MD Program
UNIVERSITY OF TORONTO

Histology

The Esophagus and Stomach

eMODULE TUTORIAL

CLICK TO BEGIN

H13 The Histology of The Digestive Tract

All images are from Junqueira's Basic Histology, 14th ed., © 2016 by Mescher, denoted by "J", a recommended resource, unless otherwise noted.

Recommended online resources:

Western University Virtual Slide Box

University of Michigan Virtual Microscopy

University of Minnesota Histology Guide

University of Leeds Histology Guide

University of Illinois Cell and Tissue Biology

When you have learned the material presented here, you will be able to:

- describe the basic structural organization of the walls of the gastrointestinal tract.
- describe the histological features that distinguish the esophagus and stomach.
- describe the structure of gastric glands and pits.
- describe the functional significance of the cells that make up the epithelium lining the stomach.

The **digestive system** can be subdivided into the **digestive tract** and **accessory organs**.

The **digestive tract** consist of:

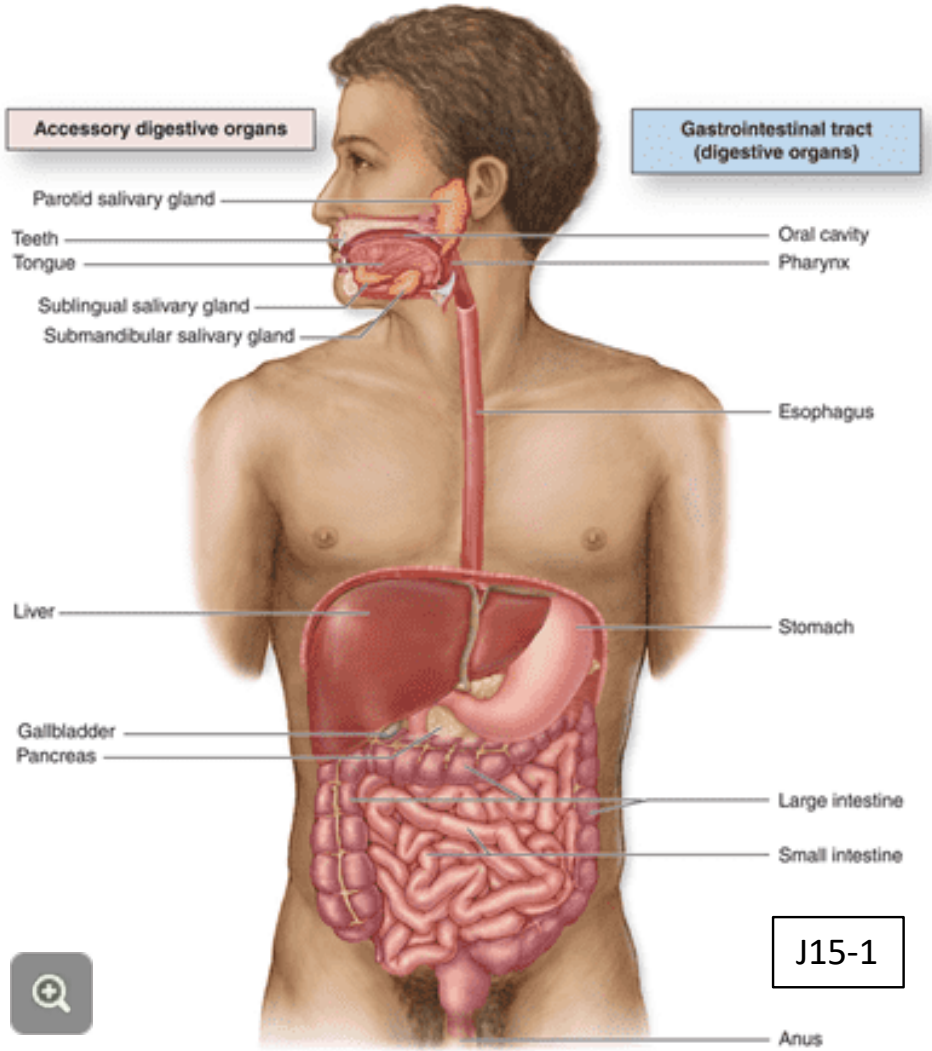
- the oral cavity
- pharynx
- esophagus
- stomach
- small intestine
- large intestine

H13 & H14 will discuss the esophagus, stomach, small and large intestine.

The **accessory digestive organs** are the:

- salivary glands, teeth and tongue
- liver
- gall bladder
- pancreas

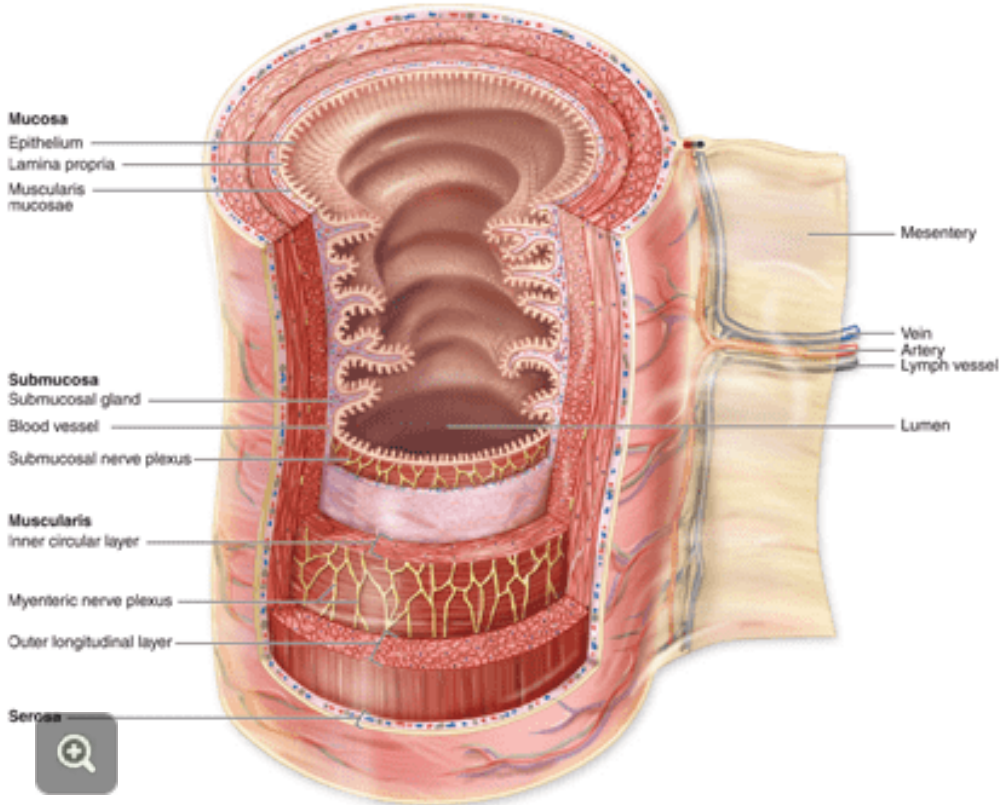
H15 will discuss the **liver, gall bladder and pancreas**.



The basic histological structure of the esophagus, stomach, small and large intestine is the same.

Each consists of **four layers**. From the lumen outward, these are the:

1. **mucosa** or mucous membrane
2. **submucosa**
3. **muscularis externa**
4. **serosa** OR **adventitia**



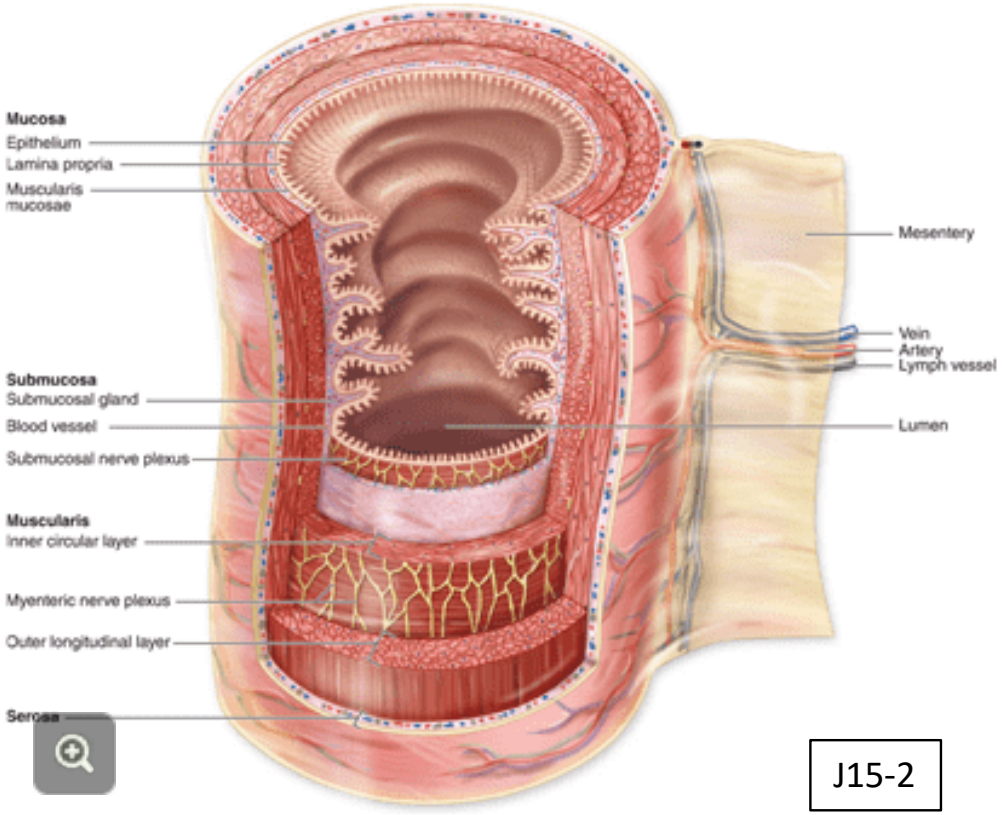
Mucosa

Remember: **mucous membranes line internal surfaces that open to the outside of the body**.
A mucous membrane consists of an **epithelium** and its underlying CT layer, the **lamina propria (LP)**.

The epithelial component of mucous membranes varies along the length of the digestive tract. It may be **simple or stratified**, it may be **squamous, cuboidal or columnar**. It often forms glands. Whatever its structure, **it is suited to the function of its location.**

The LP is loose CT; it contains blood vessels (BVs), nerves (Ns) and lymphatics (Ls). Because its overlying epithelium is the only thing separating it from the lumen, and therefore the harsh outside world (and its pathogens), the LP is **often heavily infiltrated with lymphocytes and plasma cells**.

The **muscularis mucosa** is composed of two thin layers of smooth muscle, inner circular and outer longitudinal.



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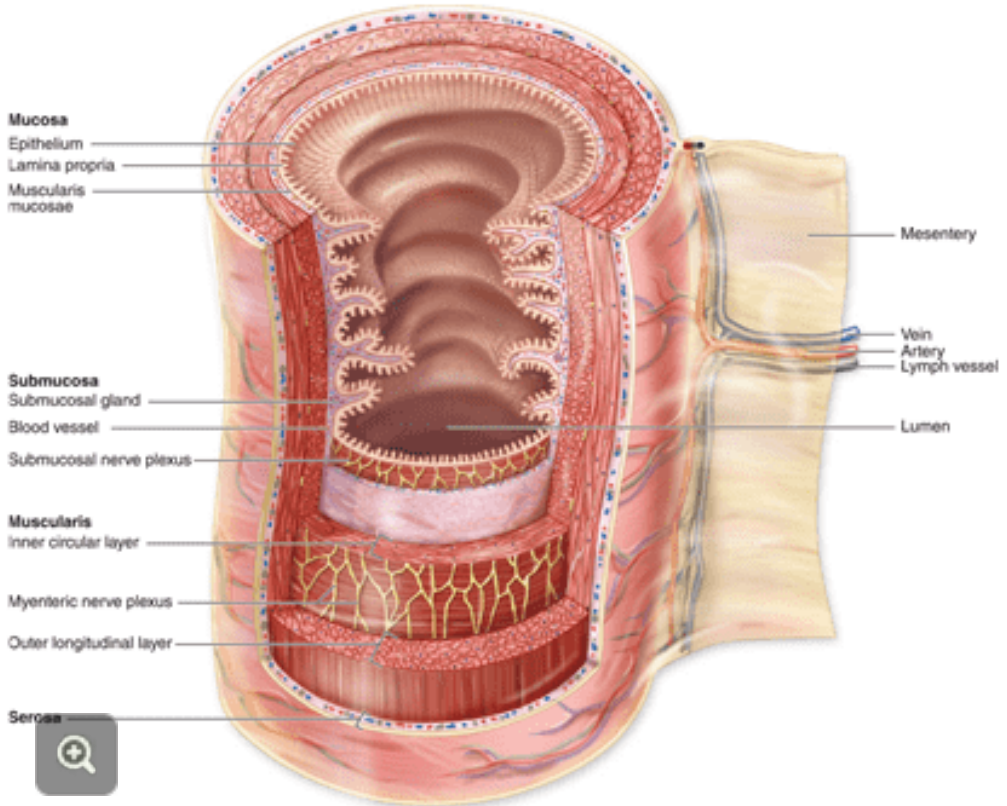
Submucosa

The submucosa is loose CT containing **blood and lymphatic vessels**. These are the parent vessels of those in the LP of the mucosa.

The submucosa also contains a **submucosal (Meissner's) nerve plexus** consisting of parasympathetic (PSy) neuronal cell bodies and sympathetic (Sy) postganglionic fibres. These fibres control the secretion of the mucosal and (if present) submucosal glands, as well as the motility of the mucosa via the muscularis mucosa.

In the **esophagus and duodenum only**, submucosal, mucous-secreting glands are present.



Muscularis Externa

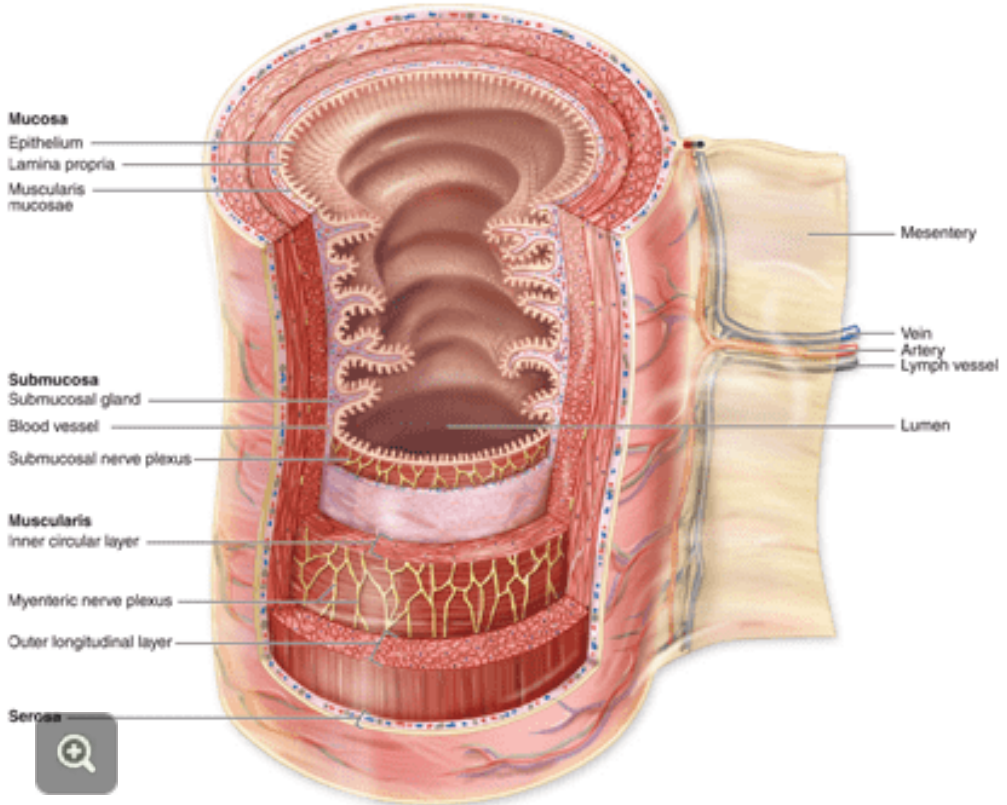
The muscularis externa usually consists of **two layers of smooth muscle**. They are thick, as compared to the muscularis mucosa. Like the muscularis mucosa, **the inner layer is arranged circularly, the outer layer longitudinally**. Their coordinated contraction causes **segmentation** and **peristalsis**.

Segmentation kneads the luminal contents, mixing it with glandular secretions from the gut wall.

Peristalsis has directionality; these wave-like contractions propel the luminal contents along the length of the gut tube.

Between the muscle layers is the **myenteric (Auerbach's) nerve plexus**, which, like the submucosal plexus, contains PSy neuronal cell bodies and Sy postganglionic fibres. It controls the motility of the gut wall, as described above.

BVs and Ls are also present between these layers of muscle.



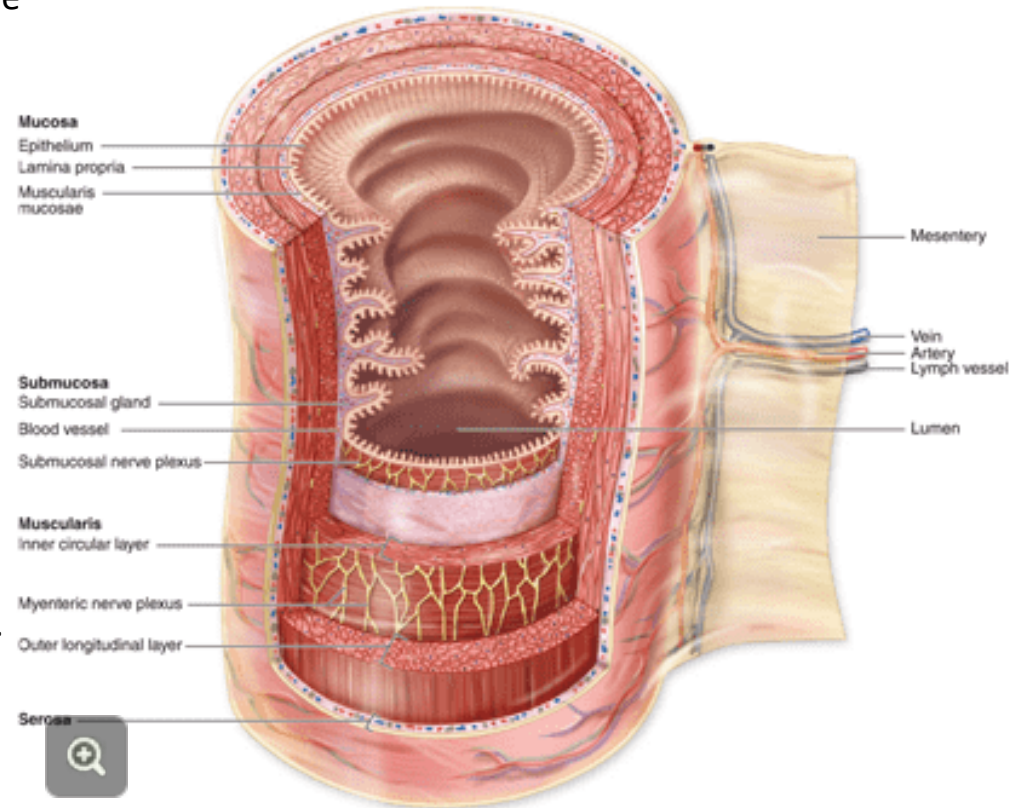
Serosa or Adventitia

Serous membranes line body cavities; i.e. they line internal surfaces that DO NOT open to the outside of the body. They consist of loose CT and adipose, with BVs, Ns and Ls, covered by **mesothelium**. Serous membranes in the peritoneal cavity are called **peritoneum**. On the surface of an abdominal organ is **visceral peritoneum**. Lining the wall of the peritoneal cavity is **parietal peritoneum**.

Thus, digestive organs facing the peritoneal cavity are covered by **serosa.**

A **mesentery** consists of **loose CT, adipose, BVs, Ns & Ls sandwiched between two layers of serous membrane**. They attach intraperitoneal organs to the body wall.

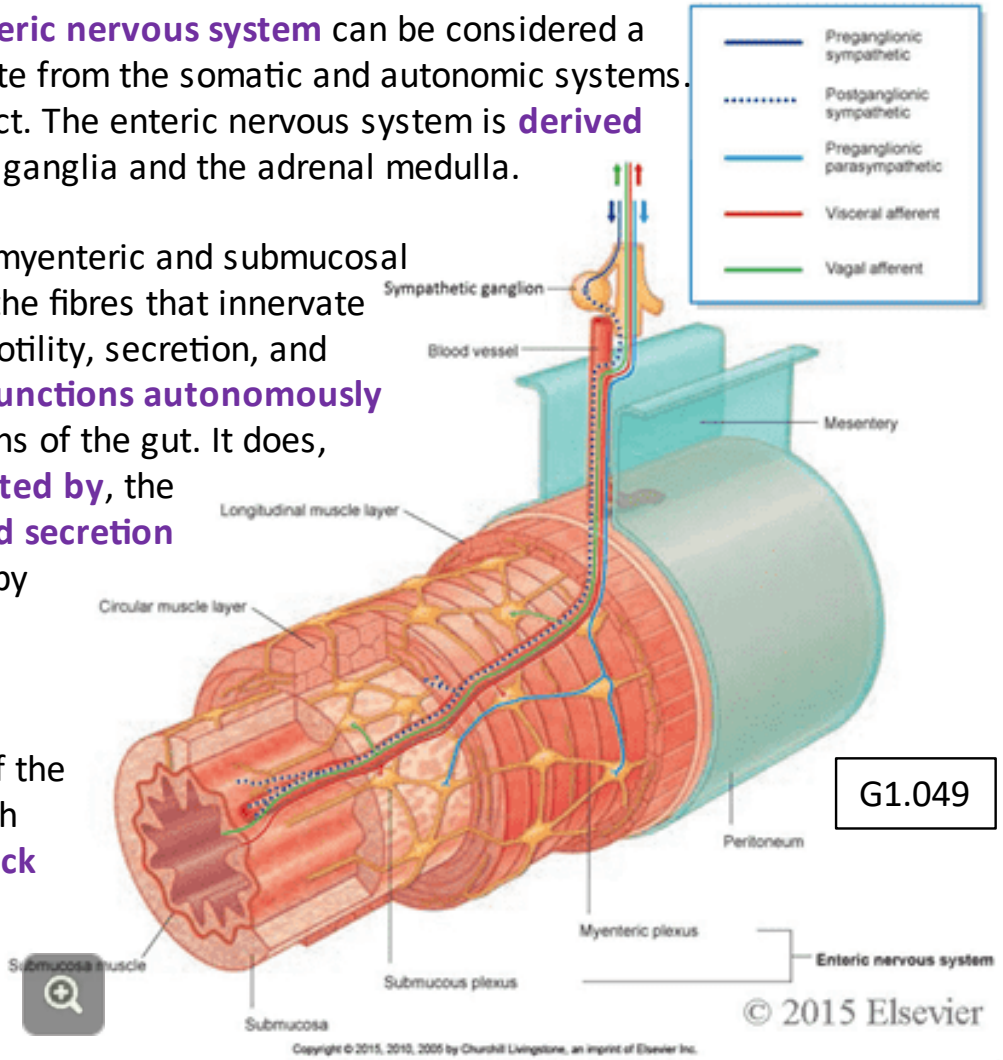
Portions of the digestive tract that do not face the peritoneal cavity are covered by an **adventitia**, a layer of loose CT that connects the organ to adjacent structures. An example is the esophagus in the posterior mediastinum, or the anal canal in the perineum.



Because it functions autonomously, the **enteric nervous system** can be considered a third division of the nervous system, separate from the somatic and autonomic systems. It is located in the walls of the digestive tract. The enteric nervous system is **derived from neural crest cells**, as are sympathetic ganglia and the adrenal medulla.

The enteric nervous system consists of the myenteric and submucosal plexuses, the fibres that connect them and the fibres that innervate the tissues of the gut wall. It controls gut motility, secretion, and vascular tone. The enteric nervous system **functions autonomously** to control activity within and between regions of the gut. It does, however, receive input from, and is **modulated by**, the autonomic nervous system. Gut **motility and secretion** are increased and decreased, respectively, by parasympathetic and sympathetic input.

Sensory information from the gut wall feeds back to the CNS. Along most of the length of the gut, **visceral pain** is conducted centrally with sympathetic efferents. **Homeostatic feedback** travels with parasympathetic efferents.



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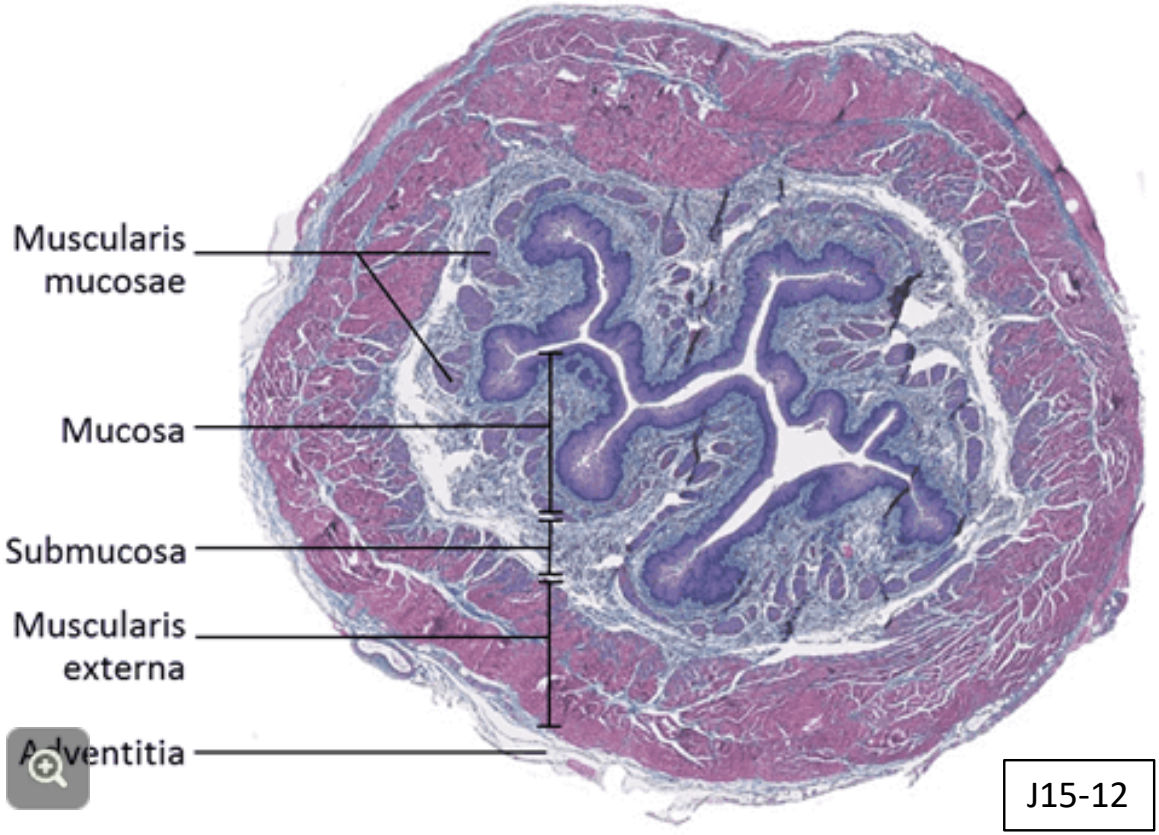
The Histology of the Esophagus

The esophagus, you'll recall from gross anatomy, is a muscular tube about 25 cm long. It begins at the **upper esophageal sphincter**, is largely located in the **posterior mediastinum**, and passes through the **esophageal hiatus** of the diaphragm to enter the **peritoneal cavity**. It ends at the **lower esophageal / cardiac sphincter**. Its function is to convey food from the pharynx to the stomach.



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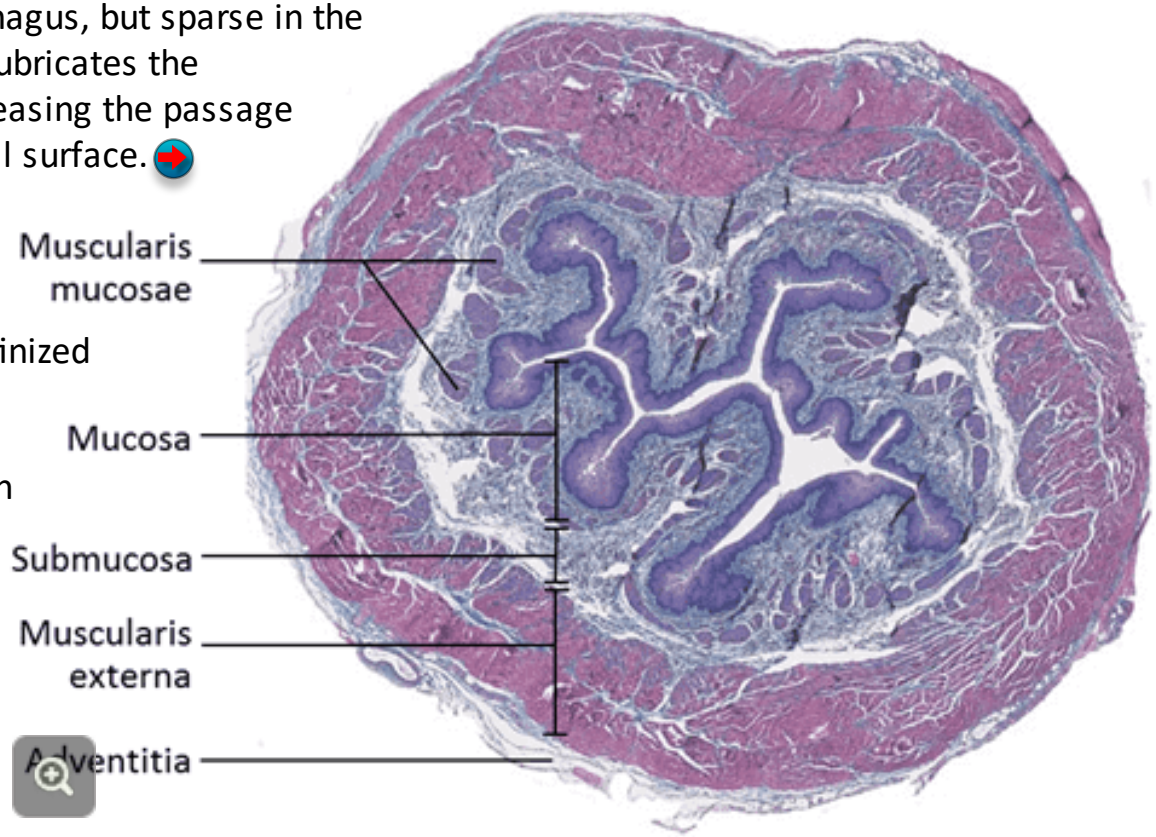
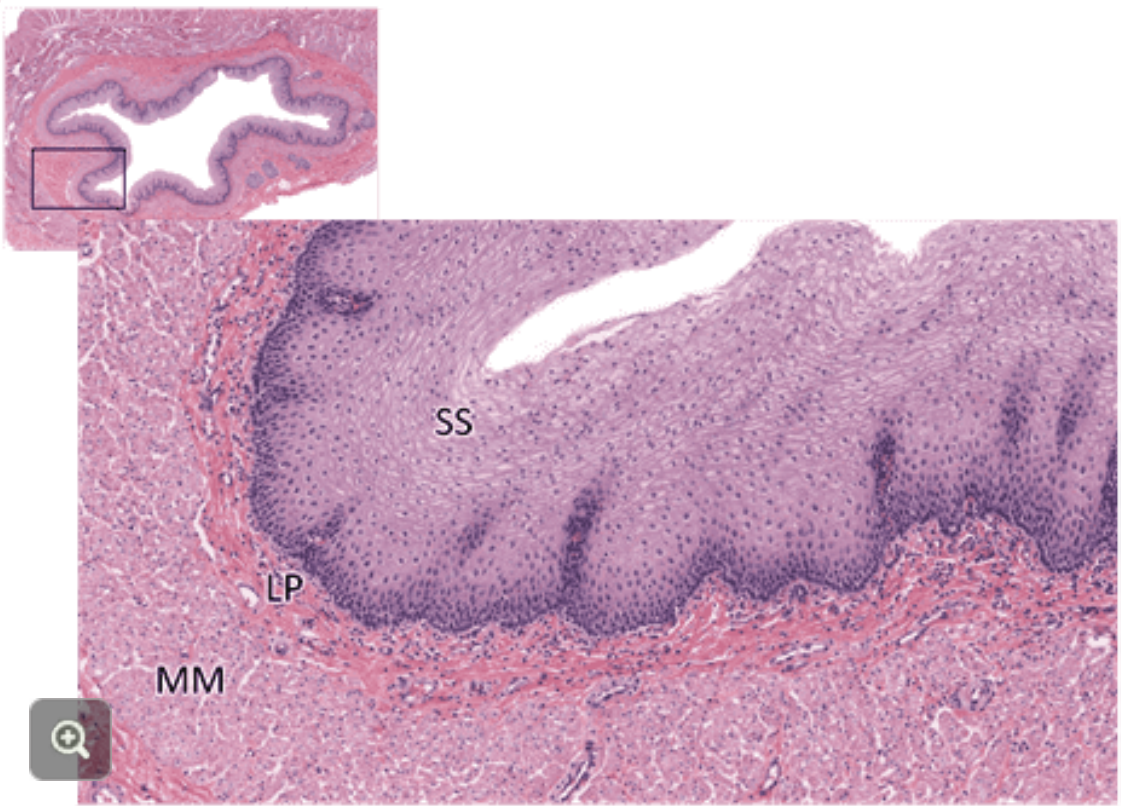
The **mucosa** of the esophagus includes **stratified squamous nonkeratinized epithelia**, which protects its luminal surface from abrasion. Like the skin, it contains **Langerhans cells**, APCs that detect antigen in ingested food. As seen in the accompanying image, the esophagus is highly folded when collapsed, but it unfolds to accommodate the passage of a bolus of food during swallowing. Esophageal **cardiac glands** are mucous-secreting glands of the LP, the ducts of which open onto the luminal surface. They are abundant at both ends of the esophagus, but sparse in the middle. The mucous they produce lubricates the luminal surface of the esophagus, easing the passage of food and protecting the epithelial surface.



INFO

Barrett's Esophagus

In **Barrett's esophagus**, the stratified squamous nonkeratinized epithelium is replaced by the simple columnar epithelium typical of the stomach. This transformation occurs in response to chronic mucosal damage due to **gastroesophageal reflux disease (GERD)**. A major symptom is a burning pain called **heartburn**. It carries with it an increased risk of **esophageal cancer**.



This histological image of the esophagus has been zoomed in to highlight the mucosal layer.

As mentioned before, the epithelial layer of the mucosa is composed of **stratified squamous non-keratinized epithelia (SS)**.

Within the **lamina propria (LP)** of the mucosa can be found Langerhans cells and cardiac glands (not shown). **The muscularis mucosa (MM)**, composed of two layers of smooth muscle can be seen deep to the lamina propria.

The submucosa of the esophagus is remarkable due to the presence of mucous-secreting **submucosal** or **esophageal glands**, the secretions of which **lubricate and protect** the esophageal wall. Unlike the esophageal cardiac glands, which are largely restricted to the two ends of the esophagus, the submucosal glands are present throughout its length.

Also present in the submucosa are clinically significant vascular and lymphatic plexuses, as well as the submucosal (myenteric) plexus of nerves.

INFO

Esophageal Varices

Portal-systemic anastomoses connect veins of the **hepatic portal system**, which drains blood from the digestive tract to the liver, to **systemic veins**, which drain blood directly to the IVC or SVC. **One such portal-systemic anastomosis occurs between the stomach and the distal esophagus.**

The **stomach** normally drains to the **hepatic portal vein**. The **distal esophagus** normally drains via the **azygous system of veins** to the **SVC**. The stomach and distal esophagus are connected by a portal-systemic anastomosis.

With **hepatic portal hypertension**, as may occur in **cirrhosis of the liver** secondary to alcoholic liver disease or viral hepatitis, veinous blood is diverted from the stomach to the submucosal venous plexus of the distal esophagus. In response to the increased venous pressure, esophageal veins dilate (**esophageal varices**), and may **rupture and hemorrhage**, a potentially life-threatening situation.

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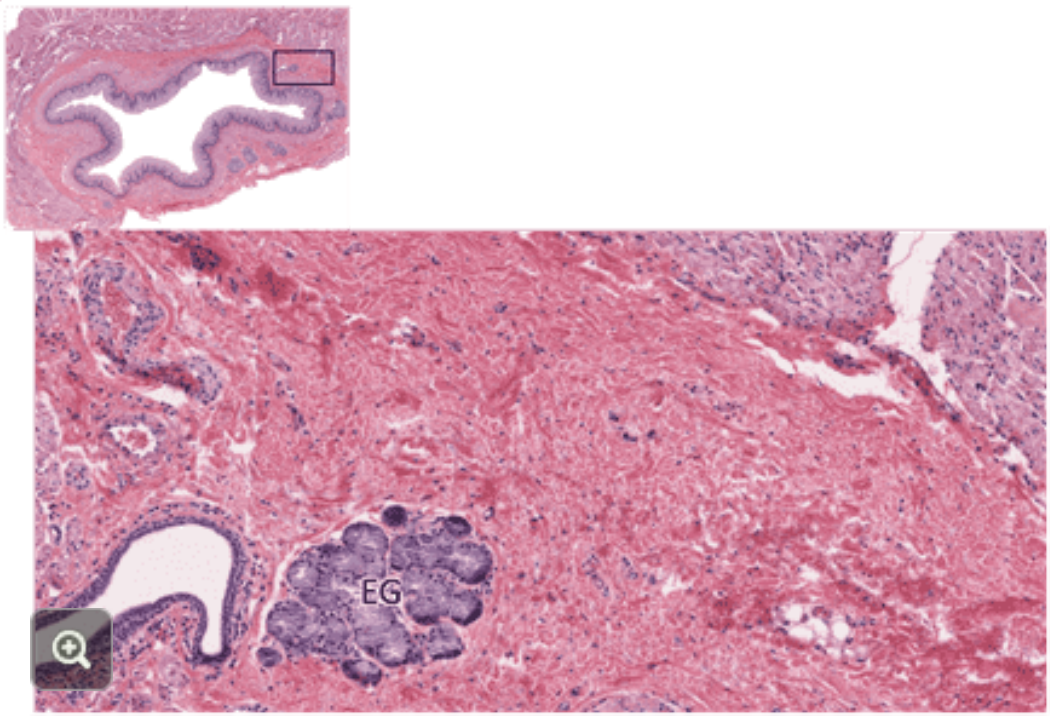


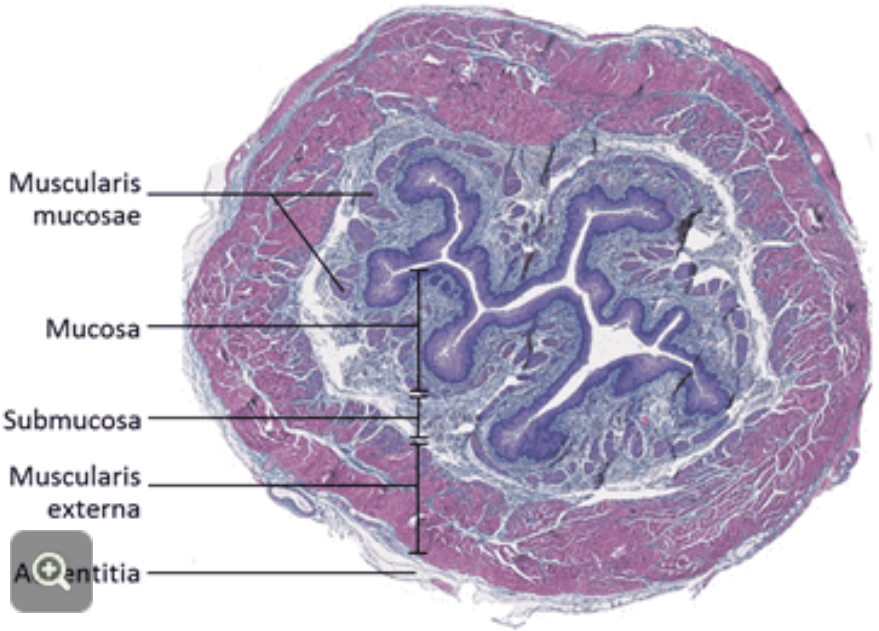
This histological image of the esophagus has been zoomed in to highlight the submucosal layer.

Submucosal or esophageal glands (E.G.) can be seen.

The muscle of the pharyngeal wall is striated. The muscle of the stomach wall is smooth. **The muscle of the esophagus transitions from striated to smooth along its length.** The proximal 1/3 is striated, the middle 1/3 is a mixture of striated and smooth, and the distal 1/3 is smooth muscle.

The inner muscular layer is **circular** (IC) and the outer muscular layer is **longitudinal** (OL). During swallowing, coordinated contraction of these layers causes **peristaltic waves** to propel food toward the stomach. Despite the fact that the muscle of the proximal esophagus is striated, its contraction during swallowing is **reflexive**, and therefore **involuntary**, as is that of the smooth muscle.

Between the two layers of muscle is the **myenteric (Auerbach's) plexus** and **vascular and lymphatic plexuses**.



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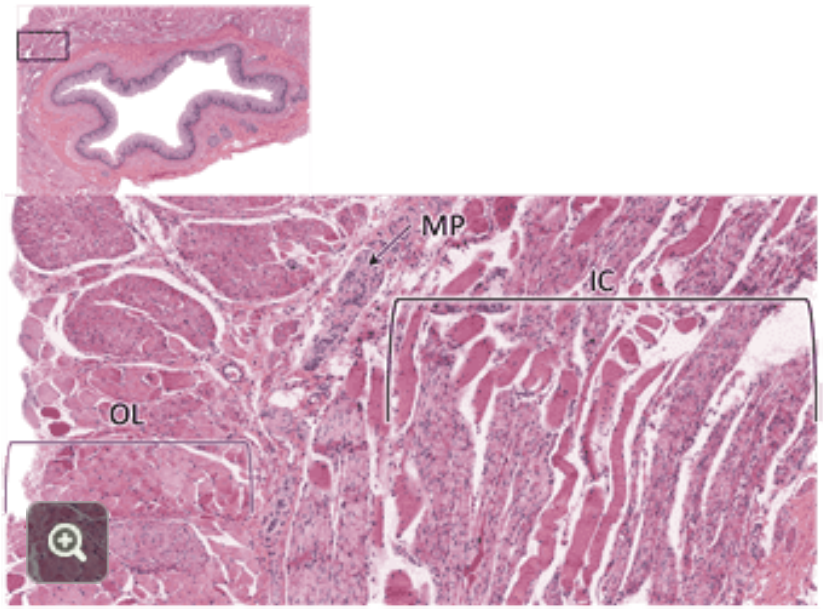


This histological image of the esophagus has been zoomed in to highlight the **muscularis externa**.

An **inner circular layer** (IC) and **outer longitudinal layer** (OL) of muscle can be seen. Note: this section was taken in the middle 1/3 of the esophagus, so both smooth and skeletal muscle can be seen. Between the two layers is the **myenteric (Auerbach's) plexus** (MP).

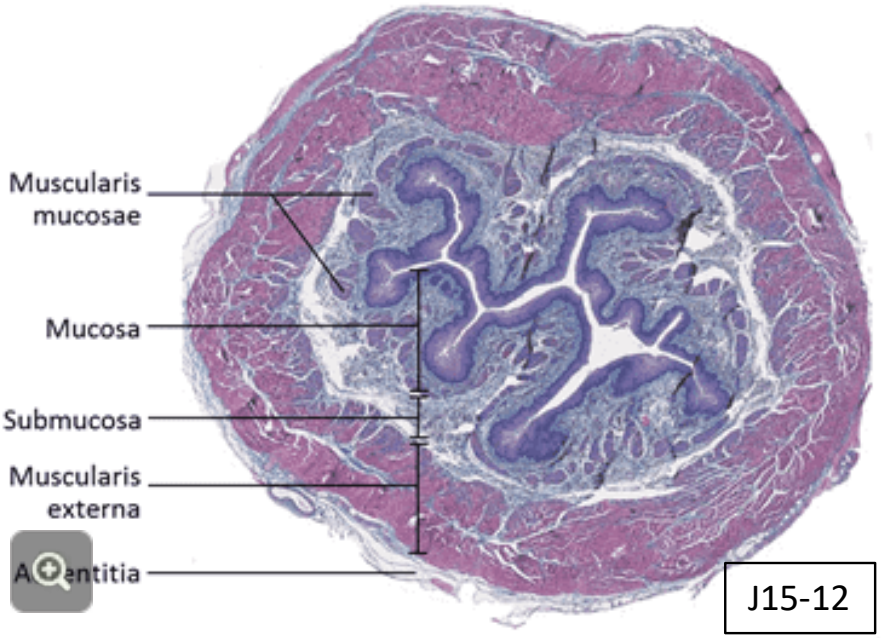
Along most of its length, the esophagus is located in the posterior mediastinum. Here it is surrounded by an **adventitia** composed of loose CT which anchors the esophagus directly to surrounding structures. The adventitia is **rich in vascular and lymphatic plexuses**.

The short length of **the esophagus below the diaphragm is intraperitoneal**, and therefore surrounded by a serosa, the **visceral peritoneum** of the esophagus.

INFO

Esophageal Cancer

Because of the rich lymphatic plexuses of the esophagus, and because along most of its length the esophagus is not separated from surrounding tissue by a limiting layer of serosa, esophageal cancer metastasizes readily to surrounding tissues, making its prognosis often poor.



J15-12

The Histology of the Stomach

The stomach is a **mixed endocrine-exocrine** organ; it digests food and secretes hormones.

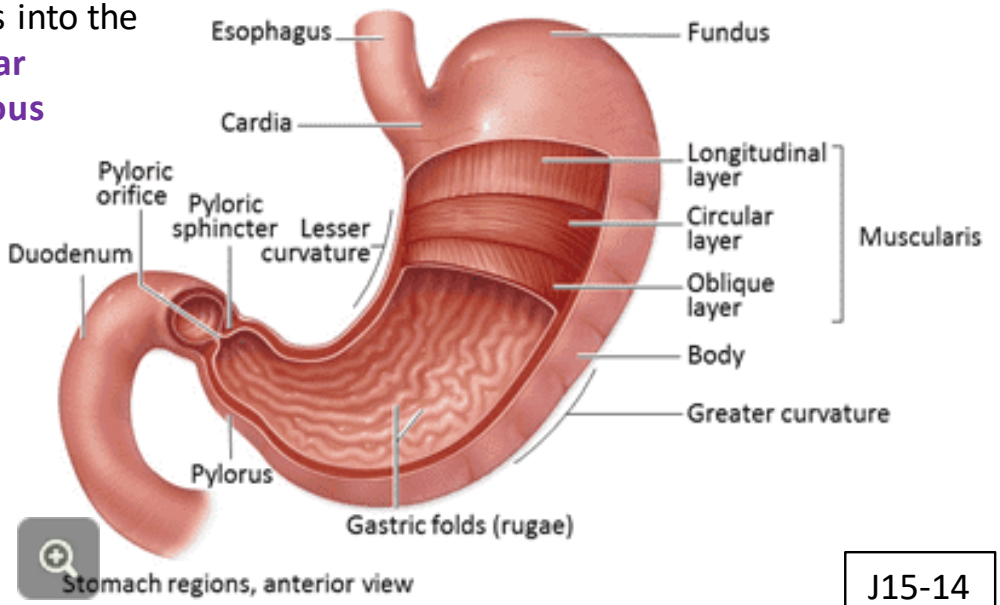
The stomach **secretes, in an exocrine fashion**, **acid and digestive enzymes**. Through the action of its muscular wall, it mixes ingested food with these secretory products to create **chyme**.

The stomach **secretes, in an endocrine fashion**, **hormones** that coordinate its activity, as well as the activity of more distal portions of the digestive tract.

At a gross level, the stomach is divided into the **cardia, fundus, body and pylorus (antrum)**.

The **cardia** is the narrow transitional zone between the esophagus and the stomach. The **pylorus / antrum** is the terminus of the stomach which transitions into the duodenum. The **cardia and pylorus are similar histologically**, and primarily function in **mucous production**. Mucous forms a physical and chemical **protective barrier** for the stomach lining.

The **fundus and body** make up the bulk of the stomach, and are dominated **histologically** by **gastric glands** which secrete **acid and enzymes**.



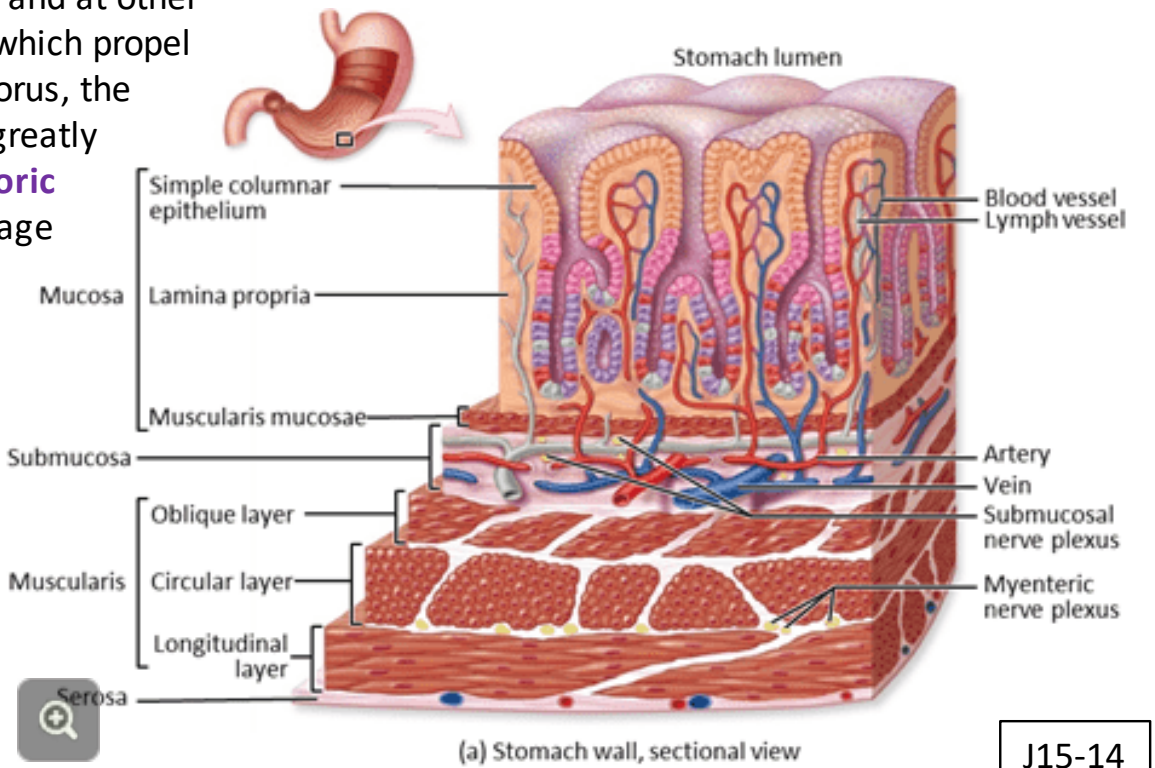
Stomach regions, anterior view

J15-14

The stomach is an intraperitoneal organ covered with a typical **serosa** which forms its **visceral peritoneum**. At its greater and lesser curvatures, its serosa continues as a component of the **greater and lesser omenta**, respectively. It is in the omenta that the major gastric vessels are located.

The **muscularis externa** of the stomach is remarkable in that it **includes a third, innermost, oblique layer**. Coordinated contractions of these layers generate **mixing waves**, which combine ingested food with the exocrine secretions of the mucosa, and at other times generate **peristaltic waves**, which propel food toward the pylorus. At the pylorus, the circular layer of smooth muscle is greatly thickened to form the powerful **pyloric sphincter**, which controls the passage of chyme into the duodenum.

The **submucosa** is loose CT with large blood and lymphatic vessels, and many lymphoid cells. It is thrown into longitudinal folds, called **rugae**, which disappear as the stomach fills. Rugae thus accommodate the great changes in stomach volume that occur after a meal.



(a) Stomach wall, sectional view

J15-14

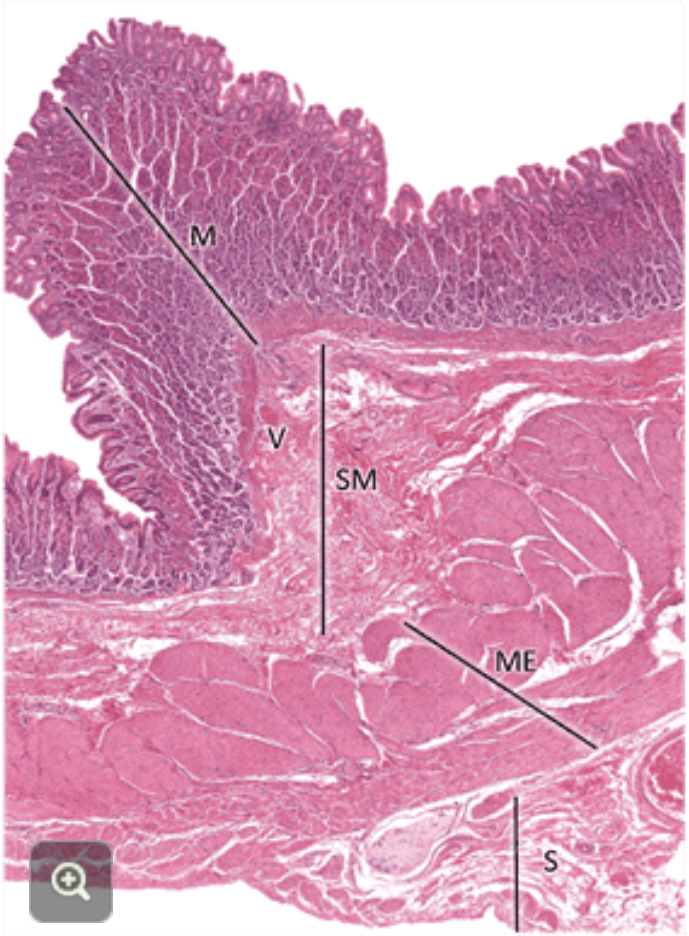
Rugae

Layers of the stomach wall demonstrating rugae.

M Mucosa - arrows indicate the muscularis mucosa
SM Submucosa
V Blood vessels in the submucosa
ME Muscularis Externa
S Serosa

Two rugae, consisting of folds of mucosa and submucosa are shown in transverse section.

Rugae



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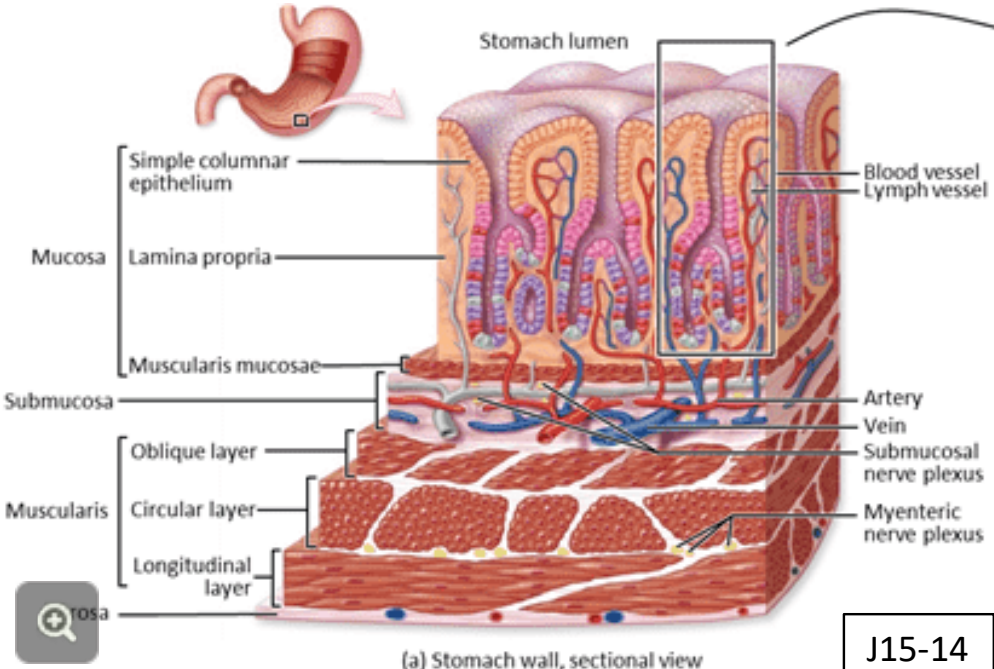
At the **esophagogastric junction**, the epithelial component of the mucosa changes abruptly from the stratified squamous epithelium typical of the esophagus, to the **simple columnar epithelium typical of the stomach**.

In the stomach, the epithelium invaginates deeply into the underlying LP, forming **gastric pits**. Each gastric pit opens, at its **neck**, into numerous **gastric glands**. A **heterogeneous population of cells** lines the luminal surface of the stomach and the walls of the gastric pits and glands. The progeny of **pluripotential stem cells** located at the neck migrate upward and downward to replace all of these various cell types.



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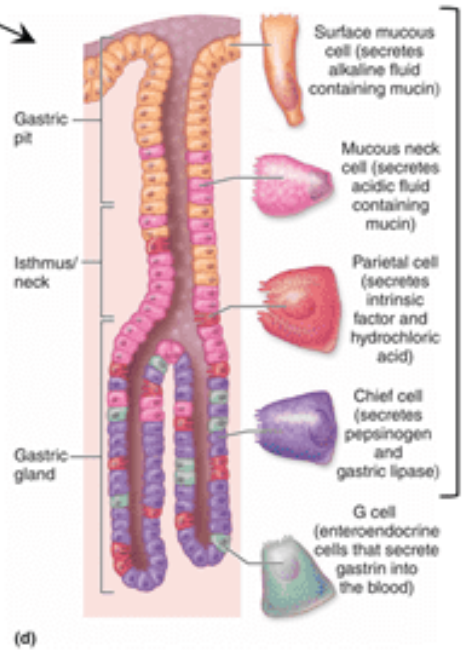
J15-14



(d)

J15-17

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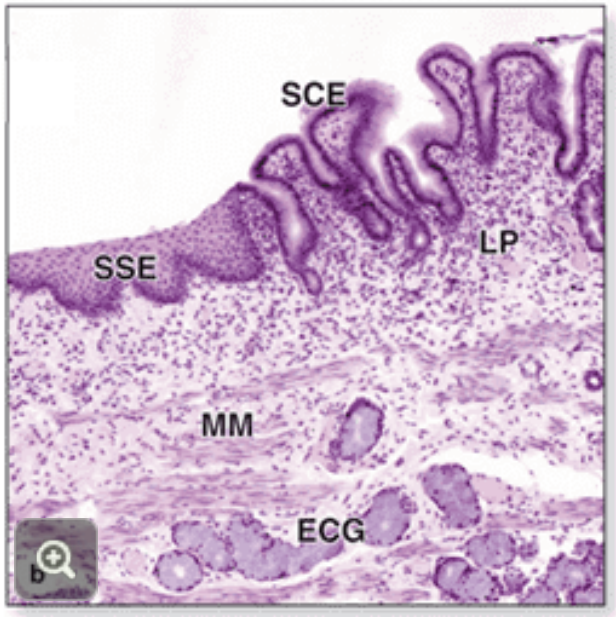
In the stomach, the epithelium invaginates deeply into the underlying LP, forming **gastric pits**. Each gastric pit opens, at its **neck**, into numerous **gastric glands**. A **heterogeneous population of cells** lines the luminal surface of the stomach and the walls of the gastric pits and glands. The progeny of **pluripotential stem cells** located at the neck migrate upward and downward to replace all of these various cell types.



J15-14

The esophagogastric junction.

SSE - stratified squamous epithelium
SCE - simple columnar epithelium
ECG - esophageal cardiac glands
LP - lamina propria
MM - muscularis mucosa

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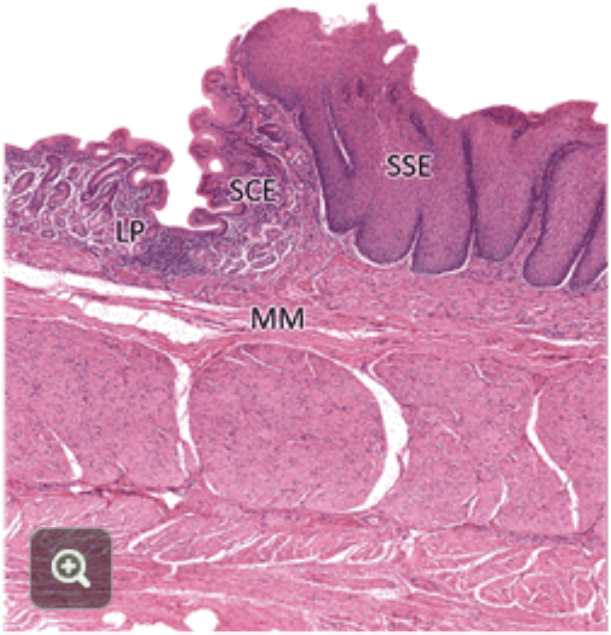

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SSE - stratified squamous epithelium
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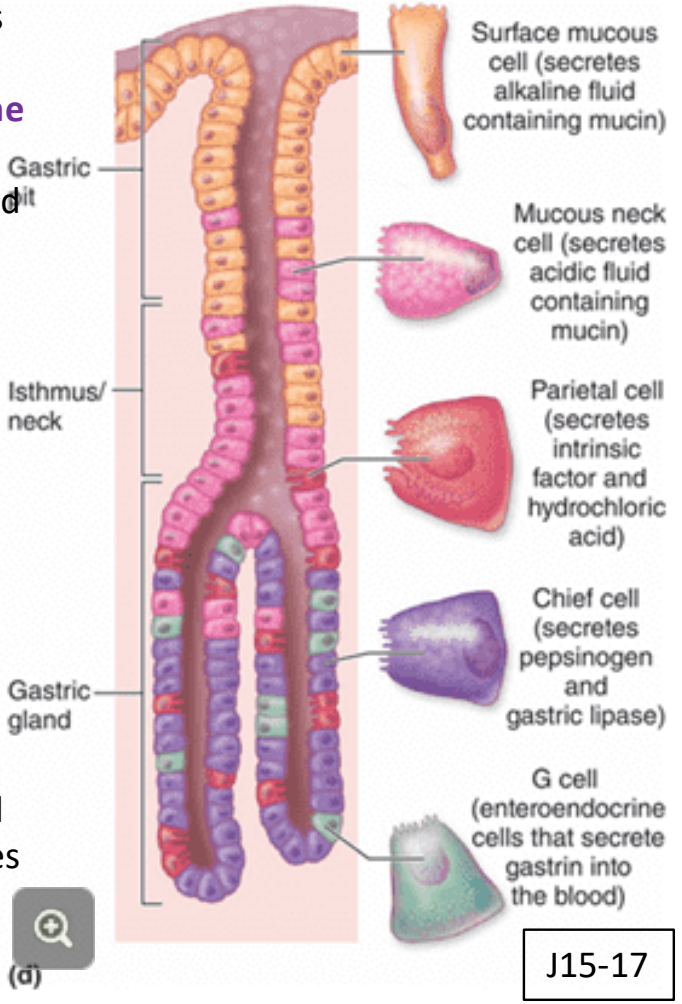
Exocrine Cells of the Gastric Mucosa

The luminal surface of the stomach and much of the gastric pit is lined by simple columnar **surface mucous cells**. Their secretory product is a **thick, bicarbonate-rich mucous that adheres to the luminal surface of the stomach**. It protects the gastric mucosa from both mechanical and chemical injury due to partially-chewed food and stomach acid, respectively.

Mucous neck cells (M) produce and secrete a less-alkaline **soluble mucous** which mixes with chyme to make it more slippery.

Parietal (oxyntic) cells (P) are numerous in the region of the neck. They produce **hydrochloric acid (HCl)** and **intrinsic factor**. HCl acidifies chyme, the low pH being required for **activation of digestive enzymes** secreted by the **chief cells**. The acid is also **bacteriocidal** and **denatures protein**. Intrinsic factor binds **vitamin B_{12}** and promotes its absorption in the small intestine.

Chief (zymogenic) cells (C) dominate in the bases of the gastric glands. They produce **pepsinogens**, proenzymes that are cleaved in the acidic chyme forming **pepsins**. Pepsins are endoproteinases which initiate the digestion of proteins. Chief cells also produce **gastric lipase**, which initiates the digestion of lipids .



J15-17

Exocrine Cells of the Gastric Mucosa

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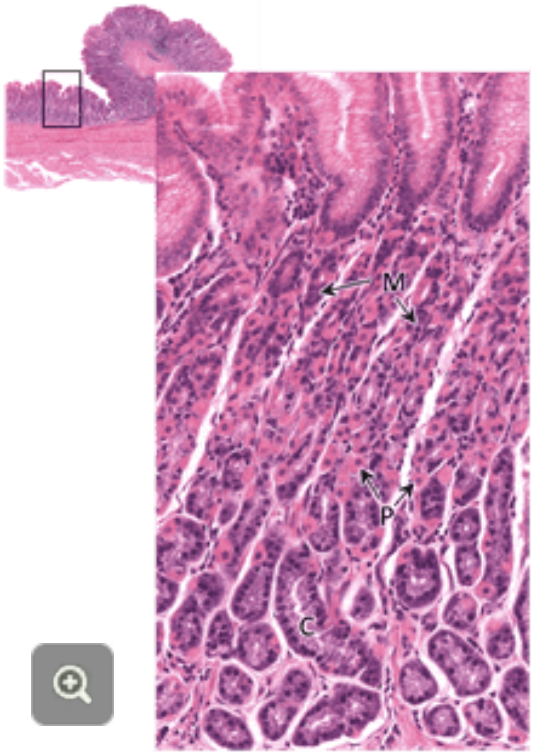


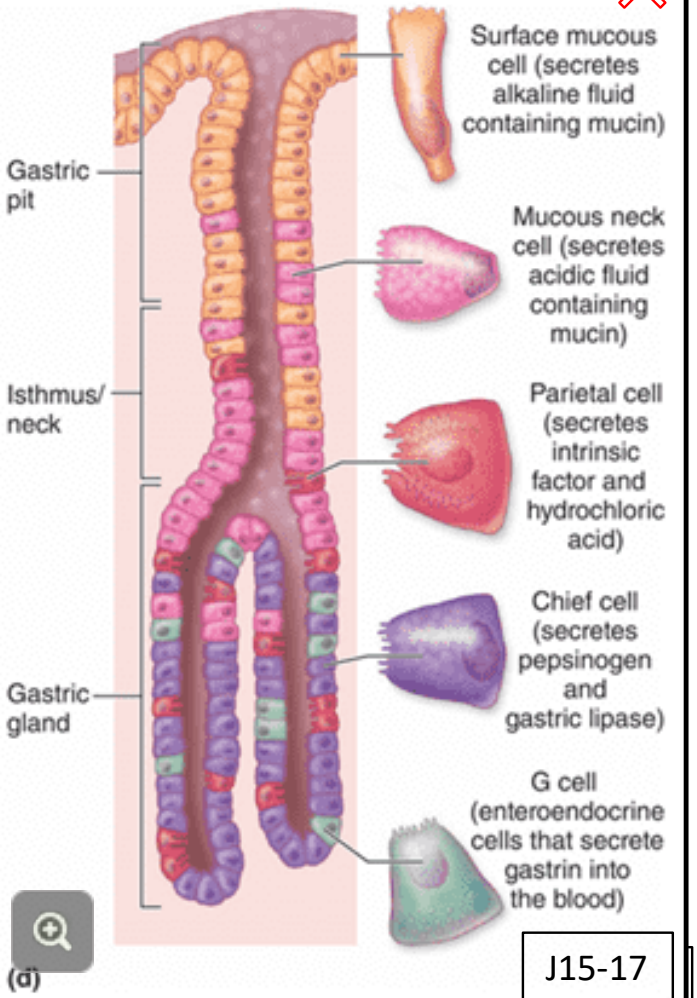
M – small basophilic cells interspersed between P cells
P – eosinophilic (pink) with central nucleus
C – base of gastric glands (basophilic)

Endocrine Cells of the Gastric Mucosa

Enteroendocrine cells belong to the **diffuse neuroendocrine system (DNES)**. These epithelial cells secrete their product across their **basal aspect** into the **interstitial fluid of the underlying LP**. They are found throughout the digestive tract, and in respiratory mucosa.

In the digestive tract, their cell products may modulate the activity of neighbouring cells in a **paracrine** manner, or modulate the activity of distal portions of the digestive tract in an **endocrine** manner. They might act on contractile cells, thereby influencing **motility**, or on secretory cells, both exocrine and endocrine, influencing **secretion**.

The convention is to name enteroendocrine cells using the first letter of their primary product. Thus **G-cells** , which are numerous in the gastric glands of the pyloric region of the stomach, produce the hormone **gastrin**. Gastrin acts in a paracrine manner on **parietal cells** to **promote the secretion of HCl**.



J15-17

INFO

Atrophic Gastritis

Autoimmune destruction of parietal cells of the gastric mucosa results in decreased secretion of HCl and intrinsic factor. Without intrinsic factor, vitamin B_{12} cannot be absorbed across the wall of the small intestine. Because B_{12} is a cofactor required for DNA synthesis, its malabsorption decreases proliferation of erythroblasts, resulting in **pernicious anemia**.

INFO

Gastric Ulcers

An **ulcer** is an open sore on an external surface of the body (i.e. in the skin) or on an internal surface of the body (i.e. in a mucous membrane). Ulcers may occur anywhere along the digestive tract, but **are most commonly found in the gastroduodenal region**. In this region, ulcers are most commonly caused by infection with the bacterium **Helicobacter pylori** and by the use of nonsteroidal anti-inflammatory drugs (**NSAIDS**).

Press **Next** to start the Quiz or **Skip** to end H13

Which of the following regions of the digestive tract includes submucosal mucous-secreting glands? Choose all that apply.

- [ ] the esophagus
- [ ] the stomach
- [ ] the duodenum
- [ ] the large intestine

SUBMIT

Which of the following products of the gastric mucosa is secreted across the basal aspect of the cell that produces it?

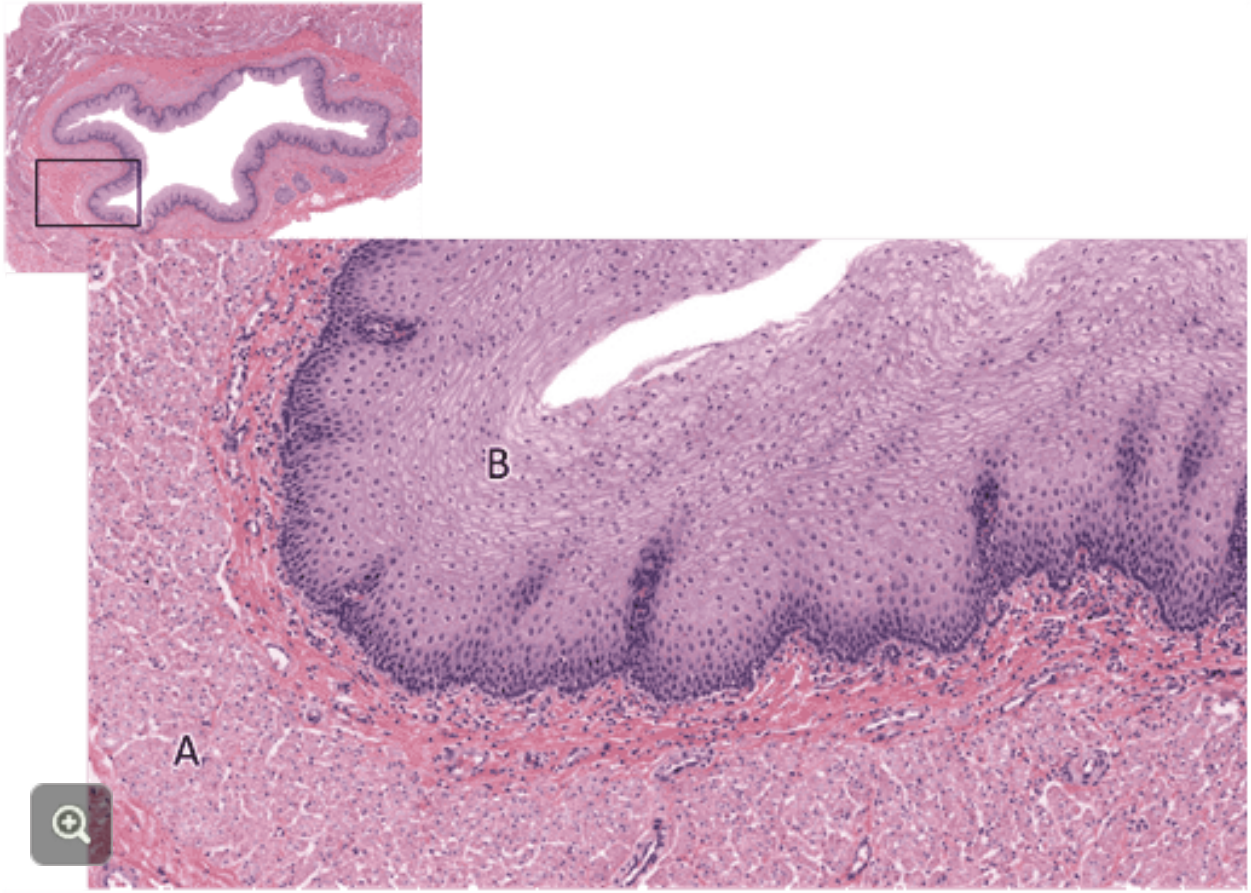
- [ ] intrinsic factor
- [ ] gastrin
- [ ] pepsinogen
- [ ] hydrochloric acid
- [ ] mucins

SUBMIT

H13 Question 3

Identify layer A.

type your text here

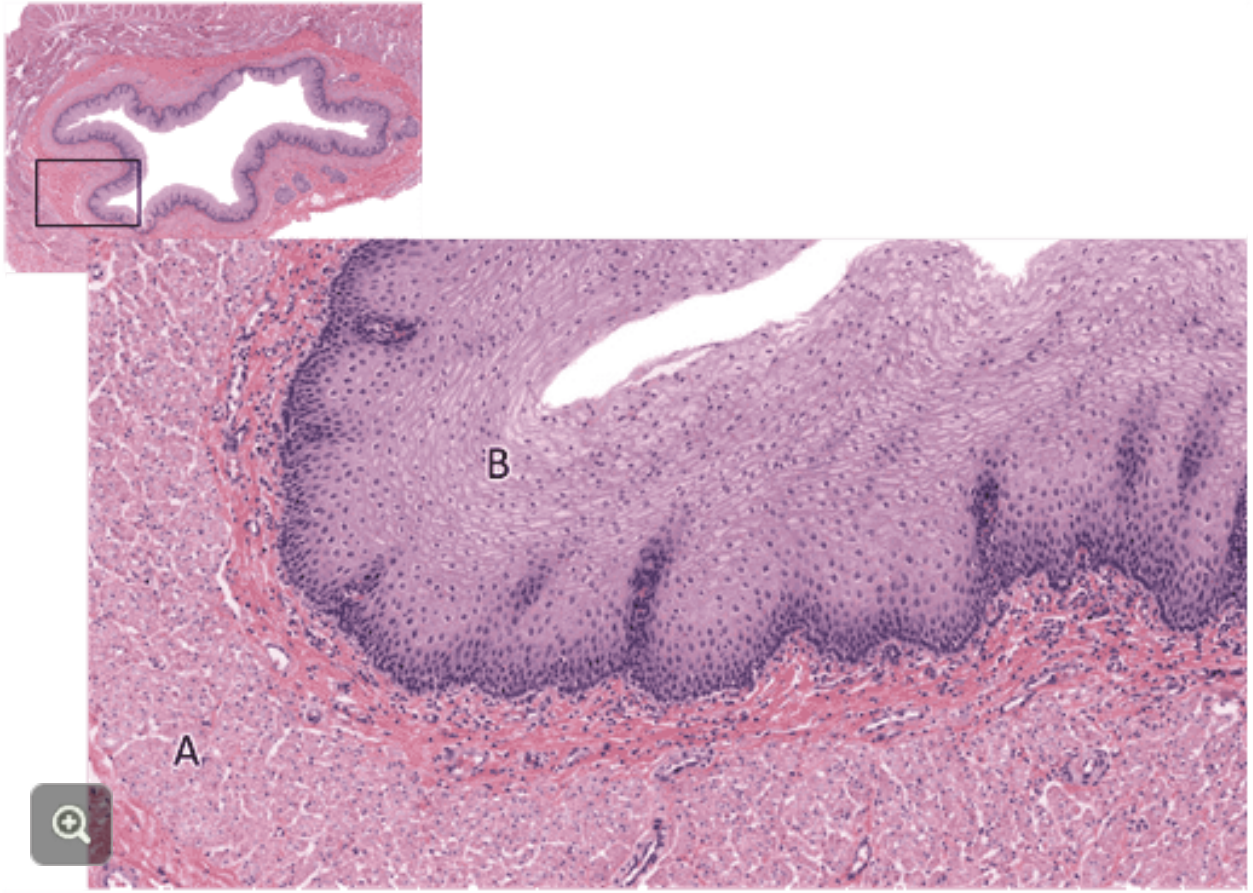


SUBMIT

H13 Question 4

Identify the class of epithelium B.

type your text here

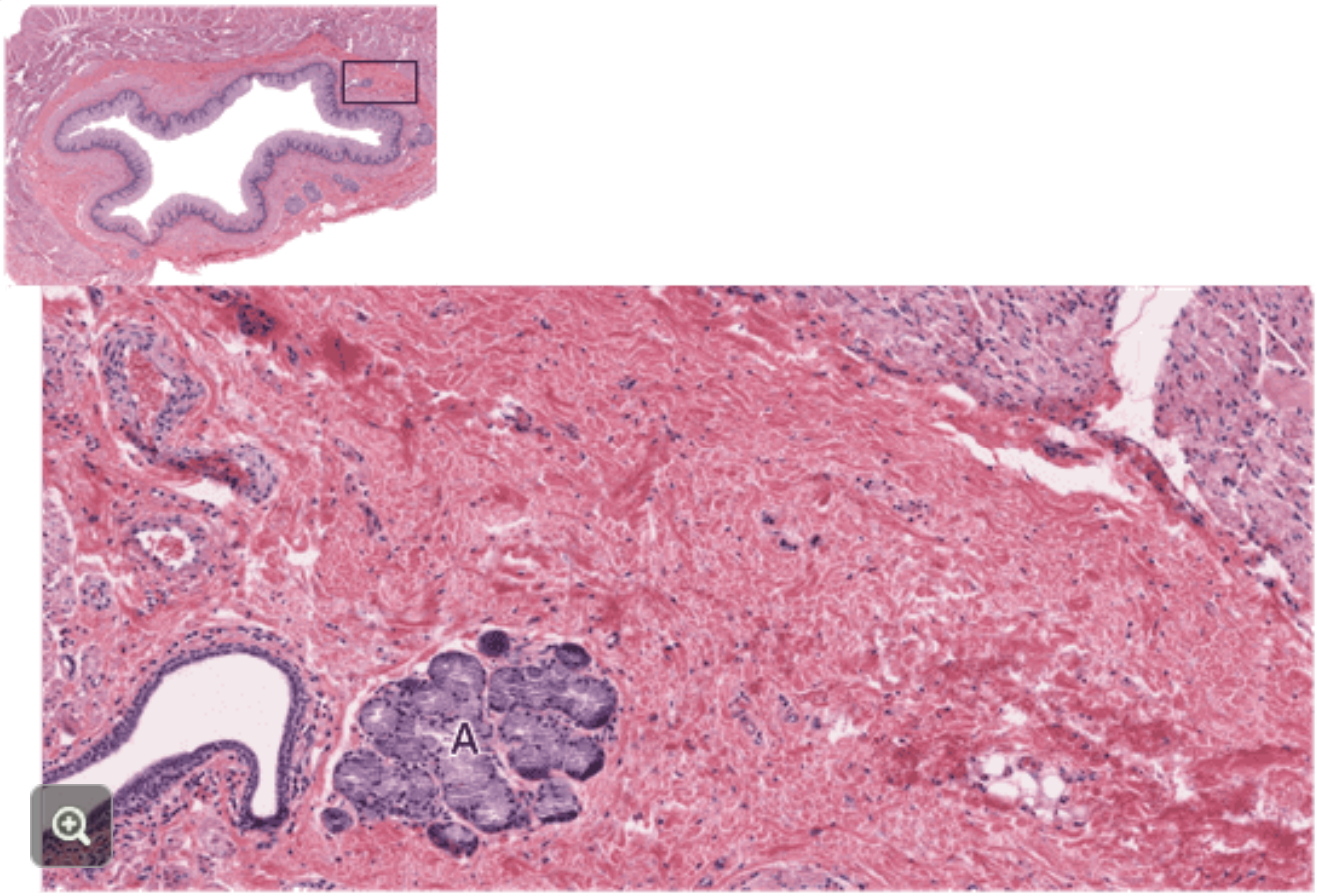


SUBMIT

H13 Question 5

Identify structures A.

type your text here

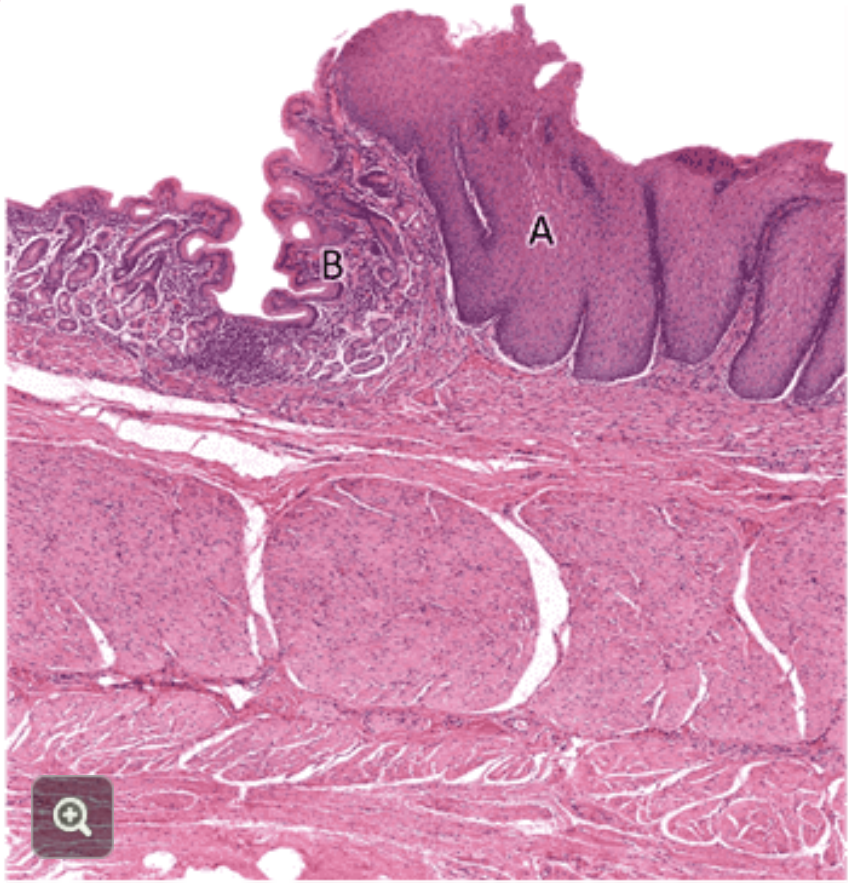


SUBMIT

H13 Question 6

Identify the class of epithelium A.

type your text here

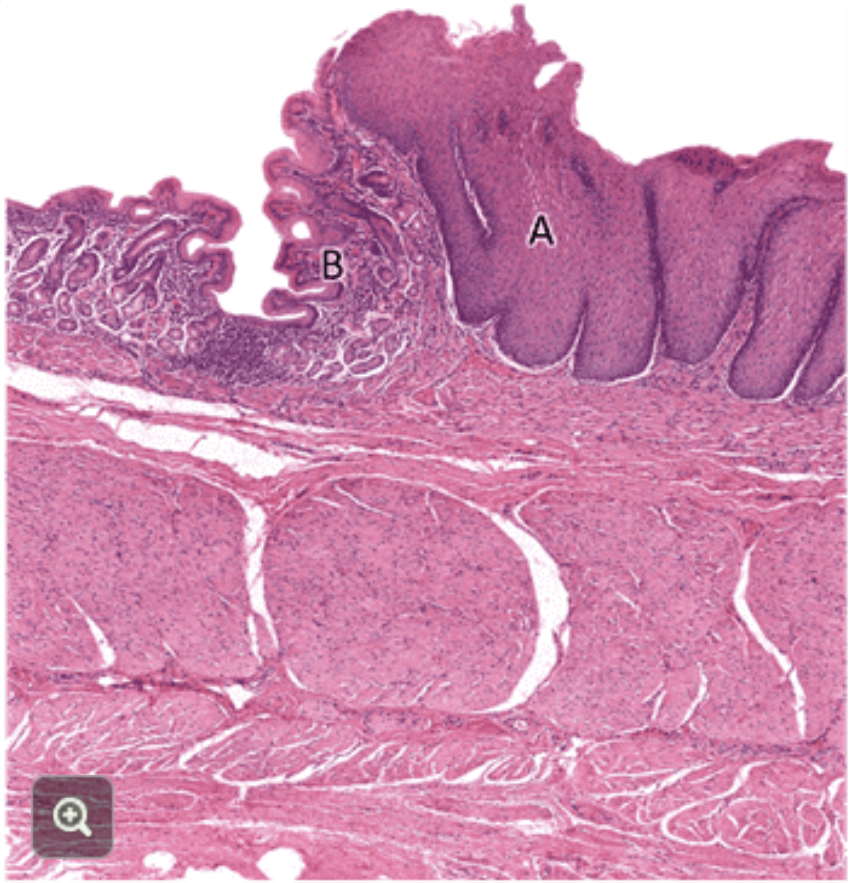


SUBMIT

H13 Question 7

Identify the class of epithelium B.

type your text here

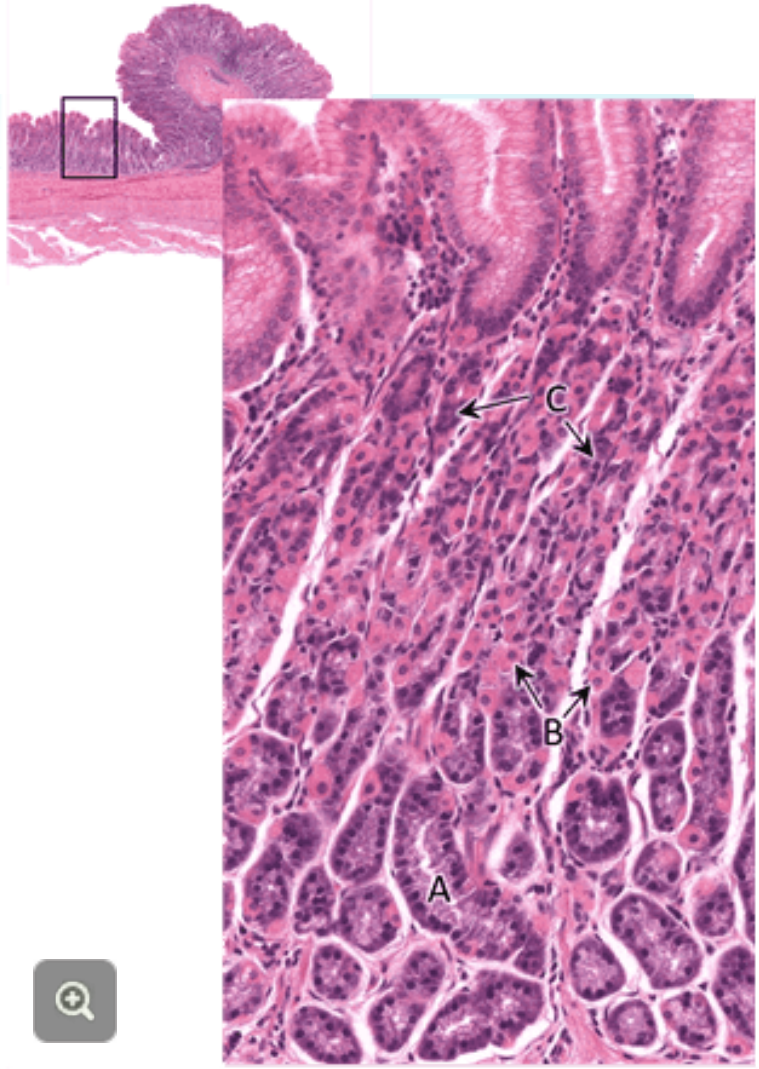


SUBMIT

H13 Question 8

Identify cell type A.

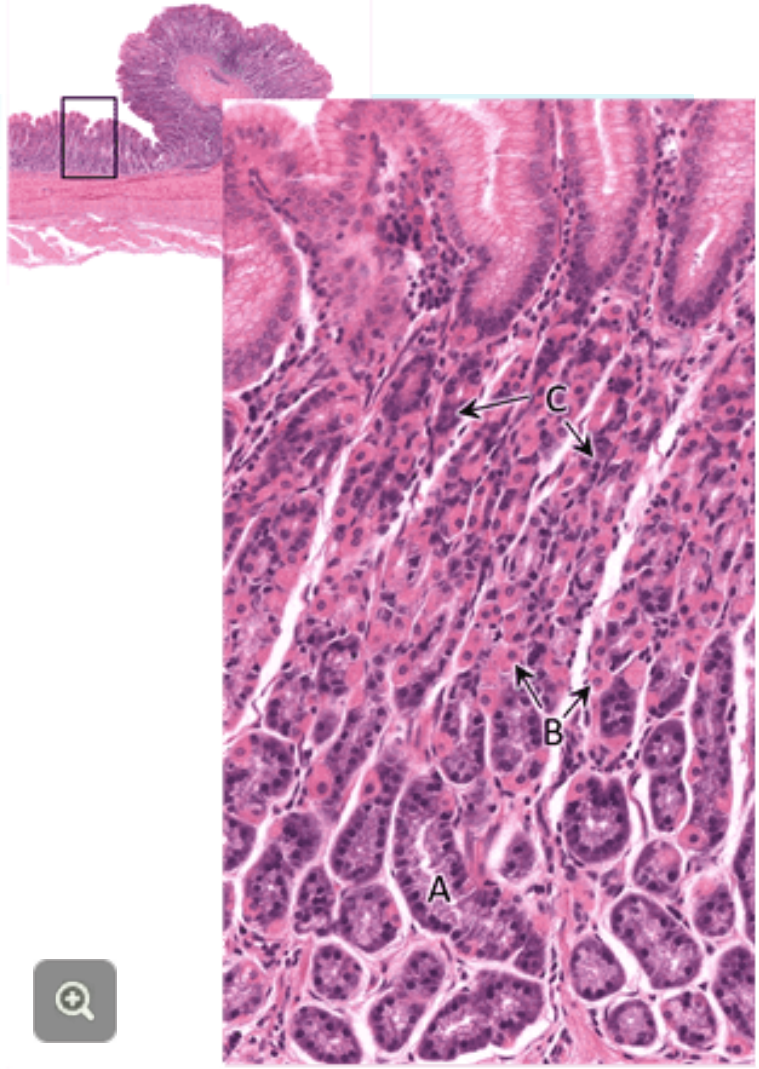
type your text here



SUBMIT

Identify cell type B.

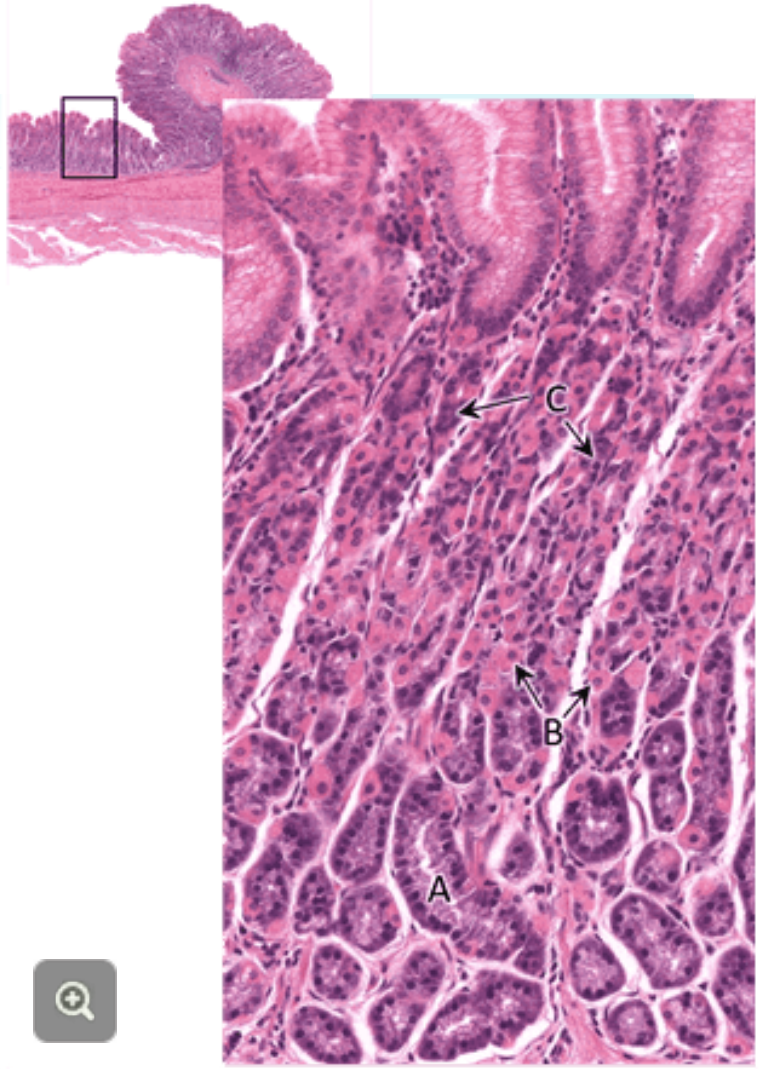
type your text here



SUBMIT

Identify cell type C.

type your text here



SUBMIT