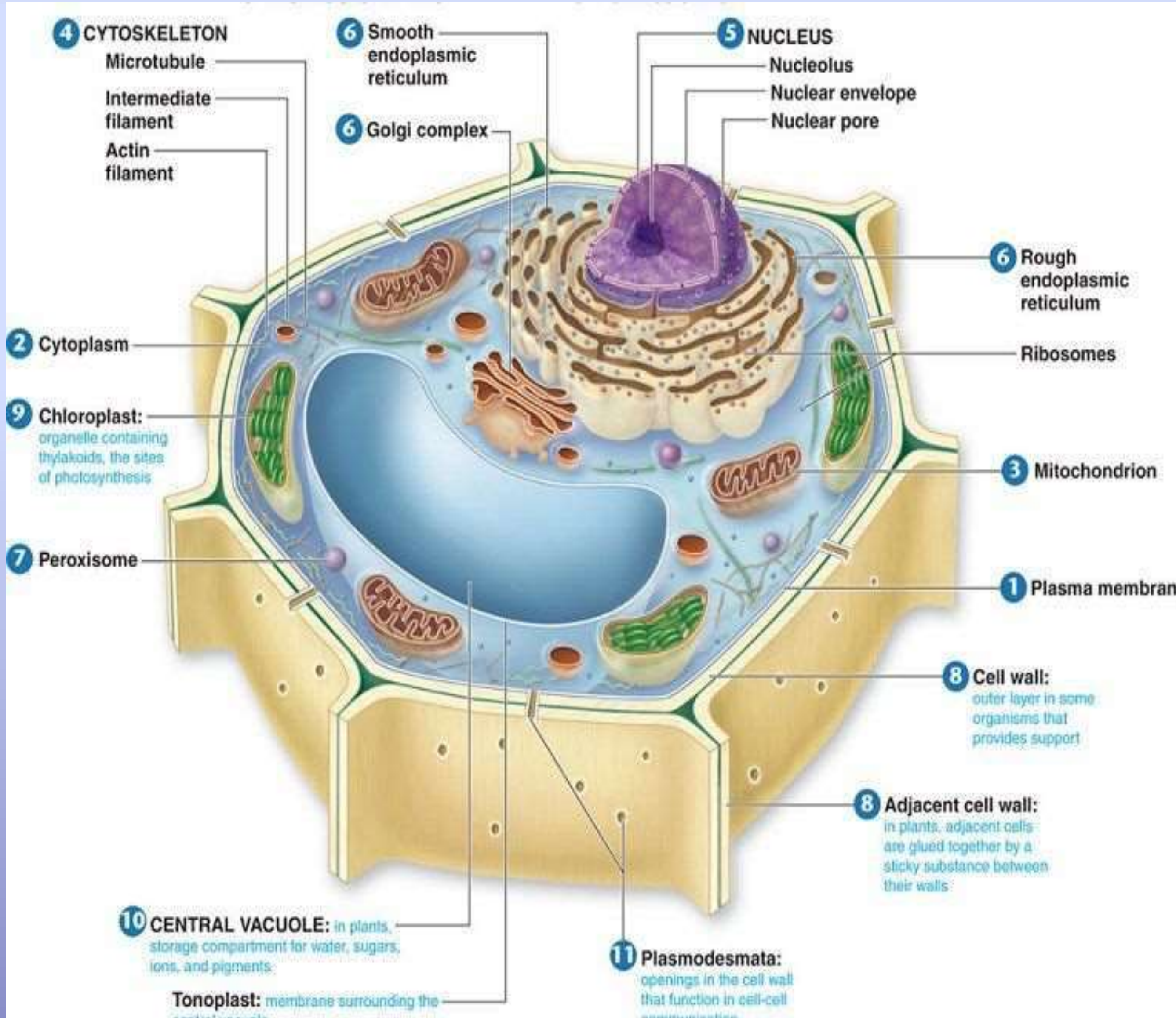
18BBO43C - CORE PAPER – V ANATOMY, MICROTECHNIQUES AND WOOD TECHNOLOGY

Ultrastructure of a Plant Cell



Introduction – Plant cell wall

- Cell walls are important features of plant cells that perform a number of essential functions, including providing shape to the many different cell types needed to form the tissues and organs of a plant.
- Forming the interface between adjacent cells, plant cell walls often play important roles in intercellular communication.
- Because of their surface location, plant cell walls play an important role in plant-microbe interactions, including defense responses against potential pathogens.

Components of Plant Cell wall

- **1. Matrix:**
- Water— 60%. Hemicellulose— 5- 15% Pectic Substances-2-8%. Lipids-0.5-3.0%. Proteins— 1-2%
- **2. Micro fibrils:**
- Cellulose/fungus cellulose— 10-15%.
- **3. Other Ingredients:**
- Lignin, cutin, suberin, silica (silicon dioxide), minerals (e.g., iron, calcium, carbonate), waxes, tannins, resins, gum— variable.
- In brief, cellulose is a water insoluble carbohydrate found in both primary and secondary cell walls whose fibrous structure enables the maintenance of structural integrity.
- Pectins, which are arguably the most complex and heterogeneous of the cell wall polysaccharides, exist predominantly in the primary cell wall and have roles in expansion, strength, porosity, adhesion, and intercellular signaling.
- Other abundant non-cellulosic polysaccharides include xyloglucan, β-1,3:1,4-glucan, xylan, mannan, and callose, which fulfill various roles in mechanical support, reserve storage and development.
- In contrast to cellulose, the pectic and non-cellulosic polysaccharides can be further distinguished by sugar substitutions and side chains that are attached to the polysaccharide backbone during biosynthesis.
- These substituents influence solubility, viscosity, and interactions with other polysaccharides and proteins within the cell wall.

Structure of Cell Wall

- A cell wall can have upto three parts— middle lamella, primary wall and secondary wall.

Middle Lamella:

- It is a thin, amorphous and cementing layer between two adjacent cells. Middle lamella is the first layer which is deposited at the time of cytokinesis (Fig. 8.13). It is just like brick work of the common wall between two adjacent rooms.
- Middle lamella is absent on the outer side of surface cells. It is made up of calcium and magnesium pectates. The softening of ripe fruits is caused by partial solubilisation of pectic compounds to produce jelly-like consistency.

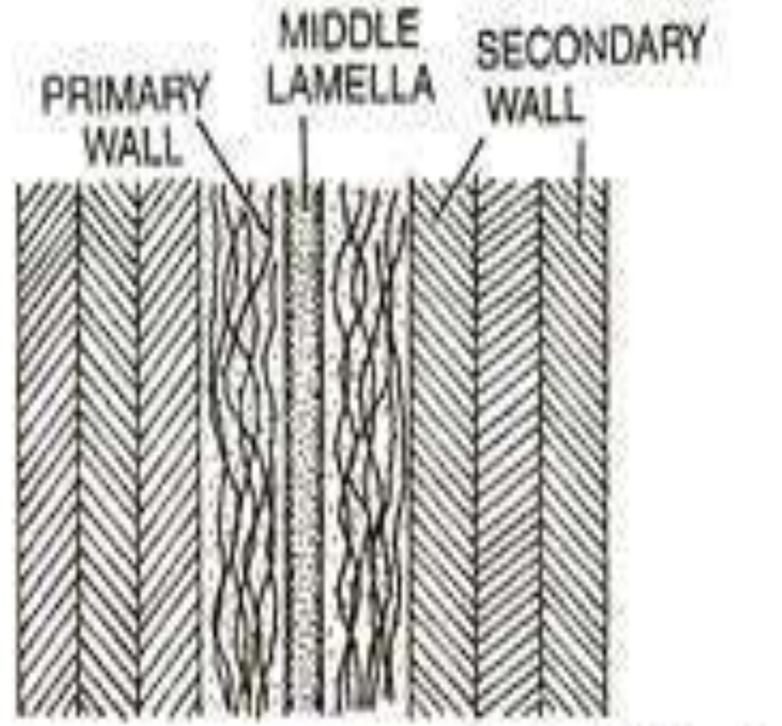


Fig. 8.14. Arrangement of microfibrils in the common wall between two adjacent cells as seen in L.S.

Primary Wall

- It is the first formed wall of the cell which is produced inner to the middle lamella. The primary wall is commonly thin (0.1-3.0 µm) and capable of extension. Some cells possess only primary wall, e.g., leaf cells, fruit cells, of cortex and pith.
- Primary wall consists of a number of micro fibrils embedded in the amorphous gel like matrix or ground substance. In the majority of plants, the micro fibrils are formed of cellulose.
- Micro fibrils are oriented variously according to the shape and thickening of the wall. Usually they are arranged in a loose network due to incomplete cross-linking.
- The matrix of the wall consists of water, pectin, hemicelluloses and glycoproteins. Pectin is the filler substance of the matrix. Proteins are structural and enzymatic. Hemicellulose binds micro fibrils with matrix.

Secondary cell wall

- In primary cell wall, the orientation of microfibril is transverse to the long axis, and during growth the arrangement may be longitudinal. The orientation in secondary wall may differ from primary wall. Tracheids and fibres show three layers in their secondary wall the outer layer (S_1), the central layer (S_2) and the inner layer (S_3), among which the central (S_2) is the thickest.
- The S_1 and S_3 layers lie adjacent to primary wall and cell lumen respectively. These layers S_1, S_2 and S_3 may be distinguished by their respective orientation of cellulose microfibrils. In S_1 and S_3, the microfibrils are in the form of a lax helix and in S_2, it is a steep one
- The microfibrils are aggregated to form macrofibrils, which are composed of about 5,00,000 cellulose molecules in transection. The macrofibrils are about 0.4 µm wide and can be visible under light microscope. Several macrofibrils are combined together to form the cell wall.

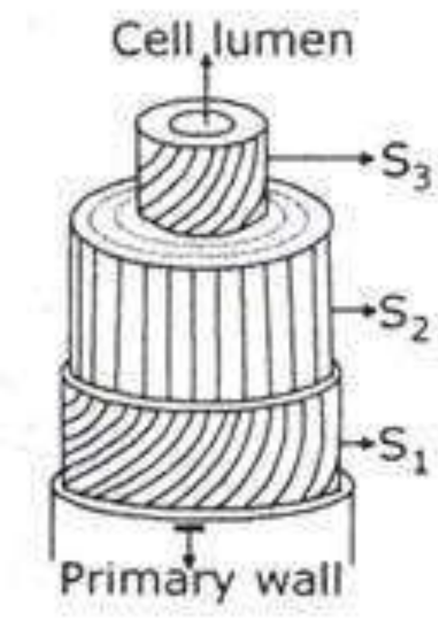


Figure 3.5

Diagrammatic illustration of the orientation of microfibrils in the secondary wall of a cell.

- The innermost layer of the secondary wall is sometimes distinct both chemically as well as in staining properties due to the presence of xylans. It is then called tertiary wall, e.g., tension wood in gymnosperms. Secondary wall may be absent, irregularly deposited or formed uniformly in the cells. This results in differentiation of cells - parenchyma, collenchyma, sclerenchyma, tracheids and vessels.

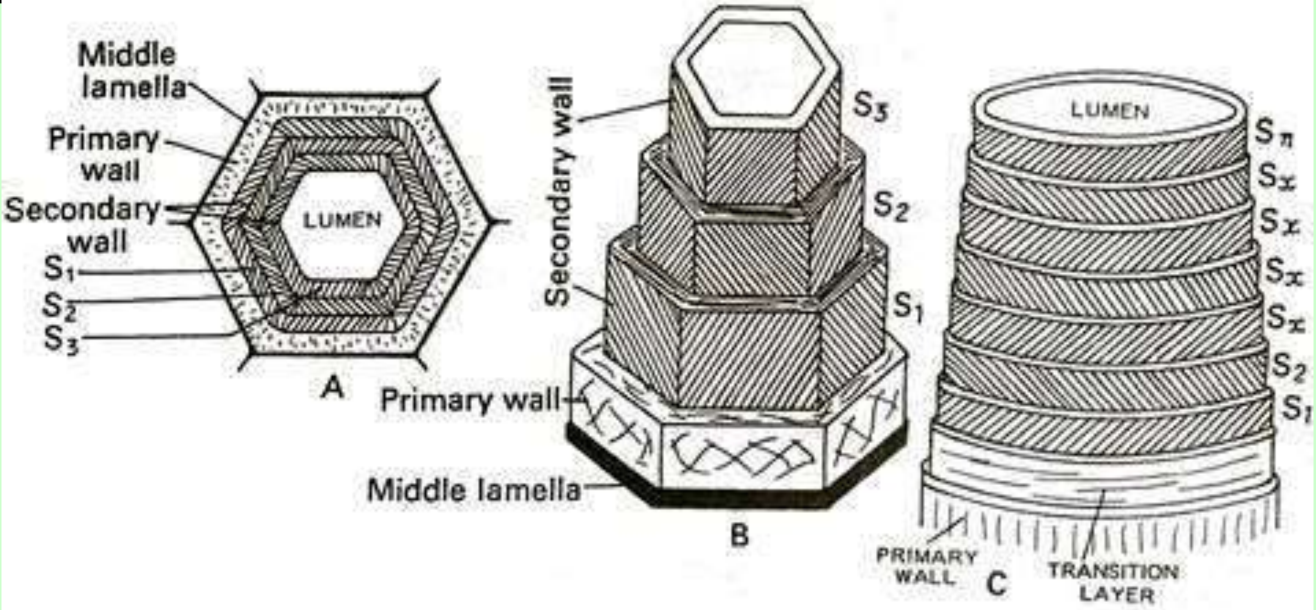


Fig. 8.15. Parts and layers of cell wall. A, a cell in T.S. showing parts of cell wall. B, typical wood fibre cut at various levels to show parts and layers of the wall. C, latex tube of *Euphorbia milli* (= *E. splendens*) cut at various levels to show parts.

Composition of secondary wall

- The composition of secondary wall is basically similar to the primary wall in having cellulose micro-fibrils embedded in a matrix of pectin and hemicelluloses. Cellulose micro-fibrils of the secondary wall lie close, parallel and at an angle to the longitudinal axis of the cell. Their orientation is different in the different layers of the secondary wall. A number of different materials may be deposited in the wall.
- **The important ones are:**
- **(a) Lignin:**
- It reduces the water content of the wall matrix and increases its hardness. However, water permeability is not affected. The characteristic of lignification's (and cutinisation) has evolved with the evolution of land plants,
- **(b) Suberin:**
- The wall of cork and endodermal cells contains a special fatty substance called suberin. Suberin makes the walls impermeable,
- **(c) Cutin:**
- The epidermal cells possess another fatty substance called cutin. Cutin is also laid as a distinct layer on the outside of the epidermal cell walls. It is known as cuticle. Cutin reduces the rate of epidermal or surface transpiration. Other substances which can be deposited in the cell wall are silica (e.g., grasses), minerals, waxes, tannins, resins, gums, etc.

Plasmodesmata

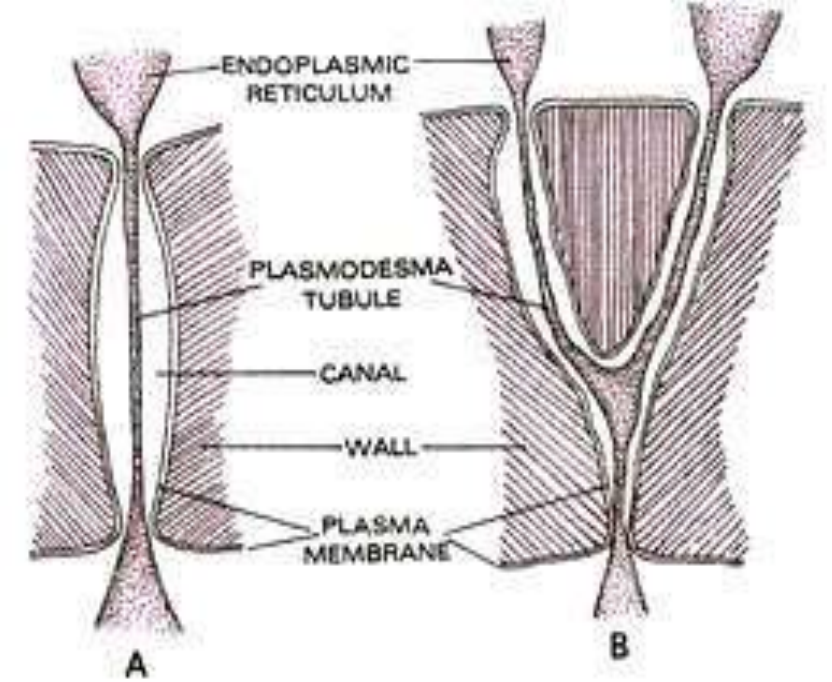
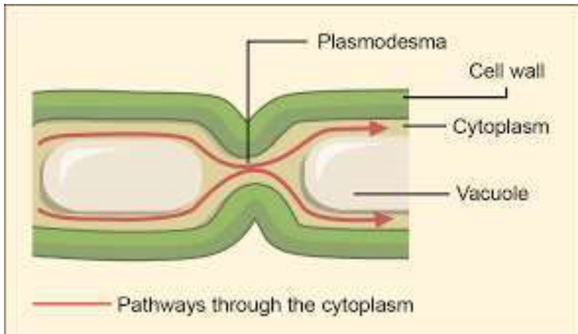
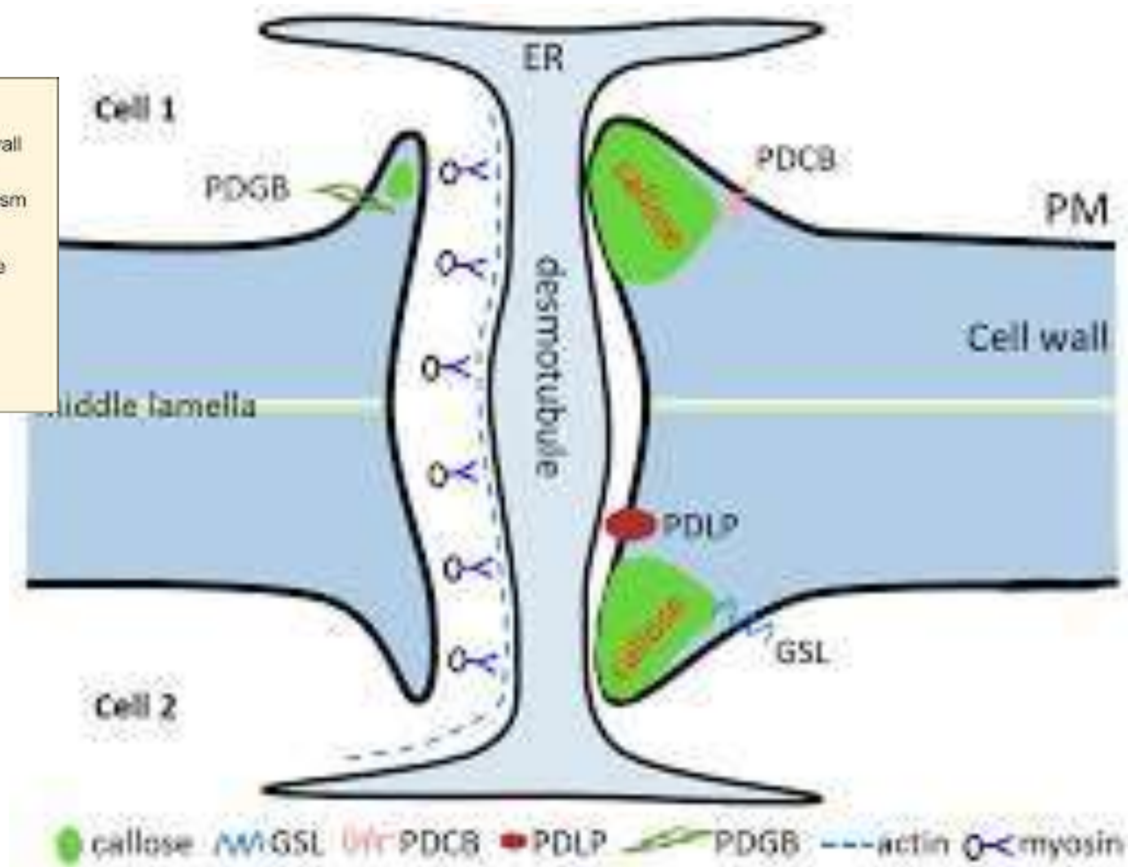


Fig. 8.16. Structure of plasmodesmata. A, simple. B, branched (as between sieve tube cells and companion cells).

Plasmodesmata are cytoplasmic bridges between adjacent plant cells which develop in the minute pores of their walls. They form a protoplasmic continuum called symplast. Cell wall and intercellular spaces form a non-living component of the plant body called apoplasm. A plasmodesma is 40—50 nm in diameter. It may be simple or branched.

PLASMODESMATA





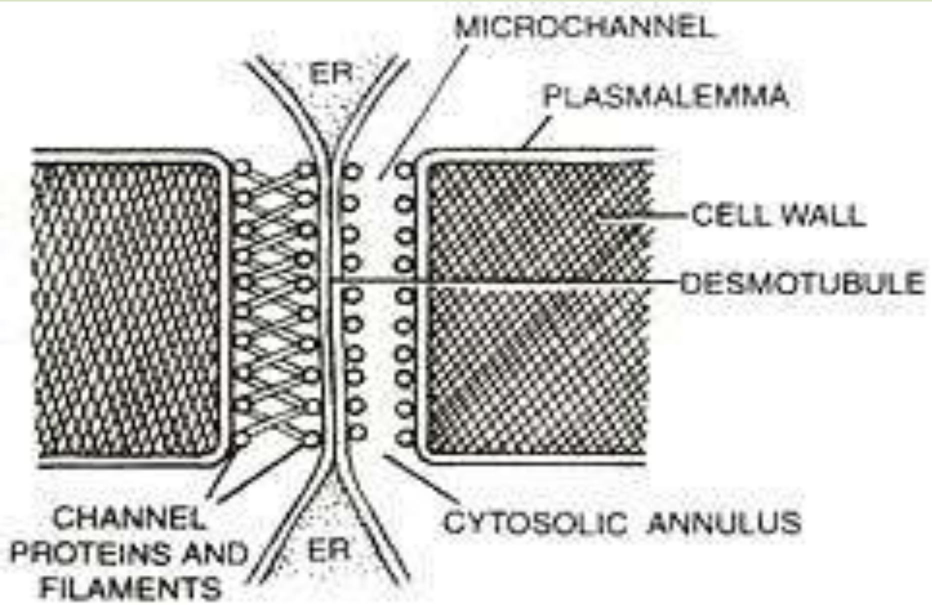


Fig. 8.17. Components of plasmodesmata.

Plasmodesma is lined by plasma membrane. It encloses tubular extention of endoplasmic reticulum called desmotubule.

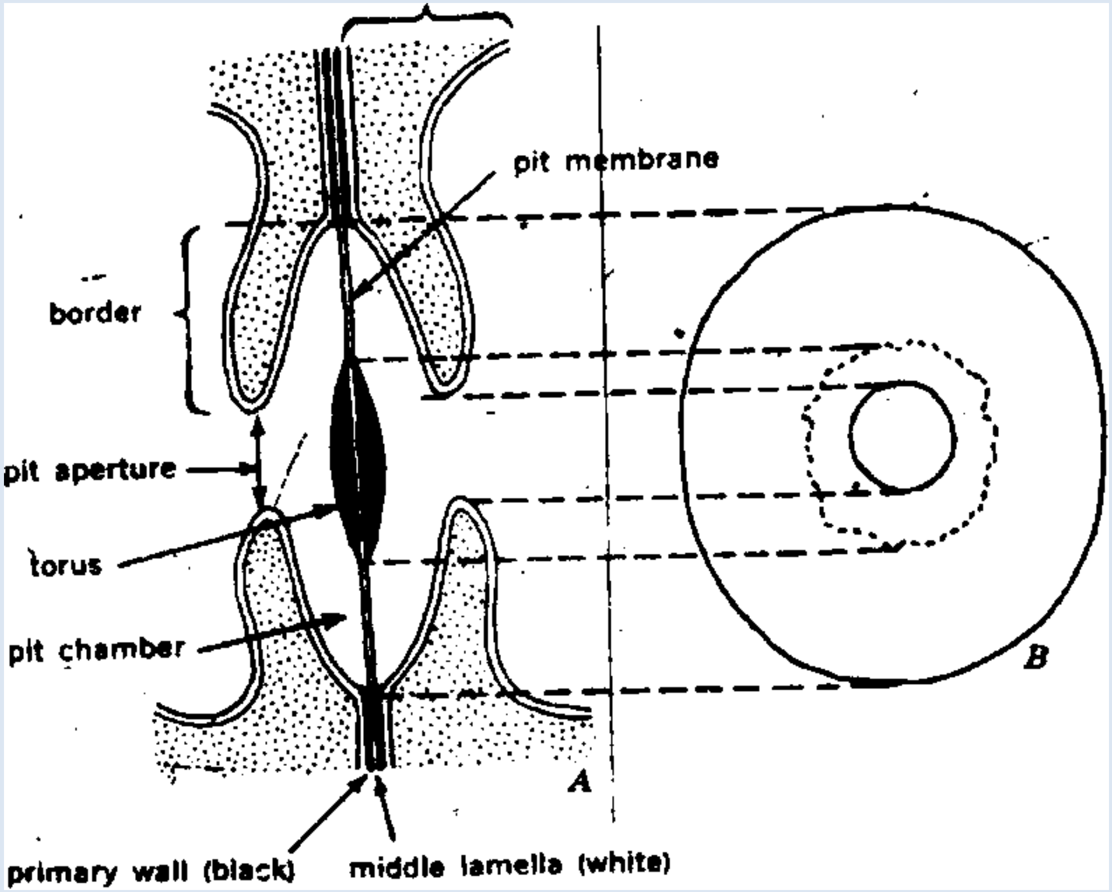
The space between desmotubule and plasma membrane contains 8-10 microchannels.

Plasmodesmata form channels for controlled passage of small sized particles between adjacent cells as well as transfer of some specific signals.

Pits

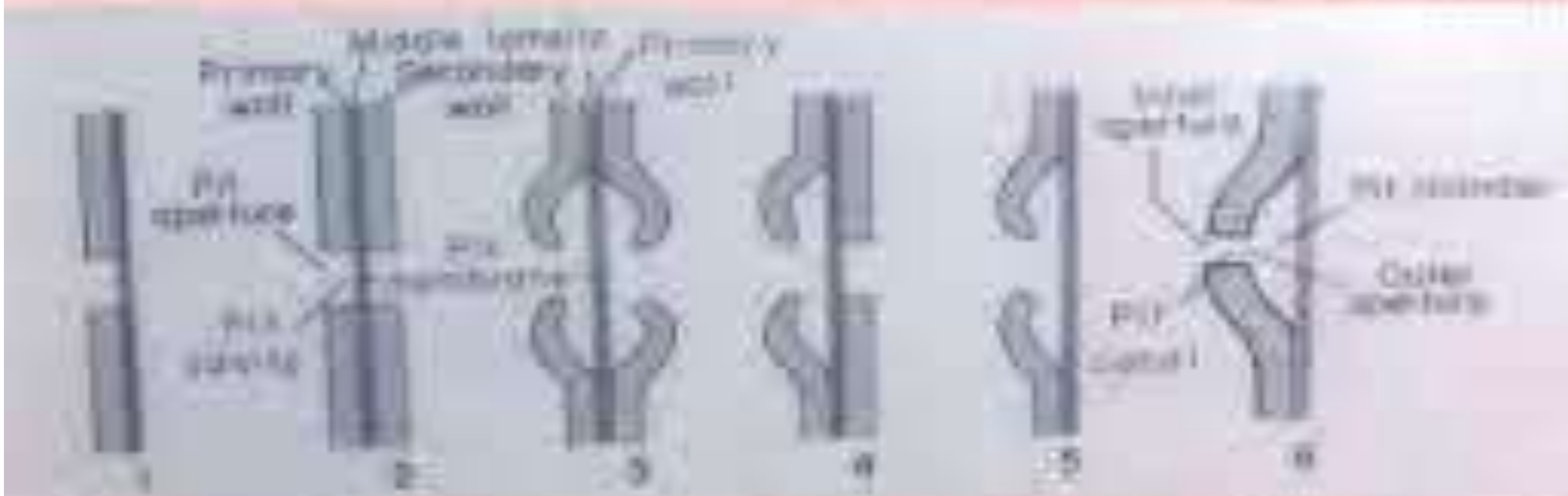
- Pits are unthickened areas in the secondary walls of plant cells. They, therefore, appear as depressions. Pits generally occur in pairs on the wall of two adjacent cells. A pit has a cavity or pit chamber and a pit membrane.
- The pit membrane consists of primary wall and middle lamella. Pits are of two types, simple and bordered. Simple pit has uniform width of the pit chamber. In bordered pit, the pit chamber is flask-shaped because the secondary wall overarches its mouth.
- Pit membrane is permeable. It may have minute sub-microscopic pores. Therefore, pits help in rapid translocation between two adjacent cells.

Structure of a Bordered pit



Types of Pits

- There are following types of pits:.
- **Simple pits:** The diameter of the pit cavity remains uniform in simple pit. Pit cavity trpens in the lumen of the cell. Therefore, the pits of the two sides of the common wall form a simple pit.
- **Bordered pits: In** this case, secondary wall arches over the cavity of the pits. Thus the pit opening become narrow than the pit diameter. Bordered pits of the opposite cells form bordered pit pair. The cavity in the thick secondary wall is called **pit chamber.** The bordered pit opens in the cell lumen by **pit aperture.** The pit aperture is circular and much narrower than ihe diameter of pit chamber. In certain cases, the pit apertures are lenticular or linear or mai. ‘the pi.t membrane of bordered pit develops an oval thickening in the middle. It is called **torus.** Pit membrane is flexible. The liquid in cell put pressure on torus membrane. Pit membrane pushes the torus. Thus the torus closes the bordered pit. It slums that torus control the passage of pit through bordered pit. Bordered pits are more complex than simple pits. These are found in the vessels. tracheids and fibers of xylem.
- **Half bordered pit pair:** In some cases, bordered pit has a complimentary simple pit. Such a pit pair is called half bordered pit pair.
- **Blind pits:** Some pits do not hate ally complimentary pit. Such pits are called blind pits.
- **Compound pits:** Sometimes, there is one pit on side. But there are two or more complimentary pits on opposite side. Such pits are called compound pits.



STRTUCTURE OF PITS: 1,simple pits. 2,simple pit pair. 3,bordered pit pair. 4,half-bordered pit pair. 5 & 6,bordered pits

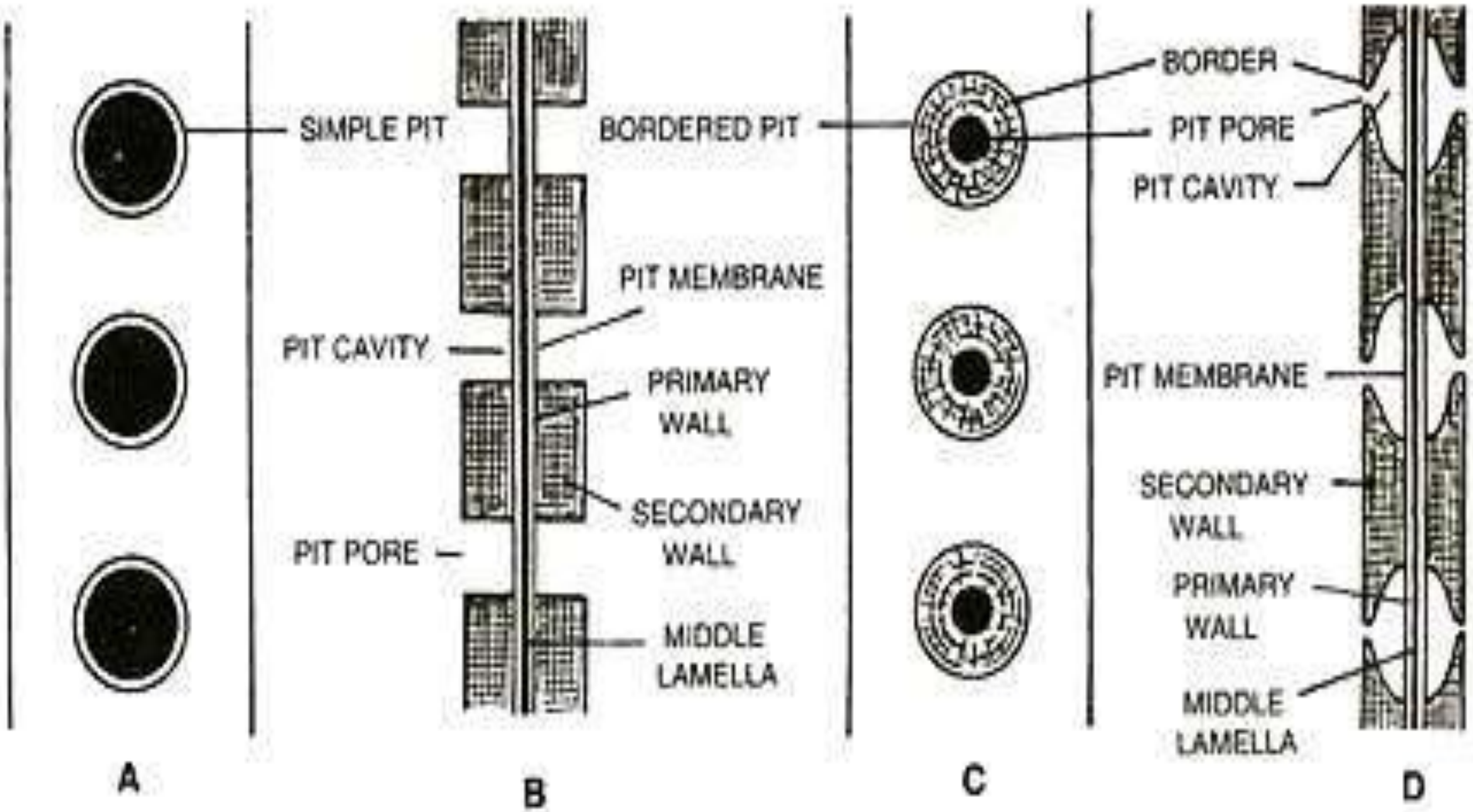


Fig. 8.18. Pits. A, surface view of simple pits. B, simple pit pairs in section. C, surface view of bordered pits. D, bordered pit pairs in section.

Meristems and its types

- Meristematic tissues are a group of young cells that are in a continuous state of division.
- These tissues are mostly found at the apices of root and shoot.

The main characteristics of cells of meristematic tissues are:

- (i) They are living and thin walled
- (ii) Vacuoles are few and small in size
- (iii) The cells contain a dense protoplasm and conspicuous nuclei
- (iv) The cells are spherical, oval or polygonal in shape
- (v) They do not store reserve food material and are in an active state of metabolism.

Types of Meristems

I. Classification based on origin and development:

On the basis of origin and development of initiating cells, meristems can be divided into three types:

(i) Promeristem or priordial meristem:

- A group of young meristematic cells of a growing organ. It is the early embryonic meristem from which other advanced meristems are derived. In a plant, it occupies a small area at the tip of stem and root. It further divides to form primary meristem.

(ii) Primary meristem:

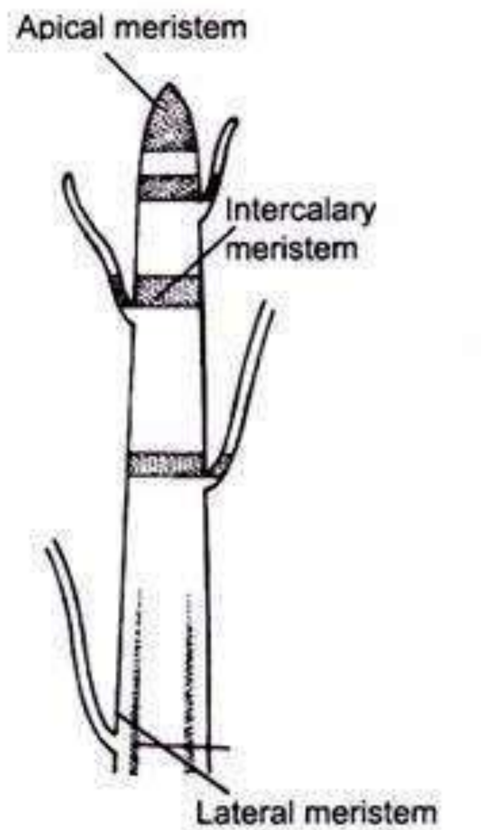
- These are derived from promeristem. They are present below the promeristem at shoot and root apices. These cells divide and form permanent tissues.

(iii) Secondary meristem:

- It is derived from primary permanent tissues which have the capacity of division e.g. Cork-cambium, cambium of roots and inter fascicular cambium of stem.

II. Classification on basis of position:

On the basis of their position in the plant body, meristems are of three types



(i) Apical meristem:

- These are found at the apices or growing points of root and shoot and bring about increase in length. It includes both pro-meristem as well as primary meristem.

(ii) Intercalary meristem:

- It lies between the region of permanent tissues and is considered| as a part of primary meristem which has become detached due to formation of intermediate permanent tissues. It is found either at the base of leaf e.g. Pinus or at the base of internodes e.g. grasses.

(iii) Lateral Meristem:

- These are arranged parallel to the sides of origin and normally divide periclinally or radially and give rise to secondary permanent tissues. These increase the thickness of the plant part.

III. Classification on basis of function:

On the basis of their function, meristems have been classified into three types:

(i) Protoderm meristem:

- It is the outermost layer of the young growing region which develops to form epidermal tissue system.

(ii) Procambium meristem:

- It is composed of narrow, elongated, prosenchymatous, meristematic cells that gives rise to the vascular tissues system.

(iii) Ground Meristem:

- It is composed of large, thick-walled cells which develop to for ground tissue system, i.e. hypodermis, cortex and pith.

IV. Classification on basis of plane of divisions:

The growth pattern and plane of division of meristematic tissue is important to govern the mode of growth.

These tissues can be divided into three types:

(i) Mass meristem:

- In such meristem, cell divisions occur in all planes resulting in an increase in volume. It can be observed in meristems of cortex and pith.

(ii) Rib or file meristem:

- The cells divide only on one plane e.g., formation of filaments in algae.

(iii) Plate meristem:

- These cells divide in two planes resulting to an increase in the area of an organ e.g. Leaf formation.

Theories of meristem

Apical cell theory

The theory was first proposed by Hofmeister (1857) and advanced by Nageli (1878). According to this theory, a single apical cell is the structural and functional unit of apical meristem which governs the entire process of apical growth. However, such organization has been found only in cryptogams.

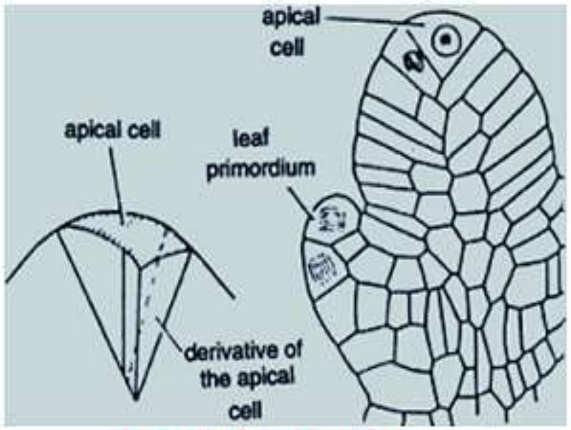
Histogen theory:

This theory was given by Hanstein (1868). According to this theory root and shoot apices consists of the central or inner mass called Plerome surrounded by the middle region composed of isodiametric cells called periblem and the outermost uniseriate layer of Dermatogen. Dermatogen gives rise to epidermis, periblem to cortex and endodermis and plerome to vascular bundle and pith. These three layers were called Histogen by Hanstein.

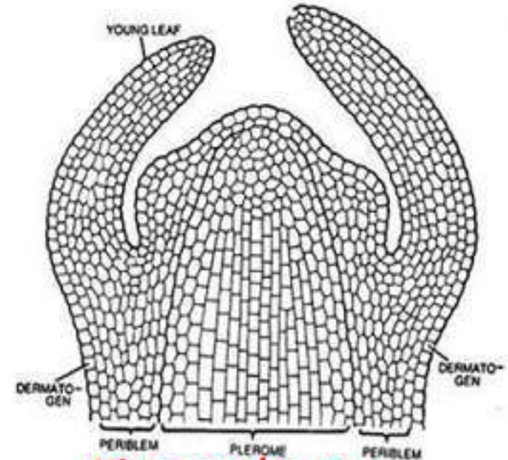
Tunica-corpus theory:

This theory was proposed by Schmidt (1924). According to this theory, mass of dividing cells are of two types: Tunica, the outer consisting of one position of different meristems or more peripheral layers of cells, forming the outer region and Corpus, the central undifferentiated multilayered mass of cell. Epidermis is derived from outer layer of tunica and other tissues from remaining layer of tunica and corpus.

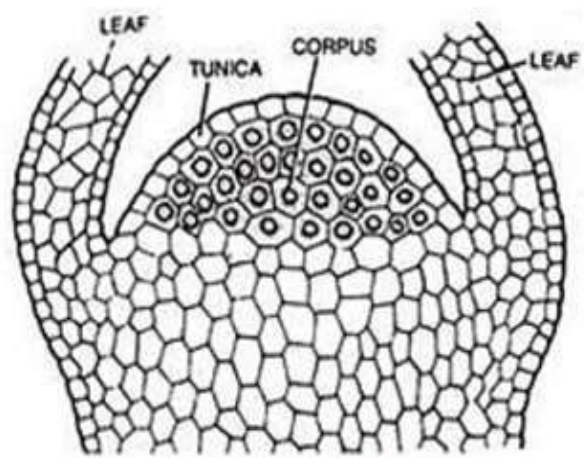
Theories explaining Apical Meristem



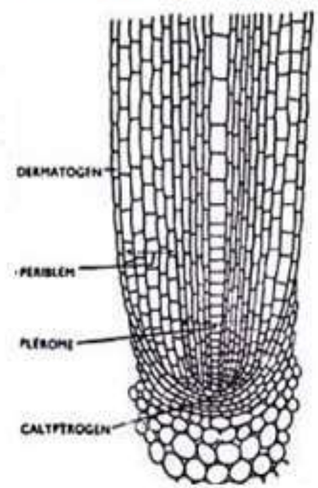
Apical cell theory



Histogen theory



Tunica Corpus theory



Shoot Apex

- The terminal part of the shoot with the leaf primordia is the shoot apex where primary organisation of the shoot is initiated.
- In size and shape it varies enormously, but in a general way it can be said that the shoot apex is more or less convex in longitudinal section.
- The apical meristem widens considerably before the initiation of the leaf and it again becomes narrow after the appearance of the leaf primordium, thus exhibiting a rhythmic phenomenon.
- The term plastochron has been used for the period between the initiation of two successive leaves. The shoot apex is usually small in angiosperms, but they are much wider in gymnosperms like Gingko and Cycas.

Shoot Apex - Angiosperms

- The generally accepted concept, tunica-corpus theory, demands that the tunica with one or few layers of cells forms an envelope round the centrally-located initials of the corpus.
- The number of layers of tunica may vary (one to nine) in the same family, genus and even in the same plant at different stages of growth. Two types of cells have been recognised in the tunica.
- One or few initials forming a central apical zone having larger size, more prominent nuclei and conspicuous vacuoles. The cells of this zone take light stain.
- The second zone consisting of comparatively smaller and deeply staining cells occur on the sides of the apex between the initials and the leaf primordium.

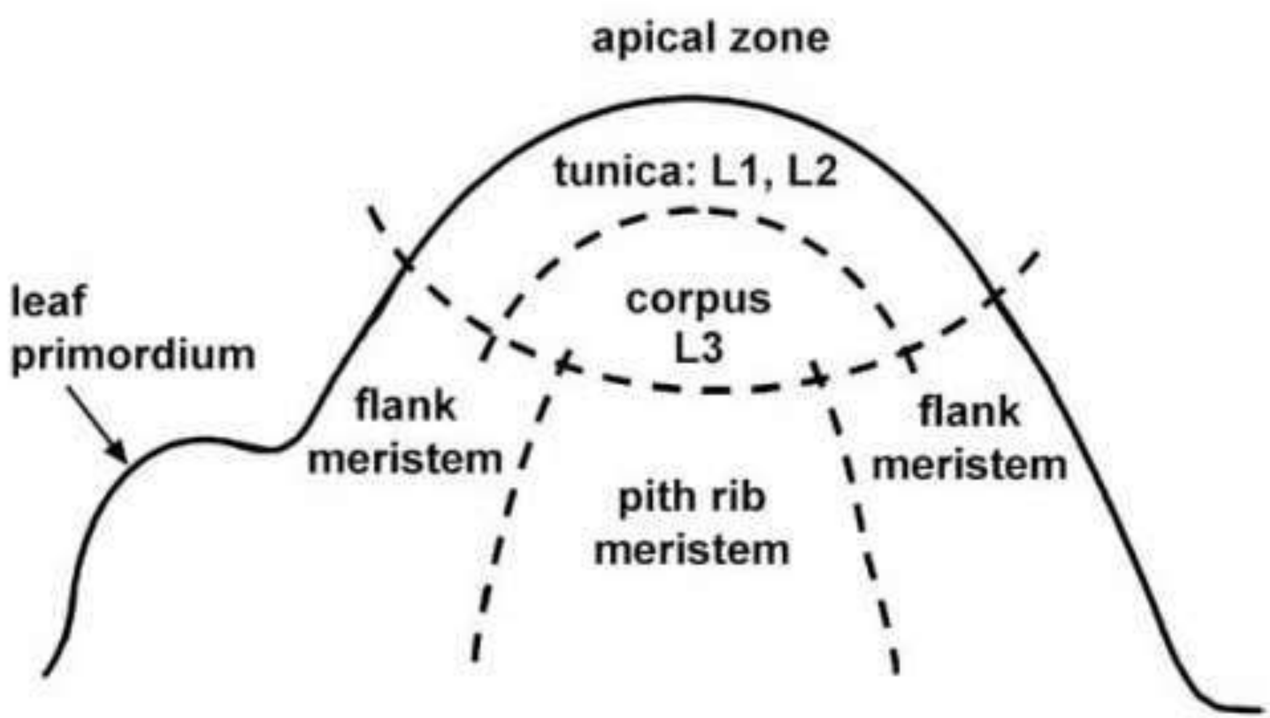


Figure 2.1 Diagram of angiosperm shoot apical organisation.

- According to internal arrangement, the corpus may be of two types—(1) the usual angiospermic type with three main zones, viz., (a) a zone of central mother cells representing the corpus initials, just below the apical portion of the tunica, (b) rib meristem, and (c) flank meristem, the last two appearing as continuations of central mother cells; (2) the Opuntia type, in which, a cup-shaped cambium-like transitional zone between the mother cells and other meristems have been recognised.
- This zone which is always associated with leaf primordium differs from the rest in that the height and diameter vary considerably during the plastochron. It is considered by some (Philipson, 1954) as only a temporary feature, because it disappears towards the end of the plastochron.

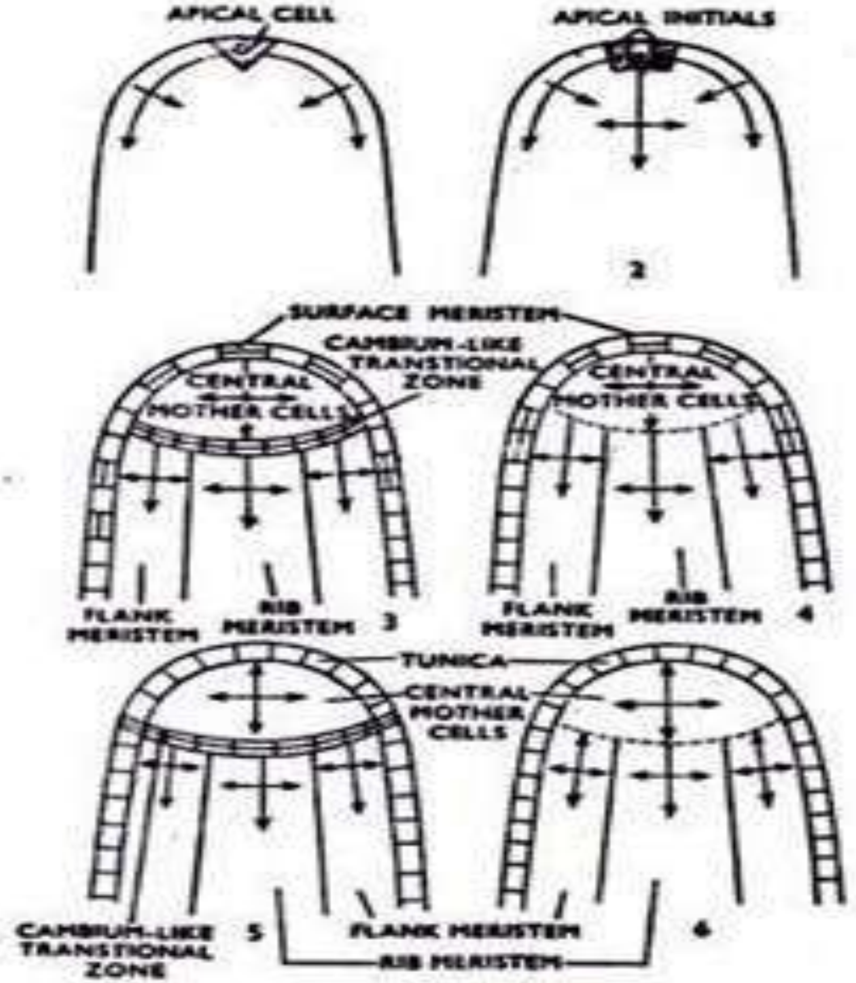


FIG. 532A. Shoot apics (diagrammatic). 1. A pteridaphyta with a single apical cell; 2. Same with apical initials; 3. *Gingko* type; 4. *Cryptomeria-Abies* types; 5. *Opuntia* type; 6. Usual angiospermic type. (*After Popham*).

Another concept about apical meristem developed on the basis of the rate of mitotic activity suggesting two zones—(1) a central apical zone with tunica and corpus initials having less frequent activity, and (2) a peripheral zone with pronounced mitotic cell division.

Many workers, mostly in France and hence called 'French school' (Plantefol, 1947-48; Buvat, 1952) maintained that an inactive zone exists at the shoot apex, which becomes active only during reproductive stage.

The vacuolated distal part of the apical meristem, according to them is of no significance in vegetative growth, the peripheral meristem with actively dividing cell and the rib meristem play the main roles in building the shoot.

The above view was seriously challenged and investigations were carried on from different aspects—histological (Popham, 1958) asserting considerable mitotic activity in the promeristem, in colcichine-induced cytochimeras (Dermen, 1951; Clowes, 1958) claiming ontogenetic continuity between promeristem and mature tissues, in tissue culture experiments suggesting the necessity of promeristem for the restoration of the entire shoot.

The Root Apex

- In comparison to the stem apex the apical meristem of the root is simpler, because of the absence of nodes and internodes and lateral appendages. But it has a protective cap, which acts as the buffer between the root-tip and the soil particles.
- As cap occupies the terminal position, the apical meristem is subterminal here. Curiously enough, growth in the root-tip proceeds in two directions opposite to each other—towards the tip in the cap and away from the tip in the root proper.
- Though histogen theory has been practically discarded in case of stem apex, it is followed in interpreting the structure and growth of root apex. The apical meristem here is rather short.
- Considerable variations exist in the relation between the cap and the tip. In fact, root apices are of a few types depending on the mode of origin of cap and relations between histogens and primary tissue regions of the root proper.
- In vascular cryptogams a solitary cell occurs at the root apex. In course of time the root proper and the cap are formed from the apical cell, though the cap and the root become structurally quite distinct.
- Two groups of initials occur at the apex of roots of many gymnosperms. Of the two the inner group forms the plerome, and the outer forms the periblem and the cap. Unlike other groups dermatogen does not occur at the apex.

- It is formed from the periblem a bit away from the apex as a ‘distal proliferation’. The outstanding features here are the formation of the cap from the cortex and at the same time outer layer of cortex becoming the epidermis—thus both cap and epidermis form the cortex.
- In angiosperms three groups of initials usually occur at the root apex. In dicotyledons (Fig. 533C), of the three groups, the terminal one forms the dermatogen and the cap; the median one forms the periblem; and the innermost one gives rise to the plerome.
- So here the cap and dermatogen have common origin. Thus cap may be considered a specialised development of the epidermis.
- In monocotyledons (Fig. 533D), the outermost group of initials produces the cap; the medium one, the dermatogen and periblem; and the inner-most one, the plerome.
- The group of initials forming dermatogen and periblem is usually one-layered, but it may be two or three layers in thickness. Independent origin of the cap is a notable feature. The histogen concerned with the formation of the cap is referred to as calyptrogen.
- The lateral and adventitious roots show same type of organisation.
- In recent years many investigators (Jensen, Clowes, and others) have claimed that a zone of low mitotic activity composed of the cells of the central part of the promeristem occur. It has been called quiscent centre.

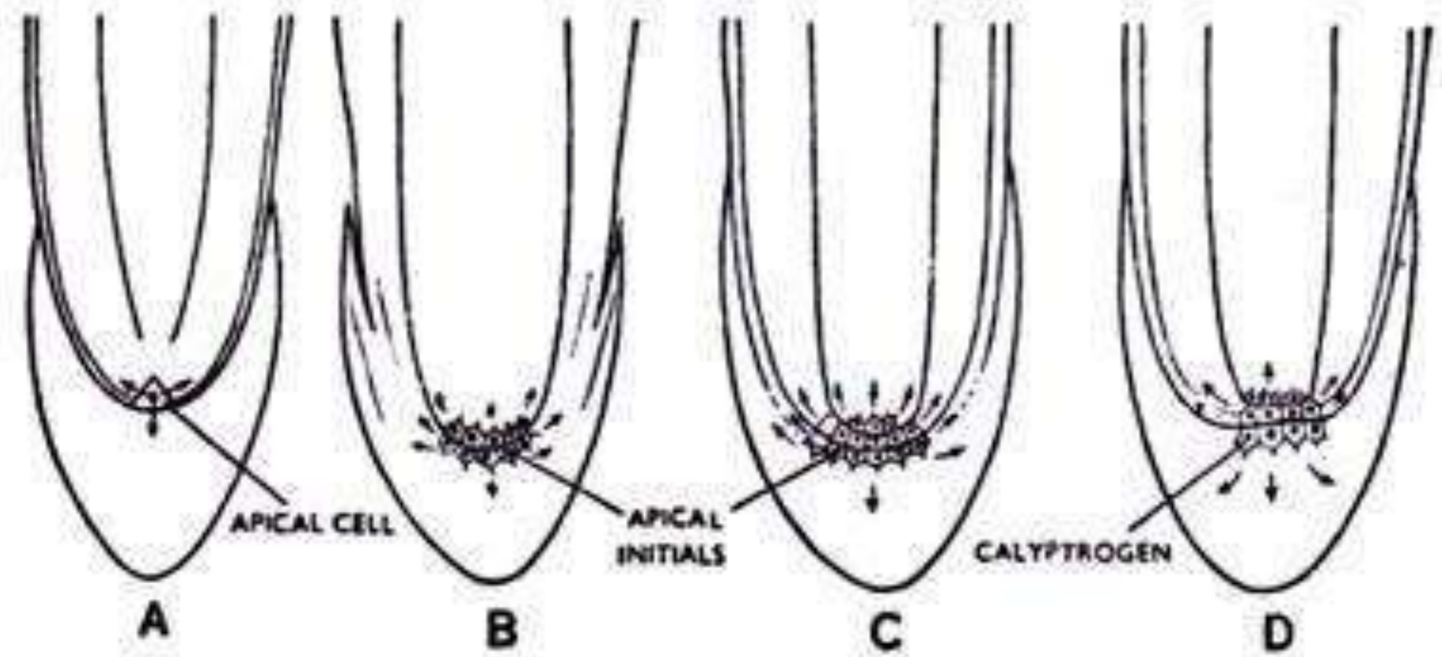
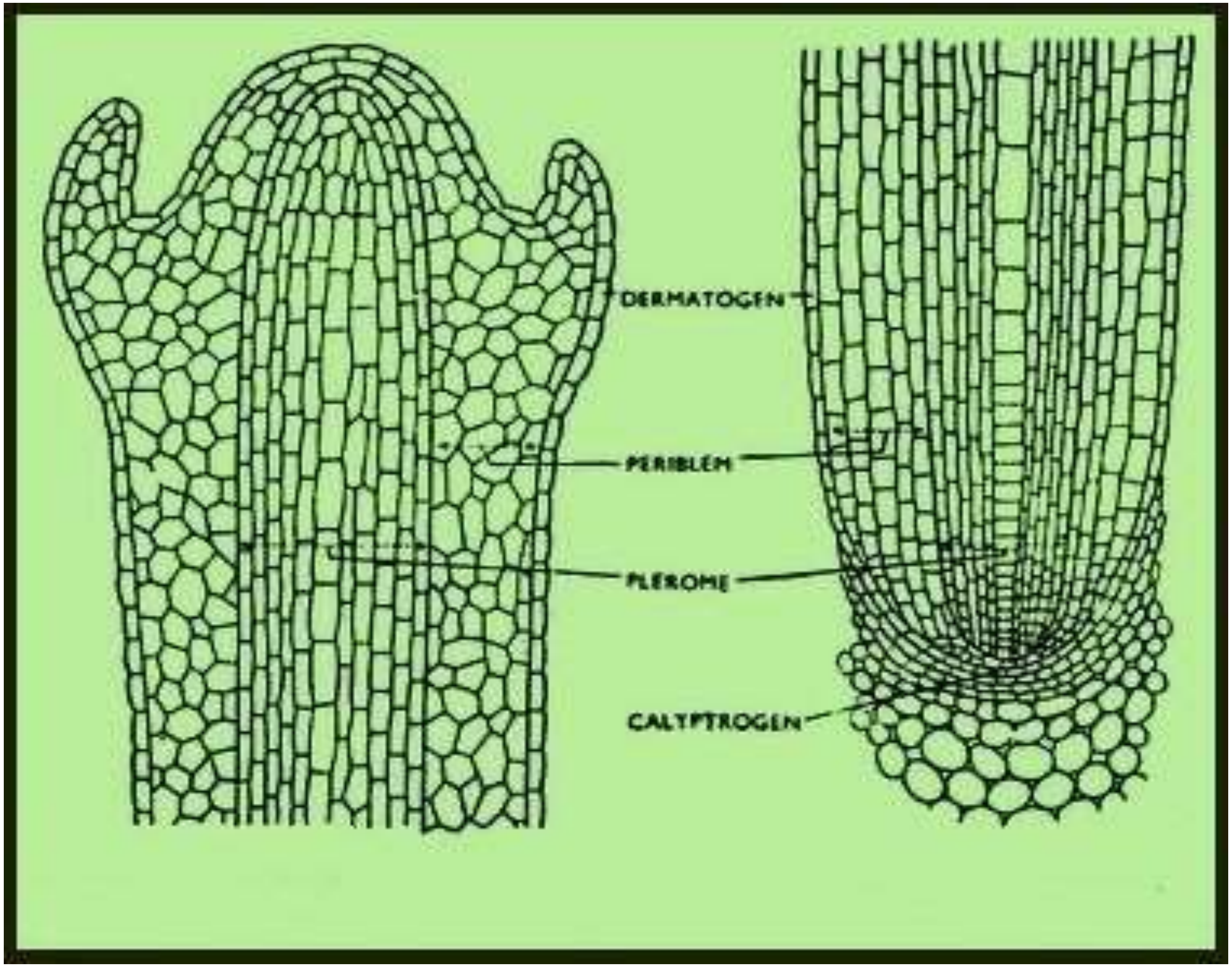


FIG. 533. Root apice. (diagrammatic)—A. Type found in pteridophytes with solitary apical cell. B. As found in gymnosperms. C. As found in dicotyledons. D. As found in monocotyledons.

- A theory—Kőrper-Kappe theory, more or less similar to the tunica-corpus of the shoot apex, was enunciated on the basis of planes of cell division. According to this theory there are two regions, outer (Kappe) and inner (Korper), and the cells divide in a pattern known as T-division.
- Kappe cells first divide horizontally and the derivatives divide at right angles to the plane of first division—the planes of two thus forming a T. In the inner region Korper T is inverted as the second division takes place in the upper daugher cells.

• Shoot and Root Apex



Plant Tissue System

- A tissue is a cluster of cells, that are alike in configuration and work together to attain a specific function. Different types of plant tissues include permanent and meristematic tissues.

Permanent tissues:

These cells have lost their ability to distribute but are specialised to offer elasticity, flexibility and strength to the plant. These tissues can be additionally categorised into:

- **Simple Permanent Tissue**: They can be classified into sclerenchyma, collenchyma and parenchyma based on their purpose.
- **Complex Permanent Tissue**: These tissues include phloem and xylem. Xylem is valuable for the transportation of water and solvable constituents. It is made up of xylem parenchyma, fibres, vessels and tracheids. Phloem is valuable in the transportation of food particles. Phloem consists of phloem parenchyma, phloem fibres, companion cells, sieve cells and sieve tubes.

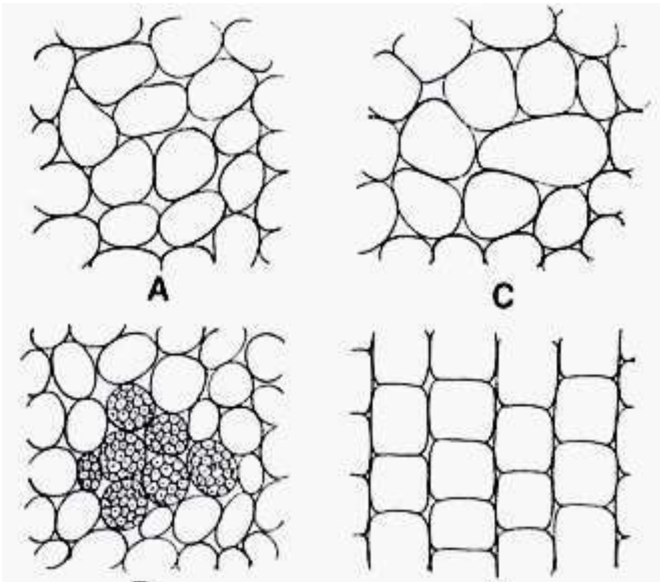
Simple Tissues

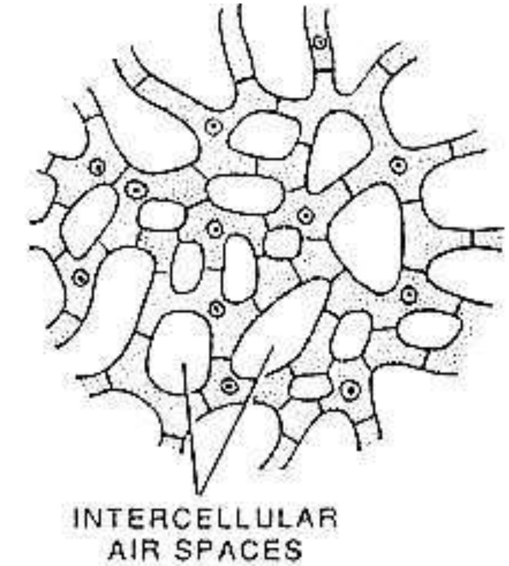
1. Parenchyma:

- The parenchyma tissue is composed of living cells which are variable in their morphology and physiology, but generally having thin walls and a polyhedral shape, and concerned with vegetative activities of the plant. The individual cells are known as parenchyma cells.
- The word parenchyma is derived from the **Greek para**, beside and **enchein**, to pour. This combination of words expresses the ancient concept of parenchyma as a semi- liquid substance poured beside other tissues which are formed earlier and are more solid.
- Phylogenetically the parenchyma is a primitive tissue since the lower plants have given rise to the higher plants through specialization and since the single type or the few types of cells found in the lower plants have become by specialization the many and elaborates types of the higher plants.
- The unspecialized meristematic tissue is parenchyma and is often called parenchyma thus it can be said that, ontogenetically parenchyma is a primitive tissue.

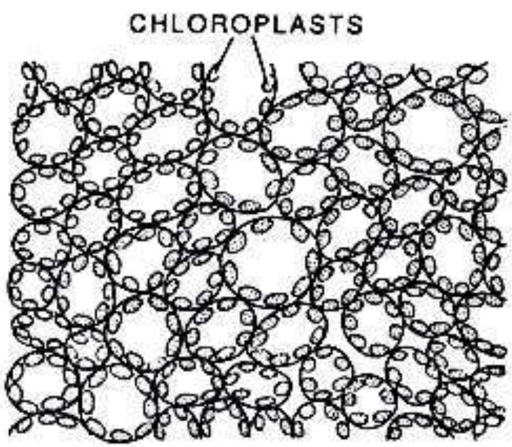
Types of parenchyma tissue

Parenchyma

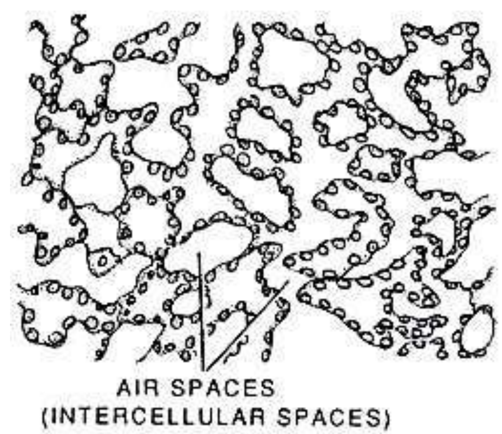




Aerenchyma—in the petiole of *Canna.*



Palisade parenchyma.



Spongy chlorenchyma.

Characteristics of parenchyma cells

- The parenchyma consists of isodiametric, thin-walled and equally expanded cells.
- The parenchyma cells are oval, rounded or polygonal in shape having well developed spaces among them.
- The cells are not greatly elongated in any direction.
- The cells of this tissue are living and contain sufficient amount of cytoplasm in them. Usually each cell possesses one or more nuclei.
- Parenchyma makes up large parts of various organs in many plants. Pith, mesophyll of leaves, the pulp of fruits, endosperm of seeds, cortex of stems and roots, and other organs of plants consist mainly of parenchyma.
- The parenchyma cells also occur in xylem and phloem.
- Commonly the parenchyma cells have thin primary walls.
- Some such cells may have also thick primary walls.
- Some storage parenchyma develop remarkably thick walls and the carbohydrates deposited in these walls, the hemicellulose, are regarded by some workers as reserve materials.

- When the parenchyma cells are exposed to light they develop chloroplasts in them, and such tissue is known as **chlorenchyma**.
- The chlorenchyma possesses well developed aerating system. Intercellular spaces are abundant in the photosynthetic parenchyma (chlorenchyma) of stems too.
- The parenchyma cells that contain chloroplasts in them make chlorenchymas which are responsible for photosynthesis in green plants.
- In water plants the **aerenchyma** keep up the buoyancy of the plants.
- Such air spaces also facilitate exchange of gases.
- In many succulent and xerophytic plants such tissues store water and known as water storage tissue.
- Vegetative propagation by cuttings takes place because of meristematic potentialities of the parenchyma cells which divide and develop into buds and adventitious roots.

Origin of parenchyma

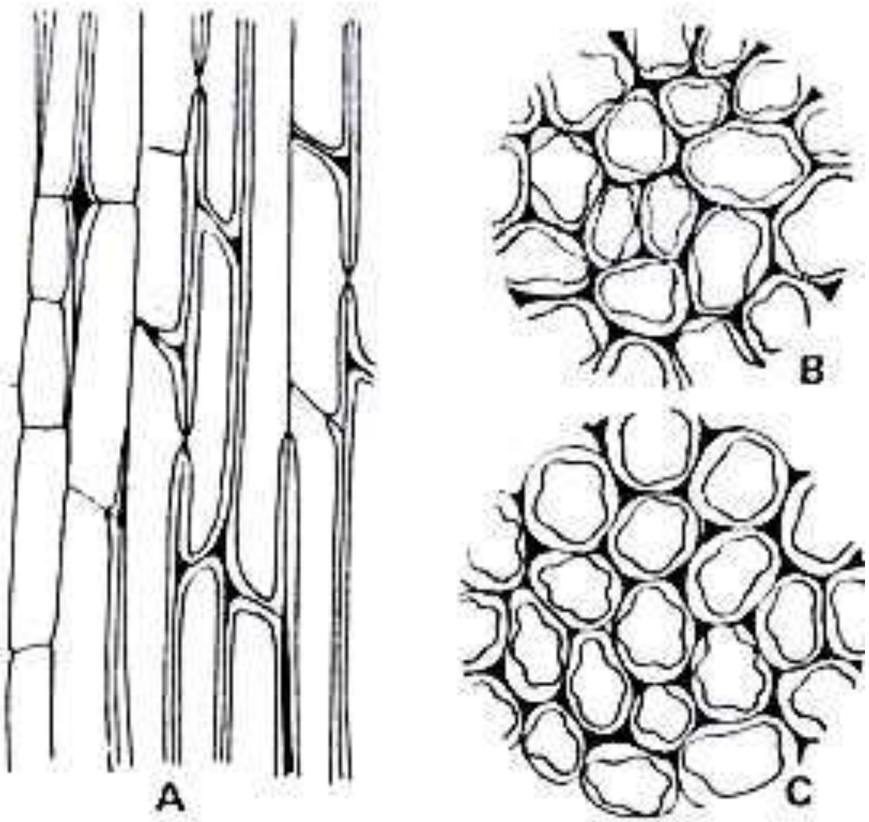
- The parenchyma tissue of the **primary plant body**, that is, the parenchyma of the cortex and the pith, of the mesophyll of leaves, and of the flower parts, differentiates from the **ground meristem**. The parenchyma associated with the primary and secondary vascular tissues is formed by the pro-cambium and the vascular cambium respectively.
- Procambium—parenchyma associated with the primary vascular tissues.
- Vascular cambium—parenchyma associated with the secondary vascular tissues.
- Parenchyma may also develop from the phellogen in the form of phelloderm, and it may be increased in amount by diffuse secondary growth.
- Phellogen—Phelloderm (parenchyma).

Collenchyma and its characters

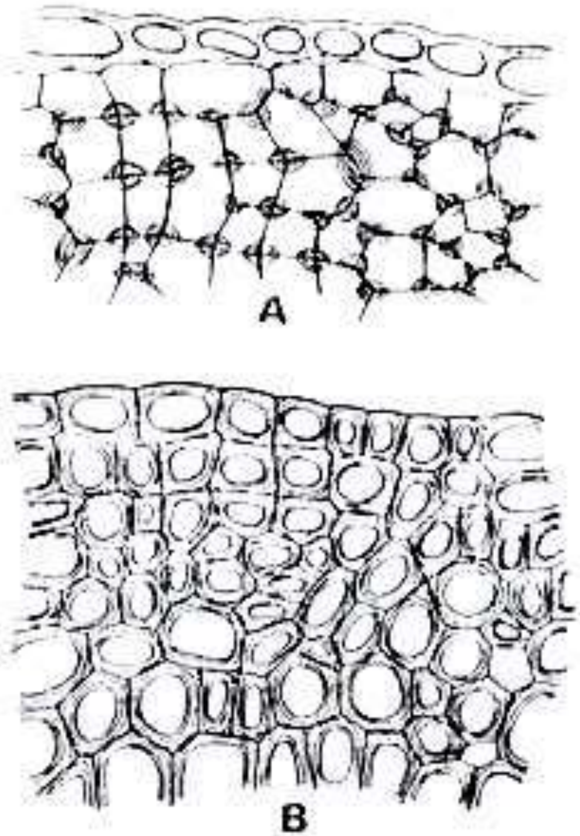
- Collenchyma is a living tissue composed of somewhat elongated cells with thick primary non-lignified walls.
- Its early development and its adaptability to changes in the rapidly growing organ, especially those of increase in length.
- When the collenchyma becomes functional, no other strongly supporting tissues have appeared.
- It gives support to the growing organs which do not develop much woody tissue. Morphologically, collenchyma is a simple tissue, for it consists of one type of cells.
- Collenchyma is a typical supporting tissue of growing organs and of those mature herbaceous organs which are only slightly modified by secondary growth or lack such growth completely.
- It is the first supporting tissue in stems, leaves and floral parts.
- It is the main supporting tissue in many dicotyledonous leaves and some green stems.
- Collenchyma may occur in the root cortex, particularly, if the root is exposed to light.

- Collenchyma chiefly occurs in the peripheral regions of stems and leaves. It is commonly found just beneath the epidermis. In stems and petioles with ridges, collenchyma is particularly well developed in the ridges. In leaves it may be differentiated on one or both sides of the veins and along the margins of the leaf blade.
- The collenchyma consists of elongated cells, various in shape, with unevenly thickened walls, rectangular, oblique or tapering ends, and persistent protoplasts. The cells overlap and interlock, forming fibre-like strands. The cell walls consist of cellulose and pectin and have a high water content.
- They are extensible, plastic and adapted to rapid growth. In the beginning the strands are of small diameter but they are added to, as growth continues, from surrounding meristematic tissue. The border cells of the strands may be transitional in structure, passing into the parenchyma type.

- Based on the cell arrangement there are three types of collenchyma — angular, lamellar and tubular.
- In angular type the cells are irregularly arranged (e.g., Ficus, Vitis, Polygonum, Beta, Rumex, Boehmeria, Morus, Cannabis, Begonia);
- In lamellar type the cells lie in tangential rows (e.g., Sambucus, Rheum, Eupatorium)
- In tubular type the intercellular spaces are present (e.g., Compositae, Salvia, Malva, Althaea).
- The walls of collenchyma are chiefly composed of cellulose and pectic compounds and contain much water. The common typical condition is that with thickenings at the corners.
- In many plants collenchyma is a compact tissue lacking intercellular spaces. Instead, the potential spaces are filled with intercellular material.
- The mature collenchyma cells are living and contain protoplasts. Chloroplasts also occur in variable numbers. They are found abundantly in collenchyma which approaches parenchyma in form. Collenchyma consisting of long narrow cells contains only a few small chloroplasts or none. Tannins may be present in collenchyma cells.
- The chief primary function of the tissue is to give support to the plant body. Its supporting value is increased by its peripheral position in the parts of stems, petioles and leaf midribs. When the chloroplasts are present in the tissue, they carry on photosynthesis.



Collenchyma. A and B, longitudinal and transverse sections from stem of *Solanum tuberosum*; C, transverse section from stem of *Abutilon*.



Collenchyma. A, angular collenchyma of *Cucurbita* stem (thickenings in the angles); B, lacunar collenchyma of *Lactuca* stem where intercellular spaces are present and the thickenings are located next to these spaces.

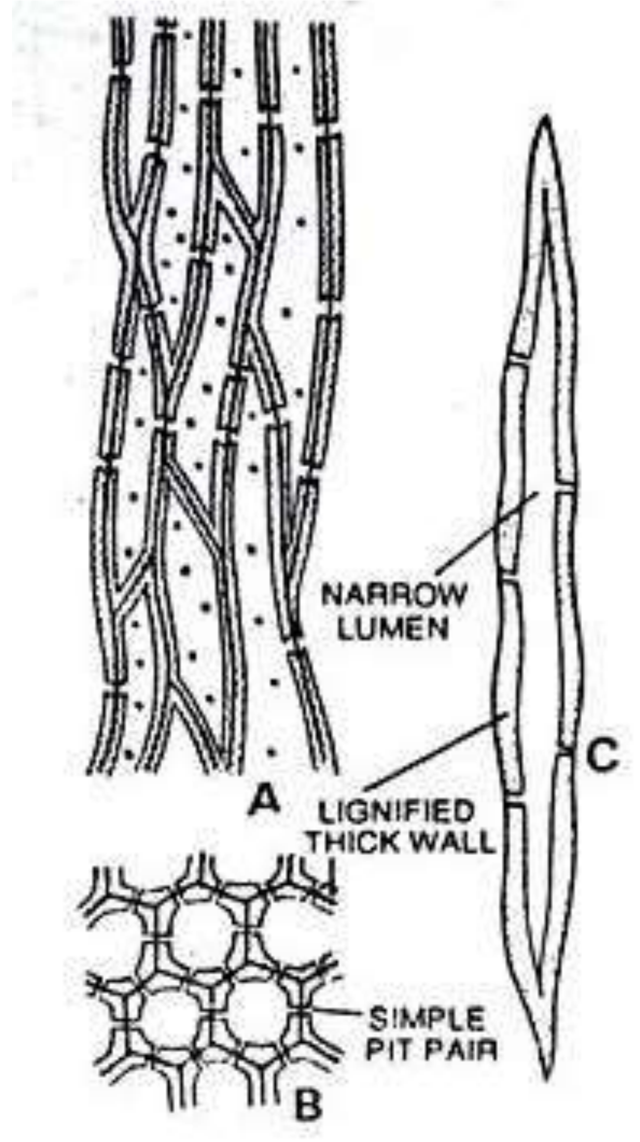
Sclerenchyma

- The sclerenchyma (Greek, sclerous, hard; enchyma, an infusion) consists of thick walled cells, often lignified, whose main function is mechanical.
- This is a supporting tissue that withstands various strains which result from stretching and bending of plant organs without any damage to the thin-walled softer cells.
- The individual cells of sclerenchyma are termed sclerenchyma cells. Collectively sclerenchyma cells make sclerenchyma tissue.
- Sclerenchyma cells do not possess living protoplasts at maturity. The walls of these cells are uniformly and strongly thickened.
- Most commonly, the sclerenchyma cells are grouped into fibres and sclereids.

The fibres are elongate sclerenchyma cells, usually with pointed ends. The walls of fibres are usually lignified. Sometimes, their walls are so much thickened that the lumen or cell cavity is reduced very much or altogether obliterated. The pits of fibres are always small, round or slit-like and often oblique.

The fibres are abundantly found in many plants. They may occur in patches, in continuous bands and sometimes singly among other cells. They are dead and purely mechanical in function. They provide strength and rigidity to the various organs of the plants to enable them to withstand various strains caused by outer agencies. The average length of fibres is 1 to 3 mm. in angiosperms.

The fibres are divided into two large groups xylem fibres and extraxylary fibres.



Sclerenchyma. A, L.S. of fibres; B, T.S. of fibres; C, a single fibre

Sclereids

- The sclereids are widely distributed in the plant body.
- They are usually not much longer than they are broad, occurring singly or in groups.
- Usually these cells are isodiametric but some are elongated too.
- They are commonly found in the cortex and pith of gymnosperms and dicotyledons, arranged singly or in groups. In many species of plants, the sclereids occur in the leaves.
- The leaf sclereids may be few to abundant. In some leaves the mesophyll is completely permeated by sclereids. Sclereids are also common in fruits and seeds.
- In fruits they are disposed in the pulp singly or in groups (e.g., Pyrus). The hardness and strength of the seed coat is due to the presence of abundant sclereids.
- The secondary walls of the sclereids are typically lignified and vary in thickness.
- In many sclereids the lumina are almost filled with massive wall deposits and the secondary wall shows prominent pits.
- Commonly the pits are simple and rarely bordered pits may also occur.

The sclereids are grouped into four categories (Foster, 1949).

1. Brachysclereids:

These stone cells or sclereids are short and more or less isodiametric. They are commonly distributed in cortex, phloem and pith of stem and in the pulp of fruits.

2. Macrosclereids:

They are more or less rod-like cells forming palisade-like epidermal layer of many seeds (of Leguminosae) and fruits and frequently found in xerophytic leaves and stem cortices.

3. Osteosclereids:

They are bone-shaped sclereids, i.e., columnar cells are enlarged at their ends. Such sclereids are commonly found in the hypodermal layers of many seeds and fruits. They are also found in xerophytic leaves.

4. Astrosclereids:

They are star-shaped sclereids; such sclereids with lobes projecting, like hairs are commonly found in the intercellular spaces of the leaves and stems of hydrophytes.

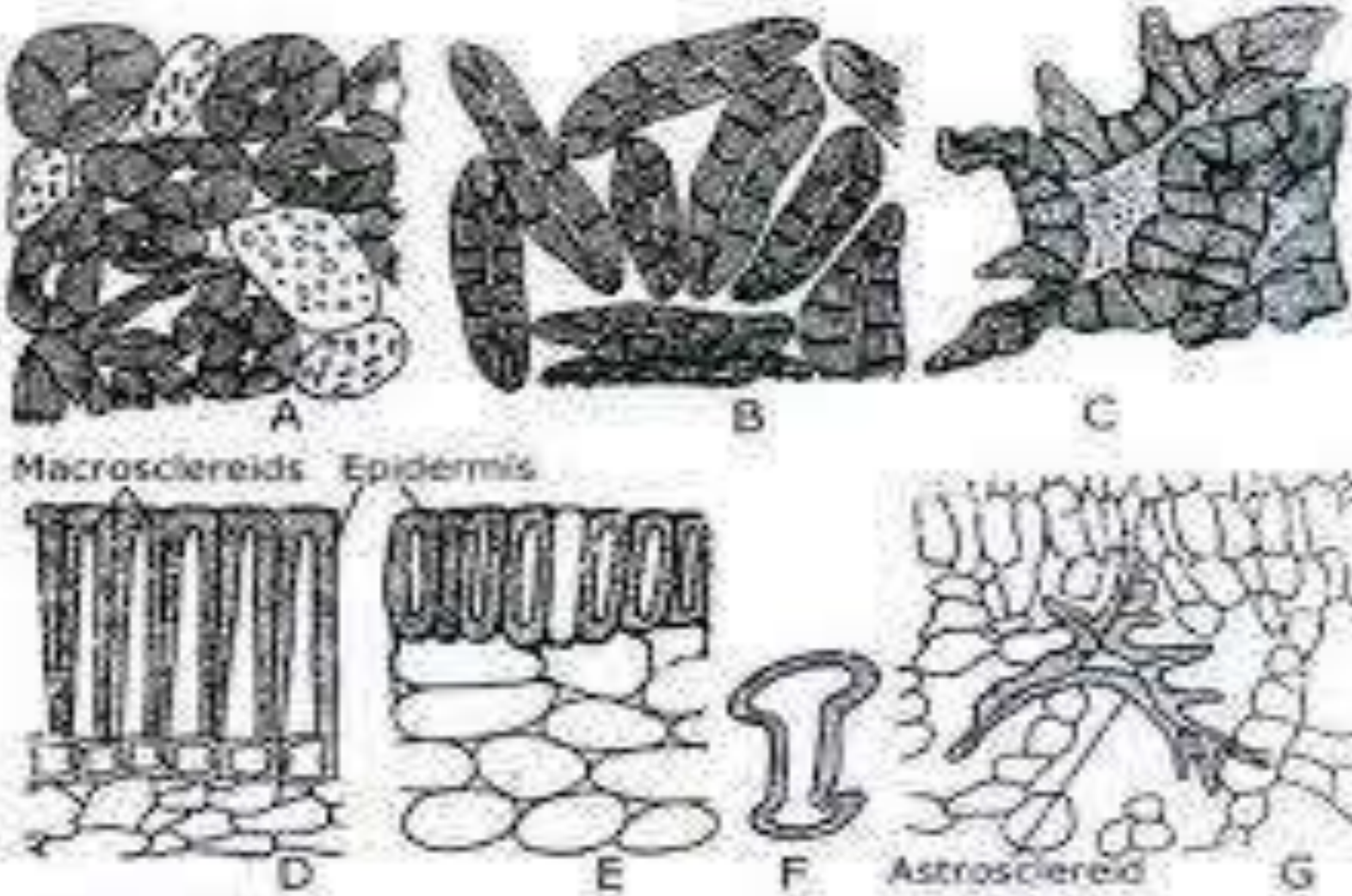
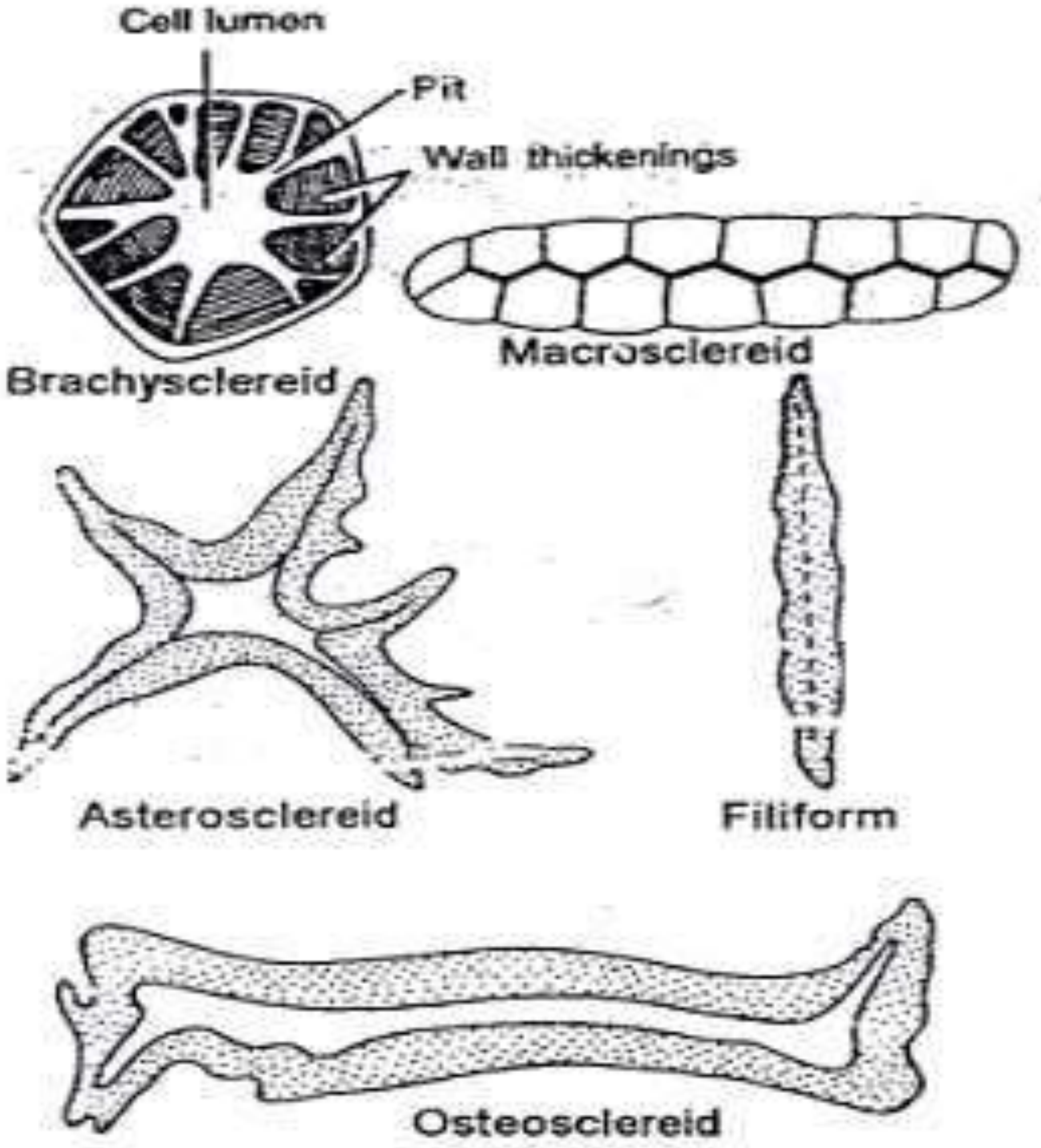


Figure 8.5

Sclereids. A. Brachysclereids from flesh of *Pyrus*. B. Same from *Cocos*. C. Irregular sclereids from *Tsuga*. D. Macrosclereids from epidermis of *Phaseolus* and E. from epidermis of *Allium sativum*. F. Osteosclereids from seed coat of *Pisum*. G. Astrosclereid from a leaf.



Types of stone cells