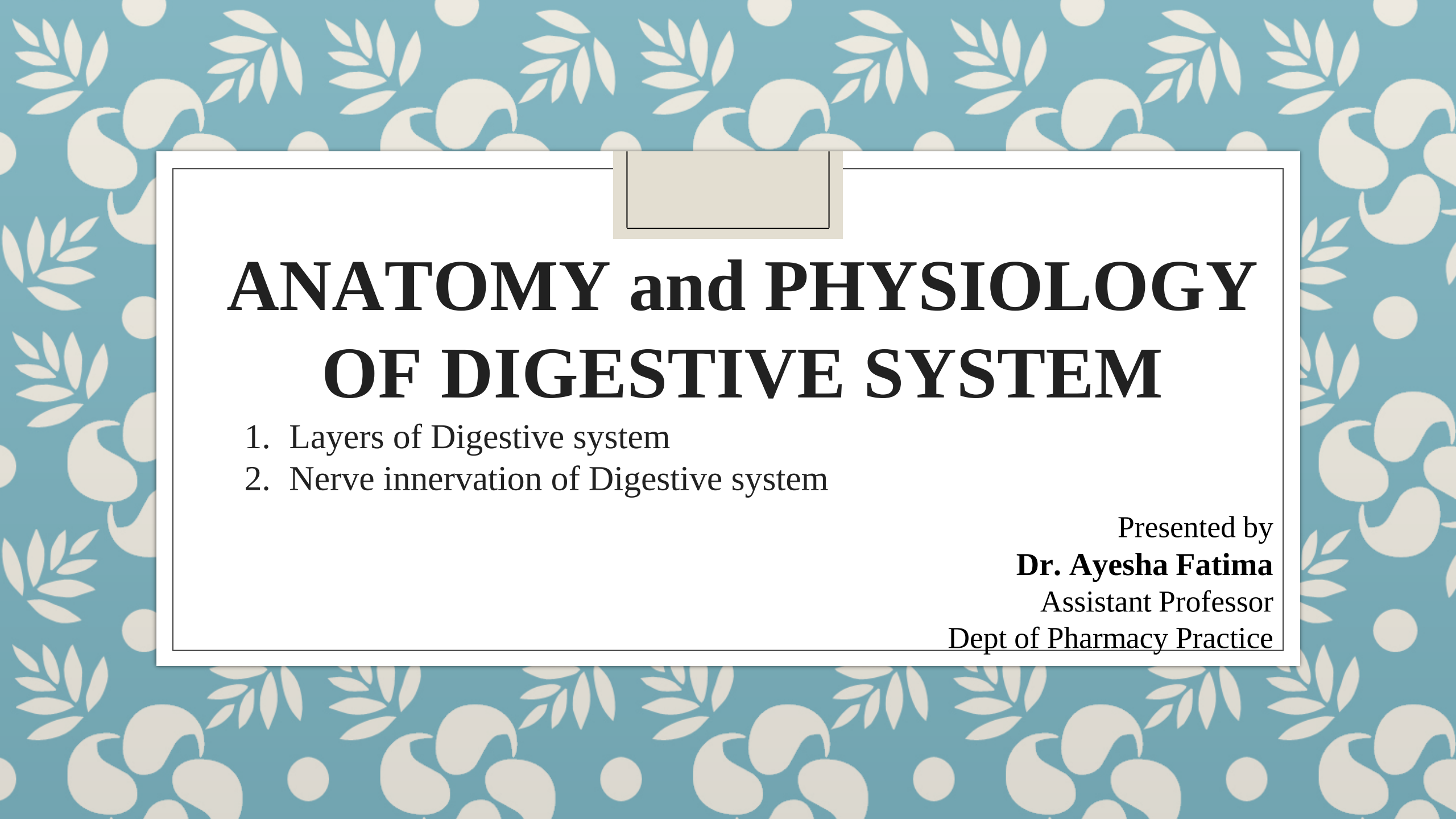




ANATOMY and PHYSIOLOGY OF DIGESTIVE SYSTEM

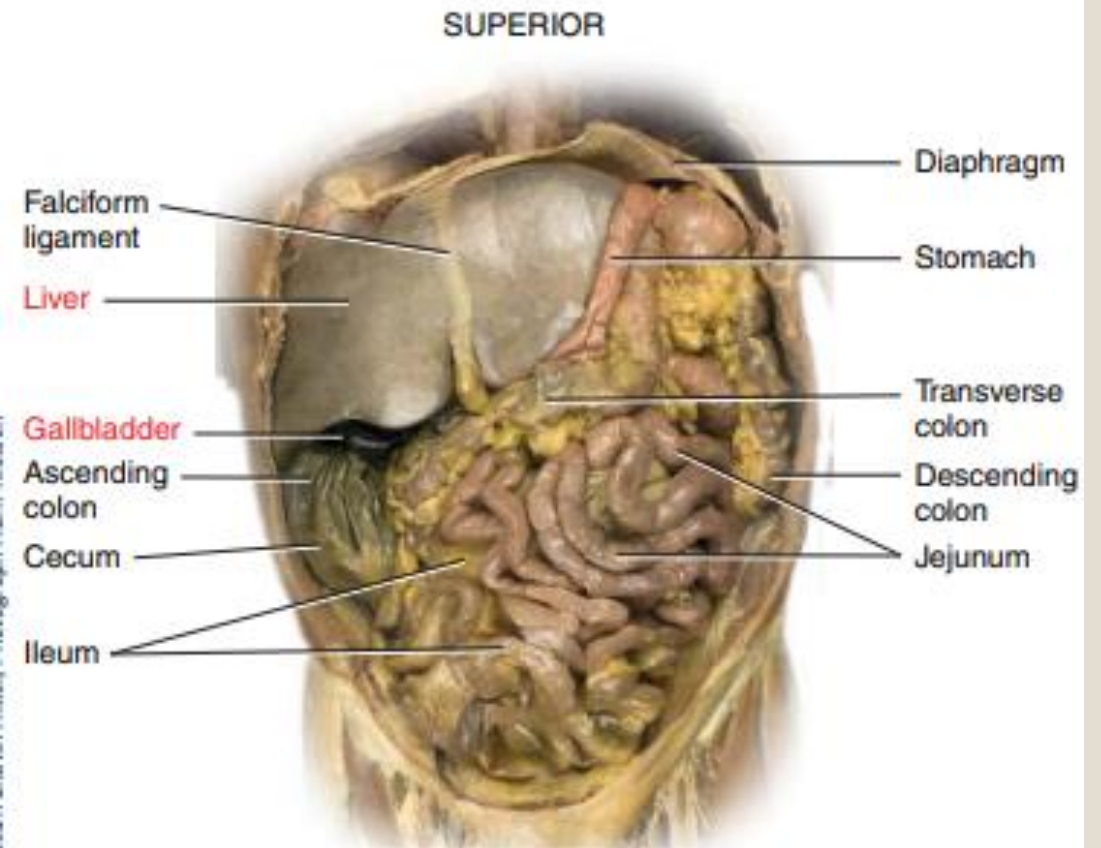
1. Layers of Digestive system
2. Nerve innervation of Digestive system

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- The **digestive system** consists of a group of organs that break down the food we eat into smaller molecules that can be used by body cells.
- Two groups of organs compose the digestive system : the **gastrointestinal (GI) tract** and the **accessory digestive organs**.
- The gastrointestinal (GI) tract, or alimentary canal, is a continuous tube that extends from the mouth to the anus through the thoracic and abdominopelvic cavities.

Functions of the Digestive System

1. Ingestion: taking food into mouth.
2. Secretion: release of water, acid, buffers, and enzymes into lumen of GI tract.
3. Mixing and propulsion: churning and movement of food through GI tract.
4. Digestion: mechanical and chemical breakdown of food.
5. Absorption: passage of digested products from GI tract into blood and lymph.
6. Defecation: elimination of feces from GI tract.



(b) Anterior view

GASTROINTESTINAL TRACT

- 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 is about 5–7 meters in a living person when the muscles along the wall of the GI tract organs are in a state of tonus .

ACCESSORY DIGESTIVE ORGANS

- The accessory digestive organs include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas.
- The other accessory digestive organs, however, never come into direct contact with food.
- They produce or store secretions that flow into the GI tract through ducts; the secretions aid in the chemical breakdown of food.

FIGURE 24.1 Organs of the digestive system.

Organs of the gastrointestinal (GI) tract are the mouth, pharynx, esophagus, stomach, small intestine, and large intestine. Accessory digestive organs include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas and are indicated in red.

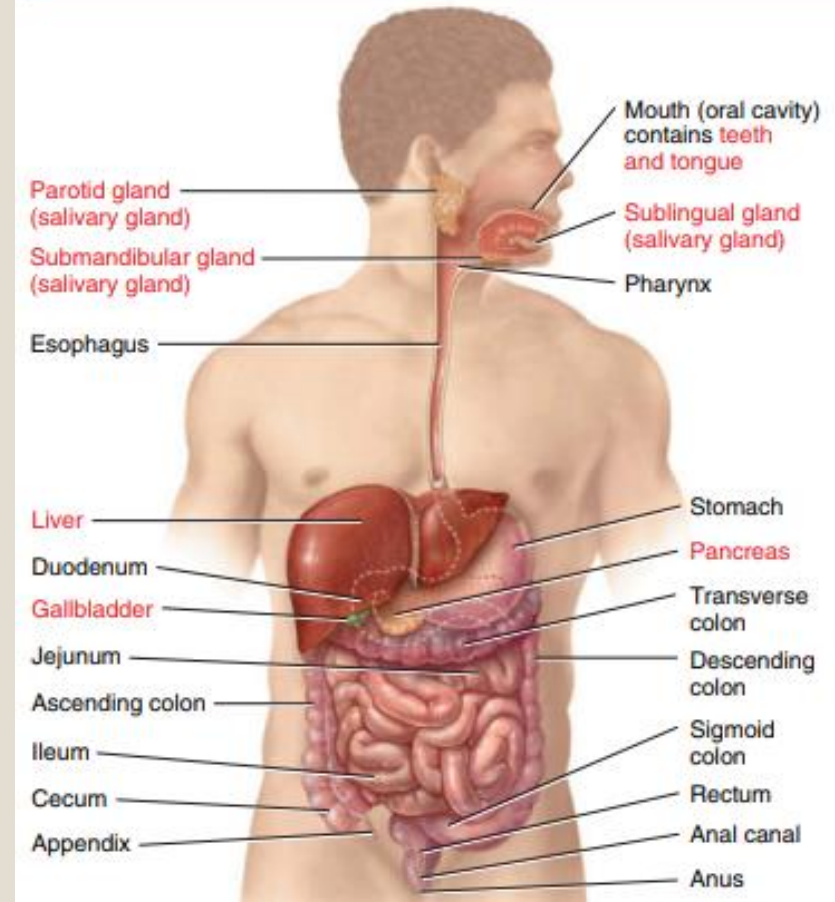
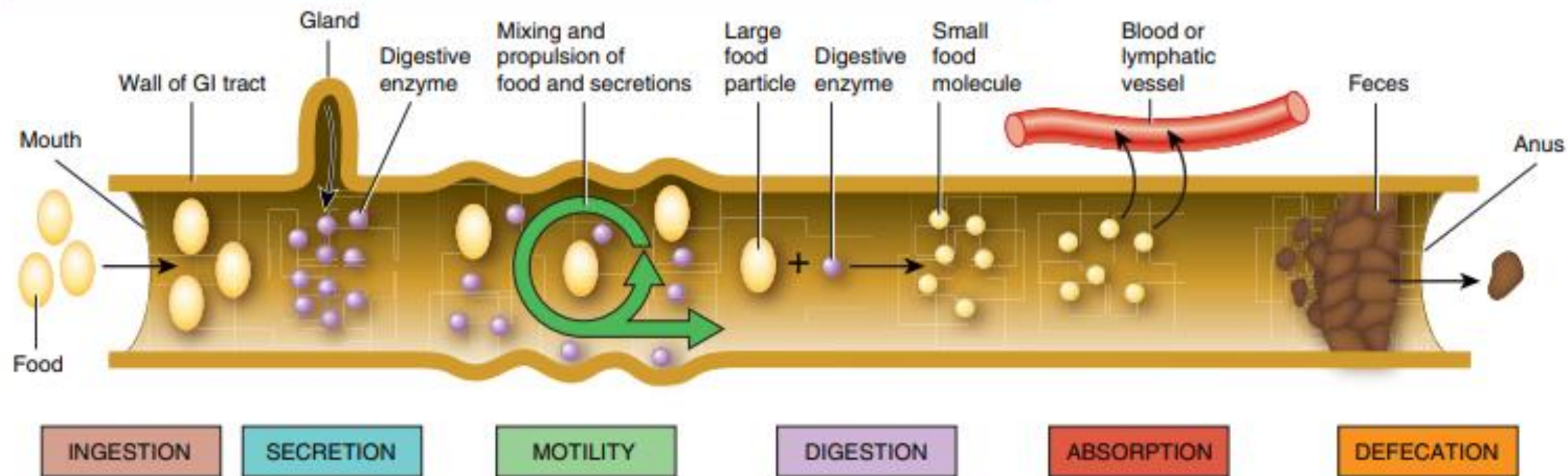


FIGURE 24.2 Digestive processes.

The digestive system performs six basic processes: ingestion, secretion, motility, digestion, absorption, and defecation.



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 of the tract.
3. **Motility.** Alternating contractions and relaxations of smooth muscle in the walls of the GI tract mix food and secretions and move them toward the anus. This capability of the GI tract to mix and move material along its length is called motility .
4. **Digestion.** Digestion is the process of breaking down ingested food into small molecules that can be used by body cells.

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 to further assist the process. 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 split into smaller molecules by hydrolysis . Digestive enzymes produced by the salivary glands, tongue, stomach, pancreas, and small intestine catalyze these catabolic reactions.

5. **Absorption.** The movement of the products of digestion from the lumen of the GI tract into blood or lymph is called absorption. Once absorbed, these substances circulate to cells throughout the body. A few substances in food can be absorbed without undergoing digestion. These include vitamins, ions, cholesterol, and water.

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 or stool.

Layers of the GI Tract

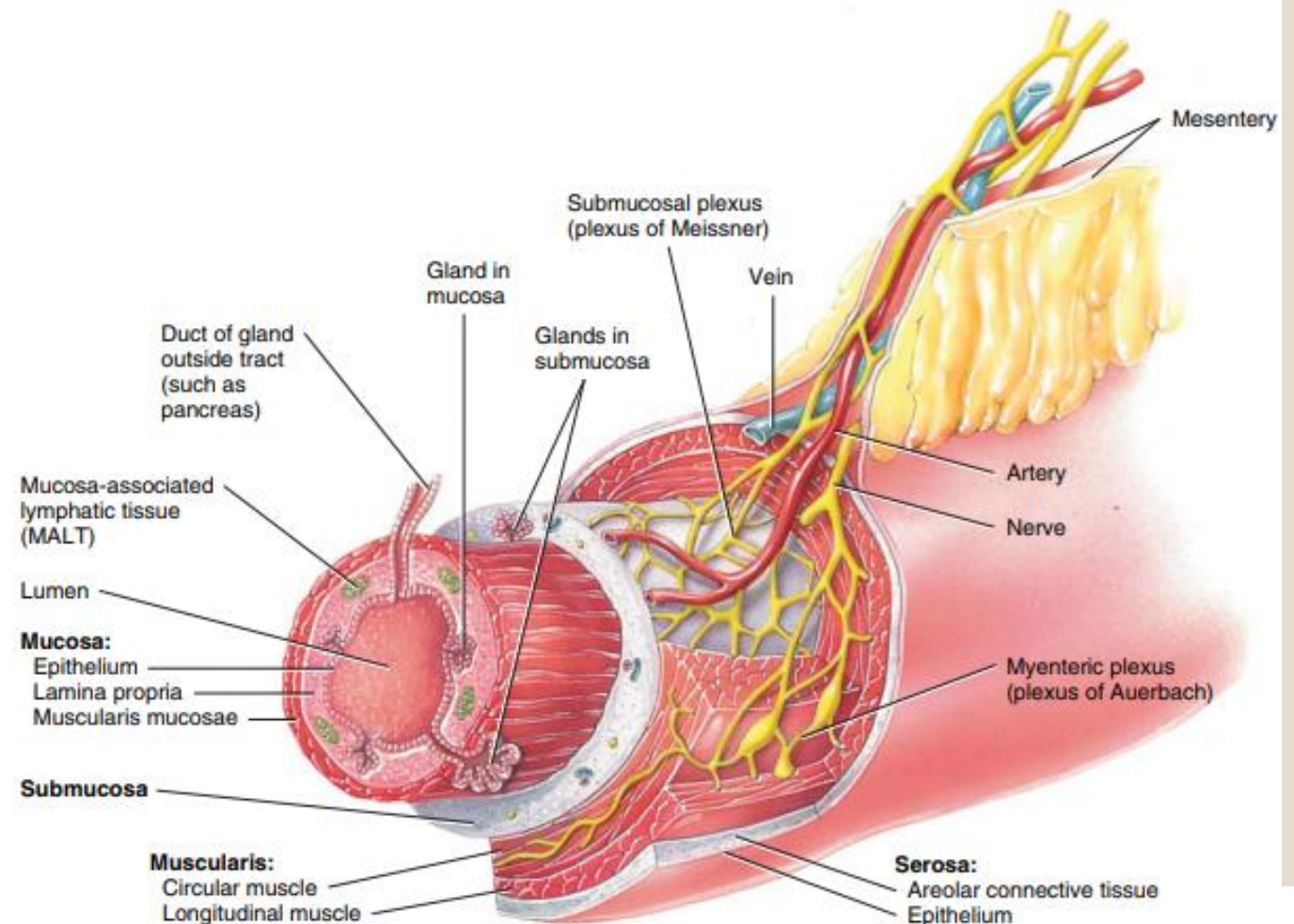
The wall of the GI tract from the lower esophagus to the anal canal has the same basic, four-layered arrangement of tissues.

The four layers of the tract, from deep to superficial, are

1. Mucosa,
2. Submucosa,
3. Muscularis,
4. Serosa/adventitia

FIGURE 24.3 Layers of the gastrointestinal tract. Variations in this basic plan may be seen in the esophagus (Figure 24.10), stomach (Figure 24.13), small intestine (Figure 24.20), and large intestine (Figure 24.25).

The four layers of the GI tract, from deep to superficial, are the mucosa, submucosa, muscularis, and serosa.



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,

(2) a layer of 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.
 - The tight junctions that firmly seal neighboring simple columnar epithelial cells to one another restrict leakage between the cells.
 - The rate of renewal of GI tract epithelial cells is rapid: Every 5 to 7 days they slough off and are replaced by new cells.
 - Located among the epithelial cells are exocrine cells that secrete mucus and fluid into the lumen of the tract, and several types of endocrine cells, collectively called enteroendocrine cells, which secrete hormones.

2. The **lamina propria** 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.
- The lamina propria also contains the majority of the cells of the mucosa-associated lymphatic tissue (MALT). These prominent lymphatic nodules contain immune system cells that protect against disease.
- MALT is present all along the GI tract, especially in the tonsils, small intestine, appendix, and large intestine.

3. A thin layer of smooth muscle fibers called the **muscularis mucosae**.

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. Also located in the submucosa is an extensive network of neurons known as the submucosal plexus.
- The submucosa may also contain glands and lymphatic tissue.

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.

Serosa

- Those portions of the GI tract that are suspended in the abdominal cavity have a superficial layer called the **serosa**.
- The serosa is a serous membrane composed of areolar connective tissue and simple squamous epithelium (mesothelium).
- The serosa is also called the visceral peritoneum because it forms a portion of the peritoneum.
- The esophagus lacks a serosa; instead, only a single layer of areolar connective tissue called the adventitia forms the superficial layer of this organ.

Neural Innervation of the GI Tract

The gastrointestinal tract is regulated by an **intrinsic set** of nerves known as the **Enteric nervous system (Brain of gut)** and by an **extrinsic set** of nerves that are part of the **Autonomic nervous system**.

It consists of about 100 million neurons that extend from the esophagus to the anus.

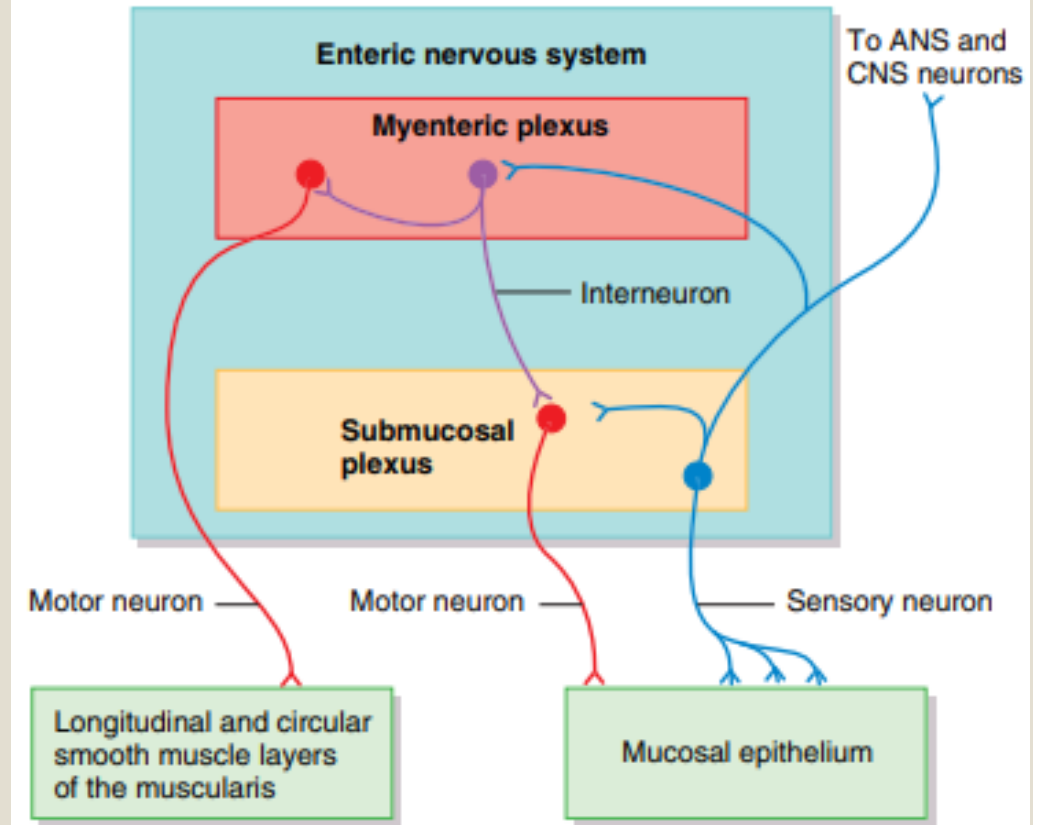
The neurons of the ENS are arranged into two plexuses: **the myenteric plexus and submucosal plexus**.

1. The **myenteric plexus, or plexus of Auerbach**, is located between the longitudinal and circular smooth muscle layers of the muscularis.
2. The **submucosal plexus, or plexus of Meissner**, is found within the submucosa.

The plexuses of the ENS consist of motor neurons, interneurons, and sensory neurons .

FIGURE 24.4 Organization of the enteric nervous system.

The enteric nervous system consists of neurons arranged into the myenteric and submucosal plexuses.



Plexus = Network of nerves

- Because the **motor neurons of the myenteric plexus** supply the longitudinal and circular smooth muscle layers of the **muscularis**, this plexus mostly **controls GI tract motility (movement)**, particularly the frequency and strength of contraction of the muscularis.
- The **motor neurons of the submucosal plexus** supply the secretory cells of the mucosal epithelium, **controlling the secretions** of the organs of the GI tract.
- The interneurons of the ENS interconnect the neurons of the myenteric and submucosal plexuses.
- The **sensory neurons of the ENS** supply the **mucosal epithelium** and contain receptors that detect stimuli in the lumen of the GI tract.
- The wall of the GI tract contains two major types of sensory receptors:
 - (1) chemoreceptors, which respond to certain chemicals in the food present in the lumen, and
 - (2) mechanoreceptors, such as stretch receptors, that are activated when food distends (stretches) the wall of a GI organ.

Autonomic Nervous System:-

- The vagus (X) nerves supply parasympathetic fibers to most parts of the GI tract, with the exception of the last half of the large intestine, which is supplied with parasympathetic fibers from the sacral spinal cord.
- Parasympathetic preganglionic neurons of the vagus or pelvic splanchnic nerves synapse with parasympathetic postganglionic neurons located in the myenteric and submucosal plexuses.
- Some of the parasympathetic postganglionic neurons in turn synapse with neurons in the ENS; others directly innervate smooth muscle and glands within the wall of the GI tract.
- **In general, stimulation of the parasympathetic nerves that innervate the GI tract causes an increase in GI secretion and motility by increasing the activity of ENS neurons.**
- Sympathetic nerves that supply the GI tract arise from the thoracic and upper lumbar regions of the spinal cord.
- Sympathetic postganglionic neurons synapse with neurons located in the myenteric plexus and the submucosal plexus.
- **In general, the sympathetic nerves that supply the GI tract cause a decrease in GI secretion and motility by inhibiting the neurons of the ENS.**
- Emotions such as anger, fear, and anxiety may slow digestion because they stimulate the sympathetic nerves that supply the GI tract.

Gastrointestinal Reflex Pathways

Many neurons of the ENS are components of GI (gastrointestinal) reflex pathways that regulate GI secretion and motility in response to stimuli present in the lumen of the GI tract.

- The initial components of a typical GI reflex pathway are sensory receptors (such as chemoreceptors and stretch receptors) that are associated with the sensory neurons of the ENS.
- The axons of these sensory neurons can synapse with other neurons located in the ENS, CNS, or ANS, informing these regions about the nature of the contents and the degree of distension (stretching) of the GI tract.
- The neurons of the ENS, CNS, or ANS subsequently activate or inhibit GI glands and smooth muscle, altering GI secretion and motility.