BRIDGE COURSE

# UNIT 4-PLANT PHYSIOLOGY

**Plant physiology**; It is a branch of botany which deals with the study of functions and processes occurring in plants.
The physiological processes will enable the plants to grow, survive and reproduce. Some of the fundamental physiological processes are 1. Absorption of nutrients from the environment 2. Transport of nutrients within the plant system 3. Photosynthesis 4. Respiration 5 .Growth and development.

## Chapter-11.TRANSPORT IN PLANTS

From the stage of germination to death, plants continuously involve in utilizing gases, minerals and water from air and soil. Water and mineral ions are absorbed by the root hairs from the soil and gases like carbon dioxide and oxygen enter the plant system through stomata/lenticels. The absorbed nutrients have to be transported to all the cells of the plant for the cellular physiological processes to happen smoothly.

**11.1 Transport** – The movement of absorbed water and mineral ions within and between the cells is called 'transport'.
Diffusion, facilitated diffusion, active transport, osmosis, and imbibition are various transport mechanisms seen in plants.

**Diffusion:** It is defined as the movement of solid, gas or liquid molecules from the region of their higher concentration to the region of lower concentration, without the expenditure of energy (passive mechanism). The molecules move randomly till the equilibrium is established. The speed of the process increases with increase in temperature and concentration gradient.

*Activity-11.1-Experiment to demonstrate diffusion*

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| Put few crystals of copper sulphate in a beaker of water. After some time you observe the gradual change in the colour of water. Water turns blue as copper sulphate crystals dissolve and spread from the bottom of the beaker up words. i.e. molecules have moved from the region of their higher concentration to the region of their lower concentration .The molecules spread in water slowly and randomly till the equilibrium is established. |

**Facilitated diffusion**: It is a type of passive transport mechanism in which the lipid insoluble substances are transported across the cell membrane along the concentration gradient with the help of membrane proteins, without the expenditure of energy.

**Active transport:** It is the transport of molecules by membrane proteins against the concentration gradient by spending energy (active mechanism). During active transport ATP is used as the source of energy. Active transport is often seen when the mineral content in the soil is lesser than that present in the root. The uptake of mineral ions takes place by active transport method.

**11.2 Water potential:** The chemical potential of water is known as 'water potential'. It is the amount of free energy available per mole of water in a system. The greater the concentration of water molecule in a system, higher will be the kinetic energy of water molecule and hence, higher will be the water potential. Water potential is denoted by 'Psi' or ψ. pure water has the highest water potential and it is zero. All solutions have a water potential less than that of pure water and their ψ value will be negative.

Water +solute= solution

The water potential of a system may be defined as the difference between the free energy of water in that system and the free energy of pure water at atmospheric pressure and a defined temperature. The components of water potential in a plant cell are,

Water potential ($\psi_w$) =Solute potential ($\psi_s$) + Pressure potential ($\psi_p$)

**Solute potential (Osmotic potential)** is the amount by which the water potential of a cell decreases due to the presence of a solute**.**

**Pressure potential** is the potential created due to turgor pressure developed inside the cell. It refers to the pressure exerted by the rigid and elastic plant cell wall on the protoplasm in a turgid cell.

**11.3 Osmosis:** The diffusion of water (solvent) molecules across a selectively permeable membrane from the region of higher water potential to the region of lower water potential is called 'osmosis'.(Passive mechanism).

Selectively permeable membrane or differentially permeable membrane is one which allows only specific solute molecules to pass though, along with the solvent molecules. All biological membranes are selectively permeable.

*Activity-11.2 Experiment to demonstrate osmosis*

Take a large sized potato. Peel its skin and scoop it into a cup carefully. Fill the cup partially with 10% sugar solution. Note the level of sugar solution in the cup by pinning. Then keep the potato cup in a Petri

dish containing pure water. After sometime observe the level of solution inside the cup. The level of sugar solution increases due to entry of water from petri dish to the cup through the selectively permeable plasma membrane surrounding the potato cells. Here water has diffused from the region of higher water potential (petri dish) to the region of lower water potential (Potato cup).

*Activity-11.3-Experiment to show exosmosis*

Soak raw mango pieces in saturated salt solution. Observe the size of mango pieces after a week. It shrinks due to loss of water. Movement of water from cell to the surrounding medium is called 'exosmosis'. Exosmosis takes place when a cell is kept in 'hypertonic solution' Hypertonic solution is one whose concentration is more than that of the cell sap.

*Activity-11.4-Experiment to show endosmosis*

Soak raisins overnight in water. Observe the size of raisins. It swells due to entry of water from the surrounding medium. Movement of water from the surrounding medium into the cell is called 'endosmosis'. Endosmosis takes place when the cell is kept in an 'hypotonic solution'. Hypotonic solution is one whose concentration is less than that of cell sap.

**Plasmolysis :** It is defined as the withdrawal of the protoplast from its cell wall and its shrinking due to the loss of water (exosmosis) when the cell is kept in hypertonic solution (Fig. 11.1).

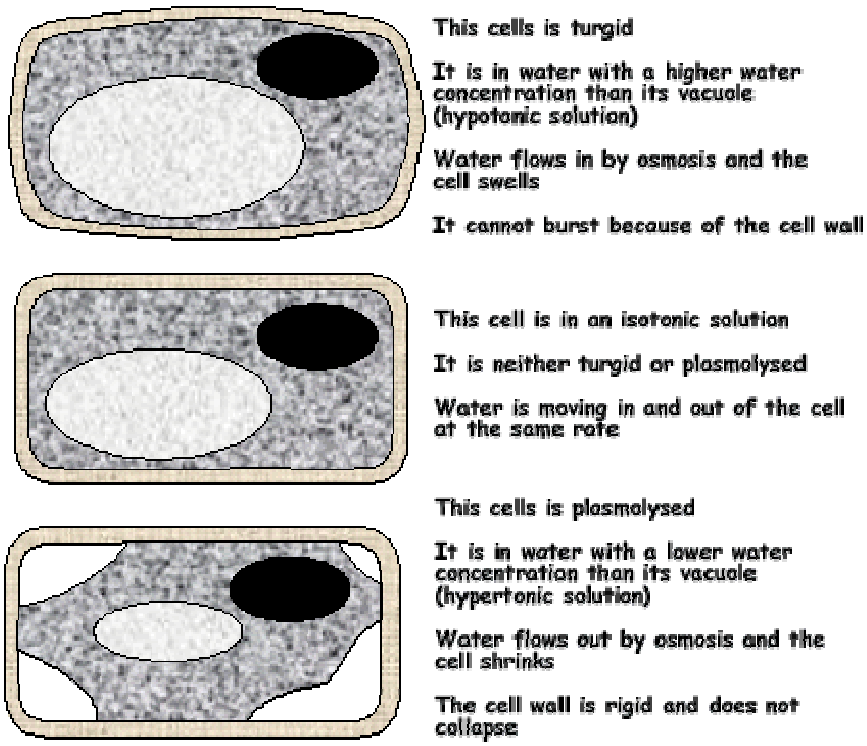


**Fig 11.1. CHANGE IN THE SHAPE OF PROTOPLAST WHEN CELLS ARE KEPT IN DIFFERENT TYPES OF SOLUTIONS**

**Imbibition :** The adsorption of water by hydrophilic colloidal substances without forming a solution is called 'Imbibition'. Swelling of dry seeds and a piece of wood when soaked in water are examples of imbibition. Imbibition is a temporary increase in volume of the cell. In plant cell substances such as cellulose, hemicellulose, pectin and lignin can imbibe water.

## 11.4 TRANSLOCATION

The long distance transport of water and mineral substances from root to the shoot system through the xylem vessels and transport of organic solutes (food) from source (leaves) to sink (storage organs) through phloem is called 'translocation'. In other words Translocation is simply long distance bulk transport of substances through vascular tissues (Fig. 11.2 and 11.3).

The translocation of substances through xylem and phloem takes place in 'en mass' or 'bulk' irrespective of their concentration. The mechanism of xylem transport is being explained by 'cohesion-tension-transpiration- pull' theory by Dixon and Jolly. The

Phloem transport mechanism is being explained by ‘mass flow hypotheses or ‘pressure flow hypotheses’ by Ernst Munch.

*Activity11.5 -Experiment to show that xylem is the water conducting tissue*

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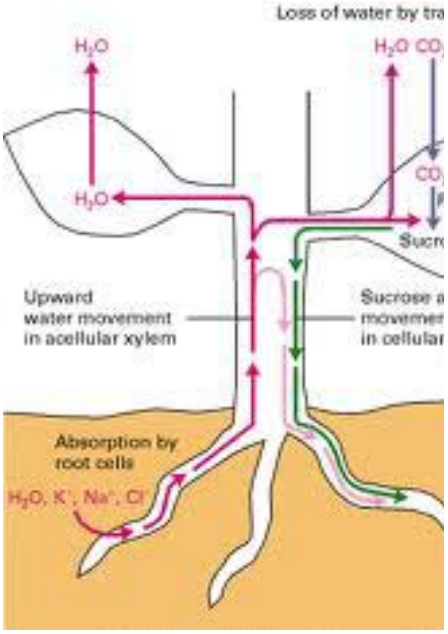
| Keep twigs of Balsam plant in a beaker containing colour (safranine) water. After an hour, take a thin section of the stem and observe under the microscope. Only the wall of the xylem vessel would appear red, indicating that water has moved upwards through xylem |



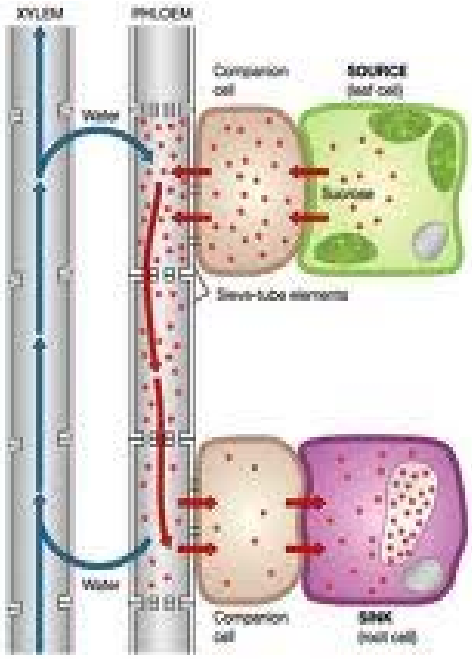




**Fig.11.2 &11.3-Translocation of water, minerals and organic solutes in vascular tissues**

*Activity11.6 –Experiment to show that phloem translocates organic solutes*

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| Girdling experiment to prove phloem is the food conducting tissue.- Remove the bark in the form of a ring of a well grown plant little above the soil level. Take care to see that central xylem is retained. After few weeks observe the swelling of the stem above the girdle due to accumulation of food. Food cannot move down as phloem<br>has been removed, causing interruption for the downward movement of food. |

11.5- **Radial transport of water-the concept of Symplast and Apoplast**

The water and mineral ions that are absorbed by the root hairs by passive and active mechanisms reach the central xylem elements passing through cells of epidermis, cortex, endodermis and pericycle. This transport along the radius of root is called 'radial transport'. (Fig. 11.4).

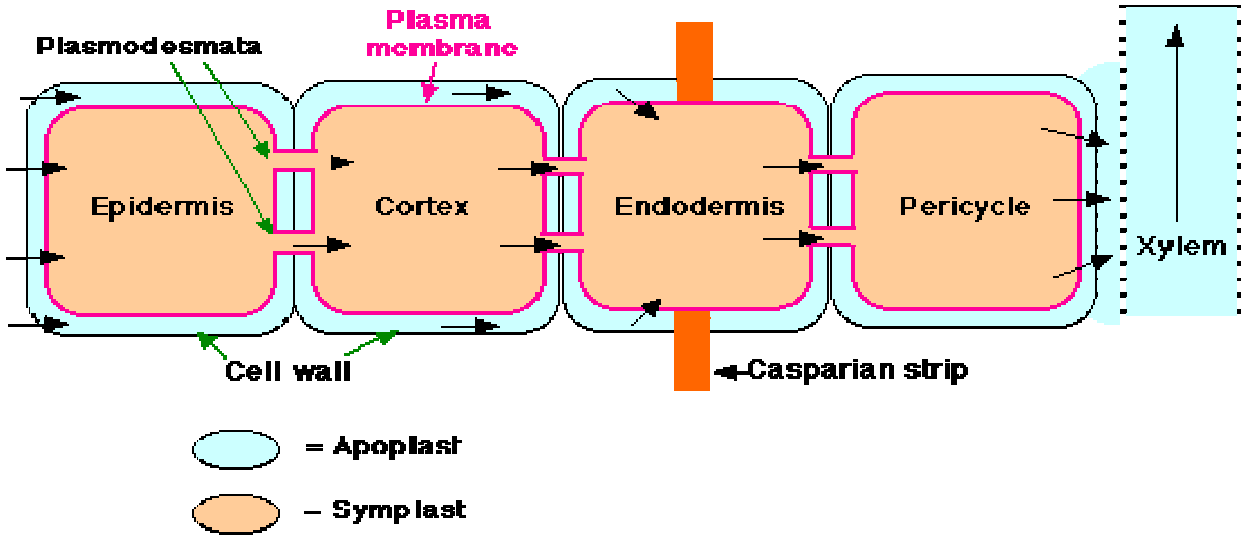


**Fig11. 4. Radial transport of water from epidermal cell to xylem**

The movement of water during radial transport may follow either one or both the pathways mentioned below (Fig.11.5)

**Symplast pathway-** movement of water through network of living material of cytoplasm ( plasmodesmata) is called 'symplast pathway'.

**Apoplast pathway-** movement of water through the non living cell walls and the middle lamella is called 'apopolast pathway'.

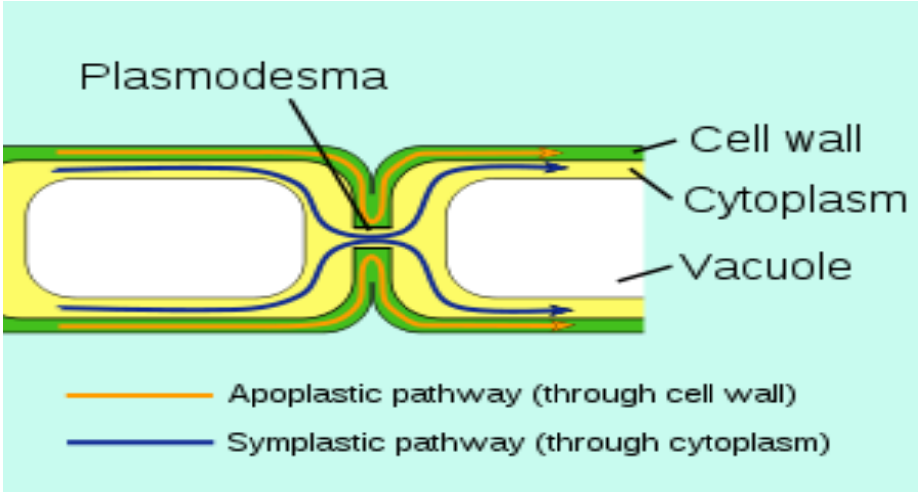


**Fig. 11.5. Apoplast and symplast pathways of transport**

**SUMMARY**

- Plants require minerals. Water, carbon dioxide and oxygen for their normal growth and development.
- They obtain it form soil and air and use it for physiological activities.
- The absorption of these substances takes place by mechanisms such as diffusion, facilitated diffusion, active transport and osmosis.
- The movement of these absorbed substances within and between the cells is called ‘transport’.
- Long distance transport of nutrients and the organic solute synthesised in the leaves through xylem and phloem is called ‘translocation’.
- Translocation takes place en mass or in bulk irrespective of the concentration of individual substances to be translocated.

**Exercise-**

1. Define plant physiology?
2. Name the important physiological processes seen in plants.
3. Differentiate between diffusion and facilitated diffusion.
4. What is a selectively permeable membrane? Give an example.
5. Differentiate between the following terms

   a. Diffusion and osmosis

   b. Active and passive transport

   c. Transport and translocation

   d. Apoplast and symplast pathways

   e. Imbibition and diffusion.

   f. Endosmosis and exosmosis

6. Define water potential. What is the water potential of pure water?
7. Name the components of water potential.
8. Explain plasmolysis. Draw a neat labelled diagram of plasmolysed cell.