

DIGESTIVE SYSTEM

The digestive system (figure 24.1) consists of the digestive tract, a tube extending from the mouth to the anus, and its associated accessory organs, primarily glands, which secrete fluids into the digestive tract. The digestive tract is also called the alimentary tract, or alimentary canal. The term gastrointestinal only refers to the stomach and intestines but is often used as a synonym for the digestive tract. The regions of the digestive tract include 1. the mouth or oral cavity, which has salivary glands and tonsils as accessory organs; 2. the pharynx, or throat, with tubular mucous glands; 3. the esophagus, with tubular mucous glands; 4. the stomach, which contains many tubelike glands; 5. the small intestine, consisting of the duodenum, jejunum, and ileum, with the liver, gallbladder, and pancreas as major accessory organs.

Functions of the Digestive System Objective:

1. Ingestion is the introduction of solid or liquid food into the stomach. The normal route of ingestion is through the oral cavity, but food can be introduced directly into the stomach by a nasogastric, or stomach, tube.
2. Mastication is the process by which food taken into the mouth is chewed by the teeth. Digestive enzymes cannot easily penetrate solid food particles and can only work effectively on the surfaces of the particles.
3. Propulsion in the digestive tract is the movement of food from one end of the digestive tract to the other. The total time that it takes food to travel the length of the digestive tract is usually about 24–36 hours.

4. Mixing. Some contractions don't propel food (chyme) from one end of the digestive tract to the other but rather move the food back and forth within the digestive tract to mix it with digestive secretions and to help break it into smaller pieces. Segmental contractions are mixing contractions that occur in the small intestine.

5. Secretion. As food moves through the digestive tract, secretions are added to lubricate, liquefy, and digest the food. Mucus, secreted along the entire digestive tract, lubricates the food and the lining of the tract.

6. Digestion is the breakdown of large organic molecules into their component parts: carbohydrates into monosaccharides, proteins into amino acids, and triglycerides into fatty acids and glycerol. Digestion consists of mechanical digestion, which involves mastication and mixing of food, and chemical digestion, which is accomplished by digestive enzymes that are secreted along the digestive tract.

7. Absorption is the movement of molecules out of the digestive tract and into the circulation or into the lymphatic system. The mechanism by which absorption occurs depends on the type of molecule involved.

8. Elimination is the process by which the waste products of digestion are removed from the body. During this process, occurring primarily in the large intestine, water and salts are absorbed and change the material in the digestive tract from a liquefied state to a semisolid state.

Histology of the Digestive Tract Objective:

Outline the basic histologic characteristics of the digestive tract. The digestive tube consists of four major layers, or tunics: an internal mucosa and an external serosa with a submucosa and muscularis in between. These four tunics are present in all areas of the digestive tract from the esophagus to the anus. Three major types of glands are associated with the intestinal tract:

- (1) unicellular mucous glands in the mucosa,
- (2) multicellular glands in the mucosa and submucosa,
- (3) multicellular glands (accessory glands) outside the digestive tract.

Mucosa :

The innermost tunic, the mucosa consists of three layers: (1) the inner mucous epithelium, which is moist stratified squamous epithelium in the mouth, oropharynx, esophagus, and anal canal and simple columnar epithelium in the remainder of the digestive tract; (2) a loose connective tissue called the lamina propria and (3) an outer thin smooth muscle layer, the muscularis mucosae.

Submucosa The submucosa:

is a thick connective tissue layer containing nerves, blood vessels, and small glands that lies beneath the mucosa.

Muscularis:

The next tunic is the muscularis, which consists of an inner layer of circular smooth muscle and an outer layer of longitudinal smooth muscle. Two exceptions

are the upper esophagus, where the muscles are striated, and the stomach, which has three layers of smooth muscle.

Oral Cavity Objective:

The oral cavity or mouth, is that part of the digestive tract bounded by the lips anteriorly, the fauces opening into the pharynx posteriorly, the cheeks laterally, the palate superiorly, and a muscular floor inferiorly. Lips and Cheeks The lips are muscular structures formed mostly by the orbicularis oris muscle. The outer surfaces of the lips are covered by skin. The keratinized stratified epithelium of the skin is thin at the margin of the lips

II. ORAL CAVITY:

A. The oral cavity is lined with a **stratified squamous epithelium** that may be keratinized or non-keratinized depending on what part of the oral cavity you are in. This epithelium is often called the **mucous epithelium**. At the mouth, the transition between the keratinized stratified squamous epithelium of the skin and the non-keratinized stratified squamous epithelium of the oral cavity occurs at the lips. The superficial (surface) cells of the non-keratinized stratified squamous epithelium are alive and nucleated (as opposed to those of keratinized epithelium of skin which are not) and have only a few granules of keratin in their cytoplasm.

Below the stratified squamous epithelium is a layer of loose connective tissue, the **lamina propria**.

a. This lamina propria interdigitates with the stratified squamous epithelium of the oral region as the dermis of the skin does with the epidermis.

b. It contains blood and lymph vessels, small glands, nerves and aggregations of lymphocytes.

Together, the stratified squamous epithelium and the lamina propria form the **oral mucosa**. Sub lingual and submandibular salivary glands lie in tissues below the mucosa.

The roof of the mouth consists of soft and hard palates:

The hard palate has an intermembranous bone backing which is covered by a lightly keratinized stratified squamous epithelium. The soft palate has a core of skeletal muscle and is covered by a non-keratinized stratified squamous epithelium.

Tongue:

The tongue consists of a mass of striated muscle covered by a mucous epithelium that varies between being keratinized (on filiform papillae) and non-keratinized (in other areas).

- a. This mucous epithelium is strongly adherent to the muscle below
- b. This is because the lamina propria penetrates into spaces between the muscle bundles.

Tongue muscle is composed of bundles that are oriented in 3 planes. This sort of structure increases both the potential stiffness and the mobility of the tongue. The dorsal surface of the tongue can be divided into two areas by a V-shaped boundary found on the posterior dorsal tongue surface. The anterior 2/3 of the tongue consists of various types of papillae and serous and mucous glands. The posterior 1/3, behind the V, is composed of small bulges that contain lymphatic nodules.

These bulges are the **lingual tonsils** that each consist of lymph nodules surrounding a single crypt. If we look at the mucous membrane of the tongue we find it is smooth on the ventral surface, but the dorsal surface is covered with **papillae** of different types.

Types of papillae found on the dorsal surface of the tongue.

a. **Filiform papillae** - have an elongated conical shape.

- * These papillae are numerous and are found over the entire dorsal surface.
- * There are no taste buds in the epithelium covering filiform papillae.
- * The filiform papillae are covered by a keratinized stratified squamous epithelium.

b. **Fungiform papillae** - these are mushroom shaped.

- * There are fewer fungiform than filiform papillae.
- * They are found interspersed between the filiform papillae over the entire dorsal surface of the tongue.
- * A few taste buds may be found in the epithelium covering these papillae.

c. **Foliate papillae** - these are arranged as closely packed folds along the posterior lateral margins of the tongue and are found in young children.

- * There are numerous taste buds in the epithelium covering foliate papillae.
- * Serous glands drain through openings at their bases.

d. **Circumvallate papillae** - these are extremely large circular papillae which have a flattened surface that extends above the other tongue papillae.

* Circumvallate papillae are distributed in the V region of the posterior dorsal surface of the tongue.

* Many taste buds can be found in the epithelium covering their lateral surfaces.

Taste buds:

Oval multicellular structures. Cells surround a small cavity that communicates with the oral cavity via a pore between the apexes of the cells surrounding the cavity. Dissolved substances enter the cavity through this pore and come into contact with the neuroepithelial sensory cells of the taste bud. The chemical stimuli are transduced to an electrical impulse that is transmitted to afferent axons that synapse on the basal portions of the neuroepithelial cells.

Teeth:

Most of them are replacements for primary, or deciduous, teeth that are lost during childhood. The deciduous teeth erupt (the crowns appear within the oral cavity) between about 6 months and 24 months of age. The permanent teeth begin replacing the deciduous teeth by about 5 years and the process is completed by about 11 years.

Each tooth consists of a crown with one or more cusps (points), a neck, and a root. The clinical crown is that part of the tooth exposed in the oral cavity. The anatomical crown is the entire enamel-covered part of the tooth. The center of the tooth is a pulp cavity, which is filled with blood vessels, nerves, and connective tissue called pulp. The pulp cavity within the root is called the root canal. The nerves and blood vessels of the tooth enter and exit the pulp through a hole at the point of each root called the apical foramen. The pulp cavity is surrounded by a living, cellular, and calcified tissue called dentin.

The dentin of the tooth crown is covered by an extremely hard, nonliving, acellular substance called enamel, which protects the tooth against abrasion and acids produced by bacteria in the mouth. The surface of the dentin in the root is covered with a cellular, bonelike substance, called cementum, which helps anchor the tooth in the jaw. The teeth are set in alveoli along the alveolar processes of the mandible and maxilla. Dense fibrous connective tissue and stratified squamous epithelium, referred to as the gingiva cover the alveolar processes. Periodontal ligaments secure the teeth in the alveoli.

Esophagus:

Basically a muscular tube that transports food from mouth to stomach. Lining same as much of the oral cavity, that is a nonkeratinized stratified squamous epithelium. Layers same as general digestive tract as outlined above.

Specializations of esophageal tissues:

1. Small mucus secreting glands called **esophageal glands proper** are present in the submucosa. Their ducts extend to the esophageal lumen.
2. Near region of stomach **esophageal cardiac glands** are found in the lamina propria. These are branched mucous glands.
3. The muscular layer of the esophagus changes from striated muscle near mouth, to smooth muscle near stomach. Why would this be the case?
4. A serosal layer with a simple squamous epithelium as its outermost component is only found between the diaphragm and the stomach. The rest of the esophagus has an adventitia, i.e. an outer layer of connective tissue that blends with surrounding tissues.

Stomach:

There are 3 major regions of the stomach, each with a different histologic structure.

1. The **cardia**
2. The **body and fundus**
3. The **pylorus**

The mucosa and submucosa of these portions of the stomach are thrown into folds called **rugae**.

1. The surface epithelium of these folds forms invaginations that penetrate into the lamina propria of the mucosa.
2. These invaginations form the **gastric pits (foveolae gastricae)** and **gastric glands**.

The upper part of the invagination forms the gastric pit. Below that lies a gastric gland with secretory function. The gastric glands may be simple or branched.

The cellular composition of the gastric glands is different in the regions of the stomach listed above.

The epithelial lining of the mucosa that lies outside the pits is formed of columnar mucus secreting cells in all parts of the stomach.

Cardiac stomach

1. A narrow band of stomach wall just below where the esophagus connects to stomach.

2. Mostly simple and a few branched, tubular cardiac glands that produce mucus form the gastric pits of this area. Also secrete lysozyme and a small amount of HCl..

Body and fundus:

1. Has branched, tubular gastric glands that open into the bottom of the gastric pits.

Six cell types are present in gastric glands of the body and fundus:

a. **Isthmus mucous cells** - present in isthmus.

* Similar to columnar mucus secreting cells that line the gastric pit.

* Secrete neutral mucus that protects surface from acid.

b. **Parietal (oxyntic) cells**

* Most are present in the upper half of gland (neck and isthmus), a few in the base.

* These are rounded or pyramidal cells with central spherical nucleus and eosinophilic cytoplasm.

* Parietal cells produce hydrochloric acid.

* When examined with EM, deep invaginations of plasmalemma into cytoplasm can be seen that form intracellular canaliculi.

c. **Neck mucous cells**

* May be present in clusters in neck of gastric gland, secrete acid mucus.

* Irregular in shape with basal nucleus.

* Thought to be the stem cells for other cell types in the gland.

d. Chief (zymogenic) cells

- * Predominant basally in glands.
- * Typical protein synthesizing and secreting cell structure.

e. Enteroendocrine cells (Argentaffin cells)

- * Have hormonal function.

f. Enteroendocrine cells:

- * Also found in gastric glands.
- * Secrete peptides that act as hormones, e.g., gastrin.
- * Hormones are secreted basally into underlying tissues.

Pylorus:

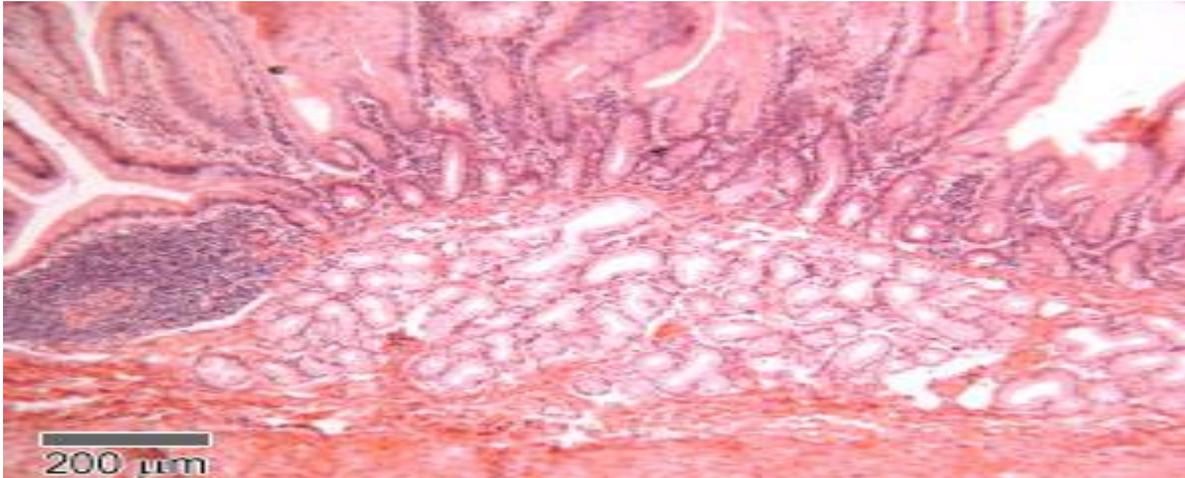
1. Has deep gastric pits that connect to pyloric glands that are similar in structure to glands of cardiac portion of stomach.
2. These glands secrete **lysozyme** into lumen of gland and **gastrin** into surrounding tissues from enteroendocrine cells.

The muscularis externa of the stomach has 3 sub layers instead of 2.

1. External muscle sublayer is longitudinal.
2. middle muscle sublayer is oblique.
3. inner muscle sublayer is circular.

Small intestine:

Duodenum



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The surface of the duodenum has several modifications that increase its surface area about 600-fold to allow for more efficient digestion and absorption of food. The mucosa and submucosa form a series of folds called the circular folds, or plicae circulares, which run perpendicular to the long axis of the digestive tract. Tiny fingerlike projections of the mucosa form numerous villi, which are 0.5 – 1.5 mm in length.

Each villus is covered by simple columnar epithelium and contains a blood capillary network and a lymphatic capillary called a lacteal. Microvilli (about 1 µm long) called microvilli, which further increase the surface area. The combined microvilli on the entire epithelial surface form the brush border. These various modifications greatly increase the surface area of the small intestine and, as a result, greatly enhance absorption. The mucosa of the duodenum is simple columnar epithelium with four major cell types: (1) absorptive cells are cells with microvilli, which produce digestive enzymes and absorb digested food; (2) goblet cells, which produce a protective mucus; (3)

granular cells (Paneth's cells), which may help protect the intestinal epithelium from bacteria; and (4) endocrine cells, which produce regulatory hormones. The epithelial cells are produced within tubular invaginations of the mucosa, called intestinal glands (crypts of Lieberkühn), at the base of the villi.

Jejunum and Ileum:

The jejunum and ileum are similar in structure to the duodenum, except that a gradual decrease occurs in the diameter of the small intestine, the thickness of the intestinal wall, the number of circular folds, and the number of villi as one progresses through the small intestine. The duodenum and jejunum are the major sites of nutrient absorption, although some absorption occurs in the ileum. Lymph nodules called Peyer's patches are numerous in the mucosa and submucosa of the ileum.

Large intestine:

The large intestine completes absorption, and retrieves water and sodium from the luminal contents which become fecal residue. It secretes large amounts of mucus, and some hormones, but no digestive enzymes.

The thick **mucosa** has deep crypts, but there are no villi. The epithelium is formed of **columnar absorptive cells** with a striated border, many goblet cells, endocrine cells and basal stem cells, but no Paneth cells. The surface epithelial cells are sloughed into the lumen, and have to be replaced around every 6 days.

The **lamina propria** and **submucosa** are similar to the small intestine.

The **longitudinal smooth muscle** in the **muscularis externa** is arranged in three longitudinal bands called **taenia coli**. At the anus, the circular muscle forms the internal **anal sphincter**.