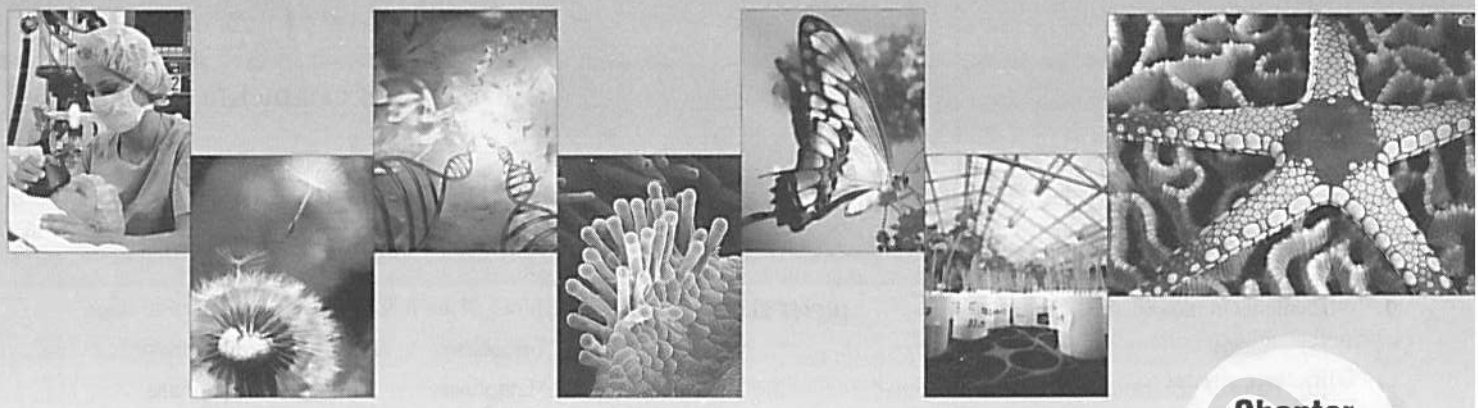


Chapter

# 4.1

# Transport in Plants

Plant physiology (Physis = nature of life; logos = study) is the branch of botany which deals with the study of life activities of plants. It includes the functional aspects of life processes both at cellular as well as sub-cellular level.

## Concept of water relation

Water is mainly absorbed by the roots of the plants from the soil, then it moves upward to different parts and is lost from the aerial parts, especially through the leaves. Before taking up the absorption and movement of water in plants, it is worthwhile to understand the phenomenon of imbibition, diffusion and osmosis involved in the water uptake and its movement in the plants.

**Imbibition (L. imbibere – to drink) :** The process of adsorption of water by hydrophilic surfaces of a substance without forming a solution is called 'imbibition'. It is a type of diffusion by which movement of water takes place along a diffusion gradient. The solid particles which adsorb water or any other liquid are called imbibants. The liquid which is imbibed is known as imbibate.

**Characteristics of imbibition :** The phenomenon of imbibition has three important characteristics :

(i) **Volume change :** During the process of imbibition, imbibants increase in volume. It has been observed that there is an actual compression of water. This is due to arrangement of water molecules on surface of imbibant and occupy less volume than the same molecules do when are in free stage in the normal liquid. *e.g.,* If a dry piece of wood is placed in water, they swell and increases in its volume.

(ii) **Production of heat :** As the water molecules are adsorbed on the surface of the imbibant, their kinetic energy is released in the form of heat which increases the temperature of the medium. It is called heat of wetting (or heat of hydration). *e. g.*, during kneading, the flour of wheat gives a warm feeling due to imbibition of water and consequent release of heat.

(iii) **Development of imbibitional pressure :** Imbibition pressure can be defined as the maximum pressure that an imbibant will develop when it is completely soaked in pure water. Imbibition pressure is also called as the matric potential because it exists due to the presence of hydrophilic substances in the cell which include organic colloids and cell wall.

**Factors influencing the rate of imbibition**

**Nature of imbibant :** Proteins are the strongest imbibants of water, starch less strong, cellulose being the weakest.

**Surface area of imbibant :** If more surface area of the imbibant is exposed and is in contact with liquid, the imbibition will be more.

**Temperature :** Increase in temperature causes an increase in the rate of imbibition.

**Degree of dryness of imbibant :** If the imbibant is dry it will imbibe more water than a relatively wet imbibant.

**Concentration of solutes :** Increase in the concentration of solutes in the medium decreases imbibition.

***pH* of imbibant :** Proteins, being amphoteric in nature, imbibe least in neutral medium. Towards highly acidic or highly alkaline *pH*, the imbibition increases till a maximum is reached, there after it starts slowing down.

**Significance of imbibition**

(1) The water is first imbibed by walls of root hairs and then absorbed.

(2) Water is absorbed by germinating seeds through the process of imbibition and helps in rupturing of seed coat (made up of cellulose).

(3) The water moves into ovules which are ripening into seeds by the process of imbibition.

**Diffusion :** The movement of the molecules of gases, liquids and solids from the region of higher concentration to the region of lower concentration is known as diffusion.

It may occur between gas and gas (*e.g.*, diffusion of ammonia into air), liquid and liquid (*e.g.*, diffusion of alcohol into water), or solid and liquid (*e.g.*, diffusion of sugar into water).

**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.

**Diffusion pressure deficit (DPD) or Suction pressure (SP) :** The term diffusion pressure (DP) and diffusion pressure deficit (DPD) were putforth by B.S. Meyer in 1938. Now a days, the term water potential ($\psi$) is used which is equal to DPD, but negative in value. The term suction pressure was putforth 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 solution. Therefore, DPD can also be called **suction pressure (SP).**

**Factors influencing rate of diffusion**

**Temperature :** Increase in temperature leads to increase in the rate of diffusion.

**Pressure :** The rate of diffusion of gases is directly proportional to the pressure. So the rate of diffusion increases with increase in pressure. Rate of diffusion $\propto$ pressure.

**Size and mass of diffusing substance :** Diffusion of solid is inversely proportional to the size and mass of molecules and ions.

$$\text{Rate of diffusion} \propto \frac{1}{\text{Size} \times \text{Mass of particles}}$$

**Density of diffusing substance :** The rate of diffusion is inversely proportional to the square root of density of the diffusing substance. Larger the molecules, slower will be the rate of diffusion. This is also called Graham's law of diffusion.

$D \propto \frac{1}{\sqrt{d}}$ (D = Diffusion and $d$ = Density of diffusing substance).

According to the density the diffusion of substances takes place in following manner :

Gas > Liquid > Solid

The vapours of volatile liquids (scent or petrol) and solids (camphor) also diffuse like gases.

**Density of the medium :** The rate of diffusion is slower, if the medium is concentrated. Thus, a gas would diffuse more rapidly in vacuum than in air. Substances in solution also diffuse but at a much slower rate than gases.

**Diffusion pressure gradient (DPG) :** The rate of diffusion is directly proportional to the difference of diffusion pressure at the two ends of a system and inversely proportional to the distance between the two.

**Significance of diffusion**

(1) Gaseous exchange during the processes of photosynthesis and respiration takes place with the help of diffusion.

(2) The process of diffusion is involved in the transpiration of water vapours.

(3) Aroma of flowers is due to diffusion of volatile aromatic compounds to attract pollinating animals.

(4) During passive salt uptake, the ions are absorbed by process of diffusion.

(5) Diffusion helps in translocation of food materials.

(6) Gaseous exchange in submerged hydrophytes takes place by general surface of the cells through diffusion.

**Permeability :** Permeability is the degree of diffusion of gases, liquids and dissolved substances through a membrane. Different types of membranes may be differentially permeable to different substances.

**Types of membranes :** On the basis of permeability.

**Permeable membrane :** These membranes allow free passage of solvent (water) and most of the dissolved substances. *e.g.*, cell wall in plant cells. Filter paper is made up of pure cellulose it also functions as permeable membrane.

**Impermeable membrane :** This type of membranes with deposits of waxy substances like cutin and suberin, do not allow the entry of water, dissolved substances and gases. *e.g.*, suberized walls of cork cells, cuticle layer of leaf.

**Semi-permeable membrane :** These membranes permit the movement of solvent molecules only through them, but prevent the movement of solute particles. *e.g.*, egg membrane, animal bladder, parchment paper, copper ferrocyanide membrane, membranes of collodion.

**Selectively or Differentially permeable membrane :** This type of membranes allow selective passage of solutes along with solvent, through them.

Many biological membranes such as cell membrane (plasmalemma), tonoplast (vacuolar membrane) and the membranes surrounding the sub-cellular organelles are selectively permeable. A non-living selectively permeable membrane is cellophane.

**Osmosis :** Osmosis (Gr. Osmos = a pushing or impulse) was discovered by Abbe Nollet in 1748 and also coined the term 'osmosis'. First of all Traube (1867) used copper ferrocyanide and developed semipermeable membrane to show its utility in the osmosis of plant physiology. First time Pfeffer in (1887) developed osmoscope by using semipermeable membrane.

Osmosis is special type of diffusion of a liquid, when solvent moves through a semipermeable membrane from a place of higher diffusion pressure to a place of lower diffusion pressure.

**Or**

It is the migration of solvent from a hypotonic solution (of lower concentration) to hypertonic solution (of higher concentration) through a semi-permeable membrane to keep the concentration equal.

In formalin preserved *spirogyra* filament, selective permeability of plasma membrane is lost and hence no effect on placing in hypertonic solution.

**Reverse Osmosis :** It is the reverse movement of water through a semipermeable membrane from a more concentrated solution to a more dilute solution by applying external pressure on the more concentrated solution.

It is used in removing salts from saline water as well as extra – purification of water.

**Osmotic pressure (OP) :** Pfeffer coined the term osmotic pressure.

Osmotic pressure is that equivalent of maximum hydrostatic pressure which is produced in the solution, when this solution is separated from its pure solvent by a semipermeable membrane. Osmotic pressure of a solution is greater than pure solvent.

**Types of osmosis :** Depending upon the movement of water into or outside of the cell, osmosis is of two types.

**Endosmosis :** The osmotic flow of water into a cell, when it is placed in a solution, whose solute concentration is less than that of the cell sap, is called endosmosis *e.g.*, swelling of raisins, when they are placed in water.

When a fish of marine water kept in fresh water then it will die due to endosmosis.

An animal cell placed in pure water will swell up and bursts.

Pollen grains of some of plants germinate on stigma soon but they burst in water or dilute sugar solution.

**Exosmosis :** The osmotic outflow of water from a cell, when it is placed in a solution, whose solute concentration is more than that of the cell sap, is called exosmosis. *e.g.*, shrinkage of grapes, when they are placed in strong sugar solution.

**Osmotic concentrations (Types of solutions)**

**Hypotonic solution** (*hypo* = less than). A solution, whose osmotic concentration (solute potential) is less than that of another solution or cell sap is called hypotonic solution. If a cell is placed in such a solution, water starts moving into the cell by the process of endosmosis, and cell becomes turgid.

**Hypertonic solution** (*hyper* = more than). A solution, whose osmotic concentration (solute potential) is more than that of another solution or cell sap is called hypertonic solution. If a cell is placed in such a solution, water comes out of the cell by the process of exosmosis and cell becomes flaccid. If potato tuber is placed in concentrated salt solution it would becomes shrink due to loss of water from its cell.

**Isotonic solution** (*iso* = the same). A solution, whose osmotic concentration (solute potential) is equal to that of another solution or cell sap, is called isotonic solution. If a cell is placed in isotonic solution, there is no net changes of water between the cell and the solution and the shape of cell remain unchanged.

In xerophytes, the osmotic concentration of cell sap is more than the normal. The osmotic pressure of given solution can be calculated by following formula.

Osmotic pressure = CST

Where, C = Molar concentration of solution, S = Solution constant, which is 0.082 and T = Absolute temperature *i.e.*, 273°*K*.

**Significance of osmosis in plants**

(1) The phenomenon of osmosis is important in the absorption of water by plants.

(2) Cell to cell movement of water occurs throughout the plant body due to osmosis.

(3) The rigidity of plant organs (*i.e.*, shape and form of organism) is maintained through osmosis.

(4) Leaves become turgid and expand due to their OP.

(5) Growing points of root remain turgid because of osmosis and are thus, able to penetrate the soil particles.

(6) Opening and closing of stomata is affected by osmosis.

(7) Movement of plants and plant parts, *e.g.*, movement of leaflet of Indian telegraph plant.

**Turgor pressure (TP) :** The plant cell, when placed in pure water, swells but does not burst. Because of negative osmotic potential of the vacuolar solution (cell sap), water will move into the cell and will cause the plasmalemma be pressed against the cell wall. The actual pressure that develops that is the pressure responsible for pushing the membrane against cell wall is termed turgor pressure.

**Significance of turgidity in plants**

(1) It provides stability to a cell.

(2) Turgidity keeps the cell and their organelles (mitochondria, plastids and microbodies) fully distended. This is essential for plants to live and grow normally.

(3) Turgor pressure helps in cell enlargement, consequently in stretching of the stems and in keeping leaves erect and fully expanded.

(4) The turgid cells provide mechanical support necessary for the non woody tissues (maize, sugarcane, banana etc.).

(5) Loss of turgidity leads to wilting of leaves and drooping of shoots.

(6) The opening and closing of stomata are regulated by the turgidity of the guard cells.

(7) Leaf movements (seismonastic movement) of many plants (such as bean, sensitive plant *Mimosa pudica*) are controlled by loss and gain of cell turgor.

(8) Due to turgor pressure plumule and radicles force out from seeds at the time of seed germination.

**Wall pressure (WP) :** Wall pressure (WP) may, therefore, be defined as 'the pressure exerted by the cell wall over the protoplast to counter the turgor pressure. Normally wall pressure is equal and opposite to turgor pressure (WP =TP) except when the cell become flaccid. The value of the two forces continue to rise with the continued entry of water, till the cell becomes fully turgid.

**Interrelationship of DPD (S.P.), OP and TP (WP) :** DPD indicates the sucking power of suction pressure. As water enters into the cell the TP of the cell is increased. Cell wall exerts equal and opposite WP against TP. The actual force responsible for entry of water will be therefore OP–TP

*i.e.*, DPD = OP – WP (As WP = TP)

DPD = OP – TP

Consider that a plant cell with OP = 10 atm. is immersed in pure water. In the beginning TP inside the cell is zero *i.e.*,

DPD = OP = 10 atm.

When water enters into the cell, TP increases. Turgidity increases and cell wall develops equal and opposite WP. At the stage of equilibrium TP = 10 atm. and DPD will become zero. It is important to note that OP was same when cell was flaccid and turgid.

DPD = OP – TP

= 10 – 0 = 10 (when flaccid)

= 10 – 10 =0 (when turgid)

The entry of water in cell to cell depends upon the DPD and not on OP and TP. This can be examplified as follows :

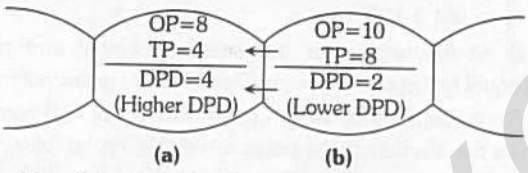



**Fig : 4.1-1 Relation between diffusion pressure deficit and entrance of water in the cell**

Since the DPD of cell A is more, it has less water and, therefore water would diffuse from cell B into the cell A (because that DPD of cell B is less than that of A or it has more water than cell A has). The entry of water into the cell A would stop when DPD of both the cells become equal. In this way water moves from a cell with less DPD into the cell with more DPD. Thus, DPD is the osmotic parameter, which determines the flow of water from one cell to another.

Under given suitable conditions, the DPD is more than OP when TP is negative.

DPD is maximum in a flaccid cell.

**Plasmolysis (Gr. Plasma = something formed; lysis = loosing) :** "The shrinkage of the protoplast of a living cell from its cell wall due to exosmosis under the influence of a hypertonic solution is called plasmolysis". The stage of plasmolysis, when the protoplast just begins to contract away from the cell wall is called incipient plasmolysis. The stage when the cell wall has reached its limit of contraction and the protoplast has detached from cell wall attaining spherical shape is called evident plasmolysis. If a cell with incipient plasmolysis is placed in a hypertonic solution it will show more plasmolysis.

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

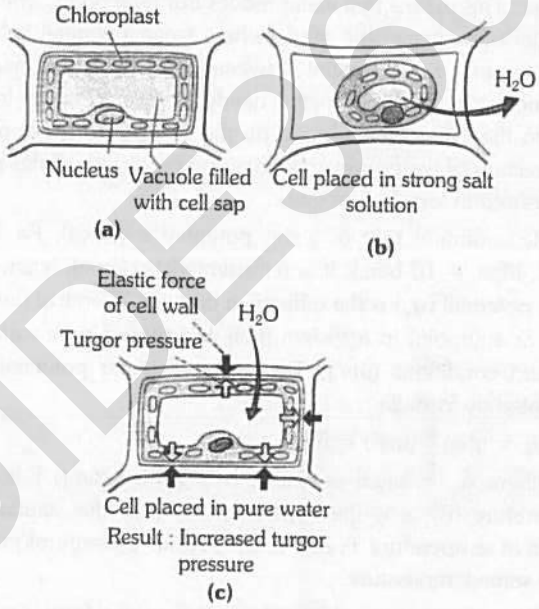



**Fig : 4.1-2 Plasmolysis and deplasmolysis (a) Normal cell (b) Plasmolysed cell (c) Deplasmolysed cell and increased turgor pressure**

**Significance of plasmolysis**

(1) The OP of a cell can be measured by plasmolysis. The OP of a cell is roughly equal to the OP of a solution that causes incipient plasmolysis in the cell.

(2) Salting of pickles, meat, fishes etc. and addition of sugar to jams, jellies, cut fruits etc., prevent their decay by microbes, as the latter get killed due to plasmolysis or due to high concentration of salt or sugar.

(3) By salting, the weeds can be killed from tennis courts and the growth of plants can be prevented in the cracks of walls.

(4) Plasmolysis is helpful in determining whether a particular cell is living or dead as plasmolysis does not occur in a dead or non living cell.

**Water potential ($\psi$) :** The term water potential was coined by slatyer and Taylor (1960). It is a modern term which is used in placed of D.P.D. The movement of water in plants cannot be accurately explained in terms of difference in concentration or in any other linear expression. The best way to express spontaneous movement of water from one region to another is in terms of the difference of free energy of water between two regions. Free energy is the thermodynamic parameter, that determine the

direction in which physical and chemical changes must occur. The potential energy of water is called water potential. *e.g.*, water is stored behind a dam. When the water runs downhill, its potential energy can be converted to electrical energy. This conversion of energy of water is due to gravity. The other source that provides energy to water is pressure. The increasing pressure increases the free energy there by increasing water potential.

Water running downhill due to gravity can be made to run uphill by overcoming the water potential (energy) by applying pressure. This means that water moves from the point, where water potential is greater to the other, where water potential is less. The difference in water potential between two points is a measure of the amount of work or energy needed to move water from one point to the other. Thus, based on the concept of water potential, the direction of water movement can be predicted. Water potential is measured in terms of pressure.

Measurement unit of water potential is pascal, Pa (1 mega pascal, Mpa = 10 bars). It is represented by Greek letter, Psi ($\psi$). Water potential ($\psi_w$) is the difference between chemical potential of water at any point in a system ($\mu\omega$) and that of pure water under standard conditions ($\mu\omega^\circ$). The value of water potential can be calculated by formula :

$$\psi_w = (\mu\omega) - (\mu\omega^\circ) = RT\ 1\ n\ e/e^\circ$$

where $\psi_w$ = water potential, R is gas constant, T is absolute temperature (K), $e$ is the vapour pressure of the solution in the system at temperature T, and $e^\circ$ the vapour pressure of pure water at the same temperature.

The direction in which water will move from one cell to another cell depends on water potential in two regions. Water potential is measured in bars. A bar is a pressure unit which equals 14.5 lb/in$^2$, 750 *mm Hg* or 0.987 *atm*.

Water potential of pure water at normal temperature and pressure is zero. This value is considered to be the highest. The presence of solute particles reduces the free energy of water and thus decreases the water potential. Therefore, water potential of a solution is always less than zero or has negative value.

**Component of water potential :** The water potential ($\psi$) in a plant cell or tissue can be written as the sum of the matric potential ($\psi m$) due to binding of water to cell walls and cytoplasm, the solute potential ($\psi s$) due to concentration of dissolved solutes, which by its effect on the entropy components reduces the water potential and the pressure potential ($\psi p$) due to hydrostatic pressure, which by its effect on the energy components increases the water potential :

$$\psi = \psi m + \psi s + \psi p \quad \ldots\ldots (1)$$

**Matric potential ($\psi m$) :** Matric is the term used for the surface (such as, soil particles, cell walls, protoplasms, etc.) to which water molecules are adsorbed. The matric potential ($\psi m$) is the component of water potential influenced by the presence of a matrix. It has got a negative value. In case of plant cells and tissues, the matric potential is often disregarded because it is not significant in osmosis. Thus, the above equation (1) may be simplified as follows :

$$\psi = \psi s + \psi p \quad \ldots\ldots (2)$$

In normal cells of mesophytes and hydrophytes it is almost negligible.

**Solute potential ($\psi s$) :** Solute potential is also known as *Osmotic potential*. It is defined as the amount by which the water potential is reduced as a result of the presence of solute. Solute potentials or osmotic potentials ($\psi s$) are always in negative values (number). The term solute potential takes the place of osmotic pressure ($\pi$; Pi) expressed in bars with a negative sign.

$$\psi_s = -\pi$$

**Pressure potential ($\psi p$) :** Plant cell wall is elastic and it exerts a pressure on the cellular contents. As a result of inward wall pressure, hydrostatic pressure is developed in the vacuole termed as turgor pressure. The pressure potential is usually positive and operates in plant cells as *wall pressure* and *turgor pressure*.

Its magnitude varies between +5 bars (during day) and +15 bars (during night).

**Physical states of cell :** Three physical states of cell, according to their water potential, are as follows :

**In case of fully turgid cell :** In case of fully turgid cell, the net movement of water into the cell is stopped. The cell is in equilibrium with the water outside. The water potential in such a case will be zero (0).

Water potential = Osmotic potential + Pressure potential

$$\psi = \psi s + \psi p$$

A cell at full turgor has its osmotic potential and pressure potential equal but opposite in sign. Therefore, its water potential will be zero. For example, supposing a cell has its $\psi s$ of –10 bars and $\psi p$ of 10 bars the resultant water potential will be zero as follows :

$$\psi = \psi s + \psi p$$
$$\psi = -10 \text{ bars} + 10 \text{ bars}$$
$$\psi = 0 \text{ bars}$$

**In case of flaccid cell :** When a plant cell is flaccid, its turgor becomes zero (corresponding to a turgor pressure of a 0 bars). Zero turgor is approached under natural conditions when a tissue is severely wilted. A cell at zero turgor has an osmotic potential ($\psi s$) equal to its water potential ($\psi$). For example, supposing a flaccid cell has an osmotic potential of –10 bars and pressure potential ($\psi p$) of 0 bars.

Water potential = Osmotic potential + Pressure potential

$$\psi = \psi s + \psi p$$
$$\psi = -10 \text{ bars} + 0 \text{ bars}$$
$$\psi = -10 \text{ bars}$$

The water potential of the cell will be –10 bars, which is less as compared to the water potential of pure water (0 bars).

**In case of plasmolysed cell :** When the vacuolated parenchymatous cells are placed in solutions of sufficient strength the protoplast decreases in volume to such an extent that they shrink away from the cell wall. The cells are plasmolysed. Such cells have negative value of pressure potential (negative turgor pressure). The resultant water potential will be more negative, as for example, a plasmolysed cell has osmotic potential of –10 bars and pressure potential of –2 bars the water potential of the cell will be –12 bars.

Water potential = Osmotic potential + Pressure potential

$\psi = \psi s + \psi p$

$\psi = -10 + (-2)$

$\psi = -12$ bars

**Movement of water between two adjacent cells :** Suppose A and B are two adjacent plant cells where osmotic movement of water can occur. Cell A has osmotic potential ($\psi s$) of –16 bars and pressure potential of 8 bars. The cell B has osmotic potential of –12 bars and pressure potential of 2 bars. The movement of water will be as follows :

| Cell A | Cell B |
|---|---|
| $\psi s = -16$<br>$\psi p = 8$ | $\psi s = -12$<br>$\psi p = 2$ |
| $\psi = \psi s + \psi p$<br>$= -16+8 = -8.$ | $\psi = \psi s + \psi p$<br>$= -12+2 = -10.$ |

**Wilting :** A plant usually fails to survive if it is conditioned to water deficiency. The symptoms appear in the plant, plant parts or in the cells due to scarcity of water are termed as wilting. It is loss of turgidity causing folding and drooping of leaves and other soft aerial parts of the plant. It is of three types :

(1) **Incipient wilting :** There is no external symptoms but the mesophyll cells lose a part of their water content during midday due to transpiration.

(2) **Temporary wilting :** It occurs during midday and is visible externally due to drooping of leaves and young shoots. At noon the rate of transpiration is quite high as compared to water absorption, which decreases further due to depletion of water around rootlets. It is corrected in the afternoon when transpiration decreases.

(3) **Permanent wilting :** It is the last stage in wilting when the aerial parts do not regain turgidity even if placed in water saturated atmosphere. It is caused by decrease in water content of the soil which increases TSMS (Total soil moisture stress) or resistance to absorption to such an extent that plant roots are unable to absorb water. Permanent Wilting Percentage (PWP) is the percentage of water on the dry weight basis of the soil that is present in the soil when the plants growing in it first touch the condition of permanent wilting. This value varies between 1–15% and depends upon the texture of the soil *e.g.*, clay has higher PWP than sand.

## Absorption of water

Water is absorbed from soil by root system and specially by younger parts (*i.e.*, root tips). In higher plants water is absorbed through root hairs.

**Soil water :** The chief source of soil water is rain. In soil water is found in different forms. The total amount of water present in the soil is called holard, of this the available to the plant is called chresard and the water which cannot be absorbed by the plants is called echard.

Water occurs freely deep in the soil and above the parent rock, it is called ground water. These are briefly described below :

**Gravitational water :** When the water enters the soil and passes the spaces between the soil particles and reaches the water table, the type of soil water is called gravitational water.

**Capillary water :** It is the water which is held around soil particles in the capillary space present around them due to force like cohesion and surface tension. This is the water which can be utilised by the plants. It is also called growth water. It occurs in the form of films coating smaller soil particles.

The availability of capillary water to the plant depends upon its diffusion pressure deficit which is termed as the soil moisture stress. The plant cells have a DPD much more than the soil moisture stress for proper absorption of water.

**Hygroscopic water :** This is the form of water which is held by soil particles of soil surfaces. The water is held tightly around the soil particles due to cohesive and adhesive forces. Cohesive and adhesive forces greatly reduce the water protential ($\psi\omega$) and thus this type of water in soil is not available to plants.

**Run-away water :** After the rain, water does not enter the soil at all, but drained of along the slopes. It is called run-away water. Plants fail to avail this water.

**Chemically combined water :** Some of the water molecules are chemically combined with soil minerals (*e.g.*, silicon, iron, aluminium, etc.). This water is not available to the plants.

**Water vapour :** That portion of the pore space in a soil which is not occupied by liquid water contain a soil atmosphere that always includes water vapour.

**Water holding capacity :** The amount of water actually retained by the soil is called field capacity or water holding capacity of the soil. It is about 25–35% in common loam soil. The excess amount of water beyond the field capacity produces water logging.

**Soil atmosphere :** In moderately coarse soils as well as in heavy soils (fine textured soil) that are with aggregated particles; there exists large interstitial spaces which facilitate the diffusion of gases. As a result the $CO_2$ produced in a soil by respiration of soil organisms and roots is able to escape rather easily and oxygen used up in this process diffuses into the soil with corresponding case.

**Water absorbing organs :** Plants absorb water mostly from the soil by their roots, but in some plants even aerial parts like stem and leaves also do the absorption of atmospheric water or moisture. Some important examples of such plants are *Vitis, Solanum, Lycopersicon, Phaseolus, Kochia baosia* and *Beta*.

However, maximum absorption of water is done by the roots.

This area is usually characterized by the presence of root hairs which serve to increase the area of contact between the root surface and soil.

The root hairs develop mainly at the tip just above the zone of elongation (cell maturation). A root hair is the unicellular tubular prolongation of the outer wall of the epiblema.

During water absorption the plasma membrane of root hair, the cytoplasm and the vacuole membrane (tonoplast) behave together as a single differentially permeable membrane. Root hairs are at the most 1.25 *cm* in length and never more than 10 *mm* in diameter.

The root-hairs of plants increase the absorption surface of a root system about 5 to 20 times and because they extend so widely through the soil they make available a supply of water that the plant could not otherwise obtain. Water potential of root hair cells is generally –1 to –4 atm.

**Pathway of water movement in root :** Water in the root moves through three pathways. Munch coined the term apoplast and symplast.

**Apoplast pathway :** The apoplastic movement of water occurs exclusively through the cell wall without crossing any membrane.

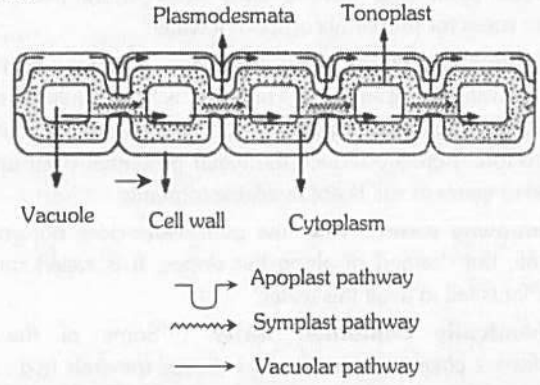



**Fig : 4.1-3 Three pathways of water movement**

**Symplast pathway :** The symplastic movement of water occurs from cell to cell through the plasmodesmata.

**Transmembrane pathway :** Water after passing through cortex is blocked by casparian strips present on endodermis. The casparian strips are formed due to deposition of wax like substance, suberin. In this pathway, water crosses atleast two membranes from each cell in its path. These two plasma membranes are found on entering and exiting of water. Here, water may also enter through tonoplast surrounding the vacuole *i.e.*, also called as vacuolar pathway.

**Mechanism of water absorption :** Two distinct mechanisms which are independently operated in the absorption of water in plants. These mechanisms are :

(1) Active absorption (2) Passive absorption

Renner (1912, 1915) coined the term active and passive water absorption.

(1) **Active absorption :** Active absorption takes place by the activity of root itself, particularly root hairs. The factor responsible for water absorption is present within the roots. It utilizes metabolic energy. There are two theories of active absorption :

**Osmotic theory :** It was proposed by Atkins (1916) and Priestley (1922). It is purely a physical process, which does not directly require expenditure of energy.

A root hair cell functions as an osmotic system. Water is absorbed by the root hair due to osmotic differences between soil water and cells sap. The osmotic pressure of soil water remains below 1 atm, but that of cell sap is usually 2–8 atms. Thus, there exists a great difference in the osmotic pressures of the two sides or in other words there exists, water potential gradient between the soil solution and cell sap. The soil solution having less OP, has higher water potential than the cell sap with more OP (*i.e.*, the cell sap has more negative water potential). Thus, water moves from the region of higher water potential towards the region of lower water potential.

**Non-osmotic theory :** It was proposed by Thimann (1951) and Kramer (1959). It has been observed that absorption of water still occurs, if the concentration of cell sap in the root hair is lower than that of the soil water, or water is absorbed against concentration gradient (*i.e.*, from higher DPD to lower DPD). Such type of water absorption occurs on the expense of energy obtained from respiration.

Following evidences support the view that energy is utilized during active absorption of water :

(i) Rate of water absorption is directly proportional to the rate of respiration.

(ii) Respiratory inhibitors such as KCN, which inhibit the absorption of water.

(iii) Auxins (growth hormones), which increase respiration also promote water absorption.

(iv) Wilting of plants occur in non-aerated soils such as water logged soils, as roots fail to absorb water in absence of respiration.

(2) **Passive absorption :** It is the most common and rapid method of water absorption. The factor responsible for water absorption is present somewhere else than roots. It accounts for about 98% of the total water uptake by plant.

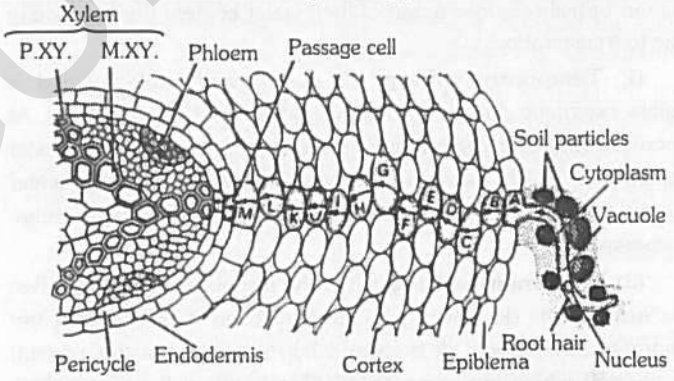



**Fig : 4.1-4 Passive absorption of water through root hair**

According to this theory, the forces responsible for absorption of water originate not in the cells of roots but in the cells of transpiring shoots. The root cells remain passive.

Due to transpiration, the DPD of mesophyll cells in the leaves increases which causes absorption of water by these cells from the xylem vessels of leaves. As the water column is continuous from leaves to roots, this deficit is transmitted to the xylem elements of roots and finally to root hairs through pericycle, endodermis and cortex. In this way water is continuously absorbed due to transpiration pull created in the leaves. This type of water transport occurs mainly through the apoplast in cortex but through the symplast in endodermis and pericycle.

The path of water from soil upto secondary xylem is :

Soil → Root hair cell wall → Cortex → Endodermis → Pericycle → Protoxylem → Metaxylem.

**Factors affecting rate of water absorption :** The different factors which influence the rate of water absorption by a plant can be divided into external or environmental and the internal factors.

**External or Environmental factors**

**The amount of soil water :** It is optimum at field capacity. Water absorption decreases above it. It begins to decline and stops at PWP.

**Concentration of the soil solution :** If the concentration of solutes increases in the soil water, its OP also increases which slows down or even inhibits the absorption of water. It happens due to addition of enough fertilizers in the soil increasing its salinity. This is popularly called as physiological dryness.

**Soil aeration :** Water absorption is done more efficiently in well aerated soil. Any deficiency of oxygen stops the respiration of roots and causes accumulation of $CO_2$ thus the protoplasm becomes viscous and the permeability of plasma membrane decreases. Due to all these factors the rate of water absorption is reduced. This is the reason for death of plants in flooded areas.

**Soil temperature :** The optimum temperature for maximum rate of water absorption ranges between 20°C and 30°C. Too high temperature kills the cells. At very low temperatures (4°C) water absorption is reduced or stopped and about O°C it is almost checked.

**Transpiration :** The rate of absorption of water is almost directly proportional to the rate of transpiration. A higher rate of transpiration increases the rate of water absorption.

**Internal factors**

**Efficiency of the root system :** A plant with deep and elaborate root system can absorb more water. The number of root hairs will be more in a highly branched and elaborate root system, thus its more surface area will be in contact with water.

In gymnosperms, the root hairs are absent, even then they are able to absorb water due to presence of mycorrhizal hyphae.

In epiphytes (orchid), the roots develop a special type of hygroscopic tissue called as velamen which can absorb atmospheric moisture.

**Metabolic activity of roots :** The poor aeration or use of metabolic inhibitors (*e.g., KCN*) inhibits the rate of water absorption. The metabolic activities help in proper growth of root system and generation of energy for absorption of certain vital minerals.

**Absorption of water through leaves :** Many species of plants can absorb atleast limited amounts of water through the leaves. Temporary immersion of aerial organs in flood waters takes place in some cases. Also the aerial organs of plants frequently become wet as a result of fog, dew or rain. Most of the water enters through the epidermal cells, although in some species hairs and specialized epidermal cells provide regions of high permeability. In general water absorption is more rapid in young leaves than in old leaves of the same plant.

## Ascent of sap

'The upward transport of water along with dissolved minerals from roots to the aerial parts of the plant is called Ascent of sap'. It is also called translocation of water. The water with dissolved minerals is called sap.

**Path of ascent of sap :** It is now well established that the ascent of sap takes place through xylem. In herbaceous plants almost all the tracheary elements participate in the process, but in large woody trees the tracheary elements of only sap wood are functional. Further, it has been proved experimentally that sap moves up the stem through the lumen of xylem vessels and tracheids and not through their walls.

**Theories of ascent of sap :** The various theories put forward to explain the mechanism of ascent of sap in plants can be placed in following three categories :

(1) Vital force theories

(2) Root pressure theory

(3) Physical force theories

(1) **Vital force theories :** According to these theories the forces required for ascent of sap are generated in living cells of the plant. These theories are not supported by experimental evidences hence they have been discarded. Some of the important vital force theories are mentioned below :

**According to Westermaier** (1883), ascent of sap occurs through xylem parenchyma; tracheids, and vessels only act as water reservoirs.

**Relay pump theory (Clambering theory) :** According to Godlewski (1884) ascent of sap takes place due to rhythmatic change in the osmotic pressure of living cells of xylem parenchyma and medullary rays and are responsible for bringing about a pumping action of water in upward direction. Janse (1887) supported the theory and showed that if lower part of the shoot is killed upper leaves were affected.

**Criticism**

(i) Strasburger (1891) and Overton (1911) used poisons (like picric acid) and excessive heat to kill the living cells of the plant. When such twigs were dipped in water, ascent of sap could still occur uninterrupted. This definitely proved that no vital force is involved in ascent of sap.

(ii) Xylem structure does not support the Godlewski's theory. For pumping action living cells should be in between two xylem elements and not on lateral sides as found.

**Pulsation theory :** Sir J.C. Bose (1923) said that living cells of innermost layer of cortex, just outside the endodermis are in rhythmatic pulsations. Such pulsations are responsible for pumping the water in upward direction. According to Bose, the pulsatory cells pump the water into vessels.

**Criticism :** Dixon failed to verify the results of Bose. It has been estimated that sap should flow through 230–240 pulsating cells per second to account for normal rate of pulsations. This rate is several times higher as would be possible to the Bose theory (Shull, MacDougal, Benedict).

(2) **Root pressure theory :** It was proposed by Priestley (1916). According to this theory the water, which is absorbed by the root-hairs from the soil collects in the cells of the cortex. The cortical cells become fully turgid. In such circumstances the elastic walls of the cortical cells, exert pressure on their fluid-contents and force them towards the xylem vessels. Due to this loss of water these cortical cells become flaccid, again absorb water, become turgid and thus again force out their fluid contents. Thus the cortical cells of the root carry on intermittent pumping action, as a result of which considerable pressure is set up in the root. This pressure forces water up the xylem vessels. Thus the pressure, which is set up in the cortical cells of the roots due to osmotic action, is known as the root pressure. This term was used by Stephan Hales. According to Style, root pressure may be defined as "the pressure under which water passes from the living cells of the root in the xylem".

**Objections**

(i) Taller plants like *Eucalyptus* need higher pressure to raise the water up. While the value of root pressure ranges from 2-5 atmospheres, a pressure of about 20 *atm.* is required to raise the water to tops of tall trees.

(ii) The absence of root pressure, ascent of sap continues.

(iii) Plants growing in cold, drought or less aerated soil, root pressure fails to appear and transport of water is normal.

In gymnosperms root pressure has rarely been observed.

(3) **Physical force theories :** According to these theories the ascent of sap is purely a physical process. Some of the physical force theories are mentioned below :

**Capillary force theory :** It was proposed by Boehm (1809). According to him, in the fine tubes, the water rises as a result of surface tension to different heights depending on the capillarity of the tube. The finer the tube, the greater will be the rise of water in it. But the xylem vessels are sometimes broader than the capillarity range, and hence the rise due to surface tension will be negligible.

**Objections**

(1) For capillarity a free surface is required.

(2) Atmospheric pressure can support a column of water only upto the height of 34 feet.

(3) Water can rise only upto the height of one meter in xylem vessels having diameter of 0.03*mm*.

(4) In gymnosperms usually the vessels are absent.

**Imbibitional theory :** It was proposed by Unger (1868) and supported by Sachs (1879). According to them, water moves upward in the stem through the walls of the xylem vessels. This theory is not accepted now because it is proved that water moves through the lumen of the xylem vessels and tracheids.

**Atmospheric pressure theory :** Due to the loss of water by transpiration, the leaves draw water from the xylem vessels through osmotic pressure. The atmospheric pressure acting on the water in the soil forces the water to rise up in the xylem vessels to fill the vacuum. But the atmospheric pressure can force the water to a height of only 10 meters. So it is evident that atmospheric pressure alone cannot force water to a height of 100 metres or more.

**Jamin's chain theory :** In xylem, water and air bubbles are found alternately. Thus upward movement occurs.

**Cohesion of water and transpiration pull theory :** This is the most widely accepted theory put forth by Dixon and Jolly in 1894, and further supported by Renner (1911, 1915), Curtis and Clark (1951), Bonner and Golston (1952), Kramer and Kozlowski (1960).

It is also known as Dixon's cohesion theory, or cohesion-tension theory.

This theory depends on the following assumptions :

(1) The xylem vessels are connected with each other, thus the water in them is in a continuous column from the root hairs to the mesophyll cells.

Walls of tracheids and vessels of xylem are made up of lignin and cellulose and have strong affinity for water (adhesion). The cell wall of adjacent cells, and those between the cells and xylem vessels all through the plant do not affect the continuity of the water column.

(2) Due to the transpiration from leaves, a great water deficit takes place in its cells. As a result of this deficit the water is drawn osmotically from the xylem cells in leaf veins, and by the cells surrounding the veins. Thus a sort of pull is produced in the uppermost xylem cells in the leaves. It is called as the transpiration pull.

(3) The water molecules have a great mutual attraction with each other or in other words we can say that they have tremendous cohesive power which is sometimes as much as 350 atmospheres. Thus the transpiration pull develops a negative pressure in the uppermost xylem cells. It is transmitted from there into the xylem of stems, and from there to the roots.

In this way the water rises due to the transpiration pull and the cohesive power of water molecules from the lowest parts of the roots to the highest peaks of the trees. The osmotic pressure in the transpiring leaf cells often reaches to 30 atmospheres whereas only 20 atmospheres are needed to raise the water to the tops of highest known trees.

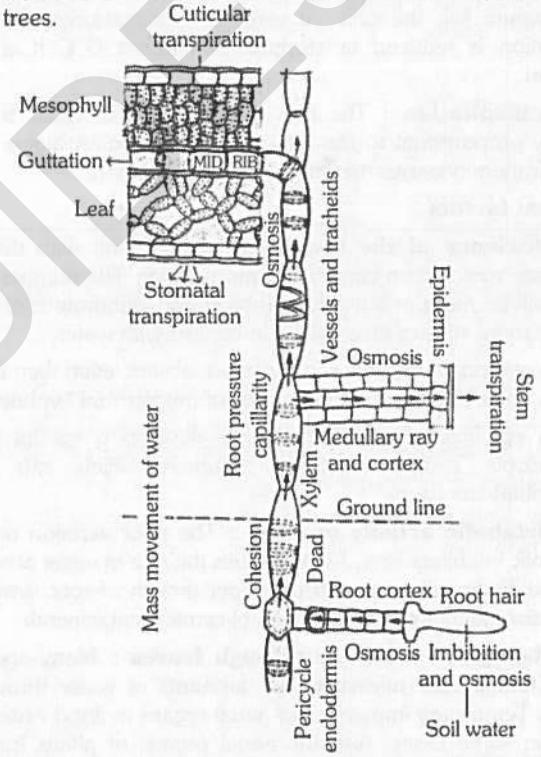



**Fig : 4.1-5 Path of ascent of sap showing transpiration pull**

**Objections :** This is the most generally accepted theory, yet there are some objections against it which it fails to explain.

The most important objection is that leaving smaller plants, the water column has been found to contain air bubbles, and so their continuity breaks at such places. This phenomenon is known as cavitation and has been demonstrated by Milburn and Johnson (1966). However, Scholander overruled this problem by suggesting that continuity of water column is maintained due to presence of pits in the lateral walls of xylem vessels.

**Velocity of ascent of sap :** Huber and Schmidt (1936) calculated the velocity of ascent of sap using radioactive $^{32}P$, specific dyes and also by heat-pulse transport between two specific points of stem. It varies between 1 and 6 meters per hour but under high transpirational conditions, it may be as high as 45 meters per hour. It is more in ring porous woods having large vessels. It is slowest in gymnosperms.

## Transpiration

"The loss of water in the form of vapours from the aerial parts of a plant is called transpiration". Maximum transpiration occurs in mesophytic plants.

About 98 percent of the water absorbed by land plants evaporates from the aerial parts and diffuse into the atmosphere.

**Table : 4.1-1**

**Differences between transpiration and evaporation**

| S.No. | Transpiration | Evaporation |
|---|---|---|
| (1) | It is a physiological process and occurs in plants. | It is a physical process and occurs on any free surface. |
| (2) | The water moves through the epidermis with its cuticle or through the stomata. | Any liquid can evaporate. The living epidermis and stomata are not involved. |
| (3) | Living cells are involved. | It can occur from both living and non-living surfaces. |
| (4) | Various forces (such as vapour pressure, diffusion pressure, osmotic pressure, etc) are involved. | Not much forces are involved. |
| (5) | It keeps the surface of leaf and young stem wet and protects from sun burning. | It causes dryness of the free surface. |

(1) **Magnitude of transpiration :** A tropical palm under well watered conditions may lose as much as 500 litres of water per day. Daily loss of water by an apple tree may be 10-20 litres. A maize plant may lose 3-4 litres of water per day.

(2) **Types of transpiration :** Most of the transpiration takes place through the leaves. It is called foliar transpiration. Stems transpire very little. Transpiration from stem is called cauline transpiration. Transpiration is of four types –

(i) **Cuticular transpiration :** Cuticle is a layer of wax like covering on the epidermis of leaves. If it is thin, upto 20 percent of the total transpiration may take place through it, but with the increase in its thickness (*e.g.*, in xerophytes), the water vapour loss is reduced.

(ii) **Lenticular transpiration :** Loss of water vapours through lenticels is called lenticular transpiration. It amounts to about 0.1 percent of the total water loss through transpiration.

(iii) **Stomatal transpiration :** The loss of water vapour, which occurs through specialized pores on leaf surface (stomata) is called stomatal transpiration. It amounts 80-90 percent of the total water vapour loss from the plants. It is the most common type of transpiration.

(iv) **Bark transpiration :** This type of transpiration occurs through corky covering of the stems. Bark transpiration is very little but its measured rate is often more than lenticular transpiration due to larger area. The amount is 0.5% of the total transpiration.

(3) **Structure of stomata :** Stomata are the microscopic openings most commonly found in the leaves. These may be present in young stems and sometimes even in fruits (*e.g.*, *citrus*, banana, *cucumber*, etc.). Each stomatal opening is surrounded by two specialized epidermal cells, called as the guard cells.

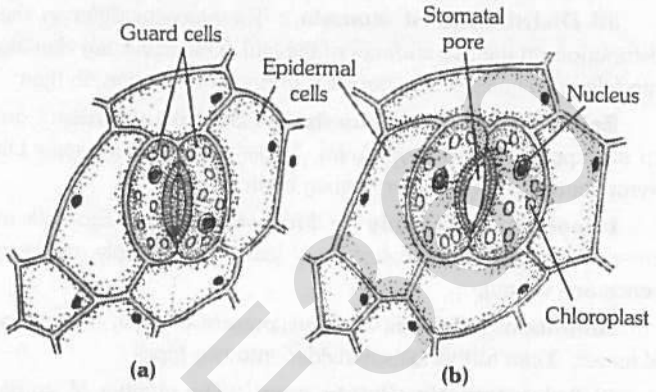



**Fig : 4.1-6 Stomatal apparatus (a) Closed (b) Open**

Because of their small size, the guard cells are rapidly influenced by turgor change and thus regulate the opening and closing of stomata. The guard cells of dicot leaves are kidney-shaped or raniform whereas those of monocots (family Gramineae) are dumbel-shaped or elliptical. The guard cells are surrounded by epidermal cells called as the accessory cells or subsidiary cells. These are different from the normal cells of epidermis having chloroplasts. These are also different from other cell as these develop from same cell from which guard cells develop. The stoma with subsidiary cells is called stomatal apparatus. Each stoma leads into a air space called sub stomatal cavity. Each guard cell has a thin layer of cytoplasm along the cell wall and a large vacuole. Its cytoplasm contains a distinct nucleus and several chloroplasts. The cell wall of guard cells around the stomatal pores are thickened and elastic due to presence of a secondary layer of cellulose.

The average length of stomata is 20–28$\mu m$ and breadth 3–10$\mu m$. The size of stomatal pore varies from species to species for example of fully opened stomatal pore of *Zea mays* measures 26$\mu m$ long and 4$\mu m$ wide.

(4) **Number of stomata on leaves :** The number of stomata is not equal on both surface of leaves in different plants. Number of stomata per square cm is 1,000–60,000 or 10–600/$mm^2$ in different plants sps.

(5) **Types of stomata :** On the basis of orientation of subsidiary cells around the guard cells, Metcalfe and Chalk classified stomata into following types :

**Anomocytic :** The guard cells are surrounded by a limited number of unspecialized subsidiary cells which appear similar to other epidermal cells. *e.g.*, in Ranunculaceae family.

**Anisocytic :** The guard cells are surrounded by three subsidiary cells, two of which are large and one is very small. *e.g.*, in Solanaceae and Cruciferae families.

**Paracytic :** The guard cells are surrounded by only two subsidiary cells lying parallel to the guard cells *e.g.*, Magnoliaceae family.

**Diacytic :** The guard cells are surrounded by only two subsidiary cells lying at right angles to the longitudinal axis of the guard cells. *e.g.*, Acanthaceae and Labiatae families.

**Actinocytic :** The guard cells are surrounded by four or more subsidiary cells and which are elongated radially to stomata.

(6) **Distribution of stomata :** The stomata differ in their distribution on the two surfaces of the leaf. The leaves are classified into following types on the basis of stomatal distribution on them :

**Epistomatic (Water Lily type) :** Stomata are present only on the upper epidermis of leaves. These are found in water Lily, Nymphaea and many other floating hydrophytes.

**Hypostomatic (Apple or Mulberry type) :** Stomata are present only on the lower surface of leaves. *e.g.*, Apple, mulberry, peach and walnut.

**Amphistomatic :** Stomata are present on both the surfaces of leaves. It can further be subdivided into two types :

(i) **Anisostomatic (Potato type) :** The number of stomata is more on the lower surface and less on the upper surface. In other words, the lower surface is multistomatic and the upper surface is paucistomatic. Such leaves are also called as dorsiventral leaves. *e.g.*, Potato, tomato, bean, pea, and cabbage.

(ii) **Isostomatic (Oat type) :** The stomata are equally distributed on both the surfaces of leaves. These leaves are also called as isobilateral leaves. These are found in monocots *e.g.*, Oat, maize, grasses, etc.

**Astomatic (Potamogeton type) :** Stomata are either absent altogether or vestigial. *e.g.*, Potamogeton and submerged hydrophytes.

(7) **Daily periodicity of stomatal movement :** Loftfield (1921) classified the stomata into four types, depending upon the periods of opening and closing.

**Alfalfa type (Leucerne type) :** The stomata remain open throughout the day but close during night, *e.g.*, Pea, bean, mustard, cucumber, sunflower, radish, turnip, apple, grape.

**Potato type :** The stomata close only for a few hours in the evening, otherwise they remain open throughout the day and night *e.g.*, Cucurbita, Allium, Cabbage, Tulip, Banana etc.

**Barley type :** These stomata open only for a few hours in the day time, otherwise they remain closed throughout the day and night, *e.g.*, Cereals.

**Equisetum type :** The stomata remain always open through out the day and night. *e.g.*, Amphibious plants or emergent hydrophytes.

(8) **Mechanism of opening and closing of stomata (Stomatal movement) :** Opening and closing of stomata occurs due to turgor pressure changes in guard cells. The transpiration is regulated by the movement of guard cells of stomata.

Several theories have been put forth to explain the opening and closure of stomata. Which have been discussed below :

**Photosynthetic theory :** According to Von Mohl (1856) the chloroplasts present in guard cells prepare osmotically active substances by photosynthesis. As a result, their osmotic pressure increases and their turgor pressure increases due to endosmosis. This results in opening of stomata.

**Objection :** In many cases, chloroplasts of guard cells are poorly developed and incapable of performing photosynthesis.

**Starch ⇌ sugar interconversion theory :** According to Lloyd (1908), turgidity of guard cell depends upon interconversion of starch and sugar. This fact was supported by Loftfield (1921) who found that guard cells contain sugar during day time when they are open and starch during night when they are closed. Later Sayre (1926) observed that stomata open in neutral or alkaline *pH* which prevails during day time due to constant removal of $CO_2$ by photosynthesis. They remain closed during night when there is no photosynthesis and due to accumulation of $CO_2$, carbonic acid is formed which causes the pH to be acidic, Sayre thus proposed that interconversion of starch and sugar is regulated by the pH. Sayre's hypothesis was supported by Scarth (1932) and Small et.al (1942). This hypothesis was further supported by detection of the enzyme phosphorylase in guard cells by Yin and Tung (1948). This enzyme is responsible for starch-glucose interconversion.

$$\underset{\text{(Stomata close)}}{\text{Starch} + \text{Pi}} \xrightarrow[pH=5\text{ (Night)}]{\text{Phosphorylase, } pH=7\text{ (Day)}} \underset{\text{(Stomata open)}}{\text{Glucose} - 1 - \text{phosphate}}$$

**Criticism**

(1) Starch ⇌ Sugar interconversion is a slow process which can not account for rapid stomatal movement.

(2) Starch or other polymerised polysaccharide do not occur in onion plant where stomatal movement occurs.

(3) Glucose is not detectable in the guard cells when stomatal opening occurs.

(4) The theory could not explain the extra-effectiveness of blue light at the time of stomatal opening.

**Stewards modification :** Steward (1964) said that glucose-I-phosphate should be further converted into glucose as glucose-I-phosphate is not capable of changing osmotic pressure. In this process of stomatal opening and closing, enzymes like phosphorylase, phosphoglucomutase, phosphatase and hexokinase are present in guard cells.

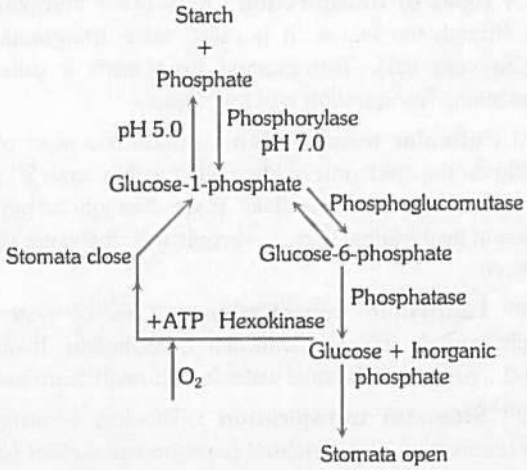



**Fig : 4.1-7 Mechanism of opening and closing of stomata according to Steward**

**Glycolate theory :** Zelitch (1963) proposed that stomata open due to production of glycolic acid by photorespiration in guard cells under low concentration of $CO_2$. The glycolic acid thus produced is converted into soluble carbohydrates which increase the O.P. of guard cells.

**Objections**

(1) It fails to explain the opening of stomata in dark (*e.g.*, in succulents).

(2) In some plants stomata have been found to remain closed even during day times.

(3) It fails to explain the effect of blue light on stomatal opening.

**Active $K^+$ ion transport theory :** Imamura (1943) and many other scientists found accumulation of $K^+$ in the guard cells when they are exposed to light. This was initially given by Fujino (1959) and later modified by Levitt (1974). This theory suggests that stomatal opening and closing occurs due to an active transport of $K^+$ into or out of the guard cells.

**Proton transport theory :** It was proposed by **Levitt** (1974). According to this theory stomatal opening and closing can be explained in the following manner :

**Mechanism of stomatal opening**

(1) During day time due to rapid rate of photosynthesis, the concentration of $CO_2$ decreases in the guard cells. As a result their *pH* is increased. At higher *pH*, starch in the guard cells is converted into organic acid by the enzyme phosphoenol pyruvate carboxylase (PEPC). This enzyme was discovered by Willmer *etal.* (1973). It can convert several other carbohydrates into organic acids.

(2) The organic acid (*e.g.*, malic acid) dissociates into $H^+$ions (protons) and malate ions.

(3) The protons ($H^+$) are actively transported into subsidiary cells in exchange for $K^+$ with the help of an energy (ATP) driven $H^+$-$K^+$-pump. The uptake of $K^+$-ions is balanced by uptake of *Cl* and the negative charge on malate-ions.

(4) Increased concentration of $K^+$ and malate ions in the guard cells increases the O.P. of guard cells.

(5) Water enters from adjoining subsidiary cells by endosmosis.

(6) Turgor pressure of guard cells increases. Turgidity of guard cell is controlled by potassium, chloride and malate.

(7) Stomata open.

**Mechanism of stomatal closure :** According to **Cowan** *et.al.* (1982) closure of stomata depends upon abscisic acid (ABA) which is in fact an inhibitor of $K^+$-uptake. It becomes functional in presence of $CO_2$ or in acidic conditions (low *pH*).

(1) During night photosynthesis stops which results in increased concentration of $CO_2$ which causes lowering of *pH*.

(2) At lower *pH*, ABA inhibits $K^+$-uptake by changing the permeability of guard cells.

(3) The $K^+$-ions now start moving out of the guard cells which results in lowering of the *pH*.

(4) At low *pH*, organic acids are converted back into starch by PEPC.

(5) The O.P. of guard cells decreases and water moves out of them into subsidiary cells by the process of exosmosis, thus decreasing their turgor pressure.

(6) The guard cells become flaccid and the stomata close.

**Stomatal opening in succulent plants (Scotoactive stomata) :** The stomata in succulent plant or CAM plants (like *Opuntia, Bryophyllum* etc.) open during night (darkness) and remain closed during the day time and found in lower surface. This type of stomatal opening is called 'Scotoactive type' and the stomata which open during day are called as photoactive. Stomata closed and open due to the activity of water. This type of stomata is known as hydroactive stomata. The opening and closing mechanism of scotoactive stomata was explained by Nishida (1963). In succulent plants, during night, there is incomplete oxidation of carbohydrates and accumulation of organic acids (*e.g.*, malic acid) without release of $CO_2$. During day time the accumulated organic acids breakdown rapidly releasing excess amount of $CO_2$ for photosynthesis as well as to keep the stomata closed.

**During night :** $2\underset{\text{Glucose}}{C_6H_{12}O_6} + 3O_2 \rightarrow 3\underset{\text{Malic acid}}{C_4H_6O_5} + 3H_2O$

**During day :** $C_4H_6O_5 + 3O_2 \rightarrow 4CO_2 + 3H_2O$.

**Factors affecting rate of transpiration**

**External factors**

**Atmospheric humidity :** If the atmosphere is humid, it reduces the rate of transpiration. When the air is dry, the rate of transpiration increases.

**Temperature :** It affects the rate of transpiration only indirectly. Increase in the temperature of the air decreases the humidity of the air and therefore more water is vapourised and lost from the transpiring surface.

**Light :** Light affects the rate of transpiration due to its effect on temperature and photosynthesis. During daytime stomata open wide but during night they close. Thus increased temperature and presence of wide open stomata increase the rate of transpiration. Light is the most important factor in the regulation of transpiration.

Maximum opening of stomata occurs in red light (660 *nm*), followed by blue light (445 *nm*) and no opening occurs in green light, UV light and far red light.

**Atmospheric pressure :** The rate of transpiration is inversely proportional to the atmospheric pressure.

**Available soil water :** If the available water in the soil is not sufficient the rate of transpiration is decreased. Under internal water deficiency the stomata are partially or completely closed.

**Wind velocity :** A transpiring surface of leaf continuously adds water vapours to the atmospheric air. Once the immediate area becomes saturated, it reduces the rate of transpiration. Wind velocity removes the air of that area, which is replaced by fresh air and result in an increase in the rate of transpiration. Wind velocity is measured by anemometer.

**$CO_2$ concentration :** Reduced $CO_2$ conc. favours opening of stomata while an increase in $CO_2$ conc. promotes stomatal closing.

Transpiration depends upon difference in vapour pressure of internal atmosphere of leaf and external environment (*i.e.*, V.P. gradient) and it is therefore, that no transpiration occurs when stomata are fully open but relative humidity is 100%.

**Internal factors/Plant factors**

**Leaf area :** If leaf area is more, transpiration is faster. However, the rate of transpiration per unit area is more in smaller leaves than in larger leaves due to high number of stomata in a small leaf. Number of stomata per unit area of leaf is called stomatal frequency.

$I = \frac{S}{E+S} \times 100$ here, I = Stomatal index

S = No. of stomata per unit area

E = No. of epidermal cells in unit area.

**Leaf structure :** The anatomical features of leaves like sunken or vestigial stomata; presence of hair, cuticle or waxy layer on the epidermis; presence of hydrophilic substances such as gums, mucilage *etc.* in the cells; compactly arranged mesophyll cells etc. help in reducing the rate of transpiration.

**Root shoot ratio :** According to Parker (1949) the rate of transpiration is directly proportional to the root-shoot ratio.

**Age of plants :** Germinating seeds show a slow rate of transpiration. It becomes maximum at maturity. However, it decreases at senescence stage.

**Orientation of leaves :** If the leaves are arranged transversely on the shoot they lose more water because they are exposed to direct sunlight. If placed perpendicularly they transpire at slower rate.

**Significance of transpiration :** The advantages and disadvantages of transpiration are discussed below :

**Advantages**

(1) Transpiration is important for plants because it directly influences the absorption of water from the soil.

(2) Transpiration exerts a tension or pull on water column in xylem which is responsible for the ascent of sap.

(3) Transpiration helps in the movement of water and minerals absorbed by the roots to the other parts of the plant.

(4) The evaporation of water during transpiration contributes to the cooling of leaves (and also the surrounding air) and protects leaves from heat injury particularly under conditions of high temperature and intense sunlight.

**Disadvantages**

(1) Transpiration often results in water deficit which causes injury to the plants by desiccation.

(2) Rapid transpiration causes mid-day leaf water deficit (temporary wilting). If such condition continues for some time, permanent water deficit (permanent wilting) may develop, which causes injury to plants.

(3) Many xerophytes have to develop structural modifications to reduce transpiration. These modifications are extra burden on the plants.

(4) Excessive rate of transpiration leads to stunted growth of plants.

(5) Since approximately 90 percent of absorbed water is lost through transpiration, the energy used in absorption and conduction of water goes waste.

Curtis (1926) truely called 'transpiration as a necessary evil'.

**Anti-transpirants :** 'The chemical substances which reduce transpiration (by increasing leaf resistance to water vapour diffusion) without affecting gaseous exchange, are called anti-transpirants'. Anti-transpirants are of two types metabolic inhibitors and film forming anti-transpirants.

**Metabolic inhibitors :** They reduce transpiration by causing partial closure of stomata without influencing other metabolite processes, the most important of these inhibitors are phenyl mercuric acetate (PMA), and abscissic acid (ABA).

**Film forming anti-transpirants :** They check transpiration by forming a thin transparent film on the transpiring surface. They are sufficiently permeable to carbon dioxide and oxygen to allow photosynthesis and respiration, but prevent movement of water vapour through them. The important chemicals of this group are silicon emulsion, colourless plastic resins and low viscosity waxes.

**Guttation :** The process of exudation of liquid drops from the edges of leaves (during night or early morning) is called guttation or the process of the escape of liquid from the tip of uninjured leaf is called guttation. It was first studied by Bergerstein in 1887. Usually it occurs through stomata like pores called hydathodes (Water Stomata). Exudation may sometime occur from stem through the scars of leaves and lenticles. Guttation usually occurs when the plant is put in more saturated atmosphere.

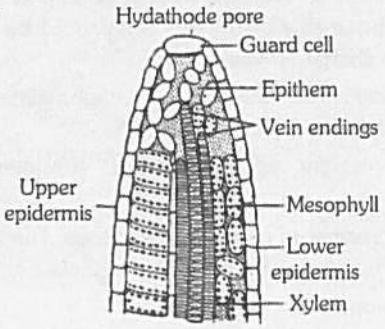



**Fig : 4.1-8 Vertical section of a leaf showing hydathode**

Hydathodes are generally present at the tip or margin of leaves. These pores are present over a mass of loosely arranged cells with large intercellular spaces called epithem. This mass of tissue lies above a vein ending. The xylem of a small vein usually terminates among the thin walled parenchymatous cells of epithem. Guttation is caused due to root pressure. It is found in 115 families and 333 genera of woody and herbaceous plants. *e.g.*, Garden nasturtium (*Tropeolum*), Oat (*Avena*), *Colocasia* etc. growing in moist, warm soil and under humid conditions. When the absorption of water exceeds that of the transpiration, hydrostatic pressure is built up in xylem ducts. As a result, water is pushed in the xylem ducts and comes out through the hydathodes. The water of guttation contains several dissolved inorganic and organic substance.

## Translocation of organic solutes

"The movement of organic food or solute in soluble form, from one organ to another organ is called translocation of organic solutes."

The process of translocation requires expenditure of metabolic energy and the solute moves at the rate of 100 *cm/hr.*

**Directions of translocation**

**Downward translocation :** It is of most important type, *i.e.*, from leaves to stem and roots.

**Upward translocation :** From leaves to developing flowers, buds, fruits and also during germination of seeds and tubers, etc.

**Radial translocation :** From pith to cortex and epidermis.

**Path of translocation**

(1) **Downward translocation of organic solutes :** Phloem is the path for downward translocation of organic food. Following evidences are in support of it :

(i) **Elimination of other tissues :** Xylem is responsible for upward movement of water and minerals, so it cannot account for downward translocation of solute at the same time. Thus only phloem is left (where there is end to end arrangement of sieve tubes united by sieve pores). Which is responsible for translocation of solutes in downward direction.

(ii) **Chemical analysis of phloem sap and xylem sap :** Chemical analysis of sieve tube sap proves that concentrated solution of sucrose is translocated from the place of synthesis to other parts of the plant body. Glucose and fructose are sometimes found in traces only. The amount of sucrose is more in phloem sap during the day and less in night. In xylem the amount of sucrose is in traces and also there is no diurnal fluctuation.

(iii) **Blocking of phloem :** Blocking of sieve pores by 'callose' during winter blocks translocation of solutes.

(iv) **Ringing or Girdling experiment :** It was first performed by Hartig (1837). On removing the ring of bark (phloem + cambium) above the root at the base of stem, accumulation of food occurs in the form of swelling just above the ring, which suggests that in absence of phloem, downward translocation of food is stopped.

(v) **Structure of phloem :** The structure of phloem tissue is well modified for conduction of solutes. Phloem tissue of an angiosperm consists of sieve tubes, companion cells several kinds of parenchyma cells, fibres and scleroids. Of these sieve tubes are involved in sugar translocation.

(2) **Upward translocation of organic solutes :** According to Curtis upward conduction of foods also takes place through phloem.

**Mechanism of translocation**

**Diffusion hypothesis :** Mason and Maskel (1928) working on cotton plant demonstrated that the translocation of foods occurs from the place of high concentration (place of manufacture or storage) to the place of lower concentration (place of consumption) but it is very slow process so Mason and Phillis (1936) modified this concept and proposed activated diffusion hypothesis. According to this concept the food particles are first energy activated then translocated. This hypothesis is not accepted due to lack of experimental evidence.

**Protoplasmic streaming hypothesis :** This concept was proposed by de Vries (1885). According to him the food is transported across by streaming current of protoplasm. The cell protoplasm shows a special locomotion movement called cyclosis. It is of two types, rotation and circulation. While rotation is circular movement of protoplasm, circulation is radial movement forming eddies around the vacuoles. The hypothesis involves two phenomenon, such as streaming of sieve protoplasm and diffusion of metabolites through sieve pores.

This hypothesis not only explains faster rate of translocation but also the bidirectional movement of metabolites across a single sieve element. This hypothesis was supported by Curtis (1950).

**Transcellular streaming :** Thaine (1964) suggested modification to cytoplasmic streaming theory. He defined transcellular streaming as "the movement of the particulate and fluid constituents of cytoplasm through linear files of longitudinally oriented plant cells. "He further proposed that transcellular strands are proteinaceous and characteristic microtubules to afford rhythmic contraction. Thus, transcellular streaming is an attractive mechanism as it would explain the phenomenon of bidirectional translocation.

**Electro-osmotic hypothesis :** A mechanism involving electro-osmosis was proposed independently by Fensom (1957) and Spanner (1958). According to this hypothesis the solute moves in the positive direction of the electrical gradient along with $K^+$ ions.

**Munch's mass flow or pressure flow hypothesis :** The mass flow or pressure flow mechanism was first proposed by Hartig (1860). It was later modified by Munch (1930). Crafts elaborated it further in 1938. Munch assumed that the protoplasm of sieve tube is connected through plasmodesmata and forms a continuous system, called as the symplast. The translocation of solutes occurs in a mass alongwith cell sap through the sieve tubes from a region of higher turgor pressure to low turgor pressure (*i.e.*, along a turgor pressure gradient).

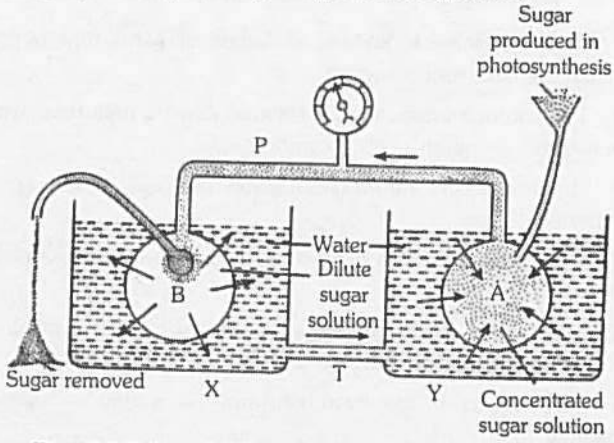



**Fig : 4.1-9 A model demonstrating the Munch mass flow hypothesis**

**Munch's hypothesis has been supported further by the following :**

When a woody or herbaceous plant is girdled, the sap containing high sugar content exudates from the cut end. Positive concentration gradient disappears when the plants are defoliated. Movement of viruses and growth hormones is fast in illuminated leaves as compared to shaded leaves.

**Objections :**

The hypothesis fails to explain bidirectional movement of metabolites which is common in plants. Osmotic pressure of mesophyll cells and that of root hair do not confirm the requirements. Munch's hypothesis gives a passive role to the seive tube elements and the protoplasm.

**Factors affecting translocation**

**Temperature :** Optimum temperature for translocation ranges between 20-30°C. The rate of translocation increases with the increase of temperature upto an upper limit and then starts declining. At low temperature, the rate of translocation decreases.

**Light :** Hartt and his coworkers (1964) proposed that the movement of assimilates of a leaf can depend upon radiant energy. The increase in light intensity more food starts being translocated to roots than to shoots. At lower intensity the growth of root and shoot is inhibited thereby the rate of translocation also decreases.

**Hormones :** Cytokinins have a pronounced effect on the translocation of water soluble nitrogen compounds.

**Oxygen :** Oxygen is necessary during transfer of food from mesophyll cells into phloem which is called as phloem loading.

**Minerals :** Boron is highly essential for translocation of sugar. Phosphorus also helps in translocation of solutes.

**Water :** Translocation of photosynthates out of the leaves is highly sensitive to the amount of water in the plant cells.

**Metabolic inhibitors :** The metabolic inhibitors which inhibit the process of respiration (*e.g.*, iodoacetate, HCN, carbon monoxide etc.) adversely affect the process of translocation because phloem loading and unloading require ATP.

## Tips & Tricks

- Stephen Hales is known as father of plant physiology. Coined the term root pressure.
- The osmotic pressure of a solution can be measured with the help of a apparatus called osmometer.
- Molar solution : 1gm mole of solute plus 1 *litre* / 1000*cc* of solution.
- Molal solution : 1gm mole of solute plus 1 *litre* / 1000*cc* of solvent.
- Cryoscopic osmometer measures the osmotic potential of solution by measuring its freezing point.
- Tensiometer is the instrument for measuring soil water potential.
- The amount of water left in the soil after the plant has permanently wilted is the wilted coefficient.
- Humus and clay are two colloidal complexes of soil.
- Cohesive force is called as tensile strength of water.
- Manometer (Gk. manos – thin, metron – measure). An instrument for measuring pressure of tension (such as root pressure) in gases and liquids.
- Cohesive strength of 47-207 atm. in xylem sap is sufficient to meet the stress of transpiration pull, so that water column does not break.
- Osmotic pressure is maximum in noon. At this time water contents in the cell are minimum.
- Osmotic pressure is highest in halophytes.
- In night, root pressure will be maximum because in night transpiration is zero.
- Pressure bomb technique was used by Scholander et al.
- Psychorometer is used for measuring relative humidity as well as transpiration.
- Hydrometer is used for measuring the density or specific gravity of a liquid.
- Barometer is used for measuring atmospheric pressure.
- Barograph represents the recording of barometer.
- Porometer is used for measuring the size of stomata.
- Atmometer is used for measuring pull caused by evaporation of water from a porous pot.
- Potometer is used for measuring the rate of transpiration.
- Potometer works on the principle of amount of water absorbed equals the amount transpired.
- Transpiration on hills : High due to lower atmospheric pressure but low due to lesser hours of light and lower temperature. Transpiration is therefore, near normal but the plants show xeromorphy due to lesser water availability.
- In Saxifraga, the rate of guttation is high during flowering.
- Maximum opening of stomata occurs at about 10:00 AM and 3:00 PM (At 12:00 noon, partial closure of stomata occurs).
- In $C_3$ plant the rate of transpiration is high.
- Cobalt chloride paper method was first used by Stahl (1894). It is used to compare rate of transpiration on two surfaces of leaf. Cobalt chloride is blue in anhydrous state. In contact with water vapour it turns pink.
- Bleeding is the exudation of sap (water along with dissolved organic and inorganic substances) from the injured parts of the plant *e.g.*, exudation of latex from laticiferous ducts in Euphorbia and members of family moraceae (mulberry family) are the cases of bleeding.
- When transpiration is very low and absorption is high, the root pressure is maximum.
- In aquatic and submerged plants stomata are absent *e.g.*, Vallisneria.
- Mittler (1958) develop a technique for the collection of phloem sap using an aphid stylet.
- The principle pathway by which water is translocated in angiosperm is xylem and vessels.

# Ordinary Thinking

## Objective Questions

### General

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

2. Some leaves are removed from the stem cuttings planted for vegetative propagation. This is done **[BHU 1994]**
   (a) To increase water uptake
   (b) Because it helps in rooting of cuttings
   (c) To reduce water loss
   (d) Because the cuttings need less food

3. Exchange of substances between individual cells and their environments takes place by **[BHU 2002]**
   (a) Osmosis (b) Diffusion
   (c) Active transport (d) All of these

4. When a bark of tissue is cut from stem, of which the vascular tissue is removed
   (a) Xylem (b) Phloem
   (c) Parenchyma (d) None of these

5. Best soil for healthy and vigorous growth of a plant is **[BVP 2004; CPMT 2010]**
   (a) Sandy soil (b) Loam
   (c) Clay (d) None of these

6. Soil formed after leaching and rich in *Al* and *Fe* is **[DPMT 2004]**
   (a) Alluvial (b) Podosol
   (c) Laterite (d) None of these

7. Active transport of ions by the cell requires **[MP PMT 2002]**
   (a) High temperature (b) ATP
   (c) Alkaline *pH* (d) Salts

8. Good soil is **[CPMT 2004]**
   (a) Which holds 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 limited amount of water to retain into it

9. Lenticels and hydathodes are small pores with following common attributes **[BHU 1994]**
   (a) Their opening and closing is not regulated
   (b) They allow exchange of gases
   (c) They always remain closed
   (d) They are found on the same organ of plants

10. Which of the events is more rapid
    (a) Suction of water and minerals due to transpiration pull
    (b) Cyclosis in cell cytoplasm
    (c) Sugar transport in phloem
    (d) Distribution of hormones from one part to other

11. Attractive forces of cell walls for water molecules is termed as **[NCERT; Kerala PMT 2010]**
    (a) Adhesion (b) Cohesion
    (c) Osmosis (d) Plasmolysis

12. In trees, death of protoplasts is essential for a vital function such as **[BHU 1994]**
    (a) Stomatal movements
    (b) Both water and food transport
    (c) Water transport
    (d) Food transport

13. Which of the following is not a function of water in cell **[RPMT 2002]**
    (a) It provides energy for chemical reaction
    (b) It acts as a solvent
    (c) It provides a medium for chemical reaction
    (d) It releases hydrogen ions on ionisation

14. Active absorption is affected by **[RPMT 1999]**
    (a) Osmotic concentration
    (b) Associate tissue structures
    (c) Transpiration
    (d) Sucking capacity of root hair

15. Which one of the following doesn't help in molecule transport **[BHU 2003]**
    (a) Diffusion (b) Osmosis
    (c) Surface tension (d) Active transport

16. 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

17. Water infiltration will be slowest in **[AIEEE Pharmacy 2004]**
    (a) Black cotton soil (b) Sandy soil
    (c) Red soil (d) Loamy soil

18. Meaningful girdling (Ringing) experiments cannot be done on sugarcane because **[CBSE PMT 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

19. The amount of water held by the soil after drainage is known as **[BHU 1999]**
    (a) Mineral water (b) Soil water
    (c) Field capacity (d) Gravitational capacity

### Membranes, Osmosis, Diffusion, Imbibition, Plasmolysis and Wilting

1. Osmosis is the diffusion of **[NCERT; Odisha JEE 2008]**
   (a) Solute (b) Free energy
   (c) Water (d) Solute and solvent

**2.** The relationship $\pi v = nRT$ is not obeyed by **[Odisha JEE 2012]**
(a) Concentrated solution (b) Dilute solution
(c) Extremely dilute solution (d) All of these

**3.** That the cell membrane is selectively permeable can be best deduced by
(a) The entry of water from root hair
(b) The entry of mineral salts from the root hair
(c) Both together
(d) The rise of sap in plants

**4.** The cell wall is permeable and not a semipermeable structure can be best deduced from the passage of water and mineral salts from
(a) Soil into periplasmic space of root hairs
(b) Root hairs to cortical cells
(c) Cortical cells to pericycle
(d) Pericycle to trachea

**5.** What happens when formalin preserved *Spirogyra* filament is placed in a hypertonic sugar solution
(a) It gains turgidity (b) It looses turgidity
(c) It becomes plasmolysed (d) Nothing happens

**6.** Selective permeability identifies the process of transmission through semipermeable membrane is called **[AFMC 2003]**

**Or**

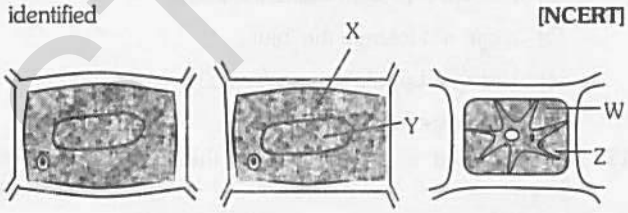
The movement of water from higher water potential to lower water potential through a semi-permeable membrane is called **[J & K CET 2010; WB JEE 2016]**

**Or**

Living cells placed in isotonic solution (0.9% saline) retain their size and shape. This is based on the concept of **[WB JEE 2012]**
(a) Diffusion (b) Osmosis
(c) Plasmolysis (d) Imbibition

**7.** The process of osmosis involves
(a) Movement of solute through semipermeable membrane
(b) Movement of solvent through a semipermeable membrane
(c) Movement of solution through a semipermeable membrane
(d) None of the above

**8.** The given figure shows plasmolysis in cell. A is normal turgid cell, B shows incipient plasmolysis and C is plasmolysed cell. Select the right option in which W, X, Y and Z are correctly identified **[NCERT]**




(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

**9.** Assume that an actively respiring cell has 3x number of $K^+$ in its cytoplasm and 2x number of $K^+$ outside. After sometime, x number of $K^+$ entered into the cell. What is the process by which $K^+$ transport has taken place **[EAMCET 2009]**
(a) Primary active transport
(b) Secondary active transport
(c) Diffusion
(d) Passive transport

**10.** A *RBC* and a plant cell (with thick cell wall) are placed in distilled water. The solute concentration is the same in both the cells. What changes would be observed in them **[KCET 2009]**
(a) Both plant cell and *RBC* would not undergo any change
(b) The *RBC* would increase is size and burst while the plant cell would remain about the same size
(c) The plant cell would increases in size and burst while the *RBC* would remain about the same size
(d) Both plant cell and *RBC* would decrease in size and collapse

**11.** In the process of osmosis **[AFMC 1995]**
(a) Both protoplasm and cell wall act as a single layer
(b) Only protoplast acts as a single layer
(c) Only cell membrane acts as a single layer
(d) None of the above

**12.** A professor kept some moist seeds in an airtight jar and started lecturing. At the end of the experiment an explosion occurred in the jar. What did the professor want to explain **[CBSE PMT 1990]**
(a) Osmosis (b) Diffusion
(c) Anaerobic respiration (d) Imbibition

**13.** Plant cell plasmolysed in a solution which is **[MP PMT 1998, 2006; Odisha JEE 2008]**

**Or**

If a cell is reduced in size on placing in a solution of sugar, the solution is **[RPMT 2002; AFMC 2009]**
(a) Hypotonic (b) Hypertonic
(c) Isotonic (d) Concentration no means

**14.** Osmosis is defined as the process in which **[MP PMT 1998]**
(a) Water diffuses from lower concentration to higher concentration
(b) Solutes diffuse from lower concentration to higher concentration
(c) Active transport of ions takes place
(d) Passive transport of ions takes place

**15.** Graham's law is correlated with **[WB JEE 2009]**
(a) Diffusion (b) Osmoregulation
(c) Osmosis (d) Adsorption

**16.** The first process by which water enters into the seed coat when a seed is placed in suitable environment for germination is **[Bihar MDAT 1995; KCET 2007; Kerala PMT 2011]**

**Or**

In seed germination, the first phenomenon take place is **[Bihar MDAT 1995]**
(a) Osmosis (b) Active transport
(c) Absorption (d) Imbibition

**17.** Which of the following experiment is called physiological demonstration of osmosis **[KCET 2007]**
(a) Thistle funnel – whose mouth is tied with egg membrane
(b) Thistle funnel – whose mouth is tied with parchment paper
(c) Potometer
(d) Bell jar experiment

**18.** An example of selectively permeable membrane is
(a) Plasmalemma (b) Cell wall
(c) Mitochondrial membrane (d) Chloroplast membrane

**19.** Plasma membrane controls
(a) Passage of water
(b) Passage of water and some solutes in and out of the cell
(c) Passage of water and solutes into the cell
(d) Movements of the cell contents out of the cell

**20.** Which plant is used for demonstrating plasmolysis in the laboratory
(a) *Tropeolum* (b) *Impatiense balsamia*
(c) *Tradescantia* (d) All the above

**21.** Force developed in cortex of root which pushes water into xylem of root from soil **[Odisha JEE 2005]**
(a) Diffusion (b) Osmotic pressure
(c) Turgor pressure (d) Root pressure

**22.** Plant cells submerged in distilled water will become **[MP PMT 1998]**
(a) Turgid (b) Flaccid
(c) Plasmolysed (d) Impermeable

**23.** Process of osmosis shall cease when
(a) Solutions become isotonic or DPD becomes equal
(b) Water concentration becomes equal
(c) There is no light
(d) The level of water falls

**24.** Which of the following has more imbibition power
(a) Cellulose (b) Hemicellulose
(c) Fat (d) Protein

**25.** Wilting occurs when **[AFMC 2004, 08]**
(a) Rate of transpiration is higher than absorption
(b) Rate of absorption is higher than transpiration
(c) Excess root pressure
(d) High relative humidity in air

**26.** When plant cells are kept in a concentrated salt solution, they are **[MP PMT 1994; BVP 2004]**
(a) Deplasmolysed (b) Plasmolysed
(c) Remains as such (d) Becomes turgid

**27.** The initial stage of water absorption by root cells is by
**Or**
Dry seeds when placed in water swells due to **[NCERT; CPMT 1994]**
(a) Adsorption (b) Absorption
(c) Osmosis (d) Imbibition

**28.** The process by which large molecules move out of the cell is called
(a) Plasmolysis (b) Deplasmolysis
(c) Phagocytosis (d) Reverse phagocytosis

**29.** In the process of plasmolysis **[CPMT 1995]**
(a) Endosmosis occurs (b) Exosmosis occurs
(c) Imbibition occurs (d) Diffusion occurs

**30.** In the process of osmosis, volume of solvent **[AFMC 1996]**
(a) Increases
(b) Decreases
(c) Remains same
(d) Volume is not related in osmosis
(e) Endosmosis

**31.** The membrane which allows passage of certain substances more readily than others is termed as **[BVP 2003]**
(a) Impermeable (b) Semisolid
(c) Permeable (d) Selectively permeable

**32.** What shall be the sequence of events during wilting of a plant **[Kerala CET 2002]**
(a) Exosmosis, deplasmolysis, wilting
(b) Endosmosis, plasmolysis, wilting
(c) Exosmosis, plasmolysis, wilting
(d) Endosmosis, deplasmolysis, wilting

**33.** A plasmolysed cell can be deplasmolysed by placing it in **[BVP 2002]**
(a) Isotonic solution
(b) Hypertonic solution
(c) Saturated solution
(d) Pure water or hypotonic solution

**34.** What would happen if a thin slice of sugar beet is kept in *NaCl* **[CPMT 2002]**
(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

**35.** When a potato piece is kept in a highly concentrated salt solution, then **[CBSE PMT 2002]**
(a) Potato is plasmolysed
(b) Potato is deplasmolysed
(c) Potato cells get bursted
(d) There is no effect due to isotonic solution

**36.** Osmosis is helpful to plant because
(a) Growth of the young cells is brought about by osmotic pressure and turgor pressure of these cells
(b) Certain turgor moments in plants are determined by osmosis
(c) Both (a) and (b)
(d) None of these

**37.** In rainy season, the doors get wet due to **[AIIMS 2001; GUJCET 2015]**
(a) Imbibition (b) Absorption
(c) Diffusion (d) Endosmosis

**38.** Due to plasmolysis, the plant cell **[Kerala CET 1999; GUJCET 2014]**
(a) Bursts (b) Swells up
(c) Becomes turgid (d) Becomes flaccid

**39.** The plant undergoes wilting when **[CPMT 1993, 94, 2002; AFMC 2005; RPMT 2005; BHU 2006; WB JEE 2009]**
(a) Xylem is blocked
(b) Cambium is blocked
(c) Phloem is blocked
(d) Some roots are reduced in number

**40.** In some plants, the leaves droop down during day while become normal during night
(a) Due to temporary wilting (b) Permanent wilting
(c) Both (a) and (b) (d) None of the above

**41.** Wilting of a plant results from excessive **[CPMT 1994; AFMC 2001]**
(a) Respiration (b) Photosynthesis
(c) Absorption (d) Transpiration

**42.** The plants face wilting due to use of excessive fertilizers because of **[CPMT 1998]**
(a) Exosmosis (b) Endosmosis
(c) Imbibition (d) None of these

**43.** How water rises from the rhizoids of *Riccia* to its assimilatory filaments ? It is through
(a) Osmosis (b) Root pressure
(c) Capillary (d) Transpiration pull

**44.** Which of the following seeds will show more imbibitional pressure
(a) Til seeds (b) Gram seeds
(c) Wheat seeds (d) Rice seeds

**45.** Movement of molecules of gases, liquids and solids from a region of higher concentration to a region of lower concentration is termed as **[KCET 1994; RPMT 1995]**
**Or**
Movement of particles of matter in the cell due to its own kinetic energy is called
(a) Diffusion (b) Evaporation
(c) Transpiration (d) Osmosis

**46.** During osmosis, water moves through a membrane **[MP PMT 1993; RPMT 1999]**

| | 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) |

**47.** Incipient plasmolysis is **[WB JEE 2016]**
(a) Last stage of plasmolysis
(b) Mid stage of plasmolysis
(c) Zero hour for inception of plasmolysis
(d) Initial stage of plasmolysis

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

**1.** The osmotic parameter determining flow of water from one cell to another is
**Or**
The actual pressure with which water enters into cell is called **[Pb. PMT 1999, 2004]**
(a) Osmotic pressure (b) Turgor pressure
(c) Diffusion pressure deficit (d) Hydrostatic pressure

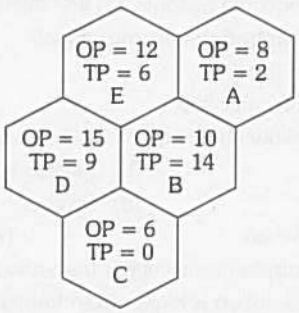
**2.** Addition of solute in the cell develops **[AFMC 2008]**
**Or**
DPD of a cells mainly depends upon **[BHU 2012]**
(a) TP (b) OP
(c) DP (d) WP

**3.** 0.1*M* solution of a solute has a water potential of **[MP PMT 1995; BVP 2002]**
(a) –2.3 bars (b) 0 bar
(c) 22.4 bars (d) + 2.3 bars

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

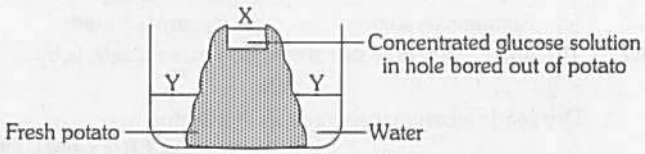
**5.** Which of the following statements are true / false
A. The positive hydrostatic pressure is called turgor pressure
B. Wall pressure exerts to prevent the increase of protoplasm size
C. Diffusion is more rapid in liquids than in gases
D. Diffusion of water through a semi–permeable membrane is called imbibition
E. Osmosis is movement of substances which takes place along a diffusion gradient **[Kerala PMT 2006]**
(a) *A* and *B* are true & *C*, *D* and *E* are false
(b) *A* and *C* are true & *B*, *D* and *E* are false
(c) *A* and *D* are true & *B*, *C* and *E* are false
(d) *A* and *E* are true & *B*, *C* and *D* are false
(e) *C*, *D* and *E* are true & *A* and *B* are false

**6.** See the following diagram, when the TP of the cell B increases to 18. What changes would be occur with regard to water movement **[NCERT]**




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

**7.** Observe the following experiment




After a few days, which of the following changes will have occurred **[NCERT]**
(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

**8.** Cell *A* has osmotic potential of –18 bars and pressure potential of 8 bars, whereas, cell *B* has osmotic potential of –14 bars and pressure potential 2 bars. The direction of flow of water will be **[AIIMS 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

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

**10.** In a fully turgid cells, the values of DPD, OP and TP will show the tendency

**Or**

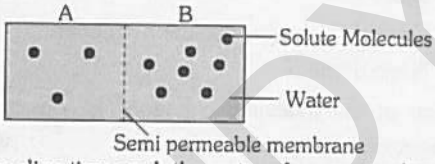
The cell is fully turgid when
**[J & K CET 2002; WB JEE 2010; Odisha JEE 2010]**
(a) DPD = 10 atm, OP = 15 atm, TP = 5 atm
(b) DPD = 5 atm, OP = 12 atm, TP = 7 atm
(c) DPD = 2 atm, OP = 7 atm, TP = 5 atm
(d) DPD = 0 atm, OP = 15 atm, TP = 15 atm

**11.** The osmotic potential and pressure potential of three cells (A, B, C) located in different parts of an actively transpiring plant are given below

| Cell | Osmotic Potential (Mpa) | Pressure Potential (Mpa) |
|---|---|---|
| A. | –0.87 | 0.44 |
| B. | –0.92 | 0.34 |
| C. | –0.68 | 0.27 |

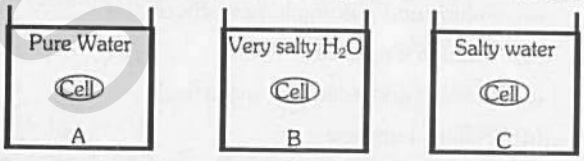
Identify these three cells as root hair, root cortical and leaf mesophyll cells respectively **[EAMCET 2009]**
(a) A, B, C (b) A, C, B
(c) C, A, B (d) B, C, A

**12.** See the following figure and point out the statement which is not correct **[NCERT]**




(a) The direction and the rate of osmosis depend upon both the pressure gradient and conc. gradient
(b) Presence of a 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

**13.** Select the correct statement for diagram below **[NCERT]**




(a) Cell "A" will gain $H_2O$, Cell "B" will lose $H_2O$, Cell "C" neither gain nor loses $H_2O$
(b) Cell "A" will gain $H_2O$, Cell "B" neither gain nor loses $H_2O$, Cell "C" will lose $H_2O$
(c) Cell "A" neither gain nor loses $H_2O$, Cell "B" will gain $H_2O$, Cell "C" will loses $H_2O$
(d) Cell "A" will lose $H_2O$, Cell "B" will gain $H_2O$, Cell "C" neither gain nor loses $H_2O$

**14.** 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 **[CBSE PMT 2007]**
(a) Movement of water from cell *B* to *A*
(b) No movement of water
(c) Equilibrium between the two
(d) Movement of water from cell *A* to *B*

**15.** If water enters in a cell, the pressure exerted by its swollen protoplast is **[AFMC 2004]**

**Or**

Turgidity of the cells is maintained by
(a) Turgor pressure (b) DPD
(c) Osmotic pressure (d) Imbibition

**16.** Addition of a solute to pure water causes **[MP PMT 2001]**
(a) Negative water potential
(b) More negative water potential
(c) Positive water potential
(d) More positive water potential

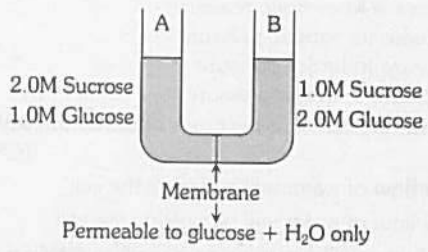
**17.** The ratio of osmotic pressure exerted by 1 *M* sucrose and 1 *M NaCl* solution will be **[AIIMS 2010]**
(a) 1 (b) 2
(c) 0.1 (d) 0.5

**18.** When 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

**19.** Which one of the following statements is wrong **[Kerala PMT 2007]**
(a) Water potential is the chemical potential of the water
(b) 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

**20.** What will be the effect of accumulation of $K^+$ *ions* in guard cells **[GUJCET 2007]**
(a) Water potential increases (b) Water potential decreases
(c) Loss of turgidity (d) Exosmosis

**21.** Observe the following figure

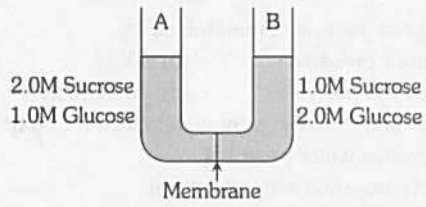



After the system reaches equilibrium, Which of the following changes will have occurred **[NCERT]**
(a) First the level of water is high in tube A and than water level is decreased
(b) No change is observed
(c) The water level is higher in side B than in side A
(d) The water level is higher in side A than in side B

**22.** Under given suitable conditions, the DPD will be more than OP **[BHU 1994]**
(a) When OP is equal to TP
(b) When OP is less than TP
(c) When OP is greater than TP
(d) When TP is negative

**23.** Water is necessary for... **[MP PMT 2005]**
(a) Content of protoplasm (b) Solvent
(c) Reagent (d) All above

**24.** See the following diagram




Initially solution in side A, with respect to side B, is **[NCERT]**
(a) Lower (b) Isotonic
(c) Hypertonic (d) Hypotonic

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

**26.** Solute potential of 0.a solution is always **[DUMET 2010]**
(a) $= 0$ (b) $> 0$
(c) $< 0$ (d) Between 0-1

**27.** Osmotic pressure of a solution is **[BVP 2004]**
(a) Greater than pure solvent
(b) Less than pure solvent
(c) Equal to pure solvent
(d) Less than or greater than pure solvent

**28.** Identify the correct relationship with reference to water potential of a plant cell. **[KCET 2006]**
(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) $\psi_w = \psi_m - \psi_s - \psi_p d$

**29.** Water potential $\Psi$ measured in *bar* or in
(a) $lb/in^2$ (b) *mm* of *Hg*
(c) atm (d) All the above

**30.** Glucose is not stored in plant due to **[CPMT 2010]**
(a) Decrease in osmotic pressure
(b) Increase in osmotic pressure
(c) Increase in turgor pressure
(d) Decrease in turgor pressure

**31.** When osmotic pressure becomes equal to the wall pressure, then **[CPMT 1995]**
(a) The flow of water will be inside the cell
(b) The flow of water will be outside the cell
(c) Both flow will occur inside as well as outside
(d) There will be no flow

**32.** 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 is separated by a semipermeable membrane **[AFMC 2003; KCET 2010]**
(a) B to A (b) A to B
(c) Both directions (d) None of these

**33.** Turgor pressure becomes equal to the wall pressure when **[Pb. PMT 1999]**
(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

**34.** When a plasmolysed cell is placed in a hypotonic solution then water will move inside the cell. Which force causes this **[RPMT 2002]**
(a) DPD (b) OP
(c) WP (d) None of these

**35.** When a cell is fully turgid, which of the following will be zero **[CBSE PMT 1997]**

**Or**

The potential energy of water is referred to as **[J & K CET 2005]**
(a) Wall pressure (b) Osmotic pressure
(c) Turgor pressure (d) Water potential

**36.** When water moves through a semipermeable membrane, which of the following is created **[CPMT 1999; BHU 2000; CBSE PMT 2001]**
(a) *OP* (b) *SP*
(c) *TP* (d) *WP*

**37.** Which statement is correct **[DPMT 2004]**
(a) Osmotic pressure of solution is greater than pure solvent
(b) Osmotic pressure of solution is lower than the pure water
(c) Osmotic pressure of solution is equal
(d) None of these

**38.** Which of the following equations is correct in respect of osmotic phenomenon **[WB JEE 2016]**
(a) $DPD = OP - TP$ (b) $DPD = OP + TP$
(c) $DPD = OP \times TP$ (d) $DPD = OP \div TP$

## Absorption of water and Ascent of sap

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

**2.** Most widely accepted explanation for the ascent of sap in tree is **[RPMT 1995; Pb. PMT 1999, 2000; BHU 2001; CBSE PMT 2001; J & K CET 2002; Kerala PMT 2009]**
(a) Capillarity
(b) Roll of atmospheric pressure
(c) Pulsating action of living cells
(d) Transpiration cohesion theory of Dixon

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

**4.** Which of the following is not true for active transport **[Odisha JEE 2012]**
(a) It is a chemical process
(b) Energy is required for this process which is obtained in the form of *ATP*
(c) It takes place through special organic molecules called carrier molecules
(d) This process is not modified by enzymes

**5.** Upward movement of water in plants is called **[BHU 2012]**
(a) Sucking (b) Ascent of sap
(c) Translocation (d) None of these

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

**7.** The factor or process which best explains the rise of water from roots(100 *mts*) to the top of tall tree is **[UGET Manipal 1995, 96, 2005; KCET 2011; Odisha JEE 2011]**
(a) Break down of ATP
(b) Root pressure
(c) Capillary rise of water in xylem
(d) Cohesion of water and transpiration pull

**8.** The path of water from soil upto secondary xylem is **[Kerala PMT 2008; KCET 2012]**
(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

**9.** Physical force theory explains
(a) Non-living cells are not essential for ascent of sap
(b) Living cells are not essential for ascent of sap
(c) Ascent of sap may occur in both living and non-living cells
(d) Both (b) and (c)

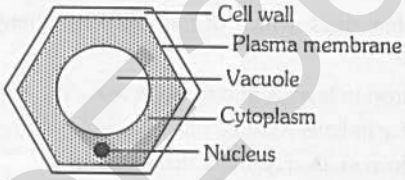
**10.** The rupture and fractionation do not usualy occur in the water column in vessel/tracheids during the ascent of sap because of **[CBSE PMT 2008]**
(a) Weak gravitational pull (b) Transpiration pull
(c) Lignified thick walls (d) Cohesion and adhesion

**11.** Which of the following would be in insignificant amount in xylem sap **[KCET 2009]**
(a) Sugar (b) Nitrates
(c) Phosphates (d) Water

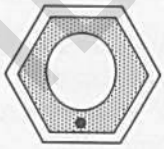
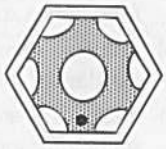
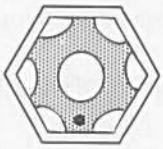
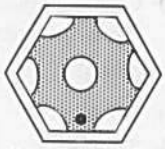
**12.** Bordered pits relating with water uptake located in
(a) Cortex
(b) Endodermis
(c) Vessel elements (Xylem duct)
(d) Tracheary elements

**13.** Most of the water flow in the root takes place *via* the apoplast because **[AMU (Med.) 2009]**
(a) Cortical cells are loosely arranged
(b) Cortical cells are living cells
(c) Cortical cells are thin walled cells
(d) All of the above

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

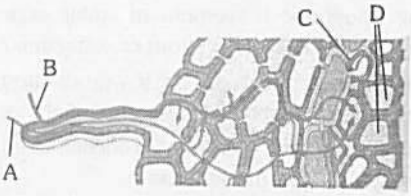



Which of the following diagrams shown below most accurately represents the appearance of this cell after immersion in a hypertonic solution **[NCERT]**

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

**15.** Which of the following helps in the absorption of water and mineral salts **[CPMT 1994; AIIMS 1999]**
(a) Mycorrhiza (b) *Anabaena*
(c) *Nostoc* (d) None of these

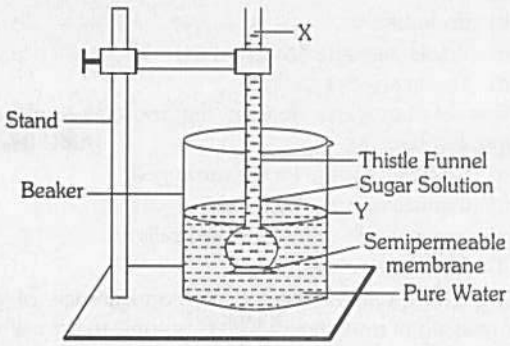
**16.** The given diagram indicates routes of transport of water and minerals from the soil through the root. Identify letters A, B, C and D **[NCERT]**




(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

**17.** The movement of water from one cell of the cortex to the adjacent one in roots is due to **[CBSE PMT 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

**18.** Examine the experiment shown in the given figure




After a few days, which of the following changes will have occurred **[NCERT]**

(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

**19.** Passage cells are thin walled cells found in **[CBSE PMT 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 emergence of growing embryonic axis during seed germination
(d) Central region of style through which the pollen tube grows towards the ovary

**20.** Movement of $H_2O$ through cell wall is called **[DPMT 2007]**

(a) Apoplast (b) Symplast
(c) Tonoplast (d) None of these

**21.** If two solutions have the same osmolarity, they are said to be **[J & K CET 2005]**

(a) Hypertonic (b) Hypotonic
(c) Isotonic (d) None of these

**22.** 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 **[Kerala PMT 2007]**

(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

**23.** Which of the following statements is incorrect

(a) Water and salts are taken simultaneously by root hairs
(b) Plants absorb one thing at a time either water or inorganic salt
(c) Plants absorb excess quantity of water
(d) All of the above

**24.** Apoplastic movement of water in plants occurs through **[DUMET 2010]**

(a) Casparian strips (b) Plasma membrane
(c) Intracellular spaces (d) Plasmodesmata

**25.** When the concentration of the soil solutes is low, the absorption of water **[KCET 2007]**

(a) Remains normal (b) Is stopped
(c) Is increased (d) Is decreased

**26.** Simultaneous movement of two molecules across a membrane in the same direction is know as **[NCERT; DUMET 2010]**

(a) Antiport (b) Symport
(c) Uniport (d) Biport

**27.** Most accepted theory for ascent of sap is **[BHU 2006]**

**Or**

Sap ascends in woody stems because of root pressure and

(a) Capillarity theory (b) Root pressure theory
(c) Pulsation theory (d) Transpiration pull

**28.** Root system in a plant is well developed **[CBSE PMT 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

**29.** During absorption of water by roots, the water potential of cell sap is lower than that of **[BHU 1994]**

(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

**30.** Storage capacity of the soil is the extent to which it can hold **[RPMT 1995; Pune CET 1998; WB JEE 2016]**

**Or**

In soil, water available for plants is **[CBSE PMT 1999; KCET 1999; BVP 2001; DUMET 2009]**

(a) Gravitational water (b) Capillary water
(c) Hygroscopic water (d) All of the above

**31.** Active transport is characterized by **[RPMT 1997; AMU (Med.) 2010]**

(a) Requires special membrane proteins
(b) Highly selective
(c) Requires ATP energy
(d) All of the above

**32.** The transport of water and salts takes place through **[CPMT 1996; MP PMT 1999, 2006]**

(a) Phloem (b) Xylem
(c) Sieve tubes (d) Sclerenchyma

**33.** The direction of water in the leaflets of *Cycas* from midrib is **[CPMT 1998]**

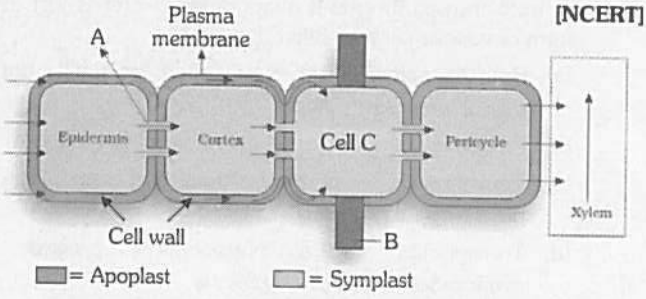
(a) Lateral (b) Downward
(c) Upward (d) Downward and upward

**34.** In plants, water supply is due to **[BHU 2006]**

(a) Osmosis (b) Imbibition

(c) Guttation (d) Adhesion force

**35.** The following diagram represent the pathway of water movement in the root. Identify A, B and C respectively **[NCERT]**




(a) Plasmodesmata, Casparian strip, Endodermis

(b) Tight junction, Casparian strip, Endodermis

(c) Gap junction, Casparian strip, Endodermis

(d) Desmosome, Casparian strip, Endodermis

**36.** The principle pathways by which water is translocated in angiosperms is **[CBSE PMT 1990; BHU 2012]**

(a) Xylem and phloem together

(b) Sieve tubes and members of phloem

(c) Sieve cells of phloem

(d) Xylem vessel system

**37.** Passive absorption of water by the root system of the result of **[KCET 2006, 10]**

(a) Forces created in the cells of the root

(b) Increased respiratory activity in root cells

(c) Tension on the cell sap due to transpiration

(d) Osmotic force in the shoot system

**38.** Root hair absorb water from the soil on account of **[RPMT 2005]**

(a) Turgor pressure (b) Osmotic pressure

(c) Suction pressure (d) Root pressure

**39.** The ability to rise in thin tubes and the Ability to resist a pulling force are respectively referred to as **[Kerala PMT 2012]**

(a) Tensile strength and capillarity

(b) Adhesion and capillarity

(c) Cohesion and adhesion

(d) Cohesion and capillarity

(e) Capillarity and tensile strength

**40.** Ascent of sap is due to which force **[RPMT 1999]**

**Or**

The most important force which pulls water up in tall trees is

(a) Imbibition (b) Cellular force

(c) Cohesive force (d) Atmospheric pressure

**41.** When water enters in roots due to diffusion, it is termed as **[AFMC 1999; BHU 2001]**

(a) Osmosis (b) Endocytosis

(c) Active absorption (d) Passive absorption

**42.** Most water absorption in plants takes place through **[MP PMT 2001]**

(a) Root cap (b) Root apex

(c) Root hair zone (d) Meristematic zone

**43.** $Na^+$, $K^+$ dependent ATPase activity helps in transport of **[DPMT 2004; Odisha JEE 2009]**

(a) $K^+$ inward, $Na^+$ outward (b) $K^+$ inward only

(c) $Na^+$ inward only (d) $K^+$ outward, $Na^+$ inward

**44.** The continuous excretion of watery substance from stump of a well watered pot plant after cutting off the shoot slightly above the base is due to **[Pb. PMT 2004]**

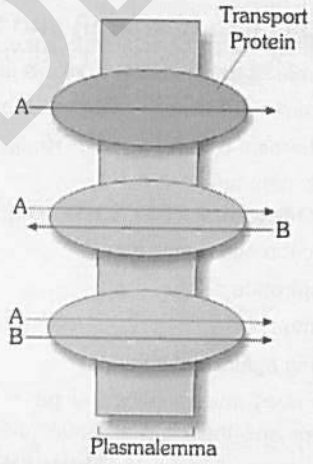
**Or**

Exudation of xylem is due to **[RPMT 1995]**

(a) Root pressure (b) Guttation

(c) Transpiration (d) Imbibition

**45.** See the following diagram and identify the process occurring in I, II and III **[NCERT]**




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

## Factors affecting absorption of water and Ascent of sap

**1.** Which of the following factors affect the absorption of water by roots

(a) Soil temperature (b) Soil aeration

(c) RH of the atmosphere (d) All the above

**2.** According to Sachs theory, the ascent of sap takes place

(a) In xylem ducts with the help of imbibition

(b) In the phloem with the help of imbibition

(c) In pith with the help of imbibition

(d) All of the above

**3.** The force of tension cohesion exceeds root pressure on a

(a) Rainy day (b) Foggy morning

(c) Sunny day (d) Full moon night

4. Many transplanted seedling may not survive because
(a) They do not like the new soil
(b) They do not get required mineral salts
(c) Most of the root hairs are lost during transplantation
(d) The leaves get damaged

5. At mid day hours, the xylem sap is in a state of
(a) Compression (b) Tension
(c) Relaxation (d) Adhesion

6. Water-logged condition will quickly occur in which type of soil **[RPMT 1997]**

**Or**

Holding capacity is highest in **[RPMT 1995]**
(a) Sand (b) Clay
(c) Gravel (d) Loam

7. When a potted plant is flooded with water, the magnitude of root pressure
(a) Increases (b) Decreases
(c) Remains unchanged (d) Becomes negative

## Transpiration (General) and Stomata

1. 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

2. Guard cells help in **[Odisha JEE 2008; CBSE PMT 2009; AFMC 2012]**
(a) Protection against grazing
(b) Transpiration
(c) Guttation
(d) Fighting against infection

3. In woody trees, the exchange of gases between the outer atmosphere and the internal tissue of the stem takes place through **[Kerala PMT 2010; NEET 2013]**
(a) Aerenchyma (b) Stomata
(c) Pneumatophores (d) Lenticels
(e) Trichomes

4. The number of stomata and epidermal cells in 1 $mm^2$ leaf area of lower epidermis of the leaves of X, Y and Z plants are 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 **[EAMCET 2009]**
(a) X, Y, Z (b) Y, Z, X
(c) Z, Y, X (d) Y, X, Z

5. Force generated by transpiration can create pressure sufficient to lift water even upto the height of **[AMU (Med.) 2012]**
(a) 130 feet (b) 130 metre
(c) 230 feet (d) 230 metre

6. Position and frequency of stomata can be determined by
(a) Calculating the loss of water
(b) Cobalt chloride paper method
(c) Potometer
(d) Porometer

7. In both transpiration and evaporation, water is lost in the form of vapour yet they differ, because
(a) Both transpiration and evaporation are similar but the rate of water loss differs
(b) Frequency of water loss is different in both of them
(c) Transpiration is a physical process and evaporation is a physiological process
(d) Transpiration is a physiological process and evaporation is a physical process

8. Out of the following, which one is the most common type of transpiration
(a) Foliar (b) Stomatal
(c) Lenticular (d) Cuticular

9. Which of the following is not the type of transpiration
(a) Stomatal transpiration (b) Cuticular transpiration
(c) Lenticular transpiration (d) Endodermal transpiration

10. Maximum transpiration occurs in **[MP PMT 1994]**
(a) Mesophytic plants (b) Hydrophytic plants
(c) Xerophytic plants (d) Algal cells

11. Transpiration facilitates **[KCET 2009]**
(a) Electrolyte balance
(b) Opening of stomata
(c) Absorption of water by roots
(d) Excretion of minerals

12. Transpiration is mainly a process of **[Odisha JEE 2005]**
(a) Osmotic pressure (b) Imbibition
(c) Diffusion (d) Respiration

13. Small (Tiny) particle is placed in the pore of stomata what will be happening **[MP PMT 2005]**
(a) It will fall on ground
(b) It will stick to lower epidermis
(c) It will be accommodate to mesophyll cell
(d) It will be accommodate in vascular tissues

14. Stomata of CAM plants **[CBSE PMT 2003; CPMT 2009; WB JEE 2016]**
(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

15. Transpiration ratio is the ratio of moles of $H_2O$ transpired/moles of $CO_2$ fixed. This ratio is measure of **[AIEEE Pharmacy 2003]**
(a) The efficiency of guard cells on stomatal movement
(b) Effectiveness of stomata is maximizing photosynthesis while minimizing water loss
(c) Distinguishing a xerophyte from a glycophyte
(d) Stomatal pore size of the leaves

**16.** Scotoactive stomata are character of which plants **[Pb. PMT 1999; RPMT 1999]**
(a) Heliophytes (b) Xerophytes
(c) CAM Plants (d) All of these

**17.** Which of the following is not a purpose of transpiration **[Kerala PMT 2012]**
(a) Helps in absorption and transport in plants
(b) Prevents loss of water
(c) Maintains shape and structure of plants by keeping the cell turgid
(d) Supplies water for photosynthesis
(e) Cools leaves surface

**18.** In which type of plants, the stomata remain closed during day time and open during night **[RPMT 1997; Odisha JEE 2012]**
(a) Photophilous (b) Succulents
(c) Sciphilous (d) Halophytes

**19.** A small mesophytic twig with green leaves is dipped into water in a big beaker under sunlight. It demonstrates **[MP PMT 1997]**
(a) Photosynthesis (b) Respiration
(c) Transpiration (d) None of the above

**20.** Which of the following plant is able to show rolling of leaf during mid of the day
(a) *Nerium* (b) *Melia*
(c) *Amophila* (d) All the above

**21.** Which of the following plants economises transpirational loss of water
(a) $C_3$ (b) $C_4$
(c) Both equally (d) $C_2$

**22.** In barley type of plant, the stomata open
(a) For few hours during day
(b) During night
(c) Throughout day and night
(d) Remain closed

**23.** Stomatal frequency means
(a) No. of stomata per unit area of leaf surface
(b) No. of epidermal cells per unit area of leaf surface
(c) No. of mesophyll cells in the per unit area of leaf
(d) None of the above

**24.** Stomatal index $I$ is equal to
(a) $\frac{S}{E-S}$ (b) $\frac{S}{E+S}$
(c) $\frac{E}{E+S}$ (d) $\frac{E+S}{E}$

**25.** In Vallisneria, stomata are **[RPMT 1995]**
(a) Present on upper epidermis of leaf
(b) Present on lower epidermis of leaf
(c) Present on both the epidermis of leaf
(d) Not present

**26.** In most of the thin leaf mesophytes, the leaf stomata open during day and close during night. It comes under
(a) Barley type (b) Potato type
(c) Alfalfa type (d) Bean type

**27.** Grafted flower is contained in saline water because **[CPMT 1996]**
(a) Suitable nutrient available to flower
(b) Flower become fresh in long duration due to less transpiration
(c) Flower become fresh in long duration due to regulated osmotic pressure of flower cell
(d) Flower is protected by microbes

**28.** Sunken stomata are found in leaves of **[Odisha JEE 2005]**
(a) *Trifolium* (b) *Lemna*
(c) *Nerium* (d) *Lilium*

**29.** Which process is favoured by transpiration
(a) Photosynthesis (b) Conduction of water
(c) Stomatal opening (d) All the above

**30.** Stomata is absent in **[CPMT 1996]**
(a) Submerged plants (b) Desert plants
(c) Floating plants (d) All the above

**31.** The following percentage of water absorbed by herbaceous plants is lost in transpiration **[JIPMER 2002]**
(a) 80 (b) 60
(c) 90 (d) 40

**32.** Stomata in angiosperms does not open during
(a) Noon (b) Twilight
(c) 11 O'clock (d) At midnight

**33.** Which of the following plants do not transpire
(a) Algae
(b) Fungi
(c) Submerged hydrophytes
(d) All the above

**34.** Stomata open at night and close during day in **[MP PMT 1999; RPMT 1999]**

**Or**

Sunken stomata are adaptations of which category of plants **[RPMT 1997]**
(a) Xerophytes (b) Gametophytes
(c) Mesophytes (d) Hydrophytes

**35.** Lenticular transpiration takes place in
(a) Fruits (b) Woody stems
(c) Leaves (d) All the above

**36.** Which of the following wall of guard cells is thick
(a) Outer (b) Inner
(c) Side wall (d) All the three

**37.** The cells surrounding the stomatal pore are
(a) Guard cells (b) Subsidiary cells
(c) Chromophil cells (d) None of the above

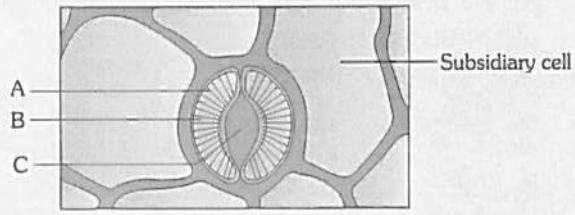
**38.** Select the correct statement(s) pertaining to transpiration process in plants **[WB JEE 2016]**
(a) It is a necessary evil for plants
(b) Loss of water takes place through hydathodes in vapour form
(c) It may also occur through lenticels
(d) The process is active during night in $C_3$ plants

## Factors affecting transpiration

1. Due to low atmospheric pressure, the rate of transpiration will
   (a) Decrease slowly (b) Decrease rapidly
   (c) Increase (d) Remain unaffected
2. Transpiration is minimised by the deposition of
   (a) Cellulose (b) Pectin
   (c) Cutin (d) Mucilage
3. Increase in temperature and velocity of wind cause an increase in transpiration initially but later it slows down, because
   (a) Of closure of stomata
   (b) Water is not made available
   (c) The air around the plant becomes humid
   (d) Of mechanical disturbance
4. Which one of the following will reduce the rate of transpiration **[Manipal MEE 1995; MP PMT 2000; J & K CET 2002]**
   (a) Increase in wind velocity
   (b) Rise in temperature
   (c) Increase in water uptake by plants
   (d) Decrease in light intensity
5. Which of the following is produced during water stress and causes closure of stomata **[BHU 2002; Odisha JEE 2009]**
   (a) Cytokinin (b) Auxin
   (c) $GA_3$ (d) ABA
6. The conditions under which transpiration would be most rapid
   (a) High humidity
   (b) Excess of water in soil
   (c) Low humidity, high temperature, guard cells are turgid (open) and moist soil
   (d) Low velocity of wind
7. The transpiration in plants will be lowest **[BHU 1994; KCET 2006]**
   (a) When there is high humidity in the atmosphere
   (b) High wind velocity
   (c) There is excess of water in the cell
   (d) Environmental conditions are very dry
8. Which of the following is not a purpose of transpiration **[Kerala PMT 2010]**
   (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
9. The rate of transpiration directly depends on
   (a) Temperature (b) Negative turgor pressure
   (c) Diffusion pressure deficit (d) Vapour pressure gradient
10. Which of the following may be used as an anti–transpirant in plant **[MP PMT 1995; KCET 2006; RPMT 2006; BHU 2008]**
    (a) Phenyl mercuric acetate (b) Cobalt chloride
    (c) Mercury (d) Potassium
11. Transpiration increase with increase in **[MP PMT 2005]**
    (a) Humidity (b) Temperature
    (c) Minerals (d) Soil moisture
12. Under what conditions the rate of transpiration increases by **[RPMT 1997]**
    (a) Increase of humidity
    (b) Increase of atmospheric pressure
    (c) Decrease of temperature
    (d) Decrease of humidity
13. Which would do maximum harm to a tree **[KCET 2007]**
    (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
14. Transpiration can be influenced by interfering with **[AFMC 1995]**
    (a) Air temperature (b) Epidermis of leaf
    (c) Guard cell (d) Osmotic pressure
15. In the terrestrial habitat which of the following factors affect temperature and rainfall conditions
    (a) Translocation (b) Transformation
    (c) Thermo-denaturation (d) Transpiration
16. Increase in $CO_2$ concentration around leaf results in **[CPMT 1995; CBSE PMT 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
17. Cobalt chloride method was first used by
    (a) F. Darwin (1912) (b) Stahl (1894)
    (c) Curtis (1926) (d) Leibeg (1840)
18. Which one of the following is not an antitranspirant **[KCET 2011]**
    (a) PMA (b) BAP
    (c) Silicon oil (d) Low viscosity

## Mechanism of opening and Closure of stomata

1. Observe the diagram of stomatal apparatus. In which of the following all the three parts labelled as A, B and C are correctly identified **[NCERT]**

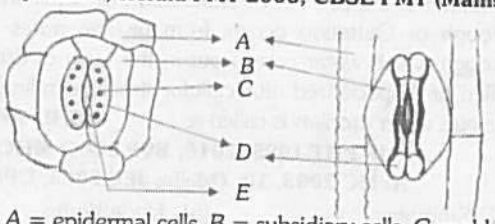



   (a) A - Guard cell, B - Stomatal aperture, C - Microfibril
   (b) A - Stomatal aperture, B - Guard cell, C - Microfibril
   (c) A - Microfibril, B - Guard cell, C - Stomatal aperture
   (d) A - Microfibril, B - Stomatal aperture, C - Guard cell
2. Stomata on the surface of the leaf, open by **[KCET 2012]**
   (a) Decreasing the solute concentration in the guard cells
   (b) Increasing the solute concentration in the guard cells
   (c) Weakening of the cell walls of the guard cells to allow them to stretch
   (d) Increasing the water potential in the guard cells

3. When stomata closes which of the following events does not occur **[Odisha JEE 2008]**
   (a) Guard cell become flaccid
   (b) Sugar is converted to starch
   (c) O.P of the guard cell decreases
   (d) Accumulation of $O_2$ takes place

4. Select the correct events leading to the opening of the stomata
   (i) Decline in guard cell solutes
   (ii) Lowering of osmotic potential of guard cells
   (iii) Rise in potassium levels in guard cells
   (iv) Movement of water from neighbouring cells into guard cells
   (v) Guard cells becoming flaccid
   **[Kerala PMT 2009]**
   (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

5. Choose the correct combination of labelling of stomatal apparatus of dicot and monocot leaves
   **[NCERT; Kerala PMT 2006; CBSE PMT (Mains) 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

6. The metal ion involved in the stomatal regulation is or Stomata will open, if there is accumulation of the following element in the guard cells
   **[JIPMER 1994; CPMT 2004; MP PMT 2005]**
   **Or**
   Opening and closing of stomata is controlled by
   **[BHU 2000; Haryana PMT 2005; Odisha JEE 2011]**
   (a) Iron ($Fe^+$) (b) Magnesium ($Mg^{2+}$)
   (c) Zinc ($Zn^+$) (d) Potassium ($K^+$)

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

8. Clarification of mechanism of opening and closing of guard cells is based on which of the following theory **[AIPMT (Cancelled) 2015]**
   (a) Entry and exit of potassium in guard cell
   (b) Photosynthetic process taking place in guard cell
   (c) Starch–sugar conversion
   (d) Transpiration

9. Stomata open during day time because the guard cells **[CPMT 1993; MP PMT 1993]**
   (a) Photosynthesize and produce osmotically active sugars or organic acids
   (b) Are thin-walled
   (c) Are bean shaped
   (d) Have to help in gaseous exchange

10. Stomatal opening or closing is due to **[CBSC PMT 2002; AMU (Med.) 2010; NEET 2017]**
   (a) Change in the turgidity of guard cells
   (b) The inner wall of each guard cells is thick and elastic
   (c) Cellulose microfibrils of guard cells are oriented radially
   (d) All of the above

11. According the Steward's starch hydrolysis theory, which one of the following is the principle reason for the opening of stomata during daytime **[KCET 2010]**
   (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

12. Basis of stomatal opening is **[MP PMT 2004]**
   **Or**
   A plant cell attains turgidity due to
   **[Kerala PMT 2004; WB JEE 2011]**
   **Or**
   Turgor pressure of a plant cell increases due to
   **[WB JEE 2016]**
   (a) Exosmosis
   (b) Endosmosis
   (c) Decrease in cell sap concentration
   (d) Plasmolysis of guard cells

13. 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

14. $Na^+ / K^+$ pump in a cell is an example of **[AMU (Med.) 2010; AIIMS 2012]**
   (a) Osmosis (b) Diffusion
   (c) Passive transport (d) Active transport

15. Stomatal opening and closing is due to the permeability of the guard cell. This fact was revealed by
   (a) Von Mohl (b) Linsbauer
   (c) Lloyd (d) Mansfield

16. Stomata open in the daytime due to **[Wardha 2005; KCET 2009]**
   (a) Increase in water potential
   (b) Decrease in water potential
   (c) Decrease in $pH$
   (d) Light

**17.** Which of the following statement is not true for stomatal apparatus **[NEET (Karnataka) 2013]**
(a) Guard cells invariably posses 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

**18.** Stomatal mechanism operates in response to **[CPMT 2005]**
(a) Temperature (b) Light
(c) Soil moisture (d) Atmospheric humidity

**19.** Levitt explanation for stomatal action is due to
(a) Increase in sugar content of guard cells
(b) Variations in *pH* value
(c) Starch is converted into organic acids
(d) Light causes opening and darkness closure

**20.** The primary osmolite which causes an opening and closing of stomata is **[RPMT 1999]**
(a) Sugars (b) Starch
(c) *K*–malate (d) Water

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

**22.** Which of the following theory gives the latest explanation for the closure of stomata **[BHU 2004]**
(a) ABA theory (b) Munch theory
(c) Starch glucose theory (d) Active $K^+$ transport theory

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

**24.** In plants opening of stomata is regulated by **[WB JEE 2016]**
(a) Red light (b) Blue light
(c) Far-red light (d) Ultraviolet light

## Guttation, Bleeding and Root pressure

**1.** Guttation is caused due to **[KCET 2000, 07; AIIMS 2000; Uttranchal 2001; BHU 2001, 06; Odisha JEE 2009; CBSE PMT (Mains) 2011]**
(a) Imbibition (b) Osmosis
(c) Positive root pressure (d) Transpiration

**2.** Guttation usually occurs when the plant is put
(a) In more saturated atmosphere
(b) In more humid soil
(c) In dry condition
(d) In deserts

**3.** Which of the following is not a controlled process **[BVP 2003]**
(a) Transpiration (b) Guttation
(c) Both (a) and (b) (d) None of the above

**4.** 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

**5.** Root pressure is due to **[Odisha JEE 2011]**
(a) Passive transport (b) Gravitation
(c) Active transport (d) None of these

**6.** Which one of the following is not related to guttation **[KCET 2011]**
(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

**7.** The process of the escape of liquid from the tip of uninjured leaf is called **[AIIMS 1998; MP PMT 2012]**
(a) Evaporation (b) Transpiration
(c) Guttation (d) Evapo-transpiration

**8.** 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 **[BHU 1995, 2004; MP PMT 1995, 2010; BVP 2001; MHCET 2002; AFMC 2003, 10; Odisha JEE 2005; CPMT 2005]**
(a) Stomata (b) Hydathodes
(c) Lenticels (d) Wounds

**9.** Guttation is found mostly in
(a) Herbaceous plant (b) Shrubs
(c) Wood plants (d) None of these

**10.** Water is lost in a liquid state in some plants through hydathodes. These hydathodes **[KCET 2006]**
(a) Remain closed at night
(b) Remain closed during day
(c) Remain always open
(d) Do not show any specificity in opening and closing

**11.** Epithem is
(a) Loosely arranged mass of parenchyma in hydathodes
(b) Large intercellular spaces of hydathodes
(c) Xylem elements of hydathodes
(d) Phloem below the air chamber

**12.** Guttation occurs in **[RPMT 1995, 99]**
(a) Morning (b) Moon
(c) Evening (d) Morning 10 O'clock

**13.** Hydathodes are also called **[MHCET 2004]**
(a) Water stomata (b) Sunken stomata
(c) Guard cells (d) Subsidiary cells

**14.** Which one is not related to transpiration **[MP PMT 1997]**
(a) Regulation of plant body temperature
(b) Absorption and distribution of mineral salts
(c) Circulation of water
(d) Bleeding

15. Which of the following is responsible for passive guttation
(a) Tension–cohesion of water molecules
(b) Activity of epithem tissue
(c) Osmotic activity of root hairs
(d) Secretion of fluid by mesophyll cells

16. Which of the following is more during the night
(a) Root pressure (b) Absorption
(c) Evaporation (d) Transpiration

## Scientists and Apparatus concerned

1. Ultrafiltration theory for permeability of cell membrane was put forth by
(a) Traube (b) Ruhland
(c) Sachs (d) None of these

2. Pressure bomb technique was used by
(a) Scholander *et al* (b) Kramer *et al*
(c) Dixon *et al* (d) None of the above

3. Who proposed the retension pressure theory for the permeability of the membrane
(a) Traube (b) Overton
(c) Cocking (d) None of these

4. 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 |

**[BHU 1999; BVP 2003; Kerala PMT 2004; KCET 2004; AIIMS 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

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

6. Theory of starch–glucose interconversion was proposed by
**Or**
Enzyme phosphorylase is first of all discovered in guard cells by
(a) Yin and Tung (b) Zelitch
(c) Imamura (d) None of the above

7. For photoactive opening of stomata, the proton transport concept was given by
(a) Levitt (b) Milborrow
(c) Ziegler (d) None of the above

8. According to one vital force theory, ascent of sap is due to active pulsation of innermost layer of cortex. This theory was given by
**Or**
In plant 'transpiration pull' theory for ascent of sap was first proposed by **[WB JEE 2016]**
(a) J. C. Bose (b) Dixon
(c) Strasburger (d) Sacks

9. The scientist, who proposed that production of glycolic acid in guard cells is an important factor in stomatal opening, is
(a) Kumar (b) Steward
(c) Zelitch (d) Lewitt

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

11. Who studied the effect of light on translocation
(a) De Vries (b) Blackman
(c) Williams (d) Hart

12. "There is no translocation at low temperature" has been invented by
(a) Swanson and Whitne (b) Fenson
(c) Spanner (d) Munch

13. Potometer works on the principle of **[CBSE PMT 2005]**
(a) Amount of water absorbed equals the amount transpired
(b) Osmotic pressure
(c) Root pressure
(d) Potential difference between the tip of the tube and that of the plant

14. Who had said that "transpiration is a necessary evil" **[MP PMT 1999]**
(a) Curtis (b) Steward
(c) Andersen (d) J. C. Bose

15. Osmoscope is used for
(a) Measuring OP (b) Measuring TP
(c) Measuring psi (d) Demonstration of osmosis

16. Which of the following is used to determine the rate of transpiration in plants **[CPMT 1994, 2009; AIIMS 2000; RPMT 2002; BHU 2003; MP PMT 2010, 12]**
(a) Porometer (b) Potometer
(c) Auxanometer (d) Tensiometer

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

18. Potometer and clinostat are used to study **[MHCET 2001]**
(a) Photosynthesis and respiration
(b) Transpiration and growth
(c) Phototropism and geotropism
(d) Transpiration and geotropism

19. Darwin's potometer determine
(a) Comparison of stomatal and cuticular transpiration
(b) Transpiration and absorption ratio
(c) Opening of stomata
(d) None of these

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

**21.** Who has used two bulbs of semipermeable membrane to explain pressure flow theory

**Or**

Gradient pressure was given as a possible mechanism of translocation of food by
(a) Munch (b) Jones
(c) Spanner (d) Fenson

**22.** The shoot pressure is measured by
(a) G.M. Counter
(b) Luxmeter
(c) Pressure bomb technique
(d) Bomb calorimeter

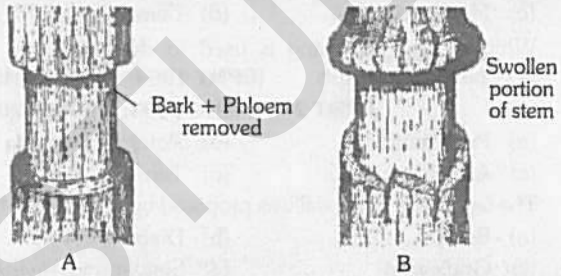
## Translocation of organic solutes

**1.** Who proposed that the upward and downward movement of materials take place
(a) Sacks (b) Boehm
(c) Dixon (d) Curtis

**2.** The direction of the conduction of food through phloem is **[MP PMT 1999]**
(a) From below upwards
(b) From top to bottom
(c) From leaves to roots
(d) Phloem never conducts food

**3.** In which form the food is translocated from endosperm to plumule of a fatty seed like castor
(a) Fatty acids (b) Fat
(c) Glucose (d) Sucrose

**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 stem has been shown. The possible cause of this swollen is **[NCERT]**




(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.** Phloem sap is mainly made of **[AMU (Med.) 2012]**
(a) Water and sucrose
(b) Water and minerals
(c) Oligosaccharides and hormones
(d) None of these

**6.** The absorption of food in phloem is
(a) Basipetal (b) Acropetal
(c) Both (a) and (b) (d) None of these

**7.** The food stored in the ripening fruit is derived from **[RPMT 1997]**
(a) Roots (b) Farthest leaves
(c) Nearest leaves (d) Aerial stem

**8.** In cell transport the difference between permeable transport and bulk transport relates to **[BHU 1994]**
(a) Structure of molecules allowed to pass through
(b) Solvent system as well as structure of molecules are applicable
(c) Solvent system is applicable
(d) Molecular weight of atoms allowed to pass through

**9.** Sinks are related to **[MP PMT 1997]**
(a) Transport of minerals (b) Stomata
(c) Enzymes (d) Phytochrome

**10.** Consider the following statements with reference to facilitated transport
A. Requires ATP energy
B. Transport Saturates
C. Highly selective
D. Requires special membrane properties
E. Uphill transport
Of the above statements **[Kerala PMT 2012]**
(a) A, B and C, are relevant but D and E are irrelevant
(b) B, C and E, are relevant but A and D are irrelevant
(c) C, D and E are relevant but A and B are irrelevant
(d) A, D, and E are relevant but B and C are irrelevant
(e) B, C and D are relevant but A and E are irrelevant

**11.** Bidirectional translocation of minerals takes place in **[CBSE PMT 1997, 99]**

**Or**

By many evidences, it can be known that the downward movement of food takes place through **[DPMT 2003]**
(a) Xylem (b) Phloem
(c) Parenchyma (d) Cambium

**12.** Leaf photosynthates are transported to other parts of higher plants through **[MP PMT 1994, 98]**

**Or**

Food is transported to various parts of the plant through **[AIIMS 1998; BVP 2004]**
(a) Cambial cells (b) Pith cells
(c) Xylem cells (d) Phloem cells

**13.** Which is correct about transport or conduction of substances **[AFMC 1994]**
(a) Organic food moves upwardly through xylem
(b) Organic food moves up through phloem
(c) Inorganic food moves upwardly and downwardly through xylem
(d) Organic food moves upwardly and downwardly through phloem

**14.** During transport of sugar or amino acid through cell membrane **[CBSE PMT 1994]**

(a) $Na^+$ ions move against the direction of 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

**15.** By protoplasmic streaming theory, how sugar is translocated from one sieve tube to other

(a) Diffusion (b) Osmosis

(c) Absorption (d) Active transport

**16.** Supply ends in transport of solute are **[MP PMT 1997]**

(a) Green leaves and storage organs

(b) Root and stem

(c) Xylem and Phloem

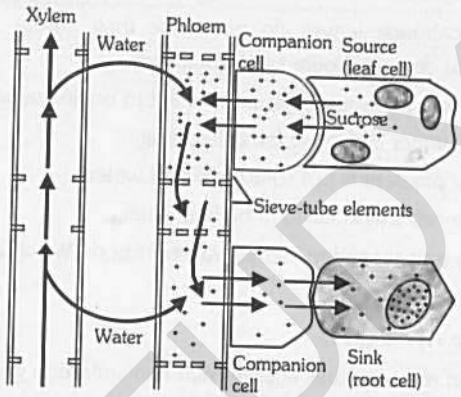
(d) Hormones and enzymes

**17.** The movement of materials through the vascular tissue of plants is called **[BHU 2002]**

(a) Transpiration (b) Translocation

(c) Transcription (d) Transduction

**18.** According to all Munch's pressure-flow hypothesis, which of the following given conditions would increase the rate of translocation **[NCERT]**




(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

**19.** Active transport of solute in plants refers to flow of solutes against a concentration gradient and therefore requires input of energy. This energy is derived **[BHU 1995; AIEEE Pharmacy 2004]**

(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

**20.** When a plant is girdled **or** In a ring girdled plant **[AIPMT (Cancelled) 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

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

**Or**

Translocation of sugar in flowering plants occurs in the form of **[NCERT; CPMT 1998; AMU (Med.) 2006; MP PMT 2006]**

(a) Glucose (b) Triose sugar

(c) Sucrose (d) Soluble starch

**22.** Starch is insoluble in water yet it is accumulated in large quantities in potato because **[CPMT 2004]**

(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

**23.** According to Munch theory, the cause of flow of soluble substances is

(a) Protoplasmic flow

(b) Mass flow due to reduction in turgor pressure

(c) Diffusion

(d) None of these

**24.** The translocation of organic solutes in sieve tube members is supported by **[CBSE PMT 2006]**

(a) Mass flow involving a carrier and ATP

(b) Cytoplasmic streaming

(c) Root pressure and transpiration pull

(d) P-proteins

**25.** Who proposed blood like translocation of solutes

(a) Spanner (b) Munch

(c) Williams (d) Jones

**26.** Organic substances such as sugars are translocated in phloem can be demonstrated by

(a) Defoliation (b) Ringing the stem

(c) Grafting (d) Root pressure

**27.** Vein loading is the active transport of sugars from **[KCET 2012]**

(a) Mesophyll cells to vessels

(b) Vessels to mesophyll cells

(c) Mesophyll cells to sieve tubes

(d) Sieve tubes to mesophyll cells

**28.** Munch hypothesis is based on **[KCET 2007]**

(a) Translocation of food due to *TP* gradient and imbibition force

(b) Translocation of food due to Turgor Pressure (TP) gradient

(c) Translocation of food due to imbibition force

(d) None of the above

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

**30.** Which of the following is the main point in disfavour of Munch theory
(a) Translocation is a pure physiological process
(b) Translocation is a pure physical process
(c) Explaination of sugar transport is not given
(d) None of these

**31.** Which of the following criteria **does not** pertain to facillitated transport **[NEET 2013]**
(a) Uphill transport
(b) Requirement of special membrane proteins
(c) High selectivity
(d) Transport saturation

## NCERT Exemplar Questions

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

**2.** Which one of the following will not directly affect transpiration **[NCERT]**
(a) Temperature
(b) Light
(c) Wind speed
(d) Chlorophyll content of leaves

**3.** The lower surface of leaf will have more number of stomata in a **[NCERT]**
(a) Dorsiventral leaf (b) Isobilateral leaf
(c) Both a and b (d) None of the above

**4.** The process of guttation takes place **[NCERT]**
(a) When the root pressure is high and the rate of transpiration is low
(b) When the root pressure is low and the rate of transpiration is high
(c) When the root pressure equals the rate of transpiration
(d) When the root pressure as well as rate of transpiration are high

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

**6.** Water potential of pure water at standard temperature is equal to **[NCERT; NEET 2017]**
(a) 10 (b) 20
(c) Zero (d) None of the above

**7.** Match the followings and choose the correct option

| | |
|---|---|
| A. Leaves | i. Anti-transpirant |
| B. Seed | ii. Transpiration |
| C. Roots | iii. Negative osmotic potential |
| D. Aspirin | iv. Imbibition |
| E. Plasmolyzed cell | v. Absorption |

Options **[NCERT]**
(a) A-iii, B-iv, C-i, D-ii
(b) A-i, B-ii, C-iii, D-iv
(c) A-iii, B-ii, C-iv, D-i
(d) A-iii, B-ii, C-i, D-iv

**8.** Mark the mismatched pair **[NCERT]**

| | |
|---|---|
| (a) Amyloplast | i. Store protein granule |
| (b) Elaioplast | ii. Store oils or fats |
| (c) Chloroplasts | iii. Contain chlorophyll pigments |
| (d) Chromoplasts | iv. Contain coloured Pigments other than chlorophyll |
| (e) Leucoplast | v. Contains colourless pigments |

## Critical Thinking Objective Questions

**1.** Purple cabbage leaves do not loose their colour 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

**2.** Primary and secondary active transport both **[WB JEE 2008]**
(a) Generate ATP
(b) Use ATP directly
(c) Can move solutes against their concentration gradient
(d) Include the passive movement of glucose molecule

**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
(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.** 0.5 M sucrose solution develops a pressure of 15 *bars* in an osmometer. Which of the following statement is wrong for such a solution
(a) That its osmotic potential is – 15 bars
(b) That its water potential is – 15 bars
(c) That its pressure potential is – 15 bars
(d) That its osmotic pressure is + 15 bars

**5.** 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 **[AFMC 2005]**
(a) Increase in size (b) Decrease in size
(c) Will be turgid (d) Will get plasmolysed

**6.** In which of the following plants would metabolism be hindered if the leaves are coated with wax on their upper surface
(a) *Hydrilla* (b) Lotus
(c) *Pistia* (d) *Vallisneria*

**7.** An osmometer is filled with 0.5 M solution of NaCl in water. In which of the following solutions it must be immersed in order to make it shrink **[KCET 2012]**
(a) 0.5 M solution (b) 0.05 M solution
(c) Distilled water (d) 0.75 M solution

**8.** In water–logged soil, plants do not grow properly because **[CPMT 1995]**
(a) The soil is physiologically dry
(b) The soil is physiologically wet
(c) Due to excessive water
(d) Due to shortage of water

**9.** Turgidity in guard cells is controlled by **[MP PMT 2001, 06]**
(a) Chloride
(b) Malic acid
(c) Potassium
(d) Potassium, chloride and malic acid

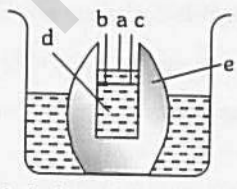
**10.** Root pressure is maximum when **[JIPMER 2002; Odisha JEE 2008]**
(a) Transpiration is high and absorption is very low
(b) Transpiration is very low and absorption is high
(c) Transpiration is very high and absorption is also high
(d) Transpiration and absorption both are slow

**11.** In which of the following the rate of transpiration is high **[MP PMT 2001]**
(a) CAM plants (b) $C_3$ plants
(c) $C_3$ and $C_4$ plants (d) $C_4$ plants

**12.** A thin film of water, held by the soil particles under the influence of internal attractive force, is called which of the following water **[Pb. PMT 2000; MHCET 2003]**
(a) Capillary (b) Combined
(c) Hygroscopic (d) Gravitational

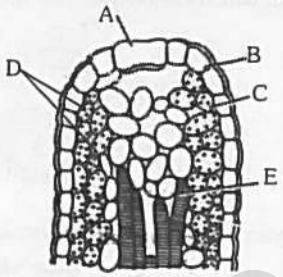
**13.** A sufficient atmospheric pressure required to push the water upto the top of tall plants must be **[BVP 2003]**
(a) 2 *atm* (b) 6 *atm*
(c) 20 *atm* (d) All of the above

**14.** Choose the correct combination of labelling of the potato osmoscope experiment **[Kerala PMT 2004]**




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

**15.** Choose the correct combination of labelling of hydathode **[Kerala PMT 2004]**




(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

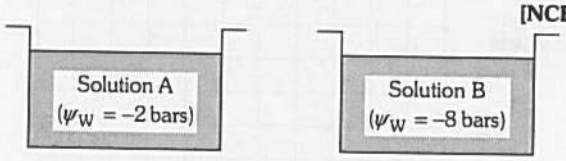
**16.** The removal of a ring of bark from trunk of a tree eventually kills it, since **[BHU 1994]**
(a) Mineral salts cannot go up
(b) Water cannot go up
(c) Food does not travel down and roots are starved
(d) The exposed part becomes infected with fungi

**17.** Where does transpiration cohesion pull theory works
(a) Active absorption
(b) Inactive absorption
(c) Active and inactive absorption
(d) None of these

**18.** The speed of water absorption will be greater if
(a) The difference between osmotic pressure of soil water and that of xylem vessels is always less
(b) The difference between osmotic pressure of soil water and that of xylem vessels is always more
(c) The osmotic pressure of soil water is always more than that of xylem vessels
(d) The osmotic pressure of soil water is always less than that of xylem vessels

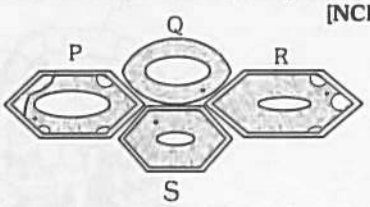
**19.** During absorption of $H_2O$ by roots, the $H_2O$ potential of cell sap is lower than that of **[DPMT 2004]**
(a) Solution outside (b) That of pure $H_2O$
(c) One (d) None of these

**20.** See the following figure and select the correct option **[NCERT]**



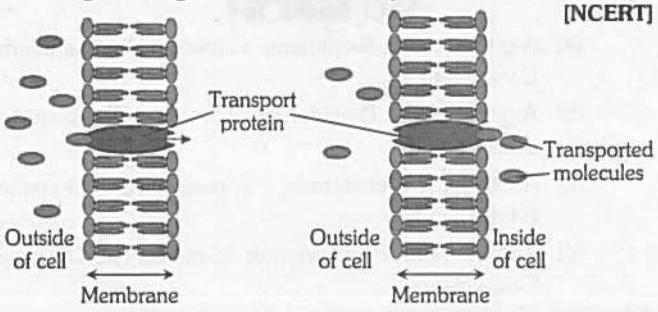

(a) Water potential has nothing to do with K.E. of water in a solution
(b) K.E. of water in A solution = K.E. of $H_2O$ in B solution
(c) K.E. of water in B solution > K.E. of water in A solution
(d) Kinetic energy (K.E.) of $H_2O$ in A solution> K.E. of water in B solution

**21.** See the following diagram of four plant cells. Select the correct option in which cells would not exit wall pressure **[NCERT]**



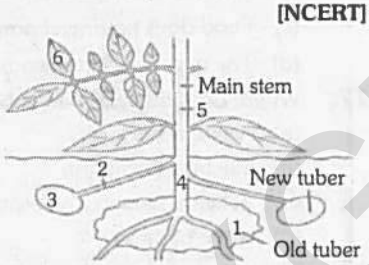

(a) R and S
(b) P and R
(c) Q and S
(d) P and Q

**22.** The given diagram shows the transportation of materials by **[NCERT]**




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

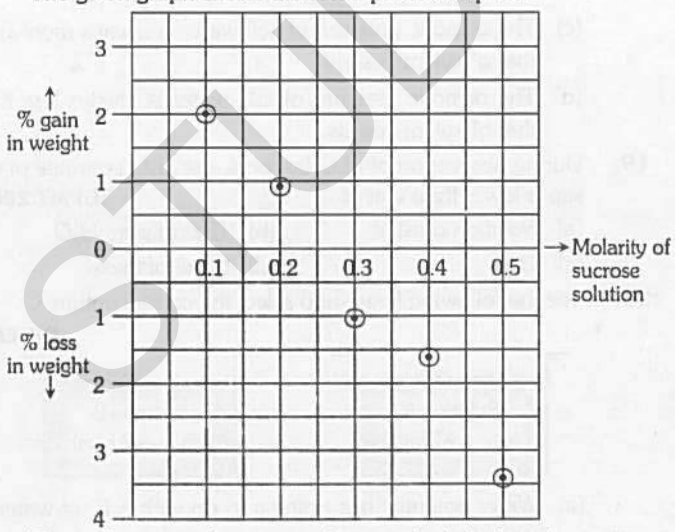
**23.** The given diagram illustrates a Potato plant forming new tubers. Which route would be taken by most of the food at this time **[NCERT]**




(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) $1 \rightarrow 4 \rightarrow 2 \rightarrow 3$

**24.** The experiment given below shows groups of potato disc were 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

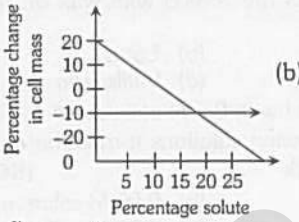
The given graph shows the result plotted as point

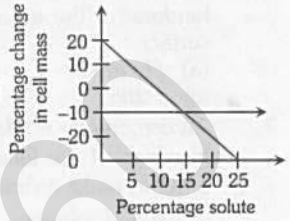


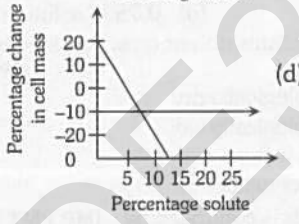

From these results it can be concluded that the water concentration of potato cell sap is approximately equivalent to that of a sucrose solution of molarity **[NCERT]**

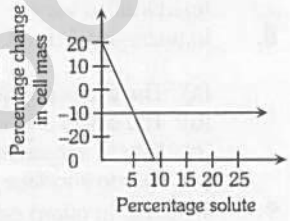
(a) 0.50 (b) 0.35
(c) 0.25 (d) 0.10

**25.** 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 **[NCERT]**

(a)



(b)



(c)



(d)



**26.** Which of the following is not correct in mass flow hypothesis **[KCET 2015]**

(a) As 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 radient that facilitates the mass movement in the phloem

**27.** Water vapour comes out from the plant leaf through the stomatal opening. Through the same stomatal opening carbon dioxide diffuses into the plant during photosynthesis. Reason out the above statements using one of following options **[NEET (Phase-I) 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 day time and the other at night

**28.** Specialised epidermal cells surrounding the guard cells are called **[NEET (Phase-I) 2016]**

(a) Complementary cells
(b) Subsidiary cells
(c) Bulliform cells
(d) Lenticels

# AR Assertion & Reason

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 reason is true*

**1.** Assertion : Xylem is principal water conducting tissue.
Reason : It has been recognised by girdling or ringing experiment. **[AIIMS 1995]**

**2.** 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. **[AIIMS 2003]**

**3.** Assertion : Long distance flow of photoassimilates in plants occurs through sieve tubes.
Reason : Mature sieve tubes have parietal cytoplasm and perforated sieve plates. **[AIIMS 2003]**

**4.** Assertion : Arid areas are not suitable for crops.
Reason : Antitranspirants are used for planting crops in arid regions.

**5.** 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. **[AIIMS 2009]**

**6.** Assertion : Film forming chemical should not be used for checking transpiration.
Reason : Film forming chemicals interrupt photosynthesis and respiration.

**7.** Assertion : Stomata are "turgor operated valves"
Reason : Stomata show reversible turgor changes.

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

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

**10.** Assertion : Seeds and spores do not lose the viability in unfavourable periods.
Reason : Seeds and spores have high osmotic pressure.

**11.** Assertion : To counteract the increase in turgour 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. **[KCET 2010]**

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

**13.** Assertion : Water absorption is reduced by lowering $O_2$ tension.
Reason : The accumulation of $CO_2$ reduces water absorption.

**14.** Assertion : Upward movement of water is called ascent of sap.
Reason : Upward movement of water occurs through xylem and phloem.

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

**16.** Assertion : Field capacity is maximum in loam soil.
Reason : In water logging condition, the soil has maximum field capacity.

**17.** Assertion : Only vertical movement of water is possible through xylem and tracheids.
Reason : The xylem ray parenchyma is responsible for the lateral transport of water.

**18.** Assertion : Light is very important factor in transpiration.
Reason : It induces stomatal opening and darkness closing. Therefore, transpiration increases in light decreases in dark. **[AIIMS 1999]**

**19.** Assertion : Waxy and cutin coating on plant parts reduce the transpiration.
Reason : These adaptation are found in xerophytes. **[AIIMS 1999]**

**20.** Assertion : Water in liquid form reaches to plant surfaces in transpiration process.
Reason : At plant surface, water changes from liquid to vapour phase.

# Answers

## General

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | a | 2 | c | 3 | d | 4 | b | 5 | b |
| 6 | c | 7 | b | 8 | b | 9 | a | 10 | a |
| 11 | a | 12 | c | 13 | a | 14 | a | 15 | c |
| 16 | d | 17 | a | 18 | c | 19 | c | | |

## Membranes, osmosis, diffusion, imbibition, plasmolysis and Wilting

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | c | 2 | c | 3 | c | 4 | a | 5 | d |
| 6 | b | 7 | b | 8 | d | 9 | b | 10 | b |
| 11 | c | 12 | d | 13 | b | 14 | a | 15 | a |
| 16 | d | 17 | b | 18 | a | 19 | b | 20 | c |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 21 | b | 22 | a | 23 | a | 24 | d | 25 | a |
| 26 | b | 27 | d | 28 | d | 29 | b | 30 | c |
| 31 | d | 32 | c | 33 | d | 34 | a | 35 | a |
| 36 | c | 37 | a | 38 | d | 39 | a | 40 | a |
| 41 | d | 42 | a | 43 | a | 44 | b | 45 | a |
| 46 | d | 47 | b | | | | | | |

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

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | c | 2 | b | 3 | a | 4 | d | 5 | a |
| 6 | d | 7 | d | 8 | b | 9 | a | 10 | d |
| 11 | c | 12 | c | 13 | a | 14 | d | 15 | a |
| 16 | a | 17 | d | 18 | a | 19 | a | 20 | b |
| 21 | d | 22 | d | 23 | d | 24 | b | 25 | c |
| 26 | c | 27 | a | 28 | a | 29 | d | 30 | b |
| 31 | d | 32 | a | 33 | b | 34 | a | 35 | d |
| 36 | a | 37 | a | 38 | a | | | | |

## Absorption of water and Ascent of sap

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | a | 2 | d | 3 | a | 4 | a | 5 | b |
| 6 | b | 7 | d | 8 | a | 9 | a | 10 | d |
| 11 | a | 12 | d | 13 | a | 14 | c | 15 | a |
| 16 | d | 17 | d | 18 | d | 19 | a | 20 | a |
| 21 | c | 22 | c | 23 | b | 24 | a | 25 | c |
| 26 | b | 27 | d | 28 | d | 29 | a | 30 | b |
| 31 | d | 32 | b | 33 | a | 34 | a | 35 | a |
| 36 | d | 37 | c | 38 | c | 39 | e | 40 | c |
| 41 | d | 42 | c | 43 | a | 44 | a | 45 | a |

## Factors affecting absorption of water and Ascent of sap

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | d | 2 | a | 3 | c | 4 | c | 5 | b |
| 6 | b | 7 | b | | | | | | |

## Transpiration (General) and Stomata

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | c | 2 | b | 3 | d | 4 | b | 5 | b |
| 6 | b | 7 | d | 8 | b | 9 | d | 10 | a |
| 11 | c | 12 | c | 13 | c | 14 | d | 15 | b |
| 16 | c | 17 | b | 18 | b | 19 | c | 20 | c |
| 21 | b | 22 | a | 23 | a | 24 | b | 25 | d |
| 26 | c | 27 | b | 28 | c | 29 | b | 30 | a |
| 31 | c | 32 | d | 33 | d | 34 | a | 35 | b |
| 36 | b | 37 | a | 38 | ac | | | | |

## Factors affecting transpiration

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | c | 2 | c | 3 | a | 4 | d | 5 | d |
| 6 | c | 7 | a | 8 | b | 9 | d | 10 | a |
| 11 | b | 12 | d | 13 | d | 14 | a | 15 | d |
| 16 | b | 17 | b | 18 | b | | | | |

## Mechanism of opening and Closure of stomata

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | c | 2 | b | 3 | d | 4 | b | 5 | a |
| 6 | d | 7 | b | 8 | a | 9 | a | 10 | d |
| 11 | d | 12 | b | 13 | c | 14 | d | 15 | b |
| 16 | b | 17 | b | 18 | b | 19 | c | 20 | c |
| 21 | c | 22 | d | 23 | b | 24 | b | | |

## Guttation, Bleeding and Root pressure

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | c | 2 | a | 3 | b | 4 | c | 5 | c |
| 6 | d | 7 | c | 8 | b | 9 | a | 10 | c |
| 11 | a | 12 | a | 13 | a | 14 | d | 15 | c |
| 16 | a | | | | | | | | |

## Scientists and Apparatus concerned

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | b | 2 | a | 3 | a | 4 | a | 5 | a |
| 6 | a | 7 | a | 8 | a | 9 | c | 10 | b |
| 11 | d | 12 | a | 13 | a | 14 | a | 15 | d |
| 16 | b | 17 | d | 18 | d | 19 | c | 20 | a |
| 21 | a | 22 | c | | | | | | |

## Translocation of organic solutes

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | d | 2 | c | 3 | d | 4 | d | 5 | a |
| 6 | a | 7 | c | 8 | a | 9 | a | 10 | e |
| 11 | b | 12 | d | 13 | d | 14 | a | 15 | a |
| 16 | a | 17 | b | 18 | b | 19 | a | 20 | a |
| 21 | c | 22 | b | 23 | b | 24 | d | 25 | b |
| 26 | b | 27 | c | 28 | b | 29 | d | 30 | c |
| 31 | a | | | | | | | | |

## NCERT Exemplar Questions

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | c | 2 | d | 3 | a | 4 | a | 5 | c |
| 6 | c | 7 | b | 8 | a | | | | |

## Critical Thinking Questions

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | a | 2 | c | 3 | d | 4 | c | 5 | b |
| 6 | b | 7 | d | 8 | a | 9 | d | 10 | b |
| 11 | b | 12 | c | 13 | c | 14 | a | 15 | c |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 16 | c | 17 | b | 18 | b | 19 | b | 20 | d |
| 21 | b | 22 | c | 23 | c | 24 | c | 25 | c |
| 26 | a | 27 | b | 28 | b | | | | |

## Assertion and Reason

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | a | 2 | a | 3 | a | 4 | b | 5 | c |
| 6 | d | 7 | a | 8 | b | 9 | e | 10 | a |
| 11 | a | 12 | b | 13 | b | 14 | c | 15 | c |
| 16 | c | 17 | e | 18 | a | 19 | a | 20 | d |

# AS Answers and Solutions

## General

**1.** (a) The guard cells of monocots (family - Gramineae) are dumbel shaped or elliptical, *e.g.*, Sugarcane.

**2.** (c) Because loss of water takes place through leaves by transpiration.

**4.** (b) On removing the ring of bark, phloem and cambium are removed from stem.

**5.** (b) Loam are sufficiently aerated and have good water holding capacity. Therefore, they are very good for water absorption and growth.

**7.** (b) Energy is usually provided by ATP or by concentration gradient of ions.

**8.** (b) Alluvial soil allows percolating the water slowly from it, hence alluvial soil is good soil.

**10.** (a) Because the water molecules have a great mutual attraction with each other or in other words they have tremendous cohesive power which is sometimes as much as 350 atmospheres.

**11.** (a) Walls of tracheids and vessels of xylem are made up of lignin and cellulose and have strong affinity for water (adhesion).

**13.** (a) ATP releases small amount of energy required for building new chemical bonds or chemical reactions in cell.

**14.** (a) Active absorption takes place by the activity of root itself, particularly root hairs. A root hair cell functions as an osmotic system. Water is absorbed by the root hair due to osmotic differences between soil water and cell sap.

**16.** (d) Root cap has no function in water absorption because it has no root hair and it is mainly for protection of root tip against any injury.

**18.** (c) In monocot like sugarcane, maize, etc. due to absence of cambium secondary growth is not found. So removal of bark (phloem) is not possible so that ringing experiment is not possible.

**19.** (c) The amount of water present in soil against gravitational force is called as field capacity.

## Membranes, osmosis, diffusion, imbibition, plasmolysis and Wilting

**3.** (c) This type of membrane allow selective passage of solutes along with solvent through them. Many biological membranes such as cell membranes, tonoplast and the membranes surrounding the sub-cellular organelles are selectively permeable.

**5.** (d) In formalin preserved *Spirogyra* filament, osmosis does not take place.

**6.** (b) Osmosis is a special type of diffusion or Osmosis through semipermeable membrane.

**7.** (b) Osmosis is a special type of diffusion of a liquid, when solvent moves through a semipermeable membrane from a place of higher diffusion pressure to a place of lower diffusion pressure.

**12.** (d) Because in imbibition process, the volume of seed is increased.

**13.** (b) Plasmolysis is the shrinkage of protoplast of a cell from its cell wall under the influence of a hypertonic solution. The hypertonic solution causes exosmosis or withdrawl of water from the cell. A solution whose osmotic concentration is more than that of another solution or cell sap is called hypertonic solution.

**14.** (a) In osmosis, movement of water takes place from hypotonic solution to hypertonic solution through semipermeable membrane.

**16.** (d) Breaking of the seed coat in germinating seeds is due to greater imbibitional swelling of the seed kernel (starch and protein) as compared to seed coverings. Seedling is able to come out of soil due to development of imbibition pressure.

**17.** (b) Thistle funnel whose mouth is tied with parchment paper is the physiological experiment of osmosis. Parchment paper is a semipermeable membrane which allows all solvents but no solute to pass through them.

**18.** (a) Plasmalemma allows selective passage of solutes along with solvent, through them.

**19.** (b) Plasma membrane shows selectively permeable membrane hence it controls passage of water and some solutes in and out of the cell.

**20.** (c) Peel of *Tradescantia* leaf is generaly used for the demonstration of plasmolysis in laboratory.

**22.** (a) When a cell is placed in distilled water, water start moving into the cell by the process of endosmosis, and cell become turgid.

**23.** (a) If a cell is placed in isotonic solution, there is no net changes of water between the cell and the solution.

**24.** (d) Proteins are the strongest imbibants of water, starch less strong, cellulose being the weakest. That is why proteinaceous pea seeds swell more than the starchy wheat seeds.

**25.** (a) At noon the rate of transpiration is maximum. The rate of water absorption is less due to shrinkage of roots and depletion of water around the root hairs.

**26.** (b) Because of exosmosis.

**27.** (d) The water is first imbibed by walls of root hairs and then absorbed and helps in rupturing of seed coat (made up of cellulose). Materials capable of imbibition such as proteins and cellulose in living beings cause seeds to swell when they are placed in water.

**28.** (d) Removal of large molecule from cell is also known as exocytosis.

**29.** (b) Due to exosmosis, the protoplasm shrinks and leaves the cell wall and thus cell becomes flaccid, which is called plasmolysed cell and this phenomenon is called plasmolysis. Thus exosmosis leads to plasmolysis.

**30.** (c) Consumption and production of solvent does not take place in osmosis. It is the just migration of solvent from the hypotonic to hypertonic solution hence volume of solvent remains same.

**31.** (d) Selectively permeable membrane such as membrane of root hairs and tonoplast membrane of vacuole allows certain substances more readily then semipermeable membranes.

**32.** (c) In case exosmosis continues, the protoplasm shrinks from the cell wall. The phenomenon is called plasmolysis (flaccid in appearance). Plant part or in the cells due to scarcity of water are termed as wilting.

**33.** (d) If the plasmolysed cell (flaccid cell) is placed in hypotonic solution then endosmosis occurs, which makes the cell again turgid and this is known as deplasmolysis.

**34.** (a) Due to exosmosis.

**35.** (a) Because water contents of potato comes out from the potato tuber or due to exosmosis.

**37.** (a) Due to adsorption of water molecules into wooden furniture it get swelled.

**38.** (d) Due to exosmosis (plasmolysis), the protoplasm shrinks and leaves the cell wall and thus cell becomes flaccid which is called plasmolysed cell.

**39.** (a) Xylem is responsible for transport of water. If xylem is blocked, plant will undergo wilting due to the lack of proper transport of water.

**40.** (a) It is the temporary drooping down of leaves and young shoots due to loss of turgidity during noon. At this time the rate of transpiration is maximum. Temporary wilting is corrected only after the rate of transpiration decreases in the afternoon accompanied by replenishment of water around the root hairs.

**41.** (d) Rapid transpiration causes mid-day leaf water deficit (temporary wilting). If such condition continues for sometime, permanent water deficit permanent wilting may develop, which causes injury to plants.

**42.** (a) Because of excessive fertilizers concentration are increased and water comes out of the plant cells due to exosmosis.

**43.** (a) Because cell wall of rhizoids and assimilatory filament cells work as semipermeable membrane.

**44.** (b) Imbibition pressure can be defined as the maximum pressure that an imbibant will develop when it is completely soaked in pure water. In Gram seeds (proteins) also have high imbibition capacity.

**45.** (a) Diffusion may be defined as, "movement of particles of a matter due to their own kinetic energy".

**46.** (d) It is the migration of solvent through a semipermeable membrane to keep the concentration equal.

**47.** (b) Plasmolysis takes place in 3 stages
(A) Limiting plasmolysis (1st stage)
(B) Incipient plasmolysis (Mid stage)
(C) Evident plasmolysis (Last stage)

## O.P., T.P., I.P., D.P.D and Water Potential

**1.** (c) The amount by which D.P. of solution is lower than that of its pure solvent, is called diffusion pressure deficit (D.P.D.).

**3.** (a) 1 *M* solution of a solute at normal temperature and pressure has water potential – 23 bars, hence 0.1 *M* solution will have water potential – 2.3 bars.

**9.** (a) Water potential of cell protoplasm is equal but opposite in sign to D.P.D. Water potential of pure water is zero and addition of solute in it, decreases it.

**10.** (d) In a fully turgid cell, O.P. is equal to T.P. and thus D.P.D. is zero.

**11.** (c) Water potentials of the given cells are
$\psi = \psi_S + \psi_R$
$A = -0.87 + 0.44 = -0.43$
$B = -0.92 + 0.34 = -0.58$
$C = -0.68 + 0.27 = -0.41$
As water moves from greater water potential to less, root hair, root cortical and leaf mesophyll cells are C, A, B respectively.

**15.** (a) The hydrostatic pressure developed inside the cell on the cell wall due to endosmosis is called turgor pressure. It is responsible for growth of young cells.

**16.** (a) The pure water, at atmospheric pressure, has zero water potential. The addition of any solute particles reduces the free energy of water. Thus the water potential will be negative.

**18.** (a) Osmotic potential or solute potential ($\psi_s$) are always in negative values and pressure potential ($\psi_p$) is usually positive. Water potential of a solution is always less than zero or has negative value.

**20.** (b) The opening and closing of stomata depends on the concentration of solutes in the guard cells (the main component of the solute concentration in guard cells is $K^+$). When the concentration of solutes, $K^+$ *ion* guard cells increases, their osmotic pressure increases. In other words, their water potential decreases. As a result of this, they absorb water from their surrounding epidermal cells, their turgidity increases.

**22.** (d) When T.P. is negative, DPD will be more than OP. D.P.D. of a cell mainly depends upon OP.

**25.** (c) $\psi = P + \pi$ ; where $\psi$ = Water potential, $P$ = Osmotic pressure, $\pi$ = Osmotic potential.

**29.** (d) A bar is a pressure unit which equals 14.5 lb/in$^2$, 750 mm Hg or 0.987 atm.

**31.** (d) When OP = WP
WP = TP
OP = TP
*i.e.*, cell has no further capacity to absorb any water.

**32.** (a) Water moves from higher water potential (Less negative) to lower water potential (more negative).

**33.** (b) Because of establishment of equilibrium.

**34.** (a) Due to endosmosis and suction pressure of the cell. Cell will get its original shape and size.

**35.** (d) In case of fully turgid cell, the net movement of water into the cell is stopped. The cell is in equilibrium with the water outside. The water potential in such case will be zero (0).

**36.** (a) Osmotic pressure of a solution is equivalent to the pressure, which must be exerted upon it to prevent the flow of solvent into it across a semipermeable membrane.

**38.** (a) Osmotic Pressure – Turgor Pressure = Diffusion Pressure Deficit (DPD).

## Absorption of water and Ascent of sap

**6.** (b) The absorption of water still occurs when concentration of outer soil water is more than root hair cell sap.

**7.** (d) Cohesion is the attraction between the molecules of the same substances. *e.g.*, water-water transpiration pull : A tension or negative pressure develops in the water column present in tracheary elements. It exerts an upward pull over the water column called transpiration pull.

**9.** (a) Physical theories believe that ascent of sap is a physical phenomenon.

**12.** (d) Tracheary elements are the part of xylem.

**15.** (a) In mycorrhiza, fungal member helps in absorption of mineral and water.

**23.** (b) Because inorganic salts are absorbed with water.

**25.** (c) When the concentration of the soil solutes is low, the absorption of water is increased. This is due to diffusion of water inside the absorbing cell. This is because water moves from high concentration (of water) to low concentration (of water). So when the soil has less solute the water concentration must be more and thus absorption of water by the cell will be more at the relatively high content of water.

**27.** (d) Ascent of sap takes place by root pressure which develops by transpiration pull.

**28.** (d) A plant with deep and elaborate root system can absorb more water. Moreover, the number of root hairs will be more in a highly branched and elaborate root system, thus its more surface area will be in contact with water.

**29.** (a) When concentration of outer soil water is more than root hair cell sap, under such conditions exosmosis should occur, but it has been seen that water is still absorbed against concentration gradient.

**30.** (b) It occurs in the form of film coating smaller soil particle. It is also called growth water.

**31.** (d) Force for absorption of water is generated in the cells of root itself. Osmotic and non-osmotic forces are involved in active water absorption.

**32.** (b) Sap moves up the stem through the lumen of xylem vessels and tracheids.

**34.** (a) Diffusion of water from its pure state or dilute solution into a solution or stronger solution when the two are separated by a semipermeable membrane is termed as osmosis. In plants water supply is due to osmosis.

**36.** (d) In angiosperms, sap moves up the stem through the lumen of xylem vessels and trachieds and not through their walls.

**38.** (c) A cell takes up water due to its suction pressure, (*DPD*) $SP = OP - TP$ .

**40.** (c) Water column remains intact despite gravitational pull because water molecules have a strong cohesion force amongst them due to presence of hydrogen bonds. Cohesion face provides a tensile strength to water column. It has a value of 45–207 atm.

**41.** (d) Here roots play passive role in water absorption, *i.e.*, forces responsible for absorption of water are not generated in roots, but in upper parts of the plant, *i.e.*, transpiration pull.

**42.** (c) Water absorbing part of the young roots is root hair zone. It lies between 2–10 *cm*. from the root tip. Root hairs are tubular extension of epiblema cells.

**43.** (a) ATPase may itself catalyze a direct transport of $K^+$, or a $Na^+/K^+$ exchange pump.

**44.** (a) Root pressure is caused by absorption of water through root hairs.

## Factors affecting absorption of water and Ascent of sap

**1.** (d) Soil temperature, soil aeration, relative humidity (R.H.), amount of soil water and transpiration are factors affect the absorption.

**2.** (a) According to imbibitional theory (Sachs 1879), water moves upward in the stem through the imbibitional activity of the walls of the xylem vessels to be responsible for the ascent of sap.

**3.** (c) Because transpiration rate is very high in sunny day.

**6.** (b) Clay particles are tiny and sticky in nature, hence holding capacity is highest in clay soil.

**7.** (b) Increased amount of water in the soil beyond a certain limit results in poor aeration of the soil which retards metabolic activities of root cells like respiration and hence, the rate of water absorption is also retarded and magnitude of root pressure is very low (about 2 atms).

## Transpiration (General) and Stomata

**1.** (c) It brings rapid translocation of water in the plant to compensate the loss of water during transpiration.

**4.** (b) Stomatal index (SI) $= \frac{S}{S+E} \times 100$

| Plant | Numbers of stomata (*S*) | No. of epidermal cells (*E*) | SI |
|---|---|---|---|
| X | 30 | 150 | 16.6 |
| Y | 60 | 240 | 20.0 |
| Z | 90 | 400 | 18.3 |

So, the arrangement of plants in decreasing order of their stomatal index is, Y, Z, X.

**6.** (b) Cobalt chloride paper method is used to compare rate of transpiration on two surfaces of leaf. Cobalt chloride is blue in anhydrous state. In contact with water vapour it turns pink.

**7.** (d) Transpiration occurs in plants, only from living cells. Evaporation occurs from any free surface. Both from living and nonliving surface.

**8.** (b) Maximum loss of water by plant takes place through stomata.

**9.** (d) Endodermis is internal layer which is not related with transpiration.

**10.** (a) About 98 percent of the water absorbed by land plants evaporates from the aerial parts and diffuses into the atmosphere.

**16.** (c) CAM plants are succulent or fleshy plants. The stomata of succulent plants remain closed during day and open during night to avoid water loss (scotoactive stomata).

**18.** (b) Such stomata are known as scotoactive stomata.

**20.** (c) Plants growing in dry conditions (xerophytes) develop some characters in leaves so as to reduce rate of transpiration like rolling of leaf during mid of the day *e.g.*, *Amophila*.

**22.** (a) Barley type stomata open only for a few hours in the day time, otherwise they remain closed throughout the day and night. *e.g.*, Cereals.

**23.** (a) Number of stomata per square *cm* is 1000 – 60,000 in different plant species. Stomatal frequency of trees and shrubs is higher than those of herbs.

**24.** (b) *S* = Number of stomata per unit area.
*E* = Number of epidermal cells per unit area.

**25.** (d) Because *Vallisneria* is an aquatic plant.

**29.** (b) It is assumed that the upward movement of water through the plant requires the occurrence of transpiration.

**33.** (d) Because algae and fungi are not differentiate in root, stem and leaves and transpiration takes place from these parts. Submerged hydrophytes possess vestigeal stomata hence transpiration are absent.

**34.** (a) Such stomata are known as scotoactive stomata. This is a mechanism to reduce water loss due to transpiration. When they are situated in grooves and sometimes protected by hairs, the rate of transpiration is further decreased. Such adaptations are found in xerophytes. These are found in plants like *Opuntia*, *Aloe*, *Bryophyllum* etc.

**35.** (b) Lenticels are the areas in the bark of woody plants which are filled with loosely arranged cells known as complementary cells. Loss of water vapour through lenticels is called lenticular transpiration.

**36.** (b) The outer wall of these cells is thin and inner wall is thick.

**37.** (a) Each stoma is bordered by two specialized epidermal cells called 'guard cells' which are generally kidney shaped or bean shaped but in grasses, guard cells are dumb-bell shaped.

**38.** (ac) Transpiration is a necessary evil for plants (water is continuously lost during the process even during stress but is important for ascent of sap and metabolism). Transpiration also occurs by lenticels.

## Factors affecting transpiration

**1.** (c) At low atmospheric pressure at high altitudes, the rate of transpiration is increased. The rate of transpiration is inversely proportional to the atmospheric pressure.

**3.** (a) Increase in temperature leads to opening of stomata even is night but within a certain physiological range. Again very high temperature leads to closing of stomata even in day (mid-day closure). Similarly very high wind velocity decreases transpiration by lowering temperature.

**4.** (d) Light affects the rate of transpiration directly by opening of stomata. In the absence of light or decrease in light intensity the stomata are closed and the stomatal transpiration is completely checked.

**5.** (d) In the case of hydroactive control abscisic acid (ABA) plays an important role in the closure of stomata, when ever there is shortage of water ABA is synthesized resulting in the closure of stomata.

**6.** (c) Increase in the temperature of the air decreases the humidity of the air and therefore more water is vapourised and lost from the transpiring surface. When soil is moist means availability of water are sufficient, stomata will open thus rate of transpiration increases.

**7.** (a) If the atmosphere is very humid and relatively saturated its capacity to absorb water is low and the rate of transpiration is slowed down.

**9.** (d) Transpiration depends upon difference in vapour pressure of internal atmosphere of leaf and external environment (*i.e.*, V.P. gradient) and it is, therefore, that no transpiration occurs when stomata are fully open but relative humidity is 100%.

**11.** (b) Temperature directly effects the transpiration. As the temperature rises so does the transpiration. Temperature in its turn is effected by light.

**12.** (d) If the atmosphere is humid, it reduces the rate of transpiration. When the air is dry, the rate of transpiration increases.

**13.** (d) Loss of half of the leaves of tree provide maximum harm to tree because rate of transpiration slows down and metabolic activity is also lowered but the plants remains alive in stressed condition.

**16.** (b) Mansfield (1965) reported that removal of $CO_2$ maintained stomatal opening even in the dark. Conversely, the stomata close in light if the $CO_2$ concentration is increase.

## Mechanism of opening and Closure of stomata

**6.** (d) When $K^+$ ions into the guard cells, stomata open and when $K^+$ ions out, stomata close. $K^+$ ion is necessary to maintain the turgidity of guard cells of stomata.

**9.** (a) Stomata open during day time because the guard cells prepare osmotically active substances by photosynthesis. As a result, their osmotic pressure increases and their turgor pressure increases due to endosmosis.

**10.** (d) Stomata in angiosperms open and close due to change of turgor pressure in cells are turgid state the stomatal aperture opens and when guard cells are in flaccid state the stomatal aperture closes.

**12.** (b) Endosmosis increases the turgidity of guard cells. The osmotic inflow of water into a cell enables a plant cell to attain turgidity.

**13.** (c) Korper – kappe theory its related to tissue system (Root and shoot).

**15.** (b) Linsbauer (1916) suggested that the removal of $CO_2$ by photosynthesis causes opening of stomata by changing the permeability of the guard cells to different kinds of solutes and guard cells are more permeable when the stomata are closed.

**17.** (b) Sometimes, a few epidermal cells in the vicinity of the guard cells become specialised in their shape and size and are known as subsidiary cells.

**21.** (c) In the evening leaf photosynthesis stops. Carbon dioxide concentration increases in the leaf interior. It results in decrease in *pH*. Glucose is phosphorylated to form glucose 6-phosphate. It is changed to glucose I-phosphate from which starch is synthesised.

Starch does not exert any osmotic potential and therefore, guard cells lose water to nearby epidermal cells. Their turgidity falls and the stomatal pore closes.

**22.** (d) As per "Active $K^+$ transport mechanism" accumulation of $K^+$ ions occurs in the guard cell during the day in response to light. It increases the turgidity of guard cells consequently stoma opens. During night, ions move out of the guard cells into surrounding epidermal cells consequently guard cells become flaccid and stomata close.

**23.** (b) Light causes photosynthesis which lead to reduction in $CO_2$ concentration → synthesis of glycolate → oxidation of glycolate → ATP synthesis → activation of $K^+$ pump → movement of $K^+$ in guard cell → movement of water into guard cells → swelling of guard cell → opening of stomata.

## Guttation, Bleeding and Root pressure

**2.** (a) Guttation is most common in plants growing in moist warm soil with their aerial parts surrounded by humid air.

**4.** (c) Exudation of liquid from the water pore or stoma is due to the development of a positive hydrostatic (root pressure) pressure in the xylem present in the vein ending. The pressure forces the liquid out through the hydathode.

**7.** (c) Guttation, is the process in which water drops come outside by margins of leaves by hydathodes.

**8.** (b) Hydathodes are usually found on the margins and tips of the leaves. Each hydathode consists of a group of loosely arranged achlorophyllous or colourless and parenchymatous cells called epithem.

**9.** (a) Guttation is found in herbaceous plant *e.g.*, Garden nasturtium (*Tropaelum najas*), oat (*Avena Sativa*), Barley (Hordeum vulgare) and colocasia (Colocasia antiquorum) etc. growing in moist, warm soil and under humid conditions.

**12.** (a) In guttation drops of liquid come out of the edges of leaves during night and early mornings.

**14.** (d) Bleeding takes place through injured organs of plants.

**16.** (a) In night, root pressure will be maximum because in night transpiration is zero.

## Scientists and Apparatus concerned

**1.** (b) W. Ruhland (1912) and Hoffman (1925) described that, small pores are found on membranes the molecules which are small in size than pores of membrane are only passed through these membranes.

**2.** (a) Scholander et.al. (1965) ever the first to measure the tension directly by using pressure chamber method.

**3.** (a) Traube (1867) proposed his "Haftdruck" or retention pressure theory. According to him the permeation of solutes through a membrane depended on their relative greatness of affinity towards the membrane substance as compared to that of water.

**5.** (a) Some stomata open during night and remain closed during the day time and found in lower surface. This type of stomatal opening is called scotoactive type. This mechanism was explained by Nishida (1963).

**6.** (a) Yin and Tung (1948). Enzyme phosphorylase in guard cells are responsible for starch glucose interconversion.

**7.** (a) It incorporates good points of scarth's classical *pH* theory and active $K^+$ transport theory.

**9.** (c) Zelitch (1963) proposed that stomata open due to production of glycolic acid by photorespiration in guard cells under low concentration of $CO_2$.

**11.** (d) Hartt and his coworkers (1964) proposed that the movement of assimilates of a leaf can depend upon radiant energy.

**12.** (a) Swanson and Whitney (1953) reported that translocation out of the leaf was highly sensitive to temperature. Optimum temperature for translocation.

**13.** (a) The rate of absorption of water is approximately equal to the rate of transpiration.

**17.** (d) Slatyer and Taylor (1960). According to him water potential is the chemical potential of water which is equivalent to DPD with negative sign.

**18.** (d) Potometer used for transpiration and clinostat used for geotropism.

**20.** (a) Godlewsky (1884) proposed Relay pump theory.

**21.** (a) Munch mass flow or pressure flow Hypothesis : According to Munch (1930), the translocation of organic solutes takes place through phloem along a gradient of turgor pressure from the region of higher conc. of soluble solutes *i.e.*, supply end to the region of lower conc. *i.e.*, consumption end.

**22.** (c) Scholander et.al. (1965) were the first to measure the tension directly by using pressure chamber method or pressure bomb technique.

## Translocation of organic solutes

**1.** (d) According to curtis upward conduction of food also takes place through phloem. This view is based upon ringing experiments.

**2.** (c) Food (carbohydrates) is translocated from leaves to roots and storage organs along the phloem in the form of sucrose. Downward translocation from leaves to stem and roots.

**3.** (d) Translocation of solutes mostly occurs in form of sucrose.

**9.** (a) It is the long distance movement of organic substnaces from the source or supply end (region of manufacture or storage) to the region of utilization or sink.

**15.** (a) The movement of the molecules of gas, liquids and solutes from the region of higher concentration to the region of lower concentration is known as diffusion.

**20.** (a) Girdling : Removal of bark (phloem) in a ring-like manner is called as girdling. Due to this the root will not get food and die.

**23.** (b) *Munch mass flow* : This theory is based on difference in osmotic pressure in leaf mesophyll cells and root cells.

**29.** (d) Boron is highly essential for translocation of sugar. Translocation of sucrose occurs in the form of sucrose – borate complex.

**30.** (c) Ziegler (1956) believes that the diffusion of sugars from the mesophyll cells to the sieve tubes may occur against a concentration gradient.

## Critical Thinking Questions

**1.** (a) The intensity of the colour increases with the increase in temperature because at higher temperature the semi-permeability of the plasma membrane is gradually lost.

**3.** (d) If a cell is placed in hypotonic solution, water start moving into the cell by the process of endosmosis and cell become turgid.

**4.** (c) The pressure potential is usually positive.

**5.** (b) Sucrose is non-ionizing substance whereas *NaCl* is ionizing and osmotic pressure of a solution of ionizing substance is greater than that of equimolar concentration of a non-ionizing substance.

**6.** (b) Covering of the leaf surface with wax will stop cuticular transpiration, block stomata, stop stomatal transpiration and gaseous exchange on that surface.

**8.** (a) In water-logged soil, plants are unable to absorb water, thus they do not grow properly.

**9.** (d) $K^+$ are balanced by organic anions *i.e.*, malate and some $Cl^-$ ions are also taken in to neutralize a small percentage of $K^+$, this mechanism is controlled the turgidity of guard cells.

**10.** (b) Stephentiales (1727) coined the term root pressure. Root pressure is developed when rate of water absorption is more than the rate of transpiration.

**11.** (b) For $C_3$ plants the ratio is 500–800. It shows that $C_4$ plants transpire less and are more efficient in conserving water than most of $C_3$ plants.

**12.** (c) The water is held tightly around the soil particles due to cohesive forces. Hygroscopic water can not be easily removed by the plants. This type of water in soil is not available to plants.

**13.** (c) Taller plants like *Eucalyptus* need higher pressure to raise the water up. While the value of root pressure ranges from 2.5 atmospheres. A pressure of about 20 atm. is required to raise the water to tops of tall trees.

**16.** (c) Ringing or girdling experiment was first performing by Hartig (1937). This experiment suggests that in absence of phloem, downward translocation of food is stopped.

**17.** (b) According to passive absorption theory, the forces responsible for absorption of water originate not in the cells of roots but in the cells of transpiring shoots.

**18.** (b) Water is absorbed by the root hair due to osmotic differences between soil water and cells sap.

**19.** (b) During absorption of water by roots the water potential of cell sap is lower than that of pure water. Due to higher osmotic pressure of water in the root hair, the water from soil passes into the root hair.

## Assertion and Reason

**1.** (a) Hartig performed ringing experiment to show path of water through xylem. Xylem is basic tissue for conduction of water in higher plants. It has vessels and tracheids which are well adapted for water translocation.

**2.** (a) In plants, usually maximum water uptake is found in the root hair zone, as this part has the maximum surface area due to the presence of root hairs. These root hairs also withdraw from interspaces, which are not in contact with epiblema of the root. Whereas, the zone of mature cells cannot absorb water because of the presence of impermeable and suberised surface layer.

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

**4.** (b) In arid and unirrigated areas crop plants cannot be grown because of excessive transpiration and reduced water availability. Substances that reduce the rate of transpiration are called antitranspirants. *e.g.*, ABA. Antitranspirants will maintain a favourable internal water balance even in cases of very low water availability. It will allow farmers to grow crop profitably in unirrigated areas and help foresters to plant trees even in extreme arid or desert areas.

**5.** (c) Oil is a nonpolar molecule, which means that it does not form hydrogen bonds with water and therefore, does not dissolve.

**6.** (d) Film forming chemicals check transpiration by forming a thin film on the transpiring surface. They are sufficiently permeable to carbon dioxide and oxygen to allow photosynthesis and respiration but prevent movement of water vapours through them. There such chemicals can be used as antitranspirants.

**7.** (a) Many plant movements are produced due to reversible turgor changes in the cells. The opening and closing of stomata are caused by gain and loss of turgidity by their guard cells. They are hence often called "turgor operated valves".

**8.** (b) Flowers, young stems and other softer organs are able to maintain their form due to turgidity or TP (turgor pressure). In case of loss of turgidity, the shoots droop down and the leaves show wilting. Turgor pressure (pressure potential or hydrostatic pressure) keeps a check on the excessive entry of water into cells.

**9.** (e) In case of loss of turgidity, the shoots droop down and the leaves show wilting. In wilting the individual cells of leaves and other softer parts become flaccid, due to loss of water from their interior. In temporary wilting, plants gain their turgidity when they are given water. If the soil does not obtain water periodically, the recovery may be only partial or it may not occur at all. The latter condition is known as permanent wilting.

**10.** (a) A high osmotic pressure has been found to protect the plants against drought and frost injury. Seeds and spores are similarly able to pass through the unfavourable periods due to high osmotic pressure (or low solute potential).

**11.** (a) Turgor pressure is the pressure which develops in the confined part of an osmotic system due to osmotic entry of water into it. It is also called hydrostatic pressure or pressure potential. The force exerted by the cell wall over the protoplast is called wall pressure. Normally wall pressure is equal and opposite to turgor pressure except when the cell becomes flaccid.

**12.** (b) Shrinkage of the protoplast of a cell from its cell wall under the influence of a hypertonic solution is called plasmolysis. Hypertonic solution causes exosmosis or withdrawl of water from the central vacuole of cell. The pressure on the wall is simultaneously reduced and the elastic wall contracts causing a reduction in cell size. This is first stage of plasmolysis called limiting plasmolysis. Initially the protoplast withdraws itself from the corners. This stage is known as incipient plasmolysis. Due to continued exosmosis, protoplast shrinks further and withdraws from the cell wall except at one or a few points. It is known as evident plasmolysis. Cells cannot survive in such case.

**13.** (b) The accumulation of $CO_2$ in the soil appears to have a greater inhibitory effect on water absorption than do lowered oxygen tensions. An increase in $CO_2$ causes an increase in the viscosity of protoplasm and a decrease in the roots permeability to water thereby bringing about a retardation in water absorption.

**14.** (c) Sap is water with dissolved ingredients. The upward movement of water from roots towards the tips of stem branches and their leaves is called ascent of sap. It occurs through the tracheary elements of xylem.

**15.** (c) Plants have the potentiality to absorb water through their entire surface right from root, stem, leaves, flowers, etc. However, as water is available mostly in the soil, only the underground root system is specialized to absorb water. In roots, the most efficient region of water absorption is the root hair zone.

**16.** (c) The optimum or maximum amount of water retained per unit dry weight of soil after the stoppage of gravitational flow is called field capacity. It is 25-35% in common loam soils. Soil moisture beyond field capacity produces water logging.

**17.** (e) Although vessels and tracheids are oriented in the plant in a vertical direction with respect to their long axis and water movement is predominantly in this direction, lateral water movement does take place. Numerous pits through which water may pass perforate the side walls of vessel elements and tracheids. The xylem ray parenchyma greatly facilitates the lateral transport of water and nutrients.

**18.** (a) Light induces opening of stomata and increase the temperature, both these factor help in increase of transpiration, while darkness causes closure of stomata and reduces the rate of transpiration. Transpiration depends on closure and opening of stomata.

**19.** (a) Waxy coating, thick cuticle, sunken stomata, hairy surface reduce transpiration and are characters of xerophytes which grow in places where water is not available in much quantity.

**20.** (d) The intercellular spaces of the transpiring organ is almost saturated with water vapours. When the stomata are open the water vapours are drawn from the substomatal cavities to the outside air due to high DPD of the latter. This increases the DPD of the substomatal air which draws more water vapours from the intercellular spaces. The latter in turn get water vapours from the wet walls of mesophyll cells.

# Transport in Plants

## SET Self Evaluation Test

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

**2.** In the process of osmosis in the cell
(a) Both cell wall and protoplasm will act as a membrane
(b) Entire protoplast act as a membrane
(c) Only outermost layer of protoplasm act as a membrane
(d) Only cell wall act as a membrane

**3.** Osmotic pressure is highest in **[RPMT 1992]**
(a) Xerophytes (b) Lithophytes
(c) Halophytes (d) Mesophytes

**4.** In which part of the plant water is stored **[CPMT 1996]**
(a) Roots (b) Stem
(c) Leaves (d) Bark

**5.** Which of the following is done during ringing experiment **[CPMT 2010]**
(a) Bark is removed (b) Pith is removed
(c) Xylem is removed (d) All of these

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

**7.** Which of the following statements is/are not true
A. In CAM plants stomata open during dark and remain closed during the day
B. Role of $Na^+$ in stomatal opening is now universally accepted
C. The water potential of root cells is higher than the water potential of soil
D. Capillarity theory is the most accepted theory of water movement through plants
E. The walls of xylem vessels made up of ligno-cellulose have strong affinity for water molecules **[Kerala PMT 2008]**
(a) B, C and E only (b) B, C and D only
(c) A, B and C only (d) B and C only
(e) A and E only

**8.** Match the column I and with column II

| Column I | Column II |
|---|---|
| 1. Bulliform cells | A. Stomata |
| 2. Guard cells | B. Aerating pore |
| 3. Lenticel | C. Accessory pore |
| 4. Subsidiary cell | D. Isobilateral leaf |

**[Manipal 2005]**
(a) 1-D, 2-A, 3-B, 4-C (b) 1-A, 2-D, 3-B, 4-C
(c) 1-D, 2-B, 3-C, 4-A (d) 1-A, 2-B, 3-C, 4-D

**9.** Guttation only occurs in
(a) Hydrophytes (b) Mesophytic herbs
(c) Mangroves (d) Marshy plants

**10.** Which is the most important precaution to be observed in finding out the rate of transpiration through Ganong's potometer
(a) A broad leaf plant need to be selected
(b) The experimental shoot should be obliquely cut
(c) The shoot should be cut under water
(d) Apparatus to be filled with water

**11.** In the resting state of the neutral membrane, diffusion due to concentration gradients, if allowed, would drive **[CBSE PMT 2004]**
(a) $Na^+$ into the cell
(b) $Na^+$ out of the cell
(c) $K^+$ into the cell
(d) $K^+$ and $Na^+$ out of the cell

## AS Answers and Solutions

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | a | 2 | c | 3 | c | 4 | c | 5 | d |
| 6 | a | 7 | b | 8 | a | 9 | b | 10 | c |
| 11 | a | | | | | | | | |

**2.** (c) Outermost layer of cell *i.e.*, plasma membrane acts as semipermeable membrane.

**3.** (c) Because halophytes are the plants of saline habitat.

**9.** (b) All plants do not show guttation. It is restricted to about 345 genera of herbaceous and some woody plants. *e.g.*, Garden Nasturtium, Oat, Balsum, Tomato etc.

**10.** (c) The shoot should be cut under water because prevent air from entering the vessels.

* * *