Chapter-1 Transport in Plants

Very Short Answers Questions:

1. What are porins? What role do they play in diffusion?

A: Porins are proteins that form huge pores in the outer membranes of the plastids, mitochondria and some bacteria.

They allow molecules up to the size of small proteins to pass through.

2. Define water potential. What is the value of water potential of pure water?

A: Water potential is the free energy available in 1 mole of water to perform a work. It is a relative term compared to water potential of pure water. Water potential of pure water is 'zero'.

3. Differentiate osmosis from diffusion?

A: Osmosis is diffusion of water (solvent) across a differentially or semipermeable membrane from higher potential to lower potential.

Diffusion is movement of solute or solvent from a region of higher concentration to a region of lower concentration.

4. What are apoplast and symplast?

A: Apoplast is non-living region in the plant including intercellular spaces and adjacent cell walls that is continuous throughout the plant except at the casparian strips of the endodermis in the roots.

Symplast is the living region in the plant including protoplasm and plasmodesmata.

5. How does guttation differ from transpiration?

A: Guttation is the water loss in the form of liquid from the margins or apex of the leaf from hydathodes.

Transpiration is the loss of water in the form of vapour from the living tissues of aerial parts of plants.

6. What are the physical properties of water responsible for the ascent of sap through xylem in plants?

A: **Cohesion:** Mutual attraction between water molecules.

Adhesion: Attraction of water molecules to the surface of tracheids.

7. With reference to transportation of food within plant, what are source and sink?

A: Photosynthetic parts like leaves and young stems are the source and the part that needs or stores food are sinks.

In spring storage structures act as source and buds act as sinks.

8. Does transpiration occur at night? Give an example?

A: Yes. Bryophyllum (with scotoactive stomata).

9. Compare the pH of guard cells during the opening and closing of stomata?

A: During opening of the stomata pH increases due to efflux of H^+.

During closing pH decreases.

10. In the wake of transpirational loss, why do the C_4 plants are more efficient thanC_3 plants?

A: Most of the water absorbed by the plant lost through transpiration.CO_2 fixation requires large amounts of water.

In C_3 plants as CO_2 is fixed only in mesophyll cells compared to mesophyll and bundle sheath cells of C_4 plants. So more water is lost in C_3 than C_4 plants.

11. What is meant by transport saturation? How does it influence facilitated diffusion?

A: When all the proteins of the membrane that are facilitating the transport of solutes are used, the rate has reached its maximal value. This is called transport saturation.

Facilitated diffusion will reach maximum at transport saturation, further increase in the concentration of the solute will not change the rate.

12. How does ABA bring about the closure of stomata under water stress conditions?

A: ABA, during stomatal closure, brings about a change in the permeability of the membrane to the K^+ ions. This closes the stomata.

During high water stress (low soil water potential) ABA is produced in the leaves and the stomata closes down to reduce transpiration.

13. Compare imbibing capacities of pea and wheat seeds?

A: Pea seeds are proteinaceous and have more imbibing capacity than starchy wheat seeds.

Proteins have more imbibing capacities compared to carbohydrates

Short Answers Questions:

1. Define and explain water potential?

Ans: Water molecules possess kinetic energy. In liquid and gaseous form they are in random motion that is both rapid and constant. This kinetic energy or free energy per mole of water is called as water potential. Pure water will have the greatest water potential.

If two systems containing water are in contact, water molecules move from the system with higher energy to the one with lower energy. Thus water will move from the system containing water at higher water potential to the one having low water potential. This process of movement of substances down a gradient of free energy is called diffusion.

Water potential is denoted by the Greek symbol **Psi or ψ_w** and is expressed in pressure units such as pascals (Pa).

Water potential is influenced by the solute dissolved in it, temperature and pressure.

By convention, the water potential of pure water at standard temperatures, which is not under any pressure, is taken to be **zero**. If some solute is dissolved in pure water, the solution has fewer free water and the concentration of water decreases, reducing its water potential. Hence, all solutions have a lower water potential than pure water; the magnitude of this lowering due to dissolution of a solute is called **solute potential** or **ψ_S. Solute potential is always negative.** The more the solute molecules, the lower (more negative) is the **ψ_S.**

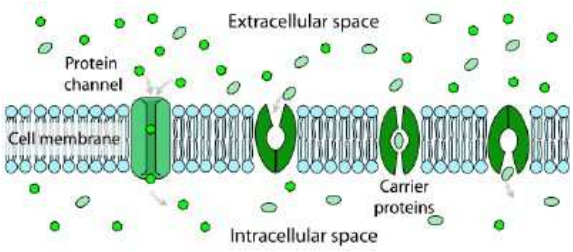
For a solution at atmospheric pressure (water potential) **ψ_w** = (solute potential) **ψ_S**

If a pressure greater than atmospheric pressure is applied to pure water or a solution, its water potential increases.

$$\psi_w = \psi_S + \psi_p$$

2. Write short notes on facilitated diffusion?

Ans: Membrane proteins provide sites at which such molecules cross the membrane. They do not set up a concentration gradient: a concentration gradient must already be present for molecules to diffuse even if facilitated by the proteins.This process is called **facilitated diffusion**.



In facilitated diffusion special proteins help move substances across membranes without expenditure of ATP energy. Facilitated diffusion cannot cause net transport of molecules from a low to a high concentration – this would require input of energy. Transport rate reaches a maximum when all of the protein transporters are being used (saturation).

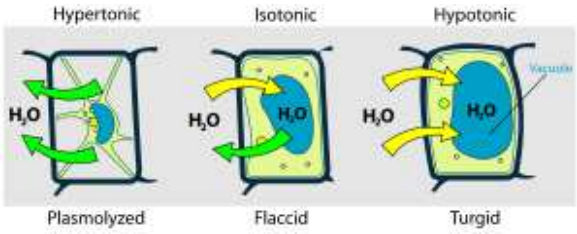
Facilitated diffusion is very specific: it allows cell to select substances for uptake. It is sensitive to inhibitors which react with protein side chains. The proteins form channels in the membrane for molecules to pass through.

Some channels are always open; others can be controlled. Some are large,allowing a variety of molecules to cross.

The **porins** are proteins that form huge pores in the outer membranes of the plastids, mitochondria and some bacteria.

3. What is meant by plasmolysis? How is it practically useful to us?

Ans: Plasmolysis is withdrawal of plasma membrane from the cell wall when protoplasm shrinks. Plasmolysis occurs when water moves out of the cell and the cell membrane of a plant cell shrinks away from its cell wall.



This occurs when the cell or tissue is placed in a solution that is hypertonic (has more solutes) to the protoplasm. Water moves out from the cytoplasm and then from the vacuole. The water when drawn out of the cell through diffusion into the extracellular (outside cell) fluid causes the protoplast to shrink away from the walls. The cell is said to be plasmolysed. The movement of

water occurred across the membrane moving from an area of high water potential (i.e., the cell) to an area of lower water potential outside the cell. It is useful in salting of pickles and preserving fish and meat in salt.

4. How does ascent of sap occurs in tall trees?

Ans: The upward movement of water along with mineral ions from the root system to the aerial parts of the plant against gravitational pull is called ascent of sap.

Dixon proposed "Cohesive-Tension theory" to explain ascent of sap in plants.

Three basic elements of the theory are:

1. Transpirational pull
2. Cohesion of water
3. Adhesion of water

Transpirational pull: Due to transpiration mesophyll cells of leaf looses water to the atmosphere.This results in decrease in water potential in the mesophyll cells.

Water from adjacent cells moves into the mesophyll cells.

A water potential gradient extends up to xylem elements and water from xylem enters leaf cells.

Due to this tension builds up in the xylem elements which extends up to roots through stem.

Cohesive and Adhesive forces of water: Water column in the xylem do not break due to Cohesive and Adhesive forces of the water molecules in the xylem. Cohesive forces are attraction between water molecules. Adhesive forces are attraction between water molecules and lignified walls of xylem elements. Due to this an uninterrupted column of water form in the xylem which moves upwards.

5. Explain pressure flow hypothesis of translocation of sugars in plants?

Ans: The accepted mechanism used for the translocation of sugars from source to sink is called the pressure flow hypothesis. As glucose is prepared at the source (by photosynthesis) it is converted to sucrose (a dissacharide).

The sugar is then moved in the form of sucrose into the companion cells and then into the living phloem sieve tube cells by active transport. This process of loading at the source produces a hypertonic condition in the phloem.

Loading of the phloem sets up a water potential gradient and hydrostatic pressure in the phloem sieve tube increases, pressure flow begins, and the sap moves through the phloem.

Water in the adjacent xylem moves into the phloem by osmosis. As osmotic pressure builds up the phloem sap will move to areas of lower pressure. At the sink osmotic pressure must be reduced.

Again active transport is necessary to move the sucrose out of the phloem sap and into the cells which will use the sugar – converting it into energy, starch, or cellulose.

As sugars are removed, the osmotic pressure decreases and water moves out of the phloem returning eventually to xylem.

6. "Transpiration is a necessary evil". Explain?

Ans: Transpiration is useful to the plants in many ways. It also has adverse effects on plants.

Curtis opined that the transpiration is a necessary evil to the plants.

Uses of transpiration to the plants:

• Creates transpiration pull for absorption and transport of water in plants.

• Supplies water for photosynthesis.

• Transports minerals from the soil to all parts of the plant along with water.

• Cools leaf surfaces, sometimes 10 to 15 degrees, by evaporative cooling.

• Maintains the shape and structure of the plants by keeping cells turgid.

Negative effects on plants:

- Excess transpiration makes cells flaccid retarding growth. It may lead to permanent wilting and ultimate death of the plant during drought conditions.
- Excess transpiration leads to stomata closure affecting gaseous exchange.

In view of the advantages and disadvantages transpiration can be described as a "necessary evil"

7. Transpiration and Photosynthesis – a compromise. Explain?

Ans: Transpiration has more than one purpose; it

• creates transpiration pull for absorption and transport of plants

• supplies water for photosynthesis

• transports minerals from the soil to all parts of the plant

• cools leaf surfaces, sometimes 10 to 15 degrees, by evaporative cooling

• maintains the shape and structure of the plants by keeping cells turgid

An actively photosynthesising plant needs large amounts of water. Photosynthesis is greatly affected by the loss of water by transpiration.

If the water lost in large amounts quickly stomata closes down affecting CO_2 entry for photosynthesis.

If water is not available formation of assimilatory power in the form of ATP and $NADPH_2$ is affected.

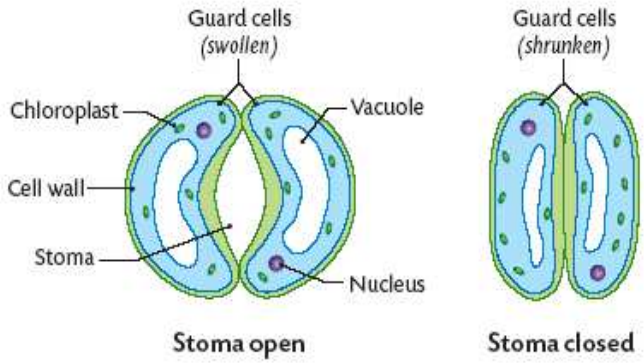
The evolution of the C_4 photosynthetic system is probably one of the strategies for maximising the availability of CO_2 while minimising water loss.

C_4 plants are twice as efficient as C_3 plants in terms of fixing carbon (making sugar). However, a C_4 plant loses only half as much water as a C_3 plant for the same amount of CO_2 fixed.

8. Explain the mechanism of opening and closing of stomata?

Ans: Transpiration is the evaporative loss of water by plants. It occurs mainly through the **stomata** in the leaves.

Structure of the stomata: Normally stomata are open in the day time and close during the night. The immediate cause of the opening or closing of the stomata is a change in the turgidity of the **guard cells**. The inner wall of each guard cell, towards the pore or **stomatal aperture,** is thick and elastic.



When turgidity increases within the two guard cells stomatal aperture or pore opens.

When the guard cells lose turgor, due to water loss, the guard cells become flaccid and the stoma closes.

Opening of stomata:

Levitt proposed K+ pump theory to explain the mechanism of opening and closing of stomata.

According to this theory accumulation of K^+ ions into the guard cells from the subsidiary cells occur in the presence of light.

This coupled with efflux of protons leads to increase in pH of guard cells.

Accumulation of K^+ ions into the guard cells is associated with passive influx of Cl^- ions thereby decreasing the water potential of the guard cells. Water thereby enters the guard cells, making

them turgid. As the outer walls are thin and elastic, the guard cells expand outwardly, leaving a minute pore at the open.

Closing of stomata:

At night, in the absence of light, the K+ and Cl- ions move out of the guard cells due to which water potential of guard cells increases and water starts moving out of them leading to closure of stomata.

Under stress conditions abscisic acid(ABA) , a natural anti-transpirant drives K^+ ions out of the guard cells making them close.