Transpiration

Transpiration and Its Types

Transpiration

The loss of water in the form of water vapours from the leaves and aerial parts of plant is called transpiration.

Types of Transpiration

- Stomatal transpiration- Occurs through stomata
- Cuticular transpiration- Occurs through surface of stem and leaves
- Lenticular transpiration- Occurs through lenticels

Occurs mainly through openings called **stomata**.

Stomata are the minute openings found in the epidermal layer of the leaves. A stoma is surrounded by two bean shaped guard cells which regulate its opening and closing.

Stomatal Transpiration

In plants, water is absorbed through the roots, This absorbed water has to be transported throughout the plant's body for various physiological functions. It rises up in the stem through xylem and reaches the tissues of leaves through veins. The mesophyll cells of the leaves have their surfaces exposed to the intercellular spaces.

Some amount of water forms a thin layer over these surfaces. The water from this film gets evaporated and form water vapours. These water vapours can diffuse through the intercellular space and reach the sub stomatal space and finally escape through stomata.

Regulation of Stomatal Transpiration

- Stomata:
- Open in the day and close during the night
- Also contribute in the exchange of O_2 and CO_2
- Opening and closing of stomata is influenced by the turgidity of the guard cells.
- Inner walls of the guard cells (towards stomatal opening): Thick and elastic
- When turgidity increases within two guard cells flanking each stomatal pore, the thin outer walls bulge out, and the inner walls assume a crescent shape.

- Radial orientation of microfibrils in the cell wall of the guard cells makes it easier for the stoma to open.
- When turgidity decreases within the guard cells, the inner walls regain their original shape, the guard cells become flaccid and stoma closes.
- Based on the distribution of stomata, 2 types of leaves:
- Dorsiventral: More number of stomata on the lower surface of leaves; found in dicots.
- Isobilateral: Equal number of stomata on both sides of leaves; found in monocots.

Differences between Evaporation and Transpiration

Evaporation	Transpiration
Loss of water from surface of water bodies in the form of vapours	Loss of water from aerial parts of plants in the form of vapours
A fast process	A slow process
A physical change controlled by temperature and pressure	A partly physical and vital process controlled by internal and external factors of leaves

Factors Affecting Transpiration and Its Significance

Factors affecting Transpiration

The factors affecting transpiration can be classified into two categories:

- **External Factors**
- **Internal Factors**

External Factors:

- **Light:** During the day time stomata is open and facilitates transpiration.
- **Wind Speed**: Rate of transpiration increases with the speed of wind.
- **Humidity**: Rate of transpiration decreases with increase in humidity.
- **Temperature**: High temperature results in more transpiration.
- **Atmospheric pressure**: Decreased atmospheric pressure increases the transpiration.
- **Carbon dioxide**: Increase in level of CO_2 causes decrease in transpiration.

Internal Factors:
Transpiration decreases when water content of the leaves decreases due to insufficient absorption by the root.

Adaptations in Plants To Reduce Excessive Transpiration

- Sunken stomata
- Less stomata
- Narrower leaves
- Loss of leaves
- Reduced exposed surface
- Thick cuticle

Significance Of Transpiration

- **Suction force**: It provides transpiration pull which is responsible for the upward movement of water in tall plants.

- **Cooling effect**: Evaporation causes cooling. Hence, transpiration helps plants in hot sunny days.

- **Distribution of water and minerals**: Since leaves are present at the tips of all branches, transpiration helps to draw water and minerals towards them, and thus helps in their distribution through out the plant's body.

Transpiration affects Climate

- Most of the plants on a daily basis loses litres of water that is released in the atmosphere.

- The released water increases moisture in atmosphere that brings rain.

Relationship of Transpiration with Photosynthesis

- Process of photosynthesis requires water. Xylem provides water to the site of photosynthesis (leaves).

- As the water evaporates, in order to maintain a thin film of water over the cells, water is pulled from the xylem to the leaves.

- Also, due to the lower concentration of water in the atmosphere, water diffuses into the atmosphere to create a pull.

- Actively photosynthesising plants need more water, and availability of water can be a limiting factor for photosynthesis.

- C_4 photosynthetic pathway makes sure that the maximum CO_2 is fixed with minimum loss of water. For same amount of CO_2 fixed, a C_4 plant loses only half the amount of water lost by a C_3 plant.

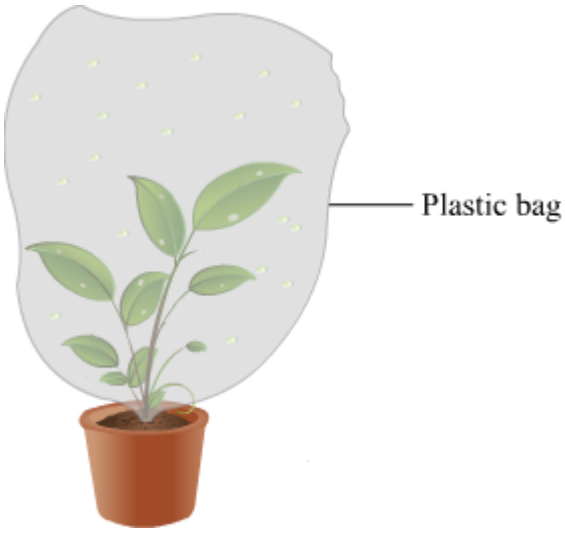
Importance of Transpiration

- Creates transpiration pull for transport
- Supplies water for photosynthesis
- Transports minerals from soil to all parts of a plant
- Cools the surface of the leaves (due to the evaporation of water)
- Keeps the cells turgid; hence, maintains their shape

Experiments Demonstrating Transpiration and Methods of Its Measurement

Experiments Demonstrating Transpiration

Experiment 1
Take a well watered medium sized plant. Cover the plant with a polythene bag. Tie its mouth near its base and pack it properly. Leave the plant out in sunlight for a few hours.



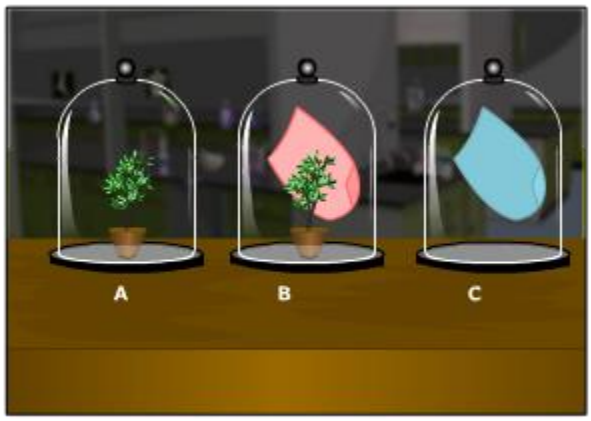
You will observe small droplets of water on the inner side of polythene bag. This is because of the water vapours given out by the leaves. When the water vapours given out condense, they form water droplets. This exhibits transpiration process in plants.

Experiment 2
Take three bell jars and name them A, B and C. In jar A, take a small, well watered

potted plant, with broad leaves. Now, cover the pot completely with a polythene bag and tie it properly to prevent escape of water vapours from pot.

In jar B, repeat the same procedure as for jar A and add a dry piece of cobalt chloride paper into the jar.

In jar C, just take the piece of dry cobalt chloride paper without the plant.



After sometime, you will observe that

- Jar A has water droplets, as water vapours condense on its inner walls.
- Jar B shows similar condensation along with change in colour of cobalt chloride paper from blue to pink.
- In jar C no colour change can be seen. This jar was used as a control to show that no moisture is present in air.
- This shows that transpiration has occurred.

Measurement of Transpiration

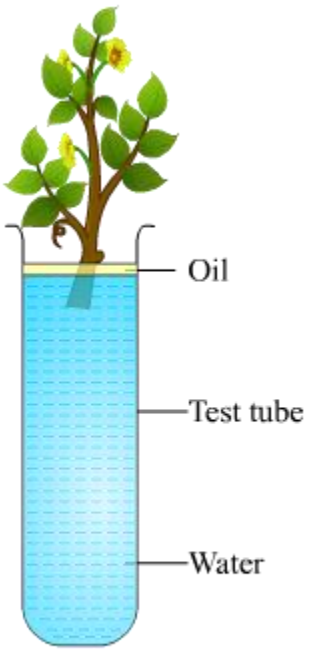
Transpiration can be measured through a number of methods. Here, we will discuss about some of them.

- **Weighing Method:**
- Take a small plant and weigh it on a weighing machine. Now cover the soil surface and pot completely so that it does not lose water by evaporation. Weigh the plant again after some time. You will observe some loss in the weight of the plant. This is due to the water loss by transpiration. The loss in weight can be measured using a weighing machine. This indicates volume of water loss can be compared with loss in weight by the weighing machine.

- **Another Weighing Method:**

- Take a test tube filled with water and insert a leafy shoot in it. Pour some oil on the surface to prevent loss of water by evaporation. Put the set up in a small beaker and

weigh it. Leave the test tube in a test tube stand for few hours. Now, weigh it again using the same process. You will observe a small difference in the weight, which indicates loss of water due to transpiration.

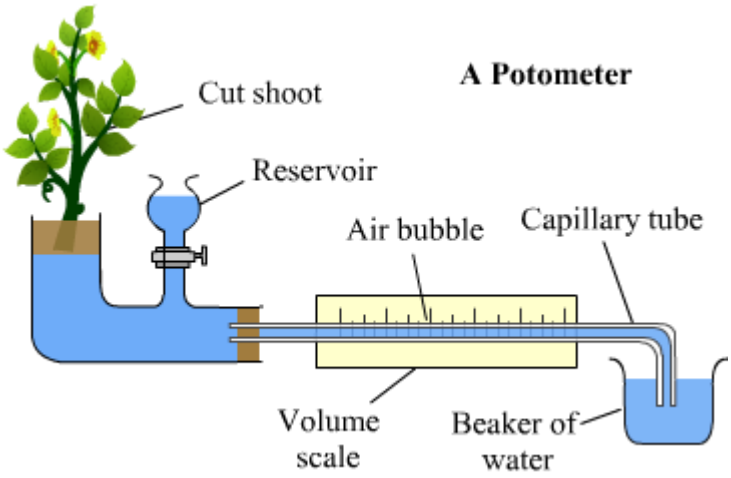


A shoot inserted in water transpires to show loss in weight

- **Potometer Method: Potometer** is a device used to measure water intake by a plant; this intake is equal to the water loss through transpiration. There are a number of designs of potometer that are used to measure transpiration.

  Some examples include Farmer's potometer and Ganong's potometer (to measure rate of water intake), Darwin's potometer (to demonstrate the suction force created by transpiration), Garreau's potometer (to demonstrate unequal transpiration from both the surfaces of a dorsiventral leaf), etc.

  Let us understand the working of a Ganong's potometer.



- Take a small twig of a plant, cut it and fix in the apparatus. Fill the apparatus with water. Introduce an air bubble in the horizontally graduated capillary tube which is dipped into a beaker containing water.

- As the twig looses water, a suction force is set up which pulls the water from the beaker and the bubble moves along. The readings on the capillary tube gives the volume of water lost in the given time by transpiration. The air bubble can be brought back to its original position by releasing some water from the reservoir by opening the stop cork.

Limitations of using potometer:

- Introducing the air bubble is not an easy task.
- The twig can die after sometime.
- Changes in outside temperature can affect the position of air bubble in the capillary tube.