

Chapter - 11

Transport In Plants

Active transport:- Movement of substances from their lower conc. to higher conc. through selectively permeable membrane using energy.

Facilitated transport : Movement of substances from higher conc. to lower conc. with the help of transport proteins.

It may be symport antiport or uniport.

Diffusion Movement of substances from higher conc. to lower conc. without involving transport protein.

Means of transport

Pressure Potential :- Magnitude of increase in water potential when it measures greater than atmospheric pressure, is applied to pure water.

Solution potential :- Magnitude of lowering of water potential when solute is added to water.

Water potential :- It is the measure of conc. of water or kinetic energy of water in a system. It is zero for pure water.

Plant water relations

Osmosis :- Movement of solvent from their higher chemical potential to their lower chemical potential through selectively permeable membrane.

Plasmolysis :- Shrinkage of protoplasm away from the cell wall due to exosmosis in hypertonic solution.

Imbibition :- Absorption of water by solid particles of an adsorbent resulting in increase in volume.

Transpiration - Removal of water in the form of water vapours through stomata of leaves.

Guttation :- Removal of water droplets through hydathodes.

Some important reactions

TRANSPORT OF SUBSTANCES IN PLANTS (source to sink)

Uptake and transport of mineral nutrients and food

Xylem Transport :- Uptake and transport of mineral nutrients through xylem. It occurs by active or passive absorption and moves along with water.

Phloem Transport :- Movement of sugar, hormones and amino acids by pressure flow or mass flow hypothesis. Absorption of sugar takes place actively.

Features involved in water movement upward

SURFACE TENSION

Cohesion-Tension - Transpiration pull theory:- Forces of adhesion and cohesion maintain water column and transpiration pull is major force driving water upward.

Root pressure theory :- A hydrostatic pressure existing in roots which pushes the water up in xylem vessels upto certain height in herbaceous plants.

Methods of water absorptions and movement to root xylem

Apoplastic Pathway : Movement through inter cellular spaces or cell wall movement is fast and most of water enters through this way.

Symplastic Pathway :- Water enters the cell through cell membrane and travel through cytoplasm and plasmodesmata; movement is slow.

At casparian strips region, water moves through symplast only.

Points To Remember

Translocation (Long distance transport) : Transport of substances in plants over longer distances through the vascular tissue (Xylem and Phloem) The transport of water and mineral in Xylem is unidirectional while transport of organic and mineral nutrients in phloem is multi-directional.

Means of transport (Short distance transport) : The transport of material into and out of the cells is carried out by a number of methods. These are diffusion, facilitated diffusion and active transport.

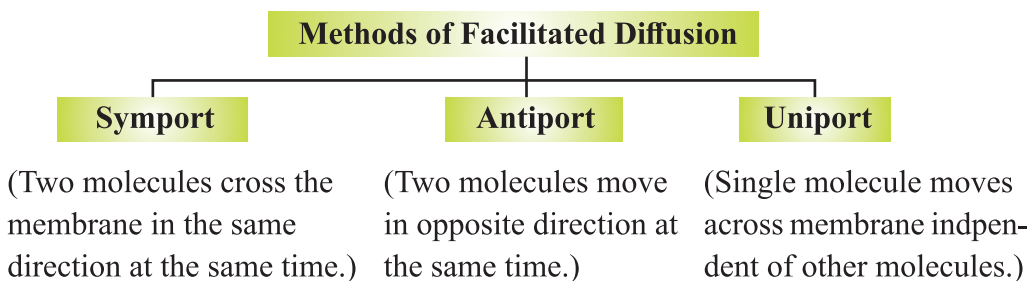
(i) **Diffusion :** Diffusion occurs from region of higher concentration to region of lower concentration. It is passive and slow process. No energy expenditure takes place. No membrane required

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

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

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

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



Transport Proteins—They are present in the membrane. They allow the passage of substances through membrane.

(i) **Carrier Proteins**—They bind to the particular solute particle to be transported and deliver these to other side of membrane.

(ii) **Channel Proteins—Ion Channel**—They are specific for different ions like K^+ , Cl^- , NO_3^- , PO_4^{3-} , Mg^{2+}

Water Channel—Surrounded by eight proteins called Aquaporins and allow passage of water or water soluble substance.

(iii) **Active transport** : Active transport is carried by the mobile carrier proteins (known as protein pumps) of membrane. Active transport uses energy to pump molecules against a concentration gradient from a low concentration to high concentration (uphill-transport). It is faster than passive transport.

Different Transport Mechanisms

S. No.	Property	Simple Diffusion	Facilitated Transport	Active Transport
1.	Required Special membrane protein	No	Yes	Yes
2.	Uphill transport	No	No	Yes
3.	Requires ATP Energy	No	No	No

- **Water potential**—(ψ_w)—Greater the concentration of water in a system, greater is its kinetic energy and greater is the water potential. It is measured in pascal (Pa) or mega pascal.
- If two systems are in contact, then there is movement of water from the solution with higher potential to lower water potential.
- **Solute potential**—(ψ_s)—Magnitude of lowering of water potential, when a solute is added to the water.
- **Pressure Potential**—(ψ_p)—Magnitude of increase of water potential, when pressure greater than atmospheric pressure is applied to pure water or a solution.
- Water potential of pure water is zero (0).
- Solute potential is always negative (–) and pressure potential is always positive (+).

$$\psi_w = \psi_s + \psi_p$$

- **Osmotic Pressure**—External pressure applied to prevent the diffusion of water. It depends upon solute concentration.
- Numerically, osmotic pressure is equal to osmotic potential. Osmotic pressure has positive (+) sign. Osmotic potential has negative (–) sign.

Turgor Pressure—Due to osmotic entry of water, the protoplasm of a plant cell presses the cell wall towards the outside with a force, it is called Turgor Pressure.

Diffusion Pressure—The pressure exerted by the tendency of the particles to diffuse from the area of higher concentration to lower concentration. It is directly proportional to the concentration of particles of diffusing substance.

Osmosis : Osmosis is movement of solvent or water molecules from the region of their higher chemical potential to the region of their lower potential across a semipermeable membrane.

Water molecules move from higher water potential to lower water potential until equilibrium is reached.

Plasmolysis : Process of shrinkage of protoplasm away from its cell wall due to exosmosis in hypertonic solution. If a plasmolysed cell is placed in water or a hypotonic solution it becomes turgid.

Hypotonic solution : The external solution which is more dilute than the cytoplasm. Cell kept in hypotonic solution become turgid.

Hypertonic solution : The external solution, which is more concentrated than the cytoplasm. Cell kept in hypertonic solution get plasmolysed

Isotonic solution : When the external solution balances the osmotic pressure of the cytoplasm. Cell kept in isotonic solution become flaccid.

Casparian strip : It is the tangential as well as radial walls of endodermal cells having the deposition of water impermeable suberin.

Imbibition : Imbibition is the phenomenon of absorption of water by the solid particles of an adsorbent causing it to enormously increase in volume without forming a solution.

Some examples of Imbibition :

- (i) If a dry piece of wood is placed in water, it swells and increases in its volume.
- (ii) If dry gum or pieces of agar-agar are placed in water, they swell and their volume increases.
- (iii) When seeds are placed in water they swell up.
- (iv) Swelling of wooden door during rainy season.

Conditions essential for imbibition

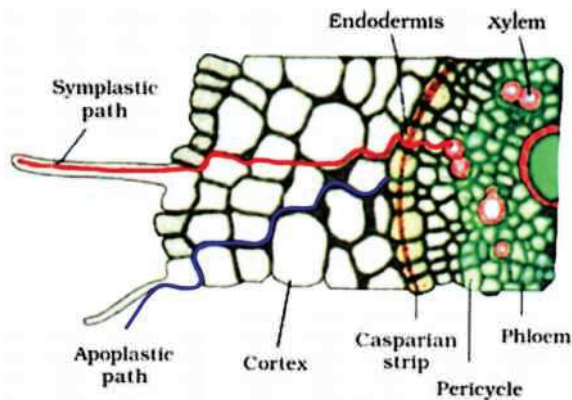
1. Water potential gradient between the surface of the adsorbent and the imbibed liquid, is essential.
2. Affinity between the adsorbent and the imbibed liquid.



Transport of water in plants : Water is absorbed by root hairs by diffusion. Then water moves upto xylem by two pathways—apoplast and symplast pathway.

Apoplast Pathway—Movement occurs through the intercellular spaces or walls of the cell, without entering the cytoplasm. This movement is fast. In roots, movement of water occurs via apoplast except at the casparian strip, most of water enters through apoplast.

Symplast Pathway—Water enters the cell through cell membrane and travels intercellularly through plasmodesmata. This movement is slow. At casparian strip region water moves only through symplast.



Apoplastic And Symplastic Pathways of Water Transport

Ascent of Sap—Upward movement of water in the form of dilute solution of mineral ions from roots to the top aerial parts of plants through tracheary elements of xylem against the gravitational force is called ascent of sap. It involves two theories—

(i) **Cohesion–Tension–Transpiration pull theory.**

(ii) **Root pressure theory.**

(1) **Cohesion-Tension-Transpiration pull theory—**

(i) **Continuity of water column**—The transport of water to the top of trees occurs through xylem vessels. The forces of adhesion and cohesion maintain a thin and unbroken column of water in the capillaries of xylem vessels through which it travels which is travels upward. Water is mainly pulled by transpiration from leaves.

(ii) **Transpiration Pull**—Transpiration accounts for loss of 99% of water in the form of water vapours from the surface of leaves. The loss is mainly through stomata.

- Pull of water as a result of tension created by transpiration is the major driving force of water movement upward in a plant. This movement is called ascent of sap.

Three physical properties of water which affect the ascent of xylem sap due to transpiration pull.

(iii) **Cohesion force or Tensile strength of water—**

- **Cohesion**—Mutual attraction between water molecules.
- **Adhesion**—Attraction of water molecules to polar surface.
- **Surface tension**—Attraction of water to each other in liquid phase to a greater extent than to water in gaseous phase.

(2) **Root pressure Theory** : A hydrostatic pressure existing in roots which pushes the water up in xylem vessels upto certain height to herbaceous plant.

Guttation : The water loss in its liquid phase in the form of water droplets at night and early morning through special openings of vein near the tip of leaves. These openings are called hydathodes.

Transpiration : The loss of water through stomata of leaves and other aerial parts of plants in form of water vapours.

Factors affecting transpiration : Temperature, light, relative humidity, wind speed, number and distribution of stomata, water status of plant, canopy structure.

Significance of transpiration—Advantages—Helps in ascent of sap, removal of excess water, cooling effect, distribution of mineral salts, supply water for photosynthesis.

Disadvantages—May cause reduced growth, wilting (loss of turgidity), reduced yield and waste of energy.

Since there are advantages as well as disadvantages of transpiration so—‘Transpiration is called a necessary evil’.

Opening and closing of stomata—Opening and closing of stomata happens due to following two reasons—

- (i) Change in the turgidity of guard cells.
- (ii) Orientation of cellulose microfibrils in the cell wall of guard cells.

Endosmosis—When a cell is placed in water or hypotonic solution, water enters into the cell. This is called endosmosis. Due to it the volume of cell increases and it creates turgor pressure.

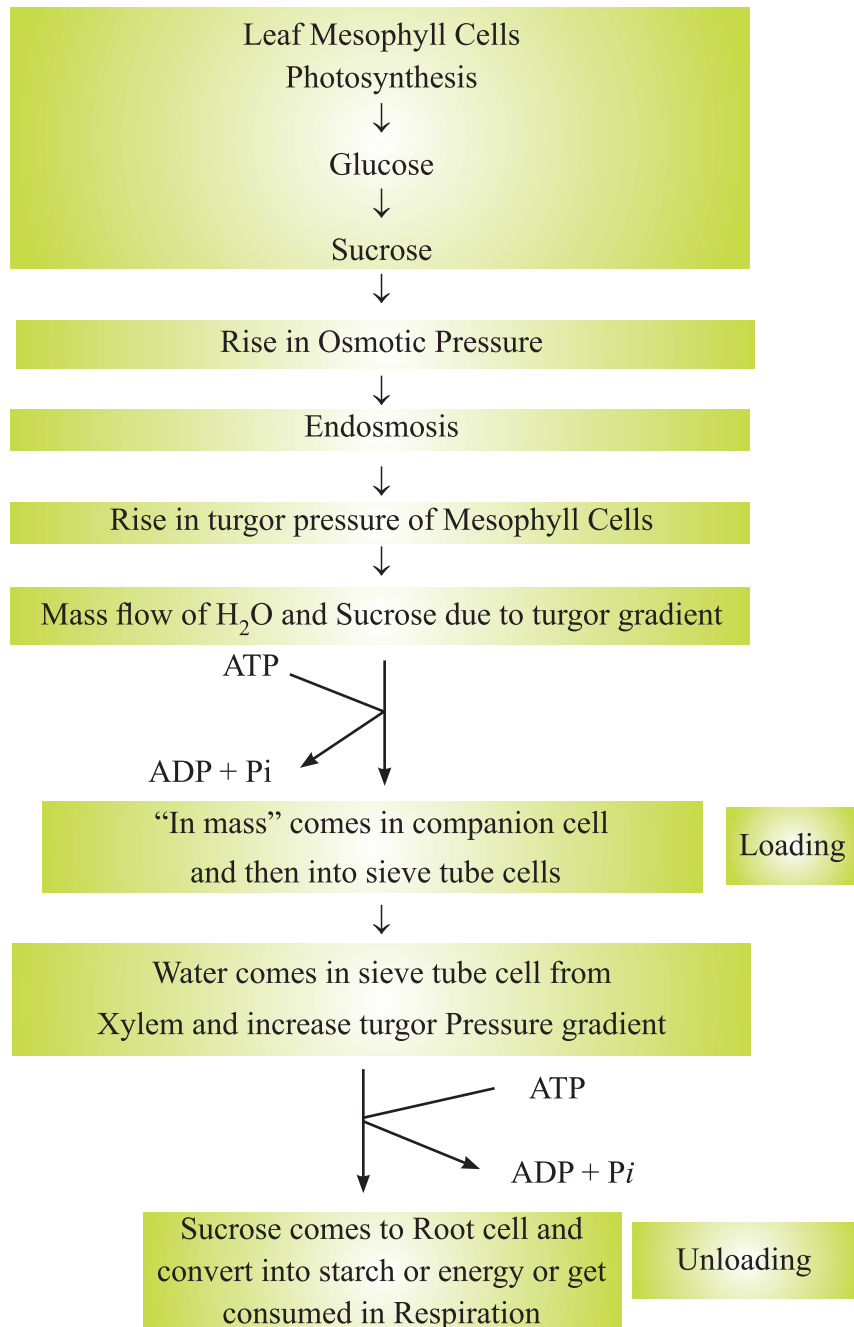
Exosmosis—When a cell is placed in hypertonic solution, water comes out of the cell, this is called exosmosis. It decreases volume of the cell.

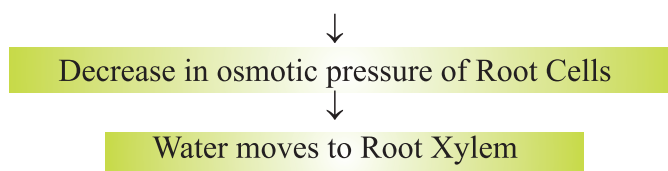
Uptake and transport of mineral nutrients—Ions are absorbed by the roots by passive and active transport. The active uptake of ions requires ATP energy. Specific proteins in membranes of root hair cells actively pump ions from the soil into the cytoplasm of epidermal cells and then xylem. The further transport of ions to all parts of the plant is carried through the water stream. Older dying leaves export much of their mineral content to younger leaves. Elements phosphorus, sulphur, nitrogen and potassium are most readily mobilised. Structural components such as calcium are not remobilised.



Mass flow : Mass flow is the movement of substances (water, minerals and food) in bulk from one point to another as a result of pressure differences between two points.

The pressure or mass flow Hypothesis :





Mycorrhiza—A mycorrhiza is a symbiotic association of a fungus with a root system. The fungal hyphae absorb mineral ions (phosphorous) and water from the soil, and provide them to the roots of plant, in turn the roots provide sugars and nitrogen containing compounds to the mycorrhizae.

Questions

(SRT) Select Response Type Question (1 mark each)

1. Which part of the root is related with the absorption of water ?

(a) root tip	(b) terminal root
(c) root hair	(d) leaf
2. What makes the raisins to swell up when kept in water ?

(a) Endosmosis	(b) diffusion
(c) Exosmosis	(d) Guttation
3. Casparian strip is made of a substance which is impervious to water. Name this substance.

(a) Lignin	(b) cellular
(c) Suberin	(d) Pectin

CONSTRUCTED RESPONSE TYPE (CRT)

Very Short Answer Questions (1 mark each)

4. What will happen to water potential when a solute is added to water ?
5. A plant cell when kept in a solution got plasmolysed. What was the nature of the solution.
6. Mention two ways of absorption of water by root hairs in plants.
7. Which form of sugar is transported through phloem ?
8. Give one example of imbibition.
9. A flowering plant is planted in an earthen pot and irrigated. Urea is added to make the plant grow faster, but after some time the plant dies. Give its possible reason.

10. Why is energy required to develop root pressure ?
11. Correct the statements :
 - (a) Imbibition is a special type of diffusion when water is absorbed by living cell.
 - (b) Most of water flow in the roots occurs via symplast.
 - (c) Cells shrink in hypotonic solution and swell in hypertonic solution.

Short Answer Questions-I

(2 marks each)

12. A well watered potted herbaceous plant shows wilting in the afternoon of a dry sunny day. Give reason.
13. Do different species of plants growing in the same soil show the same rate of transpiration at a particular time ? Justify your answer.
14. What is casparian strip ? Write its significance in plants.
15. Xylem transport is unidirectional and phloem transport bi-directional why ?
16. How is transpiration different from guttation ? Give two points.
17. Suggest two methods to increase the life of cut plants in a vase.
18. Write the chemical composition of xylem and phloem sap.
19. Transpiration is a necessary evil in plants. Explain.

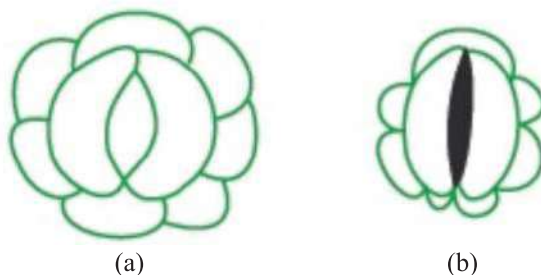
Short Answer Questions-II

(3 marks each)

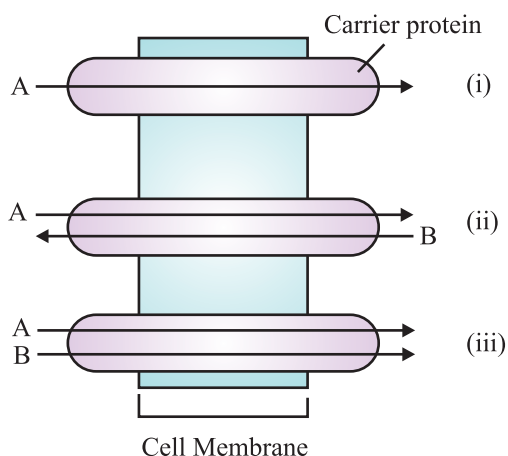
20. Why is solute potential always negative ? Explain.

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

21. Water has a very important role in sustaining the life list properties of water which make it useful for all biological processes on earth.
22. When any dry plant material or seeds is/are kept in water, they swell up.
 - (a) Name the phenomenon involved in this change.
 - (b) Define this phenomenon.
 - (c) Give two conditions essential for the phenomenon to occur.
23. Differentiate between temporary and permanent wilting. Do any of them indicate the water status of the soil ?
24. Observe the diagram and answer the following :



- (a) Which of these guard cells show a higher water content, A or B ?
 (b) Are these types of guard cells found in monocots or dicots ?
 (c) Name the element which play an important role in the opening and closing of stomata.
25. What is mycorrhiza ? How is the mycorrhizal association helpful in absorption of water and minerals in plants ?
26. Observe the given figure and give the answers of the following :
 (a) Identify the process occurring in (I), (II) and (III).
 (b) Differentiate between the process II and III.
 (c) How many types of aquaporins form the water channels in the cell membrane.



27. Give scientific term for the following statements/processes :
 (a) Movement of water in roots exclusively, through the cell wall
 (b) The positive hydrostatic pressure developed inside the cell or cell wall.
 (c) A solution having relatively less concentration.
 (d) Loss of water vapour from the aerial parts of the plants in the form of water vapours.

- (e) Movement of a molecule across a membrane independent of other molecule.
- (f) Water loss in its liquid phase through the special opening of veins near the tip of leaves of many herbaceous plants.

Long Answer Questions

(5 marks each)

- 28. Minerals are present in the soil in sufficient amount. Do plants need to adjust the types of solutes that reach the xylem ? Which molecules help to adjust this? How do plants regulate the type and quantity of solutes that reach xylem.
- 29. How do plants absorb water ? Explain transpiration pull model in this regard.
- 30. (a) Describe the pressure flow hypothesis of translocation of sugar in plants.
(b) Explain the mechanism of closing and opening of stomata.

Answers

(SRT) Select Response Type Question

(1 mark each)

- 1. (a) root tip
- 2. (a) Endosmosis
- 3. (a) Suberin

CONSTRUCTED RESPONSE TYPE (CRT)

Very Short Answer

(1 mark each)

- 4. Water potential will decrease.
- 5. Hypertonic.
- 6. Apoplast and symplast pathway.
- 7. Sucrose.
- 8. Swelling of seed when put in water/moist soil.
- 9. Due to exosmosis *i.e.*, water comes out the plant.
- 10. Every activity requires energy. Root pressure develops due to activity of living cell.
- 11. (a) Osmosis is a special type, of diffusion when water is absorbed by living cells.
(b) Most of the water flows in the roots occurs via the apoplast.
(c) Cells shrink in hypertonic, solution and swell in a hypotonic solution.

Short Answers-I

(2 marks each)

- 12. During noon, the rate of transpiration becomes higher than the rate of water absorption by plant. It causes loss of turgidity and leads to wilting.

13. Rate of transpiration is not same because transpiration is affected by numbers and distribution of stomata, and their opening.
14. Band of suberised matrix on the inner side of endodermis water molecule are unable to penetrate it.
15. In xylem movement of water is always from roots to leaves. In phloem movement of food is from source to sink and vice versa.

16.	Transpiration	Guttation
	(i) Loss of water by a plant in form of vapours.	(i) The loss of water in the form of liquid droplets from the plant.
	(ii) Occurs through the general surface of leaves (stomata) and the young stems.	(ii) Occurs at the margins and the tips of the leaves.

17. (a) By adding cytokinin into water of the vase.
(b) Preventing entry of air in the cut plants by immediately immersing the cut end in water.
18. Xylem Sap-Water, traces of all minerals.
Phloem sap-5-10% sucrose, 1% amino acids, traces of bound mineral, hormones, other organic substances and rest is water.
19. Refer to 'Points of Remember' (Significance and disadvantages of Transpiration)

Short Answers-II

(3 marks each)

20. Refer to 'Points of Remember'. (Solute Potential, Pressure Potential and Water potential)
21. Refer to 'Points of Remember', (Cohesion, Adhesion and surface tension)
22. (a) Imbibition.
(b) Refer to 'Points to Remember.'
(c) Condition necessary to imbibition.
 - (i) Water potential between the absorbent and the liquid imbibed.
 - (ii) Affinity between the adsorbent and the liquid imbibed.

23.	Temporary wilting (i) Plant recovers from temporary wilting after sometimes. (ii) Much damage is not caused. (iii) It commonly occurs during mid-day only.	Permanent wilting (i) Automatic recovery is not possible. It may recover if water is provided soon. (ii) Much damage is caused. (iii) It occurs throughout day and night.
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When wilting is permanent, water present in soil is largely in unavailable form. The soil contains 10-15% water depending, upon its texture.

24. (a) A (b) Dicots
 (c) K^+ (Potassium ions)
25. Refer points to remember.
26. (a) (i) Uniport (ii) Antiport (iii) Symport
 (b) Refer 'Points to Remember'.
 (c) 8 types of aquaporins.
27. (a) Apoplast pathway (b) Turgor pressure
 (c) Hypotonic (d) Transpiration
 (e) Uniport (f) Guttation

Long Answers

(5 marks each)

28. Refer 'Points to remember'.
 29. Refer 'Points to remember'.
 30. (a) Refer points to remember.
 (b) Refer 'Points to remember'.

Assertion Reasoning

The following question consists of 2 statements- Assertion (A) and Reason (R). Answer the question by selecting the appropriate option below :

- (a) Both A and R are true and the reason is a correct explanation of the assertion

- (b) The assertion is true but the reason is false
(c) Both the assertion and reason are false
(d) The assertion is false but the reason is true
31. **Assertion (A)** : Facilitated diffusion occurs due to channel proteins.
Reason (R) : The proteins are of extrinsic type.
32. **Assertion (A)** : Transpiration is considered as a necessary evil.
Reason (R) : Ascent of sap occurs due to three physical properties of water

SOLUTIONS

Assertion Reasoning

31. (b) 32. (b)

Source-based/Case-based/Passage-based/Integrated Assessment questions

Read the following and answer questions from given below :

33. Translocation in plants occurs by mass flow. This was a hypothesis first given by Munch and then was elaborated by Crafts. According to this theory, organic solutes are translocated 'en masse' through the sieve tubes from the source to the sink. The hypothesis fails to explain the bidirectional movement of metabolites which is common in plants. Munch and Crafts could not explain how osmotic pressure is maintained in and balanced in mesophyll cells and that of root hair. This hypothesis placed sieve tube and protoplasm in a secondary role of mass flow whereas xylem and movement of water plays important role in maintaining turgor pressure for the mass flow. Turgor pressure gradient is established across the protoplasm between the cells of the source and the cells of the sink.
- (i) What are the source and sink referred to?
- (ii) Why does water move from the xylem into the lumen of sieve tubes and causes turgor pressure gradient?
- (iii) The movement of sugars at the sink is removed by _____ (active/passive transport). Choose the correct option.
- (iv) Food prepared in leaves is moved from higher concentration to lower concentration. (T/F).

- (v) Bidirectional movement occurs in which part of the transporting tissue(s) present in plants?

SOLUTIONS

Source-based/Case-based/Passage-based/Integrated Assessment questions

33. Solution

- (i) Source is leaves, sink is the storage organs such fruits, or other parts of the plant.
- (ii) As the solute concentration increase, the water from xylem moves into the lumen of sieve tubes due to osmosis and causes turgor pressure gradient.
- (iii) Active transport
- (iv) True
- (v) Phloem

