PLANT-CELL WATER RELATION TERMINOLOGY

Cohesion:

A drop of water contains trillions of water molecules held together by weak hydrogen bonds. The tendency of water molecules to bond is called **cohesion**. The fact that water molecules cohere using weak hydrogen bonds is what gives water its fluid consistency.

Adhesive:

Water's polarity also makes it **adhesive**, which means that it will be attracted to other types of molecules with positive and negative charges. Think of how trees transport water from the soil up into their high branches without any kind of pump. Water molecules enter the root and adhere to the molecules that make up the walls of the plant's conductive tissues, called the **xylem cells**.

Osmosis:

Osmosis is the movement of water or other solvent through a plasma membrane from a region of low solute concentration to a region of high solute concentration, tending to equalise the concentrations of the solutes. **Osmosis** is passive transport, **meaning** it does not require energy to be applied.

Active transport:

Active transport is a mode of transportation in **plants**, which uses stored energy to move the particles against the concentration gradient. **Active transport** always leads to accumulation of molecules are ions towards one side of the membrane.

Passive transport:

Passive transport is a movement of ions and other atomic or molecular substances across cell membranes without need of energy input. Unlike

active **transport**, it does not require an input of cellular energy because it is instead driven by the tendency of the system to grow in entropy.
An **example** of **passive transport** is diffusion, the movement of molecules from an area of high concentration to an area of low concentration. Carrier proteins and channel proteins are involved in facilitated diffusion.

Transpiration:

Transpiration is the process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems and flowers. Water is necessary for plants but only a small amount of water taken up by the roots is used for growth and metabolism. The remaining 97–99.5% is lost by transpiration and guttation.

Evaporation:

Evaporation occurs when water changes from a liquid state to a gaseous state. When it **occurs in plants**, water is lost through microscopic pores in the **plant's** leaves (stomata). This process is called transpiration.

Evapotranspiration:

Evapotranspiration is the **process** of evaporating water from leaves through plant transpiration during photosynthesis. It varies because of a multitude of factors like wind, temperature, humidity, and water availability. **Evapotranspiration** is the sum of both Et.

Aquaporin:

In recent years some integral membrane proteins have been discovered which form water selective channels in cell membranes (lipid bilayers) and facilitate faster movement of water across the membranes into the plant cells. These channels have been called as aquaporin. The direction of water transport across the membranes however, is not affected by aquaporin.

Aquaporin's are found in both plant and animal membranes but they are relatively abundant in plants. The aquaporin's satisfactorily account for the observed rate of water movement across the membranes which could not be explained earlier simply by direct diffusion of water through lipid bilayer as the latter does not allow bulk flow of water across it.
According to Tyerman et al (2002), expression and activity of aquaporin's appear to be regulated probably by protein phosphorylation in response to availability of water.

The 2003 Nobel Prize in Chemistry was awarded jointly to Peter Agre for the discovery of aquaporin.

Absorption of Water in Plants:

Mechanism of Absorption of Water:

In higher plants water is absorbed through root hairs which are in contact with soil water and form a root hair zone a little behind the root tips. Root

hairs are tubular hair like prolongations of the cells of the epidermal layer (when epidermis bears root hairs it is also known as piliferous layer) of the roots. The walls of root hairs are permeable and consist of pectic substances and cellulose which are strongly hydrophilic (water loving) in nature. Root hairs contain vacuoles filled with cell sap.

When roots elongate, the older hairs die and new root hairs are developed so that they are in contact with fresh supplies of water in the soil.

Mechanism of water absorption is of two types:

(1) Active Absorption of Water:

In this process the root cells play active role in the absorption of water and metabolic energy released through respiration is consumed.

Active absorption may be of two kinds:

(a) Osmotic absorption i.e., when water is absorbed from the soil into the xylem of the roots according to the osmotic gradient.

(b) Non-osmotic absorption i.e., when water is absorbed against the osmotic gradient.

(2) Passive Absorption of Water:

It is mainly due to transpiration, the root cells do not play active role and remain passive.

(1a) Active Osmotic Absorption of Water:

First step in the osmotic absorption of water is the imbibition of soil water by the hydrophilic cell walls of root hairs. Osmotic Pressure (O.P.) of the cell-sap of root hairs is usually higher than the O.P. of the soil water.

Therefore, the Diffusion Pressure Deficit (D.P.D.) and the suction pressure in the root hairs become higher and water from the cell walls enters into them through plasma-membrane (semi-permeable) by osmotic diffusion. As a result, the O.P., suction pressure and D.P.D. of root hairs now become lower, while their turgor pressure is increased.

Now, the cortical cells adjacent to root hairs have higher O.P., suction pressure and D.P.D. in comparison to the root hairs. Therefore, water is drawn into the adjacent cortical cells from the root-hairs by osmotic diffusion.

In the same way, the water by cell to cell osmotic diffusion gradually reaches the innermost cortical cells and the endodermis. Osmotic diffusion of water into endodermis takes place through special thin walled passage cells because the other endodermal cells have casparian strips on their walls which are impervious to water

Water from endodermal cells is drawn into the cells of pericycle by osmotic diffusion which now becomes turgid and their suction pressure is decreased. In the last step, water is drawn into xylem from turgid pericycle cells. (In roots the vascular bundles are radial and protoxylem elements are in contact with pericycle).

(1b) Active Non-Osmotic Absorption of Water:

Sometimes, it has been observed that absorption of water takes place even when the O.P. of the soil water is higher than the O.P. of cell-sap. This type of absorption which is non- osmotic and against the osmotic gradient requires the expenditure of metabolic energy probably through respiration.

(i) The factors which inhibit respiration also decrease water absorption.

(ii) Poisons which retard metabolic activities of the root cells also retard water absorption.

(iii) Auxins (growth hormones) which increase metabolic activities of the cells stimulate absorption of water.

(2) Passive Absorption of Water:

Passive absorption of water takes place when rate of transpiration is usually high. Rapid evaporation of water from the leaves during transpiration creates a tension in water in the xylem of the leaves. This tension is transmitted to water in xylem of roots through the xylem of stem and the water rises upward to reach the transpiring surfaces.

As a result, soil water enters into the cortical cells through root hairs to reach the xylem of roots to maintain the supply of water. The force for this entry of water is created in leaves due to rapid transpiration and hence, the root cells remain passive during this process.

During absorption of water by roots, the flow of water from epidermis to endodermis may take place through two different pathways:

(i) Apoplastic pathway (cell walls and intercellular spaces)

(ii) Symplast pathway (through plasmodesmata).

The mechanism of water absorption described earlier, in-fact belongs to the second category. The relative importance of these two pathways in water

absorption by roots is not clearly established. However, a combination of these two pathways is responsible for transport of water across the root.

External Factors Affecting Absorption of Water:

1. Available Soil Water:

Sufficient amount of water should be present in the soil in such form which can easily be absorbed by the plants. Usually the plants absorb capillary water i.e., water present in films in between soil particles. Other forms of water in the soil e.g., hygroscopic water, combined-water, gravitational water etc. are not easily available to plants. Increased amount of water in the soil beyond a certain limit results in poor aeration of the soil which retards metabolic activities of root cells like respiration and hence, the rate of water absorption is also retarded.

2. Concentration of the Soil Solution:

Increased conc. of soil solution (due to the presence of more salts in the soil) results in higher osmotic pressure. If the O.P. of soil solution will become higher than the O.P. of cell sap in root cells, the water absorption particularly the osmotic absorption of water will be greatly suppressed. Therefore, absorption of water is poor in alkaline soils and marshes.

3. Soil Air:

Absorption of water is retarded in poorly aerated soils because in such soils deficiency of O_1 and consequently the accumulation of CO_2 will retard the metabolic activities of the roots like respiration. This also inhibits rapid growth and elongation of the roots so that they are deprived of the fresh

supply of water in the soil. Water logged soils are poorly aerated and hence, are physiologically dry. They are not good for absorption of water.

4. Soil Temperature:

Increase in soil temperature up to about 30°C favours water absorption. At higher temperatures water absorption is decreased. At low temp, also water absorption decreases so much so that at about 0°C it is almost checked.