MONOGASTRIC DIGESTIVE SYSTEM

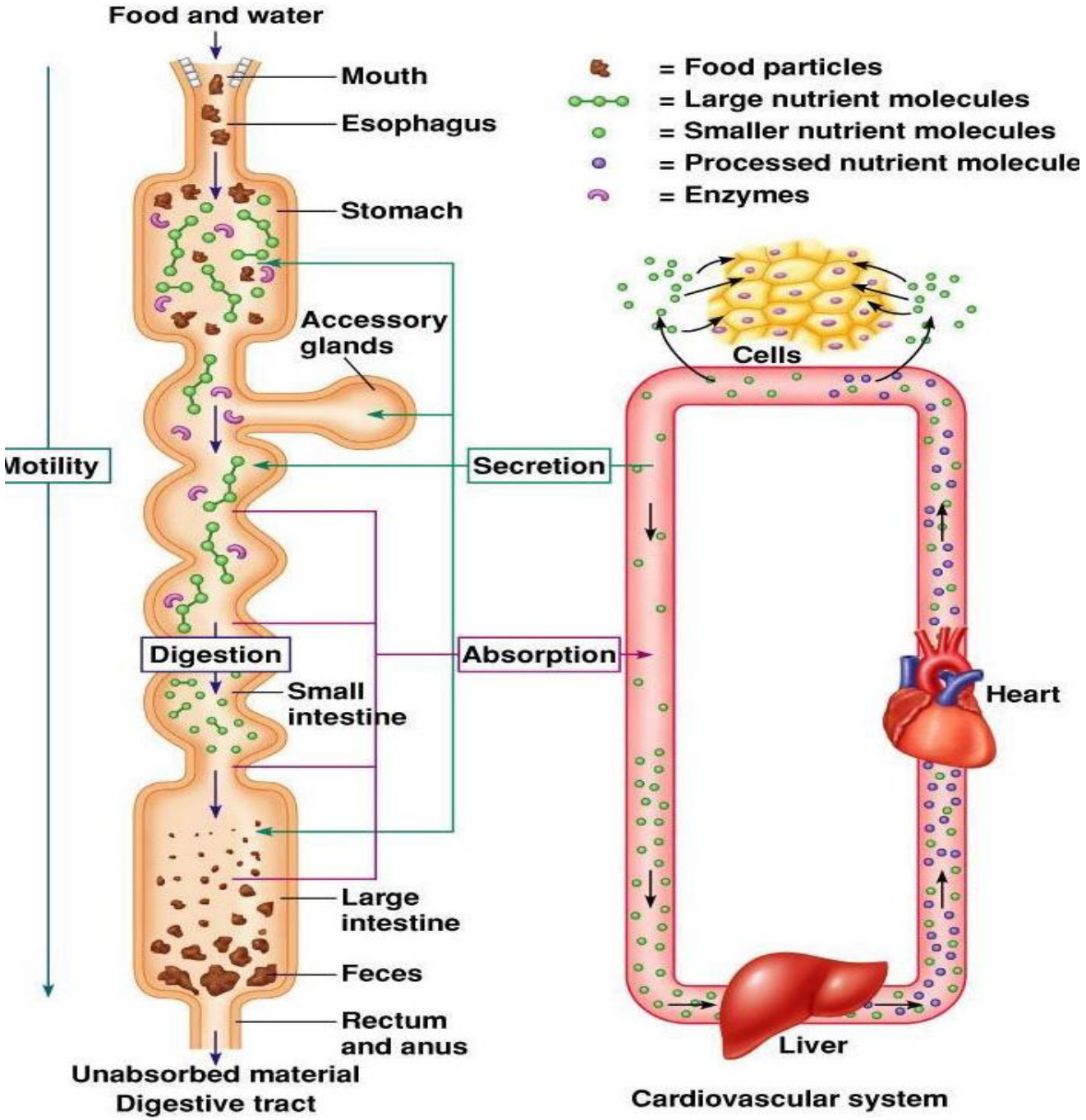
Basic Organization

- Mouth
- Esophagus
- Stomach
- Small intestine
- Large intestine
- Anus

Associated Structures

- Pancreas
- Liver
- Gallbladder
- Salivary glands

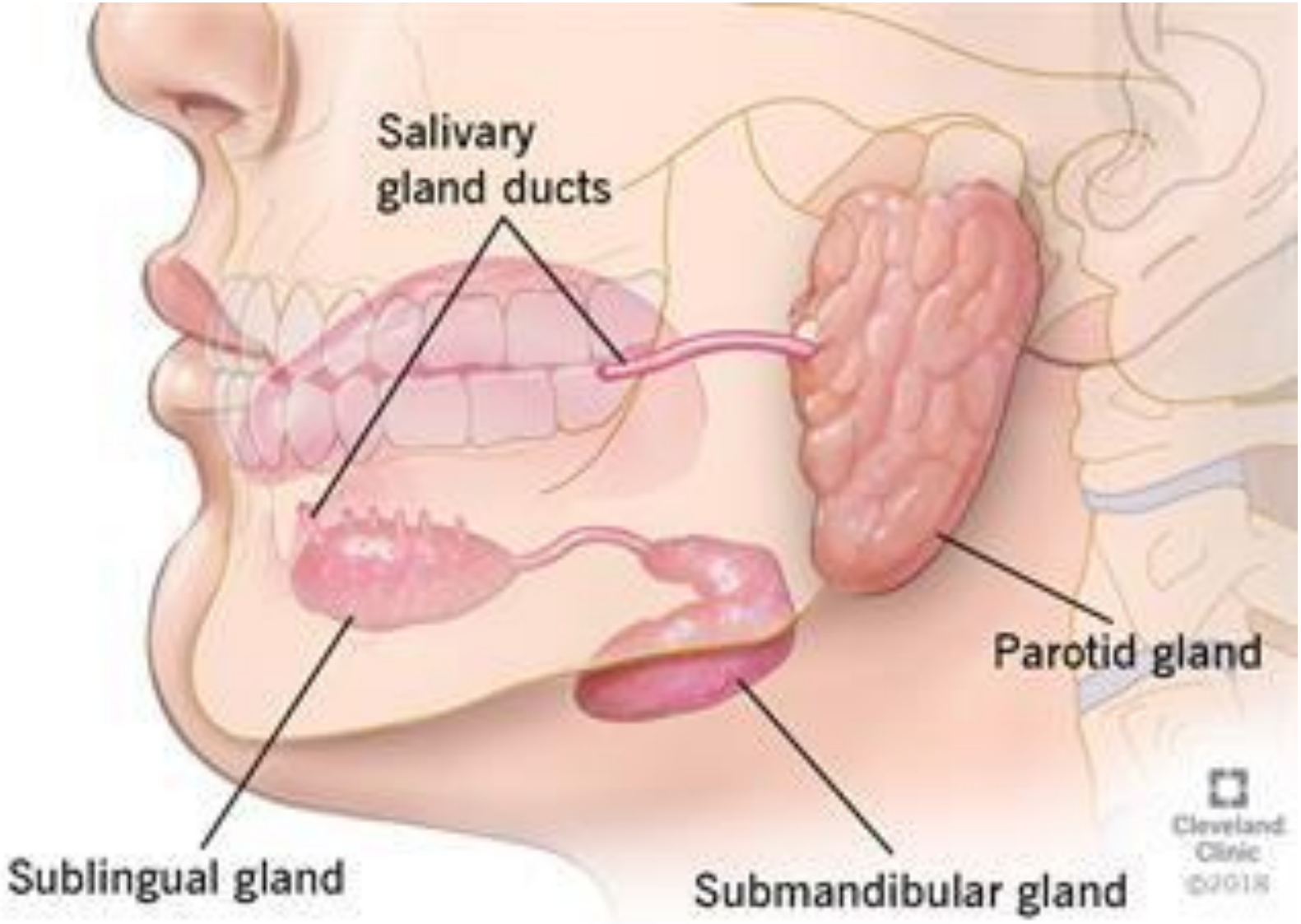
Contribute to small intestinal digestion


Food and water
Mouth
Esophagus
Stomach
Accessory glands
Motility
Secretion
Digestion
Absorption
Small intestine
Large intestine
Feces
Rectum and anus
Unabsorbed material
Digestive tract
= Food particles
= Large nutrient molecules
= Smaller nutrient molecules
= Processed nutrient molecule
= Enzymes
Cells
Heart
Liver
Cardiovascular system

Structures in Mouth

- Lips
- Teeth
- Tongue
- Salivary glands

Salivary Glands

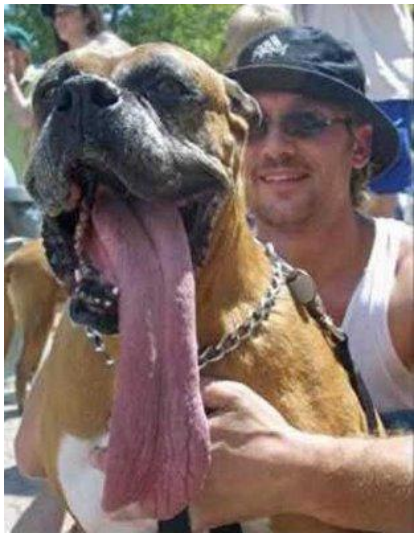


Saliva Contents

Gland	Type of secretion	Main constituents
Parotid	Serous	Water, enzymes, ions
Submaxillary	Mucous or mixed	Mucin (mucous), mucin plus enzymes (mixed), water
Sublingual	Mucous or mixed	Mucin (mucous), mucin plus enzymes (mixed), water

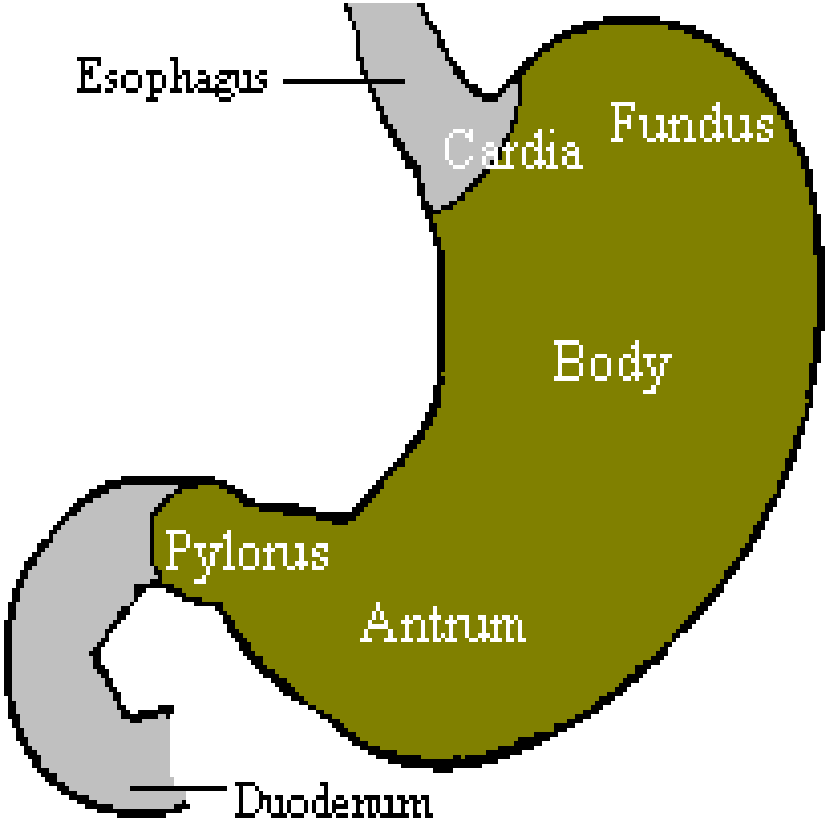
Functions of Saliva

- Moisten feed (salt and water)
- Lubrication (aids swallowing)
- Starch and(or) lipid digestion (amylase and(or) lipase)



Stomach Regions

- Esophageal
  - Non-glandular
- Cardiac
  - Secretes mucus
- Fundic
  - Parietal cells
  - Chief cells
- Pyloric
  - Mucus

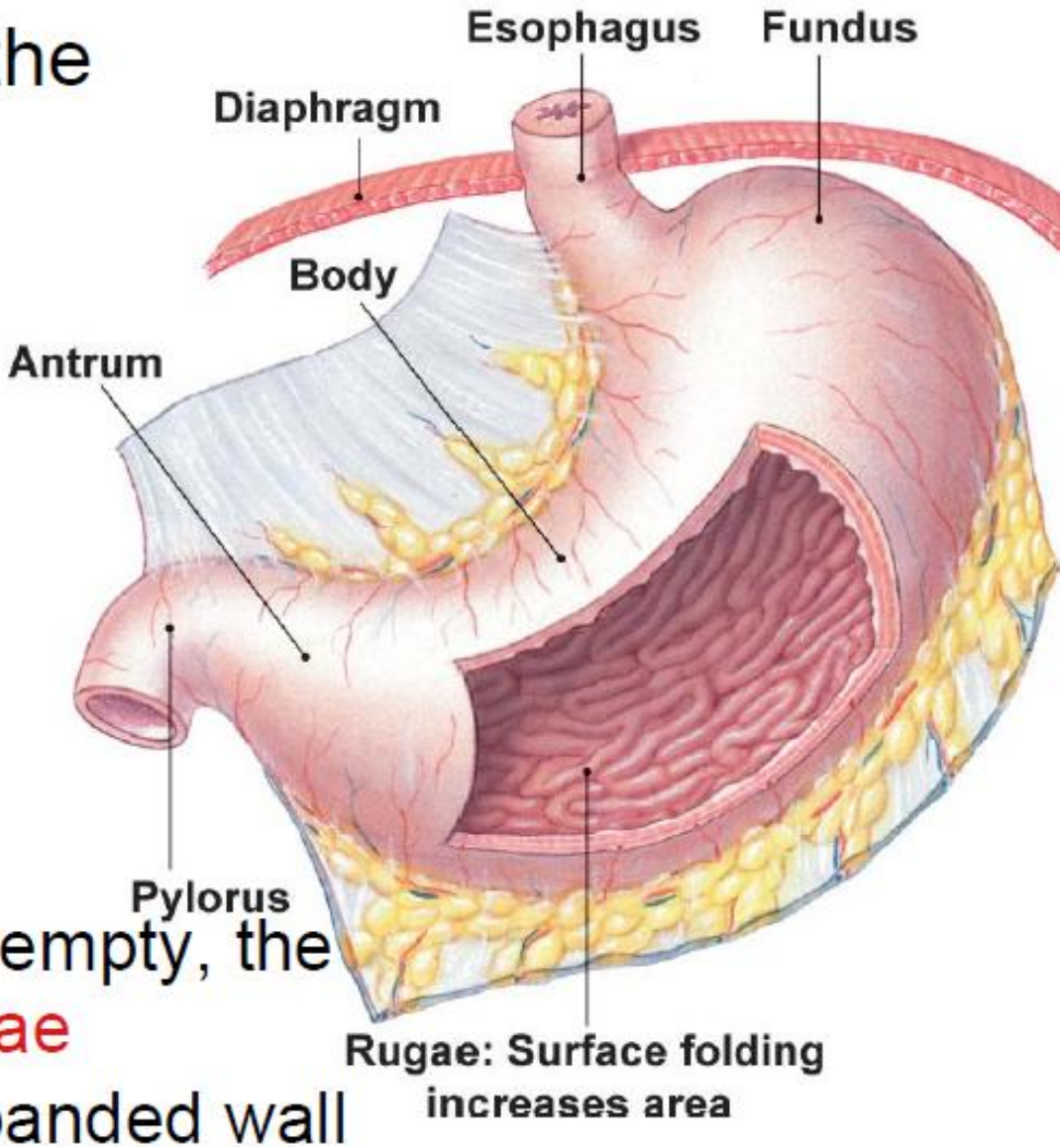


Gross Anatomy of the Stomach

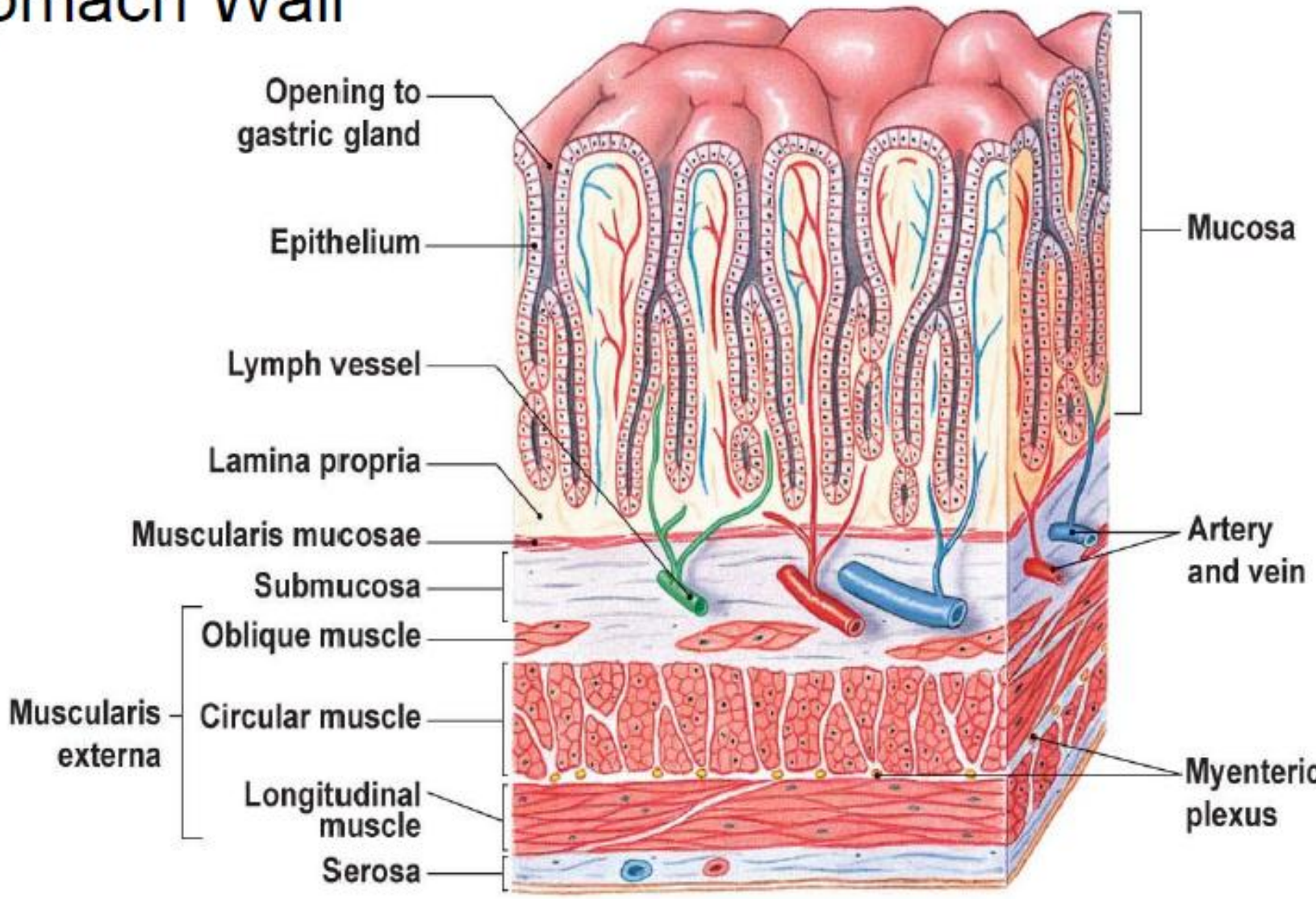
The stomach is divided into the 3 regions: the fundus, the body and the antrum and is able to hold up to 2 liters of food and fluid when completely filled

When the stomach is empty, the mucosa folds into rugae

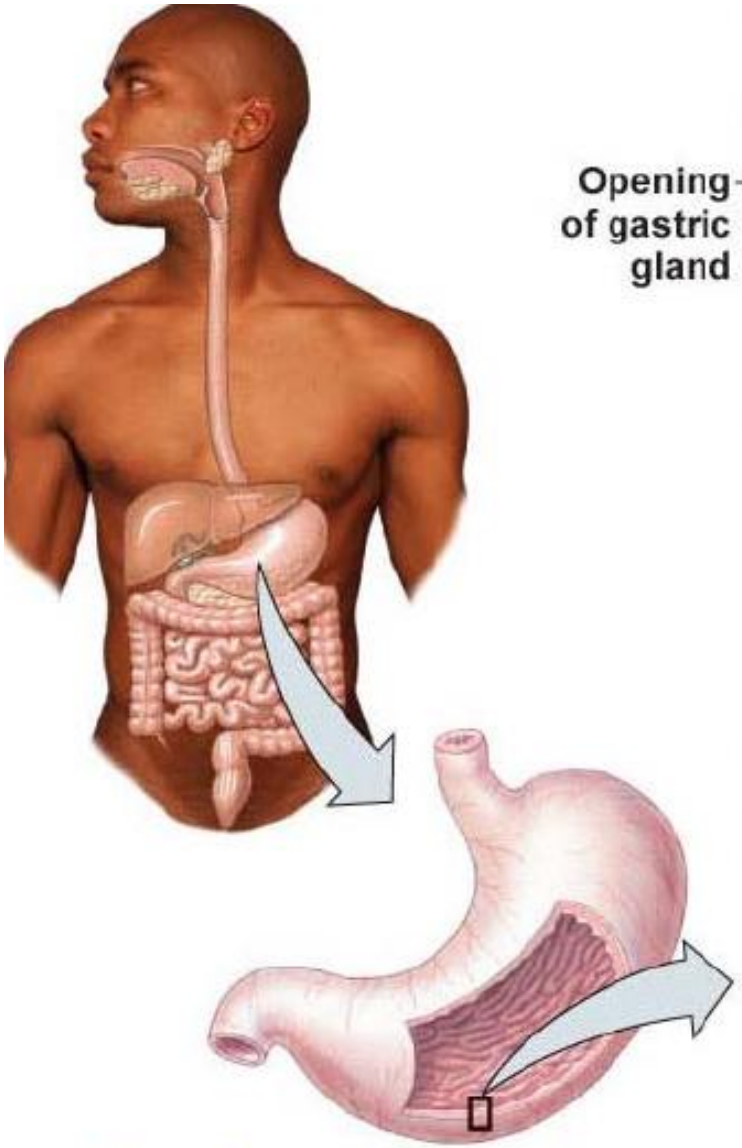
- when filled, the expanded wall of the stomach causes these folds to disappear (flatten)

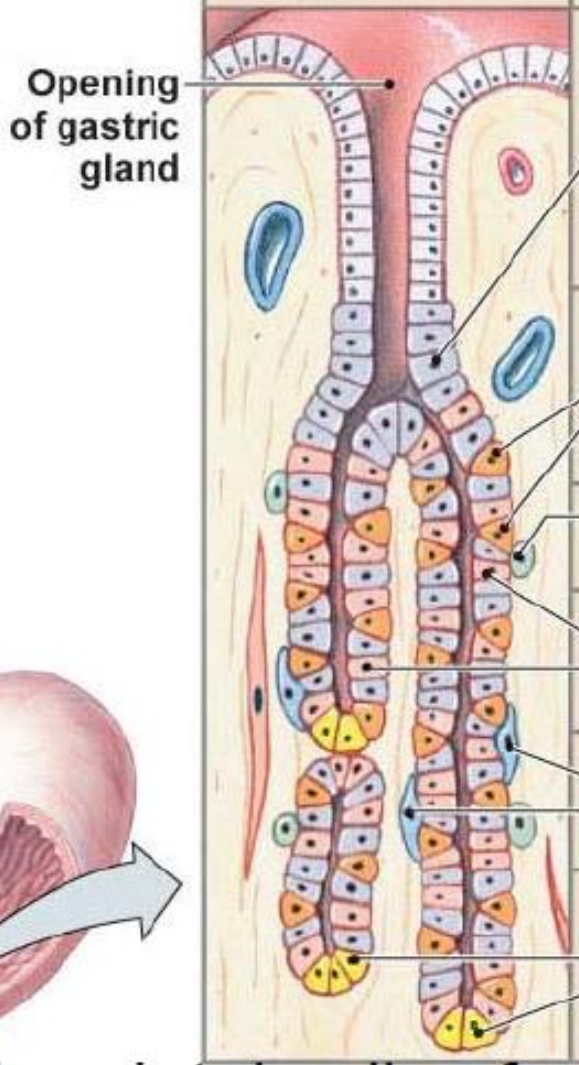


The Stomach Wall



- Tubular invaginations (depressions) of the surface epithelium called gastric glands extend down into the supporting connective tissue





Gastric mucosa	Cell Types	Substance Secreted
	Mucous neck cell	Mucus
		Bicarbonate
	Parietal cells	Gastric acid (HCl)
		Intrinsic factor
	Enterochromaffin-like cell	Histamine
	Chief cells	Pepsin(ogen)
		Gastric lipase
	D cells	Somatostatin
	G cells	Gastrin

- Chief cells and parietal cells of gastric glands secrete substances into the lumen of the stomach which combine to make gastric juice

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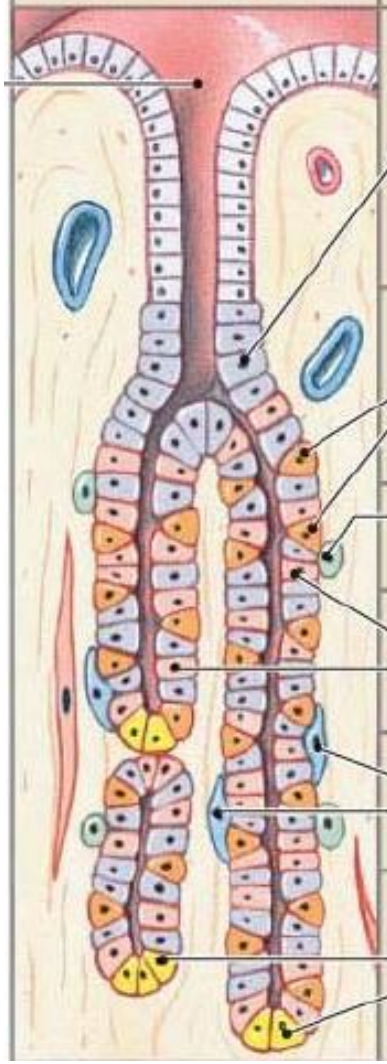	Mucous neck cell	Mucus
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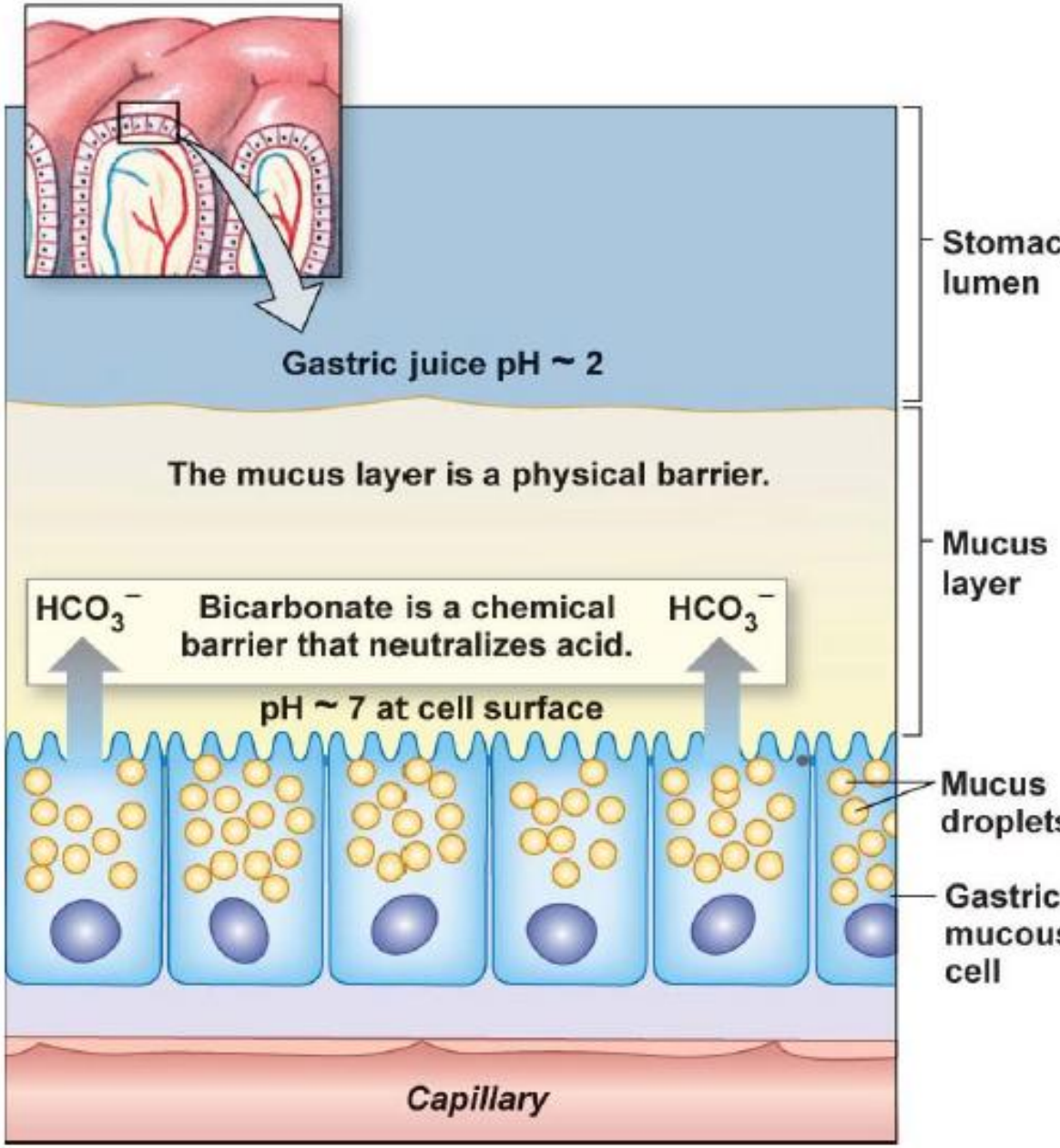
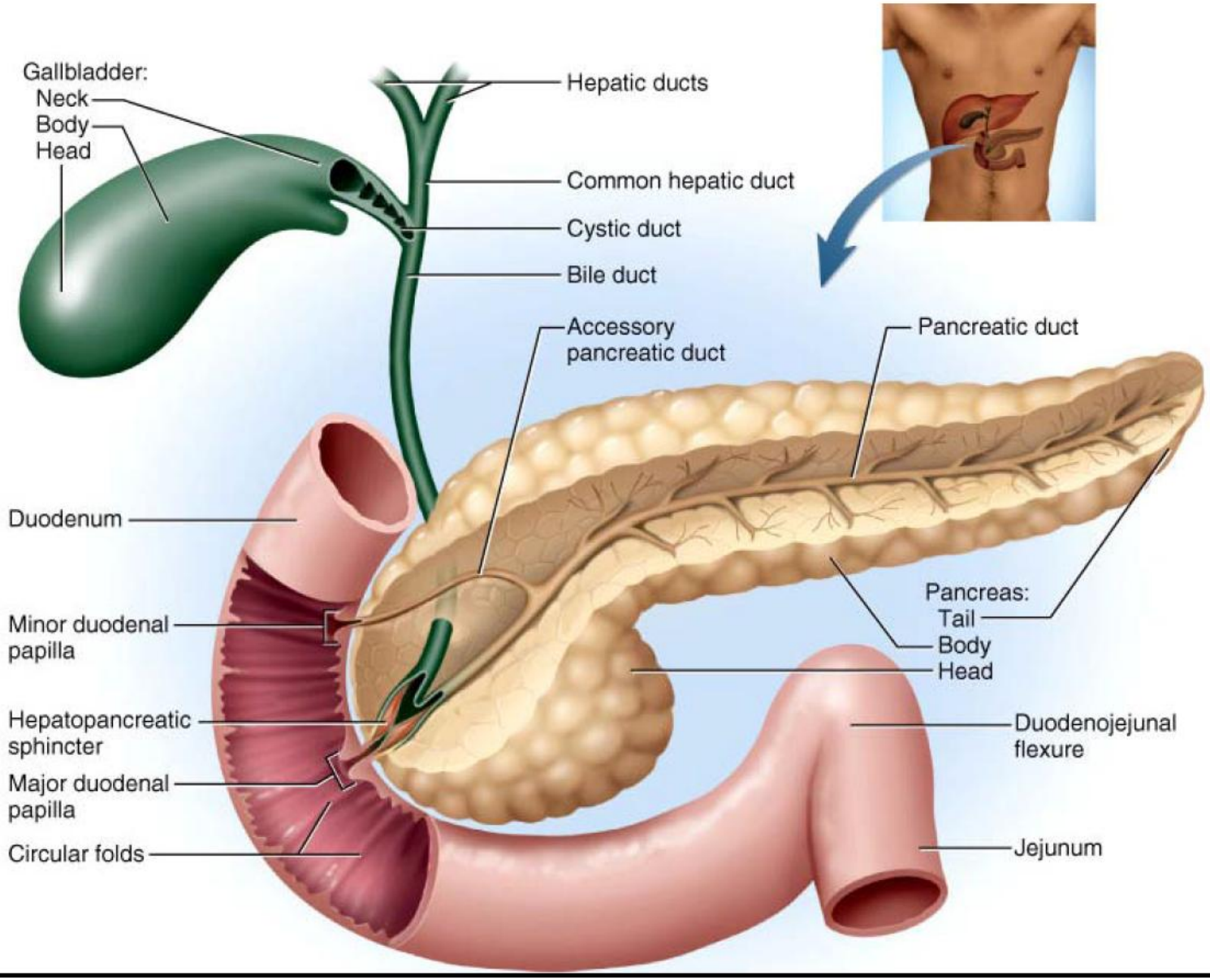
Protection of the Stomach Mucosa

Mucous cells secrete a combination of mucus (superficial physical barrier) and bicarbonate (chemical buffer barrier under mucus) to protect the mucosa from autodigestion by HCl



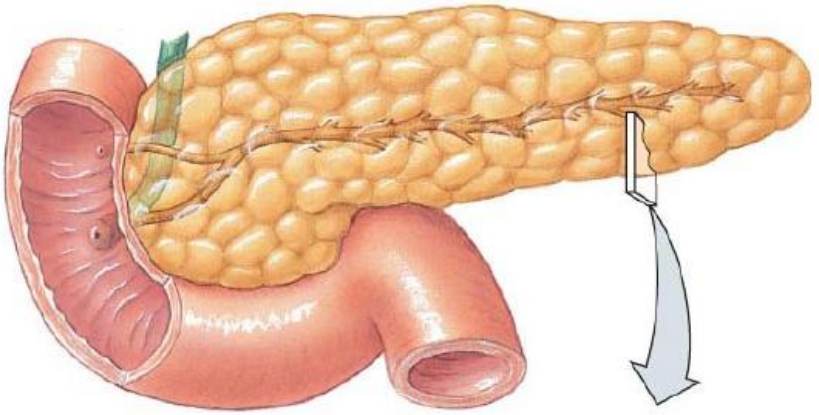
ACCESSORY GLANDS

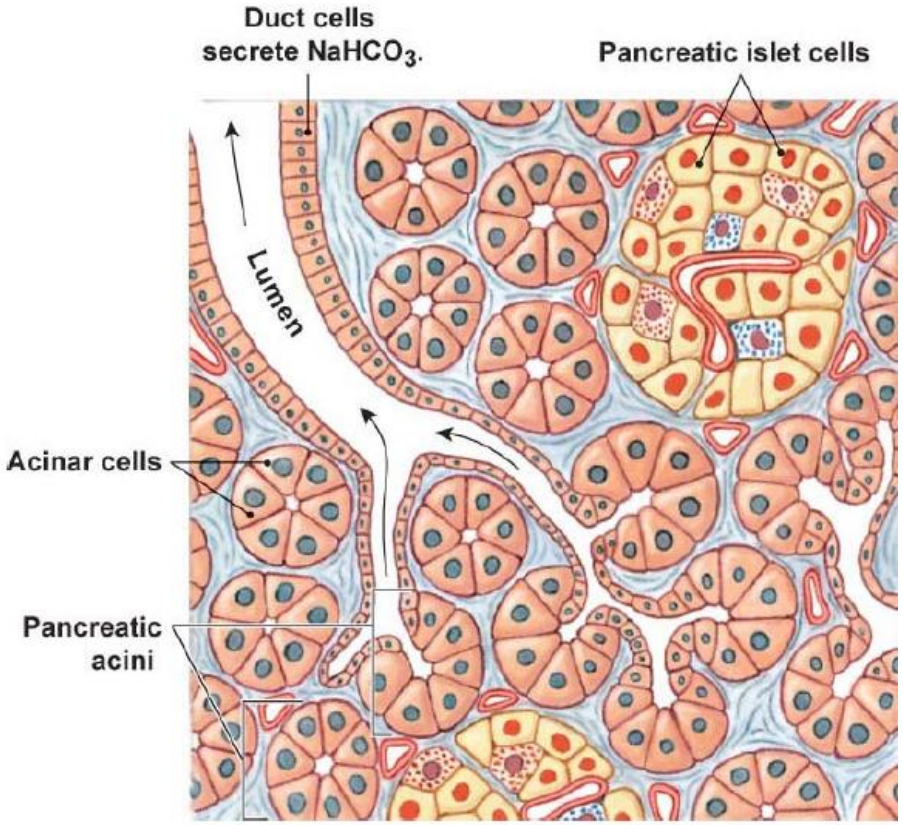


Pancreas

A triangular gland located behind the stomach which has both **exocrine** and **endocrine** functions

- Acinar (epithelial) cells secrete **pancreatic juice** into a duct that empties through the sphincter of Oddi at the duodenum
- Pancreatic islets (**islets of Langerhans**) secrete the hormones **insulin** **and** **glucagon** to control blood glucose levels





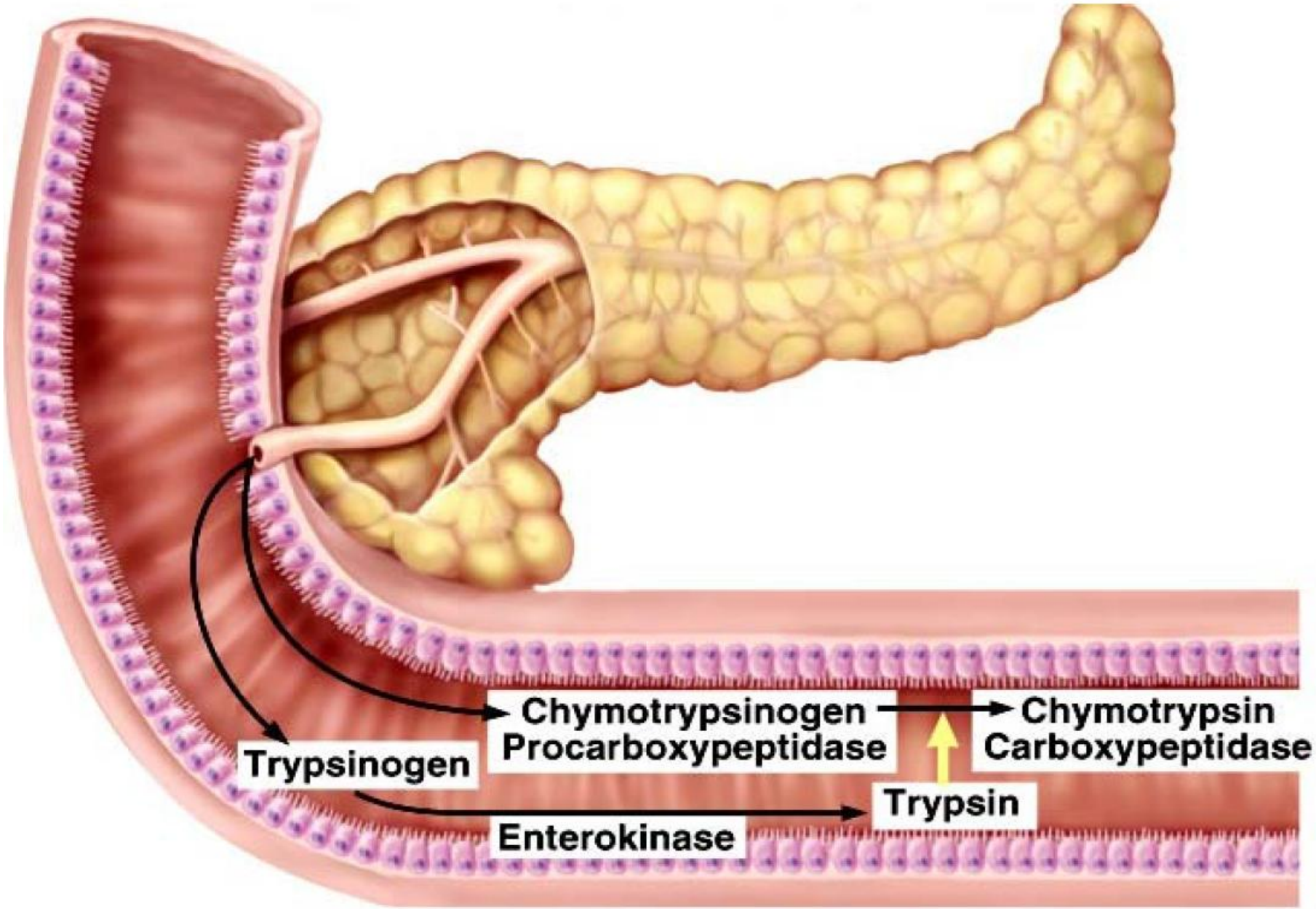
Pancreatic Juice

- Acinar cells exocytose **pancreatic juice** into the pancreatic duct which flows into the duodenum
- Pancreatic juice contains:
  - **pancreatic amylase** hydrolyzes carbohydrates
  - **pancreatic proteases** hydrolyze proteins
    - –secreted as **zymogens**
  - **pancreatic lipase** hydrolyzes lipids
  - **pancreatic nucleases** hydrolyze nucleic acids
  - **bicarbonate** (HCO_3^-)
    - a buffer secreted by duct cells that neutralizes the gastric acid, raising the pH to 8.0 (optimal for both pancreatic and intestinal enzymes)

Pancreatic Zymogens

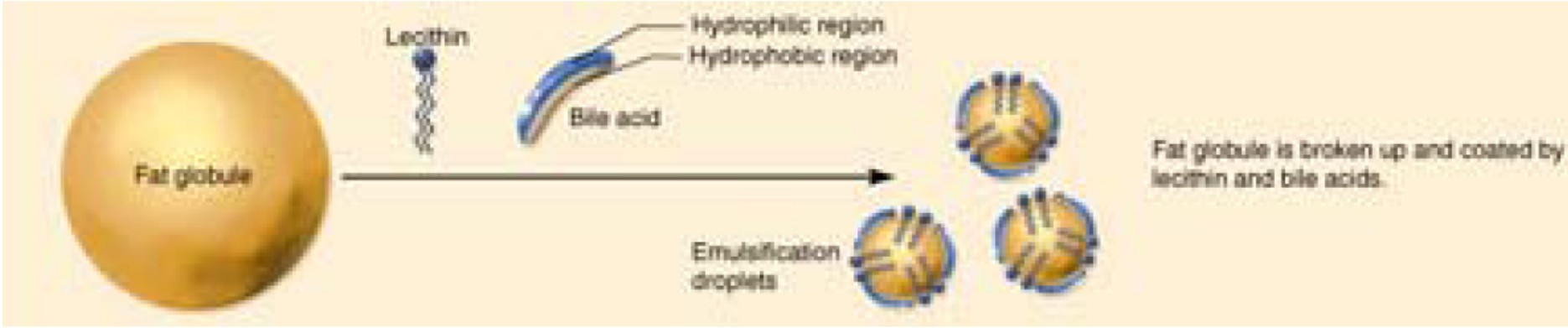
- The pancreatic zymogens include:
  - trypsinogen
  - chymotrypsinogen
  - procarboxypeptidase
- The zymogens are converted to their active form by a series of biochemical reactions initially catalyzed by the duodenal brush-border enzyme **enterokinase**
  - enzymatically hydrolyzes trypsinogen to **trypsin**
    - trypsin then activates the other 2 zymogens
      - chymotrypsinogen to **chymotrypsin**
      - procarboxypeptidase to **carboxypeptidase**

Activation of Pancreatic Zymogens



Liver and Gallbladder

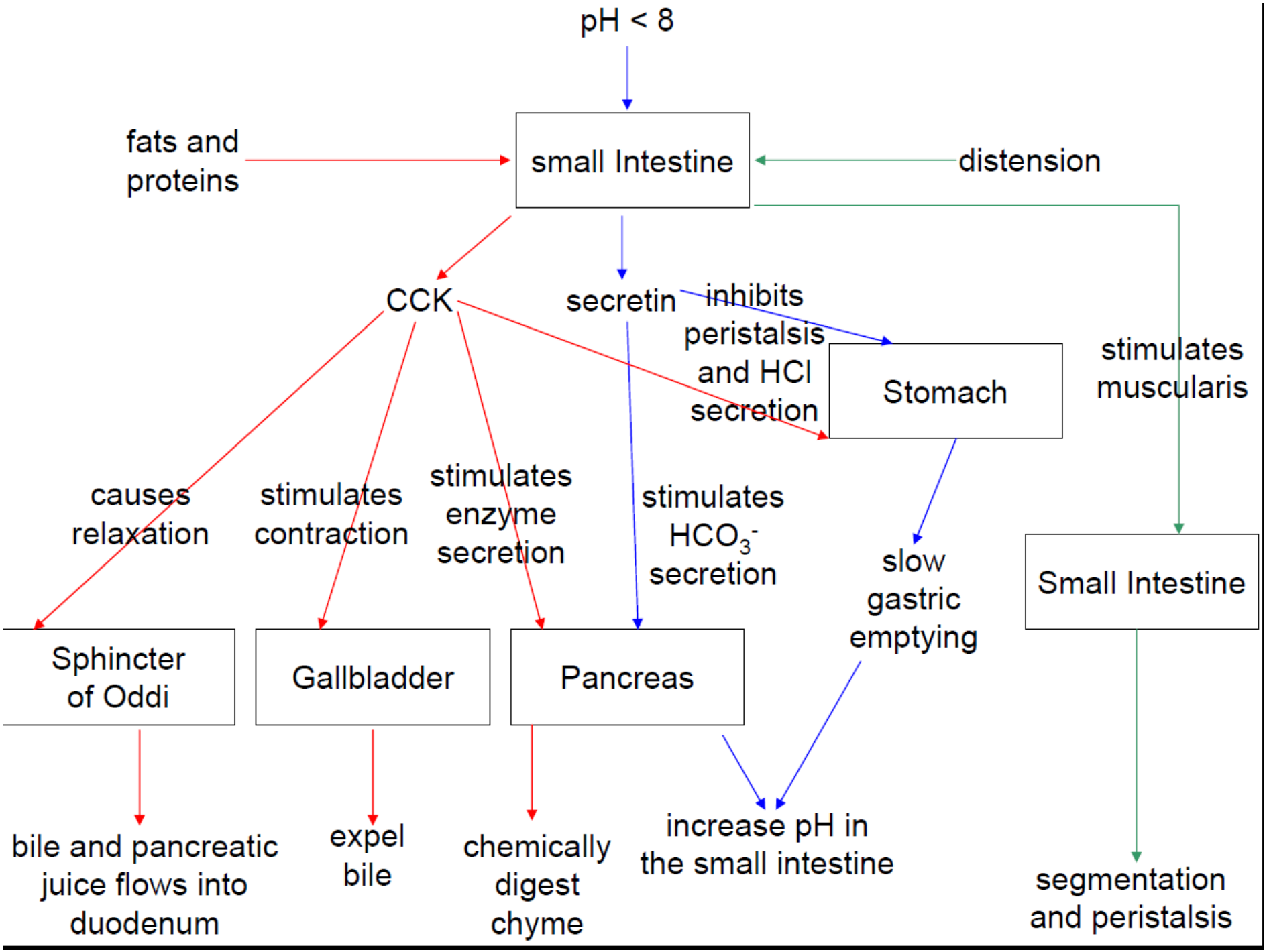
- Hepatocytes of the liver secrete **bile** into the hepatic ducts leading to the gallbladder
  - composed of bile acids and phospholipids
  - a *detergent* which causes fat **emulsification**
    - –increases the surface area of fat globules
      - increases of lipid hydrolysis by lipase



- **Gallbladder**
  - – a muscular sac that **stores** bile secreted from the liver when the sphincter of Oddi is closed

Hormonal Control of Intestinal Phase

- The presence of acidic chyme in the small intestine causes the secretion of the intestinal hormone secretin
  - stimulates the secretion of pancreatic **bicarbonate**
- The presence of fatty acids and peptides in the chyme in the small intestine causes the secretion of the intestinal hormone CCK
  - stimulates the secretion of pancreatic enzymes
  - stimulates the contraction of the gallbladder to squeeze the bile into the bile duct
  - relaxes (**opens**) the sphincter of Oddi, allowing the entry of pancreatic juice and bile into duodenum
- Both secretin and CCK inhibit HCl secretion from parietal cells and inhibit the muscularis of the stomach thus limiting the rate of acidic chyme movement into the small intestine

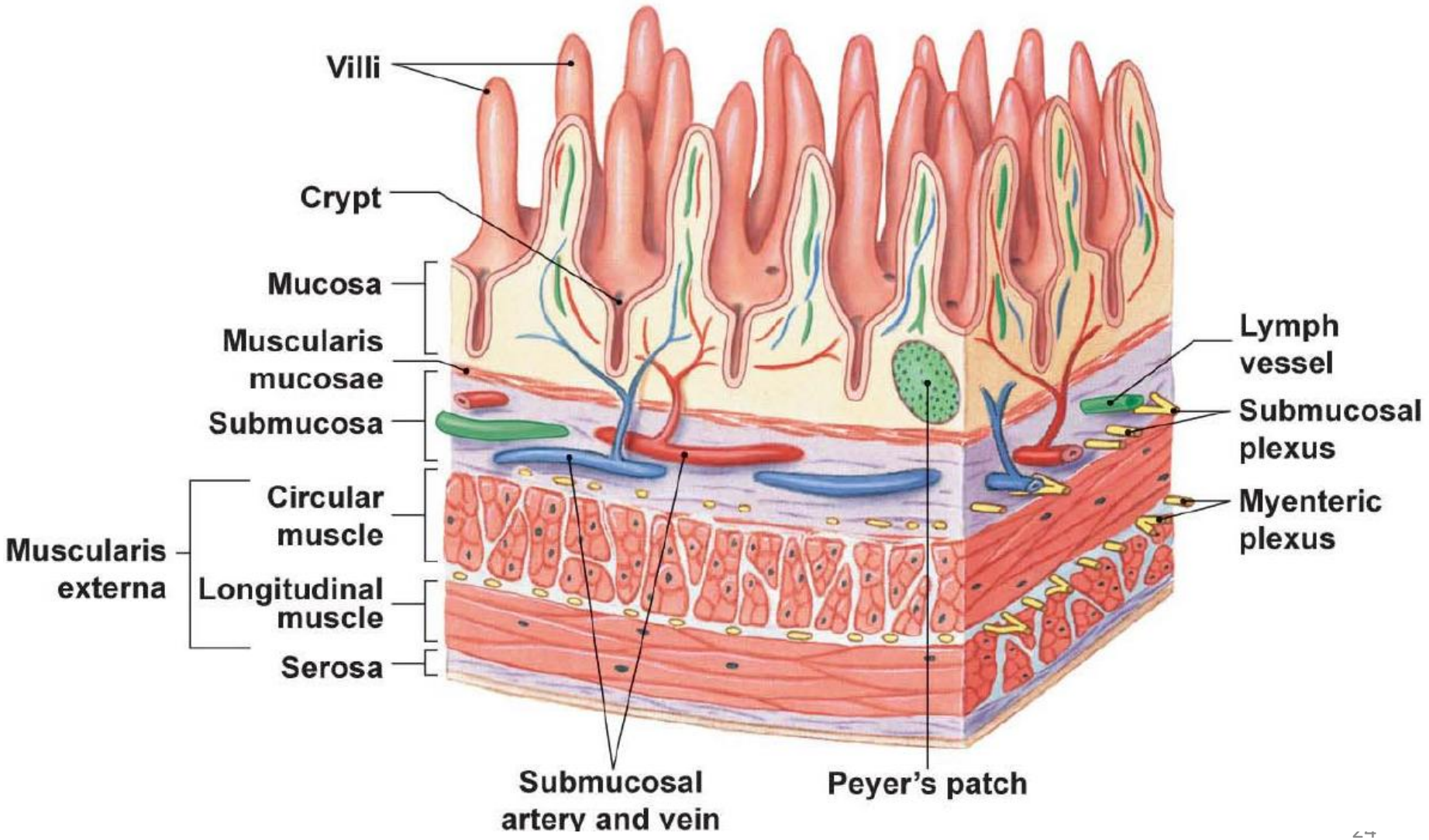

pH < 8
fats and proteins
small Intestine
distension
CCK
secretin
inhibits peristalsis and HCl secretion
Stomach
stimulates muscularis
causes relaxation
stimulates contraction
stimulates enzyme secretion
stimulates HCO_3^- secretion
slow gastric emptying
Small Intestine
Sphincter of Oddi
Gallbladder
Pancreas
bile and pancreatic juice flows into duodenum
expel bile
chemically digest chyme
increase pH in the small intestine
segmentation and peristalsis

Small Intestinal Mucosa

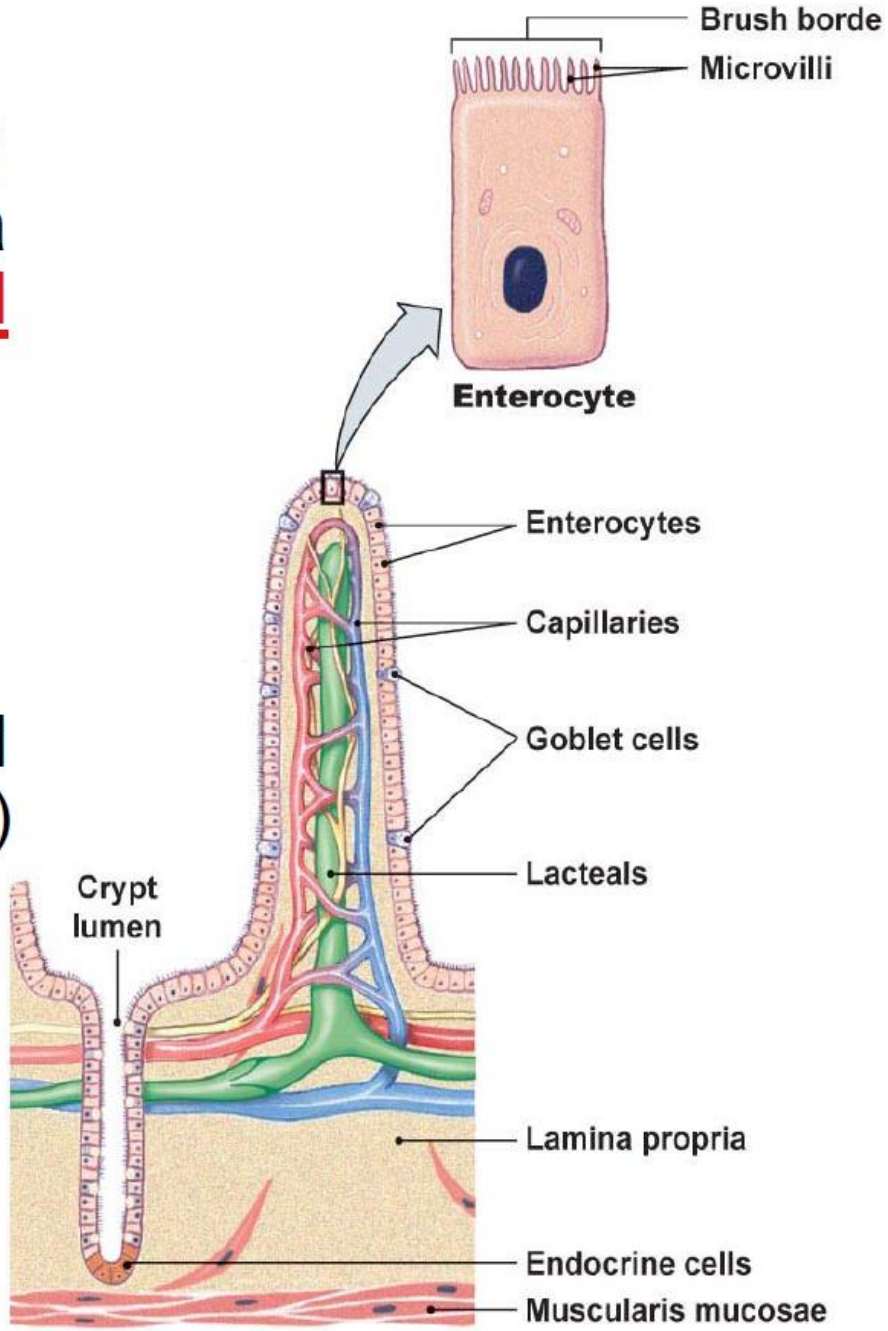
Structural modifications of the mucosa increase the amount of surface area for digestion and absorption

- When the small intestine is empty, the mucosa is folded into structures called plicae or circular folds
  - when filled, the expanded wall of the small intestine causes these folds to disappear (flatten)
- Intestinal mucosa also projects into the lumen in small fingerlike structures called villi
- Tubular invaginations (depressions) of the surface epithelium that extend down into the supporting connective tissue of the small intestine are called crypts

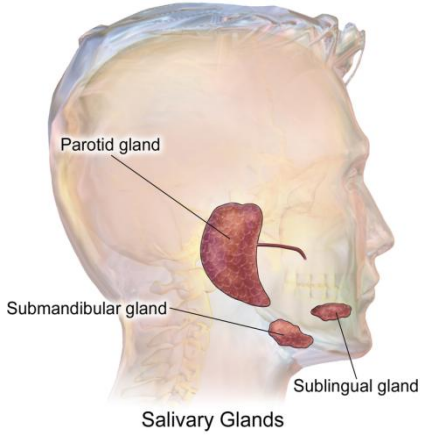
Sectional View of Small Intestine



- Individual epithelial cells of the small intestinal mucosa have a highly folded **apical cell membrane**
  - each fold is called a **microvilli** and increase the number of integral membrane proteins for digestion (enzymes) and absorption (transporters) that can be exposed to the lumen
  - aka the brush border for its bristle-like appearance



Digestion of Carbohydrates

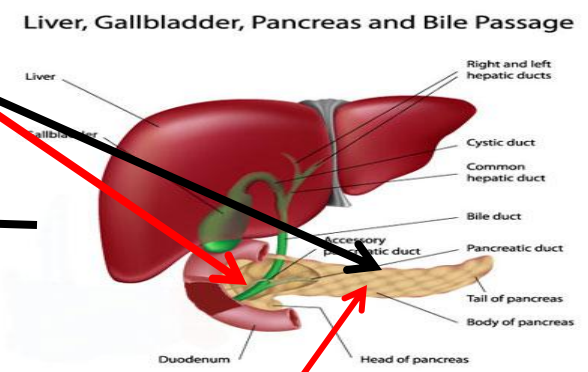


No digestion of CHO in the stomach

Oral cavity

Duodenum

CCK

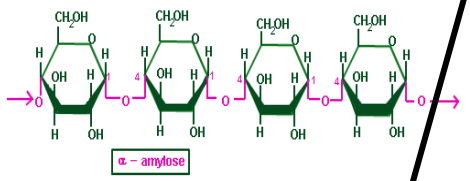


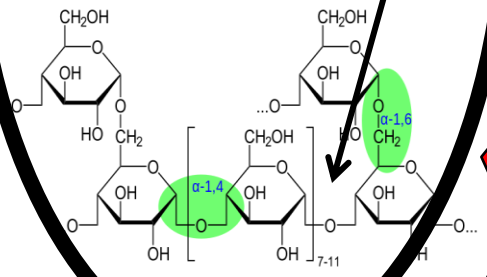
Aciner cells

Salivary α –Amylase (Ptyalin)

Pancreatic amylase

1 -4 glucosidic bonds





Maltose

Maltotriose

Sucrose

α-Limit Dextrins

Brush Border Enzymes:

- *Maltase (Glucoamylase)*
- *Lactase*
- *Sucrase*
- *Isomaltase*