Histology

faculty of medicine - JU2017

◉ Sheet ○ Slides

Number

3

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Epithelial Tissue

(Epi : upon + thele : nipple) -

Review Notes:

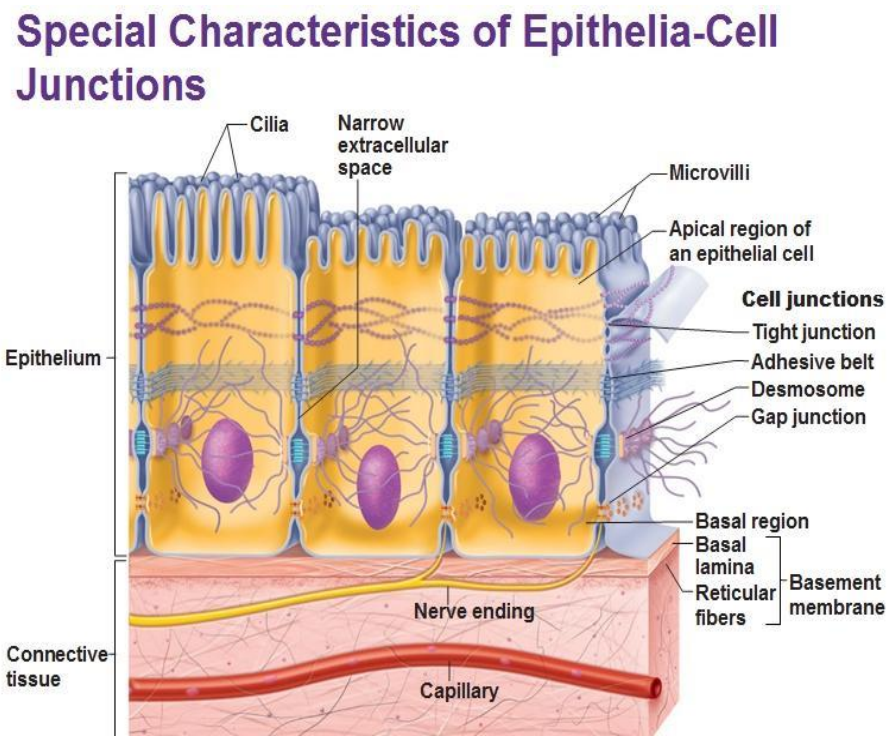
- Histology studies normal tissues, whereas pathology studies abnormal tissues.
- Histology is the field that deals with microanatomy (structures seen under a microscope)
- Gross anatomy is like histology, but studies macroscopic structures (seen with the naked eye)
- Our body has over 200 types of specialized cells
    - All cells make up only 4 tissues: Epithelial, Connective, Muscular, and Nervous
    - Each of those tissues are assembled from a group of specialized cells performing a specific function
- Levels of organization:
  Cells → Tissues → Organs → Organ Systems → Human Body
- Histology is important because when you are talking to patients and examining their body, you are ultimately dealing with their tissues!
- To clarify specific structures in histology, we use stains
    - Most commonly used stains are hematoxylin and eosin (H & E)

Structure of Epithelial tissue:

- Epithelial cells are packed tightly together to form a separating (isolating) wall.
- If this were not the case, epithelial tissue would form a net-like structure instead of forming a barrier between different compartments within our body
- Therefore, minimal amount of intercellular space exists between epithelial cells

Features of the epithelial tissue:

1. **Cellularity:** Epithelium tissue is made up of cellular sheets composed of numerous, closely packed cells (little or no intercellular spaces). Connective tissue, when compared with epithelial tissue, has a lot more ECM (extracellular matrix) components, and its cells are more dispersed.



2. **Specialized Contact:** Intercellular junctions exist between lateral surfaces of neighboring cells. Junctions could be used for both attachment and communication with other cells.

3. **Polarity:** Cells have two poles because of the existence of different structures. Due to the polarity of epithelial cells, specialized functions take place at each end. The upper surface is called the *apical surface* and lower is the *basal surface*. The surfaces that adjoin neighboring cells are *lateral surfaces "4 surfaces away from the nucleus"* (Domain = Surface). Each domain shows modifications that suit its function. Because of that, *membrane proteins* and *organelles* are distributed ***unevenly*** within the cell.

   We do not use anterior and posterior to describe cells

   E.g. The apical surface has specific proteins working as receptors (these proteins are not on other surfaces). On the other hand, the basal surface of intestinal cells has a lot of mitochondria working to regenerate ATP, which is used for transporting food molecules to blood.

   How do we know polarity exists? When using H & E, the apical pole stains differently from the basal pole (because their components are different).

4. **Avascular tissue:** Does not contain blood vessels. Epithelial cells receive nutrients and oxygen by <u>diffusion</u> from the arteries inside the connective tissue. How? The pressure inside arteries is around 120 mmHg, high enough to cause molecules to diffuse. The connective tissue underlying epithelial cells is called *laminar propria.*
   - Do epithelial cells gain access to nutrients from blood? **<u>YES</u>**
   - Do blood vessels go through epithelial cells? **<u>NO</u>**

5. **Richly innervated cells:** Innervation takes place from the basal surface, increases sensitivity.

6. **Rests on a basement membrane:** A thin extracellular "carpet" of macromolecules where epithelial cells grow on to form a barrier. The basement membrane also serves as a semipermeable filter to substances reaching epithelial cells from below. It is composed of two layers: *basal lamina* (network of fine fibrils) which lies on top of a *reticular lamina* (more diffused and fibrous)

7. **High Capacity for Regeneration:** We continuously lose epithelial cells due to friction, so they are continuously regenerated because of the high supply of blood. This increases the risk of <u>cancer</u> in this tissue because during <u>cell divisions</u>, many <u>mutations</u> can occur and cause tumors. The benefits of this feature, however, is the short time required for healing wounds.

<u>An Example: The Skin</u>

1. The skin must be packed with cells, closely and tightly attached to each other, with minimal intercellular spaces, so water and other substances cannot penetrate it.
2. The skin interacts with the external environment of the body and needs to withstand friction.
3. Epithelium covers the skin while other epithelium lines organs like the esophagus (protection).
4. The skin is highly sensitive.

Functions of Epithelial tissue:

- Covers, lines, and protects different surfaces within our body (e.g. epidermis, stomach, uterus, and lungs)
  - This epithelial function is possible due to the tight packing of epithelial cells.
- Absorption (e.g. the intestinal lining)
  - Epithelial cells can highly regulate what goes in/out of cells
- Secretion (e.g. mucus secretions in the digestive and respiratory systems,
  - Parenchymal cells of glands

- Parenchymal cells are cells (part of an organ) responsible for the organ's specific functions (make up the "bulk" of an organ)

*****Highly specialized cells of epithelia may be contractile or sensory cells.

Classification of Epithelium:

1) According to the <u>number of layers</u>:

a. Simple epithelium: one layer of cells (e.g. *kidney tubules).*

b. Stratified epithelium: more than one layer of cells, (e.g. *epidermis*). Mitotic activity in stratified epithelium is limited to the basal layer (under normal conditions).

2) According to the <u>shape of cells on the outermost layer</u>:

a. Squamous cells: square-like cells *wider than they are tall* (flattened nuclei).

b. Cuboidal cells: cube-like cells where *width and height are nearly equal* (spherical nuclei).

c. Columnar cells: column-like cells *taller than they are wide* (elongated nuclei).

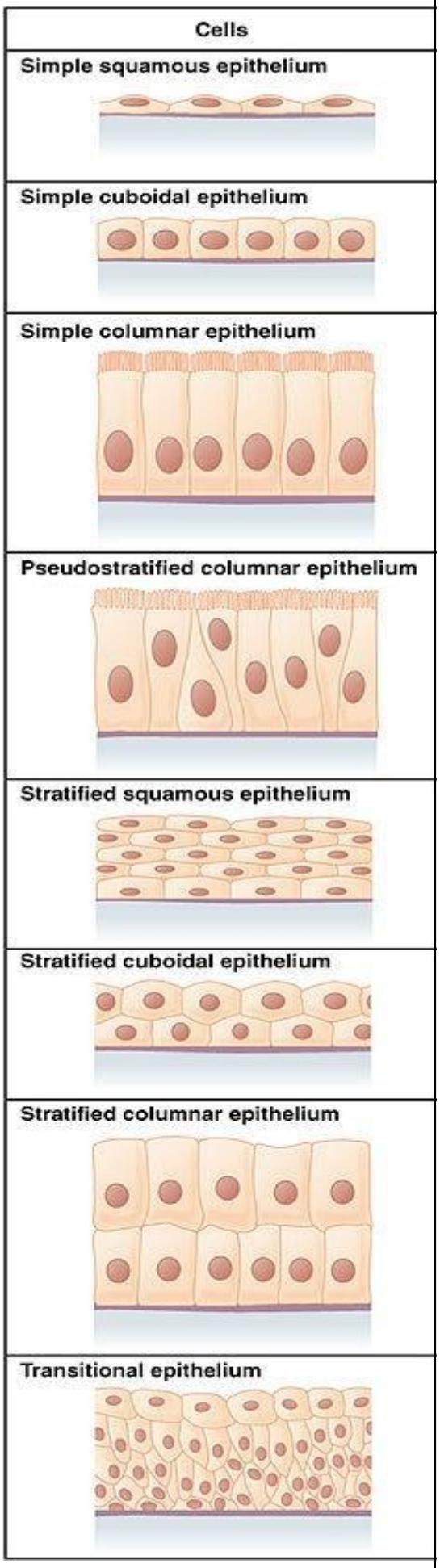
d. Special types:

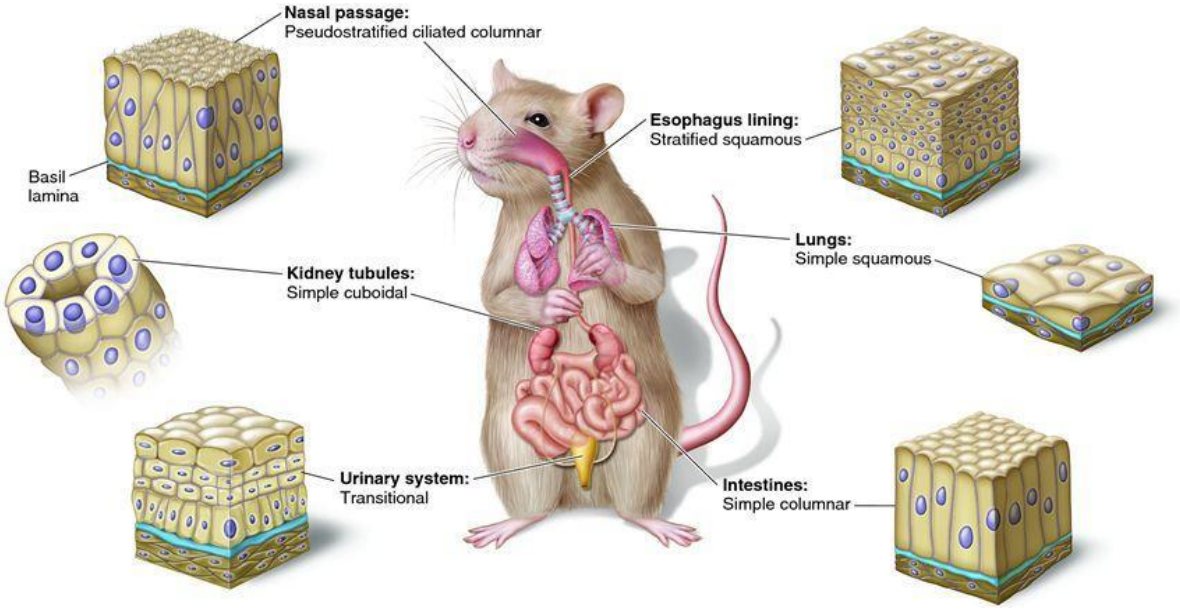
- Pseudostratified (simple) has two cells at the same level: one is big, the other is small. The larger cell can be ciliated or non-ciliated.
  - Nuclei are at different heights, appears to be stratified.
- Transitional (stratified): Can stretch when needed.

Naming of epithelium:

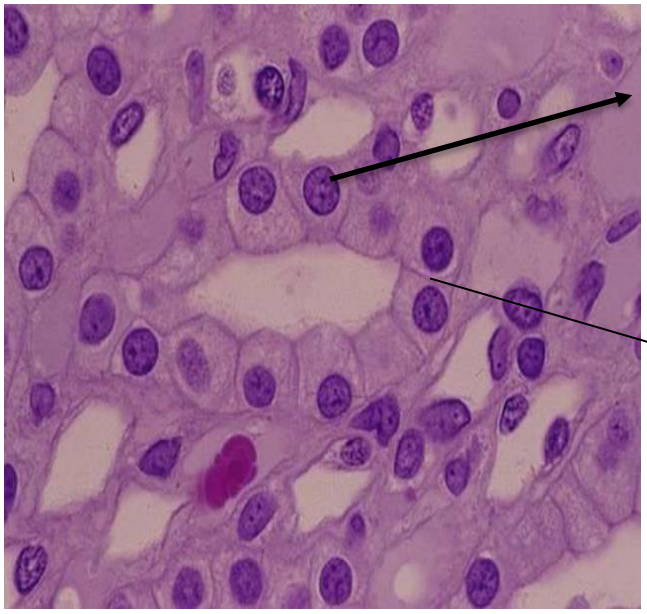
- The name should contain the number of layers first, then the shape of cells.
- E.g. simple columnar epithelium, stratified squamous epithelium.
- Some types of epithelium have more specific features.
- For example:

- Simple columnar can be <u>ciliated</u> or <u>non-ciliated</u> cells.
- Stratified squamous could be <u>keratinized</u> or <u>nonkeratinized</u> cells.





*Nuclei (stain evidently) help us determine the number of layers and the type of tissue because it isn't easy to stain and observe such thin structures (e.g. plasma membrane) using a light microscope.



Nucleus (prominent color): one layer of cells

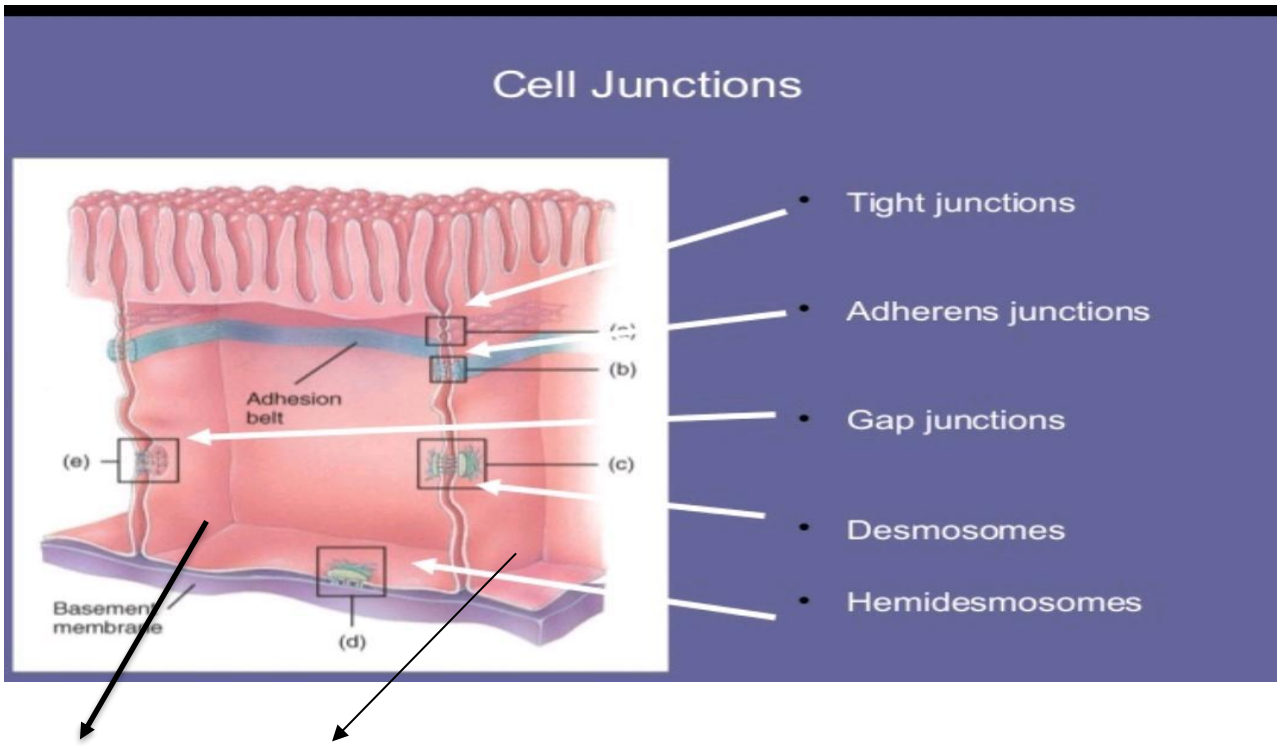
Lateral domain

Most of the stratified epithelial tissue is squamous because they are flat and can be stacked easily

LATERAL DOMAINS and JUNCTIONS

- Using **light microscopy**, histologists noticed that parts of the cell membrane in the lateral domain have been specifically stained "with pink color".
    - They concluded this pink structure is the substance that binds cells together
- They attributed the binding of cells to the presence of a <u>viscous adhesive substance</u>, which is called *intercellular cement*
- This hypothetical substance seemed to explain the close apposition of epithelial cells.
- Intercellular cement material is stainable and is visible under a **light microscope**.
- It's located at the apical (terminal) portion of the cell, forming a continuous band around the cell (bar-like)
    - Due to these properties, another name was given to this adhesive: "**terminal bar**"

- Using **electron microscopy**, scientists obtained more details about the nature of these specialized sites that join epithelial cells.
    - The components of terminal bars have been identified frequently with the EM, so as a result, a new name was given: **junctional complexes.**



The types of junctions in <u>the lateral domain:</u>

1. Tight junctions /<u>zonulae occludens</u> (occluding)
2. Adherens junctions /<u>zonulae adherens</u> (anchoring)
3. Desmosome (anchoring)
4. Gap junctions (communicating)
    a. mentioned in the textbook, not in slides

NOTE: *"Zonula indicates that the junction forms a band completely encircling each cell."*

*notice the junctions using transmission electron microscopy (TEM):

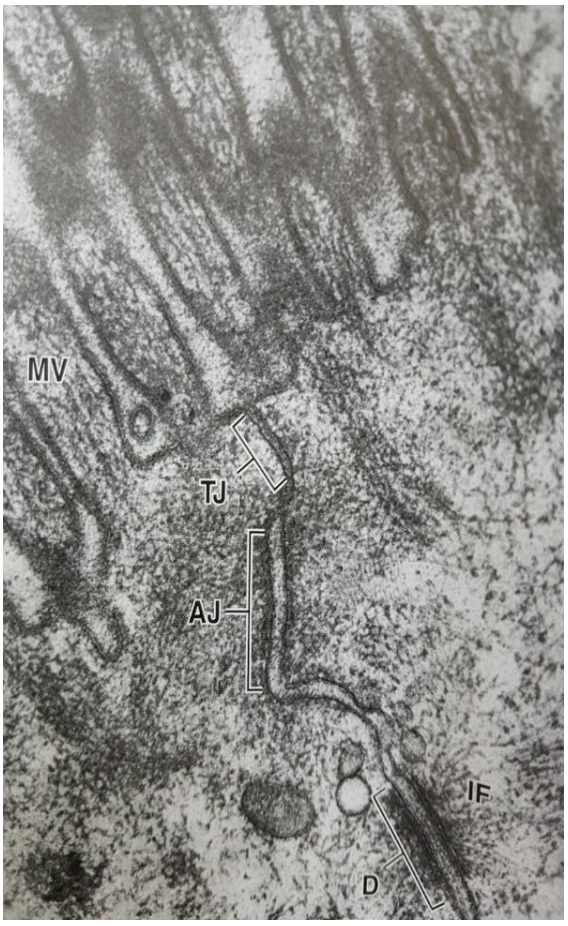
a. MV: microvilli.

b. TJ: tight junctions, the adjacent membranes here appear fused or very tightly bound.

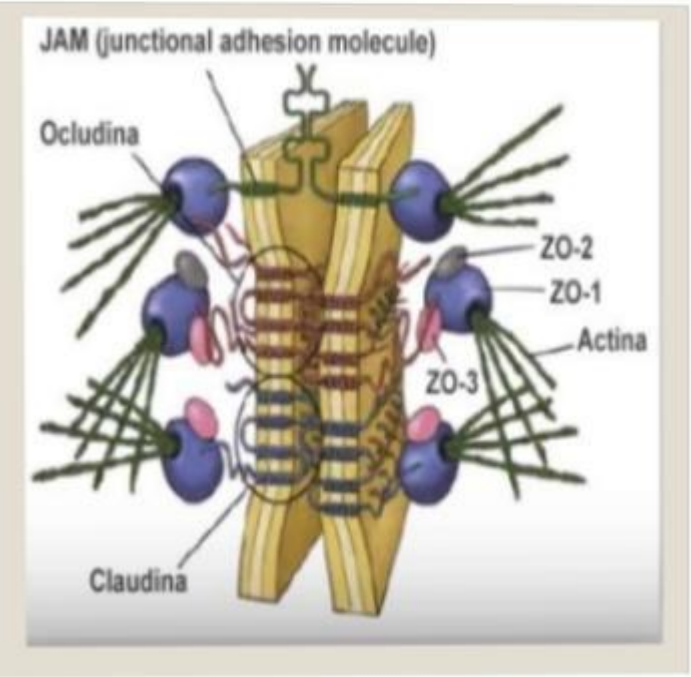
c. AJ: adherent junctions.

d. D: desmosome.

e. IF: intermediate filaments.

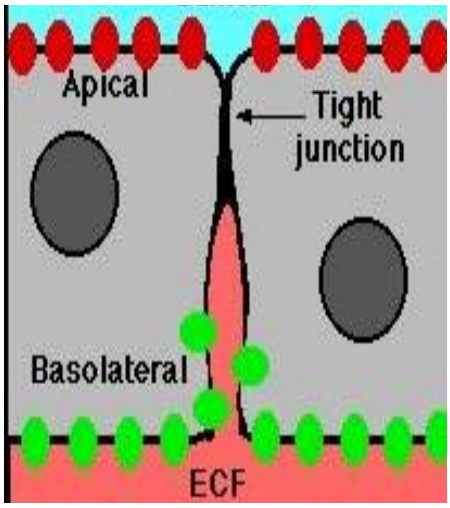


Tight Junctions

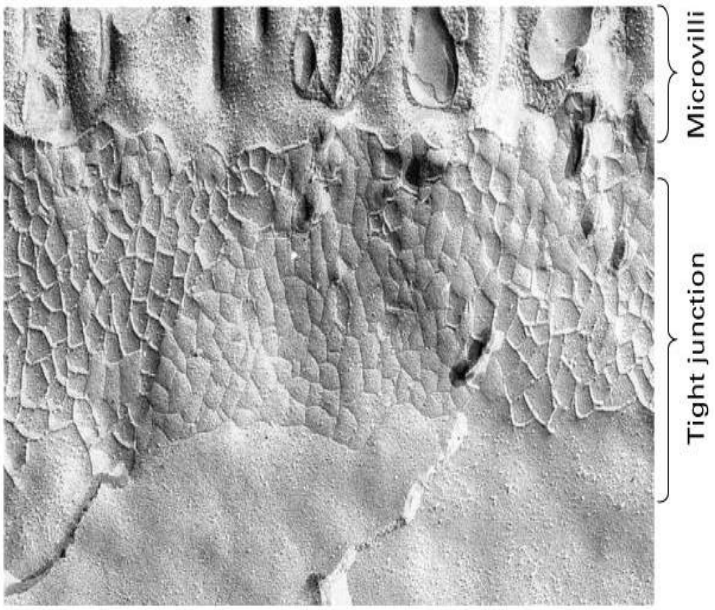


1. The most apical junction between the adjacent cells.
2. Encircles each cell, so it forms a band (zonulae).
3. The molecular structure (major components):
    a. *Occludin*
    b. *Claudin*
    c. *ZO (1,2,3)*

    NOTE: First two protein groups are transmembrane, however ZO proteins are peripheral
4. They form a series of punctate contacts of adjacent epithelial cells near the apical end (luminal surfaces).



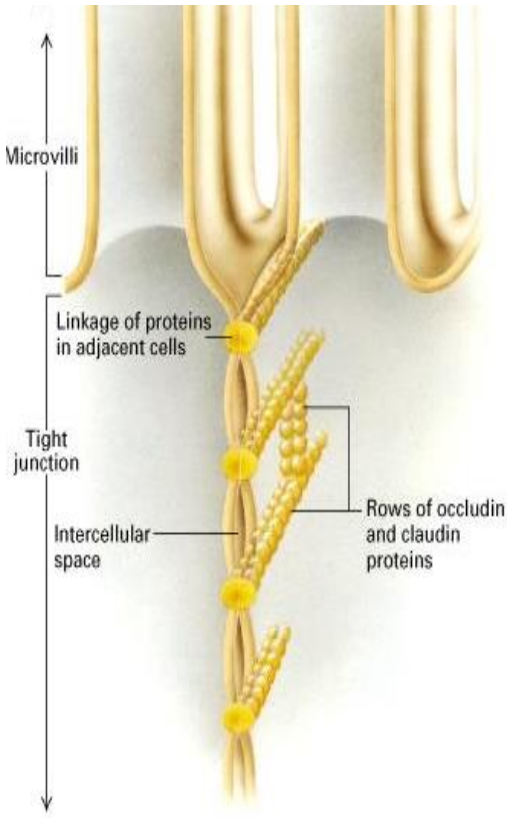
5. How do these proteins work?
   Occludins, *claudin*, and *ZO (1,2,3)* proteins anchor adjacent cells by attaching to the **actin filaments** in each cell.
6. These proteins do not attach to the cell membranes because it's just a lipid bilayer barrier and does not define the cell shape. The Cytoskeleton provides cellular structure, so *proteins need to attach to it.*
7. We use immunohistochemistry techniques and freeze fracture with Zonula Occludins to examine the proteins of tight junction by the transmission electron microscopy (TEM).
   Freeze fracture in this figure reveals ridges in membranes that correspond to sites of contact between cells
    a. Ridges are linear arrays of occludin and claudin proteins .



8. **The number of tight junctions increases a lot** in the epithelia which is in contact with fluids that must not enter the tissue.
    a. Examples are in **the stomach, intestine** and **lining of the urinary**

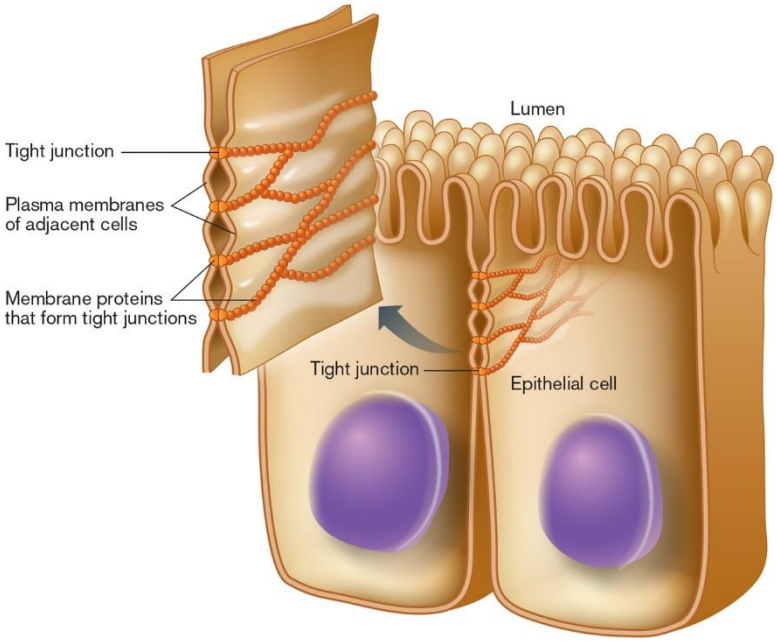
bladder. Many fused strands between cells (tight junctions) inhibit the passage of substances and prevent the contents of these organs from leaking into other tissues.

9. **The number of tight junctions decreases** in the epithelia who's function is filtration
    a. Examples include the **proximal renal tubule**, where fewer tight junctions allow certain fluids and substances to enter and leave epithelial tissue easily.
    b. Hence, in this location, epithelial tissue is more permeable to water and solutes.
10. If molecules pass an epithelium tissue by going **through** the cell, we consider that a **transcellular pathway.** This occurs under normal conditions, where proteins carry molecules into the cell using ATP.
11. Tight junctions could also increase intercellular spaces, allowing for a **paracellular pathway** which enables molecules to enter **between** cells.
12. Tight junctions are regulative barriers, in which some occludins and claudins have pores that allow selective paracellular movement of ions and solutes.



Overall:

- Tight junctions contribute to epithelial tissue's function as a barrier because they only allow certain molecules to go through the cell
- They are considered the primary intercellular diffusion barrier between adjacent cells
- Epithelial tissue helps in forming compartments (established due to their selective permeability for certain molecules)
- Tight junctions are present at the apical ends of a cell, thus, its presence prevents the migration of lipids and specialized proteins
    - This apical location of tight junctions maintains the properties of both domains.



Keep in mind: Medicine is hard work ♡💪