



Ratna Sagar

RATNA SAGAR

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BYWORD

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Education, Our Mission



As per the latest ICSE syllabus 2022

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Revised and Updated

LIVING SCIENCE BIOLOGY

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10



EDUCATION, OUR MISSION



ICSE

Living Science

Biology

Class 10

Chapter 5 **Transpiration**



LEARNING OBJECTIVES

How is water made available for transpiration?

Types of transpiration

- ❖ **Mechanism of stomatal transpiration**
- ❖ **Cuticular transpiration**
- ❖ **Lenticular transpiration**

Measuring rate of transpiration

- ❖ **Factors affecting the rate of transpiration**

How are plants adapted to reduce excessive transpiration?

- ❖ **Significance of transpiration**
- Guttation and bleeding**

What is transpiration?

The loss of water as water vapour from the leaves and aerial parts of the plant is called transpiration.



How is water made available for transpiration?

There is a continuous loss of water from the leaves by transpiration. The water lost from leaves is continuously replaced by more water which flows from leaf xylem vessels. Water flows from xylem vessels to the surface of mesophyll cells of the leaves by two routes.

❖ **Imbibition:** Most of the water flows directly through the porous cellulose walls of the mesophyll cells.

❖ **Osmosis:** A small amount of water flows by osmosis from cell to cell.

Flow of water up the xylem

As a result of transpiration, water pressure of the xylem vessels in leaves and stem becomes lower than in root xylem vessels. This pressure difference causes water to be sucked up from the roots into the leaves in a similar manner as we suck cold drink with a straw.

Flow of water from soil to root xylem

Water sucked up from roots to stem and leaves is replaced by water which flows from the soil through the freely permeable cellulose walls of root hair into the **root cortex**. This flow of water continues as long as a plant transpires.

Note: The major differences between transpiration and evaporation are given in Table 5.1.



Types of transpiration

On the basis of occurrence from different regions of a plant, transpiration is of three types: 1. Stomatal transpiration (from the leaves through the stomata) 2. Cuticular transpiration (from the waxy cuticle layer of leaves and stems) 3. Lenticular transpiration (from the lenticels present on the surface of old stems)

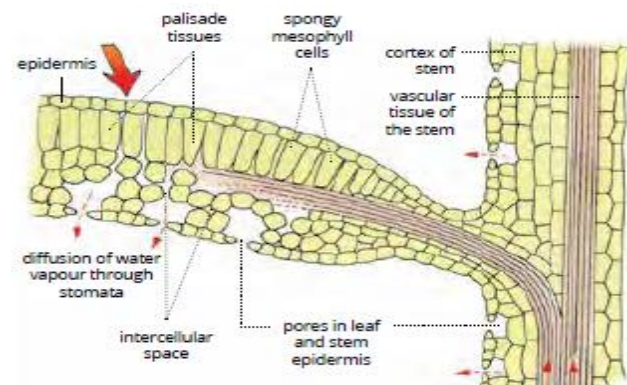
Mechanism of stomatal transpiration

Stomatal transpiration accounts for maximum (about 90%) transpiration in plants. Stomata are the minute openings present on one or both surfaces of the leaf. They facilitate exchange of gases between the leaf and the atmosphere. In stomatal transpiration, water vapour is lost through stomata in leaves.

The stomatal transpiration occurs as follows:

- ❖ The water is absorbed by root hair from the soil. This water then moves up through xylem vessels via stem into the spongy mesophyll cells of the leaves through veins.

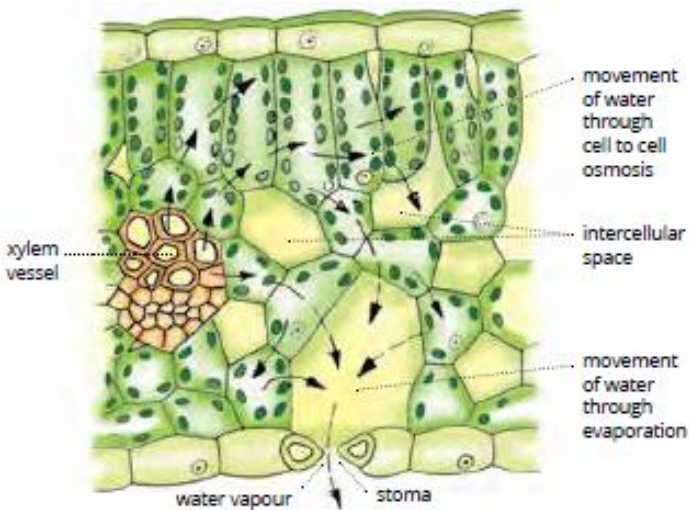
- ❖ The spongy mesophyll cells in the leaves have large number of intercellular spaces. These cells give out some water as a thin film.



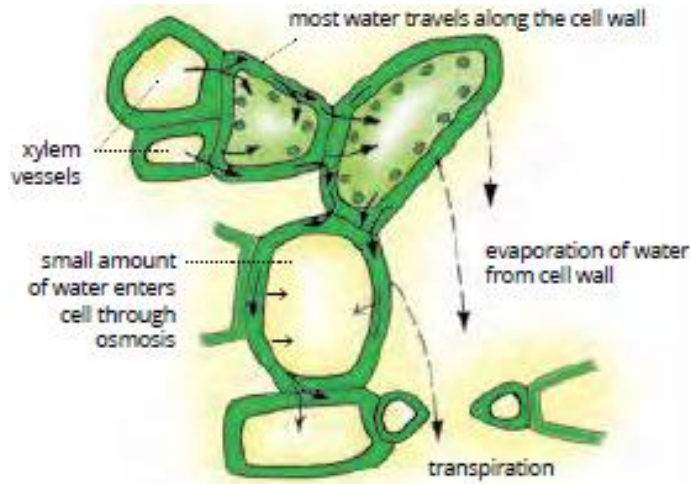
Transpiration from the stem, leaves and flowers of the flowering plant.



- ❖ The water from this thin film evaporates in the form of water vapour. The water vapour formed then saturates the air in the intercellular spaces.
- ❖ This water vapour then accumulates and reaches the substomatal space through various connecting intercellular spaces by diffusion.
- ❖ From substomatal spaces, the water vapour escapes from the stomata by the process of diffusion. The molecules of water move from the region of their higher concentration to the region of their lower concentration. The water lost by cells is replaced by more water from the nearest xylem vessel. Most of water moves along the cells by **imbibition** and only a small amount by osmosis.



a. Section through leaf blade showing movement of water through a leaf.



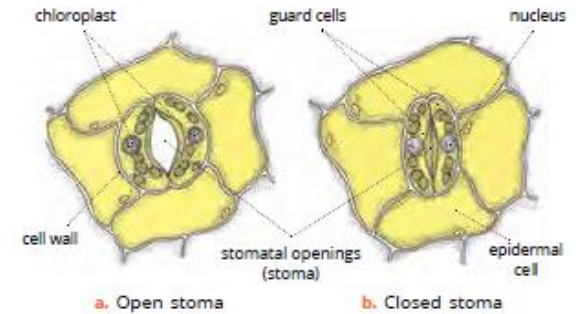
b. Movement of water through the cells of a leaf.

Process of stomatal transpiration through a leaf.



How do stomata regulate transpiration?

Stomata are minute openings found in the epidermis of leaves and stem. Each stoma contains a pore surrounded by two guard cells. Both guard cells are firmly joined at both ends but separate in the mid-region of their length. Stomata are mostly present on the lower epidermis of the leaf.



Stomata with their guard cells

The open stomata account for diffusion of water vapour through them. During the day, the cell-sap concentration becomes high due to accumulation of sugar in the guard cells as a result of photosynthesis.

This results into movement of water into guard cells from the neighbouring cells. This makes the guard cells turgid and guard cells bulge out and pull apart their inner walls and stomata open. If the availability of water is reduced, the guard cells lose their turgidity and they become flaccid by exosmosis of water from guard cells. This leads to the closing of stomata and transpiration stops.

Cuticular transpiration

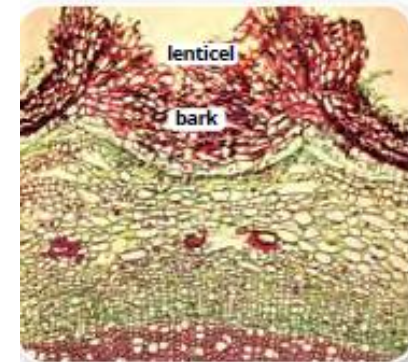
The cuticle is a waxy layer secreted by the epidermis of the leaves and young stems of the plant. Cuticular transpiration accounts for only 3–10% of the total transpiration. It continues throughout day and night.



There is very limited evaporation of water from the cuticle. The cuticular transpiration depends upon the thickness of cuticle. Greater the thickness of cuticle, lesser is evaporation of water (lower cuticular transpiration) and vice versa.

Lenticular transpiration

It occurs in the woody branches of the trees where lenticels are found. Lenticels are special openings on the older stem in place of stomata. The lenticular transpiration accounts for only 0.1% of the total transpiration. In lenticular transpiration, water from cell surface facing the lenticels evaporates directly.



Cross section of old bark of tree showing lenticular transpiration

Measuring rate of transpiration

There are mainly two methods for measuring the rate of transpiration:

1. Weighing method: In this method, a small light weight potted plant is weighed before and after a certain period of time in which transpiration has taken place. The loss in weight by the plant during the time indicates the loss of water by transpiration.



2. Potometer method: Potometer is a device that measures the rate of water intake by a plant (which is almost equal to the water lost by transpiration). There are mainly two types of potometers used in this method – **Ganong’s potometer** and **Darwin’s potometer**.

Factors affecting the rate of transpiration

A. External factors

- 1. Humidity (Vapour pressure):** High humidity in the air reduces the rate of outward diffusion of water from the sub-stomatal cavity and reduces the rate of transpiration, because the air is already laden with the water vapour.
- 2. Temperature: High temperature increases rate of transpiration** by providing the latent heat of vaporization.
- 3. Intensity of light:** Light affects the rate of transpiration indirectly. More transpiration occurs during the day. During the night they are closed, thus the rate of transpiration is minimal.
- 4. Air movement (Velocity of wind):** Moving air sweeps away the water vapour in the air outside the stomata. This speeds up diffusion of water vapour from stomata. Thus, the rate of transpiration increases with the velocity of wind.



5. Atmospheric pressure: Decrease in atmospheric pressure increases diffusion of water vapour from stomata. The lower the atmospheric pressure, the greater is the rate of evaporation of water from leaves. Thus, rate of transpiration increases with the decrease in atmospheric pressure.

6. Carbon dioxide concentration: If the concentration of carbon dioxide increases more than the normal (0.03%), the stomata get closed. This reduces the rate of transpiration.

7. Water supply to the leaf: Shortage of water in the soil affects the water supply to the leaf and in turn the stomata close and the leaf wilts. This reduces the rate of transpiration.

B. Internal factor

1. Leaf structure: The shape of the leaf and the number and position of stomata on it influence water vapour loss. In xerophytes, the cuticle is thick and there is negligible loss of water vapour (less transpiration). On the other hand, in shady plants leaf with a large surface area and a thin cuticle, the loss of water vapour is more (more transpiration).

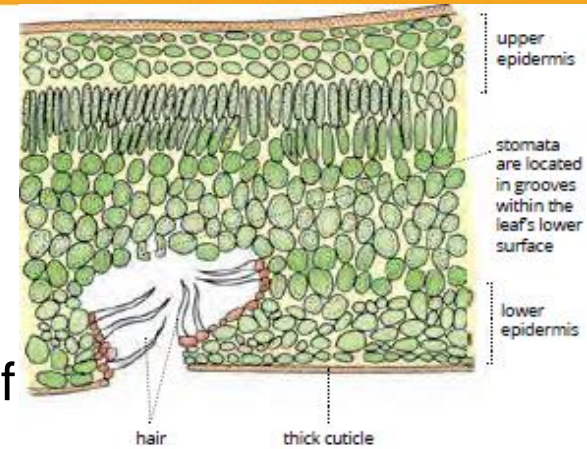
How are plants adapted to reduce excessive transpiration?

- ❖ The **stomata may be sunken or covered** by hair as in oleander.
- ❖ The **number of stomata may be reduced** as in xerophytes, like cactus.



- ❖ The leaves may become narrow to reduce leaf surface area as in *Nerium* and pine.
- ❖ The leaves may roll over or fold to reduce exposed surface and maintain moisture around stomata as in desert grass.

Sunken stomata in an oleander leaf

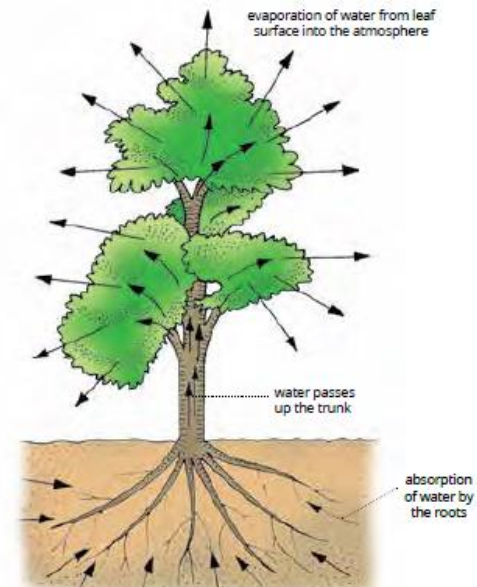


- ❖ There may be very few leaves on a plant to reduce transpiration such as in *Acacia*.
- ❖ The leaves may have thick cuticle as in mango and most evergreen trees to prevent transpiration as in banyan.

Significance of transpiration

Ascent of sap

Transpiration helps in ascent of sap due to a suction force or pull created by loss of water. As the water evaporates from leaves, a suction force is developed at the top of plant which draws more water from the soil through roots and stems.



Transpiration helps in ascent of sap



Removal of excess water

Plants absorb far more amount of water than is actually required by them. Thus, transpiration helps in removing excess of water.

Cooling effect

Solar heat during summers increases the temperature of plants which may be dangerous to the plants. Transpiration helps in reducing temperature of the leaf surface by evaporation of water vapour from it, which in turn cools the plant.

Distribution of mineral salts

The transpiration from leaf surface draws more water from the lower parts and in turn from soil. This rising column of sap from soil contains mineral salts. Thus, the mineral salts are distributed to all parts of the plants.

Guttation and bleeding

Guttation

You must have seen accumulation of water droplets on the surface of leaves early in the morning. This is due to **guttation**. Guttation is exudation of water droplets on the leaf margins of plants such as banana growing especially in warm humid conditions.



Guttation



The loss of water in the form of droplets from the margins of the leaves of certain plants during hot and humid conditions is known as **guttation** or **exudation**. It is caused due to root pressure. When rate of transpiration is low, the roots of some plants keep on accumulating minerals and absorbing water. Thus, more water enters the leaves than is transpired. As a result, the excess water is forced out through specialized structures on the margins of the leaves called **hydathodes**.

Bleeding

During injury to certain plant tissues, the plant sap escapes (bleeds) from the ruptured or cut surface of the plant. This is brought about by the root pressure generated by the plant.

Note: Refer to Table 5.2 for the Differences between transpiration and guttation



SUMMARY...

- ❖ The loss of water as water vapour from the aerial parts of the plant is called transpiration. Transpiration is different from evaporation.
- ❖ Transpiration produces a suction force which draws water up from the soil to the leaves.
- ❖ There are three types of transpiration – stomatal, cuticular and lenticular transpiration.
- ❖ Stomatal transpiration occurs by diffusion of water vapour through stomata and accounts for maximum transpiration by a plant.
- ❖ Cuticular transpiration involves the loss of water vapour from the surface of leaves and young stems of the plant. It occurs during the day and night.
- ❖ Lenticular transpiration occurs through lenticels found in the woody branches of trees. It occurs continuously.
- ❖ Transpiration rate can be measured by weighing method or with the help of a potometer.
- ❖ Rate of transpiration increases with increase in intensity of light, temperature, velocity of wind and availability of water.
- ❖ There are many advantages of transpiration to a plant such as cooling, ascent of sap, distribution of minerals and removal of excess water.
- ❖ Guttation is loss of water from the leaf margins of plants.

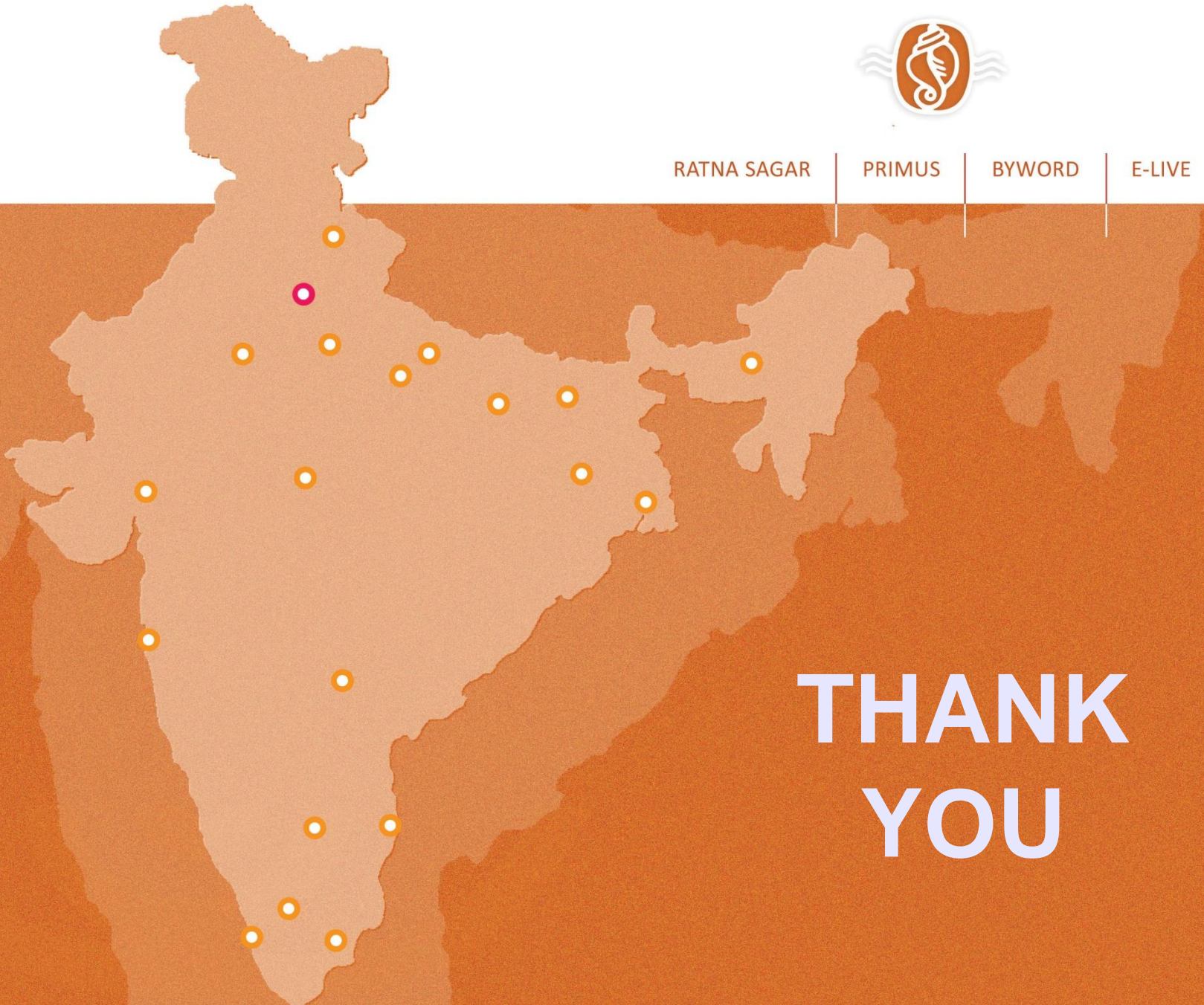


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