KRISHNAGAR ACADEMY

Chapter -3

BIOLOGY -

Absorption By Roots

Class -10

SYLLABUS

- *Absorption by roots, imbibition; diffusion and osmosis; osmotic pressure, root pressure; turgidity and flaccidity; plasmolysis and deplasmolysis; the absorption of water and minerals, active and passive transport (in brief); the importance of root hair.*
- *Characteristics of roots, which make them suitable for absorbing water, should be discussed with the process of absorption. Structure of the single full-grown root hair should be explained.*
- *Experiments to show the conduction of water through the xylem should be discussed. Mention of the causative forces must be made for better understanding but as per the syllabus.*

IMPORTANCE OF WATER

Among the different substances needed for the life activities, water is the most important component. A large part of the protoplasm is composed of water. Plants in general have more water than animals. Depending on their habitat, different types of plants have different amount of water in their body.

Organism	% of Water by Body Weight
Land plant	40 – 80%
Woody plant	40 – 50%
Herbaceous	70 – 80%
Aquatic plant	75 – 98%
Animals	60 – 80%

Water is required by the organisms mainly for the following purposes :

1. Water serves as solvent for many substances.
2. It participates in different metabolic reactions.
3. It facilitates exchange of gases between the organism and atmosphere by dissolving them.
4. It helps in movement of substances into and out of the cell.
5. It helps in heat loss.
6. It helps in opening and closing of stomata by providing turgidity to them.
7. Water is used as raw material for the process of photosynthesis.

Plant Physiology: The branch of biology which deals with the life functions of the plants.

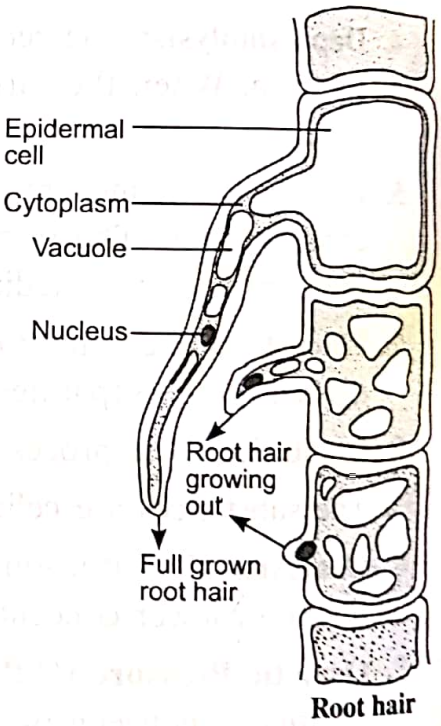
Plants lose huge quantity of water through transpiration. The excessive water loss has to be replaced or else the plants will wilt. In multicellular land plants, absorption of water occurs mainly through roots by imbibition, diffusion, osmosis, etc.

Water: Universal solvent needed for all important life activities. It is the major source of protoplasm.

Functions of the roots:

(*a*) Roots fix the plant in the soil.

(*b*) Absorbs water and minerals from the soil.



Uses of water:

(*a*) For photosynthesis.

(*b*) Transpiration creates a suction force.

(*c*) For transportation.

(*d*) For providing turgidity.

Uses of minerals: Nutrients such as calcium, potassium, etc. are absorbed from the soil by roots and are used for growth, synthesis of many substances.

Elements required by the plants:

Plants required 16 elements. Some important elements are magnesium, zinc, calcium, potassium, phosphorus, manganese. Mg is required for chlorophyll synthesis. Zn is required for leaf formation. Ca is needed to maintain the semi-permeability of cell membrane. K is required for maintaining osmotic balance of cell, also opening and closing of stomata. P is a constitute of cell membrane.

Significance of root hairs:

(*a*) It is unicellular and thin walled.

(*b*) Has enormous surface area.

(*c*) Has cell sap which has a high concentration than that of the surrounding water so that plants can absorb water by osmosis.

(*d*) Root hair has extensive root system which grows rapidly in the soil.

. **Absorption of minerals in plants are of two types:**

(*a*) Passive Mineral Absorption, (*b*) Active Mineral Absorption

(*a*) **Passive Mineral Absorption**: The process by which absorption of minerals takes place without any loss (involvement) of metabolic energy.

The following methods are by:

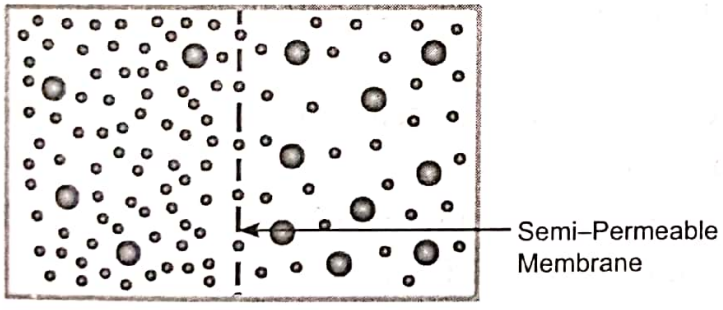
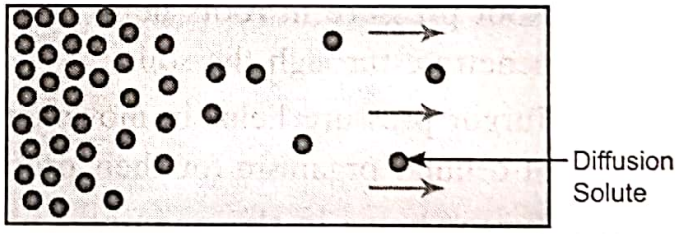
(*i*) diffusion (*ii*) mass flow (*iii*) ionic exchange (*iv*) contact exchange

(*b*) **Active Mineral Absorption:** The process can take place with the utilization of metabolic energy. It occurs in special carriers (protein molecules) that are present in the cell membrane.

Phenomena for Absorption of Water

Imbibition	Diffusion	Osmosis
The phenomenon by which living or dead cells absorb water through its hydrophilic surface (i.e., the cell membrane)	Diffusion is the movement of molecules of substance from a region of higher concentration to a region of lower concentration.	The movement of water molecules from their region of higher concentration to a region of lower concentration through a semi-permeable membrane.

. **Type of Osmosis**

Endosmosis	Exosmosis
Inward movement of water into the cell from outside. It causes swelling of cells. 	Outward movement of water from the cell. It causes the cell to shrink. 

TONICITY

Tonicity is the relative concentration of the solute in two solutions separated by semipermeable membrane. It decides the direction of the movement of water.

On the basis of tonicity there are 3 types of solutions :

(a) **Hypertonic :** It is a solution which has higher solute concentration than the cell sap. The cell shows exosmosis in this solution.

(b) **Hypotonic Solution :** It is a solution which has lower solute concentration than the cell sap. The cell shows endosmosis in it.

(c) **Isotonic :** The solution with equal solute concentration as that of the cell sap. There is no net movement of water in it.

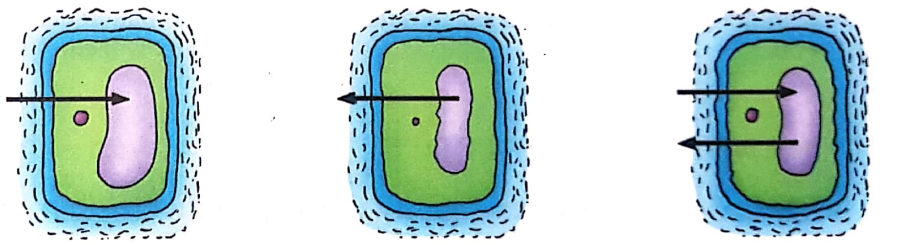


Fig. 3. Effect of tonicity of a solution on movement of water through a plant cell

PLANT CELL AS AN OSMOSCOPE

As the cell takes up water by the endosmosis its protoplast presses against the cell wall and an internal pressure is developed. This pressure is called *turgor pressure*. This pressure is equal to the back pressure which presses against the protoplasm. This back pressure exerted by the cell wall is called the *wall pressure*. The turgor pressure is said to have reached its maximum when the cell wall can be stretched no more. At this point *full turgor* is achieved and the cell is said to be *fully turgid*. The expansion of the cell due to the full turgor is called turgidity. Thus a cell having higher concentration of solutes draws water into it from its surroundings due to endosmosis which causes turgidity of the cell.

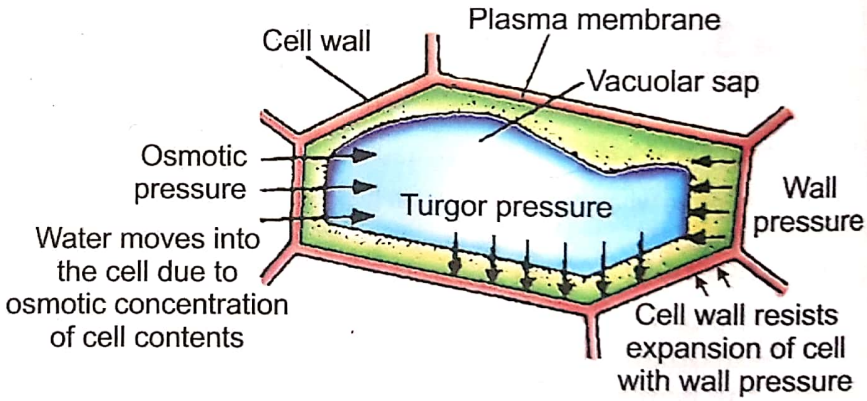
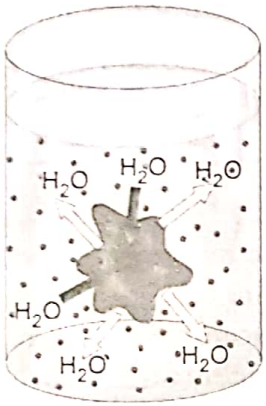
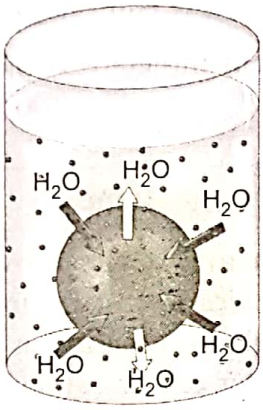
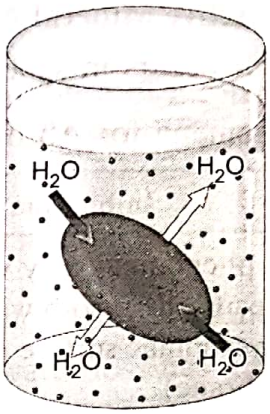


Fig. 4. Diagram indicating osmotic pressure, turgor pressure and wall pressure.

Table 5. Difference between turgor pressure and osmotic pressure.

Suppose, a cell is put into a solution. According to the concentration of solution, the cell's reaction will be:

Hypertonic solution	Hypotonic solution	Isotonic solution
The solution outside the cell has higher solute concentration than the cell sap. Water molecules move out of the cell.	The solution outside the cell has lower solute concentration than the cell sap. Water molecules move into the cell.	Relative concentration of water molecules and the solute on either side of the cell membrane is equal. No movement of water molecules.
 (Cell Shrinks) Hyperosmotic	 (Cell Expands) Hyposomotic	 (Cell Normal) Isosmotic

. **Uses of turgidity to plants.**

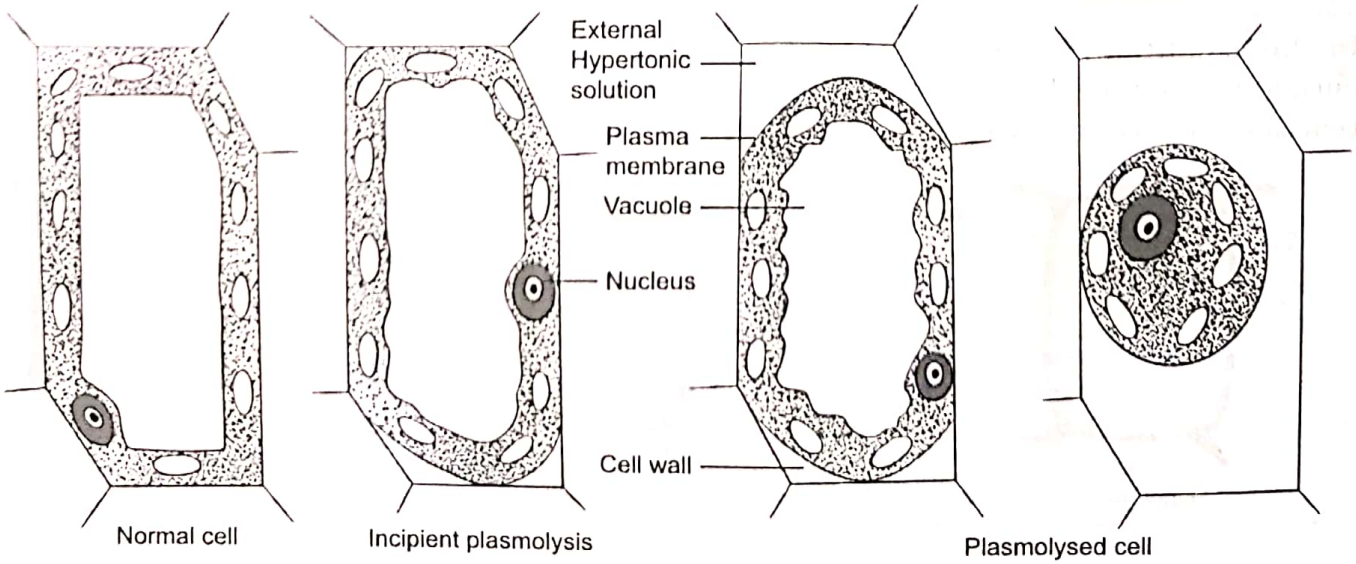
(*a*) It provides rigidity to the soft tissues which provides proper shape to the plant and also helps in stretching of softer organs.

(*b*) Root pressure in roots helps the root tips to become rigid due to turgidity, and helps its to penetrate through the soil.

(*c*) Turgor pressure helps in movement of water from cell to cell and also maintain the turgidity of cellular organism for their proper functioning.

(*d*) Turgor helps in the opening and closing of stomata and also helps in several other plant movements like drooping leaves of mimosa or leaves of insectivorous plants.

. **Plasmolysis:** When a cell is placed in a hypertonic solution, the cytoplasm of the cell moves away from cell wall as water moves out of the cell and concentrates towards the centre of the cell. The central vacuole disappears and the cell is called plasmolysed. This generally occurs because of exosmosis.



. **Deplasmolysis:** When a cell is placed in a hypotonic solution, water moves into the cell and the cytoplasm of the cell (regains itself) and sticks to the cell wall. The cell vacuole reappears and the cell is now called deplasmolysed. This generally occurs because of endosmosis.

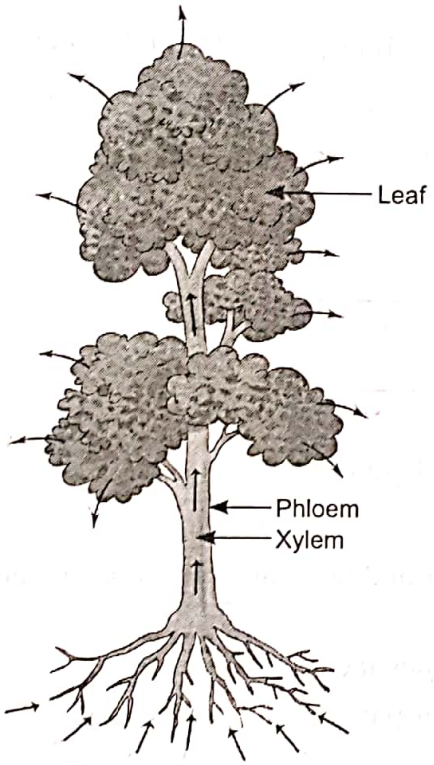
. **Application of plasmolysis**

(*a*) Salting of pickles, meat, etc. to kill bacteria and thereby preserving the pickles.

(*b*) Adding salt in the soil to kill weeds.

. **Ascent of Sap:** The movement of water from the root to the upper parts of the plant. Ascent of sap is governed by root pressure, transpiration pull, cohesive force and adhesive force.

Path of Water: Root hair → Cortex cells → Endodermis → Passage cells → Xylem vessels.



Path of Ascent of Sap

Cohesive force is the property of same or like molecules sticking together. As the water is lost by transpiration, more water molecules are pulled up due to cohesion.

Adhesion is the attraction between unlike molecules. Such as force between water molecules and xylem elements.

Transpiration pull: Due to cohesive and adhesive forces water molecules are pulled up and creates a continous column of water through the xylem. This process is called as transpiration pull.

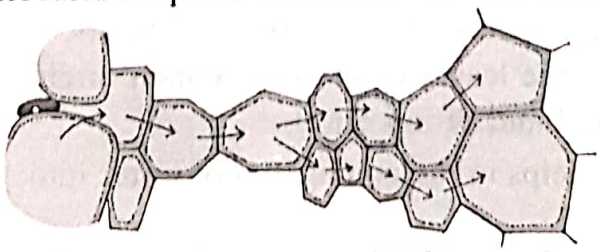
Forces that contribute to ascent of sap

(*a*) Root pressure

(*b*) Capillarity

(*c*) Movement of water due to transpiration pull of the plant.

(*d*) Adhesion of water molecules helps in movement of water column continuously.



Movement of water through xylem vessels

(b) They help in absorption of water and mineral nutrients from the soil.

(c) They help in conduction of the sap through xylem to the upper parts of the plants.

Characteristics of the Roots

(a) Roots are usually branched and have large number of root hairs that increase the surface area of absorption

(b) Root hairs have concentrated cell sap as compared to the surrounding due to which water form outside enters in the cell by the process of endosmosis.

(c) The cells of the root hairs also have thin wall so as to allow the entry of water and minerals easily.

Besides anchoring the plant to the soil, roots also absorb the water from the soil. The efficient absorption demands a large and elaborate absorptive surface. The roots are well organised and structured- to cope with this demand.

Adaptations in the Root for Absorption of Water :

(i) They offer a very large absorptive surface due to their very extensive branching in the soil and possession of numerous thin root hairs present just behind the root apex.

(ii) The root hairs have very thin wall which allows rapid movement of water molecules through it.

(iii) There is absence of the cuticle.

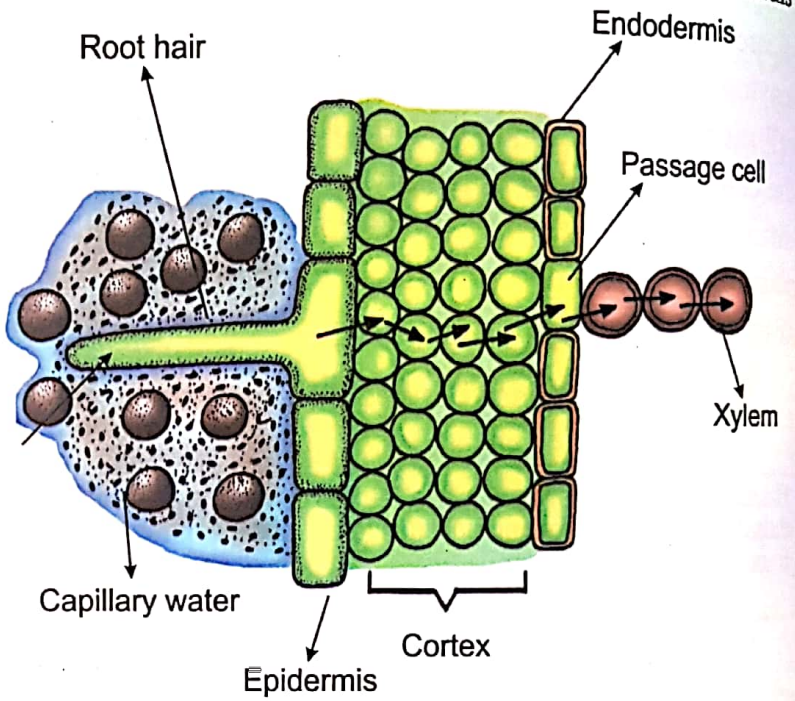


Fig. 6. Diagram showing movement of water from soil to xylem.

The root hairs are surrounded by the soil particles. The water molecules usually remain present in spaces between the soil particles. This water is called the capillary water. The root hairs, soil particles and capillary water together form the absorptive system.

The Mechanism of Absorption of Water : The cell sap in the root hair and the related epidermal cell usually has higher concentration of dissolved solutes than the capillary water. Therefore, water molecules from between the soil particles diffuse into the root hair through its wall and the membrane. The absorption of the water goes on continuously because it moves continuously to cortical cells from outside to inside through the cells of endodermis and pericycle towards the xylem vessels of the root.

Experiment to Demonstrate Root Pressure in Plants : Take a well watered potted herbaceous plant (e.g., balsam or sunflower). Cut its stem a few inches above the ground level. This process is called decapitation. With the help of a rubber tubing, fix a mercury manometer to the decapitated stump as shown in the figure.

Make all connections air tight with vaseline or paraffin. Note down the initial level of mercury in the vertical arm of the manometer.

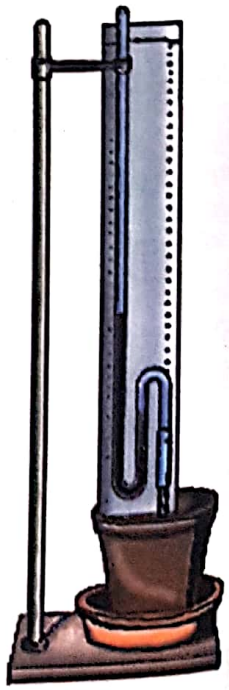


Fig. 7. Experiment to demonstrate root pressure in plants.

After a few hours, it is observed that the level of mercury in the manometer rises. The difference in the final and the initial level indicates the magnitude of the root pressure developed in the xylem due to pushing out water from the cut end of the xylem vessels into the manometer.

This experiment gives best result if cond ucted in the morning of the spring season.

Root Pressure : The accumulation of water in cortical cells produces a hydrostatic pressure in the cortex. This pressure is called root pressure. Root pressure is also responsible for the movement of the water from the cortex to the xylem of the root through the passage cells of the endodermis and cells of the pericycle. The root pressure varies from 1-3 atmosphere in plants and this may lift up the water upto 18 metres.

ABSORPTION OF MINERALS BY ROOT

The absorption of the minerals, like the absorption of the water, is also brought about by the root. Some minerals are absorbed along with the water by the free diffusion. But other minerals whose concentration in the capillary water is low as compared to their concentration in the cell sap, are absorbed by the active transport which involves the carrier molecule and expenditure of the energy. The carrier molecules are present in cell membranes of the root hairs. The energy to be utilized results from the metabolism of the root.

DEFINITION OF ACTIVE TRANSPORT

Absorption of substances from their low concentration to their high concentration by the cell at the expenditure of energy (ATP).

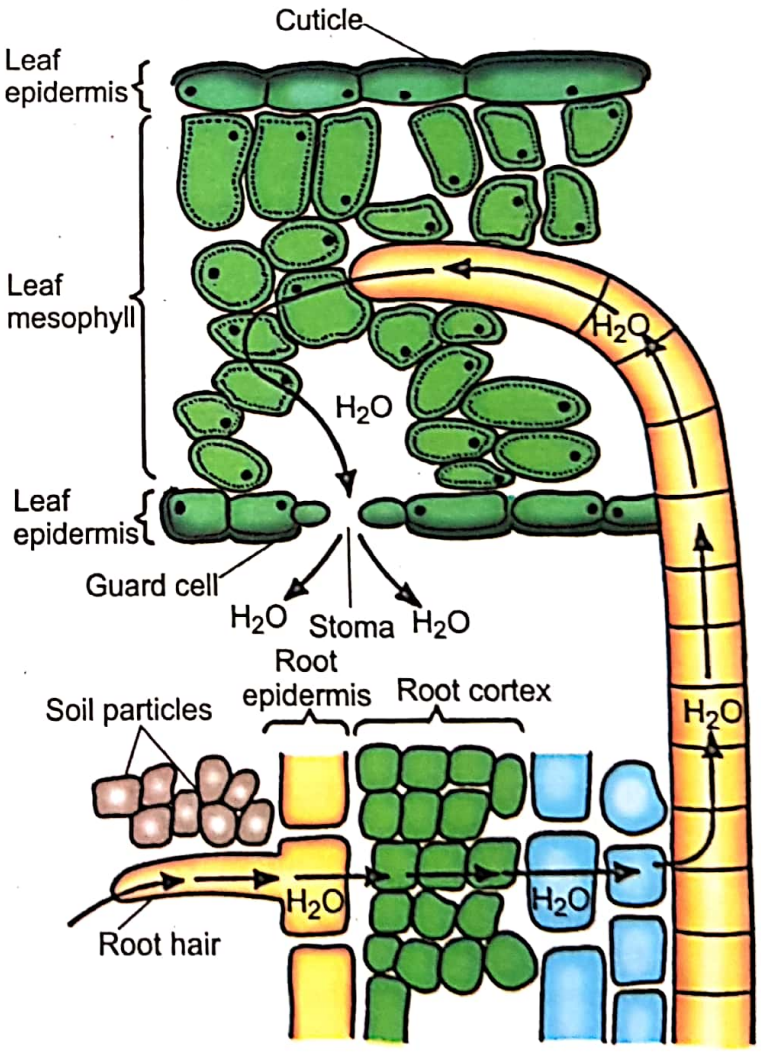


Fig. 8. Absorption of water and ascent of sap.

ASCENT OF SAP AND ITS SIGNIFICANCE

The root of a land plant absorbs a huge amount of water from the soil. The absorbed water is not pure water but it is a solution composed of water and solutes, mostly ions of minerals. This aqueous solution is called sap. The sap from the root must rise up to aerial parts of the plants, particularly leaves, to meet the physiological requirement of water and minerals. Besides being required as a raw material in the photosynthesis and as a participant or mediator in many metabolic reactions, the water is also required for the transpiration which pulls it up and ensures its continuous absorption by the root. The rise of the solution containing water and solutes from the root to aerial parts of the plants is called ascent of sap.

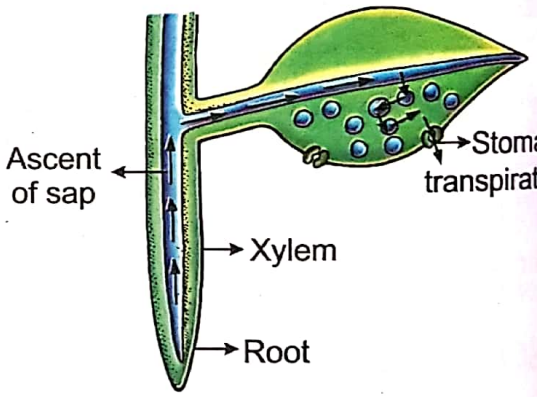


Fig. 9. Ascent of sap.

1. What do you mean by a turgid cell? How is the turgidity of a cell significant for a plant?
2. Explain the changes in a cell when placed in a hypotonic or hypertonic medium.
3. Why are osmotic changes important for the plants?
4. Describe the phenomenon of plasmolysis with the help of an experiment.
5. Draw the structure of root and categorise its various zones based on their permeability and power of absorption.
6. Differentiate between the following:
   (*a*) Osmosis and diffusion
   (*b*) Active transport and passive transport
   (*c*) Plasmolysis and deplasmolysis
   (*d*) Hypertonic and hypotonic solutions
   (*e*) Turgidity and flaccidity
   (*f*) Osmotic pressure and osmotic potential
   (*g*) Endosmosis and exosmosis
7. Give reasons for the following:
   (*a*) A closed container with soaked seeds bursts open.
   (*b*) Dried grapes swell in water.
   (*c*) Gargling with saline solution helps us to cure throat infections.
   (*d*) Continuous inflow of water does not burst a plant cell as an animal cell.
   (*e*) A well-watered plant shows wilting of leaves during hot summers.
   (*f*) Cells treated with boiling water do not exhibit plasmolysis.
   (*g*) The leaves of *Mimosa* plant droop on touching.

. The diagram 1 given below shows a root hair growing through the soil particles. The diagram 2 is the root hair of an aquatic plant :

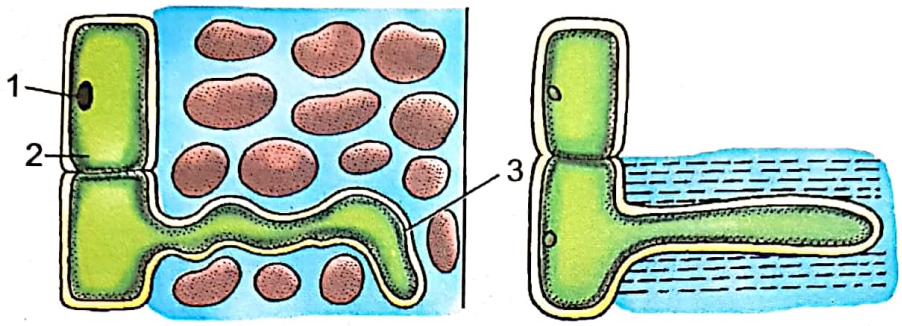
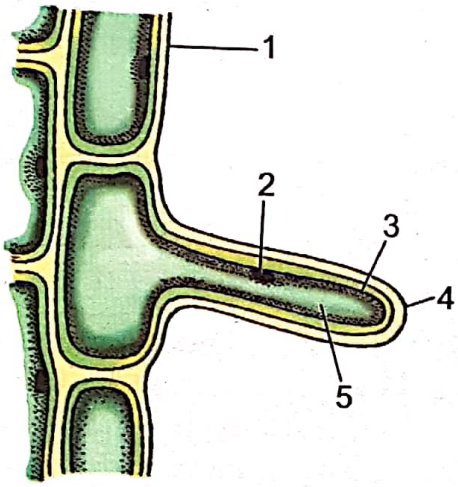


DIAGRAM 1 DIAGRAM 2

a. Label the parts 1, 2, 3.
b. Name two substances which enter the root hairs through 3. What are their uses?
c. By what process do these substance enter the root hair?
d. Account for the different shapes of roots hairs in the two diagrams.
e. Why do plants begin to die when excess of soluble fertilizers are added?
f. Leaves of a well watered potted plants were found wilted on a hot sunny day. Why?
g. What is the advantage of wilting to plants?

Given below is a figure of a root hair :



a. Label the parts numbered (1) to (5).
b. Which parts of the root hair act as semi-permeable membranes?
c. Why is the root hair usually one celled structure?

Draw the diagram in the blank space of the Cell 'A' when placed in hypotonic solution :