Epithelium

Dr. Heba Kalbouneh
Associate Professor of Anatomy and Histology
Features

- Derived from any embryonic layer
- Rests on a basal lamina (basement membrane)
- Cells are closely opposed with minimal or NO intercellular substance
- Avascular
- Richly innervated
- Has high regenerative power
- Its cells are polarized
- Modified to perform special functions
• Epithelium lining skin, mouth, nose and anus: **ectoderm**
• Epithelium lining respiratory system, digestive tract and glands of digestive tract: **endoderm**
• Epithelium lining blood vessels: **mesoderm**
What are the functions of the basement membrane?
The epithelial cell shows two domains

1- Apical
2- Baso-lateral

Each domain shows modifications to suit its functions
Functions

- Protection
- Transcellular transport
- Secretion
- Absorption (selective permeability)
- Involved in sensation
Classifications & Naming of Epithelia

- First name of tissue indicates number of layers
  - Simple – one layer of cells
  - Stratified – more than one layer of cells
Classification & Naming of Epithelia

- Last name of tissue describes shape of cells
  - Squamous – cells wider than tall (plate or “scale” like)
  - Cuboidal – cells are as wide as tall, as in cubes
  - Columnar – cells are taller than they are wide, like columns
Simple epithelium
Naming Epithelia

• Naming the epithelia includes both the layers (first) and the shape of the cells (second)
  – i.e. stratified cuboidal epithelium

• The name may also include any accessory structures
  – Keratin
  – Goblet cells
  – Cilia

• Special epithelial tissues (don’t follow naming convention)
  – Pseudostratified
  – Transitional
Stratified Epithelia

- Contain two or more layers of cells
- Regenerate from below
- Major role is protection
- Are named according to the shape of cells at apical layer

*Mitotic activity in stratified epithelium is limited to the basal layer* (under normal conditions).
Stratified Squamous Epithelium

• Specific types
  – Keratinized – contain the protective protein keratin
    • Surface cells are dead and full of keratin
  – Non-keratinized – forms moist lining of body openings

• Function
  – Protects underlying tissues in areas subject to abrasion

• Location
  – Keratinized – forms epidermis
  – Non-keratinized – forms lining of mouth, esophagus, and vagina
Non Keratinized Stratified Squamous Epithelium

Body openings
Keratinized Stratified Squamous Epithelium

Skin
- **Goblet cells** produce mucus

- **Cilia** (larger than microvilli) sweep mucus

---

**Ciliated Pseudostratified Columnar Epithelium with goblet cells**
Transitional Epithelium

- **Description**
  - Basal cells usually cuboidal or columnar
  - Superficial cells dome-shaped or squamous
- **Function**
  - Stretches and permits distension of urinary bladder
- **Location**
  - Lines ureters, urinary bladder and part of urethra
Transitional Epithelium
(urinary epithelium)
perpendicular section

simple columnar epithelium

oblique section
Apical domain

- It is the part of the cell that faces the lumen or external environment (the free surface of the cell).
- It is rich in ion channels, carrier proteins and hydrolytic enzymes.

- The apical modifications are: Microvilli, Cilia, Stereocilia
- 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 **striated border** in the intestine and the **brush border** in the kidney.
Terminal web is a cytoskeletal feature at the apical pole in many epithelial cells.
Microvilli under LM and EM
Structure

- The microvillus is 1µ in length, 0.1µ in width.
- 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 and IF at the apical part of the cell.
- The microvillus is covered by glycocalyx.
Stereocilia

- Stereocilia are long immotile microvilli present in the epididymis and inner ear. They have special functions in these places.

- They are longer than typical microvilli, more widely separated and branched.

- They contain actin filaments.
- Motile cytoplasmic hair like projections capable of moving fluid and particles along epithelial surfaces.

- **Measurements**: length 5-10μ, diameter 0.2 μ. Number of cilia/cell is variable and ranges 1-300 cilium/cell.

- They move rhythmically and rapidly in one direction
Cilia

Wiggle to move mucus

Cilia on edge of cell

A row of cells with cilia

Note: this is one cell

Nucleus
Transport of proteins upward through cilia involves kinesin II motors moving along microtubules of peripheral doublets.

Transport of proteins back to base of cilium involves cytoplasmic dynein motors moving along microtubules of peripheral doublets.
- 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 form subunit A to subunit B.
- Dynein has ATPase activity.
- Cilia are attached to basal bodies similar in structure to centrioles.
- Cilia wiggle to move mucus
- Found in respiratory epithelium
<table>
<thead>
<tr>
<th></th>
<th>Cilia</th>
<th>Microvilli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motility</td>
<td>Motile</td>
<td>Non motile</td>
</tr>
<tr>
<td>Length</td>
<td>5 to 10 µm</td>
<td>0.5 to 1.0 µm</td>
</tr>
<tr>
<td>Diameter</td>
<td>0.2 µm</td>
<td>0.1 µm</td>
</tr>
<tr>
<td>Function</td>
<td>help in rhythmic movement (sweeping).</td>
<td>help in absorption</td>
</tr>
</tbody>
</table>

**Cilia** are in the respiratory tract. They wave rhythmically to move dirt and mucus out. **Microvilli** are found in the small intestine, and increase the surface area for nutrient absorption.
Cell Junctions
Basolateral domain
Tight junction/ zonula occludens

- Occluding junction forms a band (encircles epithelial cells)
- Barrier to diffusion between cells (paracellular pathway)
- Separates apical and basolateral plasma membranes, the outer layers of 2 adjacent plasmalemma fuse together.
- TEM: is the most apical junction
- Freeze fracture of TJ reveals **ridges** in membranes that correspond to sites of contact between cells
- Ridges are linear arrays of occludin and claudin proteins
Tight Junction (Zonula occludens)

plasma membranes

tight junction proteins

Occludins and claudins

intercellular space

b. Tight junction
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 TJs.
- ZO (zonula occludens) proteins 1-3 link occludin and claudin to each other, to JAMs, and to actin filaments.
- 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
- Cadherin proteins attach to cross-linked actin filaments
- Mechanical support - ZA and actin filaments transmit and distribute stress throughout cell and to neighboring cells
Zonula adherens
Catenins join cadherins to actin filaments in adherence junctions

This junction keeps epithelial cells from slipping/sliding out of position.
Anchoring junctions
- Provides firm adhesion between cells
- Function as "spot welds" to join cells
- Located along lateral plasma membranes of columnar epithelial cells or on processes of squamous cells
- Intermediate filaments associate with plaque proteins in cytoplasm
- Non-classical cadherins interact across intercellular space
- Adaptor proteins form a dense plaque that interconnects cadherins and binds them to intermediate filaments
Desmosome (Macula adherens)

- Desmoglein and desmocollin are non-classical cadherins
- Adaptor proteins such as γ-catenin (plakoglobin) and desmoplakin link cadherins to intermediate filaments
• Channel-forming junction

• Named for gap of regular width between cells visualized by TEM

• Water-filled junctions transport molecules <1 kDa such as ions, nucleotides (including cAMP), and metabolites

• Rapid propagation of action potential from one cell to another cell
The gap junction is seen as an area of close plasma membrane apposition.
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
• Hemidesmosome - "half-desmosome" in appearance only
• Mediates attachment to basal lamina (extracellular matrix)
• Cytoplasmic plaque is attached to intermediate filaments
Integrins - membrane protein that "integrates" cell into matrix
Integrins bind to ECM (laminin and collagen 4)
Every thing that enters or leaves the body must cross an epithelial sheet.

Epithelium occurs in the body as a sheet of cells that covers a body surface, lines a cavity, or forms a gland. *Coverings, linings, forming glands.*
Blistering Disease

- Many mechanisms underlie blistering disorders of the skin
- Pemphigus group - autoimmune disease in which autoantibodies target desmogleins present in desmosomes
Pemphigus Histology
Helicobacter pylori targets ZO-1 and disrupts this junction
Summary of cell junctions found between epithelial cells (basolateral domain)
Basal lamina and basement membrane
Basement membrane is composed of two layers:
1- Basal lamina
2- Reticular lamina
Layers of basal lamina:
Lamina Lucida
Lamina Densa
Layers of basal lamina:
Lamina Lucida
Lamina Densa

Lamina lucida: The clear layer closer to the epithelium

Lamina densa: the dense layer closer to the connective tissue
• Composed of lucida and densa
• Only visible with E.M
• Found also in other tissues, muscle cells, adipocytes, peripheral neurons (external lamina)
• Components are secreted by epithelium
Molecular components are variable but include:
- Type IV collagen coated with Heparan sulfate proteoglycan: Perlecan
- Glycoproteins (Laminin, entactin…)
- Integrins
Basement membrane

• Used to specify a PAS positive layer, visible on light microscope

• It is thicker and usually formed by fusion of two basal laminae or basal lamina and reticular lamina

• the basement membrane is not actually a membrane; rather, it is a matrix
Basement membrane is thicker and usually formed by fusion of two basal laminae or basal lamina and reticular lamina.
Functions of basal lamina:

1- Support
2- Selective barrier
3- Influencing cell polarity
4- Regulation of proliferation, growth, repair and regeneration
5- Affect cell-cell interaction
6- Clinically: tissue culture and tumor grading
Endothelium is the simple squamous epithelium that lines the lumen of the cardiovascular system.
Mesothelium is the simple squamous epithelium that lines serous cavities (peritoneal, pleural, and pericardial cavities) and coats many of the organs in these cavities.