DAY THIRTEEN

Transport in Plants

Learning & Revision for the Day

- Means of Transport
- Passive Transport
- Active Transport
- Plant-Water Relations
- Long Distance Transport of Water
- Ascent of Sap
- Transpiration
- Guttation
- Uptake and Translocation of Mineral Nutrients

- In plants, the substances that need to be transported are water, mineral nutrients, organic nutrients and plant growth regulators.
- Over small distances, these substances move by diffusion or by cytoplasmic streaming supplemented by active transport. Transport over long distances proceeds through the vascular system (xylem and phloem) and is called **translocation**.
- In rooted plants, transport in xylem (water and minerals) is unidirectional, i.e. from roots to the stems. Organic nutrients undergo multidirectional transport. Organic compounds synthesised in the photosynthetic leaves are exported to all the storage organs of plants and later are re-exported.

Means of Transport

The process of transport in a plant takes place at three levels. These are

1. The uptake and release of substances within a cell, i.e. cellular level transport.
2. Transport of substances from one cell to another, i.e. short distance transport.
3. Transport of water and suger *via* xylem and phloem, i.e. long distance transport.

The various means of transport used to carry out transportation in these levels are as follows

Passive Transport

In this type of transport a molecule is transported along it's concentration gradient without the involvement of ATP. The flow of water in and out of the plant mainly occurs by passive transport. Passive transport of water and solutes in plants may take place *via* diffusion, osmosis, plasmolysis, etc.

Diffusion

- It is the movement of particles or molecules or ions from a region of higher concentration to the region of lower concentration.
- Diffusion is a passive process, which requires no expenditure of energy and remains unaffected by the concentration gradient of the other molecules. e.g.
  1. **Exchange of gases,** i.e. CO_2 and O_2 during photosynthesis and respiration.
  2. **Absorption of ions** during passive salt uptake.
  3. **Stomatal transpiration** where diffusion of water vapour takes place.
  4. **Aroma of flower** is the result of diffusion of volatile aromatic compounds.

Diffusion Pressure (DP)

It is the force or pressure developed by the movement of the diffusible particles of a substance, as they move from higher concentration to lower concentration. Diffusion pressure of pure water is maximum.

Facilitated Diffusion

- The diffusion rate depends on the size of the substances and on its solubility in lipids, the major constituent of the membrane. Substances that find difficult to pass through the membrane, their movement has to be facilitated by proteins. Such movement is called **facilitated diffusion.** However, a concentration gradient must be there for molecules to diffuse.
- Facilitated diffusion is very specific, it allows the cells to uptake only selected substances.
- The proteins called **porins** form huge pores in the outer membranes of the plastids, mitochondria and some bacteria. They allow molecules up to the size of small proteins to pass through.
- The transport proteins release the molecule inside the cell. Some transport proteins allow diffusion only when two molecules move together.
- Such a transport takes place in a **symport** where both molecules cross the membrane in the same direction.
- In an **antiport**, they move in the opposite directions.
- When a molecule moves across a membrane independent of other molecules, the process is called **uniport.**

Osmosis

- It is the diffusion of water molecules, through a differentially permeable membrane or semipermeable membrane, i.e. allow only certain substances to pass through them, e.g. all biological membranes, plasma membrane, tonoplast, etc.
- **Osmotic Pressure** (OP) is the actual pressure, which develops in a solution when it is separated from pure water by means of semipermeable membrane.
- Osmotic pressure of solution is always higher than its pure solvent.
- Highest osmotic pressure is recorded from xerophytic plant *Artiplex confertialia.*
- Osmosis is very important for plants because it is responsible for absorption of water by roots, turgidity of plant organs, cell to cell movement of water, opening and closing of stomata and resistance of plants to drought, frost, etc.
- The net movement of water *via* osmosis depends on the solution surrounding the cell sap.
- Solutions can be of three types depending on their concentration relative to the cell sap.
- When concentration of outer solution (in which cell is placed) is equal to concentration of cell sap, it is called **isotonic solution**.
- If a cell is placed in an isotonic solution, the amount of water leaving the cell equals that entering the cell and therefore, there is no net movement of water.
- When concentration of outer solution is higher than concentration of cell sap, the solution is called **hypertonic solution.**
- If a cell is placed in a hypertonic solution, exosmosis takes place and net movement of water occurs from the cell outwards.
- When concentration of outer solution is lower than concentration of cell sap, the solution is called **hypotonic solution**.
- If a cell is placed in pure water or hypotonic solution, endosmosis takes place and net movement of water occurs into the cell.

Plasmolysis

- When a cell is placed in hypertonic solution, the protoplasm shrinks and leaves the cell wall due to the exosmosis and cell becomes flaccid.
- This cell is called **plasmolysed cell** and the phenomenon is called **plasmolysis**.
- If the plasmolysed cell is placed in **hypotonic** solution, the cell again becomes turgid, due to the endosmosis and this phenomenon is called **deplasmolysis**.
- Bacteria get plasmolysed in salty pickles and sugary jams, common salt also kills weeds by plasmolysis.

Imbibition

- It is the cause of swelling of wooden doors and windows in rainy season and swelling of seeds after being dipped in water.
- The first step in imbibition is **adsorption,** i.e. attachment of liquid on the surface.

- Imbibition is important for water absorption and germination of seeds.
- Maximum absorption of water takes place by root hair zone. They increase the absorptive surface area of roots.
- In conifers (gymnosperms), root hairs are either totally absent or poorly developed and these occur in association of fungal hyphae with roots (i.e. mycorrhiza).
- Kneading of wheat floor is accompanied by release of heat which is due to the imbibition of water molecules by starch and cellulose.

Active Transport

It uses energy to pump molecules against a concentration gradient with the help of membrane-proteins. Pumps are proteins that use energy to carry substances across the cell membrane.

Various Mechanisms of Active Transport Across Plasma Membrane

Process	Passage Through	Work	Example
Endocytosis	Membrane vesicle	Large particle (phagocytosis) or small particle (pinocytosis) is engulfed by membrane, which forms vesicle around it.	Ingestion of bacteria by white blood cells (phagocytosis); 'nursing' of human egg cells (pinocytosis).
Exocytosis	Membrane vesicle	Vesicle fuses with plasma membrane and ejects its contents.	Secretion of mucus.
Sodium-potassium pump	Protein channel	Export of three Na^+ ions for every import of two K^+ ions.	Found in all cells.
Proton pump	Protein channel	Export of protons (H^+ ions) against a concentration gradient.	Chemiosmotic generation of ATP; found in chloroplasts and mitochondria.
Coupled channels	Protein channels	Import of molecule with Na^+ or H^+ ions using the concentration gradient, established by the pumps of these ions.	Import of glucose into cell.

Comparison of Simple Diffusion, Facilitated Diffusion and Active Transport

Characters	Simple Diffusion	Facilitated Diffusion	Active Transport
Type of membrane molecule involved	Lipids	Proteins	Proteins
Force driving the process	Concentration gradient	Concentration gradient	ATP hydrolysis
Direction of transport	With concentration gradient	With concentration gradient	Against concentration gradient
Specificity	Non-specific	Specific	Specific
Saturation at high concentration of transported molecules	No	Yes	Yes

Plant-Water Relation

- Water is essential for all physiological activities of the plant and plays a very important role in all living organisms.
- Distribution of water within a plant varies, i.e. woody parts have relatively very little water, while soft parts mostly contain water.

Water Potential

- The concept of water potential was proposed by **Slatyer** and **Taylor** in 1960.
- The water potential in a plant tissue is always less than zero bar and hence, a negative number. It is represented by Greek letter 'ψ' (psi).
- Water potential ψ_w of pure water is **zero** and addition of solute in it decreases its ψ_w (i.e. negative value).
- Water moves from a higher water potential (lower DPD) to lower water potential (higher DPD).
- Since water potential is measured as a negative value the water moves from less negative water potential to more negative water potential.
- Water potential is the sum of the osmotic potential and the pressure potential. This can be represented by

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

- Higher the water potential, greater is the ability of the tissue to supply water to other more dessicated cells and tissues. Thus, the water potential is used to measure water deficit and water stress in plant cells and tissues.

- The pressure that develops in a cell due to the osmotic diffusion is called Turgor Pressure (TP), as cell wall is rigid, it also exerts equal and opposite pressure to that of **turgor pressure**, which is termed as wall pressure.

$$TP = WP$$

- The difference between the diffusion pressure of the solution and its solvents at a particular temperature and atmospheric conditions is called **Diffusion Pressure Deficit** (DPD) or **Suction Pressure** (SP).
- It determines the direction of net movement of water. It has a positive value.
- If the solution is more concentrated, then its DPD increases while it decreases with the dilution of the solution.
- The relation between Diffusion Pressure Deficit (DPD), Suction Pressure (SP), Osmotic Pressure (OP), Turgor Pressure (TP) and Wall Pressure (WP) is as follows

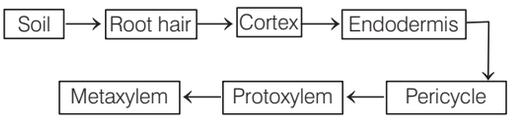
$$DPD\,(SP) = OP - TP\,(WP)$$

Absorption of Water

- The amount of water that soil can hold depends upon the total pore space in soil. Water is present in the spaces between the soil.
- The total amount of water present in the soil is called **holard**.The water available to plant for absorption is **chresard**. The rest of soil water is called **echard**.

Pathways of Water Movement

Pathway of water movement from soil to xylem can be shown as follows:



In roots, zone of cell differentiation absorbs both water and minerals.

Munch (1930) gave the concept of pathway of water from root hairs to xylem inside the root. It is of two types:

(i) **Apoplast pathway** or **apoplastic movement** The water passes from roots hairs to xylem through non-living cell walls without crossing the living cell membrane or cytoplasm. It is a faster process and is not affected by the metabolic activity of root. Apoplastic movement occurs only upto endodermis because it is interrupted by the presence of impermeable lignosuberin casparian strips in the wall of endodermal cells.

(ii) **Symplast pathway** or **symplastic movement** The water passes from cell to cell through cytoplasm *via* cell membrane and plasmodesmata without entering cell vacuoles. It is also known as transmembrane pathway. It is a slower process and is influenced by the metabolic status of root.

Vacuolar transport is the movement of water through vacuoles present in the cytoplasm of cell.

Mechanism of Water Absorption

Water absorption by plants is of two types, i.e. active and passive.

(i) **Active absorption of water** A very small amount of water (4%) is absorbed by active mechanism, it involves an expenditure of metabolic energy which comes from the respiring cells of the root. In this type of absorption, roots (particularly root hair) play active role.

(ii) **Passive absorption of water** Absorption of water takes place due to the forces developed at the transpiring surface of the plant (i.e. transpiration pull).

In this type, the cells of the root do not play any role, and energy is not required. Hence, it is known as passive absorption. Thus, in passive absorption, water is just pulled through the roots. It is the most common (96%) and rapid method of water absorption.

Ascent of Sap

- The upward movement of water from roots to the aerial parts of a plant is known as ascent of sap.
- Various experiments demonstrate that the actual pathway of ascent of sap is xylem tissue in terrestrial plants.
- Xylem contains vessels, tracheids and xylem parenchyma.
- These vessels are made up of thick-walled cells joined end to end.
- The partition wall between the cells dissolves, cell contents disappear and form a hollow tubular structure that resembles water pipes.

Following theories have been put forward to explain the mechanism of ascent of sap.

Vital Force Theory

- **Sir JC Bose** was the strong supporter of this theory.
- According to him, upward translocation of water takes place due to the pulsatory activity of living cells of innermost cortical layer just outside the endodermis. It is also called as **pulsation theory**.
- This theory was only hypothetical and was further discarded by the experiments of **Strasburger** (1891, 1893).
- He demonstrated that the ascent of sap continues even in the stems, in which living cells have been killed by the uptake of poison.

Root Pressure Theory

- This theory was put forward by **Priestley** (1916).
- Root pressure is maximum during rainy season in the tropical countries and during spring in temperate habitats.
- It is retarded or becomes absent under conditions of starvation, low temperature, drought and reduced availability of oxygen.

- Although root pressure developed in the xylem of the roots by the active absorption of nutrient from the soil and can raise water to a certain height, but it does not seem to be an effective force in ascent of sap due to the certain reasons like low magnitude (about 2 atms) of root pressure.
- It is because even in the absence of root pressure, the ascent of sap continues and in gymnosperms, root pressure has rarely been observed.

Physical Force Theories

(i) **Capillary force theory** was proposed by **Boehm** (1809). According to this theory, capillary force of vessels and tracheids is responsible for ascent of sap.

(ii) **Transpiration pull** or **Cohesion tension theory** was proposed by **Dixon** and **Jolly** (1894).

- Water molecules being held by H-bonds between them, therefore, form a solid or compact water column (i.e. cohesion) and a large tension is required to break a column of water.
- Cell walls of xylem vessels have affinity for water molecules (i.e. adhesion).
- Loss of water from aerial parts, through transpiration causes a suction pressure in the water column of plant which is called **transpiration pull.**
- Such a pull exerted on water column helps in continuous flow of water in upward direction.

Transpiration

- The loss of water in the form of water vapours from living tissues of aerial parts of plants, is called **transpiration.**
- About 95% water absorbed by roots of plant, is lost by transpiration and only 5% is used by plant.
- Transpiration is of three types, i.e. stomatal transpiration (80-90%), cuticular transpiration (3-9%) and lenticular transpiration (0.1-1%).

Stomata

- Transpiration mainly occurs through stomata (sing. stoma) (i.e. minute pores generally present on leaf epidermis).
- Each stoma is bordered by two specialised epidermal cells called **guard cells**, which are generally kidney-shaped or bean-shaped.
- Guard cells are surrounded by other specialised epidermal cells called **subsidiary cells** or **accessory cells**.
- Potometer measures the transpiration rate of plant (e.g. Ganong's potometer, Farmer's potometer) and comparative rate of transpiration of two leaf surfaces is measured by cobalt chloride paper method.
- Transpiration does not take place in submerged aquatic plants.
- There are three categories of stomata
  - **Barley type** The guard cells are dumb-bell-shaped. Number of stomata are equal on both the surfaces of leaf. They usually remain open during the day for a few hours, e.g. maize, wheat.
  - **Alfalfa type** They open during day and close during night under mesophytic conditions, e.g. pea, radish, mustard.
  - **Potato type** Stomata are more on the lower surface than on upper surface. Under mesophytic condition, the stomata can remain open throughout the day and night. Examples of this type are onion, banana, potato, etc.

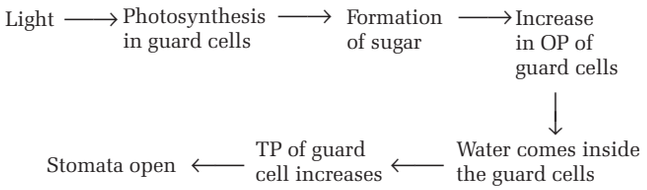
Stomatal Movement

- The opening and closing of stomatal pore is called stomatal movement. This movement is shown in response to entry or exit of water from the guard cells.
- The guard cells differ from other epidermal cells in containing chloroplast and radial thickenings of cellulosic microfibrils in their walls that face stomtal pore. In response to changes in turgor pressure, these cellulosic microfibrils radiate outwards or inwards around their circumference. Due to this, shape of guard cell changes and stomatal movement takes place.
- There are three main theories to explain the mechanism of stomatal movements. These are *as follows*
  (i) Guard cell photosynthesis theory
  (ii) Starch-sugar interconversion theory
  (iii) Malate or K^+ ion pump theory.

(i) Guard Cell Photosynthesis Theory

This theory was proposed by Von Mohl in1856. He observed that stomata open in day light and close at night. *According to him the sequence of changes in stomata are as follow*

During day



During night, there is no photosynthesis and hence, these changes are reversed.

(ii) Starch-Sugar Interconversion Theory

- This theory was given by Sayre in 1923 and was modified by Steward 1964.
- According to this theory, during day light CO_2 concentration in guard cells decreases, leading to an increase in pH.
- High pH favours hydrolysis of starch (insoluble) into glucose-1-phosphate, it further changes into glucose (soluble). Due to this, osmotic potential becomes lower in

guard cells and water from the surrounding epidermal and mesophyll cells enters into the guard cells by osmotic diffusion. Guard cells become turgid and stomata open.

- During night (dark), reverse process occurs and glucose-1-phosphate is converted into the starch in guard cells. This increases the osmotic potential and the guard cells release water. They become flaccid and stomata are closed.

During light

$$\text{Starch} + n\text{H}_3\text{PO}_4 \xrightarrow{\text{Phosphorylase}} n\,\text{Glucose-1-phosphate}$$

$$\text{Glucose-1-phosphate} \overset{\text{Mutase}}{\rightleftharpoons} \text{Glucose-6-phosphate}$$

$$\text{Glucose-6-phosphate} + \text{water} \xrightarrow{\text{Phosphatase}} \text{Glucose} + \text{H}_3\text{PO}_4$$

During dark

$$\text{Glucose} + \text{ATP} \xrightarrow{\text{Hexokinase}} \text{Glucose-6-phosphate} + \text{ADP}$$

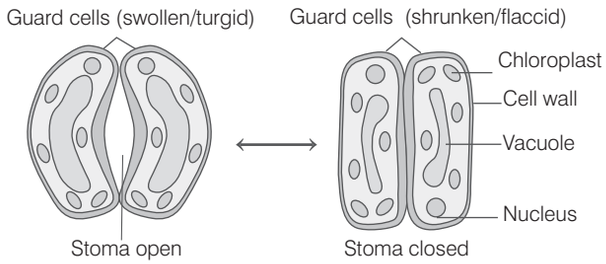
$$\text{Glucose-6-phosphate} \overset{\text{Mutase}}{\rightleftharpoons} \text{Glucose-1-phosphate}$$

$$\text{Glucose-1-phosphate} \xrightarrow{\text{Phosphatase}} \text{Starch} + \text{H}_3\text{PO}_4$$

Starch-sugar interconversion theory is not universally applicable. It may operate under certain circumstances only.

(iii) Malate or K^+ Ion Pump Theory

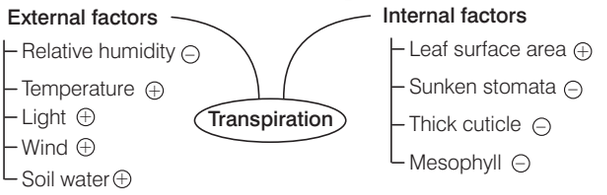
- This theory was given by **Levitt** in 1974. This is also known as the modern theory of stomatal movement.
- pH of the guard cell can rise due to active H^+ uptake by guard cell in chloroplasts or mitochondria. A rise in pH during day time causes hydrolysis of starch due to which organic acid, i.e. phosphoenol pyruvate is formed. Phosphoenol pyruvate combines with available CO_2 to produce malic acid.
- Malic acid dissociates to produce H^+ and malate. The protons (H^+) are pumped out from the guard cells into the subsidiary cells and in the exchange, K^+ ions are pumped into guard cells, from the adjacent subsidiary cells.
- This exchange of H^+ and K^+ ions is followed by the entry of Cl^- ions into the guard cells with the help of cAMP, ATP and cytokinins.
- K^+ ions immediately combine with malate and increase the osmotic concentration of the guard cells.
- As a result, guard cells absorb water from the nearby epidermal (subsidiary) cells, swells up and lead to opening of stomata.
- Reverse situation prevails during dark when stomata are closed. There is no accumulation of K^+ ions in guard cells in dark.



	During day (light)	**During night** (dark)
1	CO_2 concentration decreases	CO_2 concentration increases
2	Malic acid formed in guard cells	ABA released to stop the K^+ exchange
3	Dissociates into malate ions and H^+	K^+ ions transported back into subsidiary cells
4	K^+ ion exchange from subsidiary cells	Decreased pH of guard cells
5	OP of guard cells is increased (due to accumulation of K^+ and malate ions)	Decreased OP of guard cells due to starch synthesis in guard cells (loss of K^+ ions by guard cells)
6	Endosmosis into guard cells	Exosmosis from guard cells
7	Guard cells turgid	Guard cells looses turgidity
8	Stomata open	Stomata close

Factors Affecting Transpiration

Various factors which affect the transpiration are as follows:



⊕ = Increase in transpiration with increasing related factors.
⊖ = Decrease in transpiration with increase in related factor.

Advantages of Transpiration

Advantages of transpiration are as follows

(i) It plays an important role in the upward movement of water, i.e. ascent of sap.

(ii) It helps in the absorption and translocation of mineral salts.

(iii) Rapid evaporation of water from the aerial parts of the plant through transpiration brings down their temperature. Thus, it prevents them from excessive heating. This is also known as cooling effect.

NOTE **Antitranspirants** are inhibitors of transpiration. These may be metabolic inhibitors like PMA (Phenyl Mercuric Acetate), ABA (Abscisic Acid) and aspirin or film forming like silicon emulsions, waxes, etc.

Guttation

- At night or early morning, when evaporation is low, excess water collects in the form of droplets around special openings of veins, near the tip of grass blades and leaves of many herbaceous plants.

- The process of exudation of liquid drops from the edges of leaves is called guttation and it usually occurs through stomata like pores called **hydathodes**.

Uptake and Translocation of Mineral Nutrients

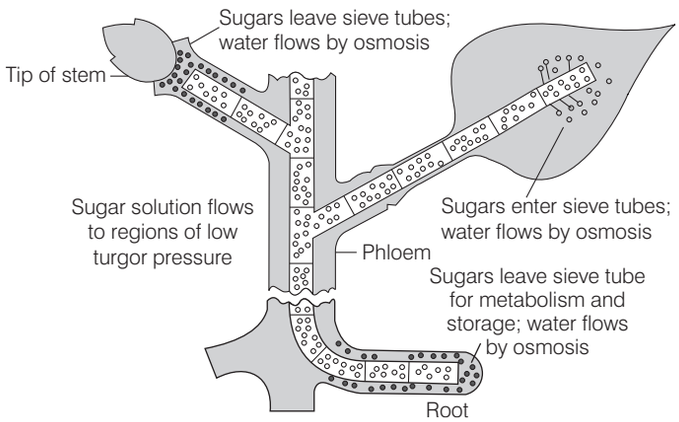
- Most minerals must enter the root by active absorption into the cytoplasm of epidermal cells. This needs energy in the form of ATP. Some ions also move into the epidermal cells passively.
- Specific proteins in the membranes of root hair cells actively pump ions from the soil into the cytoplasm of the epidermal cells.
- Transport protein of endodermal cells are control points, where plant adjusts the quantity and types of solutes that reach the xylem.
- The root endodermis because of the layer of suberin has the ability to actively transport ions in one direction only.
- The chief sinks for the mineral elements are the growing regions of the plant, such as the apical and lateral meristems, young leaves, developing flowers, fruits and seeds and the storage organs.
- Unloading of mineral ions occurs at fine vein endings, through diffusion and active uptake by these cells.
- Mineral ions are frequently remobilised, particularly from older, senescing parts. Some structural elements like calcium are not remobilised. Xylem transports only inorganic nutrients, while phloem transports only organic materials.

Phloem Transport of Food

- Sucrose is the main food transported by the vascular tissue phloem, from a source (the leaf) to sink (which stored food).
- The source-sink relationship is variable due to the season and needs. The direction of movement in the phloem is bidirectional. In xylem, the movement of water is always unidirectional, i.e. upwards.
- Phloem transports mainly water and sucrose as sap but also translocates other sugars, hormones and amino acids.

Mass Flow Hypothesis

- **Ernst Munch** (1930) was the first to propose this hypothesis of solute transport in phloem tissue.
- According to this theory, organic solutes are translocated through the sieve tubes from the source to the sink. The source and sink may be reversed depending on the plant needs. The direction of movement in phloem can be upwards or downwards.
- Water enters the mesophyll cells from the xylem and as a result, turgor pressure of the mesophyll cells increases.
- Sugar dissolved in water move from mesophyll cells into the symplast system of sieve tubes. Solutes are carried through the symplast to finally reach the consumption site (sink).
- At the sink, solutes may be used up or can be stored in insoluble forms. Hence, the osmotic concentration and turgor pressure in these cells will be low.
- A continuous pressure gradient establishes between the source and sink. Water returns to the source through the apoplast system.
  Sucrose transport from the mesophyll cells to the sink involves following three processes
  (i) **Phloem loading** It is carried out by a specific carrier protein molecule in the cell surface membrane of companion cells that use energy of ATP from the photosynthesising mesophyll cells to the sieve tubes in the veins of a leaf.
  (ii) **Long distance transport** of sucrose in the stem and root phloem.
  (iii) **Phloem unloading** of the sieve tubes takes place at the sink. It takes place passively down a concentration gradient of sucrose. The transfer cells are often present at the unloading sites.
- This process also requires metabolic energy.



Diagrammatic presentation of mechanism of translocation of sugars

- A simple experiment called girdling, was used to identify the tissues through which food is transported. This experiment proved that phloem is responsible for the translocation of food. When a plant is girdled (phloem removed), roots will die first.

NOTE
- Transfer cells are similar to ordinary companion cells, with additional development of finger-like wall ingrowths, particularly on the cell walls that face away from the sieve elements.
- These wall ingrowths greatly increase the surface area of the plasma membrane, thus increasing the potential for solute transfer across the membrane.
- P-proteins are phloem proteins found in sieve tube elements of most angiosperms including all dicots and many monocots.
- They appear to function in sealing off damaged sieve elements by plugging up the sieve plate pore.
- P- proteins are absent in gymnosperms.

DAY PRACTICE SESSION 1

FOUNDATION QUESTIONS EXERCISE

1 In which type of absorption, metabolic energy is required and roots play a positive role of absorbing water in
(a) active absorption (b) passive absorption
(c) Both (a) and (b) (d) None of these

2 Which of the following criteria does not pertain to facilitated transport? ➝ NEET 2013
(a) High selectivity
(b) Transport saturation
(c) Uphill transport
(d) Requirement of special membrane protein

3 The water potential of an aqueous solution is ➝ NEET 2017
(a) zero (b) more than one
(c) less than one (d) infinite

4 The water potential is
(a) equal in soil and atmosphere
(b) lowest in soil and highest in atmosphere
(c) highest in soil and lowest in atmosphere
(d) non-existent at both the places (soil and atmosphere)

5 Water potential in the leaf tissue is positive (+) during
(a) excessive transpiration (b) low transpiration
(c) excessive absorption (d) guttation

6 The process of movement of solvent from its higher chemical potential to its lower chemical potential (without allowing the diffusion of solute) through semipermeable membrane is known as
(a) independent diffusion (b) diffusion
(c) osmosis (d) exosmosis

7 During osmosis, water moves through a semipermeable membrane

	From		To
(a)	low water potential	—	high water potential
(b)	high solute concentration	—	low solute concentration
(c)	high osmotic potential	—	low osmotic potential
(d)	a hypotonic solution (less solution)	—	a hypertonic solution

8 Selectively (differentially) permeable membrane is that which allows
(a) all the solute particles to pass through it
(b) none of the solute particles to pass through it
(c) some of the solute particles to pass through it and prevents others
(d) all the solute particles to pass through it in the beginning for 5-10 minutes, then the rate declines

9 Osmosis is the diffusion of a solution of a weaker concentration, when both are separated by semipermeable membrane. What is the error in the statement?
(a) The movement of water molecules is not specified
(b) There is no mention of DPD
(c) Behaviour of semipermeable membrane
(d) The exact concentrations are not indicated

10 Osmosis is a passage of
(a) solute from a semipermeable membrane
(b) water or solvent without a membrane
(c) solution through a permeable membrane
(d) solvent through a semipermeable membrane from a less concentrated solution to a more concentrated solution

11 Plant cells submerged in distilled water will become
(a) turgid (b) flaccid
(c) plasmolysed (d) impermeable

12 The value of osmotic potential of an electrolyte is always
(a) more than non-electrolyte
(b) less than non-electrolyte
(c) same as non-electrolyte
(d) None of the above

13 Osmotic pressure is responsible for the turgidity of plant cells, which
(a) causes cell elongation
(b) causes opening of stomata
(c) prevents wilting of leaves
(d) All of the above

14 In modern terminology, the value of osmotic potential is
(a) positive (b) negative
(c) zero (d) None of these

15 Water will be absorbed by root hairs, when the external medium is
(a) hypotonic (b) hypertonic
(c) isotonic (d) viscous

16 Bacteria cannot survive in a highly salted pickle because
(a) salt inhibits reproduction
(b) bacteria do not get enough light for photosynthesis
(c) they become plasmolysed and consequently killed
(d) the pickle does not contain nutrients necessary for bacteria to live

17 The shrinkage of the protoplast of a cell, from its cell wall under the influence of a hypertonic solution, is known as
(a) endosmosis (b) exosmosis
(c) plasmolysis (d) deplasmolysis

18 When a fresh piece of potato is placed in a concentrated solution, it will

(a) swell up (b) remain as such
(c) shrink (d) die

19 The regaining of turgidity by a protoplast under the influence of hypotonic solution is known as

(a) deplasmolysis (b) plasmolysis
(c) exosmosis (d) endosmosis

20 Which of the following is an example of imbibition?

(a) Uptake of water by root hairs
(b) Exchange of gases through stomata
(c) Swelling of seeds when dipped in water
(d) Opening of stomata

21 Tick the correct statement.

(a) The closely packed imbibant will imbibe less water than the loosely packed one
(b) The closely packed imbibant will imbibe more water than the loosely packed one
(c) Both will imbibe the same amount of water
(d) The amount of water absorbed by closely packed and loosely packed imbibant will depend upon the temperature of the medium

22 Match the following columns.

	Column I		Column II
A.	Apoplast	1.	Molecules cross the membrane in same direction.
B.	Symplast	2.	Move in opposite directions.
C.	Porins	3.	System of interconnected protoplasts
D.	Symport	4.	Continuous adjacent cell walls
		5.	Proteins in the outer membrane

Codes

	A	B	C	D
(a)	4	3	5	1
(c)	5	4	2	1

	A	B	C	D
(b)	2	3	4	5
(d)	1	2	4	5

23 Root pressure develops due to ➝ CBSE-AIPMT 2015

(a) active absorption
(b) low osmotic potential in soil
(c) passive absorption
(d) increase in transpiration

24 Root pressure is maximum, when

(a) transpiration is high and absorption is low
(b) transpiration is very low and absorption is high
(c) transpiration and absorption both are high
(d) transpiration and absorption both are low

25 Root pressure which plays a small role in xylem flow, is caused by

(a) transpiration of water out of the xylem
(b) cohesion of water molecules to one another
(c) adhesion of water molecules to walls of the xylem
(d) osmotic flow of water in the xylem

26 According to the transpiration-cohesion theory, water is pulled upward through the xylem. The cause of the pull is

(a) guttation (b) root pressure
(c) transpiration (d) condensation

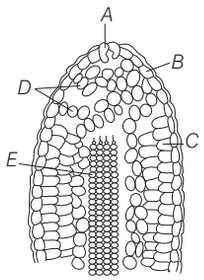
27 A column water within xylem vessels of tall trees does not break under its weight because of ➝ CBSE-AIPMT 2015

(a) dissolved sugars in water
(b) tensile strength of water
(c) lignification of xylem vessels
(d) positive root pressure

28 According to Steward, ATP is used in stomatal mechanism during

(a) opening (b) closing
(c) Both (a) and (b) (d) None of these

29 What is the correct labelling of the following figure ?



(a) *A* – Guard cell, *B* – Epithem, *C* – Mesophyll, *D* – Epidermis, *E* – Vasculature
(b) *A* – Guard cell, *B* – Epidermis, *C* – Mesophyll, *D* – Epithem, *E* – Vasculature
(c) *A* – Water pore, *B* – Epidermis, *C* – Mesophyll, *D* – Epithem, *E* – Vasculature
(d) *A* – Ostiole, *B* – Epidermis, *C* – Mesophyll, *D* – Epithem, *E* – Vasculature

30 Guard cells help in

(a) protection against grazing
(b) transpiration
(c) guttation
(d) fighting against infection

31 In land plants, the guard cells differ from other epidermal cells in having

(a) mitochondria (b) endoplasmic reticulum
(c) chloroplasts (d) cytoskeleton

32 In the mechanism of opening of stomata, the important factor is

(a) shape of the guard cells
(b) chlorophyll contents of the cell
(c) hormone contents of the cell
(d) protein contents of the cell

33 Which one of the following elements is responsible for maintaining turgor in cells ? ➝ NEET 2018

(a) Potassium (b) Sodium
(c) Magnesium (d) Calcium

34 The stomata in angiosperms open and close due to
(a) their genetical constitution
(b) the force of their habit
(c) the pressure of gases inside the leaf
(d) a change in the turgor pressure of the guard cells

35 Plants that open their stomata at night and close them during the day have
(a) C_3-pathways of photosynthesis
(b) C_4-pathways of photosynthesis
(c) Calvin Benson pathways of photosynthesis
(d) CAM pathways of photosynthesis

36 Which of the following facilitates opening of stomatal aperture? ➝ NEET 2017
(a) Contraction of outer wall of guard cells
(b) Decrease in turgidity of guard cells
(c) Radial orientation of cellulose microfibrils in the cell wall of guard cells
(d) Longitudinal orientation of cellulose microfibrils in the cell wall of guard cells

37 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 the following options. ➝ NEET-I 2016
(a) Both processes can happen together because the diffusion coefficient of water and CO_2 is different
(b) The above processes happen only during night-time
(c) One process occurs during daytime and the other at night
(d) Both processes cannot happen simultaneously

38 Active K^+ exchange mechanism for opening and closing of stomata was given by
(a) Levitt (b) Darwin (c) Scarth (d) Fujino

39 According to Sayere and Scarth, the opening and closing of stomata is governed by
(a) pH (b) enzymes
(c) phosphorylation (d) $NADPH_2$ formation

40 Stomata open during daytime because the guard cells
(a) are thin-walled
(b) are bean-shaped
(c) have to help in gaseous exchange
(d) photosynthesise and produce osmotically active sugars or organic acid

41 The stomata are widely open in
(a) red light (b) blue light
(c) green light (d) yellow light

42 The stomatal aperture is measured by
(a) porometer (b) potometer
(c) photometer (d) tensiometer

43 When stomata open at night only, they are called
(a) photoactive stomata (b) scotoactive stomata
(c) nyctinastic stomata (d) All of these

44 When stomata remain open throughout the day and night, they are called
(a) alfa-alfa type (b) potato type
(c) barley type (d) equisetum type

45 The lower surface of leaf will have more number of stomata in
(a) dorsiventral leaf (b) isobilateral leaf
(c) Both (a) and (b) (d) None of these

46 Generally, the loss of water through stomata in most of the plants is
(a) 20-50% (b) 30-50% (c) 50-88% (d) 50-97%

47 Which of the following changes in the cell sap of the guard cells are responsible for keeping the stomata open during daytime?
(a) Increase in the osmotic pressure but decrease in turgor pressure
(b) Decrease in the osmotic pressure but increase in turgor pressure
(c) Increase in both osmotic and turgor pressure
(d) Decrease in both osmotic and turgor pressure

48 The process which carried by hydathodes is
(a) photosynthesis
(b) imbibition
(c) guttation
(d) turgor pressure maintenance

49 A few drops of sap were collected by cutting across a plant stem by a suitable method. The sap was tested chemically. Which one of the following test results indicates that it is phloem sap ? ➝ NEET-II 2016
(a) Acidic (b) Alkaline
(c) Low refractive index (d) The absence of sugar

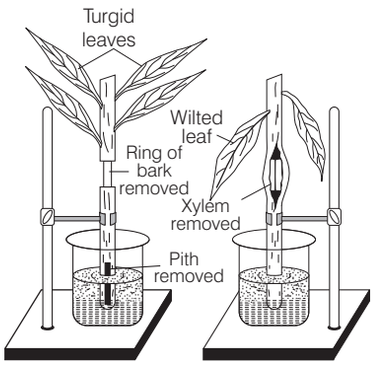
50 Food synthesised in leaves is transported to other parts by
(a) translocation (b) nastic movement
(c) chemotaxis (d) phototaxis

51 The translocation of organic solutes in sieve tube members is supported by
(a) P-proteins
(b) mass flow involving a carrier and ATP
(c) cytoplasmic streaming
(d) root pressure and transpiration pull

52 Removal of ringwood of tissue outside the vascular cambium from the tree trunk kills it because
(a) water cannot move up
(b) food does not travel down and root becomes starved
(c) shoot becomes starved
(d) annual rings are not produced

53 Most widely accepted theory of carbohydrate translocation is
(a) mass flow theory (b) root pressure theory
(c) imbibition theory (d) transpiration theory

54 Identify the process taking place in this experiment.



(a) Ringing experiment for translocation of sap
(b) Demonstration of root pressure
(c) Eosin test to demonstrate ascent of sap
(d) None of the above

55 Match the following columns.

Column I		Column II	
A.	Phloem	1.	Phloem tissues
B.	Xylem	2.	Translocation
C.	Sieve tube cells	3.	Transpiration
D.	Girdling experiment	4.	Bidirectional movement
		5.	Unidirectional movement

Codes

	A	B	C	D
(a)	2	1	5	4
(b)	4	5	1	2
(c)	1	2	3	4
(d)	5	4	2	1

DAY PRACTICE SESSION 2

PROGRESSIVE QUESTIONS EXERCISE

1 The movement of solutes in the phloem is mainly
(a) acropetal (b) lateral
(c) basipetal (d) lateral acropetal

2 The chief water conducting elements of xylem in gymnosperms are
(a) vessels (b) fibres
(c) transfusion tissue (d) tracheids

3 The form of sugar transported through phloem is
(a) glucose (b) fructose (c) sucrose (d) ribose

4 Ascent of sap in plants was demonstrated by
(a) Girdling experiment (b) Ganong's experiment
(c) Went experiment (d) Lever auxanometer

5 Addition of a solute to pure water causes
(a) negative water potential
(b) more negative water potential
(c) positive water potential
(d) more positive water potential

6 Potometer works on the principle of
(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

7 The movement of water from one cell of the cortex to the adjacent one in roots, is due to the
(a) accumulation of inorganic salts in the cells
(b) accumulation of organic compounds in the cells
(c) chemical potential gradient
(d) water potential gradient

8 In a branch cut from a rapidly transpiring plant, water snaps away from the cut end. It shows that it
(a) is under tension
(b) is in excess in vessels
(c) has been absorbed by capillary force
(d) has been absorbed by imbibition force

9 The direction of movement of water from outside into the cell and also from one cell to the next cell is
(a) from higher DPD to lower DPD
(b) from lower DPD to higher DPD
(c) from cell to cell with same values of DPD
(d) None of the above

10 If a thoroughly cleaned goat's bladder is filled with syrup, tightly tied and immersed in a vessel of water
(a) the volume of liquid within the bladder will increase
(b) the volume of liquid within the bladder will decrease
(c) the volume of liquid within the bladder will remain constant
(d) plasmolysis will occur

11 The rate of diffusion is dependent upon the permeability of that medium, it however
(a) influences the final equilibrium of diffusion as it is never reached if the medium is dense
(b) does influence the final equilibrium of diffusion
(c) does not influence the final equilibrium of diffusion
(d) None of the above

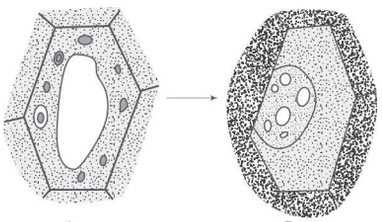
12 ..... is responsible for the movement of sugars from leaves to tap roots; ..... is responsible for the movement of sugars from tap roots to leaves.
(a) Transpiration; transpiration (b) Bulk flow; bulk flow
(c) Bulk flow; root pressure (d) Bulk flow; transpiration

13 The most accepted theory for ascent of sap is
(a) transpiration pull and cohesion-tension theory of Dixon and Jolly
(b) pulsating action of living cell
(c) role of atmospheric pressure
(d) de Vries cytoplasmic streaming theory

14 Sugar moves from leaves into the ..... of ..... by ..... .
(a) sieve tube members; phloem; active transport
(b) sieve tube members; xylem; active transport
(c) sieve tube members; phloem; diffusion
(d) tracheids; phloem; active transport

15 The process of guttation takes place
(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 is equals the rate of transpiration
(d) when the root pressure as well as rate of transpiration are high

16 Identify the figure '*A*' and '*B*' and name the different stages of the figure.



A *B*

(a) *A* – Incipient plasmolysis, *B* – Plasmolysed cell
(b) *A* – Turgid cell, *B* – Plasmolysed cell
(c) *A* – Plasmolysed cell, *B* – Turgid cell
(d) *A* – Plasmolysed cell, *B* – Incipient plasmolysis

17 Match the following columns.

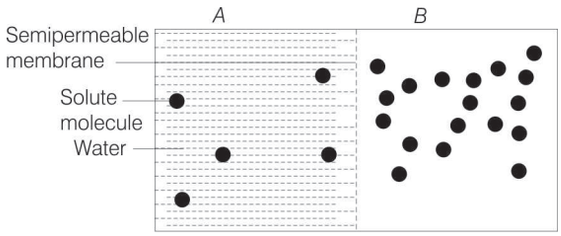
	Column I		Column II
A.	Leaves	1.	Antitranspiration
B.	Seed	2.	Transpiration
C.	Roots	3.	Imbibition
D.	Aspirin	4.	Absorbtion

Codes

	A	B	C	D		A	B	C	D
(a)	3	4	1	2	(b)	1	2	3	4
(c)	2	3	4	1	(d)	3	2	1	4

18 If cohesion-tension transpiration theory is correct then a break in water column in a xylem vessel should
(a) have no effect at all
(b) increase the rate of photosynthesis
(c) increase the water contents of leaves
(d) cause the mesophyll cells to become flaccid and result in wilting of leaves

19 Based on the figure given below which of the following statements is not correct?

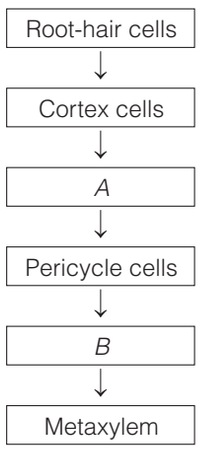


(a) Movement of solvent molecules will take place from chamber *A* to *B*
(b) Movement of solute will take place from *A* to *B*.
(c) Presence of a semipermeable is a prerequisite for this process to occur
(d) The direction and rate of osmosis depend on both the pressure gradient and concentration gradient

20 By which mechanism, the salt resistant plants can get rid of excess Na^+ ions to the outer side, through the roots ?
(a) H^+ — ATPase Uniport system
(b) Na^+ — Uniport system
(c) H^+ —Cl^- symport system
(d) Na^+ — H^+ antiport system

21 Which one is true about guttation?
(a) It occurs through specialised pores called hydathodes
(b) It occurs in herbaceous plants when root pressure is low and transpiration is high
(c) It only occurs during the daytime
(d) It occurs in plants growing under conditions of low soil moisture and high humidity

22 In the given flow chart, the flow of water is shown from soil to xylem. Mention the step *A* and *B*.



(a) *A* – Casparian strips, *B* – Protoxylem
(b) *A* – Pith, *B* – Plasmodesmata
(c) *A* – Endodermis, *B* – Casparian strips
(d) *A* – Endodermis, *B* – Protoxylem

23 Which of the following is not a purpose of transpiration?
(a) Supplies water for photosynthesis
(b) Helps in translocation of sugars from source to sink
(c) Maintains shape and structure of the plant
(d) Cools leaf surface
(e) Transports minerals from the soil to all parts of the plant

24 Path of water movement from soil to xylem is
(a) Metaxylem → Protoxylem → Cortex → Soil → Root hair
(b) Cortex → Root hair → Endodermis → Pericycle → Protoxylem → Metaxylem
(c) Soil → Root hair → Cortex → Endodermis → Pericycle → Protoxylem → Metaxylem
(d) Pericycle → Soil → Root hair → Cortex → Endodermis → Protoxylem → Metaxylem

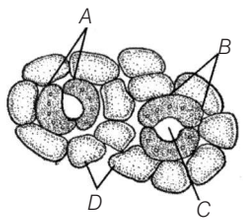
25 When a plant wilts, what will be the sequence of events?
(a) Endosmosis–Plasmolysis–Temporary and permanent wilting
(b) Exosmosis– Plasmolysis–Temporary and permanent wilting
(c) Exosmosis–Deplasmolysis–Temporary and permanent wilting
(d) Exosmosis-Plasmolysis-Deplasmolysis-Temporary and permanent wilting

26 At the time of seed germination, when water is absorbed by the seeds due to the imbibition, the seed coat breaks as it swells to a lesser degree than the kernel because
(a) the kernel is made up of proteins, lipids and starch while, the seed coat is formed of cellulose
(b) the kernel is made up of cellulose, while the seed coat is made up of proteins, lipids and starch
(c) both kernel and seed coat are made up of same constituents, it depends on the nature of medium
(d) None of the above

27 The term tensile strength represents that there is
(a) a strong cohesion force between water molecules, so the column does not break and it is stretched by transpiration pull
(b) a strong adhesion between water molecules and walls of xylem vessels so the column does not break and it is stretched by transpiration pull
(c) absence of vacuoles in the vessels, so the column does not break and it is stretched by transpiration pull
(d) loss of water by leaves, so positive tension is created and column does not break and it is stretched by transpiration pull

28 Atmospheric pressure theory was rejected for the ascent of sap because
(a) there is no free surface at the lower end of the plant, which is necessary for the operation of atmospheric pressure
(b) maximum height to which water can rise is about 50 m
(c) movement of the water is very slow and negligible and it forms only an infinitesimal small fraction of the total
(d) this is not useful in adhering water to the walls of the xylem elements

29 The following figure shows the stomatal apparatus. Identify the parts labelled as *A*, *B*, *C* and *D*. Choose the correct answer from the following.



(a) *A* – Guard cells, *B* – Stoma, *C* – Chloroplasts, *D* – Subsidiary cells
(b) *A* – Subsidiary cells, *B* – Chloroplasts, *C* – Stoma, *D* – Guard cells
(c) *A* – Guard cells, *B* – Chloroplasts, *C* – Stoma, *D* – Subsidiary cells
(d) *A* – Subsidiary cells, *B* – Stoma, *C* – Chloroplasts, *D* – Guard cells

ANSWERS

SESSION 1

1 (a)	**2** (c)	**3** (a)	**4** (c)	**5** (b)	**6** (c)	**7** (d)	**8** (c)	**9** (a)	**10** (d)
11 (a)	**12** (a)	**13** (b)	**14** (b)	**15** (a)	**16** (c)	**17** (c)	**18** (c)	**19** (a)	**20** (c)
21 (a)	**22** (a)	**23** (a)	**24** (b)	**25** (d)	**26** (c)	**27** (b)	**28** (a)	**29** (b)	**30** (b)
31 (c)	**32** (a)	**33** (a)	**34** (d)	**35** (d)	**36** (c)	**37** (a)	**38** (a)	**39** (a)	**40** (d)
41 (b)	**42** (b)	**43** (b)	**44** (d)	**45** (a)	**46** (c)	**47** (a)	**48** (c)	**49** (b)	**50** (a)
51 (b)	**52** (b)	**53** (a)	**54** (a)	**55** (b)					

SESSION 2

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