

ASCENT OF SAP

The upward movement of sap i.e. liquid & minerals from the base of the stem to its top is known as Ascent of Sap.

It is the nature of water that it can go high maximum up to ten (10) meters i.e. 32 ft due to its own i.e. atmospheric / gravitational force. There are several examples where we see that it is going quite higher than this even up to more than one hundred (100) meters in certain cases e.g. Eucalyptus, Metasequoia etc.

Its concrete and undisputed explanation is still challenging. There are various theories but none without any serious objections.

Some of these theories are as follows:

The theories related to its explanation may be grouped as:

- (A) Physical Force Theory / Theories
- (B) Root Pressure Theory / T
- (C) Vital Theory.

A PHYSICAL FORCE THEORIES

The basis of these theories is that it is (Ascent of sap) a pure physical phenomenon. Living cells have nothing to do with it. There are a number of theories but the most convincing and widely / highly accepted theory is known as

I TRANSPIRATIONAL PULL THEORY.

I) TRANSPIRATIONAL PULL THEORY. :

Dixon & Jolly in 1894. Later advocated by
Renner in 1911 & 1915;

Curtis & Clark in 1951.

Bonner & Galston in (1952)

Kramer & Kozlowski in 1960.

Milburn & Johanson in 1966

Hamel in 1967

Levitt in 1969

This theory is popularly known as

- i) Cohesion Theory
- ii) Cohesion - tension Theory
- iii) Theory of Cohesion Force.
- iv) Transpiration Pull Theory
- v) Dixon & Jolly Theory.

This theory involves several aspects.
It is better to explain it ~~at~~ under following heads.

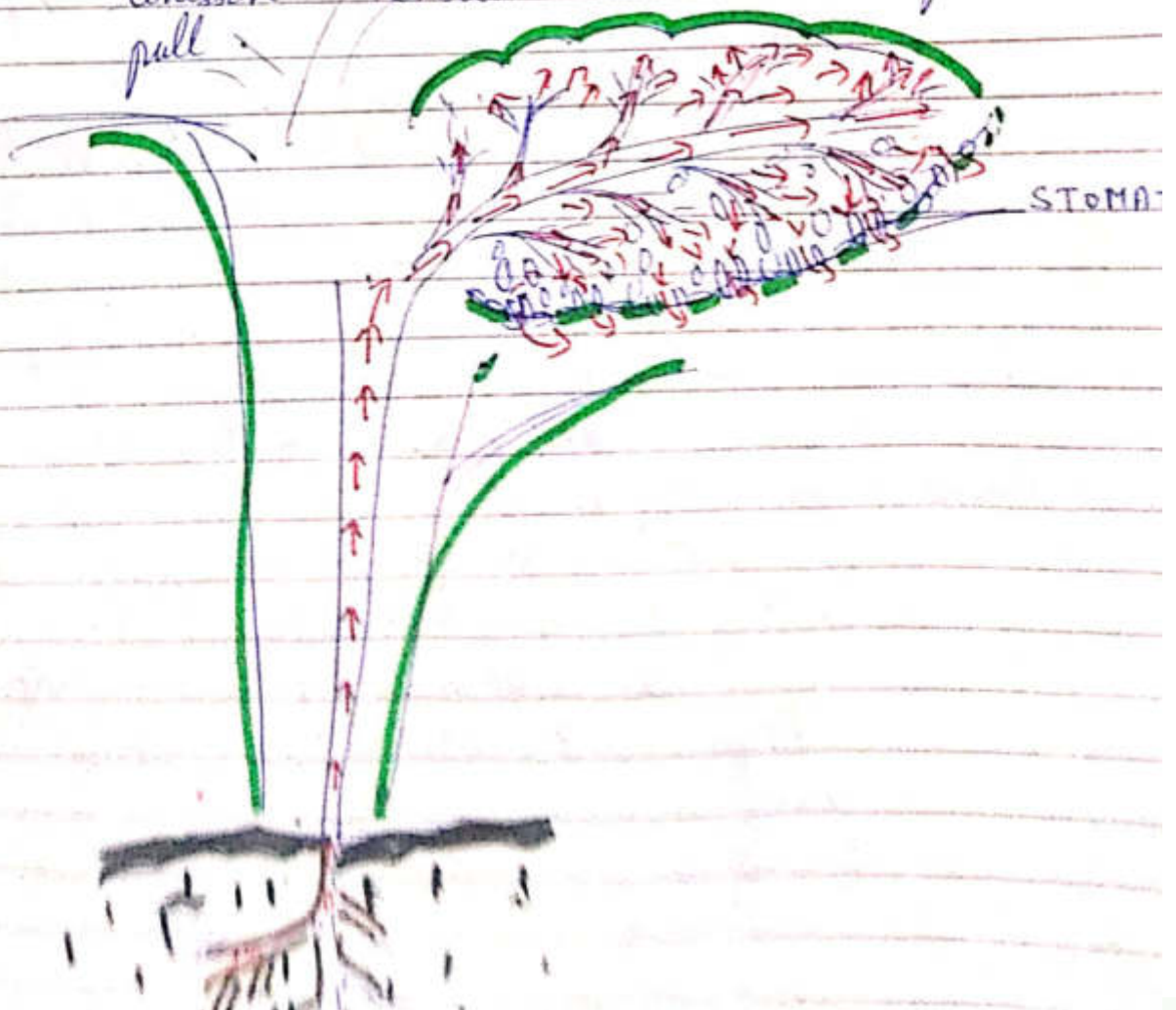
- a) COHESION.
- b) COHESION - TENSION.
- c) MECHANISM.
- d) Evidences.
- e) Objections.
- f) Explicit Explanations.

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a) COHESION: It is the force of attraction between similar molecules i.e. molecules of the same element or compound in material. The cohesive force of water molecule is three hundred fifty (350) atmosphere. It is quite ~~an~~ excess to assist the ascent of sap up to any height of plant present in nature.

b) COHESION-TENSION:

There is continuous column of water from base to the tip of plant through xylem tracheids & vessels. This column remains under cohesive-tension due to transpirational pull.



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c) Mechanism:

During transpiration there is loss of water in form of vapours from foliar stomata and other ones. But it mainly through the leaves.

To compensate this loss which is mainly coming from cells of mesophyll, there is an increase in osmotic pressure of these cells.

As the ~~rest~~ transpiration is going on so the osmotic pressure. Hence the pressure is passing through adjacent cells to cells ultimately pulls water from xylem tissue. So that the water column present in xylem develops a tension.

This tension from xylem of leaves to xylem of roots transmitted through xylem of stem.

This Transpiration develops a pull that is known as transpiration pull. It causes the upward movement of water column by mass flow. This water is not pure water but possesses minerals. This combination of water and mineral i.e. sap. Hence the ascent of sap facilitate in plants.

d) Evidences:

It is widely supported by various scientists due to following evidences in its support:

- i) Osmotic pressure of mesophyll cells are about twenty (20) atmosphere.
- ii) Tensile strength of Xylem is about twenty-five to three hundred (25-300) atmos.
- iii) Porous pot experiment.
- iv) Lewis and Sentamaris (1960)
- v) Kramer & Kozlanowski (1960)
- vi) Zimmerman (1965).

e) Objections:

There are some objection of this theory as

- i) During tensile pull during inadequate availability of water / sap at proper level gas & air bubbles may enter in the xylem vessels may cause a break of column.
- ii) It is as there are two opposite pulls i.e.
 - x) Upward Transpiration pull
 - x) downward Gravitational pull
- iii) The water columns may get choaked by gas bubbles or any other reason.



f) Explanations:

1. There are several explanations to overcome these objections as follows.

i) The continuous water column can withstand a tension of even two (200) hundred atmosphere where as a maximum tension ~~is~~ on water column from two sides may be about (50) fifty atmosphere. Hence there is no breakage.

ii) Gass bubbles are carried out along the stream in vessels
— Scholander et al.

iii) There are not a sing many water columns not a single one. If some one may get choaked others ascent of sap facilitates through others.

iv) The choaked one also become unchoaked due to release of tension as lowering of temperature ^(During Night) and or availability of water (rain)

III. ATMOSPHERIC PRESSURE THEORY:

According to this theory water in plants get rise due to atmospheric pressure.

But there are serious objections as

— To raise water in column there must be an open lower surface where atmospheric pressure get applied; but it lacks in most of the plant.

— It can raise water only up to ten (10) metres but many a trees and lianas are quite more taller than it.

III. CAPILLARY THEORY:

Xylem tracheids and vessels are like capillary tubes therefore sap may rise due to capillary action.

It is proposed by Boeken in 1809.

Objection: i) The smallest capillary size in xylem may be 0.02 m.m. in diameter. It may rise sap maximum up to 1.5 meter only.

ii) There must be an open free surface at the top for the capillary action. But this condition hardly prevails in plant.

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IMBIBITIONAL THEORY.

Proposed by Unger & in 1868 and Sachs in 1878 & 1879.

Imbibitional force are very high i.e. one hundred (100) to one thousand (1000) atmospheres.

It can raise water in plants up to any extent.

But there are certain unremovable objections —

i) Movement of water is not through the walls but through the lumen.

ii) The rate of imbibitional movement of sap is very slow almost negligible.

B

ROOT PRESSURE THEORY:

Proposed by Priestley.
As to this movement of sap in plants may be due to a pressure develops in root due to absorption of water. This pressure is known as Root Pressure.

But there are certain major objections against this.

- i) Ascend of sap may take place even in absence of
- ii) Root pressure is not found in all plants.
- iii) Maximum root pressure may be upto two (2) atmospheres which can raise it up to twenty one (21) meter only.

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VITAL THEORIES

These theories are of historical importance mainly as the main basis of these theories are that living cells are involved in trans ascent of sap.

Some of the important ones are seen as -

A) I) WESTERMEIER'S (1883-84) -> THEORY. States that Xylem parenchyma cells facilitates ascent of sap and Tracheids and vessels of Xylem act as reservoir.

II) RELAY-PUMP-THEORY -> Proposed by G. Odlewski (1884) -> all of xylem The living tissue cause a pumping action in upward direction and Tracheids and vessels of Xylem tissue acts as reservoir.

It was supported by - Jansen (1887) - Ursprung (1905-07) - Ewart (1905-08) etc.

III) PULSATION/PULSATORY THEORY ->

This theory was proposed by the great Indian Scientist Sir Dr. Jagadish Chandra Bose, commonly known as Sir J.C. Bose. in 1923.

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As to this Pulsatory activity of the innermost cortical cells are responsible for a pulsatory movement. The pulsation of these cells absorb water and pump them into vessels, and so to the upper level. Here also the tracheids and vessels of xylem tissue are considered as an reservoir for sap.

— This theory was supported by Mohl in (1828-29) also.

But these theories get a death blow by Strasburger (1891) and Overton (1911)

It has been experimentally proven (shown) that ascent of sap takes place even in absence of living cells.

Conclusion:

Ascent of sap is a pure physical phenomenon, which occurs due to transpirational pull - cohesion of water molecules and their adhesion with lumen of xylem are essentially helping this. Living cells though not required but they are somewhat helpful in it.