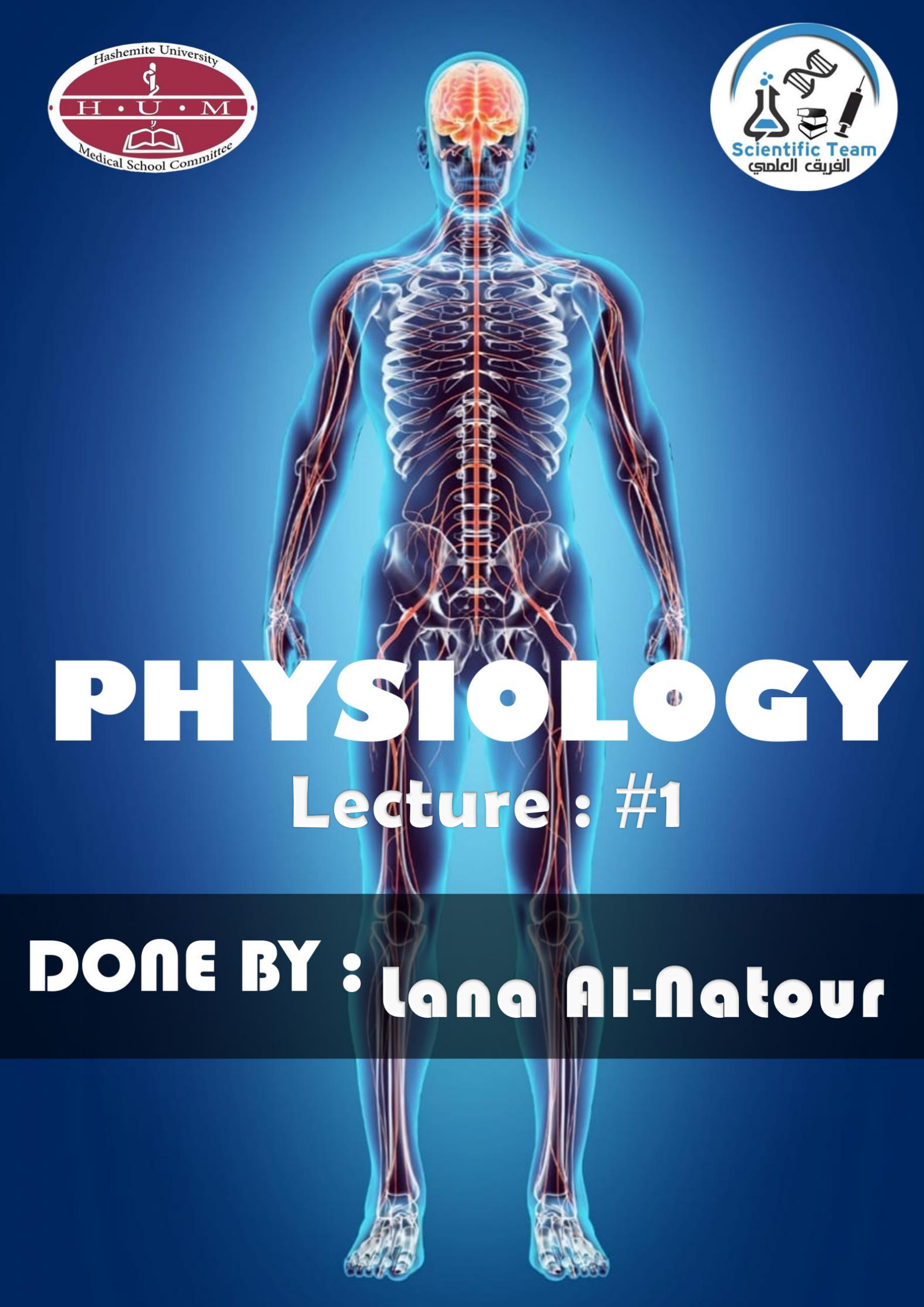


PHYSIOLOGY

Lecture : #1

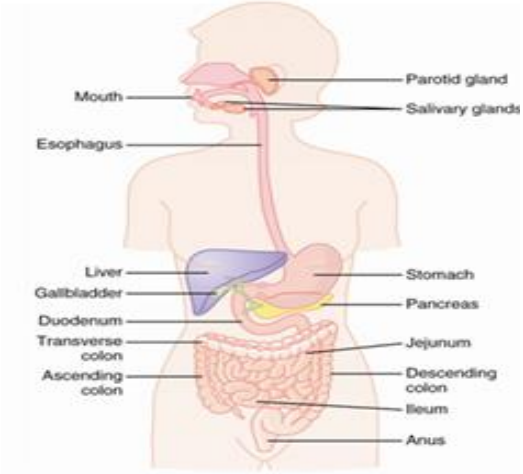
DONE BY : Lana Al-Natour

General principles of Gastrointestinal Function

Motility, Nervous Control, and Blood Circulation

سلايدات باللون الاسود/حكي الدكتورة باللون الازرق/شرح خارجي(د.ناجي) باللون الاخضر

Segments of the GI Tract



1. Mouth
2. Pharynx
3. Esophagus : passage of food
4. Stomach : storage of food
5. Small Intestine :digestion and absorption
6. Large Intestine
7. Sphincters between segments
8. Liver
9. Gall Bladder
10. Pancreas

Function:

- Provides body with water, electrolytes, vitamins, nutrients.
- Functions through:

(1) Movement of food through GIS

(2) Secretion of digestive juices

(3) Absorption of water, electrolytes, vitamins, & digestive products to circulation

Control of GI functions by local(by the GIT itself) , nervous (sympathetic and parasympathetic system), and hormonal system

Physiological anatomy of GI wall

motor functions

1. Serosa

2. LM

3. Myenteric (Auerbach's) nerve plexus

4. CM

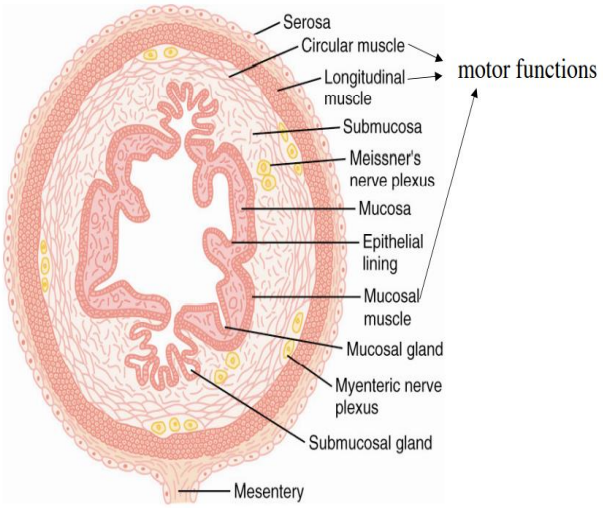
5. Submucosa

6. Submucosal (Meissner's) nerve plexus

7. Muscularis mucosae

8. Mucosa

9.Epithelial lining



As we can see In the figure this is a cross section from a gut ,there is a Connective tissue covering outside(serosa),((so GIT is formed from 4 layers from inside to outside : mucosa, submucosa, muscular layer, serosa)) the muscle is the functional unit of GIT ((motility)) so we have 2 types of muscle: longitudinal muscle along the tract itself and circular muscle.
the 2 systems innervating the GIT only are : myenteric plexus((located between LM and CM))and submucosa nerve plexus ((within submucosa))

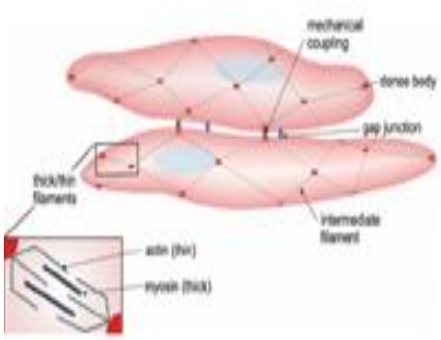
GI SM

- **Arranged in bundles of fibers separated by loose CT**
- **Electrically connected with GJ ((gap junctions in order to propagate AP)) (low-resistance movement of ions)**
- **Electrical signals initiating muscle contractions travel more rapidly along length of the bundle than sideways**
- **GI SM functions as a syncytium --- AP elicited anywhere within muscle travels in all directions in muscle**
- **Due to connection between LM and CM layers, excitation of one of these layers often excites the other**

* syncytium أي كوحدة واحدة

*وأي نشاط كهربائي يتحرك distally and longitudinal اكثر من ان يتحرك على الاطراف

*So any excitation of one type of muscle ((LM)) will lead to excitation of another muscle



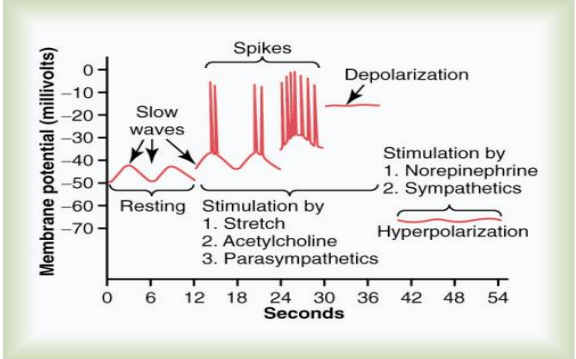
Electrical Activity of GI SM

• SM is excited by continual slow, intrinsic electrical activity along membranes of muscle fibers.

(has it's own electrical activity doesn't need any stimulation)) ((the nervous system is going to regulate such an activity))

• Normal RMP in SM of gut is - 50-60 mV (Avg −56 mV)

• Voltage of RMP of SM can change to different levels



RMP potential can change resulting in different activities

• Types of electrical waves:

• Slow waves

-Rhythmical changes in MP, not AP

Not AP: means that they can't generate actual contraction (so it is not depolarization), except in stomach they can cause some contractions

-Slow changes in RMP.

-5-15 mV intensity, 3-12/min freq.

-Cause: interactions among the SM cells & interstitial cells of Cajal (electrical pacemakers for SM cells) ---cyclic changes in MP due to activity ion channels.

Such waves are generated by interactions between smooth muscles and pacemaker results in movement of ions

-Don't cause GI muscle contraction (except stomach) -- stimulates spike potentials -- muscle contraction.

So if the RMP reach threshold ((become less negative)) they will have another type of waves called spikes

Note :these types of waves occur spontaneously

• Spikes:

• When slow waves reach threshold (-40 mV) -- spike P – depolarization- Ca2+ entery -- contraction

-True AP.

So the spike waves are important in AP (actual contraction in the gut itself) and it is generated by slow waves

So they don't happen unless there is a stimulus for example : stretch of the gut (ingestion of the meal),Ach parasympathetic ,GIT hormones.

-- Slow wave P -- spike potential frequency (range 1-10 spikes/s, duration 10-20 ms)

• AP in GI SM vs nerves:

• Nerve: Na through Na channels (rapid)

• GI SM Ca2+ (mainly)+ Na through Ca2+-Na+ channels (slow) lead to longer duration AP in GI SM

• More negative RMP – hyperpolarization((by sympathetic nervous system))

Tonic Contraction

• Continuous (no relaxation).

• Usually observed in sphincters.

• Not associated with basic electrical rhythm of the slow waves.

• Caused by :

-Continuous repetitive spike potentials

-Hormones

-Continuous entry of Ca2+ into cell in ways not associated with changes in MP

Sphincters : where the food is stopped while moving from one part to another

هلا هاي العضلة دائما منقبضة والسبب يعود حتى مايصير evacuation ويصير يرجع الاكل لورا

But unless they receive relaxation signal to open and push the food but they are usually contracted and have their own electrical activity

Neural Control of GI Tract

The autonomic nervous system (ANS) of the GI tract comprises both extrinsic (sympathetic and parasympathetic) and intrinsic nervous systems (myenteric and submucosal plexus)

• Intrinsic Control - Enteric nervous system

- Esophagus to anus

- Can function independently of extrinsic nerves

- Controls movements & secretion

- Myenteric (Auerbach's) plexus

- Submucosal (Meissner's) plexus

Both of these plexus are connected to each other so any stimulation of one of them will result to stimulate another one

regulated by the nervous system بس هو external stimulation ما اله ENSو

ENS - Myenteric Plexus

• Location - - Between longitudinal and circular SM layers

• Function - controls GI motility

- Stimulatory influences -

• - tonic contraction (tone)

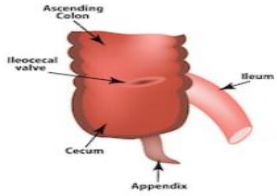
• - contraction frequency / intensity

• - velocity of conduction of excitatory waves (peristalsis)((moving food through GIT)

- Inhibitory- vasoactive intestinal polypeptide – inhibits sphincter muscles (pyloric & ileocecal valve)

Pyloric: the myenteric plexus relax the sphincter to push the food from the stomach to deudonom

Ileocecal valve: the myenteric plexus relax it to improve the evacuation from ileum to caecum



ENS – Submucosal

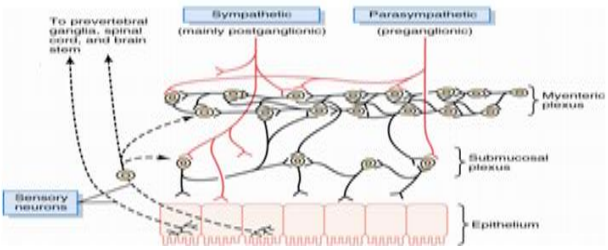
• Location - submucosa

• Function - Control secretion

- Absorption (local blood flow)

- Contraction of muscularis mucosa (infolding)((to increase the surface area for absorption))

Note :both plexuses uses local reflexes to relay information within the GI tract.



Neurotransmitters secreted by ENS

(1) Acetylcholine -- excitatory

(2) Norepinephrine/epinephrine -- inhibitory (via circulation)

(3) ATP

(4) Serotonin

(5) Dopamine

(6) Cholecystokinin

(7) Substance P

(8) Vasoactive Intestinal Polypeptide

(9) Somatostatin

(10) Leu-enkephalin

(11) Met-enkepha

(12) Bombesin

Afferent Sensory Nerve Fibers From the Gut

• Cell bodies in ENS/DRG

• Sensory signals to DRG, SC & BS

-Vagus nerve 80% afferent →brain medulla →vagal reflex

• Stimulation of afferent neurons

- Distention of gut(eating)

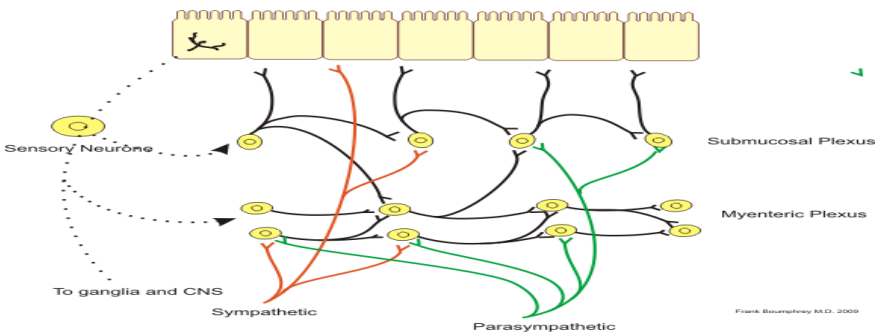
- Irritation of gut mucosa(infection)

- Chemical stimuli

• Stimulation - can excite or inhibit - Intestinal movements or secretions

This types of nerve that carry information from the GIT to the CNS in order to generate action(regulation) and electrical activity for inhibition and stimulation of intestinal movements

A figure from google in order to imagine the innervation:



• **Extrinsic Control - Autonomic nervous system**

- **Parasympathetic - mainly stimulates (Ach)**

- **Sympathetic - mainly inhibits (NE)**

Parasympathetic Innervation

• **Cranial Division - (mostly Vagus N.) - first half of gut**

• **Sacral Division (S2-4) - (Pelvic N.) - second half of gut**

• **Neurons -** ***preganglionic - long***

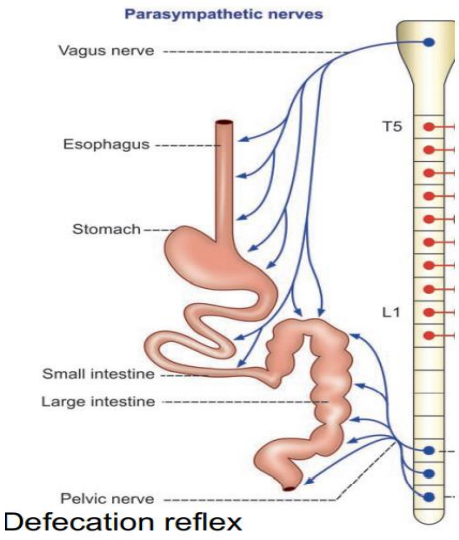
postganglionic - short, entirely in ENS

Synapse with ENS neurons (mainly)

• **Stimulation - Excites ENS (in general)**

• **Parasympathetic nerves also contain afferent sensory fibers (80%)**

Defecation reflex(increase the defecation because the parasympathetic system innervates the lower part)



Defecation reflex

Sympathetic Innervation

• **Preganglionic Neurons (long) - Originate at T5-L2 (cell bodies).**

Synapse in prevertebral ganglia

• ***Postganglionic Neurons (long) - Originate in ganglia (cell bodies)***

- Innervate entire gut. Terminate in ENS (mostly)

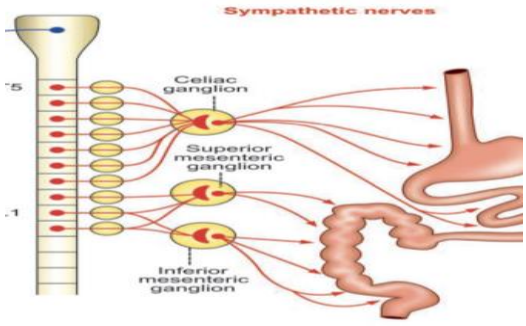
- Nerve endings mainly secrete norepinephrine

• **Inhibitory**

(a) Decreasing activity of ENS (mostly)

(b) Inhibit SM (except mucosal SM)-Slight activity

• **Sympathetic nerves also contain afferent sensory fibers(%50)**



**ننتبه على شغلة حكاها د.ناجي انه بال parasympathetic يلي بيوصل gut هو preganglionic و sympathetic يلي بيوصل لل gut هو postganglionic

Neurotransmitters (Neurocrines)

• Preganglionic efferent neurons - acetylcholine

• Postganglionic efferent neurons

PNS - acetylcholine

SNS – norepinephrine

تذكروا parasympathetic صاحب GIT ☺

GI Reflexes

• Local (within ENS)

- Afferent fibers from gut terminate in ENS

- Control secretion, peristalsis, mixing movements & local inhibitory effects

• Long loop

- Gut :Aff. N. → prevertebral symp. ganglia → Eff. N. → gut

The short reflexes are from ENS while the long reflexes are from sympathetic and parasympathetic nervous system

- Reflexes:

- **Gastrocolic (from stomach → colon evacuation)**
- **Enterogastric (from colon & SI → inhibit stomach motility & secretion)**
- **Colonoileal (from colon → inhibit emptying of ileal contents into colon)**
  ((that the GIT is busy now can't receive any food))
- **Vagovagal Reflexes**

- Stomach / duodenum → Aff. N. → BS(brainstem) →Eff. N. → stomach / duodenum
-Controls gastric motor and secretory activity

- **Defecation Reflexes**

- Colon / rectum → Aff. N. → SC → Eff. N. →colon / rectum

((evacuate the GIT system,defectaion))

Pain Reflexes: overall inhibition of GI tract •

Hormonal control of GI motility

هاد الجدول مهم وركزت عليه الدكتورة

The GIT hormones will be secreted locally and they will reach the GIT in order to work distally

Hormone	Stimuli for Secretion	Site of Secretion	Actions
Gastrin	Protein Distention Nerve Vagal/ gastrin-releasing peptide *(Acid inhibits release)*	G cells of the antrum, duodenum, and jejunum	Stimulates Gastric acid secretion Mucosal growth
Cholecystokinin	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 Appetite-vagus
Secretin	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
Gastric inhibitory peptide Glucose-dependent insulinotropic peptide	Protein Fat Carbohydrate	K cells of the duodenum and jejunum	Stimulates Insulin release Inhibits Gastric acid secretion Gastric emptying
Motilin	Fat Acid Nerve inhibited by food ingestion	M cells of the duodenum and jejunum during fasting	Stimulates interdigestive myoelectric complexes Gastric motility Intestinal motility

Note about motilin :

That this hormone is increased during fasting , it increases the gastric motility and when we eat this hormone will be suppressed

Functional types of movements in GIT

Propulsive Movements - Peristalsis

• Stimuli that initiate peristalsis

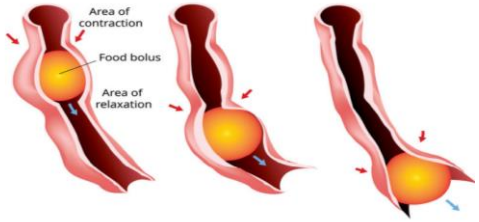
- Distention

- orad contraction with downstream receptive relaxation = "Law of the Gut"

(when we eat a bullous of food will be formed so they will go proximally to the gut from the mouth)

- Irritation of gut epithelium

- Parasympathetic nervous system



• Function

-Myenteric plexus required

- Congenital absence of plexus – no peristalsis

- Atropine (blocks Ach receptors) – low peristalsis

This type of movement push the bullous to distal relaxation part

One minute video for peristlasis : https://www.youtube.com/watch?v=kVjeNZA5pi4

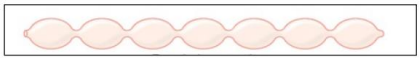
Mixing movements

• Local intermittent constrictive contractions (segmentation) → chops the GI contents + mixing it without moving it

No pushing here only mixing the food

Peristaltic contractions + sphincter → mixing

هلا هون بما انه العضلات بتضل منقبضة فبصير mixing



Muscularis Mucosae

• Function-folding of intestinal mucosa+ contraction of intestinal villi

• Mucosal folds →↑surface area exposed to chyme (gastric contents)→ ↑absorption

• Mucosal & villous contractions are initiated mainly by local nervous reflexes in the submucosal nerve plexus in response to chyme in SI.

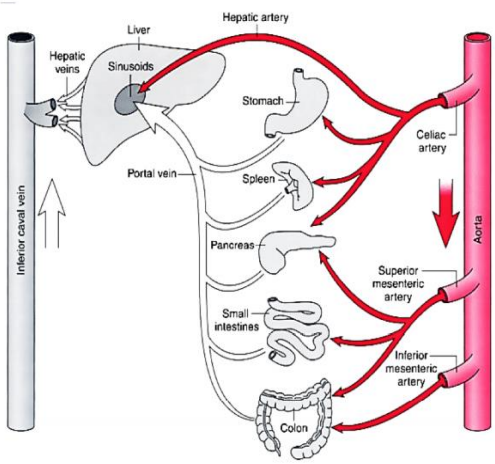
هاي العضلة مهمة عشان بما انها بتزود folds اذا بتساعد انه يصير فيه مساحة كبيرة للabsorption

GI blood flow-Splanchnic Circulation

Blood flow is important in absorption

• **Components - GI tract, spleen, pancreas, and liver**

• **Feed Arteries (25-30% CO)**



- Celiac artery - stomach, spleen

- Sup. Mesen. A. - S.I., pancreas, prox. colon

- Inf. Mesen. A. - majority of colon

• **Venous drainage**

- Portal vein to liver sinusoids to hepatic vein

To inferior vena ceva

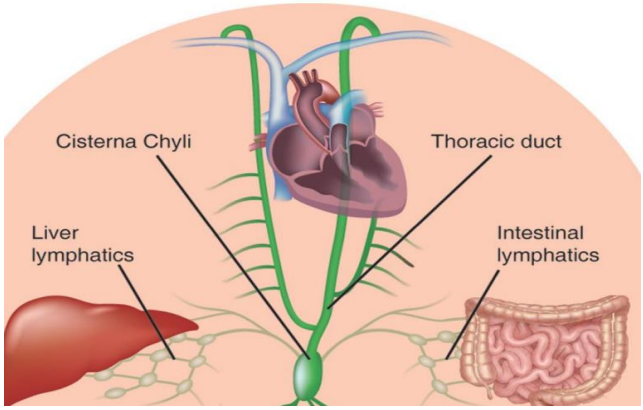
- Reticuloendothelial cells remove bacteria(by the liver)

- 1/2 to 1/3 water-soluble nutrients (Carb. & proteins) removed and stored in liver

-Fats(unsoulable) absorbed into intestinal lymphatics

to thoracic duct to systemic circulating

(bypassing the liver)



Blood flow through intestinal villus

Intestinal villis:the main absorption unit of the small intestine

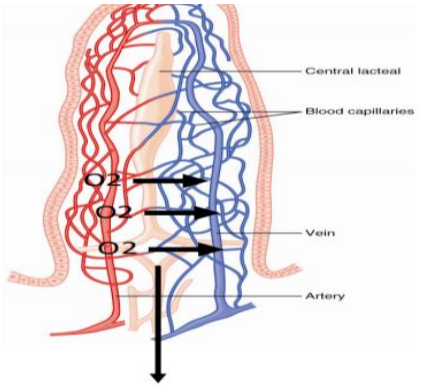
• Countercurrent Blood Flow in the Villi

- 80% oxygen is shunted from artery to vein

- Not harmful

- In disease conditions e.g Circulatory Shock → Splanchnic blood flow ↓ → Villus tip or entire villus suffers ischemic death → ↓ Absorptive capabilities

- Lymph flows freely from the central lacteals of villi into lymphatic system



Lymph to lymphatic system

We can see in the figure that the oxygen can go to the veins side before reaching the top of the villi(normal condition)but if there is shock less oxygen will be reaching the top of the villi decreasing the absorption

Control of Gut Blood Flow

• Blood flow proportional to local activity

- Meal → blood flow

- high motor activity→high blood flow

• Causes of activity induced blood flow

- Vasodilator hormones

- CCK, VIP, gastrin, secretin.

- Vasodilator kinins-kallidin, bradykinin

- Low oxygen (high adenosine)

• Nervous control of blood flow

- PNS :gut activity → high blood flow

- SNS, exercise, shock – Directly decrease low blood flow- overcome> Autoregulatory escape (local metabolic vasodilator mechanisms)

Decrease blood flow(vasoconstriction)will be overcome by vasodilator mechanisms

-SNS – vasoconstriction of intestinal and mesenteric veins to sustain (200-400 ml) the general circulation

Good luck Hope ☺