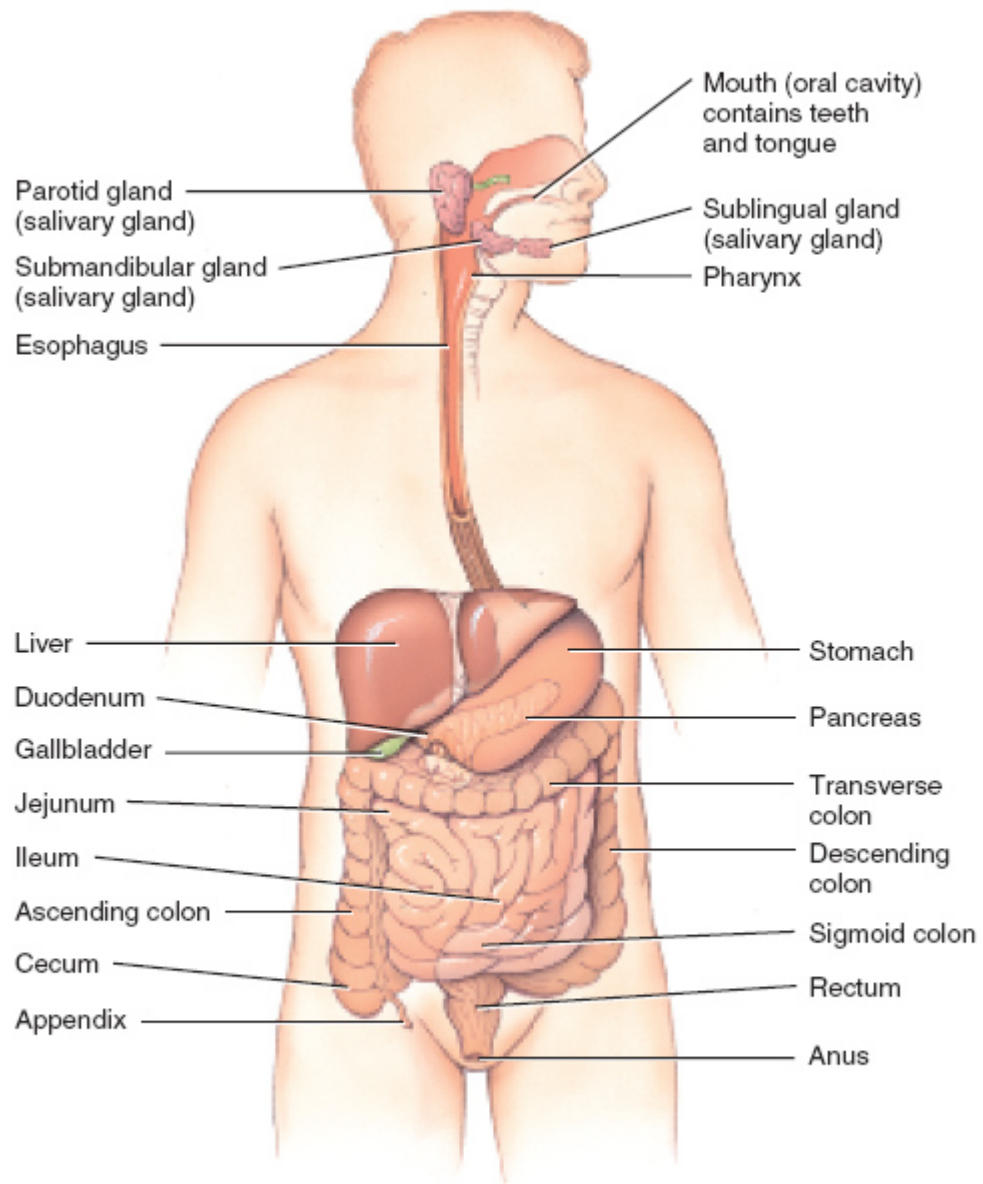


THE GI TRACT IS A CONTINUOUS MULTILAYERED TUBE EXTENDING FROM THE MOUTH TO THE ANUS THAT IS SUPPORTED AND PARTIALLY COVERED BY THE PERITONEUM.

OVERVIEW OF THE DIGESTIVE SYSTEM

Two groups of organs compose the digestive system (Figure 23-1): the gastrointestinal (GI) tract and the accessory digestive organs. The *gastrointestinal (GI) tract*, or *alimentary canal* (*alimentary* = nourishment), is a continuous tube that extends from the mouth to the anus through the ventral body cavity. Organs of the gastrointestinal tract include the mouth, most of the pharynx, esophagus, stomach, small intestine, and large intestine. The length of the GI tract taken from a cadaver is about 9 m (30 ft). In a living person, it is much shorter because the muscles along the walls of GI tract organs are in a state of tonus (sustained contraction). The *accessory digestive organs* include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas. Teeth aid in the physical breakdown of food, and the tongue assists in chewing and swallowing. The other accessory digestive organs, however, never come into direct contact with food. The secretions that they produce flow into the GI tract through ducts and aid in the chemical breakdown of food.



Right lateral view of head and neck and anterior view of trunk

Functions of the Digestive System

1. Ingests food (takes food into the mouth).
2. Secretes water, acid, buffers, and enzymes into the lumen of the GI tract.
3. Mixes and propels food through the GI tract.

4. Digests food (breaks it down mechanically and chemically).
5. Absorbs digested products from the GI tract into the blood and lymph.
6. Eliminates feces from the GI tract.

Overall, the digestive system performs six basic processes:

1. **Ingestion.** This process involves taking foods and liquids into the mouth (eating).
2. **Secretion.** Each day, cells within the walls of the GI tract and accessory digestive organs secrete a total of about 7 liters of water, acid, buffers, and enzymes into the lumen (interior space) of the tract.
3. **Mixing and propulsion.** Alternating contractions and relaxations of smooth muscle in the walls of the GI tract mix food and secretions and propel them toward the anus. This capability of the GI tract to mix and move material along its length is called **motility**.
4. **Digestion.** Mechanical and chemical processes break down ingested food into small molecules. In **mechanical digestion**, the teeth cut and grind food before it is swallowed, and then smooth muscles of the stomach and small intestine churn the food. As a result, food molecules become dissolved and thoroughly mixed with digestive enzymes. In **chemical digestion** the large carbohydrate, lipid, protein, and nucleic acid molecules in food are broken down into smaller molecules. Digestive enzymes produced by the salivary glands, tongue, stomach, pancreas, and small intestine catalyze these catabolic reactions. A few substances in food can be absorbed without chemical digestion. These include vitamins, ions, cholesterol, and water.
5. **Absorption.** The entrance of ingested and secreted fluids, ions, and the products of digestion into the epithelial cells lining the lumen of the GI tract is called **absorption**. The absorbed substances pass into blood or lymph and circulate to cells throughout the body.
6. **Defecation.** Wastes, indigestible substances, bacteria, cells sloughed from the lining of the GI tract, and digested materials that were not absorbed in their journey through the digestive tract leave the body through the anus in a process called **defecation**. The eliminated material is termed **feces**.

LAYERS OF THE GI TRACT

The wall of the GI tract from the lower esophagus to the anal canal has the same basic, four-layered arrangement of tissues. The four layers of the tract, from deep to superficial, are the mucosa, submucosa, muscularis, and serosa (Figure 23-2).

Mucosa

The *mucosa*, or inner lining of the GI tract, is a mucous membrane. It is composed of (1) a layer of epithelium in direct contact with the contents of the GI tract lumen that absorbs the digested components, (2) a layer of areolar connective tissue called the lamina propria, and (3) a thin layer of smooth muscle (muscularis mucosae).

1. The *epithelium* in the mouth, pharynx, esophagus, and anal canal is mainly nonkeratinized stratified squamous epithelium that serves a protective function. Simple columnar epithelium, which functions in secretion and absorption, lines the stomach and intestines. Located among the absorptive epithelial cells are exocrine cells that secrete mucus and fluid into the lumen of the tract, and several types of endocrine cells that secrete hormones into the bloodstream.
2. The *lamina propria* (*lamina* = thin, flat plate; *propria* = one's own) is areolar connective tissue containing many blood and lymphatic vessels, which are the routes by which nutrients absorbed into the GI tract reach the other tissues of the body. This layer supports the epithelium and binds it to the muscularis mucosae (discussed next). The lamina propria also contains *mucosa-associated lymphatic tissue (MALT)*, prominent lymphatic nodules containing immune system cells that protect against entry of pathogens through the GI tract.
3. A thin layer of smooth muscle fibers called the *muscularis mucosae* creates folds in the mucous membrane of the stomach and small intestine, which increase the surface area for digestion and absorption. Movements of the muscularis mucosae ensure that all absorptive cells are fully exposed to the contents of the GI tract.

Submucosa

The *submucosa* consists of areolar connective tissue that binds the mucosa to the muscularis. It contains many blood and lymphatic vessels that receive absorbed food molecules. The submucosa may contain glands and lymphatic tissue. Also located in the submucosa is an extensive network of neurons known as the submucosal plexus (to be described shortly).

Muscularis

The *muscularis* of the mouth, pharynx, and superior and middle parts of the esophagus contains *skeletal muscle* that produces voluntary swallowing. Skeletal muscle also forms the external anal sphincter, which permits voluntary control of defecation. Throughout the rest of the tract, the muscularis consists of *smooth muscle* that is generally found in two sheets: an inner sheet of circular fibers and an outer sheet of longitudinal fibers. Involuntary contractions of the smooth muscle help break down food, mix it with digestive secretions, and propel it along the tract. Between the layers of the muscularis is a second plexus of neurons—the myenteric plexus (*my-* = muscle) (to be described shortly).

Serosa

Those portions of the GI tract that are suspended in the abdominopelvic cavity have a superficial layer called the *serosa*. As its name implies, the serosa is a serous membrane composed of

areolar connective tissues and simple squamous epithelium. The serosa secretes slippery, watery fluid that allows the tract to glide easily against other organs. Inferior to the diaphragm, the serosa is also called the visceral peritoneum because it forms a portion of the peritoneum, which we examine next.

PERITONEUM

The *peritoneum* (per'-i-tō-NĒ-um; *peri-* = around) is the largest serous membrane of the body; it consists of a layer of simple squamous epithelium with an underlying supporting layer of connective tissue. The peritoneum is divided into the *parietal peritoneum*, which lines the wall of the abdominopelvic cavity, and the *visceral peritoneum*, which covers some of the organs in the cavity and is their serosa (Figure 23-3a). The slim space containing serous fluid that is between the parietal and visceral portions of the peritoneum is called the *peritoneal cavity*.

Some organs lie on the posterior abdominal wall and are covered by peritoneum only on their anterior surfaces. Such organs, including the kidneys and pancreas, are said to be *retroperitoneal* (*retro-* = behind).

The peritoneum contains large folds that weave between the viscera. The folds bind the organs to one another and to the walls of the abdominal cavity. They also contain blood vessels, lymphatic vessels, and nerves that supply the abdominal organs. There are five major peritoneal folds:

- The *greater omentum* (ō-MEN-tum = fat skin), the largest peritoneal fold, drapes over the transverse colon and coils of the small intestine like a “fatty apron” (Figure 23-3a, d). The greater omentum is a double sheet that folds back upon itself, giving it a total of four layers. From attachments along the stomach and duodenum, the greater omentum drapes down over the small intestine, then turns upward and attaches to the transverse colon. The greater omentum normally contains a considerable amount of adipose tissue. Its adipose tissue content can greatly expand with weight gain, giving rise to the characteristic “beer belly” seen in some overweight individuals. The many lymph nodes of the greater omentum contribute macrophages and antibody-producing plasma cells that help combat and contain infections of the GI tract.
- The *falciform ligament* (FAL-si-form; *falc-* = sickle-shaped) attaches the liver to the anterior abdominal wall and diaphragm (Figure 23-3b). The liver is the only digestive organ that is attached to the anterior abdominal wall.
- The *lesser omentum* arises as two folds in the serosa of the stomach and duodenum, and it suspends the stomach and duodenum from the liver (Figure 23-3a, c).
- A fan-shaped fold of the peritoneum, called the *mesentery* (MEZ-en-ter'-ē; *mes-* = middle), binds the small intestine to the posterior abdominal wall (Figure 23-3a, d). It extends from the posterior abdominal wall to wrap around the small intestine and then returns to its origin, forming a double-layered structure. Between the two layers are blood and lymphatic vessels and lymph nodes.
- A fold of peritoneum, the *mesocolon* (mez'-ō-KŌ-lon), binds the large intestine to the posterior abdominal wall (Figure 23-3a). It also carries blood and lymphatic vessels to the intestines. Together, the mesentery and mesocolon hold the intestines loosely in place, allowing movement as muscular contractions mix and move the luminal contents along the GI tract.

NEURAL INNERVATION OF THE GI TRACT

The gastrointestinal tract is regulated by the autonomic nervous system through an intrinsic set of enteric nerves and by an extrinsic set of sympathetic and parasympathetic nerves. The **enteric division** of the autonomic nervous system consists of about 100 million neurons that extend from the esophagus to the anus. Enteric neurons locally control the activity of the GI tract and are often thought of as the “brain of the gut.” Enteric neurons are arranged into two plexuses: the myenteric plexus and submucosal plexus (Figure 23-2). The **myenteric plexus**, or *plexus of Auerbach*, is located between the longitudinal and circular smooth muscle layers of the muscularis. The **submucosal plexus**, or *plexus of Meissner*, is found within the submucosa.

Enteric plexuses consist of motor neurons, interneurons, and sensory neurons. Enteric sensory neurons function as chemoreceptors that are activated by the presence of certain chemicals in food located in the lumen of a GI organ or serve as stretch receptors that are activated when food distends (stretches) the wall of a GI organ. Because the motor neurons of the myenteric plexus innervate the smooth muscle layers of the muscularis, this plexus mostly controls GI tract motility (movement). The motor neurons of the submucosal plexus innervate the secretory cells of the mucosal epithelium, controlling the secretions of the organs of the GI tract. Enteric interneurons interconnect the neurons of the myenteric and submucosal plexuses.

Although enteric neurons can function independently of the rest of the nervous system, they are subject to regulation through other divisions of the autonomic nervous system. Sympathetic and parasympathetic nerves link enteric neurons with the central nervous system. In general, stimulation of the GI tract by sympathetic nerves decreases GI secretion and motility by inhibiting the activity of enteric neurons, while innervation by parasympathetic nerves increases GI secretion and motility by increasing the activity of enteric neurons. Emotions such as anger, fear, and anxiety may slow digestion as the central nervous system inhibits the GI tract through sympathetic nerves.

C H E C K P O I N T

1. What are the similarities and differences between mechanical and chemical digestion?
2. Give the name and function of each of the four layers of the gastrointestinal tract.
3. Where along the GI tract is the muscularis composed of skeletal muscle? Is control of this skeletal muscle voluntary or involuntary?
4. What are the attachment sites of the mesentery, mesocolon, falciform ligament, lesser omentum, and greater omentum?
5. What are the functions of the myenteric and submucosal plexuses?
6. How are enteric plexuses regulated through the autonomic nervous system?