CELL WALL: STRUCTURE, CHEMICAL COMPOSITION & FUNCTIONS

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Introduction:

Cell wall constitutes a kind of exoskeleton that provides protection and mechanical support for the plant cells. It is found outside the plasma membrane of the cell and determines the morphology and function of the cell. It also helps in maintaining osmotic balance of the intra-cellular fluid. Initially formed thin primary wall may develop additional layers of diverse materials to provide adequate functional strength to the cell. The physical structure and chemical composition of the cell wall varies widely in different plant groups.

PHYSICAL COMPOSITION (STRUCTURE):

(i) Cell wall of higher plants is typically composed of three layers — middle lamella, primary wall and the secondary wall.

(ii) Middle lamella is an amorphous layer occurring between primary wall of adjacent cells.

– It is the first layer to be formed when a cell divides and is therefore, the initial partition between the newly formed daughter cells.

– Each daughter cell subsequently deposits a primary wall on to the middle lamella; the latter is therefore sandwiched between the primary walls of the two daughter cells.

Thus, middle lamella is a common layer between the primary walls of the two

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adjacent cells and is secreted by the dividing parent cell.

(iii) Thus middle lamella is is the only true intercellular layer in plants and probably should not be regarded as part of the cell wall.

(iv) It is free of cellulosic microfibrils and is composed mainly of pectinaceous material.

(v) In the softer tissues (e.g., pith, cambium, etc) middle lamella remain unlignified, while in woody tissues it becomes heavily permeated with lignins.

(vi) Primary wall is a flexible structure capable of growth and extension.
— It can thus accommodate the increasing size of the protoplast.

(vii) During the growth period of the cell, primary wall is composed of cellulose microfibrils embedded in matrix polysaccharides.

(viii) Towards the end of the growth period a secondary wall may or may not be deposited upon the primary wall, depending on the cell type.
— If a secondary wall is formed, the primary wall becomes heavily lignified.

(ix) The principal matrix polysaccharides of the primary wall of dicots are pectins; in monocots pectins are only a minor component of the primary wall.

(x) Albersheim (1978) proposed a tentative preliminary model of the primary wall of dicotyledonous plants. It gives an idea how the microfibrils and the various matrix polysaccharides appear to coexist in the primary wall.

(xi) During the growth period of the cell,

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cellulosic microfibrils may change their orientation with respect to each other within the polysaccharides matrix of the primary wall.

— Fluidity of the matrix allows this microfibrillar reorientation and this is lost when lignin replaces much of the water in the matrix at the end of the growth period.

(xii) In the primary cell wall of meristematic cells, microfibrils form a random network within the matrix. With cell elongation, microfibrils begin to exhibit a more organized pattern. This occurs due to fluidity of the wall matrix.

(xiii) In addition to this simple multinet structure (Roelofsen and Houwink, 1953), primary walls of many cells develop axial ribs of longitudinally oriented microfibrils between regions of simple multinet.

— Primary walls of different types of cells reflect variations in the relative contributions of the simple multinet and longitudinal ribs components.

(xiv) Primary wall is punctured at primary pit fields (areas of reduced deposition of cell wall material) by plasmodesmata, which enable transport and communication between cells.

(xv) Extra layers may be deposited on the primary wall in the cells performing specialized or added mechanical functions.

— These include secondary, tertiary or even successive wall layers.

— Lignin, suberin, Chitin, etc., may be involved in these additional wall layer deposits.

(xvi) Composition of the matrix, orientation of the microfibrils and number of sublayers may vary in the secondary and tertiary wall layers in comparision to the primary wall.

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CHEMICAL COMPOSITION:

1. Microfibrillar Polysaccharides

(i) Most common microfibrillar polysaccharide in the cell wall of plants is cellulose.

(ii) Other microfibrillar polysaccharides are chitin (common in fungi).

(iii) β-1,4-mannans occur in the walls of green algal families and β-1,3-xylans in those of some other green algae.

(iv) Cellulose molecules are complex polysaccharides having unbranched chains of D-glucopyranose residues linked by β-1,4 glycosidic bonds.

—They vary considerably in length, but the average number of glucose residues is about 8000 per molecule.

(v) Cellulose molecules in plant cell walls are organized into biological units known as microfibrils.

2. Matrix Polysaccharides

(i) They include hemicelluloses and pectins.

N.B.— The term hemicellulose proposed by Schulze (1891) is now known to be a misnomer because hemicelluloses are now known not to be the precursors of cellulose (Hemicellulose = half-built cellulose).

(ii) Xylans and mannans are the most common hemicelluloses.

(iii) Pectins are also important cell wall matrix polysaccharides.

(iv) In higher plants, pectins are polymers of α-D-galacturonic acid residues.

(v) Less abundant pectin components are Arabinans and Galactans.

3. Lignins

(i) An important component

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of the cell walls of mechanical and conducting tissues (viz., Sclerenchymatous fibres and sclereids, xylem, etc.)

(ii) It may occur in the cell walls of pith, roots, fruits, buds, bark and cork.

(iii) Lignification of the cell wall occurs usually towards the end of the growing period of the cell (exception - Protoxylem).

(iv) Lignin is the major component of secondary wall layer.

(v) Lignification strengthens the cell wall by forming a ramified network throughout the matrix, thus anchoring the cellulose microfibrils more firmly.

(vi) Lignin also protects the microfibrils of the wall from physical, chemical and biological attack.

4. Proteins

(i) Cell walls of growing cells may contain 5-10% proteins.

– These proteins may be enzymatic or structural.

(ii) Hydrolases of various kinds have been recorded in cell walls, e.g., Invertase, Glucanase, Pectin methylesterase, ATP-ase, DNA-ase, RNA-ase and several phosphatases.

– Several oxidases are also present.

(iii) Glycoproteins have also been found in the cell walls.

5. Water

(i) An important structural component of the cell wall

– It forms part of the gel structure of pectins.

6. Incrusting Substances

(i) They are deposits on the outer

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surface of epidermal cells.

(ii) Cutin and suberin are the most common chemicals found on the epidermal wall surfaces.

– Cutin forms the cuticle to reduce excessive evaporative losses of water.

– Cuticle has three layers: outermost surface layer of wax often called epicuticular wax; layer of cutin (a fatty substance) embedded in the wax and innermost layer of mixed cutin and wax.

(iii) Cutin is the principal polymer of the cuticle.

(iv) Epicuticular wax is a complex mixture of esters of fatty acids and long-chain alcohols and long-chain fatty acids.

(v) Suberin is a polymeric substance which replaces cutin

– Cork cells are suberized

– Some roots and underground tubers may also have suberin deposits on their epidermal cells.

FUNCTIONS OF THE CELL WALL

(i) Mechanical support
(ii) Provides shape to the cells
(iii) It also provides flexibility and tensile strength including inextensibility, incompressibility and shearing strength.
(iv) Provides passage to the essential materials as well as may restrict invasion by pathogens and pests.
(v) Useful to man as wood and fibres
(vi) Role in carbon economy of the biosphere.
(vii) Cell wall development is also an evolutionary diversity of the plant world.

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