

Tissues
Chapter 4

A TISSUE is a group of cells and cell products that are specialized to perform a common or related function. Tissues are not all made of the same cell type, but there is usually one main type and all of them are similar. The cells are differentiated... meaning they take on a specific role.

CELL DIFFERENTIATION is the process by which cells become progressively more specialized. It is a normal process through which cells mature.

There are over 200 unique tissues in the body, and **FOUR PRIMARY TISSUE TYPES:**

1. Epithelium
2. Connective Tissue
3. Nervous Tissue
4. Muscle Tissue

most varied

Epithelial Tissue Types

Epithelial tissues are COVERINGS. They cover surfaces exposed to external environments (skin and mucous tracts – digestive, respiratory, urinary and reproductive)

Epithelial tissues are the LININGS OF INTERNAL surfaces. They line the ventral body cavity, pleural cavity, blood vessels, eyeball, inner ear and brain vesicles.

Epithelial tissues are GLANDS!

Epithelial Tissue Has 6 Major Functions

1. Protection (mechanical abrasion, chemicals, UV, desiccation)
2. Absorption (lungs, digestive tract)
3. Filtration (kidneys)
4. Secretion (salivary enzymes, mucus, pancreas)
5. Excretion (sweat)
6. Sensory Reception

Characteristics of Epithelial Cells

- Highly cellular--cells live side by side with little extracellular material. Think of a housing project in the city.
- They have polarity--Epithelial cells have differences in their polarity between one side and the other. One side faces the outside world/internal environment and is the APICAL SURFACE. The side facing the underlying surface is the BASAL SURFACE. The sides facing adjacent cells are the LATERAL SURFACES.

- They have many **SPECIALIZED CELL JUNCTIONS**—lots of tight junctions and desmosomes.
- They have a **BASEMENT MEMBRANE** composed of two layers called **LAMINA**. The **BASAL LAMINA** is next to the epithelia and is secreted by epithelial cells. The **RETICULAR LAMINA** is secreted by the underlying connective tissue.
- They are **INNERVATED** (they have nerves!)
- They are **AVASCULAR** (they do not have blood vessels!)...except for endocrine glands, which are richly vascular.
- They are highly **REGENERATIVE**

Classification of Epithelial Tissue

Epithelial tissues are classified by the number of cell layer and the shape of the cell.

1. Number of cell layers
 - a. ONE cell layer = simple epithelia. Very delicate-used for absorption & secretion.
 - b. TWO or more cell layers = stratified epithelia. It is thicker/more protective.
2. Shape of the cell
 - a. Squamous are flat cells with a fried egg shape. It has a flat cytoplasm with bulging nuclear region.
 - b. Cuboidal are about as tall as they are wide.
 - c. Columnar are tall & thin

Specific Types of Epithelium

A. Simple epithelia

- a. **SIMPLE SQUAMOUS EPITHELIA** line protected areas of the body such as the ventral body cavity. SSE secretes a water serous fluid that allows frictionless movement between organs such as the heart and lungs. They also allow for diffusion and filtration, such as in the kidneys.
- b. **SIMPLE CUBOIDAL EPITHELIA** line most ducts and are used for secretion and absorption.
- c. **SIMPLE COLUMNAR EPITHELIA** line ducts and mucous tracts. They are used for secretion and absorption. This type is heartier than cuboidal. Some are ciliated to move mucus over the surface.
- d. **PSEUDOSTRATIFIED COLUMNAR EPITHELIA** line part of the respiratory tract and male reproductive tract. It appears to have multiple layers because the nuclei are at different heights above the basal membrane. All cells, however, do rest on the basal membrane. This type of cell

LOCATIONS
SIMPLE SQUAMOUS
heart lining
blood vessels
renal glomeruli

LOCATIONS
SIMPLE CUBOIDAL
kidney tubules
glands

LOCATIONS
SIMPLE COLUMNAR
digestive tract

LOCATIONS
PSEUDOSTRATIFIED
COLUMNAR
respiratory tract
male reproductive tract

secretes and absorbs, and the ciliated variety secrete and propel mucus.

B. Stratified Epithelia

- a. **STRATIFIED SQUAMOUS EPITHELIUM** covers external surfaces (the skin). It is made up of multiple layers which protect against mechanical abrasion. The basal cells are mitotically active...this means maturing cells are pushed toward the surface and they flatten out.
- b. **STRATIFIED CUBOIDAL EPITHELIUM** consists of two layers of cells. This type is very rare and is usually transitional...existing between two epithelia. It lines some ducts of major glands such as sweat glands and mammary glands.
- c. **STRATIFIED COLUMNAR EPITHELIUM** consists of two layers of columnar cells, with the deeper layer having a cuboidal shape. The mature surface layer is columnar. This is a very rare tissue!
- d. **TRANSITIONAL EPITHELIUM** consists of multiple layers of cuboidal to columnar cells, with no distinct layering. It is found on surface areas that need to stretch. At its relaxed state, the cells are cuboidal. As the tissue stretches, they flatten out into squamous cells.

LOCATIONS
STRATIFIED SQUAMOUS
skin
oral lining
vaginal lining

LOCATIONS
STRATIFIED CUBOIDAL
sweat glands
mammary glands

LOCATIONS
STRATIFIED COLUMNAR
glandular ducts
part of pharynx
part of urethra

LOCATIONS
TRANSITIONAL
most of urinary tract

Glands

All glands are outgrowths of epithelium. A gland is one or more cells specialized to **SECRETE** a particular product (the secretion).

Glands are classified by the type of secretion (where it's released to), their cellularity (how many cells compose the gland), their structure (branching of the duct and shape of the secretory unit) and their mode of secretion (how product released from cell).

A. Type of secretion

- a. **EXOCRINE** gland has a product secreted from the **APICAL** surface onto an **EXTERNAL** surface or into an **INTERNAL** cavity.
- b. **ENDOCRINE** gland secretes **HORMONE** into extracellular space surrounding the gland. Endocrine glands are highly vascular!

B. Cellularity

- a. **UNICELLULAR** are individual cells scattered among other epithelial cells. These are **GOBLET CELLS**. Goblet cells secrete mucus onto the surface.
- b. All others are **MULTICELLULAR**

C. Structure of the Gland

- a. Ducts can be SIMPLE—one single duct
- b. Ducts can be COMPOUND—a branched duct
- c. The secretory unit can be one of three varieties
 - i. Tubular – long, tubelike pouches
 - ii. Alveolar/Acinar – rounded, sac-like region
 - iii. Tubuloalveolar – both types are present

D. Mode of secretion.

- a. MEROCRINE Method (most common). The cell secretes by exocytosis...example is the pancreas, sweat glands and salivary glands
- b. HOLOCRINE Method. The whole cell fills with vesicles containing the material. Once full, it ruptures and releases its product...example is sebaceous glands
- c. APOCRINE Method. Apical portion of the cell fills with vesicles. The apical portion pinches off and ruptures. This occurs in animals, and it's not clear if it occurs in humans.

Connective Tissue

Connective Tissues (CT) are located everywhere in the body. CT is the MOST ABUNDANT and widespread tissue.

Characteristics of CT

- Low cellularity
- Lots of space between cells (think Little House on the Prairie)
- Abundant non-living EXTRACELLULAR MATERIAL
- Very diverse types of CT that all derive from a common origin (the stem cell that differentiates...the MESENCHYME)
- High variable vascularity (some have none, some have a lot)
- No polarity of cells (b/c they're not on the surface they have no defining orientation)

CT is made up of CELLS and MATRIX, which is the extracellular/non-living material. The matrix consists of fibers suspended in ground substance.

Types of Cells

BLAST CELLS are the:

- Fibroblasts (makes fibers)
- Chondroblasts (makes cartilage)
- Osteoblasts (makes bone)
- Hemopoietic cells (makes blood)

WHITE BLOOD CELLS (WBC) include:

- Macrophages (eaters)
- Mast cells (signaling cell, produces histamine)
- Plasma cells (a lymphocyte)
- Eosinophils (release histamine)
- Neutrophils (gobble up cells)

ADIPOCYTES are the fat cells. They are not in bone or cartilage

MESENCHYMAL CELLS are the stem cells of all connective tissue. Mesenchymal tissue is the precursor to all adult connective tissue. It is found in embryos and umbilical cord (Wharton's Jelly)

The Matrix

The Matrix consists of fibers suspended in ground substance. The fibers are long strands of protein molecules.

There are three major types of FIBERS in CT.

1. COLLAGEN (most prominent)
 - a. Dense bundles of collagen protein (think of a thick rope)
 - b. High tensile strength

2. RETICULAR fibers
 - a. Made of same protein as collagen
 - b. Thin collagen fibers arranged in networks
 - c. This creates a 3D framework in solid organs (liver, spleen, lymph nodes)
3. ELASTIC fibers
 - a. Composed of the protein elastin
 - b. Allows CT to recoil to original size
 - c. Abundant in tissues that undergo stretching (heart, skin)

The GROUND SUBSTANCE is composed of:

- Interstitial fluid (similar to blood serum)
- Cell adhesion proteins (intercellular glue that attaches the cell to matrix components)
- Proteoglycans (large protein-polysaccharide aggregates that trap water and alter the **viscosity** of the matrix).

More proteoglycans
= Higher viscosity of ground substance

Types of Connective Tissue

1. **CT Proper** supports and wraps. The two types of CT PROPER are LOOSE CT and DENSE CT.
2. **Supportive CT** is more dense and strong. CARTILAGE and BONE fall into this category
3. **Fluid CT** makes up blood, which is mainly the fluid connective tissue. Lymph can also be considered fluid connective tissue.

Blast Cell of CTP
FIBROBLAST

Blast Cell of SCT
CHONDROBLAST
OSTEOBLAST

Blast Cell of FCT
HEMOPOIETIC CELL

Connective Tissue Proper (Loose CT and Dense CT)

AREOLAR CONNECTIVE TISSUE (a LOOSE CT) is the most generalized of all the CTs. It is found throughout the body and is sort of cobweb-ish in appearance. It underlies most epithelia and has a lot of ground substance (space between cells). Other characteristics and functions include:

AREOLAR LOCATIONS
under most epithelia
throughout the body

- fills space
- binds tissues and organs together
- holds fluids, immune cells and adipose

ADIPOSE (a LOOSE CT) is similar to areolar connective tissue (how?). It is made up of abundant adipocytes that pack the tissue, with little extracellular space. The cells contain lipid droplets that take up most of the cell, with the nuclei pushed off to the side.

ADIPOSE LOCATIONS
subcutaneous tissue
around heart and kidneys
behind eyeballs

Adipose connective tissue is richly vascularized, which makes the energy in the fat available via the blood.

RETICULAR TISSUE (a LOOSE CT) is also similar to areolar. It contains ONLY reticular fibers...no collagen at all. It forms the STROMA of solid organs (the liver, spleen). Stroma refers to the internal framework of the organ.

RETICULAR LOCATIONS
liver
spleen
lymph nodes
bone marrow

DENSE REGULAR TISSUE (a DENSE CT) is made up of densely packed collagen fibers. The fibers align in the same direction, which resists linear stress. DRT has high tensile strength! It is an elastic CT, because it contains more elastin, which is stretchy. Characteristics of

DENSE REG LOCATIONS
tendons (ropes)
ligaments
aponeuroses (sheets)

the tissue include nuclei that are dense, dark and flattened. It is pretty avascular.

DENSE IR LOCATIONS
joint capsules
organ coverings
deep dermis

DENSE IRREGULAR TISSUE (a DENSE CT) is made up of thicker bundles of collagen. The bundles are arranged in multiple directions,

so this CT is found in areas where tension is applied in multiple directions. It is vascular.

Supportive Connective Tissue (Cartilage and Bone)

CARTILAGE is avascular, which is why it doesn't heal well. It is also not innervated. Cartilage has no blood and no nerves! There are THREE TYPES OF CARTILAGE:

1. Hyaline
2. Elastic
3. Fibrocartilage

HYALINE CARTILAGE is the most common type in the body. It is firm, but slightly pliable, so it can be broken. Under the microscope, hyaline looks like big bubble-like cells that tend to cluster together.

HYALINE LOCATIONS
ends of long bones
nasal bridge
sternal ends of ribs

ELASTIC CARTILAGE is similar to hyaline, but has abundant elastic fibers. So, under the microscope EC is going to look a lot like hyaline, but with the presence of dark granular fibers. It has great resiliency!

ELASTIC LOCATIONS
ear pinna
epiglottis

FIBROARTILAGE is the toughest type of cartilage. It is structurally in between hyaline (with its rows of chondrocytes) and dense regular CT (with its dense collagen fibers). It has high tensile strength and compressibility. Fibrocartilage often has a bluish stain, and to me looks a lot like dense regular CT...one notable difference is that the nuclei in fibrocartilage aren't squished like they are in DRCT.

FIBROARTILAGE LOCATIONS
intervertebral discs
pubic symphysis
knee minisci

BONE, the other type of supportive connective tissue) has a matrix embedded with mineral salts. It has more collagen than cartilage. Its dense, hard material is designed to resist compression. Bone is innervated and highly vascular.

Fluid Connective Tissue

BLOOD is the main fluid connective tissue, though some argue that lymph is also a FCT.

There are three types of blood cells:

1. erythrocytes (red blood cells)
2. leukocytes (white blood cells)
3. platelets

The MATRIX OF BLOOD is the PLASMA. Within the plasma are dissolved fibers used in clotting, and ground substance (serum). Ground substance is an aqueous solution with many dissolved substances.

Other Tissues (Membranes, Nervous Tissue & Muscle Tissue)

MEMBRANES are specialized multicellular sheets that are combinations of epithelium and connective tissue...so a combination of two types of tissue. There are three true membranes:

CUTANEOUS MEMBRANE

LOCATION	EPITHELIAL COMPONENT	CONNECTIVE TISSUE COMPONENT	CHARACTERISTICS
the skin	stratified squamous (keratinized)	areolar CT (superficial) Dense irregular CT (deep)	dry on surface

MUCOUS MEMBRANE

LOCATION	EPITHELIAL COMPONENT	CONNECTIVE TISSUE COMPONENT	CHARACTERISTICS
lining of tracts open to the exterior digestive respiratory urinary reproductive	stratified squamous (non-keratinized) OR Simple columnar	areolar CT (lamina propria)	Moist some secrete mucus

SEROUS MEMBRANE

LOCATION	EPITHELIAL COMPONENT	CONNECTIVE TISSUE COMPONENT	CHARACTERISTICS
Internal cavities that DO NOT open to outside world pleural cavity peritoneal cavity (examples)	simple squamous	areolar CT (superficial)	Secrete watery lubricating fluid called serous fluid (no friction btwn organs)

SYNOVIAL MEMBRANE (an additional one)

LOCATION	EPITHELIAL COMPONENT	CONNECTIVE TISSUE COMPONENT	CHARACTERISTICS
lining of joint cavities	Not a true epithelium. Rather, it's an incomplete layer of fibroblasts and macrophages	areolar CT	moist secrete watery synovial fluid

NERVOUS TISSUE is made up of two types of cells:

1. Neuron (can be really big). Neurons generate and transmit electrical signals. Most neurons have numerous cellular extensions (axons, etc...)
2. Glial cells (AKA "neuroglia" or "glia"). These are non-conducting support cells that insulate and protect neurons.

MUSCLE TISSUE is highly cellular and highly vascularized. The cells contain dense bundles of contractile proteins. There are three types of muscle tissue:

1. SKELETAL MUSCLE is characterized by long cells that are cylindrical (tapered at the ends). These long cells are multinucleate and the tissue itself is striated. Skeletal muscle is VOLUNTARY MUSCLE, in that it responds to nervous stimulation and we choose to move it.
2. CARDIAC MUSCLE is characterized by short cells that branch. They are uninucleate and the tissue is also striated. The hallmark feature of cardiac cells are the intercolated discs...areas where two cells are joined. Cardiac muscle is INVOLUNTARY.

- SMOOTH MUSCLE is characterized by spindle shaped cells that are uninucleate. Under the microscope it can look like dense regular connective tissue, so take note of the nuclei appearing more oval in smooth muscle, and not as squashed as in dense regular. Unlike skeletal muscle and cardiac muscle, smooth muscle is NOT STRIATED. Smooth muscle is also INVOLUNTARY (digestive system).

Tissue Repair

There are three stages of tissue repair, and they overlap a bit.

- Stage 1: Inflammation
- Stage 2: Organization
- Stage 3: Regeneration ---or--- Fibrosis

INFLAMMATION occurs when tissue damage causes a release of chemicals which signal the immune cells to come to the rescue. The chemicals increase the diameter and permeability of the capillaries so stuff can leak out and enter the damaged tissue. The things that leak out of the capillaries into the tissue are white blood cells, plasma and clotting proteins. These guys attack pathogens and seal off the area. Dead pathogens and cells are also cleared by the macrophages.

ORGANIZATION involves granulation tissue replacing damaged tissue. It is made up of new capillaries and fibroblasts. Fibroblasts secrete growth factors and lay down collagen which bridges gaps in damaged tissue, eventually pulling wound edges together.

REGENERATION is the re-growth of the original tissue. Epithelia grow in over the fibrous connective tissue scar tissue. Regeneration occurs in smaller wounds and in tissue that is highly regenerative.

----or---

FIBROSIS occurs in bigger wounds or in tissue that is not regenerative, such as cardiac muscle tissue. In fibrosis, the destroyed tissue is replaced by fibrous connective tissue scar tissue.

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<p>HIGHLY REGENERATIVE Epithelium Bones Areolar CT Dense Irregular CT Hemopoetic Tissue</p>
<p>MODERATELY REGENERATIVE Smooth Muscle Dense Regular CT (tendons, ligaments)</p>
<p>WEAKLY REGENERATIVE Skeletal Muscle Cartilage</p>
<p>DO NOT REGENERATE Cardiac Muscle Nervous Tissue</p>