INTRODUCTION

**Before you start, have a look at the last bage.

FOUR PHYSIOLOGICAL PROCESSES ARE TAKING PLACE ALONG THE GASTROINTESTINAL (GI) TRACT. THESE INCLUDE:

1. MOTILITY.
2. SECRETION.
3. DIGESTION.
4. ABSORPTION

RELATED TO THESE PROCESSES:

CONTROL SYSTEMS OF GI FUNCTIONS.

-NEURAL CONTROL

-HORMONAL CONTROL

-BLOOD FLOW TO THE GI.

FUNCTIONAL STRUCTURES IN THE GASTROINTESTINAL TRACT:

1.Smooth muscle cells

2.Interstitial cells of Cajal

3.Secretory cells

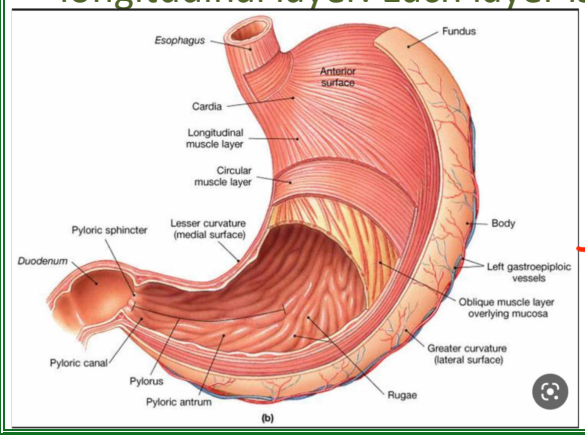
Smooth muscle cells:

2 main layers are generally forming Gastro-intestinal tract with some variations according to organ.

These layers are clearly seen in small intestine:

-Longitudinal layer: outer layer of smooth muscle cells arranged longitudinally along the digestive tract.

-Circular layer: extend circumferentially around the gut. Located beneath longitudinal layer. Each layer is forming a bundle like structure.



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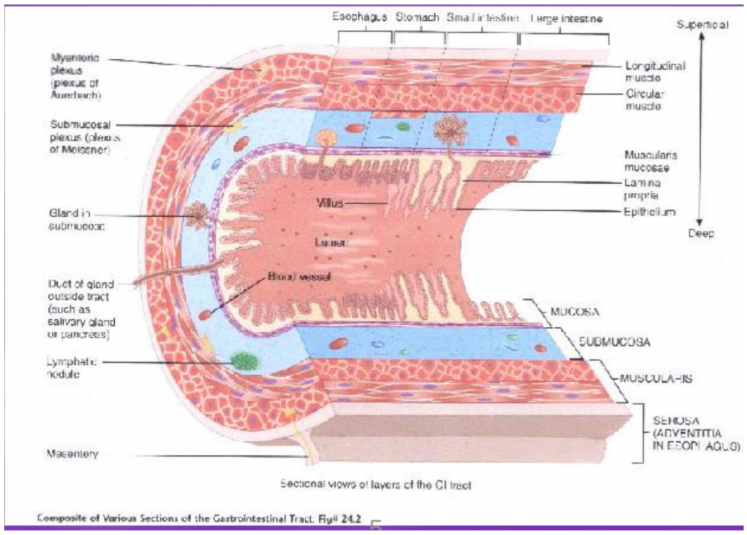
Cells in each bundle are connected together by **gap junctions** (1.Communication between cells 2.Functional syncytium) with permit these cells to function as syncytium(a large cell like structure formed by the joining toghether of two or more cells). Therefore, by this organization, a group of cells is functioning together to an effective contraction along gastro-intestinal tract. In addition to these two main layers, a third thin layer of smooth muscle cells is also described at the junction between the mucosa and submucosa which is known as **Muscularis mucosa**. This layer is involved in the *secretion from tubular glands and *movements of mucosal folds.



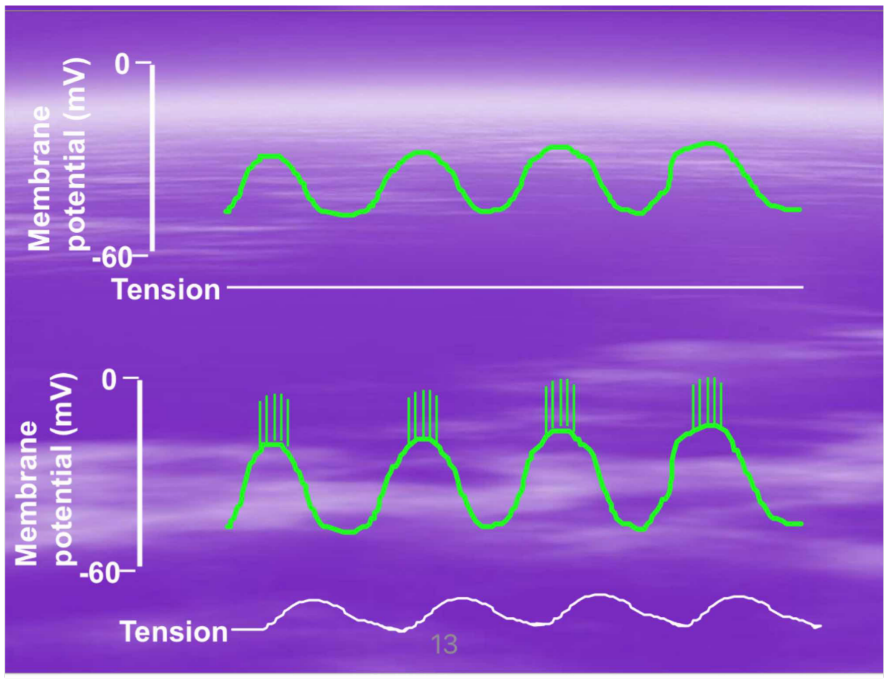
Sectional views of layers of the GI tract

Composite of Various Sections of the Gastrointestinal Tract. Fig# 24.2

Characteristics of smooth muscle cells:

*Electrical activity of smooth muscle:

Smooth muscle cells are characterized by the presence of slow waves (undulating changes in membrane potential known as **basic electrical rhythm** (BER)) and **spike potentials**. The spike potentials are the true action potentials that appear at the peak of slow waves.

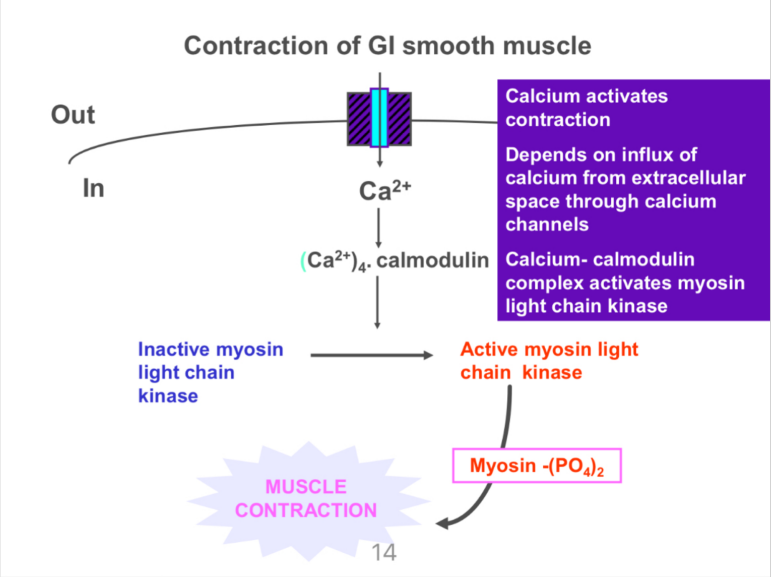


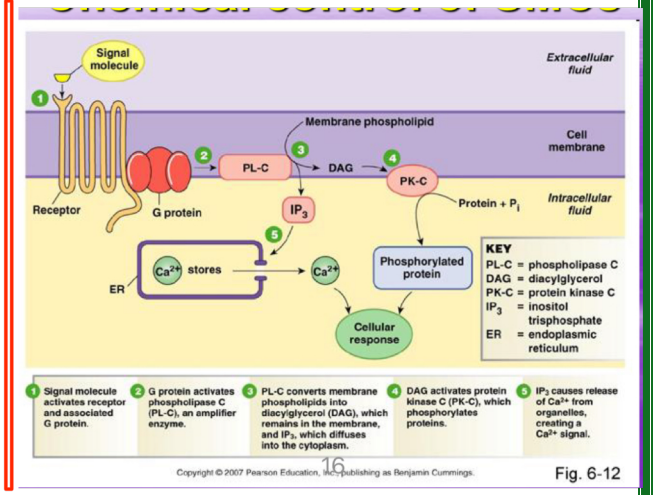
* Ca++ in smooth muscle cells contractions:

The role of calcium in smooth muscle contraction is known. The source of Ca++ for contraction is either from extracellular fluid or sarcoplasmic reticulum.

The entry of Ca++ from the interstitial fluid appears by activation of Ca++ channels. This activation is generated by **spike potentials** that occur at the peak of slow waves which represents the true action potentials at smooth muscle cells.

The release of Ca++ from sarcoplasmic reticulum occurs by formation of IP3 that results during signal transduction mechanisms by activation of phospholipase C 3 in response to binding of ligand (hormone or neurotransmitter) to its receptor. Ca++ acts via calmodulin to activate myosin filaments which results in developing of attractive forces between actin and myosin.





* Chemical control of smooth muscle cells activity:

Smooth muscle cells respond to a wide range of stimuli caused by neurotransmitter or hormones.

This activity appears by activation of receptors on smooth muscle cells. These transmitters may induce relaxation or contraction of smooth muscle cells.

Note: the response is according to the type of transmitter, type of receptor and the transduction mechanism involved in receptor activation.

Finally, integration of responses by smooth muscle cells by binding of ligands to their receptor will result in exhibition of **tonic(** contraction. Variations in the tonic contractions by increase or decrease in intens (the contractions that maintain the resting tone of our muscles).ity is seen along gastro-intestinal smooth muscle. In addition to these, also rhythmic contractions(When sufficient channels are simultaneously activated, the depolarization is large enough to activate VDCCs and the influx of Ca^{2+} produces a contraction).have also been described along gastro-intestinal tract (known also as **phasic** or **rhythmic** contractions). In the later type, a group of smooth muscle cells are exhibiting a rhythmical contractions and relaxations as we will see in small intestinal

motilities. These contractile activities are controlled mainly by the electrical rhythm that smooth muscle cells of the GI tract are displaying.

Summary of control for GI smooth muscle cells activity:

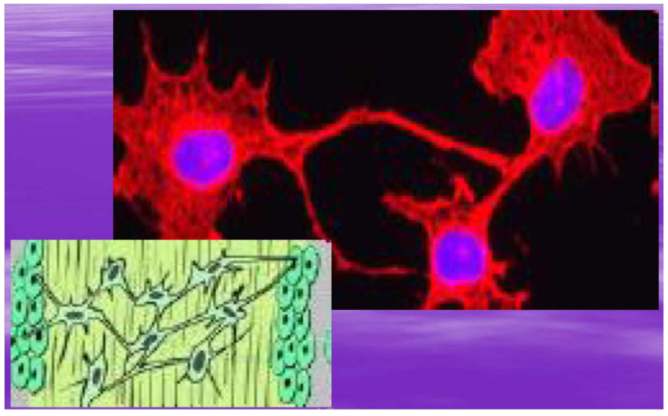
Smooth muscle cells activity is controlled by Electrical activity of smooth muscle cells: (slow waves and spike potentials).

Neurochemical control: represented by the response of smooth muscle cells of the GI to a large number of transmitters that are released by many types of neurons in the ENS.

To have an effective activity by smooth muscle cells of the GI tract, cells are functioning in syncytium (the activity is very well synchronized by organized contraction and relaxation at the segmental level which promote an efficient motility of the GI tract). The synchronization in part is provided by the ENS. In addition to these, the 4 cells of Cajal play also an important role in the synchronization of this activity.

Interstitial Cells of Cajal (ICCs):

Interstitial cells are widely spread all over the gastrointestinal tract. These cells have certain characteristics. They have large number of processes. Also, these cells communicate through these processes by gap junction with other ICCs as well as smooth muscle. In addition, these cells eliciting by themselves electrical activity as action potentials. All these have supported the theory of considering these cells as pacemaker cells of the gastro-intestinal tract.



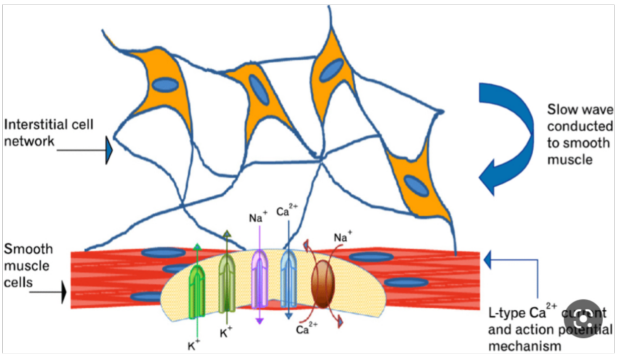
Characteristics of ICCs:

***ICCs communications:**

The ICCs-ICCs and ICCs-smooth muscle cells communication (by a gap junction) provide the basis for the synchronization of the electrical activity of smooth muscle cells as a group and consequently the harmony of contractile responses of smooth muscle cells. This will result in the functional syncytium of gastro-intestinal smooth muscle cells.

***ICCs generate slow wave:**

ICCs are excitable cells and elicit an electrical activity. These electrical activities have a sudden and periodical appearance of an upstroke from a constant resting potential of about –70mV. The initiation of these activities is believed to be metabolic dependent. The appearance of the upstroke is believed to cause the slow waves in smooth muscle cells that are in junction with ICCs or to regulate the rhythm of slow waves in smooth muscle cells.



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***ICCs also receive inputs from the ENS:**

In addition to their communication with smooth muscle cells, ICCs also receive inputs from the ENS. These inputs may give these cells an important role in mediating the activity to smooth muscle cells which promote a regulatory role of smooth muscle cells activity.

Secretory cells

These are represented as solitary cells that line the digestive tube or grouped in functional structures (known as glands). These cells are specialized in synthesis and secretion of organic substances that function as enzymes, hormones, factors or mucus. Some of these structures are secreting only water and electrolytes (this type is known as serous secretions). More details about secretory cells, their functions and regulation will be given with gastro-intestinal secretion.

Other related structures

1.Control systems of GI functions:

A.Neural control:

-Enteric nervous system

-Autonomic nervous system

B.Hormonal control: GI endocrine

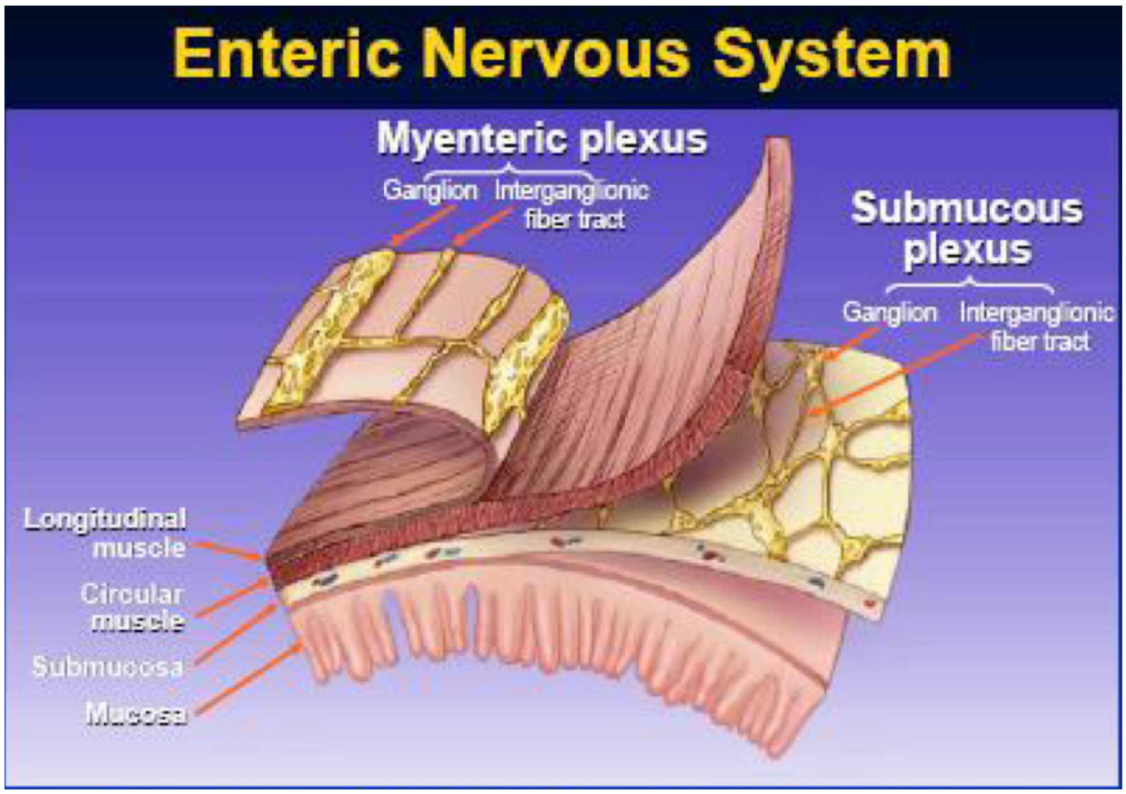
2.Blood flow to the GI.

Enteric nervous system:

(ENS) Beginning from the esophagus and extending along the entire GI tract, there is a neural network known as **Enteric Nervous System**. Neurons in this system are grouped into two main plexuses. One is located between longitudinal and circular smooth muscle layers known as myenteric plexus or Auerbach's plexus. The second plexus lies in submucosa and known as submucosal or Meissner's plexus. Neurons within each plexus are connected by nerve fibers that are projecting orally, caudally and circumferentially. Some neural fibers connect neurons from the two plexuses together.

Neurons from myenteric plexus usually control the activity smooth muscle cells from longitudinal and circular layer, and consequently, gastrointestinal movements. Submucosal plexus usually controls gastrointestinal secretion and local blood flow. Some neurons are considered sensory neurons that transmit signals from gastrointestinal epithelium to both enteric plexuses, prevertebral ganglia of sympathetic, spinal cord, and to brain stems through vagus nerve. These fibers are stimulated by excessive distension of the gut, irritation of the mucosa, or by specific chemical substances in the lumen.

Enteric neurons that control gastrointestinal functions contain transmitters that could have inhibitory or excitatory effects on motility, secretion, or vascular blood flow. Many types of transmitters have been identified in ENS, such as, Ach, SP (substance P), VIP (vasoactive intestinal peptide), CGRP (Calcitonin Gene Related Peptide), GRP (Gastrin Releasing Peptide), and many others.



Autonomic nervous system:

Parasympathetic nervous system: According to the location of neural cell bodies, it is divided into:

-Cranial division: provides innervations through vagus nerve to esophagus, stomach, pancreas, small intestine and first half of large intestine.

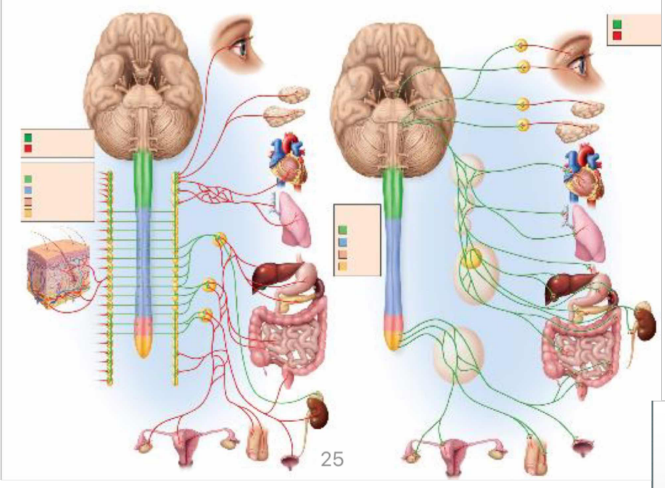
-Sacral division: Provides innervations through pelvic nerves to distal half of the colon, sigmoidal, rectum and anal region. Fibers in this division have importance in executing defecation reflex.

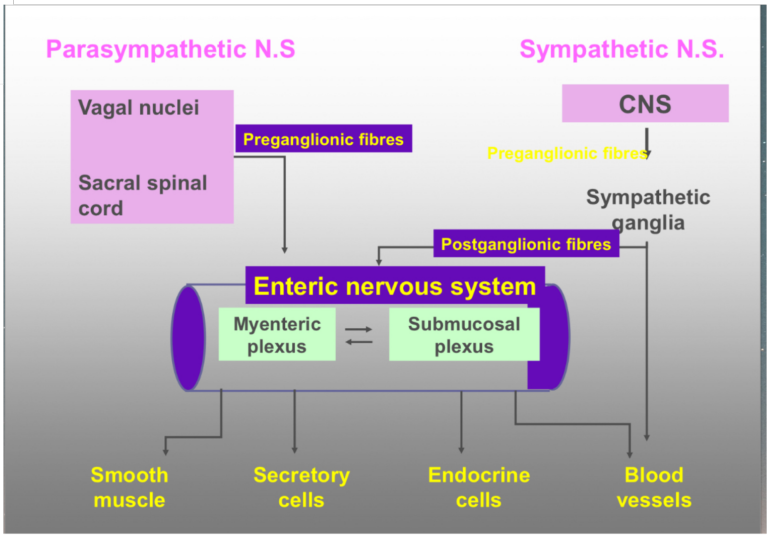
Generally, stimulation of parasympathetic system causes an increase in the activity of enteric nervous system and consequently, enhances the activity of the gastrointestinal functions. These include motility, secretion and blood flow.

Sympathetic nervous system:

Sympathetic fibers that innervate gastro-intestinal tract originate in the spinal cord (segments T5-L2). These fibers pass through paravertebral ganglia and synapse with the second neuron in celiac, superior mesenteric or inferior mesenteric ganglia.

Generally, stimulation of sympathetic system causes a decrease in the activity of enteric nervous system and GI smooth muscle cells.





Endocrine cells and Hormones in the GI.

Many hormones have been identified at the level of GI tract. Many of these have their function unidentified yet.

These hormones include:

Gastrin:

Cholecystokinin (CCK).

Secretin.

GIP (Gastric Inhibitory Peptide) other name is (Glucosedependent Insulino-tropic Polypeptide).

Others hormones are also secreted along Gastro-intestinal tract, including: Glucagon-like peptide-1(GLP-1), Motilin, Ghrelin, Amylin, Enterostatin, Neuropeptide Y (NPY), Pancreatic polypeptide which is closely related to polypeptide YY and NPY. In addition, scattered endocrine cells releasing Somatostatin, Neurotensin, Thyrotropin releasing hormone (TRH), Adrenocorticotropic hormone (ACTH) have been described along the GI tract.

Blood Flow and Local activities in the GI:

The blood flow to the gut is very well related to local activities. After meal the increase in absorption, secretion and motor activities is accompanied by an increase in blood flow. This increase continues during the next few hours after meal and return back over the next 2-4 hours.

Regulation of gastro-intestinal blood flow:

Possible factors that cause an increase in blood flow:

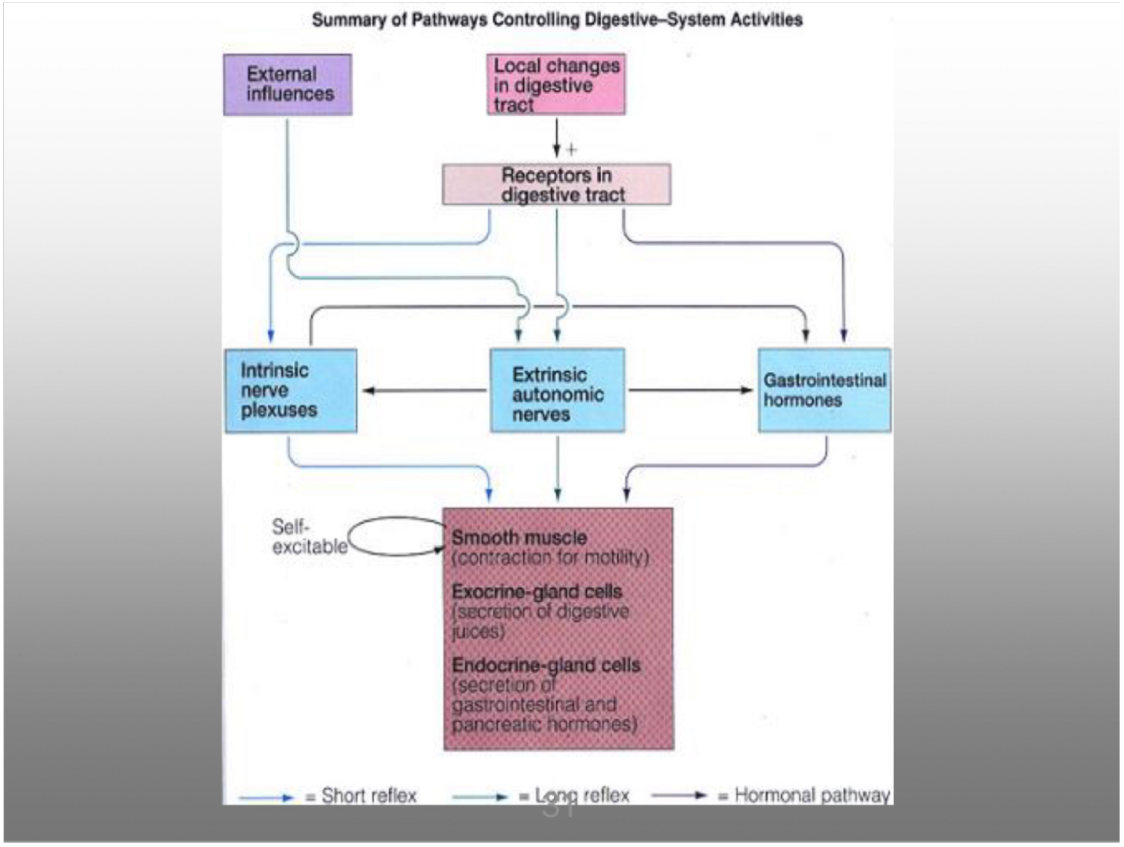
-The release of vasodilator substances after mucosal stimulation caused by meals. Such as, CCK, VIP, Gastrin and Secretin. These factors are also important in controlling smooth muscle cells activities.

-some glands release kinins (kallidin and bradykinin) into the lumen and the gut wall.

-Decreased oxygen concentration →increase blood flow possibly by the release of adenosine.

Like muscle activity, vascular flow is also under the control of enteric nervous system. Many transmitters are known to affect the vascular flow of the gastrointestinal tract, such as SP, VIP, CGRP, and others. These transmitters are released by neurons of the ENS.

The autonomic nervous system has also effects on the blood flow to the gut. Sympathetic stimulation causes vasoconstriction, which results in decreased blood flow, while parasympathetic system causes an increase in blood flow. Although, parasympathetic system has no direct effect on vessels, the effect of this system appears to be indirect by increasing glandular activity, which results in secretion of vasodilator mediators (such as kinins).



ملاحظة:المكتوب باللون الأخضر هو كلام الهانداوت نص حرفي.
المكتوب باللون الأسود من السلايدات
المكتوب بالأحمر من جوجل.

Done by:Rama Harb

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