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**Topic- Translocation of solutes-path**

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# TRANSLOCATION OF SOLUTES

**Translocation of organic solutes**

The movement of organic food materials or the solutes in soluble form one place to another in higher plants is called as translocation of organic solutes.

**Directions of translocation**

Translocation of organic solutes may take place in the following directions.

**1. Downward translocation**

Mostly, the organic material is manufactured by leaves and translocated downward to stem and roots for consumption and storage.

**2. Upward translocation**

It takes place mainly during the germination of seeds, tubers etc. When stored food after being converted into soluble form is supplied to the upper growing part of the young seedling till it has developed green leaves.

Upward translocation of solutes also takes place through stem to young leaves, buds and flowers which are situated at the tip of the branch.

**3. Lateral translocation**

Radical translocation of organic solutes also takes place in plants from the cells of the pith to cortex.

**Path of the translocation of organic solutes**

**1. Path of downward translocation**

Downward translocation of the organic solutes takes place through phloem. This can be proved by the ringing experiment.

**2. Path of upward translocation**

Although translocation of organic solutes take place through phloem, but under certain conditions it may take place through xylem.

**3. Path of lateral translocation**

Lateral translocation from pith to cortex takes place through medullary rays.

**Mechanism of translocation**

Various theories have been put forward to explain the mechanism of phloem conduction. Among them Munchs' (1930) hypothesis is most convincing.

**Munchs mass flow on pressure flow hypothesis**

According to this hypothesis put forward by Much (1930) and others, the translocation of organic solutes takes place though phloem along a gradient of turgor pressure from the region of higher concentration of soluble solutes (supply end) to the region of lower concentration (consumption end). The principle involved in this hypothesis can be explained by a simple physical system as shown in Fig.

Two members X and Y permeable only to water and dipping in water are connected by a tube T to form a closed system membrane X contains more concentrated sugar solution than in membrane Y.

Due to higher osmotic presence of the concentrated sugar solution in the membrane X, water enters into it so that its turgor pressure is increased. The increase in turgor pressure results in mass flow of sugar solution to membrane Y though the T till the concentration of sugar solution in both the membrane is equal.

In the above system it could be possible to maintain continuous supply of sugars in membrane X and its utilization on conversion into insoluble form in membrane Y, the flow of sugar solution from X to Y will continue indefinitely.

According to this theory, a similar analogous system for the translocation of organic solutes exists in plants. As a result of photosynthesis, the mesophyll cells in the leaves contain high concentration of organic food material in them in soluble form and correspond to membrane X or supply end.

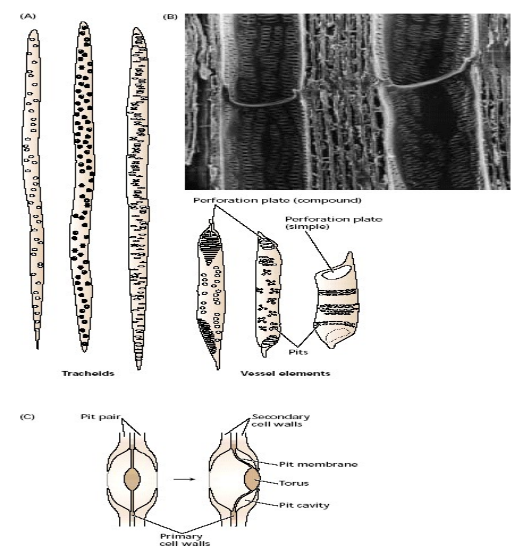
The cells of stem and roots where the food material is utilized or converted into insoluble form correspond to membrane Y or consumption end. While the sieve tubes in phloem which are placed and to end correspond to the tube T.

Mesophyll cells draw water from the xylem of the leaf due to higher osmotic pressure and suction presume of their sap so that their turgor pressure is increased. The turgor presume in the cells of stem and the roots is comparatively low and hence, the soluble organic solutes begin to flow en mass from mesophyll through phloem down to the cells of stem and the roots under the gradient of turgor presume. In the stem and the roots, the organic solutes are either consumed or converted into insoluble form and the excess water is released into xylem through cambium.

## XYLEM TRANSPORT

## ASCENT OF SAP

The water after being absorbed by the roots is distributed to all parts of the plants. In order to reach the topmost part of the plant, the water has to move upward through the stem. The upward movement of water is called as Ascent of sap.




Ascent of sap can be studied under the following two headings.

1. Path of ascent of sap
2. Mechanism of ascent of sap.

**1. Path of ascent of sap**

Ascent of sap takes place through xylem. It can be shown by the experiment. A leafy twig of Balsam plant (it has semi transpiration stem) is cut under water (to avoid entry of air bubble through the cut end of the stem) and placed in a beaker containing water with some Eosine (a dye) dissolved in it.

After sometimes coloured lines will be seen moving upward in the stem. If sections of stem are cut at this time, only the xylem elements will appear to be filled with coloured water.

**2. Ringing experiment**

A leafy twig from a tree is cut under water and placed in a beaker filled with water. A ring of bark is removed from the stem. After sometime it is observed that the leaves above the ringing part of the stem remain fresh and green. It is because water is being continuously supplied to the upper part of the twig through xylem.

**B. Mechanism of ascent of sap**

In small trees and herbaceous plants, the ascent of sap can be explained easily, but in tall trees like Eucalyptus and conifers reaching a height of 300-400 feet), where water has to rise up to the height of several hundred feet, the ascent of sap, it feet, becomes a problem. To explain the mechanism of Ascent of sap, a number of theories have been put forward.

a. vital theory
b. root pressure theory
c. physical force theory
d. transpiration pull and cohesion of water theory

**A. Vital theories**

According to vital theories, the ascent of sap is under the control of vital activities in the stem.

1. According to Godlewski (1884) – Ascent of sap takes place due to the pumping activity xylem tissues which are living.
2. According to Bose (1923) – upward translocation of water takes place due to pulsatory activity of the living cells of the inner must cortical layer just outside the endodermis.

**B. Root pressure theory**

Although, root pressure which is developed in the xylem of the roots can raise water to a certain height but does not seem to be an effective force in ascent of sap due to the following reasons. Magnitude of root pressure is very low (about 2 atmos).

Even in the absence of root pressure, ascent of sap continues. For example, when leafy twig is cut under water and placed in a beaker full of water it remains fresh and green for sufficient long time.

**A. Physical force theories**

Various physical forces may be involved in ascent of sap.

**1. Atmospheric pressure**

This does not seem to be convincing because it cannot act on water present in xylem in roots Incase it is working, and then also it will not be able to raise water beyond 34.

**2. Imbibition**

Sachs (1878) supported the view that ascent of sap could take place by imbibition through the walls of xylem. But imbibitional force is insignificant in the A. of sap because it takes place through the lumen of xylem elements and not through walls.

**3. Capillary force**

In plants the xylem vessels are placed one above the other forming a sort of continuous channel which can be compared with long capillary tubes and it was thought that as water rises in capillary tube due to capillary force in the same manner ascent of sap takes place in the xylem.

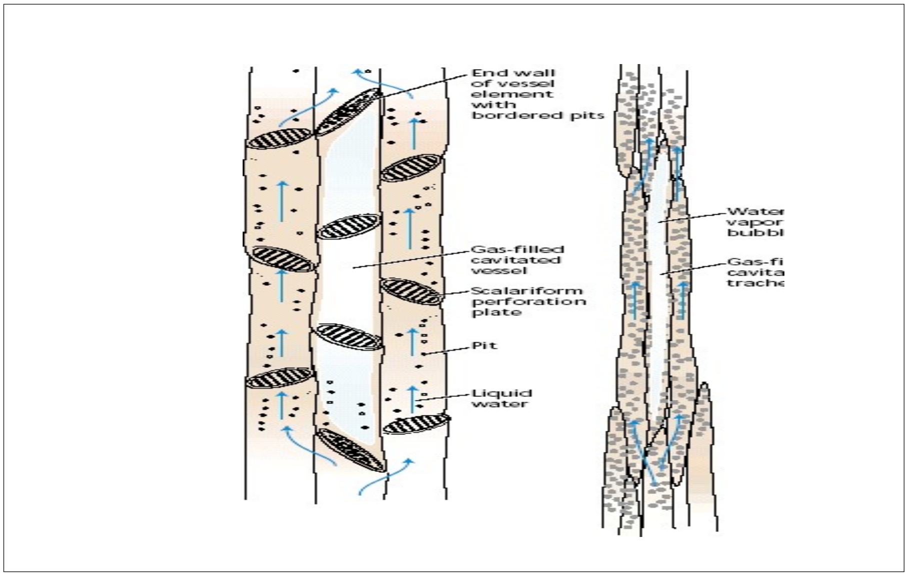
**B. Transpiration pull and cohesion of water theory**

This theory was originally proposed by Dixon and Jolly (1894) later supported and elaborated by Dixon (1924). This theory is very convincing and has now been widely supported by many workers.

Although H- bond is very weak (Containing about 5 K –cal – energy) but they are present in enormous numbers as incase of water, a very strong mutual force of attraction or cohesive force develops between water molecules and hence they remain in the form of a continuous water column in the xylem. The magnitude of this force is very high (up to 350 atm), therefore the continuous water column in the xylem cannot be broken easily due to the force of gravity or other abstractions offered by the internal tissues in the upward movement of water.

The adhesive properties of water i.e. attractions between the water molecules and the containers walls (here the walls of xylem) further ensure the continuity of water column in xylem.

When transpiration takes place in the leaves at the upper parts of the plant, water evaporates from the intercellular spaces of the leaves to the outer atmosphere through stomata. More water is released into the intercellular spaces from mesophyll cells. In turn, the mesophyll cells draw water from the xylem of the leaf. Due to all this, a tension is created in the xylem elements of the leaves. This tension is transmitted downward to water in xylem




elements of the root through the xylem of petiole and stem and the water is pulled upward in the form of continuous unbroken water column to reach the transpiring surfaces up to the top of the plant.