

THE TISSUE LEVEL OF ORGANIZATION

Chapter 4

Anatomy and Physiology Lecture

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TISSUES AND HISTOLOGY

Tissues – Are collections of similar cells and the substances surrounding them.

Four Primary Types of Tissues:

1. Epithelial tissue
2. Connective tissue
3. Muscle tissue
4. Nervous tissue

Histology – Is the microscopic study of tissue.

Pathologist - Is a physician who specializes in laboratory studies of cells and tissues.

Biopsy - Is the process of removing tissue samples from patients surgically or with a needle for diagnostic purposes.

Autopsy – Is an examination of the organs of a dead body to determine the cause of death or to study the changes caused by a disease.

Types of Tissues and Their Origins

Body tissue can be classified into four principal types according to their function and structure.

1. **Epithelial tissue**, which covers body surfaces; lines hollow organs, body cavities, and ducts, and forms glands.
2. **Connective tissue**, which protects and supports the body and its organs, binds organs together; stores energy reserves as fat; and provides immunity.

3. **Muscle tissue**, which is responsible for movement and generation of force
4. **Nervous tissue**, which initiates and transmits action potential (nerve impulses) that help coordinate body activities.

*** (About 8 days after fertilization, the mass of cells that results from several cell divisions embeds in the lining of the uterus and begins to form Primary Germ Layers.)

EPITHELIAL TISSUE

Two subtypes of Epithelial Tissue (Epithelium)

- I. Covering and Lining Epithelium
- II. Glandular Epithelium

-Forms the outer covering of external body surfaces and the outer covering of some internal organs.

-Lines body cavities and the interior of the respiratory and gastrointestinal tracts, blood vessels, and ducts.

-Makes up, along with nervous tissue, the parts of the sense organs for smell, hearing, vision, and touch which respond to stimuli.

-Is the tissue from which gametes (sperm and eggs) develop.

General Features of Epithelial Tissue

(Note: Ten general features of epithelial tissue)

Covering and Lining Epithelium (By layers and by shape)

A. Arrangement of Layers**1. Simple Epithelium**

- If the cells of the tissue are arranged in a single layer.
- If the epithelium is specialized for absorption or filtration.
- If the epithelium is in an area that has minimal wear and tear.

2. Stratified Epithelium

- If the cells of the tissue are stacked in several layers.
- If the epithelium is found in an area with a high degree of wear and tear.

3. Pseudostratified Epithelium

- Has only one layer of cell, but appear to have several.
- Some of the cells do not reach the surface- an arrangement that gives the tissue a multi-layered, or stratified, appearance.

(The cells in Pseudostratified epithelium that do reach the surface either secrete mucus or contain cilia that move mucus and foreign particles for eventual elimination from the body.)

B. Cell Shapes**1. Squamous**

- Cells are flattened and scalelike
- Are attached to each other and form a mosaic pattern

2. Cuboidal

- Cells are usually cube-shaped in cross section
- Sometimes appear as hexagons

3. Columnar

- Cells are tall and cylindrical or somewhat rectangular
- Appearing as somewhat rectangular in shape when set on end

4. Transitional

- Cells often have a combination of shapes.
- Are found where there is a great degree of distention or expansion in the body.

(Transitional cells in the basal bottom layer of an epithelial tissue may range in shape from cuboidal to columnar.)

(In the intermediate layer, they may be cuboidal or polyhedral - having many sides.)

(In the superficial layer, they may range from cuboidal to squamous, depending on how much they are pulled out of shape during certain body functions.)

D. Classification

Considering layers and cell shapes in combination, covering and lining epithelium may be classified as follows:

a. Simple

1. Squamous
2. Cuboidal
3. Columnar

b. Stratified

1. Squamous
2. Cuboidal
3. Columnar
4. Transitional

c. Pseudostratified Columnar

A. **SIMPLE EPITHELIUM**

1. **Simple Squamous Epithelium**

Description: Single layer of flat, scalelike cells.

- Its surface resembles a tiled floor.
- Centrally located nuclei.

Location: Lines air sacs of lungs, glomerular (Bowman's) capsule of kidneys, and inner surface of the membranes labyrinth and tympanic membranes of ear.

- Called Endothelium when it lines heart, blood and lymphatic vessels, and forms capillaries.
- Called Mesothelium when it lines the ventral body cavity and covers viscera as part of a serous membrane.

Function: filtration, absorption, exchange, and secretion in serous membranes, osmosis and diffusion.

2. **Simple Cuboidal Epithelium**

Description: Single layer of cube-shaped cells.

- Centrally located nuclei.

Location: Covers surface of ovary, lines anterior surface of capsule of the lens of eyes, forms pigmented epithelium of retina of eye, and lines kidney tubules and smaller ducts of many glands.

Function: Secretion and absorption.

3a. **Simple Columnar Epithelium (nonciliated)**

Description: Single layer of nonciliated rectangular cells.

- Contains goblet cells in some locations.
- Nuclei at bases of cells.

Location: Lines the gastrointestinal tract from the cardia of the stomach to the anus, excretory ducts of many glands and gallbladder.

Function: Secretion and absorption.

3b. **Simple Columnar Epithelium (Ciliated)**

Description: Single layer of ciliated columnar cells.

- Contains goblet cells in some locations.

- Nuclei at base of cells.

Location: Lines a few portions of upper respiratory tract, uterine (fallopian) tubes, uterus, some paranasal sinuses, and central canal of spinal cord.

Function: Moves mucus by ciliary action.

B. **STRATIFIED EPITHELIUM**

1. **Stratified Squamous Epithelium**

Exists in two forms: 1) **Keratinized stratified squamous epithelium**, and 2) **non-keratinized stratified squamous epithelium**.

Description: Several layers of cells;

- Cuboidal to columnar shape in deep layers.

- Squamous cells in superficial layers

- Basal cells replace surface cells as they are lost

Location: Nonkeratinized variety lines wet surfaces such as lining of the mouth, tongue, esophagus, part of epiglottis and vagina.

- Keratinized variety form outer layer of skin; tough layers.

Function: Protection.

Keratin is a protein that is waterproof and resistant to friction and helps repel bacteria. A fibrous protein of high sulfur content present in epidermal structure as horn, nails, claws, and feathers.

Non-keratinized - found on areas subject to wear and tear.

2. Stratified Cuboidal Epithelium

Description: - Two or more layers of cells in which the surface cells are cube-shaped.

Location: Ducts of adult sweat glands, fornix of conjunctiva of eye, cavernous urethra of male urogenital system, pharynx and epiglottis.

Function: Protection against infection, absorption, and secretion

3. Stratified Columnar Epithelium

Description: Several layers of polyhedral (having many sides or surfaces) cells.

-Columnar cells only in superficial layer.

Location: - Lines part of male urethra, large excretory ducts of some glands, and small areas in anal mucus membrane.

Function: Protection and secretion.

4. Transitional Epithelium

Description: Resembles Nonkeratinized stratified squamous tissue, except that superficial cells are larger and have a rounded free surface.

Location: Lines urinary bladder and portions of ureters and urethra. (stretching)

Function: Permits distention (inflation or expansion) - stretching.

C. Pseudostratified Columnar

Description: not a true stratified tissue;

-Nuclei of cells at different levels;

-All cells attached at basement membrane, but not all reach surface.

-(Has only one layer but gives the appearance of many)

Location: lines large excretory ducts of many large glands, epididymis, male urethra, and auditory (Eustachian) tubes;

-Ciliated variety with goblet cells lines most of the upper respiratory tract and some ducts of male reproductive system.

Function: Secretion and movement of mucus and sperm cells by ciliary action.

II. **Glandular Epithelium**

A Gland may consist of one cell or a group of highly specialized epithelial cells that secrete substances into ducts, onto a surface, or into the blood. Two types of glands:

1. **Exocrine Gland**

Description: Secretes products into ducts.

Location: Sweat, oil, wax, and mammary glands of the skin;
-Digestive glands such as salivary glands that secrete into mouth cavity and pancreas that secrete into the small intestine.

Function: Produces mucus, perspiration, oil, wax, milk, or digestive enzymes.

2. **Endocrine Gland**

Description: Secretes hormones into blood.

Location: Pituitary at base of brain;
-Thyroid and parathyroid near larynx;
-Adrenals (suprarenal) above kidneys,
-Ovaries in pelvic cavity,
-Testes in scrotum
-Pineal at base of brain, and
-Thymus in the thoracic cavity

Function: Produces hormones that regulate various body activities.

Functional Characteristics of Epithelial Tissues

(Most epithelial cells, some muscle cells, and some nerve cells are tightly joined to form a close functional unit.)

Cell Junctions - the points of contact between adjacent plasma membranes.

Three Types of Cell Junctions Serve Distinct Functions:

1. **Tight Junctions** form fluid -tight seals between cells like the seal on a ziploc sandwich bag. [Common among epithelial cells that line the stomach, intestine, urinary bladder.]
2. **Anchoring Junctions** fasten cells to one another or to the extracellular material. [Common in tissues subjected to friction and stretching - skin, heart, uterus.]
3. **Communicating Junctions** permit electrical or chemical signals to pass from cell to cell.

Gap Junction are microscopic structure that functions as communicating junction.

Connexon are proteins spanning the gap that form minute fluid- filled tunnels.

Anchoring Junctions include:

- a. **Adherent Junction** connect to microfilaments of the cytoskeleton and links cells to another or anchor cells to extracellular materials.
- b. **Desmosomes** form firm attachments between cells somewhat like spot welds.
- c. **Hemidesmosomes** look like half a desmosome; they anchor the basal (bottom) epithelial cell plasma membrane to extracellular materials at the junction between epithelial and connective tissues.

CONNECTIVE TISSUE

Connective Tissue is the most abundant and most widely distributed tissue in the body.

General functions:

1. Binds together, supports, and strengthens other body tissues.
2. Protects and insulates internal organs.
3. Compartmentalizes structures such as skeletal muscles.

*****Blood** is a fluid connective tissue, a major transport system within the body.

*****Adipose (fat) Tissue** also a connective tissue, is the major site of stored energy reserves.

General Features of Connective Tissue:

1. Consists of three basic elements:
 - (a) Cell
 - (b) Ground substance
 - (c) Fibers

Matrix is the combination of ground substance and fiber. Separates connective tissue cells as they rarely touch one another.

2. Do not occur on free surfaces such as the surface of a body cavity or the external surface of the body, in contrast to epithelial.

(However, joint cavities are lined by a type of connective tissue called areolar connective tissue).

3. Like epithelium, has a nerve supply, except for cartilage.
4. Is usually highly vascular (has a rich blood supply), unlike epithelium.

5. Its matrix which may be fluid, semifluid, gelatinous, fibrous, or calcified, is usually secreted by the connective tissue cells and adjacent cells and determines the tissue's qualities.

Connective Tissue Cells:

The cells are derived from mesodermal embryonic cells called mesenchymal cells.

Each major type of connective tissue contains an immature class of cell whose name ends in **-blast**.

This cell retains its capacity for division and secretes the **matrix** (ground substance and fibers) that is characteristic of the tissue.

Classification of Connective Tissues

- I. Embryonic Connective Tissue
 - A. Mesenchyme
 - B. Mucous Connective Tissue

- II. Mature Connective Tissue
 - A. Loose Connective Tissue
 1. Areolar connective tissue
 2. Adipose tissue
 3. Reticular connective tissue

 - B. Dense Connective Tissue
 1. Dense regular connective tissue
 2. Dense irregular connective tissue
 3. Elastic connective tissue

 - C. Cartilage
 1. Hyaline cartilage
 2. Fibrocartilage
 3. Elastic cartilage

D. Bone (Osseous) Tissue

E. Blood (vascular) Tissue

I. Embryonic Connective Tissue

Primarily in the Embryo or Fetus.

A. Mesenchyme

Description: Consists of highly branched mesenchymal cells embedded in a fluid substance.

Location: Under skin and along developing bones of embryo;
-Some mesenchymal cells found in adult connective tissue, especially along blood vessels.

Function: Form all other kinds of connective tissue.

B. Mucous Connective Tissue

Description: Consists of flattened or spindle-shaped cells embedded in a mucus like substance containing fine collagenous fibers.

Location: Umbilical cord of fetus.

Function: Support.

II. Mature Connective Tissue

Mature Connective Tissue is connective tissue that differentiates from mesenchyme and exists in the newborn and does not change after birth.

-It is subdivided into several kinds: Connective tissue proper, cartilage, bone tissue, and vascular tissue.

A. Connective Tissue Proper

-Has a more or less fluid intercellular material, and a typical cell is the fibroblast.

-Five examples exist:

1. Loose (areolar) Connective Tissue

Description: Consists of fibers (Collagenous, elastic, and reticular) and several kinds of cells (fibroblasts, macrophages, plasma cells, adipocytes, and mast cells) embedded in a semifluid ground substance.

Location: Subcutaneous layer of skin, mucous membranes, blood vessels, nerves, and body organs.

Functions: Strength, elasticity, and support.

2. Adipose Tissue

Description: Consists of adipocytes, "signet ring-shaped" cells with peripheral nuclei, that are specialized for fat storage.

Location: Subcutaneous layer of skin, around heart and kidneys, marrow of long bones, and padding around joints.

Function: Reduces heat loss through skin;

-Serves as an energy reserve

-Supports, and protects

3. Dense (Collagenous) Connective Tissue

Description: Consists of predominantly collagenous fibers arranged in bundles;

Location: Forms tendons, ligaments, aponeuroses, a flat sheetlike tendon, attaches muscles to bone, membranes around various organs, and fasciae.

Function: Provides strong attachment between various structures.

Dense Regular Connective Tissue

-Bundles of collagen fibers have an orderly, parallel arrangement

-Withstands pulling in one direction

-Appear in rows between the fibers

Dense Irregular Connective Tissue

-Bundles of collagen fibers inter-woven without regular orientation.

- Found in parts of the body where tensions are exerted in various directions.
- Heart valves and the perichondrium, a membrane around cartilage are examples.

4. Elastic Connective Tissue

Description: Consists of predominantly freely branching elastic fibers;

- Fibroblasts present in spaces between fibers.

Location: Lung tissue, wall of arteries, trachea, bronchial tubes, true vocal cords, and ligaments flava of vertebrae.

Function: Allow stretching of various organs.

5. Reticular Connective Tissue

Description: Consists of a network of interlacing reticular fibers with thin, flat cells wrapped around fibers.

Location: Liver, spleen, lymph nodes, and basal lamina underlying epithelia.

Function: Forms stroma of organs;

- Binds together smooth muscle tissue cells.

B. Cartilage

-Capable of enduring considerably more stress than tissues.

-Unlike other connective tissues, cartilage has no blood vessels or nerves, except for those in the perichondrium (membranes covering).

Three kinds of cartilage are recognized.

1. Hyaline Cartilage

Description: Also called Gristle;

-Appears as a bluish white, glossy mass;

-Contains numerous chondrocytes (cells of mature cartilage)

-Is the most abundant type of cartilage

Location: Ends of long bones, ends of ribs, parts of larynx, trachea, bronchi, bronchial tubes, and embryonic skeleton.

Function: Provides movement at joints, flexibility, and support.

2. Fibrocartilage

Description: Consists of chondrocytes scattered among bundles of collagenous fibers.

Location: Symphysis pubis, intervertebral discs, and menisci of knee.

Function: Support and fusion.

3. Elastic Cartilage

Description: Consists of chondrocytes located in a threadlike network of elastic fibers.

Location: Epiglottis of larynx, external ear, and auditory (Eustachian) tubes.

Function: Gives support and maintains shape.

Growth of Cartilage

The growth of cartilage follows two basic patterns:

- a. Interstitial (endogenous) growth - The cartilage increases rapidly in size through the division of existing chondrocytes and continuous deposition of increasing amounts of intercellular matrix by the chondrocytes.

-The formation of new chondrocytes and their production of new intercellular matrix causes the cartilage to expand from within - thus, the term interstitial growth.

-This growth pattern occurs while the cartilage is young and pliable- during childhood and adolescence.

- b. Appositional (exogenous) Growth - The growth of cartilage occurs

because of the activity of the inner chondrogenic layer of the perichondrium.

-The matrix is deposited on the surface of the cartilage, increasing its size.

*Appositional growth starts later than interstitial growth and continues throughout life.

c. Osseous Tissue (Bone)

Cartilage, joints, and Osseous Tissue (bone) comprise the skeletal system.

Osteocytes are mature bone cells.

Function : Support soft tissues;

-Protects delicate structures;

-Works with skeletal muscles to facilitate movement;

-Stores calcium and phosphorus;

-Houses red marrow, which produces several kinds of blood cells, and

-Houses yellow marrow, which contains lipids as an energy source.

d. Vascular Tissue (Blood)

Vascular tissue (blood) is a liquid connective tissue that consists of an intercellular substance called plasma and formed elements (cells and cell-like structures).

1. Plasma is a straw-colored liquid that consists mostly of water plus some dissolved substances (nutrients, enzymes, hormones, respiratory gases, and ions).

2. Formed elements are erythrocytes (red blood cells), leucocytes (white blood cells), and thrombocytes (platelets)

Erythrocytes (red blood cells) function in transporting oxygen to body cells and removing carbon dioxide from them.

Leucocytes (white blood cells) are involved in phagocytosis, immunity, and allergic reactions.

Thrombocytes (platelets) function in blood clotting.

MEMBRANES

Epithelial Membrane is the combination of an epithelial layer and an underlying connective tissue layer.

Example: Mucous membranes;
Serous membranes;
Cutaneous membranes, or skin, and
Synovial membrane - does not contain epithelium.

1. Mucous Membrane, or Mucosa - lines a body cavity that opens directly to the exterior.

- Lines the entire gastrointestinal, respiratory, excretory, and reproductive tracts.

- Secretes mucus, which prevents the cavities from drying out.

2. Serous Membranes, or Serosa - Lines a body cavity that does not open directly to the exterior, and it covers the organs that lie within the cavity.

a. Parietal Portion - part of serous membrane attached to the cavity wall.

b. Visceral Portion - part that covers and attaches to the organs inside these cavities.

Pleura - the serous membrane lining the thoracic cavity and covering the lungs.

Pericardium - the membrane lining the heart cavity and covering the heart.

Peritoneum - the serous membrane lining the abdominal cavity and covering the abdominal organs and some pelvic organs.

Serous Fluid - fluid secreted by serous membrane, that allows the organs to glide easily against one another or against the walls of the cavities.

3. Cutaneous membrane, or skin - constitutes an organ of the integumentary system.

4. Synovial Membranes - lines the cavities of the freely movable joints.

- Like serous membranes, they line structures that do not open to the exterior.

- Unlike mucous serous, and cutaneous membranes, they do not contain epithelium and are therefore not epithelial membranes.

Synovial Fluid - fluid secreted by synovial, which lubricates the articular cartilage at the ends of bones as they move at joints and nourished the articular cartilage covering the bones that form the joints.

MUSCLE TISSUE

Muscle Tissue is modified for contraction and thus provides motion, maintenance of posture, and heat production. Consists of fibers (cells) that are highly specialized.

1. Skeletal Muscle Tissue - is attached to bones.

-Are Striated; that is, the fibers (cells) contain alternating light and dark bands (striations) that are perpendicular to the long axes of the

bones.

-Are voluntary that is, it can be made to contract or relax by conscious control.

Description: Cylindrical, striated fibers with several peripheral nuclei;

-Are voluntary

Location: Usually attached to bones.

Function: Motion, posture, heat production.

2. Cardiac Muscle Tissue

Description: Quadrangular, branching, striated fibers with one centrally located nucleus;

-Contains intercolated discs;

-Usually involuntary

Location: Heart wall

Function: Motion (contraction of heart).

3. Smooth Muscle Tissue

Description: Spindle-shaped, nonstriated fibers with one centrally located nucleus;

-Usually involuntary.

Location: Walls of hollow internal structures such as blood vessels, stomach, intestines, and urinary bladder.

Function: Motion (constriction of blood vessels, propulsion of foods through gastrointestinal tract; contraction of gallbladder).

NERVOUS TISSUE

Two principal kinds:

a. Neurons, or nerve cells

b. Neuroglia are cells that protect and support neurons.

Description: Neurons (nerve cells) consist of a cell body and processes extending from the cell body called dendrites (usually conduct impulses toward cell body or axons (usually conduct

impulses away from cell body).

Location: Nervous system.

Function: Exhibits sensitivity to various types of stimuli, converts stimuli to nerve impulses, and conducts nerve impulses to other neurons, muscle fibers, or glands.

TISSUE REPAIR: AN ATTEMPT TO RESTORE HOMEOSTASIS

Tissue Repair is the replacement of damaged or destroyed cells by healthy ones.

-It begins during the active phase of inflammation and is not completed until after harmful substances in the inflamed area have been neutralized or removed.

Repair Process

1. If the injury is superficial (slight), tissue repair involves pus removal (if pus is present), scab formation, and parenchymal regeneration.
2. If damage is extensive, granulation tissue is involved. (ie, involves rapid cell division)

Conditions Affecting Repair

1. Nutrition is important to tissue repair:
 - a. Vitamin A is essential in the replacement of epithelial tissues, especially in the respiratory tract.
 - b. Vitamins B (thiamine, nicotinic acid, riboflavin) are coenzymes needed by many enzymes systems in cells.
-Are needed for enzymes involved in decomposing glucose to CO₂ and H₂O, which is crucial to both heart and nervous tissue.
 - c. Vitamin C directly affects the normal production and maintenance of intercellular substances.
-It is required for the manufacture of cementing elements of

connective tissue, especially collagen.

-Strengthens and promotes the formation of new blood vessels.

-With Vitamin C deficiency, even superficial wounds fail to heal, and the walls of the blood vessels become fragile and are easily ruptured.

d. Vitamin D is necessary for the proper absorption of Calcium from the intestine. Calcium gives bones their hardness and is necessary for the healing of fractures.

e. Vitamin E is believed to promote healing of injured tissues and may prevent scarring.

f. Vitamin K assists in the clotting of blood and thus prevents the injured person from bleeding to death.

2. Adequate circulation of blood is needed.
3. The tissue of young people repair rapidly and efficiently; the process slows down with aging.