11. Transport in Plants

Question 1. What are the factors affecting the rate of diffusion?

Answer:

Concentration: Diffusion of molecules is entirely dependent on moving from an area of higher concentration to an area of lower concentration. In other words, diffusion occurs down the concentration gradient of the molecule in question. If the difference in concentration is higher, then the molecules will go down the concentration gradient faster. If there is not as great of a difference in concentration, the molecules will not move as quickly and the rate of diffusion will decrease.

Temperature: Particles move due to the kinetic energy associated with them. As temperature increases, the kinetic energy associated with each particle also increases. As a result, particles will move faster. If they can move faster, then they can also diffuse faster. Conversely, when the kinetic energy associated with the molecules decreases so does their movement. As a result, the rate of diffusion will be slower.

Mass of Particle: Heavier particles will move more slowly and so will have a slower rate of diffusion. Smaller particles on the other hand will diffuse faster because they can move faster. As is key with all factors affecting diffusion, movement of the particle is paramount in determining if diffusion is slowed down or sped up.

Solvent Properties: Viscosity and density greatly affect diffusion. If the medium that a given particle has to diffuse through is very dense or viscous, then the particle will have a harder time diffusing through it. So the rate of diffusion will be lower. If the medium is less dense or less viscous, then the particles will be able to move more quickly and will diffuse faster.

Question 2. What are porins? What role do they play in diffusion?

Answer: Porins are special proteins having large pores and are present in the outer membrane of the plastids, mitochondria and bacteria. They allow molecules to pass upto size of the small proteins. They help in movement of molecules and in facilitated diffusion.

Question 3. Describe the role played by protein pumps during active transport in plants.

Answer: In plant cells, protein pumps are used to transport the substances against the concentration gradient, i.e., from a region of lower concentration to a region of higher concentration. Each protein pump is very specific in what substance it carries across the membrane. The protein pumps are made up of specific proteins called trans-membrane proteins. These specific proteins make a complex with the substance to be transported across the membrane, using the energy derived from ATP. On entering the cytoplasm, this protein–substance complex gets dissociated to liberate the substance.

Question 4. Explain why pure water has the maximum water potential.

Answer: Water potential quantifies the tendency of water to move from one part to the other during various cellular processes. It is denoted by the Greek letter Psi or Ψ. The water potential of pure water is always taken as zero at standard temperature and pressure.

It can be explained in terms of the kinetic energy possessed by water molecules. When water is in liquid form, the movement of its molecules is rapid and constant. Pure water has the highest concentration of water molecules. Therefore, it has the highest water potential. When some solute is dissolved in water, the water potential of pure water decreases.

Question 5. Differentiate between the following:

(a) Diffusion and Osmosis

(b) Transpiration and Evaporation

(c) Osmotic Pressure and Osmotic Potential

(d) Imbibition and Diffusion

(e) Apoplast and Symplast pathways of movement of water in plants

(f) Guttation and Transpiration

Answer:

(a) Diffusion and osmosis

Diffusion	Osmosis
It is the passive movement of particles, ions, and molecules along the concentration gradient.	It is the process of diffusion of a solvent through a semi permeable membrane.
It takes place in solids, liquids and gases.	It occurs in liquids only.

It does not require semi permeable membrane.	It requires semi permeable membrane.

(b) Transpiration and evaporation

Transpiration	Evaporation
It occurs in plants.	It occurs from any free surface and includes living and non-living surfaces.
It is a physiological process.	It is a physical process.
It occurs through stomatal pores on the leaves.	It occurs through any free surface.
It is controlled by environmental factors such as root-shoot ratio and number of stomata.	It is driven by environmental factors.

(c) Osmotic pressure and osmotic potential

Osmotic pressure	Osmotic potential
It is expressed in bars with a positive sign.	It is expressed in bars with a negative sign.
It is a positive pressure.	It is a negative pressure.
Its value increases with an increase in the concentration of solute particles.	Its value decreases with an increase in concentration of solute particles.

(d) Imbibition and Diffusion

Imbibition	Diffusion
It is a special type of diffusion where water is absorbed by solids and colloids, causing an enormous increase in volume.	It is the passive movement of particles, ions, molecules along the concentration gradient.
It involves water.	It involves solids, liquids and gases.

(e)Apoplast and symplast pathway

Apoplast pathway	Symplast pathway
It involves the movement of water through the adjacent cell walls of the epidermis and cortex. The movement of water is restricted at the casparian strips of the root endodermis.	It involves the movement of water through the interconnected protoplasts of the epidermis, cortex, endodermis and root pericycle.
It is a faster process.	It is a slower process.

(f) Guttation and transpiration

Guttation	Transpiration
Occurs at night	Occurs during the day
Water is lost from the leaves in the form of liquid droplets.	Water is lost in the form of water vapour.
It occurs through vein endings of leaves.	It occurs through stomata.
It is an uncontrolled process.	It is a controlled process.

Question 6. Briefly describe water potential. What are the factors affecting it?

Answer: Water potential is the quantitative measure of water to move from one part of the plant to the other part during various cellular processes such as diffusion, osmosis, etc. It is denoted by the Greek letter Psi or and is expressed in Pascals (Pa). Water pressure of pure water is taken as zero at standard temperature and pressure. A solution has less water potential due to less water concentration. Water potential of a cell is affected by solute and pressure potential.

Solute potential- The magnitude of lowering of water potential due to the dissolution of solute is called solute potential.

Pressure potential- The water potential of pure water or a solution increases on the application of pressure values more than atmospheric pressure. It is termed as pressure potential.

The relation between water potential and pressure potential is as follows:

$$\psi_w = \psi_s + \psi_p$$

Question 7. What happens when a pressure greater than the atmospheric pressure is applied to pure water or a solution?

Answer: The water potential of pure water or a solution increases on the application of pressure values more than atmospheric pressure. For example, when water diffuses into a plant cell, it causes pressure to build up against the cell wall. This makes cell wall turgid. The pressure is known as pressure potential and has a positive value.

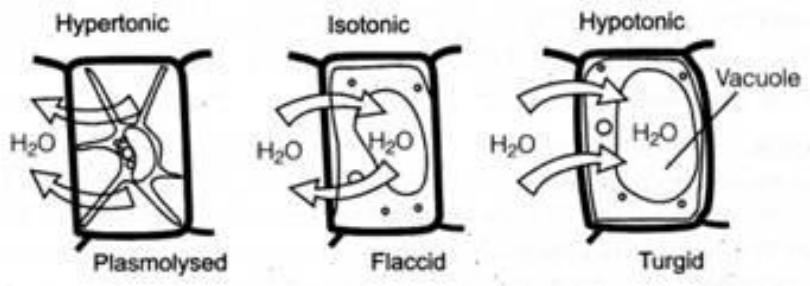
Question 8. (a) With the help of well-labelled diagrams, describe the process of plasmolysis in plants, giving appropriate examples.

(b) Explain what will happen to a plant cell if it is kept in a solution having higher water potential.

Answer:

(a) 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 is kept in a solution that is hypertonic (has more

solutes) to the protoplasm. Water moves out from the cell through diffusion causes the protoplasm to shrink away from the -walls. In such situation, cell become plasmolysed.



When the cell is placed in an isotonic solution. There is not flow of. water towards the inside or outside. If the external solution balances the osmotic pressure of the cytoplasm, it is said to be isotonic. When the water flow into the cell and out of the cells are in equilibrium the cell is called flaccid.
(b) When the plant cell is kept in a solution having high water potential (hypotonic solution or dilute solution as compared to cytoplasm), water diffuses into the cell causing the cytoplasm to build up a pressure against the wall, called turgor pressure. The pressure exerted by the protoplasts due to entry of water against the rigid walls is called pressure potential *Fp. Because of the rigidity of the cell wall, the cell does not rupture. This turgor pressure is ultimately responsible for enlargement of cells.

Question 9. How is the mycorrhizal association helpful in absorption of water and minerals in plants?

Answer: Mycorrhiza is the symbiotic association between roots of some plants and fungi. The hyphae provide a very large surface area and absorb mineral ions and water from soil. This is not possible for roots. The fungi provides mineral and water to roots. The hyphae secrete chemicals which protect the roots from pathogens.

Question 10. What role does root pressure play in water movement in plants?

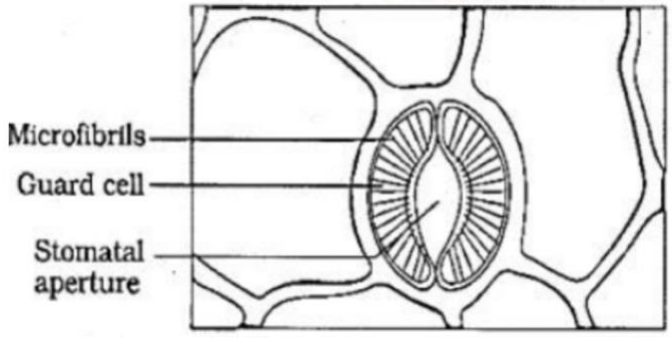
Answer: Root pressure is the positive pressure that develops in the roots of plants by the active absorption of nutrients from the soil. When the nutrients are actively absorbed by root hairs, water (along with minerals) increases the pressure in the xylem. This pressure pushes the water up to small heights. Root pressure can be observed experimentally by cutting the stem of a well-watered plant on a humid day. When the stem is cut, the solution oozes from the cut end.

Root pressure is also linked to the phenomenon of guttation, i.e., the loss of water in the form of liquid droplets from the vein endings of certain herbaceous plants.

Root pressure is only able to transport water up to small heights. However, it helps in re-establishing the continuous chains of water molecules in the xylem. Transpirational pull maintains the flow of water molecules from the roots to the shoots.

Question 11. Describe transpiration pull model of water transport in plants. What are the factors influencing transpiration? How is it useful to plants?

Answer: Transpiration is the evaporative loss of water by plants. It occurs mainly through the stomata in the leaves. Exchange of oxygen and carbon dioxide in the leaf also occurs through stomata. Normally stomata are open in the day time and close during the night. The cause is a change in the turgidity of the guard cells. The inner wall of each guard cell towards the stomatal aperture is thick and elastic. When turgidity increases, the thin outer walls bulge out and force the inner walls into a crescent shape. The opening of stoma is also aided due to the orientation of the microfibrils in the cell walls of the guard cells.



Factors affecting Transpiration: Temperature, light, humidity and wind speed.
Importance of Transpiration: Transport of liquids and minerals is facilitated because of transpiration.

Question 12. Discuss the factors responsible for ascent of xylem sap in plants.

Answer: The various factors responsible for the ascent of sap are as follows:

1. Capillarity- It is the limited rise of water in narrow tubes or capillaries due to forces of cohesion amongst the molecules of water and their property of adhesion to other substances.

2. Imbibition- It is the ability of hydrophilic colloid to attract and hold water on the surface and inside their interspaces.

3. Root pressure- It is the positive pressure that pushes sap from below due to active absorption by roots.

4. Transpiration pull- Transpiration in aerial parts brings the xylem sap under negative pressure or tension due to the 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.

Question 13. What essential role does the root endodermis play during mineral absorption in plants?

Answer:

(a) The root endodermis plays an essential role during mineral absorption in plants because it have many transport proteins embedded in their plasma membrane.
(b) These proteins are control point where the plant adjust the quantity and types of solutes that it absorbs from the soil. The root endoderm possess the layer of suberin. Suberin layer has the ability to actively transport ion in one direction only. The endodermis regulates the quantity and type of minerals and ions that reach the xylem.

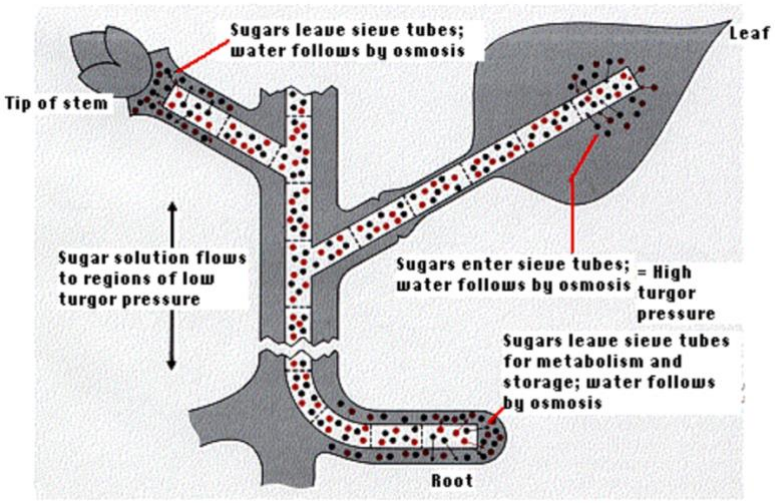
Question 14. Explain why xylem transport is unidirectional and phloem transport bi-directional.

Answer: Leaves are the site of food production for plants as they carry out photosynthesis. The major function of phloem is to conduct the food from the source to the sink. Since, here the source is single and sink can be multiple i.e. roots, branches, flower etc. so the conduction of food takes place in multiple directions. During spring also, the process of food conduction reverses and the food stored in the sink is mobilised toward the growing buds of the plant, through the phloem. Since the food is being conducted to many directions. the movement of food in the phloem is called bidirectional (i.e., upward and downward). The transport of water, on the other hand, takes place only from the roots to the leaves. Therefore, the movement of water and nutrients in the xylem is unidirectional.

Question 15. Explain pressure flow hypothesis of translocation of sugars in plants.

Answer: According to the pressure-flow hypothesis, food is prepared in the plant leaves in the form of glucose. Before moving into the source cells present in the phloem, the prepared food is converted into sucrose. Water moves from the xylem vessels into the adjacent phloem, thereby increasing the hydrostatic pressure in the phloem.

Consequently, the sucrose moves through the sieve cells of the phloem. The sucrose already presents in the sink region is converted into starch or cellulose, thereby reducing the hydrostatic pressure in the sink cells. Hence, the pressure difference created between the source and the sink cells allows sugars to be translocated from the former to the latter. This starch or cellulose is finally removed from the sink cells through active transport.



Question 16. What causes the opening and closing of guard cells of stomata during transpiration?

Answer: During transpiration the movement of potassium ions in and out of the guard cells causes the opening and closing of stomata. During day time when light falls on the leaves, the starch present in them absorbs the light. Due to this formation of malice acid takes place in the guard cells. The malice acid then dissociates to H+ ions and malate. The H+ ions move out of the guard cells and as a result K+ ions move inside the guard cells. Due to this the water potential in the guard cells decreases and water moves inside the guard cells causing them to swell up and become turgid which in turn causes the opening of stomata pores. At night K+ ions move out of them and water potential increases in the guard cells which causes water to move out of the cell and making them shrunk and closing the stomata pores.