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| 1 | Lesson Plan for  Cellular Biology |

OBJECTIVES

1. Compare and contrast the two major classes of living cells.
2. Describe and provide examples of the eight major cellular functions: movement, conductivity, absorption, secretion, excretion, respiration, reproduction, and communication.
3. Identify and describe the three principal parts of a typical eukaryotic cell.
4. Describe the location and function of the nucleus and the cytoplasmic organelles.
5. Describe the structure, composition, and function of the plasma membrane.
6. Identify the location and main functions of plasma membrane proteins.
7. Compare and contrast the three mechanisms that bind cells together: extracellular matrix, cell adhesion molecules, and specialized cell junctions.
8. Describe the following primary modes of chemical signaling: hormonal, neurohormonal, paracrine, autocrine, and neurotransmitter.
9. Illustrate and describe the first and second messenger processes in signal transduction.
10. Describe the two main processes associated with cellular metabolism, and identify the processes as energy storing (endergonic) or energy yielding (exergonic).
11. Describe the role of adenosine triphosphate (ATP) and adenosine diphosphate (ADP) in the transfer of energy to drive cellular processes.
12. List examples of the following transport mechanisms: diffusion, passive-mediated transport (facilitated diffusion), phagocytosis, pinocytosis, active transport, osmosis, and hydrostatic pressure (filtration).
13. Classify the above cellular transport mechanisms as active or passive.
14. Compare and contrast the mechanisms of transport involving vesicle formation.
15. Describe the mechanisms that establish and maintain the resting potential of a cell membrane.
16. List and describe the sequence of events involved in an action potential.
17. Identify and describe the phases of mitosis and cytokinesis.
18. Describe the mechanisms that influence the rates of cell division.
19. Identify the purpose and function of cellular growth factors.
20. Identify and describe the two main mechanisms of tissue formation.
21. Identify the location, appearance, and a major function of each of the following types of tissue: epithelial, connective, muscle, and nervous.

TEACHING FOCUS

* Cells become specialized through the process of differentiation or maturation.
* The eight specialized cellular functions are movement, conductivity, metabolic absorption, secretion, excretion, respiration, reproduction, and communication.
* The eukaryotic cell consists of three general components: plasma membrane, cytoplasm, and intracellular organelles.
* The nucleus is the largest membrane-bound organelle and is usually found in the cell’s center.
* Vaults are cytoplasmic organelles and are also called *ribonucleoproteins*. They are thought to function as cellular “trucks” carrying messenger ribonucleic acid (mRNA) from the nucleus to the ribosomal sites of protein synthesis.
* The plasma membrane encloses the cell and, by controlling the movement of substances across it, exerts a powerful influence on metabolic pathways.
* Cellular receptors are protein molecules on the plasma membrane, in the cytoplasm, or in the nucleus, capable of recognizing and binding smaller molecules, called ligands.
* Cells are held together by three different means: (a) extracellular membrane, (b) cell adhesion molecules in the cell’s plasma membrane, and (c) specialized cell junctions.
* The extracellular matrix includes three types of protein fibers: collagen, elastin, and fibronectin. The matrix helps regulate cell growth and differentiation.
* The three main types of cell junctions are desmosomes, tight junctions, and gap junctions.
* Cells communicate in three main ways: (1) display plasma membrane-bound signaling molecules (receptors) that affect the cell itself and other cells in direct physical contact, (2) by receptor proteins inside the target cell, and the signal molecule has to enter the cell to bind to them, and (3) form protein channels (gap junctions) that directly coordinate the activities of adjacent cells.
* Signal transduction involves signals or instructions from extracellular chemical messengers that are conveyed to the cell’s interior for execution.
* Two important second messenger pathways are cyclic adenosine monophosphate (cAMP) and calcium (Ca++).
* The chemical tasks of maintaining essential cellular functions are referred to as cellular metabolism. Anabolism is the energy-using process of metabolism, whereas catabolism is the energy-releasing process.
* ATP functions as an energy-transferring molecule. Molecules of carbohydrate, lipid, and protein store energy, and, when catabolized, transfer energy to ATP.
* Oxidative phosphorylation occurs in the mitochondria and is the mechanism by which the energy produced from carbohydrates, fats, and proteins is transferred to ATP.
* Water and small, electrically uncharged molecules move through pores in the plasma membrane’s lipid bilayer in the process called passive transport.
* Endocytosis is a cellular internalizing process during which a section of the plasma membrane enfolds substances from outside the cell, invaginates, and separates from the plasma membrane forming a vesicle that moves inside the cell.
* Two types of solutes exist in body fluids: electrolytes and nonelectrolytes. Electrolytes are electrically charged and dissociate into constituent ions when placed in solution. Nonelectrolytes do not dissociate when placed in solution.
* All body cells are electrically polarized, with the inside of the cell more negatively charged than the outside. The difference in voltage across the plasma membrane is the resting membrane potential.
* When an excitable (nerve or muscle) cell receives an electrochemical stimulus, cations enter the cell, causing a rapid change in the resting membrane potential known as the action potential. The action potential “moves” along the cell’s plasma membrane and is transmitted to an adjacent cell. The action potential is how electrochemical signals convey information from cell to cell.
* Cellular reproduction in body tissues involves mitosis (nuclear division) and cytokinesis (cytoplasmic division).
* Only mature cells are capable of division. Maturation occurs during a stage of cellular life called interphase (growth phase).
* The cell cycle is the reproductive process that begins after interphase in all tissues with cellular turnover. The four phases of the cell cycle are (a) the S phase; (b) the G2 phase; (c) the M phase; and (d) the G1 phase. The M phase (mitosis) involves four stages: prophase, metaphase, anaphase, and telophase.
* Cells of one or more types are organized into tissues, and different types of tissues compose organs. Organs are organized to function as tracts or systems.
* The four basic types of tissues are epithelial, muscle, neural, and connective tissues.

KEY TERMS

* Absolute refractory period, 37
* Actin filament (microfilament), 10
* Action potential, 36
* Active mediated transport (active transport), 32
* Active transport, 28
* Amphipathic molecule, 12
* Anabolism, 25
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* Cytokinesis, 37
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* Cytoplasmic matrix, 4
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* Protease, 15
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* Uniport, 31
* Vault, 8

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| STUDENT CHAPTER RESOURCES | |
| Chap. 1 | READ—Textbook (pp. 1-48)  REVIEW—Evolve Resources   * Animations * Chapter Summary Review   ANSWER—Evolve Resources   * Chapter 1 Student Review Questions |
| SG | ANSWER—Study Guide   * Chapter 1: Cellular Biology |

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| INSTRUCTOR CHAPTER RESOURCES | |
| TB | **Test Bank**   * To access the **ExamView** format, go to the [Downloads](http://coursewareobjects.elsevier.com/objects/elr/Lewis/medsurg8e/downloads/) section. |
| PPT | **PowerPoint Presentations** |
| IC | **Image Collection**   * Figure 1-1. Typical or composite cell. * Figure 1-2. The nucleus. * Figure 1-3. Endoplasmic reticulum (ER). * Figure 1-4. Golgi complex. * Figure 1-5. How the internal membrane system of a cell packages a protein for export. * Figure 1-6. Lysosomes. * Figure 1-7. Mitochondrion. * Figure 1-8. Vaults. * Figure 1-9. Cytoskeleton. * Figure 1-10. Functions of plasma membrane proteins. * Figure 1-11. Structure of a phospholipid molecule. * Figure 1-12. Lipid bilayer membranes. * Figure 1-13. Schematic representation of a prototype proteolytic cascade. * Figure 1-14. Cellular receptors. * Figure 1-15. Extracellular matrix. * Figure 1-16. Types of cell connections. * Figure 1-17. Cellular communication. * Figure 1-18. Primary modes of chemical signaling. * Figure 1-19. Schematic of a signal transduction pathway. * Figure 1-20. How extracellular messengers regulate channel function. * Figure 1-21. Extracellular messenger and activation of the cAMP second messenger system. * Figure 1-22. Extracellular messenger and activation of the calcium second messenger system. * Figure 1-23. Three phases of catabolism, which leads from food to waste products. * Figure 1-24. Glycolysis. * Figure 1-25. What happens to pyruvate, the product of glycolysis? * Figure 1-26. Passive diffusion of solute molecules across plasma membrane. * Figure 1-27. Hydrostatic pressure and oncotic pressure in plasma. * Figure 1-28. Conformational-change model of mediated transport (facilitated diffusion). * Figure 1-29. Channel mode of mediated transport (facilitated diffusion). * Figure 1-30. Mediated transport. * Figure 1-31. Active transport and the sodium-potassium pump. * Figure 1-32. Endocytosis and exocytosis. * Figure 1-33. Multiple pathways of endocytosis * Figure 1-34. Ligand internalization by means of receptor-mediated endocytosis. * Figure 1-35. Sodium-potassium pump and propagation of an action potential. * Figure 1-36. The cell cycle. * Figure 1-37. Tissue formation by mitosis and migration. * Unn Figure 1-1. Protein Folding. |

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| **TEACHING STRATEGIES** | | |
| **CONTENT FOCUS** | **CONTENT HIGHLIGHTS** | **LEARNING ACTIVITIES** |
| **Prokaryotes  and Eukaryotes, 2** |  |  |
| **Cellular Functions, 2** |  |  |
| **Structure and Function of Cellular Components, 2**  **Nucleus, 2**  **Cytoplasmic Organelles, 4**  **Plasma Membranes, 11**  **Cellular Receptors, 16** | Provide an overview of the major cellular components. | * **Activity:** Have the students visit http://www. hartnell.edu/tutorials/biology/cells.html to complete a tutorial on cell structure and function. It includes a description, animation, and quiz. |
| **Cell-to-Cell Adhesions, 17**  **Extracellular Matrix, 17**  **Specialized Cell Junctions, 18** | Describe how cells are arranged and the three ways they are held together. | * **Discussion Topic:** Explain how cells are connected to form tissues and organs.   ***Answer:*** Cells can be bound together via the extracellular matrix that the cells secrete around themselves, which is an intricate network of fibrous proteins embedded in a watery gel-like substance composed of complex carbohydrates. This substance is similar to glue, but it provides a pathway for diffusion of nutrient wastes and other water-soluble traffic between the blood and tissue cells. Interwoven within the matrix are three types of protein fibers:   * Collagen: Forms cablelike fibers or sheets that provide tensile strength or resistance to longitudinal stress. * Elastin: Is a rubberlike protein fiber that is most abundant in tissues that are capable of stretching and recoiling. * Fibronectin: Promotes cell adhesion and cell anchorage.   The matrix is not simply scaffolding for cellular attachment; it also helps regulate the functions of cells with which it interacts. The matrix helps regulate cell growth and differentiation. |
| **Cellular Communication and Signal Transduction, 20**  **Signal Transduction, 21**  **Extracellular Messengers and Channel Regulation, 22**  **Second Messengers, 22** | Describe the three ways cells communicate. | * **Online Activity:** Have the students complete the Cell Signaling Problem Set available at http://www. biology.arizona.edu/cell\_bio/problem\_sets/signaling/Index.html. |
| **Cellular Metabolism, 25**  **Role of Adenosine Triphosphate, 25**  **Food and Production of Cellular Energy, 26**  **Oxidative Phosphorylation, 27** |  |  |
| **Membrane Transport: Cellular Intake  and Output, 28**  **Movement of Water  and Solutes, 28**  **Transport by Vesicle Formation, 33**  **Movement of Electrical Impulses: Membrane Potentials, 36** |  |  |
| **Cellular Reproduction: The Cell Cycle, 37**  **Phases of Mitosis and Cytokinesis, 37**  **Rates of Cellular Division, 37**  **Growth Factors, 38** | Describe the process of meiosis, mitosis, and cytokinesis. | * **Activity:** Have the students complete the Play the Control of the Cell Cycle Game available at http://www.nobelprize.org/educational/medicine/2001/index.html. |
| **Tissues, 39**  **Tissue Formation, 39**  **Types of Tissues, 39** | Describe how cells are organized into tissues. | * **Discussion Topic:** Describe the different types of tissues and their functions.   ***Answer:*** Epithelial tissue is found on most internal and external surfaces of the body. Because of their different locations, epithelial tissues have different functions. For example, the epidermis provides protection from outside trauma. Epithelial cells found in respiratory passages assist in moving particles such as dust out of the body. Connective tissue provides strength in binding different types of tissues and organs together. As opposed to the epithelial tissue, connective tissue contains an enormous amount of extracellular matrix and is classified as either dense or loose. Muscle tissue is made up of long, slim fibers that highly contract. Different types of muscle tissue exist: skeletal, cardiac, and smooth. Neural tissue is composed of highly specialized cells that quickly receive and transmit nerve impulses across synapses. The total number of neurons is determined at birth. |

in-class/ONLINE case study

An 8-month-old infant is transported into the emergency department via ambulance. The child is currently unresponsive, and medical personnel report that the child has suffered an apparent seizure at home. As a nurse attaches the child to a cardiac monitor (that monitors heart rate, respiratory rate, and blood pressure) and a pulse oximeter (that measures oxygen concentration levels within the blood stream), another staff member collects numerous tubes of blood for testing. In addition to a complete blood count (that measures the amount of certain types of cells, such as red and white blood cells, in the blood), a complete metabolic panel (that measures electrolytes and the function of the kidneys and liver) is completed. A blood glucose level of 28 mg/dl is noted (normal range is 45 to 150 mg/dl). Staff members administer an immediate bolus dose of dextrose in an attempt to normalize the infant’s glucose level and prepare a continuous intravenous infusion of saline and glucose. While staff members work with the patient, the mother arrives in the emergency department and informs them the child had a seizure at home and an additional seizure when emergency medical service (EMS) arrived. She reports that the child has a history of mitochondrial disorder and has had seizures in the past, but changes in antiseizure medications had stopped them for the last month. (The effects of mitochondrial disease are quite varied because the distribution of defective mitochondrial deoxyribonucleic acid [DNA] may vary from organ to organ in the body.)

Mitochondria within the cells are responsible for:

1. **Cellular respiration and energy production via metabolism of carbohydrates, lipids, and amino acids**
2. Detoxifying waste in the cells or foreign components that may enter the cell
3. Storing carbohydrates and fats and metabolism via enzymatic biochemical reactions
4. Synthesizing steroidal hormones and removing toxic substances from the cell

As the work on the infant continues, further results are returned from the laboratory, and the mother continues to clarify her baby’s disease. She is primarily affected via her muscles, brain, and nerves. These areas typically use more energy than other parts of the body.

For cells to function, they must be able to extract and use the chemical energy contained within the structure of organic molecules. Chemical energy is created through metabolism. Catabolism is a metabolic pathway that breaks molecules down and releases energy.

Mitochondria produce energy from carbohydrates, lipids, and proteins and transfer that energy via a transport molecule such as ATP.

The process of catabolism involves three phases in which order:

1. **Digestion, glycolysis, and Krebs cycle**
2. Krebs cycle, osmosis, and mediated transport
3. Oxidative phosphorylation, transfer reaction, and citric acid cycle
4. Citric acid cycle, passive transport, and diffusion