Transport of water and minerals in plants and animals

Transport of water in plants

The survival of plants is dependent on a number of factors which include water, minerals, gases, and nutrients they receive. The movement of gas, water, and nutrients in plants are carried out in components. They take in carbon dioxide from the air through the stomata present in their leaves and they absorb compounds of nitrogen, phosphorus, etc., from the soil by their roots. If the distance to be traversed is relatively small, diffusion process occurs. As the distances increases in tall trees, a well-developed transportation system arises as these movements of substances have to be facilitated with extreme care.

The amount of energy required by plants is lower compared to that of animals, hence there is a requirement of slower transportation. In plants, a tube-like passage made up of vascular tissues called xylem and phloem are two modes of transportation. Water and minerals travel upwards through the xylem, while phloem transport synthesized food to other parts of the plant. The movement of water and other nutrients from one part of a plant to another is called translocation. Water gets absorbed by osmosis while minerals by active transport. The method used in the upward movement of water through the xylem is determined by the cohesion-tension theory. Here the driving force of transport is transpiration. In this process, cohesion is responsible for driving more water through the xylem and excess water molecules are pulled up by the pulling force which later evaporates through the tiny pores of stomata.

Transport of minerals in plants

Like water, minerals are also necessary for plants to survive. About 16 minerals are necessary for plants. These minerals are present in soil in the form of inorganic salts such as nitrates and phosphates. In soil, these minerals get dissolved in water and are absorbed by roots along with water. From roots, the minerals are transported to various parts of a plant along with water by xylem vessels by same procedure as described earlier.

Thus, in plants both water and minerals are transported from roots to upper parts (stems, leaves, flowers and fruits) by xylem vessels.

Transport of water in animals

A healthy sedentary adult living in a temperate climate should drink at least 1.5 liters of water per day . This level of water intake balances water loss and helps keeping the body properly hydrated. The water you consume through food and drinks follows a very precise route to arrive in your cells, of which it is a vital constituent.

After passing through the stomach, water enters the small intestine, where it is largely absorbed in the first sections, the duodenum and jejunum. The rest passes into the colon. It crosses the intestinal mucous membrane into the bloodstream, then into the interstitial tissues that make up the framework of every organ, to arrive in the cells.

Blood brings nutritional elements to cells (minerals, vitamins, protein components, lipids and carbohydrates). Waste products are then removes through urines. Water plays also an essential function in helping the regulation of temperature.

Transport of minerals and other nutrients in animals

In all leaving beings the nutrients and gases are transported to and from all parts of the body. This is essential to carry on various

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life processes. In case of unicellular and small multicellular organisms transport takes place by diffusion. However, in large multicellular organisms, as the distances between different body parts have increased, they need an elaborate and efficient system for transportation of materials. In large animals, such a system is called circulatory system in which a fluid circulates in all parts of the body. In many invertebrates this fluid is the haemolymph, where as in all vertebrates and in some higher invertebrates this fluid is the blood.

Open Circulatory System

Many invertebrates e.g. arthropods have open circulatory system.In this system the blood is pumped from the heart into the blood vessel. The blood vessels in turn, empty themselves into open spaces called sinuses. In the sinuses, the blood is in direct contact with the tissues, and after exchange of materials with the tissues it re-enters the heart for circulation again.

Closed Circulatory System

Closed circulatory system is more elaborate, complicated and efficient as compared to the open circulatory system. The closed circulatory system consists of a muscular, and contractile pumping organ, the heart with its incoming (veins) and outgoing (arteries) blood vessels. The blood remains confined in the blood vessels while circulating in the whole body e.g. earthworm, man etc.

In closed circulatory system, the heart pumps blood into the blood vessels (arteries) which take away the blood from the heart to the tissue. In the tissues, the arteries divide and subdivide into very fine branches, called the capillaries. The walls of capillaries are just one cells thick, and in them the blood is in close contact with the tissue cells. Exchange of materials with tissues is carried out here. The capillaries join and form bigger blood vessels called venules. These venules in turn join to from the veins, which ultimately transport blood back to the heart.

General Plan Of Circulatory System Of Vertebrates

In vertebrates, the circulatory system is always of closed type. The closed circulatory system is further of two types, (a) single circuit circulation, (b) double circuit circulation.

For instance in fishes the circulation is of single type. In it, only the deoxygenated blood circulates through the heart. The deoxygenated or the venous blood from all tissues of the body enters the sinus venous, from where it passes into the single auricle or atrium. From the atrium it goes in the ventricle.

From the ventricle, the blood is pumped into the gills for oxygenation. The oxygenated blood from the gills is directly distributed to all parts of the body. As the blood circulates once through the heart, therefore, this type of circulation id called single circuit circulation.

In land vertebrates, with the introduction of lung respiration, double-circuit circulation evolved.

The evolution of double circuit circulation led to the division of atrium and ventricle, each into two chambers. The atrium divided into right and left atria (plural of atrium) and likewise the ventricle also divided into two chambers. In amphibians, the ventricle is not divided and in most reptiles, the division of the ventricle is incomplete. In some reptiles and in all birds and mammals, the division of the ventricle is complete. So in these animals, oxygenated and deoxygenated bloods are completely separated from each other and there is no mixing of these two types of blood. This increases the efficiency of the circulatory System in vertebrates is

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highly developed and among them mammals have the most efficient circulatory system.

Composition And Function Of Blood

Blood makes up about 8% of the human body weight. It contains erythrocytes, leucocytes, thrombocytes (platelets) and plasma. The volume percentage of all blood cells in the whole blood is about 45% of adults (hematocrit). The rest consists of liquid plasma (e.g. water, plasma proteins, electrolytes etc.).

The blood is composed of:

Plasma

Plasma is a straw-coloured fluid in which blood cells are suspended. It is made up of approximately 90% water as well as electrolytes such as sodium and potassium and proteins.

Red Blood Cells (Erythrocytes)

The main function of red blood cells is to carry oxygen. Red blood cells contain a protein called Haemoglobin. This combines with oxygen to form Oxyhaemoglobin. Each red blood cell has a lifespan of approximately 120 days before it gets broken down by the spleen. New cells are manufactured in the bone marrow of most bones. There are approximately 4.5-5 million red cells per micro-litre of blood.

White Blood Cells (Leucocytes)

There a number of types of white blood cells, although the function of all of them is to help fight disease and infection. They typically have a lifespan of a few days and there are only 5-10 thousand WBC's per micro-litre of blood.

Platelets (Thrombocytes)

Platelets are disc shaped cell fragments which are involved in clotting the blood to prevent the excess loss of body fluids.

Functions of blood

Messenger & waste removal: Blood is the most important transport medium in the human body. It transports gases (oxygen, carbon dioxide, nitrogen etc.) as well as nutrients (metabolism) and end products of cell metabolism. Hence the blood has the task of assuring the exchange of substances. It provides the tissues with blood gases and nutrients and in exchange transports end products (e.g. carbon dioxide, urea, uric acid, creatinine etc.) to the eliminating organs (lung, liver, kidney). Furthermore, it carries chemical messengers (hormones) to their target organs.

Acid-Base Balance: The acid-base homeostasis is regulated in the blood through the diffusion of gases between alveoli and blood in the lung (alveolar diffusion) oxygen diffuses from the alveoli into the blood due to the concentration gradient. It is taken up by the carrying protein hemoglobin (hem = iron-containing, globin = protein). Contrariwise carbon dioxide diffuses from the blood into the alveoli due to its higher blood concentration where it is breathed out.

Oxygen Supply & Carbon Dioxide Removal: The blood transports the oxygen from the alveoli to the remotest cells of the body. Because of the higher gas pressure in the plasma (relative to the cells), it diffuses to the tissues.

Carbon dioxide diffuses from the cells into the blood due to the higher gas pressure in the tissue. Here it undergoes a chemical reaction and forms carbonic acid ($CO2 + H2O \rightarrow H2CO3$) which dissociates into

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hydrogen ion (H+) and bicarbonate (HCO3-). Thus the metabolism end product carbon dioxide is transported in the form of carbonic acid (or rather hydrogen ion and bicarbonate). In the lung, the above mentioned chemical reaction reverses and carbon dioxide is exhaled.

To sum it up the blood regulates the acid-base homeostasis by the gas exchange. The blood is also responsible for the homeostasis, e.g. balancing the water between the blood capillaries on the one hand and intracellular and extracellular space on the other hand. It also maintains a constant body temperature.

Coagulation: Coagulation factors (proteins) are solved in the blood and stop bleeding after a complex (cascade-like) activation of coagulation factors through damage to blood vessels finally leading to the building of thrombus (thrombogenesis). Simultaneously, fibrinogen/fibrin prevents the pathological development of blood clots in the blood vessels. Blood coagulation and fibrinolysis influence each other and maintain a sensitive equilibrium.

Coagulation of blood

Coagulation, is the process by which a blood clot is formed. The formation of a clot is often referred to as secondary hemostasis, because it forms the second stage in the process of arresting the loss of blood from a ruptured vessel. The first stage, primary hemostasis, is characterized by blood vessel constriction (vasoconstriction) and platelet aggregation at the site of vessel injury. Under abnormal circumstances, clots can also form in a vessel that has not been breached; such clots can result in the occlusion (blockage) of the vessel (see thrombosis).

Clotting is a sequential process that involves the interaction of numerous blood components called coagulation factors. There are 13 principal coagulation factors in all, and each of these has been assigned a Roman numeral, I to XIII. Coagulation can be initiated through the activation of two separate pathways, designated extrinsic and intrinsic. Both pathways result in the production of factor X. The activation of this factor marks the beginning of the so-called common pathway of coagulation, which results in the formation of a clot.

The extrinsic pathway is generally the first pathway activated in the coagulation process and is stimulated in response to a protein called tissue factor, which is expressed by cells that are normally found external to blood vessels. However, when a blood vessel breaks and these cells come into contact with blood, tissue factor activates factor VII, forming factor VIIa, which triggers a cascade of reactions that result in the rapid production of factor X. In contrast, the intrinsic pathway is activated by injury that occurs within a blood vessel. This pathway begins with the activation of factor XII (Hageman factor), which occurs when blood circulates over injured internal surfaces of vessels. Components of the intrinsic pathway also may be activated by the extrinsic pathway; for example, in addition to activating factor X, factor VIIa activates factor IX, a necessary component of the intrinsic pathway. Such cross-activation serves to amplify the coagulation process.

The production of factor X results in the cleavage of prothrombin (factor II) to thrombin (factor IIa). Thrombin, in turn, catalyzes the conversion of fibrinogen (factor I)—a soluble plasma protein—into long, sticky threads of insoluble fibrin (factor Ia). The fibrin threads form a mesh that traps platelets, blood cells, and plasma. Within minutes, the fibrin meshwork begins to contract, squeezing out its fluid contents. This process, called clot retraction, is the final step in coagulation. It yields a resilient, insoluble clot that can withstand the friction of blood flow.

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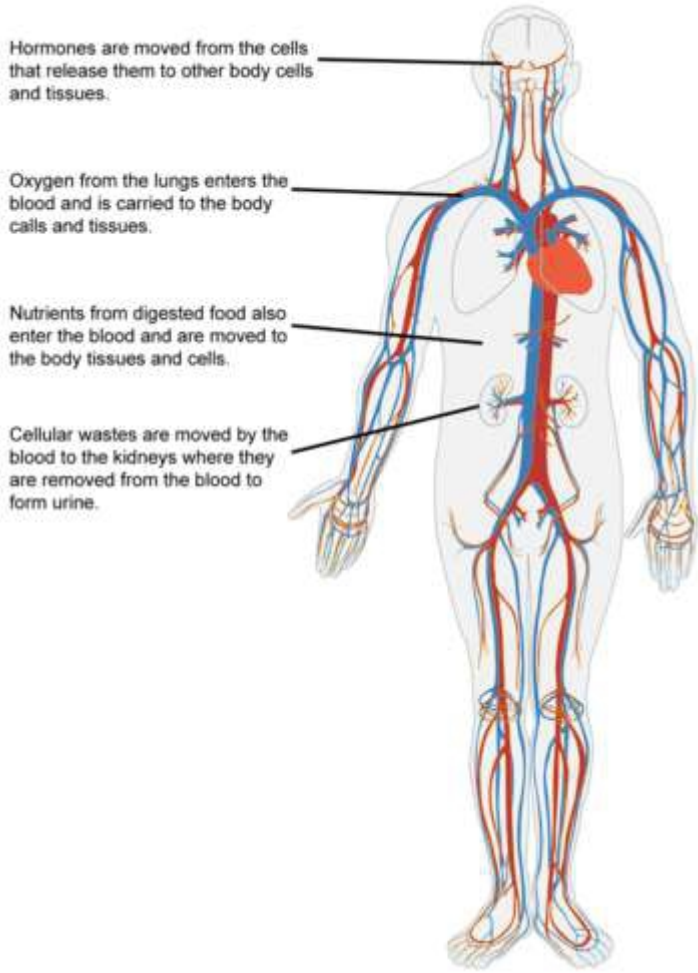
Circulatory System

- The circulatory system can be compared to a system of interconnected, one-way roads that range from superhighways to back alleys.
- Like a network of roads, the job of the circulatory system is to allow the transport of materials from one place to another.
- As described in Figure below, the materials carried by the circulatory system include hormones, oxygen, cellular wastes, and nutrients from digested food.
- Transport of all these materials is necessary to maintain homeostasis of the body. The main components of the circulatory system are the heart, blood vessels, and blood. Each of these components is described in detail below



The Heart

- The heart is a muscular organ in the chest. It consists mainly of cardiac muscle tissue and pumps blood through blood vessels by repeated, rhythmic contractions.
- The heart has four chambers, as shown in **Figure**below: two upper atria (singular, atrium) and two lower ventricles. Valves between chambers keep blood flowing through the heart in just one direction

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