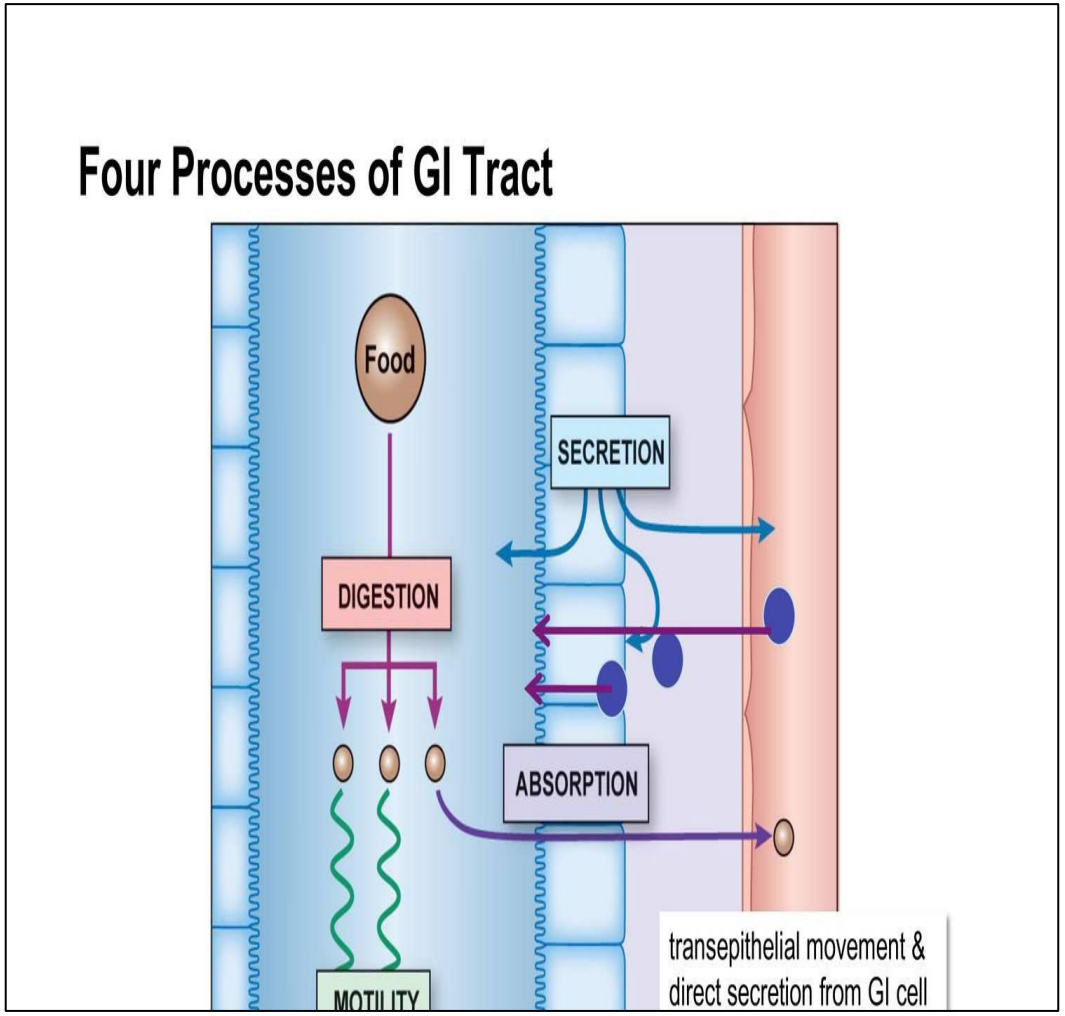
Functional Anatomy and General Principles of Regulation in the Gastrointestinal Tract

Functions of the Gastrointestinal System

- Secretion: Total about 7L into lumen.
- Motility
  - Mixing
  - propulsion
- Digestion: Breakdown of ingested food
  - Mechanical
  - Chemical
- Absorption: passage of nutrients into the blood



The gastrointestinal organs functions

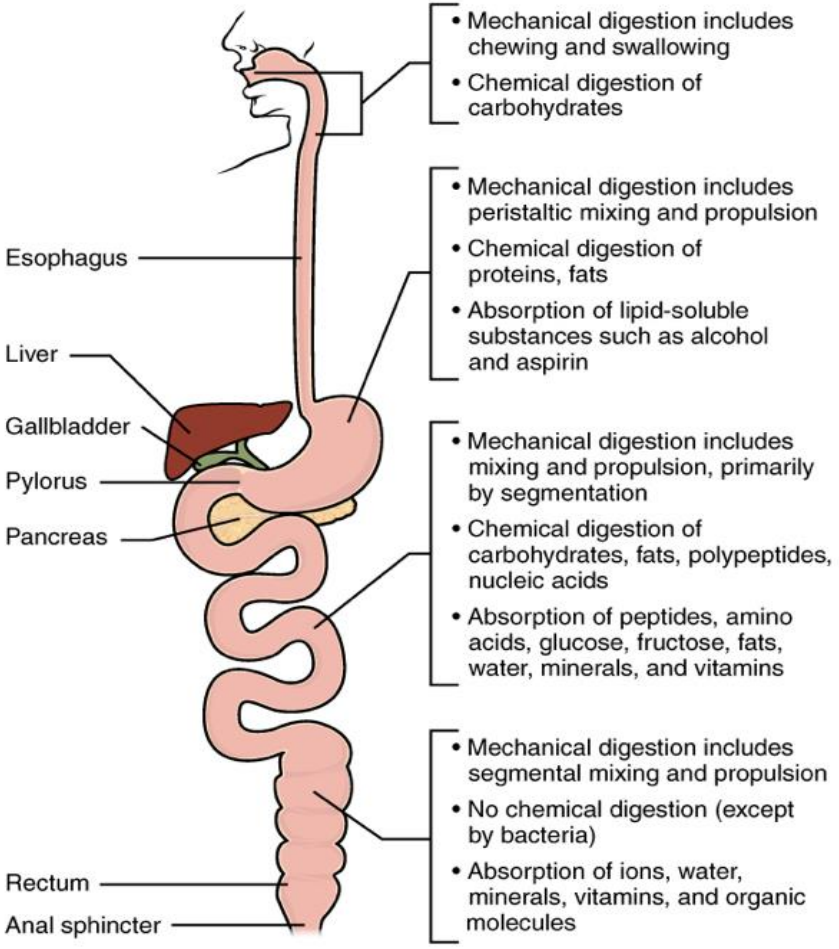
The GI tract or alimentary canal

- Ingestion of food.
- Propulsion of food and wastes from the mouth to the anus
- Secretion of mucus, water and enzymes
- Mechanical digestion of food particles
- Chemical digestion of food particles.
- Absorption of digested food.
- Elimination of waste products by defecation.

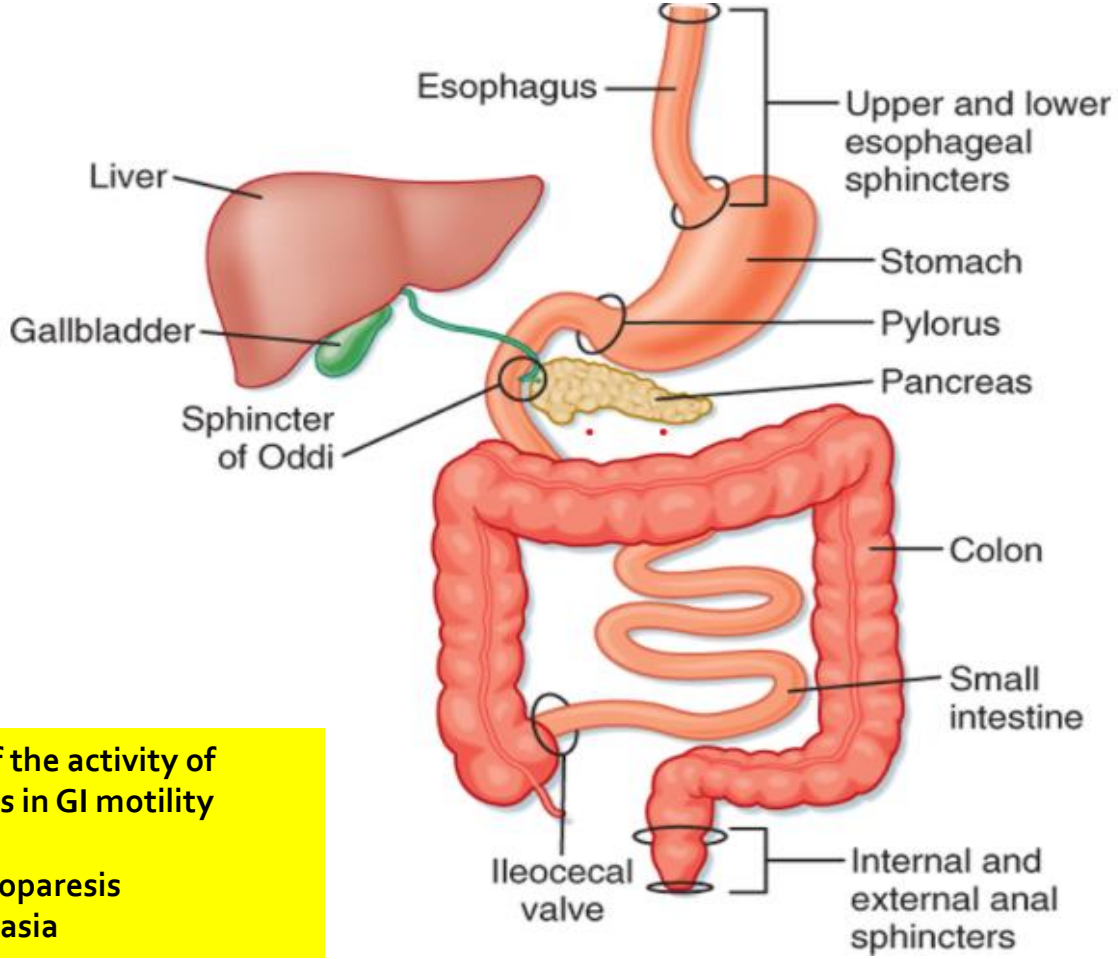
The accessory glands and organs

- The Liver, gall bladder and exocrine pancreas all secrete enzymes for the digestion of chyme.

The GI tract is a muscular tube of about *5 m* long when one is alive



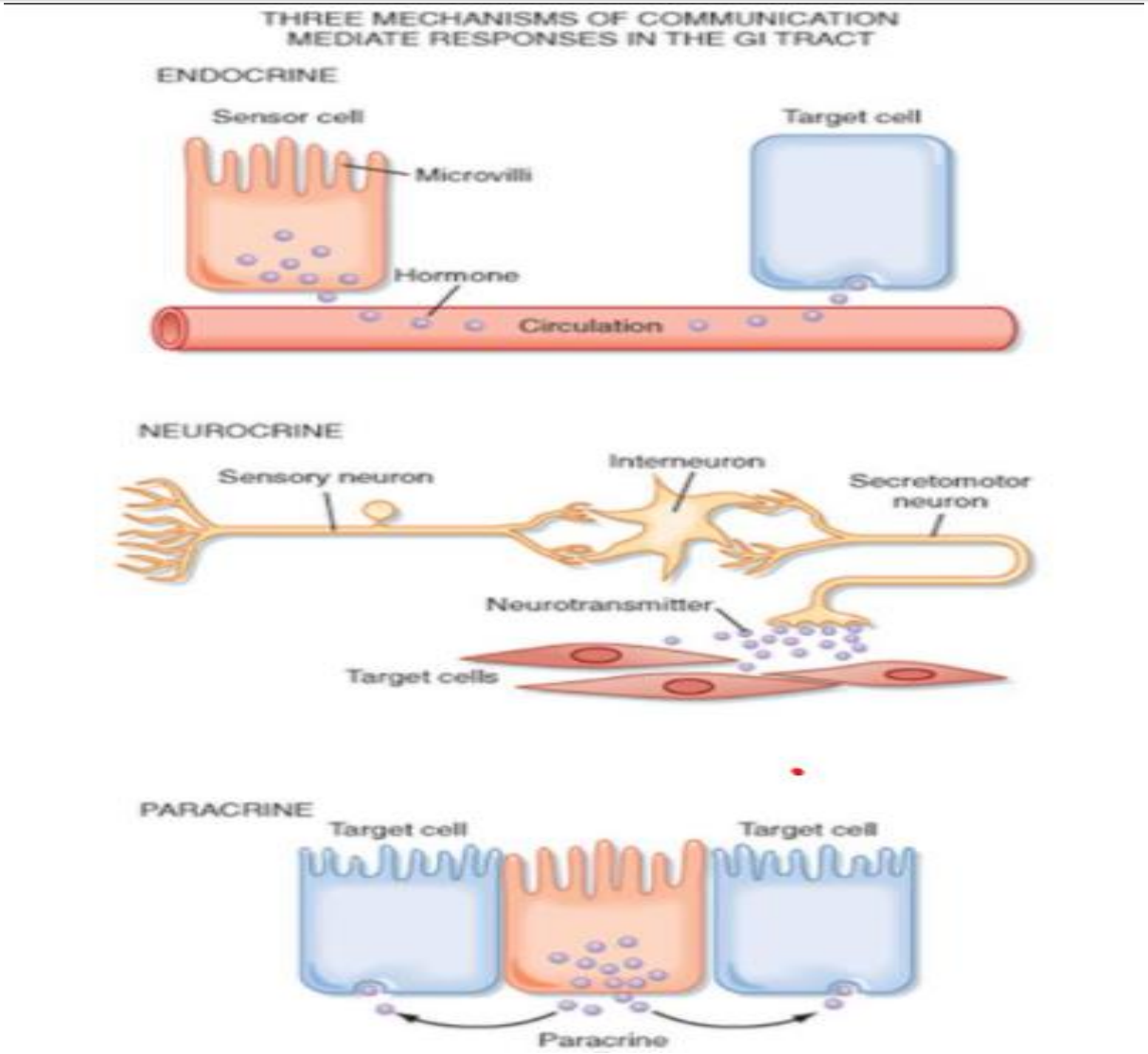
The gastrointestinal organs functions



Dysregulation of the activity of sphincters results in GI motility disorders like:

- **Gastroparesis**
- **Achalasia**

Neural and Hormonal Regulators of Gastrointestinal Function

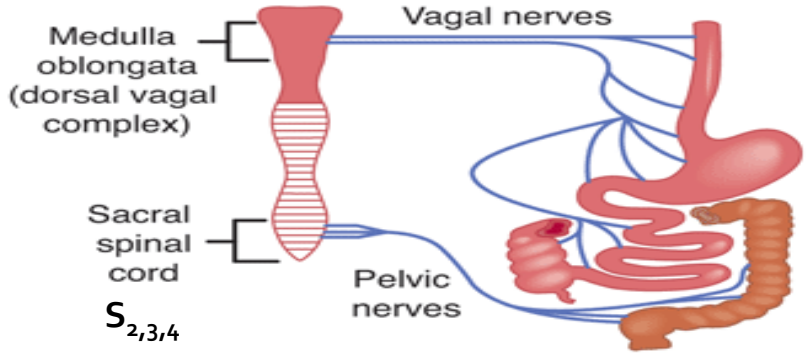


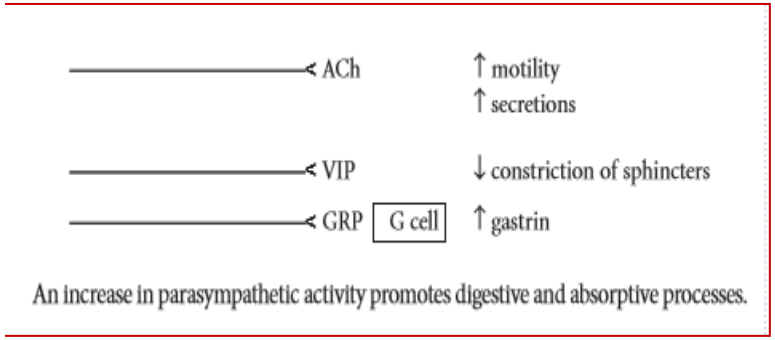
Extrinsic Nervous System

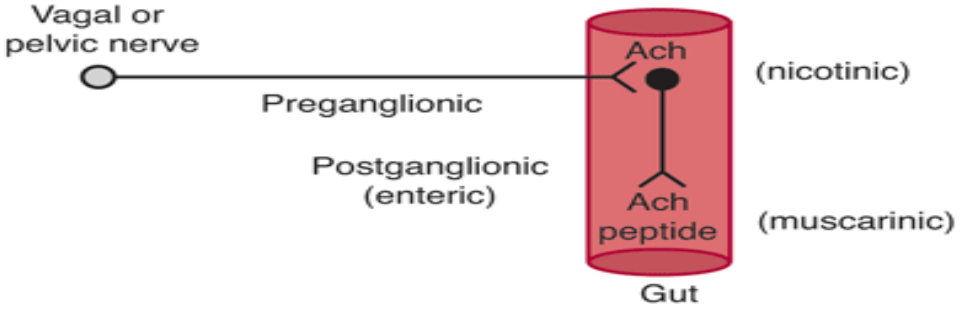
Extrinsic neural innervation to the gut is via the two major subdivisions of the ANS, namely, parasympathetic and sympathetic innervation

Parasympathetic

Neurons of the autonomic parasympathetic division project from the medulla oblongata and sacral regions of the spinal cord



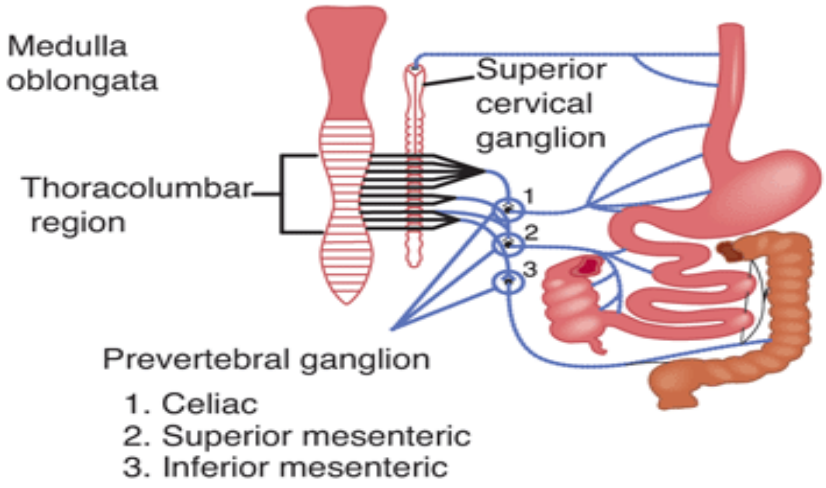


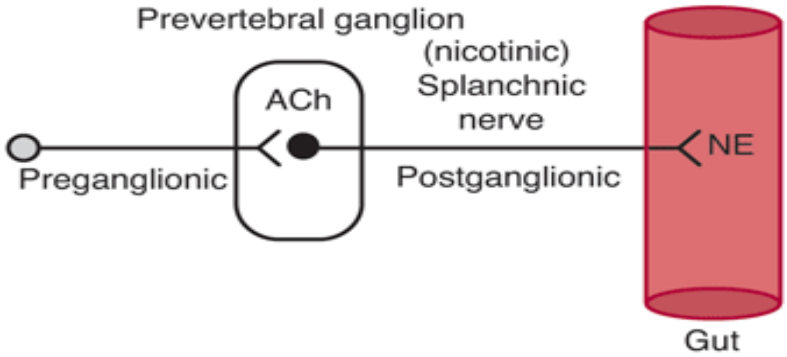


Extrinsic Nervous System

Sympathetic

Neurons of the autonomic sympathetic division project to the gut from thoracic and first lumbar segments of the spinal cord





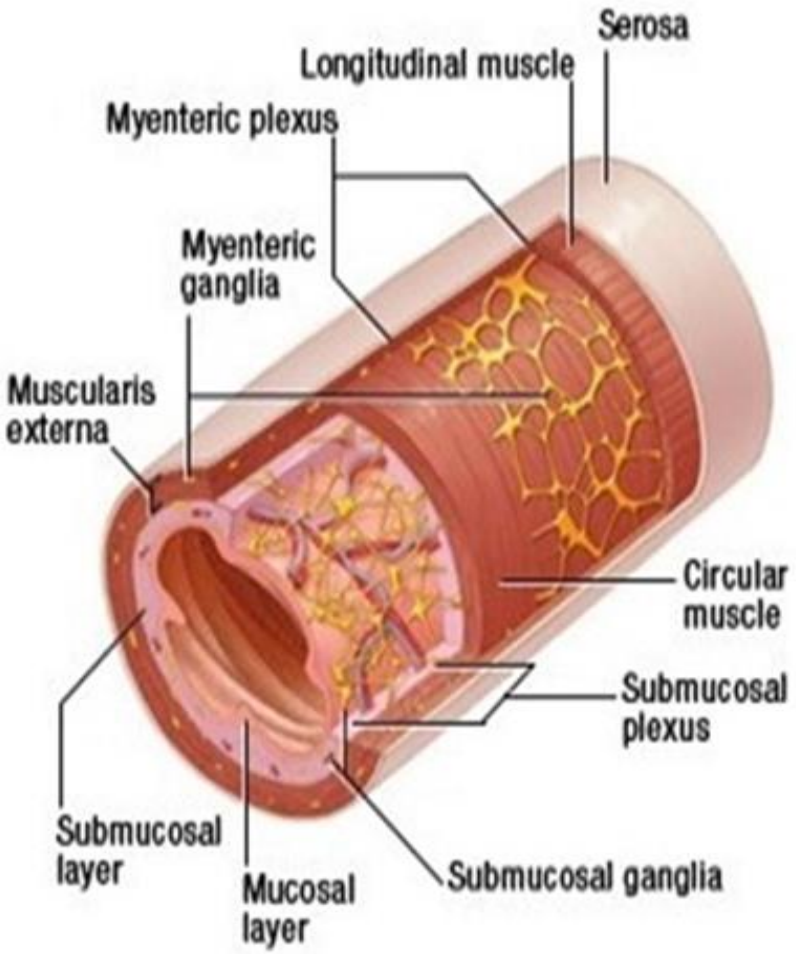
NE → ↓ motility, ↓ secretions, ↑ constriction of sphincters

An increase in sympathetic activity slows processes.

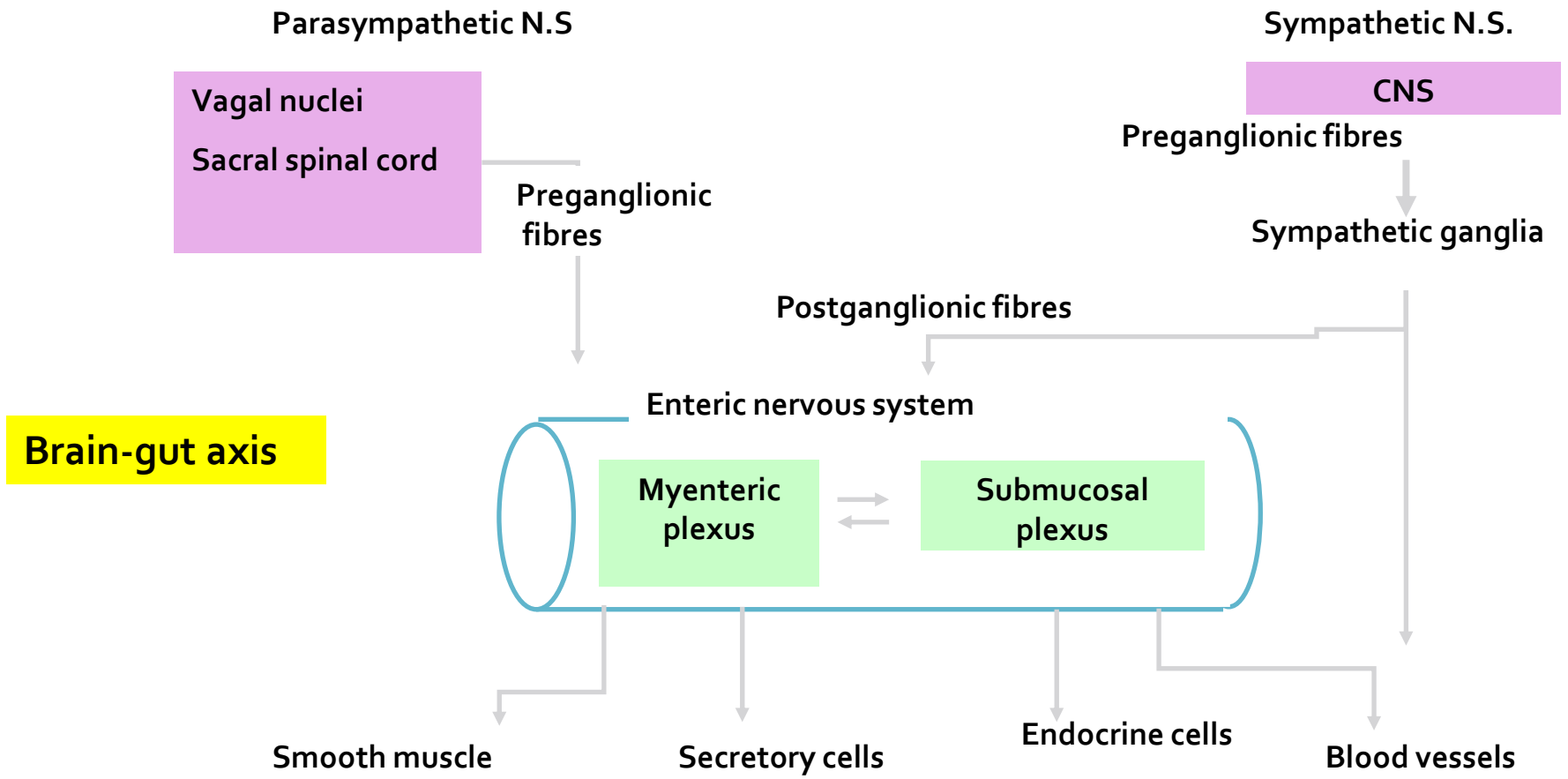
Intrinsic Neural Innervation

Enteric nervous system (little brain in the gut) is made up of two major plexuses:

- **Submucosal plexus is located within the GI submucosa and mostly regulates GI Secretion.**
- **Myenteric plexus is located between the circular and longitudinal muscle layers of the GI muscularis propria and mostly regulates GI motility.**

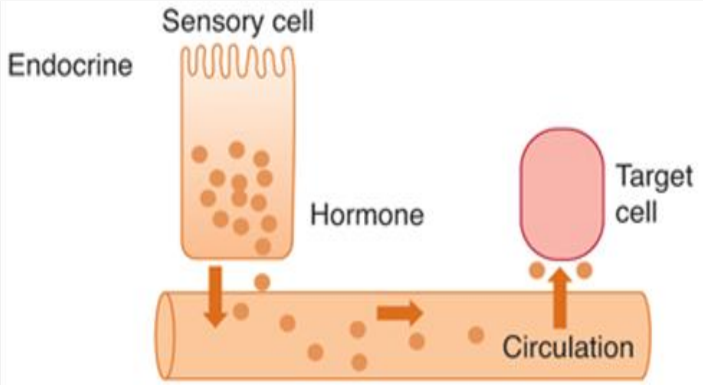


Enteric Nervous System



Endocrine regulation of GI function

- The hormone-secreting cells are called entero-endocrine cells (EECs).
  - Open
  - Closed (enterochromaffin-like (ECL))
- Based on structural and to a lesser extent functional similarity, there are two families of GI hormones:



Brain-gut peptides

Peptide hormone

Gastrin-CCK family

- Gastrin
- Cholecystokinin (CCK)

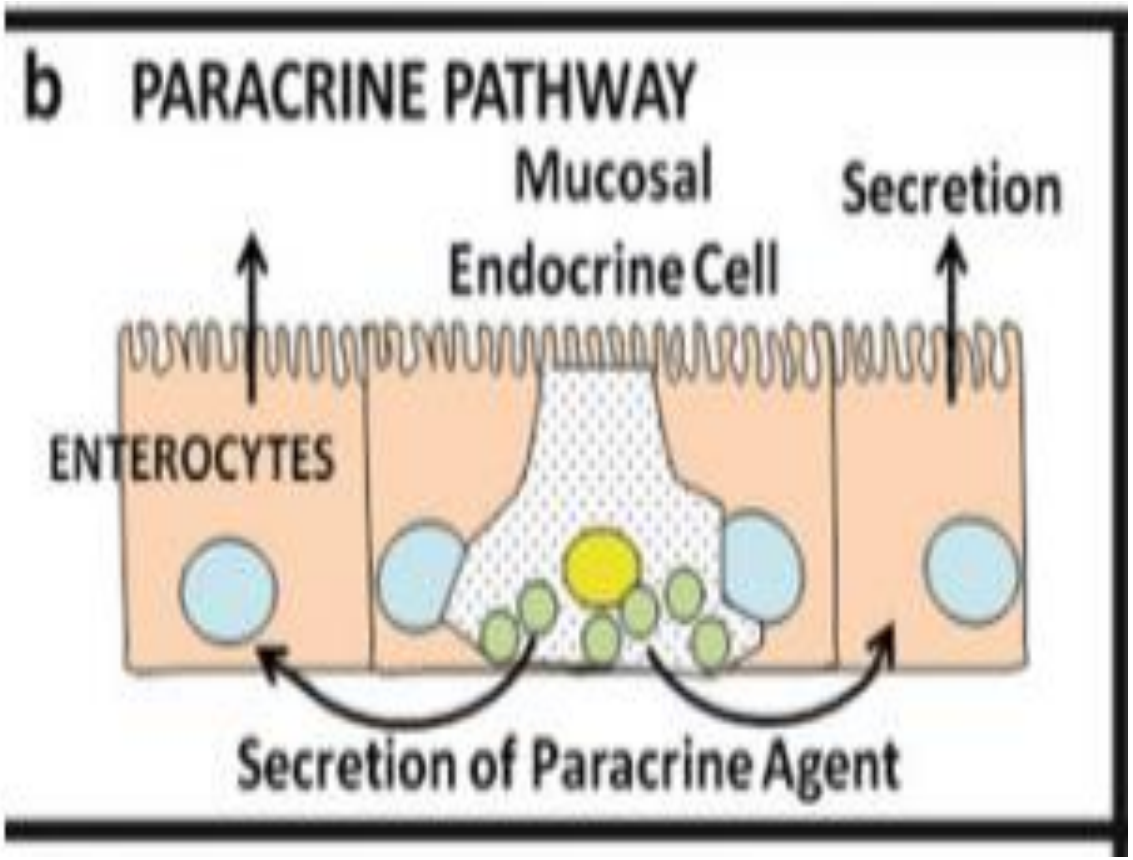
Secretin family

- Secretin
- Glucagon
- Glucose-dependent insulinotropic peptide (GIP)
- VIP

Many other peptide hormones have recently been identified, which are released by GI endocrine cells and influence gut functions:
Ghrelin, leptin, AngII, GLP1(incretin)

Paracrine regulation of GI function

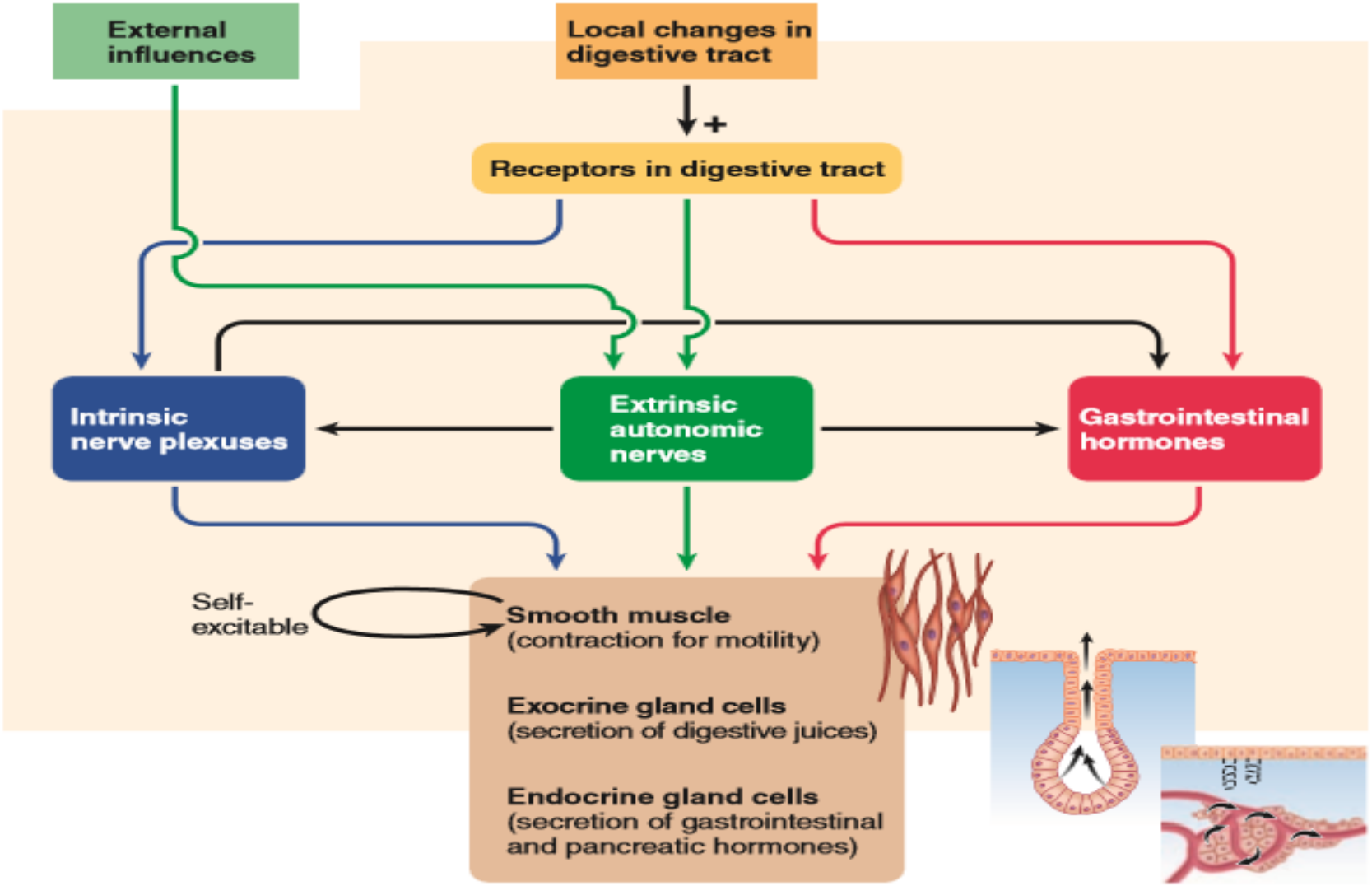
- Specialized entero-endocrine cells, called enterochromaffin-like (ECL) cells in the stomach secrete histamine that regulates gastric acid secretion.
- Some other paracrine actors – NO, PGs, adenosine.



The Endocrine Control of the GI System

Hormone	Stimuli for Secretion	Site of Secretion	Actions
Gastrin Endocrine	Protein Distention Nerve *(Acid inhibits release)*	G cells of the antrum, duodenum, and jejunum	Stimulates Gastric acid secretion Mucosal growth
Cholecystokinin Paracrine, endocrine	Protein Fat Acid	I cells of the duodenum, jejunum, and ileum	Stimulates Pancreatic enzyme secretion Pancreatic bicarbonate secretion Gallbladder contraction Growth of exocrine pancreas Inhibits Gastric emptying
Secretin Paracrine, endocrine	Acid Fat	S cells of the duodenum, jejunum, and ileum	Stimulates Pepsin secretion Pancreatic bicarbonate secretion Biliary bicarbonate secretion Growth of exocrine pancreas Inhibits Gastric acid secretion
Insulinotropic peptide (GIP) Gastric inhibitory peptide	Protein Fat Carbohydrate	K cells of the duodenum and jejunum	Stimulates Insulin release Inhibits Gastric acid secretion
Motilin	Fat Acid Nerve	M cells of the duodenum and jejunum	Stimulates Gastric motility Intestinal motility

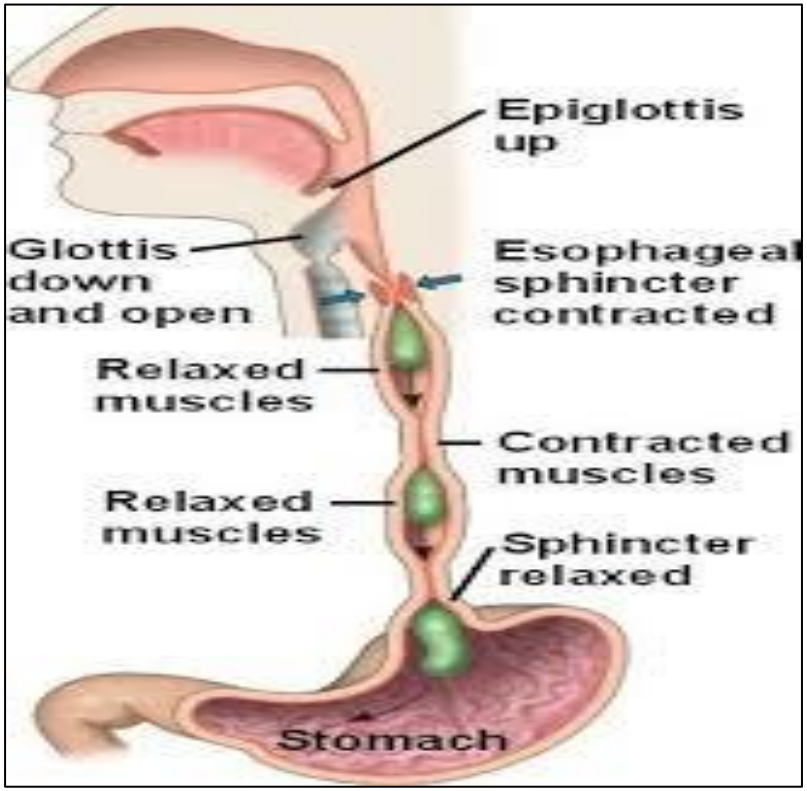
Summary of mechanisms controlling digestive system activities

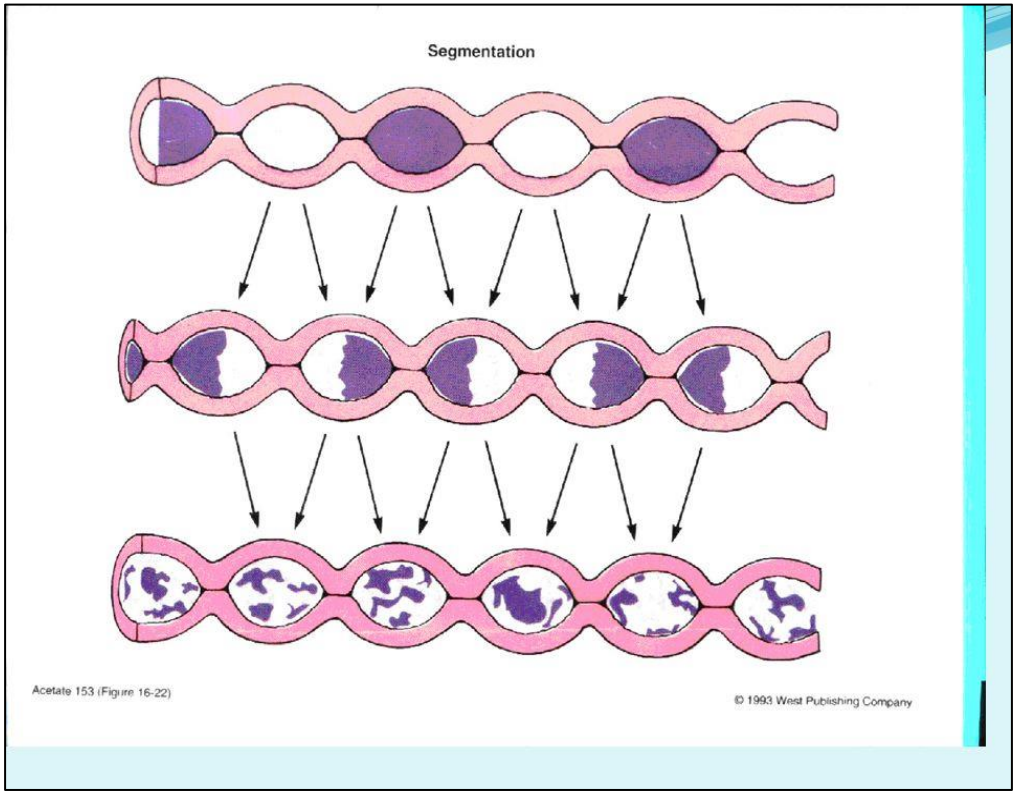


Basic mechanisms of GI motility

GI Motility

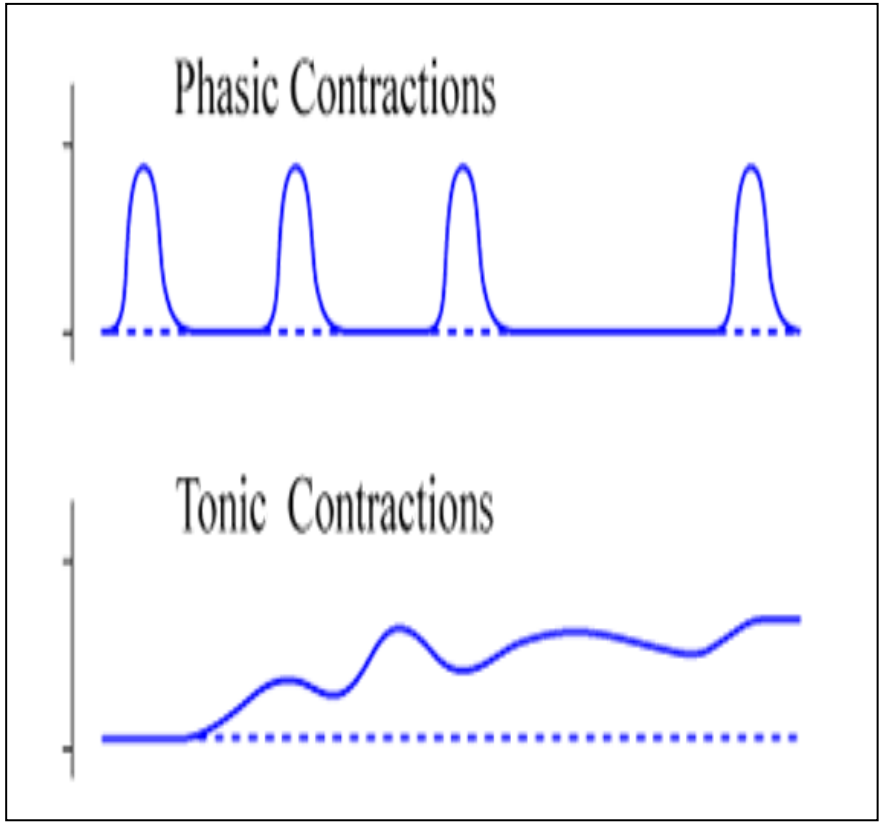
- Refers to contraction and relaxation of walls and sphincters of gastrointestinal tract
- GI Motility helps propel digested material through the alimentary tract
- GI Motility helps mix and grind digested material





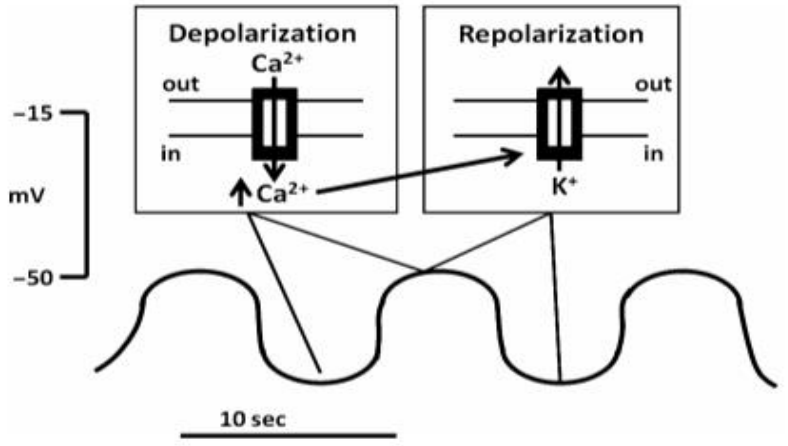
GI Motility Mechanisms

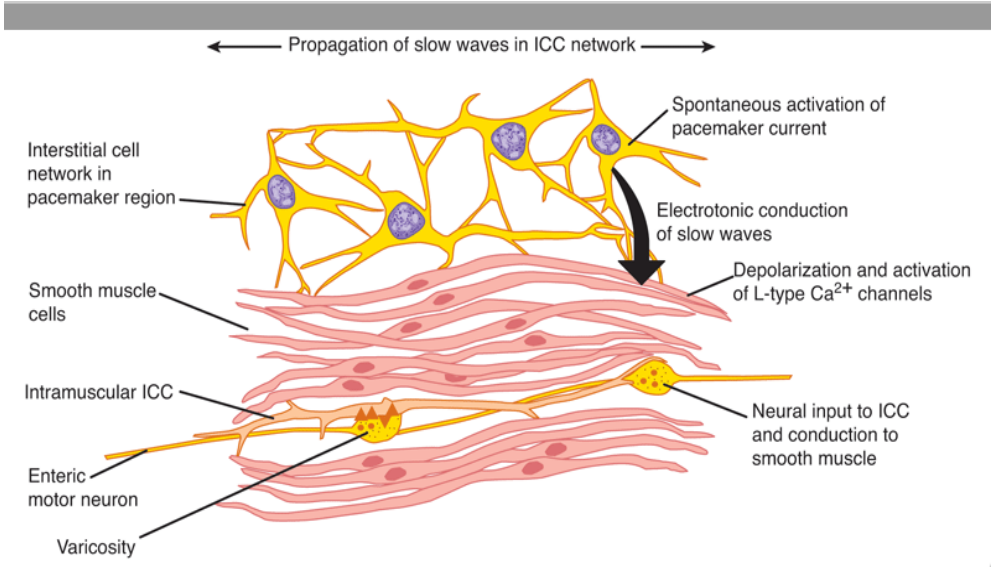
- What is the physical basis of all motility within the GI tract??
  - Regulation of contraction:
    - enteric nervous system (myenteric plexus)
    - autonomic nervous system
  - Muscular Subtypes:
    - Skeletal Muscle:
      - upper third of the esophagus, pharynx, and mouth as well as the outer anus.
    - Smooth Muscle
  - Muscular Geometry of Smooth Muscle:
    - circular pattern
    - longitudinal pattern
  - Muscular Contraction:
    - Tonic Contraction
    - Phasic (Rhythmic) Contraction



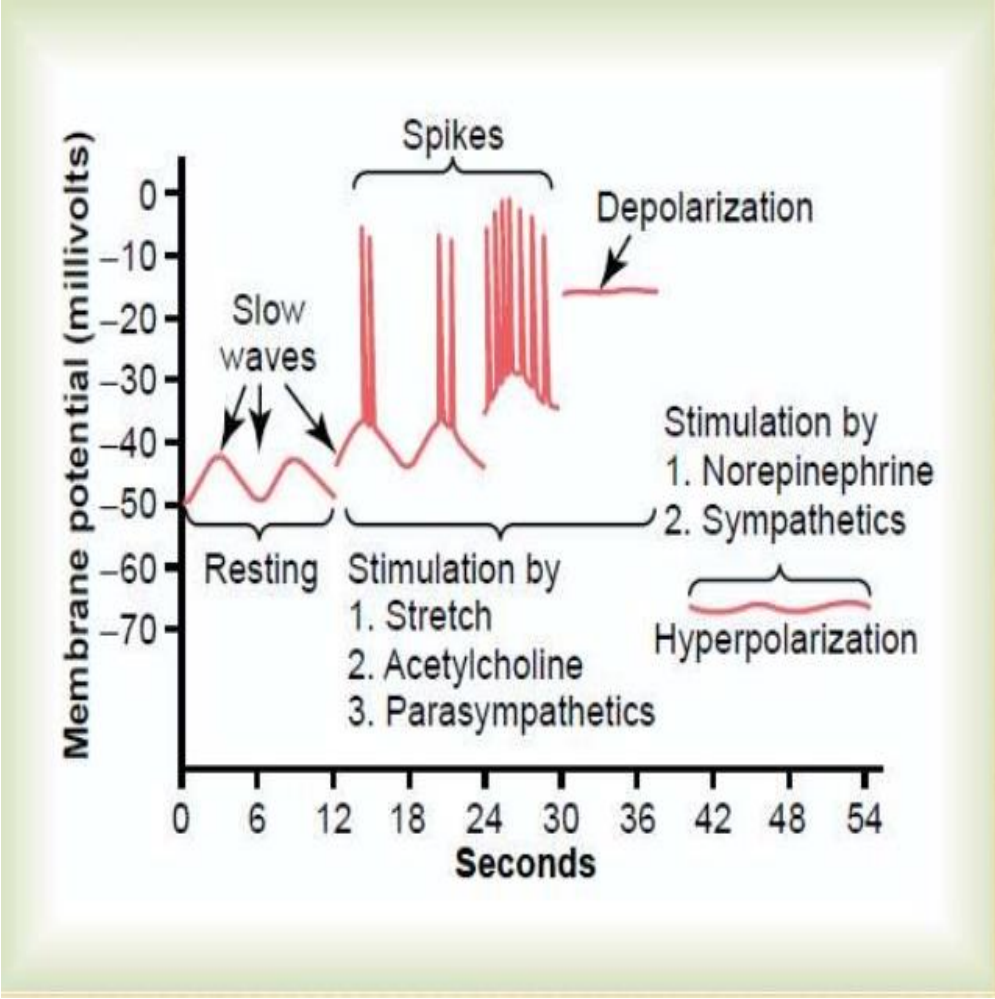
Slow waves and spike

- Two types of electrical activity are found in gut smooth muscle cells; they are
  - slow waves which contribute to the basic electrical rhythm (BER)
  - spike potentials.
- Origin of slow waves
  - occur at interstitial cells of Cajal:
    - Pacemaker
    - transmit information from enteric neurons to the smooth muscle cells
- The rate of slow wave (BER):
  - Stomach - 3/min
  - Duodenum ~ 12/min
  - Jejunum ~ 10/min
  - Ileum ~ 8/min





Slow waves and spike



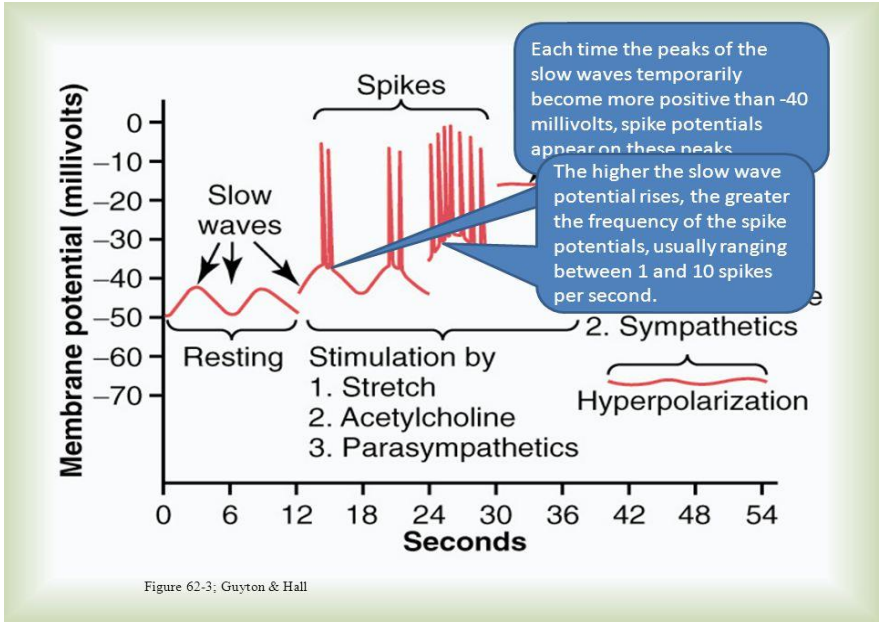
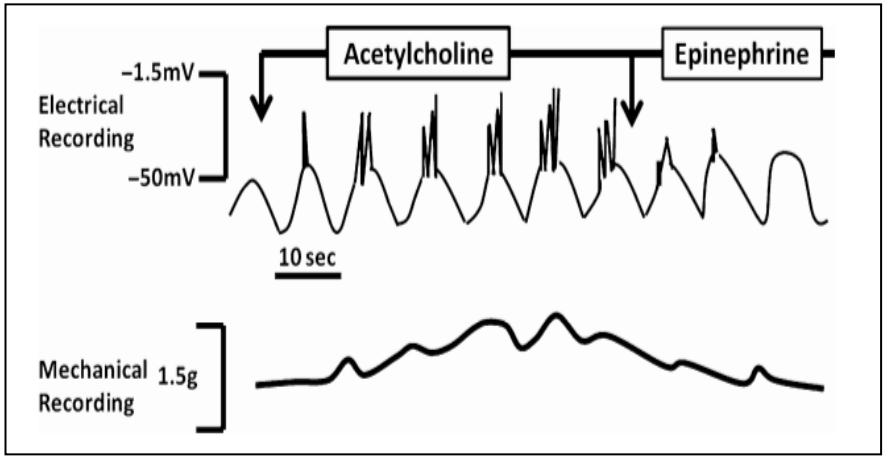
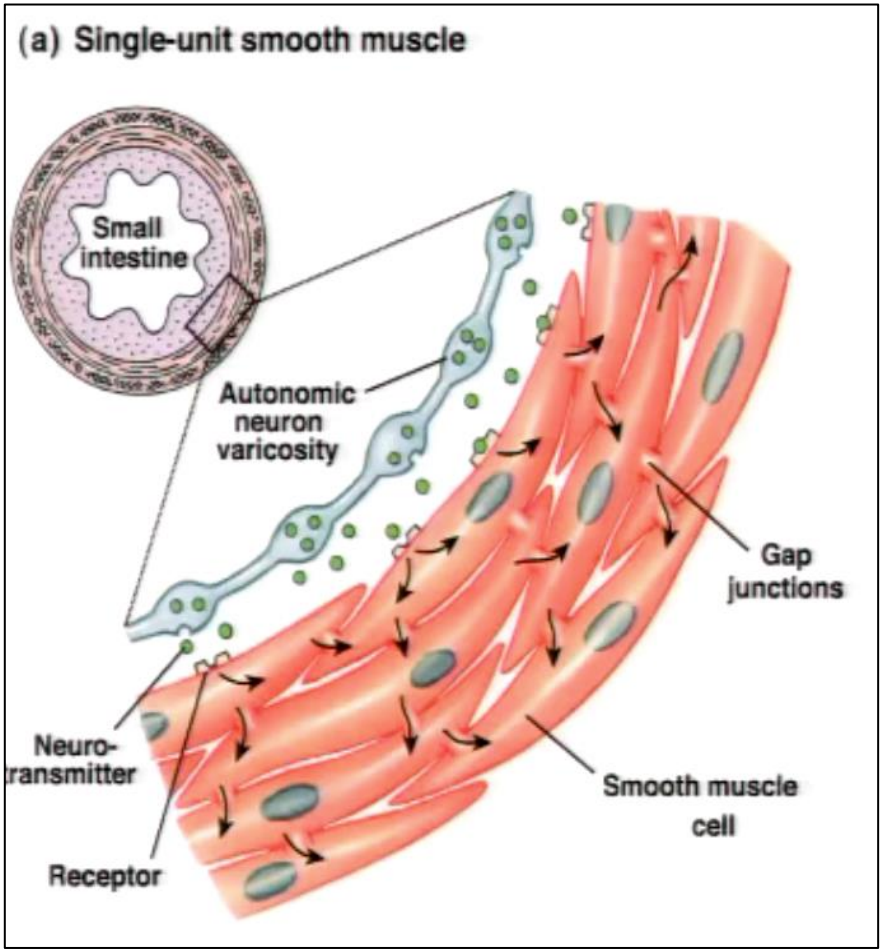
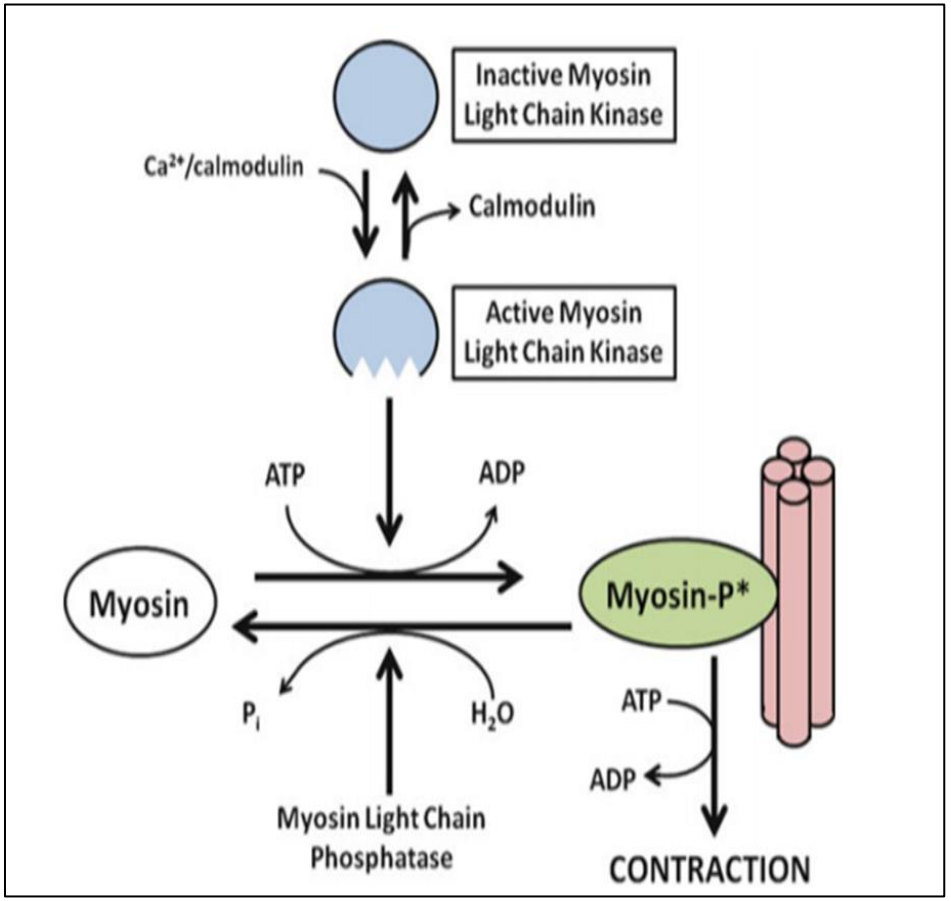


Figure 62-3; Guyton & Hall



Electrical Basis of GI Rhythmic Contractions





Types of Gut Motility