Course –B.Sc.Bot.Part II

Role of enzymes in plant disease

The activity of pathogens in plants is largely chemical in nature. Phytopathogens secrete a large number of enzymes which degrade the host protective layers. Thus the enzymes are chemical weapons of phytopathogens. They enter into the host either through natural openings (stomata, lenticels, hydathodes, and nectarthodes), wounds or mechanically penetrating the host protective layers. Entry of fungal pathogens may take place by any or more above means. Bacteria enter the host tissues through any opening in the host surface because most of them do not secrete wall degrading enzymes. Enzymes are generally large protein molecules that catalyze biochemical reactions. Some enzymes are constitutive, active all time and catalyze all the vital reactions needed to the organism whereas some enzymes are produced only when they are needed by the cell in response to internal or external factors.

Generally the first contact of pathogens with their host occurs at plant surface such as leaves for aerial pathogens. They have to break the protective layers first to get entry into the host. Plants are protected by several layers of protection which check the easy invasion by any organism. The outer most protective layer of leaves is cuticle which is composed of cutin mixed with waxes. Next to it lies pectin and hemicelluloses. These are the middle lamella components. Cellulose, which is the most abundant polymer in plants, forms the cell wall. The penetration of pathogens into parenchymatous tissues is facilitated by the breakdown of the internal cell walls, which are composed of cellulose, pectins hemicelluloses and structural proteins, and of the middle lamella, which consists primarily of pectins. The degradation of each of the substances is brought about by the action of many sets of enzymes secreted by the pathogens.

Phytopathogens secrete some important enzymes as given below :-

Cutinases- These degrade cutin. Cuticle is made up of cutin which is admixed with waxes at upper part and in the lower part it is admixed with pectin and cellulose. Cuticular waxes are found as granular or rod like projections or as a continuous layer outside or within the cuticle. Pathogens have the ability to degrade this. This has been found in ***Puccinia hordei*** which produces enzymes degrading waxes. Many fungi and bacteria are known to produce cutinase.These enzymes break the cutin to release monomers and oligomers of the component fatty acid derivatives from the insoluble cutin polymer. The highest amount of cutinase is produced at the time of penetration.

Pectinases: - Pectinases are also known as pectolytic or pectinolytic enzymes. These enzymes degrade pectic substances. Pectic substances are polysaccharides consisting mostly of chains of galacturonan molecules interspersed with a much smaller number of rhamnose and a small side chains of galacturonan, xylan and some other pentose sugars. Pectic substances make also a large portion of primary cell wall in the form of amorphous gel, filling the spaces between the cellulose microfibrils.Pectinases are substrate induced enzymes which are induced by the galacturonan monomers, dimers or oligomers released by the activity of constitutive pectolytic enzymes.

Pectinases play important role in disease development especially in rots. Pectin degradation results into liquefaction of the pectic substances and weakening of cell walls, leading to cell maceration and pulpy touch of the soft tissues. They cause plugging of the xylem tissues causing wilt symptoms.

There are many types of pectinases, which are Pectin methyl esterase (PME), Polygalacturonases (PG), Pectin lyases.

Pectin methyl esterase (PME) removes small branches off the pectic chains. They alter the solubility of pectin.

Polygalacturonases (PG), split the pectic chain by adding a molecule of water and breaking (hydrolyzing) the linkage between two galacturonan molecules. ;others ,known as pectin lyases, split the pectic chain by removing a water molecule from the linkage, thereby breaking it and releasing products with an unsaturated double bond.

Cellulases (Cellulolytic enzymes):- These enzymes degrade cellulose, the chief constituent of cell walls. These are produced by many phytopathogens such as fungi, bacteria and nematodes. Saprophytic fungi and bacteria break down most of the cellulose in nature. Cellulases degrade cellulose to facilitate penetration and spread of the pathogen into the host tissue. They degrade cellulose in a series of steps, which are catalysed by series of enzymes, known as cellulose complex .These are classified as **C1, C_2** and **C_x. C_1** breaks the native cellulose by cleaving cross linkages between chains. **C_2** enzyme also attacks native cellulose and breaks them into shorter chains, which are then attacked by the next group **C_x. C_x** degrade them into disaccharide units cellobiose.Cellobiose is further degraded to glucose monomers. Thus, phytopathogens degrade the firm compact water insoluble cellulose into the soluble form, glucose. This glucose serves its best food to establish into the host tissues.

Native cellulose--------→**C_1**---→Linear anhydrous glucose chain---→ C_2 -----C_x---→Cellobiose--→

Cellobiose----→ Cellobiase->-→ Glucose

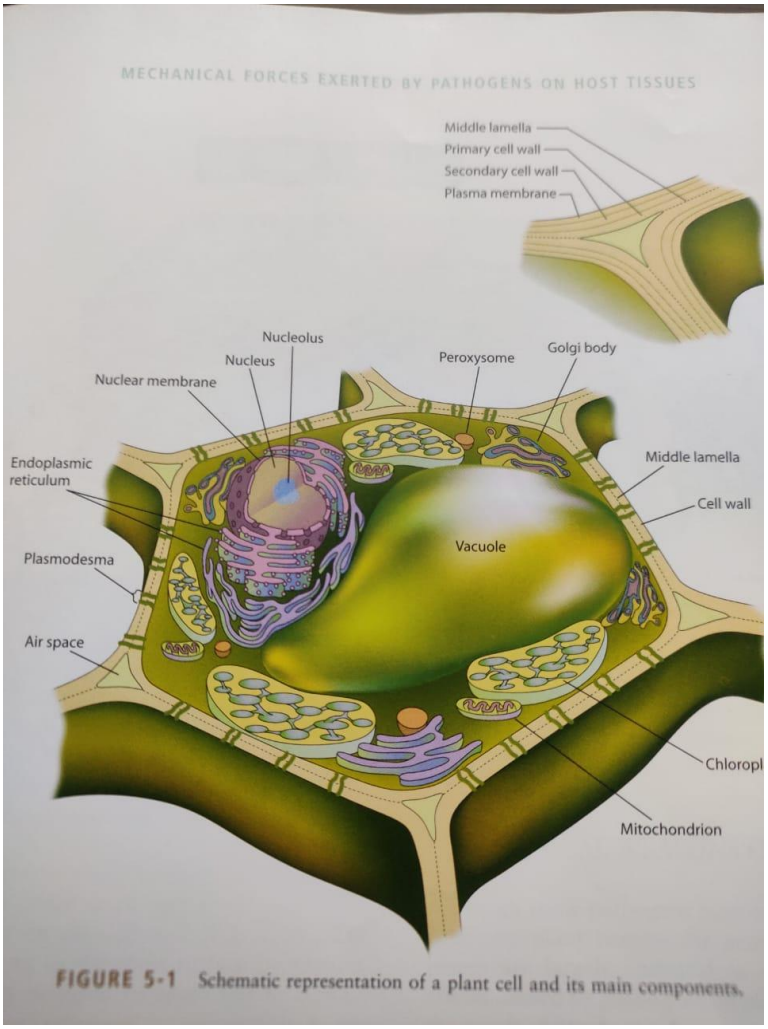

FIGURE 5-1 Schematic representation of a plant cell and its main components.

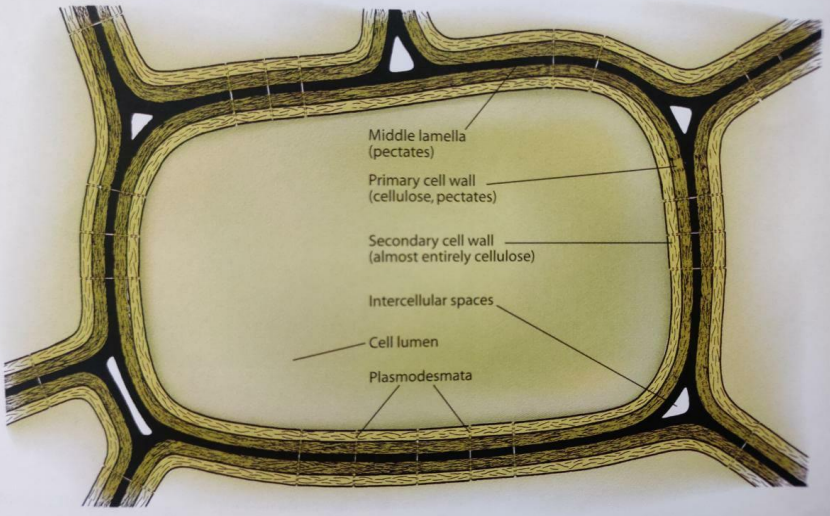

FIGURE 5-6 Schematic representation of the structure and composition of plant cell walls.

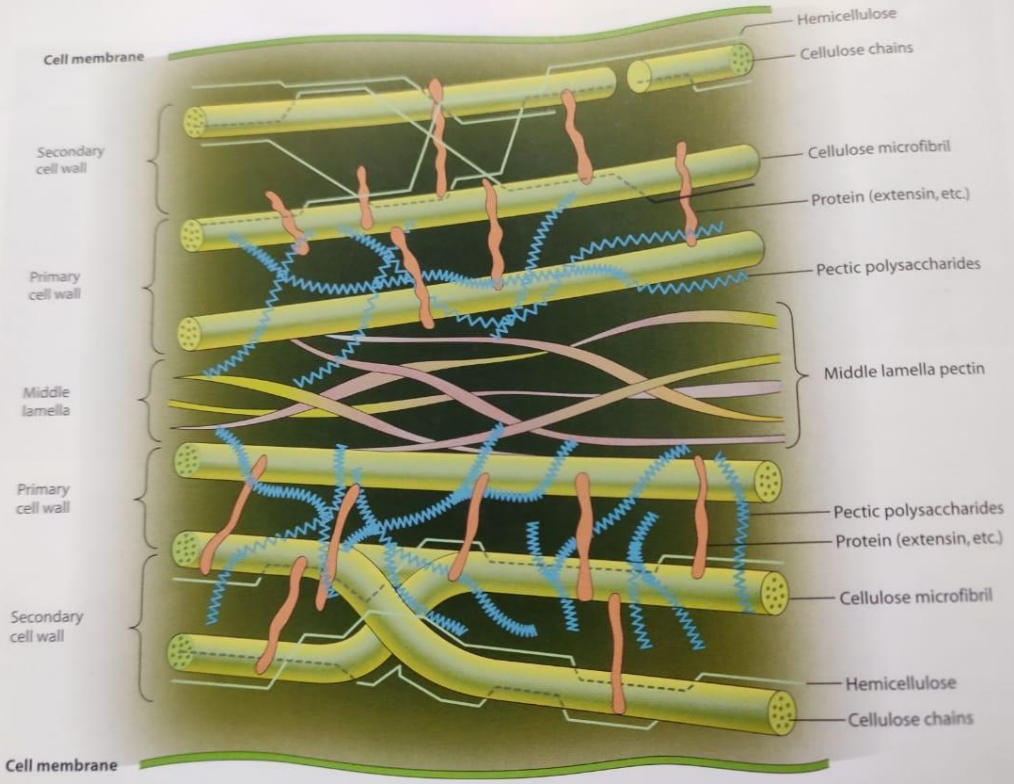

FIGURE 5-10 Schematic diagram of morphology and arrangement of some cell wall components.

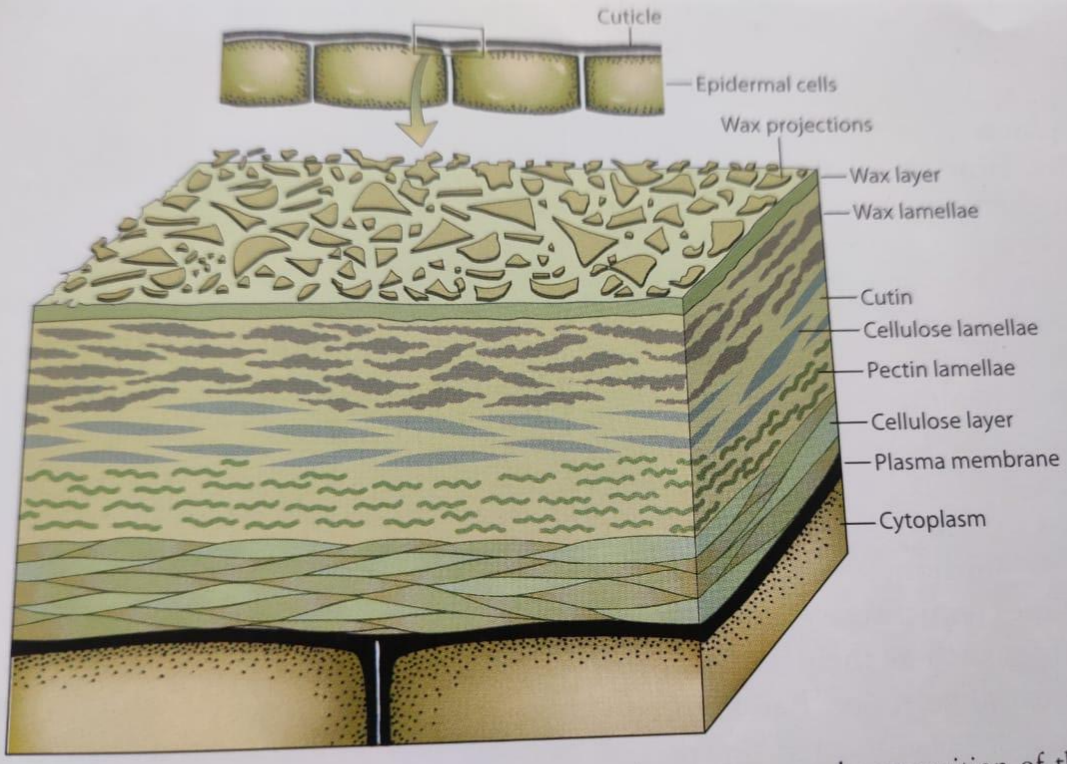

FIGURE 5-3 Schematic representation of the structure and composition of the cuticle and cell wall of foliar epidermal cells. [Adapted from Goodman *et al.* (1967).]

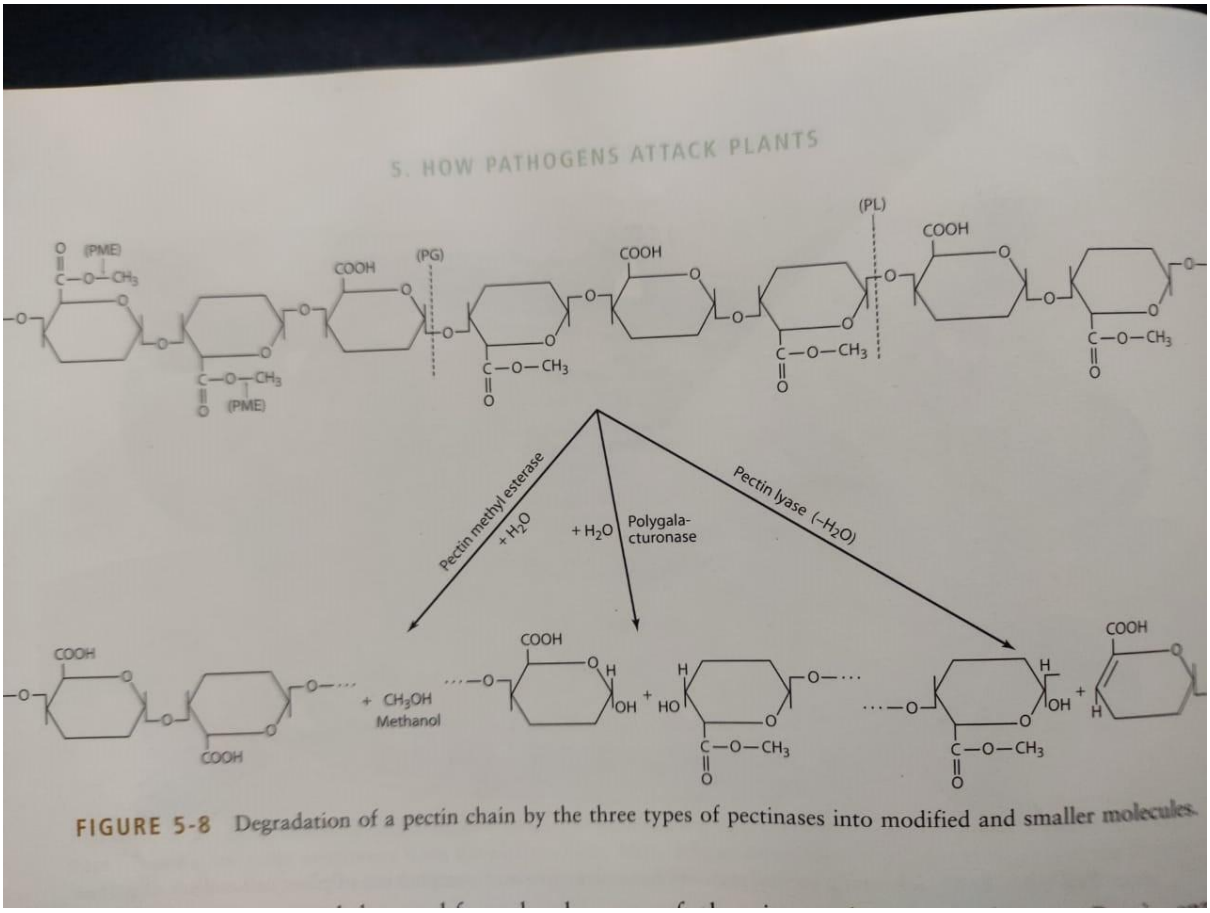

FIGURE 5-8 Degradation of a pectin chain by the three types of pectinases into modified and smaller molecules.

Figs.Curtesy: Plant Pathology, G.N.Agrios.Elsevier Academic Press.USA.

Hemicellulases:- Hemicelluloses are complex mixtures of polysaccharide polymers.They constitute primary cell wall as a major constituent. They are also constituent in varying level in middle lamella and secondary cell wall..Many pathogens are known to secrete hemicellulases which degrade hemicelluloses to monomer units.

Ligninases: - These are lignin degrading enzymes. Lignin is found in the middle lamella as well as in the secondary wall of xylem vessels and the fibres . Lignin gives hard texture to the wood and it is impervious to water and air. It is composed of phenylpropanoid units. Ligninases re produced in many basidiomycetous fungi, particularly wood rotting fungi. They degrade wood by dissolving lignin of wood making their food available and degrading the wooden logs. Most of lignin in the world is degraded and utilized by a group of basidiomycete fungi known as white rot fungi. In addition to basidiomycetous fungi, many other pathogens including some ascomycetes and fungi imperfecti members and certain bacteria are also known to secrete lignolytic enzymes.