

Chapter 2

Transport in living organisms

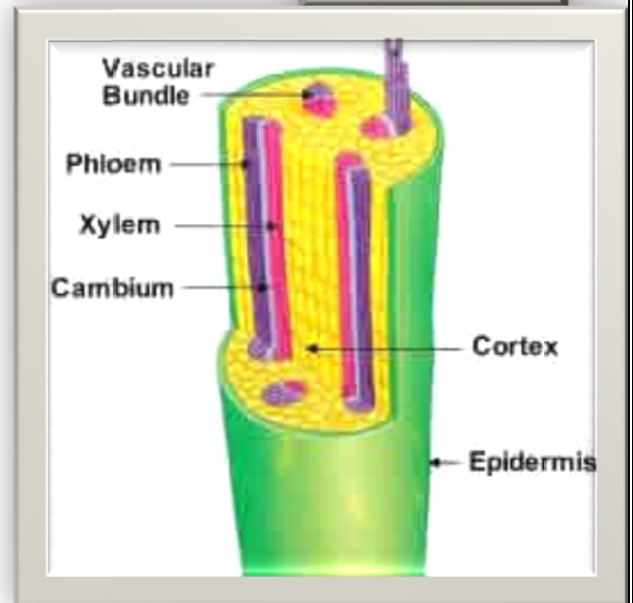
The concept of transport and the need for it:

- 1- All plants need CO₂, water and mineral salts to perform photosynthesis
- 2- In primitive plants such as algae these materials move from one cell to another by osmosis or active transport, so they are in no need for a specialized transport system
- 3- In higher plants gases move by diffusion but water and mineral salts are moving by a specialized transport system (vascular tissue)
- 4- In small animals like hydra and protozoan gases and food substances move by diffusion.
- 5- Higher animals have a specialized transport system



Transport in higher plants:

- 1- Water passes from the soil to the xylem of the root then xylem of stem then xylem of the leaves, Leaves carry out photosynthesis and produce food (Carbohydrates, Fats, and proteins) which are transported to the places of storage and consumption.
- 2- Food passes through sieve tubes in the phloem of leaves, stems, and roots.



Structure of young stem of dicot plant:

1- Epidermis:

One row of adjacent barrel shaped parenchyma cells (the outer cells are covered with cuticles)

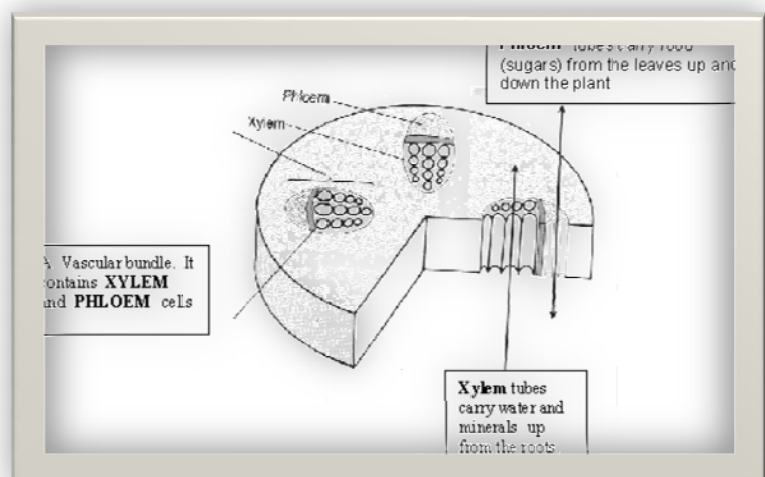
2- Cortex:

- 1- Several rows of collenchyma cells
- 2- The corners of the cells are thickened by deposition of cellulose (which help as a mechanical support for the stem)
- 3- The presence of some chlorophyll in the collenchyma cells make them participate in photosynthesis.
- 4- They are followed internally by several rows of parenchyma cells (with plenty of intercellular spaces)
- 5- The innermost row of cells in the cortex is the starch sheath (for storage of the starch)



3- Vascular cylinder:

- 1- occupies much of the stem
- 2- consists of
 - a. **pericycle:** parenchyma cells alternate with fibers (to make the stem strong and elastic)
 - b. **Vascular bundles:** They are arranged in a cylinder, Each bundle is a triangular shape its base directed



outwards and consists of:

i. Phloem:

- 1.** The outer tissue of the bundle.
- 2.** Consists of Sieve tubes, Companion cells and phloem parenchyma.
- 3.** Transports organic food substances.

ii. Cambium:

- 1.** one or more rows of meristematic cells
- 2.** lies between phloem and xylem
- 3.** When they divide they give rise to secondary phloem externally and secondary xylem internally.

iii. Xylem:

- a.** The internal part of the bundle
- b.** Transports water and solutes
- c.** Act as a support for the stem
- d.** Consists of:

1. Vessels:

- a- Tubes formed from elongated cylindrical cells joined end to end
- b- Transverse walls dissolved making one tube
- c- The cellulose wall becomes thickened by lignin (impermeable to water and solutes)
- d- The protoplasmic content dies leaving hollow vessels
- e- Numerous pits are scattered over the wall (Where the primary wall is left without being thickened)
- f- Pits permit water to pass outside the vessels
- g- Lignin is laid down the inner wall on different forms such as annular or spiral (they support the vessel and prevent it from collapse)

2. tracheids:

- a- Mostly similar to vessels but they appear pentagonal or hexagonal in T.S
- b- They are pitted
- c- Their ends are pointed and closed

3. Xylem parenchyma

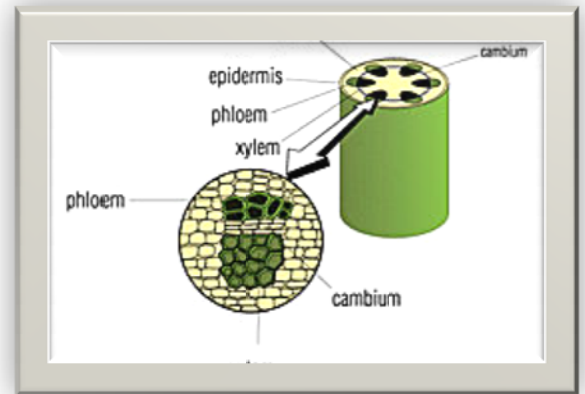
- a- One row of cells between xylem vessels
- b- A network of vessels spread all over the plant (connect xylem of root, stem and leaves also phloem of them together)

4. pith

- a- Occupies the center of stem
- b- Contains parenchyma (for storage).

5. Medullary rays

- a- extend between vascular bundle in the form of parenchyma cells
- b- They join to the cortex with the pith



Factors responsible for ascent of sap:

1- Root pressure theory:

- 2- If a plant stem is cut very near to the soil level, you can see exudation of water from the stump. This phenomenon is known as exudation,
- 3- Due to the root pressure continuing to force water up the plant. An osmotic pressure mechanism in the root tissues leading to continuous and direct root absorption from the soil.
- 4- Water is forced vertically upward through xylem vessels for a short distance to a certain level.
- 5- At this level, the water stops because the opposing pressure of the water column in xylem vessels has become equal to the root pressure.
- 6- The maximum root pressure does not exceed 2 atmospheres.

- 7- Pinus and other conifers have no root pressure.
- 8- The force of root pressure is affected quickly by external factors.
- 9- So we can say that root pressure is not enough to explain the ascent of sap.

2- Imbibition theory:

- 1- The colloidal nature of cellulose and lignin has helped the walls of xylem vessels imbibe water.
- 2- Imbibition has a very limited effect on the ascent of sap,
- 3- Experiments have proved that the sap ascends through the cavities of the xylem vessels and not along their walls.
- 4- The importance of this phenomenon is restricted to the transport of water along the cell walls until it reaches the walls of vessels and tracheids the root, and from these vessels and tracheids to the neighbor cells in the leaves.

3- Capillarity theory:

- 1- Water rises through tiny tubes by capillarity.
- 2- Xylem vessels are considered as capillary tubes with diameters ranging from 0.02 mm to 0.5 mm.
- 3- Water will rise in these by the phenomenon of capillarity.
- 4- The finest capillary tube does not allow the rise of water more than a height of 150 cm.
- 5- Capillarity is a weak secondary force for the ascent of sap.

4-Transpiration pull – Cohesion - Adhesion theory:

- 1- (By H. H. Dixon and J. Joly in 1895).
- 2- Plant physiology proved that these are the principal forces which pull the water upward to very high levels, approximately 100 meters.
- 3- This theory states in brief, that the water column ascends through the xylem vessels depending upon the following forces:
 - a. **Cohesive force:** due to the existence of strong mutual attraction between the molecules of water inside the xylem vessels and tracheids. This explains the existence of a continuous column of water.
 - b. **Adhesive force:** between water molecules and those of the walls of xylem vessels. It helps the water column to be held against the effects of gravity.
 - c. **Transpiration pull:** this attracts the water column upwards due to the continuous process of transpiration in the leaves.

Water has been shown to have a high pulling force in tubes under the following conditions:

- 1- It must be a capillary tube.
- 2- The walls of the tube must possess an adhesive force to attract water.
- 3- The tubes must be free of any gas or air bubbles to avoid any breaking and therefore descent of the water column.

The path of the sap during its ascent from the root to the leaves:

- 1- Transpiration lessens the water concentration in the air chamber above the stoma in the leaf.
- 2- Evaporation will therefore, increase from the cells of the mesophyll surrounding the stomata chamber.
- 3- This will lessen the water content of these cells and increase their concentration.
- 4- This state will create a diffusion pressure gradient for the water called "***pulling force***" which attracts water from the surrounding cells.
- 5- This will continue as far as the xylem elements in the venules and veins, finally form the midrib of the leaf.
- 6- Being subjected to a great force, the water will ascend through the xylem vessels and tracheids of both the stem and the root as they are connected to one another.
- 7- Transpiration pull of the leaf will not only pull water that has reached the vascular cylinder of the root up, but it will also help in the lateral pull of water from the root hairs.

Transport of manufactured food from the leaf to other parts of the plant

- 1- Food manufactured by the leaf must :
 - a. Move upwards in order to feed the stem

- b. Move downwards to feed the root system.
- 2- The phloem consists of sieve-tubes that appear in a longitudinal section as elongated cells, arranged end to end.
- 3- They contain cytoplasm without a nucleus,
- 4- Each sieve-tube has a nucleated companion cell.
- 5- Vital functions the sieve tube are organized by the ribosome and mitochondria present in companion cell.
- 6- The sieve-tubes are separated from each other by perforated (has tiny pores) cross-walls
- 7- Cytoplasm strands extend from one tube to another.

Some experiments to prove the role of the sieve-tubes is the transport of ready-made food substances to various parts of the plant.

1- Rapeden and Bohr in 1945

- a. They supplied a green bean leaf with CO₂ (containing radioactive carbon ¹⁴C)
- b. The plant carried out photosynthesis and to produce radioactive carbohydrates.
- c. These carbohydrates, being radioactive, could be traced during their path in the plant.
- d. It was discovered that they are transported upwards as well as downwards in the stem.

2- The scientist Mittler

- a. He used the aphid insect, to describe the content of the sieve-tubes
- b. Aphid penetrates the tissues of the plant until it reaches the sieve tubes, by its piercing mouth parts.
- c. During the process of feeding, the scientist separated the whole body of the insect from its mouthparts, he collected a sample of the sieve tube's contents.
- d. By analyzing this sample it was shown to consist of the organic substances manufactured in the leaves (sucrose and amino acids).
- e. To make sure that this was the phloem content, he sectioned the region of the plant where the proboscis of the insect was inserted. It appeared to be inserted in a sieve-tube by its piercing mouthparts.

3-Thain and canny 1961:

- a- They could see long cytoplasmic threads which contain organic substances inside the sieve tubes, and these lines extend through tiny pores from one tube to another.
- b- And so they explained the transportation of the organic substances in the phloem on the basis of cytoplasmic streaming, i.e. the cytoplasmic circular movement inside the sieve tubes and companion cells during that,
- c- The organic substances translocate from one end to other end then they pass to the neighboring sieve tubes through the cytoplasmic threads which pass from one tube to another.
- d- They explained that this activity needs more of ATP molecules which exist in the companion cell.
- e- And this is proved later by experiments which show that the transportation process is delayed with the decrease of temperature or oxygen in cells, thus delaying the movement of cytoplasm tubes (sieve tubes)

Questions on Chapter 2

Complete the following:

- 6- All plants need, and mineral salts to perform photosynthesis
- 7- In plants such as algae materials move from one cell to another by or active transport, so they are in no need for a specialized system
- 8- In higher plants gases move by but water and mineral salts are moving by a specialized transport system (..... tissue)
- 9- In small animals like hydra and protozoan gases and food substances move by
- 10- Water passes from the soil to the xylem of the root then xylem of then xylem of the
- 11- Leaves carry out and produce food
- 12- Carbohydrates, Fats, and proteins are transported to the places of and
- 13- Food passes through sieve tubes in the of leaves, stems, and roots.

- 14- is one row of adjacent barrel shaped parenchyma cells (the outer cells are covered with
- 15- are several rows of collenchyma cells,
- 16- The corners of the cortex cells are thickened by deposition of
- 17- Cellulose help as a mechanical for the stem
- 18- The presences of some in the collenchyma cells make them participate in photosynthesis.
- 19- Cortex are followed internally by several rows of cells (with plenty of intercellular spaces)
- 20- The innermost row of cells in the cortex is the (for storage of the starch)
- 21- cylinder occupies much of the stem
- 22- in parenchyma cells alternate with fibers (to make the stem strong and elastic)
- 23- Vascular bundles are arranged in a cylinder, each bundle is a shape its base directed
- 24- Vascular bundle consist of, and,
- 25- The outer tissue of the bundle is
- 26- consists of Sieve tubes, Companion cells and parenchyma.
- 27- transports organic food substances.
- 28- is one or more rows of meristimetic cell that lies between phloem and xylem
- 29- When cambium divides they give rise to secondary phloem and secondary xylem
- 30- is the internal part of the bundle which transports water and solutes
- 31- Xylem act a s a mechanical for the stem
- 32- Consists of vessels, tracheids, parenchyma, pith and Medullary rays
- 33- are tubes formed from elongated cylindrical cells joined end to end
- 34- Transverse walls of vessels dissolved making one
- 35- The cellulose wall of vessels becomes thickened by (impermeable to water and solutes)
- 36- The protoplasmic content of the vessels leaving hollow vessels
- 37- Numerous are scattered over the wall of the vessels
- 38- permit water to pass outside the vessels
- 39- is laid down the inner wall of vessel on different forms such as annular or spiral (they support the vessel and prevent it from collapse)
- 40- Tracheids are Mostly similar to vessels but they appear or in T.S
- 41- are pitted
- 42- Tracheids ends are and closed
- 43- Xylem is one row of cells between xylem vessels
- 44- occupies the center of stem and contains parenchyma (for storage).
- 45- Medullary extend between vascular bundle in the form of parenchyma cells and
- 46- rays join to the cortex with the pith
- 47- If a plant stem is cut very near to the soil level, you can see of water from the stump. This phenomenon is known as,
- 48-

Correct the underlined words:

- 1- All animals need CO₂ , water and mineral salts to perform photosynthesis
- 2- In higher plants such as algae these materials move from one cell to another by osmosis or active transport, so they are in no need for a specialized transport system
- 3- In primitive plants gases move by diffusion but water and mineral salts are moving by a specialized transport system (vascular tissue)
- 4- In large animals like hydra and protozoan gases and food substances move by diffusion.
- 5- Water passes from the soil to the phloem of the root then xylem of stem then xylem of the leaves.
- 6- Leaves carry out respiration and produce food
- 7- Respiration, Fats, and proteins are transported to the places of storage and consumption.
- 8- Food passes through xylem tubes in the phloem of leaves, stems, and roots.
- 9- Endodermis is one row of adjacent barrel shaped parenchyma cells (the outer cells are covered with proteins)
- 10- Epidermis are several rows of collenchyma cells,
- 11- The middle of the cells are thickened by deposition of cellulose

Put T in front of the true statement and F in front of the false one:

- 1- Cellulose help as a mechanical support for the stem
- 2- The presences of some fats in the collenchyma cells make them participate in photosynthesis.
- 3- Cortex are followed internally by several rows of parenchyma cells (with little intercellular spaces)
- 4- The outer row of cells in the cortex is the starch sheath (for storage of the starch)
- 5- Vascular cylinder occupies much of the stem
- 6- Pericycle in parenchyma cells alternate with fibers (to make the stem strong and elastic)
- 7- Vascular bundles are arranged in a cylinder , Each bundle is a triangular shape its base directed outwards
- 8- Vascular bundle consist of phloem, cambium and xylem,
- 9- The inner tissue of the bundle is phloem
- 10- Phloem Consists of Sieve tubes, Companion cells and parenchyma.
- 11- Phloem transports organic food substances.
- 12- Cambium is one or more rows of meristimetic cell that lies between phloem and xylem
- 13- When cambium divide they give rise to secondary phloem internally and secondary xylem internally.
- 14- Xylem is the internal part of the bundle which transports water and solutes
- 15- Xylem act a s a support for the stem
- 16- Phloem Consists of vessels, tracheids, parenchyma, pith and Medullary rays

Join:-

1- Vessels are tubes formed from	a. annular or spiral
2- Transverse walls of vessels dissolved making	b. pass outside the vessels
3- The cellulose wall of vessels becomes thickened by	c. over the wall of the vessels
4- The protoplasmic content of the vessels	d. dies leaving hollow vessels
5- Numerous pits are scattered	e. lignin
6- Pits permit water to	f. one tube
7- Lignin is laid down the inner wall of vessel on different forms such as	g. elongated cylindrical cells joined end to end

Give reasons for:

- 1- Primitive plants such as algae are in no need for a specialized transport system
- 2- Cellulose help the plant
- 3- Some stems can perform photosynthesis.
- 4- The innermost row of cells in the cortex (the starch sheath) is important to the plant.
- 5- Pericycle in parenchyma cells alternate with fibers
- 6- Cambium act as double layers
- 7- Transverse walls of vessels dissolved
- 8- The cellulose wall of vessels becomes thickened by lignin
- 9- The protoplasmic content of the vessels dies
- 10- Numerous pits are scattered over the wall of the vessels
- 11- Lignin is laid down the inner wall of vessel
- 12- Tracheids are Mostly similar to vessels but still there are differences
- 13- Pith occupies the center of stem and contains parenchyma
- 14- Root pressure is not enough to explain the ascent of sap
- 15- Imbibition is not enough to explain the ascent of sap
- 16- Capillarity is not enough to explain the ascent of sap
- 17- Dixon and joly explained the ascent of sap
- 18- Some seedlings, when transplanted from a nursery to open soil, fail to grow if they remain exposed to the sun for a long time before they are transplanted in the new soil?

Best wishes and always remember to do your best to get the best Mr.Ayman Elsangary.