

ST. CATHERINE  
UNIVERSITY

# Histology: The Study of Tissues



# Tissues

- ▶ A collection of specialized cells.
- ▶ Made of cells and matrix
  - Matrix: extracellular material (ground substance), fibers, minerals, gases, nutrients, wastes, etc.
- ▶ 4 types of tissues:
  - Epithelial
  - Connective
  - Nervous
  - Muscle
- ▶ Tissue types differ by their types of cells and function, characteristics of the matrix, and the ratio of cells:matrix.



Tissues are a collection of specialized cells which perform the same function. They are formed by cells and matrix.

The matrix is the extra cellular material, the material that surrounds the cells. It is composed of fibers and clear gel-like substance (ECF) or ground substance and contains minerals, gases, nutrients, wastes and other chemicals.

There are 4 categories of tissues: epithelial, connective, muscle, and nervous. They differ by their cell types, function, characteristics of matrix, and ratio of cells to matrix.

# Epithelial Tissue

- General Characteristics:
  - Avascular
  - Used for surfaces
  - Tightly packed cells, little to no matrix
  - Nerve supply
  - Basement membrane
  - Basal Surface
  - Apical Surface



Epithelial tissue is avascular (no blood supply), has tightly packed cells, very little to no space between cells, little to no matrix (stuff outside of the cell). It does have a nerve supply via nerve endings found in the tissue. Epithelial tissue usually lines surfaces. It also functions to protect, in secretion and excretion, absorption, filtration (primarily in the urinary system), and sensation.

Epithelial tissue also has basement membrane. The basement membrane is a layer of large, complex molecules (such as collagen adhesive molecules and proteins) between epithelial tissue and the underlying tissue. It helps to anchor the epithelial tissue.

Epithelial tissues also have Basal and Apical surfaces. The basal surface touches the basement membrane while the apical surface is the open and exposed, or the top surface.

Epithelial tissue can also be referred to as epithelium, so do not be confused if you see it written that way.

## Epithelial Tissue Con'td

- Simple Epithelial
  - Squamous – lines air sacs, blood vessels
  - Cuboidal – glands
  - Columnar – lines stomach, intestines, uterus
- Stratified Epithelial
  - Squamous – skin, tongue, mouth
  - Cuboidal – sweat glands, reproductive ducts
  - Columnar – pharynx, larynx
- Pseudostratified Columnar – respiratory tract
- Transitional – urinary system



The types of epithelial are determined by the number of layers and the shape of the cells.

Simple epithelial have one layer of cells, every cell touches the basement membrane. Within simple epithelial, there are three cell shapes.

1. Squamous which is thin and squished. It is found in the air sacs and inner lining of the heart and blood vessels.

2. Cuboidal which is square or roundish. The cells have the same height and width. This is most commonly found in the glands and ducts.

3. Columnar which is tall and narrow and rectangular in shape. Often they have microvilli (small cilia) and goblet cells. Goblet cells are mucous secreting cells. It is found in the stomach, intestines, gall bladder, uterus, and uterine tubes

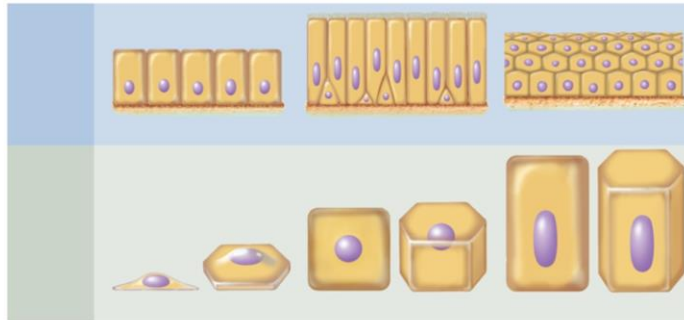
Stratified epithelial have 2 or more layers of cells. It also has the cell shapes of squamous, cuboidal, and columnar. Stratified squamous is found in the skin, tongue, anal canal, vagina, and oral mucosa. Stratified cuboidal is found in the sweat glands and sperm/egg producing ducts. Stratified columnar are very rare and usually found where epithelial types meet like pharynx, larynx, anal canal, and male urethra.

**\*\*NOTE: Need both shape and layer to correctly name epi tissue.\*\*** For example: simple squamous or stratified cuboidal.

Pseudostratified columnar is a unique type of tissue. It looks multilayered, but is technically simple. Not all the cells of pseudostratified columnar reach the free surface, but all touch the basement membrane, which makes it simple and not stratified. We call the cells columnar because they are often long and thin. It is found in the respiratory tract and male urethra.

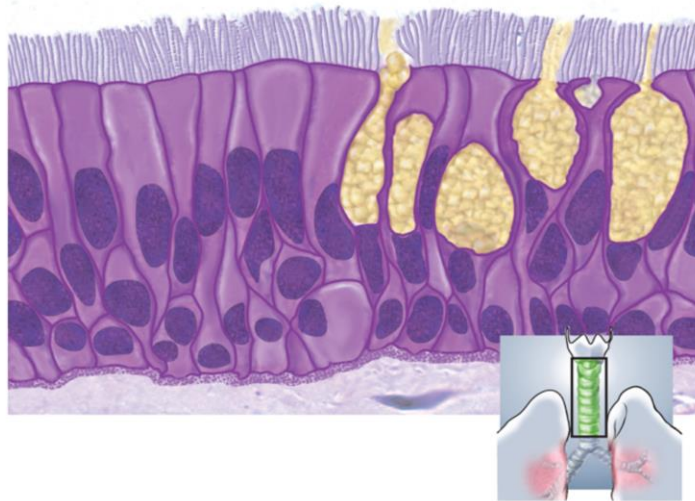
Transitional epithelial has an odd cell appearance. It changes from flat to round on the surface in shape in order to stretch. It is found in the urinary tract and bladder. It is really important for stretching within the urinary system.

## Epithelial Tissue Cont'd



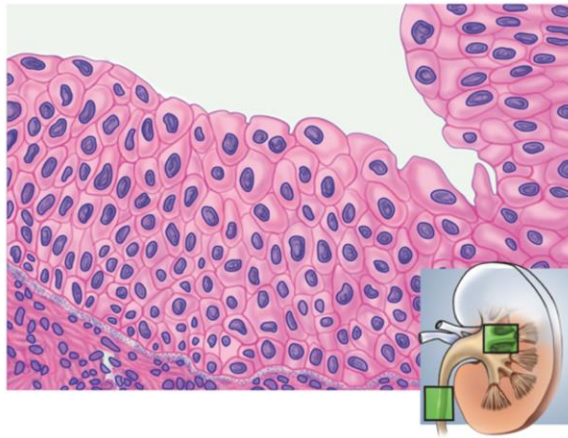
The top row shows simple vs stratified. The top left is an example of simple, every cell touches the basement membrane. If you notice in the middle picture, not all the cells go to the top, but every one touches the basement membrane. This is an example of psuedostratified epithelial tissue. It looks like the cells are stacked, but technically, every cell touches the basement membrane. The top right shows stratified. Only one layer touches the basement membrane and all other cells are stacked in layers on top of that bottom, or basal, layer. The second row shows the various shapes: squamous on the left, cuboidal in the middle, and columnar on the right..

## Epithelial Tissue Cont'd



This is pseudostratified columnar with cilia and goblet cells. The cilia are the hair-like looking structures across the top of the cells. The goblet cells look like fatty globs that are packed between cells. Pseudostratified columnar are commonly found in the upper respiratory tract.

## Epithelial Tissue Cont'd



Here is our transitional epithelial. Notice their odd shapes and how they change as they go from the basement membrane to the free surface.



## Connective Tissue

- ▶ Consists of mostly fibers and ground substance with widely spaced cells.
- ▶ Vascular with Nerve Supply
- ▶ Functions
  - Binding of organs
  - Support
  - Physical Protection
  - Immune Protection
  - Movement
  - Storage
  - Heat Production
  - Transportation



Connective tissue consists mostly of fibers and ground substance with widely spaced cells. This greatly contrasts to epithelial that has little fibers and ground substance and the cells are tightly packed together.

It also differs from epithelial tissue in that it is vascular (has a blood supply). It also has a nerve supply.

Connective tissue has many functions, but mainly it does what the name implies, connect. Connective tissue is used in the:

1. Binding of organs, or enclosing of the organs
2. Support of the body, keeping us upright
3. Physical Protection of vital organs, as in how the skull protects the brain
4. Immune protection, for example, the White Blood cells that look for infectious microorganisms
5. Movement, our bones are levers for the muscles to act on
6. Energy storage, in the form of lipids
7. Heat production and temperature regulation
8. Transportation of nutrients and gases via the blood

## Connective Tissue Cont'd

### ► Components

- Cells:
  - Stem
  - Fibroblasts
  - Mast cells
  - Macrophages
- Matrix:
  - Fibers
    - Collagenous
    - Reticular
    - Elastic
  - Ground Substance
    - Glycosaminoglycan
    - Proteoglycan
    - Adhesive glycoprotein



Connective tissue has two primary components: cells and matrix.

There are a number of different cell types found in connective tissue:

1. Stem Cells are the basic, building cells and will become whatever type of cell that is specialized for that tissue.
2. Fibroblasts produce the fibers and ground substance. They are flat with wispy branches.
3. Mast cells are found along blood vessels and secrete hormones that regulate blood flow and clotting.
4. Macrophages are white blood cells that ingest and help get rid of particles and infectious microorganisms.

The matrix, or the stuff outside of the cells, has fibers and ground substance.

Fibers are found in three forms.

1. Collagenous are made of collagen. Collagen is one of the most abundant proteins in the body. They are tough and flexible and resist stretching. These types of fibers are going to be common in tendons, ligaments, and skin. They can also be found in cartilage and bone.
2. Reticular have thin collagen fibers covered in glycoprotein (a protein with a carbohydrate bonded to it). They are most commonly associated with the lymphatic system and help provide a sponge like framework for the spleen.

3. Elastic are very thin collagen fibers that stretch and recoil. They are made of a protein called elastin that allows the fibers to spring back after being stretched. They are found in areas that need to be able to stretch like arteries and skin.

Ground Substance is usually featureless and has a gelatinous, rubbery consistency due to three classes of very large molecules. It acts as a shock absorber and protects the cells.

1. Glycosaminoglycan is a long polysaccharide composed of amino sugars and uronic acid. It is negatively charged so it attracts ions and can absorb and hold water.

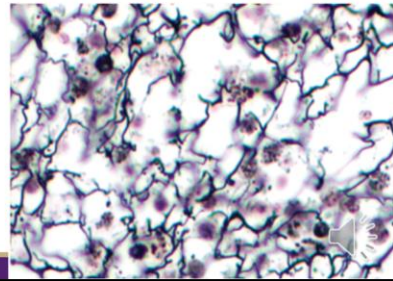
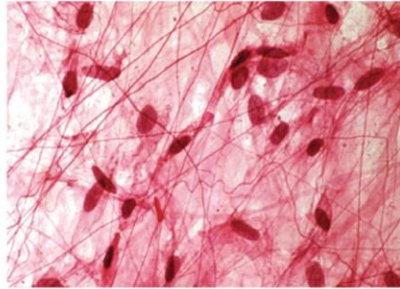
2. Proteoglycan is a large molecule that looks like a test tube brush or pipe cleaner. It forms a thick clumpy gel that slows the movement of pathogens, helps create structural bonds between cells, and holds tissues together.

3. Adhesive glycoproteins are a protein-carbohydrate complex and is used as an adhesive.

Water is another major component of ground substance.

## Connective Tissue Cont'd

- **Loose Fibrous Connective Tissue**
  - **Areolar Tissue**
    - Lost of Space!!!!!!
    - Elastic and collagenous fibers
    - Lots of ground substance and blood vessels
    - Underlying nearly all epithelial
  - **Reticular Tissue**
    - Loose reticular fibers
    - Lymphatic system



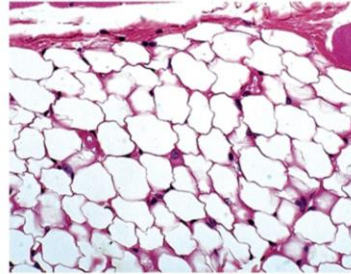
Loose Fibrous Connective Tissue has lots of open space. This space is formally ground substance that has been dissolved. The cells are not in any particular arrangement like we saw in epithelial tissue and there are lots of fibers. There are two types.

Areolar has a loose arrangement of collagenous and elastic fibers, scattered cells of various types, lots of ground substance and blood vessels. It is found underlying nearly all epithelial tissue, surrounds blood vessels and nerves, and can also be found in the esophagus, trachea, and between muscles. It functions to loosely bind epithelial tissue and provides blood and nutrients for epithelial (remember that epithelial tissue does not have a blood supply). It also provides passages for blood vessels and nerves through other tissues.

Reticular also has a loose arrangement of fibers, mainly reticular fibers. In addition, there are numerous lymphocytes and other blood cells. It is found in the lymph nodes, spleen, thymus, and bone marrow and functions as a supportive framework for the lymphatic system. The arrangement of fibers allows for filtering of lymphatic fluid.

## Connective Tissue Cont'd

- **Adipose**
  - Big “empty” cells
  - Energy storage

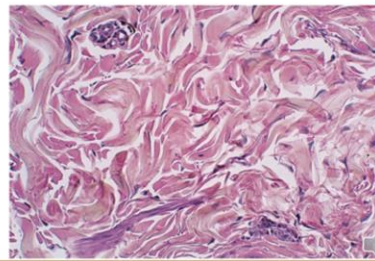
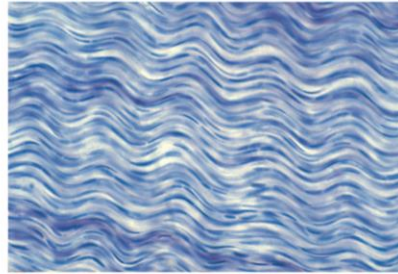


Adipose tissue looks like big “empty” cells, they are not empty, but they look almost clear. There is also a good blood supply. Adipose functions as the fat under the skin and breasts, on the heart’s surfaces, and surrounds kidneys and eyes. It is a form of energy storage, provides insulation, protects organs, and gives shape to the body.

## Connective Tissue Cont'd

- **Dense Fibrous Connective**

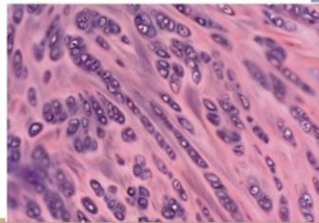
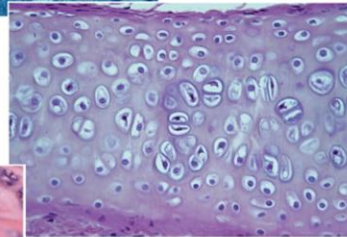
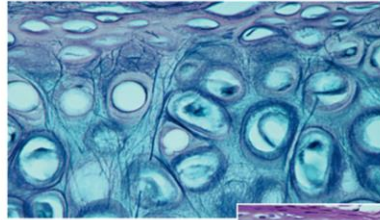
- Thin sheets
- Few cells
- Lots of collagen and elastin fibers
- Ligaments and tendons
- Regular and Irregular



Dense Fibrous Connective tissue is found in two forms: Regular and Irregular. Dense Regular is strong and found in thin sheets. It is characterized by few cells, but numerous collagen and elastic fibers. Fibers occupy more space than cells or ground matrix, so the fibers really stand out. Dense regular has an organized, wavy pattern. This is how it gets its name, the fibers are densely packed together, but in an organized, parallel manner. This particular arrangement resists stretching in one direction. It is found in ligaments and tendons. Dense Irregular also has few cells and a lot of collagen fibers, but the fibers are not organized, they are all over the place. This arrangement of fibers resists stretching in multiple directions. Dense Irregular is found in the dermis and forms fibrous sacs around some organs like the kidney.

## Connective Tissue Cont'd

- Cartilage
  - AVASCULAR
  - Chondroblasts
  - Rubbery Matrix
  - 3 types
    - Elastic
    - Hyaline
    - Fibrocartilage



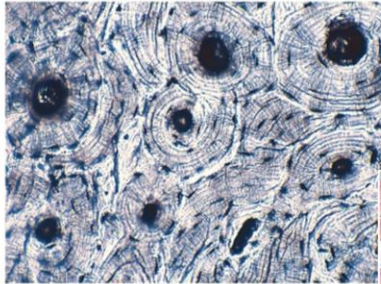
Cartilage has a flexible, rubbery matrix. Their fibroblasts are specialized and called chondroblasts. Cartilage is the only connective tissue that is avascular. There are three forms.

Elastic Cartilage (the top photo) has lots of elastic fibers and can be found in the external ear and epiglottis of the throat.

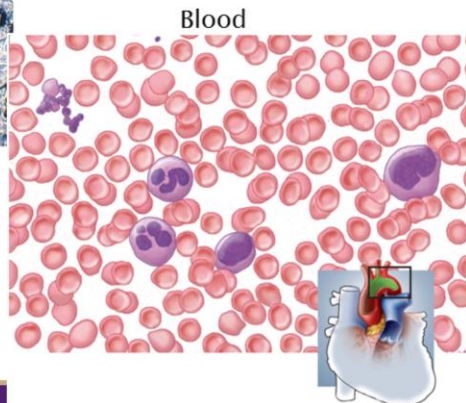
Hyaline Cartilage (middle photo) is the most common. It has a clear and glassy appearance and contains collagen fibers but they are thin and not always visible. It can be found in joints, the vocal chords, and is a precursor to bones in juveniles.

Fibrocartilage (bottom photo) has course, visible bundles of collagen and is found in intervertebral discs.

## Connective Tissue Cont'd



Bone



Blood

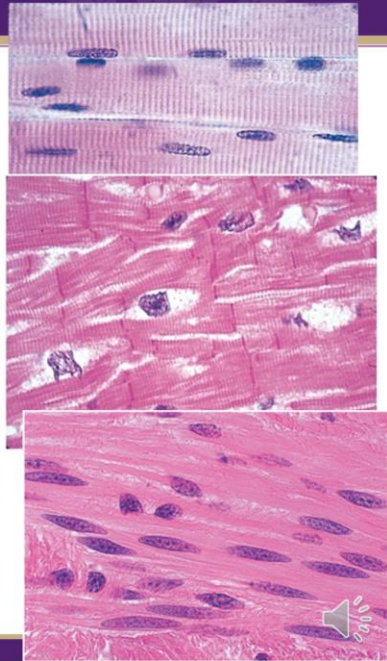
Bone looks like tree rings. The rings are the matrix and called lamellae and form around a central canal. The small cavities around the lamellae are called Lacunae and where mature bone cells, osteocytes, are found. In bone, we also have other cells such as osteogenic cells, osteoblasts, and osteoclasts. Osteogenic cells are our stem cells, osteoblasts are bone forming cells, and osteoclasts are bone destroying cells. We will discuss the unique properties bone tissue further during the skeletal system

Blood has red blood cells that are little disc shaped cells and look like Spaghetti O's. The big purpled stained cells are white blood cells. The space between the cells is filled with blood plasma. We will also discuss blood in greater detail later in the semester with the Blood and Cardiovascular chapters.



# Muscle Tissue

- 3 types
  - Skeletal
    - Striations, multiple nuclei, voluntary
  - Cardiac
    - Striations, intercalated discs, involuntary
  - Smooth
    - No striations or intercalated discs, involuntary



The next category of tissue is muscle. There are 3 forms of muscle tissue

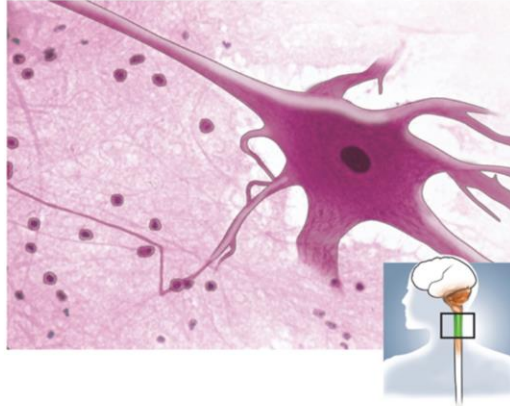
Skeletal is for movement and it is voluntary (meaning you have conscious control over it). It is characterized by long cylindrical cells that have striations (the stripes that run across the cells), and multiple nuclei.

Cardiac is found in the heart and is involuntary (you do not have conscious control over it). It is characterized by shorter and branched cells, striations, and intercalated discs. Intercalated discs are the slightly darker bands where two cells meet. They allow the cardiac cells to communicate.

Smooth are longer, tapered cells that are also involuntary. There are no striations or intercalated discs. You will find smooth muscle in systems such as the Digestive and Respiratory tracts.

# Nervous Tissue

- Neurons and neuroglia cells



Nervous tissue is recognizable by big star shaped cells called neurons. It will also contain neuroglia cells, or helper cells. We will spend more time on this later when we do the nervous system, but for now, be able to recognize it and know that it is a distinct form of tissue.



# Membranes



# Membranes

- A flat sheet or layer made up of epithelial tissue and a layer of connective tissue.
- Mucous Membranes
  - Line passages
  - 3 layers
    - Epithelium
    - Areolar connective tissue
    - Smooth muscle
  - Goblet cells
  - Absorb, secrete, and protect



A membrane is a flat sheet or layer made up of epithelial tissue (surface) and a layer of connective tissue underneath. There are a few different types.

The first type is a mucous membrane. Mucous membranes line passages that open to exterior of the body. For example, the digestive, respiratory, reproductive, and urinary tracts.

There are 3 layers: epithelium (the type of epithelial tissue varies based on the organ and system), areolar, and this membrane actually has a layer of smooth muscle to help move things along. This membrane functions in absorption, secretion, and protection. Goblet cells are often found in this membrane for the production of mucous.

# Membranes

- Serous Membranes
  - Simple squamous over areolar
  - Produces serous fluid
  - Lines/surrounds organs
  - Found in the 3 primary body cavities
  - 2 primary types
    - Parietal
    - Visceral



The serous membrane is simple squamous epithelial over a thin layer of areolar tissue. It produces serous fluid which is a watery fluid that lubricates. It is found on organs and lines/surrounds cavities. The fluid produced by the serous membrane helps reduce friction as organs can rub against each other when they move. This membrane lines cavities that are not exposed to external environments. It is found in 3 primary body cavities as well as the pleural and pericardial which are smaller cavities inside the thoracic. The membrane has two layers, the parietal membranes and the visceral. The parietal lines the actual cavity, like along the inside of your rib cage, and the visceral surrounds the actual organ. We'll come back to these in more detail when we do the cardiovascular and respiratory chapters. The serous membrane can also be found in the abdominopelvic cavity and is called the peritoneal.

# Membranes

- Synovial
  - Made only of Connective Tissue
  - Protects joints
  - Synovial Fluid
- Endothelium
  - Lines Circulatory System
  - Simple squamous resting on areolar
  - Allows for exchange
- Cutaneous
  - Skin



## SYNOVIAL MEMBRANE

This membrane is made only of connective tissue and is associated with joints. It secretes synovial fluid which helps to protect and lubricate joints. We'll see this one again when we discuss joints.

## ENDOTHELIUM

The endothelium lines the vessels of the circulatory system. It is made of simple squamous epithelial tissue resting on thin layer of areolar connective tissue. Because it is so thin it allows for exchange of nutrients and gases from the blood to the surrounding tissues. Again, we'll talk about this one later on in the semester when we discuss the cardiovascular system.

## CUTANEOUS MEMBRANE

This is commonly know as skin and we will actually be discussing this in the next module.