Mechanical Tissue System in Plants:

The tissue system that gives mechanical support to the whole plant and their growing organs against different external and internal forces is called mechanical tissue system.It was variously termed as stereome by Haberlandt (1918) and stereids by Schwendener (1874).

Plant organs are subjected to various strains and stresses like bending and shearing stresses, stretching due to presence of large fruits, bending due to natural calamities like storm, heavy snow etc.

The stem has to withstand compression due to heavy weight of the large number of branches and leaves in the canopy. The branches, again have to withstand bending as they are oriented obliquely or horizontally. The fruit stalks bear weight of fruits and the roots are also subjected to extension when the stem bends due to strong wind.

Cell walls of all types of cells provide mechanical strength and rigidity to the plant. The woody plants achieve the structural stability and strength by the cell walls which contribute to 95% of the dry weight of the wood.

The mechanical strength of non-lignified cell walls is due to the orientation of cellulose microfibrils. Lignification in the walls of wood gives further strength. When cellulose is absent other wall polysaccharides may form microfibrils to give strength.

In stem the microfibrils of the thin-walled parenchymatous cells remain oriented transversely on the vertical walls so as to bend without break. In roots the microfibrils shows helical orientation to resist extensions.

Collenchyma and sclerenchyma cells, however, give maximum mechanical strength. Collenchyma walls get thickened at the corners or at the tangential walls due to the deposition of pectin, cellulose, and hemicelluloses.

As the collenchyma cells are living they can regulate the deposition and orientation of wall materials according to the needs of the developing organs. The collenchyma cells are also elastic due to the presence of hydrated pectin on the walls.

Principles Governing the Construction of Mechanical Tissue Systems:

The principle governing the construction and distribution of mechanical tissue system is the economy of material and to ensure maximum efficiency by minimum expenditure of material. (maximum mechanical rigidity and elasticity with minimum expenditure of materials.) This principle is observed in all the plant parts.

Mechanical cells are developed to resist different strains and stresses. 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).**

1. Inflexibility:

Aerial parts of the plants are constantly subjected to bending strains in different planes. When the straight rod is bent, the convex side is elongated and concave side is shortened but the centre is least affected. So the peripheral parts in plants are subjected to the greatest tension which decreases gradually to zero in the centre.

In cylindrical organs (stem), to resist bending in several directions at right angles to the longitudinal axis, many I-girders are so arranged that they have a common neutral axis and their flanges come in contact laterally forming a mechanical cylinder. A typical girder consists of two flanges (horizontal plates) of iron ((sclerenchyma and wood in plants) joined together by a vertical piece (web) which is of vascular tissues or parenchyma in plants.

Girder arrangement is widely found in plants to provide inflexibility to its organs:

In stem of Labiatae, mechanical tissues are deposited at the four angles forming two sub-epidermal girders which are diagonally placed. This is one of the simplest of mechanical constructions found in higher plants.

Typical dicot plants of the family compositae like Helianthus (sunflower) possess mechanical tissues in hypodermis, in the region of pericycle and in association with vascular tissues.

In cucurbita, the hypodermis is partially collenchymatous and there is a sclerenchymatous ring inside (pericycle). In this way a similar combination of systems of I- girders for adequate mechanical strength is provided.

Some members of sedge family Cyperaceae contain patches of mechanical tissues just internal to epidermis and corresponding semi lunar patches of the same on the lower side of the bundle. These two patches constitute the flanges of a girder.

Fig. mechanical tissues in monocots – Cyperus, maize

In a typical monocotyledon like maize sclerenchyma is present in as a band in hypodermal regions and the bundles with sclerenchymatous sheaths (bundle sheath) remain more crowded towards the periphery.

Bilaterally symmetrical organs like the leaves have mechanical tissues arranged in the form of I-girders parallel to one another and at right angles to the surface. In the leaves of many grasses and sedges sub-epidermal I-girders extend from one surface to another, the web being composed of the bundle and parenchyma. In case of long leaves like banana, date etc. the upper surface is subjected to more vigorous tension and so patches of sub-epidermal mechanical tissues occur at the lower surface to prevent tension, and the small I-girders present at the lower surface are meant for withstanding compression, e.g., banana.

2. Inextensibility:
The underground anchoring organs like rhizomes, roots, etc. have to face longitudinal pull or tensions. Resistence to this is provided by the concentration of the resistant elementsinto a single, compact and cylindrical strand. The degree of resistance depends upon the cross sectional areas of the resistant elements. Thus roots have mechanical tissues associated with the vascular elements inside the stele.

The stilt roots of the members of the grass family, e.g., maize faces both flexion and longitudinal pull, so in addition to aggregation to mechanical tissues at the central region, a peripheral band is also present The rhizome also possess centrally located hollow or solid mechanical strand.

(The centrally located mechanical tissues to resist longitudinal tension can be compared with electrical cable. Here rigidity is obtained from the central axial strands made up of metallic wires. This principle is observed in roots as well as in other inextensible organs.)

3. Incompressibility:
The stems encounter longitudinal compression developed by the weight of the canopy. This situation can be compared with a heavy load on the top of a cylindrical axis where the axis is subjected to longitudinal compression. The mechanical tissues are effectively aggregated at the central position which serve as a solid column for withstanding longitudinal compression.

The underground and submerged organs of plants are subjected to radial compression or crushing pressure by the surrounding medium like the soil and water respectively. The aquatic plants have loosely arranged cortical cells which give requisite protection. The roots of grasses in particular develop tubular sheath of cells, often with

suberised walls.

Normally in young dicot and monocot roots special mechanical tissues are not much required. Turgidity of cells, thickening bands (casperian stripes) and sometimes additional thickening of the endodermal walls and lignified xylem are sufficient to give the requisite strength. Monocots sometimes develop sclerenchymatous pith in addition to thick walled endodermis as in orchids. In these roots in addition to centrally aggregated mechanical cells which resist longitudinal extension, sclerenchyma cells are present in the periphery to resist compression. Zea mays roots have peripheral sheet of sclerenchyma in the cortex.

4. Shearing Stress:

The flat organs like leaves are often encountered by violent shearing stresses due to strong wind or water current. Such force acts at right angles to the surface of the leaves causing laceration. Dicot leaves are mechanically more resistant against such stress.

The I-girders present in them are firmly held together by a large number of cross links in the form of vein network (Fig. 5.70C). In monocot leaves parallel I-girders formed by fibrovascular bundles are present (Fig. 5.70B). Sclerotic strands are also present at the hypodermal region and leaf margins and the leaf blades are usually cuticularised to withstand shearing stress.

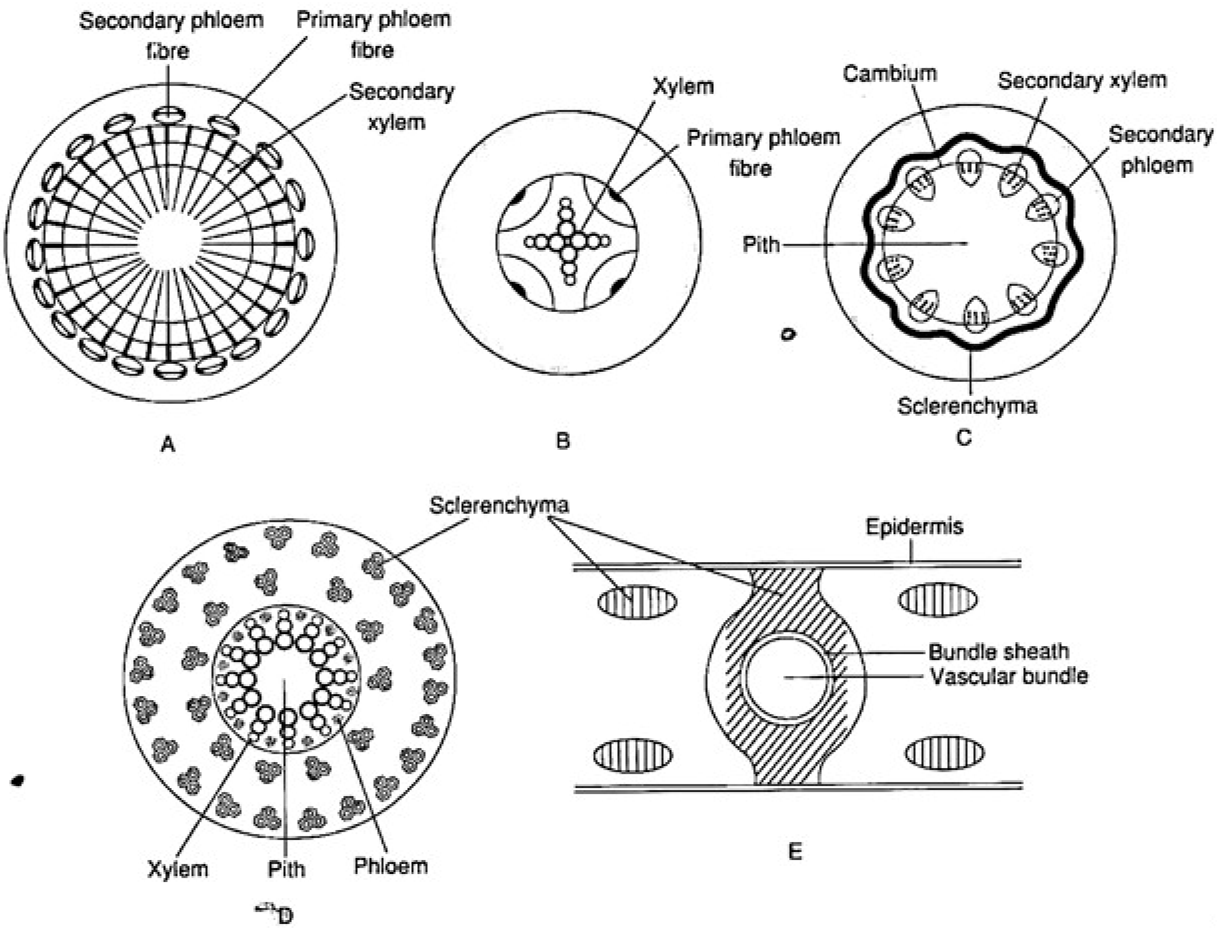

Fig. 5.68 : Diagram showing the distribution of sclerenchyma in T.S. in different plant organs : A. Stem of *Tilia*, B. Sclerenchyma in *Phaseolus* root. C. *Tinospora* stem. D. Scleren-chyma patches in stilt root of *Pandanus*. E. In monocotyledonous leaf

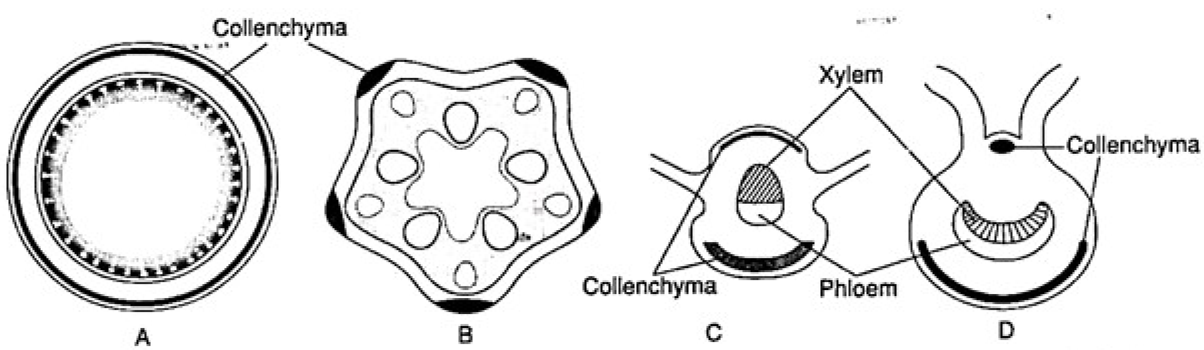

Fig. 5.67 : Diagrammatic representation of the distribution of collenchyma in t.s. of stems and leaves : A. *Sambuscus* stem. B. *Cucurbita* stem. C and D. Mid veins of leaves

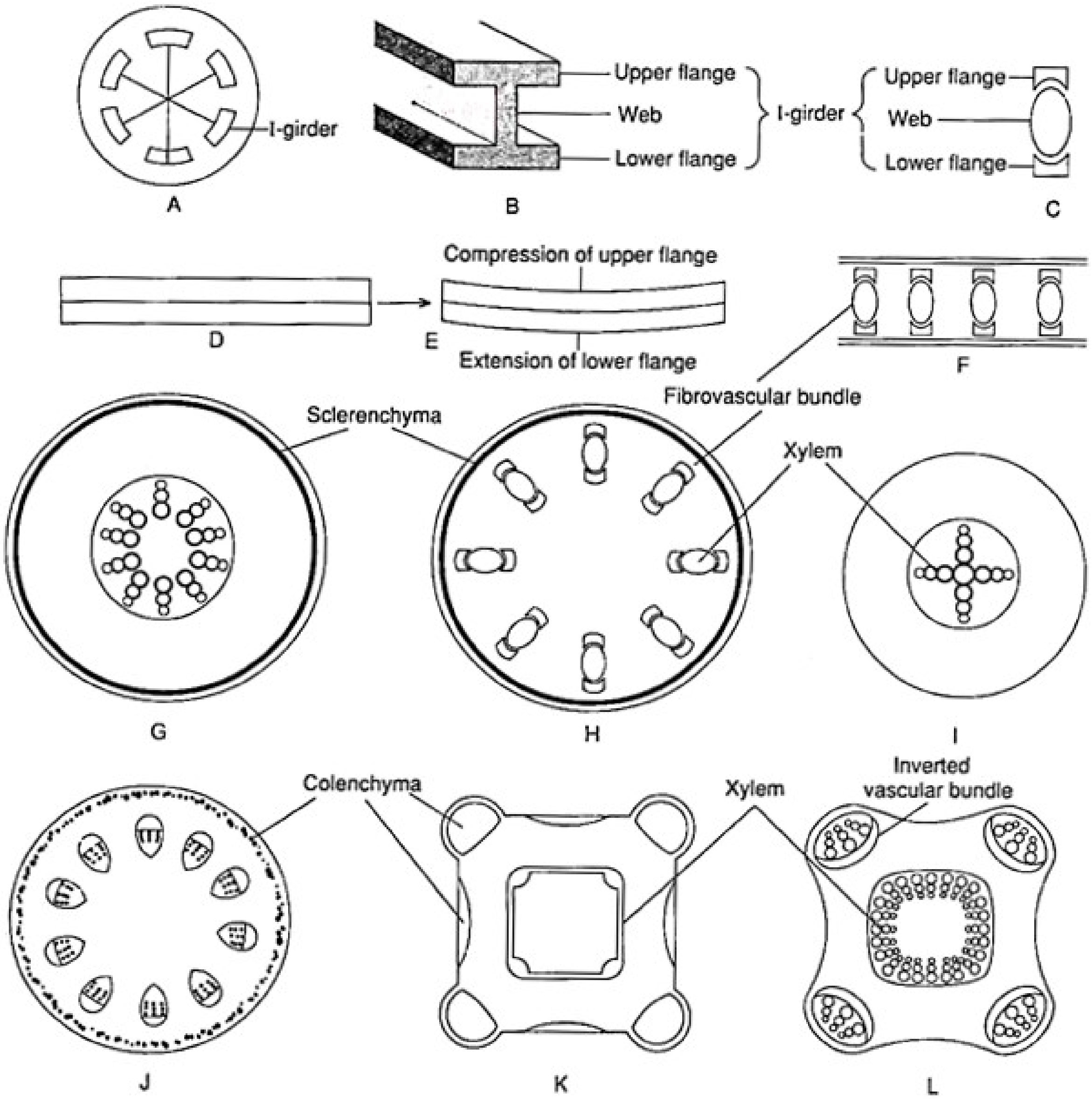

Fig. 5.69 : Principles of composite I-girder formation in different plants : A. A Composite I-girder, B. A portion of I-girder or railway line, C. A fibrovascular bundle compared with I-girder, D & E. I-girders before and after bending respectively, F. Parallel distribution of fibrovascular bundles as mechanical tissues, G. Diagrammatic representation of the mechanical tissues in stilt root of maize, H. Same in the stem of *Cyperus*, I. Mechanical tissue system in dicot root, J. Same in *Helianthus* stem, K. In *Leonurus* stem, L. In *Nyctanthes* stem

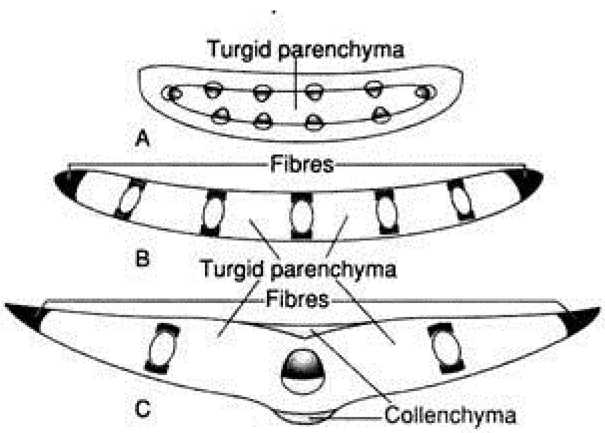

Fig. 5.70 : Diagrammatic representation of the distribution of fibres, collenchyma and turgid parenchyma : A. In succulent leaf of *Gasteria* (Liliaceae) in T.S.. B. In monocotyledonous leaf and C. In a diocot leaf in T.S.