

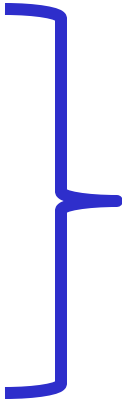
The Digestive System



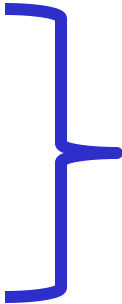
6.1.1 Why digest food?

Food consists of:

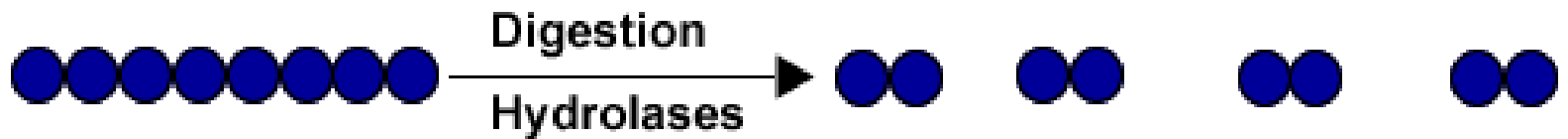
- Carbohydrates
- Lipids
- Proteins
- Nucleic acids
- Minerals
- Vitamins
- Water



These are large, insoluble polymer molecules. They must be digested into monomers small enough to pass through the cell membrane of the cells lining the digestive tract so they can be absorbed in to the blood stream

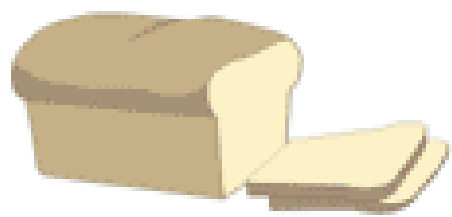


Can be absorbed directly (because of small size), so do not need to be “digested”

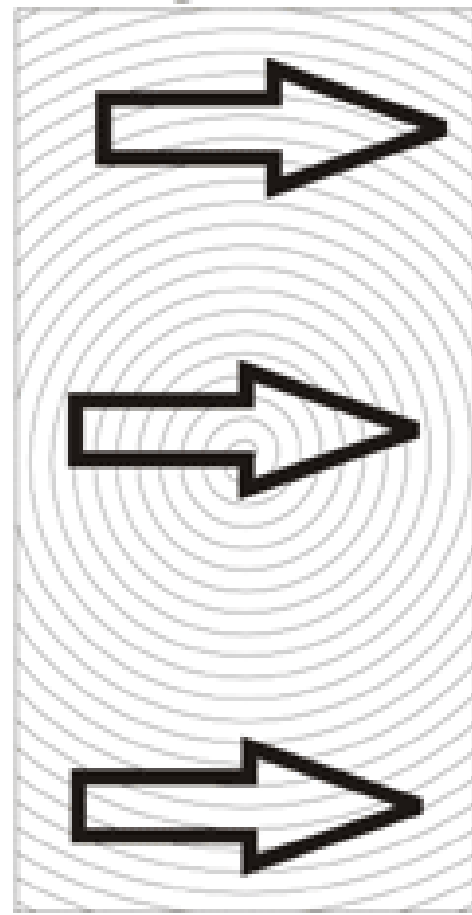


Insoluble food molecule

Soluble Products



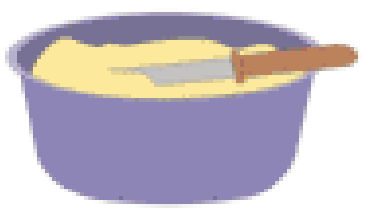
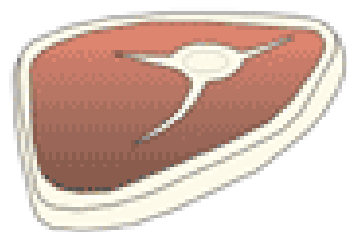
digestion



glucose

amino acids

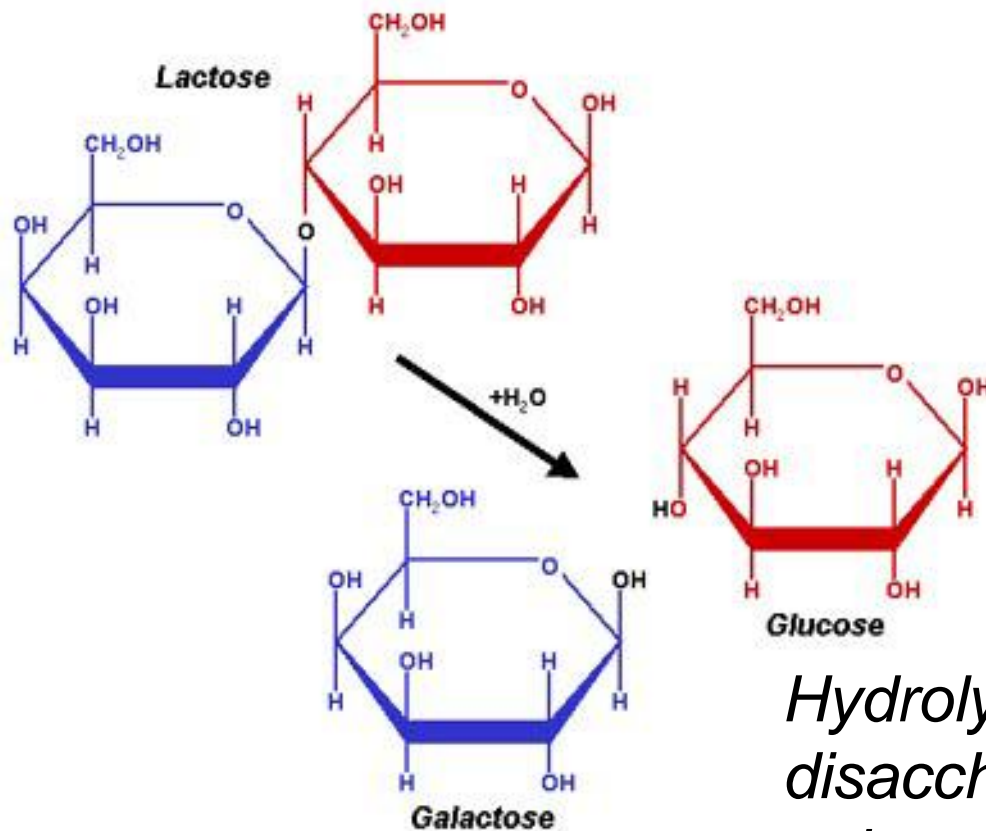
fatty acids



6.1.2 Enzymes and digestion

- Digestion involves **hydrolysis** of food molecules

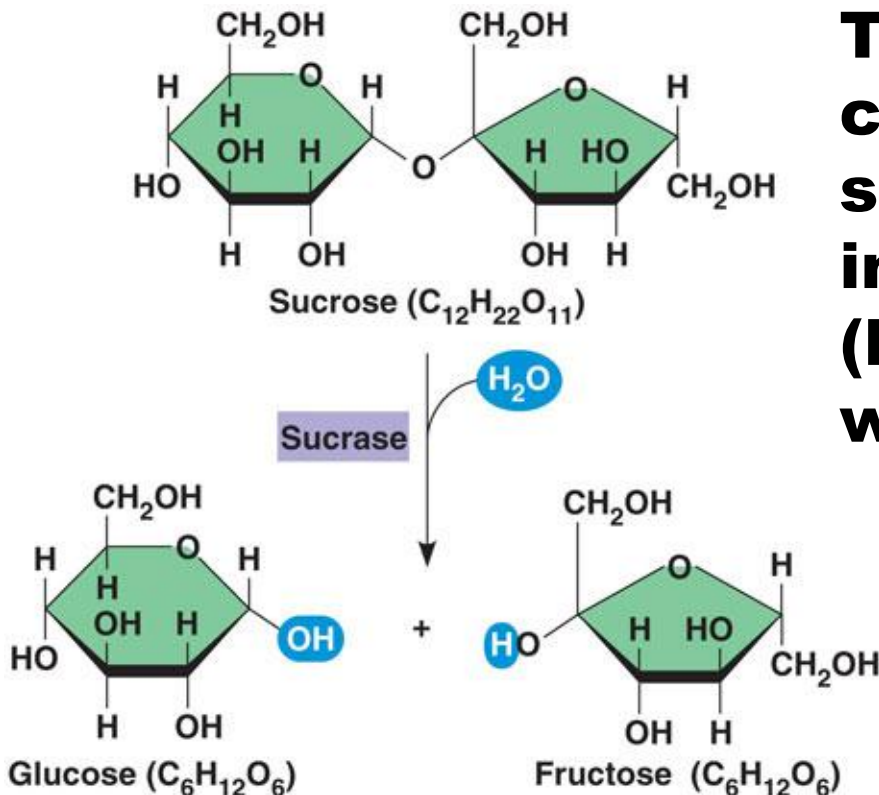
***breaking
apart
molecules by
adding water***



Hydrolysis of lactose (a disaccharide) into glucose and galactose (both monosaccharides) with the addition of water

- Digestive enzymes **catalyze** the hydrolysis of insoluble food molecules to soluble end products

→ Increase the rate



The enzyme sucrase catalyzes the hydrolysis of sucrose (a disaccharide) into glucose and fructose (both monosaccharides) with the addition of water

6.1.2 Enzymes and digestion

Digestive Enzymes

Break down complex substances into simpler substances that can be absorbed by the body

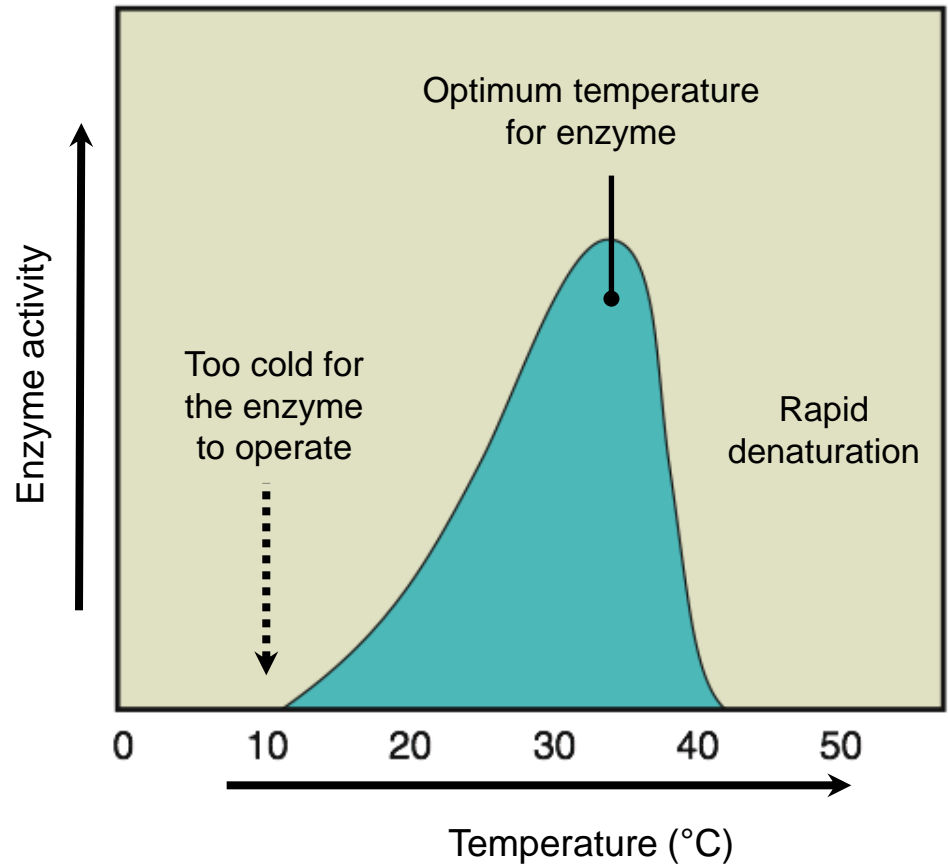
Complex proteins → **Amino acids**

Complex sugars → **Glucose**

Fat molecules → **Fatty acids**

Digestive enzymes work best at 37⁰ C (body temp)

- Reactions occur faster at higher temperatures, but the rate of denaturation of enzymes also increases at higher temperatures.
- High temperatures break the bonds important for the tertiary structure of the enzyme.
- This destroys the active sites and therefore makes the enzyme non-functional.



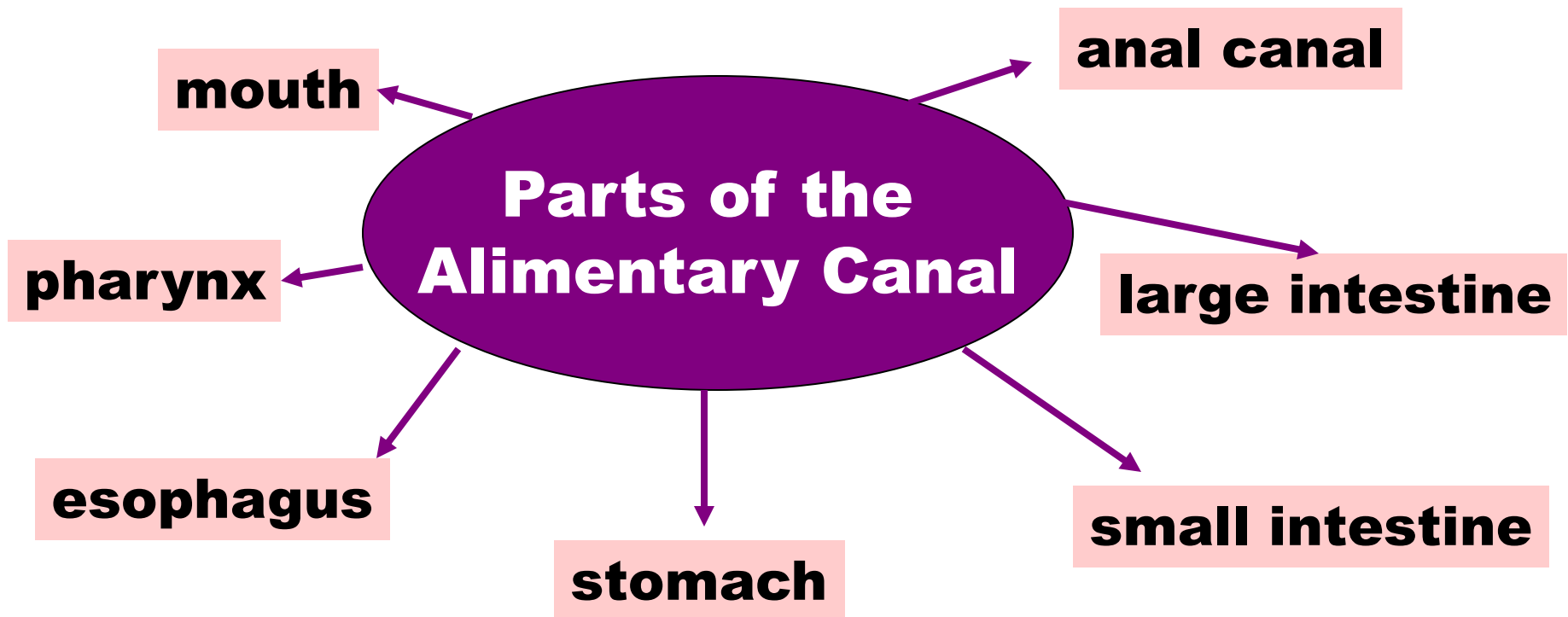
6.1.3 Examples of digestive enzymes

Class of Enzyme	Example	Source	Substrate	Product	Optimal pH
Amylase digest carbohydrates	Salivary amylase	Salivary glands	Starch	Maltose (disaccharide)	7-8
Protease digest proteins	Pepsin	Stomach cells	polypeptides	Shorter polypeptides	2-3
Lipase digest fats	Gastric lipase	Stomach cells	triglyceride	Glycerol and 3 fatty acids	2-3

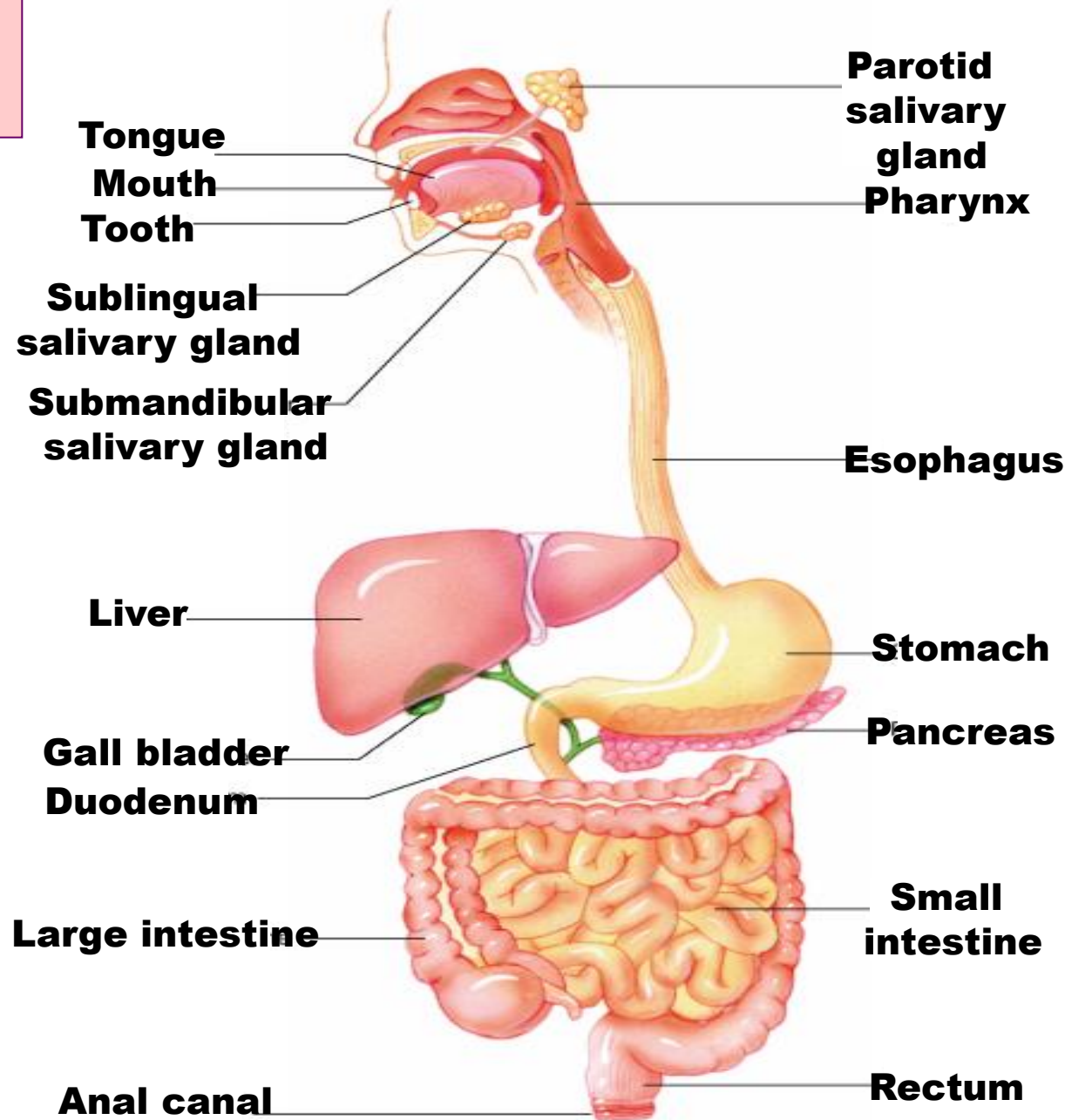
6.1.4 Digestive System

The Digestive System

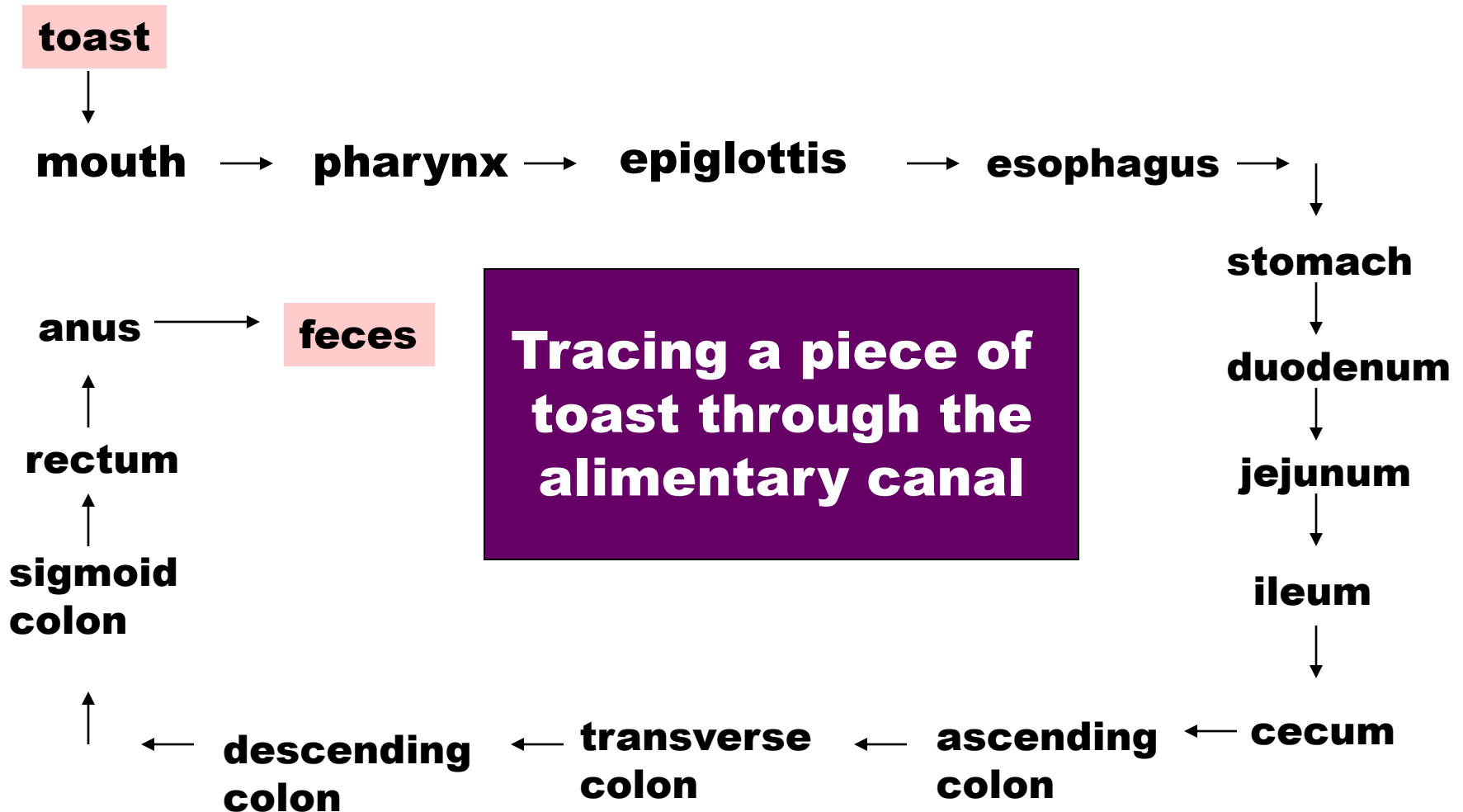
Consists of the **alimentary canal** (the long tube) and several accessory organs.



Organs of the Digestive System



Structure and Function



Animation of digestive system

6.1.5 Function of the Stomach

1. Mechanical Digestion

- Muscle contractions break apart and mix food

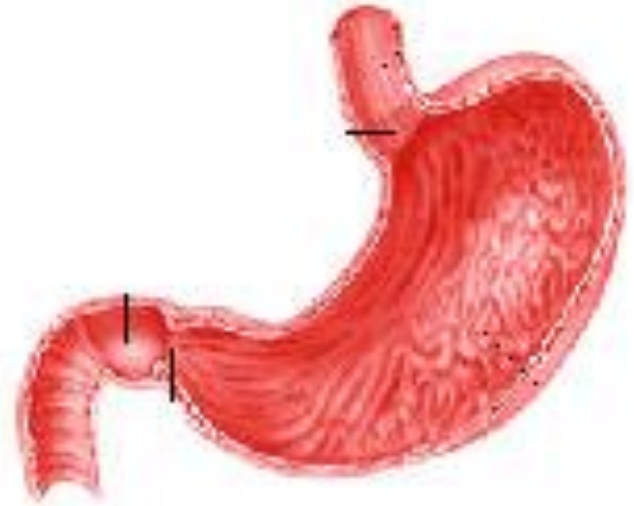
• bolus → chyme

↓
Mass of solid food

↓
Semi-fluid mass of partly digested food

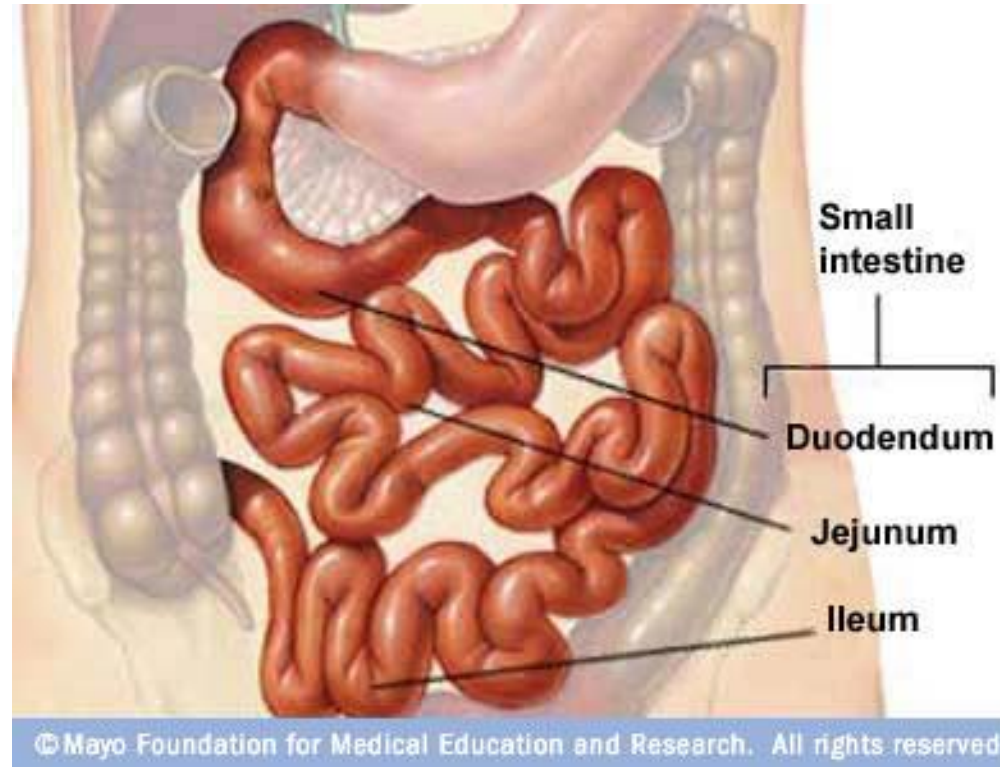
2. Chemical Digestion

- Enzymes and HCl digest chyme



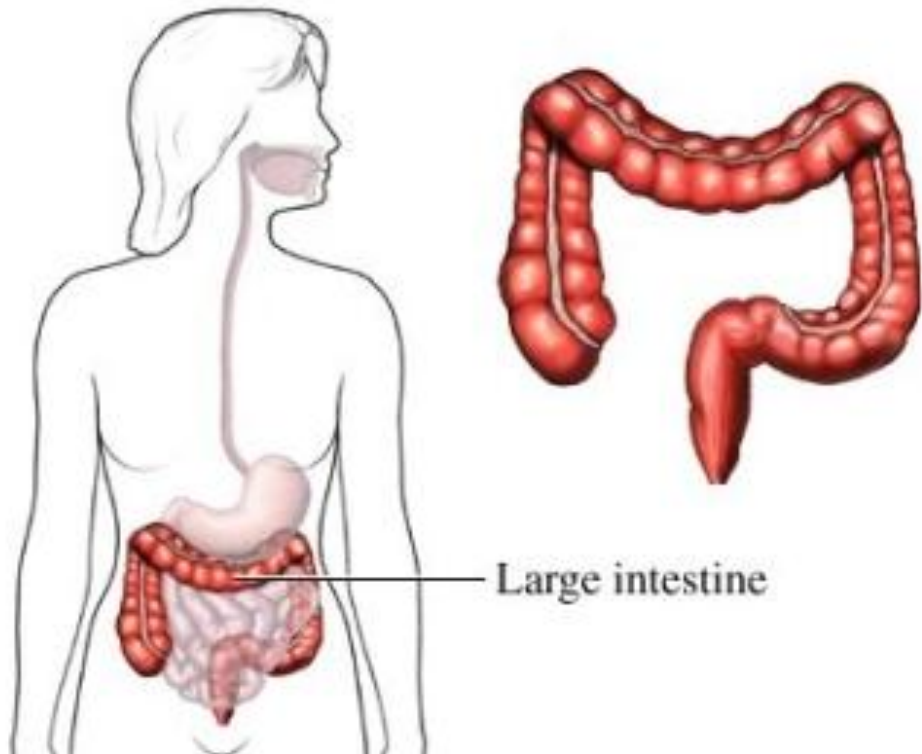
6.1.5 Function of the Small Intestine

1. Digestion by enzymes in the duodenum (first 50 cm)
2. Absorption of nutrients into the blood stream (see 6.1.7)



6.1.5 Function of the Large Intestine

Removes water and minerals



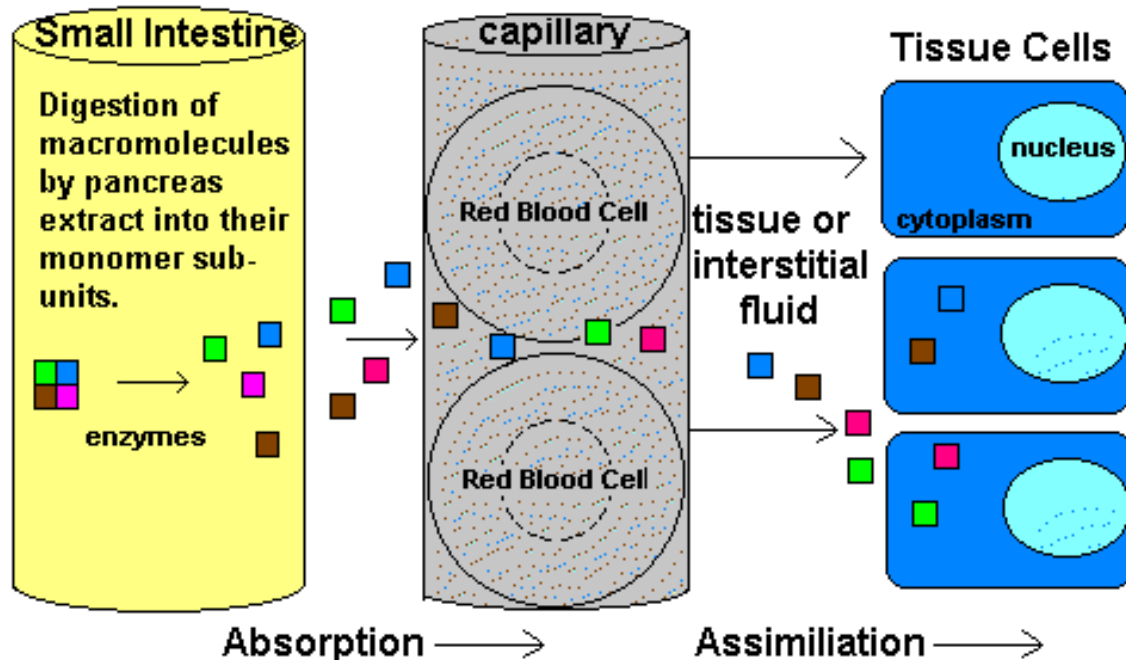
6.1.6 Absorption and Assimilation

ABSORPTION

Transport of molecules from the intestine to the blood stream

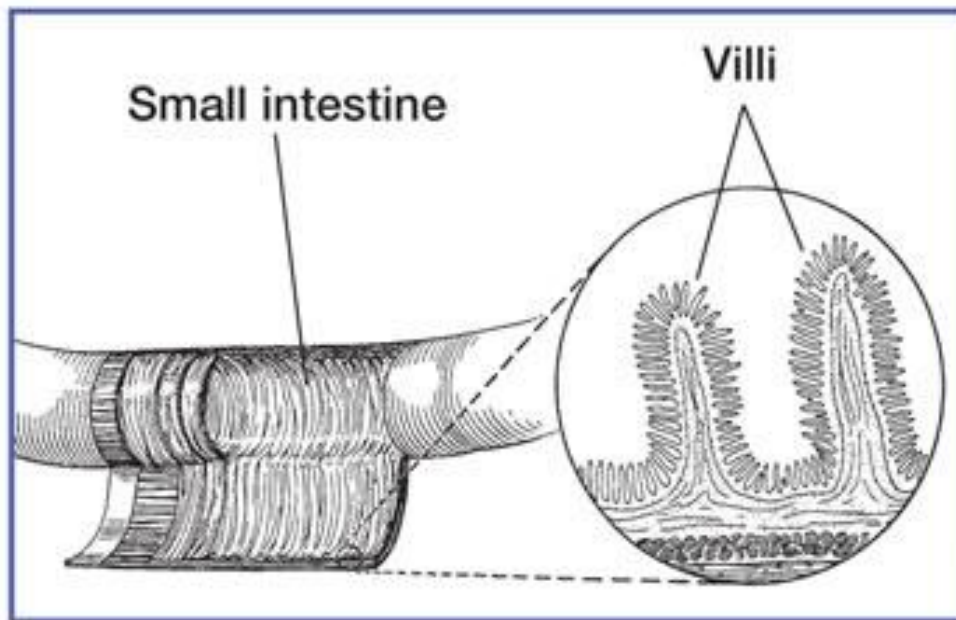
ASSIMILATION

Incorporation of molecules from the blood stream into cellular structures



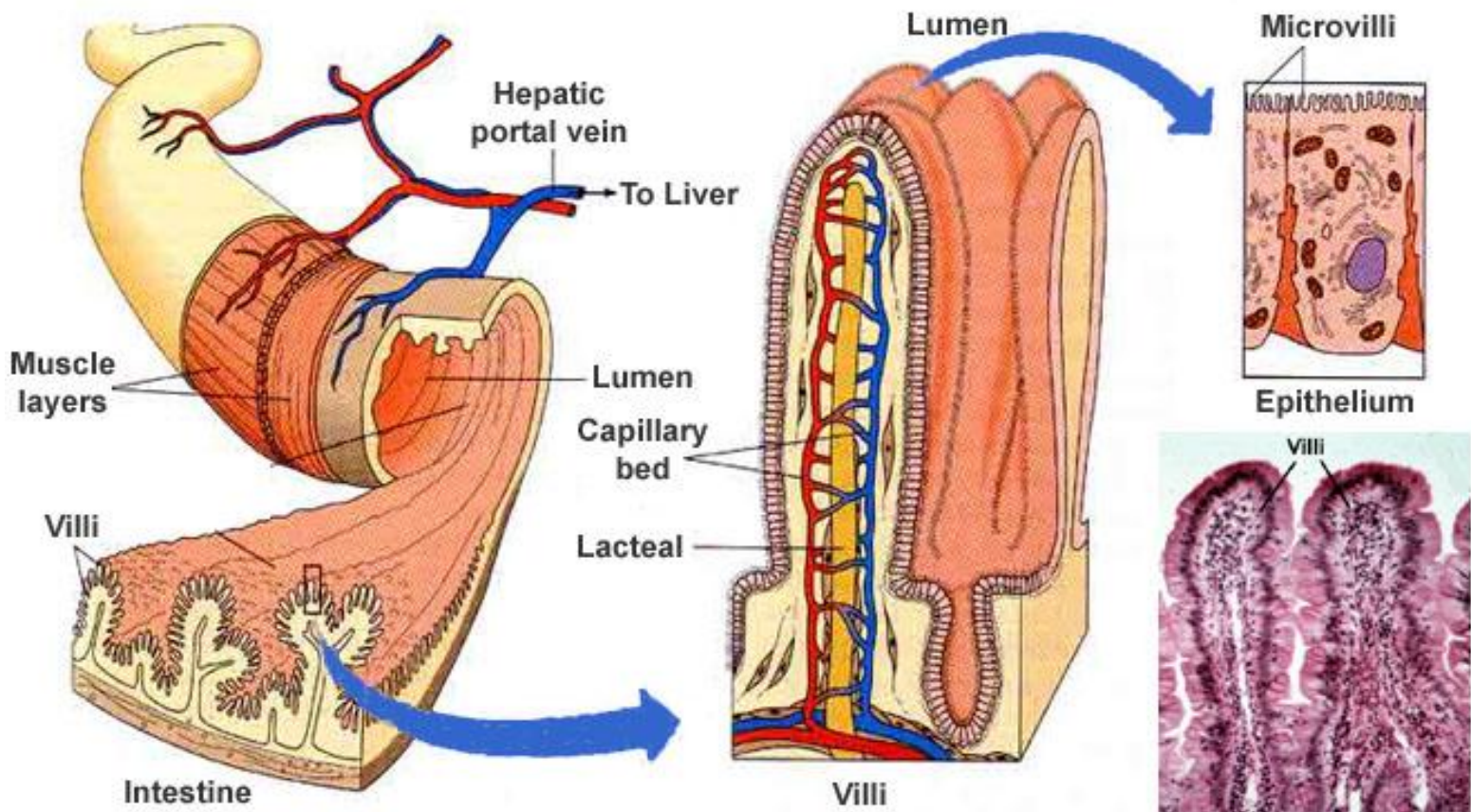
6.1.7 Structure of Villus

The small intestine has large folds which increase the surface area for absorption. One finger-like projection is called a villus (plural: villi).



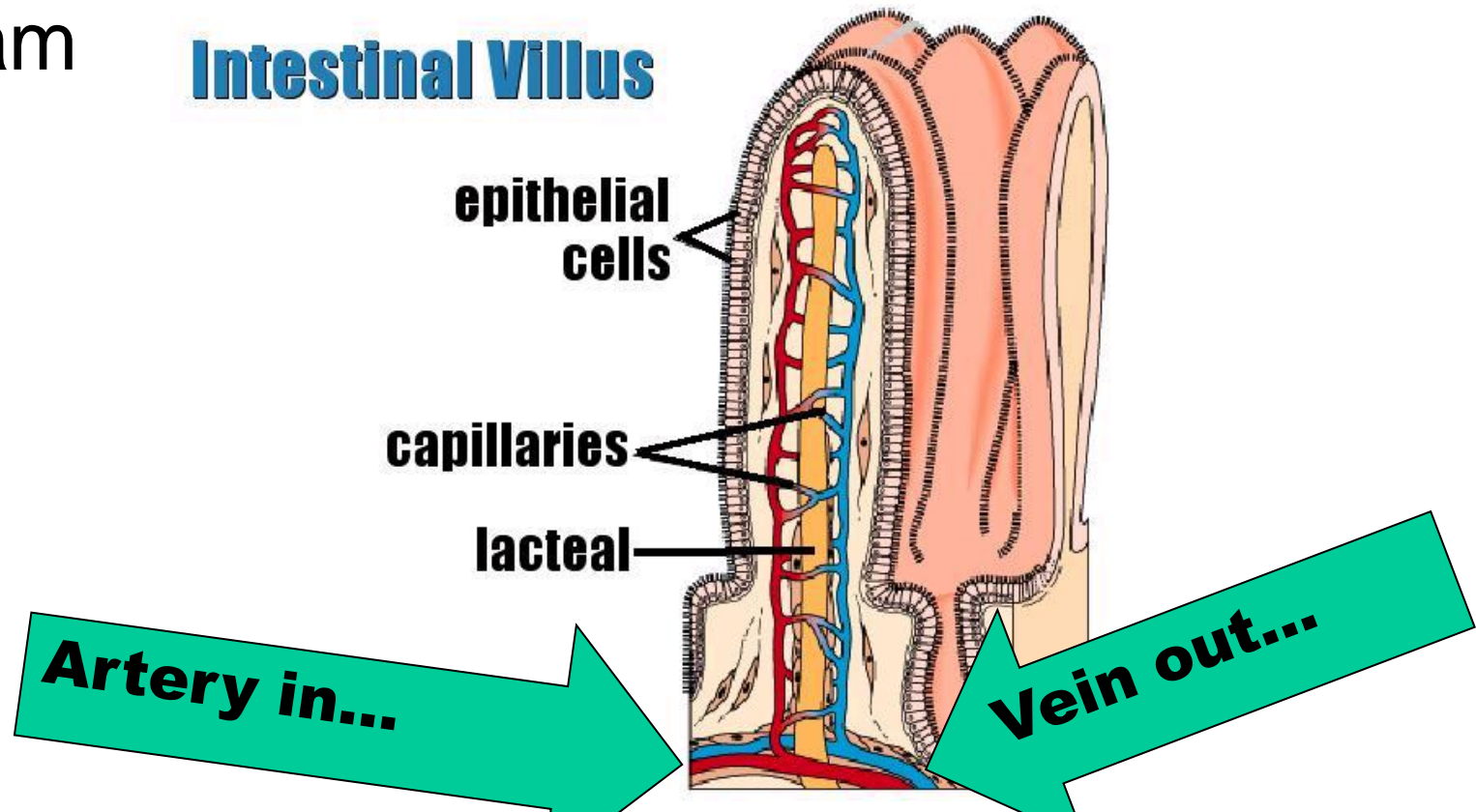
6.1.7 Structure of Villus

A single layer of epithelial cells line the villi. These cells have **microvilli** that increase the surface area for absorption



6.1.7 Structure of Villus

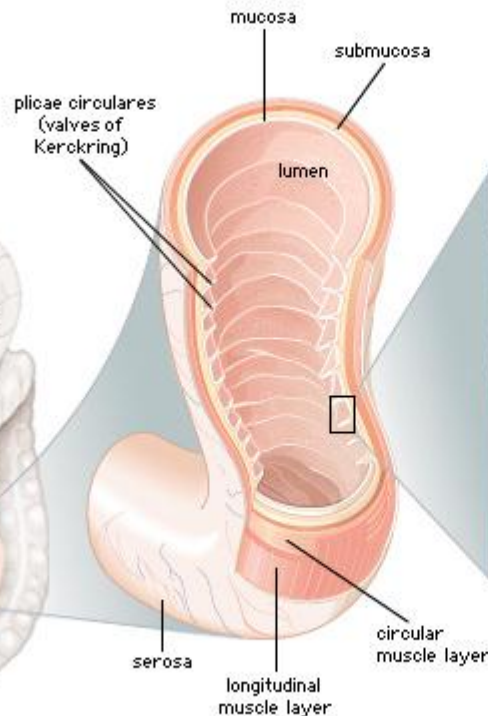
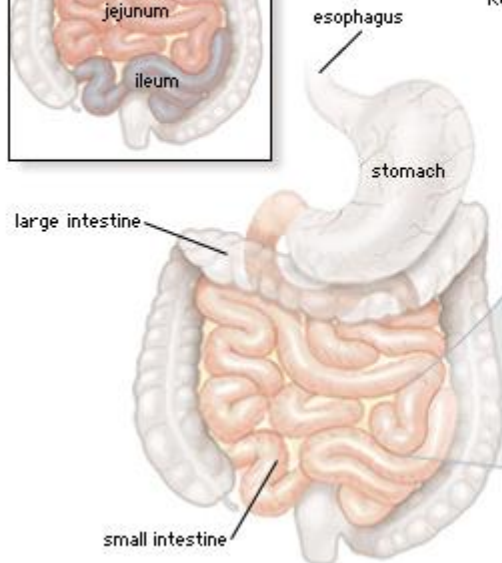
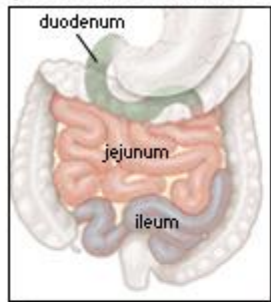
Each villus has a capillary bed that **absorbs** small molecules from the small intestine and **transport** the molecules in the blood stream



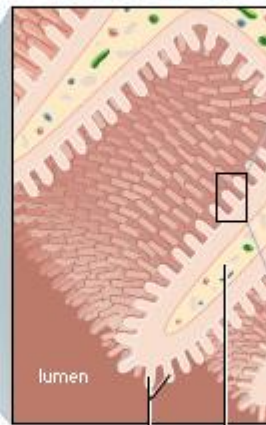
6.1.7 Structure of Villus

The **lacteal** absorbs fats that pass through the villi epithelium.

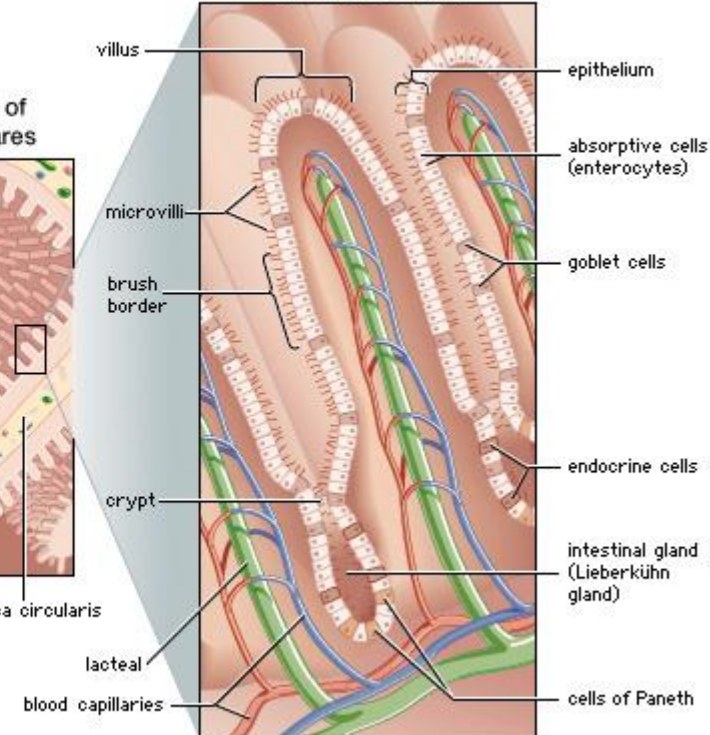
Regions of the small intestine



Enlargement of plicae circulares




Structure of a villus



H.2.1 Digestive Juices and Glands

- **EXOCRINE** glands are different than **ENDOCRINE** glands



Secrete **other stuff** (sweat, oil, wax, enzymes etc) into **ducts** (a pipe or tube)



Secrete **hormones** directly into the **blood stream**

Digestive “Juices” are...

- ENZYMES
- Good time to review
- Catalyst
- Lower activation energy
- In the case of digestion, this is catabolic rxns

- Salivary glands in the mouth
 - Secrete amylase
 - Breaks starch (polysaccharide) into maltose (disaccharide)
- Gastric glands in the stomach wall
 - Secrete pepsin
 - Break proteins into smaller polypeptide chains
- Pancreas
- Glands in the wall

Pancreatic Amylases (Amylose to Maltose)
 Trypsin (Protein to Polypeptides) Endopeptidase
 Chymotrypsin (Protein to Polypeptides)
 Endopeptidase
 Amino/ carboxypeptidases both are Exopeptidases

Carbohydrases (maltase, sucrase, lactase)
 Dipeptidases (DIpeptides to Amino Acids)
 Enterokinase

H.2.2 Structure of Glands

- Exocrine glands contain a glandular portion and a duct portion.



- **Secretory cells** form a single layer around the **duct**.
- The secretory cells release the secretion into the lumen of the duct.
- Ducts open onto surfaces such as the skin or another cavity (mouth, alimentary canal).
- [A good additional resource can be found here](#)

H.2.3 Composition of Digestive Juices

GLAND	COMPOSITION of "JUICE"
Salivary gland (mouth)	Water, salts, amylase, mucus
Gastric glands (stomach)	Water, mucus, HCl, enzymes (i.e. pepsin)
Pancreas	Water, bicarbonate (buffers acid from stomach), enzymes (i.e. amylase, lipase)
Small intestine	Enzymes (i.e. carbohydrases to break down carbohydrates)

H.2.4 Control of Gland Secretions

The activities of the digestive system are regulated by both hormones and neural reflexes.

HORMONES

- The physical presence of food in the lower region of the stomach stimulates the endocrine cells within the stomach wall to release the protein hormone “gastrin”.
- Gastrin is released into the blood and travels back to the heart and through the arteries only to return to the digestive system to induce the secretion of gastric juice.

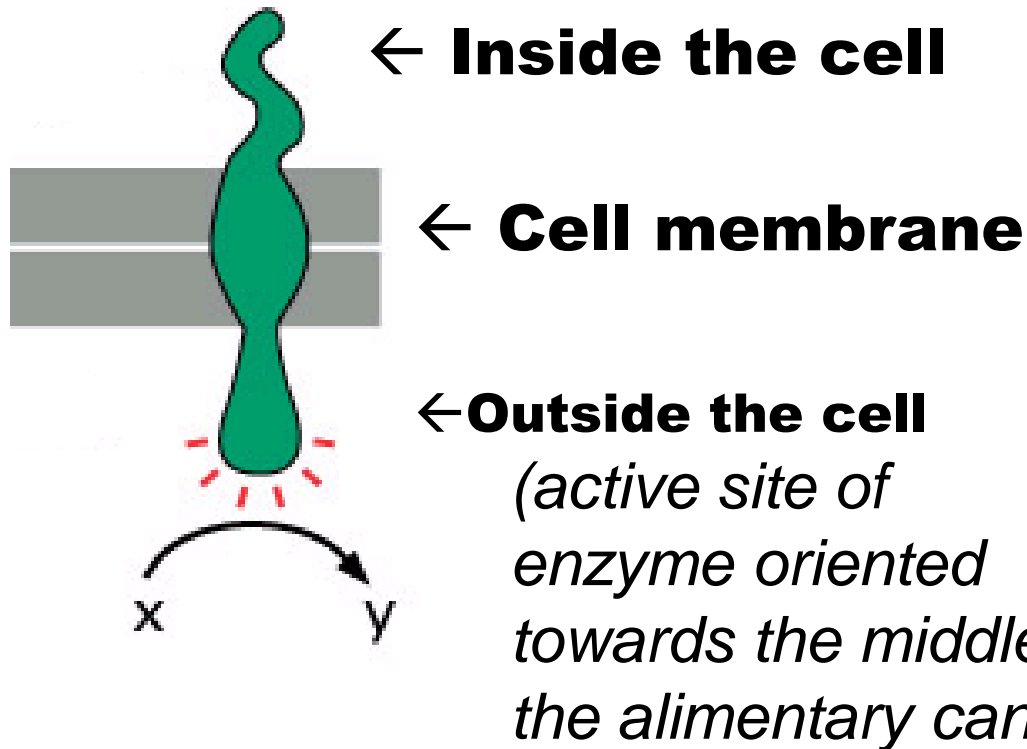
NEURAL

- Nerves come to the digestive organs from the brain or the spinal cord.
- The nervous system is triggered by the senses (touch, smell, sight, feeling...)
- The nerves release chemicals which cause the speed up or delay of the movement of food and the production of juices by the digestive organs.

H.2.5 Membrane Bound Enzymes

- Many digestive enzymes are embedded in the membrane of cells that line the digestive tract.

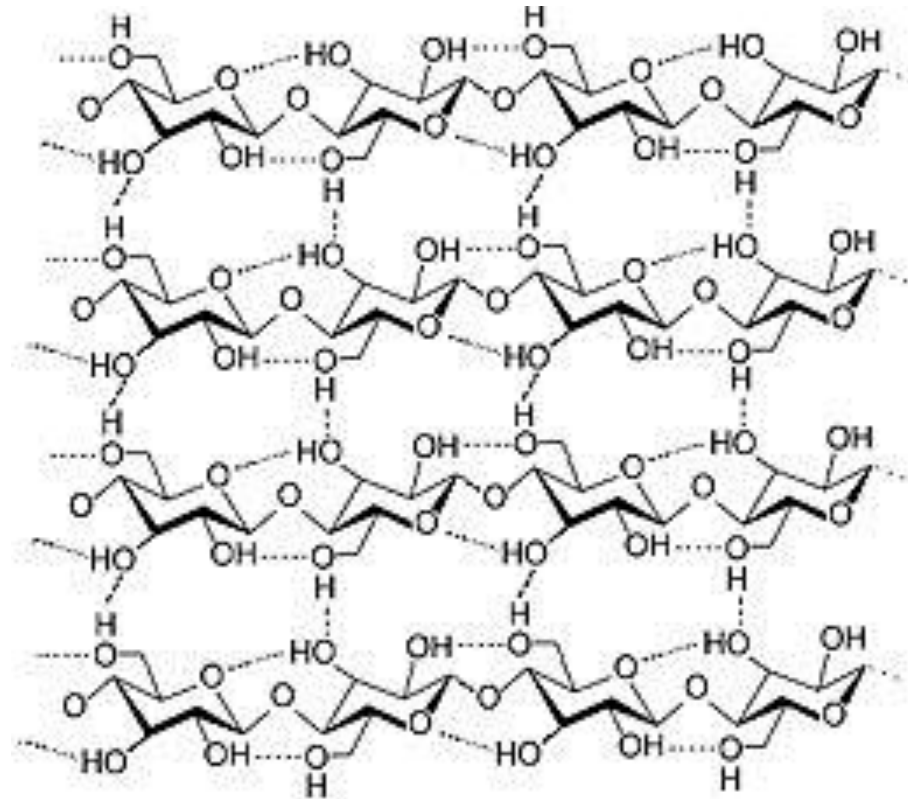
ENZYMES



Being fixed to the membrane is efficient since the enzyme is not removed (can be reused) and can be linked to secondary functions including membrane transport.

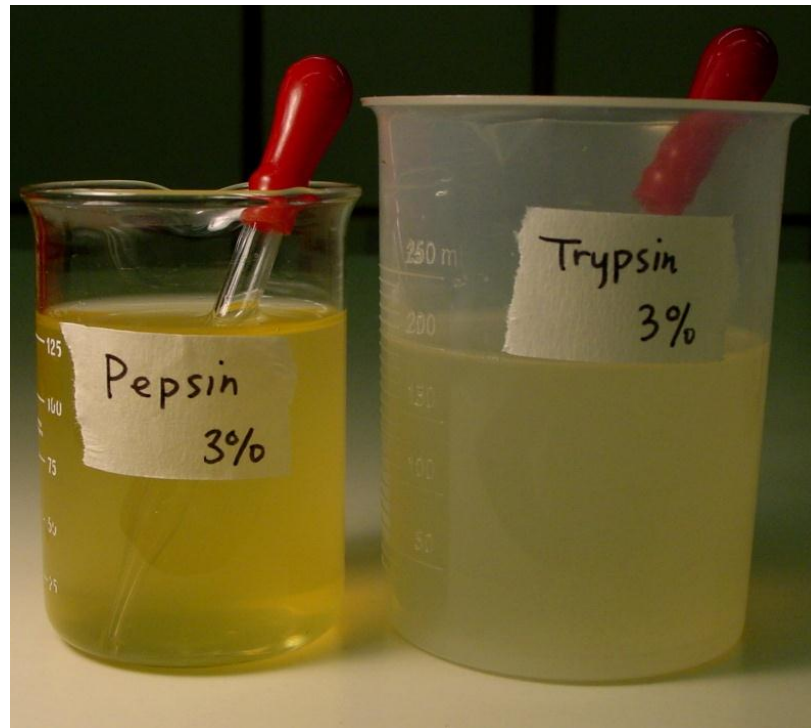
H.2.6 Cellulose Digestion

- Cellulose is the major constituent of the plant cell wall.
- Humans cannot digest cellulose.
 - We don't produce the cellulase enzymes
 - We don't carry the bacteria in the gut which produce cellulase (like cows do)
- Cellulose remains undigested and is part of feces



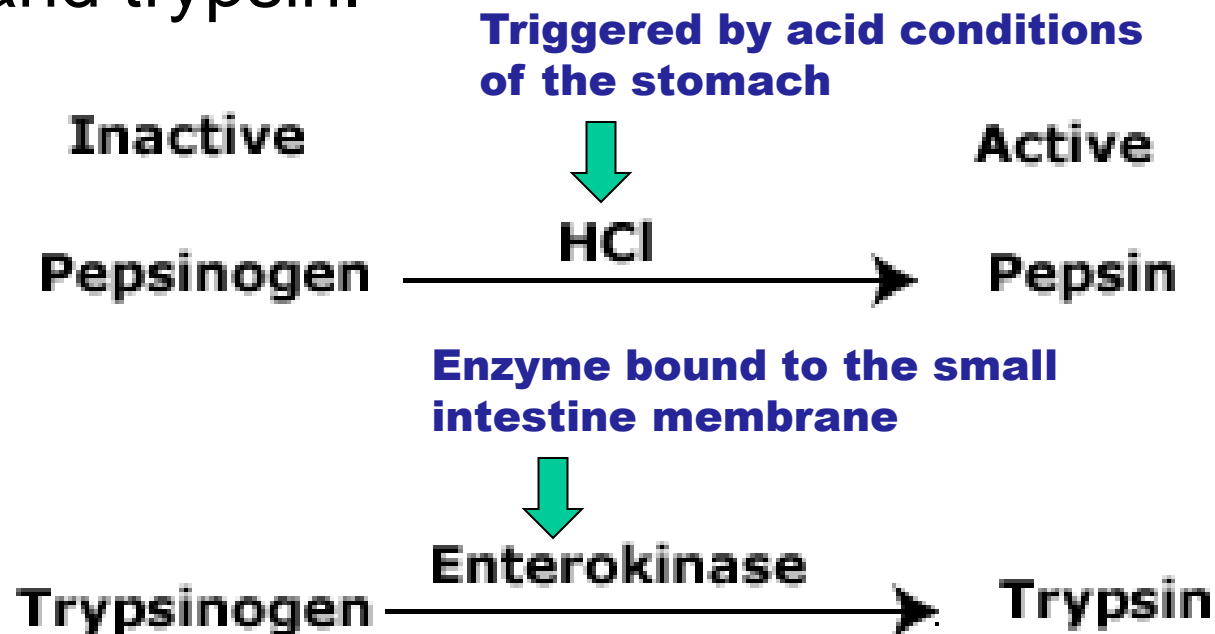
H.2.7 Pepsin and Trypsin

- Pepsin and trypsin are both protease enzymes (they break proteins into smaller amino acid strands)
 - Pepsin is produced by stomach exocrine cells
 - Trypsin is produced by pancreas exocrine cells



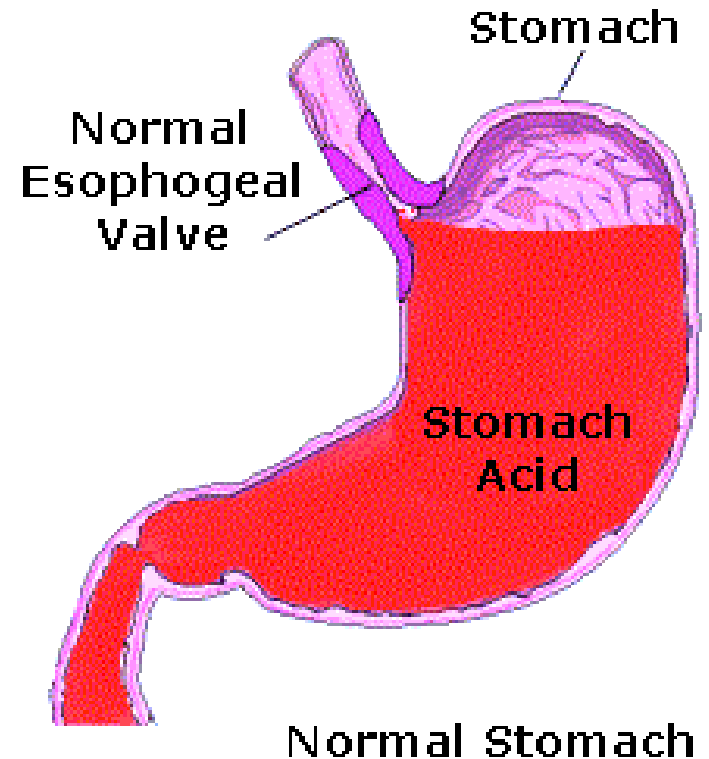
H.2.7 Pepsin and Trypsin

- Both are initially synthesized as inactive precursors.
- Both are chemically altered after secretion to produce the active forms of the enzyme.
- This prevents self digestion of the cells that produce pepsin and trypsin.



H.2.8 Stomach Ulcers and Cancer

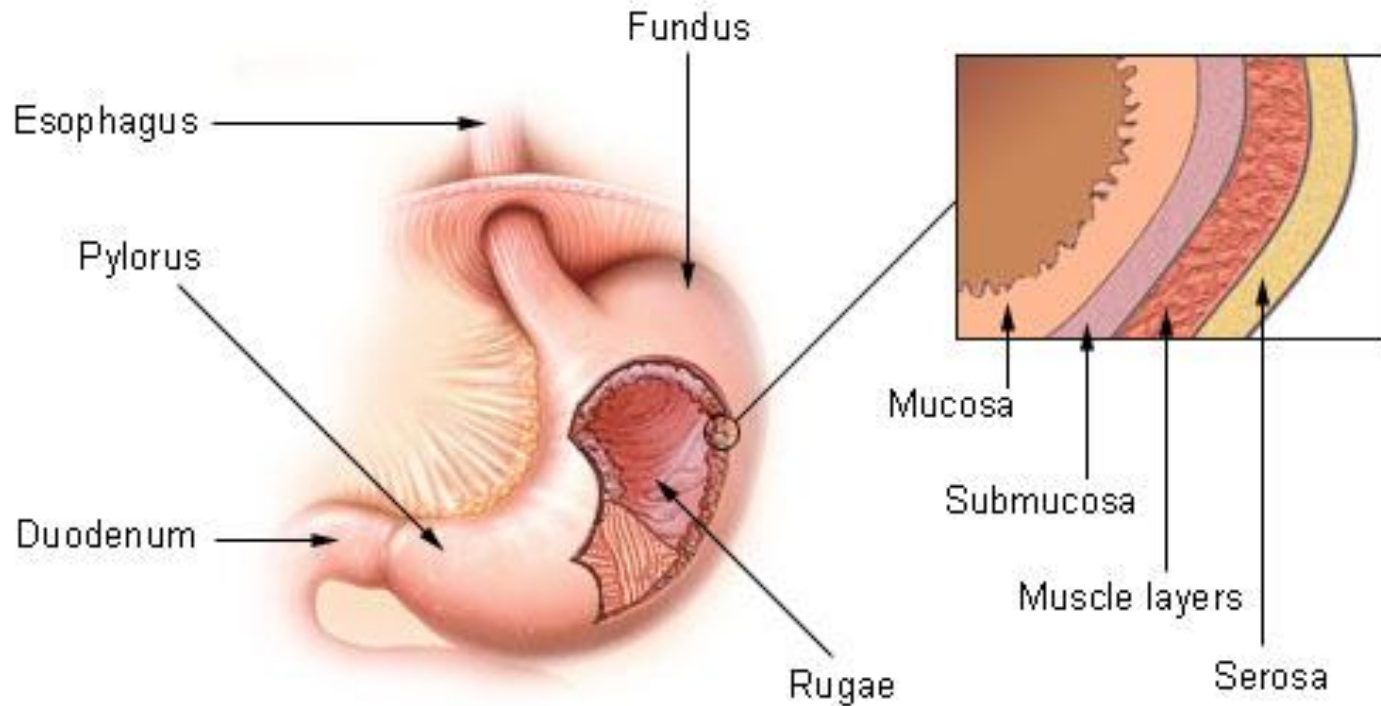
- The stomach has an acidic environment caused by the secretion of HCl.
 - The acid is a barrier to infection from microorganisms ingested with food.



H.2.8 Stomach Ulcers and Cancer

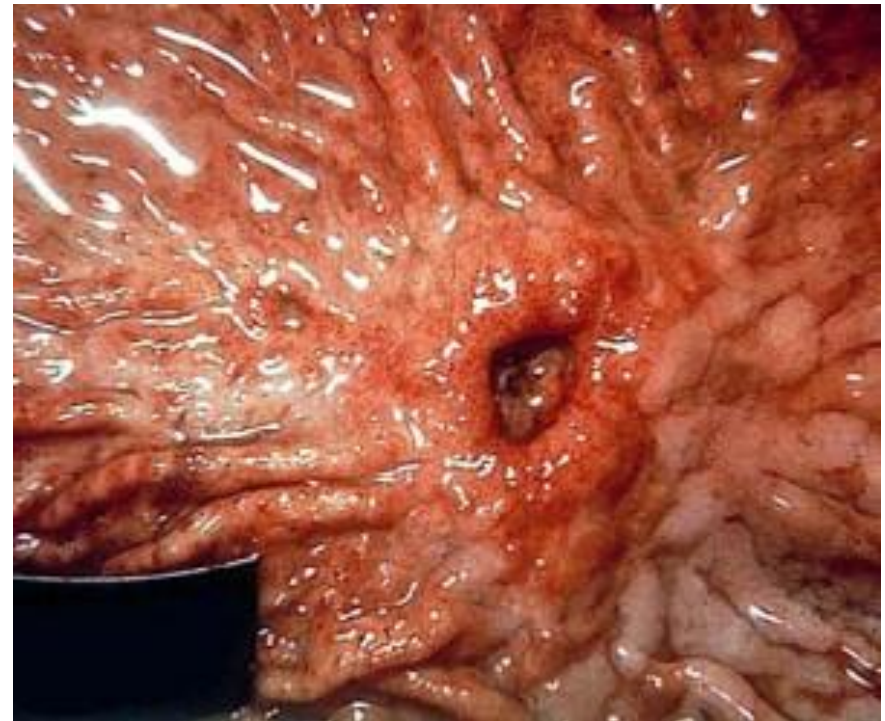
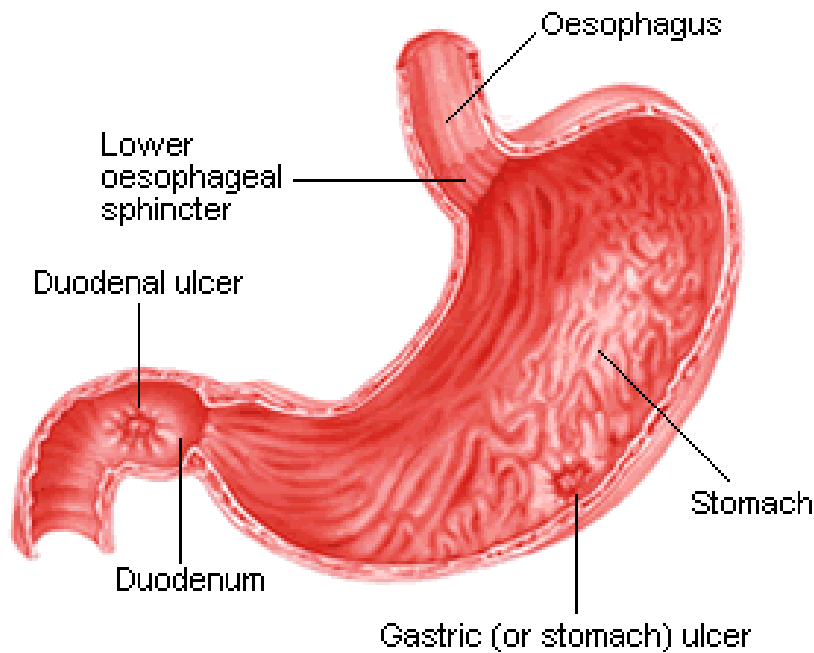
- To protect the stomach wall from its own acid and digesting enzymes, a mucus lining covers the surface.

Stomach



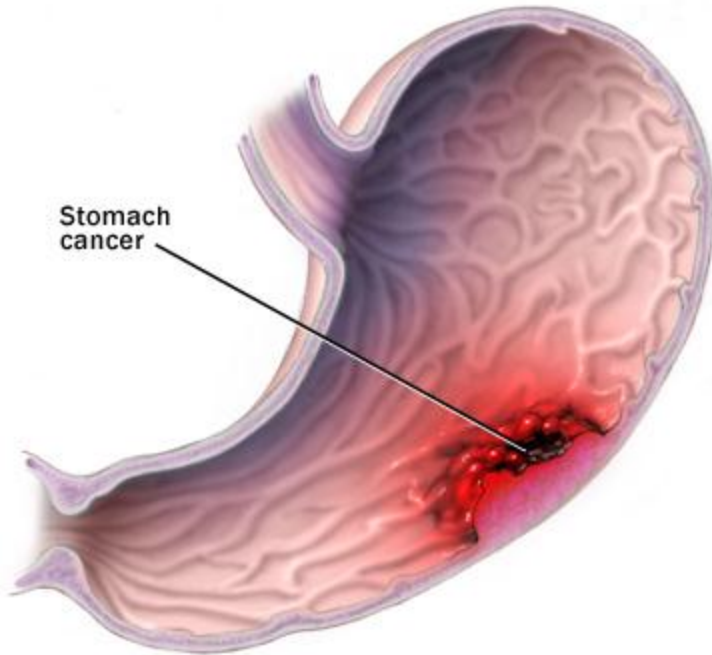
H.2.8 Stomach Ulcers and Cancer

- Stomach ulcers are areas where the mucus layer has eroded, leaving the stomach muscle layers unprotected and exposed to gastric acids and digestive enzymes.



H.2.8 Stomach Ulcers and Cancer

Stomach cancer can develop from ulcers (however, having an ulcer does not mean you will develop cancer.)



H.2.8 Stomach Ulcers and Cancer

- Stomach ulcers occur with an infection of the bacterium *Helicobacter pylori*.
- YES! Ulcers are caused by an infectious disease.
- [Check out this site for additional information...](#)
 - *No. Really. Read this information.*

H.2.9 Lipid digestion in a hydrophilic medium