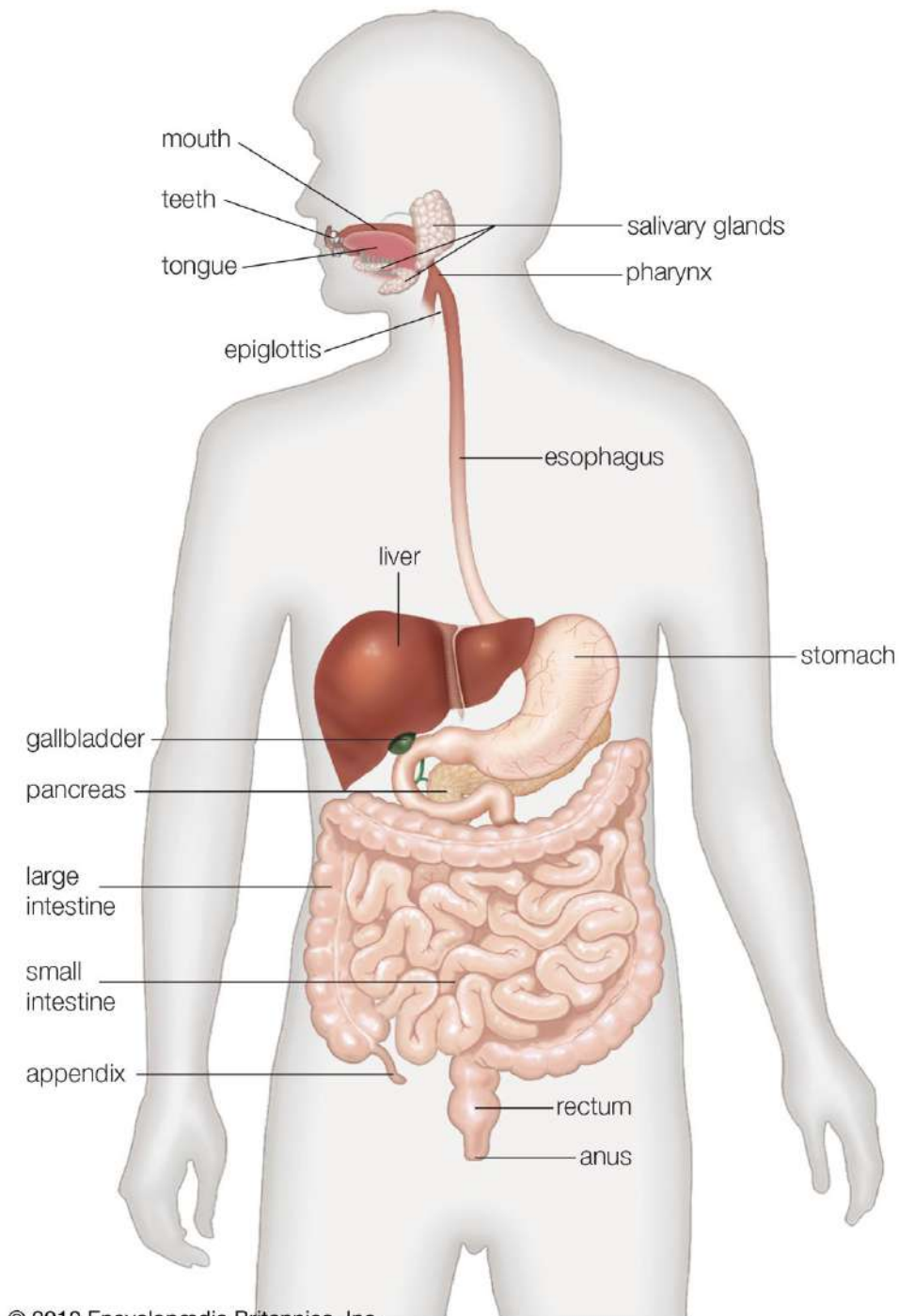


# UNIT 5 – DIGESTIVE SYSTEM

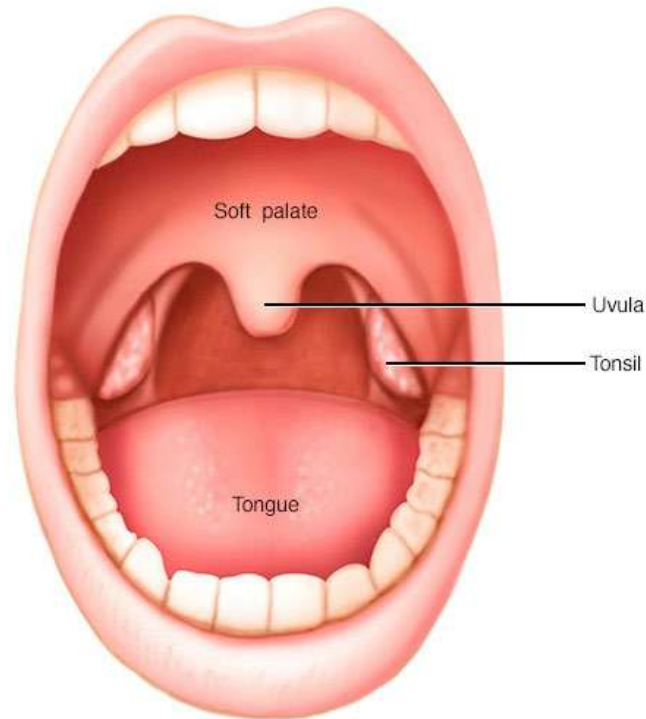
Ms. Martel

# 5.1 – DIGESTIVE SYSTEM

- Digestion takes place within a tube called the digestive tract, which **begins with the mouth and ends with the anus.**
- Digestion involves **mechanical digestion and chemical digestion.**
  - Mechanical digestion begins with the chewing of food in the mouth, and continues with the **churning and mixing of food in the stomach.**
  - Chemical digestion uses many different enzymes to **break down macromolecules to small organic molecules.**

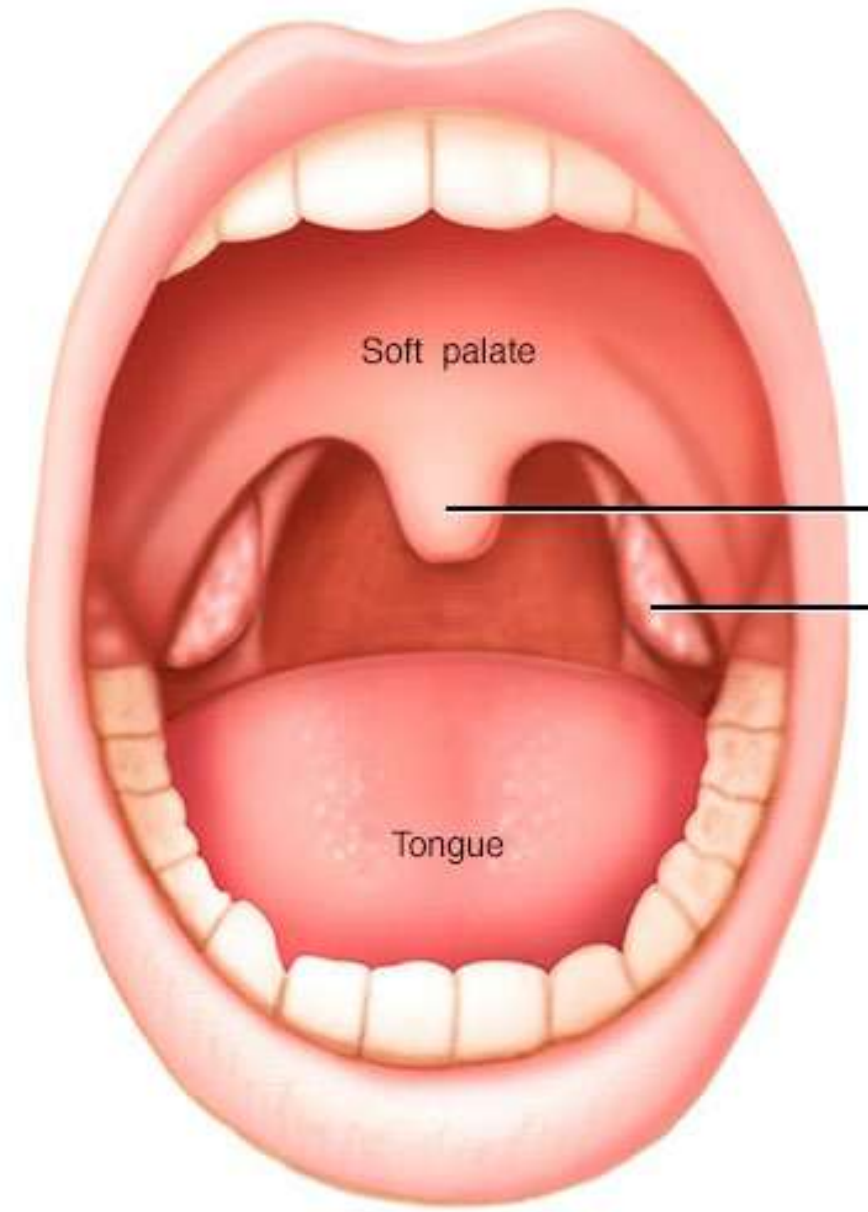


# THE MOUTH

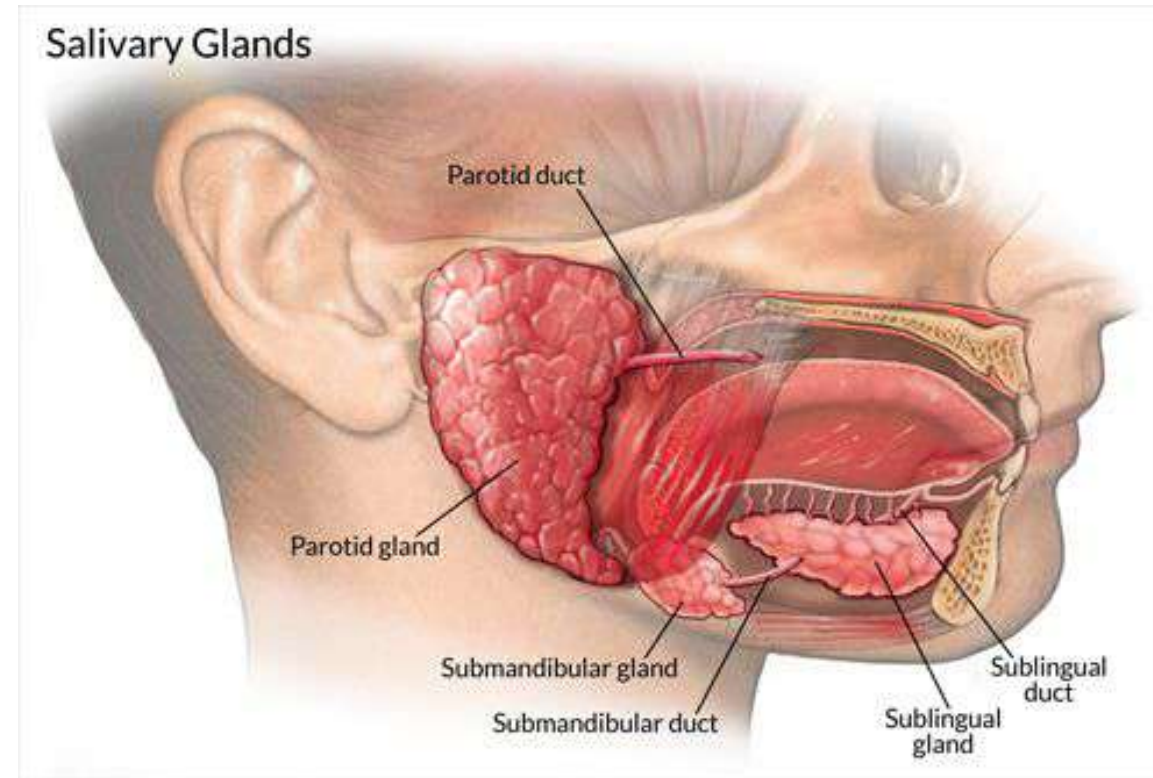


- The mouth is bounded externally by the **lips and cheeks.**
- The tongue is composed of **skeletal muscles that contract to change the shape** of the tongue.
- The roof of the mouth separates the **nasal cavity from the mouth**, preventing food from entering the nasal cavity.
  - The roof has two parts: **the hard palate and the soft palate.**
  - The hard palate contains **several bones**, the soft palate is made of **muscle & connective tissue.**

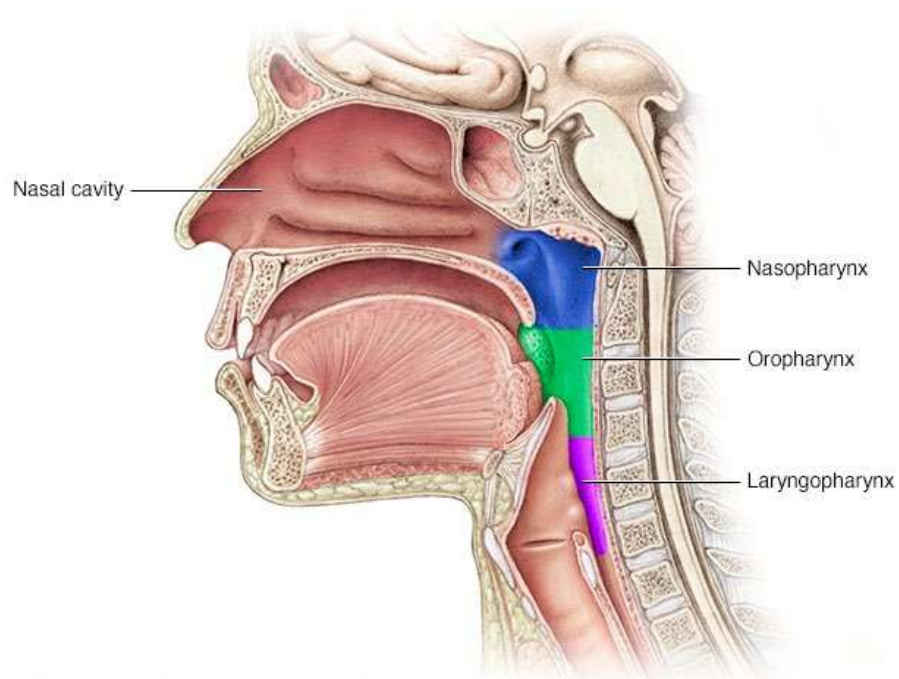
- The tonsils **are in the back of the mouth**, on either side of the tongue.
- The tonsils contain **lymphoid tissue** that helps protect the body against infection.
- If the tonsils become inflamed, they have tonsillitis. **If it recurs repeatedly, the tonsils may be removed.**



- Three pairs of salivary glands produce saliva.
- Saliva keeps the mouth moist and **contains an enzyme that starts digesting starch.**
- One pair lies on **either side of the face, immediately below and in front of the ears.**
- Another pair lies **beneath the tongue**, and another pair lies **below the floor of the mouth.**



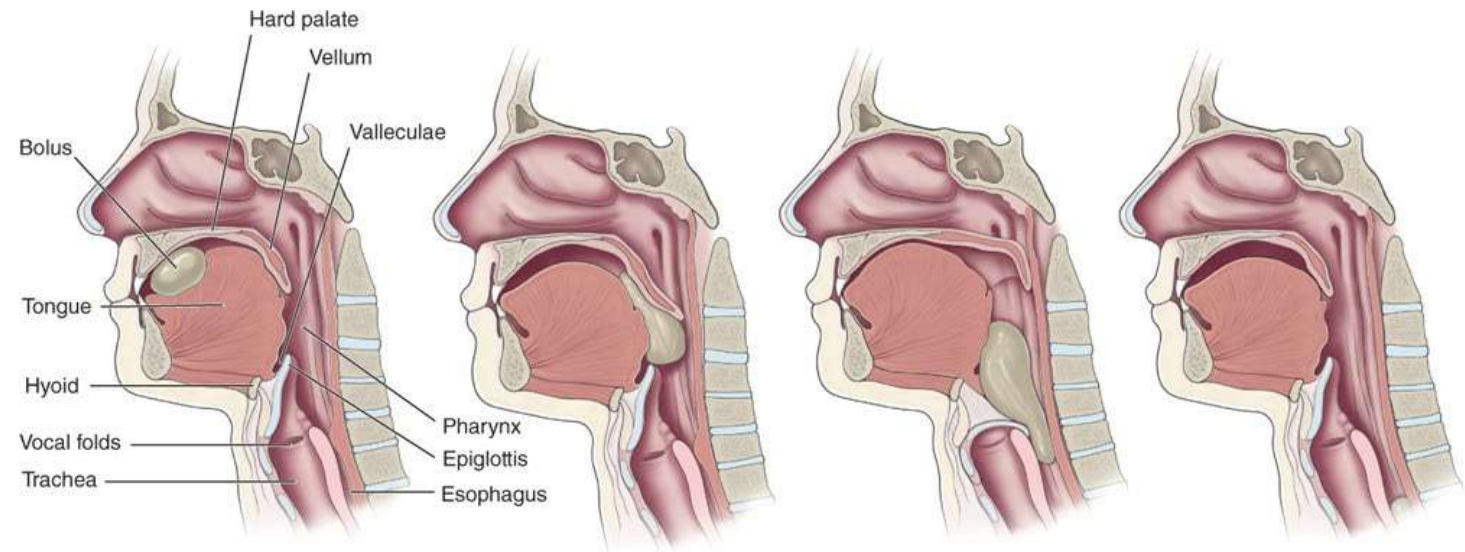
# THE PHARYNX



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- This is a region that **receives air from the nasal cavities and food from the mouth.**
- The food passage and air passage cross in the pharynx because the **trachea is in front of the esophagus which takes food to the stomach.**

- Swallowing is a **reflex action that occurs in the pharynx**.
- Here the soft palate moves back to close off the **nasopharynx**, and the trachea moves up under the **epiglottis to cover the glottis**.
- The glottis is the **opening of the larynx** (vocal chords).
- This ensures that food enters the esophagus **because the air passages are blocked**



A Oral preparatory phase

B Oral transit phase

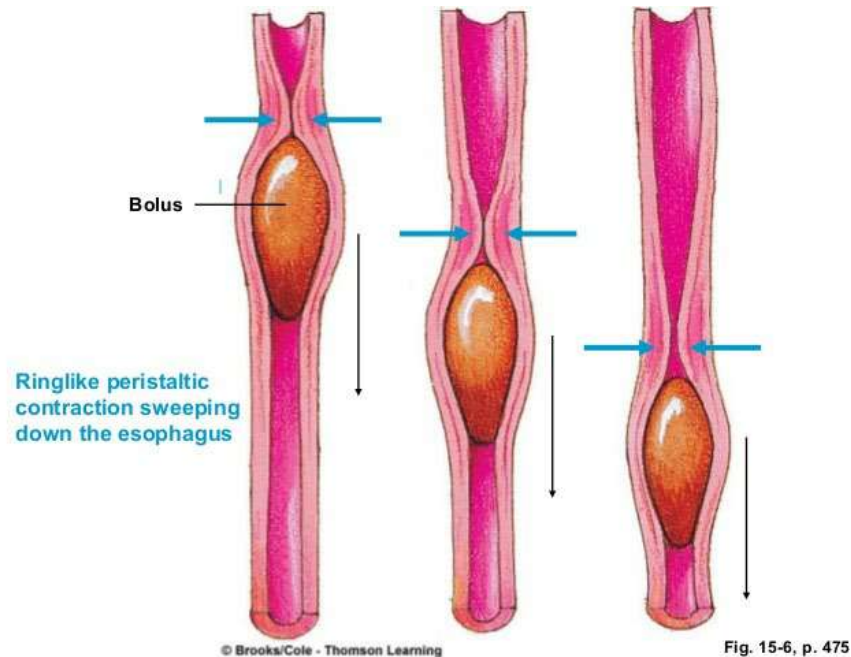
C Pharyngeal phase

D Esophageal phase

Source: Sylvia C. McKean, John J. Ross, Daniel D. Dressler, Danielle B. Scheurer: Principles and Practice of Hospital Medicine, Second Edition, [www.accessmedicine.com](http://www.accessmedicine.com)  
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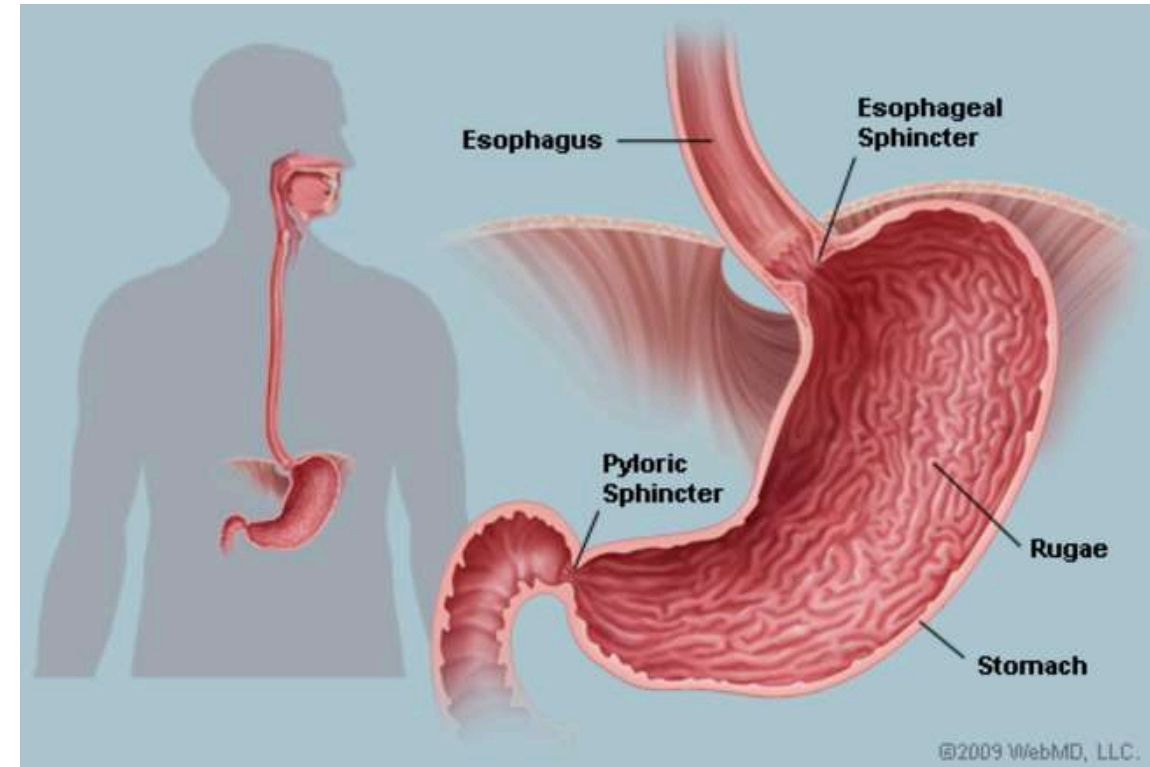
# THE ESOPHAGUS

- This is a long muscular tube that **passes from the pharynx**, through the thoracic cavity and diaphragm, and **joins the stomach in the abdominal cavity**.
- It is collapsed most of the time until opens to **receive the bolus when swallowing**.
- Peristalsis is rhythmic muscular contractions that **push the food along the digestive tract**.
- This begins in the esophagus.

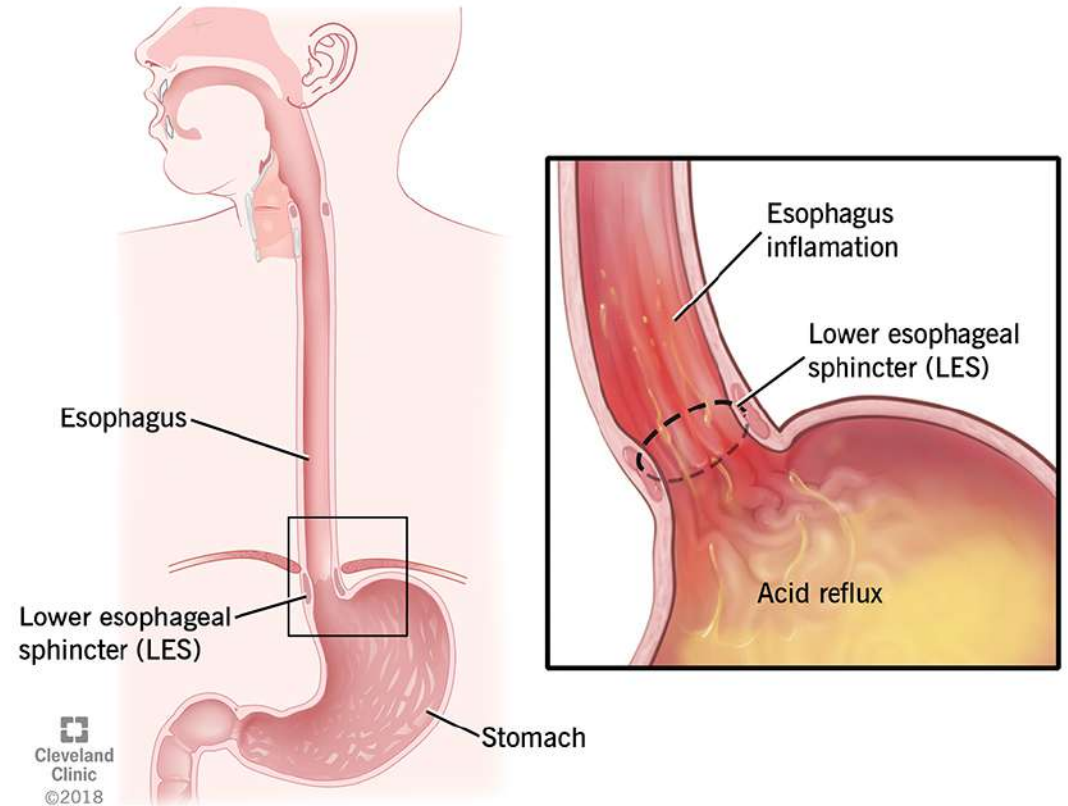




- The sole purpose of the esophagus is to **move the food bolus from the mouth to the stomach.**
- Sphincters are muscles that encircle tubes in the body, **acting as valves.**
  - The cardiac sphincter is the **entrance from the esophagus to the stomach.**
  - Relaxation allows the bolus to **pass into the stomach**, contraction prevents acidic contents of the stomach from **going back up into the esophagus.**
  - This is a **very weak sphincter.**



- Heartburn occurs when some of the stomach contents **escape into the esophagus**.
- Vomiting occurs when **cells in the intestine and brainstem** trigger the contraction of abdominal muscles and diaphragm to **force the contents of the stomach upward through the esophagus**.

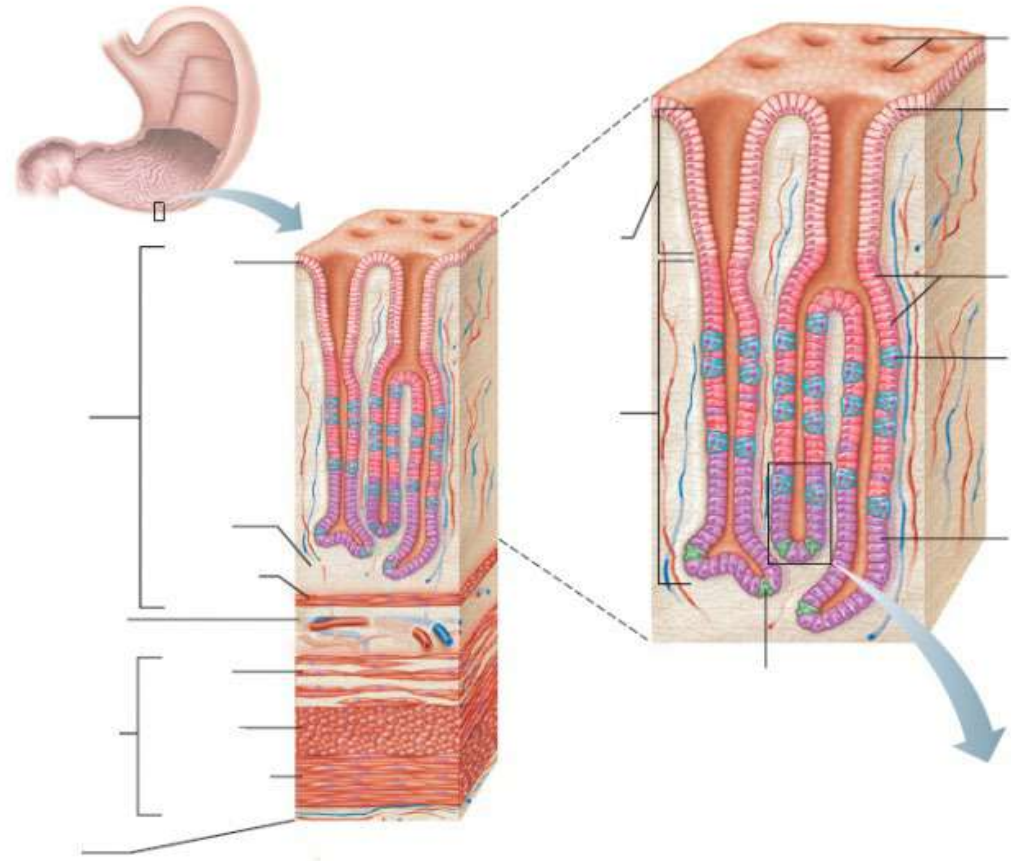


# THE STOMACH

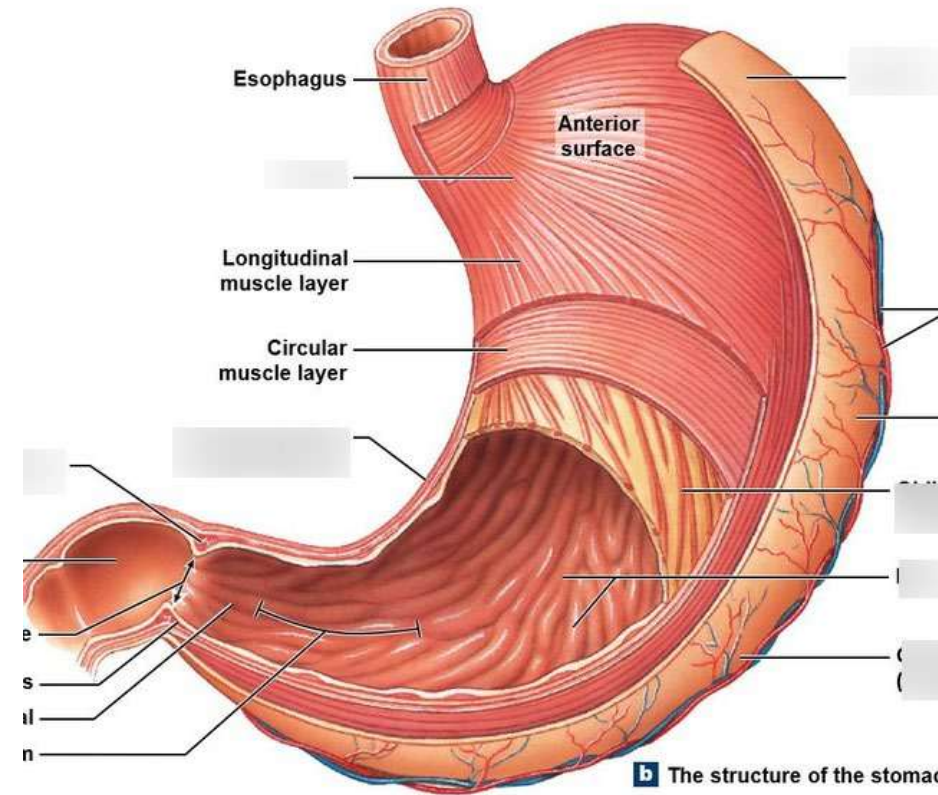
- The stomach **receives food from the esophagus**, starts the digestion of proteins, and **moves food into the small intestine.**
- The stomach can expand to hold **approximately 4L.**



- The inside layer of the stomach has millions of **gastric pits leading into gastric glands.**
- These glands produce gastric juice which contains **pepsinogen, hydrochloric acid (HCl) and mucus.**
- It is beneficial for the stomach to have a high acidity because it **kills most of the microbes present in food.**

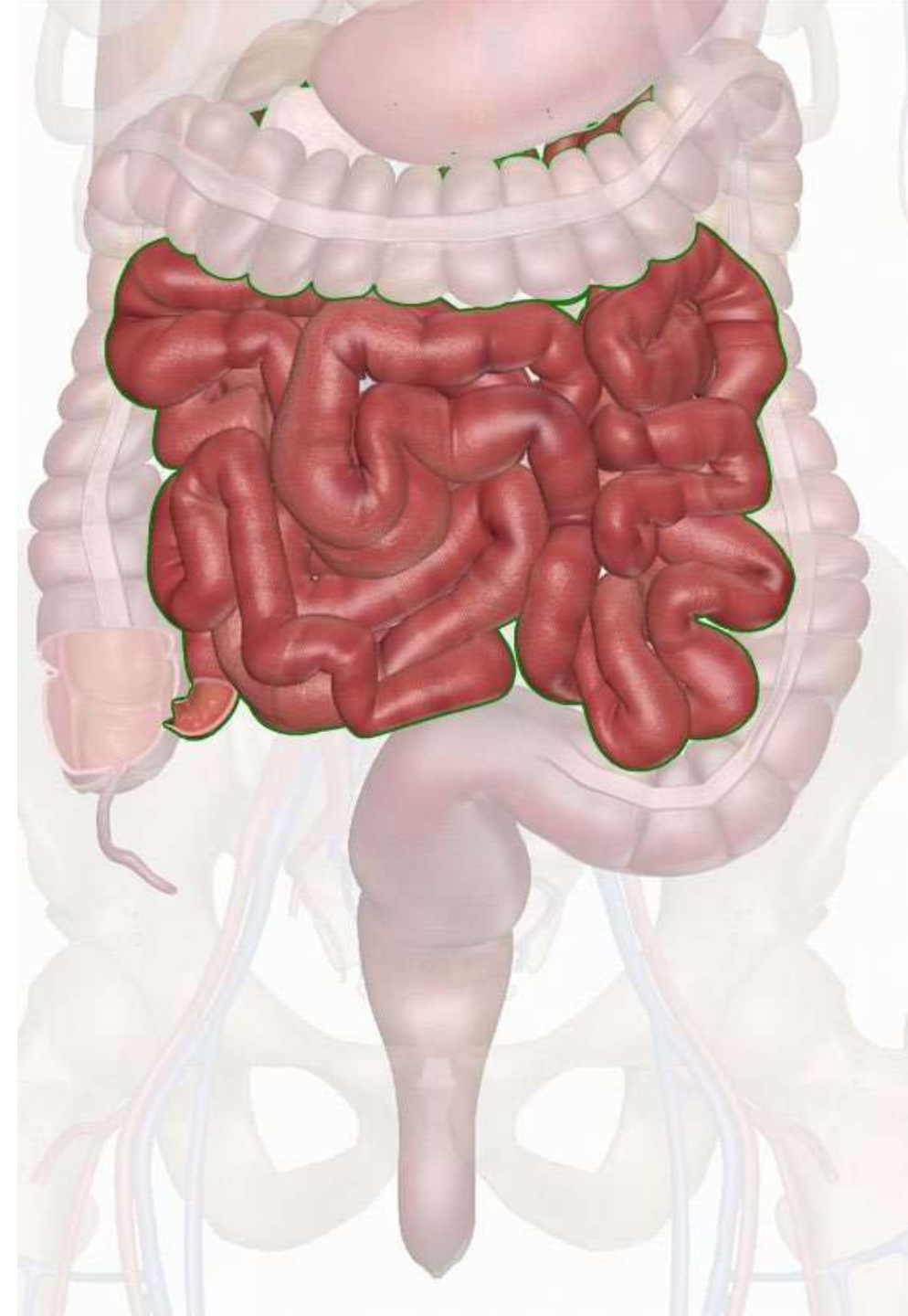


- The stomach acts both **mechanically and chemically on food.**
- The stomach wall contains 3 muscular layers:
  - **Longitudinal**
  - **Circular**
  - **Oblique**
- The contraction of these muscle layers helps to mix the food with the **gastric juices as well as mechanically break it down into smaller pieces.**
- Alcohol and other liquids are absorbed in the stomach **but not solid food.**
- When food leaves the stomach, it is a **thick soupy liquid called chyme.**
  - Chyme entering the small intestine is controlled by the **pyloric sphincter.**

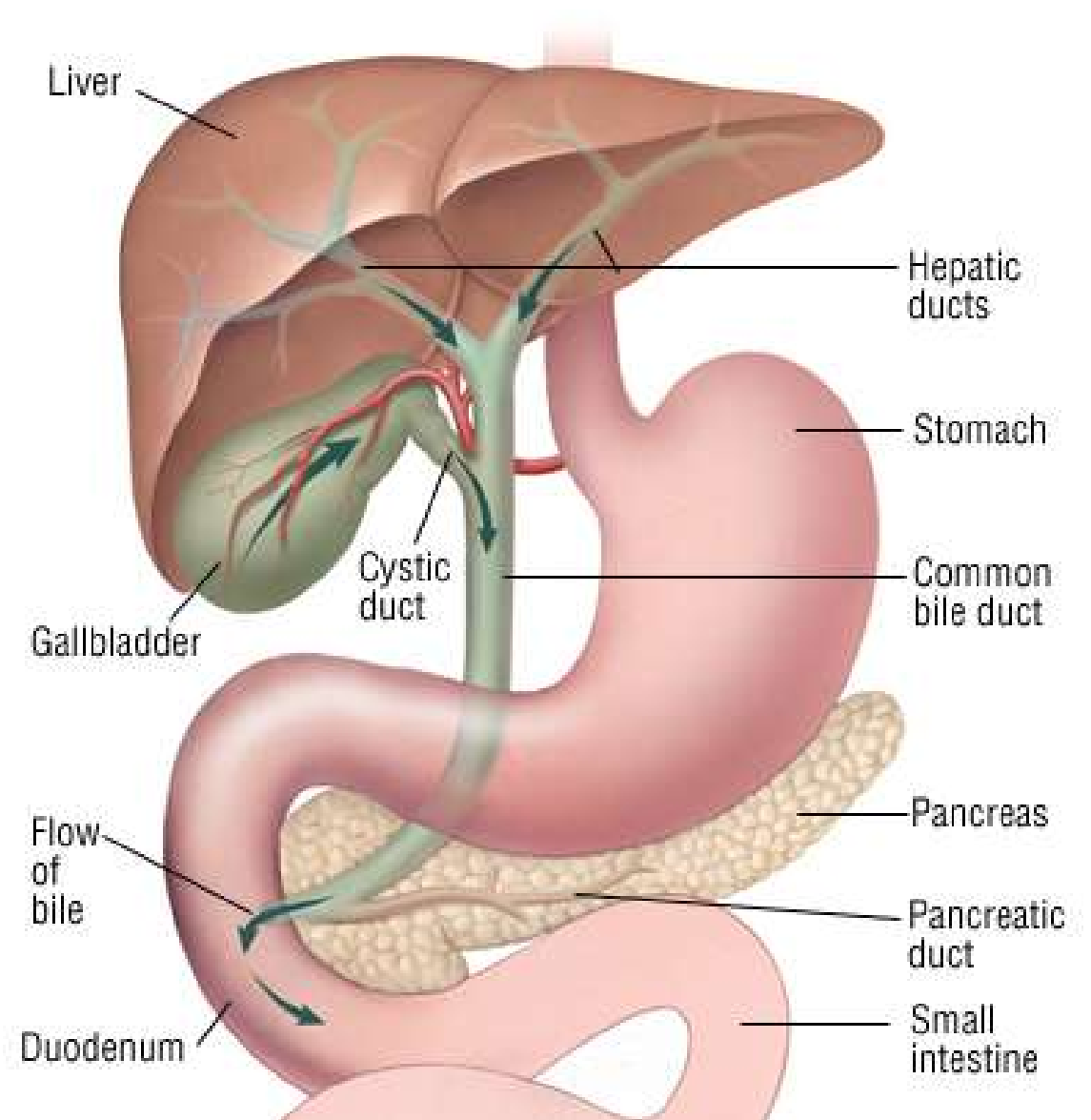


# THE SMALL INTESTINE

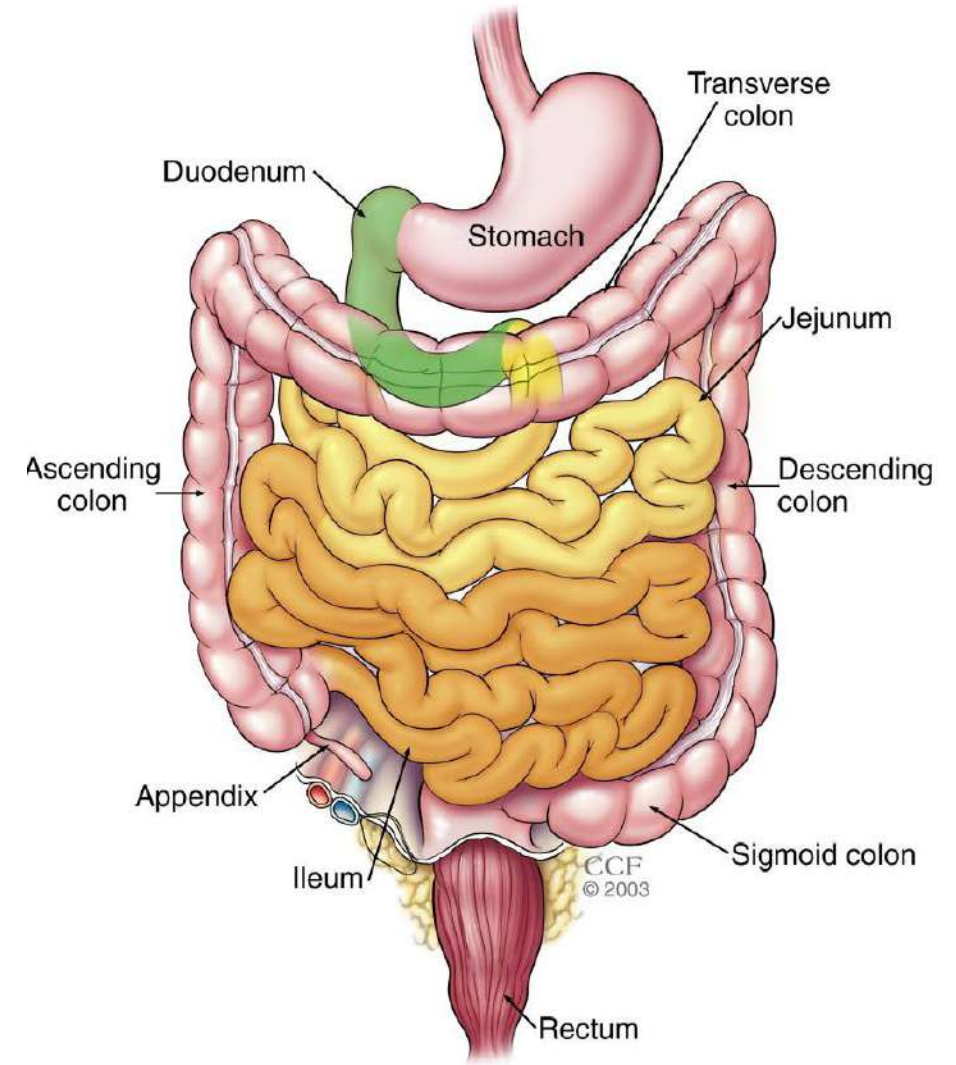
- The small intestine is named so because it has a **smaller diameter than the large intestine**.
- However, the small intestine is **approximately 6m in length**, compared to the large intestine which is about 1.5m long.



- The first 25cm of the small intestine is called the **duodenum**.
- Ducts from the liver and pancreas join to form **one common bile duct that enters the duodenum**.
- The small intestine receives **bile from the liver, and pancreatic juice from the pancreas** via this duct.
- The intestine has a pH of 8 because the **sodium bicarbonate delivered from the pancreatic juice neutralizes the acid in the chyme**.



- The enzymes produced by the pancreas and intestinal wall **complete chemical digestion of food.**
- The middle part of the small intestine is called the **jejunum**, and the remainder is the **ileum.**
- The ileum contains lymphoid tissue called **Peyer's patches**, which generate **immune responses to intestinal pathogens.**
- The small intestine has a very large surface area due to:
  - **Villi on the intestinal wall**
  - Each villi contain thousands of **microvilli**, which aids with **absorption of nutrients.**





○ **Nutrients are absorbed** into the vessels of each villus.

○ Each villus contains:

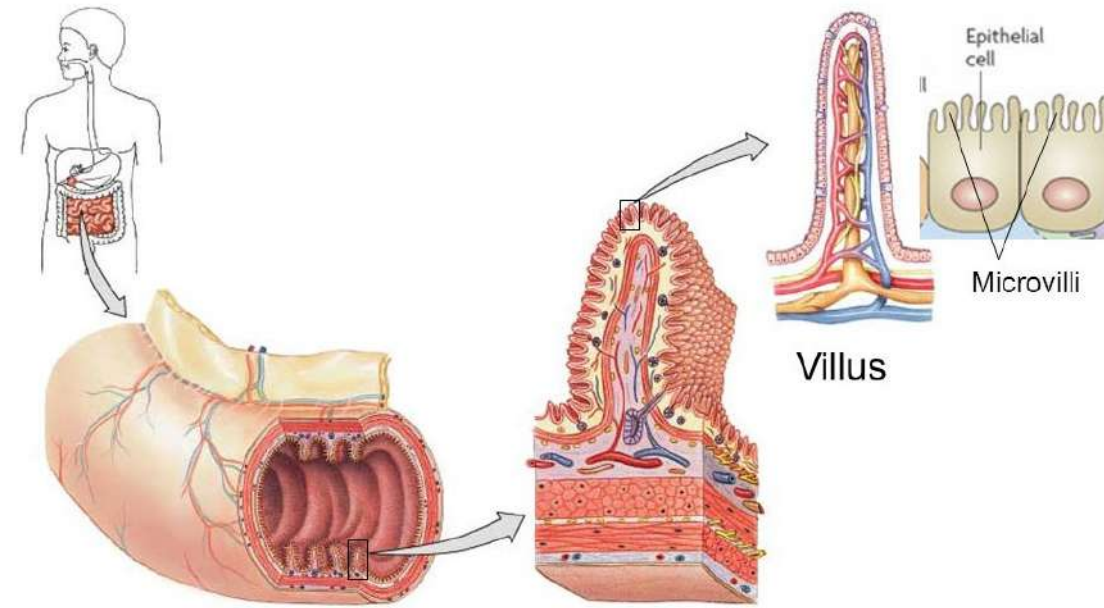
○ **Blood capillaries**

○ **Small lymphatic capillary called a lacteal**

○ **Sugar and amino acids enter the blood capillaries** where they are carried to the cells of the body.

○ **Glycerol and fatty acids are packaged as lipoprotein droplets that enter a lacteal.**

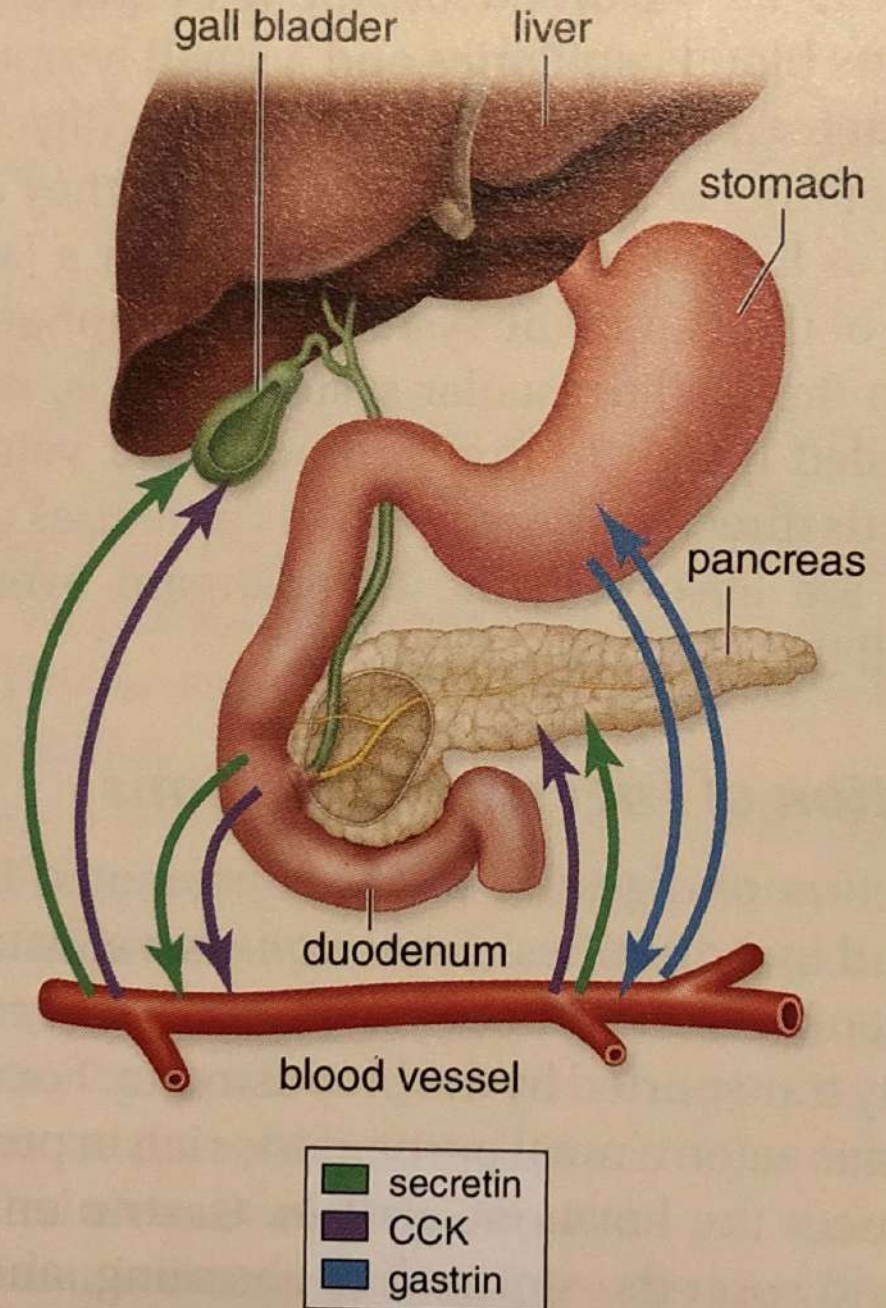
○ Lacteals are part of the **lymphatic system.**



# REGULATION OF DIGESTIVE SECRETIONS

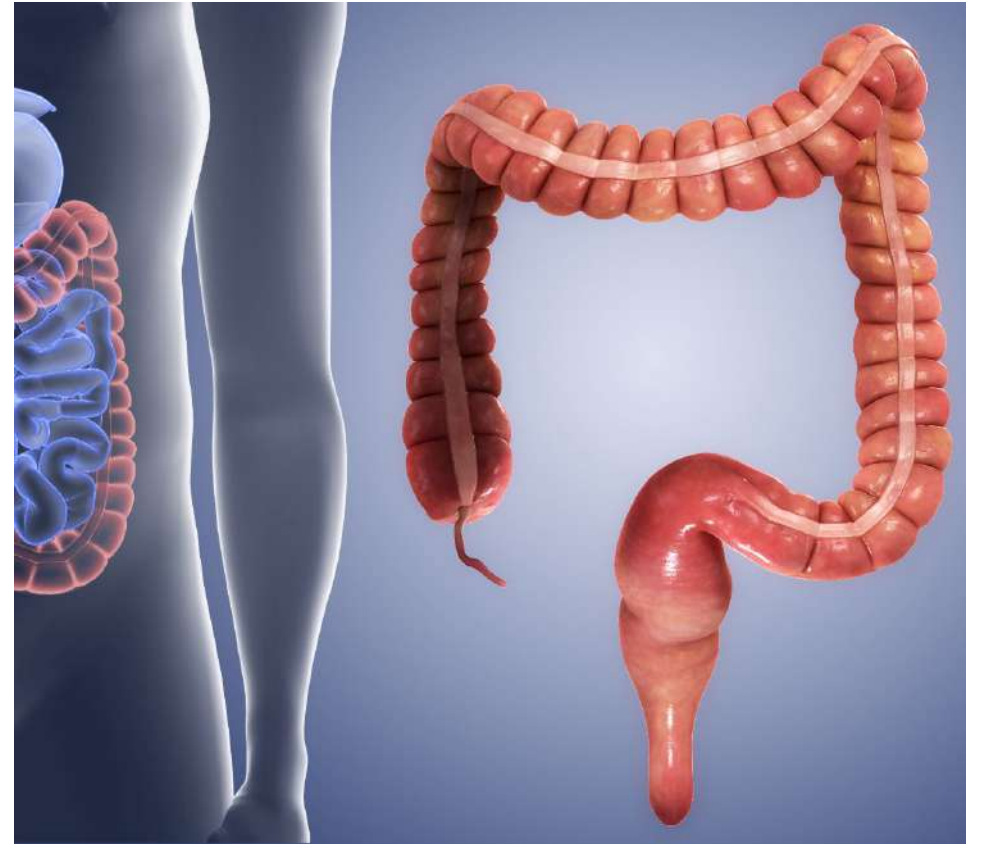
- Digestive juice secretion is promoted by the **nervous system and by hormones.**
  - A hormone is a substance **produced by one set of cells that affects a different set of cells.**
  - Hormones are usually transported by the **bloodstream.**
- The stomach produces gastrin in response to protein. Gastrin stimulates the stomach to churn, and **increases the gastric gland secretions.**

- The duodenal wall produces two other important hormones – **secretin** and **CCK**.
- **Acid** stimulates the release of **secretin**, while **partially digested protein and fat** stimulates the release of **CCK**.
- Soon after these hormones enter the blood stream, the pancreas increases its **output of pancreatic juice**, and the liver increases its **output of bile**

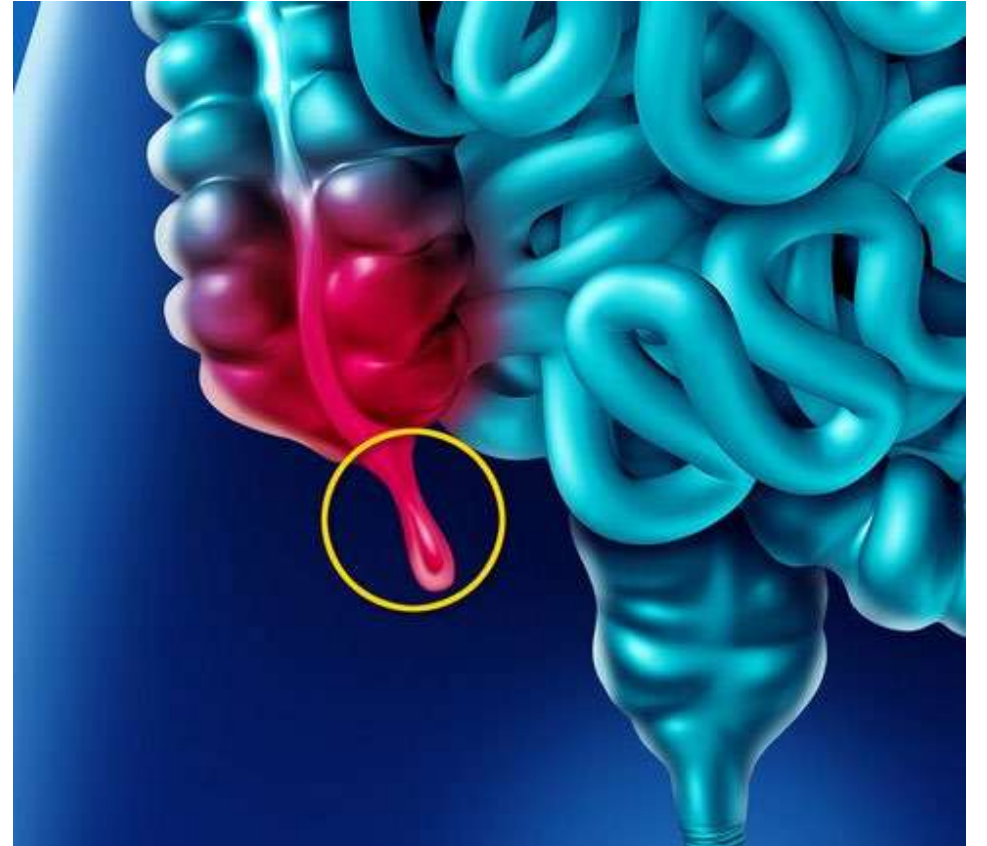


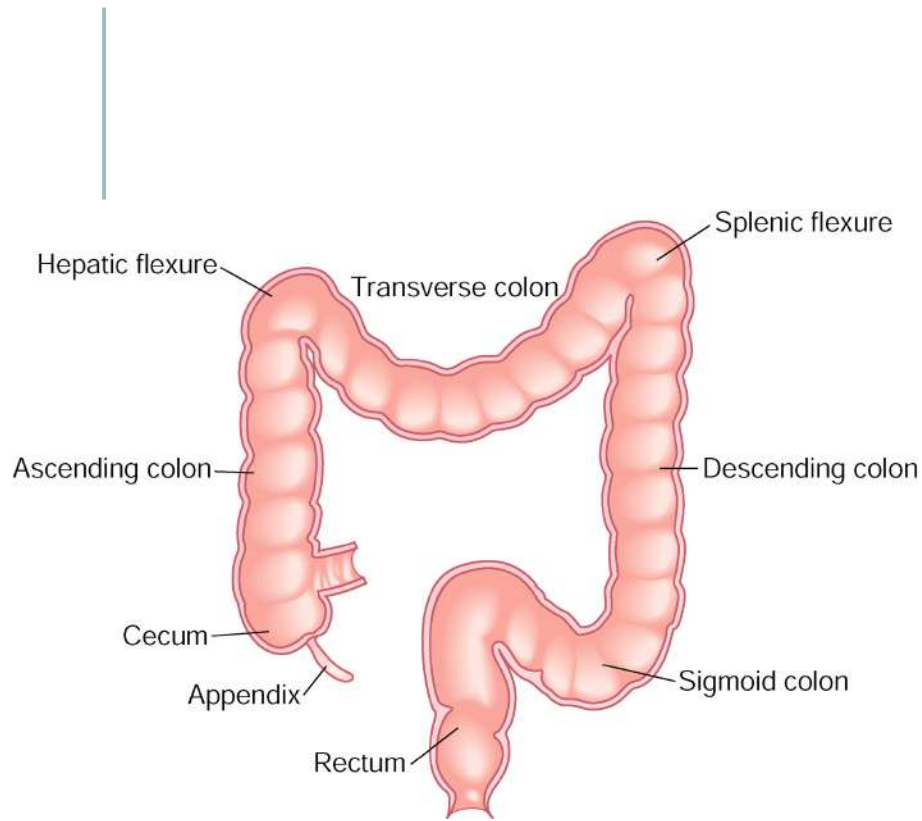
# THE LARGE INTESTINE

- The large intestine includes the **cecum, colon, rectum, and anal canal.**
- The large intestine absorbs **water, salts, and vitamins.**
- It also stores indigestible material until it is **eliminated as feces.**



- **The cecum is a small pouch** that forms the first part of the large intestine. It also has a small projection called the **appendix**.
- The appendix may play a role in **fighting infection**.
- However, if it becomes inflamed, this condition is known as **appendicitis** and **the organ must be removed immediately before it bursts and causes sepsis**.

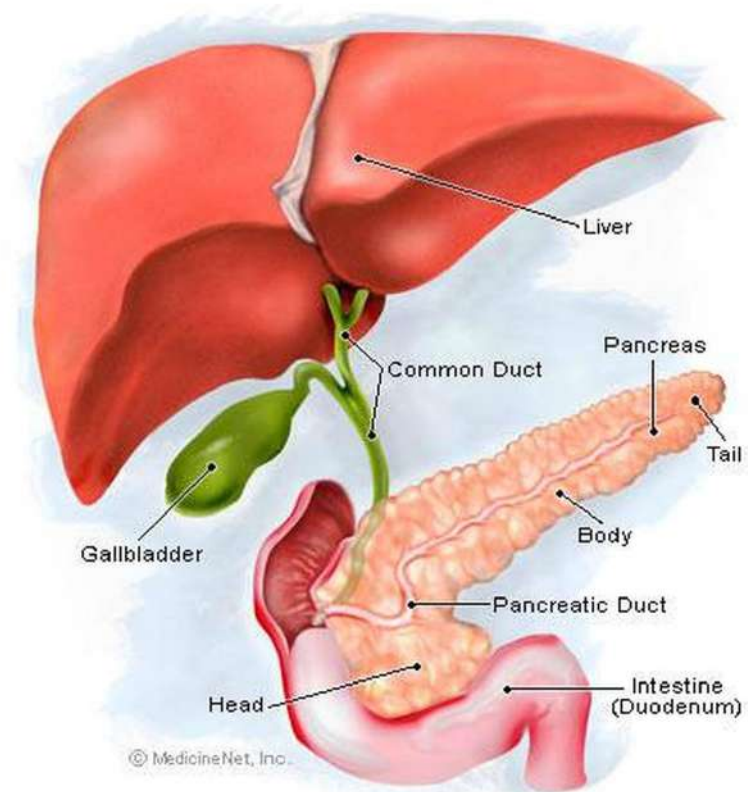




- The colon includes the **ascending, transverse, and descending colon**, which enters the rectum, the last 20 cm of the large intestine.
  - The rectum opens at the anus where **defecation occurs.**
- When feces are forced into the rectum by peristalsis, a **defecation reflex occurs:**
  - The stretching of the rectal wall initiates nerve impulses to the spinal cord, then the **rectal muscles contract and the anal sphincters relax.**
- About 40-50% of fecal mass consists of bacteria and other microbes.
  - These bacteria break down some **indigestible material and produce some vitamins that our bodies absorb and use.**

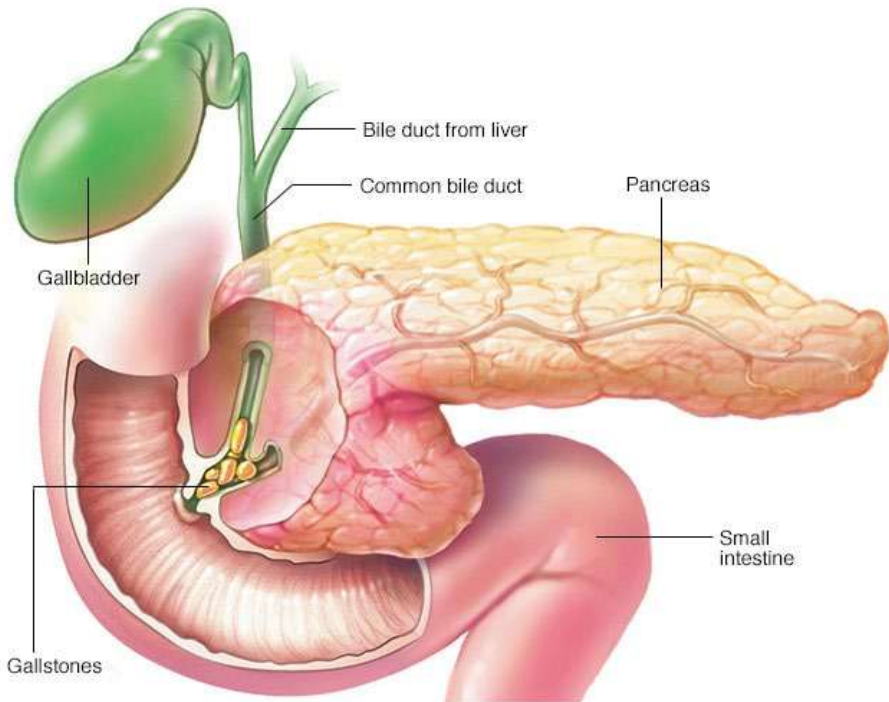
## 5.2 – ACCESSORY ORGANS OF DIGESTION

- The accessory organs **assist the primary digestive organs** in the process of food digestion in your body.
- Accessory organs include:
  - **Salivary glands**
  - **Pancreas**
  - **Liver**
  - **Gall bladder**



# THE PANCREAS

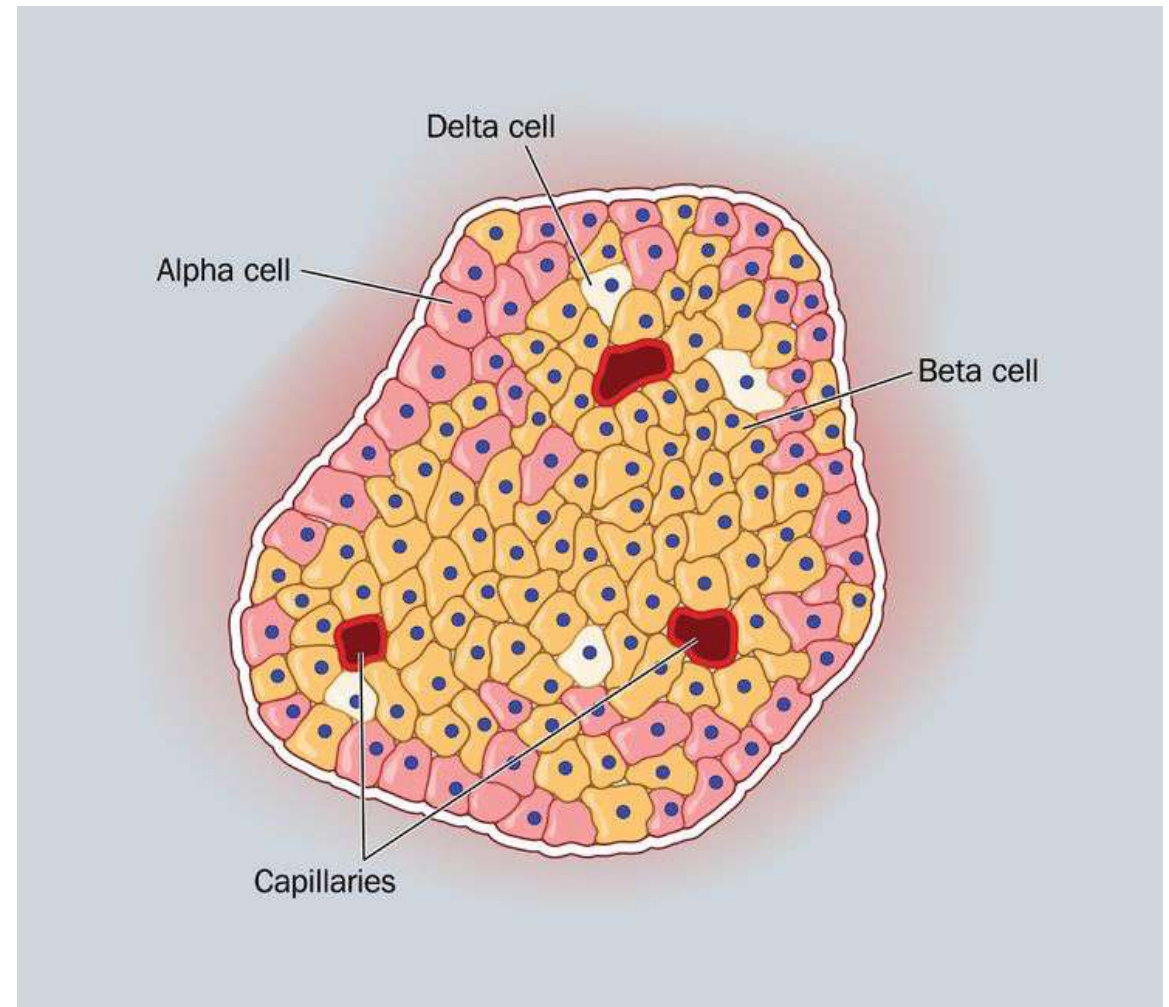
- The pancreas has both **endocrine and exocrine functions**.
- Exocrine functions include producing pancreatic juice, which contains **sodium bicarbonate ( $\text{NaHCO}_3$ )**, and **digestive enzymes**.
- Endocrine functions include **secreting insulin and glucagon**, hormones that keep the **blood glucose levels within normal limits**.





○ The pancreatic islets are clusters of at least three types of endocrine cells:

- 1) Alpha cells that produce **glucagon**
- 2) Beta cells that produce **insulin**
- 3) delta cell that produce **somatostatin.**



- Insulin is secreted when the **blood glucose level is high**, usually right after eating.
  - Insulin stimulates the **uptake of glucose by cells** in the liver, muscles, and adipose tissue.
  - In liver and muscle cells it then becomes stored as glycogen.
- Glucagon is secreted from the pancreas, usually before eating when **blood sugar levels are low**.
  - The major target of glucagon are the **liver and adipose tissue**.
  - Glucagon stimulates the **breakdown of glycogen into glucose**

- Somatostatin is a **growth hormone inhibitor**.
- Besides the pancreas, somatostatin is also produced by **cells in the stomach and small intestine**.
- Its main effects are:
  - Inhibit the **release of growth hormone**
  - Suppress the release of various hormones **produced by the digestive system**
  - The overall effect on the digestive track is to **decrease the absorption of nutrients**.



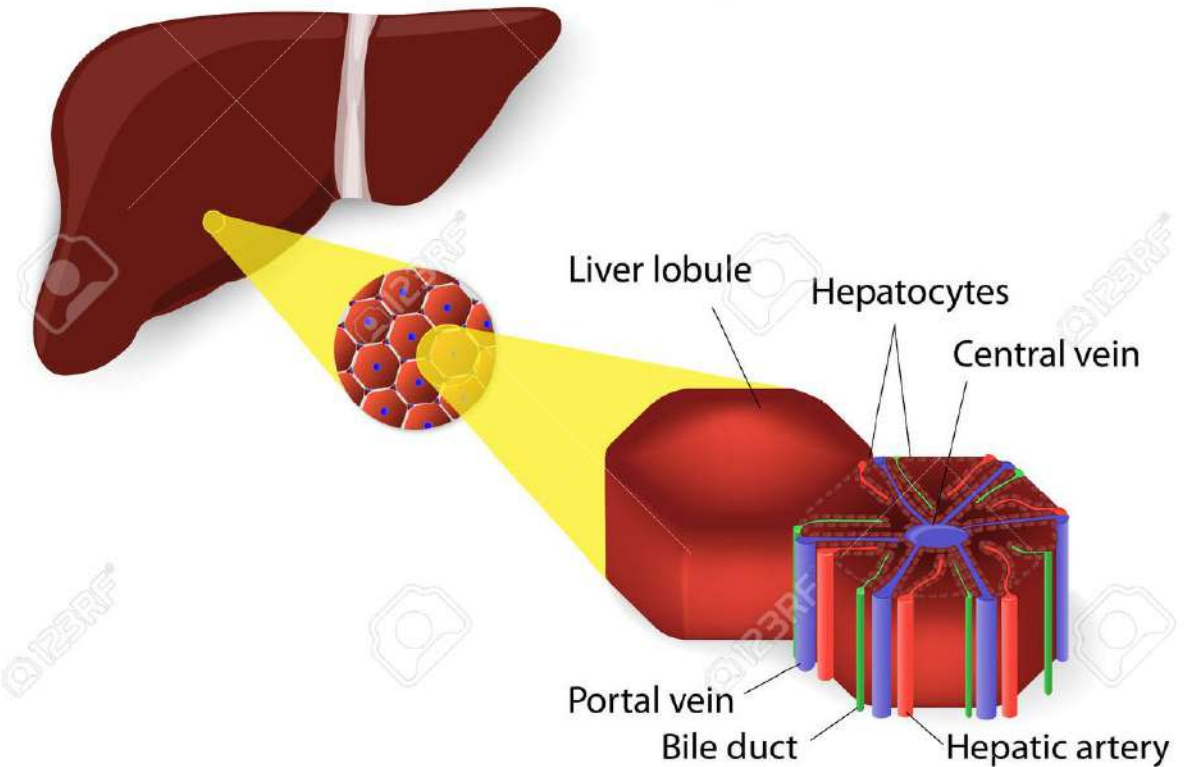
# THE LIVER

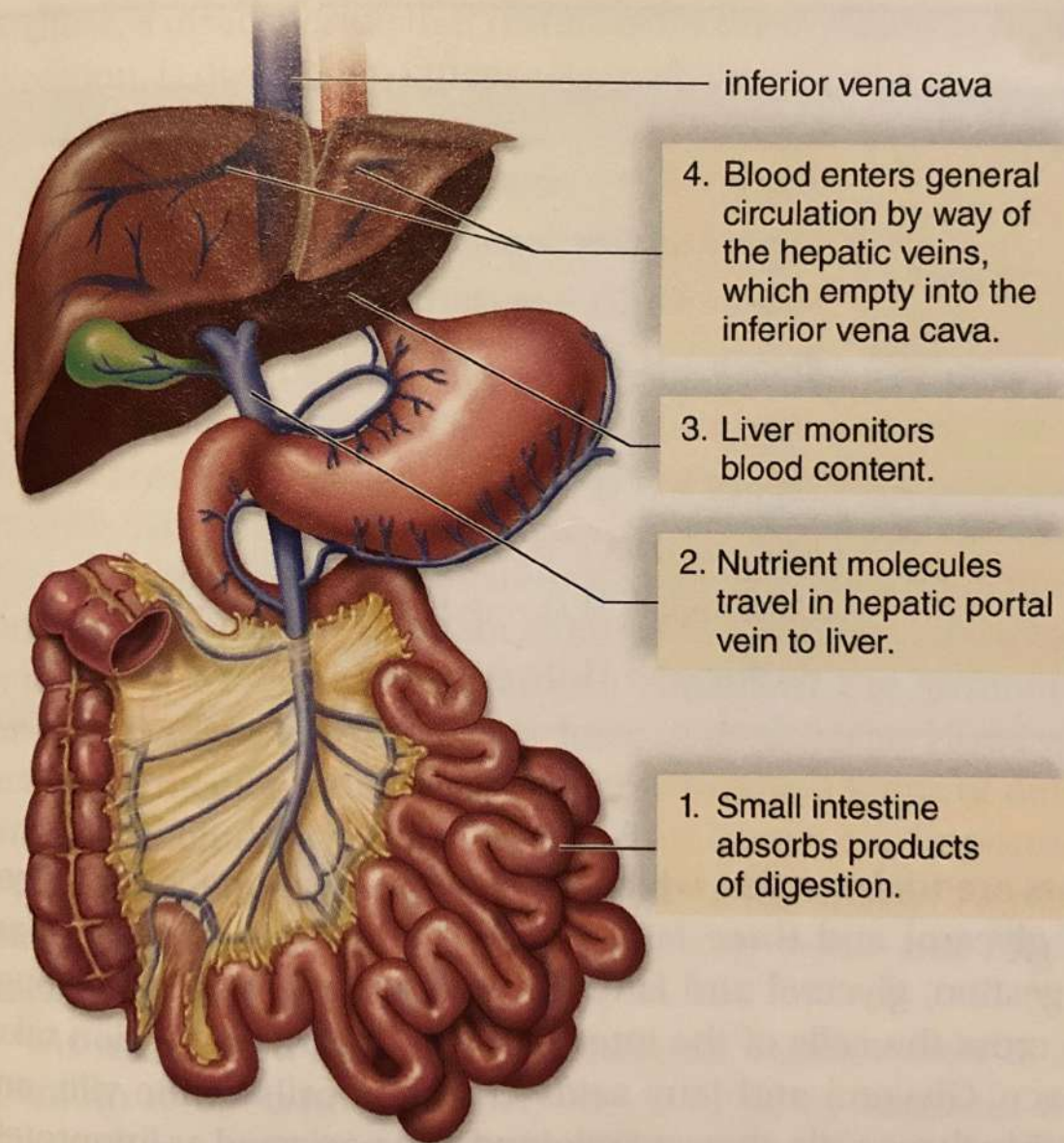
- The liver is the largest gland in the body, and lies **under the right side of the diaphragm.**
- It contains approximately **100 000 lobules that serve as structural and functional units.**



- Three structures are located between the lobules:
- 1) a bile duct that **takes bile away from the liver**
- 2) a branch of the hepatic artery that **brings oxygen to the liver**
- 3) a branch of the hepatic portal vein that **transports nutrients from the intestine.**

## STRUCTURE OF LIVER LOBULE



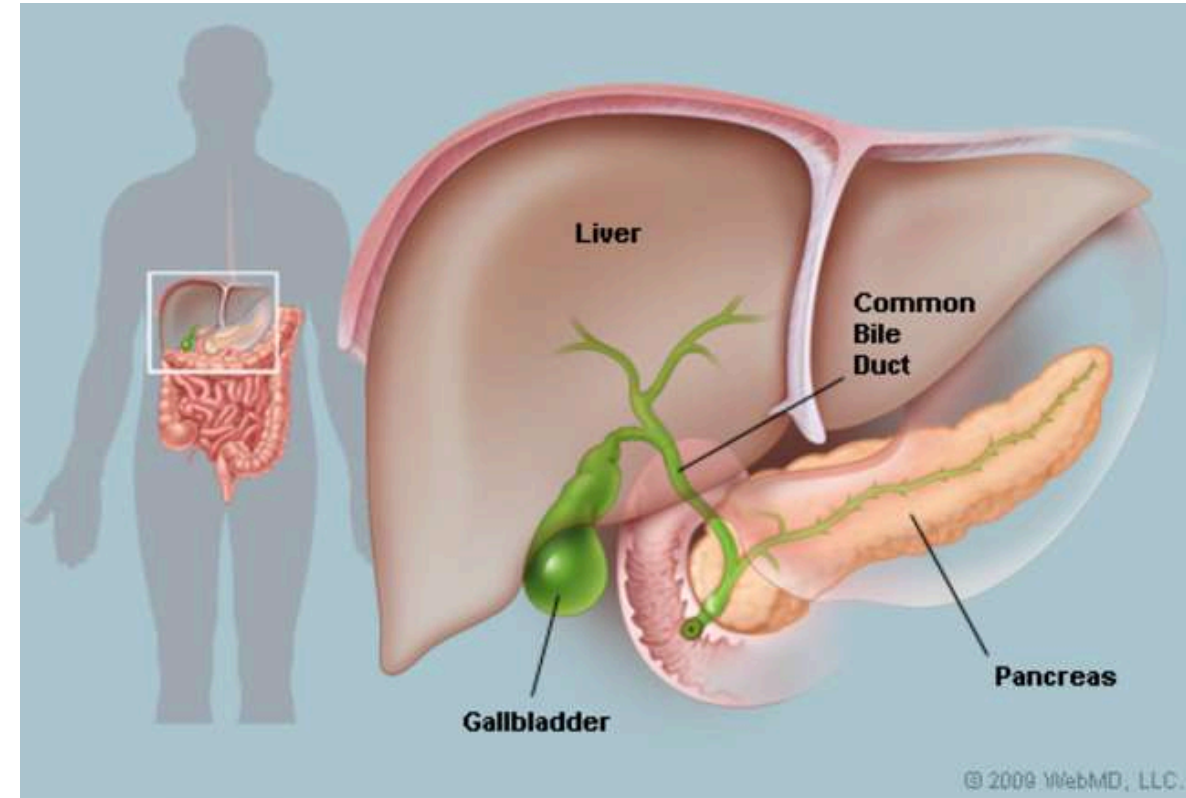


- The liver acts as the gatekeeper to the blood in the following ways:
  - The liver removes poisonous substances from the blood as it **passes through the hepatic portal vein.**
  - It removes and stores **iron and vitamins.**
  - It makes plasma proteins and **helps regulate cholesterol levels in the blood.**
  - It maintains blood glucose levels by **storing excess glucose as glycogen, and then converting glycogen back into glucose** in between meals.
- It also **produces bile, stored in the gall bladder.** Bile emulsifies fats.



# THE GALL BLADDER

- The gall bladder is a **muscular sac attached to the liver.**
- The liver produces 400-800mL of bile each day, **any excess is stored in the gall bladder.**
- When needed, the bile leaves the gall bladder and **proceeds to the duodenum via the common bile duct.**





## 5.3 – DIGESTIVE ENZYMES

- Digestive enzymes are proteins that speed up **specific chemical reactions**.

### Digestive enzymes in the mouth:

- Starch is a carbohydrate, its digestion begins in the mouth. Saliva contains **salivary amylase, which breaks down starch into maltose, a disaccharide**.

### Digestive enzymes in the stomach:

- Protein digestion begins here. **Pepsinogen and HCl are secreted by the gastric glands**.
- When combined, pepsinogen is converted into the **active pepsin enzyme**, which breaks **proteins into peptides** (precursors of amino acids).

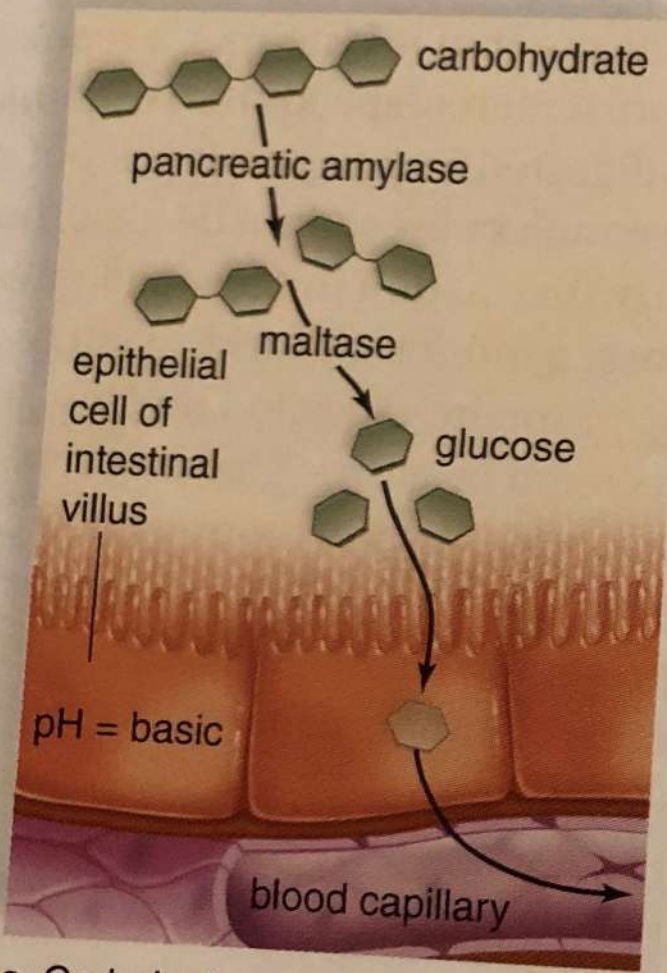
- The small intestine contains enzymes produced in both the **pancreas and small intestine.**

*Digestive enzymes produced by the pancreas:*

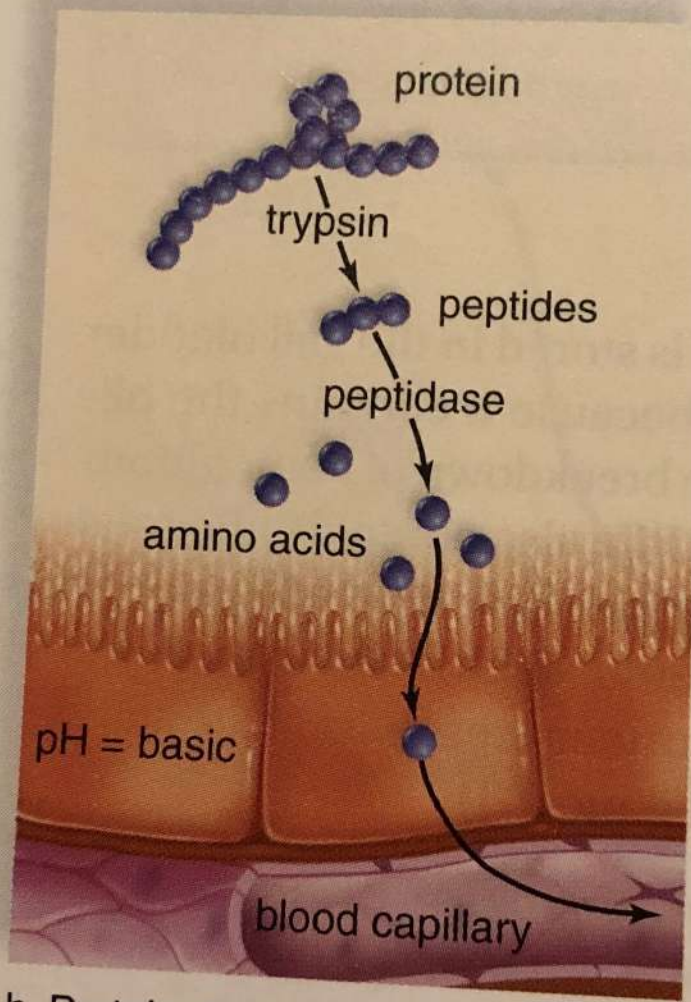
- **Pancreatic amylase digests starch**
- **Trypsin digests protein**
- **Lipase digests fat molecules.**

*Digestive enzymes produced by the small intestine:*

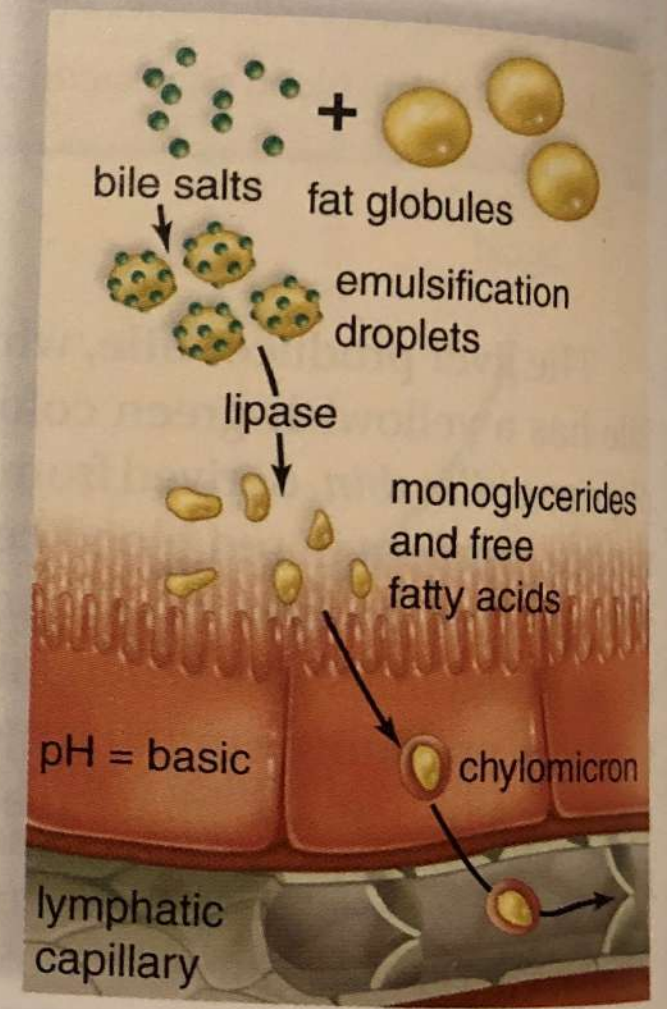
- **Peptidase completes the digestion of protein to amino acids**
- **Maltase completes the digestion of starch to glucose**



a. Carbohydrate digestion



b. Protein digestion



c. Fat digestion

- The absence of enzymes can **cause illness**.
- The most common involves a deficiency of lactase, the enzyme that dissolves lactose.
  - Symptoms include diarrhea, gas, cramps, which is caused by the **fermentation of nondigested lactose by intestinal bacteria**.
- Since our body's temperature remains constant at approximately  $37^{\circ}\text{C}$ , **enzyme activity is largely controlled by pH**.
  - **pH 7** in the mouth
  - **pH 2** in the stomach
  - **pH 8** in the intestine

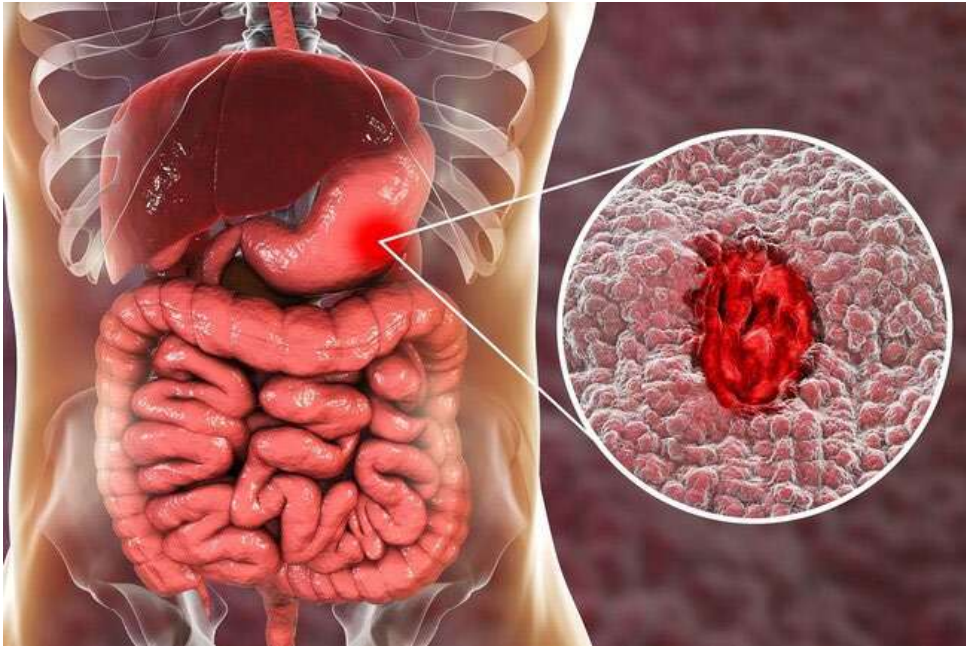
# 5.4 – DISORDERS OF THE DIGESTIVE SYSTEM

- Disorders of the digestive system can be grouped into two categories:
  - **Disorders of the digestive tract**
  - **Disorders of the accessory organs**



# DISORDERS OF THE DIGESTIVE TRACT

## Stomach Ulcers



- Mucus normally **protects the wall of the stomach.**
- If this is broken down, the **stomach wall can be damaged by the acid in the stomach resulting in an ulcer, or open sore in the wall.**
- Most are caused by **bacterial infection.**

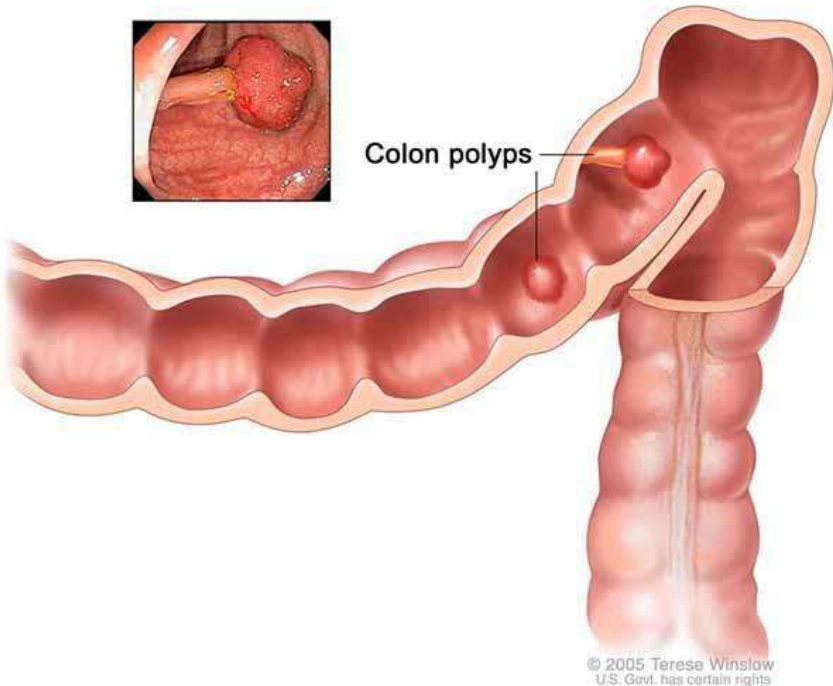


## Intestinal Disorders



- Diarrhea occurs due to infections of the **small or large intestine by bacteria or viruses**. Collectively known as food poisoning, here the intestinal wall becomes **irritated by the infection or toxins and peristalsis increases**.
  - Less water is absorbed which helps **rid the body of infectious organisms**.
- Constipation is when the feces is dry and hard. This can be attributed to **diet or by ignoring the defecation reflex**.
- Chronic constipation can lead to the development of hemorrhoids, which are **large and inflamed blood vessels of the anus**.

## Polyps and Colon Cancer



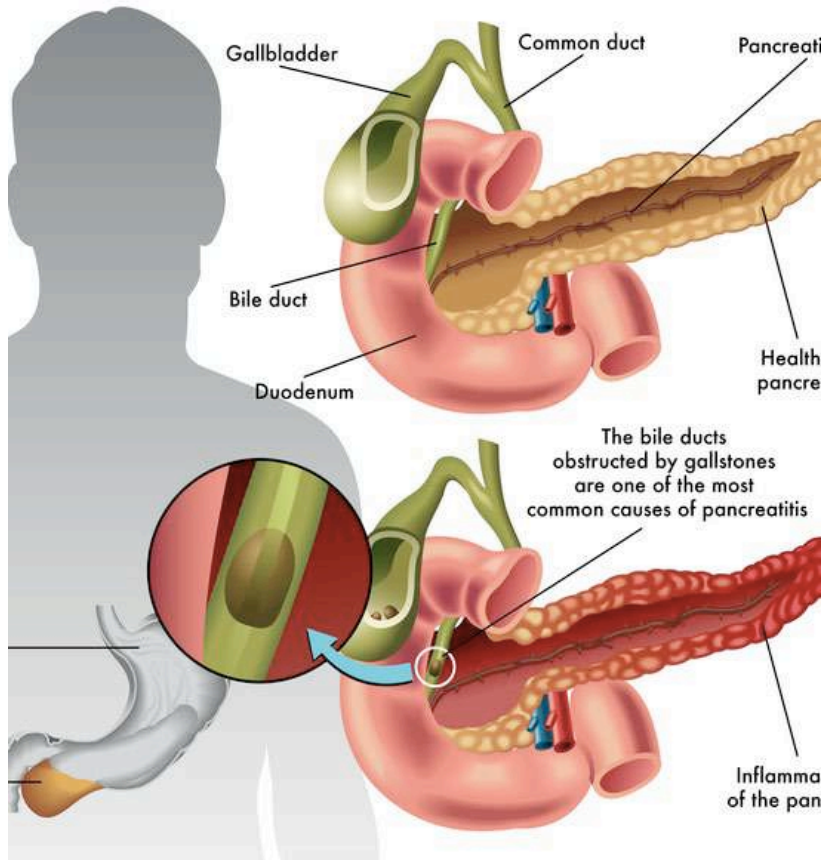
- The colon is subject to the development of polyps. **These are small growths arising from the epithelial lining.** They may be benign or cancerous.
- Polyps can be detected by a **colonoscopy.**
- Some investigators believe that dietary fat increases the likelihood of colon cancer because **dietary fat causes an increase in bile secretion.**
- **Intestinal bacteria may convert these bile salts** to substances that promote the development of cancer.



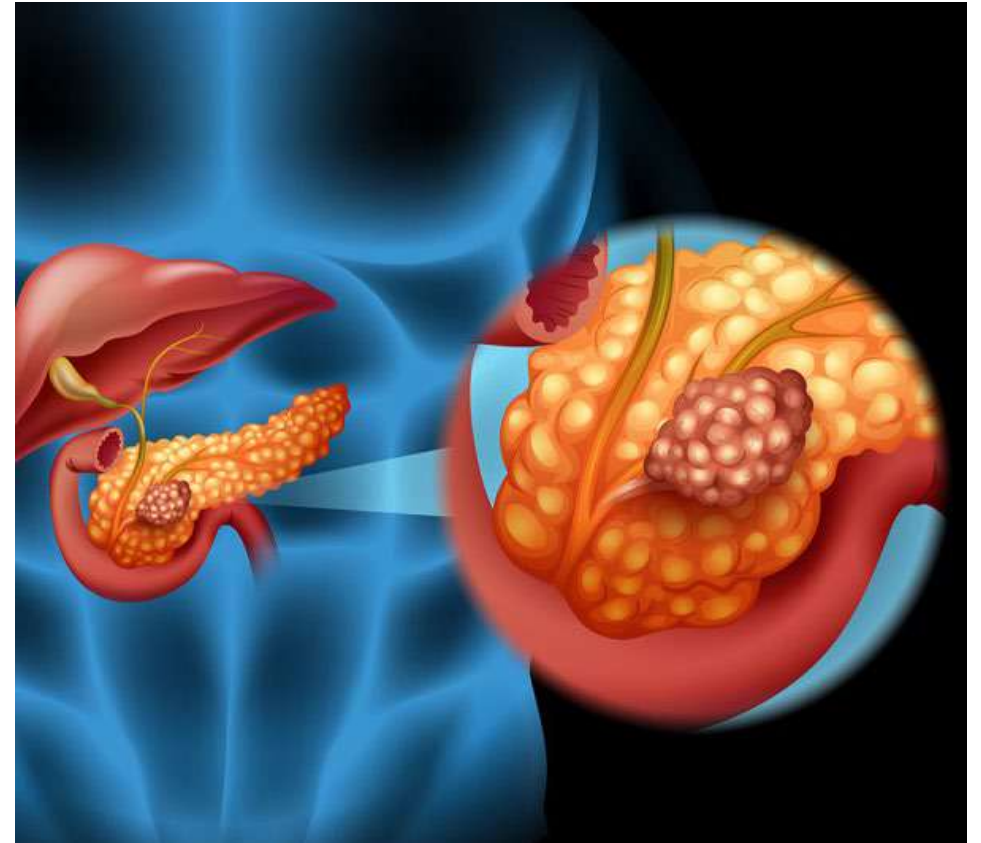
# DISORDERS OF THE ACCESSORY ORGANS

## Disorders of the Pancreas

- **Pancreatitis is an inflammation of the pancreas.** It can be caused by drinking too much alcohol, by gallstones that block the pancreatic duct or by other unknown factors.



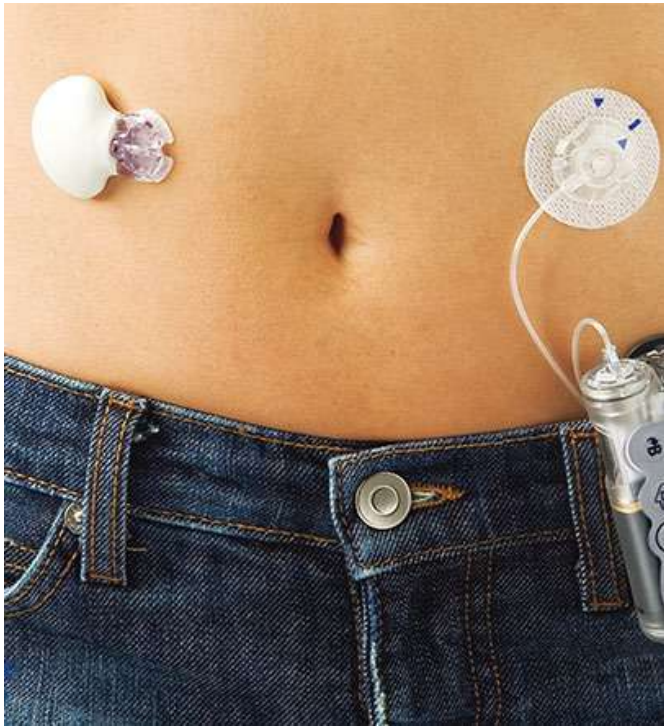
- Pancreatic cancer is unfortunately almost always fatal.
- Only approximately 20% of patients **are alive one year after their diagnosis**. This is largely due to the cancer cells spreading to **other organs before any symptoms appear**.
- Steve Jobs, Apple CEO died in 2011 at the age of 56 after a 7 year battle with pancreatic cancer.



## Diabetes Mellitus



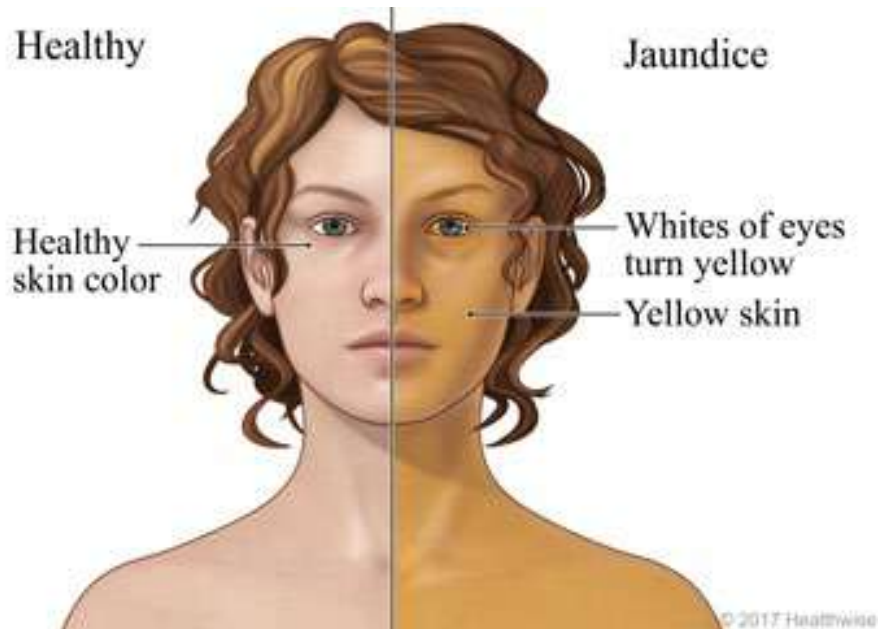
- In 2014, it was estimated that over 3 million Canadians **were living with diabetes mellitus.**
- People with diabetes **either do not produce enough insulin** (type 1) or **cannot properly use the insulin they produce** (type 2).
  - In either case, blood glucose levels stay high because **the use of glucose by cells is impaired.**
  - Because glucose in the blood cannot be used, the body turns to the metabolism of fat, which **leads to the buildup of ketones in the blood.**
  - The ketones are broken down into acids, which can **build up in the blood and lead to coma and death.**



- About 10% of diabetics in Canada have type 1 diabetes.
  - These individuals suffer from insulin shortage, so their **treatment includes insulin injections or pumps.**
- Most diabetics in Canada have type 2 diabetes.
  - Often the patient is overweight and fat tissue may **produce a substance that impairs insulin receptor function.**
  - Treatment usually involves weight loss, however, many also have **low insulin levels so they may require insulin injections.**
- Long term complications of both types are **blindness, kidney disease, and cardiovascular disorders including reduced circulation.**

## Disorders of the Liver and Gall Bladder

- Diseases that affect the liver can be life threatening.
- A tell-tail sign is the development of jaundice, which is a **yellowish colouring in the whites of the eyes and the skin.**
- Hepatitis, or inflammation of the liver, is **most commonly caused by one of several viruses.**



- **Cirrhosis is another chronic disease** of the liver often seen in alcoholics.
  - First the liver becomes infiltrated with fat, and then the **fatty liver tissue is replaced with scar tissue.**
- In some individuals, the cholesterol present in bile can form crystals, if they are **large enough they form gallstones.**
  - **If the gallstones block the common bile duct** then the gall bladder will have to be removed.

