

Plant physiology

Lecture series-1c

Ascent of sap

The upward movement of water from roots to aerial parts of plants through xylem is called

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Declaration

The source of Data/Text used in the preparation of power point presentation were Google, E-Books, Books and Journals. It is used for teaching purpose only.

Ascent of sap

SUBTOPICS...

INTRODUCTION

WHAT IS SAP ??

ASCENT OF SAP

MECHANISM OF ASCENT OF SAP

STRUCTURES INVOLBED IN THE PROCESS
OF ASCENT OF SAP

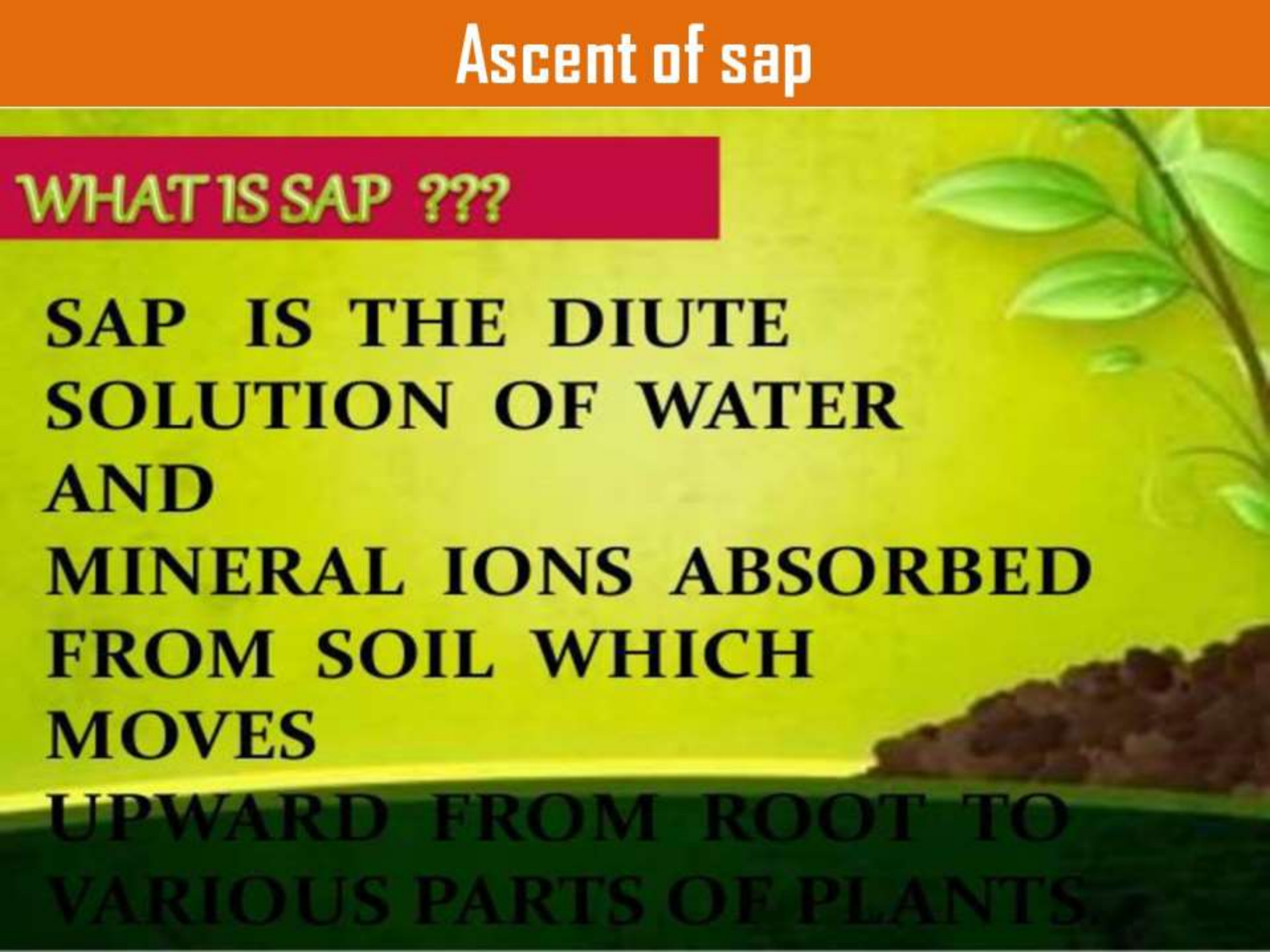
THEORIES OF ASCENT OF SAP

CONCLUSION

Ascent of sap

WHAT IS SAP ???

**SAP IS THE DIUTE
SOLUTION OF WATER
AND
MINERAL IONS ABSORBED
FROM SOIL WHICH
MOVES
UPWARD FROM ROOT TO
VARIOUS PARTS OF PLANTS.**

A green plant with several leaves is shown on the right side of the slide. Below it is a mound of brown soil. The background is a gradient of yellow and green.

Ascent of sap

What is ASCENT OF SAP ??

The upward movement of water from the root to aerial parts of the plant body is called ascent of sap or often called translocation of water. It is fascinating to understand how water moves in plants to such great heights such as 400 ft. or more. For example, trees like Sequoia semipervians are as tall as 300 to 400 ft. They are the 4000 yrs old and giants among the tree plants. These plants transport water through their stem must be incredible.

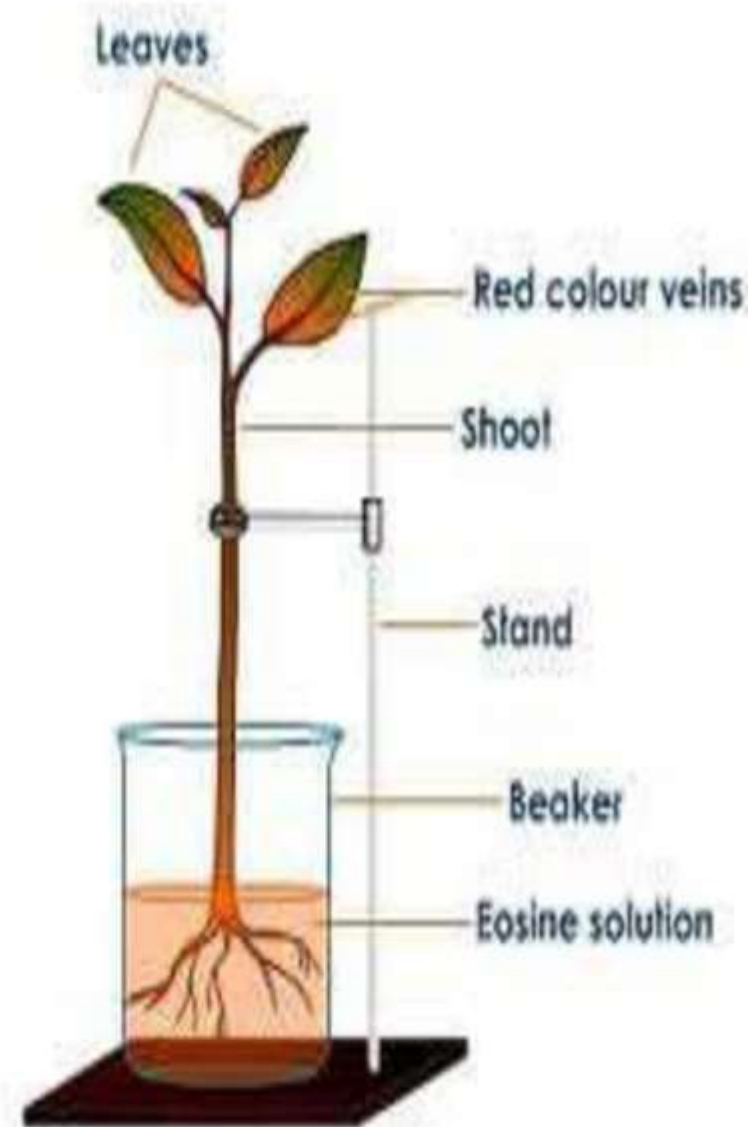
Demonstrate xylem is the pathway for ascent of sap?

Materials:

- A beaker, Water, Eosin stain (red ink), stand, White balsam plant with roots.

Procedure:

- Put few drops of eosin stain in a beaker containing water.
- Insert a balsam plant into it. Fix to stand. Keep it for few hours.
- Red lines can be seen in the transparent stem and in the veins of leaves.
- When a section of the stem is observed under the microscope, it shows that only the xylem vessels are coloured.
- This expt confirms xylem is the pathway for ascent of sap.



Structure of Vascular Tissue Related to the Transport

Xylem

Consists of four types of cells; vessel, tracheid, parenchyma and fibres.

1. Xylem vessel

- Xylem vessel are long, hollow and continuous tubes.
- Dead cells, no protoplasm to easier the flow of water.
- The cell walls are strengthened by lignin, deposited in various patterns and gives mechanical support.
- The cell wall with numerous hole or pit to allow water and mineral pass side way between the cells.

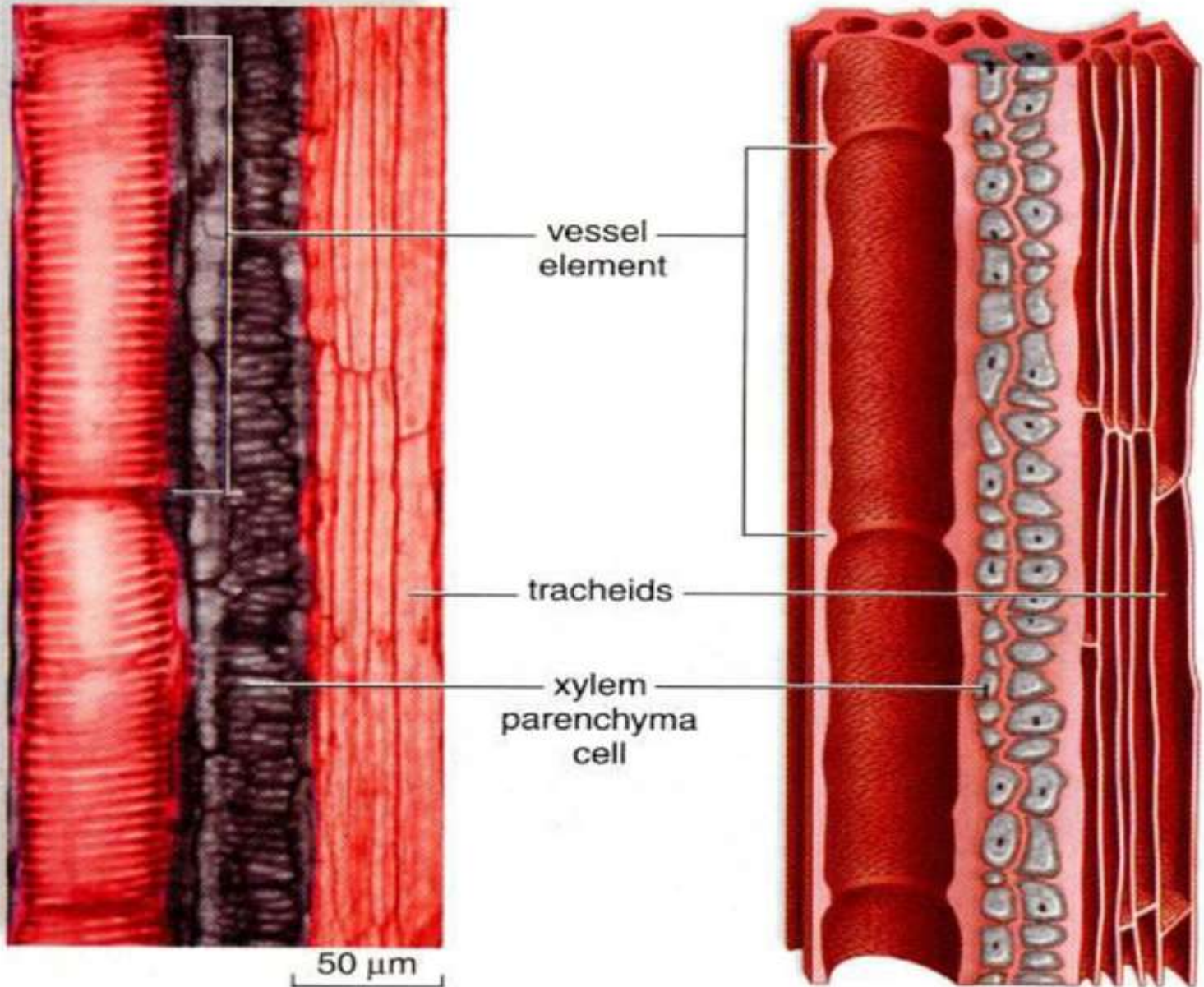
2. Tracheid

- Also dead cells and hollow but more longer and smaller than xylem vessel.
- Pointed end and pitted.

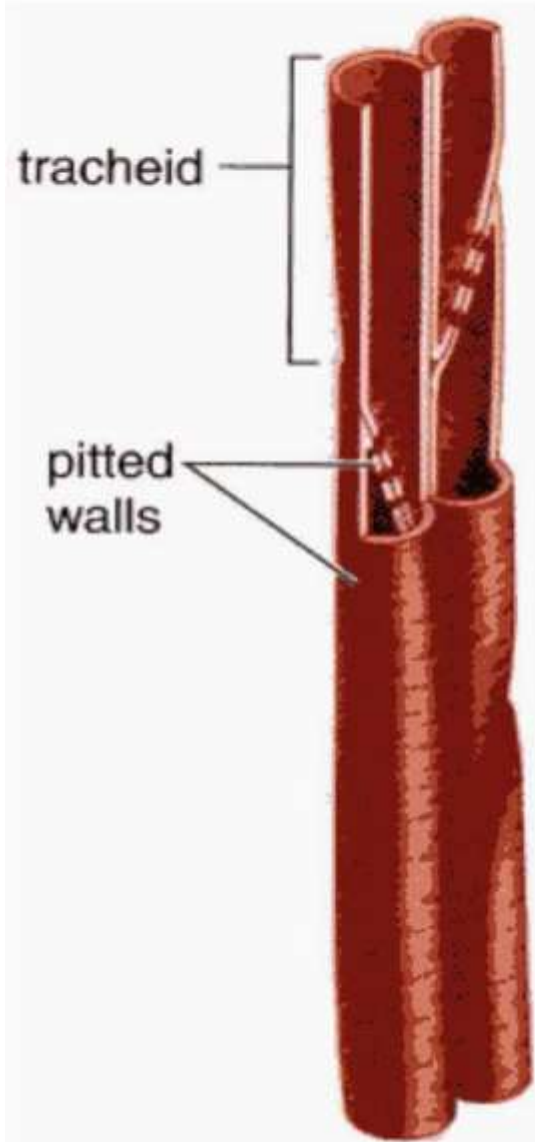
2. Parenchyma and fibres

- Parenchyma stores food.
- Fibres provide support

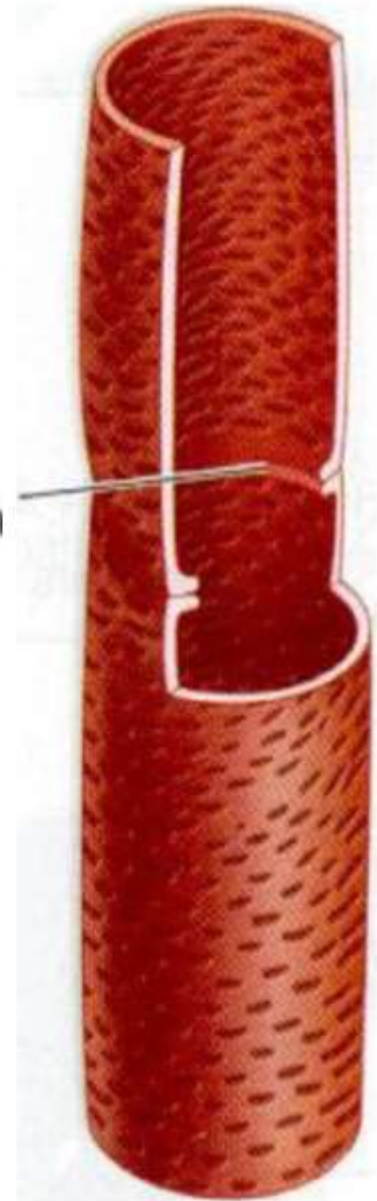
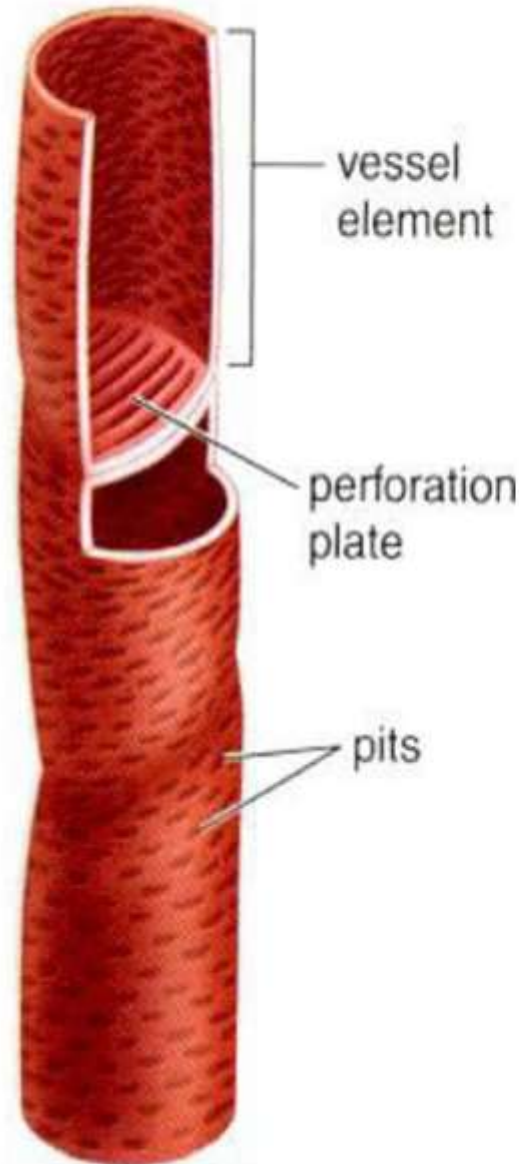
Structure of Xylem



Structure of Xylem

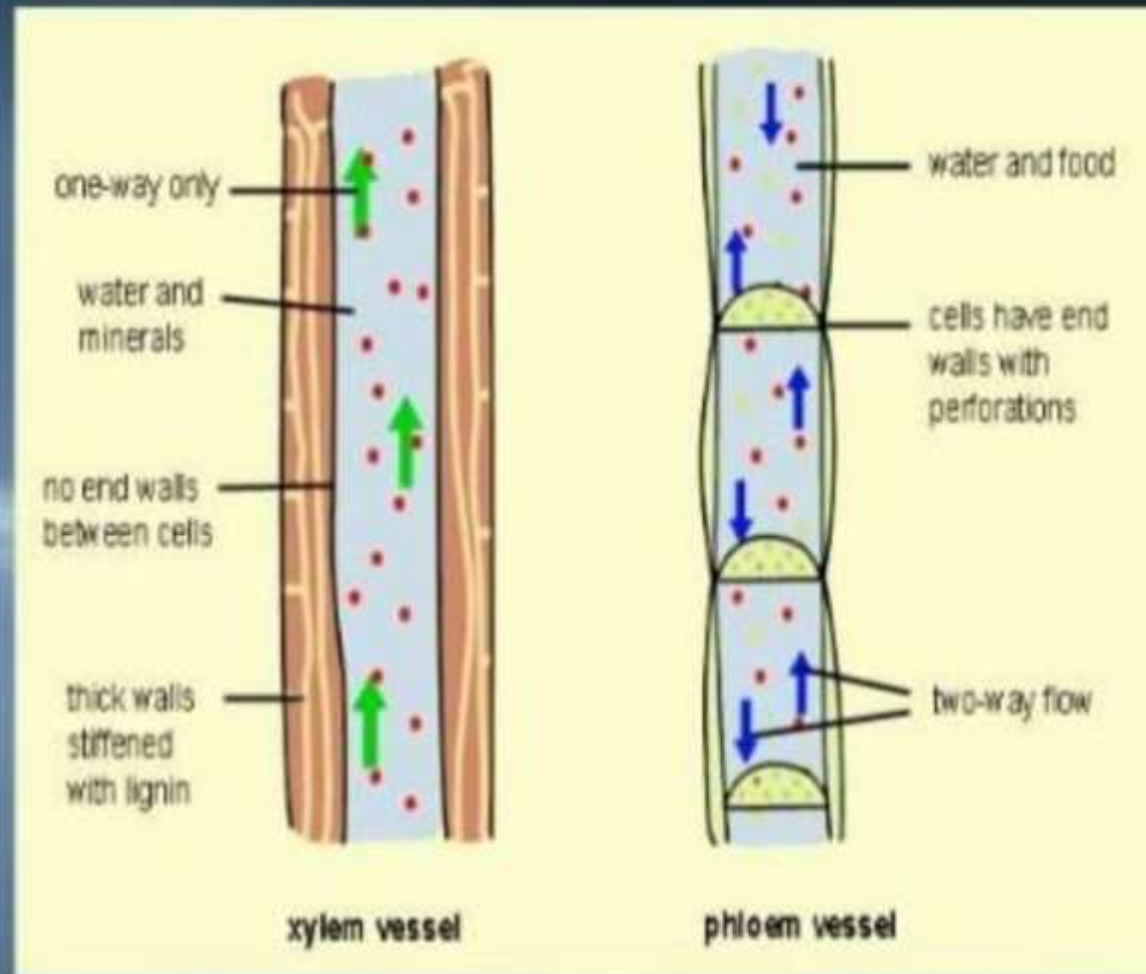


c. Tracheids

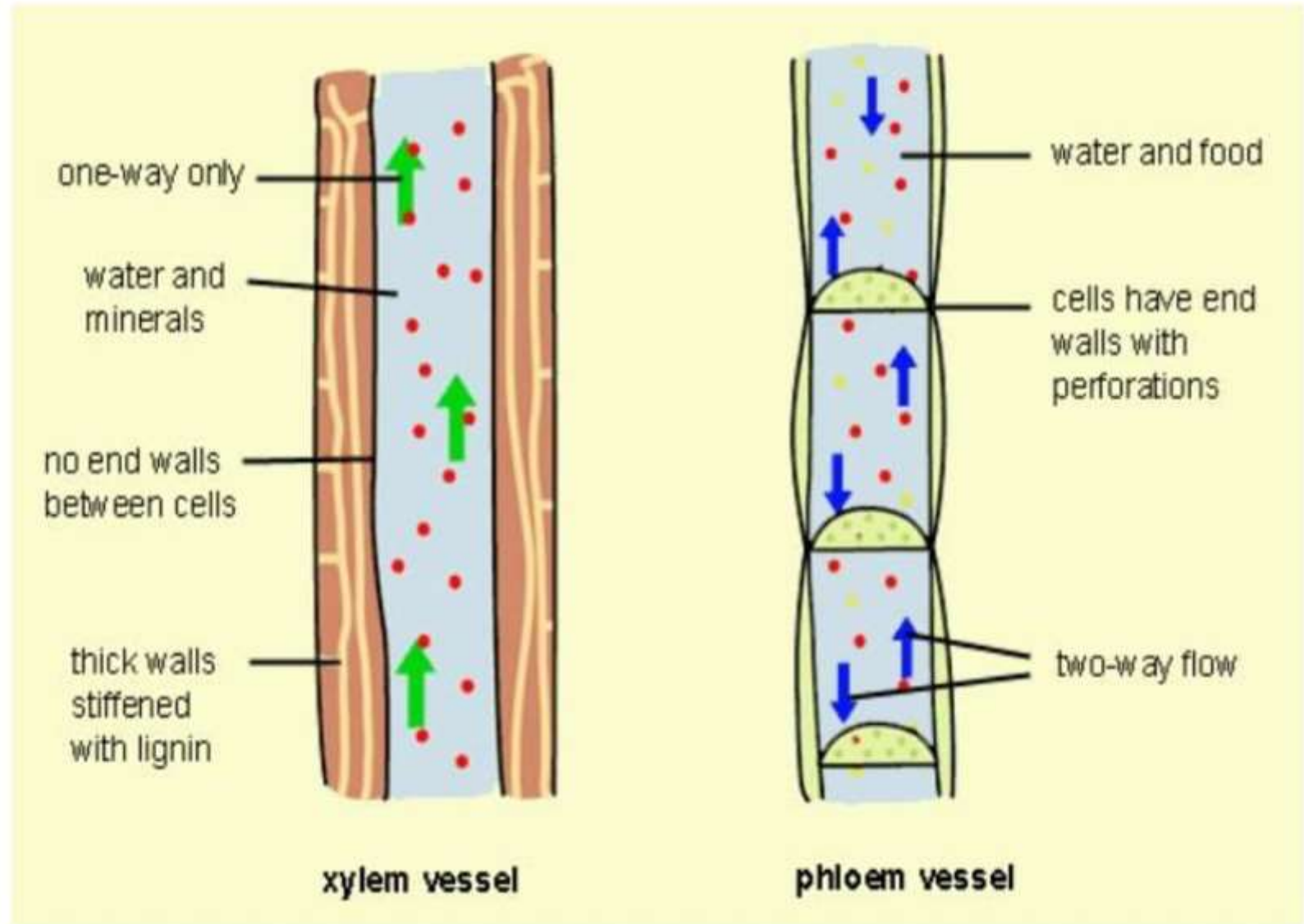


Path of water movement

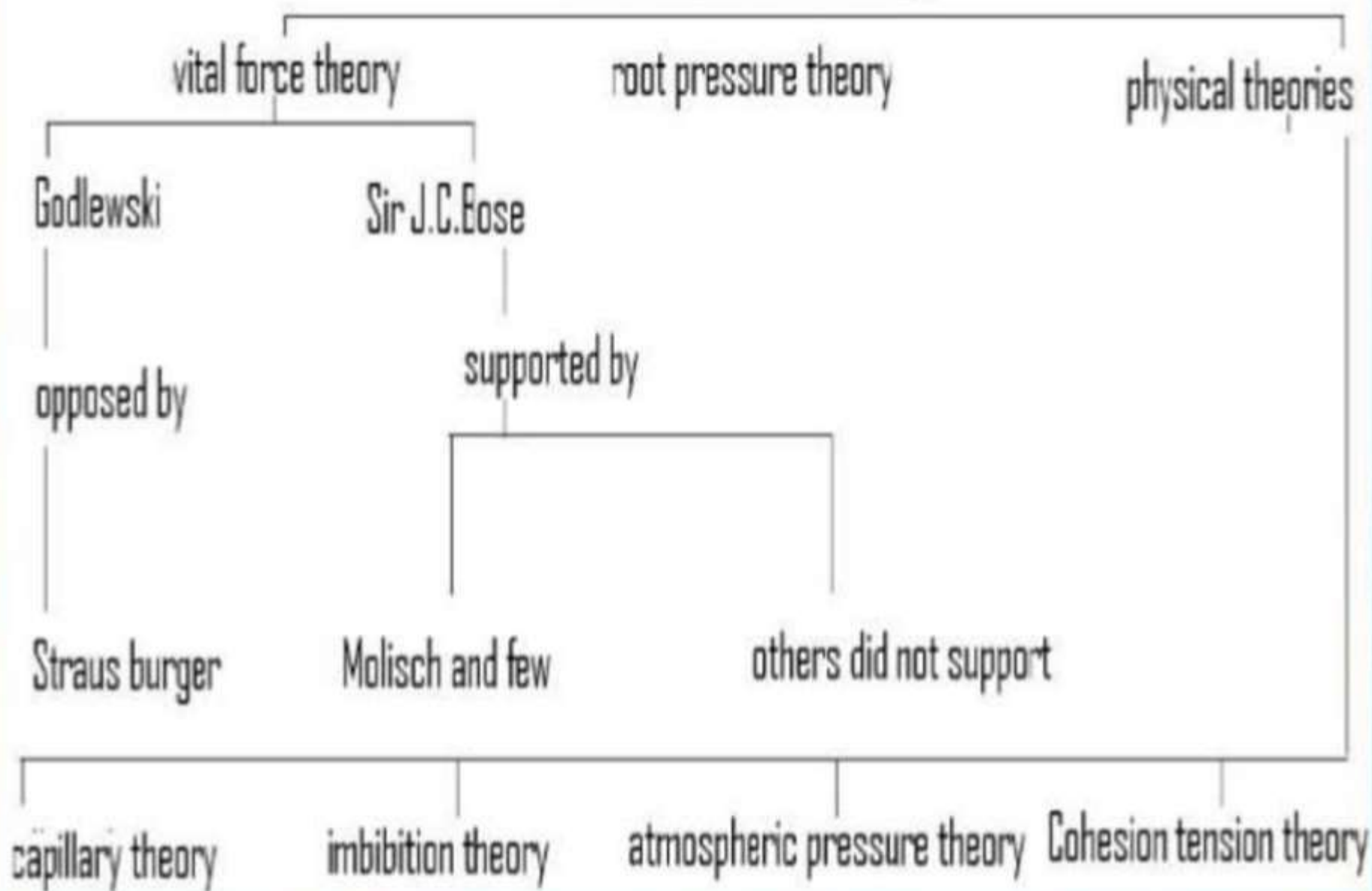
- Tracheids have large septal perforations that provide continuous system and do not afford much resistance for the smooth flow of water.
- The xylem parenchyma provides access for the lateral movement of water towards cortical cells.
- It contains many inorganic and organic components absorbed by the root system.
- So the trachea and tracheids with their large lumen and end to end association act as excellent pipelines for the movement of water, minerals .



Path of water movement



theories of ascent of sap.



VITAL FORCE THEORY

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graph TD; A[VITAL FORCE THEORY] --> B[GODLEWSKI RELAY PUMP THEORY/  
CLANBERING THEORY]; A --> C[PULSATION THEORY  
(J.C.BOSE)]; B --> D[OPPOSED BY  
STRAUS BURGER]; C --> E[SUPPORTED BY  
MOLISCH]; C --> F[OTHERS DID NOT  
SUPPORTED];
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The diagram is a hierarchical flowchart set against a background of purple flowers. At the top is a box labeled 'VITAL FORCE THEORY'. Two lines descend from this box to two separate boxes: 'GODLEWSKI RELAY PUMP THEORY/ CLANBERING THEORY' on the left and 'PULSATION THEORY (J.C.BOSE)' on the right. From the 'GODLEWSKI...' box, a line goes down to a box labeled 'OPPOSED BY STRAUS BURGER'. From the 'PULSATION THEORY...' box, two lines branch out downwards to two boxes: 'SUPPORTED BY MOLISCH' on the left and 'OTHERS DID NOT SUPPORTED' on the right. All boxes are light blue with a darker blue border and a slight drop shadow.

GODLEWSKI RELAY
PUMP THEORY/
CLANBERING THEORY

OPPOSED BY
STRAUS BURGER

PULSATION THEORY
(J.C.BOSE)

SUPPORTED BY
MOLISCH

OTHERS DID NOT
SUPPORTED

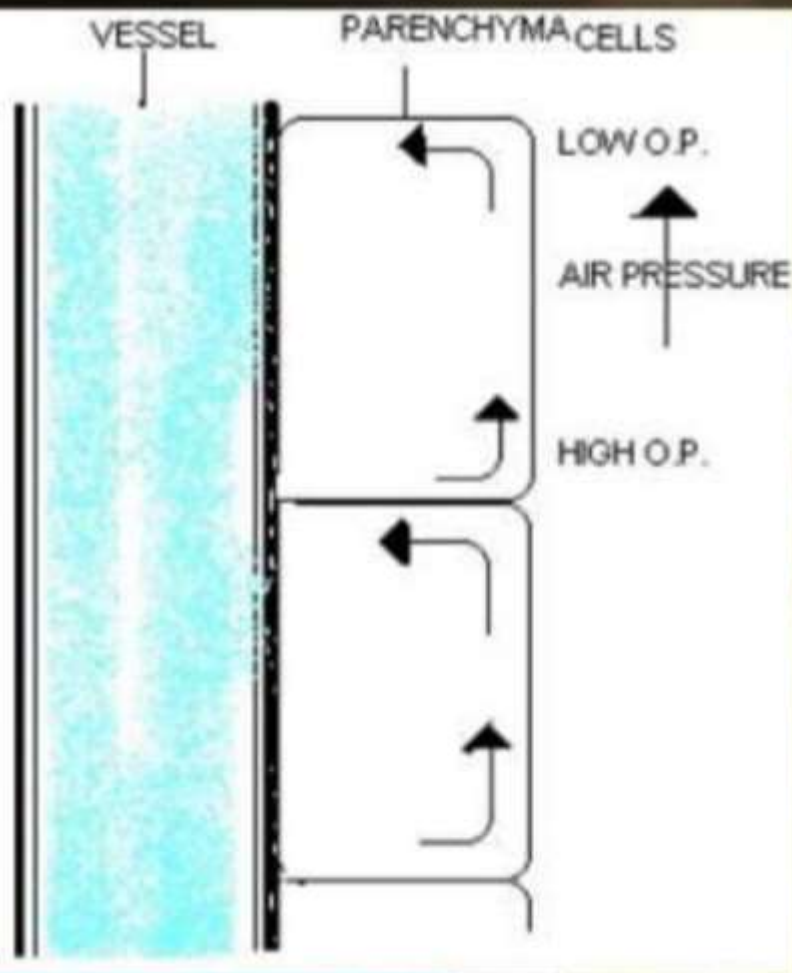
Theories of Ascent of Sap

VITAL FORCE THEORY

According to these theories the forces required for ascent of sap are generated in living cells of plants. Some of the important vital force theories are GODLEWSKI RELAY PUMP THEORY AND PULSATION THEORY.

Theories of Ascent of Sap

Godlewski relay pump theory

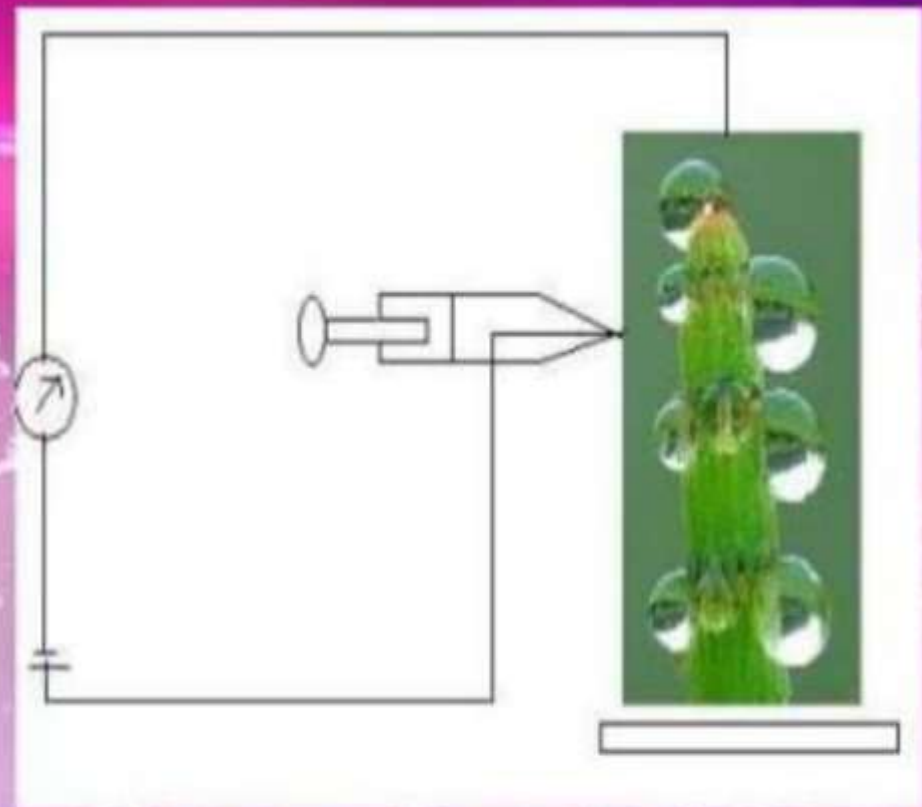


- Due to rhythmic change in O.P. of xylem elements
- Living cells absorb water by osmosis
- And finally water is pumped into xylem vessel due to lowering of pressure in living cells
- Thus staircase type of movement occurs

Theories of Ascent of Sap

Pulsation theory { sir J.C. Bose }

- Living cells of innermost layer of cortex had rhythmic pulsations.
- These pulsations are responsible for the upward movement of water.
- Fine needle attached to galvanometer was inserted in plant stem
- Galvanometer shows slow oscillations but when it touched cortex cells it turned violent indicating that the cells were pulsating.



Theories of Ascent of Sap

Root pressure theory ..

- When watered plant is cut near base xylem sap flow out at the end with a pressure.
- Mainly observed in herbaceous plants
- Water oozes out due to bleeding
- This is due to hydrostatic pressure inside root c/a root pressure
- Root pressure appear due to osmotic pressure.
- If root is supplied with isotonic or hypertonic solution root pressure disappears.

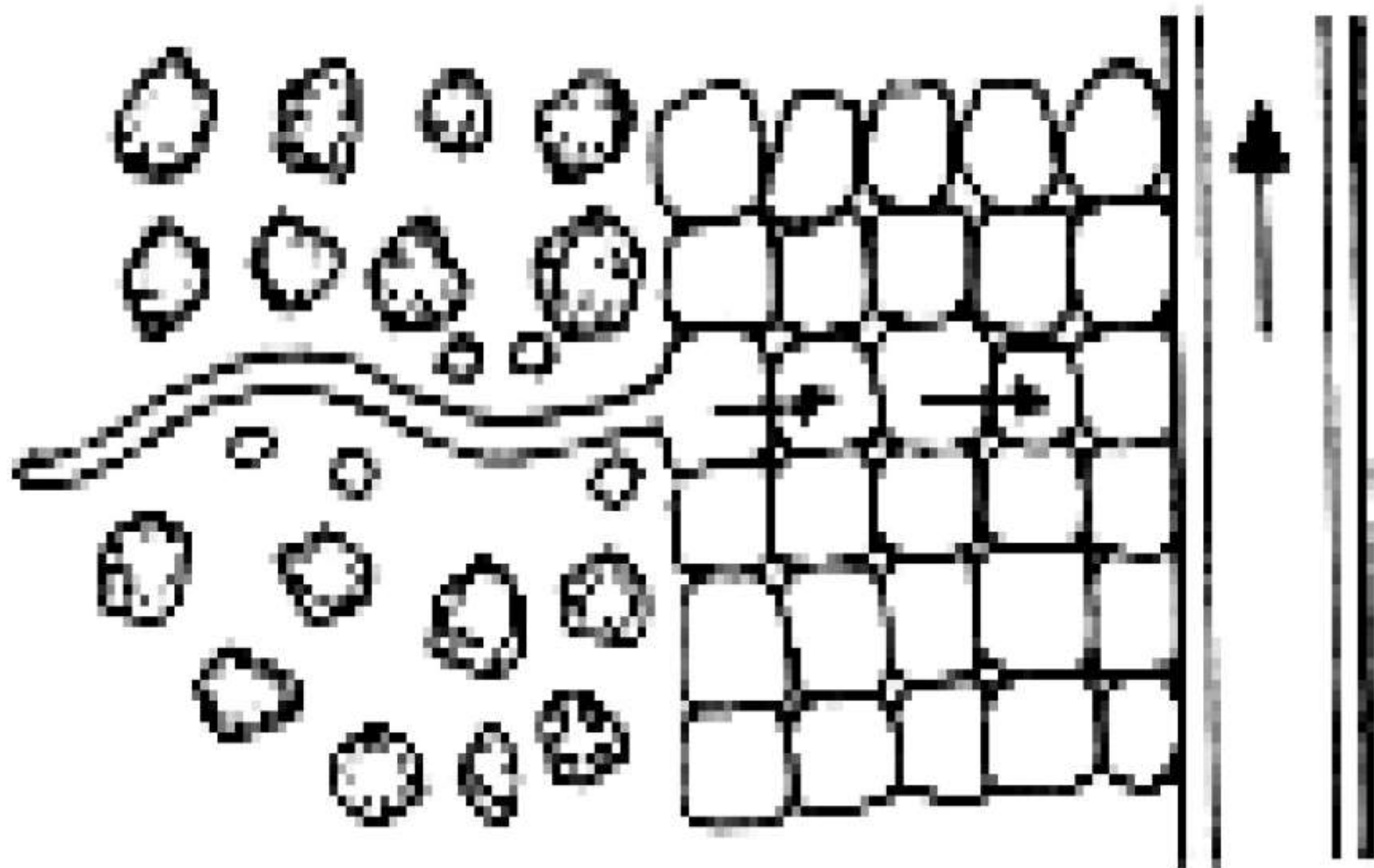


Theories of Ascent of Sap

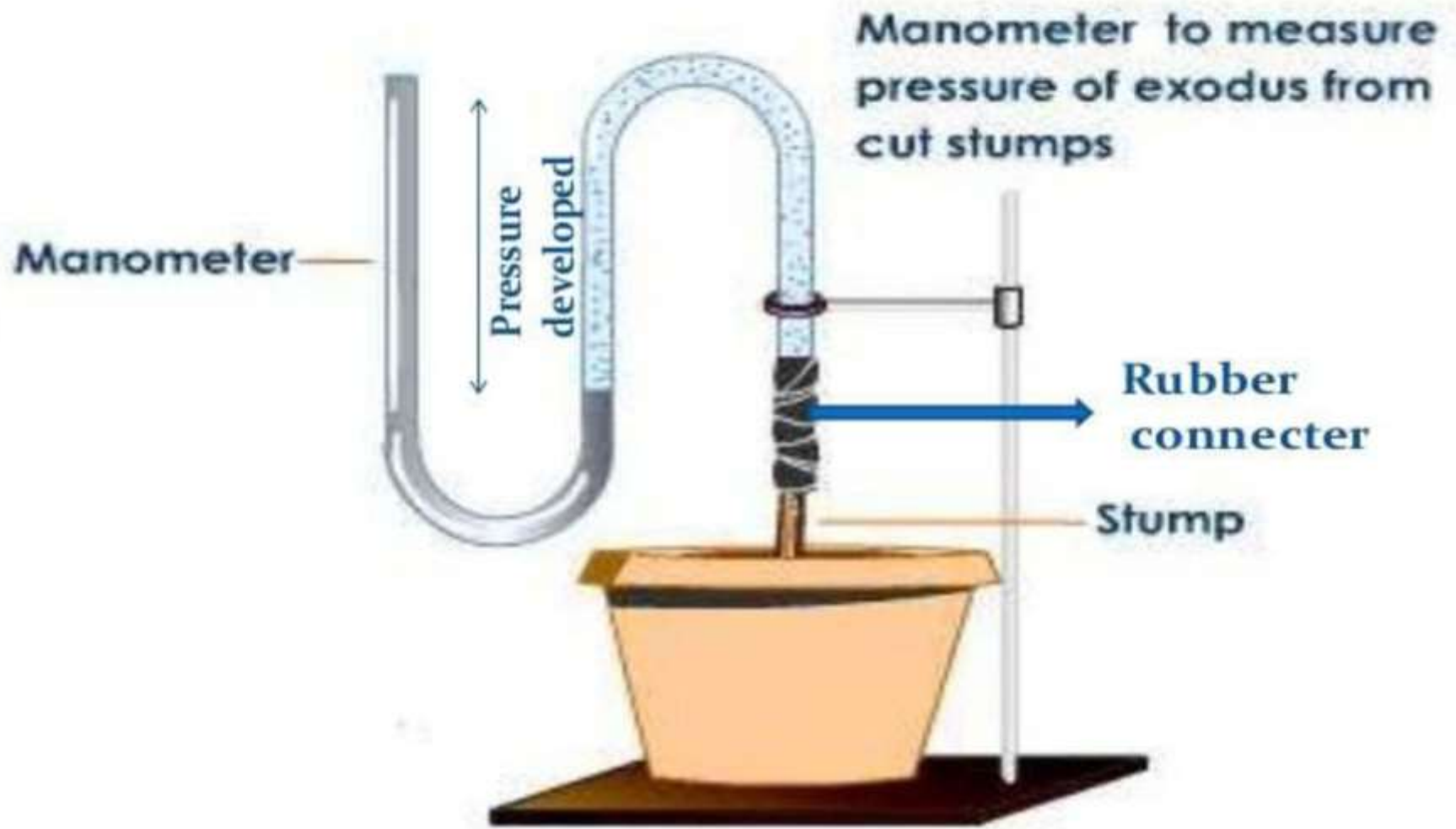
Root Pressure

- ❖ The surrounding soil water is hypotonic to the cell sap of root hair because it contains salt, sugar and amino acid.
- ❖ Therefore, water diffuses into root hair by osmosis.
- ❖ The entry of water into root hair dilutes its cell sap to become hypotonic to the adjacent cells.
- ❖ The water moves again to the next cell until it crosses the cortex tissue by osmosis.
- ❖ This water concentration gradient existed in the cortex creates a force called **root pressure** to push water into xylem.

Theories of Ascent of Sap



Theories of Ascent of Sap

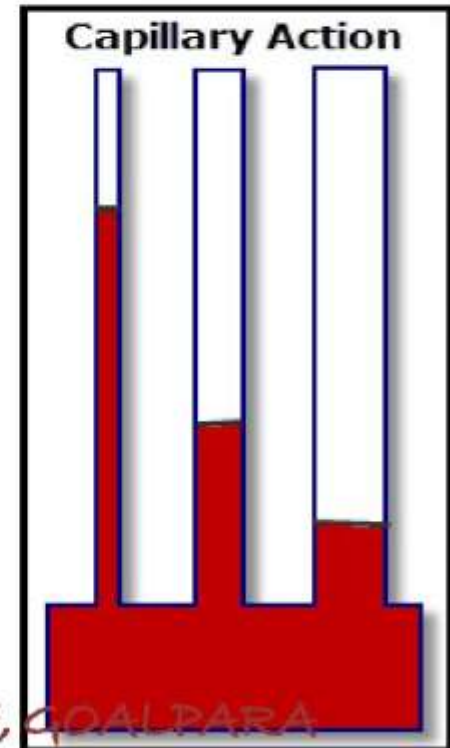


Experiment to demonstrate root pressure-B

Theories of Ascent of Sap

Capillary Action Theory

- Capilarity is the raising of water in a narrow tube due to surface tension.
- Capillary action is a combination force of cohesion and adhesion which enable the water move up along the narrow xylem vessel.
- Cohesive force is the attraction of one molecule to other molecule of water.
- Meanwhile, adhesive force is the attraction between water molecules and the wall of xylem vessel.
- Therefore, xylem vessel forms a continuous Column of water from root through the stem to the leaf.



Theories of Ascent of Sap

Imbibitional force :

- Water rises by imbibition through the thick walls of the xylem cells, as well as of the sclerenchyma of the phloem.
- The forces of imbibition seem adequate for carrying water to any required distance.
- This imbibitional force works with the other forces to aid in the ascent of sap.
- The magnitude of imbibition force may be upto 1000atm.
- But discarded due to the fact that water moves in the lumen of xylem vessel rather than through the wall.

Theories of Ascent of Sap

Transpiration pull and cohesion theory:

- The theory was proposed by Dixon and Jolly (1894).

This theory is based on

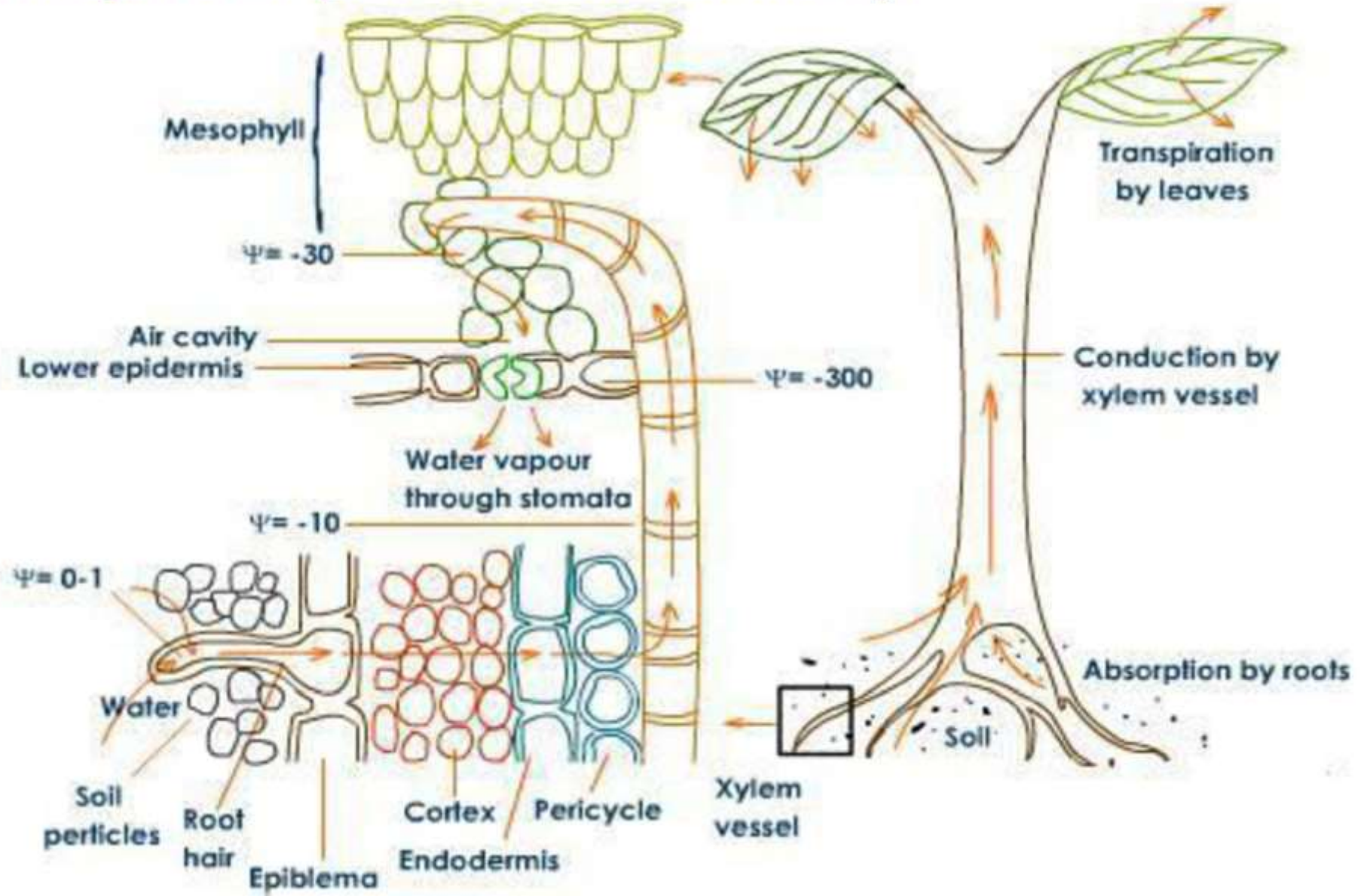
1. Cohesive and adhesive properties of water.
 2. Transpiration pull force developed in leaves by transpiration.
- Cohesion is the phenomenon of attraction between similar molecules. The water molecules remain attracted by the cohesive force.
 - There is attraction between water molecules and the inner wall of xylem by adhesive property.
 - Due to this water forms a continuous column in xylem vessel.

Theories of Ascent of Sap

- **Transpiration pull and cohesion theory:**
- During day time mesophyll cells loses water due to transpiration.
- As a result turgor pressure and water potential of mesophyll cells decreases.
- At the same time water potential of xylem vessels of leaf is high.
- The mesophyll cells sucks the water from xylem vessels.
- Due to this –ve force called transpiration pull force develops.
- This force moves to the xylem vessels and pulls water on upwards.

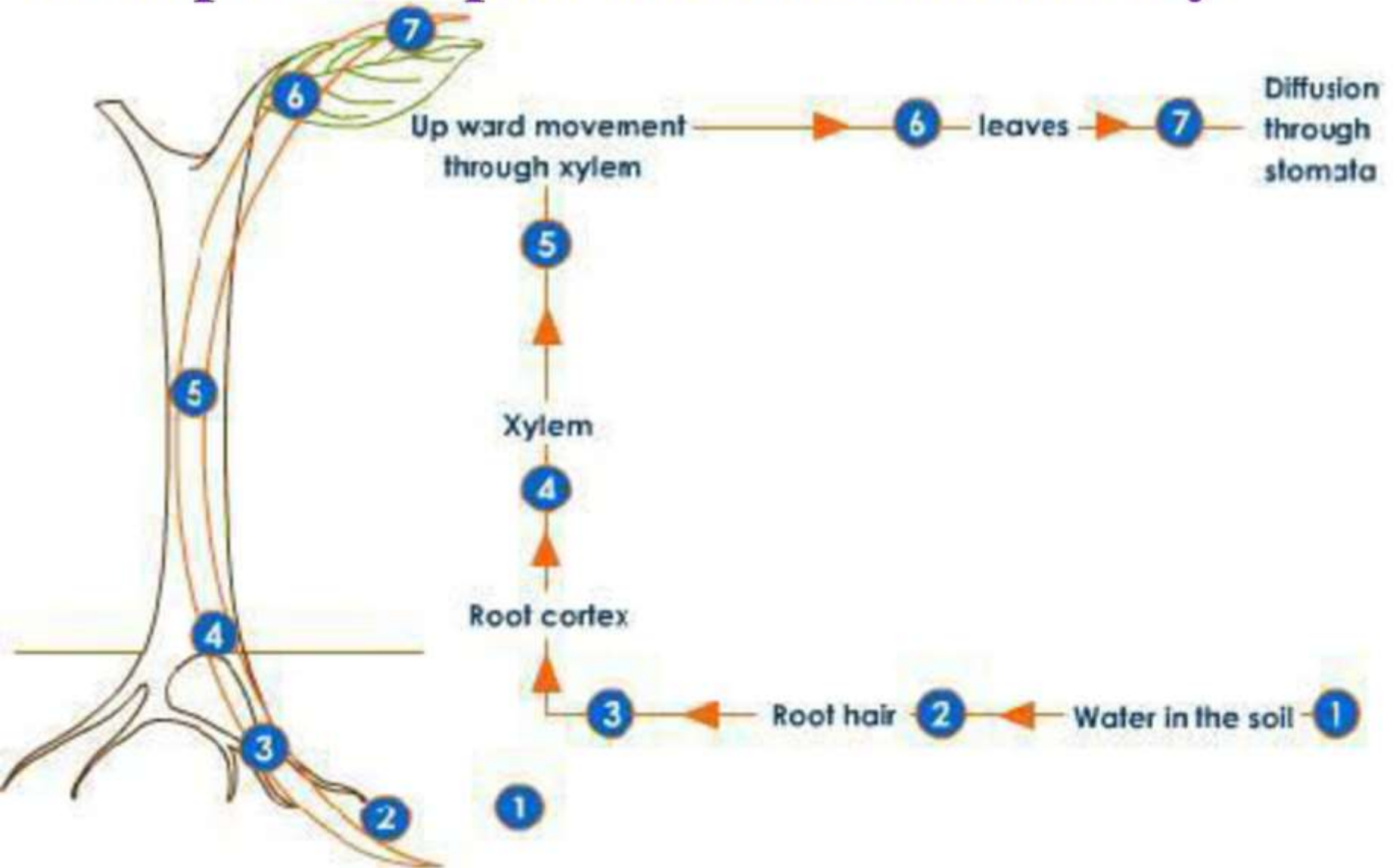
Theories of Ascent of Sap

Transpiration pull and cohesion theory:



Theories of Ascent of Sap

Transpiration pull and cohesion theory:



Theories of Ascent of Sap

EVIDENCE IN SUPPORT OF COHESION TRANSPIRATION PULL THEORY

1. Transpiration pull developed in the aerial regions at 50% RH in the air is more than 1000 bars.
2. Cohesive force that holds the water molecules in a column as narrow as xylem vessels is very strong and they withstand the opposing transpiration and gravitational pulls.
3. Because of the opposing forces, tension develops in the water column. As a result, xylem elements become slightly narrow. This results in the contraction and expansion of the stem which has been demonstrated by using dendrometer. The diurnal behavior of rhythmic contraction and expansion is a good evidence for the water column to be in tension which the transpiration is rapid or not.
5. The forces that operate cohesion transpiration pull are just passive forces and no metabolic energy is involved in this phenomenon, because present the movement of water upwards.

THANK YOU