5 Transpiration

Syllabus : *Transpiration, process and significance; experimental work includes the loss in weight of a potted plant or a leafy shoot in a test tube, the use of cobalt chloride paper. Ganong's potometer and its limitations. The effect of external conditions on the rate of water loss should be stressed.*

Scope of syllabus : Mechanism of stomatal transpiration must be explained so that concept of the process is clear. Adaptations in plants to reduce transpiration to be discussed. A brief idea of guttation and bleeding should be given.

Transpiration is a very useful process for plants for two reasons : ***one***, creating suction force in the stem to enable the roots to absorb water and mineral nutrients, and ***two***, for cooling the plant in hot weather. The process is demonstrated and studied by a number of experiments, which are very interesting to perform.

5.1 TRANSPIRATION

Transpiration is the evaporative loss of water from the aerial parts (leaves and stem) of the plant.

OR

Transpiration is the loss of water in the form of water vapour from the leaves and aerial parts of the plant.

All plants continuously absorb water through their roots. This water is conducted upwards through the stem and is distributed to all the aerial parts including the leaves. Only a small quantity of this water (about 2%) is used by the plant in photosynthesis and other activities. The rest of it is almost lost to the atmosphere as water vapour during transpiration.

5.2 DEMONSTRATION OF TRANSPIRATION

Experiment 1. Take a medium-sized well-watered potted plant. Cover the plant with a transparent polythene bag and tie its mouth around the base of the stem (Fig. 5.1). Leave the plant in **sunlight** for an hour or two. Drops of water will soon appear on the inner side of the bag due to the saturation of water vapour given out by the leaves ***(the water vapours condense only if the outside temperature is cool enough)***. A similar empty polythene bag with its mouth tied and kept in sunlight will show no drops of water. This is a control to show that plants transpire water in the form of vapour. If tested with dry cobalt chloride paper, the drops will be confirmed as water only if the blue paper turns pink.

Fig. 5.1 : An experiment to demonstrate the release of water vapour (transpiration) from a plant, by enclosing the plant in a polythene bag.

Experiment 2 : (Fig. 5.2). Arrange three set-ups A, B and C as follows :

Set-up A. Take a small well-watered potted plant, preferably one with broad leaves. Enclose the pot completely within a polythene bag and tie the mouth of the bag firmly around the base of the stem. This would prevent the escape of water vapour from the pot. Now cover the entire plant under a bell jar as in (A).

Set-up B. Arrange another similar plant and cover it with a bell jar exactly in the same manner as the first one, except that here you also keep a piece of **dry cobalt chloride paper** by the side of the plant inside the bell jar (B). The paper may be pinned to a wooden stick or to a strip of cork sheet.

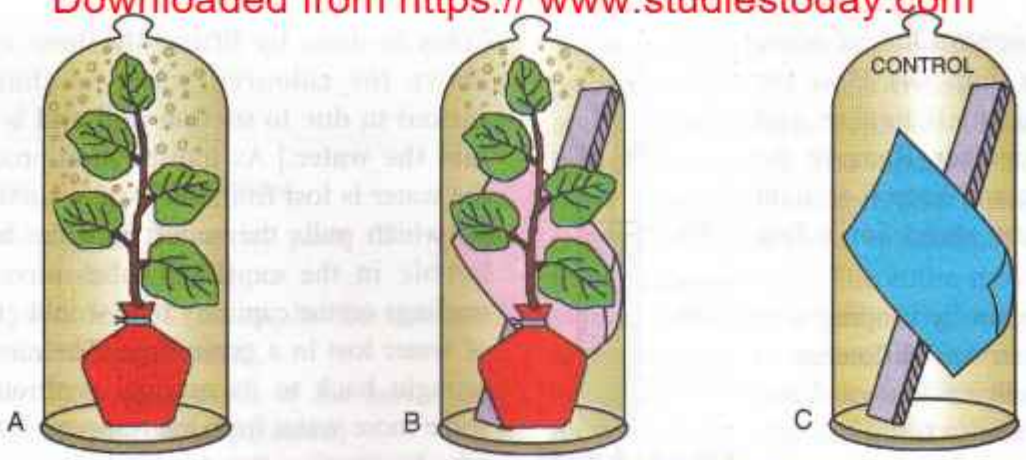


Fig. 5.2 : An experiment to demonstrate transpiration in plants. Firstly, the water droplets appear in bell jars A and B containing plants; secondly, the cobalt chloride paper turns from blue to pink in bell jar B but not in C

Cobalt chloride paper is an indicator of moisture : —	
Blue when dry	**Pink when exposed to moisture**

Set-up C. Take a third bell jar without the plant, but still containing a similar piece of cobalt chloride paper (C). Now, keep all the three bell jars together in the sun.

After about half an hour we observe that,

- The first bell jar (A) would show **water vapour condensing** on its inner walls.
- The second bell jar (B) would also show a similar **condensation** and at the same time, the initially blue cobalt chloride paper in it would **turn pink**.
- The blue colour of the cobalt chloride paper in the third bell jar (C) does not change at all and there are no water drops on the jar's inner walls either.

  The third bell jar in this experiment is a **control** which proves that there was no moisture in the air due to transpiration as there was no plant in it.

By taking the three bell jars as described above, there is a double visual proof of transpiration : (1) condensation of water vapour into droplets and (2) change of colour in cobalt chloride paper. You may simplify the experiment either by taking (B) and (C) only, or by taking the bell jar A and another empty bell jar without the plant or the paper.

5.3 MEASUREMENT OF TRANSPIRATION

There are a number of methods for measuring transpiration. Some of these are:

1. *Weighing method.* A small light weight potted plant can be weighed before and after the end of a certain period of time. The soil surface and the pot should be fully covered to prevent evaporation from the surfaces other than the plant. The loss in weight by the plant during that time is due to the loss of water by transpiration.

   An improvement in the weighing method can be made by using a glass bottle with a graduated side tube, filled with water and a tube fitted into it as shown in Fig. 5.3A. The water level in the side tube falls to demonstrate loss of water through transpiration from the leaves.

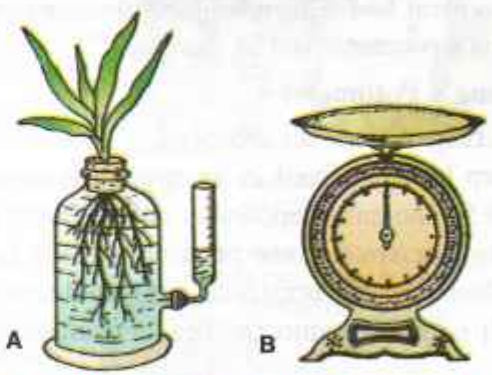


Fig. 5.3 : An experiment to show loss of water by volume as well as by weight

This would indicate the ***volume of water loss*** that can be compared with the loss in weight with the help of a weighing machine (B) or by converting cc into grams (1 cc water weighs 1g).

Another weighing experiment can be made by using a test-tube filled with water and inserting a leafy shoot (no roots) in it and pouring some oil on

the surface to prevent loss of water by evaporation (Fig. 5.4). Place the test-tube in a small beaker and weigh them together. Remove the intact test-tube and keep it straight in the test-tube stand for a few hours.

Weigh it again by keeping it in the same beaker. Any difference in weight will indicate loss of water by the shoot (due to transpiration). Since there are no roots to actively absorb water, the water loss through transpiration will be much less.

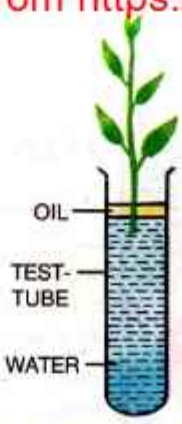


Fig. 5.4 : A shoot inserted in water transpires to show loss in weight

2. ***Potometer method.*** Potometer means a device that measures the rate of **water intake** by a plant (*poton*: drink, *meter* : measure), and this water intake is almost equal to the water lost through transpiration.

Note : Potometer's are of various types designed by various scientists to study and measure the rate of transpiration, namely, Farmer's potometer, and Ganong's potometer. which helps to measure the **rate of water intake by a plant**. Darwins potometer helps to demonstrate the **suction force created** due to transpiration and Garreau's potometer to demonstrate **unequal transpiration from the two surfaces of a dorsiventral leaf**. Given below is the commonly used Ganong's potometer and its working.

Ganong's Potometer :

A twig of some suitable plant (e.g. coleus) cut with a sharp knife is fixed in an apparatus as shown in Fig. 5.5. The entire apparatus is filled with water so that no air spaces are present. An air bubble is introduced into the horizontal graduated capillary tube which is dipping into the beaker containing water.

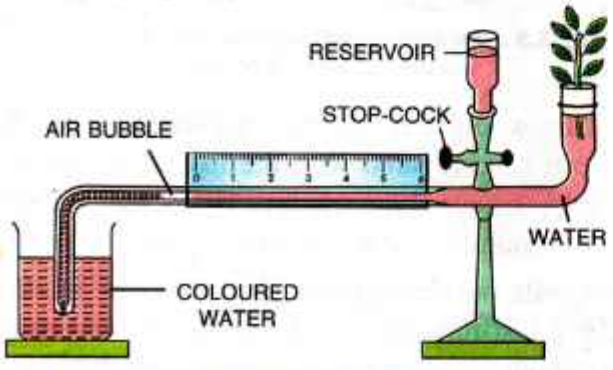


Fig. 5.5 : Ganong's potometer for measuring water uptake

[This is done by lifting the bent capillary tube above the coloured water so that air may be sucked in due to suction pull and is again dipped into the water.] As transpiration proceeds, *i.e.*, as the water is lost from the twig, a suction force is set up which pulls the water from the beaker and the bubble in the capillary tube moves along. The readings on the capillary tube would give the volume of water lost in a given time. The air bubble can be brought back to its original position by releasing some more water from the reservoir into the capillary tube by opening the stop cock.

[Potometers do not measure the water lost during transpiration but measure the water uptake by the cut shoot (L. *potos* : drink). Some of the water is used by the cells to carry out other processes, for example, manufacture of food (Photosynthesis). The potometer should be made completely water-tight and the twig should be cut obliquely (to allow larger surface for the water intake) and under water to avoid suction of an air bubble into the twig which will stop the absorption of water into the xylem.]

Limitations in the use of potometer

(i) Introducing the air bubble is not very easy.

(ii) The twig may not remain fully alive for a long time.

(iii) Any changes in the outside air temperature may affect the position of the air bubble in the capillary tube.

? PROGRESS CHECK

1. Transpiration is best defined as (tick-mark the correct option)
   (a) loss of water from the plant.
   (b) loss of water as vapour from the plants.
   (c) evaporation of water from the surface of leaves.
2. In one of the experiments to demonstrate transpiration, we used cobalt chloride paper. What are the characteristics of this paper that suit the experiment?
   .....
   .....
3. Look at the experiment shown in Fig. 5.4. Suppose you took a single flower with a long stalk dipping in water, instead of a leafy twig. Will it serve the purpose?
   Yes / No .....
   Give reason .....
   .....

4. Mention any two limitations in the use of potometers
   (i) .....
   (ii) .....

5.4 KINDS OF TRANSPIRATION

Transpiration from the aerial parts of a plant occurs from three different regions :

(i) From the leaves through the stomata **(stomatal transpiration),**
(ii) Directly from the surface of the leaves and stems **(cuticular transpiration)**
(iii) From the lenticels which are the minute openings on the surface of old stems **(lenticular transpiration).**

The major part of the transpiration occurs through the stomata, whereas the other two types of transpiration contribute very litttle.

5.4.1 Mechanism of stomatal transpiration

Stomata are minute openings in the epidermal layer of leaves. A stoma is surrounded by two bean-shaped guard cells (Fig. 6.2 p.65). During day-time, the stomata are wide open primarily for the intake of CO_2 for photosynthesis. The number of stomata may range from 1,000–10,000 per cm^2.

In stomatal transpiration, the water vapour escapes through the stomata of the leaf. Water, after absorption by the roots from the soil, rises up through the stem and reaches the tissues of the leaves through veins. A large number of spongy mesophyll cells in the leaves have their surfaces exposed to the intercellular spaces.

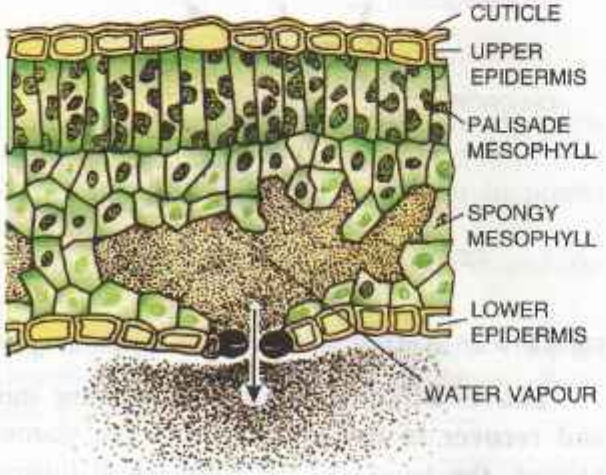


Fig. 5.6 : Vertical section of a part of a leaf showing diffusion of water vapour from its high concentration inside the porous regions of the leaf to the lower concentration in the outside atmosphere through stomata

These surfaces of the cells give out some of the water as a thin film. The water from this film evaporates and the water vapour formed saturates the air in the intercellular spaces. The vapour then diffuses into the other connecting intercellular spaces and finally reaches the sub-stomatal space, from where it escapes through the stomata. The entire movement of water vapour from the surface of the cell into the outside atmosphere is a result of diffusion (Fig. 5.6). The molecules of water vapour, like those of any gas, move from the region of their higher concentration to the region of their lower concentration.

Figure 5.7A shows the movement of water through a leaf. The cell sap in each cell exerts a turgor pressure outward on the cell wall. This pressure forces some water out of the cell wall into the air space between the cells. Here, the water evaporates and the water vapour diffuses through the

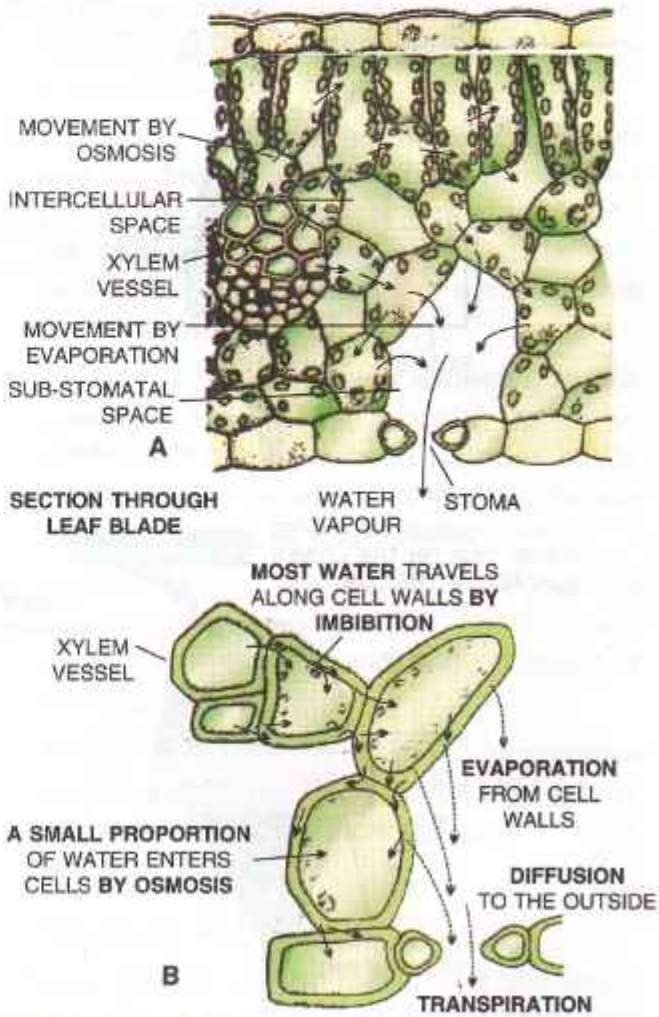


Fig. 5.7 : A–Movement of water through a leaf
B–Probable pathway of water through leaf cells

air spaces between the mesophyll cells into the **sub-stomatal space** from where it finally goes out by diffusion through the **stomata**.

The cells that lose water in this way replace it by drawing more of it from the nearest vein. Most of this water travels **along the cell walls** (by **imbibition**) and only a small quantity enters the cell by osmosis (Fig. 5.7B).

Thousands of leaf cells evaporate water in this way, causing more of water to be pulled from below via the xylem vessels. ***The transpiration pull thus created can draw up water to about 50 metres or more in the tall trees.***

More transpiration occurs from the undersurface of a leaf. There are more stomatal openings on the undersurface of a **dicot leaf** and therefore, more transpiration occurs from the undersurface. This can be proved by an experiment in which pieces of **dry cobalt chloride paper** are attached to the two surfaces of a leaf and held in position by two glass slides on either side tied together by elastic bands or held by clips (Fig. 5.8). **The leaf should remain attached to its own plant.** The piece of paper which is facing the upper surface of the leaf either does not turn pink or turns pink in a much longer time than the one on the lower surface which turns pink much faster. This proves that more transpiration takes place from the lower surface, which is on account of the numerous stomata found on it.

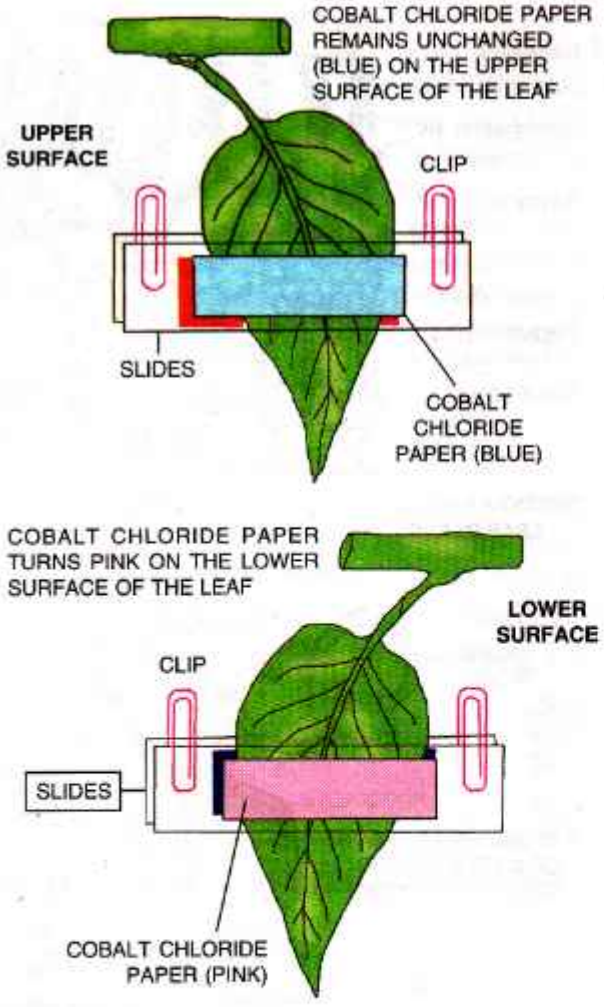


Fig. 5.8 : Result of an experiment to demonstrate the different magnitudes of transpiration from the two surfaces of a dicot leaf

Stomatal regulation of transpiration

Stomata (Fig. 5.9) are minute structures occurring in large numbers on the lower epidermis of a leaf. Transpiration occurs as long as the stomata are open, but it stops when they are closed. The opening and closing mechanism of stomata is regulated by the amount of water and solutes present in the guard cells. As the stomata open during the daytime, the diffusion of gases in and out starts fulfilling the need for photosynthesis as well as allowing transpiration. If for any reason, the water content of the leaf is falling short, the guard cells fail to remain turgid, rather, they turn flaccid (lose turgidity), thereby closing the stomatal opening and transpiration stops. A more detailed account of closing and opening mechanism of the stomata is given in the next chapter under section 6.4.

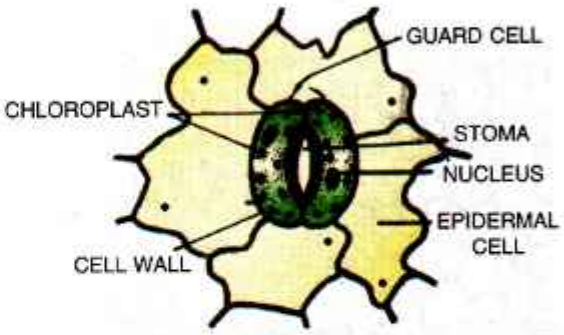


Fig. 5.9 : Portion of leaf epidermis showing one single stoma

Leaves of some plants wilt during midday and recover in the evening. In some plants, e.g. balsam, the leaves of the plants wilt during the midday in spite of the fact that there is plenty of water in the soil. In such cases, the rate of transpiration during midday exceeds the rate of

absorption of water by the roots. The cells, therefore, lose turgidity. In the evening or during the night, the stomata are constricted and the temperature is not high, therefore, there is no loss of water through transpiration and the turgidity of the leaves is re-acquired and they stand out erect.

Stomatal transpiration is controlled by the plant by adjusting the size of the stoma, whereas this does not happen in the case of cuticular and lenticular transpiration.

5.4.2 Cuticular transpiration

Cuticle is a waxy layer secreted by the epidermis on the two surfaces of the leaf. The thickness of the cuticle varies from plant to plant. Primarily, the cuticle serves to prevent evaporation of water from the leaf surfaces. However, some evaporation does occur. ***The greater the thickness of the cuticle, the lesser is the evaporation (transpiration).*** Desert plants tend to have thicker cuticles to cut down transpiration.

5.4.3 Lenticular transpiration

Lenticels are special openings that develop on the older stem in place of stomata. These allow diffusion of gases for respiration as well as for photosynthesis. ***Lenticels never close. They remain open all the time.*** Water from the cell surfaces directly facing the lenticel evaporates and contributes to transpiration.

The amount of transpiration from lenticels is certainly more than the cuticular transpiration, but very much less than the stomatal transpiration.

? PROGRESS CHECK

1. Pick out from the following list, the parts through which the water vapour of transpiration leaves the leaf and rearrange them in proper sequence.
   Xylem vessels, mesophyll cells, stoma, intercellular space and substomatal space.
2. Does diffusion play a role in the passage of water vapour from the leaf during transpiration? If so, how ? .....
   .....
3. In any experiment to demonstrate transpiration, the leaf must remain attached to its parent plant. Why is this so?
4. Out of the three kinds of transpiration, which one is maximum and which one is minimum?
   (i) Maximum .....
   (ii) Minimum .....

5.5 FACTORS WHICH AFFECT TRANSPIRATION

A. EXTERNAL FACTORS

1. ***Intensity of Sunlight :*** During the day, the stomata are open to facilitate the inward diffusion of CO_2 for photosynthesis. At night they are closed. Therefore, ***more transpiration occurs during the day***. When it is cloudy during the day, the stomata are partially closed and transpiration is reduced.
2. ***Temperature :*** If the outside temperature is higher, there is more evaporation from the leaves, therefore, more transpiration. ***Increase in temperature allows more water to evaporate*** and the decrease in temperature reduces evaporation. Warm air can hold more water than cold air.
3. ***Velocity of wind : Transpiration increases with the velocity of wind.*** If the wind blows faster, the water vapour released during transpiration is removed faster and the area outside the leaf does not get saturated with water vapour.
4. ***Humidity : Transpiration is reduced if the air outside is humid.*** High humidity in the air reduces the rate of outward diffusion of the internal water vapour across stomata, thereby reducing the rate of transpiration.
5. ***Carbon dioxide :*** Increase in the CO_2 level in the outside air over normal 0.03% causes stomatal closure and results in the decrease of transpiration.
6. ***Atmospheric pressure :*** Rate of transpiration increases with the decrease in atmospheric pressure. Thus, it enhances diffusion of water vapour.

B. INTERNAL FACTOR

Water content of the leaves : If the water content of the leaves decreases due to insufficient absorption of water by the roots, the leaves wilt

and transpiration is reduced. Such ***reduction in transpiration is indirectly due to the closure of stomata*** and it is a natural mechanism of conserving water within the plant.

Adaptations in plants to reduce excessive transpiration

Many plants and specially those which grow in a dry climate have evolved a variety of permanent adaptations to curtail transpiration. Some of these adaptations are as follows :

1. ***Sunken stomata :*** The stomata may be sunken or covered by hairs (e.g. *Nerium*) (Fig. 5.10).

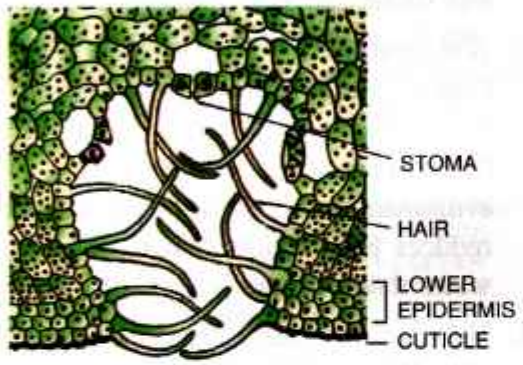


Fig. 5.10 : Sunken stomata covered by hair, in oleander *(Nerium)*

2. ***Fewer stomata :*** The number of stomata may be reduced.
3. ***Narrow leaves :*** The leaves may become narrower to reduce surface area (e.g. *Nerium*).
4. ***Reduced exposed surfaces :*** In some cases, leaves may get wavy, rolled or folded to reduce exposed surface.
5. ***Loss of leaves :*** In some cases, leaves may be dropped or may be absent or changed into spines as in most cacti.
6. ***Thick cuticle :*** The leaves may be covered by thick cuticle, (e.g. Banyan), and most evergreen trees.

PROGRESS CHECK

1. How will the following conditions affect transpiration ?
   (i) Still air .....
   (ii) Midday high temperature .....
   (iii) Dim sunlight .....
   (iv) Dry air .....
   (v) Insufficient absorption of water by the roots .....
2. List any three adaptations in plants to reduce transpiration.
   (i) .....
   (ii) .....
   (iii) .....

5.6 SIGNIFICANCE OF TRANSPIRATION

Transpiration has great significance for the plants. Its main advantages are: (1) cooling, (2) creating suction force, and (3) distributing water.

1. ***Cooling effect :*** Evaporation reduces temperature of leaf surface. Therefore, transpiration is useful to plants on hot sunny days. (At intense heat, the enzymes are destroyed).
2. ***Suction force :*** Transpiration helps in the ascent of sap by producing a suction force acting from the top of a plant. Evaporation from the leaves concentrates cell sap and increases their osmotic pressure. This draws water from the cells at the lower levels in a sequential manner (ascent of sap) and finally favours absorption of water from the soil by the roots (Fig. 5.11).

   Figure 5.11 also represents **the transpiration stream.** As the water evaporates from the leaves, a suction force is produced at the top

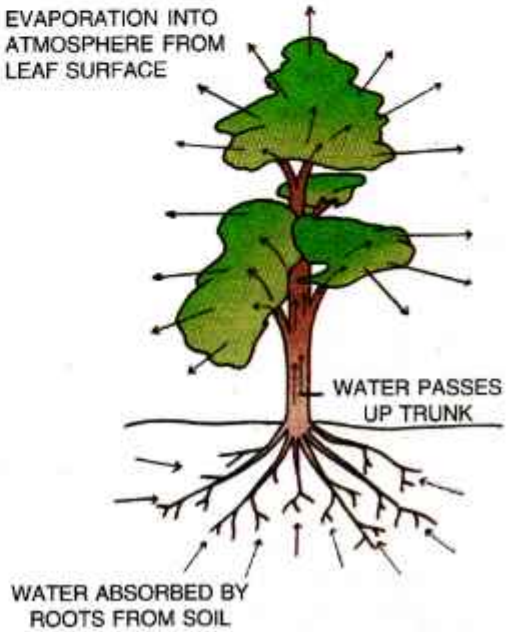


Fig. 5.11 : The transpiration stream

of the plant drawing more water up through the stem and making the roots absorb more of it from the soil.

3. ***Distribution of water and mineral salts:*** Since leaves are present at the tips of all branches and twigs, transpiration from their surfaces tends to draw water towards them and thus helps in the distribution of water throughout the plant body. Higher the rate of transpiration, greater the rate of absorption of water and solutes from the soil.

Is transpiration an **excretory process** in the plants ? ..... No!
It is not appropriate to relate transpiration to excretion or elimination of "excess water". Excretion wherever it occurs, is a deliberate active process carried out by the organism to get rid of unwanted and metabolic waste substances.

Transpiration affects climate

It has been shown experimentally that plants give out large quantities of water during transpiration.

- A full grown single sunflower plant is estimated to lose about **half a litre** of water per day in the form of water vapour.
- A single maize plant loses about **2 litres** of water per day.
- A large apple tree may lose about **30 litres** of water per day.

These figures give an idea of the huge quantities of water released into the atmosphere by vast stretches of fields and particularly forests. **Thus, transpiration increases the moisture in the atmosphere and brings rain.** In this way, transpiration from plants affects climate.

Forests contribute in bringing rain — Transpiration is the secret.

Table 5.1 : Differences between evaporation and transpiration

EVAPORATION	TRANSPIRATION
1. Loss of water from the surface of the water bodies in the form of vapour.	1. Loss of water in the form of vapour from aerial parts of the plant.
2. It is a physical change controlled by the temperature and humidity of the atmosphere.	2. It is a vital and partly a physical process controlled by both internal and external factors.
3. It is a fast process.	3. It is a slow process.

5.7 DIRECT LOSS OF WATER BY PLANTS — GUTTATION AND BLEEDING

Some plants may lose water directly, i.e., in liquid form and not as water vapour. It occurs in two ways — guttation and bleeding.

Guttation (*gutta* : to pour out, to drop) : The leaves of certain plants exhibit droplets of water along their margins in the morning (Fig. 5.12). This particularly happens in plants growing in warm humid conditions. **A humid environment hampers transpiration while the roots continue to absorb water from the soil.** This builds up a big hydrostatic pressure within the plant and "forces out" the excess water directly from the tips of veins in the leaf. Special pore-bearing structures called **hydathodes** are present on the margins of the leaf to allow this exudation. Guttation can be observed

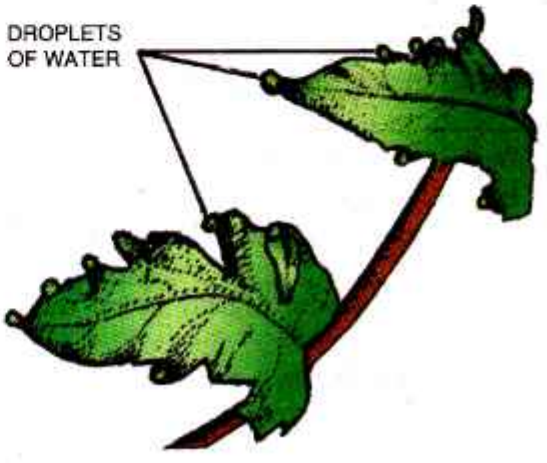


Fig. 5.12 : Leaves of a herbaceous plant showing guttation

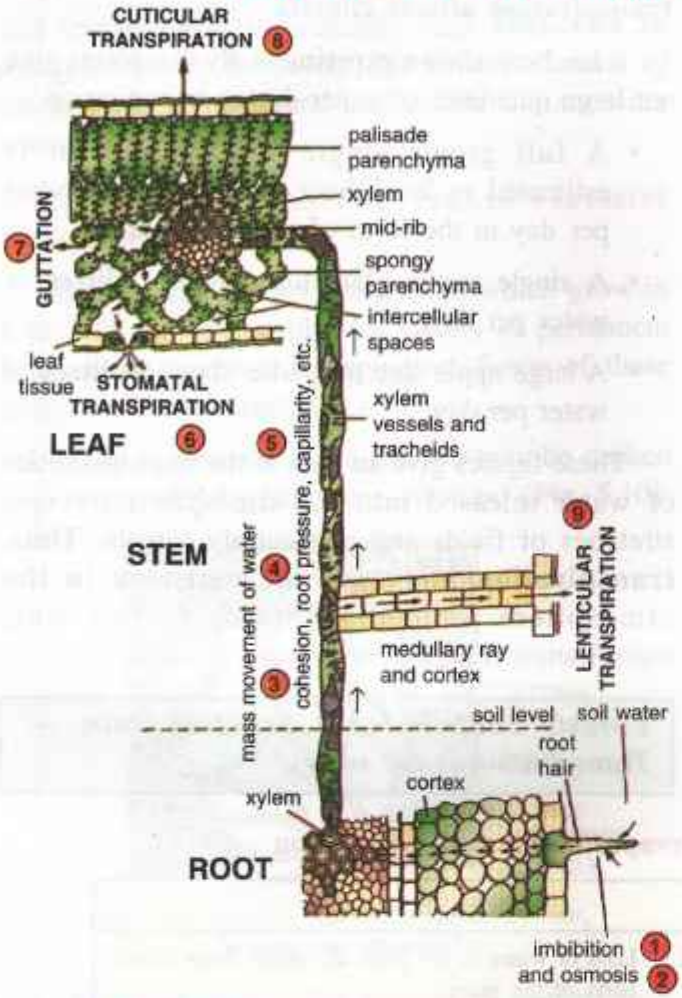


Fig. 5.13 : Diagrammatic representation of the path of water through the plant and the various physical forces which are responsible for the movement within and loss of water outside

in many plants and is quite common in banana, nasturtium and strawberry.

Bleeding : This happens only due to injury. The plant sap escapes ("bleeds") from the ruptured or cut surfaces of a plant. The root pressure generated by a plant assists in bleeding.

Summing up : The Fig. 5.13 schematically represents most of the phenomena (1 to 9) related to the intake and loss of water in a plant (through transpiration, etc.)

? PROGRESS CHECK

1. List any four advantages of transpiration to the plant.
   (i) .....
   (ii) .....
   (iii) .....
   (iv) .....
2. How would you justify the statement that transpiration contributes in bringing rain?
   .....
3. Differentiate between guttation and transpiration.
   .....
   .....
   .....
4. Plants have no blood, yet we sometimes say that a plant is "bleeding". How do you justify this ?
   .....
   .....

Table 5.2 : Differences between transpiration and guttation

TRANSPIRATION	GUTTATION / EXUDATION
1. Water is lost in the form of vapour.	1. Water is lost in the form of water droplets.
2. Pure water only changes into vapour.	2. Water lost contains mineral salts in solution.
3. Water vapour is lost through **stomata**, **lenticels** and cuticle.	3. Water is lost through pores **(hydathodes)** found at the ends of veins.
4. May lead to loss of turgidity in leaf cells to cause wilting.	4. No effect on the turgidity of leaf.
5. Stomatal transpiration is regulated by guard cells.	5. Opening of hydathodes cannot be regulated.
6. It occurs in the presence of sunlight.	6. It occurs at night or early morning.
7. It cools the plant body.	7. No such effect on the plant.
8. Occurs during dry conditions	8. Occurs in humid conditions.

REVIEW QUESTIONS

A. MULTIPLE CHOICE TYPE

(Select the most appropriate option in each case)

1. **Transpiration pull** will be maximum under which set of the following conditions?
   (a) Open stomata, dry atmosphere and moist soil
   (b) Open stomata, high humid atmosphere and well irrigated soil
   (c) Open stomata, high humid atmosphere and dry soil
   (d) Closed stomata, dry atmosphere and dry soil

2. With decrease in atmospheric pressure, the **rate of transpiration** will
   (a) increase (b) decrease rapidly
   (c) decrease slowly (d) remain the same

3. The **rate of transpiration** is more when
   (a) atmosphere is dry
   (b) temperature is high
   (c) humidity is high
   (d) atmosphere is dry and temperature is high

4. One of the **internal factors** which affect the rate of transpiration, is
   (a) big size of the leaf (b) colour of the leaf
   (c) sunken stomata (d) sunny day

5. **Guttation** takes place through
   (a) stomata (b) lenticels
   (c) lower epidermis of leaves (d) hydathodes

6. The loss of water as water vapour from the aerial parts of a plant is known as
   (a) evaporation (b) perspiration
   (c) guttation (d) transpiration

7. Transpiration will be **fastest** when the day is
   (a) cool, humid and windy
   (b) hot, humid and still
   (c) hot, humid and windy
   (d) hot, dry and windy

8. Most of the transpiration in tall trees occurs through
   (a) Stomata (b) Lenticels
   (c) Cuticle (d) Bark

9. Transpiration is **best defined** as
   (a) loss of water by the plant.
   (b) evaporation of water from the aerial surfaces of a plant.
   (c) loss of water, as water vapour, by a plant.
   (d) release of water by a plant into the atmosphere.

B. VERY SHORT ANSWER TYPE

1. **Name the following :**
   (a) **Openings on the stem** through which transpiration occurs.
   (b) The **process** by which the intact plant loses water in the form of droplets.
   (c) An **instrument** used to find the rate of transpiration.
   (d) A **plant** in which the **stomata are sunken.**
   (e) The **apparatus** to record the rate of transpiration in a cut shoot.
   (f) Any two **parts of a leaf** which allow transpiration.
   (g) The **structure in a leaf** that allows guttation.
   (h) **Loss of water as droplets** from the margins of certain leaves.

2. **Fill in the blanks :**
   (a) Transpiration is the loss of water as water ..... from the ..... parts of the plant.
   (b) Closing of ..... and shedding of leaves reduce .....
   (c) Transpiration helps in creating ..... force and in eliminating excess .....

C. SHORT ANSWER TYPE

1. Given below is an example of a certain structure and its special functional activity :

   chloroplasts and photosynthesis.

   In a similar way, **write the functional activity** against each of the following :
   (a) Hydathodes and .....
   (b) Leaf spines and .....
   (c) Lenticels and .....
   (d) Xylem and .....

2. (a) **State** whether the following statements are **True** (T) or **False** (F) ?
   (i) Most transpiration occurs at midnight. (T/F)

(ii) Transpiration creates a pull for upward movement of the sap. (T/F)

(iii) Wind velocity has an effect on transpiration. (T/F)

(iv) Voltmeter is an instrument used for measuring the rate of transpiration in green plants. (T/F)

(b) **Rewrite** the false statements, in *(a)* above, in the correct form by changing either the first or the last word only.

3. **Give suitable explanation** for the following :
   (a) A higher rate of transpiration is recorded on a windy day rather than on a calm day.
   (b) Excessive transpiration results in the wilting of the leaves.
   (c) Water transpired is the water absorbed.
   (d) More transpiration occurs from the lower surface of a dorsiventral leaf.
   (e) Cork and bark of trees help in preventing loss of water.
   (f) Perspiration and transpiration help to cool the body temperature of the organism.
   (g) On a bright sunny day, the leaves of certain plants roll up.
4. **Which** of the following statements are ***true*** and which ones are ***false***? Give reason in support of your answer.
   (a) Potometer is an instrument used for demonstration of transpiration occurring from the lower surface of a leaf.
   (b) Forests contribute in bringing rains.
   (c) Hydathodes are similar to stomata in plant physiology.
   (d) Atmospheric humidity promotes transpiration from a green plant.
   (e) Some desert plants have sunken stomata on their leaves.
   (f) Most transpiration occurs during midday.
5. **Differentiate** between guttation and bleeding in plants.

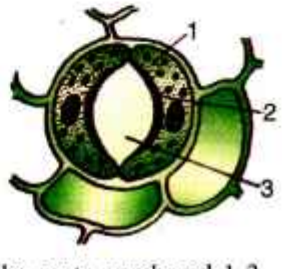
D. LONG ANSWER TYPE

1. **What** is wilting? Some plants show wilting of their leaves at noon even when the soil is well watered. Why is it so?
2. **Why** are the stomata in most plants more numerous on the lower surface of a leaf instead of being on the upper surface?
3. Suppose you have a small rose plant growing in a pot. **How** would you demonstrate transpiration in it?
4. **What** is a potometer?
5. **What** is lenticular transpiration? Mention one major difference between lenticular transpiration and stomatal transpiration.
6. **List** any three major factors that accelerate the rate of transpiration.
7. There is a general belief that forests tend to bring more frequent rains. **Can you explain** it scientifically?
8. **List** the four advantages of transpiration to the plants.
9. **Mention** any three methods by which the plants tend to reduce transpiration.
10. Droplets of water may sometimes be seen along the margins of the leaves of a banana plant, growing in wet soil, in the mornings. **Are** these dew drops? **Comment** upon your answer.
11. **Briefly explain** how the rate of transpiration is affected by
    (a) Intensity of light
    (b) Humidity of the atmosphere.

E. STRUCTURED/APPLICATION/SKILL TYPE

1. In an experiment, four freshly plucked leaves (A-D) of a plant, such as those of China-Rose, were treated as follows :
   (A) coated with vaseline on its upper surface.
   (B) coated on the lower surface.
   (C) coated on both surfaces.
   (D) left uncoated.

   All the four leaves A, B, C & D were left in a room for about 24 hours.
   (i) **Which leaf** would become most limp? Why ?
   (ii) **Which leaf** would show least limping? **Why** ?
2. Given below is a diagrammatic sketch (surface view) of a stomatal apparatus from a dicot leaf.

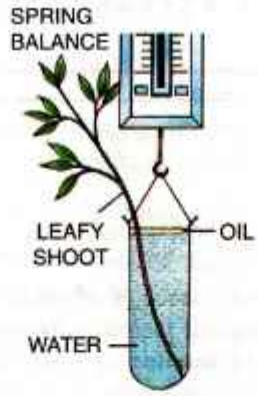


   (a) **Label** the parts numbered 1-3.
   (b) **Is this state**, open or closed?

(c) **Is this stoma**, of a dicot leaf or a monocot leaf?

(d) **Redraw** a sketch of the stomatal apparatus in the state opposite to the one shown here.

3. Given alongside is the diagram of an experimental set-up to demonstrate a certain phenomenon in plants.



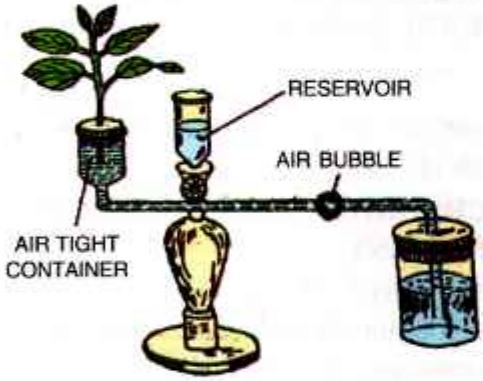
(a) **Name** the phenomenon being demonstrated.

(b) **What is** the purpose of putting oil in the test tube?

(c) **What** is the purpose of the spring balance in the set-up?

(d) **Would** it make a difference if the experimental set-up is kept in bright sunshine?

4. Given below is the diagram of an apparatus used to study a particular phenomenon in plants :



(a) **Name** the apparatus.

(b) **What** is it used for?

(c) **What** is the role played by the air-bubble in this experiment?

(d) **What** is the use of the reservoir?

(e) **What** happens to the movement of the air-bubble if the apparatus is kept :

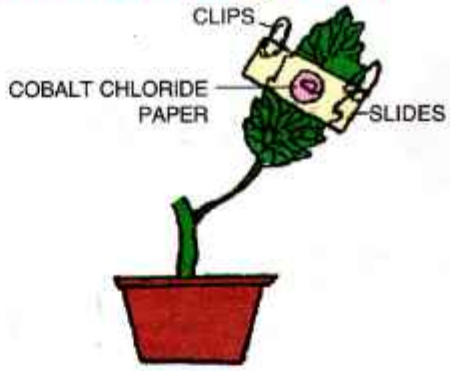
(i) in the dark; (ii) in sunlight; (iii) in front of a fan?

Give a reason in each case.

5. Given ahead is the diagram of an experimental set up to study the process of transpiration in plants. Study the same and then answer the questions that follow :

(a) **Name** the colour of dry cobalt chloride paper?

(b) **Is** the experimental leaf a monocot or a dicot? **Give** a reason to support your answer.



(c) **Why** are glass slides placed over the dry cobalt chloride papers?

(d) After about half an hour **what** change, if any, would you expect to find in the cobalt chloride paper placed on the dorsal and ventral sides of the leaf? Give a reason to support your answer.

6. The apparatus shown in the following diagram is Garreau's potometer designed to demonstrate unequal transpiration from the two surfaces of a dorsiventral leaf. Before keeping the leaf in between the cups, anhydrous calcium chloride ($CaCl_2$) contained in two small vials were weighed and placed in both the cups. The ends of the cups were closed with corks through which two mercury manometers were connected. After few hours, $CaCl_2$ vials were taken out and weighed again.

(a) **What** is the purpose of keeping $CaCl_2$ vials inside the cup?

(b) After few hours $CaCl_2$ vials were taken out and weighed again. Will you expect any difference in weight? If so, give reason.

(c) **What** was the purpose of using a manometer?

(d) **What** do you mean by transpiration?