19.4.20

Ascent of Sap :

Upward translocation of sap or water is called ascent of sap. The water absorbed by the plant roots invariably contents solutes dissolved in it. It is ∴ termed as sap which is then translocated upward upto the highest point in the plant. The ascent of sap in moderately growing plants occurs through enzyme tissues.

Mechanism of Ascent of Sap :

The mechanism by which sap moves to the top of a lofty tree is a puzzle to the physiologist & which is still not satisfactorily solved. Stephen Hales (1769) was the 1st person to realize that there was a relationship betn the transpiration of plant & the upward movement of sap in the wood. General theories have been put forwarded by diff. scientist to explain the phenomenon of ascent of sap. The imp ones are described below.

1) Vital Force Theory : Adherence of this theories believe that vessels through translocation takes place are non living & are in contact with living cells. For this reason proponents of these theory, suggested that the upward translocation of water & other sub. takes place by the vital activities of the living cells which show some kind of pulsating action & the pulsation of cells at successive intervals lifts the cell sap up.

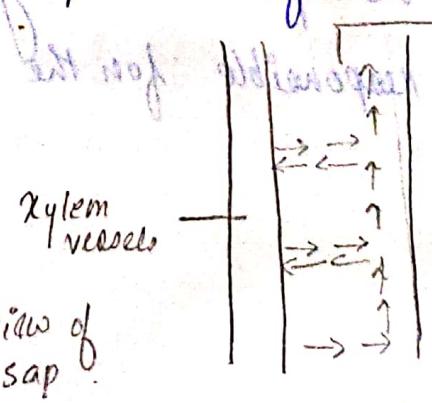


Fig: Goldewshi's view of ascent of sap

The main advocates of this theories are Goldewski's (1896) Boae (1923). Goldewski's proposed the Relay pump theory which tells that the movement of sap through the xylem are due to rhythmic changes in the osmotic pressure of the cells of wood parenchyma. However, anatomical studies have failed to show any pumping action in the xylem. Further numerous exp. have demonstrated clearly that living cells are not involved in the translocation of sap in the stem.

2. Root Pressure theory: Acc. to the root pressure theory, the positive pressure developed in the roots pumps the sap up in the xylem duct. This theory seems to be applicable to many species that generate considerable amount of root pressure. For eg. grape vines have been shown to generate root pressure upto 5 to 6 bars which can support a water column upto 150-160 feet. However, root pressure cannot account for sap translocation in many situations because the phenomenon of root pressure is not observed in most conifers & other gymnosperms which are among the tallest of trees. Secondly, the pressure generated is so low that it cannot account for upward translocation even upto a few feet. Further, the rate of translocation by root pressure is not adequate to account for rate of transpiration. In temperate regions, root pressure is generally negligible during summer period when rate of transpiration is high. For this region, root pressure cannot be held responsible for the rise of sap in large tree.

Or Transpiration Pull Theory :

3. Cohesion Theory : The cohesion theory was developed by an Irish Botanist Henry Dixon and a physicist John Jolly (1894). The essential components of this theory are as follows :

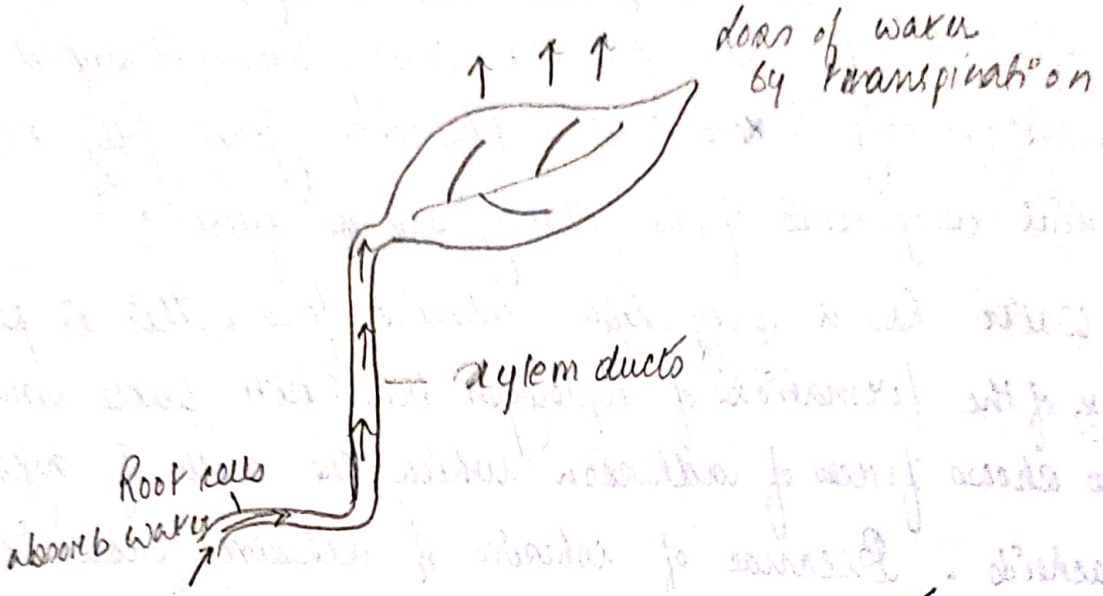
1) Water has a very high cohesive force. This is primarily because of the formation of hydrogen bonds betn water molecules. Water also shows forces of adhesion which the walls of xylem vessels & Tracheids. Because of cohesive & adhesive forces it exists as a column in the xylem elements.

2) The water column is continuous from the transpiring leave cells to the walls of absorbing root cells via the xylem conducting system.

3) The energy for upward movement of this water column is provided by transpiration from leaf cells. This creates are more -ve water potential in the leaf cells causing water to move from the xylem ducts to the cells.

4) The reduction in water potential in apical cell is transmitted to the periphery of absorbing root cells where it causes inflow of water from the soil.

Under the conditions of high transpiration rate, there is a continuous mass flow of H_2O from the soil through the roots, stems & leaves & other apical portion of the plants. The ascent of sap through cohesion, adhesion & transpiration pull is represented below :



Considering all the foregoing theories regarding the ascent of sap in plants it is evident that not a single theory can explain the mechanism of water translocation but an amalgated effect of all this theories will be helpful in elluciditing the process of water translocation in plants. The root pressure gives the pressure from below & the active transpiration pulls the water column through the xylem vessels which are in a cohesion tension thus favouring the easy flow of lipids through the stem to the top of a lofty tree.

Physical Theories of Ascent of Sap

Imbibition Theory

It was proposed by Unger (1868) and supported by Sachs (1878). According to these theory, the water ascends due to imbibitional forces through the walls of xylem tracheids and their lumen have no relation with the ascent of sap, but modern scientists have proved that ascent of sap stops and the leaves wilt if the lumens of xylem vessels and tracheids are blocked with the wax. Thus, this theory proves to be wrong.

Capillary Force Theory

This theory was proposed by Boehm (1869). He was of the opinion that water ascends in the xylem vessels through capillary action. If we vertically place a capillary tube in the water, the water ascends automatically in the tube up to some distance because of capillary force. The xylem vessels are also quite thin like capillary tube. Thus, water ascends in them like capillary tube. It has been proved that through capillary force the water can ascend only upto some distance. Thus, this theory is not applicable for very tall plants.