Tissues

Presented by Dr. Jil Simmons BSc ND

4 Basic Tissue Types

- Of all the cells in the body, they combine to make only 4 basic tissue types:
- Epithelial tissues
- Connective tissues
- Muscular tissues
- Nervous tissues

Tissues

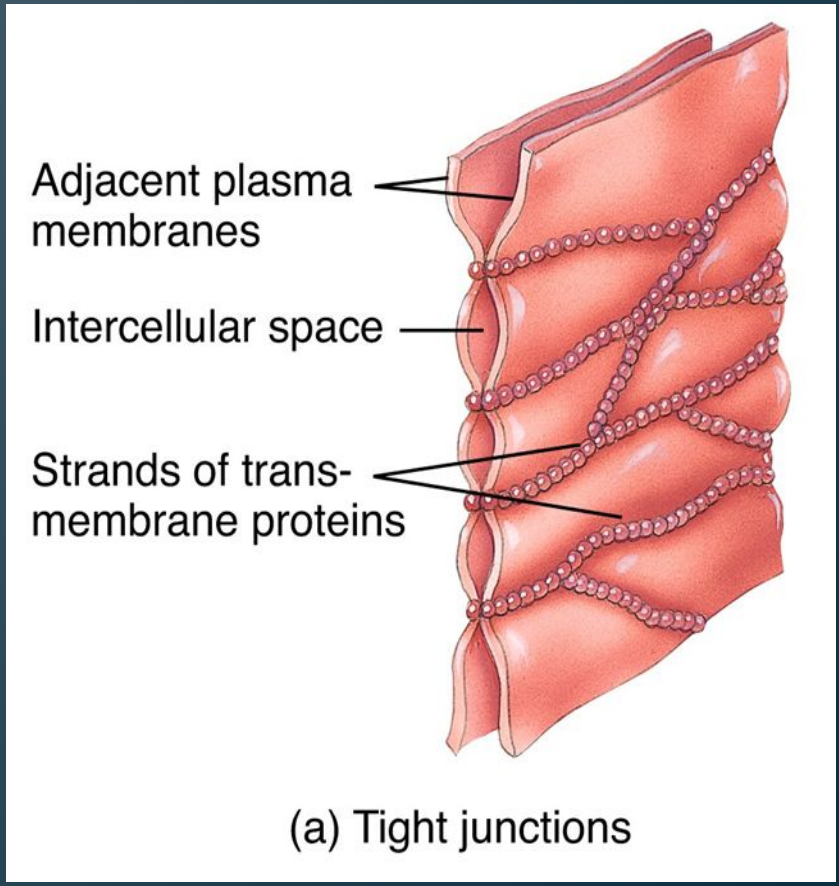
- Tissues are a group of cells with a common embryonic origin that function together to carry out specialized activities.
- They include various types, ranging from hard (bone) to semisolid (fat) to liquid (blood).

Intercellular Junctions

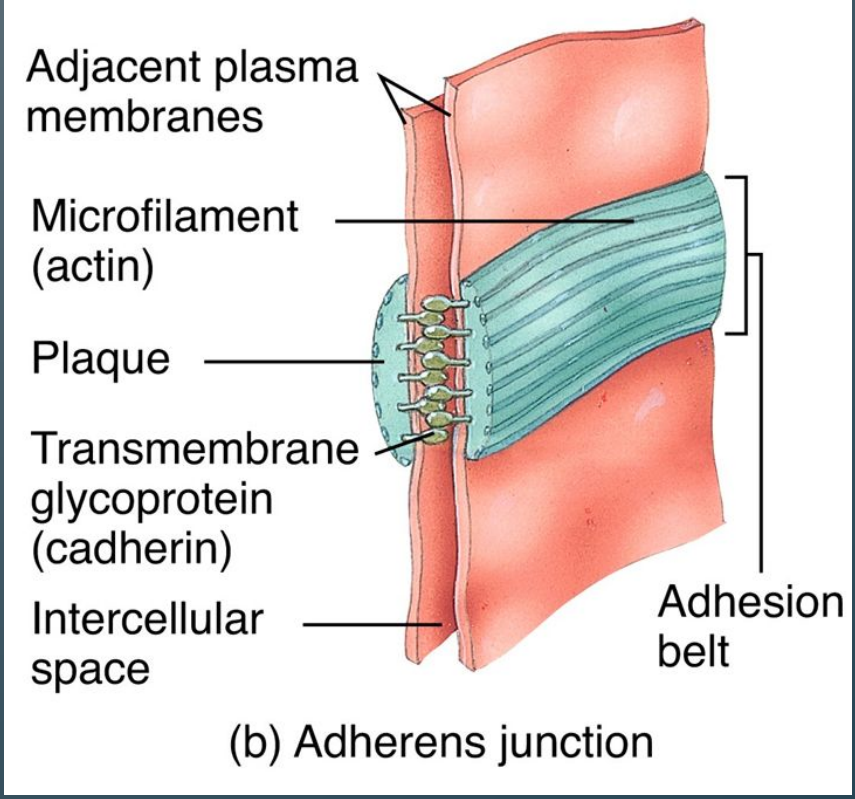
- Intracellular Junctions are ways to connect adjacent cells to each other.
- All tissues are formed by grouping cells together using a variety of Intercellular Junctions
- They connect adjacent cells mechanically at the cell membranes or through cytoskeletal elements within and between cells.
- Include
  - Tight Junctions
  - Adherens
  - Desmosomes
  - Hemidesmosomes
  - Gap Junctions
- https://youtu.be/goa1TkA9VNc

Tight Junctions

- Found where a leak-proof seal is needed between cells. They keep materials from leaking out of organs like the stomach, intestines and bladder.
- Like a "ziplock"



Adherens

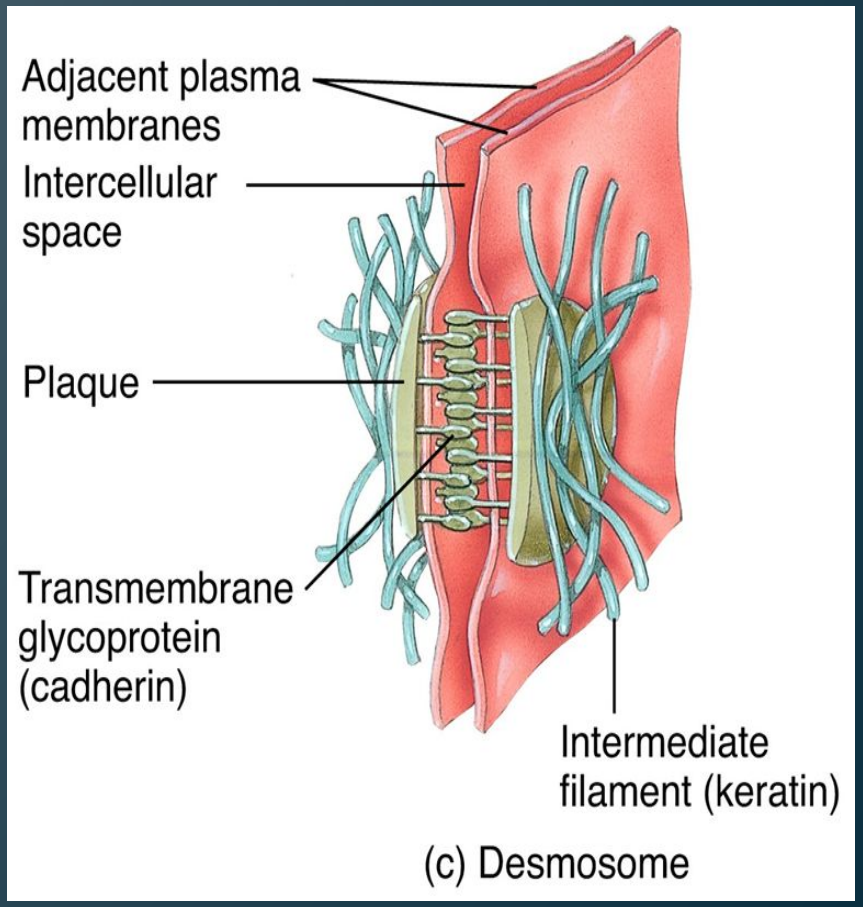


(b) Adherens junction

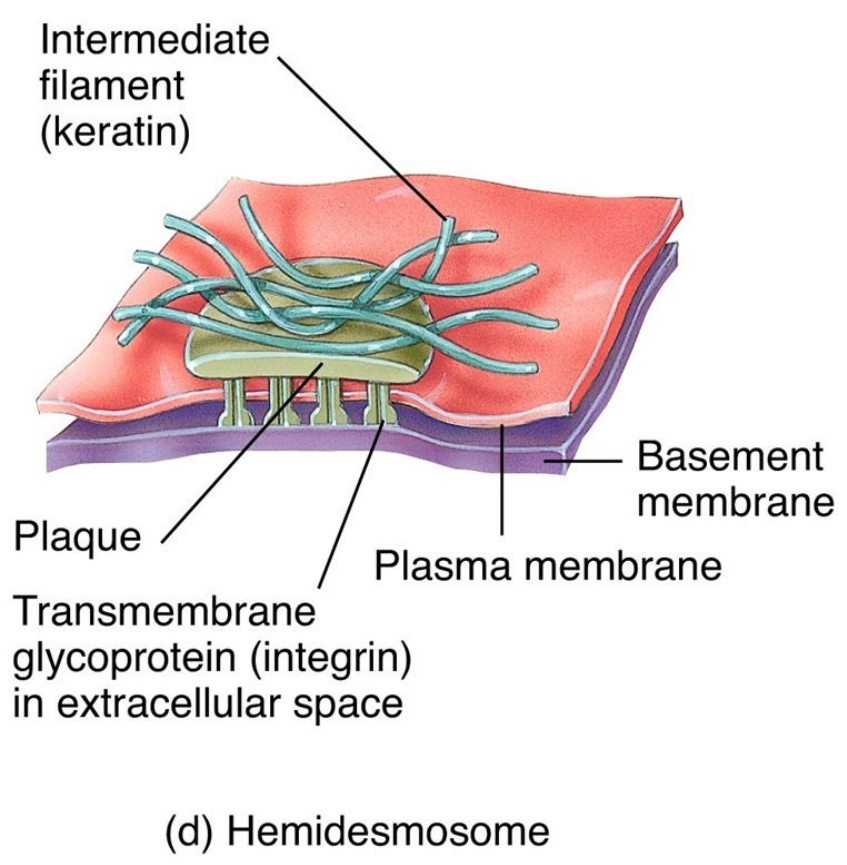
- make an adhesion belt that keeps tissues from separating as they stretch and contract.
- Cadherin is a glycoprotein that forms the belt-like "plaque" – it requires Calcium for its formation
- Like a "velcro strip"

Desmosomes

- act as “spot welds”. They also use cadherin glycoprotein (plus intermediate filaments) to hook into the cytoplasm
- Commonly found in the epithelium & cardiac muscle cells



Hemidesmosomes

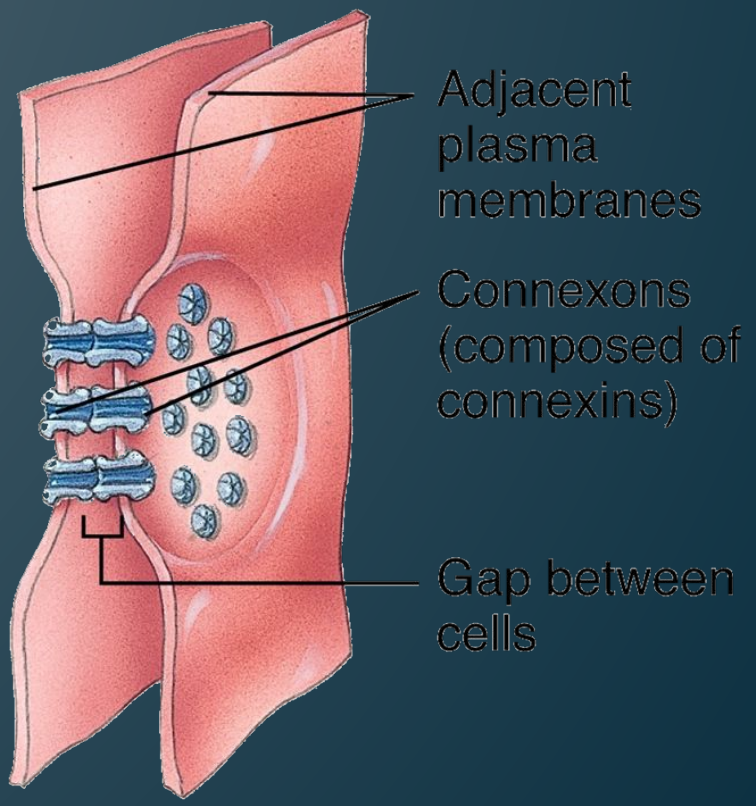


- half-welds that join cells to the basement membrane
- Use Integrin glycoproteins (not cadherins)

Gap Junctions

- are pores that allow small substances like ions to pass between cells.
- If one of the cells gets sick or dies, these seal like a hatch to prevent damage to other cells

Connexin proteins form Connexons that allow ions & small molecules to travel from cell to neighbouring cell



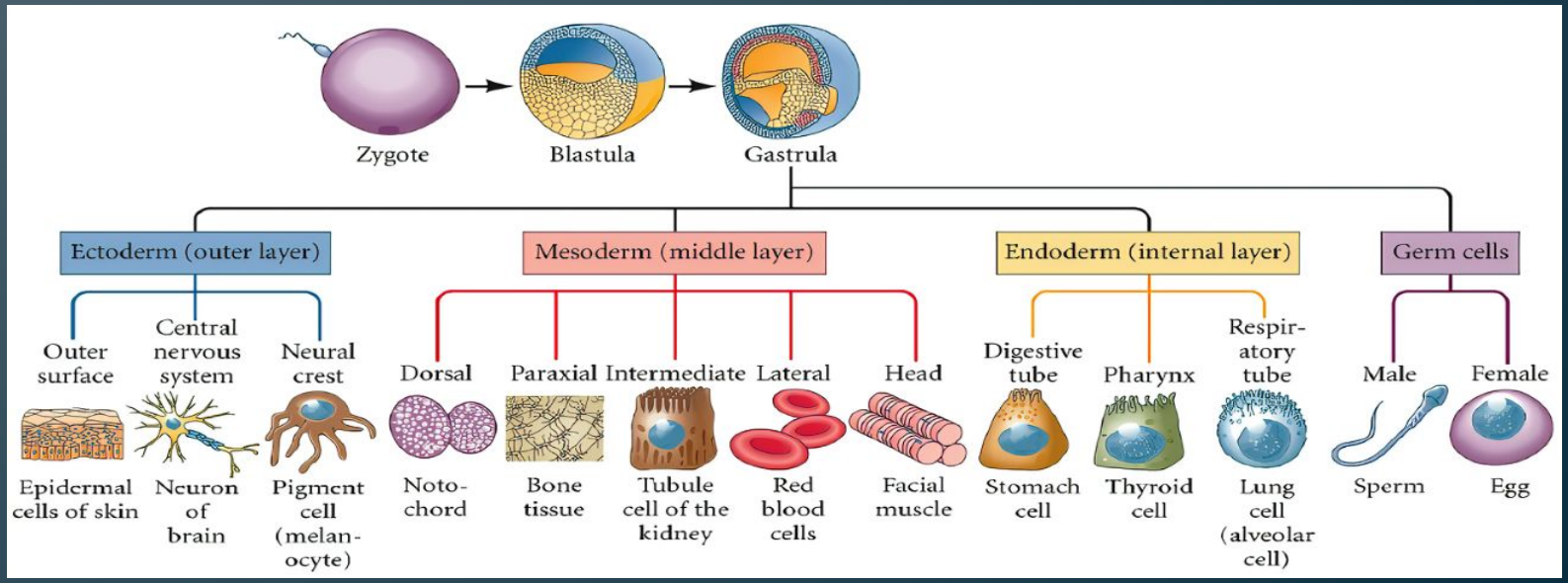
(e) Gap junction

Tissue types Demystified…

- **Epithelial tissues** - cover body surfaces and form glands and line hollow organs, body cavities, and ducts.
- **Connective tissues** (C.T.)- protect, support, and bind organs.
  - Fat is a type of C.T. that stores energy. Blood is also C.T.
- **Muscular tissues**- generate the physical force needed to make body structures move. They also generate heat used by the body.
- **Nervous tissues** - detect changes in the body and respond by generating nerve impulses.

Germ Layers - How Tissues Develop

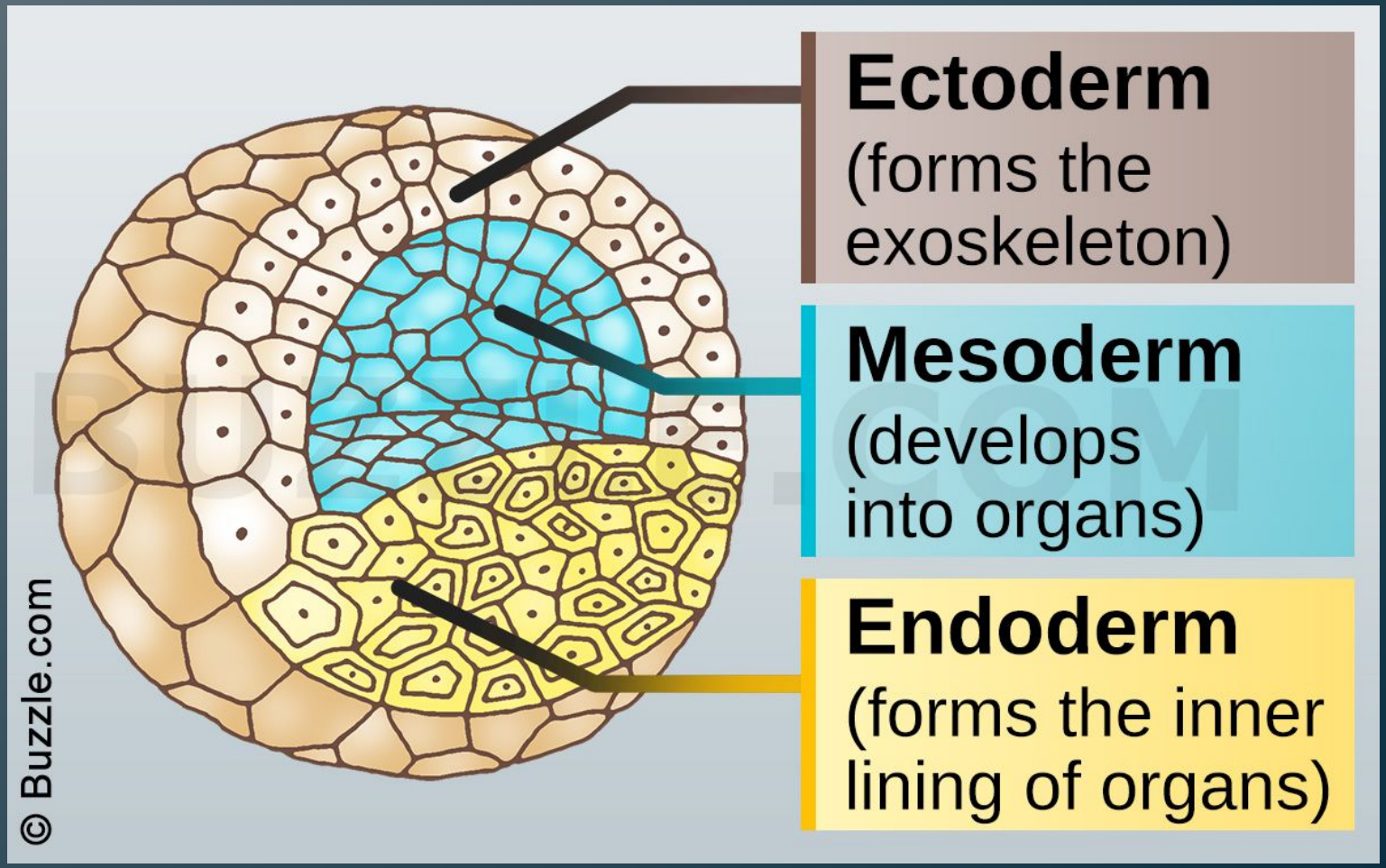
- **Germ Layer** - a group of cells in an **embryo** that interact with each other as the embryo develops and contribute to the formation of all organs and tissues. All animals, except perhaps sponges, form two or three germ layers. The germ layers develop early in embryonic life.



Endo, Ecto and Meso

- Tissues of the body develop from three primary germ layers: Endoderm, Mesoderm, and Ectoderm.
- **Endoderm** - inner layer
- **Ectoderm** – outer layer
- **Mesoderm** - interacts with endoderm and ectoderm to give rise to the digestive tract, the heart and skeletal muscles, red blood cells, and the tubules of the kidneys, as well as a type of connective tissue called mesenchyme

Germ Layer


Ectoderm
(forms the exoskeleton)
Mesoderm
(develops into organs)
Endoderm
(forms the inner lining of organs)
© Buzzle.com

Continued

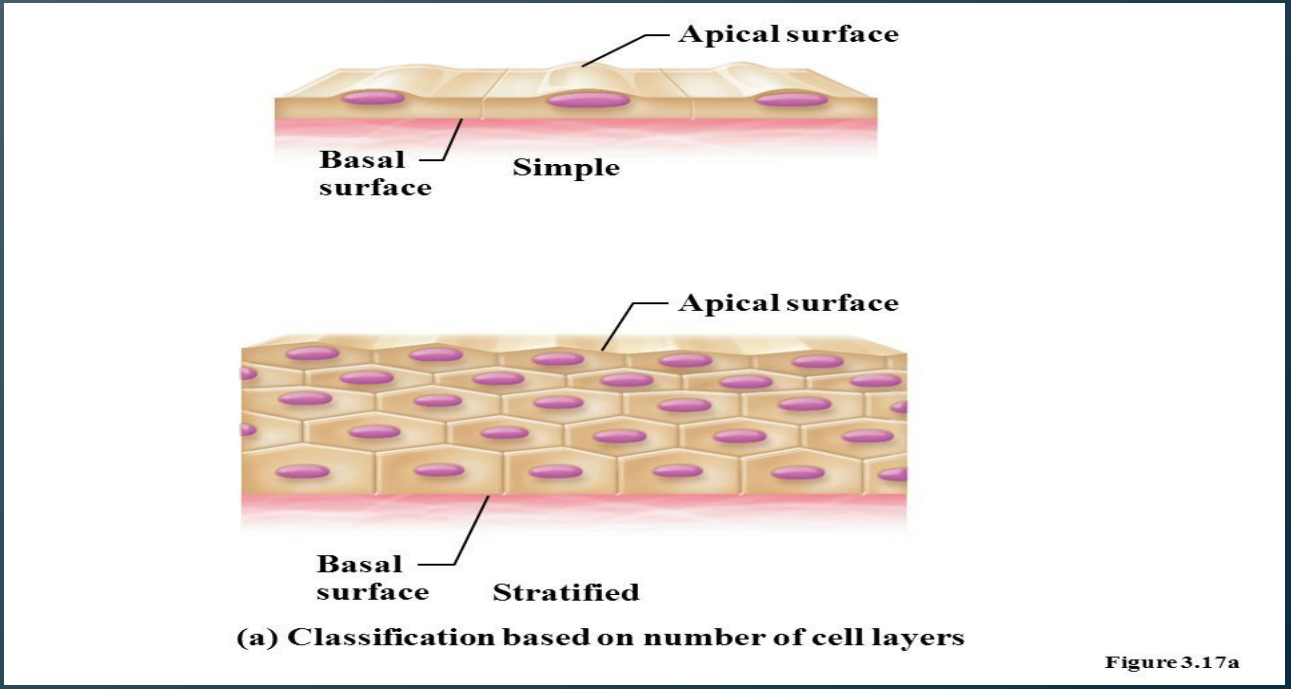
- Epithelial tissues from all three germ layers
- C.T. and muscle are derived from mesoderm.
- Nervous tissue develops from ectoderm

https://youtu.be/7bRWPutNP5g

Epithelium

Epithelium

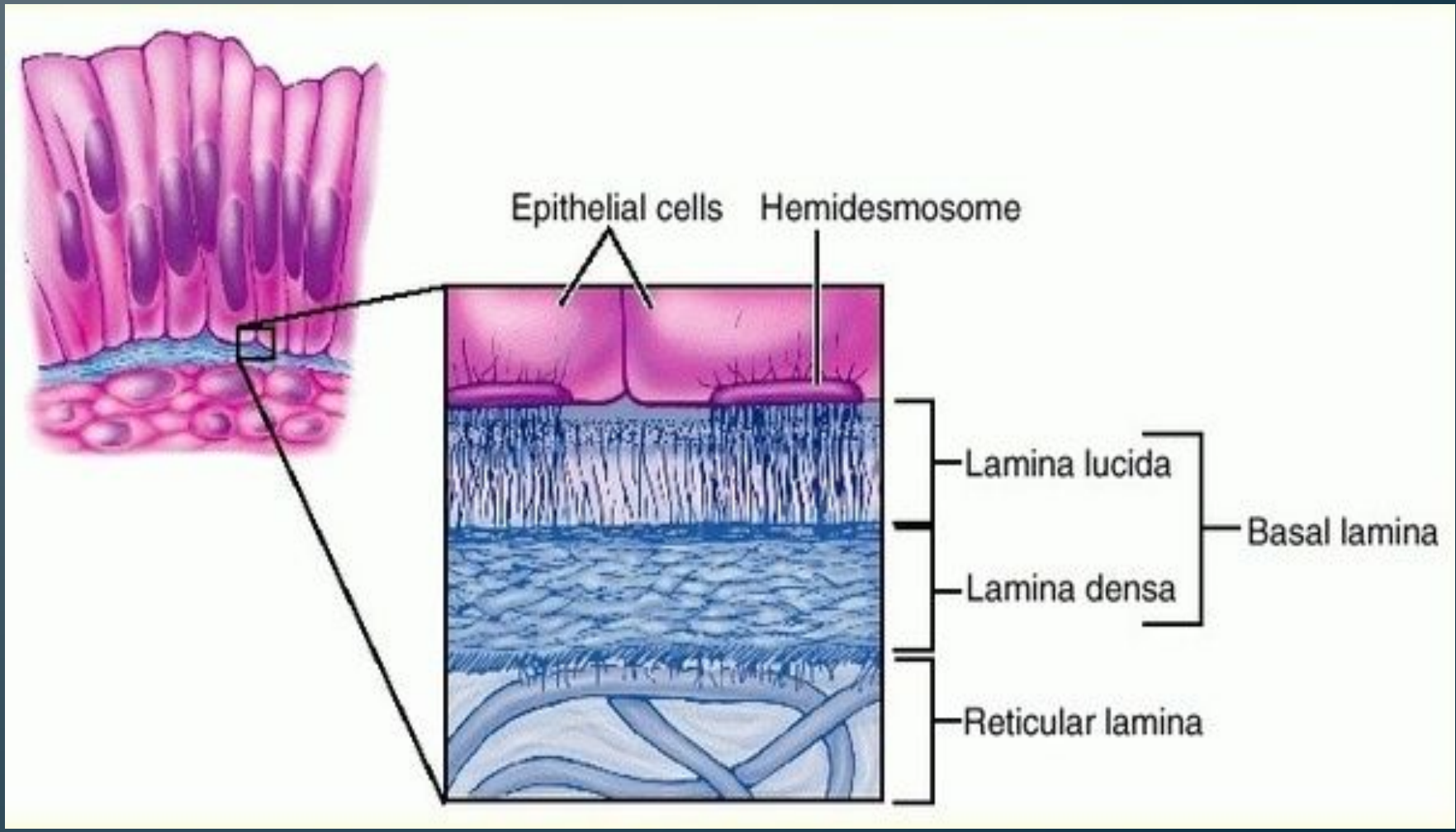
- Epithelium is used to line surfaces and form protective barriers. Epithelium is also good at secreting things like mucus, hormones, and other substances
- All epithelia have a free apical surface and an attached basal surface.



Basement Membrane

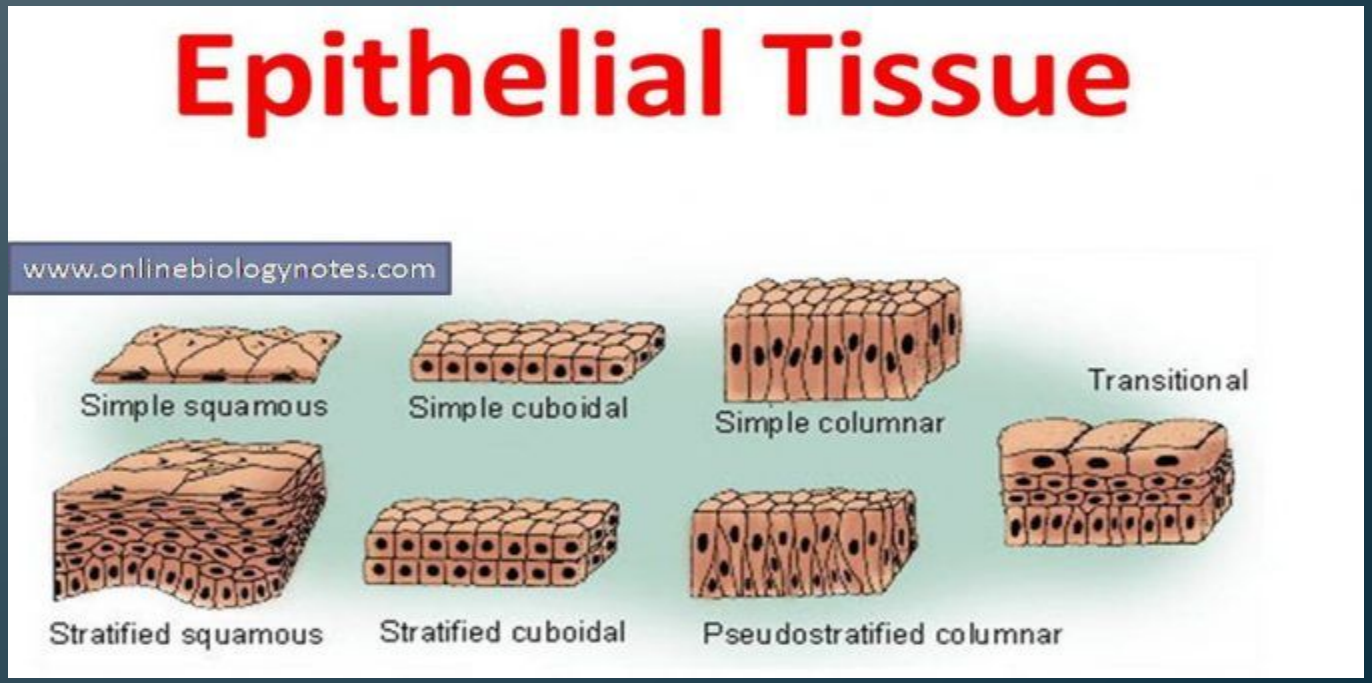
- The basal layer of the epithelium secretes a basal lamina; the underlying C.T. secretes a reticular lamina.
- Together the basal lamina and the reticular lamina form a non-cellular basement membrane on which the epithelium sits.
- **Basement membrane** is a **non-cellular structure** which consists of two layers:
- **1) Basal Lamina**
- (i) Lamina Lucida : It is outer thin layer (near the epithelial cells), composed of mucopolysaccharides and glycoproteins, both secreted by epithelial cell.
- (ii) Lamina Densa : composed of collagen or reticular fibres of the underlying connective tissue.
- **2) Reticular Lamina**
- The basement membrane provides **elastic support.** It also allows **selective chemical exchange between epithelial tissues and surrounding blood vessels.**

Basement Layer



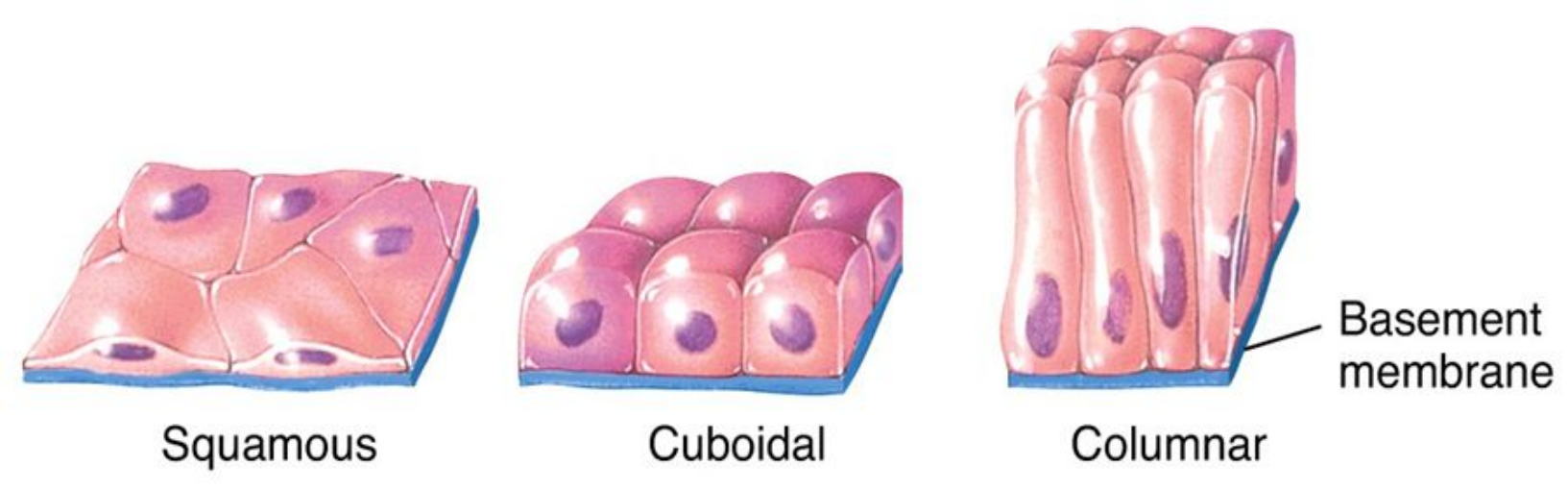
Naming Epithelia

- Epithelia are named according to the **shape** of their cells, and the **thickness** or arrangement of their layers (of cells)



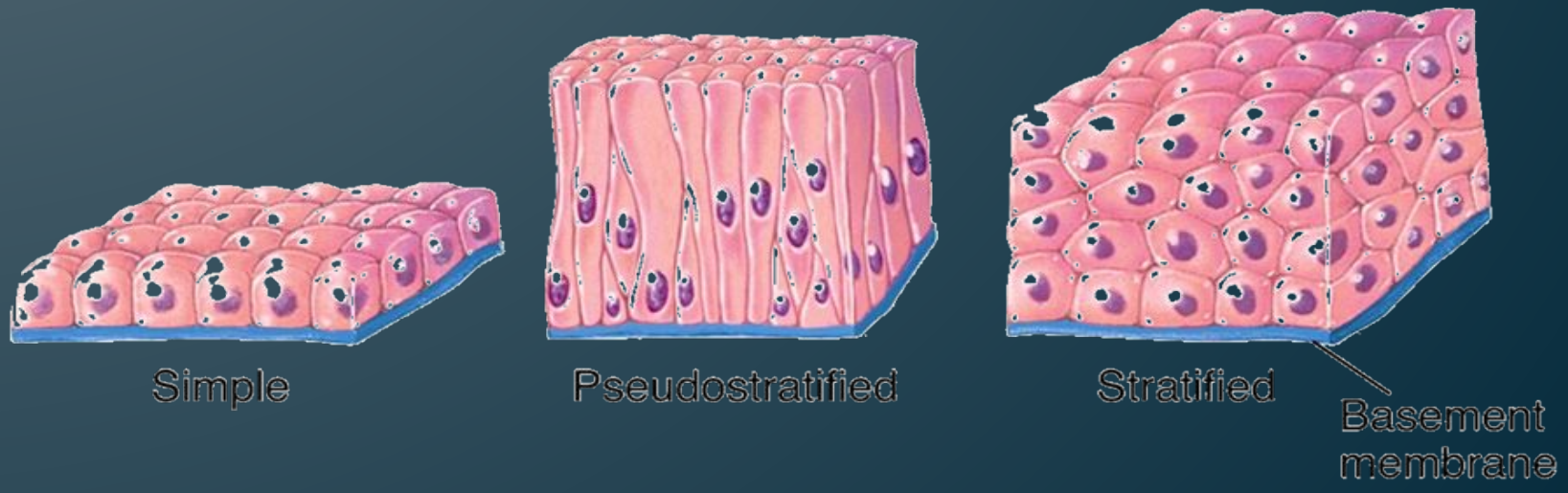
Naming according to Shape

- **Squamous** – Flat wide "paving stones" cells
- **Cuboidal** – As tall as they are wide
- **Columnar** – Taller then they are wide



Naming according to arrangement

- **Simple** – All cells are in one layer and have contact with the basement membrane
- **Pseudostratified** - Appears to have layers but all cells go from apex to base
- **Stratified** - Two or more layers, only one in contact with basement membrane

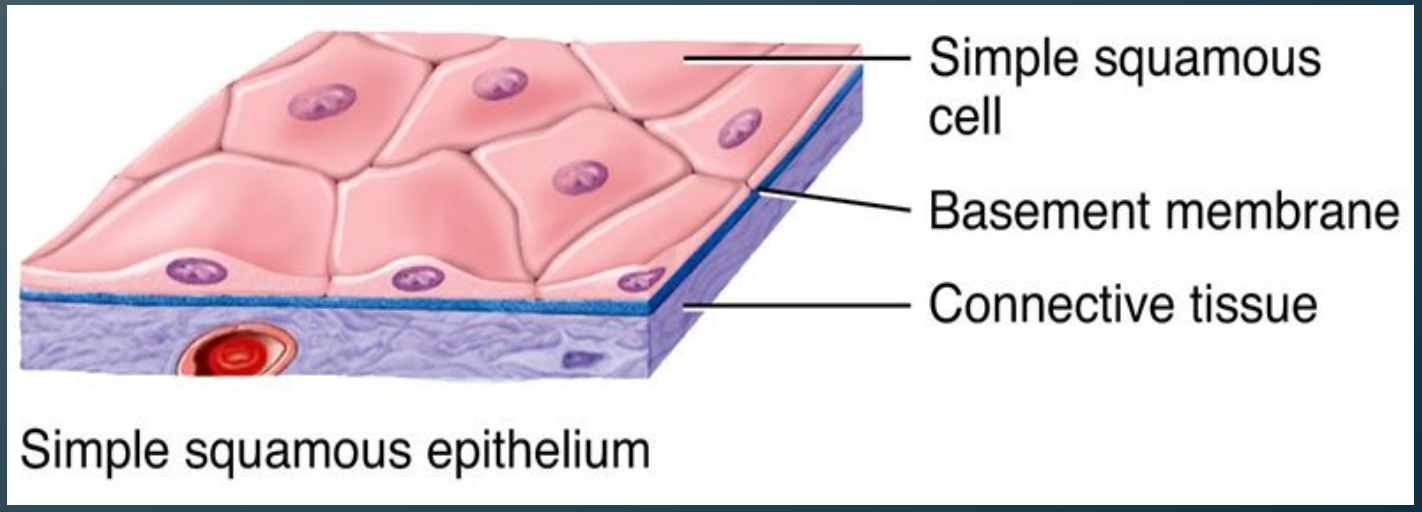


Naming continued

- Three different cell shapes x three different cell arrangements = nine possibilities. Two of these are not used. Add transitional (cells that change shape), so there are **eight possible combinations**.
- If different shapes are present in layers of cells, the epithelium is always named by the shape of cells in the apical (outermost) layer.

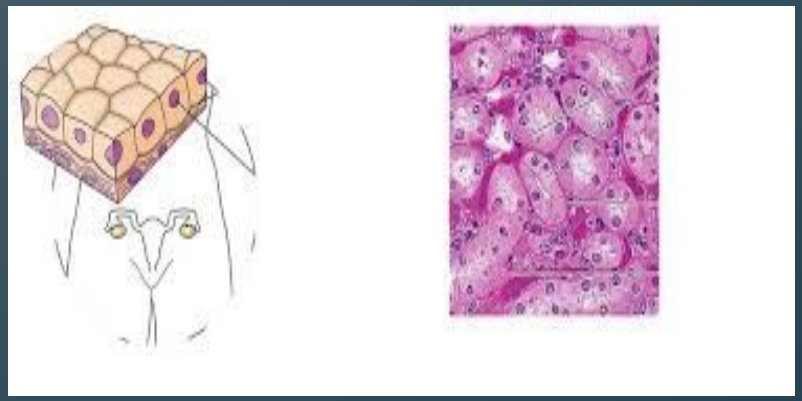
Simple Squamous

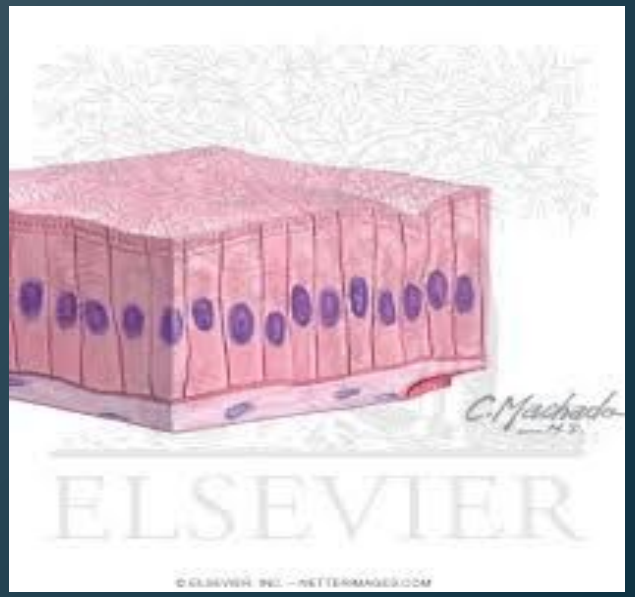
- composed of a single layer of flat cells found in the air sacs of the lungs, in the lining of blood vessels, the heart, and lymphatic vessels, in all capillaries, including those of the kidney, the major part of a serous membrane.



Simple Epithelium Continued

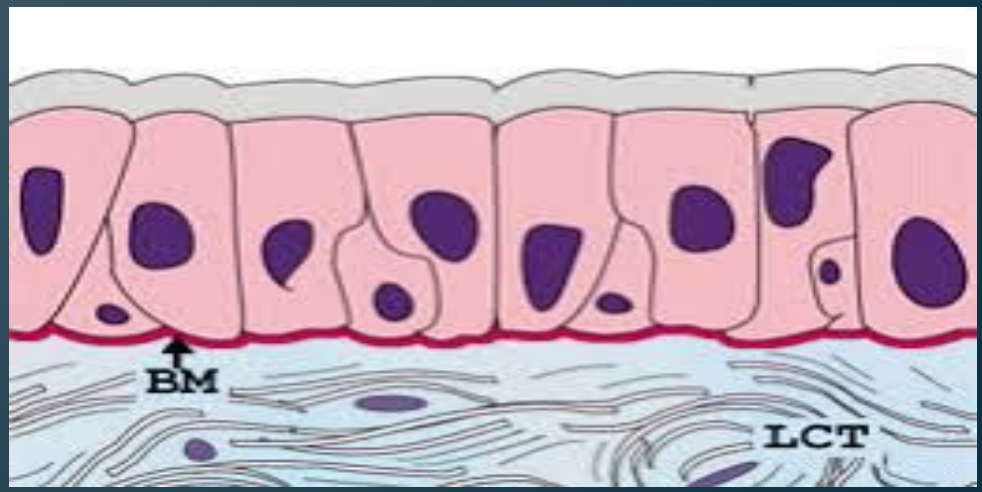
- **Simple Cuboidal Epithelium** - composed of a single layer of cube shaped cells. It is often found lining the tubules of the kidneys and many other glands.
- **Simple Columnar Epithelium** - forms a single layer of column-like cells
- Lines Most Digestive organs





Pseudostratified Columnar Epithelium

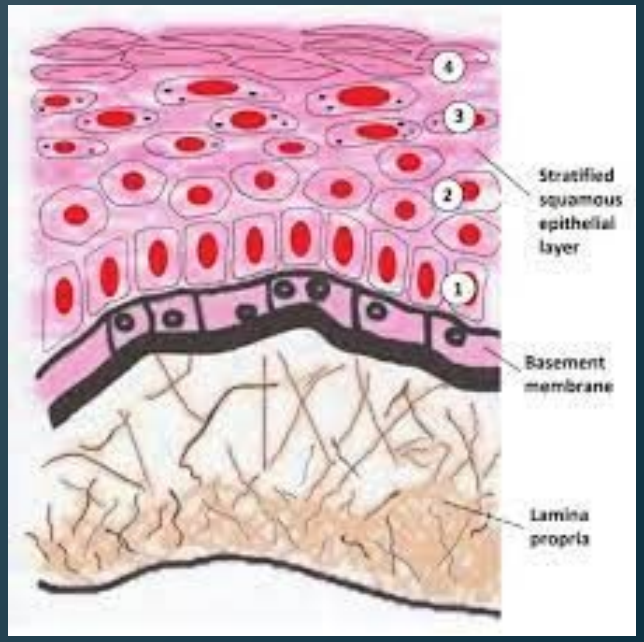
- appears to have layers, due to nuclei which are at various depths. In reality, all cells are attached to the basement membrane in a single layer, but some do not extend to the apical surface.
- Found in the Respiratory tract



Stratified Epithelium

- **Stratified Squamous Epithelium** has an apical surface that is made up of squamous (flat) cells. The other layers have different shapes, but the name is based on the apical layer. The many layers are ideal for protection against strong friction forces. Main location is the **external skin**.
- **Stratified Cuboidal Epithelium** has an apical surface made up of two or more layers of cube-shaped cells. Locations include the sweat glands and part of the ♂ urethra.
- **Stratified Columnar Epithelium** is very rare

Stratified Epithelium



Transitional Epithelium

- The cells of Transitional Epithelium change shape depending on the state of stretch in the tissue. The apical "dome cells" of the top layer are an identifiable feature and signify an empty bladder. In a full **bladder**, the cells are flattened.
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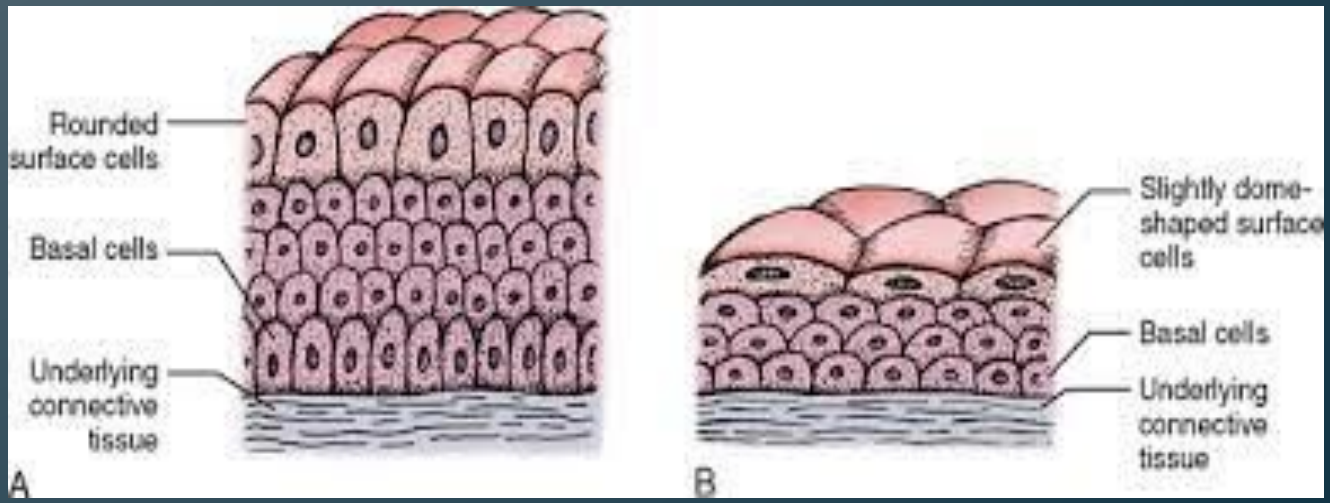


Glandular Epithelium

Glandular Epithelium

Gland – May consist of a single cell or group of cells that secrete into a duct, onto a surface or into the blood

- Two types
  - **Endocrine Glands** - Glands that secrete their contents directly into the ***bloodstream***
  - **Exocrine Glands** - Glands that secrete their contents ***into a lumen or duct***

Examples

- Exocrine Glands
  - Secretions of the exocrine gland include mucus, sweat, oil, earwax, saliva, and digestive enzymes.
  - Examples of exocrine glands are sweat glands.
- Endocrine Glands
  - Hormones
  - Examples: Pituitary gland, Thyroid gland, adrenal glands

Structural Classification of *Exocrine Glands*

- Unicellular or Multicellular
- Unicellular
  - single cell, Ex Goblet cell – secrete mucus directly on apical surface of a lining
- Multicellular
  - Many cells, form a distinctive microscopic or macroscopic organ. Ex- sweat or sudoriferous gland
  - Most Exocrine glands are multicellular

Classifications of multicellular Exocrine Glands

- 2 ways
  - Whether the ducts are branched or unbranched
  - Shape of the secretory portions of the gland
- Unbranched = Simple Gland
- Branched = Compound Gland
- Tubular Secretory parts – Tubular Glands
- Rounded Secretory parts – Acinar Glands

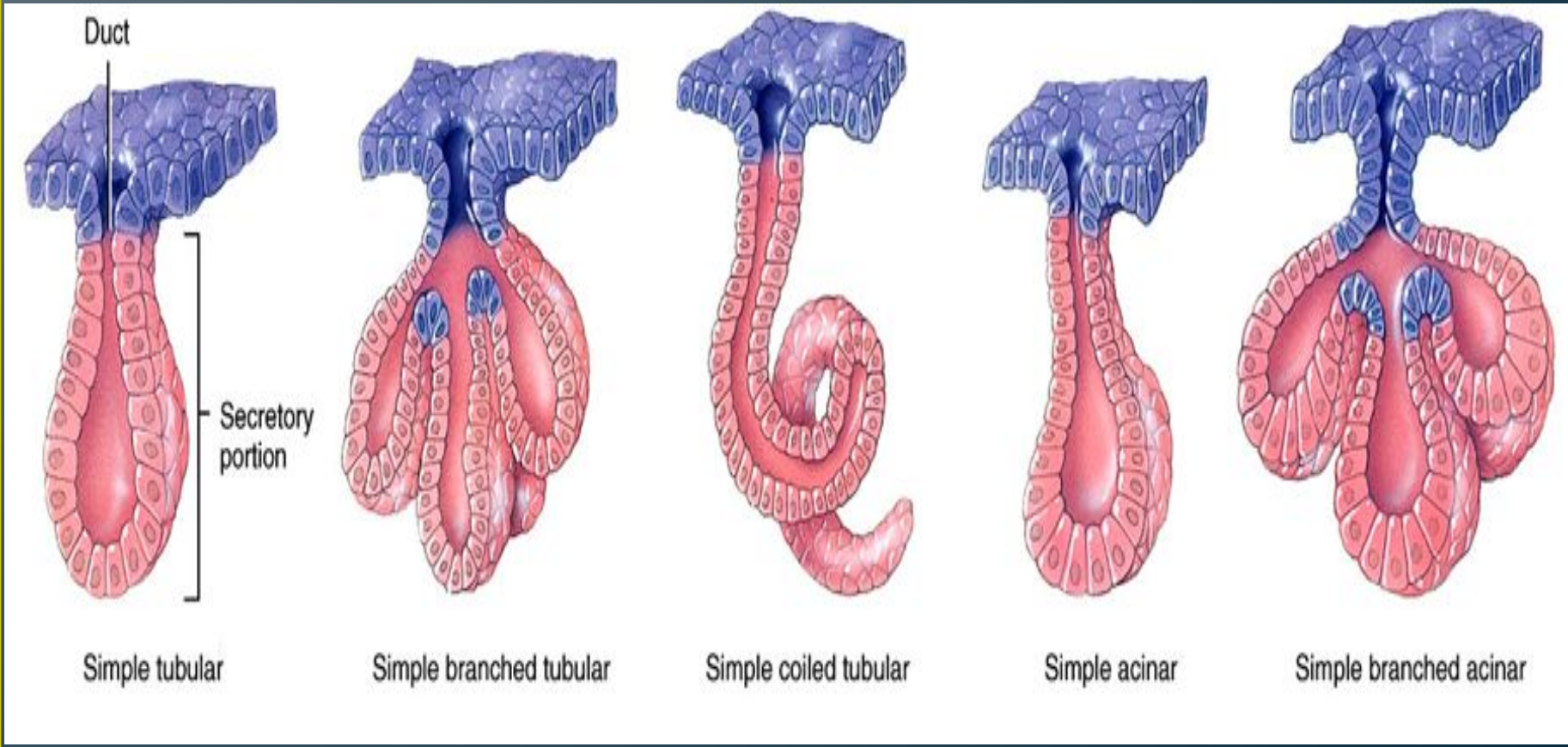
Structural Classification scheme

- Combinations of the structural features are the criteria for classification of multicellular exocrine glands
- Simple Glands
  - **Simple Tubular** – secretory part is straight and attaches to a single unbranched duct. Ex – glands in large Intestine
  - **Simple coiled** – tubular portion coiled, single unbranched duct. Ex – Gastric Duct

Simple Glands Continued

- **Simple Acinar** – Secretory portion is rounded, attaches to a single unbranched duct. Ex glands of the male urethra
- **Simple Branched Acinar** – Rounded secretory portion is branched and attaches to a single unbranched duct. Ex Sebaceous glands

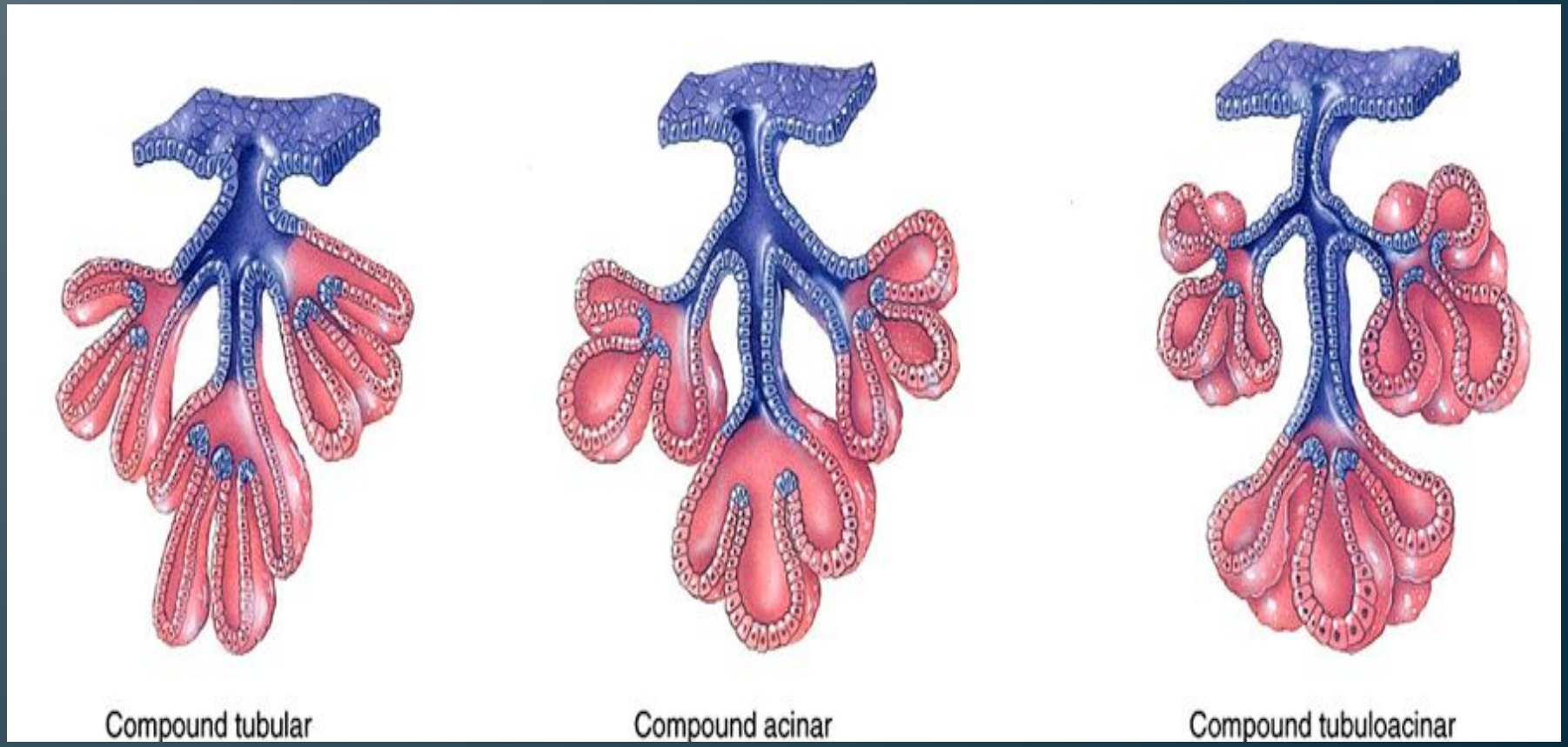
Simple Glands



Compound Glands

- **Compound Tubular** – Secretory portion is tubular and attaches to a branched duct. Ex Cowper's Glands (located beneath the prostate gland)
- **Compound Acinar** – Secretory portion is rounded and attaches to a branched duct. Ex mammary glands
- **Compound Tubuloacinar** – Secretory portion is both rounded and tubular and attaches to a branched duct. Ex Acinar glands of the pancreas

Compound Glands



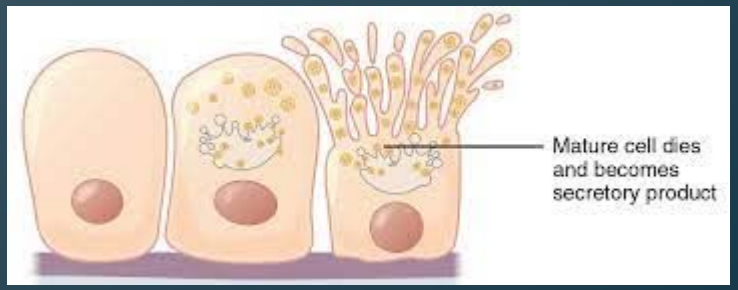
Functional Classification of Exocrine Glands

- The criteria for categorizing multicellular glands according to function is based on the manner in which the gland secretes its product from inside the cell to the outside environment.
- 1-Merocrine
- 2-Apocrine
- 3-Holocrine

Holocrine Glands

- Accumulate Secretory substance in the cytosol. As the cell matures it ruptures and becomes the product
- Contains a large amount of lipids and intracellular membranes
- Sloughed of and replaced with a new one
- Ex Sebaceous gland of the skin

https://youtu.be/A3An8mGcC-I

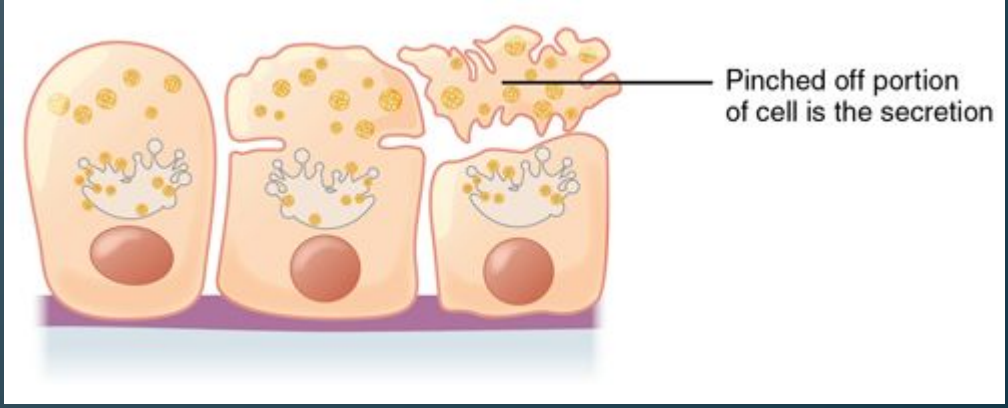


Apocrine Glands

The top (Apical) part of the cell gets pinched off as the secretion is released.

Eg. Mammary glands

Eg. Apocrine sweat glands - the kind found in areas with many hair follicles such as armpits and groin

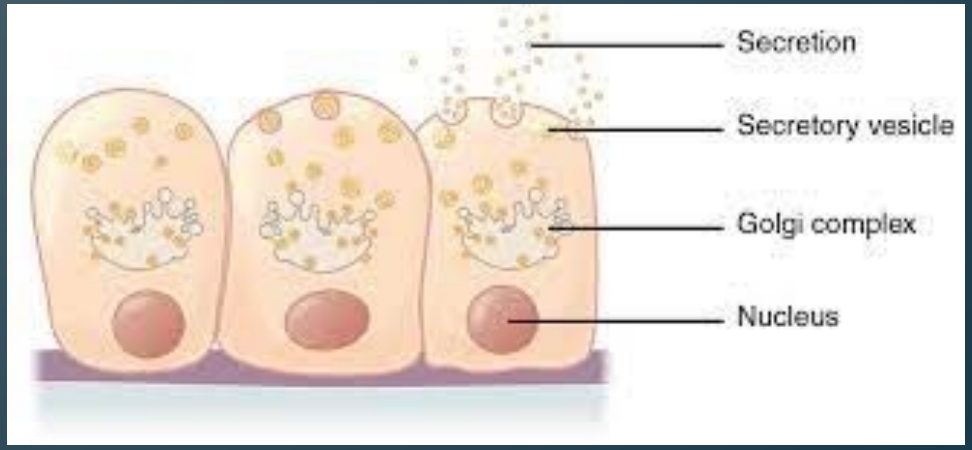


Merocrine Glands

The glands secretions are released by exocytosis with no damage to the cell.

The most common type of exocrine gland

Eg. Salivary glands, pancreatic glands, Eccrine sweat glands (the kind that is less smelly & sweat is more watery)



Epithelial Membranes

Epithelial Membranes

- Combining two tissues creates an organ. However, most of the organs and organs systems contain 4 basic types of tissues
- Epithelial membranes are the simplest organs in the body, constructed of only epithelium and a little bit of connective tissue. They include
  - Mucous membranes
  - Serous membranes
  - Cutaneous membrane = skin

Mucous Membrane

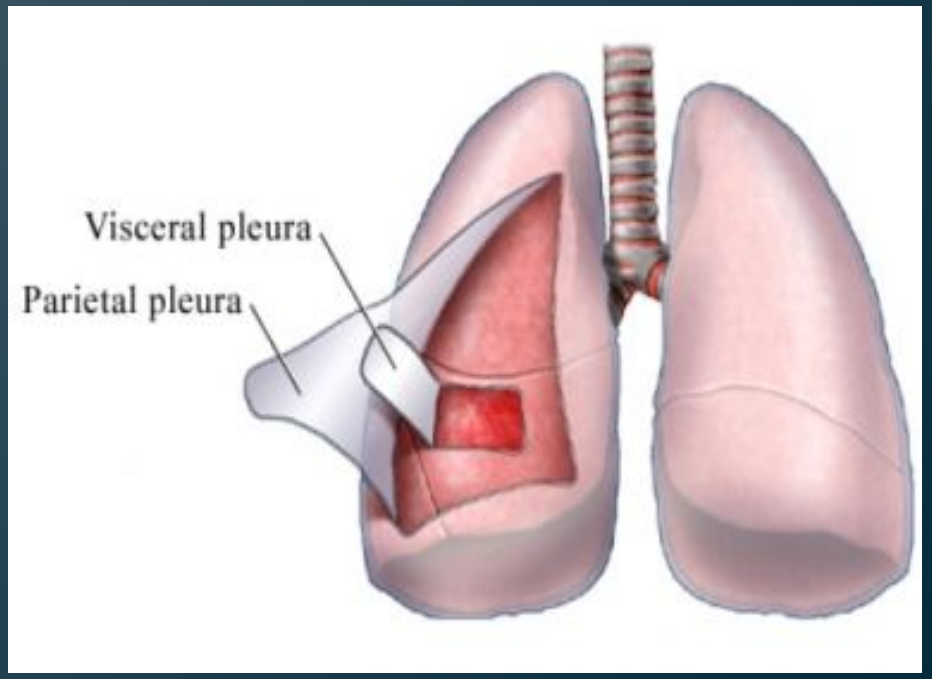
- line “interior” body surfaces that open to the outside:
  - Digestive tract
  - Respiratory tract
  - Reproductive tract
  - Much of the urinary tract
- Consist of a layer of epithelium and underlying layer of connective tissue
- Important in immunity – pathogens have difficulty getting past
- Mucous, and enzymes can be secreted by cells in the membrane
- Diffusion of waste and nutrients pass between the epithelial and connective tissue layers

Serous Membranes

- Serous membranes line cavities that do not open to the outside of the body:
  - Thoracic Cavity, abdominal cavity
- It also covers organs that are within the cavity
  - Parietal layer connects to the cavity wall
  - Serous fluid between layers
  - Visceral layer connects to organ
- Simple squamous epithelium (mesothelium) and areolar connective tissue
- Mesothelium secretes serous fluid – allows gliding of organs on each other and cavity wall

Examples

- Covering lungs – Pleural Cavity
- Covering heart – Pericardium
- Covering thoracic cavity - Peritoneum



Cutaneous Membranes

- SKIN
- Covers entire surface of the body
- 2 main layers
  - Epidermis – Keratinized stratified squamous epithelium
  - Dermis – dense irregular CT & Areolar CT

Synovial Membranes

- Lack Epithelial Cells
- Line structures that do not open to the outside
- Composed of discontinuous layer of cells called synoviocytes (located closer to joint space) and a deep layer of alveolar and adipose CT
- Synoviocytes secretes some components of synovial fluid

Connective Tissue

Connective Tissue

- Connective Tissues are the most abundant and widely distributed tissues in the body. They perform numerous functions:
  - Bind tissues together
  - Support and strengthen tissue
  - Protect and insulate internal organs
  - Compartmentalize and transport
  - Energy reserves and immune responses

General Features of Connective Tissue

- Consists of 2 basic elements
  - Extracellular matrix and cells
- Extracellular matrix
  - Material located between the widely spaced cells
  - Consists of protein fibres (primarily collagen) and ground substance
  - Fibres are secreted by connective tissue cells and account for functional properties of the tissue
  - Structure determines tissue qualities, ex cartilage firm but pliable, bone hard and inflexible

General Features Continued

- Does not usually occur on body surfaces
- Usually highly vascular except cartilage which is avascular and tendons very little blood supply
- Most CT is well supplied with nerves except for cartilage

Connective Tissue Cells

- Mesenchymal cells give rise to Connective Tissues
- Each major type of connective tissue contains immature "blast cells". They retain capacity for division and secrete extracellular matrix
  - EX loose & dense connective tissue – Fibroblasts; cartilage – Chondroblasts; Bone – Osteoblasts
- Once the matrix is produced they mature and differentiate into "cytes"
  - Fibrocytes, chondrocytes & Osteocytes
  - Mostly involved in monitoring and maintaining matrix

Types of Cells

- Vary according to tissue type and include the following
  - Fibroblasts – present in all general CT, usually most numerous, secrete fibres and components of ground substance
  - Macrophages – Develop from a monocyte, capable of engulfing bacteria and cellular debris. Fixed stay in a particular tissue, Wandering move throughout the tissue

Types of CT cell - in the blood

- Plasma Cells – Develop from a B lymphocyte (WBC) – Secrete antibodies, most reside in connective tissue especially in GI and Respiratory Tracts
- Mast Cells – Abundant along blood supply of CT, produce histamine as part of the inflammatory response, can bind, ingest and kill bacteria

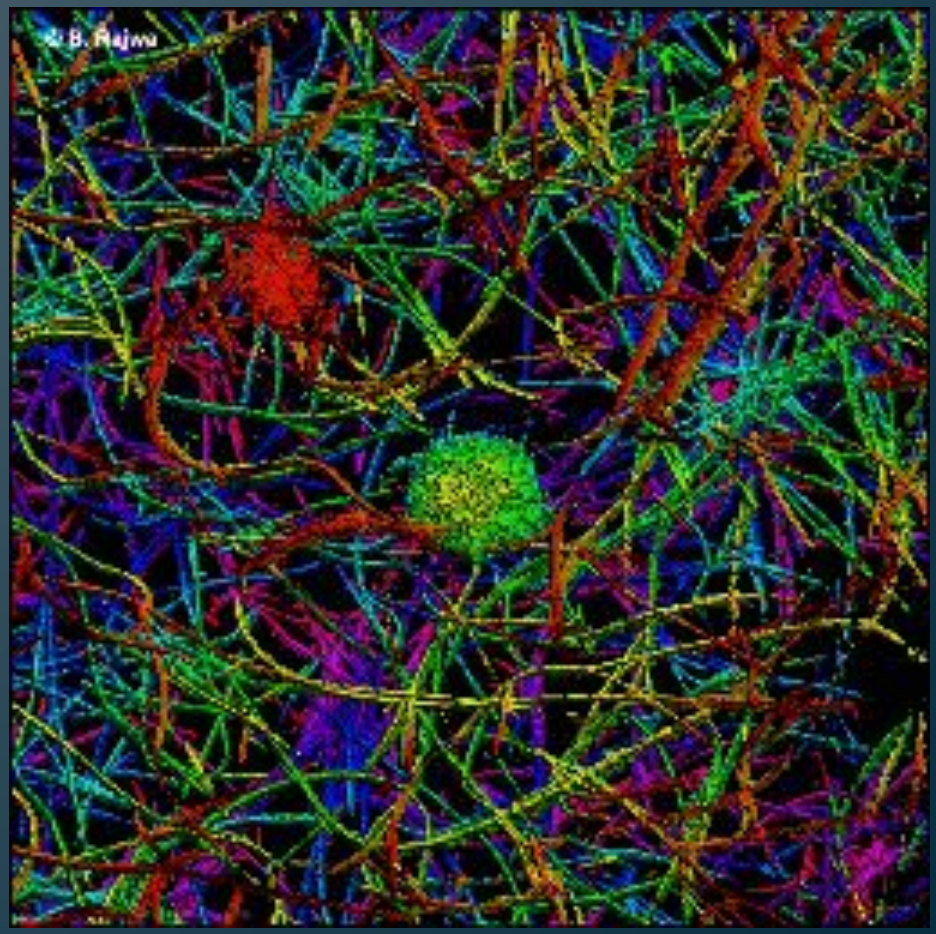
Types of cells continued

- In the blood:
- Leukocyte – White Blood Cells – not found in significant numbers in normal CT. Can migrate in response to certain conditions.

- In the Adipose tissue:
- Adipocytes – Store triglycerides, found deep to skin as well as around the organs (heart and kidneys)

Extracellular Matrix revisited

- 2 major components
  - Ground substance
  - Fibres



Ground Substance

- Found between cells and fibres
- May be fluid, semifluid, gelatinous or calcified
- Functions include
  - Supports cells
  - Binds cells together
  - Stores water
  - Area for substance exchange b/w blood and cells
  - Role in how tissues develop, migrate, proliferate, change shape and carry out metabolic function

Ground substance make up

- Large organic molecules including
  - Polysaccharides and protein, many combinations
- Polysaccharides include
  - Chondroitin sulfate
  - Keratan Sulfate
  - Known as GAGs Glycosaminoglycans
- GAGs associated with proteins are Proteoglycan
- **Hyaluronic acid** – Viscous, slippery substance that binds cells together, lubricate joints and maintain eyeball shape
- **Adhesion proteins** – links components of ground substance to each other and cell surfaces ex Fibronectin

Fibers

- 3 types embedded in the Extracellular matrix
  - Collagen fibers
  - Elastin fibers
  - Reticular fibers
- **Collagen** – Very strong and resist pulling but are not stiff which allows flexibility.
- **Elastin** – smaller diameter than collagen, form a fibrous network in the tissue, add strength and stability but can be stretched 150 times their relaxed length w/o breaking and can return to their original shape
- **Reticular** – collagen arranged in fine bundles with a glycoprotein coating, support walls of blood vessels, form an network around the cells in some tissues, thinner than collagen, help form the basement membrane

Classification of Connective Tissue

- Not always clear cut due to diversity of cell and extracellular matrix
- Several classifications exist
- Embryonic Connective Tissue
  - Mesenchyme
  - Mucous connective tissue
- Present primarily in the embryo to birth

Mature Connective Tissue

- Mature connective tissue
  - **Loose connective tissue**
    - Areolar connective tissue
    - Adipose tissue
    - Reticular connective tissue
  - **Dense Connective Tissue**
    - Dense regular connective tissue
    - Dense Irregular connective tissue
    - Elastic connective tissue

Mature Connective tissue continued

- **Cartilage**
  - Hyaline cartilage
  - Fibrocartilage
  - Elastic Cartilage
- **Bone Tissue**
  - Compact
  - Spongy
- **Liquid Connective Tissue**
  - Blood Tissue
  - Lymph

Loose Connective Tissue

- **Areolar Connective Tissue -** is the most widely distributed in the body. It contains several types of cells and all three-fiber types. It is used to attach skin and underlying tissues, and as a packing between glands, muscles, and nerves.
- **Adipose tissue -** is located in the subcutaneous layer deep to the skin and around organs and joints. It reduces heat loss and serves as padding and as an energy source.
- **Reticular connective tissue -** is a network of interlacing reticular fibers and cells. It forms scaffolding used by cells of lymphoid tissues such as the spleen and lymph nodes

Dense Connective Tissue

- **Dense Irregular** Connective Tissue consists predominantly of fibroblasts and collagen fibers randomly arranged. It provides strength when forces are pulling from many different directions
- **Dense regular** Connective Tissue comprise tendons, ligaments, and other strong attachments where the need for strength along one axis is mandatory.
- **Elastic Connective Tissue** consists predominantly of fibroblasts and freely branching elastic fibers.It allows stretching of certain tissues like the elastic arteries (the aorta).

Cartilage

- **Hyaline cartilage** is the most abundant type of cartilage; it covers the ends of long bones and parts of the ribs, nose, trachea, bronchi, and larynx. It provides a smooth surface for joint movement.
- **Fibrocartilage** with its thick bundles of collagen fibers, is a very strong, tough cartilage. Fibrocartilage discs in the intervertebral spaces and the knee joints support the huge loads up and down the long axis of the body.
- **Elastic cartilage** consists of chondrocytes located in a threadlike network of elastic fibers. It makes up the malleable part of the external ear and the epiglottis.

Bone, Blood and Lymph

- Bone
  - calcified intracellular matrix. In the right circumstances, the chondrocytes of cartilage are capable of turning into the osteocytes that make up bone tissue.
- Blood and lymph
  - An atypical liquid connective tissues. As we have seen, blood has many cells. It also has fibers (such as fibrin that makes blood clot).

Muscular Tissue

Muscular Tissue

- Elongated cells called muscle fibers or Myocytes
- Uses ATP to generate force
- Provides protection
- Classified into 3 Types
  - Skeletal
  - Cardiac
  - Smooth

Nervous Tissues

Nervous Tissue

- Consists of 2 types of cells
  - Neurons
  - Neuroglia
- Neurons (nerve cells)
  - Convert stimuli into action potentials (nerve impulses)
  - Contains dendrites, cell body and axons
- Neuroglia
  - Do not generate or conduct nerve impulses
  - Provide supportive functions

Excitable Cells

- Neurons and muscle fibers are considered excitable cells because they exhibit electrical excitability, the ability to respond to certain stimuli by producing electrical signals such as action potentials.
- Action potentials can propagate (travel) along the plasma membrane of a neuron or muscle fiber due to the presence of specific voltage-gated ion channels.

Tissue Repair

Tissue Repair

- A convenient way to refer to certain cells when discussing a tissue is Parenchyma or Stroma.
- Parenchymal cells of an organ consist of that tissue which conducts the specific function of the organ.
- Cells of the stroma are everything else—connective tissue, blood vessels, nerves.
- For example: The parenchyma of the heart is cardiac muscle cells. The nerves, intrinsic blood vessels, and connective tissue of the heart comprise the stroma.

Repair Continued

- When tissue damage is extensive, return to homeostasis, depends on active repair of both parenchymal cells and stroma.
  - Fibroblasts divide rapidly
  - New collagen fibers are manufactured
  - New blood capillaries supply materials for healing
- All of these processes create an actively growing connective tissue called granulation tissue

https://youtu.be/WIo8Yeupdfg

Tissue and aging

Tissue and Aging

- Tissue heals faster in young adults.
- Surgery of a fetus normally leaves no scars.
- Young tissues have a better nutritional state, blood supply, and higher metabolic rate.
- Extracellular components also change with age.
- Changes in the body's use of glucose, collagen, and elastic fibers contribute to the aging process.