

Stomata

Stomata are tiny openings or pores in plant tissue that allow for gas exchange. Stomata are typically found in plant leaves but can also be found in some stems. The continuity of the epidermis of aerial organs is interrupted by the presence of stomata, through which exchange of gases takes place between the internal tissues and the outer atmosphere. The pore is bordered by a pair of specialized parenchyma cells known as guard cells that are responsible for regulating the size of the stomatal opening. Often other epidermal cells adjacent to the stoma undergo modifications. They differ from other epidermal cells and become associated with the stoma functionally. These are referred to as subsidiary or accessory cells. Though gaseous interchange actually occurs through the pore, called stomatal aperture or opening, the term stoma includes the whole thing, the pore, guard cells and subsidiary cells, when present.

In surface view the guard cells look crescent or kidney-shaped in appearance, being attached to each other at the margin of the concave side with the aperture lying in between them. They may be easily distinguished from ordinary epidermal cells, because they possess dense cytoplasm, prominent nuclei, chloroplasts, and even starch grains. A cavity is present just beneath the stoma, what is called sub-stomatal chamber or cavity. It is in communication with the intercellular space system of the internal tissues. The walls of the guard cells are unevenly thickened, the wall along the aperture being strongly built and that away from the aperture being thin and extensible. The guard cells have cutinised outer walls with a layer of cuticle which extends through the aperture and joins the inner wall. Due to strong cutinisation often ledges of wall materials are noticed on the upper and lower sides of the ventral wall, so that in sectional view they appear like horns or beaks. The ledges project above and below and overarch the two chambers, referred to as the front cavity and back cavity, which communicate with each other through the pore.

Types of Stomata:

In dicotyledons following four main types of stomata are found:

1. Anomocytic or Type A (Ranunculaceous or irregular-celled type)

- i. No subsidiary cells are present.

- ii. Stoma remains surrounded by several irregularly arranged ordinary epidermal cells.
- iii. This type is also called Ranunculaceous type or irregular-celled type. These types of stomata are found commonly in several dicotyledons, including *Tridax*, *Citrullus*, *Ranunulus*, etc.

2. Anisocytic or Type B (Cruciferous or unequal-celled type):

- i. Stoma remains surrounded by three subsidiary cells.
- ii. Of the three subsidiary cells, one is distinctly- smaller than the other two.
- iii. This type of stomata is also called unequal- celled type or Cruciferous type. These types of stomata are seen commonly in genera such as *Brassica*, *Sedum* etc.

3. Paracytic or Type C (Rubiaceous or parallel-celled type):

- i. One or more subsidiary cells are present.
- ii. Subsidiary cells flank the stoma parallel with the long axis of the guard cells.
- iii. This type of stomata are also called parallel- ceiled type or Rubiaceous type. This type is commonly seen in members of Rubiaceae, and genera such as *Vigna*, etc.

4. Diacytic or Type D (Caryophyllaceous or cross-walled type):

- i. Stoma remains surrounded by a pair of subsidiary cells.
- ii. Common walls of subsidiary cells remain at right angles to the long axis of the guard cells.
- iii. This type is also called cross-celled type or Caryophyllaceous type. These types of stomata are commonly seen in *Ocimum*, Caryophyllaceae (e.g., *Diantbus*), etc.

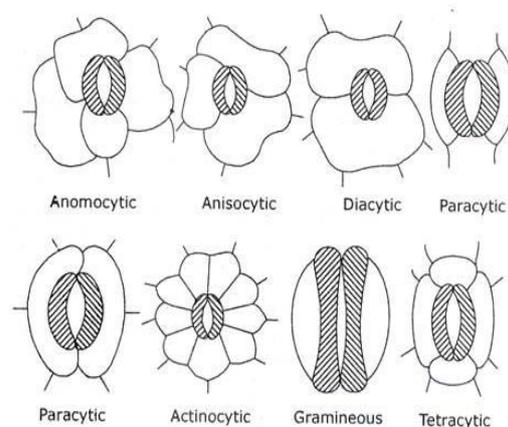


Figure 12.9

5. Actinocytic:

- i. Actinocytic stoma remains surrounded by a circle of radiating cells.

Ex. *Ancistrocladus* and *Euclea pseudebenus* (Ebenaceae).

- ii. Van Cotthem described actinocytic stoma where at least five subsidiary cells surround a stoma (actinocytic = star-celled).
- iii. Stace described the subsidiary cells of actinocytic stoma as somewhat 'radially elongated' cells.

6. Gramineous:

- i. Gramineous stoma possesses two guard cells that are shaped like dumb-bells. Each guard cell has a narrow middle portion and two bulbous ends.
- ii. The narrow middle portion is strongly thickened. The subsidiary cells occur parallel to the long axis of pore.
- iii. Ex. Gramineae and Cyperaceae.

Metcalf and Chalk in the Introduction of their book illustrated anomocytic, anisocytic, paracytic and diacytic as Type A, Type B, Type C and Type D respectively. They thought that more terms would be necessary and so added another term —actinocytic.

The terms Ranunculaceous, Cruciferous, Rubiaceous and Labiatous or Caryophyllaceous stoma were coined by Vesque in 1889. Later studies revealed that these types are not confined to respective families only. Therefore Metcalfe and Chalk proposed new terms respectively anomocytic, anisocytic, paracytic and diacytic instead of Ranunculaceous, Cruciferous, Rubiaceous and Labiatous or Caryophyllaceous.

Tetracytic stoma characterizes numerous monocotyledonous families. It is also reported from dicotyledons, e.g. *Tilia* and some members of *Asclepiadaceae*. The seven types of stoma (five from dicotyledons and two from monocotyledons) according to Metcalfe and Chalk and Metcalfe are shown in Fig. 12.9.

(Diagrammatic representation of different types of stoma in dicotyledons and monocotyledons. Guard cells are hatched. The other are subsidiary cells/epidermal cells)

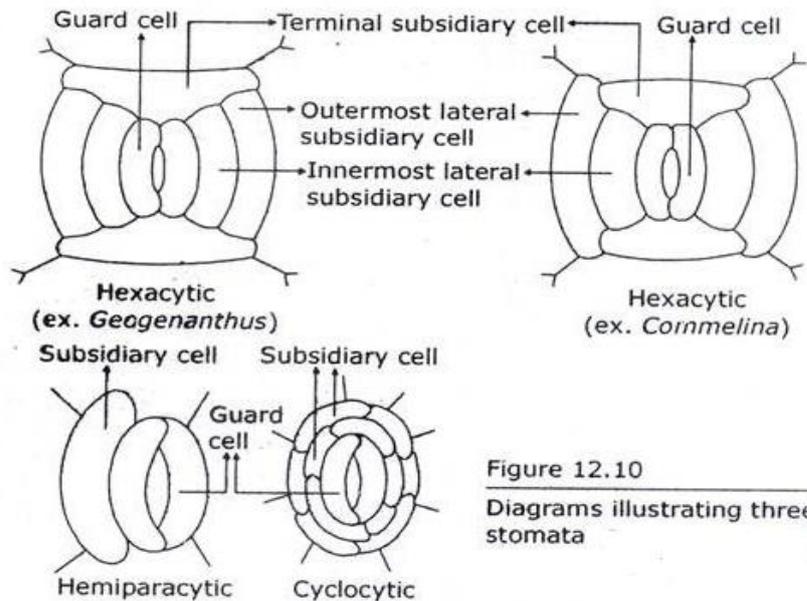


Figure 12.10
Diagrams illustrating three stomata

7. Hemiparacytic:

The stoma is accompanied by a single subsidiary cell, which is placed parallel to the long axis of the pore and this cell may be long or short in length in contrast to the guard cells. Example: *Glinus latiodides* and *Trianthema lancastrum* etc.

8. Hexacytic:

The stoma is surrounded by six subsidiary cells among which two are situated on the two polar sides and rest two pairs occur on the two lateral sides being parallel to the long axis of the guard cells.

The size of subsidiary cells may be of two different types:

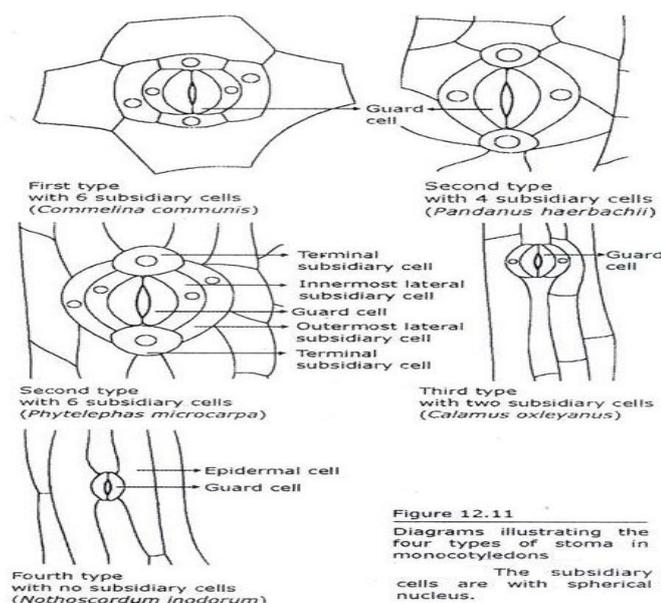
- (a) The two polar cells may be as broad as the stomatal complex (e.g. *Geogenanthus*), and
- (b) The length of the outer most lateral subsidiary cells may as long as stomatal complex (e.g. *Commelina*).

Stace (1965) illustrated the cyclocytic (Fig. 12.10) stoma in dicotyledons. The stoma is surrounded by four or more subsidiary cells, which form one or two narrow rings around the guard cells.

Example:

Lumnitzera, *Laguncularia* etc.

Stebbins and Khush (1961) recognized four categories of stomatal complex in monocotyledons. The basis of classification is the presence or absence of subsidiary cells and when present the number, shape and arrangement in relation to guard cells form the basis. Stebbins and Khush did not propose any terminology to aid their concepts and distinguished them as First type, Second type, Third type and Fourth type which are as follows (Fig. 12.11):



First type:

The two reniform guard cells of stoma remain surrounded by subsidiary cells that are 4-6 in number. In *Rhoeo*, *Tradescantia* and *Zebrina* of Commelinaceae there are four subsidiary cells. Each subsidiary cell occurs on each of the four sides of paired guard cells. As a result the stomatal complex has square appearance in surface view.

Commelina of the same family has six subsidiary cells. The additional subsidiary cells occur on the lateral sides of stoma, each being present on each of the two lateral sides. In contrast to *Zebrina*, *Commelina* has four subsidiary cells on lateral sides, two being present on each of the two lateral sides of paired guard cells.

Second type:

The two reniform guard cells of stoma remain surrounded by subsidiary cells that are 4-6 in number. Two subsidiary cells are smaller and roundish than the rest. The roundish cells are present at the ends of paired guard cells —each being present on each end. In *Pandanus*

haerbachii (Pandaceae) there are four subsidiary cells among which two are smaller and roundish than the other two.

The roundish cells occur at the ends and other two elongated subsidiary cells are present on the lateral sides of the paired guard cells. In *Phytelephas microcarpa* there are well defined six subsidiary cells.

The roundish cells are situated at the ends of paired guard cells, each being on each end. The rest occurs on lateral sides, two being on each side. Such type of stomatal complex with four subsidiary cells occurs in Calycanthaceae.

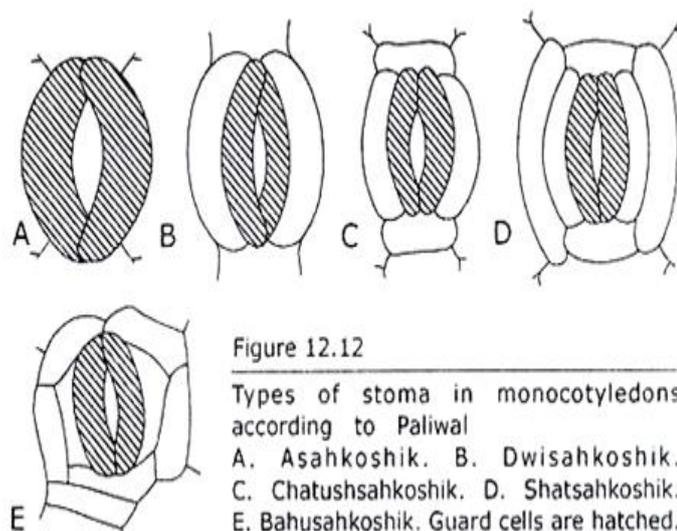
Third type:

The two guard cells of stoma remain surrounded by two subsidiary cells each being present on each lateral side of guard cells. This is the most common and predominant type of stomatal complex and spreads over 24 monocot families so far investigated. Ex Juncales, Graminales, Cyperales, Typhales etc.

Fourth type:

The two guard cells of a stoma are without any subsidiary cells. A stoma appears to be embedded in the epidermal cells. Ex. Amaryllidales, Iridales, Orchidales etc.

Paliwal (1969) distinguished morphologically five main types of stoma in monocotyledons (Fig. 12.12) on the basis of number and arrangement of subsidiary cells and suggested special terminology for them. The terms were derived from the word 'sahkoshik' which in the language of Sanskrit means subsidiary cells.



The stomatal complexes are as follows:

1. Asahkoshik (Sans: 'A'= without + Sahkoshik):

There are no subsidiary cells in this type of stoma and the stomatal complex consists of two guard cells only. Ex. Members of Liliaceae, Orchidaceae etc.

2. Dwisahkoshik (Sans: 'Dwi' = two + Sahkoshik):

In this type of stoma there are two subsidiary cells each of which is situated laterally on either side of the pair of guard cells. Ex. Cyperaceae, Palmae etc.

3. Chatushsahkoshik (Sans: 'Chatus' = four + Sahkoshik):

In this type of stoma there are four subsidiary cells, which are arranged in two different ways:

(a) A pair of subsidiary cell is placed laterally on two sides of the guard cells. Ex. Members of Zingiberaceae and

(b) Each of the four subsidiary cells is situated on the four sides of guard cells, i.e. two polar and two laterals. Ex. Rhoec.

4. Shatsahkoshik (Sans: 'Shat' = six + Sahkoshik):

In this type of stoma there are six subsidiary cells of which two are placed on the two polar sides and a pair on two lateral sides of the guard cells. Ex. Members of Commelinaceae, Palmae, Musaceae etc.

5. Bahusahkoshik (Sans: 'Bahu' = many + Sahkoshik):

In this type of stoma there are more than six subsidiary cells, which are either arranged irregularly or form a ring around the guard cells. Ex. Agavaceae, Araceae etc.

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