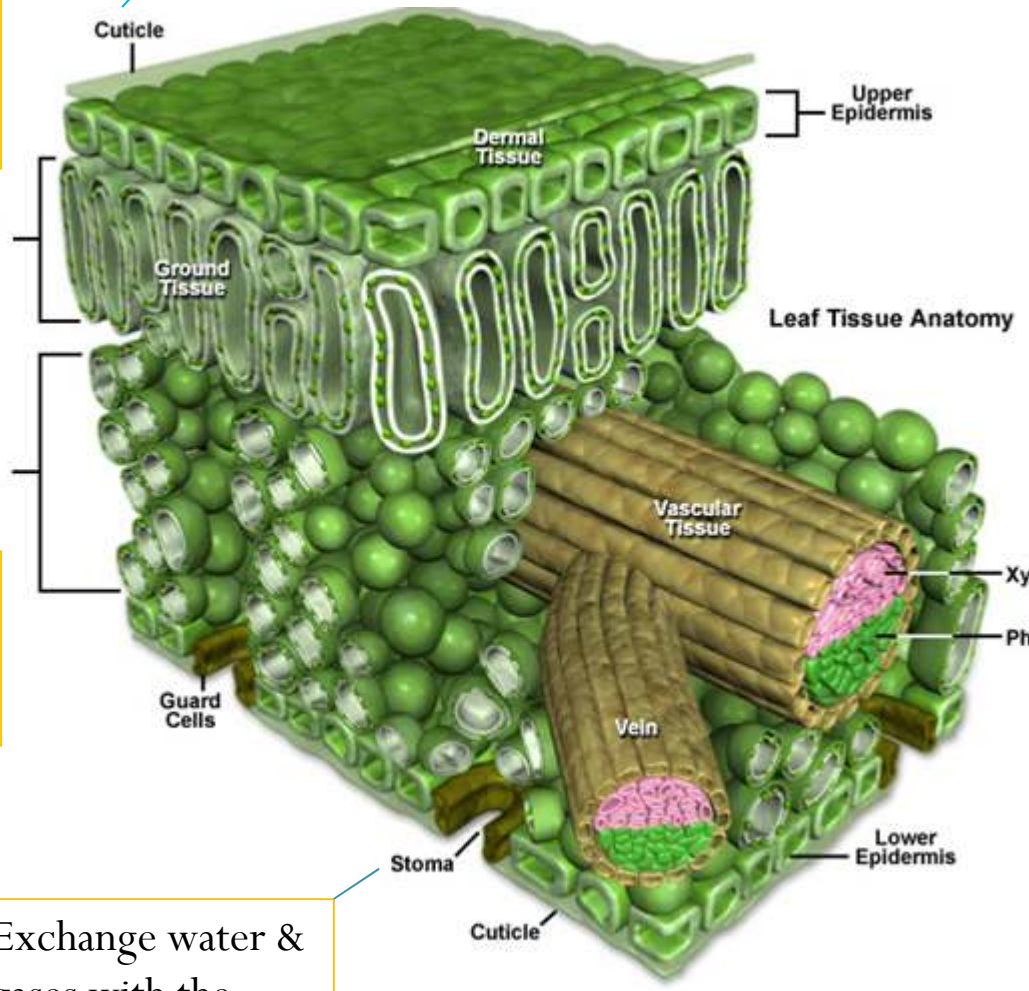

TRANSPORT IN PLANTS

Recap

Waxy layer which protects the plant & conserves water

Contains chloroplasts: Specialized for light absorption



Vascular Tissue

Layer contains air spaces: Specialized for gas exchange

Exchange water & gases with the atmosphere

What you will learn (Transport Structures)

- **Xylem vessels and phloem (Vascular Tissue)**
  - Know their positions and functions within a ***dicotyledonous*** leaf and stem, under light microscope
- **Root**
  - Understand its structure (root hairs) and functions
  - Facilitate water & ion (minerals) uptake

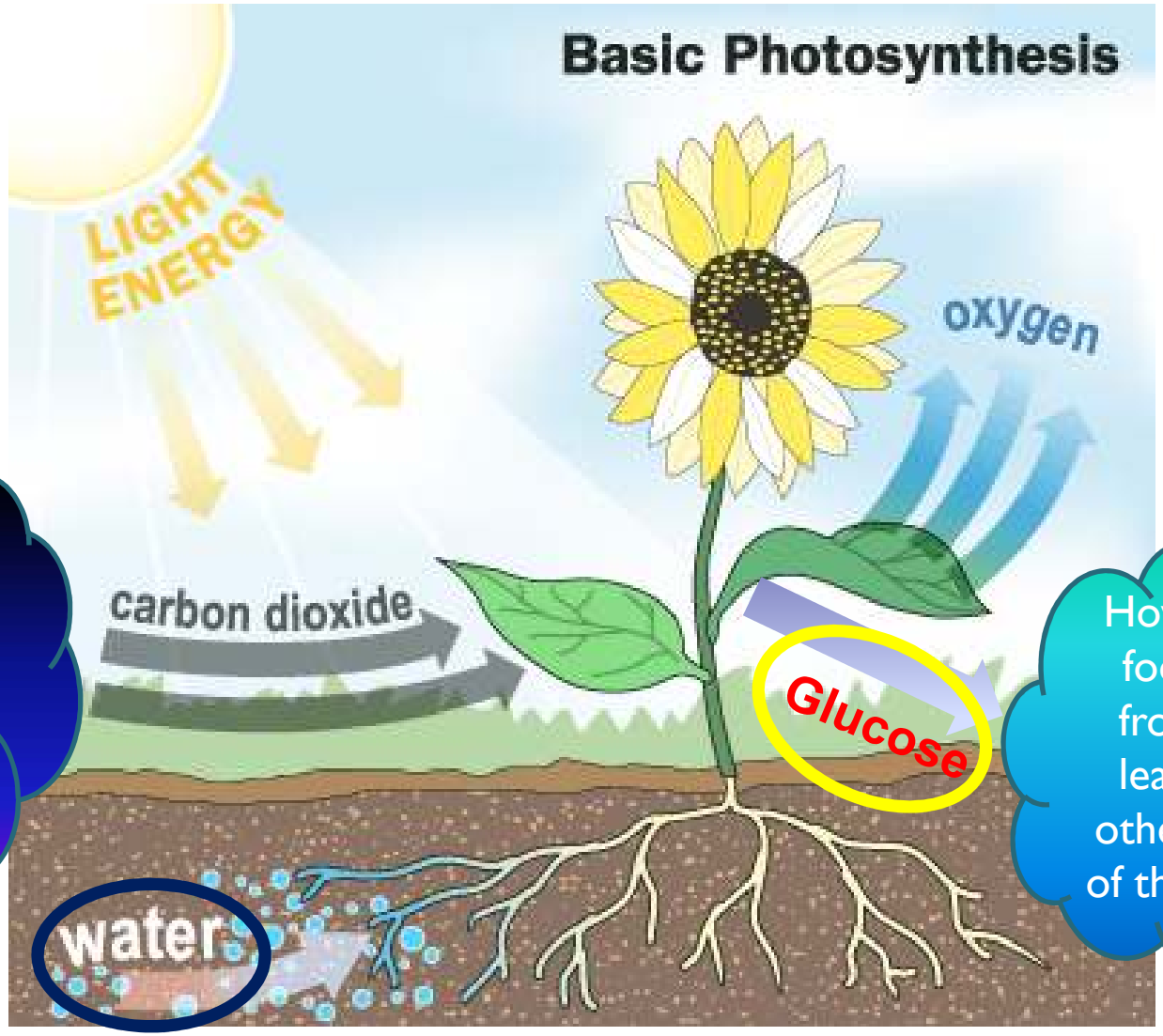
What you will learn (Transport of water)

- Briefly explain the **movement of water** from the roots to the leaves
  - Through Xylem Vessels
- Define the term '**transpiration**'
  - Understand that transpiration pull helps to move the water upwards; from the roots to the leaves
  - Create a water potential gradient
- **4 Factors** affecting transpiration rate

What you will learn (Transport of Food)

- **Translocation** (Transport of food)
  - Through Phloem tissue
- Briefly illustrate translocation through **translocation studies**
  - Using aphids
  - The Ringing Experiment
  - Using Radio-isotopes
- Wilting
  - Advantages and Disadvantages

Recall on Photosynthesis

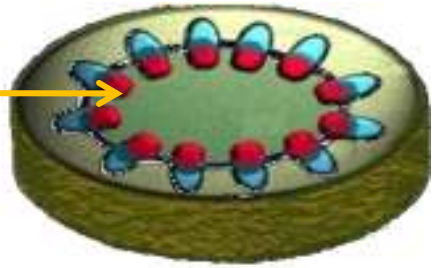


How does water get absorb from the soil into and move around the plant?

How does food get from the leaves to other parts of the plant?

Transport Structures

Xylem



Long hollow tube extending from the root to the leaves

Structures

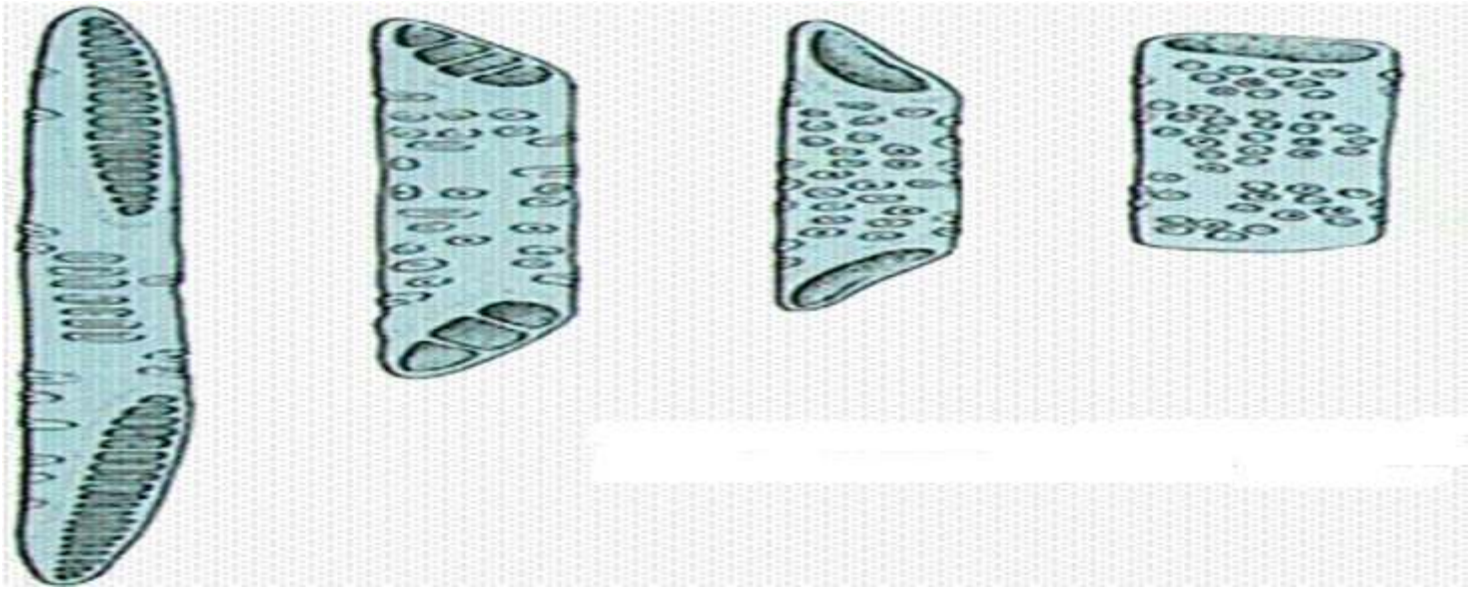
1. Dead tissue
2. Long and empty lumen

Water transport

3. Walls are thicken strengthen with lignin

Mechanical support

Development of Xylem

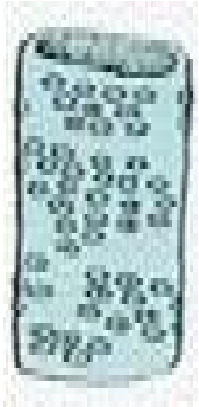


Tracheids → **Xylem vessels**

Xylem tissue contains

Xylem cells (Tracheids) and **Xylem vessels**

- **Tracheids (Xylem Cells)**
  - Long, tapered cells with pitted walls that transport materials upwards
  - At maturity,
    - **lignin** can be seen deposited at the cell walls and the tracheids gradually dies
    - **no cytoplasm**

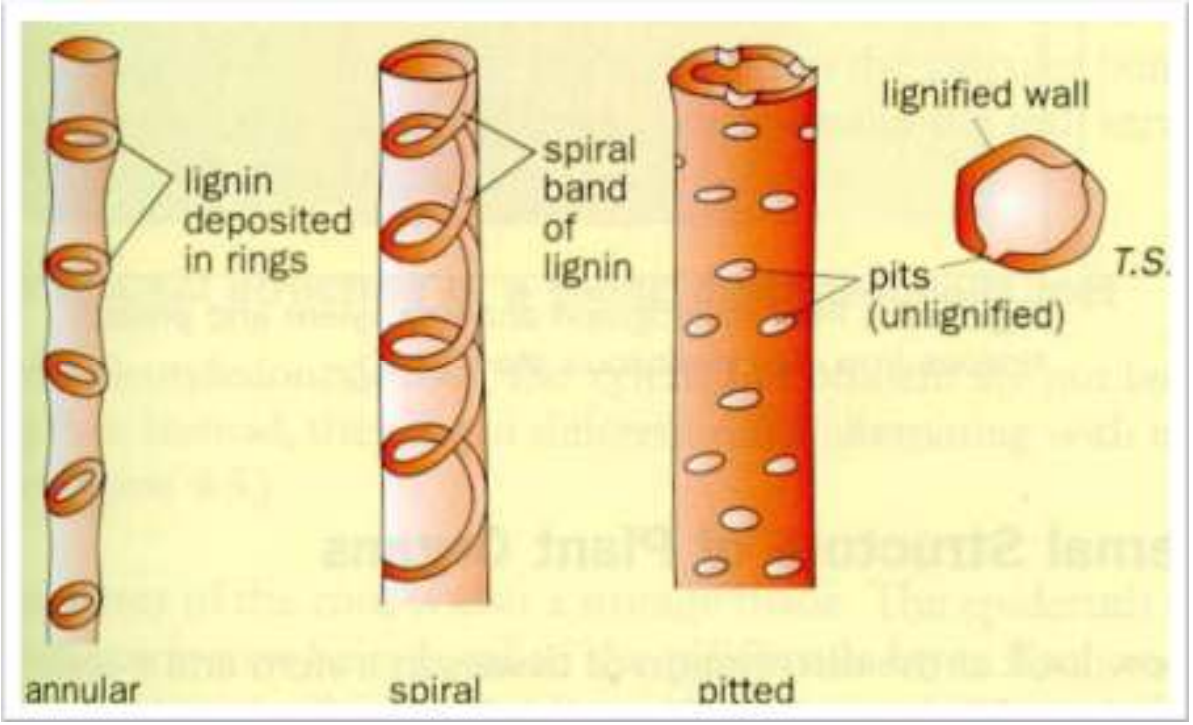


- **Xylem Vessels**
  - Long continuous, nonliving hollow tube
  - **No cytoplasm**
  - Walls are strengthened by **lignin**

Xylem vessels are essentially mature stage Tracheids

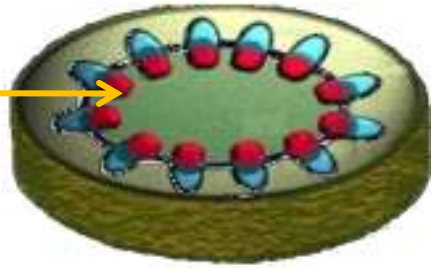
Lignin

- Hard and rigid substance
- Named after the latin word "Lignum", which means "Wood"



- Lignin maybe deposited in different ways, giving rise to annular, spiral or pitted xylem vessels

Xylem



2 Functions

a) Conducts water and dissolved minerals from the roots to all other parts of the plant

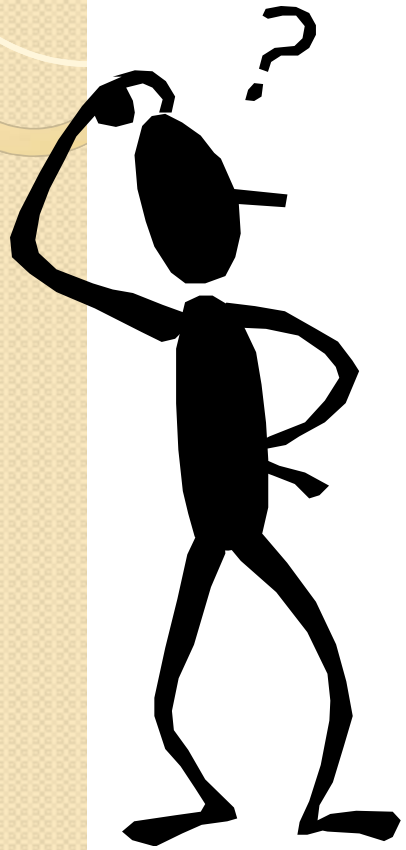
b) Provides mechanical support to the plant due to the presence of lignin

2 Adaptations

a) Having a continuous lumen without any protoplasm within to hinder transport of water & dissolved minerals

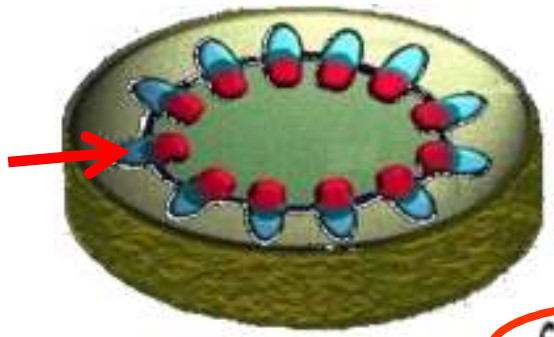
b) Having lignified walls which prevent collapse of the vessels

Do you know?



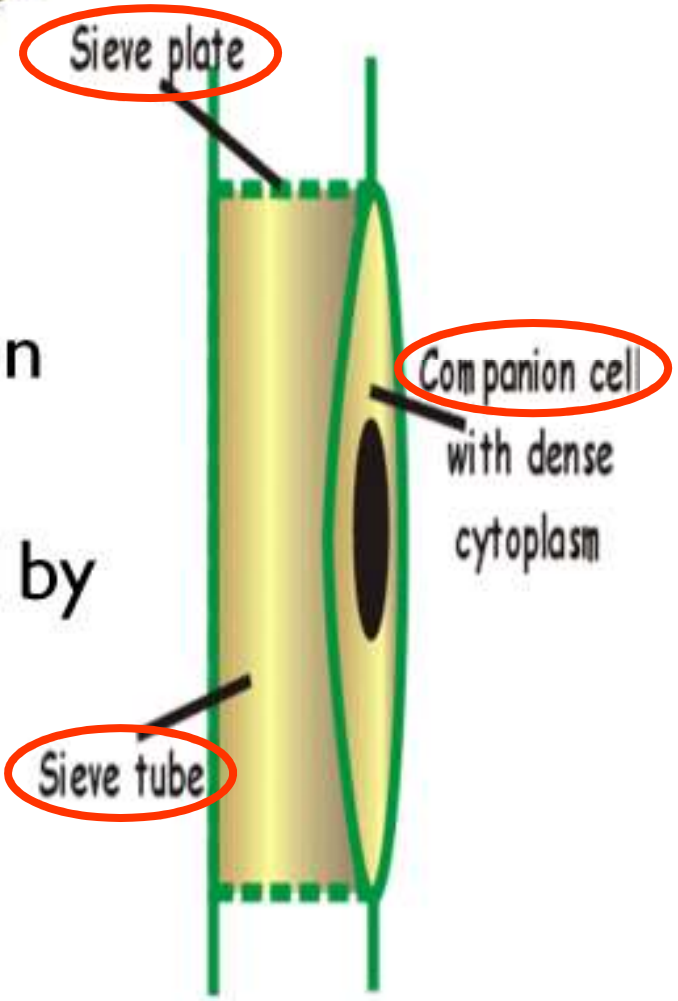
A CLOSE LOOK AT TREE RINGS THAT ARE MADE OF XYLEM.

Phloem



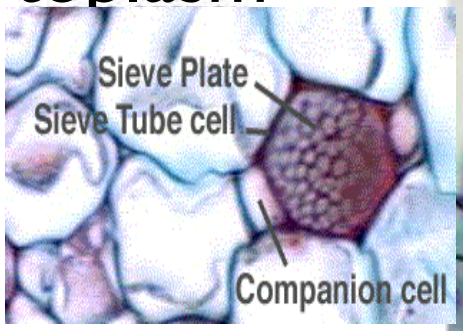
Structures

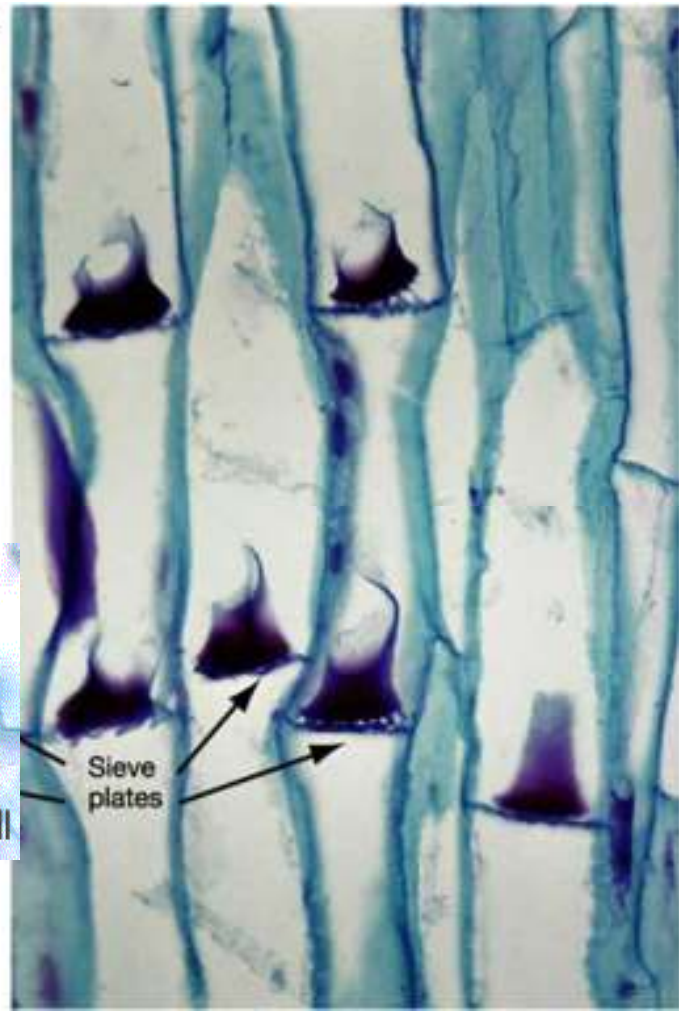
- Consists of a column of sieve tubes and companion cells
- Sieve tubes are separated by sieve plates



Sieve Tubes

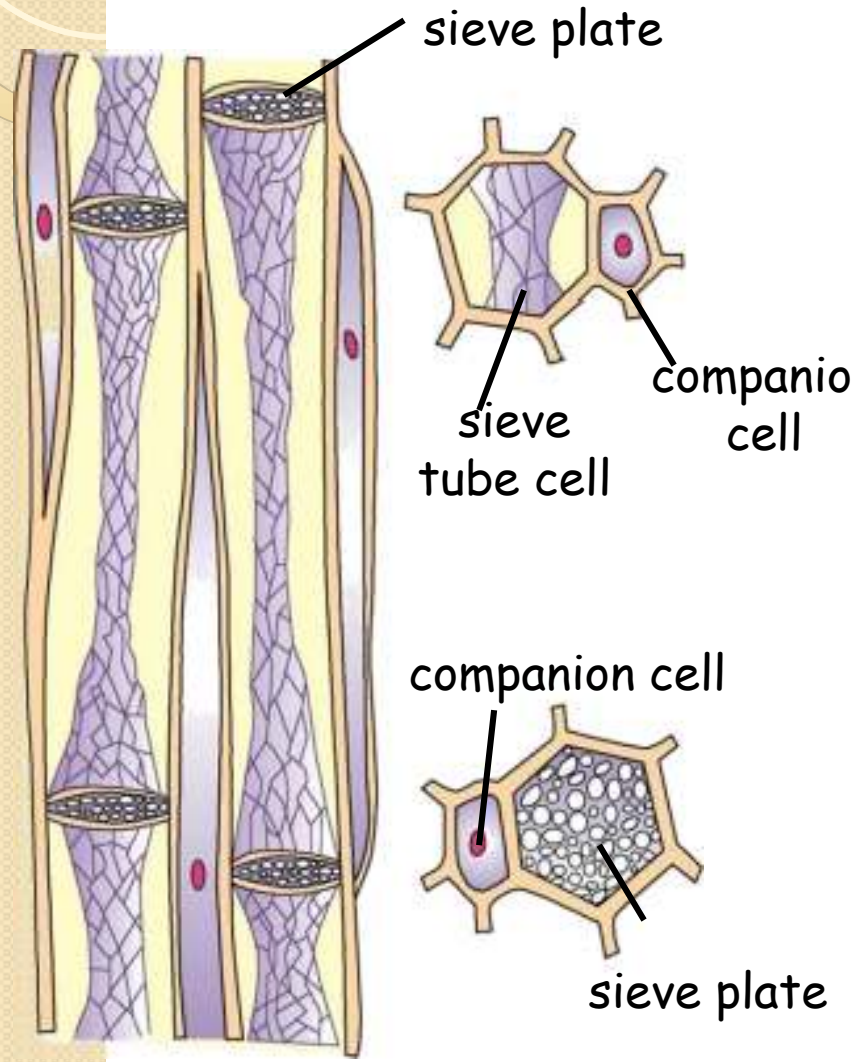
- Degenerate Protoplasm
  - No vacuole
  - No nucleus
  - Presence of cytoplasm





Cytoplasm remains so that concentration gradient of manufactured food can be maintained

Companion Cells



Narrow, thin wall with abundance of cytoplasm and a nucleus

Functions

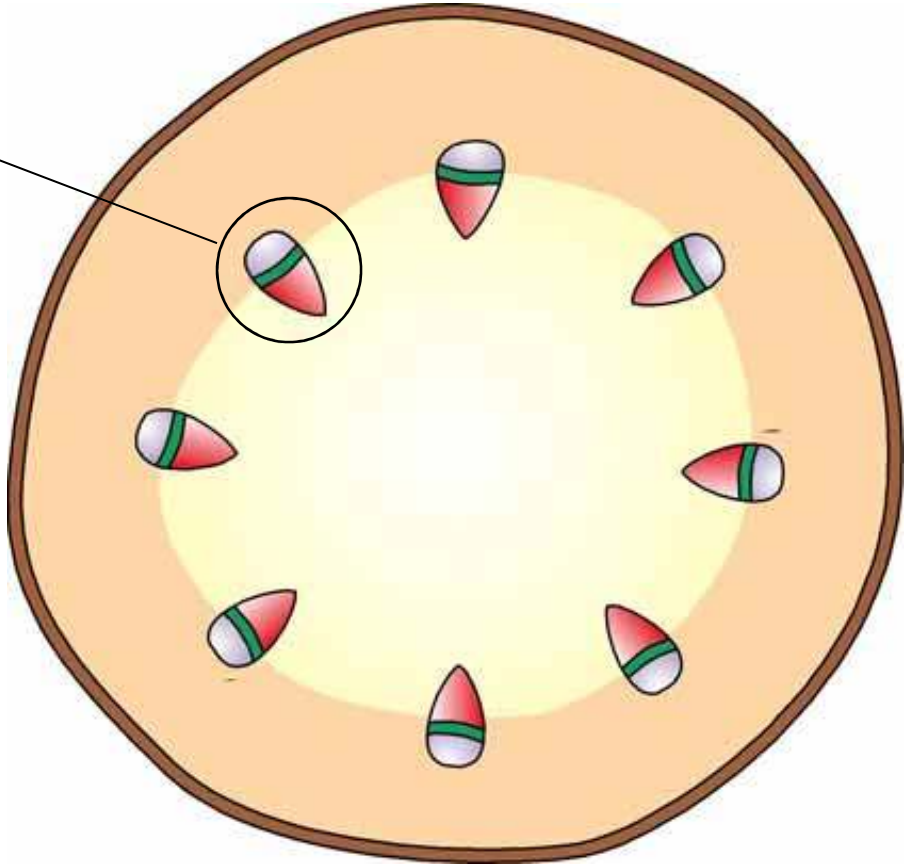
a) Keep the sieve tube alive
   - Provide nutrients

b) Contains many mitochondria
   - Provide energy for translocation

Organization of vascular tissue in **Stem**

1. Vascular Bundle

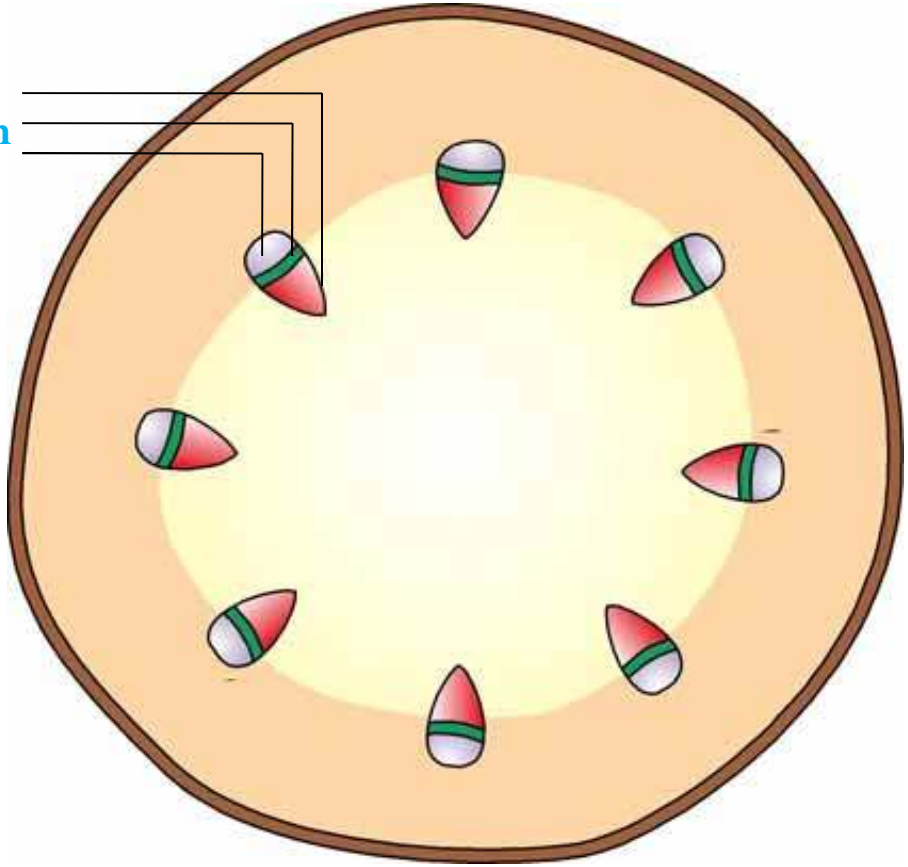
The xylem and phloem are grouped together to form the vascular bundles



Organization of vascular tissue in **Stem**

1. Vascular Bundle
2. Cambium

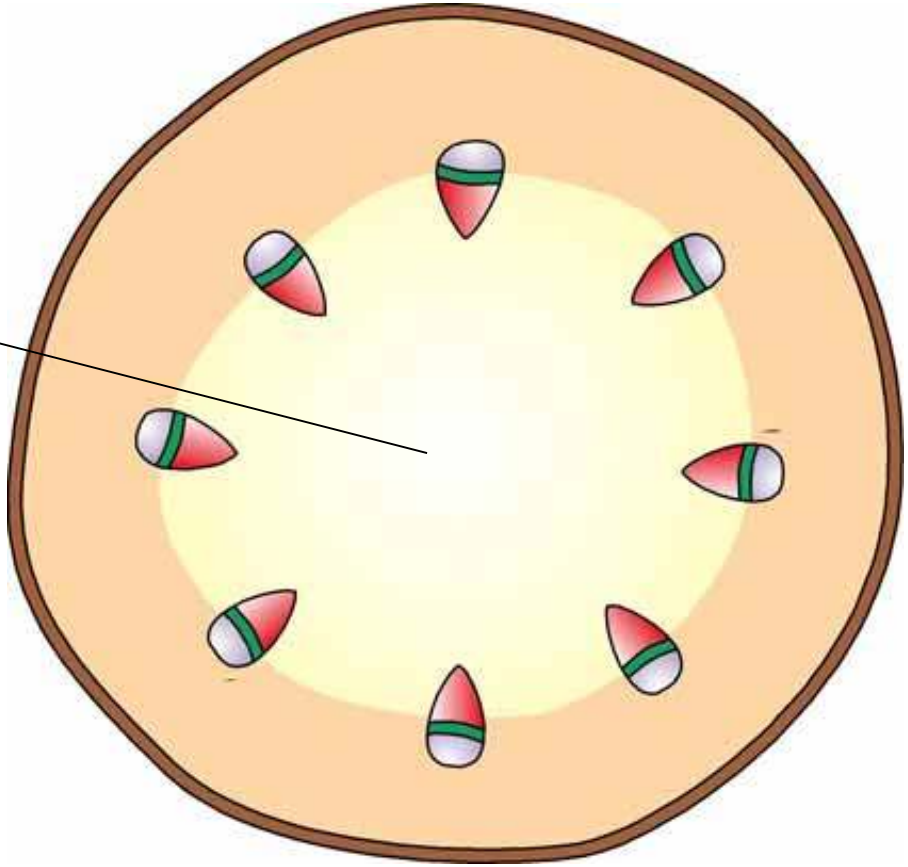
Cambium cells can divide to give rise to new xylem and phloem tissues, hence thickening of the stem



Organization of vascular tissue in **Stem**

1. Vascular Bundle
2. Cambium
3. Pith

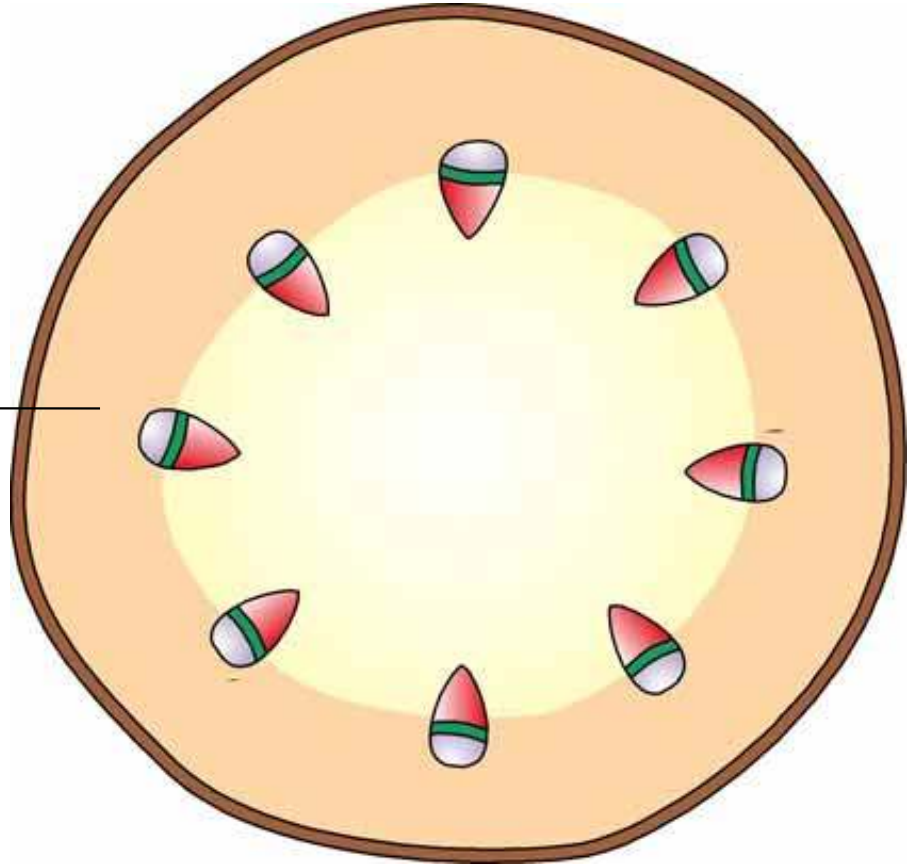
The vascular bundles are arranged in a ring surrounding a central region called pith which serves as a storage tissue



Organization of vascular tissue in **Stem**

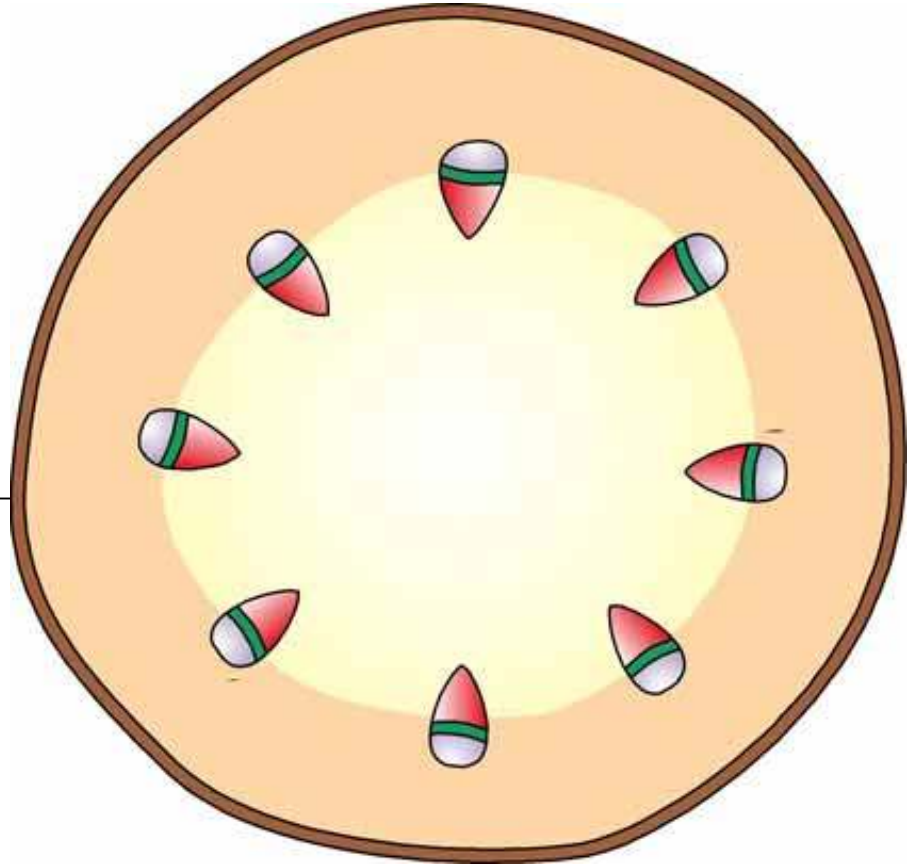
1. Vascular Bundle
2. Cambium
3. Pith
3. Cortex

The region between the vascular bundles and epidermis is the cortex, which also serves as a storage tissue for food



Organization of vascular tissue in **Stem**

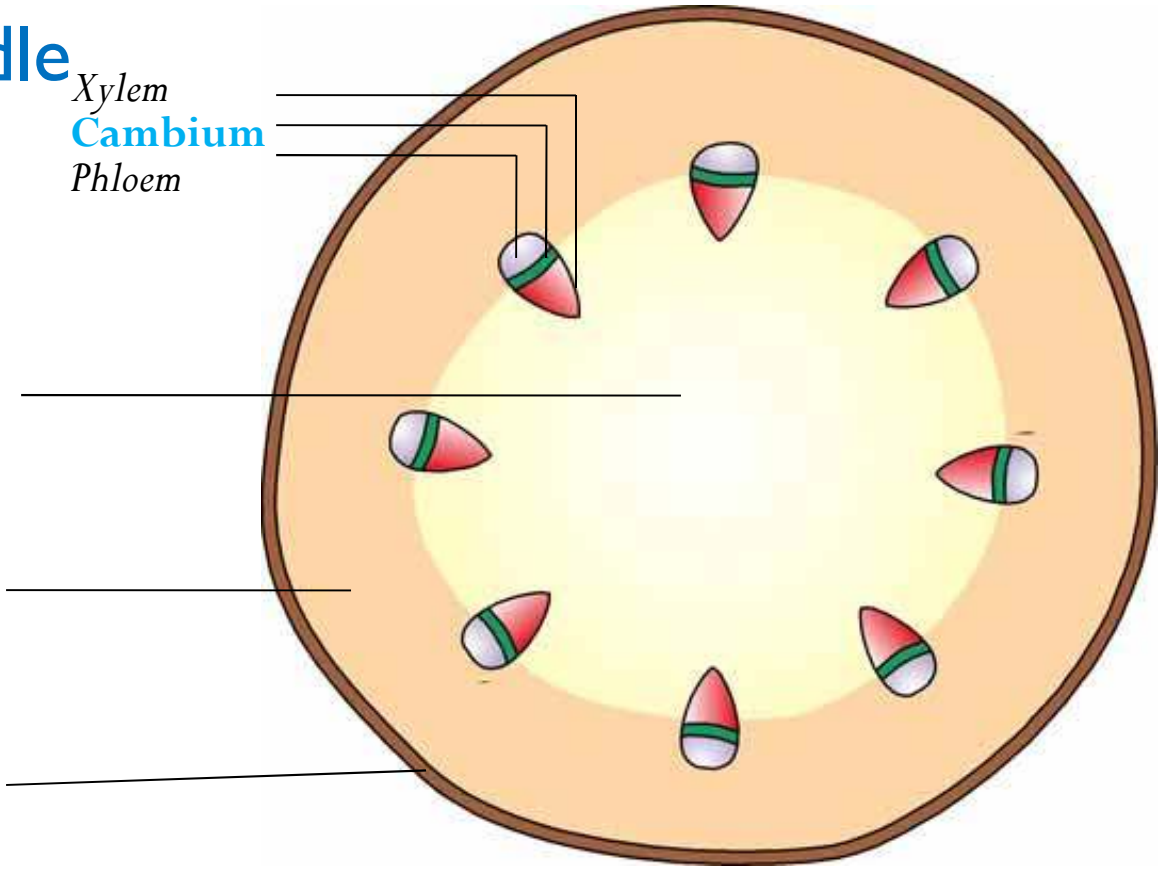
1. Vascular Bundle
2. Cambium
3. Pith
4. Cortex
5. Epidermis



The epidermal cells are covered with a layer of wax called cuticle which prevents excessive loss of water from the stem

Organization of vascular tissue in **Stem**

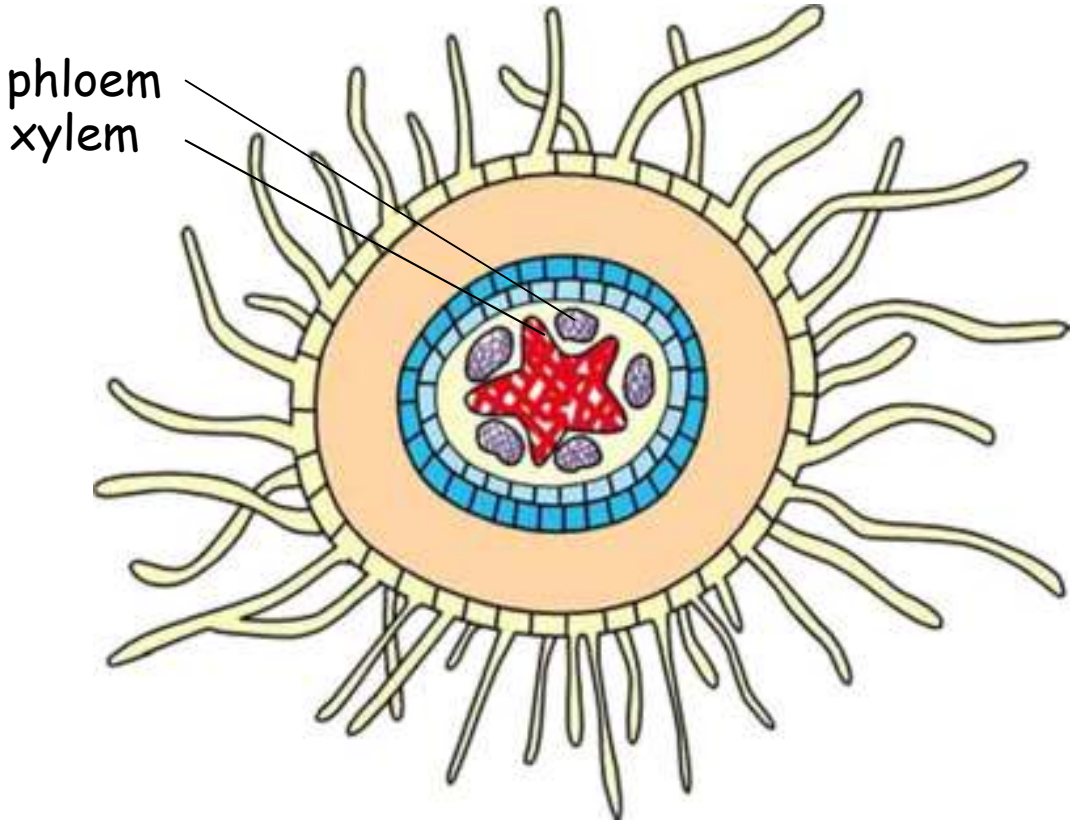
1. Vascular Bundle
2. Cambium
3. Pith
4. Cortex
5. Epidermis



Organization of vascular tissue in **Root**

1. Vascular Tissue

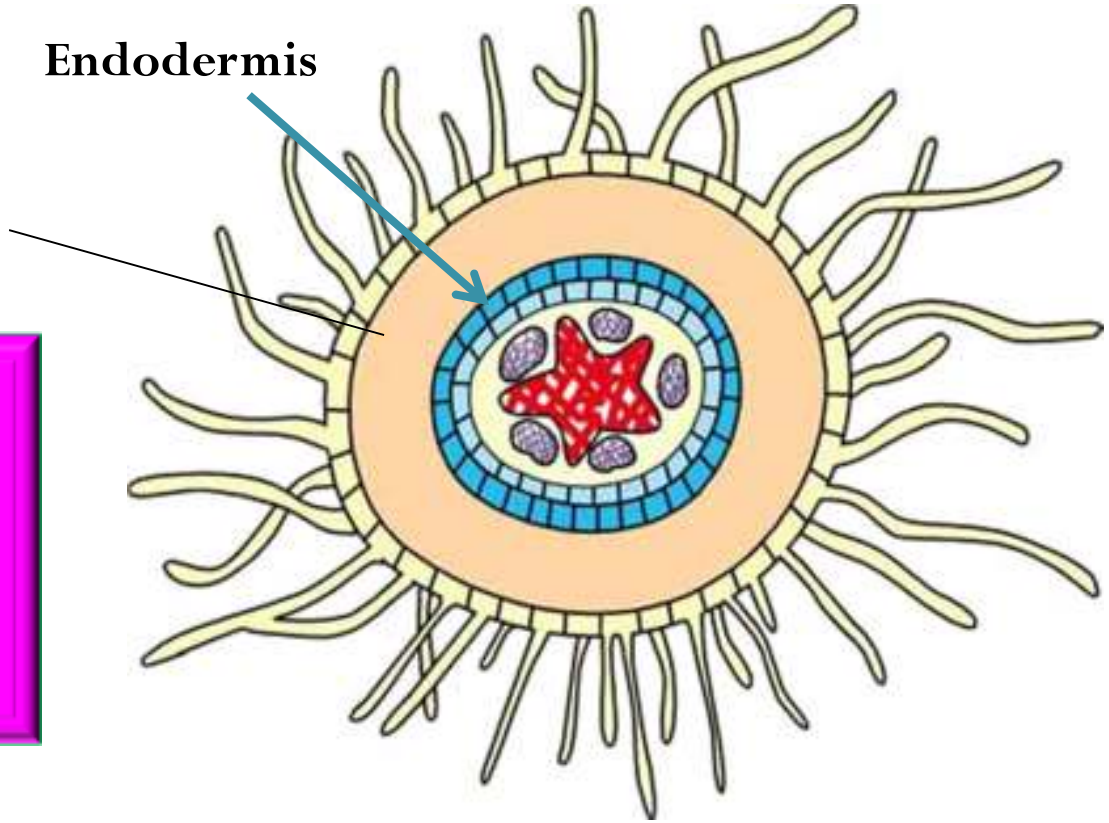
The xylem and phloem are **NOT** bundle together. They alternate with each other



Organization of vascular tissue in **Root**

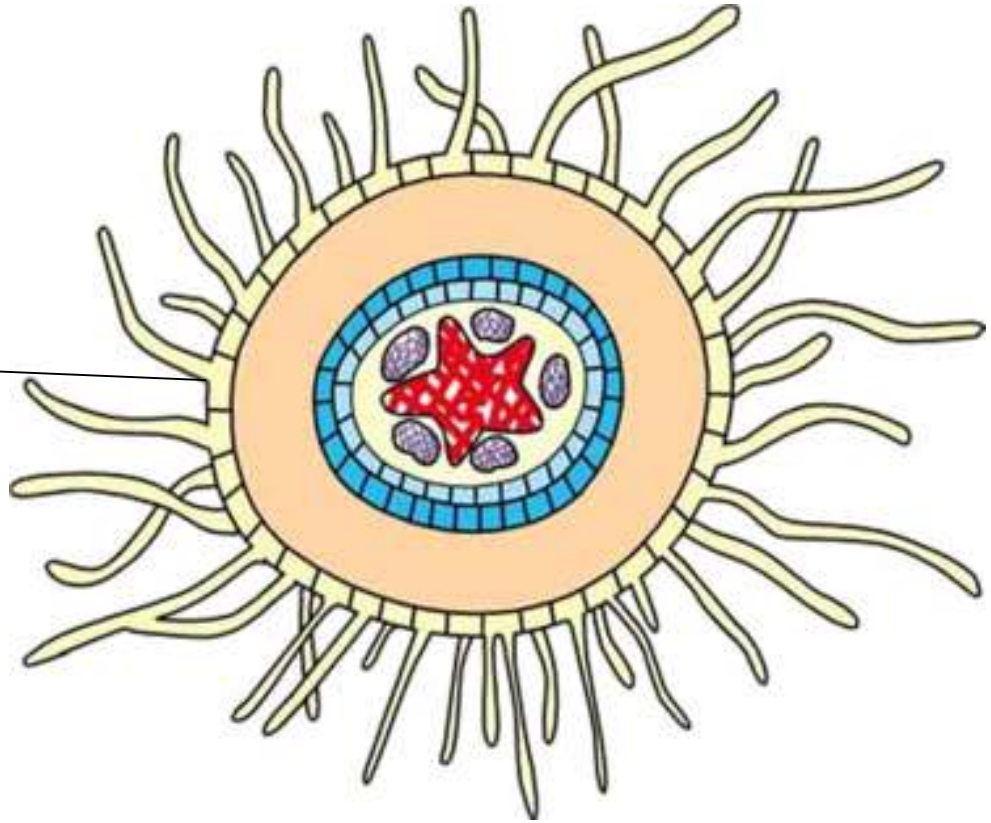
1. Vascular Tissue
2. Cortex

The region between the epidermis and the endodermis lies the Cortex, which serves as storage tissue



Organization of vascular tissue in **Root**

1. Vascular Tissue
2. Cortex
3. Piliferous layer

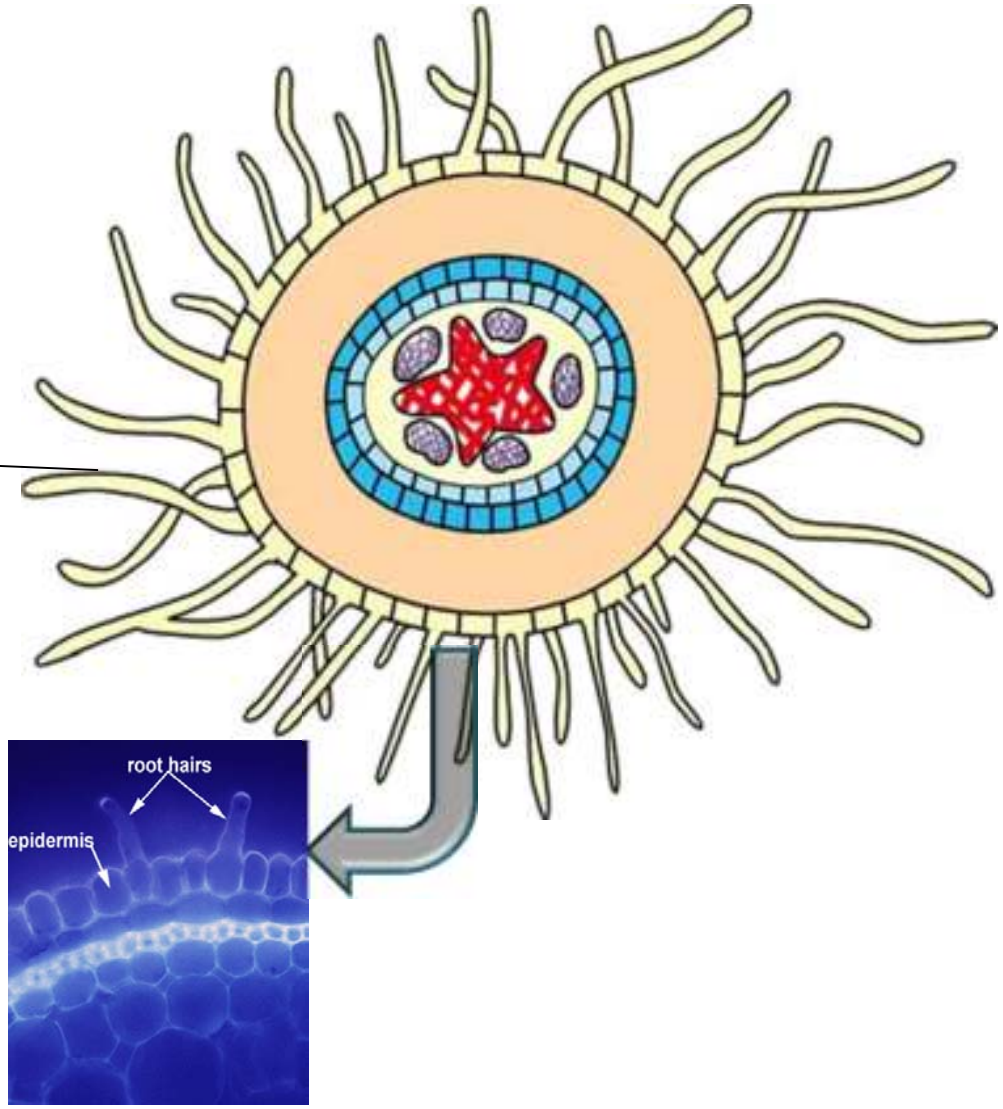


The epidermis of the root bearing the root hairs are called the piliferous layer.
NO cuticle is present!
Why?

Organization of vascular tissue in **Root**

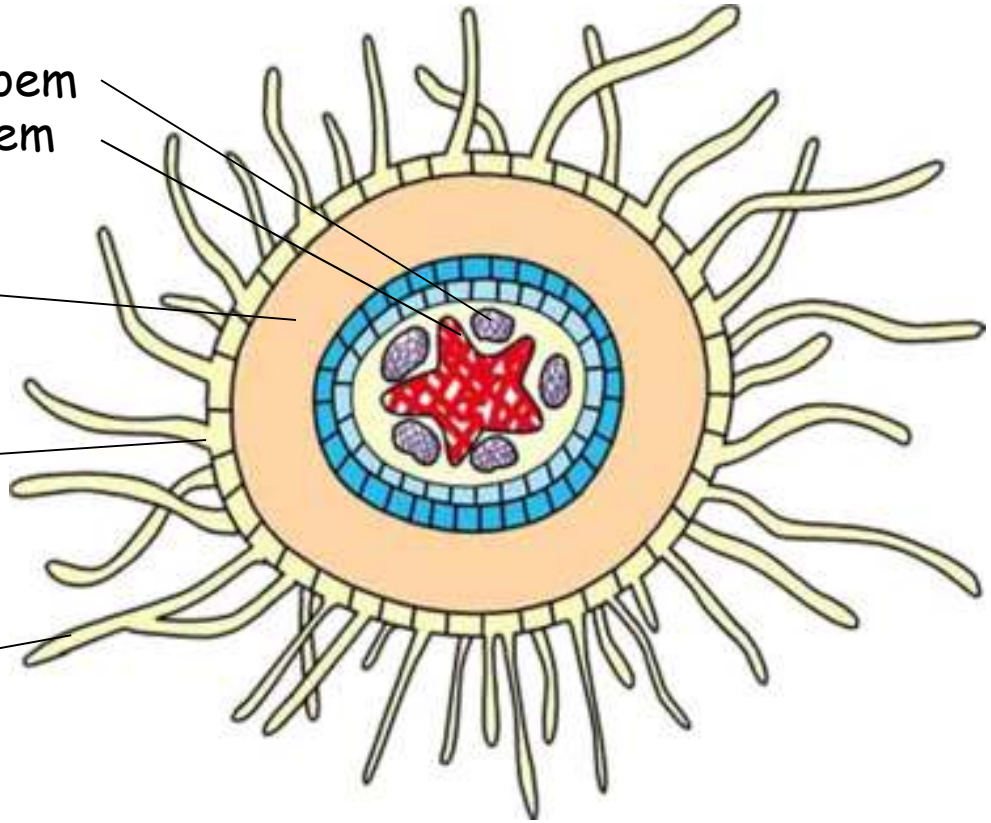
1. Vascular Tissue
2. Cortex
3. Piliferous layer
4. Root hair

Each root hair is a tubular outgrowth of an epidermal cell.



Organization of vascular tissue in **Root**

1. Vascular Tissue
2. Cortex
3. Piliferous layer
4. Root hair



NO distinct central pith &
Cambium between xylem and phloem

What are the functions and adaptations of Root/ Root hairs?

Functions

1. Anchor the plant
2. Specialized in absorption of water & dissolved minerals

Adaptations

1.Long and narrow

- **Increase surface area to volume ratio**

2.Cells are alive

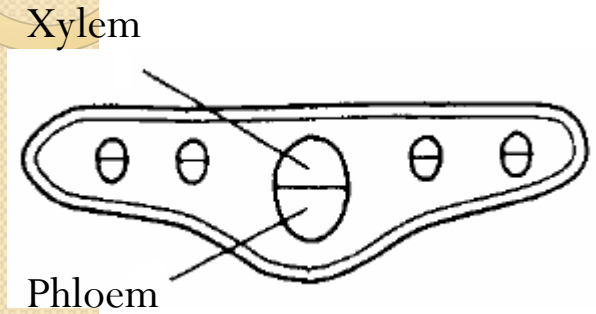
- **Provide energy for active transport**

3.Root hairs have cell sap of higher concentration than surrounding soil solution

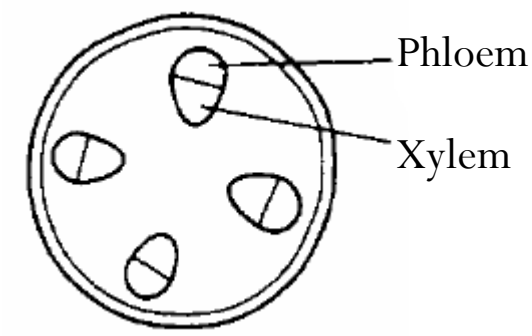
- **Cell sap contains sugar, mineral salts which helps to prevent water leaking out of cell. Assist in osmosis**

Transport Structures

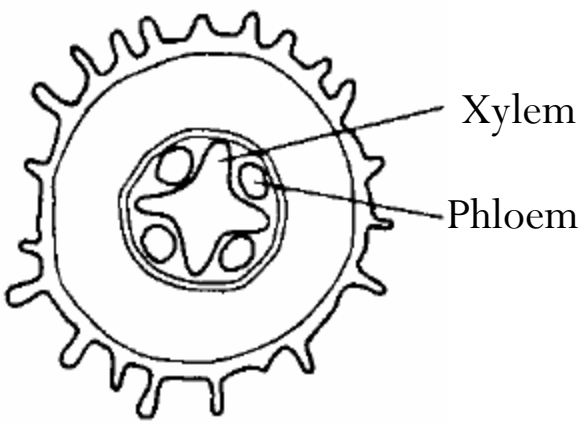
Leaf

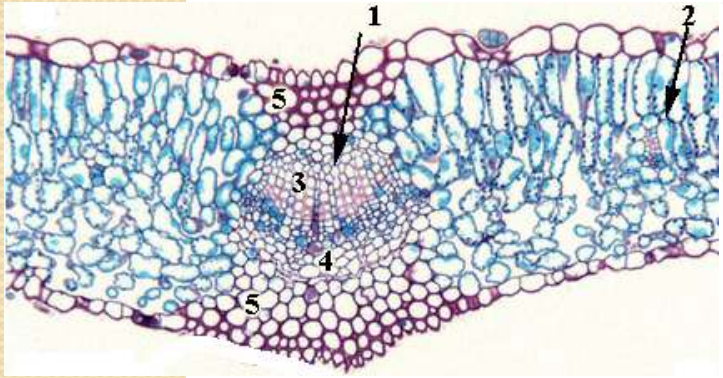


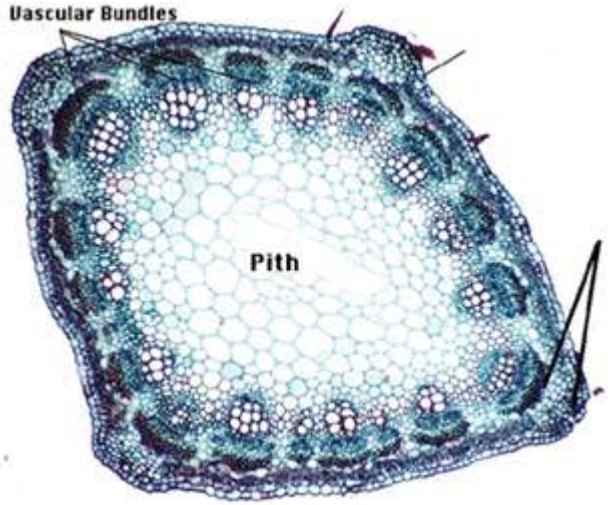
Stem

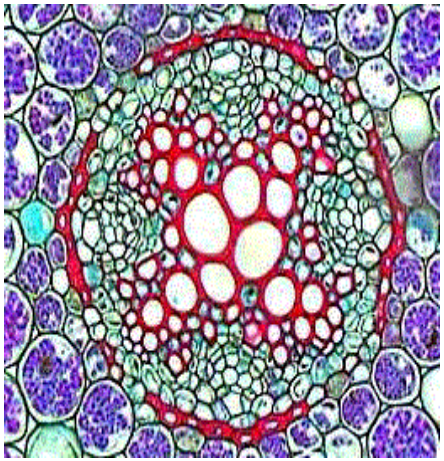


Root

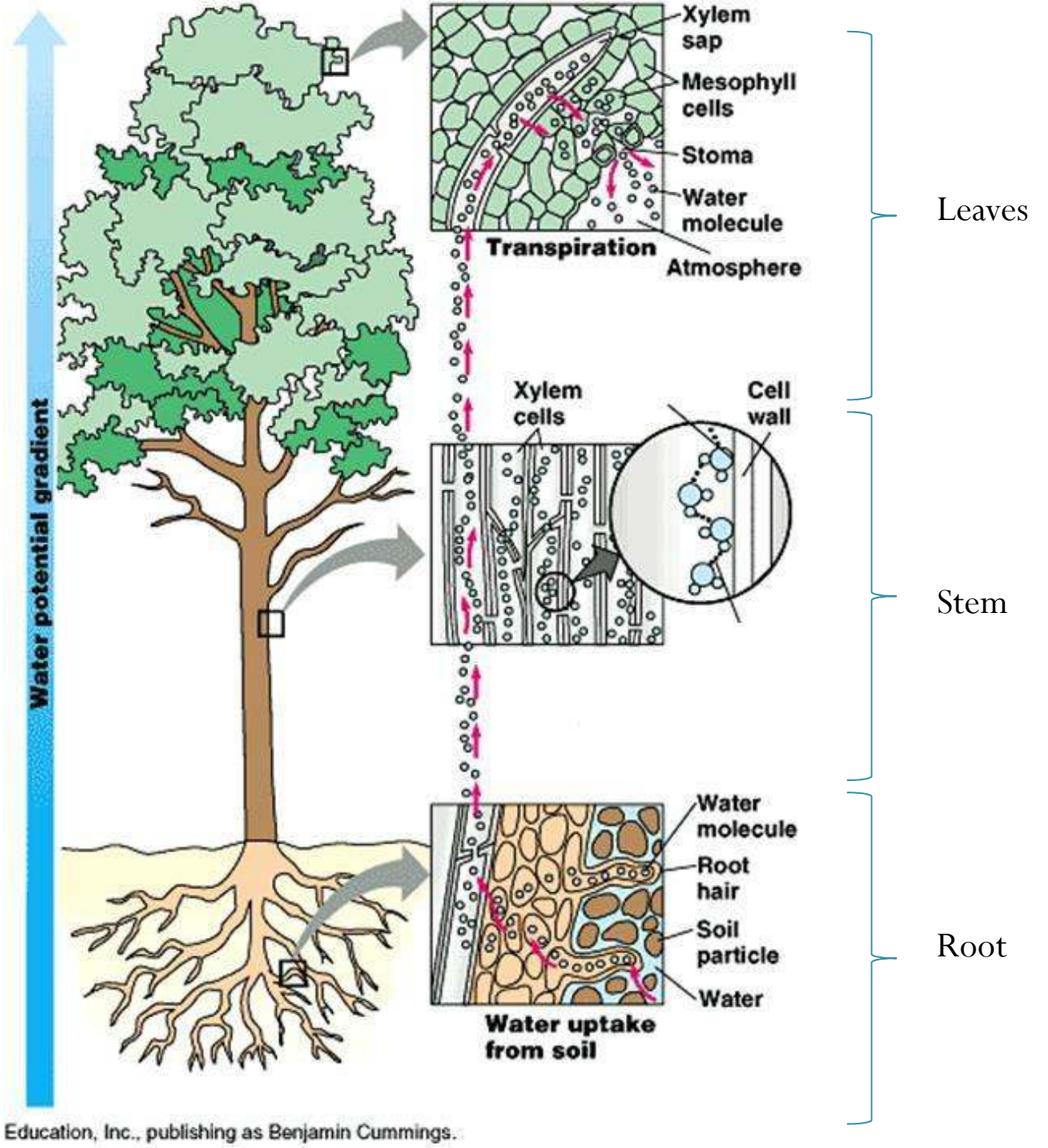








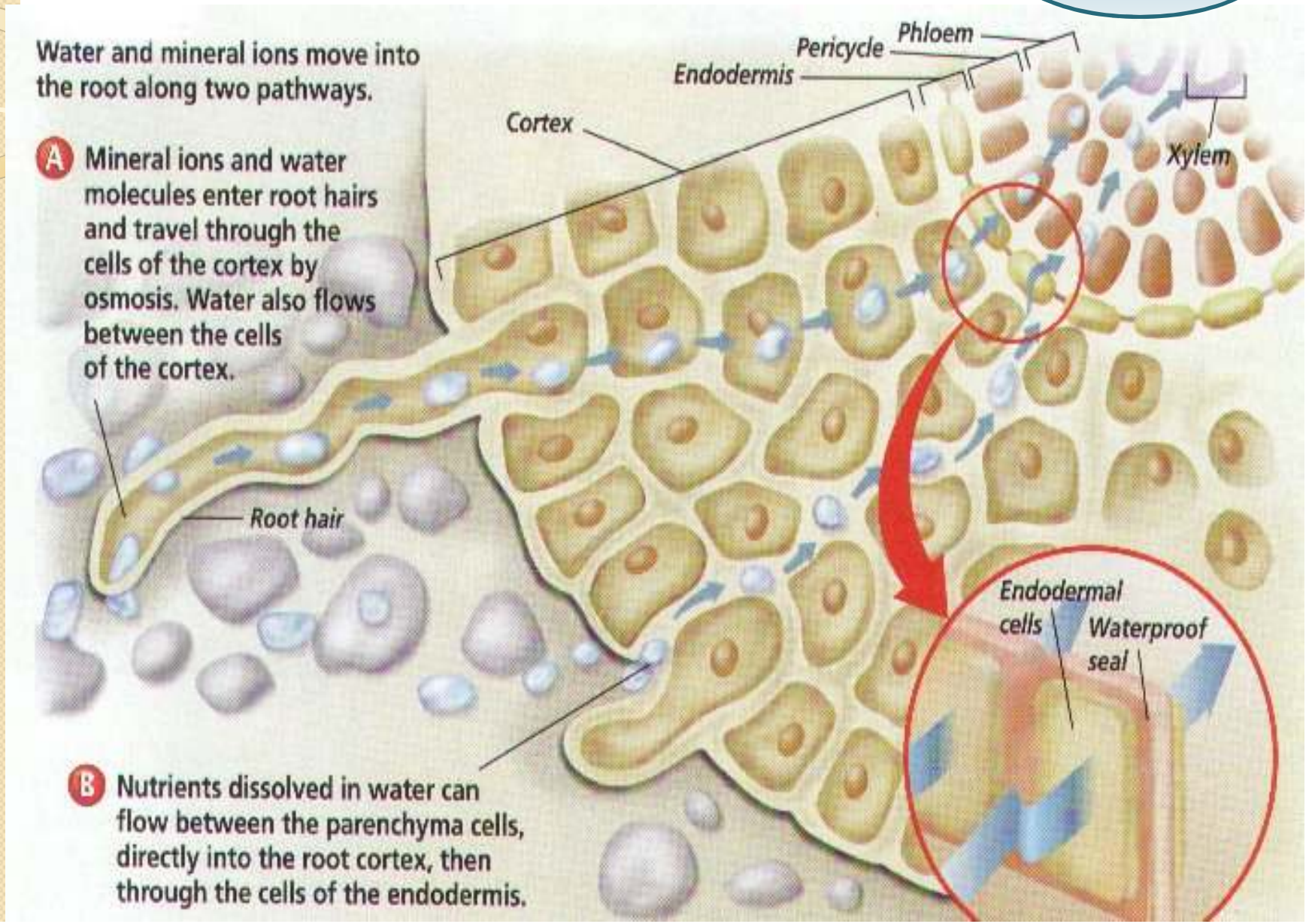
Transport of Water



Education, Inc., publishing as Benjamin Cummings.

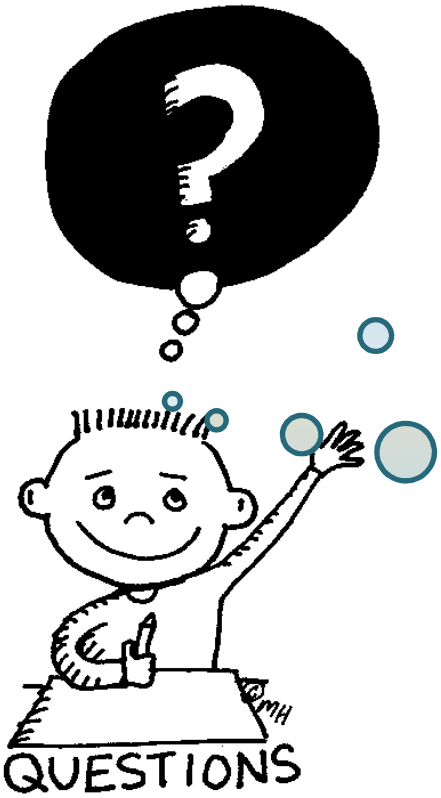
Water uptake in ROOT

Animation



Root Pressure

- Osmotic pressure that build up within the root cells which forces water up the root xylem

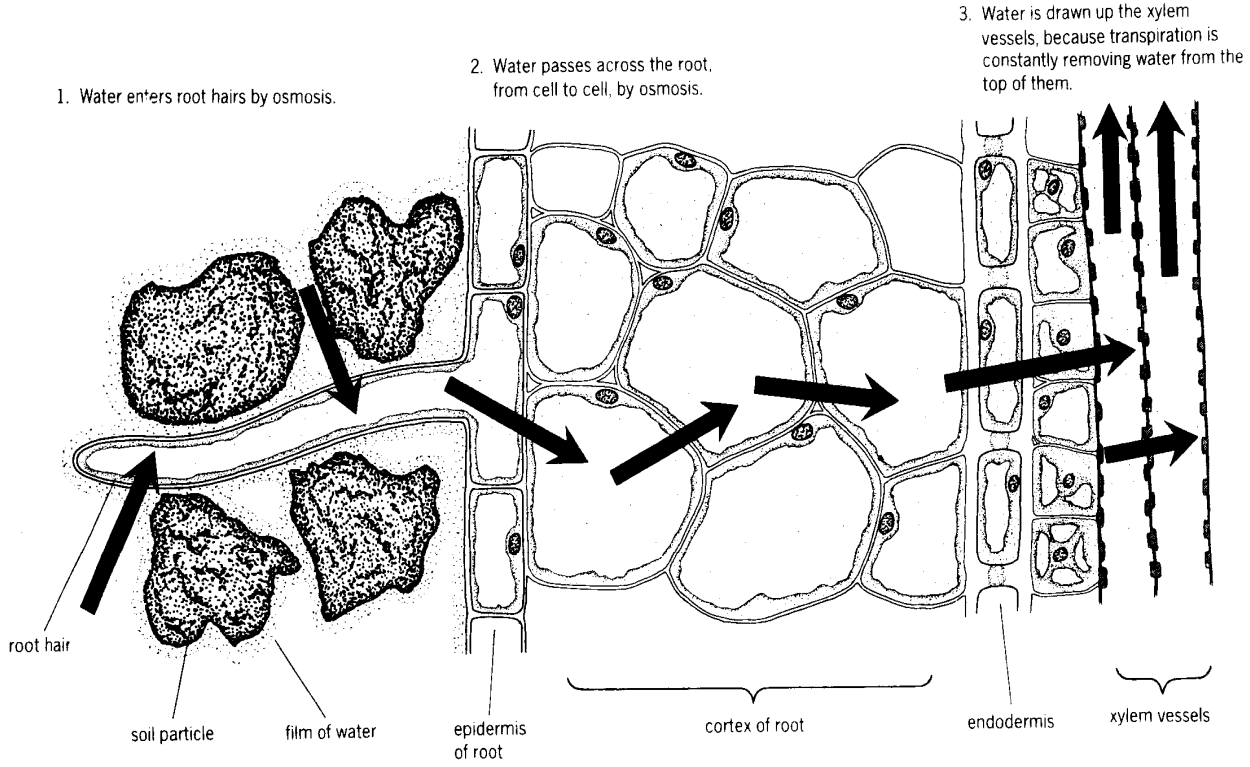


Recap on Osmosis

How does the root maintain a concentration gradient?

Root Pressure

- Uptake of water by the root hair by Osmosis
- Uptake of dissolved minerals through **active transport**
  - Cell sap within the root hairs becomes more concentrated than the water in the soil



Root Pressure

- Occurs when the soil moisture level is high either at night or when transpiration is low during the day

- Can only raise the water in some plants up to 20m
- Not the main force

Water transport in STEM

You have learnt that water is transported from the root to the stem and the leaf.

How does the plant transport water upwards against gravity??

Transpiration

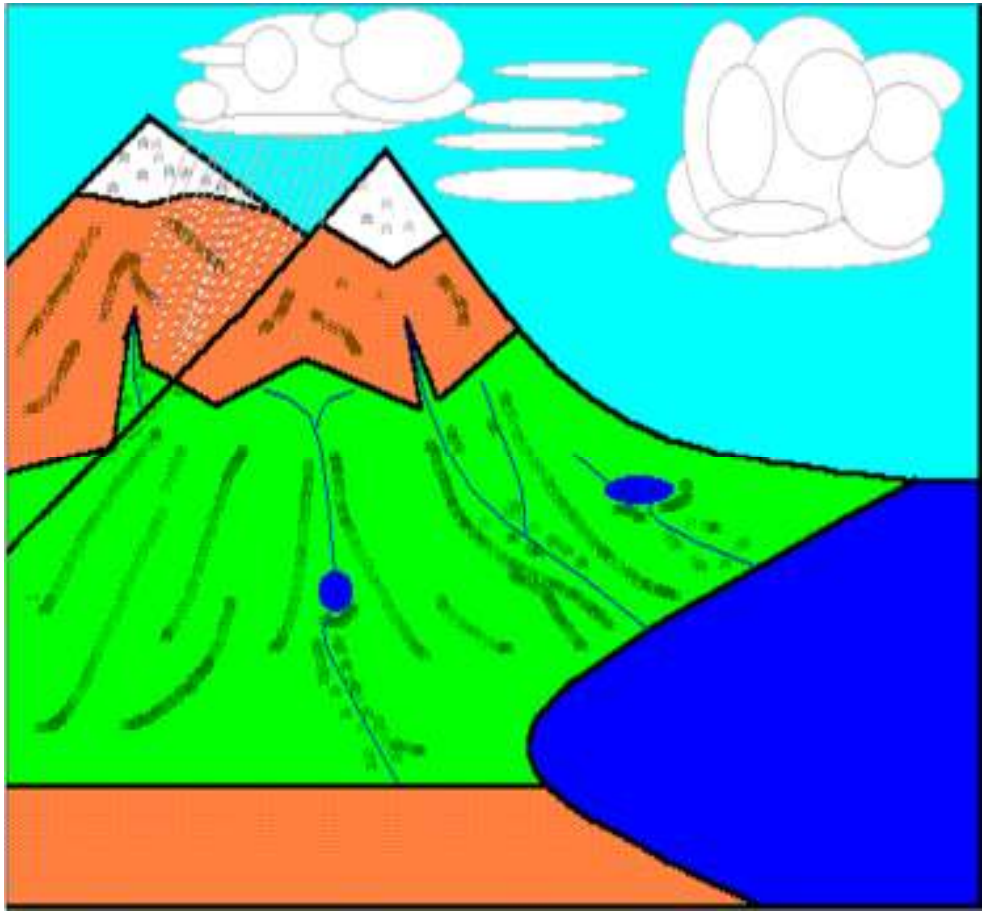
- Evaporation of water from the plant
  - Loss of water vapor through the stomata on the underside of the leaves

1. The mesophyll cells in the leaves are covered with a thin layer of moisture
   - Essential for efficient gas exchange to occur
2. Some of this moisture evaporates into the intercellular spaces which diffuses through the stomata into the 'drier' air
   - Water is pulled upwards through osmosis (***Transpiration Pull***)
3. The waterway in which the water moves from a higher water potential to a lower water potential
   - ***Transpiration Stream***

4 Environmental Factors that affect Transpiration

Animation

1. Wind speed
2. Humidity
3. Light intensity
4. Temperature
5. Water supply



Light intensity

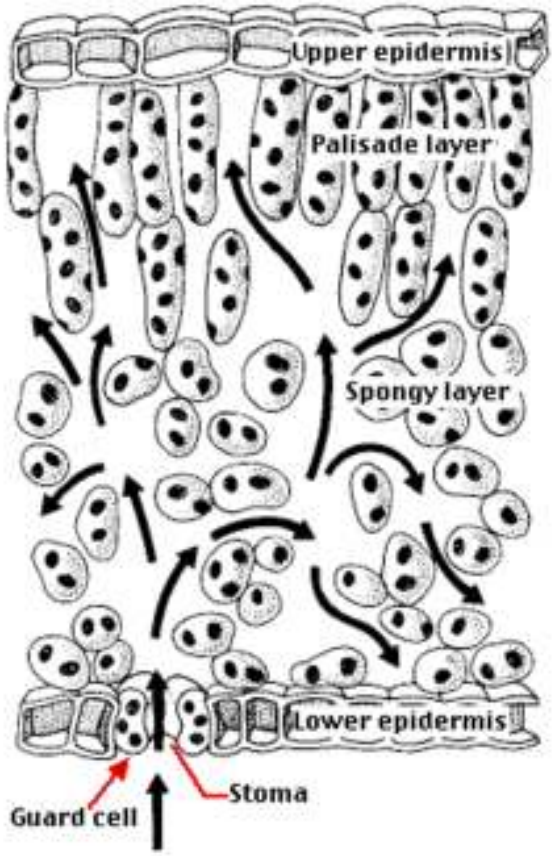
During the day, stomata of the leaves open. Why?

Photosynthesis!!

↓

Gases exchange (CO_2 & O_2)

Water vapor also evaporates (Transpiration)



Temperature

The higher the temperature, the higher the air water capacity to hold moisture

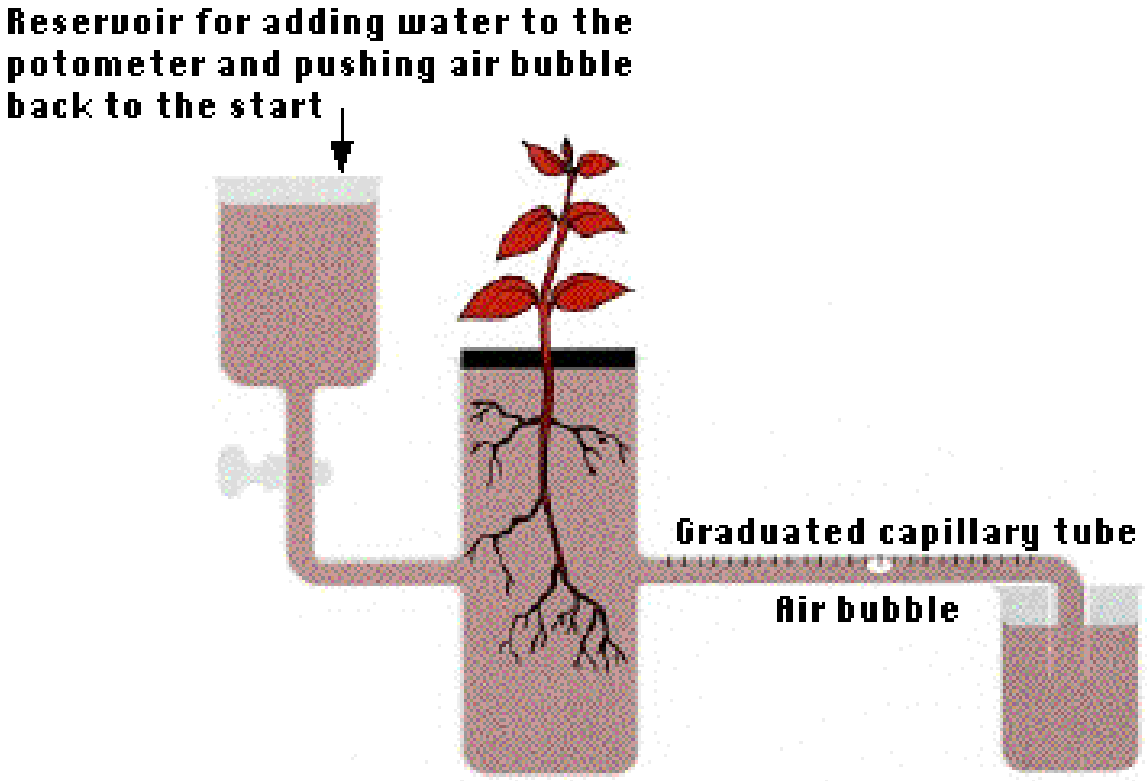
At 30°C, a leaf may transpire 3 times as fast as it does at 20°C

5 Factors that affect Transpiration

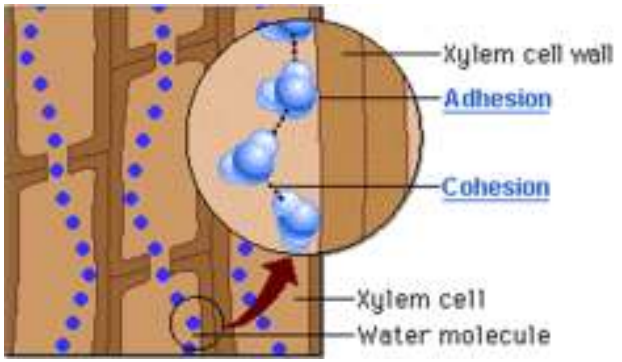
1. Wind speed
   - Increases → Increases transpiration rate
2. Humidity
   - Increases → Decreases transpiration rate
3. Light intensity
   - Increases → Increases transpiration rate
4. Temperature
   - Increases → Increases transpiration rate
5. Water supply
   - Decreases → Decreases transpiration rate

Potometer

The rate at which plants take up water depends on the rate of transpiration- the faster a plant transpires, the faster it takes up water.

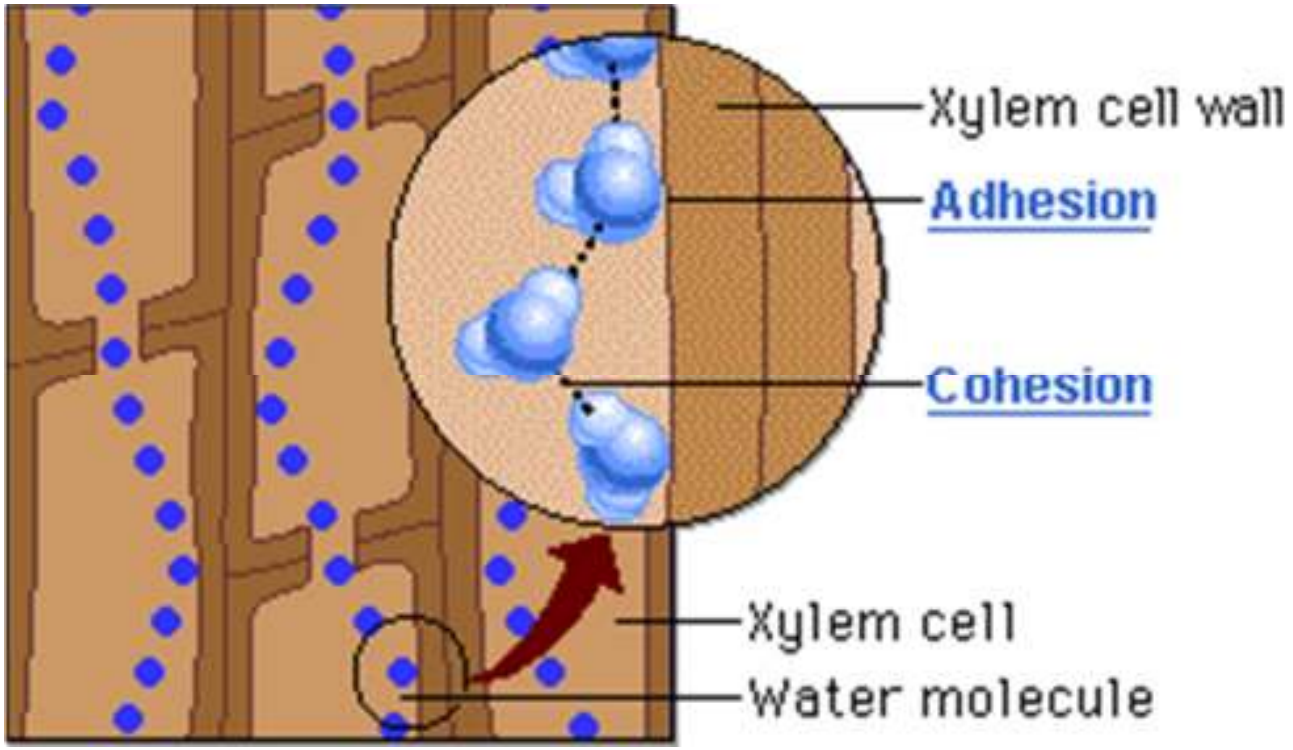


Capillary Action

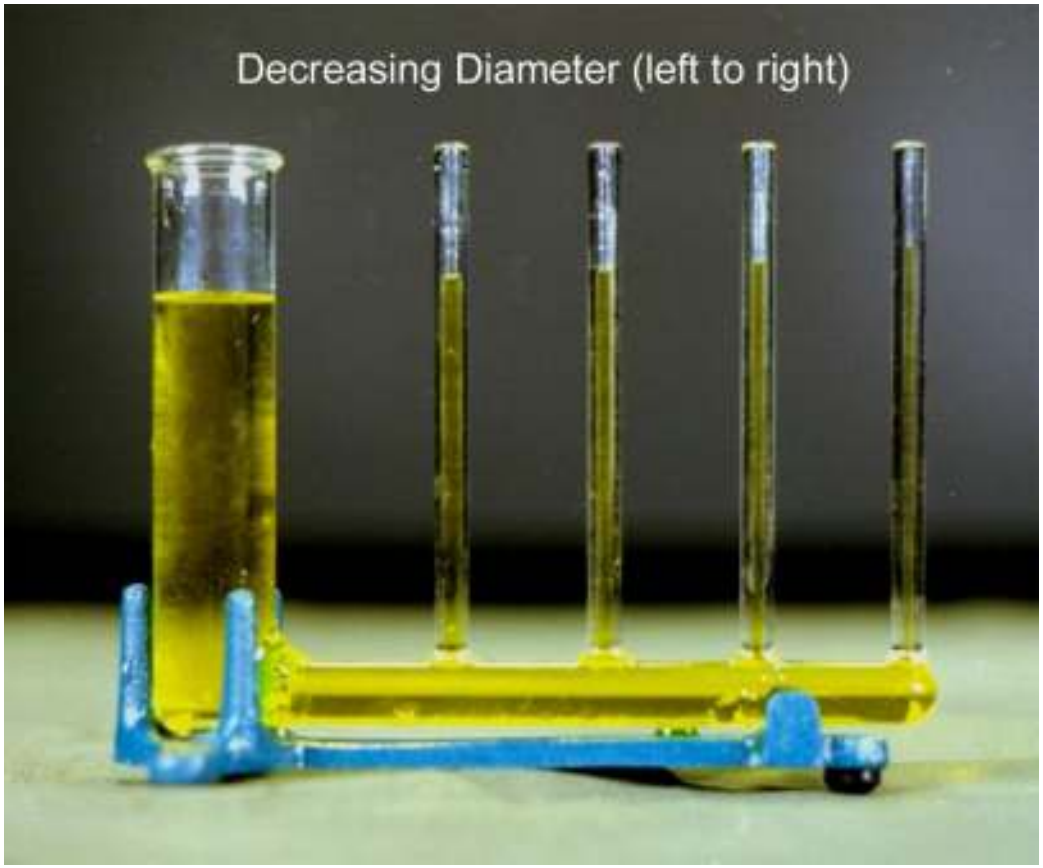


- The attractive force between the molecules of a particular liquid is known as **Cohesion**
  - Water coheres to each other via chemical bonds called hydrogen bonds (holds the droplets of water together)
- The attractive force between two unlike materials is known as **Adhesion**
  - Adhesion causes water to stick to the inside of the glass

When water passes up the thin xylem vessels, it adheres to the surface of the vessels, while the force of osmosis gently 'pushes' the water molecules, which cohere to each other, upwards


Xylem cell wall
Adhesion
Cohesion
Xylem cell
Water molecule

Capillary Action



Forces that promotes uptake of water

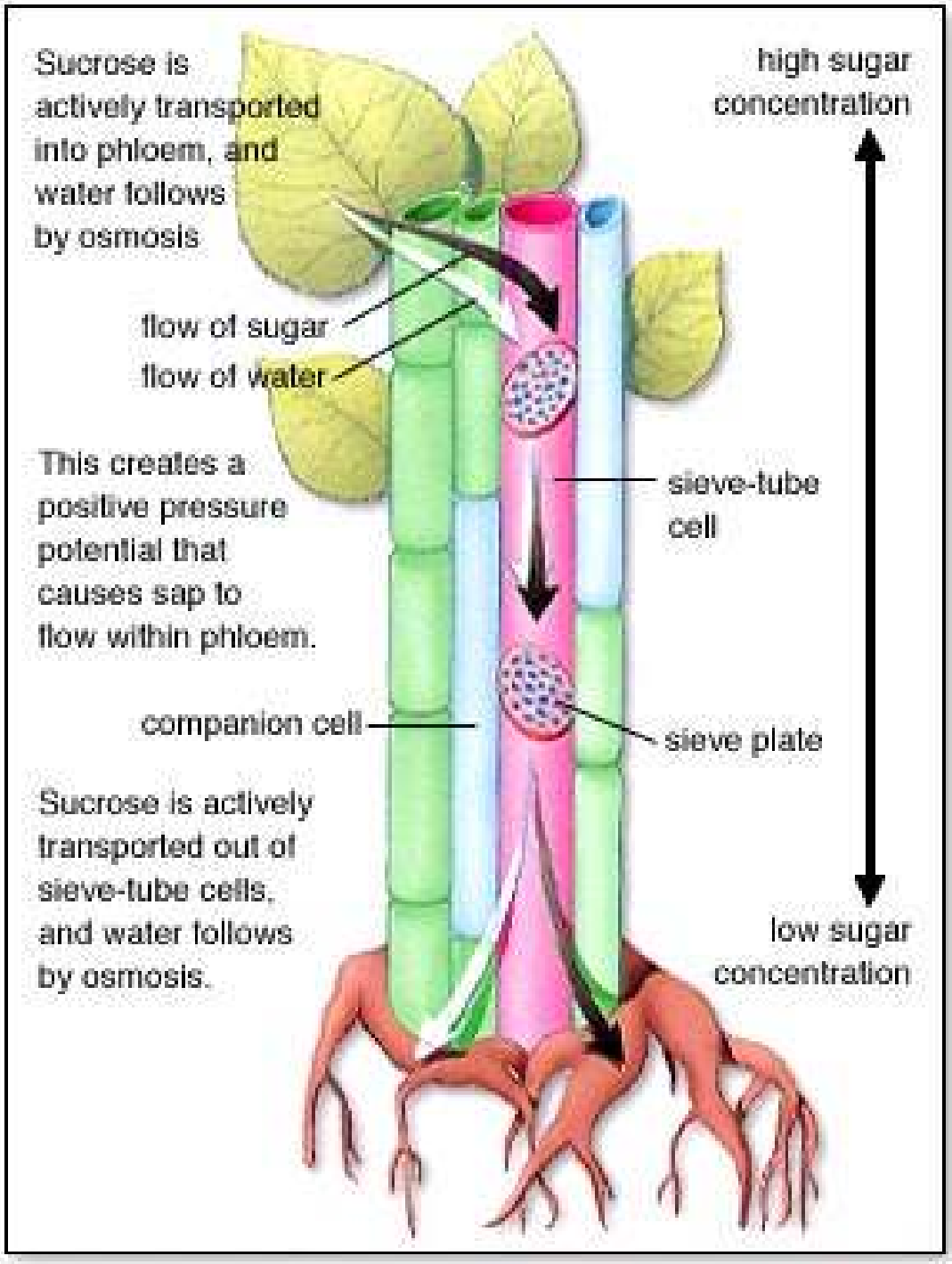
1. Root Pressure
   - Promotes uptake of water in the root
2. Transpiration pull
   - Main force to 'suck' up the water
3. Capillary Action
   - Pushes the water upwards due to the adhesion between the walls of the xylem vessels and water molecules as well as the cohesion between the water molecules

Transport of Food

Transport of Food in plant

- Food substances (sugar & amino acids) are manufactured in the green leaves through the process called photosynthesis

- **Translocation** is the process of transporting food substances downwards from the leaves to all other parts of the plant, through the phloem



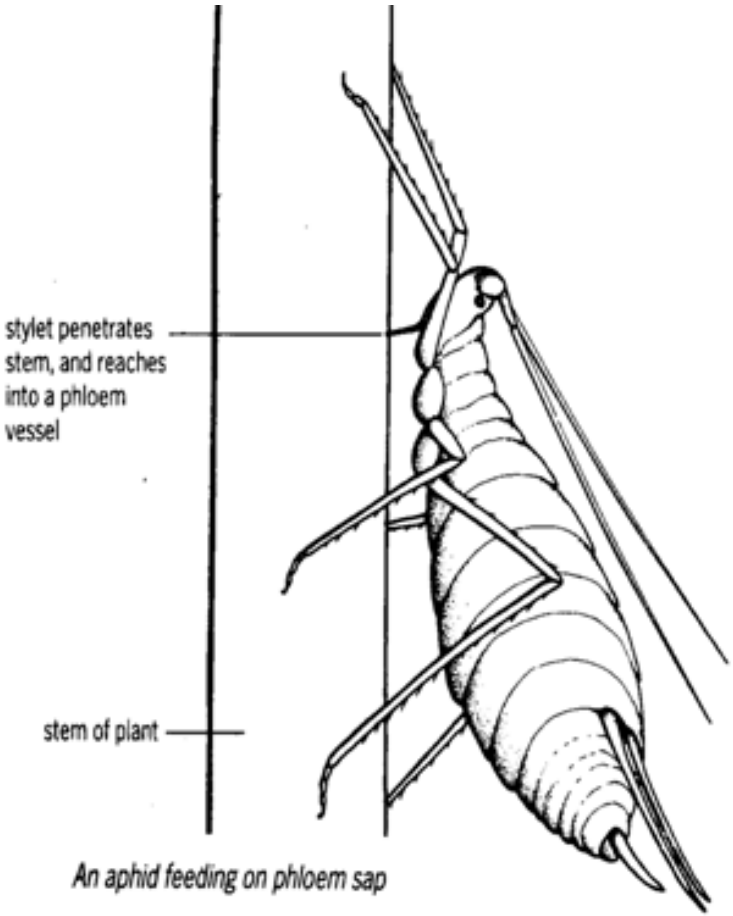
Animation

Animation

How would you show phloem transports food substances?

3 experiments to show phloem transport food substances

1. Using Aphids

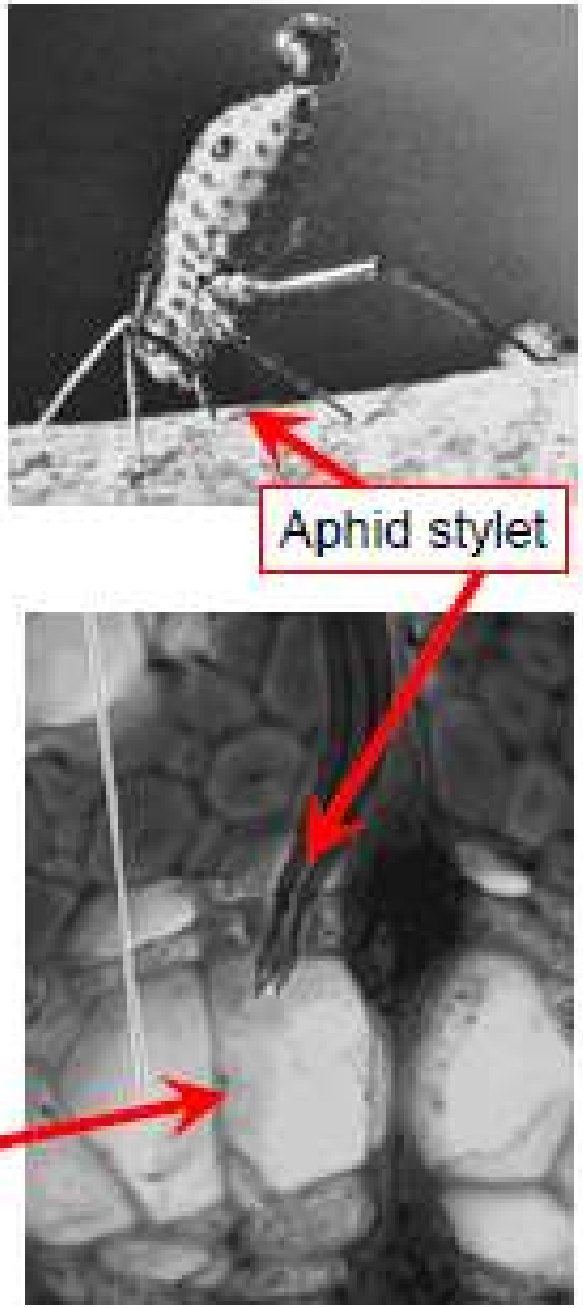


An aphid feeding on phloem sap

Aphid penetrates the stem into the phloem using its mouthpart called stylet and sucks the plant sap

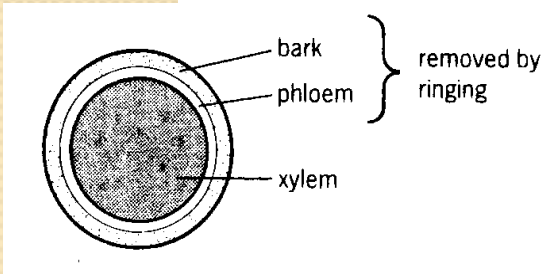
A feeding aphid can be anaesthetized and the stylet cut off

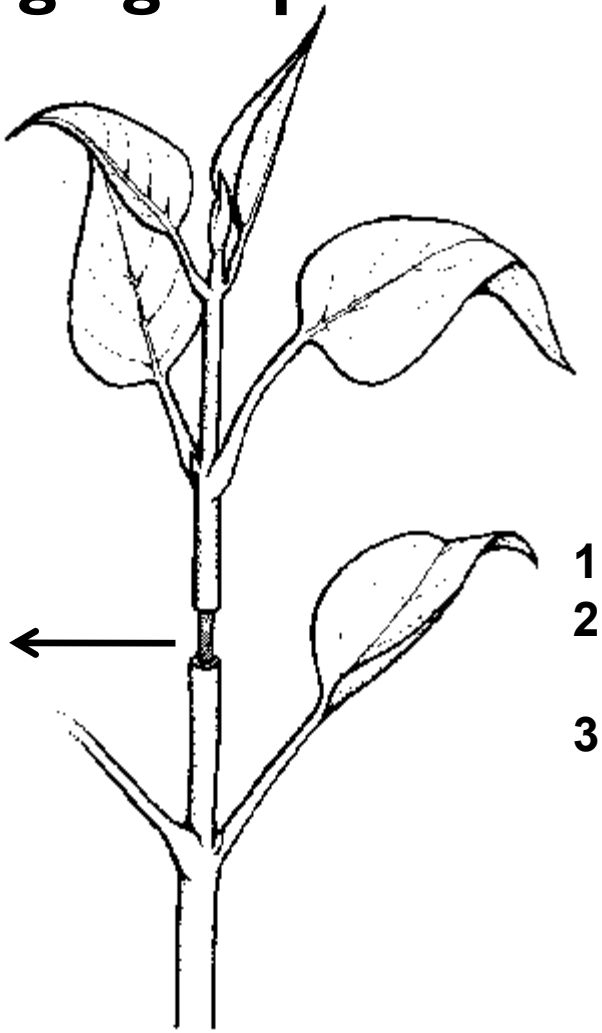
The phloem sap flows out through the stylet and can be analysed. It is found to contain sugars and other organic substances

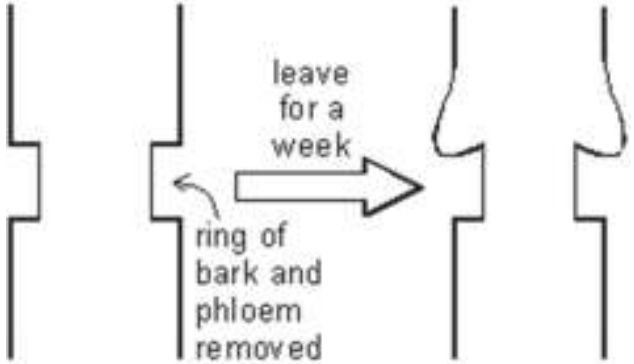

Aphid stylet

3 experiments to show phloem transport food substances

2. The Ringing Experiment



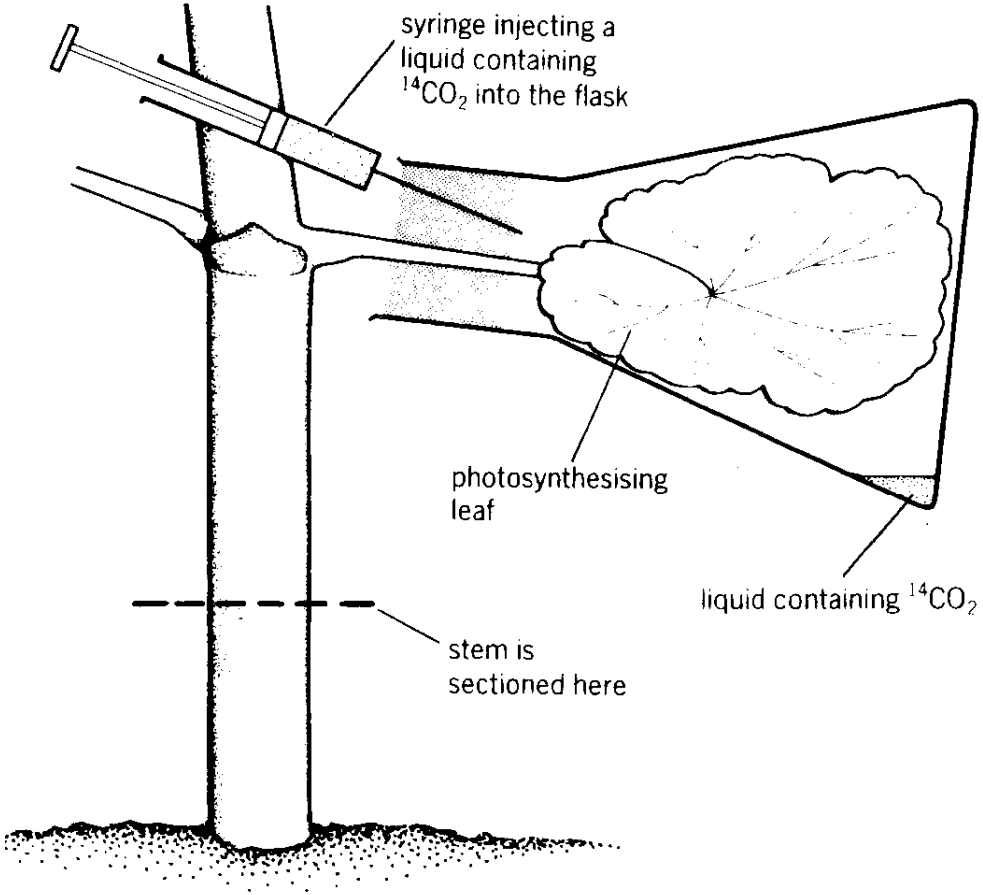




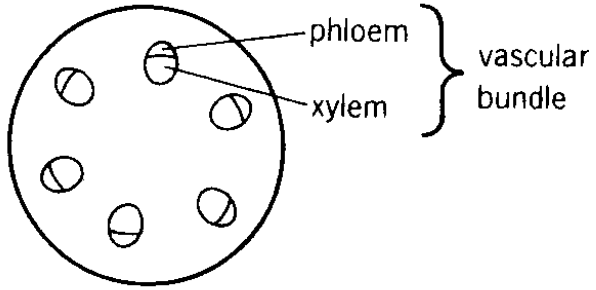
1. **Swelling above the ring**
2. **Reduced growth below the ring**
3. **Leaves are unaffected**

3 experiments to show phloem transport food substances

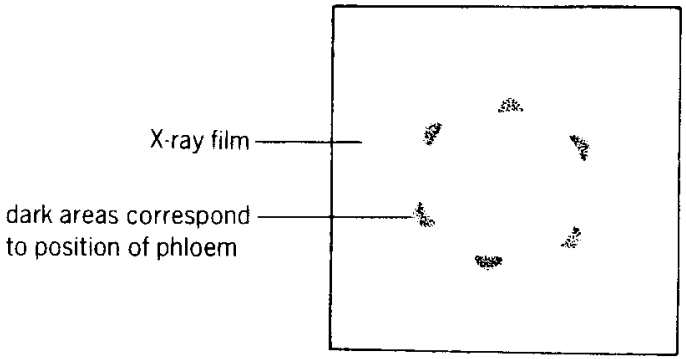
3. Using radio-isotopes



The leaf is supplied with radioactive carbon in the form of $^{14}CO_2$.



When the leaf has had a chance to photosynthesise, a thin section is cut from the stem.



The section is placed on X-ray film. The radioactivity darkens the film.

Wilting of plant

Wilt

Temporary or permanent **loss of turgor pressure** due to excessive transpiration of the leaves & shoot

Result in **flaccid appearances** of leaves & shoot

Characterized by **drooping & shriveling** of soft tissue

a. Is wilting necessary a disadvantage to the plants? Why?

b. Wilting reduces loss of water in leaves. How does it affect intake of water for photosynthesis?

c. How is it the prolong process of wilting cause harm to plants?

d. What other conditions may cause plants to wilt?

Advantage of wilting

- **Rate of transpiration reduces** as the leaves folds up, reducing surface that is exposed to sunlight.
- This will cause **guard cells** to **become flaccid** and the **stomata will close to conserve water** in the plant.

Disadvantage of wilting

- Rate of photosynthesis will be reduced due to the following reasons:
- **Water** becomes a limiting factor now.
- The amount of **sunlight** that can be absorbed becomes a limiting factor as leaves shriveled up.
- The amount of **carbon dioxide** becomes a limiting factor as the stomata are closed.

Things to ponder

- What time of the day should you water your plant?
- Too much water, is it good for your plant?

People often give potted houseplants more fertilizer than they need. As a result, the plants begin to wilt and eventually die instead of getting larger and healthier. What could be the reason for this result?

"Girdling" or ring-barking is a term referring to the bark of the tree in a complete ring around the trunk or a branch. Predict the effect that girdling will have on a tree. Explain. Beneficial or Destructive to plants?