

BMED 3600 Physiology of Cellular and Molecular Systems

Credit: 3-0-3

Prerequisite(s): BIOL 1510 (w/minimum grade of “C”) and (CHEM 3511 or CHEM 4511)

Catalog Description

In depth cell and molecular physiology focused on cellular responses to stimuli, including cell organization/reorganization, membrane transport/kinetics, cell signaling/molecular biology, mechanobiology and energy requirements.

Textbooks:

Molecular Biology of the Cell, 5th ed., Alberts et al. (Required)

Human Physiology, Silverthorn (Suggested)

Directed reading of original literature

Objectives

To introduce BME students to the physiology of mammalian cells with an emphasis on structure, organization and function of organelles, cellular communication and transport, cell growth and death, and gene expression. In addition, concepts of homeostasis, the role of the extracellular matrix, stem cells, cell and tissue engineering, and excitable cell physiology will be introduced. Lectures and assignments will stress the development of quantitative analytical techniques and their use in the study of cells and tissues as well as to produce products for cell and gene therapy, tissue engineering, and molecular imaging.

Outcomes

At the end of the course, the students will:

1. understand the structure and functional organization of cell organelles, especially membrane, cytoskeleton, extracellular matrix and nucleus (Program Outcome 1)
2. understand the quantitative aspects of membrane transport and cell signaling pathways (Program Outcome 1)
3. understand the mechanisms regulating cell growth and death (Program Outcome 1)
4. understand basic regulatory mechanisms of gene expression and protein synthesis and apply them to problems in biomedical engineering (Program Outcome 1)
5. understand mechanisms RNA silencing and apply them to gene expression control
6. understand homeostasis and how it is achieved in cell systems and be able to apply this information to product design problems (Program Outcome 1)
7. understand the role of membranes in excitable cell physiology (Program Outcome 1)
8. understand how cells interact with their substrate and apply this knowledge to the design of cell-scaffold constructs for tissue engineering (Program Outcomes 1 and 2)
9. know basic constituents of the extracellular matrix produced by cells and how they contribute to the mechanical properties of cells and tissues (Program Outcome 1)
10. develop the ability to read scientific literature (Program Outcomes 8 and 9)
11. develop the ability to apply course outcomes 1-10 to the study of applications in biomedical engineering (Program Outcome 9)

Topical Outline

1. Introduction to cellular and molecular physiology
 - a. Role of technology in facilitating discovery
 - b. What is a cell?
 - c. Organelle structure/function
2. Cells as systems
 - a. What is necessary for a cell to function within a tissue, organ, or organism
 - b. How do cells process and store information?
3. Membranes
 - a. Membrane composition, proteins, and synthesis
 - b. Specialized membranes (caveolae, lipid rafts)
4. Signaling mechanisms
 - a. Endocrine, paracrine, autocrine and contact-dependent signaling
 - b. Steroid hormone and ion channel linked receptors
 - c. Enzyme and enzyme linked receptors
 - d. G-protein coupled receptors
 - e. Mechanical signaling via integrins
5. Regulation of gene expression and protein synthesis
 - a. Transcriptional and post-transcriptional regulation
 - b. Protein synthesis
 - c. Role of membranes in compartmentalizing cell function
 - d. Membrane transport and vesicle trafficking
6. Cytoskeleton
 - a. Actin microfilaments
 - b. Microtubules
 - c. Intermediate filaments
7. Cell/cell interactions
 - a. Junctional apparatus
 - b. Gap junctions
 - c. Excitable cell physiology
8. Cell/matrix interactions
 - a. What is extracellular matrix?
 - b. Integrins and other attachment mechanisms
 - c. Other roles for ECM
 - d. Mechanotransduction
9. Cell proliferation
10. Cell migration
11. Cell death
 - a. Apoptosis, autophagy and necrosis
12. Energy requirements and mitochondria
13. Homeostasis
 - a. Systemic regulators
 - b. Local regulators
14. Stem cells
15. Microscopy
15. DNA technology