GIT Physiology

Lec. 1

- *The alimentary tract provides the body with a continual supply of water, electrolytes, and nutrients, To achieve this requires :*
- *(1) Movement of food through the alimentary tract.*
- *(2) Secretion of digestive juices and digestion of the food.*
- *(3) Absorption of water, various electrolytes, and digestive products.*
- *(4) Circulation of blood through the gastrointestinal organs to carry away the absorbed substances.*
- *(5) Control of all these functions by local, nervous, and hormonal systems.*
- *Figure below shows the entire alimentary tract. Each part is adapted to its specific functions: some to simple passage of food, such as the esophagus; others to temporary storage of food, such as the stomach; and others to digestion and absorption, such as the small intestine.*

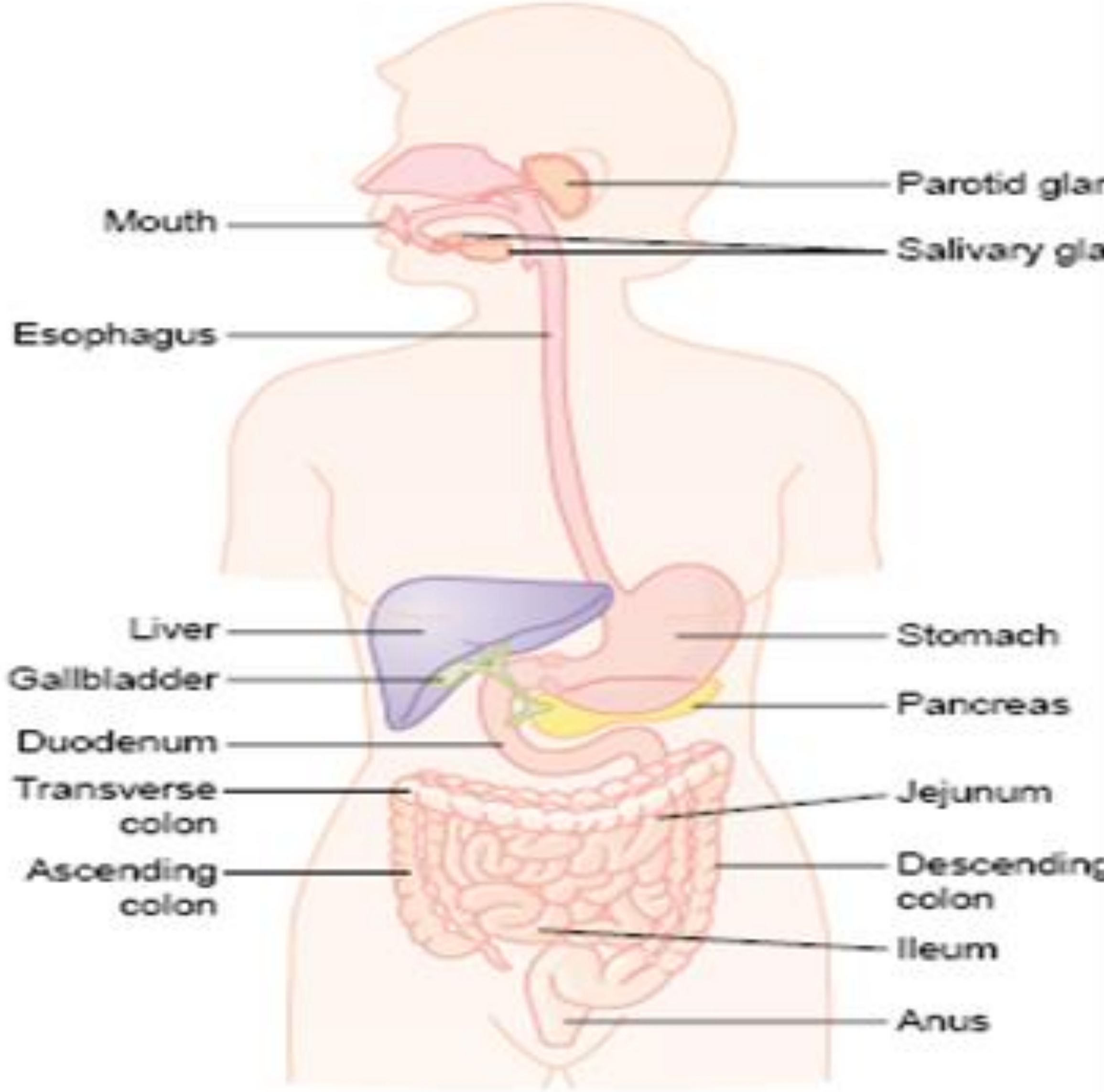

Figure 62–1

Alimentary tract.

General Principles of Gastrointestinal Motility

- ***Physiologic Anatomy of the Gastrointestinal Wall***
- *Figure below shows a typical cross section of the intestinal wall, including the following layers from outer surface inward:*
- *(1) The serosa.*
- *(2) A longitudinal muscle layer.*
- *(3) A circular muscle layer.*
- *(4) The submucosa.*
- *(5) The mucosa.*
- *In addition, sparse bundles of smooth muscle fibers, the mucosal muscle, lie in the deeper layers of the mucosa. The motor functions of the gut are performed by the different layers of smooth muscle.*

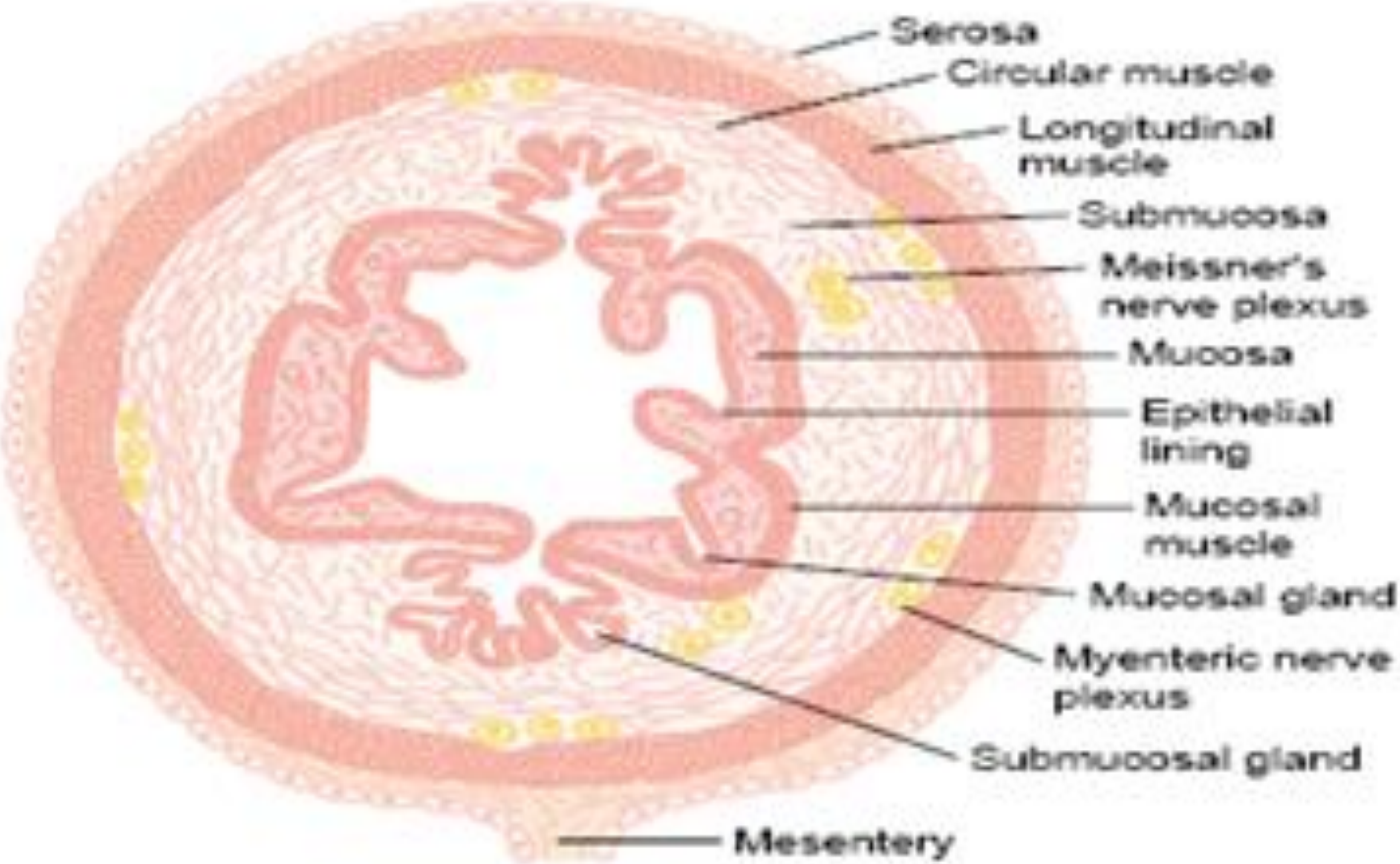

Figure 62–2

Typical cross section of the gut.

- ***Neural Control f Gastrointestinal Function—Enteric Nervous System***
- *The gastrointestinal tract has a nervous system all its own called the enteric nervous system. It lies entirely in the wall of the gut, beginning in the esophagus and extending all the way to the anus. The number of neurons in this enteric system is about 100 million, almost exactly equal to the number in the entire spinal cord. This highly developed enteric nervous system is especially important in controlling gastrointestinal movements and secretion. The enteric nervous system is composed mainly of two plexuses, shown in figure below:*
- *(1) An outer plexus lying between the longitudinal and circular muscle layers, called the myenteric plexus or Auerbach's plexus.*
- *(2) An inner plexus, called the submucosal plexus or Meissner's plexus, that lies in the submucosa.*

- *The nervous connections within and between these two plexuses*
- *The myenteric plexus controls mainly the gastrointestinal movements, and the submucosal plexus controls mainly gastrointestinal secretion and local blood flow.* Note the extrinsic sympathetic and parasympathetic fibers that connect to both the myenteric and submucosal plexuses. *Although the enteric nervous system can function on its own, independently of these extrinsic nerves, stimulation by the parasympathetic and sympathetic systems can greatly enhance or inhibit gastrointestinal functions*, as we discuss later.

- *Also sensory nerve endings that originate in the gastrointestinal epithelium or gut wall and send afferent fibers to both plexuses of the enteric system, as well as:*
- *(1) To the prevertebral ganglia of the sympathetic nervous system.*
- *(2) To the spinal cord.*
- *(3) In the vagus nerves all the way to the brain stem.*
- *These sensory nerves can elicit local reflexes within the gut wall itself and still other reflexes that are relayed to the gut from either the prevertebral ganglia or the basal regions of the brain.*

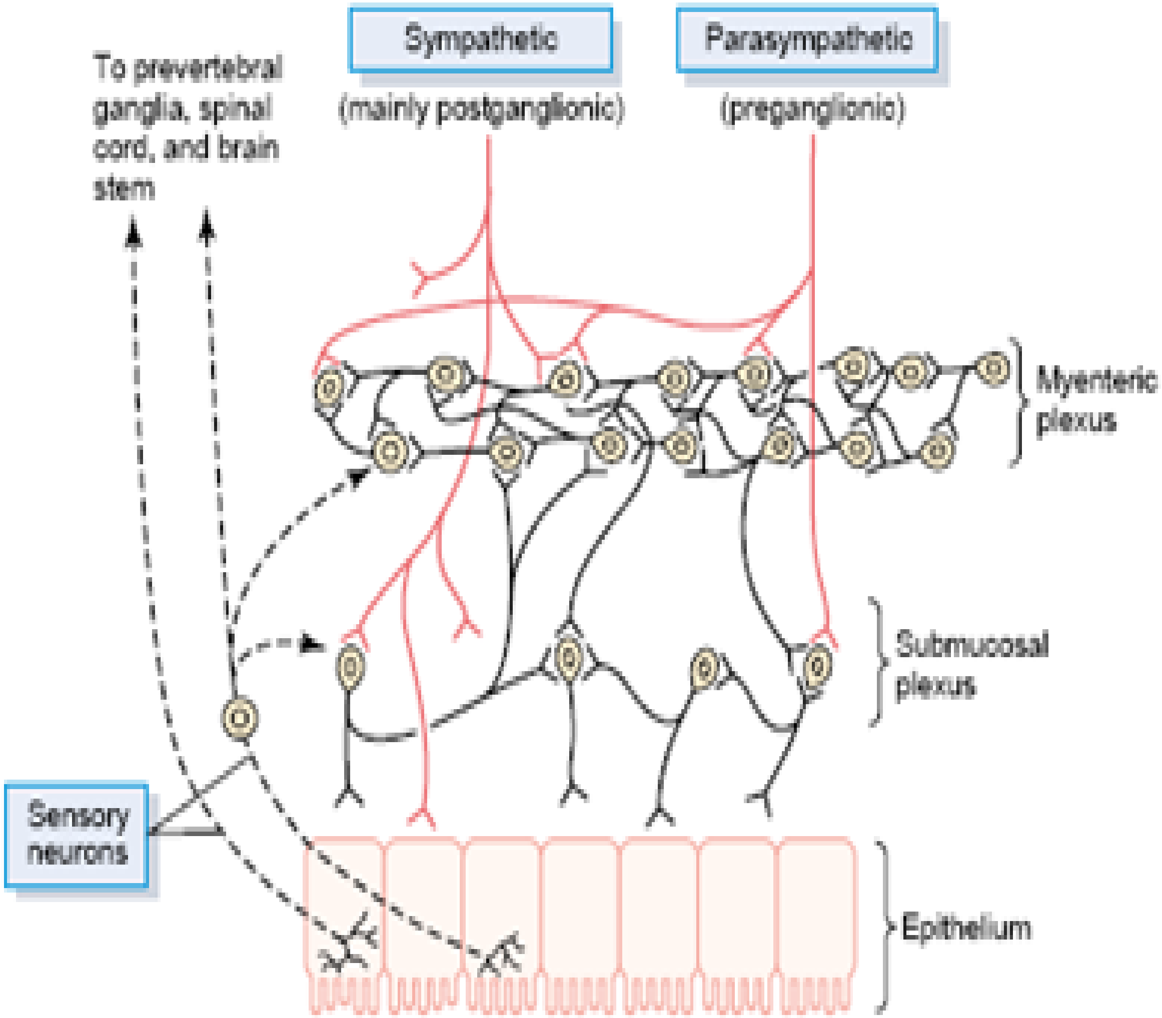

Figure 62–4

Neural control of the gut wall, showing (1) the myenteric and submucosal plexuses (*black fibers*); (2) extrinsic control of these plexuses by the sympathetic and parasympathetic nervous systems (*red fibers*); and (3) sensory fibers passing from the luminal epithelium and gut wall to the enteric plexuses, then to the prevertebral ganglia of the spinal cord and directly to the spinal cord and brain stem (*dashed fibers*).

- ***Differences Between the Myenteric and Submucosal Plexuses***
- *The myenteric plexus consists mostly of a linear chain of many interconnecting neurons that extends the entire length of the gastrointestinal tract. A section of this chain is shown in figure above. Because the myenteric plexus extends all the way along the intestinal wall and because it lies between the longitudinal and circular layers of intestinal smooth muscle, it is concerned mainly with controlling muscle activity along the length of the gut. When this plexus is stimulated, its principal effects are:*
- *(1) Increased tonic contraction, or "tone," of the gut wall.*
- *(2) Increased intensity of the rhythmical contractions.*
- *(3) Slightly increased rate of the rhythm of contraction.*
- *(4) Increased velocity of conduction of excitatory waves along the gut wall, causing more rapid movement of the gut peristaltic waves.*

- ***The myenteric plexus*** *should not be considered entirely excitatory because some of its neurons are inhibitory; their fiber endings secrete an inhibitory transmitter, possibly vasoactive intestinal polypeptide or some other inhibitory peptide. The resulting inhibitory signals are especially useful for inhibiting some of the intestinal sphincter muscles that impede movement of food along successive segments of the gastrointestinal tract, such as the pyloric sphincter, which controls emptying of the stomach into the duodenum, and the sphincter of the ileocecal valve, which controls emptying from the small intestine into the cecum.*

- ***The submucosal plexus***, *in contrast to the myenteric plexus, is mainly concerned with controlling function within the inner wall of each minute segment of the intestine. For instance, many sensory signals originate from the gastrointestinal epithelium and are then integrated in the submucosal plexus to help control local intestinal secretion, local absorption, and local contraction of the submucosal muscle that causes various degrees of infolding of the gastrointestinal mucosa.*

- ***Types of Neurotransmitters Secreted by Enteric Neurons***
- *In an attempt to understand better the multiple functions of the gastrointestinal enteric nervous system, research workers the world over have identified a dozen or more different neurotransmitter substances that are released by the nerve endings of different types of enteric neurons. Two of them with which we are already familiar are (1) acetylcholine and (2) norepinephrine. Others are (3) adenosine triphosphate, (4) serotonin, (5) dopamine, (6) cholecystokinin, (7) substance P, (8) vasoactive intestinal polypeptide, (9) somatostatin, (10) leu-enkephalin, (11) met-enkephalin, (12) bombesin.*
- *The specific functions of many of these are not known well enough to justify discussion here, other than to point out the following.*
- *Acetylcholine most often excites gastrointestinal activity. Norepinephrine almost always inhibits gastrointestinal activity.*

- ***Autonomic control of the gastrointestinal tract.***
- ***Parasympathetic stimulation increases activity of the enteric nervous system.***
- *The parasympathetic supply to the gut is divided into cranial and sacral divisions, Except for a few parasympathetic fibers to the mouth and pharyngeal regions of the alimentary tract, the cranial parasympathetic nerve fibers are almost entirely in the vagus nerves. These fibers provide extensive innervations to the esophagus, stomach, and pancreas and somewhat less to the intestines down through the first half of the large intestine.*

- ***Sympathetic stimulation usually inhibits gastrointestinal tract activity.***
- *The sympathetic fibers to the gastrointestinal tract originate in the spinal cord between segments T5 and L2. Most of the preganglionic fibers that innervate the gut, after leaving the cord, enter the sympathetic chains that lie lateral to the spinal column, and many of these fibers then pass on through the chains to outlying ganglia such as to the celiac ganglion and various mesenteric ganglia.*

- *Most of the postganglionic sympathetic neuron bodies are in these ganglia, and postganglionic fibers then spread through postganglionic sympathetic nerves to all parts of the gut. The sympathetics innervate essentially all of the gastrointestinal tract, rather than being more extensive nearest the oral cavity and anus, as is true of the parasympathetics. The sympathetic nerve endings secrete mainly norepinephrine but also small amounts of epinephrine.*

- ***Afferent sensory nerve fibers from the gut.***
- *Many afferent sensory nerve fibers innervate the gut. Some of them have their cell bodies in the enteric nervous system itself and some in the dorsal root ganglia of the spinal cord. These sensory nerves can be stimulated by:*
- *(1) irritation of the gut mucosa.*
- *(2) excessive distention of the gut.*
- *(3) presence of specific chemical substances in the gut.*

- *Signals transmitted through the fibers can then cause excitation or, under other conditions, inhibition of intestinal movements or intestinal secretion. In addition, other sensory signals from the gut go all the way to multiple areas of the spinal cord and even the brain stem. For example, 80 percent of the nerve fibers in the vagus nerves are afferent rather than efferent. These afferent fibers transmit sensory signals from the gastrointestinal tract into the brain medulla, which in turn initiates vagal reflex signals that return to the gastrointestinal tract to control many of its functions.*

- ***Gastrointestinal reflexes.***
- *The anatomical arrangement of the enteric nervous system and its connections with the sympathetic and parasympathetic systems support three types of gastrointestinal reflexes that are essential to gastrointestinal control. They are the following:*
- ***1.*** *Reflexes that are integrated entirely within the gut wall enteric nervous system. These include reflexes that control much gastrointestinal secretion, peristalsis, mixing contractions, local inhibitory effects, and so forth.*

- ***2.*** *Reflexes from the gut to the prevertebral sympathetic ganglia and then back to the gastrointestinal tract. These reflexes transmit signals long distances to other areas of the gastrointestinal tract, such as signals from the stomach to cause evacuation of the colon (the gastrocolic reflex), signals from the colon and small intestine to inhibit stomach motility and stomach secretion (the enterogastric reflexes), and reflexes from the colon to inhibit emptying of ileal contents into the colon (the colonoileal reflex).*

- ***3.*** *Reflexes from the gut to the spinal cord or brain stem and then back to the gastrointestinal tract. These include especially*
- *(1) Reflexes from the stomach and duodenum to the brain stem and back to the stomach by way of the vagus nerves to control gastric motor and secretory activity.*
- *(2) Pain reflexes that cause general inhibition of the entire gastrointestinal tract.*
- *(3) Defecation reflexes that travel from the colon and rectum to the spinal cord and back again to produce the powerful colonic, rectal, and abdominal contractions required for defecation (the defecation reflexes).*

- ***Hormonal control of gastrointestinal motility***
- ***1. Gastrin***
- *Is secreted by the “G” cells of the antrum of the stomach in response to stimuli associated with ingestion of a meal, such as distention of the stomach, the products of proteins, and gastrin releasing peptide, which is released by the nerves of the gastric mucosa during vagal stimulation. The primary actions of gastrin are:*
- *(1) Stimulation of gastric acid secretion.*
- *(2) Stimulation of growth of the gastric mucosa.*

- ***2.Cholecystokinin (CCK)***
- *Is secreted by “I” cells in the mucosa of the duodenum and jejunum mainly in response to digestive products of fat, fatty acids, and monoglycerides in the intestinal contents. This hormone strongly contracts the gallbladder, expelling bile into the small intestine where the bile in turn plays important roles in emulsifying fatty substances, allowing them to be digested and absorbed. Cholecystokinin also inhibits stomach contraction moderately. Therefore, at the same time that this hormone causes emptying of the gallbladder, it also slows the emptying of food from the stomach to give adequate time for digestion of the fats in the upper intestinal tract.*

- ***3.Secretin***
- *Was the first gastrointestinal hormone discovered and is secreted by the "S" cells in the mucosa of the duodenum in response to acidic gastric juice emptying into the duodenum from the pylorus of the stomach. Secretin has a mild effect on motility of the gastrointestinal tract and acts to promote pancreatic secretion of bicarbonate which in turn helps to neutralize the acid in the small intestine.*

- ***4.Gastric inhibitory peptide***
- *Is secreted by the mucosa of the upper small intestine, mainly in response to fatty acids and amino acids but to a lesser extent in response to carbohydrate. It has a mild effect in decreasing motor activity of the stomach and therefore slows emptying of gastric contents into the duodenum when the upper small intestine is already overloaded with food products.*

- ***5.Motilin***
- *Is secreted by the upper duodenum during fasting, and the only known function of this hormone is to increase gastrointestinal motility. Motilin is released cyclically and stimulates waves of gastrointestinal motility called interdigestive myoelectric complexes that move through the stomach and small intestine every 90 minutes in a fasted person. Motilin secretion is inhibited after ingestion by mechanisms that are not fully understood.*

- ***Functional types of movements in the gastrointestinal tract***
- *Two types of movements occur in the gastrointestinal tract:*
- *(1) Propulsive movements, which cause food to move forward along the tract at an appropriate rate to accommodate digestion and absorption,*
- *(2) Mixing movements, which keep the intestinal contents thoroughly mixed at all times.*

- **1. Propulsive movements—Peristalsis**
- *The basic propulsive movement of the gastrointestinal tract is peristalsis, A contractile ring appears around the gut and then moves forward; this is analogous to putting one's fingers around a thin distended tube, then constricting the fingers and sliding them forward along the tube. Any material in front of the contractile ring is moved forward. Peristalsis is an inherent property of many syncytial smooth muscle tubes; stimulation at any point in the gut can cause a contractile ring to appear in the circular muscle, and this ring then spreads along the gut tube. (Peristalsis also occurs in the bile ducts, glandular ducts, ureters, and many other smooth muscle tubes of the body.)*

- *The usual stimulus for intestinal peristalsis is distention of the gut. That is, if a large amount of food collects at any point in the gut, the stretching of the gut wall stimulates the enteric nervous system to contract the gut wall 2 to 3 centimeters behind this point, and a contractile ring appears that initiates a peristaltic movement. Other stimuli that can initiate peristalsis include chemical or physical irritation of the epithelial lining in the gut. Also, strong parasympathetic nervous signals to the gut will elicit strong peristalsis.*

- ***Function of the myenteric plexus in peristalsis.***

- *Peristalsis occurs only weakly or not at all in any portion of the gastrointestinal tract that has congenital absence of the myenteric plexus. Also, it is greatly depressed or completely blocked in the entire gut when a person is treated with atropine to paralyze the cholinergic nerve endings of the myenteric plexus. Therefore, effectual peristalsis requires an active myenteric plexus.*

- **Directional movement of peristaltic waves toward the anus.**

- *Peristalsis, theoretically, can occur in either direction from a stimulated point, but it normally dies out rapidly in the orad direction while continuing for a considerable distance toward the anus. The exact cause of this directional transmission of peristalsis has never been ascertained, although it probably results mainly from the fact that the myenteric plexus itself is "polarized" in the anal direction, which can be explained as follows.*

Peristaltic reflex and the "Law of the Gut."

- *When a segment of the intestinal tract is excited by distention and thereby initiates peristalsis, the contractile ring causing the peristalsis normally begins on the orad side of the distended segment and moves toward the distended segment, pushing the intestinal contents in the anal direction for 5 to 10 centimeters before dying out. At the same time, the gut sometimes relaxes several centimeters downstream toward the anus, which is called "receptive relaxation," thus allowing the food to be propelled more easily anally than orad. This complex pattern does not occur in the absence of the myenteric plexus. Therefore, the complex is called the myenteric reflex or the peristaltic reflex. The peristaltic reflex plus the anal direction of movement of the peristalsis is called the "law of the gut."*

- ***2. Mixing movements***
- *Mixing movements differ in different parts of the alimentary tract. In some areas, the peristaltic contractions themselves cause most of the mixing. This is especially true when forward progression of the intestinal contents is blocked by a sphincter, so that a peristaltic wave can then only churn the intestinal contents, rather than propelling them forward. At other times, local intermittent constrictive contractions occur every few centimeters in the gut wall. These constrictions usually last only 5 to 30 seconds; then new constrictions occur at other points in the gut, thus "chopping" and "shearing" the contents first here and then there. These peristaltic and constrictive movements are modified in different parts of the gastrointestinal tract for proper propulsion and mixing.*

Thank you..