1. Details of Module and its structure

Module Detail	
Subject Name	Biology
Course Name	Biology 02 (Class XI, Semester - 2)
Module Name/Title	Digestive System – Part 1
Module Id	kebo_21601
Pre-requisites	Basics about Food components and Digestion in Animals.
Objectives	After going through this lesson, the learners will be able to understand the following: 1. Alimentary Canal 2.1. Mouth 2.1.1. Teeth 2.2. Pharynx 2.3. Esophagus 2.4. The Wall of the Digestive Tract 2.5. Stomach 2.6. Intestine 2.6.1. Small Intestine 2.6.2. Large Intestine 2. Digestive Glands 3.1. Liver 3.2. Pancreas 3.3. Gall bladder 3.4. Salivary glands
Keywords	Alimentary Canal, Mouth, Teeth, Pharynx, Esophagus, The Wall of the Digestive Tract, Stomach, Intestine, Small Intestine, Large Intestine, Digestive Glands, Liver, Pancreas, Gall bladder, Salivary glands

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1. Introduction

Food is one of the basic requirements of all living organisms. The major components of our food are carbohydrates, proteins and fats. Vitamins and minerals are also required in small quantities. Food provides energy and organic materials for growth and repair of tissues. The water we take in, plays an important role in metabolic processes and also prevents dehydration of the body. Biomacromolecules in food cannot be utilised by our body in their original form. They have to be broken down and converted into simple substances in the digestive system. This process of conversion of complex food substances to simple absorbable forms is called digestion and is carried out by our digestive system by mechanical and biochemical methods.

The digestive system consists of Alimentary canal and Digestive glands.

2. Alimentary Canal

The organs of the digestive system are located within a tube called the **alimentary canal,** or **gastrointestinal tract.** The tube begins with the mouth and ends with the anus (Fig. 1). Although the term digestion, strictly speaking, means the breakdown of food by enzymatic

action, we will expand the term to include both the physical and chemical processes that reduce food to small, soluble molecules. The functions of the digestive system are to:

1. Ingest the food.In stock.

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2. Break food down into small molecules that can cross plasma membranes.

3. Absorb these nutrient molecules.

4. Eliminate nondigestible wastes.

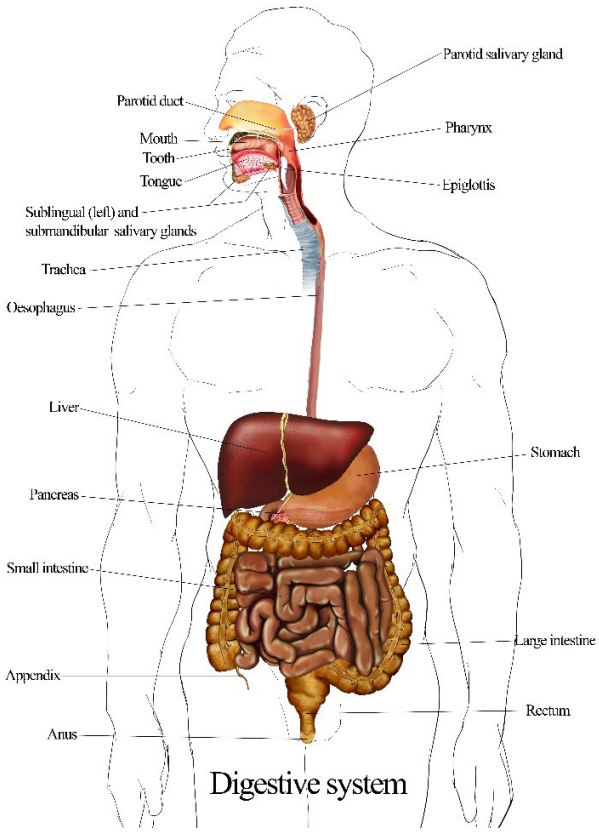

Figure 1. Digestive System of Humans

2.1. Mouth

The **mouth,** which receives food, is bounded externally by the lips and cheeks. The space between the lips and cheeks and the teeth is the **vestibule.**

The tongue is composed of skeletal muscle whose contraction changes the shape of the tongue. Muscles exterior to the tongue cause it to move about.

Rough projections on the tongue, called papillae, help it handle food and also contain the sensory receptors called taste buds. A fold of mucous membrane, called a frenulum, on the underside of the tongue attaches it to the floor of the mouth. If the frenulum is too short, the individual cannot speak clearly and is said to be tongue-tied. Posteriorly, the tongue is anchored to the hyoid bone.

The mouth has a roof that separates it from the nasal cavities. The roof has two parts: an anterior (toward the front) **hard palate** and a posterior (toward the back) **soft palate** (Fig. 2). The hard palate contains several bones, while the soft palate is muscular only. The soft palate ends in a finger-shaped projection called the **uvula.**

Three pairs of salivary glands are present in mouth that will be discussed in digestive glands.

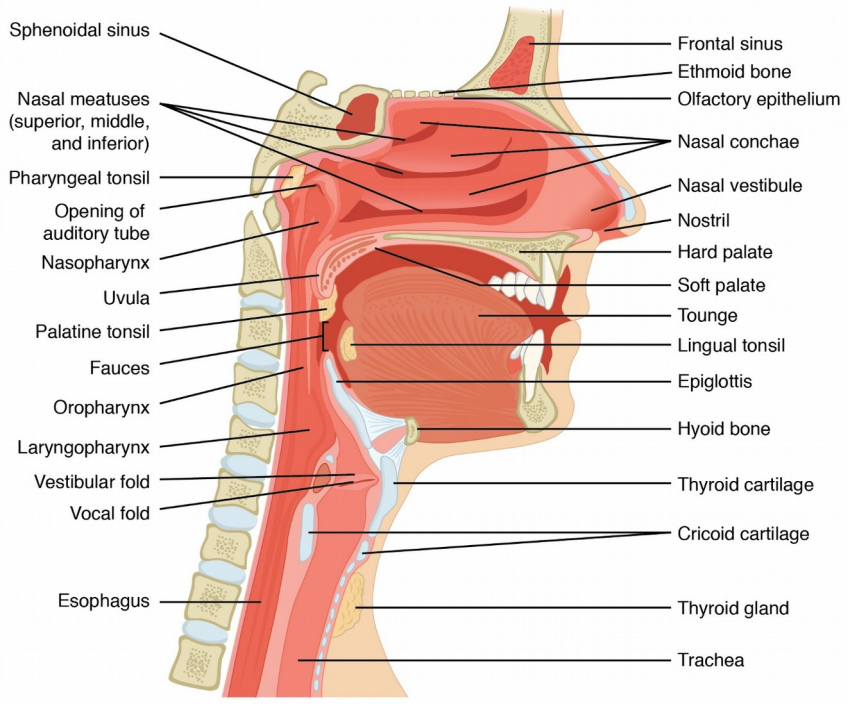

Figure 2. Structure of Mouth

https://upload.wikimedia.org/wikipedia/commons/d/dc/2303_Anatomy_of_Nose-Pharynx-Mouth-Larynx.jpg **(Under CC-BY)**

2.1.1. Human Teeth

During the first two years of life, the 20 deciduous, or baby, teeth appear. Eventually, the deciduous teeth are replaced by the adult teeth. Normally, adults have 32 teeth (Fig. 3). One-half of each jaw has teeth of four different types: (1) two chisel-shaped incisors for biting, (2) one pointed canine (cuspid) for tearing, (3) two fairly flat premolars (bicuspids) for grinding and (4) three more flattened molars for crushing. The last molars, called the wisdom teeth, may fail to come in, or if they do, they may grow in crooked and be useless. Frequently, wisdom teeth are extracted.

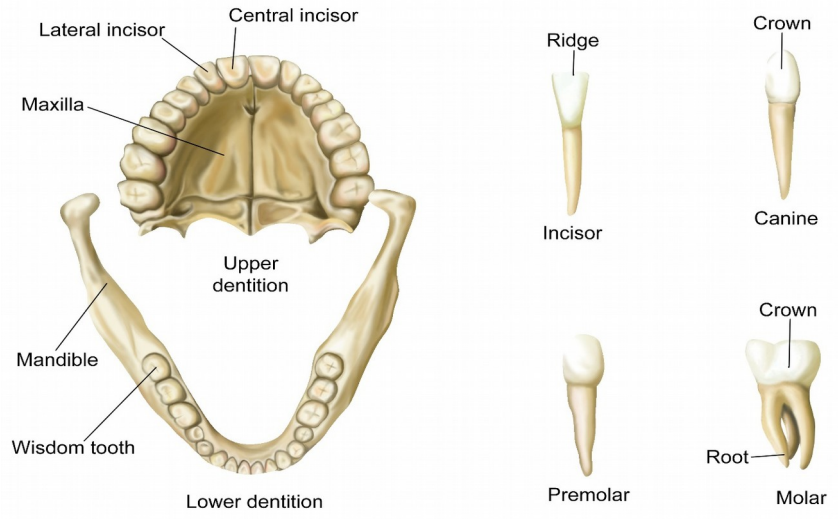

Figure 3. Human Teeth

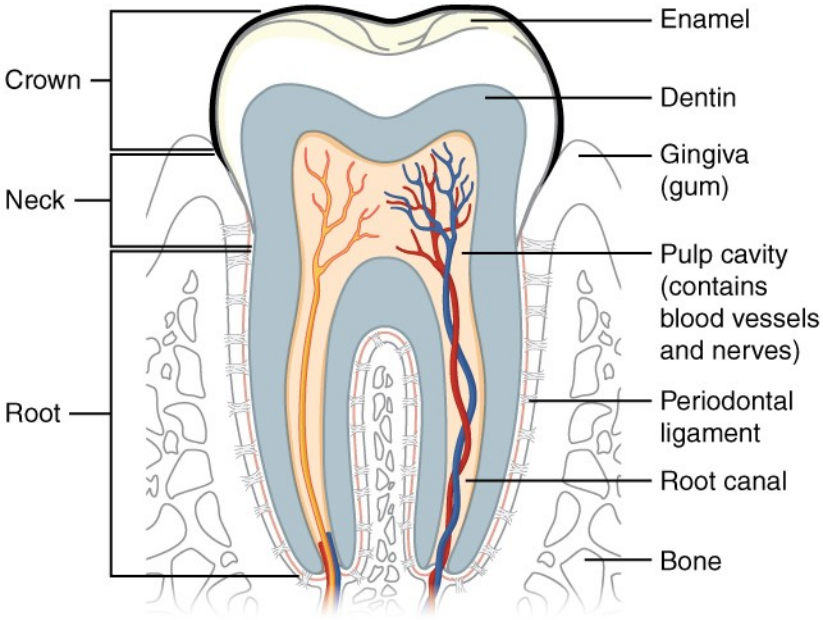

Figure 4. Structure of Tooth

https://upload.wikimedia.org/wikipedia/commons/f/fe/2409_Tooth.jpg (Under CC-BY)

Each tooth (Fig. 4) has a crown and a root. The crown has a layer of enamel, an extremely hard outer covering of calcium compounds; dentin, a thick layer of bonelike material; and an inner pulp, which contains the nerves and blood vessels. Dentin and pulp are also in the root. **Caries,** tooth decay commonly called cavities, occur when bacteria within the mouth break down sugar and give off acids that corrode the teeth. Once these acids dissolve the enamel and dentin, the pulp is compromised, triggering a toothache. Fluoride treatments, particularly in children, can make the enamel stronger and more resistant to decay. Gum disease is more likely as we age. One example is inflammation of the gums, called **gingivitis,** that may spread to the periodontal membrane lining the tooth socket. When this occurs, the individual develops **periodontitis,** characterized by loss of bone and loosening of the teeth. Brushing and flossing the teeth after every meal cleans the teeth and stimulates the gums, preventing these conditions. Care should be taken to brush away from the gums to prevent gum recession.

2.2. The Pharynx

From the mouth, food passes through the pharynx and esophagus to the stomach, small intestine, and large intestine. The food passage and the air passage cross in the **pharynx** because the trachea is anterior to the esophagus, a long muscular tube that takes food to the stomach (Fig. 2).

The tonsils are embedded in the mucous membrane of the pharynx. The **palatine tonsils** are on either side of the tongue close to the soft palate, and the **pharyngeal tonsils,** or adenoids,

are in the nasopharynx. The tonsils help protect the body against infection. When the tonsils become inflamed, the person has tonsillitis. If the tonsillitis keeps recurring, the tonsils may be surgically removed (called a tonsillectomy).

The pharynx has three parts:

(1) The **nasopharynx,** posterior to the nasal cavity, serves as a passageway for air;

(2) the **oropharynx,** posterior to the soft palate, is a passageway for both air and food;

(3) the **laryngopharynx,** just inferior to the esophagus, is a passageway for food entering the esophagus.

2.3. The Esophagus

The **esophagus** is a muscular tube that passes from the pharynx through the thoracic cavity and diaphragm into the abdominal cavity, where it joins the stomach. The esophagus is ordinarily collapsed, but it opens and receives the bolus when swallowing occurs. A rhythmic contraction called **peristalsis** pushes the food along the alimentary canal. Peristalsis begins in the esophagus and continues in all the organs of the alimentary canal. Occasionally, peristalsis begins even though there is no food in the esophagus. This produces the sensation of a lump in the throat.

2.4. The Wall of the Digestive Tract

The wall of the esophagus in the abdominal cavity is comparable to that of the alimentary canal, which has these layers (Fig. 5):

A. ***Mucosa*** (mucous membrane layer) A layer of epithelium supported by connective tissue and smooth muscle lines the **lumen** (central cavity). This layer contains glandular epithelial cells that secrete digestive enzymes and goblet cells that secrete mucus.

B. ***Submucosa*** (submucosal layer) A broad band of loose connective tissue that contains blood vessels lies beneath the mucosa. Lymph nodules, called Peyer patches, are in the submucosa. Like the tonsils, they help protect us from disease.

C. ***Muscularis*** (smooth muscle layer) Two layers of smooth muscle make up this section. The inner, circular layer encircles the gut; the outer, longitudinal layer lies in the same direction as the gut. (The stomach also has oblique muscles.)

D. ***Serosa*** (serous membrane layer) Most of the alimentary canal has a serosa, a very thin, outermost layer of squamous epithelium supported by connective tissue. The serosa secretes a serous fluid that keeps the outer surface of the intestines moist so that the organs of the abdominal cavity slide against one another. The esophagus has an outer layer composed only of loose connective tissue called the *adventitia*.

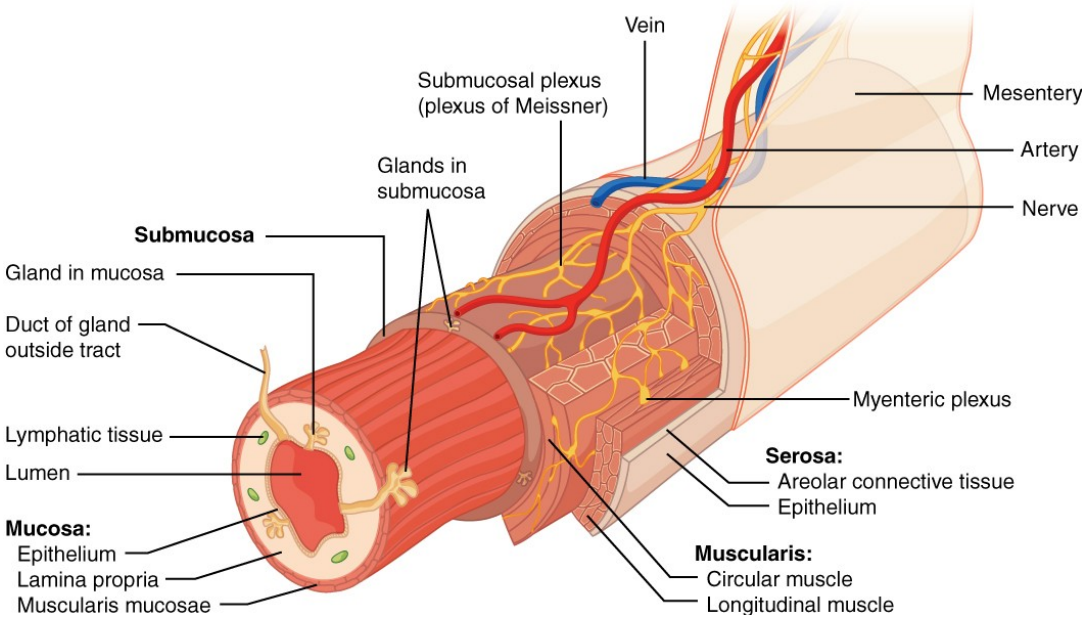

Figure 5. Wall of the Digestive Tract

https://upload.wikimedia.org/wikipedia/commons/b/b1/2402_Layers_of_the_Gastrointestinal_Tract.jpg (Under CC-BY)

2.1.5. The Stomach

The **stomach** (Fig. 6) is a thick-walled, J-shaped organ that lies on the left side of the abdominal cavity deep to the liver and diaphragm. The stomach is continuous with the esophagus above and the duodenum of the small intestine below.

The length of the stomach remains at about 25 cm (10 in.) regardless of the amount of food it holds, but the diameter varies, depending on how full it is. As the stomach expands, deep folds in its wall, called **rugae,** gradually disappear. When full, it can hold about 4 liters (1 gallon). The stomach receives food from the esophagus, stores food, mixes food with its juices (thereby starting the digestion of proteins), and moves food into the small intestine.

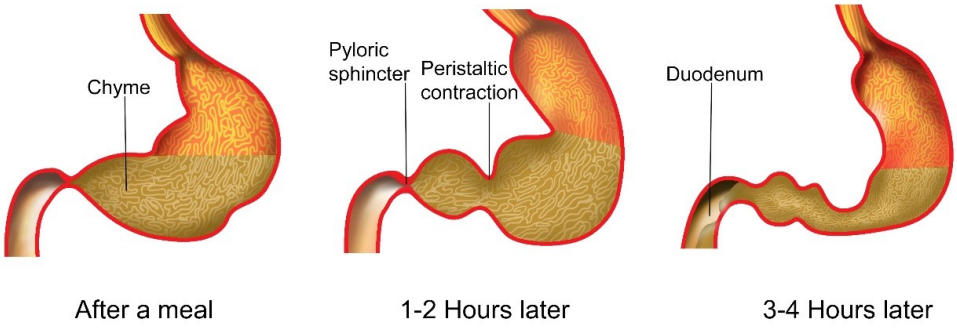

Figure 6. Stomach - Movement of food

The stomach has four regions. The cardiac region, which is near the heart, surrounds the lower esophageal sphincter where food enters the stomach. The fundic region, which holds food temporarily, is an expanded portion superior to the cardiac region. The body region, which comes next, is the main part. The pyloric region narrows to become the pyloric canal

leading to the pyloric sphincter through which food enters the duodenum, the first part of the small intestine.

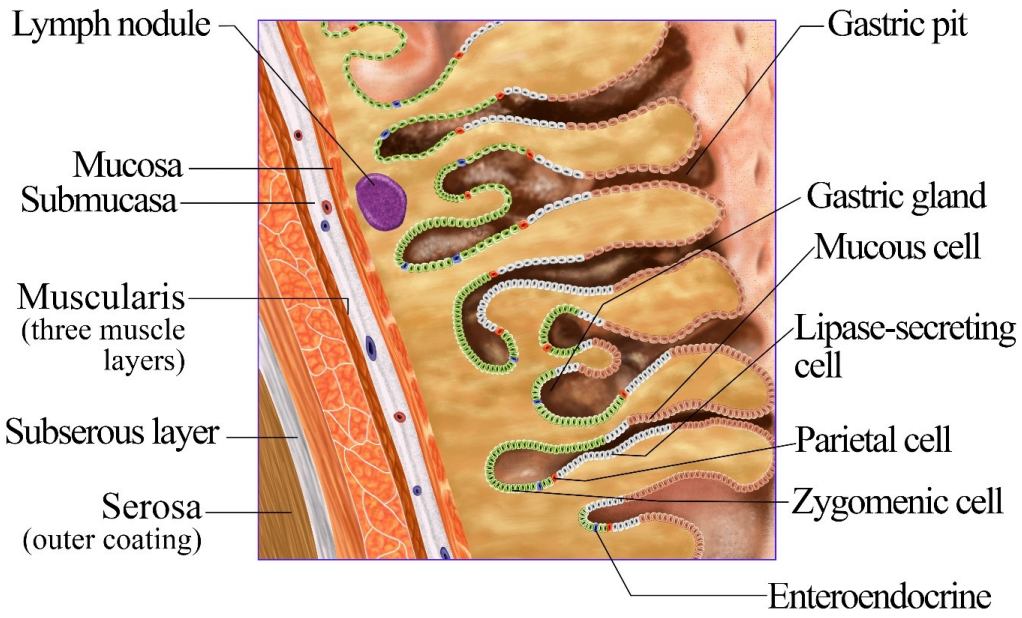

Figure 7. Walls of Stomach

The abdominal wall and the organs of the abdomen are covered by peritoneum, a serous membrane (Fig. 7). The portion of the peritoneum that lines the wall is called the parietal peritoneum. The portion that covers the organs is called the visceral peritoneum. In between the organs, the visceral peritoneum is a double-layered mesentery that supports the visceral organs, including the blood vessels, nerves, and lymphatic vessels

Some portions of the mesentery have specific names. The **lesser omentum** is mesentery that runs between the stomach and the liver. The **greater omentum** is indeed "greater." It hangs down in front of the intestines like a large, double layered apron. The greater omentum has several functions: It contains fat that cushions and insulates the abdominal cavity; it contains macrophages that can take up and rid the body of pathogens; and it can wall off portions of the alimentary wall that may be infected, keeping the infection from spreading to other parts of the so-called peritoneal cavity.

2.6. The Small Intestine

The **small intestine** extends from the pyloric valve of the stomach to the ileocecal valve, where it joins the large intestine. It is named for its small diameter (compared to that of the large intestine), but perhaps it should be called the long intestine. The small intestine takes up a large portion of the abdominal cavity, averaging about 6 m (18 ft) in length. All the contents of food—fats, proteins, and carbohydrates— are digested in the small intestine to soluble molecules that can be absorbed. To this end, the small intestine receives secretions from the pancreas and liver and produces intestinal juices. Absorption of nutrients for the body's cells,

such as amino acids and sugars, occurs in the small intestine. It also transports nondigestible remains to the large intestine.

Regions of the Small Intestine

The small intestine has the following regions (Fig. 8):

A. Duodenum The first 25 cm (10 in.) contain distinctive glands that secrete mucus and also receive the pancreatic secretions and the bile from the liver through a common duct. Folds and villi (Fig. 15.6) are more numerous at the end than at the beginning.

B. Jejunum The next 1 m (3 ft) contains folds and villi, more at the beginning than at the end.

C. Ileum The last 2 m (6–7 ft) contain fewer folds and villi than the jejunum. The ileum wall contains Peyer patches, aggregates of lymph nodules.

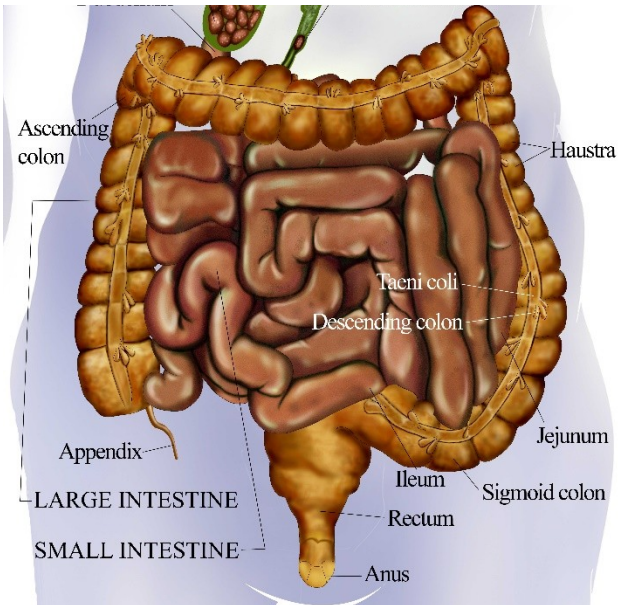

Figure 8. Intestine

2.7. The Large Intestine

The **large intestine,** which includes the cecum, the colon, the rectum, and the anal canal (Fig. 8), is larger in diameter than the small intestine (6.5 cm compared to 2.5 cm), but it is shorter in length. The large intestine absorbs water, salts, and some vitamins. It also stores indigestible material until it is eliminated at the anus.

The **cecum,** which lies below the junction with the small intestine, is the blind end of the large intestine. The cecum has a small projection called the **vermiform appendix** (*vermiform* means wormlike). In humans, the appendix also may play a role in fighting infections. This organ is subject to inflammation, a condition called appendicitis. If inflamed, the appendix should be removed before the fluid content rises to the point that the appendix bursts, a situation that may cause **peritonitis,** a generalized infection of the lining of the abdominal cavity. Peritonitis can lead to death.

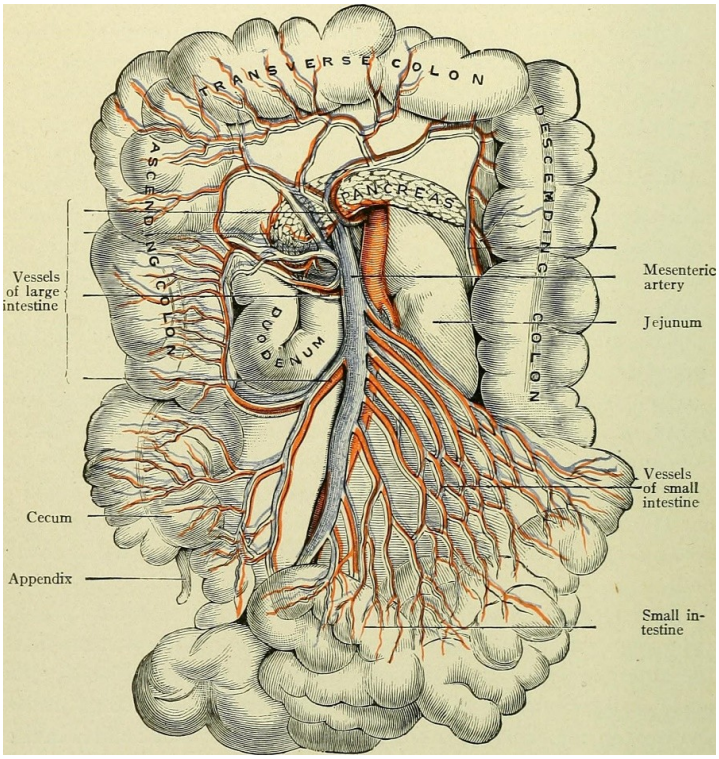

Figure 9. Large Intestine

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The **colon** has four portions: the **ascending colon,** which goes up the right side of the body to the level of the liver; the **transverse colon,** which crosses the abdominal cavity just below the liver and the stomach; the **descending colon,** which passes down the left side of the body; and the **sigmoid colon,** which enters the **rectum,** the last 20 cm of the large intestine. The rectum opens at the **anus,** where **defecation,** the expulsion of faeces, 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, and shortly thereafter the rectal muscles contract and the anal sphincters relax. Ridding the body of indigestible remains is another way the digestive system helps maintain homeostasis.

3. Digestive Glands

The digestive glands associated with the alimentary canal include the salivary glands, the liver, gall blader and the pancreas.

3.1. The Pancreas

The **pancreas** lies deep in the abdominal cavity, behind the peritoneum, resting on the posterior abdominal wall. Its broad end, called the head, more than fills the loop formed by the duodenum, and its tail extends in the opposite direction (Fig. 10 & 11). The pancreas has both an endocrine and an exocrine function. Pancreatic islets (islets of Langerhans) secrete insulin and glucagon, hormones that help keep the blood glucose level within normal limits.

In this chapter, however, we are interested in the exocrine function of the pancreas. Most pancreatic cells, called pancreatic acinar cells, produce pancreatic juice, which is secreted into tiny tubes that unite, forming ever-larger ones. Finally, a single pancreatic duct extends the length of the pancreas to the duodenum.

Pancreatic Juice

Pancreatic juice contains sodium bicarbonate ($NaHCO_3$) and digestive enzymes for all types of food. Sodium bicarbonate neutralizes chyme; whereas pepsin acts best in an acid pH of the stomach, pancreatic enzymes require a slightly basic pH. **Pancreatic amylase** digests starch, **trypsin** digests protein, and **lipase** digests fat. Pancreatic juice also contains two nucleases, which are enzymes that break down nucleic acid molecules into nucleotides. In cystic fibrosis, a thick mucus blocks the pancreatic duct, and the patient must take supplemental pancreatic enzymes by mouth for proper digestion to occur.

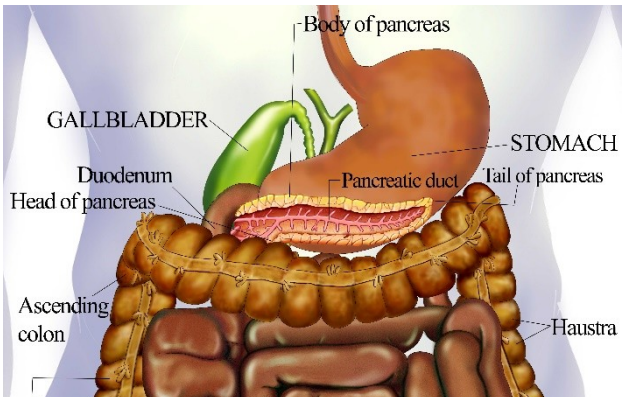

Figure 10. Pancreas

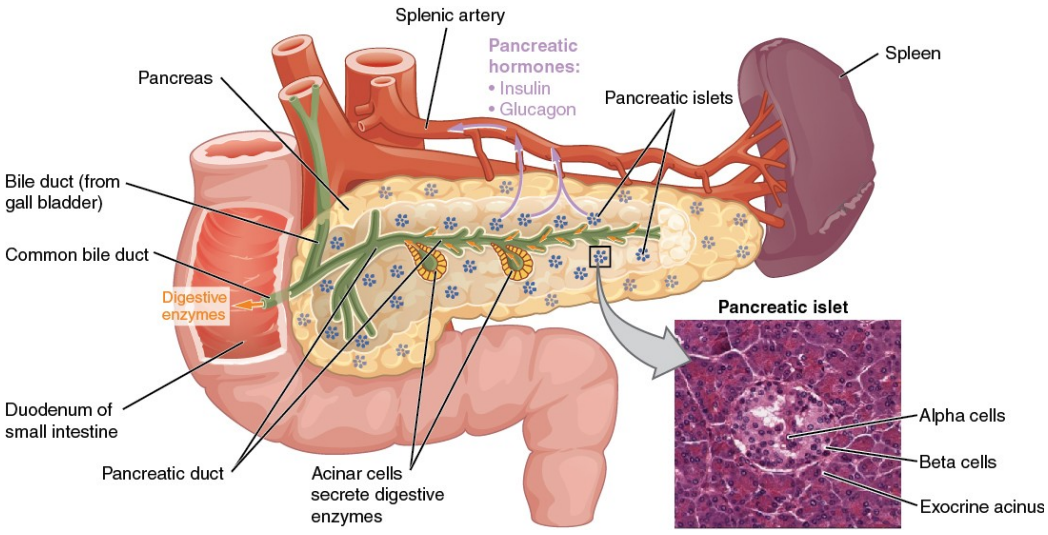

Figure 11. Pancreas - Internal Structure

https://upload.wikimedia.org/wikipedia/commons/e/e0/1820_The_Pancreas.jpg (Under CC-BY)

3.2. The Liver

The **liver,** which is the largest organ in the body, lies mainly in the upper right section of the abdominal cavity, just inferior to the diaphragm. *Liver Structure* The liver has two main

lobes, the right lobe and the smaller left lobe, separated by a ligament. Each lobe is divided into many hepatic lobules that serve as its structural and functional units (Fig. 12).

A lobule consists of many hepatic cells arranged in longitudinal groups that radiate out from a central vein. Hepatic sinusoids separate the groups of cells from each other. Large fixed phagocytic cells called *Kupffer cells* are attached to the lining of the hepatic sinusoids. They remove pathogens and debris that may have entered the hepatic portal vein at the small intestine. **Portal triads** consisting of the following three structures are located between the lobules: a bile duct that takes bile away from the liver; a branch of the hepatic artery that brings O2-rich blood to the liver; and a branch of the hepatic portal vein that transports nutrients from the intestines. The bile ducts merge to form the common hepatic duct. The central veins of the lobules enter a hepatic vein. With the help of Figure 13, trace the path of blood from the intestines to the liver via the hepatic portal vein and from the liver to the inferior vena cava via the hepatic veins.

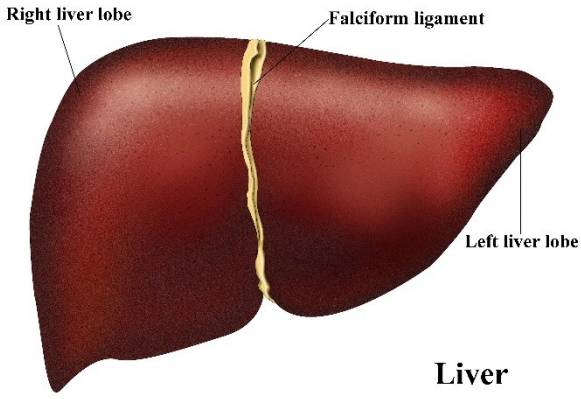

Figure 12. Liver

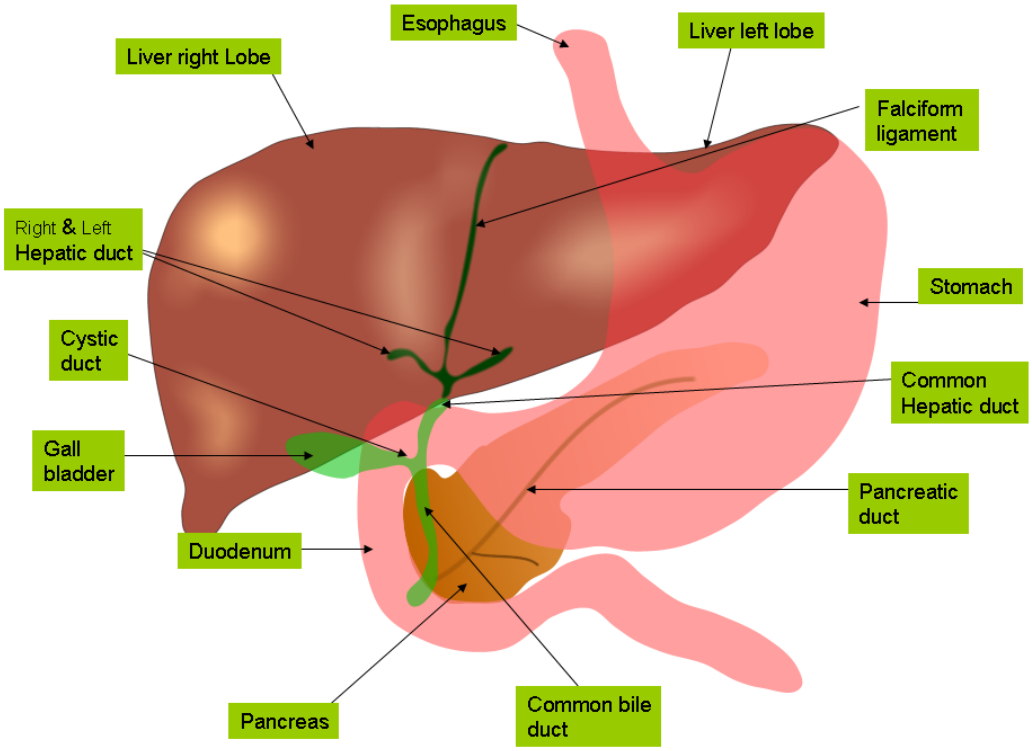

Figure 13. Blood supply in Liver

3.3. The Gallbladder

The **gallbladder** is a pear-shaped, muscular sac located in a depression on the inferior surface of the liver (see Fig. 13). About 1,000 ml of bile are produced by the liver each day, and any excess is stored in the gallbladder. Water is reabsorbed by the gallbladder so that bile becomes a thick, mucus like material. When needed, bile leaves the gallbladder by way of the cystic duct. The cystic duct and the common hepatic duct join to form the common bile duct, which enters the duodenum. The cholesterol content of bile can come out of solution and form crystals. If the crystals grow in size, they form gallstones. The passage of the stones from the gallbladder may block the common bile duct and cause obstructive jaundice. Then the gallbladder may have to be removed.

3.4. Salivary glands

Three pairs of **salivary glands** send juices (saliva) by way of ducts to the mouth. The parotid glands lie anterior and somewhat inferior to the ears between the cheek and the masseter muscle (See Fig. 2). They have ducts that open on the inner surface of the cheek at the location of the second upper molar. The parotid glands swell when a person has the mumps, a disease caused by a viral infection. The sublingual glands are located beneath the tongue, and the submandibular glands are in the floor of the mouth on the inside surface of the lower jaw. The ducts from the sublingual and submandibular glands open under the tongue. You can locate the openings for the salivary glands if you use your tongue to feel for small flaps on the inside of your cheek and under your tongue. Saliva contains bicarbonate and an enzyme called **salivary amylase** that begins the process of digesting starch.

4. Summary

The digestive system of humans consists of an alimentary canal and associated digestive glands. The alimentary canal consists of the mouth, buccal cavity, pharynx, oesophagus, stomach, small intestine, large intestine, rectum and the anus. The accessory digestive glands include the salivary glands, the liver (with gall bladder) and the pancreas.