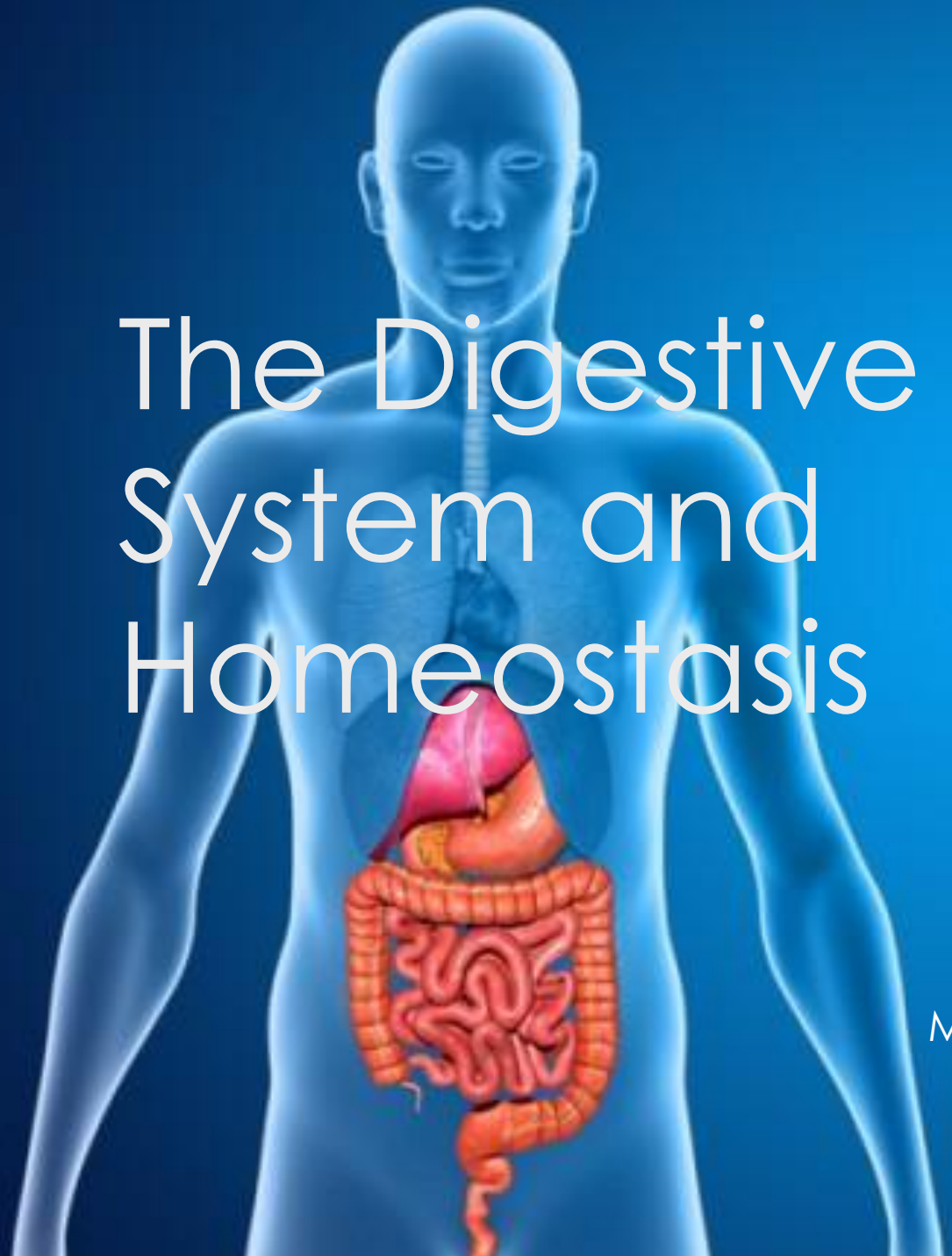
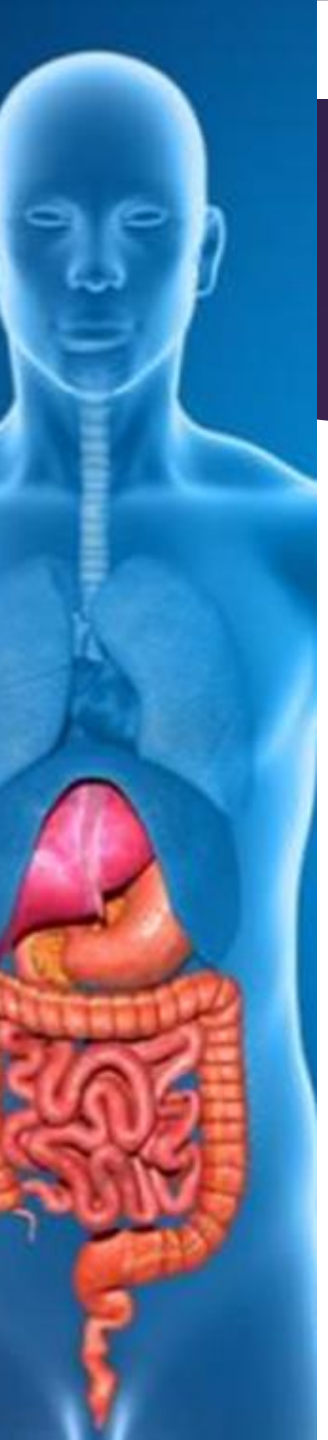
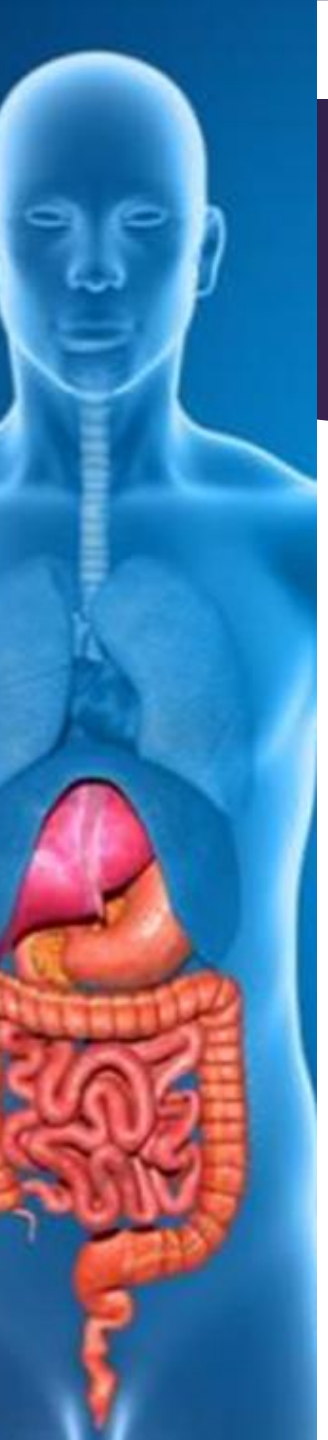
The Digestive System and Homeostasis



MR. GILLAM HOLY HEART

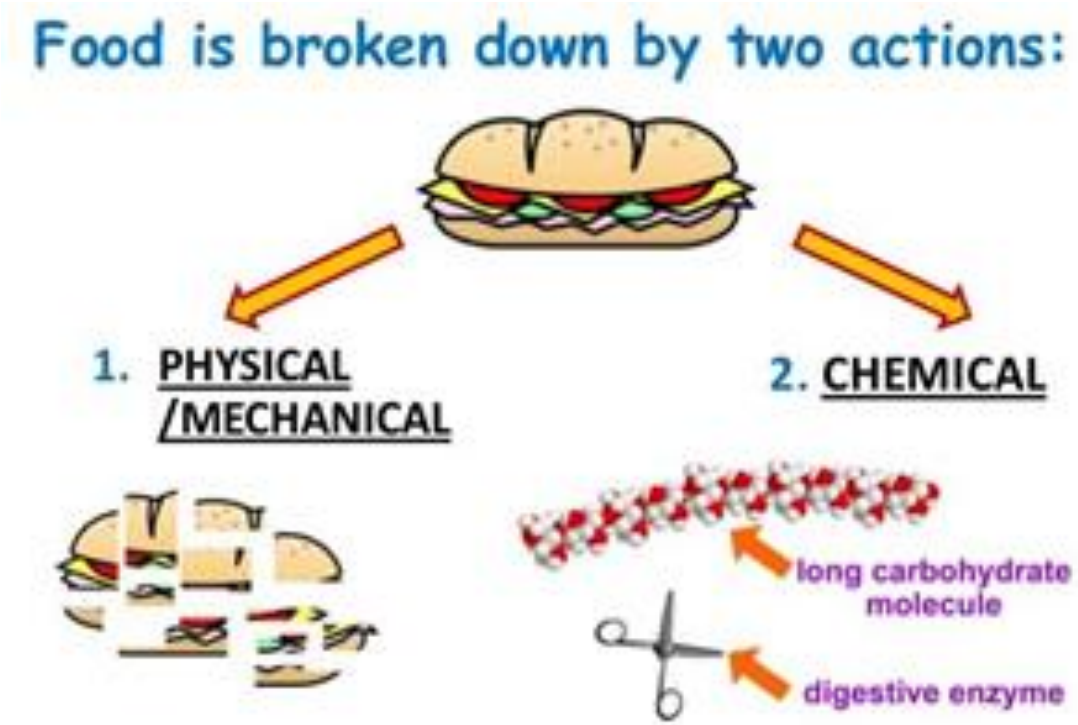


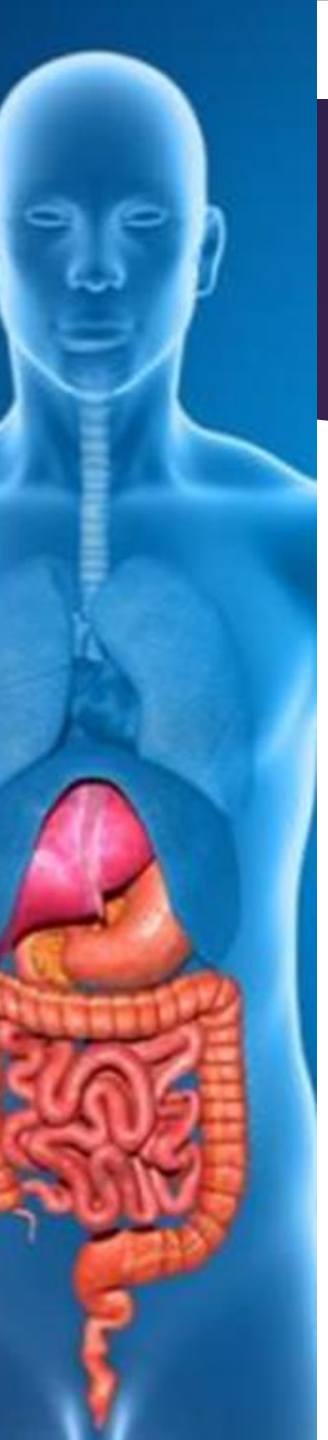
- Launch Lab Technology Provides Tools to Learn More



Structure and Functions

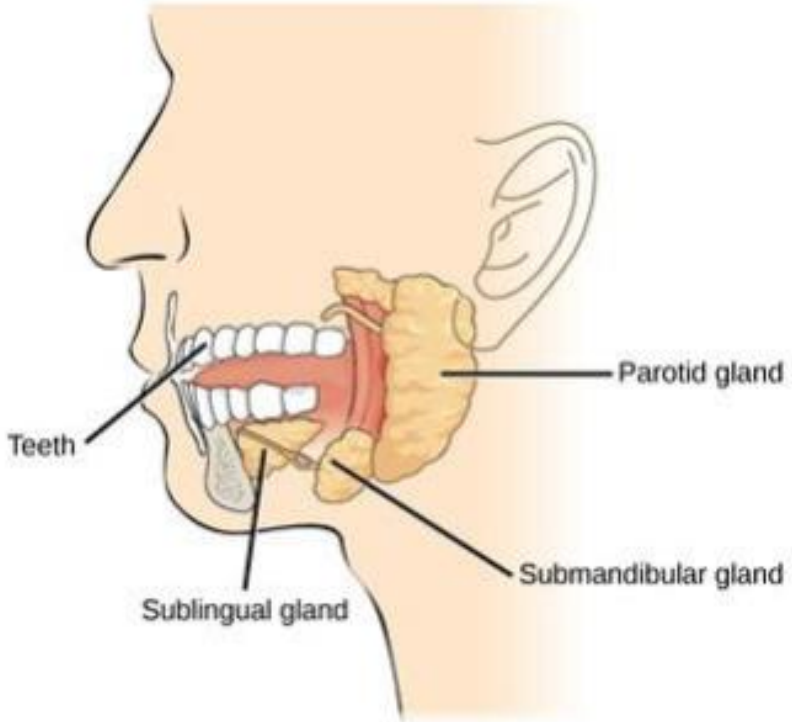
- **Digestive system** system into which food is taken and broken down
- **Mechanical digestion** breakdown of food through chewing or churning
- **Chemical digestion** chemical breakdown of food by enzymes and other digestive juices

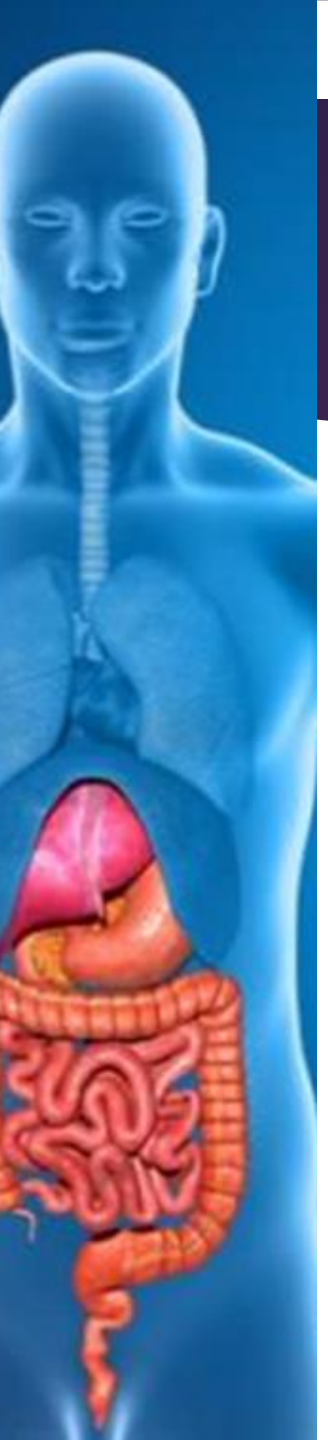




Structure and Functions

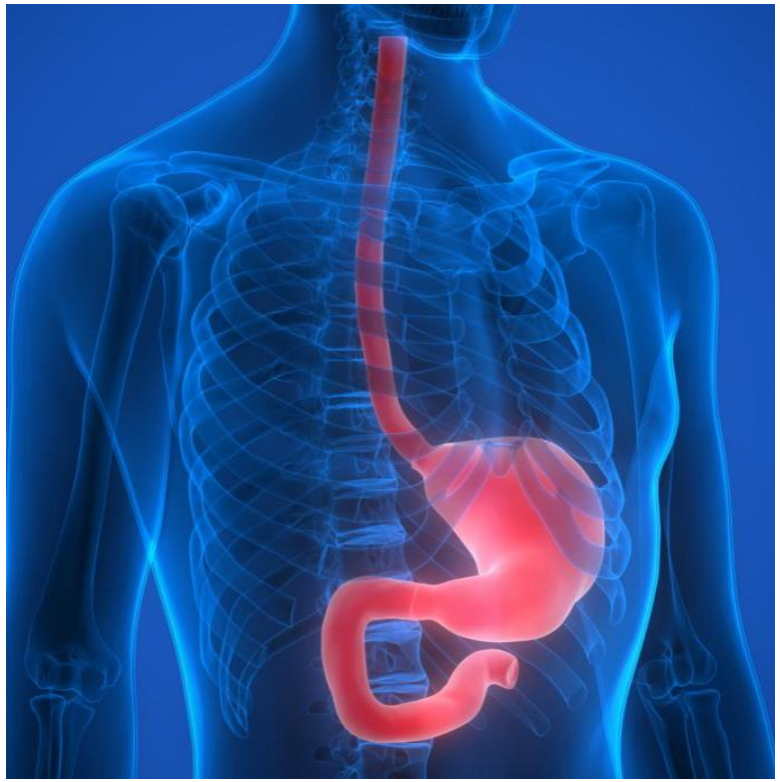
- **Mouth** part of the digestive system where ingestion occurs
- **Ingestion** process of taking food into the body
- **Salivary glands** secrete a watery fluid that contain starch digesting enzymes
  - **Salivary amylase** an enzyme in saliva that breaks down starch into simpler sugars (disaccharides).

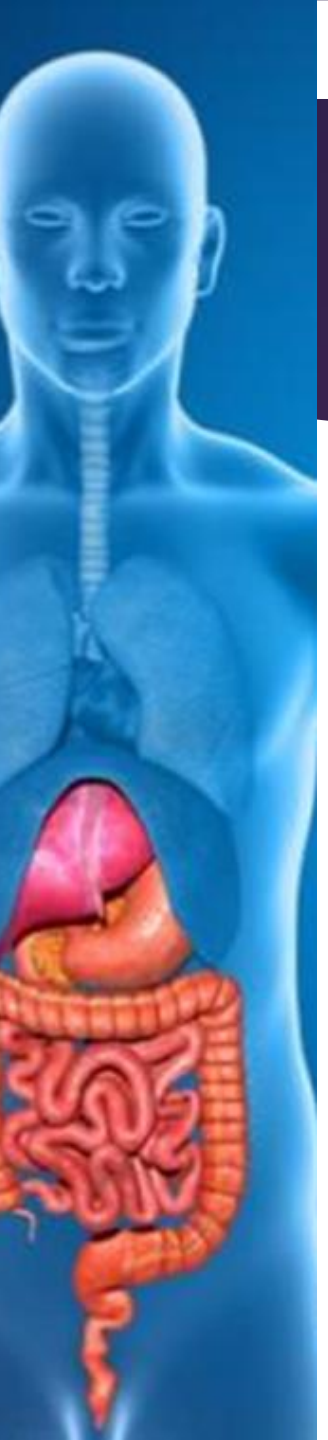




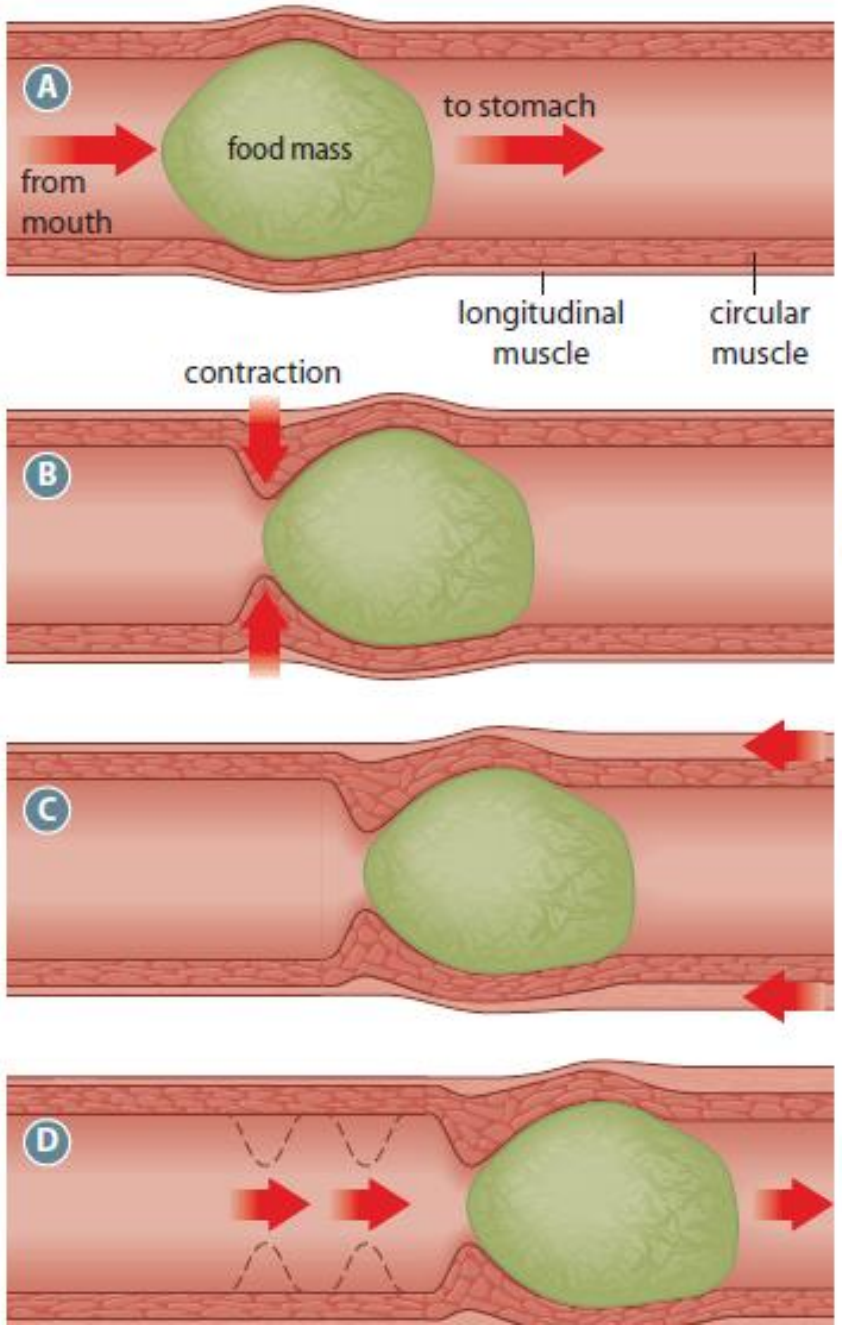
Structure and Functions

- **Esophagus** muscular portion of the digestive tract that directs food from the mouth to the stomach
  - **peristalsis** wavelike series of muscular contractions and relaxations that moves food through the digestive system





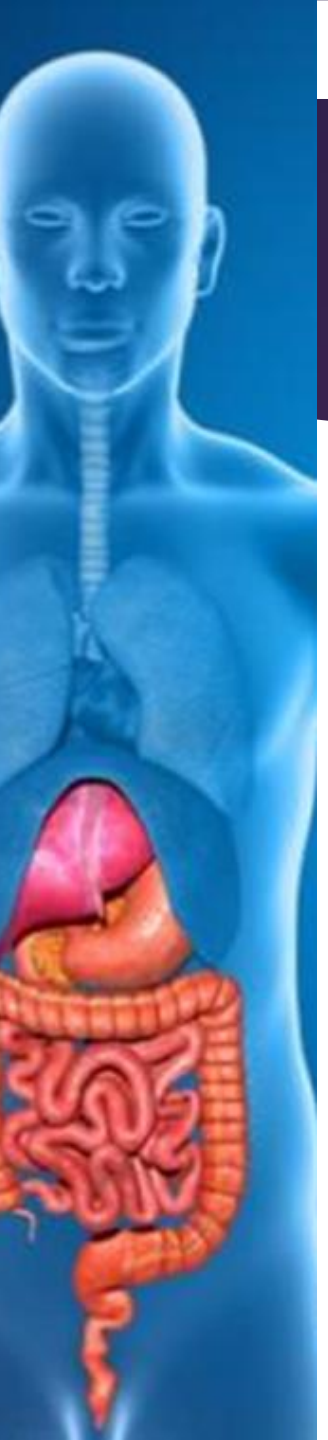
Peristalsis



Contraction of circular muscles behind food mass

Contraction of longitudinal muscles ahead of food mass

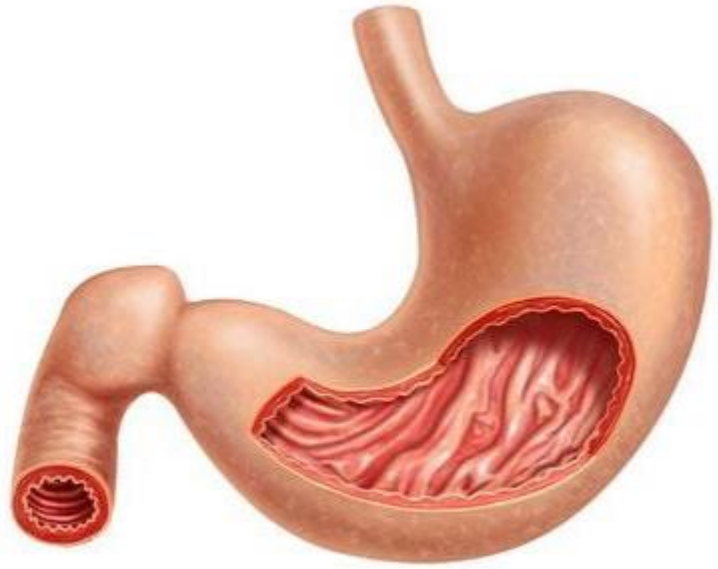
Contraction in circular muscle layer forces food mass forward

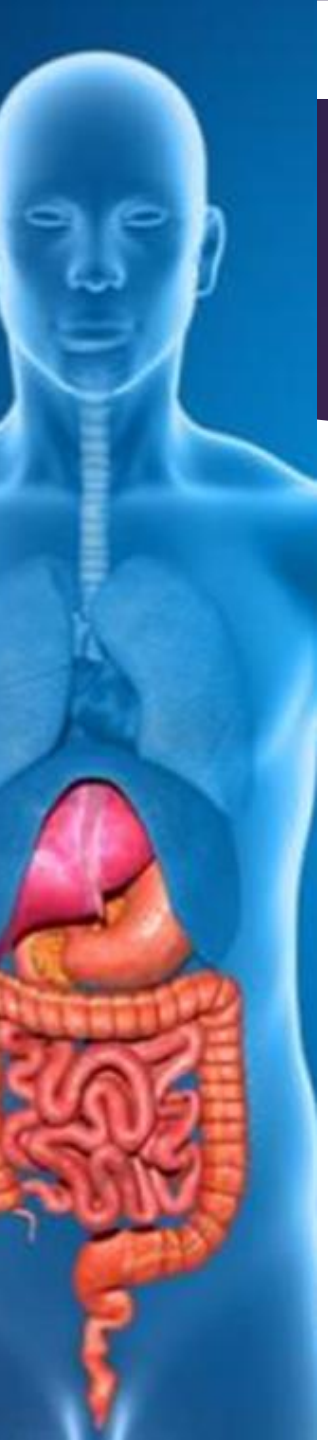


Structure and Functions

- **Stomach** J-shaped sac whose muscles and secretions break down food and push it into the small intestine

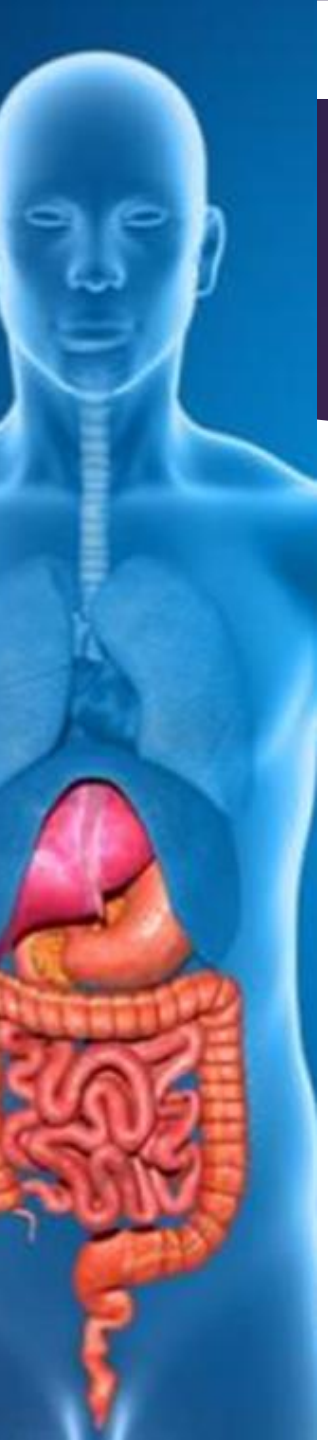
- Mechanical and chemical digestion occur in the stomach. Waves of peristalsis push food against the bottom of the stomach, churning it backward, breaking it into smaller pieces, and mixing it with gastric juice to produce a thick liquid called *chyme*.
- Gastric juice is responsible for chemical digestion in the stomach. It is made up of water, mucus, salts, hydrochloric acid, and enzymes.



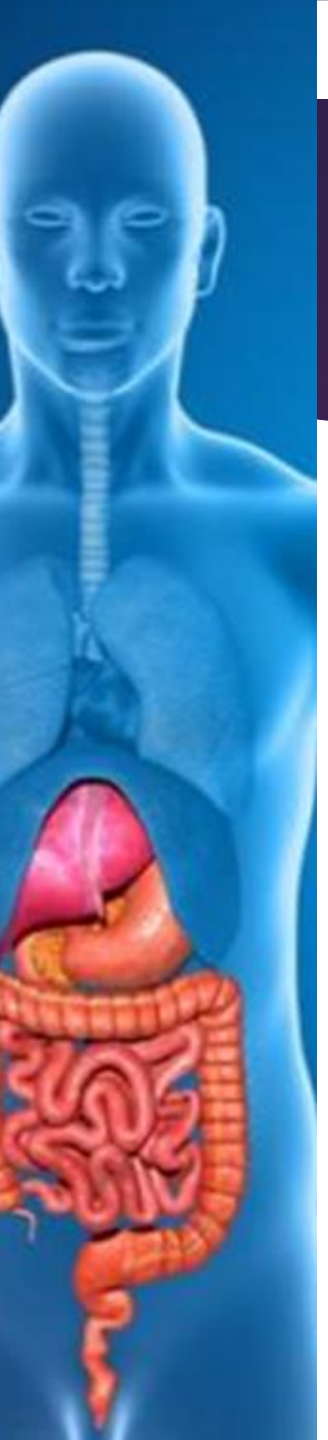


Structure and Functions

- The strong **hydrochloric acid** has a pH of 1 to 3. It provides a highly acidic environment that begins to soften and break down proteins in the chyme.
- The low pH also serves to kill most bacteria that are ingested along with the food we eat. (Some disease-causing bacteria escape this fate, however, because they have an outer coating that resists stomach acid.)
- **pepsin** protein-digesting enzyme secreted in the stomach – is not activated until it comes into contact with hydrochloric acid.
  - Your stomach will not digest itself ☺

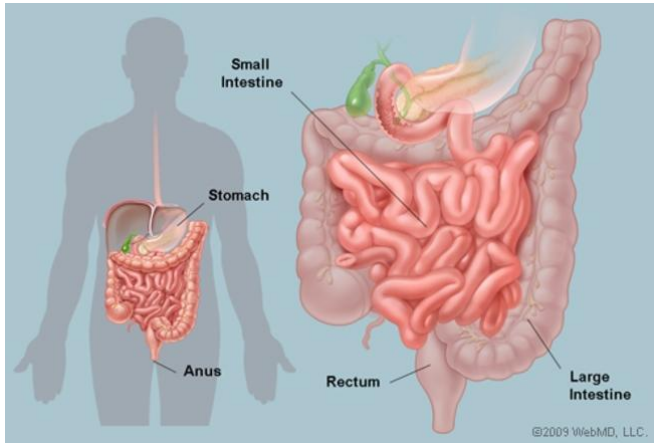


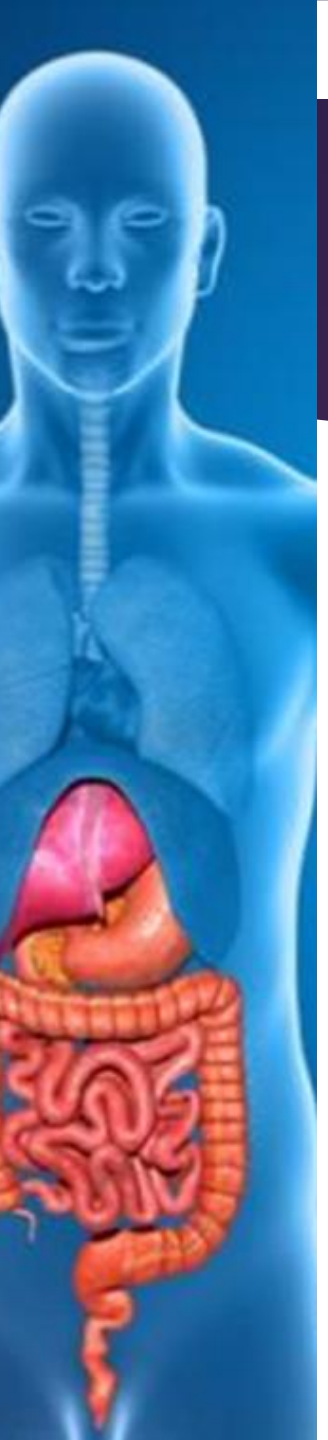
Activity 5.3 Scientific Inquiry in Action



Structure and Functions

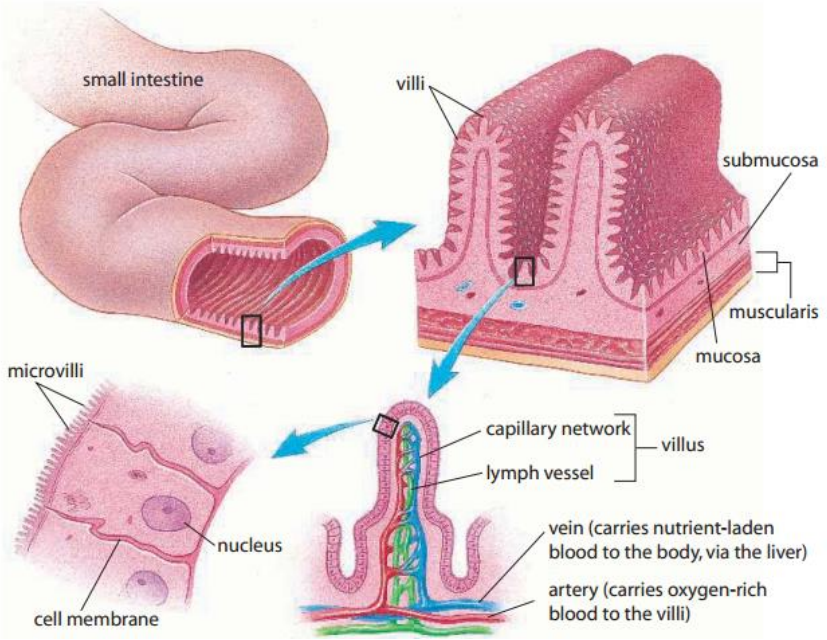
- **Small intestine** length of the digestive tract between the stomach and the large intestine (secretes enzymes that digest macromolecules; absorbs hydrolyzed molecules into bloodstream)
  - segmentation a process by which some mechanical digestion occurs in the small intestine. During this process, the chyme sloshes back and forth between segments of the small intestine that form when bands of circular muscle briefly contract. Meanwhile, peristalsis pushes the food along the intestine.

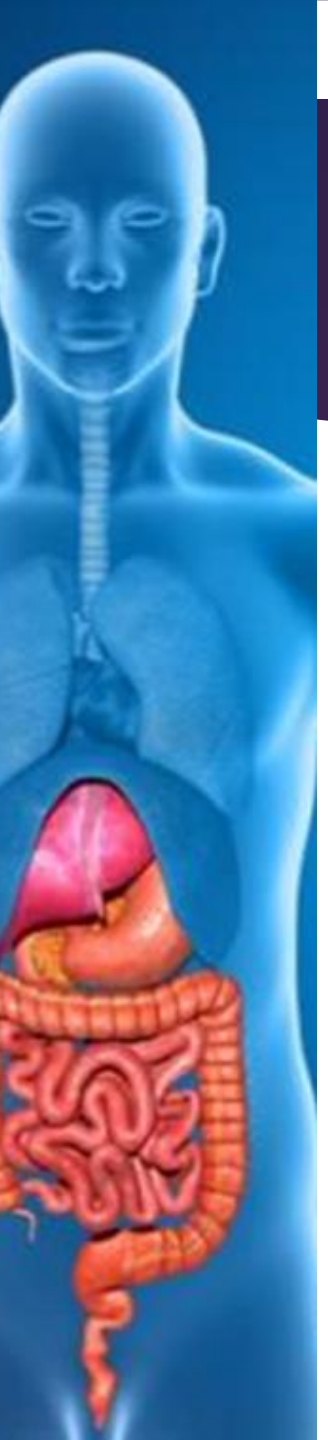




Regions and Structures of the Small Intestine

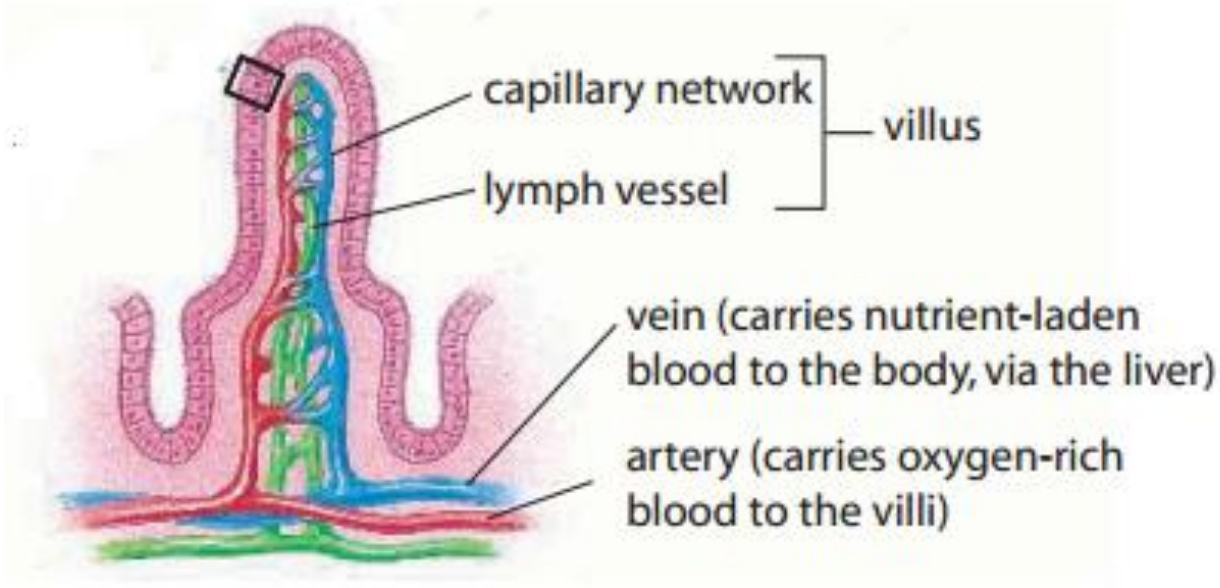
- The first 25 cm of the small intestine is called the **duodenum**. The duodenum is generally U-shaped and is the shortest and widest of the three regions. Ducts (channels) from the liver and pancreas join to form one duct that enters the duodenum.
- Thus, the duodenum is an important site for the chemical digestion of the chyme received from the stomach.
  - villus (villi) finger-like projection along the ridges of the small intestine; increases surface area to aid in the absorption of nutrients
  - microvillus (microvilli) microscopic projection found along exposed cell surfaces that greatly increases the surface area of the cell.

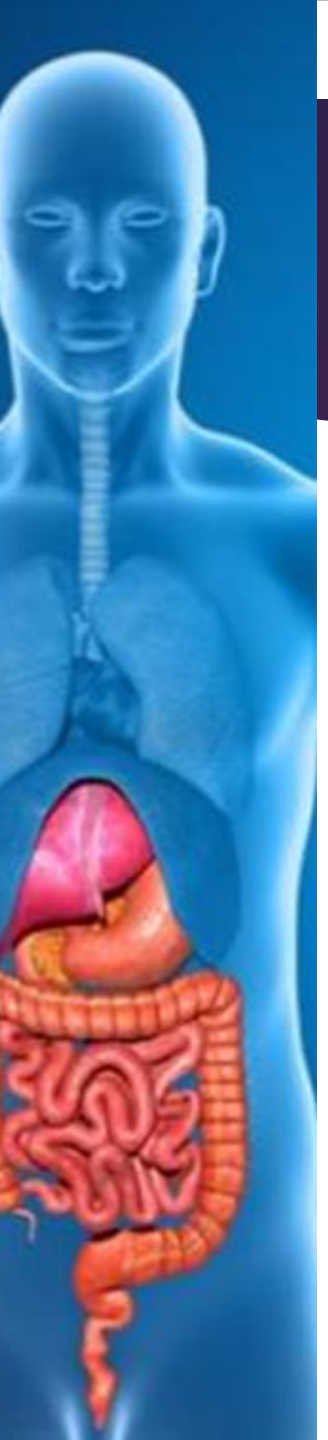




Regions and Structures of the Small Intestine

- Each villus contains tiny structures called capillary networks and lymph vessels.
- These structures are part of the circulatory system.
- They conduct absorbed substances from the small intestine into the bloodstream and the lymphatic system.

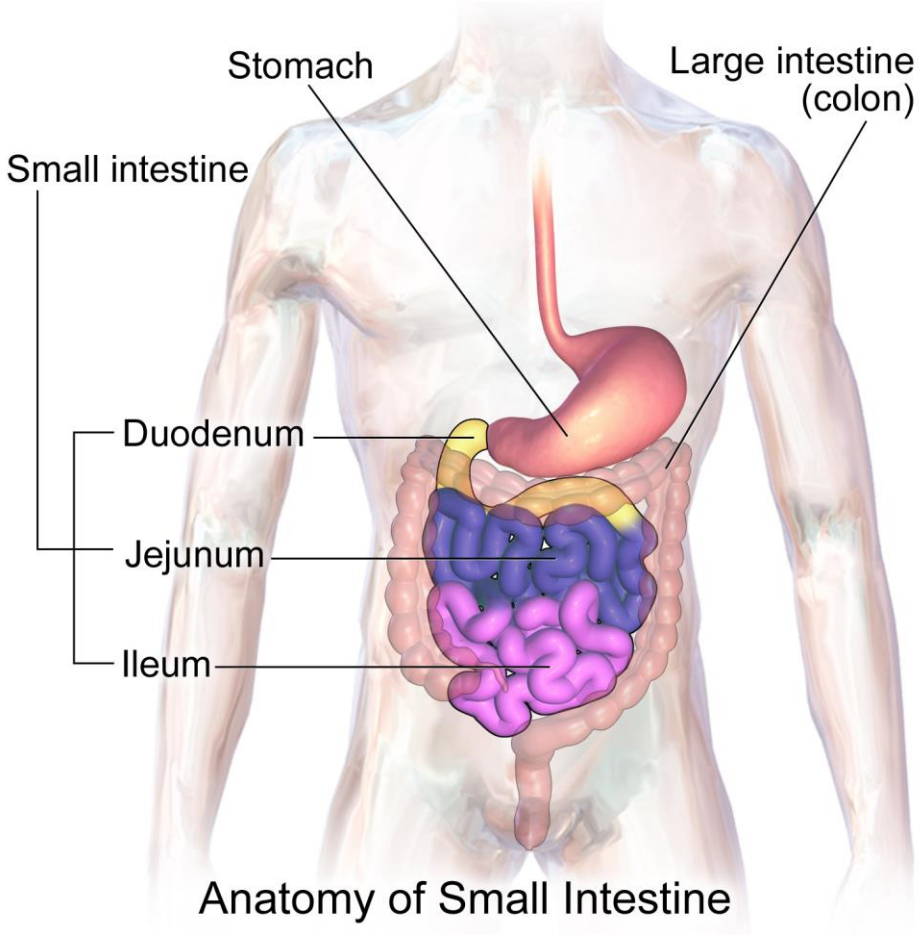




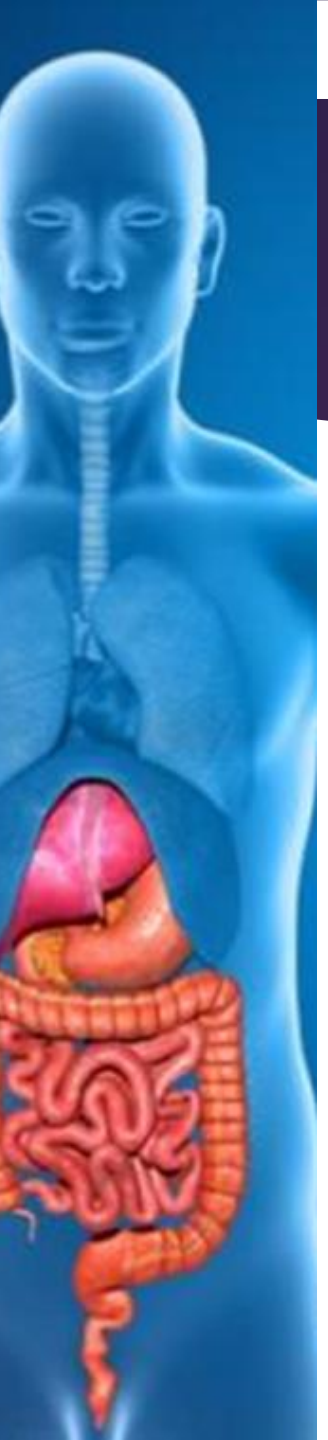
Regions and Structures of the Small Intestine

- The other regions of the small intestine are the jejunum and the ileum, and they are quite similar to the duodenum.

- The **jejunum**, which is about 2.5 m long, contains more folds and secretory glands than the duodenum. It continues to break down food so that the end products can be absorbed.
- The **ileum**, which is about 3 m long, contains fewer and smaller villi. Its function is to absorb nutrients and to push the remaining undigested material into the large intestine.

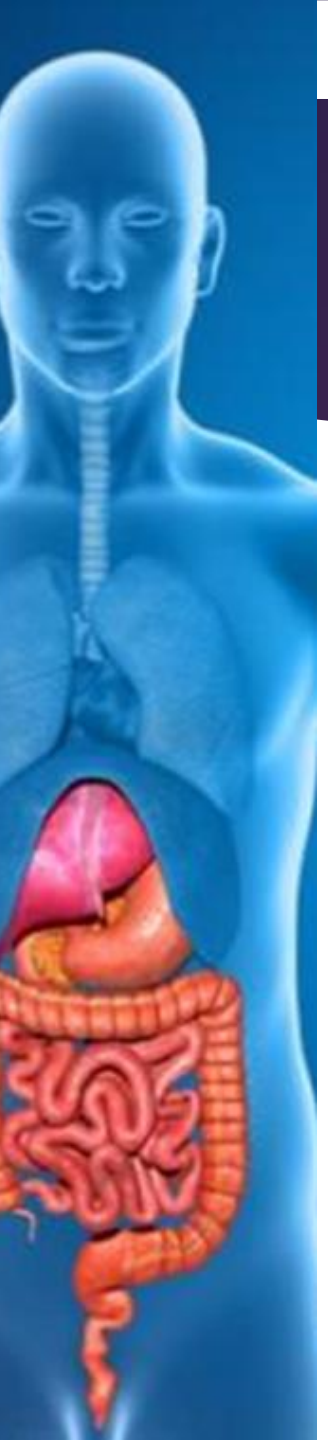


Anatomy of Small Intestine



Structure and Functions

- **Accessory organs**
- **Liver** organ found in the abdomen that performs hundreds of functions as an accessory organ of the digestive system, including **the secretion of bile to digest fats.**

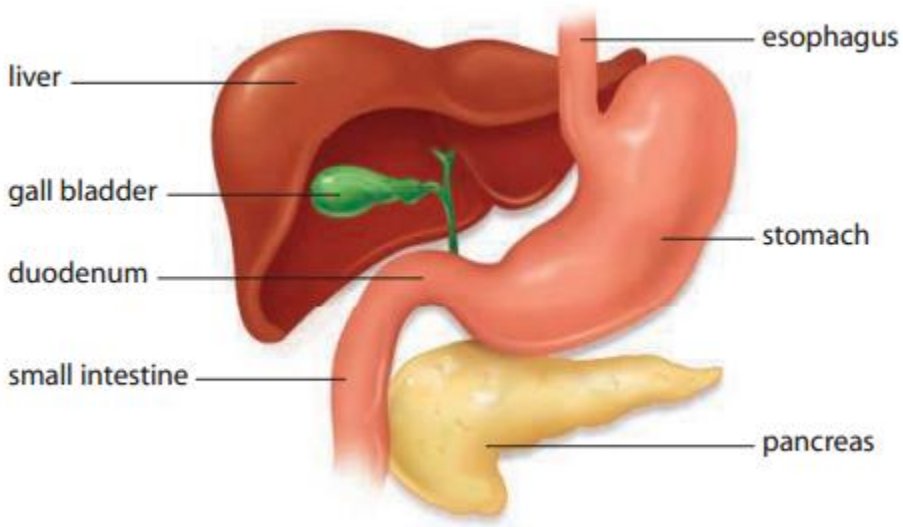


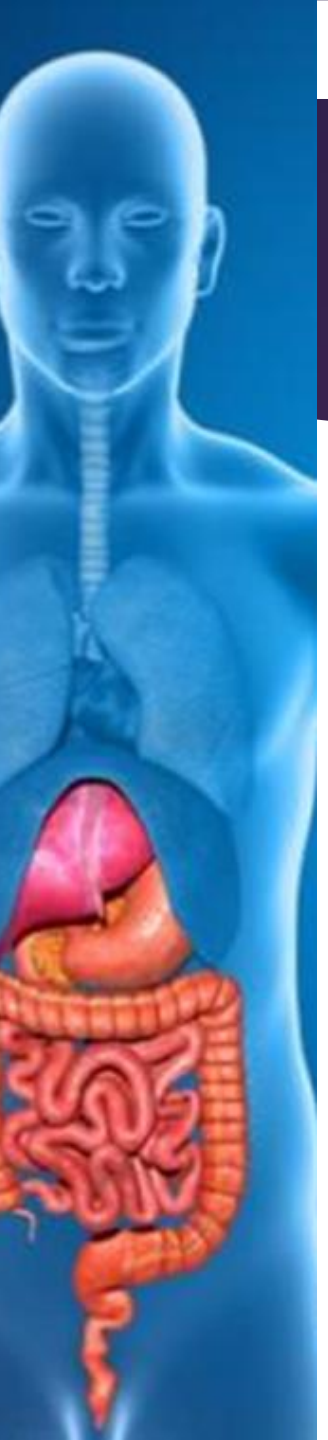
Structure and Functions

- **Accessory organs**
- **Gall bladder** organ that stores bile produced by the liver

- Bile is a greenish-yellow fluid mixture that is made up of bile pigments and bile salts.
- **Bile** breaks down fats into fatty acids that can be absorbed into the digestive tract.

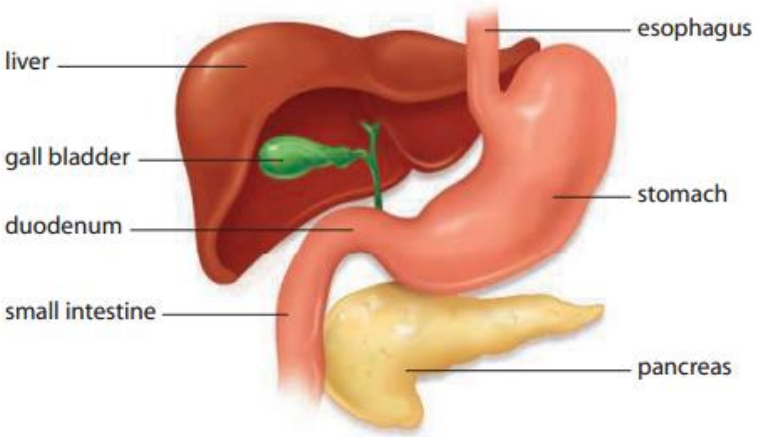
- After bile is produced in the liver, it is sent to the gall bladder, which stores the bile between meals. The arrival of fat-containing chyme in the duodenum stimulates the gall bladder to contract. This causes bile to be transported through a duct (shared by both the gall bladder and the liver) and injected into the duodenum.

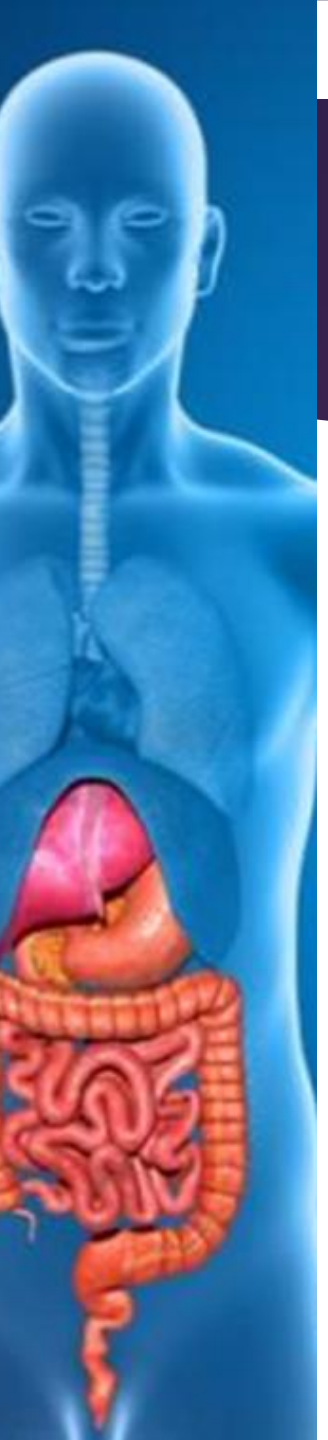




Structure and Functions

- **Accessory organs**
- **Pancreas** manufactures digestive enzymes to digest macromolecules; secretes **bicarbonate to neutralize stomach acid** that enters small intestine
- The pancreas delivers about 1 L of pancreatic fluid to the duodenum each day. Pancreatic fluid contains a multitude of enzymes, including the following:
- •trypsin and chymotrypsin, which are **peptidases that digest proteins**
- •pancreatic amylase, which is a **carbohydrase that digests starch** in the small intestine
- •**lipase, which digests fat**





Structure and Functions

- **Bile Salts**
- Bile salts assist lipases in accessing fats because they are partly soluble in water and partly soluble in fats.
- Bile salts work like a detergent, dispersing large fat droplets into a fine suspension of smaller droplets in the chyme. This emulsification process produces a greater surface area of fats on which the lipases can act. As a result, the digestion of fats can occur more quickly.

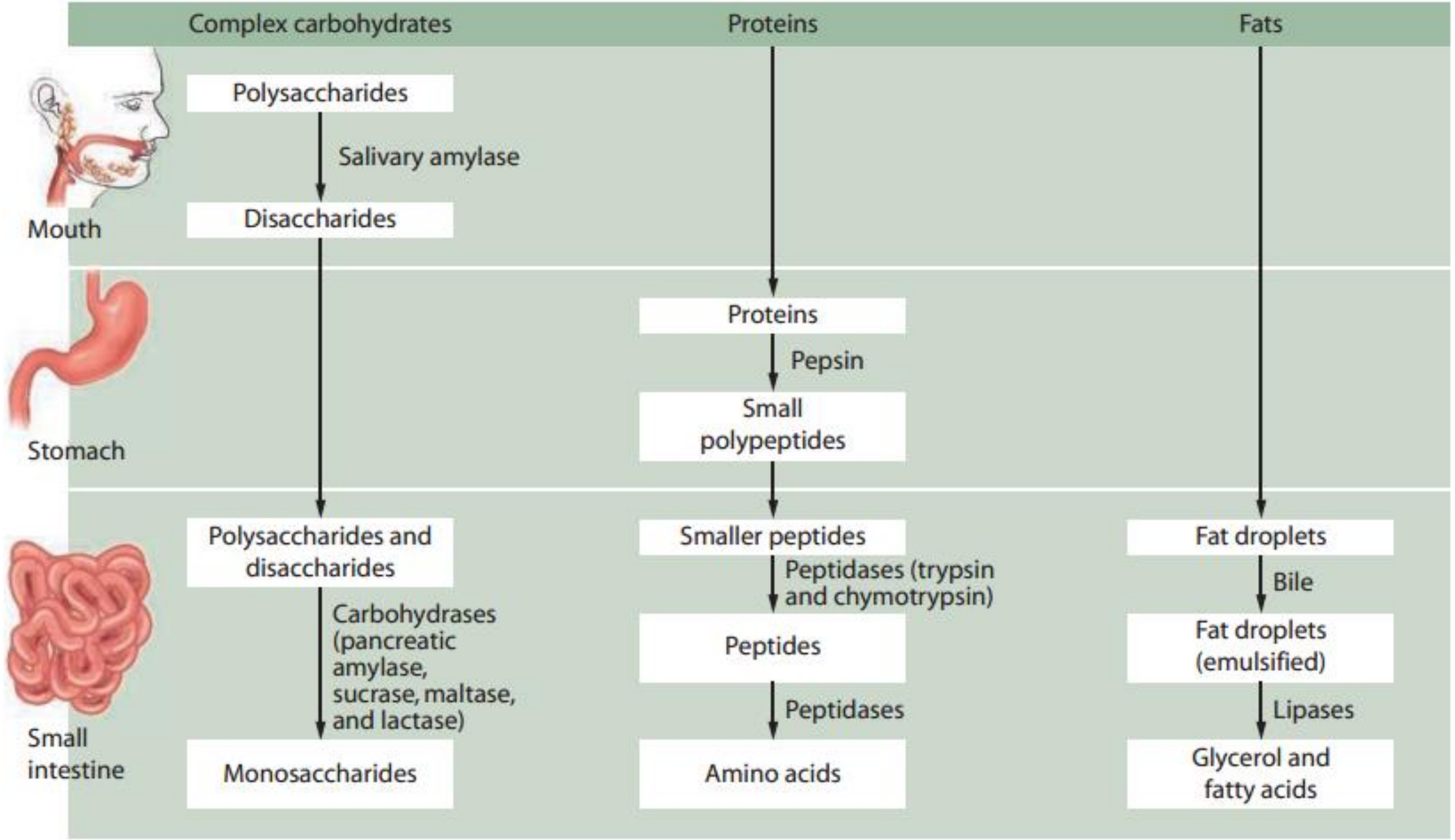
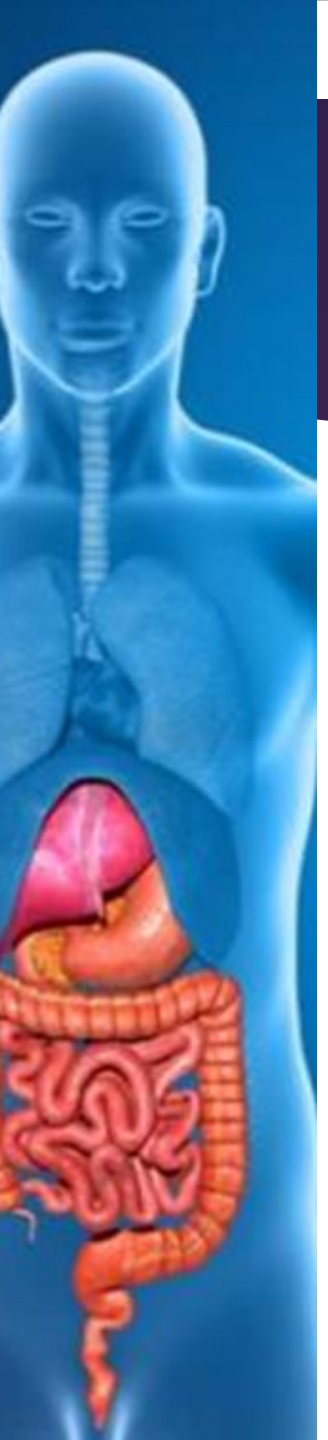


Figure 5.10 An overview of chemical digestion and absorption in the small intestine

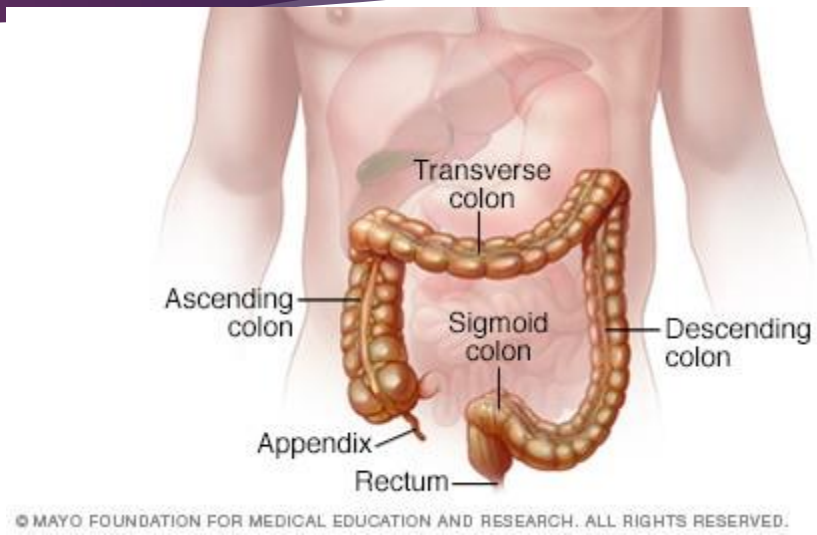
Table 5.2 Selected Enzymes of the Digestive System

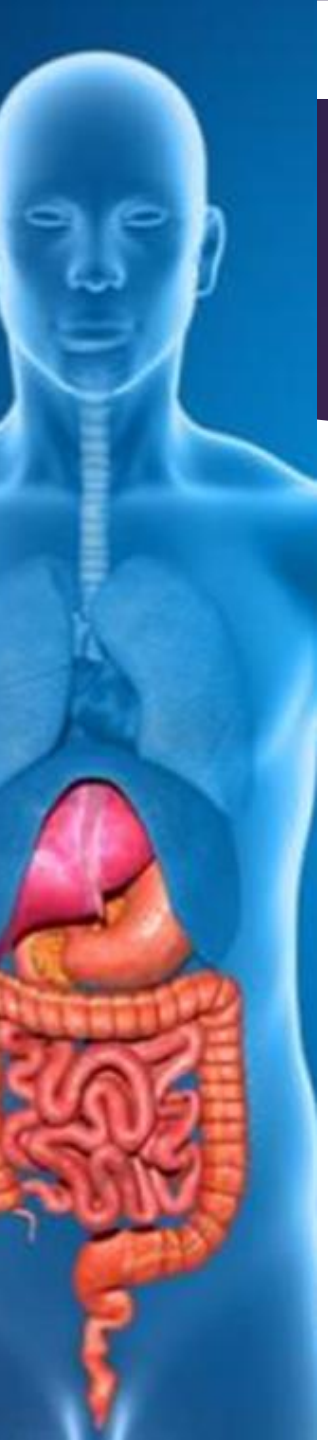
Enzyme	Where Enzyme Acts/pH	Substrate (food) Digested	Products of Digestion	Origin of Enzymes
salivary amylase	mouth/7	starch, glycogen	maltose (disaccharide)	salivary glands
pancreatic amylase	small intestine/8	starch, glycogen	maltose	pancreas
carbohydrases • sucrase • maltase • lactase	small intestine/8	 sucrose maltose lactose	 glucose + fructose glucose glucose + galactose	small intestine
pancreatic lipase	small intestine/8	lipids	fatty acids and glycerol	pancreas
peptidases • pepsin • trypsin • chymotrypsin	 stomach/1–2 small intestine/8 small intestine/8	 protein peptides peptides	 peptides smaller peptides smaller peptides	 stomach pancreas pancreas
peptidases	small intestine/8	peptides	amino acids	small intestine



Structure and Functions

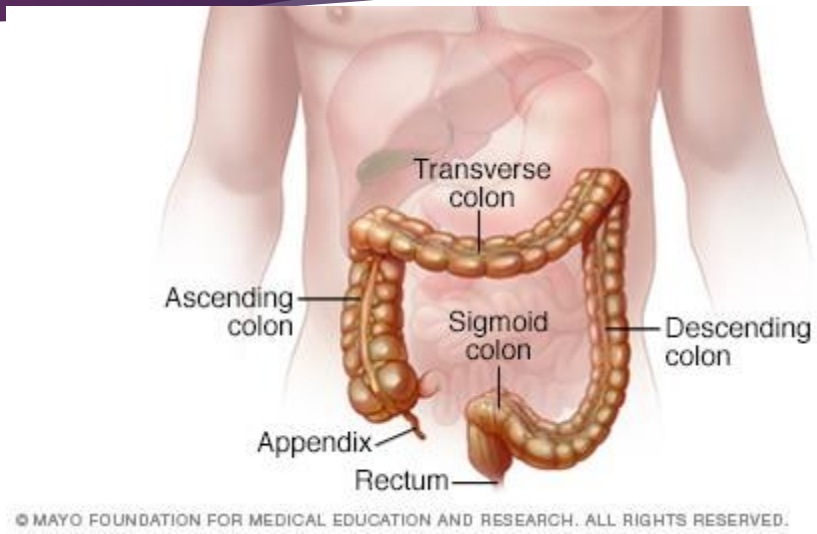
- **Large intestine** final portion of the digestive system; absorbs water and salts; passes remaining undigested material and some water out of body
- **reabsorption** the process by which materials are reabsorbed into the bloodstream
- Measuring only about 1.5 m long, it has a diameter of about 2.5 cm.
- Digestion does not occur in the large intestine
- Each day, the large intestine receives about 500 mL of indigestible food residue, reduces it to about 150 mL of feces by reabsorbing water and salts, and eliminates the feces.

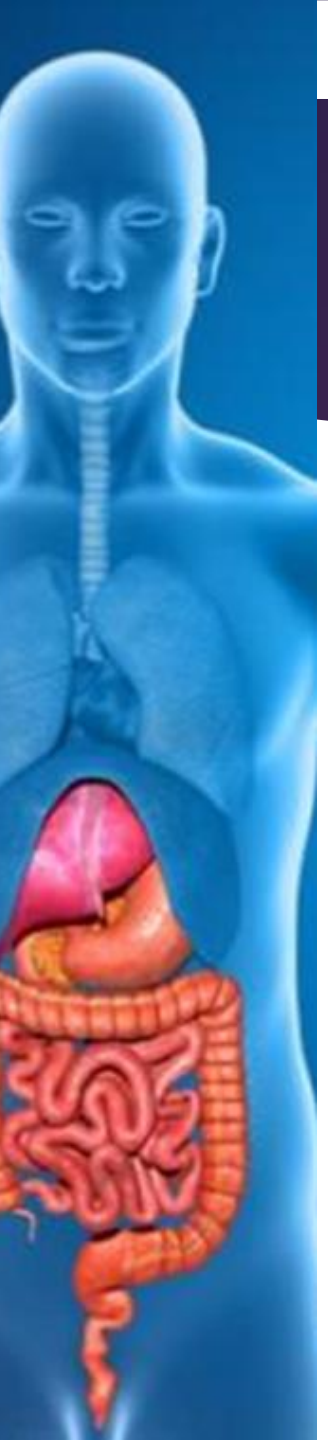




Structure and Functions

- **Large Intestine CONTINUTED**
- In the colon, water and salts are reabsorbed from any undigested food, while billions of anaerobic intestinal bacteria break it down further.
- These bacteria produce vitamins B12 and K, and some amino acids.
- At the end of this process, any remaining indigestible materials, along with the colon bacteria, form the feces.



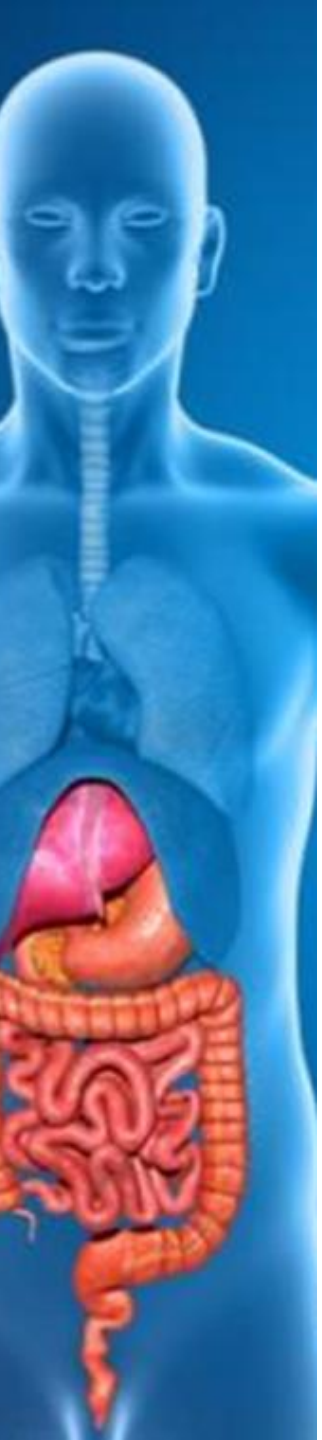


Structure and Functions

- **Large Intestine CONTINUTED**
- The feces pass into the rectum and anal canal, which comprise the last 20 cm of the large intestine.
- From there, the feces pass out of the body through the anus.

- **Rectum** stores waste prior to elimination. The rectum has three folds that enable it to retain the feces while passing gas.

- **Anus** holds rectum closed; opens to allow elimination



Accessory Organs (Structures That Aid Digestion)

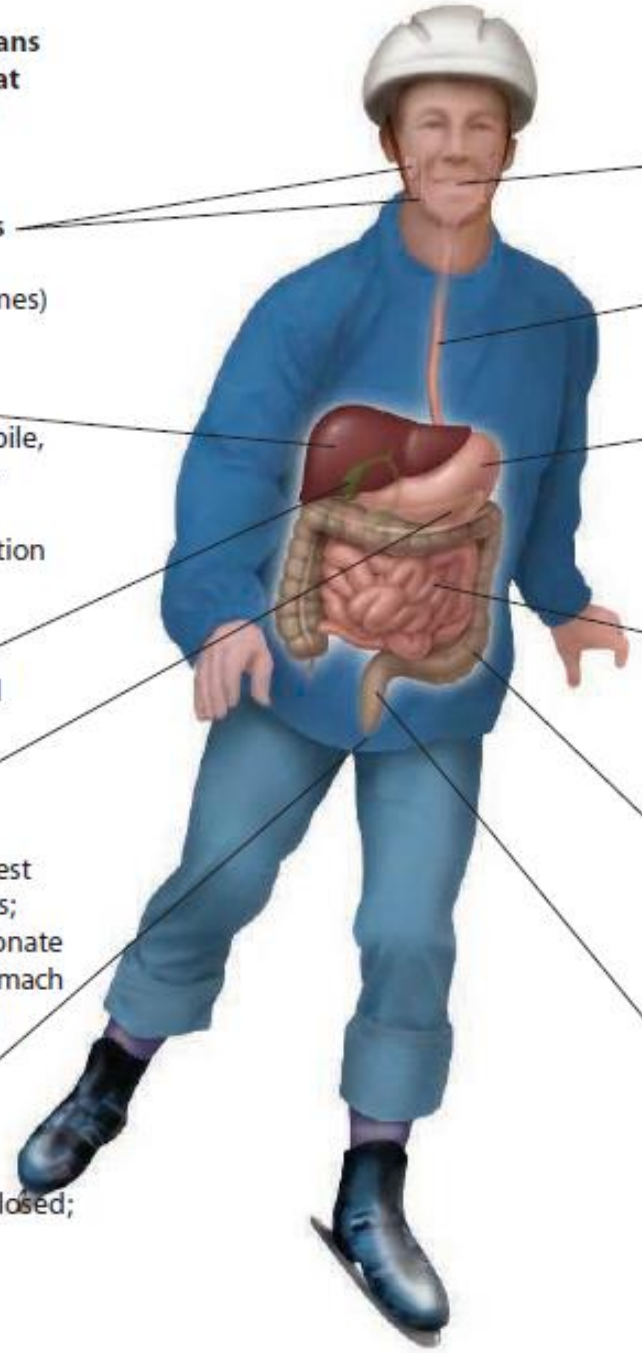
salivary glands
(secrete starch-digesting enzymes)

liver
(manufactures bile, a detergent-like substance that facilitates digestion of fats)

gall bladder
(stores bile until needed)

pancreas
(manufactures enzymes to digest macromolecules; secretes bicarbonate to neutralize stomach acid that enters small intestine)

anus
(holds rectum closed; opens to allow elimination)



The Digestive Tract (Organs That Contain Food)

mouth
(chews and mixes food with saliva)

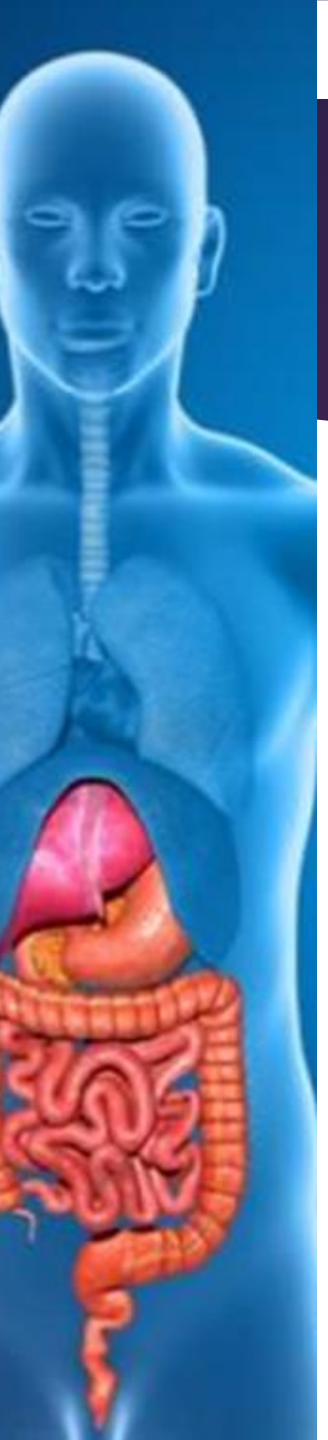
esophagus
(directs food from mouth to stomach)

stomach
(adds acid, enzymes, and fluid; churns, mixes, and grinds food to a liquid mass)

small intestine
(secretes enzymes that digest macromolecules; absorbs hydrolyzed molecules into bloodstream)

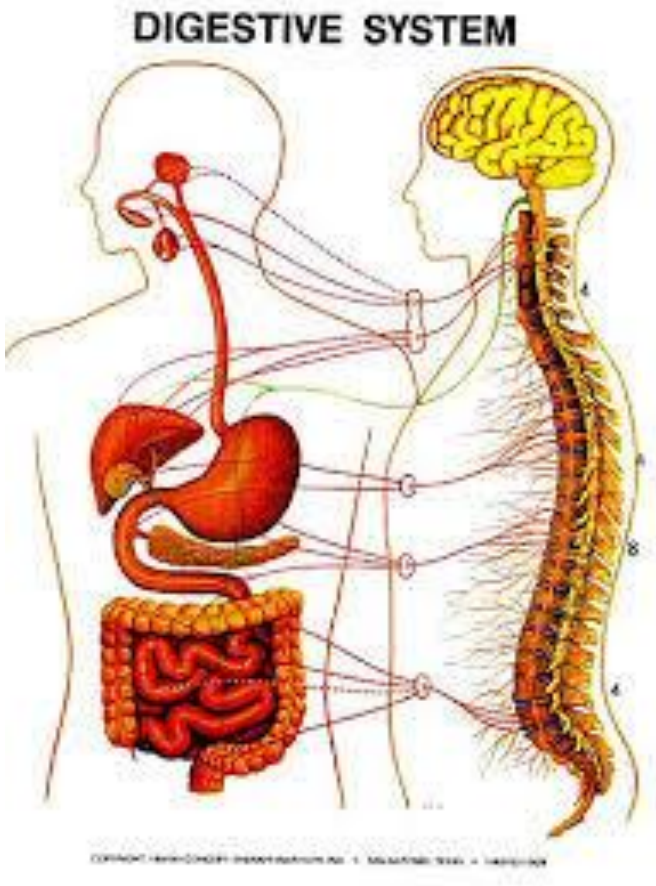
large intestine
(absorbs water and salts; passes remaining undigested material and some water out of body)

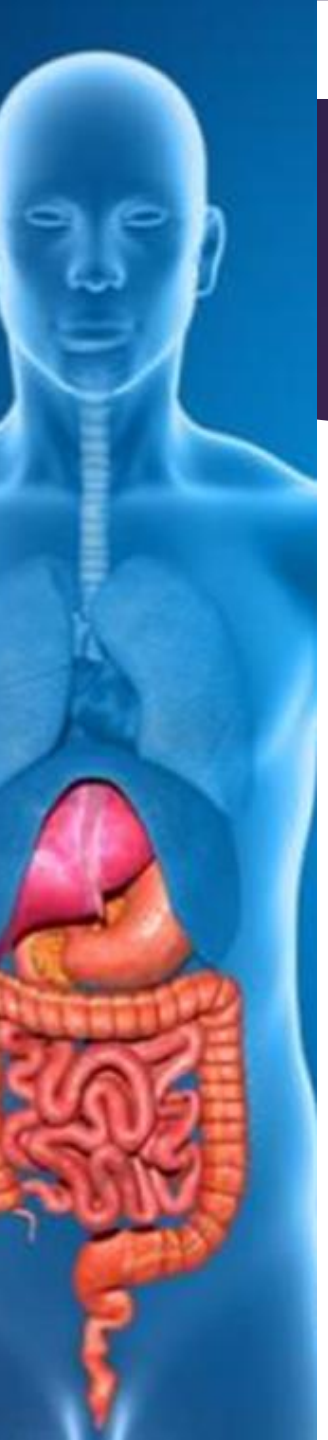
rectum
(stores waste prior to elimination)



Systems Work Together to Maintain Homeostasis in the Digestive Tract

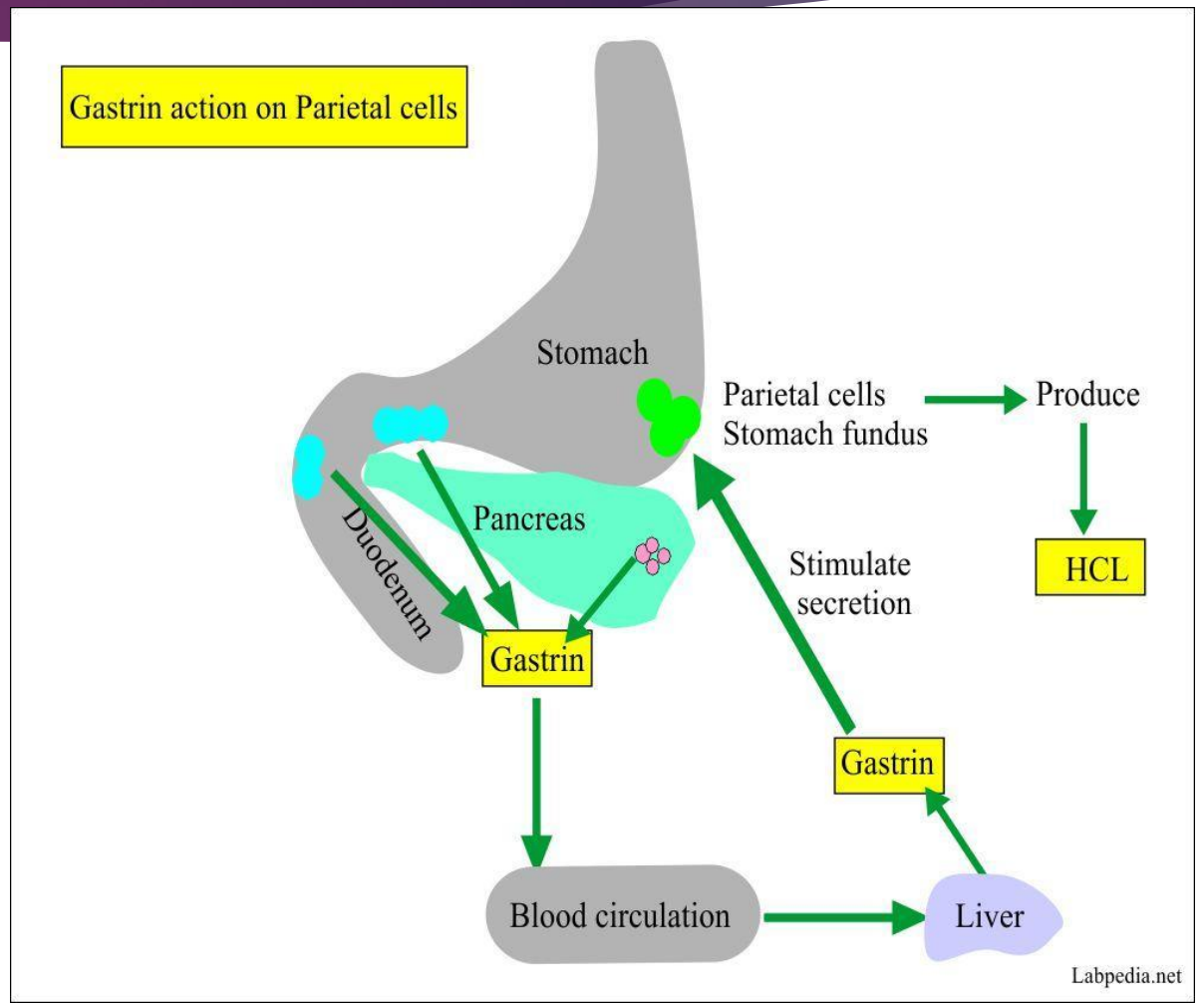
- the activities of the digestive tract are coordinated by the nervous system and the endocrine system.
- The nervous system stimulates salivary and gastric secretions in response to the sight, smell, and consumption of food.
- When food arrives in the stomach, proteins in the food stimulate the secretion of a stomach hormone called gastrin.

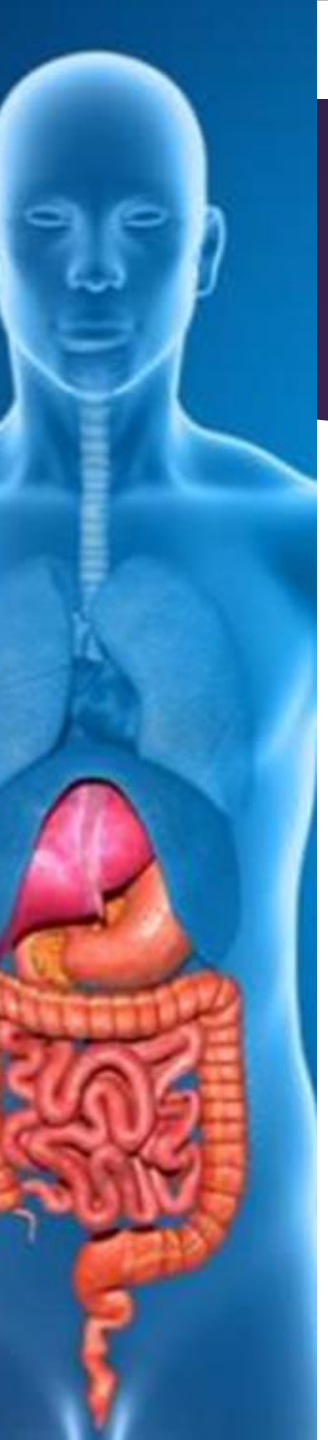




Systems Work Together to Maintain Homeostasis in the Digestive Tract

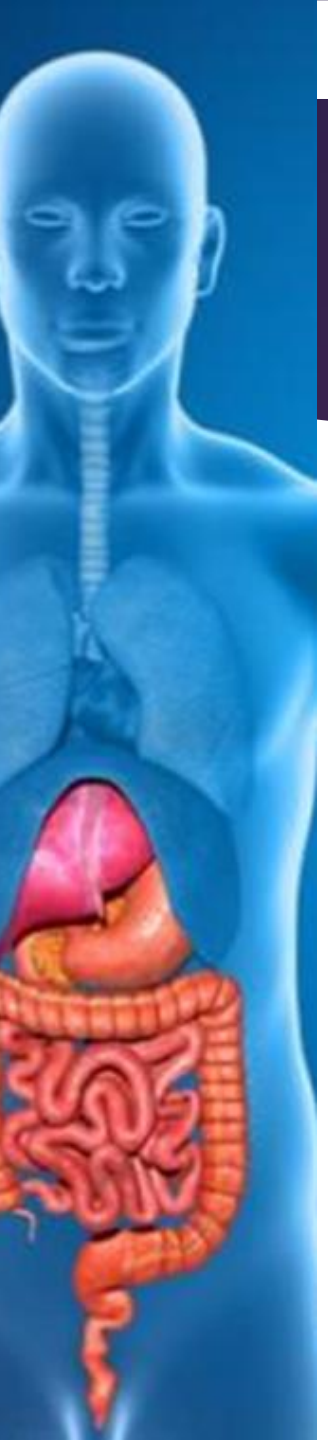
- **Gastrin** then stimulates the secretion of hydrochloric acid and the inactive precursor molecule of pepsin from glands in the stomach.
  - The secreted hydrochloric acid lowers the pH of the gastric juice, which acts to inhibit further secretion of gastrin. Because the inhibition of gastrin secretion reduces the amount of hydrochloric acid that is released into the gastric juice, a negative feedback mechanism is completed.
  - In this way, homeostasis (the secretion and concentration) of gastric fluid is maintained.





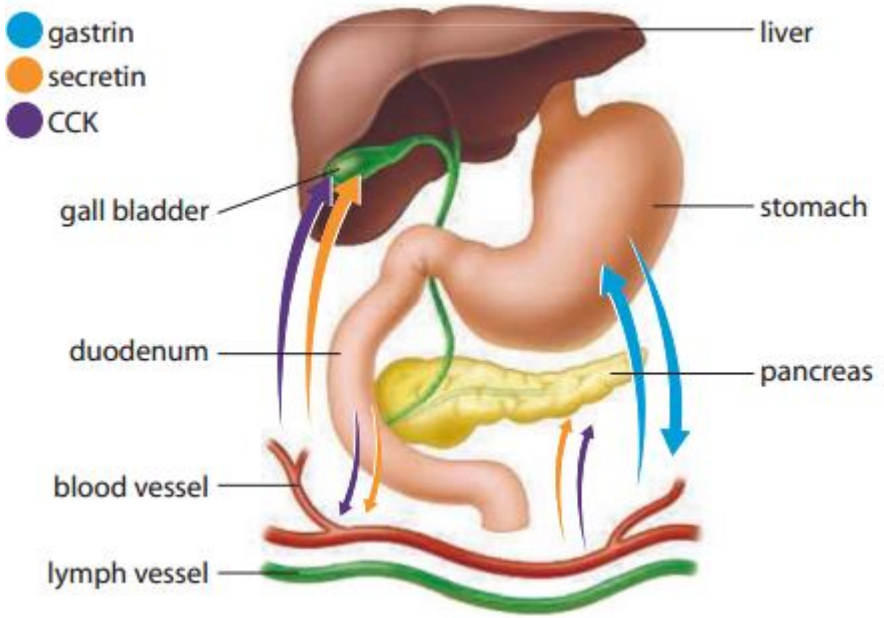
Systems Work Together to Maintain Homeostasis in the Digestive Tract

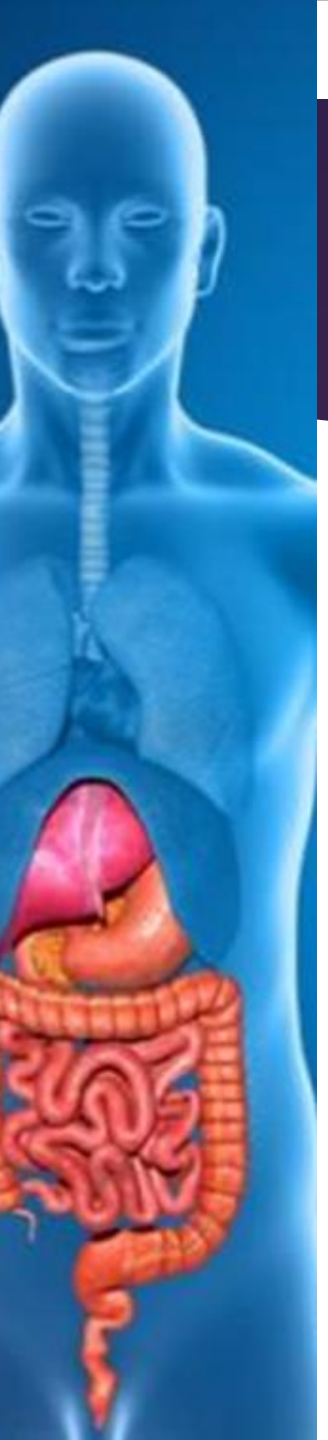
- The passage of chyme from the stomach into the duodenum inhibits the contractions of the stomach, so that no additional chyme can enter the duodenum until the previous amount has been processed.
- **Secretin, and CCK(cholecystokinin) two hormones secreted into the bloodstream by the duodenum cause inhibition of stomach contractions**
- CCK and secretin also have other regulatory functions in digestion.
- CCK stimulates increased pancreatic secretions of digestive enzymes and gall bladder contractions. Gall bladder contractions inject more bile into the duodenum, which enhances the emulsifying and digestion of fats.
- Secretin also stimulates the pancreas to release more bicarbonate to neutralize acidic chyme.



Systems Work Together to Maintain Homeostasis in the Digestive Tract

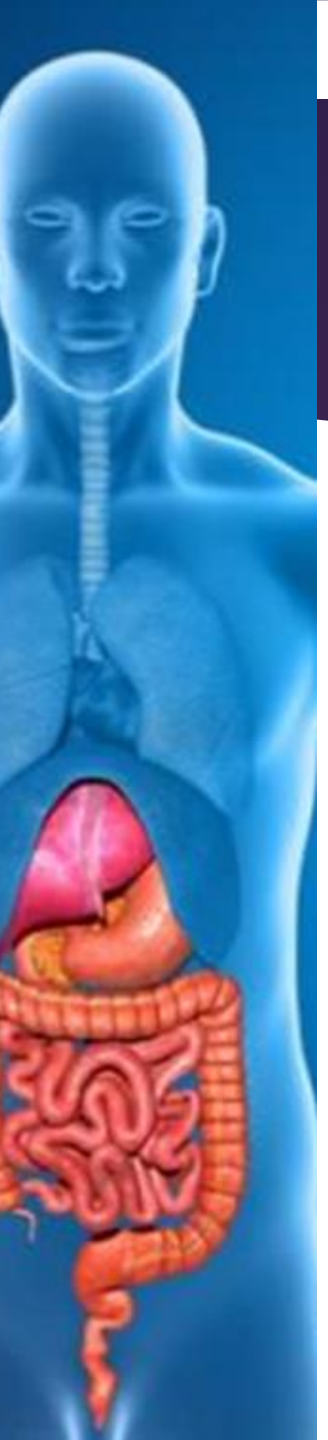
- Gastrin, secretin, and CCK are hormones that must be transported by the bloodstream from their place of origin to the place where they act to stimulate the release of digestive secretions.
- Lymph vessels carry absorbed fats.





Investigation 3.B

- Factors Affecting Enzyme Activity



Health and the Digestive System

- The effects of poor dietary and lifestyle habits may take weeks, months, or even years to show up.
- Good nutrition is the only way to provide the energy our bodies need to carry out their many activities, **such as nerve transmission, muscle contraction, and cell repair and replacement.**
- Good nutrition provides the raw materials our bodies need as building blocks but are unable to manufacture themselves.
- One part of eating a well-balanced diet includes consuming the proper amount of vitamins and minerals.
- **Vitamins and minerals are organic and inorganic substances that enable chemical reactions to occur and aid in tissue development, growth, and immunity.**
- **Vitamins and minerals are needed by a healthy, functional human body. They are needed in small amounts, but because the body cannot manufacture vitamins and minerals, they must be ingested, either in the food we eat or in the form of supplements.**

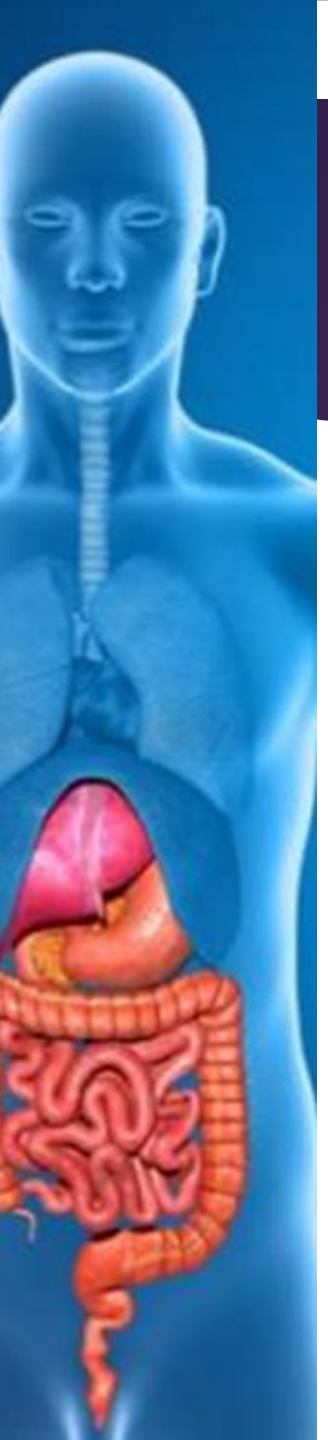
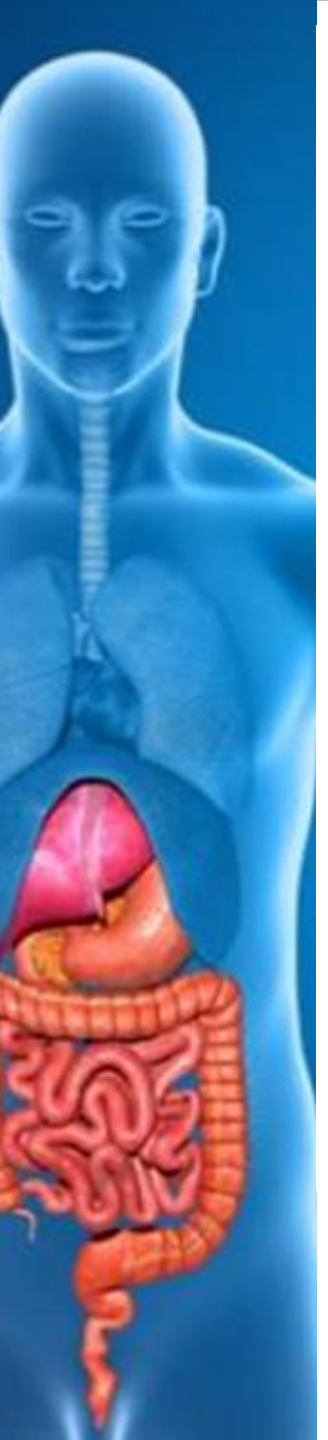
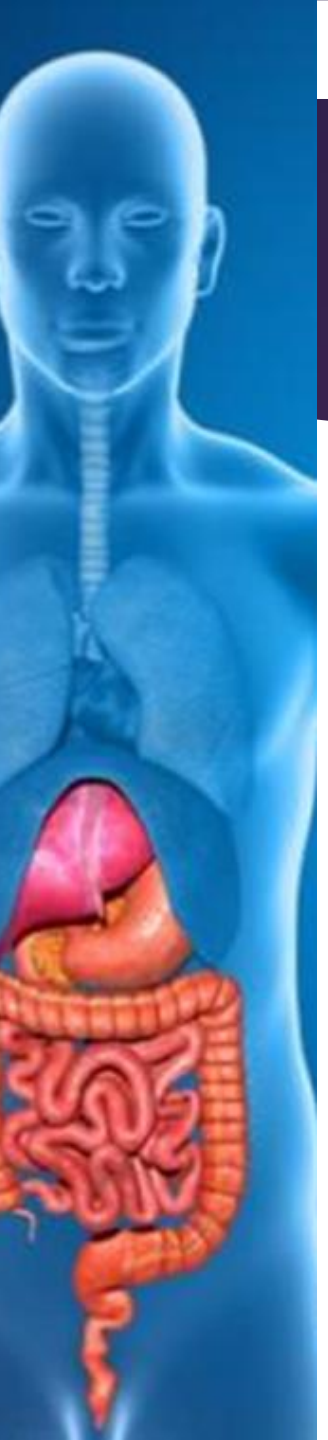


Table 5.4 Functions and Possible Sources of Selected Vitamins and Minerals

	Key Functions in the Body	Possible Sources
Vitamin		
A (carotene)	• good vision • healthy skin and bones	vitamins A, C, and E: fruit 
B1 (thiamine)	• metabolizing carbohydrates • growth and muscle tone	vitamin B1: beans 
C (ascorbic acid)	• healthy bones, teeth, gums, and blood vessels • boosting immune system	see above
D	• absorbing calcium • forming bone	vitamin D: fish 
E	• strengthening red blood cell membranes	see above
K	• blood clotting	vitamin K: dark, leafy greens 



Mineral		
calcium	• forming bone • conducting nerve signals • contracting muscle • clotting blood	calcium: dairy products 
iron	• producing hemoglobin	iron: red meat 
magnesium	• supporting enzyme functions • producing protein	magnesium: dark, leafy greens 
potassium	• conducting nerve signals • contracting muscle	potassium: grains 
sodium	• conducting nerve signals • balancing body fluid	sodium: salt 
zinc	• supporting immune system • cell growth • wound healing	zinc: nuts 



Allergic Responses

- Protein molecules are normally too large to pass through the cell membranes of the cells that make up the intestinal lining.
- **Occasionally, however, whole proteins are absorbed by these cells. When this happens, the undigested proteins are recognized as "foreign" by the body's immune system, leading to unpleasant allergic reactions.**
- This is why some people must avoid certain protein-rich foods, such as eggs, fish, and nuts

- The importance of scientific research to support claims made about diets should be discussed. Students should evaluate the reliability of each information source examined.

- Diet Poster Assignment

- STSE Case Study Eating Well