Tissue type and function

- **Epithelial tissue**
- **Connective tissue**
- **Muscle tissue**
- **Nervous tissue**

Stomach

Muscle

Neurons

*LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 41.2 Four Types of Tissue* © 2004 Sinauer Associates, Inc. and W. H. Freeman & Co.
Simple squamous
- Lines blood vessels and air sacs of lungs
- Permits exchange of nutrients, wastes, and gases

Stratified squamous
- Outer layer of skin, mouth, vagina
- Protects against abrasion, drying out, infection

Simple cuboidal
- Lines kidney tubules and glands
- Secretes and reabsorbs water and small molecules

Stratified cuboidal
- Lines ducts of sweat glands
- Secretes water and ions

Simple columnar
- Lines most digestive organs
- Absorbs nutrients, produces mucus

Stratified columnar
- Lines epididymus, mammary glands, larynx
- Secretes mucus

(a) Most epithelial tissues line or cover surfaces or body cavities

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A **gland** is an organ that synthesizes a substance for release of substances such as hormones, breast milk, often into the bloodstream (endocrine gland) or into cavities inside the body or its outer surface (exocrine gland).
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.
Histologically, glands are described using some standard vocabulary, with which you should be familiar.

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

- Pineal gland
- Hypothalamus
- Posterior pituitary
- Anterior pituitary
- Thyroid
- Parathyroid
- Thymus
- Heart
- Liver
- Stomach and small intestine
- Pancreas
- Adrenal cortex
- Adrenal medulla
- Kidney
- Skin
- Gonads
- Ductless glands that produce hormones
- Secretions include amino acids, proteins, glycoproteins, and steroids

Endocrine Glands
- More numerous than endocrine glands
- Secrete their products onto body surfaces (skin) or into body cavities
- Examples include mucous, sweat, oil, and salivary glands
- The only important unicellular gland is the goblet cell
- Multicellular exocrine glands are composed of a duct and secretory unit
• Classified according to:
  ◦ **Simple or compound duct type**
  ◦ Structure of their secretory units
<table>
<thead>
<tr>
<th>Endocrine Glands</th>
<th>Exocrine Glands</th>
</tr>
</thead>
<tbody>
<tr>
<td>No duct system</td>
<td>Ducts to release products</td>
</tr>
<tr>
<td>Secretions directed into the extracellular fluid (basal side), move into vascular system</td>
<td>Secretions released to the apical cell surface, move out of ducts to outside environment</td>
</tr>
</tbody>
</table>
A gland is one or more cells that makes and secretes an aqueous fluid.

- Classified by:
  - Site of product release – **endocrine or exocrine**
  - Relative number of cells forming the gland – **unicellular or multicellular**

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

**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.

**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.

**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.
Exocrine glands — secrete their products through a duct or directly onto the apical surface, the glands in this group can be divided into three groups:

• **Merocrine glands** — cells secrete their substances by exocytosis (e.g., mucous and serous glands). Also called "eccrine".

• **Apocrine glands** — a portion of the secreting cell's body is lost during secretion. *Apocrine gland* is often used to refer to the apocrine sweat glands, however it is thought that apocrine sweat glands may not be true apocrine glands as they may not use the apocrine method of secretion.

• **Holocrine glands** — the entire cell disintegrates to secrete its substances (e.g., sebaceous glands)
- Merocrine,
- Apocrine,
- Holocrine secretions

**Mechanism of secretion**
**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.
The term **eccrine** is specifically used to designate merocrine secretions from

- sweat glands (eccrine sweat glands)
- Salivary glands
- Pancreatic glands
- Certain sweat glands (eccrine and apocrine)
Merocrine glands have three primary functions:

• **Thermoregulation.** Sweat cools the surface of the skin and reduces body temperature. This cooling is the primary function of sensible perspiration, and the degree of secretory activity is regulated by neural and hormonal mechanisms. When all of the merocrine sweat glands are working at maximum, the rate of perspiration may exceed a gallon per hour, and dangerous fluid and electrolyte losses can occur. For this reason athletes in endurance sports must pause frequently to drink fluids.

• **Excretion.** Merocrine sweat gland secretion can also provide a significant excretory route for water and electrolytes, as well as for a number of prescription and nonprescription drugs.

• **Protection.** Merocrine sweat gland secretion provides protection from environmental hazards by diluting harmful chemicals and discouraging growth of microorganisms.
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.

• **Apocrine glands become functional at puberty.**

• They respond to emotional or sensory stimuli (not to heat).

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,
  • The ceruminous glands of the external acoustic meatus.
  • Scrotum
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.

• This type of secretion occurs primarily in **sebaceous glands within the skin, but also in the tarsal (Meibomian) glands of the eyelid.**
### Mechanism of Secretion

<table>
<thead>
<tr>
<th>Merocrine</th>
<th>Apocrine</th>
<th>Holocrine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expelled by exocytosis</td>
<td>Uses membrane vesicles</td>
<td>Entire secretory cell lost, as plasma membrane breaks to release product</td>
</tr>
<tr>
<td>Only secretory product is lost</td>
<td>Secretory product and some membrane lost</td>
<td>Sebaceous glands use this method</td>
</tr>
</tbody>
</table>
Ways of Secretion and exocrine type
<table>
<thead>
<tr>
<th>Simple duct structure (duct does not branch)</th>
<th>Tubular secretory structure</th>
<th>Alveolar secretory structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Simple tubular</td>
<td>(b) Simple branched tubular</td>
<td>(c) Simple alveolar</td>
</tr>
<tr>
<td>Example: intestinal glands</td>
<td>Example: stomach (gastric)</td>
<td>Example: No important example in humans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(d) Simple branched alveolar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: sebaceous (oil) glands</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compound duct structure (duct branches)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(e) Compound tubular</td>
<td>(f) Compound alveolar</td>
<td>(g) Compound tubuloalveolar</td>
</tr>
<tr>
<td>Example: duodenal glands of small intestine</td>
<td>Example: mammary glands</td>
<td>Example: salivary glands</td>
</tr>
</tbody>
</table>

Key:  = Surface epithelium  = Duct  = Secretory epithelium
A: secretory parts of the gland: the secretory cells are full of mucus (in white)

B: duct of the gland (the nuclei of the duct cells are round --> simple cuboidal epithelium)
nucleus
lumen
capillary (you can see the red blood cells in red and distinguish the fine simple squamous epithelium with its flat nuclei surrounding them)
UNICELLULAR EXOCRINE GLANDS
The epithelium (B) bordering the lumen (D) is simple columnar. In this photo, the unicellular glands are goblet cells (A) that manufacture and secrete mucus (C). In this specific case, goblet cells are unicellular glands because they do not associate with each other to form secretory units (= multicellular exocrine glands). They are instead scattered amongst the non secretory cells of the epithelium and secrete mucus directly in the lumen.
Unicellular Glands
The glandular epithelial structures are classified into two major categories; namely, the unicellular glands and the multicellular glands. The multicellular glands are further divided into the exocrine glands and the endocrine glands, i.e., those with and those without a duct system.
Simple Exocrine Glands

Simple Coiled Tubular Gland
Thick skin.

Simple Branched Saccular Gland
Associated with the hair follicle in thin skin.

Simple Straight Tubular Gland
Large intestine, intestinal gland or "crypt of Lieberkuhn"
Compound Saccular Gland
Active mammary gland.
Intralobular Duct
Parotid gland
Goblet Cell

Unicellular secretion

Microvilli

Secretory vesicles containing mucin

Golgi apparatus

Nucleus

Rough ER

Figure 4.3b
The type of secretory product of an Exocrine gland may also be one of three categories:

**Serous glands** — secrete a watery, often protein-rich product.

**Mucous glands** — secrete a viscous product, rich in carbohydrates (e.g., glycoproteins).

**Sebaceous glands** — secrete a lipid product. These glands are also known as oil glands.
<table>
<thead>
<tr>
<th>Type of Secretion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serous</td>
</tr>
<tr>
<td>Thin, watery protein-rich secretion</td>
</tr>
</tbody>
</table>
Serous secreting cells

Merocrine glands
<table>
<thead>
<tr>
<th><strong>Unicellular Glands</strong></th>
<th><strong>Multicellular Glands</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Made of only one glandular epithelium cell; called intraepithelial cells</td>
<td>Multiple cells make up one gland; called extraepithelial cells</td>
</tr>
<tr>
<td>Goblet cells are the only human example</td>
<td>Many examples, including secretory sheets in the human stomach</td>
</tr>
</tbody>
</table>