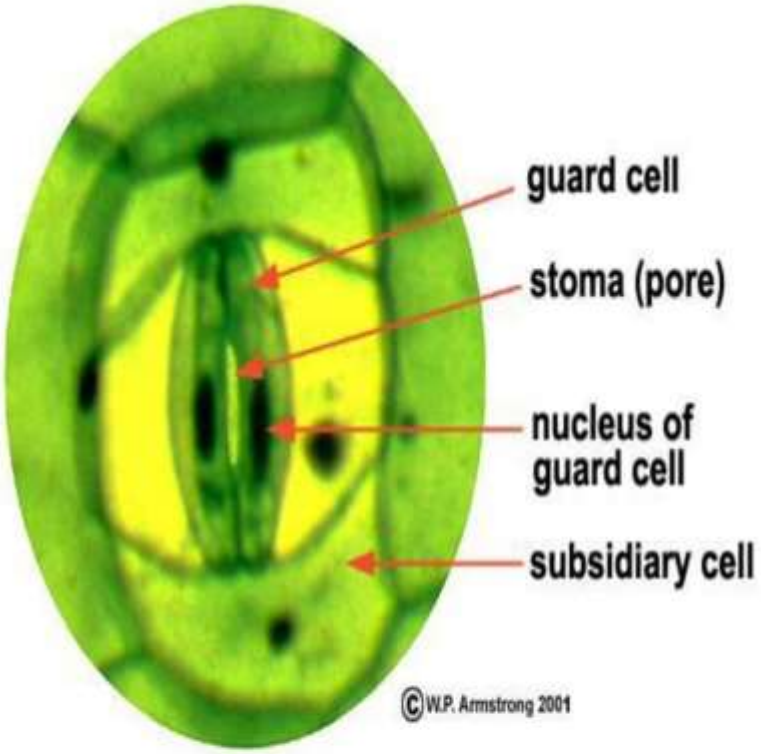
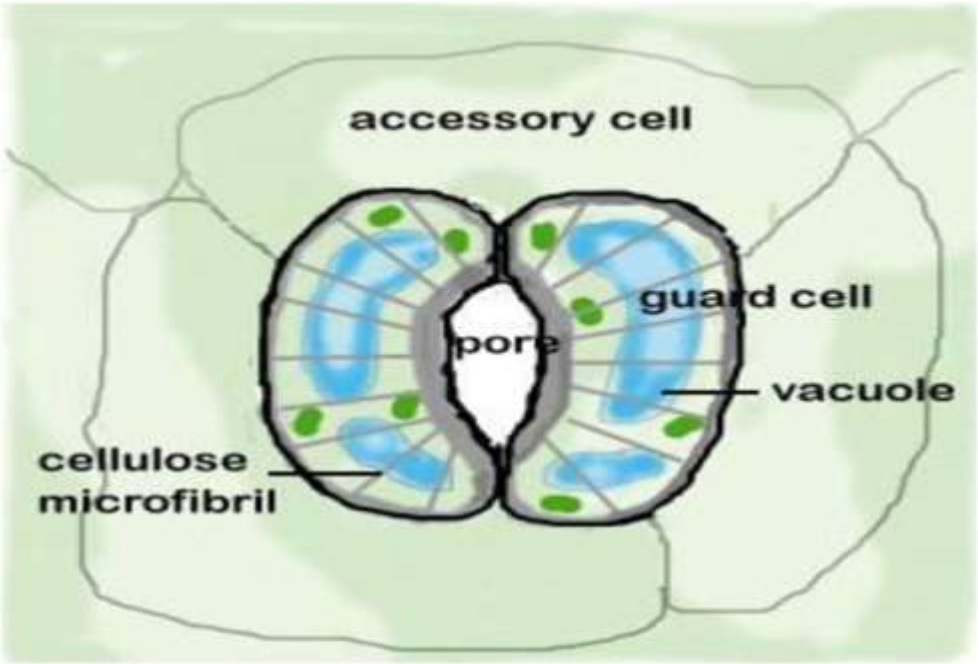
PLANT WATER RELATION

UNIT-1 (Lecture – 5)

STOMATAL MOVEMENT



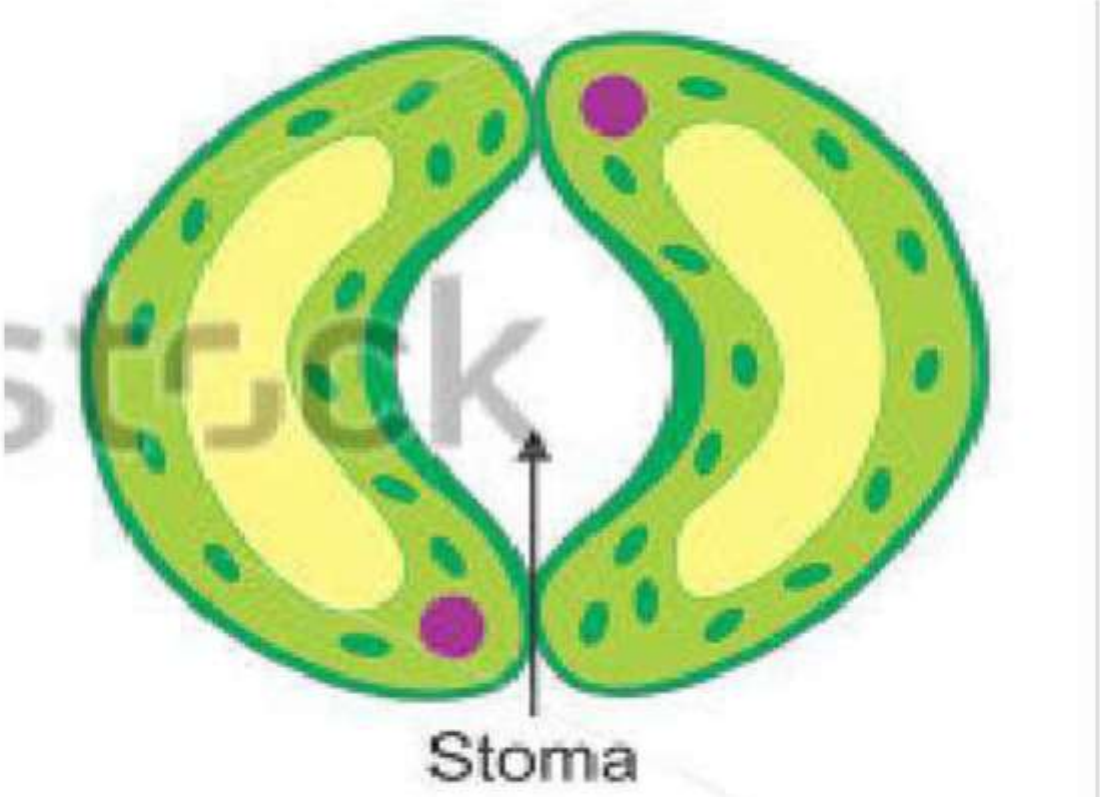


Declaration

The source of Data/Text used in the preparation of power point presentation were Google, E-Books, Books and Journals. It is used for teaching purpose only.

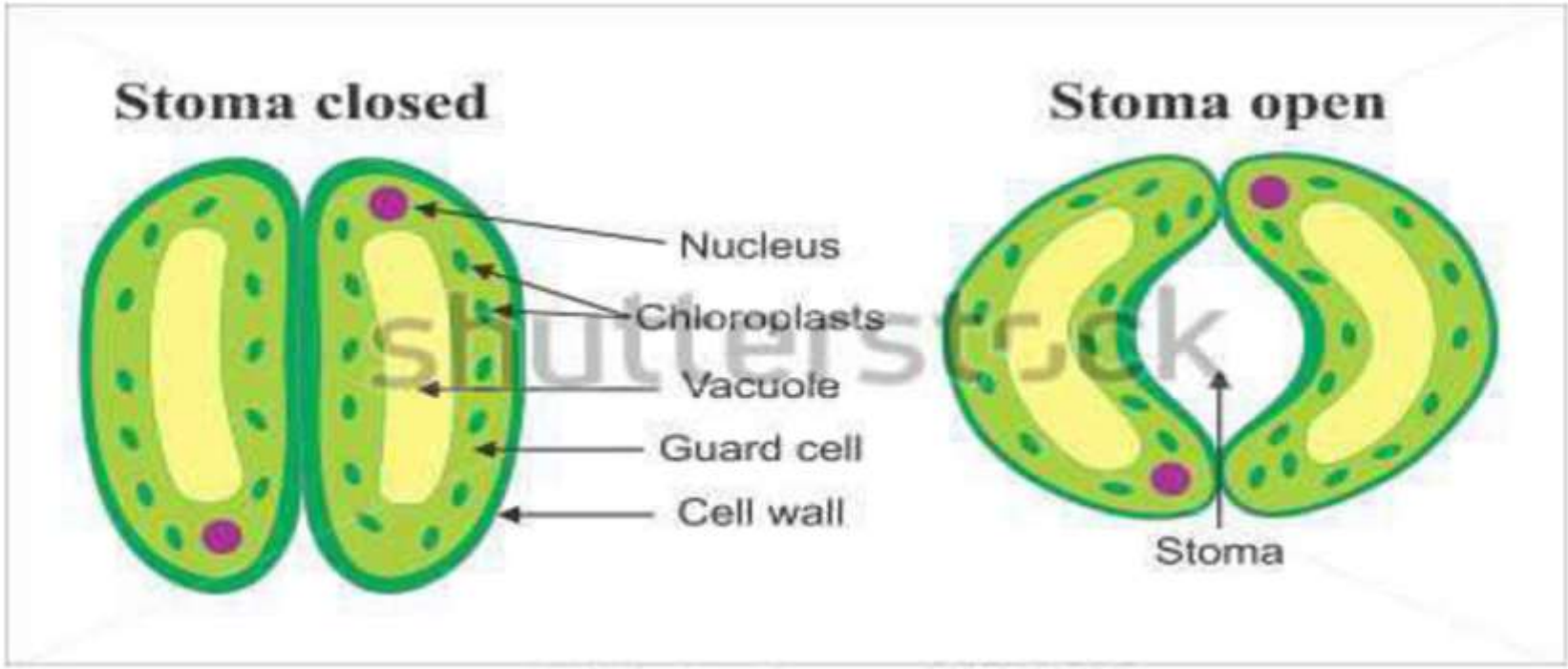
What is Stomata?

- Stomata are pore in leaf epidermis of plants through which water and gases are exchanged between the plant and the atmosphere.



Structure of stomata

- Each stoma in surrounded by a pair of kidney shaped guard cells.
- Each guard cell is a modified epidermal kidney shaped cell showing a prominent nucleus, cytoplasm and plastids.
- The wall of the guard cell is differentially thickened. The inner wall of each guard cell facing the stomata is concave and is thick rigid.
- The guard cells are surrounded by a variable number of epidermal cells called subsidiary cells.



Opening and closing of stomata

- Opening and closing of stomata takes place due to changes in turgor pressure of guard cells.

- During the day water from subsidiary cell enters the guard cell making the guard cells fully turgid and the stomata open.

- During night time, water from guard cells enters the subsidiary cells and as a result the guard cells become flaccid due to decrease in turgor pressure and the stomata close.

Mechanism of stomata opening

❖Many theories have been proposed regarding opening and closing of stomata.

Some important theories are given bellow..

1. Theories of photosynthesis in guard cell.

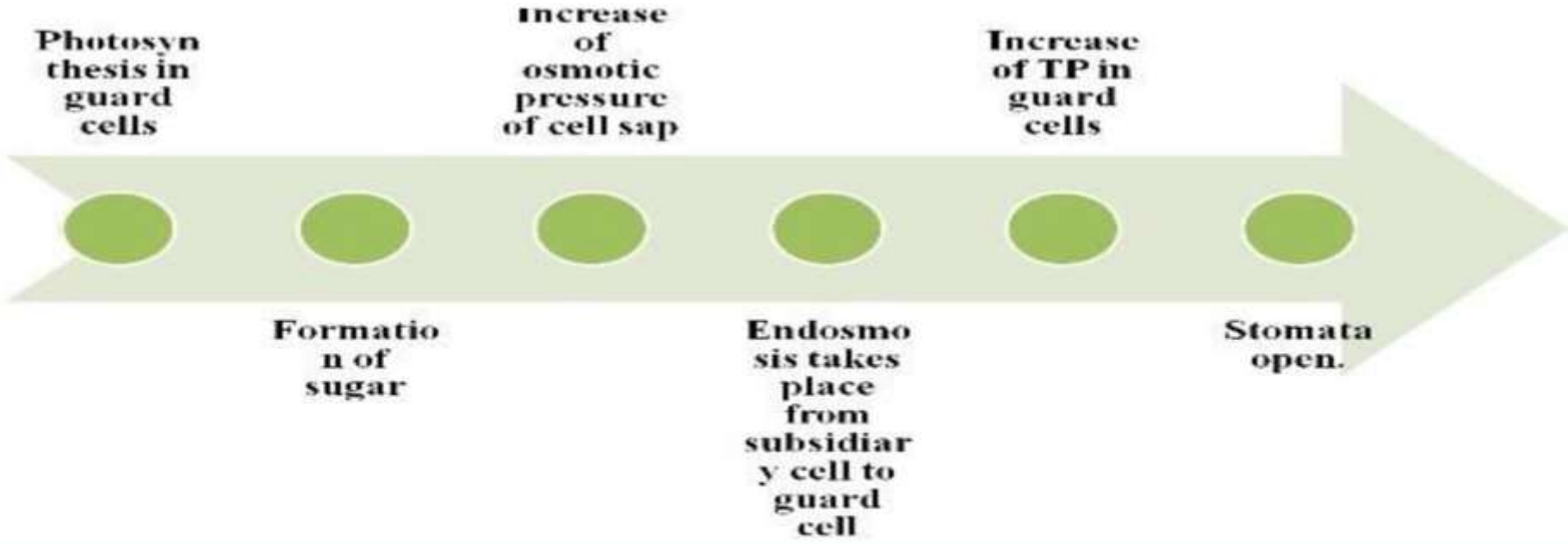
2. Starch sugar inter conversion theory.

3. Theory of glycolate metabolism.

4. Active potassium transport ion concept.

Theory # 1. Theory of Photosynthesis in Guard Cells:

Von Mohl (1856) observe that stomata open in light and close in the night. He then proposed that chloroplasts present in the guard cells photosynthesize in the presence of light resulting in the production of carbohydrate due to which osmotic pressure of guard cells increases.



In Light:

Photosynthesis (1) →Decreased CO_2 Concentration in leaf cells (2) →Increase in pH of guard cells(3) → Hydrolysis of starch to sugar by enzymes (4) → Increase of O.P. of guard cells(5) → Endosmosis of water in guard cells (6) →Increase in T.R of guard cells (7) →Aperture opens (Fig. 4.6)

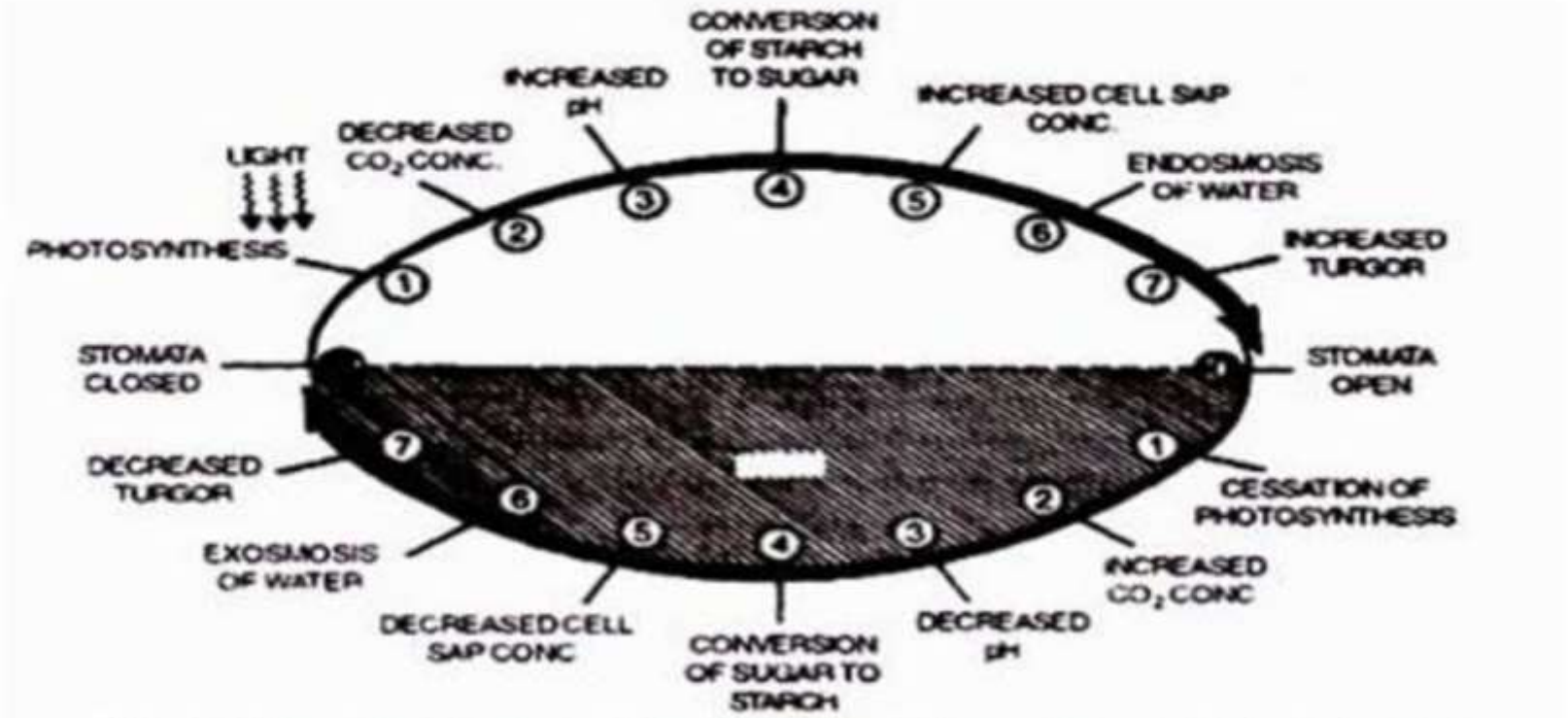
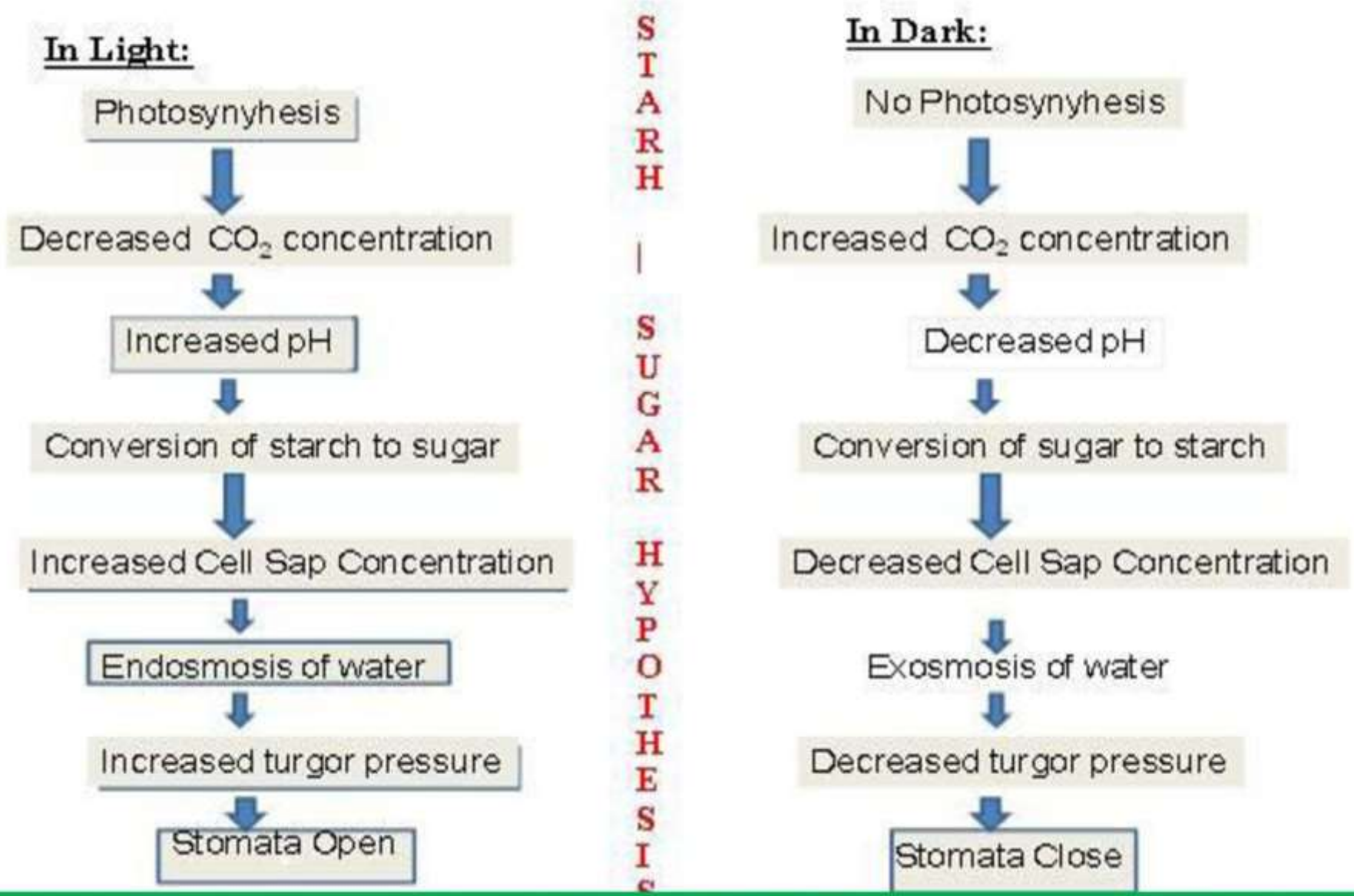


Fig. 4.6 Summary diagram of the mechanism of opening and closing of stomata as explained by starch-sugar interconversion theory.

Sayre's Starch sugar inter conversion theory.



Stewards Starch Glucose conversion

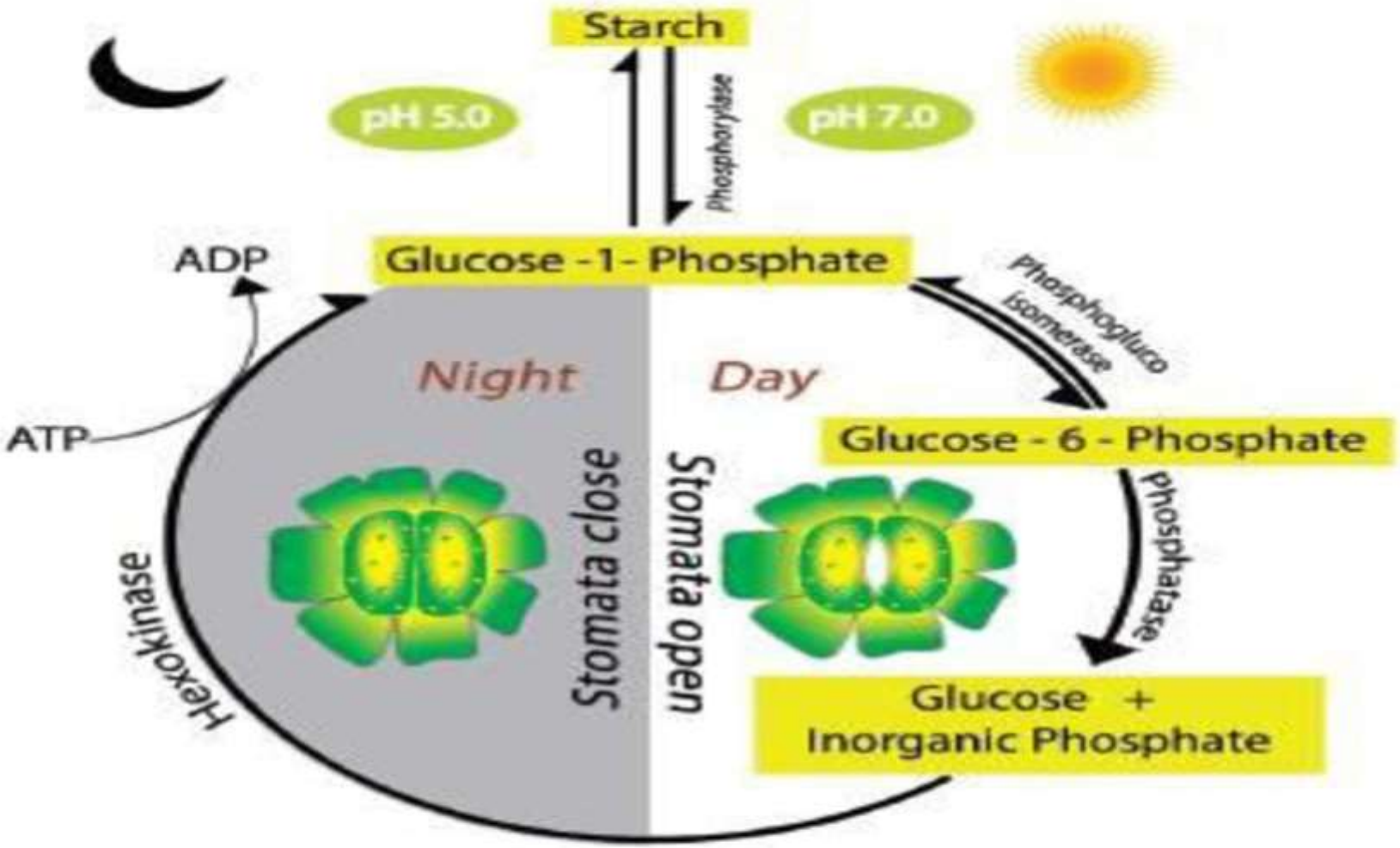


Figure 11.15: Steward Scheme

Theory # 3. Theory of Glycolate Metabolism:

Zelitch (1963) proposed that production of glycolic acid in the guard cells is an important factor in stomatal opening

Under low concentration of CO_2 Glycolate is produced

Glycolate gives rise to carbohydrate, thus raising the osmotic pressure and also that it could participate in the production of ATP

Which might **provide energy required** for the opening of stomata.

Active potassium transport ion concept.

The concept of K^+ ion transport was given by **Fujino**. It was supported and elaborated by **Levitt & Rashke in 1975** It appears to be an active mechanism which needs ATP. It is based on recent observations and (explains the mechanism as follows.

In the guard cells, starch is converted into malic acid in presence of light (during day time).

Protons (H^+) thus formed are used by the guard cells for the uptake of K+ ions (in exchange for the protons H^+). This is an active ionic exchange and requires ATP energy and cytokinin (a plant hormone). In this way, the concentration of K^+ ions increases in guard cells. At the same time, the concentration of H+ ions decreases in guard cells. The pH of the cell sap in guard cells also increases simultaneously (pH becomes more than 7 and the medium becomes alkaline).

There is also an increased uptake of CI" (anions) by the guard cells to maintain the electrical and ionic balance inside and outside the guard cells. The malate anions formed in the guard cells are neutralized by the K+ ions. This results in the formation of potassium malate.

Malate anions + K^+ →Potassium malate:

Potassium malate enters the cell sap of the guard cells thereby reducing the water potential while increasing the osmotic concentration (and the O.P.) of the cell sap. Hence, endosmosis occurs, guard cells become turgid and kidney-shaped and the stomata opens.

It is also observed that the CO_2 concentration is low in and around guard ceils during day time. This is due to high photosynthetic utilization of CO_2. It helps in opening of stomata.

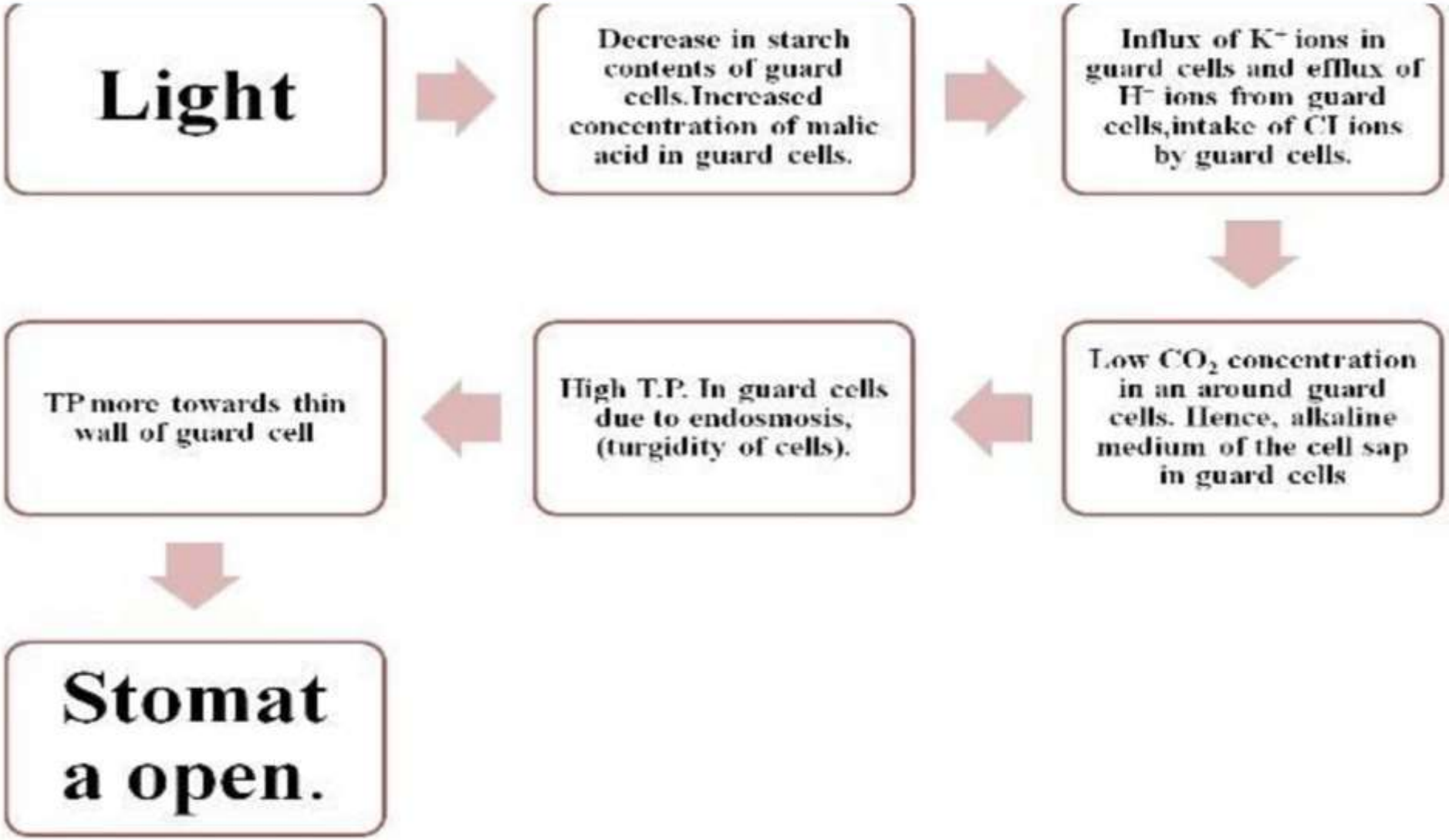
Role of hormones in Stomatal movements Cytokinin/ABA

Presence of Cytokinin (Plant growth regulator) is needed for the active uptake of K^+ ions

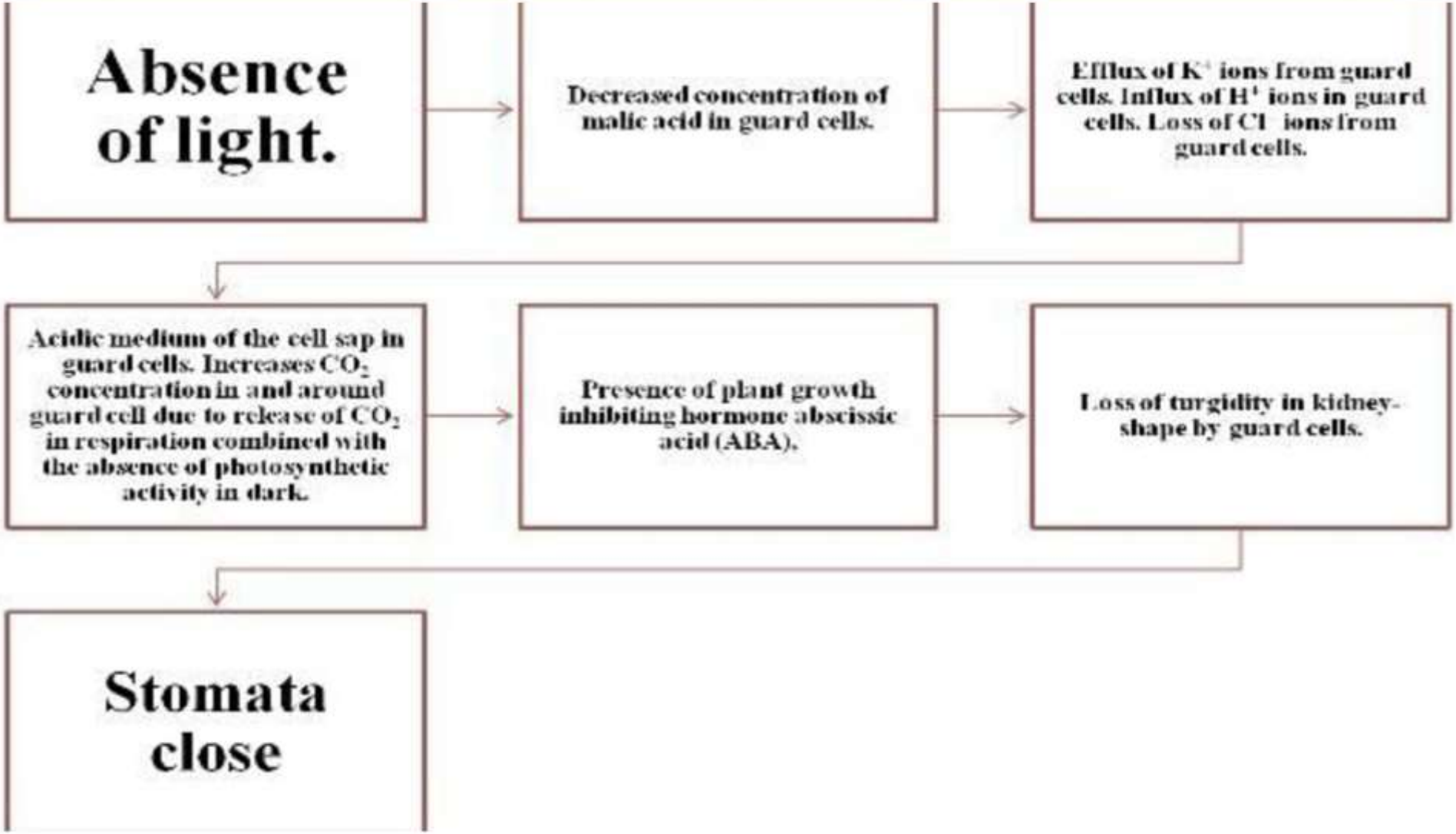
ABA :

Presence of ABA (abscissic acid, a plant growth inhibiting hormone) favours closing of stomata by blocking uptake of K^+ by guard cells in the dark. It also prevents efflux of H^+ ions from guard cells. ABA and CO2 cone, together help in lowering the pH in guard cells and making the medium acidic. This helps in closing of stomata. ABA act as stress hormone during drought condition.

Active potassium transport ion concept.



Active potassium transport ion concept.



Active potassium transport ion concept

During day (light)

CO_2 concentration decreases

↓

Malic acid formed in guard cells

↓

Dissociates into malate ions and H^+

↓

K^+ are taken into guard cells and H^+ are transported out of guard cells (ion exchange)

↓

O.P. of guard cells increased (due to entry of K^+ and malate ions)

↓

Endosmosis into guard cells

↓

Guard cells become turgid

↓

Stomata open

During day (dark)

CO_2 concentration increases

↓

Due to decreased pH of guard cells, ABA released to stop the K^+ exchange

↓

Malate ions present in guard cell cytoplasm combine with H^+ to form malic acid.

↓

K^+ ions transported back into subsidiary cells resulting in decreased osmotic concentration of guard cells

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Exosmosis from guard cells

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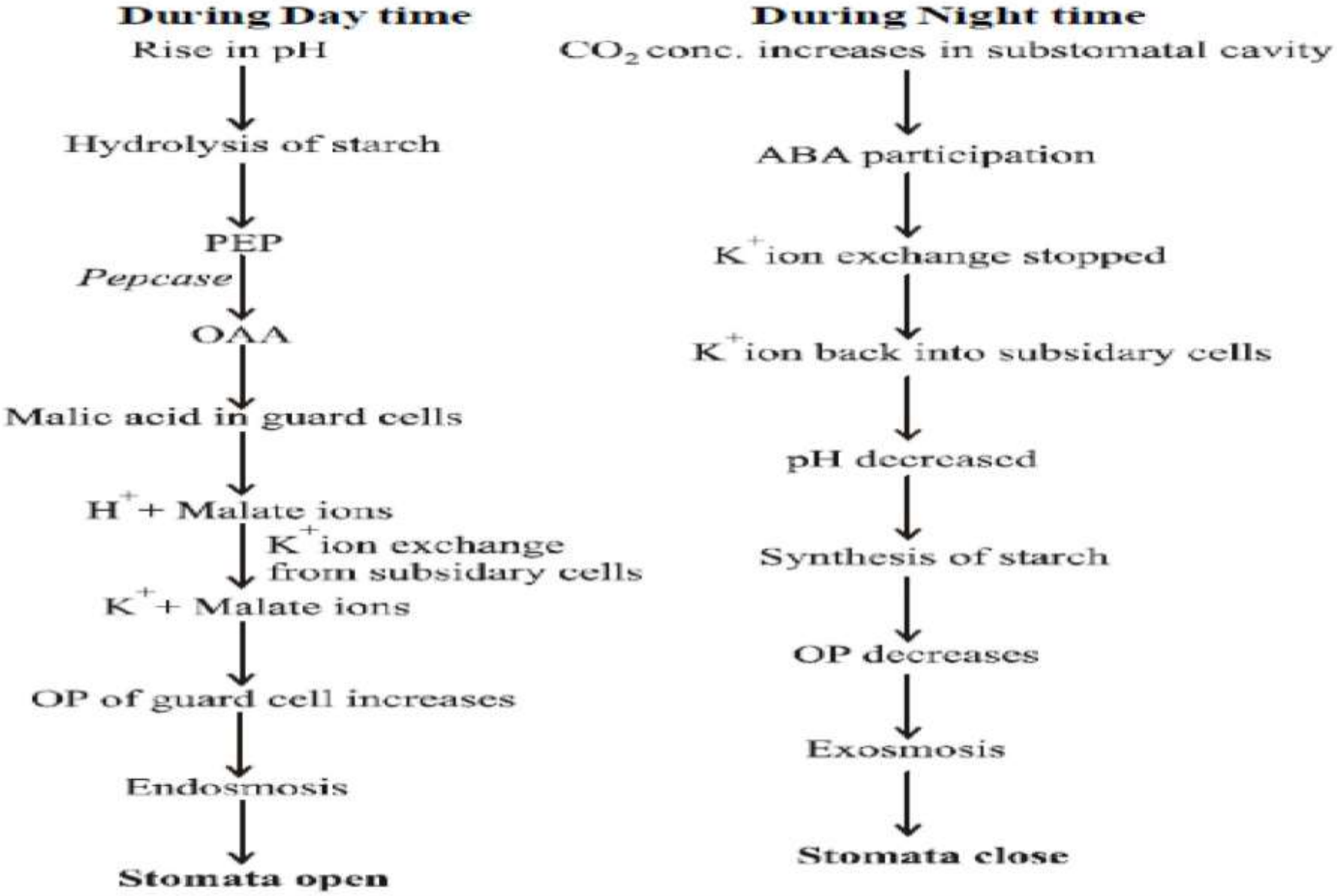
Guard cells become flaccid

↓

Stomata close

Active potassium transport ion concept



Factors affecting stomatal movement

1. Light:

light greatly influences the opening and closing of stomata. It is stimulates production of malic acid due to conversion of starch to sugar. Stomata so not open in U-V light and green light but remain opened in the blue and red regions of the spectrum.

2. Temperature :

Stomata open with rise in temperature and close at lower temperature as light and temperature are directly are directly related. Higher temperature also case stomatal closure.

Factors affecting stomatal movement

3.Potassium chloride:

Accumulation of potassium chloride causes opening of stomata

4.Organic Acid:

The increase of organic acid content in the guard cells causes stomata to open.

5.Carbondioxide concentration:

At low concentration of CO_2, the stomata open. with increase in the concentration of CO_2 ,the stomata begin to close and when CO_2 concentration of cells is higher than its concentration in the air, the stomata completely close.

Factors affecting stomatal movement

6.water:

Water is responsible for causing changes in the turgor off the guard cells. Guard cells become flaccid on losing water and stomata close. when the guard cells become fully turgid on water and stomata open.

7. Abscisic:

Abscisic acid accumulates in the leaves when the plants experience water stress or water deficit. It has been observed that ABA stimulates closure of stomata under these condition.

Thanks for Attentation