Introduction to Glandular Tissue
(Basic Terminology)

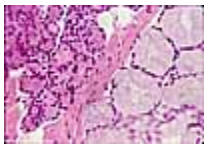
http://www.siumed.edu/~dking2/erg/glands.htm

Glands are organized arrangements of secretory cells. All exocrine glands (and also most endocrine glands), are composed of epithelial tissue. Although most glands give the appearance of being "solid" tissue, their epithelial nature is expressed by the organization of secretory cells into tubules, acini, or cords. Every exocrine secretory cell has some portion of its plasma membrane exposed to an external surface, communicating with the outside of the body by a system of ducts.

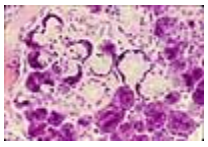
Histologically, glands are described using some standard vocabulary, with which you should be familiar.

Destination of product:	**exocrine / endocrine**
Nature of product:	**serous / mucous / mixed**
Location of gland:	**mucosal / submucosal**
Arrangement of secretory cells:	**acinus / tubule / cord**
Number of interconnected units:	**simple / compound**
Duct function:	**intercalated / striated** **secretory / excretory**
Duct location:	**intralobular / interlobular / interlobar**
Tissue composition:	**parenchyma / stroma**

Serous / Mucous / Mixed

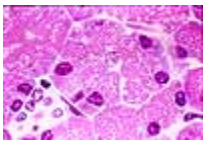


The **serous** / **mucous** distinction is based on the secretory cell's product -- whether it is a clear, watery solution of enzymes (*serous*, like *serum*) or else a glycoprotein mixture (mucous, like *mucin*). These two categories of secretory products come from two distinct categories of cells, each with a characteristic appearance.



Mixed glands (e.g., most salivary glands) contain *both* types of cells. Glands which contain only one of these two cell types may be described either as **serous glands** (e.g., parotid gland or pancreas) or as **mucous glands** (e.g., Brunner's glands).

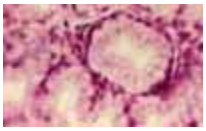
Serous Secretion



Serous cells are specialized to secrete an enzyme solution. Examples include serous cells of the salivary glands, exocrine cells of the pancreas, gastric chief cells, and Paneth cells of intestinal crypts. Serous cells of the pancreas and the salivary glands are typically organized into secretory units called acini.

In routine light microscopy, serous cells are distinguished by basophilic basal cytoplasm, a centrally-located nucleus, and variously-staining secretory vesicles (zymogen granules) in apical cytoplasm. These features are all associated with organized mass production of protein for export. **More.**

Mucous Secretion



Cells which are specialized to secrete mucus are called **mucous cells**. Examples in the GI system include secretory cells of the salivary glands, esophageal glands, stomach surface, pyloric glands, and Brunner's glands of the duodenum. These cells are typically organized into tubular secretory units.

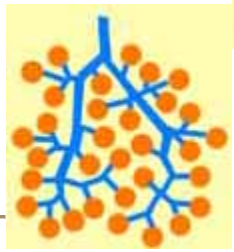
Goblet cells are mucous cells which stand alone within the intestinal epithelium. Goblet cells take their name from their characteristic shape, with a broad opening at the apical end and a narrow, "pinched" base. Cells with this goblet shape are also characteristic of the respiratory tract and the female reproductive tract.

In routine light microscopy, mucous cells are most conspicuously distinguished by "empty"-appearing (i.e., poorly stained) apical cytoplasm and by densely-stained, basal nuclei. **More.**

Simple / Compound

The **simple** / **compound** distinction is based on on duct shape.

A *simple* gland has either an unbranched duct or no duct at all. In either case, there is only a single secretory unit (acinus or tubule). Examples include sweat glands, individual gastric glands, and intestinal crypts.

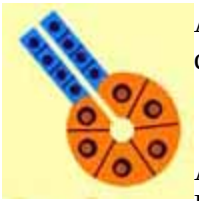


A *compound* gland has a branching duct. Salivary glands and pancreas are familiar examples. Compound glands are typically fairly bulky and contain very many individual secretory units (acini or tubules).

Acinus / Tubule / Cord

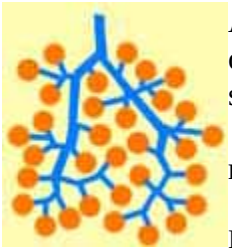
Each secretory unit of a gland consists of cells arranged into an **acinus**, a **tubule**, or a **cord**. Each of of these arrangements has a different and characteristic appearance when viewed in section.

Acinus (or alveolus)

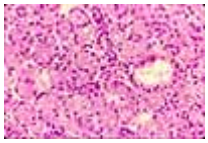


An **acinus** (from Latin, *grape*) is a small ball of secretory epithelial cells containing a tiny central lumen. Acini are usually formed by serous cells. [Acini are sometimes called *alveoli*, from L., *small cavity*.]

A typical **acinar cell** is shaped like a pyramid. Its **basal surface**, located at periphery of the acinus, rests on the basement membrane separating the acinus from the underlying stroma. Its **lateral surfaces** (the sides of the pyramid) are attached to adjacent secretory cells. Its **apical** surface is free and faces the acinar lumen, which communicates by duct with the outside. The acinar cell's **cytoplasm** is also visibly polarized, usually with basophilic basal cytoplasm and variously-staining secretory granules concentrated in apical cytoplasm. For more, see serous cells.



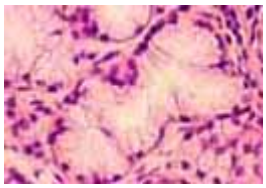
A compound **acinar gland** can be quite accurately modelled as a bunch of grapes embedded in Jello™. The grapes are the acini, the branching stems are the ducts, and the Jello™ represents the rest of the stroma. Major and minor branches of the bunch represent lobes and lobules, respectively, separated by greater amounts of connective tissue.



In routine tissue sections, most acini are cut in random planes and look like solid lumps, made of cells having various sizes and shapes. The **lumen** of an acinus is typically tiny (i.e., much smaller than a cell) and so is visible only when an acinus is sliced neatly across the middle. In such a slice, the cells look like slices of pie, with the lumen in the center.

Tubules

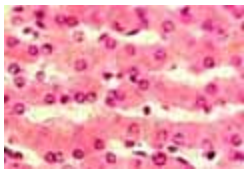
In contrast to the small balls of cells which comprise secretory acini, secretory cells may also arrange themselves into secretory **tubules**. This is a common form for mucous glands (e.g., esophageal glands, pyloric glands, Brunner's glands, salivary glands). Other tubular glands include sweat glands and gastric glands.



Because tubules are elongated, random sections commonly include the lumen as well as the secretory cells themselves (in contrast to the situation with acini). But interpretation of the sectioned appearance of tubular glands will depend on whether the tubules are simple or branched, on whether they are straight or twisted, and on whether or not adjacent tubules lie parallel to one another.

Cords

Cords are arrangements of cells attached to one another to form sheets. In section, the predominant pattern appears linear, even though the lines may twist and branch.



Cords are a common arrangement for epithelial cells that are specialized for endocrine secretion. The cells retain an epithelial character, attached to neighboring cells, even though they may no longer comprise a surface barrier between interstitial space and a secretory lumen that leads to the outside. Examples of endocrine cells arranged into cords include the epithelial cells of pancreatic islets, parathyroid, adrenal cortex, and **liver**.

The **liver** is notable for having cells arranged into cords in spite of its major exocrine function. In order to maintain communication with ducts, the liver cords contain a network of intercellular channels called bile canaliculi.

Endocrine / Exocrine

The suffix *-crine* refers to secretion; the prefix *endo-* or *exo-* tells where the secretory product goes.

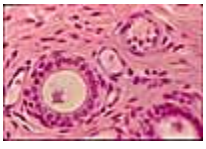
The product of **exocrine glands** leaves the body proper, either by direct secretion onto the body's surface (e.g., sweat) or into the lumen of an organ (e.g., gastric juice) or else by flowing through a system of ducts (e.g., saliva, pancreatic enzymes, bile). The cells of exocrine glands are generally arranged into secretory units in the form of acini or tubules (although the liver has a remarkable arrangement of cords).

The product of **endocrine glands** is secreted into interstitial fluid and hence into capillaries and general circulation. The cells of endocrine glands are often arranged into cords adjacent to capillaries or sinusoids.

Link to the endocrine system.

Ducts

Ducts are relatively simple tubular structures which are (usually) easily distinguished from blood vessels by their conspicuous cuboidal to columnar epithelial lining. Blood vessels, of course, are lined by simple squamous endothelium.



The glandular cells which comprise ducts generally receive much less attention than those which actually secrete the gland's product. However, the complete understanding of a gland requires some awareness of and attention to the duct system through which it

drains. Ducts are not just passive "plumbing". Some duct segments actively modify the secretory product passing through, concentrating it by removing water).

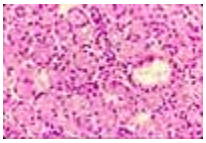
In general, cells lining ducts may often be distinguished by one or more of the following:

- cytoplasm rather pale (relative to most serous secretory cells);
- nucleus centrally located (as opposed to somewhat basal for most mucous secretory cells).
- basal and apical cytoplasm not obviously differentiated (but this isn't always obvious for secretory cells either, and striated ducts do have specialized basal cytoplasm);
- cells relatively short (cuboidal) relative to many (but not all) secretory cells (and larger ducts may be lined by columnar cells);

For the purpose of describing duct structure and function, some special terminology can be useful. (By and large, the distinctions that these terms allow represent minor details rather than essential knowledge.)

Intercalated / Striated Ducts

Intercalated ducts are small, short ducts which drain individual secretory units. These are usually inconspicuous, lined by a simple epithelium consisting of low cuboidal cells.



Striated ducts are duct segments specialized for concentrating the secretory product that is flowing through the duct. Striated ducts found in some but not all glands (notably salivary glands), where they follow after intercalated ducts and are lined by a simple epithelium consisting of conspicuous cuboidal to columnar cells.

The cells of the striated ducts are specialized for concentrating the secretory product that is flowing duct. They do this by pumping water and ions across the duct epithelium, from the duct lumen and into interstitial fluid. Remember the kidney? An extreme example of the striated duct is represented by the proximal tubule of a nephron in the kidney.

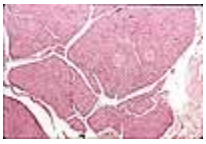
Ultrastructurally, striated duct cells display extensive infoldings of the basal membrane. These folds are closely associated with mitochondria that provide ATP for the membrane pumps. In light microscopy, the basal folds and mitochondria are sometimes visible as basal *striations*, hence the name *striated duct*.

Secretory / Excretory Ducts

Both intercalated and striated ducts are sometimes called **secretory ducts**. They are located within lobules (*intralobular*, next paragraph). More distal ducts (*interlobular*, next paragraph), sometimes called **excretory ducts**, are generally passive conducting tubes. Their size varies, depending on how many branches have converged distally. Larger excretory ducts may be lined by *columnar* or by *stratified* cuboidal epithelium.

It is sometimes convenient to refer to ducts by location within the gland. The following terms are all directly descriptive. *Intra-* means *within*. *Inter-* means *between*. **Lobes** and **lobules** are clusters of secretory units served, respectively, by major and minor branches

of the duct tree. Within a lobule, individual secretory units are separated from one another by little more than basement membranes and capillaries. In contrast, the stroma which separates lobules and lobes consists of thicker septa of connective tissue. (The distinction between lobes and lobules is arbitrary; lobes are evident upon gross inspection while lobules are evident to low power microscopy.)



Intralobular -- Located *within lobules*, with no more connective tissue intervening between ducts and secretory units (i.e., acini or tubules) than between adjacent secretory units. Intercalated and striated ducts are intralobular.

Interlobular -- Located *between lobules*, within the thin connective tissue septa that separate lobules. All interlobular ducts are excretory.

Interlobar -- Located *between lobes*, within conspicuous, thick connective tissue septa that separate lobes. All interlobar ducts are excretory.

Parenchyma / Stroma

The **parenchyma** of an organ consists of those cells which carry out the specific function of the organ and which usually comprise the bulk of the organ. **Stroma** is everything else -- connective tissue, blood vessels, nerves, and ducts.

The **parenchyma / stroma** distinction can be convenient for describing not only glands but also other organs and even tumors. Examples:

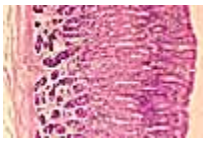
- Hepatocytes comprise the *parenchyma* of the liver. Everything else is *stroma*.
- Neurons comprise the *parenchyma* of the brain. Everything else is *stroma*.
- Cardiac muscle cells comprise the *parenchyma* of the heart. Everything else is *stroma*.
- Cancer cells comprise the *parenchyma* of malignant neoplasms. Everything else is *stroma*.

Because parenchyma often seems more interesting, **stroma** is commonly ignored as just boring background tissue. But no organ can function without the mechanical and nutritional support provided by the stroma. In any gland, connective tissue and capillaries of the stroma envelope every acinus, tubule, or cord, although they are often inconspicuous.

Pay attention to the stroma. If an organ is inflamed, the signs of inflammation appear first in the stroma. For an example from liver, see WebPath.

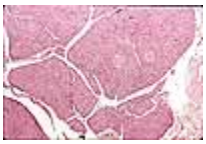
Historical note: Ignoring inconspicuous tissue features can have consequences. Stromal capillaries are seldom evident in tissue specimens. Nothing calls them to one's attention, so they are often ignored and forgotten. Unfortunately, just such inattention may have delayed for decades the realization that interfering with tumor vasculature might powerfully inhibit tumor growth.

Gastric Glands



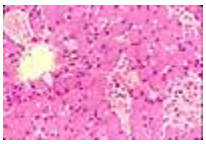
Gastric glands are the simple tubular mucosal glands of the stomach. These glands consist predominantly of parietal cells which secrete acid and serous chief cells which secrete gastric enzymes.

Pancreas



Functionally, the **pancreas** has two more-or-less independent roles.

1. Exocrine secretion of proteolytic enzymes into the intestine.
2. Endocrine secretion of several hormones into blood.



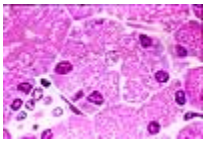
Structurally, the **pancreas** is a compound, acinar, serous, exocrine gland with scattered islets of endocrine tissue. If you're familiar with basic gland terminology, little else needs to be said.

In **pancreatitis**, the appearance of the pancreas may be altered by inflammatory infiltrate in the stroma. In **acute pancreatitis**, release of pancreatic enzymes can cause proteolytic digestion and associated haemorhagic necrosis. **Chronic pancreatitis** can lead to atrophy and fibrosis of the parenchyma. For print images, see Milikowski & Berman's *Color Atlas of Basic Histopathology*, pp. 304-306. For interactive specimens, see the Virtual Slidebox of Histopathology.

Autolysis (self-digestion) may also occur postmortem in normal pancreas, so that autopsy specimens often reveal mush rather than typical acinar architecture.

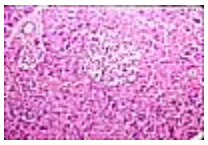
Upon cell death, the proteolytic enzymes stored in pancreatic acinar cells immediately begin reacting with the cells themselves, destroying normal cell structure. (Ideally, histological specimens are fixed by perfusion of fixative through blood vessels, to preserve cells quickly and simultaneously throughout the specimen. This procedure is not available for post-mortem specimens, where the deceased may wait several hours before autopsy. Even specimens removed surgically are usually dropped as bulk samples into fixative, so preservation may vary between the center and the periphery of the specimen.

A couple quaint details, of no special significance, also characterize the tissue organization of the pancreas.



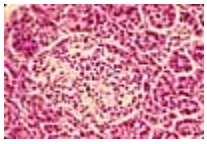
The serous acini of the pancreas have *centroacinar cells*. In other serous glands, the intercalated ducts begin at the edges of the acini. The ducts of the pancreas actually begin within the acini. The nuclei which commonly appear in the centers of pancreatic acini are those of the first cells of the intercalated ducts.

The pancreas and parotid gland differ in the amount of stromal fat, with adipocytes common in the stroma of the parotid but fairly rare in the pancreas.



[These details may serve to determine whether a small unlabelled specimen belongs to pancreas or to the parotid gland, which is also a compound, acinar, serous, exocrine gland. A small specimen of pancreas, lacking islets, can be positively distinguished by the presence of *centroacinar cells*; the parotid gland can usually be positively distinguished by the presence of abundant adipocytes in glandular stroma.]

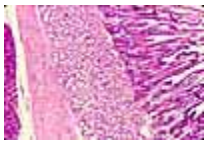
Pancreatic islets and their hormones are covered elsewhere.



Brunner's glands

Brunner's glands provide abundant alkaline mucus to neutralize the acid contents entering the duodenum from the stomach.

Thus, **Brunner's glands** are compound, tubular, mucous glands located in the submucosa of the duodenum. They fill this region so completely that the typical submucosal connective tissue is obscured.



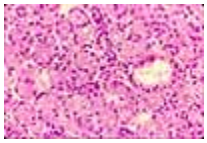
Essentially, **Brunner's glands** represent a continuation of the pyloric glands of the stomach. At the stomach/intestine junction, mucous glands of the pyloric mucosa are replaced by Brunner's glands of the duodenal submucosa.

Salivary Glands

Salivary glands produce saliva, a watery mixture of enzymes and mucus. The enzymes and the mucus are produced by two distinct cell types, called serous cells and mucous cells. Release of saliva is facilitated by contraction of myoepithelial cells.

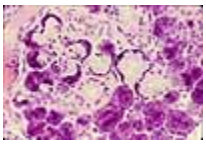
Autoimmune involvement of salivary glands in **Sjogren's syndrome** is associated with inflammation, atrophy, and fibrosis. See WebPath or Milikowski & Berman's *Color Atlas of Basic Histopathology*, p. 220.

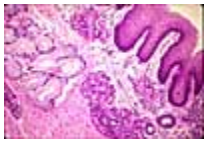
The **parotid gland** (named for its location, *par* + *otid*, beside the ear) is a classic example of a compound, acinar, serous, exocrine gland. Together, these terms pretty well describe everything significant about the tissue composition of the parotid gland. The parenchyma of the parotid consists exclusively of serous cells (no mucous cells).



The parotid gland has structure and appearance similar to the pancreas (i.e., the pancreas is also a compound, acinar, serous, exocrine gland). An unlabelled specimen of parotid gland can usually be positively distinguished from pancreas by the presence of abundant adipocytes in glandular stroma; the pancreas can be positively distinguished by the presence of *endocrine islets* and of *centroacinar cells*.

All other salivary glands are **mixed glands**, containing both serous cells and mucous cells. The proportion of serous to mucous varies from gland to gland (and from sample to sample within a gland). The *submandibular gland* is mostly serous. The *sublingual glands* are mostly mucous.





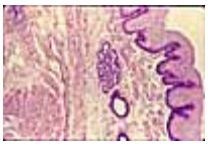
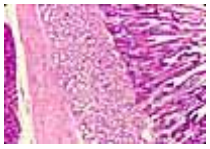
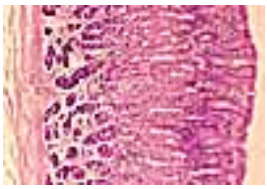
Numerous **minor salivary glands**, both serous and mucous, are found throughout the oral mucosa, in lips, cheeks, palate, and tongue.

Mucosal and Submucosal Glands

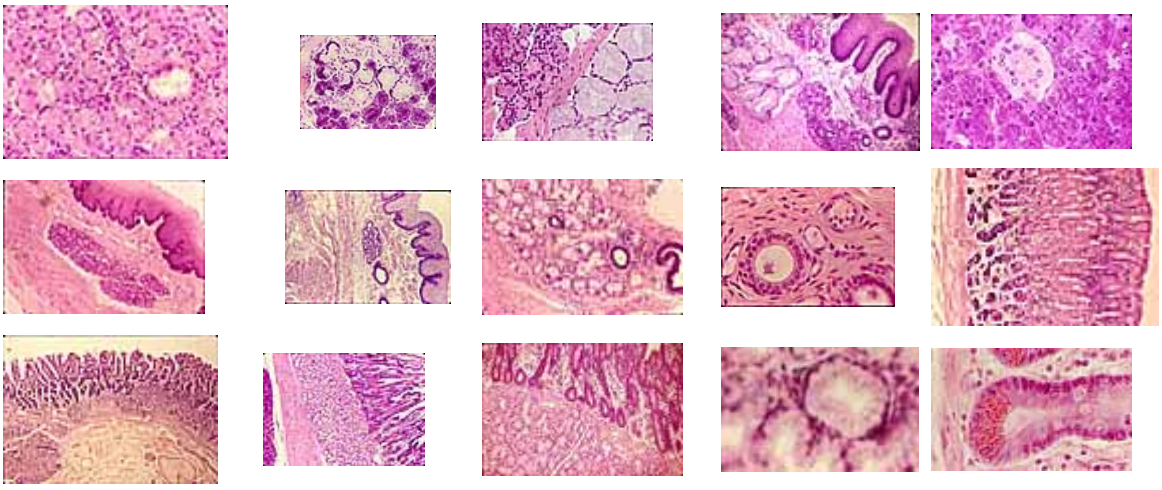
The terms **mucosal** and **submucosal** refer to location within the wall of the digestive tract (i.e., in the mucosa or in the submucosa, respectively.)

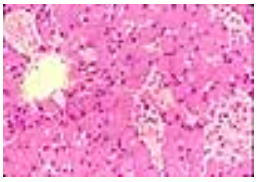
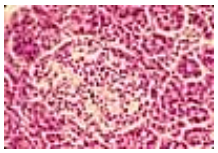
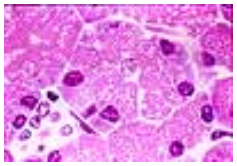
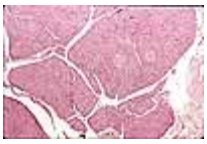
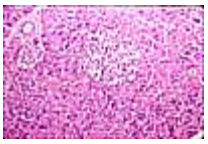
Esophageal glands and duodenal Brunner's glands are *submucosal glands*.

Gastric glands and intestinal crypts are *mucosal glands*.


Glands of the GI system. Click on a thumbnail image for a labelled enlargement.



Reproductive Glands

Endocrine Glands