EPITHELIAL TISSUE

Epithelial tissue, often colloquially referred to as epithelium (plural: epithelia), finds its nomenclature origins in the term introduced by Ruysch. Functioning as a protective covering, epithelial tissue is a crucial component that constitutes one or more layers of cells, enveloping both external and internal surfaces of diverse body parts. It is noteworthy that glands, integral for secretion processes, also comprise epithelial tissue.

- **Structural Composition:** Epithelial tissue is characterized by cells of varying shapes arranged closely within one or more layers, and the intercellular material between these cells is minimal. The structural foundation of epithelial tissue involves two distinct surfaces: the basal surface and the free surface.
  Basal Surface: Positioned in proximity to a delicate non-cellular layer known as the basement membrane. The basement membrane serves a dual purpose—it offers elastic support and secures the epithelial tissue to the underlying connective tissue, facilitating nutrient absorption.
  Free Surface: The free surface of epithelial tissue is oriented towards either a body fluid or the external environment. This positioning imparts a protective covering to both external and internal exposed surfaces of bodily structures.
- **Functionality and Significance:** Epithelial tissue serves as a dynamic shield, providing a defensive layer to safeguard exposed surfaces from the external environment or body fluids. Its strategic arrangement ensures optimal protection and selective permeability. Additionally, the basal surface, tethered to the basement membrane and connective tissue, ensures stability and sustenance.

Types of Epithelial Tissue

The categorization of epithelial tissue, a vital component in the body's structural integrity, is delineated into two principal groups: Simple Epithelium and Compound Epithelium. This classification is instrumental in understanding the diverse roles and functionalities of epithelial tissue within the intricate framework of bodily systems.

- **Simple Epithelium:** Simple epithelium is characterized by a single layer of cells that rests upon a basement membrane. Primarily, this type of epithelium serves as a protective lining for an array of bodily structures, including cavities, ducts, and tubes.

On the basis of structural modification of the cells, simple epithelium is further divided into the following types:

- Squamous
- Cuboidal/Cubical
- Columnar
- Ciliated.
- Pseudostratified
- Glandular

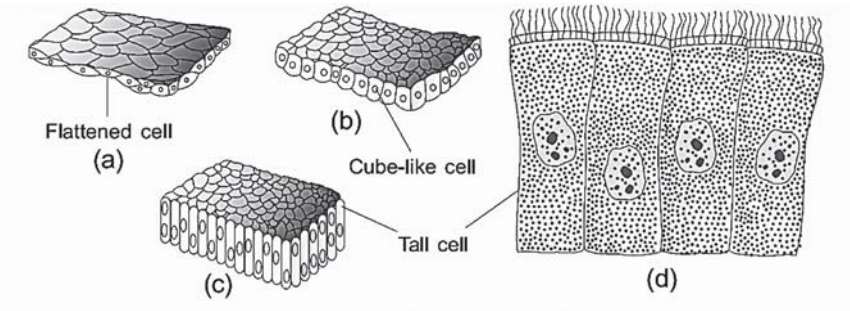


Fig.: Types of simple epithelium :
(a) Squamous, **(b)** Cuboidal; **(c)** Columnar, **(d)** Columnar cells bearing cilia

- **Squamous Epithelium:** Squamous epithelium, a vital component in the realm of tissue structures, is characterized by a single thin layer of flattened cells. These cells, akin to tiles in a floor, form a closely fitted arrangement, earning it the moniker "pavement epithelium." Delving into the intricacies of this epithelium, we uncover its structural nuances, nomenclature variations, specific locations in the body, and pivotal functions.

  Structural Characteristics:

  Cell Arrangement: The cells in squamous epithelium exhibit irregular boundaries and are tightly packed, resembling the organization of tiles in a pavement.

  Cell Shape: When observed from the surface, these cells appear polygonal, and their nuclei are typically flat, often centrally positioned.

  Alternative Term: Tessellated epithelium is an alternate designation for simple squamous epithelium.

  Locations:

  Endothelium: Forms the innermost lining of blood vessels, contributing to what is known as endothelium.

  Alveoli of the Lungs: Constitutes the inner lining of air sacs in the lungs.

  Lymph Vessels: Presents itself in the walls of lymph vessels.

  Bowman's capsule: Comprises the inner wall of Bowman's capsule in the kidneys.

  Loops of Henle: Found in the loops of Henle within the nephrons of the kidneys.

  Coelomic Cavities: Occurs in the linings of coelomic cavities.

  Functions:

  Filtration in Bowman's capsule: Squamous epithelium facilitates the crucial process of filtration in Bowman's capsule within the kidneys.

  Exchange of Materials: It plays a pivotal role in mediating the exchange of materials between blood capillaries and tissue fluid.

  Exchange of Gases: In structures like the alveoli of the lungs, squamous epithelium enables the exchange of gases, contributing to respiratory functions.

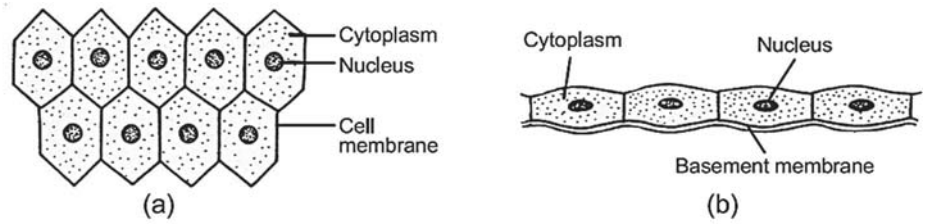


Fig.: Simple squamous epithelium: **(a)** Surface view, **(b)** Vertical section

- **Cuboidal Epithelium:** Cuboidal epithelium, a distinctive member of the epithelial tissue family, boasts a single layer of cube-like cells strategically positioned on a basement membrane. Recognizable by their rounded nuclei and versatile surface features, these cells play essential roles in diverse anatomical regions.

  Features of Cuboidal Epithelium:

  Cell Structure: Comprising cube-shaped cells, this epithelium forms a singular layer resting on a basement membrane. Nuclei are rounded and centrally located within the cells. The free surfaces of these cells may exhibit either a smooth texture or be adorned with minute finger-like projections termed microvilli. In instances where microvilli are present, the epithelium is coined as brush-bordered cuboidal epithelium, imparting a brush-like appearance to the free border.

  Microvilli and Brush-Bordered Appearance: Microvilli are minute projections on the cell surface, enhancing the surface area several times over. The brush-bordered cuboidal epithelium, characterized

by microvilli, is notably found in the tubular parts of nephrons, gland ducts, thyroid follicles, and reproductive organs such as ovaries and testes (germinal epithelium).

Anatomical Locations:

Nephrons in Kidneys: Prevalent in the tubular segments of nephrons, especially prominent in the proximal convoluted tubule (PCT), where microvilli contribute to the brush-bordered appearance.

Gland Ducts: Constitutes the lining of ducts in various glands.

Thyroid Follicles: Forms the epithelial lining of thyroid follicles.

Reproductive Organs: Present in ovaries and testes, contributing to the germinal epithelium.

Functional Significance:

Reabsorption in Proximal Convoluted Tubule (PCT): The brush-bordered cuboidal epithelium in the PCT of nephrons is actively involved in the reabsorption of essential substances, ensuring their retention within the body.

Secretion and Excretion: Engaged in the secretion and excretion processes carried out by various glands.

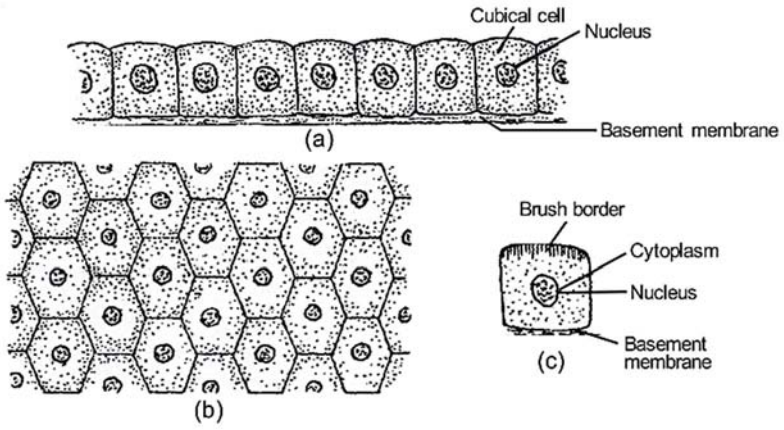


Fig.: Simple cubical or Cuboidal epithelium:
(a) Vertical section, **(b)** Surface view, **(c)** A cell with brush border

- **Columnar Epithelium:** Columnar epithelium, a prominent member of the epithelial tissue family, stands out with its single layer of tall and slender cells strategically positioned on a basement membrane. With nuclei aligned along the long axis and versatile surface features, these cells play crucial roles in absorption and secretion within the body.

  Features of Columnar Epithelium:

  Cell Structure: Composed of elongated and slender cells forming a single layer on a basement membrane. Nuclei, somewhat elongated, are positioned near the bases of the cells. The free surface may exhibit a smooth texture or be adorned with microvilli, enhancing the absorptive surface area. Goblet cells, interspersed among these cells, contribute to mucus production.

  Mucus Production: Goblet cells, specialized mucus-secreting cells, are present in some areas of columnar epithelium. The collective epithelium containing mucus-secreting cells, coupled with the supporting connective tissue, is termed mucosa or mucous membrane. Mucosa and Brush-Bordered Columnar.

  Epithelium: The intestinal mucosa, featuring microvilli, earns the designation of brush-bordered columnar epithelium.

  Anatomical Locations:

  Stomach and Intestine Lining: Predominantly found in the lining of the stomach and intestine.

Functional Significance:

Absorption: Columnar epithelium, especially in the intestinal mucosa with microvilli, excels in absorption processes, ensuring the uptake of essential substances.

Secretion: Goblet cells contribute to mucus secretion, aiding in protective and lubricating functions.

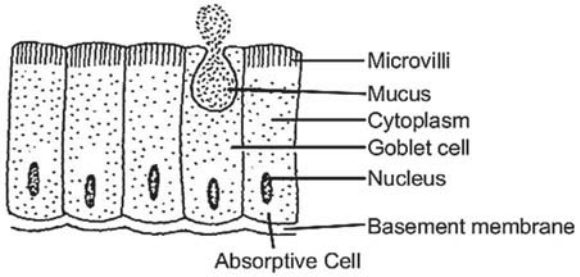


Fig.: Simple columnar epithelium

- **Ciliated Epithelium:** Ciliated epithelium, a dynamic variation of epithelial tissue, boasts columnar or cuboidal cells adorned with hair-like cilia on their free surfaces. This unique feature endows them with the ability to create rhythmic motions, orchestrating a current for the purposeful transport of materials. This specialized epithelium resides above a basement membrane, engaging in essential functions in various anatomical locations.

  Features of Ciliated Epithelium:

  Cilia Presence: Cells, whether columnar or cuboidal, exhibit cilia on their free surfaces. The number of cilia varies, ranging from a single cilium to numerous, contributing to their orchestrated motion.

  Rhythmic Motion: Cilia engage in continuous rhythmic motion, working collaboratively to generate a current.

  Transport Function: The primary function of ciliated epithelium is to transport materials in a specific direction over the epithelial surface.

  Types of Ciliated Epithelium:

  Ciliated Cuboidal Epithelium: Comprising cubical cells adorned with cilia on their free surfaces. Frequently found in smaller bronchioles.

  Ciliated Columnar Epithelium: Featuring columnar cells equipped with cilia on their free surfaces. Commonly present in the inner linings of hollow organs such as fallopian tubes (oviducts) and the majority of the respiratory tract.

  Functional Significance:

  Fallopian Tube Passage: Ciliated columnar epithelium plays a crucial role in facilitating the passage of the ovum through the fallopian tube.

  Respiratory Tract Maintenance: In the respiratory tract, particularly in the bronchi and bronchioles, ciliated columnar epithelium aids in expelling mucus and particles trapped within it. This expulsion occurs towards the pharynx (throat), contributing to respiratory hygiene.

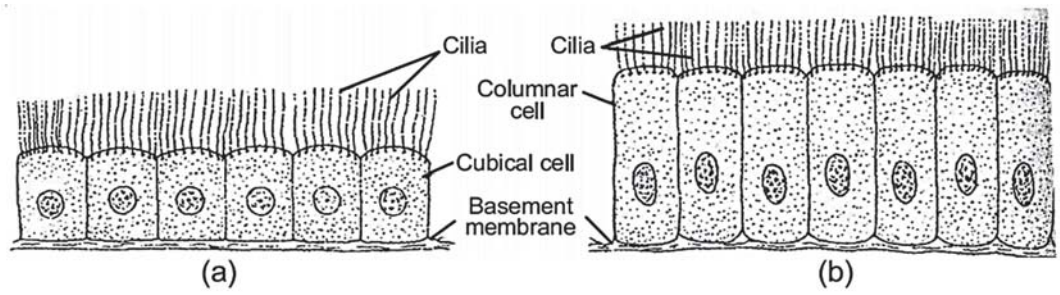


Fig.: Simple ciliated epithelium : **(a)** Cubical, **(b)** Columnar

- **Pseudostratified Epithelium:** Pseudostratified epithelium, a fascinating cellular arrangement, creates an illusion of multilayering despite being composed of only a single layer of cells. The term "pseudostratified" originates from its deceptive appearance, where nuclei are staggered, resembling the stratified epithelium. This distinctive epithelial type, found in specific anatomical locations, exhibits both ciliated and non-ciliated variations.

  Structural Characteristics:

  Cell Types: Pseudostratified epithelium consists of columnar cells, varying in size within the single-layered arrangement. Long cells extend to the free surface, while shorter cells do not reach the outermost surface.

  Nuclei Arrangement: Oval nuclei characterize the long cells, providing a contrast to the rounded nuclei of the shorter cells. Nuclei are positioned at different levels across cells, contributing to the pseudostratified appearance.

  Goblet Cells: Mucus-secreting goblet cells are interspersed within this epithelium, adding to its functional diversity.

  Types of Pseudostratified Epithelium:

  Pseudostratified Non-ciliated Columnar Epithelium: Located in the urethra of human males and the large ducts of certain glands, such as the parotid salivary gland. Absence of cilia distinguishes this type within the pseudostratified category.

  Pseudostratified Ciliated Columnar Epithelium: Found in the trachea and large bronchi of the respiratory system. Features cilia on the free surface, contributing to its role in respiratory functions.

  Functional Significance:

  Urethral and Glandular Roles: Pseudostratified non-ciliated columnar epithelium in the male urethra contributes to structural support. In glandular ducts, it aids in facilitating secretory processes.

  Respiratory Maintenance: Pseudostratified ciliated columnar epithelium in the respiratory tract plays a vital role in moving mucus and particles away from the lungs, promoting respiratory hygiene.

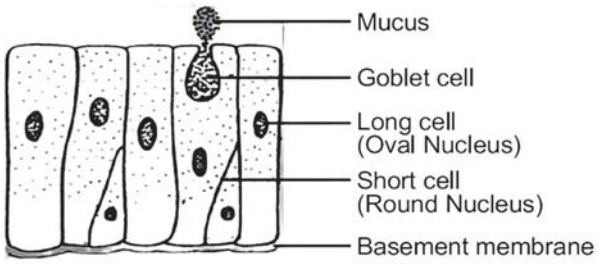


Fig.: Pseudostratified epithelium

- **Glandular Epithelium:** Glandular epithelium represents a distinct adaptation of certain epithelial cells for the pivotal function of secretion. Within this specialized epithelium, cells take on a columnar or cuboidal form to facilitate their secretory roles. The resulting glands, which can be unicellular or multicellular, play crucial roles in various physiological processes through the release of specific substances.

  Characteristics of Glandular Epithelium:

  Cell Shape: Glandular epithelial cells exhibit a columnar or cuboidal outline, emphasizing their secretory specialization.

  Gland Formation: Glands, essential structures for secretion, originate from glandular epithelium and can be composed of a single cell, a tissue, or an entire organ.

  Types of Glands:

  Unicellular Glands: Single, isolated cells functioning as glands. Specialized for the secretion of mucus, earning them alternative names like mucous cells or mucocytes. Example: Goblet cells in the alimentary canal.

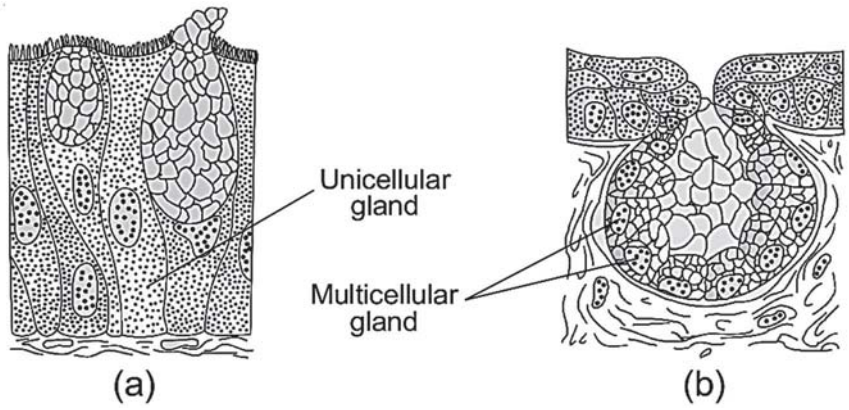
  Multicellular Glands: Comprised of clusters of cells forming both ducts and secretory regions. Diverse in function, secreting substances such as saliva, earwax, oil, milk, digestive enzymes, and other cellular products. Example: Salivary glands, sweat glands, gastric glands, and sebaceous (oil) glands.

Classification Based on Gland Types:

- **Cell Number:**

  Unicellular Glands: Isolated individual cells with glandular functions.

  Multicellular Glands: Complex structures consisting of both ducts and secretory components.



- **Mode of Pouring Secretions:**

  Exocrine Glands: Drain secretions to body surfaces or surfaces continuous with them. Examples include salivary glands, gastric glands, intestinal glands, oil glands, mammary glands, and tear glands.

  Endocrine Glands: Lack ducts, releasing hormones directly into the bloodstream. Thyroid, pituitary, adrenal, and hypothalamus are examples of endocrine glands.

  Functions of Glandular Epithelium:

  Unicellular Glands: Goblet cells secrete mucus in the alimentary canal, contributing to lubrication and protective functions.

  Multicellular Glands: Diverse secretions from various multicellular glands support essential physiological processes, such as digestion, temperature regulation, and hormonal balance.

- **Compound Epithelium:** Compound epithelium, characterized by its multilayered structure, serves primarily as a protective barrier against various environmental stresses. Comprising more than one layer of cells, it is particularly adept at safeguarding underlying tissues from mechanical, chemical, thermal, or osmotic challenges. While not actively involved in significant secretion or absorption, compound epithelia play a pivotal role in fortifying tissues against external threats.
- **Types of Compound Epithelium:**
  Stratified Epithelium:
  Structure: Multiple layers of epithelial cells with only the deepest layer resting on the basement membrane.
  Variations:
  Stratified Cuboidal Epithelium: Cuboidal superficial cells lining larger salivary and pancreatic ducts.
  Stratified Non-keratinized Squamous Epithelium: Covers moist surfaces like the buccal cavity, pharynx, and esophagus, featuring superficial living squamous cells and deeper interlinked polygonal cells.
  Stratified Keratinized Squamous Epithelium: Protects the dry skin surface, with superficial layers consisting of horny, scale-like remnants of dead squamous cells and deeper living polygonal cells.
  Function: Offers protection against mechanical abrasion and external factors. The keratinized version is impervious to water.
  Transitional Epithelium:
  Characteristics: Thinner and more stretchable than stratified epithelium.
  Composition: Single layer of cuboidal cells at the base. 2-3 middle layers of large polygonal or pear-shaped cells. Superficial layer of large, broad, rectangular, or oval cells.
  Location: Lines the inner surface of the urinary bladder and ureters.
  Functions of Compound Epithelium:
  Protection: Shields underlying tissues against mechanical, chemical, thermal, and osmotic stresses. Varied stratified epithelia provide different levels of defense, with keratinized versions offering enhanced protection.
  Stretch ability: Transitional epithelium allows considerable expansion of organs like the urinary bladder, adapting to changes in volume without compromising structural integrity.

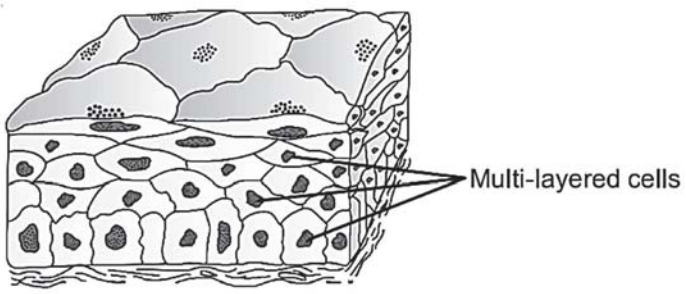


Fig.: Compound epithelium

Cell Junctions

In the intricate landscape of tissues, cells forge connections through specialized intercellular junctions, forming the foundation for both structural integrity and functional coherence. Among these crucial cellular interfaces, three distinct types of cell junctions play pivotal roles not only in maintaining tissue integrity but also in facilitating communication and coordination among cells.

Types of Cell Junctions:

- **Tight Junctions (Zonula Occludes):**
  Description: Function as barriers to prevent the leakage of substances across tissues.

Structural Basis: Plasma membranes in the apical regions of neighboring epithelial cells tightly pack together, sometimes fusing to create these impermeable junctions.

- **Gap Junctions:**
  Role: Facilitate rapid communication between cells by establishing a direct connection between their cytoplasm.
  Communication Medium: Enables the swift transfer of ions, small molecules, and occasionally larger molecules.
  Structural Significance: Intricately linked channels foster direct cytoplasmic exchange, fostering coordination among cells.
- **Adhering Junctions (Macula Adherens or Desmosomes):**
  Function: Act as molecular cement, ensuring the cohesion of adjacent cells.
  Structural Features: Strong, disc-like junctions with intercellular proteins. Thicker plaque-like structures containing protein plates. Microfilaments extending from the plaque-like structure into the cytoplasm, composed not of actin but of keratin-like proteins (tonofibrils).
  Anchoring Function: Desmosomes serve as anchoring points, contributing to the structural stability of tissues.
- **Functions of Cell Junctions:**
  Tight Junctions: Prevent indiscriminate passage of substances across tissues, maintaining selective permeability. Ensure the integrity of cellular barriers.
  Gap Junctions: Enable rapid communication and coordination among neighboring cells. Facilitate the transfer of ions and molecules crucial for cellular function.
  Adhering Junctions (Desmosomes): Cement adjacent cells together, reinforcing tissue cohesion. Provide structural support and stability through anchoring functions.