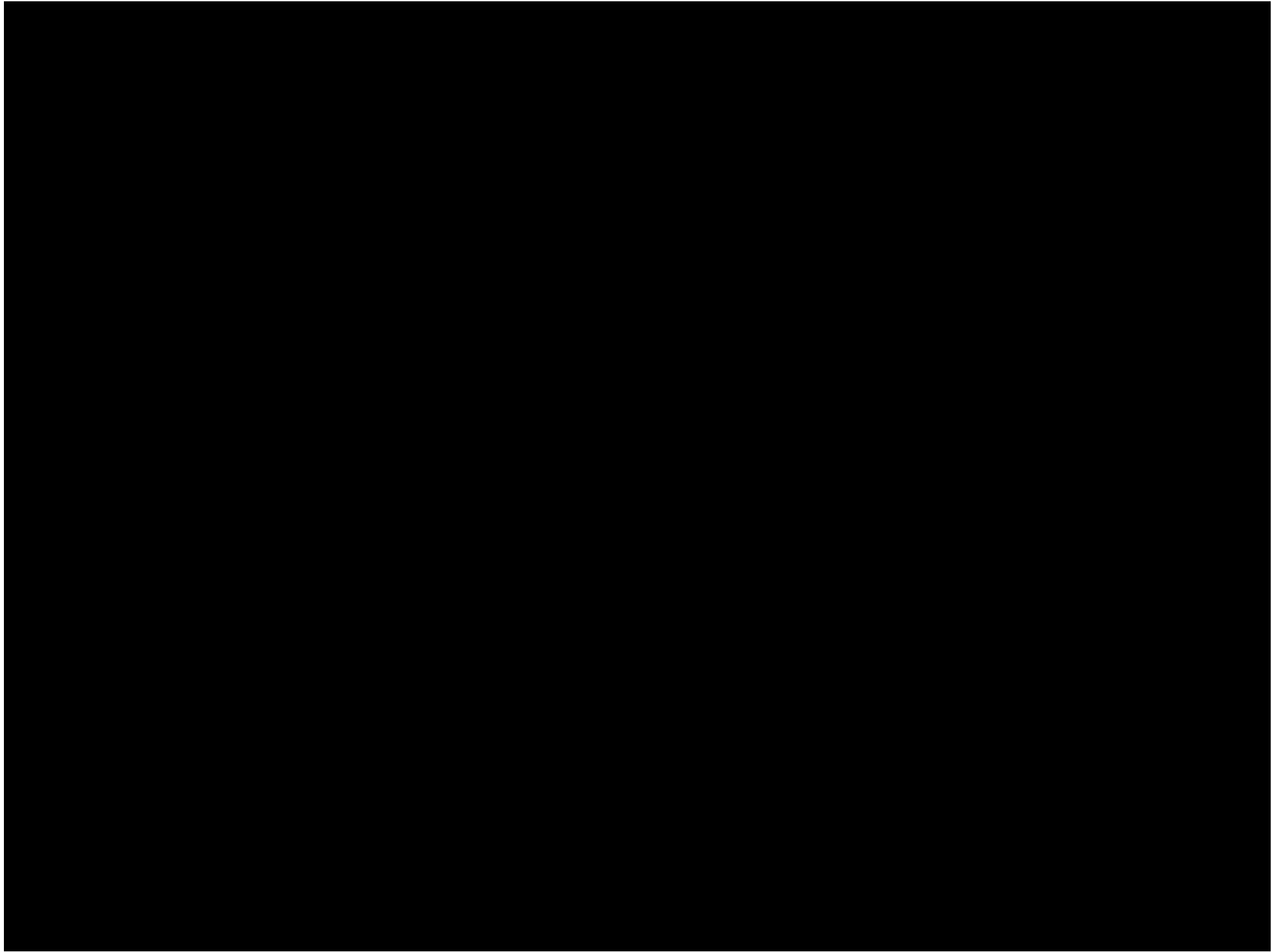


# Human Anatomy

## Digestion

Biology 12

# Stages of Digestion



## **Purpose of the Digestive System:**

To change the food we eat into a form that can be absorbed by our cells and utilized for energy

## **The following processes are involved in the Human Digestive System:**

### **1. Ingestion**

Putting food in your mouth

### **2. Digestion**

CHEMICAL and MECHANICAL breakdown of the food we eat (occurs throughout the digestive system)

### **3. Mastication**

Chewing to break apart the food and mix it with your saliva

### **4. Swallowing**

Move the food from the mouth into the esophagus

### **5. Peristalsis**

Wave-like, smooth muscle contractions that move food through the gastrointestinal tract

### **6. Absorption**

Passage of food molecules through the wall of the small intestine

### **7. Defecation**

Discharge of indigestible waste (feces) from the gastrointestinal tract

# Major Digestive Organs and their Functions:

## 1. Mouth/Oral Cavity

- Food enters the digestive system is torn apart and mixed with saliva

## 2. Esophagus

- Transports food to the stomach

## 3. Stomach

- Stores the food, mixes it with gastric juice.

## 4. Accessory Organs :

### Liver

- Secretes bile

### Gallbladder

- Stores, concentrates and releases bile

### Pancreas

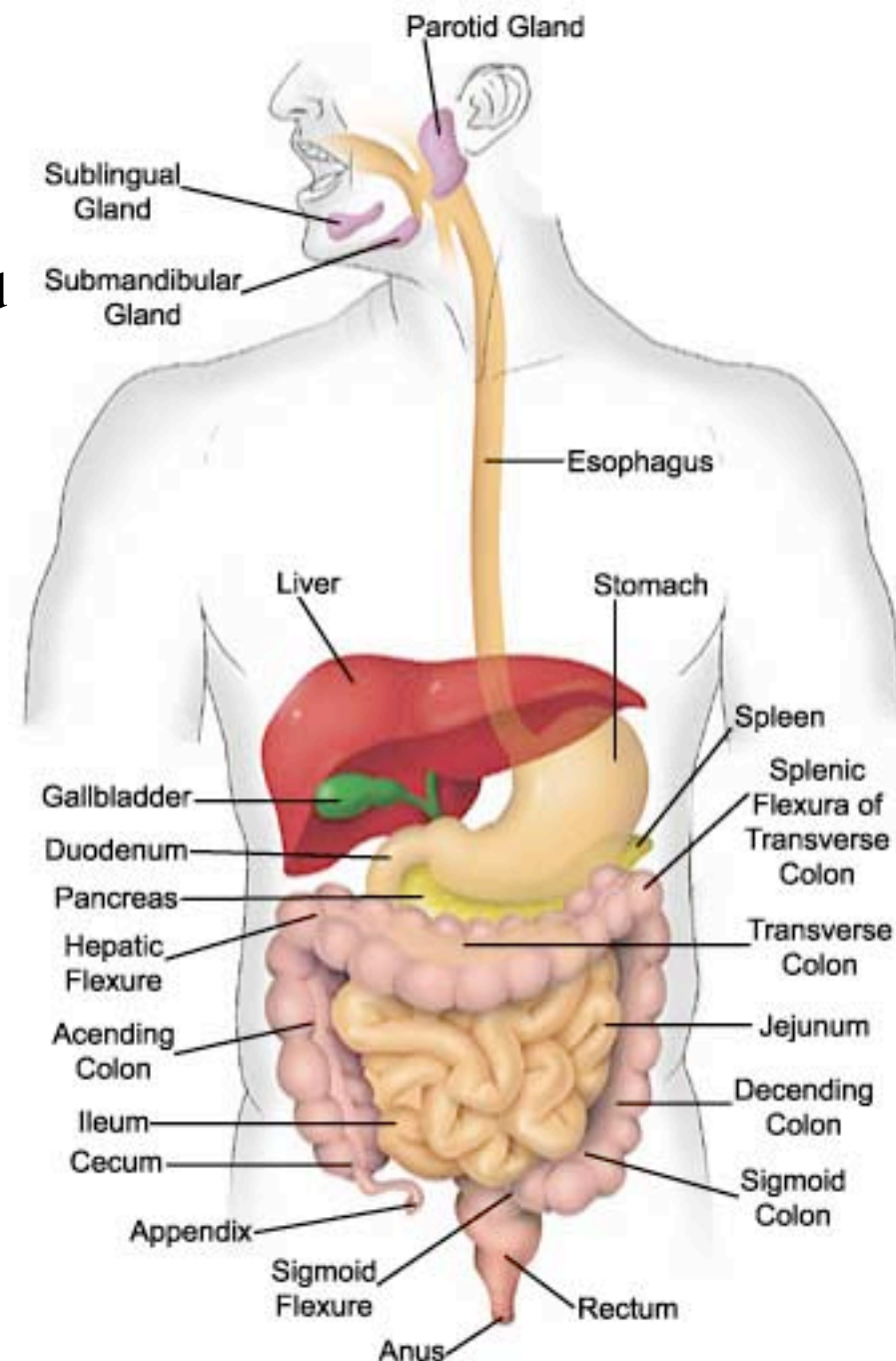
- Produces insulin and glucagons

## 5. Small Intestine

- Nutrient absorption

## 6. Large Intestine

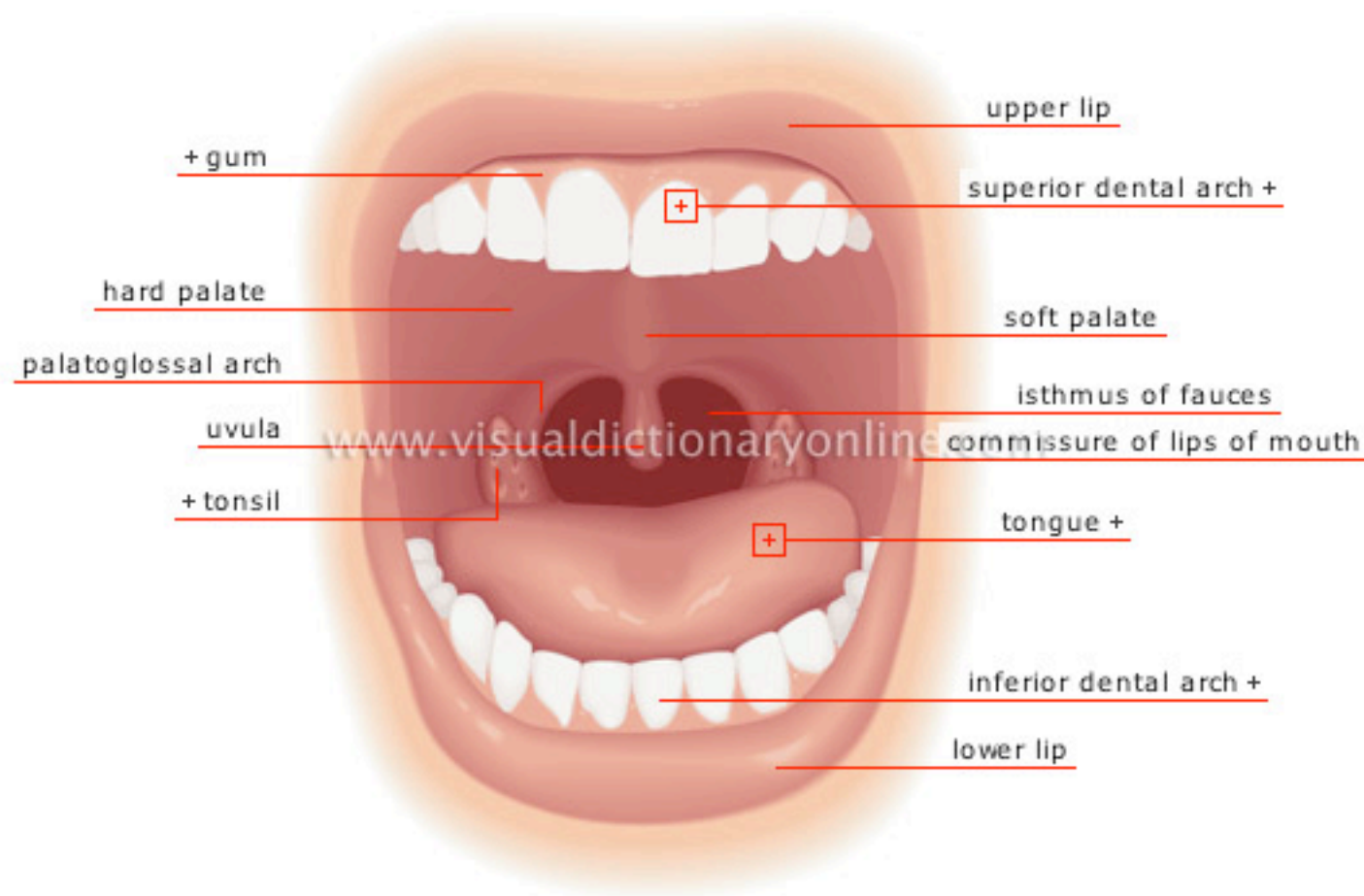
- Absorbs fluid and some nutrients, stores and eliminates waste



# Mouth/Oral Cavity

## Function:

- Receives food
- Mechanical and chemical digestion
- Formation of **bolus**: mixture of chewed food and saliva



# Mouth/Oral Cavity

## Structures:

Roof of mouth → separates the oral cavity from the nasal cavity

**Hard palate** → front of roof of mouth, composed of bones

**Soft palate** → back of roof of mouth, composed of muscle

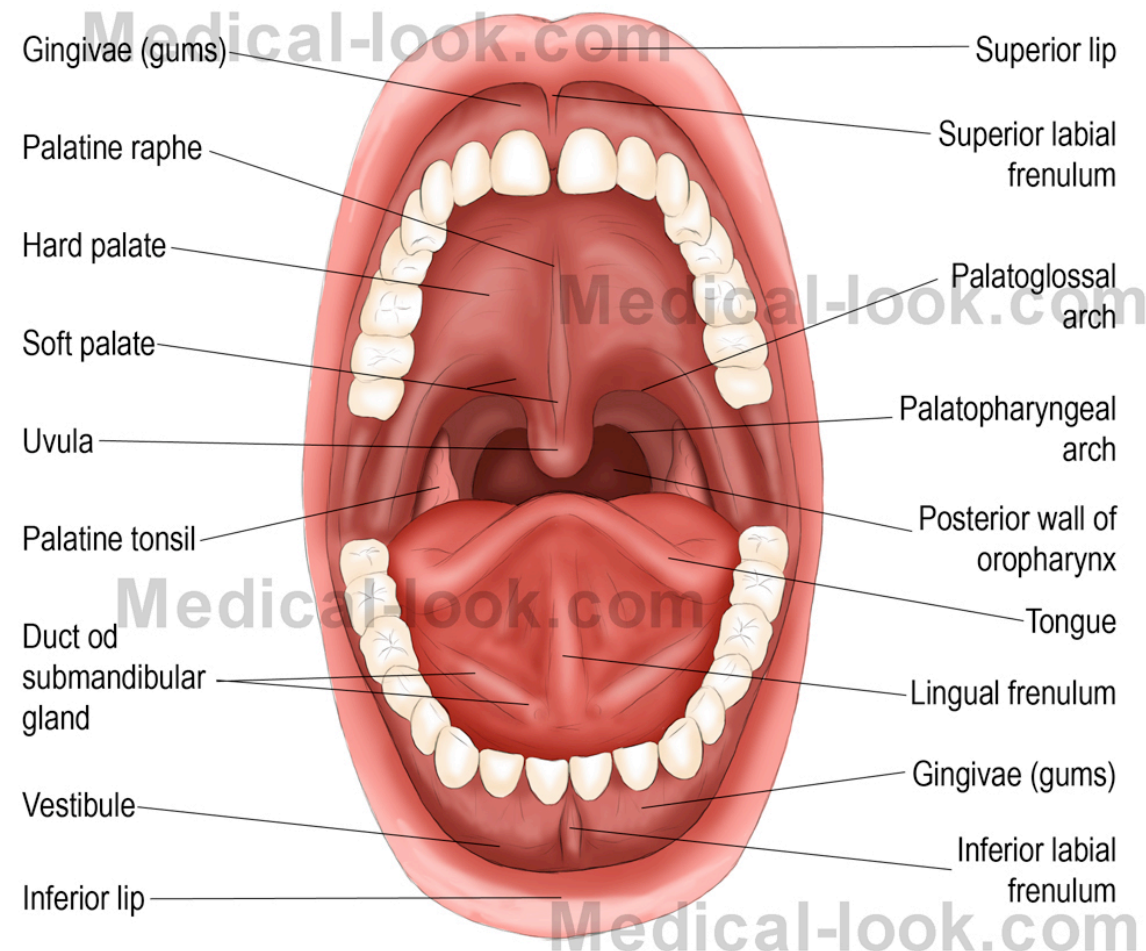
Ends in **uvula** “hangy ball” at back of throat

Tongue → composed of skeletal muscle, movement of food in oral cavity, mixes it with saliva

Taste buds → sensory receptors on tongue

Tonsils → on either side of the tongue, help protect body against infection

Teeth → mechanical breakdown of food into pieces small enough for swallowing



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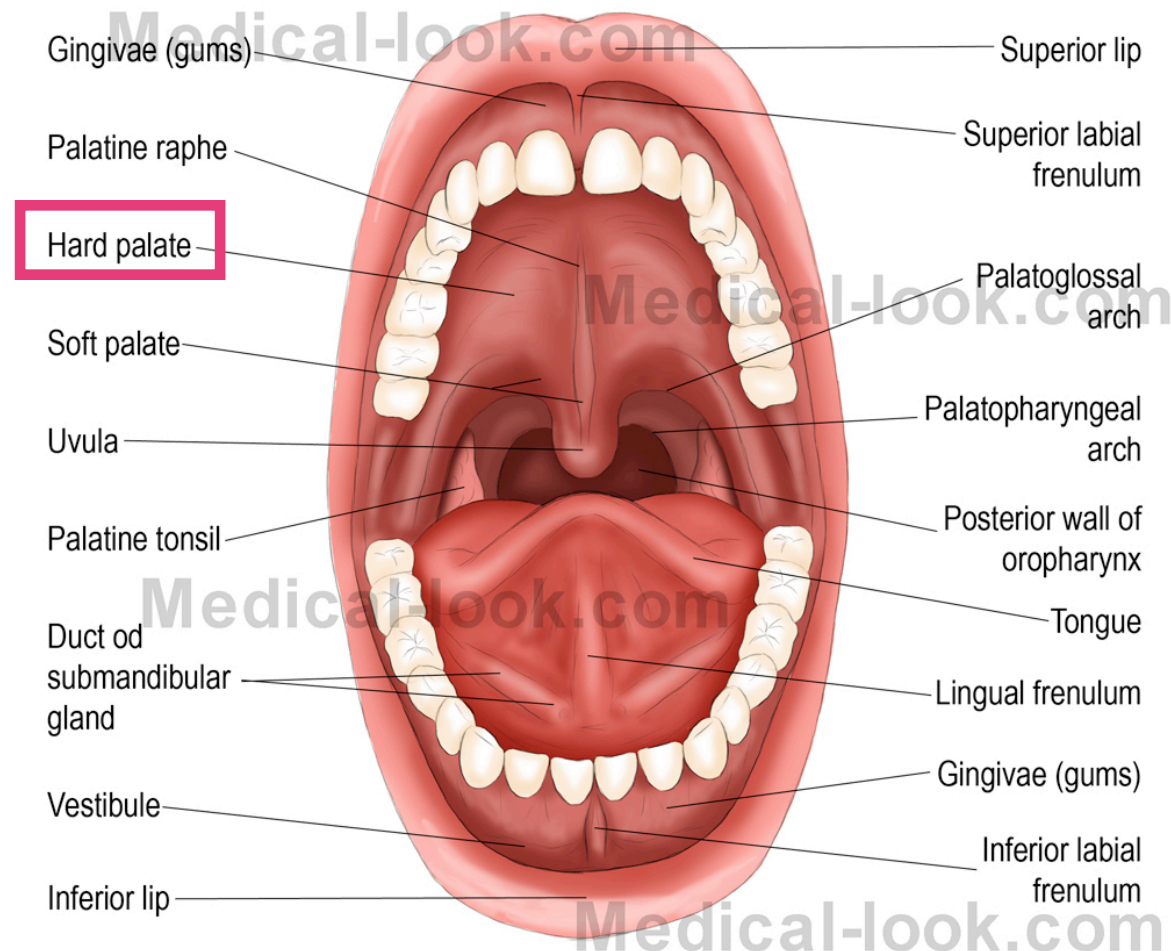
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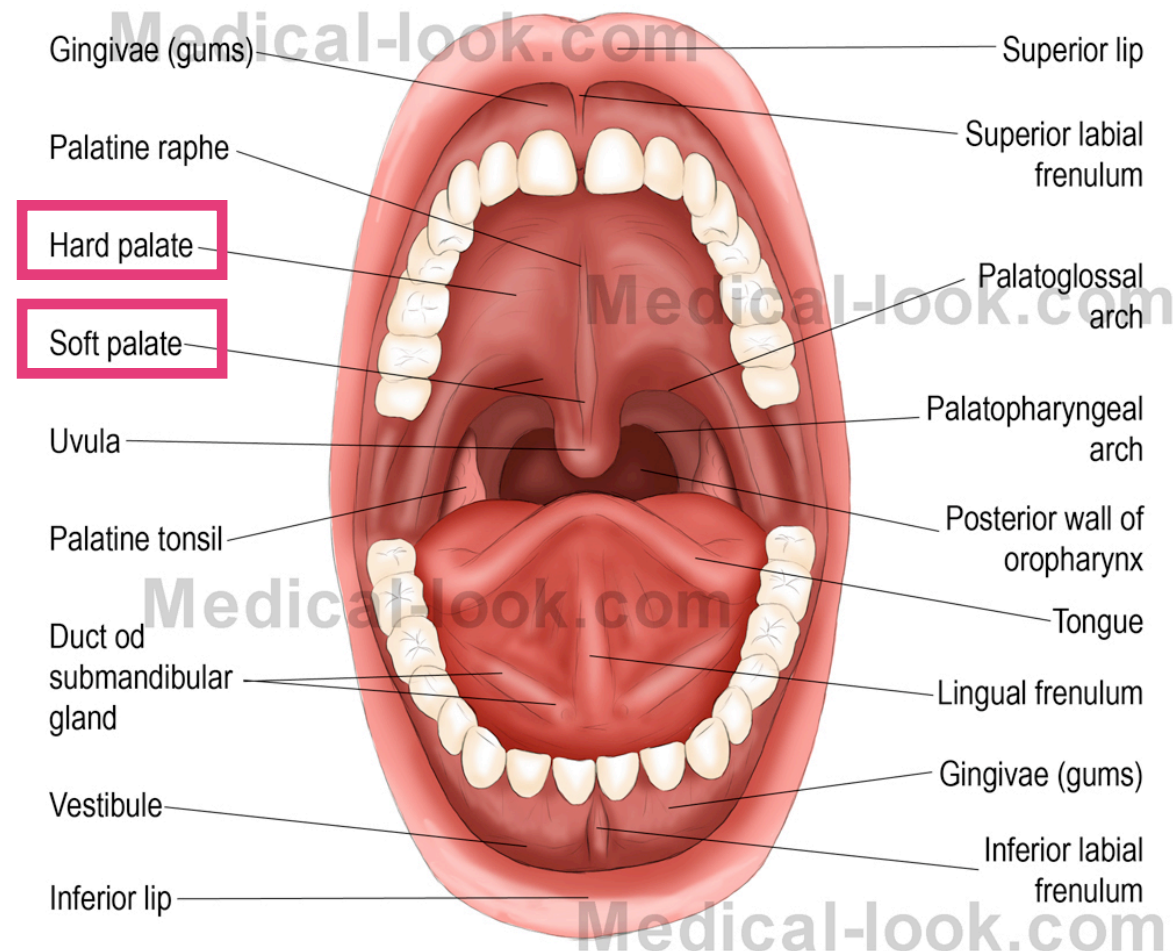
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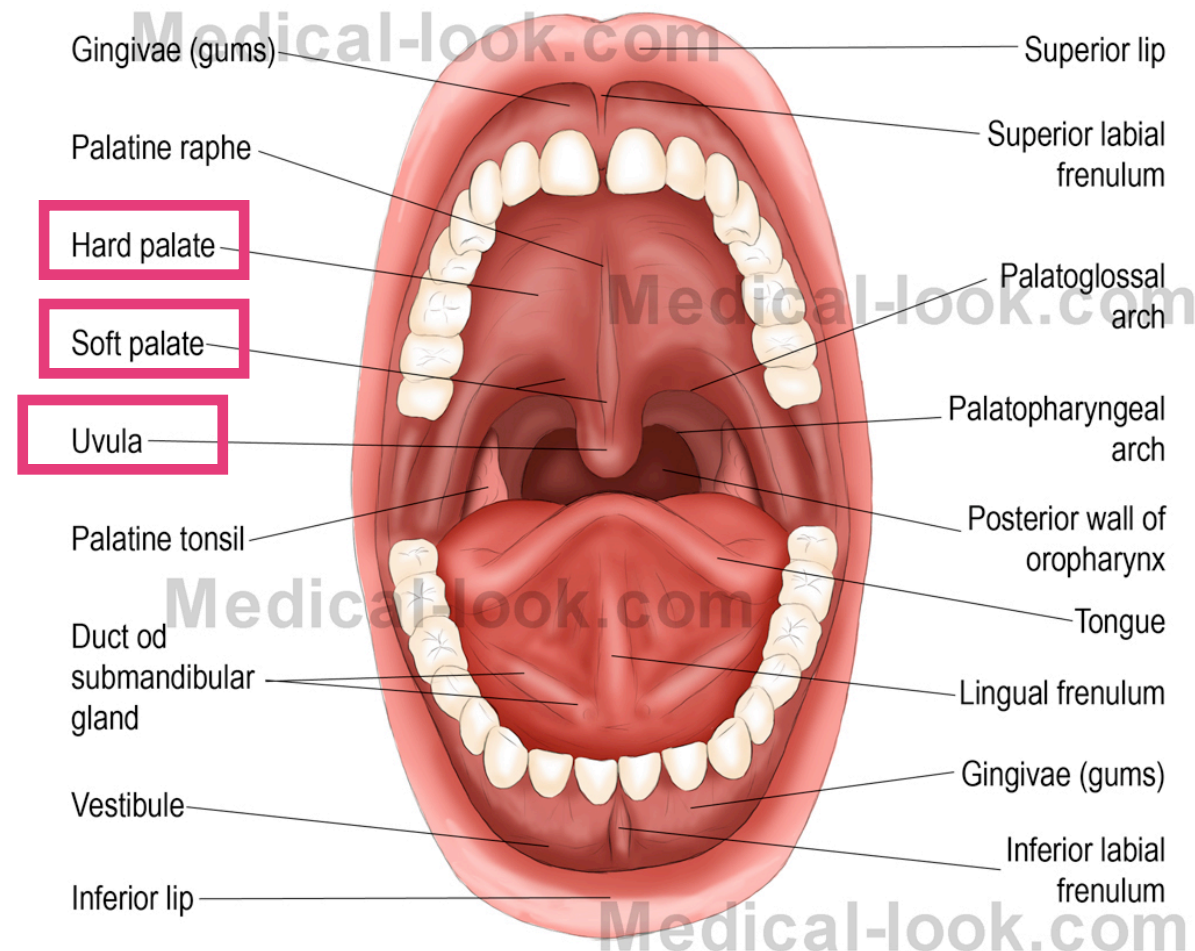
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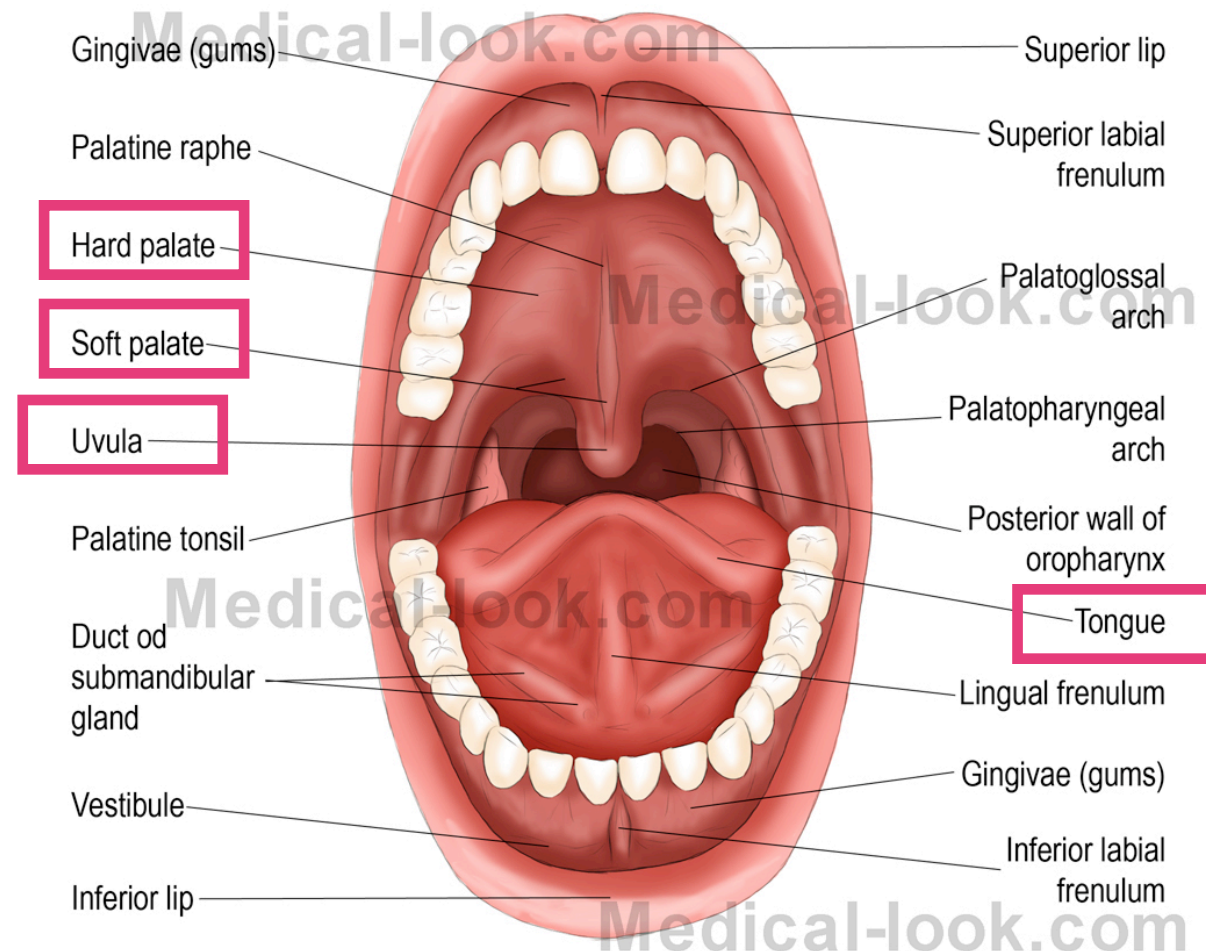
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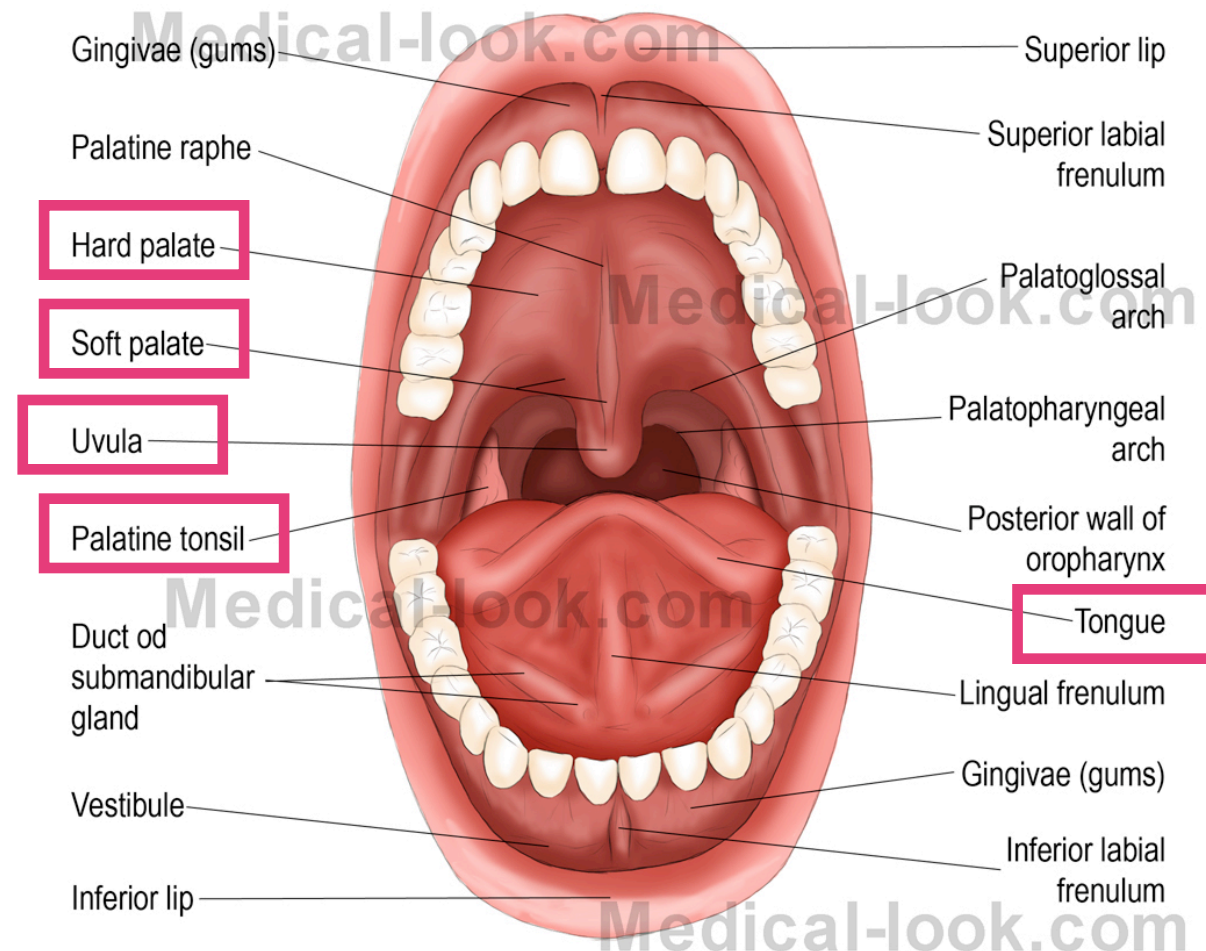
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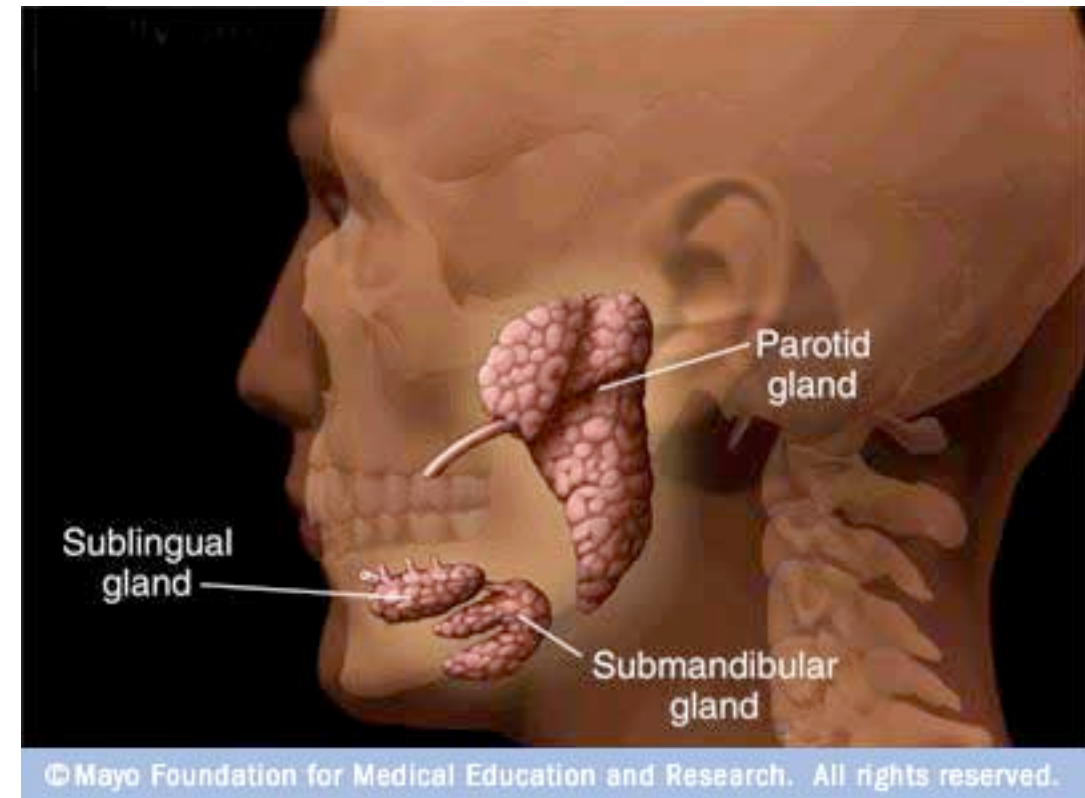
Teeth → mechanical breakdown of food into pieces small enough for swallowing



# Mouth/Oral Cavity

## Salivary Glands (3 pairs)

1. Parotid: Side of face
  2. Sublingual: Beneath the tongue
  3. Submandibular : Beneath floor of oral cavity
- \* Can secrete between 1-1.5 L of saliva per day



## Functions

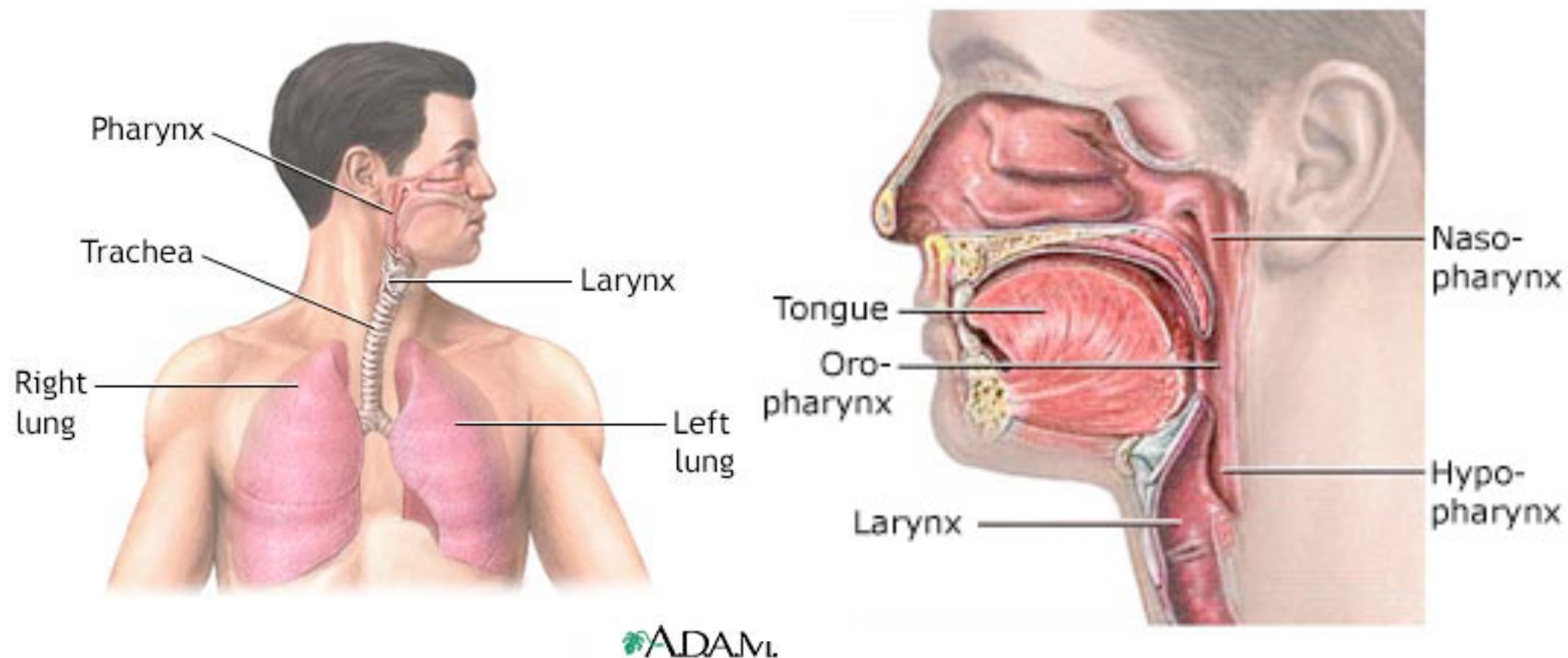
- Contains **amylase**, which begins starch digestion
- Cleanses teeth and dissolves food molecules
- Lubricates food for swallowing



# Pharynx

## Function:

- Receives food and air
- Connects the oral and nasal cavities to the esophagus and larynx
- Site of swallowing



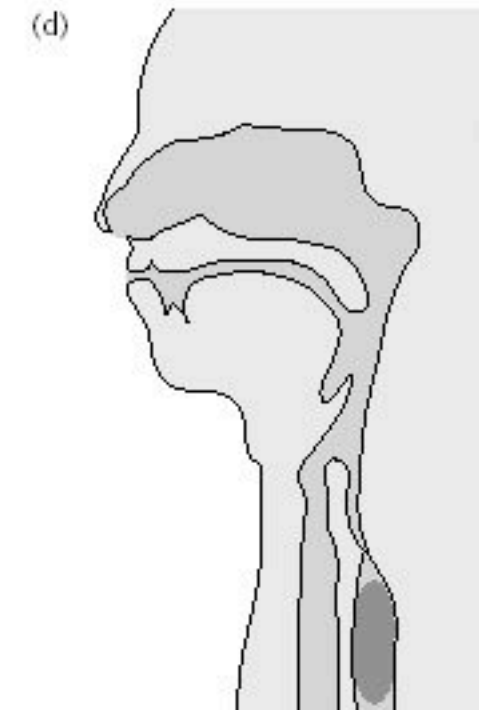
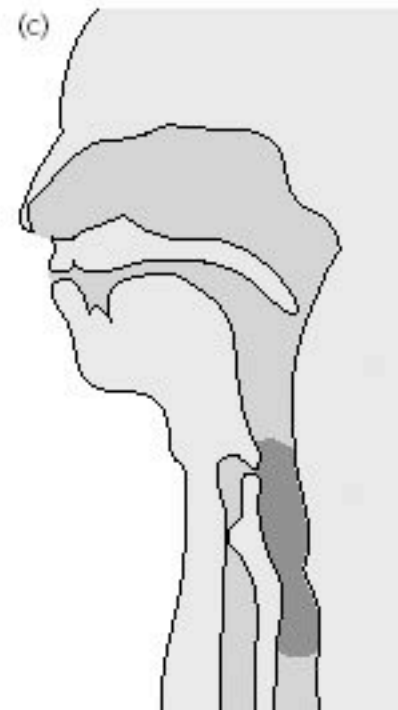
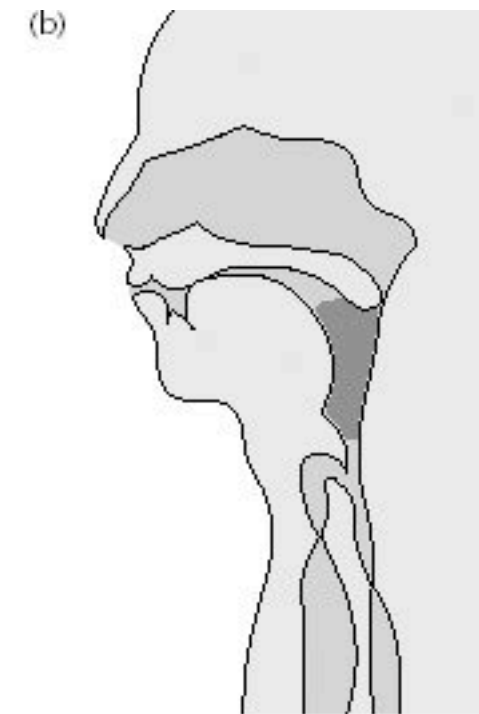
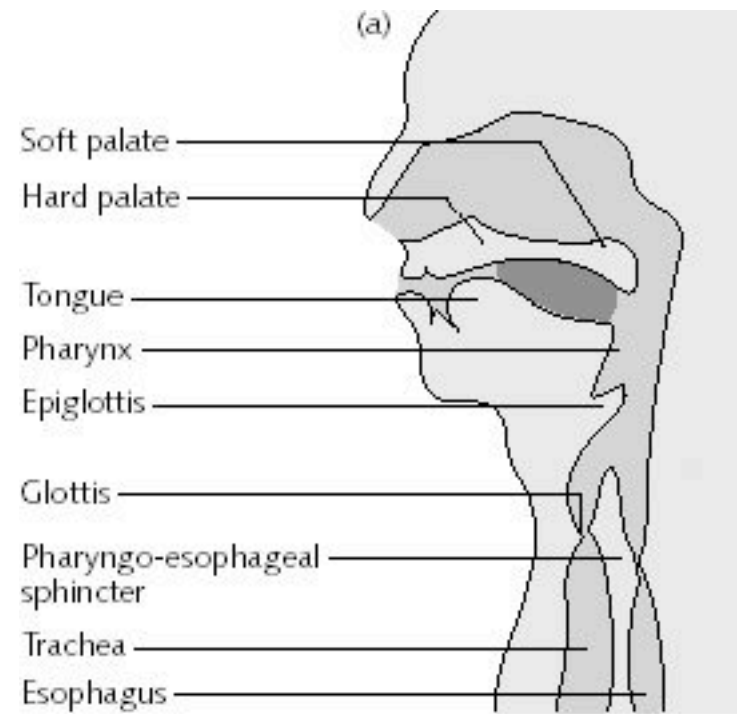
# Swallowing (deglutition)

-Reflexive action (performed without conscious thought)

-Soft palate moves BACK to close off nasopharynx (entrance to nasal cavity)

-Trachea (leading to the lungs) moves UP under the epiglottis to cover the opening to the larynx (glottis)

-Food passes into the esophagus (leading to stomach)









# Esophagus

## Function:

- Carries bolus of food and fluids from the oral cavity to the stomach
- No chemical digestion takes place

## Structures:

**Muscular tube** (approx 25 cm long) that lies behind the trachea

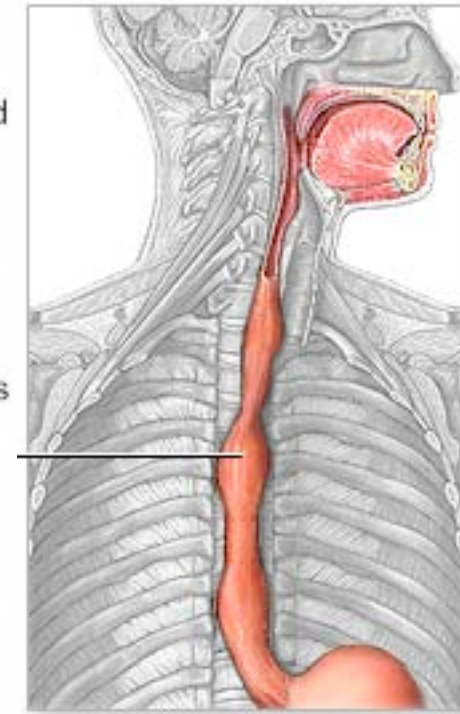
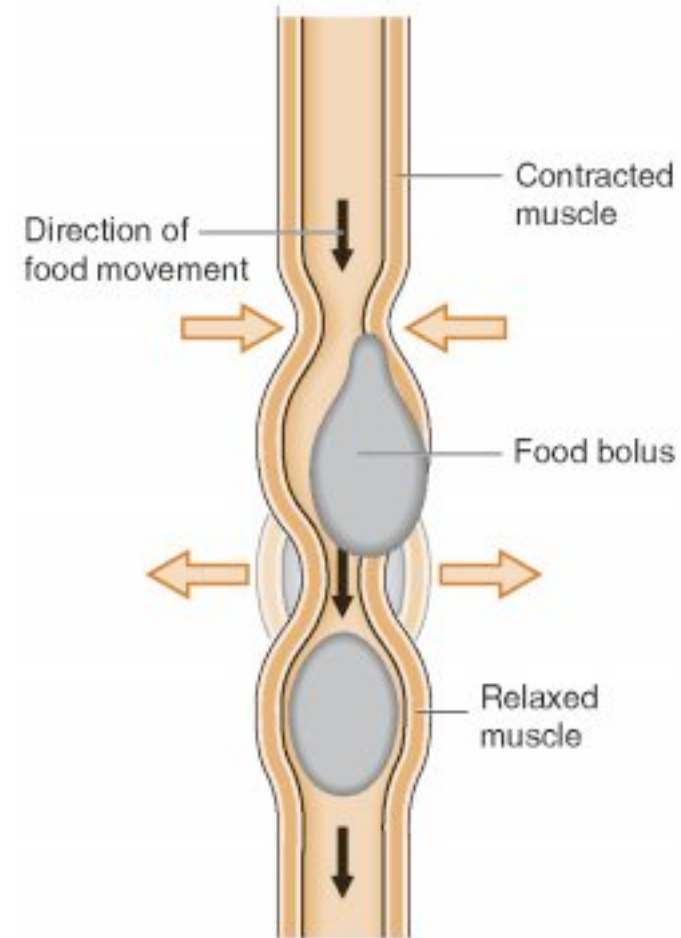
Passes from pharynx → through the thoracic cavity and the diaphragm → into the abdominal cavity → to the stomach

**Lower esophageal sphincter:** thickening of the muscle fibers at the junction of the esophagus and the stomach  
when the circular muscle contracts → opening to stomach is closed  
therefore allows bolus to enter the stomach and prevents the contents of the stomach from escaping

**Heartburn** = stomach contents which are acidic escaping into the esophagus

# Peristalsis

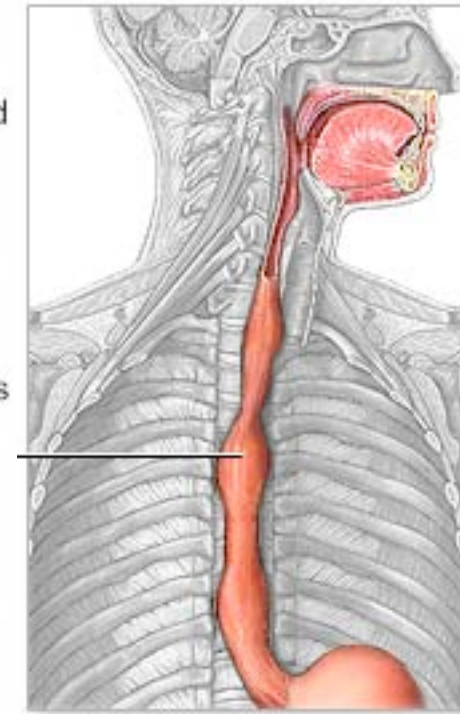
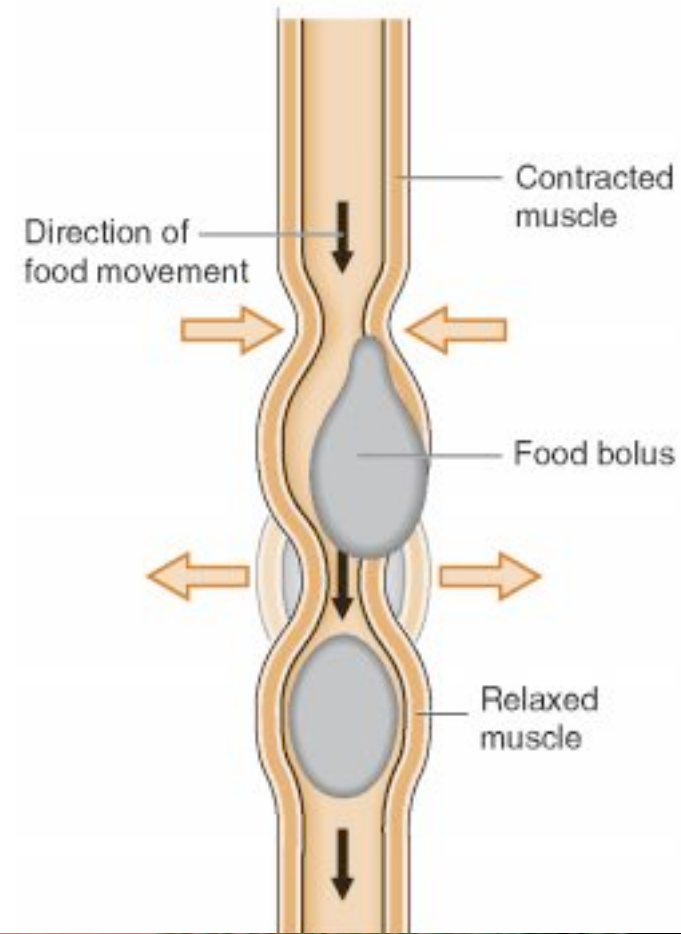
Rhythmic contraction of smooth muscles in the GI tract to transport bolus.



ADAM.

# Peristalsis

Rhythmic contraction of smooth muscles in the GI tract to transport bolus.

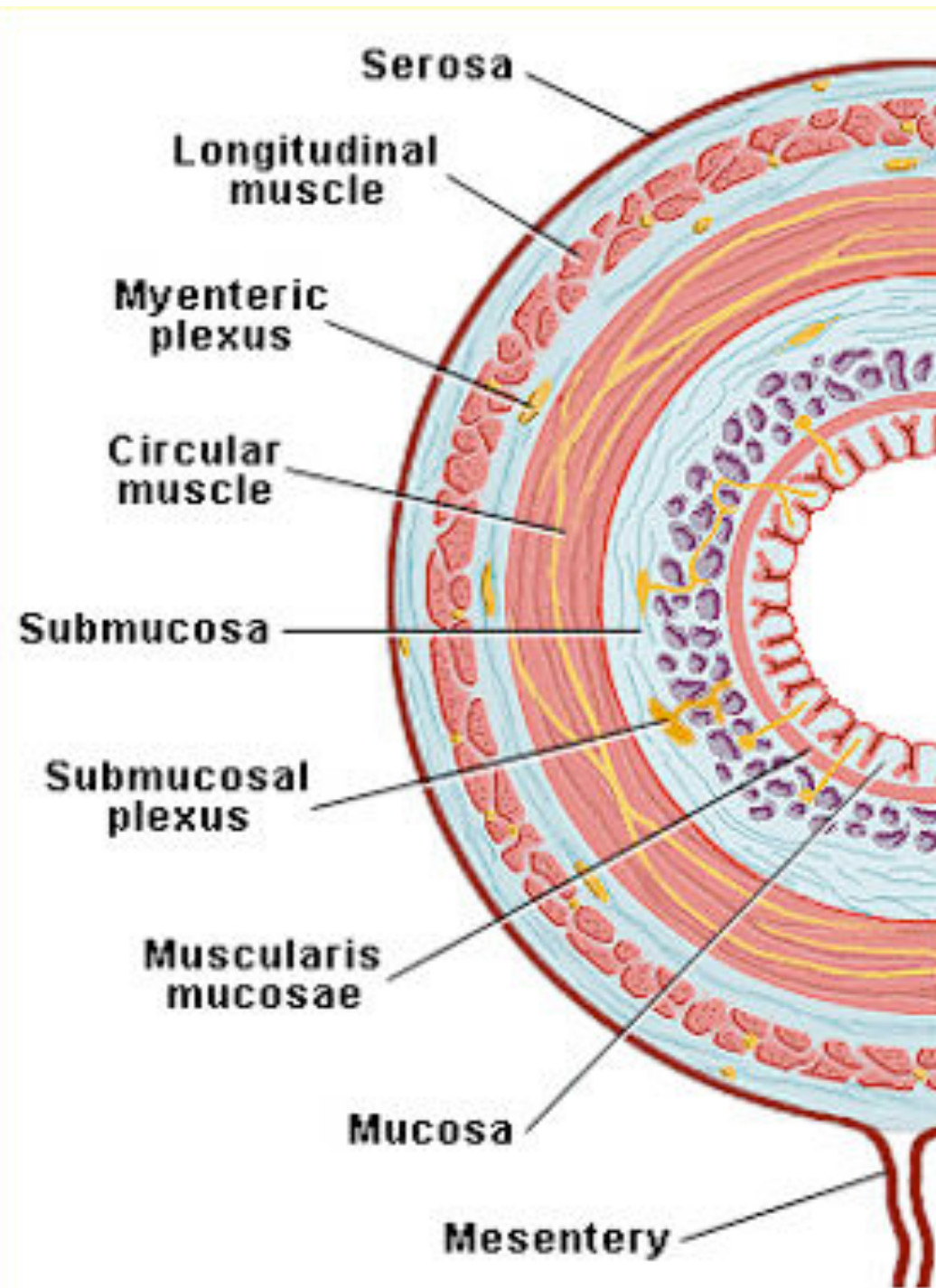


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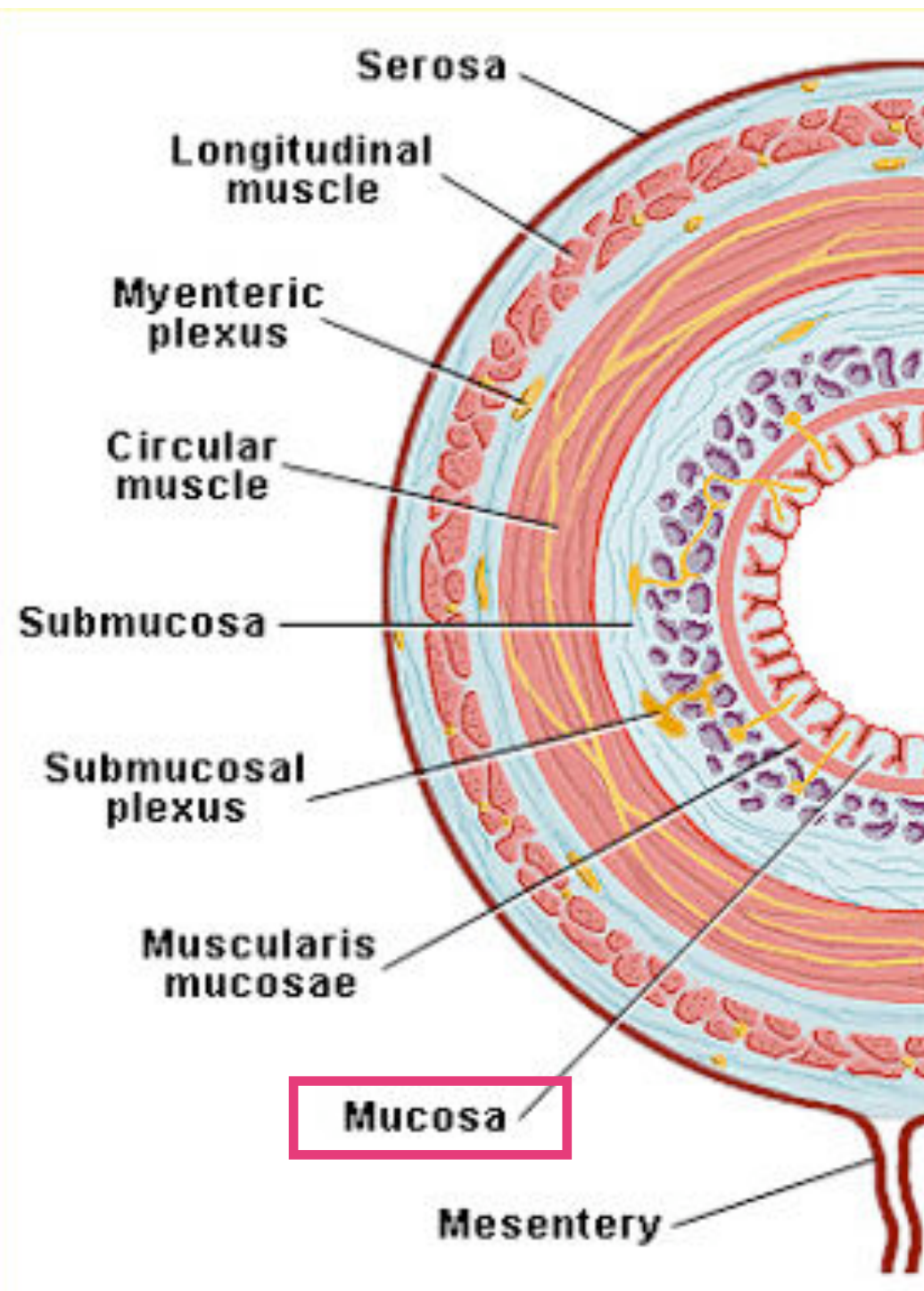


# Layers of the Gastrointestinal Tract

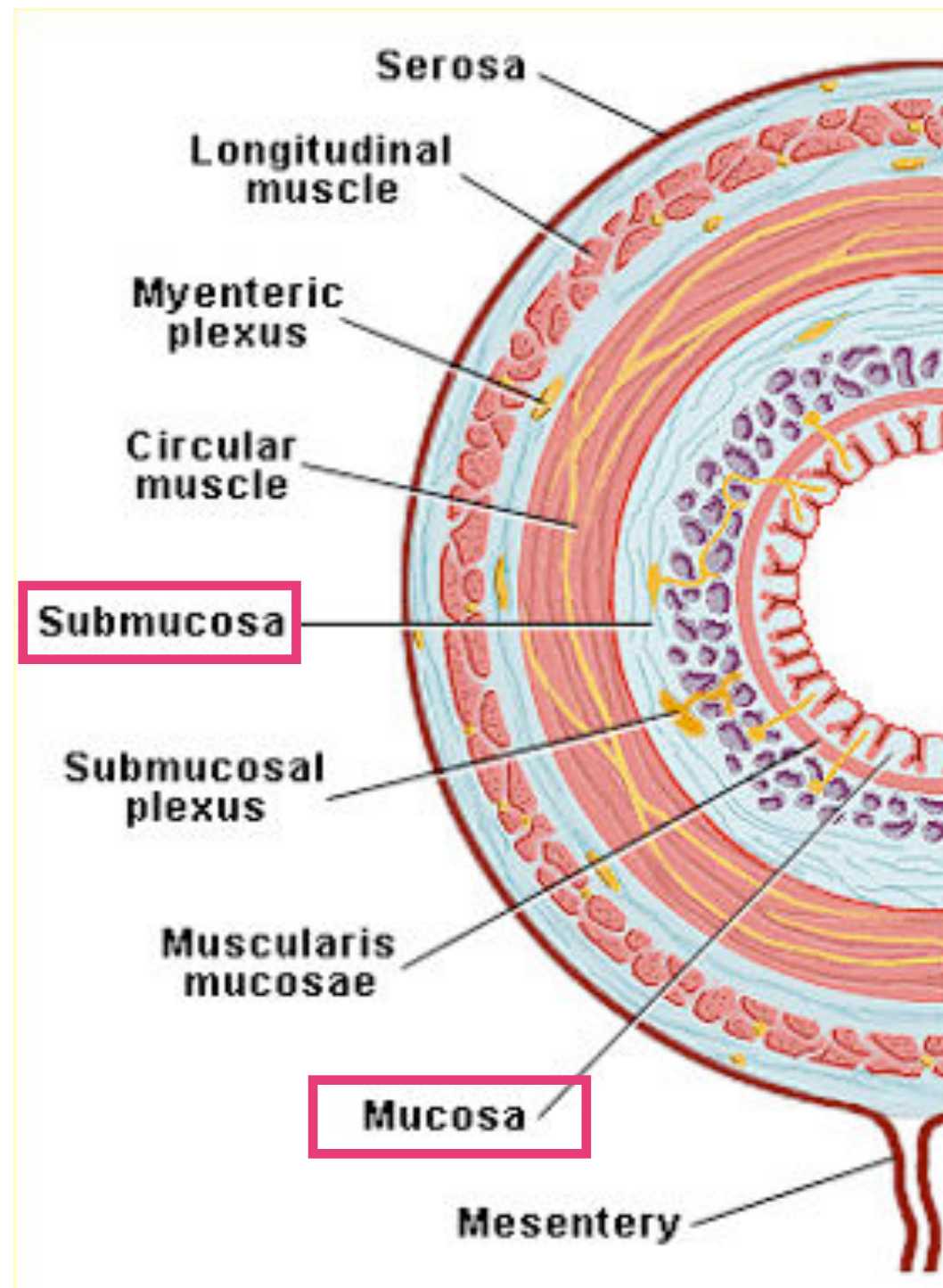




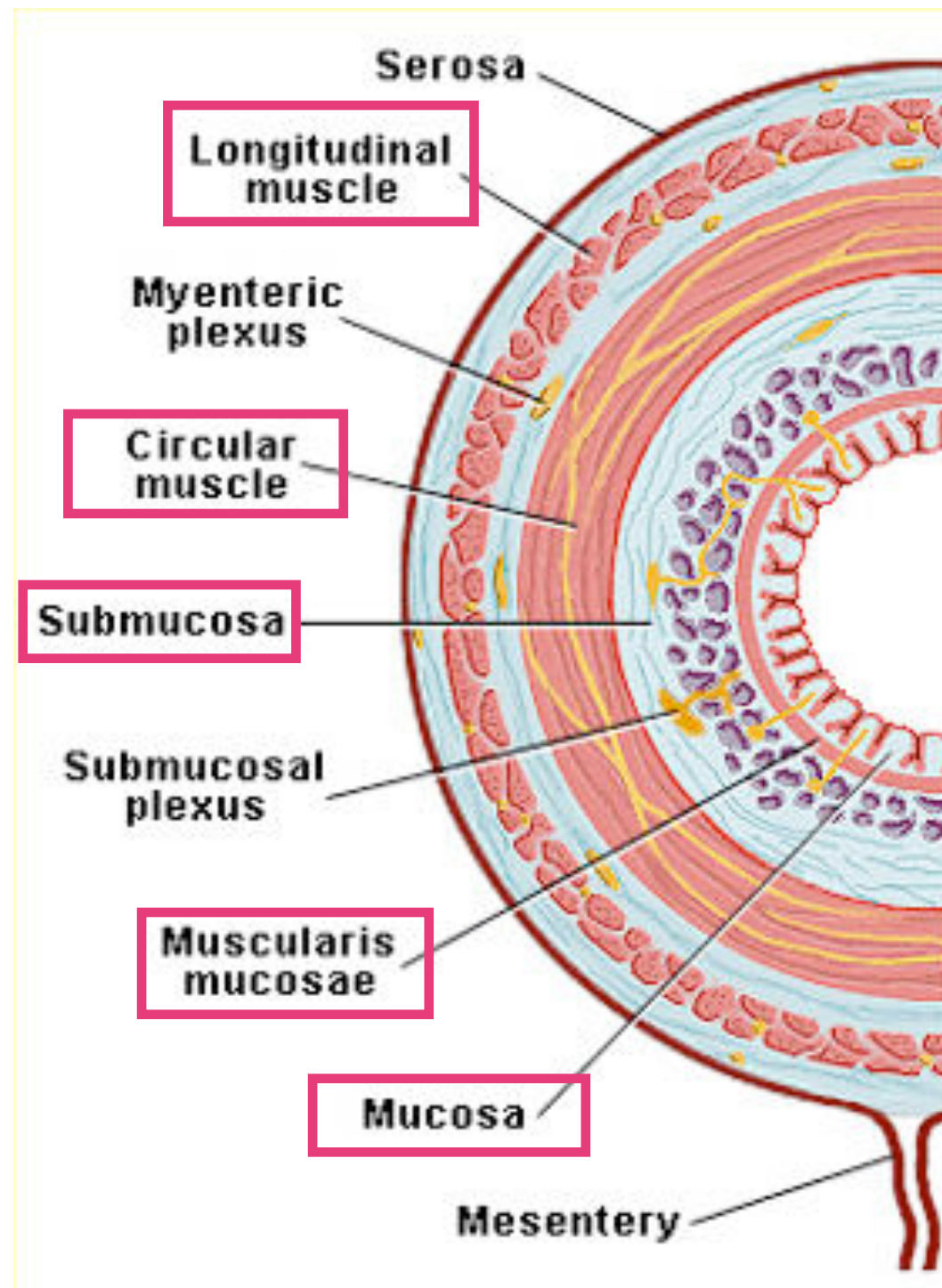
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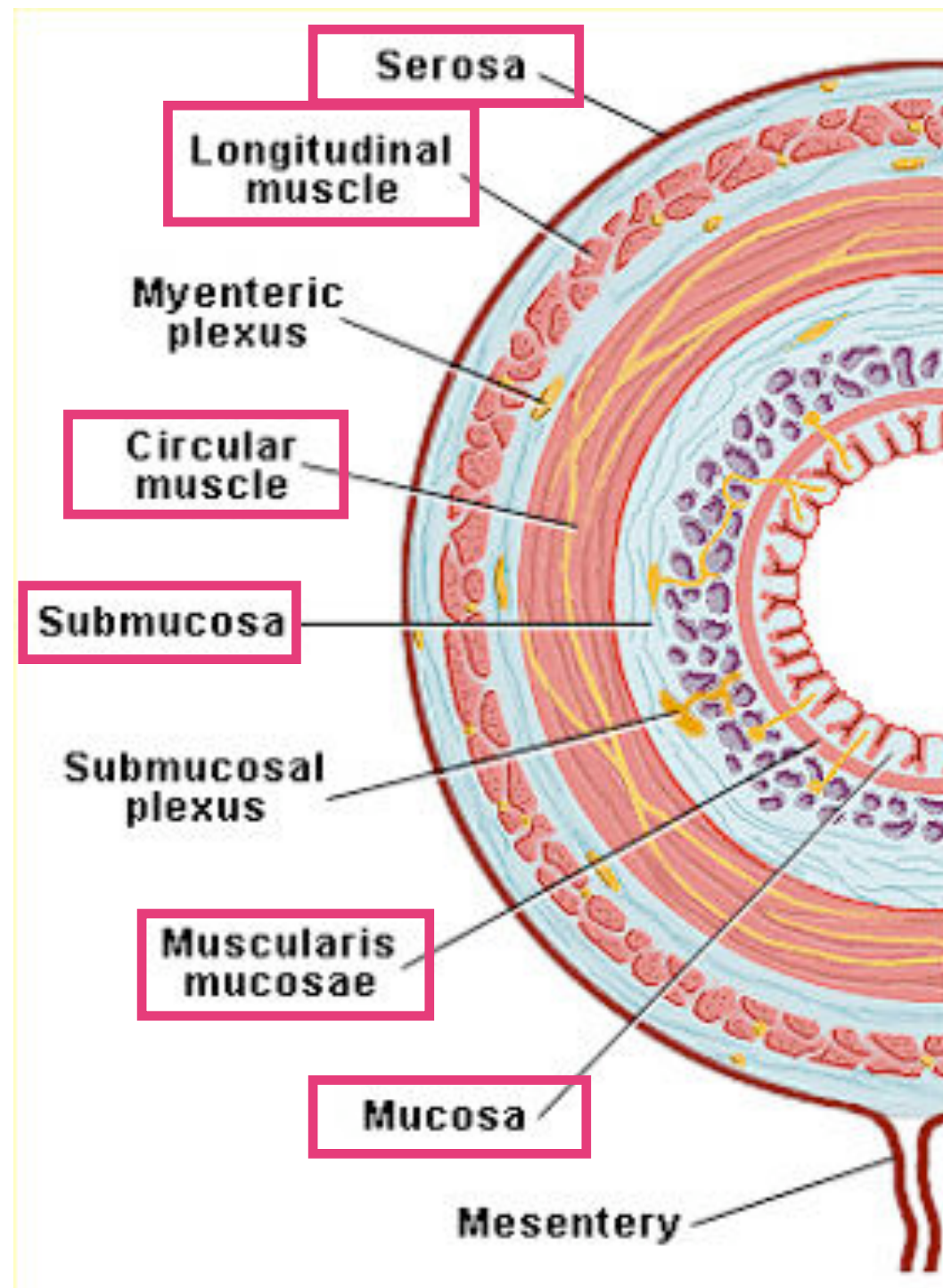


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# Layers of the Gastrointestinal Tract



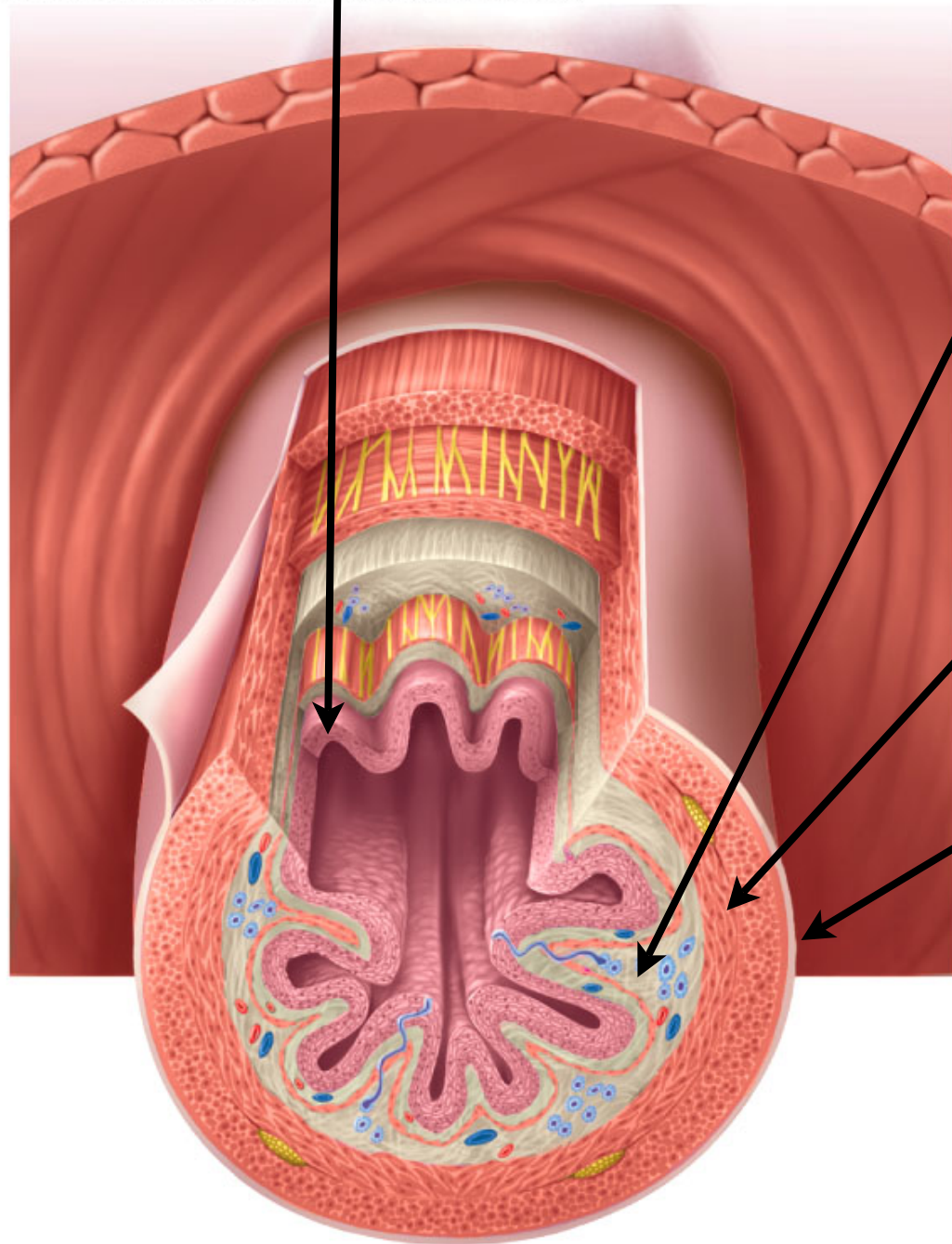
# Mucosa (mucous membrane layer)

Lines the lumen (central cavity) of the GI tract

Contains glandular cells that secrete digestive enzymes

Contains goblet cells that secrete mucous

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## Submucosa (loose connective tissue)

Contains blood vessels

Contains lymph nodes (essential to protect from disease)

## Muscularis (smooth muscle layer)

2 layers of smooth muscles (cause of peristalsis)

Inner circular layer

Outer longitudinal layer

## Serosa (outermost layer)

Very thin

Secretes fluid to keep outer surface of intestine moist

# Stomach

## Function:

- Stores food
- Aids in digestion
- Formation of **chyme** (mixture of gastric (stomach) secretion and mechanically digested food)
- Absorbs alcohol but not food substances.

## Structures:

**Thick Muscular Walls** (really stretchy, distensible): Mix food with gastric juice to form

**J Shaped**

**Lies on the left side of the body beneath the diaphragm**

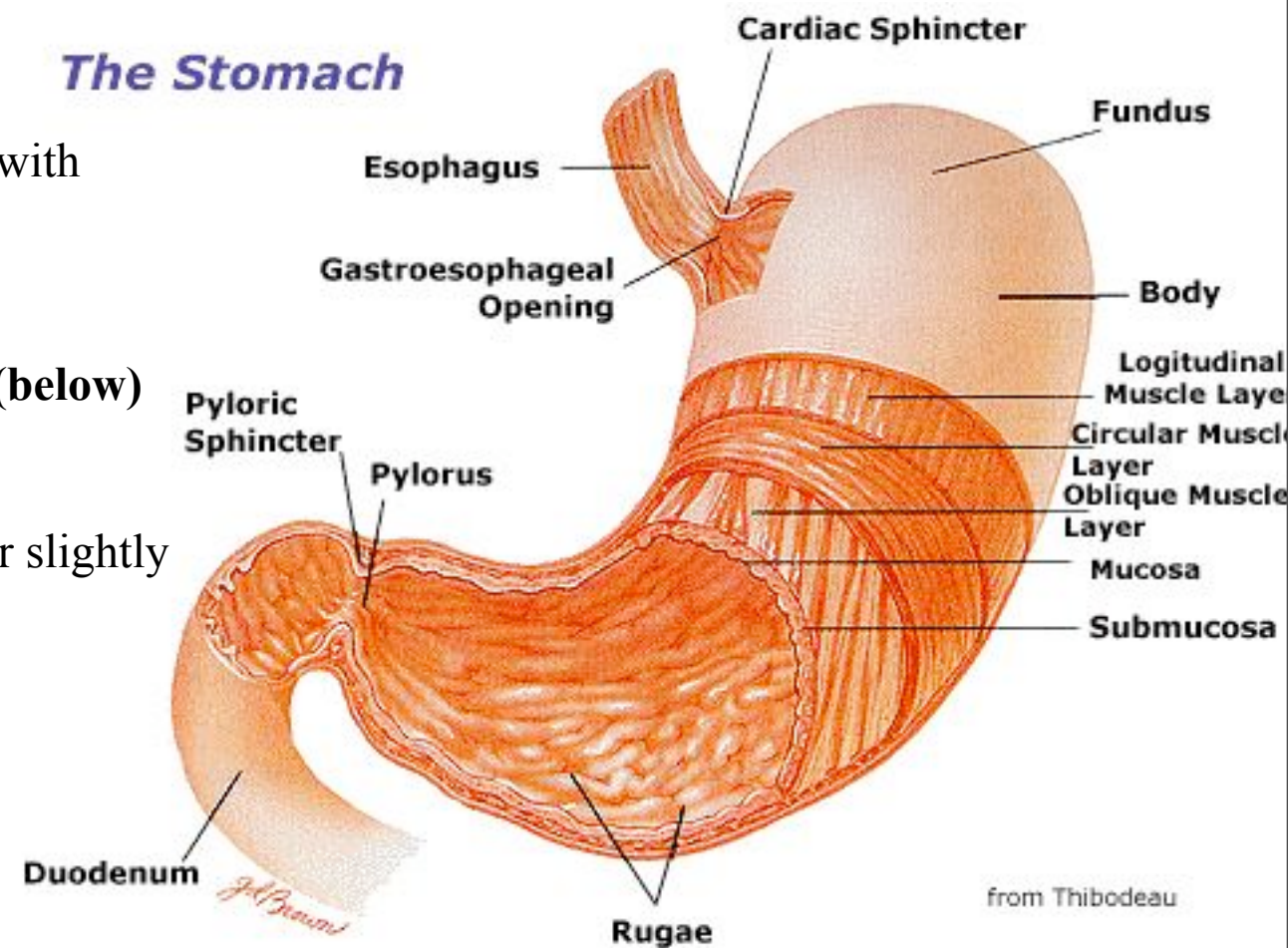
**Continuous with the esophagus (above) and the duodenum (below)**

**Cardiac Sphincter:** At the entrance of the stomach

**Pyloric Sphincter:** At the exit of the stomach

**Acidic Environment: pH 2** (the rest of the GI tract is neutral or slightly basic)

**Empties every 2-6 hours**







# Stomach

## Stomach Mucosa (lining of stomach):

Deep folds to allow to stretching

Epithelial lining of the stomach is composed of microscopic gastric pits which give rise to gastric glands

## Gastric Glands: Secrete gastric juices, each type of cell secretes a specific component

**Goblet cells:** Secrete protective mucous to protect the stomach wall from the acid

**Parietal cells:** Secrete HCl

- Kills bacteria that enter stomach
- Breaks apart connective tissue in meat
- Activates the enzyme pepsin
- \* Ulcer: Damaged tissue where HCl has penetrate the mucous

**Chief Cells (principal cells):** Secrete pepsinogen (inactive form of the enzyme pepsin)

**Pepsin:** Begins protein digestion by breaking proteins in peptides

# Stomach

## Pyloric Sphincter:

**Exit from the stomach**

**Repeatedly opens and closes**

**Squirts chyme from stomach into the upper section of small intestine (pylorus)**

## Proteins:

Protein rich foods include red meat, poultry, dairy products, legumes, nuts and cereals

Proteins are digested, amino acids enter the bloodstream and are distributed to tissues

Amino acids are not usually used for energy

Amino acids are required to form structural proteins (ie: muscles, skin, hair, nails)

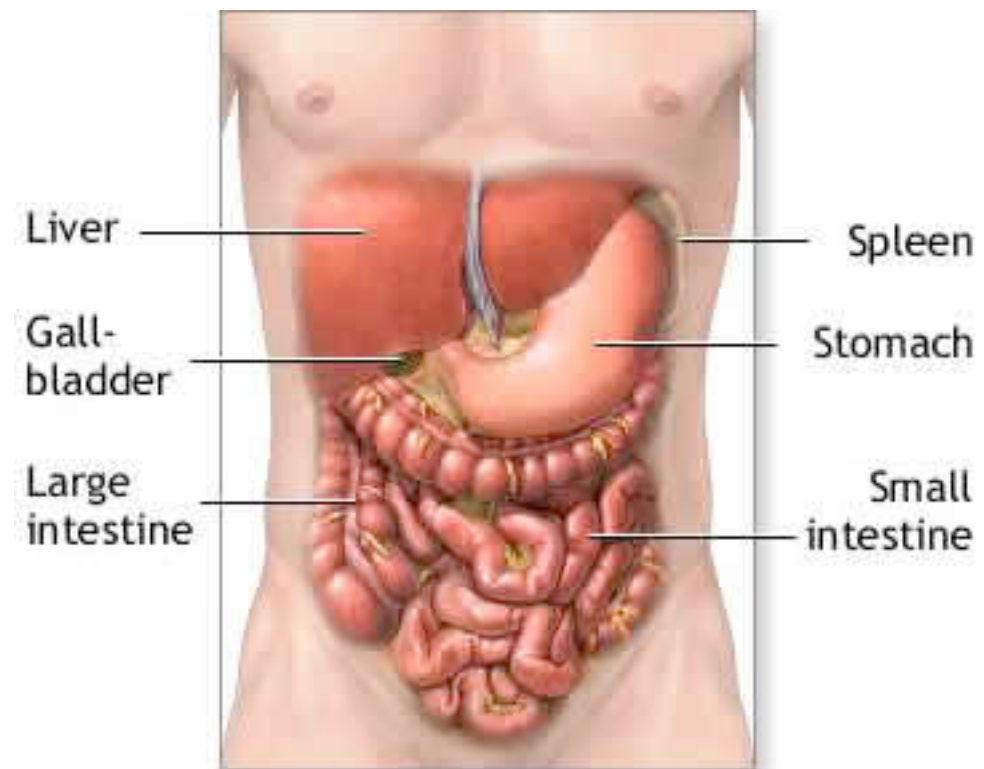
Protein digestion begins in the stomach (PEPSIN) and continues in the small intestine (TRYPSIN and PEPTIDASE)

# Summary

Component	Source	Function
Mucous	Goblet Cells	Protection of stomach wall from acid. Lubrication of stomach contents
HCl	Parietal Cells	Breaks down CT of meat. Protects stomach from bacteria. Activates pepsinogen.
Pepsinogen	Chief Cells	Inactive form of pepsin (enzyme)

Enzyme	Source	Digestion
Pepsin	Chief Cells	Begins the digestion of almost all types of proteins

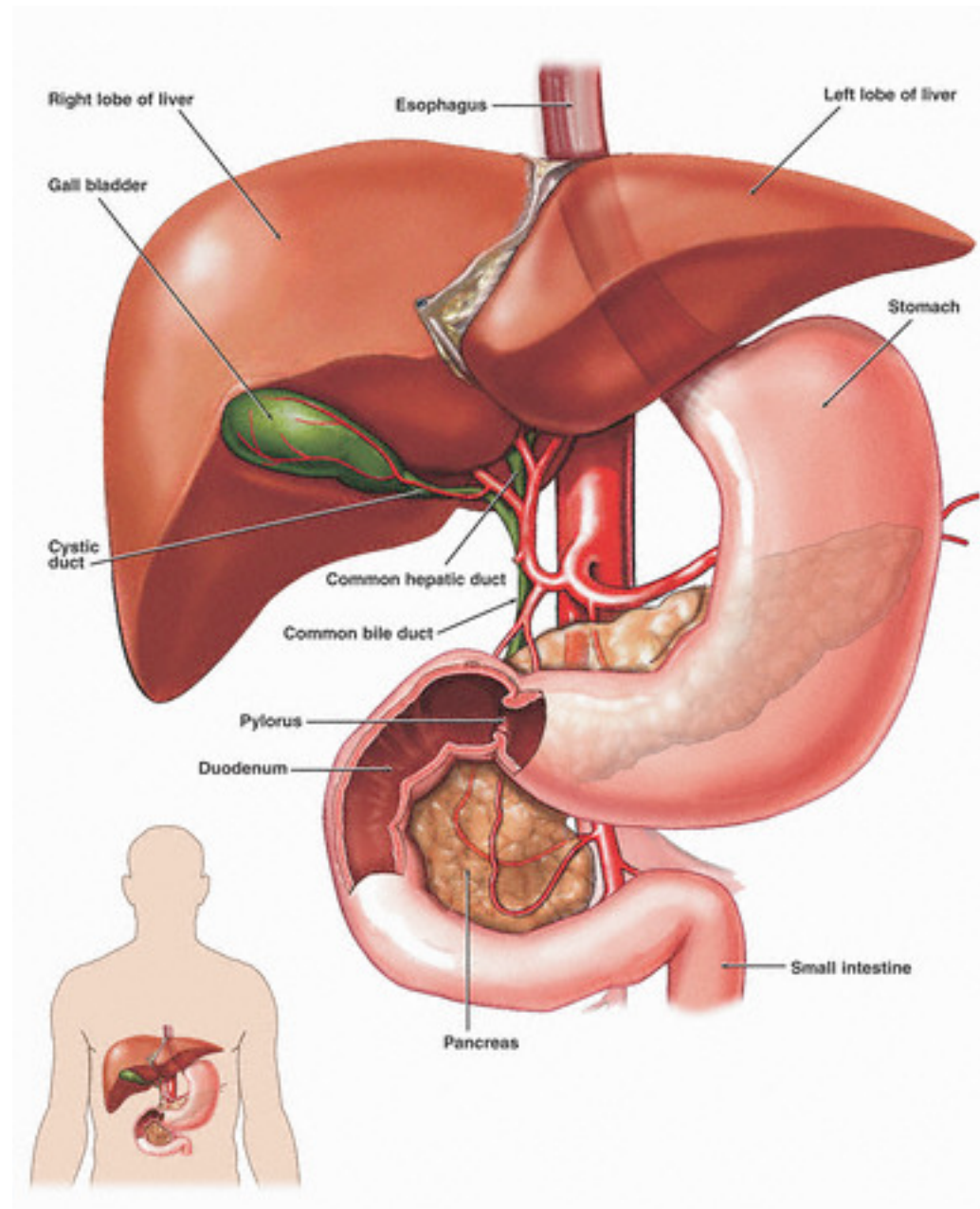
# The LIVER



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## Functions

- Blood from the intestines passes through the liver where harmful substances are removed and the liver works to keep the contents of the blood constant
- Detoxifies blood by metabolizing and removing harmful substances
- Stores iron  $\text{Fe}^{2+}$  and the fat soluble vitamins ADE and K
- Produces plasma proteins (ie albumin and fibrinogen) from amino acids



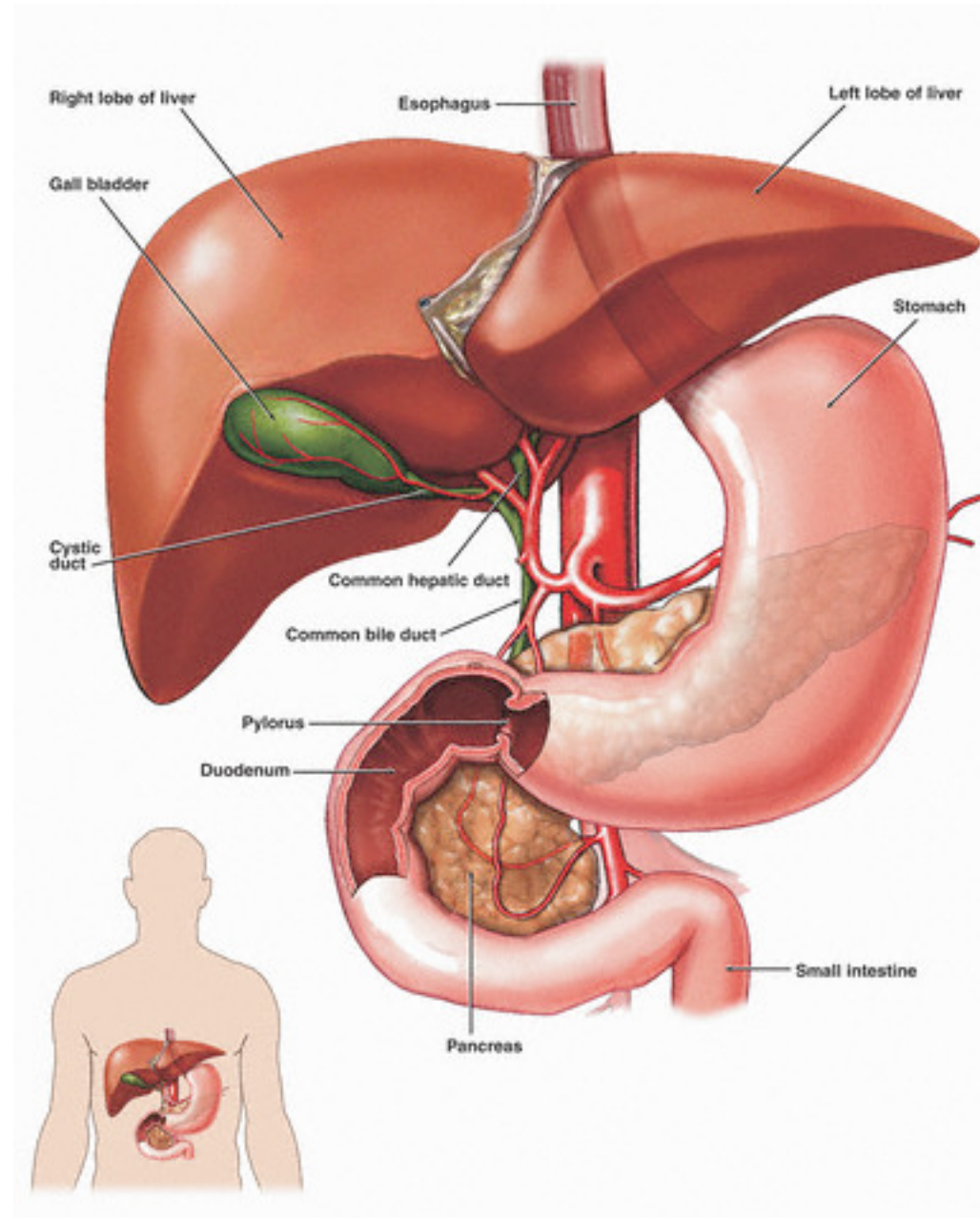


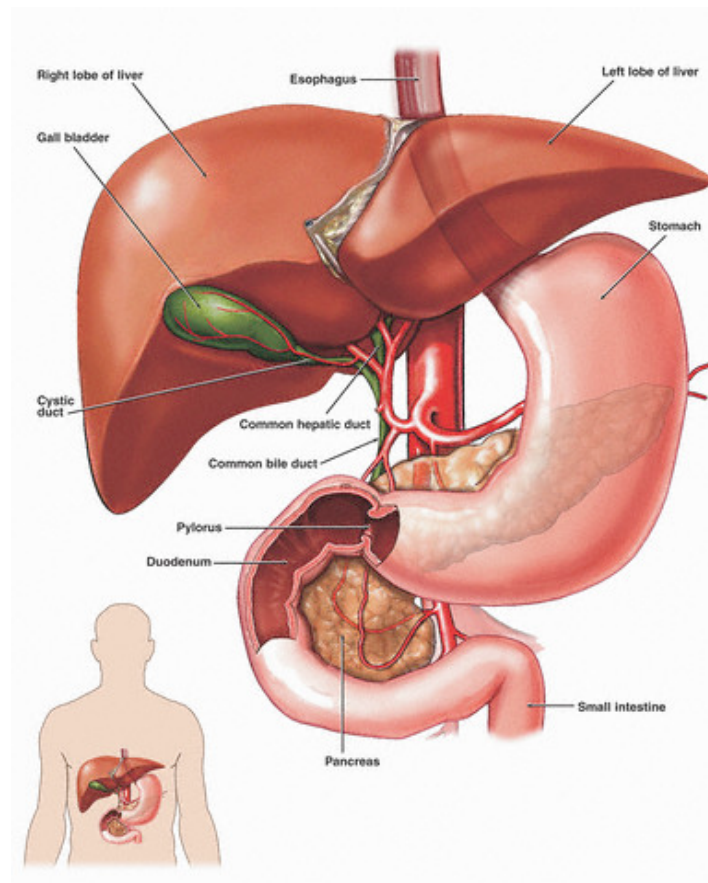
# More Functions...

- Stores glucose as glycogen after eating and breaks down glycogen to glucose to maintain glucose levels between meals
- Produces urea (nitrogen containing waste product) from the breakdown of amino acids
  - if glycogen is depleted, the liver will convert glycerol and amino acids to glucose,
  - requires deamination of amino acids
  - Urea is formed through a metabolic pathway that combines ammonia with carbon dioxide
  - Urea is excreted by the kidneys
- Removes bilirubin (a breakdown product of hemoglobin) from the blood and excretes it in BILE
  - Breakdown of hemoglobin (the red pigment in RBC's) produces bilirubin
  - Bilirubin gives bile a yellowish green color
  - Bile is stored in the gall bladder
  - Bile also contains bile salts which emulsify fat in the small intestine
  - Emulsification of fats creates small droplets with increased surface area for enzyme action
- Produces lipids from fatty acids and helps regulate blood cholesterol

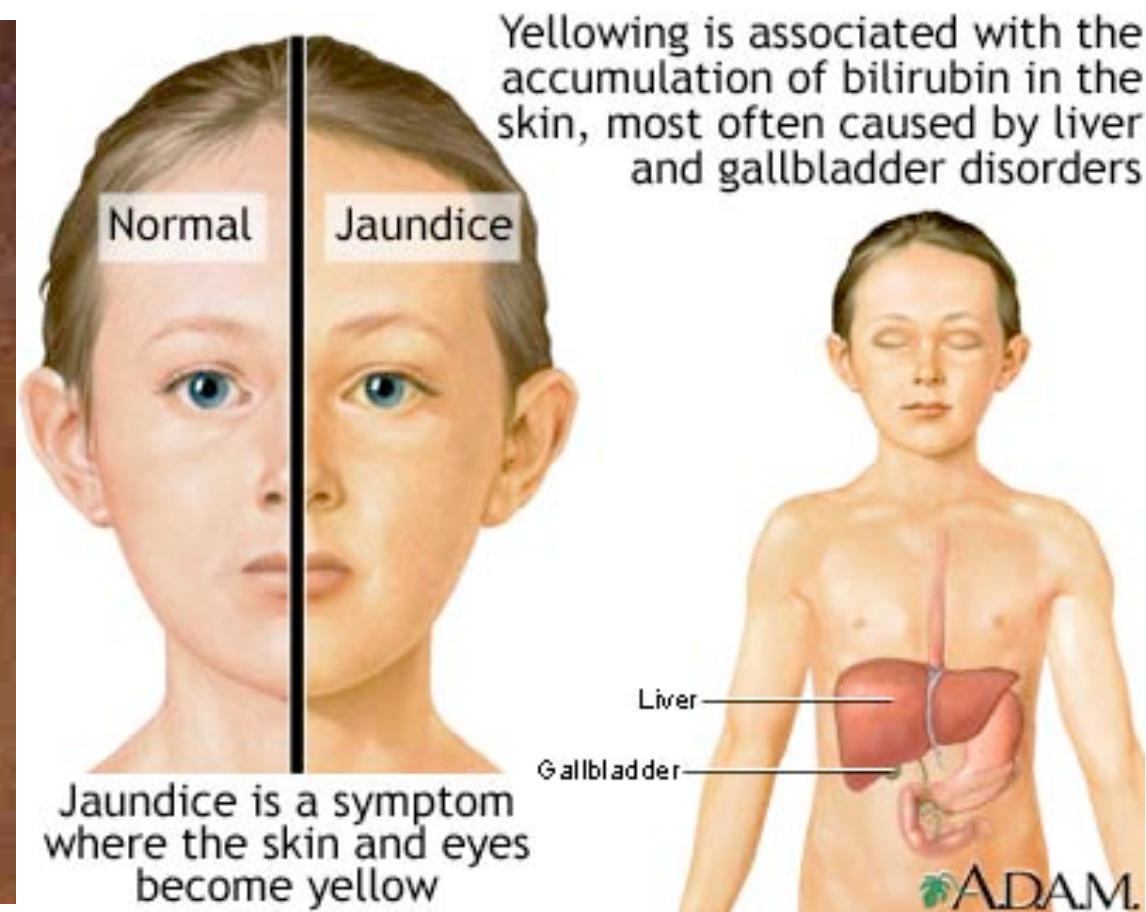
## Structure

- Largest organ in the body
- All blood from the stomach and the small intestine passes thru the liver
- Lies under the diaphragm in the upper right section of the abdominal cavity
- Two lobes





- Each lobe contains lobules (the functional units of the liver)
- Between the lobules are:
  - A branch of the hepatic artery that supplies oxygenated blood to the liver
  - A branch of the hepatic portal vein that transports nutrients from the small intestine to the liver
  - A bile duct that takes bile away from the liver
- The central vein of each lobule enters the general circulation via the hepatic vein which enters the vena cava fig 12.11

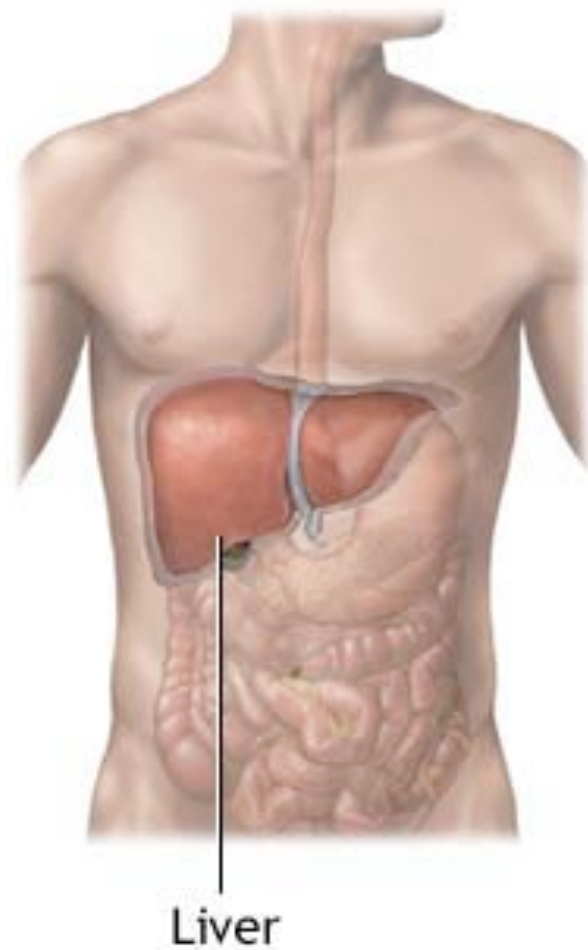


## Liver Disorders

### ○ Jaundice

- ♣ abnormally large amount of bilirubin present in the blood is deposited in the skin giving it a yellowish tint
- ♣ caused by abnormally large amount of RBC breakdown (hemolytic jaundice)
- ♣ caused by blocked bile ducts or damaged liver cells (obstructive jaundice)





In aggressive hepatitis,  
the liver becomes  
chronically inflamed and  
fibrotic, shrinking slightly

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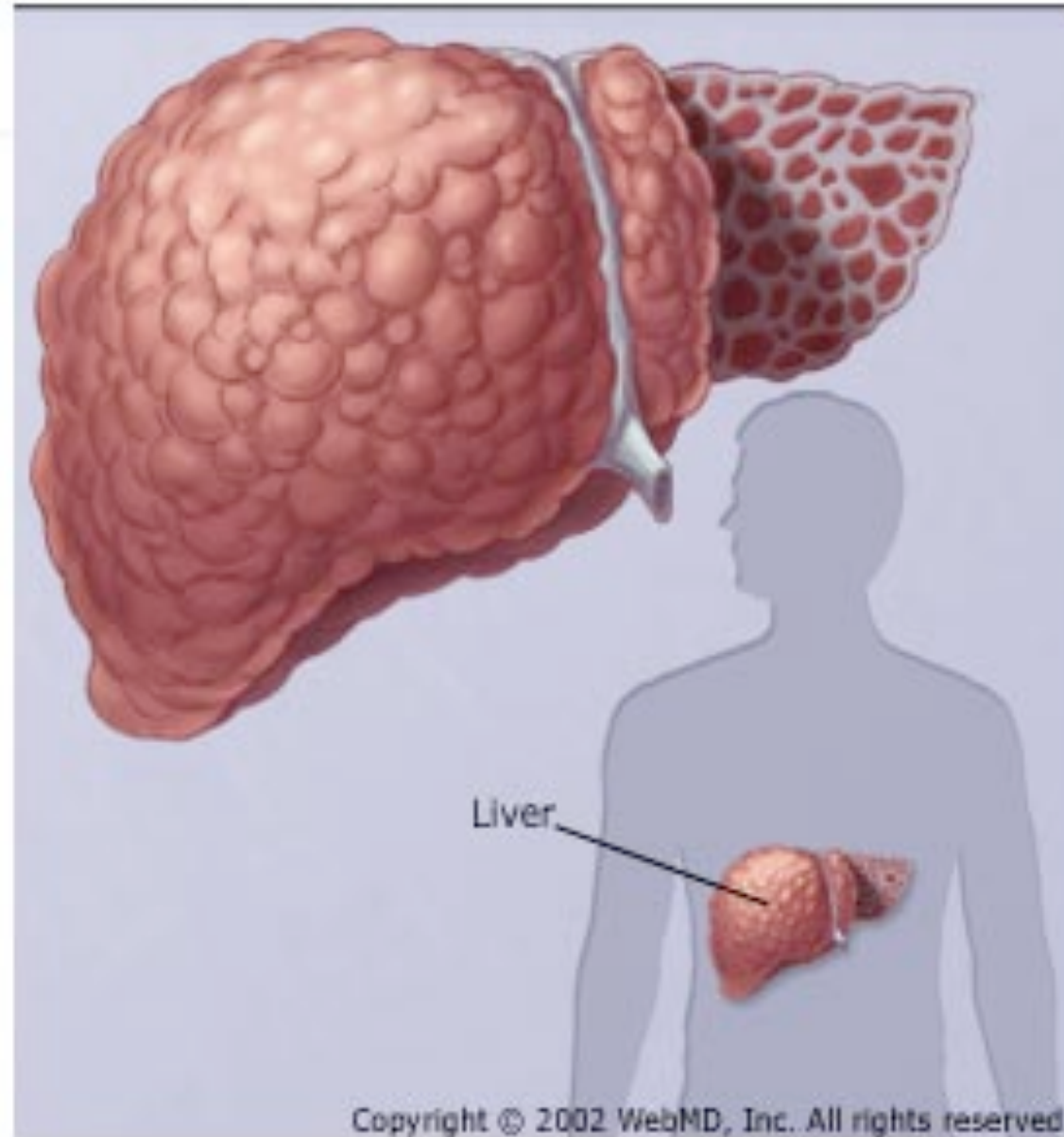
#### ○ Hepatitis

- ♣ Inflammation of the liver
- ♣ Several forms Hep A, B and C
- ♣ Hep A from contaminated water
- ♣ Hep B spread by sexual contact, blood transfusions and contaminated needles (vaccine available)
- ♣ Hep C contact with infected blood, no vaccine, can lead to chronic hepatitis, liver cancer and death

- Cirrhosis

- ♣ Liver becomes fatty and replaced by inactive scar tissue
- ♣ Often seen in alcoholics

Cirrhosis



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# Gallbladder

## Function

- Storage and delivery of bile to the duodenum
- Concentrates bile by removing water

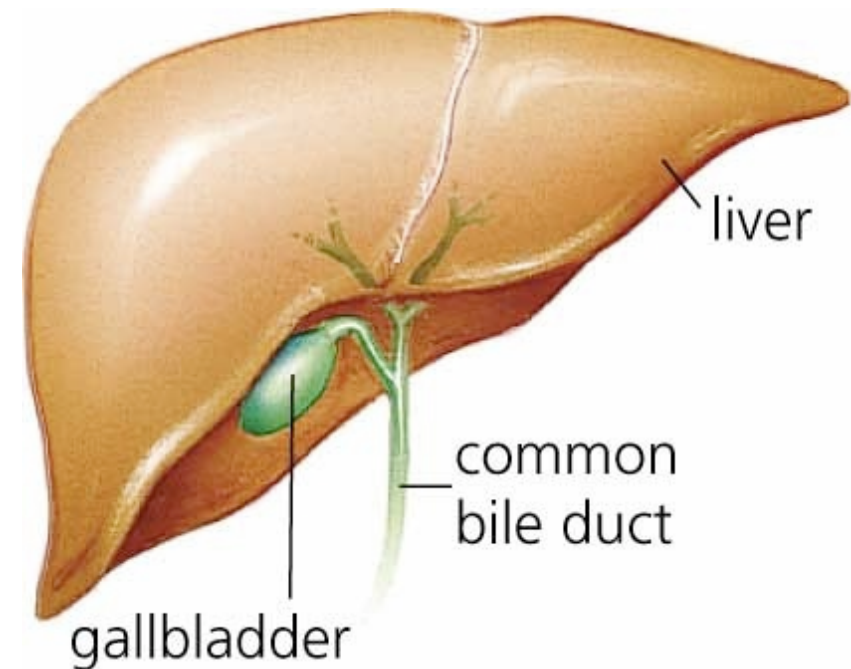
## Structure

- Pear shaped
- Muscular sac
- Attached to the surface of the liver

## Disorders

### Gallstones

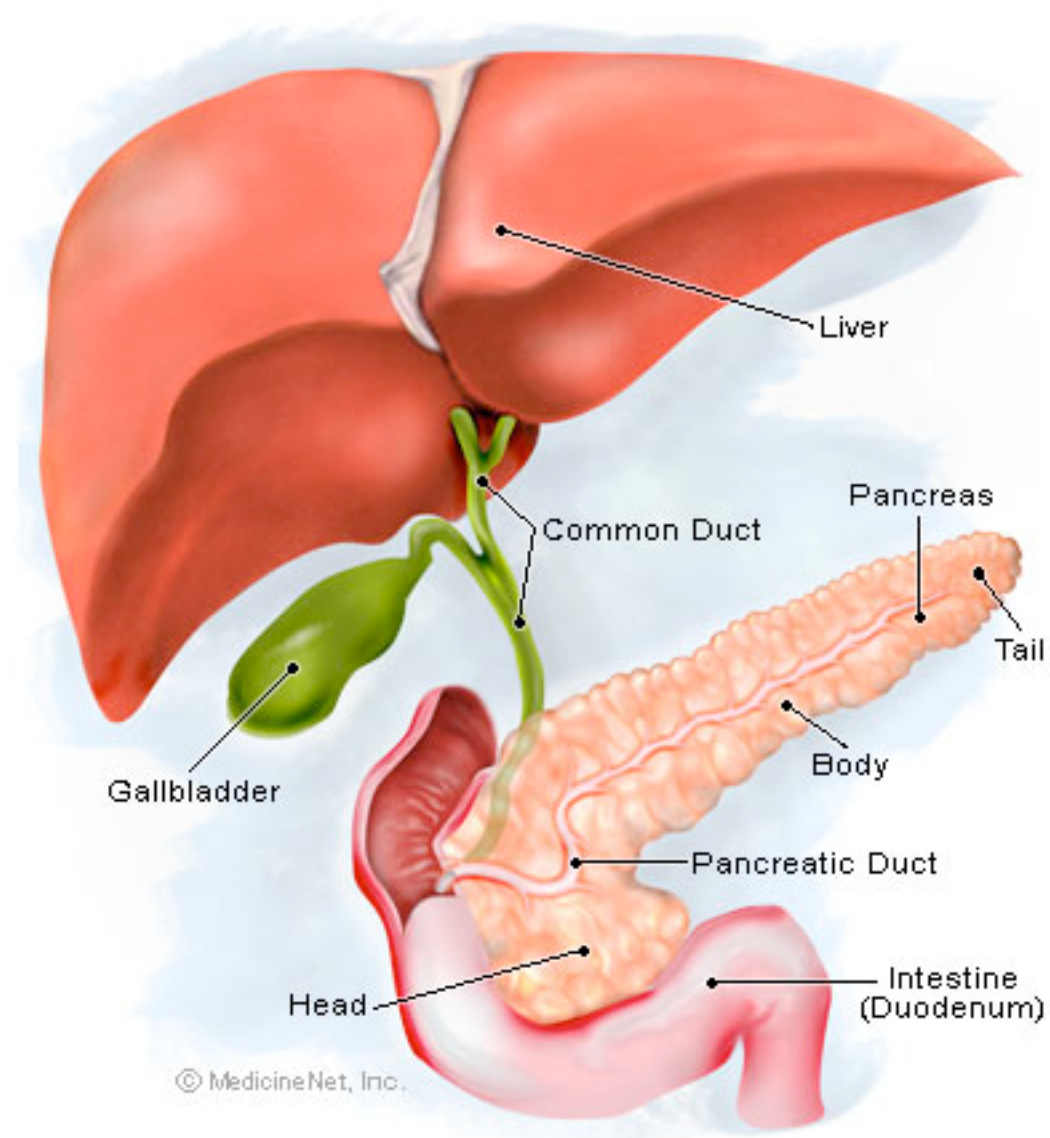
- The crystal content of bile can come out of solution and form crystals that block the bile duct



# Pancreas

## Functions

- Endocrine gland secretes the hormones INSULIN and GLUCAGON into the blood stream to regulate blood glucose levels



# Pancreatic Hormones

Hormone	Action
Insulin	Promotes the movement of glucose through the cell membranes. Stimulates the liver to convert glucose to glycogen. Causes blood glucose to DECREASE.
Glucagon	Stimulates liver to convert glycogen to glucose. Cause blood sugar to increase.

## Diabetes

- Type 1 results from the destruction of insulin producing cells in the pancreas and can be treated through insulin injection
  - Type 2 results from decreased sensitivity of tissue cells to the effects of insulin and can often be controlled by diet and exercise
  - Important to monitor blood glucose levels and administer necessary amounts of insulin to maintain balanced carbohydrate metabolism
  - Excess insulin can result in extreme nervousness and tremors, followed by convulsion and loss of consciousness
  - Insulin shock can be treated through IV glucose
- 
- Exocrine gland secretion of pancreatic juice through pancreatic duct into the duodenum



# Pancreatic Enzymes

Enzyme	Digestive Action
<b>Amylase</b>	Converts starch and glycogen into disaccharides
<b>Lipase</b>	Converts fats into fatty acids and glycerol
<b>Peptidases</b> Trypsin, Chymotrypsin, Carboxypeptidase.	Converts proteins or partially digested proteins into amino acids
<b>Nucleases</b>	Converts nucleic acids into nucleotides

\*pancreatic juice also contains sodium bicarbonate which neutralizes chime from the stomach

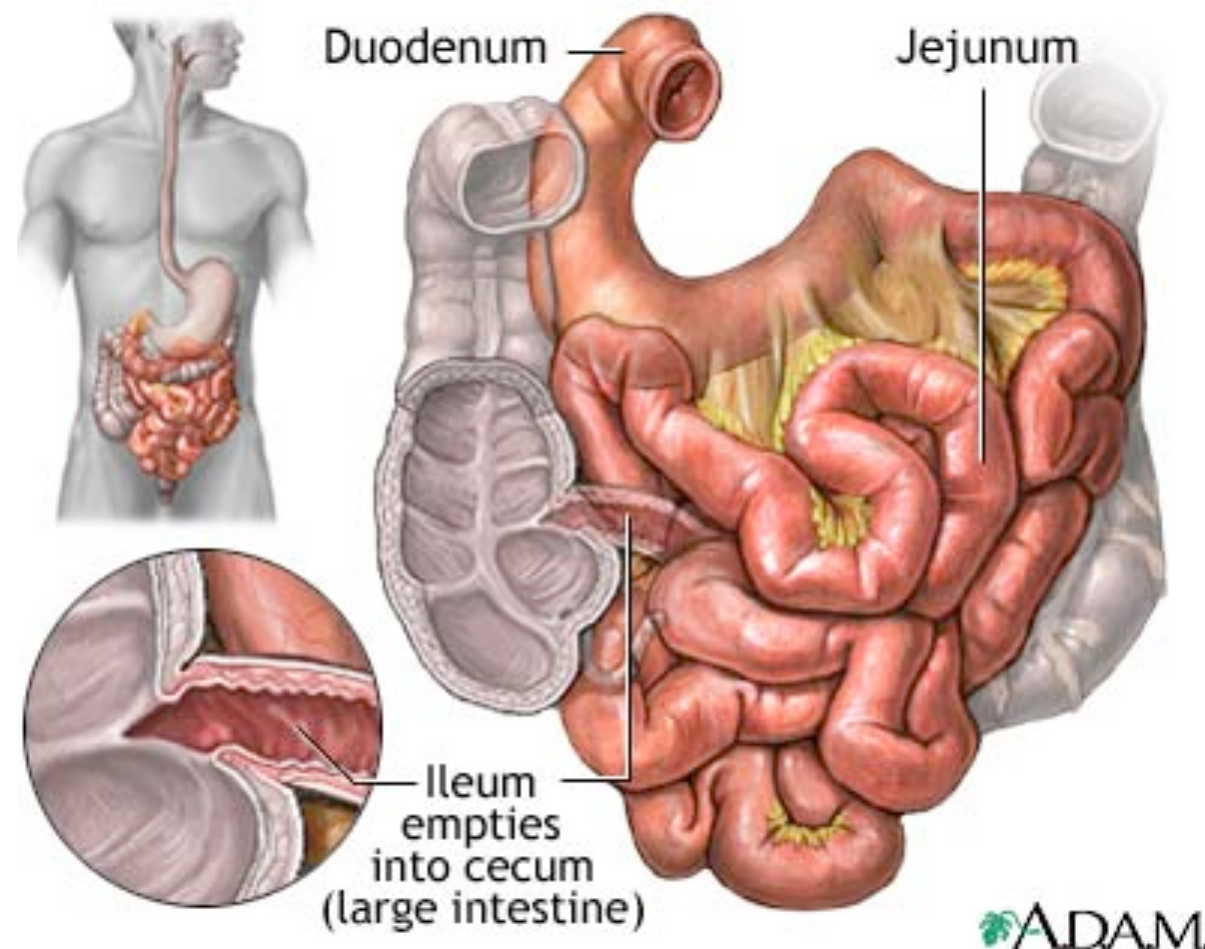
## Regulation of Digestive Secretions

- Digestive secretions are regulated by the nervous system and hormones
- Hormonesubstances produced by one set of cells that affects a different set of cells (target cells), usually transported by the bloodstream
- Digestive hormones:
  - Gastrin
  - Secretin
  - CCKcholecystokinin
- These hormones are released by digestive organs into the blood, travel through the circulatory system through the heart and arteries and return to the digestive system
- they stimulate secretion of digestive juices and cause organ movement
- Gastrin:
  - Produced by the stomach
  - Protein rich foods entering the stomach stimulates the release of gastrin
  - Acts on the stomach to increases gastric secretions
  - Stimulates muscle contractions in the stomach (churning)
- Secretin:
  - Produced in the wall of the duodenum
  - The presence of the acid in chyme stimulates release of secretin
  - Acts on the pancreas to secrete pancreatic juice
  - Acts on the gallbladder to release bile
- CCK:
  - Produced in the wall of the duodenum
  - The presence of partially digested fat and protein stimulates release of CCK
  - Acts on the pancreas to secrete pancreatic juice
  - Acts on the gallbladder to release bile

# Small Intestine

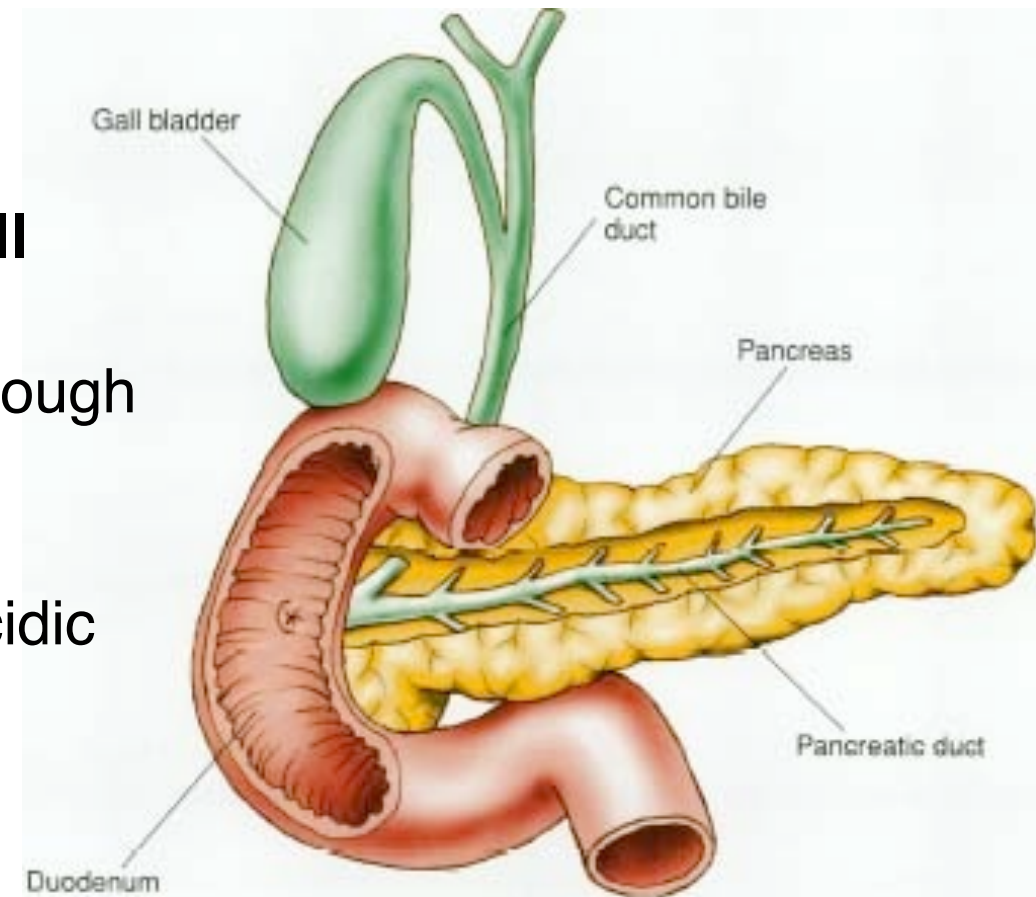
## General Description of the Anatomy of the Small Intestine-

- Lies between the **pyloric sphincter** of the stomach and the **ileocecal valve** that opens into the large intestine
- Positioned in the central lower portion of the **abdominal cavity**
- Approximately **3m long** and **1inch wide** (in a living person), 7m long in a cadaver
- Called the small intestine due to its relatively **small diameter** (compared to the large intestine)
- It is divided into 3 regions
  - Duodenum
  - Jejunum
  - Ileum



- **Duodenum**

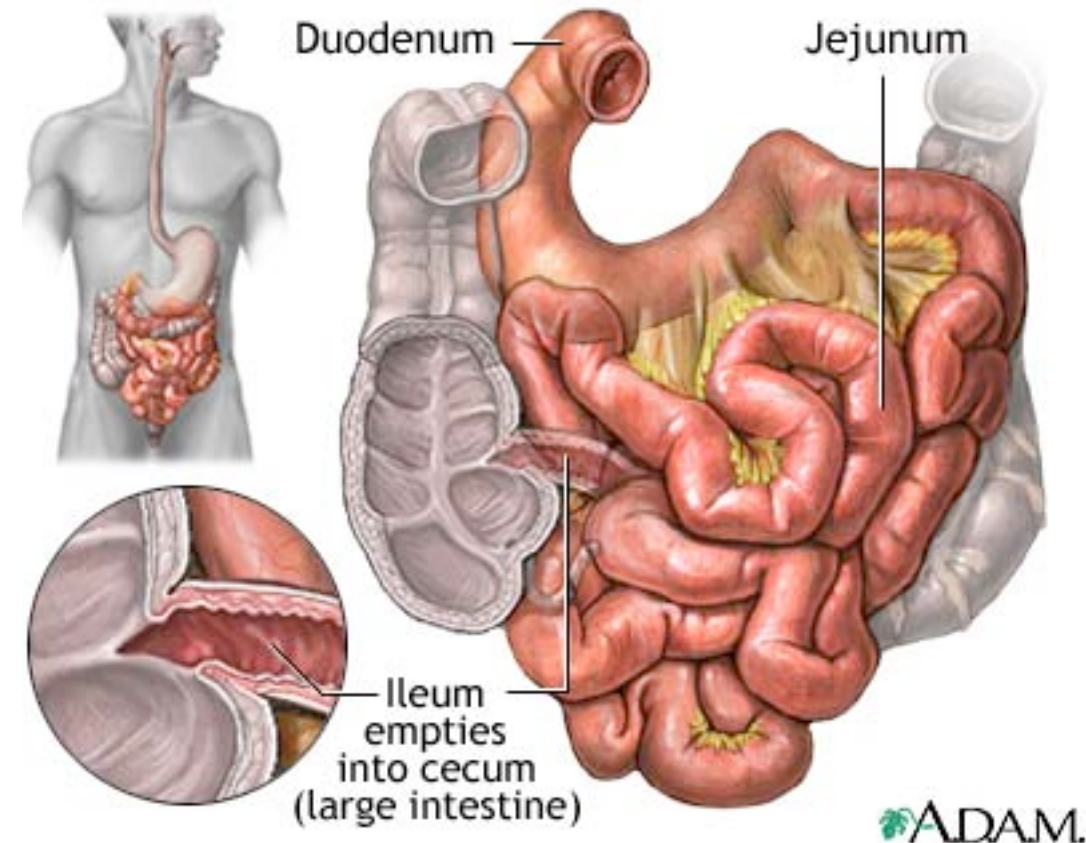
- C shaped, approximately 25 cm long
- Receives secretions from the **liver** and **gall bladder** thru the **common bile duct**
- Receives secretions from the pancreas through the **pancreatic duct**
- This regions has **Brunner's glands** which secrete mucous to protect the wall from acidic chyme from the stomach





- **Jejunum**

- Approximately 1m long
- Similar in structure to the ileum except with more internal folds and a slightly larger lumen



- **Ileum**

- Approximately 2m long
- Empties into the **cecum** via the **ileocecal valve**
- Has lymph nodules in its walls

## General Functions of the Small Intestine

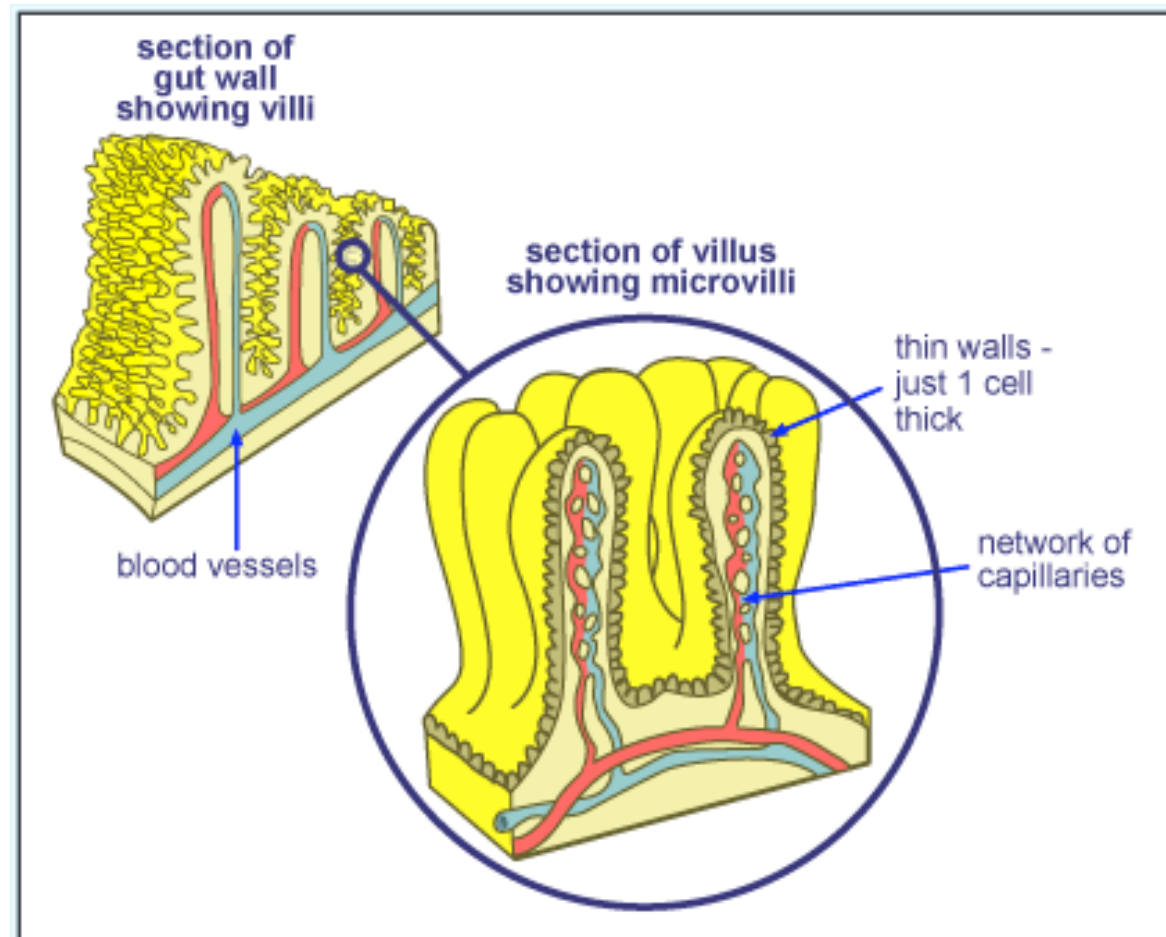
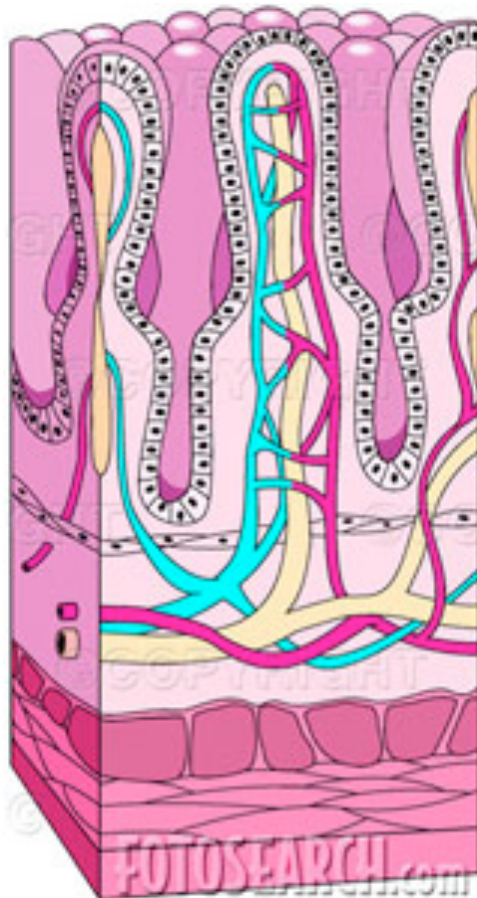
- mixing and transporting of luminal contents
- production of digestive enzymes
- **Absorption** of nutrients into the blood stream

## Enzymes of the Small Intestine

- Nutrient molecules must be in their simplest (monomer) form to pass through the epithelial cells of the small intestine
- The small intestine has a pH of approximately 7 (neutralized by alkaline secretions from the pancreas)
- A summary of the **enzymes produced in the small intestine**, their substrates and products is given in your notes.

## Structural Modifications of the Small Intestine

- Four specializations of the small intestine increase the intestinal surface area for absorption
  - Its **length** (3m in a living person)
  - Large **macroscopic folds** (plicae ciculares)
  - **Villi**- finger like macroscopic folds
  - **Microvilli**- microscopic projections formed by the folding of the epithelial cell membrane



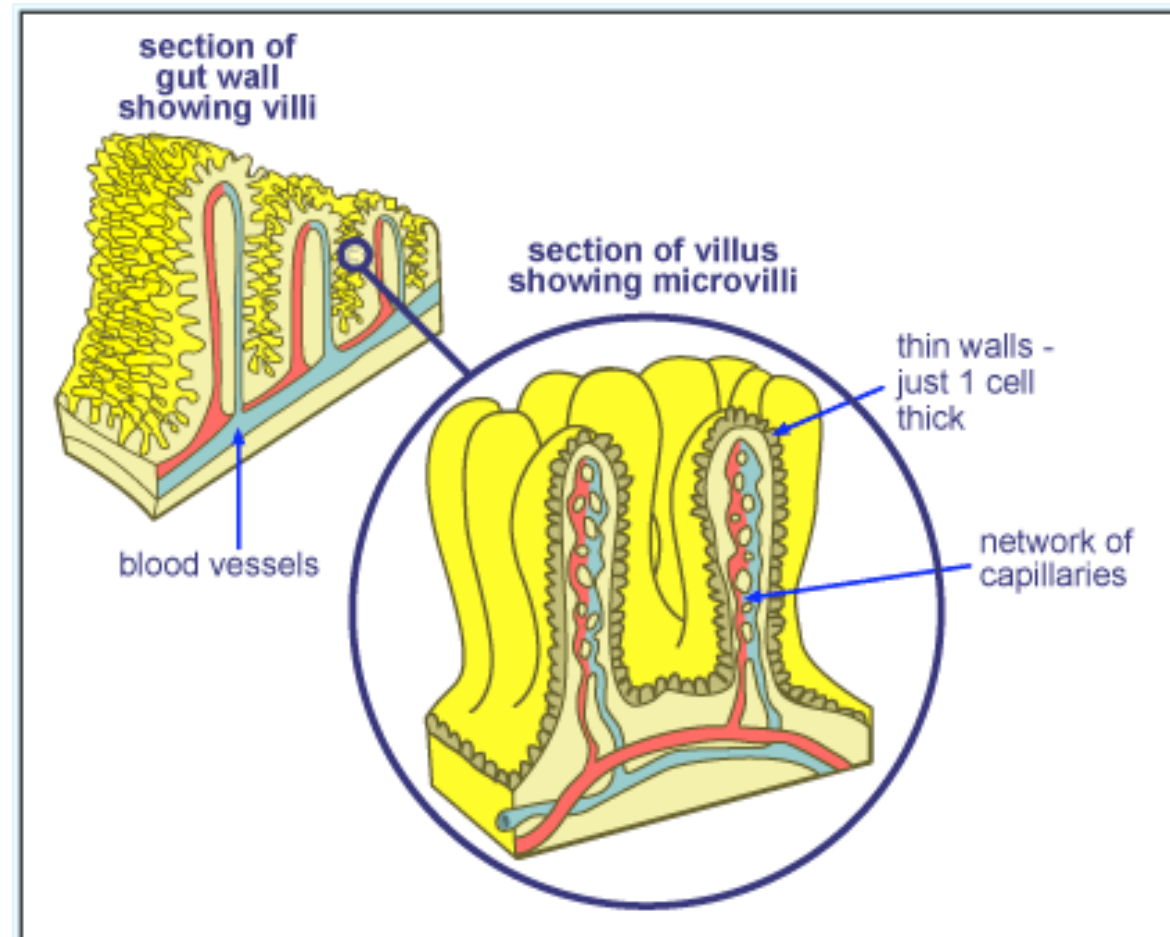
## Villi & Microvilli

### Function

- they increase the surface area of the intestine walls
- site of absorption of nutrients to the cardiovascular system

### Structure

- the villi are finger-like projections on the surface of the small intestine
- the microvilli are hair-like projections on the surface of the villi



## Epithelial Cells

### Function

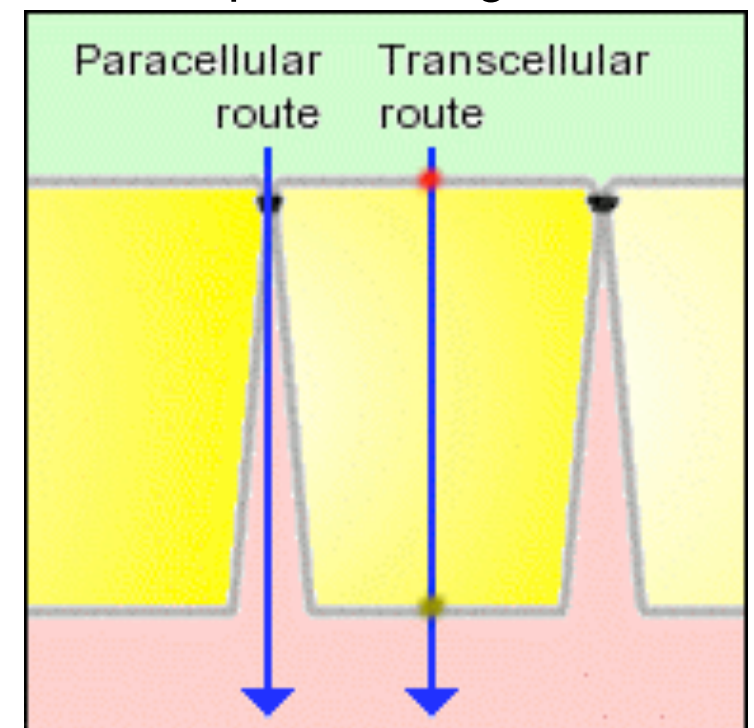
- allows organic materials to pass through

from the small intestine into the cardiovascular system.

- large nutrients pass through the cells via transport molecules (**transcellular route**)
- smaller nutrients pass through the cell's tiny junctions (**paracellular route**)

### Structure

- epithelial cells make up the epithelial membrane of the small intestine
- tight junctions in between them to allow small organic molecules to pass through into the cardiovascular system to be transported throughout the body
- contain transport molecules to aid in getting large organic molecules to pass through into the cardiovascular system to be transported throughout the body





## **Blood Vessels & Capillaries**

- found in villi
- lymphatic capillary = lacteal

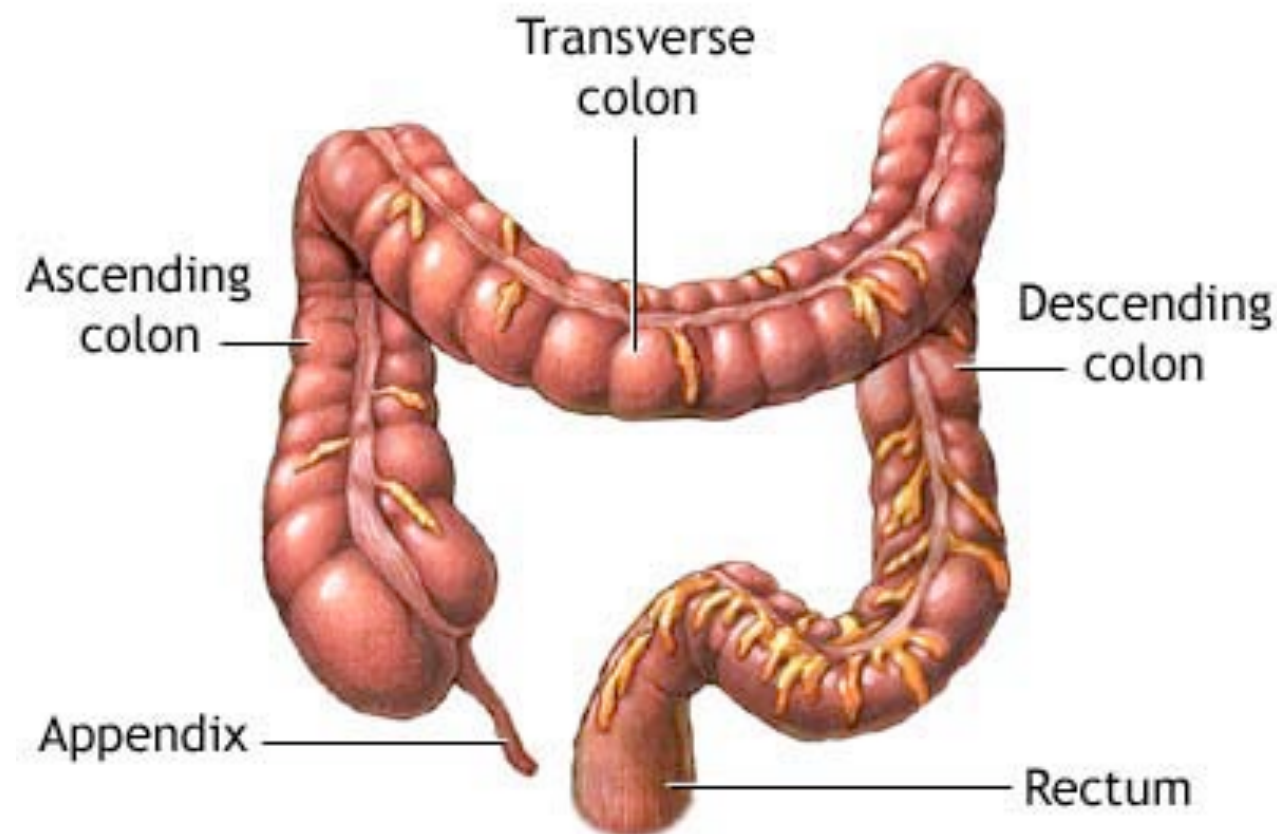
## **Function**

- vessels carry fluid called lymph to cardiovascular veins
- **capillaries** take in **glucose** and **amino acids**
- **glycerol and fatty acids** join together in epithelial cells and then enter **lacteals**

# Large Intestine

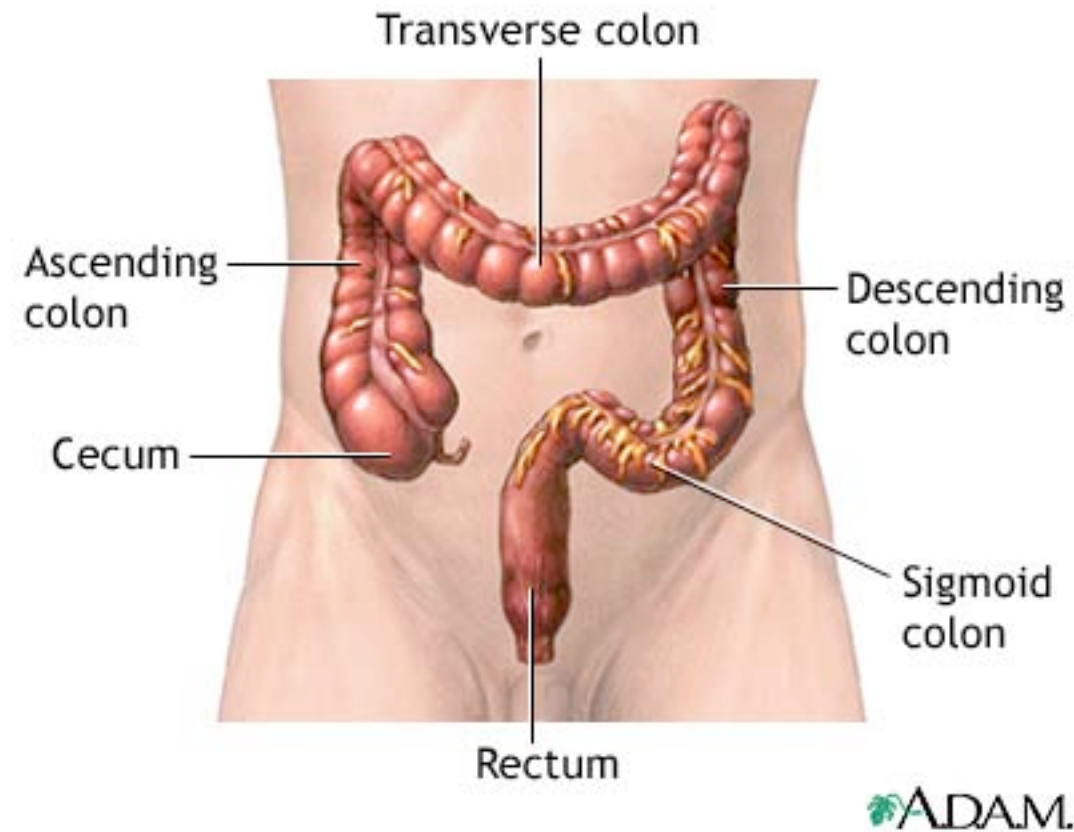
## Functions:

- Absorption of water (approximately 850 ml/day), salts and vitamins
- Storage of indigestible material until it is eliminated
- No production of digestive enzymes



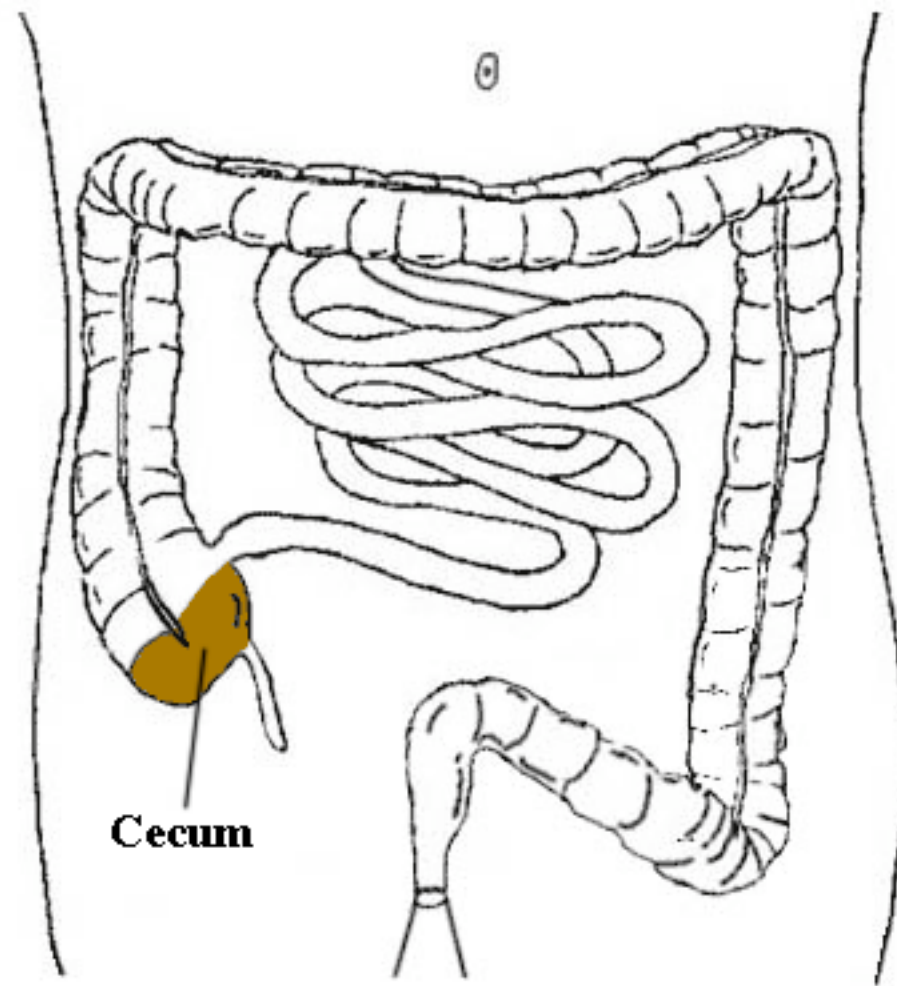
## Structure

- Larger in diameter than the small intestine but shorter (1.5m) in length
- Includes the cecum, the colon, the rectum and the anal canal



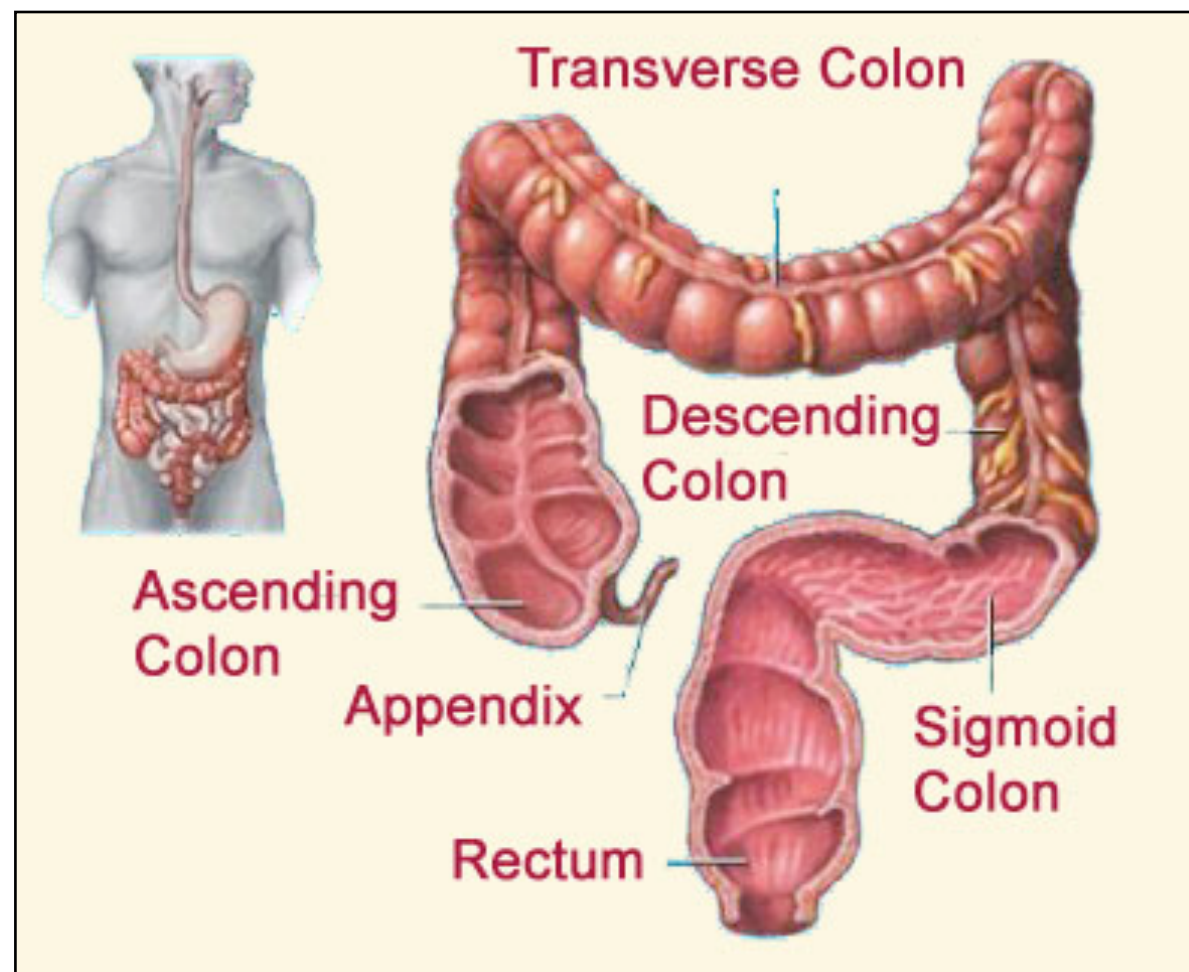
## Cecum

- Lies below the junction of the large intestine with the small intestine
- Has a small projection appendix
- Appendix may play a role in fighting infections but can become inflamed and must be removed. Appendicitis, if it is not removed it may burst and cause peritonitis which is a general infection of the abdominal cavity and can lead to death



## Colon

- Divided into the ascending, transverse and descending colon
- Ascending colon travels up the right side of the body to the level of the liver
- Transverse colon travels across the abdominal cavity below the stomach and the liver
- Descending colon travels down the left side of the body



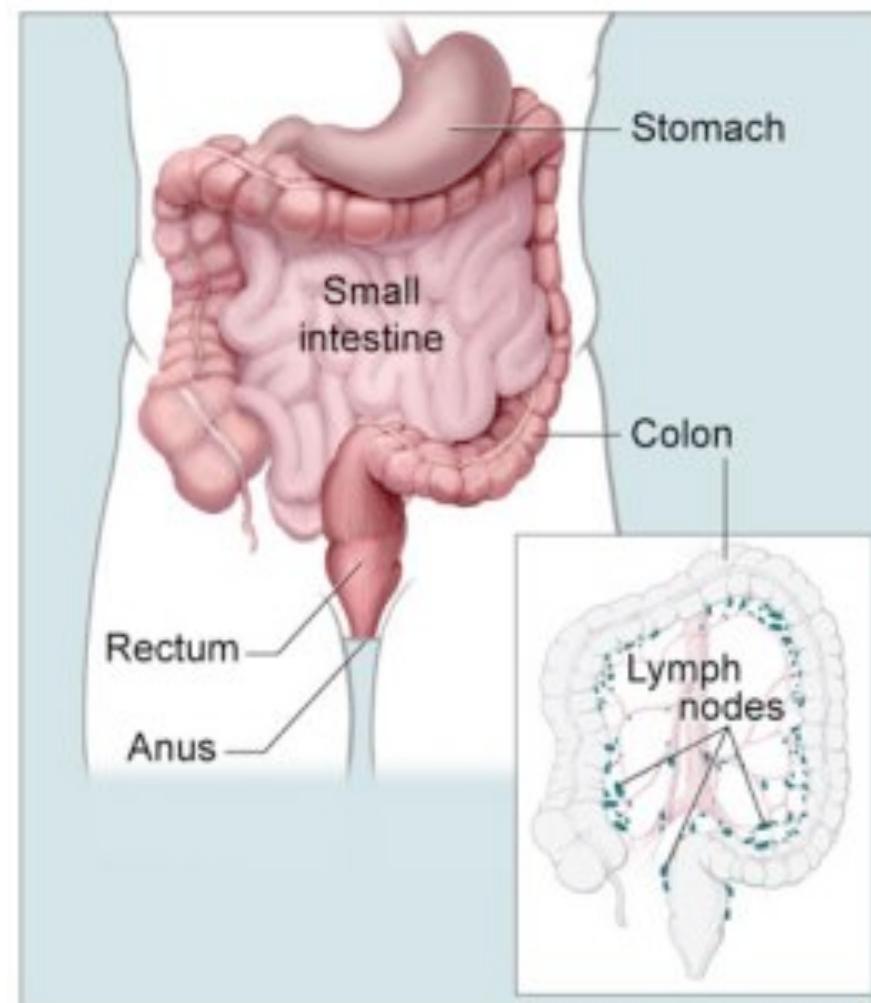


## Rectum

- Last 20cm of the large intestine

## Anus

- Expulsion of feces (defecation)
- When feces reach the rectum, stretching of the rectal wall initiates nerve impulses to the spinal cord causes contraction of rectal muscles and relaxation of anal sphincters
- Feces  $\frac{3}{4}$  water and  $\frac{1}{4}$  indigestible solids (bacteria, fiber and other indigestible materials), brown down to bilirubin, smelly due to the breakdown products of bacteria



### Bacteria in the large intestine

- Break down indigestible materials in the large intestine by product is GAS!
- Also produce vitamins and other molecules that can be absorbed by the body therefore good for us
- May be facultative (can survive with or without oxygen) such as E.Coli
- May be obligate anaerobes will die in the presence of oxygen

## Disorders of the Large Intestine

- Polyps small growths in the epithelial lining of the large intestine, may be benign or cancerous, can be removed surgically
- Diarrhea
  - due to infection of the lower tract, intestinal wall becomes irritated, peristalsis increases, water is not absorbed and diarrhea rids the body of infectious organisms
  - can lead to dehydration
- Constipation
  - Feces are dry and hard
  - Results from ignoring the need to defecate
  - Can be prevented by water and fiber intake
  - Chronic constipation can lead to hemorrhoidsenlarged, inflamed blood vessels of the anus

