

# The Digestive System 2

# Learning Outcomes

- Identify the organs of the digestive system and their basic functions.
- Describe the four layers that form the wall of the gastrointestinal tract.
- Identify the locations of the salivary glands, and describe the functions of their secretions.
- Describe the location, structure, and functions of the pharynx and esophagus.
- Describe the location, structure, and functions of the stomach.
- Describe the location, structure, and functions of the pancreas.
- Describe the location, structure, and functions of the liver and gallbladder.

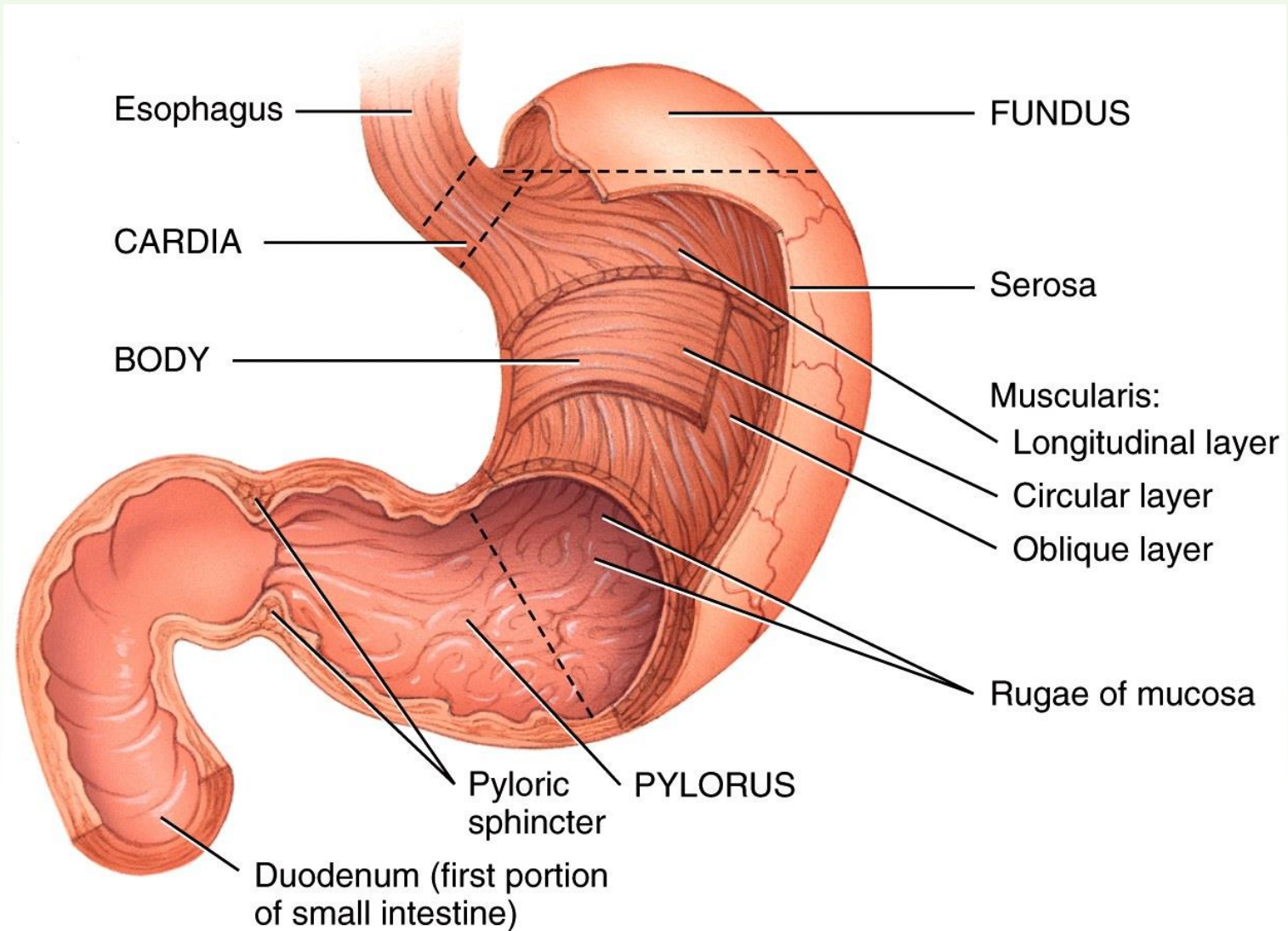
# Learning Outcomes

- Describe the location, structure, and functions of the small intestine.
- Describe the location, structure, and functions of the large intestine.
- Describe the three phases of digestion.
- Describe the major hormones that regulate digestive activities

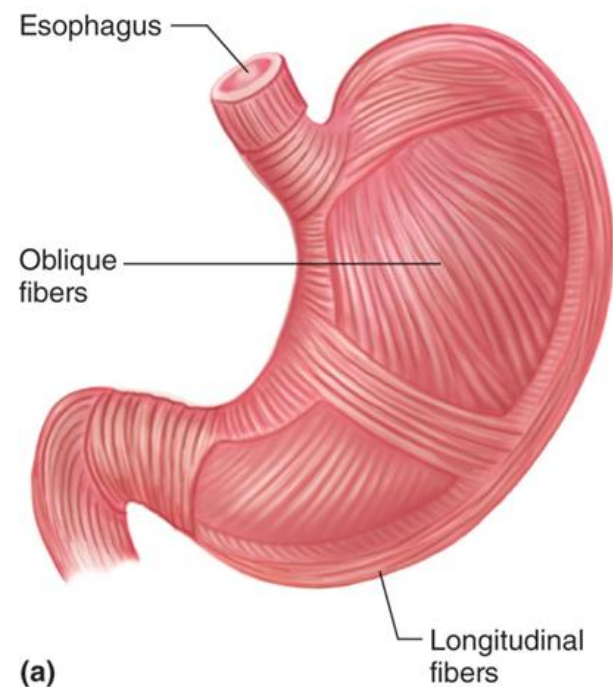
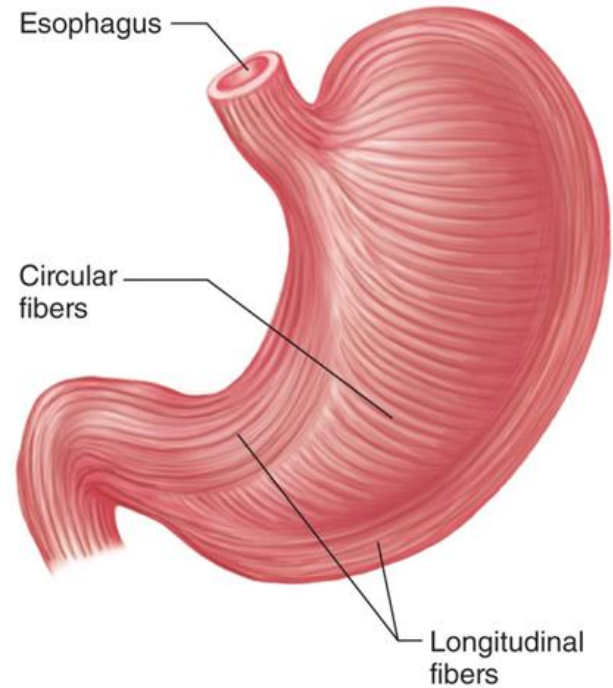
# Stomach

- J- shaped, expanded part of GI tract between esophagus and small intestine
- Act as a food blender and reservoir; converts a mass of food into a liquid mixture (chyme)
- Expandable and can hold up to 2 to 3 liters of food
- Four regions
  - Cardiac – surrounding the esophageal orifice
  - Fundus – dilated superior part and related to left dome of diaphragm
  - Body – large central portion
  - Pylorus – lower part leading to pyloric sphincter
- Has 2 sphincters
  - Esophageal sphincter
  - Pyloric sphincter

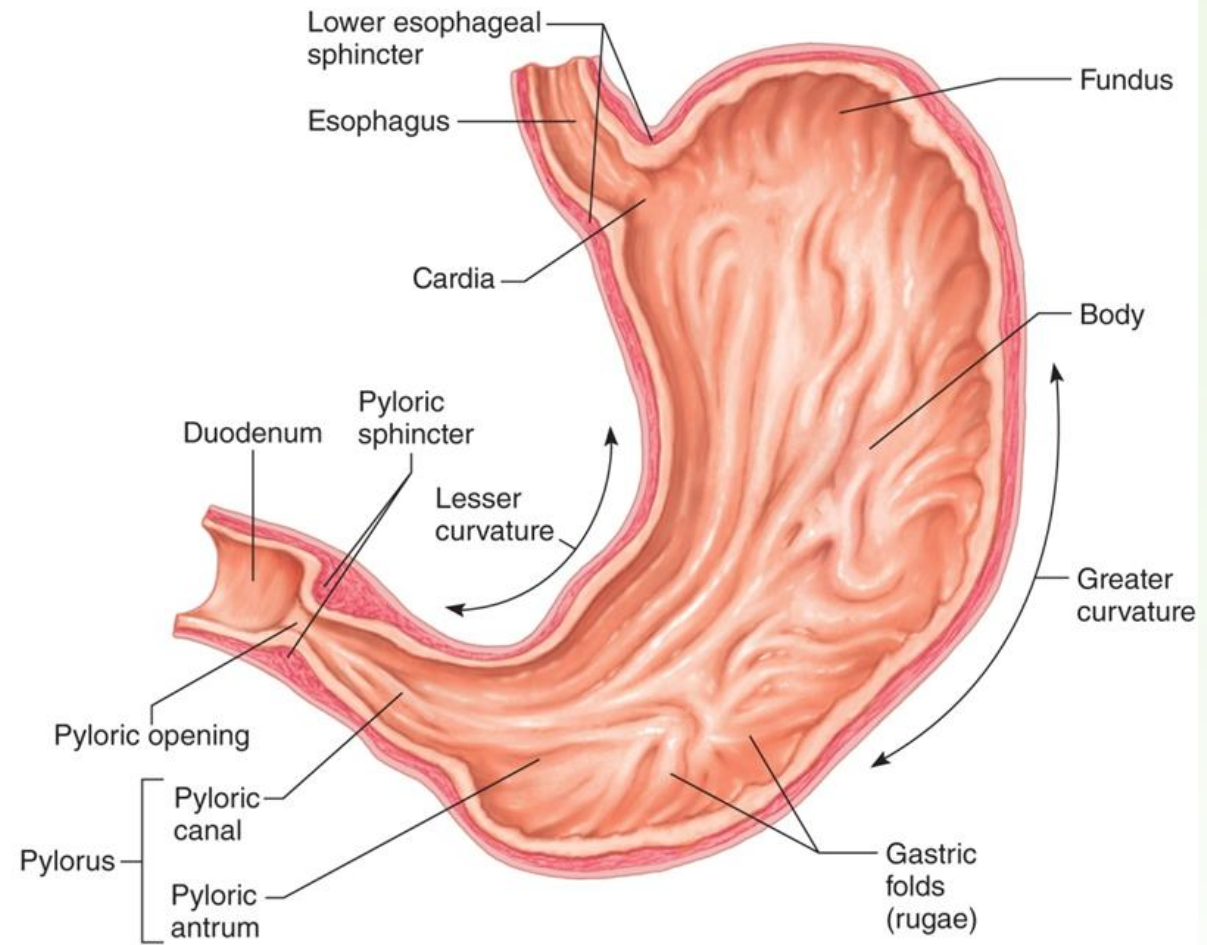
# Stomach



Anterior view of external and internal anatomy



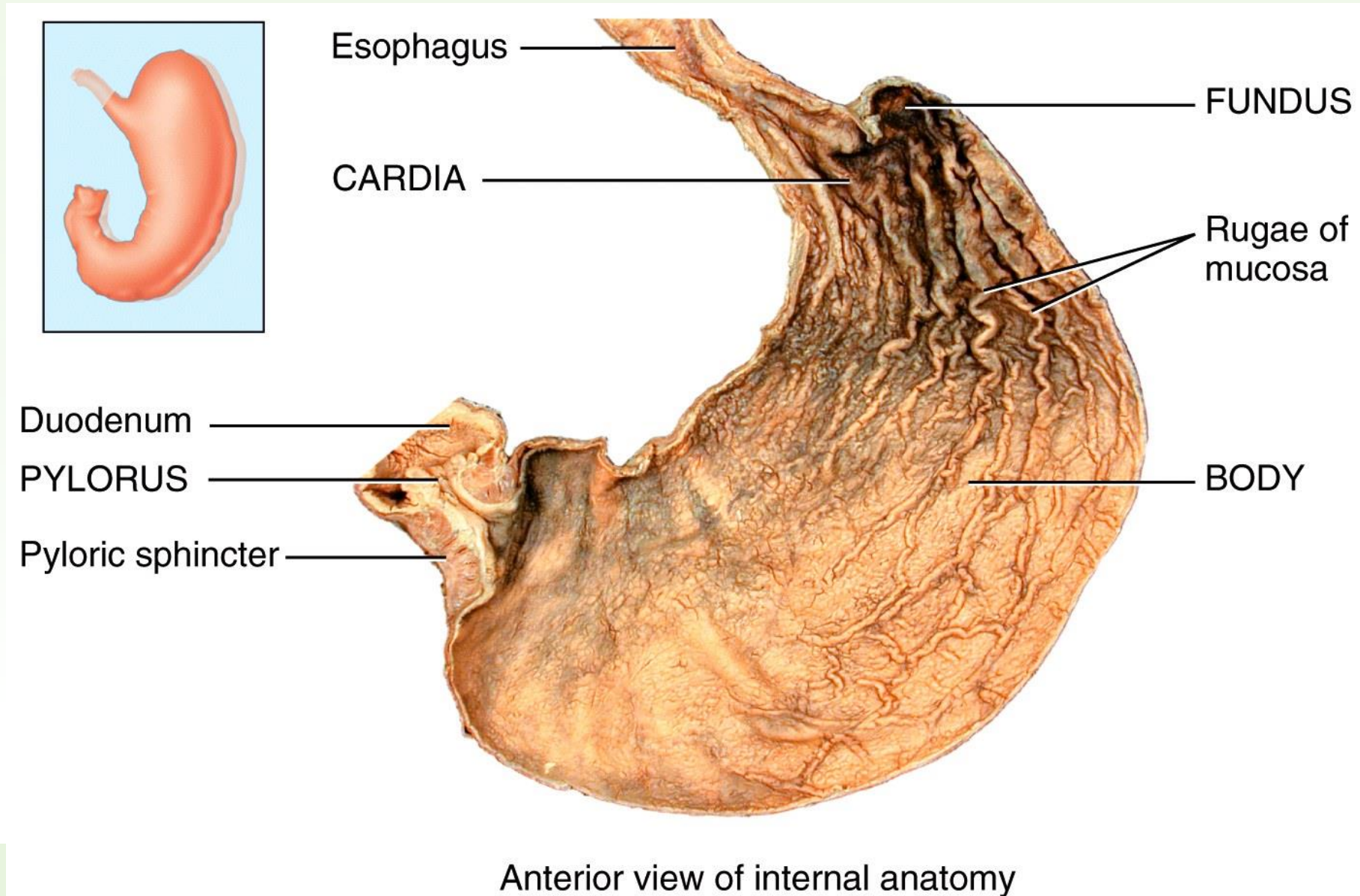
(a)



(b)



# Stomach



# Stomach Wall: Four Layers

## 1. Mucosa

- Empty stomach lies in folds called rugae
- Epithelium: simple columnar; glands secrete mucus
- Gastric glands line gastric pits
- Mucous cells → mucus
- Parietal cells → HCl and intrinsic factor
  - These secretions collectively called gastric juice
  - Intrinsic factor helps with vitamin B<sub>12</sub> absorption needed for RBC formation. If missing → anemia
- Chief cells → inactive enzyme pepsinogen
- G cells secrete gastrin hormone into blood



# Stomach Wall: Four Layers

## 2. Submucosa

- Rich in blood vessels, lymphatic vessels and nerves

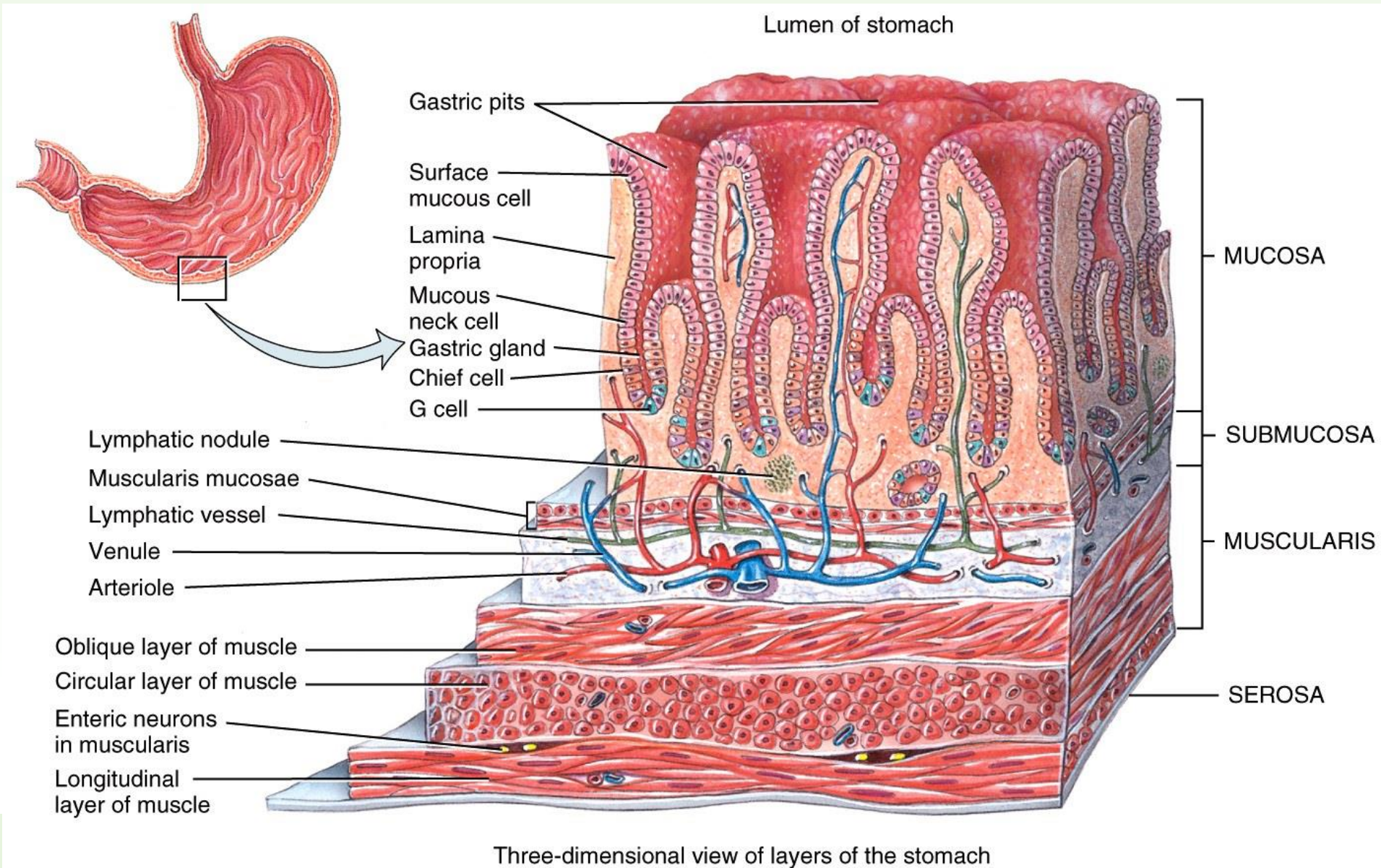
## 3. Muscularis: three layers

- Outer: longitudinal
- Middle: circular
- Inner: oblique (extra layer not in other organs) provides for efficient gastric contractions

## 4. Serous membrane (serosa)

- Visceral peritoneum: covers organs
- Extensions of serosa
  - Greater omentum: hangs from curve of stomach
  - Mesentery: attaches small intestine to posterior wall of abdomen and provides route for vessels

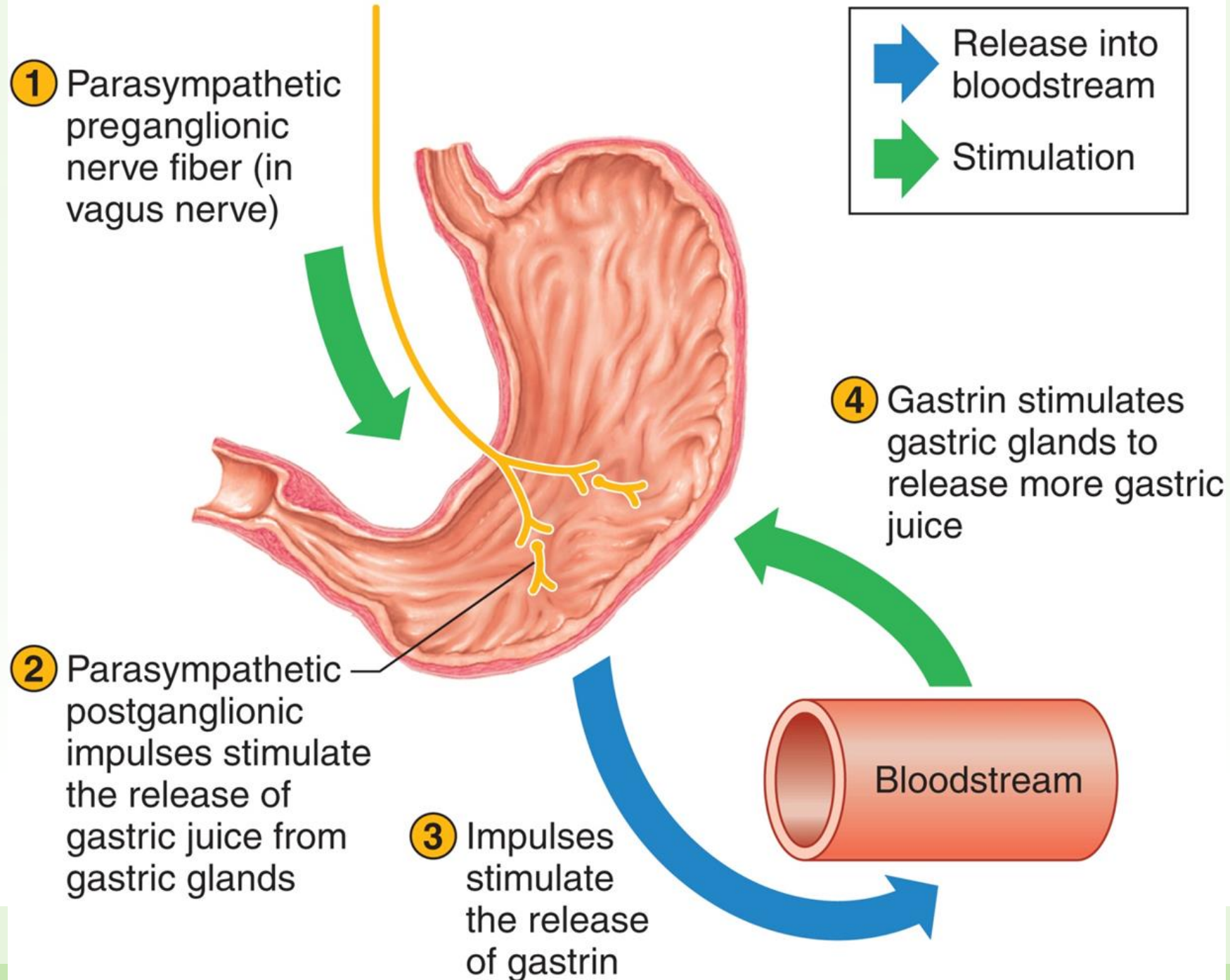
# Stomach Wall: Four Layers



# Digestion and Absorption

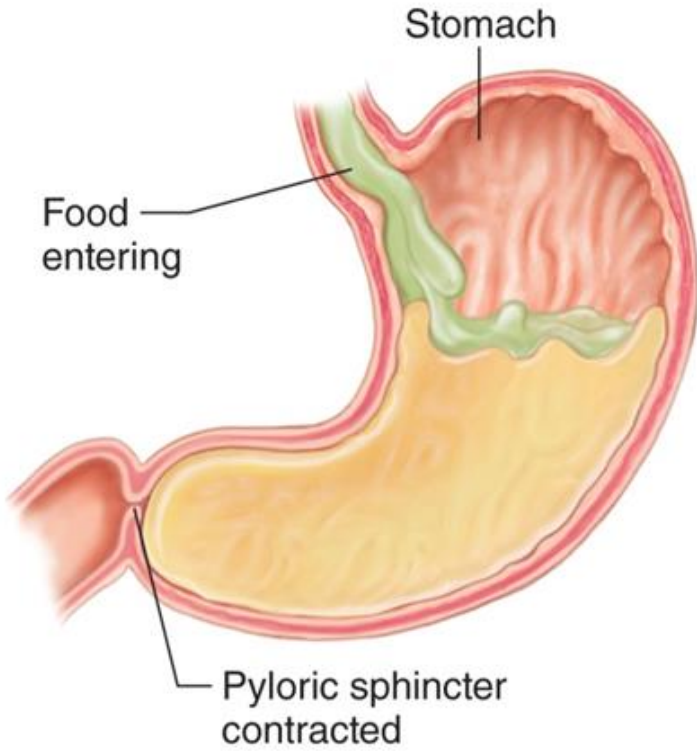
- Digestion
  - Mechanical digestion
    - Stretching of stomach wall → nerve impulses →
    - Secretion + mixing waves →
    - Food mixed with juice → now called chyme
  - Chemical digestion
    - Pepsin (pepsinogen + HCl) digests protein → peptides (small chains of amino acids)
  - Gastric emptying through pyloric sphincter
    - Carbohydrates fastest, proteins next, fats last
    - Once in duodenum → feedback inhibition of stomach
- Little absorption: water, ions, some drugs



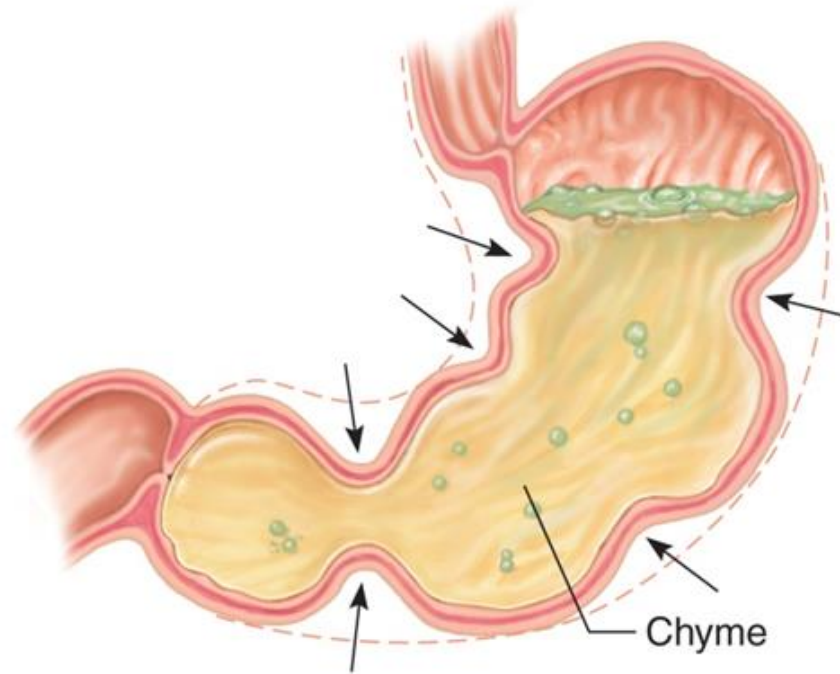


**TABLE 17.6** | **Phases of Gastric Secretion** **AP|R**

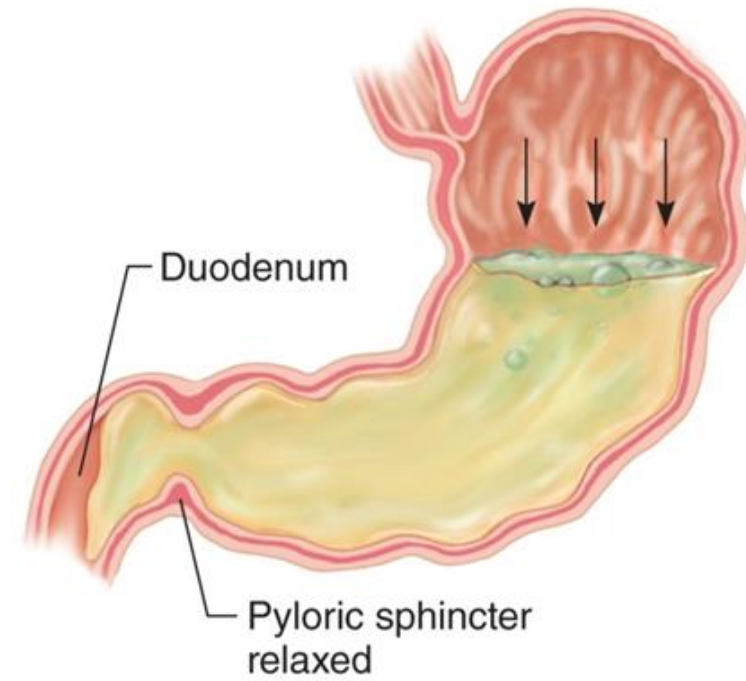
Phase	Action
Cephalic phase	The sight, taste, smell, or thought of food triggers parasympathetic reflexes. Gastric juice is secreted in response.
Gastric phase	Food in stomach chemically and mechanically stimulates release of gastrin, which, in turn, stimulates secretion of gastric juice; reflex responses also stimulate gastric juice secretion.
Intestinal phase	As food enters the small intestine, it stimulates intestinal cells to release intestinal gastrin, which, in turn, briefly promotes the secretion of gastric juice from the stomach wall. This phase primarily inhibits gastric juice secretion.



(a)

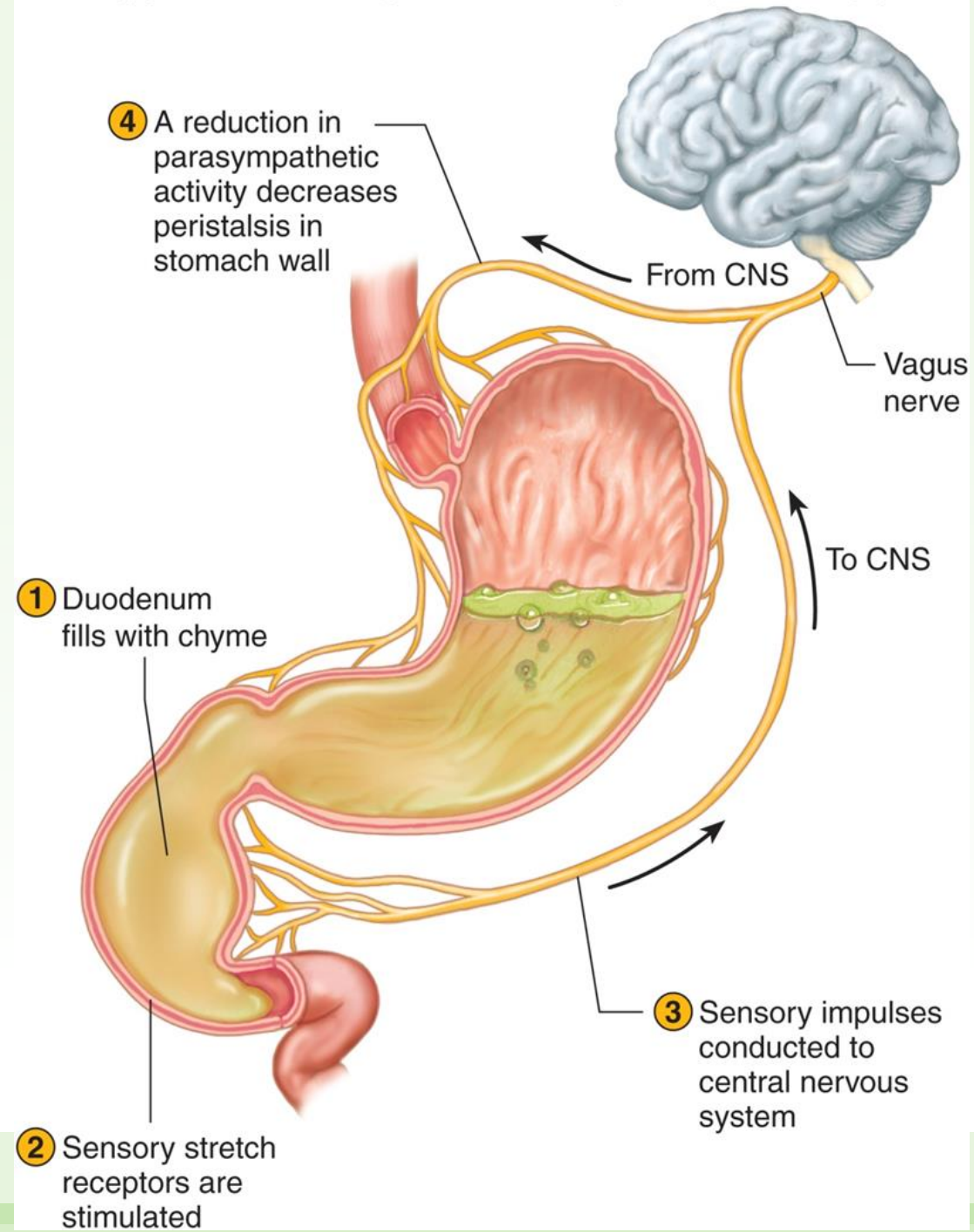


(b)



(c)





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**TABLE 17.5** | Major Components of Gastric Juice **AP|R**

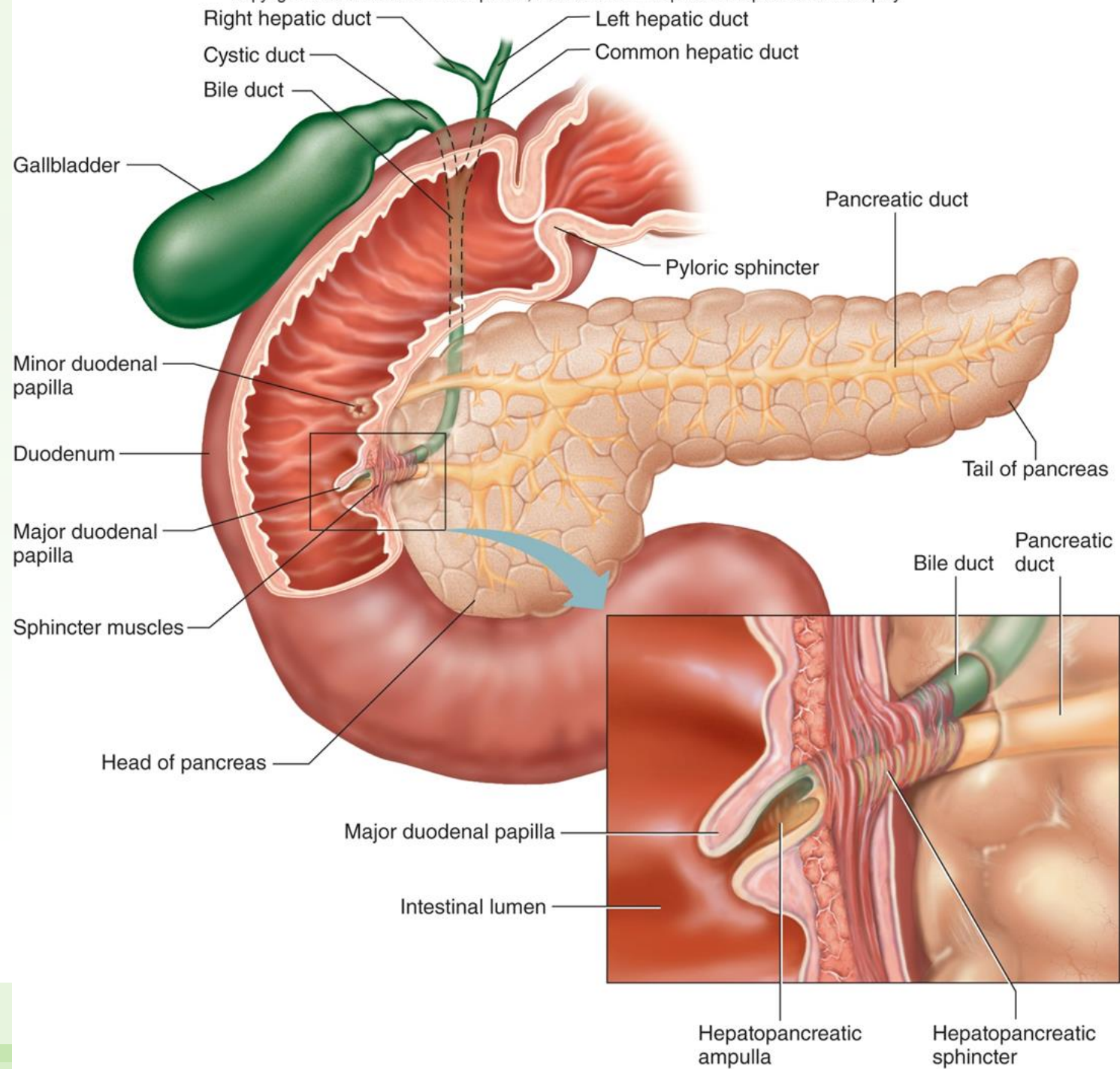
Component	Source	Function
Pepsinogen	Chief cells of the gastric glands	Inactive form of pepsin
Pepsin	Formed from pepsinogen in the presence of hydrochloric acid	A protein-splitting enzyme that digests nearly all types of dietary protein into polypeptides
Hydrochloric acid	Parietal cells of the gastric glands	Provides the acid environment needed for production and action of pepsin
Mucus	Mucous cells	Provides a viscous, alkaline protective layer on the stomach's inner surface
Intrinsic factor	Parietal cells of the gastric glands	Aids in vitamin B <sub>12</sub> absorption in the small intestine

# Pancreas

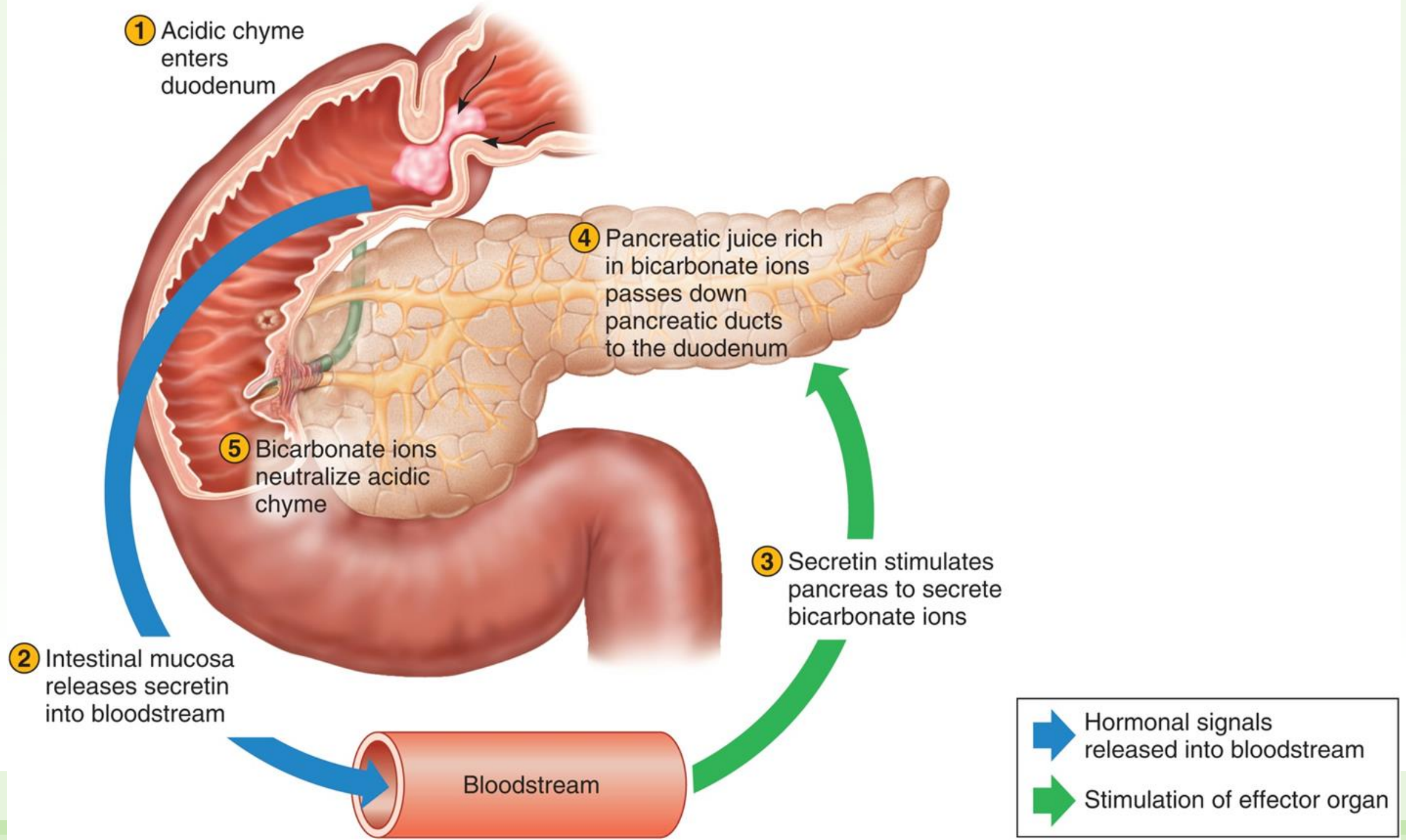
- Location
  - Posterior to the stomach
  - Lies between the duodenum on the right and spleen on the left
  - in retroperitoneal space
- Shape
  - an oblong-shaped appearance
- Produces pancreatic juice in acinar cells
- Passes into duodenum via pancreatic duct

# Pancreas

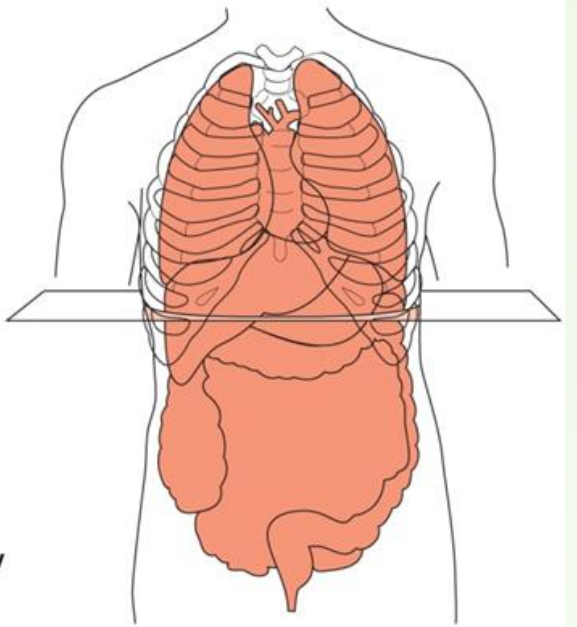
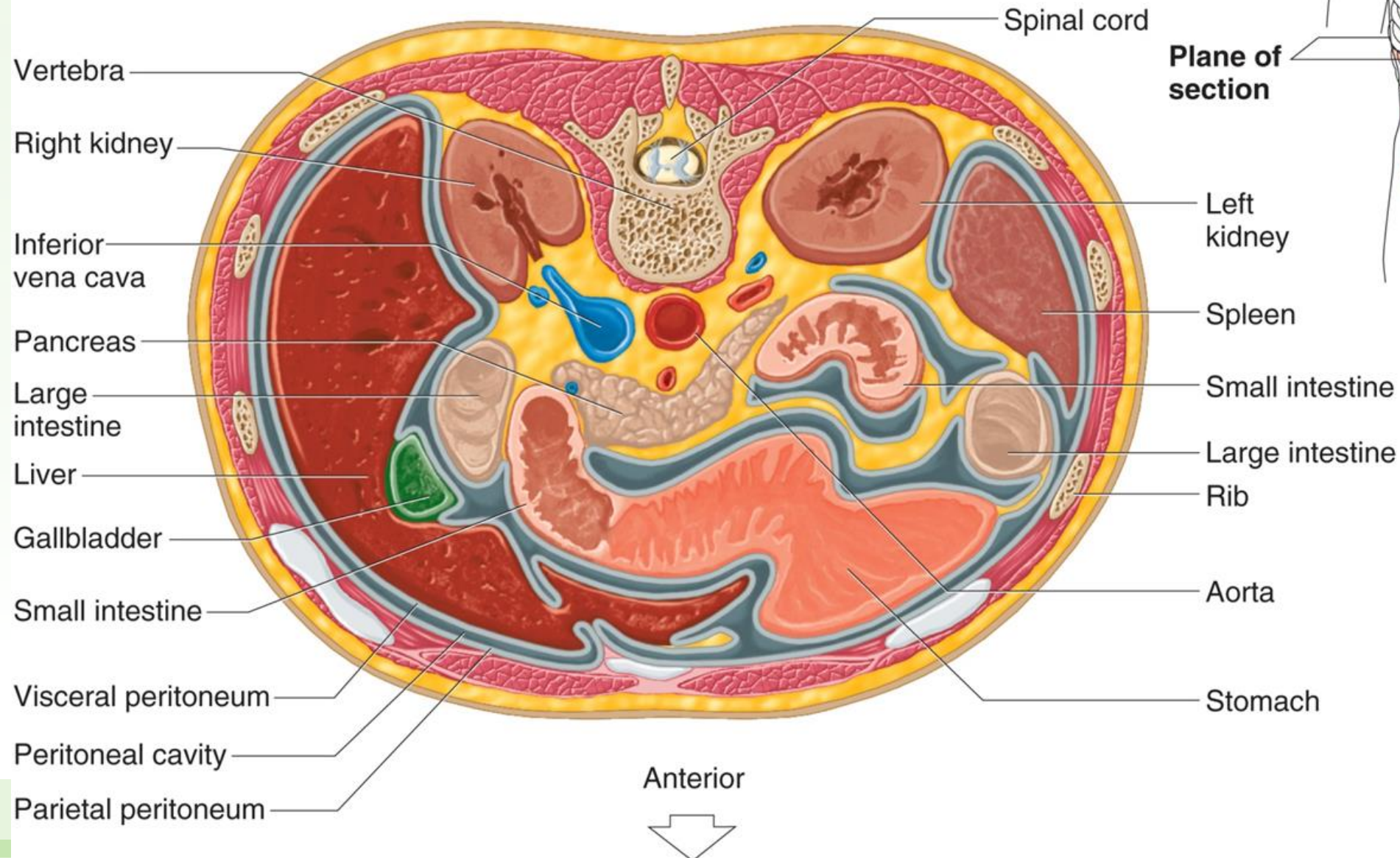
- Secretions that help digestion
  - Sodium bicarbonate ( $\text{NaHCO}_3$ ): pH 7.1-8.2)
  - Digestive enzymes: many
    - Pancreatic lipase: fat-digesting
    - Pancreatic amylase: starch-digesting
    - Proteases: made in inactivated form
      - Activated by enterokinase from small intestine
      - Chymotrypsinogen, trypsinogen, carboxypeptidase
      - RNAase and DNAase





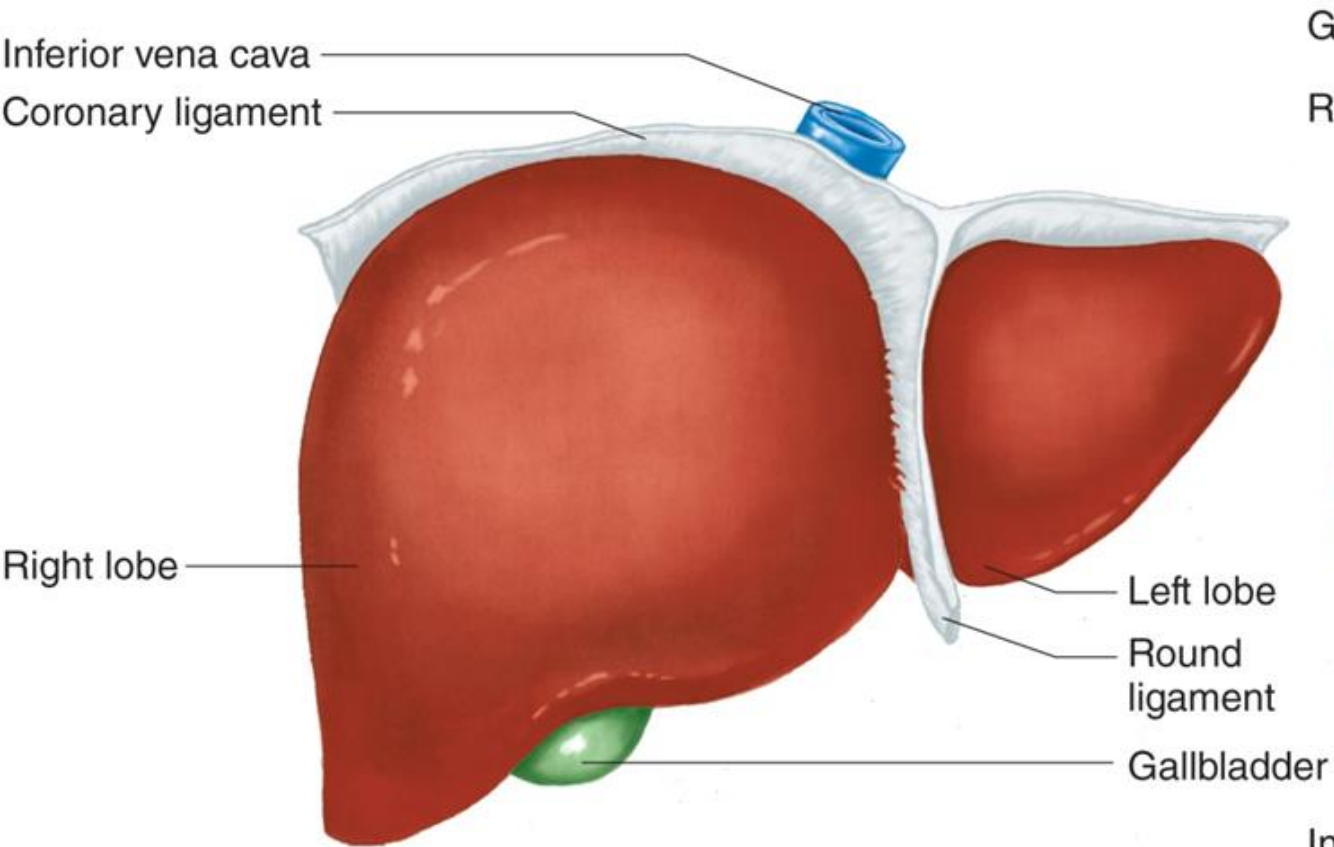




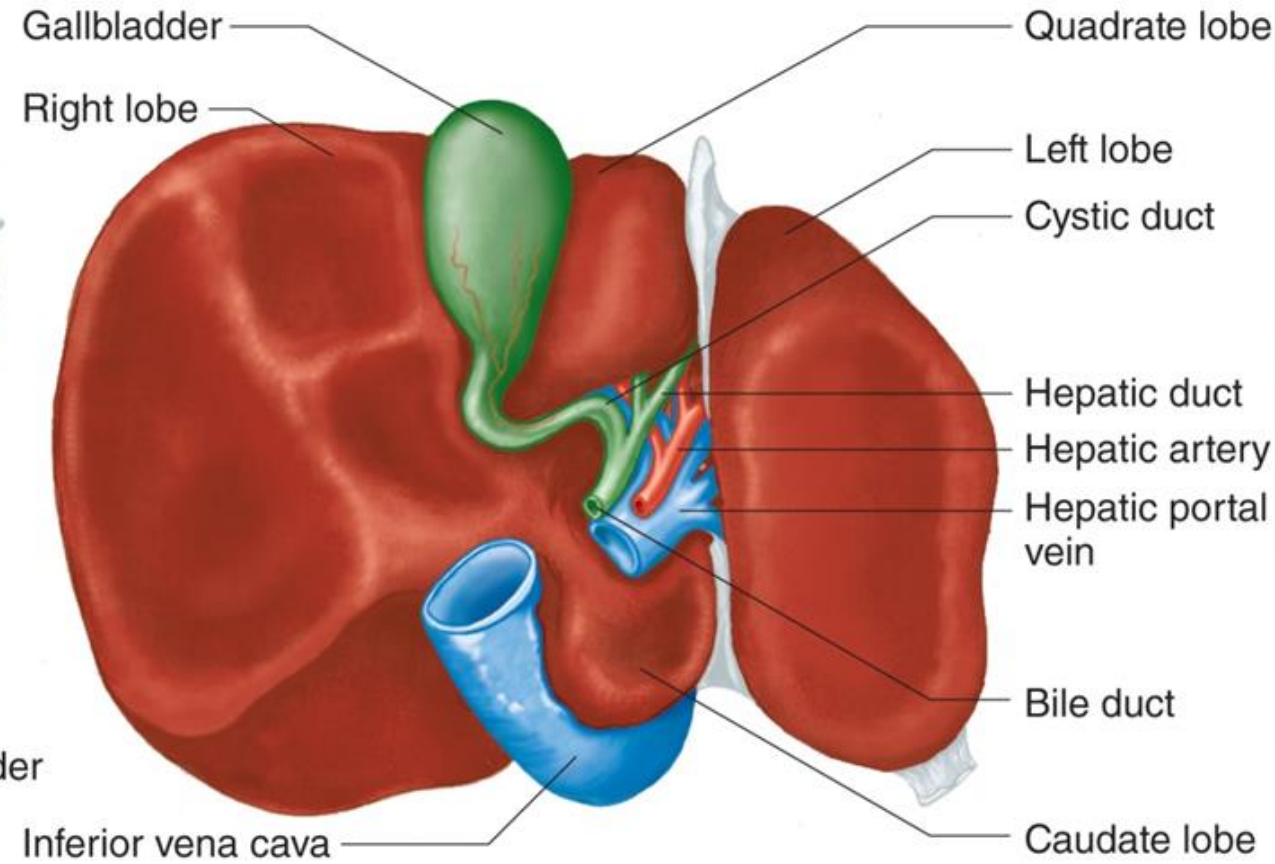


# Liver and Gallbladder

- Weighs 1.4 kg (3 lb): 2<sup>nd</sup> largest organ in the body; large right lobe + 3 smaller parts
- In right upper quadrant, below diaphragm
- Bile production and pathway
  - Hepatocytes (liver cells) make bile →
  - Bile canaliculi → bile ducts → hepatic duct →
  - Gallbladder (green, pear-shaped organ that stores bile) →
  - Cystic duct → common bile duct → duodenum



(a)



(b)

# Liver and Gall Bladder

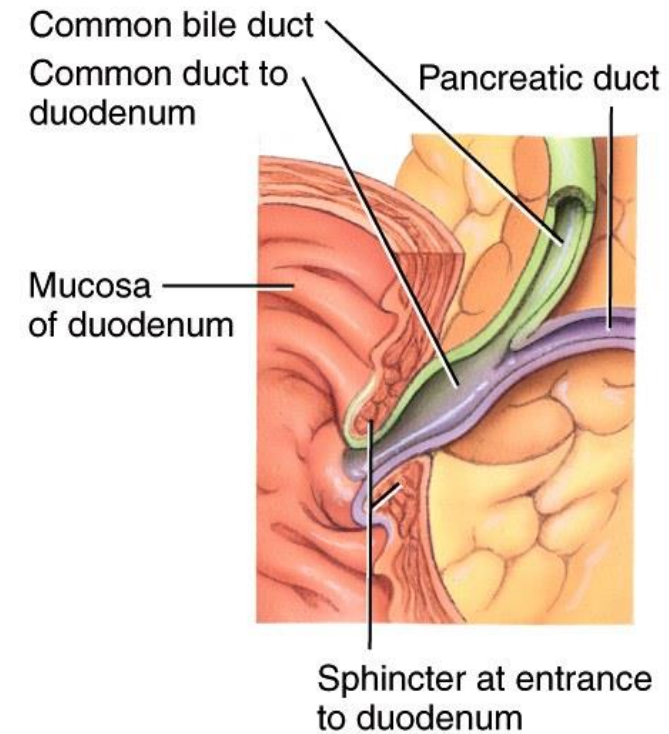
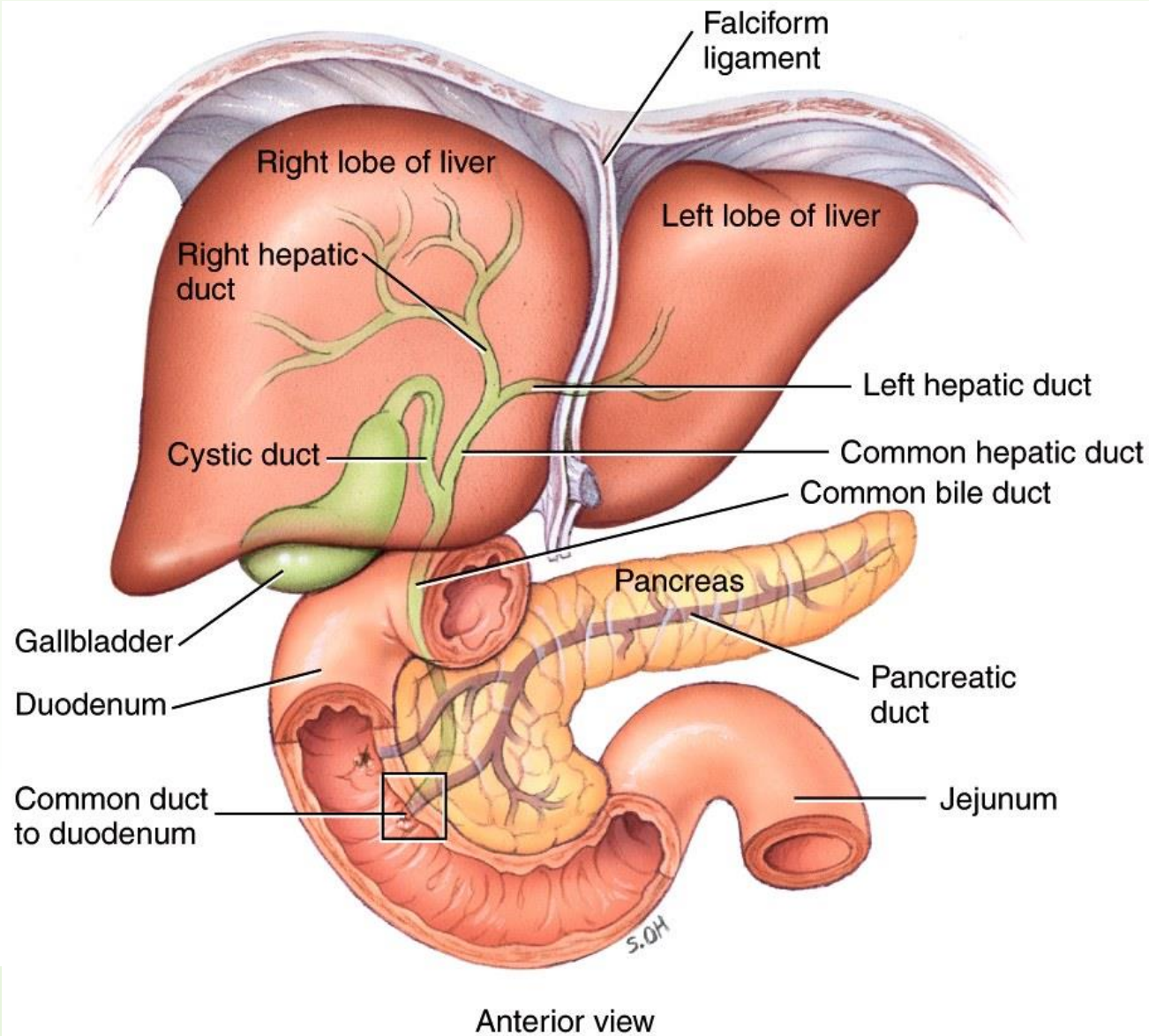
- Functional unit is lobule
  - Consists of hepatocytes in rows that radiate around central vein
  - Sinusoids (permeable capillaries with phagocytic [Kupffer] cells) are between cells
  - Blood reaches liver lobules from
    - Hepatic artery (branch of celiac): blood high in  $O_2$
    - Hepatic portal vein (formed by veins from digestive organs and spleen): blood low in  $O_2$  but rich in nutrients from digestive organs



# Bile

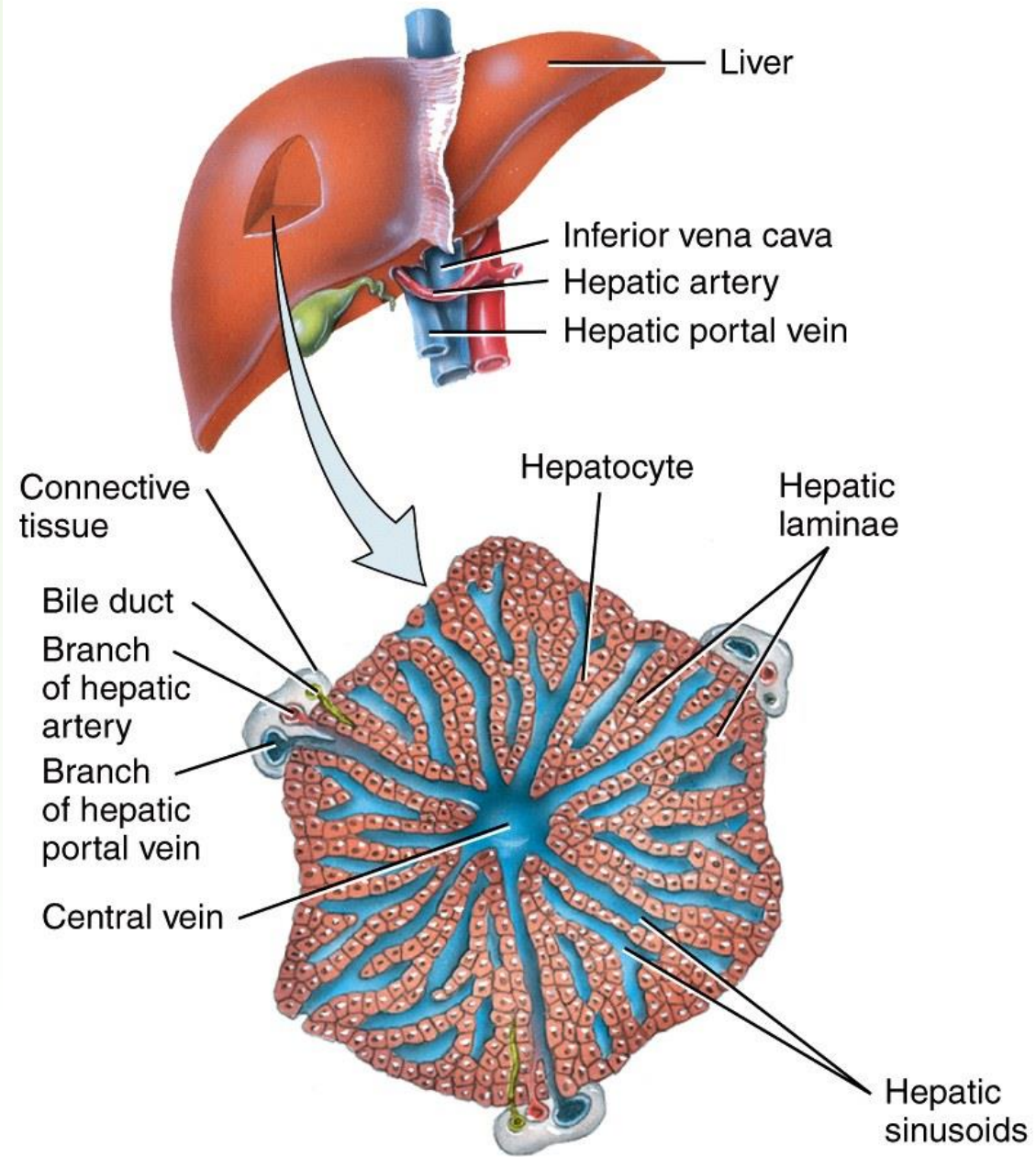
- Functions of bile
  - Emulsification: breaking apart clusters of fats so they are more digestible
  - Absorption of fats
- Formation and recycling of bile
  - Bilirubin from heme when RBCs broken down
  - Bile is digested → stercobilin: gives feces brown color
  - Bile salts reabsorbed into blood in small intestine (ileum) → portal vein → liver
- Gallstones may form from bile
  - Obstruct bile ducts from gallbladder → pain

# Liver, Gallbladder, Duodenum



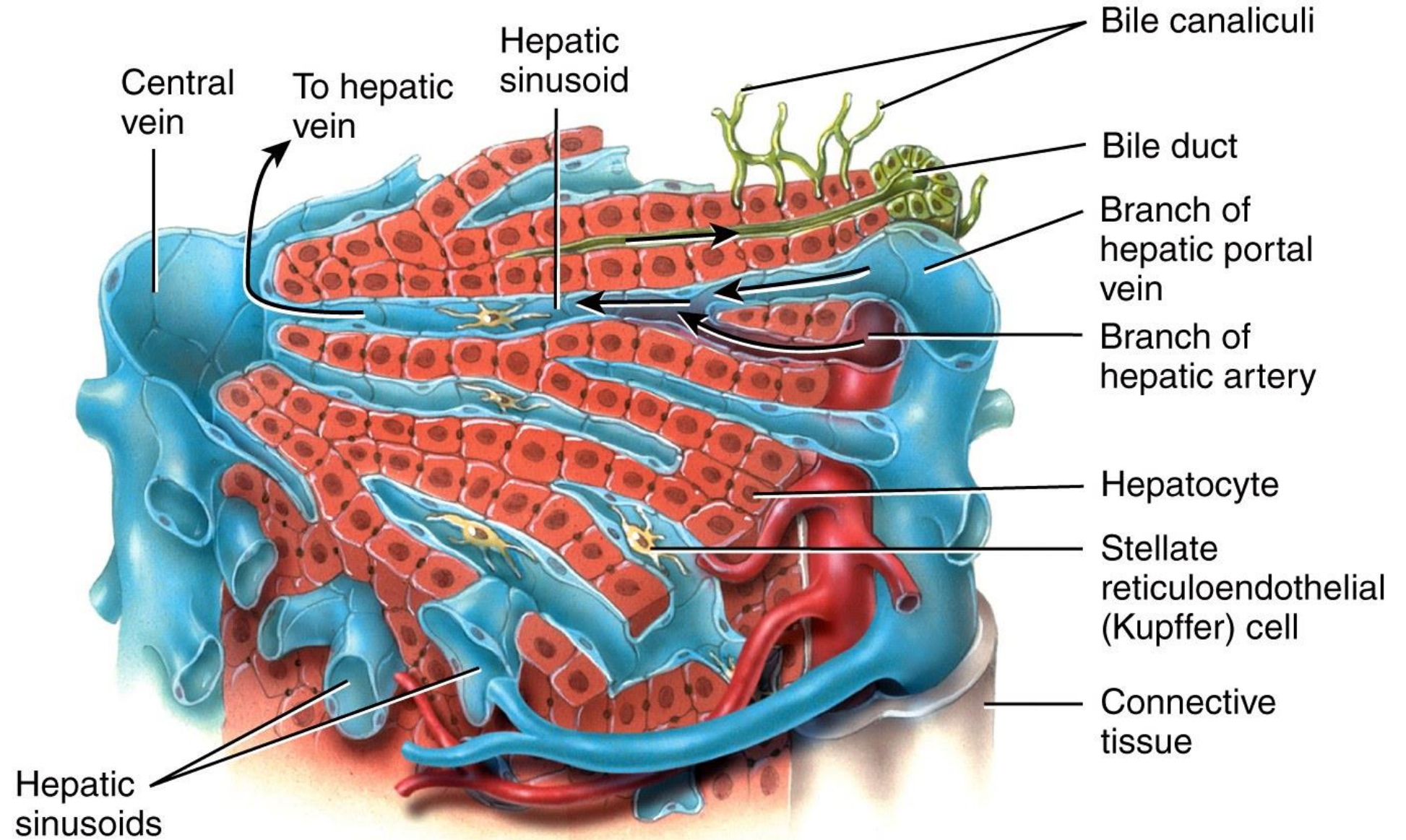


# Liver



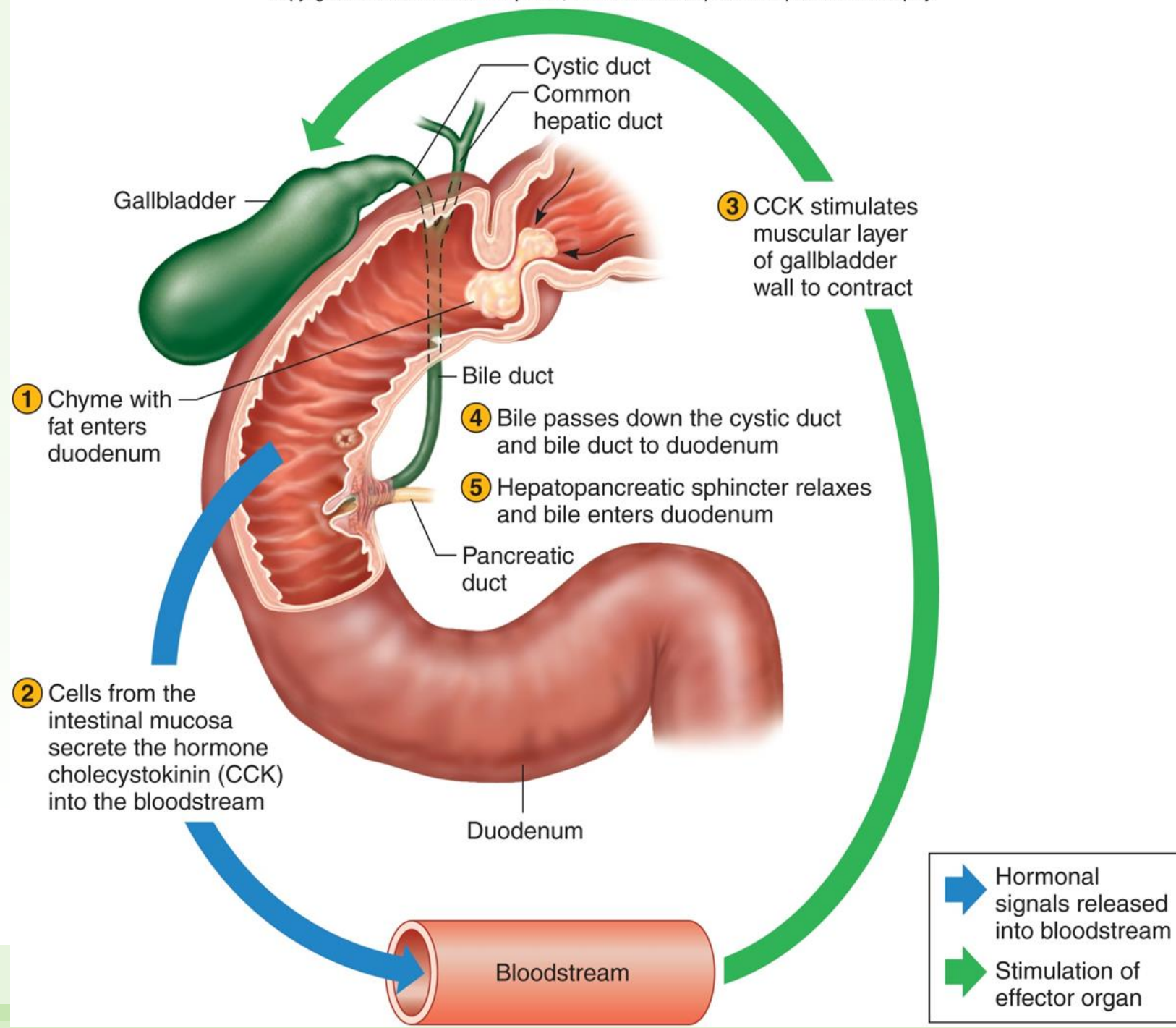
Overview of microscopic components of liver

# Liver



Details of microscopic components of liver





# Liver Functions

## 1. Carbohydrate metabolism

- Polysaccharide stored in liver as glycogen
- Converts glycogen, fructose, galactose, lactic acid, amino acids → glucose to ↑ blood glucose

## 2. Lipid metabolism

- Produces cholesterol, triglycerides; makes bile
- Makes lipoproteins for lipid transport

## 3. Protein metabolism

- Remove  $\text{NH}_2$  from amino acids → ammonia ( $\text{NH}_3$ ) → urea → to kidneys (urine)
- Synthesize most plasma proteins: albumin

# Liver Functions

4. Removes many harmful substances from blood

- Detoxifies alcohol
- Inactivates steroid and thyroid hormones
- Eliminates some drugs (like penicillin) into bile

5. Excretion of bilirubin

- From heme (in RBCs) to bile → feces

6. Stores fat-soluble vitamins (ADEK) and minerals (Fe, Cu)

7. Activates vitamin D

**TABLE 17.7** | Major Functions of the Liver

General Function	Specific Function
Carbohydrate metabolism	Polymerizes glucose to glycogen; breaks down glycogen to glucose; converts noncarbohydrates to glucose
Lipid metabolism	Oxidizes fatty acids; synthesizes lipoproteins, phospholipids, and cholesterol; converts portions of carbohydrate and protein molecules into fats
Protein metabolism	Deaminates amino acids; forms urea; synthesizes plasma proteins; converts certain amino acids into other amino acids
Storage	Stores glycogen, vitamins A, D, and B <sub>12</sub> , iron, and blood
Blood filtering	Removes damaged red blood cells and foreign substances by phagocytosis
Detoxification	Removes toxins from the blood
Secretion	Produces and secretes bile



**TABLE 17.8** | Hormones of the Digestive Tract

Hormone	Source	Function
Gastrin	Gastric cells, in response to food	Increases secretory activity of gastric glands
Intestinal gastrin	Cells of small intestine, in response to chyme	Increases secretory activity of gastric glands
Somatostatin	Gastric cells	Inhibits secretion of acid by parietal cells
Intestinal somatostatin	Intestinal wall cells, in response to fats	Inhibits secretion of acid by parietal cells
Cholecystokinin	Intestinal wall cells, in response to proteins and fats in the small intestine	Decreases secretory activity of gastric glands and inhibits gastric motility; stimulates pancreas to secrete fluid with a high digestive enzyme concentration; stimulates gallbladder to contract and release bile
Secretin	Cells in the duodenal wall, in response to acidic chyme entering the small intestine	Stimulates pancreas to secrete fluid with a high bicarbonate ion concentration