



Histology

faculty of medicine - JU2015

LECTURE#4

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EPITHELIUM TISSUE

Part 2

#Apical features of epithelial cells:

*the apical surface can have modifications like:

1-Microvilli

2-Cilia

3-stereocilia

4-flagella

1) Microvilli (cytoplasmic extensions)

*In cells such as those lining the small intestine, apical surfaces are densely covered with microvilli

-Function: increase the surface area

-Under LM: They are visible as a brush or striated border.

-Under EM: finger-like cytoplasmic extensions covered by a layer of glycocalyx

*in kidney tubules it's called brush border

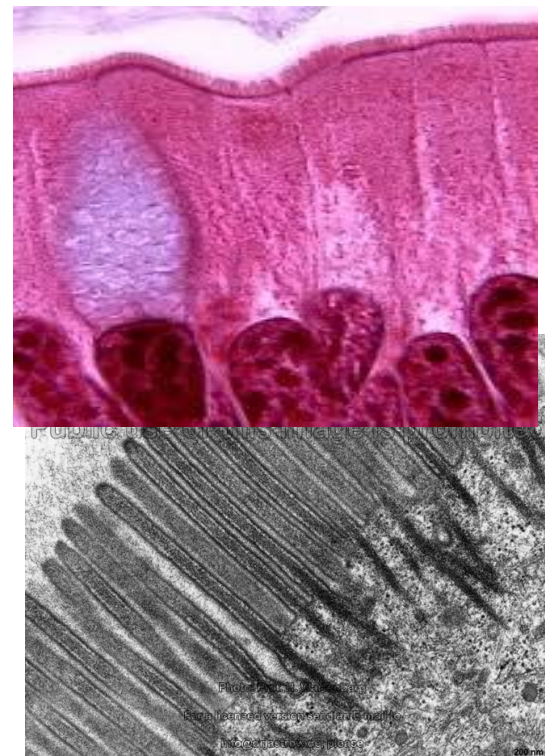
in intestine it's called striated border

- Each microvillus is 1µm long and 0.1µm wide

The core protein is actin filaments and other associated proteins

-**Terminal web:** Network of cytoskeletal elements (actin filaments, intermediate filaments and other proteins) in the apical cytoplasm, microvilli are inserted into these filaments

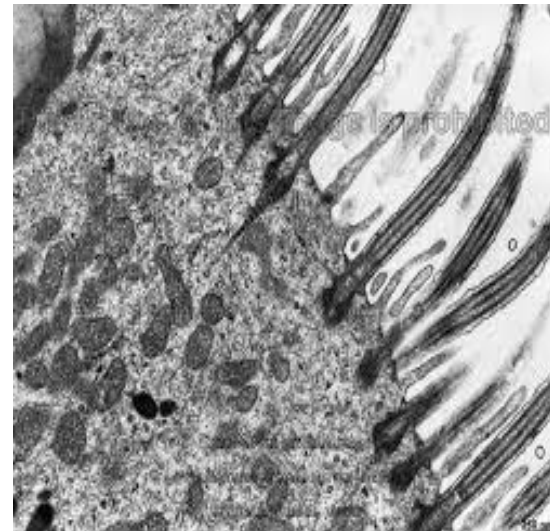
-microvilli are non-motile structures but they are dynamic structures (they become longer or shorter depending on the cell activity)



Summary:

Microvilli

- Present mainly in absorptive cells.
- Their number and size vary according to the degree of activity of the cell.
- They are usually crowded on the cell apex forming the **striate border** in the intestine and the **brush border** in the kidney.
- Each microvillus contains a core of 25-30 actin filaments.
- Actin filaments are cross-linked with villin.
- The actin filaments are inserted into the **terminal web**.
- The terminal web is a network of actin and spectrin supported by myosin, IF, and camodulin in the apical part of the cell.
- The microvillus is covered by **glycocalyx**.

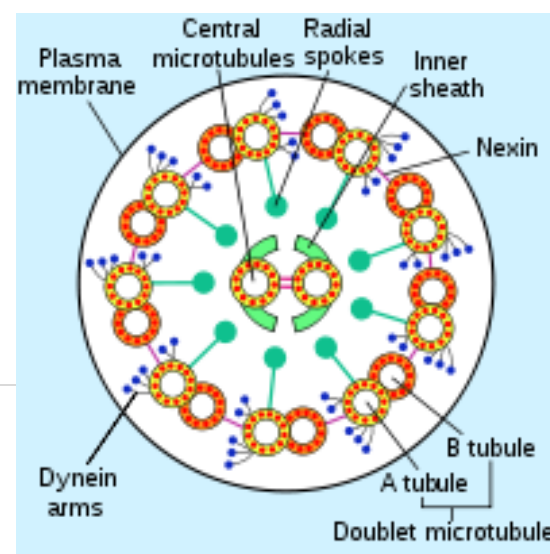


2) Cilia (cytoplasmic extensions from the apical surface)

- Motile cytoplasmic hair like projections capable of moving fluid and particles along epithelial surfaces.
- **Measurements**: length 5-10 μ , diameter 0.2 μ .
- Number of cilia/cell is variable and ranges 1-300 cilium/cell.
- They move rhythmically and rapidly in one direction.
- longer and larger than microvilli
- more widely separated (less number than microvilli per cell)

-visible under LM (hair like projections)

- The core of the cilium is called **axoneme**.



- The axoneme consists of longitudinal microtubules arranged as 9 (doublets) peripheral surrounding 2 (singlets) central (9+2).
- The singlets are separated by 13 protofilaments.
- The doublets are composed of 2 subunits A & B.
- Subunit A is formed of 13 protofilaments.
- Subunit B is formed of 10 protofilaments.
- Neighboring doublets are connected by nexin.
- Doublets are connected to the singlets by radial spokes.
- Dynein radiates from subunit A to subunit B.
- Dynein has ATPase activity.
- Cilia are attached to basal bodies similar in structure to centrioles

***Basel body:** is a protein structure found at the base of a cilium, which has structure similar to that of centrioles, with triplets of microtubules (9+0). It acts as a nucleation site for the growth of the axoneme microtubules

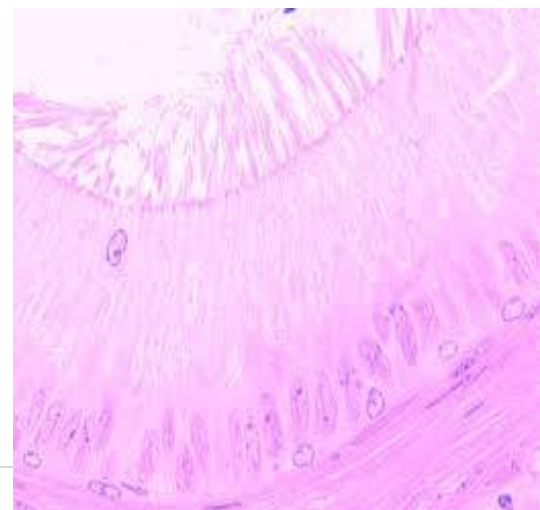
Microvilli increase the surface area, meaning that they are expected to be found in, for example; the intestines, because the main function of the intestine is absorption. While the Cilia is expected to be found in the respiratory tract, since its function is to sweep substances such as mucus that is produced by the goblet cells. Smoking can have a very dangerous effect on the Cilia, because its toxins destroy the Cilia preventing them from getting rid of the mucus, in addition, the number of goblet cells increases in smokers (the mucus secretion is increased), so smokers need to forcefully cough in order to clean their respiratory passageways.

3)stereocillia(stereo=static>>non-motile structure)

-same structure as microvilli

-it called stereocillia because it is longer than microvilli, more widely distributed and could be branched

-the core protein is actin filaments



-it has the same diameters of microvilli

-function: increase the surface area (like microvilli), and other special functions

-found in male reproductive system and the inner ear

* stereocilia are found in the sensory cells of inner ear (important for hearing and balance)

	Microvilli	stereocilia	Cilia
Size	1micrometer in length smaller in diameter	Longer than microvilli , same thickness as microvilli	5-10 micrometer in length thicker than microvilli
function	Increase surface area	Increase surface area	Sweeping the substances over the surface
Core structure	Actin filaments	Actin filaments	Microtubules
location	Cells made for like absorption intestines	Male reproductive system	Respiratory tract
How many per cell	More		Less

#Intercellular junction:

*In order to perform protection function, the epithelial cells should be closely packed and have junctions

-the cell junctions divided into three types:

1) occluding junction (fusion between two plasma membranes of two cells)>>closes the intercellular space, so no material can pass between the cells (most apical junction)

2) anchoring junction>>adhere two cells together, firmly attach two cells

3) gap junctions (channels between cells)>>communication between cells, allow diffusion of small molecules

The three types of junctions in details:-

1) Occluding junction-tight junction>> zonula occludens (zonula=belt)

- Occluding junction forms a band (encircles epithelial cells)
- Barrier to diffusion between cells (paracellular pathway)
- Separates apical and basolateral plasma membranes.
- We said these cells have minimal intercellular spaces, and for the material to pass from the luminal side to the basal side of the cell or to the extracellular fluid, they need to pass either through the cell itself (trans-cellular pathway) or the spaces between cells (para-cellular pathway). Having the tight junction in between the cells, this closes the para-cellular pathway. In this case, the material must pass only through the cell itself in order to reach the extracellular fluid.
- Another function for the tight junction or the occluding junction is that it separates apical and baso-lateral plasma membrane (The outer layer of 2 adjacent plasma membrane) fuse together: Plasma membrane has a lot of integral proteins and receptors. Proteins in general and even phospholipids are in continuous lateral movement within the membrane, and we call this the lateral movement of cell membrane. Having tight junctions prevents the integral proteins from the apical surface to move to the baso-lateral surface. This is why the molecular composition on the apical surface is different from the baso-lateral surface, due to tight junction preventing the lateral movement of proteins

-Functions: 1-closes the intercellular space

2-separate the apical and basolateral domains

-The Structure:

-the cell membrane contains many integral proteins (transmembrane protein)

-every protein contains extracellular domain and intracellular domain

-the interaction between the extracellular domains (ECDs) of two transmembrane proteins forms the tight junction

-Under SEM: the lateral surface of the epithelium cell contains lines/ ridges/ strands>> each strand is a row of transmembrane proteins in both PMs with ECDs joining together

- Occludins and claudins are transmembrane proteins that interact across the intercellular space to form tight junctions
- ZO (zonula occludens) proteins 1-3 link occludin and claudin to each other and to actin filaments

2) anchoring junction

A- Adherens junction >>Zonula adherens

- Anchoring junction (encircles the cell)
- belt junction, or belt desmosome
- Located "under" tight junction in epithelial cells
- Connected to actin microfilaments that join terminal web
- Prevent cells from moving up and down (not side to side movement)
- major transmembrane protein: cadherin proteins>>depend on Ca^{+2}
- Cadherin proteins attach to crosslinked actin filaments
- Mechanical support - ZA and actin filaments transmit and distribute stress throughout cell and to neighboring cells
- Adaptor proteins:Catenin complexes

-the interaction between the extracellular domains of two transmembrane proteins forms the adherens junction

B-Desmosome (spot like junction)

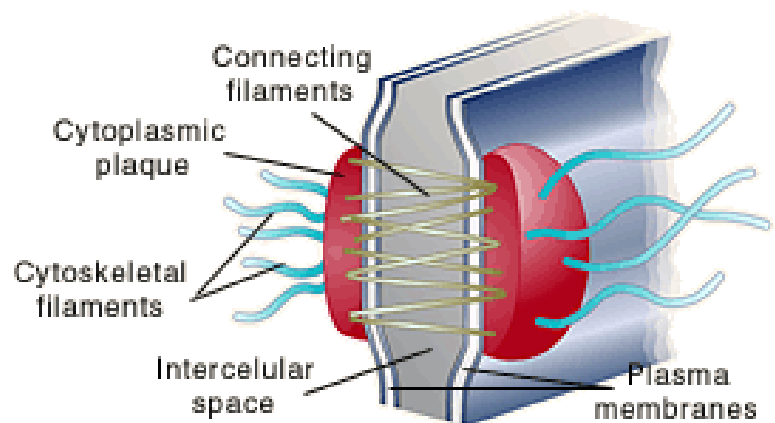
- prevent side to side movement (pulling apart force)
- there is a high amount of desmosome in the epithelium of skin (as skin is subjected to many frictional forces and stresses in different directions)
- Located along lateral plasma membranes of columnar epithelial cells or on processes of squamous cells
- Intermediate filaments associate with plaque proteins in cytoplasm
- Under EM: appears as two discs (plaques) opposing each others

-Major transmembrane proteins:1-desmogleins

2-desmocollin

- desmosome is the strongest junction, because intermediate filaments of the cytoskeleton are strong and desmosomes are distributed in high numbers at the lateral surfaces of the cells

Desmosomes



C-Hemidesmosome(hemi=half)

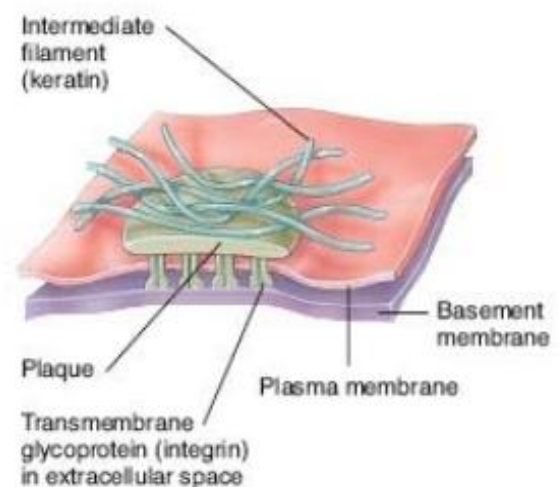
-located between the basal surface of the cell and basement membrane

-Under TEM: one black disc connected to intermediate filaments

- Hemidesmosome - "half-desmosome" in appearance only

- Mediates attachment to basal lamina (extracellular matrix)

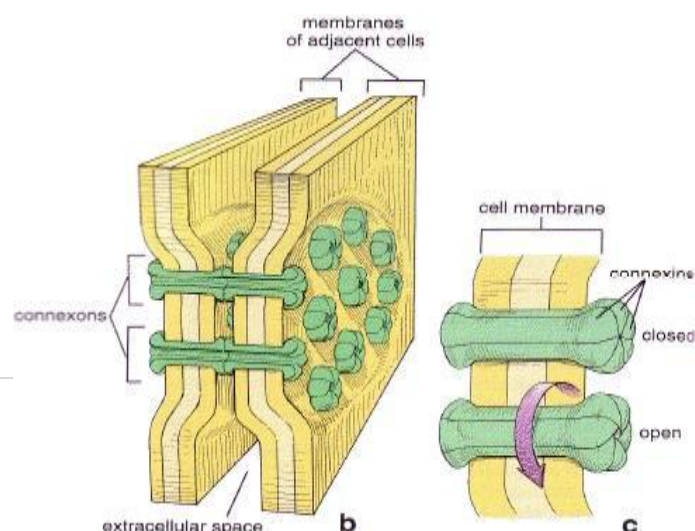
- The extracellular domain of the transmembrane protein is connected to the extracellular matrix (such as collagen,...etc)



Hemidesmosome

- Integrins - membrane protein that "integrates" cell into matrix
- Integrins bind to ECM (laminin and collagen 4)

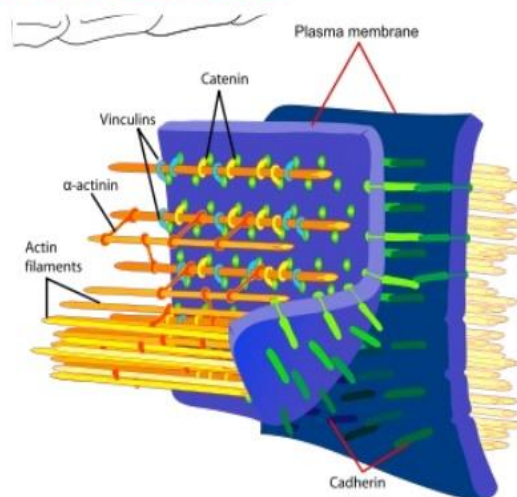
3) Gap junction(communicating junction)



- Channel-forming junction
- Named for gap of regular width between cells visualized by TEM
- Water-filled junctions transport molecules <1 kDal such as ions, nucleotides (including cAMP), and metabolites
- Rapid propagation of action potential from one cell to another cell, the heart must contract as one unit, so its cells have gap junctions
- Connexin - protein subunit, six form a hexameric connexon
- Connexons - two align to form the gap junction channel
- Each connexon has a hydrophilic pore of 1.5nm in diameter
- Regulation - elevated calcium concentrations close channel
- The gap junction is seen as an area of close plasma membrane apposition

Adherens Junction

A **adherens junction** is a “sticky” junction where the transmembrane protein fibers adhere to each other in the extracellular matrix.

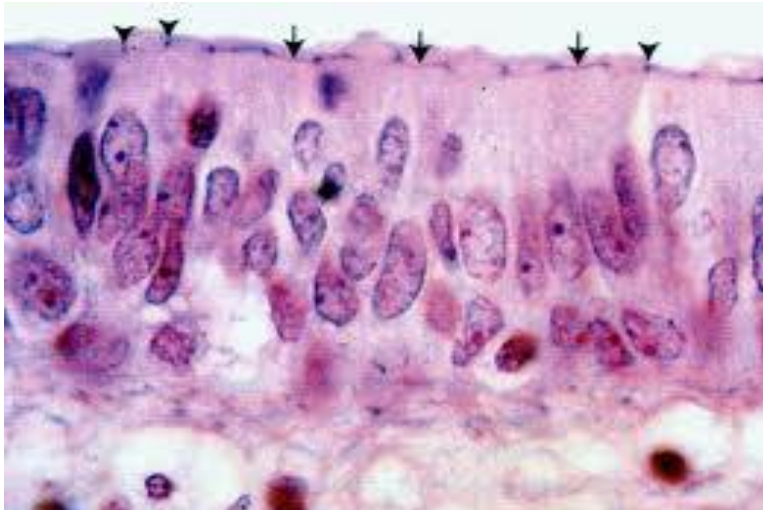


http://en.wikipedia.org/wiki/Adherens_junction

Terminal bars are light micro

scopic structures at the site of contact of cells. Appear as dots between the cells (they represent the belt junctions (zonula occludens and zonula)adherens

Terminal web: appears as a line at the apical pole of the cell



#blistering (bullous) diseases:

*In this case the body makes antibodies against its own antigens

*these antibodies target the proteins of desmosome, so the epithelial cells separate from each other, causing blisters and sores on the skin or mucous membranes

Gastric ulcers:

*bacteria called *Helicobacter pylori* secret toxins

And these toxins target the zonula occludens proteins (tight junction)

So the contents of the stomach (acid (HCL) for example) pass between the epithelial cells and reach the underlying tissue, causing irritation and disintegration of stomach lining (ulceration).

