

## Plant Water Relation

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### EXERCISES [PAGES 132 - 133]

#### Exercises | Q 1.01 | Page 132

##### Multiple Choice Question:

In soil, water available for absorption by root is \_\_\_\_\_.

1. gravitational water
2. **capillary water**
3. hygroscopic water
4. combined water

**Solution:** In soil, water available for absorption by root is capillary water.

#### Exercises | Q 1.02 | Page 132

##### Multiple Choice Question:

The most widely accepted theory for ascent of sap is \_\_\_\_\_.

1. capillarity theory
2. root pressure theory
3. diffusion
4. **transpiration pull theory**

**Solution:** The most widely accepted theory for ascent of sap is transpiration pull theory.

#### Exercises | Q 1.03 | Page 132

##### Multiple Choice Question:

Water movement between the cells is due to \_\_\_\_\_.

1. T.P.
2. W.P.
3. **DPD**
4. incipient plasmolysis

**Solution:** Water movement between the cells is due to DPD

#### Exercises | Q 1.04 | Page 132

**Multiple Choice Question:**

In guard cells, when sugar is converted into starch, the stomatal pore \_\_\_\_\_.

1. **closes almost completely**
2. opens partially
3. opens fully
4. remains unchanged

**Solution:** In guard cells, when sugar is converted into starch, the stomatal pore **closes almost completely**.

**Exercises | Q 1.05 | Page 132**

**Multiple Choice Question:**

Surface tension is due to \_\_\_\_\_.

1. diffusion
2. osmosis
3. gravitational force
4. **cohesion**

**Solution:** Surface tension is due to **cohesion**.

**Exercises | Q 1.06 | Page 132**

**Multiple Choice Question:**

Which of the following type of solution has a lower level of solutes than the solution?

1. Isotonic
2. **Hypotonic**
3. Hypertonic
4. Anisotonic

**Solution: Hypotonic**

**Exercises | Q 1.07 | Page 132**

**Multiple Choice Question:**

During rainy season wooden doors warp and become difficult to open or to close because of \_\_\_\_\_

1. plasmolysis
2. **imbibition**

3. osmosis
4. diffusion

**Solution:** During rainy season wooden doors warp and become difficult to open or to close because of imbibition.

**Exercises | Q 1.08 | Page 132**

**Multiple Choice Question:**

Water absorption takes place through \_\_\_\_\_.

1. lateral roots
2. root cap
3. **root hair**
4. primary root

**Solution:** Water absorption takes place through root hair.

**Exercises | Q 1.09 | Page 132**

**Multiple Choice Question:**

Due to low atmospheric pressure the rate of transpiration will \_\_\_\_\_.

1. **increase**
2. decrease rapidly
3. decrease slowly
4. remain unaffected

**Solution:** Due to low atmospheric pressure, the rate of transpiration will increase.

**Exercises | Q 1.1 | Page 132**

**Multiple Choice Question:**

Osmosis is a property of \_\_\_\_\_.

1. solute
2. **solvent**
3. solution
4. membrane

**Solution:** Osmosis is a property of solvent.

**Exercises | Q 2.1 | Page 132**

**Very short answer question.**

What is osmotic pressure?

Explain the term osmosis.

**Solution:**

- i. The pressure exerted due to osmosis is called osmotic pressure.
- ii. Osmotic pressure is a pressure of the solution, which is required in opposite direction, so as to stop the entry of solvent molecules into the cell.

OR

Osmotic pressure of a solution is equivalent to the pressure which must be exerted upon it to prevent flow of solvent across a semipermeable membrane.

**Exercises | Q 2.2 | Page 132****Very short answer question.**

Name the condition in which protoplast of the plant cell shrinks.

**Solution:**

Plasmolysis

**Exercises | Q 2.3 | Page 132**

What happens when a pressure greater than the atmospheric pressure is applied to pure water or a solution?

**Solution1:**

The water potential of pure water or a solution increases on the application of pressure values more than atmospheric pressure. For example: when water diffuses into a plant cell, it causes pressure to build up against the cell wall. This makes the cell wall turgid. This pressure is termed as pressure potential and has a positive value.

**Solution2:**

If a pressure greater than atmospheric pressure is applied to pure water or a solution, its water potential increases. It is equivalent to pumping water from one place to another. Pressure can build up in a plant system when water enters a plant cell due to diffusion causing a pressure built up against the cell wall, it makes the cell turgid.

**Exercises | Q 2.4 | Page 132**

**Very short answer question.**

Which type of solution will bring about deplasmolysis?

**Solution:**

Hypotonic solution can bring about deplasmolysis.

**Exercises | Q 2.5 | Page 132**

**Very short answer question.**

Which type of plants have negative root pressure?

**Solution:**

The plants in which transpiration occurs rapidly especially during midsummer shows negative root pressure.

**Exercises | Q 2.6 | Page 132**

**Very short answer question.**

In which conditions transpiration pull will be affected?

**Solution:**

For transpiration pull to operate, the water column should be unbroken and continuous. However, due to temperature fluctuations during day and night, gas bubbles may enter in water column breaking the continuity.

**Exercises | Q 2.7 | Page 132**

**Very short answer question.**

Mention the shape of guard cells in Cyperus.

**Solution:**

In Cyperus, both kidney-shaped and dumbbell-shaped guard cells are present.

**Exercises | Q 2.8 | Page 132**

**Very short answer question.**

Why do diurnal changes occur in osmotic potential of guard cells?

**Solution:**

1. According to Steward, diurnal changes occur in the osmotic potential of guard cells due to starch-sugar inter-conversion.
2. Whereas according to Levitt active transport of potassium ions into the guard cells and out of them causes diurnal changes in the osmotic potential of guard cells.
3. Endo-osmosis and exo-osmosis occur due to diurnal changes in osmotic potential of guard cells.

### Exercises | Q 2.9 | Page 132

#### **Very short answer question.**

What is the symplast pathway?

#### **Solution:**

When water passes across from one living cell to another living cell through plasmodesmata, then it is called the symplast pathway. It is also called the trans-membrane pathway.

### Exercises | Q 3.01 | Page 132

#### **Answer the following question.**

Describe the mechanism for absorption of water.

#### **Solution:**

#### **A mechanism for absorption of water:**

1. In plants, water is absorbed mainly by two processes: Passive absorption and Active absorption

#### **2. Passive absorption:**

- a. About 98% of the total water absorbed in plants occurs passively.
- b. In passive absorption, living cells of the root do not play an important role in water absorption.
- c. The driving force is transpiration pull and it thus proceeds through the DPD gradient.
- d. There is no expenditure of energy (ATP) as water moves in accordance with the concentration gradient. Hence, it is passive absorption.
- e. Passive absorption occurs during day time when transpiration is in progress. It stops at night when transpiration stops.
- f. Rapid transpiration creates tension in the xylem vessel due to negative water potential. This tension is transmitted to xylem in the roots. Consequently, water is pulled upwards passively.

g. During passive absorption, no ATP is utilized. Thus, the rate of respiration is not affected.

### **3. Active absorption:**

- a. In this water is absorbed due to the activity of roots.
- b. Root cells play an active role in the absorption of water.
- c. The driving force is the root pressure developed, in the living cells of the root.
- d. Active absorption occurs usually at night when transpiration stops due to closure of stomata.
- e. As water absorption is against the DPD gradient, there is an expenditure of ATP (energy) generated through the respiratory activity of cells.

### **Exercises | Q 3.02 | Page 132**

**Answer the following question.**

Discuss theories of water translocation.

**Solution:**

**Theories of water translocation:**

- i. Various theories have been put forth to explain the mechanism of translocation of water. These theories include Vital force theory, Relay pump theory, Physical force theory, Root pressure theory, etc.
- ii. **Root Pressure Theory (Vital Theory):** This theory was proposed by J. Priestley. According to this theory, the activity of living cells of the root is responsible for the translocation of water.
- iii. **Capillarity theory (physical force theory):** This theory was put forth by Boehm in (1863). According to this theory, physical forces and dead cells are responsible for the ascent of sap.
- iv. **Cohesion- tension theory (Transpiration pull theory):** This theory was put forth by Dixon and Jolly (1894). This is presently a widely accepted theory explaining the ascent of sap in plants. This theory is based on two principles i.e. Cohesion and adhesion, and transpiration pull.

### **Exercises | Q 3.03 | Page 132**

**Answer the following question.**

What is transpiration? Describe the mechanism of opening and closing of stomata.

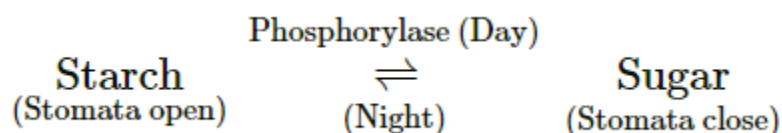
**Solution:**

**Transpiration:**

The loss of water in the form of vapor is called transpiration that occurs through leaves, stem, flowers, and fruits.

**Mechanism of opening and closing of stomata:**

1. The opening and closing of stoma is controlled by turgor of guard cells.
2. During day time, guard cells become turgid due to endo-osmosis.
3. Thus turgor pressure is exerted on the thin walls of guard cells.
4. Being elastic and thin, lateral walls are stretched out.
5. Due to kidney or dumb-bell like shape, inner thick walls are pulled apart to open (widen) the stoma.
6. During night time, guard cells become flaccid due to exo-osmosis.
7. Flaccidity closes the stoma almost completely.
8. Endo-osmosis and exo-osmosis occur due to diurnal changes in osmotic potential of guard cells.
9. According to starch-sugar inter-conversion theory (Steward 1964), during day time, enzyme phosphorylase converts starch to sugar, thus increasing the osmotic potential of guard cells causing entry of water, thereby guard cells are stretched and stoma widens. The reverse reaction occurs at night bringing about the closure of the stoma.



10. According to the theory of proton transport (Levitt-1974), stomatal movement occurs due to the transport of protons  $H^+$  and  $K^+$  ions. During the daytime, starch is converted into malic acid. Malic acid dissociates to form malate ions and protons. Protons are transported to subsidiary cells and  $K^+$  ions are imported from them. Potassium Malate is formed that increases osmolarity and causes endoosmosis. Uptake of  $K^+$  ions is always accompanied by  $Cl^-$  ions. At night, uptake of  $K^+$  and  $Cl^-$  ions is prevented by abscisic acid, changing the permeability of guard cells. Due to this guard cells become hypotonic and thereby become flaccid.

**Exercises | Q 3.04 | Page 133**

**Answer the following question.**



What is transpiration? Explain role of transpiration.

**Solution:**

**Transpiration:**

The loss of water in the form of vapor is called transpiration that occurs through leaves, stem, flowers, and fruits.

**Role of transpiration:**

- i. It removes excess of water.
- ii. It helps in the passive absorption of water and minerals from the soil.
- iii. It helps in the ascent of sap.
- iv. As stomata are open, gaseous exchange required for photosynthesis and respiration is facilitated.
- v. It maintains the turgor of the cells.
- vi. Transpiration helps in reducing the temperature of leaf and in imparting a cooling effect.

**Exercises | Q 3.05 | Page 133**

**Answer the following question.**

What is significance of transpiration? Explain root pressure theory and its limitations

**Solution:**

**Significance of transpiration:**

1. It removes excess of water.
2. It helps in the passive absorption of water and minerals from the soil.
3. It helps in the ascent of sap.
4. As stomata are open, gaseous exchange required for photosynthesis and respiration is facilitated.
5. It maintains the turgor of the cells.
6. Transpiration helps in reducing the temperature of leaf and in imparting a cooling effect.

**Root pressure theory (Vital theory):**

1. This theory was proposed by J. Priestley.
2. According to this theory, the activity of living cells of root is responsible for the translocation of water.

3. When a stem of a potted plant is cut few inches above the soil by a sharp knife, xylem sap is seen flowing out/ oozing out through the cut end.
4. This exudation at the cut end of the stem is a good proof for the existence of root pressure.
5. As water absorption by roots is a constant and continuous process, hydrostatic pressure is developed in the living cells of cortex of the root. This is termed as root pressure (coined by S. Hales).
6. It is due to root pressure water along with dissolved minerals is not only forced into xylem but it is also conducted upwards against the gravity.
7. Root pressure seems to be largely an osmotic phenomenon and its development is an active process.
8. The value of root pressure is +1 to +2 bars which is enough to pump water to a height of 10 to 20 meters.
9. The factors like oxygen, moisture, the temperature of the soil, salt contents, etc. influence the root pressure.

#### **Limitations of root pressure theory:**

Although, ascent of sap takes place due to root pressure, there are certain objections raised, such as;

1. It is not applicable to plants taller than 20 meters.
2. Ascent of sap can also occur even in the absence of root system.
3. Root pressure value is almost nearly zero in taller gymnosperm trees.
4. In actively transpiring plants, no root pressure is developed.
5. Xylem sap under normal condition is under tension i.e. it shows negative hydrostatic pressure or high osmotic pressure.

Thus, root pressure is not the sole mechanism explaining the ascent of sap in all plants of varying heights.

#### **Exercises | Q 3.06 | Page 133**

#### **Answer the following question.**

Explain capillarity theory of water translocation.

#### **Solution:**

#### **Capillarity theory of water translocation:**

1. This theory was put forth by Boehm in (1863).
2. According to this theory, physical forces and dead cells are responsible for the ascent of sap. For e.g. Wick dipped in an oil lamp, shows capillarity due to which oil is raised

upwards. The conduction of water in a straw dipped in water is raised to a certain height because of capillarity. The height to which water is raised depends on the diameter of the straw.

3. Capillarity is because of surface tension, and forces of cohesion (attraction between like molecules) and adhesion (attraction between unlike molecules).

4. Xylem vessel/ tracheid with its lumen can be compared with straw.

5. Water column exists because of combined cohesive and adhesive forces of water and xylem wall, due to capillarity.

6. Due to capillarity, water is raised or conducted upwards against gravity, to few centimeters only.

### Exercises | Q 3.07 | Page 133

#### Answer the following question.

Why is transpiration is called 'a necessary evil'?

#### Solution:

Curtis (1926) regarded transpiration as 'a necessary evil', because;

1. For stomatal transpiration to occur, stoma must remain open, during day time.
2. When stomata are open then only the gaseous exchange needed for respiration and photosynthesis will take place.
3. If stomatal transpiration stops, it will directly affect the productivity of the plant through the loss of photosynthetic and respiratory activity.
4. Hence for productivity, stomata must remain open.
5. Consequently transpiration cannot be avoided.

### Exercises | Q 3.08 | Page 133

#### Answer the following question.

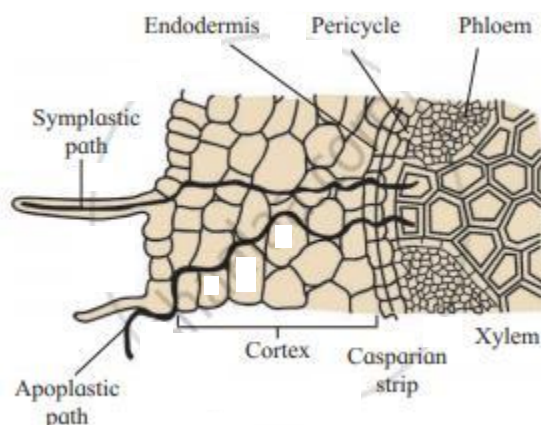
Explain the movement of water in the root.

#### Solution:

Journey of water from soil to xylem in roots (from epiblema upto xylem in the stelar region):

1. Water is absorbed by root hair cells through processes like imbibition, diffusion, osmosis which occur sequentially.
2. Water passes through the epidermal cell (epiblema), cortex, endodermis, Casparian strip, pericycle, and then to protoxylem.

3. When the root hair cell absorbs water it becomes turgid. Its turgor pressure increases, but its DPD value decreases.
4. However, the immediately adjacent cortical cell inner to it, has more DPD value, because its O. P. is more.
5. Therefore, cortical cells will absorb water from the turgid root hair cell. It then becomes turgid.
6. The flaccid root hair cell now absorbs water from the soil.
7. Water from the turgid cortical cell is absorbed by the inner cortical cell and the process goes on.
8. Thus, a gradient of suction pressure (DPD) is developed from cells of epiblema to the cortex of the root.
9. Consequently water moves rapidly across the root through loosely arranged living cells of cortex, followed by passage cells of endodermis and finally into the cell of pericycle.
10. Protoxylem is in close proximity to the pericycle.
11. It is due to root pressure, water from pericycle is forced into the xylem.
12. Pathway of water across the root occurs in two types: Apoplast pathway and Symplast pathway
13. **Apoplast pathway:** When some amount of water passes across the root through the cell wall and the intercellular spaces of cortical cells of the root, it is then called the apoplast pathway. This pathway occurs up to endodermis.
14. **Symplast pathway:** When water passes across from one living cell to another living cell through plasmodesmata, then it is called the symplast pathway. It is also called the trans-membrane pathway.



### Exercises | Q 3.09 | Page 133

Answer the following question.

Define and or explain the term:

Plasmolysis

**Solution1:**

Plasmolysis - The shrinkage of cytoplasm of a living cell as a result of exosmosis is known as plasmolysis.

**Solution2:**

1. When a living cell is placed in a hypertonic solution, exo-osmosis occurs. This is called plasmolysis.
2. During plasmolysis, the protoplast of the cell shrinks and recedes from the cell wall due to which cell becomes flaccid. Such a cell is called a plasmolysed cell.
3. In a plasmolyzed cell, a gap is developed between the cell wall and the protoplast. This gap is filled up by the outer solution.

**Exercises | Q 3.09 | Page 133**

**Very short answer question.**

What is osmotic pressure?

Explain the term osmosis.

**Solution:**

- i. The pressure exerted due to osmosis is called osmotic pressure.
- ii. Osmotic pressure is a pressure of the solution, which is required in opposite direction, so as to stop the entry of solvent molecules into the cell.

OR

Osmotic pressure of a solution is equivalent to the pressure which must be exerted upon it to prevent flow of solvent across a semipermeable membrane.

**Exercises | Q 3.09 | Page 133**

**Answer the following question.**

Define and or explain the term:

Diffusion

**Solution:**

1. Diffusion means to disperse.
2. Diffusion can be defined as the movement of ions/ atoms/ molecules of a substance from the region of their higher concentration to the region of their lower concentration till equilibrium is reached.
3. The movement is due to the kinetic energy of the molecules.
4. Water passes into the cell by diffusion through a freely permeable cell wall.

### Exercises | Q 3.09 | Page 133

#### Answer the following question.

Define and or explain the term:

imbibition

#### Solution:

1. Imbibition is swelling up of hydrophilic colloids due to the adsorption of water.

OR

The adsorption of water by hydrophilic compounds is called imbibition.

2. Substance that adsorbs water/liquid is called imbibant and water/ liquid that gets imbibed is called imbibate.
3. The root hair cell wall is made up of pectic compounds and cellulose which are hydrophilic colloids.
4. During imbibition, water molecules get tightly adsorbed without the formation of a solution.
5. Imbibition continues until the equilibrium is reached. In other words, water moves along the concentration gradient.
6. Imbibition is significant in soaking of seeds, swelling up of dried raisins, kneading of flour etc.

### Exercises | Q 3.09 | Page 133

#### Answer the following question.

Define and or explain the term:

Guttation

#### Solution:

1. The loss of water in the form of liquid is called guttation.
2. It occurs through special structures called water stomata or hydathodes.

### Exercises | Q 3.09 | Page 133

#### Answer the following question.

Define and or explain the term:

Transpiration

**Solution:**

- i. The loss of water in the form of vapour is called transpiration that occurs through leaves, stem, flowers and fruits.
- ii. Transpiration occurs through three main sites - cuticle, stomata, and lenticels.

**Exercises | Q 3.09 | Page 133**

**Answer the following question.**

Define and or explain the term:

Ascent of sap

**Solution:**

The transport of water with dissolved minerals from the root to other aerial parts like stem and leaves, against the gravity, is called translocation or ascent of sap.

**Exercises | Q 3.09 | Page 133**

**Answer the following question.**

Define and or explain the term:

Active absorption

**Solution:**

1. In this water is absorbed due to the activity of roots.
2. Root cells play an active role in the absorption of water.
3. The driving force is the root pressure developed, in the living cells of the root.
4. Active absorption occurs usually at night when transpiration stops due to the closure of stomata.
5. As water absorption is against the DPD gradient, there is an expenditure of ATP (energy) generated through the respiratory activity of cells.

**Exercises | Q 3.09 | Page 133**

**Answer the following question.**

Define and or explain the term:

DPD

**Solution:**

1. Diffusion pressure of pure solvent (pure water) is always more than the diffusion pressure of the solvent in a solution. The difference in the diffusion pressures of pure

solvent and the solvent in a solution is called Diffusion Pressure Deficit (DPD) or Suction Pressure (SP).

2. The term DPD was coined by B.S. Meyer (1938). Nowadays, term water potential is used for DPD.
3. In colloquial language, the term DPD is actually the thirst of a cell with which it absorbs water from the surroundings.
4. The water around the cell wall has more diffusion pressure than cell sap. Due to this, water moves in the cell by diffusion.

### **Exercises | Q 3.09 | Page 133**

#### **Answer the following question.**

Define and or explain the term:

Turgor pressure

#### **Solution:**

Turgor pressure (T.P) is the pressure exerted by turgid cell sap on to the cell membrane and cell wall.

### **Exercises | Q 3.09 | Page 133**

#### **Answer the following question.**

Define and or explain the term:

Water potential

#### **Solution:**

- i. Chemical potential of water is called water potential.
- ii. It is represented by Greek letter psi ( $\psi$ ).
- iii. The unit of measurement of water potential is bars/ pascals/ atmospheres.
- iv. Water potential of protoplasm is equal but opposite in sign to DPD. It has a negative value.
- v. Water potential of pure water is always zero. The addition of any solute in it decreases its psi ( $\psi$ ) value. Therefore, it has a negative value.
- vi. Difference between water potential of the adjacent cells decides the movement of water through plasmodesmata across the cells.



vii. Water always flows from less negative potential to more negative water potential (i.e. from high water potential area to low water potential area).

### Exercises | Q 3.09 | Page 133

**Answer the following question.**

Define and or explain the term:

Wall pressure

**Solution:**

The cell wall is thick and rigid, exerts a counter pressure on the cell sap. This is called Wall pressure (W. P).

### Exercises | Q 3.09 | Page 133

**Answer the following question.**

Define and or explain the term:

Root pressure

**Solution:**

1. During the absorption of water, the continuous flow of water develops hydrostatic pressure in living cells of the root. This is called root pressure.
2. Root pressure causes water to flow from pericycle into the xylem. It also causes upward conduction of water against gravity.
3. A manometer is used to measure the root pressure.

### Exercises | Q 3.1 | Page 133

**Answer the following question.**

Distinguish between Osmotic pressure and Turgor pressure.

**Solution:**

Osmotic pressure	Turgor pressure
Osmotic pressure is a pressure of the solution, which is required in opposite direction, so as to stop the entry of solvent molecules into the cell.	Turgor pressure is the pressure exerted by turgid cell sap on to the cell membrane and cell wall.

### Exercises | Q 3.1 | Page 133

**Answer the following question.**

Distinguish between Diffusion and Osmosis

**Solution:**

Diffusion	Osmosis
1. It takes place in solid, gas, or liquid medium.	1. It takes place only in a liquid medium.
2. It does not require the presence of a semi-permeable membrane.	2. It requires the presence of a semipermeable membrane.
3. In diffusion, the movement of ions/atoms/molecules from a region of higher concentration to the region of lower concentration takes place.	3. In osmosis, diffusion of the only solvent from a lower concentration of solution to a higher concentration of solution occurs
4. It is influenced by the diffusion pressure	4. It is only influenced by the turgor pressure.

**Exercises | Q 3.11 | Page 133****Answer the following question.**

Enlist macronutrients and micronutrients required for plant growth.

**Solution:****1. Macronutrients:**

Some minerals like C, H, O, P, N, S, Mg, K, Ca required in large quantity for normal growth of the plant, are called macro elements. Macronutrients are required in large quantities. They mainly play nutritive and structural roles.

**2. Micronutrients:**

Some minerals like Cu, Mo, Mn, Cl, Bo, Zn required in small quantities for the growth of a plant, are called microelements.

Micronutrients are required in traces because they function in the catalytic role as co-factors.

**Exercises | Q 3.12 | Page 133****Answer the following question.**

How are the minerals absorbed by the plants?

**Solution:**

i. The analysis of plant ash demonstrates that minerals are absorbed by plants from soil and surroundings.

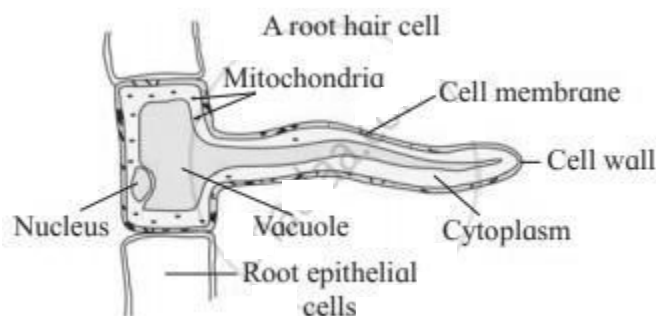
- ii. Minerals are absorbed by plants in the ionic (dissolved) form, mainly through roots and then transported.
- iii. Mineral ion absorption is independent of water absorption.
- iv. It can occur in two ways i.e. active and passive absorption.
- v. In passive absorption, the movement of mineral ions into root cells occurs as a result of diffusion. Mineral ions diffuse from a region of their higher concentration to a region of their lower concentration without the expenditure of energy.
- vi. Most minerals in the soil are charged particles hence, they cannot pass across the cell membranes. Hence most of the minerals are absorbed actively with the expenditure of energy.
- vii. In active absorption, minerals are absorbed against the concentration gradient with the expenditure of energy.
- viii. Absorbed mineral ions are pulled in an upward direction along with xylem sap because of transpiration pull.
- ix. Hence, mineral ions are pulled from the source (root) and are transported ascendingly through the sap to the needed areas like apical, lateral, young leaves, developing flowers, fruits, seeds, and storage organs.
- x. Mineral ions get unloaded by fine veins through the process of diffusion in the vicinity of cells. Cells uptake them actively.

### Exercises | Q 4.1 | Page 133

#### Long answer question.

Describe structure of root hair.

**Solution:**



1. Root hair is a cytoplasmic extension (prolongation) of epiblema cell.
2. Each root hair may be approximately 1 to 10 mm long and tube-like structure.
3. It is colourless, unbranched, short-lived (ephemeral), and very delicate.
4. It has a large central vacuole surrounded by a thin film of cytoplasm, plasma membrane and thin cell wall, which is two-layered.

5. Outer layer is composed of pectin and the inner layer is made up of cellulose.
6. Cell wall of a root hair is freely permeable but the plasma membrane is selectively permeable.

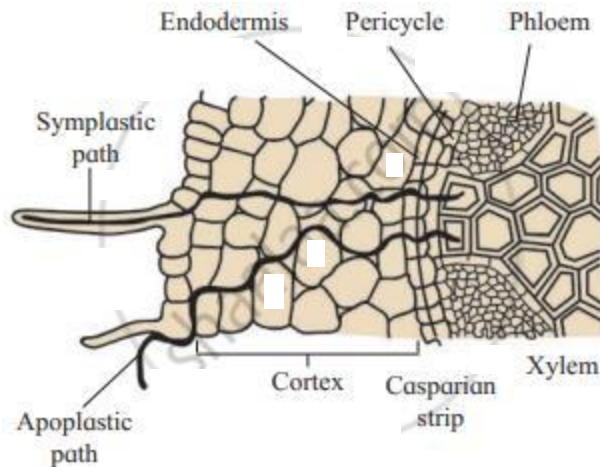
### Exercises | Q 4.2 | Page 133

#### Long answer question.

Write on journey of water from soil to xylem in roots.

#### Solution:

1. Water is absorbed by root hair cells through processes like imbibition, diffusion, osmosis which occur sequentially.
2. Water passes through the epidermal cell (epiblema), cortex, endodermis, casparian strip, pericycle and then to protoxylem.
3. When root hair cell absorbs water it becomes turgid. Its turgor pressure increases, but its DPD value decreases.
4. However, the immediately adjacent cortical cell inner to it, has more DPD value because its O. P. is more.
5. Therefore, the cortical cells will absorb water from the turgid root hair cell. It then becomes turgid.
6. The flaccid root hair cell now absorbs water from the soil.
7. Water from the turgid cortical cell is absorbed by the inner cortical cell and the process goes on.
8. Thus, a gradient of suction pressure (DPD) is developed from cells of epiblema to the cortex of the root.
9. Consequently water moves rapidly across the root through loosely arranged living cells of cortex, followed by passage cells of endodermis and finally into the cell of pericycle.
10. Protoxylem is in close proximity with pericycle.
11. It is due to root pressure, water from pericycle is forced into the xylem.
12. Pathway of water across the root occurs in two types: Apoplast pathway and Symplast pathway
13. Apoplast pathway: When some amount of water passes across the root through the cell wall and the intercellular spaces of cortical cells of the root, it is then called the apoplast pathway. This pathway occurs up to endodermis.
14. Symplast pathway: When water passes across from one living cell to another living cell through plasmodesmata, then it is called the symplast pathway. It is also called the trans-membrane pathway.



### Exercises | Q 4.3 | Page 133

#### Long answer question.

Explain cohesion theory for translocation of water.

#### Solution:

1. This theory was put forth by Dixon and Jolly (1894).
2. This is presently a widely accepted theory explaining the ascent of sap in plants.
3. This theory is based on two principles i.e. Cohesion and adhesion, and transpiration pull.

#### 4. Cohesion and adhesion:

- a. A strong force of attraction between water molecules is called cohesive force.
- b. While a strong force of attraction between water molecules and the lignified wall of the lumen of the xylem vessel, is called adhesive force.
- c. Due to combined cohesive and adhesive forces a continuous water column is developed (formed) in the xylem right from root up to the tip of the topmost leaf in the plant.

#### 5. Transpiration pull:

- a. The transpiration pull developed in the leaf vessel is transmitted down to the root and thus accounts for the ascent of sap.
- b. Excess water is lost in the form of vapour, mainly through the stomata found on a leaf.
- c. This water loss increases the D.P.D. of mesophyll cells. These cells withdraw water ultimately from the xylem in the leaf.

d. In other words, due to continuous transpiration, a gradient of suction pressure (i.e. D.P.D.) is developed right from guard cells up to the xylem in the leaf. This will create a tension (called a negative pull or transpiration pull) in the xylem.

e. Consequently, the water column is pulled out of xylem. Thus, water is pulled upwards passively against the gravity leading to the ascent of sap.

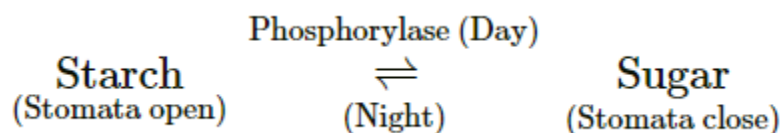
### Exercises | Q 4.4 | Page 133

#### Long answer question.

Write mechanism of opening and closing of stoma.

#### Solution:

1. Opening and closing of stoma is controlled by the turgor of guard cells.
2. During day time, guard cells become turgid due to endo-osmosis.
3. Thus turgor pressure is exerted on the thin walls of guard cells.
4. Being elastic and thin, lateral walls are stretched out.
5. Due to kidney or dumb-bell like shape, inner thick walls are pulled apart to open (widen) the stoma.
6. During night time, guard cells become flaccid due to exo-osmosis.
7. Flaccidity closes the stoma almost completely.
8. Endo-osmosis and exo-osmosis occur due to diurnal changes in the osmotic potential of guard cells.
9. According to starch-sugar inter-conversion theory (Steward 1964), during day time, enzyme phosphorylase converts starch to sugar, thus increasing the osmotic potential of guard cells causing entry of water, thereby guard cells are stretched and stoma widens. The reverse reaction occurs at night bringing about the closure of the stoma.



10. According to the theory of proton transport (Levitt-1974), stomatal movement occurs due to the transport of protons  $H^+$  and  $K^+$  ions. During the daytime, starch is converted into malic acid. Malic acid dissociates to form malate ions and protons. Protons are transported to subsidiary cells and  $K^+$  ions are imported from them. Potassium Malate is formed that increases osmolarity and causes endosmosis. The uptake of  $K^+$  ions is always accompanied by  $Cl^-$  ions. At night, uptake of  $K^+$  and  $Cl^-$  ions is prevented by abscisic acid, changing the permeability of guard cells. Due to this guard cells become hypotonic and thereby become flaccid.

### Exercises | Q 4.5 | Page 133

#### Long answer question.

What is hydroponics? How is it useful in identifying the role of nutrients?

#### Solution:

1. Hydroponics is a technique in which plants are grown in nutrient solutions in absence of soil. Roots are immersed in an adequately aerated, dilute, and defined solution of nutrients. Purified water and mineral salts are used in the nutrient medium.
2. In hydroponics, the concentration of a particular mineral in a solution of nutrients in which roots are immersed can be increased or decreased. By this method, essential elements can be identified and their deficiency symptoms can be discovered. Thus it helps to identify the role of nutrients in plant growth.

### Exercises | Q 4.6 | Page 133

#### Long answer question.

Explain the active absorption of minerals.

#### Solution:

1. Uptake of mineral ions against the concentration gradient is called active absorption.
2. Such movement requires an expenditure of energy by the absorbing cell. This energy is derived from respiration and is supplied through ATP.
3. The rate of active absorption of minerals depends upon respiration.
4. When the roots are deprived of oxygen, they show a sudden drop in the active absorption of minerals. The mineral ions accumulated in the root hair pass into the cortex and finally reach the xylem.
5. The minerals in the xylem are then carried along with water to other parts of the plant along the transpiration stream and are subsequently assimilated into organic molecules and then redistributed to other parts of the plant through the phloem.

### Exercises | Q 4.7 | Page 133

#### Long answer question.

Write on macro and micro nutrients required for plant growth.

#### Solution:

On the basis of the required quantity, nutrients can be classified as:

##### i. Macronutrients:

Some minerals like C, H, O, P, N, S, Mg, K, Ca required in large quantity for normal growth of the plant, are called macro elements. Macronutrients are required in large quantities. They mainly play nutritive and structural roles.

**ii. Micronutrients:**

Some minerals like Cu, Mo, Mn, Cl, Bo, Zn required in small quantities for the growth of a plant, are called micro elements. Micronutrients are required in traces because they function in the catalytic role as co-factors.