

CHAPTER 2: THE CELL: BASIC UNIT OF STRUCTURE AND FUNCTION

CHAPTER OVERVIEW

This chapter presents the cell, the fundamental structure and functional unit of the human body (and all living things). In chapter 2, the generalized structure of a cell is described, as well as how cells vary from one to another. This chapter establishes that cells are highly organized units, many with complex functions. The chapter also emphasizes how specialized structures, organelles, enable the cells to perform the activities necessary for life. The cell cycle is discussed in a detailed, yet clear and understandable, manner. Cell aging as a process of apoptosis (programmed cell death) is also presented. Many new terms are introduced in this chapter, as will be true for most chapters in this manual.

The cell is the basic living unit of all organisms. Thus, learning how these units function individually and together is critical to understanding the anatomy of the human body. A solid understanding of the structure and functions of cells is necessary for the understanding of tissues, organs, and systems. The most difficult challenge when studying cell structure and function involves visualizing the membrane's proteins, the minute cytoplasmic organelles, and the ways they function in the various cell types of the body.

KEY POINTS TO EMPHASIZE WHEN TEACHING THE CELL

1. It is important that students understand that the cell shown in figure 2.3 is a generalized cell and that all cells do not contain each organelle. Cells are specialized according to function. Good examples are the red blood cell (no nucleus) and the skeletal muscle cell (many nuclei).
2. By learning the structure of each organelle, including the roles of the membranes associated with it, students can quickly recall the function of each one.
 - a. Students may need help in tying the chemical properties of the components of organelles to the cellular functions performed by those organelles.
 - b. Those students lacking a background in chemistry will be the first to get lost as you try to explain how chemical structure influences organelle function.
 - c. As an alternative, try viewing the cell membrane and the interior of the cell as a manufacturing plant. Students can relate to this much better than to chemistry. (Chapter 2 deals with the chemical information in an easy-to-understand manner, and, if you follow that lead, you'll have greater success in teaching students about the structure and function of cells.)
 - d. Describe the nucleus as the control center of the cellular manufacturing plant. It can be viewed as the "intellectual" or "smart" part of the cell that gives directions to the rest of the "plant." Also, explain the role of the nucleolus in the production of rRNA.
3. There are a lot of "C" words associated with the nucleus; they tend to confuse students. The words chromosome, chromatin, chromatids, centromere, centrioles, and centrosome are difficult for students to keep straight.

- a. Thus, it's a good idea to go over the definitions of all these words at one time (this helps get through to some). Show that the first four are related, as are the last two.
 - b. Most often it is necessary to repeat the differences between chromatin and chromosomes.
4. Mitochondria are the "power packs" of the cell. They make, store, and release most energy (in the form of ATP) used by cells. This is a good time to explain the importance of glucose in the production of ATP. Also, explain why some cells have many mitochondria and others have few.
5. Understanding transport mechanisms of substances across the plasma membrane is very important, particularly for understanding the functions of several systems later in the text (e.g., respiratory, digestive). Thus, a thorough explanation of the mechanisms is vital.
6. Explain that the plasma membrane is the barrier between the intracellular and extracellular material, and is very selective in determining what moves into and out of the cell. The membrane-bound organelles are also surrounded by a plasma membrane-like structure and are therefore able to regulate the flow of materials between one part of the cell and another. Some substances can cross plasma membranes by simple diffusion; others cannot. The ability to cross the membrane is usually restricted to substances that are lipid soluble.
7. Discuss the mechanisms by which lipid-insoluble compounds can cross the cellular membranes. This will help students more fully understand the transport molecules and membrane channels and how they can overcome transportation problems like molecular size and lipid insolubility of the substance to be transported.
8. Students often get confused when dealing with carrier molecules and channel proteins. Point out that channel proteins allow things like ions to cross the membrane by opening and closing holes (or channels) through the membrane; a carrier molecule must grab onto, hold, and carry the molecule that is being transported through the membrane.
9. Explaining diffusion can be a fun experience for the class. Rather than using the traditional dye-in-water or agar demonstrations, try using the SBD ("silent but deadly") analogy: flatulence! Students do not forget the concept after visualizing the spread of methane gas and sulfur compounds from high concentration to low concentration until equilibrium is reached and without energy expended.
10. Osmosis seems to be difficult for many. Remind them that osmosis is simply diffusion of water from high concentration of water to low concentration of water until equilibrium is reached. No energy is expended here either.
11. Facilitated diffusion is another place where students get lost. Point out that this process follows all the rules of diffusion (from high to low concentration until equilibrium is reached). The only difference is that facilitated diffusion requires a transport protein to help get the dissolved substance through the plasmalemma. The cell expends no energy.
12. When dealing with endocytosis, it can be helpful to relate the terms *pinocytosis*, *phagocytosis*, and *receptor-mediated endocytosis* to a dining experience. If you create the visual of going out to dinner, endocytosis can be related to "cell dining." Pinocytosis parallels "cell drinking"; phagocytosis resembles "indiscriminate cell eating" (like at a buffet where you "pig out" on everything); and receptor-mediated endocytosis is like the habits of a picky eater (like an ovovegetarian who only eats eggs and veggies). To complete the whole thing, describe *exocytosis* as "cell barfing." This is a little gross, but students seem to relate to it quite well. If you have time, discuss *cytrophagocytosis* as "cell biting" (cytrophagocytosis is the mechanism by which melanosomes are transferred from melanocytes to stratum basale).

cells in the epidermis—also, possibly, the mechanism for the transfer of ferritin from reticulum cells to erythroblasts).

13. The cell cycle—particularly interphase and mitosis—seems complicated to students at first, but, with vivid explanations, most can grasp this important process. Also, explain that “cytokinesis” is not part of “mitosis.” Mitosis refers to the division of the nucleus; cytokinesis refers to the actual division of the cell. After they understand this, point out that mitosis without cytokinesis is possible (in multinucleated skeletal muscle cells).

VISUALS, IN-CLASS DEMONSTRATIONS, AND DISCUSSIONS

1. Using micrographs of specific cells and their organelles are quite helpful to the student. You can also talk about cell sections and why there are some weirdly shaped organelles.
2. Use figure 2.2 to help students visualize the cilia on cells of respiratory epithelium. Students often have difficulty visualizing the structure of cells, since they cannot be seen in three dimensions under a light microscope. In SEM (scanning electron microscope) micrographs, the three-dimensional structures can be easily seen.
3. Project figures 2.4, 2.5, 2.6, and 2.7 to illustrate membrane transport mechanisms.
4. Charts of the generalized cell and its contents are useful for visualization and review.
5. Have students scrape some cells off the inside of the mouth. Ask them to locate as many organelles as they can (nucleus and nucleolus are about all they will see). Generate a discussion about the usefulness of these cells as forensic evidence.
6. For chromosome understanding, get a copy of the chart produced by the Human Genome Project. It shows every known gene on each chromosome. Discuss the genes of interest to your students.
7. Project a slide of a karyotype of human chromosomes, plus those of other animals. This is a good visual for learning the different shapes and sizes of chromosomes.
8. Toss out this question: Why is damage to the brain more serious than damage to the liver (or to other organs that have regenerative properties)? Discuss the cell’s ability to divide/reproduce itself.
9. To get students thinking about the relevance of cell structure and function, explain stem cells.
 - a. Then stimulate discussion with the students on the possibilities of stem cell research (totipotent and pluripotent stem cells) and its potential importance to cancer and spinal cord injuries. Try to keep the discussion on the science of stem cells; stay away from the religious and emotional stuff. Include the fact that stem cell research involves or may involve fetal stem cells and, increasingly, adult stem cells.
 - b. Students often find it interesting if you discuss the extensive methods used to freeze stem cells: Water must be removed from the cells by osmosis prior to freezing because, if the water remains, it will cause the cell to burst (this gets them thinking about the amount of water in cells and its properties).
10. The concepts associated with the aging of cells are of interest to many students. The idea of “programmed cell death” (apoptosis) is amazing to most.
11. Ask them if they consider one organelle in the cell to be more important than another. If so, why? If not, why not? This gets students thinking about the integrated functions of the organelles.

12. Models of mitosis are good visuals. For example, show slides of whitefish blastula mitosis so they can see what the process really looks like.

CHAPTER OUTLINE

1. The Study of Cells (pp. 24–26)
 - A. Using the Microscope to Study Cells (pp. 24–25; Figs. 2.1, 2.2)
 - Light microscope
 - Transmission electron microscope
 - Scanning electron microscope
 - B. General Functions of Human Body Cells (pp. 25–26; Tab. 2.1)
 - Covering
 - Lining
 - Storage
 - Movement
 - Connection
 - Defense
 - Communication
 - Reproduction
2. A Prototypical Cell (pp. 27–29; Fig. 2.3; Tab. 2.2)
3. Plasma Membrane (pp. 30–36)
 - Plasmalemma
 - A. Composition and Structure of Membranes (pp. 30–31; Fig. 2.4)
 - i. Lipids (p. 30; Fig 2.4)
 - a. Phospholipids
 - b. Cholesterol
 - c. Glycolipids
 - ii. Proteins (p. 30; Fig 2.4)
 - a. Integral proteins
 - Membrane channels
 - Receptors
 - b. Peripheral proteins
 - Enzymes
 - Glycoproteins
 - B. Protein-Specific Functions of the Plasma Membrane (pp. 31–32)
 - Transport
 - Intercellular connection
 - Anchorage for cytoskeleton
 - Enzyme (catalytic) activity
 - Cell-cell recognition
 - Signal transduction
 - C. Transport Across the Plasma Membrane (pp. 32–36; Tab. 2.3)
 - Transport proteins
 - Plasma membrane structure

- Concentration gradient
- Ionic charge
- Lipid solubility
- Molecular size
- i. Passive transport (p. 32; Tab. 2.3)
 - a. Simple diffusion
 - b. Osmosis
 - c. Facilitated diffusion
 - d. Bulk filtration
- ii. Active transport (p. 33; Tab. 2.3)
 - a. Ion pumps (Fig. 2.5)
 - b. Bulk transport
 - Exocytosis (Fig. 2.6)
 - Endocytosis (Fig. 2.7)
 - Phagocytosis (Fig. 2.7a)
 - Pinocytosis (Fig. 2.7b)
 - Receptor-mediated endocytosis (Fig. 2.7c)
- 4. Cytoplasm
 - A. Cytosol
 - B. Inclusions
 - C. Organelles
 - i. Membrane-bound organelles (pp. 37–41)
 - a. Endoplasmic reticulum (ER) (Fig. 2.8)
 - Smooth ER
 - Rough ER
 - b. Golgi apparatus (Fig. 2.9)
 - c. Lysosomes (Fig. 2.10)
 - d. Peroxisomes (Fig. 2.11)
 - e. Mitochondria (Fig. 2.12)
 - ii. Non-membrane-bound organelles (pp. 42–44)
 - a. Ribosomes (Fig. 2.13)
 - Large subunit (Fig. 2.13a)
 - Small subunit (Fig. 2.13a)
 - Free ribosomes (Fig. 2.13b)
 - Fixed ribosomes (Fig. 2.13b)
 - b. Cytoskeleton (Fig. 2.14)
 - Microfilaments
 - Intermediate filaments
 - Microtubules
 - c. Centrosome and centrioles (Fig. 2.15)
 - d. Cilia and flagella (Fig. 2.16)
 - e. Microvilli (Fig. 2.3)
- 5. Nucleus (pp. 44–46; Fig. 2.17)
 - A. Nuclear Envelope
 - B. Nucleoli

C. DNA, Chromatin and Chromosomes	(Fig. 2.18)
6. Life Cycle of the Cell	(pp. 46–49)
A. Interphase	(p. 47; Figs. 2.19, 2.20)
i. G ₁ phase	
ii. S phase	
iii. G ₂ phase	
B. Mitotic (M) Phase	(p. 47; Figs. 2.19, 2.20)
i. Prophase	
ii. Metaphase	
iii. Anaphase	
iv. Telophase	
• Cytokinesis	
7. Aging and the Cell	(p. 49)
• Cancer	
• Apoptosis	
• Necrosis	
8. Clinical Terms	(p. 51)
9. Chapter Summary	(pp. 51–52)
10. Challenge Yourself	(pp. 52–53)
11. Answers to “What Do You Think?”	(p. 53)