Ratna Sagar

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Education, Our Mission

As per the latest ICSE syllabus 2022

Ratna Sagar
Education, Our Mission!

Revised and Updated

LIVING SCIENCE BIOLOGY

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10

EDUCATION, OUR MISSION

ICSE
Living Science
Biology

Class 10

Chapter 4 Absorption by Roots

LEARNING OBJECTIVES

Why do plants need water and minerals?

- How are roots adapted for absorption of water?
- How do absorption and conduction of water and minerals occur?
- Diffusion
- Osmosis

Tonicity: Isotonic, hypotonic and hypertonic solutions

- Imbibition
- Turgidity and flaccidity
- Plasmolysis and deplasmolysis

Absorption of water and minerals by the root

- Ascent of sap
- Causative forces for ascent of sap

Why do plants need water and minerals?

Need for water

❖ **For photosynthesis:** Water is used as a raw material for the synthesis of glucose during the process of photosynthesis.

❖ **For transpiration:** It is used for cooling the tree in warm weather and for generating a pull/suction force for the movement of sap by transpiration.

❖ **For transportation:** It helps in the upward transport of minerals from the roots into the shoot system and for food manufactured in leaves to other parts.

❖ **For mechanical strength:** It is required for providing turgidity that makes plant tissues stiff and gives them strength.

Need for mineral nutrients

❖ For movement of substances through the cell membrane (calcium)

❖ For respiration (iron) and cell division (phosphorus)

❖ For activating the enzymes (potassium, magnesium)

❖ To make chlorophyll (magnesium)

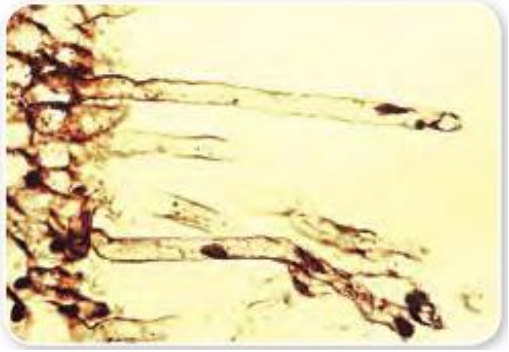
❖Part of nucleic acids, chlorophyll, proteins (nitrogen)

❖ As building blocks of many compounds synthesized by plants such as a new protoplasm, etc.

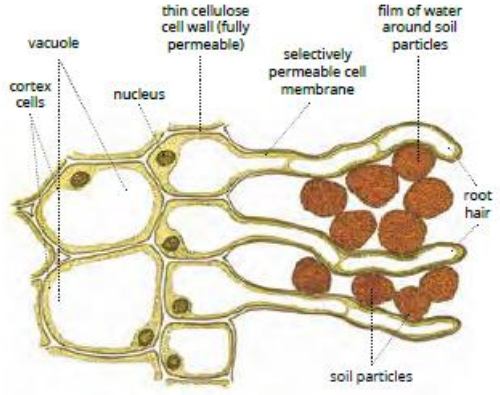
How are roots adapted for absorption of water?

❖ **Roots contain root hair that provide large surface area:** A plant may contain millions of root hair which together provide large surface area for absorption of water

❖ **The epidermis of root hair is permeable to water:** The root hair have very thin walls that are freely permeable to water.



A fully grown root hair



Cross section of root showing association of soil particles with root hair.

Root hair contain cell sap, which is at a higher concentration than the surrounding water: The large vacuoles in the plant cells contain a solution called **cell sap** which contains dissolved salts and is therefore of a higher concentration than the surrounding water. This facilitates osmosis, as a result of which water from outside is drawn inside the root hair.

How do absorption and conduction of water and minerals occur?

The absorption of water and minerals from the soil by the root hair, its movement through the thickness of the root and then upward conduction through the stem to the leaves of the plant takes place through the following processes.

Diffusion

The movement of molecules of a substance from a region of their higher concentration to a region of their lower concentration is called diffusion.

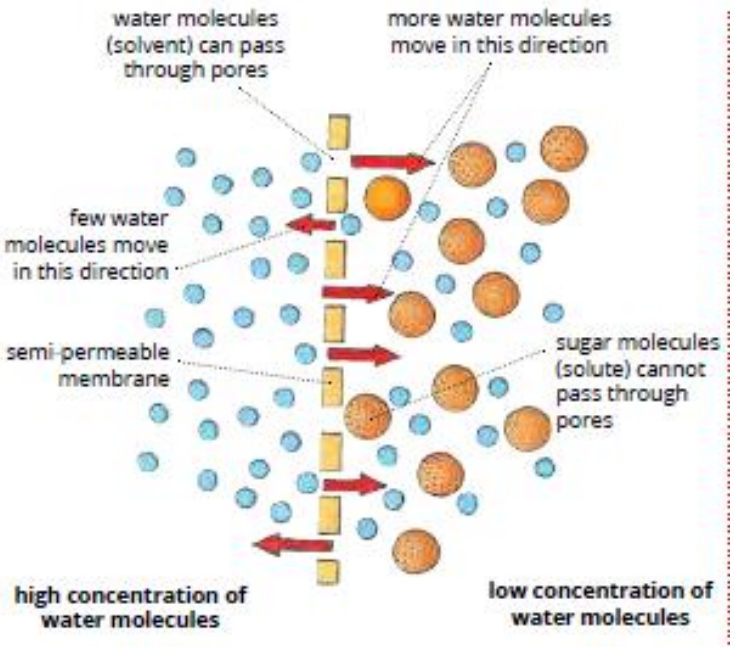
Importance of diffusion

- ❖ Diffusion of water keeps the wall of the internal plant tissue moist.
- ❖ It helps in distribution of ions and molecules throughout the protoplast.
- ❖ Loss of water vapour from stomata during transpiration is through diffusion.
- ❖ Aroma (smell) of flowers is due to diffusion of aromatic compounds from flowers to attract pollinators.

Osmosis

The movement of water molecules from a region of their higher concentration (more dilute solution) to their lower concentration (less diluted solution)through a semi-permeable membrane is called osmosis.

Note: The differences between diffusion and osmosis are given in the Table 4.1.



Movement of water molecules through a semi-permeable membrane

Endosmosis and Exosmosis

The inward movement of water molecules through a semipermeable membrane when the surrounding solution is less concentrated is called **endosmosis**. Endosmosis leads to swelling up of cells.

The outward movement of water molecules through a semipermeable membrane when the surrounding solution is more concentrated is called **exosmosis** . Exosmosis leads to shrinking of the cells.

Osmotic pressure

The osmotic pressure is the minimum pressure that needs to be applied to a solution to prevent inward flow of pure solvent (water) into the solution when separated by a semi-permeable membrane.

Osmotic potential

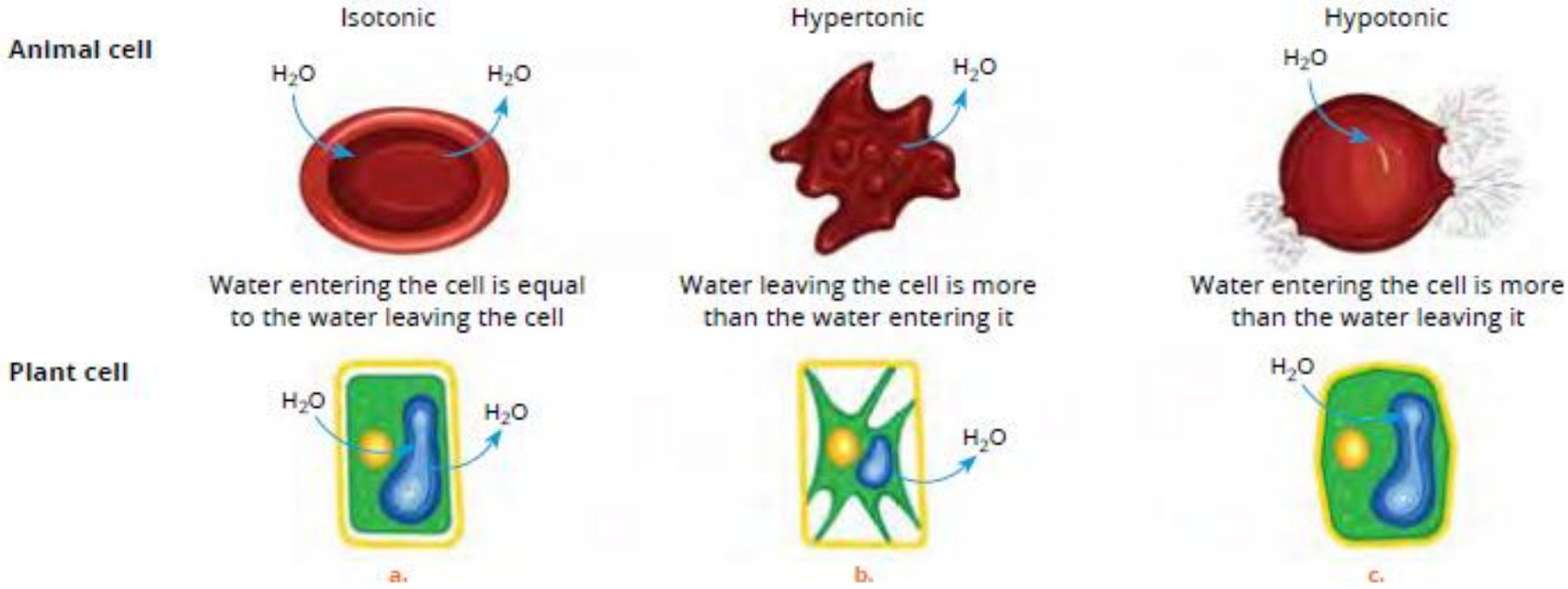
The osmotic potential of a solution is a measure of the tendency of water molecules to diffuse out of it. A concentrated solution that has relatively few water molecules has a **low osmotic potential**. On the other hand, a dilute solution with a larger proportion of water molecules has a **high osmotic potential**.

Importance of osmosis

- ❖ Water absorbed by roots moves to upper parts of a plant from cell to cell through osmosis.
- ❖ Osmosis plays a key role in growth of radicle and plumule during seed germination.
- ❖Cell to cell movement of water occurs through osmosis.
- ❖ Living cells remain turgid or distended due to osmosis.
- ❖ The stomata open and close in response to increase or decrease in osmotic pressure of the guard cell.

Tonicity: Isotonic, hypotonic and hypertonic solutions

The relative concentration of a solution which determines the direction and extent of diffusion is called tonicity. Based on tonicity, solutions can be classified into three types – isotonic, hypotonic and hypertonic.



Behaviour of animal and plant cell placed in solutions of different concentration

Note: Refer to Table 4.2 for the Differences between isotonic, hypertonic and hypotonic solutions

Imbibition

Imbibition is the process by which plant cells (living or dead) absorb water by surface attraction. Imbibition results in swelling of tissues and rupturing of seed coat for germination of seeds. Swelling of wooden doors during rainy season is also due to imbibition.

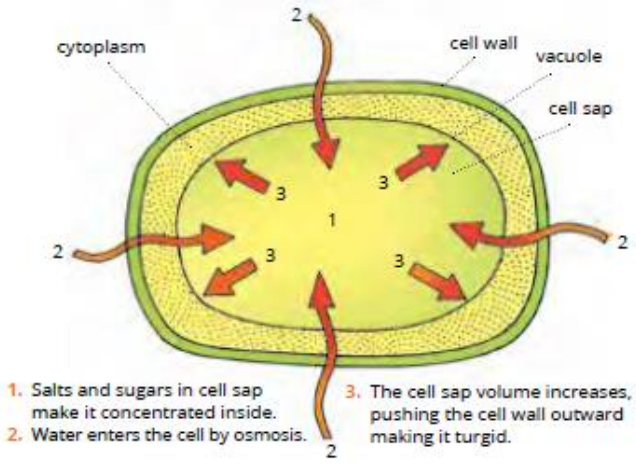
Active transport

The passage of salt or ions of a substance from its lower concentration to higher concentration utilizing the energy from the cell through a living membrane is known as **active transport**. Active transport is just opposite to diffusion. The ions of certain elements such as nitrates, sulphates, manganese, etc., cannot easily pass through the cell membranes of root cells.

Turgidity and flaccidity

Turgidity: The root hair of plants are permeable to water. The cell sap inside the vacuole contains salts and sugars, and is highly concentrated. If this cell is surrounded by water, osmosis will cause water to enter the cell sap. As a result the vacuole would expand, pushing the cell cytoplasm against the cell wall. Eventually a condition will arise when no more water can enter the cell. Such a cell cannot accommodate any more water and is called turgid and the condition is called turgidity.

Turgor pressure: The pressure of the cell contents against the cell wall due to movement of water into the cell during osmosis is called turgor pressure. The pressure exerted by the cell wall on the cell contents is called wall pressure.



Uses of turgor pressure

- Turgor pressure keeps the cells and their organelles stretched, which is essential for proper functioning of a cell.
- It is necessary for the enlargement of cells.
- It provides support to living tissues like parenchyma.
- It keeps the leaves fully-expanded and oriented towards the light. In case of loss of turgidity the shoots **droop down** and leaves wilt. Rapid drooping of the leaves of sensitive plant, *Mimosa pudica* in response to touch is due to turgor movement.Flowers, soft stems and other soft parts of a plant are able to maintain their shape due to turgidity or turgor pressure.
- It keeps a check on the excessive entry of water into cells.

Turgor pressure in root cells builds up root pressure

Root pressure is the pressure developed in the roots due to the continued inflow of water by cell to cell osmosis. This helps in ascent of sap upwards through the stem.

Turgor pressure helps in opening and closing of stomata

During photosynthesis, glucose is synthesized from CO_2 and H_2O. This causes an increase in the osmotic pressure of the contents of guard cells. As a result, guard cells absorb more water from the neighbouring cells, thus becoming turgid. The high turgor pressure causes the guard cells to bulge out and the stoma opens.

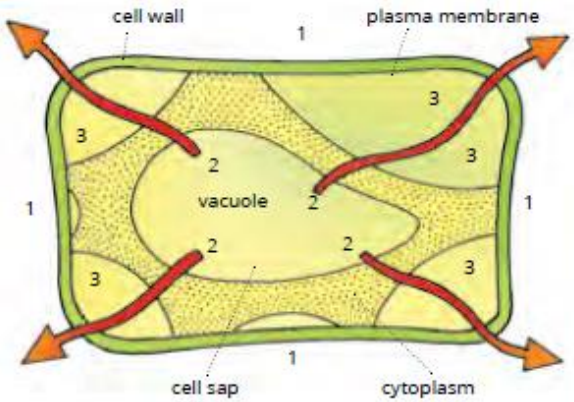
Turgor movement

In the sensitive plant, *Mimosa pudica*, the stimulus of touch leads to loss of turgor pressure at the base of leaflets and the leaves droop down (fold) within 2–3 secondsof touching. This is an example of turgor movement.

Flaccidity

Flaccidity is reverse of turgidity. If a fully-distended (turgid) cell is placed in a hypertonic solution, the water moves out of the cell due to exosmosis, cell cytoplasm will shrink and the plasma membrane will withdraw from the cell wall. The cell is called flaccid and

the phenomenon is known as flaccidity. A condition in which the cell contents shrink and the cell loses its turgidity is called flaccidity.



1. Solution outside is more concentrated than the cell sap.
2. Water passes out of the vacuole by osmosis.
3. The vacuole shrinks, pulling the cytoplasm away from the cell wall and leaving the cell flaccid.

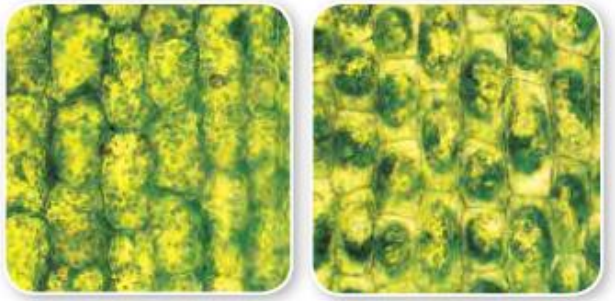
Root pressure

The pressure developed in the roots due to continuous inflow of water, which helps in pushing the plant sap upwards is called root pressure.

Plasmolysis and deplasmolysis

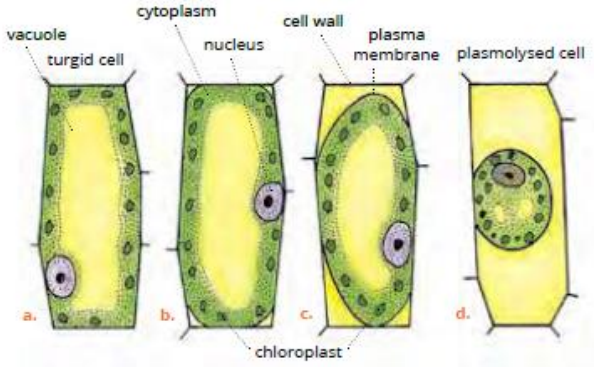
Plasmolysis

Shrinkage or contraction of the cytoplasm (cell content) of a cell from its cell wall when placed in a hypertonic solution is called plasmolysis.



a. Cells in normal turgid condition

b. Plasmolysed cells after being kept in 5% salt solution. The cytoplasm shrinks and the cell becomes flaccid.



a. A cell in normal turgid condition;
b.–d. Successive stages in shrinkage of cytoplasm from the cell wall after being placed in a hypertonic solution.

Diagrammatic representation of plasmolysis in a cell

Deplasmolysis

If a plasmolysed cell is placed in water, its shrunk cytoplasm swells up and presses against the cell wall. This happens due to endosmosis. The swelling up of a plasmolysed cell under the influence of hypotonic solution or water is called deplasmolysis. Deplasmolysis is possible only if the cell is alive and its cytoplasm s not dead or damaged.

Absorption of water and minerals by the root

Absorption of water

The absorption of water occurs through root hair. Root hair are thin-walled extensions from the cells of the outer layer of a root. They grow out pushing between the soil particles.

There is a film of water that surrounds the soil particles and in turn root hair also. The root hair contains cell sap which has a higher concentration of salts than the outside soil water.

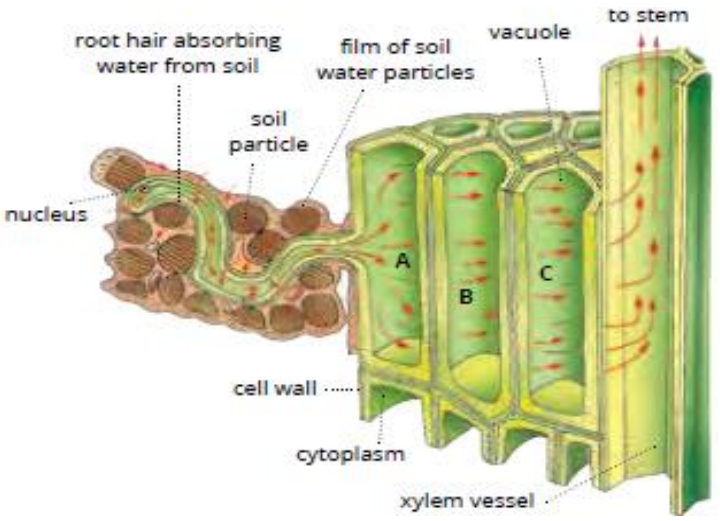
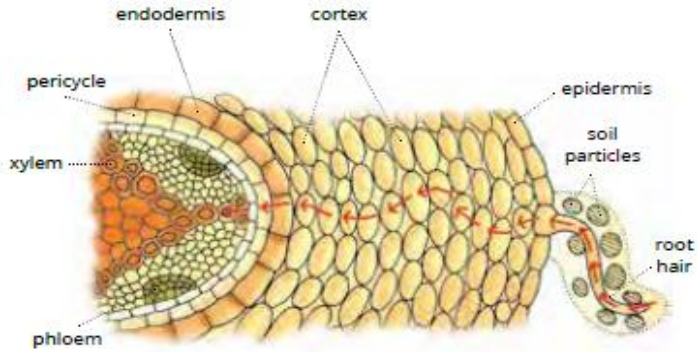


Diagram to show cell to cell passage of water from soil to xylem vessels in a root

This causes osmosis and the water from outside diffuses into the cells of root hair. This is due to root pressure.

Absorption of minerals

Absorption of mineral elements by the root from the soil takes place by active transport. The water film around the soil particles also contains a low concentration of mineral elements. These mineral elements move from soil into the root cells against the concentration gradient. Energy in the form of ATP is required by the cell for the absorption of minerals.



a. Transverse section through a dicot root showing absorption of water by root hair

Ascent of sap

The upward movement of water and mineral salts from roots to the aerial parts (leaves, flowers, branches, etc.) of the plant, against the gravitational force is called ascent of sap.

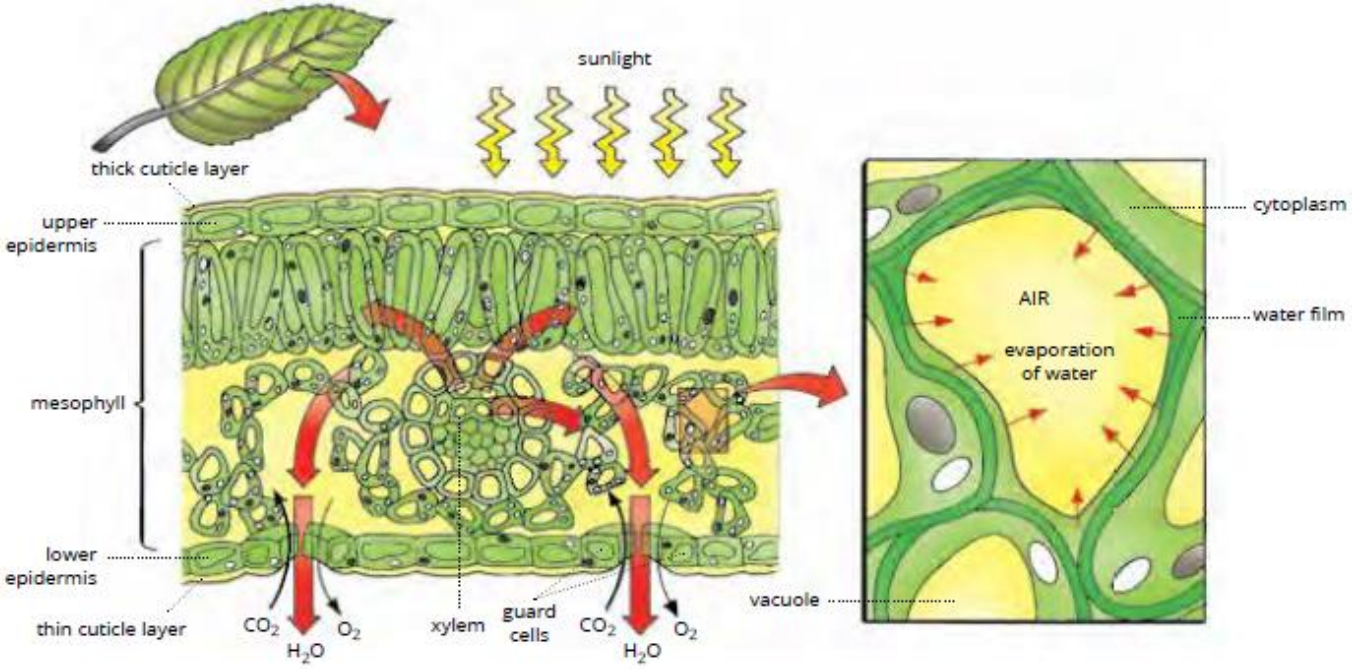
Water enters the root hair cells by **imbibition** and then by the process of **osmosis**. This water from the root hair cells passes into the xylem vessels through the cells of cortex, endodermis and pericycle. Ascent of sap takes place from the root, into the stem and finally the leaf veins through the xylem vessels and tracheids by means of a pull exerted by the leaf cells at the top of the sap column.

Note: **Refer to Activity 5 To show that xylem is the path of ascent of sap.**

Causative forces for ascent of sap

As the water moves upward from roots to the leaves, a lot of it evaporates through the stomata present on the lower surface of a leaf. This process of evaporation of water from leaves and other aerial parts of the plant is called **transpiration.**

The **xylem sap** (water containing minerals) rises against the gravity without the help of any mechanical pump. The xylem sap is largely pulled upward by transpiration – cohesion–tension mechanism, also called transpiration pull.



Transpiration pull

Note: Refer to Activity 6 To show that water is conducted through xylem tissues.

SUMMARY...

- ❖ Plants need water and minerals for growth, photosynthesis, transpiration, mechanical strength and transportation of nutrients.
- ❖ Roots contain root hair that provide enormous surface area. The epidermis of root hair is permeable to water.
- ❖ The movement of molecules or ions of a substance from a region of their higher concentration to a region of their lower concentration is called diffusion. Diffusion of water molecules keeps the cell wall of the internal plant tissues moist and helps in the transpiration of water vapour from stomata.
- ❖ Osmosis is the movement of water from its pure state or diluted solution into a concentrated solution through semi-permeable membrane. Inward movement of water is called endosmosis and outward movement is called exosmosis.
- ❖ The osmotic pressure is the maximum pressure which can develop in an osmotically active solution when it is separated by a semi-permeable membrane to stop further endosmosis of water from a region of low concentration to the region of higher concentration of solute.
- ❖ Imbibition is the process by which plant cells absorb water by surface attraction.
- ❖ The passage of salt of a substance from its lower concentration to higher concentration through a living cell membrane using the energy from the cell is called active transport.

❖ The condition, when a cell reaches a state when it cannot accommodate any more water is called turgidity.

❖ The pressure of the cell contents against the cell wall is called turgor pressure. Flaccidity is reverse of turgidity.

❖ Shrinkage of cytoplasm of a cell from its cell wall under the influence of a hypertonic solution is called plasmolysis. The condition opposite to it is deplasmolysis.

❖ Absorption of water occurs through root hair by the process of osmosis. Minerals move from soil into root hair through active transport.

❖ The water and mineral salts enter the root by moving between the cells before entering xylem. Water also enters root hairs; then pass through the cells of the cortex and endodermis to reach xylem vessels.

❖ The water and minerals absorbed by roots are conducted up through the xylem tissue.

❖ The upward movement of water and minerals from roots to the aerial parts of plants against the gravitational force is called ascent of sap.

❖ Xylem sap is pulled upward by root pressure, capillary action of xylem vessels, transpiration – cohesion – tension mechanisms, and cohesion and adhesion of water.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