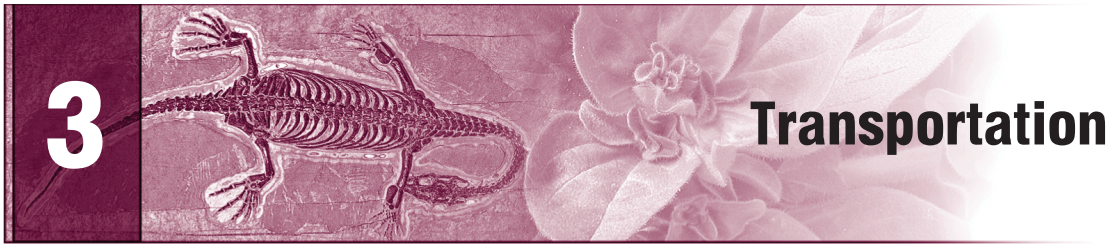

3 Transportation

In order to carry out various life processes like nutrition and respiration, organisms require food and oxygen. It is also necessary for the organisms to get rid of the waste products of cellular processes. Food, oxygen and waste products need to be carried from one part of the body to another. 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. If the distance between the roots and leaves is very small, food and other materials can be transported by diffusion. But the distances between different plant parts are often quite large, as in tall trees. Therefore, most plants need a proper transport system to carry materials from one part to another.

Plants do not move much and have many dead cells in their tissues. Therefore, they do not need much 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 the roots through the stem and continues up to the leaves. In the leaves it is clearly seen as a pattern of veins. Water and minerals are transported from the roots upwards through the xylem tubes. Phloem transports synthesized food from the 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

The xylem tissue transports water and minerals. It consists of interconnected vessels and tracheids organized into continuous conducting tubes stretching from the roots to the leaves. These tubes carry water and minerals to all parts of the plant. Plants absorb water from the soil through the root and transport it to the stem, leaves and flowers. Roots have root hairs that are unicellular, thin-walled outgrowths of the epiblema (skin of the root). The root hairs are in close contact with the thin film of water surrounding the soil particles. There are mineral salts such as nitrates, chlorides, sulphates, phosphates, etc., dissolved in this water. Water is absorbed by osmosis, while the minerals are absorbed as ions by active transport (transport against the law of diffusion, by spending cellular energy). The cell membrane has transport proteins that allow the ions to cross the membrane. The ions then move upward through the xylem, to the leaves and other aerial parts of the plant.

Ascent of Sap

The transport of water and dissolved mineral salts from the roots to the leaves is known as ascent of sap. The cell wall of each root hair is permeable to water and minerals, but its cell membrane and the membrane around the vacuole are semipermeable membranes. The root hair cells take up mineral ions by active transport. This creates a concentration difference of these ions between the root and the soil. Now, the soil solution has higher water content than the cell sap of the root hair. Hence, water from the soil diffuses into the root hair. The root hair cells now become turgid, while the adjacent cells of the cortex have lower water content. This results in the diffusion of water from the root hairs into the cortical cells (Figure 3.1). After passing through the cortical cells by osmosis the water reaches the endodermis (tissue separating the cortex from the vascular tissues). The endodermis forces water into the xylem tubes through passage cells.

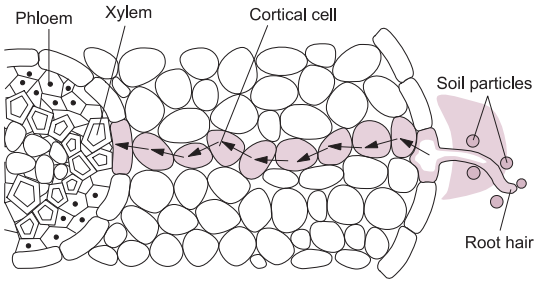

Fig. 3.1 Absorption of water through root hair

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. In tall trees, this type of absorption plays a minor role in transporting water. This process is slow, and it cannot make up for the water lost by transpiration (the evaporation of water from the leaves). Transpiration is rapid during the day. The loss of water due to transpiration creates a suction force that pulls water up through the xylem vessels. This transpiration pull serves as the main force that transports water through the xylem. Root pressure helps in the transport of water at night.

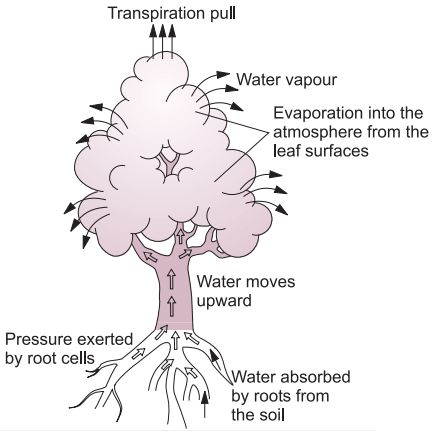

Fig. 3.2 Relationship between transpiration and absorption. Water absorbed by the root passes up to the leaf through the xylem of the stem.

Fig. 3.3 Plants lose excess water by transpiration.

ACTIVITY

Take a healthy potted plant and enclose some of its leaves in a plastic sheet. Then keep the plant in bright sunlight. After some time, you will observe droplets of water on the inner surface of the plastic sheet. This water was lost through the stomata on the leaves as a result of transpiration. The rate of transpiration is high if the atmosphere is warm and dry.

Transport of Food and Other Substances

The food manufactured in the 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. A continuous column from the leaves to other parts of the plant is formed by the arrangement of sieve tubes one above the other. Besides sieve tubes, the phloem also 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.

When sucrose is synthesized in the leaf cells, the osmotic pressure of the cells increases. As a result, water from the surrounding cells is forced to flow into the leaf cells by osmosis. This causes sucrose to be translocated from the point of its synthesis to the receiving end in the form of a solution. This process is dependent on the requirement of the plant. For example, in the flowering season, when vegetative activity is more at the apex of the plant, sugar in the leaves will be readily consumed. This is the reason for the translocation of sugar to the buds from the storage regions (root, stem, etc.) during spring. Excess food is transported to the storage regions when the vegetative activity of the plant is reduced.

Table 3.1 Differences between xylem and phloem

1.	Xylem cells are dead, whereas phloem cells are alive.
2.	Xylem carries mainly water and minerals, while phloem carries organic compounds such as sugar and amino acids.
3.	The flow of liquid in xylem is upward only, whereas the flow of liquid in phloem is in all directions.

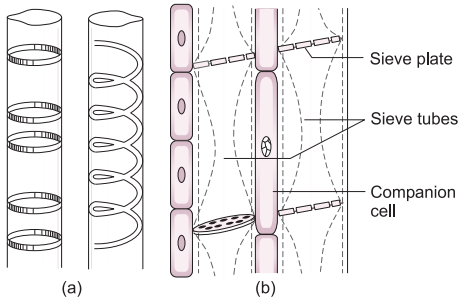

Fig. 3.4 (a) Xylem vessels (b) Phloem tubes (in longitudinal section)

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 various other substances from one part of the body to the other. This transport system, also called the circulatory 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. In many invertebrates, plasma contains the respiratory pigment.

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.