

Mechanism of Ascent of sap

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The upward movement of water and minerals through **xylem vessels** is called **Ascent of sap**.

Path of Ascent of sap

With the help of various experiments, it is well established that ascent of sap takes place through the xylem. The most important among them are

1. A leafy twig of balsam cut underwater to avoid air bubbles and put inside a beaker containing **eosin solution** (colored dye). After sometime colored lines will be seen moving upward staining only **xylem vessels**.
2. **Ringing Experiment** – In this experiment, a ring of bark (cortical layer) from a leafy twig is removed below the leafy part leaving only the central column and placed the twig underwater. It is observed that the removal of the cortical ring from the twig does not affect the transport of water to the upper leafy portion. That shows that water moves upward through the central column of the stem.

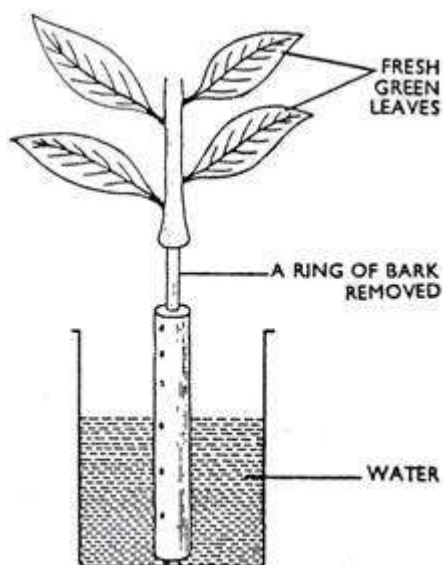


Fig. 6.1. Ringing Experiment.

Mechanism of Ascent of sap

Many theories have been put forward from time to time to explain the mechanism of the ascent of sap. These theories can be classified into three headings

(i). Vital theories

(ii). Root pressure theory

(iii). Physical theories

(i). Vital theories – According to these theories living cells of plants are responsible for upward movement of water (Ascent of Sap). Despite the number of important proponents like Goldlewski (1884), Sir J.C.Bose (1923) and Mollisch (1928) vital theories have not to be excepted very much due to lack of strong experimental support.

(ii). Root pressure theory – The hydrostatic pressure developed due to the accumulation of water absorbed by the roots is called the root pressure, but it is not itself is sufficient to drive water to tall trees due to following reasons-

- a. The magnitude of the root pressure not sufficient for very tall trees.
- b. The root pressure is not observed in many plant species and water continues to rise in the absence of root pressure.
- c. The rate of sap exudation is not adequate to compensate for the known rate of transpiration.
- d. It was observed that xylem sap is normally under tension instead of under pressure

(iii). Physical theories – All those theories which consider the dead cells of the plant to be responsible for the ascent of sap are called physical theories.

1. **Boehm's Theory** – **Boehm (1809)** believed that ascent of sap in plants is partly due to the phenomenon of capillarity of the trachea

and partly due to the atmospheric pressure but the atmospheric pressure can support the rise of water only up to 34ft.

2. **Jamin's chain theory** – **Jamin** believed that air and water were alternately arranged inside the plant. He assumed that when air expands it moves up carrying along with them the water column present above. But it also fails to explain the rapid unidirectional flow of sap.
3. **Imbibition theory** – **Sachs (1878)** try to explain that imbibitional activity of the cell wall of the xylem vessels is responsible for the up rise of water in plants
4. **The cohesion of water and transpiration pull theory** – This theory was proposed by **Dixon and Jolly (1894)**. This is the most accepted theory to explain the rise of water even in the tallest trees.

This theory has three essential features

- a. **Strong cohesive and adhesive properties of water** – Water molecules have strong mutual attraction due to the presence of hydrogen bond, although H-bond is very weak bond when they are present in enormous number as in case of water, a strong cohesive force develops between water molecules and they remain in the form of a continuous water column in xylem vessels. This magnitude of the force is so high that the continuity of the water column in the xylem cannot be broken easily due to the force of gravity or other forces.
The adhesive properties of water between water molecules and xylem wall also ensures the continuity of the water column in the xylem.
- b. **Continuity of water column in the plant** – A strong objection against this theory has been raised by various scientists as the evidence of the presence of air bubbles and gases in the water column of the xylem element that can disturb the continuity of water column in the xylem. According to Dixon water present in different xylem ducts did not operate separately and that individual unbroken water columns were continuous with each other both in vertical as well as lateral direction through the cell walls and a meshwork of water column is presently extending

from roots to the leaves constituting single continuous water-conducting unit

- c. **Transpiration pull force** - According to **Dixon and Jolly** when transpiration takes place transpiration pull force developed in leaves, water evaporates from the wall of the mesophyll cells to the outer atmosphere through stomata. The diffusion pressure deficit of the water in the mesophyll cells increases and the cell absorbs water from the adjoining cells. As a result, the water saturation deficit develops in the walls of leaf mesophyll cells. This water deficit continues from cell to cell until it reaches the leaf xylem, from there to stem xylem and finally to root hairs through root xylem. This way tension is created and the water pulled upward in the form of a continuous water column to reach the transpiring surface. This tension in the water column is called transpiration pull.

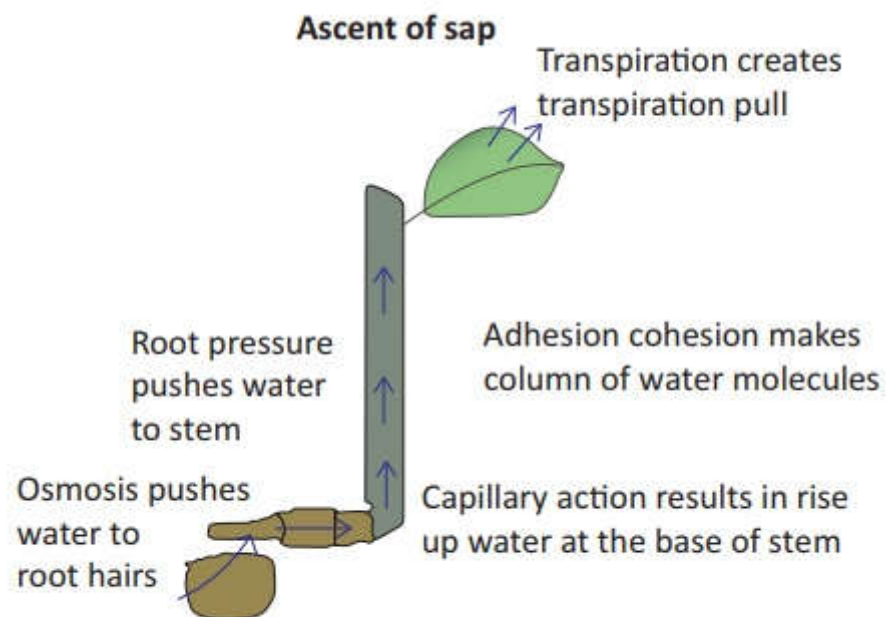


Figure 14.8 Ascent of Sap

LEARNING OUTCOME

1. What are the different theories to explain the mechanism of ascent of sap.
2. Which theory is most accepted theory to explain the mechanism of Ascent of sap.

