

Digestive System

The function of the digestive system is the mechanical and chemical breakdown of food and its absorption into the blood. The digestive system is composed of the gastrointestinal (GI) tract, including the mouth, pharynx, esophagus, stomach, small intestine, and large intestine, and the accessory organs of digestion, the teeth, tongue, gallbladder, salivary glands, liver, and pancreas. The digestive process includes: ingestion, propulsion through the system (swallowing and peristalsis), mechanical breakdown (chewing, churning and segmentation. The last term refers to the rhythmic local constrictions of the intestine.), chemical digestion (the enzymatic breakdown of food into simpler compounds), absorption (the movement of the breakdown products from the lumen of the GI tract into the blood or lymph), and defecation (the elimination of indigestible substances).

Chemical digestion is the breaking down of complex organic molecules by hydrolysis. Polysaccharides are broken down to monosaccharides, proteins to amino acids, fats to fatty acids and monoglycerides and nucleic acids to their nucleotide monomers.

The Mouth

In the mouth (oral or buccal cavity) are the teeth, tongue, and salivary glands. The first teeth, called deciduous teeth, appear at about 6 months. The last deciduous teeth appear at about 2 to 3 years. There are a total of 20 deciduous teeth:

- 8 incisors (chisel-shaped for cutting)
- 4 canines or cuspids (shaped for tearing and shredding)
- 8 molars (shaped for grinding)

The deciduous teeth are lost by partial reabsorption of the root when the permanent teeth push through.

There are a total of 32 permanent teeth:

- 8 incisors
- 4 canines or cuspids
- 8 premolars or bicuspid
- 12 molars including the wisdom teeth which may or may not be showing.

Each tooth has two major regions – the crown and the root. The crown is the exposed part of the tooth above the gingiva (gum). It is covered with enamel, the hardest substance in the body, made of densely packed calcium crystals. The root of the tooth is embedded in the jawbone. Between the crown and root is a constricted area near the gumline called the neck. The outer surface of the root is covered with a calcified connective tissue called cementum. This attaches the tooth to the periodontal ligament which anchors the tooth in the bony alveolus of the jaw. Inside the tooth is a bone-like substance called dentin which makes up the bulk of the tooth and surrounds the pulp cavity. The pulp includes connective tissue, blood vessels and nerve fibers. Where the pulp cavity extends into the root it is called the root canal.

The tongue is made up of bundles of skeletal muscles. It mixes the food with saliva and forms it into a compact bolus. A fold of mucosa, the lingual frenulum, secures the tongue to the floor of the mouth.

Although some saliva is produced in the buccal glands of the mouth, most comes from three pairs of extrinsic salivary glands: the parotid glands anterior to the ear and opens next to the second upper molar, the submandibular glands lie medially to the mandibular body and open at the base of the lingual frenulum, and the sublingual glands which lie anterior to the submandibular glands and open into the floor of the mouth. Saliva is made up of 99% water, salts, and salivary amylase (a digestive enzyme) as well as the antibacterial lysozyme and IgA antibodies.

Deglutition (swallowing) is performed in the oropharynx. There are three stages:

- the tongue positions the bolus into the oropharynx. This is the only voluntary stage.

- the food goes through the pharynx into the esophagus. The epiglottis serves to block access to the respiratory pathway.
- the food passes through the esophagus by peristalsis to the stomach.

The esophagus is about 25cm in length and joins the stomach at the gastroesophageal (cardiac) sphincter which keeps the esophagus closed when food is not being swallowed.

Gastroesophageal reflux disease (GERD) occurs when stomach acid regurgitates into the esophagus causing a burning sensation in the chest that is often confused with a heart attack.

Stomach

Large longitudinal folds called rugae line the inside of the stomach. They allow the stomach to distend with food. The major regions of the stomach are the cardia, located near the esophageal opening; the fundus, the rounded superior region that can be used for short term food storage; the body, the main portion of the stomach; and the pylorus, the bottom portion that leads to the small intestine. The pylorus is continuous with the small intestine through the pyloric sphincter which controls stomach emptying. The convex lateral surface of the stomach is called the greater curvature and the concave medial surface is the lesser curvature.

The abdominopelvic cavity is lined with parietal peritoneum and the organs of the cavity are covered with visceral peritoneum. Mesenteries are double serous membranes holding many of the organs in place and anchoring them to the posterior abdominal wall. Attached to the two stomach curvatures are two mesenteries, the greater and lesser omenta that anchor the stomach and some intestines to the body wall. The stomach has three muscular layers (longitudinal, circular and oblique) which allow the stomach to churn and mix, breaking the food down into smaller particles. The epithelium of the stomach mucosa is composed of goblet cells. Among these are millions of gastric pits harboring gastric glands which contain a number of specialized secretory cells. Parietal cells produce hydrochloric acid which is very acidic (pH = 1 – 2) and intrinsic factor (necessary for the absorption of vitamin B12). The chief cells secrete pepsinogen which converts to the active enzyme pepsin in the presence of HCl. Pepsin begins the process of protein digestion.

There are three phases in the production of gastric secretions (juices):

- cephalic phase occurs when you see or smell food nerve impulses are transmitted via the vagus nerve resulting in stimulation of the gastric glands.
- gastric phase (3 to 4 hours) occurs when the food reaches the stomach. The glands are stimulated by distension, peptides and acidity.
- Intestinal phase has two components. The food, now a paste-like material called chyme, is moved to the small intestine where hormones are released that inhibit gastric secretions and cause the pyloric sphincter to tighten.

Gastric ulcers are erosions of the stomach wall usually caused by the bacteria *Helicobacter pylori*. Vitamin B12 is necessary for the maturation of RBC's. Without intrinsic factor it cannot be absorbed resulting in pernicious anemia.

Small Intestine

The small intestine is the body's major digestive organ, approximately 6 – 7m long and about 3 – 4cm in diameter. The first part, extending from the pyloric sphincter for about 25cm, is the duodenum. Here is found the hepatopancreatic ampulla and sphincter controlling the inflow of juices from the liver and pancreas. The second part is called the jejunum, about 2.5m. The last part is the ileum, about 3.6m in length, which extends to the ileocecal valve where it empties into the large intestine. Most of the digestion takes place in the proximal part of the small intestine.

There are a number of structural adaptations that increase the surface area of the small intestine. Deep circular folds about 1cm tall spiral the chyme through the lumen. Villi are fingerlike projections (about 1mm high). The columnar epithelial cells of the villi do the work of absorption. In the core of each villus are blood capillaries and a lymph capillary. Microvilli on the plasma membrane of the epithelium are referred to collectively as the brush border. These bear enzymes that complete the digestive process. There

are also many goblet cells that secrete mucus to lubricate the lumen. Among the villi are pits leading to glands that secrete intestinal juice (largely water).

A cross section of the small intestine reveals four tunics typical of the GI tract: the mucosa containing the epithelial cells, the submucosa made up of areolar connective tissue, and the muscularis mucosae, a thin layer of smooth muscle. The muscularis externa is made of longitudinal and circular smooth muscle, and the outer adventitia (serosa) of fibrous connective tissue. Within the submucosa of the duodenum are Brunner's glands which secrete a protective alkaline mucus. Also within the submucosa and increasing in abundance along the length of the small intestine, are Peyer's patches, aggregations of lymphoid tissue that help protect against bacteria entering the bloodstream. They reach their highest density in the ileum. Muscular movement of the small intestine involves segmentation, the creation of small compartments for more effective mixing, and peristalsis that moves the food along its length.

The liver is located under the diaphragm almost entirely within the rib cage. It is the largest visceral organ (about 3 lbs) and chief metabolic organ of the body but its digestive function is to produce bile that is a fat emulsifier, breaking fat globules into tiny particles to increase the surface area for digestive enzymes. Among the main ingredients of bile are bile salts (mostly derivatives of cholesterol) and bile pigments, mainly bilirubin (a breakdown product of hemoglobin). Besides producing bile, the liver has many other functions such as storing iron, vitamin A and glucose (as glycogen); the detoxification of chemicals; and the synthesis of many lipoproteins, cholesterol, and certain blood proteins. The gall bladder, located under the liver, stores and concentrates excess bile. When there is no food in the small intestine, the entrance of bile is restricted and so backs up through the cystic duct into the gall bladder. The cystic duct from the gall bladder joins the hepatic duct from the liver to form the common bile duct leading to the hepatopancreatic ampulla into the duodenum.

Gallstones are crystallized cholesterol that can block the flow of bile through the cystic duct causing extreme pain. A number of viruses cause hepatitis. Chronic hepatitis is caused by HVC, primarily blood borne, and HVB which is transmitted via the blood and other body fluids. HVB is also the most potent carcinogen second only to tobacco. Cirrhosis of the liver is a result of scar tissue that builds up from chronic hepatitis or chronic alcoholism.

The pancreas lies deep to the greater curvature of the stomach. Acinar cells within the pancreas produce pancreatic juice containing many enzymes for the breakdown of protein, fat, carbohydrate and nucleic acid. The main pancreatic duct joins the common bile duct just before entering the small intestine. Pancreatic juice is alkaline (about pH 8) which enables it to neutralize the chyme entering the duodenum.

Large Intestine

The large intestine is about 1.5m in length, 7cm in diameter and extends from the ileocecal valve to the anus. Its function is to absorb water and eliminate indigestible food residues as feces. The walls of the large intestine consist of pouch-like sections called haustra. Food residues remain in the large intestine 12 to 24 hours. There are a number of divisions of the large intestine:

- cecum is a blind pouch below the ileocecal valve. Attached to it is the vermiform appendix containing masses of lymphoid tissue.
- colon which includes the ascending colon up the right side, the hepatic flexure, the transverse colon, the splenic flexure, and the descending colon down the right side.
- sigmoid colon is the s-shaped part of the colon in the pelvis.
- rectum is the pouched part of the colon just above the anal canal.
- anal canal is about 3cm and extends from the point where the rectum penetrates the pelvic floor to the anus at the body exterior. It contains the involuntary internal anal sphincter and the voluntary external anal sphincter.

The large intestine supports a normal bacterial flora which ferments some of the indigestible food residues releasing gases. They also synthesize some of the B complex vitamins and nearly all the vitamin K.

Stretching of the rectal walls initiates the defecation reflex causing the sigmoid colon and rectum to contract and the anal sphincters to relax. The external anal sphincter is under voluntary control so that defecation may be delayed.

