I. Types of tissues and their origin: There are 4 basic types of body tissues
   a) Epithelial Tissue
      i) Covers the body’s surface
      ii) lines the hollow organs, body cavities, and ducts
      iii) Forms glands
   b) Connective Tissue
      i) Protects and the supports the body and its organs
      ii) Binds organs together
      iii) Stores excess energy as fat
      iv) Provides immunity to disease-causing organisms
   c) Muscle Tissue
      i) Generates the physical force needed to make body structures move
   d) Nervous Tissue
      i) Detects changes in conditions inside and outside the body
      ii) Generates nerve impulses to help maintain homeostasis
   e) All tissues of the body develop from three primary germ layers
      i) Primary Germ Layers: the first tissues that form in the human embryo
         (1) Endoderm, Mesoderm, & Ectoderm
         (2) All three germ layers give rise to epithelial tissue
            (a) Mesoderm gives rise to all connective tissue and most muscle tissue.
            (b) Ectoderm gives rise to nervous tissue
   II. Epithelial Tissue
      a) Consists of cells arranged in continuous sheets of single or multiple layers
      b) Held tightly together by many cell junctions allowing very little or no intercellular space between adjacent cells.
      c) The surfaces of epithelial tissue differ in structure & function.
         i) Apical Surface: the free end of the cell
            (1) Faces the body surface, the lumen of an internal organ or duct, or a body cavity.
         ii) Lateral Surfaces: face the adjacent cells on either side of the cell.
         iii) Basal Surface: opposite the apical surface and adheres to extracellular materials, a deeper layer of epithelial cells, or the basement membrane.
            (1) Basement Membrane: Thin, extracellular anchor for the epithelium.
               (a) Composed of proteins of collagen and other connective tissue
      d) Epithelial tissue is avascular (or without its own blood supply) but has its own nerve supply.
         i) It receives its nutrition via diffusion
      e) Epithelial tissue lines the body surfaces and is therefore, subjected to a high level of physical stress and injury.
         i) A high rate of cell division allows the epithelium to repair and renew itself often.
      f) Epithelial tissue plays many roles in the body.
         i) Protection, filtration, secretion, absorption, and excretion.
         ii) Combines with nervous tissue to provide for smell, vision, hearing, and touch.
      g) There two basic types of Epithelium
         i) Covering and lining epithelium: forms the outer covering of the skin and some internal organs and the lining of blood vessels, ducts, body cavities, and the internal respiratory, digestive, urinary, and reproductive systems.
ii) **Glandular Epithelium**: the secreting portion of glands such as the thyroid, sweat glands, and adrenal glands.

h) **Covering and Lining Epithelium**: classified into two characteristics
   i) Arrangement of cells into layers
   ii) Shapes of cells

i) **Layers of epithelium classification:**
   i) **Simple Epithelium**: single layer of epithelial cells
      1) Usually functions in diffusion, osmosis, filtration, secretion, and absorption
      a) mucous membranes, lining of internal organs
   ii) **Stratified Epithelium**: 2 or more layers protecting underlying tissues in areas of
      1) wear and tear (skin, finger tips)
   iii) **Pseudostratified Epithelium**: A single layer, but looks like multiple layers
      1) because the nuclei are at different layers and not all cells reach the apical surface.

j) **Cell Shape Classification**:
   i) **Squamous Cells**: thin, arranged like floor tiles.
      1) Easy for allowing rapid movement of substances through them.
   ii) **Cuboidal Cells**: cube-shaped or hexagon-shaped.
      1) Allow for absorption and secretion.
   iii) **Columnar Cells**: taller than they are wide
      1) Also for secretion and absorption

k) **Transitional Cells**: Change shape from cuboidal to flat and back to cuboidal.
   i) Allow organs to stretch to larger sizes and return (urinary bladder)

l) Considering the arrangements and shapes, there are many types of covering and lining epithelium.

m) **Simple Epithelium**
   i) **Simple Squamous**: single layer of flat cells
      1) **Endothelium**: lines the heart, blood vessels, and lymphatic vessels.
      2) **Mesothelium**: forms the serous membranes (the membrane that lines an organ or body
         cavity, that does not expose to the exterior)
   ii) **Simple Cuboidal**: single layer of cuboidal cells
      1) lines the lumen of the kidney tubules and the follicles of the thyroid
   iii) **Simple Columnar**: single layer of columnar cells (lines the lumen of the small & large
      intestine)
      1) **Microvilli**: small, finger-like projections on the surface of non-ciliated, simple columnar
         epithelium to increase surface area for increased absorption.
      2) **Goblet cells** are modified, non-ciliated, simple columnar epithelial cells that produce
         mucous.
      3) **Ciliated Simple Columnar Epithelium**: found amidst goblet cells, so that the mucous
         from the goblet cells can trap foreign particles and the cilia can sweep them away for
         elimination from the body. Or so the cilia can move an egg through a uterine tube toward
         the uterus.

n) **Stratified Epithelium**
   i) **Stratified Squamous**: multiple layers of squamous cells (lines the female reproductive
      organs and the esophagus
      1) Deeper layers undergo cell division and new cells migrate toward the surface as older
         surface cells die off and are sloughed off and disposed of)
      2) Some stratified squamous epithelium’s surface is lined with keratin, or **keratinized
         stratified squamous epithelium** (as found in the epidermis of the skin)
         a) Keratin is a dehydrated, fibrous protein, that protects the skin and underlying tissues
            from heat, microbes, and chemicals.
         b) Non-keratinized stratified squamous epithelium has no keratin and remains moist.
ii) **Stratified Cuboidal**: multiple layers of cuboidal cells
   (1) Rare, functions in protections and some absorption/secretion.
   (2) found in sweat glands, esophageal glands, and ovaries.
iii) **Stratified Columnar**: multiple layers of columnar
     (1) Also rare and functions in protection, and secretion
     (2) large ducts of the salivary glands
iv) ** Transitional**: Looks like cuboidal, but can change shape to allow an organ to stretch and return to shape
     (1) Only found in the urinary system to accommodate a variable volume of fluid w/o rupturing (lines the cavity of the urinary bladder, lumen of the ureter, and umbilical cord)
v) **Pseudostratified columnar**: all cells are attached to the basement membrane in this *single layer of columnar epithelium*, but not all cells rise to the apical surface.
     (1) Some of these cells are ciliated (contain cilia) and some are goblet cells.
     (2) lines the lumen of the trachea

III. **Connective Tissue (CT)**: one of the most abundant and widely spread tissues in the human body.
   a) Connective tissue has many functions
      i) Binds together, strengthens, and supports other body tissues
      ii) Protects and insulates the internal organs
      iii) Compartmentalizes structures, such as skeletal muscles
      iv) Major transport system within the body (i.e. blood)
      v) The major site of stored energy reserves (adipose tissue)
      vi) The main site of immune responses
   b) General Features of Connective tissue
      i) There are two basic elements of connective tissue
         (1) Cells
         (2) **Matrix**: fills the wide spaces between the cells
            (a) Consists of protein-based fibers and *ground substance* (the material between the cells and fibers).
            (b) The matrix is usually secreted by the cells and determines the cells qualities.
            (c) Cartilage: matrix is firm, but pliable
            (d) Bone: matrix is hard and non-pliable
      c) Connective tissue does not cover body surfaces or line internal organs.
   d) Most connective tissue has a rich blood supply
      i) except cartilage (no blood supply) and tendons (small blood supply)
   e) **Connective Tissue Cells**
      i) Each major type of connective tissue contains an immature class of cells whos name ends in – *blast*, which means “bud or sprout”.
      ii) These blasts give rise to specific mature versions of connective tissue cells.
         (1) **Fibroblasts**: large, flat cells with branching processes found in loose & dense connective tissue
         (2) **Chondroblasts**: give rise to cartilage
         (3) **Osteoblasts**: give rise to bone
         (4) Blast cells retain their capacity for cell division and secrete the matrix
         (5) In cartilage and bone, once the matrix is produced, the blasts mature and become *chondrocytes* or *osteocytes*.
            (a) Mature cells have a reduced capacity for cell division and matrix production and mainly function to maintain the matrix.
Macrophages: develop from monocytes (a type of white blood cell) and are capable of engulfing bacteria and cellular debris via phagocytosis.

(a) Some macrophages are fixed and stay within one tissue all the time. Others are wandering macrophages and roam around the body gathering at cites of infection or inflammation.

Plasma Cells: small cells that develop from a type of white blood cell called a B Lymphocyte.

(a) Secrete antibodies, which attack foreign substances in the body.
(b) Important to the immune system.
(c) Found in connective tissues in the GI and respiratory tract, as well as in red bone marrow, salivary glands, & lymph nodes.

Mast Cells: Produce histamine, the chemical that dilates blood vessels as part of the inflammatory response to injury or infection.

Adipocytes: adipose cells. Store triglycerides

(a) Found beneath the skin and around organs such as the heart and kidneys.

White Blood Cells: gather in connective tissue in response to infection and allergic reactions.

iii) Connective Tissue Matrix

1) Ground Substance: made up of water and many molecules that are complex combinations of polysaccharides and proteins.

(a) The polysaccharides are called glycosaminoglycans (GAGs)
(b) The GAGs are associates with proteins called proteoglycans, which form a core protein that the GAGs project off of like bristles from a brush.
(c) The GAGs trap water making the ground substance more jelly-like.
   (i) Hyaluronic Acid: a think (viscous), slippery substance, that binds cells together, lubricates joints, and helps maintain the shapes of the eyeballs.
   (ii) Chondroitin Sulfate: provides support and adhesiveness in cartilage, bone, skin, and blood vessels.
(d) Adhesion proteins: link components of the ground substance to each other and to the surface cells.
   (i) Fibronectin: the main adhesion protein of connective tissue; links collagen and ground substances together

2) Fibers: there are three types of fibers embedded in the matrix between the cells.

(a) Collagen Fibers: very strong and resist pulling forces
   (i) Not stiff: promote tissue flexibility
   (ii) Found in most types of connective tissue, especially bone, cartilage, tendons, and ligaments.
   (iii) The protein, collagen, is the most abundant protein in the body
(b) Elastic Fibers: Strong, but can be stretched up to 150% of their relaxed length without breaking and then return to normal.
   (i) This property is called elasticity
   (ii) Contain a protein called elastin
   (iii) Abundant in skin, blood vessel walls, and lung tissue
(c) Reticular Fibers: Thinner than collagen fibers, also made of a network of collagen proteins
   (i) Provide structural support and strength by forming a branching network around the cells of certain tissues
   (ii) Found in the blood vessel walls, adipose tissue, smooth muscle, tissue.
   (iii) Form the stroma, which means “bed or covering” and forms the supporting framework of many soft organs (spleen, lymph nodes) and the basement membrane.
f) **Types of Mature Connective Tissue (6)**

   i) **Loose Connective Tissue**: loosely intertwined fibers amidst many cells
   
   (1) **Areolar CT**: contains all three CT types (collagen, elastic, reticular)
   (a) combines with adipose tissue to form the **subcutaneous layer**, the layer of tissue that attaches the skin to underlying tissues and organs.
   
   (2) **Adipose Tissue**: made of cells called **adipocytes**, which are specialized for storage of triglycerides.
   (a) Function in energy storage, heat insulation, and support & protection of the body’s organs.
   
   (3) **Reticular CT**: Form the stroma for the liver, spleen, and lymph nodes.
   (a) Also helps filter blood in the spleen and remove old blood cells as well as filter lymph in the lymph nodes and remove bacteria.

   ii) **Dense CT**: contains more numerous, thicker, and denser fibers amidst considerably fewer cells than loose CT.
   
   (1) **Dense Regular CT**: Bundles of collagen fibers are regularly arranged in parallel patterns for great strength that withstand pulling along the axis of the fibers.
   (a) Silvery white and somewhat pliable
   (b) i.e. Tendons and most ligaments
   
   (2) **Dense Irregular CT**: collagen fibers packed more closely together than in dense regular CT and arranged irregularly.
   (a) found in parts of the body where forces are exerted in various directions
   (b) occurs in sheets, such as the dermis of the skin or the pericardium around the heart

   iii) **Elastic CT**: strong and elastic.
   
   (1) Lung tissue and elastic arteries

   iv) **Cartilage**: A dense network of collagen firmly embedded in chondroitin sulfate
   
   (1) Can endure more stress than loose and dense CT.
   
   (2) Formed by **chondrocytes**, cartilage cells.
   
   (3) **Hyaline Cartilage**: The most abundant cartilage in the body
   (a) Affords flexibility and support
   (b) Reduces friction and absorbs shock between joints
   (c) Is the weakest of the cartilages
   
   (4) **Fibrocartilage**: Combines strength and rigidity
   (a) Intervertebral discs
   (b) Strongest of the cartilages
   
   (5) **Elastic Cartilage**: provides strength and elasticity to maintain the shape of certain structures
   (a) The pinna of the ear

   (6) **Bone**
   
   (a)

IV. **Cell Junctions**

   a) In normal situations of an adult, most cells in a body remain anchored to other cells, to a basement membrane, and to connective tissues.

   b) **Cell Junctions** are contact points between the plasma membranes of cells that may serve one of three functions:
   i) Form a zip-lock type seal between cells
   ii) Anchoring cells to one another or to extracellular material
   iii) Provide channels that allow ions and molecules to pass from cell to cell within a tissue.

   c) There are 5 important types of cell junctions
   i) **Tight Junctions**: found in epithelial cells that line the stomach, intestines and urinary bladder
(1) slow the passage of substances between cells in order to prevent leakage of the contents into the blood or surrounding tissues.

ii) **Adherens Junctions**: contain a dense layer of protein, called a **plaque**, on the cytosol side of the plasma membrane, that attaches to the cytoskeleton fibers and transmembrane glycoproteins, called **cadherins**.
   (1) These cadherins attach to other cadherins on the adjacent cell, binding them together.
   (2) Adherins junctions help epithelial surfaces resist separation.

iii) **Desmosomes**: Same structure as adherins junctions with one addition
   (1) **Intermediate Filaments** made of keratin attach to a desmosome on the cytosol side and cross the cytosol to attach to another desmosome within the same cell.
   (2) Contributes to the stability of the cell and tissue structure
   (3) Found in the epidermis (outermost layer of the skin) and the heart muscle to contribute strength against tension and contraction.

iv) **Hemidesmosomes**: Similar to desmosomes, but do not attach to other cells. Rather they attach to the basement membrane.
   (1) In hemidesmosomes, the cadherins are called **Integrins**

v) **Gap Junctions**: Membrane proteins called **connexins** form tiny, fluid-filled tunnels called **connexons**, that attach to the neighboring cell.
   (1) There is a small gap between cells joined by gap junctions. Ions and small molecules can freely flow from the cytosol of one cell to that of another.
   (2) Gap junctions allow the cells of certain tissues communicate with each other as well as increase the speed of nerve impulses along muscle cells in the heart and stomach.

V. **Glandular Epithelium**: cells that make up and form **glands** that function in secretion
   a) **Secretion**: the production and release of a physiologically active substance from a cell or gland
   b) **Gland**: a single cell or group of cells that secrete substances into ducts, onto a surface, or into the blood.
   c) **Glands are classified as either endocrine or exocrine glands**
   d) **Endocrine Glands**: secrete substances that enter the interstitial fluid and then diffuse directly into the bloodstream without flowing through a duct.
      i) These secretions are called **hormones**
      ii) Hormones regulate many metabolic and physiological activities to help maintain homeostasis.
      iii) Examples of endocrine glands are: the pituitary, thyroid, and adrenal glands.
   e) **Exocrine Glands**: secrete their substances into ducts that empty onto the surface of a layer of covering and lining epithelium.
      i) Secretions are released onto the skin surface or into the lumen of a hollow organ.
      ii) Examples of exocrine secretions are: mucus, sweat, oil, cerumin (earwax), saliva, and digestive enzymes.
      iii) Sweat (sudoriferous) glands, salivary glands, and the digestive portion of the pancreas are examples of exocrine glands.
   iv) **Structural classification of exocrine glands**
      (1) Unicellular: single celled exocrine glands
         (a) i.e. mucus-secreting goblet cells
         (b) do not secrete into ducts, but directly onto the apical surface of the epithelium.
      (2) Multicellular: composed of many cells that form a distinctive microscopic structure or macroscopic organ.
         (a) i.e. sweat, oil, salivary glands.
      (3) **Multicellular glands are categorized by two criteria**:
         (a) Whether the ducts of the gland are branched or unbranched.
         (b) **Simple Gland**: the duct of the gland does not branch
         (c) **Compound Gland**: the duct of the gland branches
(d) **Tubular Glands:** glands whose secretory portions are tubular
(e) **Acinar Glands:** glands whose secretory portions are round.
(f) **Tubuloacinar glands:** glands that have both round and tubular secretory portions.

(4) **The Classification Scheme for Multicellular Exocrine Glands**

(a) **Simple Glands**
   (i) **Simple Tubular:** tubular secretory part is straight and attaches to a single, unbranched duct.
      1. i.e. glands of the large intestine
   (ii) **Simple Branched tubular:** tubular secretory part is branched and attaches to a single, unbranched duct.
      1. i.e. gastric glands of the stomach
   (iii) **Simple Coiled tubular:** tubular secretory part is coiled and attaches to a single, unbranched duct.
      1. i.e. sweat (sudoriferous) glands
   (iv) **Simple Acinar:** secretory portion is rounded and attaches to a single, unbranched duct
      1. i.e. glands of the penile urethra
   (v) **Simple branched Acinar:** rounded secretory portion is branched and attaches to a single, unbranched duct.
      1. i.e. sebaceous (oil) glands

(b) **Compound Glands**
   (i) **Compound Tubular:** secretory portion is tubular and attaches to a branched duct.
      1. i.e. bulbourethral glands
   (ii) **Compound Acinar:** secretory portion is rounded and attaches to a branched duct.
      1. i.e. mammary glands
   (iii) **Compound Tubuloacinar:** secretory portion is both tubular and rounded and attaches to a branched duct.
      1. i.e. acinar glands of the pancreas

(v) **Functional Classifications of Exocrine Glands**
(1) Based on how their secretion is released
(2) **Merocrine Glands:** the secretion is synthesized on ribosomes attached to rough ER, processed, sorted, & packaged by the Golgi complex, and released from the cell in secretory vesicles via exocytosis.
   (a) Most merocrine glands in the human body are merocrine glands.
(3) **Apocrine Glands:** accumulate their secretory product at the apical surface of the cell, then that portion of the cell pinches off the rest of the cell to release the secretion.
   (a) The remaining portion of the cell repairs itself and repeats the process.
   (b) It is likely that there are no apocrine glands in the human body.
(4) **Holocrine Glands:** accumulates the secretion in the cytosol and as the cell matures, it ruptures and becomes the secretory product itself.
   (a) The ruptured cell is replaced by a new one.
   (b) i.e. sebaceous (oil) glands

VI. **Membranes**
   a) Flat sheets of pliable tissue that cover or line a part of the body
   b) **Epithelial Membrane:** the combination of the epithelial layer and an underlying layer of connective tissue.
c) **Mucous Membranes (or mucosa):** Lines a body cavity that opens directly to the outside environment.
   i) Digestive system, respiratory system, urinary system, reproductive system
   ii) Microbes and pathogens (germs) cannot easily cross the epithelial layer of the mucosa (held together by tight junctions)
   iii) Goblet cells of the epithelial layer produce mucus, which prevents the cavities from drying out.
   iv) The CT layer of the mucosa is areolar CT and is called the **lamina propria**
      (1) Supports the epithelium, binds it to the underlying tissues and provides some flexibility to the mucosa.
      (2) Holds the blood vessels in place and protects the underlying muscles from abrasion or puncture.

d) **Serous Membranes (or serosa):** Lines a body cavity that does not open directly to the outside environment.
   i) Contains a layer of areolar CT covered by **mesothelium** (simple squamous)
   ii) The serosa has two layers:
      (1) **Parietal Layer:** the layer attached to the cavity wall
      (2) **Visceral Layer:** The layer that covers and attaches to the organs inside the cavity.
   iii) The mesothelium secretes a fluid called **serous fluid,** which lubricates the organs so they can glide easily over each other and the walls of the cavity,

e) **Synovial Membranes:** lines the cavities of freely moveable joints (do not open to the external environment).
   i) Lacks epithelium
   ii) Areolar CT, elastin fibers, and adipose compose synovial membranes.
   iii) Secrete **synovial fluid,** which lubricates and nourishes the cartilage covering the bones of moveable joints.

VII. **Muscle Tissue**
   a) Cells: muscle fibers made of proteins called **actin & myosin**
      i) Actin & myosin allow the muscle fibers to contract (shorten in length)
      ii) This allows muscles to move the bones they’re attached to, beat the heart, and squeeze substances through tubes (arteries, digestive tract)
   b) There are three classes of muscles tissue
   c) **Skeletal Muscles** (voluntary) are attached to bones by tendons and contract to allow bones to move at the joints by pulling on their attachment sites.
      i) Skeletal muscles are voluntary because they are under conscious control.
      ii) The muscles fibers of skeletal muscle have dark & light alternating bands making it looked striped or **striated.**
   d) **Smooth muscle** (involuntary visceral) lines the digestive tract, urinary system, blood vessels, and uterus.
      i) This muscle type is not striated and is not under voluntary control.
   e) **Cardiac muscle** (heart muscle) is found in the walls of the heart’s chambers.
      i) When cardiac muscle contracts, the walls of the heart chambers close down, squeezing the blood out toward the openings of the heart.
      ii) Striated but involuntary.

VIII. **Nervous Tissue**
   a. **Cells:** neurons and neuroglia
   b. **Neurons** can conduct electricity in the form of nerve impulses so different parts of our body can communicate with each other.
      i. Neurons are packed together to form nerves that travel to and from the brain & spinal cord to nearly every tissue in our bodies.
ii. Neurons consist of dendrites, bodies, and axons.
iii. Dendrites receive impulses from sensory receptors or other neurons
iv. Bodies have all of the typical organelles and cytoplasm
v. Axons transmit nerve impulses to other neurons or cells
c. Neuroglia: the non-neuron supporting cells of the nervous system.