

Chapter 3: Cells

I. Introduction

- A. An adult human body consists of about 75 trillion cells.
- B. There are at least 260 different varieties of cells.
- C. Cells are measured in units called micrometers.
- D. A micrometer equals one thousandth of a millimeter.
- E. A human egg cell is about 140 micrometers in diameter.
- F. A red blood cell is about 7.5 micrometers in diameter.
- G. Typically the shape of a cell makes possible its functions.

II. A Composite Cell

A. Introduction

- 1. It is not possible to describe a typical cell because cells vary greatly in size, shape, content and function.
- 2. A composite cell includes many known cell structures.
- 3. The three major parts of a cell are the nucleus, cytoplasm, and cell membrane.
- 4. The nucleus is enclosed by a nuclear envelope.
- 5. The nucleus contains DNA.
- 6. The cytoplasm is a mass of fluid that surround the nucleus and is itself encircled by the cell membrane.
- 7. The cell membrane surrounds the cytoplasm.
- 8. Specialized structures within the cytoplasm are called organelles.
- 9. Cytosol is a liquid that suspends organelles.

B. Cell Membrane

1. General Characteristics

- a. The cell membrane controls the entrance and exit of substances into and out of the cell.
- b. The cell membrane is called selectively permeable because it

allows the entry and exit of only certain substance.

c. Signal transduction is the process in which a cell receives and responds to incoming messages.

2. Membrane Characteristics

a. The cell membrane is mainly composed of lipids and proteins, with some carbohydrates.

b. The cell membrane has a double layer of phospholipids.

c. The surfaces of the cell membrane are formed by phosphate groups of phospholipid molecules.

d. The interior of the cell membrane is formed by the fatty acids of phospholipid molecules.

e. The phospholipid bilayer is permeable to lipid-soluble substances such as lipids, steroid hormones, oxygen, and carbon dioxide.

f. The phospholipid bilayer is not permeable to water-soluble substances such as proteins, sugars, nucleic acids, amino acids, and various ions.

g. Cholesterol molecules help to stabilize the cell membrane.

h. Five types of membrane proteins are receptor proteins, integral proteins, enzymes, cellular adhesion molecules and cell surface proteins

i. Receptor proteins function to receive and transmit messages into a cell.

j. Integral proteins function to form pores, channels, and carriers in cell membranes.

k. Enzymes of the membrane function in signal transduction.

l. Cellular adhesion molecules function to enable cells to stick to each other.

m. Cell surface proteins function to establish the cell as “self” or

not foreign.

3. Intercellular Junctions

- a. Intercellular junctions connect cell membranes.
- b. Three types of intercellular junctions are tight junctions, desmosomes, and gap junctions.
- c. Tight junctions are located in cells that form sheetlike layers.
- d. Tight junctions function to close spaces between cells.
- e. Desmosomes are located in cells of the skin.
- f. Desmosomes function to form a reinforced structural unit.
- g. Gap junctions are located in cells of the heart muscle and muscles cells of the digestive tract.
- h. Gap junctions function to link the cytoplasm of adjacent cells and allow ions, nutrients, and other small molecules to move between them.

4. Cellular Adhesion Molecules

- a. Two examples of CAMs are selectin and integrin.
- b. Selectin functions to coat white blood cells so that they can slow down in the turbulence of the bloodstream.
- c. Integrin functions to anchor white blood cells to an injured blood vessel wall.

C. Cytoplasm

1. The cytoskeleton is protein rods and tubules that form a supportive framework within a cell.
2. The structure of endoplasmic reticulum is a complex o connected, membrane-bound sacs, canals, and vesicles.
3. The function of endoplasmic reticulum is to transport materials within the cell, to provide attachments sites for ribosomes, and to synthesize lipids and proteins.
4. Rough endoplasmic reticulum is studded with ribosomes.

5. The ribosomes are sites of protein synthesis.
6. Proteins move from the ER to the Golgi apparatus.
7. Smooth endoplasmic reticulum is endoplasmic reticulum that lacks ribosomes.
8. SER contains enzymes that are used for lipid synthesis, fat absorption, and the break down of drugs.
9. Two places ribosomes are found are on endoplasmic reticulum and free floating in the cytoplasm.
10. Ribosomes are composed of RNA and proteins.
11. Ribosomes are the sites of protein synthesis.
12. The structure of the Golgi apparatus is a group of flattened, membranous sacs.
13. The Golgi apparatus functions to package and modify proteins from transport and secretion.
14. Vesicle trafficking is the movement of substances within cells by way of vesicles.
15. The structure of mitochondria is a membranous sac with inner partitions.
16. The two layers of a mitochondrion are an outer membrane and an inner membrane.
17. Cristae are shelflike partition of the inner membrane of a mitochondrion.
18. Mitochondria function to release energy from food molecules and transform energy into usable forms.
19. Lysosomes function to digest worn out cellular parts of substances that enter cells.
20. Lysosomes contain digestive enzymes.
21. Peroxisomes contain enzymes called peroxidases.
22. Peroxisomes are most abundant in cell of the liver and kidneys.

23. The enzymes of peroxisomes function to breakdown many important organic molecules.
24. The structure of a centrosome is a nonmembranous structure composed of two rodlike centrioles.
25. A centrosome is usually located near the nucleus.
26. Centrosomes function to distribute chromosomes to new cells during cell division and to initiate formation of cilia.
27. The structure of a cilium is a motile projection that is attached to basal body beneath the cell membrane.
28. The function of cilia is to propel fluid over a cellular surface.
29. The structure of a flagellum is a motile projection that is attached to a basal body beneath the cell membrane.
30. The function of flagella are to enable sperm cells to move.
31. Vesicles are membranous sacs.
32. Vesicles are formed by the pinching off of the cell membrane.
33. Vesicles function to store and transport substances within the cell.
34. Microfilaments are tiny rods of the protein actin that typically occur in meshworks of bundles
35. Microfilaments cause various kinds of cellular movements.
36. Microtubules are long, slender tube with diameters larger than those of microfilaments.
37. Three functions of microtubules are to maintain the shape of a cell, and to provide movement in cilia and flagella.
38. Inclusions are chemical in the cytoplasm.

D. Cell Nucleus

1. The nucleus contains DNA.
2. Chromosomes are extremely long molecules that contain DNA and proteins.
3. The nucleus is enclosed by the nuclear envelope.

4. Nuclear pores are round openings in a nuclear envelope.
5. Messenger RNA and various other substances move through nuclear pores.
6. Nucleoplasm is the fluid inside the nucleus.
7. Two structures found in nucleoplasm are the nucleolus and chromatin.
8. The nucleolus is composed of RNA and protein.
9. The nucleolus is the site of ribosome production.
10. Chromatin is DNA and proteins called histones.

III. Movements Into and Out of the Cell

A. Introduction

1. The cell membrane controls which substances enter or exit the cell.
2. Four types of physical processes are diffusion, facilitated diffusion, osmosis, and filtration.
3. Three types of physiological mechanisms are active transport, endocytosis, and exocytosis.

B. Diffusion

1. Diffusion is the tendency of atoms, molecules, and ions in a liquid or air solution to move from areas of higher concentration to areas of lower concentration.
2. A concentration gradient is the difference in concentrations.
3. Diffusional equilibrium is the condition of having a uniform concentration of substances throughout a solution.
4. Substances diffuse down a concentration gradient.
5. Two conditions that allow a substance to diffuse across a membrane are the permeability of the cell membrane to a substance and the existence of a concentration gradient across the membrane.
6. In body cells, oxygen usually diffuses into a body cell and carbon dioxide diffuses out of a body cell.
7. A physiological steady state is where concentrations of diffusing

substances are unequal but stable.

8. Five substances that cross the cell membrane through simple diffusion are lipid-soluble substances, oxygen, carbon dioxide, steroids, and general anesthetics.

9. The three most important factors that influence diffusion rate are distance, concentration gradient, and temperature.

10. In general, diffusion is more rapid over shorter distances, larger concentration gradients, and at higher temperatures.

C. Facilitated Diffusion

1. Facilitated diffusion requires proteins channels or protein carriers.
2. Substances that move across the cell membrane through facilitated diffusion are glucose and other sugars.
3. The hormone insulin promotes facilitated diffusion of glucose.

D. Osmosis

1. Osmosis is the diffusion of water molecules from a region of higher water concentration to a region of lower water concentration across a selectively permeable membrane.
2. Osmotic pressure is the ability of osmosis to generate enough pressure to lift a volume of water.
3. Water always tends to diffuse toward solutions of greater osmotic pressure.
4. Isotonic solutions are solutions with the same osmotic pressure as body fluids.
5. Hypertonic solutions are solutions with a greater osmotic pressure than body fluids.
6. Hypotonic solutions are solutions with a lower osmotic pressure than body fluids.
7. Cells shrink in hypertonic solutions.
8. Cells swell in hypotonic solutions.

E. Filtration

1. The process of forcing molecules through a membrane is filtration.
2. Filtration is commonly used to separate solids from water.
3. In the body the force for filtration is produced by blood pressure.

F. Active Transport

1. Movement against a concentration gradient is active transport.
2. Active transport is similar to facilitated diffusion because it requires protein channels or protein carriers.
3. Substances that move across the cell membrane through active transport are sugars, amino acids, and ions such as sodium, potassium, hydrogen, and calcium.
4. Active transport requires cellular energy.

G. Endocytosis

1. Endocytosis is the process of a cell engulfing a substance by forming a vesicle around the substance.
2. Exocytosis is the process of secreting a substance from a cell stored in a vesicle.
3. Three forms of endocytosis are phagocytosis, pinocytosis, and receptor-mediated endocytosis.
4. Pinocytosis is endocytosis of tiny droplets of liquids.
5. Phagocytosis is endocytosis of solids.
6. Phagocytes are cells that can take in solid particles such as bacteria and cellular debris.
7. Receptor-mediated endocytosis moves very specific kinds of particles into the cell.
8. In receptor-mediated endocytosis, a substance must bind to a receptor before it can enter the cell.
9. A ligand is a molecule that binds specifically to receptors.
10. An example of a molecule that moves into a cell through

receptor-mediated endocytosis is cholesterol.

H. Exocytosis

1. Exocytosis is the reverse of endocytosis.
2. Cells secrete some proteins through exocytosis.
3. Nerve cells secrete neurotransmitters through exocytosis.

I. Transcytosis

1. Transcytosis moves substances from one end of a cell to the other end of the cell.
2. A virus that uses transcytosis to infect humans is the HIV.

IV. The Cell Cycle

A. Introduction

1. The cell cycle is the series of changes a cell undergoes, from the time it forms until the time it divides.
2. Daughter cells are two cells that are products of cell division.
3. The four phases of the cell cycle are interphase, mitosis, cytoplasmic division, and differentiation.

B. Interphase

1. During interphase, a cell grows and maintains its routine functions as well as its contributions to the internal environments. DNA also replicates during interphase.
2. The phases of interphase are two G phases and one S phase.
3. During the S phase, the cell is replicating its DNA.
4. During the G phases, the cell is growing and synthesizing structures other than DNA.

C. Mitosis

1. Mitosis is a form of cell division that occurs in somatic cells and produces two daughter cells from an original cell.
2. In mitosis, the resulting daughter cells are genetically identical.
3. At the end of mitosis, each resulting daughter cell has 46

chromosomes.

4. Meiosis is a form of cell division that occurs only in sex cells.
5. The division of nuclear material is called karyokinesis.
6. The division of cytoplasm is cytokinesis.
7. The four stages of mitosis are prophase, metaphase, anaphase, and telophase.
8. In prophase, centrioles move to opposite sides of the cytoplasm.
9. In prophase, the nuclear envelope disappears.
10. In prophase, microtubules form the spindle apparatus.
11. In prophase, chromatin condenses into chromosomes.
12. Centromeres are attachment sites of chromatids.
13. In metaphase, spindle fibers attach to centromeres.
14. In metaphase, the chromosomes align midway between centrioles.
15. In anaphase, the centromeres of the chromatids separate.
16. In anaphase, chromosomes move toward centrioles.
17. Telophase begins when the chromosomes complete their migration toward the centrioles.
18. In telophase, a nuclear envelope reforms.
19. In telophase, chromosomes begin to elongate to form chromatin threads.

D. Cytoplasmic Division

1. Cytoplasmic division begins in anaphase and ends in telophase.
2. Contractile rings are responsible for pinching the cytoplasm in half.
3. The resulting daughter cells have identical chromosomes but they may vary in size and number of organelles and inclusions.

V. Control of Cell Division

- A. Three cell types that divide continually are skin cells, blood-forming cells, and cells that line the intestines.
- B. Cells of the liver divide a specific number of times and then cease.

- C. In laboratory conditions, cells divide forty to sixty times.
- D. Telomeres are tips of chromosomes that signal cells to stop dividing.
- E. When chromosome tips wear down, a cell stops dividing.
- F. Two types of proteins called kinases and cyclins also control cell division.
- G. When a cell becomes too large to obtain nutrients, it is likely to divide.
- H. Two examples of external controls that influence cell division are hormones and growth factors.
- I. Hormones are biochemicals manufactured in a gland and transported in the bloodstream to a site where they exert an effect.
- J. Growth factors are like hormones in function but act closer to their sites of synthesis.
- K. Contact inhibition prevents cell division.
- L. A tumor results from too frequent mitoses.
- M. A benign tumor is one that remains in place, eventually interfering with the function of healthy tissue.
- N. A malignant tumor is invasive and extends into surrounding tissues.
- O. Two types of genes that cause cancer are oncogenes and tumor suppressor genes.
- P. Apoptosis is cell death.

VI. Stem and Progenitor Cells

- A. A stem cell divides mitotically to produce either two daughter cells like itself, or one daughter cell that is a stem cell and one that is partially specialized.
- B. A progenitor cell is a partly specialized cell that is intermediate between a stem cell and fully differentiated cell.
- C. A neural stem cell gives rise to cell that part of neural tissue but not part of muscle or bone tissue.
- D. A totipotent cell can give rise to every cell type.
- E. Pluripotent cells are cells that can follow any of several pathways in development but not all of them.

F. Cells specialize by using some genes and ignoring others.