BIOLOGY

TRANSPORT IN PLANTS

Translocation

Long distance transport occurs through vascular system, xylem and phloem called translocation through mass flow. The direction of translocation may be unidirectional as in case of water and multidirectional as in minerals and organic solutes.

Means of transport (Short distance transport)

The transport of material into and out of the cells is carried out by number of methods. These are diffusion, facilitated diffusion and active transport.

Diffusion

In this system, the molecules move from a region of higher concentration to a region of lower concentration. This process requires no energy.

Factors affecting diffusion: Permeability of membrane, Temperature, pressure, gradient of concentration and the size of substances.

Facilitated diffusion: The diffusion of hydrophilic substances along the concentration gradient through fixed membrane transport protein without involving energy expenditure. For this the membrane possess aquaporins and ion channels. No ATP energy is utilized in this process.

Methods of Facilitated Diffusion:

- **Symport:** Two molecules cross the membrane in the same direction at the same time.
- **Antiport:** Two molecules move in opposite direction at the same time.
- **Uniport:** Single molecules moves across membrane independent of other molecules.

Porins: The proteins that form huge pores in the outer membranes of the plastids, mitochondria and some bacteria which allow the small size molecules to pass through.

Aquaporins: Proteins that facilitate diffusion of water molecules through/ across the plasma membrane of cell.

Facilitated Transport

Here, the system moves molecules from a region of higher concentration to a region of lower concentration with the help of a carrier, usually a protein. This process does not require any energy and hence is known as the passive process.

Active Transport

This mechanism transfers molecules from a region of lower to a region of higher concentration with the help of membrane proteins. This system is termed as active transport because it requires ATP to function.

Water Potential

Water potential is used by the plants to transport water to the leaves that help in carrying out photosynthesis. Solute potential and pressure potential are the two main components of water potential.

Solute potential is also known as osmotic potential and is negative in the plant cell. Pressure potential is positive in the plant cell. Higher the concentration of water in the system, greater will be the water potential.

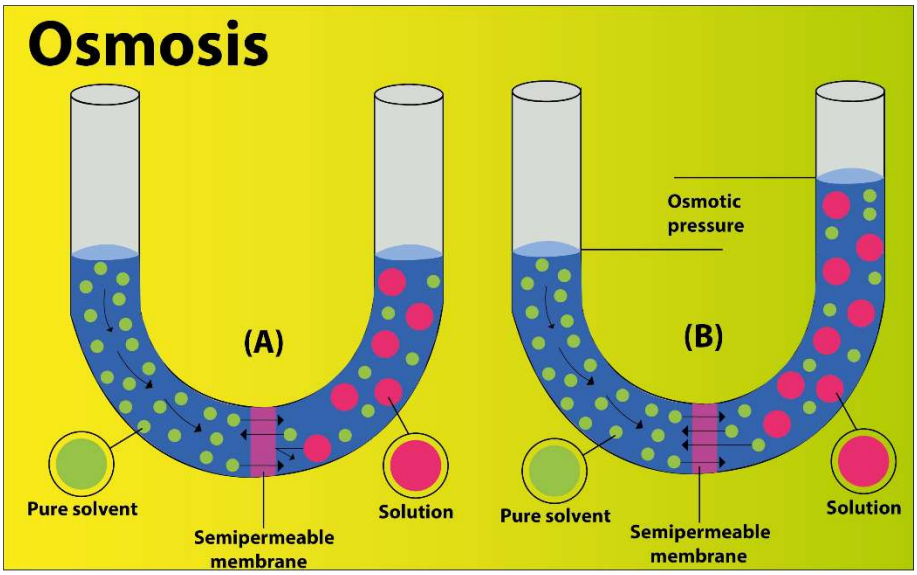
Osmosis

Osmosis is the movement of molecules from a region of higher concentration to a region of lower concentration across a semi-permeable membrane until an equilibrium is reached.

The plant cell wall is freely permeable to substances in solution and water.

Osmosis is of two types:

- **Endosmosis:** This is the movement of water molecules enters into the cell when the cell is placed in a hypotonic solution.
- **Exosmosis:** This is the movement of water molecules out of the cell when the cell is placed in a hypertonic solution.



Isotonic: If the surrounding solution balances the osmotic pressure of cytoplasm, the solution

is called isotonic.

Hypotonic: If the external solution is more dilute than cytoplasm, it is hypotonic. The cells swell up when placed in hypotonic solution.

Hypertonic: If the external solution is more concentrated than cytoplasm, it is hypertonic. Cell will shrink in hypertonic solution.

Plasmolysis

Plasmolysis is the shrinkage of the cytoplasm of the cell away from its cell wall under the influence of hypertonic solution. The pressure of plasmolysis is usually reversible when the cell is placed in hypotonic solution.

Turgor pressure

The pressure builds up against the wall due to movement of water inside is called turgor pressure. It is responsible for enlargement and extension growth of cells.

Imbibition

Imbibition is a special type of diffusion when water is absorbed by solid colloids causing them to increase in volume. For example, absorption of water by seeds and dry woods. Imbibition is also a kind of diffusion because movement of water is from higher concentration to lower concentration.

Mass or bulk flow system

Long distance transport of water in plants takes place by mass or bulk flow system. It is the movement of substance in bulk from one point to another as a result of pressure difference between two points.

Absorption of water by plants

Water is absorbed along with mineral solutes by root hairs by diffusion. The absorbed water passes to deeper layer by two pathways.

Apoplast pathway

- It consists of non-living parts of plants body such as cell wall and intercellular spaces.
- There is little resistance in movement of water.
- It is faster.
- Metabolic state of root does not affect apoplast pathway.

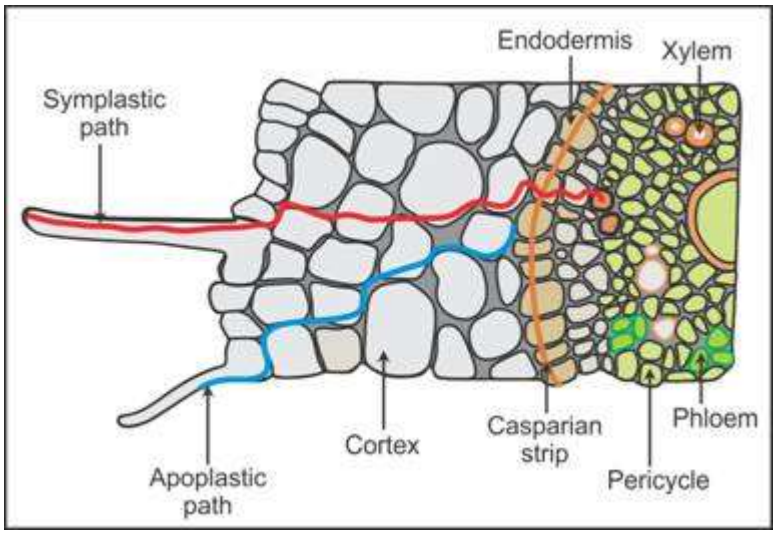
Symplast pathway

- It consists of living parts of plant body such as protoplast connected to plasmodesmata.
- Some resistance occurs in the movement of water.
- It is slightly slower.
- Metabolic state of root directly affect symplast pathway.

Casperian strip

The inner boundary of cortex, endodermis is impervious to water due to suberised matrix called Casperian strip. Water molecules are directed through wall regions that are not suberised.

Water flows through the different layers of roots to reach the xylem tissues as follows:



Mycorrhiza

A mycorrhiza is the symbiotic association between a fungus and angiospermic roots. The fungal filaments form a network around the young root to have large surface area that help to absorb mineral ions and water from the soil. The fungus provides minerals and waters and roots in turn provide organic and nitrogen containing compounds.

Vital force theory

Vital force theory was forwarded by J.C. Bose in 1923. This theory believes that the innermost cortical cells of the root absorb water from the outer side and pump the same into xylem channels.

Pressure theory

Root pressure theory was forwarded by Priestley in 1916. Root pressure is positive pressure that develops in the xylem sap of the root of plants. It can be responsible for pushing up water to small heights in plants.

Guttation

Loss of water in liquid phase by herbaceous plants from the tips of leaf blades is known as guttation.

Theory of Capillarity

Water rises in tubes of small diameters, kept in vessels having water due to force of surface tension. Similarly, water rises in the walls of xylem channels due to adhesion and cohesion. This theory is called Theory of Capillarity.

Tension theory

Cohesion Tension theory was put forwarded by Dixon and Joly in 1894. According to this theory water is mostly pulled due to driving force of transpiration from the leaves. The water molecules remain attached with one another by cohesion force. The water molecule does not break in vessels and tracheid due to adhesive force between their walls and water molecules. Because of tension created by transpiration, the water column of plant is pulled up passively from roots to great heights.

Transpiration is the loss of water in the form of water vapour from aerial parts of plants. The following purpose is fulfilled by transpiration.

- Creates transpirational pull for absorption and transport in plants.
- Supplies water for photosynthesis.
- Transport minerals and salts from soil to other parts of plant.
- Cool the leaves and maintain their shape and size.

Photosynthesis is limited by available water. C_4 plants are twice as efficient as C_3 plants in term of fixing carbon. Although C_4 plants uses half as much water as C_3 plants for the same amount of CO_2 fixed.

Uptake and transport of mineral nutrients

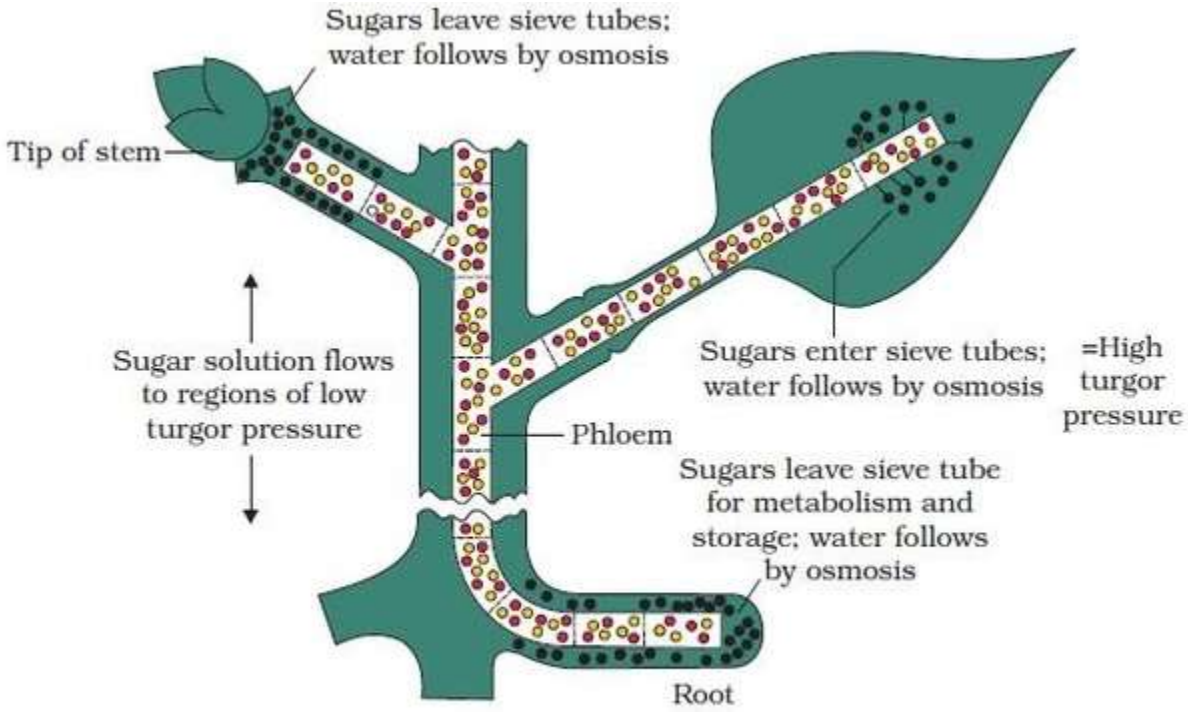
- Most of the minerals enter the roots by active absorption into the cytoplasm of epidermal cells because.
- Minerals are present in the soil as charged particles (ions) which cannot move across cell membranes.
- The concentration of ions in soil is usually lower than concentration in roots.
- Active absorption needs energy in form of ATP. Active uptake of ions is also responsible for water potential gradient in roots.

- Transport proteins of epidermal cells are control point where quantity and type of solutes that reach the xylem is adjusted.
- The ions that reaches to xylem by active or passive transport moves further upward along with transpirational pull.
- The chief sink of mineral elements are growing region of plants like apical meristem, young leaves, growing flower and fruit, and the storage organs.
- Minerals are frequently remobilized from older senescing part of the plants to young growing parts of plant.
- The elements most readily mobilized include phosphorus, Sulphur, nitrogen and potassium. The element like calcium is not mobilized as it is the structural components of plant body.

Phloem transport

Flow from Source to Sink

- Food (sucrose) is transported by phloem from source to sink. The part of plant that synthesize the food is called source and part where food is used or stored is called sink.
- The source and sink can be reversed by the plants depending upon the season or plant's need. So, the direction of movement in the phloem is bi-directional.
- Phloem sap is mainly water and sucrose, but other sugars, hormones and amino acids are also translocated through it.



Diagrammatic presentation of mechanism of translocation

Pressure flow or Mass flow hypothesis

- It is the most accepted theory for the translocation of sugar from source to sink. Glucose is prepared at source by photosynthesis which is converted into disaccharides (sucrose). Sucrose moves into companion cells and then into sieve tube cells by active transport.
- Loading of phloem at source creates a water potential gradient that facilitates the mass movement in the phloem.
- Sieve tube cells of phloem forms a long column with holes in their wall called sieve plates. Cytoplasmic strands pass through the hole in the sieve plates to form continuous filament. Hydrostatic pressure developed in sieve tube cells moves the sap in the phloem.
- At sink, incoming sugar is actively moved out of the phloem as complex carbohydrates. The loss of solute produces a high-water potential in the phloem and water passes out and returning into xylem.

CHAPTER : 11 TRANSPORT IN PLANTS

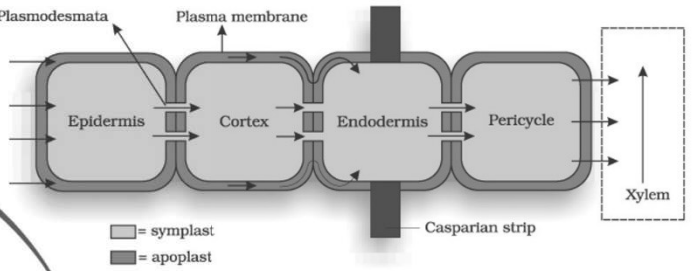
Transport in Plants

Means of Transport

- **Diffusion** — Passive movement of substances from high concentration to low concentration.
- **Facilitated Diffusion**
  - Uniport — One molecule move independent of other.
  - Symport — When both molecules move in the same direction
  - Antiport — Both molecules move in opposite direction
- **Active Transport** — Energy is required to pump molecules against concentration gradient.

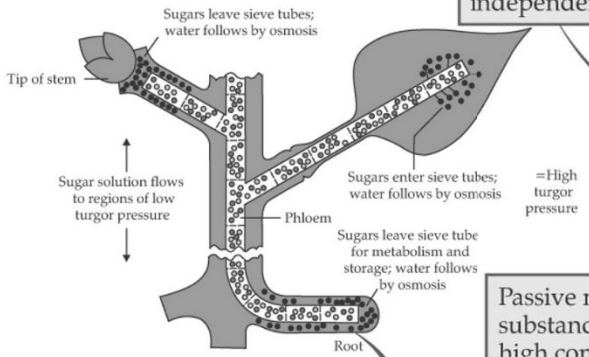
Plant Water Relations

- Water Potential (ψ_w) : $\Psi s + \Psi p$
- Osmosis Diffusion of solvent (water) across the semi-permeable membrane.
- Plasmolysis: Shrinkage of protoplasm in a cell, away from its cell wall and toward the center
- Imbibitions



Mass flow hypothesis

It is the most accepted theory for the translocation of sugar from source to sink.
- Source cells are cells which are the supplier of the food material, mainly leaves.
- Sink cells are cells which require food material for growth and repair.



Transpiration

It is the loss of water through stomata of leaves and other aerial parts of plants in form of water vapour.

Water movement up a plant

- **Root pressure** — It is a positive pressure that develops in the roots by the active absorption of nutrients from the soil.
- **Transpiration pull** — Transpiration creates transpirational pull for absorption and transport in plants.

Uptake and Transport of Mineral Nutrients

- **Uptake of Mineral Ions** — Minerals are absorbed by the roots by passive and active transport. The active uptake of ions requires ATP energy.
- **Translocation of Mineral Ions** — Unloading of mineral ions occur at fine vein endings of the leaves through diffusion. Some minerals are also remobilised from old senescing parts N, P K, S.

Absorption of water

- Symplast Pathway
- Apoplast Pathway

Important Questions

➢ Multiple Choice Questions:

Question 1. The movement of molecules of solids, liquids and gases from the region of their higher concentration or kinetic energy through semi- permeable membrane to the region of lower concentration or kinetic energy is termed as

(a) Imbibition
(b) Diffusion
(c) Osmosis
(d) All of these

Question 2. The phenomenon of absorption of water or any other liquid by the soil particles of a colloidal substance without forming a solution is called

(a) Imbibition
(b) Diffusion
(c) Osmosis
(d) None of these

Question 3. In a fully turgid cell turgor pressure (T.P.) is equal to

(a) Osmotic pressure
(b) Diffusion pressure deficit
(c) Wall pressure
(d) None of these.

Question 4. The contraction of the protoplast due to exosmosis when the cell is placed in hypertonic solution is called

(a) Deplasmolysis
(b) Plasmolysis
(c) Both (a) and (b)
(d) None of these.

Question 5. If turgidity of a cell surrounded by water increases, the wall pressure will

(a) Decrease
(b) Increase
(c) Fluctuate
(d) Remain unchanged.

Question 6. Positive pressure developed in tracheary elements of the root as a result of metabolic activities of the root of plant for pushing the water upwards through xvlem into the shoot system is termed

(a) Diffusion pressure
(b) Osmotic pressure

(c) Turgor pressure
(d) Root pressure.

Question 7. Guttation in plants is regulated by

(a) Humidity
(b) Availability of water in soil
(c) Temperature
(d) AH of these.

Question 8. The conducting tissue which takes part in the path of ascent of sap is

(a) xylem
(b) phloem
(c) Both (a) and (b)
(d) None of these.

Question 9. Water potential in the leaf cells is positive during:

(a) Guttation
(b) Low transpiration
(c) Excessive transpiration
(d) Excessive absorption.

Question 10. Stomata are mainly concerned with

(a) Transpiration
(b) Gaseous exchange
(c) Both (a) and (b)
(d) none of these.

Question 11. Stomata open during day and close during night under inesophytic conditions in type.

(a) Leucerne
(b) Patato
(c) Cereal
(d) Barley

Question 12. Rate of transpiration depends upon

(a) Increase or decrease of atmospheric temperature
(b) Increase in light intensity upto certain limit.
(c) Difference in vapour pressure of intercellular spaces of mesophyll tissue and atmospheric air.
(d) All of these

Question 13. The direction and rate of water movement from cell to cell is based on:

(a) Wall pressure

(b) Turgor pressure
(c) Incipient plasmolysis
(d) Diffusion pressure deficit.

Question 14. Passive of water from one cell to another is controlled by:

(a) Wall pressure
(b) Diffusion pressure deficit
(c) Hydrostatic pressure
(d) Osmotic pressure.

Question 15. Imbibition involves:

(a) Capillary
(b) Diffusion
(c) Osmosis
(d) Both (a) and (b)

➢ Fill In the Blanks:

1. Transport over longer distances proceeds through the vascular system and is called …….
2. ……. is very important to plants since it the only means for gaseous movement within the plant body.
3. Water ehannels-made up of 8 different types of …….
4. Water is essential for all …… activities of the plant and plays a very important role in all living organisms.
5. ……. and ……. are the two main components that determine water potential.
6. Pressure potential is usually positive, though in plants negative potential or tension in the water column in the xylem plays a major role in water …… up a stem.

➢ True or False:

1. Transport over longer distances proceeds through the vascular system (the xylem and the phloem) and is called transpiration.
2. Diffusion rates are affected by the gradient of concentration, the permeability of the membrane separating them, temperature and pressure.
3. Some channels are always open; others can be controlled. Some are large, allowing a variety of molecules to cross.
4. When a molecule moves across a membrane independent of other molecules, the process is called uniport.
5. A seed may appear dry but it still has water-otherwise it would not be alive and respiring.
6. Water potential is denoted by the greek symbol psi or ψ and is expressed in pressure units

such as pascals (Pa).

➢ Very Short Question:

1. Define heat of wetting or hydration.
2. What phenomenon is always associated with imbibition?
3. Which solution de-plasmolyse the plasmolyse solution?
4. What is the full form of D.P.D.?
5. Name the element that regulates turgidity in guard cells.
6. Which type of guard cells are found in grasses?
7. Which is the important factor that affects water potential?
8. Why do plants growing in arid regions bear small leaves with sunken stomata?
9. Name two antitranspirants.
10. When does wilting occur?

➢ Short Questions:

1. What is osmosis?
2. What is the active transport of water?
3. Define permanent wilting co-efficient or permanent wilting percentage.
4. What are the conditions for imbibition to take place?
5. Give an account of the water relations of a plant cell when it is placed in

   (a) Hypertonic solution,

   (b) Hypotonic solution.
6. What is the ascent of sap?
7. What are the advantages of transpiration?
8. Define water holding capacity or field capacity of the soil.

➢ Long Questions:

1. Describe the theories related to the translocation of water.
2. Is there a general mechanism to explain the opening and closing of stomata? Justify your answer.
3. Mention some factors that influence stomatal opening and closing. How are these factors involved in regulating stomatal behaviour?
4. Write short notes on:

   (i) Cohesion-Tension and Transpiration pull theory.

(ii) Mass flow hypothesis.

Assertion Reason Question-

1. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.
   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
   (c) If Assertion is true but Reason is false.
   (d) If both Assertion and Reason are false.

   Assertion: No energy expenditure is observed in the process of diffusion.

   Reason: Diffusion occurs along the concentration gradient, i.e., from a region of higher concentration to a region of lower concentration.

2. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.
   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
   (c) If Assertion is true but Reason is false.
   (d) If both Assertion and Reason are false.

   Assertion: b -cyanine does not diffuse to the outside of the cell through washed beet root slices when kept in cold water.

   Reason: Membrane is not permeable to pigment b -cyanine.

✓ Answer Key-

➢ Multiple Choice Answers:

1. (b) Diffusion
2. (a) Imbibition.
3. (a) Osmotic pressure.
4. (b) Plasmolysis.
5. (b) Increase.
6. (d) Root pressure.
7. (d) All of these.
8. (a) xylem.
9. (d) Excessive absorption.
10. (c) both (a) and (b).
11. (a) Leuceme

12. (d) All of these.
13. (d) Diffusion pressure deficit.
14. (b) Diffusion pressure deficit.
15. (d) Both (a) and (b).

➢ Fill In the Blanks:

1. translocation
2. Diffusion
3. aquaporins
4. physiological
5. Solute potential, pressure potential
6. transport

➢ True or False:

1. False
2. True
3. True
4. True
5. True
6. True

➢ Very Short Answers:

1. Answer: Imbibition of water is always associated with heat generation is called wetting or hydration.
2. Answer: Heating of wetting or hydration.
3. Answer: Hypotonic solution.
4. Answer: Diffusion pressure deficit.
5. Answer: Potassium.
6. Answer: Dumb bell-shaped.
7. Answer: Solute concentration.
8. Answer: To reduce transpiration.
9. Answer: Abscisic acid (ABA), Phenyl Mercuric Acetate (PMA).
10. Answer: When the rate of evaporation of water exceeds the rate of uptake of water by roots.

➢ Short Answer:

1. Answer: It is the movement of water molecules from a region of its higher concentration to low concentration through the plasma membrane. It is a vital process. Various physiological process in plants takes through osmosis.
2. Answer: It is the transport of water molecules against the concentration gradient with the utilization of energy (ATP). The molecules from low to high concentration move through the active transport of water.
3. Answer: The percentage of water on a dry weight basis of the soil that still remains at the time when the plant shows permanent wilting is termed as permanent wilting co-efficient. It various between 1-1.5% depending upon the texture of the soil. It is higher in clayey soil than sandy soil.
4. Answer: There are two conditions necessary for imbibition to take place:

   i. Water potential gradient between the surface of the adsorbent and the liquid imbibed.

   ii. The affinity between the adsorbent and the imbibed liquid. It is a type of diffusion by which the movement of water takes place.
5. (a) Answer: When the cell is placed in hypertonic solution exosmosis occurs, the protoplast contracts and the cell membrane detaches from the cell wall and contracted protoplast. This contraction of the protoplast by ex¬osmosis is termed plasmolysis.

   (b) Answer: When a plasmolysed cell is placed in water or hypotonic solution, endosmosis occurs and the protoplast regains the original position. This phenomenon is termed de-plasmolysis.
6. Answer: Water and minerals absorbed by the plants through roots from the soil are transported to different parts of the plant as these play a vital role in their growth. Water along with various dissolved inorganic substances in it are termed sap. The upward translocation of sap (water and dissolved inorganic substances) from the roots to the aerial parts of the plant is termed ascent of sap.
7. Answer:

   1. Ascent of sap: Transpiration pull created in leaves is responsible for ascent of sap.

   2. Absorption of water: Transpiration pull is also responsible for passive absorption of water.

   3. The distribution of minerals in different parts of the plant is done by transpiration.

   4. Cooling effect: Transpiration lowers the temperature of the leaf and causes a cooling effect.

   5. The increased rate of transpiration favours the development of tissue, which provides strength to the plant.

   6. Excessive transpiration induces hardness which imparts resistance of plants to drought.

8. Answer: After heavy rainfall or irrigation, the amount of water actually retained by soil even against the force of gravity is termed as water holding capacity or field capacity of the soil. It is expressed in terms of the percentage of water present per unit dry weight of soil.

➢ Long Answer:

1. Answer: There are three most important theories related to the translocation of water.

    i. Root pressure theory

    ii. Capillarity

    iii. Cohesion theory.

    i. Root pressure theory: Water flows from higher water potential to low water potential. Water from the soil is absorbed by root hairs and conducted through xylem vessels. Mineral ions from the soil are taken up by roots and get deposited in the xylem vessels.

    When the stem of a plant is cut transversely above the soil surface, a drop of the xylem sap will exude from the cut surface. This indicates the presence of positive pressure in the xylem. This pressure is known as Root Pressure.

    ii. Capillarity: Capillarity means a rise in water in tubes of small diameter kept in a water vessel. The uptake of water through xylem vessel is possible in small size plants through capillarity. This is due to the forces of adhesion and cohesion.

    Adhesive forces attract molecules of different kinds whereas cohesive forces attract molecules of the same kind to each other. According to this theory, water is taken due to the force of adhesion and flows upward due to the force of cohesion.

    iii. Cohesion: This is the most important theory of water movement through plants. It is based on the force of cohesion between water molecules. This sets up a continuous water column from the top to the root tip of the plant. According to this theory water evaporates from the leaf to the atmosphere, results in a decrease in the water potential of epidermal cells.

    This loss of water is balanced by water moving from adjacent cells along a water potential gradient. The movement of the water occurs from the soil to the root. Uptake of water is termed as cohesion theory and also known as transpirational pull.

2. Answer: There is no general mechanism to explain the opening and closing of stomata. Because opening and closing of stomata are regulated by the accumulation of solute in the guard cells. Solutes are taken in the guard cells, as a result, osmotic potential and water potential of guard cells are lowered, the guard cells become turgid and swell size, resulting in the stomatal opening. With a decline in guard cell solutes, water moves out, resulting in the stomatal opening.

    There are two theories to explain the mechanism of opening and closing of stomata.

    i. Classical starch sugar conversion theory: According to this theory, the change in osmotic concentration is brought about due to the conversion of starch into glucose and vice-versa.

    ii. K+ Influx and Efflux theory: According to this theory when the leaf is exposed to light, the pH of

the guard ceils rises due to the active transfer of H+ ions from the cytoplasm into chloroplast's utilization of CO. in photosynthesis. In the majority of plants, stomata remain open during the day and close at night.

Hence, there is no general mechanism to explain the stomatal opening and closing.

3. Answer: Factors affecting stomatal movements:

i. Light: In most of the plant's stomata open during the day. The effect of light causes the opening of stomata or it may be either due to the hydrolysis of starch into glucose.

ii. The water content of leaves: A decrease of water content in stomatal cells results in an increase in their D.P.D. Water from guard cells moves into these cells and stomata close.

iii. CO_2 concentration: Low CO_2 concentration in guard cells causes the opening of stomata.

iv. pH: High pH stimulates the opening of stomata and low pH causes closure of stomata and high concentration of CO_2 causes closure of stomata.

v. Temperature: High temperature stimulates the opening of the stomata.

vi. Atmospheric Humidity: Humid environment favours opening and dryness causes closure of stomata.

vii. Minerals: Minerals like P, Mg, Ca etc. affect the stomatal opening. A high concentration of K+ ions causes the opening of stomata.

viii. Growth Hormones: Cytokinins stimulates the opening of stomata. Abscisic acid induces the closure of stomata.

4. (i) Answer: Transpiration pull theory: Ascent of sap has been explained satisfactorily by Dixon with the help of a theory called Transpiration pull theory. According to this theory water continuously evaporates from the turgid and moist cell walls of mesophyll cells in the leaves.

It makes the mesophyll air saturated. The air outside the leaf is dry. So a gradient is set up which allows the water vapours to go out from the interior of the leaf to the outside through the stomata. The mesophyll cells draw water from the deeper tissue, which in turn take water from the xylem of the leaf. It creates a kind of pull in the leaf called transpiration pull.

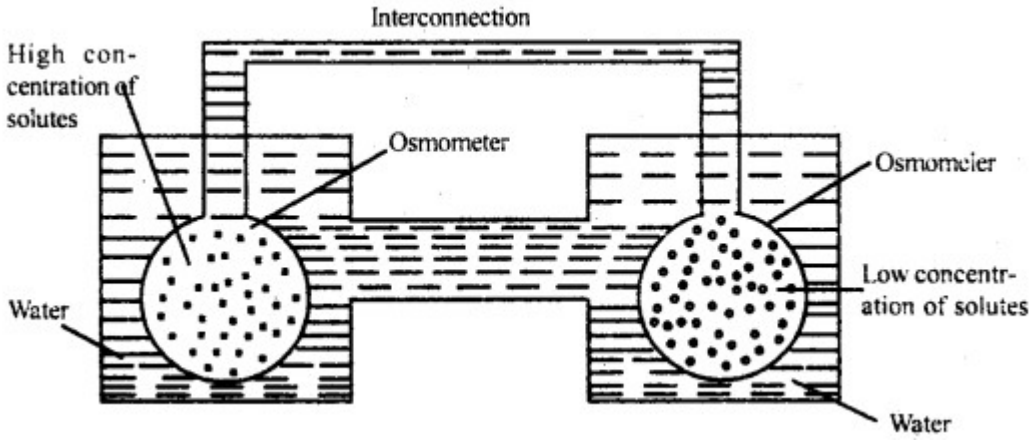
The xylem of the leaf is connected to the xylem of the stem and further to the xylem of the roots. Since there is a continuous column of water in the plant, water is virtually lifted up due to transpiration pull a situation similar to one like drawing a bucket of water from a well. The column of water does not break because of the great force of cohesion among the water molecules. This theory is also called the cohesion of water molecules theory.

(ii) Answer: Mass flow hypothesis: The carbohydrates prepared in the leaves are translocated to other parts of the plant in the form of sucrose through phloem at the expense of metabolic energy. Munch's mass flow hypothesis is the most accepted theory for the translocation of organic food.

According to this hypothesis, organic substances move from the region of high osmotic pressure

to the region of low osmotic pressure due to the development of a gradient of turgor pressure. This can be proved by taking two interconnected osmometers. One of the osmometers has a high solute cone than the other. The whole apparatus is placed in water.

Water enters the osmometer with a high solute cone. It creates high turgor pressure in it. High turgor pressure forces the solution to move through the tube to the other osmometer. It is called mass flow. If somehow, the solute is continuously added to the donor osmometer and converted into the osmotically inactive compound in the other osmometer, this system can work indefinitely.



Munch's mass flow apparatus.

Assertion Reason Answer-

1. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   Explanation: Process diffusion can be defined more meaningfully as the net transport of solute or solvent from a region of higher chemical potential or higher concentration to lower chemical potential or lower concentration area where ion, atoms or molecules moves randomly without the involvement of energy.

2. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   Explanation: Process of diffusion can be summarised easily as the movement of uncharged ions, atoms or molecules through a biological membrane depends upon the permeability of biological membrane. Depending upon the permeability, the membrane may be semi permeable or differentially permeable, selectively permeable and impermeable. Here, the membrane is impermeable to pigment betacynin. That is why, pigment betacynin is unable to colourise the water.