7. (a) With fhe help of well-labelled diagrams, describe the process of plasmolysis in plants, giving appropriate examples.
(b) Explain what will happen to a plant cell if it is kept in a solution having higher water potential.
Solution: (a) Shrinkage of the protoplast of a cell from its cell wall under the influence of a hypertonic solution is called plasmolysis. Hypertonic solution causes exosmosis or withdrawal of water from cytoplasm and then the central vacuole of cell. The size of cytoplasm as well as central vacuole and hence protoplast becomes reduced. The first stage of plasmolysis is called limiting plasmolysis. At limiting plasmolysis, the pressure potential (ψ_p) is zero and the osmotic concentration of cejl interior is just equivalent to that of external solution (isotonic). The cell is called flaccid. When pressure potential becomes negative, the protoplast withdraws itself from the comers. This stage is known as incipient plasmolysis. At incipient plasmolysis, the cell wall exerts no pressure on the cell contents (i.e. ψ_p is zero). Hence at this stage $\psi_w = \psi_s$. The hypertonic solution now enters the cell in between the protoplast and the cell wall. Due to continued exosmosis, protoplast shrinks further and withdraws from the cell wall except one or a few points. It is known as evident plasmolysis.

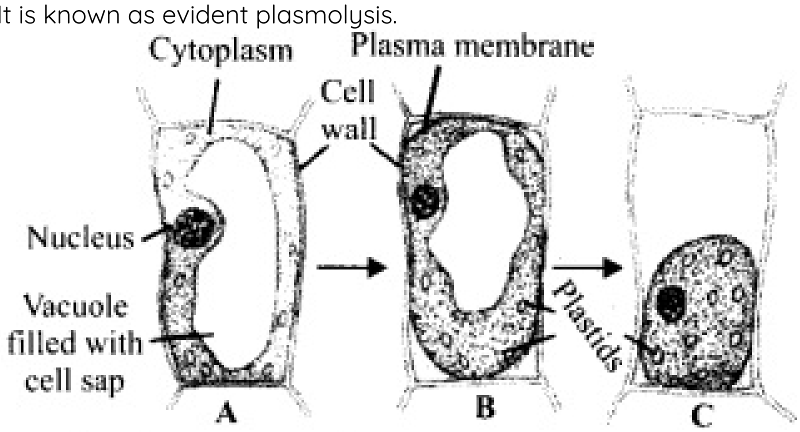

Fig.: Various stages in plasmolysis: **A.** Normal cell; **B.** Incipient plasmolysis; **C.** Plasmolysed cell.

Examples of plasmolysis :
(i) Pickles, meat and fish are preserved by salting. Similarly, jams and jellies are preserved by sweetening with sugars. Salting and sweetening create hypertonic condition in which the fungi and bacteria get killed by plasmolysis.
(ii) Salting kills the weeds of lawns by inducing plasmolysis in their cells.
(iii) Plasmolytic method is applied for the determination of osmotic pressure of a cell in the laboratory.

(b) When the cells are placed in a solution having higher water potential i.e., hypotonic solution (dilute solution as compared to the cytoplasm), water diffuses into the cell causing the cytoplasm to build up a pressure against the wall, that is called turgor pressure. The pressure exerted by the protoplasts due to entry of water against the rigid walls is called pressure potential ψ_p. Because of the rigidity of the cell wall, the cell does not rupture. This turgor pressure is ultimately responsible for - enlargement and extension of cells.

8. How is the mycorrhizal association helpful in absorption of water and minerals in plants?
Solution: Some plants have additional structures associated with them that help in water (and mineral) absorption. A mycorrhiza is a symbiotic association of a,fungus with a root system. The fungal filaments form a network around the young root or they penetrate the root cells. The hyphae have a very large surface area that absorb mineral ions and water from the soil from a much larger volume of soil that perhaps a root cannot do. The fungus provides minerals and water to the roots, in turn the roots provide sugars and N-containing compounds to the mycorrhizae. Some plants have an obligate association with the mycorrhizae. For example Pinus seeds cannot germinate and establish without the presence of mycorrhizae.

9. What role does root pressure play in water movement in plants?
Solution: As various ions from the soil are actively transported into the vascular tissues of the roots, water follows (its potential gradient) and increases the pressure inside the xylem. This positive pressure is called root pressure, and can be responsible for pushing up water to small heights in the stem. Root pressure can, at. best, only provide a modest push in the overall process of water transport. They obviously do not play a major role in water movement up tall trees. The greatest contribution of root pressure may be to re-establish the continuous chains of water molecules in the xylem which often break under the enormous tensions created by transpiration.

10. Describe transpiration pull model of water transport in plants. What are the factors influencing transpiration? How is it useful to plants?
Solution: Transpiration pull or cohesion-tension theory was originally proposed by Dixon and Joly in 1894 and further improved by Dixon in 1914. According to this theory, a continuous column of water is present in the xylem channels of plant. The continuity of water column is maintained in the plant because of cohesive force of water molecules. There is another force of adhesion which holds water tp the walls of xylem vessels. During transpiration in plants, water is lost, in form of water vapour, from the mesophyll cells to exterior, through stomata. As a result, the turgor pressure of these cells decreases and the diffusion pressure deficit (DPD) increases. Now these cells take water from adjoining cells and the turgor of those adjoining cells decreases. This process is repeated and ultimately water is absorbed from nearest xylem vessels of leaf. As there is a continuous water column inside the xylem elements, a tension or pull is transmitted down and finally transmitted to root, resulting in the upward movement of water. Factors affecting transpiration include both environmental and internal factors. Environmental factors:

- Relative humidity - The rate of transpiration is inversely proportional to the relative humidity, i.e., the rate of transpiration is higher when the relative humidity is lower and lower when the relative humidity is higher.
- Atmospheric temperature - A high temperature opens stomata even in darkness. Besides producing a heating effect, it lowers the relative humidity of the air and increases vapour pressure inside transpiring organ. Consequently, rate of transpiration increases.
- Light - Because most of the transpiration occurs through stomata, the rate of transpiration is quite high is light. It falls down appreciably in the darkness.
- Air movements - Transpiration is lower in the still air because water vapours accumulate around the transpiring organs and

reduce the DPD of the air. The movement of the air increases the rate of transpiration by removing the saturated air around the leaves.
- Atmospheric pressure - Low atmospheric pressure enhances evaporation, produces air currents and increases the rate of transpiration.
- Availability of water - The rate of transpiration depends upon the rate of absorption of soil water by roots. This is further influenced by a number of soil factors like soil water, soil particles, soil temperature, soil air, etc.

Internal or plant factors :

1. Leaf area (transpiring area) - A plant with large leaf area will show more transpiration than another plant with less leaf area.
2. Leaf structure - Leaf structure affects transpiration in following ways:
(a) Cuticular transpiration decreases with the thickness of cuticle and cutinisation of epidermal walls.
(b) Because most of the transpiration takes place through the stomata, their number and position influences the rate of transpiration.
(c) The sunken stomata are device to reduce the rate of transpiration by providing an area where little air movement occurs.
3. Root/shoot ratio - A low root/shoot ratio decreases the rate of transpiration while a high ratio increases the rate of transpiration.
4. Mucilage and solutes - They decrease the rate of transpiration by holding water tenaciously.
Transpiration is useful to plants in the following ways:
(i) Removal of excess water - It has been held that plants absorb far more amount of water than is actually required by them. Transpiration, therefore, removes the excess of water.
(ii) Root system - Transpiration helps in better development of root system which is required for support and absorption of mineral salts.
(iii) Quality of fruits - The ash and sugar content of the fruit increases with the increase in transpiration.
(iv) Temperature maintenance - Transpiration prevents overheating of leaves. However, plants growing in areas where transpiration is meagre do not show over¬heating. Some succulents can endure a temperature of 60°C without any apparent damage.
(v) Pole in ascent of sap and turgidity - Ascent of sap mostly occurs due to transpiration pull exerted by transpiration of water. This pull is important in the absorption of water. Further, transpiration maintains the shape and structure of plant parts by keeping cells turgid.
(vi) Distribution of mineral salts- Mineral are mostly distributed by rising column of sap.
(vii) Photosynthesis - Transpiration supplies water for photosynthesis.

11.Discuss the factors responsible for ascent of xylem sap in plants.
Solution: Xylem sap ascends mainly due to forces generating in the foliage of plants as a result of active transpiration. Thus, the factors which enhance the rate of transpiration are also the factors responsible for ascent of xylem sap in plants.
Various factors responsible for ascent of xylem sap in plants are as follows:
(i) Capillarity: There is limited rise of water in narrow tubes or capillaries due to forces of cohesion amongst molecules of water and their property of adhesion to other substance.
(ii) Root pressure: It is positive pressure that pushes sap from below due to active absorption by root.
(iii) Transpiration pull: Transpiration in aerial parts brings the xylem sap under negative pressure or tension due to continuous

withdrawal of water by them. Water column does not break due to its high tensile strength related to high force of cohesion and adhesion.

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