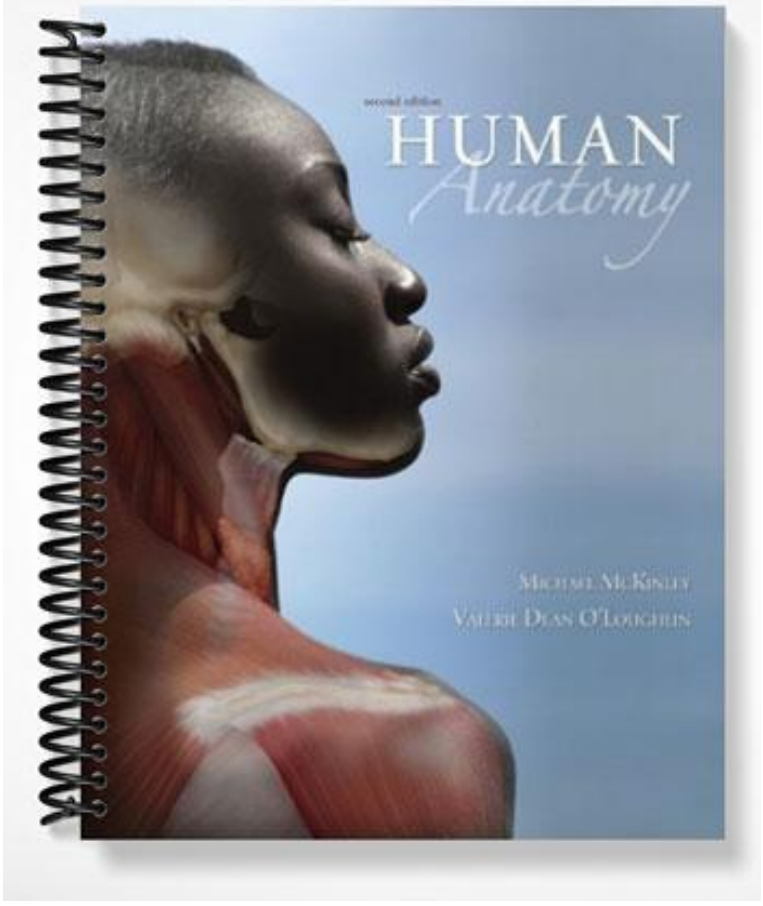
SOLUTIONS MANUAL



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 the future.

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 the structure and functions of cells is necessary for the understanding of tissues, organs and systems. The most difficult parts of cell structure and function are visualizing the membrane's proteins, the minute cytoplasmic organelles, and how they function in the various cell types of the body.

KEY POINTS TO EMPHASIZE WHEN TEACHING THE CELL

1. It's important that students understand that the cell shown in Figure 2.1 is a generalized cell and that all cells do not contain each organelle. Cells are specialized according to function. Good examples: RBC=no nucleus; Skeletal muscle cell=many nuclei.
2. By learning the structure of each organelle, including the role of membranes associated with them, students can quickly recall their function.
    a. Students may need help in tying the chemical properties of the components of organelles and 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 dealing with 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 R-RNA.
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 definition of each word at one time (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 point to explain the importance of glucose in the production of ATP. Also, explain why some cells have many mitochondria and others have few.
5. Transport mechanisms of substances across the plasma mambrane is very important, parituclarly 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 also surrounded and 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; carrier molecules must grab onto, hold, and carry the molecule that's 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, try using the analogy of an SBD ("Silent but Deadly"…flatulence!). Students don't forget the concept after visualizing the spread of methane gas and sulfur compounds from high concentration to low concentration until equilibrium 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 expended here either.
11. Facilitated diffusion is another place where students get lost. Point out that this process follows all the rules of diffusion ([high] to [low]) until equilibrium is reached. The only thing different 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=cell drinking; phagocytosis=non-discriminate cell eating (like at a buffet where you pig-out on everything); Receptor-mediated endocytosis=a picky eater (like an ovovegetarian who only eats eggs and veggies). To complete the whole thing, describe "Exocytosis" as "cell-barfing." A little gross but students seem to relate to this quite well. If you have time, discuss "cytophagocytosis" as "cell-biting" (cytophagocytosis 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 get it, point out that mitosis without cytokinesis is possible (multinucleated skeletal muscle cells).

VISUALS—IN CLASS DEMONSTRATIONS/DISCUSSIONS

1. Discussions of PowerPoint (or 35mm) slides of photomicrographs of specific cells and their organelles are quite helpful to the student. You can also talk about cell sections and why there are some weird shapes of organelles.
2. Use the transparency of Figure 2.2 to help students visualize the cili on cells of respiratory epithelium. Students often have difficulty visualizing the structure of cells since they cannot be seen in 3-dimensions under a Light Microscope. By showing SEM pictures the 3-dimensional structures can me easily seen.
3. Project the transparencies of 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 is about all they'll 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 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. It's a good visual for learning the different shapes and sizes of chromosomes.
8. Toss out the question: why is damage to brain more serious than damage to the liver (or other organ that has regenerative properties). Deal with the cell's ability to divide/reproduce its self.
9. To get them 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 pleuripotent stem cells) and its potential importance to cancer and spinal cord injuries. Try to keep it on the science of stem cells…keep away from the religious and emotional stuff.
    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 (gets them thinking about the amount of water in cells and its properties).
10. The concepts of 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? Gets them thinking about the integrated functions of the organelles.

12. Models of mitosis are quite visual. Show slides of whitefish blastula mitosis so they can see what the process really looks like.

CHAPTER OUTLINE

1. The Study of Cells **(p. 24; Fig. 2.1, 2.2)**
    - A. Using the microscope to study cells **(p. 24; Fig. 2.1, 2.2)**
    - B. Light Microscope
    - C. Transmission Electron Microscope **(Fig. 2.2)**
    - D. Scanning Electron Microscope **(Fig. 2.2)**
    - E. General Functions of Human Body Cells **(p. 25; Table 2.1)**
        - i. Covering
        - ii. Lining
        - iii. Storage
        - iv. Movement
        - v. Connection
        - vi. Defense
        - vii. Communication
        - viii. Reproduction
2. A Prototypical Cell **(p. 27; Fig. 2.3; Tab. 2.2)**
    - A. Plasma (Cell) Membrane **(p. 30; Fig. 2.4)**
        - i. Plasmalemma
    - B. Composition and Structure of Membranes **(p. 30; Fig. 2.4)**
        - i. Lipids
            1. Phospholipids
            2. Cholesterol
            3. Glycolipids
        - ii. Proteins
            1. Integral proteins
                a. Membrane channels
                b. Receptors
            2. Peripheral proteins
            3. enzymes
            4. glycoproteins
    - C. Protein-Specific Functions of the Plasma Membrane **(p. 31)**
        - i. Transport
        - ii. Intercellular connection
        - iii. Anchorage for cytoskeleton
        - iv. Enzyme (catalytic) activity
        - v. Cell-cell recognition
        - vi. Signal transduction
    - D. Transport Across the Plasma Membrane **(p. 32; Tab. 2.3)**
        - i. Transport proteins
        - ii. Plasma membrane structure
        - iii. Concentration gradient
        - iv. Ionic charge

v. Lipid solubility
vi. Molecular size
vii. Passive transport **(Tab. 2.3)**
    1. Simple diffusion
    2. Osmosis
    3. Facilitated diffusion
    4. Bulk filtration
viii. Active transport **(Tab. 2.3)**
    1. Ion pumps **(Fig. 2.5)**
    2. Bulk transport
        a. Exocytosis **(Fig. 2.6)**
        b. Endocytosis **(Fig. 2.7)**
        c. Phagocytosis **(Fig. 2.7a)**
        d. Pinocytosis **(Fig. 2.7b)**
        e. Receptor-mediated endocytosis **(Fig. 2.7c)**

E. Cytoplasm **(pp. 36-44)**
    i. Cytosol
    ii. Inclusions
    iii. Organelles
        1. Membrane-bound organelles **(p. 37)**
            a. Endoplasmic reticulum (ER) **(Fig. 2.8)**
            b. Smooth ER
            c. Rough ER
            d. Golgi apparatus **(Fig. 2.9)**
                1. **Structure of Golgi** **(Fig. 2.9a)**
                2. **Functions of Golgi** **(Fig. 2.9b)**
            e. Lysosomes **(Fig. 2.10)**
            f. Peroxisomes **(Fig. 2.11)**
            g. Mitochondria **(Fig. 2.12)**
    iv. Non-membrane-bound organelles **(pp. 42-44)**
        1. Ribosomes **(Fig. 2.13)**
            a. Large subunit **(Fig. 2.13a)**
            b. Small subunit **(Fig. 2.13a)**
            c. Free ribosomes **(Fig. 2.13b)**
            d. Fixed ribosomes **(Fig. 2.13b)**
        2. Cytoskeleton **(Fig. 2.14)**
            a. Microfilaments
            b. Intermediate filaments
            c. Microtubules
            d. Centrosome and centrioles **(Fig. 2.15)**
            e. Cilia and flagella **(Fig. 2.16)**
            f. Microvilli **(Fig. 2.3)**

F. Nucleus **(p. 44; Fig. 2.17)**
    i. Nuclear Envelope **(p. 44)**
    ii. Nucleoli **(p. 45)**
    iii. DNA, Chromatin and chromosomes **(p. 45; (Fig. 2.18)**

3. Life Cycle of the Cell **(p. 46; Fig. 2.19; Tab. 2.4)**
    i. Interphase **(p. 47; Fig. 2.19, 2.20; Tab 2.4)**
        1. G1-phase
        2. S phase **(Fig. 2.18a, 2.19)**
        3. G2-phase
    ii. Mitotic (M) Phase **(p. 47; Fig. 2.20; Tab 2.4)**
        1. Prophase **(Fig. 2.20b)**
        2. Metaphase **(Fig. 2.20c)**
        3. Anaphase **(Fig. 2.20d)**
        4. Telophase and cytokinesis **(Fig. 2.20e)**
4. Aging and the Cell **(p. 50)**
    i. Necrosis
    ii. Apoptosis
    iii. Cancer
5. Clinical Terms **(p. 51)**
6. Chapter Summary **(pp. 51-52)**
7. Challenge Yourself **(pp. 52-53)**
8. Answers to “What Do You Think?” **(p. 53)**