Histology: The science concerned with the minute structure and organization of cells and tissues in relation to their function.

Definition of Tissue: Collection of similar cells that perform a common function and the surrounding intercellular substances (extracellular matrix).

Four Types of Tissue:
- Epithelial – covering/lining/gland forming
- Connective – supporting/binding
- Nervous – communication/control
- Muscle – movement

Definition of Organ: structure composed of at least 2 types of tissues that performs specific functions for the body.

Epithelial Tissue: a sheet of cells that covers a body surface, lines a body cavity, or forms a gland.

Functions of Epithelial Tissue:
- Protection – from mechanical/physical injury and infection; ex: skin
- Absorption – of nutrients, H2O, hormones, growth factors; ex: intestine
- Filtration – of blood/body fluids; ex: capillaries
- Excretion – of unwanted substances; ex: kidney tubule cells
- Secretion – of hormones, growth factors, lubricating substances; ex: stomach
- Sensory reception – some sensory receptors are modified epithelial cells; ex: gustatory (taste) cells

Distinguishing Characteristics of Epithelial Tissue:
- Cellular contribution: high; closely packed cells; relatively little extracellular matrix
- Specialized contacts: membrane junctions
  ~ Tight junctions
  ~ Gap junction
  ~ Desmosomes
- Polarity: highly polar; apical surface vs. basal surface
- Basement membrane: on basal surface; thin layer of extracellular material that supports the epithelial cells
- Vascularity: avascular; no blood vessels
- Regeneration: high capacity for regeneration

**Can be classified by their shape and their arrangement.

Classifications of Epithelia:
- Simple
- Stratified
- Squamous
- Cuboidal
- Columnar

Note that basal cells regenerate; as apical cells slough off, they are replaced by basal cells.
Major types of Epithelia:
Simple squamous, Stratified squamous, Simple cuboidal, Simple columnar, Pseudostratified Columnar, Transitional epithelium

2 Specialized subtypes of simple epithelial: 1. Endothelium (Lines blood vessels, inside of heart and inside of lymphatic vessels; made of endothelial cells.) 2. Mesothelium (lines the ventral body cavity and organs; part of peritoneum; Made of mesothelial cells)
(c) Simple columnar epithelium

**Description:** Single layer of tall cells with round to oval nuclei; some cells bear cilia; layer may contain mucus-secreting unicellular glands (goblet cells).

**Function:** Absorption; secretion of mucus, enzymes, and other substances; ciliated type propels mucus (or reproductive cells) by ciliary action.

**Location:** Nonciliated type lines most of the digestive tract (stomach to anal canal), gallbladder, and excretory ducts of some glands; ciliated variety lines small bronchi, uterine tubes, and some regions of the uterus.

**Photomicrograph:** Simple columnar epithelium of the stomach mucosa (1150x).

(d) Pseudostratified columnar epithelium

**Description:** Single layer of cells of differing heights, some not reaching the free surface; nuclei seen at different levels; may contain mucus-secreting goblet cells and bear cilia.

**Function:** Secretion, particularly of mucus; propulsion of mucus by ciliary action.

**Location:** Nonciliated type in male's sperm-carrying ducts and ducts of large glands; ciliated variety lines the trachea, most of the upper respiratory tract.

**Photomicrograph:** Pseudostratified ciliated

(e) Stratified squamous epithelium

**Description:** Thick membrane composed of several cell layers; basal cells are cuboidal or columnar and metabolically active; surface cells are flattened (squamous); in the keratinized type, the surface cells are full of keratin and dead; basal cells are active in mitosis and reproduce the cells of the more superficial layers.

**Function:** Protects underlying tissues in areas subjected to abrasion.

**Location:** Nonkeratinized type forms the moist linings of the esophagus, mouth, and vagina; urethra and anus; keratinized variety forms the epidermis of the skin, a dry membrane.

**Photomicrograph:** Stratified squamous epithelium lining the esophagus (430x).
Glandular epithelia - epithelia that forms a gland or part of a gland

Definition of gland: 1 or more cells that make and secrete a cellular product

Examples of secreted products: saliva, hormones, mucin

Most glands form by invagination of an epithelial sheet

Endocrine: secrete hormones/product → into surrounding extracellular space → taken up by blood, lymph and travel to target organs
--mostly ductless glands
--not all are epithelia-derived
--Exs: adrenal gland (located in the kidney/adrenaline is released); pituitary gland (located in the brain)
Exocrine- secrete product → onto epithelial surface or into body cavities
--mostly epithelia-derived
--most have a duct (except unicellular exocrine glands)
--more numerous than endocrine glands
--may be unicellular or multicellular

Exs: unicellular-goblet cells multicellular- salivary glands

Pancreas - Both an exocrine and an endocrine gland (some products are released directly and some are released through a duct)
Release of insulin and glucagon – endocrine
Release of digestive enzymes – exocrine (via a duct)

Connective Tissue: Four Subclasses
1. CT (connective tissue) proper
2. Cartilage
3. Bone
4. Blood

Major functions
--support and binding- bones to bones and bones to muscle
--protection- from shock, abrasion, infection
--insulation- heat retention
--transportation of substances- O2/CO2, nutrients

Distinguishing characteristics of CT
--Origin: all 4 types are derived from mesenchyme (embryonic tissue of the mesoderm)
--Vascularity: variable
--Cellular contribution: low cellular content compared to other tissue types; mostly ECM

Structural elements of CT
--ground substance- amorphous material that fills space between CT cells; contains fibers and holds fluid.
Composed of: interstitial fluids, adhesion proteins, and proteoglycans

->Proteoglycans = protein core + glycosaminoglycans (polysaccharides) ex: heparin
--fibers- elongated fibrous protein structures that provide support
--collagen- collagen protein monomers secreted by cells into ECM → assembled into tough, thick fibers in the ECM; very strong
- elastic: made of the protein elastin-coiled structure that stretches and recoils; found in skin, lungs, blood vessels
- reticular: fine protein fibers that form networks that support soft tissues and small vessels

"GROUND SUBSTANCE AND FIBERS COMprise THE ECM"

**Cells**

Immature-“blast”- actively mitotic cells that form the ECM and produce more “blast” CT cells which mature into “cytes”

Mature- “cyte” maintain health of the ECM; can produce proteins Ex.

**Types of Connective Tissue (all derived from mesenchyme)**

*Connective Tissue Proper*

--Loose- most widely distributed; absorbs H2O; usually vascular

--Aerolar- gel-like matrix with 3 fiber types; found under epithelial tissue and surrounding capillaries

Figure 4.8 -->

adipose-
stores nutrients, cushions, prevents heat loss; found in hypodermis, abdomen, breasts
Reticular—network of reticular fibers in the ECM; found in lymphatic tissues, bone marrow

Dense—durable; used for structure/binding; found in tendons, most ligaments, dermis, walls of large arteries

Cartilage - non-vascular, resilient, flexible CT

*hyaline cartilage*—most abundant cartilage type—“gristle” provides firm support matrix appears amorphous and glassy
exs: nose, trachea, larynx, ends of long bones

*elastic cartilage*—abundant in elastin fibers gives extra flexibility
exs: ears, epiglottis

*fibrous cartilage*—absorbs compressive shock well contains thick collagen fibers
exs: intervertebral discs, knee

Bone - osseous tissue;
matrix similar to cartilage except harder due to collagen fibers and Ca2+ salts; site of blood cell formation; vascularized

**Figure 4.8c**

**Figure 4.8g**

**Figure 4.8j**
Blood - blood cells surrounded by a fluid matrix; fibers are soluble proteins (fibrinogen) that aggregate and become visible upon clotting.

Covering and Lining Membranes
Definition - a continuous multicellular sheet composed of at least 2 primary tissue types: an epithelium bound to an underlying layer of CT proper.

Three major types
1. Cutaneous (skin)
   - comprised of keratinized stratified squamous epithelium (epidermis) firmly attached to a thick layer of dense CT (dermis)
   - is exposed to air and is a dry membrane
2. Mucous (mucosae)
   - Comprised of stratified squamous or simple columnar epithelium with underlying loose CT called Lamina propria
   - Wet membranes bathed by secretions (mucous or urine)
   - Found in open body cavities: digestive tract, respiratory tract, and urogenital tract
   - adapted for: absorption and secretion
3. Serous (serosae)
   - simple squamous epithelium with underlying loose CT
   - double-walled “sacs” containing fluid
   - wet membranes
   - Found in closed body cavities (thorax, abdominal cavities)
   - parietal surface - faces the outside surface of the organ
   - visceral surface - closest to the visceral organ (lines the cavity)
**3 types of serous membranes:
1. pleura - serosae lining the thoracic wall and covering the lungs
2. pericardium - serosa enclosing the heart
3. peritoneum - serosae of the abdominal cavity and visceral organs (contains mesothelium)
Nervous Tissue - makes up the nervous system (brain, spinal cord, nerves & sensory cells)

1. Neurons - highly specialized cells that generate and conduct electrical signals; usually contain processes (extensions of the cell)
   - Dendrites – carry electrical signals toward the cell body
   - Axons – carry electrical signals away from the cell body

2. Supporting cells (glia) - non-neuronal cells of the nervous system that insulate, protect, support and enhance the electrical activities of neurons

Muscle Tissue - highly cellular; well-vascularized; composed of elongated cells containing actin and myosin filaments; is responsible for most body movements
Cardiac muscle cells - shorter, uni-or binucleate cells with branching fibers that join at intercalated discs; found only in the heart; striated

**Cardiac muscle**

*Description:* Branching, striated, generally uninucleate cells that interdigitate at specialized junctions (intercalated discs).

*Function:* As it contracts, it propels blood into the circulation; involuntary control.

*Location:* The walls of the heart.

Smooth muscle cells - (called smooth muscle fibers); spindle-shaped; uninucleate cells with no striations

**Smooth muscle**

*Description:* Spindle-shaped cells with central nuclei; no striations; cells arranged closely to form sheets.

*Function:* Propels substances or objects (foodstuffs, urine, a baby) along internal passageways; involuntary control.

*Location:* Mostly in the walls of hollow organs.

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**Tissue Repair (3 steps) and Regenerative Capacity of Different Tissues**

*read pp. 138-141 (to “Development Aspects...”) – know which tissues have different regeneration capacity

**3 defenses exerted at the body's external boundaries**

1. intact mechanical barriers such as the skin and mucosae
2. the cilia of epithelial cells lining the respiratory tract
3. the strong acid (chemical barrier) produced by the stomach glands

**Inflammatory response** - nonspecific reaction that develops quickly wherever tissues are injured

**Immune response** - extremely specific, but takes longer to take action

**Regeneration** - replacement of destroyed tissue with the same kind of tissue

**Fibrosis** - proliferation of fibrous connective tissue (scar tissue - strong, but lacks the flexibility and elasticity of most normal tissues; cannot perform the normal functions of the tissue it has replaced)
Steps of tissue repair

Regenerative Capacity of Different Tissues

Excellent capacity for regeneration:
-- epithelial tissues
-- bone
-- areolar connective tissue
-- dense irregular connective tissue
-- blood forming tissue

Moderate capacity for regeneration:
-- smooth muscle
-- dense regular connective tissue

No functional regenerative capacity (replaced by scar tissue):
-- cardiac muscle
-- nervous tissue

Terms used to describe altered cells, tissues and organs

Hypertrophy - enlargement of a cell mass, tissue or organ due to an increase in the size of cells
Hyperplasia - enlargement of a cell mass, tissue or organ due to an increase in the number of cells
Atrophy - decrease in the size of a cell mass, tissue or organ due to a decrease in the size or number of cells
Metaplasia - altered differentiation of cells to a type different than in the original tissue; may lead to → dysplasia → cancer