ANATOMY OF FLOWERING PLANTS
THE TISSUES

THE TISSUES

- A tissue is a group of cells having a common origin and usually performing a common function.
- A plant is made up of different kinds of tissues. Carl Nageli classified tissues into two main groups, namely, (A) Meristematic and (B) Permanent tissues based on whether the cells being formed are capable of dividing or not.

(A) Meristematic Tissues:

- Meristem is a part of the embryonic tissue.
- Growth in plants is largely restricted to specialised regions of active cell division called meristems (Gk. meristos: divided).

Characteristics of Meristematic Cells:

(i) Meristematic cells are isodiametric, small & thin walled.

(ii) They are compactly arranged without intercellular spaces.

(iii) They have dense cytoplasm with a prominent nucleus.

(iv) The vacuoles are either small or absent.

(v) Endoplasmic reticulum is not fully developed.

(vi) They possess plastids in protoplastid stage.

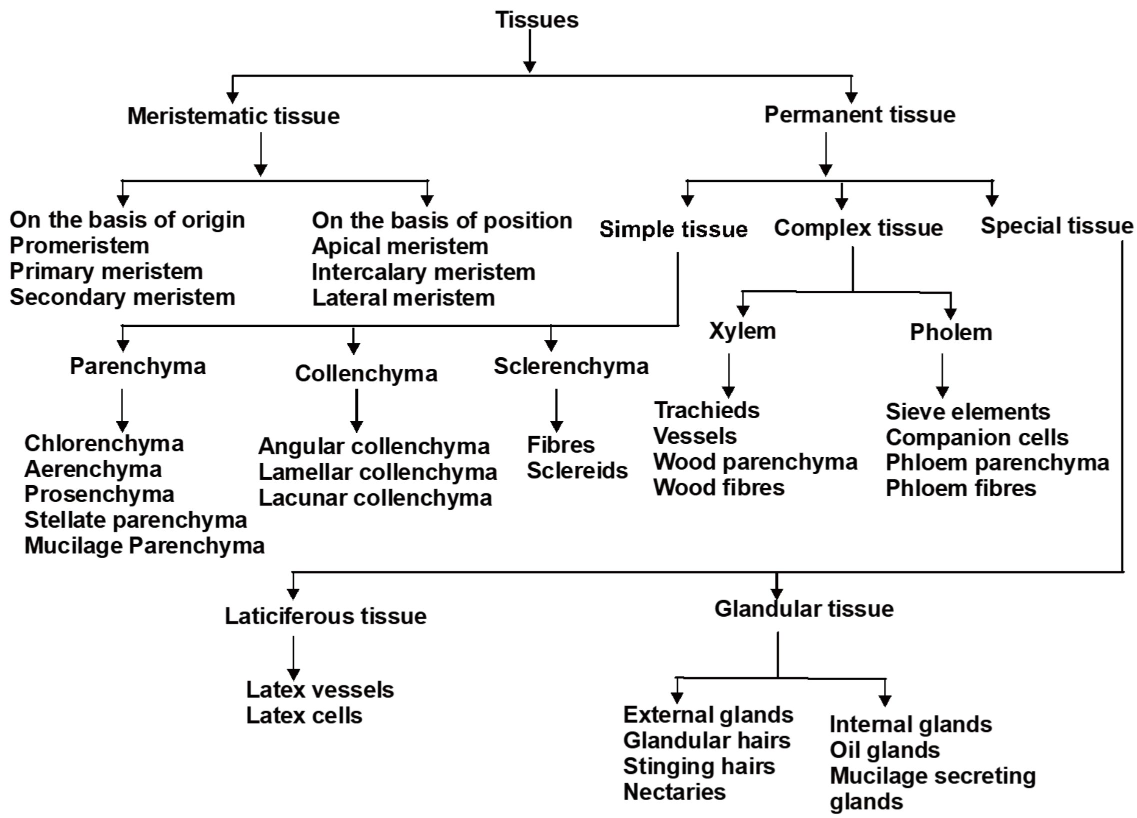
(vii) Metabolically, these are the most active cells.

(viii) Cell cycle of meristem is in continuous state of division. It means they have the capacity to divide continuously. So meristematic tissue is composed of immature cells.

CLASSIFICATION OF MERISTEMATIC TISSUE/MEIDSTEM:

Plants have different kinds of meristems.

Meristems are classified on the basis of plane of **division, origin & development, position and function**.



(A) MERISTEM BASED ON ORIGIN AND DEVELOPMENT

On the basis of origin and development meristems can be divided into following three types

(i) PROMEIDSTEM/PRIMORDIAL MEIDSTEM/URMEIDSTEM

This meristem develops in the beginning during embryonic stage. It forms primary meristem. eg. Embryonic meristem

(ii) PRIMARY MEIDSTEM

- Meristematic cells developed from promeristem are known as primary meristem.
- It appears early in the life of a plant & contribute to the formation of the primary plant body.
- Cells are always in division phase and form primary permanent tissue by the process of differentiation.

e.g. Apical meristem, intercalary meristem, intrafascicular cambium (Fascicular vascular cambium).

(iii) SECONDARY MERISTEM

- Secondary meristem develops from primary permanent tissue by the process of dedifferentiation.
- Secondary meristem appears later than primary meristem .
- By the activity of secondary meristems, secondary growth takes place .

  e.g. Interfascicular cambium & cork cambium of diCot stem, vascular cambium & cork cambium of dicot root.

Promeristem
↓
Primary meristem
Differentiation ↓
Primary permanent tissue
Dedifferentiation ↓
Secondary meristem
Redifferentiation ↓
Secondary permanent tissue

MERISTEMS BASED ON POSITION:

Meristems can occur in different positions in the plant body. These are as follows:

1. **Apical meristems:**

- **The meristems which occur at the tips of roots and shoots and produce primary tissues are called apical meristems.**
- **Root apical meristem occupies the tip of a root while the shoot apical meristem occupies the distant most region of the stem axis.**
- **During the formation of leaves and elongation of stem, some cells 'left behind' from shoot apical meristem, constitute the axillary bud. Such buds are present in the axils of leaves and are capable of forming a branch or a flower.**

2. **Intercalary meristem:**

   The meristem which occurs between mature tissues is known as intercalary meristem. They occur in grasses and regenerate parts removed by the grazing herbivores.

- **Both apical & intercalary meristems are primary meristems as they appear early in life of plant and contribute to the formation of the primary plant body.**

LATERAL MERISTEM :

- Lateral meristem occurs on lateral side of plant organs.
- Activity of lateral meristem increases the circumference/girth/thickness of plant organ.
- All secondary meristems are lateral meristems.
- Lateral meristems are both primary and secondary in origin
  (mostly secondary in origin).

(I) Primary lateral meristems :

1. **Marginal meristem**
2. **Intrafascicular cambium**

1. **Marginal meristem :-** It occurs at the margin of young leaf. Its activity increases the width of leaf (not thickness). For total growth of leaf only primary meristems are responsible.
2. **Intrafascicular cambium /fascicular cambium :** This cambium occurs inside the vascular bundles of dicot stems and gymnosperms stems.

(II) Secondary lateral meristems :- Interfascicular cambium and cork cambium (phellogen) of dicot stem and gymnosperm stem. Cork cambium and vascular cambium of dicot roots

Note : Generally lateral meristems are cylindrical.

Note : The meristem that occurs in the mature regions of roots and shoots of many plants. particularly those that produce woody axis and appears later than primary meristem is called the secondary meristem.

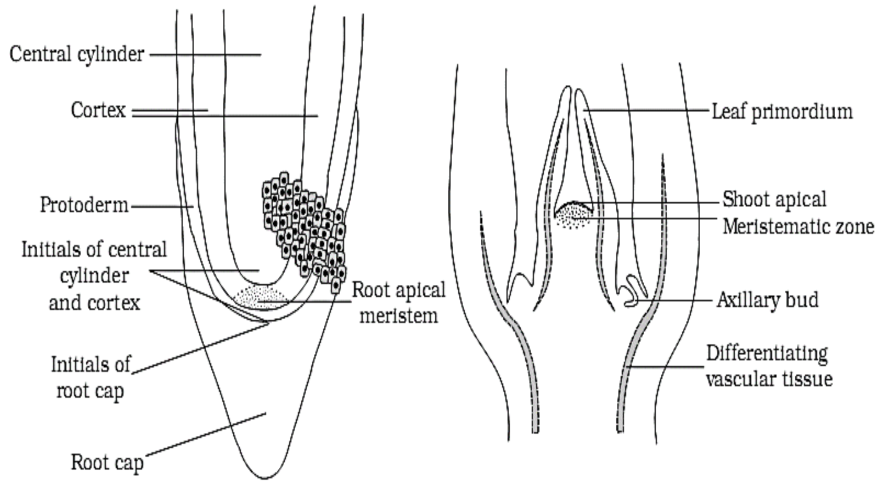


Fig. Apical meristem: (i) Root (ii) Shoot

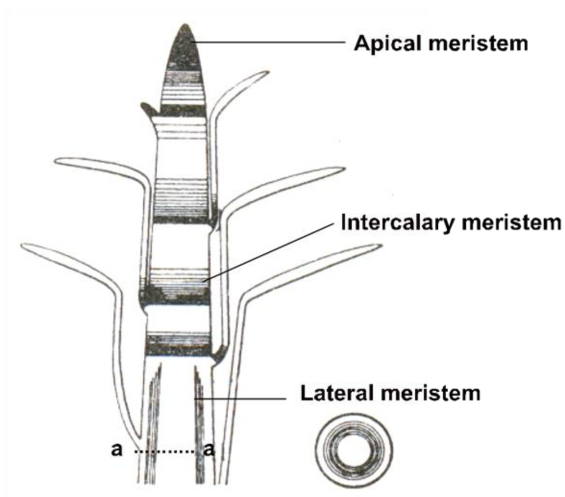


Fig. Different types of meristems on the basis of position in plant body

COMPOSITION/ORGANISATION OF APICAL MERISTEM IN DIFFERENT PLANTS

- Apical meristem is absent in most of the algae and fungi. All the cells of these plants are divisible, so they do not show apical growth. Thus such type of growth in these plants is called diffused growth. Diffused growth also occurs in animals.
- In some algae (eg.- brown algae), bryophytes and some pteridophytes one meristematic cell is present at the apex. Generally the shape of apical cell is pyramid like.
- In ferns, gymnosperms and angiosperms apical meristem consists of many cells.

1. HISTOGEN THEORY :

- This is most valid theory for root apex organisation.
- This theory was proposed by Han stein (1870).
- According to Han stein, the apical meristems (root and shoot apices) are distinguished into three histogens (meristematic regions). These are as follows.

(i) Dermatogens :- This is the outermost histogen & composed of single layer of cells. These cells form uniseriate (single layered) epidermis.

(ii) Periblem :- This region is situated just below the dermatogen. It forms cortex (hypodermis, general cortex and endodermis).

(iii) Palermo :- This is the innermost histogen. Stele formation ta,kes place by division of these cells. It means formation of pericycle, vascular bundles, pith rays (medullary rays) and pith(medulla).

- This theory is true only for root apex. It is not applicable for shoot apex of higher plants because in most of the gymnosperms and angiosperms, shoot apex is not differentiated into three histogens.
- Including above described three histogens, a fourth histogen is also present in monocotyledon root apex. This is known as calyptrogen. Root cap is produced by calyptrogen in monocots. Root cap & epiblema/epidermis are produced by dermatogen in dicotyledons. Due to presence of root cap, position of root apical meristem is sub terminal/sub apical, so maximum growth in root takes place behind the apex.
- In hydrophytes root cap is absent eg. Pistia. In place of root cap, root pockets are present.
- Generally, root cap is single but in Pandanus (screw pine) multiple root cap is present.
- Root cap is living, it contains large amount of golgi bodies which secrete mucilage, which makes the root slimy.
- In monocot root, epidermis and calyptrogens are derived from dermatogens.

Type of root	Number of histogens	Outer most histogen	Root cap is formed by
Dicot root	3	Dermatogen	Dermatogen
Monocot root	4	Calyptrogen	Calyptrogen

Note :- Root cap is formed by calyptrogens (If dicot or monocot is not given)

QUIESCENT CENTRE :-

- Quiescent centre term was coined by "Clowes". Quiescent centre was discovered by Clowes in Maize root.
- A group of inactive or less active cells present between the dermatogen and calyptrogen of monocot root is called quiescent centre. The cells of quiescent centre contain less amount of DNA, RNA, light cytoplasm, small nuclei and synthesis of protein is also less.

  Function : The quiescent centre in the root meristem serves as a reserve for replenishment of damaged cells of the meristem or Inactive cells of quiescent centre become active when previously active initials of calyptrogen get damaged.

  Quiescent centre is crescentic shaped.

2. TUNICA CORPUS THEORY :-

This theory was proposed by Schmidt (1924). It is most valid theory for shoot apex organisation of angiosperms. It is based on planes of division. According to this theory two zones are found in the shoot apex:-

(I) TUNICA:

- This is peripheral layer. In tunica cells, anticlinal division takes place only in one plane. Epidermis is formed by tunica.
- Generally, tunica is single layered, but sometimes it is multilayered, then the outer most layer forms the epidermis and remairiing layers of tunica form rest types of tissues with the assodation of corpus.

(II) CORPUS : The mass of cells present below the tunica is called corpus. The cells of this zone divides in all directions (all planes) due t? which volume increases. The cells of corpus are usually larger than the cells of tunica.

Function : Formation of ground tissue system and vascular tissue system. or Formation of cortex and stele.

3. CYTO-HISTOLOGICAL ZONATION THEORY :-

According to Foster, shoot apical meristem is classified into two regions on the basis of rate of division :- **(I). Summit** **(II). Flanks**

VEGETATIVE SHOOT APEX:-

(I) SUMMIT :

The rate of division is slow in this region. This region is located at the apex.

(II) FLANKS :

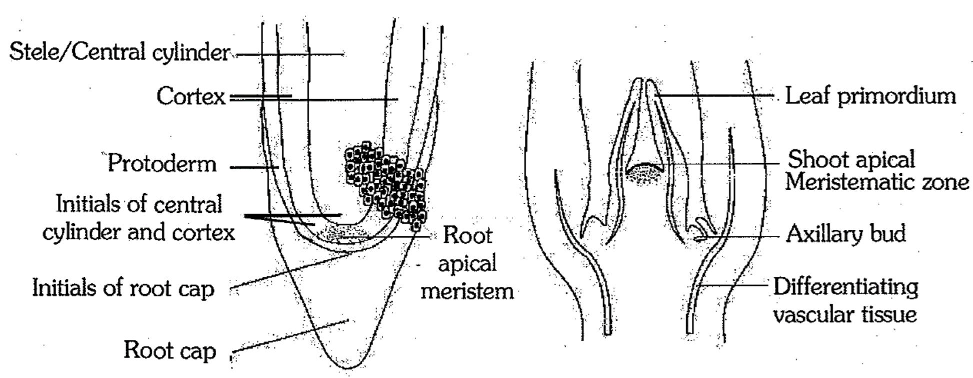
The rate of division is very fast in this region. This region lles behind/below the summit and leaf primordial are formed by this region.

- Time period between initiation of two successive leaf primordial is called 'Plastochron'.
- Shape of vegetative shoot apex → Dome (mainly) or conical shaped
- Shape of reproductive shoot apex → Broad & flat
- Shoot apex is terminal in position
- Growth of leaf primordium → First apical then marginal.
- Function of leaf primordium → Provide protection to shoot apex.

REPRODUCTIVE SHOOT APEX:

During reproductive phase i.e., at the time of flowering, vegetative shoot apex transforms into reproductive shoot apex. This change of shoot apex is induced by florigen & light.

- In reproductive shoot apex, summit zone is more active (rate of cell division fast) and it forms stamens (androecium) & carpels (gynoecium) and flanks zone is less active (rate of cell division slow) and it forms sepals (calyx) and petals (corolla).



Apical meristem : (a) Root (b) Shoot

- During the formation of leaves and elongation of stem some cells "Left behind" from shoot apical meristem, constitute the axillary bud. Such buds are present in the axils of leaves and are capable of forming a branch or a flower.
- Root apical meristem occupies the tip of a root while shoot apical meristem occupies the distant most region of the stem axis

Permanent tissues:

- **Following divisions of cells in both primary and as well as secondary meristems, the newly formed cells become structurally and functionally specialised and lose the ability to divide. Such cells are termed permanent or mature cells and constitute the permanent tissues.**
- Cell cycle of permanent tissue is **arrested at G_0 stage.**
- Permanent tissues developing from primary meristematic tissue (e.g.– promeristem) are called **primary permanent tissues (e.g.– parenchyma, collenchyma etc).**
- Similarly, permanent tissues developing from secondary meristematic tissue (e.g., cork cambium) are known as **secondary permanent tissues (e.g.– cork, secondary xylem and secondary phloem).** Its cells may be living or dead.

- Permanent tissues can be divided into three groups:

a. **Simple tissues** b. **Complex tissues**

A. SIMPLE TISSUES:

- **Permanent tissues having all cells similar in structure and function are called simple tissues.**
- These occur in homogeneous groups. Simple tissues include Parenchyma, Collenchyma, and Sclerenchyma.

Parenchyma (Term coined by Grew):

(ii) **Parenchyma forms the majorcomponent within organs.**

(iii) **The cells of the parenchyma are generally isodiametric.**

(iv) **They may be spherical, oval, round, polygonal or elongated in shape.**

(v) **Their walls are thin and made up of cellulose.** Usually **secondary wall is absent** in it.

(vi) **They may either be closely packed or have small intercellular spaces.** They are schizogenous in origin.

(vii) Internally each cell encloses a large central vacuole and a peripheral cytoplasm containing nucleus.

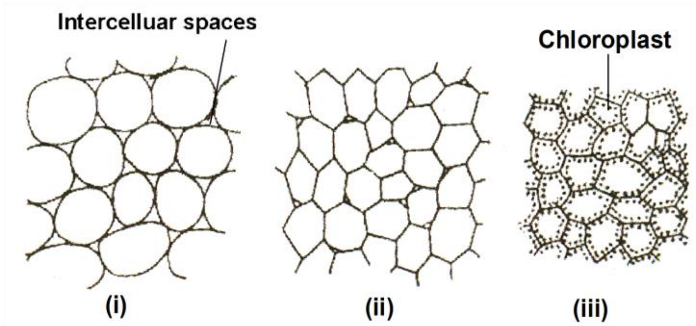


Fig. Types of parenchyma (Rounded, (ii) Angular, (iii) Chlorenchyma

Modifications of parenchyma:

1. Prosenchyma:

- Its cells are long with pointed ends.
- **It forms the pericycle of roots**. It helps in mechanical support, protection & conduction.

Stellate parenchyma:

- Its cells are stellate and branched with less developed air spaces.
- Main function of this parenchyma is to provide mechanical support.
- **It is found in the leaf bases of banana**.

Aerenchyma:

- Its cells are rounded surrounded by the large air chambers.
- **Air chambers are Iysigenous in origin**.
- Oxygen is stored in these chambers which is evolved from photosynthesis which help in respiration.
- It is found in cortex region.
- **It provides buoyancy to hydrophyte plants.**

Chlorenchyma: chloroplasts are found in it. Two types of chlorenchyma are present in dorsiventral leaves.

(b) **Palisade tissues:**

- Their cells are rectangular, tightly fitted together & inter cellular spaces are absent.
- They are present towards **adaxial / ventral / upper** side of leaf.
- Number of chloroplasts are more in palisade tissue as compare to spongy parenchyma.
- So upper surface of a leaf appears greener as compared to lower surface.

Spongy parenchyma:

- Large intercellular spaces are present between these cells.
- So they facilitates transpiration and gaseous exchange.
- They are present towards **abaxial / dorsal / lower** side of leaf.

Mucilage Parenchyma: It has large vacuoles and mucilage e.g. Succulent xerophytic plants such as Aloe. Function-storage of water.

Idioblast cells: Some cells of parenchyma store waste materials. They are called "idioblast cells". The latter store oils, tannin and crystal of calcium oxalate.

Function- storage of water. Functions of parenchyma :

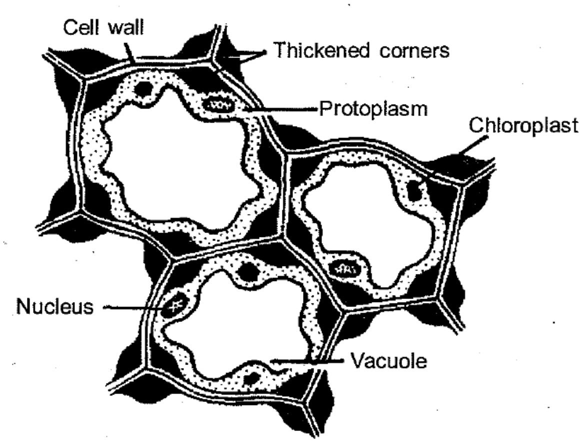
- The parenchyma performs various functions like storage. photosynthesis. secretion etc.
- The main function of this tissue is storage of food.
- Some cells of parenchyma store waste materials. They are called "idioblast cells". ldioblast cells store oils, tannin and crystals.
- Photosynthesis (by chlorenchyma)

COLLENCHYMA : Term was coined by Schleiden.

Main characteristics :

- Collenchyma is a living mechanical tissue.
- It is made up of more or less elongated cells (In transverse section cells appear ovaL spherical/rounded or polygonal in shape).
- Localized deposition of pectin (mainly). cellulose & hemicellulose occurs mainly at comers.

- Usually intercellular spaces are absent.
- Generally chloroplasts are found in the cells of collenchymas or cells often contain chloroplasts.
- These cells assimilate food when they contain chloroplasts.



T.S. of Collenchyma (Angular)

- Collenchyma is not a universal tissue. It is found in the stems of herbaceous dicotyledons (young dicot stem) below the epidermis either as a homogenous layer (in sunflower stem) or in patches (in Cucurbita stem).
- Collenchyma forms the hypodermis of dicotyledon stems. Cells of collenchyma are flexible due to hydrophilic nature of pectocellulose, so flexibility occurs in dicotyledonous/dicot stems.
- Margins of leaf lamina and petiole of leaves also bear collenchyma. It protects the lamina margins from cracking by the action of wind.
- Collenchyma is absent in mature/woody plant parts (After secondary growth in dicot stem), roots and monocotyledons.

Modification of Collenchyma

- Collenchyma is not a universal tissue. It is found in the stems of herbaceous dicotyledons either as a homogenous layer or in patches. **Collenchyma is absent in parts of woody plant parts, roots and Monocotyledons.**

According to **Majumadar,** collenchyma is of three types on the basis of the thickening:

(i) Lamellate Collenchyma: The thickenings occur on the tangential walls (plate thickenings), **e.g. Stem of Sunflower.**

(ii) Angular Collenchyma: The thickenings are present at the angles (angular thickenings), **e.g. Stem of Tomato.**

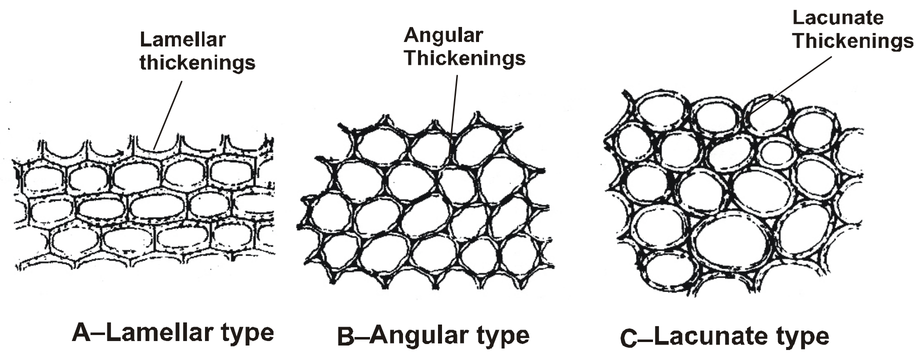


Fig. Types of collenchyma

(iii) Lacunar / tubular collenchyma: Cells bear large intercellular spaces. Deposition of pectocellulose takes place on the marginal wall of intercellular spaces. **e.g. Hypodermis of Cucurbits stem and aerial roots of Monstera.**

FUNCTIONS :-

- Collenchyma performs both functions mechanical as well as biological/vital functions. Provides tensile strength against bending & swaying (mechanical function).
- They provide mechanical support to the growing parts of the plant such as young stem and petiole of a leaf.
- Due to the presence of chloroplast, photosynthesis process (assimilation of food) takes place in collenchymas (vital function).

SCLERENCHYMA:

- **Sclerenchyma consists of long, narrow cells with thick and lignified cell walls having a few or numerous pits. They are usually dead and without protoplasts.**

  On the basis of variation in form, structure, Origin and development, sclerenchyma may be of two types:

  (A) Sclerenchyma fibres

  (B) Sclereids

(A) Sclerenchyma Fibres:

(i) The scIerenchyma fibres are highly elongated (1-90cm), narrow and spindle shaped thick-walled dead cells with pointed ends.

(ii) Cells wall is thick and lignified.

(iii) The fibres generally occur in longitudinal bundles where the pointed ends of adjacent fibres get interlocked to form a strengthening tissue.

(iv) Commercial fibres obtained from plants are usually scIerenchyma fibres. **e.g. Jute, Flax, Hemp**.

(B) Sclereids:

(i) **They may be spherical, oval and cylindrical.**

(ii) **They are lignified, extremely thick walled. So the lumen of the cells is almost obliterated. They are found in hard parts of the plant. Fruit walls of nuts; pulp of fruits like guava, pear and sapota; seed coats of legumes and leaves of tea.**

The grittiness of the fruits like guava and pears is due to the occurrence of stone cells in their pulp.

Types of sclereids:

On the basis of structure **Sclereids** involve following types

1. **Brachysclereids (Stone cells):** They are thick walled isodiametric cells **e.g. bark, pith, phloem, cortex, hard endocarp and fleshy portion of some fruits like guava, pear and sapota**
2. **Macrosclereids (Rod cells):** These are elongated **rod like e.g. seed coat of leguminous plants.**
3. **Osteosclereids (Prop cells):** These are **bone like** with dilated ends or barrel shaped **e.g. leaves and seed coat of many monocots.**

4. **Asterosclereids (Star cells):** These are **stellate** in form or star shaped. **e.g. stem and leaves of xerophytes**.
5. **Trichosclereids (Internal hair):** Long, **hair like** branched sclereids. Branching project inter cellular spaces. **e.g. hydrophytes, Olea.**

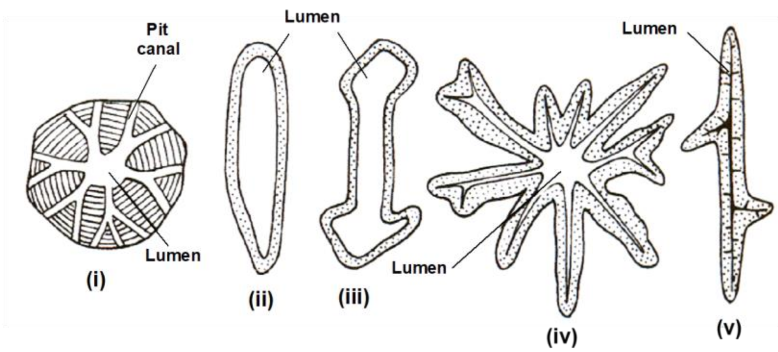


Fig. Types of sclereids: (i) Brachysclereid (stone cells); (ii) Macrosclereid; (iii) Osteosclereid ; (iv) Astrosclereid ; (v) Filiform sclereid (Trichosclereids)

On the basis of position, fibres are divided into three types -

(a) **Surface fibres :-** They are present on the surface of seeds, fruits etc. These fibres are also called filling

(i) **Seed surface fibres –**

Example

i. Cotton fibres (Gossypium fibres)- Cotton fibres are out growth of seed coat/festa.
Cotton fibres are composed of cellulose. They are non-lignified~ So cotton fibres are not true fibres. Two types of fibres are found in cotton. Long fibres are called 'lint' and small fibres are known as 'fuzz'. Lint fibres are used in cloth industry. Fuzz are filling fibres.

ii. Coir of coconut is also a type of surface fibres. They are derived/ obtained from the fibrous mesocarp of coconut (Cocos nucifera). These are true fibres, because they are lignified.

(b) **Xylary fibres/lntraxylary fibres/Wood fibres :-** These are hard fibres. These fibres are not·flexible. These fibres are obtained from xylem (mainly from secondary xylem or wood). Ex. Munj fibre (Saccharum munja)

(c) Phloem fibres/Extra xylary fibres I Bast fibres :-These are commercial fibres. These fibres are flexible and can be knitted (weaved) easily. They have great economic value.

Functions:

(i) Sclerenchyma is the **chief mechanical tissue** of the mature plant organs.

(ii) It allows the plant organs to tolerate bending, shearing, compression and pull caused by environmental factors like wind.

B. Complex Permanent Tissue

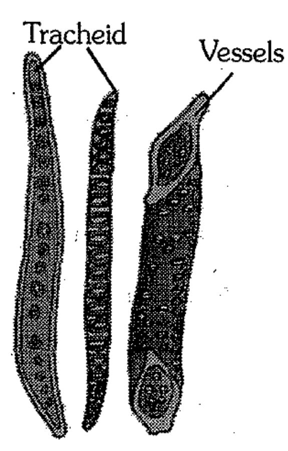
- The complex tissues are made of more than one type of cells or different types of cells and these work together as a unit. Complex tissues are heterogeneous.
- Complex tissues are absent in gametophytes.
- During vascularisation in plants differentiation of procambium is followed by the formation of primary phloem and primary xylem simultaneously.
- Complex tissues are also known as vascular tissues or conducting tissues.

Complex tissues are of two types -

(a) Xylem **(b)** Phloem

(a) Xylem

- The term 'Xylem' was coined by Nageli .
- The function of xylem is to conduct water & mineral salts upwards from the roots to stem & leaves and to give mechanical strength to the plant parts.
- For efficient conduction of water death of protoplasm is must. Dead tissues are more developed in water scares conditions.
- In hydrophytes xylem is poorly developed, while in xerophytes xylem is well developed.
- On the basis of origin, xylem is divided into primary xylem and secondary xylem.



1. **Primary xylem** originates from procambium during vascularisation. Xylem which is formed early in the life of a plant is known as primary xylem. On the basis of development primary xylem is divided into two parts.

(1) Protoxylem **(2) Metaxylem**

- Cells of protoxylem are small as compared to metaxylem. The first formed primary xylem elements are called protoxylem and the later formed primary xylem is called metaxylem.

2. **Secondary xylem** originates from vascular cambium during secondary growth. Xylem which is formed during secondary growth is known as secondary xylem. Secondary xylem is not differentiated into protoxylem and metaxylem.

- Xylem is composed of four different kinds of elements. The elements of xylem are

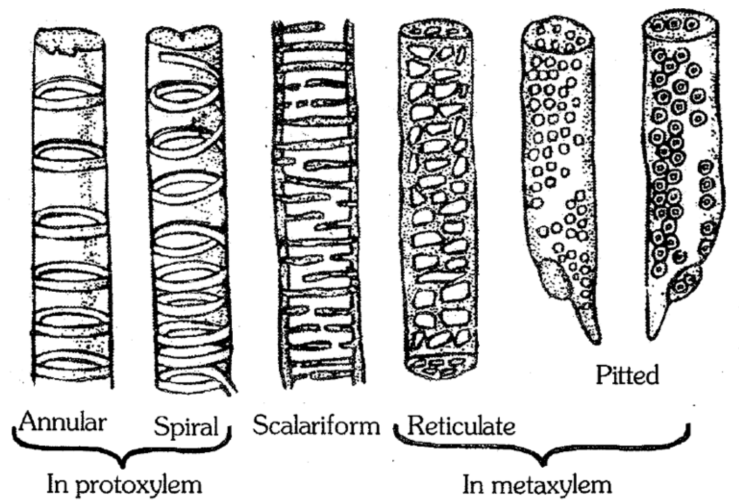
(1) Tracheids, (2) Vessels or tracheae, (3) Xylem fibres (4) Xylem parenchyma

Dead elements Living element

1. TRACHEIDS :

- Tracheids are primitive conducting elements of xylem .
- A single tracheid is elongated or tube like cell with thick and lignified walls and possess a narrow lumen. The ends of tracheids are tapering or chisel like.
- The tracheids found one above the other and are separated by cross wall I end wall which bears bordered pits.
- Usually bordered pits are present at the end walls of tracheids.
  The maximum bordered pits are found in the tracheids of Gymnosperm plants.
- Tracheids are dead (without protoplasm) and lignified cells.
- Tracheids are found in pteridophytes, gymnosperms and angiosperms.
- End walls of tracheids are imperforated (not porous) but pitted (Pits are present).
- Tracheids are unicellular.
- The inner layers of cell walls have thickenings which vary in form.
- Types of thicknening in tracheids and vessels are annular, spiral, reticulate, pitted and scalariform.
- The deposition of lignin on cell wall is responsible for the formation of different types of thickenings.i.e., annular (primitive type), spiral, scalariform, reticulate and pitted.

- Annular and spiral type of thickening of lignin is found in protoxylem.
- Reticulate and pitted (mainly) type of thickening of lignin is found in metaxylem.
- Scalariform Gadder like) type of thickening is found in metaxylem tracheids of pteridophytes and in metaxylem tracheids of Cycas (gymnosperm).
- Maximum deposition of lignin is found in pitted type of this;kening and pits are formed in this type of thickening.
- Pits are unlignified areas on lignified walls



Different types of thickening on the walls of tracheids and vessels

2. VESSELS = TRACHEAE

- Vessel is an advanced conducting element of xylem.
- Vessel is a long cylindrical. tube like structure with lignified walls and a wide Qarge) central lumen/cavity.
- Vessel is multicellular, it is made up of many cells called vessel members or vessel elements.
- Vessel is an example of dead syncyte. Vessel cells are also devoid of protoplasm.
- The end wall is perforated. Thus vessels are more capable for conduction of water than tracheids. Due to presence of perforated end walls, vessels work as a pipe line during conduction of water.
- Vessel members are interconnected through perforations in their common walls. The perforation may be simple (only one pore) or multiple (several pores). Vessels contain usually simple pits on their lateral walls.

(i) Presence of vessels is a characteristic feature of angiosperms Vessels are usually absent in gymnosperms but exceptionally vessels are present in some gymnosperms like Ephedra, Gnetum and Welwitschia (order Gnetales).

(ii) Vessels are absent in some angiosperm plants such as Dracaena, Yucca, Dagenaria, Drimys. There are some angiosperm families in which vessel less angiosperms are included. e.g.Winteraceae, Tetracentraceae and Trochodendraceae.

(iii) Tracheids and vessels are called tracheary elements of xylem.

(iv) In flowering plants, tracheids and vessels are the main water transporting elements.

Syncyte: Structure which is formed by fusion of cells is called syncyte.j

3. XYLEM FIBRES = WOOD FIBRES :

- They may either be septate or aseptate.
- Xylem fibres provide strength to the tracheids and vessels .
- They have highly thickened walls and obliterated central lumens.
- They are abundantly found in secondary xylem (wood).
- They are generally not found in gymnosperm wood (so gymnosperms are also called soft wood spermatophytes).

4. XYLEM PARENCHYMA :

- Cells living and thin walled and their cell walls are made up of cellulose.

  Function : Storage of food materials in the form of starch or fat and storage of other substances like tannins.

  Note : Function of ray parenchymatous cells (xylem rays) - radial conduction of water.

  Hadrome:-

  Conducting part of xylem is known as hadrome.

  Tracheids and vessels are collectively known as water conducting elements or "Hadrome". Hadrome term was proposed by Haberlandt.

(I) Phloem

- The term **'Phloem'** coined by **Nageli.**
- Phloem is classified into **two** categories **on the basis of origin.**

(i) **Primary phloem** (ii) **Secondary phloem.**

(i) Primary phloem

- Primary phloem originates from **procambium** while secondary phloem by **vascular cambium.**
- On the basis of **development** primary phloem divided into **protophloem** and **metaphloem.**
- **The protophloem has narrow sieve tubes whereas metaphloem has large sieve tubes.**
- Phloem remains active for less duration as compared to xylem.

(ii) Secondary phloem.

- Phloem is composed of 4 **types** of cells.

Sieve tube:

- They are **living and thin walled.**
- **Sieve tube elements are also long, tube-like structures, arranged longitudinally and are associated with the companion cells.**
- A mature sieve tube element lacks nucleus. Thus these are **enucleated** living cells. In this condition there function is controlled by adjacent companion cells.
- **In Angiosperm plants,** these elements are arranged with their ends and form **sieve tube.**
- **Sieve plate (oblique transverse perforated septa)** is present between the two sieve tube elements at their end wall. It is porous. Materials are transported through these pores.
- **Large central vacuole** is present in each mature sieve tube element. Cytoplasm of sieve tube element shows **cyclosis** in the form of thin layer around the vacuole.

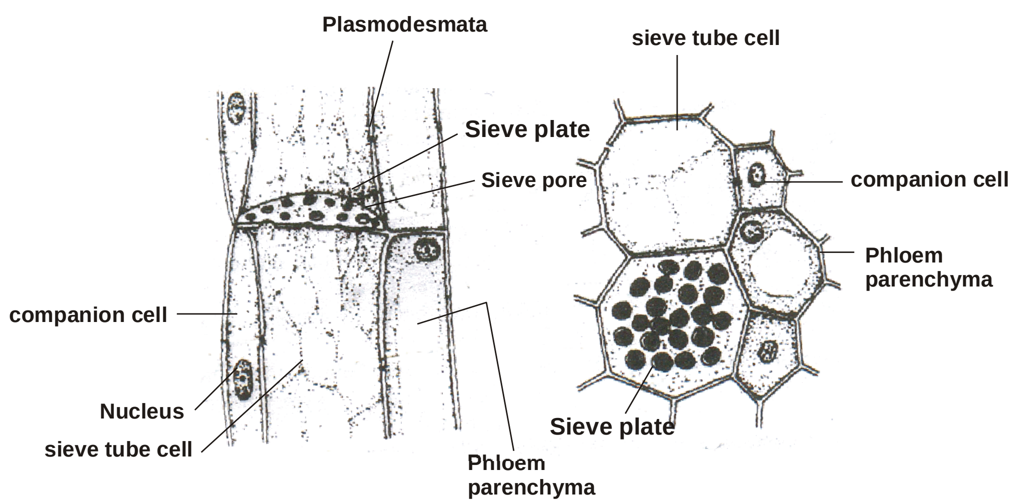


Fig. (i) L.S. of phloem   Fig. (ii) T.S. of phloem

Special points

- **Callose** deposited on the radius of pores in dropping season of leaves **during autumn** to form a thick layer. It is called **Callose pad.** It hinders the conduction of food but on the onset of the spring season this callose pad is dissolved (by callase enzyme) and conduction again restarted.
- In Angiosperms food conduction is erect and efficient. Sieve elements bear special type of **protein-P-protein** (p-phloem). Function of p-protein is sealing mechanism on wounding and it is also related with conduction of food. Food conduction is **bidirectional** in sieve tube.

Companion cells:

- These are **thin walled living cells.**
- Sieve tube element and companion cell originates together. Both of them originates from a single mother cell. So called as sister cells.
- **The sieve tube elements and companion cells are connected by pit fields present in their longitudinal walls which is common wall for both and with the death of one, other cell also dies.**
- A companion cell is laterally associated with a sieve tube element in Angiospermic plants (ln carrot more than one) by cytoplasmic connections that are called **plasmodesmata.**
- Companion cell is a living cell with large nucleus. This nucleus also controls the activity in cytoplasm of sieve tube element.
- **The companion cells play an important role in the maintenance of a pressure gradient in the sieve tubes. Occurrence of companion cells is a characteristic feature of Angiosperms.**

Phloem Parenchyma:

- **Phloem parenchyma is made up of elongated, tapering cylindrical cells which have dense cytoplasm and nucleus. The cell wall is composed of cellulose and has pits through which plasmodesmatal connections exist between the cells.**
- **Phloem parenchyma is absent in most of stems of monocots.**
- **The phloem parenchyma stores food material and other substances like resins, latex and mucilage.**

Phloem fibres (Bast fibres):

- **Phloem fibres (bast fibres) are made up of sclerenchymatous cells.**
- **These are generally absent in the primary phloem but are found in the secondary phloem. These are much elongated, unbranched and have pointed, needle like apices.**
- These fibres **provide mechanical support** to the conducting elements (sieve cells and sieve tube). **These are used for making ropes and rough cloth. e.g. Fibre of jute, flax and hemp.**

Functions of Phloem:

- **Phloem transports food materials, usually from leaves to other parts of the plant(source to sink).**

Special Points

1. Special type of cells are connected with the sieve cells in **gymnosperm and pteridophytes** in place of companion cell. These cells are called as **albuminous cells.**
2. Albuminous cells of conifers are analogous to companion cells of angiosperms. They are modified phloem parenchyma cells.
3. Sieve cells of phloem of pteridophytes and gymnosperms are comparable to the tracheids.
4. The conducting element of phloem is called **Leptom by Haberlandt.**
5. **Hadrom** term was proposed by **Haberlandt** for conducting part of xylem.