Topic: Principle and Distribution of Mechanical Tissue
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Principle and Distribution of Mechanical Tissue

Those problems which are faced by an engineer while constructing a new building are also faced by plants when they organize them multicellular structure. The engineer has to keep in mind that maximum rigidity has to be achieved by minimum expenditure of material and similar problems are also employed while making the distribution of the mechanical tissue in plants.

A plant has note learn anything from an engineer regarding the solution of its mechanical problems. Its internal composition are so that the taller plants and then the different organs easily encounter one or more types of strains from outside i.e., binding stress, longitudinal compression, radial pressure, longitudinal pull and showing stresses.

The problem of is not to acute in case of small herbaceous plants growing in water because the cell wall and turgidity of cells may be adequate enough to keep there in a proper position. Thus the latter plants in order to guard themselves against various injuries and stresses have definitely developed a mechanical tissue system.

The tissue system that gives mechanical supports to the whole plant and their growing an organ against different external and internal forces is called mechanical tissue system.

It is 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 tend to be extended due to 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 95% of the dry weight of the wood.

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

The mechanical strength is more in the direction parallel to the microfibrils in both types of cell walls. Due to secondary growth several layers of different microfibrillar orientation are developed. Therefore, the cell wall is strong enough to resist forces from any direction.

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, hemicellulose, and protein.

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.

In some plants the branches and stems show special adaptation to resist the gravitational force by the formation of reaction wood. It differs in structure and location from ordinary wood. In conifers, this wood is located at the lower side of branches and stems to resist compression while in dicots it is present on the upper side of the branches to resist tension.

Principles Governing the Construction of Mechanical Tissue Systems

The principle governing the construction of mechanical tissue system is the orientation of the mechanical tissues to obtain the maximum mechanical rigidity and elasticity with minimum expenditure of materials. This principle is observed in roots, stems, fruit stalks, branches etc.

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).

The principles of the construction and distribution of the mechanical tissues to form a system are-

Inflexibility

Both the terrestrial arboreal plants as well as the herbs are encountered by forces to bend laterally. The plants with arborial habit resist such forces by the formation of heart- wood at the centre whereas the herbaceous plants resist through the formation of mechanical cells All the aerial organs are the inflexible organs as they face lateral bending strain due to application of lateral forces like high wind.

For inflexibility of plants the mechanical cells remain distributed in different organs like ‘I’-girders as railway lines, and also that are used in the construction of bridges, buildings etc. The girder consists of two upper and lower horizontal plates again connected by a vertical plate.

In cross-sectional view it resembles the English capital letter T. The horizontal plates are called flanges and the connecting vertical plate is called the web. If a load is applied at the middle of I-girder a bending strain is encountered.

The upper flange tends to be compressed and the lower one tends to be extended. The flanges only suffer and resist the neither strains, the web on the other hand neither subjected to

compression nor extension strains. This vertical line is termed as null-line as it is neutral regarding the strains.

A single I-girder can resist the lateral force in a single plane from both directions only. To resist such lateral forces from different directions several I-girders remain oriented in a circle perpendicular to the long axis. I-girders are arranged in such a way that their null-lines intercept at a common point forming a composite I-girder that can resist lateral forces from all directions.

This simple I-girder formation is the characteristic of many plants and thus they resist bending forces either singly or in suitable combinations. This I-girder formation is found in fibrovascular bundles where bands of sclerenchyma are present above and below the actual vascular strand.

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

In the cylindrical stems and other organs the mechanical cells remain at the periphery. In the hypodermis, collenchyma and sclerenchyma cells are found in dicot and monocot stems respectively. They are present either continuously or as isolated patches forming the flanges of composite I-girder.

In some members of Compositae sclerenchymatous bundle caps are present. In case of rectangular or square stems (Leonurus, Leucas etc.) the mechanical collenchyma cells are present at the four corners to form the flanges and the pith acts as the web.

Thus, diagonally opposite I-girders are formed. In Nyctanthes inverted vascular bundles are present at the four corners to act as flanges. In Zea mays stem sclerenchymatous bundle sheath is present and the stele is atactostele.

Inextensibility

The underground anchoring organs like rhizomes, roots, etc. have to face longitudinal tensions. The fruit stalks, the climbers and lianes also have 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.

Many rooted hydrophytes have to be longitudinally stretched due to water current. The mechanical tissues in the centre of the hydrophyte -stems (Potamogeton lanceolatus), in the fruit stalks (Cucurbita) and in the lianes (Dioscorea) help to resist longitudinal stretching.

The centrally located mechanical tissues to resist longitudinal tension can be compared with electrical cable v. here rigidity is obtained from the central axile strands made up of metallic wires. This principle is observed in roots as well as in other inextensible organs. In roots the stele is small in comparison to the other external tissues and xylem and sclerenchyma are condensed within the stele.

Incompressibility

The stems are encountered by the 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 metallic rods remain condensed at the centre of the axis like the effective aggregation of the mechanical tissues at the centre of the stems.

The subterranean and submerged organs of plants are encountered by radial compression or crushing pressure by the surrounding medium like the soil and water, respectively. Mechanical cells in these organs remain at the periphery to resist such radial compression.

The stilt roots of Zea mays and Pandanus the mechanical cells are distributed as such so that they can resist both compression and extension forces. The stilt roots on the wind blowing side have to withstand longitudinal extension and those present on the opposite side have to resist longitudinal compression. Thus the same root is periodically compressed and extended.

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 whereas Pandanus has developed isolated patches of sclerenchyma in the periphery of the cortex.

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-ties in the form of vein network. In monocot leaves parallel I-girders formed by fibro vascular bundles are present. Sclerotic strands are also present at the hypodermal region and leaf margins and the leaf blades are usually cuticularised to withstand shearing stress.

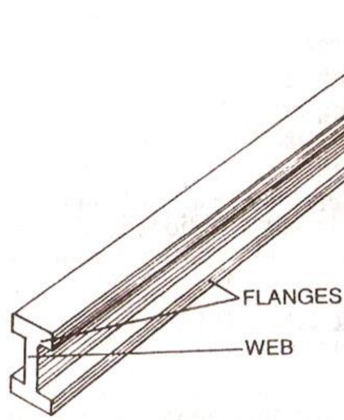

Fig. The mechanical tissue – Girder – The wide portions at the top and bottoms are the flanges; the narrow connection is the web.

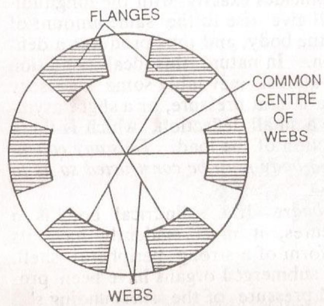

Fig. The mechanical tissue—Diagram of cross-section of a compound girder composed of I—beams the webs of which have a common centre.

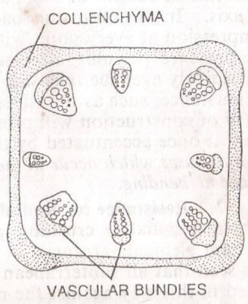

Fig. The mechanical tissue—collenchyma. Diagram showing arrangement of vascular bundle and collenchyma in a four-cornered stem.

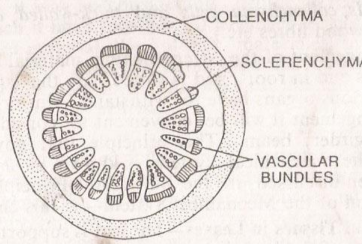

Fig. The mechanical tissue—collenchyma and sclerenchyma. Diagram of dicot stem showing sclerenchyma just outside of each bundle, and collenchyma forming a hollow cylinder within the epidermis.

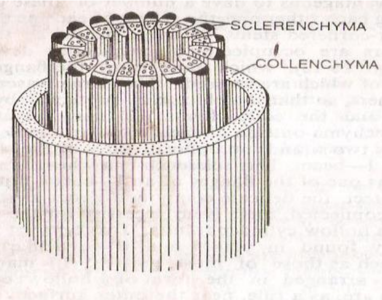

Fig. The mechanical tissue—collenchyma and sclerenchyma. Diagram showing collenchyma forming a hollow cylinder at the periphery of the stem, and of sclerenchyma, exterior to each vascular bundle and forming an interrupted cylinder.

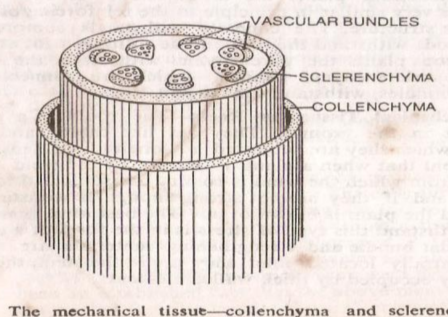

Fig. The mechanical tissue—collenchyma and sclerenchyma. Diagram showing arrangement of collenchyma, forming a hollow cylinder at the periphery of the stem, and sclerenchyma forming one exterior to the bundles.