Transportation is a life process in which a substance absorbed or made in one part of the body of an organism is carried to other parts of its body through various means. In unicellular organisms and many simple multicellular organisms, materials are transported by osmosis and diffusion. In higher organisms, this is done by a specialized transport system called the 'vascular system'.

Transportation in Plants

Plants take in some compounds like carbon dioxide through their leaves. They absorb some other materials such as compounds of nitrogen, phosphorus etc from the soil through their roots. Most plants need a proper transport system to carry materials from one part to other. Plants do not move much and hence they need less energy. So, they have transport systems slower than those of animals. In plants, the transport system consists of tubelike passages made up of vascular tissue. There are two types of vascular tissues in plants: xylem and phloem.

The vascular system extends from roots through the stem and continues up to the leaves. Water and minerals are transported from roots upwards through the xylem tubes. Phloem transports synthesized food from leaves to the rest of the plant body. The transport of water, nutrients and other substances from one part of a plant to another is called 'translocation.' The medium of transport in plants is water.

Transport of Water and Minerals

Xylem tissue transports water and minerals. It consists of interconnected vessels and tracheids organized into continous conducting tubes stretching from the roots to the leaves. Plants absorb water from the soil through the root and transport it to the stem, leaves and flowers. Roots have hairs that are in contact with thin layer of water surrounding the soil particles.

Water is absorbed by osmosis, while the minerals (such as nitrates, chlorides, sulphates, phosphates) are absorbed as ions by active transport. The ions then move upward through the xylem, to the leaves and other aerial parts of the plant.

The pressure with which water is pushed into the xylem tubes of the root is called 'root pressure'. The water moving upwards forms a column, which is maintained up to a certain height due to root pressure.

Transpiration: loss of water in the form of vapour from the aerial parts of the plant. It takes place mainly through stomata. It has the following advantages:

1. It helps in the absorption and upward movement of water and minerals creating a 'transpiration pull.'
2. It helps in the regulation of temperature.
3. It maintains a constant supply of ions to the leaves.
4. It removes excess water.

Transport of Food and other substances

Translocation: the transport or movement of soluble products (sugar) of photosynthesis from leaves to other parts of the plant is termed as 'translocation.'

The food manufactured in leaves is translocated upwards, downwards and laterally to all parts of the plant through the phloem. The phloem also conducts some other substances such as amino acids. The conducting cells of the phloem are cylindrical cells called 'sieve tubes', which have sievelike partitions at both ends. These partitions are called 'sieve plates.' Besides sieve tubes, phloem has companion cells and phloem parenchyma.

Sucrose is the main form of carbohydrate that is translocated in plants. Its translocation into the phloem tissue occurs with the expenditure of energy through ATP, which increases the osmotic pressure of the tissue causing water to move into it.

Difference between Xylem and Phloem vessels

Xylem	Phloem
Have dead long and hollow vessels	Have living tin tubes placed end to end.
Have lignified cell wall thickenings	Ends are connected to each other by sieve

	plates.
Provides cell wall thickenings	Sieve tube is filled with cytoplasm
Prevents vessels from collapsing.	Companion cells contain nuclei and control activities of sieve tubes.
Movement of water is in upward direction from soil to leaves.	Transport of substances in all directions to all parts of the plant.
It carries mainly water and minerals.	It carries organic compounds such as sugar and amino acids.

Exercise 1

1. Why do we need a proper transportation system in plants?
2. What is the significance of transpiration in plants?
3. Define translocation.

Transportation in Animals

In very simple animals, materials are transported through diffusion. In complex animals, there is a special transport system to carry oxygen, carbon dioxide, nutrients, waste products, food and other various substances from one part of the body to the other. This transport system, also called 'circular system', comprises a blood vascular system and a lymphatic system. The blood vascular system has three components: blood, blood vessels and the heart. The lymphatic system includes lymph, lymph vessels and lymph nodes.

Blood: a fluid transport medium

Blood is a liquid connective tissue having two main components: plasma and blood corpuscles. Plasma is the liquid part of the blood. It is made up of water with various substances dissolved in it. These include proteins, salts, glucose, nitrogenous compounds and so on.

Corpuscles are cells floating in the plasma, Red Blood Cells, a type of corpuscle in vertebrates, contain a red coloured respiratory pigment called haemoglobin.

Heart: a pumping organ

The heart is a muscular pumping organ. It pumps blood that comes to it from other parts of the body through the circulatory system. It pumps deoxygenated blood to the lungs for oxygenation and oxygenated blood to all parts of the body.

Control of Heart

The invertebrate heart is generally fully controlled by the nervous system. The vertebrate heart is controlled by a pacemaker system made up of specialized cardiac muscles.

Chambers in the heart

The heart is divided into chambers in order to prevent the mixing of oxygenated blood with deoxygenated blood. A complete vertical partition of the heart into left and right chambers ensures a complete separation of oxygenated and deoxygenated blood. This type of partition is seen in animals having a double circulation system with two circuits. These animals (e.g. mammals, birds and crocodiles) have lungs.

In one circuit blood flows between the heart and the lungs and in the second circuit it flows between the heart and the body. The heart has four chambers: two atria (often called auricles) and two ventricles. Such a heart is called double heart. This type of complete separation into chambers provides an ample supply of oxygen to all parts of the body. These animals are quite active, so they have a high rate of respiration and require an efficient supply of oxygen. Birds and mammals, being warm blooded, need to spend energy to regulate their body temperature. This also requires oxygen.

Some vertebrates do not use energy for temperature regulation. Their temperature fluctuates with that of the environment and we call them cold blooded. In these animals (except crocodiles) there is some mixing of oxygenated and deoxygenated blood in the heart. This does not harm the animals as their energy demands are not very high. In amphibians the heart is three chambered,

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having two atria and a single ventricle. Such a heart is called 'transitional heart'. In most reptiles there are two atria and an incompletely divided ventricle.
Fish have a single circulation system. Their heart is two chambered, having one atrium and one ventricle. Such a heart is called 'single heart'. The fish heart receives and pumps only impure blood. The impure blood goes to the gills for oxygenation and from there it goes to different parts of the body. The impure blood returns to the heart for being pumped out to the gills. Therefore, the fish heart is also called 'venous heart'.

Blood Vessels:
In vertebrates the blood vessels are arteries, veins and capillaries. Arteries are more muscular, while veins are more elastic. Capillaries are made up of a single layer of squamous epithelium. In invertebrates the blood vessels are not properly distinguished as arteries and veins.

Circulatory System in Humans

Blood
Blood, is a liquid connective tissue that circulates in a closed system of blood vessels. An adult man has about five to six litres of blood, while a woman, on an average has about one litre less. Our blood consists of:

a) Solid elements: which include Red Blood Corpuscles (RBC's), White Blood Corpuscles (WBC's), and blood platelets.
b) Liquid elements: the plasma.

The corpuscles comprise about 45% and the plasma about 55% of the volume of blood.

Plasma: Plasma is a straw coloured liquid in which the RBC's, WBC's and platelets float. It contains mainly water, in which are dissolved various substances such as plasma proteins, food substances (amino acids, glucose, fats), nitrogenous compounds and ions of sodium, potassium, calcium, magnesium and phosphorus.
Blood corpuscles
Blood is red in colour due to the presence of RBC;s. The RBC's contain red coloured respiratory pigment 'haemoglobin.' This iron – protein compound transports oxygen from the lungs to the tissues. RBC's also transport carbon dioxide. WBC's protect the body from infection. Platelets help in the clotting of blood. Red blood cells are produced in bone marrow of long bones, like bone of thigh. The normal range of haemoglobin in humans is 120 – 180 g/L or 12 – 18 g/dL of blood. A below normal level of haemoglobin may indicate anaemia due to vitamin deficiencies or lack of iron in the diet.

Blood clotting by platelets
Platelet cells are present in our blood and they circulate all around the body through it. Whenever there is bleeding these platelets act as a plug to stop it. The clot, which forms at the point of wound, is a microscopic network of insoluble fibrous protein. It minimizes the loss of blood. If number of platelets decreases in our blood it could lead to excess of bleeding and that could be fatal for us.

Functions of blood:
1. Transport of respiratory gases: blood carries oxygen from lungs to the tissues. It also carries carbon dioxide from the tissues to the lungs.
2. Transport of nutrients: nutrients absorbed in the small intestine enter the blood capillaries. Blood carries these nutrients and distributes them to all parts of the body.
3. Transport of waste products: waste products of the body, such as urea, uric acid etc, are carried by blood to the excretory organs.
4. Regulation of water content of cells: Blood regulates the water content of the cells. When the water content in cells increases, blood takes up the excess amount of cellular water. Blood provides water to cells when they need it.
5. Regulation of body temperature: increased body temperature resulting from excess respiration of a particular tissue is equalized by circulation of blood.

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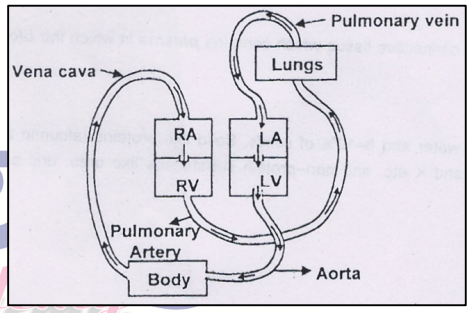
6. Defence against infection: blood protects the body against circulation.
7. Prevention of bleeding: clotting of blood prevents excess bleeding.

Blood vessels

Three types of blood vessel namely, arteries, veins and capillaries are involved in blood circulation. They are all connected to form one continous closed system.

1. Arteries: these are wide, elastic and thick walled vessels as they carry blood away from the heart to the limbs and organs of the body. They have thick, elastic walls to withstand the high pressure of the blood emerging from the heart.
2. Veins: these bring blood from the tissues and organs to the heart. The blood in veins flow under less pressure than that in arteries. Therefore, veins do not have thick walls. But veins can accommodate more blood. Veins have valves that allow blood to flow in one direction only.
3. Capillaries: arteries branch out into smaller and thinner blood vessels called arterioles. These divide into still smaller vessels to provide blood to all the cells. The thinnest blood vessels are called capillaries. Their walls have just one layer of squamous cells. These walls are permeable, so water and dissolved substances pass in and out, exchanging oxygen, carbon dioxide, dissolved nutrients and waste products with the tissues around the capillaries. These capillaries form a dense network, reaching out to every part of the human body. The flow of blood is slow in capillaries.

Human Heart



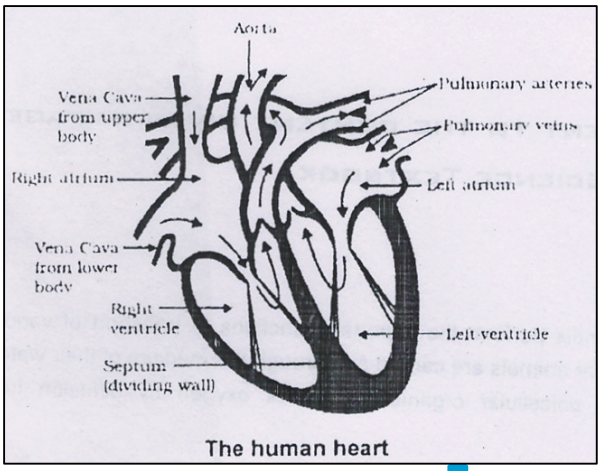
Structure: The heart is a muscular, conical and dark red organ that plays the role of pump in the circulatory system. Its pumping action maintains the circulation of blood.

In man, the heart weighs about 0.43 % of the body. It is located in the middle of the thoracic cavity, but its apex is tilted towards the left side. The heart is enclosed in the 'pericardium', a tough, inflexible membrane. Between the heart and the pericardium is a fluid which reduces the friction produced during heartbeat. The heart is made up of cardiac muscles. These muscles contract with considerable force, squeezing the blood out into the arteries. The heart beats non stop throughout one's life.

It is due to the rhythmic contraction and expansion of the heart muscles. There are four chambers in the heart- two atria, with thin walls, and two ventricles, with thin walls.

Working of the heart

Blood from different parts of the body comes to the right atrium when it expands. This impure blood is brought from the upper part of the body through the 'superior vena cava' and from the lower part of the body through the 'inferior vena cava'. As the right atrium contracts, the blood goes to the right ventricle, which dilates.



The human heart

The atrioventricular aperture is closed by valve after the blood transfer. Valves prevent the backflow of blood when the atria or ventricles contract.

When the right ventricle contracts, the blood is forced out to the lungs for

oxygenation through the pulmonary artery, guarded by another valve. In the lungs, there is an exchange of oxygen and carbon dioxide. After the blood has received oxygen from the lungs and given off carbon dioxide, the oxygenated blood returns to the left atrium. Pulmonary veins bring this oxygenated blood from the lungs to the left atrium, as it relaxes. When the left atrium contracts, blood is transferred to the left ventricle, which expands. The aperture between the left atrium and left ventricle is guarded by a valve. The wall of the left ventricle is three or four times thicker than the wall of the right ventricle, as it pumps blood to the body. When the left ventricle contracts, the oxygen rich blood is pumped into the aorta for circulation to different parts of the body. The opening of the aorta is also guarded by a valve. Deoxygenated blood is collected from different parts of the body by small veins. These open into larger veins, which bring blood back to the right atrium.

Cardiac cycle: One sequence of the filling of the heart with blood and its pumping is called the 'cardiac cycle'. The phase of contraction of the ventricle is called 'systole' and its relaxation phase is called 'diastole'.

Blood pressure: As blood flows, it exerts a force on the walls of the blood vessels. This is much greater in the arteries than in the veins. The pressure of flow of blood in the aorta and its main branches is defined as blood pressure. The heart has to develop a high pressure so that blood can be pumped through the arteries, capillaries and veins.

During the ventricular contraction, or systolic phase, it is equal to that exerted by a column of 120 mm of mercury. During the ventricular relaxation, or diastolic phase, it is about 80 mmHg. Thus, the normal blood pressure is said to be '120/80'. However, the blood pressure varies from person to person and is affected by age, sex, heredity, physical and emotional states, and other factors. An instrument called sphygmomanometer is used to measure blood pressure. Abnormally high blood pressure is called hypertension. It may be associated with a disease or may occur due to anxiety. During hypertension, the arterioles get constricted and increase resistance to blood flow. High blood pressure can cause the rupture of blood vessels, internal bleeding or stroke. If a blood vessel is ruptured in the brain, that part does not get blood, oxygen and nutrients, and loses its function.

The Lymphatic system

Lymph is another type of fluid that takes part in transportation. Blood containing oxygen and food flows under tremendous pressure in the arteries, which divide into arterioles and eventually into capillaries. When the blood from an arteriole enters a capillary, it is under so much pressure and the capillary walls are so thin that a clear liquid is forced out of the capillary walls into the spaces between the surroundings cells. This liquid is called tissue fluid. Tissue fluid carries with it oxygen, food and other useful substances to the cells. It also takes away carbon dioxide and waste products from the cells.

If tissue fluid were to accumulate in the tissues and organs, it would cause swelling. So, it is returned to the bloodstream through another system of vessels, called the lymphatic system. The lymphatic system consists of lymph, lymph vessels and lymph nodes.

Most of the tissue fluid drains into lymph vessels and flows as lymph. Lymph is similar to blood except that it does not have RBCs and blood platelets, and has a lesser amount of proteins. Therefore, lymph is colourless or slightly yellowish and is similar to blood plasma.

The lymphatic system maintains the balance between tissue fluid and blood. Lymph carries digested fat from the intestine and drains excess fluid from the intercellular spaces back into the blood. Before lymph enters the blood, it passes through the number of lymph nodes. These are small globular masses of lymphatic tissue. Lymph nodes produce WBCs that prevent infections.

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Worksheet 1

1. What is the composition of blood? Mention the function of each component.
2. Differentiate xylem from phloem.
3. How is food transported in plants?
4. Explain the double circulation in human heart with a flowchart of routes of oxygenated and deoxygenated blood through the human body.
5. Illustrate the internal structure of the human heart with a diagram. Outline the path of blood flow in the diagram
6. How does hemoglobin help in gaseous exchange? What property of hemoglobin helps in this process?
7. What makes plasma yellowish in colour?
8. What will happen, if haemoglobin is destroyed or present in small amount in our blood?
9. What are the functions of phloem tissues besides the translocation of food?
10. Differentiate single circulation from double circulation.
11. Why is a lot of energy spent in the translocation of food and minerals through the plant body'?
12. Name the term for transport of food from leaves to other parts of plants.
13. Name the largest artery in the human body.
14. Which among the four chambers of the human heart has the thickest muscular walls?
5. Give the function of lymph.

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