Course: Botany Honours (CBCS); Semester: II

CORE COURSE-3: PLANT ANATOMY (BOT-A-CC-2-3-TH)

6. Mechanical tissues

Syllabus: Mechanical tissues and the Principles governing their distribution in plants

Construction and Distribution of Mechanical Cells in Plants

The principle regarding the construction of mechanical tissue is to obtain maximum mechanical rigidity and elasticity with minimum expenditure of materials. This principle is observed in roots, stems, fruit stalks, branches etc., but the arrangement of mechanical cells varies greatly in them.

The organs of plants are subjected to different strains and stresses and accordingly the mechanical cells are developed to resist them. The resistances are designated as Inflexibility (resistance to lateral bending), Inextensibility (resistance to stretching), Incompressibility (resistance to compression) and Shearing stress (resistance to shearing action).

The mechanical cells are developed accordingly, and the principle of construction and distribution of them are discussed below:

Inflexibility:

The terrestrial plants with arboreal habit are mechanically rigid due to formation of heartwood at the centre. The herbs are the sufferers and so they form the mechanical cells to resist the forces. The aerial organs like stem, stilt root, branches etc. are the inflexible organs as they are subjected to lateral bending strain due to application of lateral forces like high wind.

The distribution of mechanical cells in inflexible organs was compared with the railway line or girder, which is used in the construction of bridges, buildings etc. by Schwendener. The girder or railway line consists of two horizontal plates, upper and lower, which are connected by a vertical plate.

In cross sectional view it resembles the English alphabet capital T or two capital 'T's joined by vertical strands and so these are called I—girder. The horizontal plates and the connecting vertical plate are termed as flanges and web respectively (Fig. 13.4K). If a load is hanged at the middle of I-girder, it is subjected to bending strain.

The upper flange tends to be compressed and the lower flange is subjected to extension (Fig. 13.4C). It is the two flanges that suffer the strains and the resistance to these strains depends

Made by: Dr. Joy Sarkar

on the flanges only. At the middle of the web, neither the compression nor the extension strain is operative. This line is termed as null-line as it is neutral regarding the strains.

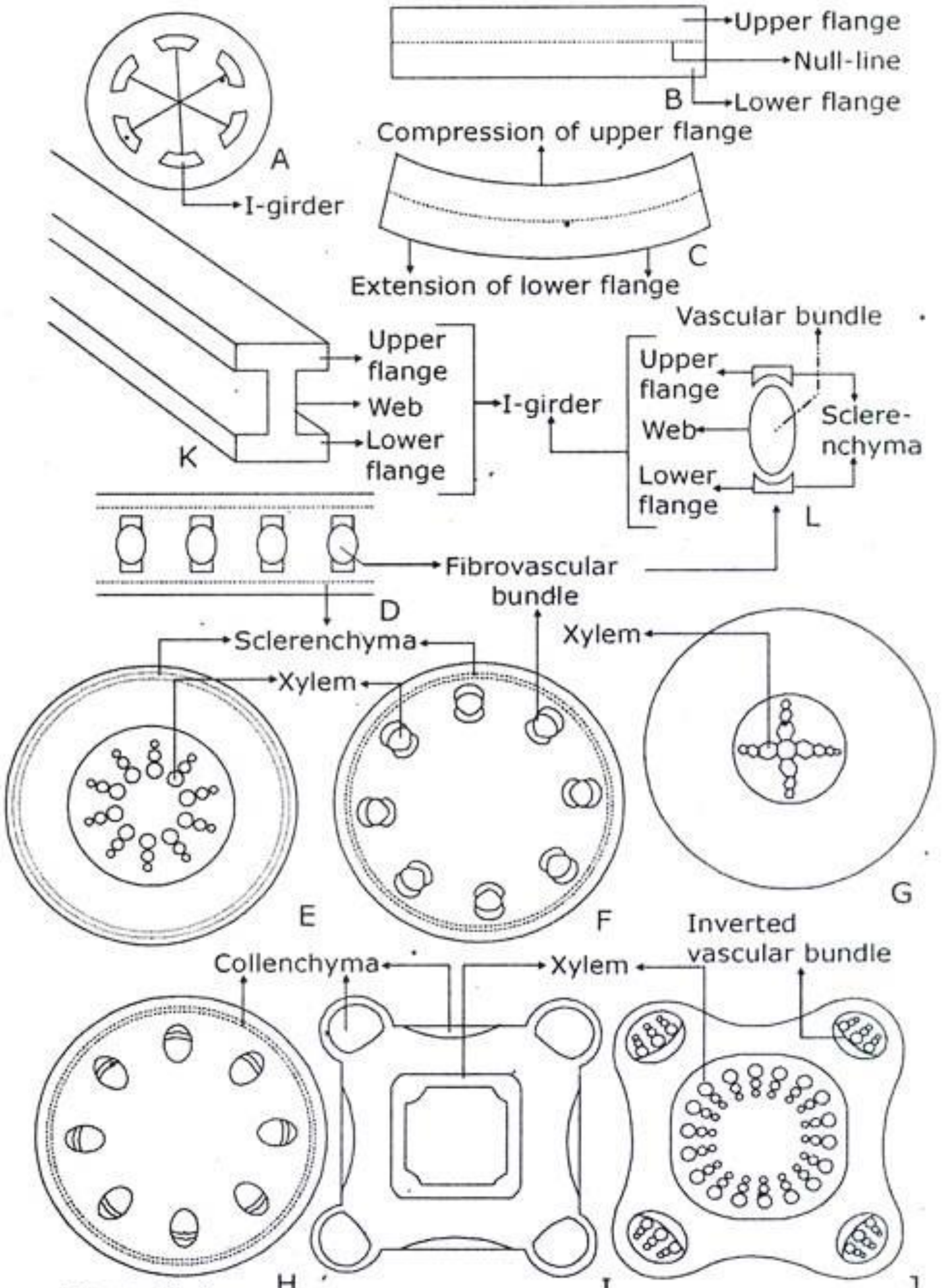

Figure 13.4

A. Composite I-girder formation. B. I-girder before bending. C. I-girder after bending. D. Distribution of mechanical cells and fibrovascular bundle in a leaf (diagrammatic). Diagrammatic representation showing the distribution of mechanical tissues in stilt root of maize (E), stem of *Cyperus* (F), dicot root (G), stem of *Helianthus* (H), stem of *Leonurus* (I) and stem of *Nyctanthes* (J). K. A portion of girder or railway line. L. A fibrovascular bundle.

A single I-girder can resist the lateral force from a single direction only. Forces may operate from any directions. To resist these forces several I-girders are constructed perpendicular to long axis in a circular manner. The flanges are arranged in such a way that the middle of the web or null-line intercepts a common point forming a composite I-girder that can resist forces from all directions (Fig. 13.4A).

This simple I-girder formation is observed in plants and they operate either singly or in suitable combination of parallel or circular arrangements. The simple I-girder construction is observed in fibrovascular bundles (Fig. 13.4L). In these bundles bands of sclerenchyma are present above and below the vascular strand.

These bands represent the upper and lower flanges and the vascular strand represents the web. The fibrovascular bundles are present in monocot leaves, e.g. *Cyperns*, where they are arranged in parallel. In monocot stem, the vascular bundles are completely encircled by sclerenchyma termed bundle sheath.

Schwendener is of opinion that the same I-girder principle is applicable to cylinders also. When a cylinder is subjected to lateral bending strain, the side of the cylinder present towards the direction of force is extended and the side opposite to force is compressed. So the peripheral sides of a cylinder are mechanically rigid and they form the flanges and the web may be made up of some weak materials; in extreme case the centre region of a cylinder may be hollow.

In the cylindrical organs like stems etc. the mechanical cells are present at the periphery. So in the hypodermis, collenchyma and sclerenchyma cells are found in dicot and monocot stems respectively. They are present either continuously or as isolated patches. They form the flanges of composite I-girder. In some members of Compositae sclerenchymatous bundle caps are present.

In *Zea mays* stem sclerenchymatous bundle sheath is present and the stele is atactostele. In rectangular or square stems (e.g. *Leonurus, Leucas* etc.) the mechanical cells (collenchyma) are present at the four corners (Fig. 13.4I). They form the flanges and the pith is the web. Thus diagonally opposite I-girders are formed. In *Nyctanthes* (Fig. 13.4J) inverted vascular bundles are present at the four corners that are considered as flanges.

Sclerenchymatous sheet or patches are present at the hypodermis of some monocot leaves and the fibrovascular bundles are arranged in parallel to resist the lateral forces and shearing stress.

Inextensibility:

The rhizomes, roots and the other anchoring organs are sometimes subjected to longitudinal tension. The fruit stalks, the climbers and lianes are to withstand the longitudinal tension, as they are to bear the weight of fruits and their own weight respectively when they hang over the supporting object.

Made by: Dr. Joy Sarkar

Many rooted hydrophytes are longitudinally stretched due to water current. All these inextensible organs develop centralized mechanical cells to withstand longitudinal tension that can be compared with electrical cable. In the cable, mechanical rigidity is obtained from the central axile strand made up of metallic wire.

This principle is observed in roots and other inextensible organs. In roots the stele is small as compared with the entire transverse section and the mechanical tissue like xylem and sclerenchyma are condensed within the stele. The formation of mechanical cells at the centre is also observed in hydrophytes (e.g. *Potamogeton lanceolatus*), in the fruit stalks (e.g. Cucurbita) and in the lianes (e.g. *Dioscorea*) etc.

Incompressibility:

The cylindrical stems are to withstand the longitudinal compression as they are weighted at their upper end by the branches and leaves. If the line of action of the load coincides exactly with the longitudinal axis of the stem, mechanical tissues are condensed at the centre, and it acts like a pillar. But in nature this ideal condition is seldom found where the stem is as straight as a pillar. A slight asymmetry of construction is always present and the mechanical cells are distributed like inflexible organs.

The subterranean and submerged organs of plants are subjected to radial compression, as they remain surrounded by the soil and water respectively. In these organs mechanical cells are present at the peripheral sides to withstand radial compression.

The nodal roots of *Zea mays* and Pandanus exhibit a remarkable combination of incompressibility and inextensibility in the distribution of mechanical cells. The stilt roots occurring on the windward are to withstand longitudinal stretching and those present on the leeward suffer from longitudinal compression.

Thus the same root is sometimes compressed and extended. So, in addition to centralized mechanical cells to withstand longitudinal extension, sclerenchyma is present at the periphery to ensure incompressibility. In Zea mays roots sheet of sclerenchyma is present at the periphery of cortex whereas in Pandanus isolated patches of sclerenchyma are present.

Shearing Stress:

The leaves and similar organs of terrestrial and aquatic plants are to withstand the shearing stress when they lacerate and move violently by the action of wind and water current respectively. Shearing stress is the action of force causing two contacting parts or layers to move apart in opposite direction.

Made by: Dr. Joy Sarkar

Dicot leaves are mechanically rigid, as they possess reticulate venation. In monocot leaves parallel I-girders formed by fibrovascular bundles are present. Moreover, sclerotic strands are present at the hypodermal region and leaf margins. The leaf may be cuticularized to withstand shearing stress (Fig. 13.5).

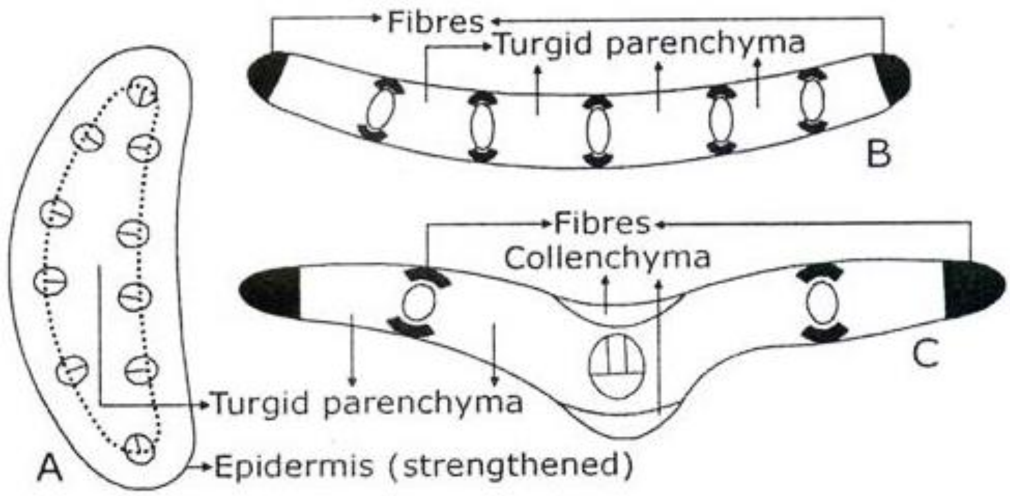

Figure 13.5

Diagrammatic representation of distribution of mechanical cells (fibres, collenchyma and turgid parenchyma) in A. succulent leaf of *Gasteria* (Liliaceae), B. monocotyledonous leaf and C. in a dicotyledonous leaf.

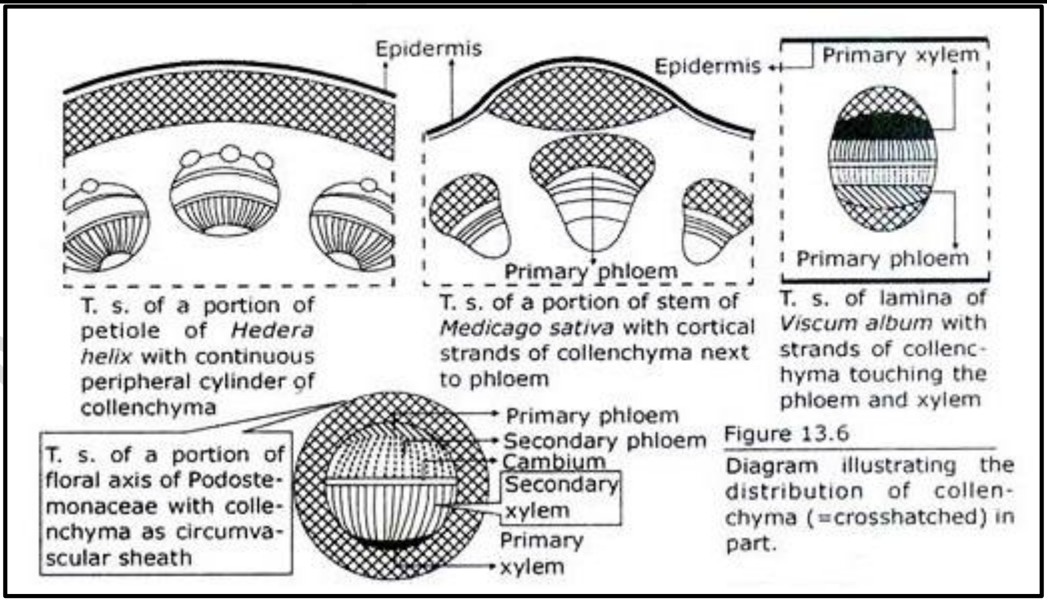

Figure 13.6

Diagram illustrating the distribution of collenchyma (=crosshatched) in part.