Anatomy and Physiology: The Digestive System

CHAPTER 1

It is important to have a solid understanding of the digestive system (the gastrointestinal [GI] tract); this will allow healthcare providers to assess a patients' GI health and identify potential issues. Many patients require care related to the digestive system. Monitoring and managing these patients effectively are key to ensuring that they are safe, comfortable, pain-free and receiving the appropriate medications, dietary restrictions or other treatments. Knowledge of the digestive system is essential for providing comprehensive, patient-centred care, thereby contributing to better patient outcomes and overall healthcare quality.

This digestive system is around 10 m long. It traverses the length of the body, begins at the mouth, passes through the thoracic, abdominal and pelvic cavities and ends at the anus (see Figure 1.1). The digestive system has one primary function: to convert food into a form that can be used by the cells of the body, allowing them to perform their specific functions. The food, once absorbed by the body, is converted into energy, this process is known as metabolism.

The digestive system is also known as the GI tract, this is a long, tube-like structure that starts at the mouth and ends at the anus. It plays a crucial role in the digestion and absorption of food and nutrients in the human body and the elimination of waste products through the excretion of faeces.

This chapter discusses the structure and function of the digestive system and explains how dietary nutrients are broken down and used by the body for cell metabolism, growth and repair. This chapter provides a comprehensive overview of the structure and function of the digestive system, offering the reader a foundation for their practice. See Figure 1.1 for the digestive system.

THE DIGESTIVE SYSTEM

The activity of the digestive system can be classified into five processes:

1. Ingestion: taking food into the digestive system.
2. Propulsion: movement of the food along the length of the digestive system.
3. Digestion: breaking down of food. This can be achieved mechanically as food is chewed or moved through the digestive system or chemically through the action of enzymes that are mixed with the food.
4. Absorption: the products of digestion leave the digestive system and enter the blood or lymph capillaries for distribution to where they are required.
5. Elimination: the waste products of digestion are excreted from the body as faeces.

The digestive system consists of the main digestive system structures and the accessory organs. The main digestive system structures include the mouth, pharynx, oesophagus, stomach, small intestine and large intestine. Accessory organs also contribute to the function of the digestive system. The accessory organs are the salivary glands, the liver, the gallbladder and the pancreas.

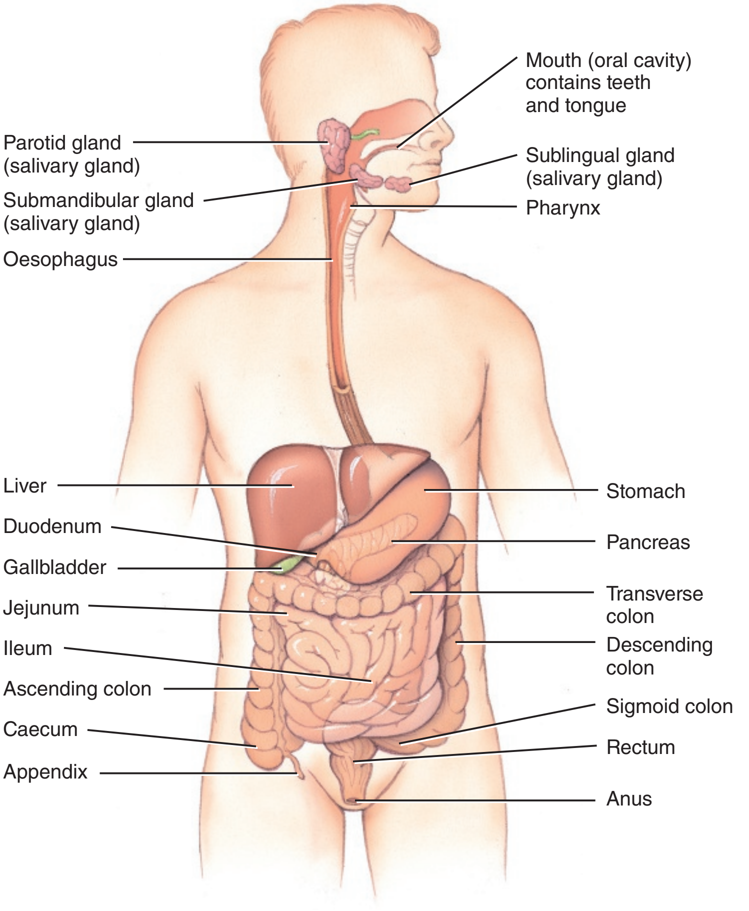


FIGURE 1.1 The digestive system

THE DIGESTIVE ORGANS

These digestive organs work in a coordinated manner as they break down food into its basic components (nutrients) and eliminate waste products from the body. Table 1.1 outlines the various organs and their functions.

THE MOUTH

The mouth or oral cavity is where the process of digestion begins (Figure 1.2). It has three functions related to digestion:

1. Mastication (the mechanical chewing of food)
2. Salivation (moistening of the food)
3. Deglutition (swallowing of the food)

Table 1.1 Digestive organs and functions

Digestive organ	Function
Mouth	The digestive process begins in the mouth, where food is broken down mechanically through chewing and mixed with saliva, which contains enzymes that start to break down carbohydrates.
Pharynx	Plays a role in swallowing, pushing food down the oesophagus.
Oesophagus	The oesophagus is a muscular tube that transports food from the mouth to the stomach. It does this through a series of coordinated muscle contractions called peristalsis.
Stomach	The mechanical breakdown of food. The stomach is a muscular organ that continues the digestion of food by mixing it with stomach acid and digestive enzymes. It breaks down proteins and forms a semi-liquid substance called chyme, which commences the digestion of protein.
Small intestine: efficient nutrient absorption	The small intestine is where most of the digestion and nutrient absorption occurs. It is divided into three sections: 1. Duodenum 2. Jejunum 3. Ileum The pancreas and liver release enzymes and bile into the duodenum to further break down carbohydrates, fats and proteins. The small intestine has numerous tiny, finger-like projections called villi and microvilli that increase its surface area for efficient nutrient absorption.
Liver	An accessory organ. The liver produces bile, which is stored in the gallbladder and released into the small intestine to help emulsify and digest fats.
Pancreas	An accessory organ. The pancreas releases digestive enzymes into the small intestine to break down carbohydrates, fats and proteins. It also plays a crucial role in regulating blood glucose levels by producing insulin and glucagon.
Large intestine (the colon)	The large intestine is responsible for absorbing water and electrolytes, forming and storing faeces, It also houses beneficial bacteria that assist in the fermentation of undigested carbohydrates.
Rectum	The rectum is the final portion of the large intestine and acts as a temporary storage area for faeces before they are eliminated from the body.
Anus	The anus is the opening through which faeces are expelled from the body during defaecation.

Source: Adapted from Peate (2022).

The lips and cheeks are made of muscle and connective tissue, allowing them to move food mixed with saliva around the mouth and begin mechanical digestion. The teeth also play a role in mechanical digestion by grinding and tearing food. This process of chewing and mixing food with saliva is known as mastication. The oral cavity can be exposed to very hot and cold food as well as rough food particles. It is covered with mucus-secreting, stratified squamous epithelial cells, which provide some protection against abrasion, the effects of heat and continuous wear and tear.

The lips and cheeks are also involved in speech and facial expression.

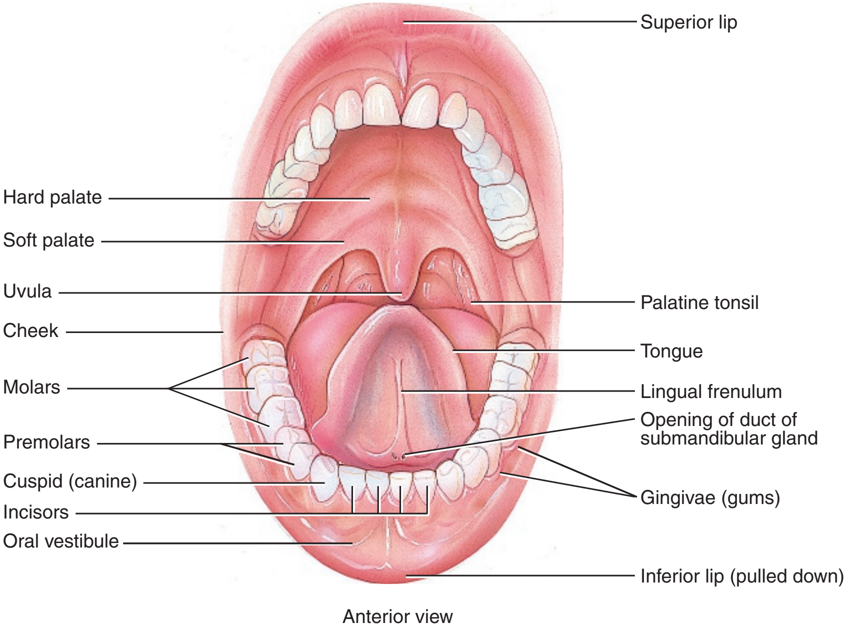


FIGURE 1.2 The oral cavity

TONGUE

The tongue is a large, voluntary muscular structure that occupies much of the oral cavity. It is attached posteriorly to the hyoid bone and inferiorly by the lingual frenulum (see Figure 1.3).

The tongue is covered in stratified squamous epithelium for protection against wear and tear. This surface also contains many small projections called papillae. The papillae (or taste buds) house the nerve endings responsible for the sense of taste (Tortora and Derrickson 2012). The taste buds contribute to our enjoyment of food. In addition to taste, other functions of the tongue include swallowing (deglutition), holding and moving food around the oral cavity and speech.

PALATE

The palate forms the roof of the mouth, consisting of two parts: the hard palate and the soft palate. The hard palate is located anteriorly and is bony. The soft palate lies posteriorly and consists of skeletal muscle and connective tissue (see Figure 1.2). The palate plays a role in swallowing. The palatine tonsils are located laterally and are composed of lymphoid tissue. The uvula is a fold of tissue that hangs down from the centre of the soft palate.

TEETH

The function of the teeth is to chew food. Temporary teeth, also known as deciduous teeth or milk teeth, begin to appear at about six months old. There are 20 temporary teeth, which are replaced by permanent teeth around six years (McErlean 2020). There are 32 permanent teeth in total with 16 located in the maxilla arch (upper) and 16 located in the mandible (lower; see Figure 1.2).

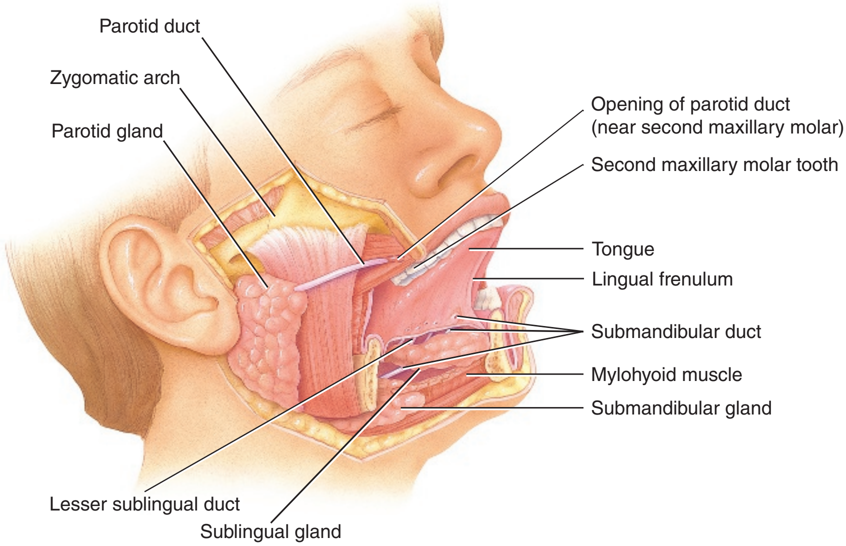


FIGURE 1.3 Salivary glands

The visible part of the tooth is called the crown and sits above the gum or gingiva. The centre of the tooth is called the pulp cavity where blood and lymph vessels as well as nerves enter and leave the tooth. The tooth receives nutrients and sensations via the pulp. Surrounding this pulp is a calcified matrix, similar to bone, called the dentine and around that is a very hard, protective material called enamel. The neck of the tooth is where the crown meets the root.

SALIVARY GLANDS

There are three pairs of salivary glands (see Figure 1.3). The parotid glands are the largest, located anterior to the ears. Saliva from the parotid glands enters the oral cavity close to the level of the second upper molar tooth. The submandibular glands are located below the jaw on each side of the face. Saliva from these glands enters the oral cavity beside the lingual frenulum of the tongue. The sublingual glands are the smallest, located on the floor of the mouth.

While saliva is continuously secreted to keep the oral cavity moist, the activity of the parasympathetic fibres that innervate the salivary glands leads to an increased production of saliva in response to the sight, smell or taste of food. The action of sympathetic fibres decreases secretion of saliva. In a healthy individual, approximately 1–1.5 L of saliva is secreted daily. Saliva consists of

- Water
- Salivary amylase
- Mucus
- Mineral salts
- Lysozyme
- Immunoglobulins
- Blood clotting factors

Saliva has several important functions:

- Salivary amylase is a digestive enzyme responsible for beginning the breakdown of carbohydrate molecules from complex polysaccharides to the disaccharide maltase.
- The fluid nature of saliva moistens and lubricates food entering the mouth. This makes it easier to hold the food in the mouth, assisting in forming the food into a bolus ready for swallowing.
- The continuous secretion of saliva is cleansing. Lack of moisture can lead to oral mucosal infections and the formation of mouth ulcers.
- The oral cavity is an entry route for pathogens from the external environment. Lysozyme, a component of saliva, has antibacterial properties. Immunoglobulin and clotting factors also contribute to the prevention of infection.
- Tasting is only possible when food is moist. Saliva helps to moisten the food.

PHARYNX

The pharynx is made up of three parts:

1. The oropharynx
2. The nasopharynx
3. The laryngopharynx

The nasopharynx is considered a structure of the respiratory system. The oropharynx and the laryngopharynx are passages for both food and respiratory gases (see Figure 1.4). The epiglottis is responsible for closing the entrance to the larynx during swallowing and this essential action prevents food from entering the larynx and obstructing the respiratory passages.

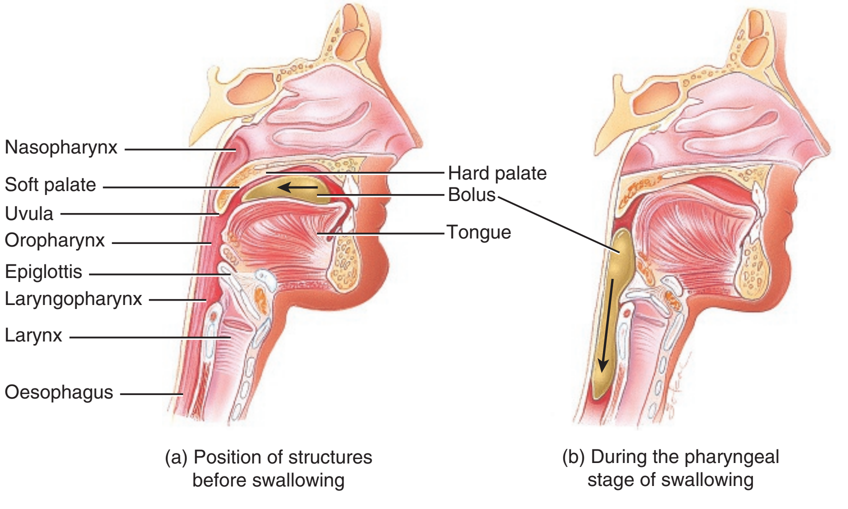


FIGURE 1.4 Swallowing

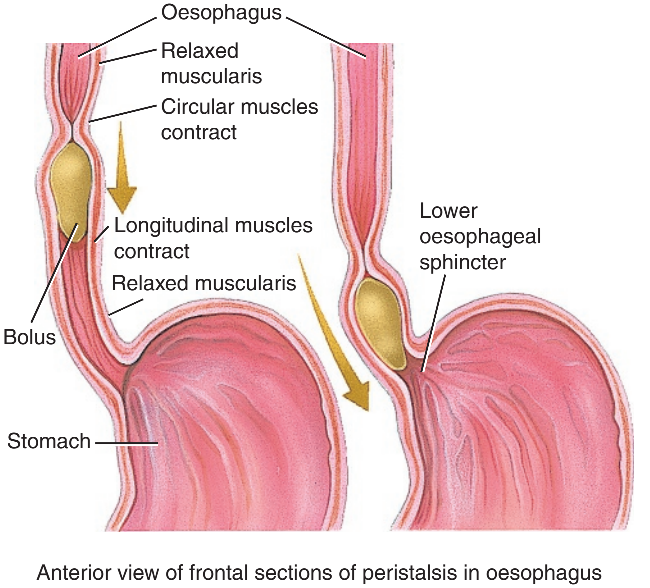


FIGURE 1.5 Oesophageal peristalsis

SWALLOWING (DEGLUTITION)

When ingested food has been adequately chewed and formed into a bolus, it is ready to be swallowed. Swallowing (deglutition) occurs in three phases.

1. The voluntary phase: The action of the voluntary muscles serving the oral cavity manipulates the food bolus into the oropharynx. The tongue, pressed against the palate, prevents the food from moving forward again.
2. The pharyngeal phase: A reflex action is initiated during this phase in response to the sensation of the food bolus in the oropharynx. This reflex is coordinated by the swallowing centre in the medulla oblongata and the motor response is contraction of the muscles of the pharynx. The soft palate rises, closing off the nasopharynx, preventing the food bolus from using this route. The larynx moves upward and forward, allowing the epiglottis to cover the entrance to the larynx and prevent the food bolus from moving into the respiratory passages.
3. The oesophageal phase: The food bolus moves from the pharynx into the oesophagus. Waves of oesophageal muscle contraction move the food bolus down the length of the oesophagus and into the stomach. This wave of muscle contraction is known as peristalsis (see Figure 1.5).

OESOPHAGUS

As food leaves the oropharynx, it enters the oesophagus. The oesophagus extends from the laryngopharynx to the stomach. This is a thick-walled structure and measures about 25 cm in length and lies in the thoracic cavity, posterior to the trachea. The function of the oesophagus is to transport substances (food bolus) from the mouth to the stomach. Thick mucus is secreted by the mucosa of the oesophagus, helping the passage of the food bolus, protecting the oesophagus from abrasion. The upper oesophageal sphincter regulates the movement of substances allowed into the oesophagus and the lower oesophageal sphincter (also known as the cardiac sphincter) regulates the movement of substances from the oesophagus to the stomach. The muscle layer of the oesophagus is different from the rest of the digestive tract as the superior portion is made up of skeletal (voluntary) muscle and the inferior portion is made up of smooth (involuntary) muscle. Breathing and swallowing cannot occur at the same time.

THE STRUCTURE OF THE DIGESTIVE SYSTEM

There are four layers of tissue or tunics (see Figure 1.6).

The mucosa is the innermost layer. The products of digestion are in contact with this layer as they pass through the digestive tract, there are three layers:

1. The mucous epithelium (mucous membrane) secretes mucus and other digestive system secretions such as gastric juice. Helps to protect the digestive system from the continuous wear and tear it endures. In the small intestine, this layer is involved in the absorption of the products of digestion.
2. The lamina propria, consists of loose connective tissue, supporting the blood vessels and lymphatic tissue of the mucosa.
3. The outermost layer, the muscularis mucosa, consists of a thin smooth muscle layer, helps to form the gastric pits or the microvilli of the digestive system.

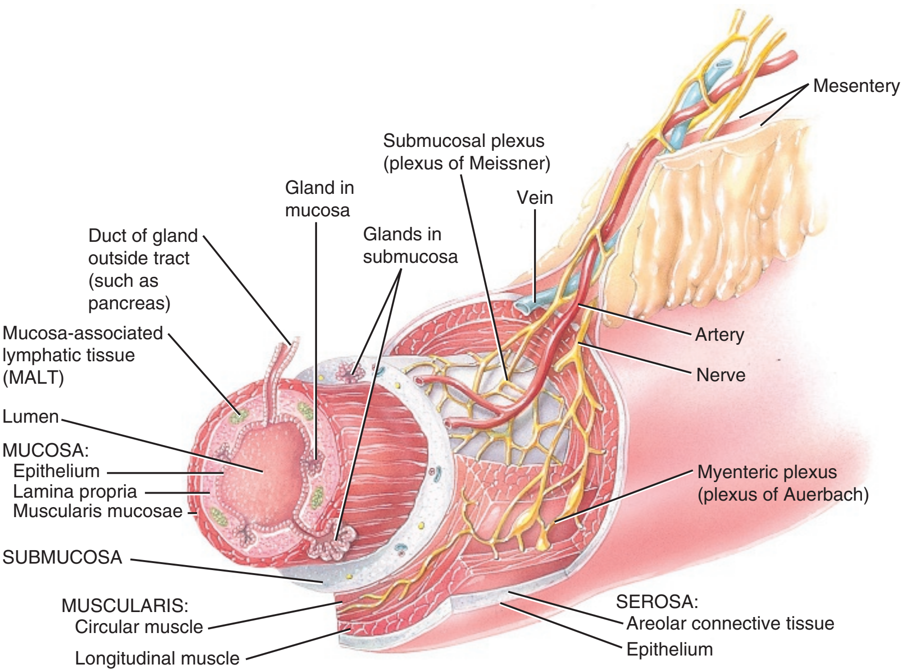


FIGURE 1.6 Structure of the digestive tract

The submucosa is a thick layer of connective tissue, containing blood and lymphatic vessels and some small glands. It also contains Meissner's plexus – nerves that stimulate the intestinal glands to secrete their products.

The muscularis consists of an inner layer of circular smooth muscle and an outer layer of longitudinal smooth muscle. The stomach has three layers of smooth muscle and the upper oesophagus has skeletal muscle. Blood and lymph vessels and the myenteric plexus (a network of sympathetic and parasympathetic nerves) are located between the two layers of smooth muscle. The wave-like contraction and relaxation of this muscle layer are responsible for moving food along the digestive tract, peristalsis. Peristalsis helps to churn and mechanically digest food.

The outer layer of the digestive tract is the serosa (adventitia). The largest area of serosa is located in the abdominal and pelvic cavities, known as the peritoneum. The peritoneum is a closed sac. The visceral peritoneum covers the organs of the abdominal and pelvic cavities, the parietal peritoneum lines the abdominal wall. A small amount of serous fluid is found between the two layers. The peritoneum has a good blood supply and contains many lymph nodes and lymphatic vessels. It acts as a barrier, protecting the structures it encloses and can isolate areas of infection to prevent damage to neighbouring structures.

STOMACH

The stomach lies in the abdominal cavity. It lies between the oesophagus superiorly and the duodenum of the small intestine inferiorly. It is divided into regions (see Figure 1.7).

Entry to the stomach is from the oesophagus via the lower oesophageal sphincter or cardiac sphincter, leading to a small area in the stomach called the cardiac region or cardia. The fundus is the dome-shaped region located in the superior aspect of the stomach. The body

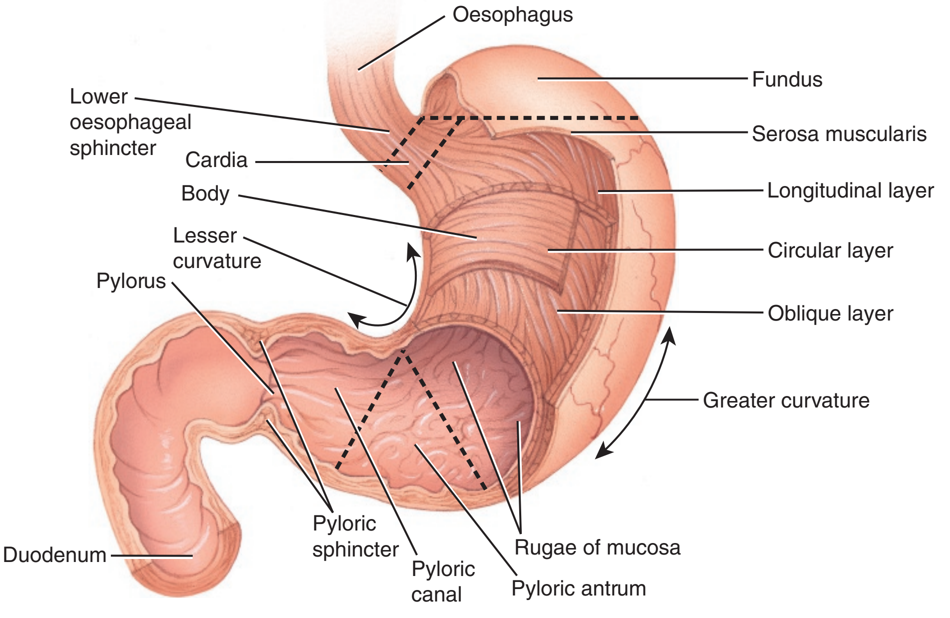


FIGURE 1.7 The stomach

region occupies the space between the lesser and greater curvature of the stomach, the pyloric region narrows into the pyloric canal. The pyloric sphincter controls the exit of chyme from the stomach into the small intestine. Chyme, the name given to the food bolus as it leaves the stomach.

The stomach receives arterial blood from a branch of the coeliac artery and venous blood leaves the stomach via the hepatic vein. The vagus nerve innervates the stomach with parasympathetic fibres, stimulating gastric motility and the secretion of gastric juice. Sympathetic fibres from the coeliac plexus reduce gastric activity.

The stomach is made up of the same four layers of tissue as the digestive tract, but with some differences. The muscularis contains three layers of smooth muscle instead of two. It has longitudinal, circular and oblique muscle fibres. The extra muscle layer enables the churning, mixing and mechanical digestion of food occurring within the stomach, as well as supporting the onward journey of the food by peristalsis.

The mucosa within the stomach is also different from the rest of the digestive tract. When the stomach is empty, the mucosal epithelia fall into long folds called rugae. The rugae fill out when the stomach is full. A very full stomach can contain approximately 4 L of food and liquid, while an empty stomach contains only about 50 mL (Marieb and Keller 2022). The shape and size of the stomach vary from person to person and depend on the quantity of food stored within it. The mucosa contains many gastric glands, secreting different substances (see Figure 1.8).

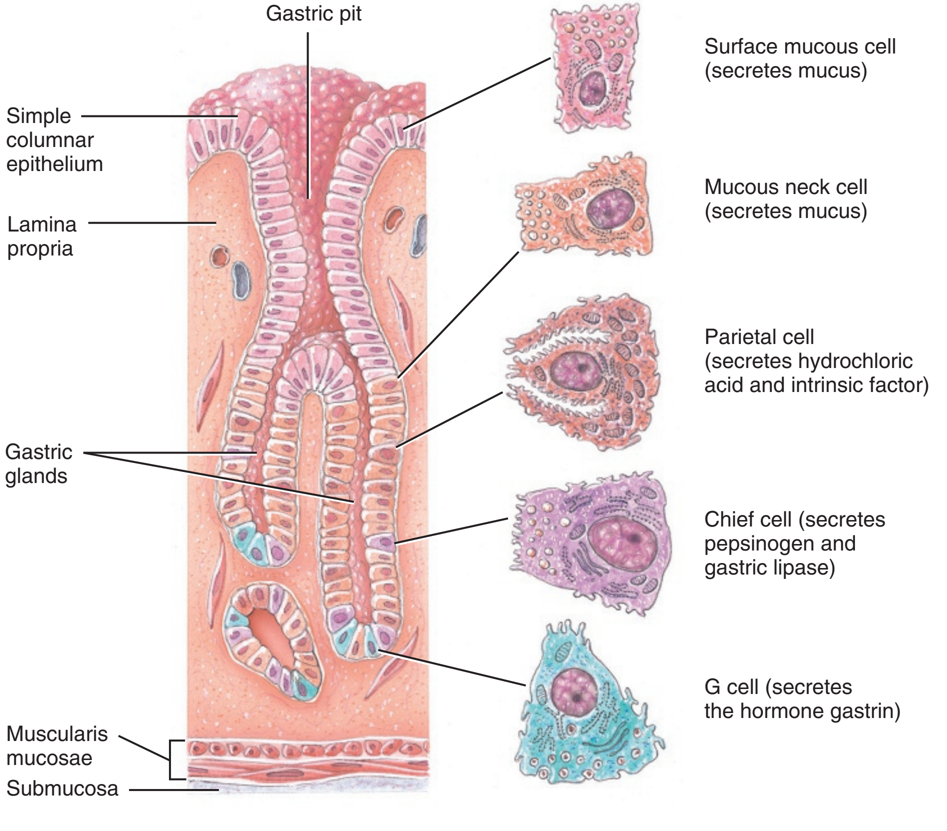


FIGURE 1.8 Gastric glands and cells

- Surface mucous cells produce thick bicarbonate-coated mucus. This protects the stomach mucosal epithelia from corrosion by acidic gastric juice. When these cells become damaged, they are quickly shed and replaced.
- Mucous neck cells also secrete mucus – this mucus is different from surface cell mucus.
- Parietal cells produce hydrochloric acid and intrinsic factor. Intrinsic factor is needed for the absorption of vitamin B12, essential for the production of mature erythrocytes. Hydrochloric acid creates the acidic environment of the stomach (pH 1–3) and begins denaturing dietary protein ready for the action of pepsin.
- Chief cells produce pepsinogen, which is converted to pepsin in the presence of hydrochloric acid. Pepsin is required for the breakdown of protein into smaller peptide chains.
- Enteroendocrine cells, for example, G cells, produce a number of hormones, including gastrin. These hormones help regulate gastric motility.

This mixture of secretions and water and mineral salts is more commonly called gastric juice. Approximately 2 L of gastric juice is produced daily.

Regulation of gastric juice secretion is divided into three phases (see Figure 1.9).

1. The cephalic phase: The sight, taste or smell of food stimulates gastric juice secretion.
2. The gastric phase: As food enters the stomach, gastrin (a hormone) is secreted into the bloodstream, this stimulates the secretion of gastric juice. The secretion of hydrochloric acid reduces the pH of the stomach contents and when the pH drops below 2 the secretion of gastrin is inhibited.
3. The intestinal phase: As the acidic contents of the stomach enter the duodenum, the hormones secretin and cholecystokinin (CCK) are secreted. These also act to reduce the secretion of gastric juice and gastric motility.

Table 1.2 provides an overview of the digestive system's hormones.

Table 1.2 Digestive system hormones

Hormone	Origin	Target	Action	Stimulus
Gastrin	Stomach	Stomach	Increases gastric gland secretion of hydrochloric acid. Gastric emptying	Presence of protein in the stomach
Secretin	Duodenum	Stomach	Inhibits gastric gland secretion. Inhibits gastric motility	Acidic and fatty chyme in the duodenum
		Pancreas	Increases pancreatic juice secretion. Promotes cholecystokinin action	
		Liver	Increases bile secretion	
Cholecystokinin	Duodenum	Pancreas	Increases pancreatic juice secretion	Chyme in the duodenum
		Gallbladder	Stimulates contraction	
		Hepatopancreatic sphincter	Relaxes – entry to duodenum open	

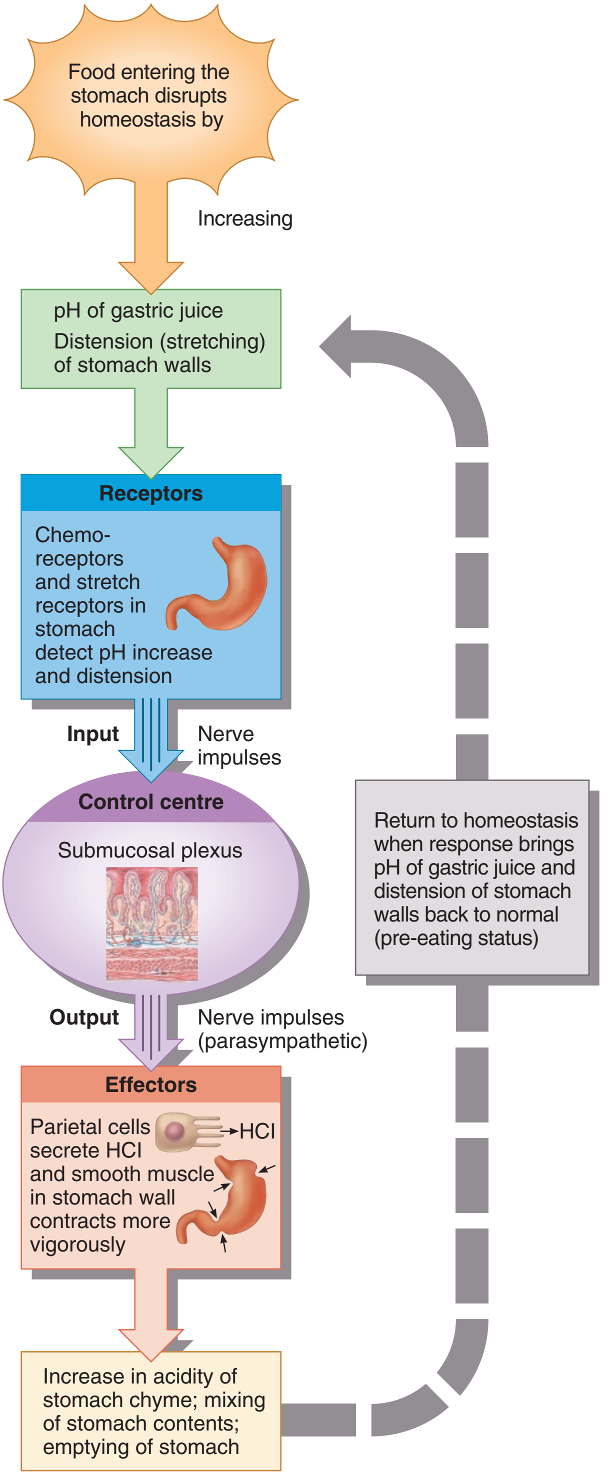


FIGURE 1.9 Phases and secretion of gastric juices

The rate of gastric emptying depends on the size and content of the meal. Liquids quickly pass through the stomach; solids require longer to be thoroughly mixed with gastric juice. Most meals will have left the stomach four hours after ingestion. The functions of the stomach are:

- Act as a reservoir for food.
- Produce mucus to protect the stomach.
- Provide mechanical digestion, by the churning action enabled by an additional layer of smooth muscle.
- Mix food with hydrochloric acid to help destroy pathogens and denature proteins in preparation for the action of pepsin.
- Produce of chyme.
- Produce of intrinsic factor.

SMALL INTESTINE

The small intestine is approximately 6 m long. In the small intestine, food is further broken down by mechanical and chemical digestion, and absorption of the products of digestion takes place. The small intestine is divided into three parts (see Figure 1.10):

1. The duodenum is approximately 25 cm long. It is the entrance to the small intestine.
2. The jejunum measures 2.5 m and is the middle part of the small intestine.

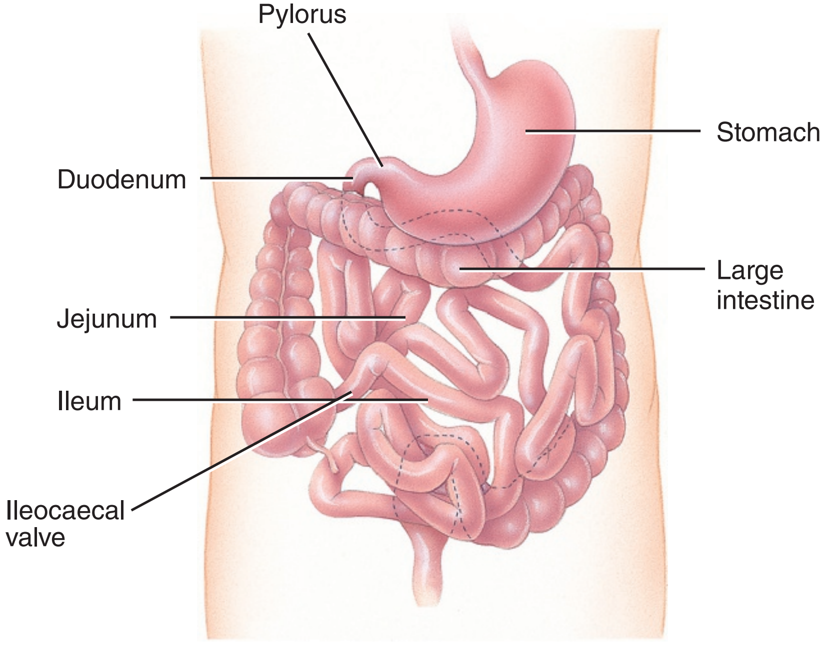
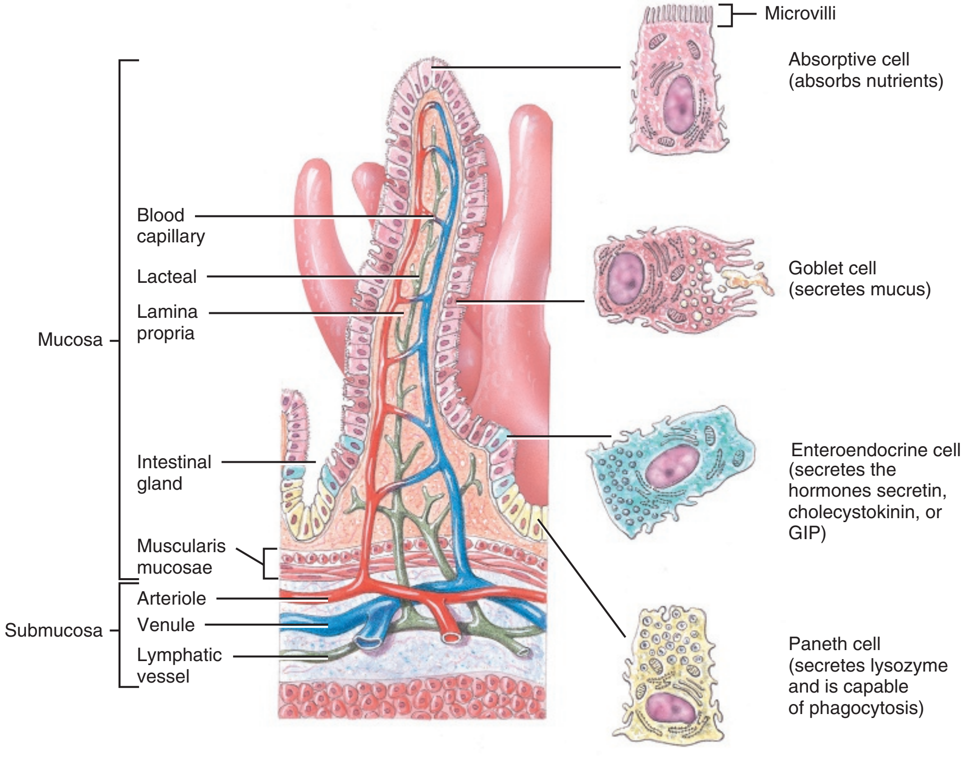


FIGURE 1.10 The small intestine

3. The ileum measures 3.5 m. It meets the large intestine at the ileocaecal valve. This valve prevents the backflow of the products of digestion from the large intestine back into the small intestine.

The small intestine is innervated with parasympathetic and sympathetic nerves. It receives its arterial blood supply from the superior mesenteric artery and nutrient-rich venous blood drains into the superior mesenteric vein and eventually into the hepatic portal vein towards the liver. There are four types of cell present in the mucosa of the small intestine (see Figure 1.11):

1. The absorptive cell produces digestive enzymes and absorbs digested foods.
2. Goblet cells secrete mucus to protect the intestine from abrasion and from the acidic chyme entering the small intestine.
3. Enteroendocrine cells produce regulatory hormones such as secretin and CCK. These hormones are secreted into the bloodstream and act on their target organs to release pancreatic juice and bile.
4. Paneth cells produce lysozyme, which protects the small intestine from pathogens that have survived the acid conditions of the stomach. Peyer's patches (lymphatic tissue of the small intestine) also protect the small intestine.



Enlarged villus showing lacteal, capillaries, intestinal glands and cell types

FIGURE 1.11 Cells within the villi of the small intestine

Partially digested food enters the small intestine, spending three to six hours moving through its 6 m length. Smooth muscle activity continues the process of mechanical digestion. There are two types of mechanical digestion in the small intestine: segmental contractions, helping to mix the various enzymes in the small intestine with the contents of the chyme; and peristalsis, which propels the food down the length of the small intestine as well as facilitating mixing.

Chemical digestion completes the breakdown of the carbohydrates, fats and proteins. Pancreatic juice from the pancreas, bile from the gallbladder and intestinal juice contribute to this.

CHEMICAL DIGESTION

Within the small intestine, any carbohydrates that have not been broken down by the action of salivary amylase will be broken down by pancreatic amylase.

Bile emulsifies fat and fatty acids, making it easier for lipase (also from pancreatic juice) to break the fats into fatty acids and glycerol. Proteins are denatured by hydrochloric acid in the stomach. In the small intestine, they are further processed by the enzymes trypsin, chymotrypsin and carboxypeptidase. The end products of protein digestion are tripeptidases, dipeptidases and amino acids.

The small intestine produces 1–2 L of intestinal juice daily. It is secreted from the cells of the crypts of Lieberkühn (located between the villi) in response to either acidic chyme irritating the intestinal mucosa or distension from the presence of chyme in the small intestine. Intestinal juice is slightly alkaline (pH 7.4–8.4) and watery. Intestinal juice and pancreatic juice from the pancreas mix with the acidic chyme as it enters the duodenum and increases pH, thus preventing the corrosive action of chyme on the mucosa of the duodenum. Intestinal juice contains mucus, which helps protect the intestinal mucosa, mineral salts and enterokinase.

The key function of the small intestine is absorption of water and nutrients. It has several anatomical adaptations to facilitate this:

- Permanent circular folds, called plicae circulares, within the mucosa and submucosa slow down the movement of the products of digestion, allowing time for absorption of nutrients to occur.
- On the surface of the mucosa are tiny, finger-like projections called villi. At the centre of the villi is a capillary bed and a lacteal (lymph capillary). This allows nutrients to be absorbed directly into the blood or the lymph.
- On the surface of the villi are cytoplasmic extensions called microvilli. The presence of the microvilli greatly increases the surface area available for absorption. The appearance of the microvilli resembles the surface of a brush; hence, it is called the brush border. The brush border produces some enzymes used to further break down carbohydrates such as lactase, maltase, dextrinase and sucrase. It also produces enzymes to further break down proteins: aminopeptidase, carboxypeptidase and dipeptidase.

The absorption of nutrients occurs by diffusion or active transport. Some nutrients will be absorbed into the blood capillaries and some will be absorbed into the lacteal.

FUNCTION OF THE SMALL INTESTINE

- Production of mucus to protect the duodenum from the effects of the acidic chyme.
- Secretion of intestinal juice and pancreatic juice from the pancreas increases the pH of the chyme to enable the action of the enzymes.
- Bile enters the small intestine to emulsify fat so that it can be further broken down by the action of lipase.
- Many enzymes are secreted to complete the chemical digestion of carbohydrates, proteins and fats.
- Mechanical digestion by peristalsis and segmentation slows down to allow adequate mixing and maximum absorption.
- The small intestine is structurally designed with a large surface area for maximum absorption of the products of digestion.
- The small intestine is where the majority of nutrients, electrolytes and water are absorbed.

The liver, gallbladder and pancreas are essential organs in the digestive system, each playing distinct but interconnected roles in the process of digestion and nutrient absorption (see Figure 1.12).

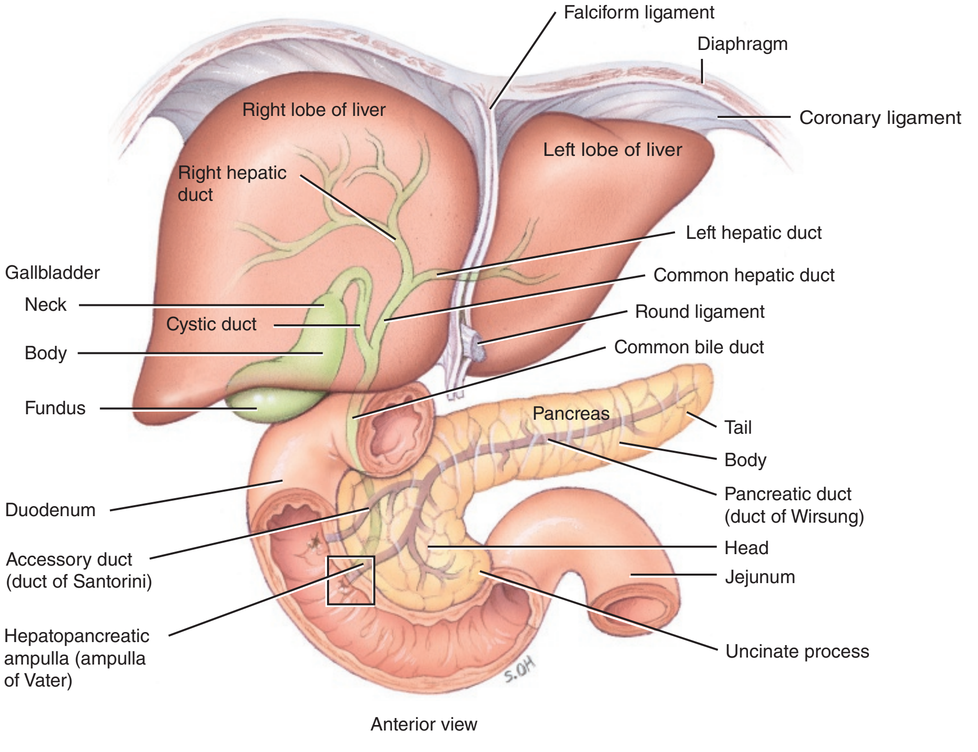


FIGURE 1.12 Liver, gallbladder and pancreas

Table 1.3 outlines the broad functions of the liver, gallbladder and pancreas.

Table 1.3 Broad functions of the liver, gallbladder and pancreas

Organ	Discussion
Liver	• The liver is the largest internal organ in the human body and performs a wide range of functions in the digestive process. • The liver is composed of tiny hexagonal-shaped lobules that contain hepatocytes (see Figure 1.13). The hepatocytes are protected by Kupffer cells (hepatic macrophages). The Kupffer cells deal with any foreign particles and worn-out blood cells. • It produces bile, a greenish-yellow fluid that aids in the digestion and absorption of fats. Bile is stored in the gallbladder before being released into the small intestine. • The liver also metabolises and stores nutrients such as glucose (as glycogen), vitamins and minerals. • It detoxifies the blood by removing harmful substances and metabolising drugs and toxins. • The liver is involved in the synthesis of plasma proteins, including those responsible for blood clotting and maintaining blood volume. • It helps regulate blood glucose levels by releasing glucose when needed and storing excess glucose as glycogen. • The liver processes and stores excess amino acids, converts ammonia to urea and plays a role in protein metabolism. • It produces and releases substances such as cholesterol, essential for various bodily functions.
Gallbladder	• The gallbladder is a small, pear-shaped organ located beneath the liver. • Its primary function is to store and concentrate bile produced by the liver. • When a meal is eaten that contains fats, the gallbladder contracts and releases bile into the small intestine, where it emulsifies fats. Emulsification breaks down large fat molecules into smaller droplets, making them more accessible for digestion by pancreatic enzymes. • Bile also aids in the absorption of fat-soluble vitamins (A, D, E and K) and fatty acids.
Pancreas	• The pancreas is a dual-function organ with exocrine and endocrine functions. • Exocrine function: The pancreas produces digestive enzymes and releases them into the small intestine to break down carbohydrates, proteins and fats. These enzymes include amylase (for carbohydrate digestion), proteases (for protein digestion) and lipase (for fat digestion). • Endocrine function: The pancreas contains clusters of cells known as the islets of Langerhans, which secrete hormones such as insulin and glucagon into the bloodstream. These hormones help regulate blood glucose levels by facilitating the uptake of glucose into cells or stimulating the release of stored glucose from the liver when necessary.

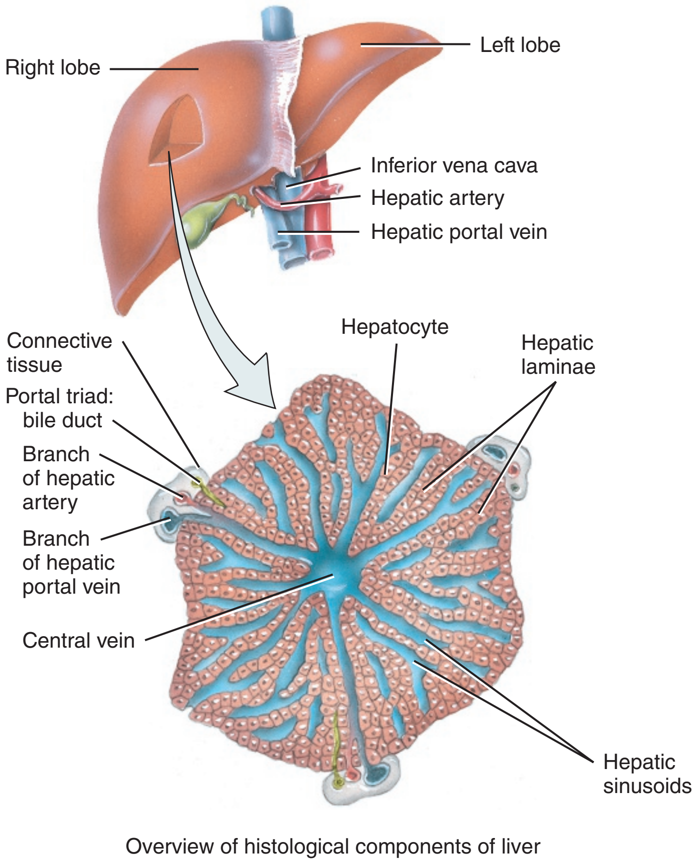


FIGURE 1.13 Liver lobule

THE LARGE INTESTINE

The contents of the small intestine move slowly through it by a process called segmentation, allowing time to complete digestion and absorption. Entry to the large intestine is controlled by the ileocaecal sphincter. The sphincter opens in response to the increased activity of the stomach and the action of gastrin. Once food residue has reached the large intestine, it cannot back flow into the ileum (see Figure 1.14).

The large intestine measures 1.5 m in length and 7 cm in diameter and is continuous with the small intestine from the ileocaecal valve, ending at the anus. Food residue enters the caecum and has to pass up the ascending colon, along the transverse colon, down the descending colon and out of the body via the rectum, anal canal and anus. The caecum is a descending, sac-like opening into the large intestine. The vermiform appendix is a narrow, tube-like structure that leaves the caecum and is closed at its distal end. Composed of lymphoid tissue, it plays a role in immunity.

Two sphincter muscles control exit from the anus. The internal anal sphincter is smooth muscle and is under the control of the parasympathetic nervous system, whereas the external anal sphincter is composed of skeletal muscle and is under voluntary control.

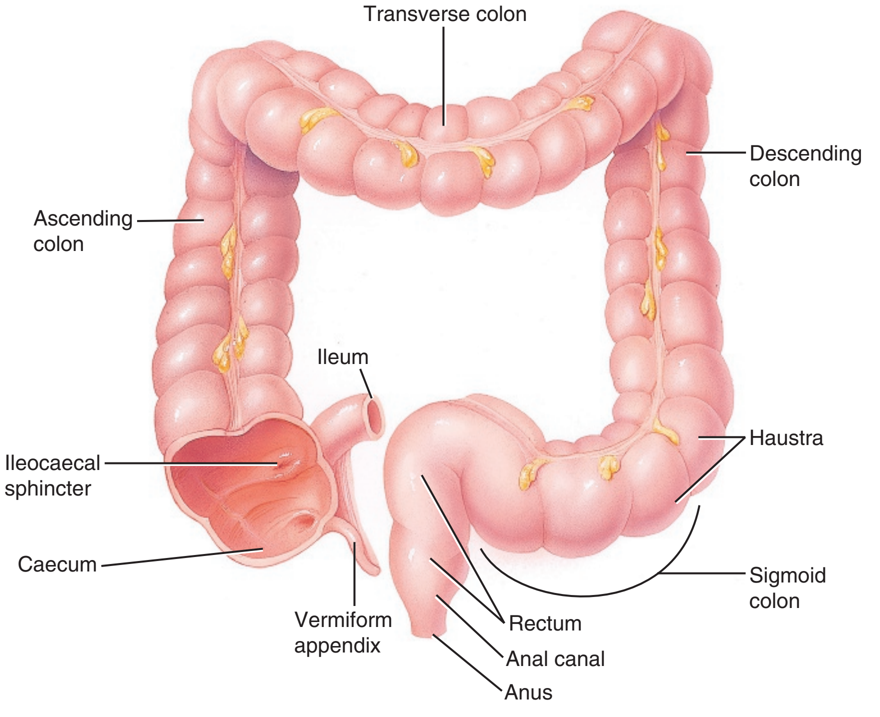


FIGURE 1.14 Large intestine

The large intestine mucosa contains large numbers of goblet cells secreting mucus to ease the passage of faeces and protect the walls of the large intestine. The simple columnar epithelium changes to stratified squamous epithelium at the anal canal. Anal sinuses secrete mucus in response to faecal compression. This protects the anal canal from the abrasion associated with defaecation.

The longitudinal muscle layer of the large intestine is formed into bands called the taeniae coli. These give the large intestine its gathered appearance. The sac created by this gathering is called a haustrum.

The food residue from the ileum is fluid when entering the caecum and contains few nutrients. The small intestine is responsible for some of the absorption of water, but the primary function of the large intestine is to absorb water and turn the food residue into semisolid faeces. The large intestine also absorbs some vitamins, minerals, electrolytes and drugs. Food residue usually takes 24–48 hours to pass through the large intestine; 500 mL of food residue enters the large intestine daily and approximately 150 mL leaves as faeces.

As faeces enter the rectum, the stretching of the rectal walls initiates the defaecation reflex. The external anal sphincter is under voluntary control, and, if it is appropriate to do so, defaecation can occur. Contraction of the abdominal muscles and diaphragm (the Valsalva manoeuvre) creates intra-abdominal pressure and assists in the process of defaecation. If it is not appropriate to defaecate, as it is under voluntary control, it can be postponed. After a few minutes, the urge to go will subside and will only be felt again when the next mass movement through the large intestine occurs.

Faeces is a brown, semi-solid material. It contains fibre, stercobilin (from the breakdown of bilirubin), water, fatty acids, shed epithelial cells and microbes. Stercobilin gives faeces its brown colour. An excess of water in faeces results in diarrhoea. This occurs when food residue passes too quickly through the large intestine, so the absorption of water cannot occur. Conversely, constipation occurs if food residue spends too long in the large intestine.

CONCLUSION

The digestive system is a complex, dynamic and multifaceted system that plays a central role in the digestion and absorption of food, along with the elimination of waste from the body. Digestion and nutrition play a vital role in the maintenance of health. By comprehending the anatomy, physiology, common disorders and care considerations related to the digestive system, can help provide holistic, patient-centred care to those with a wide range of GI issues. Maintenance of homeostasis is achieved through the ingestion of a balanced diet, containing a variety of elements from each of the food groups.

GLOSSARY OF TERMS

Absorption: The process by which digested nutrients are taken up by the bloodstream or lymphatic system from the small intestine for transport to cells throughout the body.

Amylase: An enzyme that aids in the digestion of carbohydrates by breaking down starches into sugars, such as maltose.

Anus: The opening at the end of the digestive tract through which solid waste (faeces) is eliminated from the body.

Bile: A greenish-yellow fluid produced by the liver and stored in the gallbladder, which is released into the small intestine to emulsify and aid in the digestion of fats.

Colon: The large intestine, which absorbs water and electrolytes from undigested food, forming faeces.

Digestion: The process of breaking down food into smaller, absorbable molecules through mechanical and chemical means, occurring in the gastrointestinal tract.

Enzyme: A biological catalyst that facilitates chemical reactions in the body, including the digestion of food.

Gallbladder: A small organ that stores and releases bile, aiding in the digestion of fats.

Gastrointestinal tract: Also known as the gastrointestinal system. The continuous tube-like structure that includes the mouth, oesophagus, stomach, small intestine and large intestine, is responsible for digestion and absorption of nutrients.

Intestines: The small and large intestines, together, are responsible for further digestion and absorption of nutrients.

Lumen: The inner space or cavity within a tubular structure, such as the hollow interior of the digestive tract.

Mucosa: The innermost layer of the gastrointestinal tract, which contains mucous-secreting cells and plays a role in protecting and lubricating the lining.

Oesophagus: The muscular tube that connects the throat (pharynx) to the stomach and transports food from the mouth to the stomach through a series of contractions.

Peristalsis: The coordinated, rhythmic contractions of the muscles in the digestive tract that move food and substances through the system.

Rectum: The last portion of the large intestine, where faeces are stored before elimination.

Sphincter: A ring-like muscle that controls the flow of substances between different parts of the digestive tract, such as the lower oesophageal sphincter, pyloric sphincter and anal sphincter.

Stomach: A muscular organ in the upper abdomen that stores, mixes and partially digests food through the action of gastric juices.

Villi: Tiny, finger-like projections in the lining of the small intestine that increase surface area for nutrient absorption.

MULTIPLE CHOICE QUESTIONS

1. What is the primary function of the digestive system?
a) Respiration
b) Transportation of oxygen
c) Breakdown of food for absorption
d) Regulation of body temperature

2. Which enzyme is responsible for digesting proteins in the stomach?
a) Lipase
b) Amylase
c) Pepsin
d) Lactase

3. Where does the majority of nutrient absorption occur in the digestive system?
a) Stomach
b) Oesophagus
c) Small intestine
d) Large intestine

4. Which organ produces bile?
a) Liver
b) Stomach
c) Gallbladder
d) Pancreas

5. Which sphincter separates the stomach from the small intestine?
a) Lower oesophageal sphincter
b) Pyloric sphincter
c) Anal sphincter
d) Ileocecal sphincter

6. What is the role of amylase in the digestive system?
a) Break down proteins
b) Digest carbohydrates
c) Emulsify fats
d) Absorb water

7. Which part of the digestive system primarily absorbs water and electrolytes?
   a) Stomach
   b) Small intestine
   c) Large intestine
   d) Liver

8. What is the term for the coordinated, rhythmic contractions of the digestive tract muscles?
   a) Peristalsis
   b) Segmentation
   c) Deglutition
   d) Mastication

9. Which organ stores faeces before elimination from the body?
   a) Liver
   b) Stomach
   c) Rectum
   d) Pancreas

10. What are the tiny, finger-like projections in the small intestine that increase the surface area for nutrient absorption called?
   a) Villi
   b) Crypts
   c) Sphincters
   d) Rugae

REFERENCES

Marieb, E.N. and Keller, S.M. (2022). *Essentials of Human Anatomy and Physiology,* 13e. Harlow: Pearson.

McErlean, L. (2020). The digestive system (Chapter 10). In: *Fundamentals of Anatomy and Physiology,* 3e (eds. I. Peate and S. Evans), Oxford: Wiley.

Peate, I. (2022). *Anatomy and Physiology at a Glance,* 12e. Oxford: Wiley.

Tortora, G.J. and Derrickson, B.H. (2012). *Essentials of Anatomy and Physiology,* 9e. New York: Wiley.