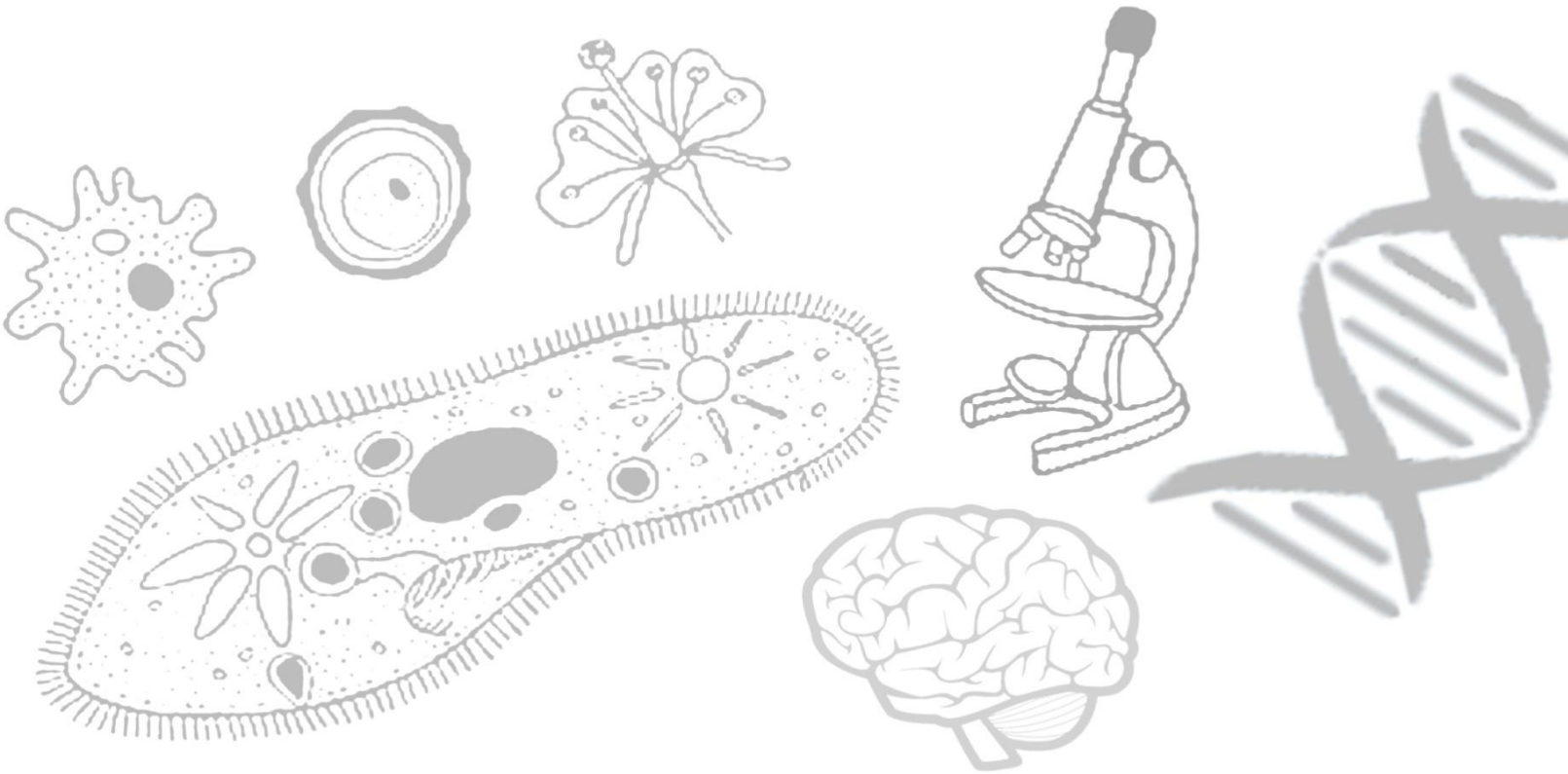
Chapter Notes

BIOLOGY



Translocation, Symplastic and Apoplastic Pathways

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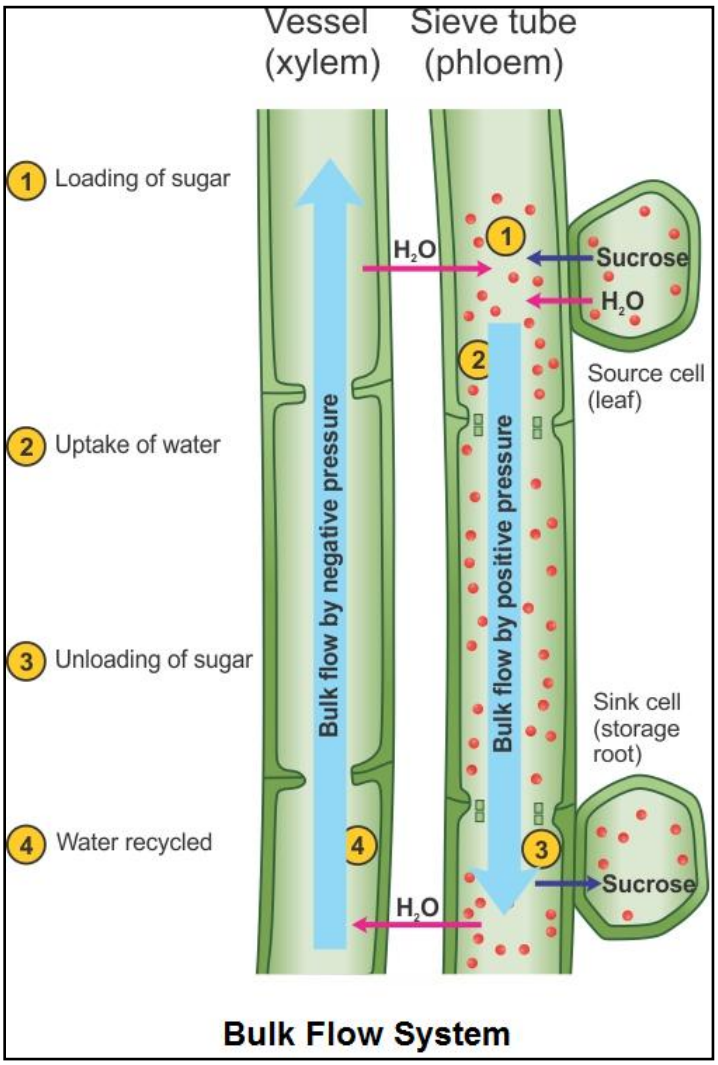
Transport of Water and Soil Water Relations

Bulk Flow System

- In large and complex organisms, the sites of production or absorption and the sites of storage are very far from each other.
- In such cases, a special, long-distance transport system is essential so as to move substances over long distances and at a much faster rate.
- Water, minerals and food are generally moved by a mass/bulk flow system.



Bulk Flow System

- A mass flow or bulk flow system is responsible for the movement of substances in bulk or en mass from the sites of production or adsorption to the sites of storage or consumption as a result of pressure differences between the two sites.
- Bulk flow can be achieved through either a positive hydrostatic pressure gradient or a negative hydrostatic pressure gradient.
- The bulk movement of substances through the conducting or vascular tissues of plants is called translocation.

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- Xylem is associated with the translocation of mainly water, mineral salts, some organic nitrogen and hormones, from the roots to the aerial parts of plants. The phloem translocates a variety of organic and inorganic solutes, mainly from the leaves to the other parts of plants.

Soil Water Relation

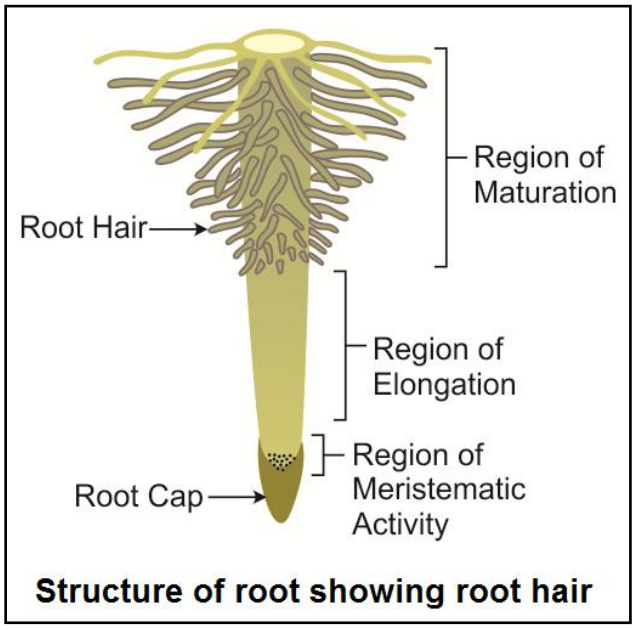
- Soil plays an important role for water storage and a medium for root growth. It also acts as a reservoir of mineral nutrients and provides anchorage for plants.
- Water is a universal component of soil present in traces to sufficient concentrations.
- The water present in soil is known as soil water, soil solution or the water relation of the soil.
- Various terms have been used for soil according to its availability and non-availability to plants.
- The total amount of water present in the soil is called holard.
- The amount of water available to plants is called chresard.
- The amount of water which cannot be absorbed by plants and exists as soil water is called echard.

DID YOU KNOW ?

We can identify five stages of water in the soil which differ in their availability to plants. These include gravitational water, capillary water, hygroscopic water, runoff water and chemically combined water.

Water-absorbing Structure

- The water-absorbing structure of the plant is the root hair zone.
- Root hair develop mainly at the tip just above the zone of elongation.



Structure of root showing root hair

- A root hair is a unicellular tubular propagation of the outer wall of the epiblema.
- Root hair are about 10 µm in diameter.

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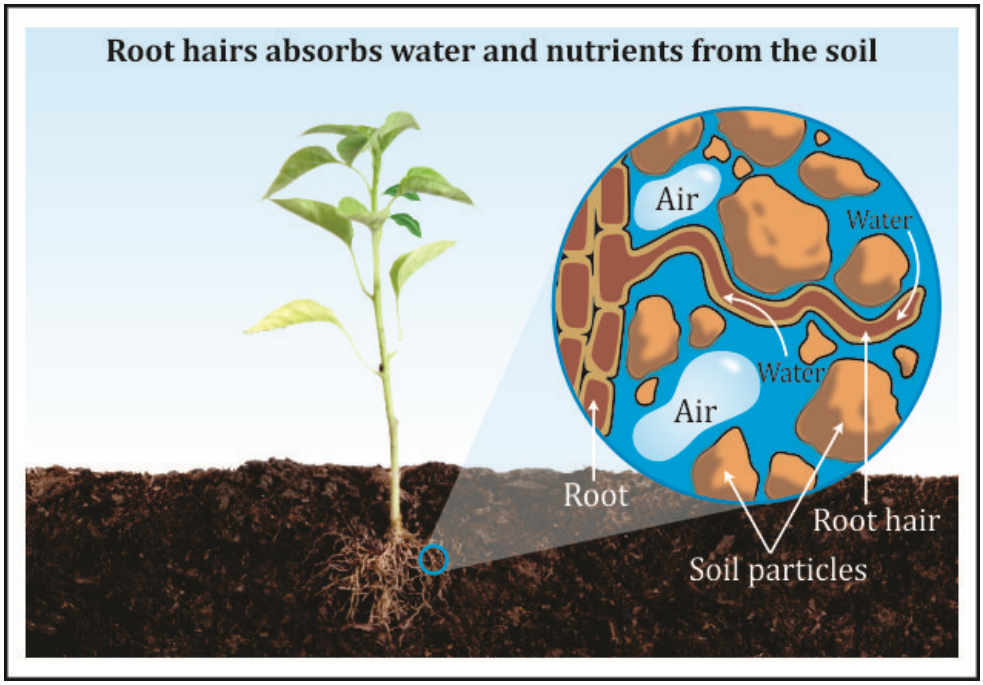
- The cell wall of root hair is composed of two distinct layers. The outer wall is made of pectin which dissolves in water so that the root hair becomes slimy and sticky. The inner wall is made of cellulose.
- The osmotic pressure of root hair is higher (about 3–8 atm) as compared to that of soil solution (less than 1 atm).
- During transplantation, the root hair are removed. That is why, the plant remains wilted in the new habitat.
- Many forest trees, shrubs and some conifers have scanty root hair so as to form a symbiotic association with the fungi called mycorrhiza.



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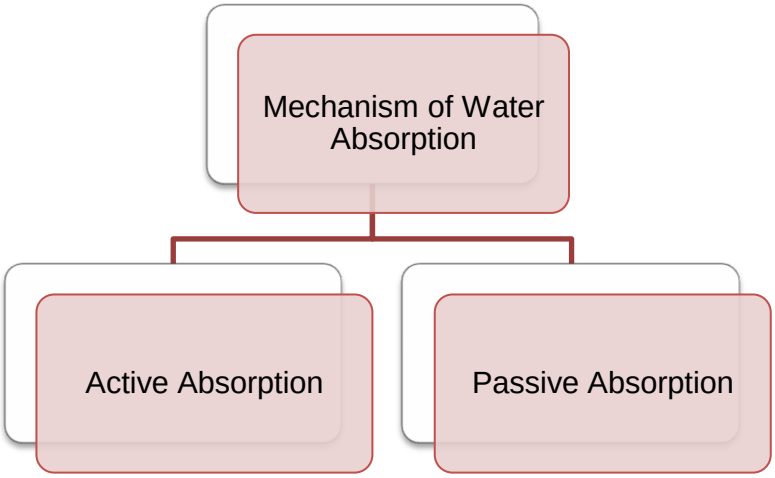
Mechanism of Water Absorption

- The absorption of water by plants is also known as water uptake.
- Kramer identified two distinct mechanisms which independently operate in the absorption of water in plants. They are active absorption and passive absorption.



Active Absorption of Water

- In active absorption, roots, particularly root hair, are actively involved in the absorption of water.
- It involves an expenditure of metabolic energy which comes from the respiring cells of the roots.
- A very small amount of water (4%) is absorbed by the active mechanism of absorption.

Passive Absorption of Water

- In passive absorption, absorption of water occurs because of forces developed at the transpiring surface of the plant.
- The cells of the root do not play any role, and hence, there is no consumption of energy.
- A large amount of water (96%) is absorbed by the passive mechanism of absorption.
- Passive absorption is the most common and a rapid method of water absorption.

Differences between Active Absorption and Passive Absorption

Active Absorption	Passive Absorption
1. Forces for active absorption develop inside the root.	1. Forces for passive absorption lie inside the shoot.
2. Osmotic pressure and energy play a major role in active absorption.	2. Transpiration pull plays a major role in passive absorption.
3. A positive pressure is developed inside the xylem.	3. A negative pressure is developed inside the xylem.
4. Rate of absorption is low.	4. Rate of absorption is high.
5. Accounts for only 4% of total water uptake.	5. Accounts for only 96% of total water uptake.
6. Active absorption occurs in slowly transpiring plants.	6. Passive absorption occurs in rapidly transpiring plants.

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Factors Affecting Water Absorption

Available soil water	•Absorption of water is more if the amount of available water in soil is more.
Soil air	•Absorption of water takes place rapidly in well-aerated soil.
Concentration of soil solution	•If the soil solution is highly concentrated, then it will inhibit water absorption.
Soil temperature	•An increase in soil temperature up to about 30°C promotes water absorption.

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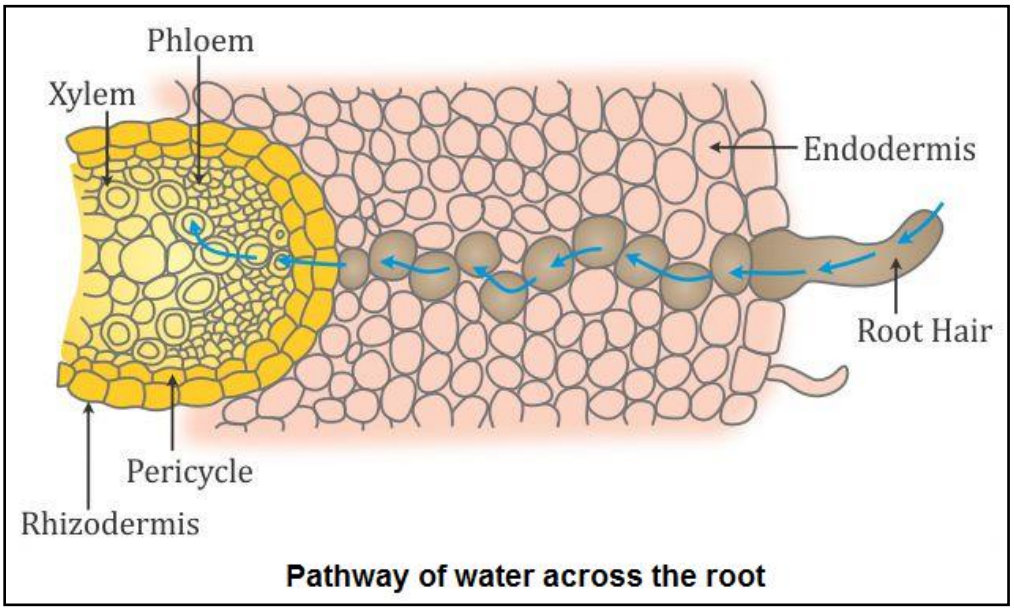
Pathways of Water Movement in Roots

- When water is absorbed by the root hair and other epidermal cells, it moves centripetally across the cortex, endodermis, pericycle and finally enters the xylem.
- Water moves from cell to cell along the concentration gradient.



Pathway of water across the root

- Two possible pathways for the movement of water along the roots are the apoplast pathway and the symplast pathway.

DID YOU KNOW ?

The terms apoplast and symplast were proposed by Munch.

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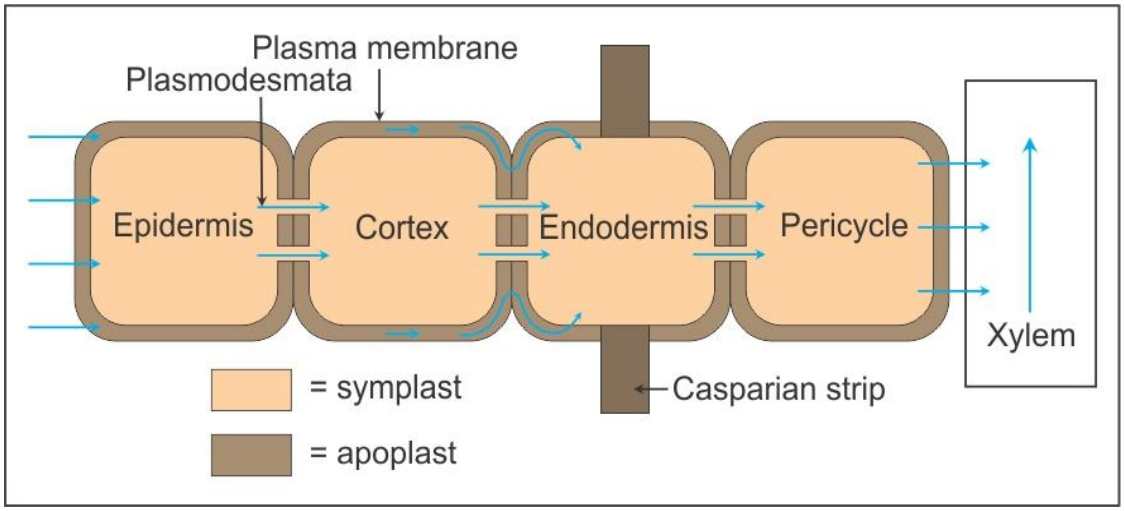
Apoplast Pathway

- The apoplast system includes interconnecting cell walls, intercellular spaces, cell walls of endodermis excluding Casparian strips, xylem tracheids and vessels.
- In the apoplast pathway, water moves from the root hair to the xylem through the walls of intervening cells without crossing any membrane or cytoplasm. This movement of water occurs through bulk or mass flow.
- In this way, the apoplast pathway does not provide any barrier to the movement of water.
- The apoplastic movement of water beyond the cortex is obstructed because of the presence of casparian strips in the endodermal cells.
- The major movement of water through the cortical cells occurs by this method as the cortical cells offer least resistance to the movement of water.
- The apoplast system is continuous throughout the plant.
- Because of the absence of living parts in this system, the water moves mainly due to capillary action or free diffusion along the gradient.



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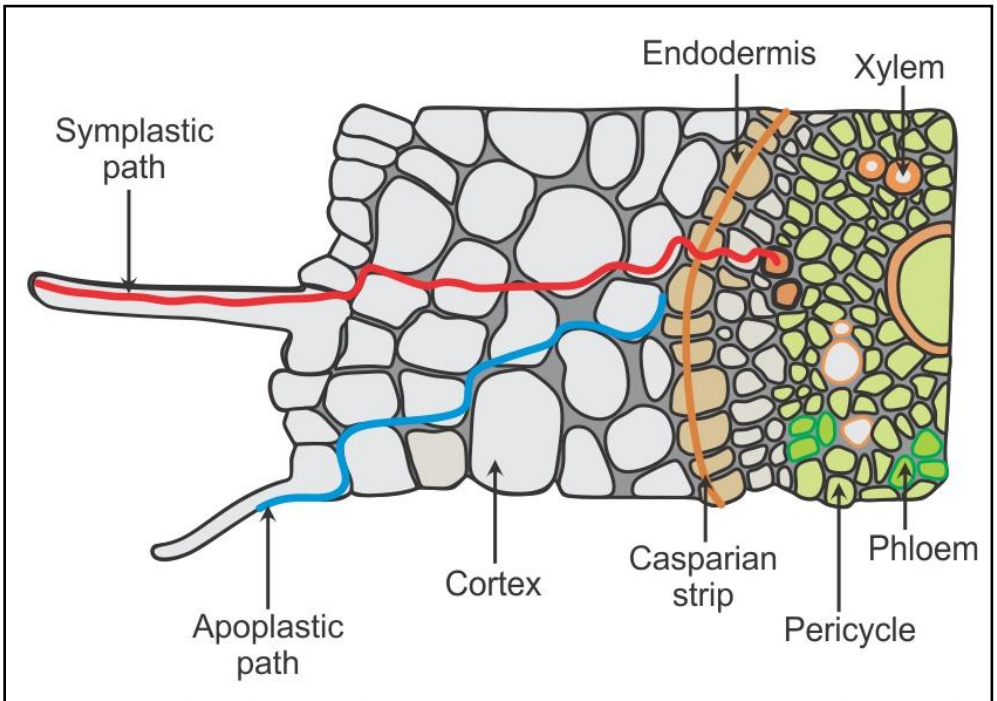
Symplast Pathway

- The symplast pathway includes the living parts of the plant made of interconnected protoplasts of neighbouring cells.
- The cortical cells are living cells which remain interconnected with each other through the plasmodesmata traversing through their cell walls.
- The water entering the cell sap of root hair moves into the underlying cortex cells through the plasmodesmata.
- All the cells of the cortex are bounded by a continuous selectively permeable membrane.
- Because the cell membrane of one cell is connected with the cell membrane of the adjacent cell through plasmodesmata, the water moves from one cell to another cell by the symplast method.
- The endodermal cells of the root have a conspicuous waxy thickening, the casparian strip, in their cell walls which blocks the movement of water and minerals from one side to the other side via the cell wall route.
- Therefore, water can reach up to the endodermis through the apoplast, but it moves through the endodermis by the symplast.
- The symplast pathway is also known as the transmembrane pathway. This may occur by two methods:
  i. Non-vacuolar symplast pathway: Water passes between the adjacent cells through the plasmodesmata. It does not enter the vacuoles.
  ii. Vacuolar symplast pathway: Water crosses the tonoplast surrounding the vacuole. This pathway offers a lot of resistance.



Symplast and Apoplast Pathway of Water Movement in Root

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Role of Mycorrhiza

- Mycorrhiza represents a mutualistic symbiotic association between the root system of higher plants and fungal hyphae.
- The fungal hyphae form a network around the young root and invade the root cells.
- The external hyphae greatly increase the surface area for absorption of minerals and water.
- The fungal hyphae penetrating into the root cells provide a direct passage for the transport of water, sugar and nitrogenous compounds into the root.

FACT !

Some plants such as *Pinus* and some orchids have obligate association with mycorrhizae. The *Pinus* seeds germinate only when they get associated with mycorrhizae.

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