MEDICINE 438's

GIT PHYSIOLOGY

LECTURE I: General Principles of GIT Physiology

EDITING FILE

IMPORTANT | MALE SLIDES | EXTRA | FEMALE SLIDES | LECTURER'S NOTES

1 GENERAL PRINCIPIES OF GIT PHYSIOLOGY

Lecture One

OBJECTIVES

- Physiologic Anatomy of the Gastrointestinal Wall
- The General/specific Characteristics of Smooth Muscle
- Smooth muscle cell classifications and types of contraction
- Muscle layers in GI wall
- Electrical Activity of Gastrointestinal Smooth Muscle
- Slow Waves and spike potentials
- Calcium Ions and Muscle Contraction
- Neural Control of Gastrointestinal Function–Enteric Nervous System (ENS)
- Differences Between the Myenteric and Submucosal Plexuses
- Types of Neurotransmitters Secreted by Enteric Neurons
- Autonomic Control of the Gastrointestinal Tract
- Hormonal Control of Gastrointestinal Motility
- Functional Types of Movements in the GI Tract
- Gastrointestinal Blood Flow (Splanchnic Circulation)
- Effects of Gut Activity and Metabolic Factors on Gastrointestinal Blood Flow

Case Study

Term baby boy born to a 29 year old G2P1+ 0 by NSVD found to have features of Down's syndrome. At 30 hours of age Baby was feeding well but didn't pass meconium. On examination abdomen distended. Anus patent in normal position. During PR examination passed gush of meconium.

Diagnosis: Hirschsprung disease.

It is a developmental disorder characterized by the absence of ganglia in the distal colon, resulting in a functional obstruction.

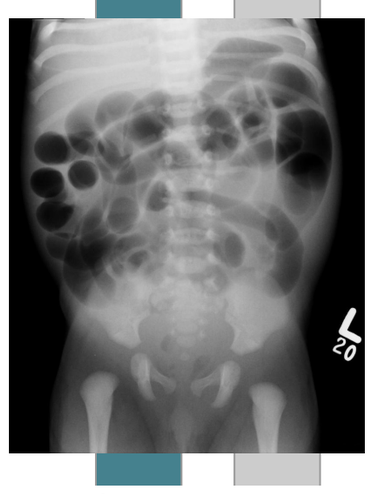


Figure 1-1

Gastrointestinal System

Gastrointestinal Tract (GIT)

- ★ A hollow tube from mouth to anus
- ★ Hollow organs are separated from each other at key locations by sphincters.

Accessory (Glands & Organs)

- ★ Produce secretions.

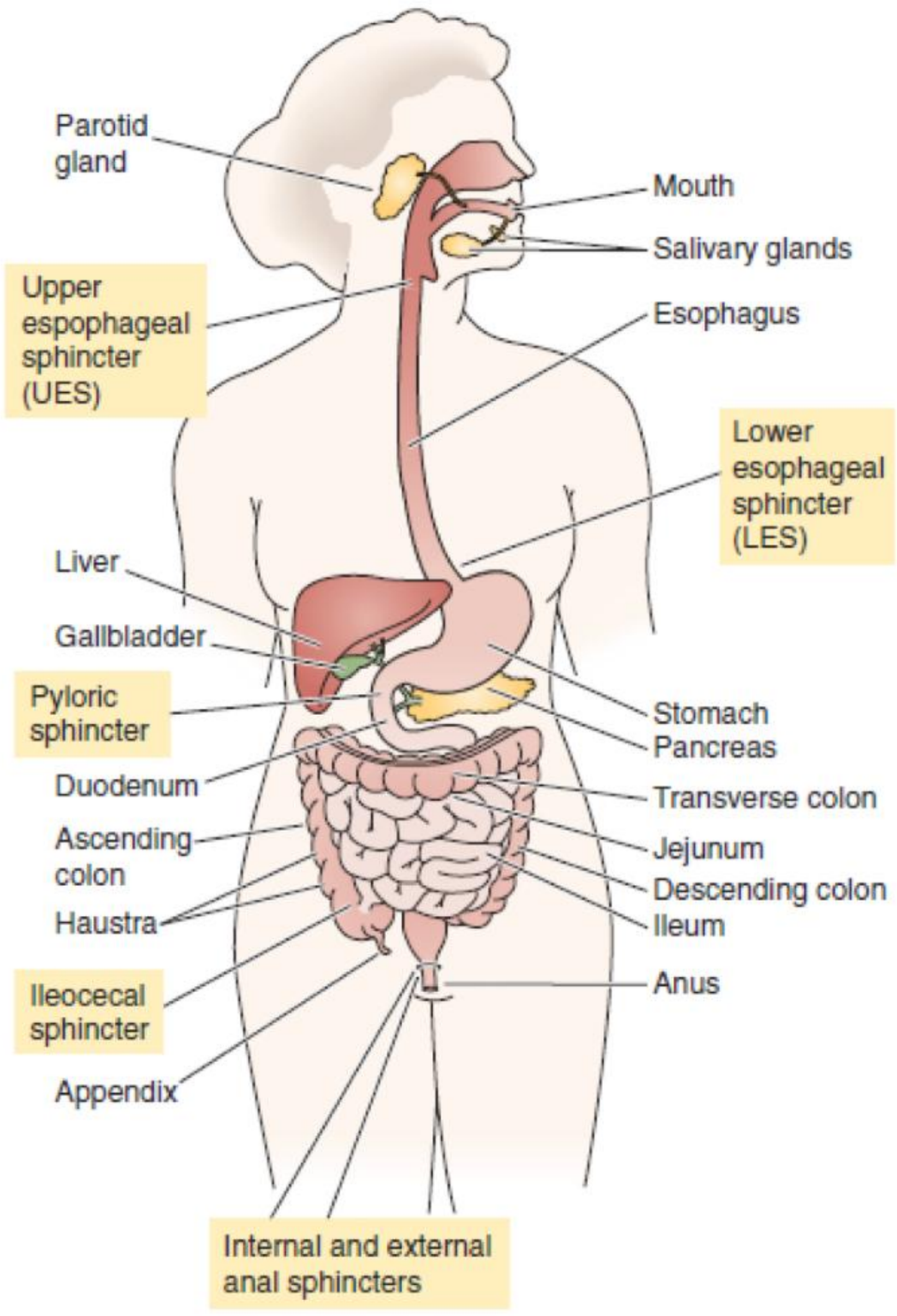


Figure 1-2

Functions of the GI System (Alimentary Tract)

provides the body with a continual supply of

- **Water**
- **Electrolytes**
- **Nutrients**

★ To achieve this function it requires:

1. Movement of food through the alimentary tract (motility).
2. Secretion of digestive juices & digestion of the food.
3. Absorption of : 1. Water 2. Various electrolytes 3. Digestive products.
4. Circulation of blood through the gastrointestinal organs to carry away the absorbed substances.

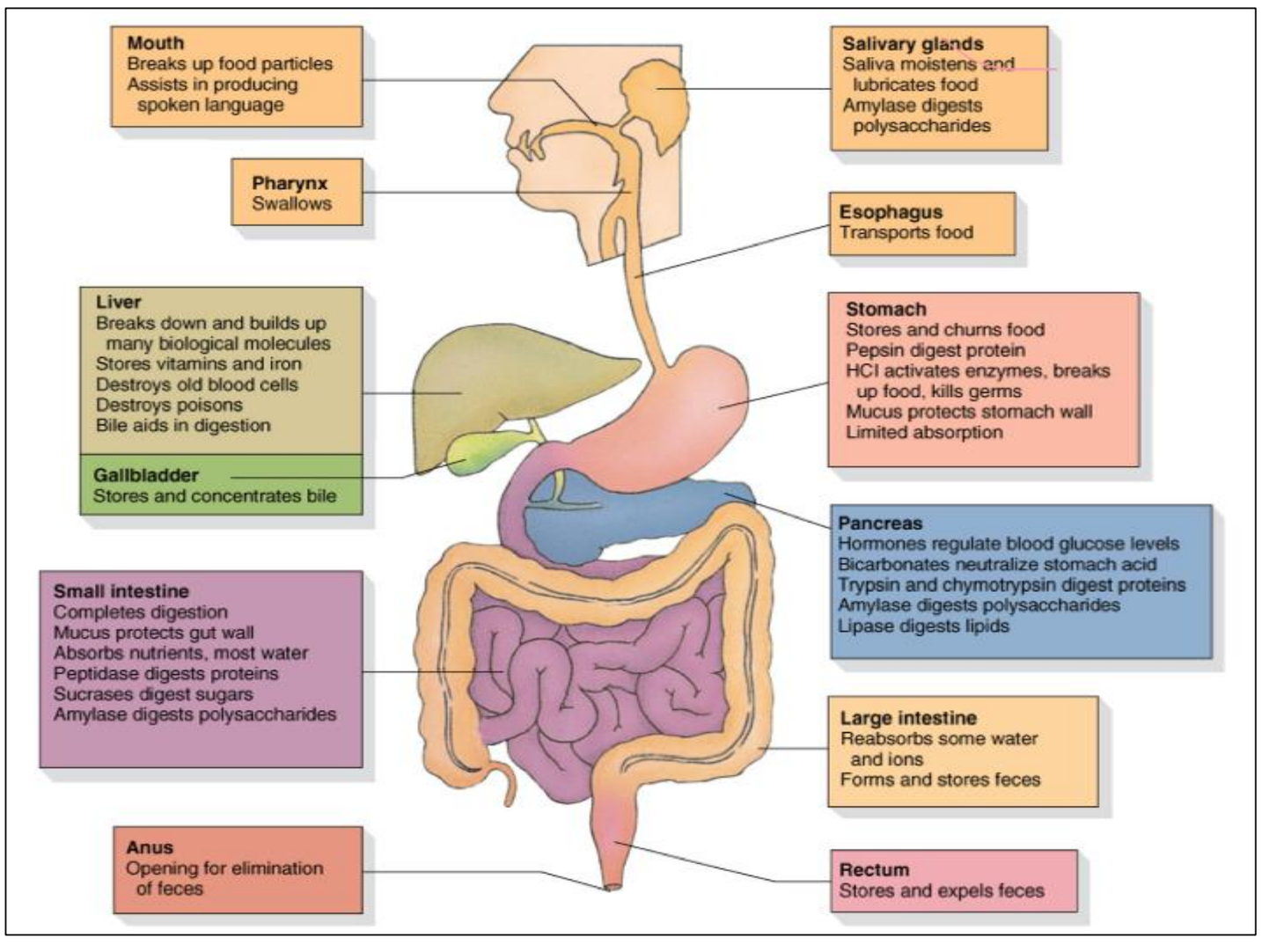


Figure 1-3

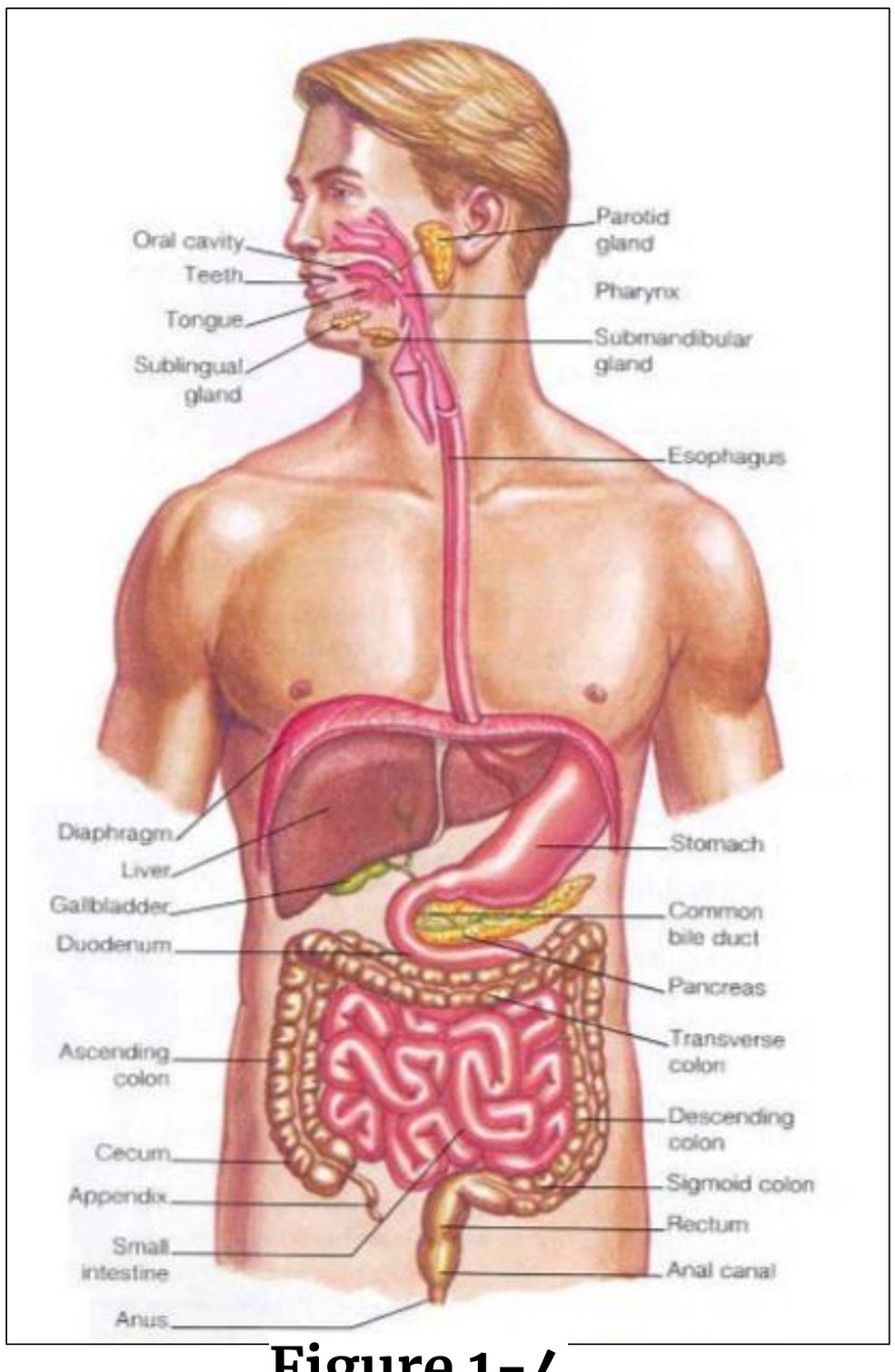


Figure 1-4

Functions of the GI System

The sedentary human body requires

≈ 30 kcal/Kg BW per day.

The food we consume is not in a form that can be directly absorbed by the small intestine.

Dietary nutrient	Consumed form	Absorbed form
Fat (lipids)	Triglycerides	• Fatty acids • Monoglycerides
Proteins	• Proteins • Large peptides	Amino acids
Carbohydrates	• Starch • Disaccharides • Monosaccharides	

Functions of the GI System

- Processes consumed food
  - Chemically
  - Mechanically
  - facilitate absorption.
- Excretion of waste material
  - Non-digested non-absorbed dietary products.
  - Colonic bacteria & their products.
  - Heavy metals (iron & copper)
  - Organic cations & anions (e.g. drugs)
- Regulation of balance of
  - Water
  - Electrolyte
- Immunity[1]

Dr Maha's note:
Factors that contribute to immunity:
1- Tight junctions in epithelial cells
2- HCl (Acidic environment)
3- Mucin (glycosylated protein)
4- Gut-associated lymphoid tissue (GALT)

FOOTNOTES

1. Check further readings, no. 1.

Functional Anatomy of the Wall of GIT

★ The anatomy of the wall varies but there is a common general theme.

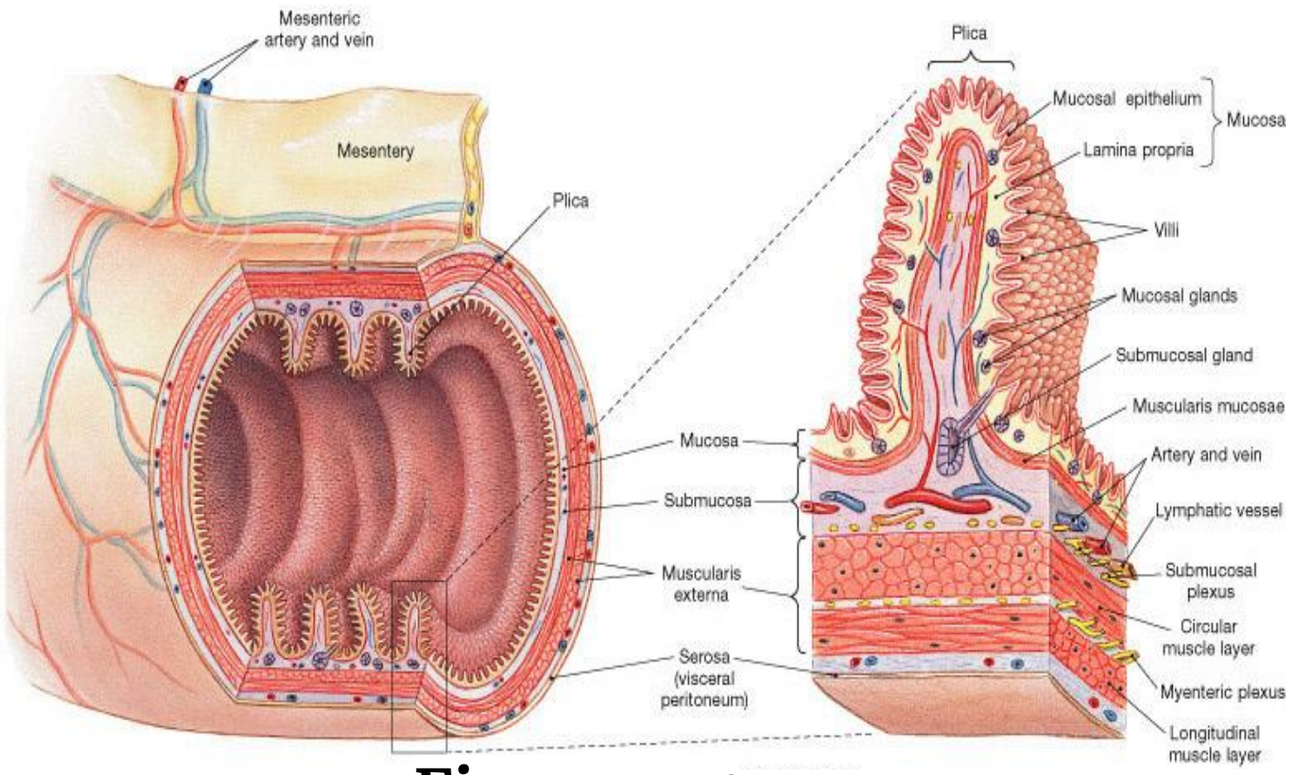


Figure 1-5

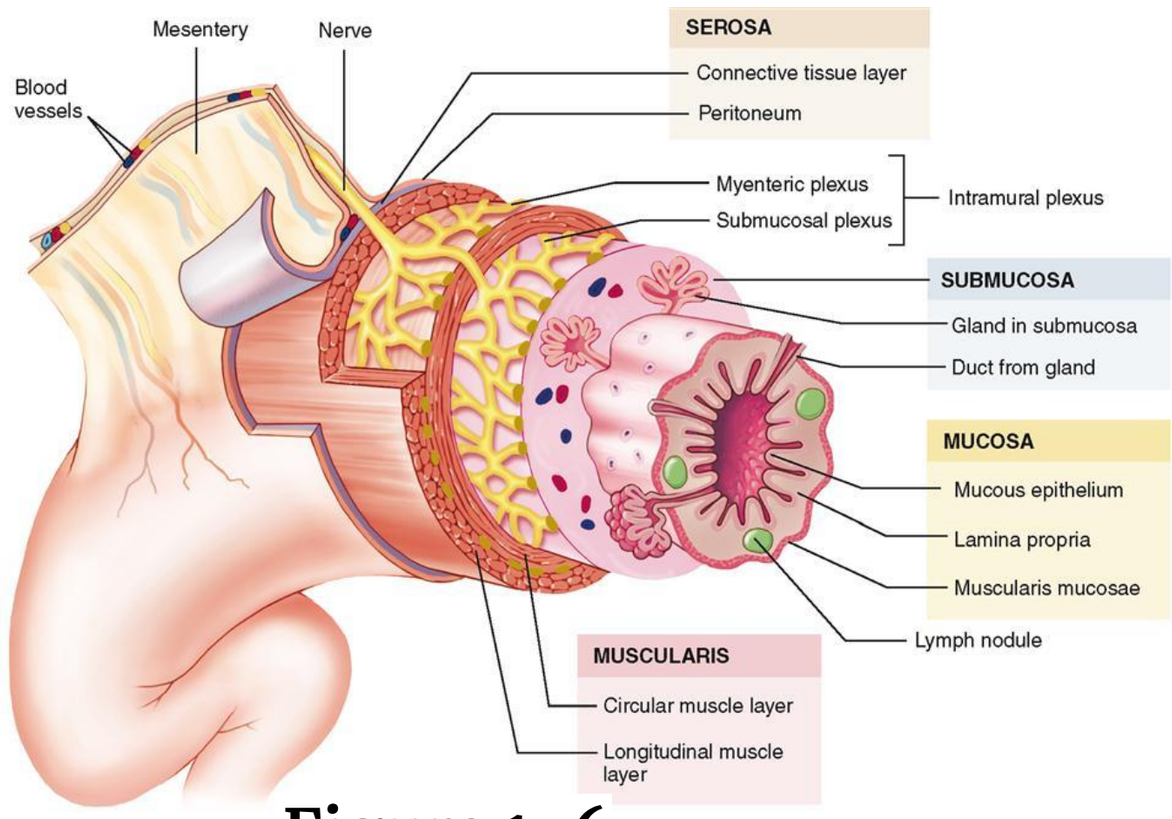


Figure 1-6

The General Characteristics of Smooth Muscle

★ The role of 2 .. Cerebellum lecture attack.

2 Main muscle layers

1. Longitudinal Smooth Muscles

★ **Contraction:**
- Expands the lumen.
- Shortens the segment.

★ innervated by enteric nervous system (ENS), and mainly by **Excitatory** motor neurons.

★ Ca^{+2} influx from **outside** is important in their activity.

2. Circular Smooth Muscles

★ **Contraction:**
- Reduces the diameter of the lumen
- Increases the length.

★ innervated by ENS, **both** excitatory & inhibitory motor neurons.

★ **Intracellular** release of Ca^{+2} is more important.

★ **Thicker and more powerful**

★ **More gap junctions**

2 Muscle classification

1. Unitary (single-unit)

★ **Contracts**
- in the absence of neural or hormonal influence.
- in response to stretch.

★ **Examples:**
- Stomach & intestine.

★ Cells are electrically coupled via **gap junctions.**

2. Multi-unit

★ **Does not Contract**
- in the absence of neural or hormonal influence.
- in response to stretch.

★ **Examples:**
- Esophagus & gall bladder, iris and constrictor pili.

2 Types of contraction

1. Phasic (rhythmical)

Smooth muscle cells contract **rhythmically** or intermittently.

➢ **Periodic** contractions followed by relaxation

★ **Example:**

Walls of the GI tract.
- Gastric antrum
- Small intestine
- Esophagus.

2. Tonic Check further readings, no. 2.

Smooth muscle cells continuously active maintaining a **"tone"**

➢ **Continuous** partial contraction.

★ **Examples:**
- sphincters:
  - Lower esophageal .
  - Ileocecal .
  - Internal anal.
- vascular & respiratory smooth muscle
- Orad region of the stomach

★ **Caused by:**
- Repetitive spike potentials.
- Hormones.
- Continuous entry of Ca^{+2} ions (not associated with changes in membrane potentials)
  - Not associated with slow waves (often lasting several minutes or hours).

Examples of the Different Types of Smooth Muscle

Single-unit smooth muscle

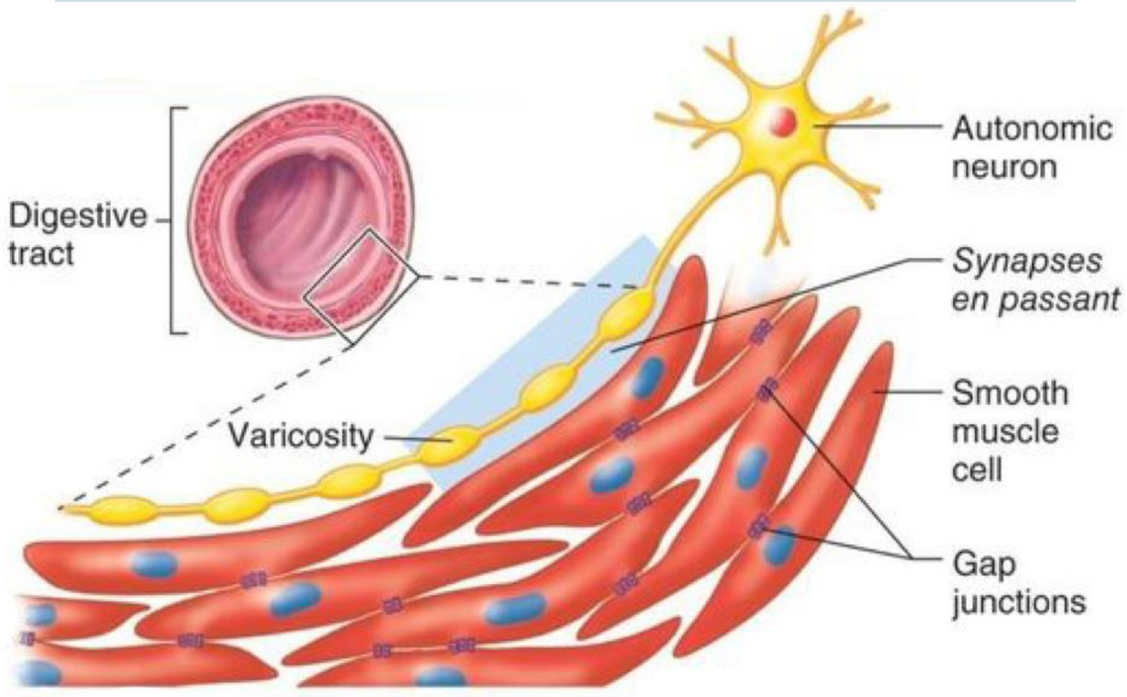


Figure 1-7

Multi-unit smooth muscle

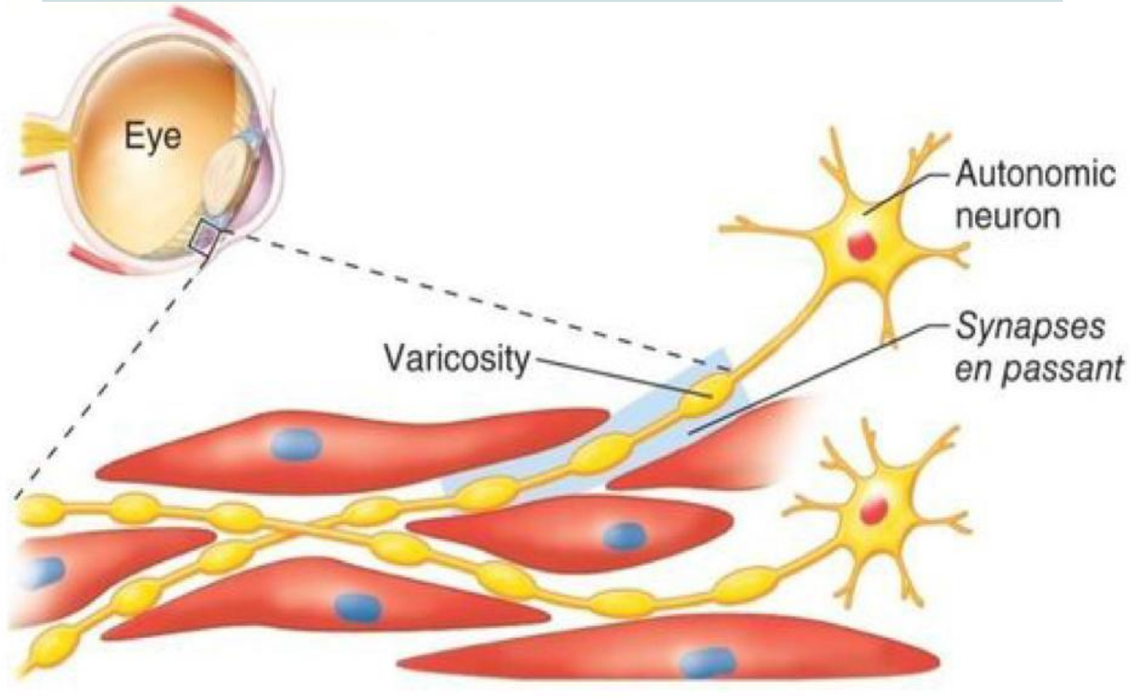


Figure 1-8

Contractile Mechanism of Smooth Muscle

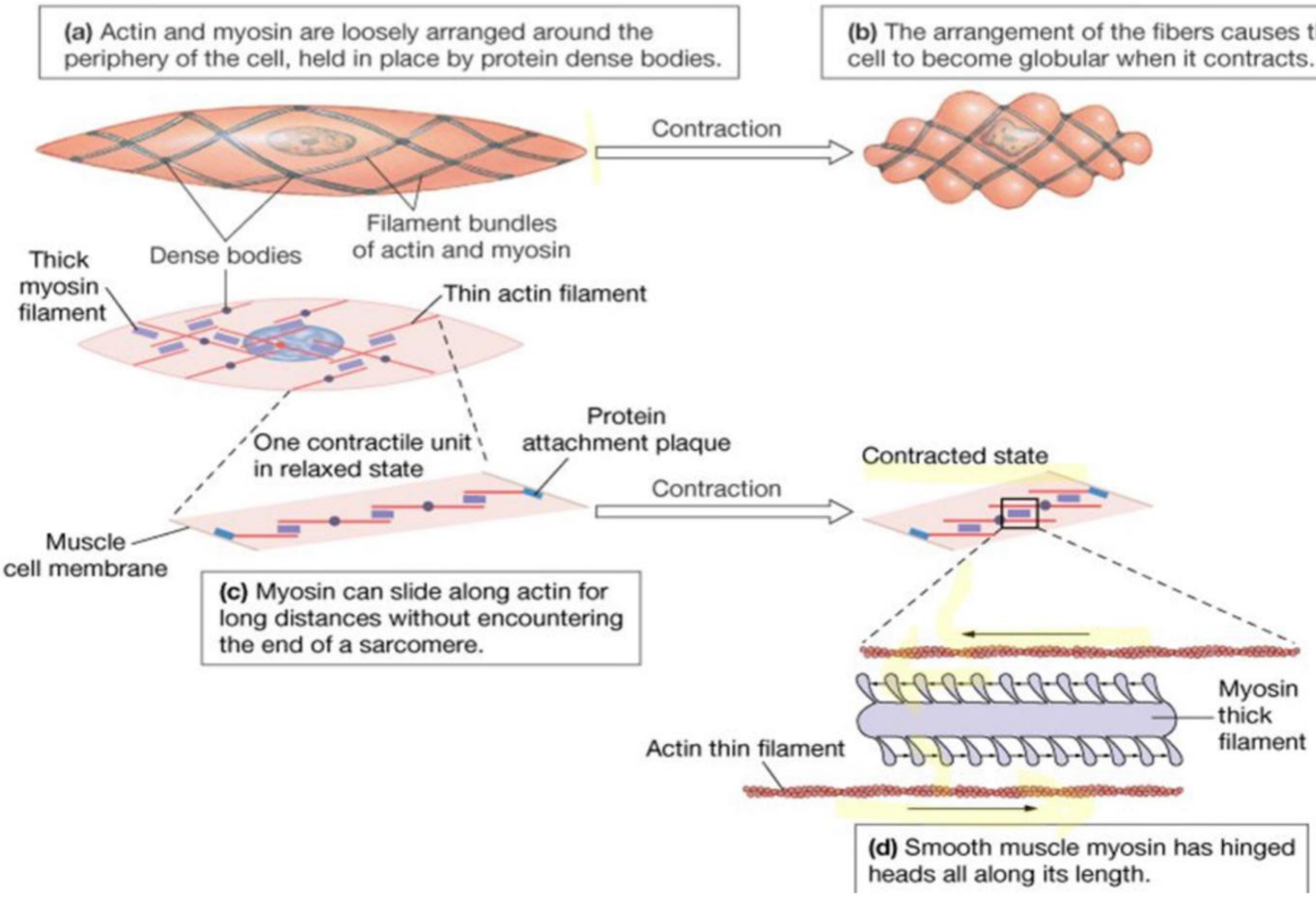


Figure 1-9

Molecular Basis of Smooth Muscle Contraction

1. ↑ Intracellular ca^{+2} concentration by:
   - Entry to cell
   - Ca^{+2} release from sarcoplasmic reticulum
2. Ca^{+2} binds to calmodulin (CaM)
3. Ca^{+2}-calmodulin activates Myosin Light Chain Kinase (MLCK)
4. MLCK phosphorylates light chains in myosin heads and increases myosin ATPase activity
5. Active myosin crossbridges slide along actin and create muscle tension.

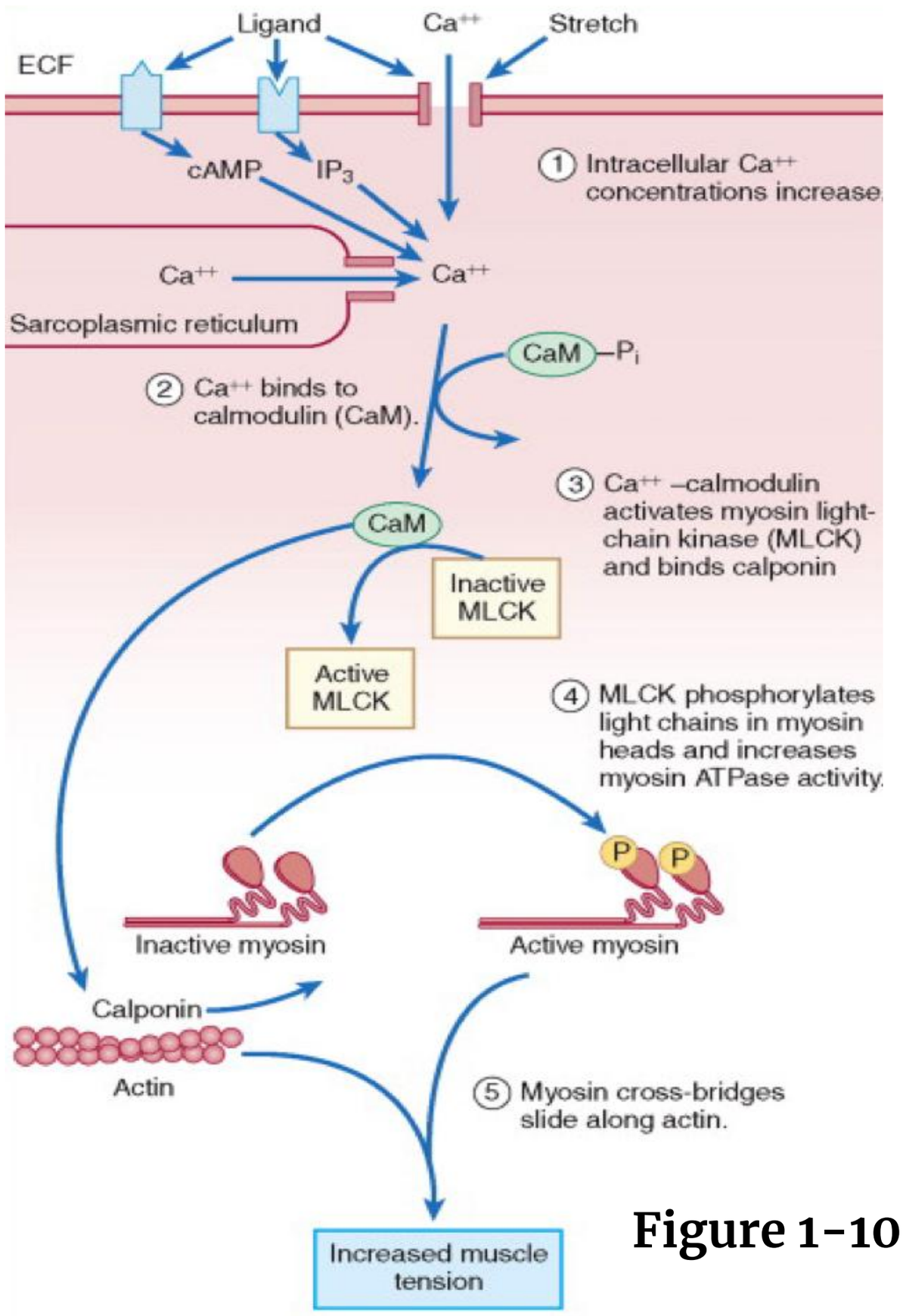


Figure 1-10

How Does Smooth Muscle Contraction Stop ?

Relaxation

- Drop in Ca^{+2} → Deactivation of MLCK
- Dephosphorylation by Myosin Phosphatase → Deactivation of phosphorylated myosin heads

Skeletal VS Smooth

- ★ Somatic neuron.
- ★ Branching end feet.
- ★ Acetylcholine.
- ★ varicosities[1].

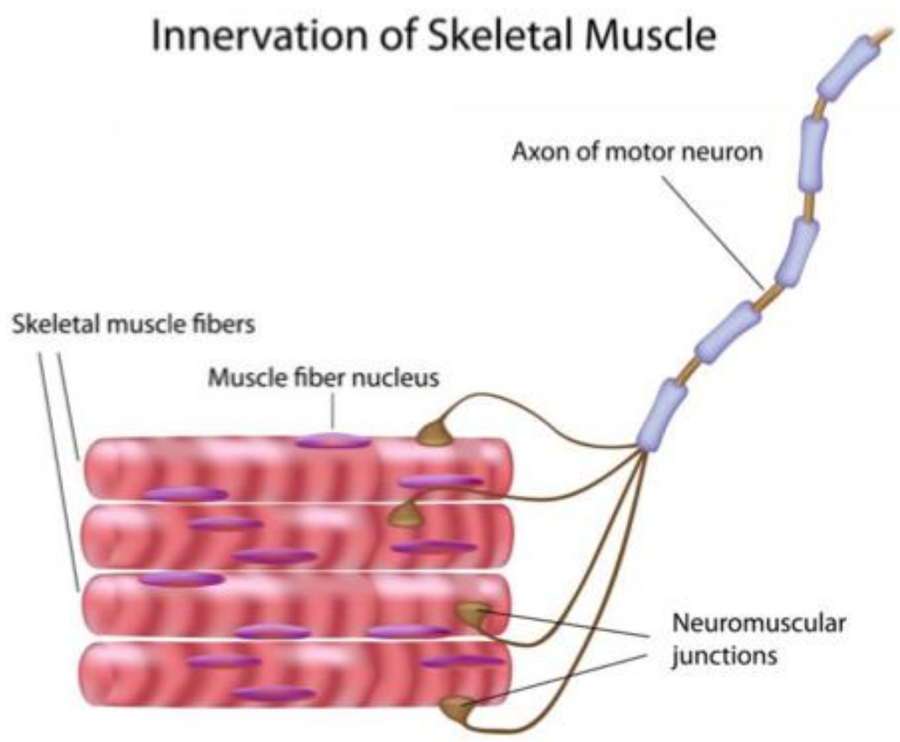


Figure 1–11

- ★ Autonomic neuron.
- ★ Multiple varicosities[1].
- ★ Acetylcholine & Noradrenaline
- ★ Contraction can happen in the absence of action potential.
- ★ Can be stimulated to contract by many types of signals.

Pacemaker activity	Hormonal
Mechanical	Nervous

- e.g. stretch.

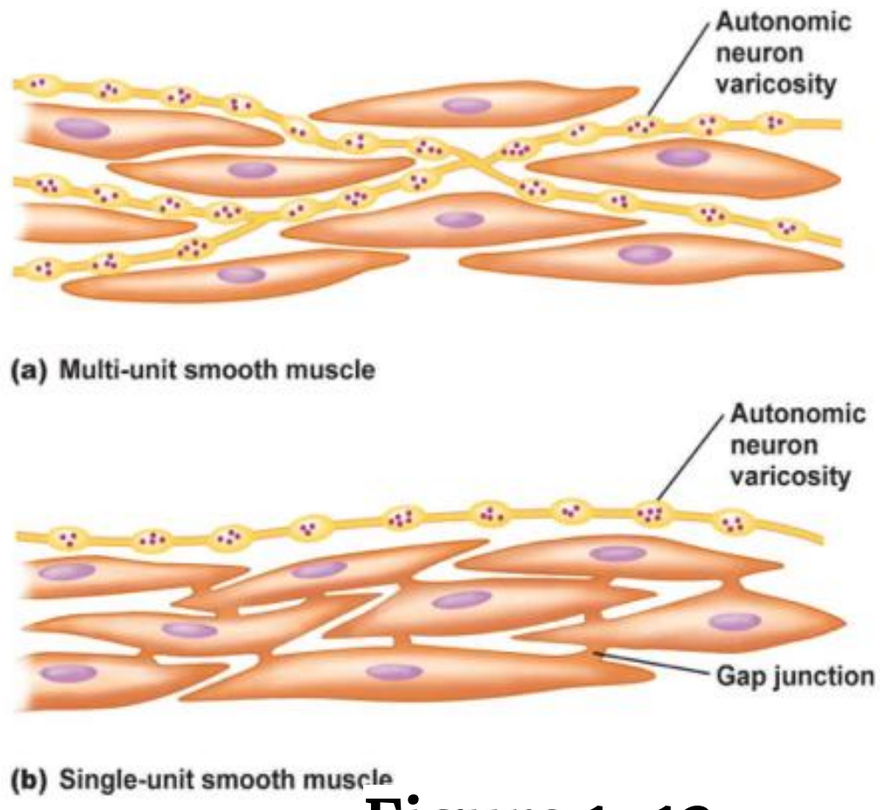


Figure 1–12

The Specific Characteristics of Smooth Muscle in Gut

1- Action potentials

Special type of channels:

- Slower to open and close than the rapid Na channels of large nerve fibers.
- Passes:

↑ Number of Ca^{+2}

↓ Number of Na^{+}

FOOTNOTES

1. Varicosities are the swellings of nerve fibers that contain the neurotransmitter prior to its release from vesicles. The term is used more with smooth muscle fibers. Whereas in case of skeletal muscles we refer to those interactions as neuromuscular junctions (NMJ).

2- Electrical activity

- Continual.
- Slow.
- Intrinsic.

Slow (myogenic) Waves[1]

Definition :
Rhythmic oscillating depolarization and repolarization in the resting membrane potential with unknown cause.

Origin:
Interstitial cells of Cajal (ICC)

- It's the GI pacemaker.
- Abundant in myenteric plexuses (between smooth muscle layers)
- form a network with each other
- synaptic-like contacts to smooth muscle cells.

Function:
Determine the rhythm of GI contraction

Features:
- No Ca entry (only Na)
- Not action potentials (because it's below threshold)
- No muscle contraction
- Intensity : 5-15 **mV**
- Frequency 3-12/ **min**
  - Ranges in different parts of GI tract
    - Stomach: **3**/min
    - Duodenum: **12**/min
    - Ileum: **8-9**/min

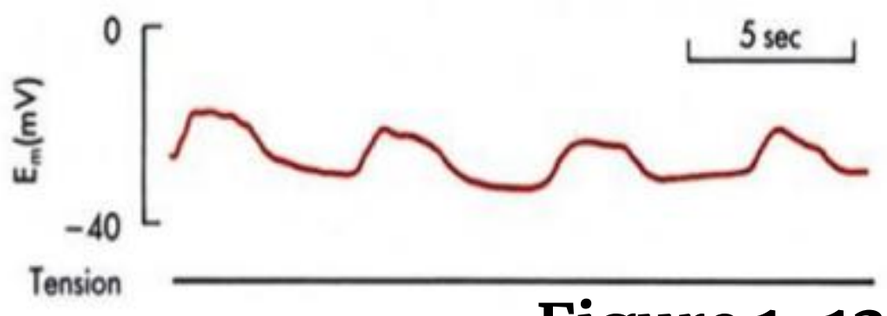


Figure 1-13

Spike potentials[1]

★ True Action potentials

Generation:
- Automatically when the resting membrane potential becomes more positive <-40 mV (Resting membrane potential : -50 - -60 mV)
- At the peaks of slow waves.

Frequency:
1-10 spikes/min

Duration:
Each spike lasts as long as 10-20 **ms**
10-40 times as long as the action potentials in large nerve fibers

Direct Relation with slow waves:
↑ slow wave potential (above threshold) → ↑ frequency of the spike potentials

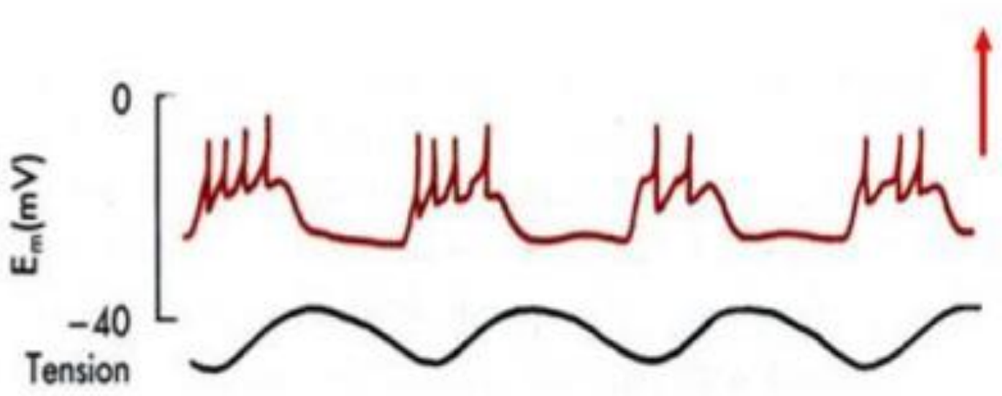
FOOTNOTES

1. It's important to point out that action potentials only occur when these slow-wave potentials are superimposed by excitatory neurotransmitters released by nerve endings. Which means that slow-wave potentials provide the threshold required for excitatory neurotransmitters to fulfill their activities.

2- Electrical activity

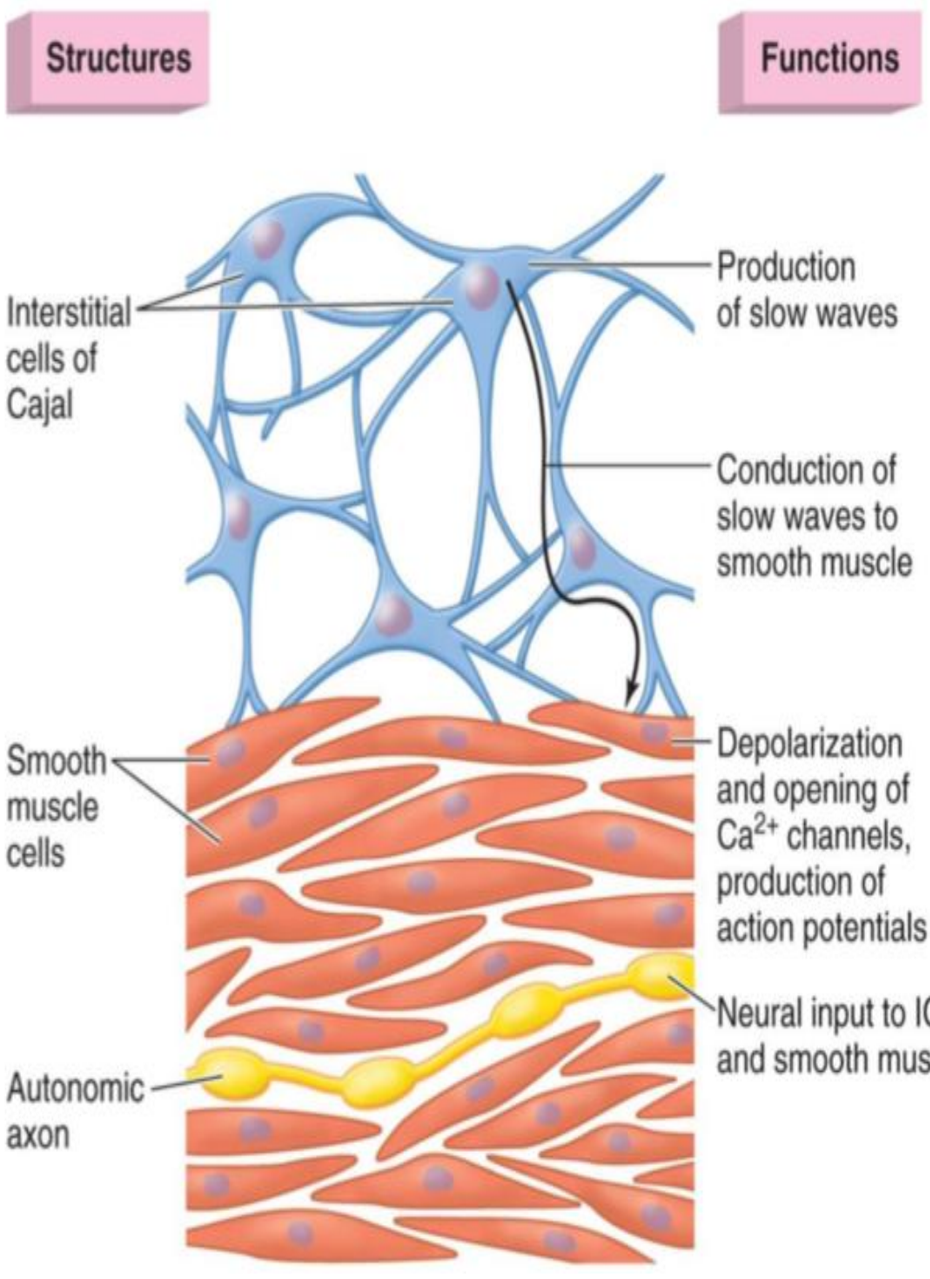
Changes in Voltage of the Resting Membrane Potential.

Factors **depolarize** the membrane (make it **more** excitable)	Factors **hyperpolarize** the membrane (make it **less** excitable)
1- Muscle stretch[1]. 2- Acetylcholine (parasympathetic stimulation). 3- Specific GI hormones.	Sympathetic stimulation ▪ Epinephrine (mainly). ▪ Norepinephrine.



With parasympathetic input, the membrane at the plateau of the slow wave depolarizers all the way to threshold; action potentials occur "on top of" the slow wave, and these set off contractions. The contraction / tension follows slightly after the electrical response.

If resting potential is shifted to more negative values (from sympathetic input) spikes and contractions will not occur.



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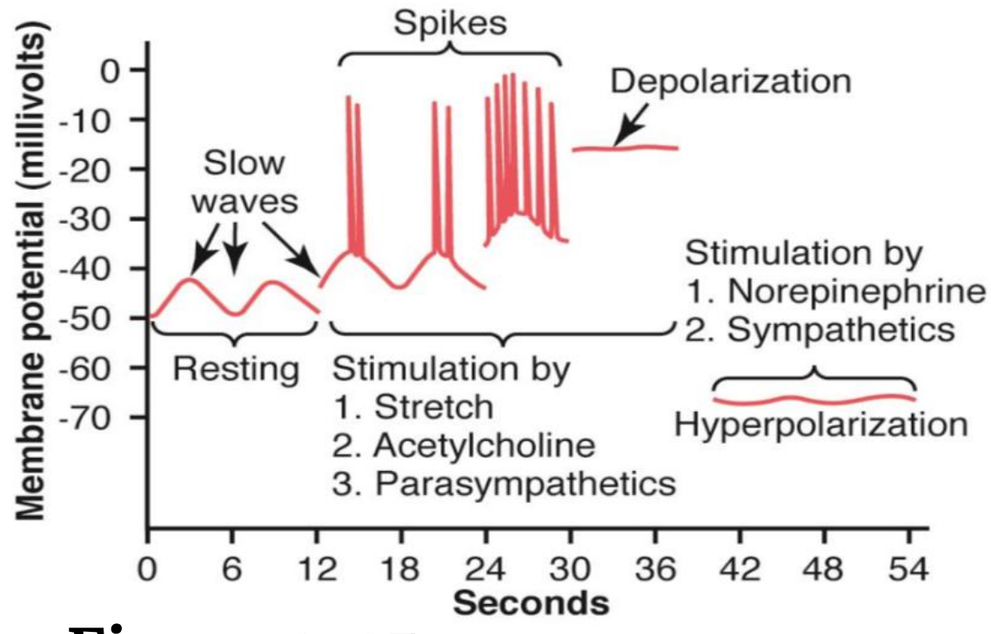


Figure 1–15

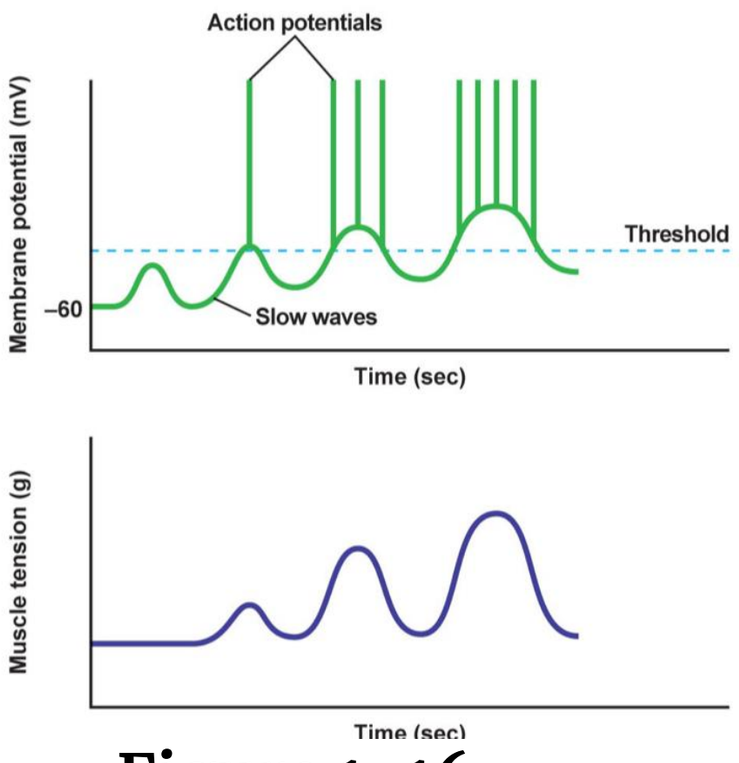


Figure 1–16

FOOTNOTES

1. To conceptualize this, just beneath the epithelium there are mechanosensitive sensory neurons that can communicate with ENS in response to stretch to initiate contraction.

3- Syncytial function

Syncytium:
when an action potential is elicited anywhere within the muscle mass, it generally travels in all directions in the muscle.

Muscle fibers:
- Length: 200 – 500 µm.
- Diameter: 2 – 10 µm.
- Arrangement: Bundles.

Muscle bundle :
- 1000 parallel fibers.
- Gap junctions connect muscle fibers.

Control of GI Function

Neural | Hormonal | GI contents

1. Enteric Nervous system:

- The nervous system of GI tract.
- Lies entirely in the wall of the gut.
  - esophagus → anus.
- Has as many neurons as spinal cord (~ 100 million).
- Its function is largely independent of the extrinsic NS "mini-brain"
- Parasympathetic & sympathetic systems[1] Can greatly enhance or inhibit gastrointestinal functions.

The sensory nerve endings send afferent fibers to:

01. **Plexuses of the enteric system** .
02. **Prevertebral ganglia (sympathetic NS).**
03. **Spinal cord.**
04. **Vagus nerves (80% afferent).**

→ To the brain stem (Medulla) .
- Vagovagal reflexes

→ Elicit local reflexes within the gut wall.

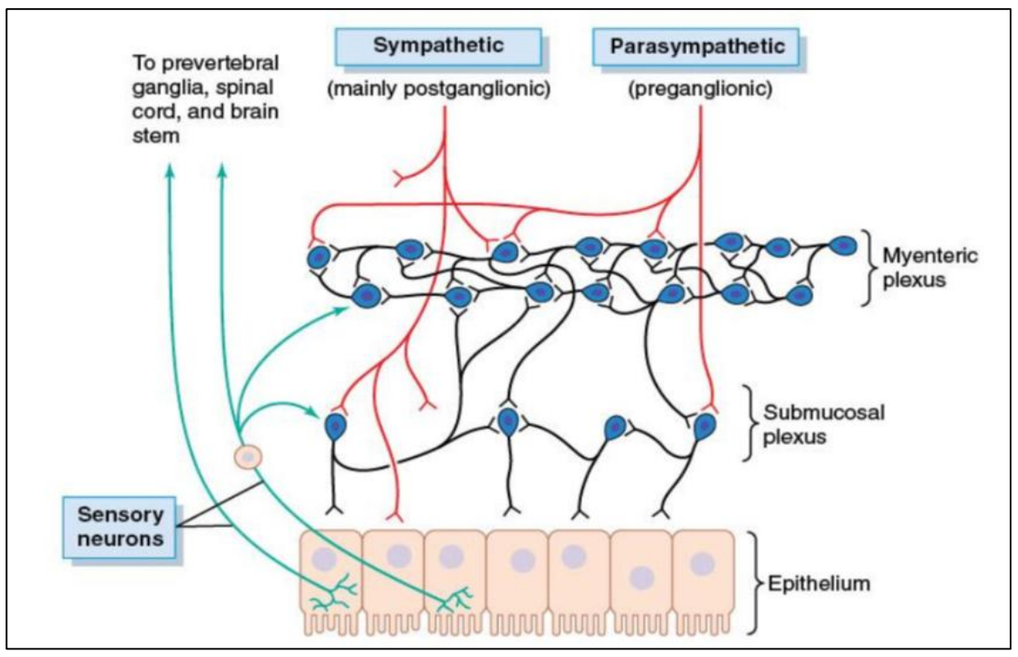


Figure 1-17

FOOTNOTES

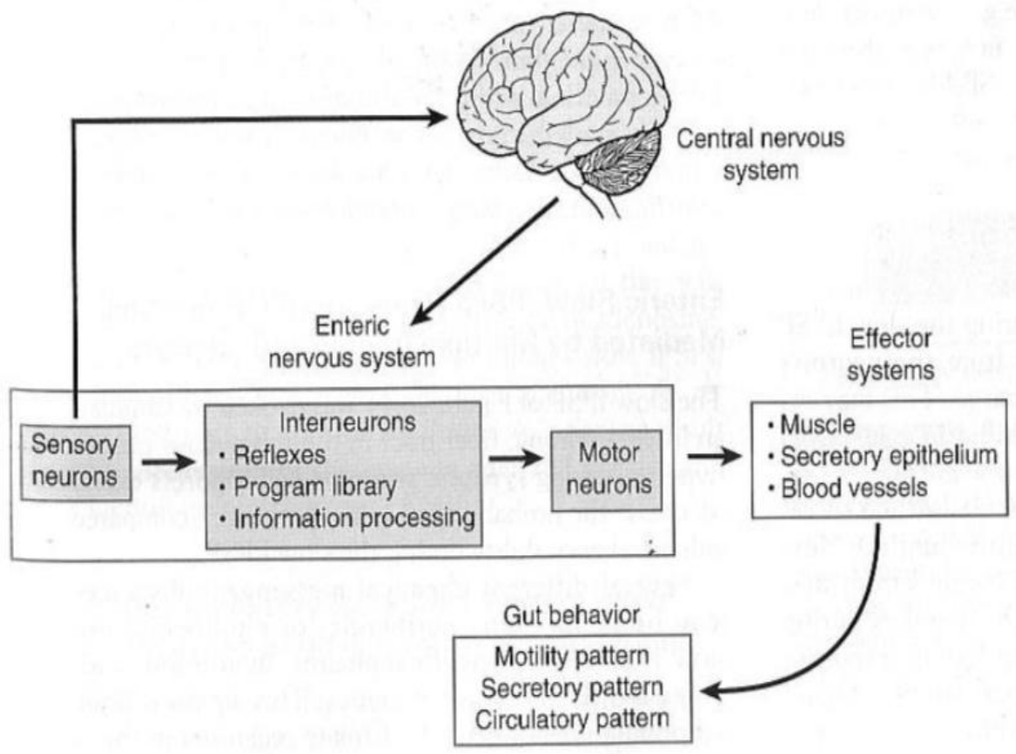
1. Note that parasympathetic nervous system acts via preganglionic neurons, meaning it has to synapse within the the ENS to induce any physiological effect, in-order for the preganglionic to become postganglionic. Whereas sympathetic nervous system can act directly and indirectly, sympathetic nerves can also inhibit ACh release by acting on vagal nerve endings. This contributes to their inhibitory function.

Control of GI Function

Neural | Hormonal | GI contents

1. Enteric Nervous system:

★ 2 main plexuses	
Myenteric "Auerbach's"	**Submucosal** "Meissner's"
Outer	Inner
between longitudinal & circular muscle layers.	In submucosa
Found throughout the GIT	Only in small & large intestine
Controls GI **movement** . "Motility"	Controls **secretions** & local **blood flow**.
1. ↑ Tonic contraction. 2. ↑ Intensity and rate of rhythmical contractions. 3. ↑ Velocity of conduction of excitatory waves along the gut wall.	**Controls :** 1. local intestinal secretion. 2. local absorption. 3. local contraction of submucosal muscle. → various degrees of enfolding of the GI mucosa.
Consists mostly of a linear chain of many interconnecting neurons.	
Has excitatory & inhibitory motor neurons.	



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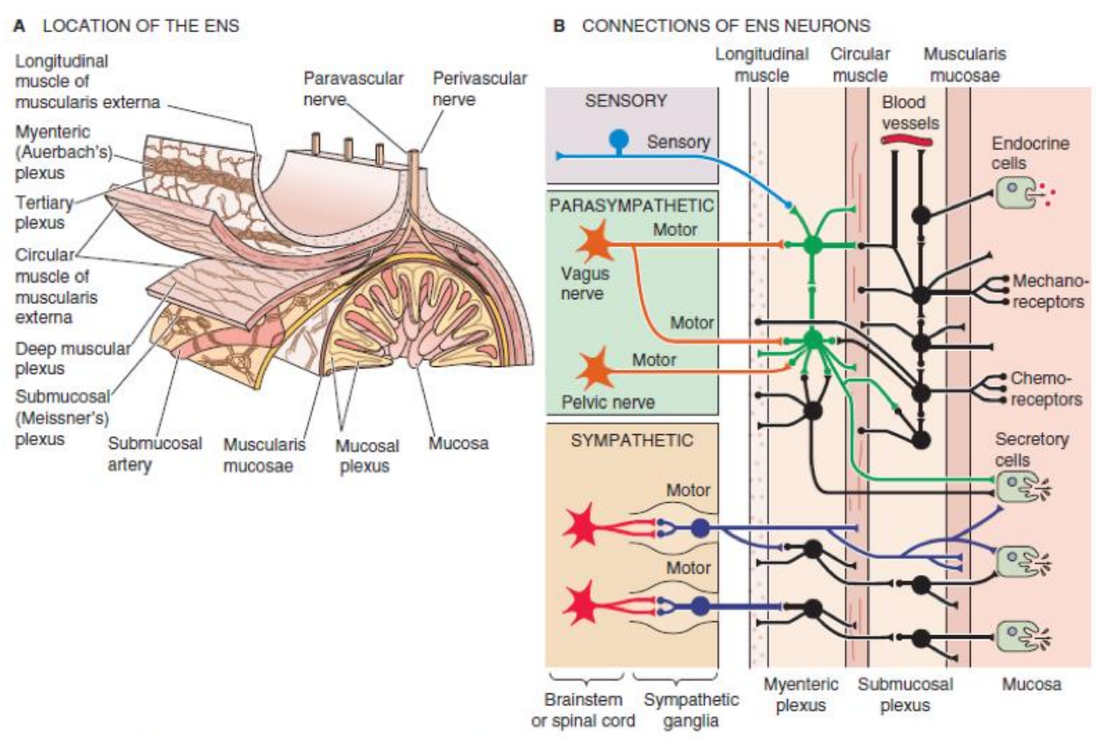


Figure 41-3 Schematic representation of the ENS. **A,** The submucosal (or Meissner's) plexus is located between the muscularis mucosae and the circular muscle of the muscularis externa. The myenteric (or Auerbach's) plexus is located between the circular and longitudinal layers of the muscularis externa. In addition to these two plexuses that have ganglia, three others—mucosal, deep muscular, and tertiary plexus—are also present. **B,** The ENS consists of sensory neurons, interneurons, and motor neurons. Some sensory signals travel centrally from the ENS. Both the parasympathetic and the sympathetic divisions of the ANS modulate the ENS. This figure illustrates some of the typical circuitry of ENS neurons.

Figure 1–19

Control of GI Function

Neural | Hormonal | GI contents

1. Enteric Nervous system:

Neurotransmitters
Specific functions aren't well known

Excitatory

Motor neurons
- Substance P.
- Ach.

Secretomotor neurons
- vasoactive intestinal peptide (VIP)
- Histamine.
- Ach.

★ Release water, electrolytes and mucus from crypts of Lieberkuhn[1].

Inhibitory

Motor neurons
(Deactivation of phosphorylated myosin heads)
- Adenosine tri-peptide (ATP)
- Nitric oxide (NO)
- VIP.

Afferent Sensory Nerve Fibers from the Gut

- **Cell bodies location:**
  - Enteric nervous system.
  - Dorsal root ganglia.
- **Stimuli**
  i. Irritation of the gut mucosa.
  ii. Excessive distention of the gut.
  iii. Presence of specific chemicals in the gut.
- **Type of signal transmitted**
  - Excitatory.
  - Inhibitory.

FOOTNOTES

1. Crypts of Lieberkuhn: Remember that the gut mucosa is far-away from smooth, it is invaginated into "pits", with mucus cells at the surface. These pits are called crypts of lieberkuhn, check further readings for more.

Control of GI Function

Neural | Hormonal | GI contents

★ Autonomic nervous system (ANS) is divided into:
- Parasympathetic
- Sympathetic
- Enteric Nervous System (ENS)

2. Sympathetic nervous system:

- Origin: T5-L2
- Innervates essentially GI tract.
- Nerve endings secrete mainly norepinephrine.
- Stimulation inhibits activity of the GI.
- Strong stimulation → can inhibit motor movements so greatly → block movement of food.

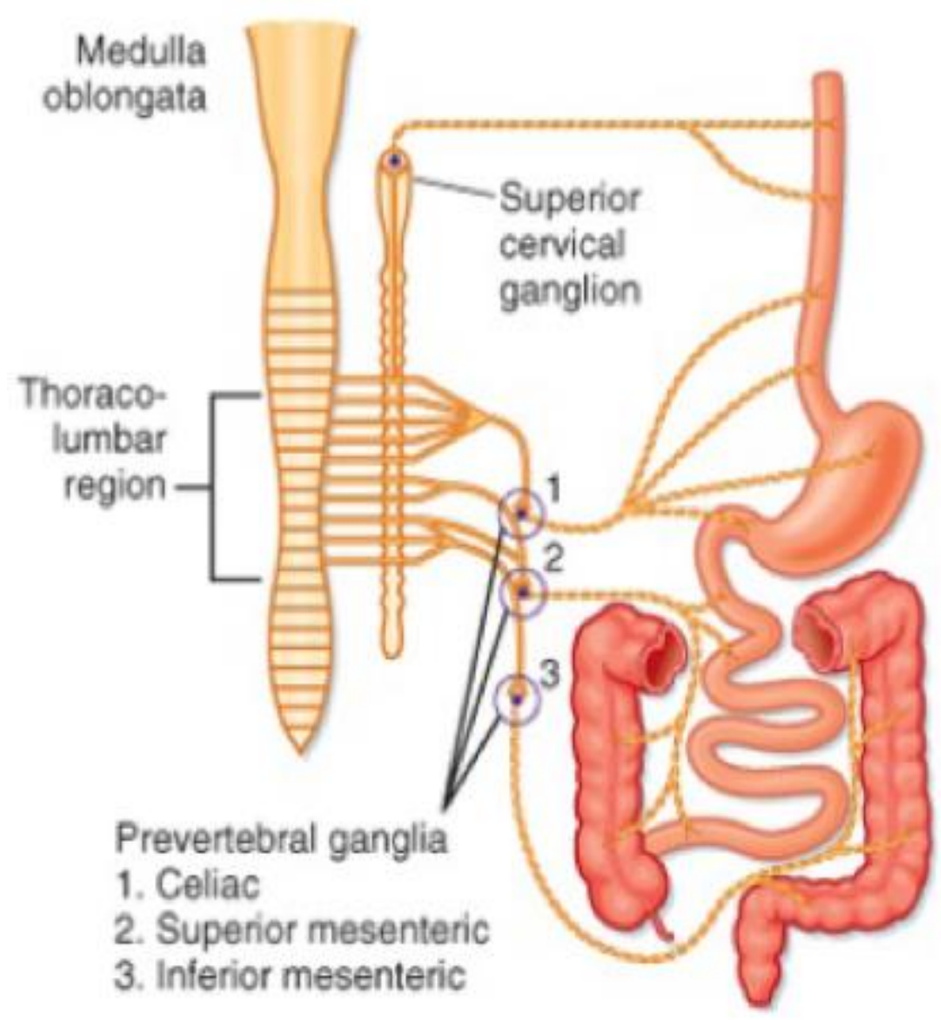


Figure 1-20

3. Parasympathetic nervous system:

- Vagus nerves (cranial division) innervate:
  - Esophagus.
  - Stomach.
  - Pancreas.
  - Intestines down to the first half of the large intestine.
- Pelvic nerves (sacral division) innervate:
  - Distal half of the large intestine.
  - Anus.

(To execute the defecation reflexes).

- Postganglionic neurons are located mainly in the myenteric and submucosal plexuses.
- Stimulation causes general increase in activity of the enteric nervous system.

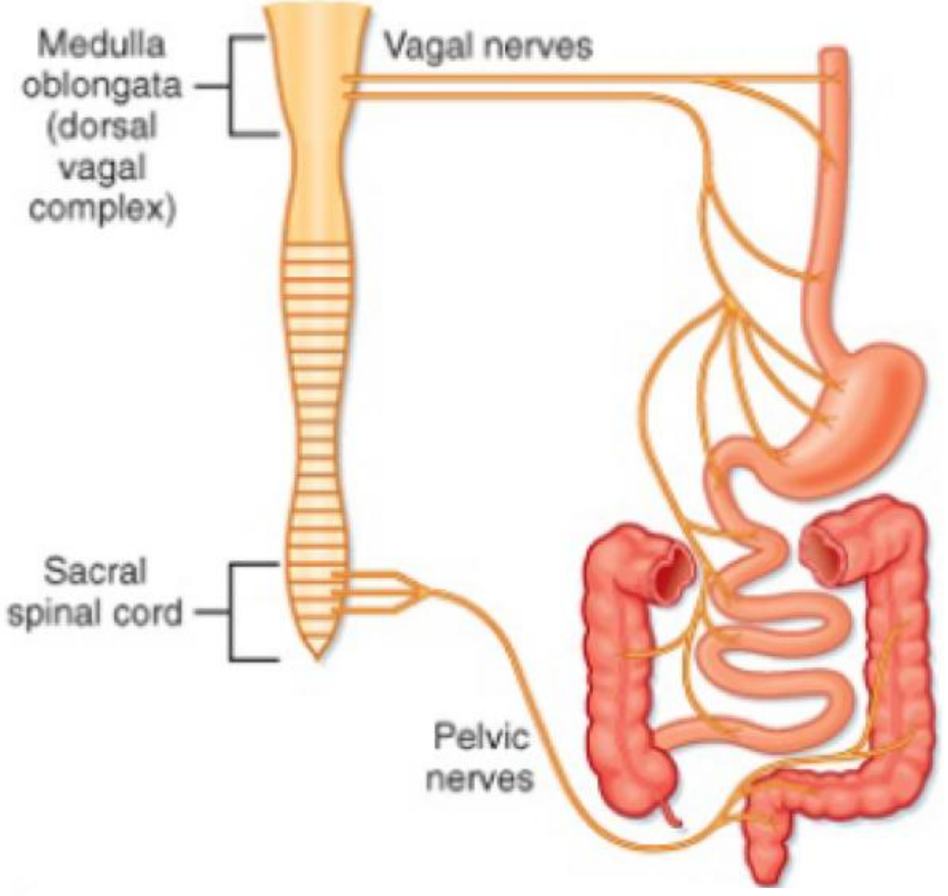
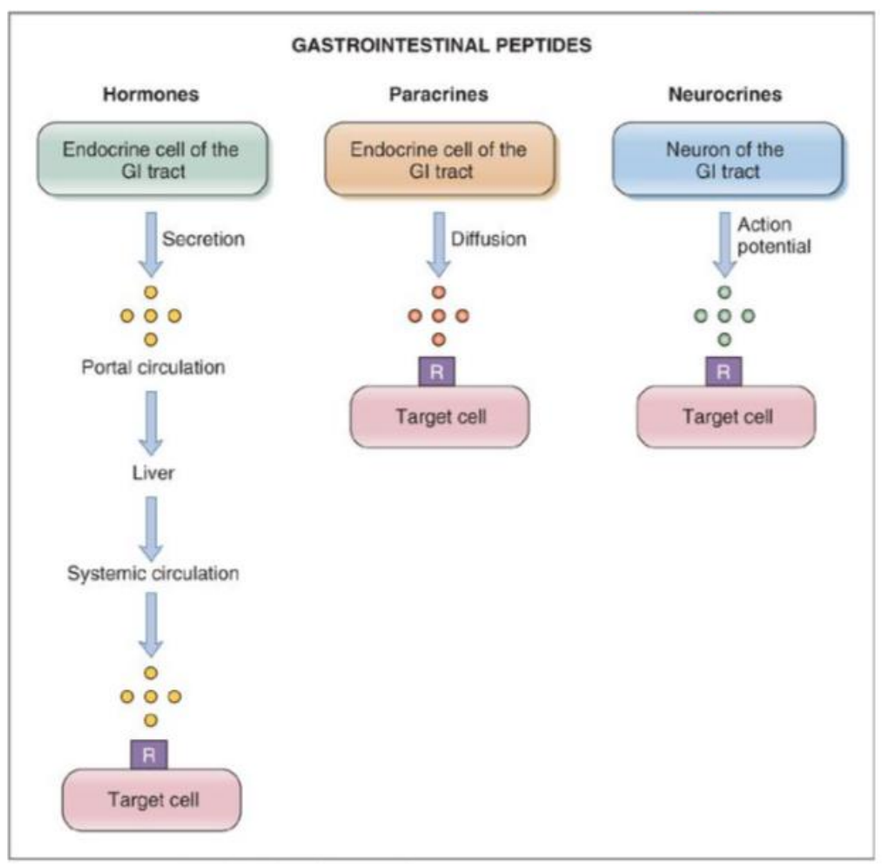


Figure 1-21

Control of GI Function

Neural | Hormonal | GI contents

Hormone	Site of action	Stimuli	Actions
Gastrin	**G cells** - Antrum - Duodenum - Jejunum	• Protein. • Distention of the stomach. • Vagal stimulation (**GRP**). • Acid (**inhibits release**).	**Stimulates:** • Gastric H+ secretion. • Growth of gastric mucosa.
Cholecystokinin (CCK)	**I cells** - Duodenum - Jejunum - Ileum	• Protein. • Fatty acids. • Acids.	**Stimulates:** • Pancreatic enzyme secretion. • Pancreatic HCO-3 secretion. • Gallbladder contraction. • Exocrine pancreas growth. • Relaxation of the sphincter of Oddi.[1] **Inhibits:** Gastric emptying
Secretin	**S cells** - Duodenum - Jejunum - Ileum	• Acids. • Fat. (in the duodenum)	**Stimulates:** • Pepsin secretion. • Pancreatic HCO -3 secretion. • Biliary HCO -3 secretion. • Exocrine pancreas growth. **Inhibits:** Gastric H+ secretion
Glucose-Dependent Insulinotropic Peptide (GIP)	**K cells** - Duodenum - jejunum	• Protein. • Fatty acids. • Oral glucose.	**Stimulates:** Insulin secretion (from pancreatic β cells) **Inhibits:** Gastric H+ secretion
Motilin	**M cells** - Duodenum - Jejunum	• Fat. • Acid. • Nerve.	**Stimulates:** • Gastric motility. • Intestinal motility.



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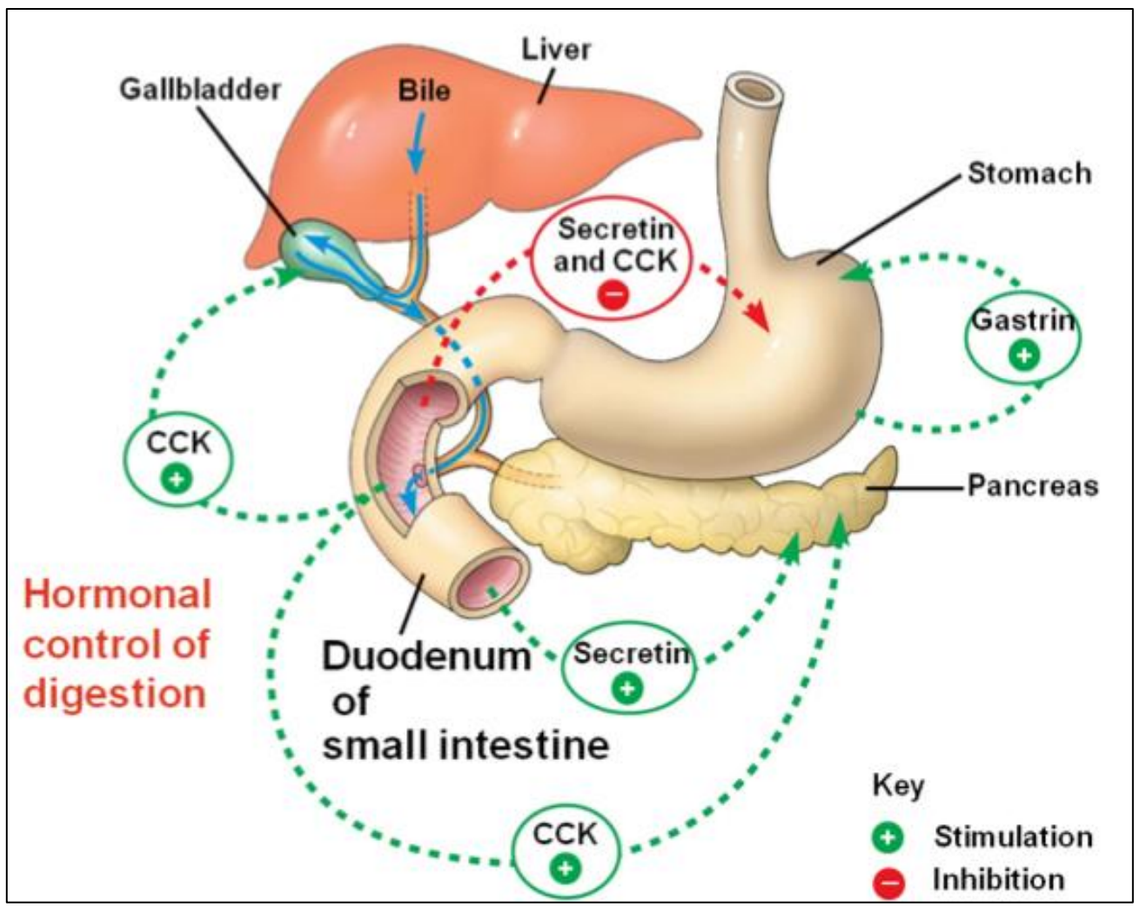


Figure 1-23

FOOTNOTES

1. Sphincter of Oddi: most of food absorption occurs in jejunum, and duodenum serves in digestion of food before absorption in jejunum. This digestion is helped by pancreatic and biliary secretions that contain many enzymes and are collected in a common duct that empties into the duodenum, the sphincter for this duct is the sphincter of Oddi.

GI reflexes

Integrated within ENS

Local effects

- GI secretions
- Peristalsis
- Mixing movement

Integrated at Sympathetic ganglia

Signals Travel Long distance in GIT

Gastrocolic

★ Stomach → colon.

Enterogastric

★ Colon & small intestine → stomach
★ inhibit motility & secretion.

Colonoileal

★ Colon → ileum
★ inhibit emptying into the colon.

Integrated at spinal cord/brain stem

Control gastric motor and secretory activity

Vagus N.

Duodenum & Stomach ⇄ Brain stem

Pain reflexes

★ Cause general inhibition of the entire GI tract.

Defecation reflexes

Colon & Rectum ⇄ Spinal cord

★ Produce the powerful contractions required for defecation:
- Colon.
- Rectum.
- Abdomen.

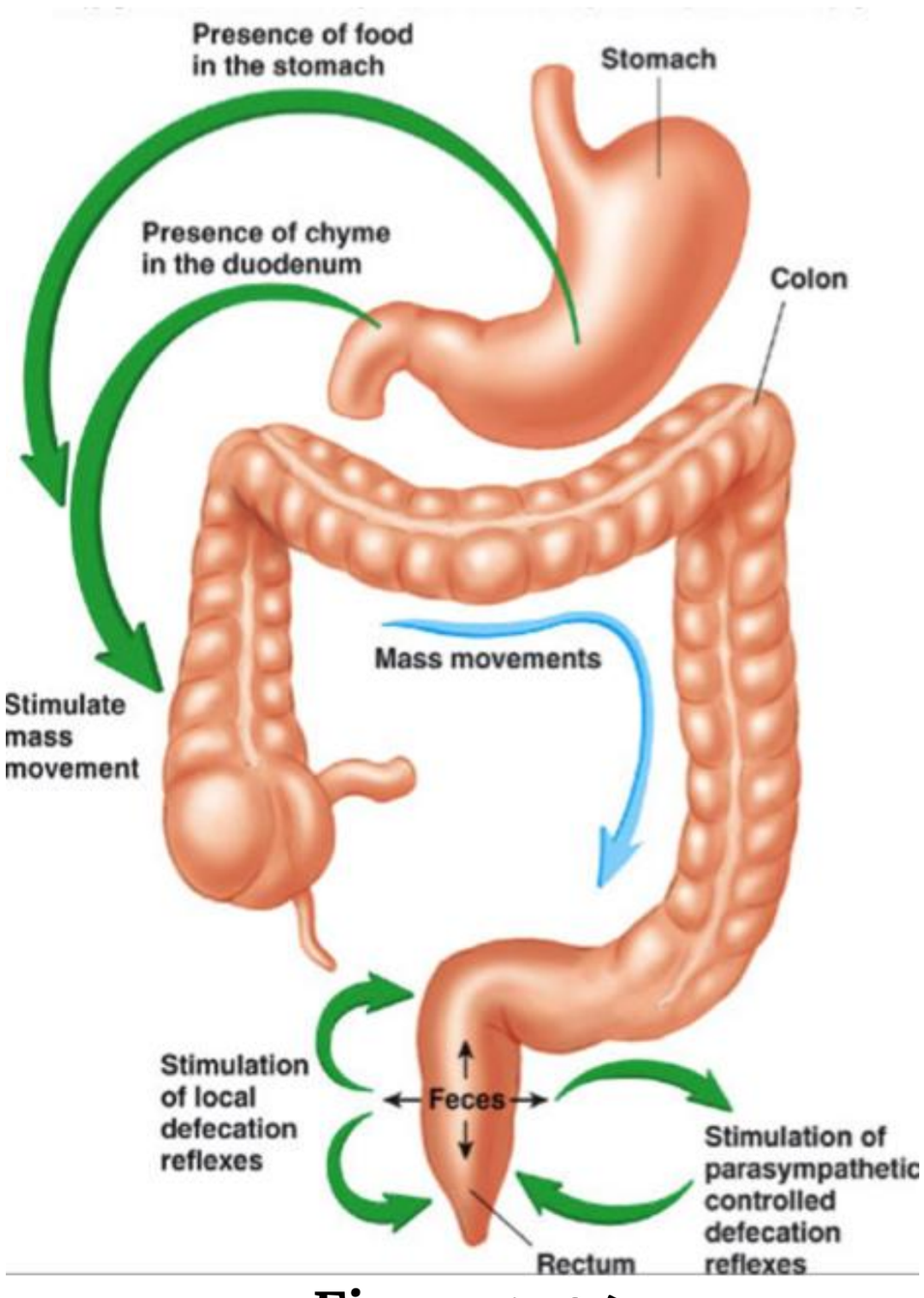


Figure 1-24

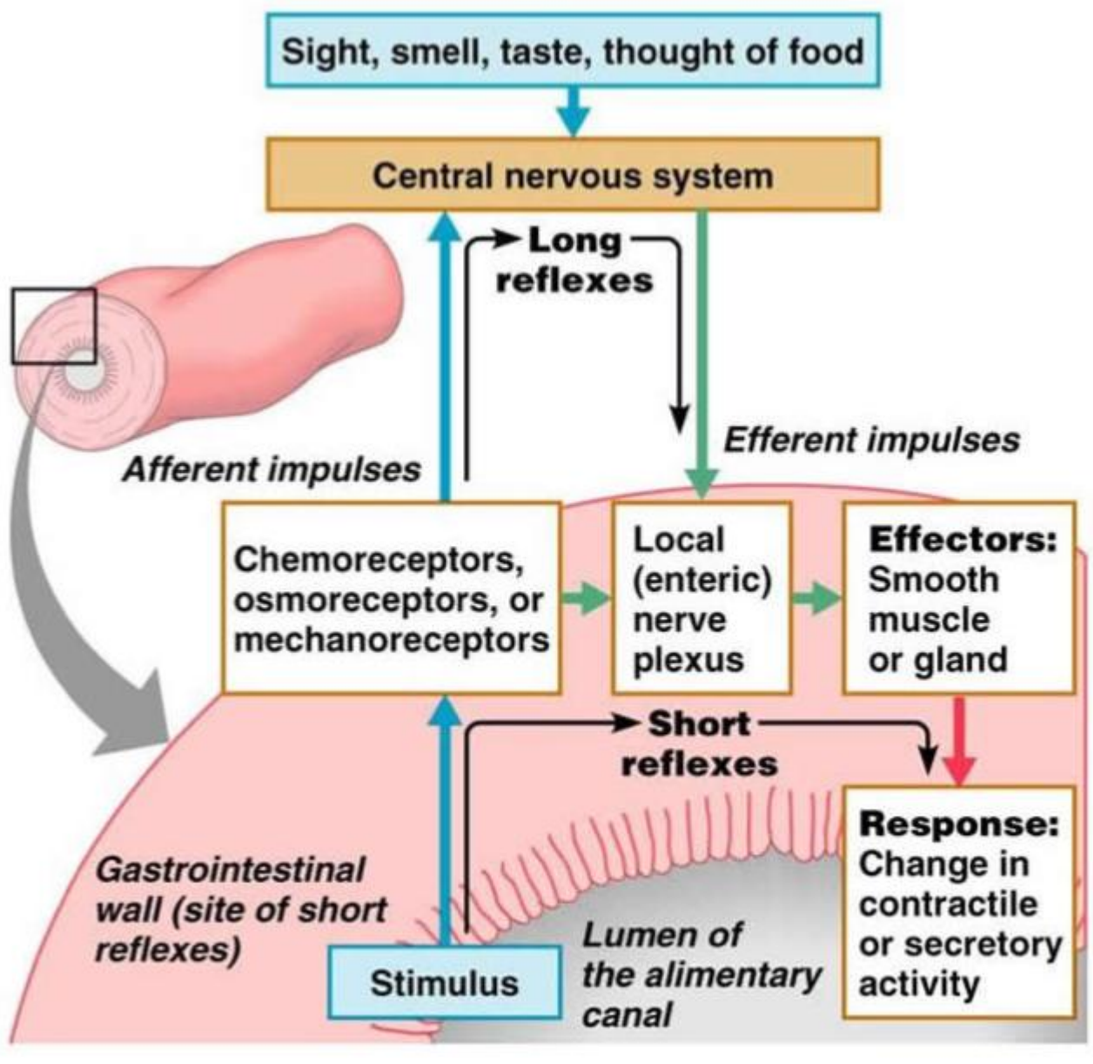


Figure 1-25

Functional Types of Movement in the GIT

Propulsive (Peristalsis)	**Mixing (segmentation)**
Progressive wave of contraction & relaxation. To push food forward	Non-propulsive segmental contractions. To break food into smaller pieces
Organizes propulsion of material over variable distances within the GI lumen.	★ Blend different juices with the chime. ★ Bring products of digestion in contact with absorptive surfaces.
★ **Propulsive (upstream) segment** - Contraction (circular Muscle) - Relaxation **(longitudinal Muscle)** ★ **Receiving (downstream) segment** - Contraction **(longitudinal Muscle)** - Relaxation (circular Muscle)	★ **Propulsive segment.** - Contraction (circular Muscle) ★ **Receiving segment.** - Relaxation (circular Muscle)
★ Stimulus: distention. **Others :** - Chemical irritation. - Physical irritation.	
★ Myenteric plexus is important. ★ Atropine (cholinergic blocker) depresses propulsion.	

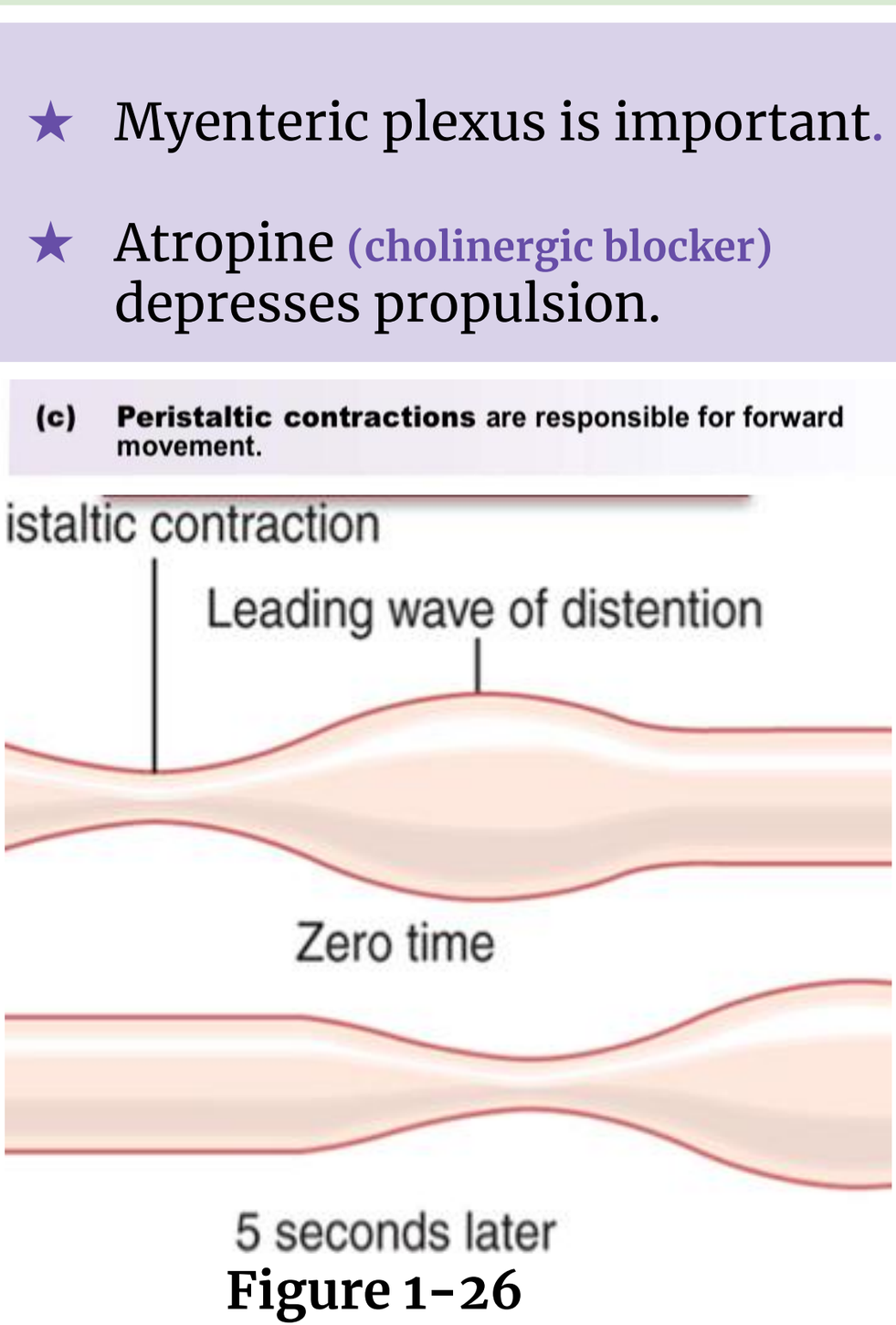


Figure 1-26

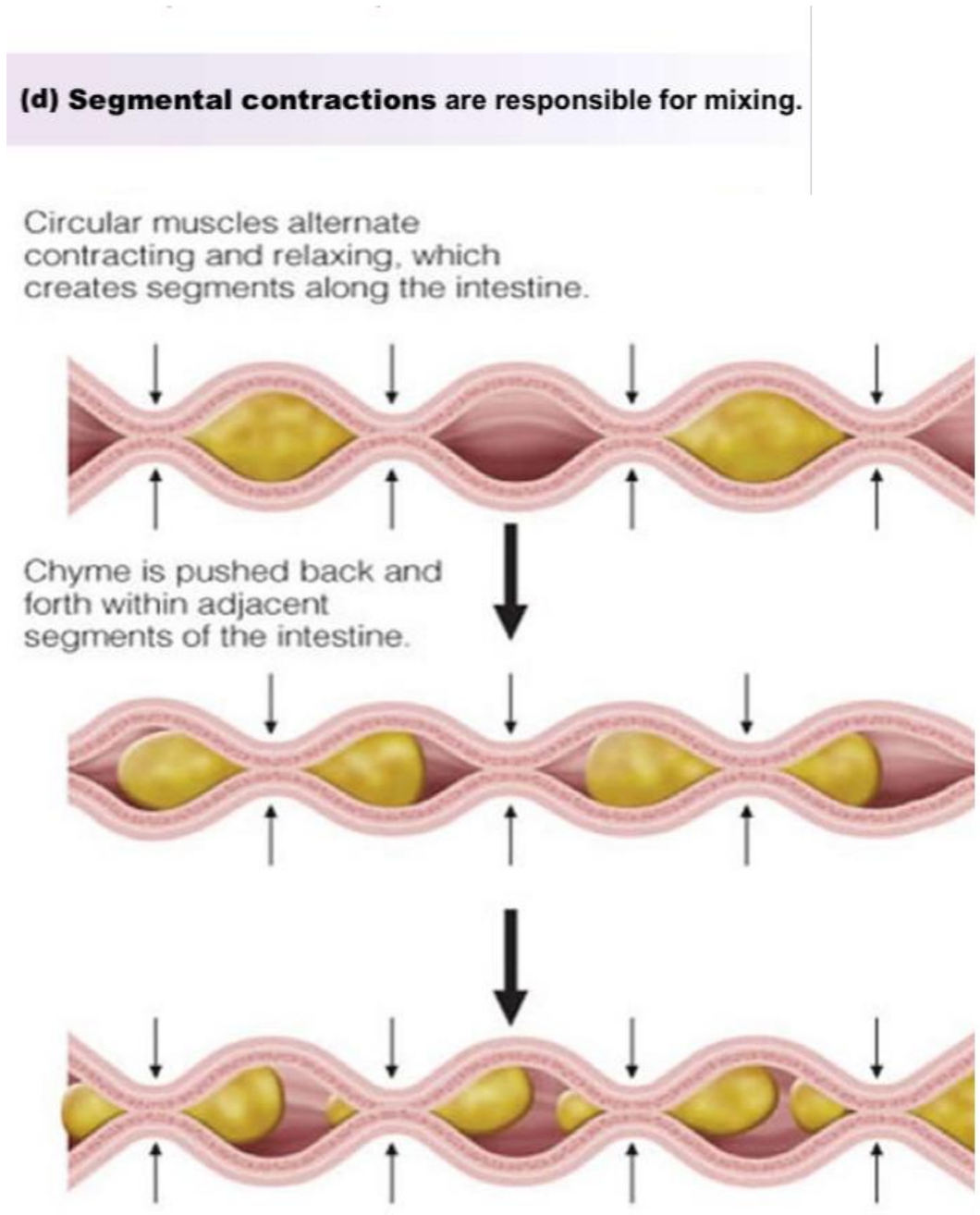


Figure 1-27

Functional Types of Movement in the GIT

Peristaltic Reflex and the "Law of the Gut"

When a segment of the intestinal tract is excited by distention and initiates peristalsis:

The contractile ring

1. begins on the **Orad** side of the distended segment.
2. Moves toward the distended segment.

→ Pushing the intestinal contents in the **anal (Caudad)** direction for **5 - 10** cm before dying out.

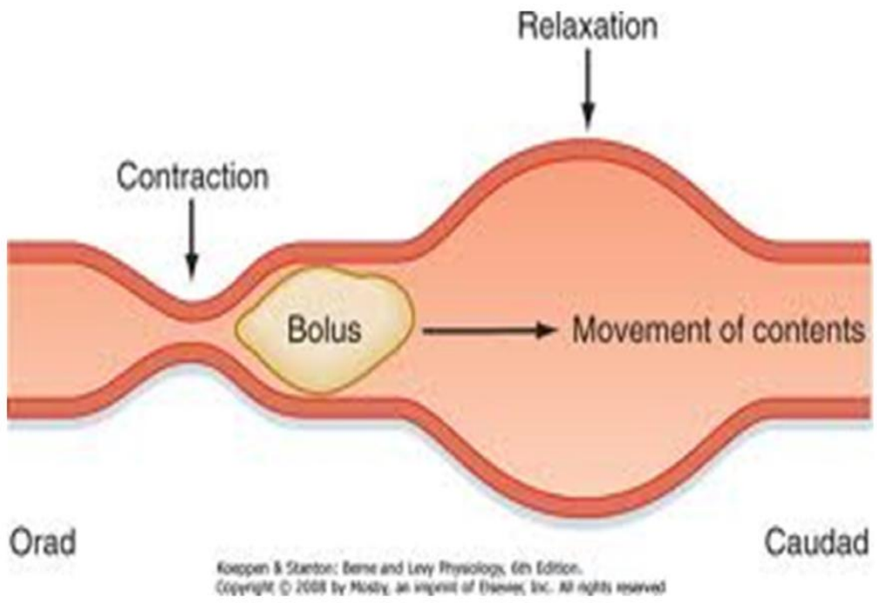


Figure 1-28

Does the Bowel Move in the Fasting State?

During fasting between periods of digestion, the pattern of electrical and motor activity in GI smooth muscle becomes modified

Migrating motor complexes (MMC):

Definition:
Cycles of motor activity (periodic gastric contractions).

Location:
Migrate from the stomach to the distal ileum.

Occurrence:
Every **90-120** min

Function:
Clear the stomach & small intestine of any residue remaining from the previous meal.
its absence has been associated with gastroparesis, Intestinal pseudo-obstruction and small intestinal bacterial growth.

Characters:
Increase in

- Gastric secretion.
- Bile flow.
- Pancreatic secretion .

Mediator:
Motilin

- 22–amino acid peptide.
- Not a member of the gastrin-CCK or the secretin-glucagon family.
- Secreted from the upper duodenum.
- believed to increase gastro-intestinal motility .
- initiate MMC.

4 phases:

Phase I
Quiescent period
Phase II
Irregular electrical and mechanical activity
Phase III
Burst of regular activity
Phase IV
Declining activity which merges with the next Phase I.

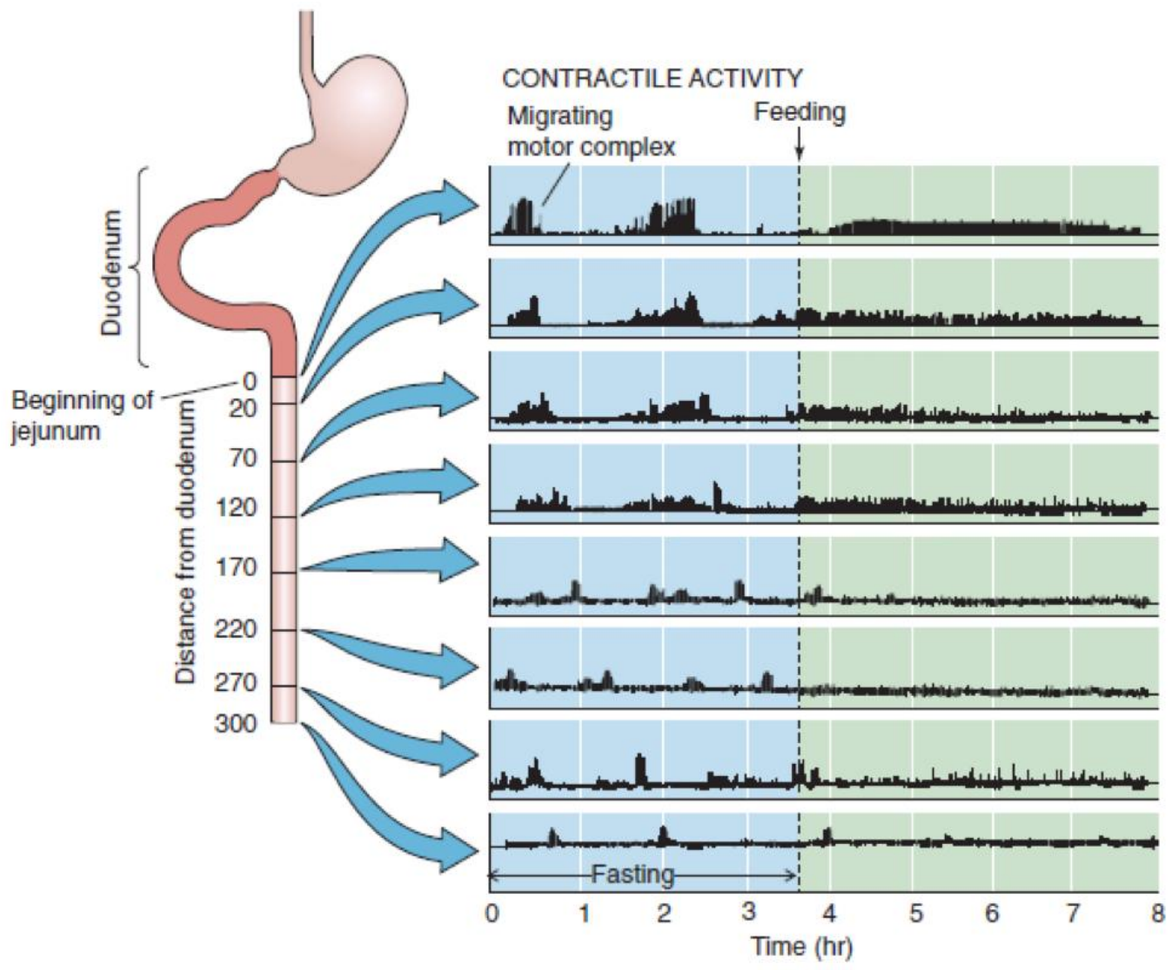


Figure 1-29

GI Blood Flow "Splanchnic Circulation"

Gut | **Spleen** | **Pancreas**

↓

Liver

★ through millions of minute liver sinusoids[1].

↓

Hepatic veins

↓

Vena cava

★ General circulation

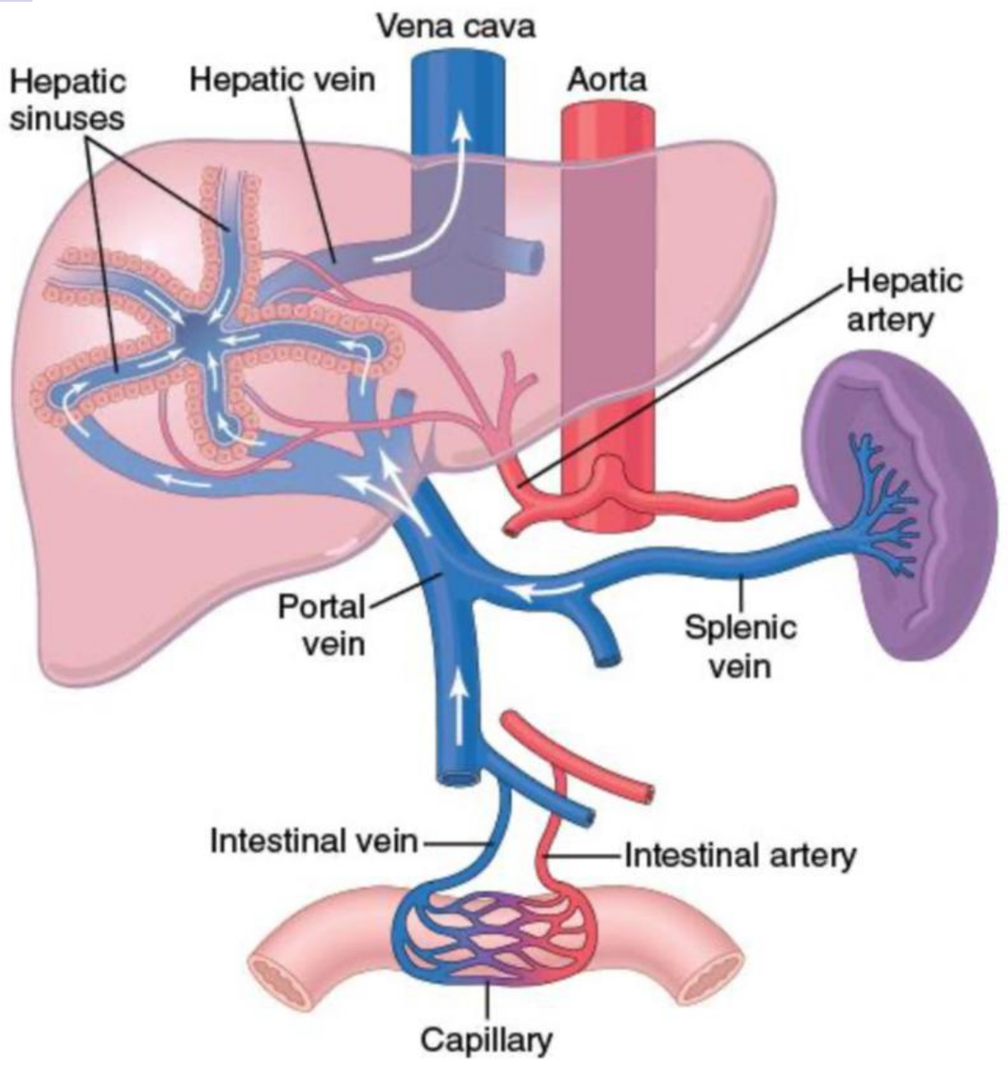


Figure 1-30

Control of GI Blood flow

Neural | **Gut activity**

Parasympathetic stimulation

↑ Local blood flow

↑ Glandular secretion

Sympathetic stimulation

intense **vasoconstriction** of the arterioles

↓ Local blood flow (greatly)

★ The local metabolic vasodilator mechanisms override the sympathetic effects, returning the normal blood flow to GI muscle and glands.

FOOTNOTES

1. Sinusoids are minute vessels that are lined by phagocytic cells called, Kupffer cells, these help in phagocytosis of microorganisms helping us avoid states like septicemia.

Control of GI Blood flow

Neural

Gut activity

Possible causes of the increased blood flow during gut activity:

1. Most of the peptide hormones:
   - CCK
   - VIP
   - Gastrin
   - Secretin

2. Some of the GI glands release into the gut wall two kinins (vasodilators):
   - Kallidin
   - Bradykinin

3. ↓ O_2 conc. in the gut wall:
   - ↑ intestinal blood flow at least **50 – 100%**.

Summary

★ From dr's slides

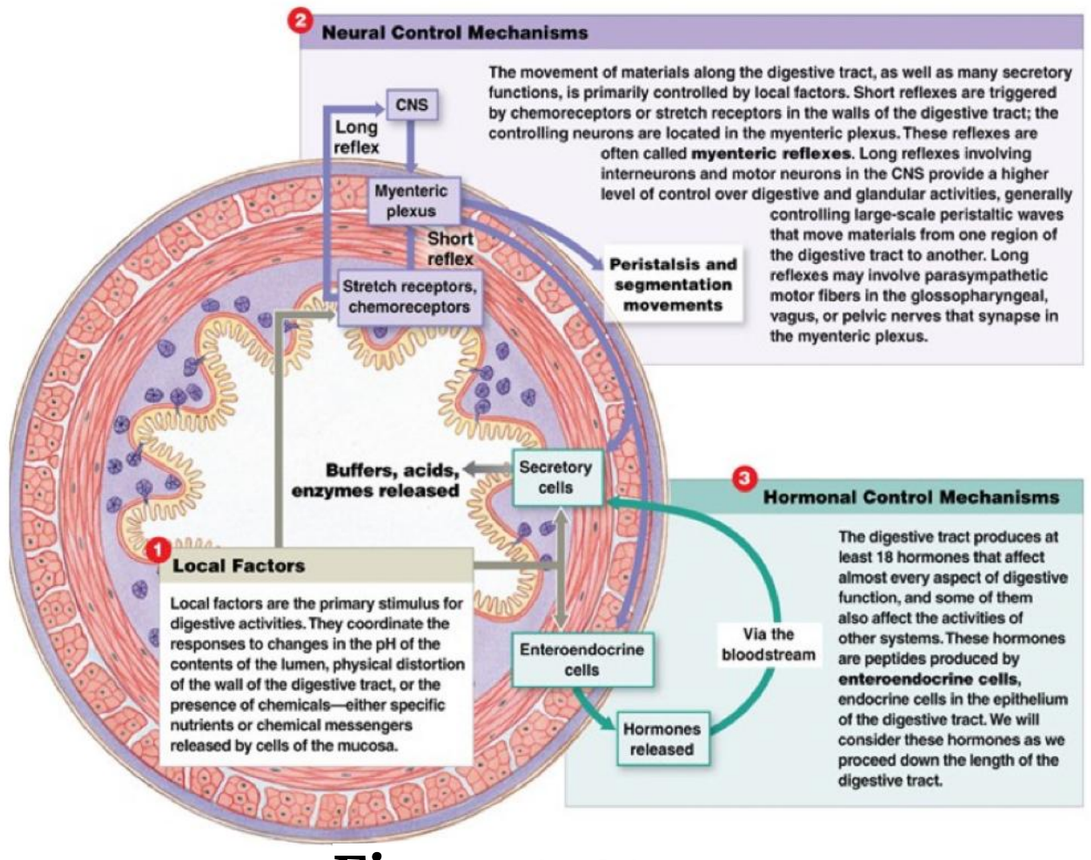


Figure 1-31

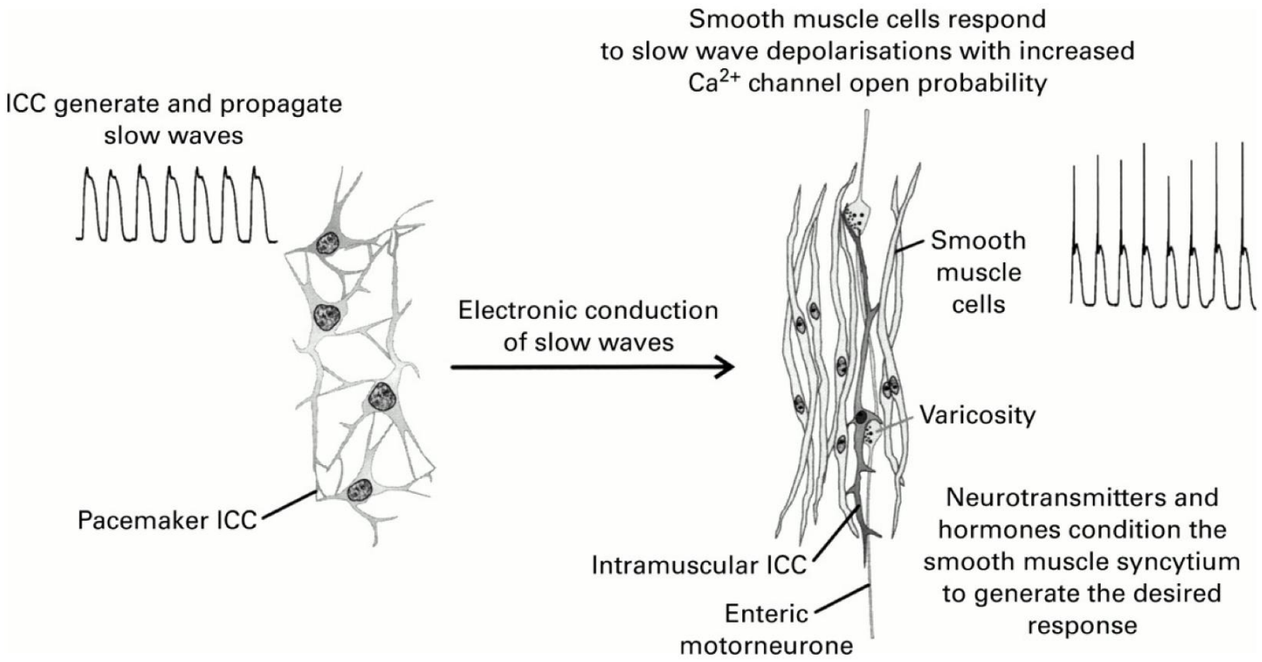
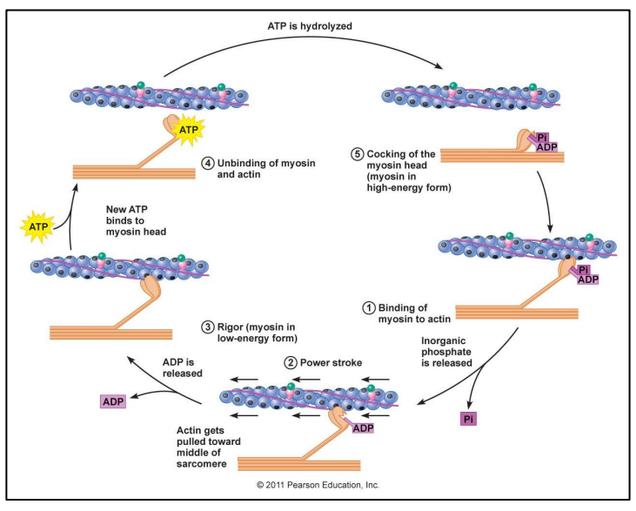


Figure 1-32

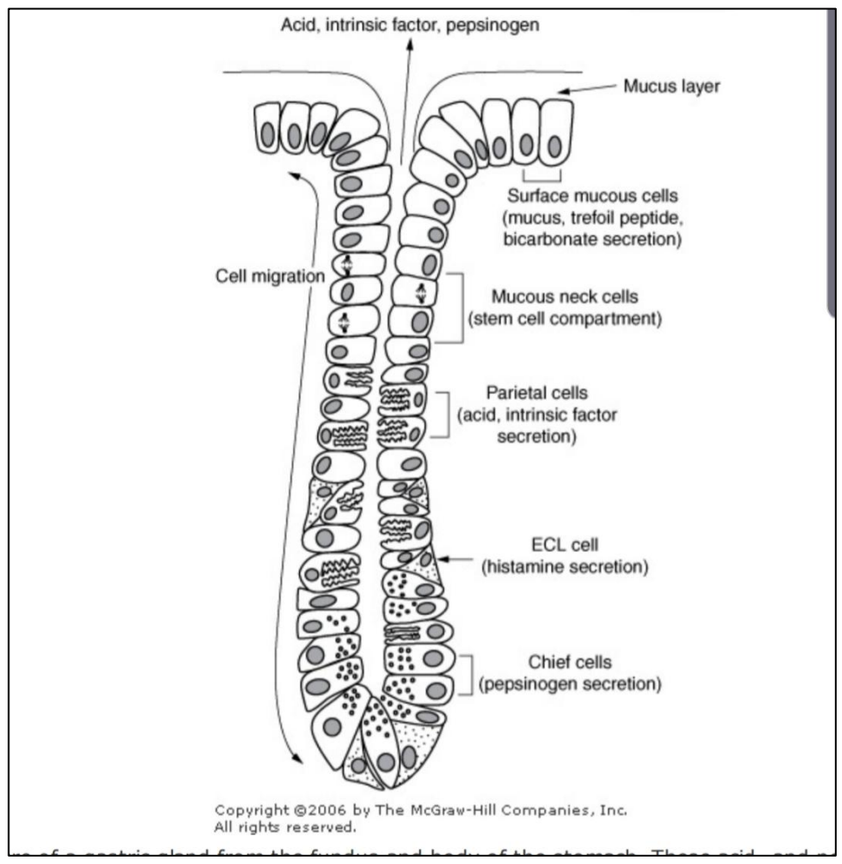
FURTHER READINGS

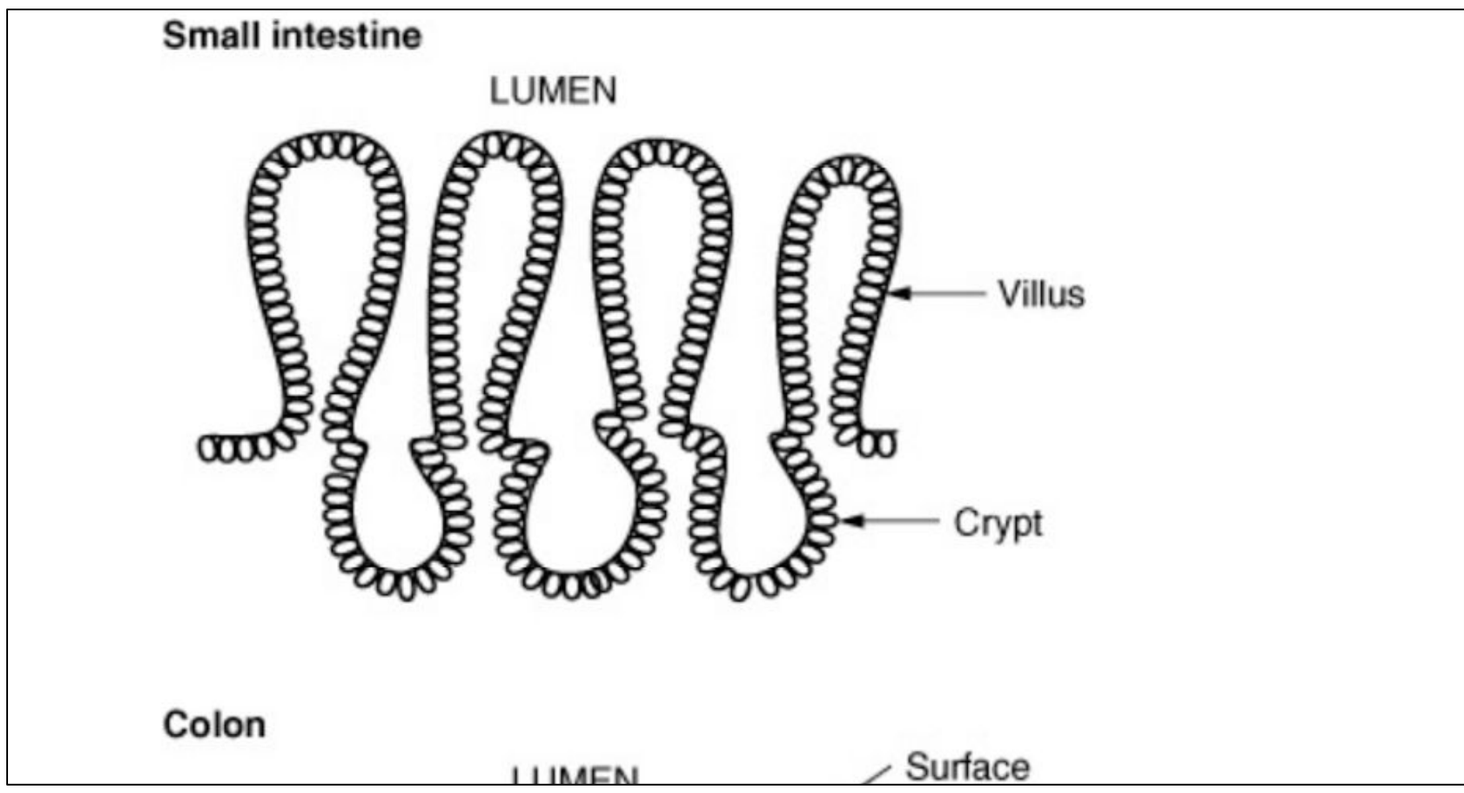
1. **How the gastrointestinal system influences the immune system?** This is done mainly through the gut microbiome. The gut microbiome help boost T-cell numbers early in life, they feed us with a list of antigens that we should be tolerant to, studies even proved this germ-free mice and then after they were injected with a single microbe, Bacteroides fragilis. Bacteroides fragilis in the gut had an antigen that boosted T-cell number early in-life and even protected against diseases like multiple sclerosis! People born with C-section have abnormal microbiome, their immune system is tolerant to less antigens and easily triggers inflammation, the consequence is that people with abnormal gut microbiome are more prone to bronchial asthma.

2. **Mechanism of tonic contraction**: From what we know from mechanisms of contraction, myosin binds to actin which forms what we call a "cross-bridge formation", the myosin then consequently pulls actin towards the center or belly of the muscle, the muscle shortens then and contracts. In smooth muscle cells, during the time in which myosin pulls the actin, a certain regulatory protein called myosin-light chain can get dephosphorylated, if this protein gets dephosphorylated during contraction then the muscle will remain contracted with constant force, **this is called the latch mechanism for muscle contraction,** and is the basis for tonic contraction in smooth muscle cells including sphincter, this process does not require much ATP. Allowing sphincters to function optimally.



3. **Crypts of lieberkuhn:** The surface of the intestinal mucosa is highly folded, forming the gland formation seen below. The pit or hole of this folding is called a “crypt”. We can see in the first figure that there is surface mucus cells which are columnar, this is seen below the esophagus in GI tract, remember that it is lined by stratified squamous. Within the neck of this pit we see mucus neck cells, along with stem cells. Stem cells then can differentiate and migrate below to form parietal, chief or ECL cells, they lie in the depth of the pit among others. This whole structure is called a gland.





QUIZ

MEDICINE438's GITPHYSIOLOGY

1. Which hormone is released by the presence of fat and protein in the small intestine and has a major effect in decreasing gastric emptying?
A) CCK
B) Gastrin
C) Motilin
D) Secretin

2. Which one of the following GI reflexes inhibit stomach motility and secretion?
A) Gastrocolic reflex
B) Enterogastric reflex
C) Colonoileal reflex
D) Intestino-intestinal reflex

3. Myenteric plexus of the wall of the stomach is present:
A) In the serosa
B) Between the middle circular muscle layer and the mucosa
C) Between the outer longitudinal muscle layer and circular muscle layer
D) In the muscularis mucosa

4. Cholecystokinin is synthesized and released by
A) S cells
B) G cells
C) D cells
D) I cells

5. Gastric pepsin helps in digestion of
A) carbohydrate
B) Lipids
C) Iron
D) Proteins

SHORT ANSWER QUESTIONS

1. List three factors that cause increase blood flow during GI activity.
2. What are the plexuses of the enteric nervous system & their functions?

1.
- Gastrin
- Bradykinin
- Decrease oxygen concentration

2.
- Myenteric plexus: controls GI motility.
- Submucosal plexus: controls secretions & local blood flow.

ANSWER KEY: A, B, C, D, D

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MEDICINE438's GITPHYSIOLOGY

REFERENCES

- Guyton and Hall Textbook of Medical Physiology
- Ganong's Review of Medical Physiology