**LESSON 1**

**ORGANIZATION AND GENERAL PLAN OF THE BODY**

**LEVELS OF ORGANIZATION**

The human body is organized into structural and functional levels of increasing complexity. Each higher level incorporates the structures and functions of the previous level, as you will see. We will begin with the simplest level, which is the chemical level, and proceed to cells, tissues, organs, and organ systems.

**CHEMICALS**

The chemicals that make up the body may be divided into two major categories: inorganic and organic. **Inorganic chemicals** are usually simple molecules made of one or two elements other than carbon (with a few exceptions). Examples of inorganic chemicals are water (H2O); oxygen (O2); one of the exceptions, carbon dioxide (CO2); and minerals such as iron (Fe), calcium (Ca), and sodium (Na). **Organic chemicals** are often very complex and always contain the elements carbon and hydrogen. In this category of organic chemicals are carbohydrates, fats, proteins, and nucleic acids.

**CELLS**

The smallest living units of structure and function are **cells**. There are many different types of human cells, though they all have certain similarities. Each type of cell is made of chemicals and carries out specific chemical reactions.

**TISSUES**

A **tissue** is a group of cells with similar structure and function. There are four groups of tissues:

* **Epithelial tissues**—cover or line body surfaces; some are capable of producing secretions with specific functions. The outer layer of the skin and sweat glands are examples of epithelial tissues. Internal epithelial tissues include the walls of capillaries (squamous epithelium) and the kidney tubules (cuboidal epithelium).
* **Connective tissues**—connect and support parts of the body; some transport or store materials. Blood, bone, cartilage, and adipose tissue are examples of this group.
* **Muscle tissues**—specialized for contraction, which brings about movement. Our skeletal muscles and the heart are examples of muscle tissue.
* **Nerve tissue**—specialized to generate and transmit electrochemical impulses that regulate body functions. The brain and optic nerves are examples of nerve tissue.

**ORGANS**

An **organ** is a group of tissues precisely arranged so as to accomplish specific functions. Examples of organs are the kidneys, individual bones, the liver, lungs, and stomach. The kidneys contain several kinds of epithelial, or surface tissues, for their work of absorption. The stomach is lined with epithelial tissue that secretes gastric juice for digestion. Smooth muscle tissue in the wall of the stomach contracts to mix food with gastric juice and propel it to the small intestine. Nerve tissue carries impulses that increase or decrease the contractions of the stomach.

**ORGAN SYSTEMS**

An **organ system** is a group of organs that all contribute to a particular function. Examples are the urinary system, digestive system, and respiratory system. The urinary system, which consists of the kidneys, ureters, urinary bladder, and urethra all contribute to the formation and elimination of urine.

**TERMINOLOGY AND GENERAL PLAN OF THE BODY BODY PARTS AND AREAS**

The term *femoral* always refers to the thigh. The femoral artery is a blood vessel that passes through the thigh, and the quadriceps femoris is a large muscle group of the thigh. Another example is *pulmonary*, which always refers to the lungs, as in pulmonary artery, pulmonary edema, and pulmonary embolism. Although you may not know the exact meaning of each of these terms now, you do know that each has something to do with the lungs.

**TERMS OF LOCATION AND POSITION**

When describing relative locations, the body is always assumed to be in anatomic position: standing upright facing forward, arms at the sides with palms forward, and the feet slightly apart. The terms of location are listed in table below, with a definition and example for each. Notice also that these are pairs of terms and that each pair is a set of opposites. This will help you recall the terms and their meanings.



**BODY CAVITIES AND THEIR MEMBRANES**

The body has two major cavities: the dorsal cavity (posterior) and the ventral cavity (anterior). Each of these cavities has further subdivisions, as shown at the right.

**Dorsal Cavity**

The dorsal cavity contains the central nervous system, and consists of the cranial cavity and the vertebral or spinal cavity. The dorsal cavity is a continuous one; that is, no wall or boundary separates its subdivisions. The cranial cavity is formed by the skull and contains the brain. The spinal cavity is formed by the backbone (spine) and contains the spinal cord. The membranes that line these cavities and cover the brain and spinal cord are called the **meninges**.

**Ventral Cavity**

The ventral cavity consists of two compartments, the thoracic cavity and the abdominal cavity, which are separated by the diaphragm. The diaphragm is a large, dome-shaped respiratory muscle. It has openings for the esophagus and for large blood vessels, but otherwise is a wall between the thoracic and abdominal cavities. The pelvic cavity may be considered a subdivision of the abdominal cavity

Organs in the **thoracic cavity** include the heart and lungs. The membranes of the thoracic cavity are serous membranes called the **pleural membranes**. The parietal pleura lines the chest wall, and the visceral pleura covers the lungs. The heart has its own set of serous membranes called the **pericardial membranes**. The parietal pericardium lines the fibrous pericardial sac, and the visceral pericardium covers the heart muscle. Organs in the **abdominal cavity** include the liver, stomach, and intestines. The membranes of the abdominal cavity are also serous membranes called the peritoneum and mesentery. The **peritoneum** is the membrane that lines the entire abdominal wall, and the **mesentery** is the continuation of this membrane, folded around and covering the outer surfaces of the abdominal organs. The **pelvic cavity** is inferior to the abdominal cavity. Although the peritoneum does not line the pelvic cavity, it covers the free surfaces of several pelvic organs. Within the pelvic cavity are the urinary bladder and reproductive organs such as the uterus in women and the prostate gland in men.

**PLANES AND SECTIONS**

When internal anatomy is described, the body or an organ is often cut or sectioned in a specific way so as to make particular structures easily visible. A **plane** is an imaginary flat surface that separates two portions of the body or an organ.

* **Frontal (coronal) section**—a plane from side to side separates the body into front and back portions.
* **Sagittal section**—a plane from front to back separates the body into right and left portions. A midsagittal section creates equal right and left halves.
* **Transverse section**—a horizontal plane separates the body into upper and lower portions.
* **Cross-section**—a plane perpendicular to the long axis of an organ. A cross-section of the small intestine (which is a tube) would look like a circle with the cavity of the intestine in the center.
* **Longitudinal section**—a plane along the long axis of an organ. A longitudinal section of the intestine is shown in the figure, and a frontal section of the femur (thigh bone) would also be a longitudinal section

**AREAS & REGIONS OF THE ABDOMEN**

The abdomen is a large area of the lower trunk of the body. If a patient reported abdominal pain, the physician or nurse would want to know more precisely where the pain was. To determine this, the abdomen may be divided into smaller regions or areas, which are shown in the figure below.

* **Quadrants**—a transverse plane and a midsagittal plane that cross at the umbilicus will divide the abdomen into four quadrants. Clinically, this is probably the division used more frequently. The pain of gallstones might then be described as in the right upper quadrant.
* **Nine areas**—two transverse planes and two sagittal planes divide the abdomen into nine areas:

*Upper areas*—above the level of the rib cartilages are the left hypochondriac, epigastric, and right hypochondriac.

*Middle areas*—the left lumbar, umbilical, and right lumbar

*Lower areas*—below the level of the top of the pelvic bone are the left iliac, hypogastric, and right iliac.

These divisions are often used in anatomic studies to describe the location of organs. The liver, for example, is located in the epigastric and right hypochondriac areas.

**Homeostasis**

**Homeostasis** is the relative constancy of the body’s internal environment. Because of homeostasis, even though external conditions may change dramatically, internal conditions stay within a narrow range. For example, regardless of how cold or hot it gets, the temperature of the body stays around 37°C (97° to 99°F). No matter how acidic your meal, the pH of your blood is usually about 7.4, and even if you eat a candy bar, the amount of sugar in your blood is just about 0.1%. It is important to realize that internal conditions are not absolutely constant; they tend to fluctuate above and below a particular value. Therefore, the internal state of the body is often described as one of *dynamic* equilibrium. If internal conditions change to any great degree, illness results. This makes the study of homeostatic mechanisms medically important.

**Negative Feedback**

**Negative feedback** is the primary homeostatic mechanism that keeps a variable close to a particular value, or set point. A homeostatic mechanism has three components: a sensor, a regulatory center, and an effector . The sensor detects a change in the internal environment; the regulatory center activates the effector; the effector reverses the change and brings conditions back to normal again. Now, the sensor is no longer activated.

***Mechanical Example***

A home heating system illustrates how a negative feedback mechanism works. You set the thermostat at, say, 68°F. This is the set point. The thermostat contains a thermometer, a sensor that detects when the room temperature falls below the set point. The thermostat is also the regulatory center; it turns the furnace on. The furnace plays the role of the effector. The heat given off by the furnace raises the temperature of the room to 70°F. Now, the furnace turns off.

Notice that a negative feedback mechanism prevents change in the same direction; the room does not get warmer and warmer because warmth inactivates the system.

***Human Example: Regulation of Blood Pressure***

Negative feedback mechanisms in the body function similarly to the mechanical model. For example, when blood pressure falls, sensory receptors signal a regulatory center in the brain. This center sends out nerve impulses to the arterial walls so that they constrict. Once the blood pressure rises, the system is inactivated.

***Human Example: Regulation of Body Temperature***

The thermostat for body temperature is located in a part of the brain called the hypothalamus. When the body temperature falls below normal, the regulatory center directs (via nerve impulses) the blood vessels of the skin to constrict. This conserves heat. If body temperature falls even lower, the regulatory center sends nerve impulses to the skeletal muscles, and shivering occurs. Shivering generates heat, and gradually body temperature rises to 37°C. When the temperature rises to normal, the regulatory center is inactivated.

When the body temperature is higher than normal, the regulatory center directs the blood vessels of the skin to dilate. This allows more blood to flow near the surface of the body, where heat can be lost to the environment. In addition, the nervous system activates the sweat glands, and the evaporation of sweat helps lower body temperature. Gradually, body temperature decreases to 37°C.

**Positive Feedback**

**Positive feedback** is a mechanism that brings about an ever greater change in the same direction. A positive feedback mechanism can be harmful, as when a fever causes metabolic changes that push the fever still higher. Death occurs at a body temperature of 45°C because cellular proteins denature at this temperature and metabolism stops. Still, positive feedback loops such as those involved in blood clotting, the stomach’s digestion of protein, and childbirth assist the body in completing a process that has a definite cutoff point. Consider that when a woman is giving birth, the head of the baby begins to press against the cervix, stimulating sensory receptors there. When nerve impulses reach the brain, the brain causes the pituitary gland to secrete the hormone oxytocin.

Oxytocin travels in the blood and causes the uterus to contract. As labor continues, the cervix is ever more stimulated, and uterine contractions become ever stronger until birth occurs.

**Disease**

**Disease** is present when homeostasis fails and the body (or part of the body) no longer functions properly. The effects may be limited or widespread. A *local disease* is more or less restricted to a specific part of the body. On the other hand, a **systemic disease** affects the entire body or involves several organ systems. Diseases may also be classified on the basis of their severity and duration. **Acute diseases** occur suddenly and generally last a short time. **Chronic diseases** tend to be less severe, develop slowly, and are long term.

**LESSON 2**

**BIOCHEMISTRY: CHEMISTRY OF LIFE**

**Elements**

1. Elements are the simplest chemicals, which make up all matter.
2. Carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, and calcium make up 99% of the human body.
3. Elements combine in many ways to form molecules.

**Atoms**

1. Atoms are the smallest part of an element that still retains the characteristics of the element.

2. Atoms consist of positively and negatively charged particles and neutral (or uncharged) particles.

* Protons have a positive charge and are found in the nucleus of the atom.
* Neutrons have no charge and are found in then nucleus of the atom.
* Electrons have a negative charge and orbit the nucleus.

3. The number and arrangement of electrons give an atom its bonding capabilities.

**Chemical Bonds**

1. An ionic bond involves the loss of electrons by one atom and the gain of these electrons by another atom: Ions are formed that attract one another

* Cations are ions with positive charges: Na+,Ca+2
* Anions are ions with negative charges: Cl-, HCO3-.
* Salts, acids, and bases are formed by ionic bonding.
* In water, many ionic bonds break; dissociation releases ions for other reactions.

1. A covalent bond involves the sharing of electrons between two atoms.

* Oxygen gas (O2) and water (H2O) are covalently bonded molecules.
* Carbon always forms covalent bonds; these are the basis for the organic compounds.
* Covalent bonds are not weakened in an aqueous solution.

1. A disulfide bond is a covalent bond between two sulfur atoms in a protein; it helps maintain the three-dimensional shape of some proteins.
2. A hydrogen bond is the attraction of covalently bonded hydrogen to a nearby oxygen or nitrogen atom.

* The three-dimensional shape of proteins and nucleic acids is maintained by hydrogen bonds.
* Water is cohesive because of hydrogen bonds.

**Chemical Reactions**

1. A change brought about by the formation or breaking of chemical bonds.
2. Synthesis—bonds are formed to join two or more molecules.
3. Decomposition—bonds are broken within a molecule.

**Inorganic Compounds of Importance**

1. Water—makes up 60% to 75% of the body.

* Solvent—for transport of nutrients in the blood and excretion of wastes in urine.
* Lubricant—mucus in the digestive tract.
* Changes temperature slowly, and prevents sudden changes in body temperature; absorbs body heat in evaporation of sweat.
* Water compartments—the locations of water within the body.

Intracellular—within cells; 65% of total body water.

Extracellular—35% of total body water

— Plasma—in blood vessels.

— Lymph—in lymphatic vessels.

— Tissue fluid—in tissue spaces between cells.

1. Oxygen—21% of the atmosphere.

* Essential for cell respiration: the breakdown of food molecules to release energy.

1. Carbon dioxide

* Produced as a waste product of cell respiration.
* Must be exhaled; excess CO2 causes acidosis.

1. Cell respiration—the energy-producing processes of cells.

* Glucose \_ O2 → CO2 \_ H2O \_ ATP \_ heat
* This is why we breathe: to take in oxygen to break down food to produce energy, and to exhale the CO2 produced.

1. Trace elements—minerals needed in small amounts
2. Acids, bases, and pH

* The pH scale ranges from 0 to 14; 7 is neutral; below 7 is acidic; above 7 is alkaline.
* An acid increases the H+ ion concentration of a solution; a base decreases the H\_ ion concentration (or increases the OH- ion concentration)
* The pH of cells is about 6.8. The pH range of blood is 7.35 to 7.45.
* Buffer systems maintain normal pH by reacting with strong acids or strong bases to change them to substances that do not greatly change pH.
* The bicarbonate buffer system consists of H2CO3 and NaHCO3.

**Organic Compounds of Importance**

**1. Carbohydrates**

• Monosaccharides are simple sugars. Glucose, a hexose sugar (C6H12O6), is the primary energy source for cell respiration.

Pentose sugars are part of the nucleic acids DNA and RNA.

* Disaccharides are made of two hexose sugars.

Sucrose, lactose, and maltose are digested to monosaccharides and used for cell respiration.

* Oligosaccharides consist of from 3 to 20 monosaccharides; they are antigens on the cell membrane that identify cells as “self.”
* Polysaccharides are made of thousands of glucose molecules.

Starches are plant products broken down in digestion to glucose.

Glycogen is the form in which glucose is stored in the liver and muscles.

Cellulose, the fiber portion of plant cells, cannot be digested but promotes efficient peristalsis in the colon.

**2. Lipids.**

* True fats are made of fatty acids and glycerol; triglycerides are a storage form for potential energy in adipose tissue. The eyes and kidneys are cushioned by fat. Fatty acids may be saturated or unsaturated. Saturated fats and hydrogenated or trans fats contribute to atherosclerosis.
* Phospholipids are diglycerides such as lecithin that are part of cell membranes. Myelin is a phospholipid that provides electrical insulation for nerve cells.
* Steroids consist of four rings of carbon and hydrogen. Cholesterol, produced by the liver and consumed in food, is the basic steroid from which the body manufactures others: steroid hormones, vitamin D, and bile salts.

**3. Proteins**

* Amino acids are the subunits of proteins; 20 amino acids make up human proteins. Peptide bonds join amino acids to one another.
* A protein consists of from 50 to thousands of amino acids in a specific sequence (primary structure) that is folded into a specific shape (secondary and tertiary structures). Some proteins are made of two or more amino acid chains; some proteins contain trace elements.
* Amino acids in excess of the need for protein synthesis are converted to simple carbohydrates or to fat, for energy production.
* Enzymes are catalysts, which speed up reactions without additional energy. The active site theory is based on the shapes of the enzyme and the substrate molecules: These must “fit”. The enzyme remains unchanged after the product of the reaction is released. Each enzyme is specific for one type of reaction. The functioning of enzymes may be disrupted by changes in pH or body temperature or by the presence of a poison, which changes the shape of the active sites of enzymes.

**4. Nucleic acids.**

* Nucleotides are the subunits of nucleic acids. A nucleotide consists of a pentose sugar, a phosphate group, and a nitrogenous base.
* DNA is a double strand of nucleotides, coiled into a double helix, with complementary base pairing: A–T and G–C. DNA makes up the chromosomes of cells and is the genetic code for the synthesis of proteins.
* RNA is a single strand of nucleotides, synthesized from DNA, with U in place of T. RNA functions in protein synthesis.
* ATP is a nucleotide that is specialized to trap and release energy. Energy released from food in cell respiration is used to synthesize ATP from ADP + P. When cells need energy, ATP is broken down to ADP + P and the energy is released for cell processes.

**LESSON 3**

**CELLS**

Human cells vary in size, shape, and function. Our cells function interdependently to maintain homeostasis.

Cell Structure—the major parts of a cell are the cell membrane, nucleus (except mature RBCs), cytoplasm, and cell organelles

1. Cell membrane—the selectively permeable boundary of the cell.

* Phospholipids permit diffusion of lipid-soluble materials.
* Cholesterol provides stability.
* Proteins form channels, transporters, “self” antigens, and receptor sites for hormones or other signaling molecules.

1. Nucleus—the control center of the cell; has a double-layer membrane.

* Nucleolus—forms ribosomal RNA.
* Chromosomes—made of DNA and protein;

DNA is the genetic code for the structure and functioning of the cell. A gene is a segment of DNA that is the code for one protein. Human cells have 46 chromosomes, and their genetic information is called the genome.

1. Cytoplasm—a watery solution of minerals, gases, and organic molecules; contains the cell organelles; site for many chemical reactions.
2. Cell organelles—intracellular structures with specific functions.

**Cellular Transport Mechanisms—the processes by which cells take in or secrete or excrete materials through the selectively permeable cell membrane.**

1. Diffusion—movement of molecules from an area of greater concentration to an area of lesser concentration; occurs because molecules have free energy: They are constantly in motion. Oxygen and carbon dioxide are exchanged by diffusion in the lungs and tissues.
2. Osmosis—the diffusion of water. Water diffuses to an area of less water, that is, to an area of more dissolved material. The small intestine absorbs water from digested food by osmosis. Isotonic, hypertonic, and hypotonic
3. Facilitated diffusion—transporters (carrier enzymes) that are part of the cell membrane permit cells to take in materials that would not diffuse by themselves. Most cells take in glucose by facilitated diffusion.
4. Active transport—a cell uses ATP to move substances from an area of lesser concentration to an area of greater concentration. Nerve cells and muscle cells have sodium pumps to return Na+ ions to the exterior of the cells; this prevents spontaneous impulses. Cells of the small intestine absorb glucose and amino acids from digested food by active transport.
5. Filtration—pressure forces water and dissolved materials through a membrane from an area of higher pressure to an area of lower pressure. Tissue fluid is formed by filtration: Blood pressure forces plasma and dissolved nutrients out of capillaries and into tissues. Blood pressure in the kidney capillaries creates filtration, which is the first step in the formation of urine.
6. Phagocytosis—(a form of endocytosis) a moving cell engulfs something; white blood cells phagocytize bacteria to destroy them.
7. Pinocytosis—(a form of endocytosis) a stationary cell engulfs small molecules; kidney tubule cells reabsorb small proteins by pinocytosis.

**The Genetic Code and Protein Synthesis**

1. DNA and the genetic code

* DNA is a double helix with complementary base pairing: A–T and G–C.
* The sequence of bases in the DNA is the genetic code for proteins.
* The triplet code: three bases (a codon) is the code for one amino acid.
* A gene consists of all the triplets that code for a single protein.

1. RNA and protein synthesis

* Transcription—mRNA is formed as a complementary copy of the sequence of bases in a gene (DNA).
* mRNA moves from the nucleus to the ribosomes in the cytoplasm.
* tRNA molecules (in the cytoplasm) have anticodons for the triplets on the mRNA.
* Translation—tRNA molecules bring amino acids to their proper triplets on the mRNA.
* Ribosomes contain enzymes to form peptide bonds between the amino acids.

1. Expression of the genetic code

* DNA - RNA - proteins (structural proteins and enzymes that catalyze reactions) - hereditary characteristics.
* A genetic disease is a “mistake” in the DNA, which is copied by mRNA and results in a malfunctioning protein.

**Cell Division**

1. Mitosis—one cell with the diploid number of chromosomes divides once to form two cells, each with the diploid number of chromosomes (46 for humans).

* DNA replication forms two sets of chromosomes during interphase.
* Stages of mitosis: prophase, metaphase, anaphase, and telophase. Cytokinesis is the division of the cytoplasm following telophase.
* Mitosis is essential for growth and for repair and replacement of damaged cells.
* Most adult nerve and muscle cells seem unable to divide; their loss may involve permanent loss of function.

1. Meiosis—one cell with the diploid number of chromosomes divides twice to form four cells, each with the haploid number of chromosomes (23 for humans).

* Oogenesis in the ovaries forms egg cells.
* Spermatogenesis in the testes forms sperm cells.
* Fertilization of an egg by a sperm restores the diploid number in the fertilized egg.

**LESSON 4**

**TISSUES**

A tissue is a group of cells with similar structure and function. The four main groups of tissues are epithelial, connective, muscle, and nerve.

Epithelial Tissue—found on surfaces; have no capillaries; some are capable of secretion; classified as to shape of cells and number of layers of cells.

1. Simple squamous—one layer of flat cells; thin and smooth.

Sites: alveoli (to permit diffusion of gases); capillaries (to permit exchanges between blood and tissues).

1. Stratified squamous—many layers of mostly flat cells; mitosis takes place in lowest layer.

Sites: epidermis, where surface cells are dead (a barrier to pathogens); lining of mouth; esophagus; and vagina (a barrier to pathogens).

1. Transitional—stratified, yet surface cells are rounded and flatten when stretched.

Site: urinary bladder (to permit expansion without tearing the lining).

1. Simple cuboidal—one layer of cube-shaped cells.

Sites: thyroid gland (to secrete thyroid hormones); salivary glands (to secrete saliva); kidney tubules (to reabsorb useful materials back to the blood).

1. Simple columnar—one layer of column-shaped cells.

Sites: stomach lining (to secrete gastric juice); small intestinal lining (to secrete digestive enzymes and absorb nutrients—microvilli increase surface area for absorption).

1. Ciliated—columnar cells with cilia on free surfaces.

Sites: trachea (to sweep mucus and bacteria to the pharynx); fallopian tubes (to sweep ovum to uterus).

1. Glands—epithelial tissues that produce secretions.

* Unicellular—one-celled glands. Goblet cells secrete mucus in the respiratory and digestive tracts.
* Multicellular—many-celled glands.

Exocrine glands have ducts; salivary glands secrete saliva into ducts that carry it to the oral cavity.

Endocrine glands secrete hormones directly into capillaries (no ducts); thyroid gland secretes thyroxine.

**Connective Tissue—all have a non-living intercellular matrix and specialized cells**

1. Blood—the matrix is plasma, mostly water; transports materials in the blood. Red blood cells carry oxygen; white blood cells destroy pathogens and provide immunity; platelets prevent blood loss, as in clotting. Blood cells are made in red bone marrow.
2. Areolar (loose)—cells are fibroblasts, which produce protein fibers: collagen is strong, elastin is elastic; the matrix is collagen, elastin, and tissue fluid. White blood cells and mast cells are also present.

Sites: below the dermis and below the epithelium of tracts that open to the environment (to destroy pathogens that enter the body).

1. Adipose—cells are adipocytes that store fat; little matrix.

Sites: between the skin and muscles (to store energy); around the eyes and kidneys (to cushion). Also involved in appetite, use of insulin, and inflammation.

1. Fibrous—mostly matrix, strong collagen fibers; cells are fibroblasts.

Regular fibrous sites: tendons (to connect muscle to bone); ligaments (to connect bone to bone); poor blood supply, slow healing.

Irregular fibrous sites: dermis of the skin and the fascia around muscles.

1. Elastic—mostly matrix, elastin fibers.

Sites: walls of large arteries (to maintain blood pressure); around alveoli (to promote normal exhalation).

1. Bone—cells are osteocytes; matrix is calcium salts and collagen, strong and not flexible; good blood supply, rapid healing.

Sites: bones of the skeleton (to support the body and protect internal organs from mechanical injury).

1. Cartilage—cells are chondrocytes; protein matrix is firm yet flexible; no capillaries in matrix, very slow healing.

Sites: joint surfaces of bones (to prevent friction); tip of nose and external ear (to support); wall of trachea (to keep air passage open); discs between vertebrae (to absorb shock).

**Muscle Tissue—specialized to contract and bring about movement**

1. Skeletal—also called striated or voluntary muscle. Cells are cylindrical, have several nuclei, and have striations. Each cell has a motor nerve ending; nerve impulses are essential to cause contraction.

Site: skeletal muscles attached to bones (to move the skeleton and produce heat).

1. Smooth—also called visceral or involuntary muscle. Cells have tapered ends, one nucleus each, and no striations. Contraction is not under voluntary control.

Sites: stomach and intestines (peristalsis); walls of arteries and veins (to maintain blood pressure); iris (to constrict or dilate pupil).

1. Cardiac—cells are branched, have one nucleus each, and faint striations.

Site: walls of the four chambers of the heart (to pump blood; nerve impulses regulate the rate of contraction).

**Nerve Tissue—neurons are specialized to generate and transmit impulses**

1. Cell body contains the nucleus; axon carries impulses away from the cell body; dendrites carry impulses toward the cell body.
2. A synapse is the space between two neurons; a neurotransmitter carries the impulse across a synapse.
3. Specialized cells in nerve tissue are neuroglia in the CNS and Schwann cells in the PNS.
4. Sites: brain; spinal cord; and peripheral nerves (to provide sensation, movement, regulation of body functions, learning, and memory).

**Membranes—sheets of tissue on surfaces, or separating organs or lobes**

1. Epithelial membranes

* Serous membranes—in closed body cavities; the serous fluid prevents friction between the two layers of the serous membrane.
* Thoracic cavity—partial pleura lines chest wall; visceral pleura covers the lungs.
* Pericardial sac—parietal pericardium lines fibrous pericardium; visceral pericardium (epicardium) covers the heart muscle.
* Abdominal cavity—peritoneum lines the abdominal cavity; mesentery covers the abdominal organs.

1. Mucous membranes—line body tracts that open to the environment: respiratory, digestive, urinary, and reproductive. Mucus keeps the living epithelium wet; provides lubrication in the digestive tract; traps dust and bacteria in the respiratory tract.