MMBB 475/575: Molecular **Biology of Cells**

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Textbook: Molecular Cell Biology (Lodish, Berk, Zipursky, Matsudaira, 2003.)

Prerequisites: Biology 115 (or equivalent) **and** 300-level course in biochemistry, **or** permission of instructor.

**Course format**: Cell biology encompasses an overwhelming range of material. Rather than attempting to cover everything, this course will focus on the most fundamental processes that allow eukaryotic cells and tissues to carry out their daily operations.

We will discuss how the molecular assemblies in the cell govern cell locomotion, nutrient uptake, membrane excitation, intracellular communication, and several representative signal transduction processes with special attention to oncogenes and anti-oncogenes that regulate and restrict cell growth.

It is hoped that this will provide the foundation necessary to continue your studies on your own.

**The topics will include:**

**Cells in isolation**

1. Introduction to the cell

(*This course will concentrate on the morphological and biochemical features that are common to all cell types, and introduce a few of the special properties found in some cells of multicellular organisms)*.

a. Introduction to the diversity of cell shapes, polarity and cortical patterning, and to the roles of special cells in multicellular organisms.
b. Introduction to the structural architecture of cells, and to the internal divisions with cells.

2. Chemical components of cells

(*The orderly development of the organism arises from an energetically costly reduction in disorder at the molecular level*.)

a. Structure of water, interactions of water and hydrophilic and hydrophobic substances, partitioning processes of small molecules in solution (with special attention to fatty acids).
b. Membrane structure, heterogeneity, and fluidity.

3. Protein architecture and folding

(*The chemical properties of proteins that allow them to stick to themselves via specific domains.)*

a. Classes of macromolecules.
b. Proteins.
c. Spontaneous folding vs. Chaperone-assembly processes.

4. Self-assembly processes and dynamic equilibria

(*Interactions between specific domains of proteins can lead to ordered macromolecular structures arising from disordered solutions of subunits.)*

a. Self-assembly as typified by virus assembly.
b. Microtubule assembly as an example of directed and regulated assembly.

5. Cell growth in tissue culture

(*The maintenance of a living cell depends on continually importing and exporting molecules from one location to another*.)

a. Introduction to the cell cycle process.
b. Nutritional and hormonal rerequisites for growth and division of cells in tissue culture.
c. Anchorage-dependent growth, contact inhibition, and immortality.

6. Cell migration and the cytoskeleton

(*Actin filaments provide an internal skeleton while myosin provides a motor that helps cells pull their bulk along from place to place*.)

a. Introduction to actin and myosin.
b. Architecture of the cytoskeleton.
c. Cell attachment and movement.
7. Cell migration continued

(*Cell movement requires signaling processes to coordinate different molecular machines.)*

a. Varied roles of calcium in regulating polymerization processes.
b. Myosin can act as a molecular motor.

8. Molecular Motors

a. Molecular motors.
b. Kinesins and dyneins.
c. Moving cargo to the extremes of the cell.

9, Membrane transport and the acquisition of water

(*The import of water and carbon sources achieves high selectivity through the use of successive sieves and screens.)*

a. Introduction to the uptake of water and ions.
b. Basics of membrane transport.

**Molecular processes associated with specialized cells.**

10. Properties of transporters

(*Different cells employ a variety of channels and pumps to obtain and retain critical molecules*.)

a. Moving molecules against a gradient.
b. Structure and regulation of glut1.
c. ATP as an allosteric regulator.
d. ATP hydrolysis as a way to make reactions irreversible.

11. Coupled transport processes.

(*The uptake of rate-limiting nutrients often requires coupling uptake either to the import or the export of specific inorganic salts*.)

a. Symporters and antiporters.
b. Priming pumps through the hydrolysis of ATP

12. Electrically-excitable membranes

(*The asymmetrical flow of ions creates a membrane potential*)

a. Introduction to the electrochemical gradients and membrane potential of cells.
b. Ionophores.
c. Specialized structure of neurons.

13. Generation of action potentials

(*Neurons can rapidly change the electrical charge on their membranes. This change can release a chemical signal to adjacent cells to trigger an analogous change there*.)

a. Action potentials.
b. Neurotransmitters and their receptors.

14. Chemical events at the synapse

(*Intracellular communication through the release and perception of unique chemical signals*.)

a. Synapses and neuromuscular junctions.
b. Modulating nerve conduction.

15. Muscle cell contraction and relaxation

(*Changes in* $Ca^{+2}$ *levels trigger coordinated contraction of muscle cells*.)

a. Arrangement of actin and myosin in specialized cells.
b. Membrane depolarization and the release of $Ca^{+2}$.

16. Introduction to the cell cycle

(*Cell division consists of the orderly and coordinated progression of biochemically unrelated pathways*.)

a. Marking events in the cell cycle of *Saccharomyces*.
b. Isolation of mutants.
c. Cyclins and CDC kinases.

17. Kinase/ phosphatase control over cell cycles; comparison of the yeast and mammalian cycles.

(*Each step in the cell cycle is monitored for completion and checked for errors by redundant cell sensors*.)

a. Check points.
b. Contrasts between the yeast and mammalian cell cycle.

18. Introduction to the cellular phenomenon of cancer

(The loss of checkpoint constraints leads to excessive proliferation.)

a. Properties of transformed cells in vitro and in vivo.
b. Invasiveness.
c. Oncogenes and anti-oncogenes.