Simple Tissues

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PLANT organs are made of tissues. These are functional units of an organ. A tissue is a collection of cells performing a particular function. Its cells are alike in structure having similar growth and development. Thus cells forming a tissue are homogeneous in structure and function.

CLASSIFICATION OF TISSUES

Tissues primarily fall in two groups, meristematic and permanent. Meristematic tissues are growth tissues. Their cells are constantly dividing and produce new cells indefinitely. These cells after growth and differentiation assume a permanent form and produce permanent tissues. Thus meristems are tissues which bring about growth. The apical meristems at the tip of root and the stem and the vascular cambium are examples. Permanent tissues are those which have assumed permanently a paricular structure for performing a certain function. Thus they are tissues in which cells have ceased to grow and have assumed a particular form suited for the function they perform, permanently. Parenchyma, xylem, collenchyma, phloem, and sclerenchyma are examples of permanent tissues. Permanent tissues may be further classified into simple and complex. Simple tissues are those in which the constituent cells are alike in structure and function. They are homogeneous in every respect. Collenchyma, sclerenchyma and parenchyma are examples of simple tissues. Complex tissues are those in which the constituent cells are not homogeneous in structure and function. Xylem and phloem are examples of complex tissues. Thus xylem tissue is made up of both living and non-living cells. The cell walls are made of cellulose or lignin. Tracheids and xylem vessels possess a particular structure and perform the primary function of the tissue viz. conduction. The wood fibres associated with Xylem possess a different structure and perform a mechanical function. Cells of wood parenchyma differ from vessels and fibres in their structure and perform the function of storage. Thus cells of xylem tissue are heterogeneous in structure and function. The function of fibres and parenchyma is complementary to the primary function of conduction performed by xylem vessels.

Tissue systems :—The term tissue system is used in a physiological sense. Tissue systems are made up of a number of tissues and all of them perform the same general function. Also the tissues in tissue systems may be widely separated from one another. Well-known examples are the dermal tissue system, the ground tissue system and the vascular tissue system. The dermal tissue system consists of a layer of epidermal cells which protect the underlying parts. There are stomata scattered among the epidermal cells which carry on the function of aeration. Lastly hairs present on the epidermal cells keep the surface cool due to their being turgid with water. All these together form the dermal tissue system.

SIMPLE TISSUES

Parenchyma :—It forms the ground tissue or the frame work of all plant organs and all other tissues are embedded in it. It forms the pith and the cortex of stems and roots, the mesophyll of leaves, the ground tissue in cotyledons and endosperm, and the pulp of fruits. From the evolutionary point of view it is the oldest tissue and the bodies of most primitive plants like the algae and the bryophytes are made up of parenchyma. The meristematic tissues which give rise to all the permanent tissues of the plant body are also made of parenchyma

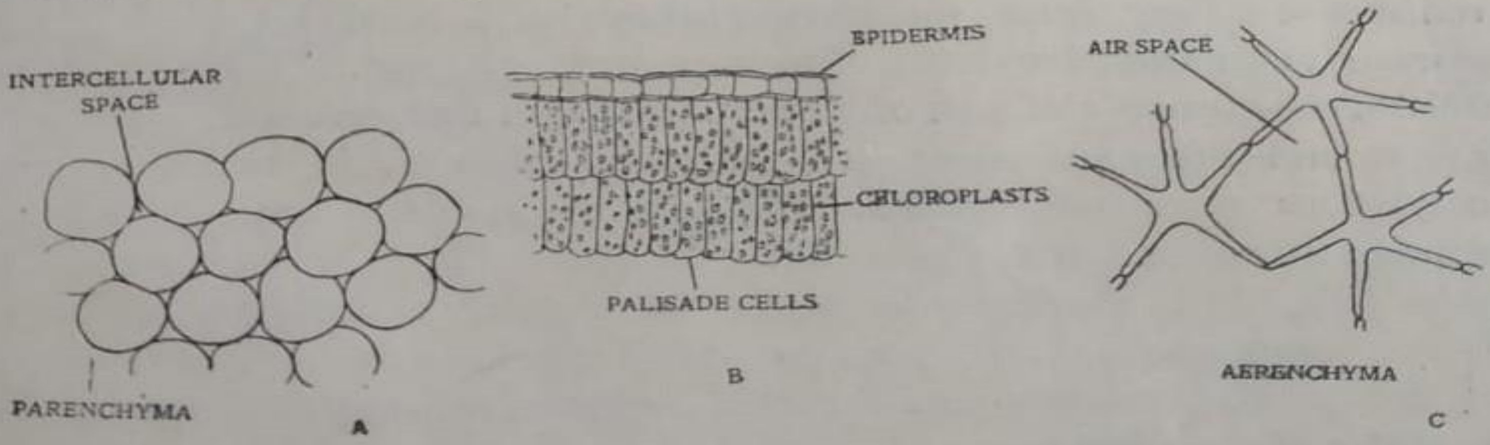

Fig 25. Parenchyma. A, Isodiametric type from cortex. B, Palisade parenchyma from leaf. C, Aerenchyma from water plant.

Origin and structure :—Parenchyma is derived from the ground meristem layer of the apical meristem. In the secondary xylem and phloem it is produced by the vascular cambium. It is also produced by the cork cambium and is known as Phelloderm. The cells constituting the parenchyma are unusually isodiametric in shape with diameters equal (Fig 25, A). There are intercellular spaces formed schizogenously. They are living cells and the cytoplasm contains a big vacuole in the centre. The walls are usually thin and are made of cellulose. There are primary pit-fields in the walls. The palisade parenchyma cells in leaves are elongated and closely packed and do not possess conspicuous intercellualr spaces like the cells of the cortex and pith (Fig. 25, B.). Cells of endosperm tissue show compact arrangement without intercellular spaces. The mesophyll cells of *Pinus* leaf have peg-like ingrowths of cellulose inside the cells (Fig 73). They compensate for the reduced area of the leaf by increasing the wall area. In water plants, stellate parenchyma is present (Fig 25, C). Each cell has several arms like a star and hence the name stellate. Between the arms of stellate cells there are air spaces which facilitate circulation of air in the body of the plant. Therefore it is also known as aerenchyma.

Function :—The cells of parenchyma are turgid with water and give rigidity to the plant body, forming a major part of it. If parenchyma cells lose turgidity, plant organs droop down. This can be observed when plants suffer from temporary wilting in hot days of summer due to water deficit. Because of the conspicuous intercellular spaces possessed by them, parenchyma cells facilitate circulation of air in the plant body In leaves and herbaceous stems they contain chloroplasts and form chlorenchyma. They carry on photosynthesis and build up food. Food storage is another important function they perform. Parenchymatous cells in the cortex and pith of woody plants, in underground organs like roots and tuberous stems, in xylem and phloem, in endosperm and cotyledons, store starch grains. Parenchyma cells also function as water storage tissue in fleshy stems like *Opuntia* (Fig 123) and leaves like *Aloe* (Fig 127). Aerenchyma serves for passage of air in water plants. Finally parenchyma cells take up meristematic activity and form the inter fascicular cambium and the cork cambium during secondary growth in stems of dicotyledons.

COLLENCHYMA

It is a simple tissue and is found in herbaceous stems and leaves. It is not found in woody stems which have undergone secondary growth and in stems of monocotyledons. In stems it forms two or three hypodermal layers below the epidermis. In the leaves it is found in the petiole and the mid-rib and at the margins of the lamina.

Cells of collenchyma are characterized by thickening of the cell wall and is usually of three types. In the lamellar type thickening takes place in the tagential walls (Fig. 26, A). This type is found in the stems of dicotyledons like sunflower. In the angular type, the thickening takes place at the angles of the cells as in the stem of african marigold, *Tagetes* and *Pancratium* leaf (Fig. 26, B). In the lacunate type, the walls bordering the inter-cellular spaces are thickened *e.g.*, Cucurbita stem (Fig. 26, C). But the types are not well marked and both the lamellar and angular type of thickening may be found in the same strand of collenchyma. The most important feature of the thickening is that it is made of cellulose and pectic substances. Because of pectic substances it can hold large amounts of water and makes the wall highly plastic. There are simple pits in the walls and these can be easily seen in the *Nerium* stem. The cells are slightly elongated but they may be as long as broad. They are living and may contain chloroplasts.

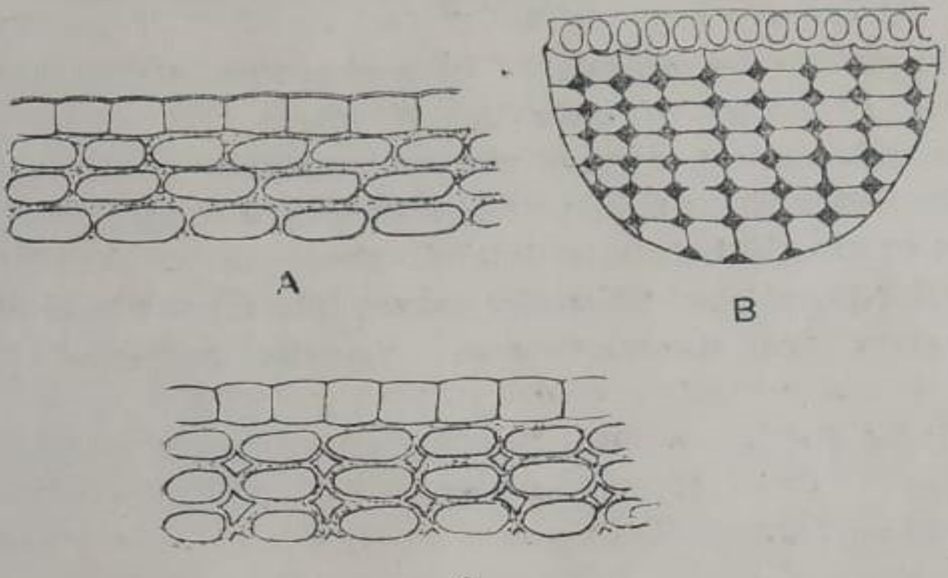

Fig. 26. Collenchyma. A, Lamellar type from sunflower stem. B, Angular type from Pancratium leaf. C, Lacunate type from Cucurbita stem.

Function :—In herbaceous stems, it performs a mechanical function due to its plasticity. The stem can resist the pulling and compression at the surface due to the action of wind. In leaves it gives rigidity to the frame work formed by the midrib and the veins. There are several layers of the tissue in the petiole, mid-rib and bigger veins below the epidermis. At the margins of the lamina there are patches of collenchyma which prevent cutting due to the action of wind. In the elongated leaves of many monocotyledons, like *Crinum* and *Pancratium* there are strands of collenchyma along the entire length of lamina which help to keep it erect.

SCLERENCHYMA

It is a simple tissue and is characterized by lignification of the cell wall. It is made up of two types of cells, the sclerenchymatous fibres and Sclereids. Fibres are elongated and sclereids are isodiametric. The two types will be considered separately.

FIBRES

They occur in groups or strands. In herbaceous stems the pericycle outside the vascular bundles is made up of fibres. In some stems like *Aristolochia*, *Cucurbita*, and *Piper*, whole pericycle is fibrous. In the secondary xylem, fibres form a very large proportion and are known as wood fibres. In monocotyledonous stems there is a sheath of fibres around the vascular bundles. In many leaves like *Cycas* and *Pinus* there is a hypodermal layer of sclerenchyma. In the roots of majority of monocotyledons there is a ring of fibres in which the vascular bundles are embedded. It will thus be seen that fibres of sclerenchyma are widely distributed in all plant organs and forms the bulk of mechanical tissue.

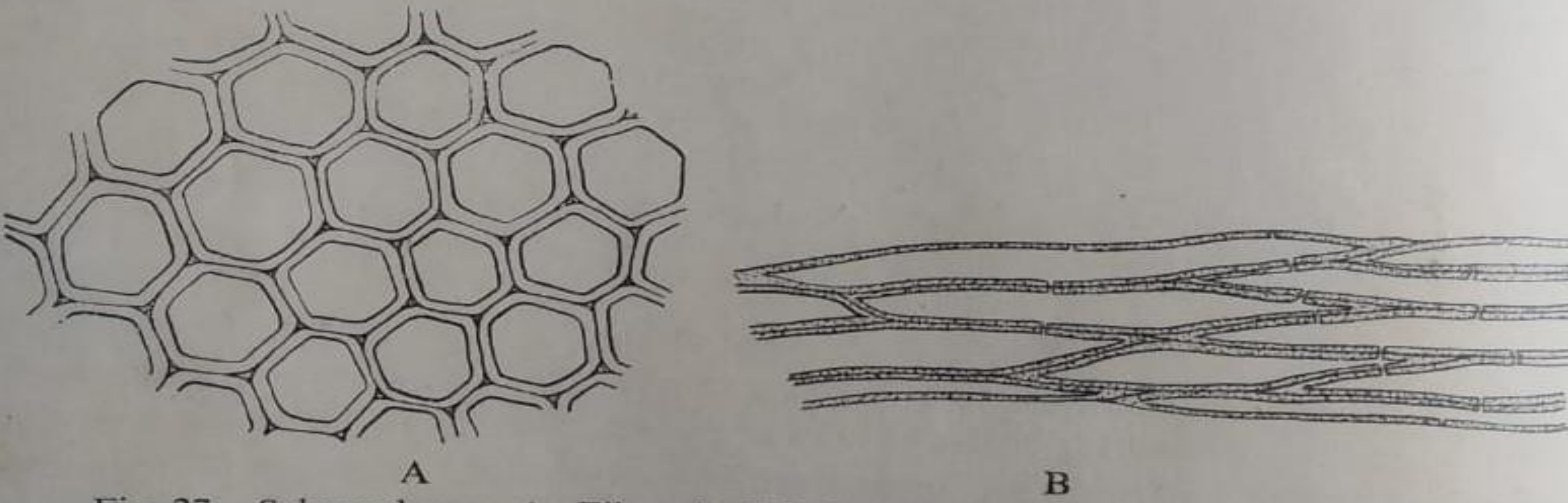

Fig. 27. Sclerenchyma. A, Fibres in T.S. from pericycle of *Aristo lochia* stem.
vitis quadrangularis B, Entire fibres from the stem of *vitis quadrangular is in* L.S.

Structure and function :—Fibres are elongated cells with pointed ends (Fig. 27, B). The cells possess secondary walls which are very much thickened. Thickening is made of lignin. In transverse sections, fibres show characteristic structure (Fig. 27 A). The middle lamella is clearly seen, with the secondary wall much thickened and the lumen of the cells very much reduced. Mature cells are dead and possess simple pits in their walls. Fibres arise from the ground meristem. Wood fibres arise from the vascular cambium. Fibres of sclerenchyma perform a mechanical function and give rigidity and support to the organ in which they are found. In herbaceous stems, fibres in the hard bast form supporting girders. In trees, the major part of wood is formed by fibres. In the leaf fibres give rigidity to the mesophyll. In sclerophyllous leaves of xerophytes fibres prevent shrinking of the leaf and loss of water due to transpiration.

SCLEREIDS

They are distinguished from the fibres by their being isodiametric. They are common in tropical leaves, fruit walls and seed coats. There are various types of sclereids. Brachysclereids or stone cells are found in fruit walls like custard apple and the Sapodilla, the flesh of pear fruit and endosperm of areca-nut (Fig 28, A). Macrosclereids are rod shaped and are found in the palisade-like epidermis of leguminous seeds like bean and pea (Fig. 28, B). Osteosclereids are bone shaped and are found in xerophytic leaves like *Hakea* and stem of *Capparis aphylla* (Fig. 28, C). Astrosclereids possess star-like arms and are found in *Nymphaea* (Fig. 28, D). They are also known as stellate sclereids. Of these four types, stone cells which are isodiametric are very common.

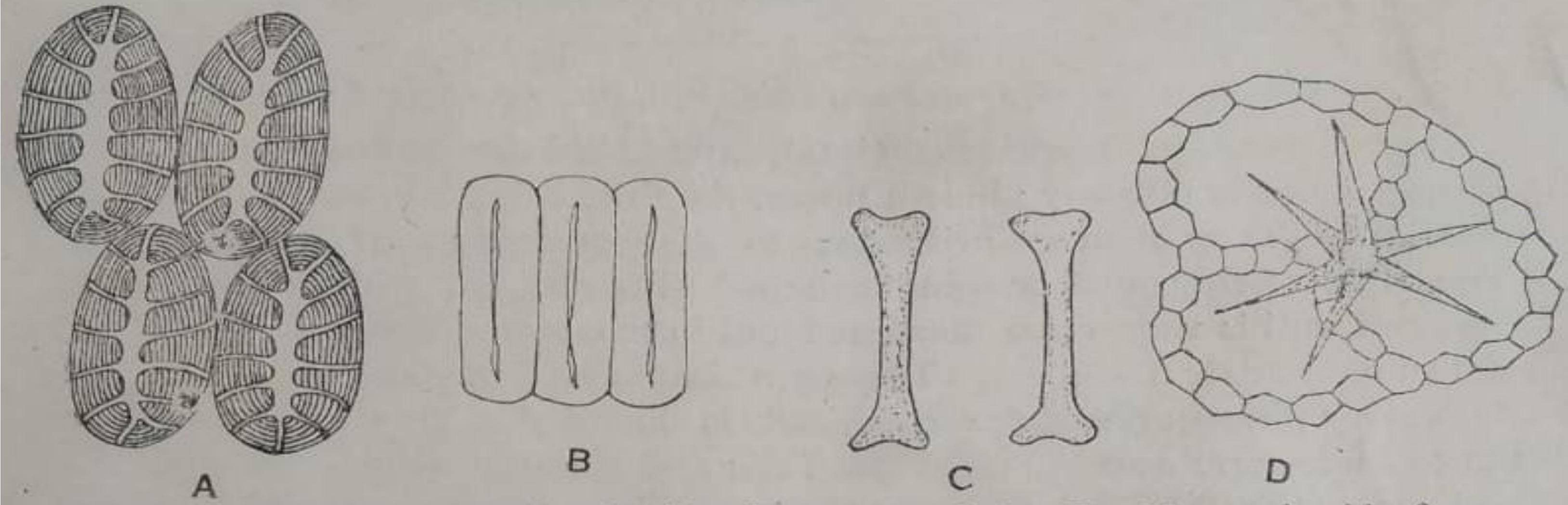

Fig. 28. Sclereids. Brachysclereids from pear fruit. B, Macrosclereids from testa of bean seed. C, Osteosclereids from *Hakea* leaf. D, Astrosclereids from *Nymphaea* leaf.

Structure :—The walls of sclereids are highly thickened and due to it, the lumen is very small and is often seen as a streak in the centre. The wall shows secondary thickening which is made of lignin. There are simple pits in the walls and the pit canals are sometimes branched. The thickening shows concentric lamellation. Sclereids are formed by sclerosis of parenchyma cells or may arise from meristems. They perform a mechanical function and give rigidity to the organ.

PHLOEM FIBRES

Phloem fibres are also known as bast fibres. They are of two types, primary phloem fibres and secondary phloem fibres. Primary fibres are found in many stems like *Calatropis, Vinca, Nerium, Linum* (flax), Cannabis (Hemp), *Corchorus* (jute), and *Hibiscus cannabinus* (deccan hemp). In the primary phloem fibres, the thickening is usually made of cellulose. They seem to arise due to disorganization of protophloem. The cells are elongated or spindle-shaped (Fig. 29, B), with pointed ends. The cell wall is very much thickened and in transverse section (Fig. 29, A), shows concentric markings. There are simple pits in the walls. In the secondary phloem fibres the cell wall is lignified. They are found in the secondary phloem of stems like *Tilia* and *Eugenia* (Figs. 79 and 80) and roots (Fig. 92, C). In stems they arise from fusiform initials of the cambium and in roots, by the disorganisation of primary phloem. In structure they resemble fibres of sclerenchyma.

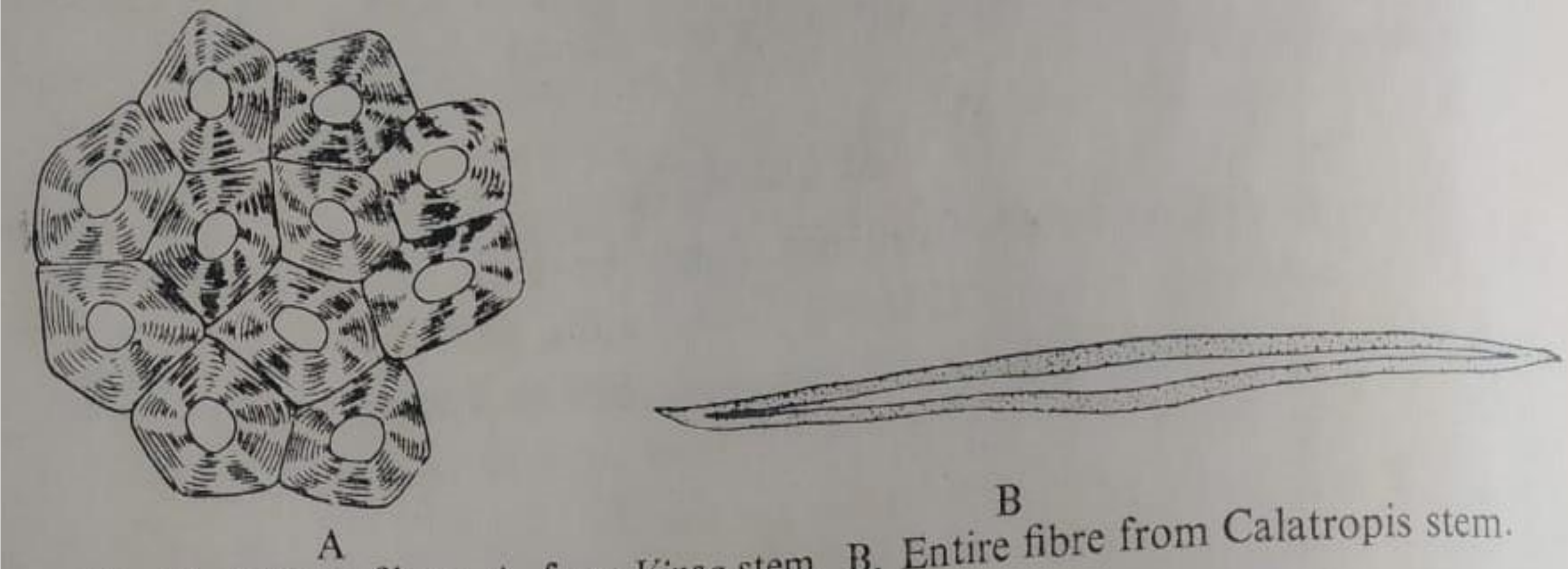

Fig. 29. Phloem fibres. A, from *Vinca* stem. B, Entire fibre from Calatropis stem.

Primary phloem fibres form commercial fibres like flax, hemp and jute. In the preparation of fibres for commercial purposes, plants are subjected to retting. In this process, bacteria and fungi act on the tissue surrounding the fibres. They can then be easily separated from the stem of the fibre plant.

Complex Tissues

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THOSE tissues which are made up of cells which differ in structure are known as complex tissues. Xylem and phloem are examples of complex tissues. Thus xylem is made up of both living and nonliving cells and of cells with cell walls made of lignin or cellulose. As already seen, simple tissues are made up of cells which are alike in structure. The different cells of complex tissues perform a function complementary to the main function.

XYLEM

Xylem is a complex tissue, being made up of cells which differ in structure. It includes tracheids, xylem vessels, wood fibres, and xylem parenchyma. Together with phloem, it forms the conducting or vascular system of the plant body. It is found in the pteridophytes, gymnosperms and angiosperms. It is derived from the procambium of the apical meristems during the development of the plant body from the embryo. Secondary xylem arises from the vascular cambium. Two types of cells carry on the conduction of water, the tracheids and xylem vessels. Tracheids are single cells and vessels are formed from a number of cells.

Tracheids :—They are found in pteridophytes, gymnosperms, in primitive families of angiosperms like *Magnoliaceae* and in the secondary wood of dicotyledons. A tracheid is an elongated cell with tapering ends. It is a dead cell devoid of protoplasm. The walls are lignified and are very hard but they are not very thick. The thickening lignified and are very hard but they are not very thick. The walls are present in the secondary walls. There are bordered pits in the walls (Fig 30, B and C). The tracheids are placed one above the other with their end walls in contact. The diffusion of water and dissolved salts takes place through the pit-membranes of pits on the end walls in contact. There are minute pores in the pit membrane through which water diffuses from cell to cell. The bordered pits in gymnosperms are rounded and possess a thickening in the pit-membrane known as torus. The pits on the lateral walls of the tracheid allow water to pass from cell to cell. The pit-membrane is elastic and when it is under pressure. the torus presses against the opening of the pit. When this happens, the flow of liquid from one tracheid to the adjoining tracheid is stopped. The bordered pits in the pteridophytes are of the scalariform type and the tracheids are known as scalariform pitted tracheids (Fig. 30, A). This is to dintinguish them from vessels with scalariform thickening in their walls. During the differentiation of xylem from the procambium, the first formed elements are known as protoxylem and the later formed elements as metaxylem. The tracheids in the protoxylem possess annular and spiral type of thickening. The metaxylem elements possess bordered pits in their walls. Function of tracheids is conduction of water. They also perform a mechanical function due to their hard and lignified walls.

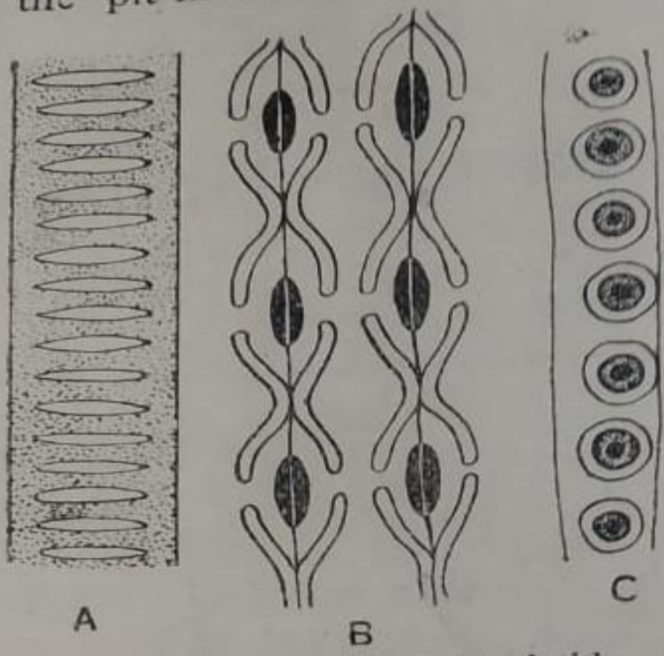

Fig. 30. Tracheids. A, Scalariform pitted tracheid from fern petiole. B, Tracheid from *Cycas* rachis in tangential L.S. showing bordered pits in section. C, Same as in B, showing radical L.S. with bordered pits in surface view.

Xylem vessels :—They are present in the angiosperms, the order *Gnetales* of the gymnosperms, the fern *Pteridium* and the genus *Selaginells* of the *Lycopodinae*. Those monocotyledons which show secondary thickening like *Dracaena* and *Yucca*, do not possess vessels. Also in certain xerophytes, parasites, and aquatic plants, vessels have been lost in reduction. Each vessel is made up of a number of cells or vessel members placed one above the other, with their common walls perforated. Perforations in the cross walls between the vessel members are of various types like simple or with a number of circular or scalariform openings. Vessels have been derived from tracheids, firstly by the dissolution of pit-membranes and than by the dissolution of walls between the pits. In the angiosperms the vessels have been derived from scalariform pitted tracheids and in the *Gnetales*, from tracheids with circular bordered pits. The mature vessels are dead cells with walls having secondary thickening of lignin. The walls are not so thick. The first formed elements of xylem, the protoxylem vessels, show annular and spiral type of thickening. Thus first formed thickening is in the form of rings (Fig. 31, A) and further thickening between the rings connects them and forms spiral or helical type of thickening (Fig. 31, B). When the wall is furthert hickened, scalariform and reticulate type of thickening is produced (Fig 31, C and D). In the metaxylem vessels, the whole wall is thickened except small apertures, the simple pits. This is known as pitted thickening (Fig. 31. E). Bordered pits sometimes occur in the walls of the vessels as in tomato stem. Vessels vary in length in different plants from 2 to 10 feet. The main function of vessels is conduction of water. They also perform a mechanical function due to their lignified walls.

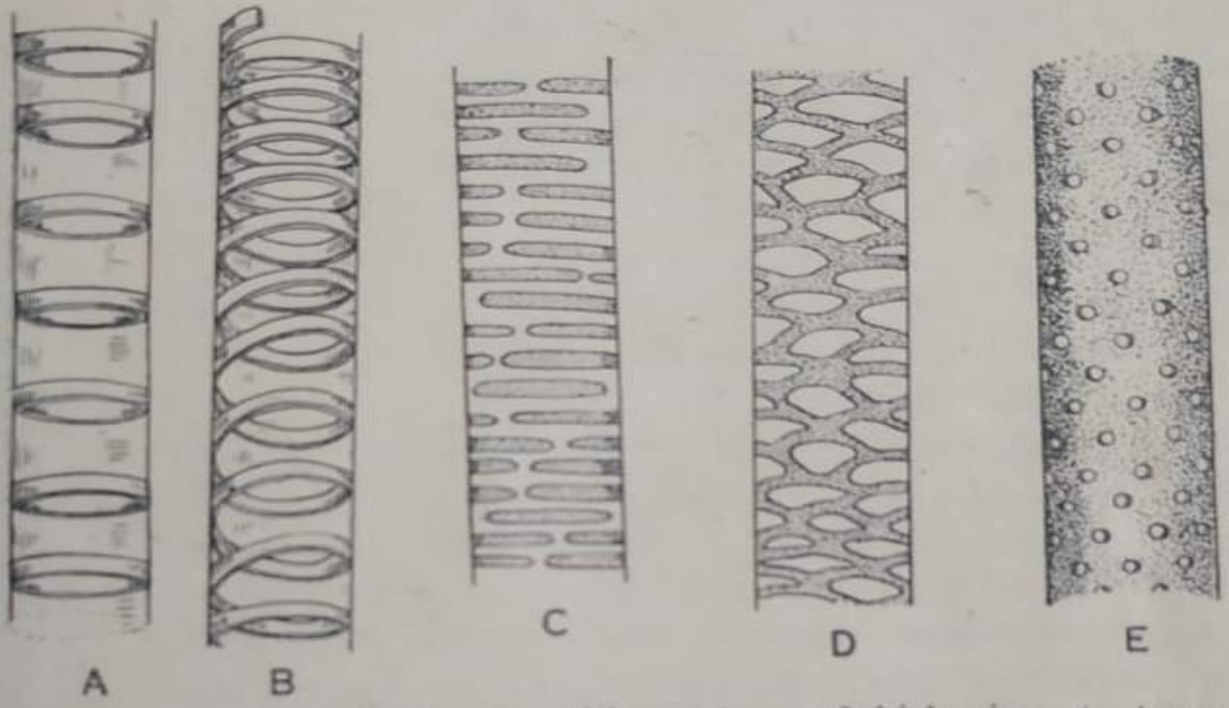

Fig. 31. Xylem vessels showing different types of thickening. A, Annuar B, Spiral. C, Scalariform. D, Reticulate and E, Pitted thickening.

The study of the development of vessels is important from the point of evolution of angiosperms. Vessels in angiosperm and the *Gnetales* have arisen from tracheids of different types. Angiospermic vessels have arisen from scalariform pitted tracheids and those in the *Gnetales* from tracheids with rounded bordered pits. Angiosperms do not therefore seem to have arisen from the Gnetales or other higher Gymnosperms. The origin of vessels in dicotyledons and monocotyledons is independent and the latter do not seem to have been evolved from the dicotyledons. They have been derived from a common ancestor before vessels were developed. The structure of the xylem in herbaceous stems is highly evolved and it shows their origin from tree-like dicotyledons.

Wood fibres: (Fig 32, A & B) They are found both in primary and secondary xylem. They are dead cells and their walls are very much thickened and lignified. They have been derived from tracheids. There are two types of wood fibres, fibre tracheids and libriform fibres. A typical wood fibre is the libriform fibre and fibre tracheid shows a stage in the evolution of typical wood fibres from tracheids. Typical fibres have very thick walls with a narrow lumen. The number and size of the pits is reduced. Also the border of the pits is reduced so that they are almost simple. The fibre tracheids are intermediate between tracheids and libriform fibres and show a transitional stage in the thickening of the wall and the pits. The wall is thicker than that of a tracheid and the pits are smaller in size and not so numerous. The length is also reduced. Some plants have septate fibres e.g., *Sweitenia* (Fig. 32, B). In these, the cells undergo mitosis followed by formation of septa. Septate fibres retain their living contents for a long time. In the secondary xylem there is a considerable proportion of fibres. They give rigidity to the organ.

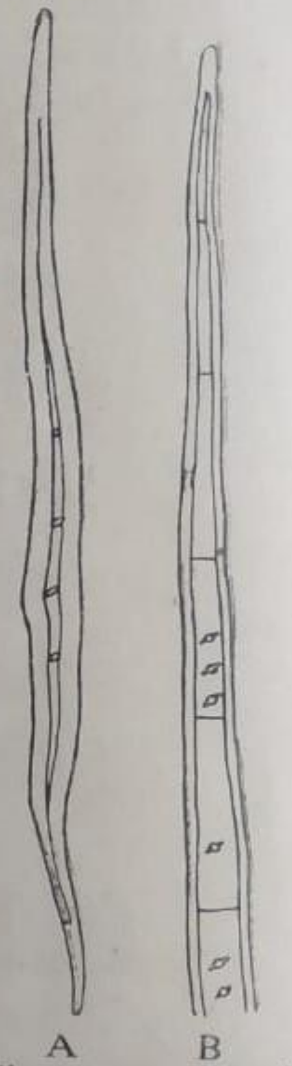

Fig. 32. Wood fibres. A, Libriform fibre. B, Septate fibres from Mahogany stem.

Wood parenchyma. Parenchyma cells are always found associated with xylem. In the primary xylem, there is a considerable proportion of parenchyma. In the secondary xylem there are two types of parenchyma cells. One is wood parenchyma in which the cells are elongated in verticle direction. The second is ray paranchyma in which the cells are elongated in radial direction (Fig. 57, 78, 79). The cells are living so long as the xylem is carrying on conduction. The cell wall is thin and is made of cellulose. In the secondary xylem, wood parenchyma cells often possess thickened and lignified walls. The function of wood parenchyma is storage of food like starch and fat. In primary xylem it forms the ground tissue in which the xylem vessels are embedded. The ray parenchyma may be concerned with the radial conduction of water.

PHLOEM

Phloem is a complex tissue and consists of different types of cells. It is made up of sieve elements including sieve tubes and sieve cells, companion cells, phloem parenchyma and phloem fibres. The term bast has been used to describe the phloem because bast means to bind and phloem fibres like flax and hemp are used for binding. In the primary struc- ture the term bark means the phloem and all the tissues outside it including the cortex. In the secondary structure, bark includes phloem, cortex and the periderm. It is a non-technical term. Haberlandt used the word leptom to describe the phloem.

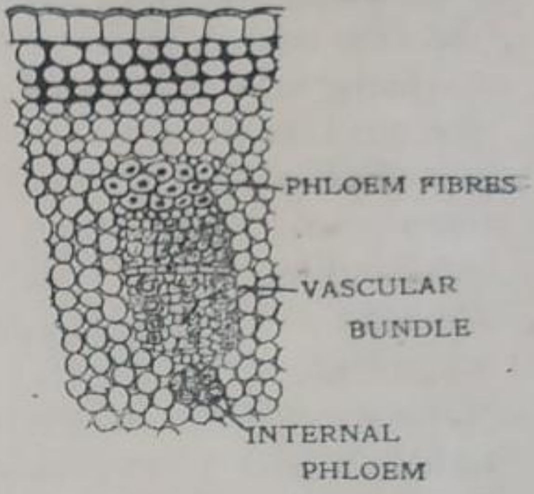

Fig. 33. Internal phloem in Vinca stem.

Primary phloem is developed from the procambium of the apical meristem. It is situated outside the xylem. In many families e.g. *Myrtaceae*, *Apocynaceae*, *Asclepiadaceae*, *Convolvulaceae*, and *Solanaceae* (Fig. 33.) strands of additional phloem elements are found in the pith inside the ring of vascular bundles. It is known as internal phloem. In the family *Cucurbitaceae*, there are phloem strands on both sides of the xylem in each vascular bundle (Fig. 55). It is described as a bicollateral bundle. In internal phloem the strands are distinct and separate from the vascular bundles.

Sieve elements :—Sieve elements are of two types. Those found in the ① angiosperms with sieve plates on the cross walls and with associated companion cells are known as sieve tubes. ② In the gymnosperms and the pteridophytes, the sieve elements have sieve plates on the lateral walls and lack companion cells. They are known as sieve cells. The sieve tubes are arranged in a series one above the other forming a continuous system. The sieve cells are not arranged in a series. Sieve elements are elongated living cells (Fig. 35, A). They possess a primary wall made of cellulose. There is a big central vacuole in a thin layer of cytoplasm lining the cell wall on the inside. As the sieve elements mature, the nucleus disintegrates. Thus sieve tubes and cells are unique in functioning without a nucleus in the living state.

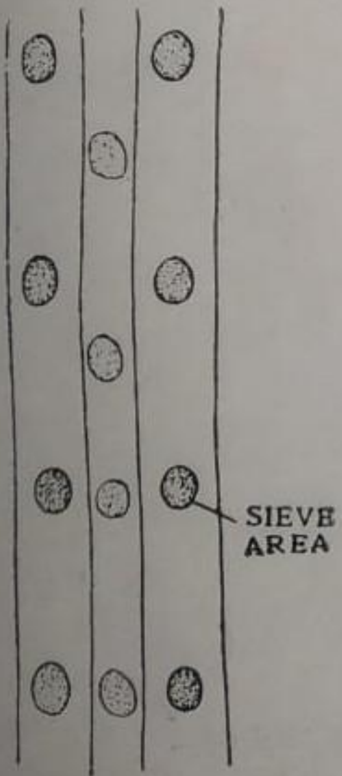

Fig. 34. Diagrammatic figure of Sieve cells.

The vacuole contains slimy substances proteinaceous in nature. They appear in the form of masses scattered throughout the vacuole. In many plants sieve elements contain leucoplasts. They manufacture starch which accumulates near the sieve plates. The most characteristic feature of the sieve elements are the sieve like areas with perforations known as sieve plates (Fig 35, B). In the sieve tubes these are situated on the cross walls. The sieve plates may be oblique or transverse. In mature sieve tubes the sieve plates are very much thickened and biconvex. Each has a large number of perforations. There is a tubular thickening around each perforation made of a substance known as callose (Fig. 35, C). Aniline blue stains the callose blue. The perforations form connecting strands between two sieve elements. They are developed from primary pit-fields between two sieve tubes and are wider in diameter than the pit-fields. In many plants like *Vitis* and *Tilia* there are compound sieve areas having many sieve plates (Fig. 35, D). They are known as compound sieve plates. They occur on radial walls. Majority of plants possess a single sieve plate on the transverse cross

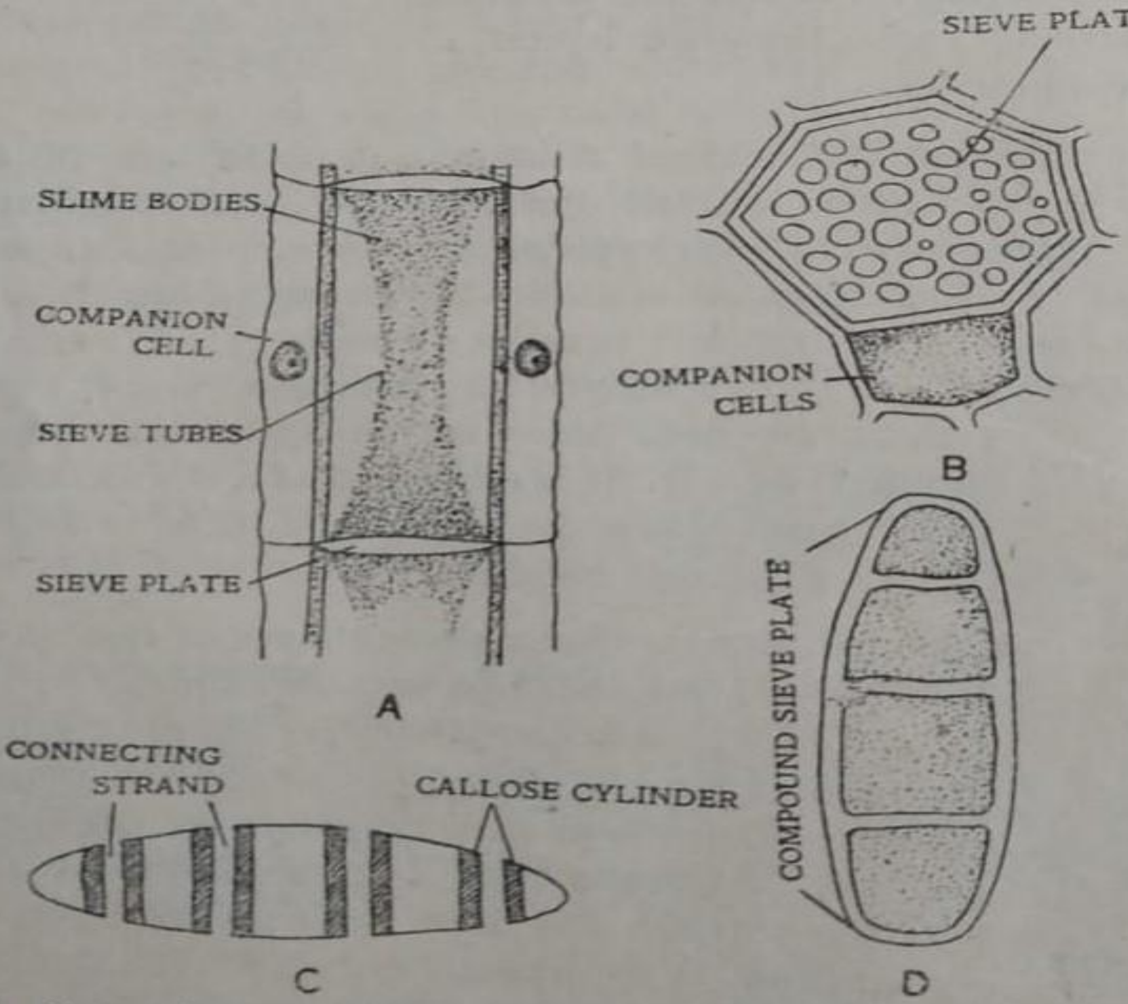

Fig. 35. Sieve tubes. A, Sieve tube in L.S. and B, in T.S. C, Sieve plate in L.S. showing connecting strands and Callose cylinders. D, Compound sieve plate of *Tilia*.

walls. These are known as simple sieve plates. The food material from one sieve tube passes into another through the connecting strands of the sieve plates.

In all plants sieve plates remain active for a short time. In the primary phloem sieve tubes are active for a few days only and in the secondary phloem for a year or so. When sieve tubes have functioned for a considerable time, callose is deposited both on the walls of the plate and in the perforations. Thus a cushion of callose is formed on the sieve plate and the connecting strands are completely obliterated. This cushion of callose is known definitive callus. The word callus means accumulation of the callose. This accumulation of callose indicates the cessation of the activity of the sieve tubes.

Sieve cells are found in the pteriodephytes and gymnosperms. Their sieve plates are situated on the lateral walls (Fig 34) and there are no companion cells associated with them as in the angiosperms. The connecting strands in the sieve plates do not possess a tubular thickening of callose. It is found around the whole sieve plate. The diameter of the connecting strands is less than that of those in angiosperms. They may function for a longer period than the sieve tubes which may be several years. Sieve cells are long and slender and their end walls are tapering or oblique. They are not arranged in a series like the sieve tubes.

Sieve tubes have been derived from sieve cells. In this process the sieve area is shifted to cross walls. The cross walls themselves have become firstly oblique and then finally transverse. The connecting strands have developed a tubular thickening of callose and increased in diameter. The sieve areas have decreased and in highly developed sieve tubes there is a single sieve plate. Also they are arranged one above the other.

Companion cells :—These are parenchymatous cells closely associated with the sieve tubes of angiosperms. They are absent in pteridophytes and gymnosperms. Companion cells arise from the mother cell of the sieve tube by longitudinal division. One daughter cell becomes the sieve tube and the other, the companion cell. Usually there is one long cell associated with a sieve tube in primary phloem of herbaceous plants. But more than one companion cell may be associated with a single sieve tube as in Carrot. In secondary phloem of woody plants many short cells are associated with sieve tube. Companion cells have thin walls and a big nucleus. In transverse section they appear rounded or polygonal. It is not easy to make out to which sieve tube a particular cell belongs when the sieve tubes are crowded together. Slime bodies similar to those found in sieve tubes have been found in companion cells. Companion cells are closely associated with sieve tubes and are crushed when sieve tubes are disorganised.

Phloem parenchyma :—Apart from the companion cells there are parenchyma cells in the phloem in considerable proportion and are known as phloem parenchyma. They are concerned with storage of food like starch and fat. Tannins and resins accumulate in these cells in many plants. In secondary phloem elongated cells with their long axis parallel to the axis form phloem parenchyma (fig. 80). Those elongated in radial direction form phloem rays. In active phloem these cells have walls made up of cellulose. When phloem ceases to function the cells are lignified to form phloem fibres. The cell wall possesses primary pit-fields. Vascular bundles of monocotyledons do not possess phloem parenchyma *e.g.*, maize (Fig. 58,B).

Phloem fibres :—These have been discussed under Fibres. The phloem fibres differ from wood fibers in possessing simple pits. The thickening in primary phloem fibres is of both cellulose and lignin. In the secondary phloem fibres it is always lignin. Phloem fibres are supposed to arise by the sclerosis of phloem parenchyma when primary phloem is disorganized after secondary growth. Protophloem elements when disorganised also give rise to fibres.

PRIMARY PHLOEM

Primary phloem like primary xylem is divided into protophloem and metaphloem. Protophloem is developed before an organ completes its growth and the metaphloem, after the growth has taken place. The sieve tubes of protophloem often lack companion cells. They are narrow in diameter. They function for a short time and are destroyed soon after maturation of the organ by the pressure of surrounding cells of metaphloem. The sieve tubes are crushed and the process is known as obliteration. The crushed cells in many plants give rise to fibres found in primary phloem. In gymnosperms and agniosperms it is difficult to make out the protophloem but in some Pteridophytes it can be distinguished. Thus in the stolon of ferns a ring of protophloem made up of small cells is found outside the metaphloem. Metaphloem elements mature after the an organ completes its growth. In herbaceous dicotyledons and monocotyledons which do not show secondary thickening, metaphloem carries on the function of conduction of food throughout the life of an organ. In those herbaceous and woody plants which undergo secondary growth, metaphloem becomes inactive. The sieve tubes may be disorganised or obliterated. The sieve tubes of metaphloem are longer