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.

<table>
<thead>
<tr>
<th>Destination of product:</th>
<th><strong>exocrine</strong> / <strong>endocrine</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of product:</td>
<td><strong>serous</strong> / <strong>mucous</strong> / <strong>mixed</strong></td>
</tr>
<tr>
<td>Location of gland:</td>
<td><strong>mucosal</strong> / <strong>submucosal</strong></td>
</tr>
<tr>
<td>Arrangement of secretory cells:</td>
<td><strong>acinus</strong> / <strong>tubule</strong> / <strong>cord</strong></td>
</tr>
<tr>
<td>Number of interconnected units:</td>
<td><strong>simple</strong> / <strong>compound</strong></td>
</tr>
<tr>
<td>Duct function:</td>
<td><strong>intercalated</strong> / <strong>striated</strong></td>
</tr>
<tr>
<td></td>
<td><strong>secretory</strong> / <strong>excretory</strong></td>
</tr>
<tr>
<td>Duct location:</td>
<td><strong>intralobular</strong> / <strong>interlobular</strong> / <strong>interlobar</strong></td>
</tr>
<tr>
<td>Tissue composition:</td>
<td><strong>parenchyma</strong> / <strong>stroma</strong></td>
</tr>
</tbody>
</table>

---

**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 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 (acinus 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 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 haemorrhagic 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.