

Chapter 3- Cells and tissues

- I. Cells and tissues
 - A. Carry out all chemical activities needed to sustain life
 - B. Cells are the building blocks of all living things
 - C. Tissues are groups of cells that are similar in structure and function
- II. Anatomy of the cell
 - A. Cells are not all the same
 - B. All cells share general structures
 - C. All cells have three main regions
 1. Nucleus
 2. Cytoplasm
 3. Plasma membrane
- III. Nucleus
 - A. Control center of the cell
 - B. Contains genetic material (DNA)
 - C. Three regions
 1. Nuclear envelope (membrane)
 2. Nucleolus
 3. Chromatin
 - D. The nucleus
 1. Nuclear envelope (membrane)
 2. Barrier of the nucleus
 3. Consists of a double membrane
 4. Contains nuclear pores that allow for exchange of material with the rest of the cell
 5. Nucleoli
 - a. Nucleus contains one or more nucleoli
 - b. Sites of ribosome assembly
 - c. Ribosomes migrate into the cytoplasm through nuclear pores
 6. Chromatin
 - a. Condenses to form chromosomes when cell divides
 - b. Present when the cell is not dividing
 - c. Composed of DNA and protein
 - d. Scattered throughout the nucleus
- IV. Plasma Membrane
 - A. Barrier for cell contents
 - B. Double phospholipid layer
 - C. Hydrophilic heads
 - D. Hydrophobic tails
 - E. Also contains proteins, cholesterol, and glycoproteins
 - F. Plasma membrane specializations

1. Microvilli
2. Finger-like projections that increase surface area for absorption
3. Membrane junctions
 - a. Tight junctions
 - b. Impermeable junctions
 - c. Bind cells together into leak proof sheets
 - d. Desmosomes
 - e. Anchoring junctions that prevent cells from being pulled apart
 - f. Gap junctions
 - g. Allow communication between cells

V. Cytoplasm

- A. Cytoplasm is the material outside the nucleus and inside the plasma membrane
- B. Contains three major elements
- C. Cytosol
- D. Fluid that suspends other elements
- E. Organelles
- F. Metabolic machinery of the cell
- G. "Little organs" that perform functions for the cell
- H. Inclusions
- I. Chemical substances such as stored nutrients or cell products

VI. Cytoplasmic organelles

- A. Mitochondria
 1. "Powerhouse" of cell
 2. Change shape continuously
 3. Carry out reactions where oxygen is used to break down food
 4. Provides ATP for cellular energy
- B. Ribosomes
 1. Made of protein and RNA
 2. Sites of protein synthesis
 3. Found at two locations
 - a. Free in the cytoplasm
 - b. As part of the rough endoplasmic reticulum
- C. Endoplasmic reticulum (ER)
 1. Fluid-filled tubules for carrying substance
 2. Two types of ER
 - a. Rough ER
 - 1) Studded with ribosomes
 - 2) Synthesizes proteins
 - b. Smooth ER
 - 1) Functions in lipid metabolism and detoxification of drugs and pesticides
- D. Golgi apparatus

1. Modifies and packages proteins
2. Produces different types of packages
3. Secretory vesicles
4. Cell membrane components
5. Lysosomes

E. Lysosomes

1. Contain enzymes that digest worn-out or nonusable materials within the cell

F. Peroxisomes

1. Membranous sacs of oxidase enzymes
 - a. Detoxify harmful substances such as alcohol and formaldehyde
 - b. Break down free radicals (highly reactive chemicals)
 - c. Replicate by pinching in half

G. Cytoskeleton

1. Network of protein structures that extend throughout the cytoplasm
2. Provides the cell with an internal framework
3. Three different types of elements
 - a. Microfilaments (smallest)
 - b. Intermediate filaments
 - c. Microtubules (largest)

H. Centrioles

1. Rod-shaped bodies made of microtubules
2. Direct the formation of mitotic spindle during cell division

I. Cellular projections

1. Cilia move materials across the cell surface
 - a. Located in the respiratory system to move mucus
2. Flagella propel the cell
 - a. The only flagellated cell in the human body is sperm

VII. Cell diversity

A. A tour of the cell

B. Cell physiology: membrane transport

1. Membrane transport- movement of substances into and out of the cell
2. Two basic methods of transport
 - a. Passive transport
 - 1) No energy required
 - b. Active transport
 - 1) Cells must provide metabolic energy (ATP)

C. Solutions and transport

1. Solution- homogeneous mixture of two or more components
 - a. Solvent- dissolving medium; typically water in body
 - b. Solute- components in smaller quantities within a solution
2. Intracellular fluid- nucleoplasm and cytosol
3. Interstitial fluid- fluid on the exterior of the cell

- D. Selective permeability
 - 1. The plasma membrane allows some materials to pass while excluding others
 - 2. This permeability influences movement both into and out of the cell
- E. Passive transport processes
 - 1. Diffusion
 - a. Particles tend to distribute themselves evenly within a solution
 - b. Movement is from high concentration to low concentration, or down a concentration gradient
 - 2. Types of diffusion
 - 3. Simple diffusion
 - a. An unassisted process
 - b. Solutes are lipid-soluble materials or small enough to pass through membrane pores
 - 4. Types of diffusion (continued)
 - a. Osmosis- simple diffusion of water
 - 1) Highly polar water molecules easily cross the plasma membrane through aquaporins
 - 5. Facilitated diffusion
 - a. Substances require a protein carrier for passive transport
 - b. Transports lipid-insoluble and large substances
 - 6. Filtration
 - a. Water and solutes are forced through a membrane by fluid, or hydrostatic pressure
 - b. A pressure gradient must exist
 - 1) Solute-containing fluid is pushed from a high-pressure area to a lower pressure area
- F. Active transport processes
 - 1. Substances are transported that are unable to pass by diffusion
 - a. Substances may be too large
 - b. Substances may not be able to dissolve in the fat core of the membrane
 - c. Substances may have to move against a concentration gradient
 - d. ATP is used for transport
 - 2. Two common forms of active transport
 - a. Active transport (solute pumping)
 - 1) Amino acids, some sugars, and ions are transported by protein carriers called solute pumps
 - 2) ATP energizes protein carriers
 - 3) In most cases, substances are moved against concentration gradients
 - b. Vesicular transport
 - 1) Exocytosis
 - a) Moves materials out of the cell

- b) Material is carried in a membranous vesicle
- c) Vesicle migrates to plasma membrane
- d) Vesicle combines with plasma membrane
- e) Material is emptied to the outside

2) Endocytosis

- a) Extracellular substances are engulfed by being enclosed in a membranous vesicle
- b) Types of endocytosis
 - i. Phagocytosis- "cell eating"
 - ii. Pinocytosis- "cell drinking"

VIII. Cell life cycle

A. Cells have two major periods

- 1. Interphase
 - a. Cell grows
 - b. Cell carries on metabolic processes
- 2. Cell division
 - a. Cell replicates itself
 - b. Function is to produce more cells for growth and repair processes

B. DNA replication

- 1. Genetic material is duplicated and readies a cell for division into two cells
- 2. Occurs toward the end of interphase
- 3. DNA uncoils and each side serves as a template

C. Events of cell division

- 1. Mitosis- division of the nucleus
 - a. Results in the formation of two daughter nuclei
- 2. Cytokinesis- division of cytoplasm
 - a. Begins when mitosis is near completion
 - b. Results in the formation of two daughter cells
- 3. Stages of mitosis
 - a. Prophase
 - 1) First part of cell division
 - 2) Centrioles migrate to the poles to direct assembly of mitotic spindle fibers
 - 3) DNA appears as double-stranded chromosomes
 - 4) Nuclear envelope breaks down and disappears
 - b. Metaphase
 - 1) Chromosomes are aligned in the center of the cell on the metaphase plate
 - c. Anaphase
 - 1) Chromosomes are pulled apart and toward the opposite ends of the cell
 - 2) Cell begins to elongate

- d. Telophase
 - 1) Chromosomes uncoil to become chromatin
 - 2) Nuclear envelope reforms around chromatin
 - 3) Spindles break down and disappear
- e. Cytokinesis
 - 1) Begins during late anaphase and completes during telophase
 - 2) A cleavage furrow forms to pinch the cells into two parts

IX. Cells and tissues

A. Protein synthesis

1. Gene- DNA segment that carries a blueprint for building one protein
2. Proteins have many functions
 - a. Building materials for cells
 - b. Act as enzymes (biological catalysts)
 - c. RNA is essential for protein synthesis
3. Role of RNA
 - a. Transfer RNA (tRNA)
 - 1) Transfers appropriate amino acids to the ribosome for building the protein
 - b. Ribosomal RNA (rRNA)
 - 1) Helps form the ribosomes where proteins are built
 - c. Messenger RNA (mRNA)
 - 1) Carries the instructions for building a protein from the nucleus to the ribosome
4. Transcription and translation
 - a. Transcription
 - b. Transfer of information from DNA's base sequence to the complimentary base sequence of mRNA
 - c. Three-base sequences on mRNA are called codons
5. Transcription and translation
 - a. Translation
 - 1) Base sequence of nucleic acid is translated to an amino acid sequence
 - 2) Amino acids are the building blocks of proteins

X. Body tissues

A. Tissues

1. Groups of cells with similar structure and function
2. Four primary tissue types
 - a. Epithelial tissue (epithelium)
 - b. Connective tissue
 - c. Muscle tissue
 - d. Nervous tissue

B. Epithelial tissues

1. Locations
 - a. Body coverings
 - b. Body linings
 - c. Glandular tissue
2. Functions
 - a. Protection
 - b. Absorption
 - c. Filtration
 - d. Secretion
3. Epithelium Characteristics
 - a. Cells fit closely together and often form sheets
 - b. The apical surface is the free surface of the tissue
 - c. The lower surface of the epithelium rests on a basement membrane
 - d. Avascular (no blood supply)
 - e. Regenerate easily if well nourished
4. Classification of epithelia
 - a. Number of cell layers
 - 1) Simple- one layer
 - 2) Stratified- more than one layer
 - b. Shape of cells
 - 1) Squamous- flattened
 - 2) Cuboidal- cube-shaped
 - 3) Columnar- column like
5. Simple epithelia
 - a. Simple squamous
 - 1) Single layer of flat cells
 - 2) Usually forms membranes
 - a) Lines body cavities
 - b) Lines lungs and capillaries
 - 3) Simple cuboidal
 - a) Single layer of cube-like cells
 - b) Common in glands and their ducts
 - c) Forms walls of kidney tubules
 - d) Covers the ovaries
 - 4) Simple columnar
 - a) Single layer of tall cells
 - b) Often includes mucus-producing goblet cells
 - c) Lines digestive tract
 - 5) Pseudostratified columnar
 - a) Single layer, but some cells are shorter than others
 - b) Often looks like a double layer of cells
 - c) Sometimes ciliated, such as in respiratory tract

d) May function in absorption or secretion

6. Stratified epithelia

a. Stratified squamous

- 1) Cells at the apical surface are flattened
- 2) Found as a protective covering where friction is common
- 3) Locations
- 4) Skin
- 5) Mouth
- 6) Esophagus

b. Stratified cuboidal

c. Stratified columnar

d. Stratified cuboidal and columnar

- 1) Rare in human body
- 2) Found mainly in ducts of large glands

e. Transitional epithelium

- 1) Shape of cells depends upon the amount of stretching
- 2) Lines organs of urinary system

7. Glandular epithelium

a. Gland

- 1) One or more cells responsible for secreting a particular product

b. Two major types of

- 1) Endocrine gland
 - a) Ductless since secretions diffuse into blood vessels
 - b) All secretions are hormones
- 2) Exocrine gland
 - a) Secretions empty through ducts to the epithelial surface
 - b) Include sweat and oil glands

C. Connective tissue

1. Found everywhere in body

2. Includes the most abundant and widely distributed tissues

3. Functions

- a. Binds body tissues together
- b. Supports the body
- c. Provides protection

4. Connective tissue characteristics

a. Variations in blood supply

- 1) Some tissue types are well vascularized
- 2) Some have a poor blood supply or are avascular

b. Extracellular matrix

- 1) Non-living material that surrounds living cells
- 2) Two main elements

- a) Ground substance- mostly water along with adhesion proteins and polysaccharide molecules
- b) Fibers- produced by cells (3 types)
 - i. Collagen (white) fibers
 - ii. Elastic (yellow) fibers
 - iii. Reticular fibers

5. Connective tissue types

- a. Bone (osseous tissue)
 - 1) Composed of:
 - a) Bone cells in lacunae (cavities)
 - b) Hard matrix of calcium salts
 - c) Large numbers of collagen fibers
 - d) Used to protect and support the body
- b. Hyaline cartilage
 - 1) Most common type of cartilage
 - 2) Composed of
 - a) Abundant collagen fibers
 - b) Rubbery matrix
 - 3) Locations
 - a) Larynx
 - b) Entire fetal skeleton prior to birth
- c. Elastic cartilage
 - 1) Provides elasticity
 - 2) Location: supports external ear
- d. Fibrocartilage
 - 1) Highly compressible
 - 2) Location
 - a) Forms cushion-like discs between vertebrae
- e. Dense connective tissue (dense fibrous tissue)
 - 1) Main matrix element is collagen fiber
 - 2) Fibroblasts are cells that make fibers
 - 3) Locations
 - a) Tendons-attach skeletal muscle to bone
 - b) Ligaments- attach bone to bone at joints
 - c) Dermis- lower layers of skin
- f. Loose connective tissue types
 - 1) Areolar tissue
 - 2) Most widely used distributed connective tissue
 - 3) Soft, pliable tissue like "cobwebs"
 - 4) Functions as a packing tissue
 - 5) Contains all fiber types

- 6) Can soak up excess fluid (causes edema)
- 7) Loose connective tissue types
 - a) Adipose tissue
 - i. Matrix is an areolar tissue in which fat globules predominate
 - ii. Many cells contain large lipid deposits
 - iii. Functions
 - iv. Insulates the body
 - v. Protects some organs
 - vi. Serves as a site of fuel storage
 - b) Reticular connective tissue
 - i. Delicate network of interwoven fibers
 - ii. Forms stroma (internal supporting network) of lymphoid organs
 - iii. Lymph nodes
 - iv. Spleen
 - v. Bone marrow
- g. Blood (vascular tissue)
 - 1) Blood cells surrounded by fluid matrix called blood plasma
 - 2) Fibers are visible during clotting
 - 3) Functions as the transport vehicle for materials

D. Muscle tissue

- 1. Function is to produce movement
 - a. Three types
 - 1) Skeletal muscle
 - 2) Cardiac muscle
 - 3) Smooth muscle
- 2. Muscle tissue types
 - a. Skeletal muscle
 - 1) Under voluntary control
 - 2) Contracts to pull on bones or skin
 - 3) Produces gross body movements or facial expressions
 - 4) Characteristics of skeletal muscle cells
 - a) Striated
 - b) Multinucleate (more than one nucleus)
 - c) Long, cylindrical
 - b. Cardiac muscle
 - 1) Under involuntary control
 - 2) Found only in the heart
 - 3) Functions to pump blood
 - 4) Characteristics of cardiac muscle cells

- a) Cells are attached to other cardiac muscle cells at intercalated disks
 - b) Striated
 - c) One nucleus per cell
 - c. Smooth muscle
 - 1) Under involuntary muscle
 - 2) Found in walls of hollow organs such as stomach, uterus, and blood vessels
 - 3) Characteristics of smooth muscle cells
 - a) No visible striations
 - b) One nucleus per cell
 - c) Spindle-shaped cells
 - E. Nervous tissue
 - 1. Composed of neurons and nerve support cells
 - 2. Function is to send impulses to other areas of the body
 - a. Irritability
 - b. Conductivity
- XI. Tissue repair (wound healing)
- A. Regeneration
 - 1. Replacement of destroyed tissue by the same kind of cells
 - B. Fibrosis
 - 1. Repair by dense (fibrous) connective tissue (scar tissue)
 - C. Determination of method
 - 1. Type of tissue damaged
 - 2. Severity of the injury
 - D. Events in tissue repair
 - 1. Capillaries become very permeable
 - a. Introduce clotting proteins
 - b. A clot walls off the injured area
 - 2. Formation of granulation tissue
 - a. Growth of new capillaries
 - b. Rebuild collagen fibers
 - 3. Regeneration of surface epithelium
 - a. Scab detaches
 - E. Regeneration of tissues
 - 1. Tissues that regenerate easily
 - a. Epithelial tissue (skin and mucous membranes)
 - b. Fibrous connective tissues and bone
 - 2. Tissues that regenerate poorly
 - a. Skeletal muscle
 - 3. Tissues that are replaced largely with scar tissue
 - a. Cardiac muscle

b. Nervous tissue within the brain and spinal cord

XII. Developmental aspects of tissue

- A. Epithelial tissue arises from all three primary germ layers
- B. Muscle and connective tissue arise from the mesoderm
- C. Nervous tissue arises from the ectoderm
- D. With old age, there is a decrease in mass and viability in most tissues