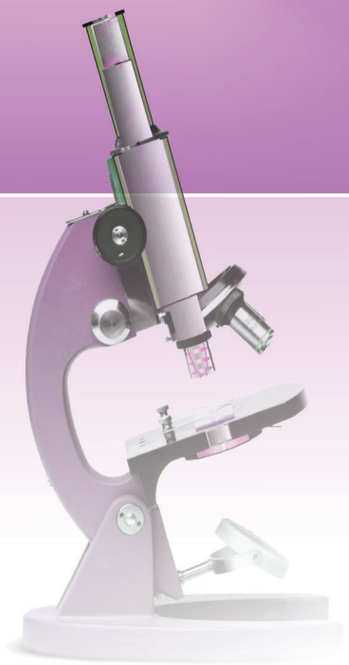

Chapter

5

Epithelial Tissue

Competencies: AN 65.1 and 65.2

Objectives

- To classify the tissue of the body and to give their location and function
- To define epithelial tissue and to list its functions
- To classify the epithelial tissue and to give their location, structure and functions
- To describe the specialization of the epithelial tissue with their functions
- To define and classify the exocrine glands and to give their structure and locations

TISSUES OF THE BODY

Tissues are defined as "group of cells having similar origin, structure and function". They are aggregates or groups of cells organized to perform one or more specific function. Although it is frequently said that the cell is the basic functional unit of the body, but in reality, it is tissues, through the collaborative efforts of their individual cells that are responsible for maintaining body functions.

Types: There are four types of basic tissues in the body:

1. Epithelial tissue
2. Connective tissue
3. Muscular tissue
4. Nervous tissue

Cartilage and bone are specialized connective tissues.

EPITHELIAL TISSUE

It is a layer of cells, which covers the external surface (skin) or lines the internal surface (lumen) of gastrointestinal, respiratory, and urogenital tracts. They are structurally minor but functionally important component of an organ. Glands are epithelial invagination from the lumen into the underlying connective tissue layer.

Features

- The cells are arranged in single or many layers. They are continuously renewed and replaced. Cells closest to the basal lamina (or basement membrane) undergo continuous mitosis, and their progeny replace the surface cells.
- They are avascular. They receive nutrition from the blood vessels present in underlying connective tissue through diffusion.
- They are adherent to one another by means of cell-to-cell adhesion molecules that form cell junctions.
- The basal surface is attached to an underlying basement membrane, non-cellular, protein-polysaccharide-rich layer.
- They have little intercellular substance. The cells are densely packed and closely apposed.
- They undergo metaplasia (they change from one type to another) when exposed to chronic environment changes.
- They are derived from all the three germ layers (ectoderm, endoderm and mesoderm).

Functions

- **Mechanical protection:** It protects the body surface from drying or bacterial invasion. Epithelium covering the skin called epidermis which protects the body.

- **Transport:** Transport of materials or cells along the surface of an epithelium propelled by motile cilia or transport of materials across an epithelium (pinocytosis or endocytosis) to and from connective tissue.
- **Secretion:** The cells secrete the product synthesized, either to the lumen (e.g. lining epithelium of stomach) to the blood.
- **Excretion:** May excrete metabolic waste products.
- **Absorption:** It absorbs essential substances from the lumen of the gastrointestinal tract and kidney tubules (where it is called reabsorption).
- **Lubrication:** The epithelium lining the body cavities (mesothelium) serve this function.
- **Sensory:** In the skin (touch sensation), nasal mucosa (smell sensation) and tongue (taste sensation), it serves as sensory organ.

Epithelioid tissue: Cells are closely opposed to one another in such a way that they lack apical free surface. They rest on basement membrane. They are derived from progenitor mesenchymal cells (undifferentiated cells of embryonic origin).

Distribution: Interstitial cells of Leydig in the testis, lutein cells of ovary, the islets of Langerhans in the pancreas, parenchyma of the adrenal gland, cells of anterior pituitary.

Endothelium: The epithelial lining of the blood vessels and lymphatic vessels.

Endocardium: The epithelium lining of the atria and ventricles of the heart.

Mesothelium: The epithelium that lines the walls of closed cavities of the body (pericardial, pleural and peritoneal cavities).

Types of Epithelia

Epithelium is classified into simple, pseudostratified and stratified varieties (Fig. 5.1 and summary in Table 5.1).

1. Simple Epithelium

It consists of single layer of cells resting on a basement membrane.

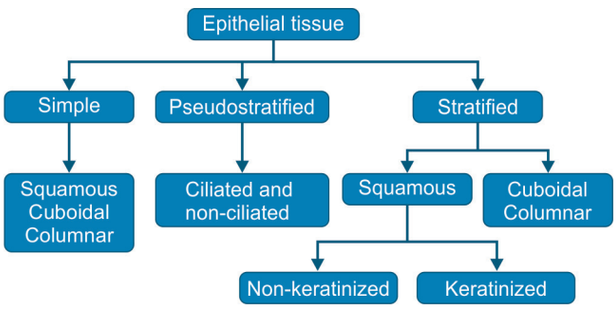

Fig. 5.1. Classification of epithelial tissue

a. Simple squamous: The cells are irregular flat, plate like cells that function as a semipermeable barrier between compartments. These are the cells with height less than width (Fig. 5.2A and 5.3A).
Distribution: Alveoli of the lungs, Bowman's capsule and loop of Henle of kidney, mesothelium—the lining of peritoneum peritoneal, pleura and pericardial cavities, endothelial cells lining blood vessels.

b. Simple cuboidal: The height and width of the cell is nearly equal, and nuclei are central in position (Figs 5.2B and 5.3B).
Distribution: Lining epithelium of proximal convoluted tubules of the kidney, follicles of the thyroid (during moderate activity), walls of the secretory and excretory ducts of salivary glands and surface of the ovary (germinal epithelium). Their function includes protection, regulation of ion and water concentration (in ducts) or secretion (thyroid follicles) or reabsorption (renal tubules).

c. Simple columnar: The cells are cylindrical with height is greater than width. Nuclei are elongated and placed towards the base. The apical (free) surface of the cell may be covered by microvilli or cilia or without any surface modifications (Figs 5.2C to F and 5.3C to F). Its function is absorption, secretion and when ciliated, propulsion of mucus and trapped debris.
Distribution: Non-ciliated simple columnar epithelium lines the stomach. Simple columnar epithelium with microvilli lines the intestine. Simple columnar epithelium with cilia lines the bronchioles.

2. Pseudostratified Columnar Epithelium

It is a single layer of epithelial cells resting on a basement membrane. Some cells are shorter and do not reach the lumen, while tall cells reach the lumen. The nuclei of the cells therefore lie at different levels. This gives the impression of stratification (false stratification) (Figs 5.2G and 5.3G).

a. Pseudostratified non-ciliated
Distribution: Male urethra (membranous and penile part), auditory tube and vas deferens.

b. Pseudostratified ciliated: Cells that reach the surface are ciliated.
Distribution: Upper part of the respiratory tract (trachea and larger bronchi).
Goblet cells are mucous secreting (unicellular glands) cells located in between the simple columnar cells of the intestine or pseudostratified columnar epithelium of the respiratory tract. They have narrow bases and wide apex with basal nucleus. The apical part of the cell shows mucin vesicles. They protect and lubricate the epithelial surfaces of the respiratory and digestive tracts by producing mucus.

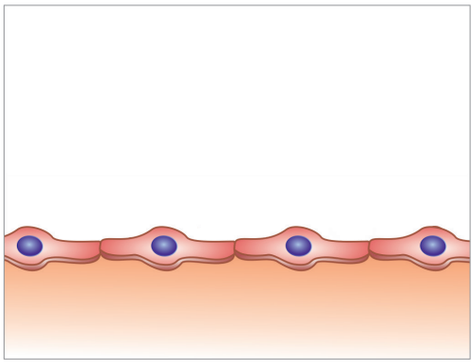

Fig. 5.2A: Simple squamous epithelium

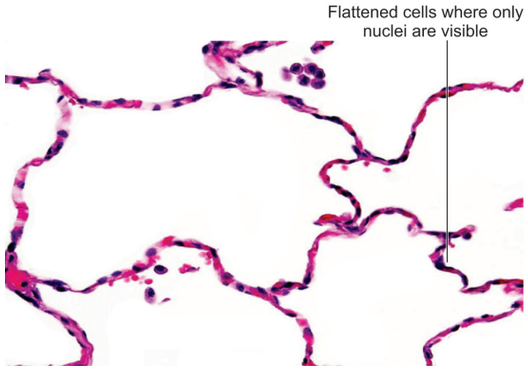

Fig. 5.3A: Simple squamous epithelium

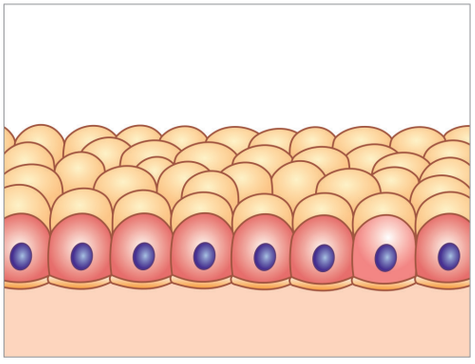

Fig. 5.2B: Simple cuboidal epithelium

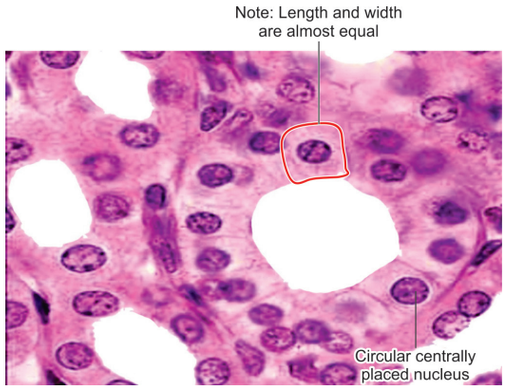

Fig. 5.3B: Simple cuboidal epithelium

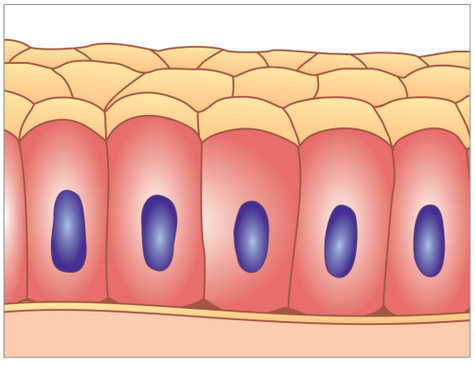

Fig. 5.2C: Simple columnar epithelium

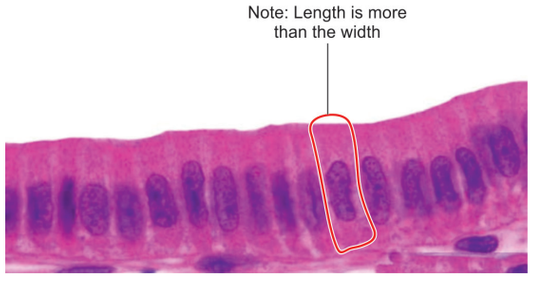

Fig. 5.3C: Simple columnar epithelium

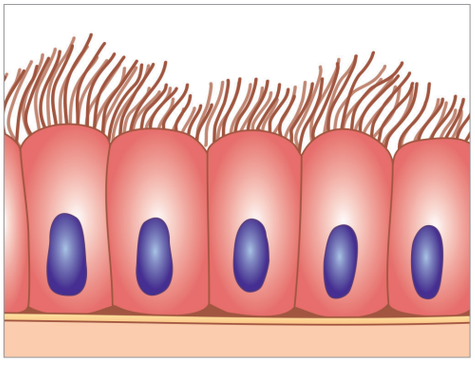

Fig. 5.2D: Simple columnar ciliated epithelium

Fig. 5.3D: Simple columnar ciliated epithelium

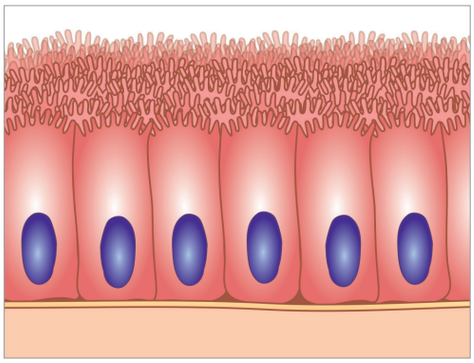

Fig. 5.2E: Simple columnar epithelium with microvilli

Fig. 5.3E: Simple columnar epithelium with microvilli

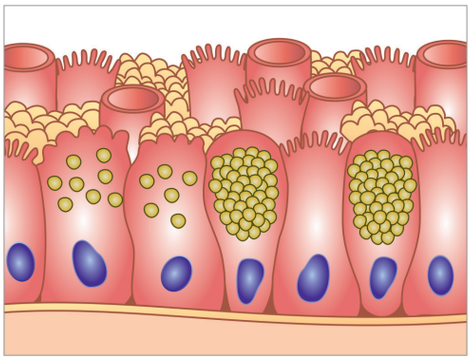

Fig. 5.2F: Simple columnar epithelium with goblet cells

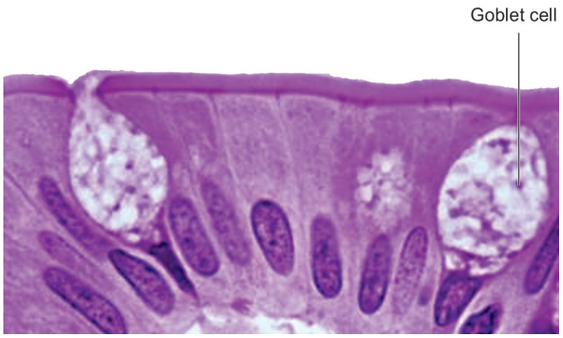

Fig. 5.3F: Simple columnar epithelium with goblet cells

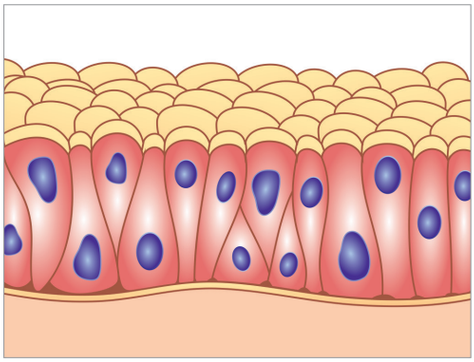

Fig. 5.2G: Pseudostratified columnar epithelium

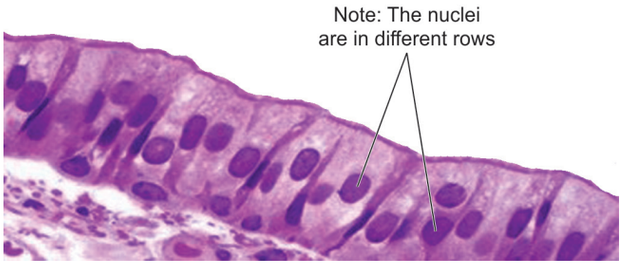

Fig. 5.3G: Pseudostratified columnar epithelium

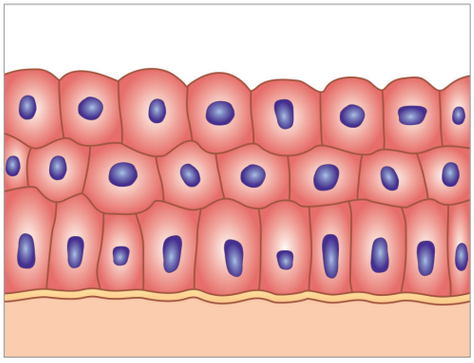

Fig. 5.2H: Stratified cuboidal epithelium

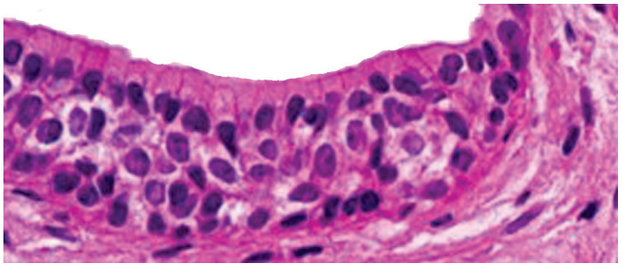

Fig. 5.3H: Stratified cuboidal epithelium

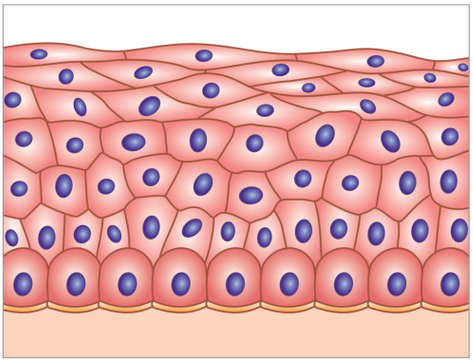

Fig. 5.2I: Stratified squamous non-keratinized epithelium

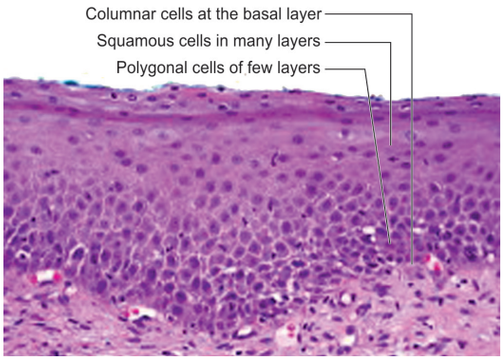

Fig. 5.3I: Stratified squamous non-keratinized epithelium

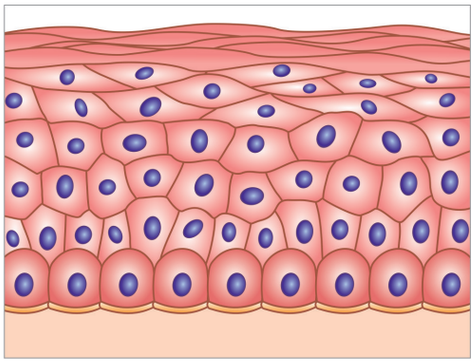

Fig. 5.2J: Stratified squamous keratinized epithelium

Fig. 5.3J: Stratified squamous keratinized epithelium

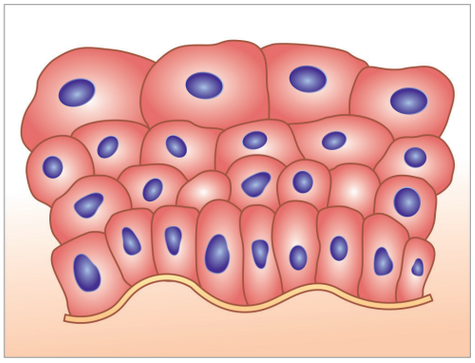

Fig. 5.2K: Transitional epithelium—relaxed

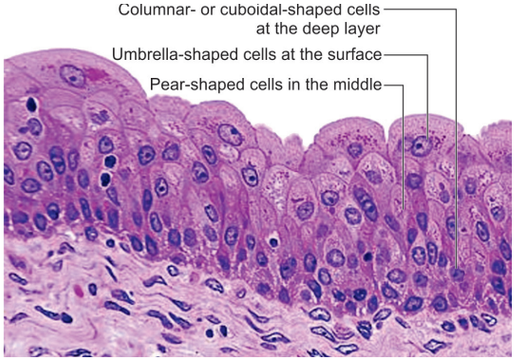

Fig. 5.3K: Transitional epithelium—relaxed

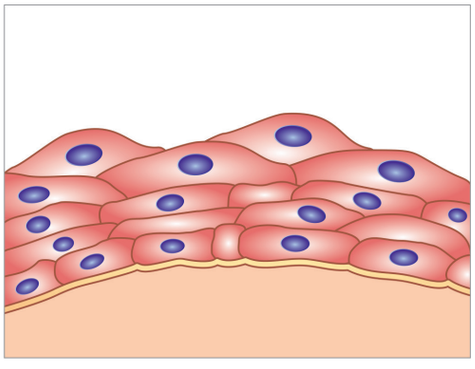

Fig. 5.2L: Transitional epithelium—stretched

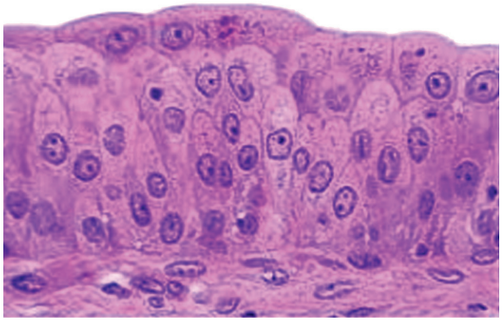

Fig. 5.3L: Transitional epithelium—stretched

3. Stratified Epithelium

The epithelium is made up of many layers of cells. They are found in areas, which are subjected to friction.

a. Stratified cuboidal epithelium: It consists of few (Two to Three) layers of cuboidal cells.
Distribution: Ducts of sweat glands (Figs 5.2H and 5. 3H).

b. Stratified columnar epithelium: It consists of two or more layers of cells. The basal cells are polyhedral, while superficial cells are columnar.
Distribution: Larger ducts of some glands, conjunctiva, over the respiratory surface of the epiglottis.

c. Stratified squamous non-keratinized
Epithelium is made up of many layers of cells. Basal cells resting on the basement membrane are columnar or low cuboidal. The superficial cells are squamous and flat, hence called stratified squamous epithelium. It is less resistant to water loss than the keratinized type (Figs 5.2I and 5.3I).
Distribution: Epithelium lining mouth, pharynx and oesophagus, anal canal, vagina and cornea.

d. Stratified squamous keratinized epithelium
The superficial layer consists of non-living cells with keratin in their cytoplasm (Figs 5.2J and 5. 3J). They are tough and water-resistant.
Distribution: Epidermis of the skin.

4. Transitional Epithelium (Urothelium)

This is a stratified epithelium with three to four layers of cells. The deepest cells are columnar or cuboidal. The middle layers are made up of polyhedral or pear-shaped cells. The cells of the surface are large and are shaped like an umbrella (Figs 5. 2K and L to 5.3K and L). The surface cells are often binucleated. It mainly lines the urinary bladder. When the bladder is empty, the surface cells appear dome-like, giving the epithelium a "cobblestone' appearance; when the bladder is full, the surface cells stretch and flatten. Transitional epithelium can be stretched considerably without being damaged. When stretched the cells become flattened. Presence of a glycoprotein membrane on the surface cells is believed to protect the underlying tissue from toxic substances present in the urine.

Distribution: Renal pelvis, ureter, urinary bladder and proximal part of the urethra.

Specialization of the Epithelial Cells

Each cell has three surfaces when viewed from the lateral side: an apical (free) surface, lateral surfaces that bound neighboring cells, and a basal surface attached to the basal lamina.

1. Basal Surface Specialization

The basal surface contacts the basal lamina. Because it is the surface closest to the underlying blood supply, it often contains receptors for blood-borne factors such as hormones.

a. Basal lamina: It is a sheet-like structure typically composed of type IV collagen, proteoglycan (usually heparin sulfate), laminin (a glycoprotein that binds cells to the basal lamina) and entactin (a glycoprotein associated with laminin). The basal lamina has two layers—lamina lucida and lamina densa (20–100 nm thick). In some sites, a layer of type III collagen fibers (reticular fibers), produced by connective tissue cells called reticular lamina

Table 5.1: Summary of the epithelial tissue

Type	Location	Function
Simple squamous	Alveoli of the lung, lining cells of the blood vessels	Diffusion, filtration, osmosis
Simple cuboidal	Linings of the renal tubules in the kidney, linings of the ducts of the glands, outer covering of the ovary	Absorption, secretion
Simple columnar	Linings of stomach	Absorption, secretion and protection
Simple columnar with microvilli	Lining of the intestine	Absorption, secretion and protection
Simple columnar with cilia	Lining of bronchioles of lung	Protection
Pseudostratified columnar	Lining upper respiratory passage (trachea)	Movement of mucus, protection, secretion
Stratified squamous—non-keratinized	Lining oral cavity, pharynx, oesophagus, anal canal, vagina	Protection
Stratified squamous—keratinized	Outer layer of the skin (epidermis)	Protection
Stratified columnar	Lines part of the male urethra	Protection and secretion
Transitional	Lines the urinary bladder, ureter and part of the urethra	Distensibility and protection
Glandular epithelium	Endocrine, salivary and sweat glands	Secretion

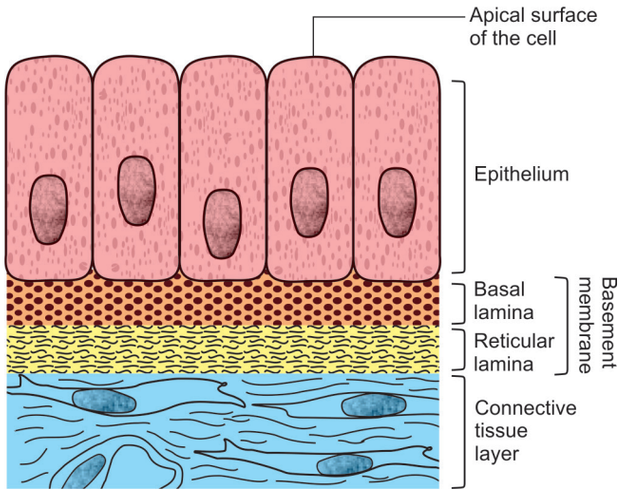

Fig. 5.4: A schematic representation of the basement membrane

lies beneath the basal lamina (Fig. 5.4). Attachment between epithelial cells and their basal lamina is maintained by a protein called integrins.

b. **Hemidesmosomes:** They are located on the inner surface of the basal lamina in epithelia exposed to extreme stress (e.g. stratified squamous).

c. **Sodium-potassium ATPase:** It is a plasma membrane bound enzyme localized preferentially in the basal and basolateral regions of the epithelial cells. It transports sodium out and potassium into the cell.

2. Apical Surface Specialization

The cells apical surface is on the organs external or internal (lumen) surface. It is specialized to carry out functions that occur at these interfaces, including secretion, absorption, and movement of luminal contents.

a. **Cilia:** They are common surface modification of cells. They are hair-like extensions of the apical plasma membrane containing microtubule protein-axoneme. The axoneme extends from the basal body, a centriole-derived, microtubule-organizing center located in the apical region of ciliated cells. In general cilia are classified as motile and primary. **Motile cilia** have an internal structure (typical 9 + 2 axonemal organization) that allow them to move. Ciliated epithelia are found in upper respiratory tract where they move mucus and trapped epithelium. The **primary cilia** are also called monocilia. Only single cilium per cell is present. They are **immotile** because of different arrangements (9 + 0) of microtubules in the axoneme and lack of microtubule-associated motor proteins. They function as chemosensors, osmosensors and mechanosensors (glomerulus and tubular cells of kidney).

b. **Flagella:** They are concerned with movement. Spermatozoa formed inside the seminiferous tubules of the testis are the example.

c. **Microvilli:** They are extensions of plasma membrane from the apical surface of the cell. Inside each microvillus, there are about 20 to 30 actin microfilaments. Their plus ends are connected through villin. The actin filaments extend down into the apical cytoplasm through terminal web (Fig. 5.5). The actin filaments are cross-linked to each other through proteins like fascin, espin and fimbrin. By interacting with myosin I, the microfilaments contract, shortening the microvilli aiding the absorption. In the epithelium lining the intestine it is referred as striated border or brush border.

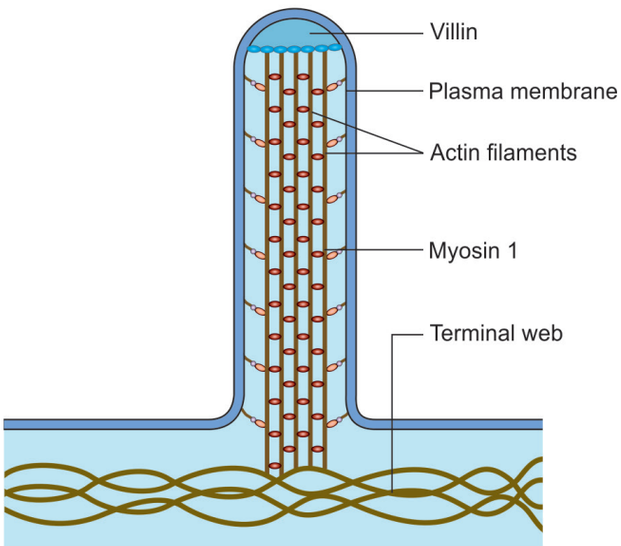

Fig. 5.5: Structure of a microvillus (schematic)

d. **Stereocilia:** They are not cilia but elongated microvilli. They are located in epididymis and vas deferens of male reproductive tract where they have absorptive function. They are also present in hair cells of internal ear where they have sensory function.

3. Lateral Surface Specialization

Epithelial cells attach tightly to one another by specialized intercellular junctions.

There are three types of junctional complexes. They are:

Communicating junctions (gap junctions): They allow direct communication between adjacent cells by diffusion of small molecules.

Structurally they are in three major forms: **zonulae** are band-like and completely encircle the cell; **maculae** are disk-like and attach two cells at single spot; and **gap junctions** are macular in shape but differ in composition and function. A junctional complex is a combination of intercellular junctions, typically lying near the cell apex (Fig. 5.6).

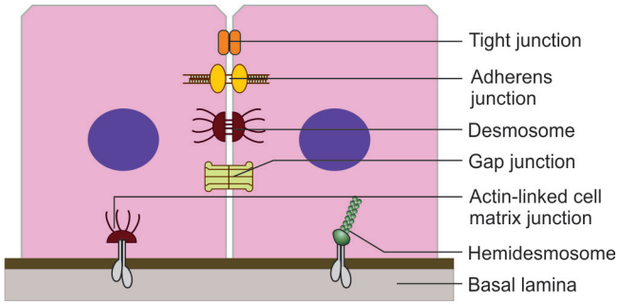

Fig. 5.6: Types of intercellular junction (schematic)

a. **Zonula occludens (tight junction or occluding junction):** They are located near the cell apex and seals off the intercellular space. They are mostly impermeable and allow epithelial cells to function as a barrier. They are created by localized sealing of the plasma membrane of adjacent cells. This structural arrangement allow the epithelium to isolate certain body compartments (e.g. it helps keep intestinal bacteria and toxins out of the bloodstream). The pattern results from the fusion of the two trilaminar plasma membranes of adjacent cells, which forms a pentalaminar structure; this fusion requires that attachment of specific integral membrane "tight-junction proteins" to those adjacent membranes. Several proteins are involved in the formation of zonula occludens strands, which includes occludin, claudins, and junctional adhesion molecule. Zonula occludens plays a major role in the selective passage of substances from one side of the epithelium to the other. Permeability of the zona occludens depends on complexity and number of strands and also presence of functional aqueous channel formed by various claudin molecules. In some tissues, tight junctions can be disrupted by calcium ion removal or protease treatment.
b. **Zonula adherens (belt desmosome):** This lateral adhesion device occurs in a continuous band or belt-like configuration around the cell; thus, the adhering junction is referred to as a zonula adherens. An electron-dense plaque containing myosin, tropomyosin, α-actinin are located on the participating membranes cytoplasmic surfaces. Actin-containing **microfilaments** arising from each cell's terminal web insert into the plaques to stabilize the junction. It is composed of the transmembrane cell adhesion molecule E-cadherin. On the cytoplasmic side, the tail of E-cadherin is bound to catenin. The resulting E-cadherin–catenin complex binds to vinculin and α-actinin.
c. **Macula adherens (desmosome):** They provide a localized spot-like junction between epithelial cells. They mediate direct cell-to-cell contact by providing anchoring sites for intermediate filaments. The intermediate filaments of adjacent cells are linked by desmosomes through a series of strong protein-protein interactions. In the area of the macula adherens, desmogleins and desmocollins (glycoproteins) provide the linkage between the plasma membrane of adjacent cells. Desmosomes provide stable attachments between lateral surfaces of epithelial cells but do not prevent the flow of substances between cells.
d. **Gap junctions:** They are also called communicating junctions or nexuses. They are only known cellular structure that permit the direct passage of signaling molecules from one cell to another. The gap between the two-cell membrane is filled with a structure (integral membrane protein) called **connexons**. Each connexon is made up of six symmetrical subunits (hexamer) of an integral membrane protein called connexin. This hexamer is paired (connected) with similar structure from the adjacent membrane. Each connexon has a central pore. Connexons in one membrane link with those in the other cell membrane to form continuous pores that bridge the intercellular gap, allowing smooth molecule. They are present in variety of tissue-like epithelia, smooth muscle, cardiac muscle, and nerves.

Clinical Notes

Epithelial metaplasia: It is a reversible conversion of one matured epithelial cell type to another mature epithelial cell type. It is due to repeated inflammation or because of abnormal stimuli. It occurs because of reprogramming of epithelial stem cells that change the patterns of their gene expression. It is reversible, if the stimulus that caused metaplasia is removed, tissues return to their normal pattern. If abnormal stimulus persists for long time the squamous metaplastic cells may transform into squamous cell carcinoma (cancers of the lung, cervix of the uterus). The metaplastic columnar cells may give rise to glandular adenocarcinoma.

Columnar to squamous: Columnar cells will replace by stratified squamous epithelium. This is called squamous metaplasia. The pseudostratified epithelium of the respiratory tract is replaced by stratified squamous epithelium in people who smoke cigarette. In females repeated uterine infection results in transformation of simple columnar epithelium of the uterine cervix into stratified squamous non-keratinized epithelium.

Squamous to columnar: People with chronic gastro-oesophageal reflux (stomach content entering back to lower end of the oesophagus), the stratified squamous non-keratinized epithelium of the lower part of the oesophagus undergo

metaplastic transformation to simple columnar epithelium.

Junctional complexes as a target of pathogenic agent: Since epithelium lines the lumen of respiratory, gastrointestinal and many other tubular structures, it acts as a barrier preventing the entry of harmful substances like viruses, bacteria and parasites. Gastroenteritis (food poisoning) characterized by intense abdominal pain and diarrhea that begins 8 to 22 hours after eating food contaminated with bacteria *Clostridium perfringens*. This bacterium attacks zonula occludens junction. Dehydration that occurs with this type of food poisoning is a result of severe movement of fluid via paracellular pathways into the lumen of the intestine. *Helicobacter pylori* is a bacterium presents within the stomach can destroy zona occludens barrier and results in rearrangements of cytoskeleton. *Helicobacter pylori* causes injury to the protective barrier of the stomach that may lead to the development of gastric ulcers and gastric carcinomas.

GLANDULAR EPITHELIUM

The epithelial cells are specialized to perform secretory function. Such epithelial cell in-groups constitute glands (single epithelial cell can also be a gland—unicellular).

There are two main types of glands:

Exocrine glands: When the secretion from the gland is poured through duct system, they are called exocrine glands, e.g. salivary gland. Exocrine glands are classified as either unicellular or multicellular.

Unicellular glands: Single secretory cells scattered among other epithelial cells (e.g. goblet cells).

Multicellular glands: They are composed of more than one cell. Their structural organization allows further classification according to the arrangement of secretory cells (parenchyma) and presence or absence of branching of the duct element. The secretory part of the gland (end piece) may be in the form of rounded sac (or acini) or flask-shaped tube (alveoli). If the duct part of the gland is unbranched then it is called simple, if the duct is branched then it is called compound. If the secretory portion is shaped like tube, the gland is called tubular, if it is shaped like a flask or grape, the gland is alveolar or acinar and if the tube ends in a sac-like dilation, the gland is tubuloalveolar. Exocrine glands may be in the form of (Fig. 5.7):

- **Simple tubular gland:** Secretory portion of the gland is a straight tube formed by the secretory cells (e.g. intestinal glands).
- **Simple coiled tubular:** Coiled tubular structure is composed of the secretory portion located deep in the dermis (e.g. eccrine sweat gland).

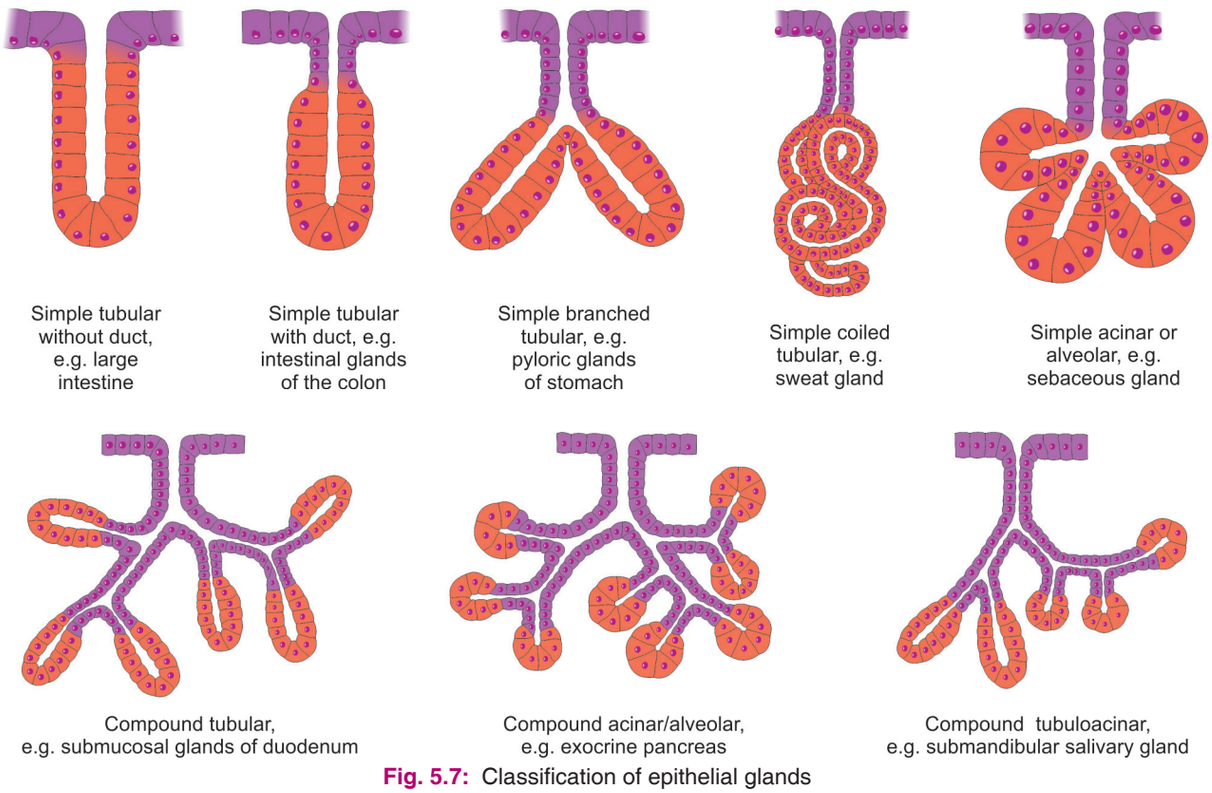

Fig. 5.7: Classification of epithelial glands

- **Simple branched tubular:** Branched tubular glands with wide secretory portion are formed by the secretory cells and produce a viscous mucous secretion (e.g. mucus secreting glands of pylorus of the stomach.
- **Simple acinar (alveolar) gland:** It represents a stage in the development of simple branched glands.
- **Branched acinar (alveolar) gland:** The secretory portions are formed by mucus secreting cells, the short single duct portion opens directly into the lumen (e.g. mucus secreting glands of cardiac end of the stomach, sebaceous glands of the skin).
- **Compound tubular gland:** Compound tubular glands with coiled secretory portions are located deep in the submucosa of the duodenum (e.g. duodenal submucosal glands of Brunner).
- **Compound acinar (alveolar) gland:** Compound acinar glands with alveolar-shaped secretory units are formed by pyramid-shaped serous-secreting cells (exocrine portion of pancreas).
- **Compound tubuloacinar (alveolar) gland:** Compound tubuloacinar glands can have both mucous branched tubular and serous branched acinar secretory units; they have serous end caps (submandibular salivary gland).

Depending upon the nature of secretion, the exocrine glands may be classified into mucous glands and serous glands. The mucous glands secrete 'mucopolysaccharide' and secretions of serous glands are watery in nature rich with proteins.

Glands are also classified (on the basis of type of secretory product) into:

a. **Apocrine gland:** The luminal part of the cell disintegrates as a part of secretion. The basal part will regenerate, e.g. mammary gland.

b. **Holocrine gland:** The cell itself will be disintegrated as a part of secretion, e.g. sebaceous gland.

c. **Merocrine gland (epocrine gland):** The secretion is discharged without disintegrating the cell. Most of the glands belong to this type.

Endocrine glands: These glands are 'ductless' and pour their secretion directly into the blood stream. Their secretion is called 'hormone'. The cells of the endocrine glands are usually arranged in cords or in clumps with rich network of blood capillaries around them.

Major Types of Epithelial Cells

1. Epithelial Cells Specialized for Transport

Some cells are specialized for transcellular transport. They pump ions across their entire thickness. These cells are responsible for maintaining the concentration of ion and water. These cells have highly infolded basal plasma membranes that interdigitate with mitochondria. The ion pump is specific for sodium (i.e. it is Na^+/K^+-ATPase), and chloride ions and water follow the sodium passively. Ion-transporting cells occur in kidney tubules (PCT and DCT), striated ducts of salivary gland and choroid plexus. Some epithelial cells are specialized for pinocytosis having abundant pinocytotic vesicles. These vesicles transport substances across cell from luminal to basal surface, and vice versa. Endothelial cells are the best example for this variety.

2. Epithelial Cells Specialized for Absorption

Cells lining the intestine have many microvilli which increase the surface area for absorption. The nutrients enter the microvilli and contraction of microfilaments cause shortening of microvilli which bring the nutrients to the cytoplasm. Some nutrients are pinocytosed between microvilli.

3. Epithelial Cells Specialized for Secretion

a. **Protein secreting cells:** Proteins secreted by epithelial cells include the digestive enzymes, produced by pancreatic acinar cells and gastric chief cells are the examples. Serum albumin produced by the liver cells and protein parathormone secreted by cells of parathyroid glands are also the example. These cells have abundant rough endoplasmic reticulum, well developed Golgi complex and often accumulate secretory granules in the cell apex.

b. **Polypeptide-secreting cells:** These cells have few rough endoplasmic reticulum, supranuclear Golgi complex and abundant secretory granules in their bases. APUD (amine precursor uptake and decarboxylation) cells are the example. These cells have epinephrine, norepinephrine and serotonin in their cytoplasm. They may absorb these amines from the blood stream or synthesize them from amino acid precursors by means of abundant amino acid decarboxylases. Most APUD cells are unicellular glands scattered among other epithelial cells. They are also described as diffuse neuroendocrine system (DNES). These cells may have local paracrine effects or enter the blood stream to reach the target cells. The important polypeptide includes glucagon, insulin from the pancreas, gastrin from stomach, small intestine. Tumors composed of APUD cells are called apudomas.

c. **Mucous cells:** Cells of sublingual salivary gland. The secretion is thick and highly glycosylated glycoproteins (mucins). Cells are light staining, foamy in appearance, owing to the large mucous-containing vesicles near the cell apex. Cells are acidophilic in H&E staining.

d. **Serous cells:** Pancreatic acinar cells and secretory cells of parotid salivary glands are the example. They are protein secreting cells and usually stain dark. The secretion is thin, watery containing proteins and glycoproteins.

e. **Steroid secreting cells:** Cells of endocrine gland or tissue are best example for this type of cells. These cells are usually polygonal with centrally placed nucleus, acidophilic cytoplasm containing lipid droplets. The smooth endoplasmic reticulum present in it contains enzymes for cholesterol synthesis and for converting steroid hormone precursors into specific hormones.

4. Contractile Epithelial Cells

They are also called myoepithelial cells. They are stellate or spindle-shaped flattened cells with finger-like processes that embrace an acinus or duct. They are located between the epithelial cells and their basal lamina. Their cytoplasm obviously contains myosin, microfilaments, tropomyosin and intermediate filaments. Several myoepithelial cells may surround a single acinus or duct; their contraction expels exocrine products. Myoepithelial cells occur in lacrimal, salivary, mammary and sweat glands and around the seminiferous tubules of the testes.

MCQs

1. Which type of epithelium lines most of the urinary passages?
A. Stratified cuboidal
B. Transitional
C. Pseudostratified columnar
D. Stratified squamous non-keratinized

2. Which of these protein components of the basal lamina that connects directly to integrins in the basal plasma membrane of the epithelial cells?
A. Desmoplakin B. Desmoglein
C. Laminin D. Type III collagen

3. Which of the following cells contain abundant mitochondria between the basal infoldings of the plasma membrane?
A. Steroid secreting cells B. Peptide secreting cells
C. Protein secreting cells D. Ion-transporting cells

4. Which of the following cells often contain mitochondria with tubular cristae?
A. Steroid secreting cells B. Peptide secreting cells
C. Protein secreting cells D. Ion-transporting cells

5. Which of the following cell types is best characterized as having abundant smooth endoplasmic reticulum?
A. Steroid secreting cells
B. Peptide secreting cells
C. Protein secreting cells
D. Ion-transporting cells

6. Which of the following cell types is best characterized as having abundant rough endoplasmic reticulum?
A. Steroid secreting cells B. Peptide secreting cells
C. Protein secreting cells D. Ion-transporting cells

7. Which of the following is true of stereocilia?
A. Contain nine microtubule triplets at their core
B. Contain actin filaments in their core
C. Are underlain by a basal body
D. Contain an axoneme

8. Which of the following is true of the zona occludens?
A. Is characterized by dense intracellular plaque
B. Surrounds entire columnar cells in the basal region of their lateral plasma membrane
C. Is characterized by the presence of abundant cytokeratin filaments in the vicinity of the junction
D. Is characterized by the fusion of the outer leaflets of adjacent trilaminar unit membranes into a single pentalaminar unit

9. Which of the following is true of merocrine glands?
A. Secretory cells contain secretory granules
B. Secretory cells lose their apical cytoplasm during secretion
C. Entire secretory cell is released as secretion
D. Secretory cells lack a well-developed Golgi apparatus

10. Which of the following is true of holocrine secretion?
A. Occurs in endocrine glands
B. Occurs in sebaceous glands
C. Involves secretion of chlorine and bromine ions
D. Is the typical mode of secretion of DNES cells

11. Which of the following is true of epithelial tissues?
A. They are incapable of metaplasia
B. They are highly vascularized
C. They rest on basal laminae
D. Epithelial cells attach to one another by hemidesmosomes

ANSWERS TO THE MCQs

1. B	2. C	3. D	4. A	5. A
6. C	7. B	8. D	9. A	10. B
11. C				

JUST BEFORE THE EXAM

- Every student must know the distribution of different types of epithelia in the body.
- **Simple squamous epithelium:** Alveoli of the lungs, Bowman's capsule and loop of Henle of kidney, mesothelium—lining the peritoneum, pleura and pericardial cavities and endothelial cells lining blood vessels.
- **Simple cuboidal epithelium:** Walls of the secretory and excretory ducts, convoluted tubules of the kidney and surface of the ovary (germinal epithelium).
- **Non-ciliated simple columnar epithelium:** Lines the gastrointestinal tract from stomach to rectum, gallbladder, lines small bronchi and bronchioles, uterine tube and efferent ductules of the testes.
- **Pseudostratified non-ciliated epithelium:** Lines the male urethra (membranous and penile part), auditory tube and vas deferens.

- **Pseudostratified ciliated columnar epithelium:** Lines the upper part of the respiratory tract (trachea and larger bronchi).
- **Goblet cells** are mucous secreting (unicellular large and are shaped like an umbrella. It mainly glands) cells located in between the simple columnar cells of the intestine or pseudostratified epithelium of the respiratory tract.
- **Stratified squamous non-keratinized epithelium:** Epithelium lining of the mouth, pharynx and oesophagus, anal canal,vagina and cornea.
- **Stratified squamous keratinized epithelium:** Lines the external aspect of the skin.
- **Stratified cuboidal epithelium:** Lines the ducts of sweat glands.
- **Stratified columnar epithelium:** Lines the larger ducts of some glands, conjunctiva, over the respiratory surface of the epiglottis.
- **Transitional epithelium (urothelium):** Lines urinary bladder, ureter and upper part of the urethra.
- Basal lamina is made up of type IV collagen fibres. It has two layers—lamina lucida and lamina densa.