

Digestive System

- Before the nutrients we ingest can be absorbed and used by our cells, they must first be released from the food that contains them.

The digestive system is involved in six essential activities:

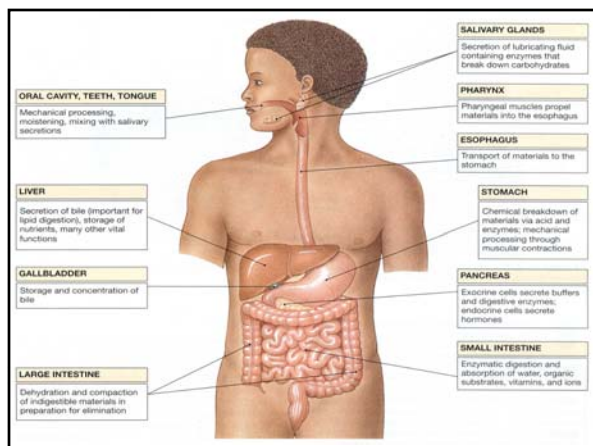
1. **Ingestion** - Taking food into the mouth.
2. **Propulsion** - Voluntary at first then the involuntary process of **peristalsis**.
3. **Mechanical digestion** - Chewing, churning, etc.
4. **Chemical digestion** - Enzyme action. Polymers & Monomers
5. **Absorption** - Movement of nutrients from the lumen into the blood or lymph.
6. **Defecation** - Elimination of indigestible substances.

OVERVIEW OF THE DIGESTIVE SYSTEM

The organs of the digestive system can be divided into two major groups.

Alimentary canal organs (AKA gastrointestinal or GI tract). This canal is a tube about 9 meters in a cadaver. Both ends of the tube are open. The alimentary organs include: **mouth, pharynx, esophagus, stomach, small intestine, and large intestine**.

Accessory digestive organs. These organs are not part of the tube and include: **teeth, tongue, gallbladder, salivary glands, liver, and pancreas**.

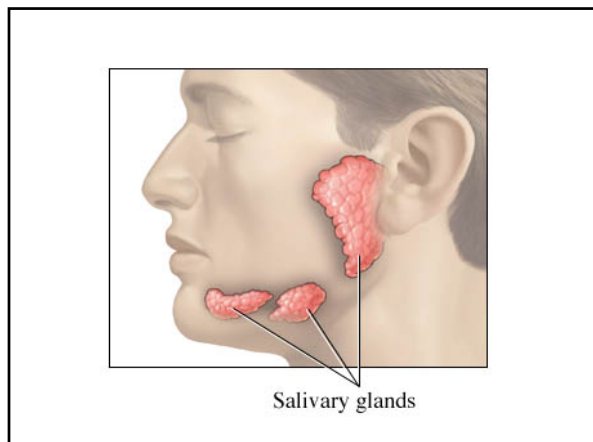


The Oral Cavity aka Buccal Cavity

- The teeth and tongue provide mechanical processing

Salivary Glands

- All are *exocrine* glands.
- Both extrinsic and intrinsic types exist. The smaller intrinsic glands are located in the oral mucosa and supplement the larger extrinsic glands.



Composition of Saliva

- 1) **Water** - 97 - 99.5%. pH is between 6.35 - 6.85.
- 2) **Salivary amylase** - aka ptyalin. This enzyme digests starch & glycogen.
- 3) **Solutes** - Mostly electrolytes like; Na⁺, K⁺, Cl⁻, HCO₃⁻
- 4) **Proteins** - The following three are examples.
 - Mucin - provides lubrication.
 - Lysozyme - a bacteriolytic enzyme that provides protection.
 - IgA - antibodies that also fight against microbes in the mouth.
- 5) **Metabolic wastes** - urea and uric acid.
- 6) **Growth factor** - may aid in the healing of licked wounds.

The Pharynx

- Connects the nasal and oral cavities with the larynx and esophagus.

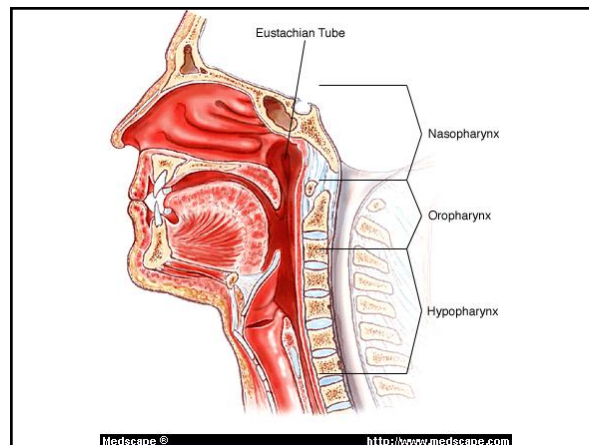
Divided into three portions

- 1) **Nasopharynx** - Continuous with the nasal cavity. Contains the pharyngeal tonsils (aka *adenoids*). Eustachian tube apertures are located here. No digestive role!
- 2) **Oropharynx** - The middle portion, located at the rear of the oral cavity
- 3) **Laryngopharynx** - The lower portion, continuous with the esophagus.

Note: The *epiglottis* keeps the bolus out of the trachea.

Analysis: Swallowing a *bolus*.

(Swallowing = **Deglutition**) (Chewing = **Mastication**)



The Esophagus

- A straight, collapsible tube with muscular walls about 25 cm long.

- Located posterior to the trachea, the esophagus contains all four basic layers.

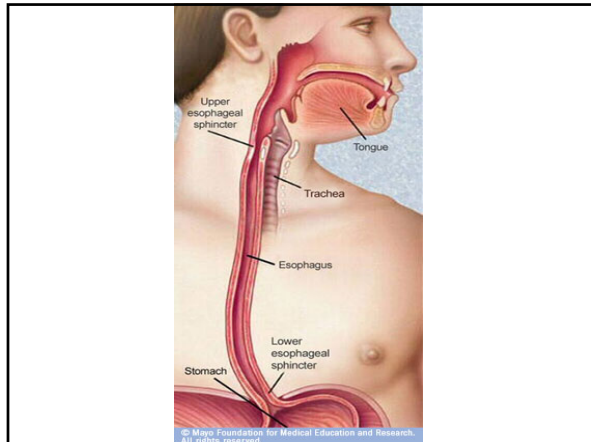
- The muscularis externa initially is composed of skeletal muscle but this gradually gives way to smooth muscle.

- Peristalsis passes food through this tube and into the stomach.

- The esophagus penetrates the diaphragm through an opening, the *esophageal hiatus*.

- Mucus glands scattered throughout its mucosa keep it moist and well lubricated.

- No enzymes are added here. The food doesn't stay long (few seconds).

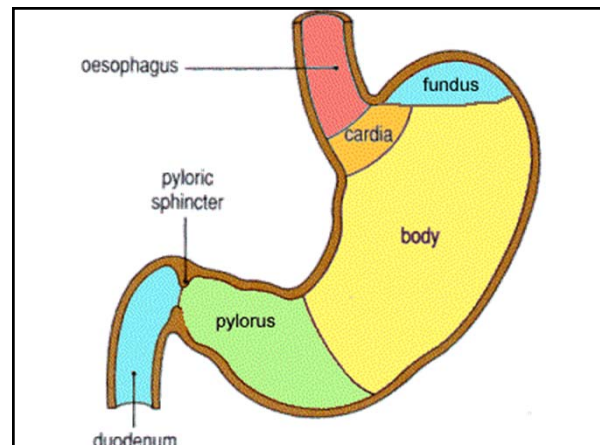


The Stomach

- J-shaped, saclike organ with a capacity of around 4 L. (The empty volume is 50 ml)
- Occupies the upper left portion of the abdominal cavity.

Can be divided into the following regions:

1. **Cardiac region** - A small area near the heart. The first portion of the stomach.
2. **Fundus** - A dome-shaped bulge. This part is tucked under the diaphragm.
3. **Body** - Midportion of the stomach.
4. **Pyloric region** - The last portion. It is shaped like a funnel. It ends at the *pylorus*.



Rugae - Internal folds which disappear when the stomach is distended (full).

Muscularis with three layers of smooth muscle (*oblique, circular, longitudinal*)

Cardiac and **pyloric sphincters** are located at the beginning and end of the organ.

- Greater and lesser **curvatures**

- The **greater omentum** hangs down from the greater curvature. It covers the intestines like an apron.

- A close look at the stomach's lining reveals millions of holes called **gastric pits**.

- The pits lead into the **gastric glands**. These tubular glands consist of four cell types.

- The collective secretion of three of these four cells is called **gastric juice**.

Gastric juice is made of a variety of things including...

1. Mucus

2. HCl

3. Intrinsic factor

4. Pepsinogen – Once released it becomes the protein splitting enzyme known as **pepsin**. Pepsin splits big proteins into small pieces called *proteoses* and *peptones*.

•The living stomach lining has several mechanisms that keep it from digesting itself.

1. The production of an alkaline mucous to coat it.

2. Epithelial cells are quickly replaced. The entire stomach epithelium is replaced every three to six days.

•Following a meal, the churning action of the stomach mixes the food into a semifluid paste called **chyme**. Peristaltic waves push the chyme toward the pyloric region. The pyloric sphincter begins to relax and the muscular pyloric region pumps the chyme into the duodenum a little at a time.

The amount of time food spends in the stomach varies.

- * Liquids pass through quickly.
- * Carbohydrates stay 1 - 2 hours.
- * Proteins stay 3 - 4 hours.
- * Fatty foods stay 3 - 6 hours.

Emesis - Vomiting. A complex reflex that empties the stomach. Stimulation can come from a variety of sources:

1. Toxins from food poisoning microbes.
2. Emetics (drugs that stimulate vomiting).
3. Rapid changes in body motion.
4. Certain sights, sounds, smells, tastes, emotional feelings.
5. Mechanical stimulation to the back of the pharynx.

The Small Intestine

•**A most important organ!** Digestion is completed & absorption of nutrients occurs here.

•A muscular tube 6 meters (2 meters in a living person) long. 2.5 cm in diameter.

•This organ begins at the **pyloric sphincter** and ends at the **ileocecal valve**.

•The chyme takes 3 to 10 hours to pass through.

•The small intestine is divided into three portions.

1. Duodenum

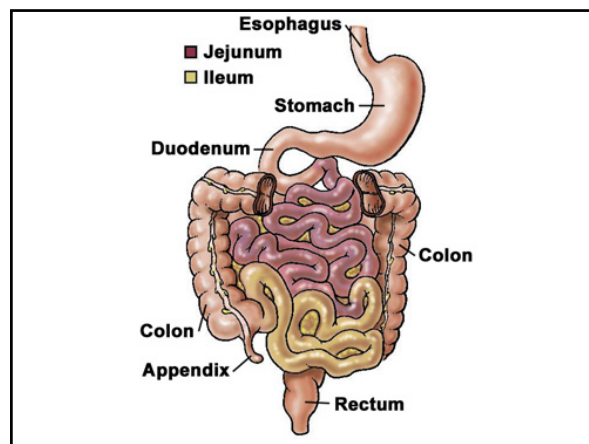
- a) C-shaped tube, 25 cm in length.
- b) Retroperitoneal.
- c) The pancreatic duct and the bile duct enter the lumen here, often as one.

2. Jejunum

- a) Suspended by a fold of the peritoneum called mesentery.
- b) 2.5 meters long, this is the middle portion of the small intestine.

3. Ileum

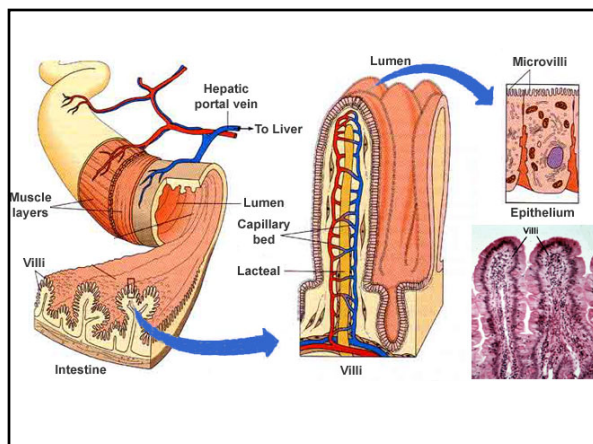
- Also suspended in the mesentery.
- 3.6 meters long, this is the most distal portion of the small intestine.
- Empties into the cecum through the *ileocecal valve*.



Microscopic Anatomy of the Small Intestine - Modifications for absorption.

- Digestion is completed by finishing enzymes in the duodenum. Therefore, much absorption takes place. In order to increase surface area, the following have evolved.
 - Plicae circulares** - Circular folds, like a washboard. These 1-cm tall folds force the chyme to spiral through the lumen, mixing and absorbing.
 - Villi** - Fingerlike projections around 1 mm tall. Between the villi, the mucosa is studded with pits that lead into tubular intestinal glands called **crypts of Lieberkuhn**.

- Microvilli** - These are very tiny projections clearly visible with an electron microscope. They extend into the lumen from the free end of the columnar epithelium. Sometimes called the **brush border** due to the fact that under light microscopic examination they appear to look like tiny paint brushes. The brush border secretes some important enzymes.



The Large Intestine

- Begins at the ileocecal valve and ends at the anus. 1.5 meters in length.

Can be subdivided into the following portions:

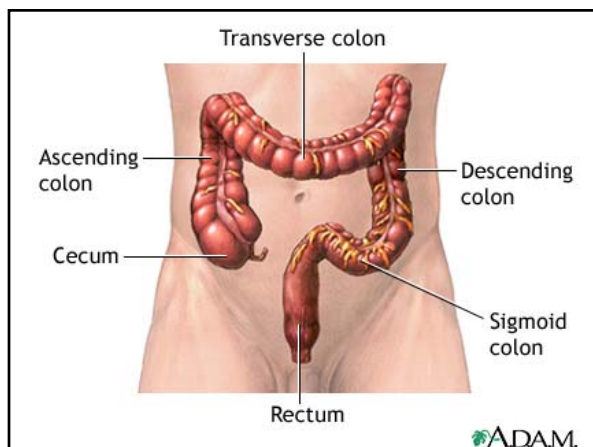
- Cecum** - A dilated pouch-like structure that hangs slightly below the ileocecal valve. Attached to the cecum is the **vermiform appendix**. The human appendix has no known digestive function but it does contain lymphatic tissue and therefore plays an immunological role.

2) Colon - The largest portion. Four parts

- a) Ascending colon - Leads to the hepatic flexure.
- b) Transverse colon - Leads to the splenic flexure.
- c) Descending colon
- d) Sigmoid colon - An S-shaped curve leading to the rectum.

3) Rectum - Located next to the sacrum. Has internal folds that keep feces out of the anal canal.

4) Anal Canal - The last 2.5 - 4.0 cm of the large intestine. Due to abrasion its mucosa is stratified squamous instead of columnar. The mucosa is folded into a series of *anal columns*. The anus proper is guarded by two muscles (external & internal *anal sphincters*).



Functions of the large intestine

- Little or no digestive function.
- Propulsion of the feces toward the anus is the major role.
- Since you can live without one, it is not essential.
- While chyme is present, water is being absorbed. The amount of time feces stays, will dictate the consistency. Compare *constipation* to *diarrhea*.
- Cellulose is indigestible and provides "roughage" that stimulates the colon to contract. Therefore, cellulose is an important dietary need.

Bacterial activity - The colon is inhabited by billions of resident bacteria. Their enzymes work on undigested material and some of their products like vitamins are helpful and are absorbed.

- Some products of bacterial activity are discomforting (gases like carbon dioxide, sulfur oxides, etc.). These gases result in **flatulence** and or **eructation**.

The Pancreas

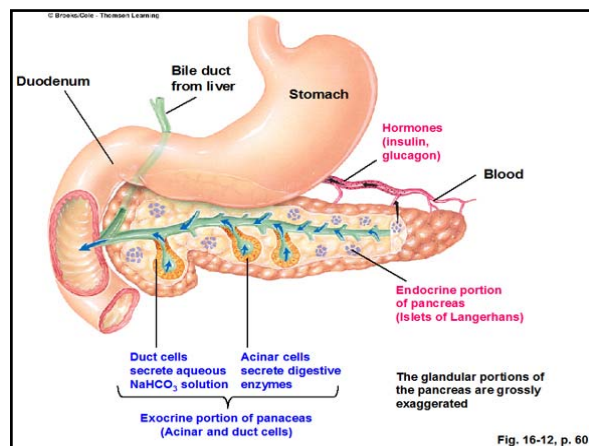
- A soft, pink, some elongated and triangular gland (tadpole shaped)
- It lies deep to the greater curvature of the stomach.
- Food entering the duodenum causes hormones, secretin and CCK, to be released from cells in the intestinal wall. These hormones in turn, signal the pancreas to release *pancreatic juice* with its digestive enzymes. This secretion is alkaline (pH 8) and helps to neutralize the acid from the gastric juice.

Contains two types of glandular tissue.

1) Acini - The more numerous of the two types.

These clusters of cells secrete pancreatic juice containing digestive enzymes into tiny ducts that eventually lead to the *pancreatic duct*.

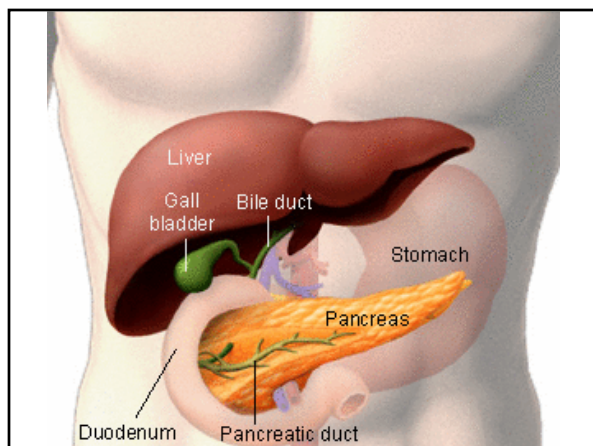
2) Pancreatic islets - Also called *Islets of Langerhans*, they are scattered around the acini tissue where they produce the sugar regulating hormone *insulin*. Thus, the pancreas plays a dual role in that it is both an *exocrine* gland and an *endocrine* gland. The pancreatic islets are ductless, the acini have ducts that lead to the large pancreatic duct.



The Liver

- Most of the liver is located in the upper right portion of the abdominal cavity.
- It is the largest gland in the body. Weight is 1.1 - 1.6 kilograms.
- There are four primary lobes.
- The pear shaped **gallbladder** fits into a depression between the right anterior and the quadrate lobes. The gallbladder is a storage place for **bile**. When food enters the duodenum, CCK is released by the intestinal mucosa. The CCK signals the gallbladder to release its bile which travels via the **common bile duct** to the duodenum.

- Bile is carried to the gall bladder by the *left and right hepatic ducts* which meet at the *cystic duct*. The cystic duct then carries the bile into the gallbladder.
- The structural and functional units of the liver are tiny hexagon shaped structures called **liver lobules**. These lobules have a diameter of 1 -2 mm. As blood flows through these lobules, numerous functions occur.



Functions of the Liver

- **Bile secretion.** Bile plays a role in the emulsification of fats. Bile is made of among other things, bile salts, cholesterol, and pigments like bilirubin. **There are no enzymes in bile!**
- Deamination of excess amino acids.
- Maintains blood glucose level. (homeostasis)
- Synthesis of several blood proteins. For example, prothrombin, a protein involved in the formation of blood clots.

- Alters the composition of toxic substances in the body fluids.
- Synthesis of cholesterol, lipoproteins, and phospholipids.
- Blood filtering. Removal of worn out erythrocytes, etc.
- Storage of glycogen, iron, vitamins A, D, B₁₂.