11. Transport in Plants

Transportation is the process of transporting water, minerals and food to all parts of the plant body. The specialized tissues involved in the transportation of water and organic solutes are Xylem and Pholem.

1. Means of Transport

Transport in plants occurs at three levels:

- The uptake and release of water and solute by individual cells.
- Short distance transport of substances from one cell to another.
- Long distance transport of sap within xylem and phloem.

Various materials are transported into and out of a living cell, by a number of methods like active transport and passive transport.

1.1. Active Transport

It is the transport of materials across a membrane with the help of mobile carrier protein and ATP. Different proteins in the membrane play a major role in both active as well as passive transport. Pumps are proteins that use energy to carry substances across the cell membrane. These pumps can transport substances from their low concentration to high concentration so it is an uphill transport (i.e., against concentration gradient) and 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.

1.2. Passive Transport

A molecule is transported along it's concentration gradient without the involvement of ATP.The flow of water in and out of the plant mainly occurs by passive transport.

- **Diffusion**

  The movement of molecules or ions from the region of their higher concentration to the region of their lower concentration, until the molecules are evenly distributed throughout the available space is known as diffusion. The diffusing particles create a certain pressure called as diffusion pressure (DP) which is directly proportional to the number of concentration of diffusing particles. The molecules move from higher DP to lower DP.

- **Characteristic of diffusion**
  - The diffusing molecules move randomly along concentration gradient.
  - The direction of diffusion of one substance is independent of the movement of another substance.
  - it is the only means for gaseous movement within the plant body.
  - Diffusion rates are affected by the gradient of concentration, the permeability of the membrane separating them, temperature and pressure.

  Factors influencing Rate of diffusion are Size of molecule, Temperature, Concentration gradient and surface area of the cell.

  Diffusion pressure : It is a hypothetical term coined by Meyer (1938) to denote the potential ability of the molecules or ions of any substance to diffuse from an area of their higher concentration to that of their lower concentration.

- **Facilitated diffusion**

  The diffusion of hydrophilic substances along the concentration gradient through fixed membrane transport protein without energy involvement is called facilitated diffusion.

  There are certain proteins which provide the site for such molecules to pass through the membrane. They do not set up concentration gradient; a concentration gradient must already be present for molecules to diffuse even if facilitated by the proteins.

  Transport proteins involved in facilitated diffusion are of two types

  (a) Carrier Proteins : They bind to the substance and carry it to the other side.

  (b) Channel Protein : They allow diffusion of solute of appropriate size only. Some examples of channel proteins are

  (i) Porins : Proteins which form huge pores in the outer membranes of the plastids, mitochondria and some bacteria allowing specific molecules to pass through them.

  (ii) Aquaporins : Theses are membrane proteins with 8 units that unite to form a water channel. It allows transport of water.

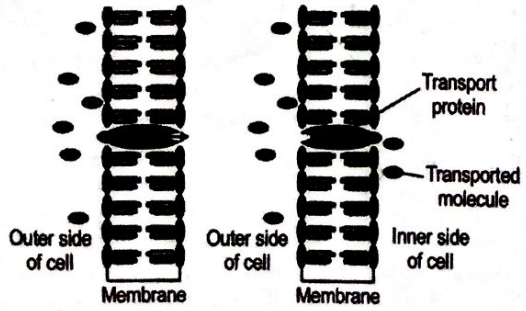


Fig. : Facilitated Diffusion

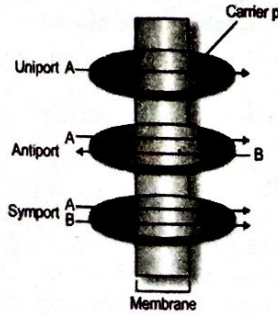


Fig. : Facilitated Diffusion

- **Types of Facilitated Diffusion**
  (i) Uniport : It is the transport of a molecule or substances across the membrane independent of other molecules or substances.
  (ii) A symport : is the transport of two types of molecules across the membrane in the same direction.
  (iii) An antiport : is the transport of two different molecules or substances in opposite directions.

2. Plant Water Relationship

2.1. Osmosis

Osmosis can be defined as "the passage of solvent molecules from a region of their higher concentration to a region of their lower concentration through semi-permeable". It occurs spontaneously in response to a driving force.

- **Osmotic pressure (π) :** It was proposed by Pfeiffer It can be defined as the actual pressure , that develops in a solution, when it is separated from its pure solvent (water) by means of a semipermeable membrane.
- **Osmosis is driven by two factors :** Concentration of dissolved solutes in a solution, and Pressure gradient.
  Both these factors determine the chemical potential of water, which is the driving force for water movement in plants. At equilibrium the two chambers should have the same water potential. Osmosis can be demonstrated by a simple experiment in a laboratory.
- **Potato osmometer :** If the tuber is placed in water, the cavity in the potato tuber containing a concentrated solution of sugar collect water due to osmosis.
- **Thistle funnel experiment":** So, $\Psi_s = -\pi$

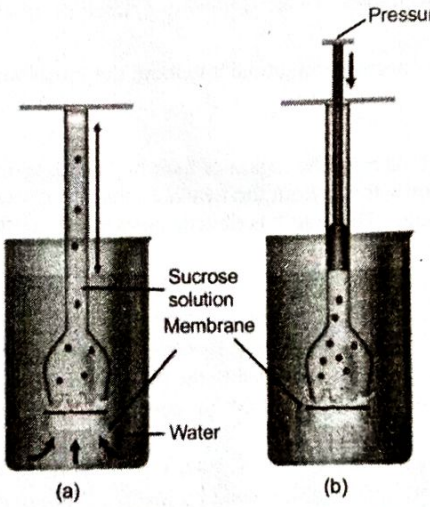


Fig. : A demonstration of osmosis. A thistle funnel is filled with sucrose solution and kept inverted in a beaker containing water.
(a) Water will diffuse across the membrane (as shown by arrows) to raise the level of the solution in the funnel
(b) Pressure can be applied as shown to stop the water movement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

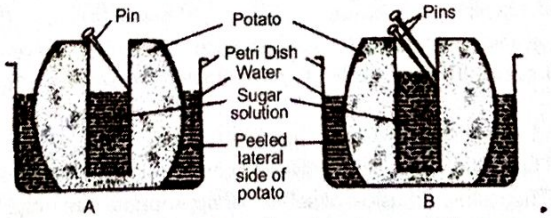


Fig. : Potato osmoscope experiment to demonstrate osmosis
A. Original level, **B.** Final level

Factors affecting Osmotic Pressure are Solute Concentration ,Surface area of cell, and pressure gradient.

- **The importance of osmosis in plants :**
  - It helps the root system of the plants to absorb water and minerals from the soil and helps maintain the turgidity (shape) of the plant cell.
  - It play a key role in the movement of water and other substances from one cell to another, enables the plants to overcome harsh conditions such as drought and frost.
- **Reverse Osmosis**
  Reverse osmosis occurs when the water is moved across the membrane against the concentration gradient, from lower concentration to higher concentration. To illustrate, imagine a semipermeable membrane with fresh water on one side and a concentrated aqueous solution on the other side. If normal osmosis takes place, the fresh water will cross the membrane to dilute the concentrated solution. In reverse osmosis, pressure is exerted on the side with the concentrated solution to force the water molecules across the membrane to the fresh water side

2.2. Plasmolysis

The behaviour of the plant cells (or tissues) with regard to water movement depends on the surrounding solution, a solution can be termed as hypotonic, hypertonic or isotonic depending upon its osmotic concentrations with respect to another solution or cell sap.

(a) **Hypotonic solution :** A solution, whose osmotic concentration (solute potential) is less than that of another solution or cell sap is called hypotonic solution.

(b) **Hypertonic solution :** A solution, whose osmotic concentration (solute potential) is more than that of another solution or cell sap is called hypertonic solution.

(c) **Isotonic solution :** A solution, whose osmotic concentration (solute potential) is equal to that of another solution or cell sap is called isotonic solution.

Plasmolysis is withdrawal of protoplast of a plant cell from its wall due to excessive loss of water from cell due to osmotic action. It occurs, when a plant cell is placed in hypertonic solution, due to exosmosis, water is first lost from the cytoplasm and then from the vacuole. This process is usually reversible. The space between the cell wall and the shrunken protoplast in the plasmolysed cell occupies external hypertonic solution.

- **Importance of Plasmolysis**
  - Plasmolysis proves that the cell membrane is elastic and semipermeable.
  - Plasmolysis can be shown only by living cells. weeds can be killed due to permanent plasmolysis
  - Plants are not allowed to grow in the cracks of the walls by the method of salting.Salting of pickles, meat and fish and sweetening of the jams and jellies with sugar, kill the spores of fungi and bacteria.

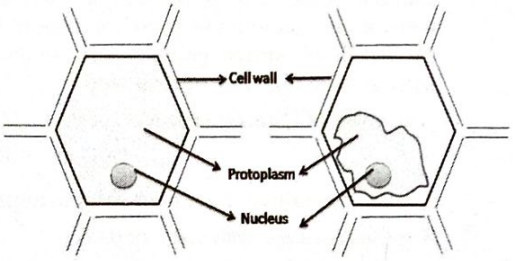


Fig. : Plasmolysis in a cell

2.3. Imbibition

The process of absorption of water by hydrophilic solid particles of a substance without forming a solution is called "Imbibition". It is a special type of diffusion, as water moves along its concentration gradient. Therefore, the water absorbed by solid substances or colloids results in enormous increase in their volume. Such solid substances which take part in imbibitions are called imbibants e.g., seeds, dry wood. The liquid (usually water) which is imbibed is known as imbibate. It is reversible process. Two conditions are necessary for the imbibitions to occur. They are :

(a) Water potential gradient between the surface of absorbent and the liquid imbibed.

(b) Affinity between the absorbent i.e., solid substance and the imbibed liquid.

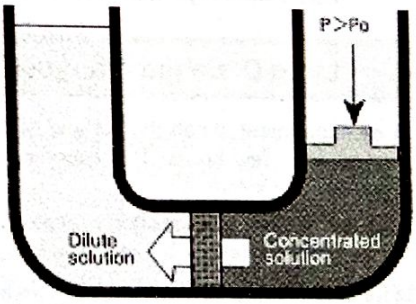
The examples of imbibition are absorption of water by seeds and dry wood. The pressure that is produced by the swelling of wood had been used by prehistoric man to split rocks and boulders. This process plays an important role in the germination of seed, rupturing of seed coat and emergence of seedlings is due to high imbibition pressure developed by seed kernel. Among plant imbibants, phycocolloids are the best imbibants followed by proteins and cellulose.

• **Imbibition Pressure -** When the imbibing substance is kept in a confined space, pressure is developed due to the increase in the volume of the imbibant. This is called imbibition pressure. It develops due to the matric potential of the imbibant, hence called matric potential and is denoted as π_m (= psi) π_m measured in bars or mega pascals (MPa).

- **Factors Influencing Imbibition**

  Capacity as well as the degree of imbibition vary in different imbibing substances and depend up on following factors
  - Texture of the imbibant,
  - Affinity of the imbibant for the imbibate
  - Temperature,
  - Pressure
  - *pH* of the medium.

- **Significance of Imbibition**
  - Imbibition is the first step in the absorption of water by the roots and cells,
  - Imbibition is the first step of seed germination, seedling is able to come out of soil due to development of imbibitional pressure.
  - Imbibition is maximum in agar followed by pectin, protein, starch and cellulose.



Important

Role of membrane permeability in transport **:** Membrane permeability is the ability of a membrane to allow passage of gases, liquids or solutes (dissolved substances) through it. It depends on (i) nature (membrane composition) of membrane (ii) nature of molecules or ions passing through it.

On the basis of their permeability, membranes are of four types :

(1) **Impermeable membranes :** Such membranes do not allow the passage of substances through them, e.g., suberised cell walls, cutinized cell walls.

(2) **Permeable membranes :** These allow the passage of substances through them, e.g., cellulosic cell walls.

(3) **Semipermeable membranes :** Such membranes are those membranes which permit the movement of solvent molecules through them but prevent the movement of solute particles, e.g., egg membrane, parchment membrane etc.

(4) **Selectively or differentially permeable membranes :** These are normally semipermeable but allow selective passage of solutes through them, e.g., plasmalemma (plasma membrane) tonoplast (the membrane of the vacuole).

2.4. Water Potential (Chemical Potential of water) (Ψ_w)

Water potential in a plant cell or tissue can be written as the sum of matrix potential (due to binding of water to cell and cytoplasm) the solute potential (due to concentration of dissolve solutes which by its effect on the entropy components reduces the water potential) and pressure potential or turgor pressure (due to hydrostatic pressure, which by its effect on energy components increases the water potential).

$$\Psi_w = \Psi_s + \Psi_p + \Psi_m$$

In case of plant cell, Ψm is usually disregarded and it is not significant in osmosis. Hence, the above given equation is written as follows.

$$\Psi_w = \Psi_s + \Psi_p$$

2.5. Osmotic or Solute Potential (Ψ_s)

Osmotic potential is the decrease in chemical potential of pure water due to the presence of solute particles in it. It is the potential of water molecules to move from less concentrated solution to a more concentrated solution across the semipermeable membrane. The magnitude of osmotic pressure and osmotic potential are numerically equal.only difference is osmotic pressure gas positive sign and osmotic potential has negative sign

The valve of Osmotic potential is calculated by following formula

$$(\Psi_s) = C \times R \times T$$

C = concentration of solute particles in mole/l.

R = Gas constant with valve of 0.083.

T = Temperature in absolute degrees

2.6. Turgor Pressure (Ψ_p)

Turgor pressure is the force within the cell that pushes the plasma membrane against the cell wall. It is also called *hydrostatic pressure*, and the pressure measured by a fluid, measured at a certain point within itself when at equilibrium. Turgor pressure is caused by the osmotic flow of water and occurs in plants, fungi, and bacteria. Absence of a cell wall would cause the cell to lyse when under too much pressure. The pressure exerted by the osmotic flow of water is called turgidity. The force exerted by the cell wall over the protoplast against the turgor pressure is called wall pressure and mostly it is equal to the turgor pressure.

2.7. Matric Potential (Ψ_m)

It is an expression of adsorption of water by colloidal particles or surfaces in plant cells. Value of matric potential is negligible.

2.8. Chemical Potential

It is the quantitative expression of the free energy associated with water. It is the difference between the potential of a substance in a given state and the potential of same substance in standard state.

2.9. Diffusion Pressure Deficit (DPD) or Suction Pressure (SP)

The term diffusion pressure (DP) and diffusion pressure deficit (DPD) were put forth by B.S. Meyer in 1938. Now a days, the term water potential (ψ) is used which is equal to DPD, but negative in value. The term suction pressure was put forth by Renner (1915). The amount by which the diffusion pressure of water or solvent in a solution is lower than that of pure water or solvent is known as diffusion pressure deficit (DPD)'. Diffusion pressure deficit is the water absorbing capacity of a cell. Therefore, DPD can also be called suction pressure (SP).

3. Long Distance Transport of Water

In an experiment, when the cut end of the twig bearing white flowers is kept inside a coloured water. It is observed that the colour of twig changes after few hours. This experiment demonstrates that the movement of water occurs in plants through the vascular bundles, more especially, the xylem.

Diffusion is slow process. It can account for short distance movement of molecules. For example, the movement of a molecule across a typical plant cell (about 50 μm) takes approximately 2.5 second.

In large and complex plants, substances move across very large distances. Special long distance transport systems become necessary so as to move substances across long distances and at much faster rate. Water and minerals and food are generally moved by mass or bulk-flow system.

It is quite different from diffusion where substances move independently according to their concentration gradients. This bulk flow is a accomplished either through a positive hydrostatic pressure gradient (e.g., a garden hose) or a negative hydrostatic pressure gradient (e.g., suction through a straw).

The bulk movement of substances through the conducting or vascular tissues of plants like xylem and phloem, is called translocation. The higher plants like angiosperms etc. have highly specialised vascular tissues. They are :

Xylem : It is associated with translocation of mainly water, mineral salts, some organic nitrogen and hormones. It translocates materials from roots to the aerial parts of the plants.

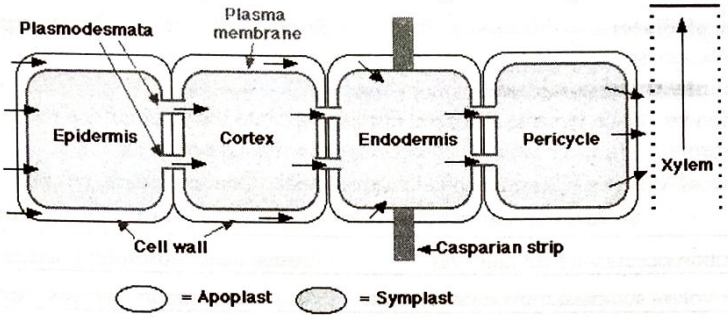
Phloem : It translocates various organic and inorganic solutes mainly from the leaves to other parts of the plants.

3.1. Pathways of water movement

- **Apoplast Pathway :** In this pathway, water passes from root hairs to xylem through the walls of intervening cell without crossing any membrane or cytoplasm. This pathway provides least resistance to the movement of water. However, it is interrupted by the presence of impermeable casparian strips in the walls of endodermal cells because they are made up of a mixture of wax-like suberin.

  The movement of water through this pathway is due to Transpiration pull and Adhesion-cohesion forces.

- **Symplast pathway :** It is the pathway formed by the system of interconnected protoplasts of different cells. Neighbouring cells are connected through cytoplasmic strands that extend through plasmodesmata. During symplastic movement, the water travels through the cells-their cytoplasm; intercellular movement is through the plasmodesmata. Water has to enter the cells through the cells membrane, hence movement is relatively slower. Movement is again down a potential gradient.



Most of the water flow in 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. Therefore, water molecules are unable to penetrate such layer, hence are directed towards wall regions that are not suberised and finally into the cells proper through the membranes. After reaching endodermis layer, the movement of water occurs through symplastic system. Because, this is the only way left for water and other solutes to reach vascular cylinder i.e., xylem.

Once the water enters xylem vessels, it is again free to move between cells as well as though them. In young roots, Water enters directly into the xylem vessels and/or tracheoids. These are non-living components of xylem tissue and are a part of the apoplastic pathway.

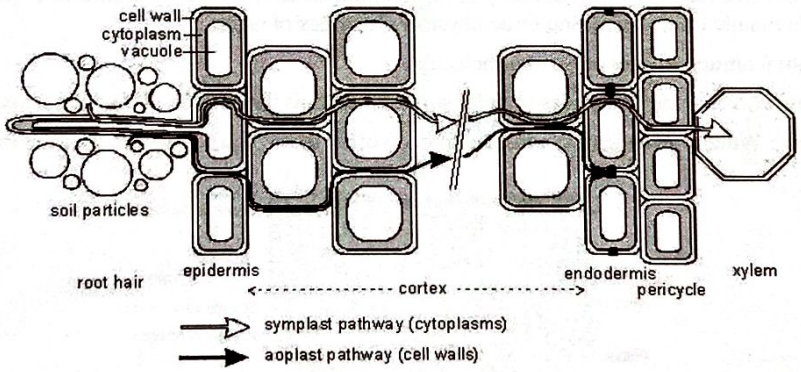


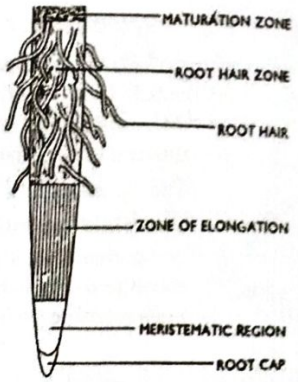
Fig. : Symplastic and apoplastic pathway of water and ion absorption and movement in roots

Some plants have additional structures associated with them that help in water and mineral absorption instead of root hairs. They use mycorrhiza for absorption of water. Mycorrhiza is a symbiotic association between a fungus and young roots of a plant. The hyphae or filaments of fungi form an extensive network around the young root, they can even penetrate the root cells, increasing surface area of absorption. They absorb mineral ions and water from the soil from a much larger volume of soil that perhaps a root cannot do. The fungus associated with the roots of plants provide minerals and water to them and in turn get sugar and nitrogen containing compounds from them. Such mycorrhizal association is obligate in many plants. For example, seeds of Pinus cannot germinate properly without developing a mycorrhizal association.

Difference between apoplast pathways and symplast pathways of water movement

	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.

3.2. Mechanism of water absorption



In higher plants water is absorbed through root hairs which are in contact with soil. Root hairs are tubular hair like prolongations of the cells of the epidermal layer (when epidermis bears root hairs it is also known as piliferous layer) of the roots. The walls of root hairs are permeable and consist of pectic substances and cellulose which are strongly hydrophilic (water loving) in nature. Root hairs contain vacuoles filled with cell sap

When roots elongate, the older hairs die and new root hairs are developed so that they are in contact with fresh supplies of water in the soil.

It is of two types

- **Active Absorption of Water -** In this process the root cells play active role in the absorption of water and metabolic energy released through respiration is consumed.

  Active absorption may be of two kinds

  (a) Osmotic absorption i.e., when water is absorbed from the soil into the xylem of the roots according to the osmotic gradient.

  (b) Non-osmotic absorption i.e., when water is absorbed against the osmotic gradient.
- **Passive Absorption of Water -** It is mainly due to transpiration, the root cells do not play active role and remain passive.

Difference between Active and Passive Water Absorption

1	Active water absorption occurs via root hair cells	Passive water absorption occurs when transpiration rate is high.
2	Active absorption involves symplast movement of water	Passive absorption involves apoplast movement of water
3	Active absorption utilizes metabolic energy	Passive absorption utilizes solar energy for transpiration.
4	Active absorption is independent of transpiration	Passive depends upon transpiration.
5	Water is absorbed by osmotic and non osmotic process in active absorption.	Water is absorbed as a result of tension created by transpiration pull in passive absorption.

3.3. Ascent of sap (Translocation of water)

Upward conduction of water in the form of dilute solution of mineral ions (sap) from roots to aerial parts is called ascent of sap. It occurs through the tracheary element of xylem. Many theories were put forward to explain the mechanism of ascent of sap but most accepted theory is Cohesive force or transpiration pull or cohesion tension theory. (Dixon and Joly). The transpiration driven ascent of xylem sap depends mainly on the following three physical properties of water :

(i) Cohesion : Mutual attraction between water molecules.

(ii) Adhesion : Attraction of water molecules to polar surfaces (such as the surface of tracheary elements).

(iii) Surface tension : Water molecules are attracted to each other in the liquid phase more than to water in the gas phase.

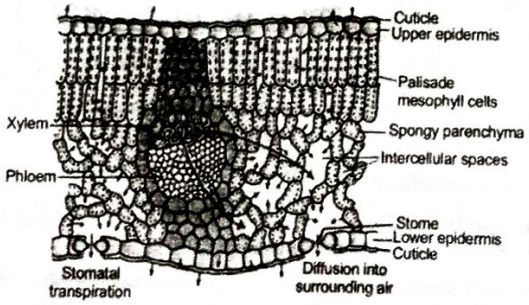


Fig. : Water movement in the leaf. Evaporation from the leaf sets up a pressure gradient between the outside air and the air space of the leaf. The gradient is transmitted into the photosynthetic cells and on the water fluid xylem in the leaf vein.

Water molecules remain attached to one another by a strong mutual force of attraction called cohesive force. On account of this force, the cohesive force is also called tensile strength. The magnitude of tensile strength of water is 10-30 PMa. Water column does not break its connection from the tracheary elements (vessels and tracheid) because of another force called adhesive force between the walls (lignocellulosic) and water molecules. Water molecules attracted to one another more than the water molecules in the gaseous state. It produces surface tension for high capillarity through tracheids and vessels.

In plants, capillarity is added by the small diameter of the tracheary elements – the tracheids and vessel elements.

Transpiration supplies water for photosynthesis. The system of xylem vessels from the root to the leaf vein can supply the needed water. As water evaporates through the stomata, since the thin film of water over the cells is continuous, it results in the development of strong negative water potential which further results pulling of water, molecules 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 pressure sufficient to lift a xylem sized column of water over 130 meters high.

3.4. Water movement up in plants

Plants absorb water from the soil and move it into the vascular tissue through apoplast or symplast pathways upto xylem. Root pressure and transpiration pull play important role in upward movement of water.

(a) Pressure present inside xylem channel of roots i.e., root pressure.

(b) Forces of transpiration (i.e., cohesion, adhesion etc.) or we can say mainly due to transpiration.

- **Root Pressure Theory**

  As various mineral ions from the soil are actively transported into the vascular tissue of the roots, water follows (its potential gradient) and increase the pressure inside the xylem. This positive pressure is called root pressure. It also refers to the positive hydrostatic pressure which can be responsible for pushing up water column to a small heights in the stem of herbaceous plants.

  The effect of root pressure is observable during early morning and at night, when transpiration is low, it decreases as the day advances. In many herbaceous plants (Tomato, Oat, Garden Nasturtium), root pressure has one more effect. When root pressure is high and transpiration is low, herbaceous plants may lose small quantities of excess water in the form of drops from the margins or tips of leaves (Guttation).

  Its greatest contribution may be to re-establish the continuous chains of water molecules in the xylem which often break under the enormous tensions created by transpiration. Root pressure does not account for the majority of water transport, most plants meet their demand by transpiratory pull. Magnitude of root pressure is 1-2 atm which can raise water up to 10-20 m height of the plant.

- **Demonstration of root pressure**

  Root pressure can be demonstrated experimentally, by choosing a small herbaceous plant. Take a well-watered and soft-stemmed herbaceous plant. On a day when there is plenty of atmospheric moisture, cut the stem horizontally near the base (approximately, 5-8 cm above the soil level) with the help of sharp blade or knife, early in the morning. Then observe drops of solution i.e., xylem sap flowing out the cut stem. This happens due to the positive root pressure. You can collect and measure the rate of exudation by fixing rubber tube to the cut stem as a sleeve. The exudates can also be collected in a glass tube, for studying its composition.

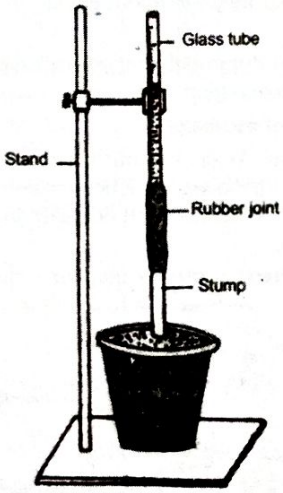


Fig. : Exudation of sap from stump to demonstrated root pressure

- **Cohesion-Tension and Transpirational Pull Theory**

  The flow of water upward through the xylem in plants can achieve fairly high rates upto 15 metres per hour. Most researchers believe that water is mainly "pulled" through the plant and the driving force for this process is transpiration from the leaves. This model which explains translocation of water by the process of transpiration, is known as cohesion-tension transpiration pull model of water transport. Water is transient in plants. Less than 1 percent of water reaching the leaves is uses in photosynthesis and plant growth. Most of it is lost through stomata in the leaves. This water loss is known as transpiration.

4. Transpiration

Transpiration is the loss of water in the form of vapours from the aerial parts of the plant. The loss of water is so great that it reduces water level in the soil and can lead to the death of plant, but transpiration is said to be necessary for water and mineral absorption, ascent of sap and lowering the temperature (cooling effect). It occurs mainly through the stomata in the leaves.

4.1. Types of transpiration

- **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.

- **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.
- **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).
- **Bark transpiration :** This occurs through the bark of woody stem. It contributes about 1% of the total transpiration
- **Structure of stomata :** Stomata are the tiny apertures found on the epidermis of leaves and young green stems. Each stoma is surrounded by two specialized epidermial cells, called guard cells. They differ from epidermial cells in their shape (kidney or bean shaped) and in the presence of chloroplasts. The inner wall of the guard cell is thick and elastic, whereas the outer wall is thin. The immediate cause of the opening or closing of the stomata is a change in the turgidity of the guard cells. when turgidity increases within the two guard cells flanking each stomatal aperture or pore, the thin outer walls bulge out and force the inner walls into a crescent shape. Opening of the stoma is also aided due to the orientation of the microfibrils in the cell walls of the guard cells. Cellulose microfibrils are oriented radially rather than longitudinally, making it easier for the stoma to open. Guard cells are bordered by one or more modified epidermal cell called subsidiary cells or accessory cells. Usually the lower surface of a dorsiventral (often dicotyledonous) leaf has a greater number of stomata while in isobilateral (often monocotyledonous) leaf they are about equal on both surfaces.

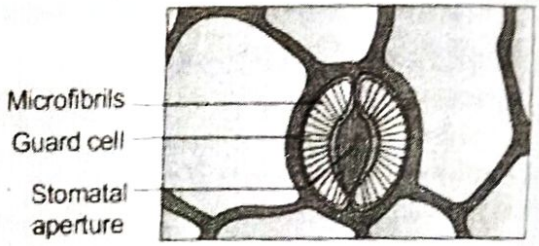


Fig. : A stomatal aperture with guard cells

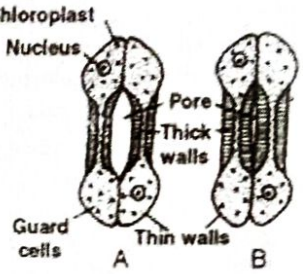


Fig. : Monocotyledonous stomata - A. Open, **B.** Closed

In monocots, guard cells are ellipsoidal or dumb-bell shaped (called graminaceous stomata or poaceous stomata). These stomata have thin end walls and thick walled middle region.

- **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 becomes flaccid and hence get closed. This increase and decrease in osmotic concentration is explained by a number of theories but most accepted one is described below.

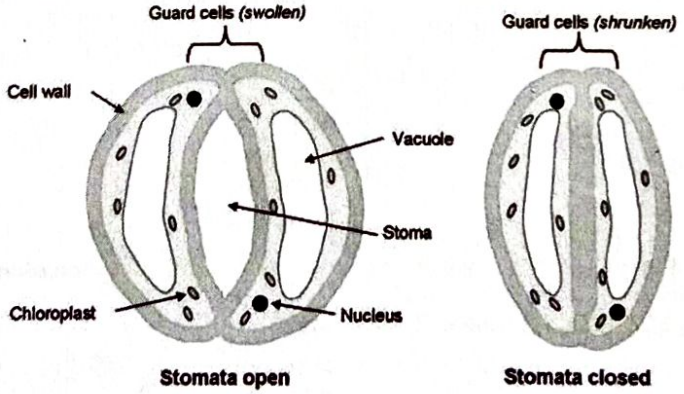


Fig. : Dicotyledonous stomata

Active K^+ transport or(Potassium pump theory) - Two Japanese scientists, S. Imamura and M. Fujino showed the accumulation of K^+ in the guard cells during stomatal opening. Later, Levitt (1974) explained the influx of K^+ ions in the guard cells and their critical role in stomatal movement.

(a) Opening of stomata in light - 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 (PEPCase). Malic acid dissociates into malate ion and protons (H^+) in the guard cells. 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. 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. The process of ion exchange requires ATP and thus, it is an active process. 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. Turgor pressure of the guard cells increases due to endomosis and the stomata gets open.

(b) **Closing of stomata in the dark** - As CO_2 is not utilized in photosynthesis during night, hence its concentration in the sub stomatal cavity increases. 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. The K^+ ions are transported back to the epidermal or subsidiary cells from the guard cells.

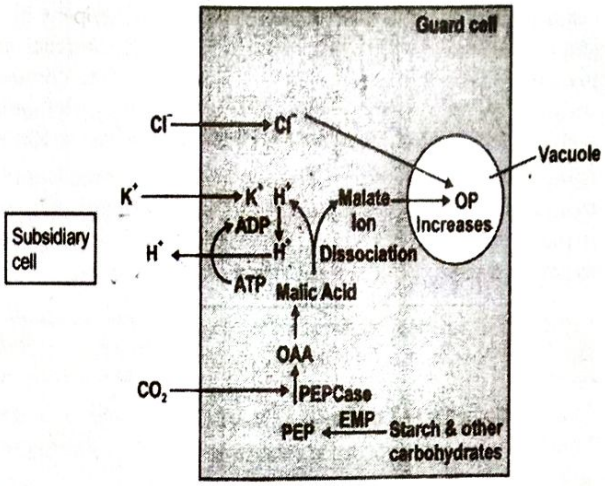


Fig.: Role of potassium, chloride and malate ions in stomatal opening

- **Factors affecting transpiration**

(A) External factors

(i) Light :. Blue and red light are effective for transpiration, constituting its action spectrum.

(ii) Relative humidity (vapour pressure gradient) : In humid atmosphere (when the relative humidity is high), the rate of transpiration decreases.

(iii) Temperature : Higher the temperature more is the rate of transpiration (higher vapour pressure gradient).

(iv) Wind : The blowing wind (slow breeze) removes the accumulated humidity and the rate of transpiration is enhanced.

(v) Available soil water : If the available water in the soil is not sufficient, the rate of transpiration is decreased.

(B) Plant factors

(i) Root-shoot ratio : low root-shoot ratio decreases the rate of transpiration or vice-versa.

(vi) Structure of leaf : Many features like thick cuticle, waxy coating, thick walled hypodermis, sunken stomata reduce the rate of transpiration.

(vii) Number and distribution : of stomata, number of stomata open, plant water status, canopy structure are other factors that affect transpiration.

- **Demonstration of transpiration**

Bell Jar Experiment : Transpiration can be easily demonstrated by placing a bell jar over a plotted plant with the pot enclosed in a plastic bag to prevent water loss from the soil. As transpiration occurs, the drops of water appears on the inside of the bell jar, the water cannot come from the outside air and not from the water present in the soil of the pot because both have been properly sealed. The water vapours can come only from the exposed aerial shoot of the plant.

Cobalt chloride paper test : Dry cobalt chloride paper of blue colour becomes pink in contact with water vapour of transpiring leaf surface.

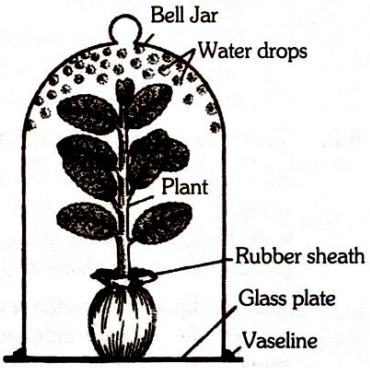


Fig. Demonstration of transpiration

- **Significance of Transpiration :**

(a) Creates or exerts transpiration pull for absorption and transport in plants.

(b) Supplies water needed for photosynthesis.

(c) Transports minerals along with water from the soil to various parts of the plant.

(d) Cools leaf surfaces, sometime it can lower plant body temperature upto 10 to 15 degrees.

(e) Also helps in maintaining the shape and structure of the plants by keeping their cells in turgid condition.

- **Transpiration and photosynthesis – a compromise**

An actively photosynthesizing plant requires good quantity of water and minerals. Transpiration creates a pull for absorption and translocation of water as well as minerals. Photosynthesis rate is limited by available amount of water which is swiftly depleted by transpiration. It is found in rain forests where humidity in air is kept high due to cycling of water from root to leaf and then to atmosphere, which is again put back to the soil. Transpiration and photosynthesis occur simultaneously due to opening of stomata which leads to gaseous exchange but water vapour also escapes from it side by side.

The evolution of the C_4 photosynthetic system in plants is probably one of the strategies for maximising the availability of CO_2 while minimising water loss. Such C_4 plants (like sugarcane, maize, etc.) use water more efficiently as compared to C_3 plants (e.g. rice, wheat). C_4 plants lose only half as much of water as C_3 plant for the same amount of CO_2 fixed. Hence, they are better adapted to live in hot arid habitats (e.g., deserts grasslands).The C_4 plants are twice more efficient as C_3 plants in terms of fixing carbon (making sugar). The CO_2 fixation in C_4 plants takes place by a different pathway than C_3 plants, due to peculiar leaf anatomy (Kranz anatomy).

5. Guttation

Guttation is the exudation of drops of xylem sap on the tips or edges of leaves of some vascular plants, such as grasses. Such lost water contains several dissolved inorganic and organic substances. Guttation is not to be confused with dew, which condenses from the

atmosphere onto the plant surface. Guttation happens in certain plants that have vascular systems, such as grass, wheat, barley, tomatoes, strawberries and other small plants. Since guttation relies on pressure, this happens due to the development of positive pressure in the xylem present at the vein endings, which forces liquid to come out through these special openings i.e. hydathodes. This is due to the high root pressure as the result of active or more absorption of water at night or early mornings and low transpiration rate. It cannot occur in large plants, such as trees, because the pressure required to force the water out is too large.

Guttation happens at night when the soil is very moist and the roots absorb water. If there is too much water, root pressure causes the water to squeeze out of the plant and onto the tips of the leaves or the blades of the plant. As water from soil passes through the guttation process, it picks up minerals, enzymes and other chemicals and is called xylem sap. Guttation generally occurs at night and early hours of the morning.

6. Uptake and Transport of Mineral Nutrients

Plants obtain mineral elements from atmosphere, soil and water. They obtain carbon from CO_2. They also obtain oxygen from outside. Hydrogen for carbon fixation is made available by water and the remaining minerals are obtained from soil.

6.1. Uptake of Mineral Ions

Unlike water, all minerals cannot be passively absorbed by the roots. It is so because of following facts:

- Minerals are present in the soil as charged ions which cannot move across the cell membranes.
- The concentration of minerals in the soil is usually lower than the concentration of minerals in the root. So, all minerals cannot be absorbed passively by roots.

Due to above reasons, most minerals enter the root by active absorption into the cytoplasm of epidermal cells. This movement of ions from soil to interior of root is against concentration gradient and require energy. The active uptake of ions is partly responsible for water potential gradient in roots and therefore helps in uptake of water by osmosis. Some ions can be absorbed passively into the epidermal cells of roots by mass flow and diffusion.

Hence, ions are absorbed from the soil by both passive and active transport. Passive transport occurs through mass flow or bulk flow system and diffusion while active transport takes place due to the presence of specific proteins in the membrane of root hair cells. these specific proteins actively pump ions from the soil into the cytoplasms of the epidermal cells of root hairs. Energy is provided by ATP.

Like all cells, the endodermal cells have many transport proteins in their plasma membrane, they let some solute to cross the membrane but restrict others. Transport proteins of endodermal cells are control proteins, where plants can adjust the quantity and type of solutes that reach the xylem, according to its variable requirement.

6.2. Translocation of mineral ions

After the ions have reached xylem vessels through active or passive absorption or combination of the two, they are further transported upwards to the stem and all the stem and all other parts of plant through the transpiration stream. This allows movement of minerals from their conducting tissue towards the area of their sink. The chief sinks for the mineral elements are the growing regions of the plants such as the apical and lateral meristems, young leaves developing flowers, fruits and seeds and the storage organs.

Minerals flow towards these areas and the unloaded at fine vein endings through diffusion. They are picked up by cells through active uptake. The mineral ions are frequently remobilised inside the plant particularly from their older senescing parts to younger growing parts.

The older falling or dying leaves, export much of their minerals to younger leaves and other parts. Elements most readily mobilised are phosphorus, nitrogen and potassium. Only those elements incorporated in structural components are not remobilised e.g.,. calcium. The remobilised minerals become available to young growing leaves an other sinks.

Though it is generally believed that xylem transports only inorganic nutrients while phloem transports only organic material, is not exactly true. As per recent analysis, it is revealed that in xylem sap, some of the nitrogen travels as inorganic ions, much of it is carried in the organic form as amino acids and related compounds. Similarly, small amounts of phosphorous and sulphur are carried as organic compounds. Not only this, small amount of exchange of material takes place between xylem and phloem. Therefore, mineral elements are translocated through xylem in both inorganic and organic form.

7. Phloem Transport : Flow From Source To Sink

Long distance movement of organic substances from the source or supply end (region of manufacture of leaf) to the region of utilization or storage or sink. But the source and sink may be reversed depending on the season or need of the plants.
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 and require energy for their growth and development. Since the source-sink relationship is variable the direction of movement of organic solutes in phloem can be upwards or downwards i.e., bi-directional. It is in contrast to unidirectional movement of water in the xylem. phloem sap is mainly water and non-reducing sugar like sucrose, other sugars, hormones and amino acids are also translocated through phloem.

7.1. The pressure flow or mass flow hypothesis

In plants, the most accepted mechanism used for the translocation of sugars from source to sink; is called the pressure flow hypothesis (proposed by E. Munch and elaborated by Grafts). According to mass flow or pressure flow hypothesis, organic substances (i.e., sucrose) flow in solution in sieve elements (phloem) due to development of an osmotically generated pressure gradient between source and sink ends.

In plants, the mesophyll cells of leaves synthesise carbohydrates (i.e., glucose) by process of photosynthesis. This glucose is readily converted into sucrose (a disaccharide sugar). Mesophyll cells are only few cells away from sieve tube elements.

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

Phloem contains sieve tube cells which form long columns with their end walls called sieve plats. Cytoplasmic strands pass through holes in the sieve plates, so forming continuous filaments. That assists in flow of phloem sap from one element to the next.

As hydrostatic pressure in phloem sieve tube increases, pressure flow begins, and the sap moves through the phloem. Meanwhile, at the sink, incoming sugars are actively transported out of the phloem and removed as complex carbohydrates (like starch, cellulose, etc.).

This loss of sucrose and other sugars from phloem sap, produces a high water potential in it. As a consequence water moves out of the phloem cells, returning eventually to xylem.

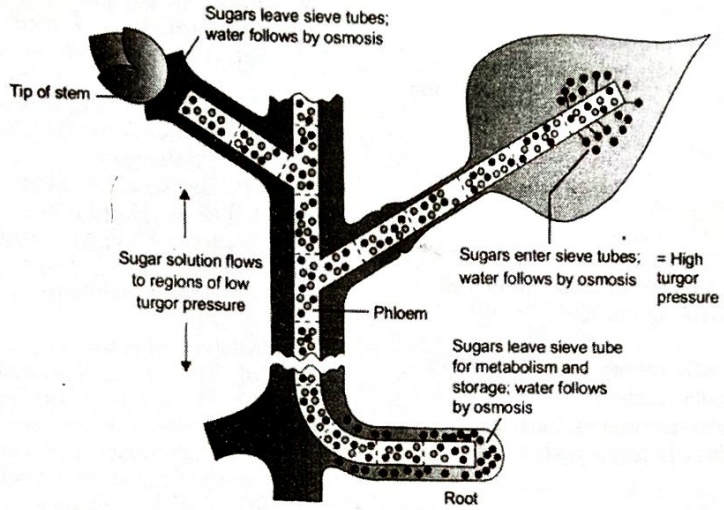


Fig. : Diagrammatic representation of mechanism of translocation

- **Demonstration of translocation of food by phloem by Girdling experiment**

This experiment was conducted by Malpighi, to demonstrate the pathway of translocation of organic nutrient and also to identify tissue involved in it. In this experiment, following steps are involved :

On the trunk of a tree, a ring of bark upto a depth of the phloem layer is carefully removed. This narrow ring of bark consists of phloem, cortex and cork. After a few weeks, the bark above the ring on the stem swells. The leaves do not wilt but growth below the ring was reduced.

This swelling of bark above the ring was due to the accumulation of nutrients in that region. As the translocation of sugars and other materials down the plant was stopped whereas the upward movement of water was not affected. This experiment proves that phloem is the responsible tissue for translocation of food in one direction, i.e., towards the roots.

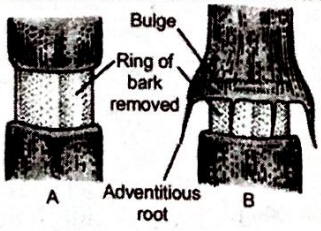


Fig. : Girdling of tree trunk to show that organic nutrients accumulate in the bark above the girdle where a bulge is also produced

11. Transport In Plants – Multiple Choice Questions

1. General

1. Good soil is
   (a) Which holds the whole of the water that enters into it
   (b) Which allows percolating the water slowly from it
   (c) Which allows water to pass very quickly from it
   (d) Which allows a limited amount of water to retain into it
2. Soil formed after leaching and rich in *Al* and *Fe* is
   (a) Alluvial (b) Podosol
   (c) Laterite (d) None of these
3. When a bark of tissue is cut from the stem, which of the vascular tissue is removed
   (a) Xylem (b) Phloem
   (c) Parenchyma (d) None of these
4. Attractive forces of cell walls for water molecules is termed as
   (a) Adhesion (b) Cohesion
   (c) Osmosis (d) Plasmolysis
5. Which of the following is not a function of water in the cell
   (a) It provides energy for a chemical reaction
   (b) It acts as a solvent
   (c) It provides a medium for chemical reaction
   (d) It releases hydrogen ions on ionization
6. Root cap has no function in water absorption, because
   (a) Its vascular system is not directly connected
   (b) Its cells are loosely placed
   (c) It has cells without chloroplast
   (d) It has no root hair
7. The amount of water held by the soil after drainage is known as
   (a) Mineral water (b) Soil water
   (c) Field capacity (d) Gravitational capacity
8. The lower surface of the leaf will have number of stomata in an
   (a) Dorsiventral leaf (b) Isobilateral leaf
   (c) Both a and b (d) None of the above
9. Purple cabbage leaves do not lose their color in cold water but do so in boiling water because
   (a) Plasma membrane get inactivated in boiling water
   (b) Hot water can enter the cells readily
   (c) The pigment is not soluble in cold water
   (d) The cell wall is killed in boiling water
10. Exchange of substances between individual cells and their environments takes place by
    (a) Osmosis (b) Diffusion
    (c) Active transport (d) All of these
11. Lenticels and hydathodes are small pores with the following common attributes
    (a) Their opening and closing is not regulated
    (b) They allow the exchange of gases
    (c) They always remain closed
    (d) They are found on the same organ of plants
12. Water infiltration will be slowest in
    (a) Black cotton soil (b) Sandy soil
    (c) Red soil (d) Loamy Soil
13. Mark the mismatched pair

(a)	Amyloplast	(i)	Store protein granule
(b)	Elaioplast	(ii)	Store oils or fats
(c)	Chloroplasts	(iii)	Contain chlorophyll pigments
(d)	Chromplasts	(iv)	Contain colored pigments other than chlorophyll
(e)	Leucoplast	(v)	Contains colorless pigments

2. Membranes, Osmosis, Diffusion, Imbibition, Plasmolysis and Wilting

1. If a cell is reduced in size by placing in a solution of sugar, the solution is
   (a) Hypertonic (b) Hypotonic
   (c) Isotonic (d) Saturated
2. Which of the following experiment is called a physiological demonstration of osmosis
   (a) Thistle funnel – whose mouth is tied with egg membrane
   (b) Thistle funnel – whose mouth is tied with parchment paper
   (c) Photometer
   (d) Bell jar experiment
3. A cell is plasmolyzed after being kept in a hypertonic solution. What will be present between the cell wall and plasmalemma
   (a) Isotonic solution (b) Hypertonic solution
   (c) Air (d) Hypotonic solution
4. Wilting occurs when
   (a) The rate of transpiration is higher than absorption
   (b) The rate of absorption is higher than transpiration
   (c) Excess root pressure
   (d) High relative humidity in the air
5. Which of the following statement is correct
   (a) The plant absorbs an excess quantity of water
   (b) Plants take in a small number of mineral salts through soil water
   (c) Water and inorganic salt are taken in simultaneously by root hairs
   (d) Plant absorb only one thing at a time water or inorganic salts
6. A plasmolyzed cell can be deplasmolyzed by placing it in
   (a) Isotonic solution
   (b) Hypertonic solution
   (c) Saturated solution
   (d) Pure water or hypotonic solution
7. The membrane which allows passage of certain substances more readily than others is termed as
   (a) Impermeable (b) Semisolid
   (c) Permeable (d) Selectively permeable
8. What would happen if a thin slice of sugar beet is kept in *NaCl*
   (a) It should lose water from the cell
   (b) It should become turgid
   (c) It should neither absorbed water nor lose it
   (d) It should absorb water from the soil solution
9. The plant undergoes wilting when
   (a) Xylem is blocked
   (b) Cambium is blocked
   (c) Phloem is blocked
   (d) Some roots are reduced in number
10. During osmosis, water moves through a membrane

	From	To
(a)	Low water potential	High water potential
(b)	High solute concentration	Low solute concentration
(c)	High osmotic potential	Low osmotic potential
(d)	A hypotonic solution (less solute)	A hypertonic solution (more solute)

11. Percentage of water left in the soil when a plant wilts, is known as
    (a) Turgidity
    (b) Field capacity
    (c) Water retaining power of the soil
    (d) Wilting coefficient

12. Movement of molecules of gases, liquids, and solids from a region of higher concentration to a region of lower concentration is termed as
(a) Diffusion (b) Evaporation
(c) Transpiration (d) Osmosis

13. In the process of osmosis, the volume of solvent
(a) Increases
(b) Decreases
(c) Remains same
(d) Volume is not related to osmosis

14. Which plant is used for demonstrating plasmolysis in the laboratory
(a) *Tropaeolum* (b) *Impatience balsamic*
(c) *Tradescantia* (d) All the above

15. In the process of osmosis
(a) Both protoplasm and cell wall act as a single layer
(b) The only protoplast acts as a single layer
(c) Only cell membrane acts as a single layer
(d) None of the above

16. Which of the following statements does not apply to reverse osmosis
(a) It is used for water purification
(b) In this technique, a pressure greater than osmotic pressure is applied to the system
(c) It is a passive process
(d) It is an active process

17. A cell when dipped in 0.5 *M* sucrose solution has no effect but when the same cell will be dipped in 0.5 *M NaCl* solution the cell will
(a) Increase in size (b) Decrease in size
(c) Will be turgid (d) Will get plasmolyzed

18. Imbibition process involves
(a) Both diffusion and capillary action
(b) Only diffusion
(c) Only capillary action
(d) None of the above

19. Osmosis is the diffusion of
(a) Solute (b) Free energy
(c) Water (d) Solute and solvent

20. Living cells placed in isotonic solution (0.9% saline) retain their size and shape. This is based on the concept of
(a) Osmosis (b) Diffusion
(c) Facilitated diffusion (d) Transpiration

21. Assume that an actively respiring cell has 3x number of K^+ in its cytoplasm and 2x number of K^+ outside. After some time, x number of K^+ entered into the cell. What is the process by which K^+ transport has taken place
(a) Primary active transport
(b) Secondary active transport
(c) Diffusion
(d) Passive transport

22. The first process by which water enters into the seed coat when a seed is placed in the suitable environment for germination is

Or

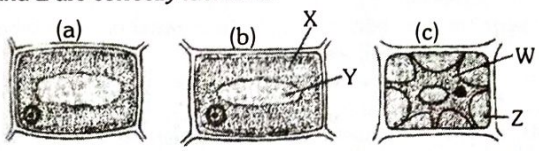
In seed germination, the first phenomenon takes place is
(a) Osmosis (b) Active transport
(c) Absorption (d) Imbibition

23. Force developed in the cortex of root which pushes water into xylem of root from soil
(a) Diffusion (b) Osmotic pressure
(c) Turgor pressure (d) Root pressure

24. Osmosis is defined as the process by which
(a) Water diffuses from lower concentration to higher concentration
(b) Solvent diffuse from lower concentration to higher concentration
(c) Active transport of ions takes place
(d) Passive transport of ions takes place

25. Why osmosis cannot be demonstrated by a potato osmoscope using a solution of *NaCl* instead of sugar; because the potato tissue is
(a) Permeable to *Na* ion
(b) Permeable to *Cl* ion
(c) Permeable to the salt solution
(d) Impermeable to the salt solution

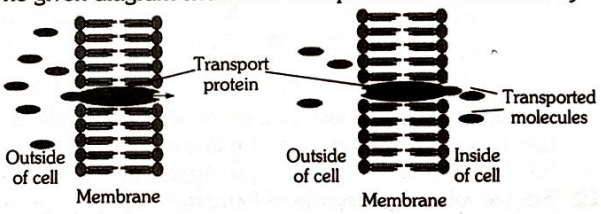
26. The given figure shows plasmolysis in the cell. A is a normal turgid cell, B shows incipient plasmolysis and C is plasmolyzed cell. Select the right option in which W, X, Y, and Z are correctly identified



(a) Shrunken protoplast, Protoplast, Vacuole, Hypotonic solution
(b) Shrunken protoplast, flaccid protoplast, Vacuole, External solution
(c) Turgid protoplast, Protoplast, Vacuole, External solution
(d) Shrunken protoplast, Protoplast, Vacuole, External solution

27. Which of the following is an example of imbibition
(a) Uptake of water by root hair
(b) Exchange of gases in stomata
(c) Swelling of seed when put in the soil
(d) Opening of stomata

28. The given diagram shows the transportation of materials by



(a) Secondary active transport
(b) Primary active transport
(c) Facilitated diffusion
(d) Simple diffusion

3. O.P., T.P., I.P., D.P.D and Water potential

1. DPD is equal to
(a) OP × TP (b) OP + TP
(c) OP – TP (d) TP – OP

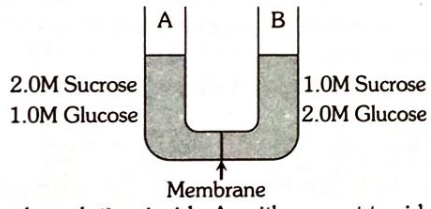
2. When a cell is fully turgid which of the following will be zero
(a) Turgor pressure (b) Wall pressure
(c) Suction pressure (d) Osmotic pressure

3. In a fully turgid cells, the values of DPD, OP and TP will show the tendency
(a) DPD = 10 atm, OP = 15 atm, TP = 5 atm
(b) DPD = 5 atm, OP = 12 atm, TP = 7 atm
(c) DPD = 2 atm, OP = 7 atm, TP = 5 atm
(d) DPD = 0 atm, OP = 15 atm, TP = 15 atm

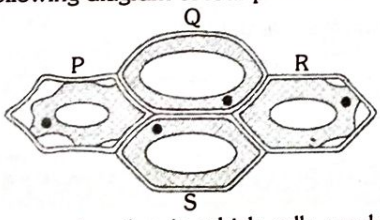
4. In hypertonic solution a cell water potential
(a) Decreases
(b) Increases
(c) First increases then decrease
(d) No change

5. If water enters in a cell, the pressure exerted by its swollen protoplast is
(a) Turgor pressure (b) DPD
(c) Osmotic pressure (d) Imbibition

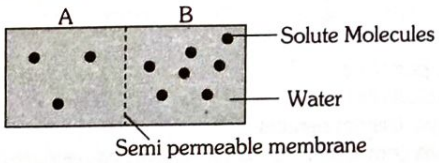
6. When an osmotic potential is either zero or negative and pressure potential is positive, then the water potential will be
   (a) Negative
   (b) Positive
   (c) Sometimes negative and sometimes positive
   (d) None of the above
7. What will be the effect of the accumulation of K^+ *ions* in guard cells
   (a) Water potential increases
   (b) Water potential decreases
   (c) Loss of turgidity
   (d) Exosmosis
8. Turgor pressure becomes equal to the wall pressure when
   (a) Water leaves the cell
   (b) No exchange of water takes place
   (c) Water enters the cell
   (d) Solute goes from the cell into water
9. What will be the direction of movement of water, when a solution A having water potential of - 9 bars and another solution B of - 4 bars are separated by a semipermeable membrane
   (a) B to A (b) A to B
   (c) Both directions (d) None of these
10. A 0.1*M* solution of a solute has a water potential of
   (a) –2.3 bars (b) 0 bar
   (c) 22.4 bars (d) + 2.3 bars
11. See the following diagram



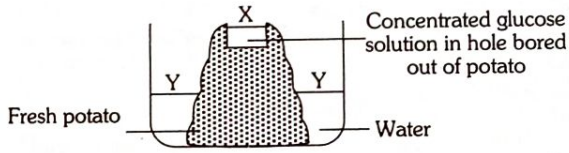
Initially, the solution inside A, with respect to side B, is
   (a) Lower (b) Isotonic
   (c) Hypertonic (d) Hypotonic
12. See the following diagram of four plant cells



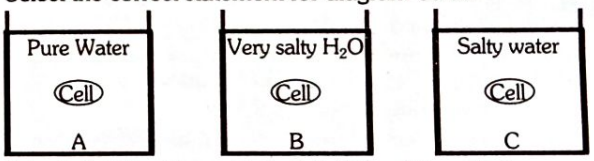
Select the correct option in which cells would not exit wall pressure
   (a) R and S (b) P and R
   (c) Q and S (d) P and Q
13. Addition of solute in the cell develops
   (a) TP (b) OP
   (c) DP (d) WP
14. The actual pressure with which water enters into the cell is called
   (a) DPD (b) OP
   (c) WP (d) Diffusion
15. Which one of the following statements is wrong
   (a) Water potential is the chemical potential of the water
   (b) The solute potential is always negative
   (c) Pressure potential is zero in a flaccid cell
   (d) Water potential equals solute potential in a fully turgid cell
   (e) Pressure potential is negative in a plasmolyzed cell
16. Identify the correct relationship with reference to the water potential of a plant cell.
   (a) $\psi_w = \psi_m + \psi_s + \psi_p$ (b) $\psi_w = \psi_m + (\psi_s - \psi_p)$
   (c) $\psi_w = \psi_m - (\psi_s + \psi_p)$ (d) $\psi_w = \psi_m - \psi_s - \psi_p$
17. Which statement is correct
   (a) The osmotic pressure of the solution is greater than the pure solvent
   (b) The osmotic pressure of the solution is lower than the pure water
   (c) The osmotic pressure of the solution is equal
   (d) None of these
18. See the following figure and point out the statement which is not correct



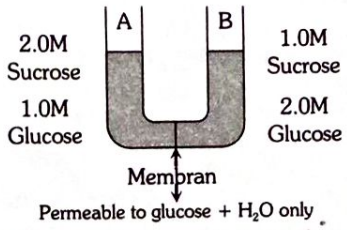
   (a) The direction and the rate of osmosis depend upon both the pressure gradient and conc. gradient
   (b) Presence of an SPM is a prerequisite for this process to occur
   (c) Movement of solute will take place from chamber A to B
   (d) Movement of solvent molecules will take place from chamber A to B
19. Observe the following experiment



After a few days, this of the following changes will have occurred
   (a) A drop in level X and a rise in level Y
   (b) A rise in level X and a rise in level Y
   (c) A drop in level X and a drop in level Y
   (d) A rise in level X and a drop in level Y
20. Select the correct statement for diagram below

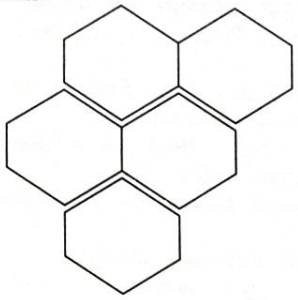


   (a) Cell "A" will gainH_2O, Cell "B" will lose H_2O
   (b) Cell "A" will gain H_2O, Cell "B" neither gains nor loses H_2O, Cell "C" will lose H_2O
   (c) Cell "A" neither gain nor loses H_2O, Cell "B" will lose H_2O, Cell "C" will gain H_2O
   (d) Cell "A" will lose H_2O; Cell "B" will gain H_2O, Cell "C" neither gains nor loses H_2O
21. Observe the following figure



After the system reaches equilibrium, this of the following changes will have occurred
   (a) First, the level of water is high in tube A and then water level is decreased
   (b) No change is observed
   (c) The water level is higher inside B than inside A
   (d) The water level is higher inside A than inside B

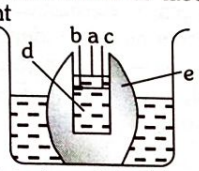
22. See the following diagram, when the TP of the cell B increases to 18. What changes would occur with regard to water movement



(a) No movement of water will occur
(b) B actively absorb water from the neighbor cell
(c) Water diffuses into B from the outer cell
(d) Cells A, C, D and E absorb water from B

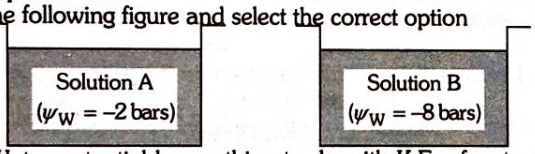
23. Water potential of pure water at standard temperature is equal to
(a) 10 (b) 20
(c) Zero (d) None of the above

24. Choose the correct combination of labeling of the potato osmoscope experiment



(a) a final level, b-dot pin, c-initial level, d-sugar solution, e-potato tuber
(b) a-initial level, b-dot pin, c-final level, d-water, e-potato tuber
(c) a final level, b-dot pin, c-initial level, d-water, e-potato tuber
(d) a final level, b-dot pin, c-final level, d-water, e-container
(e) a-initial level, b-dot pin, c-final level, d-coconut oil, e-potato tuber

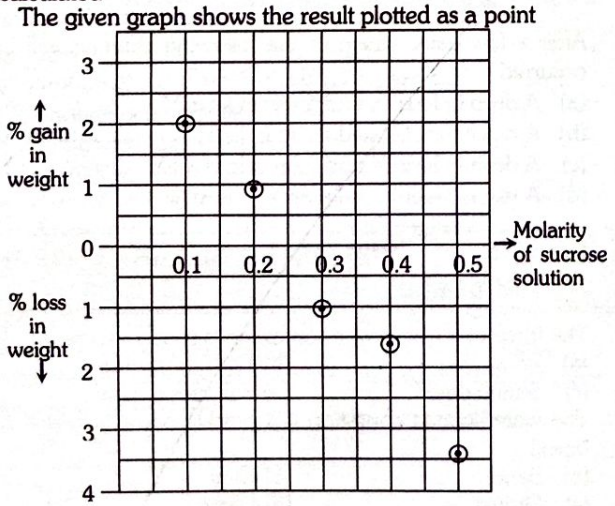
25. See the following figure and select the correct option



(a) Water potential has nothing to do with K.E. of water in a solution
(b) K.E. of water in A solution = K.E. of H_2O in B solution
(c) K.E. of water in B solution > K.E. of water in A solution
(d) Kinetic energy (K.E.) of H_2O in A solution> K.E. of water in B solution

26. The experiment given below shows groups of potato disc was weighed and then each group was immersed in one of a series of sucrose solutions. After two hours each group was reweighed and its percentage gain or loss in weight was calculated

The given graph shows the result plotted as a point



27. From these results, it can be concluded that the water concentration of potato cell sap is approximately equivalent to that of a sucrose solution of Molarity
(a) 0.50 (b) 0.35
(c) 0.25 (d) 0.10

4. Absorption of water and Ascent of sap

1. The factor or process which best explains the rise of water from roots (100 *pts*) to the top of the tall tree is
(a) Break down of ATP
(b) Root pressure
(c) Capillary rise of water in xylem
(d) Cohesion of water and transpiration pull

2. Water will be absorbed by root hairs when
(a) The concentration of salt in the soil is high
(b) The concentration of solutes in the cell sap is high
(c) The plant is rapidly respiring
(d) They are separated from soil by a permeable membrane

3. Sap ascends in woody stems because of root pressure and
(a) Transpiration pull (b) Capillarity
(c) Molecular adhesion (d) Photosynthesis

4. When the concentration of the soil solutes is low, the absorption of water
(a) Remains normal (b) Is stopped
(c) Is increased (d) Is decreased

5. During the absorption of water by roots, the water potential of cell sap is lower than that of
(a) Pure water and soil solution
(b) Neither pure water nor soil solution
(c) Pure water but higher than that of soil solution
(d) Soil solution but higher than that of pure water

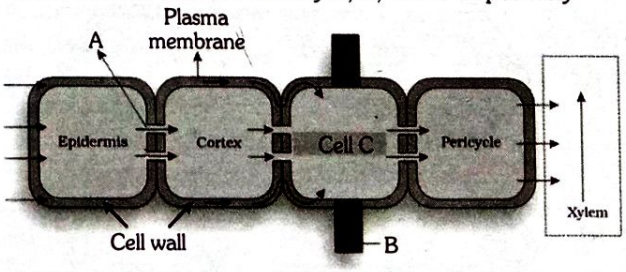
6. Active transport is characterized by
(a) Requires special membrane proteins
(b) Highly selective
(c) Requires ATP energy
(d) All of the above

7. The ascent of sap is due to which force
(a) Imbibition (b) Cellular force
(c) Cohesive force (d) Atmospheric pressure

8. Na^+, K^+ dependent ATPase activity helps in the transport of
(a) K^+ inward, Na^+ outward (b) K^+ inward only
(c) Na^+ inward only (d) K^+ outward, Na^+ inward

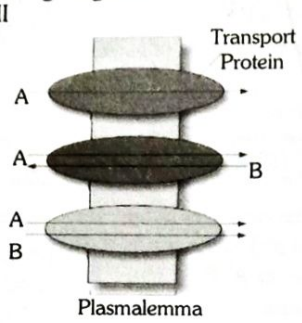
9. Most water absorption in plants takes place through
(a) Root cap (b) Root apex
(c) Root hair zone (d) Meristematic zone

10. The following diagram represents the pathway of water movement in the root. Identify A, B, and C respectively



(a) Plasmodesmata, Casparian strip, Endodermis
(b) Tight junction, Casparian strip, Endodermis
(c) Gap junction, Casparian strip, Endodermis
(d) Desmosome, Casparian strip, Endodermis

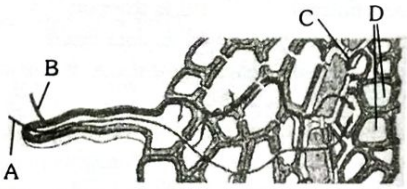
11. See the following diagram and identify the process occurring in I, II and III



	I	II	III
(a)	Uniport	Antiport	Symport
(b)	Symport	Co port	Antiport
(c)	Antiport	Uniport	Symport
(d)	Co port	Symport	Antiport

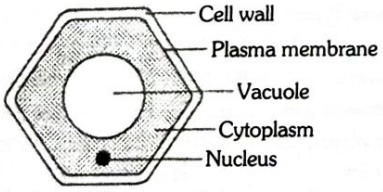
12. The continuous excretion of watery substance from the stump of a well-watered pot plant after cutting off the shoot slightly above the base is due to
(a) Root pressure (b) Guttation
(c) Transpiration (d) Imbibition

13. The given diagram indicates routes of transport of water and minerals from the soil through the root. Identify letters A, B, C and D

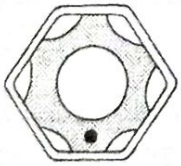
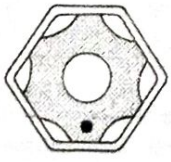
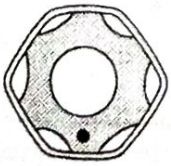


(a) A - Apoplastic, B - Symplastic, C - Cellulosic strip, D - Xylem vessels
(b) A - Symplastic, B - Apoplastic, C - Cellulosic strip, D - phloem vessels
(c) A - Apoplastic, B - Symplastic, C - Casparian strip, D - Xylem vessels
(d) A - Symplastic, B - Apoplastic, C - Casparian strip, D - Xylem vessels

14. The given diagram shows the appearance of plant cell immersed in a solution which is isotonic to the cell's sap



Which of the following diagrams shown below most accurately represents the appearance of this cell after immersion in a hypertonic solution

(a) 
(b) 
(c) 
(d) 

15. Upward movement of water in plants is called
(a) Sucking (b) Ascent of sap
(c) Translocation (d) None of these

16. The path of water from the soil up to secondary xylem is
(a) Soil → Root hair cell wall → Cortex → Endodermis → Pericycle → Protoxylem → Metaxylem
(b) Metaxylem → Protoxylem → Cortex → Soil → Root hair
(c) Cortex → Root hair → Endodermis → Pericycle → Protoxylem → Metaxylem
(d) Pericycle → Soil → Root hair → Cortex → Endodermis → Protoxylem → Metaxylem

17. Most of the water flow in the root takes place *via* the apoplast because
(a) Cortical cells are loosely arranged
(b) Cortical cells are living cells
(c) Cortical cells are thin-walled cells
(d) All of the above

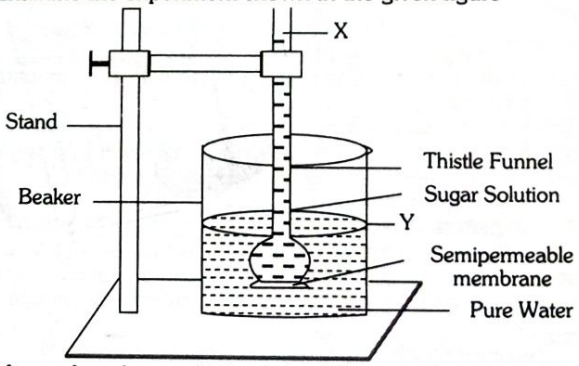
18. Which of the following statements is/are true
A. The apoplastic movement of water occurs exclusively through the cell wall without crossing any membranes
B. Solutes present in a cell (or in any solution) increase the free energy of water or water potential
C. The symplastic movement occurs from cell to cell through the plasmodesmata
D. Membrane permeability depends on the membrane composition, as well as the chemical nature of the solute
(a) A and B only (b) B and D only
(c) A, C and D only (d) A, B and D only
(e) C only

19. Movement of H_2O through cell wall is called
(a) Apoplast (b) Symplast
(c) Tonoplast (d) None of these

20. Simultaneous movement of two molecules across a membrane in the same direction is known as
(a) Antiport (b) Symport
(c) Uniport (d) Biport

21. Most accepted theory for the ascent of sap is
(a) Capillarity theory (b) Root pressure theory
(c) Pulsation theory (d) Transpiration pull

22. Examine the experiment shown in the given figure



After a few days, which of the following changes will have occurred
(a) A drop in level X and a rise in level Y
(b) A rise in level X and a rise in level Y
(c) A drop in level X and a drop in level Y
(d) A rise in level X and a drop in level Y

5. Factors affecting absorption of water and Ascent of sap

1. The force of tension cohesion exceeds root pressure on
(a) Rainy day (b) Foggy morning
(c) Sunny day (d) Full moon night

2. The water-logged condition will quickly occur in which type of soil
(a) Sand (b) Clay
(c) Gravel (d) Loam

3. When a potted plant is flooded with water, the magnitude of root pressure
   (a) Increases (b) Decreases
   (c) Remains unchanged (d) Becomes negative
4. At mid day hours, the xylem sap is in a state of
   (a) Compression (b) Tension
   (c) Relaxation (d) Adhesion
5. A suitable temperature for active absorption of water by root is
   (a) 40-45° C
   (b) 10-15° C
   (c) 20-35° C
   (d) Can take at any temperature

6. Transpiration (General) and Stomata

1. The number of stomata and epidermal cells in 1 mm^2 leaf area of the lower epidermis of the leaves of X, Y and Z plants is given below. Arrange the plants in decreasing order of their stomatal index.

Cell	Numbers of Stomata	Numbers of epidermal cells
X	30	150
Y	60	240
Z	90	400

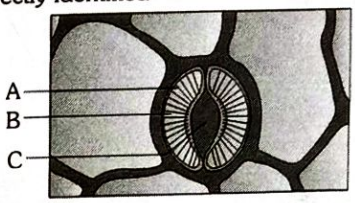
The correct answer is
   (a) X, Y, Z (b) Y, Z, X
   (c) Z, Y, X (d) Y, X, Z
2. The chief role of transpiration in plants is to cause
   (a) Loss of surplus water (b) Cooling of the plant
   (c) Rapid ascent of sap (d) Rapid rise of minerals
3. In hot summer day, plant cooling is due to
   (a) Loss of water vapors from leaf
   (b) Transport of water in the plant
   (c) Loss of liquid water
   (d) Loss of water from the entire plant
4. Out of the following, which one is the most common type of transpiration
   (a) Foliar (b) Stomatal
   (c) Lenticular (d) Cuticular
5. Photoactive stomata are character of which plants
   (a) Heliophytes (b) Xerophytes
   (c) CAM Plants (d) All of these
6. In which type of plants, the stomata remain closed during daytime and open during the night
   (a) Photophilous (b) Succulents
   (c) Sciphilous (d) Halophytes
7. Sunken stomata are adaptations of which category of plants
   (a) Hydrophytes (b) Sciophytes
   (c) Xerophytes (d) Halophytes
8. Which of the following plant is able to show rolling of the leaf during mid of the day
   (a) *Nerium* (b) *Melia*
   (c) *Amophila* (d) All the above
9. In Vallisneria, stomata are
   (a) Present on upper epidermis of the leaf
   (b) Present on lower epidermis of the leaf
   (c) Present on both the epidermis of the leaf
   (d) Not present
10. The number of stomata present per cm^2 of leaf is
   (a) Less than 100 (b) 1000 to 60000
   (c) One million (d) None of the above
11. When strips of chloride papers are placed on either side of a dorsiventral leaf, why the strips on the lower side become speedily pink. Because
   (a) More CO_2 is evolved from the lower side
   (b) More O_2 is evolved from the lower side
   (c) More H_2O is lost from the lower side
   (d) All the above
12. Which of the following wall of guard cells is thick
   (a) Outer (b) Inner
   (c) Side wall (d) All the three
13. Maximum transpiration occurs in
   (a) Mesophytic plants (b) Hydrophytic plants
   (c) Xerophytic plants (d) Algal cells
14. Which of the following 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 plants
   (d) Cools leaf surfaces
   (e) Transports minerals from the soil to all parts of the plant
15. In which of the following the rate of transpiration is high
   (a) CAM plants (b) C_3 plants
   (c) C_3 and C_4 plants (d) C_4 plants
16. Force generated by transpiration can create pressure sufficient to lift water even up to the height of
   (a) 130 feet (b) 130 metre
   (c) 230 feet (d) 230 metre
17. Transpiration is mainly a process of
   (a) Osmotic pressure (b) Imbibition
   (c) Diffusion (d) Respiration
18. Transpiration facilitates
   (a) Electrolyte balance
   (b) Opening of stomata
   (c) Absorption of water by roots
   (d) Excretion of minerals
19. Transpiration ratio is the ratio of moles of H_2O transpired/moles of CO_2 fixed. This ratio is a measure of
   (a) The efficiency of guard cells on stomatal movement
   (b) The effectiveness of stomata is maximizing photosynthesis while minimizing water loss
   (c) Distinguishing a xerophyte from a glycophyte
   (d) Stomatal pore size of the leaves
20. A small mesophytic twig with green leaves is dipped into water in a big beaker under sunlight. It demonstrates
   (a) Photosynthesis (b) Respiration
   (c) Transpiration (d) None of the above
21. In most of the thin leaf mesophytes, the leaf stomata open during the day and close during the night. It comes under
   (a) Barley type (b) Potato type
   (c) Alfalfa type (d) Bean type
22. The following percentage of water absorbed by herbaceous plants is lost in transpiration
   (a) 80 (b) 60
   (c) 90 (d) 40
23. Sunken stomata are found in leaves of
   (a) Trifolium (b) Lemna
   (c) Nerium (d) Lilium
24. Stomata is absent in
   (a) Submerged plants (b) Desert plants
   (c) Floating plants (d) All the above
25. Stomata in angiosperms do not open during
   (a) Noon (b) Twilight
   (c) 11 O'clock (d) At midnight
26. Root pressure is maximum when
   (a) Transpiration is high and absorption is very low
   (b) Transpiration is very low and absorption is high
   (c) Transpiration is very high and absorption is also high
   (d) Transpiration and absorption both are slow

7. The Factors affecting transpiration

1. Which of the following is produced during water stress and causes closure of stomata
   (a) Cytokinin (b) Auxin
   (c) GA_3 (d) ABA
2. Which one of the following will reduce the rate of transpiration
   (a) Increase in wind velocity
   (b) Rise in temperature
   (c) Increase in water uptake by plants
   (d) The decrease in light intensity
3. The conditions under which transpiration would be most rapid
   (a) High humidity
   (b) Excess of water in the soil
   (c) Low humidity, high temperature, guard cells are turgid (open) and moist soil
   (d) Low velocity of the wind
4. Which would do maximum harm to a tree
   (a) Loss of half of its branches
   (b) Loss of all of its leaves
   (c) Loss of all its bark
   (d) Loss of half of its leaves
5. Under what conditions the rate of transpiration increases by
   (a) Increase of humidity
   (b) The increase of atmospheric pressure
   (c) Decrease of temperature
   (d) Decrease of humidity
6. Transpiration can be incensed by interfering with
   (a) Air temperature (b) Epidermis of leaf
   (c) Guard cell (d) Osmotic pressure
7. Cobalt chloride method was first used by
   (a) F. Darwin (1912) (b) Stahl (1894)
   (c) Curtis (1926) (d) Leibeg (1840)
8. Which one of the following will not directly affect transpiration
   (a) Temperature
   (b) Light
   (c) Wind speed
   (d) Chlorophyll content of leaves

8. Mechanism of opening and Closure of stomata

1. When an oak leaf stoma is open more widely, the most likely process involved is
   (a) Water molecules are entering in the guard cells through adjacent cells
   (b) The atmosphere outside the stoma is becoming less humid
   (c) Salt molecules are being excreted by the adjacent guard cells
   (d) Auxins are accumulating in the guard cells
2. Which of the following theories is not related to the opening of stomata
   (a) Sachs (b) K^+ transport
   (c) Korper–Kappa theory (d) Levitt theory
3. Which of the following theory gives the latest explanation for the closure of stomata
   (a) ABA theory (b) Munch theory
   (c) Starch glucose theory (d) Active K^+ transport theory
4. Observe the diagram of the stomatal apparatus. In which of the following all the three parts labeled as A, B and C are correctly identified

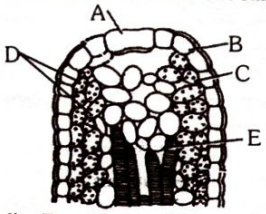


   (a) A - Guard cell, B - Stomatal aperture, C - Microfibril
   (b) A - Stomatal aperture, B - Guard cell, C - Microfibril
   (c) A - Microfibril, B - Guard cell, C - Stomatal aperture
   (d) A - Microfibril, B - Stomatal aperture, C - Guard cell
5. Select the correct events leading to the opening of the stomata
   (i) The decline in guard cell solutes
   (ii) Lowering of osmotic potential of guard cells
   (iii) The rise in potassium levels in guard cells
   (iv) Movement of water from neighboring cells into guard cells
   (v) Guard cells becoming flaccid
   (a) (i) and (v) only (b) (ii), (iii) and (iv) only
   (c) (i), (iii) and (iv) only (d) (ii), (iv) and (v) only
   (e) (iii) and (v) only
6. According to Steward's starch hydrolysis theory, which one of the following is the principal reason for the opening of stomata during daytime
   (a) Influx of K^+ ions into guard cells under the influence of ABA hormone
   (b) Conversion of sugar into starch in guard cells
   (c) Efflux of K^+ ions from guard cells under the influence of ABA hormone
   (d) Photosynthetic utilization of CO_2 in guard cells
7. The primary osmolyte which causes an opening and closing of stomata is
   (a) Sugars (b) Starch
   (c) *K*–malate (d) Water

9. Guttation, Bleeding and Root pressure

1. Guttation is the process of elimination of water from plants through or Guttation occurs from or The pores in leaves through which water comes out in the form of droplets are called or A specialized multicellular structure in leaves which excretes water droplets is called as
   (a) Stomata (b) Hydathodes
   (c) Lenticels (d) Wounds
2. From active hydathodes, the water comes out by
   (a) Osmotic pressure
   (b) Secreted by force developed within cells themselves
   (c) By root pressure
   (d) None of the above
3. Guttation occurs in
   (a) Morning (b) Moon
   (c) Evening (d) Morning 10 O'clock
4. Which one is not related to transpiration
   (a) Regulation of plant body temperature
   (b) Absorption and distribution of mineral salts
   (c) Circulation of water
   (d) Bleeding

5. Choose the correct combination of labeling of hydathode



(a) A-guard cells, B-epithem, C-mesophyll, D-epidermis, E-vasculature
(b) A-guard cells, B-epidermis, C-mesophyll, D-epithem, E-vasculature
(c) A-ostiole, B-epidermis, C-mesophyll, D-epithem, E-vasculature
(d) A-water pore, B-hypodermis, C-mesophyll, D-epithem, E-vasculature

6. Which of the following is done during the ringing experiment
(a) Bark is removed (b) Pith is removed
(c) Xylem is removed (d) All of these

7. Which one of the following is not related to guttation
(a) Water is given out in the form of droplets
(b) Water given out is impure
(c) Water is given out early morning
(d) Guttation is of universal occurrence

8. Root pressure is due to
(a) Passive transport (b) Gravitation
(c) Active transport (d) None of these

9. Water is lost in a liquid state in some plants through hydathodes. These hydathodes
(a) Remain closed at night
(b) Remain closed during the day
(c) Remain always opens
(d) Do not show any specificity in opening and closing

10. Hydathodes are also called
(a) Water stomata (b) Sunken stomata
(c) Guard cells (d) Subsidiary cells

11. The removal of a bark from the trunk of a tree eventually kills it, since
(a) Mineral salts cannot go up
(b) Water cannot go up
(c) Food does not travel down and roots are starved
(d) The exposed part becomes infected with fungi

10. Scientists and Apparatus concerned

1. Who explained the photoactive opening of stomata
(a) Nishida (b) Palls
(c) Ehrler (d) None of the above

2. Photometer and clinostat are used to study
(a) Photosynthesis and respiration
(b) Transpiration and growth
(c) Phototropism and geotropism
(d) Transpiration and geotropism

3. The best vital force theory was proposed by
(a) Godlewsky (b) Strasberger
(c) Dixon (d) Esau

4. *'Guttation'* word is given by
(a) Fritz (b) Burgerstein
(c) Noggle (d) Lewitt

5. According to one vital force theory, the ascent of sap is due to active pulsation of the innermost layer of cortex. This theory was given by

Or

In plant 'transpiration pull' theory for the ascent of sap was first proposed by
(a) J. C. Bose (b) Dixon
(c) Strasburger (d) Sacks

6. Gradient pressure was given as a possible mechanism of translocation of food by
(a) Curtis (b) Munch
(c) Dixon and Jolly (d) Mason and Maskel

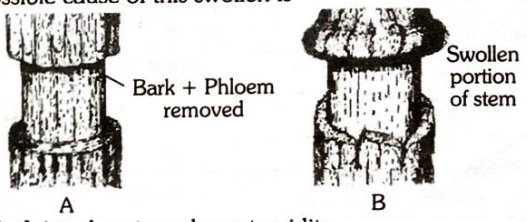
11. Translocation of organic solutes

1. The direction of the conduction of food through phloem is
(a) From below upwards
(b) From top to bottom
(c) From leaves to roots
(d) Phloem never conducts food

2. Sinks are related to
(a) Transport of minerals (b) Stomata
(c) Enzymes (d) Phytochrome

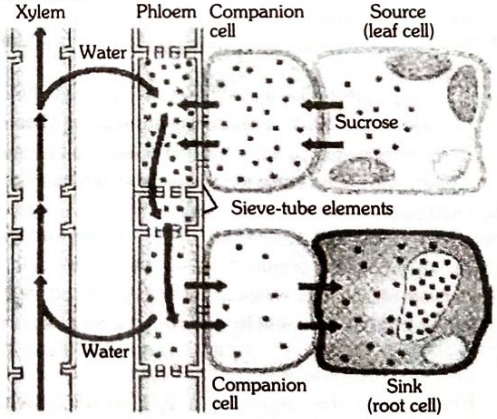
3. Which one of the following elements is necessary for the translocation of sugars in plants
(a) Iron (b) Manganese
(c) Molybdenum (d) Boron

4. The figure indicates the ringing or girdling experiment. Bark having phloem is removed. This experiment proves that phloem is the path for translocation of food. In this experiment swollen part of the stem has been shown. The possible cause of this swollen is



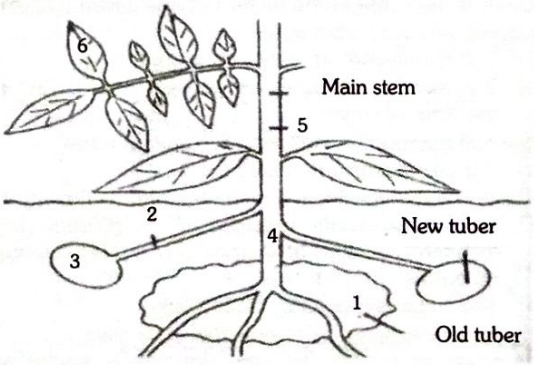
(a) Injured parts undergo turgidity
(b) A repairing mechanism is taken place
(c) Accumulation of water and mineral just above the Ring
(d) Accumulation of food material just above the ring (As downward movement of food is inhibited)

5. According to all Munch's pressure-flow hypothesis, which of the following given conditions would increase the rate of translocation



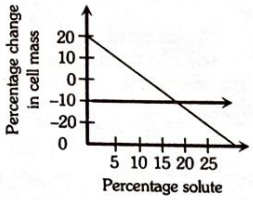
(a) A decrease in the photosynthesis
(b) An increase in the sucrose production at the source
(c) A decrease in phloem unloading at the sink
(d) An increase in the humidity in the outside air

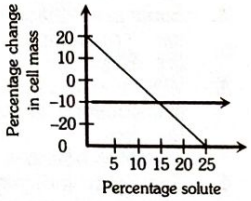
6. The given diagram illustrates a Potato plant forming new tubers. Which route would be taken by most of the food at this time

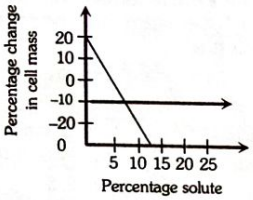


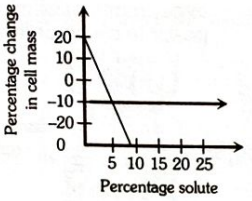
(a) $6 \rightarrow 5 \rightarrow 4 \rightarrow 1$ (b) $1 \rightarrow 4 \rightarrow 5 \rightarrow 6$
(c) $6 \rightarrow 5 \rightarrow 2 \rightarrow 3$ (d) $1 \rightarrow 4 \rightarrow 2 \rightarrow 3$

7. The effect of solute concentration on the mass of tissue cells is studied. It is observed from the collected data that the tissue cells were isotonic to 10 % solute concentration. Which of the following graph represents that the cells are isotonic to 10 % solute concentration

(a) 

(b) 

(c) 

(d) 

8. Phloem sap is mainly made of
(a) Water and sucrose
(b) Water and minerals
(c) Oligosaccharides and hormones
(d) None of these

9. Which is correct about transport or conduction of substances
(a) Organic food moves upwardly through xylem
(b) Organic food moves up through the phloem
(c) Inorganic food moves upwardly and downwardly through xylem
(d) Organic food moves upwardly and downwardly through the phloem

10. Supply ends in the transport of solute are
(a) Green leaves and storage organs
(b) Root and stem
(c) Xylem and Phloem
(d) Hormones and enzymes

11. Active transport of solute in plants refers to the flow of solutes against a concentration gradient and therefore requires the input of energy. This energy is derived
(a) Always from hydrolysis of ATP
(b) Not only from ATP hydrolysis but also from the collapse of a proton motive force
(c) Partly form the input from ATP hydrolysis and partly from the collapse of a proton motive force
(d) From the different sources depending on the solutes

12. Vein loading is the active transport of sugars from
(a) Mesophyll cells to vessels
(b) Vessels to mesophyll cells
(c) Mesophyll cells to sieve tubes
(d) Sieve tubes to mesophyll cells

13. Starch is insoluble in the water yet it is accumulated in large quantities in potato because
(a) It is synthesized in potato tuber itself
(b) It is translocated from the leaves to the potato tuber in the form of sugar
(c) Soil micro-organism deposit starch in tuber
(d) It is useful consumption

14. Which of the following is not correct in mass flow hypothesis
(a) As the hydrostatic pressure in the phloem sieve tube increases pressure flow stops and sap is accumulated in phloem
(b) The sugar is moved bidirectionally
(c) The sugar which is transported is sucrose
(d) Loading of the phloem sets up a water potential gradient that facilitates the mass movement in the phloem

12. NEET-AIPMT/CBSE PMT

1. Meaningful girdling (Ringing) experiments cannot be done on sugarcane because **[1994]**
(a) Phloem is present inside the xylem
(b) It can not tolerate the injury
(c) Vascular bundles are scattered
(d) Plants are very delicate

2. The most abundant intracellular cation is **[2013]**
(a) K^+ (b) Na^+
(c) Ca^{++} (d) H^+

3. According to the well-known theory of transport of solutes across a cell membrane, what happens when sugar is passed through it **[1992]**
(a) Na^+ flows in the direction of the sugar
(b) Na^+ flows independent of sugar molecules
(c) Na^+ flows against the sugar molecules
(d) Na^+ ions do not flow at all

4. Water potential can be obtained by **[1988]**
(a) $OP + TP$ (b) $OP = WP$
(c) $P + \pi$ (d) $OP - DPD$

5. When water moves through a semipermeable membrane, which of the following is created **[2001]**
(a) *OP* (b) *SP*
(c) *TP* (d) *WP*

6. Two cells *A* and *B* are contiguous. Cell *A* has osmotic pressure 10 *atm*, turgor pressure-7 *atm* and diffusion pressure deficit 3 *atm*. Cell *B* has osmotic pressure 8 *atm*, turgor pressure 3 *atm* and diffusion pressure deficit 5 *atm*. The result will be **[2007]**
(a) Movement of water from cell *B* to *A*
(b) No movement of water
(c) The equilibrium between the two
(d) Movement of water from cell *A* to *B*

7. When a cell is fully turgid, which of the following will be zero **[1997]**
(a) Wall pressure (b) Osmotic pressure
(c) Turgor pressure (d) Water potential

8. Root pressure develops due to **[2015]**
(a) The low osmotic potential in soil
(b) Passive absorption
(c) Increase in transpiration
(d) Active absorption

9. Root system in a plant is well developed **[1990]**
(a) Due to deficiency of auxin
(b) Due to deficiency of cytokinins
(c) Due to deficiency of minerals
(d) For increased absorption of water

10. The principal pathways by which water is translocated in angiosperms is **[1990]**
(a) Xylem and phloem together
(b) Sieve tubes and members of phloem
(c) Sieve cells of phloem
(d) Xylem vessel system

11. Transpiration and root pressure cause water to rise in plants by **[2015]**
(a) Pulling and pushing it, respectively
(b) Pushing it upward
(c) Pushing and pulling it, respectively
(d) Pulling it upward

12. The rupture and fractionation do not usually occur in the water column in vessel/tracheids during the ascent of sap because of **[2008]**
(a) Weak gravitational pull (b) Transpiration pull
(c) Lignified thick walls (d) Cohesion and adhesion

13. Passage cells are thin-walled cells found in **[2007]**
(a) Endodermis of roots facilitating rapid transport of water from cortex to pericycle
(b) Phloem elements that serve as entry points for substances for transport to other plant parts
(c) Testa of seeds to enable the emergence of growing embryonic axis during seed germination
(d) The central region of style through which the pollen tube grows towards the ovary

14. In soil, water available for plants is **[1999]**
(a) Capillary water (b) Hygroscopic water
(c) Gravitational water (d) Chemically bound water

15. The movement of water from one cell of the cortex to the adjacent one in roots is due to **[1995]**
(a) Accumulation of inorganic salts in the cells
(b) Accumulation of organic compounds in the cells
(c) Chemical potential gradient
(d) Water potential gradient

16. A column of water within xylem vessels of tall trees does not break under its weight because of **[2015]**
(a) The tensile strength of water
(b) Lignification of xylem vessels
(c) Positive root pressure
(d) Dissolved sugars in water

17. Guard cells help in **[2009]**
(a) Protection against grazing
(b) Transpiration
(c) Guttation
(d) Fighting against infection

18. In woody trees, the exchange of gases between the outer atmosphere and the internal tissue of the stem takes place through
(a) Aerenchyma (b) Stomata
(c) Pneumatophores (d) Lenticels
(e) Trichomes

19. Stomata of CAM plants **[2003]**
(a) Never open
(b) Are always open
(c) Open during the day and close at night
(d) Open during the night and close during the day

20. Stomata in grass leaf are **[2018]**
(a) Barrel shaped (b) Rectangular shaped
(c) Kidney shaped (d) Dumb-bell shaped

21. The transpiration in plants will be lowest **[1988]**
(a) When there is high humidity in the atmosphere
(b) High wind velocity
(c) There is an excess of water in the cell
(d) Environmental conditions are very dry

22. Increase in CO_2 concentration around leaf results in **[2000]**
(a) Rapid opening of stomata
(b) Partial closing of stomata
(c) Complete closure of stomata
(d) There will be no effect on stomatal opening

23. Which of the following may be used as an antitranspirant in plant **[1988]**
(a) Phenyl mercuric acetate (b) Cobalt chloride
(c) Mercury (d) Potassium

24. In the terrestrial habitat which of the following factors affect temperature and rainfall conditions **[1989]**
(a) Translocation (b) Transformation
(c) Thermo-denaturation (d) Transpiration

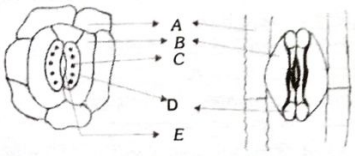
25. Stomata in angiosperms open and close due to **[1988, 2002]**
(a) Their genetic constitution
(b) Effect of hormones
(c) Changes of turgor pressure in guard cells
(d) The pressure of gases inside the leaves

26. In guard cells when sugar is converted into starch, the stomatal pore **[1992]**
(a) Opens fully (b) Opens partially
(c) Closes completely (d) Remains unchanged

27. The basis of the stomatal opening is **[1988]**
(a) Exosmosis
(b) Endosmosis
(c) Decrease in cell sap concentration
(d) Plasmolysis of guard cells

28. Which of the following statement is not true for stomatal apparatus **[2013]**
(a) Guard cells invariably possess chloroplasts and mitochondria
(b) Guard cells are always surrounded by subsidiary cells
(c) Stomata are involved in gaseous exchange
(d) Inner walls of guard cells are thick

29. Choose the correct combination of labeling of the stomatal apparatus of dicot and monocot leaves **[2006; 2010]**



(a) A=Epidermal cells, B=Subsidiary cells, C=Chloroplast, D=Guard cells, E=Stomatal aperture
(b) A=Epidermal cells, B=Guard cells, C=Chloroplast, D=Subsidiary cells, E=Stomatal aperture
(c) A=Epidermal cells, B=Subsidiary cells, C=Chloroplast, D=Stomatal aperture, E=Guard cells
(d) A=Subsidiary cells, B=Epidermal cells, C=Chloroplast, D=Stomatal aperture, E=Guard cells
(e) A=Guard cells, B=Epidermal cells, C=Stomatal aperture, D=Subsidiary cells, E=Chloroplast

30. Conversion of starch to organic acid is essential for **[1992, 94]**
(a) Stomatal closure (b) Stomatal opening
(c) Stomatal initiation (d) Stomatal growth

31. Water vapor 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 the following options **[2016]**
(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 daytime and the other at night

32. Stomatal movement is not affected by **[2018]**
(a) CO_2 concentration (b) O_2 concentration
(c) Light (d) Temperature

33. The term water potential was proposed by **[2001]**
(a) Bose (b) Dixon
(c) Godlewski (d) Slatyer and Taylor

34. When a plant is girdled **[2015]**
(a) The root dies first
(b) The shoot dies first
(c) The root and shoot die at the same time
(d) Neither the root nor the shoot will die

35. The translocation of organic solutes in sieve tube members is supported by **[2006]**
(a) Mass flow involving a carrier and ATP
(b) Cytoplasmic streaming
(c) Root pressure and transpiration pull
(d) P-proteins

36. Which of the following criteria does not pertain to facilitated transport **[2013]**
(a) Uphill transport
(b) The requirement of special membrane proteins
(c) High selectivity
(d) Transport saturation

37. Bidirectional translocation of minerals takes place in **[1997, 99]**
(a) Xylem (b) Phloem
(c) Parenchyma (d) Cambium

38. During transport of sugar or amino acid through cell membrane **[1994]**
(a) Na^+ ions move against the direction of the concentration gradient
(b) Na^+ ions move in both directions irrespective of its concentration gradient
(c) No net Na^+ ions movement
(d) Na^+ ions move in the direction of its concentration gradient

39. The carbohydrates synthesized in the leaves are transported through sieve tubes most commonly in the form of **[1992]**

Or

Translocation of sugar in flowering plants occurs in the form of
(a) Glucose (b) Triose sugar
(c) Sucrose (d) Soluble starch

13. AIIMS

1. The sugarcane plant has **[2004]**
(a) Dumb-bell shaped guard cells
(b) Pentamerous flowers
(c) Reticulate venation
(d) Capsular fruits

2. In the rainy season, the doors get wet due to **[2001]**
(a) Imbibition (b) Absorption
(c) Diffusion (d) Endosmosis

3. When a plant cell is placed in a solution which is hypotonic to the cell sap, which of the following conditions will not apply **[1990]**
(a) The water potential of the cell sap will rise
(b) The suction pressure of the cell sap will fail
(c) The cell will become turgid
(d) The wall pressure of the cell will fail

4. In the process of osmosis in the cell **[1992]**
(a) Both cell wall and protoplasm will act as a membrane
(b) Entire protoplast act as a membrane
(c) An only outermost layer of protoplasm act as a Membrane
(d) Only cell wall act as a membrane

5. Cell *A* has the osmotic potential of –18 bars and pressure potential of 8 bars, whereas, cell *B* has the osmotic potential of –14 bars and pressure potential 2 bars. The direction of the flow of water will be **[2009]**
(a) From cell *B* to cell *A* (b) From cell *A* to cell *B*
(c) No flow of water (d) In both the directions

6. The ratio of osmotic pressure exerted by 1 *M* sucrose and 1 *M* *NaCl* solution will be **[2010]**
(a) 1 (b) 2
(c) 0.1 (d) 0.5

7. Which of the following helps in the absorption of water and mineral salts **[1999]**
(a) Mycorrhiza (b) *Anabaena*
(c) *Nostoc* (d) None of these

8. Stomata open at night and close during the day in **[1987]**
(a) Xerophytes (b) Gametophytes
(c) Mesophytes (d) Hydrophytes

9. Glycolate induces opening of stomata in **[2010]**
(a) Presence of oxygen (b) Low CO_2 concentration
(c) High CO_2 concentration (d) Absence of CO_2

10. Na^+ / K^+ pump in a cell is an example of **[2012]**
(a) Osmosis (b) Diffusion
(c) Passive transport (d) Active transport

11. Guttation is caused due to **[2011]**
(a) Imbibition (b) Osmosis
(c) Positive root pressure (d) Transpiration

12. The process of the escape of liquid from the tip of the uninjured leaf is called **[1998]**
(a) Evaporation (b) Transpiration
(c) Guttation (d) Evapo-transpiration

13. Match the theories given in column I with the names of scientists listed in column II. Choose the answer which gives the correct combination of the alphabets

Column – I (Names of theories)		Column – II (Names of scientists)	
A.	Relay pump theory	p.	Stocking
B.	Transpiration cohesion theory	q.	Sir J.C. Bose
C.	Mass flow	r.	Godlewski
D.	Pulsation theory	s.	Dixon and Jolly
		t.	Ernst Munch

[2013]

(a) A = r; B = s; C = t; D = q
(b) A = s; B = r; c = p; d = q
(c) A = r; B = q; C = t; D = q
(d) A = q; B = p; C = t; D = r

14. Which of the following is used to determine the rate of transpiration in plants **[2000]**
(a) Porometer (b) Potometer
(c) Auxanometer (d) Tensiometer

15. Leaf photosynthates are transported to other parts of higher plants through

Or

Food is transported to various parts of the plant through **[1998]**
(a) Cambial cells (b) Pith cells
(c) Xylem cells (d) Phloem cells

14. Assertion and Reasoning

Read the assertion and reason carefully to mark the correct option out of the options given below :
(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but the reason is true

1. Assertion : Water and mineral uptake by root hairs from the soil occurs through apoplast until it reaches endodermis.
Reason : Casparian strips in endodermis are suberized.

2. Assertion : Arid areas are not suitable for crops.
Reason : Antitranspirant are used for planting crops in arid regions.

3. Assertion : Wilting occurs due to a loss of turgidity.
Reason : Turgor pressure checks the excessive entry of water into cells.

4. Assertion : Plasmolysis will be severe if the process is in the order, limiting → incipient → evident.
Reason : Plasmolysis is exosmosis.

5. Assertion : Light is a very important factor in transpiration.
Reason : It induces stomatal opening and darkness closing. Therefore, transpiration increases in light decreases in the dark.

6. Assertion : Xylem is the principal water-conducting tissue.
Reason : It has been recognized by girdling or ringing experiment.

7. Assertion : Long distance flow of photoassimilates in plants occurs through sieve tubes.
Reason : Mature sieve tubes have parietal cytoplasm and perforated sieve plates.

8. Assertion : Oil will form a film on the top of the water affecting the amount of light entering the water.
Reason : Oil is a polar molecule, and forms hydrogen bonds.

9. Assertion : Temporary and permanent wilting result in plant death.
Reason : Plant parts become flaccid in wilting condition.

10. Assertion : To counteract the increase in turgor pressure in plant cells, the cell wall produces an equal and opposite pressure, *i.e.*, wall pressure.
Reason : When plant cells undergo endosmosis, they swell but do not burst.

11. Assertion : Plants absorb water mostly by roots.
Reason : Root cap region participates actively in water absorption.

12. Assertion : Waxy and cuticle coating on plant parts reduce the transpiration.
Reason : These adaptations are found in xerophytes.