TRANSPORT IN PLANTS — ABSORPTION, CONDUCTION AND RISE OF SAP

2

SYLLABUS

Transport, absorption, conduction, rise of cell sap in plants.

* Demonstrating conduction in plants (E).

Transpiration in plants.

TRANSPORT IN PLANTS

Plants need water and mineral for their survival. Do you know, where these substances come from ? These substances are absorbed by the plants from the soil through their roots. They are then transported upwards to various parts of the plant, like stem, leaves, *etc.*

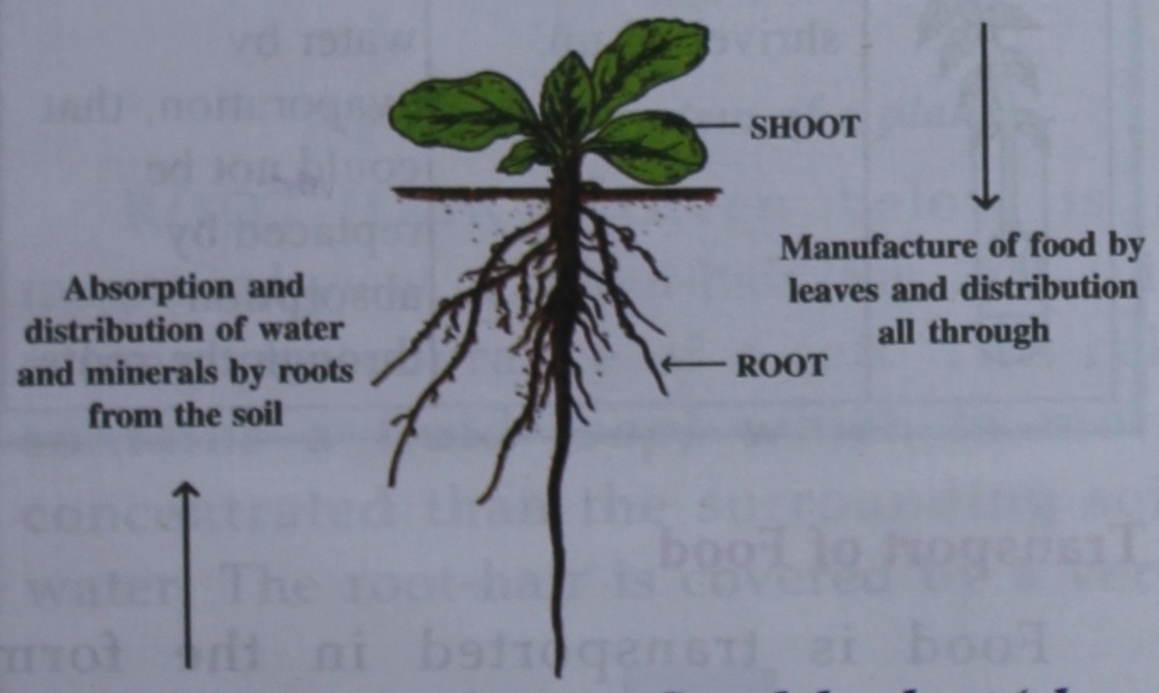


Fig 2.1 The root (underground) and the shoot (above ground) are the conducting systems of a plant

Similarly, the leaves prepare the food from water and carbon dioxide during photosynthesis, and this food is transported downwards to all parts of the plant including roots.

Besides absorbing water and minerals from the soil, roots also fix the plant firmly in the ground.

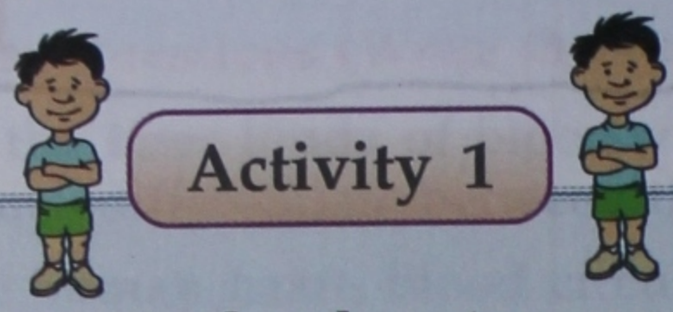
Transportation in plants is the process in which a substance absorbed or synthesized in one part of the plant is moved to the other parts of the plant.

Transportation in plants is carried out by a **conducting system** consisting of two tissues — **xylem** and **phloem**.

Transport of Water and Minerals

You have already learnt about the conducting tissues of plants *i.e.* xylem and phloem. The xylem has *two* types of components, the **tracheids** and **vessels**. It is through these components that water and minerals absorbed by the roots move up to the stem and leaves. The **tracheids** and vessels are dead and highly thick-walled. These are long thin, spindle-shaped cells with pits in their walls. Water and minerals flow from one tracheid to another through these pits. Similarly, **vessels** are in the form of perforated long cells. These cells have tubular passages which are joined with each other end to end forming continuous channels. Water and minerals flow through these channels by the process of osmosis and diffusion.

The roots alone can absorb water, whereas the leaves or the stem cannot. This can be demonstrated by the following simple experiment.

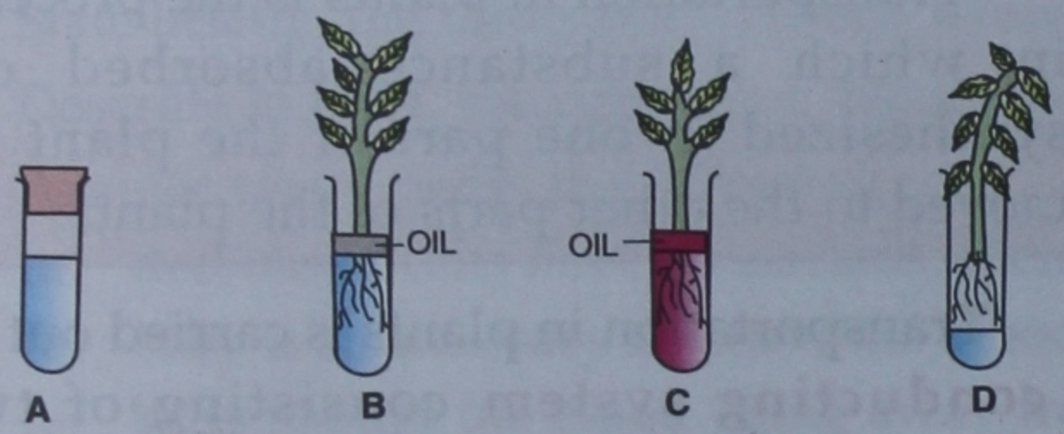


Activity 1

Only the roots absorb water

Take four test tubes and mark them A, B, C and D.

Fill water in tubes A, B and C up to about three-quarters, and only a little amount of water in tube D at its bottom.



Start of the experiment

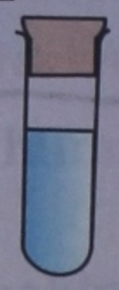
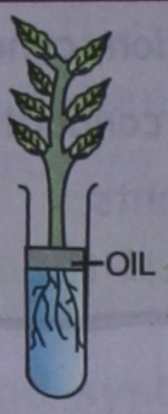
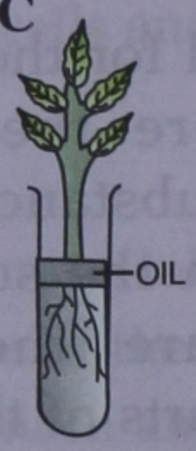
Fix a cork firmly over the mouth of the tube A and leave it.

Take three young small–sized plants such as balsam with their roots intact. Wash their roots under tapwater and insert them in the test tubes B, C and D in a manner that the roots get fully dipped in water in test tubes B and C but remain well above in test tube D.

In C, add a dye (such as pink-coloured carmine) to water. Pour a few drops of oil (like mustard oil) in B and C which will float on the surface and prevent any loss of water by evaporation.

Mark the levels of water in the four test tubes with a glass pencil. Leave this set-up for about 24 hours and look for any change in their water levels.

Result of the experiments

Test Tube	*Observation*	*Conclusion*
A 	Water level remains unchanged.	No loss of water.
B 	Water level falls [not by evaporation from the water surface due to the presence of oil].	Water was absorbed by the plant through its roots dipped in water.
C 	Water level falls just as in tube B, but here, the veins in the leaves have taken up the red colour of water.	Water got into the plant through the roots, and reached the leaves.
D 	The leaves shrivelled up.	The leaves lost water by evaporation, that could not be replaced by absorption through the roots.

Transport of Food

Food is transported in the form of watery solution through the phloem. Unlike the xylem, the pholem is a living tissue. It consists of living cells called **sieve tubes**.

The food produced in the leaf enters the phloem cells, and is transported upwards and downwards to all parts of the plant including its roots.

WATER ABSORPTION BY THE ROOTS

We are familiar with the absorption of water by blotting paper or by cotton dipped in water. In both cases, water is absorbed by the property of capillarity (attraction of water molecules towards narrow spaces) and surface tension. But the absorption of water by the roots is quite different. To understand it, let us first consider the structure of the roots.

The root system of plants consist of the ***main root,*** which gives out ***lateral (branch) roots.*** The lateral roots bear a large number of fine outgrowths called ***root-hairs*** (Fig. 2.2).

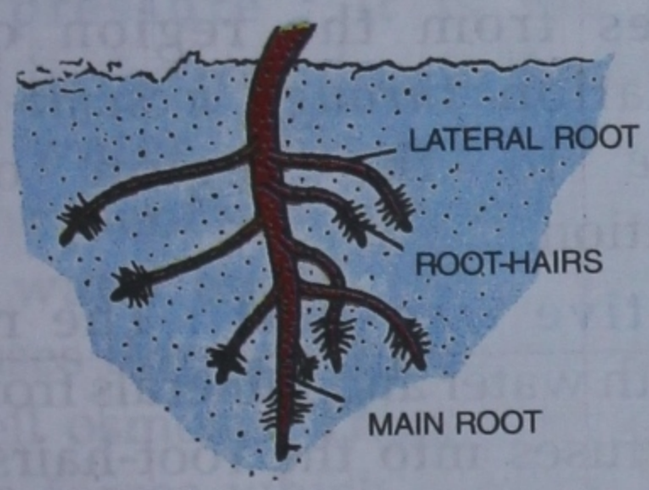


Fig 2.2 Root system of a plant

ROOT-HAIR : Given below is a magnified view of a root-hair (Fig. 2.3). It is a long protuberance of a cell. This cell contains a fluid **(*sap*)** which is more concentrated than the surrounding soil water. The root-hair is covered by a very thin cell membrane that allows water molecules to pass through, but prevents the other larger molecules. Such a membrane is called semi-permeable membrane.

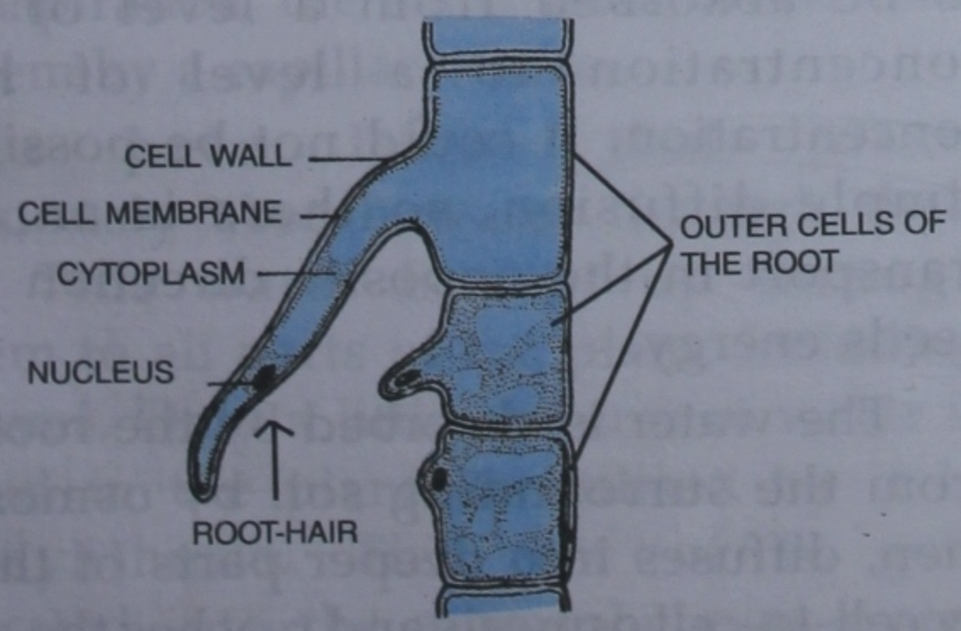


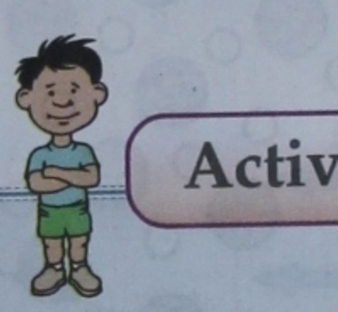
Fig. 2.3 Root-hair (Highly magnified)

Speciality of root-hairs

The root hairs are suited for absorbing water from the soil in three ways :

1. The root-hairs present a **large surface area**. The more the surface area, the greater is the absorption.
2. Each root-hair has a **semi-permeable membrane**.
3. It contains a solution (cell sap) of a **higher concentration** than the surrounding soil water.

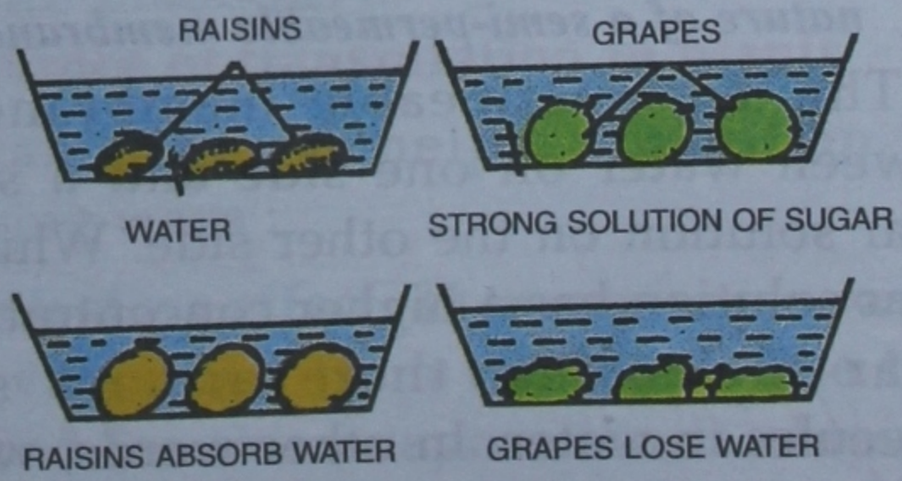
Let us try another experiment to understand how the root-hairs absorb water.



Activity 2

Raisins swell in water and grapes shrink in thick syrup

Put some raisins in a bowl containing water, and some soft-skinned grapes in another bowl containing thick syrup of sugar. After 10–12 hours, you will



Effect on raisins and grapes when kept in water and syrup respectively

notice that the raisins have **swelled** up, whereas the grapes have **shrunken**. The raisins have absorbed water but the grapes have lost it. In both cases, the gain or loss of water is through the peel acting as a kind of semi-permeable membrane.

This experiment shows that the peel over the raisins and that over the grapes acts like a semi-permeable membrane. This membrane has very minute pores which allow water molecules to pass through, but prevent the larger ones of sugar.

The nature of a semi-permeable membrane can be illustrated by a diagram as shown below (Fig. 2.4).

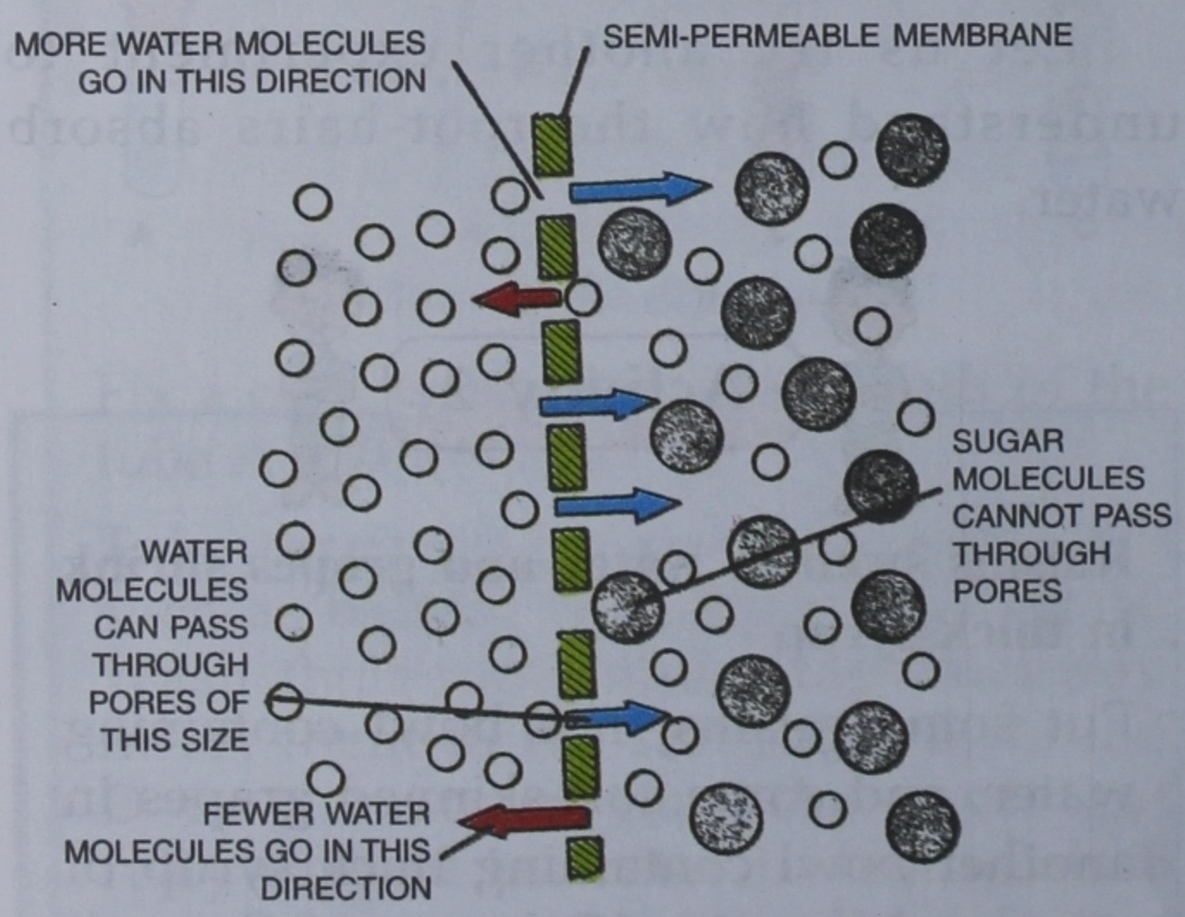


Fig. 2.4 Diagrammatic representation of the nature of a semi-permeable membrane

The semi-permeable membrane lies between water on one side and a strong sugar solution on the other side. While the sugar solution has a higher concentration of sugar molecules, there are no sugar molecules in water. In other words, we can say that there are more water molecules on the left side of the membrane than in the sugar solution on the right side.

After some time, you will notice that the strong sugar solution has become diluted. It is because, the water molecules from the other side have moved into the sugar solution. Such movement of water molecules is known as OSMOSIS.

Three types of movements of molecules

1. Diffusion : Soil water moves into the root-hairs by the simple process of diffusion (movement of molecules – gas, liquid or solid) *i.e.* from higher concentration to lower concentration. *For example*, while adding sugar in milk, sugar molecules diffuse into the milk evenly, occupying intermolecular spaces of milk.

2. Osmosis : It is the **movement of water molecules** from the region of higher concentration *through a semi-permeable membrane* to the region of lower concentration.

3. Active transport : The root-hairs absorb both water and minerals from the soil. Water diffuses into the root-hairs directly, because its concentration is higher in the soil than inside the root-hairs. But the in case of minerals, it is just the opposite. They have more **concentration** inside the root-hairs than outside in the soil. If it was simple diffusion, the minerals from the root-hairs would have passed out into the soil. But here, the requirement is opposite. The minerals have to be absorbed from a level of lower concentration to a level of higher concentration. It could not be possible by simple diffusion, so there is an active transport in the opposite direction which needs energy.

The water is absorbed by the root-hairs from the surrounding soil by osmosis. It, then, diffuses into deeper parts of the root by cell-to-cell osmosis and reaches the central portion (Fig. 2.5). Here it enters certain

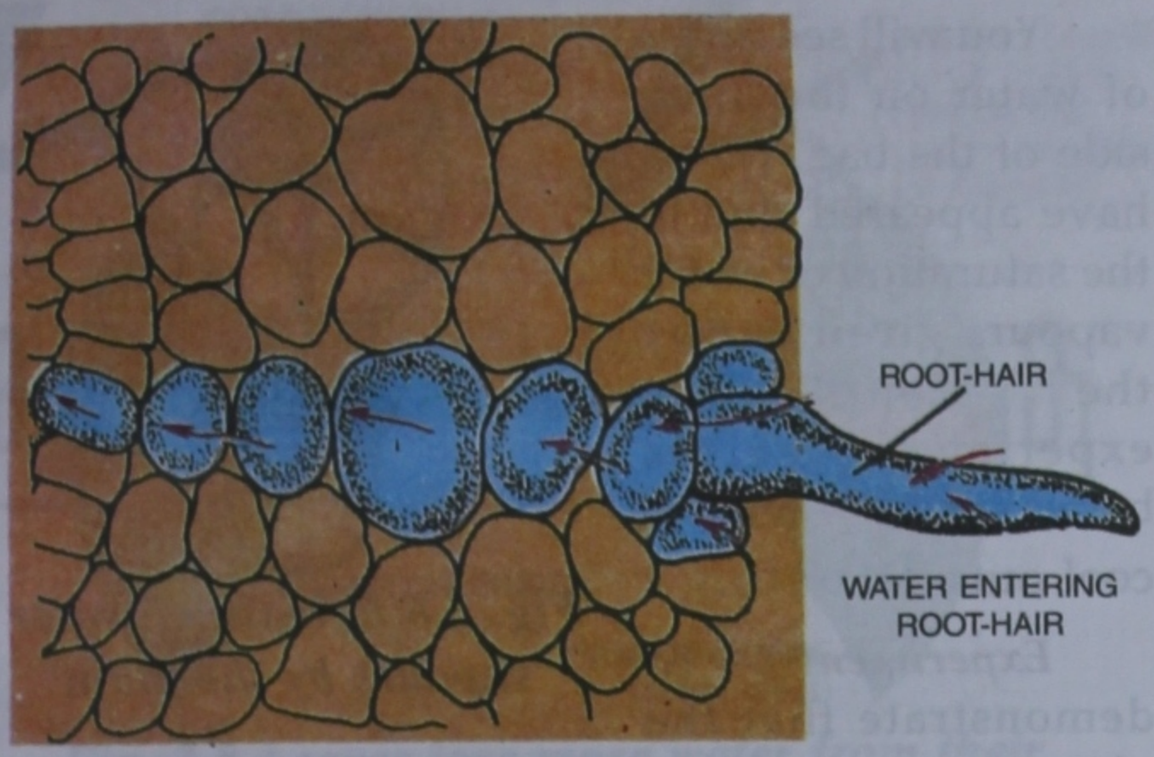


Fig. 2.5 Movement of water in plant

vertical tubes (xylem), which continues upward into the stem and the leaves. This upward movement of sap that contains water and minerals is called **ascent of sap**.

Root pressure : It is the pressure developed in the root due to the continuous inflow of water. This pressure helps in pushing the plant sap upwards. Due to this pressure, water enters the xylem vessels, which passes through the cortex cells of the root by cell osmosis. Thus, root pressure is one of the forces which contributes to the ascent of sap through the stem into the leaves to a certain height.

TRANSPIRATION

Xylem tissues are in the form of capillary tubes (the narrower the diameter, the greater will be the force). Whenever the xylem vessels lay empty, such as during the loss of water by transpiration, the water from below rises into them by a capillary force.

You have learnt that plants continuously absorb water through their roots. This water is sent up through the stem to all parts of the plant, including the leaves. Only a little amount of water is retained in the plant or utilised by it in photosynthesis. The rest of it gets evaporated into the atmosphere as water vapour from the leaves.

Transpiration is the loss of water in the form of water vapours from the aerial parts of a plant.

During daytime, water is lost from the surface of the leaves by the process of transpiration. In this process, more and more water molecules are pulled up due to their tendency of remaining joined (cohesion). Such pulling force created by the leaves is very important in the case of tall trees where an upward conduction of water takes place.

Factors affecting the rate of transpiration

The following main factors affect the rate of transpiration :

1. Sunlight : During daytime, the rate of transpiration is faster. This is because the stomata remain open to allow the inward diffusion of carbon dioxide for photosynthesis. During dark, the stomata are closed, and hence transpiration hardly occurs at night.

2. Temperature : Transpiration is faster on hot summer days as compared to cold winters.

3. Wind : Transpiration is more when the wind is blowing faster as the water vapours remove faster from the leaves.

4. Humidity : Transpiration is reduced if the air is humid. Air cannot hold any water molecules when it is already laden with moisture (humidity).

Importance of transpiration in plants

Transpiration helps a plant in the following ways :

1. Cooling effect : In transpiration, water gets evaporated from the plant. The heat required for this evaporation is obtained from the plant itself (latent heat) and thus the plant is able to cool itself when it is hot outside.

2. Transpiration helps in maintaining the concentration of the sap inside the plant body : The roots continue to absorb water from the soil. If excess water is not evaporated out, the sap would become dilute, preventing further absorption of water along with the minerals required by the plant.

Use of water in the plant

The water absorbed by the roots is important for the plant in three main ways — Transportation, food production and cooling.

1. **Transportation.** The water in the plant body transports substances in solution from one part to another.
2. **Food production.** Water is used in producing food (photosynthesis) by combining it with carbon dioxide from the air in the presence of sunlight.
3. **Cooling.** Water is used to cool the plant by evaporation through leaves when it is hot outside.

You must have experienced that standing under a tree on a hot summer midday, gives you a cooling effect. This cooling is not entirely due to shade, but also due to the loss of water from the surface of the leaves by evaporation. Since evaporation produces coolness, it makes the air cool. The cool air being heavier, tends to settle down and makes the surroundings pleasant.

EXPERIMENTS TO DEMONSTRATE TRANSPIRATION

Experiment 1 : Take a small-sized, well-watered potted plant. Cover the plant with a transparent polythene bag and tie its mouth around the base of the stem. Leave the plant in sunlight and note the change after a few hours.

You will see drops of water on the inner side of the bag, which have appeared due to the saturation of water vapours given out by the plant. The experiment gives better results when it is cool outside.

Fig. 2.6 Release of water vapours by the plant

Experiment 2 : To demonstrate that the plants lose water through its leaves.

Take one small–sized, well–watered potted plant having a few branches. Place a polythene bag over its one branch as shown in A and tie it with a rubber band.

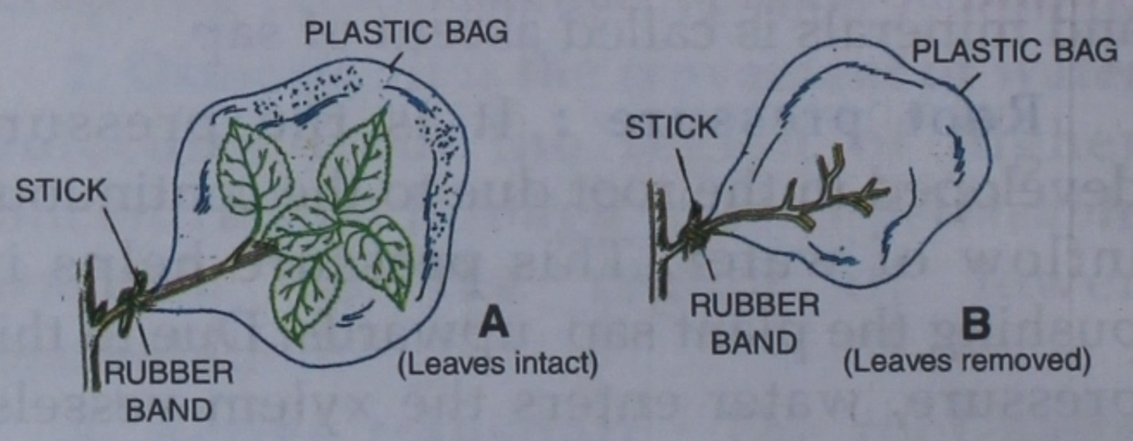


Fig. 2.7 The plant loses water by the leaves

Remove all the leaves from another branch (B) of the same plant, cover this also with a polythene bag and tie it with a rubber band.

Place the plant in sunlight, and observe it after 4–6 hours. You will notice that drops have appeared on the inner surface of the polythene bag over branch A, while no water drops appear on branch B.

This set-up indicates that most water gets evaporated from the plant through its leaves.

Experiment 3 : To demonstrate that leaves lose more water from their lower surface.

[**Test for moisture :** Take some strips of dry (blue) cobalt chloride paper. Put a drop of water on one of these strips. The colour of the paper changes from blue to pink. This is the test for moisture].

Fold a strip of cobalt chloride paper and attach it on the two sides of a healthy leaf of a well–watered potted plant. Hold the paper in place by keeping it between two glass slides as shown in Fig. 2.8. Half of the paper will touch the upper surface of the leaf

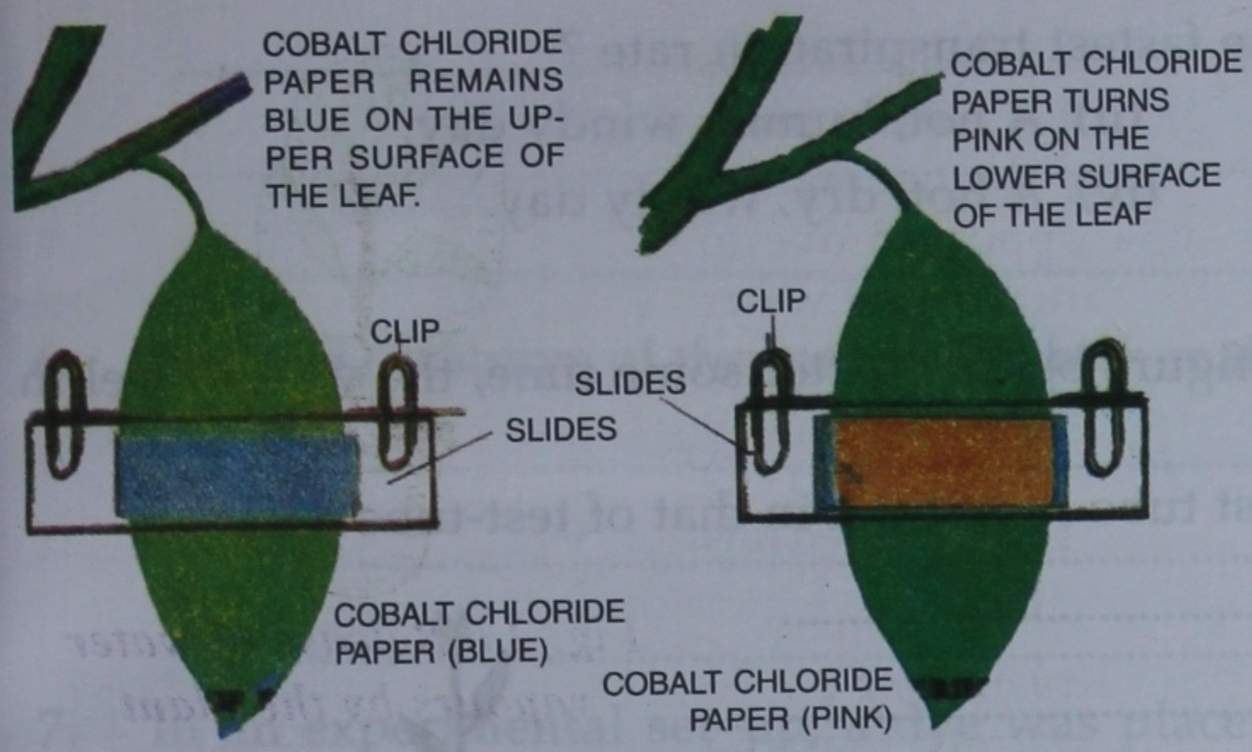


Fig. 2.8 Leaves lose more water from their lower surface

while the other half will touch the lower surface. Leave the plant in open sunshine.

Remove the paper after 1–2 hours and compare the two sides of the paper. The portion of the paper touching the lower surface of the leaf turns more pink than the one touching the upper surface.

This shows that the leaves lose more water from their lower surface. It is because the leaves have more stomata on their lower surface.

REVIEW QUESTIONS

Multiple Choice Questions :

1. Put a tick mark (✓) against the correct alternative in the following statements :

(a) Diffusion occurs when molecules move :
- (i) from lower concentration to higher concentration.
- (ii) from higher concentration to lower concentration through a membrane.
- (iii) from higher concentration to lower concentration.
- (iv) when energy is used.

(b) Ascent of sap in plants takes place through :
(i) Cortex (ii) Epidermis (iii) Xylem (iv) Phloem

(c) If the xylem vessels of a plant are plugged :
(i) The leaves will turn yellow (ii) No food will be made
(iii) The plant will wilt (shrivel) (iv) The plant will continue to grow

(d) Force responsible for the ascent of sap is :
(i) Capillary force (ii) Root pressure
(iii) Transpirational pull (iv) All the three

(e) Raisins swell when put in :
(i) Rain water (ii) Tap water (iii) Mustard oil (iv) Saturated sugar solution

(f) The root-hairs are suited for absorbing water from the soil because :
(i) Roots have a large surface area (ii) Roots have a semi-permeable membrane
(iii) Roots contain a solution of higher concentration than the surrounding water.
(iv) All the three.

(g) Transpiration is defined as
- (i) the rise of water up to the stem of a plant.
- (ii) the elimination of water with dissolved water products.
- (iii) the loss of water as water vapour from the aerial parts of a plant.
- (iv) the loss of water as water vapour from the roots as well as the leaves of the plant.

(h) Which one of the following favours the fastest transpiration rate ?

(i) A cool, humid, windy day, (ii) A hot, humid, windy day,

(iii) A hot, humid, still day, (iv) A hot, dry, windy day.

Short Answer Questions :

1. An experiment was set up as shown in the figure below. After some time, the water level in test tube A fell down but not in test tube B.

Why was there a fall in the water level of test tube A and not in that of test-tube B ?

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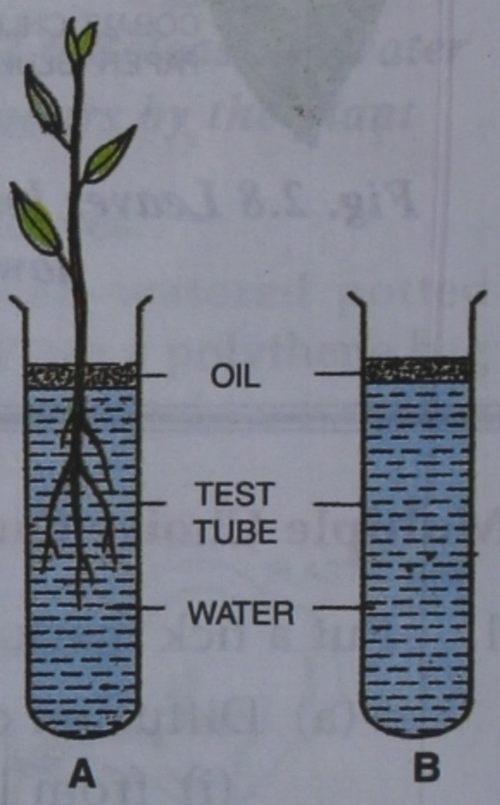

2. Give any *two* functions of the root :

(i) .....

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(ii) .....

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3. What is a semi-permeable membrane ?

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4. Define the term 'osmosis'.

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5. Given here is an enlarged diagram of a part of the root. Draw arrows on the diagram to show the movement of water passing through different parts.

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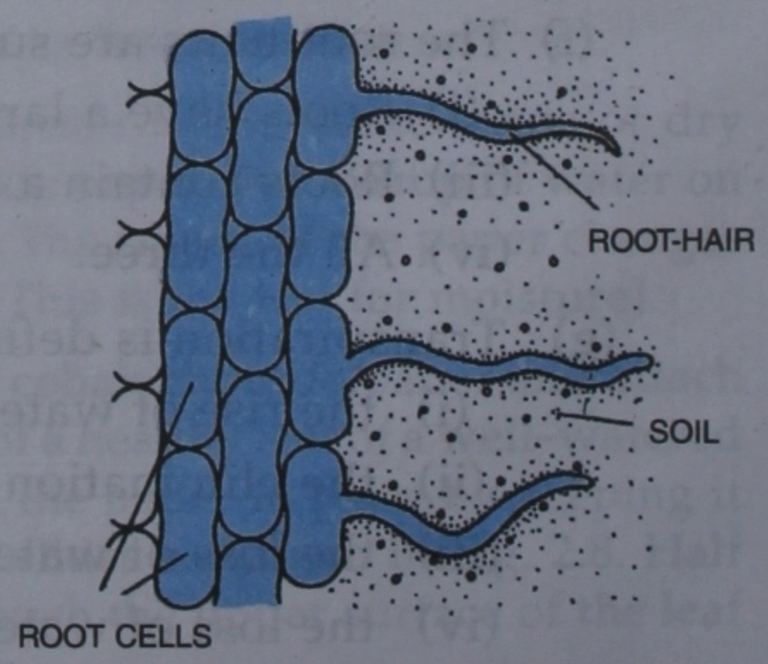

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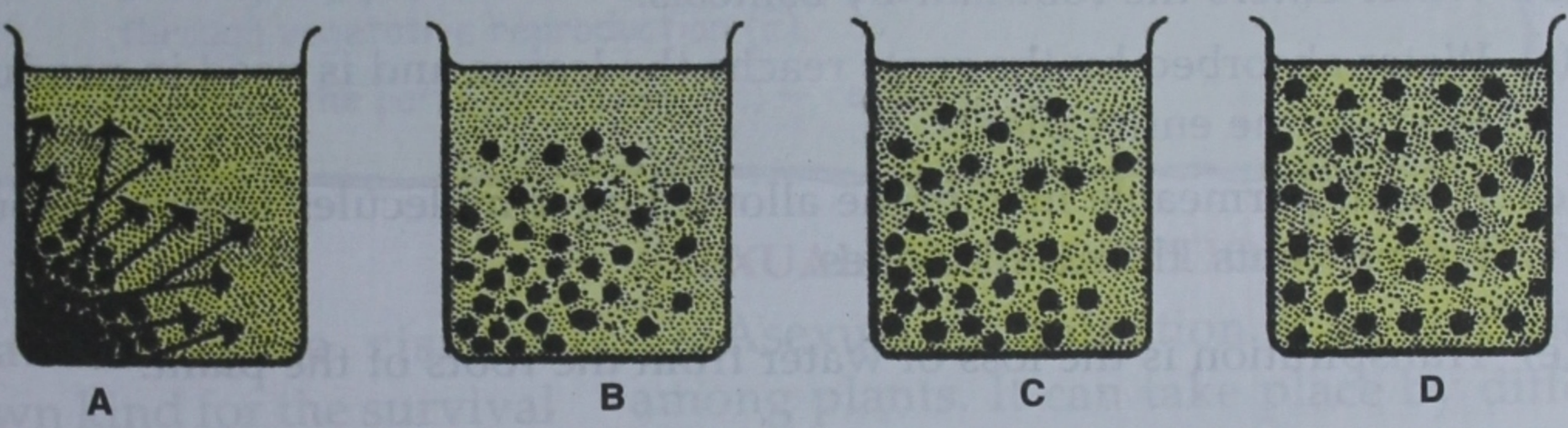
6. List *three* features of the root-hair which make it suitable for absorbing water from the soil:

(a) .....

(b) .....

(c) .....

7. In an experimental set–up, a dye was placed at the bottom of a beaker filled with water as shown in figure A below. After some time, the entire water in the beaker got coloured uniformly as shown in D.



(a) Name and define the phenomenon shown in the experiment.

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(b) In all the four figures, two kinds of molecules are shown symbolically – larger and smaller. Which molecules are of the solute and which are of the solvent ?

Larger : .....

Smaller : .....

(c) If all the dark shaded molecules in A are tightly enclosed in a cell membrane, what will be the nature of movement of the molecules, if any ?

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8. Give *two* points of significance of transpiration.

(a) .....

(b) .....

9. List any *three* factors that affect transpiration.

(a) ..... (b) ..... (c) .....

10. An apparatus shown alongside was set up in sunlight for about an hour. It was observed that drops of water appeared on the inside of the polythene bag.

(a) Name the process which is being demonstrated.

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(b) Why were the pot and its soil left uncovered by the polythene bag ?

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(c) Why was the pot left in sunlight ?

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(d) Suppose the pot in this experiment was placed inside a room instead of placing it under sunlight. What difference would be noticed ?

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11. State whether the following statements are *True* or *False* :

(a) Water absorption mainly occurs through the root-hair.

(b) Water enters the root-hair by osmosis.

(c) Water absorbed by the roots reachs the leaves and is used in producing food for the entire plant.

(d) A semi-permeable membrane allows larger molecules to pass through, but prevents the smaller ones.

(e) Transpiration is the loss of water from the roots of the plant.

(f) During transpiration, the leaves lose more water from their upper surface.

(g) Transpiration cools the plant when it is hot outside.

12. Fill in the blanks with suitable terms given here :

(Fast, Leaves, Stomata, Closed, Transpiration, Humid)

(a) Transportation in plants is carried out by a ..... system.

(b) The xylem has two types of components, the ..... and the ..... .

(c) Water is absorbed by the property of ..... and ..... .

(d) The upward movment of sap that contains water and minerals is called ..... of sap.

(e) The leaves have more ..... on their lower surface.

(f) Transpiration is more when the wind is blowing ..... .

(g) Most water gets evaporated from the plant from its ..... .

(h) Transpiration is reduced if the air is ..... .

Long Answer Questions (*Write the answers in your notebook*) :

1. Give a magnified view of the root-hair, and describe, how it helps in the absorption of water from the soil.
2. "Raisins swell in water, and grapes shrink in syrup." Explain this phenomenon briefly.
3. How does transpiration help the roots absorb water and minerals from the soil ?
4. Describe the three processes by which plants absorb water and minerals from the soil.
5. How water absorbed by the roots is important for the plants ?
6. Describe the factors which affect the rate of transpiration ?
7. Mention the *two* ways in which transpiration helps the plants.
8. Describe an experiment to show that the plant loses water through its leaves.