

Glandular Epithelium

Definition of Epithelium -

- 1) Epithelia is avascular tissue comprised of cells that cover the exterior surfaces of the body and line both the internal closed cavities and those body tubes that communicate with the exterior (the alimentary, respiratory, and gastrointestinal tract).
- 2) Epithelia also form the receptors of certain sensory organs.
- 3) Epithelia form the secretory portions (or parenchyma) of glands and their ducts (a.k.a. glandular epithelium or exocrine glands).

Function of Epithelium:

Examples:

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| 1) Mechanical protection | - skin or in body tubes (stratified squamous) |
| 2) Permeability barrier BVs (selective) | - cells lining the GI tract regulates what enters (simple columnar cells of small intestine) |
| 3) Absorption | - small intestine (simple columnar) |
| 4) Filtration | - epithelium of renal corpuscle (simple squamous) |
| 5) Secretion | - glandular epithelium (simple cuboidal in ducts) |
| 6) Diffusion of gases or fluids | - lung alveoli or blood vessels (simple squamous) |
| 7) Surface transport over epithelium | - respiratory tract (pseudostratified columnar ciliated) or oviduct (simple columnar ciliated) |
| 8) Sensory | - epithelium often specialized among sense organs |

Major Types of Glands: The two types are based on the mechanism of their secretion.

- 1) **Exocrine Glands** – Glands that secrete their products onto the apical (or epithelia) surface directly OR via epithelial ducts or tubes that are connected to the apical surface. These exocrine glands are composed of highly specialized epithelial cells and thus are classified as **glandular epithelia**.

- 2) **Endocrine Glands** - Glands that release their products basally, so the secretion goes through the basal lamina, moves into the underlying connective tissue, and enters the vascular system. Endocrine glands lack a duct system.
- a) **Paracrine Glands** – These glands are similar to endocrine glands, but their secretions reach target cells by diffusion through the extracellular space or immediately subjacent connective tissue. These secretory products are not delivered to their target tissue via ducts or the bloodstream. We will discuss endocrine and paracrine glands, later this semester with endocrine glands covered in great detail.

Classification of Glandular Epithelia: This classification system is based on five different morphological criteria.

- 1) Number of secretory cells
- a) **Unicellular glands** – Mucus-secreting **goblet cells** are the only example of these single-celled glands in humans. These goblet cells secrete mucus and are easily visualized in slides of the small intestine. In routine (H&E) preparations, the cytoplasmic mucin is not preserved (and therefore, not stained) giving the cells an empty appearance. The mucus is not preserved. The unicellular Goblet cells are best seen in Periodic Acid Schiff (PAS) staining.
- b) **Multicellular glands** - These glands have many cells. In addition to the ways that multicellular glands are classified (listed below), they may also form a secretory sheet of epithelial cells like the linings of the stomach and the uterus.
- 2) Nature of secretion
- a) **Serous** – A cell-type that produces a thin watery, protein-rich secretion (e.g. the pancreas and parotid salivary glands are entirely serous in nature).
1. Serous cells are polyhedral or pyramidal, with round, centrally located nuclei.
 2. These cells exhibit a well-defined polarity. In the basal region, serous cells display an intense basophilia, which results

from large accumulations of rough endoplasmic reticulum (rER) and free ribosomes.

3. In the apical region, serous cells contain prominent Golgi apparatus and numerous rounded, protein-rich, membrane-bound vesicles called secretory granules. In cells that produce digestive enzymes (e.g. pancreatic acinar cells), these vesicles are called **zymogen granules**.

4. Adjacent serous cells are joined together by junctional complexes and usually form a spherical mass of cells called an **acinus**, with a lumen in the center. This structure can be likened to a grape attached to its stem; the stem corresponds to the duct system.

5. The pancreas and parotid gland are entirely serous in composition. The percentage of serous versus mucous cells allows an individual to differentiate between the pancreas and parotid from the submandibular gland (predominantly serous with some mucous cells present) and the sublingual gland (predominantly mucous in nature).

b) **Mucous** – A cell type that is characterized by numerous large, lightly staining granules containing strongly hydrophilic glycoproteins called **mucins**, viscous secretions that have a lubricating or protective function.

1. Mucous cells also display a distinct polarity as the apical cytoplasm is predominantly mucinogen granules that do not stain with H&E sections due to the high carbohydrate content of the glycoprotein of the mucin (use a PAS stain instead).

2. Their nuclei are basally located (as compared to the centrally-located nuclei in serous cells).

3. The base of the mucous cells also contains rough endoplasmic reticulum. The Golgi complex, located just above the nucleus, is exceptionally well developed.

4. When mucins are released from the cell, they become highly hydrated and form mucus, a viscous, elastic, protective lubricating gel.

5. The mucous cells show great variability in their morphological features and in the chemical nature of their secretions. They are usually cuboidal or columnar in shape.

6. Mucous cells are most often organized as tubules, consisting of cylindrical arrays of secretory cells surrounding a lumen.

7. Sublingual glands contain mucous acini predominantly.

c) **Mixed** – These glands have both serous and mucous cells.

1. The mucous cells form tubules, but their ends are capped by serous cells that secrete between the mucous cells' intercellular space. These serous caps on mucous cells are called **serous demilunes**.

a. Approximately 10% of submandibular glands contain serous demilunes, but these glands are predominantly serous acini, which constitute 90% of the gland.

b. The sublingual gland contains serous demilunes amidst its predominant mucous cell population. Serous cells are present exclusively on demilunes of mucous tubules.

3) **Mechanism of secretion** (the way in which the secretory products leave the cell) – The three mechanisms by which secretions for exocrine glands are extruded are merocrine, apocrine, or holocrine secretions.

a) **Merocrine secretion** (aka eccrine secretion) - This is the most common type of glandular epithelium secretion where secretory granules within the cytoplasm of the cell gather at the apical region of the cell. Then, the granule's limiting membrane fuses with the apical membrane and the contents of the granule are opened and released. This process of fusion and release are collectively referred to as exocytosis. The secretory granules leave the cell with no loss of other cellular material. Mucous and serous cells exhibit this type of secretion.

b) **Apocrine secretion** – A rare type of secretion dependent on sex hormones where secretory granules within the cytoplasm gather at the apical region of the cell. Then, a portion of the cytoplasm of the cell simply pinches off enclosing the granules. Within the lumen, this small secretory vesicle breaks down and releases the gland's products.

1. Apocrine glands become functional at puberty.

2. They respond to emotional or sensory stimuli (not to heat).
 3. Examples of apocrine glands include lactating mammary glands, apocrine glands of skin in the pubic and axilla regions, ciliary (Moll's) glands of the eyelid, and the ceruminous glands of the external acoustic meatus.
- c) **Holocrine secretion** – This secretion consists of disintegrated cells of the gland itself. Granules fill the cell until the entire cell becomes “bloated” with secretory products. Instead of being released (merocrine) or pinched off (apocrine), the whole cell is discharged into the lumen. Once inside the lumen, the cell degenerates and the secretory products are released.
1. This type of secretion occurs primarily in sebaceous glands within the skin, but also in the tarsal (Meibomian) glands of the eyelid.
- 4) **Shape of Secretory Units** – Remember exocrine glands have a **secretory portion**, which contains the cells responsible for the secretory process, and **ducts**, which transport the secretion to the exterior of the gland.
- a) **Tubular** - An elongated group of secretory cells with a tube-shaped lumen. Mucous cells are most often organized as tubules, consisting of cylindrical arrays of secretory cells surrounding a lumen.
 - b) **Acinar** (or alveolar) - A small grape-like (acinus means “grape”) or sac-like (alveolus means “sac”) group of secretory cells arranged about a small lumen. These cells, as they are in other glandular units, are attached to a basement membrane. Some authors distinguish between acinus and alveolus, but others use them interchangeably. The two terms will be synonymous in this course. Remember, adjacent serous cells usually form an acinus with a lumen in the center.
 - c) **Tubulo-alveolar** – Lumen of secretory units have both of the above listed shapes (seen in mixed glands with serous demilunes).
- 5) **Arrangement (branched or not) and Occurrence of Duct System**
- a) **Simple** glands - Glands that have an unbranched duct into which the cells secrete. Each secretory portion empties separately on an epithelial surface.

- b) **Branched** glands – These glands have several secretory units empty into an unbranched excretory duct.
- c) **Compound** glands - These glands have a highly branched duct system. Secretory portions empty into an elaborate branched duct system, which, in turn, drain into larger ducts.

Types of Exocrine Glands

- 1) **Simple tubular glands** - These glands are epithelial-lined tubules, which open on the apical surface. There are three types.
 - a) **Simple straight tubular glands** - The long crypts of Lieberkühn, located within the colon, are a great representation of tubular glands that runs a straight, unbranched course.
 - b) **Simple coiled tubular glands** - Within the dermis, eccrine sweat glands are located. The deeper portion of these simple coiled tubular glands is easily seen; however, the long unbranched lumen that goes to the apical surface is rarely seen in cross-section.
 - c) **Simple branched tubular glands** - These simple branched tubular glands are found primarily in the stomach
- 2) **Simple alveolar (acinar) glands** - The best representation of simple alveolar glands is the paraurethral glands located in the penile urethra or the sebaceous glands located in the skin.
- 3) **Simple tubular-alveolar glands** - Some of the secretory cells are arranged as acini (alveoli) and others are arranged as tubules. Examples of these include some of the smaller glands of the respiratory tract; minor salivary glands located within the oral cavity are other examples.
- 4) **Compound tubular glands** - These glands have a highly branched duct system. The secretory cells at the ends of the ducts are in the form of tubules. Brunner's glands of the duodenum are compound tubular glands.
- 5) **Compound alveolar glands** - The duct system is similar to the compound tubular and compound tubulo-alveolar glands; however, compound alveolar glands differ from other compound glands in that the ducts end in alveoli

with dilated sac-like lumina. The pancreas and parotid gland are the best examples of compound alveolar glands as they are entirely serous.

- 6) **Compound tubulo-alveolar glands** - These glands also have a highly branched duct system, but some of the ducts end as tubules and others end as alveoli. Two of the major salivary glands, the submandibular and the sublingual glands, are examples of compound tubulo-alveolar glands (as they are mixed glands).

Ducts of Exocrine Glands – The lumen of the glandular epithelium is continuous with its surface epithelium via a duct system. Several different types of ducts exist along the lumen of the glands based upon the nature of the secretory product.

- 1) **Intercalated ducts** – The part of the duct system where secretory end pieces initially empty.

- a) Intercalated ducts are lined with low cuboidal epithelial cells that possess carbonic anhydrase activity.
- b) They secrete bicarbonate ion into the acinar product and absorb chloride ion
- c) Intercalated ducts are present in serous and mixed glands, but rarely in mucous glands, where the secretory product is rarely modified. If present in mucous glands, these ducts are poorly developed.

- 2) **Striated ducts** – Intercalated ducts empty into striated ducts, which are characterized by radial striations that extend from the bases of the cells to the level of the nuclei.

- a) These ducts are formed by simple cuboidal epithelium that becomes columnar as it approaches the excretory duct.
- b) Striated ducts are named due to longitudinally oriented, elongated mitochondria that form “striations” or an infolding of basal plasma membrane.
- c) Striated ducts have centrally-located nuclei.

d) These ducts reabsorb sodium from secretion and add potassium. Sodium is reabsorbed at a higher rate, so secretion becomes hypotonic.

e) Striated ducts are only present in serous secretions; mucous glands DO NOT have striated ducts

f) Striated and intercalated ducts are also called intralobular ducts because of their location within the lobule.

3) **Excretory ducts** (a.k.a. interlobular) – Striated ducts converge and drain into these ducts located in the connective tissue septae separating the lobules.

a) The epithelial lining of excretory ducts is highly variable (based on the size of the exocrine gland); it may vary from simple cuboidal to stratified columnar epithelia.

b) These ducts do not modify the glandular secretion and only serve as a conduit to the surface epithelium.

Myoepithelial Cells – These are contractile cells that lie within the basal lamina in the secretory portion of glands and intercalated ducts, which form the initial portion of the duct system. They are instrumental in moving the secretions toward the excretory duct.

1) Myoepithelial cells are spindle-shaped and lie parallel to the length of an exocrine gland's duct.

2) Although the contraction of these cells accelerates the secretions along the duct system, their main function seems to be the prevention of end piece distension during secretion due to the increase in intraluminal pressure.

Salivary Glands – The main functions of the salivary glands are to lubricate and moisten the oral mucosa and the ingested food, to initiate the digestion of carbohydrates and lipids (by means of amylase and lingual lipase activities, respectively), and to secrete germicidal protective substances such as the immunoglobulin IgA, lysozyme, and lactoferrin. These lubricating, digestive, and protective functions are performed by minor glands scattered throughout the oral cavity and 3 pairs of large salivary glands: parotid, submandibular, and sublingual glands. The minor glands secrete approximately 10% of the total volume of saliva, but they account for approximately 70% of the mucus

secreted. The parenchyma of the large salivary glands consists of a secretory portion (the serous and mucous cells) and a duct system that modifies and conducts the saliva to the oral cavity.

- 1) **Parotid Gland** – This compound acinar gland is composed of secretory units that are entirely serous in nature. Its secretion has a high amylase activity, which is responsible for most of the hydrolysis of ingested carbohydrates. The parotid gland is characterized by numerous fat cells (Do you remember that frustrating buccal fat pad containing the branches of the facial nerve?) and a high number of striated ducts.
- 2) **Submandibular Gland** – This compound tubulo-acinar gland contains both mucous and serous cells (a mixed gland). Serous cells are the main component of this salivary gland (90%), but upon close inspection, mucous tubules and serous demilunes can be found. Serous cells are responsible for the weak amylolytic activity present in this gland and its saliva. The components of the serous demilunes secrete lysozyme, whose main action is to hydrolyze the walls of certain bacteria.
- 3) **Sublingual Gland** - This compound tubulo-acinar gland is a mixed gland that is predominantly mucous in nature. The characteristics of this gland are a high concentration of mucous cells, lack of intercalated ducts, and sparse striated ducts.

The Exocrine Pancreas - This compound acinar gland is similar in structure to the parotid gland as both glands are entirely serous in nature. The pancreas can be distinguished from the parotid gland by the absence of striated ducts and the presence of the **islets of Langerhans**, or clusters of endocrine epithelial cells. Another distinguishing feature is that the initial portions of the intercalated ducts of the pancreas penetrate the lumen of the serous acini. Nuclei, surrounded by a pale cytoplasm, belong to **centroacinar cells** that constitute the intra-acinar portion of the intercalated duct. These cells are only found in pancreatic acini. Remember, the exocrine portion of the pancreas produces a wide variety of digestive enzymes that are activated in the lumen of the duodenum after secretion.