Chapter 15

Gastrointestinal System

Dr. LL Wang
E-mail: wanglinlin@zju.edu.cn
Rm 608, Block B, Research Building, School of Medicine, Zijingang Campus

Gastrointestinal System

- 1. G.I. Physiology: general organization of G.I. tract
- 2. Mastication and deglutition
- 3. Gastric secretion
- 4. Regulation of gastric secretion
- 5. Pathophysiology of peptic ulcer
- 6. Biliary and pancreatic secretions
- 7. Physiology of colon
- 8. Pathophysiology of diarrhea disease

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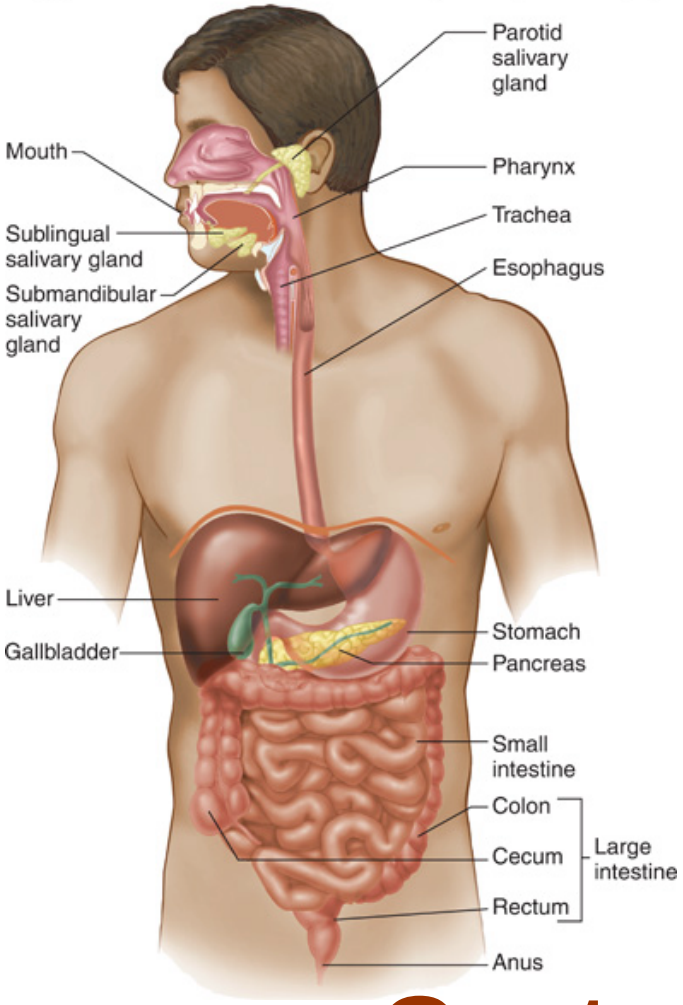
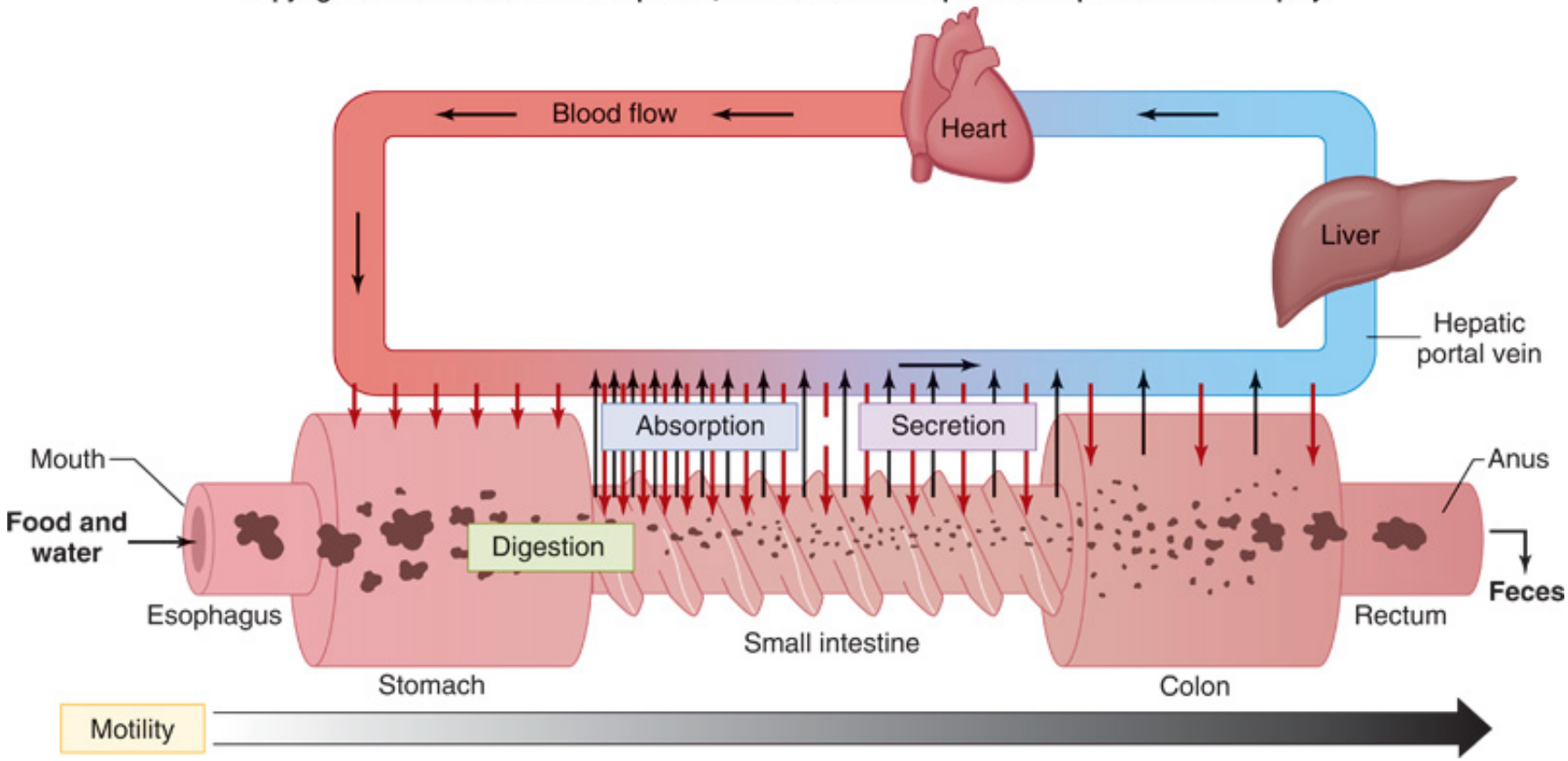


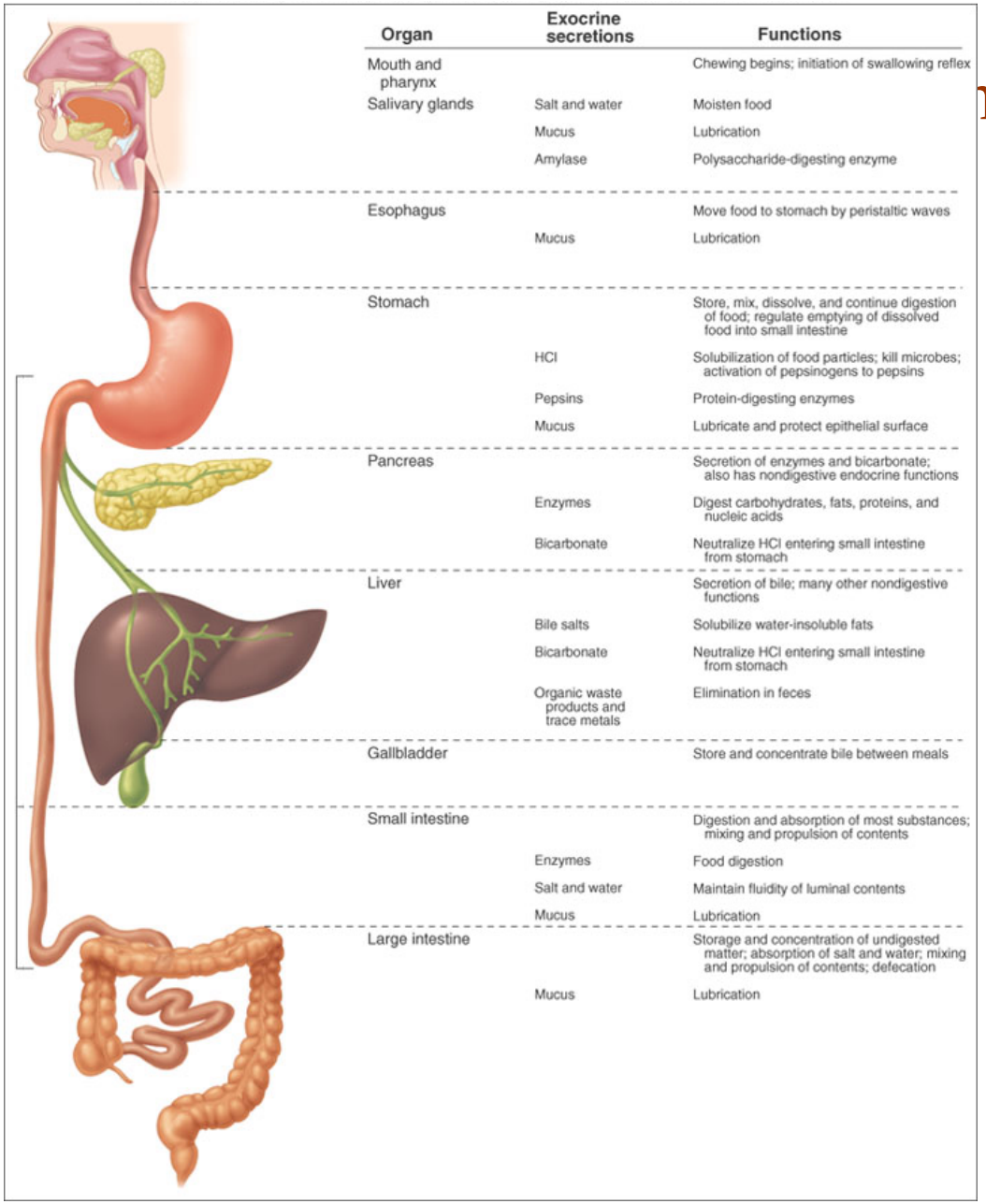
Gastrointestinal System includes GI tract plus the accessory organs.

Anatomy of Gastrointestinal System

Four processes carried out by the GI tract



Functions of **Gastrointestinal System**



Organ	Exocrine secretions	Functions
Mouth and pharynx		Chewing begins; initiation of swallowing reflex
Salivary glands	Salt and water	Moisten food
	Mucus	Lubrication
	Amylase	Polysaccharide-digesting enzyme
Esophagus		Move food to stomach by peristaltic waves
	Mucus	Lubrication
Stomach		Store, mix, dissolve, and continue digestion of food; regulate emptying of dissolved food into small intestine
	HCl	Solubilization of food particles; kill microbes; activation of pepsinogens to pepsins
	Pepsins	Protein-digesting enzymes
	Mucus	Lubricate and protect epithelial surface
Pancreas		Secretion of enzymes and bicarbonate; also has nondigestive endocrine functions
	Enzymes	Digest carbohydrates, fats, proteins, and nucleic acids
	Bicarbonate	Neutralize HCl entering small intestine from stomach
Liver		Secretion of bile; many other nondigestive functions
	Bile salts	Solubilize water-insoluble fats
	Bicarbonate	Neutralize HCl entering small intestine from stomach
	Organic waste products and trace metals	Elimination in feces
Gallbladder		Store and concentrate bile between meals
Small intestine		Digestion and absorption of most substances; mixing and propulsion of contents
	Enzymes	Food digestion
	Salt and water	Maintain fluidity of luminal contents
	Mucus	Lubrication
Large intestine		Storage and concentration of undigested matter; absorption of salt and water; mixing and propulsion of contents; defecation
	Mucus	Lubrication

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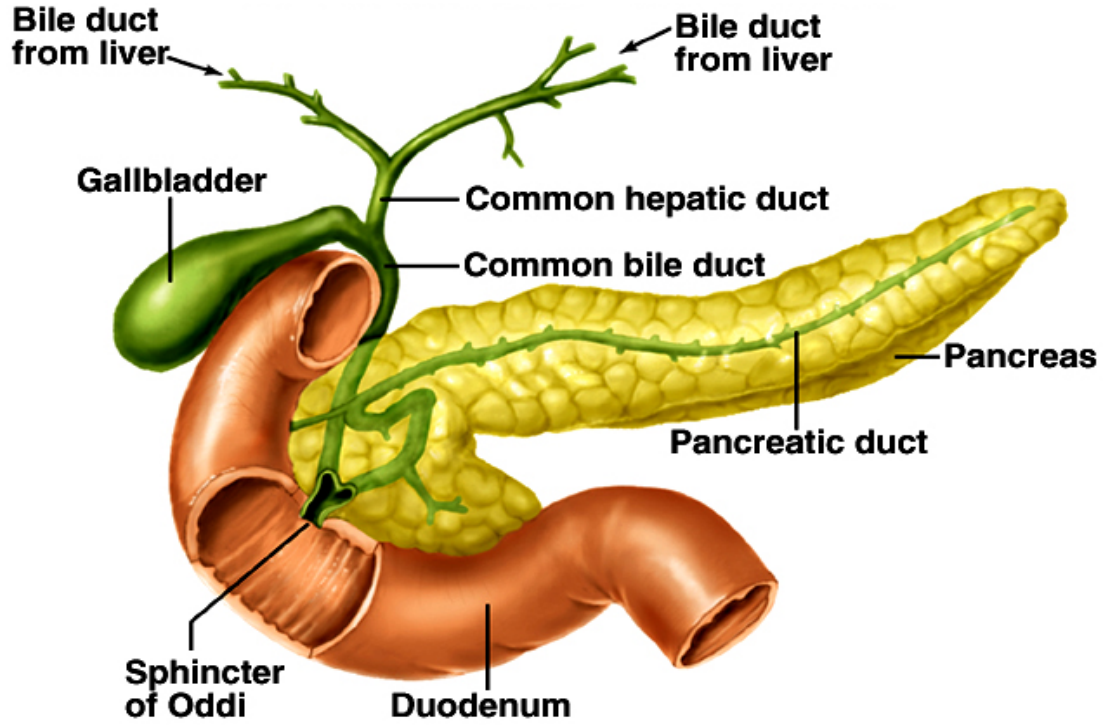
System

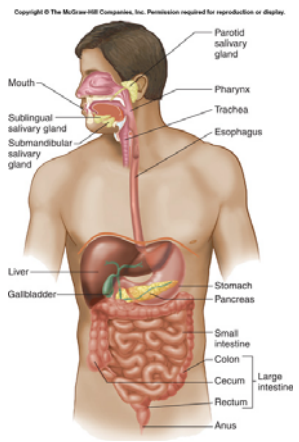
Many functions in the gut are found in specific locations along its length. Most of the absorption of nutrients occurs in the small intestine, so most of digestion is accomplished there or upstream. p576



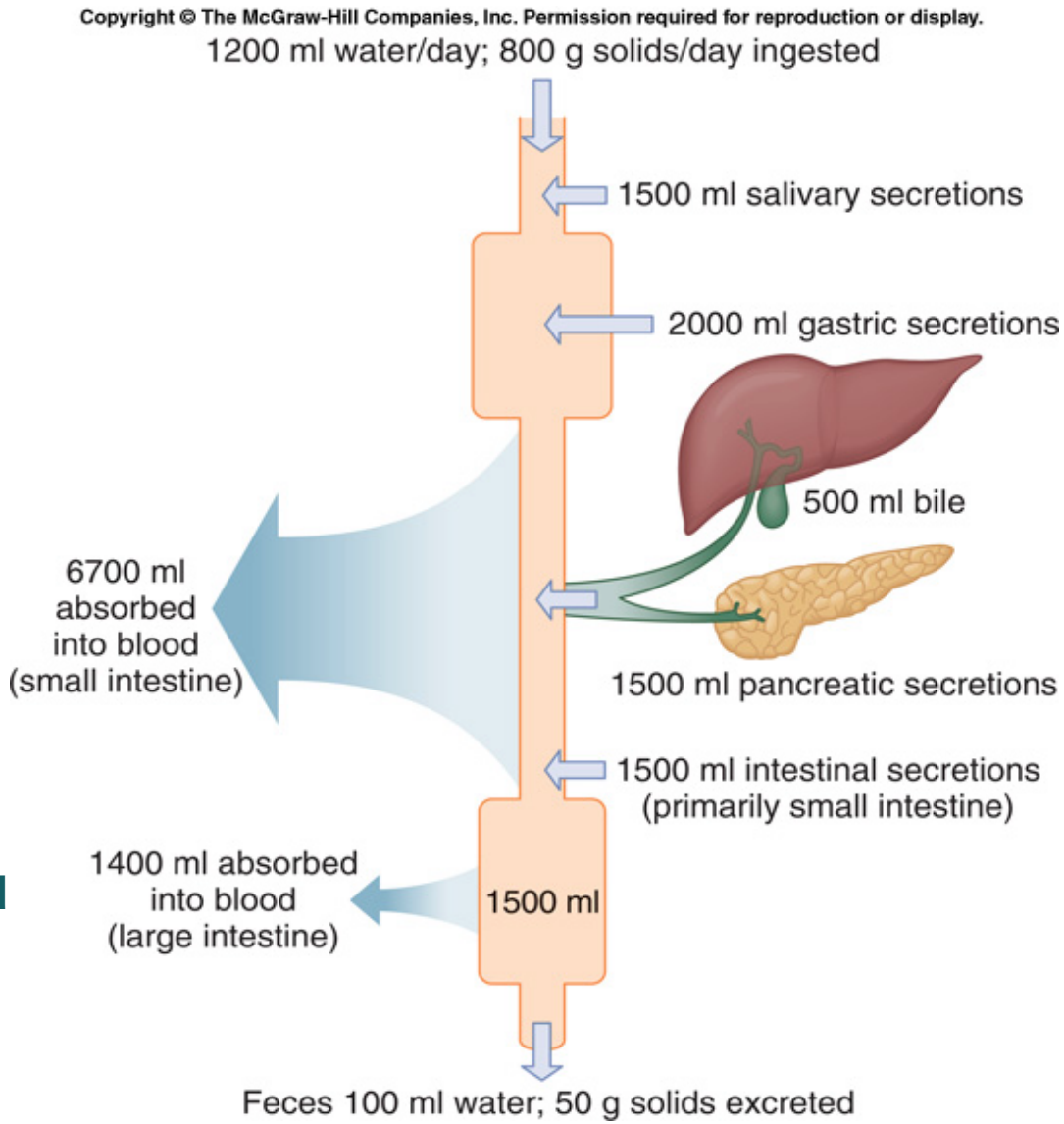
Digestive secretions from the liver and the pancreas are delivered into the duodenum of the small intestine through the sphincter of Oddi.

Functions of small intenstine movements

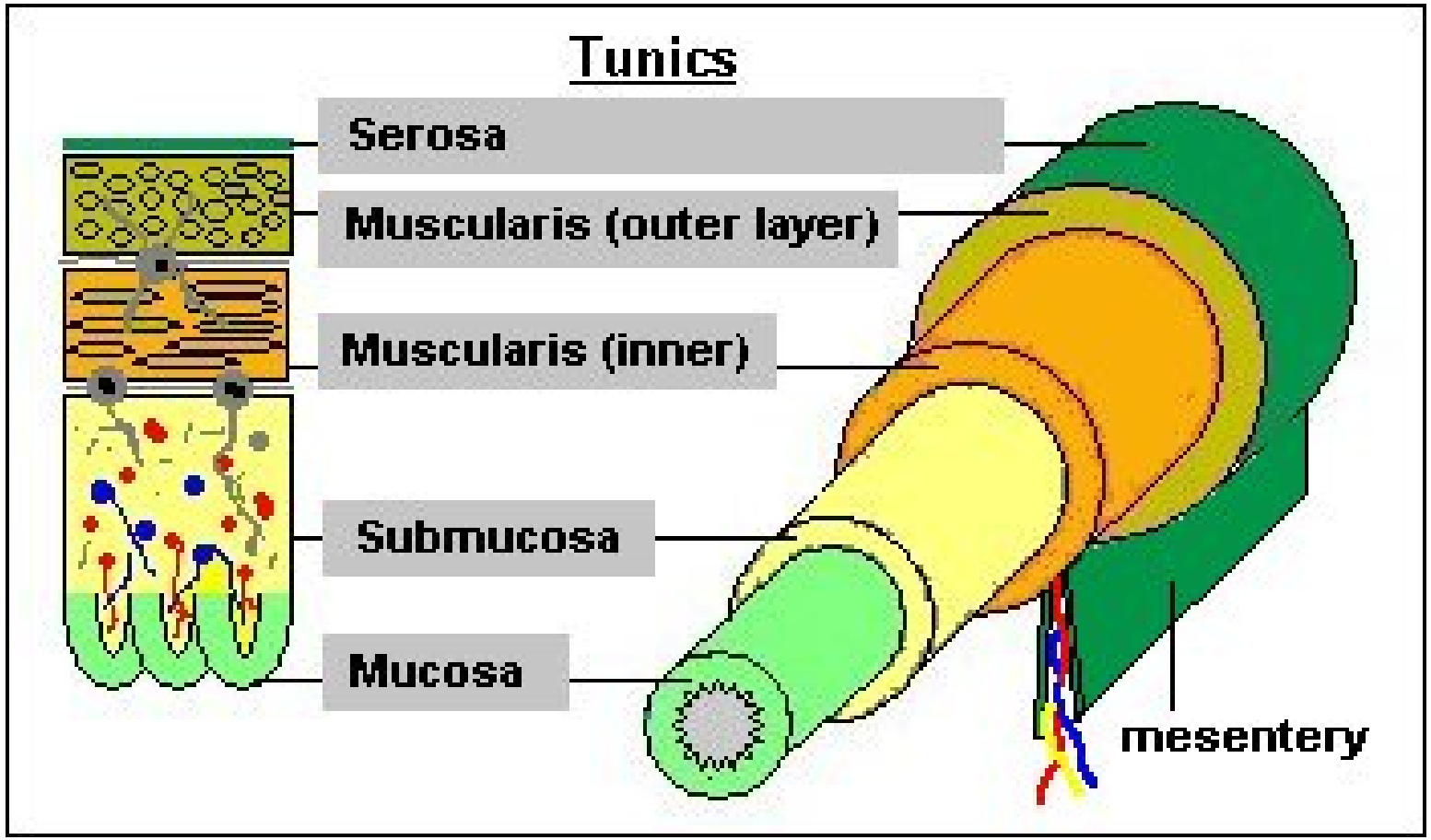
- Mixes the luminal contents with secretions
- Brings the contents nto contact with the epithelial surface
- Slowly advances the luminal material toward the large intenstine

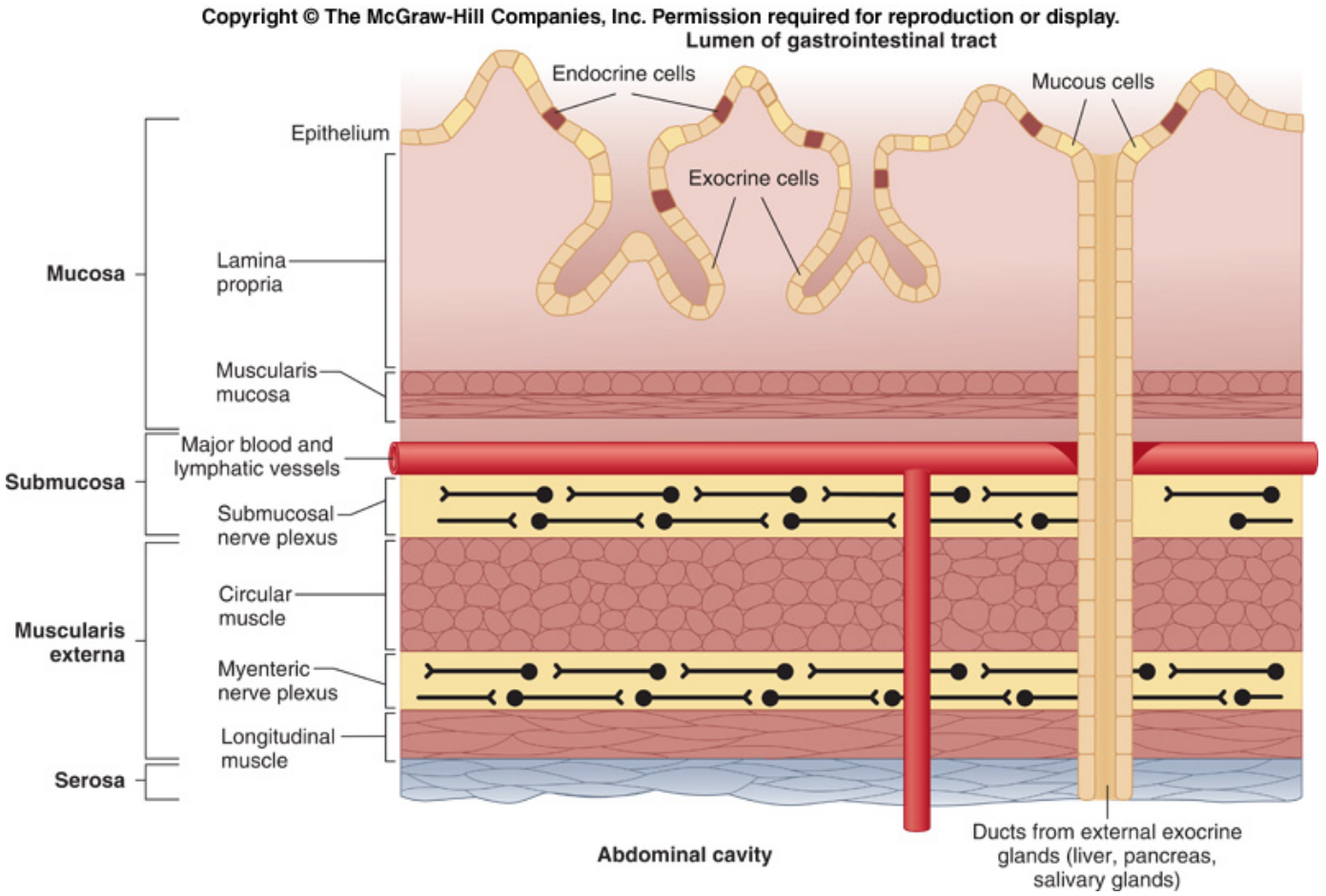


Digestive secretions are mostly water, with the average amounts indicated here. Note that only 100 ml are excreted in feces, so the mechanisms for water absorption are efficient (recall the kidneys' primary role in water and osmotic homeostasis).

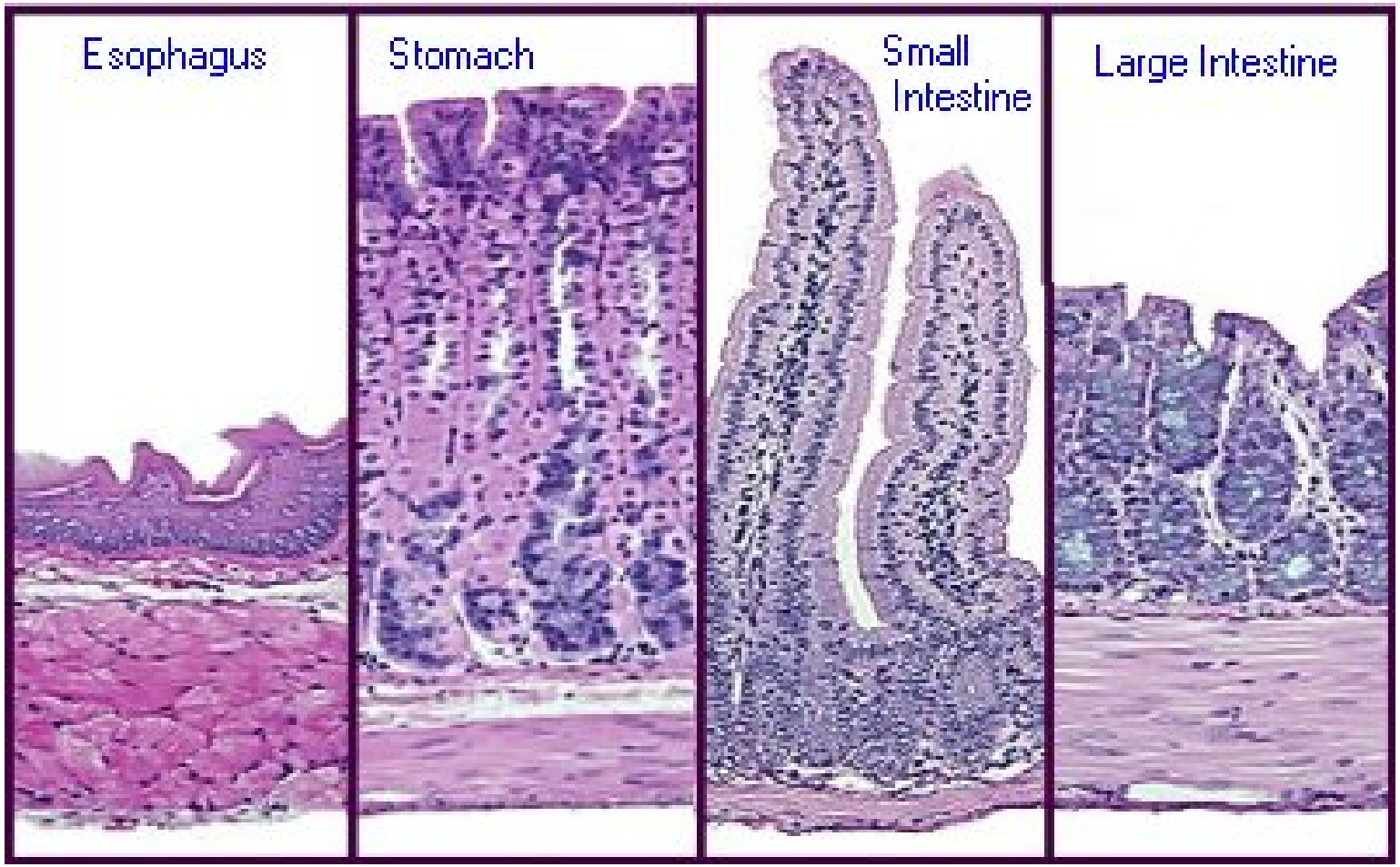


Structure of the GI Tract Wall



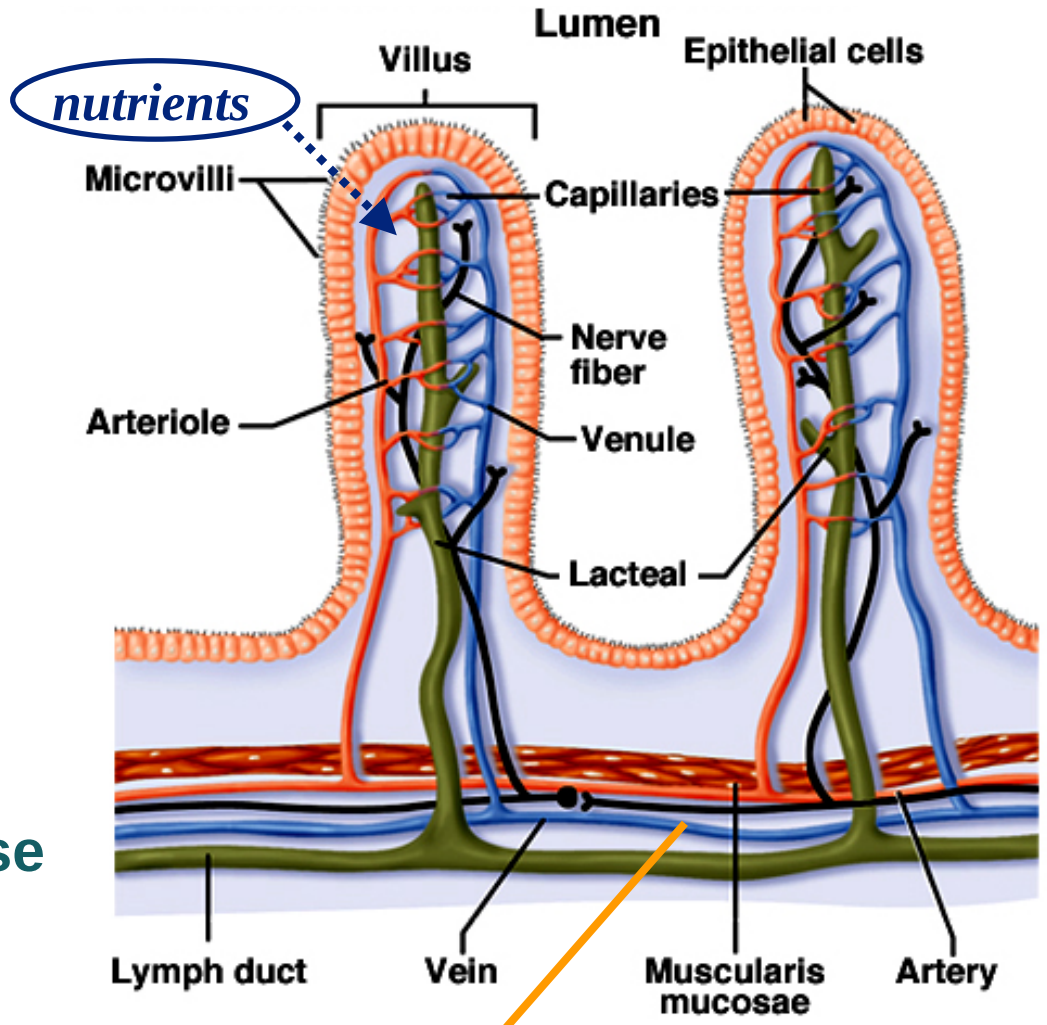


The gut wall has a layered organization, with the absorptive cells lining the lumen and neural and muscular components below. Blood and lymph vasculature is abundant to transport absorbed nutrients.

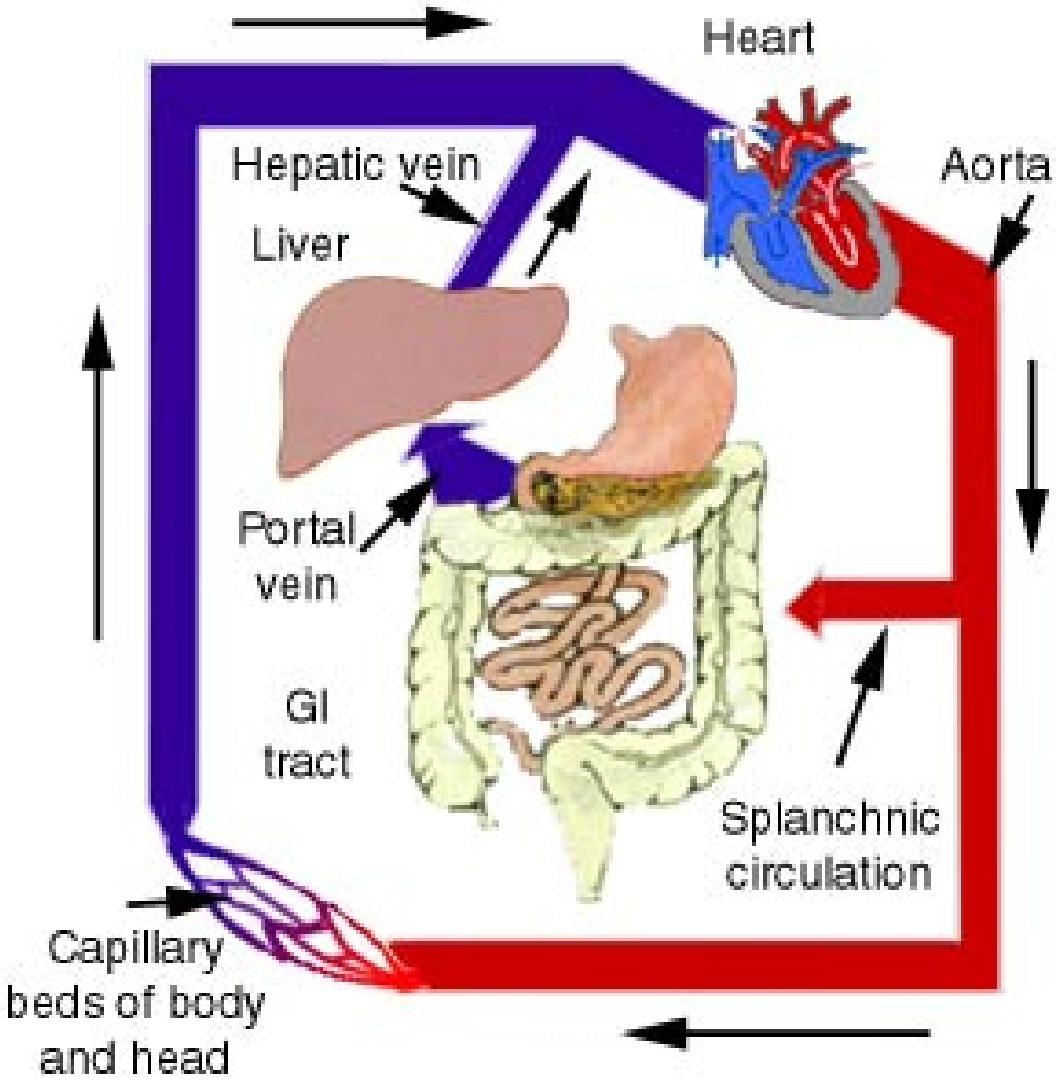

Esophagus
Stomach
Small Intestine
Large Intestine

By projecting into the lumen, the villi increases the surface area for absorption of nutrients.

Microvilli [brush border] fringe the villi to further increase surface area.



Detoxify ← Hepatic portal vein



Gastrointestinal circulation

(I) Physiological properties of gastrointestinal smooth muscle

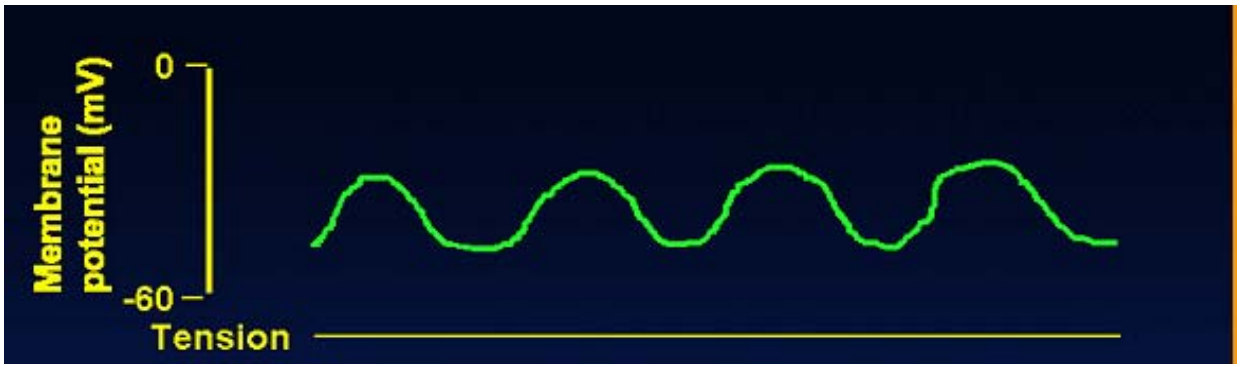
(1) General properties

- Low excitability
- High extensibility
- Tonic contraction
- Autorhythmicity
- High sensitivity to temperature, stretch & chemical stimulation

(2) Electrophysiological properties

(a) Resting potential:

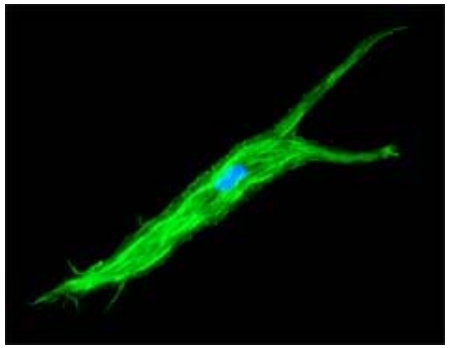
- between -50 and -60 Mv
- Ionic basis
  - Em (selective membrane permeability to K^+)
  - Electrogenic Na^+-K^+ pump

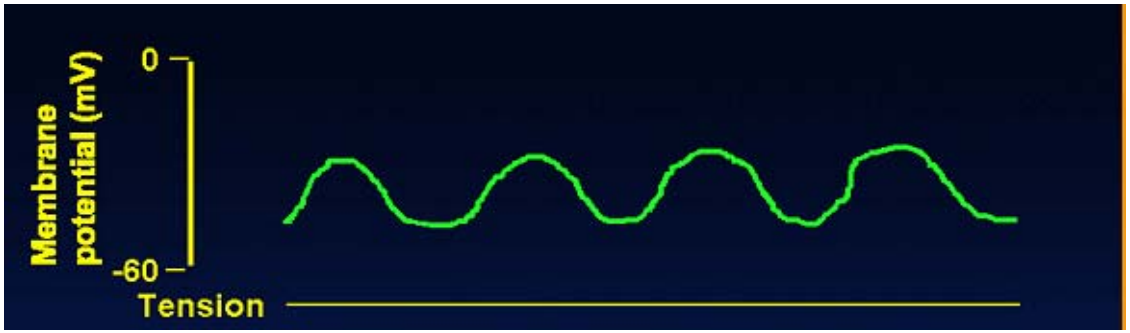


(b) Slow wave (basic electrical rhythm,BER)

– The spontaneous rhythmic, subthreshold depolarizations of the cell membrane **(slow wave)** of the gastrointestinal tract

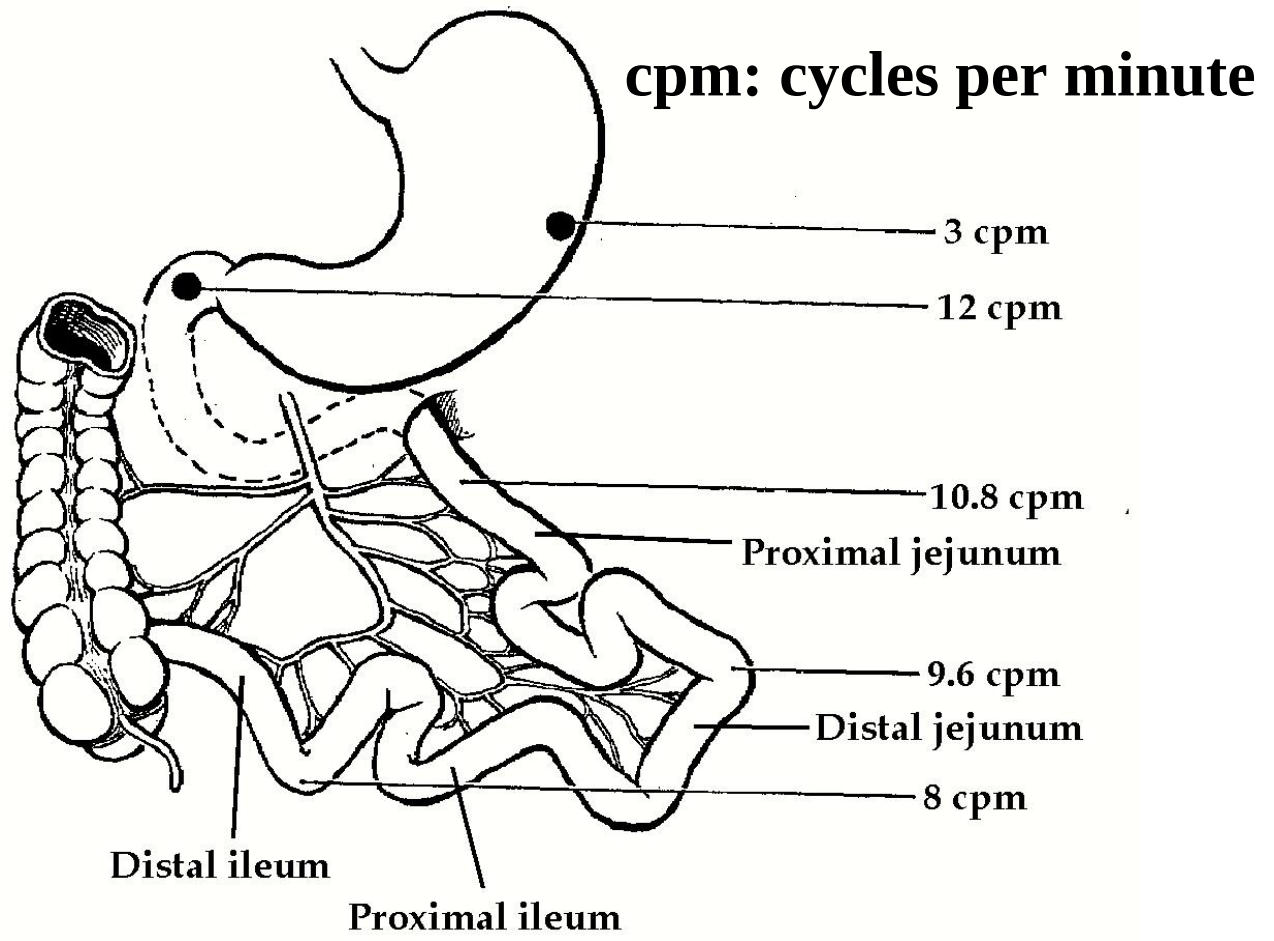
– Initiated in the interstitial cells of Cajal (ICC) (pacemaker cell)



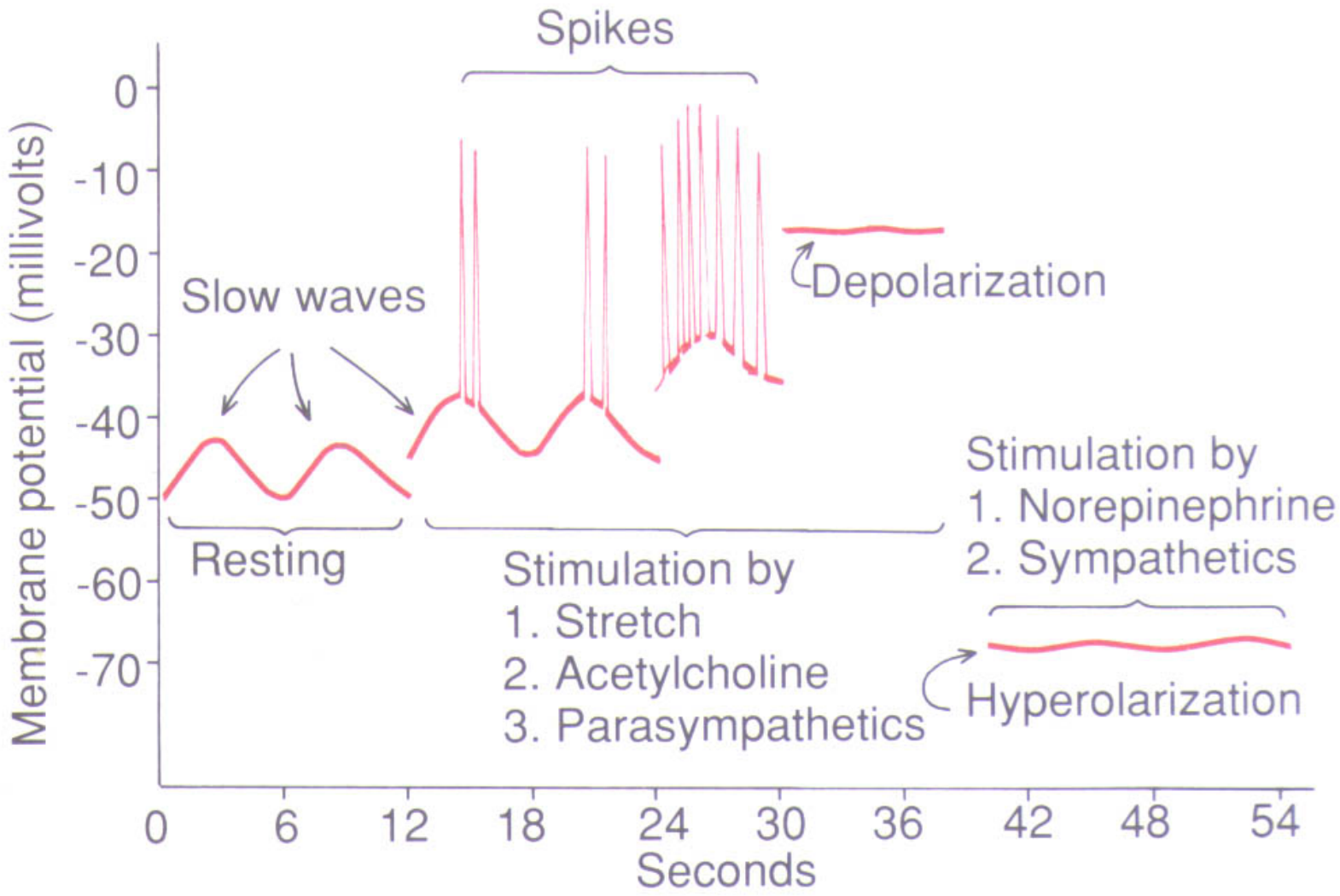


- **Slow wave (basic electrical rhythm)**
  - Intensity: 5~15 mV
  - Frequency: 3~12 cpm
  - Ionic mechanism
    - spontaneous rhythmic changes in Na^+-K^+ pump activity

- **Frequencies: 3-12 per minute**

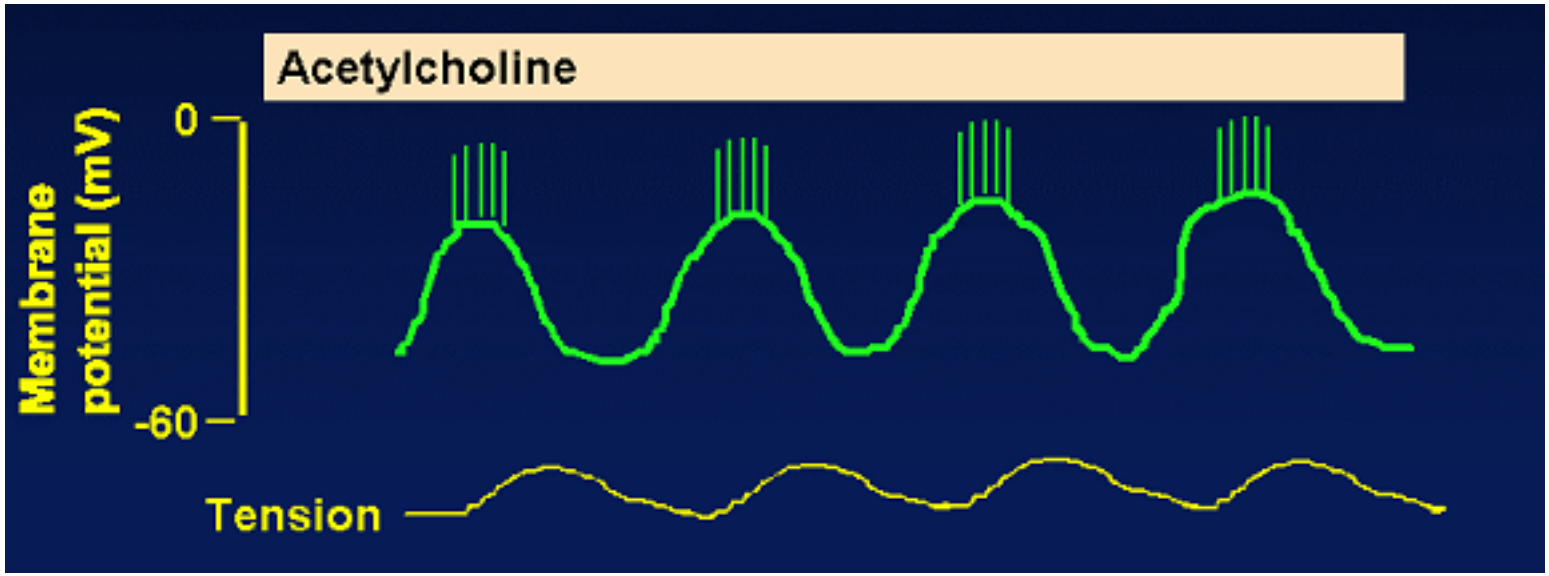


- **Mechanisms**
  - BER might be due to spontaneous rhythmic changes in Na^{+}-K^{+} pump activity
  - BER not generated by nervous activity


Spikes
Membrane potential (millivolts)
0
-10
-20
-30
-40
-50
-60
-70
Slow waves
Depolarization
Stimulation by
1. Norepinephrine
2. Sympathetics
Resting
Stimulation by
1. Stretch
2. Acetylcholine
3. Parasympathetics
Hyperolarization
0
6
12
18
24
30
36
42
48
54
Seconds

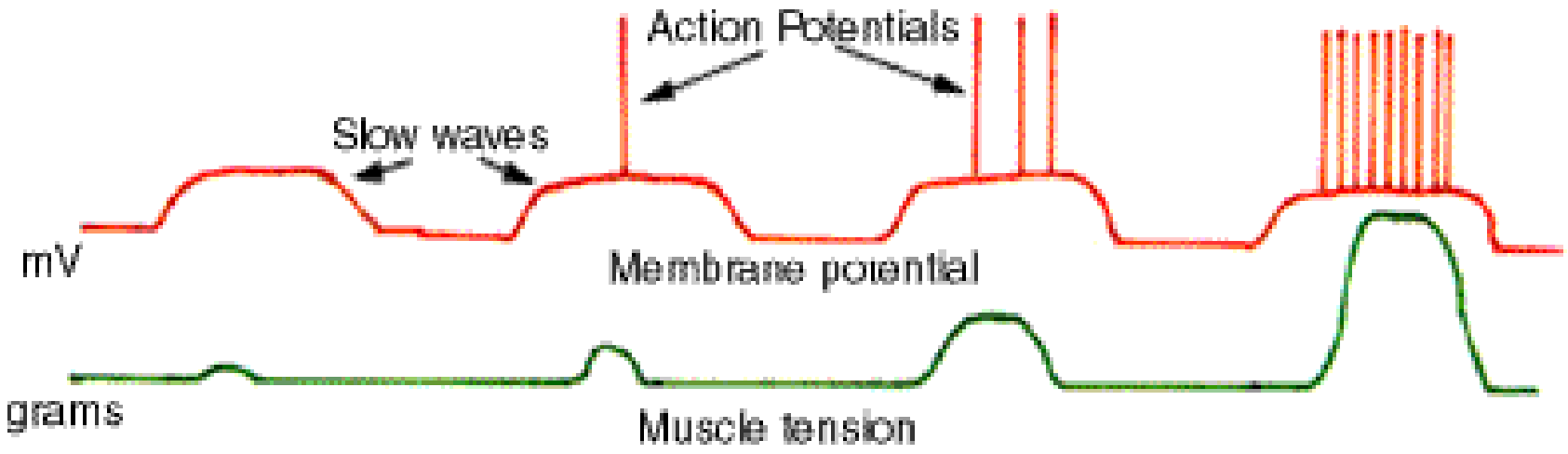
(c) Spike potentials (action potentials)

- only at the peaks of slow waves
- Threshold: –40 mV



- **Spike potential (Action potential)**
  - Duration: 10~20 ms
  - Ionic mechanism:
    - Depolarization: Ca^{2+} influx
    - Repolarization: K^{+} efflux

- The higher the slow wave potential rises, the greater the frequency of the spike potentials



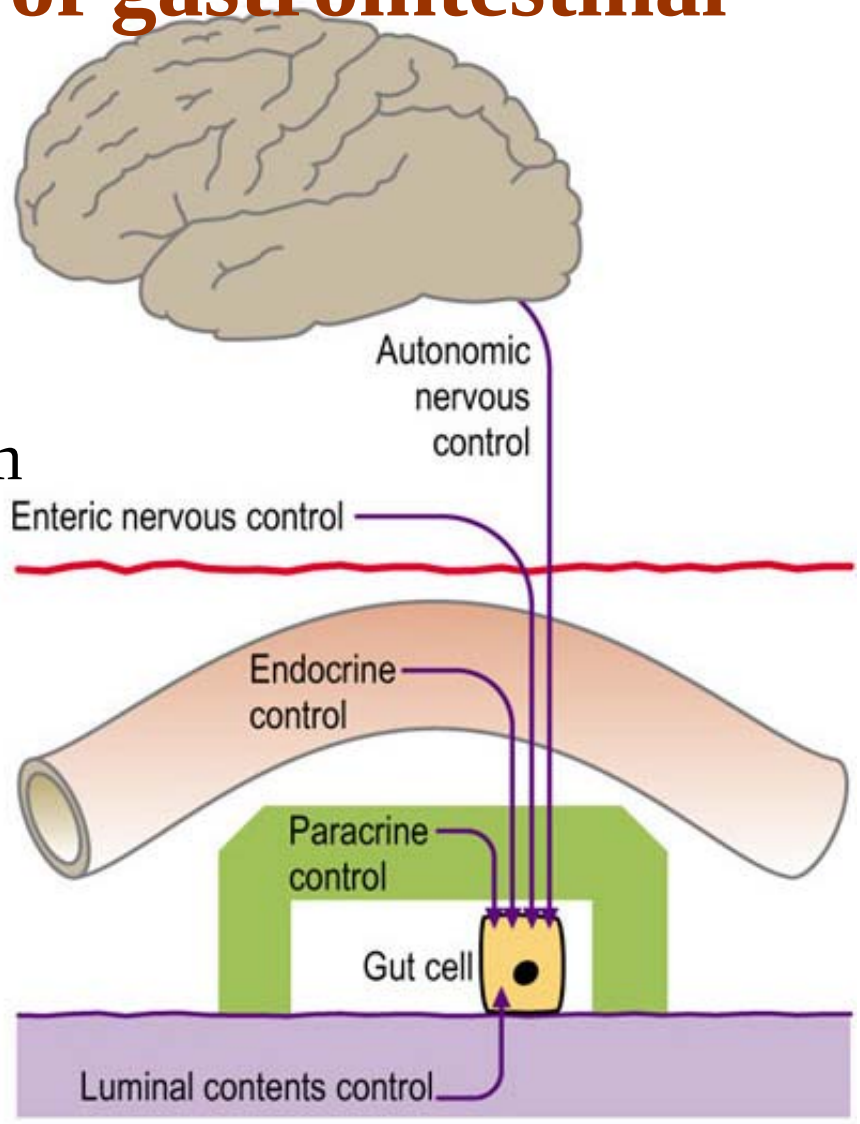
(3) muscle contraction

- Ca^{2+} binds to calmodulin (intracellular protein) → activates myosin light chain kinase → phosphorylates myosin light chain → phosphorylated myosin then (in the presence of ATP) binds to actin

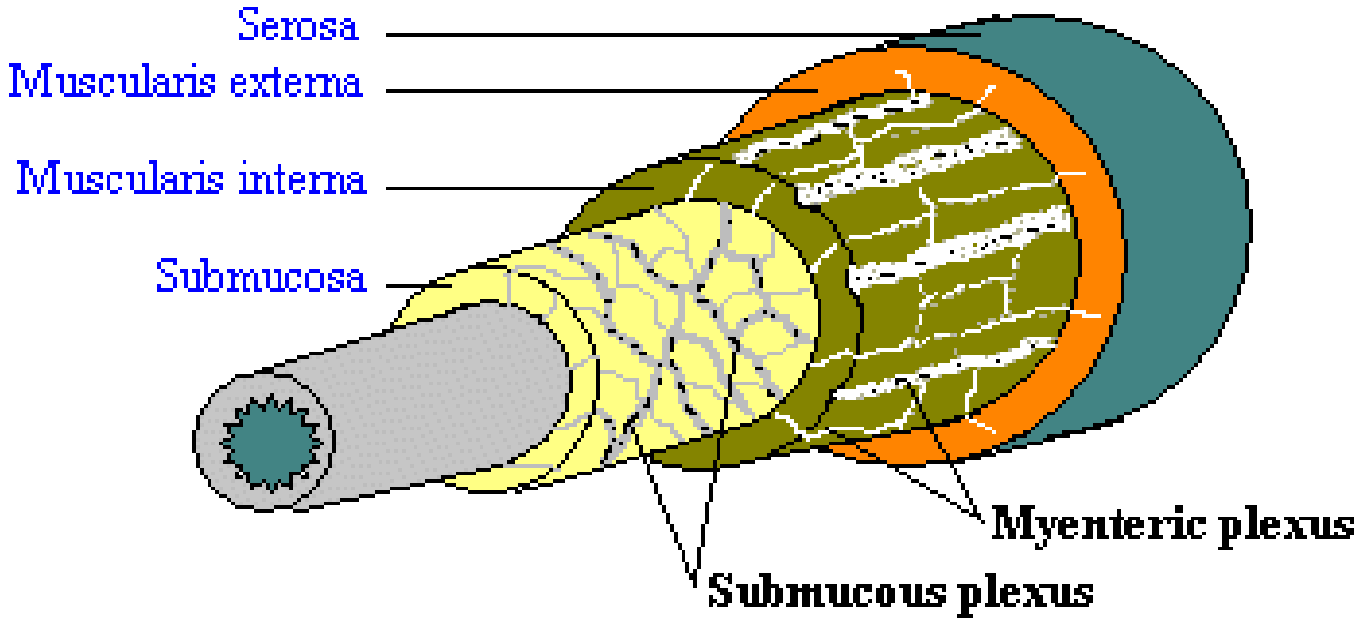
(II) Neural control of gastrointestinal function

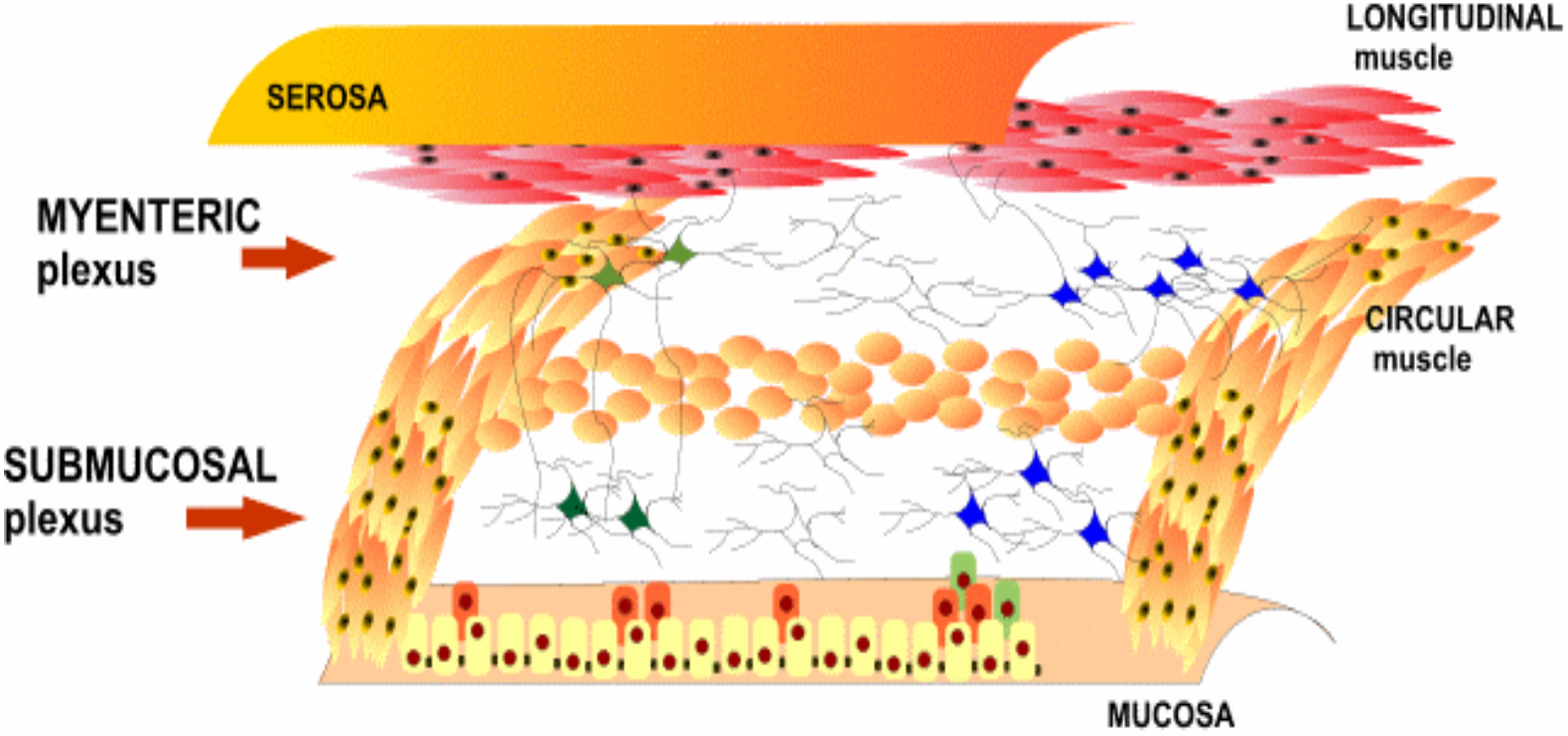
- Enteric nervous system
- Extrinsic nervous system

(p588)



(1) Enteric nervous system





Activation of MYENTERIC PLEXUS:

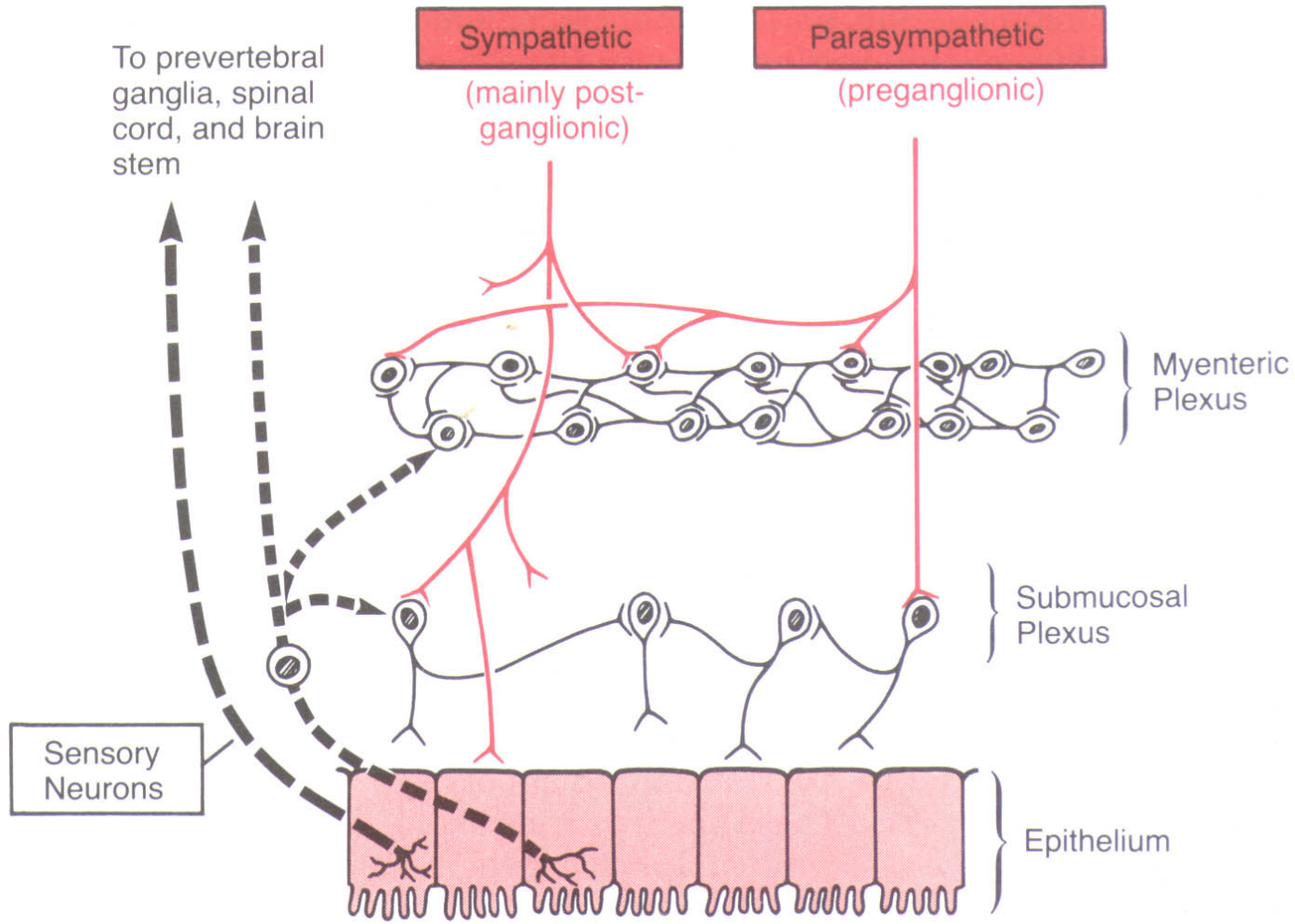
- increases tonic contraction
- increases intensity of rythmic contractions
- increases rate of rythmic contractions
- increases velocity of conduction

Activation of SUBMUCOSAL PLEXUS:

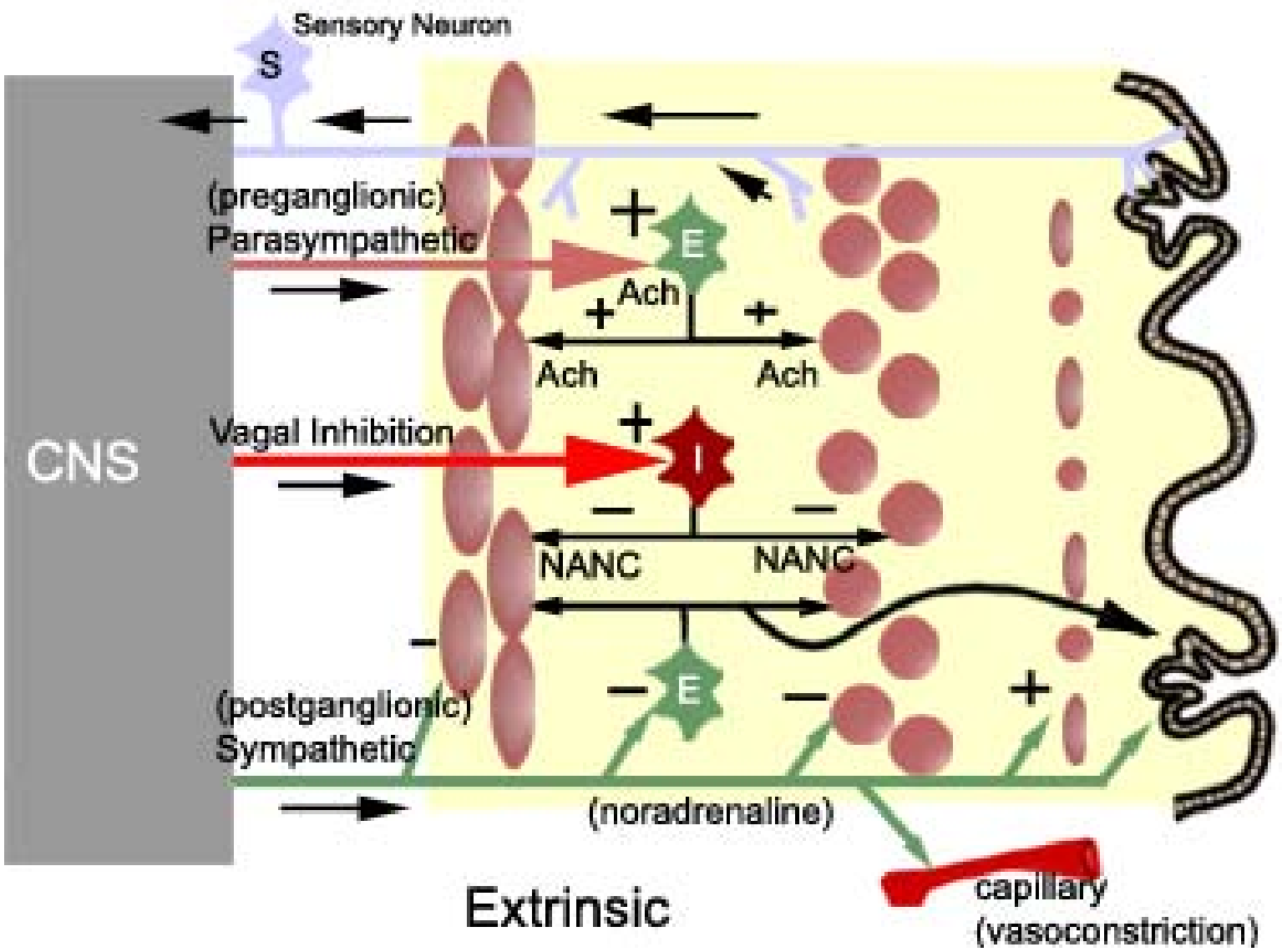
- increases secretory activity
- modulates intestinal absorption

- Function
  - Myenteric plexus : control over GI motility
  - Submucous plexus: regulate gastrointestinal blood flow and control GI secretion

- Local reflex



- Neurotransmitters secreted by enteric neurons
  - Ach:
  - NE: inhibitory
  - Others: Substance P, Nitric oxide , Vasoactive intestinal polypeptide (VIP), Opioid peptide, serotonin, histamine, ATP…


Sensory Neuron
S
CNS
(preganglionic)
Parasympathetic
E
Ach
Ach
Ach
Vagal Inhibition
I
NANC
NANC
(postganglionic)
Sympathetic
E
(noradrenaline)
capillary
(vasoconstriction)
Extrinsic

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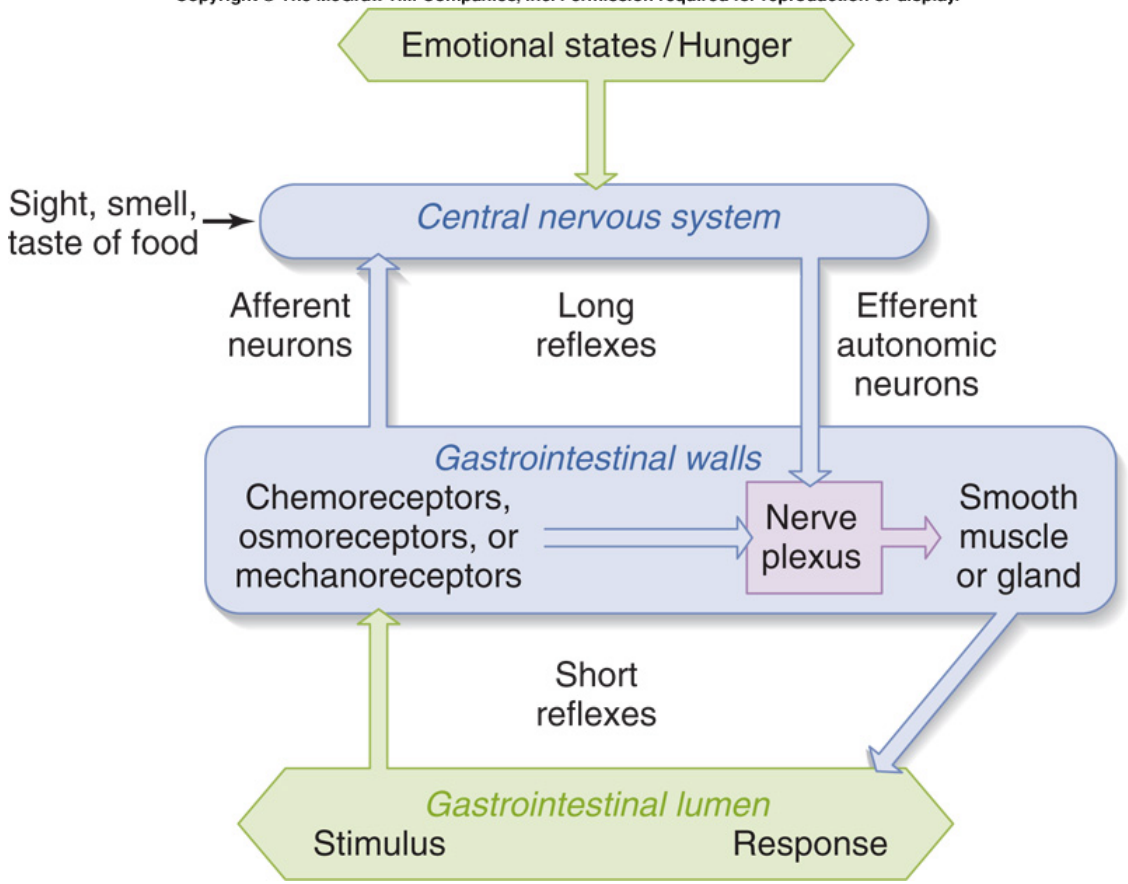


The enteric nervous system coordinates digestion, secretion, and motility to optimize nutrient absorption. Its activity is modified by information from the CNS and from local chemical and mechanical sensors.

(III) Hormonal Regulation
----GI hormones

- The hormones synthesized by a large number of endocrine cells within the gastrointestinal tract
- **Brain-gut peptides:** a number of the classical GI hormones are also synthesized in the brain

- Physiological functions
  - control of the digestive function
  - the release of other hormones
  - trophic action

Four main types

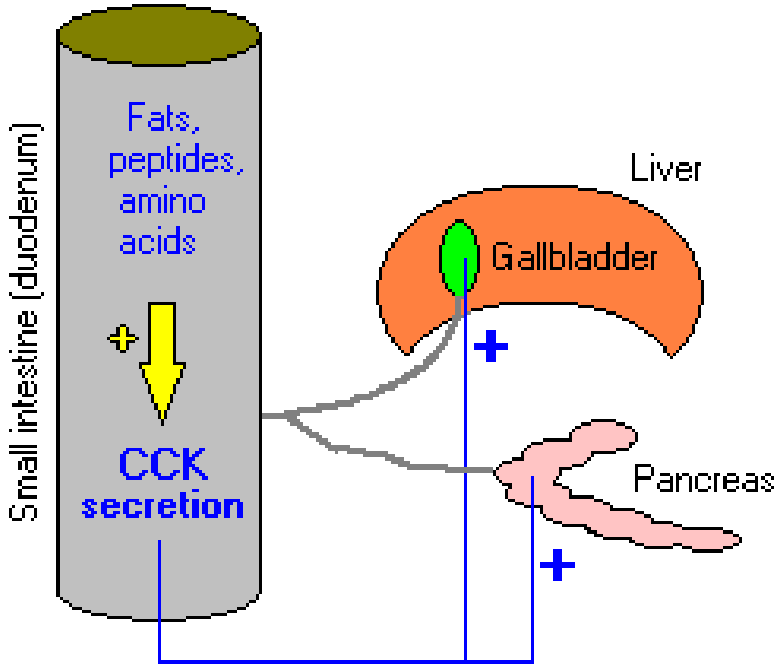
- Gastrin
- Cholecystokinin
- Secretin
- Gastric inhibitory polypeptide (GIP)

(1) Gastrin

- Synthesized in G cells
- Stimulated by amino acids in stomach
- Functions
  - Regulator gastric acid secretion
  - Proliferation of gastric epithelium

(2) Cholecystokinin

- Secreted by I cells in the duodenum and jejunum
- contraction of the gallbladder
- Inhibits stomach motility
- Stimulates secretion of pancreatic enzymes



(3) Secretin

- Secreted by S cells in the duodenum
- Response to acidic gastric juice emptying into the duodenum
- Inhibits the motility of most of gastrointestinal tract
- Stimulates secretion of water and bicarbonate from the pancreas and bile ducts

(4) Glucose-dependent insulinotropic peptide (GIP)

- Secreted by the mucosa of the upper small intestine
- Response to fatty acids and amino acids
- Inhibits gastric secretion and motility
- Potentiates release of insulin from beta cells in response to elevated blood glucose concentration

(IV) Phases of Gastrointenstinal Control

- Cephalic phase
- Gastric phase
- Intenstinal phase
- Three phase of gastric secretion.swf

Summary

- **Terms:**
  - Basic electrical rhythm (BER) or slow waves
  - Gastrointestinal (GI) hormones
- Three phase of gastric secretion

Intensive reading

- **Textbook of Human Physiology**
  - **P575-590**


Thank you!