XI
11

TRANSPORT IN PLANTS

SYLLABUS

Movement of water, gases and nutrients; Cell to cell transport-Diffusion, facilitated diffusion, active transport;
Plant – water relations – Imbibition, water potential, osmosis, plasmolysis; Long distance transport of water – Absorption, apoplast, symplast, transpiration pull, root pressure and guttation; Transpiration-Opening and closing of stomata; Uptake and translocation of mineral nutrients-Transport of food, phloem transport, Mass flow hypothesis; Diffusion of gases (brief mention).

KEY CONCEPTS

INTRODUCTION

* Plant physiology (*Physis* = nature of life; *logos* = study) is the branch of botany which deals with the study of life activities of plants. It includes the functional aspects of life processes both at cellular as well as sub-cellular level.
* Stephan Hales is known as father of plant physiology.
* J.C. Bose is known as father of Indian plant physiology.
* Water is mainly absorbed by the roots of the plants from the soil, then it moves upward to different parts and is lost from the aerial parts, especially through the leaves.
* Transport of substances in plants over longer distances through the vascular tissue (Xylem and Phloem) is called **translocation.**
* The small distance transport of material into and out of the cells is carried out by a number of methods. These are diffusion, facilitated diffusion and active transport.

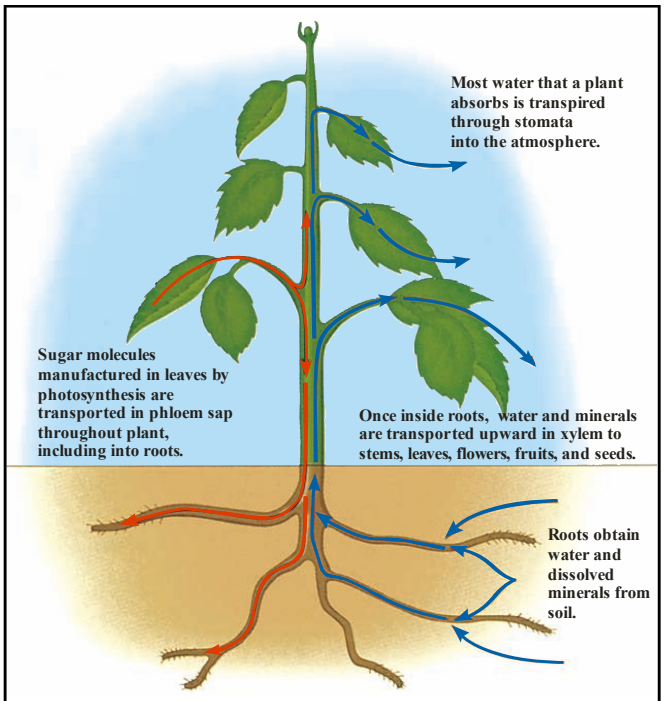


Figure : Overview of transport in vascular plants. Xylem transport is explained on the right side of the figure (start at the bottom and work upward), whereas phloem transport is on the left side.

DIFFUSION

* The movement of molecules or atoms or ions of a materials from an area of higher concentration to an area of their lower concentration is called diffusion.
* The diffusion is continue till the dynamic equilibrium is not established. At this stage the net movement of molecules is equal in both direction.
* The kinetic energy, which is present in the molecules of material is distributed equally in their available space by their nature.
* The diffused molecules or ions exert a pressure on the substance or medium in which diffusion takes place, known as diffusion pressure. This is developed due to difference in the concentration of molecules of the material.
* Water molecules moves from their higher concentration to the their lower concentration in plants.
* The rate of diffusion decreases with increasing size of molecules.
* The rate of diffusion increases with increase in temperature. This is because free energy of molecules increases with rise in temperature.
* The rate at diffusion would be slower if the medium is concentrated, i.e., increase in the number of foreign molecules causes the rate of diffusion to decrease. Thus a gas would diffuse more rapidly in vacuum than in air.
* Diffusion pressure gradient (DPG). It is the difference in the concentration of the diffusing molecules between one area and another over a specific distance. The steeper is the diffusion, pressure gradient, the faster is the rate of diffusion.

Significance of Diffusion

1. Exchange of gases like CO_2, O_2 take place through the diffusion.
2. The distribution of hormones in the plants take place through the diffusion.
3. The process of transpiration is a diffusion process:. The evaporation of water from the intercellular spaces is linked with diffusion during the transpiration.
4. The ions of the minerals may diffused into the plant body.
5. The process of osmosis is a special type of diffusion of solvent molecules through semipermeable membranes.

FACILITATED DIFFUSION

* The diffusion of hydrophilic substances along the concentration gradient through fixed membrane transport protein without involving energy expenditure is called facilitated diffusion.
* The diffusion of any substance across a membrane also depends on its solubility in lipids, the major constituent of the membrane.
* Substances soluble in lipids diffuse through the membrane faster.
* 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).**
* It is very specific. It is sensitive to inhibitors which react with protein side chains.
* The **porins** form huge pores in the outer membranes of the plastids, mitochondria and some bacteria allowing molecules upto the size of small proteins to pass through.
* **Water channels** are made up of eight different types of aquaporins.

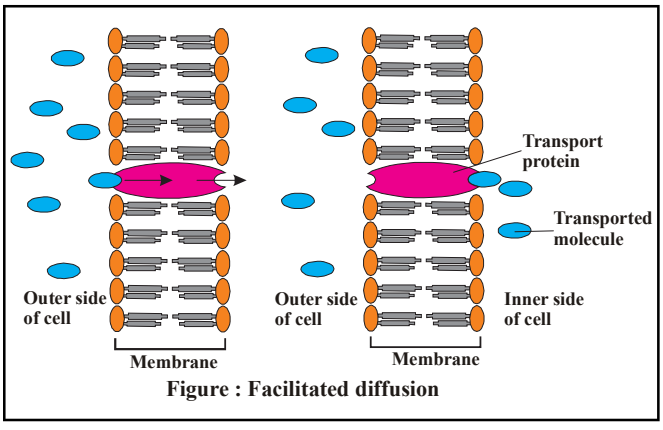


Figure : Facilitated diffusion

Passive symports and antiports

(a) Uniport: When a molecule moves across a membrane independent of other molecules.

(b) **Cotransport:** When two types of molecules move together with the help of carrier protein. It is of two types:

(i) **Symport:** Both molecules cross the membrane in the same direction at the same time.

(ii) **Antiport:** Both molecules move in opposite direction.

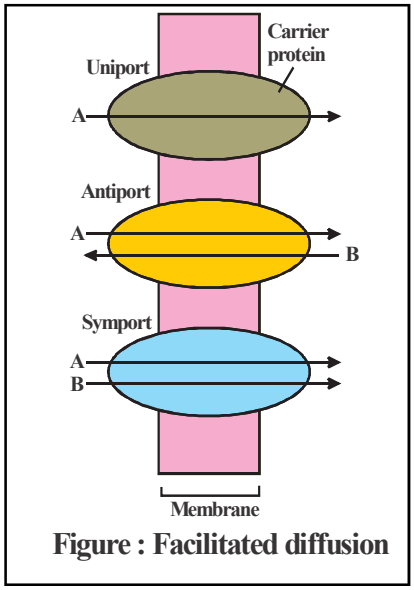


Figure : Facilitated diffusion

ACTIVE TRANSPORT

* Active transport is carried by the movable carrier proteins (pumps) of membrane.

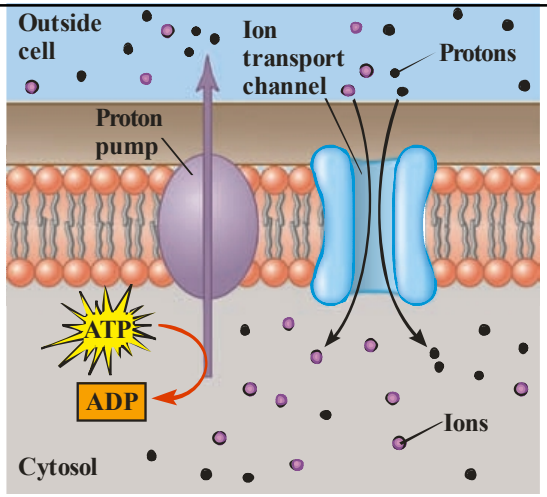


Figure : Movement of mineral ions by carrier-mediated active transport. The lipid bilayer of plant membranes is impermeable to mineral ions, which can only pass through ion transport channels. The hydrolysis of ATP pumps protons outside the cell, forming an energy-charged proton gradient. Ion transport channels allow mineral ions to enter the cell with protons.

* Active transport uses energy to transport and pump molecules against a concentration gradient from a low concentration to high concentration (uphill-transport).
* It is faster than passive transport.
* The rate of active transport reaches a maximum when all the protein pumps have been used in transport this is called **saturation effect.**
* Carrier proteins are **highly specific** like enzymes.
* They are also **sensitive to inhibitors** that react with protein side chains.
* **Table : Comparison of Different Transport Mechanisms**

Property	Simple Diffusion	Facilitated Transport	Active Transport
Requires special membrane proteins	No	Yes	Yes
Highly selective	No	Yes	Yes
Transport saturates	No	Yes	Yes
Uphill transport	No	No	Yes
Requires ATP energy	No	No	Yes

PERMEABILITY

* Permeability is the degree of diffusion of gases, liquids and dissolved substances through a membrane.
* Normally, permeability of a given membrane to a particular substance remains unchanged.
* However, changes in permeability can be brought about by many artificial and natural changes in the environment.
* Following four types of membranes have been recognized on the basis of permeability:

1. **Permeable :** This type of membrane allows a free diffusion of both solvent and solute or ions through them. *e.g.,* plant cell wall *i.e.,* cellulosic and lignified.

2. **Impermeable :** The membranes with deposits of cutin and suberin do not allow the entry of water, dissolved substances and gases, hence, called impermeable, *e.g.,* cell wall with thick layer of cutin on its surface.

3. **Semi-permeable.** A membrane that is impermeable to solute molecules but is permeable to the solvent is called a **semipermeable membrane**. This forms a perfect partition between two osmometers. *e.g.,* copper ferricyanide membrane, parchment membrane, cellophane, collodion membranes.

4. **Selectively or differentially permeable membrane.** This membrane allows some molecules and ions to enter readily, while allowing others more slowly and does not allow certain molecules at all (*i.e.,* **different** substances **diffuse at different rates).** Biological membranes, particularly the cell membrane (plasmalemma), tonoplast (vacuolar membrane) and the membranes surrounding sub cellular organelles are selectively permeable.

OSMOSIS

* Osmosis is defined as the special diffusion of solvent (water in this context) from the solution of lower concentration to the solution of higher concentration when the both are separated by a semipermeable membrane.
* Osmosis was discovered by Abbe Nollet.
* The detailed explanation of osmosis has been given by Traube and Duterochat.
* Osmosis can be demonstrated by a simple experiment in laboratory.
* Animal bladder or parchment membrane is tied to the wide mouth of a thistle funnel.
* Concentrated sugar solution or syrup is filled in the tube of the thistle funnel.
* Now, the wide mouth of thistle funnel is immersed in a beaker containing water.
* The level of the solution in the tube of the funnel is marked.
* After sometime, the level in the tube increases.
* This is due to the entry of water molecules from beaker into the thistle funnel.
* The concentration of water molecules in the beaker is more than their concentration inside the thistle funnel.
* Water molecules move from the region of their higher concentration *(i.e.,* from beaker) to the region of their lower concentration *(i.e,* inside the funnel)

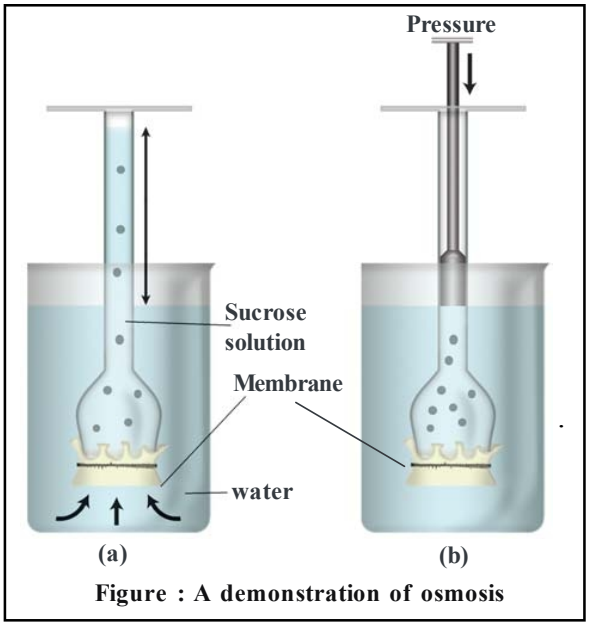


Figure : A demonstration of osmosis

* A thistle funnel is filled with sucrose solution and kept inverted in a beaker containing water. (a) Water will diffuse across the membrane (as shown by arrows) to raise the level of the solution in the funnel (b) Pressure can be applied as shown to stop the water movement into the funnel.

Endosmosis :

* When a cell is placed in a hypotonic solution water will enter into the cell from the outer (hypotonic) solution.
* It is because the cell sap is more concentrated (has less water molecules) than the outer solutions.
* This process of diffusion of water into the cell from outside is known as endosmosis.
* It will result in increase in the volume of the cell. *e.g.,* Raisins placed in water.

Exosmosis :

* When a cell is immersed in hypertonic solution, water will diffuse out of the cell, because the concentration of water molecules in the cell is more than the outer solution.
* This process is described as exosmosis. *e.g.,* grapes placed in sugar solution.

Significance of Osmosis :

1. Root hairs of the roots absorb water from the soil through the process of osmosis.

2. The conduction of water from one cell to another cell in plant and distribution of water in plant through the osmosis.
3. Turgidity is developed by the process of endosmosis which helps to maintain a definite shape of leaves, stem and flowers. Turgidity also provides mechanical strength to the plants.
4. The opening and closing of stomata are also depend on the process of osmosis.
5. The leaves of Mimosa pudica ("Touch me not") are drooping down only by contact and dehiscence of fruits are depends upon turgor changes after osmosis.
6. The resistance power increased due to high osmotic concentration against the dry climate and cold temperature.

OSMOTIC PRESSURE

* Term given by Pfeffer.
* It is the "maximum pressure which can develop in a osmotically active solution when it is separated from pure water by a semi-permeable membrane".
* It is also defined as "the pressure needed to prevent the passage of pure water into an aqueous solution through a semipermeable membrane thereby preventing an increase in the volume of the solution".
* The osmotic pressure (OP) depends upon (i) the concentration of solute particles, (ii) ionisation of solute particles, (iii) hydration of solute particles, (iv) temperature.
* An increase in the concentration of solutes in the solution increases the osmotic pressure.
* If the solute ionises in solution, the number of particles increase, thus raising the osmotic pressure.
* If solute molecules are hydrated, the water molecules bound with the solute are not able to diffuse and hence increase the osmotic pressure.
* An increase in temperature raises the osmotic pressure of solution.
* Plant cells exhibit a considerable range of variations in osmotic pressure.
* In land plants, it varies from 5-30 atms. In aquatic plants, it varies from 1-3 atmp.
* Plants of arid regions possess high OP.
* Highest osmotic pressure is recorded in a halophytic plant, *Atriplex confertifolia* i.e., 202.5 atms.
* OP of electrolyte is greater than a nonelectrolyte.
* OP of 1M NaCl is higher than solution of 1M glucose.
* Water moves from lower OP towards the higher OP.
* Osmotic pressure can be calculated by
  $OP(\pi) = m\ i\ R\ T$
  m = Molar concentration,
  i = Ionization constant, R = Gas constant,
  T = Temperature (273°K)
* Osmotic pressure is numerically equal to osmotic / solute potential (ψ_S) but has a positive value.
  $\psi_S = -\pi$

Factor affecting OP

(1) Concentration of solute particles: If the concentration of solute is increased then the OP of solution is also increased.

(2) Ionization of the solute molecule: Increased number of ions increases the OP.

(3) Temperature: OP of solution increases with increase in temperature.

(4) Hydration: Hydrated solute molecules will decrease the number of free water molecules, thereby increasing OP.

Reverse Osmosis:

* It is the reverse movement of water through a semipermable membrane from a more concentrated solution to a more dilute solution by applying external pressure on the more concentrated solution, the pressure required to bring about reverse osmosis is more than the one required to prevent osmotic entry of water into it.
* The method pushes out pure water.
* Reverse osmosis is used in chemical industries to obtain pure water and also to purify water for drinking purposes.

TYPES OF SOLUTIONS

* In relation to cell sap, solutions can be of following three types:

1. **Hypertonic solution :** A solution whose concentration is more than that of the cell sap is known as hypertonic. If a cell is placed in such a solution, water will diffuse out of it (exosmosis) and the protoplasm would contract or shrink.
2. **Hypotonic solution :** When the concentration of a solution is less than that of the cell sap, it is known as hypotonic. If a cell is immersed in hypotonic solution, water will diffuse into the cell (endosmosis) and it will increase in size.
3. **Isotonic solution.** A solution with concentration equal to that of cell sap, is known as isotonic. If a cell is placed in isotonic solution there would be no net diffusion of water. As a result there is no change in the volume and weight of the cell. (Neither endosmosis nor exosmosis).

TURGOR PRESSURE (TP)

* It is a pressure which is developed in an osmotic system due to entry of water.
* It causes swelling of the system.
* Protoplasm of a plant cell functions as an osmotic system such that on absorption of water it becomes turgid and the turgid protoplast presses the cell wall towards the outside with a force called **turgor pressure**.
* The cell wall also exerts a pressure over the protoplast, it is called wall pressure (WP).
* Normally wall pressure is equal but opposite to turgor pressure (WP = TP).
* Turgor pressure and wall pressure are positive pressures (negative TP is characteristic of plasmolysed cell and xylem vessels).
* Reduced turgor pressure results in loss of turgidity.
* Turgor change is also responsible for different types of plant movements and also for stomatal movement.

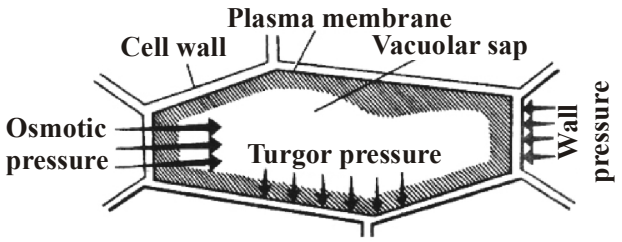


Figure : A cell showing Turgor pressure, Wall pressure and Osmotic pressure

DIFFUSION PRESSURE DEFICIT (DPD)

(Term by Meyer) or Suction Pressure (SP) (term by Renner)

* Each liquid has a specific diffusion pressure.
* Pure water has the maximum diffusion pressure.
* The solution prepared by dissolving solute (such as sugar or salt) in pure water has lesser diffusion pressure as compared to pure solvent or water (though the solution has higher osmotic pressure).
* In this way, there is always a difference between the diffusion pressure of solvent and its solution.
* Therefore, diffusion pressure deficit (DPD) may be defined as **the difference between the diffusion pressure of a solution and a pure solvent, when both are subjected to the same atmospheric pressure.**
* To remove this deficit, the solution would absorb more solvent molecules, means water moves from low DPD to high DPD.
* In this way, diffusion pressure deficit is the water absorption capacity of a solution.
* Therefore, DPD can also be called as suction pressure. Its value is always positive for a cell.

Diffusion Pressure Deficit
= Osmotic pressure – Turgor pressure

* The above relationship indicates, that

(1) When a cell is flaccid, its DPD = OP.
(2) The entry of water into the cell causes development of TP.
(3) When the increasing turgor pressure becomes equal to that of decreasing osmotic pressure, the entry of water into the cell would stop. This is called turgid condition of the cell. This can be expressed as OP – TP = 0, thus DPD = 0

WATER POTENTIAL OR ψ_w

* Chemical potential of water is called **water potential**.
* This term was introduced by **Slatyer** and **Taylor**.
* Chemical potential of pure water at normal temperature and pressure is taken zero.
* Chemical potential of water in any system, like in solution or in a cell will be less than zero *i.e.,* negative.
* Water always flows from higher water potential to lower water potential.
* Water potential is represented by Greek word ψ (Psi)/ψ_W and it is measured in bars or Pascal (Pa).
* Water potential is equal to DPD, but opposite in sign. Its value is negative.

$$\psi_W = - DPD$$

Components of Water Potential

1. **Solute potential (ψ_s) :** It is decrease in chemical potential of water over its pure state due to addition of solute particles because the solution has fewer free water molecules. Its value is always negative. More the solute particles, more negative will be the ψ_s.
2. **Pressure potential (ψ_p) :** It is positive pressure which develops in a system due to osmotic entry of water into it. Value of pressure potential is equal to value of turgor pressure. It is negative in plasmolysed cell and xylem vessel.

Hence, $\psi_w = \psi_s + \psi_p$.

For a solution at atmospheric pressure, ψ_w is equal to ψ_s.

(1 Bar = 10^6 dyne/sq. cm. or 0.987 atm.
1 megapascal = 10 bars)

PLASMOLYSIS

* If a plant cell placed in a hypertonic solution, water molecules diffused out from the cell.
* As a result of exosmosis the protoplasm of the cell detached from the cell wall and starts shrinking. This is called plasmolysis.
* Water is first lost from the cytoplasm and then from the vacuole. This process is usually reversible.
* TP as plasmolysed cells is –ve.
* The various sequences of plasmolysis are :

(i) In a turgid cell, the cell sap pushed away the protoplasm so that it is in contact with cell wall. When it placed in a hypertonic solution, the volume of the cell reduces due to shrinking of cell because some amount of water of cell sap diffused out by exosmosis. Turgor pressure decreases by which cell wall is not pushed by the protoplasm, so that shrinking cell membrane reduces in total volume of the cell. This situation, is called the first stage of plasmolysis or **limiting plasmolysis.**

(ii) If the diffusion of water to the outside is continued by the exosmosis then central vacuole contracts and with this protoplasm also shrinks but cell wall is not contracting. So that protoplasm is seems to detaching from the corners of cell wall. This condition is known as second phase of the plasmolysis or **incipient plasmolysis.**

(iii) The shrinking of protoplasm is continuous due to continuous exosmosis, it detached from the cell wall and assumed a spherical shape. This phase is known as **evident plasmolysis / full plasmolysis.**

Hypertonic solution is present in between the cell wall and protoplasm.

Significance of Plasmolysis :

* A living cell is distinguished from the non living (dead) cell through the plasmolysis. Because plasmolysis is not occurs in dead cell
* The osmotic pressure of any cell can be measured by incipient plasmolysis.
* If the plasmolysis-remains for long duration in a cell then it dies. To destroy the weeds, salts puts in their roots.

Fishes and meats prevented from spoilage by salting, which inhibits the growth of bacteria and fungus.

* Higher concentration of sugar in jams and jellies stops the growth of bacteria and fungus.
* High amount of chemical fertilizers near the root causes death or browning of the plant due to plasmolysis.
* The fresh water growing plants are either wilted or die when they are kept in marine water.

Deplasmolysis :

* "The swelling up of a plasmolysed protoplast due to endosmosis under the influence of a hypotonic solution or water is called deplasmolysis'.
* Deplasmolysis is possible only immediately after plasmolysis otherwise the cell protoplast becomes permanently damaged.
* The value of TP becomes zero at the time of limiting plasmolysis and below zero during incipient and evident plasmolysis.
* Leaf of *Tradescantia* is used for demonstration of plasmolysis in laboratory.

WATER POTENTIAL RELATION

Relation of the three phases of the cell by the water potential

(a) In case of fully turgid cell :

* There is no flow of water in a turgid cell , because the cell is a equilibrium condition with water which presents outside the cell.
* So that water potential will be zero at this state. Because osmotic potential and pressure potential are equal in the cell.
* For example, if the value of osmotic potential of a cell is –10 and pressure potential (ψ_P) is +10 then water potential will be zero as :

$\psi_W = \psi_S + \psi_P$, $\psi_W = -10 + 10$, $\psi_W = 0$

(b) In case of flaccid cell :

* When water flows into the cell and out of the cell and are in equilibrium, the cells are said to be flaccid.
* Turgor pressure is zero at this stage. It means pressure potential is zero.
* If osmotic potential of the cell is –10 bars then

$\psi_W = \psi_S + \psi_P$; $\psi_P = 0$ = TP ;
$\psi_W = -10 + 0$ bar ; $\psi_W = -10$ bar

(c) In Plasmolysed cell :

* The pressure potential (ψ_P) means turgor pressure is negative in this stage. Therefore water potential (ψ_W) of this cell will be more negative [more –ve].
* If the value of osmotic potential is –10 bar of a plasmolysed cell and value of pressure potential is 2 bars then its water potential (ψ_W) will be – 12 bars.

$\psi_W = \psi_S + \psi_P$, $\psi_W = -10 + (-2)$ bar,
$\psi_W = -12$ bar

* This is the conclusion that water always move from higher water potential towards the lower water potential.
* For example if the water potential of A cell is –10 bars and water potential of B cell is – 12 in two cells, then water will be flow from A cell to the B cell.
* Demand of water = Plasmolysed cell > Flaccid cell > Partially turgid cell > Fully turgid cell

IMBIBITION

* Adsorption of undissolved liquid by any solid material is called imbibition or adsorption of water by hydrophilic colloids is known as imbibition.
* This is a physical process by which a dry solid colloid material swells up by adsorption of water,
* The cell wall is made up of colloidal substances as cellulose, pectin, hemicellulose etc. All they are hydrophilic in nature. Therefore they imbibe water.
* Proteins, Agar-agar, starch etc., these all are imbibant materials.
* Agar - agar can adsorbs 99 times more water than that of its weight. Some of the protein adsorb 15 times more water.
* Affinity should be must between imbibant and liquid material and movement of water occurs in order of water potential gradient.

Imbibition power = Agar-Agar > Pectin > Protein > Starch > Cellulose

* The heat is released during the imbibition is called heat of wetting.

* A huge pressure is developed in material due to imbibition. This pressure is called Imbibition pressure (IP).
* Dry wood is filled in the natural grooves of rocks and watered them. The rocks are broken due to their swelling.
* The imbibition is less in compact arranged material like wood, and more in lighter or soft material like gelatin.
* Imbibition decreases with increasing pressure on imbibant material.

Significance of Imbibition :

1. Absorption of water during the seed germination is only initiate through the imbibition.
2. Breaking of seed coat during-the seed germination is due to imbibition process. Proteins, fats and starch is present in their kernel. This kernel swells up more as compared to the seed coat which breaks the seed coat.
3. Initial process of water absorption in roots by root hairs is imbibition.
4. Resurrection in many plants like Selaginella, Lichen, takes place due to the process of imbibition.
5. The water enter into the aerial roots and dry fruits is due to imbibition.
6. Newly formed wood swells up in rainy season.

NOTE :

Movement of water molecules :

Higher D.P. → Lower D.P.

Lower O.P. → Higher O.P.

Lower D.P.D. → Higher D.P.D.

Higher (less –ve) ψ_W → Lower (more –ve) ψ_W

Higher T.P. → Lower T.P.

Hypotonic → Hypertonic

Lower concentration of solution → Higher concentration of solution

TRANSPORT OF WATER IN PLANTS

* The amount of water that can be held by soil, depends upon the total pore space in the soil.
* Water is present in the spaces between the soil.
* The total amount of water present in soil is called **Holard**.
* The water available to plants is **Chresard**.
* The rest of soil water is called **Echard**.
* The responsibility of absorption of water and minerals is more specifically the function of the root hairs that are present in millions at the tips of the roots.
* Root hairs are thin-walled slender extensions of root epidermal cells that greatly increase the surface area for absorption.
* Water is absorbed along with mineral solutes, by the root hairs, purely by diffusion.
* Once water is absorbed by the root hairs, it can move deeper into root layers by two distinct pathways:

(i) **Apoplast pathway :** The apoplast is the system of adjacent cell walls that is continuous throughout the plant, except at the casparian strips of the endodermis in the roots

* Movement of water takes place exclusively through the intercellular spaces and the walls of the cells.
* Movement through the apoplast does not involve crossing the cell membrane.
* Movement depends on the gradient.
* The apoplast does not provide any barrier to water movement.
* Water movement is through mass flow.
* As water evaporates into the intercellular spaces or the atmosphere, tension develop in the continuous stream of water in the apoplast, hence mass flow of water occurs due to the adhesive and cohesive properties of water.

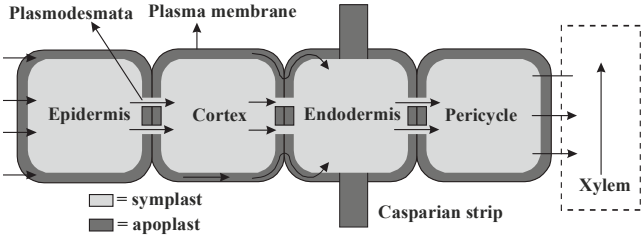


Figure : Pathway of water movement in the root

(ii) Symplast pathway :

* System of interconnected protoplasts.
* Neighboring cells are connected through cytoplasmic strands that extend through **plasmodesmata.**
* Water enters into the cytoplasm by crossing the plasma membrane.
* Intercellular movement is through the plasmodesmata.
* Movement is relatively slower. Movement is again down a potential gradient. Symplastic movement may be aided by cytoplasmic streaming.
* Path of water absorption
  Soil solution → Root hairs → Epiblema / Epidermis → Cortex → Endodermis (Passage cells) → Pericycle cells → Protoxylem → Metaxylem.

* **Difference between Apoplast pathways and Symplast pathways of water movement**

S.N.	Apoplast pathway	Symplast pathway
1.	It consists of non-living parts of plant body, i.e. cell walls and intercellular spaces.	It consists of living parts of plant body, i.e., protoplasts connected by plasmodesmata.
2.	There is little resistance in the movement of water.	Some resistance occurs in the movement of water through symplast.
3.	It is faster.	It is slightly slower.
4.	Metabolic state of root does not affect apoplast pathway.	Metabolic state of root directly affects symplast pathway.

* Most of the water flow in the roots occurs via the apoplast since the cortical cells are loosely packed, and hence offer no resistance to water movement. However, the inner boundary of the cortex, the endodermis, is impervious to water because of a band of suberised matrix called the **casparian strip**. Water molecules are unable to penetrate the layer, so they are directed to wall regions that are not suberised, into the cells proper through the membranes. The water then moves through the symplast and again crosses a membrane to reach the cells of the xylem.

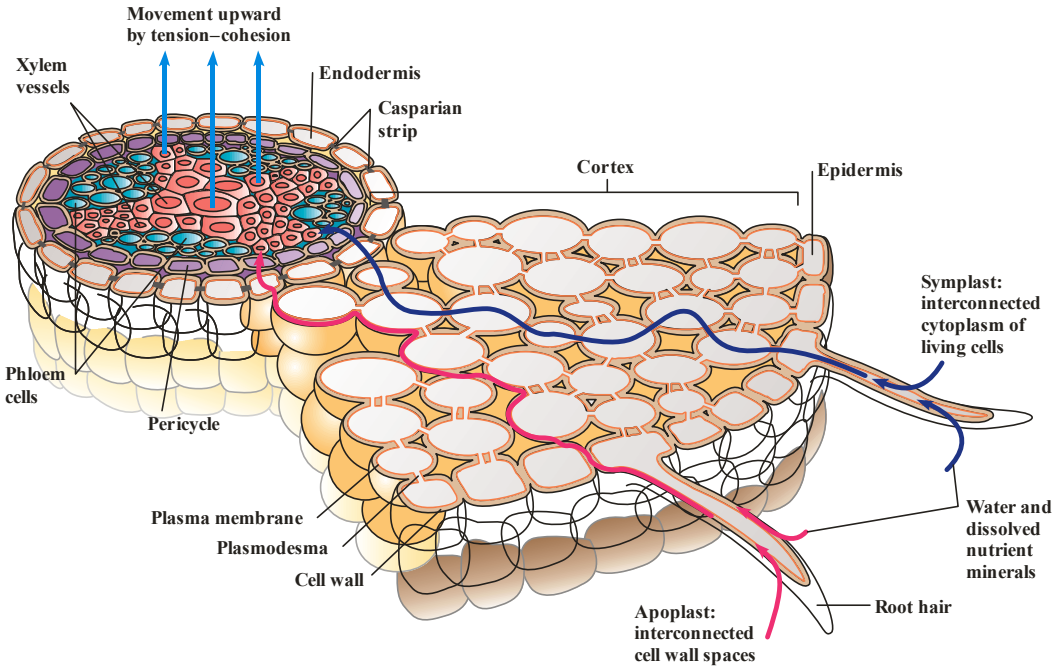


Figure : Pathways of water and dissolved minerals in the root Water and dissolved minerals travel from cell to cell along the interconnected porous cell walls (the apoplast) or from one cell's cytoplasm to another through plasmodesmata (the symplast). On reaching the endodermis, water and minerals can move into the root's center only if they pass through a plasma membrane and enter the cytoplasm of an endodermal cell.

* The movement of water through the root layers is ultimately symplastic in the endodermis.
* Once inside the xylem, water is again free to move between cells as well as through them. In young roots, water enters directly into the xylem vessels and/or tracheids. These are non-living conduits and so are parts of the apoplast.
* 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.

Water Movement up a Plant

(i) Root Pressure :

* 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.
* Effects of root pressure is also observable at night and early morning when evaporation is low, and excess water collects in the form of droplets around special openings of veins near the tip of grass blades, and leaves of many herbaceous parts. Such water loss in its liquid phase is known as **guttation**.
* Phenomenon is commonly seen in Oat, Tomato, Cucumber, Garden Nasturtium and *Saxifraga* etc.
* The **root pressure is built** up which pushes the water up in the xylem ducts, from where it comes out on the leaf surface through special structures called hydathodes.

Figure : Guttation- Shown is a compound leaf of strawberry (*Fragaria*) with water droplets formed by guttation.

* **Hydathodes** are present at the tips of veins in leaves.
* A hydathode consists of a pore in the epidermis followed by large intercellular spaces and loosely arranged parenchyma called **epithem** and blindly ending xylem elements.
* Guttated water contains inorganic and organic salts and is not pure.
* Root pressure does not account for the majority of water transport; most plants meet their need by transpiratory pull.

(ii) Transpiration pull :

* Water evaporates from mesophyll cells of the leaf due to transpiration.
* This results in an increase in their diffusion pressure deficit (DPD) or suction pressure.
* Since the water in the mesophyll cells is in contact with xylem sap of stem and roots through tracheids in the veins, the diffusion pressure gradient gradually passes down to the xylem of the root (negative pressure) and water is pulled up.
* Due to transpiration, there is a constant pull or tension on water column in upward direction. This is called transpiration pull or tension in the water column of xylem due to transpiration.
* Water potential as low as **(-3 MPa or -30 bars)** has been measured in the leaves borne on tree tops.

* This can overcome gravitational pull and resistance offered by the capillaries of xylem vessels.
* The theory assumes tracheids to be more efficient than vessels.
* They believed that partition walls of the tracheids confer stability on the stressed transpiration stream.
* **Cohesion :** Mutual attraction between the water molecule is known as cohesion, which form a continuous water column in xylem elements.
* **Adhesion :** Attraction between xylem walls and water molecules is called adhesion force, which helps in maintenance of water column of xylem.
* **Transpiration pull :** A tension or negative pressure develops in xylem, due to rapid transpiration in leaves (because of high DPD), this creates a transpiration pull, which is responsible for the pulling up of water column in xylem. So ascent of sap is constitutive effect of cohesion, adhesion and transpiration pull.

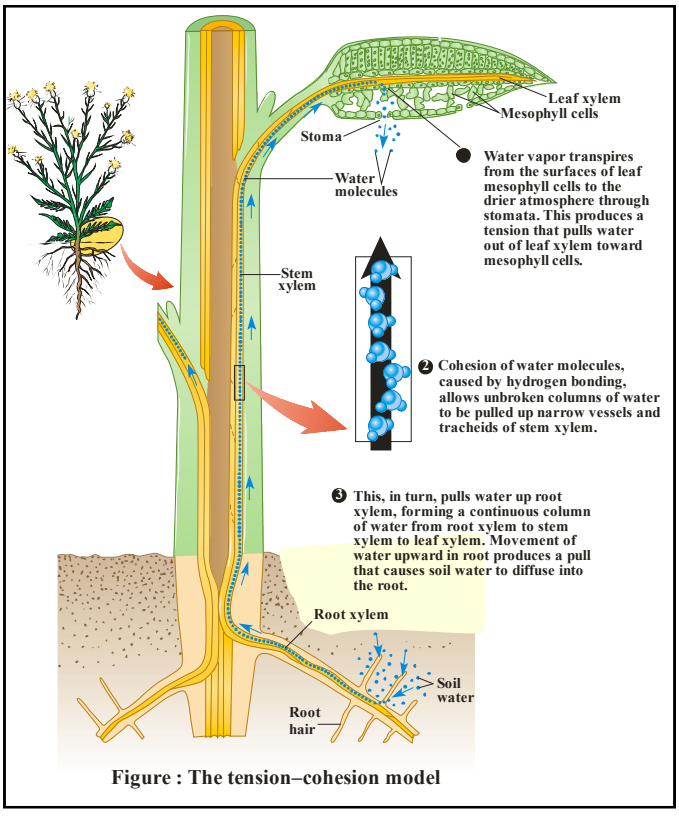


Figure : The tension–cohesion model

Passive absorption

* Force for passive absorption lies in shoot
* Transpiration pull plays the major role
* A negative pressure is developed in xylem
* Rate of absorption is high
* Responsible for 96% of total water absorption
* Takes place in rapidly transpiring plants
* Water absorption through the roots
* It is apoplastic

Active absorption

* Force for active absorption develops in root.
* OP and energy play the major role
* A positive pressure is developed in xylem
* Rate of absorption is low
* Accounts for only 4% of water uptake
* Takes place in slowly transpiring plants
* Water absorption by the roots
* It is symplastic

Factors affecting water absorption :

(1) **Available soil water :** Absorption of water is more, if the amount of available water is more. Rate of water absorption decreases, if the amount of soil water is below permanent wilting percentage or beyond field capacity.

(2) **Soil air :** Absorption of water takes place at a rapid rate in well aerated soil. Oxygen deficiency retards the growth of roots, thus inhibiting absorption of water. In the soil, if all the air spaces are filled with water the condition is known as **water logging of soil.** Such soil is physiologically dry soil.

(3) **Concentration of soil solution :** If the soil solution is highly concentrated due to the presence of salts, it will inhibit the water absorption. It is also a kind of physiological dryness.

(4) **Soil temperature :** An increase in soil temperature upto about 30°C favours water absorption. At higher temperatures water absorption is decreased and at 0°C it is almost checked.

TRANSPIRATION

* Loss of water in vapour form, from the aerial parts(organs) of living plants is known as Transpiration.
* Only few percentage [1-2%] of absorbed water is used by the plants while remaining [98-99%] of water lost atmosphere.

* Transpiration is an essential evil – by Curtis
* Transpiration is an unavoidable evil-by Steward.
* The minimum transpiration is found in succulent xerophytes & no transpiration in submerged hydrophytes.
* Maximum transpiration is found in mesophytes.

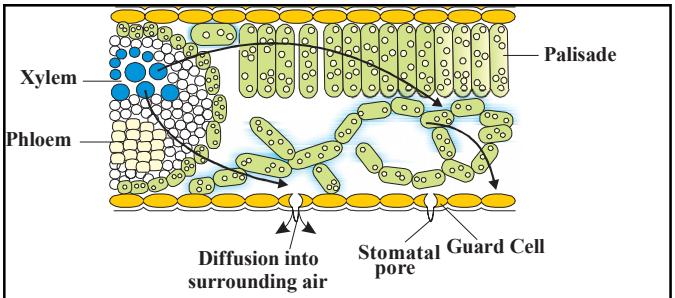


Figure : Water movement in the leaf. Evaporation from the leaf sets up a pressure gradient between the outside air and the air spaces of the leaf. The gradient is transmitted into the photosynthetic cells and on the water-filled xylem in the leaf vein.

* As water evaporates through the stomata, since the thin film of water over the cells is continuous, it results in pulling of water, molecule by molecule, into the leaf from the xylem. Also, because of lower concentration of water vapour in the atmosphere as compared to the substomatal cavity and intercellular spaces, water diffuses into the surrounding air. This creates a 'pull'.
* Measurements reveal that the forces generated by transpiration can create pressures sufficient to lift a xylem sized column of water over 130 metres high.

Types of transpiration

* Based on the plant parts or structure involved, following four types can be recognised:

1. **Stomatal transpiration:** It is the transpiration that occurs through the stomata. The epidermis of leaves and green stems have numerous stomata. These are responsible for about 50-97% of the total water transpired.
2. **Cuticular transpiration :** Water vapours are also lost directly from the outer walls of the epidermal cells through the cuticle. Cuticle is a wax like layer of cutin that covers the epidermis of leaves and stems. It reduces the water loss but may give out water vapours through the cracks. It commonly constitutes 3-10% of total transpiration. It is maximum upto 50% in herbaceous plants, ferns etc. growing in shady places.
3. **Lenticular transpiration :** Lenticels are aerating pores in the cork of the woody stems, twigs and fruits. Water vapours are lost through these openings. The amount of water vapours lost through lenticels is usually insignificant (approximately 0.1% of the total water loss).
4. **Bark transpiration:** This occurs through the bark of woody stem. It contributes about 1% of the total transpiration.

Structure of stomata :

* Stomata are found on the aerial delicate organs and outer surface of the leaves in the form of minute pores.
* Stomatal pore is surrounded by two specialised epidermal cells called as **guard cell.**
* They are kidney shaped. The number of guard cells are two.
* The structure of guard cells in monocots (Gramineae) is dumbbell shaped.
* Guard cells are epidermal cells. But due to presence of chloroplast they are different from that of **epidermal cells.**
* The outer wall of the guard cells is thin and elastic while inner wall is thick and non-elastic.
* Guard cells are surrounded by some specialized epidermal cells called **subsidiary cells** or **accessory cells.**
* Stomata are found on both upper and lower surface. Stomata attached with air chambers and forms a cavity is called **sub-stomatal-cavity.**

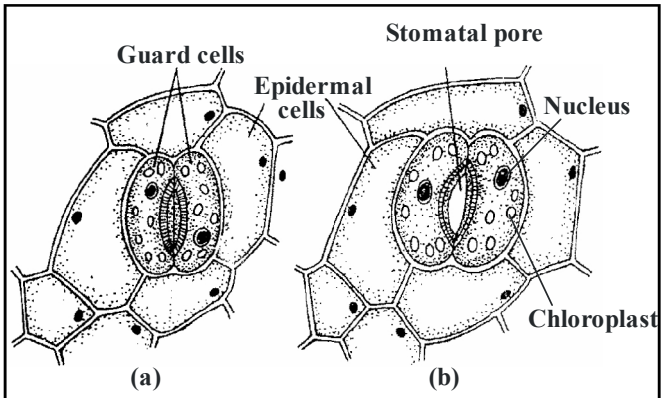


Figure : Stomatal apparatus (a) Closed (b) Open

* In xerophytic plants position of stomata is deep in the surface of the leaf. Stomata are present in this position are called sunken stomata.

Mechanism of Opening and Closing of Stomata :

* Stomata function as turgor operated valves.
* When osmotic concentration of guard cells increases, water comes in and guard cells become turgid and stomata gets open.
* Whenever, osmotic concentration of guard cells decreases water moves out, guard cells become flaccid and hence get closed.

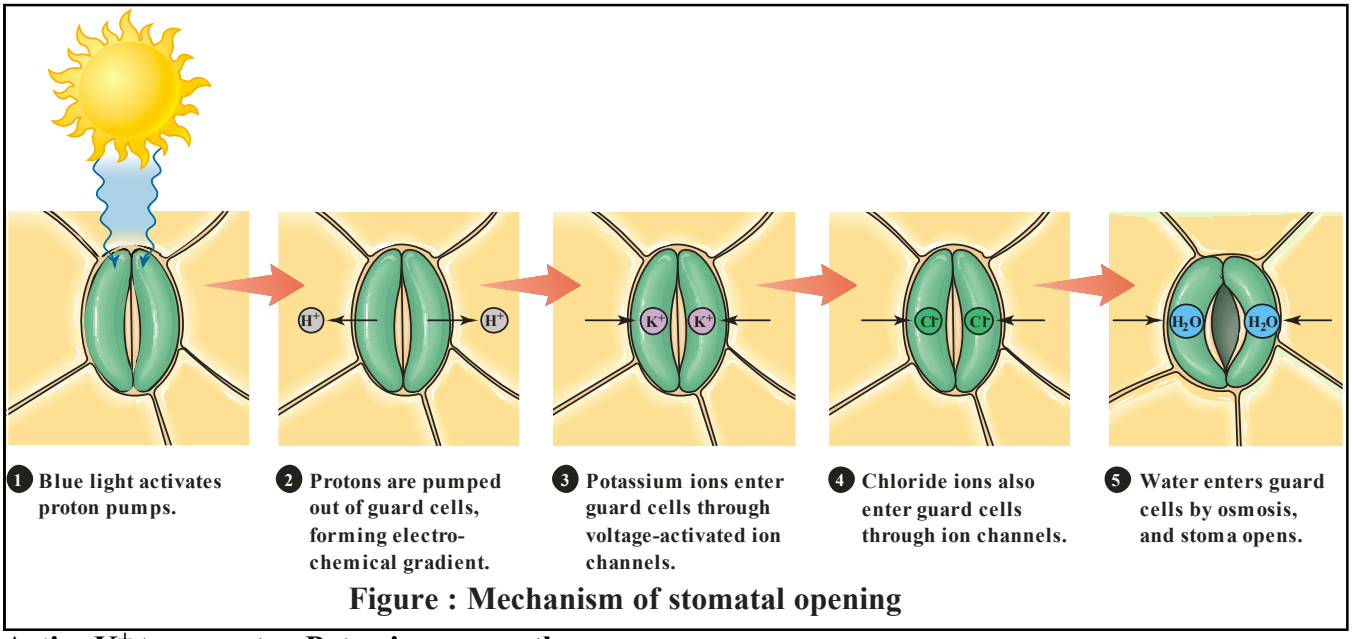


Figure : Mechanism of stomatal opening

Active K^+ transport or Potassium pump theory

(a) Opening of stomata in light:

(i) In light, starch in the guard cells is incompletely oxidized into phosphoenol pyruvate (PEP). It is later converted into organic acids, particularly malic acid. This reaction is catalyzed by an enzyme phosphoenol pyruvate carboxylase (PEPCO or PEPCase).

(ii) Malic acid dissociates into malate ion and protons (H^+) in the guard cells.

(iii) H^+ from guard cells, are transported to epidermal cells and K^+ from epidermal cells gets into the guard cells through the agency of hydrogen-potassium ion exchange pump in the plasma membrane.

(iv) In the guard cells, K^+ ions are balanced by malate anions. Besides, small amount of Cl^- ions are also absorbed which neutralize a small percentage of K^+ ions.

(v) The process of ion exchange requires ATP and thus, it is an active process.

(vi) Increased K^+ and malate ions forms potassium malate and store it in vacuoles of the guard cells, increasing their osmotic concentration. Hence, water enters the guard cells by endosmosis.

(vii) Turgor pressure of the guard cells increases due to endosmosis and the stomata gets open.

(b) Closing of stomata in the dark:

(i) As CO_2 is not utilized in photosynthesis during night, hence its concentration in the sub-stomatal cavity increases.

(ii) An inhibitor hormone-abscissic acid (ABA) functions in the presence of CO_2, It inhibits K^+ ion uptake by changing the diffusion and permeability of the guard cells for positive ions.

(iii) The K^+ ions are transported back to the epidermal or subsidiary cells from the guard cells.

Factors affecting stomatal opening and closing :

1. Light :

* In most of the plants stomata open during the day except succulent xerophytic plants and close during the dark.
* Opening of stomata completes in the presence of blue and red light.
* Blue light is most effective and causing stomatal opening.

2. CO_2 concentration :

* Stomata are sensitive towards the internal CO_2 concentration in the leaves.
* It is internal leaf CO_2 concentration rather than the atmospheric CO_2 concentration that ditactes stomatal opening.
* Stomata opens at low concentration of CO_2 while closed at high concentration of CO_2.

3. Growth Hormones :

* Cytokinin hormone induce opening of stomata.
* It increase the influx of K^+ ions and stimulate the stomata for opening. While ABA stimulate the stomata for closing.
* This hormone oppose the induction effect of cytokinin.
* ABA effects the permeability of the guard cells. It prevent the out flux of H^+ ions and increase the out flux of K^+ ions. Because of this pH of the guard cells decreased. Cl^- ions also plays important role in stomatal movement. Above mentioned effects also found in high amount of CO_2.
* ABA is formed due to high water stress in chloroplast of leaves.

4. Atmospheric humidity :

* Stomata opens for long duration and more widen in the presence of humid atmosphere, while stomata remains closed in dry atmosphere or partial opening at higher atm, humidity transpiration will be stop but stomata remain completely open.

Factors affecting the rate of transpiration

(A) External factors :

(i) Atmospheric humidity :

$$T_r \propto \frac{1}{\text{Relative humidity}}$$

* This is the most important factor. The rate of transpiration is higher in low atmospheric humidity while at higher atmospheric humidity, the atmosphere is moistened, result in decrease of rate of transpiration.
* Therefore, the rate of transpiration is high during the summer and low in rainy season.

(ii) Temperature : $T_r \propto$ Temperature

* The value of Q_{10} for transpiration is 2. It means by increasing 10°C temperature, the rate of transpiration is approximately double.
* Water vapour holding capacity of air increased at high temperature, resulting the rate of transpiration increased.
* On contrary vapour holding capacity of air decreased at low temperature so that the rate of transpiration is decreased.

(iii) Light :

* Light stimulates, transpiration by heating effect on leaf. Action spectrum of transpiration is blue and red.
* Rate of transpiration is faster in blue-light than that of red light. Because stomata are completely opened as their full capacity in the blue light.

(iv) Wind velocity : $T_r \propto$ Wind velocity

* Transpiration is less in constant air but if wind velocity is high the rate of transpiration is also high, because wind removes humid air (saturated air) around the stomata.
* Transpiration increases in the beginning at high wind velocity [30 - 35 km./hour] But latter on it cause closure of stomata due to mechanical effect and transpiration decrease.

(v) Atmospheric Pressure :

* The speed of the air increase at low atmospheric pressure, due to this rate of the diffusion increase which increase the rate of transpiration.
* The rate of transpiration is found maximum in the high intensity of light at high range of hills.

Transpiration ratio (TR) : Moles of H_2O transpired / moles of CO_2 assimilated.

* Ratio of the loss of water to the photosynthetic CO_2 fixation is called TR.
* TR is low for C_4 plants (200-350) while high for C_3 plants (500-1000). It means C_4 conserve water with efficient photosynthesis.
* CAM plants passes minimum TR (50-100).

(vi) Anti transpirants :

* Chemical substances which reduce the rate of transpiration are known as antitranspirants.

Anti transpirants are as follows :

* Phenyl mercuric acetate (PMA], Aspirin (Salicyclic acid), Abscisic acid [ABA], Oxi-ethylene, Silicon oil, CO_2 and low viscous wax. Antitranspirants are used in dry farming.

(B) Internal factors :

(i) Transpiring area : Pruning increase the rate of transpiration per leaf but overall reduce the transpiration.

(ii) Stomatal characteristics : Transpiration is effected by the structure of stomata, position of stomata, distance between the stomata, number of stomata per unit area and activity of the stomata.

(iii) Canopy structure

(iv) Water status of Leaves

(v) Root - Shoot Ratio :

* The rate of transpiration decreases with decrease in root - shoot ratio.
* The rate of transpiration increases with increase root - shoot ratio.
* The following characteristics are found in leaf to reduce the transpiration.
  (a) Leaves modified into spines.
  (b) Leaves transformed into needle e.g. Pinus.
  (c) Folding and unfolding of leaves by Bulliform cells. e.g. Amophilla, Poa etc.
  (d) Small size of the leaves.
  (e) Presence of thick waxy layer on the leaves. e.g. Banyan tree.

* **Difference between Transpiration and Guttation**

S.N.	Transpiration	Guttation
1.	It is the loss of water by a plant in the form of vapours.	Guttation is the loss of liquid droplets from the plant.
2.	The transpired water is pure water.	Guttated water is a dilute solutions of both organic and inorganic substances.
3.	Transpiration occurs through the general surface of the leaves and young stems.	Guttation commonly occurs at the margins and the tips of the leaves.
4.	It does not leave anything on the surface of the plant.	An incrustation of salts is formed on the surface after the guttated liquid evaporates.
5.	Most of the transpiration occurs during the day.	Guttation mostly occurs during night and early hour of the morning.
6.	Transpiration occurs through stomata, lenticels and epidermal cells.	Guttation occurs only through water pores. (Hydathodes)

Significance of transpiration

1. In regulation of temperature : Cooling effect on the surface of leave is produced by the process of transpiration due to which the temperature remain constant of the plants.
2. In mineral Absorption
3. In ascent of sap
4. In water absorption
5. Distribution of absorbed salts
6. Gaseous exchange
7. Control of hydrological cycle

Transpiration and Photosynthesis – a Compromise

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.
* 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.

TRANSPORT OF MINERAL NUTRIENTS

(i) Uptake of mineral ions :

* Most minerals enter the root by active absorption into the cytoplasm of epidermal cells. This needs energy in the form of ATP. The active uptake of ions is partly responsible for the water potential gradient in roots, and therefore for the uptake of water by osmosis. Some ions also move into the epidermal cells passively.
* Ions are absorbed from the soil by both passive and active transport.
* Specific proteins in the membranes of root hair cells actively pump ions from the soil into the cytoplasms of the epidermal cells.

* The endodermal cells have many transport proteins embedded in their plasma membrane; they let some solutes cross the membrane, but not others.
* Transport proteins of endodermal cells are control points, where a plant adjusts the quantity and types of solutes that reach the xylem.
* The root endodermis because of the layer of suberin has the ability to actively transport ions in one direction only.

(ii) Translocation of mineral ions :

* After the ions have reached xylem they further transport up the stem to all parts of the plant is through the transpiration stream.
* The chief sinks for the mineral elements are the growing regions of the plant, such as the apical and lateral meristems, young leaves, developing flowers, fruits and seeds, and the storage organs.
* Unloading of mineral ions occurs at the fine vein endings through diffusion and active uptake by these cells.
* Mineral ions are frequently remobilised, particularly from older, senescing parts. Older dying leaves export much of their mineral content to younger leaves.
* Similarly, before leaf fall in decidous plants, minerals are removed to other parts. Elements most readily mobilised are phosphorus, sulphur, nitrogen and potassium. Some elements that are structural components like calcium are not remobilised.
* An analysis of the xylem exudates shows that though some of the nitrogen travels as inorganic ions, much of it is carried in the organic form as amino acids and related compounds.
* Small amounts of P and S are carried as organic compounds.

PHLOEM TRANSPORT: FLOW FROM SOURCE TO SINK

* Food, primarily sucrose, is transported by the vascular tissue phloem from a source to a sink.
* Food in phloem sap can be transported in any required direction (**bi-directional** i.e., upwards or downwards) so long as there is a source of sugar and a sink able to use, store or remove the sugar. Ex. Sugar stored in roots may be mobilised to become a source of food in the early spring when the buds of trees, act as sink; they need energy for growth and development of the photosynthetic apparatus.
* Phloem sap is mainly water and sucrose, but other sugars, hormones and amino acids are also transported or translocated through phloem.

The Pressure or Mass Flow Hypothesis :

* The glucose is prepared at the source by the process of photosynthesis and is converted to sucrose (sugar).
* This sugar is then moved into sieve tube cells by active transport. It produces hypertonic condition in phloem.

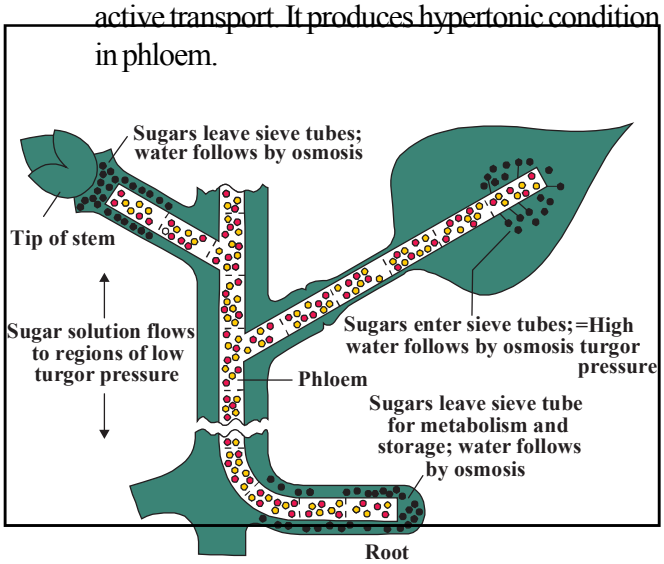


Figure : Mechanism of translocation

* Water in the adjacent xylem moves into phloem by osmosis.
* Due to osmotic (turgor) pressure, the phloem sap moves to the areas of lower pressure.
* At the sink, osmotic pressure is decreased.
* The incoming sugar is actively transported out of the phloem and removed as complex carbohydrates (sucrose).

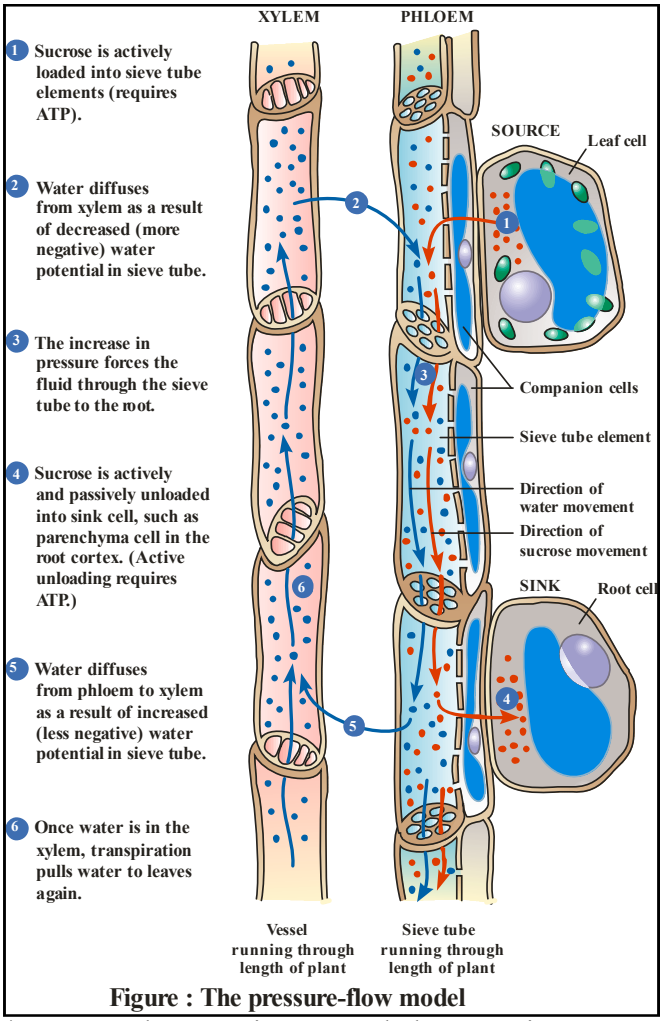


Figure : The pressure-flow model

* As the sugar is removed, the osmotic pressure decreases, the water moves out of the phloem and returns to the xylem.

Factors affecting Translocation of Solutes

* **Temperature:** Optimum temperature for translocation is 20°C and 30°C. The rate of translocation increases with increase in temperature. The temperature influences the root more than the shoot, since it acts as sink for the sugars.
* **Light:** The root/shoot dry weight ratio increases with increased light intensities. This indicates that translocation to root increases as compared to shoot when light intensity is increased.
* **Metabolic inhibitors:** The metabolic inhibitors can inhibit carbohydrate translocation. These include dinitrophenol (DNP), arsenite, azide, fluoride and hydrogen cyanide.
* **Mineral deficiencies:** The absorption and translocation of sucrose by a leaf is facilitated by **boron.** It helps sucrose to move easily through the cell membranes in the form of boron-sucrose complex.
* **Hormones:** Sucrose is much more efficiently translocated when growth regulators are applied such as kinetin, IAA and gibberellic acid.

CONCEPT REVIEW

* Plants obtain a variety of inorganic elements (ions) and salts from their surroundings especially from water and soil.
* Movement of these nutrients from environment into the plant as well as from one plant cell to another plant cell essentially involves movement across a cell membrane.
* Transport across cell membrane can be through diffusion, facilitated transport or active transport.
* Water and minerals absorbed by roots are transported by xylem and the organic material synthesised in the leaves is transported to other parts of plant through phloem.
* Passive transport (diffusion, osmosis) and active transport are the two modes of nutrient transport across cell membranes in living organisms.
* In passive transport, nutrients move across the membrane by diffusion, without any use of energy as it is always down the concentration gradient and hence entropy driven.
* This diffusion of substances depends on-their size, solubility in water or organic solvents.
* Osmosis is the special type of diffusion of water across a semi-permeable membrane which depends on pressure gradient and concentration gradient.
* In active transport, energy in the form of ATP is utilised to pump molecules against a concentration gradient across membranes.
* Water potential is the potential energy of water which helps in the movement of water. It is determined by solute potential and pressure potential.
* The behaviour of the cells depends on the surrounding solution. If the surrounding solution of the cell is hypertonic, it gets plasmolysed.

* The absorption of water by seeds and dry wood takes place by a special type of diffusion called **imbibition.**
* In higher plants, there is a vascular system, xylem and phloem, responsible for **translocation**. Water minerals and food cannot be moved within the body of a plant by diffusion alone. They are therefore, transported by a mass flow system- movement of substance in bulk from one point to another as a result of pressure differences between the two points.
* Water absorbed by root hairs moves deeper into the root by two distinct pathways, i.e., **apoplast** and **symplast**.
* Various ions and water from soil can be transported upto a small height in stems by **root pressure**.
* **Transpiration pull model** is the most acceptable to explain the transport of water.
* Transpiration is the loss of water in the form of vapours from the plant parts through stomata. Temperature, light, humidity, wind speed and number of stomata affect the rate of transpiration.
* Excess water is also removed through tips of leaves of plants by guttation.
* Phloem is responsible for transport of food (primarily) sucrose from the source to the sink. The translocation in phloem is bi-directiorial; the source-sink relationship is variable.
* The translocation in phloem is explained by the pressure flow hypothesis.

IMPORTANT POINTS

* Raisins places in water swell up due to endosmosis.
* A cell increases in volume if the external medium is hypotonic.
* Wilting in plants occurs when xylem is removed/ blocked.
* Stomatal opening is under the control of guard cells.
* Guttation is mainly due to root pressure.
* Stomata open and close due to turgor pressure of guard cells.
* Water is plants is transported by or ascent of sap takes place through xylem.
* First theory for ascent of sap was proposed by Goldewski.
* Plant cells kept in hypertonic solution will get plasmolysed.
* Plant cooling occurs due to transpiration.
* Use of excessive fertilisers causes wilting due to exosmosis.
* Loss of water from tips of leaves is guttation.
* In root har, water enters due to O.P.
* Cohesion force existing amongst water molecules contributes to ascent of sap.
* Passive absorption occurs due to tension in xylem sap.
* Correct pathway of water movement in plant roots is
  Soil water → Root hair cell → Cortical cells → Passage cells → Pericycle xylem.
* The main reason of osmotic pressure of the opened stomata is the potassium chloride or potassium malate.
* Transpiration measuring instrument is called potometer. The rate of absorption of water is measured through this instrument. In potometer rate of water absorption is proportional to the transpiration.
* Manometer is used to measure root pressure.
* Osmotic pressure is maximum in noon. At this time water contents in the cell are minimum.
* Psychorometer is used for measuring relative humidity as well as transpiration.
* In Saxifraga, the rate of guttation is high during flowering.
* Maximum opening of stomata occurs at about 10:00 AM and 3:00 PM (At 12:00 noon, partial closure of stomata occurs).
* In C_3 plant the rate of transpiration is high.
* If the external solution is hypotonic, the cells swell and become turgid.
* If the external solution is hypertonic, the animal cells become plasmolysed.
* If the external solution is isotonic, no net movement of water occurs between cell and its surroundings.
* Most of the water flow in the roots occurs via the apoplast.

QUESTION BANK

EXERCISE - 1 (LEVEL-1) [NCERT EXTRACT]

SECTION - 1 (VOCABULARY BUILDER)

Choose one correct response for each question.
For Q.1-Q.3
Match the column I with column II.

Q.1

	Column I	Column II
a.	Hypotonic	i. Water
b.	Hypertonic	ii. Sucrose
c.	Solute	iii. Lower tonicity
d.	Solvent	iv. Higher tonicity

Codes
(A) a-i, b-ii, c-iii, d-iv (B) a-iv, b-ii, c-i, d-iii
(C) a-iii, b-iv, c-ii, d-i (D) a-iii, b-i, c-ii, d-iv

Q.2

	Column I		Column II
(a)	Abscissic acid (ABA)	i.	Model that explains movement of water through xylem over short distances resulting in guttation.
(b)	Adhesion	ii.	Plant adapted to hot, dry conditions.
(c)	Apoplast	iii.	Plant hormone responsible for stomatal closure under stressful conditions.
(d)	Root pressure	iv.	Spaces between parenchyma cells in the root cortex
(e)	Xerophyte	v.	Tendency of water molecules to stick to other types of molecules, including the cell walls of xylem.

Codes :
(A) (a) -iii, (b)-v, (c)-iv, (d)-i, (e)-ii
(B) (a) - i, (b)-ii, (c)-iii, (d)-iv, (e)-v
(C) (a) - ii, (b)-i, (c)-iii, (d)-v, (e)-iv
(D) (a) - v, (b)-i, (c)-ii, (d)-iv, (e)-ii

Q.3

	Column I	Column II
a.	Water potential of 10% salt solution	i. Positive
b.	Pressure potential in a normal cell.	ii. Negative
c.	Pressure potential in a plasmolysed cell	iii. Zero
d.	Metric potential on the surface of the wood	

(A) a-i, b-ii, c-iii, d-i (B) a-iii, b-ii, c-i, d-ii
(C) a-ii, b-iii, c-ii, d-i (D) a-ii, b-iv, c-i, d-ii

SECTION - 2 (BASIC CONCEPTS BUILDER)

For Q.4 to Q.36 :
Choose one word for the given statement from the list.

Isotonic, Sugars, Transpiration, C_4, C_3, Diffusion, Xylem, Suction pressure, Plasmolysis, Cell membrane, Protein, Antiport transport, Hydathode, Pressure and concentration gradient, Ascent of sap, Xylem Parenchyma, Medullary rays, Exosmosis, Mass or bulk flow, Holard, Slower, Water, Pressure, Transpiration pull

Q.4 Movement of molecules in three forms of matter, from a region of higher concentration to a region of lower concentration can be termed as ____.

Q.5 If the osmotic pressure of cytoplasm in a cell is balanced by external solution, the solution must be ____.

Q.6 Root hair absorbs water from soil with the help of ____.

Q.7 Ions are transported through _____ in plants.

Q.8 The accepted mechanism used for the translocation of _____ from source to sink is called pressure flow hypothesis.

Q.9 Loss of water in liquid phase by guttation takes place through a specialised structure called ___.

Q.10 ____ occurs when the water moves out of the cell and the ____ of a plant cell shrinks away from the cell wall.

Q.11 Smaller, lipid soluble molecules diffuse faster through cell membrane, but the movement of hydrophilic substances are facilitated by certain transporters which are chemically _____.

Q.12 In a passive transport across a membrane, when two protein molecules move in opposite direction and independent of each other, it is called as ____.

Q.13 Osmosis is a special kind of diffusion, in which water diffuses across the cell membrane. The rate and direction of osmosis depends upon both ___.

Q.14 A flowering plant is planted in an earthen pot and irrigated. Urea is added to make the plant grow faster, but after some time the plant dies. This may be due to _____.

Q.15 Absorption of water from soil by dry seeds increases the _____, thus helping seedlings to come out of soil.

Q.16 Water moves up against gravity and even for a tree of 20m height, the tip receives water within two hours. The most important physiological phenomenon which is responsible for the upward movement of water is _____.

Q.17 The C_4 plants are twice as efficient as C_3 plants in terms of fixing CO_2 but lose only _____ as much water as C_3 plants for the same amount of CO_2 fixed.

Q.18 Rate of diffusion would be ____ if the medium is concentrated.

Q.19 Direction of translocation is essentially unidirectional in case of _____ .

Q.20 Upward conduction of water in the form of dilute solution of mineral ions from roots to aeriar parts is called ____.

Q.21 According to relay pump theory/conduction at water occurrs due to activity of ____ & _____ .

Q.22 _____ maintains the shape and structure of plants by keeping cells turgid.

Q.23 A _____ plant loses only half as much water as a ____ plant for the same amount of CO_2 fixed.

Q.24 Water & minerals, and food are generally moved by a _____ system.

Q.25 Total amount of water present in soil is called __

Q.26 Two types of molecules move in opposite direction with the help of an antiport carrier protein. **[True / False]**

Q.27 Facilitated and active transport mechanisms are similar in the presence of saturation effect. **[True / False]**

Q.28 Development of root pressure is the result of an active absorption. **[True / False]**

Q.29 Photosynthetic theory for the stomatal movement was given by Von Mohl and Schwendener. **[True / False]**

Q.30 In plasmolysis, water is first lost from vacuole and then from the cytoplasm. **[True / False]**

Q.31 Jamming of wooden frames during rains is caused by swelling of wood due to imbibition. **[True / False]**

For Q.32-Q.36

If the statement is false, make it correct by changing the underlined word(s).

Q.32 In osmosis, water flows from an area of higher water potential to an area of lower water potential. **[True / False]**

Q.33 Antiport will move a substance across a cell membrane in the same direction as the flow of protons. **[True / False]**

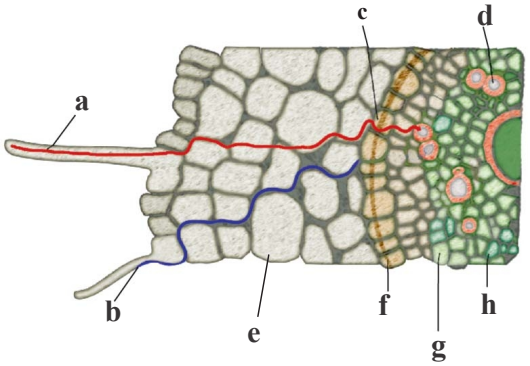
Q.34 A slight charge difference on the two sides of a cell membrane is known as a membrane potential. **[True / False]**

Q.35 Facilitated diffusion is a type of passive transport that uses transmembrane protein channels. **[True / False]**

Q.36 Wilting is a result of loss of turgor pressure. **[True / False]**

SECTION - 3 (ENHANCE DIAGRAM SKILLS)

Q.37 A portion of transverse section of root is shown in the diagram. Label a-h in the given diagram and choose the correct option accordingly.



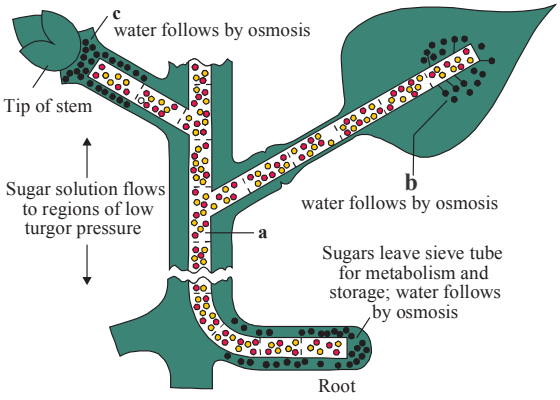
(A) a-Apoplastic path; b-Symplastic path; c-Endodermis; d-Pholem; e-Cortex; f-Casparian strip; g-Pericycle; h-Xylem

(B) a-Symplastic path; b-Apoplastic path; c-Xylem; d-Pholem; e-Endodermis; f-Cortex; g-Casparian strip; h-Pericycle

(C) a-Symplastic path; b-Apoplastic path; c-Endodermis; d-Xylem; e-Cortex; f-Casparian strip; g-Pericycle; h-Phloem

(D) a-Apoplastic path; b-Symplastic path; c-Endodermis; d-Cortex; e-Casparian strip; f-Xylem; g-Phloem; h-Stele

Q.38 In the given diagram identify the marked phenomenon / part and choose the correct option accordingly.



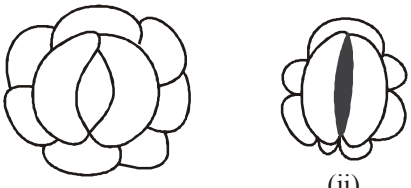
(A) a-Phloem, b-Sugar leaves sieve tube, c-Sugar enters sieve tube.

(B) a-Xylem, b-Sugars leaves sieve tube, c-Sugar enters sieve tube.

(C) a-Phloem, b-Sugars enters sieve tube, c-Sugars leaves sieve tubes.

(D) a-Xylem, b-Sugar enters sieve tube, c-Sugars leaves sieve tubes.

Q.39 Observe the diagram and choose the correct statement



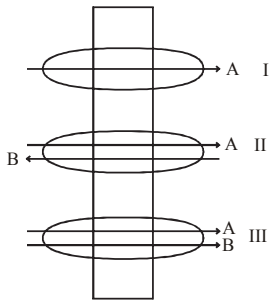
(A) These types of guard cells are found in dicots

(B) (i) shows higher water content.

(C) K^+ element plays an important role in the opening and closing of stomata.

(D) All of these

Q.40 Identify the process occurring in I, II and III



(A) I-Uniport, II-Antiport, III-Symport
(B) I-Antiport, II-Uniport, III-Symport
(C) I-Uniport, II-Symport, III-Antiport
(D) I-Symport, II-Antiport, III-Uniport

SECTION - 4 (ENHANCE PROBLEM SOLVING SKILLS)

Choose one correct response for each question.

PART - 1 : MEANS OF TRANSPORT

Q.41 In plants, long distance transport of organic and inorganic substances occur through –
(A) simple permanent tissues.
(B) complex permanent tissues.
(C) meristematic tissues.
(D) epithelial tissues.

Q.42 Which of the following affect the transport of molecules when carrier mediated facilitated diffusion is involved?
(A) Solubility of molecule in lipids.
(B) Concentration gradient.
(C) Availability of carrier molecule.
(D) All of the above

Q.43 Diffusion, a process occur(s) along the concentration gradient is actively involved in –
(A) transpiration (B) respiration
(C) photosynthesis (D) All of these

Q.44 What are the aquaporins in facilitated diffusion process?
(A) Membrane proteins (B) Carrier proteins
(C) Channel proteins (D) Carrier lipids

Q.45 Uphill transport is a type of –
(A) active transport (B) passive transport
(C) facilitated diffusion (D) simple diffusion

Q.46 What is mandatory in the process of facilitated diffusion?
(A) Presence of concentration gradient.
(B) A carrier protein.
(C) A hydrophilic moeity
(D) All of the above

Q.47 Which of the following is responsible for the transport of water and minerals from roots to stems, leaves, flowers and fruits in rooted plants?
(A) Xylem (B) Phloem
(C) Either (A) or (B) (D) Both (A) and (B)

Q.48 Which of the following pair is selective and specific mode of transport?
(A) Passive transport and active transport.
(B) Passive transport and facilitated diffusion.
(C) Facilitated diffusion and active transport.
(D) Simple diffusion and facilitated diffusion.

Q.49 Which of the following affects the rate of diffusion?
(A) Concentration gradient
(B) Permeability of the membrane
(C) Temperature and pressure
(D) All of the above

Q.50 Carrier protein, which allows the diffusion of two type of molecules in the same direction is
(A) symport (B) antiport
(C) Both (A) and (B) (D) uniport

PART - 2 : PLANT WATER RELATION

Q.51 Osmosis involves –
(A) flow of water through a semipermeable membrane.
(B) flow of water without a membrane.
(C) flow of solute through a semipermeable membrane.
(D) flow of solute without a membrane.

Q.52 Osmotic pressure is highest in which of the following plant type ?
(A) Mesophytes (B) Xerophytes
(C) Halophytes (D) Hydrophytes

Q.53 Phenomenon of plasmolysis can be exploited for
(A) Causing plasmolysis of microbes in highly salted pickles.
(B) Preventing growth of mirobes in jams and jellies.
(C) Elimination of weeds
(D) All of these

Q.54 If solute particles are added in pure water, its diffusion pressure will be –
(A) increased (B) decreased
(C) remain constant (D) become less than zero

Q.55 Diffusion pressure deficit is also called
(A) suction pressure (B) turgor pressure
(C) osmotic pressure (D) None of these

Q.56 When solute is mixed, the water potential of a cell –
(A) Increases
(B) Decreases
(C) First increases and then decreases
(D) No change occurs

Q.57 Two cell (A and B) have osmotic potential and pressure potential –18 bars and 8 bars, and –14 bars and 2 bars respectively. What will be the direction of water flow?
(A) From cell A to cell B.
(B) Flow of water does not takes care.
(C) In both direction
(D) From cell B to cell A

Q.58 Which substance acts as best imbibant?
(A) Phycocolloids (B) Protein
(C) Starch (D) Cellulose

Q.59 Two cells a and b are connected and have OP 10 and 8 atm, TP 7 and 3 atm, DPD 3 and 5atm. The direction of water flow will be –
(A) movement of water from cell b to a.
(B) no movement of water.
(C) equilibrium between the two cells.
(D) movement of water from cell a to cell b.

Q.60 When a cell is fully turgid. which of the following will be zero?
(A) Osmotic pressure (B) Turgor pressure
(C) Wall pressure (D) Suction pressure

Q.61 What is the value of DPD?
(A) DPD = TP
(B) DPD = OP – SP
(C) DPD = OP – WP
(D) Equal to wall pressure

Q.62 Which among the following represents the correct relationship for a plasmolysed cell?
(A) $\psi_W = \psi_S + \psi_P$ (B) $\psi_S = \psi_W + \psi_P$
(C) $\psi_W = \psi_S$ (D) $\psi_W = \psi_P$

Q.63 Why seeds imbibe and swell after keeping in water?
(A) OP inside the seed is low.
(B) OP of water is high.
(C) Water potential gradient developes between the seed coat and water.
(D) Diffusion pressure deficit of seed is very high.

Q.64 Water potential increases due to –
(A) addition of solute
(B) evaporation
(C) addition of inorganic substances
(D) increase in pressure

Q.65 The space between the plasma membrane and the cell wall of plasmolysed cell surrounded by a hypertonic solution is occupied by –
(A) hypertonic solution (B) hypotonic solution
(C) isotonic solution (D) water

PART - 3 : LONG DISTANCE TRANSPORT OF WATER

Q.66 How would you differentiate between apoplast and symplast?
(A) Apoplast relies on active transport.
(B) Symplast deals in non-living spaces and cell walls.
(C) Apoplast prevents passive diffusion.
(D) Apoplasts deals in non-living spaces and cell walls.

Q.67 Passive absorption of water is related to all, except –
(A) Apoplastic pathway.
(B) Transpiration pull plays the major role.
(C) Development of a positive pressure in xylem
(D) Water absorption through the roots.

Q.68 Pathway of water conduction from soil to xylem is–
(A) soil → root hair → cortex → pericycle → endodermis → metaxylem → protoxylem
(B) soil → root hair → cortex → endodermis → pericycle → protoxylem → metaxylem
(C) soil → root hair → epidermis → endodermis → phloem → xylem
(D) soil → root hair → epiderrnis → cortex → phloern → xylem

Q.69 No rupture and fraction occur in water column of vessels and tracheids during ascent of sap. It is due to –
(A) they are lignified thick walls.
(B) they have weak gravitational pull.
(C) cohesion and adhesion.
(D) transpiration pull.

Q.70 Adhesion is caused by –
(A) formation of hydrogen bond between water molecules.
(B) transpiration pull.
(C) higher surface tension.
(D) attraction of water molecule to polar surface.

Q.71 Which pathway applies least resistance to the movement of water?
(A) Apoplast pathway
(B) Symplast pathway
(C) Trans membrane pathway
(D) Vacuolar pathway

Q.72 In mycorrhizal association, which one of the following increases the surface area available for absorption of water and minerals by roots?
(A) Mycorrhiza
(B) Numerous branches of root
(C) Root hairs
(D) None of the above

Q.73 Both minerals and water are absorbed by
(A) Zone of elongation in root.
(B) Growing point in root.
(C) Root hair zone.
(D) Zone of mature cells.

Q.74 Who proposed cohesion theory of water movement in plants?
(A) JC Bose (B) Priestly
(C) Dixon and Jolly (D) TV Englemann

Q.75 During process of active absorption of water
(A) The responsible force develops in roots.
(B) Rate will be higher then passive absorption.
(C) A negative pressure is developed in root xylem.
(D) OP and energy play no role.

Q.76 If stem of plant is cut under a state of tension in xylem sap, what will be the result?
(A) The xylem sap sprout out.
(B) Xylem sap will accumulate at cut surface.
(C) The cut surface will form air bubbles, when placed in water.
(D) Air will be pulled into the xylem.

Q.77 Which one of the following is part of symplast?
(A) Cytoplasm (B) Protoplast
(C) Plasmodesmata (D) All of these

Q.78 All given factors promote absorption of water by roots, except –
(A) Well aerated soil
(B) Highly concentrated soil solution
(C) Optimum soil temperature
(D) Available water in soil

Q.79 A soil sample contain 25% of its volume as soil water. Out of this, 10% is hygroscopic and balance is capillary water. What is the field capacity of soil?
(A) 15% (B) 25%
(C) 35% (D) 65%

Q.80 What are the location of casparian strips-which interrupts the movement of water inside a root?
(A) Endodermis (B) Pericycle
(C) Cortex (D) Hypodermis

PART - 4 : TRANSPIRATION

Q.81 Loss of water in liquid phase (in form of droplets) from the margin of leaves in many herbaceous plants is –
(A) guttation (B) root pressure
(C) transpiration (D) transpiration pull

Q.82 Which of the following contributes about 1% of the total transpiration in plants?
(A) Bark transpiration
(B) Cuticular transpiration
(C) Lenticular transpiration
(D) Stomatal transpiration

Q.83 Which of the following lacks stomata?
(A) Aquatic plants with floating leaves.
(B) Xerophytes
(C) Aquatic submerged plants
(D) Sciophytes

Q.84 Which is not true regarding stomata?
(A) They are turgor operated valves.
(B) Have differentially thickened walls of guard cells.
(C) They open when OP of guard cell decreases
(D) Show scotoactive opening in CAM plants

Q.85 Sunken stomata are usually found in the leaves of
(A) xerophytes (B) hydrophytes
(C) mesophytes (D) sciophytes

Q.86 Tension, one of the important factor in the movement of xylem sap in a tree is a result of
(A) cohesive nature of water.
(B) capillary size of xylem tube.
(C) transpiration at the leaf surface.
(D) All at the above.

Q.87 Which of the following gets accumulated in vacuoles of guard cells during stomatal opening?
(A) Malate and ions of K^+ and Cl^-
(B) Malate and ions of K^+ and Na^+
(C) Starch and ion of K^+ and Cl^-
(D) Water, calcium and magnesiun

Q.88 Which is not an advantage of transpiration?
(A) Development of mechanical tissues.
(B) Development of root system
(C) Distribution of minerals
(D) Fixation of nitrogen

Q.89 Passive absorption of water by root system is due to –
(A) force created in roots.
(B) tension in sap due to transpiration.
(C) osmotic force in root and shoot.
(D) high respiratory activity.

Q.90 Which of the following ion helps in the opening and closing of stomata?
(A) K^+ (B) Mn^+
(C) Mg^{2+} (D) Ca^{2+}

Q.91 Xylem sap is made up of –
(A) water alone (B) water and minerals
(C) minerals alone (D) sugar and water

Q.92 Transpiration is the manifestation of –
(A) root pressure (B) turgor pressure
(C) wall pressure (D) suction pressure

Q.93 Mechanism of opening and closing of stomata is controlled by
(A) guard cells (B) accesary cells
(C) epidermal cells (D) None of these

Q.94 Which of the following statement is not related to guttation?
(A) Guttation is of universal occurance.
(B) Water is given out during day time.
(C) Excreted water is impure.
(D) Water is excreted in liquid phase.

Q.95 In dry and arid condition, the leaves of some monocots, like grasses curls inwards to reduce transpiration. This is due to the presence of –
(A) Parallel venation (B) Bulliform cells
(C) Large xylem cavities (D) Thick cuticles

Q.96 Transport of minerals through xylem is
(A) active and energy is provided by ATP.
(B) passive and no energy is provided.
(C) active and no requirement of energy.
(D) passive and energy is provided by ATP.

Q.97 Some organs of woody plants are covered by periderm and also lack stomata, but some gaseous exchange still takes place through –
(A) cuticle (B) lenticels
(C) parenchyma (D) trichomes

PART - 5 : TRANSPORT OF MINERAL NUTRIENTS

Q.98 Minerals are present in the soil as ____, which cannot move across cell membranes.
(A) macromolecules (B) charged particles
(C) insoluble compounds (D) solute particles

Q.99 Translocation of photosynthates occur in form of –
(A) Starch (B) Glucose
(C) Sucrose (D) 3PGA

Q.100 Unloading of minerals occur at –
(A) apical meristem (B) fine vein ending
(C) fruits (D) All of these

Q.101 Transport proteins of endodermal cells are ____, where a plant adjusts the _____ and _____ of solutes that reaches the _____.
(A) control points, ratio, type, xylem
(B) regulators, quantity, type, phloem
(C) control points, quantity, type, xylem
(D) regulators, quantity, size, pholem

PART - 6 : PHLOEM TRANSPORT

Q.102 Which of them is/are correct regarding pressure flow model for translocation?
I. Sugar is transported through phloem as glucose.
II. Movement of sugar is carried out through sieve tube near the source region.
III. Concentration of sugar is always highest near the sink region.
IV. Water from the adjacent xylem moves into phloem by osmosis.
(A) II and IV (B) II and III
(C) I, II and III (D) Only IV

Q.103 Which of the following is appropriate for mass-flow hypothesis ?
(A) Transpiration pull is responsible for the absorption of ions.
(B) Large amount of ions are also absorbed along with the absorption of water.
(C) As suction pressure increases, absorption of water increases and along with water, absorption of ion also increases.
(D) All of the above

Q.104 The direction of movement in phloem is ___ and that of xylem is ____.
(A) downwards; downwards
(B) only upwards; only downward
(C) unidirectional; bidirectional
(D) bidirectional; unidirectional

Q.105 Who described mass flow hypothesis?
(A) Munch
(B) Sir JC Bose
(C) Kursanov
(D) Buchmann and Priestly

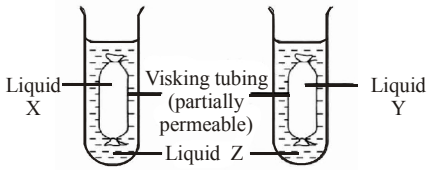
EXERCISE - 2 (LEVEL-2)

Choose one correct response for each question.

Q.1 Aquaporins function in transport across the membrane
(A) binding to a molecule of water and carrying it.
(B) using Na^+ as a driving ion to transport water in the same direction.
(C) forming a channel to facilitate the rapid diffusion or water.
(D) inhibiting the activity of the Na^+/K^+ pump.

Q.2 Which is an example of carrier-mediated transport?
(A) simple diffusion
(B) facilitated diffusion
(C) movement of water through aquaporins
(D) osmosis

Q.3 An experiment was set up as shown in the diagram below. After some time has elapsed, the Visking tube containing liquid X collapsed while the tubing containing liquid Y was firm and hard.

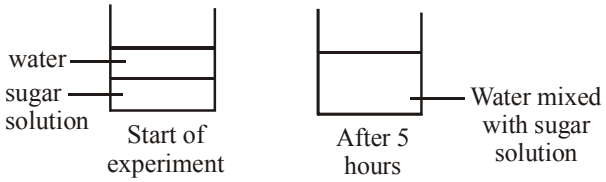


Which of the following could be a correct description of the liquids at the start of the experiment?
(A) Liquid X-Concentrated sucrose solution, Liquid Z- Water, Liquid Y-Dilute sucrose solution
(B) Liquid X-Dilute sucrose solution, Liquid Z-Concentrated sucrose solution Liquid Y- Water
(C) Liquid X -Water, Liquid Z-Concentrated sucrose solution, Liquid Y- Dilute sucrose solution
(D) Liquid X -Water, Liquid Z-Dilute sucrose solution, Liquid Y-Concentrated sucrose solution.

Q.4 A cube of fresh potato is weighed. It is then placed in a test tube containing a dilute solution of sucrose. After a day, its mass has increased. Which process has occurred and what has happened to the concentration of the solution in the test tube?
(A) Process occurred-Diffusion of sucrose molecules. Concentration of solution-Decreased
(B) Process occurred-Diffusion of sucrose molecules. Concentration of solution-Increased.
(C) Process occurred-Osmosis of water molecules. Concentration of solution-Decreased
(D) Process occurred-Osmosis of water molecules. Concentration of solution-Increased.

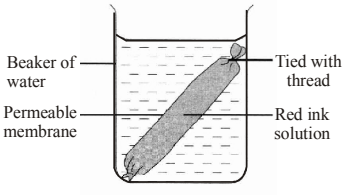
Q.5 The passive movement of a substance down its concentration gradient is called __ .
(A) active transport (B) diffusion
(C) exocytosis (D) symport

Q.6 The diagrams show a mixture of water and sugar solution at two different times.



By what process has the two liquids been mixed?
(A) Absorption (B) Conduction
(C) Diffusion (D) Osmosis

Q.7 The apparatus shown in the diagram was set up. After one hour, the water in the beaker turned red.

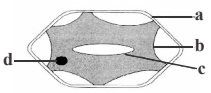


What is the most likely reason for this colour change?
(A) Molecules of red ink move through the membrane by diffusion.

(B) Molecules of red ink move through the membrane by osmosis.
(C) Molecules of water move through the membrane by diffusion.
(D) Molecules of water move through the membrane by osmosis.

Q.8 When sugars enter sieve tubes, water flows by osmosis, resulting in –
(A) water potential (B) osmotic gradient
(C) turgor pressure (D) DPD

Q.9 The diagram below shows a plant cell which was placed in 10% sucrose solution.



Which structure allows dissolved substances to pass through freely?
(A) a (B) b
(C) c (D) d

Q.10 Which of the following mechanism can explain the transport of sucrose from source to sink?
(A) Osmotic movement of water into sugar loaded sieve tube cells which create a higher hydrostatic pressure into the source than in the sink.
(B) Tension created by differences in pressure potential between source and sink.
(C) Active absorption of sucrose through sieve tube membrane driven by a specific pump.
(D) Transpiration and active transport of sugar from source to sink.

Q.11 A plant cell placed in a hypertonic solution will –
(A) remain unchanged (B) become crenated
(C) undergo lysis (D) undergo plasmolysis

Q.12 Diffusion rate depends on –
(A) the flow of water
(B) concentration gradient
(C) kinetic energy
(D) B and C are correct

Q.13 The translocation of organic solutes in sieve tube members is supported by –
(A) root pressure and transpiration pull
(B) P-proteins
(C) mass-flow involving a carrier and ATP
(D) cytoplasmic streaming

Q.14 The energy-requiring transport of solutes against their concentration gradient is called –
(A) osmosis
(B) receptor-mediated endocytosis
(C) active transport
(D) facilitated diffusion

Q.15 An animal cell in a hypertonic solution would
(A) swell
(B) swell and exhibit turgor
(C) exhibit plasmolysis
(D) shrink and then swell

Q.16 Which processes requires the cell to expend metabolic energy directly (for example, from ATP)?
(A) active transport
(B) facilitated diffusion
(C) all forms of carrier-mediated transport
(D) osmosis

Q.17 A root hair cell absorbs water through __ because the cell sap of the root hair cell has ___ a water potential than the water in the soil.
(A) osmosis; higher (B) osmosis; lower
(C) diffusion; higher (D) diffusion; lower

Q.18 Why legume seeds imbibe more water than any other seed, when kept in water?
(A) Imbibition capacity of protein is more than that of starch.
(B) Presence of less hydrophilic colloids in starch containing grains.
(C) Cell membrane of legume seeds is more permeable.
(D) Cell membrane of carbohydrate containing seeds is less permeable.

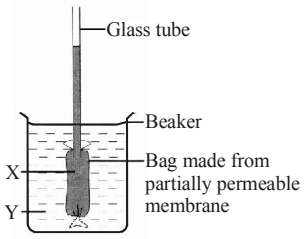
Q.19 Which of the following are examples of osmosis?
(a) The absorption of water by root hairs.
(b) The absorption of mineral salts by root hairs.
(c) The absorption of water by dry cotton wool.

(d) The absorption of water by the large intestines.
(e) The movement of water across the surface of the floor.
(A) (a) and (b) only (B) (c) and (e) only
(C) (a) and (d) only (D) (a), (d) and (e) only

Q.20 Which of the following requires ATP?
(A) the uptake of cholesterol by a cell
(B) the facilitated diffusion of glucose into a cell
(C) countercurrent exchange
(D) the diffusion of oxygen into a fish's gills.

Q.21 All of the following cellular activities require ATP EXCEPT
(A) sodium-potassium pump
(B) cells absorbing oxygen
(C) receptor-mediated endocytosis
(D) amoeboid movement

Q.22 The diagram below shows an experimental set-up to investigate osmosis.



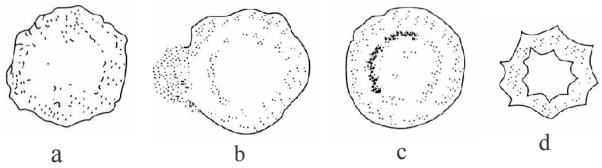
Which of the following combinations of liquids would cause X to rise to the highest level in the glass tube after three hours?
(A) Liquid X-Concentrated sucrose solution
Liquid Y-Dilute sucrose solution
(B) Liquid X-Concentrated sucrose solution
Liquid Y-Water
(C) Liquid X-Dilute sucrose solution
Liquid Y-Concentrated sucrose solution
(D) Liquid X-Water
Liquid Y-Concentrated sucrose solution

Q.23 Which is an example of diffusion in a plant?
(A) Carbon dioxide from the air moving into a photosynthesizing leaf.
(B) Nitrate ions moving into root hairs against a concentration gradient.
(C) Sugars in the phloem moving from leaves to roots.
(D) Water in the xylem moving from roots to leaves.

Q.24 The cytoplasmic channels between plant cells are called –
(A) desmosomes (B) middle lamellae
(C) plasmodesmata (D) tight junctions

Q.25 Which of the following processes involves osmosis?
(A) Circulation of blood in the blood vessels.
(B) Conduction of water up the xylem.
(C) Absorption of water in the large intestines of humans.
(D) Uptake of oxygen in the alveoli.

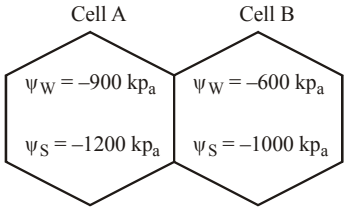
Q.26 Red blood cells were placed in water and in three salt solutions of different concentrations. Cells from each solution were examined under the microscope. Which diagram shows the appearance of a cell in pure water?



(A) a (B) b
(C) c (D) d

Q.27 Choose true & false statements from the following.
I. Mycorrhizal association between fungus and root of plant (*Pinus*) is often obligate.
II. *Pinus* and orchid seeds can germinate and grow into plant in absence of mycorrhizal association.
III. Absorption of water along with mineral solute by root hairs is purely a process of diffusion.
IV. In apoplast pathway, movement of water takes place through cell wall and intercellular spaces. Choose the correct option.
(A) I, II, and III are true while IV is false
(B) IV is true while I, II and III are false.
(C) I and IV are true.
(D) I and II are true.

Q.28 What would be ψ_P of cell sap in cell-A and cell-B respectively ?



(A) 300, 400 kP_a (B) –300, – 400 kP_a
(C) –1100, –1600 kP_a (D) 900, 600 kP_a

For Q.29-Q.31

In a two-compartment system separated by a selectively permeable membrane, Compartment A is filled with a 0.5 M solution of NaCl and Compartment B is filled with a 1M solution of NaCl. Assuming that NaCl dissociates completely in an aqueous solution and that the membrane is freely permeable to Na^+, Cl^- and H_2O, characterize the following aspects of the system.

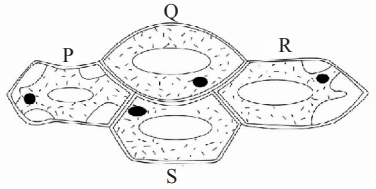
Q.29 Compartment B is _____ compared to Compartment A.
(A) hypotonic (B) isotonic
(C) hypertonic (D) None of these

Q.30 Initially, there is __ .
(A) no net movement of solutes (Na^+ and Cl^-)
(B) net movement of solutes (Na^+ and Cl^-) from A to B.
(C) net movement of solutes (Na^+ and Cl^-) from B to A.
(D) None of these

Q.31 Initially, there is __ .
(A) no net movement of water
(B) net movement of water from A to B
(C) net movement of water from B to A
(D) None of these

For questions 32 and 33

Refer to the following diagram of four plant cells.



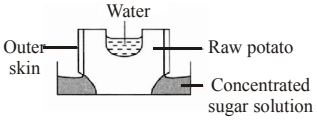
Q.32 Which of the cells shown above have low water potential?
(A) P and Q (B) Q and S
(C) P and R (D) R and S

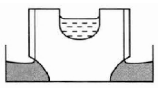
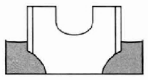
Q.33 If the cells remain in contact as shown, which of the following shows the direction of movement of water molecules?
(A) R to Q and Q to P (B) Q to S and R to Q
(C) P to Q and R to S (D) Q to P and S to R

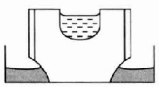
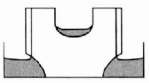
For questions 34 and 35

Refer to the following diagram which represents an experiment that used to investigate movement of substances in potato tissue.

Q.34 Which diagram shows the result after twenty-four hours?



(A)  (B) 

(C)  (D) 

Q.35 Which of the following processes are shown in the above experiment?
(A) Photosynthesis (B) Osmosis
(C) Respiration (D) Diffusion

Q.36 The physical process involved in the release of molecular oxygen from leaves is :
(A) Diffusion (B) Transpiration
(C) Osmosis (D) Capillarity

Q.37 Osmosis is the diffusion of a solution of a weaker concentration when both are separated by semipermeable membrane. What is error in the statement.
(A) The movement of solvent molecule is not specified.
(B) There is no mention of DPD.
(C) Behavior of semipermeable membrane is not specified.
(D) The exact concentration of solutions are not indicated.

Q.38 What statement can be cited for 10% sodium chloride solution and 10% sugar solution present–
(A) Both have equal OP.
(B) The concentration of sodium chloride solution will be less than concentration of sugar solution.
(C) The OP of sugar solution will be higher than OP of sodium chloride solution.
(D) DPD of sodium chloride solution will be higher than DPD of sugar solution.

Q.39 If a plant cell is immersed in water, the water continues to enter the cell until the :
(A) Concentration of the salts is the same inside the cell as outside.
(B) Cell bursts.
(C) Concentration of water is the same inside the cell as outside.
(D) Diffusion pressure deficit is the same inside the cell as outside.

Q.40 If a cell swells, after being placed in solution, the solution
(A) Neutral (B) Hypotonic
(C) Hypertonic (D) Isotonic

Q.41 Osmosis means –
(A) Solute from low concentration to higher.
(B) Solute from higher concentration to low.
(C) Solvent from low concentration of solution to higher concentration of solution.
(D) Solvent from higher concentration solution to low concentration solution.

Q.42 Which of the following statement is not correct :
(A) Plants absorb excess quantity of water.
(B) Plants take small quantity of mineral salts through soil water.
(C) Water and inorganic salts may also simultaneously by root hair.
(D) Plant absorb only one thing at a time water or inorganic salts.

Q.43 Which of the following is a rapid type of absorption :
(A) Passive absorption (B) Active absorption
(C) Salt absorption (D) Root absorption

Q.44 The form of water absorbed by plant's root system, from the soil is :
(A) Hygroscopic water (B) Gravitational water
(C) Capillary water (D) All of these

Q.45 Generally, stomata opens when –
(A) guard cells swell by endosmosis due to the influx of protons (H^+).
(B) guard cells swell due to the increase in their water potential.
(C) guard cells swell due to the decrease in their water potential.
(D) guard cells swell by endosmosis due to the efflux of potassium ions.

Q.46 Humus in soil is necessary for plant growth because it :
(A) Increases aeration & water absorption capacity of soil.
(B) Makes soil compact.
(C) Makes soil sterile.
(D) Decreases rate of percolation.

Q.47 Water will be absorbed by root hairs when :
(A) Concentration of salts in the soil is high.
(B) Concentration of solutes in the cell sap is high.
(C) The plant is rapidly respiring.
(D) They are separated from the soil by a semipermeable membrane.

Q.48 Water in plants is transported by ascent of sap takes place through :
(A) Cambium (B) Phloem
(C) Xylem (D) Epidermis

Q.49 In poorly aerated soil, the rate of water absorption will :
(A) Increase (B) Decrease
(C) Remains the same (D) None of these

Q.50 The pH in the guard cells was observed when stomata were open it ranges :
(A) 9 - 10 (B) 4 - 5
(C) 7-7.5 (D) 2 - 4

Q.51 What will be the effects on stomata, if relative humidity is 100% in atmosphere :
(A) Completely open. (B) Partially open.
(C) No effects (D) Closed

Q.52 Active K^+ ion exchange mechanism of opening and closing of stomata was given by :
(A) Khorana (B) Scrath
(C) Levitt (D) Kohli

Q.53 The metal ion involved in the stomatal regulation is :
(A) Iron (B) Magnesium
(C) Zinc (D) Potassium

Q.54 The following percentage of water absorbed by herbaceous plants is lost in transpiration :
(A) 80% (B) 60%
(C) 40% (D) 99%

Q.55 Transpiration from plants would be most rapid when :
(A) There is lot of humidity in atmosphere
(B) The air is more humid
(C) There is excess rain full
(D) Environmental conditions are dry

Q.56 Processes occur in leaves, which may lower their temperature–
(A) Respiration (B) Photosynthesis
(C) Hydrolysis (D) Transpiration

Q.57 Who is called father of plant physiology :
(A) K.V. Thimann (B) Stephan Hales
(C) M. Calvin (D) E. Rabinowitch

Q.58 Who is called father of Indian plant physiology :
(A) J.C. Bose (B) Calvin
(C) R. Mishra (D) K. K. Nanda

Q.59 One molar solution of which substance will have maximum O.P. –
(A) NaCl (B) Glucose
(C) Fructose (D) Starch

Q.60 Pieces of beet root do not lose their colour in cold water, but do so in boiling water because :
(A) The cell wall is killed in boiling water.
(B) Hot water can enter the cells readily.
(C) The plasma membrane gets killed in boiling water and becomes permeable.
(D) The pigment is not soluble in cold water.

Q.61 The type of diffusion in which substances move across the membrane along their concentration gradient in the presence of certain carriers or transport proteins is called –
(A) simple diffusion (B) facilitated diffusion
(C) osmosis (D) active transport

Q.62 Water passes into a cell due to –
(A) OP (B) DPD
(C) turgor pressure (D) diffusion

Q.63 Which is not a purpose of transpiration?
(A) Supplies water for photosynthesis.
(B) Helps in translocation of sugars from source to sink.
(C) Maintains shape and structure of the plant.
(D) Cools leaf surface

Q.64 When transport proteins simultaneously move two molecules across a membrane in the same direction, the process is called –
(A) uniport (B) antiport
(C) symport (D) diffusive ports

Q.65 The correct relationship among different type of soil water is –
(A) Chresard = Echard + Hollard
(B) Hollard = Chresard + Echard
(C) Echard = Hollard + Chresard
(D) Hollard = Chresard – Echard

Q.66 Movement of solvent molecule from a region of its higher concentration to a region of its lower concentration through a semipermeable membrane, is referred to as
(A) simple diffusion (B) facilitated diffusion
(C) osmosis (D) active transport.

Q.67 In _____ pathway, water crosses at least two membranes for each cell in its path (i.e., plasma membrane on entering and exiting).
(A) apoplast (B) symplast
(C) transmembrane (D) both (A) and (C)

Q.68 Unidirectional flow of water, minerals, some organic nitrogen and hormones occurs through
(A) xylem (B) phloem
(C) root (D) vascular tissue

Q.69 Select the correct option in reference with the statements given below.
I. Facilitated diffusion cannot cause net transport.
II. Transport rate in case of facilitated diffusion never reaches to a maximum level.
III. Facilitated transport is selective to inhibition proteins.
IV. Concentration gradient is not required in case of facilitated diffusion.
(A) II and IV (B) I, II, III and IV
(C) I and III (D) None of these

Q.70 Salt is added to preserve meat, pickles, etc. because salting kills bacteria by the process of
(A) dissolution (B) distillation
(C) plasmolysis (D) imbibition

Q.71 The cell A has an osmotic potential of – 20 bars and a pressure potential of + 6 bars. What will be its water potential?
(A) – 14 bars (B) + 14 bars
(C) – 20 bars (D) – 26 bars

Q.72 The transpiration-driven ascent of xylem sap depends mainly upon __ property of water.
(A) cohesion (B) adhesion
(C) surface tension (D) all of these

Q.73 Read carefully the following statement and identify which of them is/are correct?
I. Accumulation of K^+ ions in the guard cells does not require energy.
II. A high pH favours stomatal opening.
III. Movement of chloride ions into the guard cells occur in the response to the electrical differential created by K^+ ions.
IV. With the entry of several K^+ ions and chloride ions, the water potential of guards cells increases.
(A) I and II (B) II and IV
(C) III and V (D) II and III

EXERCISE - 3 (LEVEL-3)

Choose one correct response for each question.

Q.1 Stomata of a plant open due to –
(A) Influx of potassium ions
(B) Efflux of potassium ions
(C) Influx of hydrogen ions
(D) Influx of calcium ions

Q.2 When Oak leaf stomata opens, process is :
(A) Water molecules enter adjacent guard cells.
(B) Atmosphere outside stomata become less humid.
(C) Auxins are accumulated in guard cells.
(D) Salt molecules are excreted by adjacent guard cells.

Q.3 Wilting of a plant result from excessive :
(A) Respiration (B) Photosynthesis
(C) Absorption (D) Transpiration

Q.4 The rate of transpiration is high when :
(A) The atmosphere is saturated with water vapour.
(B) Light is very dim.
(C) The temperature is low.
(D) The atmosphere is dry and the temperature is high.

Q.5 Excessive loss of water causes wilting of leaves, it can be prevented by :
(A) Keeping the plant in bright light
(B) Spraying the plant with alcohol
(C) Applying vaseline on the leaf surface
(D) Adding high amounts of fertilizers to the soil

Q.6 Leaves which appear wilted in the day time recover at night because :
(A) Light is essential for photo synthesis.
(B) The stomata close down, temperature decrease, transpiration is reduced and the plant is able to absorb more water from the soil.
(C) Respiration and translocation of organic substance both increases.
(D) The plant is sleeping because of dark conditions.

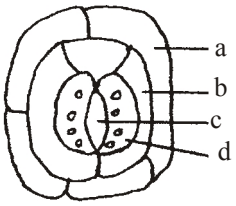
Q.7 Conversion of starch to organic acid is essential for :
(A) Stomatal closure (B) Stomatal opening
(C) Stomatal initiation (D) Stomatal growth

Q.8 Increase in CO_2 concentration around leaf results in :
(A) Rapid opening of stomata
(B) Partial closure of stomata
(C) Complete closure of stomata
(D) No effect on stomatal opening

Q.9 Which of the following wall of guard cells is thick
(A) Outer (B) Inner
(C) Sidewall (D) All the three

Q.10 Guard cells help in
(A) Fighting against infection
(B) Protection against grazing
(C) Transpiration
(D) Guttation

Q.11 Given below is the diagram of a stomatal apparatus. In which of the following all the four parts labelled as a, b, c and d are correctly identified?



(A) a-Subsidiary cell, b-Epidermal cell, c-Guard cell, d-Stomatal aperture
(B) a-Guard cell, b-Stomatal aperture, c-Subsidiary cell, d-Epidermal cell
(C) a-Epidermal cell, b-Guard cell, c-Stomatal aperture, d-Subsidiary cell
(D) a-Epidermal cell, b-Subsidiary cell, c-Stomatal aperture, d-Guard cell

Q.12 Function of companion cells is
(A) Loading of sucrose into sieve elements by passive transport.
(B) Loading of sucrose into sieve elements.
(C) Providing energy to sieve elements for active transport.
(D) Providing water to phloem.

Q.13 Loading of phloem is related to
(A) Increase of sugar in phloem
(B) Elongation of phloem cell
(C) Separation of phloem parenchyma
(D) Strengthening of phloem fibre

Q.14 The translocation of organic solutes in sieve tube members is supported by
(A) Cytoplasmic streaming
(B) Root pressure and transpiration pull
(C) P-proteins
(D) Mass flow involving a carrier and ATP

Q.15 The spray of PMA causes :
(A) Decrease in transpiration.
(B) Increase in transpiration.
(C) Increase in absorption.
(D) Increase in guttation.

Q.16 When the stomata are opening; we observe following changes in the guard cells :
(A) OP increase, TP decreases.
(B) OP & TP increases.
(C) OP decreases, TP increases.
(D) OP & TP decreases.

Q.17 Cuticular transpiration is observed mainly in :
(A) Xeropytes (B) Herbaceous plants
(C) Trees (D) Shrubs

Q.18 What is action spectrum of transpiration :
(A) Green and U.V (B) Blue and Yellow
(C) Blue and far red (D) Blue and red

Q.19 In which of the following plants, the metabolism will be hindered if upper surface of leaves are coated with wax –
(A) Hydrilla (B) Nelumbium
(C) Vallisneria (D) Utricularia

Q.20 Which of the following substance serve as an anti-transpirant in plant –
(A) Phenyl mercuric acetate (B) Aspirin
(C) Silicon oil (D) All of these

Q.21 Which of the atmospheric factor act as anti-transpirant
(A) SO_2 (B) CO
(C) CO_2 (D) All pollutant gasses

Q.22 Transpiration is a non-enzymatic process its Q_{10} value
(A) 1 (B) 2
(C) 3.5 (D) Zero

Note (Q.23-Q.26) :
(A) Statement- 1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement -1.
(B) Statement-1 is True, Statement-2 is True ; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement - 1 is True, Statement- 2 is False.
(D) Statement -1 is False, Statement -2 is False.

Q.23 **Statement 1 :** Long distance flow of photoassimilates in plants occurs through sieve tubes.
Statement 2 : Mature sieve tubes have parietal cytoplasm and perforated sieve plates.

Q.24 **Statement 1 :** Water potential is new term for diffusion pressure deficit.
Statement 2 : Both diffusion pressure deficit and water potential have a negative value.

Q.25 **Statement 1 :** Wilting occurs due to loss in turgidity.
Statement 2 : Turgor pressure checks the excessive entry of water into cells.

Q.26 **Statement 1 :** When dried seeds of pea are placed in a tin and water added up to their upper level and then a lid is put tightly over it. Within an hour, the lid will blown off.
Statement 2 : Due to rapid division in pea seeds.

Q.27 Match Column-I with Column-II and select the correct option from the codes given below.

	Column-I	**Column-II**
a.	Dixon and Jolly	(i) Root pressure
b.	Stomata	(ii) Only water available to plants
c.	Manometer	(iii) Transpiration
d.	Capillary water	(iv) Transpiration pull
e.	Potometer	(v) Rate of transpiration

(A) a-(iv), b-(iii), c-(v), d-(ii), e-(i)
(B) a-(i), b-(iii), c-(iv), d-(ii), e-(v)
(C) a-(iv), b-(iii), c-(i), d-(ii), e-(v)
(D) a-(v), b-(iv), c-(iii), d-(ii), e-(i)

Q.28 Which of the following occupies the space between the cell wall and the shrunken protoplast in a plasmolysed cell?
(A) Isotonic solution (B) Hypotonic solution
(C) Hypertonic solution (D) Water

Q.29 The manufactured food in a green plant moves from the leaves to other parts through
(A) xylem (B) phloem
(C) cortex (D) pith

Q.30 In apoplast pathway, water moves exclusively through the
(A) plasmodesmata (B) cell walls
(C) intercellular spaces (D) both (B) and (C)

Q.31 The values of osmotic potential (π) and pressure potential (ρ) of cells a, b, c and d are given below.

Cell	π	ρ
a	–1.0	0.5
b	–0.6	0.3
c	–1.2	0.6
d	–0.8	0.4

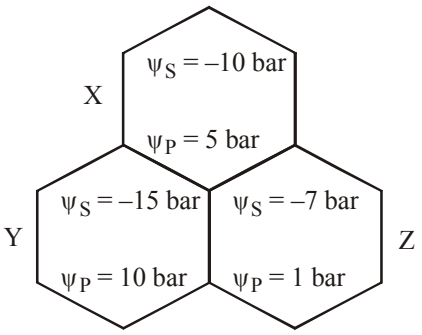
Identify the correct sequence that shows the path of movement of water and choose the correct options.
(A) d → c → a → b (B) b → d → a → c
(C) b → c → d → a (D) c → b → a → d

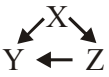
Q.32 In a stomatal apparatus, cellulosic microfibrils are oriented
(A) Longitudinally on subsidiary cells.
(B) Radially in the cell walls of guard cells.
(C) Radially and longitudinally in wall of guard cells.
(D) Longitudinally on both guard cells.

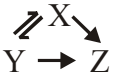
Q.33 Stomatal opening is affected by –
(A) nitrogen concentration, carbon dioxide concentration and light.
(B) carbon dioxide concentration, temperature and light.
(C) nitrogen concentration, light and temperature
(D) carbon dioxide concentration, nitrogen concentration and temperature.

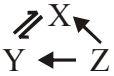
Q.34 Munch hypothesis is based on –
(A) translocation of food due to TP gradient and imbibition force.
(B) translocation of food due to turgor pressure (TP) gradient.
(C) translocation of food due to imbibition force.
(D) None of the above

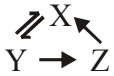
Q.35 Find correct pathway of movement of water in given presentation of cells.



(A) 

(B) 

(C) 

(D) 

Q.36 In land plants the guard cells differ from other epidermal cells in having –
(A) Chloroplasts
(B) Cytoskeleton
(C) Mitochondria
(D) Endoplasmic reticulum

Q.37 Which of the following get accumulated in the vacuoles of guard cells during stomatal opening?
(A) Water, calcium and magnesium
(B) Starch, potassium and chloride ions
(C) Malate, sodium and potassium ions
(D) Malate, potassium and chloride ions

Q.38 (a) In dry atmosphere, the relative humidity is low, so the rate of transpiration increases.
(b) Slow breeze promotes the rate of transpiration
(c) ABA promotes transpiration.
(d) A high salt concentration in soil water increases transpiration.
(A) c and d are correct.
(B) b and c are correct.
(C) a and c are correct.
(D) a and b are correct.

Q.39 Choose **incorrect** option w.r.t. evolution of the C_4 photosynthetic system in plants
(A) For maximizing the availability of CO_2.
(B) For minimizing the water loss.
(C) For increasing photosynthesis even in diffused light intensity.
(D) For increasing photosynthesis at high atmospheric temperature.

EXERCISE - 4 (PREVIOUS YEARS AIPMT/NEET EXAM QUESTIONS)

Choose one correct response for each question.

Q.1 Which of the following criteria does not pertain to facillitated transport ? **[NEET 2013]**
(A) Uphill transport
(B) Requirement of special membrane proteins
(C) High selectivity
(D) Transport saturation

Q.2 In a ring girdled plant : **[AIPMT 2015]**
(A) The root dies first.
(B) The shoot and root die together.
(C) Neither root nor shoot will die.
(D) The shoot dies first.

Q.3 Which one gives the most valid and recent explanation for stomatal movements ? **[AIPMT 2015]**
(A) Potassium influx
(B) Starch hydrolysis
(C) Guard cell photosynthesis
(D) Transpiration

Q.4 Transpiration and root pressure cause water to rise in plants by : **[AIPMT 2015]**
(A) pulling and pushing it, respectively
(B) pushing it upward
(C) pushing and pulling it, respectively
(D) pulling it upward

Q.5 A column of water within xylem vesels of tall trees does not break under its weight because of: **[RE-AIPMT 2015]**
(A) Tensile strength of water
(B) Lignification of xylem vessels
(C) Positive root pressure
(D) Dissolved sugars in water

Q.6 Root pressure develops due to : **[RE-AIPMT 2015]**
(A) Low osmotic potential in soil.
(B) Passive absorption.
(C) Increase in transpiration.
(D) Active absorption.

Q.7 Water vapour comes out from the plant leaf through the stomatal opening. Through the same stomatal opening carbon dioxide diffuses into the plant during photosynthesis. Reason out the above statements using one of following options **[NEET 2016 PHASE 1]**
(A) Both processes cannot happen simultaneously.
(B) Both processes can happen together because the diffusion coefficient of water and CO_2 is different.
(C) The above processes happen only during night time.
(D) One process occurs during day time, and the other at night.

Q.8 A few drops of sap were collected by cutting across a plant stem by a suitable method. The sap was tested chemically. Which one of the following test results indicates that it is phloem sap? **[NEET 2016 PHASE 2]**
(A) Acidic (B) Alkaline
(C) Low refractive index (D) Absence of sugar

Q.9 Which of the following facilitates opening of stomatal aperture? **[NEET 2017]**
(A) Contraction of outer wall of guard cells.
(B) Decrease in turgidity of guard cells.
(C) Radial orientation of cellulose microfibrils in the cell wall of guard cells.
(D) Longitudinal orientation of cellulose microfibrils in the cell wall of guard cells.

Q.10 The water potential of pure water is – **[NEET 2017]**
(A) Zero
(B) Less than zero
(C) More than zero but less than one
(D) More than one

Q.11 Stomatal movement is not affected by **[NEET 2018]**
(A) O_2 concentration (B) Light
(C) Temperature (D) CO_2 concentration

Q.12 What is the direction of movement of sugars in phloem? **[NEET 2019]**
(A) Non-multidirectional (B) Upward
(C) Downward (D) Bi-directional

Q.13 Xylem translocates. **[NEET 2019]**
(A) Water only
(B) Water and mineral salts only
(C) Water, mineral salts and some organic nitrogen only
(D) Water, mineral salts, some organic nitrogen and hormones

ANSWER KEY

EXERCISE-1 (SECTION-1&2)

(1) (C) **(2)** (A) **(3)** (C)
(4) Diffusion **(5)** Isotonic
(6) Suction pressure **(7)** Xylem
(8) Sugars **(9)** Hydathode
(10) Plasmolysis, Cell membrane
(11) Protein **(12)** Antiport transport
(13) Pressure and concentration gradient.
(14) Exosmosis **(15)** Pressure
(16) Transpiration pull **(17)** Half
(18) Slower **(19)** Water
(20) Ascent of sap
(21) Xylem parenchyma, Medullary rays
(22) Transpiration, **(23)** C_4, C_3
(24) Mass or bulk flow, **(25)** Holard
(26) True **(27)** True
(28) True **(29)** True
(30) False **(31)** True
(32) True **(33)** Fasle-Symport
(34) True **(35)** False. Active
(36) True

EXERCISE - 1 [SECTION-3 & 4]																									
Q	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**
A	C	C	D	A	B	D	D	C	A	D	A	C	D	A	A	C	D	B	A	B	A	A	D	D	C
Q	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**
A	C	C	D	A	D	C	B	C	D	A	A	C	C	A	D	D	B	B	A	A	A	C	C	A	C
Q	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**	**101**	**102**	**103**	**104**	**105**						
A	A	D	B	A	B	B	A	B	B	A	B	B	C	D	C	D	D	D	A						

EXERCISE - 2																									
Q	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
A	C	B	D	D	B	C	A	C	A	A	D	D	C	C	C	A	B	A	C	A	B	B	A	C	C
Q	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
A	B	C	A	C	C	B	C	D	B	B	A	A	D	D	B	C	D	A	C	C	A	B	C	B	C
Q	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**		
A	A	C	D	D	D	D	B	A	A	C	B	B	B	C	B	C	C	A	C	C	A	D	D		

EXERCISE - 3																									
Q	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
A	A	A	D	D	C	B	B	B	B	C	D	B	A	C	A	C	B	D	B	D	C	B	A	C	B
Q	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**											
A	C	C	C	B	D	B	B	B	B	B	A	D	D	C											

EXERCISE - 4													
Q	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
A	A	A	A	A	A	D	B	B	C	A	A	D	D

SOLUTIONS

EXERCISE-1

(1) (C) **(2)** (A)

(3) **(C).** The water potential of 10% salt solution is negative. Pressure potential in a normal cell is zero, while that of a plasmolysed cell is negative. Metric potential on the surface of the wood is positive.

(4) Diffusion **(5)** Isotonic

(6) Suction pressure **(7)** Xylem

(8) Sugars **(9)** Hydathode

(10) Plasmolysis, Cell membrane

(11) Protein **(12)** Antiport transport

(13) Pressure and concentration gradient.

(14) Exosmosis **(15)** Pressure

(16) Transpiration pull **(17)** Half

(18) Slower **(19)** Water

(20) Ascent of sap

(21) Xylem parenchyma, Medullary rays

(22) Transpiration, **(23)** C_4, C_3

(24) Mass or bulk flow, **(25)** Holard

(26) True **(27)** True

(28) True **(29)** True

(30) False **(31)** True

(32) True **(33)** Fasle-Symport

(34) True **(35)** False. Active

(36) True **(37)** (C)

(38) (C) **(39)** (D) **(40)** (A)

(41) **(B).** Long distance transport of organic and inorganic substances in plants occur through complex permanent tissues. Vascular tissues are also permanent tissues, i.e., xylem and phloem.

(42) **(D).** In facilitated diffusion, the rate of diffusion is affected by the solubility of molecules in lipids, concentration gradients, molecular size of the molecules, etc. Availability of carrier molecules also affects the rate of diffusion in facilitated transport.

(43) **(D).** Process of diffusion is actively involved in various processes of life like transpiration by plants, respiration in livings and photosynthesis. It is a part of all the three processes.

(44) **(C).** Aquaporins are present in cell membranes. They facilitate the transport of water soluble substances through it. Aquaporins are also known as channel proteins.

(45) **(A).** Active transport of solute occurs against the concentration gradient or potential gradient, i.e movement of solute takes place from a lower chemical concentration to higher chemical concentration. That is why, it is also considered as uphill transport.

(46) **(D).** Movement of hydrophilic moeity substance is facilitated by aquaporin and ion channels, which is the constituent of cell membranes. They plays a role in passive transport of water soluble substances and do not set up a concentration gradient.
Hence, diffusion of hydrophilic substances along the concentration gradient through transporter carrier protein, with no energy involvement is termed as facilitated diffusion.

(47) **(A).** In rooted plants, transport of inorganic substances like water and minerals occur by xylem and it is unidirectional in case of water.

(48) **(C).** Facilitated diffusion and active transport are two important processes of movement of substances, into and out of the cells. These two processes are selective and specific i.e., cells are allowed to select the uptake substances (facilitated diffusion) while active transport is highly specific due to the expenditure of energy.

(49) **(D).** In diffusion process, the rate of diffusion of substances depend upon the concentration gradient, permeability of the membrane, temperature and pressure.

(50) **(A).** When carrier proteins allow two type of molecular movements together, it is termed as co-transport. It can be further divided into two types; symport and antiport. In symport process, two types of material are diffused in same direction.

(51) **(A).** Osmosis is the flow of solvent, (water) from lower concentration to higher concentration through a differentially permeable membrane. It is a special type of diffusion of water through semipermeable or differentially membrane.

(52) **(C).** Halophytes or plants in saline soil shows maximum osmotic pressure, e.g., *Atriplex confertifolia* has an OP of 202.42 atm. Mesophytes have an osmotic pressure of 5-15 atm. whereas 10-30 atm is exhibited by xerophytes.

(53) (D)

(54) **(B).** Pure water has maximum diffusion pressure. If solute particles are added in pure water, its diffusion pressure gets lowered and this reduction/decrease in diffusion pressure of water in a solution in reference to its pure state is termed as diffusion pressure deficit.

(55) **(A).** DPD or Diffusion Pressure Deficit is an older term, which was used for water potential. Due to the presence of DPD in a solution, it tends to make up the reduction in diffusion pressure by absorbing water. Therefore, DPD is also called as suction pressure.

(56) (B)

(57) **(A).** The water potential (ψ_W) is equal to osmotic potential (ψ_S) + pressure ootential (ψ_P). Osmotic potential is always in negative value. The water potential is the chemical potential of water, which is equivalent to DPD with negative sign.

Therefore, water potential (ψ) of cell A is

$$\psi_A = \psi_S + \psi_P = -18 + 8 = -10$$

Water potential of cell B (ψ_B) is

$$\psi_B = \psi_S + \psi_P = -14 + 2 = -12$$

Since, water moves from higher water potential to lower potential, i.e., the flow of water will be from cell A (–10 bars) to cell B (–12 bars).

(58) (A)

(59) **(D).** The water move from lower DPD to higher DPD so the water will move from cell a to cell b, because cell a have low DPD than cell b.

(60) (D)

(61) **(C).** The value of diffusion Pressure Deficit (DPD) is equal to the difference between the Turgor Pressure (TP) and the Osmotic Pressure (OP) in a solution in the cell or system. In full turgid cell.

DPD = OP – WP = OP – TP

(62) **(C).** Positive force-turgor pressure (hydrostatic pressure) or pressure potential (ψ_P) is kept under check by wall pressure. In a plasmolysed cell, turgor pressure is nill therefore, osmotic pressure (ψ_S) becomes equal to DPD (ψ_W).

(63) **(C).** The imbibants have negative water potential. As a result when they come in contact with water, a steep water potential is established between the imbibant and imbibate

(64) **(D).** Water potential is the difference in free energy or chemical potential per unit molal volume of water in a system in reference to pure water at normal temperature and pressure and by increasing the pressure its value also increases.

(65) **(A).** When sugars actively move into a cell, the turgor pressure of the cell increases as the water moves into the cell.

(66) **(D).** Apoplast pathway consists of interconnecting cell wall, intercellular spaces, cell wall of endoderm is excluding the casparian strips, xylem and tracheary elements. This system is considered non-living and is continuous throughout the plant. Symplast pathway consists of the living parts of the plant and is made up of interconnected protoplast adjacent cells.

(67) (C)

(68) **(B).** The pathway of water conduction/ movement from the soil to xylem is :

Soil → Root hair → Cortex → Endodermis → Pericycle → Protoxylem → Metaxylem

(69) **(C).** Conduction of water in vertical direction from root to aerial parts of the plant is known as ascent of sap. The molecules remain joined to each other in water column due to the force of cohesion. The force between the walls of treachery elements and water molecule is called as adhesion force. These two forces ensure the continuity of water column in xylem.

(70) **(D).** Movement of water inside the roots from soil to xylem and then in most of the plant parts takes place by transpiration forces, which provides both energy and necessary pull. Cohesion force is responsible to join the water molecule with one another in water column. While force between tracheary wall and water molecule produces surface tension which accounts high capillarity through tracheary elements, which is called as adhesion force. These forces help to ensure the continuity of water column in xylem.

(71) **(A).** Apoplast pathway of water movement inside the roots provide the least resistance to movement of water. However, the presence of lignin suberin layer interrupts the water movement. This layer is known as casparian strips.

(72) **(A).** In mycorrhizal association, a large number of fungal hyphae are associated with the roots of higher plants in which hyphae extend to sufficient distance into soil and have a large surface area. These hyphae absorb water and mineral from the soil and pass them to roots. Roots provide sugar & nitrogen compound to the fungal hyphae.

(73) **(C).** In plants, water and minerals both are absorbed by root hairs of root hair zone. The root hair zone is also known as zone of differentiation or maturation. The cells of this zone undergo maturation and differentiation into different types of primary tissue of the roots.

(74) **(C).** Cohesion tension theory was proposed by Henry Dixon and Jolly in 1894. It is greatly supported and elaborated by Dixon (1914, 1924). It is also called as transpiration pull theory and is based on the following assumptions.

1. Cohesive and adhesive properties of water molecules.
2. Continuous water column from root hairs through stem to tip of leaves.
3. Strong transpiration pull exerted by all the transpiring leaves on the stem.

(75) (A)

(76) **(D).** If the stem of plant is cut under a state of tension in xylem sap, the air will be pulled into the xylem and the transport of water (xylem sap) remains in continuity, However, it can be discontinued with the introduction of air bubble in the xylem. Copeland (1902) believed that air bubbles enter into the xylem and break the tensile strength or cohesion force between the water molecule.

(77) (D) **(78)** (B)

(79) **(B).** Field capacity is generally defind as the water content of an undisturbed soil. It is a point of saturation by rainfall and drainage of gravitational water when later has completely stopped. i.e., maximum amount of water retained per unit dry weight of soil after stoppage of the gravitational flow. It is 25-35% in common loamy (best for agricultural purpose) soil.

(80) (A)

(81) **(A).** Loss of water in liquid phase from the margin and tips of leaves in many herbaceous plant is refered to as guttation. Bargerstein first studied the phenomenon of guttation in 1887. Guttation is not observed in all plants, it is observed in cereals like wheat, maize, oat, etc.

(82) (A)

(83) **(C).** Transpiration is the loss of water from the aerial part of a living plant. Transpiration may be stomatal (90%), cuticular (3-9%) and lenticular (0.1%). Transpiration is absent in submerged hydrophytes due to the absence of stomata in the leaves of submerged plants, i.e., potamogeton.

(84 (C)

(85) **(A).** Generally, stomata are associated with the water loss from aerial parts of plants. But plants which grow in xeric habitat have sunken stomata in their lower epidermis of leaves to minimise the loss, e.g., *Nerium*.

(86) **(C).** Loss of water from the aerial parts of plant through continuous transpiration causes a suction pressure or tension in the water column of plant. This tension develops due to transpiration and is also called as transpirational pull.

(87) **(A).** Levitt (1974) proposed the proton transport concept to explain the mechanism of opening and closing of stomata, During opening of stomata influx K^+ ions occur in guard cells. The source of these K^+ ions are neighbouring subsidiary and epidermal cells. This uptake of K^+ ions is balanced by Cl^- of guard cells. The malic acid dissociate into hydrogen and malate ion. The synthesis of malic acid in guard cells accompanies the influx or potassium ions.

(88) (D)

(89) **(B).** Passive absorption of water by root system is the result of tension on cell sap of water column. This tension develops due to transpiration at the leaves surfaces. So, it is also known as transpiration pull.

(90) **(A).** According to active K^+ theory proposed by Levitt, opening of stomata occurs due to the influx of K^+ ions into the guard cells. The source of K^+ ions are neighbouring subsidiary of epidermal cells.
The stomata closure is considered to be brought by the excretion of K^+ and Cl^- ions from the guard cells to epidermal tissue.

(91) **(B).** Xylem sap is water with dissolved ions. Unidirectional upward movement of water and mineral from the soil to the tip of leaves through stem and branches of plants is called as ascent of sap, which is carried out by tracheary elemental xylem.

(92) **(B).** Transpiration is the manifestation of turgor pressure. More than 95% of total loss of water occur through stomata of leaves and the mechanism of closing and opening of stomata is regulated by turgidity of guard cells of stomata.

(93) **(A).** Opening and closing of stomata is controlled and regulated by guard cells of stomata. Each stoma is surrounded by two small specialised green epidermal cells. These two cells are called as guard cells. Their wails are differentially thickened and elastic. The shape of guard cells are kidney shaped and dumb-bell shaped in dicot and monocot, respectively.

(94) **(B).** Guttation is a process of excretion or loss of water in liquid phase (droplet) from the tip of leaves and uninjured part of plants. Guttation occurs through special structure hydathode. It occurs usually from the tips and margin of leaves during early morning when there is high atmospheric humidity as during wet seasons. Water excreted by guttation is impure.

(95) **(B).** The upper epidermis of monocotyledons have large, thin walled and empty bulliform cells or motor cells containing water. These cells are mainly associated with rolling and unrolling of leaf. It is temporary or transient e.g, wilting of leaves and is quite common during noon due to transpiration.

(96) **(A).** Transport of minerals through xylem from soil takes place by active transport because the ions are transported against concentration gradient. So, there is a requirement of energy which is provided by ATP.

(97) **(B).** Mature stem of woody plants contain a water proof peripheral tissue called cork or phellem. A number of scars are found on the surface of cork. These scars are called as lenticels. They are specialised for gaseous exchange between the atmosphere and living cells of plants below the cork. Lenticular transpiration occurs through these lenticels.

(98) **(B).** Minerals are present in the soil as charged particles or ions, which cannot move across the cell membranes.

(99) (C)

(100) **(D).** The chief sinks for the mineral elements are the growing regions of the plant, such as the apical and lateral meristems, young leaves, developing flowers, fruits and seeds, and the storage organs. Unloading of mineral ions occurs at the fine vein endings through diffusion and active uptake by these cells.

(101) (C)

(102) **(D).** According to pressure flow hypothesis, sieve tube system shows better adaptation for mass flow of organic nutrients.
Due to the process of photosynthesis, source region is always rich in osmotic

concentration. So, they pass organic nutrient into sieve tube by active process which in turn produce high osmotic concentration in sieve tube.

Sieve tube absorbs water from adjacent xylem and develop a gradient of turgor pressure. Now, the organic nutrients are transported from an area of higher turgor pressure to the region of lower tugor pressure (sink or utilisation site).

(103) (D). According to mass-flow hypothesis, there is a mass flow of mineral ions into the root along with the transpiration current. Actually, transpiration creates a suction pressure or transpirational pull, conveyed from leaf xylem to root hair, which causes absorption of water from the soil passively. A large amount of ions are also absorbed along with the absorption of water. When the rate of transpiration is high, absorption of water increases due to increased suction pressure and along with water, absorption of ions also increases.

(104) (D). The direction of movement in phloem is bidirectional and that of xylem is unidirectional. Since the source-sink relationship is variable, the direction of movement in the phloem can be upwards or downwards, i.e., bidirectional. This contrast with that of the xylem, where the movement is always unidirectional, i.e., upwards.

(105) (A). Mass flow or pressure flow hypothesis for translocation of organic food was proposed by Munch (1930). According to the hypothesis, organic substances are transported from a higher osmotic pressure to an area of lower osmotic pressure. This occurs due to the development of a gradient turgor pressure. Flow of organic solution takes place from a region of higher turgor pressure (source) to an area of lower turgor pressure (sink) or utilisation site.

EXERCISE-2

(1) (C) **(2)** (B) **(3)** (D) **(4)** (D)
(5) (B) **(6)** (C) **(7)** (A)

(8) (C). The movement of sugars in the phloem begins at the source, where sugars are loaded (actively transported) into a sieve tube. Loading of the phloem steps up a water potential gradient that facilitates the mass movement in the phloem.

(9) (A)

(10) (A). Munch (1930) proposed the pressure flow hypothesis which best explain the transport of organic nutrients from the source (supply) to sink (utilisation site). According to this theory, source shows a high osmotic concentration than the sink.

When the organic substances from mesophyll cells are (act as source) passed to the sieve tube of phloem through their companion cell by active transport, a high osmotic concentration is developed in sieve tube and acts as a source. Water is absorbed by sieve tubes from the adjacent xylem and develop a high turgor pressure. Thus, the translocation of organic nutrient takes place from a region of higher turgor region to the area of lower turgor pressure.

(11) (D). Osmotic removal of water can lead to extensive cell shrinkage and retraction from cell walls. **(12)** (D)

(13) (C). According to mass-flow hypothesis, the transport of organic solutes takes place from source to sink. This transport depends on metabolic energy.

(14) (C)

(15) (C). An animal cell in a hypertonic solution would shrink because the concentration of water is greater inside the cell than outside the cell. Since water flows down a gradient, it would flow out of the cell. Plasmolysis means cell shrinking.

(16) (A) **(17)** (B)

(18) (A). Pea seeds contain protein, while wheat contains starch, the imbibition capacity of proteins is more than that of starch. That is why, pea seeds imbibe more water and show more swelling than those of wheat grains.

(19) (C)

(20) (A). The uptake of cholesterol occurs by receptor-mediated endocytosis, which

requires energy. (B) is an example of facilitated diffusion, and (C) and (D) are examples of countercurrent exchange. (B), (C), and (D) are all examples of passive transport and do not require energy.

(21) **(B).** Oxygen is absorbed by diffusion. All the other choices are examples of active transport.

(22) (B) **(23)** (A)

(24) **(C).** Plasmodesmata are functionally like gap junctions in animal cells and are a means of cytoplasmic communication among plant cells. A system of plasmodesmata is called a symplast.

(25) (C) **(26)** (B)

(27) **(C).** *Pinus* and orchid seeds cannot germinate and develop into plants in the absence of mycorrihzal association. In mycorrihzal association, the fungal hyphae are specialised for absorption of water and minerals by extending sufficient distance into soil. The mycorrhizal association between fungus and roots of plant are obligate. Absorption of water along with mineral is an active absorption and followed by osmosis.

(28) (A)

(29) **(C).** Because total solute concentration is greater in compartment B, it is considered hypertonic compared to A.

(30) **(C).** Because solutes moved passively down their concentration gradient, there is net movement of solutes from compartment B to compartment A until equilibrium is reached.

(31) **(B).** Because water moves passively form a solution of lesser solute communication to a solution of greater solute concentration, there is net movement of water from compartment A to compartment B until equilibrium is reached.

(32) (C) **(33)** (D) **(34)** (B) **(35)** (B)
(36) (A) **(37)** (A) **(38)** (D) **(39)** (D)
(40) (B) **(41)** (C) **(42)** (D) **(43)** (A)
(44) (C)

(45) **(C).** During day time, photosynthesis occurs in guard cells of stomata as they contain chloroplast. The soluble sugar formed by the process of photosynthesis decreases the water potential of guard cell and hence results in stomatal opening.

(46) (A) **(47)** (B) **(48)** (C) **(49)** (B)
(50) (C) **(51)** (A) **(52)** (C) **(53)** (D)
(54) (D) **(55)** (D) **(56)** (D) **(57)** (B)
(58) (A) **(59)** (A) **(60)** (C)

(61) **(B).** The diffusion of hydrophilic substances along the concentration gradient through fixed membrane transport proteins without involving energy expenditure, is called facilitated diffusion. Facilitated diffusion is very specific as it allows cell to select substances for uptake. It is sensitive to inhibitors as well as show saturation effect. Two major typesof transport proteins are known viz., carrier proteins (also called carriers, transporters) and channel proteins. Carrier proteins bind the particular solute to be transported and deliver the same to the other side of the membrane.

(62) **(B).** Movement of water (solvent) takes place from lower DPD to high DPD or from higher water potential to lower water potential.

(63) **(B).** Transpiration does not help in translocation of sugars from source to sink.

(64) **(C).** Some carrier proteins allow transport only if two types of molecules move together. This is called cotransport. It is of two types: symport and antiport method. In symport method of cotransport, both molecules cross the membrane in the same direction at the same time. In antiport method of cotransport, both molecules move in opposite direction. When a molecule moves across a membrane independent of other molecule, the process is called uniport.

(65) **(B).** Hollard is the amount of total water present in the soil. Water amount available to the plants is known as chresard, while echard is the amount of water, which cannot be absorbed by the plants.
Therefore, it can be summarised as Hollard = Chresard + Echard.

(66) **(C).** When the two solutions having different osmotic concentrations are separated by means of a semipermeable membrane, the molecules of solvent or water move from the region of their higher diffusion pressure (or free energy) to the region of their lower diffusion pressure (or free energy). This movement of water or solvent is called osmosis.

(67) **(C).** The transmembrane (or vacuolar) pathway is the route followed by water that sequentially enters a cell on one side, exits the cell on the other side, enters the next in the series and so on. In this pathway, water crosses at least two membranes for each cell in its path (the plasma membrane on entering and on exiting).

(68) **(A).** There are two types of vascular tissues in plants, xylem and phloem. Xylem translocation is mainly from roots to aerial parts. It passes water with mineral salts, some organic nitrogen and hormones. Phloem translocates organic substances and some inorganic solutes first from leaves to all other parts of the plant and storage organs. Storage organs re-export organic nutrients to those parts which require the same as newly formed leaves and fruits.

(69) **(C).** Concentration gradient must already be present for molecules to diffuse even if facilitated by proteins. Transport rate in facilites'diffusion reaches a maximum when all of the protein transporters are being used (saturation).

(70) **(C).** Plasmolysis is the characteristic feature of living walled cells. All living walled cells plasmalyse when kept in a hypertonic solution. Pickels, 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.

(71) **(A).** $\psi_w = \psi_s + \psi_p$
where, ψ_w = water potential, ψ_s = osmotic potential and ψ_p = pressure potential.
$\psi_w = (-20) + (+6) = -14$ bars

(72) **(D).** There is a continuous column of water from root through the stem and into the leaves. The water column is present in tracheary elements. The column of water does not fall down under the impact of gravity because forces of transpiration provide both energy and necessary pull. Cohesion, adhesion and surface tension keep the water in place.

(73) **(D).** During day time, the pH of guard cells is increased due to the consumption of CO_2 in the process of photosynthesis. Guard cells receives K^+ ions from the subsidiary epidermal cells. This influx of K^+ ions decreases the water potential of the guard cells. So, endosmosis takes place, which leads to the entry of water into the guard cells from subsidiary cell, than guard cells became turgid to open the stomatal aperture. Uptake of K^+ ions are balanced by Cl^- ions.

EXERCISE-3

(1)	(A)	**(2)**	(A)	**(3)**	(D)	**(4)**	(D)
(5)	(C)	**(6)**	(B)	**(7)**	(B)	**(8)**	(B)
(9)	(B)	**(10)**	(C)	**(11)**	(D)	**(12)**	(B)
(13)	(A)	**(14)**	(C)	**(15)**	(A)	**(16)**	(C)
(17)	(B)	**(18)**	(D)	**(19)**	(B)	**(20)**	(D)
(21)	(C)	**(22)**	(B)				

(23) **(A).** Sieve tubes are the conducting elements of phloem (a permanent vascular tissue which conducts organic food in plant body) which are elongated tubular channels formed by end to end union of numerous cells. The septa between individual sieve tube cells or sieve elements are bulged out. They are called sieve plates possessing a number of perforations (sieve pores or sieve pits) and helps in conduction of food.

(24) **(C).** The reduction in the diffusion pressure of water in a solution over its pure state is called diffusion pressure deficit or DPD. It is a term coined by Meyer (1938). It has positive value. Water potential is a modern term coined by Slatyer and Taylor (1960) which is equivalent to DPD, but it has a negative value.

(25) **(B).** Flowers, young stems and other softer organs are able to maintain their form due to turgidity or TP.

(26) **(C).** Air dried seeds of pea on coming in contact with water can develop an imbibition pressure, which is mainly responsible for the uptake of water. This leads to changes in the volume of each seed. Thus, the lid tightly put over a tin containing seeds with water will be blown off.

(27) (C) **(28)** (C)

(29) **(B).** The sugars, synthesized in leaves (as a result of photo-synthesis) are translocated downwards, upwards and laterally to storage organs mainly through phloem. These sugars are translocated in the form of sucrose.

(30) **(D).** Apoplast pathway consists of non-living parts of plant body i.e., cell walls and intercellular spaces. In apoplast pathway, water passes from root hair to xylem through the walls of intervening cells without crossing any membrane orcytoplasm.The pathway provides the least resistance to movement of water. However, it is interrupted by the presence of impermeable ligno-suberin casparian strips in the walls of endodermal cells.

(31) **(B).**

Cell	Water potential (osmotic potential + pressure potential)	DPD
a	–1 + 0.5 = – 0.5	+ 0.5
b	–0.6 + 0.3 = – 0.3	+ 0.3
c	–1.2 + 0.6 = – 0.6	+ 0.6
d	–0.8 + 0.4 = – 0.4	+ 0.4

(32) (B)

(33) **(B).** Carbon dioxide is an effective anti transpirant. A little rise in CO_2 concentration induces partial closure of stomata. Its higher concentration results in complete closure of stomata.

Light affects the rate of transpiration in two ways, firstly by controlling the stomatal opening and secondly by affecting the temperature. Increase in temperature increases the rate of transpiration.

(34) **(B).** Munch hypothesis is based on translocation of food due to Turgor Pressure (TP) gradient.

(35) (B) **(36)** (A) **(37)** (D)

(38) (D) **(39)** (C)

EXERCISE-4

(1) **(A).** Downhill movement. Net transport of molecules is from high concentration to low concentration.

(2) **(A).** In girding or ringing experiment, a ring of bark is cut from the stem. It also removes phloem. Nutrients collect above the ring where the bark also swells up and may give rise to adventitious roots. Growth is vigorous above the root. The tissues below the ring not only show stoppage of growth but also begin to shrivel (contract). Roots begin to starve first if the ring is not healed, after sometime roots will die, which will kill the whole plant.

(3) (A) **(4)** (A)

(5) **(A).** The column of water within Xylem vessel of tall trees does not break under its weight due to high tensile strength of water. Tensile strength is the ability to resist pulling forces.

(6) **(D).** As various ions from the soil are actively transported into the vascular tissues of the roots, water follows and increases the pressure inside the xylem i.e., root pressure (positive pressure).

(7) **(B).** Diffusion of water vapour and CO_2 are independent process. Their diffusion depends on the difference in their partial pressure.

(8) **(B).** Alkaline pH (7.8 – 8.0) is present in phloem sap where as xylem sap is acidic.

(9) **(C).** Cellulose microfibrils are oriented radially rather than longitudinally which makes easy for the stoma to open.

(10) **(A).** By convention, the water potential of pure water at standard temperature, which is not under any pressure, is taken to be zero.

(11) **(A).** Light, temperature and concentration of CO_2 affect opening and closing of stomata while they are not affected by O_2 concentration.

(12) **(D).** The direction of movement of sugar in phloem is bi-directional as it depends on source-sink relationship which is variable in plants.

(13) **(D).** Xylem is associated with tanslocation of mainly water, mineral salts, some organic nitrogen and hormones.