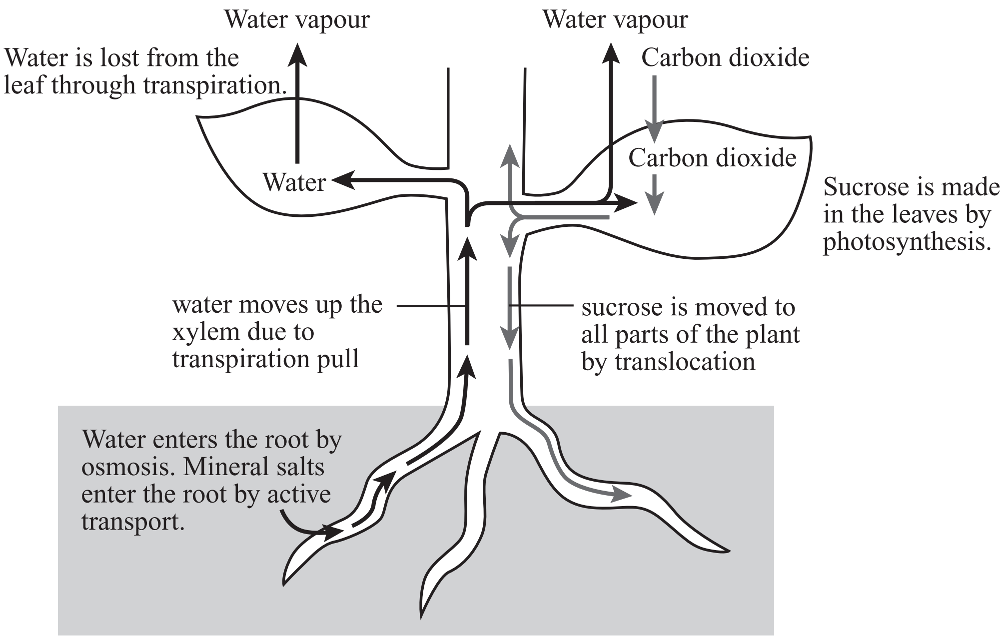


Fig 15.16 Transpiration and translocation

3. Evidence that shows food is transported in the phloem can be seen through translocation studies.

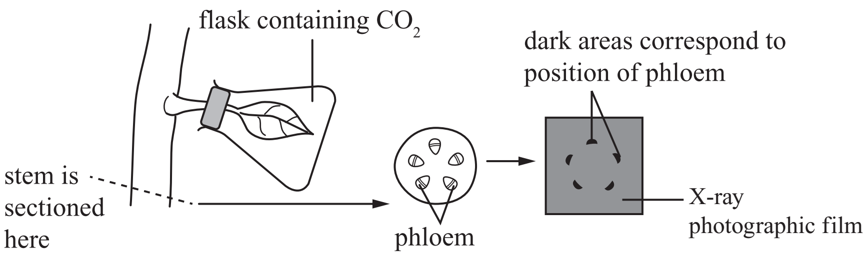


Fig 15.17 Radioactive carbon-14 is supplied to plant. Plant will use the carbon-14 for photosynthesis and incorporate it into sucrose that is manufactured. A transverse-section of the stem is obtained and imaged using X-ray radiophotography. The radioactivity can only be detected in the phloem.

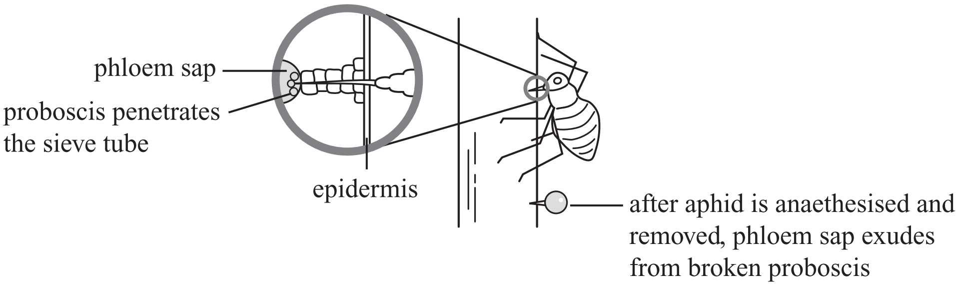


Fig 15.18 Aphids are insects that obtain food from the phloem of plant. They insert their proboscis into the stem or leaf. When the body of the aphids are cut off, leaving their proboscis behind, liquid that exudes from the cut end of the proboscis contains sucrose and amino acids.

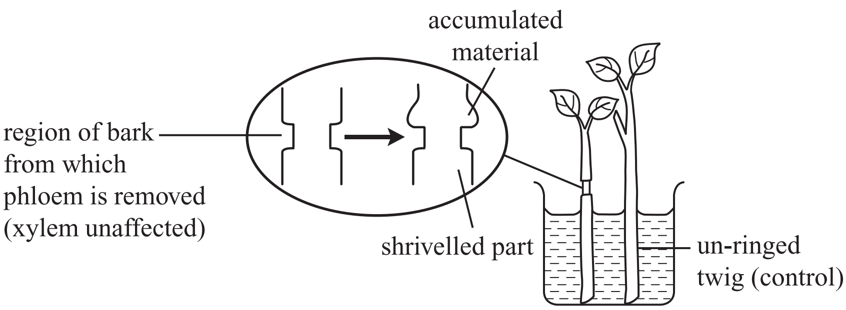


Fig 15.19 Ringing experiment also shows evidence of translocation. An outer ring of the bark is removed. This results in the removal of phloem. After some time, swelling is observed above the ring, caused by the accumulation of sucrose.

15.5 Transport in Humans

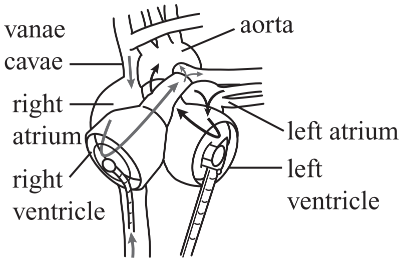


Fig 15.20 An artificial heart is a device that can replace a failing heart. Artificial hearts are typically used to bridge the time to heart transplantation, or to permanently replace the heart in the case that a heart transplant is impossible. Although other similar inventions preceded it from the late 1940s, the first artificial heart to be successfully implanted in a human was done in 1982.

Pulmonary hypertension is a type of high blood pressure which affects the arteries in the lungs and the right side of the heart. In one form of pulmonary hypertension known as pulmonary arterial hypertension (PAH), the blood vessels in the lungs are narrowed, blocked or destroyed. The damage can cause blood flow through the lungs to slow down resulting in blood pressure in the lung arteries to rise. As a result, the heart will need to work harder so as to pump blood through the lungs. This extra effort can cause the heart muscle to become weak and fail eventually.

1. The human circulatory system is a closed system that ensures blood flows in one direction.
2. The human circulatory system consists of the heart, blood vessels (mainly arteries, veins and capillaries) and blood.
3. The human circulatory system transports:
   (a) oxygen from the lungs to all parts of the body,
   (b) digested food from the small intestine to all parts of the body,
   (c) wastes from all parts of the body to excretory organs (e.g. lungs, kidney).
4. These substances are carried in the blood. The heart pumps blood to all parts of the body.

Double Circulation

1. The heart is divided into the left and right side.
2. The human circulatory system is a double circulatory system as blood goes through the heart twice for each circulation of blood.
3. Deoxygenated blood enters the right side of the heart which is then pumped to the lungs.
4. At the lungs, blood becomes re-oxygenated and goes back to the left side of the heart.
5. This is known as the pulmonary circulation.
6. Oxygenated blood is then pumped out of the left side of the heart to the rest of the body.
7. This is known as systemic circulation.

8. Double circulation has its advantages:
   - Prevents mixing of deoxygenated and oxygenated blood to ensure oxygenated blood reaches the body cells efficiently.
   - Allows the blood to be pumped out at high pressure from the left side of the heart to reach all body cells quickly.

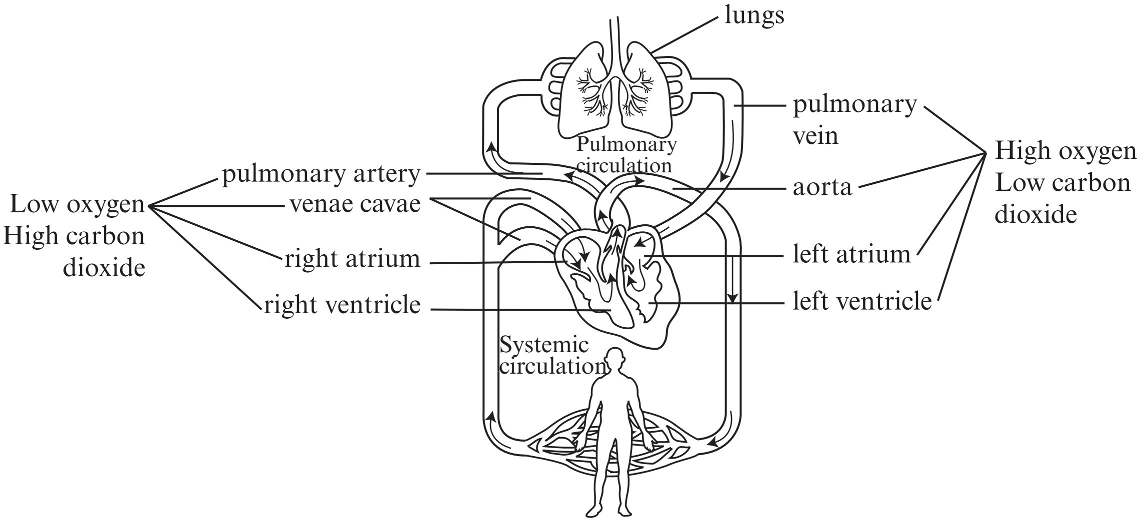


Fig 15.21 The human circulatory system is a double circulatory system.

The Heart

1. The heart is made up of muscles and valves.
2. The heart muscles undergo a cycle of contraction and relaxation, pumping the blood to the lungs and the rest of the body.
3. The heart also consists of valves that prevent the backflow of blood, ensuring that blood flow is unidirectional.
4. The right side of the heart pumps deoxygenated blood to the lungs (via the pulmonary artery).
5. In the lungs, the blood plasma loses carbon dioxide and the red blood cells take in oxygen via **diffusion**. The blood then becomes oxygenated.
6. The oxygenated blood flows (via the pulmonary veins) to the left side of the heart which pumps it to the rest of the body.
7. The heart has four chambers: right atrium, right ventricle, left atrium and left ventricle.

8. The superior and inferior vena cava carry deoxygenated blood from the rest of the body into the right atrium.
9. At the same time, pulmonary veins carry oxygenated blood from the lungs to the left atrium.
10. Both the right and left atria contract at the same time, pushing the blood into the right and left ventricles respectively.
11. Both the right and left ventricles contract at the same time, pushing blood into the pulmonary artery and aorta respectively.
12. The AV valves (tricuspid and bicuspid valves) close. This prevents blood from flowing back into the atria. This creates the "lub" sound of the heartbeat.
13. The pulmonary artery carries deoxygenated blood from the right side of the heart to the lungs. The blood is re-oxygenated at the lungs.
14. The aorta carries oxygenated blood from the left side of the heart of the rest of the body.
15. The ventricles relax and the next round of circulation starts again.
16. When the ventricles relax, the semi-lunar valves in the pulmonary artery and aorta close, preventing the backflow of blood into the ventricles. This creates the "dub" sound of the heartbeat.
17. Since the left side of the heart needs to pump out blood to the whole body, its wall is thicker than the wall of the right side.

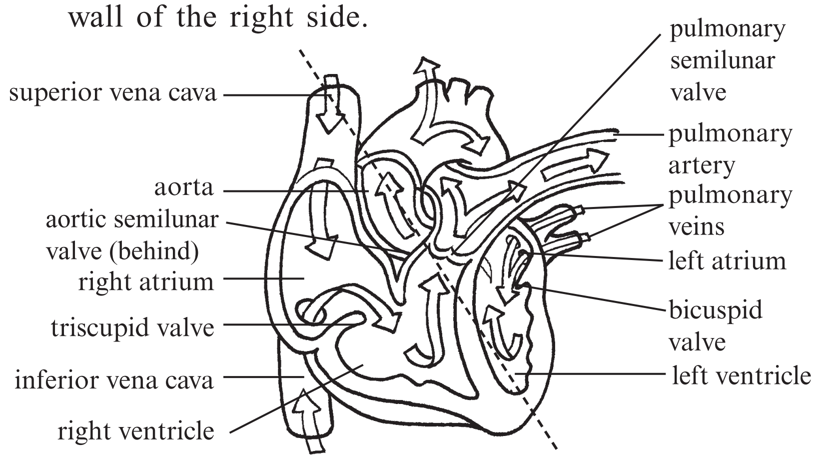


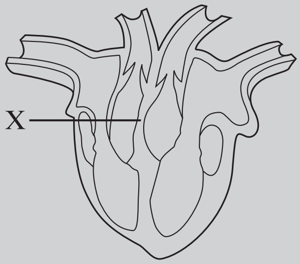
Fig 15.22 The right atrium receives deoxygenated blood from the veins and passes it to the right ventricle which sends it to the pulmonary artery. The left atrium receives oxygenated blood from the pulmonary vein and passes it to the left ventricle which sends it to the aorta.

Note

The main blood vessels in our bodies are veins and arteries. All veins but not all arteries contain valves. Valves in the circulatory system maintain the direction of blood flow. Our heart pumps blood which will be carried by arteries from the heart to other tissues. Hence, arteries do not have valves, except two which are the pulmonary trunk and the aorta. They have valves known as heart valves so as to prevent backflow.

SCIENCE AROUND US

Some people have a medical condition in which there is a hole in X.
Suggest one problem that this hole may cause and one symptom that the patient may experience. [3]



ANSWER

With a hole in X, oxygenated blood and deoxygenated blood are mixed. The body cells will not receive as much oxygenated blood. Hence, the patient feels breathless/ tired more easily.

The Cardiac Cycle

Extension Knowledge

1. The cardiac cycle shows the beginning of one heartbeat to the next. It consists of two phases: diastole and systole.
2. Diastole is the period where the ventricles are relaxed and the atria may then contract, filling the ventricles with blood.
3. The atrial pressure increases due to the contraction of the atria, pumping blood into the ventricles.
4. Ventricular pressure increases slightly due to blood being pumped into it.
5. When the atria start to relax, the atrial pressure decreases.
6. Systole is the period where the ventricles contract, pushing blood to the pulmonary artery and aorta from the right and left side of the heart respectively.
7. At the start of systole, the tricuspid and bicuspid valves (collectively known as atrioventricular or AV valves) close to prevent backflow of blood into the atria.
8. The ventricular pressure increases sharply as the ventricular muscles contract.
9. Pressure in the aorta increases soon after as blood is pumped into the aorta.
10. When the ventricles start to relax, the ventricular pressure decreases. The aortic pressure also decreases and the semilunar valves close to prevent backflow of blood into the ventricles.

11. During systole, the atrial pressure increases slowly as the atria fills with blood again.

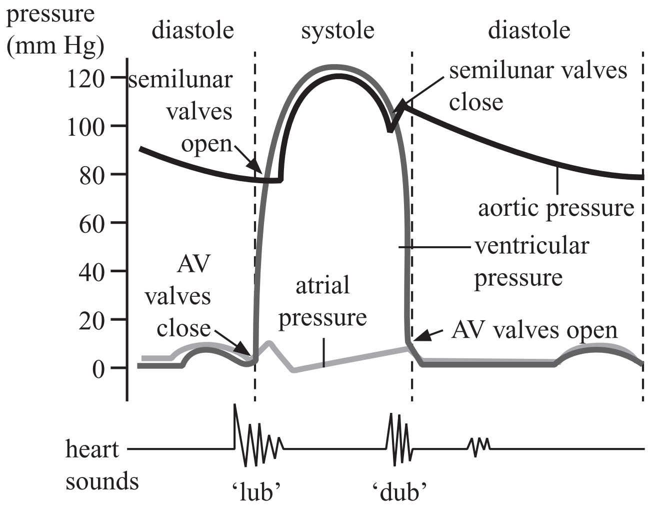
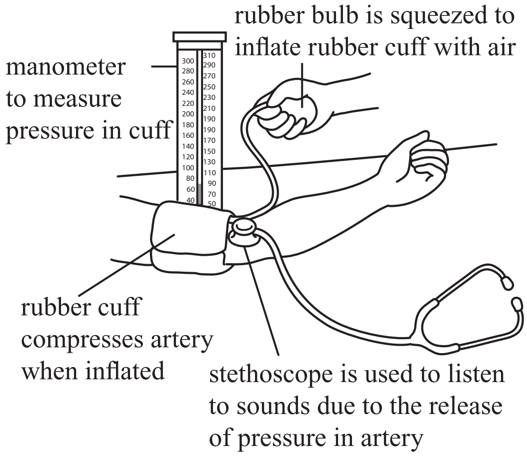


Fig 15.23 During systole, the left ventricle contracts to eject blood into the aorta. During diastole, the ventricles relax and blood from the atria flows into the ventricles.

Extra

Sphygmomanometer is the blood pressure monitoring machine commonly seen in homes or clinics.
They measure a patient's blood pressure by measuring the mean arterial pressure so as to determine the systolic and diastolic measurements. The device's name is derived from the Greek word "sphygmos," which means "pulse," and the scientific term "manometer," which refers to a means of measuring pressure.



Blood Vessels

1. **Arteries** are vessels that carry blood away from the heart.
2. Arteries transport oxygenated blood to the cells of the body. (The pulmonary artery, however, transports deoxygenated blood to the lungs.)
3. **Veins** are vessels that carry blood to the heart.
4. Veins transport deoxygenated blood. (The pulmonary vein, however, transports oxygenated blood from the lungs.)

5. The pulmonary artery carries deoxygenated blood towards the lungs and the pulmonary veins carry oxygenated blood away from the lungs.
6. The hepatic artery carries oxygenated blood towards the liver and the hepatic vein carries deoxygenated blood away from the liver.
7. The hepatic portal vein carries blood rich in nutrients (digested food) from the intestines to the liver.
8. The renal artery carries oxygenated blood towards the kidneys and the hepatic vein carries deoxygenated blood away from the kidney.

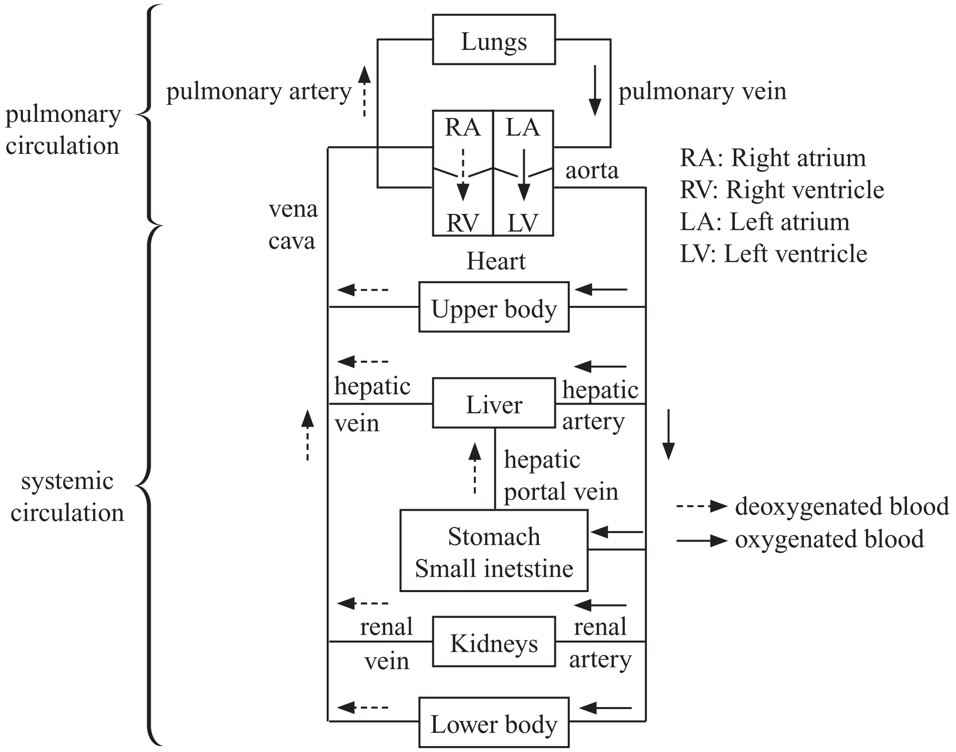


Fig 15.24 The human circulatory system

9. Arteries receive blood that is pumped out of the heart. Hence, the blood flowing in the arteries has the highest pressure.
10. As blood flows through the body, blood pressure decreases. The blood pressure in the veins is lower than the arteries.
11. This difference in blood pressure helps to ensure unidirectional blood flow as fluids flow from an area of high pressure to an area of low pressure.

12. Arteries have a thick layer of smooth muscle and elastic fibres. They also have a small lumen (hollow passageway).
13. Veins have a thin layer of smooth muscle and elastic fibres. They have a wide lumen.

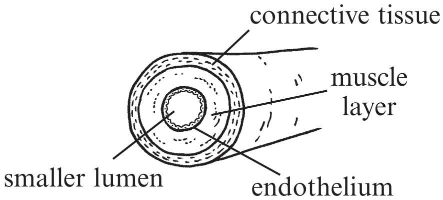
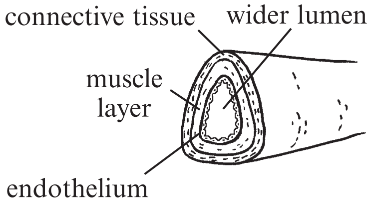
Structure	**Artery**	**Vein**
		
Thickness of muscle wall	Has a thick layer of smooth muscle and elastic fibres. The smooth muscles allow the artery to expand when blood is pumped through it. This enables the artery to withstand high blood pressure. The elastic fibres enable the artery to recoil after expansion, helping to maintain the high blood pressure so that blood can be transported to the rest of the body quickly.	Has a thin layer of smooth muscles. The blood is at lower pressure in the veins. Hence, the veins do not need a thick layer of smooth muscles to withstand high blood pressure.
Lumen size	Small lumen increases resistance and maintains high blood pressure.	Wider lumen decreases resistance, allowing blood to flow back to the heart more easily.
Presence of valves	There are no valves present as blood will not backflow due to the high blood pressure.	Valves are present to prevent blood from backflowing due to the low pressure of blood.

Table 15.3 The structure of the artery supports its function of transporting blood at high pressure to the rest of the body quickly. The structure of the vein supports its function of transporting blood at low pressure back to the heart efficiently.

14. **Capillaries** are the smallest blood vessels.
15. Arteries branch out into arterioles which branch out further into blood capillaries.
16. Blood capillaries rejoin to form venules. Venules join together to form veins.
17. Exchange of substances between the blood and tissue fluid occurs at the capillaries.

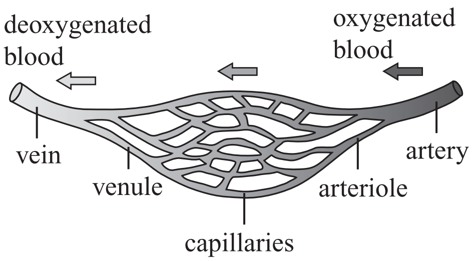


Fig 15.25 Arterioles carry oxygenated blood from the artery to the capillaries. From the capillaries, deoxygenated blood passes into venules, then into veins to return to the heart.

18. Optional for **N(A)**
- Due to a higher blood pressure in the artery, fluid from blood is forced out of blood capillary.
- Body cells around the capillaries are thus flooded with the fluid.
- Useful substances such as oxygen and nutrients diffuse out of the blood capillaries into the tissue fluid.
- Wastes such as carbon dioxide and urea diffuse into the blood capillaries from the tissue fluid.
- The water together with dissolved waste substances, re-enters the capillaries by osmosis.

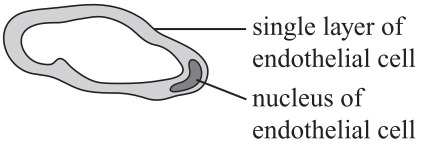
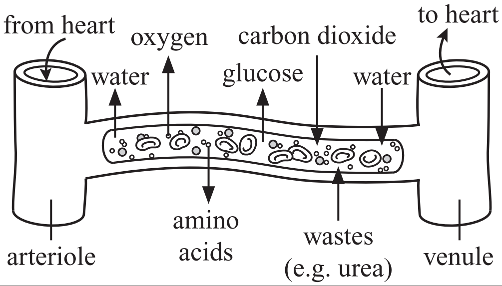
Structure	Function
One-cell thick endothelial layer 	Allows for faster exchange of substances via diffusion 
Highly branched blood capillaries	The branching decreases blood pressure and the flow of blood slows down. This allows more time for exchange of substances to occur.
Endothelial layer is "leaky"	This allows for fluids and white blood cells to move through the endothelial layer into the tissue fluid. White blood cells can move to the site of infection.

Table 15.4 The structure of the blood capillary supports its function for efficient exchange of substances.

The Blood Tissue

1. The blood consists of plasma, red blood cells, white blood cells and platelets.
2. The plasma is a mixture of dissolved substances in water (90%). The dissolved substances include soluble proteins, minerals (potassium, sodium, sulfate and phosphate), vitamins, digested food and waste products (urea and carbon dioxide).

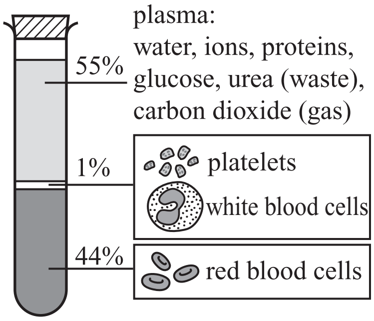


Fig 15.26 Components of blood

3. The red blood cell is a circular, flattened, biconcave shaped cell that does not contain a nucleus. The red blood cell contains the protein haemoglobin that binds to oxygen.

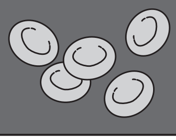
Structure 	**Function**
Contains haemoglobin	Binds to oxygen
Has no nucleus	Able to pack more haemoglobin molecules per red blood cell to transport more oxygen
Biconcave shape	Increases surface area to volume ratio for faster diffusion of oxygen.

Table 15.5 Structure-function relationship of red blood cells

4. White blood cells are irregularly shaped and have a large nucleus.
5. White blood cells fight against foreign bodies such as pathogens.
6. They can move about and ingest bacteria in a process known as phagocytosis.
7. They can also secrete antibodies, preventing the pathogens from infecting our body cells.

Structure 	**Function**
Has a large nucleus	Able to produce many proteins such as antibodies to fight against pathogens
Able to move on its own	Allows it to move to the site of infection

Table 15.6 Structure-function relationship of white blood cells

8. Platelets are needed for normal blood clotting.
    - When bleeding occurs, platelets stick to the wound and help to convert fibrinogen to fibrin.
    - Fibrin is a mesh-like structure that covers the wound and traps more platelets and blood cells at the wound. This forms a clot and stops the bleeding.
    - The clot also prevents pathogens from entering the body.
    - When the clot dries, a scab is formed.

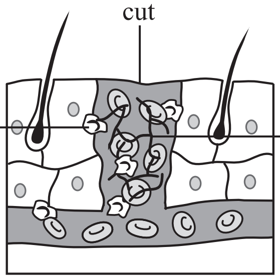
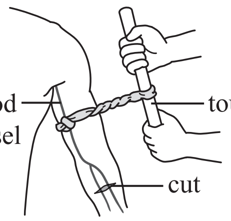


Fig 15.27 Fibrin links and binds platelets in the plasma together so as to stop the bleeding by forming a clot over the injury.

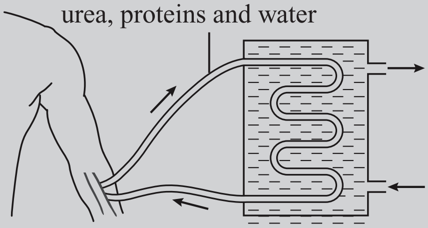
Extra

Accidental cuts can lead to huge wounds and potential rapid loss of blood from the human body. A tourniquet can be used to stop the bleeding. It is a device that is placed around a bleeding arm or leg. Tourniquets work by squeezing large blood vessels. The squeezing will help to stop blood loss so as to buy time for professional medical assistance to arrive. First-aiders are often required to know how to tie a tourniquet efficiently.



SCIENCE AROUND US

The diagram shows a dialysis machine used by kidney failure patients. The tubing that is immersed in a fluid bath is a partially permeable membrane.



(a) The tubing should draw blood from the artery and not from the vein. Suggest a reason for this. [1]

(b) Explain why the dialysis fluid bath has the same concentration of glucose as the blood. [2]

(c) Waste substances such as urea in the blood diffuse through the tubing and into the dialysis fluid. Explain how this happens? [2]

(d) Suggest why particles such as blood cells do not move out of the tubing. [1]

ANSWER

(a) *Pressure in the artery is high enough to allow blood to flow more easily into the dialysis machine.*

(b) *The concentration of glucose in the dialysis fluid bath and blood are the same so that there is no net diffusion of glucose out of the blood. Hence, the patient does not lose nutrients/energy source.*

(c) *There is a lower concentration of waste substances in the dialysis fluid. The waste substances diffuse out down the concentration gradient.*

(d) *The blood cells are too big to pass through the pores in the tubing/pass through the tubing.*

Blood Group

Extension Knowledge

1. There are four types of blood groups: A, B, AB and O.
2. These blood groups are further differentiated by a Rhesus factor. An individual with blood group A and positive for Rhesus factor has an A+ blood group. An individual with blood group A and negative for Rhesus factor has an A- blood group.
3. The type of blood group is determined by proteins that are found on the surface of the red blood cells.
4. Blood transfusion can only occur between individuals with compatible blood groups.
5. Individuals with O- blood group are known as universal donors as they can donate blood to all blood groups.
6. Individuals with AB+ blood group are known as universal acceptors as they can accept all blood from all blood groups.

		Donor's blood type							
		O–	O+	B–	B+	A–	A+	AB–	AB+
Recipient's blood type	AB+	✓	✓	✓	✓	✓	✓	✓	✓
	AB–	✓		✓		✓		✓	
	A+	✓	✓			✓	✓		
	A–	✓				✓			
	B+	✓	✓	✓	✓				
	B–	✓		✓					
	O+	✓	✓						
	O–	✓							

Table 15.7 This table shows that if your blood type is A+, you can donate your blood to people with A+ and AB+, and can receive blood from people with O+, O-, A+ and A-.

Coronary Heart Disease

Extension Knowledge

1. The coronary arteries supply oxygenated blood to the heart.
2. When the coronary arteries are blocked by fat deposits (plaque), it narrows the artery.
3. This can partially or totally block the supply of oxygenated blood to the heart. This is known as coronary heart disease.
4. Risk of coronary heart disease is increased by smoking, high blood pressure, high cholesterol, sedentary lifestyle, diet high in fats, sugars, drug abuse and stress.
5. Coronary heart disease can be prevented by not smoking, exercising regularly, having a balanced diet, not abusing drugs, reducing and managing stress.

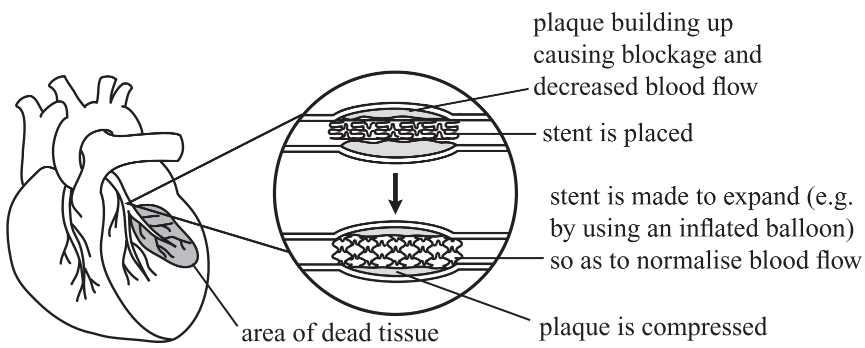


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Fig 15.28 A stent is a tiny tube that helps keep the arteries open. The use of stents has prolonged the lives of many people who are suffering from coronary heart disease.

Heart Transplant

1. Coronary heart disease, if not managed, may develop into end-stage heart failure.
2. There are no treatment options for patients with end-stage heart failure. They require a heart transplant.
3. Heart donors can only come from patients who have suffered brain death.
4. Transplanted organs may be rejected by the recipient’s body as it is recognised as a foreign object. White blood cells may attack the transplanted organ and destroy it.

5. To reduce the chances of organ rejection, doctors ensure that the donor and recipient have the same blood type.
6. Recipients usually have to be on immunosuppressant drugs (drugs that suppress the immune system) for the rest of their lives.
7. In Singapore, all citizens and permanent residents above the age of 21 are organ donors unless they opt out of the organ donation program.
8. Citizens who opt out of the program have a lower priority than one who has not opted out of the program in receiving an organ should they require a transplant in future.
9. Citizens that are under 18 would require the consent of their parents or guardians to donate their organ should they suffer from brain death.
10. It may be emotionally difficult for family members to accept the diagnosis of a brain death and agree to an organ donation.

Extra

The first heart transplant in the world was done on 3 December 1967. 53-year-old Louis Washkansky received the first human heart transplant at Groote Schuur Hospital in Cape Town, South Africa. After his surgery, Louis was given drugs to suppress his immune system so as to keep his body from rejecting the new heart. Unfortunately, the administered drugs caused him to be susceptible to sickness. Louis died from pneumonia 18 days later. However, with advancements in medicine, heart transplant patients are able to lead longer lives.