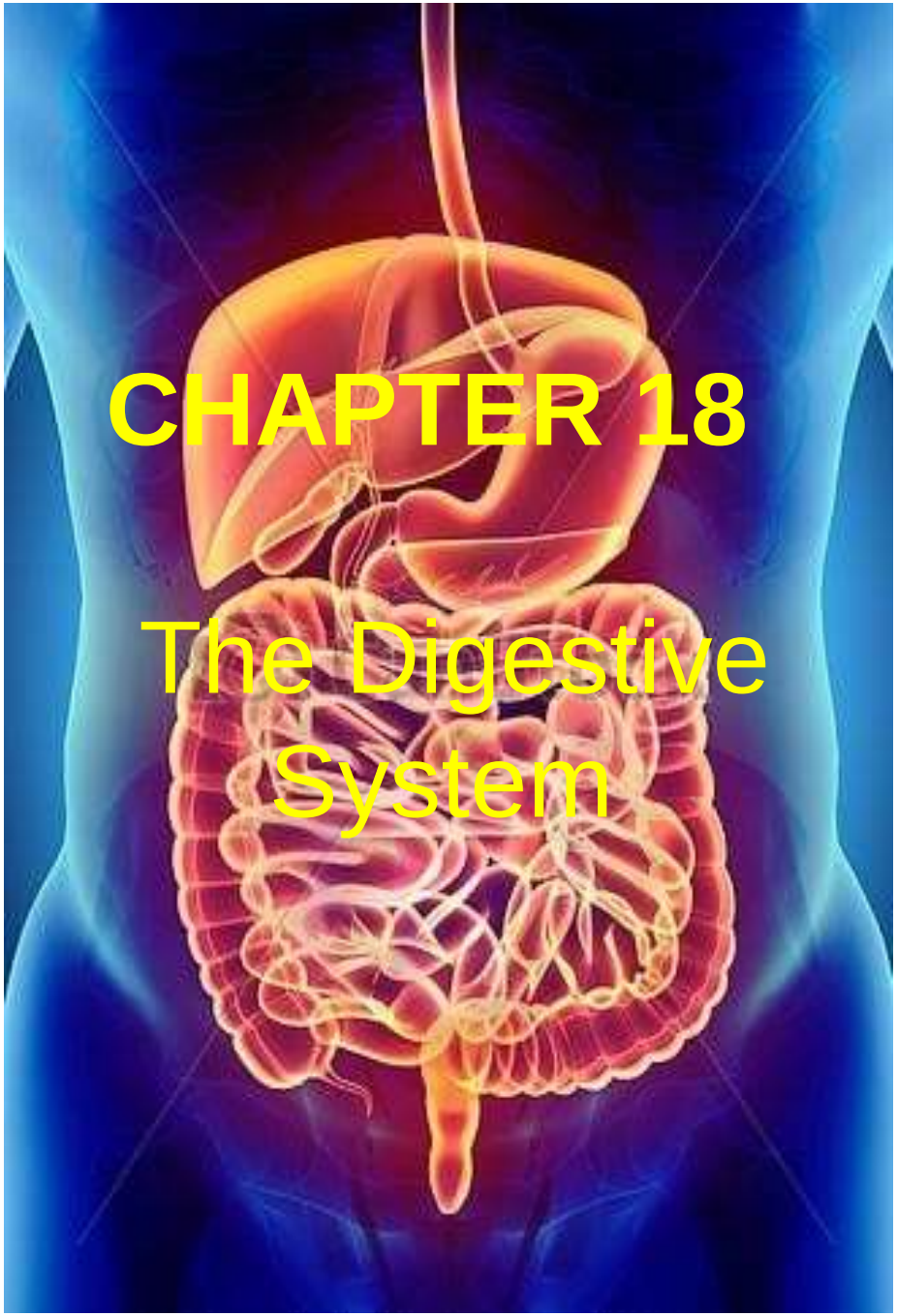

# CHAPTER 18

## The Digestive System

# Introduction

- **Digestion:** is how your body turns food you eat into nutrients it uses for energy, growth, and cell repair.
- **Absorption:** Digestion is the breakdown of large insoluble food molecules into small water-soluble food molecules so that they can be absorbed into the watery blood plasma. In certain organisms, these smaller substances are absorbed through the small intestine into the blood stream
- **Gastroenterology:**
- **Proctology :** the branch of medicine concerned with the anus and rectum.

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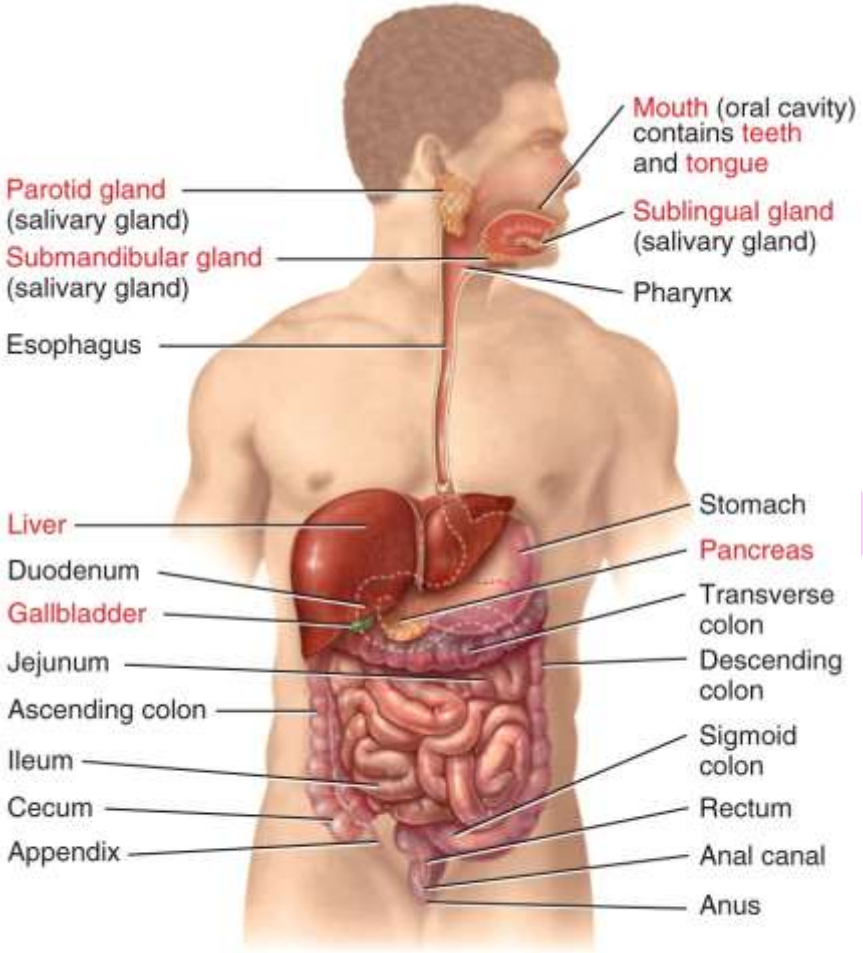
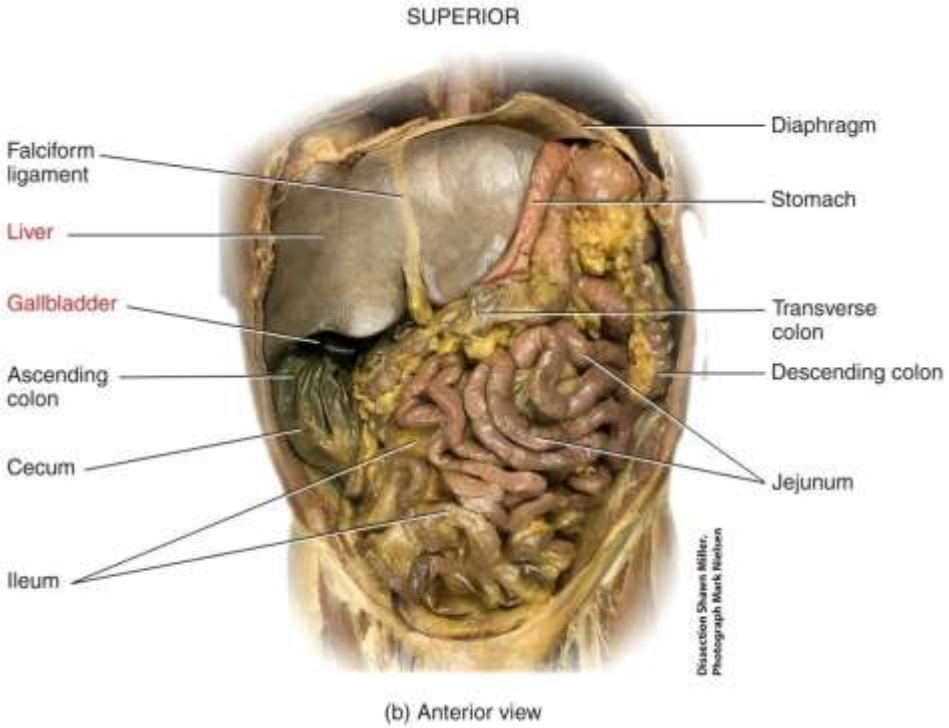
# Organs of the Digestive System




(a) Right lateral view of head and neck and anterior view of trunk




(b) Anterior view

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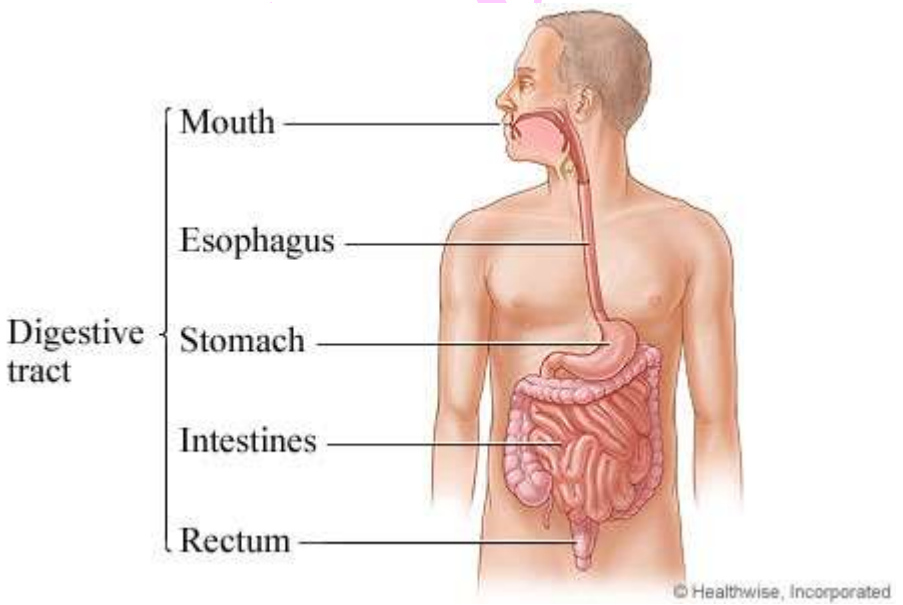
# Overview of the Digestive System

- Gastrointestinal (GI) tract, or alimentary canal, consists of:
  - Mouth
  - Pharynx
  - Esophagus
  - Stomach
  - Small intestine
  - Large intestine

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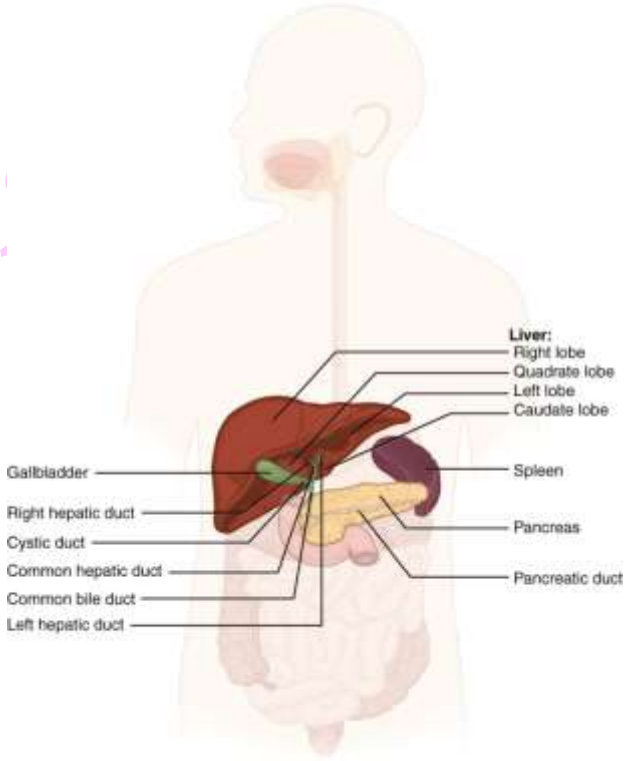
# Overview of the Digestive System

- The accessory digestive organs include:
  - Teeth
  - Tongue
  - Salivary glands
  - Liver
  - Gallbladder
  - Pancreas

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# Overview of the Digestive System

- Functions of the digestive system:
  - Ingestion: is the process of taking in food through the mouth. In vertebrates, the teeth, saliva, and tongue play important roles in mastication (preparing the food into bolus). While the food is being mechanically broken down, the enzymes in saliva begin to chemically process the food as well
  - Secretion
  - Mixing and propulsion
  - Digestion
  - Absorption
  - Defecation

*N.B.: Best points to improve ingestion are window to sky points*

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# Mechanical Digestion in the Gastrointestinal Tract *Interactions Animation*

- Mechanical Digestion in the Gastrointestinal Tract

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# Introduction to Chemical Digestion
## *Interactions Animation*

- Introduction to Chemical Digestion

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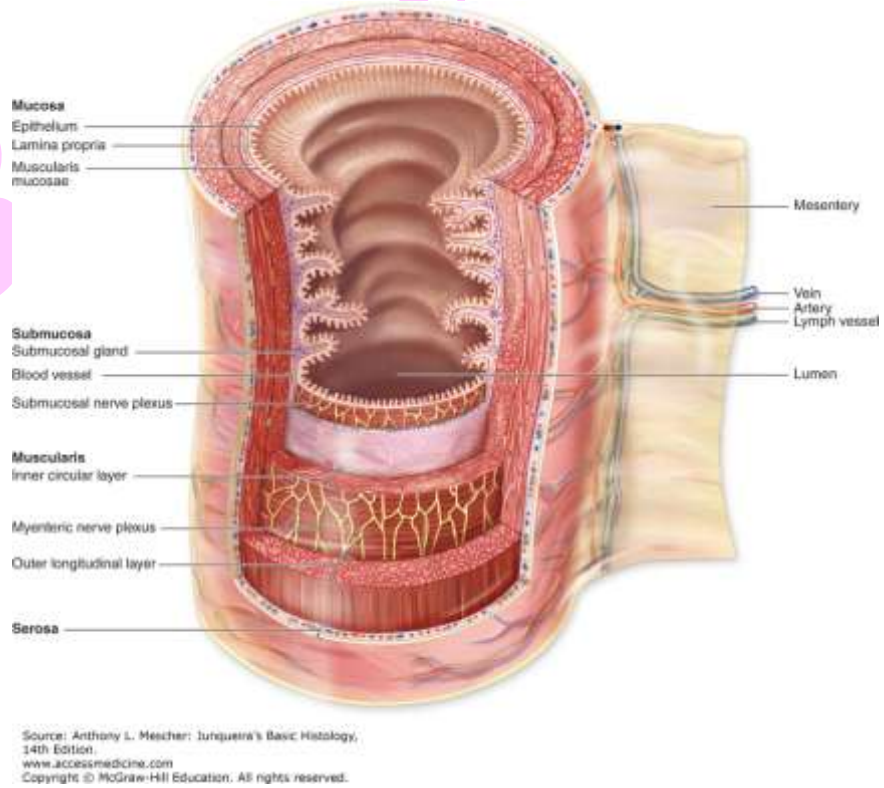
# Mucosa

- The mucosa, or inner lining of the GI tract, is a mucous membrane composed of:
  - Epithelium
  - Lamina propria
  - Muscularis mucosae

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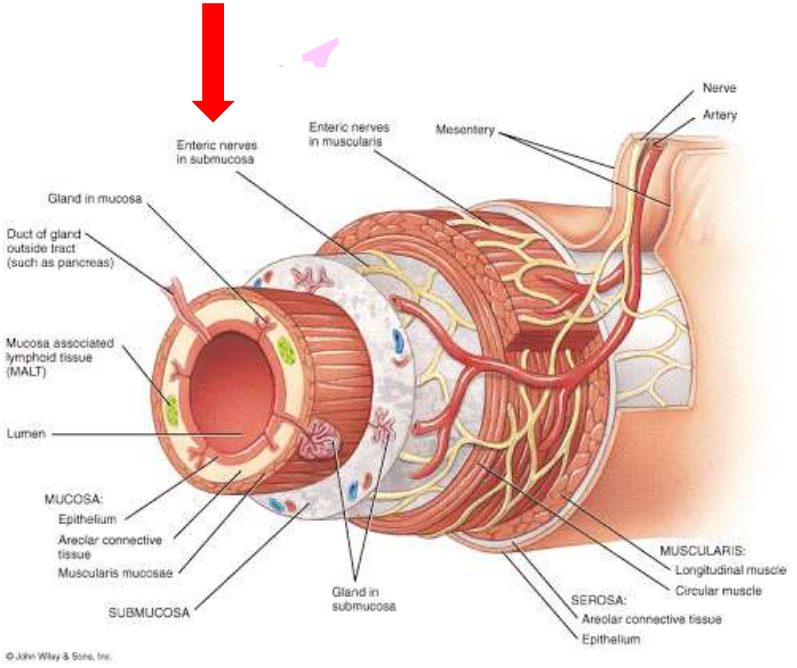
# Submucosa

- A thin meshwork of collagenous fibers, nerves, and blood vessels
- Highly vascular and contains the submucosal plexus, or plexus of Meissner, a portion of the ANS called the enteric nervous system (ENS)
- The submucosal plexus regulates movements of the mucosa and vasoconstriction of blood vessels.
- Innervates secretory cells of mucosal glands

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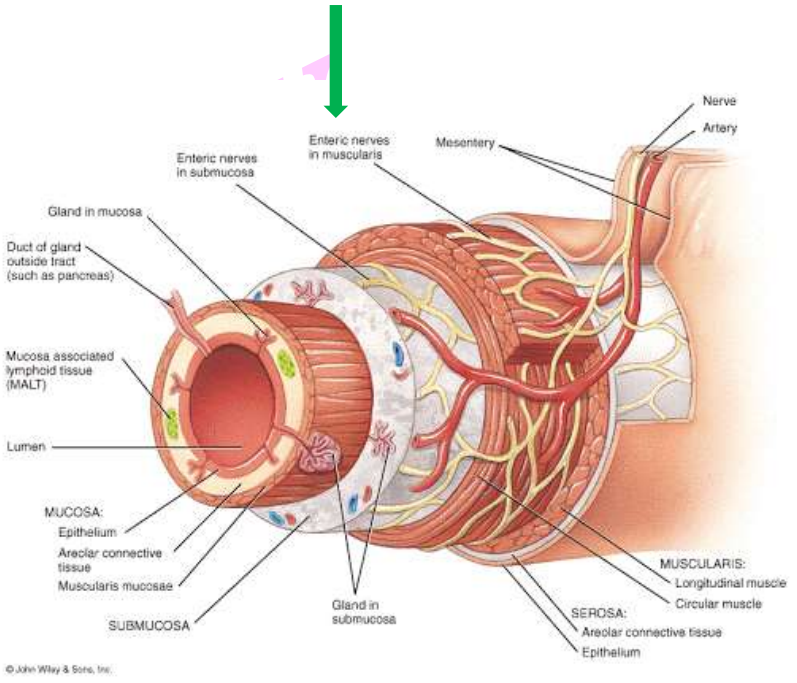
# Muscularis

- Consists of smooth muscle, an inner sheet of circular fibers, and an outer sheet of longitudinal fibers
- Contains the myenteric plexus, or plexus of Auerbach
  - This plexus mostly controls GI tract motility (movement).

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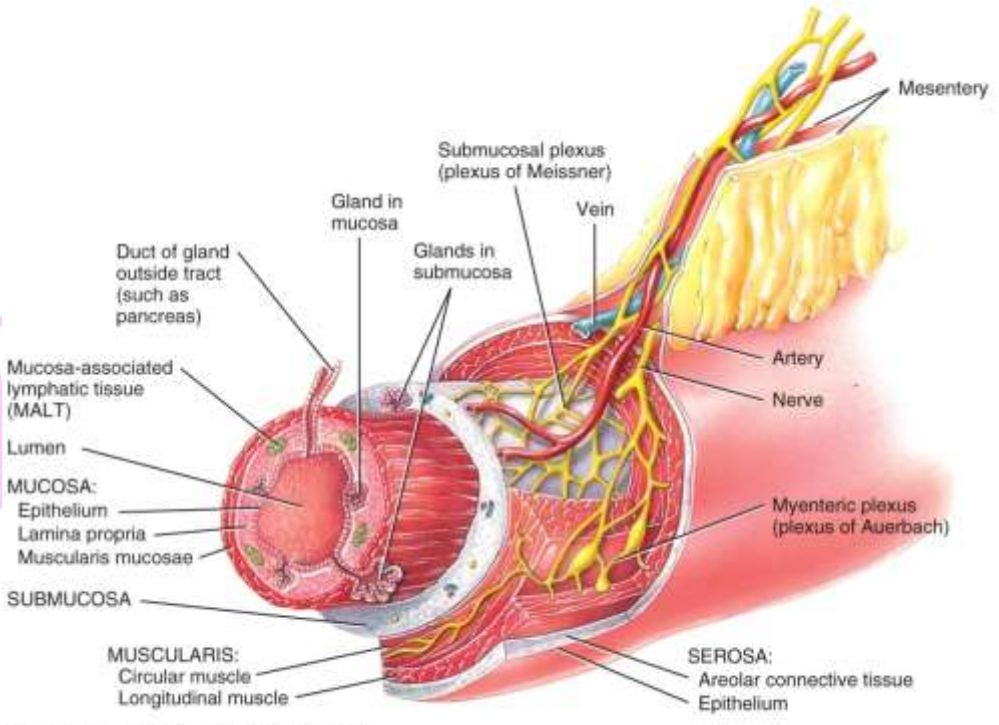
# Serosa

- Superficial layer of those portions of the GI tract that are suspended in the abdominopelvic cavity
- Secretes a serous fluid

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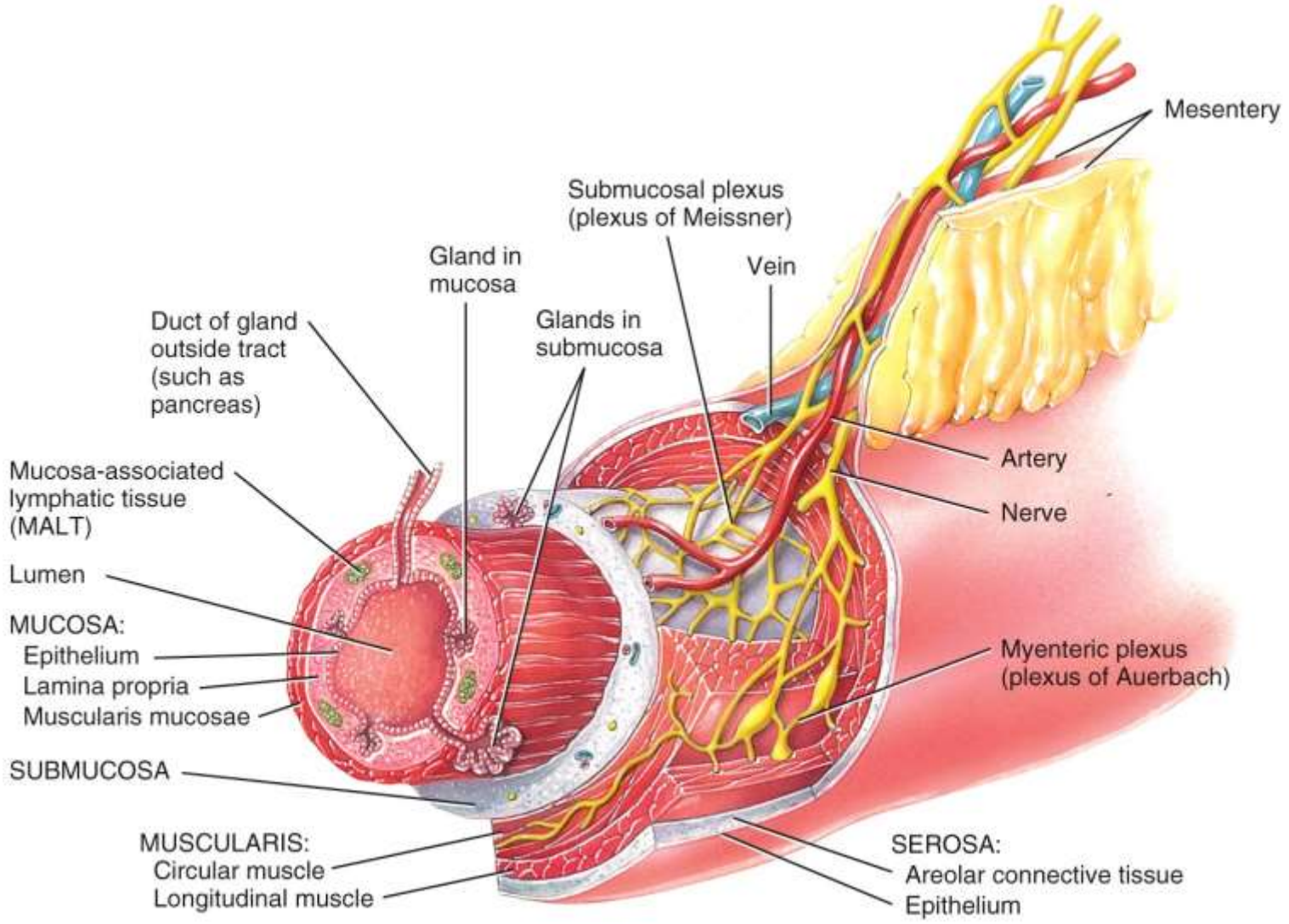
# Layers of the Gastrointestinal Tract

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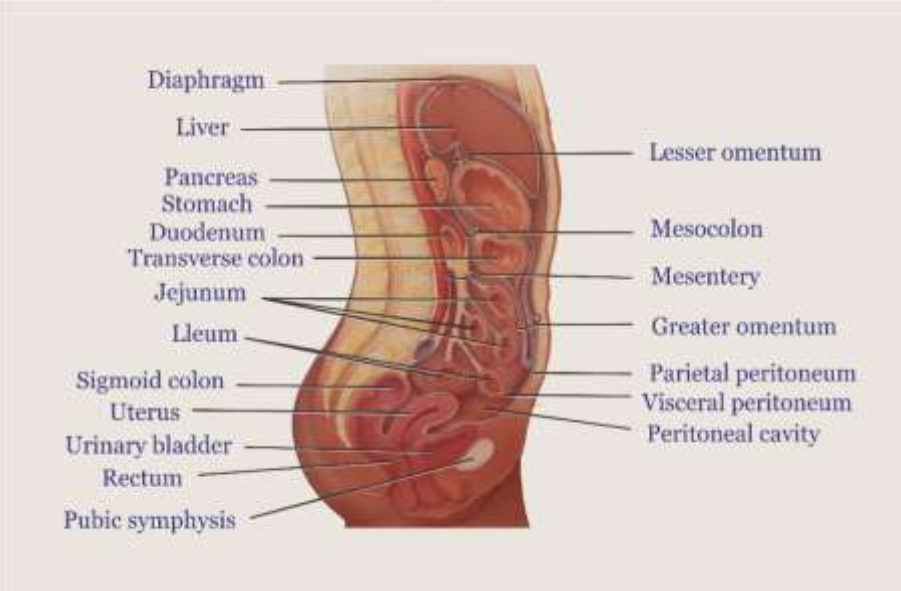
# Peritoneum

- Largest serous membrane of the body
- Divided into:
  - Parietal peritoneum
  - Visceral peritoneum or serosa
- Retroperitoneal organs
- Greater omentum
- Lesser omentum

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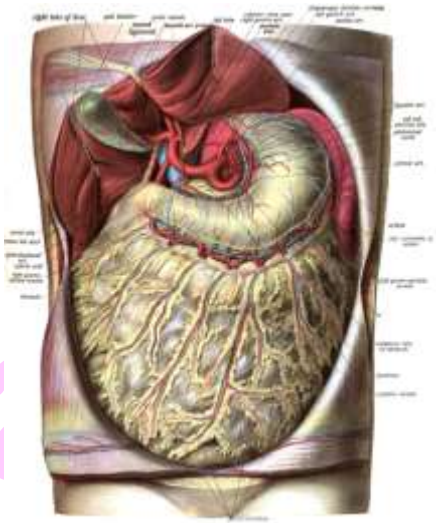
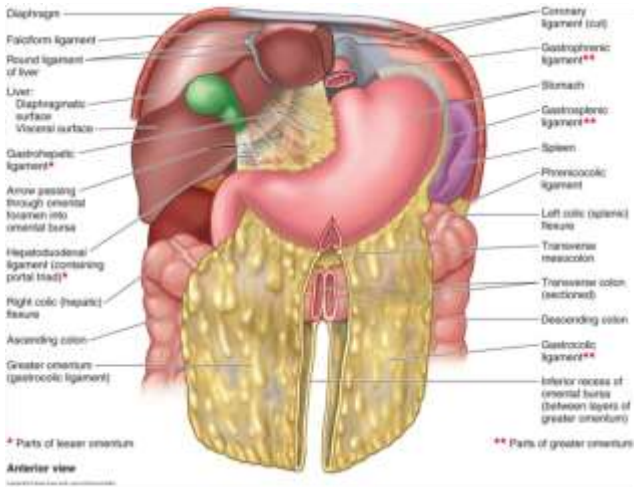
# Peritoneum

- **Retroperitoneal organs:** Retroperitoneal structures include the rest of the duodenum, the ascending colon, the descending colon, the middle third of the rectum, and the remainder of the pancreas. Other organs located in the retroperitoneal space are the kidneys, adrenal glands, proximal ureters, and renal vessels.
- **Greater omentum:** is a prominent peritoneal fold that hangs down from the stomach anterior to the transverse colon, to which it is attached. The **greater omentum** is a double fold that **connects** the stomach to the posterior abdominal wall
- **Lesser omentum:** is the double layer of peritoneum that extends from the liver to the **lesser** curvature of the stomach (hepatogastric ligament) and the first part of the duodenum (hepatoduodenal ligament)



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# Clinical Connection

- **Peritonitis:** is an inflammation of the peritoneum, Peritonitis is usually caused by infection from bacteria or fungi and it is a medical emergency.

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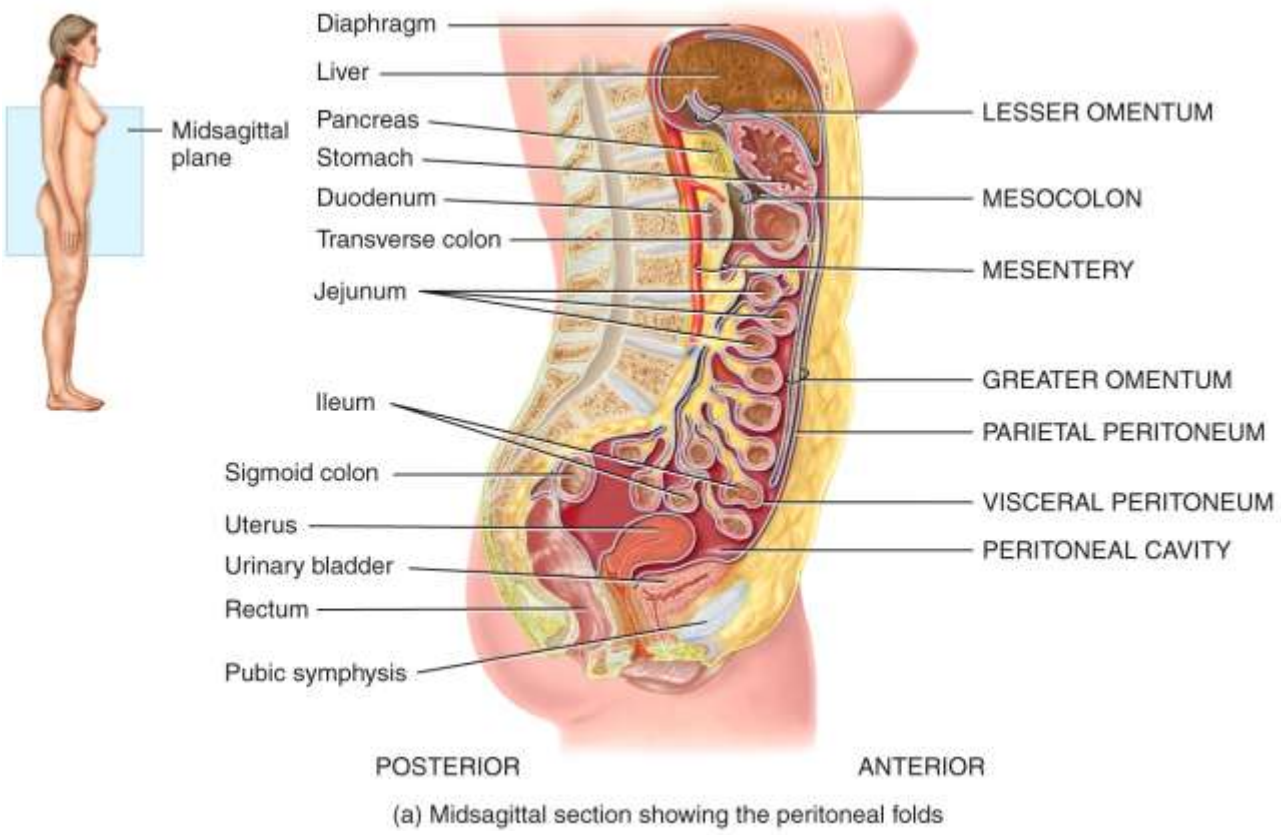
# Relationship of the Peritoneal Folds to Each Other and to Other Organs of the Digestive System




(a) Midsagittal section showing the peritoneal folds

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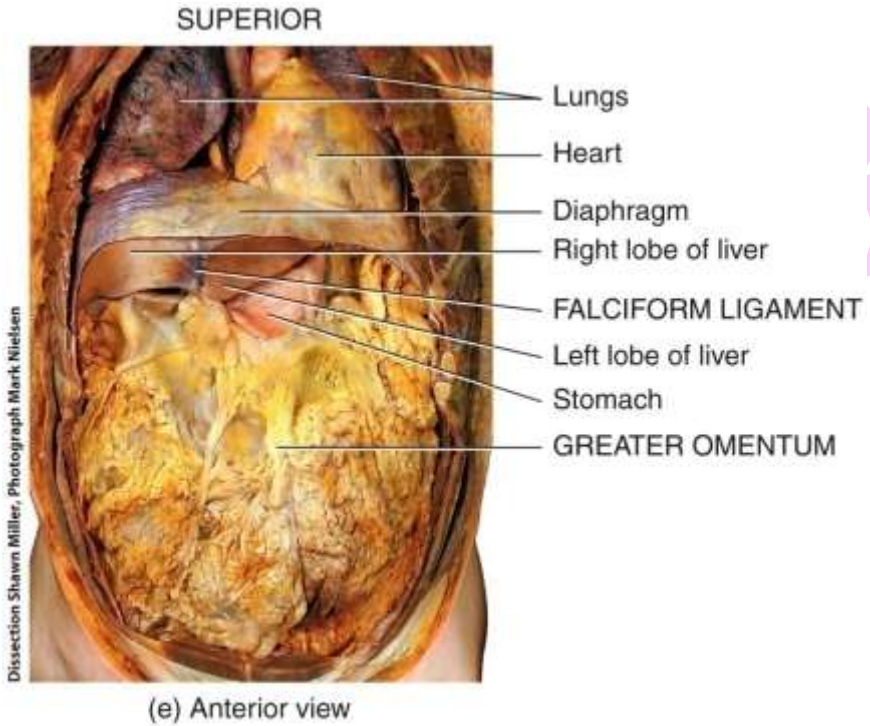
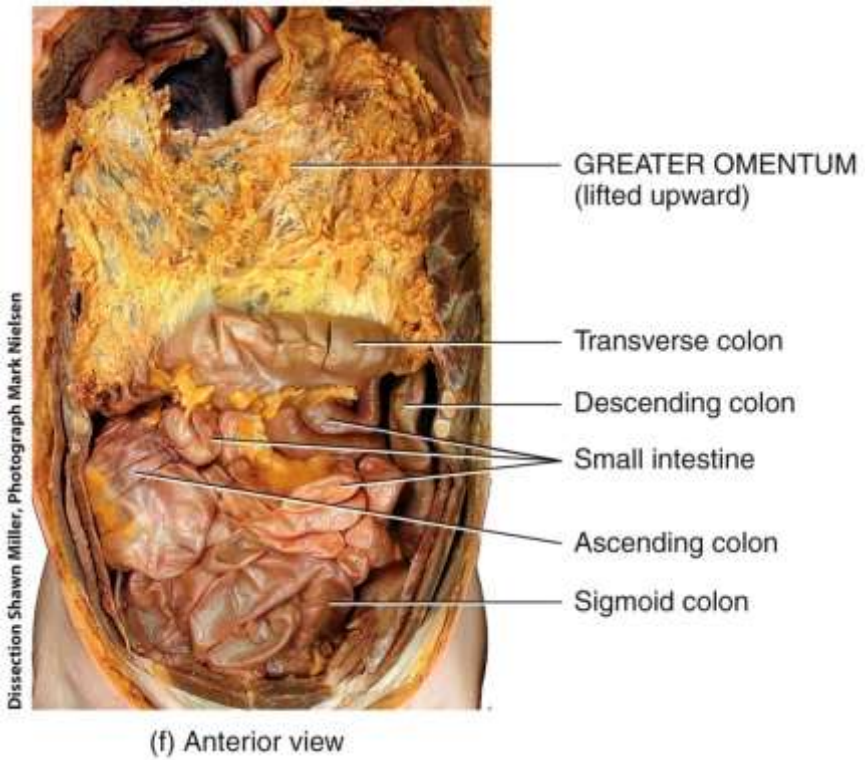
# Relationship of the Peritoneal Folds to Each Other and to Other Organs of the Digestive System



(e) Anterior view



(f) Anterior view

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# Mouth

- Also called oral or buccal cavity
- Formed by cheeks, hard and soft palates, and tongue
- Cheeks covered externally by skin and internally by a mucous membrane
- Buccinator muscles and connective tissue lie between the skin and mucous membranes of the cheeks.

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# Mouth

- Lips or labia
- Labial frenulum
- Oral vestibule
- Fauces
- Hard palate
- Soft palate
- Uvula

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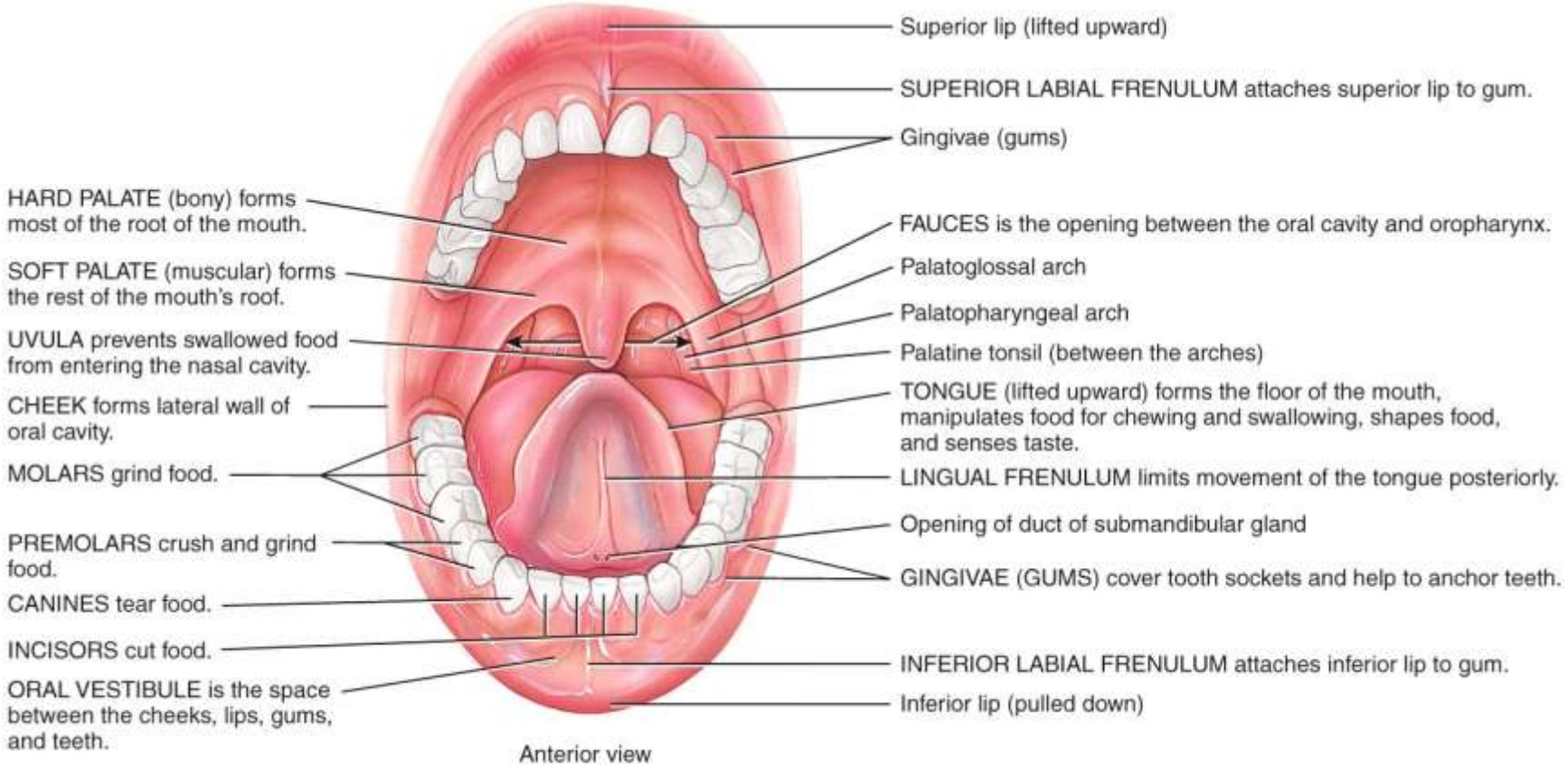
# Structures of the Mouth (Oral Cavity)




Anterior view

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# Salivary Glands

- Three pairs of major salivary glands:
  - Parotid glands
    - Parotid (Stensen's) duct
  - Submandibular glands
    - Submandibular (Wharton's) ducts
  - Sublingual glands
    - Lesser sublingual (Rivinus') ducts

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# Salivary Glands

- The salivary glands receive both sympathetic and parasympathetic innervation.
- Saliva
  - Salivary amylase plays a minor role in the breakdown of starch in the mouth.
  - Lingual lipase and mucus are secreted by lingual glands.

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# Clinical Connection

- **Mumps:** is a viral disease caused by the mumps virus. Initial signs and symptoms often include fever, muscle pain, headache, poor appetite, and feeling generally unwell. This is then usually followed by painful swelling of one or both parotid salivary glands.

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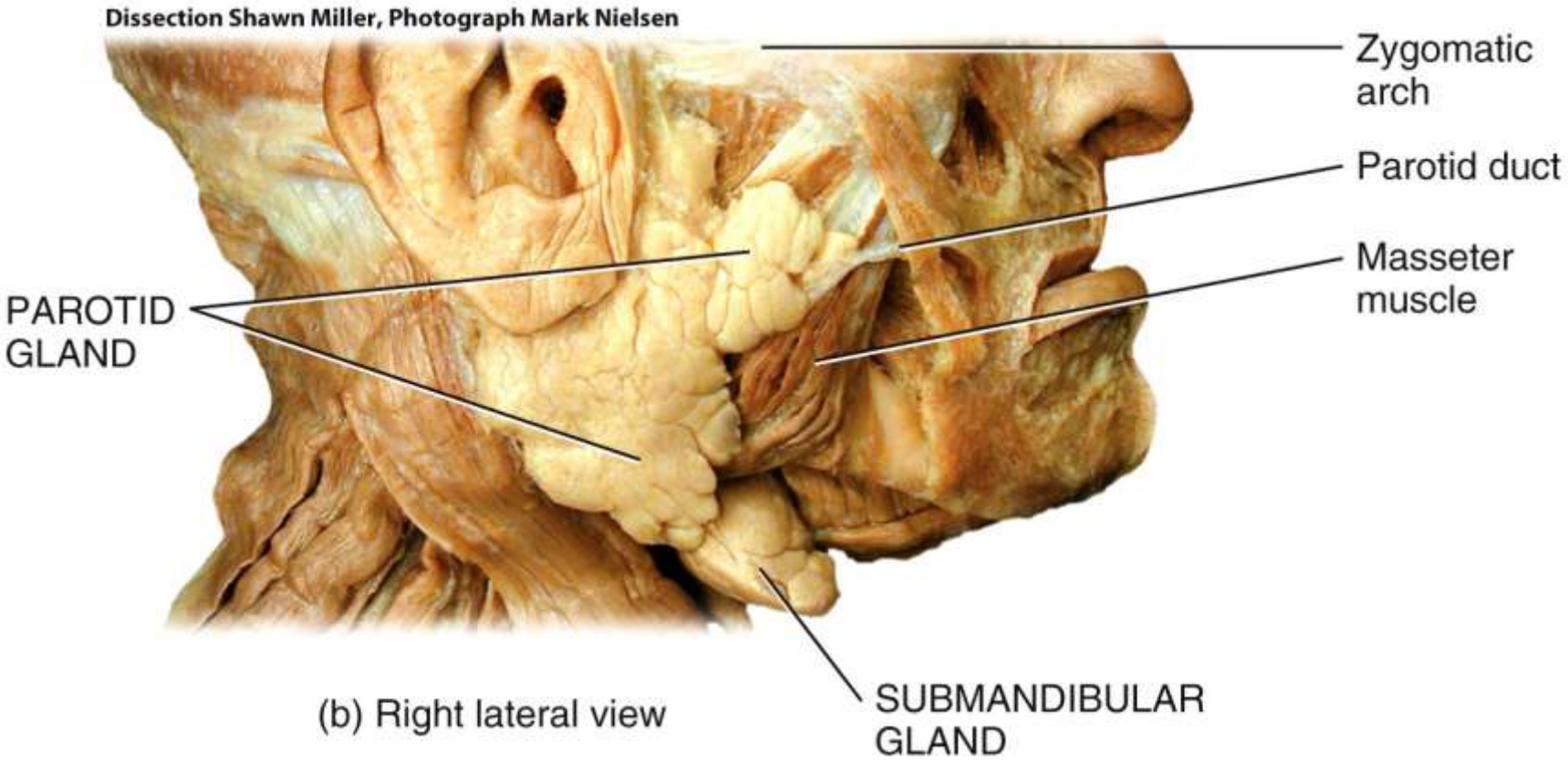
# The Three Major Salivary Glands—Parotid, Sublingual, and Submandibular

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# Tongue

- Accessory digestive organ composed of skeletal muscle covered with mucous membrane
- Extrinsic muscles of the tongue
- Intrinsic muscles of the tongue
- Lingual frenulum
  - Ankyloglossia

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# Teeth

- Also called dentes
- Gingivae or gum
- Periodontal ligament or membrane

Teeth are composed of:

- Crown
- Neck
- Dentin
- Enamel
- Pulp cavity

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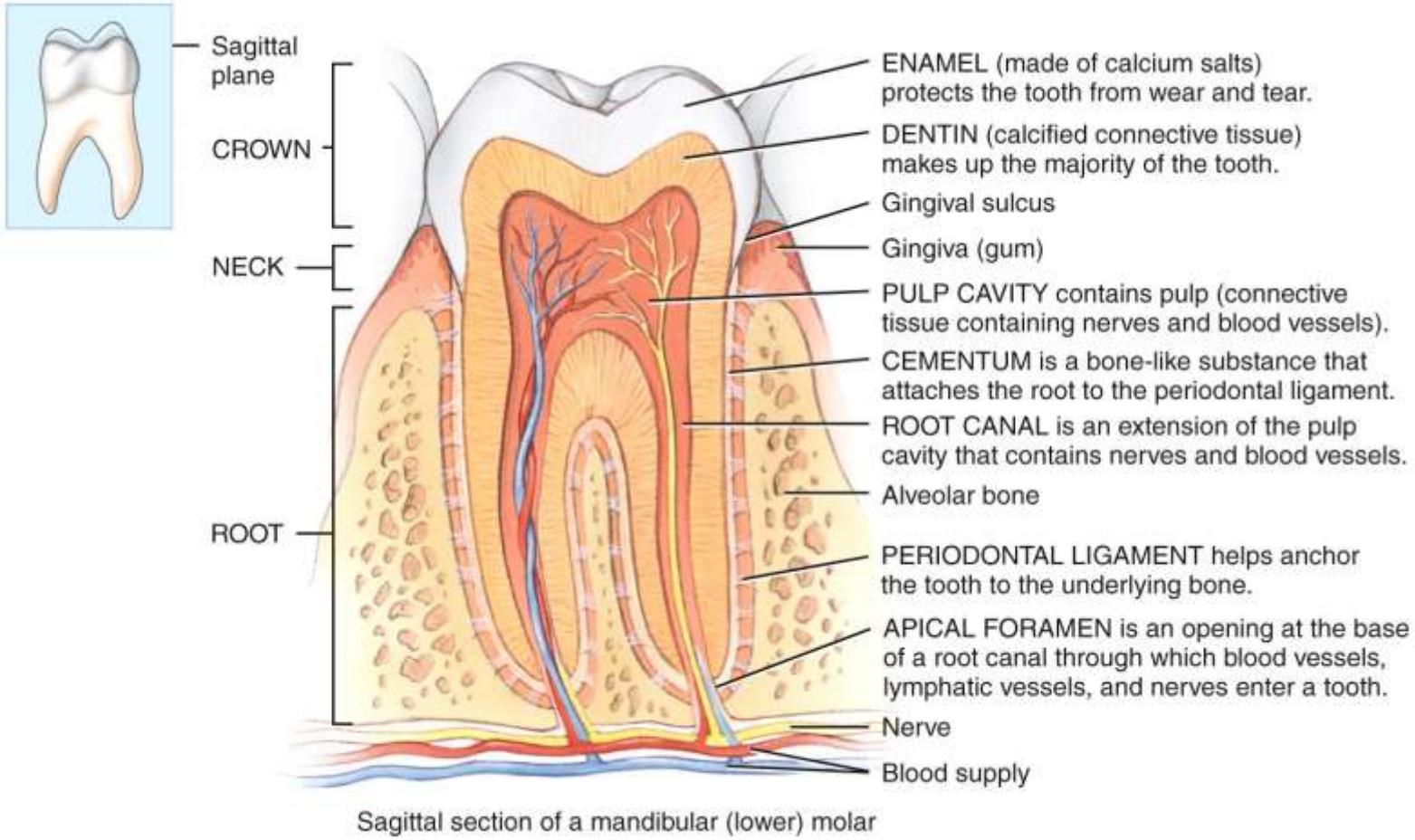
# A Typical Tooth and Surrounding Structures




Sagittal section of a mandibular (lower) molar

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# Clinical Connection

- **Root canal therapy:** is a treatment sequence for the infected pulp of a tooth which is intended to result in the elimination of infection and the protection of the decontaminated tooth from future microbial invasion.

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# Human Teeth

- Deciduous teeth
  - First and second deciduous molars
- Central or lateral incisors
- Permanent teeth
  - First and second premolars (bicuspids)

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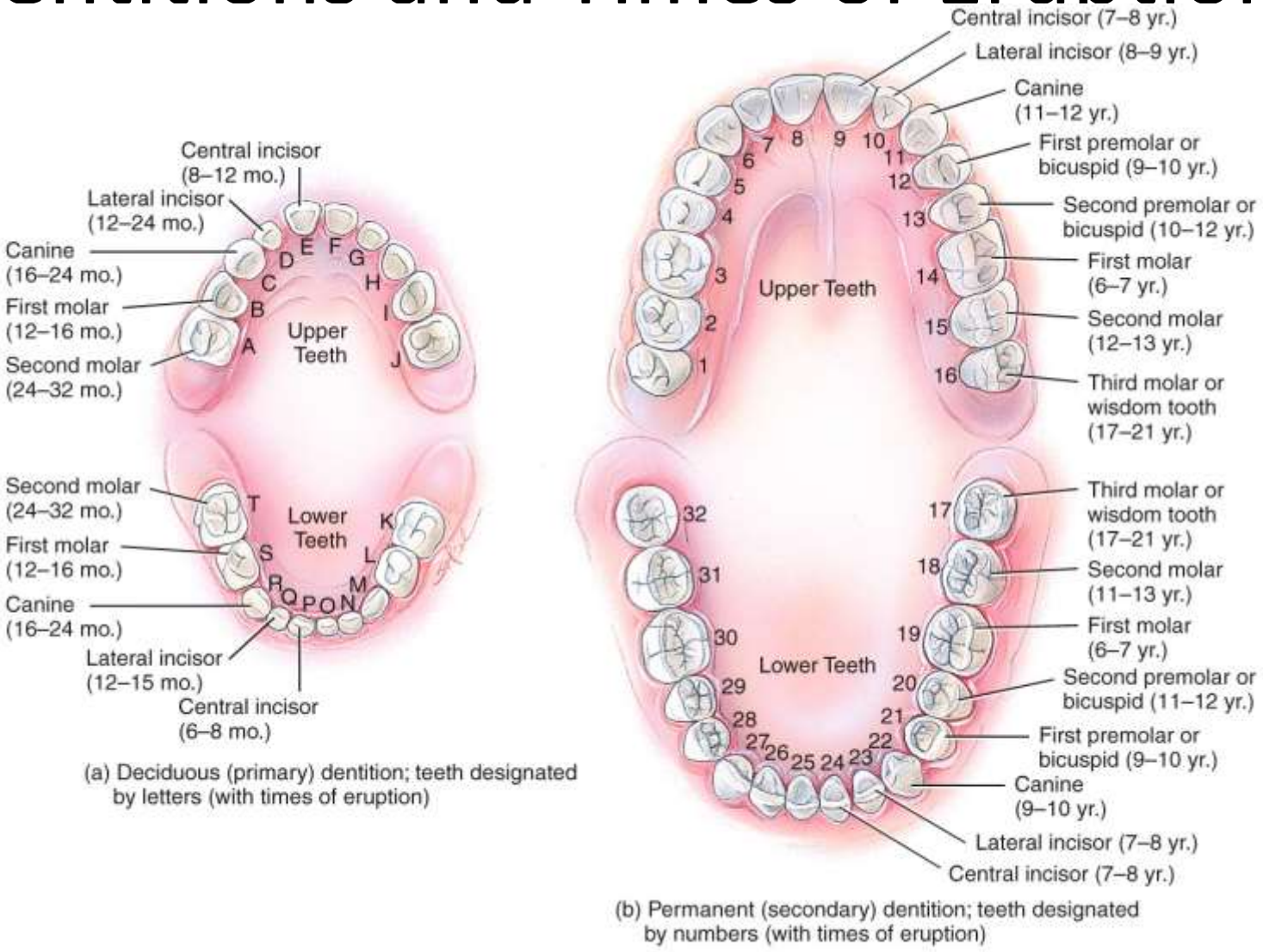
# Dentitions and Times of Eruptions




(a) Deciduous (primary) dentition; teeth designated by letters (with times of eruption)

(b) Permanent (secondary) dentition; teeth designated by numbers (with times of eruption)

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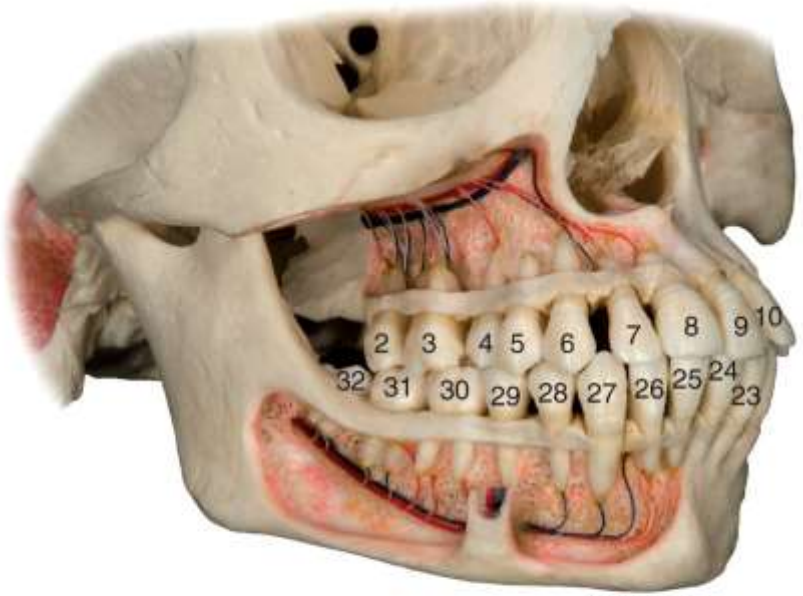
# Dentitions and Times of Eruptions

Right anterolateral view

DECIDUOUS TEETH:
A - First molar (maxillary)
B - Second molar (maxillary)
C - Canine (maxillary)
R - Canine (mandibular)
S - First molar (mandibular)
T - Second molar (mandibular)

PERMANENT TEETH:
8, 9, 24, 25 - Central incisor
7, 26 - Lateral incisor
6, 27 - Canine
5, 28 - First premolar
4, 29 - Second premolar
3, 30 - First molar
2, 31 - Second molar

(c) Mandible and maxilla of an eight-year old child showing erupted deciduous teeth and unerupted permanent teeth




Right anterolateral view

8, 9, 24, 25 - Central incisor
7, 10, 23, 26 - Lateral incisor
6, 27 - Canine
5, 28 - First premolar
4, 29 - Second premolar
3, 30 - First molar
2, 31 - Second molar
32 - Third molar

(d) Mandible and maxilla showing permanent teeth and blood and nerve supply to them

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# Clinical Connection

- **Periodontal disease:** Also known as gum disease, is a set of inflammatory conditions affecting the tissues surrounding the teeth. In its early stage, called gingivitis, the gums become swollen, red, and may bleed. Periodontal disease is generally due to bacteria in the mouth infecting the tissue around the teeth.
- **Dental caries:** Tooth decay, also known as dental caries or cavities, is a breakdown of teeth due to acids made by bacteria. The cause of cavities is acid from bacteria dissolving the hard tissues of the teeth (enamel, dentin and cementum)

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# Pharynx

- Extends from the internal nares to the esophagus posteriorly and the larynx anteriorly
- Composed of skeletal muscle and lined by mucous membrane
- Nasopharynx
- Oropharynx
- Laryngopharynx
- Deglutition is a mechanism that moves food from the mouth to the stomach.

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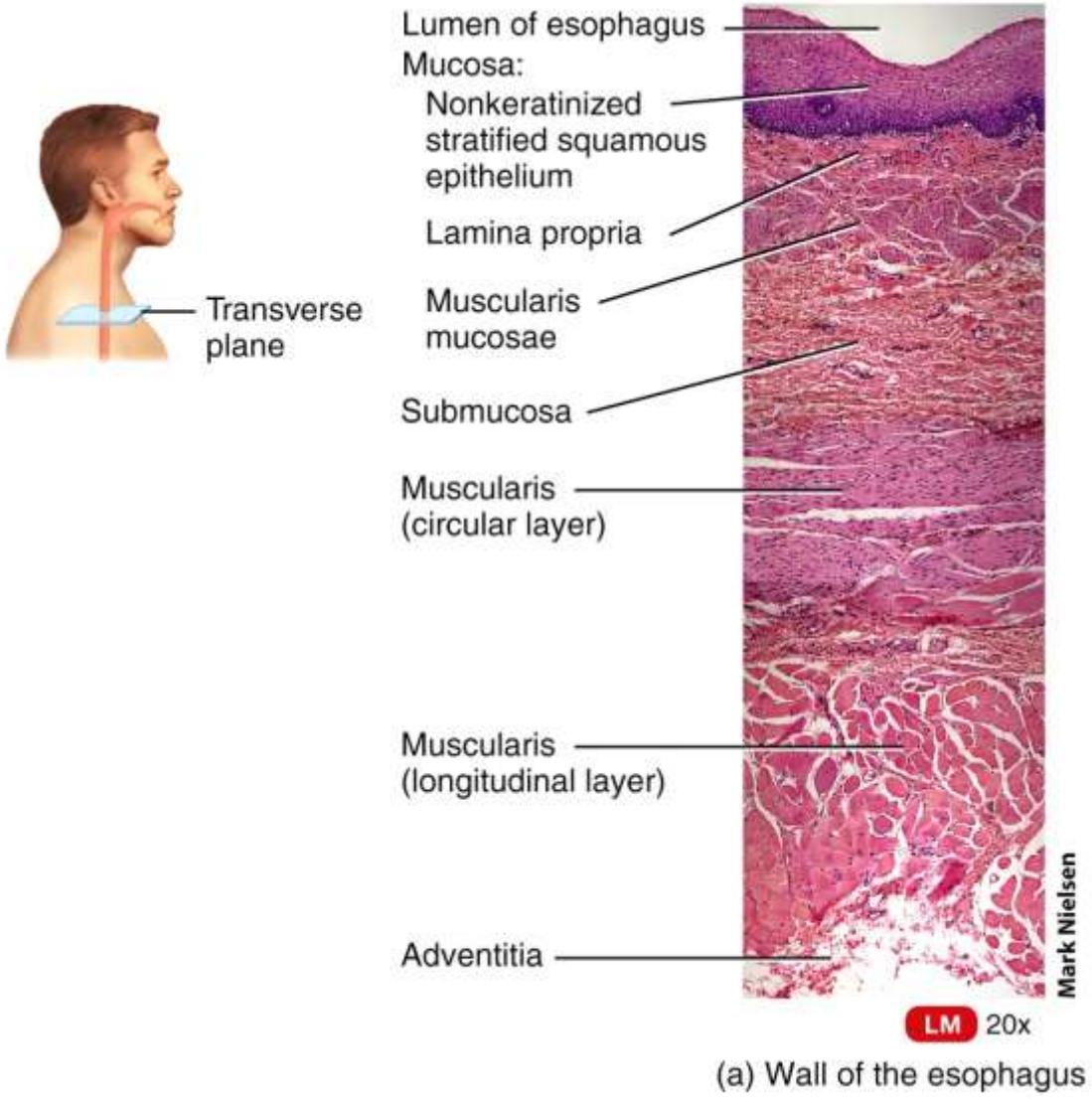
# Histology of the Esophagus




(a) Wall of the esophagus

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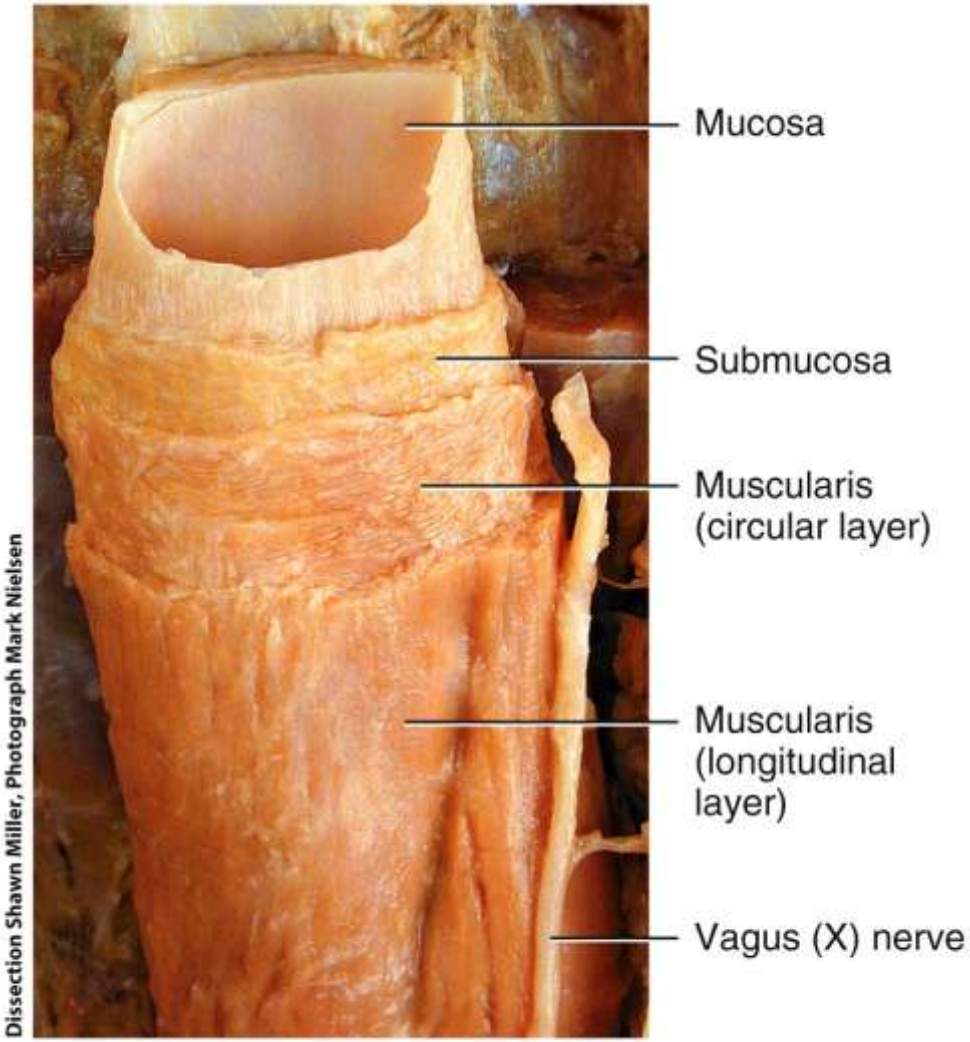
# Histology of the Esophagus




(b) Anterosuperior view of step dissection of esophagus

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# Functions of the Esophagus

- Upper esophageal sphincter (UES)
- The elevation of the larynx causes the sphincter to relax, allowing the bolus to enter the esophagus.
- Peristalsis
- Mucus secreted by esophageal glands lubricates the bolus and reduces friction.
- Lower esophageal sphincter (LES), also called gastroesophageal or cardiac sphincter

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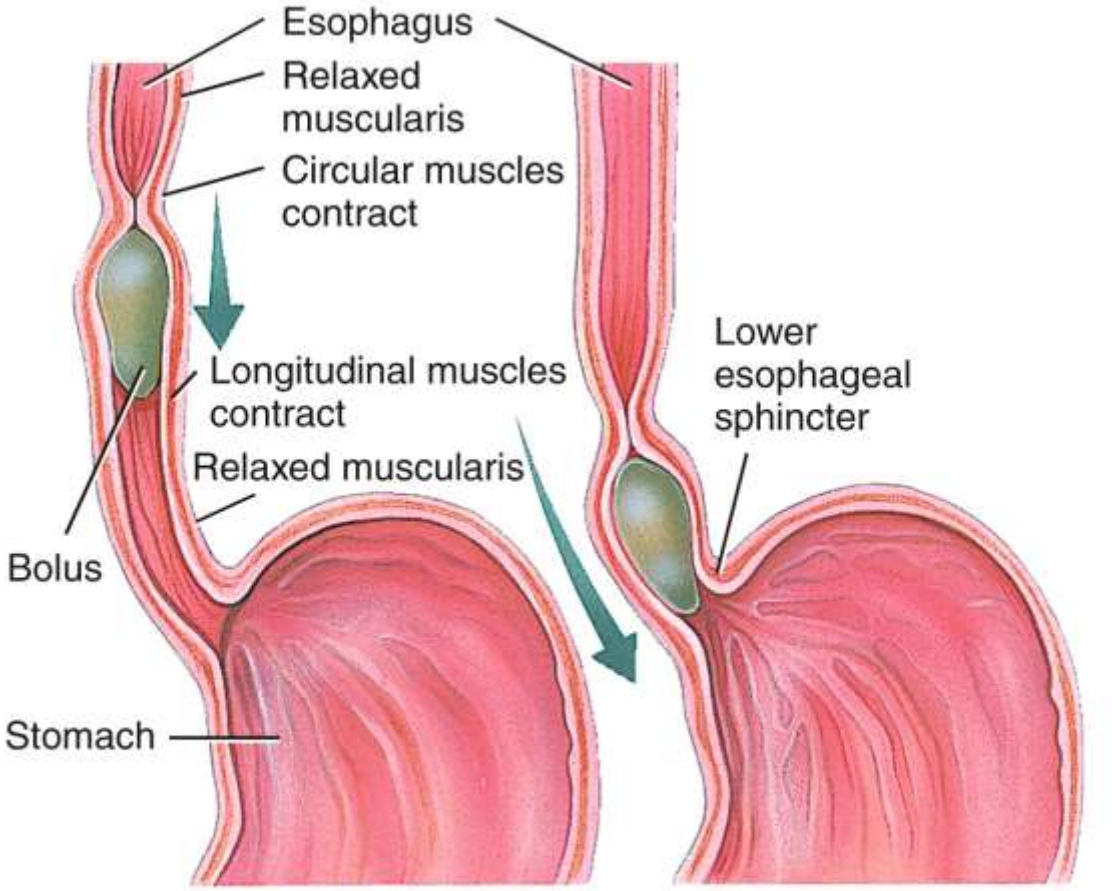
# Peristalsis During Deglutition (Swallowing)




Anterior view of frontal sections showing peristalsis in esophagus

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# Clinical Connection

- **Gastroesophageal reflux disease (GERD)**
  - Is a digestive disorder that occurs when acidic stomach juices, or food and fluids back up from the stomach into the esophagus. ... Asthma flare-ups can cause the lower esophageal sphincter to relax, allowing stomach contents to flow back, or reflux, into the esophagus.

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# Stomach

- J-shaped enlargement of the GI tract
- Connects the esophagus to the duodenum
- Functions as a mixing area and holding reservoir
- Position and size of the stomach vary continually.
- In the stomach, the digestion of starch that began in the mouth continues, digestion of proteins and triglycerides begins, the semisolid bolus is converted to a liquid, and certain substances are absorbed.

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# Anatomy of the Stomach

- The stomach has four main regions:
  - Cardia
  - Fundus
  - Body
  - Pyloric part
    - Pyloric part consists of 3 regions:
      - Pyloric antrum (connects to body of stomach)
      - Pyloric canal (leads to pylorus)
      - Pylorus (connects to the duodenum)

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# Anatomy of the Stomach

- Rugae
- Pyloric sphincter
- Lesser curvature
- Greater curvature

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# Histology of the Stomach

- Gastric glands contain three types of exocrine gland cells:
  - **Mucous neck cells**: are found in the upper parts (isthmus and neck) of the gastric glands (SEM). They are smaller than surface mucous cells. They *secrete an acidic fluid* containing mucin proteins. This differs from the mucus produced by surface mucous cells which is alkaline.
  - **Chief cells:** (also known as a zymogenic cell or peptic cell) is a cell in the stomach that releases pepsinogen and chymosin. Pepsinogen is activated into the digestive enzyme *pepsin* when it comes in contact with acid produced by gastric parietal cells.
  - **Parietal cells:** (also known as oxyntic or delomorphous **cells**) are the epithelial **cells** that secrete *hydrochloric acid* (HCl) and intrinsic factor. These **cells** are located in the gastric glands found in the lining of the fundus and in the cardia of the stomach
  - **G cells:** or gastrin cell, is a type of cell in the stomach and duodenum that secretes *gastrin*. It works in conjunction with gastric chief cells and parietal cells. G cells are found deep within the pyloric glands of the stomach antrum, and occasionally in the pancreas and duodenum.

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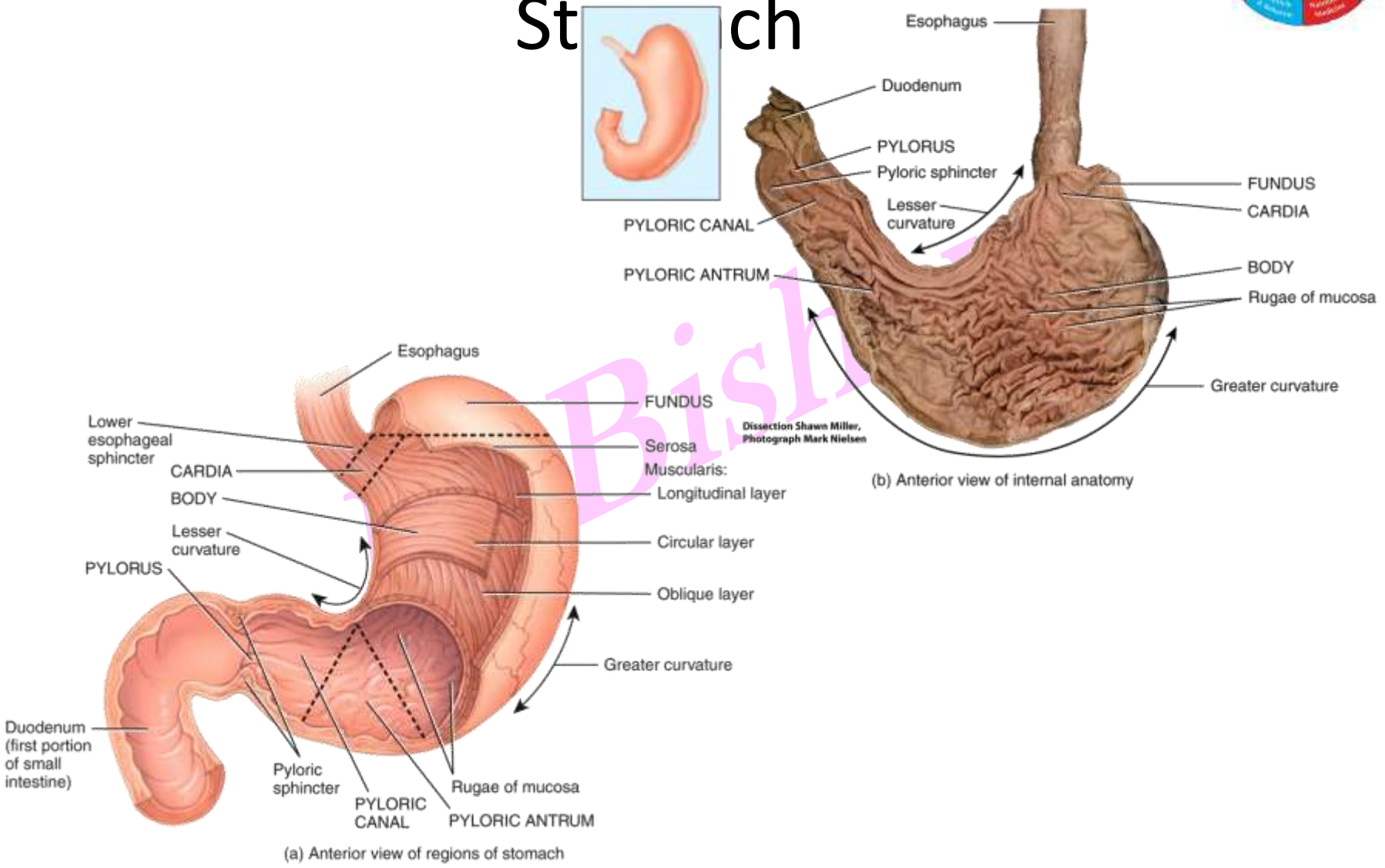
# External and Internal Anatomy of the St ch

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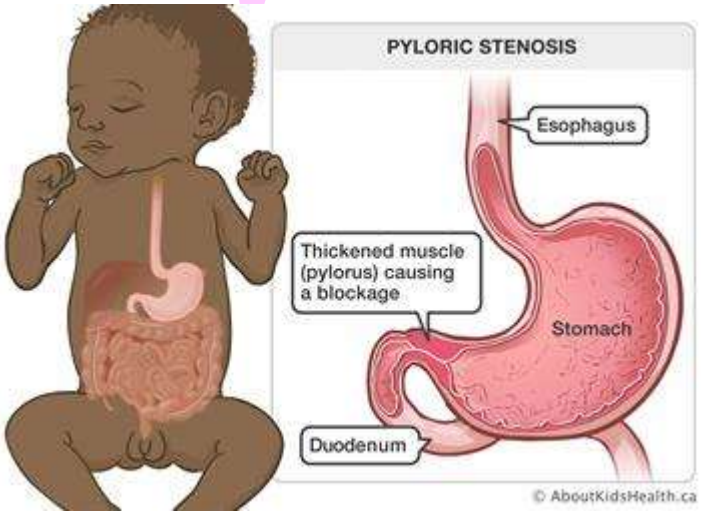
# Clinical Connection

- **pyloric stenosis:** is a problem that affects babies between birth and 6 months of age

  *(Usually first baby, boy and with blood group O)* and causes forceful vomiting that can lead to dehydration. It is the second most common problem requiring surgery in newborns.

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# Histology of the Stomach

- Submucosa
- Muscularis
  - Outer longitudinal layer
  - Middle circular layer
  - Inner oblique layer
- Serosa is composed of:
  - Simple squamous epithelium (mesothelium), also
    - called visceral peritoneum
  - Areolar connective tissue

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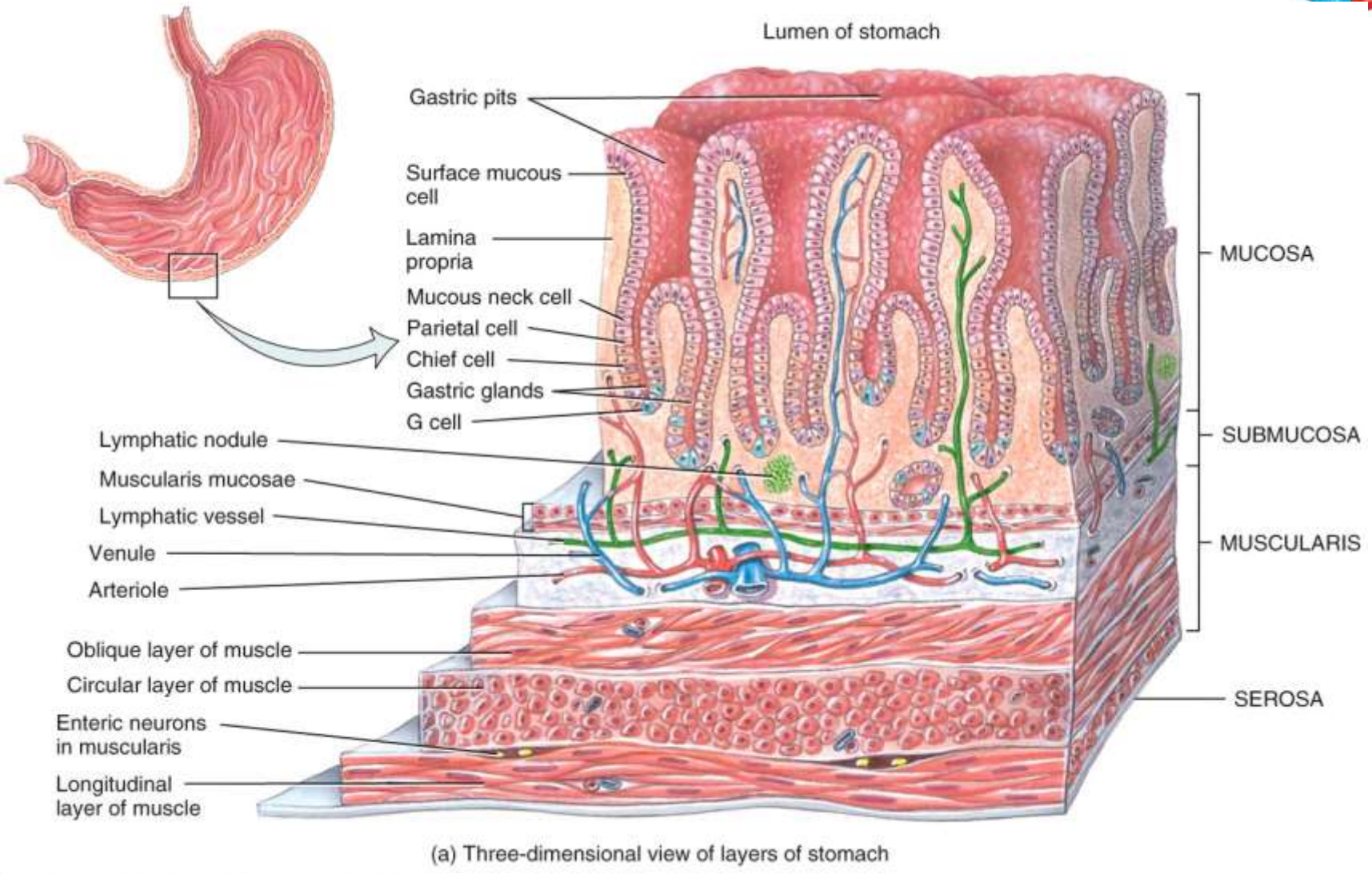
# Histology of the Stomach




(a) Three-dimensional view of layers of stomach

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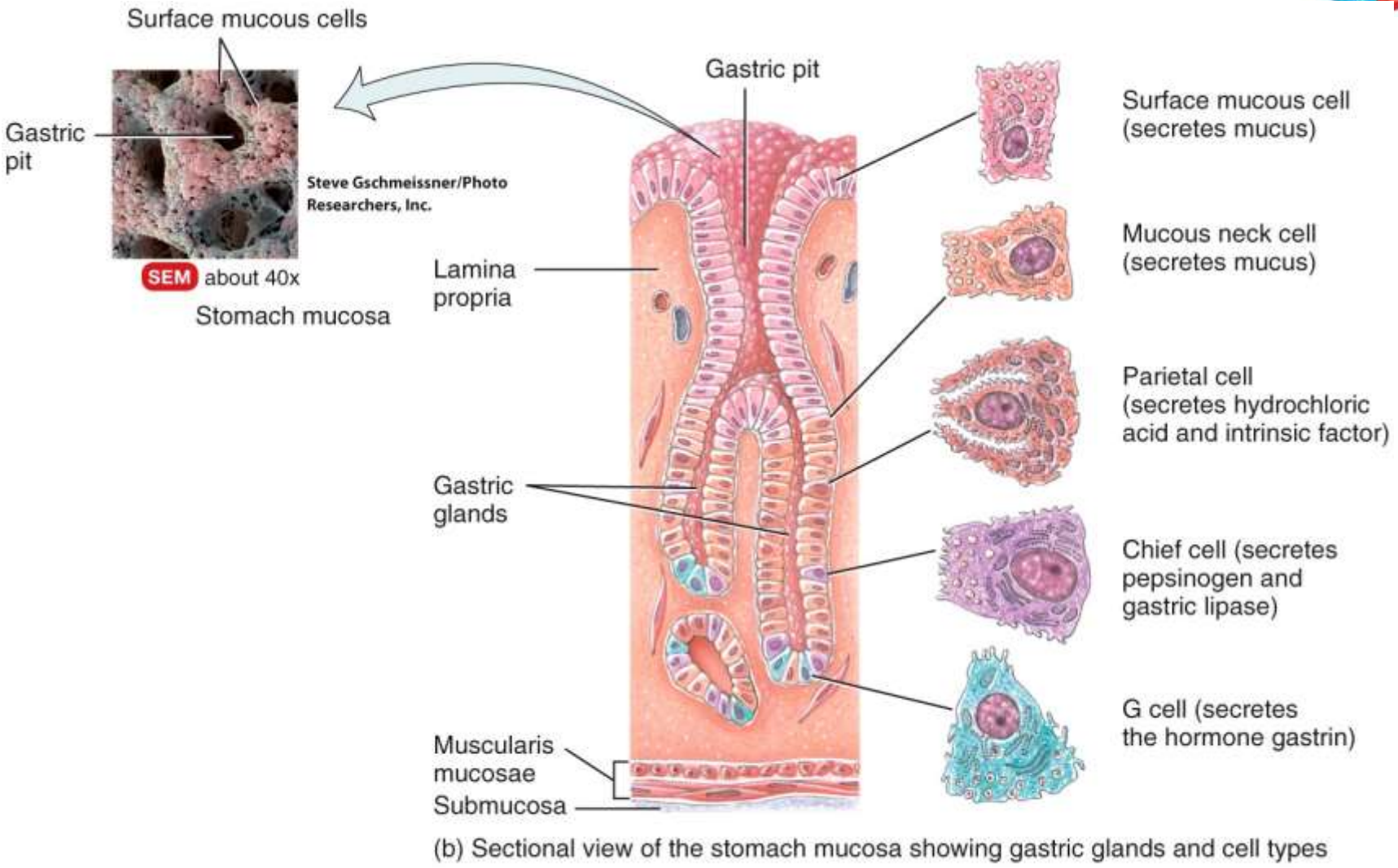
# Histology of the Stomach




(b) Sectional view of the stomach mucosa showing gastric glands and cell types

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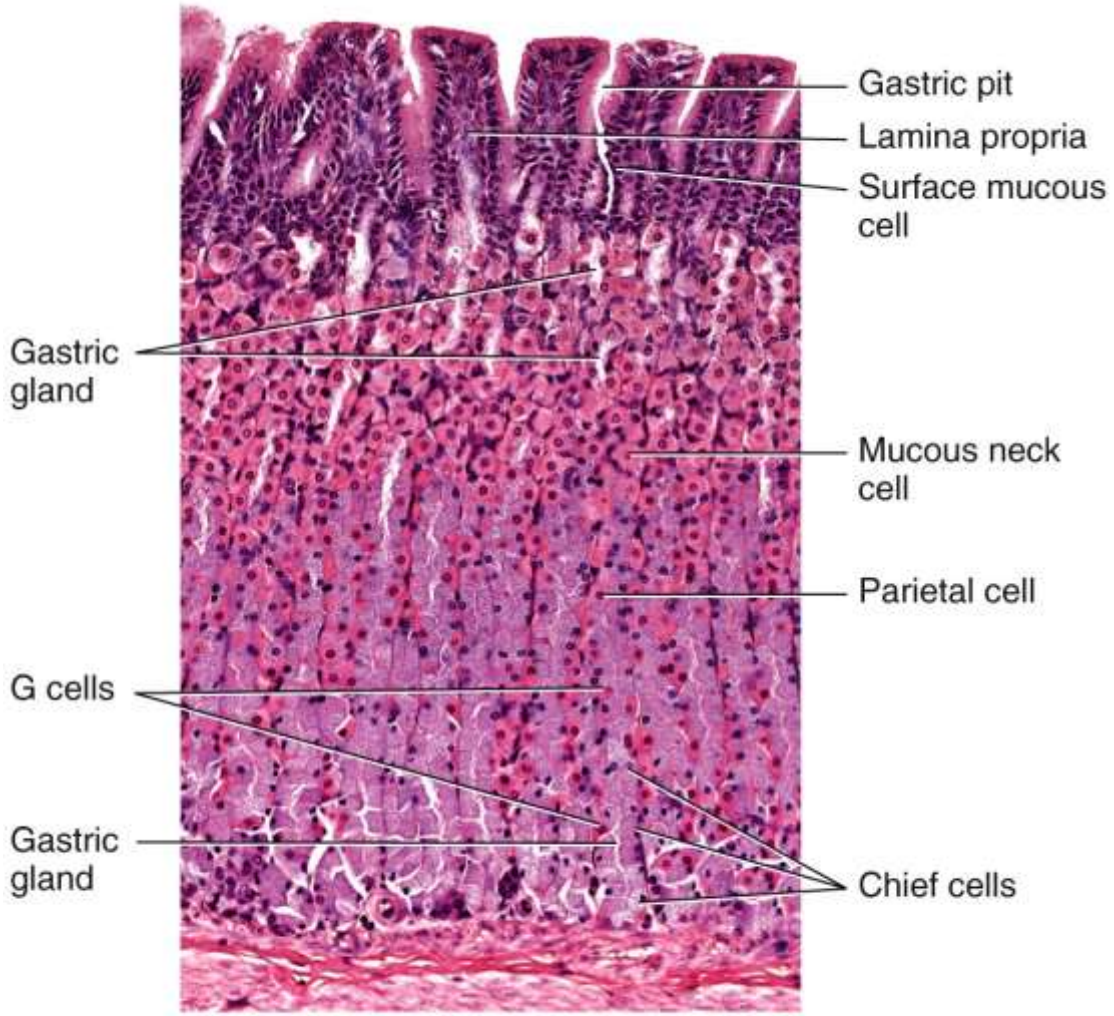
# Histology of the Stomach




(c) Fundic mucosa

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# Functions of the Stomach

- Digestion
  - Propulsion and retropulsion (peristaltic waves)
  - Chyme
  - Gastric emptying
  - Pepsin
  - Gastric lipase
  - Pancreatic lipase

R. Bishay

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# Clinical Connection

- **Vomiting:** is the forcible emptying of the stomach in which the stomach has to overcome the pressures that are normally in place to keep food and secretions within the stomach.
- *In TCM: Vomiting is rebellious stomach Qi*

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# Protein Digestion and Absorption
## *Interactions Animation*

- Protein Digestion and Absorption

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# Carbohydrate Digestion and Absorption

## *Interactions Animation*

- Carbohydrate Digestion and Absorption

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# Lipid Digestion and Absorption
## *Interactions Animation*

- Lipid Digestion and Absorption

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# Nucleic Acid Digestion and Absorption
## *Interactions Animation*

- Nucleic Acid Digestion and Absorption

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# Hormonal Control of Digestive Activities

## *Interactions Animation*

- Hormonal Control of Digestive Activities

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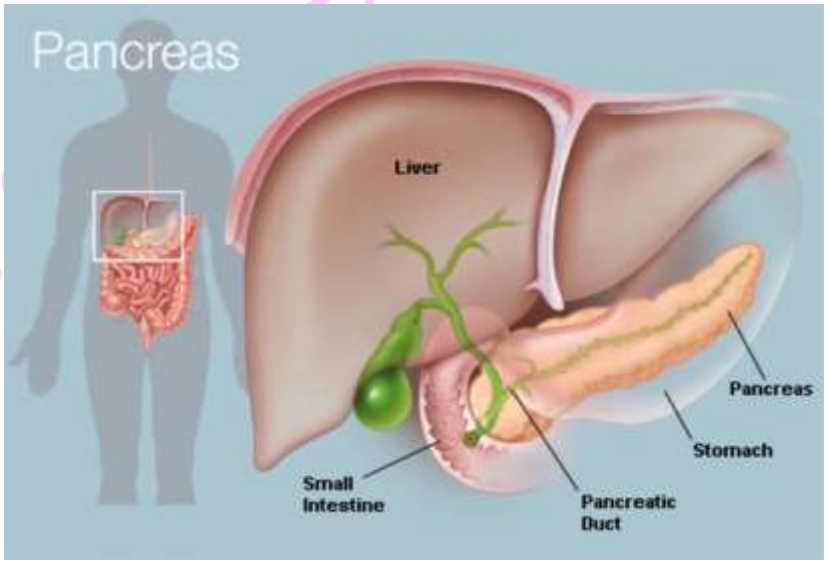
# Anatomy of the Pancreas

- The pancreas consists of:
  - Head
  - Body
  - Tail
  - Pancreatic duct (duct of Wirsung)
  - Hepatopancreatic ampulla (ampulla of Vater)
  - Major duodenal papilla
  - Accessory duct (duct of Santorini)

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# Clinical Connection

- **Pancreatitis:** is a disease in which your pancreas becomes inflamed. and pancreatic cancer.
- **Pancreatic cancer:** is cancer that forms in the cells of the pancreas. Pancreatic cancer begins in the tissues of your pancreas.

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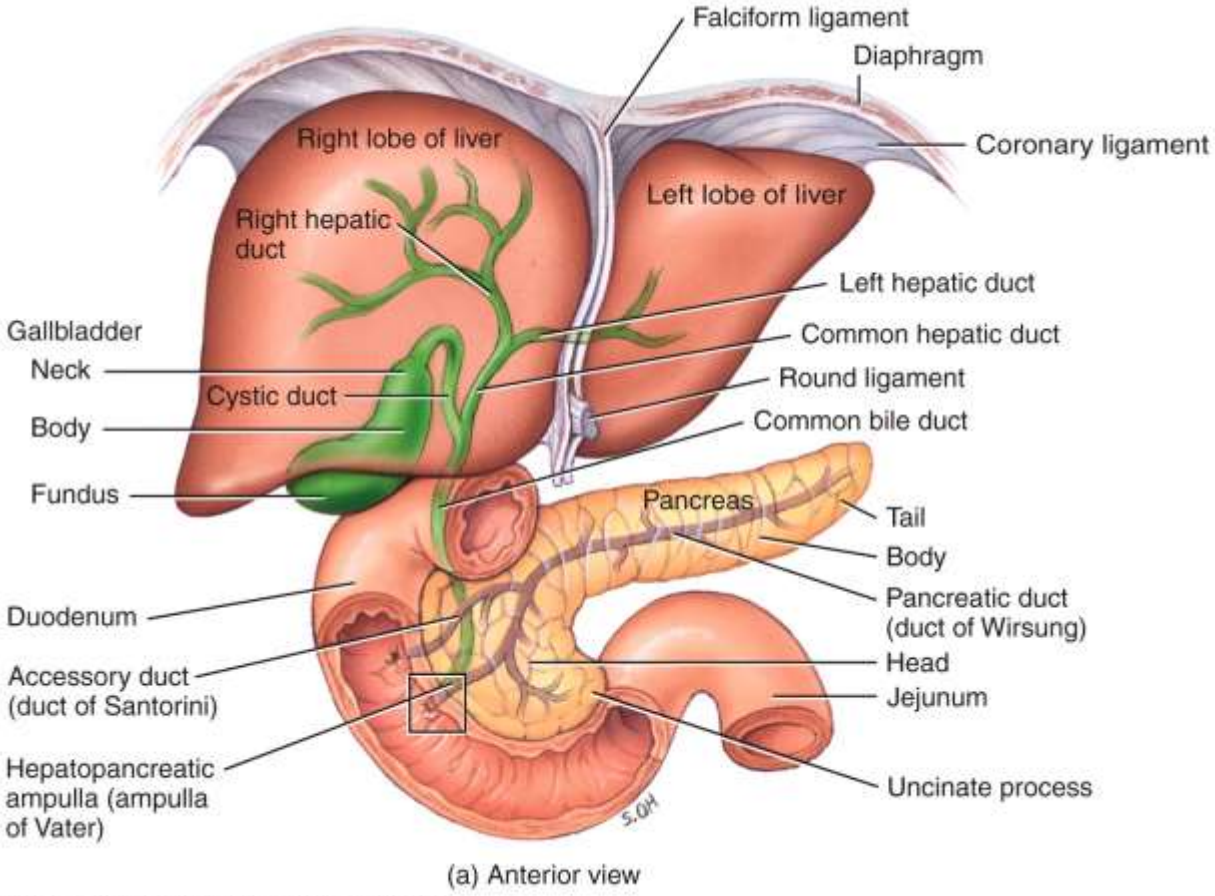
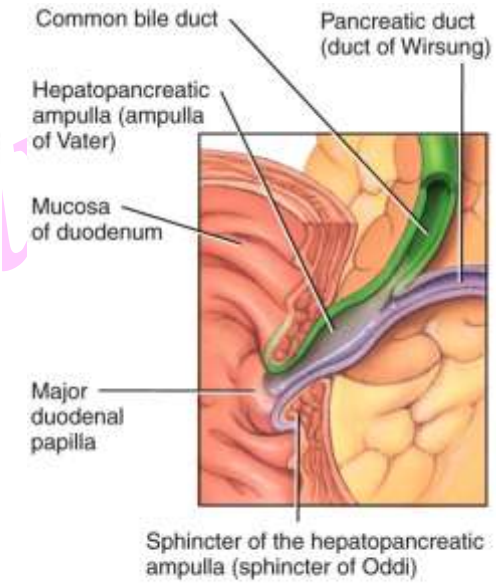
# Relationship of the Pancreas to the Liver, Gallbladder, and Duodenum




(a) Anterior view




(b) Details of hepatopancreatic ampulla

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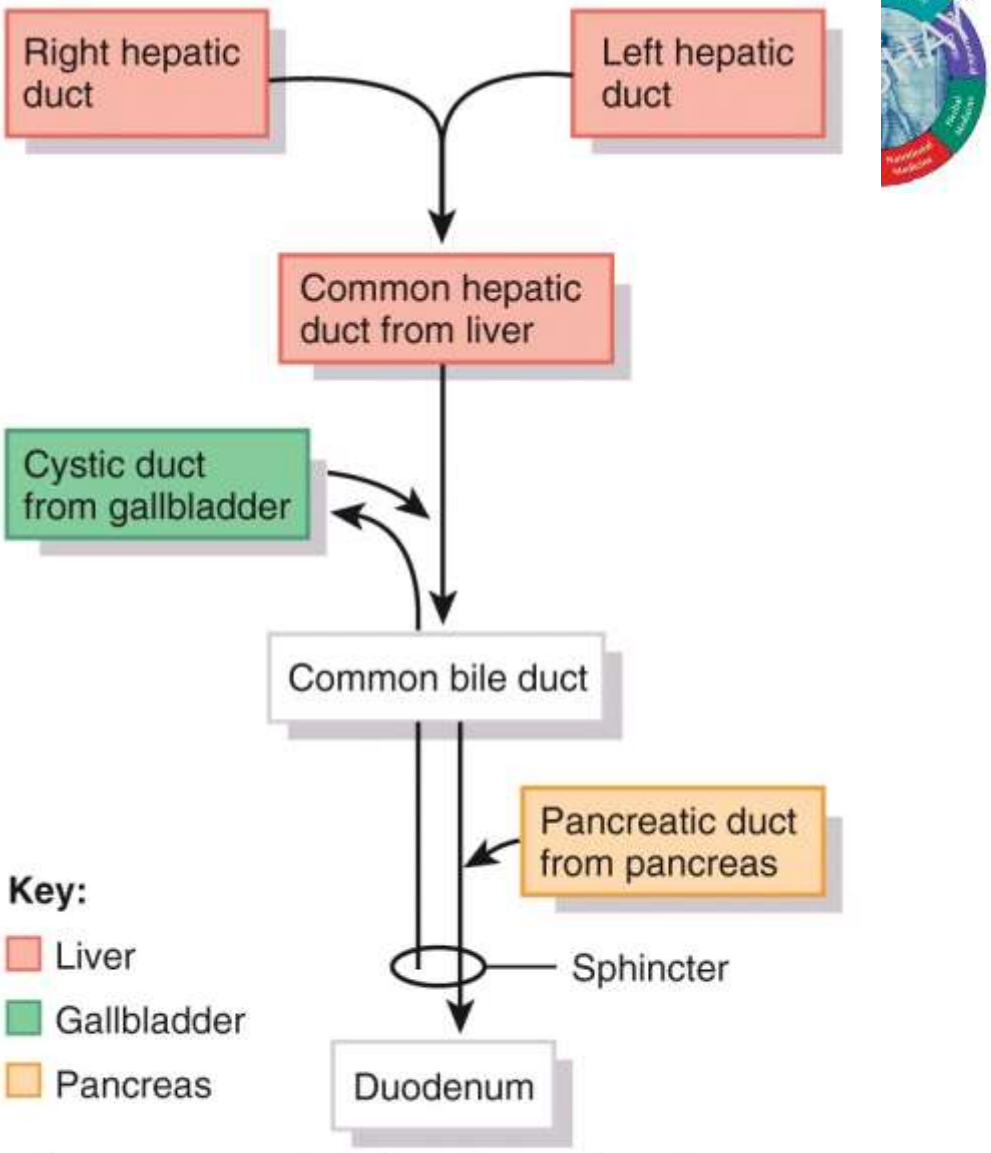
# Relationship of the Pancreas to the Liver, Gallbladder, and Duodenum




(c) Ducts carrying bile from liver and gallbladder and pancreatic juice from pancreas to the duodenum

R. F

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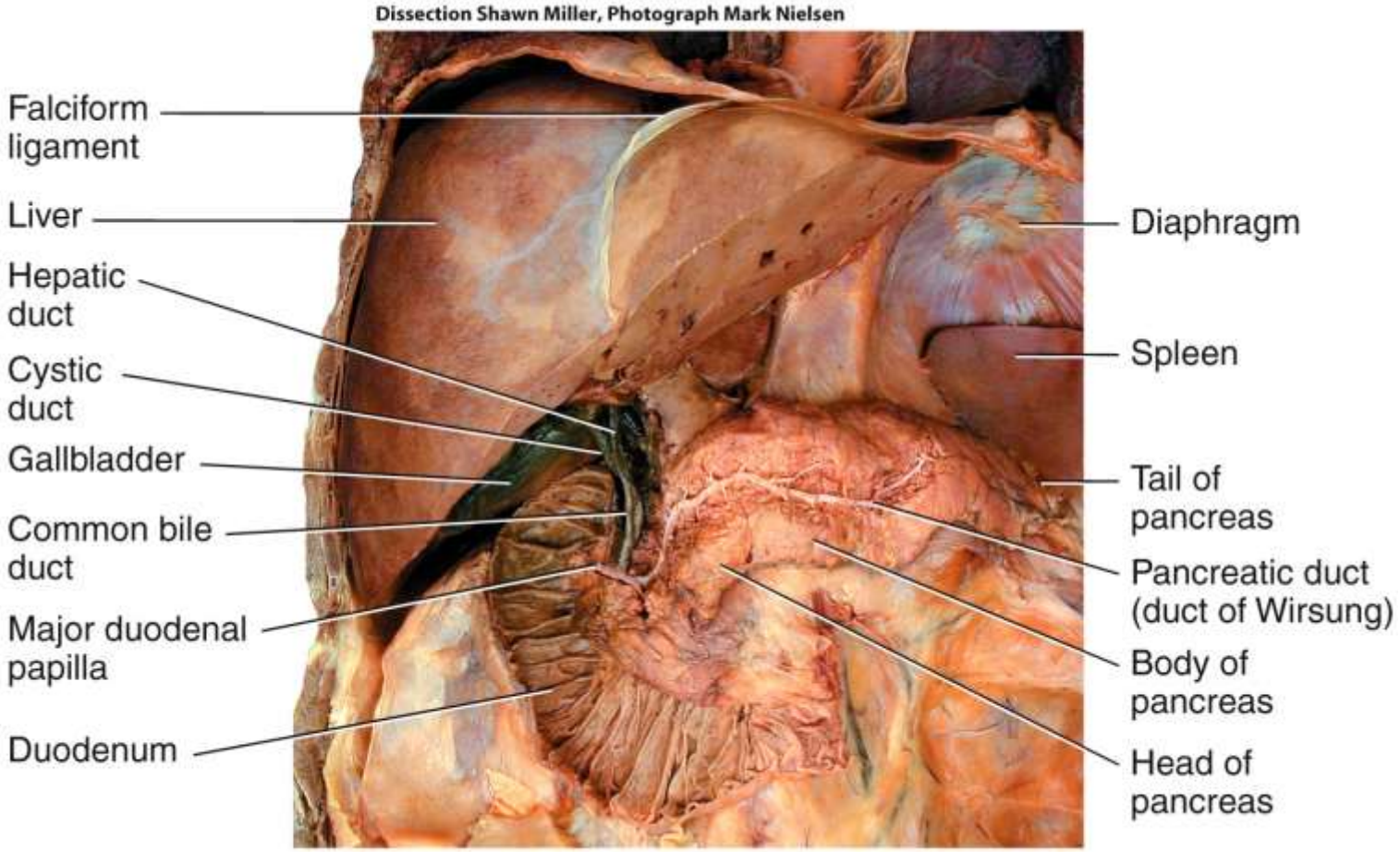
# Relationship of the Pancreas to the Liver, Gallbladder, and Duodenum




(d) Anterior view

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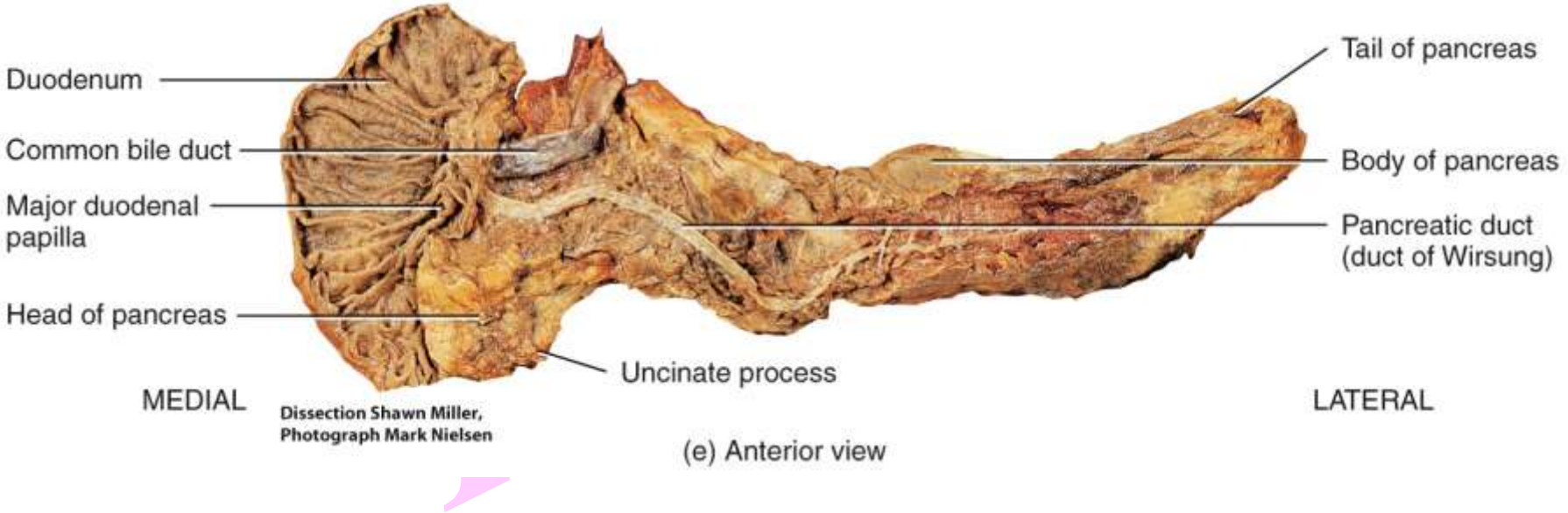
# Relationship of the Pancreas to the Liver, Gallbladder, and Duodenum

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# Histology of the Pancreas

- Acini – cluster of cells
- Pancreatic juice
- Pancreatic islets (islets of Langerhans)

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# Functions of the Pancreas

- Pancreatic amylase (digests starch)
- Enzymes that digest protein
  - Trypsin
  - Chymotrypsin
  - Carboxypeptidase
  - Elastase
- Principle triglyceride-digesting enzymes in adults:
  - Pancreatic lipase
  - RNA- and DNA-digesting enzymes called ribonuclease and deoxyribonuclease

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# Functions of the Pancreas

- **Islets of Langerhans**
  - **Alpha cells** or **α-cells:** They make up to 20% of the human islet cells synthesizing and secreting the peptide hormone glucagon, which elevates the glucose levels in the blood.
  - **Beta cells:** they constitute the predominant type of cell. The beta cells make and release insulin, a hormone that controls the level of glucose (sugar) in the blood.
  - **Delta cells, δ-cells or D cells :** are somatostatin-producing cells. They can be found in the stomach, intestine and the pancreatic islets, it serves to block the secretion of both insulin and glucagon from adjacent cells. Insulin, glucagon, and somatostatin act in concert to control the flow of nutrients into and out of the circulation.
  - **F cells, Pancreatic polypeptide cells (PP cells):** or formerly as gamma cells, or F cells, are cells which produce pancreatic polypeptides in the pancreatic islets (Islets of Langerhans) of the pancreas. They are very few in number and are polygonal in shape

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# Anatomy of the Liver and Gallbladder

- Liver
  - Divided into two lobes by the falciform ligament
  - Quadrate and caudate lobes
  - Ligamentum teres (round ligament)
  - Coronary ligaments
- Gallbladder
  - Fundus
  - Body
  - Neck

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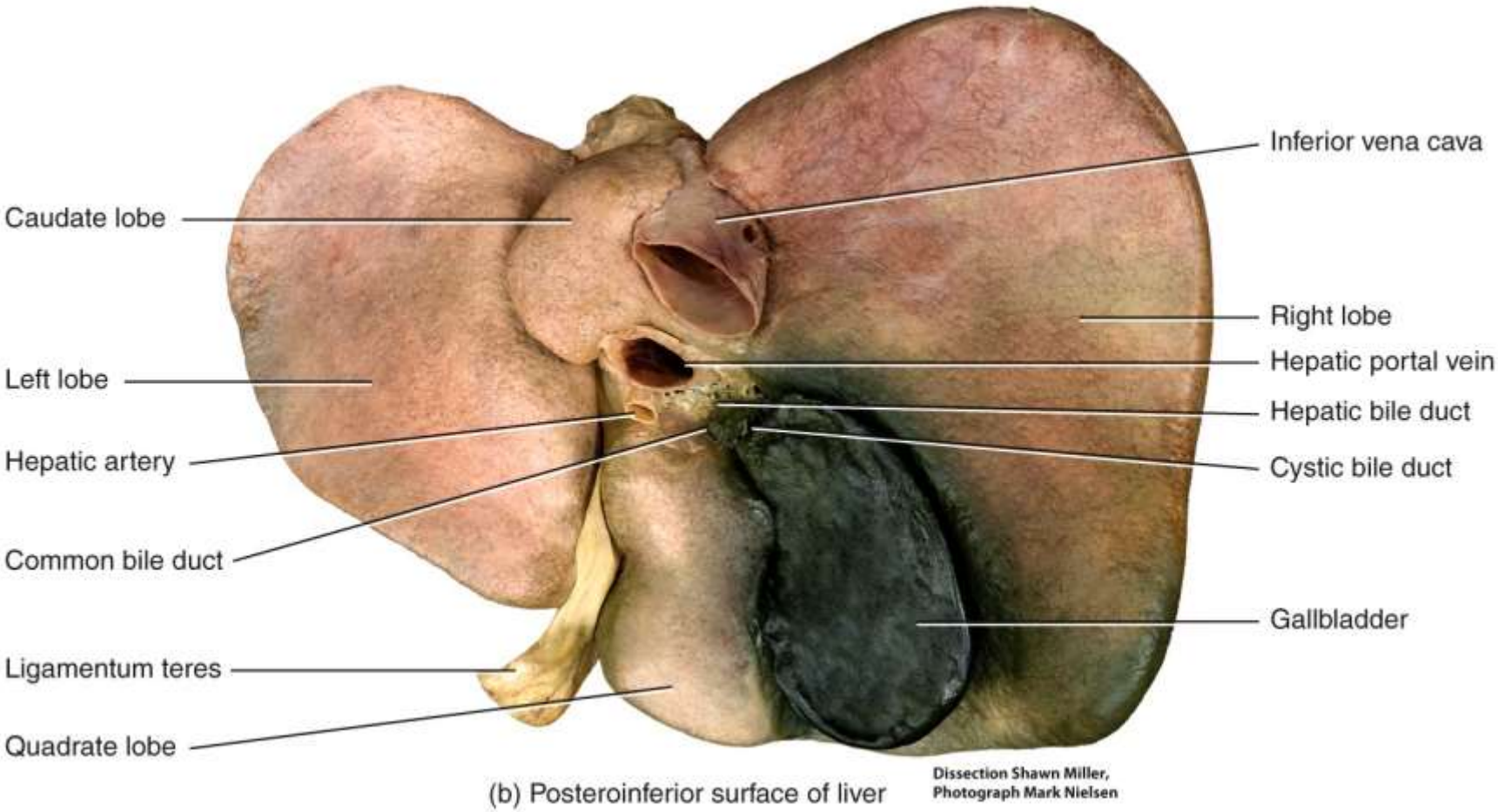
# External Anatomy of the Liver

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# Histology of the Liver and Gallbladder

- Liver
  - Hepatocytes
    - Hepatic laminae
  - Bile canaliculi
    - Bile ductules and bile ducts
    - Right and left hepatic ducts
    - Common hepatic duct
    - Cystic duct
    - Common bile duct
  - Hepatic sinusoids
    - Central vein
    - Hepatic veins

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# Histology of the Liver and Gallbladder

- Portal triad
- Hepatocytes, bile duct system, and hepatic sinusoids can be organized into anatomical and functional units in three different ways:
  - Hepatic lobule
  - Portal lobule
  - Hepatic acinus

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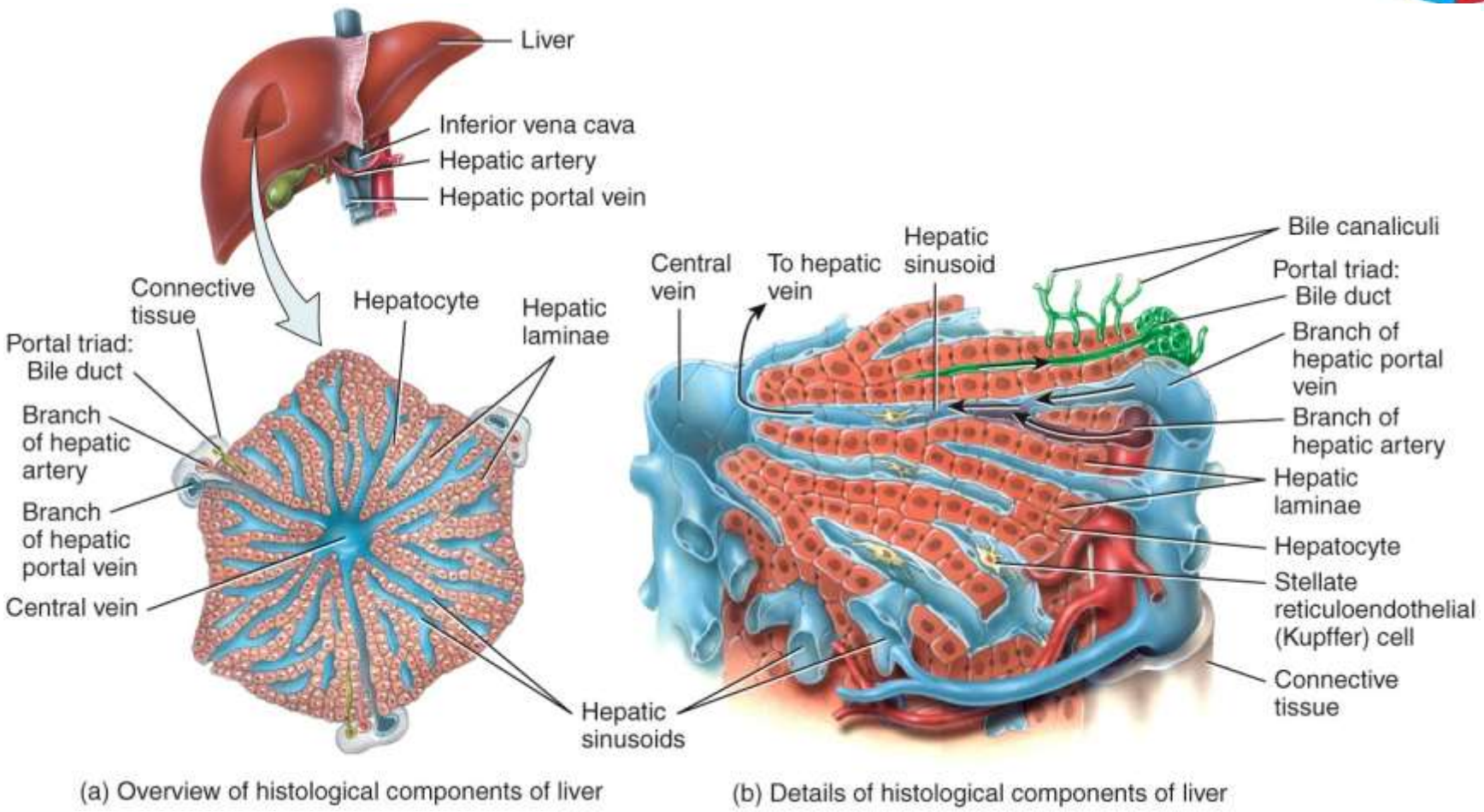
# Histology of the Liver

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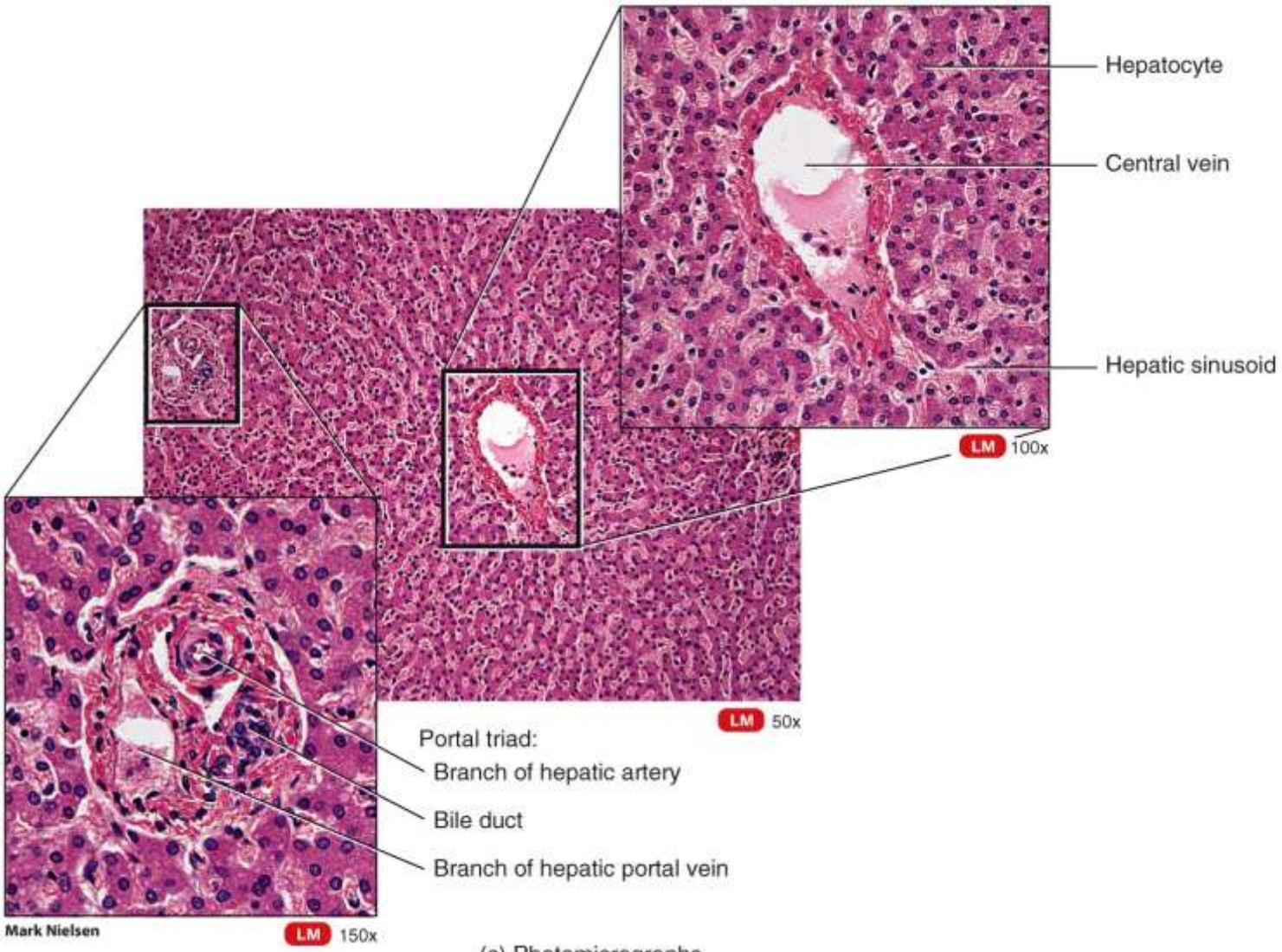
# Histology of the Liver




(c) Photomicrographs

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# Clinical Connection

- **Hepatitis:** refers to an inflammatory condition of the liver. It's commonly caused by a viral infection, but there are other possible causes of hepatitis. These include autoimmune hepatitis and hepatitis that occurs as a secondary result of medications, drugs, toxins, and alcohol.

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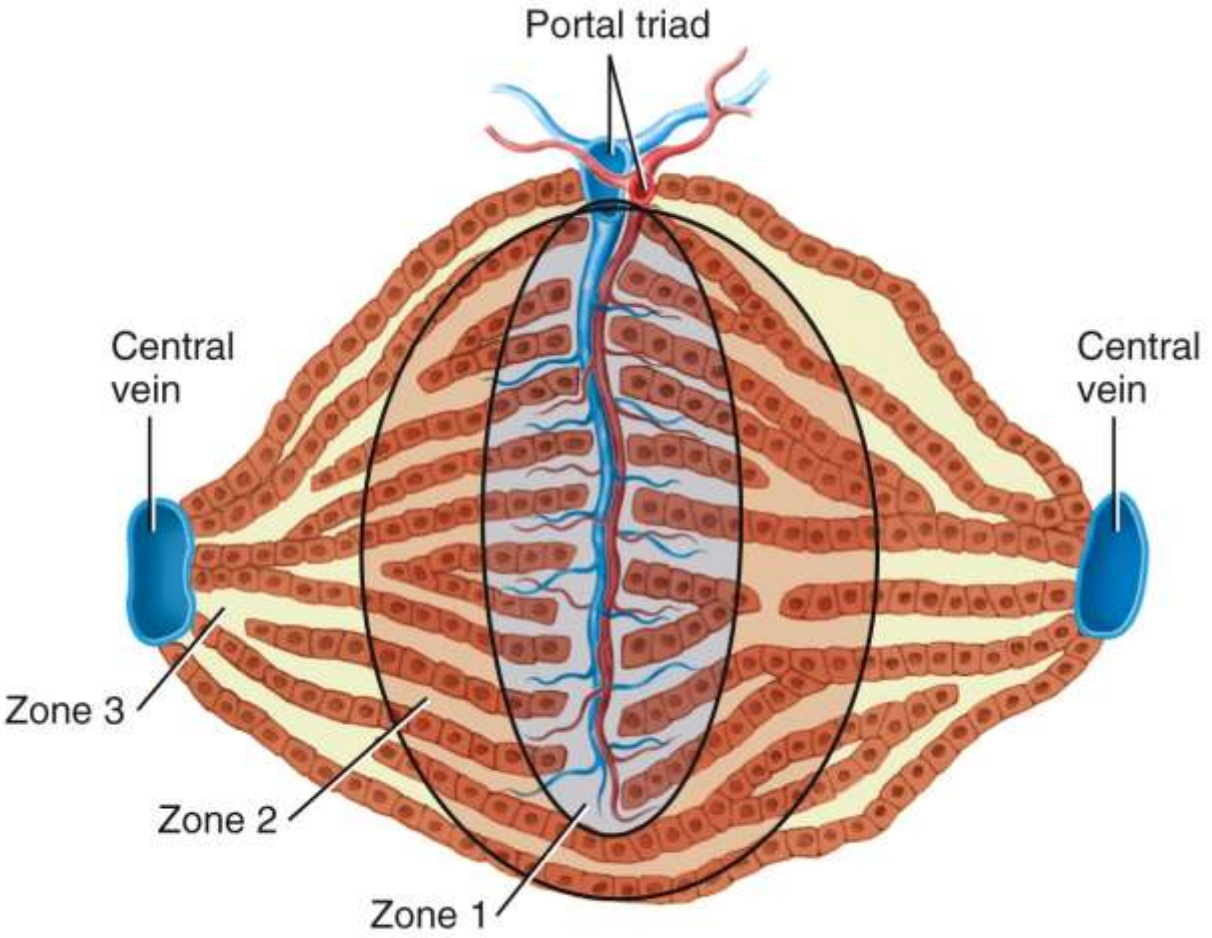
# Histology of the Liver




(e) Details of hepatic acinus

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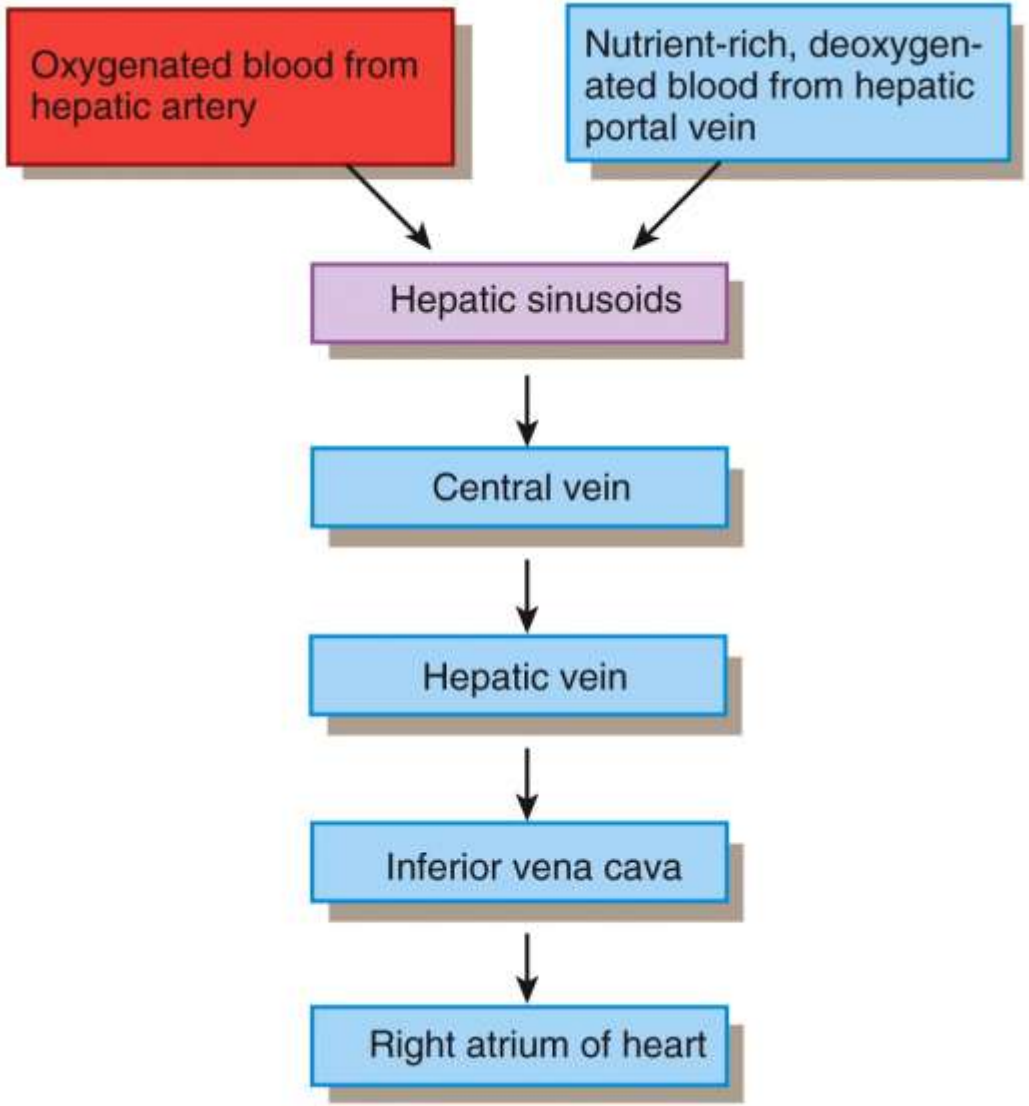
# Hepatic Blood Flow: Sources, Path Through the Liver, and Return to the Heart

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# Clinical Connection

- **Liver function tests:** also referred to as a hepatic panel, are groups of blood tests that provide information about the state of a patient's liver.
- The ALT and AST tests measure enzymes that your liver releases in response to damage or disease.
- The albumin test measures how well the liver creates albumin,
- While the bilirubin test measures how well it disposes of bilirubin.
- ALP (Alkaline phosphatase) can be used to evaluate the bile duct system of the liver.

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# Functions of the Liver and Gallbladder

- **Emulsification:** is a process in which large lipid globules are broken down into several small lipid globules. Emulsification is important for the digestion of lipids because lipases can only efficiently act on the lipids when they are broken into small aggregates
- **Absorption:**
- **Bile storage:**
  - Sphincter of the hepatopancreatic ampulla
- **Carbohydrate metabolism:** is a fundamental biochemical process that ensures a constant supply of energy to living cells. The most important carbohydrate is glucose, which can be broken down via glycolysis, enter into the Kreb's cycle and oxidative phosphorylation to generate ATP.
- **Lipid metabolism:** is the synthesis and degradation of lipids in cells, involving the breakdown or storage of fats for energy and the synthesis of structural and functional lipids, such as those involved in the construction of cell membranes.
- **Protein metabolism:** denotes the various biochemical processes responsible for the synthesis of proteins and amino acids (anabolism), and the breakdown of proteins by catabolism

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# Functions of the Liver and Gallbladder (continued)

- Processing of drugs and hormones
- Excretion of bilirubin
- Synthesis of bile salts
- Storage
- Phagocytosis
- Activation of vitamin D

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# Clinical Connection

- **Gallstones:** are hardened deposits of bile that can form in your gallbladder.
- The stones form when the amount of cholesterol or bilirubin in the bile is high. ... Pigment stones form most often in people with liver disease or blood disease, who have high levels of bilirubin.

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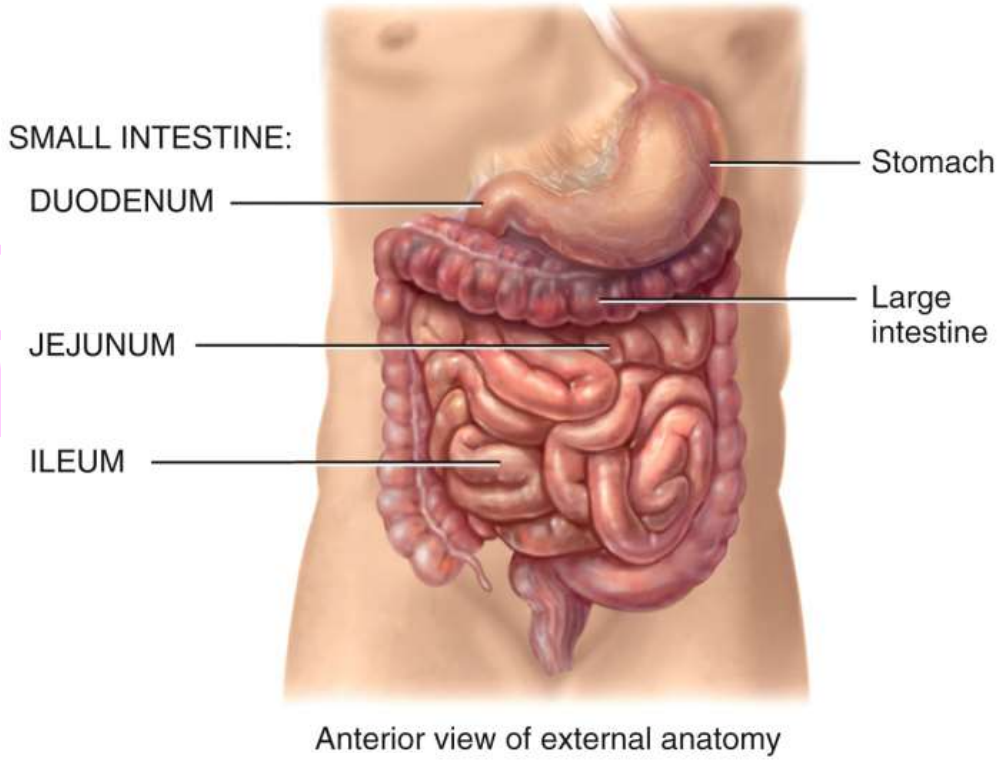
# Anatomy of the Small Intestine

- Three regions of the small intestine:
  - Duodenum
  - Jejunum
  - Ileum
- Ileocecal sphincter (valve)



Anterior view of external anatomy

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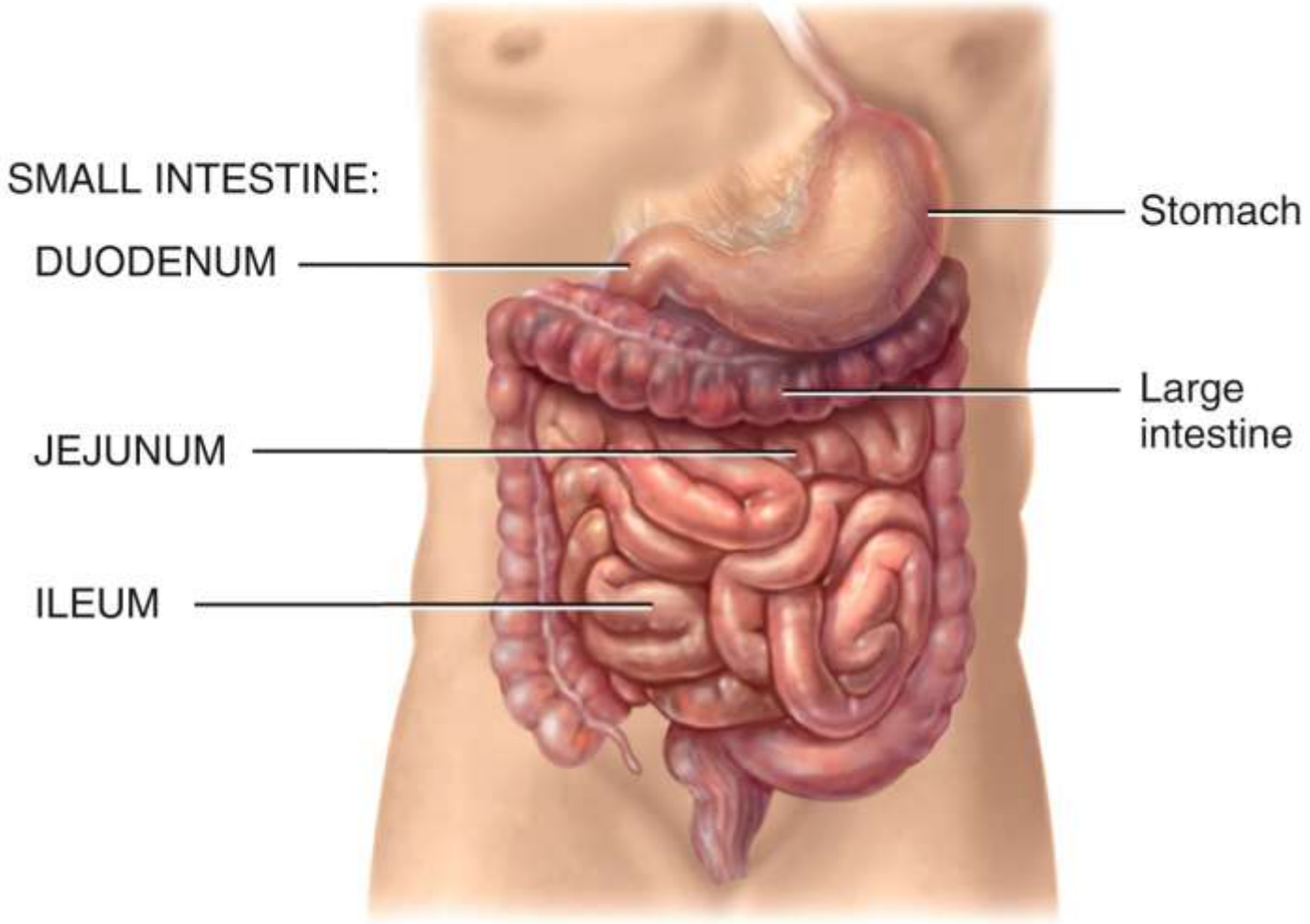
# Regions of the Small Intestine




Anterior view of external anatomy

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# Histology of the Small Intestine

- Mucosa is composed of a layer of epithelium, lamina propria, and muscularis mucosae.
- Absorptive cells of the epithelium digest and absorb nutrients in small intestine.
- Goblet cells secrete mucus.
- Small intestinal mucosa contains many deep crevices lined with glandular epithelium.
- Intestinal glands (crypts of Lieberkühn) secrete intestinal juice.
- Paneth cells secrete lysozyme.

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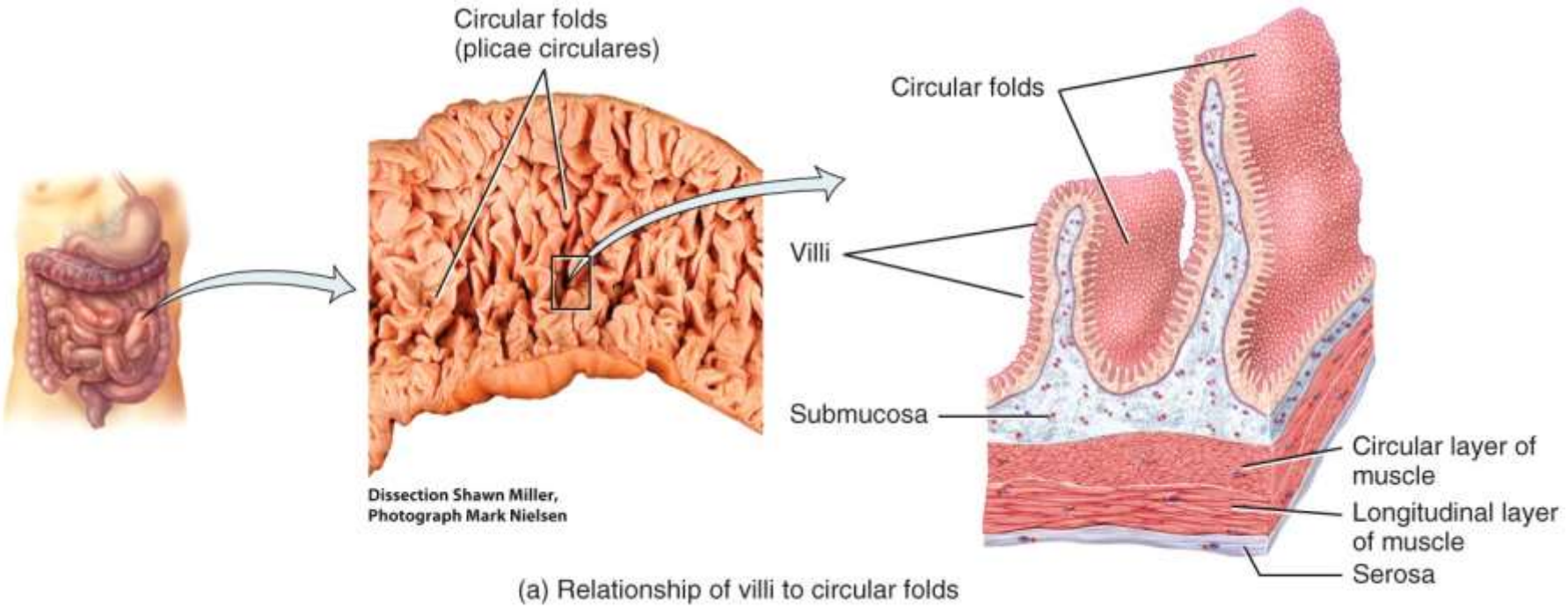
# Histology of the Small Intestine




(a) Relationship of villi to circular folds

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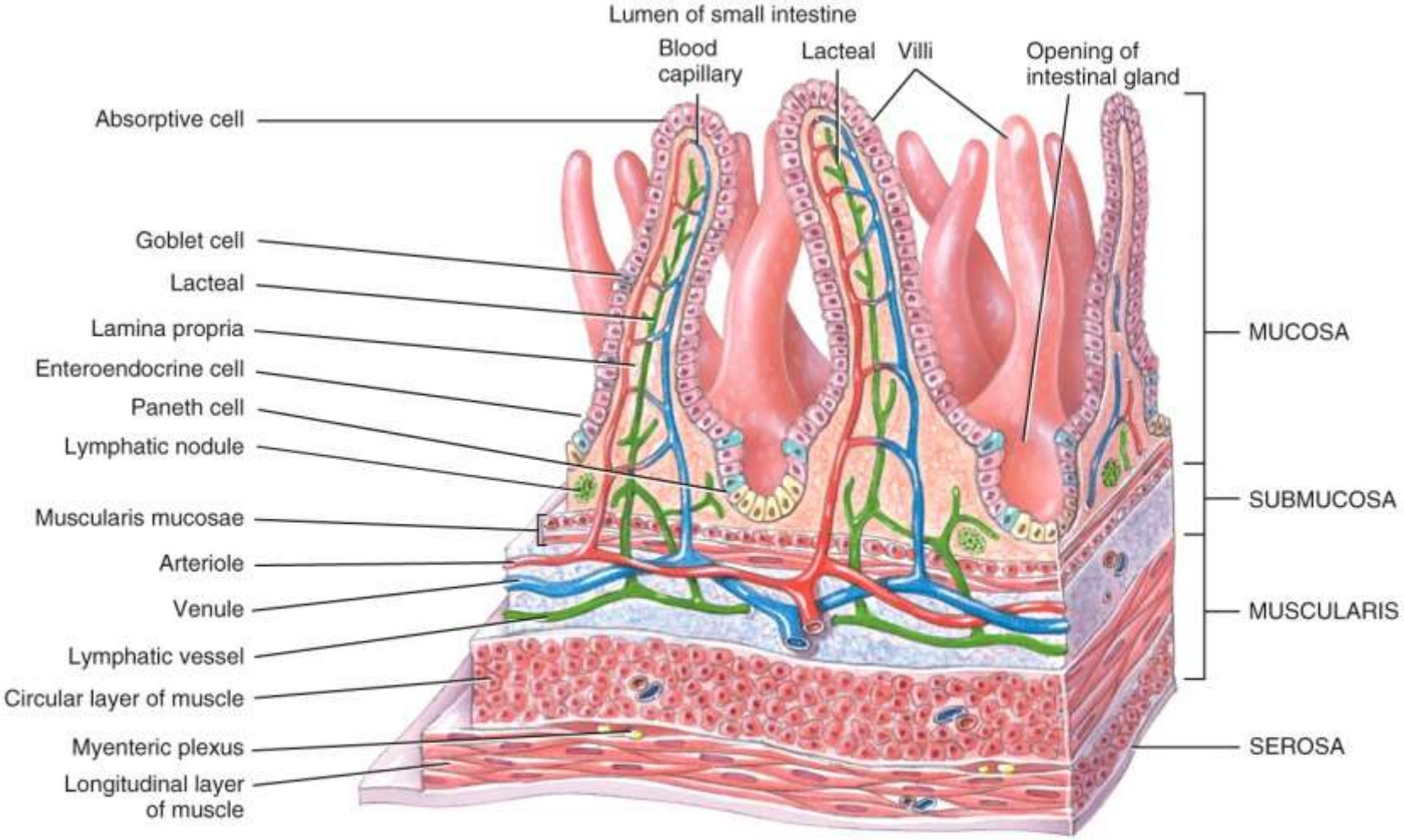
# Histology of the Small Intestine




(b) Three-dimensional view of layers of the small intestine showing villi

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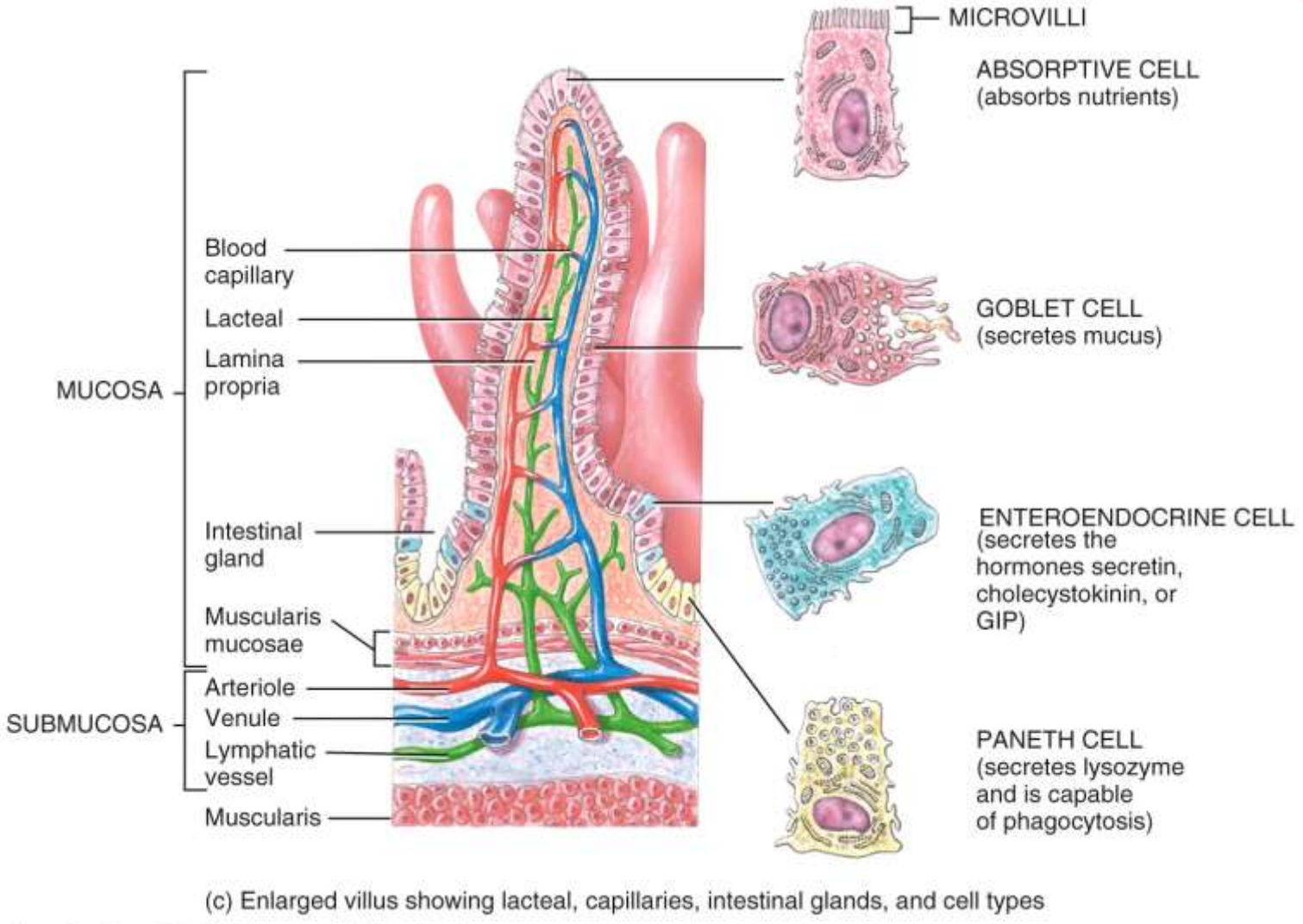
# Histology of the Small Intestine




(c) Enlarged villus showing lacteal, capillaries, intestinal glands, and cell types

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# Histology of the Small Intestine

- Three types of enteroendocrine cells are found in the intestinal glands of the small intestine:
  - S cells
  - CCK cells
  - K cells
- Groups of lymphatic nodules referred to as aggregated lymphatic follicles (Peyer's patches) are present in the ileum.
- The submucosa of the duodenum contains duodenal (Brunner's) glands.

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# Histology of the Small Intestine

- **S cells:** which release secretin, found in the jejunum and duodenum. They are stimulated by a drop in pH to 4 or below in the small intestine's lumen.
- Secretin helps *regulate the pH* of the duodenum by (1) inhibiting the secretion of gastric acid from the parietal cells of the stomach and (2) stimulating the production of bicarbonate from the ductal cells of the pancreas.
- **CCK cells:** Cholecystokinin, officially called pancreozymin, is synthesized and secreted by enteroendocrine cells in the duodenum, Its presence causes the *release of digestive enzymes* and bile from the pancreas and gallbladder, respectively, and also acts as a hunger suppressant.
- **K cells:** which are found in the mucosa of the duodenum and the jejunum of the gastrointestinal tract, Secrete Gastric inhibitory polypeptide (GIP), or gastric inhibitory peptide, also known as glucose-dependent insulinotropic polypeptide (also abbreviated as GIP), is an inhibiting hormone of the secretin family of hormones. While it is weak inhibitor of gastric acid secretion, its main role is to stimulate insulin secretion.

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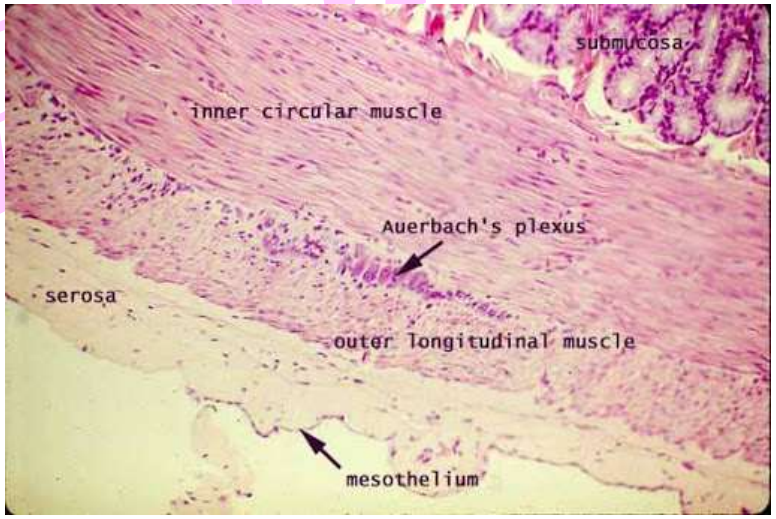
# Histology of the Small Intestine

- Muscularis of the small intestine consists of two layers of smooth muscle:
  - Outer, thinner layer of longitudinal fibers
  - Inner, thicker layer of circular fibers

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# Functions of the Small Intestine

- The completion of the digestion occurs in the small intestine.
- Intestinal juice
- Brush-border enzymes:
  - $\alpha$-dextrinase, maltase, sucrase, and lactase
  - Peptidases (aminopeptidase and dipeptidase)
  - Nucleosidases and phosphatases
- Segmentations

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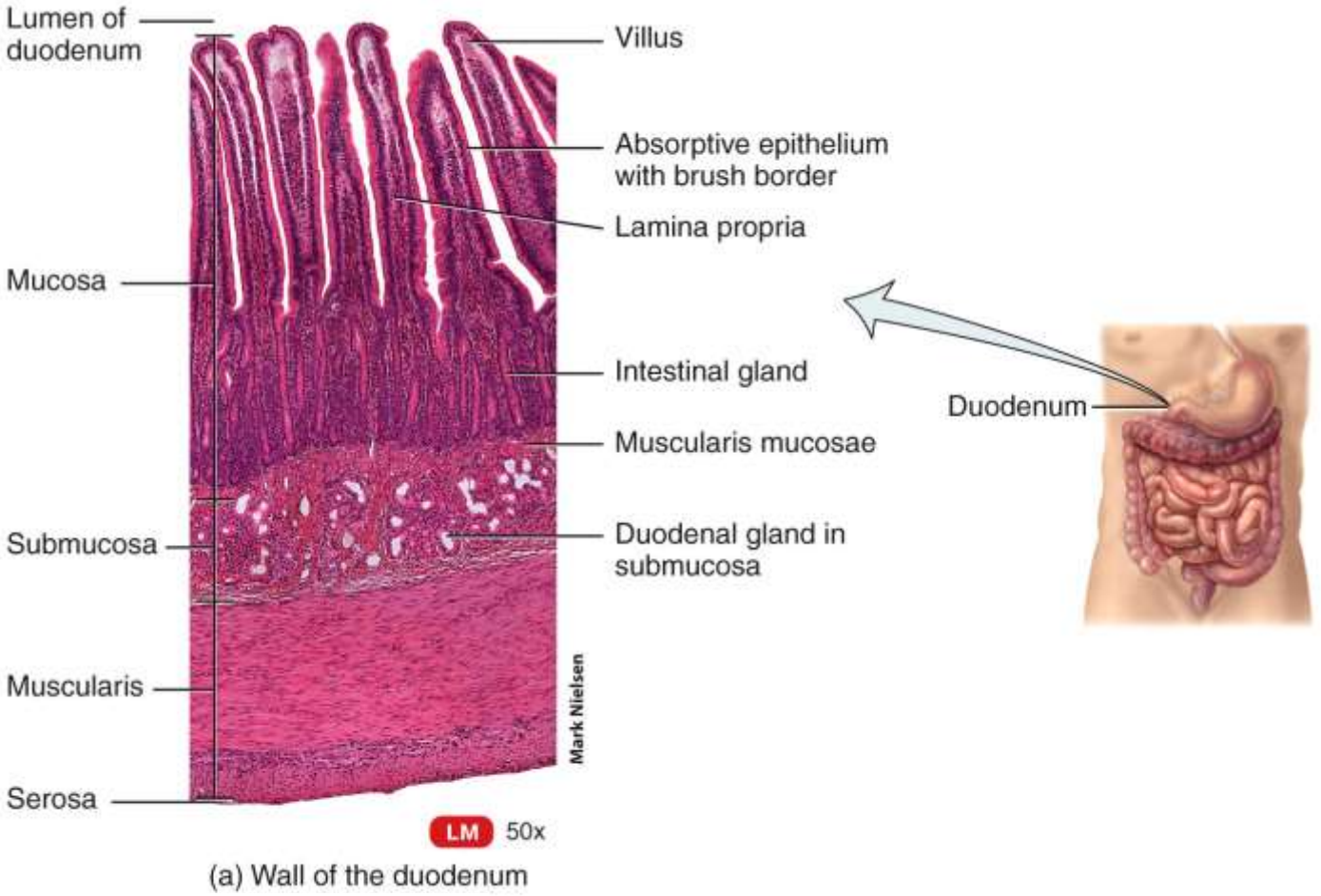
# Histology of the Duodenum and Ileum




(a) Wall of the duodenum

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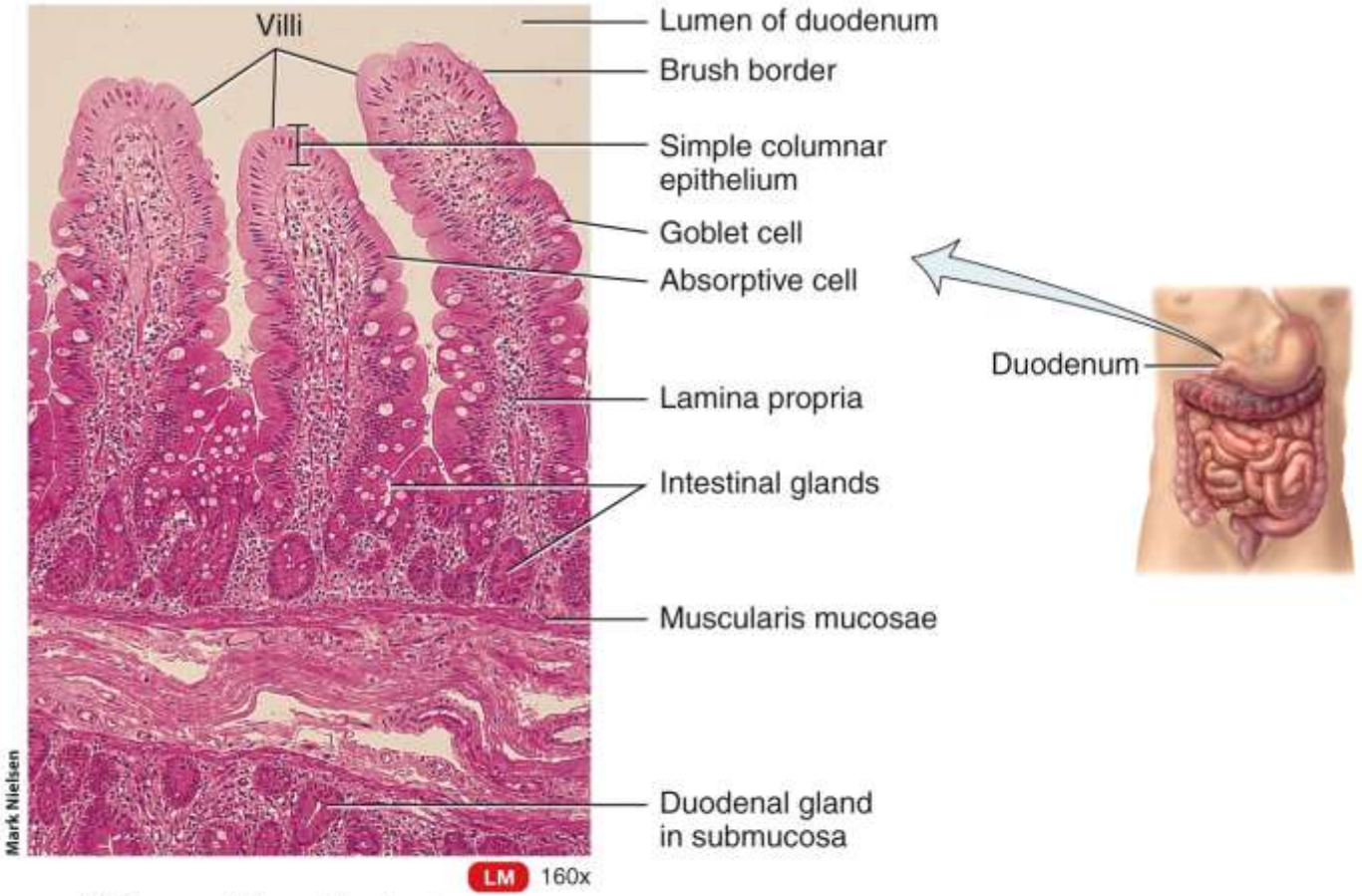
# Histology of the Duodenum and Ileum




(b) Three villi from the duodenum

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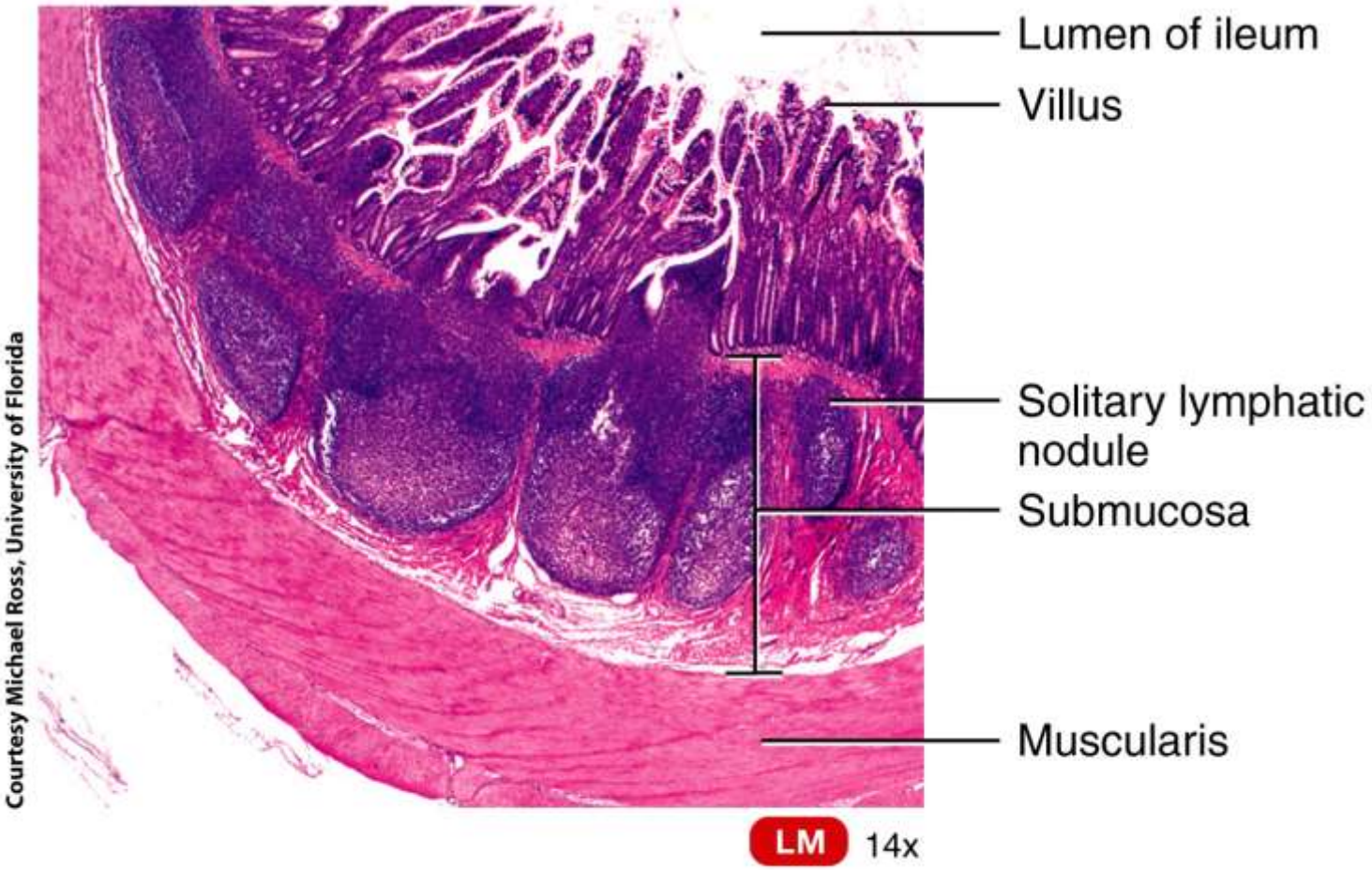
# Histology of the Duodenum and Ileum




(c) Lymphatic nodules in ileum

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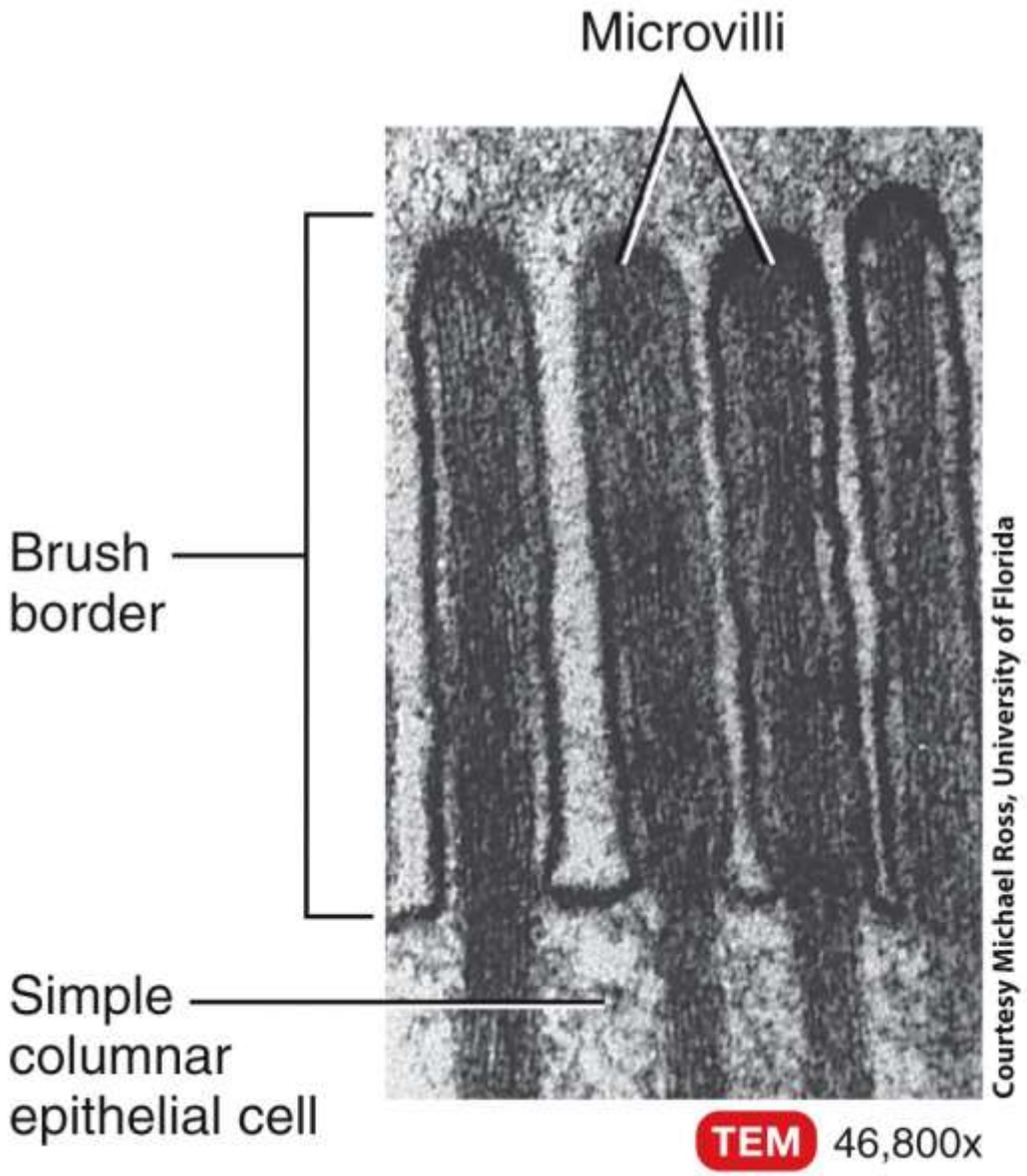
# Histology of the Duodenum and Ileum




(d) Several microvilli from duodenum

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# Clinical Connection

- **Lactose intolerance:** is when a person has symptoms due to a decreased ability to digest lactose, a sugar found in dairy products. Those affected vary in the amount of lactose they can tolerate before symptoms develop. Symptoms may include abdominal pain, bloating, diarrhea, gas, and nausea.

R. Bish

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# Clinical Connection

- **Peptic ulcer disease:** is a condition in which there are painful sores or ulcers in the lining of the stomach or the first part of the small intestine (the duodenum). Normally, a thick layer of mucus protects the stomach lining from the effect of its digestive juices.
- In TCM: peptic ulcer is stomach fire

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# Clinical Connection

- **Bariatric surgery:** Surgery on the stomach and/or intestines to help a person with extreme obesity lose weight. Bariatric surgery is an option for people who have a body mass index (BMI) above 40. ... An example of restrictive surgery is adjustable gastric banding also called lap band surgery .

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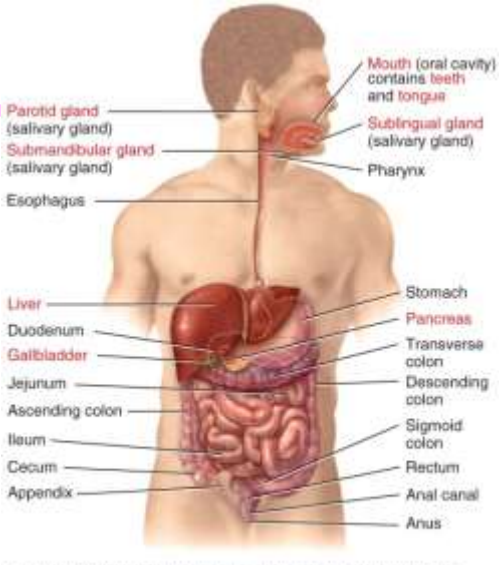
# Anatomy of the Large Intestine

- Extends from the ileum to the anus
- Mesocolon
- Four principal regions of the large intestine:
  - Cecum
  - Colon
  - Rectum
  - Canal

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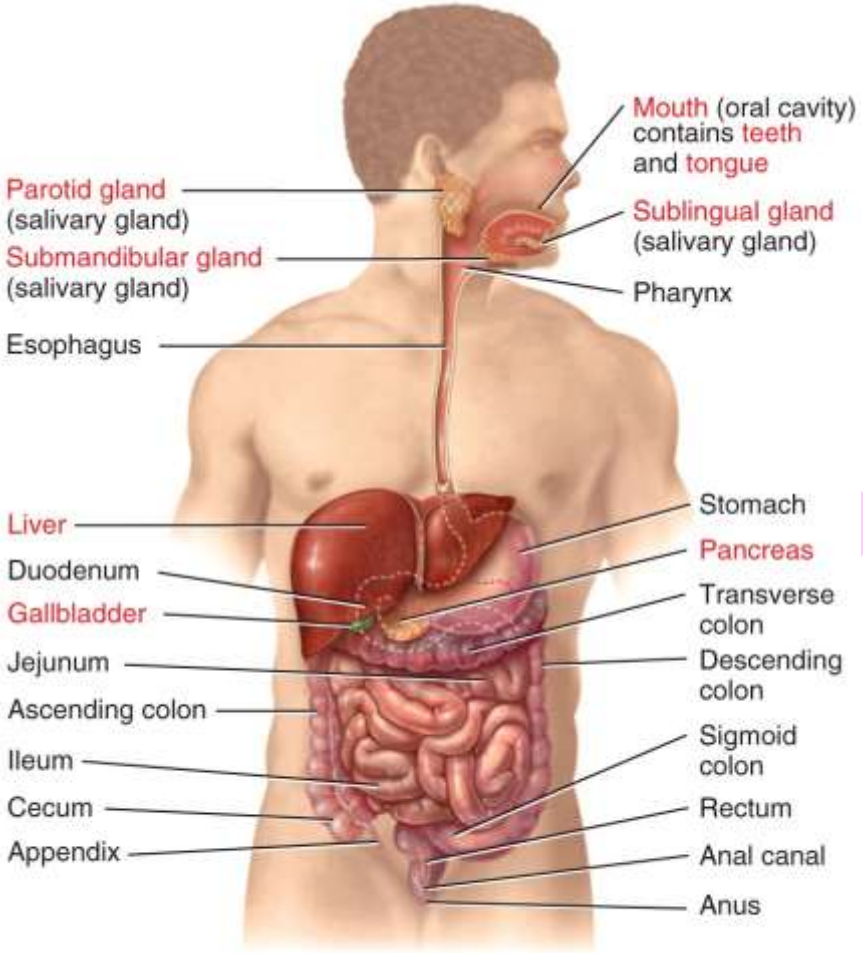
# Organs of the Digestive System




(a) Right lateral view of head and neck and anterior view of trunk

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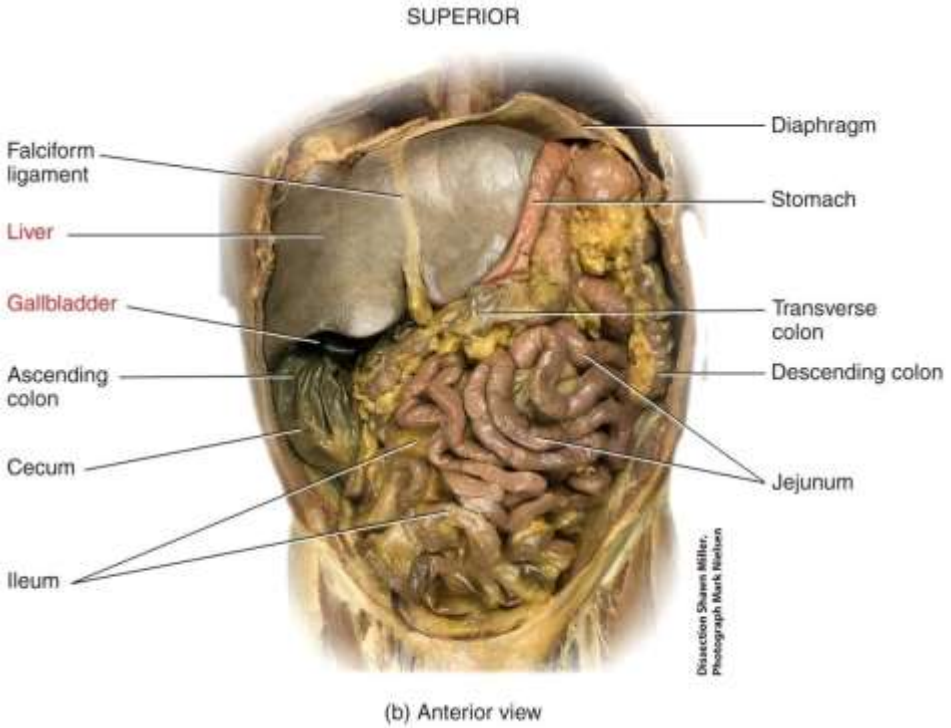


(b) Anterior view

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# Anatomy of the Large Intestine

- Ileocecal sphincter
- Cecum
- Appendix or vermiform appendix
- Mesoappendix

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# Histology of the Large Intestine

- The wall of the intestine contains the typical four layers found in the rest of the GI tract:
  - Mucosa
  - Submucosa
  - Muscularis
  - Serosa
- Intestinal glands (crypts of Lieberkühn): mainly secrete mucus
- Teniae coli: (also **teniae coli** or **tenia coli**) are three separate longitudinal ribbons (taeniae meaning ribbon in latin) of smooth muscle on the outside of the ascending, transverse, descending and sigmoid colons. They are visible and can be seen just below the serosa or fibrosa
- Haustra: refer to the small segmented pouches of bowel separated by the **haustral** folds. They are formed by circumferential contraction of the inner muscular layer of the colon. The outer longitudinal muscular layer is organized into three bands (taeniae coli) which run from the cecum to the rectum.

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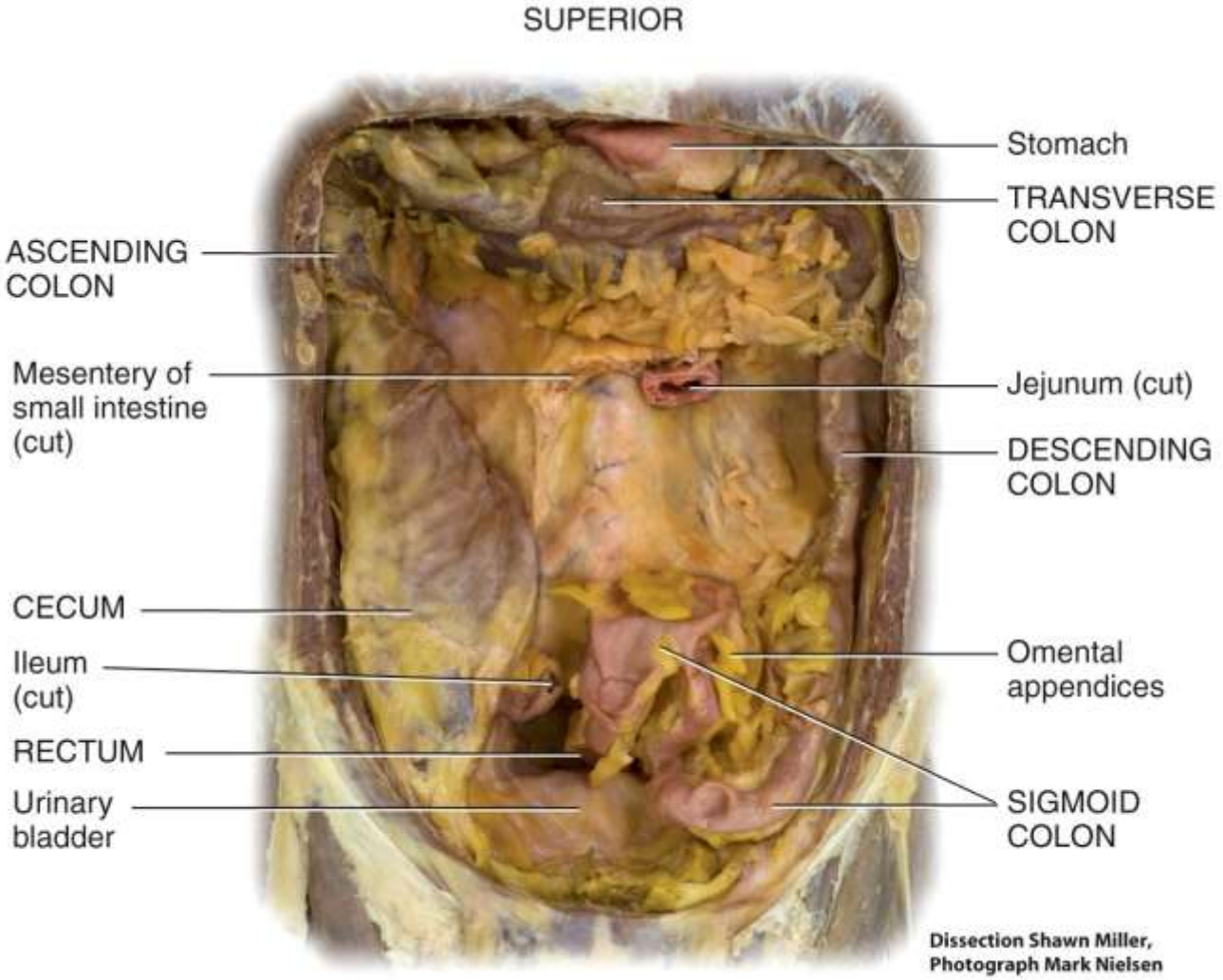
# Anatomy of the Large Intestine




(c) Anterior view

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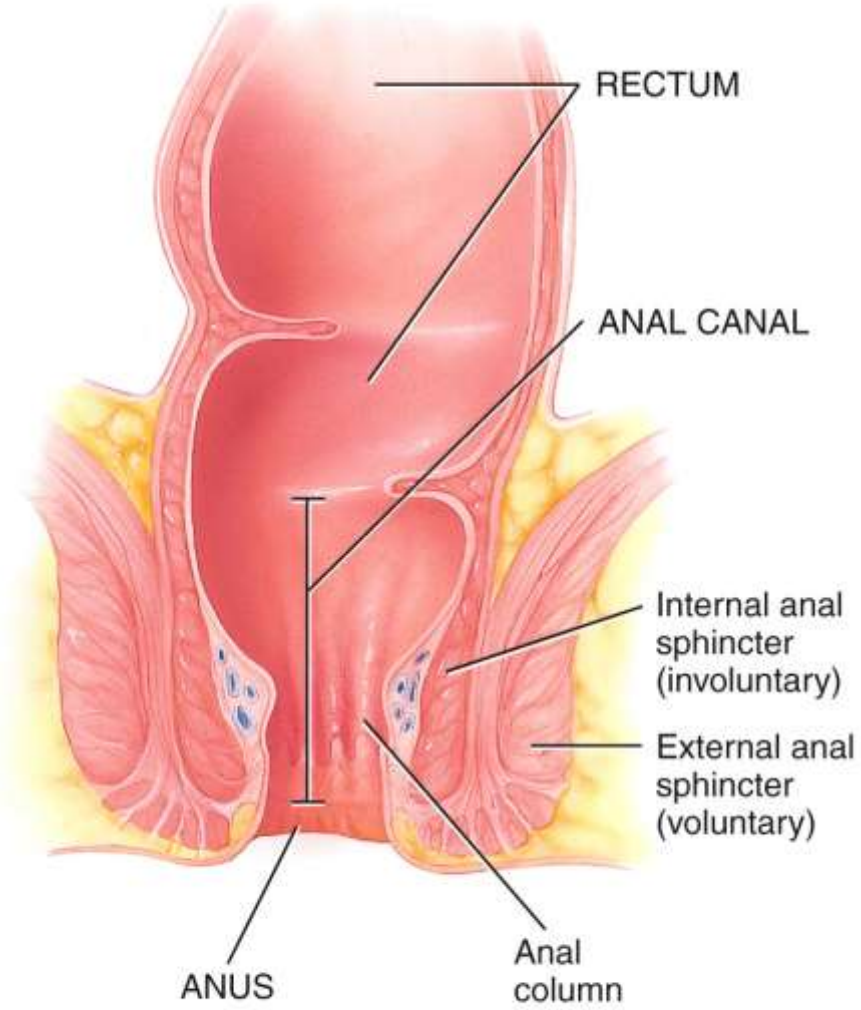
# Anatomy of the Large Intestine




(b) Frontal section of anal canal

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# Clinical Connection

- **Colonoscopy:** is an exam used to detect changes or abnormalities in the large intestine (colon) and rectum. During a colonoscopy, a long, flexible tube (colonoscope) is inserted into the rectum. A tiny video camera at the tip of the tube allows the doctor to view the inside of the entire colon.

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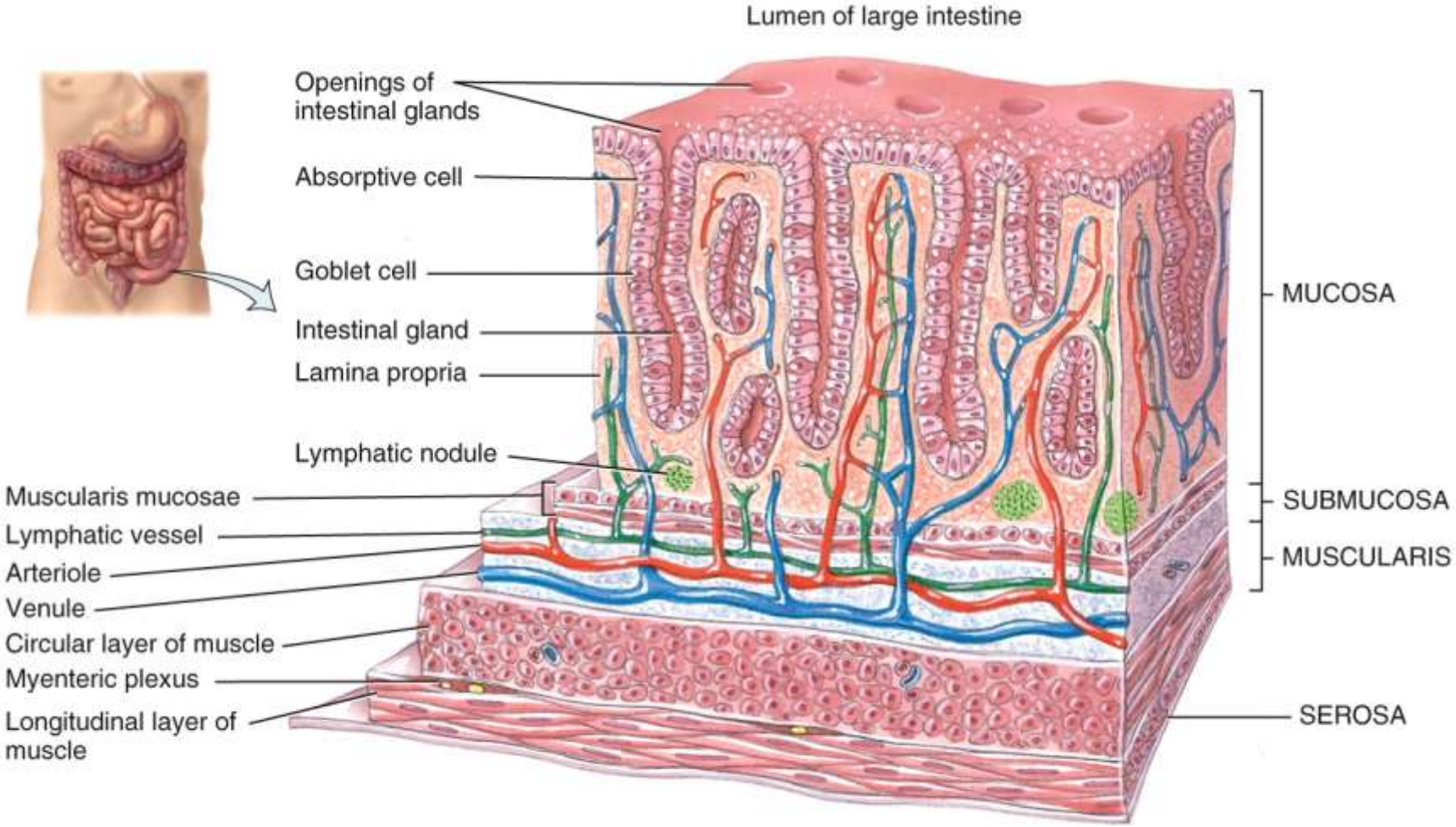
# Histology of the Large Intestine




(a) Three-dimensional view of layers of the large intestine

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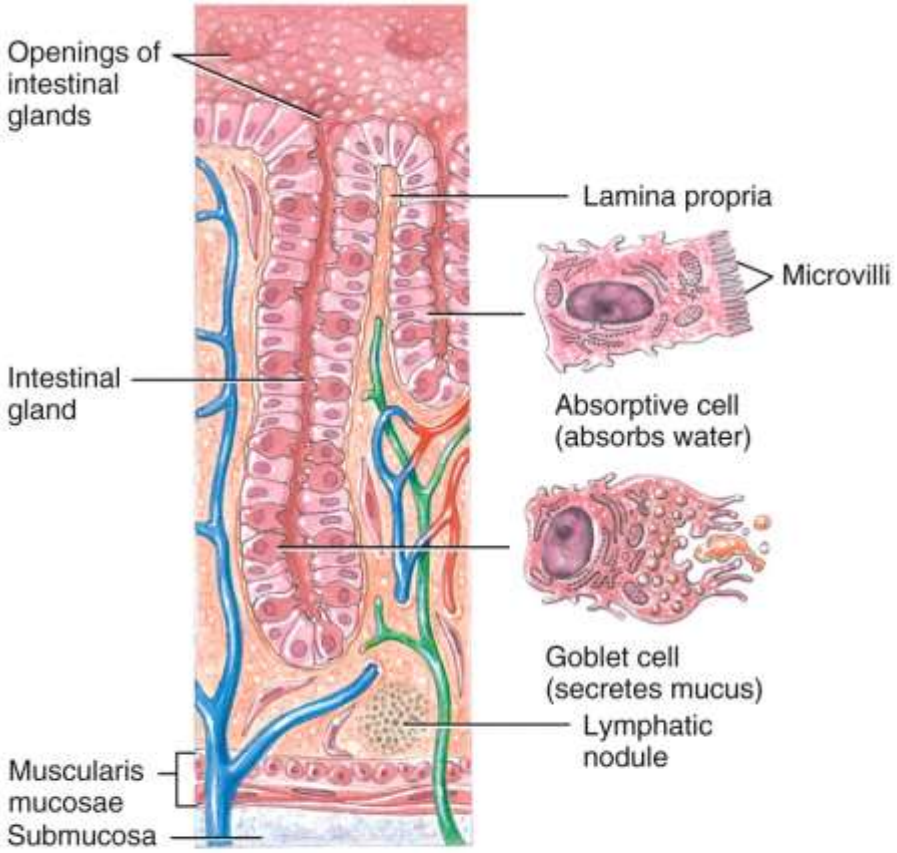
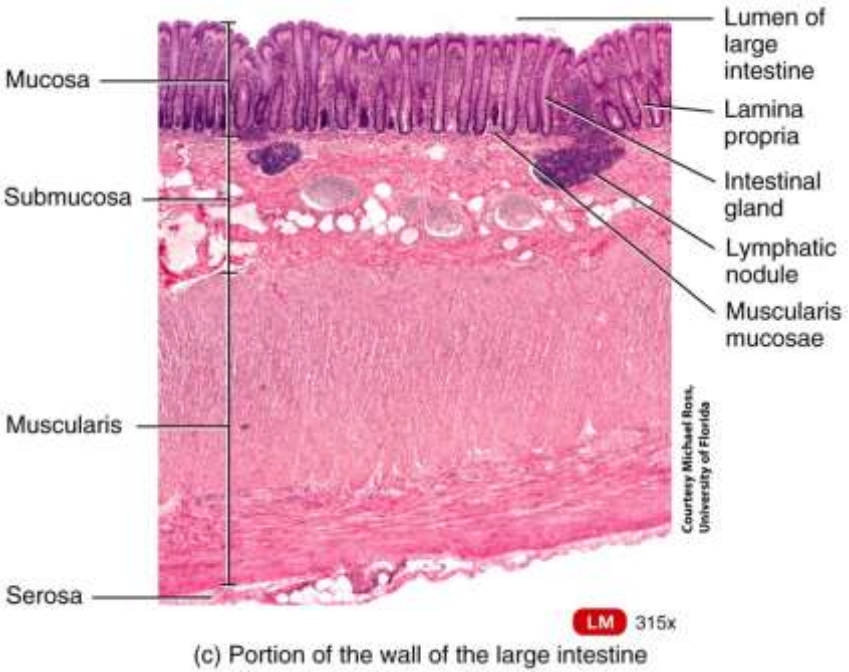
# Histology of the Large Intestine




(b) Sectional view of intestinal glands and cell types




(c) Portion of the wall of the large intestine

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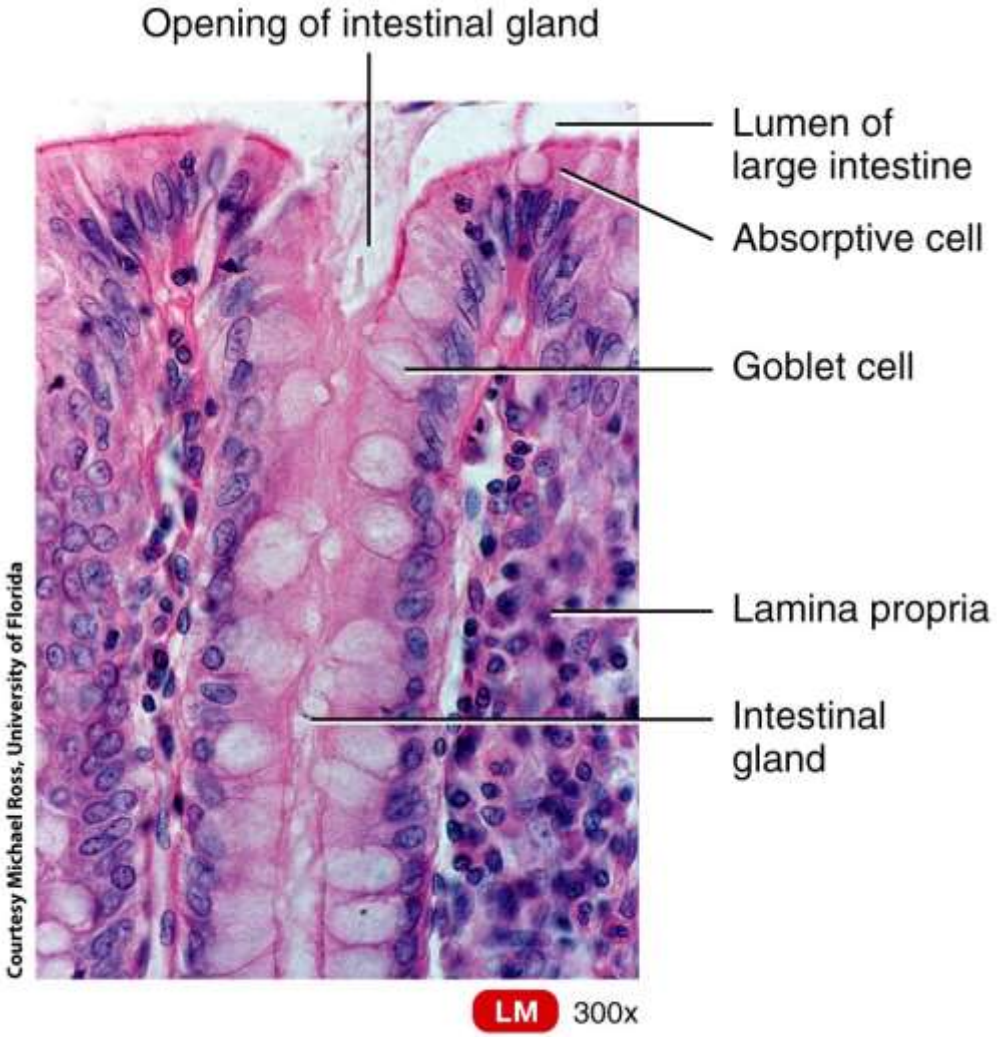
# Histology of the Large Intestine




(d) Details of mucosa of large intestine

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# Functions of the Large Intestine

- **Haustral churning:** is the movement through the large intestine. The haustra remains relaxed while filling. They become distended and the walls contract and push the contents into the next haustra
- **Peristalsis:** is a series of wave-like muscle contractions that moves food to different processing stations in the digestive tract. ... Peristalsis concludes in the large intestine where water from the undigested food material is absorbed into the bloodstream.
- **Mass peristalsis:** A brief, high-intensity peristaltic wave that moves bowel content through the lower gastrointestinal tract

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# Functions of the Large Intestine

- Final stage of digestion occurs in the colon.
  - **Mucus:** to liquify the contents of the large intestine
  - **Flatus:** gas in or from the stomach or intestines, produced by swallowing air or by bacterial fermentation and released through the rectum
  - **Bacteria:** We will be focusing on prokaryotic, as well as eukaryotic, organisms that reside in the large intestine. The bacteria that will be discussed include the following: Lactobacillus, Bifidobacterium, Methanogens, Sulfate reducing bacteria, Bacteroides, Enterococcus, Escherichia coli, and Clostridium.
  - The many bacteria that inhabit the large intestine can further digest some material, creating gas. Bacteria in the large intestine also make some important substances, such as vitamin K, which plays an important role in blood clotting.
  - **Stercobilin:** is a tetrapyrrolic bile pigment and is one end-product of heme catabolism. It is the chemical responsible for the brown color of human feces
  - **Feces:** (or faeces) are the solid or semisolid remains of food that could not be digested in small intestine. Bacteria in the large intestine further break down the material.

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# Clinical Connection

- **Diarrhea:** A common condition that involves unusually frequent and liquid bowel movements. Persistent diarrhea is both uncomfortable and dangerous to the health because it can indicate an underlying infection and may mean that the body is not able to absorb some nutrients due to a problem in the bowels
- *In TCM: diarrhea is spleen rebellious Qi*
- **Constipation:** refers to bowel movements that are infrequent or hard to pass. The stool is often hard and dry. Other symptoms may include abdominal pain, bloating, and feeling as if one has not completely passed the bowel movement. Complications from constipation may include hemorrhoids, anal fissure or fecal impaction.

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# Development of the Digestive System

- **Endoderm**
- Primitive gut
- Endodermal layer
- Mesodermal layer
- Foregut
- Midgut
- Hindgut

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