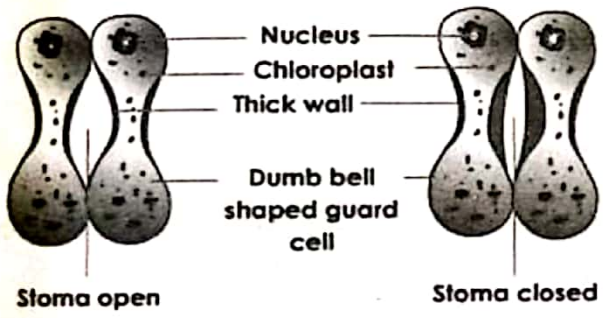
## Mechanism of opening and closing of stomata

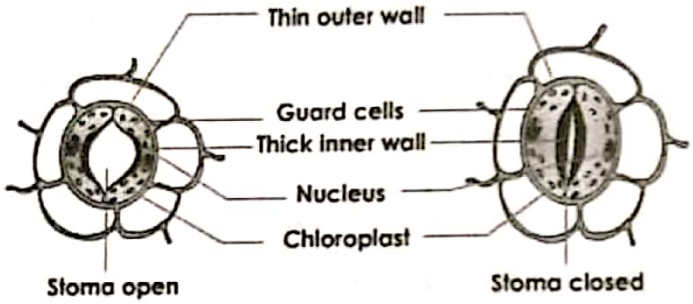
The small pores in epidermis of leaves are called stomata. Stomata are derivative of epidermal cells.

**In dicots:** Stomata are bean/ kidney shaped in dicots. Dicot leaves are bifacial i.e. upper surface dark green and lower surface is light green.

**In monocots:** Stomata are bidumbel shaped in monocot leaves. Monocot leaves are unifacial.




Monocot stomata




Dicot stomata

**Structure of stomata**

Each stomata is consists of two guard cells. The outer wall of guard cell is thin and elastic. The inner wall of guard cell is thick and inelastic. Each guard cell contain single nucleus and contain chloroplast. Starch is synthesized in guard cell. Those epidermal cells which surround the guard cells are called subsidiary cells.

**Stomatal apparatus:** The stomatal pore, guard cells and subsidiary cells collectively called stomatal apparatus.

Stomata play role in gaseous exchange and transpiration. About 90% transpiration occur through stomata.

**There are two theories regarding opening and closing of stomata**

1. Sugar starch theory
2. Potassium (K) ion inflow theory

## 1. Sugar Starch theory

This theory was proposed by a German Botanist, Van Mohl (1854).

**During daytime:**

- Carbon dioxide is absorbed from atmosphere to carryout photosynthesis and produce carbohydrate
- It causes a decrease in $H^+$ concentration.
- As a result pH of guard cells is increased (alkaline). In this condition
- Starch $\xrightarrow[\text{pH=alkaline}]{\text{Phosphorylase}}$ Glucose + Phosphate
- Starch is converted by phosphorylase into glucose and phosphate.
- The glucose gets dissolved in guard cell sap due to which solute potential /osmotic pressure increased.
- Diffusion pressure deficit (DPD) is also increased
- It causes absorption of water from surrounding epidermal cells.
- As a result, guard cells become turgid and swell up. This causes stomata open.

**At night time:**

- At night time photosynthesis stops and respiration continues which results in production of carbon dioxide.
- As a result $CO_2$ get accumulated in sub-stomatal cavity.
- It makes the guard cells acidic (pH=decreased).
- In acidic condition the activity of phosphorylase reversed and convert glucose back to starch.

$$\text{Glucose} \xrightarrow[\text{(pH=Acidic)}]{\text{Phosphorylase}} \text{Starch}$$

- When glucose is converted into starch. Solute/osmotic potential of guard cell sap is also decreased
- DPD is also decreased.
- Thus water move to the surrounding epidermal cells.
- Guard cells become flaccid and stomata are closed.

## 2. Potassium (K) ion inflow theory

This theory was proposed by Imamura of Japanese (1943).

**During day time:**

- Starch in guard cells is converted into phosphorylated hexose sugar.
- The phosphorylated hexose sugar is then converted into phosphoenol pyruvic acid (PEP).
- The PEP combines with $CO_2$ and converted into malic acid.
- Malic acid then dissociates into malate anion and hydrogen ions ($H^+$).

- The $H^+$ ions come out of guard cells and in exchange $K^+$ ions inflow into guard cell occurs.
- Thus increased concentration of $K^+$ ions increase the solute potential inside the guard cells.
- As a result water is absorbed from surrounding epidermal cells into the guard cells.
- Guard cells become turgid and stomata open.



**At night time:**

- $Co_2$ accumulate in sub-stomatal cavity.
- It makes the guard cells acidic thereby affecting the permeability of guard cell membrane i.e. the proton concentration gradient across the guard cell membrane is affected.
- As a result, pH of guard cell sap is decreased i.e. become acidic.
- In acidic medium concentration of Abscissic acid (ABA) is increased.
- ABA inhibits the inflow of $K^+$ ions into the guard cells and out flow of $H^+$ ions.
- $H^+$ ions again combine with malate anion and form malic acid.
- As a result, osmotic potential of guard cells is decreased.
- Water move out of the guard cells into the surrounding epidermal cells.
- Guards cell become flaccid and stomata are closed.