

Chapter 3 -Cells

3.1 Introduction (Fig. 3.1)

- A. The human body consists of 75 trillion cells that vary considerably in shape and sizes yet have much in common.
- B. Differences in cell shape make different functions possible.

3.2 A Composite Cell (Fig 3.2)

- A. A composite cell includes many known cell structures.
- B. A cell consists of three main parts---the nucleus, the cytoplasm, and the cell membrane.
- C. Within the cytoplasm are specialized organelles that perform specific functions for the cell.
- D. Cell Membrane (Fig. 3.3)
 - 1. The cell membrane regulates the movement of substances in and out of the cell, participates in signal transduction, and helps cells adhere to other cells.
 - 2. General Characteristics (Fig. 3.2)
 - a. The cell membrane is extremely thin and selectively permeable.
 - b. It has a complex surface with adaptations to increase surface area.
 - 3. Cell Membrane Structure (Fig. 3.3)
 - a. The basic framework of the cell membrane consists of a double layer of phospholipids, with fatty acid tails turned inward.
 - b. Molecules that are soluble in lipids (gases, steroid hormones) can pass through the lipid bilayer.
 - c. Embedded cholesterol molecules strengthen the membrane and help make the membrane less permeable to water-soluble substances.
 - d. Many types of proteins are found in the cell membrane, including transmembrane proteins and peripheral membrane proteins. Because of the combination of the oily phospholipids and the embedded proteins, the membrane is called a “fluid mosaic.”
 - e. Membrane proteins perform a variety of functions and vary in shape.
 - f. Some proteins function as receptors on the cell surface, starting signal transduction.
 - g. Other proteins aid the passage of molecules and ions.
 - h. Proteins protruding into the cell anchor supportive rods and tubules.
 - i. Still other proteins have carbohydrates attached; these complexes are used in cell identification. Membrane proteins called cellular adhesion molecules (CAMs) help determine one cell’s interactions with others.

E. Cytoplasm (Table 3.1)

- 1. The cytoplasm consists of a clear liquid (cytosol), a supportive cytoskeleton, and networks of membranes and organelles.
 - a. Endoplasmic reticulum is made up of membranes, flattened sacs, and vesicles, and provides a tubular transport system inside the cell. (Fig 3.4)
 - i. With ribosomes, endoplasmic reticulum (ER) is rough ER, and functions in protein synthesis.
 - ii. Without ribosomes, it is smooth ER, and functions in lipid synthesis.
 - b. Ribosomes are found with ER and are scattered throughout the cytoplasm. They are composed of protein and RNA and provide a structural support for the RNA molecules that come together in protein synthesis.
 - c. Golgi apparatus (Figs. 3.2, 3.5) is composed of flattened sacs, and refines, packages, modifies, and delivers proteins.
 - i. Vesicles formed on ER travel to the Golgi apparatus, which modifies their contents chemically.

- ii. The vesicle may then move to the cell membrane and secrete its contents to the outside.
 - iii. Vesicles form a “delivery service,” carrying chemicals throughout the cell (vesicle trafficking).
 - d. Mitochondria (Figs 3.2, 3.6) are the powerhouses of the cell and contain enzymes needed for aerobic respiration.
 - i. The inner membrane of the mitochondrion is folded into cristae, which hold the enzymes needed in energy transformations to make ATP.
 - ii. Very active cells contain thousands of mitochondria.
 - e. Lysosomes are the "garbage disposals" of the cell and contain digestive enzymes to break up old cell components and bacteria. (Fig. 3.2)
 - f. Peroxisomes contain enzymes that function in the synthesis of bile acids, breakdown of lipids, degradation of rare biochemicals, and detoxification of alcohol. Peroxisomes are abundant in liver and kidney cells.
 - g. Microfilaments and microtubules (Fig. 3.7) are thin, threadlike structures that serve as the cytoskeleton of the cell.
 - i. Microfilaments, made of actin, cause various cellular movements.
 - ii. Microtubules, made of the globular protein tubulin, are arranged in a 9 + 2 pattern of tubules.
 - h. Centrosome (Figs. 3.2, 3.8) is structure made up of two hollow cylinders called centrioles that function in the separation of chromosomes during cell division.
 - i. Cilia and flagella (Figs. 3.2, 3.9) are motile extensions from the cell; shorter cilia are abundant on the free surfaces of certain epithelial cells (respiratory linings, for example), and a lengthy flagellum can be found on sperm cells.
 - j. Vesicles form from part of the cell membrane or the Golgi and store materials. (Fig. 3.2)
- F. Cell Nucleus (Figs. 3.2, 3.10)
 - 1. The fairly large nucleus is bounded by a double-layered nuclear membrane containing relatively large nuclear pores that allow the passage of certain substances.
 - a. The nucleolus is composed of RNA and protein and is the site of ribosome production.
 - b. Chromatin consists of loosely coiled fibers of protein and DNA.

3.3 Movements Through Cell Membranes (Table 3.2)

- A. The cell membrane controls what passes through it.
- B. Mechanisms of movement across the membrane may be passive, requiring no energy from the cell (diffusion, facilitated diffusion, osmosis, and filtration) or active mechanisms, requiring cellular energy (active transport, endocytosis, and exocytosis).
- C. Passive Mechanisms
 - 1. Diffusion (Figs. 3.11-3.13)
 - a. Diffusion is caused by the random motion of molecules and involves the movement of molecules from an area of greater concentration to one of lesser concentration until equilibrium is reached.
 - b. Diffusion enables oxygen and carbon dioxide molecules to be exchanged between the air and the blood in the lungs, and between blood and tissue cells.
 - 2. Facilitated Diffusion (Fig. 3.14)
 - a. Facilitated diffusion uses membrane proteins that function as carriers to move molecules (such as glucose) across the cell membrane.

- b. The number of carrier molecules in the cell membrane limits the rate of this process.
 - 3. Osmosis (Figs. 3.15, 3.16)
 - a. Osmosis is a special case of diffusion in which water moves from an area of greater water concentration (where there is less osmotic pressure) across a selectively permeable membrane to an area of lower water concentration (where there is greater osmotic pressure).
 - b. Osmotic pressure is the ability of osmosis to lift a volume of water.
 - c. A solution with the same osmotic pressure as body fluids is called isotonic; one with higher osmotic pressure than body fluids is hypertonic; one with lower osmotic pressure is hypotonic.
 - 4. Filtration (Fig. 3.17)
 - a. Because of hydrostatic pressure, molecules can be forced through membranes by the process of filtration. Blood pressure is a type of hydrostatic pressure.
- D. Active Mechanisms
 - 1. Active Transport (Fig. 3.18)
 - a. Active transport uses ATP to move molecules from areas of low concentration to areas of high concentration through carrier molecules in cell membranes.
 - b. As much as 40% of a cell's energy supply may be used to fuel this process.
 - c. The union of the specific particle to be transported with its carrier protein triggers the release of cellular energy (ATP), which in turn alters the shape of the carrier protein, releasing the particle to the other side of the membrane.
 - d. Particles that are actively transported include sugars, amino acids, and sodium, potassium, calcium, and hydrogen ions, as well as nutrient molecules in the intestines.
 - 2. Endocytosis and Exocytosis (Figs. 3.19-3.20)
 - a. In endocytosis, molecules that are too large to be transported by other means are engulfed by an invagination of the cell membrane and carried into the cell surrounded by a vesicle.
 - b. Exocytosis is the reverse of endocytosis.
 - c. Three forms of endocytosis are pinocytosis, phagocytosis, and receptor-mediated endocytosis.
 - i. Pinocytosis is a form of endocytosis in which cells engulf liquids.
 - ii. Phagocytosis is a form of endocytosis in which the cell takes in larger particles, such as a white blood cell engulfing a bacterium.
 - iii. Receptor-mediated endocytosis allows the cell to take in very specific molecules (ligands) that pair up with specific receptors on the cell surface.

3.4 The Cell Cycle (Fig. 3.21)

- A. The series of changes a cell undergoes from the time it is formed until it reproduces is called the cell cycle.
- B. The cell cycle consists of interphase, mitosis, cytokinesis, and differentiation.
- C. The cell cycle is highly regulated. Most cells do not divide continually. Cells have a maximum number of times they can divide because of built-in “clocks” (telomeres) on the tips of chromosomes.
- D. Interphase
 - 1. Interphase is a period of great metabolic activity in which the cell grows and synthesizes new molecules and organelles.

2. During the S phase (synthesis phase) of interphase, the DNA of the cell is replicated in preparation for cell division.
 3. During the G₁ and G₂ phases of interphase, the cell grows and other structures are duplicated.
- E. Cell Division (Fig. 3.22)
1. There are two types of cell division – meiosis and mitosis. In meiosis, four cells (sperm or ova) are produced, each of which contains half of the parent cell's genetic information. The second type of cell division, mitosis, is necessary for growth and development.
 2. Mitosis is a carefully orchestrated division of the nucleus of the cell that results in each daughter cell receiving an exact copy of the mother cell's genetic material.
 3. Mitosis is described as a series of four stages, but the process is actually continuous.
 4. Prophase, the first stage of mitosis, results in the DNA condensing into chromosomes, centrioles migrating to the poles, microtubules of the cytoskeleton reorganizing into spindle fibers, and the disappearance of the nuclear membrane.
 5. Metaphase occurs as spindle fibers attach to centromeres on the chromosomes and the chromosomes align midway between centrioles.
 6. Anaphase occurs as the spindle fibers contract and pull the sister chromatids toward the centrioles.
 7. Telophase, the final stage of mitosis, begins when the chromosomes have completed their migrations, the nuclear envelope reappears, and the chromosomes begin to unwind.
- F. Cytoplasmic Division
1. Cytokinesis begins during anaphase of mitosis and continues as a contractile ring pinches the two new cells apart.
 2. The two daughter cells may have varying amounts of cytoplasm and organelles, but they share identical genetic information.
- G. Cell Differentiation (Fig. 3.23)
1. The process by which cells develop into different types of cells with specialized functions is called differentiation.
 2. Cell differentiation reflects genetic control of the nucleus as certain genes are turned on while others are turned off.
- H. Cell Death
1. Apoptosis is a form of cell death that is a normal part of development.