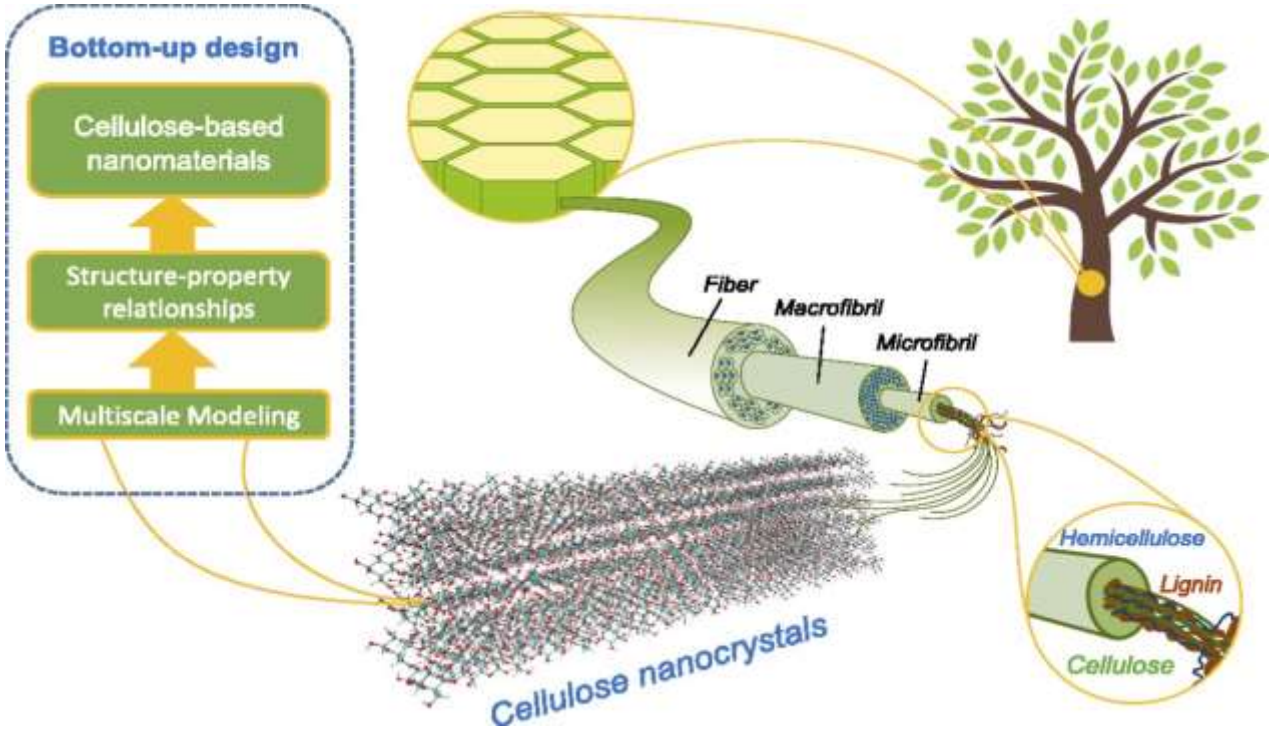
“Cytology and Research Techniques in Life Sciences”

B. Sc III Sem V Sec I

“Cell as a Unit of Life”

by Dr. A. R. Alvikar

Ultra structure of cell wall



Ultra-structure of plant cell wall

The primary wall and the secondary wall have the same basic structure.

❖Cellulose micro-fibrils (chief constituent) are found embedded in an amorphous gel-like matrix (proteins and two polysaccharides :**hemicelluloses and pectins**)

❖Each cellulose chain (1 -5 μm long) consists of about **2000-25000 glucose units**.

❖Nearly 100 cellulose chains arranged parallel to form minute bundle called **crystalline domain or micelle** (1.0 nm thick).

❖ Micelle is the smallest structural unit of cell wall.

❖About **20-40 micelles** assemble in the matrix to form a **microfibril (**2.6 nm thick).

❖Nearly **250 microfibrils** aggregate in bigger bundles called **macrofibrils** (~ 0.5 μm in diameter, may reach, 4μm in length).

A cotton fiber has 1500 macro fibrils.

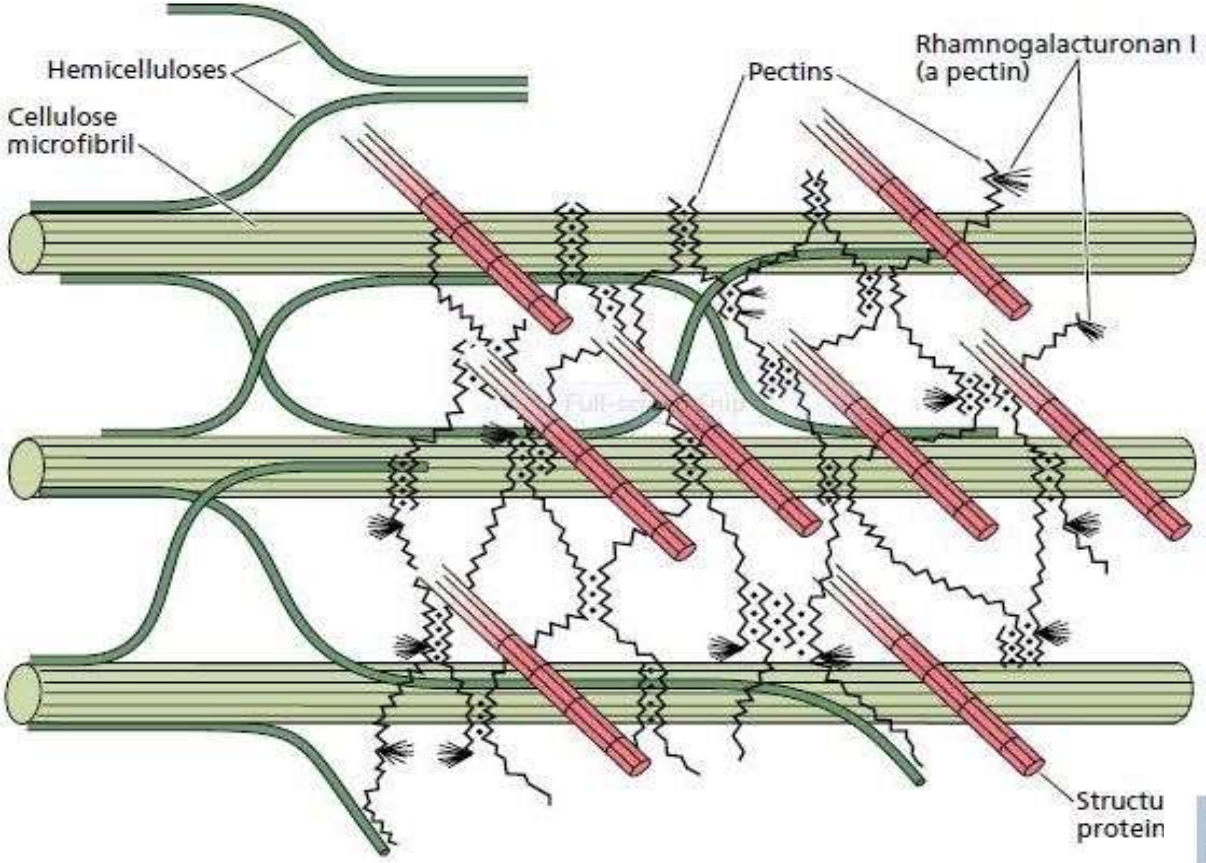


FIGURE 15.4 Schematic diagram of the major structural components of the primary cell wall and their likely arrangement. Cellulose microfibrils are coated with hemicelluloses (such as xyloglucan), which may also cross-link the microfibrils to one another. Pectins form an interlocking matrix gel, perhaps interacting with structural proteins. (From Brett and Waldron 1996.)

TABLE 15.1
Structural components of plant cell walls

Class	Examples
Cellulose	Microfibrils of (1→4)β-D-glucan
Matrix Polysaccharides	
Pectins	Homogalacturonan
	Rhamnogalacturonan
	Arabinan
	Galactan
Hemicelluloses	Xyloglucan
	Xylan
	Glucomannan
	Arabinoxylan
	Callose (1→3)β-D-glucan
	(1→3,1→4)β-D-glucan [grasses only]
Lignin	(see Chapter 13)
Structural proteins	(see Table 15.2)

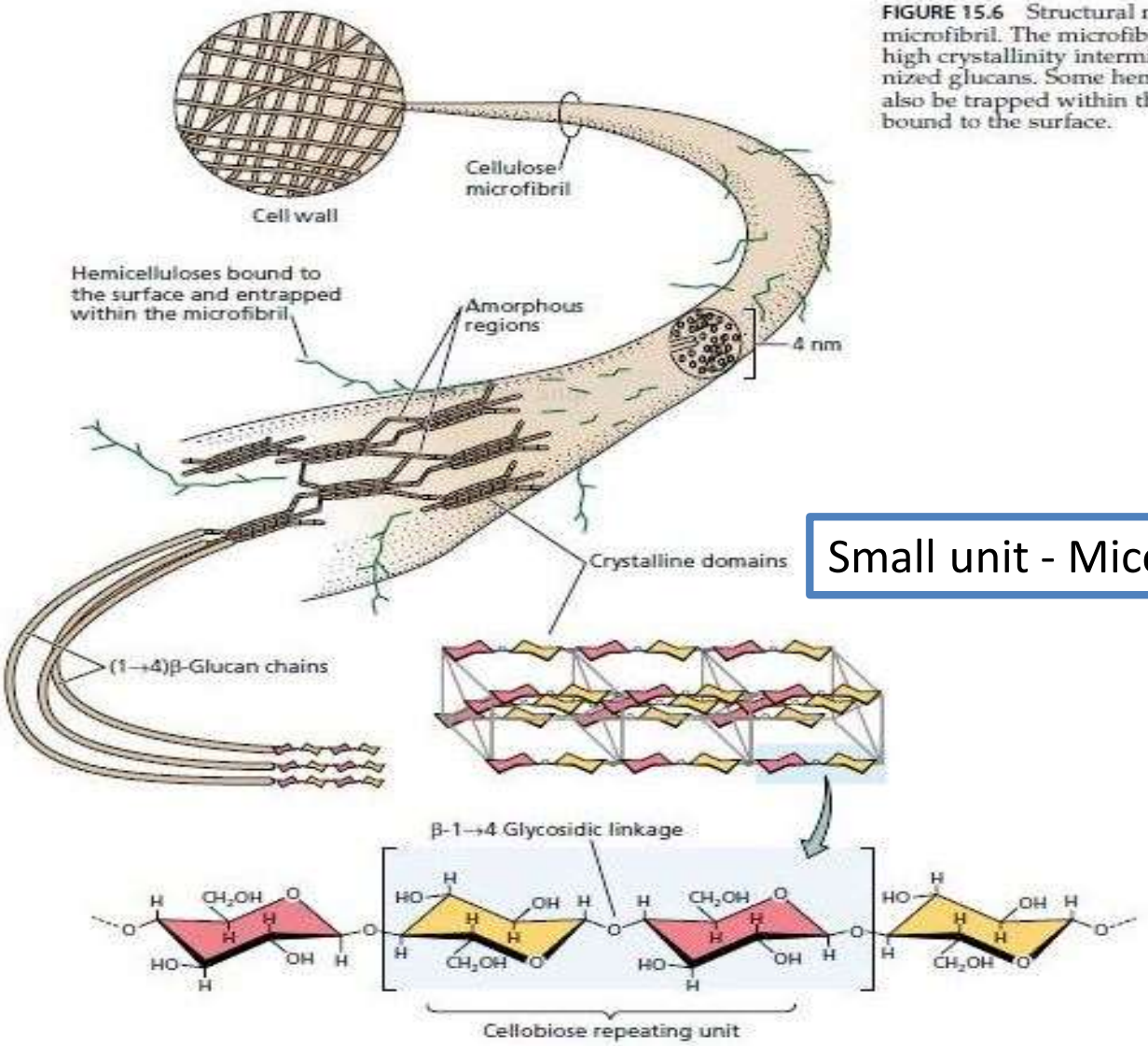


FIGURE 15.6 Structural model of a cellulose microfibril. The microfibril has regions of high crystallinity intermixed with less organized glucans. Some hemicelluloses may also be trapped within the microfibril and bound to the surface.

Small unit - Micelle

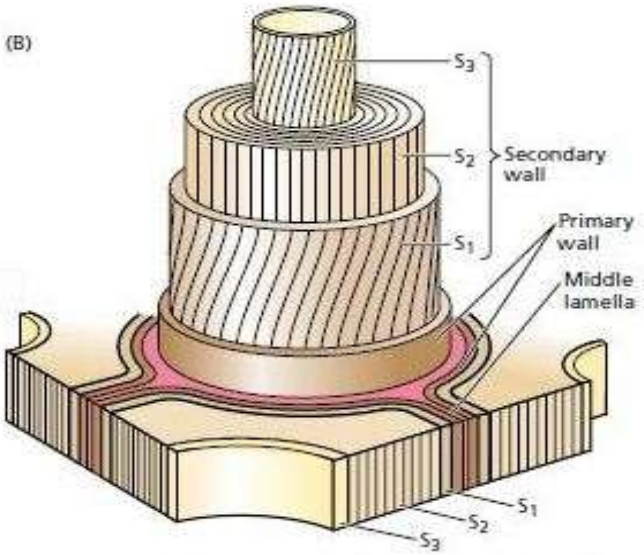


FIGURE 15.17 (A) Cross section of a *Podocarpus* sclereid, in which multiple layers in the secondary wall are visible. (B) Diagram of the cell wall organization often found in tracheids and other cells with thick secondary walls. Three distinct layers (S_1, S_2, S_3) are formed interior to the primary wall. (Photo ©David Webb.)

➢ 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.**

➢secondary wall

Outer layer (S1)

Central layer (S2) Thick

Inner layer (S3)

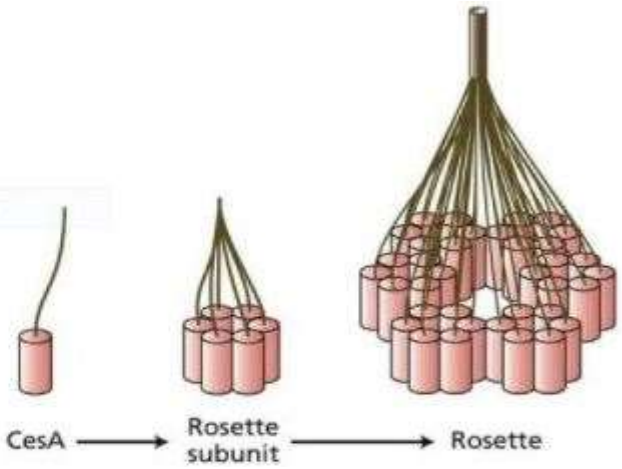
• The S1 and S3 layers lie adjacent to primary wall and cell lumen respectively.

• These layers S1, S2 and S3 may be distinguished by their respective orientation of cellulose microfibrils.

Biogenesis of cell wall

• Origin of cell wall takes place from cell plate during cytokinesis.
•Many cell wall vesicles provided by Golgi bodies and Endoplasmic reticulum combine to form a cell plate .
•After some physical and chemical changes , the cell plate (rich in pectin) grows on both sides to form a middle lamella, which glues neighbouring plant cells
•After which primary wall and secondary walls are laid down on the middle lamella to form cell wall.
•More than **2000 genes** are required for the synthesis and metabolism of cell wall components
•Plant cell wall biosynthesis involves multiple cellular compartments.
➢As cells expand, new components of the cell wall are deposited **outside the plasma membrane**

Cellulose microfibrils are synthesized by large protein complexes "rosettes" – made up of six subunits, each of them contains multiple units of cellulose synthase (or cellulose synthase-like enzymes)



❑ Cellulose is synthesized by a plasma membrane multiunit enzyme complex (cellulose synthase) having at least three different enzymes and probably some other proteins.

❑ From cellulose, microfibrils are synthesized and deposited directly into the extracellular matrix.

❑ Microfibrils are synthesized on the plasma membrane by protein complexes called particle rosettes.

❑In expanding cells, the newly synthesized cellulose microfibrils are deposited at right angles to the direction of cell elongation.

❑ Matrix components, including hemicelluloses , pectins and glycoproteins, are synthesized in the **Golgi apparatus (endomembranous system)** and delivered to the wall via **secretory vesicles**.

❑ Components synthesized in different locations are assembled into a functional wall matrix with the help of different kind of proteins.

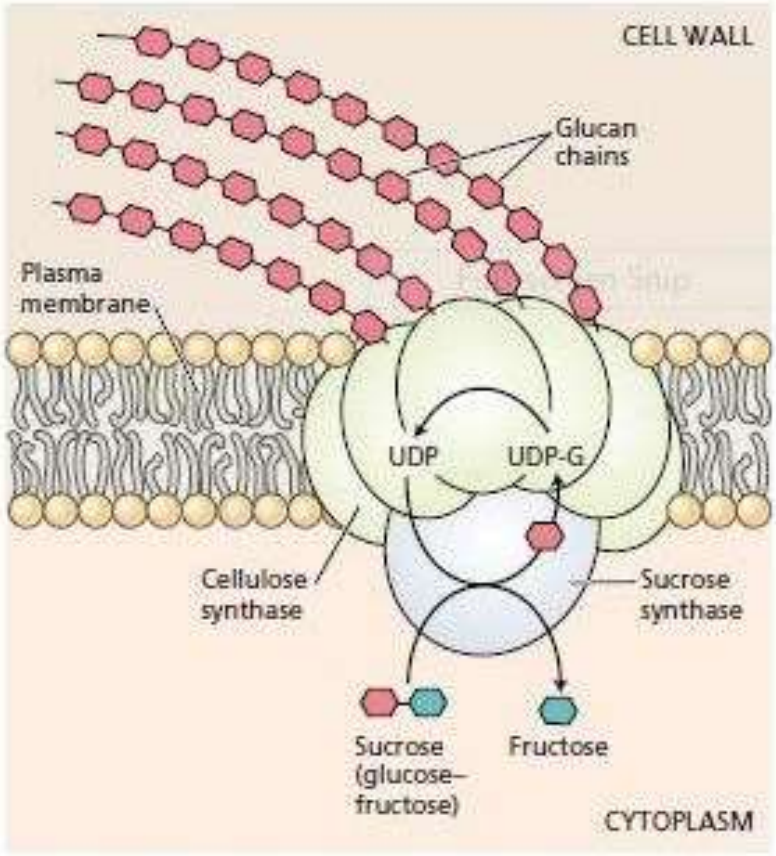


FIGURE 15.8 Model of cellulose synthesis by a multisubunit complex containing cellulose synthase. Glucose residues are donated to the growing glucan chains by UDP-glucose (UDP-G). Sucrose synthase may act as a metabolic channel to transfer glucose taken from sucrose to UDP-glucose, or UDP-glucose may be obtained directly from the cytoplasm. (After Delmer and Amor 1995.)

Matrix contains a glycoprotein called expansin which causes the loosening and expansion of cell wall by the addition of cellulose molecules to the microfibrils.

✓The cell walls are the products of the cytoplasm. The cytoplasmic organelles such **as endoplasmic reticulum, Golgi apparatus,** etc. play a very important role in the formation of cell wall.

✓The cell wall formation is started by formation of **phragmoplast cell plate**. The cell plate is formed by the small vesicles of endoplasmic reticulum which cut off from the endoplasmic reticulum and migrate from the periphery to the equator of the cell.

✓In the equator region of the dividing cells, the vesicles of endoplasmic reticulum get arranged on the equator and thus, separate the two daughter parts of the cytoplasm.

✓Later on, all the vesicles, except a few which form the plasmodesmata, fuse with one another to form a discontinuous cell plate.

✓The cell plate in later stages develops pectin and changes into middle lamella.

✓Golgi apparatus which provide noncellulose material.

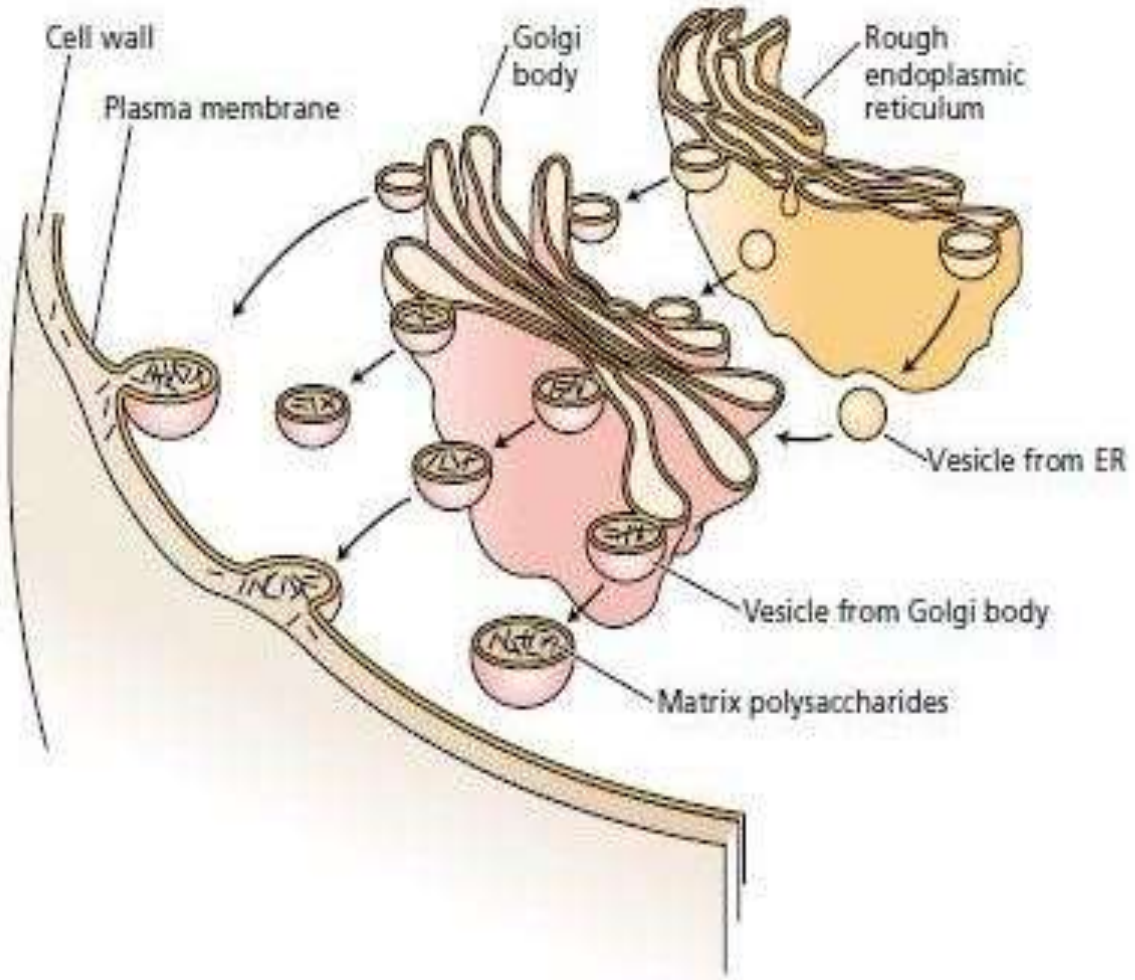


FIGURE 15.9 Scheme for the synthesis and delivery of matrix polysaccharides to the cell wall. Polysaccharides are synthesized by enzymes in the Golgi apparatus and then secreted to the wall by fusion of membrane vesicles to the plasma membrane.