SA #20 BIO 2500	PLANT CELLS, CELL WALLS, and CYTOKINESIS Stern, Ch. 3

OVERVIEW: We have completed our taxonomic survey of the prokaryotic autotrophs of Kingdoms Bacteria and Archaebacteria; and, the eukaryotic autotrophs of Kingdom Protista. Before we proceed into the Plant Kingdom where multicellular species are the rule, it will be helpful to take a closer look at plant cellular structure and the mechanism of *cytokinesis*, or cytoplasmic division.

THEME: Plant cells with emphasis on cell wall structure and how the cell wall is formed.

FORWARD: Chapter 3 presents a review of plant cell structure and function. "Introduction to Biology" will have introduced you to some of the content of this chapter. The "THEME" above is supported by the following sections of Chapter 3:

a) Pages 33-36 – plant cells, cell wall structure, and communication between cells.
b) Pages 31-41 – especially endoplasmic reticulum and dictyosomes (Golgi bodies)
c) Pages 44-51 – especially the cytoskeleton, mitosis, and cytokinesis.

The following STUDY OUTLINE highlights cell wall structure and the combined function of cytoskeleton, membrane system in formation of the cell wall.

LECTURE DISCUSSION QUESTIONS:

1. Discuss the roles of the *plasma membrane*, the *membrane system*, and the *cytoskeleton* in coordinating activities of a plant cell. In particular, make application to *cytokinesis.*

2. Explain two routes by which substances can move from one plant cell to another.

STUDY OUTLINE: Plant cell walls and how they are formed by membrane system and cytoskeleton.

I. Cell Wall -- Consists of primary wall, secondary wall (if present) and middle lamella
   A. Composition – See Figure 3.6A and B.
      1. Primary Cell Wall
         a. Celluloses and pectin; little lignin
         b. Constitutes the only cell wall of dividing cells
      2. Secondary Cell Wall
         b. Added inside primary wall (next to plasma membrane)
         c. Lignified for rigidity
      3. Suberized walls
         a. Contain waterproofing substance, *suberin*
         b. Example: cork cells of outer bark of trees
      4. Middle Lamella
         a. Located between primary walls of adjacent cells; "cell glue"
         b. Composition: pectic substances; green apple skins are rich in pectin

B. Plasmodesmata
   1. Channels through cell walls of adjacent cells, lined with plasma membrane
   2. Allow for exchange of materials between cells without crossing membrane; thus, there is a lower resistance to intercellular dye and ion movement because of the plasmodesmata
   3. Location -- prominent in tubular conductive cells (*e.g.* phloem) and secretory cells

II. Cytoskeleton
   A. Components – See Figure 3.15 and 3.19
      1. Microtubules -- tubular, assembled from *dimers* of tubulin protein (18-25 nm)
      2. Actin Filaments -- thinner and composed of two strands of actin (7 nm)
      3. Intermediate filaments -- intermediate in size, various proteins
   B. Dynamics of Cytoskeleton
      1. Microtubules and actin filaments assemble at one end and disassemble at other; changes shape of cytoskeleton and cytosol. [Colchicine, vinblastin, and taxol (from *Taxus brevifolia*) are antimitotic; inhibit microtubule depolymerization. *Creation Res. Soc. Quart.* 30(1993): 135-140]
      2. Intermediate filaments remain rigid

   C. Function of Cytoskeleton in Internal Cellular Transport
      1. Cytoplasmic transport "paths" set by microtubules and actin filaments of cytoskeleton
      2. *Cyclosis* – the circular streaming of chloroplasts, mitochondria, etc.
      3. Enhances exchange of materials among organelles, membranes, and whole cells

   B. Function of Cytoskeleton in Flagella:
      1. Flagella: membrane encloses 10 pairs of microtubules, each attached to dynein arms
      2. Plant Kingdom -- sperm are the only swimming cells; and these are rare in seed plants
      3. Algae have swimming gametes and zoospores

III. Membrane System – concept and function:
   A. Includes -- all membranes in physical contact, or which exchange membrane segments
   B. Structure -- phospholipid bilayer with embedded proteins, glycoproteins
   C. Functions
      1. Surfaces for biochemical processes -- *e.g.* photosynthesis, ATP synthesis
      2. Making other membranes
      3. Selective permeability (e.g. ion pumping)
      4. Cellular communication -- membrane receptors for proteins, hormones
   D. Plasma Membrane
      1. Differentially permeable barrier
      2. Signal receptor and transducer to influence cell metabolism
      3. Accepts packets of raw material from dictyosome vesicles for exocytosis and secretion

E. Endoplasmic Reticulum (ER)
   1. System of flattened tubes and sacs linking nuclear envelope to plasma membrane
   2. Rough ER -- ribosomes attached; protein synthesized and released from cell in vesicles
   3. Smooth ER -- synthesis of new membranes, phospholipid, cell wall components, etc.

F. Dictyosomes (Golgi Bodies) -- stacks of flattened, membranous vesicles
   1. "Two-faced" -- one face toward ER, one toward plasma membrane
   2. Dictyosomes serve in repackaging and handling of materials
      a. ER-facing side receives substances from ER directly or within vesicles
      b. Substances are modified and sorted, then sent to sites on membrane or cytosol
   3. Role in *exocytosis*, in which secretory vesicles move material outside cell by fusing with plasma membrane--*e.g.* c.w. materials, nectar, resins, oils, fragrances
   4. Role in cell division
      a. Dictyosomes, guided by microtubules, move to cell equator
      b. Fuse and spread across equator toward parent cell walls forming *cell plate*
      c. Provide membrane and c.w. material for new partition between daughter cells
   5. Role in secondary cell wall formation -- carry wall material to plasma membrane and release by exocytosis to site of growing wall

G. Vacuoles -- larger sacs formed by fusion of vesicles from ER and dictyosomes
   1. Form a large *central vacuole* in mature plant cell
      a. Occupies up to 95% of mature cell volume
      b. Tonoplast is membranous boundary
      c. Serves in cellular osmoregulation; influences turgor *vs.* wilting
   2. Contents are diverse
      a. Enzymes to degrade old organelles
      b. Pigments color some flowers petals and fruits
      c. Alkaloids inhibit insect and other animals from feeding
      d. Storage reserve for salt ions, oxalic acid (tartness)

H. Microbodies -- peroxisomes (peroxide metabolism) and glyoxisomes (lipid to CH_2O)

IV. Plant Cell Wall Synthesis

Concept: Cell wall synthesis is a result of a coordinated process in which the membrane system supplies cell wall precursors under the direction of the cytoskeleton.

Objective: Having studied the Outline above and assigned reading in Chapter 3, you should become prepared to explain the role of the cytoskeleton and membrane system in the process of cytokinesis and subsequent cell wall development.