Review of Anatomy and Physiology

Ch 1-3

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Introduction to Anatomy

A. Anatomy Defined

1. **Anatomy** is the study of structures of the body and the relationships among structures.
2. **Physiology** is the study of functions of the parts of the body; physiology is dependent on anatomy because a body part is able to perform a specific function due to that part's specific structure.
3. There are several major subdisciplines of anatomy
    a. Embryology

b. Developmental Biology
c. Cytology
d. Histology
e. Surface Anatomy
f. Gross Anatomy
g. Systemic Anatomy
h. Regional Anatomy
i. Radiographic Anatomy
j. Pathological Anatomy

B. Levels of Body Organization

1. The human body consists of several interrelated levels of structural organization ranging from the least complex chemical level to the most complex organismal level.
2. At the **chemical level**, atoms are organized into molecules.
3. At the **cellular level**, molecules are organized into cells which are the basic structural and functional living units of an organism; cells are the smallest living units in the human body.
4. At the **tissue level**, cells are organized into tissues, which are groups of similar cells that usually have similar embryological origins and perform specialized functions.
   There are four major families of tissues:
   i. Epithelial tissue
   ii. Connective tissue
   iii. Muscle tissue
   iv. Nervous tissue
5. At the **organ level**, several kinds of tissue are organized into organs, which are structures that have specific functions and usually have recognizable shapes.
6. At the **system level**, related organs are organized into systems, which are functionally related groups of organs that cooperate to perform a common general function.
   There are eleven systems in the body
   i. Integumentary System
   ii. Skeletal System
   iii. Muscular System
   iv. Cardiovascular System
   v. Lymphatic and Immune Systems
   vi. Nervous System
   vii. Endocrine System
   viii. Respiratory System
   ix. Digestive System
   x. Urinary System
   xi. Reproductive Systems
7. At the **organismal level**, all the systems are structurally integrated and function cooperatively to constitute the total organism.

C. Basic Anatomical Terminology

1. **Anatomical Position:**
   When describing any region of the body, it is assumed that the body is in the anatomical position, a standard position that ensures directional terms are clear so that any body part can be clearly described relative to any other part. In the anatomical position, the body is erect with the feet flat on the floor, and the upper limbs are at the sides with the palms facing forward.
2. Regional Names:

These are terms given to specific regions of the body; important examples include head (cephalic), neck (cervical), trunk, upper limb, lower limb, etc.

3. Planes and Sections

   A **plane** is an imaginary flat surface that passes through the body in order to provide an informative view of a specific region of the body; important examples include sagittal, frontal or coronal, transverse, and oblique planes. A **section** is a flat surface of the body that may be studied after the body has been cut along a specific plane; examples include transverse, frontal, and midsagittal sections, so named according to the plane along which the body was cut.

4. Directional Terms

   These are terms used to accurately locate one body structure relative to another body structure; important examples include superior, inferior, anterior, posterior, medial, lateral, proximal, distal, etc. (see Exhibit 1.1).

5. Body Cavities

   Body cavities are enclosed spaces within the body that help protect, separate, and support internal organs that are located in the cavities; important examples include the following:

   i. Cranial cavity
   ii. Vertebral (spinal) canal
      - the walls of the cranial cavity and vertebral canal are lined by the protective **meninges**
   iii. Thoracic cavity (including the pericardial cavity and two pleural cavities)
   iv. Abdominopelvic cavity (including abdominal and pelvic cavities)

   The **viscera** (organs) within the thoracic and abdominal cavities as well as the walls of these cavities are lined with a **serous membrane**; the latter consists of a visceral layer (covering the viscera) and a parietal layer (lining the walls of the cavities) with a lubricating serous fluid between the two layers. The serous membrane of the pleural cavities, pericardial cavity and abdominal cavity are called the **pleura**, **pericardium** and **peritoneum**, respectively.

6. Abdominopelvic Regions and Quadrants

   In order to easily describe the precise locations of internal organs, the abdominopelvic cavity is divided into nine abdominopelvic regions including the epigastric region, the right lumbar region, the left inguinal (iliac) region, etc. (see Table 1.3); for clinical purposes, the abdominopelvic cavity is more simply divided into four quadrants known as the right/left, upper/lower quadrants.

D. Medical Imaging

1. A variety of medical imaging techniques are available to permit study of the interior of the human body; important techniques include the following

   i. Radiography
   ii. Magnetic resonance imaging (MRI)
   iii. Computed tomography (CT)
   iv. Ultrasound Scanning
   v. Positron emission tomography (PET)
   vi. Radionuclide scanning

Lecture Outline

Atoms, Ions, and Chemical Bonds

- Atoms
  - Atomic Mass and Atomic Number
- Chemical Bonds, Molecules, and Ionic Compounds
  - Covalent, Ionic, and Hydrogen Bonds [van der Waals forces]
  - Water—Polar Solvent
    - Dissociation of Ionic Bonds—Ions
- Acids and Bases
  - pH Scale—Acidosis vs. Alkalosis
  - Role of Bicarbonate Buffer
- Organic Molecules

Carbohydrates and Lipids

- Carbohydrates (Saccharides)
  - Dehydration Synthesis
  - Hydrolysis
- Lipids
  - Nonpolar Characteristic
  - Categories

Proteins

- Amino Acids (20)
  - Peptide (covalent) Bonds
  - Dehydration Synthesis
- Protein Structures
- Functions, Diversity, and Specificity

Nucleic Acids

- Deoxyribonucleic Acid (DNA)
- Ribonucleic Acid (RNA)
- Complementary Base Pairing

Lecture Outline

Plasma Membrane and Associated Structures

- Plasma Membrane—Chemistry and Structure
- Phagocytosis (Endocytosis)
- Exocytosis
- Cilia—(Primary Cilium)
- Flagellum (Sperm)

Cytoplasm and Its Organelles

- Cytoplasm and Cytoskeleton
- Lysosomes
- Peroxisomes
- Mitochondria
    - Mitochondrial DNA
- Ribosomes
- Endoplasmic Reticulum
    - Granular
    - Agranular
- Golgi Complex—Vesicle Formation

Cell Nucleus and Gene Expression

- DNA
- Genome vs. Proteome
- Chromatin: Histones and Nucleosomes
    - Euchromatin vs. Heterochromatin
- RNA Synthesis
    - RNA Interference (RNA Silencing)

Protein Synthesis and Secretion

- Protein (Polypeptide) Formation
    - Transcription and Translation
    - Transfer RNA
    - Endoplasmic Reticulum and Golgi Complex
- Protein Degradation
    - Ubiquitin
    - The Proteosome

DNA Synthesis and Cell Division

- DNA Replication

The Cell Cycle

Cyclin Proteins

Apoptosis

Mitosis

Meiosis

LECTURE OUTLINE

A. A Generalized Cell

1. A human cell consists of three major parts
    a. **Plasma membrane**
    b. **Cytoplasm** which includes the **cytosol** and **organelles**
    c. **Nucleus** (is technically an organelle but is described separately)

B. Plasma Membrane

1. Every cell is enclosed by a thin barrier called the plasma (cell) membrane which has two major roles:
    a. it separates the internal cellular components from the external environment
    b. it regulates the movements of substances into and out of the cell.
2. The fluid mosaic model describes the structure of the plasma membrane.
3. The major chemical components are lipids and proteins.
4. The membrane lipids include:
    a. phospholipids, which form a bilayer that is the basic framework of the plasma membrane
    b. cholesterol molecules, which strengthen the membrane
    c. glycolipids, which perform functions on the membrane's outer surface.
5. The membrane proteins include:
    a. integral proteins, primarily transmembrane proteins (many of these are glycoproteins) and lipid-linked proteins
    b. peripheral proteins, which are located on the inner and outer surfaces of the phospholipid bilayer; the carbohydrate portions of the glycolipids and glycoproteins form a cell surface coat called the glycocalyx.
6. Membrane proteins perform a variety of important functions:
    a. some proteins form ion channels through which specific substances may pass into or out of the cell
    b. some proteins are transporters (carrier proteins) that carry specific substances across the membrane
    c. some proteins are receptors for extracellular signalling molecules called ligands
    d. some proteins are enzymes
    e. some glycoproteins and glycolipids are cell identity markers involved in recognition of other cells
    f. some proteins serve as linkers which anchor membrane proteins of neighboring cells to each other or to filaments inside and outside the cell.
7. Due to its chemistry and structure, the plasma membrane has selective permeability that selectively regulates the passage of specific substances into and out of the cell.

8. The various fluids that substances move to or from include:
    a. **intracellular fluid** (**ICF**) or **cytosol**
    b. **extracellular fluid** (**ECF**), which includes:
        i. **interstitial fluid** (or intercellular fluid) located between cells of tissues
        ii. **plasma** located in blood vessels
        iii. **lymph** located in lymphatic vessels
9. Specific substances move across the plasma membrane by either **passive processes**, **active processes**, or **vesicular transport** .
10. In passive processes, substances move across a plasma membrane, due to their own kinetic energy, down a concentration gradient or pressure gradient. There are several types of passive processes:
    a. **simple diffusion** is a process in which substances move down a concentration gradient without any aid provided by membrane components
    b. **facilitated diffusion** is a process in which substances move down a concentration gradient with the aid of a membrane transporter (carrier) protein
    c. **osmosis** is a process in which water molecules diffuse down their concentration gradient through membrane channels and between neighboring phospholipids
    d. **filtration** is a process in which substances move across a plasma membrane down a pressure gradient.
11. In active processes, substances move across a plasma membrane, due to energy provided by ATP, against a concentration gradient. There is one type of active process described:
    a. **active transport** is a process in which substances move against a concentration gradient with the aid of a membrane carrier protein
12. In vesicular transport, energy (from ATP) is expended so that **vesicles** (membranous sacs) either detach from the plasma membrane to import substances into the cell or fuse with the plasma membrane to export substances from the cell; there are several types of vesicular transport including:
    a. **endocytosis** is a process in which extracellular molecules and particles are surrounded, enclosed, and brought into the cell by a segment of the plasma membrane; the three basic types of endocytosis are:
        i. **receptor-mediated endocytosis** (involving a membrane receptor)
        ii. **phagocytosis** ("cell eating")
        iii. **bulk-phase endocytosis** or pinocytosis ("cell drinking")
    b. **exocytosis** is a process in which intracellular vesicle-enclosed substances are released into the extracellular fluid by membrane fusion with the plasma membrane

C. Cytoplasm

1. The **cytosol** is the intracellular fluid in which **organelles** are suspended and in which solutes are dissolved; collectively, all of these intracellular components form the **cytoplasm**.
2. The cytosol is the site of numerous events including metabolic reactions, the transport of substances, etc.

D. Organelles

1. Organelles are intracellular structures that have characteristic shapes and perform specialized functions.
2. **Cytoskeleton**

a. network of three types of protein filaments that provide shape to the cell and play roles in cell movements as well as in movements of organelles within cells:
    i. microfilaments are thin filaments that perform these functions (as well as playing a role in muscle cell contraction); they also provide mechanical support, e.g., within fingerlike projections of the plasma membrane called microvilli
    ii. microtubules are long, thin, cylindrical structures that participate in determining cell shape and function in the intracellular transport of organelles; microtubules are also important components of flagella, cilia, centrioles, and the mitotic spindle
    iii. intermediate filaments have a diameter between that of microfilaments and microtubules; they help to position organelles as well as to strengthen and give shape to the cell

3. **Centrosome (and Centrioles)**
    a. a centrosome is located near the nucleus and consists of a pair of centrioles (oriented at right angles to each other) plus surrounding pericentriolar material
    b. each centriole is a cylindrical structure that consists of a bundle of parallel microtubules
    c. the centrosome organizes the formation of cytoplasmic microtubules in nondividing cells and the mitotic spindle in dividing cells
    d. centrioles are identical to basal bodies which play a role in the formation of flagella and cilia

4. **Cilia and Flagella**
    a. they are motile projections of the cell surface; each consists of a hair-like projection of the plasma membrane which encloses a bundle of parallel microtubules
    b. cilia are typically short and numerous; cilia are found in several types of human cells where their function is to move materials past the surfaces of these cells (e.g., move mucus along the surfaces of cells that form the inner lining of the respiratory tract)
    c. flagella are typically long and few in number; the only example of a flagellum in a human cell is the tail of a sperm cell where its function is to propel the cell
5. **Ribosomes**
    a. numerous tiny granules, each consisting of 2 subunits and composed of ribosomal RNA and associated proteins
    b. free ribosomes float in the cytosol whereas membrane-bound-ribosomes are attached primarily to the endoplasmic reticulum
    c. are organelles where protein synthesis occurs
6. **Endoplasmic reticulum (ER)**
    a. network of interconnected membrane-enclosed passageways called cisternae
    b. rough ER membranes are studded with ribosomes that synthesize proteins destined to be secreted or delivered to lysosomes or to the plasma membrane
    c. smooth ER membranes have no ribosomes but are sites for lipid synthesis, toxin detoxification, calcium storage in muscle cells, etc.
7. **Golgi complex**
    a. series of flattened, membrane-enclosed sacs called cisternae stacked upon each other
    b. receives proteins from the rough ER

c. modifies, sorts, and packages these proteins (and lipids) into vesicles for delivery to lysosomes, the plasma membrane or to be secreted

8. **Lysosomes**
    a. spherical membrane-enclosed sacs that form from the Golgi complex
    b. contain numerous digestive enzymes for intracellular digestion of other old organelles or materials that have been brought into the cell or for extracellular digestion
9. **Peroxisomes**
    a. small, spherical membrane-enclosed sacs
    b. contain enzymes that use molecular oxygen to oxidize various organic molecules
    c. important in liver and kidney cells where they detoxify toxic substances
10. **Proteasomes**
    a. tiny structures which contain proteases used for the destruction of cytosolic proteins
11. **Mitochondria**
    a. membrane-enclosed organelles that are often sausage-shaped
    b. described as the "powerhouses" of the cell because they produce, via cellular respiration, large quantities of energy-rich ATP molecules that are subsequently used throughout the cell to provide energy for cellular processes
    c. self-replicating organelles that contain their own (mitochondrial) DNA molecules that direct the synthesis of several mitochondrial proteins by mitochondrial ribosomes

E. Nucleus

1. largest organelle, usually spherical or oval-shaped
2. some cells are anucleate (erythrocytes) and some cells are multinucleate (skeletal muscle cells)
3. enclosed by two-layered nuclear envelope which contains numerous nuclear pores through which substances move between the nucleus and the cytosol
4. contains one or more spherical **nucleoli** where the subunits of ribosomes are produced
5. nucleus also contains chromatin (condensed into chromosomes during mitosis) which is composed of DNA and associated proteins; the DNA contains the hereditary information

F. Somatic Cell Division

1. Somatic cells progress through a **cell cycle** that consists of **interphase** and a **mitotic (M) phase**, which results in the formation of two daughter cells having the same genetic information found in the parent cell; sperm and egg cells are produced by reproductive cell division.
2. During interphase, consisting of G_1, S and G_2 phases, a cell grows and replicates its DNA; nondividing cells (e.g., most neurons) remain in G_1 and are said to be in the G_0 state.
3. The mitotic phase consists of two major events: **mitosis** and **cytokinesis**.
4. **Mitosis** is a process that separates the replicated DNA in order to ensure that each daughter cell receives the same quantity and type of DNA that was present in the parent cell so that each daughter cell remains a diploid cell; mitosis consists of four phases:
    a. Prophase, in which the chromatin condenses into 23 pairs of homologous chromosomes (each consisting of two sister chromatids connected at the

centromere), the nuclear envelope and nucleoli disappear, and the mitotic spindle develops
   b. Metaphase, in which the chromosomes are aligned at the equator of the cell
   c. Anaphase, in which each centromere splits so that sister chromatids are separated (to form daughter chromosomes) and move toward opposite poles of the cell
   d. Telophase, in which the daughter chromosomes at both poles decondense into chromatin, a nuclear envelope reforms around each mass of chromatin, nucleoli reappear, and the mitotic spindle disintegrates.
5. **Cytokinesis** is a process that divides the cytoplasm into two masses resulting in the formation of two daughter cells, each with its own set of identical genetic material; cytokinesis begins toward the end of mitosis and involves the formation of a cleavage furrow typically at the equator of the cell.

G. Control of Cell Destiny

1. A cell may either function without dividing, or grow and divide, or may be destined to die.
2. Certain cells undergo orderly, genetically programmed death, called **apoptosis,** during embryological, fetal and postnatal development.
3. Apoptosis is triggered by intracellular or extracellular agents that induce activation of enzymes by "cell-suicide" genes.
4. These enzymes damage cytoplasmic components, resulting in death of the cell.
5. Apoptosis differs from **necrosis** which is a pathological type of cell death that results from tissue injury.

H. Reproductive Cell Division

1. **Meiosis**, which occurs only in the gonads, produces gametes in which the number of chromosomes is reduced by half; as a result, gametes are haploid cells.
2. Meiosis consists of two stages, **meiosis I** and **meiosis II**.
3. Meiosis I produces two haploid daughter cells that are genetically different from each other and different from the parent cell that produced them.
4. In meiosis II, each of the two daughter cells produced by meiosis I divides, resulting in the formation of four haploid gametes.

I. Cellular Diversity

1. The human body consists of approximately 100 trillion cells; they are classified into about 200 different cell types having various sizes and shapes that are related to the functions they perform.

J. Aging and Cells

1. Aging is a normal process accompanied by a progressive change in the body's homeostatic adaptive responses.
2. The signs of aging arise from a net decrease in cell numbers, chemical changes within cells and outside cells, and the malfunctioning of cells.
3. Several theories have been proposed to explain the aging process.

K. Key Medical Terms Associated with Cells

1. Students should familiarize themselves with the glossary of key medical terms.

Chapter 3

LECTURE OUTLINE

A. Types of Tissues and Their Origins (p. 58)

1. A tissue is a group of similar cells that usually have a common embryological origin and function together to carry out specialized activities.
2. The body is composed of four major families of tissues:
    i. **Epithelial tissue** covers body surfaces; lines hollow organs, body cavities, and ducts; it also forms glands.
    ii. **Connective tissue** protects and supports the body and its organs; binds organs together; stores energy reserves as fat; provides immunity.
    iii. **Muscular tissue** generates physical force for movement.
    iv. **Nervous tissue** detects changes in a variety of conditions and responds by initiating and transmitting nerve impulses (signals) that help control and coordinate body activities.
3. All tissues develop from three (embryonic) primary germ layers: **ectoderm, endoderm,** and **mesoderm.**

B. Cell Junctions (p. 58)

1. Cell junctions are points of contact between neighboring plasma membranes.
2. There are five major types of cell junctions:
    i. **Tight junctions**
        a. form tight seals between cells such as the epithelial cells that comprise the inner lining of the stomach, intestines, and urinary bladder
        b. these junctions prevent the passage of molecules between cells
    ii. **Adherens junctions**
        a. strongly fasten cells to each other; they help epithelial surfaces resist separation
    iii. **Desmosomes**
        a. strongly fasten cells to each other; they prevent epidermal cells from separating under tension and cardiac muscle cells from pulling apart during contraction
    iv. **Hemidesmosomes**
        a. strongly anchor cells to an underlying basement membrane
    v. **Gap junctions**
        a. formed by minute, fluid-filled tunnels that permit passage of electrical signals or chemicals (i.e., ions and small molecules) from one cell to a neighboring cell
        b. located in some parts of the nervous system, in heart muscle, and in the gastrointestinal tract

C. Epithelial Tissue or **Epithelium** (p. 60)

1. General features:
    a. cells arranged in continuous sheets in either single or multiple layers
    b. usually closely packed cells with little extracellular material between neighboring cells
    c. cells have **lateral surfaces**, **apical surfaces** and **basal surfaces**; the latter are connected to underlying connective tissue via a thin extracellular **basement membrane**

d. numerous cell junctions that securely attach neighboring cells
e. avascular tissue that exchanges materials with adjacent connective tissue via diffusion
f. has a nerve supply
g. high capacity for cell division in order to replace cells lost due to wear and tear and injury
h. numerous functions including:
    protection
    filtration
    secretion
    absorption
    excretion

2. Divided into two major types:
    a. **covering and lining epithelium**
    b. **glandular epithelium**
3. **Covering and Lining Epithelium** (p. 61)
    a. arrangement of cells into layers reflects its location and function
    b. arrangements include:
        i. **Simple epithelium** (single layer of cells)
        ii. **Stratified epithelium** (two or more layers of cells)
        iii. **Pseudostratified epithelium** (single layer that appears stratified)
    c. cells may be categorized by cell shape:
        i. **Squamous** cells are flattened
        ii. **Cuboidal** cells are usually cube-shaped or hexagons
        iii. **Columnar** cells are tall and cylindrical
        iv. **Transitional** cells are able to undergo changes in shape caused by distension
    d. according to number of layers present and cell shapes in the surface layer, epithelium may be classified into (see Table 3.1):
        I. **Simple squamous epithelium** located in areas subject to little wear and tear, and adapted for diffusion and filtration (e.g., inner lining of heart chambers and blood vessels)
        II. **Simple cuboidal epithelium** adapted for secretion and absorption (e.g., lines kidney tubules and smaller ducts of many glands)
        III. **Simple columnar epithelium** which in some areas (e.g., upper respiratory passageways) has cilia (to move materials past the cells) while in other areas (e.g., small intestine) may have microvilli (to increase efficiency of absorption)
        IV. **Pseudostratified columnar epithelium** which functions in secretion or movement of materials by ciliary action (e.g., part of male urethra, upper respiratory passageways)
        V. **Stratified squamous epithelium** provides protection in areas subject to wear and tear (e.g., outer layer of skin, lining of mouth)
        VI. **Stratified cuboidal epithelium** (rare type) which provides protection (e.g., ducts of adult sweat glands)
        VII. **Stratified columnar epithelium** (rare type) which functions in protection and secretion (e.g., large ducts of some glands)
        VIII. **Transitional epithelium** contains cells that may undergo changes in shape and therefore is located in areas subject to stretching (e.g., urinary bladder)

4. **Glandular Epithelium** (p. 69)
    a. specialized epithelial cells organized to form **glands** that **secrete** substances into ducts, onto a surface, or into the blood
    b. **endocrine glands** are ductless (e.g., thyroid gland, adrenal glands) and secrete **hormones** which diffuse through the extracellular fluid into the blood.
    c. **exocrine glands** (e.g., sweat glands, salivary glands) secrete substances (e.g., sweat, saliva) into **ducts**, are structurally classified into **unicellular** and **multicellular glands** (including **simple** or **compound** as well as **tubular**, **acinar** and **tubuloacinar** glands), and are functionally classified into **merocrine**, **apocrine**, and **holocrine** glands

D. Connective Tissue (p. 71)

1. Connective tissue is the most abundant and most widely distributed tissue in the body.
2. Its functions include:
    a. binds together, supports and strengthens other tissues
    b. protects and insulates internal organs
    c. compartmentalizes certain structures (e.g., skeletal muscles)
    d. blood is a connective tissue that transports substances
    e. adipose (fat) tissue stores energy reserves.
3. General features of connective tissue:
    a. composed of cells separated by an extracellular **matrix** that consists of ground substance and fibers; matrix has variable characteristics (e.g., fluid, gelatinous, calcified); matrix is usually secreted by the connective tissue cells; matrix determines the tissue's properties
    b. not usually located on free surfaces; but joint cavities are lined with areolar connective tissue
    c. has a rich blood supply (except in cartilage and tendons)
    d. has a nerve supply (except in cartilage)
4. Connective tissue cells have the following characteristics:
    a. derived from mesenchyme
    b. immature cells have names that end with -blast (e.g., osteoblast); they retain the capacity for cell division and secrete the matrix
    c. mature cells have names that end with -cyte (e.g., osteocyte); they usually have a reduced capacity for cell division and matrix secretion; their major role is maintenance of the matrix
    d. some notable examples of cells include fibroblasts, macrophages, plasma cells, mast cells, adipocytes, and leukocytes
5. Connective tissue matrix consists of:
    a. **ground substance** that may be fluid, gel, or solid and is composed of numerous polysaccharides (i.e, glycosaminoglycans)and proteins (e.g., proteoglycans)
    b. protein **fibers** including:
        i. **collagen fibers** which provide strength to the tissue
        ii. **elastic fibers** which provide strength and elasticity
        iii. **reticular fibers** which provide support and strength
6. Classification of connective tissues:
    I. **Embryonic connective tissue** [see Table 3.2]
        A. **Mesenchyme** gives rise to all other connective tissues
        B. **Mucous connective tissue** is found primarily in the umbilical cord of the fetus
    II. **Mature connective tissue** (p. 74) [see Table 3.3]

A. **Loose connective tissue** has loosely arranged fibers in the matrix
   i. **Areolar connective tissue**
      - has several types of cells including fibroblasts, macrophages, etc.
      - has all three types of fibers
      - ground substance is semifluid
      - located in subcutaneous layer of skin, blood vessels, etc.
      - provides strength, elasticity, and support
   ii. **Adipose tissue**
      - contains **adipocytes** that store triglycerides
      - located in subcutaneous layer, around organs, etc.
      - white adipose tissue insulates, stores energy reserves, supports and protects various organs; brown adipose tissue generates heat in the newborn
   iii. **Reticular connective tissue**
      - contains reticular fibers and reticular cells
      - binds together cells of smooth muscle tissue, forms stroma (framework) of organs, etc.

B. **Dense connective tissue** has densely arranged fibers in the matrix
   i. **Dense regular connective tissue**
      - contains rows of fibroblasts located between numerous parallel (i.e., regularly arranged) bundles of collagen fibers
      - forms tendons and most ligaments
      - provides strong attachment between various structures
   ii. **Dense irregular connective tissue**
      - contains fibroblasts scattered among randomly oriented (i.e., irregularly arranged) collagen fibers
      - located in fascia, periosteum, heart valves, etc.
      - provides strength
   iii. **Elastic connective tissue**
      - contains fibroblasts scattered among elastic fibers
      - located in walls of elastic arteries, bronchial tubes, etc.
      - provides elasticity and strength

C. **Cartilage** contains **chondrocytes** embedded in the **lacunae** (spaces) of a gelatinous matrix that includes collagen fibers and elastic fibers; it is avascular (and therefore heals slowly) and lacks nerves
   i. **Hyaline cartilage**
      - has fine collagen fibers that are not visible with ordinary staining techniques used in light microscopy
      - is most abundant (but weakest) type of cartilage
      - located on ends of long bones, nose, trachea, etc.
      - provides flexibility and support; at joints, it reduces friction and absorbs shocks
   ii. **Fibrocartilage**
      - contains visible bundles of collagen fibers
      - located in intervertebral discs, knee menisci, etc.
      - provides strength and rigidity as well as flexibility and support
   iii. **Elastic cartilage**
      - contains network of elastic fibers
      - located in epiglottis, external ear, etc.

- maintains shape and provides strength and elasticity

D. **Bone (osseous) tissue** contains **osteocytes** embedded in lacunae of a rigid, calcified matrix (arranged in the form of concentric rings or **lamellae**) that includes collagen fibers; it is classified as:
   i. **Compact (dense) bone** composed of **osteons (Haversian systems)**
   ii. **Spongy (cancellous) bone** consisting of **trabeculae**.

   Bone supports, protects, helps generate movement, stores minerals, and houses red marrow and yellow marrow.

E. **Blood tissue** consists of a liquid matrix called **plasma** in which the following **formed elements** are suspended:
   i. **Erythrocytes** (red blood cells) transport the gases oxygen and carbon dioxide
   ii. **Leukocytes** (white blood cells) are involved in phagocytosis, immunity, and allergic reactions
   iii. **Platelets** play a role in blood clotting

F. **Lymph** is interstitial fluid that flows in lymphatic vessels.

E. Membranes (p. 82)

1. An **epithelial membrane** consists of an epithelial layer and an underlying connective tissue layer.
2. The principal epithelial membranes are:
   a. **Mucous membrane (mucosa)** lines a cavity that opens to the exterior (e.g., gastrointestinal tract, respiratory tract, etc.); it forms a barrier against entry of microbes, secretes mucus to prevent dehydration and trap pathogens, etc.
   b. **Serous membrane (serosa)** lines (parietal layer) a body cavity that does not open to the exterior (e.g., thoracic cavity, abdominal cavity), and it covers (visceral layer) organs inside these cavities (e.g., lungs, stomach); the epithelial layer secretes a lubricating serous fluid that reduces friction between the organs and the walls of the cavities.
   c. **Cutaneous membrane** (skin) is discussed in the next chapter.
3. **Synovial membranes** (which lack an epithelial layer) line joint cavities, bursae, and tendon sheaths; they secrete a lubricating synovial fluid that reduces friction during movements.

F. Muscular Tissue (p. 84)

1. Muscular tissue consists of cells, usually called muscle fibers, that are specialized to **contract** and therefore provide motion, maintain posture, and generate heat.
2. There are three major types (see Table 3.4):
   a. **Skeletal muscle tissue** is attached to bones and consists of long, cylindrical cells that are **striated** and multinucleate; it is under voluntary control
   b. **Cardiac muscle tissue** forms most of the wall of the heart and consists of **striated**, branching cells connected by **intercalated discs**; it is under involuntary control
   c. **Smooth muscle tissue** is located primarily in the walls of hollow internal organs (e.g., stomach, blood vessels, etc.) and consists of **non-striated** spindle-shaped cells; it is usually under involuntary control.

G. Nervous Tissue (p. 86)

1. Nervous tissue consists of two major kinds of cells (see Table 3.5):

a. **Neurons** detect stimuli, convert stimuli into nerve impulses, and conduct these messages to other neurons, muscle fibers or glands; neurons consist of:
    i. **cell body** which contains the nucleus and most other organelles
    ii. branched processes called **dendrites**
    iii. process called **axon** which conducts nerve impulses away from the cell body
b. **Neuroglia** provide protection and support to the neurons.

H. Aging and Tissues (p.86)

1. Tissues heal faster and leave less obvious scars in the young than in the aged.
2. The extracellular components of tissues, such as collagen and elastic fibers, change with age.

I. Key Medical Terms Associated with Tissues (p. 88)

1. Students should familiarize themselves with the glossary of key medical terms.