

Mechanism of stomatal movement

Q. → Illustrate the mechanism of opening and closing of stomata giving proper illustration?

Ans. → Introduction → Transpiration is a process which acts for energy dispersal it is considered that the chief function of transpiration is the dispersal of excess energy which the plant receives from the sun. There is general conception that about 80-90% transpiration occurs through minute pores in the epidermis called as stomata. The opening & closing of stomata is controlled by guard cells. The stomata vary slightly in their structure but greatly in their distribution which depend primarily on habits & habitat of plants. These minute pores become like valves.

Definition → The stomata are defined as minute pores of elliptical shape having valve acting as check site for transpiration & gaseous exchange.

Structure of stomata → The stomata are surrounded by two

specialized guard cells which are generally kidney shaped. But dumbbell shaped members of Gramineae Cyperaceae. The guard cells having supplied with dense & granular cytoplasm. The inner wall of guard cells is thicker than outer ones. They are surrounded by two subsidiary cells which is turn appear covered by several epidermal cells. The size of stomatal pore depend upon the turgidity of the guard cells.

Mechanism of stomatal movement : →

Detailed

Stomatal studies have clearly indicated that the opening & closing of stomata depends upon the changes in the turgidity of their cells. But how this change in turgidity in guard cells is brought about has remain a question of great controversies. Many theories have been proposed to explain it some important theories of stomatal movement are the following →

(1) Photo Synthetic production in guard cells →

Von Mohl (1856) observed that stomata open in light & close in the night (dark). He suggested that the photosynthetic products formed during the day time increase in the osmotic pressure of guard cells, which finally more are the turgidity to open the pore. It can be depicted as follows.

* Light → Photosynthesis in guard cells.
 formation of sugar → increase in osmotic pressure of guard cells → Endosmosis → Turgidity of guard cells → stomata open.

* Objections → (a) Slow production of Carbohydrate in guard cells can not increase the turgidity of the same fastly.

(b) Starch has been also observed in guard cells of leaves kept in dark.

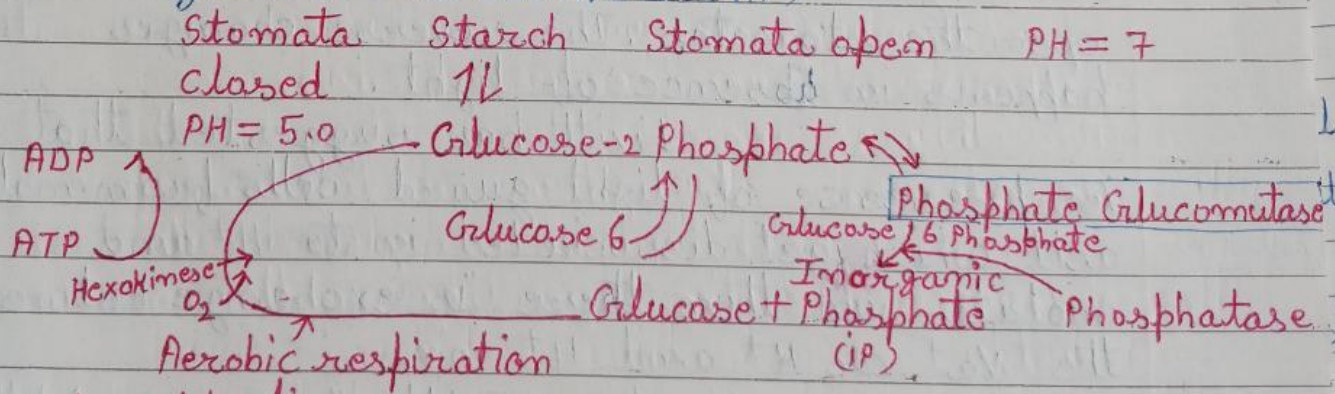
(c) Starch has been also reported in albino leaves.

(2) Starch Sugar hypothesis → It was proposed ^{workers like} by Lloyd (1908) & them supported by Lottifield (1921) Sayre (1926) Young & Tun (1948) Steward others. The hypothesis is based on following features.

- (i) Presence of sugar in guard cells during day time.
- (ii) Presence of starch in guard cells during night.
- (iii) High PH of guard cells during day time.
- (iv) Low PH of guard cells during night.
- (v) Presence of starch phosphorylase in guard cells which catalyses inter-conversion of starch & sugar.

The presence of sugar during day time increases osmotic pressure of guard cells resulting in the final result comes out as opening of stomata. The reverse reaction occurs in absence of light or during night.

Steward (1964) has supported the above view but with certain modification. He has proposed the follow scheme about the opening & closing of stomata. (Starch glucose interconversion.)



* objection →

- (i) These only show inter conversion of starch into sugar & vice-versa.
- (ii) Guard cells of onion, garlic etc lock.
- (iii) Starch.

Stomata can open independently CO₂ concentration such as by light and Temperature.

(iv) Generally closure of stomata at mid day takes place without any changes in the starches content.

(v) Blue light has been found more effective in opening the stomata.

(3) Protons transport hypothesis →

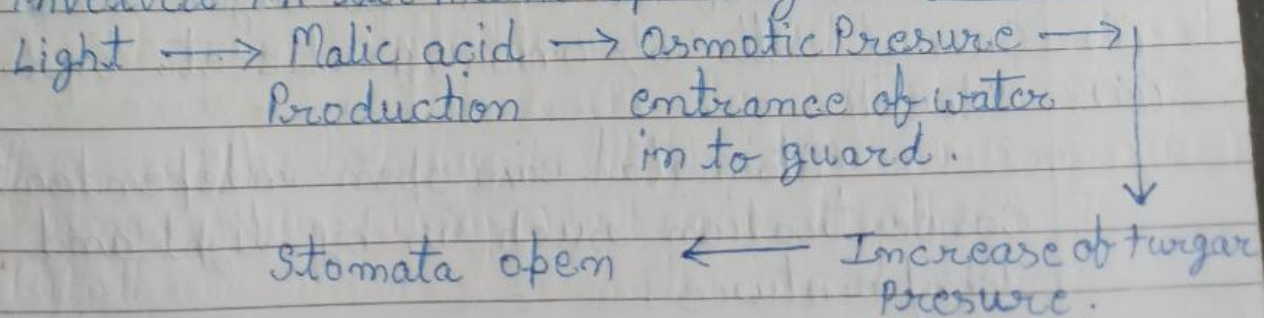
It was suggested by Levitt (1974) and then supported by a number of important workers like Fujima (1975) Raschke (1976) Bhatia & Mallick (1977) Ramaraja (1977) Noggle and Fritly (1979-80) and many others.

A/c to this view the subsidiary and epidermal cells of plants contain either Na^+ or K^+ ions acting as osmoticum. These ions migrate into the guard cells in presence of light to increase their osmotic pressure.

This is followed by endosmosis in the guard cells which becomes turgid to open the stomata. The reverse changes happens in absence of light.

Levitt has suggested that in presence of light guard cells form malic acid which get dissociated into H^+ and malates ion. Then there is exchange between the Na^+ or K^+ and H^+ ions.

Noggle & Fritly (1974-1980) has summarised the sequence of events involved in stomatal opening or closure.

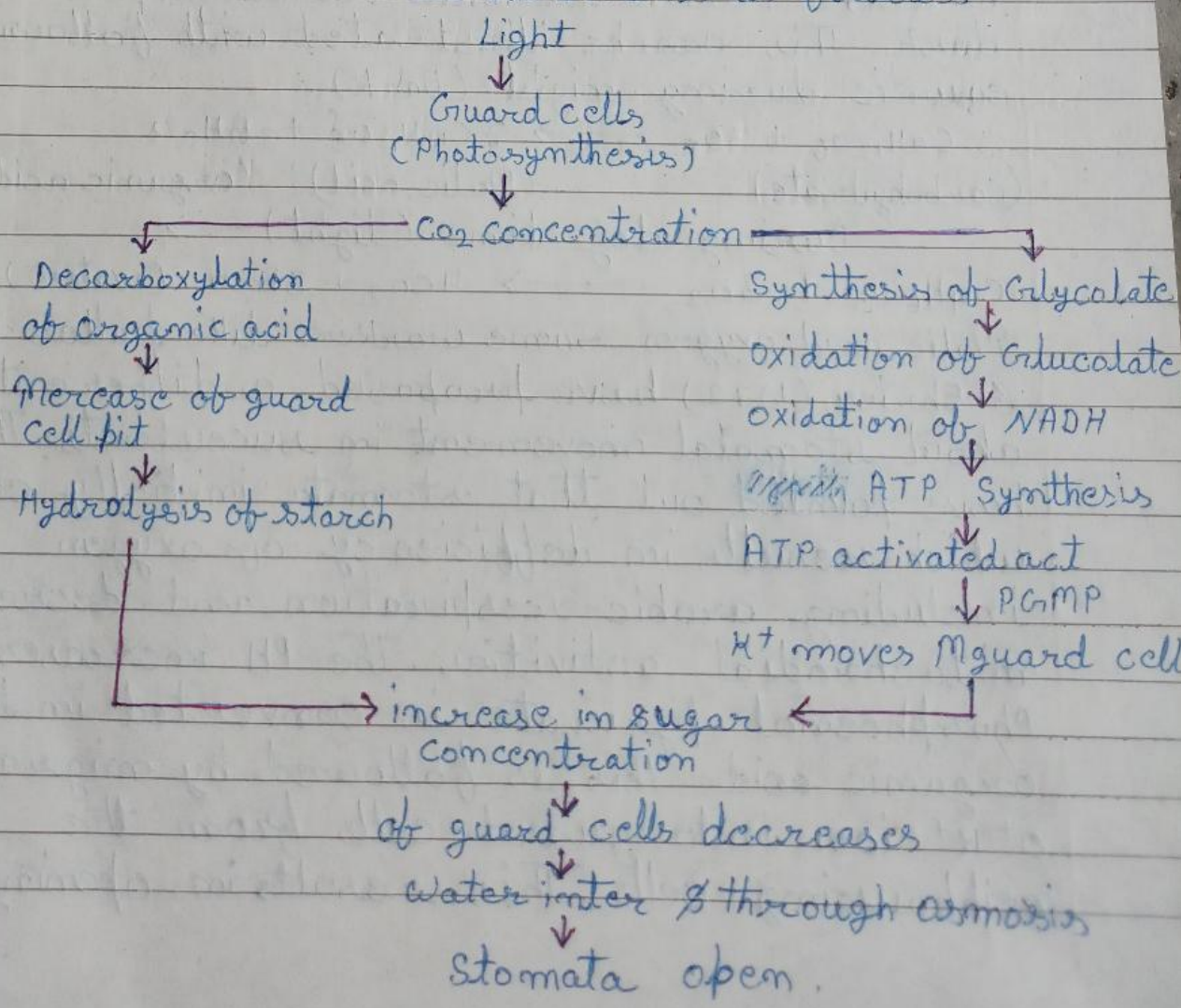


Objection: →

- (i) There are ^{Kind of biological clock is maintained in the guard cells} this hypothesis fails to explain it.
- (ii) Moisture around a leaf affect stomatal movement. It is not clearly understood.
- (iii) Absisic closes stomata. The mechanism is not clearly known.
- (iv) Workers have observed that the stomata of upper a surface of a leaf behave differently when exposed to some intensity of light 'O₂' CO₂ concentration.

Multisystem control hypothesis: →

Some recent workers have proposed that stomatal movement is studied through a number of factors jointly. These include light CO₂ concentration PH value. Moisture others. The scheme is as follows.



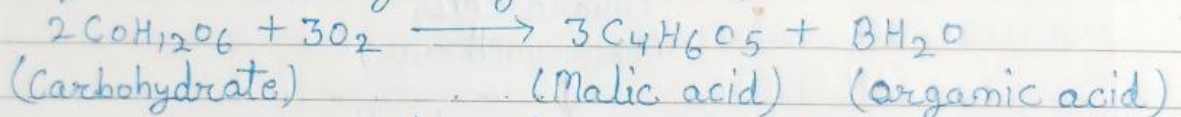
Objection : →

- (i) It is very difficult to suppose that several factors can act jointly open the stomatal apparatus.
- (ii) It fails to explain the use of metabolic energy.

(5) Stomatal opening in succulent plants : →

In succulent stomata open in the night and remain closed during the day time. This type of opening of stomata at night is called succulent type.

Wishida (1963) has explained stomatal movement in succulent on the basis of incomplete oxidation of carbohydrate & accumulation of organic acid. This results in accumulation of CO_2 in the guard cells in night and as a result stomata remain open in dark. This can be illustrated with following equation during night (Dark).



During day time (light) →



Malic acid oxygen. Some workers like Pallas (1969) & Ehrler (1972) have proposed a different view about stomatal movement in succulents. They have pointed out that stomata initially close which results in deficiency of oxygen including aerobic respiration and decreasing mitochondrial activities. The pH increases and Phosphoenol pyruvate is converted into organic acid. This is followed by migration of K^+ ion into guard cells from the neighbouring cells. This results in opening