

#1 General principles of GIT physiology

objectives :

- Physiologic anatomy of gastrointestinal wall.
- The general characteristics of smooth muscle.
- The specific characteristics of smooth muscle.
- Control of gastrointestinal function (ENS).
- Types of neurotransmitters secreted by enteric neurons.
- Functional types of movements in the gastrointestinal tract.
- Gastrointestinal blood flow (Splanchnic circulation).
- Effects of gut activity and metabolic factors on GI blood flow.



■ Doctors' notes

■ Extra

■ Important

Revised by

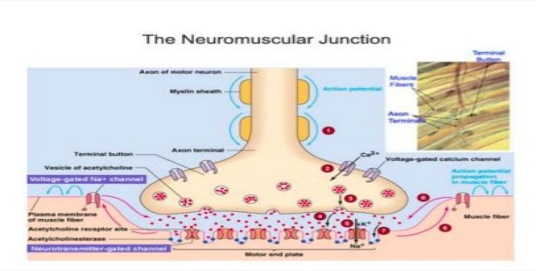
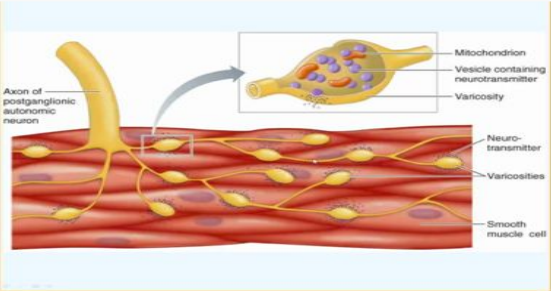
خولة العماري & هشام الغفيلي

Resources: 435 Boys' & Girls' slides | Guyton and Hall 12th & 13th edition

[Editing file](#)

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► **First of all, you have to know the difference between Skeletal and smooth muscles :**

Skeletal muscles	Smooth muscles
<ul style="list-style-type: none"> ● Nervous control ● Neuromuscular junctions 	<ul style="list-style-type: none"> ● Smooth muscle doesn't have the same striated arrangement as is found in skeletal muscle. ● They are arranged in bundles, each bundle is partially separated from the next by loose connective tissue. ● Stimulated by the autonomic nervous system ● Nerve endings branch with varicosities (dilated structures containing neurotransmitter vesicles) ● No myelin sheath 

Guyton corner : Comparison of Smooth Muscle Contraction and Skeletal Muscle Contraction

Although most skeletal muscles contract and relax rapidly, most smooth muscle contraction is prolonged tonic contraction, sometimes lasting hours or even days. Therefore, it is to be expected that both the physical and the chemical characteristics of smooth muscle versus skeletal muscle contraction would differ.

► **Parts and functions of gastrointestinal tract (GIT)**

❖ **Functions of GIT:**

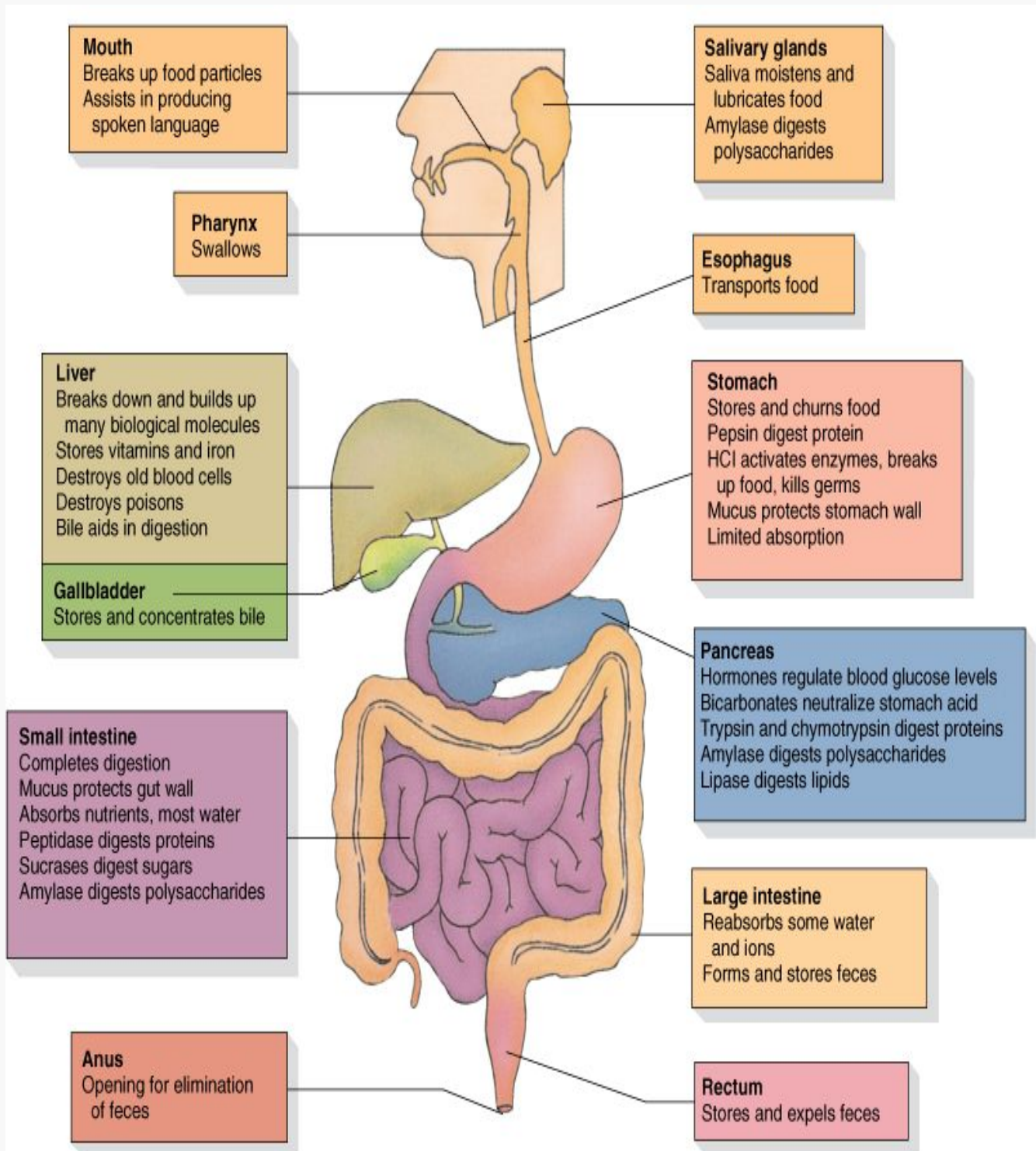
- Movement of food
- Secretion of digestive juice
- Digestion
- Absorption
- Circulation of blood
- Control of all these functions by local, nervous, and hormonal systems

❖ **The GIT provides the body with continuous supply of water, electrolytes, vitamins and nutrients.**

The GIT is a hollow tube that consists of different layers along its entire length, every part is specialized in term of structure and function.



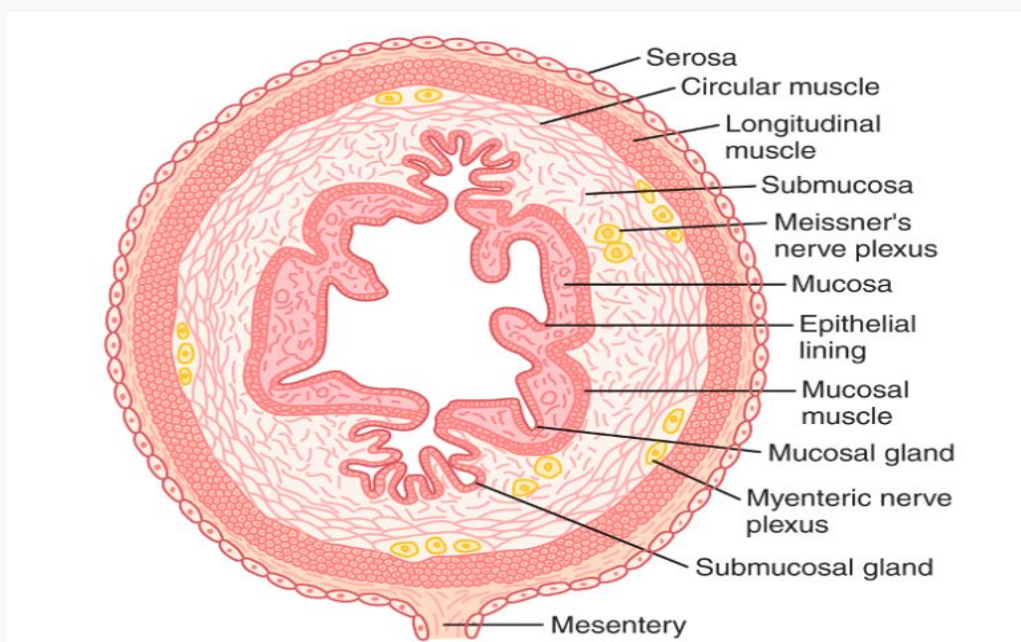
“This picture summarizes GIT structures and their main functions”



► Physiologic anatomy of gastrointestinal wall

More details in histology lecture

<p>❖ Mucosa</p>	<p>the innermost, moist, epithelial membrane that lines the entire digestive tract.</p> <ul style="list-style-type: none">● It secretes mucus, digestive enzymes, and hormones.● Absorb digestive end product into the blood.● Protects against infectious disease. <p>It consist of:</p> <ul style="list-style-type: none">● Lining epithelium: simple columnar epithelium and goblet cells.● Lamina propria: areolar C.T. with capillaries and lymphoid follicles.● Muscularis mucosa: thin layer, produces local movement of the mucosa.
<p>❖ Submucosa</p>	<p>Is a moderately dense connective tissue layer containing blood and lymphatic vessels, lymphoid follicles and nerve fibers.</p>
<p>❖ Muscularis externa</p>	<p>Typically consist of smooth muscle and is responsible for peristalsis and segmentation.</p> <p><u>It contains:</u> the myenteric plexus of Auerbach, the other major intrinsic nerve plexus.</p> <p><u>Located:</u> between the two layers of smooth muscle, controls motility of the GIT.</p> <p>Arranged in circular and longitudinal layers. The outer longitudinal is involved in peristalsis.</p>
<p>❖ Serosa</p>	<p>The protective outer layer of the intraperitoneal organs, is the visceral peritoneum</p>



► General and specific characteristics of smooth muscle

❖ The general characteristics :



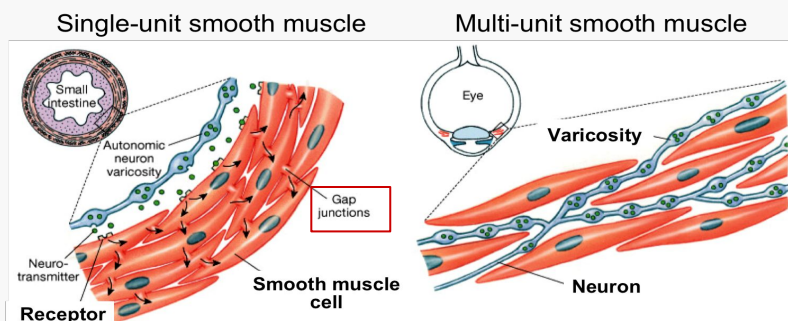
Types of smooth muscles

Multi-unit

- Each fiber can contract **independently**
- **Controlled mainly by nerve signals.**
- **Examples:**
ciliary & iris muscles in the eye,
piloerector muscles of the hair,
esophagus and gallbladder.

Single unit Unitary (syncytial or visceral smooth muscle)

- Mass of 100-1000 smooth muscle fibers
- Contract as a single unit in response to **stretch** (mechanical stimulus) مثل إذا امتلأت المعدة بالأكل هذا يكون المحفز في هذا النوع
- Arranged in sheets or bundles
- Cell membranes are adherent at multiple points
- Many **gap junctions** that allow ion movements so the whole muscle contracts at the same time
- When action potential is generated it **travel in all directions**
- **Examples:**
GIT, stomach, intestine, bile ducts, ureters, uterus, blood vessels.

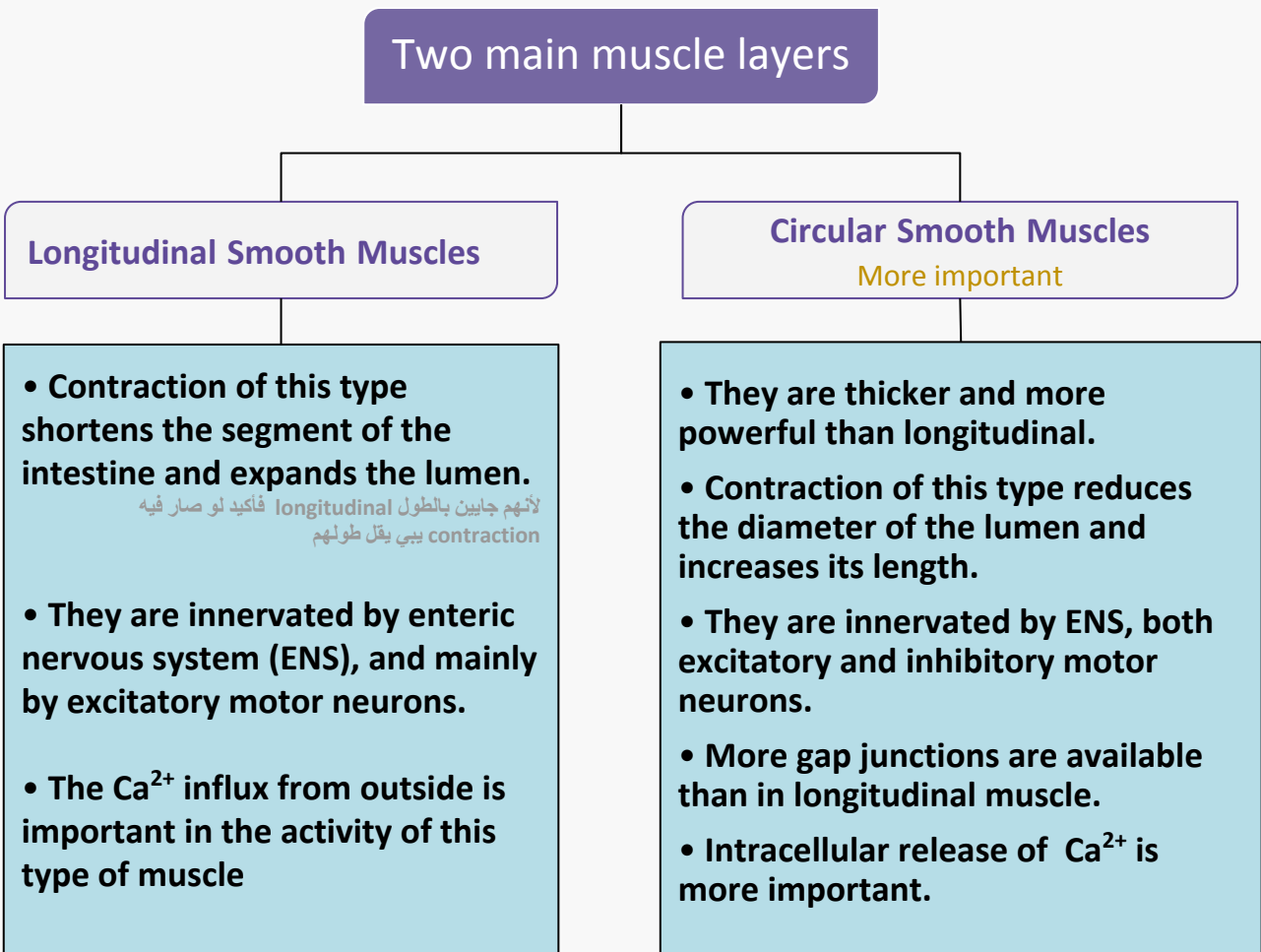
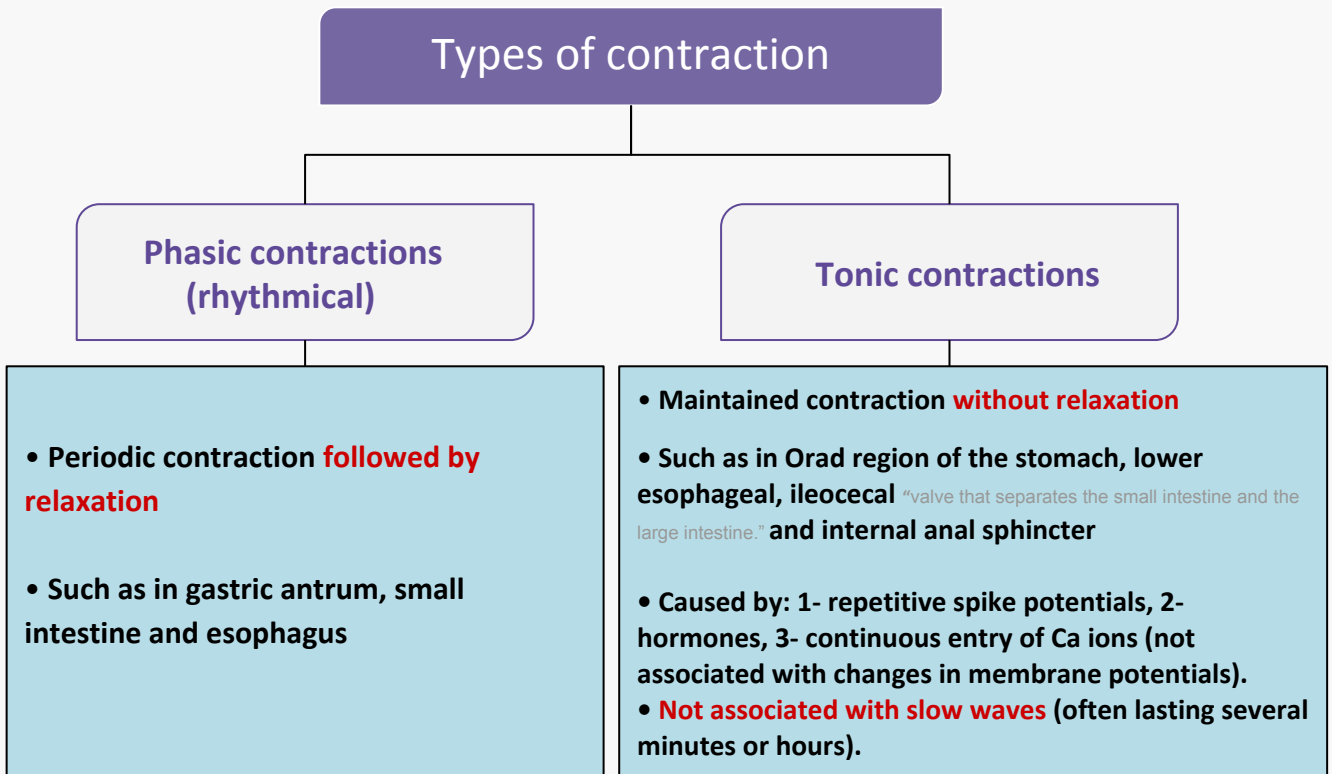


Guyton corner : Multi-unit smooth muscle: is composed of discrete, separate smooth muscle fibers. Each fiber operates independently of the others and often is innervated by a single nerve ending, as occurs for skeletal muscle fibers. Further, the outer surface of these fibers, like those of skeletal muscle fibers, are covered by a thin layer of basement membrane - like substance, a mixture of fine collagen and glycoprotein that helps insulate the separate fibers from one another.

Unitary smooth muscle: is also known as syncytial smooth muscle because of its syncytial interconnections among fibers. It is also called visceral smooth muscle because it is found in the walls of most viscera of the body.

► General and specific characteristics of smooth muscle

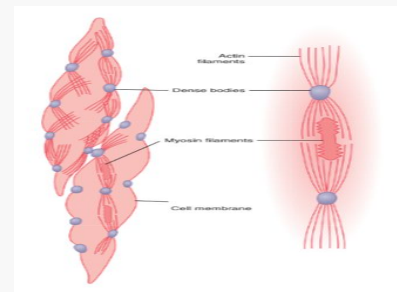
❖ The general characteristics (Cont.) :



❖ The specific characteristics of smooth muscle:

(1) GI smooth muscle functions as a syncytium :

- Each muscle layer functions as a **syncytium**; that is, when an action potential is elicited anywhere within the muscle mass, it generally travels in all directions.
- There are large numbers of actin filaments attached to so called dense bodies.
- Some of these bodies are attached to the cell membrane.
- Others are dispersed inside the cell.
- Some of the dense bodies of adjacent cells are bonded together by intracellular protein bridges through these bonds that the force of contraction is transmitted from one cell to the next (**gap junction**).
- Slow cycling of the myosin cross-bridges
- Low energy requirements
- Slowness of onset of contraction and relaxation.
- Greater max. force of contraction.
- **Latch mechanism: Tonic contraction; meaning the contraction needs less energy and it's long lasting in contrast to the rapid contraction and relaxation of skeletal muscle that actually needs more energy.** "For better understanding, read guyton corner in page 10"
- **Stress-relaxation: A good example of this is when the bladder fills up with urine, as the pressure builds up in the bladder, if you're not ready for micturition, stress relaxation will relax the walls of the bladder and the urge to urinate will fade for a while before the bladder fills up again.**
- **Reverse stress-relaxation: If we were to continue with the bladder example, reverse stress relaxation would be the contraction of the bladder following its emptying (when pressure drops and there's no need for relaxation)**



Guyton corner : Gastrointestinal Smooth Muscle Functions as a Syncytium.

In the *longitudinal muscle layer*, the bundles extend longitudinally down the intestinal tract; in the *circular muscle layer*, they extend around the gut.

Within each bundle, the muscle fibers are electrically connected with one another through large numbers of *gap junctions* that allow low-resistance movement of ions from one muscle cell to the next. Therefore, electrical signals that initiate muscle contractions can travel readily from one fiber to the next within each bundle but more rapidly along the length of the bundle than sideways.

Each bundle of smooth muscle fibers is partly separated from the next by loose connective tissue, but the muscle bundles fuse with one another at many points, so in reality each muscle layer represents a branching latticework of smooth muscle bundles. Therefore, each muscle layer functions as a **syncytium**; that is, when an action potential is elicited anywhere within the muscle mass, it generally travels in all directions in the muscle. The distance that it travels depends on the excitability of the muscle; sometimes it stops after only a few millimeters and at other times it travels many centimeters or even the entire length and breadth of the intestinal tract.

Also, a few connections exist between the longitudinal and circular muscle layers, so excitation of one of these layers often excites the other as well.

(2) Electrical activity of GI smooth muscle :



- There is continuous slow intrinsic electrical activity
- Most GI contractions occur rhythmically
- Rhythm is determined by the frequency of slow waves

Smooth muscle resting potential is -50mV to -60mV (that of skeletal muscles is -90mV)

Guyton corner : Electrical Activity of Gastrointestinal Smooth Muscle

The smooth muscle of the gastrointestinal tract is excited by almost continual slow, intrinsic electrical activity along the membranes of the muscle fibers. This activity has two basic types of electrical waves: (1) *slow waves* and (2) *spikes*. In addition, the voltage of the resting membrane potential of the gastrointestinal smooth muscle can be made to change to different levels, and this, too, can have important effects in controlling motor activity of the gastrointestinal tract.

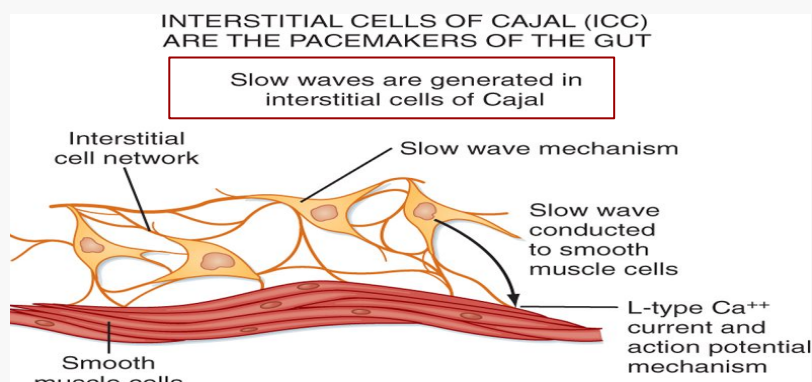
- There are two basic types of electrical waves:

❖ Slow waves:

- Are changes in resting membrane potential
- **Are not** action potentials
- Their intensity: **5-15 mv**
- Frequency: **3-12/min** (Stomach **3/min**, duodenum **12/min** and ileum **8-9/min**)
Caused by interaction between smooth muscle cells & interstitial cells of Cajal

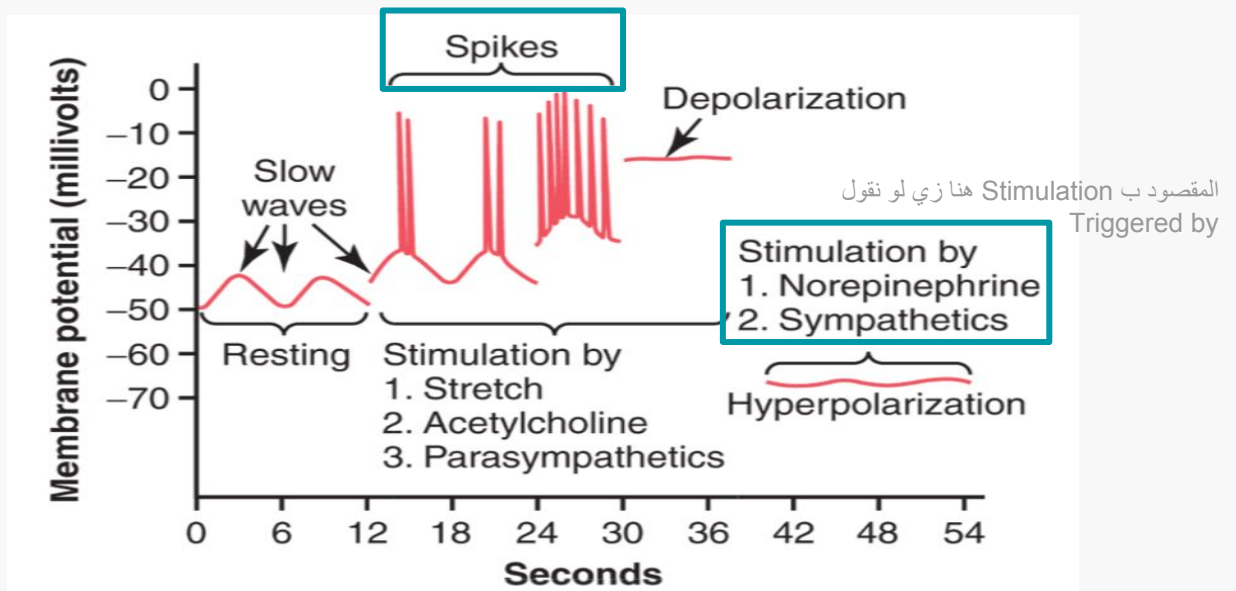
- more slow wave contractions, due to its small size and it only functions in admixing enzymes with churns of food) .
- cells of Cajal resemble dendritic cells and act as heart pacemaker (they depolarize cells).

- **Do not** by themselves cause muscle contractions
- **Do not** cause calcium ions to enter (**only sodium ions**)
- Mainly excite the appearance of intermittent spike potentials
They **DO NOT** exceed the **threshold of contraction**.



❖ Spike potential :

- Are **TRUE** action potentials
- Occur when resting membrane potential become **more positive than -40 mv** (Normal range **-50mv to -60mv**) appear on the peaks.
- The **HIGHER** the slow wave potential the **GREATER** the frequency (**1-10 spikes/sec**)
- Channels responsible for action potential are **calcium-sodium channels**
- These channels are much slower to open and close
- They allow large number of Calcium ions to enter + smaller number of sodium ions
- They cause **muscle contraction**
- **Hyperpolarization** triggered by : 1) **Norepinephrine** 2) **Sympathetic NS.**



Guyton's discription of this picture :

Membrane potentials in intestinal smooth muscle. Note the slow waves, the spike potentials, total depolarization, and hyperpolarization, all of which occur under different physiologic conditions of the intestine.

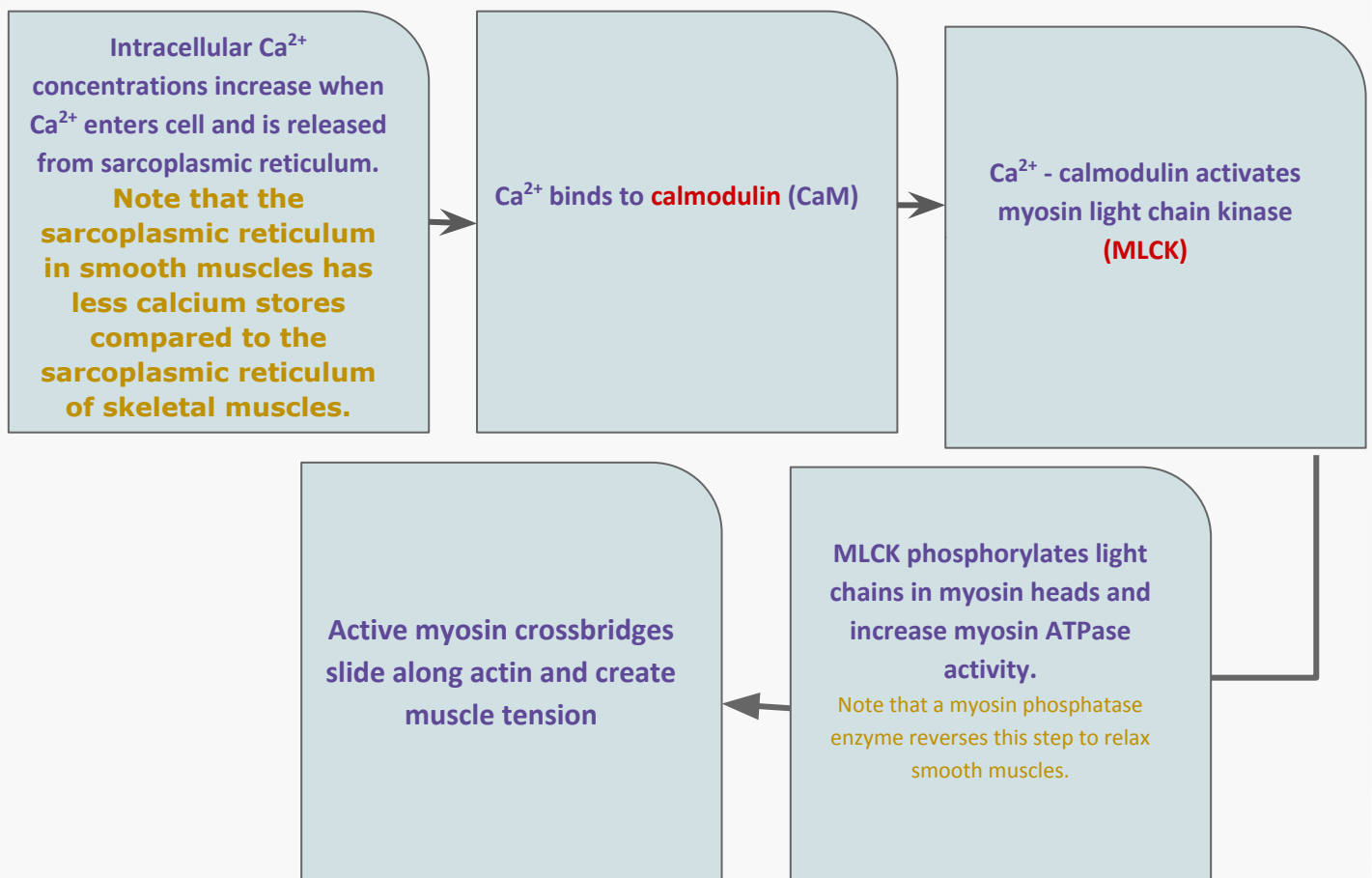
- We can conclude that there are 2 main characteristics of the GI smooth muscles :
1- GI smooth muscle functions as syncytium (Page 7)
2- Electrical activity of smooth muscles (Slow wave & spike potentials)

Guyton corner :

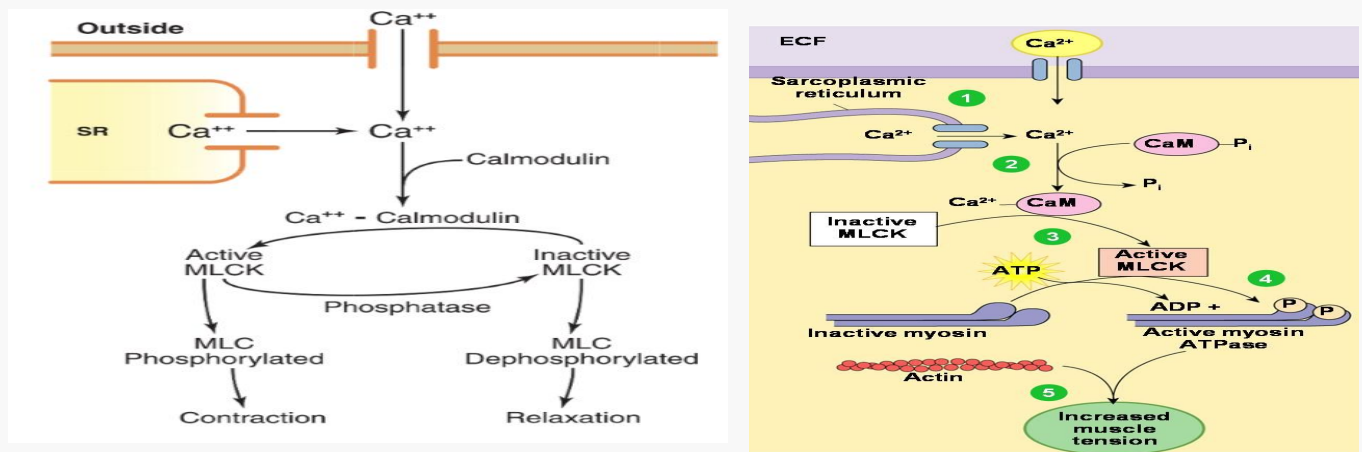
Latch mechanism: facilitates prolonged holding of contractions of smooth muscle. Once smooth muscle has developed full contractions, the amount of continuing excitation can usually be reduced to far less than the initial level even though the muscle maintains its full force of contraction. Further, the energy consumed to maintain contraction is often minuscule, sometimes as little as 1/300 the energy required for comparable sustained skeletal muscle contraction. The importance of the latch mechanism is that it can maintain prolonged tonic contraction in smooth muscle for hours with little use of energy.

Stress-Relaxation of Smooth Muscle. Another important characteristic of smooth muscle, especially the visceral unitary type of smooth muscle of many hollow organs, is its ability to return to nearly its original *force* of contraction seconds or minutes after it has been elongated or shortened. For example, a sudden increase in fluid volume in the urinary bladder, thus stretching the smooth muscle in the bladder wall, causes an immediate large increase in pressure in the bladder. However, during the next 15 seconds to a minute or so, despite continued stretch of the bladder wall, the pressure returns almost exactly back to the original level. Then, when the volume is increased by another step, the same effect occurs again. Conversely, when the volume is suddenly decreased, the pressure falls drastically at first but then rises in another few seconds or minutes to or near to the original level. These phenomena are called *stress-relaxation* and *reverse stress-relaxation*. Their importance is that, except for short periods of time, they allow a hollow organ to maintain about the same amount of pressure inside its lumen despite long-term, large changes in volume.

► Mechanism of smooth muscle contraction :



Mechanism of smooth muscle contraction (EXTRA)



(Figure 8-3)

Guyton corner : As is true for skeletal muscle, the initiating stimulus for most smooth muscle contraction is an increase in intracellular calcium ions. This increase can be caused in different types of smooth muscle by nerve stimulation of the smooth muscle fiber, hormonal stimulation, stretch of the fiber, or even change in the chemical environment of the fiber. Yet smooth muscle does not contain troponin, the regulatory protein that is activated by calcium ions to cause skeletal muscle contraction. Instead, smooth muscle contraction is activated by an entirely different mechanism, as follows.

Calcium Ions Combine with Calmodulin to Cause Activation of Myosin Kinase and Phosphorylation of the Myosin Head.

In place of troponin, smooth muscle cells contain a large amount of another regulatory protein called *calmodulin* (Figure 8-3). Although this protein is similar to troponin, it is different in the manner in which it initiates contraction. Calmodulin does this by activating the myosin cross-bridges. This activation and subsequent contraction occur in the following sequence:

1. The calcium ions bind with calmodulin.
2. The calmodulin-calcium complex then joins with and activates *myosin light chain kinase*, a phosphorylating enzyme.
3. One of the light chains of each myosin head, called the *regulatory chain*, becomes phosphorylated in response to this myosin kinase. When this chain is not phosphorylated, the attachment-detachment cycling of the myosin head with the actin filament does not occur. But when the regulatory chain is phosphorylated, the head has the capability of binding repetitively with the actin filament and proceeding through the entire cycling process of intermittent “pulls,” the same as occurs for skeletal muscle, thus causing muscle contraction.

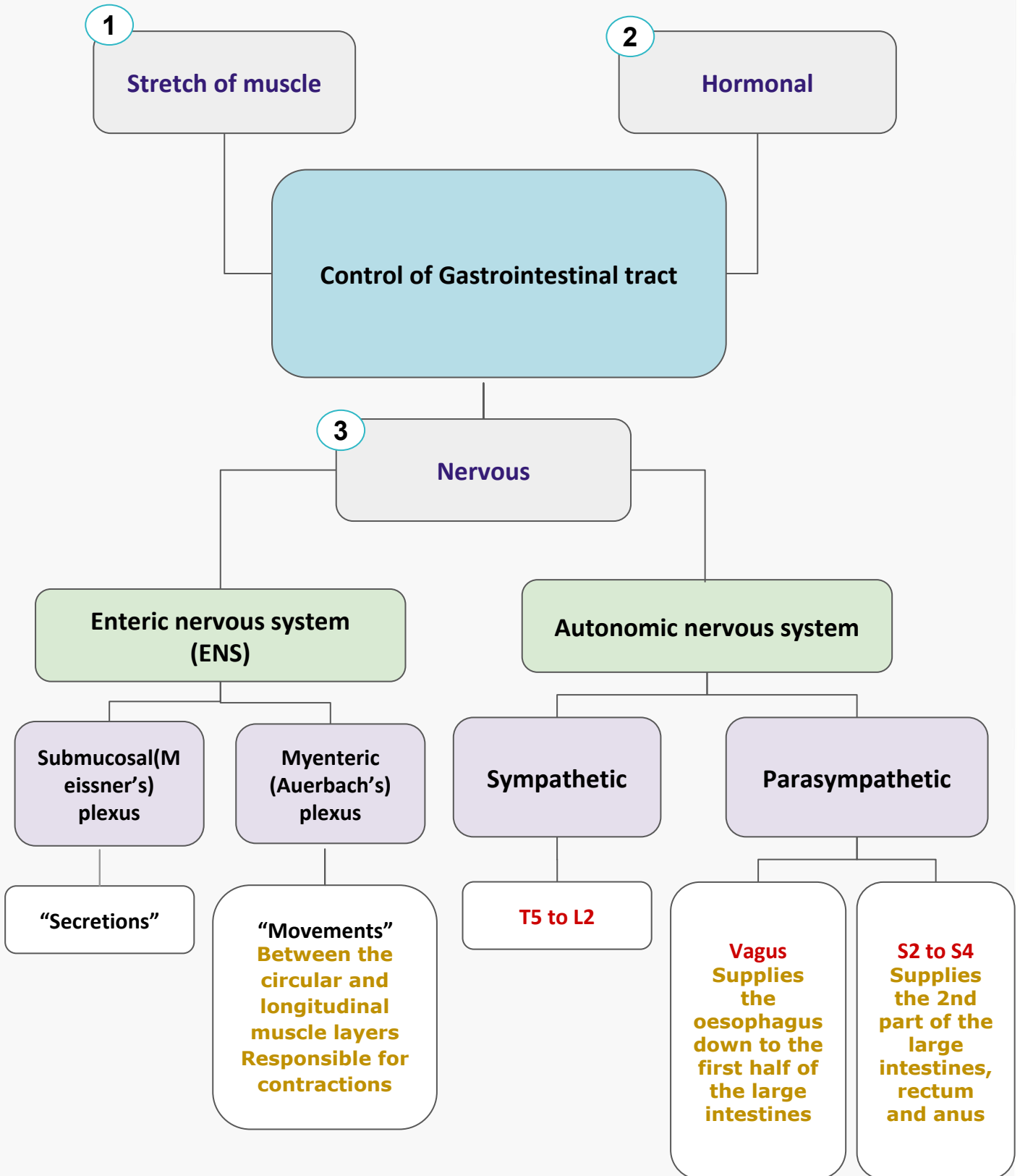
Myosin Phosphatase Is Important in Cessation of Contraction.

When the calcium ion concentration falls below a critical level, the aforementioned processes automatically reverse, except for the phosphorylation of the myosin head. Reversal of this requires another enzyme, *myosin phosphatase* (see Figure 8-3), located in the cytosol of the smooth muscle cell, which splits the phosphate from the regulatory light chain. Then the cycling stops and contraction ceases. The time required for relaxation of muscle contraction, therefore, is determined to a great extent by the amount of active myosin phosphatase in the cell.

Possible Mechanism for Regulation of the Latch Phenomenon

Because of the importance of the latch phenomenon in smooth muscle, and because this phenomenon allows longterm maintenance of tone in many smooth muscle organs without much expenditure of energy, many attempts have been made to explain it. Among the many mechanisms that have been postulated, one of the simplest is the following. When the myosin kinase and myosin phosphatase enzymes are both strongly activated, the cycling frequency of the myosin heads and the velocity of contraction are great. Then, as the activation of the enzymes decreases, the cycling frequency decreases, but at the same time, the deactivation of these enzymes allows the myosin heads to remain attached to the actin filament for a longer and longer proportion of the cycling period. Therefore, the number of heads attached to the actin filament at any given time remains large. Because the number of heads attached to the actin determines the static force of contraction, tension is maintained, or “latched”; yet little energy is used by the muscle because ATP is not degraded to ADP except on the rare occasion when a head detaches.

► Control of gastrointestinal function :



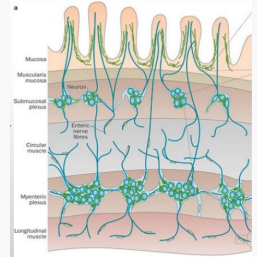
Clinical Case:

What would happen if the enteric nervous system isn't functioning?
[Hirschsprung Disease](#)

► Enteric nervous system(ENS) : (the 3rd division of ANS)



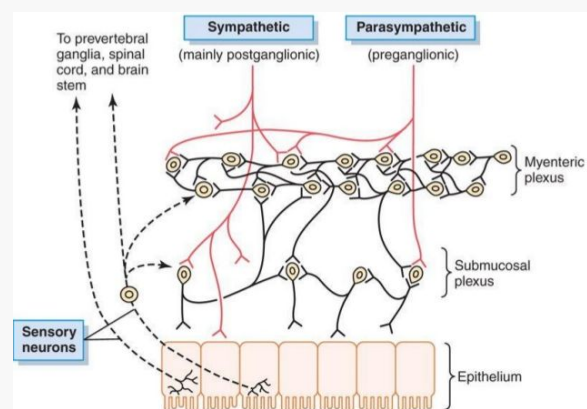
- Also called **little brain** because it can act autonomously (independently).
- Lies in the wall of the gut, beginning in the esophagus and extending all the way to the anus and contain 100 million neurons
- Sympathetic and parasympathetic fibers connect **ENS to CNS**
- It has many types of neurotransmitters like : **Ach,NE,GABA,serotonin,dopamine,cck,VIP..etc.**
- It has 2 main parts :
 1. **Myenteric or Auerbach's plexus** → **controls movements and contraction**
 2. **Submucosal or Meissner's plexus** → **controls secretions**



	Myenteric (Auerbach's) plexus	Submucosal (Meissner's) plexus
Layer	Muscularis externa	Submucosa
Location	A linear chain of interconnecting neurons <u>between longitudinal and circular muscles</u> (outer plexus)	(inner plexus)
Controls	movements	Control the function within inner wall of each minute segment Secretions, absorption and local blood flow
Inhibitory neurons?	Yes (some neurons are inhibitory) (eg. pyloric & ileocecal valves)	no
Type of control	Increase tone, rate, intensity and velocity of <u>rhythmic contraction</u>	Segmental contraction

- **Myenteric (Auerbach's) plexus can secrete an inhibitory peptide that inhibit intestinal sphincter muscles like : pyloric sphincter and ileocecal valve.**

These sphincters normally delay and obstruct gut contents so by inhibiting them you increase the movement and enable food to leave the stomach with less resistance.



❖ Types of neurotransmitters secreted by enteric neurons: (د.محمد يقول احفظوها)

- **Acetylcholine**
- **Norepinephrine**
- **Substance P**
- **Vasoactive intestinal peptide (VIP)**
- **Somatostatin**
- **Serotonin**
- **Dopamine**
- **Cholecystokinin (CCK)**
- **Gamma aminobutyrate (GABA).**
- **The gases nitric oxide (NO) & carbon monoxide (CO)**

Excitatory (Evoke muscle contraction & intestinal secretion)	Inhibitory (Suppress contr.)
<ul style="list-style-type: none"> ● Neurotransmitters of <u>motor</u> neurons: 1. Substance P 2. Ach ● Neurotransmitters of <u>secretomotor</u> neurons (releasing of water, electrolytes and mucus from crypts of Lieberkuhn): 1. Ach 2. VIP (Vasoactive intestinal peptide) 3. Histamine (neurogenic secretory diarrhea) 	<ol style="list-style-type: none"> 1. ATP 2. NO 3. VIP

TABLE 8-1. Neurotransmitters and Neuromodulators in the Enteric Nervous System

Substance	Source	Actions
Acetylcholine (ACh)	Cholinergic neurons	Contraction of smooth muscle in wall Relaxation of sphincters ↑ Salivary secretion ↑ Gastric secretion ↑ Pancreatic secretion
Norepinephrine (NE)	Adrenergic neurons	Relaxation of smooth muscle in wall Contraction of sphincters ↑ Salivary secretion
Vasoactive intestinal peptide (VIP)	Neurons of mucosa and smooth muscle	Relaxation of smooth muscle ↑ Intestinal secretion ↑ Pancreatic secretion
Gastrin-releasing peptide (GRP) or bombesin	Neurons of gastric mucosa	↑ Gastrin secretion
Enkephalins (opiates)	Neurons of mucosa and smooth muscle	Contraction of smooth muscle ↓ Intestinal secretion
Neuropeptide Y	Neurons of mucosa and smooth muscle	Relaxation of smooth muscle ↓ Intestinal secretion
Substance P	Cosecreted with ACh	Contraction of smooth muscle ↑ Salivary secretion

● **Guyton corner :**

Types of Neurotransmitters Secreted by Enteric Neurons

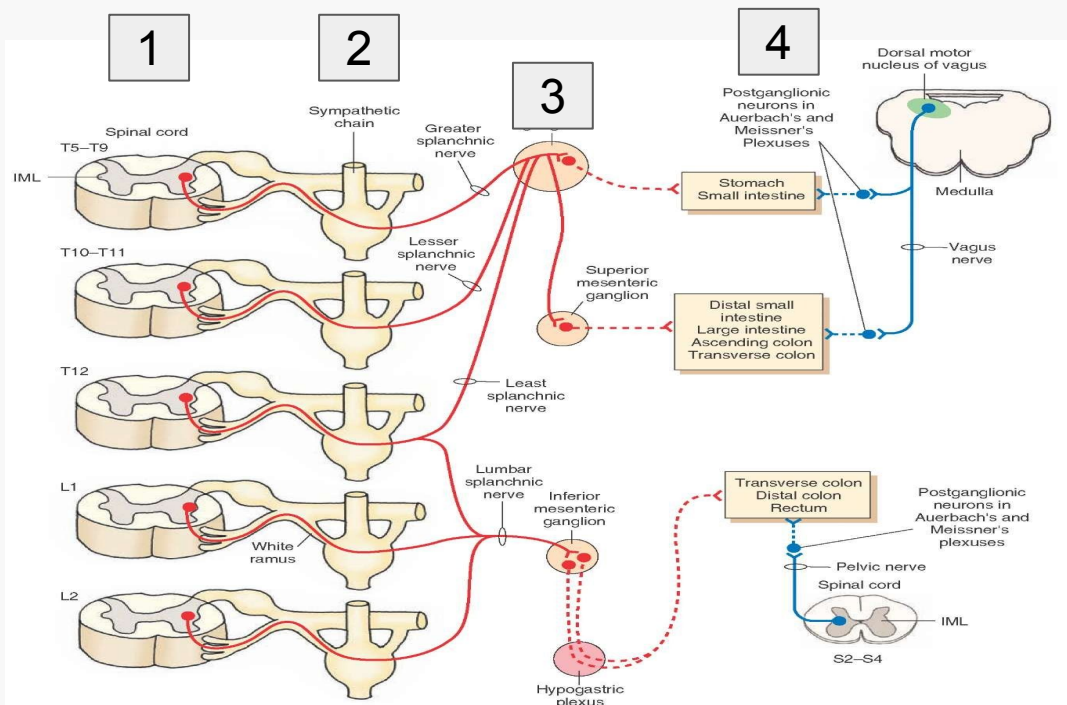
In an attempt to understand better the multiple functions of the gastrointestinal enteric nervous system, research workers the world over have identified a dozen or more different neurotransmitter substances that are released by the nerve endings of different types of enteric neurons. Two of them with 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, and (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. This is also true of epinephrine, which reaches the gastrointestinal tract mainly by way of the blood after it is secreted by the adrenal medullae into the circulation. The other aforementioned transmitter substances are a mixture of excitatory and inhibitory agents, some of which we discuss in the following chapter.

► Autonomic Nervous System: Parasympathetic control :

(Stimulation causes general **Increase** in activity of both myenteric and submucosal plexus)

- ❖ **Cranial** "Almost entirely in the vagus nerve (except mouth and pharynx)"
 - Esophagus+stomach+pancreas+small intestine+first half of large intestine = innervated by **Vagus nerve**
- ❖ **Sacral** :
 - Distal half of large intestine + anus = innervated by the segment S2 to S4 of spinal cord through **Pelvic nerves**
- ❖ Postganglionic neurons are located in myenteric and submucosal plexuses
- ❖ Parasympathetic innervate oral cavity and anus more extensively.

► Autonomic Nervous System: Sympathetic control :



Red fibers represent sympathetic while blue fibers represent parasympathetic

1- Sympathetic fibers originate from Spinal cord specifically from **T5-L2**

"بالضبط مثل ما هو موجود على يسار الصورة"

2- Then it enter Sympathetic chain.

3- Then it passes through 3 ganglia:

- Celiac ganglia
- Superior mesenteric ganglia
- Inferior mesenteric ganglia

4- Postganglionic fibers spread to all parts the gut

- The main neurotransmitter here is **Norepinephrine** (adrenergic)
- Sympathetic stimulation **inhibits** GIT smooth muscle movement **except mucosal muscles**.
- Sympathetic = decrease GI tract motility and secretions increase in sphincter contraction.

► Nervous Control of Gastrointestinal Blood Flow

❖ Stimulation of the parasympathetic

- Nerves going to the stomach and lower colon increases local blood flow at the same time that it increases glandular secretion.

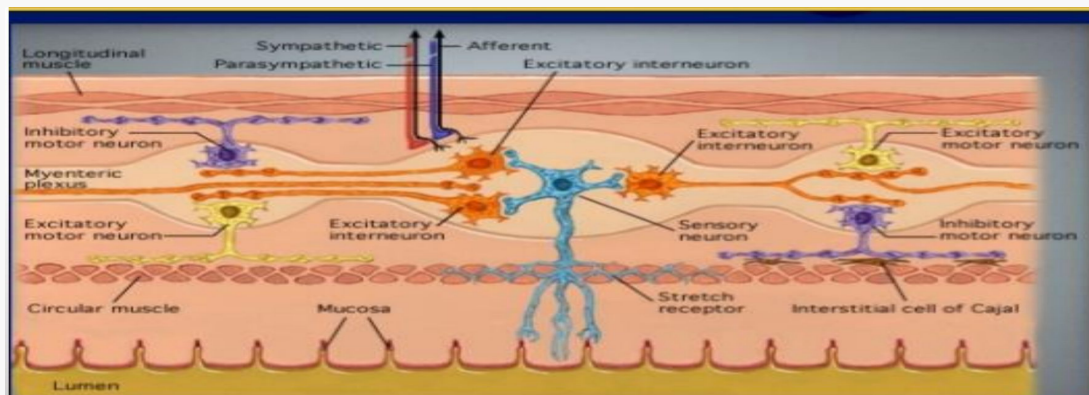
❖ Stimulation of the sympathetic

- By contrast, has a direct effect on essentially all the gastrointestinal tract to cause intense **vasoconstriction** of the arterioles with greatly decreased blood flow. But the local metabolic vasodilator mechanisms override the sympathetic vasoconstriction effects, returning the normal blood flow to GI muscle and glands.

► Neural control of GI tract: ENS (intrinsic) / ANS (extrinsic)

The enteric nervous system can function on its own, independently of the parasympathetic and sympathetic systems, however, these extrinsic nerves can greatly enhance or inhibit gastrointestinal functions. The sensory nerve endings send afferent fibers to both plexuses of the enteric system and then to: (1) the prevertebral ganglia of the sympathetic nervous system, (2) the spinal cord, and (3) the vagus nerves all the way to the brain stem. These sensory nerves can elicit local reflexes within the gut wall.

- Vagus nerve is **80%** sensory (Afferent) and **20%** motor.
- They send fibers (excitatory or inhibitory) through sensory nerves to initiate reflexes.
- Sensory (Afferent) signals transmitted by sensory nerve fibers = **initiate GI tract reflexes.**
- We can stimulate sensory nerves by :
 - 1-Irritation of gut mucosa (the innermost layer)
 - 2-Excessive distension of the gut (pressure from the inside by mechanoreceptors)
 - 3- Presence of specific chemicals (by chemoreceptors)
- ENS and dorsal root ganglia both have sensory nerve fiber cell bodies



You can see that the sensory nerve cell body in the ENS. There are fibers coming from sympathetic and parasympathetic to these sensory cell bodies And acts on sensory neurons to initiate the reflexes. What are these reflexes? Next page



► Gastrointestinal tract reflexes :

- 1- Reflexes integrated within gut wall
- 2- Reflexes from gut to sympathetic ganglia to gut again
- 3- Reflexes from gut to spinal cord or brainstem then to gut again (back to GIT)

❖ Reflexes integrated within gut wall :

(also called intrinsic or local reflexes)

Reflexes that control secretions, peristalsis (involuntary wavelike movement that push contents forward), mixing contractions and local inhibition.

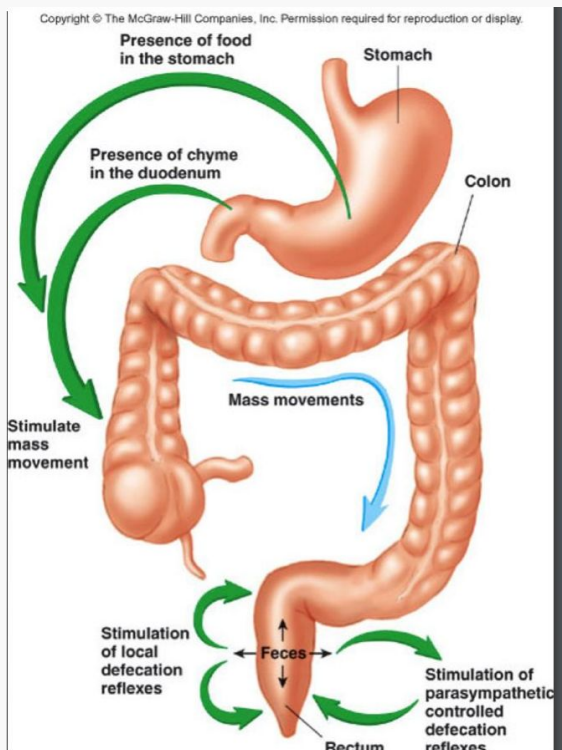
❖ Reflexes from gut to sympathetic ganglia to gut again :

(also called extrinsic GI tract reflexes)

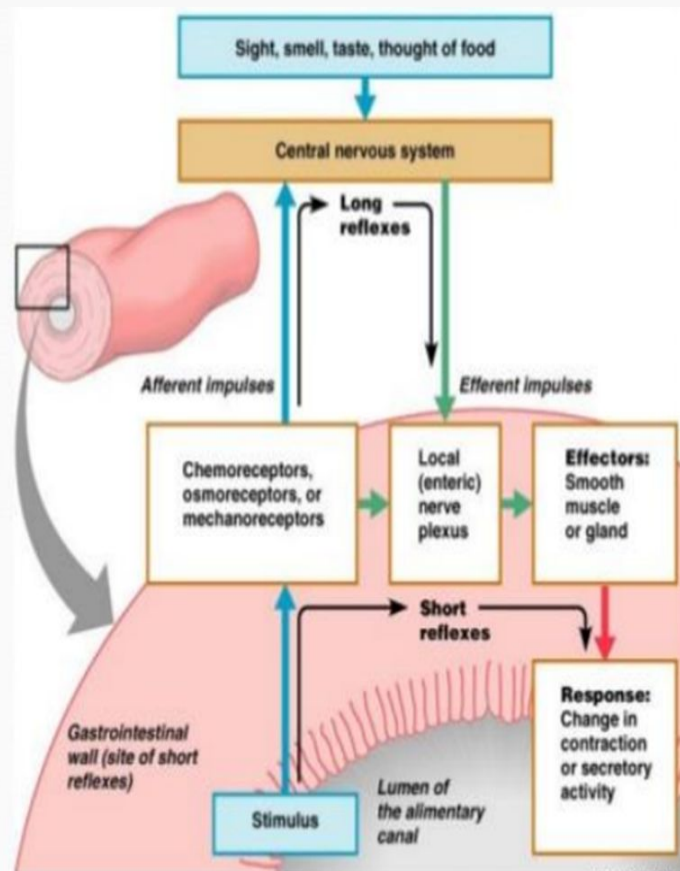
- **Gastrocolic reflex** : **stimulate** (not under sympathetic) evacuation of the colon once there is food in the stomach.
- **Enterogastric reflex**: **inhibition** stomach motility and secretions. Basically inhibition of emptying of stomach (when there is a problem in the duodenum).
- **Colonoileal reflex**: **inhibition** ileal emptying.

❖ Reflexes from gut to spinal cord or brainstem to gut again:

- **Pain reflex** that cause general **inhibition** of GIT
- **Defecation reflex** from colon and rectum to spinal cord and back to cause **powerful contraction of abdomen, colonic and rectal** to discharge feces.
- From stomach and duodenum to the brain stem and back to stomach to **control gastric motor and secretory activity**.



Gastrocolic reflex



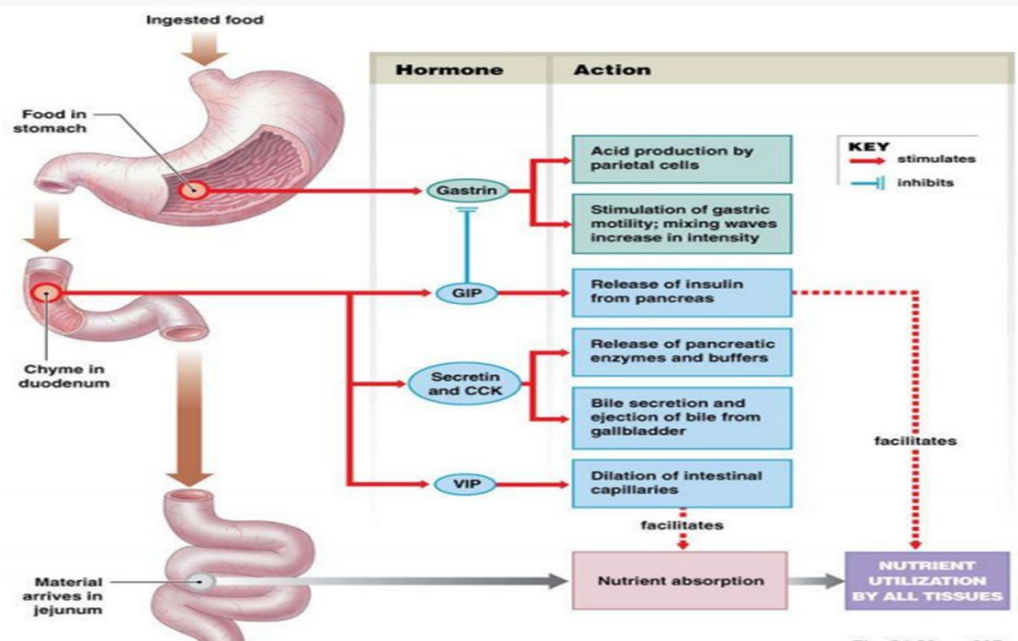


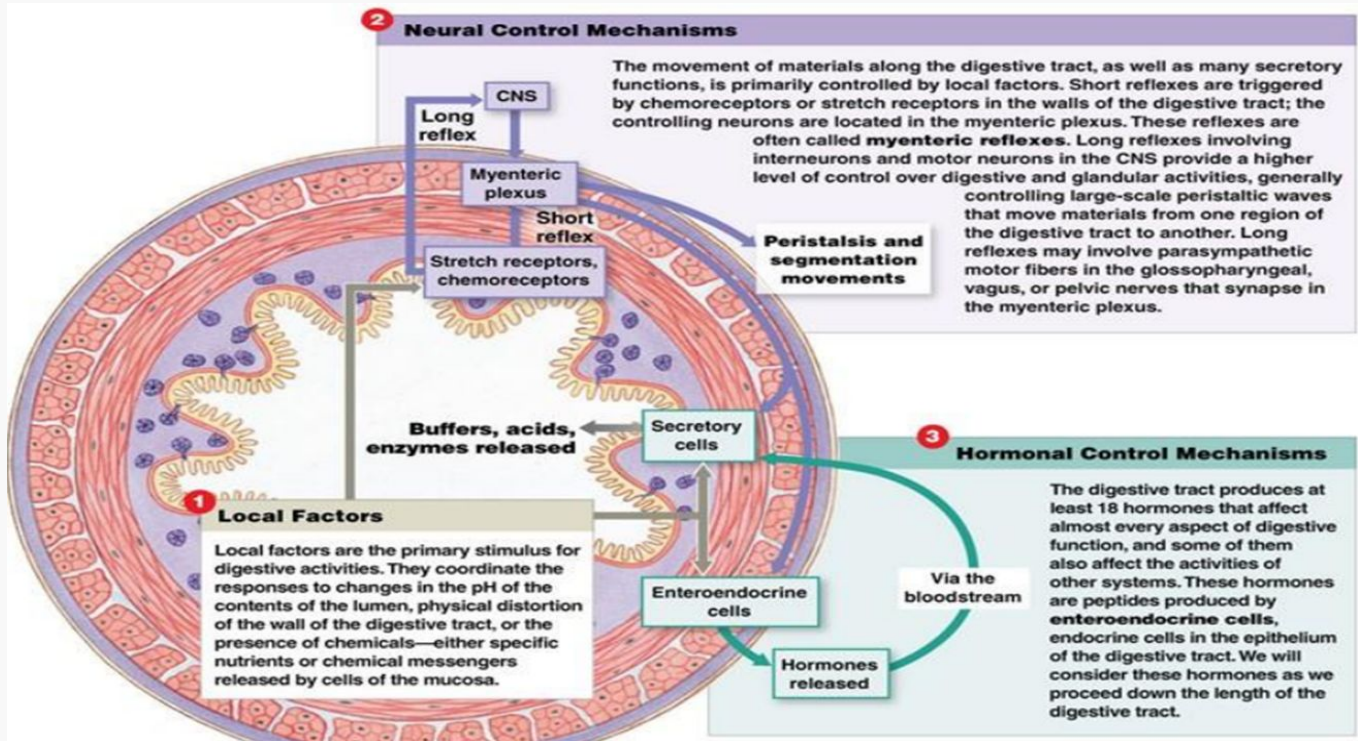
Hormonal control of GI tract :

You have to read it 3 times a day !

Hormone	Stimuli of Secretion	Site of Secretion	Action	
			Stimulates	inhibits
Gastrin (important)	Protein - Distention - Nerve - (Acid inhibits release)	G cells of pyloric antrum, duodenum and jejunum	<ul style="list-style-type: none"> gastric acid secretion mucosal growth. 	-
Cholecystikinin (CCK) Chole: bile ducts Cholecyst: gallbladder	Protein - Fat - Acid	I cells of duodenum, jejunum and ileum	<ul style="list-style-type: none"> Pancreatic enzyme Pancreatic bicarbonate secretions. Gall bladder contraction Growth of exocrine pancreas 	gastric emptying.
Secretin	Acid - Fat	S cells of duodenum, jejunum and ileum	pepsin, pancreatic bicarbonate, Biliary bicarbonate secretions, growth of exocrine pancreas	gastric acid secretion.
Gastric Inhibitory peptide (GIP)	Protein - Fat - Carbohydrate	K cells of duodenum and jejunum	insulin release	gastric acid secretion.
Motilin	Fat - Acid - Nerve	M cells of duodenum and jejunum	gastric, intestinal motility.	-

The main actions of the major digestive tract hormones





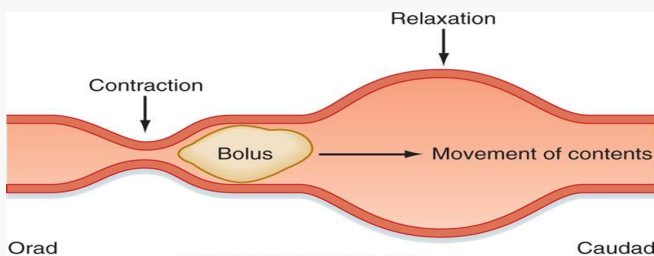
► Functional types of movements in the GIT :



Propulsive movements (most common)

- Peristalsis which is inherent property of syncytial smooth muscle tube.
- Stimulus is distention of the gut.
- Stimulation of enteric nervous system.
- Contractile ring 2-3 Cm behind stimulus. Contractile ring moves forward.
- Atropine (cholinergic blocker) depresses propulsion
- **Can not occur in absence of Myenteric plexus.**
- **Peristaltic (myenteric) reflex and the low of gut**

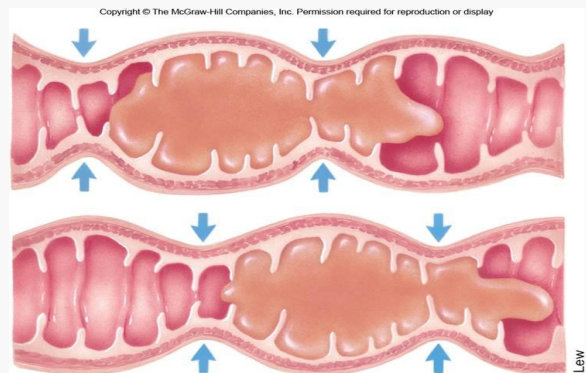
نقدر نقول إنها مجرد تحريك للكمة من مكان لآخر بدون وجود أي إفرازات أو هضم



Segmentation & Mixing movements

- Provides mixing of intestinal contents (known as chyme) with digestive juices.
- Segment of bowel contracts at both ends.
- A second contraction occurs in the center of the segment.
- Chyme is forced forward and backward.
- Can occur independent of central input.
- **Occur in all parts of GIT except esophagus**

في هذا النوع من التحريك يحصل خلط للكمة مع إفرازات الجدار الهضمي ويكون الضغط "عليها من كلا الجهتين" مثل العصارة



- **Guyton corner :**

Propulsive movement of the GI is peristalsis which requires an active myenteric plexus.

Mixing movement : local intermittent constrictive contraction occur every few cm in the gut wall.

► Migrating motor complex (MMC) :

Cycles of motor activity migrate from the stomach to the distal ileum.

◆ Have 3 phases:

Phase 1:
Quiescence “dormancy”

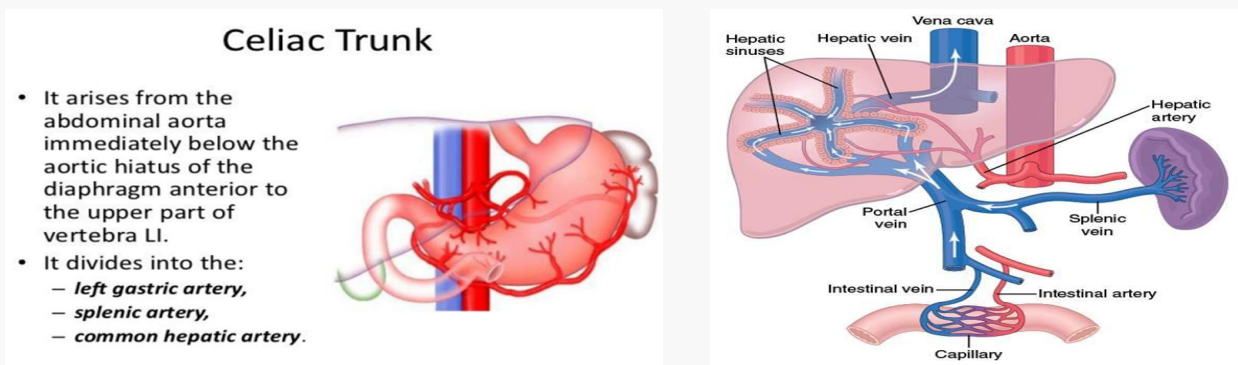
Phase 2:
irregular electrical
and mechanical activity.

Phase 3:
burst of regular activity.

- Occurs **during fasting**.
- Initiated by motilin.
- Migrate at a rate of **5 cm/min**.
- Occurs at intervals of **~ 90 min**. (1hr and half)
- Accompanied by increase gastric, bile and pancreatic secretion.
- Serve to clear the stomach and small intestine of luminal contents.

► GI blood flow (Splanchnic circulation) :

It's different from other circulations because the blood coming to the stomach, spleen, pancreas and intestine will go through the venous collection and collect into the portal vein which go through the liver that means that anything passes the GIT will go to the liver which act as a sorting area that kills and get rid of toxins and poisons materials from going to the systemic circulation and will also store nutrient. *More details in Anatomy lecture*



► Effects of gut activity & metabolic factors on GI blood flow :

- **Blood flow in GIT is directly related to local activity.**
- **Blood flow in villi during active absorption increased up to 8 folds.**
- **After a meal blood flow increases greatly then return to resting level over 2-4 h.**
(so we shouldn't exercise right after eating because the blood supply will shift to the muscles)
- **Causes of increased blood flow :**
- **Vasodilators such as peptide hormones** including cholecystokinin (CCK), vasoactive intestinal peptide (VIP), gastrin, and secretin.
- **Kinins secreted by GI glands** (kallidin & bradykinin)
- Decreased oxygen concentration **increase blood flow 50-100%**
- **Four folds increase** in adenosine (vasodilator) secretion due to decrease oxygen.

SUMMARY

❖ Structure of the GIT wall:

❖ Mucosa :

Epithilium - Lamina propia - Muscularis mucosae

❖ Submucosa

❖ Muscularis externa:

The myenteric plexus, Circular & Longitudinal muscle

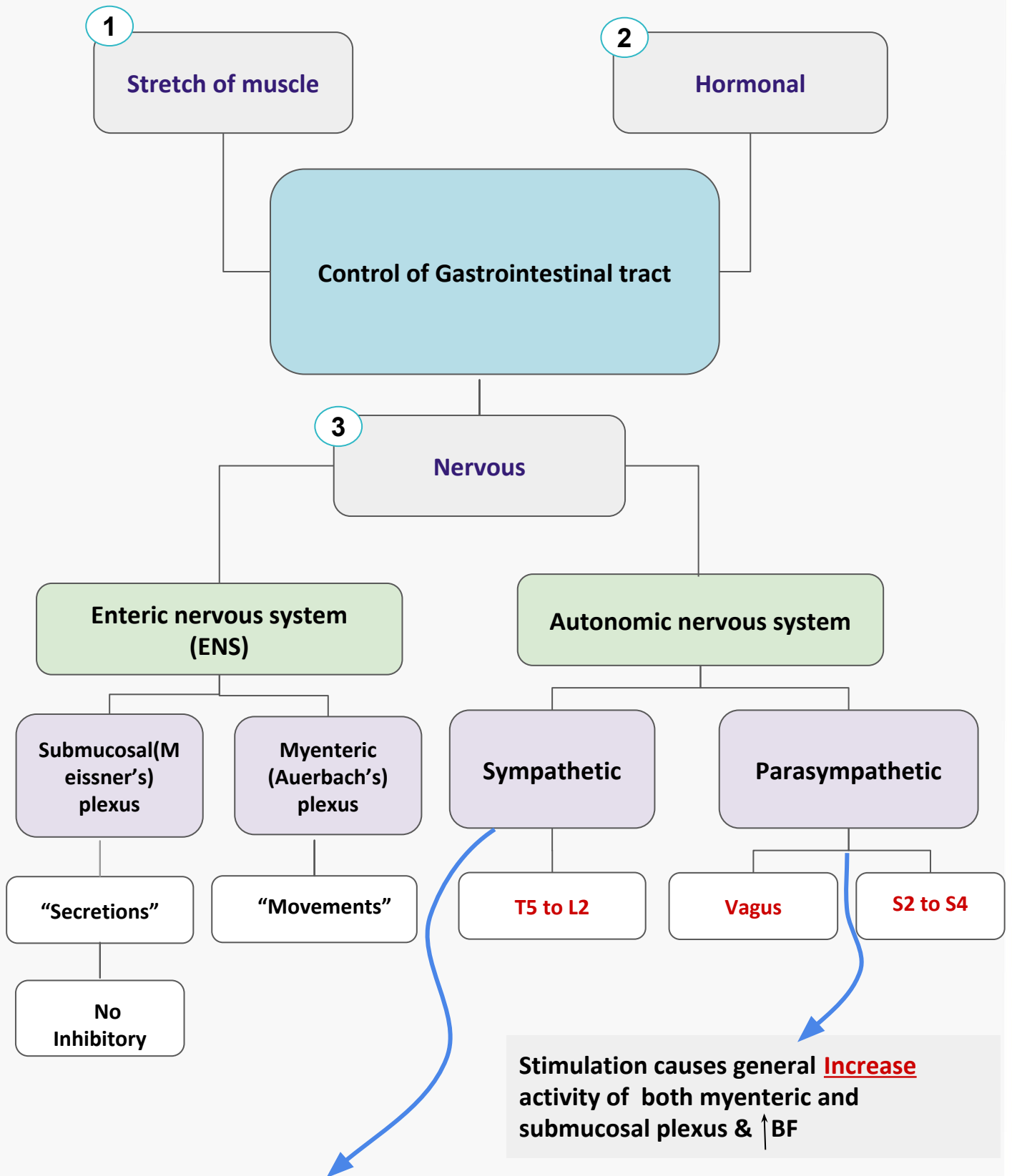
❖ Serosa

Multi-unit Smooth muscle	Single unit smooth muscle
contract independently Controlled mainly by nerve signals.	Contract in response to stretch Many gap junctions action potential travels in all directions
Phasic contractions (rhythmical)	Tonic contractions
Periodic followed by relaxation Ex. gastric antrum, small intestine and esophagus	Maintained without relaxation Orad region of the stomach, lower esophageal, ileocecal and internal anal sphincter
Longitudinal Smooth Muscles	Circular Smooth Muscles
shortens the segment, expands the lumen	Lengthens the segment, contracts the lumen

❖ Electrical activity of GI smooth muscle :

Slow waves	Spike potential
changes in resting membrane potential intensity: 5-15 mv Frequency: 3-12/min Use sodium ion channels Do not cause muscle contraction	TRUE action potentials Intensity: -50mv to -60mv Frequency: 1-10 spikes/sec Use calcium-sodium channels cause muscle contraction

SUMMARY



- The main neurotransmitter here is **Norepinephrine** (adrenergic)
- **Sympathetic** = inhibit GIT movement except mucosal muscles.
- **Sympathetic** = decrease GI tract motility and secretions increase in sphincter contraction.
- **Vasoconstriction** = decrease BF

SUMMARY

1- Reflexes integrated within gut wall

*Gastrointestinal tract reflexes :

2-Reflexes from gut to sympathetic ganglia to gut again

3-Reflexes from gut to spinal cord or brainstem to gut again

*Functional types of movements in the GIT

Propulsive movements
(most common)

Segmentation & Mixing movements

- Can not occur in absence of Myenteric plexus.

*Migrating motor complex (MMC) →

- Occurs **during fasting.**

Cycles of motor activity migrate from the stomach to the distal ileum. Have 3 phases :

Phase 1
Quiescence "dormancy"

Phase 2
irregular electrical and mechanical activity.

Phase 3
burst of regular activity.

MCQs

1) Which one of the following structures has spontaneous contraction in response to mechanical stimulation

- A. Stomach
- B. Intestine
- C. Esophagus
- D. a&b

2) The ENS lies in:

- A. Mouth.
- B. from Esophagus all the way to the Anus
- C. Pharynx
- D. Mouth and Pharynx

3) Resting membrane potential FOR Smooth Muscle in the Gut IS:

- A. -40 MV
- B. -50 MV
- C. -75 MV
- D. -90 MV

4) DEPOLARIZATION OF Smooth Muscle in the Gut IS STIMULATED BY :

- A. Parasympathetic
- B. Sympathetic
- C. Norepinephrine
- D. Epinephrine

5) Maintained contraction without relaxation REFER TO WHICH ONE TYPE OF CONTRACTIONS :

- A. Tonic
- B. Phasic
- C. Rhythmical
- D. None of them

6) WHICH OF THE FOLLOWING IS NOT TRUE ABOUT CIRCULAR MUSCLE :

- A. Thick and more powerful than longitudinal muscle
- B. Expand diameter and decrease length of intestine segment
- C. Innervated by enteric nervous system
- D. Use mainly intracellular calcium

7) WHICH ONE OF THE FOLLOWING STRUCTURES IS MAINLY RESPONSIBLE FOR GASTROINTESTINAL MOTILITY :

- A. Outer plexus
- B. Inner plexus
- C. Mucosal gland
- D. Submucosal gland

8) WHICH OF THE FOLLOWING Neurotransmitters CAN CAUSE CONTRACTION OF SMOOTH MUSCLE AND INCREASE GASTRIC SECRETION :

- A. Norepinephrine
- B. Neuropeptide y
- C. Acetylcholine
- D. Vasoactive intestinal peptide

9) Which of the following secretes hormones and digestive enzymes:

- A. Mucosa
- B. Submucosa
- C. Muscularis externa
- D. Serosa

10) Which of the following is not true as regard peristalsis:

- A. Peristalsis is a reflex response
- B. It occurs in all parts of the GIT except the esophagus
- C. Its occurrence is independent of the extrinsic innervation
- D. It is initiated when the gut wall is stretched by the contents of the lumen

مع جزيل الشكر لمصمم قالب العمل : هشام الغفيلي

عمر آل سليمان
عبدالعزيز الحماد
عبدالرحمن السيارى
محمد أبونيان
عبدالرحمن البركه
إبراهيم النفيسه
محمد البشر
عمر العتيبي
حمزة الفعر
عبدالله الجعفر
عبدالله الضحيان
حسن البلادي
حسن الشماسي
عبدالله الضبيب
محمد الفواز
محمد السحيباني
وائل العود
رواف الرواف
عمر الشهري

خولة العمّاري
نجدود الحيدري
نورة الطويل
لولوة الصغير
لجين السواط
رزان السبتي
ربى السليمي
ديما الفارس
خولة العريني
ملاك الشريف
منيرة الحسيني
مروج الحربي
أفنان المالكي
دلال الحزيمي
رناد القحطاني
سارة الخليفة
فرح مندوزا
مي العقيل
نورة الخراز
سارة الخليفة
نورة الخيال
رغد النفيسة
منيرة السلولي
نوف عبدالكريم
سها العنزي
نورة القحطاني

