Absorption by Roots – The Processes Involved

The most important function of the root is to absorb water and mineral nutrients from the soil.

Need of Water and Minerals for Plants

Need for Water

Photosynthesis	Water is one of the raw materials required to carry out photosynthesis.
Transpiration	Water is given out in the form of water vapour by the plant.
Transportation	Transport of minerals and sugar from the roots to the other parts of the plant body.
Mechanical Stiffness	Water provides turgidity which is necessary for the stiffness of plant tissues.

Need for Minerals

Salts	Ions
Nitrates, phosphates, sulphates	Potassium, calcium, magnesium, chlorine

Characteristics of Roots for Absorbing Water

The ability of roots to draw water from the soil is dependent on the following factors:

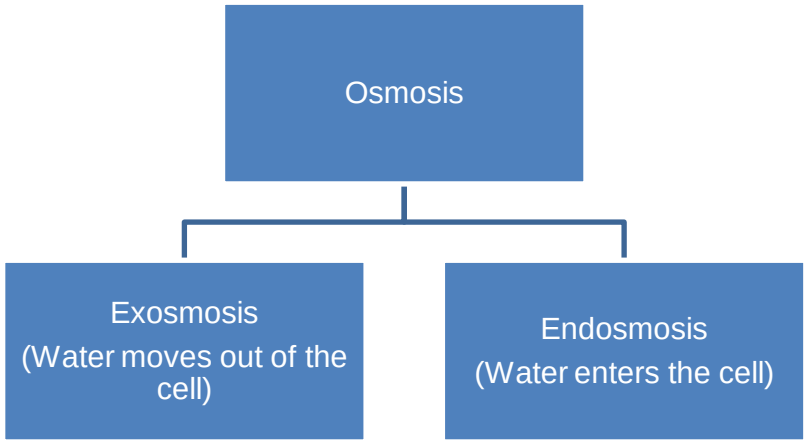
- The surface area provided by rootlets and root hair is enormous.
- Root hair contains cell sap of a higher concentration than that of the surrounding water which allows the movement of water by osmosis.
- Root hair has thin cell walls and cell membranes which allow the movement of water molecules and dissolved substances in and out of the cell.

Absorption and Conduction of Water and Minerals

The mechanism of absorbing water and minerals from the soil by roots occurs by five phenomena.

Process of Absorption and Conduction of Water	Description
1. Imbibition	• Living or dead plant cells absorb water by surface attraction. • In germinating seeds, the seed coat ruptures due to imbibition.
2. Diffusion	• The free movement of molecules of a substance from the region of its higher concentration to the region of its lower concentration.
3. Osmosis	• Movement of water molecules across a semi-permeable membrane from a more dilute solution to a less dilute solution.
4. Active Transport	• Active transport is the passage of a substance from its lower concentration to its higher concentration through a living cell membrane using energy from the cell. • Nutrients are absorbed by roots by active transport.

A semi-permeable membrane is one which allows the passage of molecules selectively.



Osmosis should continue until the concentration of water molecules becomes equal on both sides of the membrane.
A stage will be reached when no osmosis occurs even if the concentration of water molecules is not the same on the two sides of the membrane. This is due to the osmotic pressure.

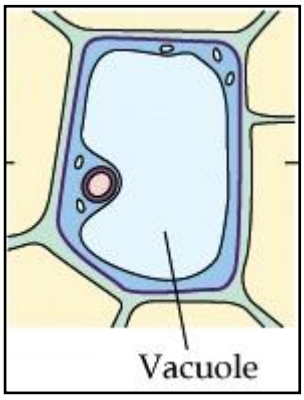
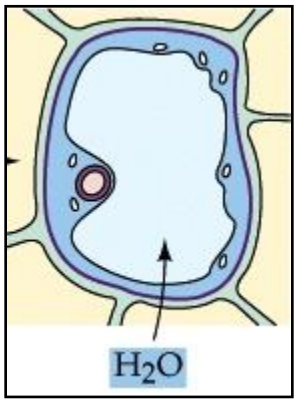
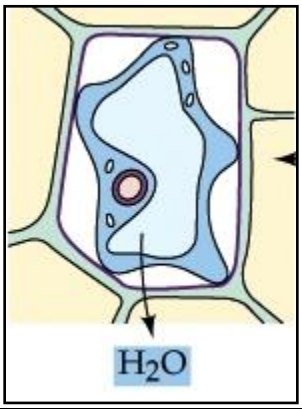
Osmotic Pressure

Osmotic pressure is the minimum pressure which must be exerted to prevent the passage of the pure solvent into the solution when the two are separated by a semi-permeable membrane.

Tonicity

Relative concentration of the solutions which determines the direction and extent of diffusion is called **tonicity**.

Based on tonicity, solutions can be of three types:

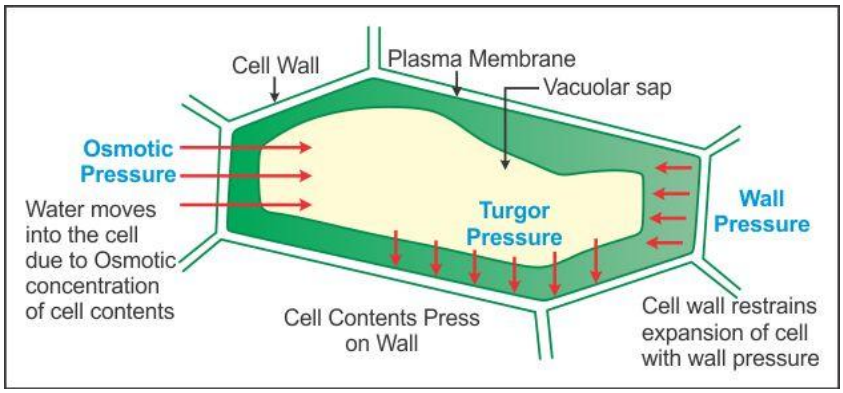
Isotonic Solution	Hypotonic Solution	Hypertonic Solution
• The relative concentration of water molecules and the solute on either side of the cell membrane is the same. • Cell shape and size remain unchanged. • Plant cell in isotonic solution: 	• The solution outside the cell has a lower solute concentration than the fluids inside the cell. • Endosmosis occurs as the water molecules move into the cell. • Cells shrink in size and lose shape. • Plant cell in hypotonic solution: 	• The solution outside the cell has higher solute concentration than the fluids inside the cell. • Exosmosis occurs as the water molecules move out from the cell. • Cells slightly enlarge or even burst. • Plant cell in hypertonic solution: 

Differences between Diffusion and Osmosis

Diffusion	Osmosis
• Movement of a substance from its higher concentration to its lower concentration when the two are in direct contact. • No membrane is involved. • Direct contact between the two substances is necessary. • It occurs in gases as well as in liquids.	• Diffusion of water molecules across a semi-permeable membrane from a more dilute solution to a less dilute solution. • Osmosis occurs across a semi-permeable membrane. • Two solutions are separated by a semi-permeable membrane. • Only water can move from its high concentration to its low concentration.

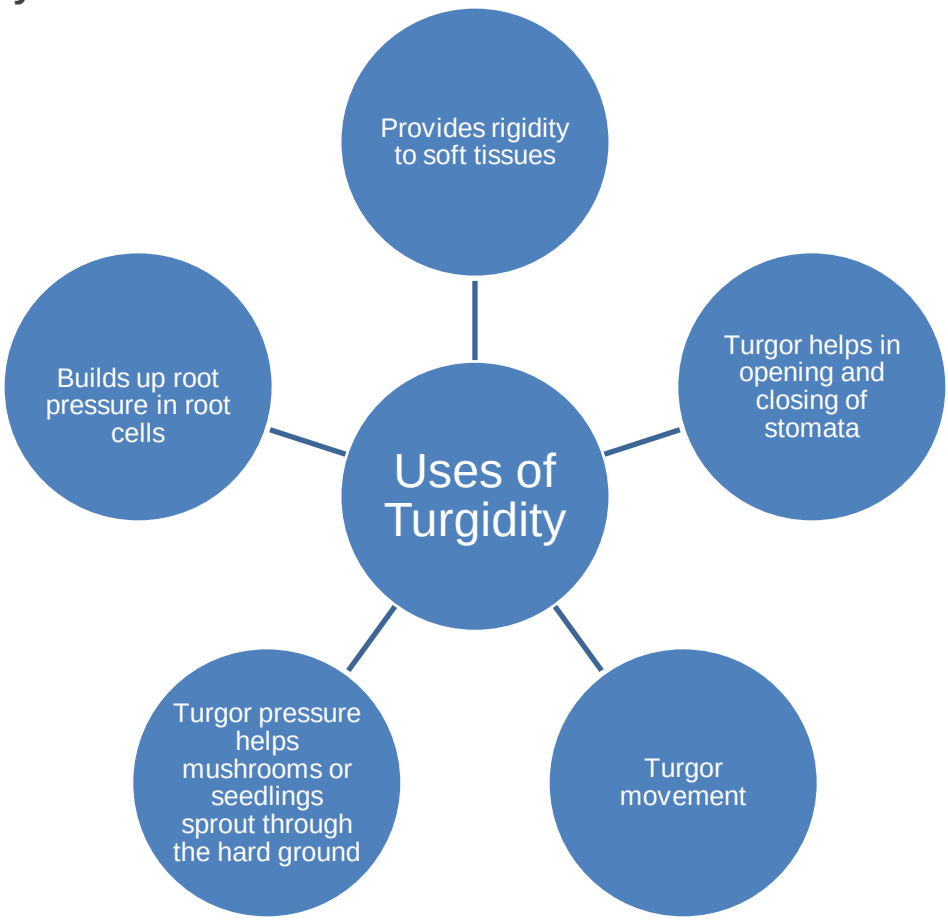
1. Turgidity and Flaccidity

When a plant cell reaches a state where it cannot accommodate any more water, i.e. it is fully distended, it is called turgid, and the condition or phenomenon is called **turgidity**.



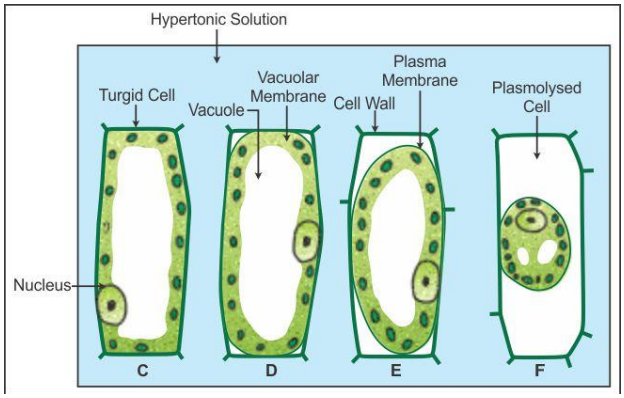
When the cell wall is unable to bear the turgor pressure, it ruptures and the cell contents burst out.

Uses of Turgidity in Plants



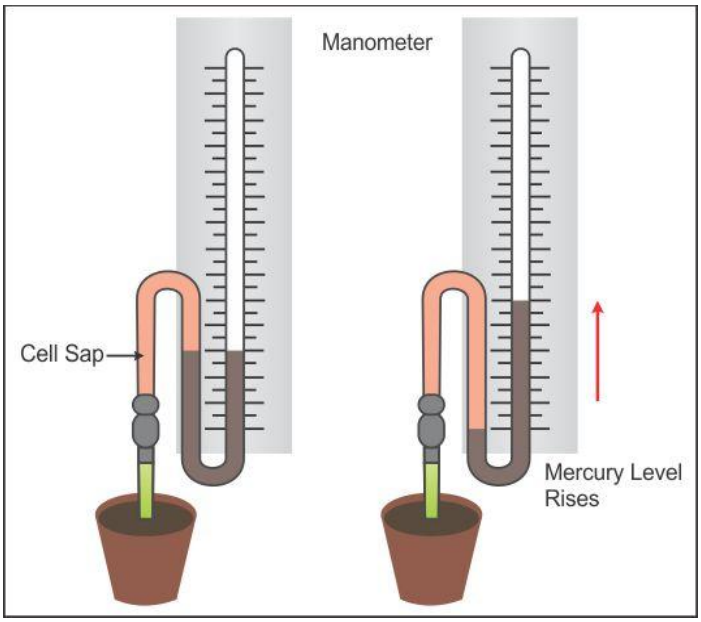
2. Plasmolysis and Flaccidity

- If a fully distended plant cell is kept in a salt solution for a few minutes, then it will lose its distended appearance and the cytoplasm will shrink. The plasma membrane will be withdrawn away from the cell wall. This shrinkage from the cell wall is called **plasmolysis**, and the condition is called **flaccidity**.
- The recovery or the reversal of plasmolysis is called **deplasmolysis**.
- Salting of meat or addition of salt to pickles is a method of killing bacteria by plasmolysis. Water is drawn out of bacterial cells, and thus, cells are killed.



Root Pressure: It is the pressure developed in the roots due to the continued inward movement of water through cell-to-cell osmosis which helps in the ascent of cell sap through the stem.

Experiment on Root Pressure: The upward flow of water is due to heavy pressure from the roots.



Bleeding: Loss of water, i.e. cell sap, through a cut stem.

Guttation

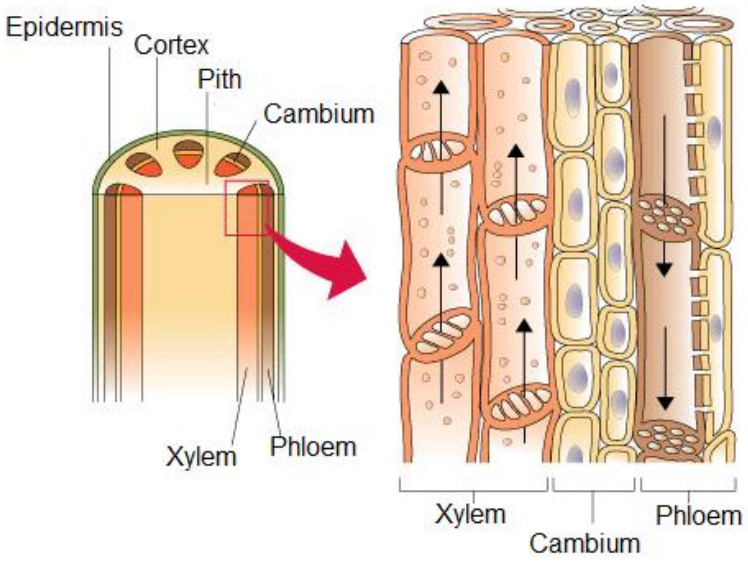
Sometimes, due to high root pressure, water is forced out through the end of leaf veins. This water appears as tiny drops along the margins or the tip of the leaves.
This loss of excessive water is called **guttation**.

Importance of Root Hair and Ascent of Sap

- Root hair contains cell sap which has higher concentration of salts as compared to the outside soil water. This difference sets off osmosis, and thus, the roots absorb water.
- Absorption of mineral elements from the soil involves active transport by cells.

Vascular Bundles

Vascular bundles constitute xylem and phloem.
Xylem and phloem collectively form the transport system throughout the entire plant.



Xylem

- It conducts water upwards in a plant.
- It is situated deeper at the centre of the stem.

Phloem

- It conducts food from the leaves downwards to the stem.
- The phloem is situated in the peripheral region of the stem, interior to the cambium.
- If the phloem is girdled off, then the sap from the cut part will start oozing out, showing that the material is carried in the downward direction in the phloem.

Forces Contributing to Ascent of Sap

Root Pressure	Builds up sufficient force to push the sap in the xylem vessels up to a certain height.
Capillarity	Narrow diameter of xylem vessels causes the water to rise from a lower level to fill up the vacuum created by the loss of water due to transpiration.
Transpiration Pull	Because water is lost by transpiration, more water is pulled up. Thus, a continuous column of water is produced throughout the stem.
Adhesion	Adhesion causes water to stick to the surface of cells and draws more water. This kind of force is important in all trees.