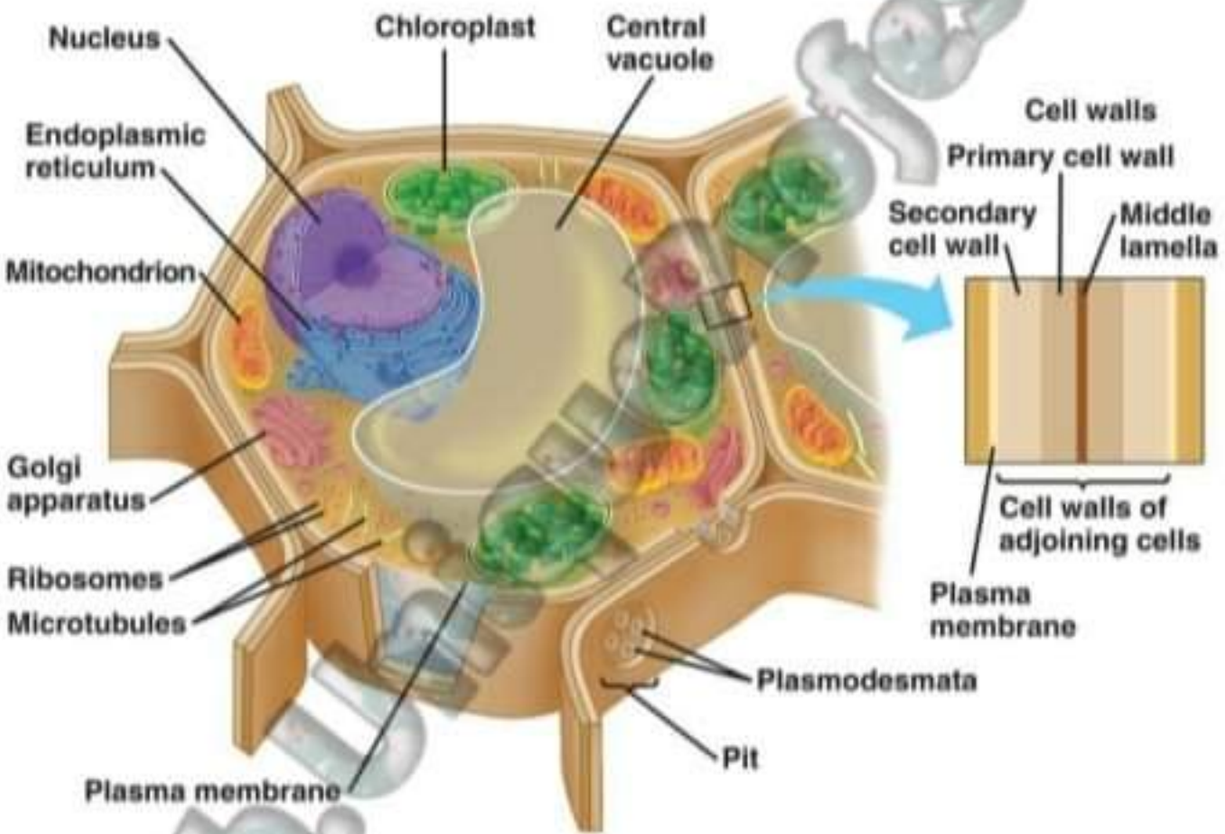
The Cell Wall

Cell wall is a characteristic of a plant cell and it distinguishes it from the animal cell. The cell wall is considered as an Ergastic Substance, i.e., secreted by the living substance (protoplasm) but it-self is non-living. The synthesis of cell wall is controlled by Golgi complex.



Three layers of cell wall can be distinguished:

Middle Lamella:

It is the cement that holds the individual cells together and it is found between the primary cell walls of neighbouring cells. It is an amorphous substance and isotropic. It may also fill the intercellular spaces in the supporting tissue. The middle lamella mainly consists of pectic substances. The pectinase enzyme can dissolve the middle lamella and as a result the tissue can separate into individual cells. This process is termed as **Maceration.**

Primary Wall:

It is the first wall that develops in the new cell by protoplasm. The wall is formed of cellulose. It is the wall develops in growing cells. It is thin and elastic.

Secondary Wall:

It is found on the inner surface of the primary wall. It begins to develop in cells or parts of them which have ceased to grow. Generally, three layers of secondary wall can be observed the outer layer, central layer and the inner layer. The central layer is usually the thickest. It mainly consists of cellulose and is rigid.

Tertiary Wall:

In some cases, a wall is present on the inner side of the secondary wall. This is called tertiary wall. It is dried up residue of degenerated plasma lining.

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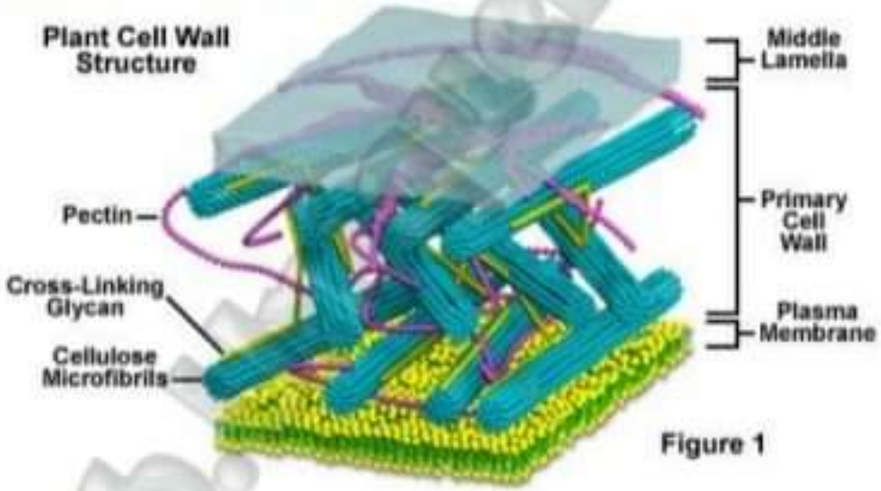


Figure 1

Formation of Wall:

During cell division, at telophase new cell wall formation takes place. The **Phragmoplast**, a fibrous steucture formed by microtubules, appears during mitosis between the two daughter nuclei and within the cell plate which divides the parent cell in two. It widens and become barrel shaped. At the same time the cell plate (first partition between the new protoplasts) begins to form inside the phragmoplasts. The microtubles of phragmoplasts disappear from the area in which the Cell Plate is formed and regenrate at the circumference of the cell plate. With the enlargement of the cell plate, the

microtubules of the phragmoplasts approach the wall of the dividing cells, the phragmoplast disappear. The cell plate formed of pectic compounds (Ca & Mg pectate). The cell plate gradually undergoes changes to form the middle lamella.

On both sides of the middle lamella, thin lamellae are laid down by the daughter protoplast. This is the beginning of the development of the new walls of the daughter cells. The walls consist of cellulose Microfibrils and of non-cellulose matrix. The matrix of the wall consists of pectic substances and hemicelluloses.

The new and old middle lamellae are separated from one another by the primary wall of the parent cell. The secondary wall develops on the inner surface of the primary wall and is composed of cellulose microfibrils. The matrix consisting of polysaccharides, deposit of lignin, suberin, cutin, waxes etc.

Structure of Cell Wall:

Primary Structure:

Cell wall has complex structure and can be divided into different layers. Cell walls vary greatly in composition and morphology according to the age and function of cell. It has following demarcation.

Primary Wall:

The outer most layer of cell wall is known as primary wall which is elastic and transparent. It is first formed wall in developing cell and may remain primary in many types of mature cells. The primary wall undergo increase in length and size as the cell grows. The primary wall is chiefly formed of cellulose, hemicelluloses and pectic material. The primary wall may increase in thickness but this thickness is due to successive layer of cellulose layer towards the inner side of the cell.

Middle Layer:

Middle Layer join the primary walls of cells. At maturity, it is not differentiated from the primary wall due to deposition of lignin in both the layers.

Secondary Wall:

Secondary wall laid down inner to the primary wall when the primary wall cessation of growth of the cell. The secondary wall has no surface growth but

undergo increase in thickness. The thickness is due to deposition of successive layers of lignin inside the primary wall. At maturity, some cells like tracheida the protoplast is replaced by secondary wall. So, the cells become dead at maturity.

Sub-Microscopic Structure of Cell Wall:

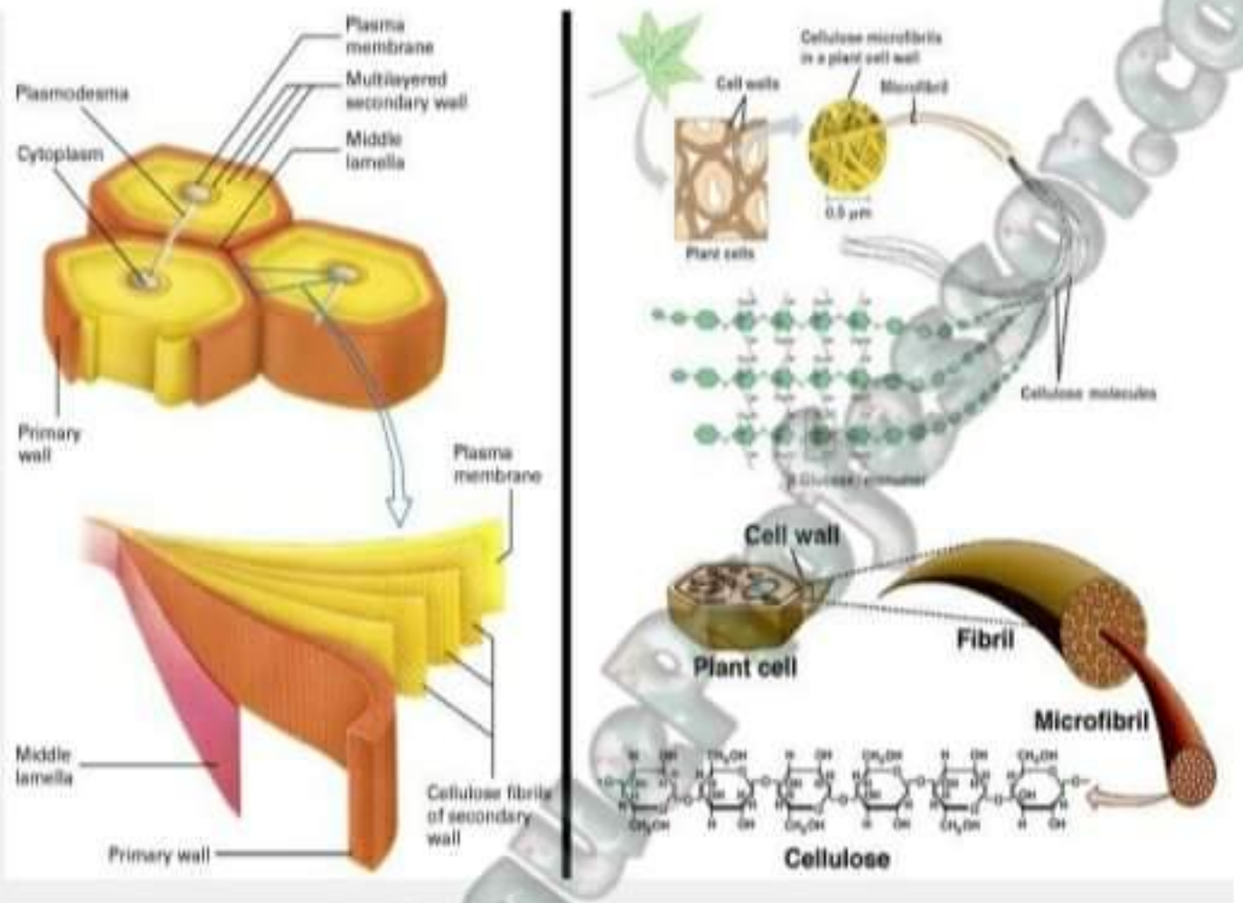
The bundles of cellulose molecules (micelle) are interconnected by the means of the lower chain molecules and form a porous coherent system, the **Miceller System,** interpenetrated by an equal coherent system, formed of microcapillary spaces filled with non-cellulose matrix like lignin, cutin, suberin, hemi-cellulose, etc. The **Intermiceller System.**

As the cell matures additional substance are introduced in place of the matrix in which the cellulose framework is embedded. This process is termed as **Increstation.** As a result of this additional change in chemical nature of cell wall takes place. Most important incrusting process is **Lignification** (addition of lignin), While **Suberisation** (addition of suberin), and **Cutinisution** (addition of cutin), also take place.

Ultra-Structure of Cell Wall:

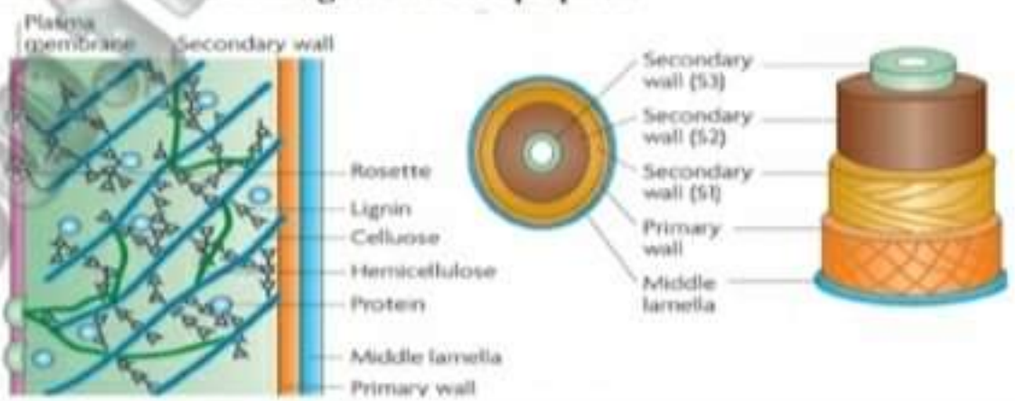
Structurally the cell wall is considered to be a fine interwoven network of cellulose strands of varying complexity and size. The compound microscope shows that the cell wall is composed of large fibrils, the Microfibrils. But the electron microscope reveals that the fundamental units of the miceller system is chain-like cellulose molecules of different lengths formed of about (3000 to 6000 glucose molecules linked together). Approximately 100 cellulose chains aggregate to form an Elementary fibril or miceller.

The miceller are interconnected with each other and form a coherent porous system the Miceller System. The elementary fibril or miceller form a bundle Microfibrils. Each microfibrils about 2000 cellulose molecules or (20) twenty micelle. Microfibrils in turn to form Macrofibrils containing about 500,000 cellulose molecules.



Orientation of Microfibrils:

The orientation of microfibrils and micelle in the secondary walls differ in different plants. In cell walls with three layers of secondary wall (vessel members, trachieds, fibres), the orientation in the outer layer and inner layer is almost horizontal or the microfibrils are orientated in a very low spiral. The orientation in the central layer is almost parallel to the long axis of the cells, the microfibrils are arranged in a steep spiral.



Thickening of Cell Wall:

The secondary thickening due to lignification is uniform all around the cell but in trachieds and vessels the thickening localized to specific areas. The secondary thickenings of lignin may form various patterns. These are:

Annular (Ring-Like): Rings of lignin are deposited one above the other in the anterior of the original c ell wall.

Spiral (Helical-Like): Thickening of lignin are deposited in the form of spiral bands.

Scalariform (Ladder-Type): Lignin is deposited in the form of the steps of a ladder along the inner side of the cell wall.

Reticulate: The lignin thickening is deposited in irregular manner and a network is formed.

Pitted: The entire inner surface of cell wall is thickened, leaving small untickened areas called pits.

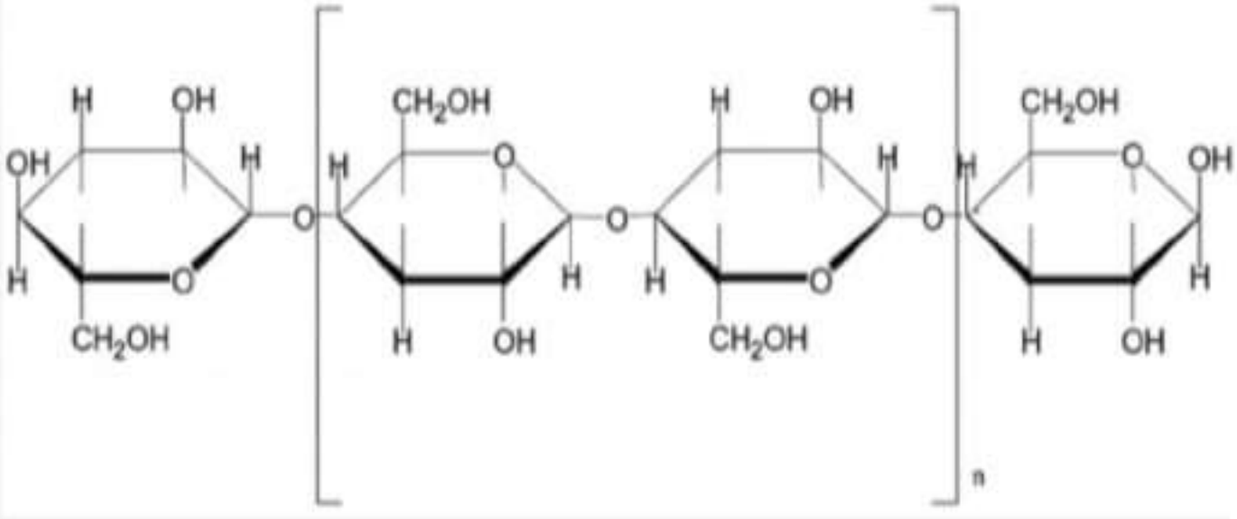
Chemical Composition of Cell Wall:

The cell is composed of following chemical compounds.

Cellulose:

It is a carbohydrate and the most common compound present in cell walls. It is a hydrophilic, Crystalline, compound polysaccharide. The molecules of the cellulose are chain-like and are formed by glucose residues held together by oxygen though beta-linkage. Most of the cell wall is formed of it.

Cellulose Structure



Hemicellulose: It is a group of polysaccharides with different solubilities, such as xylans, mannans, glucans, etc.

Pectic Substances:

They are closely related to the hemicelluloses. They found in three forms, protopectin, pectic and pectic acid and are polymers composed of uronic acid. The pectic compounds are amorphous and hydrophilic. They form middle lamella.

Lignin:

It is a polymer of high carbon content, distinct from carbohydrates. The lignin of conifers and dicots differ from one another. Its deposition bring change in the chemical nature off cell wall.

Cutin, Suberin & Waxes:

These are fatty substances, Cutin and Suberin are closely related, polymerized compounds consisting of fatty acids. Suberin occurs in association with cellulose in cork cells of periderm. Cuin occurs with cellulose in the outer walls of epidermis. Cutin forms a contnous layer, The Cuticle, on the surface of the epidermis of all aerial parts.

Gums & Mucilages:

These are related to pectic substances and swell up in water. Gums appear in plants due to break-down of wall and cell components. Mucilages appear in some gelatinous or mucilaginous types of cell walls.

Formation of Intracellular Spaces:

The intercellular spaces are formed by two methods:

The cell walls are separated each other along areas of contact. The mechanism is thought to involve splitting of the middle lamella. Such intercellular spaces are called Schizogenous Intercellular Spaces. The intra-wall cavity, which is formed for making collection of middle lamella with the mother middle lamella develops into an intercellular space. If a similar space is already present, the new intercellular space joins it to form large single space.

Sometimes the intercellular space is formed by the dissolution of entire cell. Such intercellular spaces are termed as Lysigenous Intercellular Spaces for example, large air spaces present in aquatic plants and in some monocot roots, and secretory cavities found in *Citrus*.