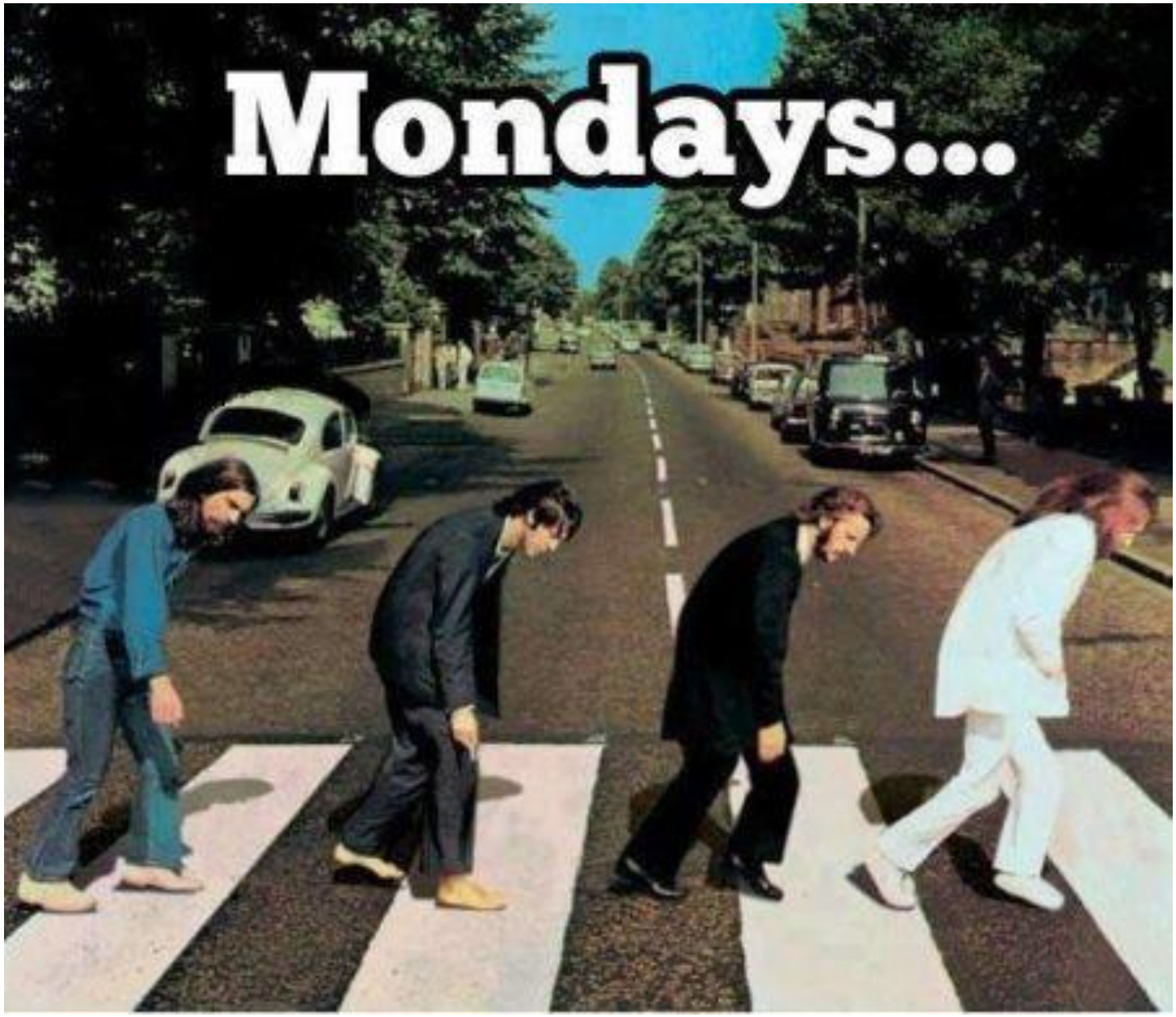

So which of the
favors of your
Lord
will you deny?
(QURAN 55:13)


Mondays...


Monday
Me
TRUE STORY
www.thefunnyblog.org

Gastrointestinal Physiology

General principles of gastrointestinal motility


Start everything with
بسم الله

Learning Objectives

After this lecture the student should be able to:

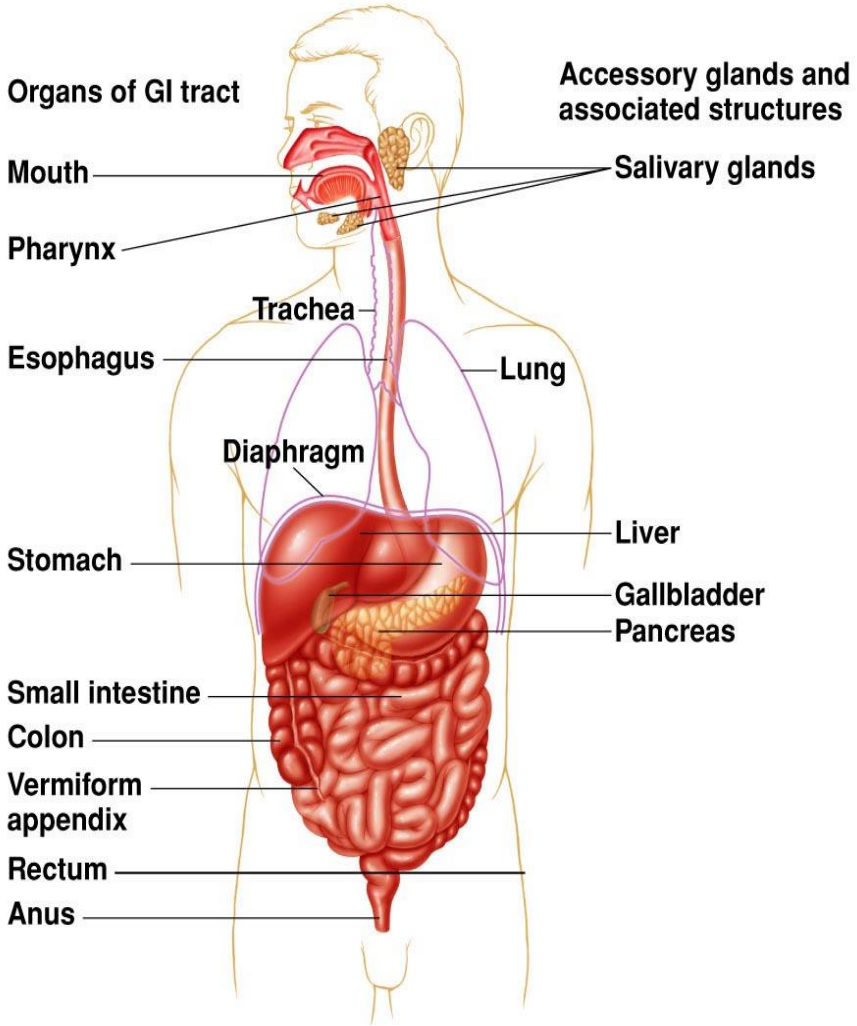
- Describe electrical activity of gastrointestinal smooth muscle
- Differentiate between slow wave and spike potential
- Describe the mechanism of excitation of smooth muscle of gastrointestinal tract
- Describe law of gut.

Recall your knowledge…

Physiological Anatomy

The Digestive System

- ✓ A series of organs that are involved in the breaking down of food and converting it into essential nutrients that are absorbed in the body
- ✓ The digestive organs also remove waste materials from the body.

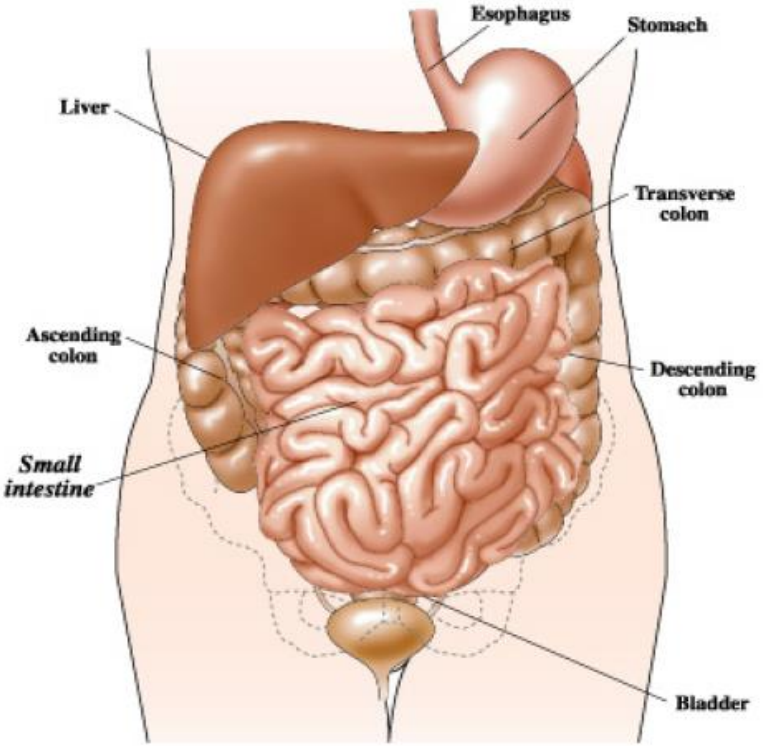


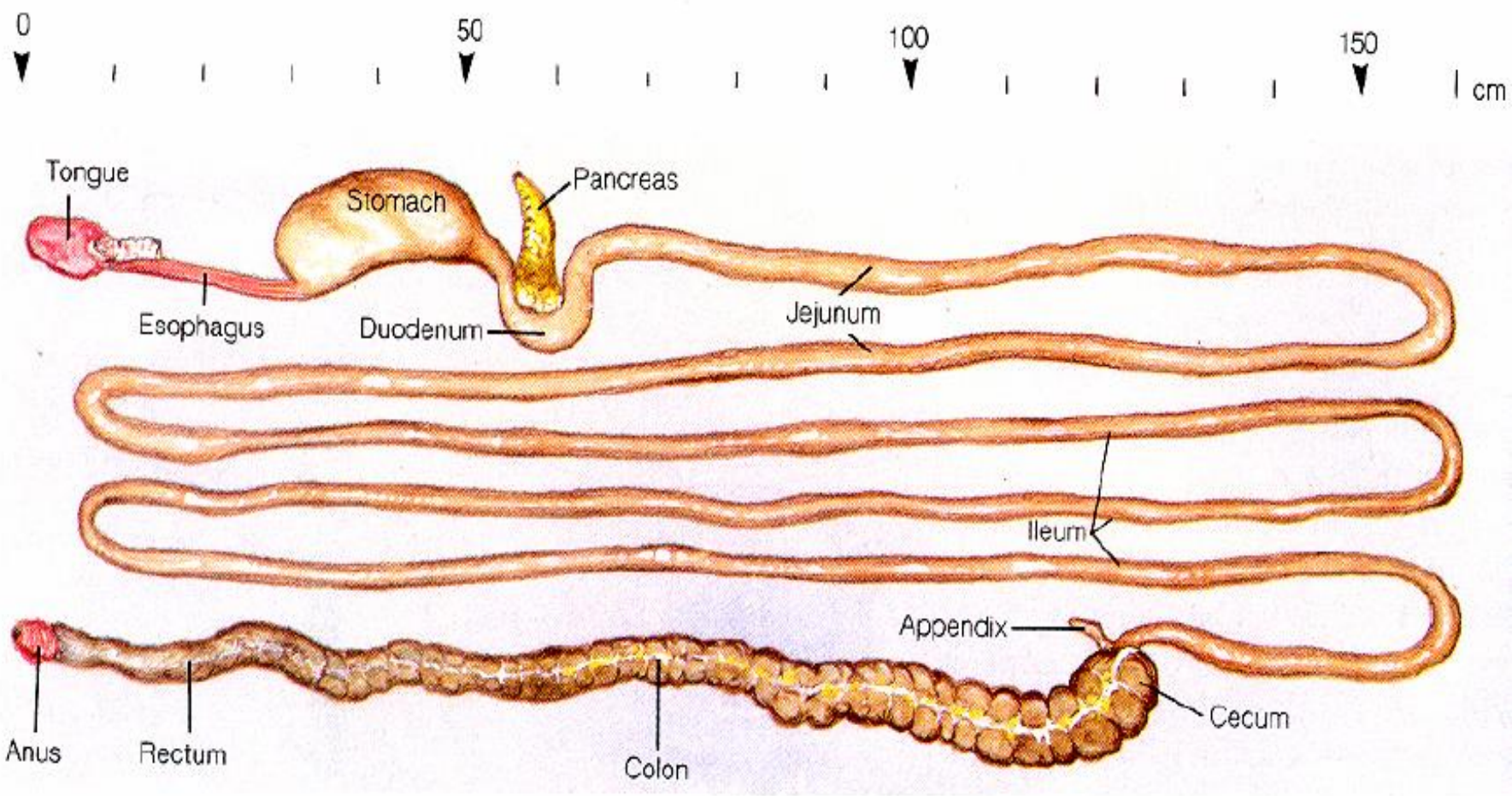
Digestive Tract

The Gastrointestinal Tract of an adult, is a 9m long tube, and extends from oral cavity to anus –

Regions can be broadly classified into:

- Mouth
- most of pharynx
- Esophagus
- Stomach
- Small intestine
- Large intestine





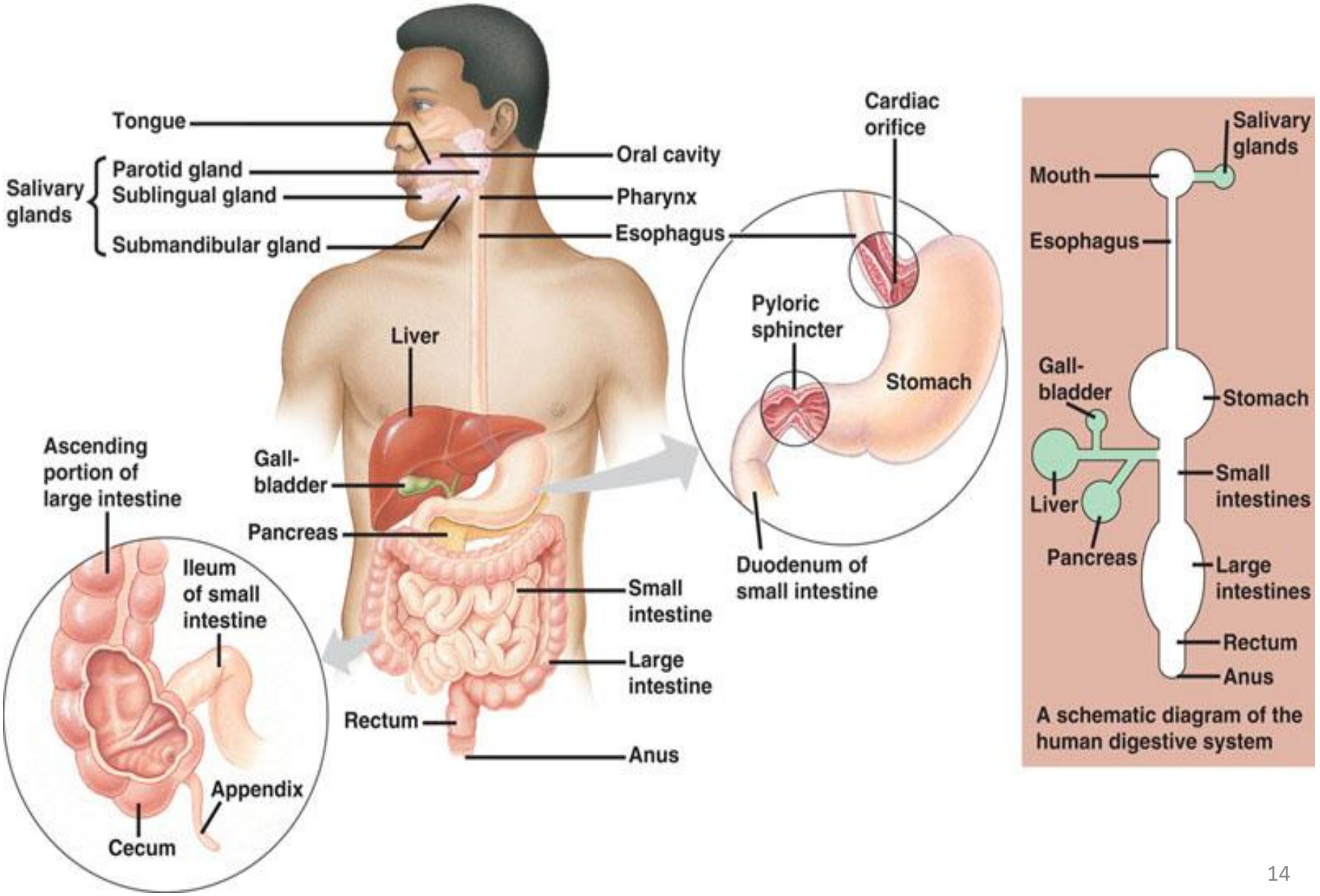
Aprox. 30 ft in the cadaver.

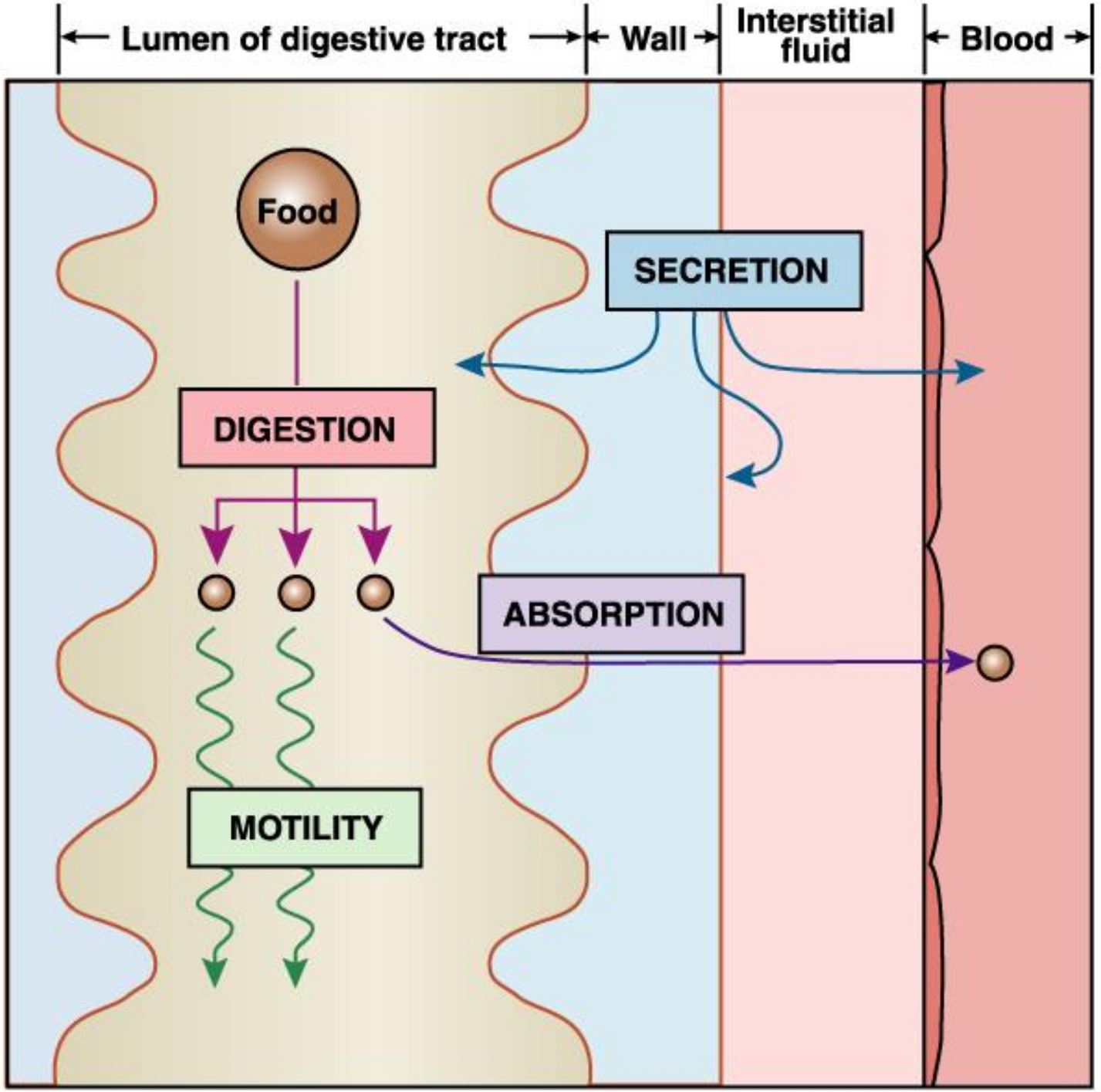
Accessory Organs

The organs which lie outside the GIT and aid in digestion by mechanical manipulation and by emptying their secretions into the lumen:

- Teeth
- Tongue
- Salivary Glands
- Liver
- Gall bladder
- Pancreas

Overview of the Digestive System




Lumen of digestive tract
Wall
Interstitial fluid
Blood
Food
SECRETION
DIGESTION
ABSORPTION
MOTILITY

Anatomy of wall of GIT

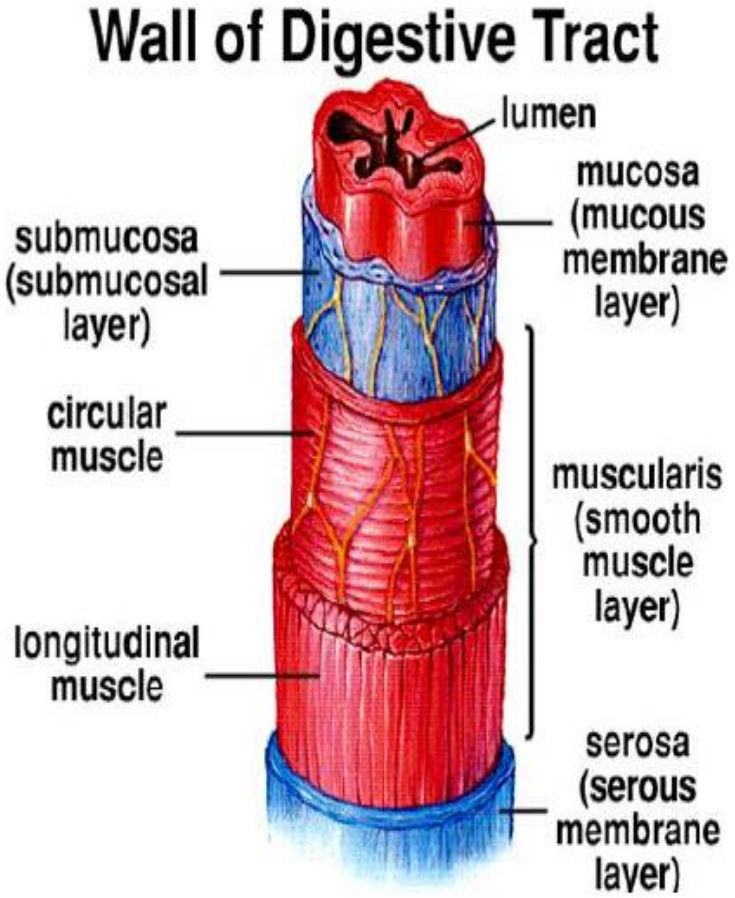
Layers of the Intestinal wall

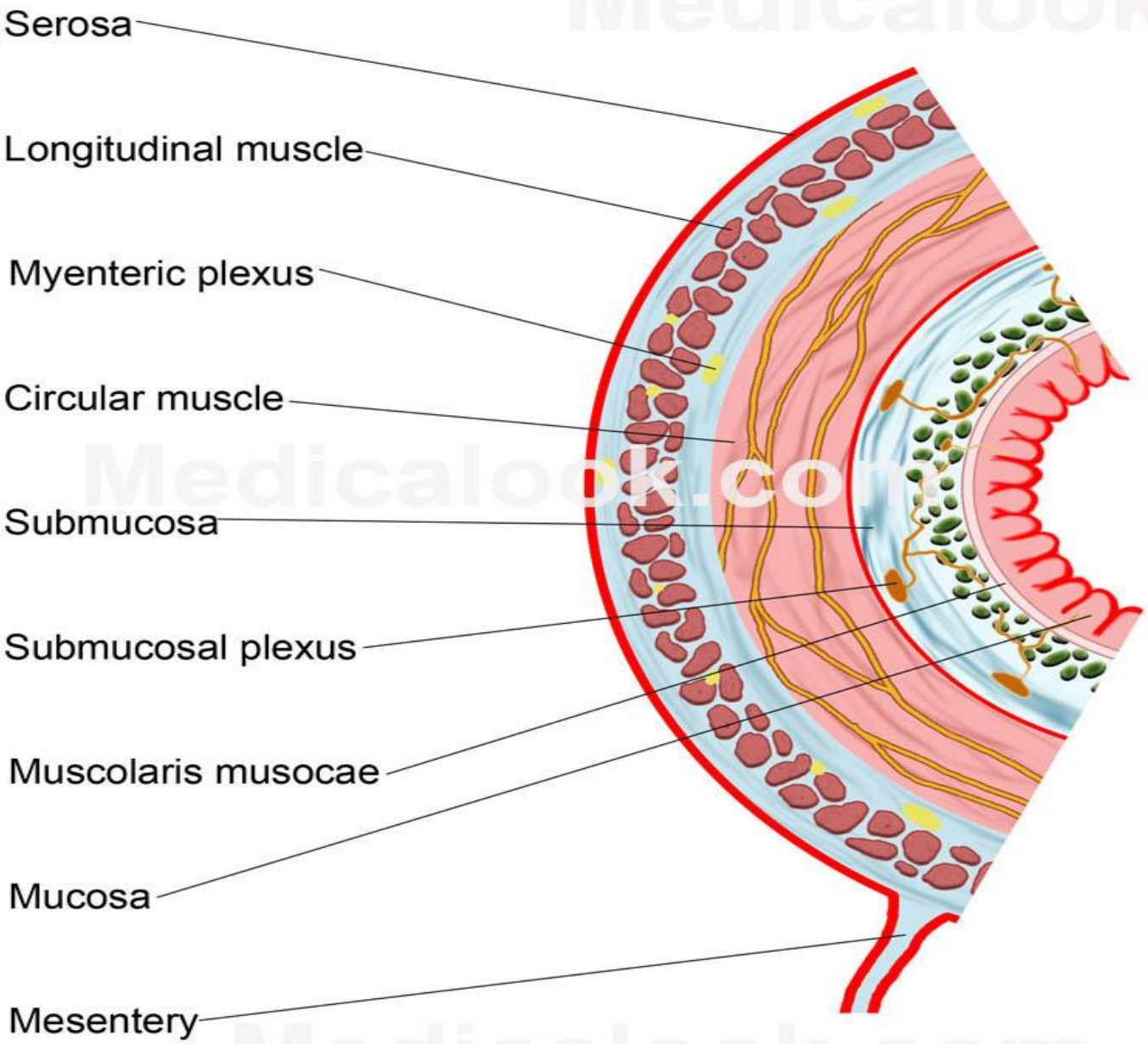
1. **Mucosa**
   i. Muscularis mucosa
   ii. Lamina propria
   iii. Epithelium

2. **Submucosa**

3. **Muscularis Externa**
   i. Longitudinal muscle
   ii. Circular muscle

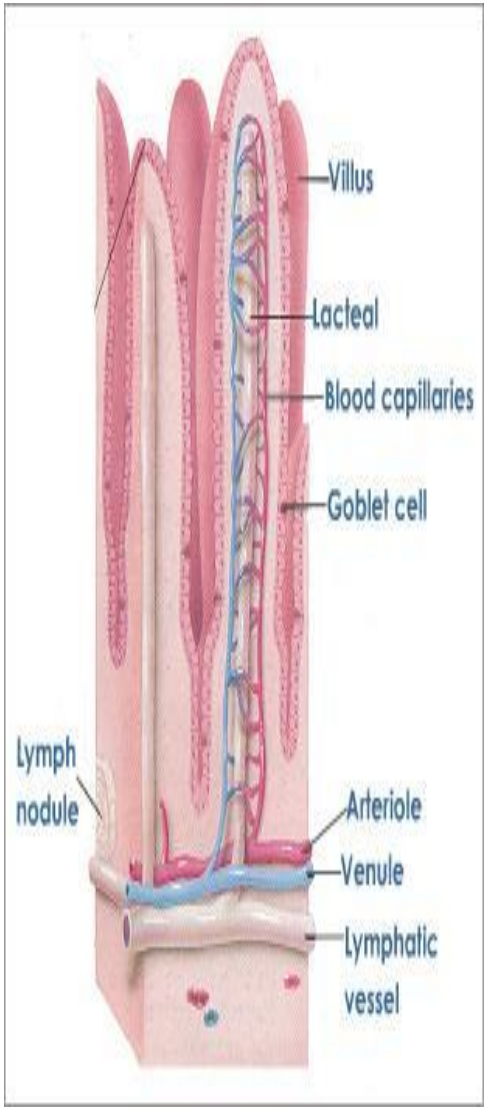
4. **Serosa** (Peritoneum)



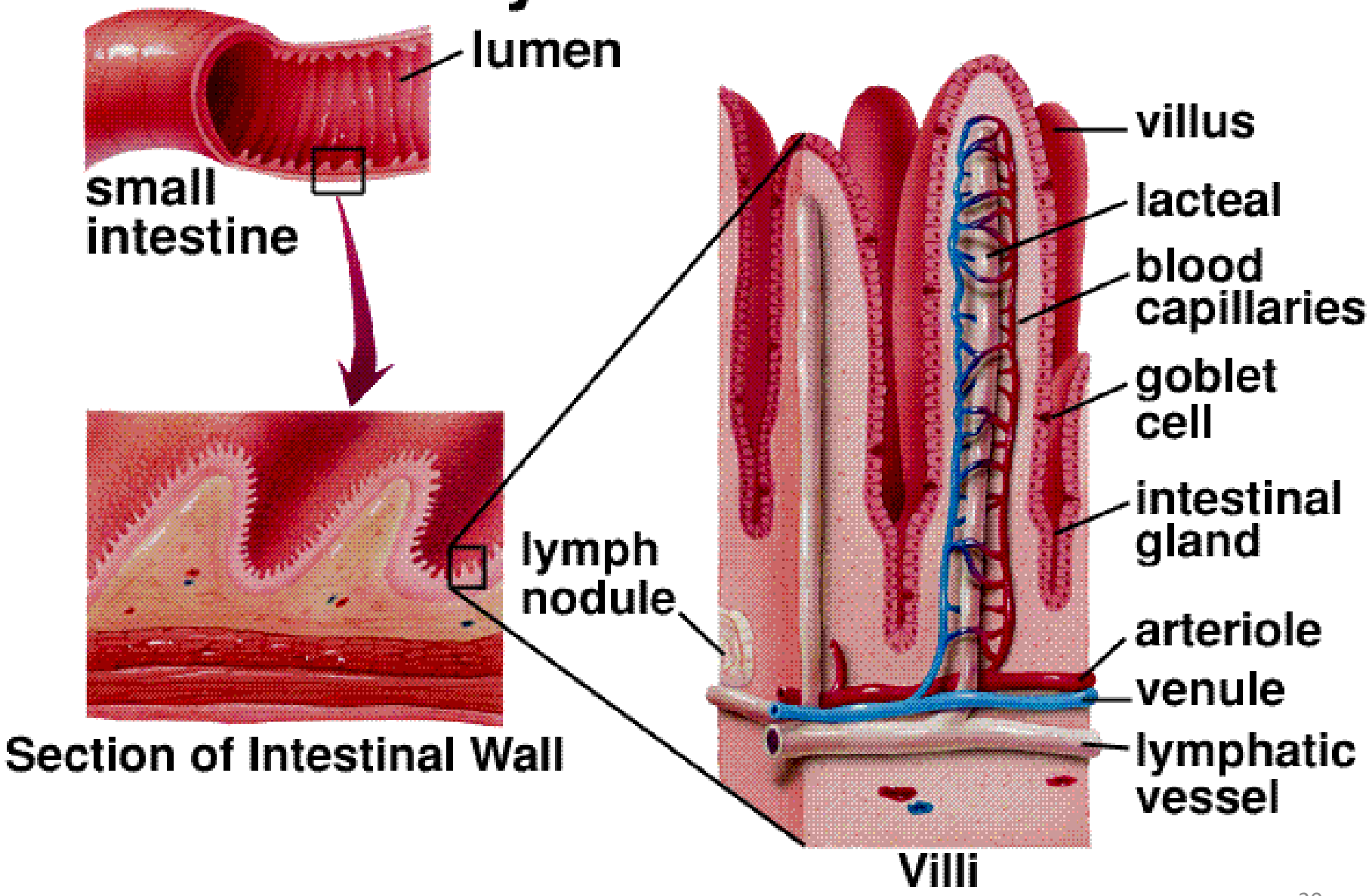


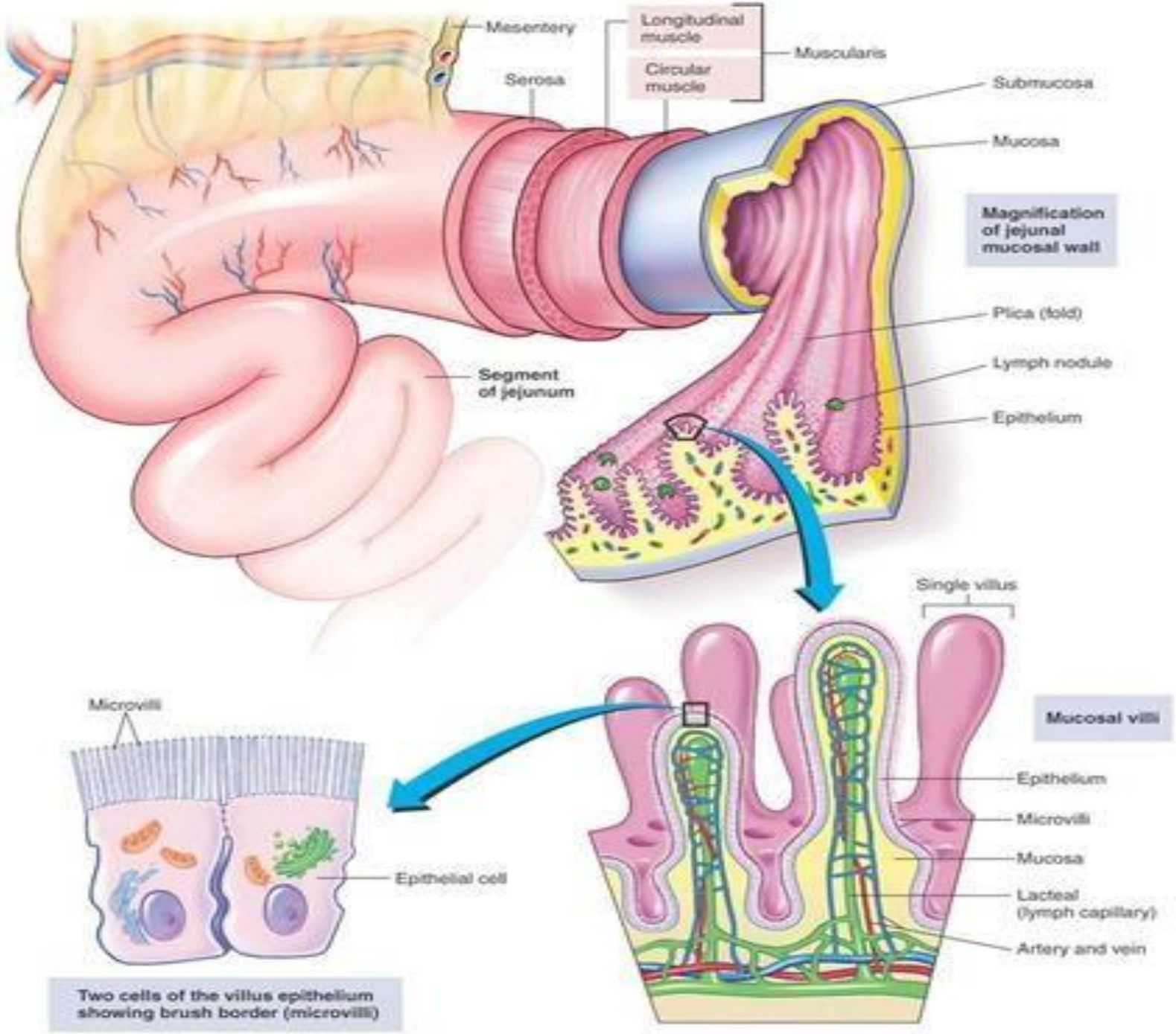
The Villi

- The lining of the small intestine is thrown into circular folds called "**plicae circulares.**"
- The plicae are lined with **fingerlike villi.**
- villus consists of columnar cells which are covered with **microvilli.**

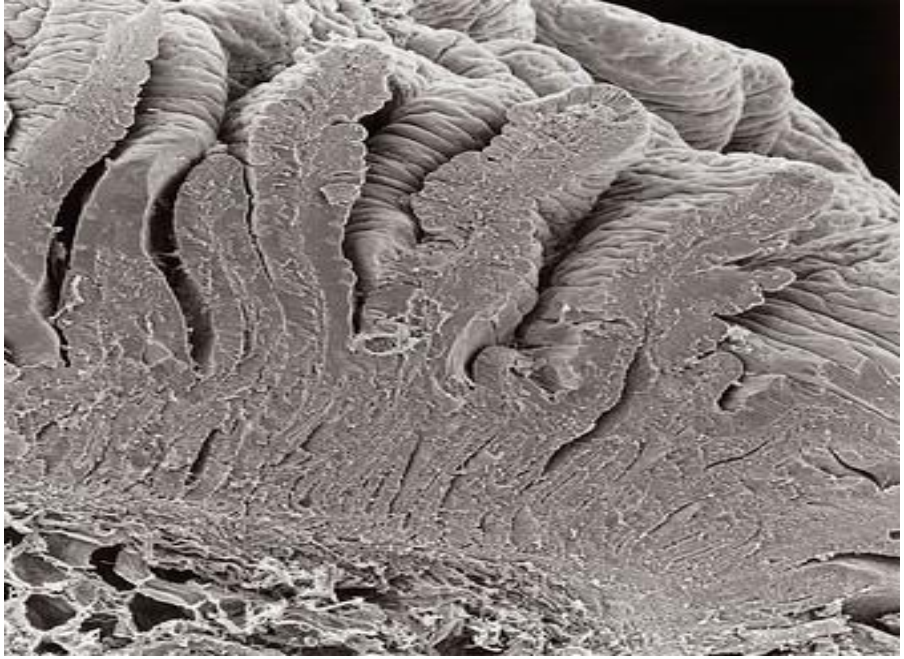


Anatomy of Small Intestine

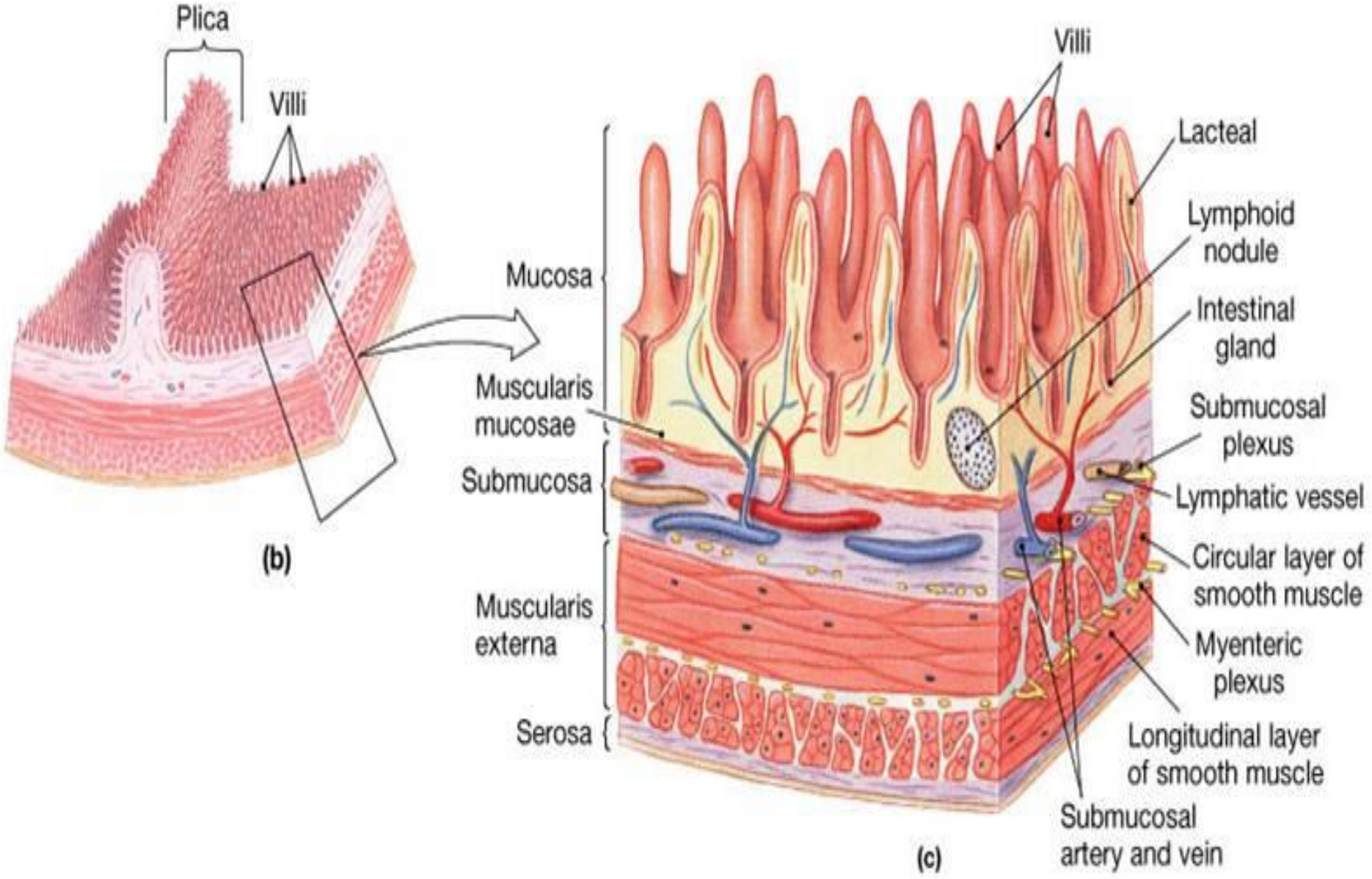


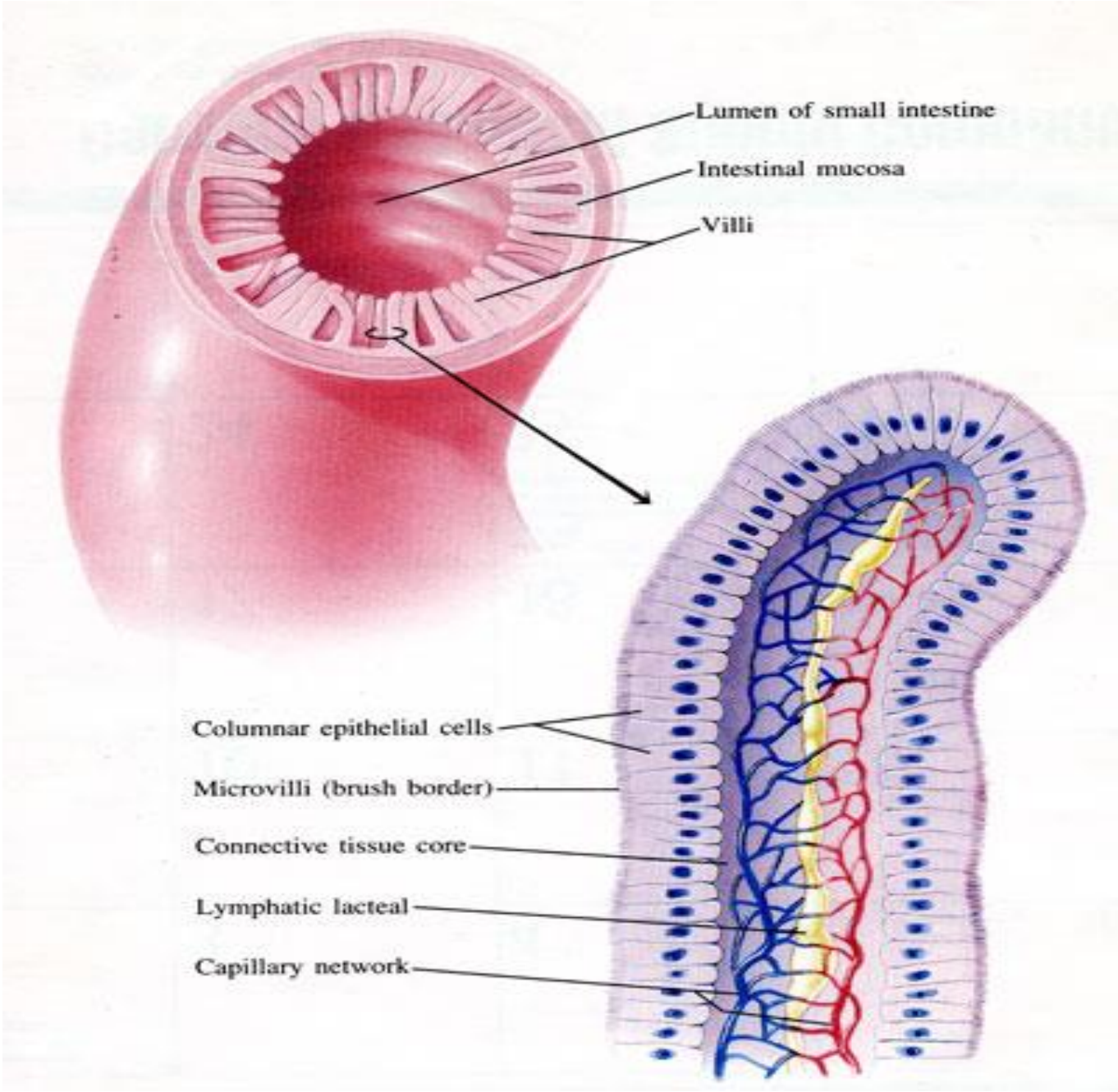

Mesentery
Longitudinal muscle
Circular muscle
Muscularis
Serosa
Submucosa
Mucosa
Magnification of jejunal mucosal wall
Plica (fold)
Lymph nodule
Epithelium
Segment of jejunum
Single villus
Mucosal villi
Epithelium
Microvilli
Mucosa
Lacteal (lymph capillary)
Artery and vein
Microvilli
Epithelial cell
Two cells of the villus epithelium showing brush border (microvilli)

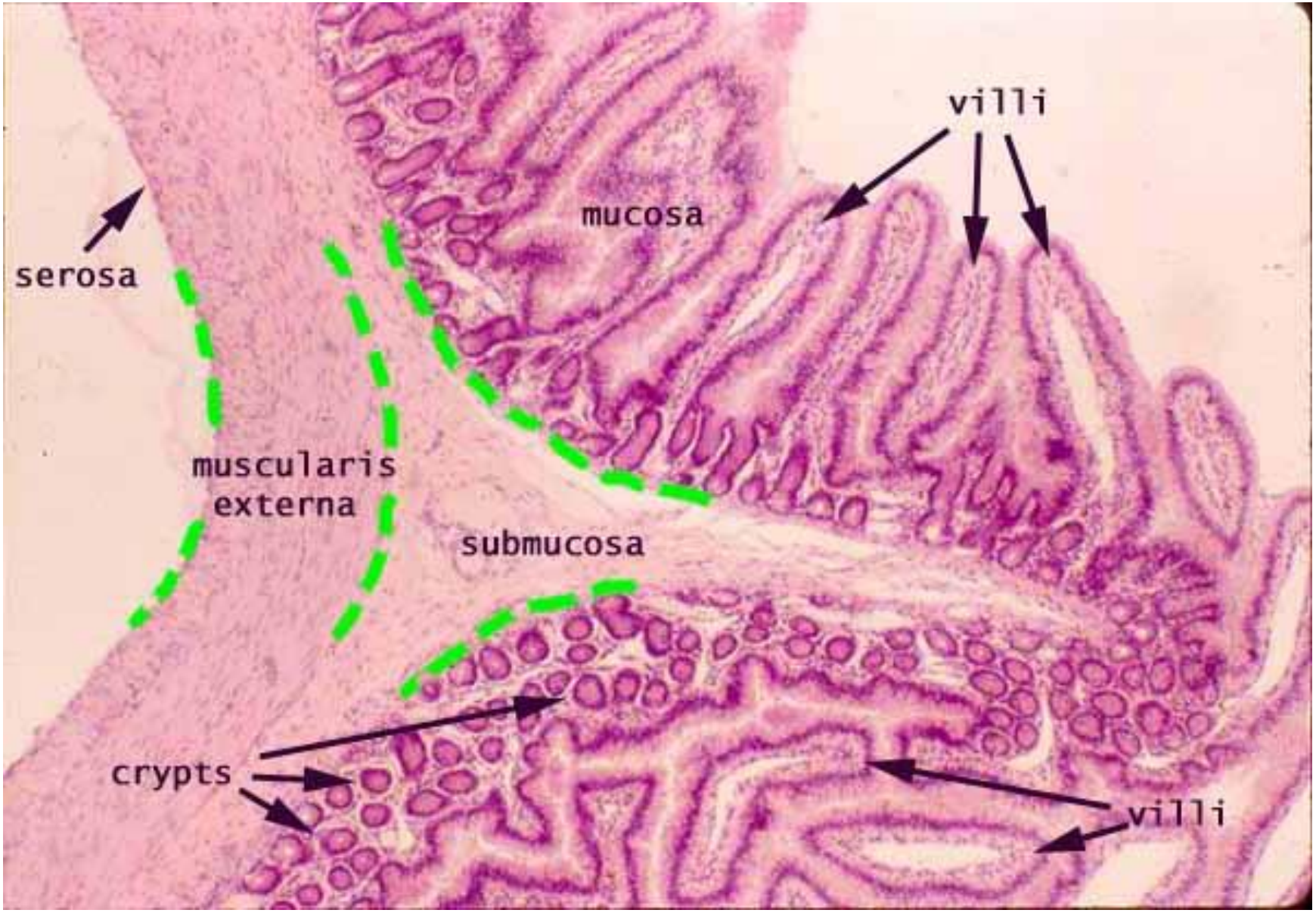

SCIENCE PHOTO LIBRARY




visuals unlimited


Plica
Villi
(b)
Villi
Lacteal
Lymphoid nodule
Intestinal gland
Mucosa
Muscularis mucosae
Submucosal plexus
Submucosa
Lymphatic vessel
Circular layer of smooth muscle
Muscularis externa
Myenteric plexus
Serosa
Longitudinal layer of smooth muscle
Submucosal artery and vein
(c)


Lumen of small intestine
Intestinal mucosa
Villi
Columnar epithelial cells
Microvilli (brush border)
Connective tissue core
Lymphatic lacteal
Capillary network


villi
mucosa
serosa
muscularis
externa
submucosa
crypts
villi

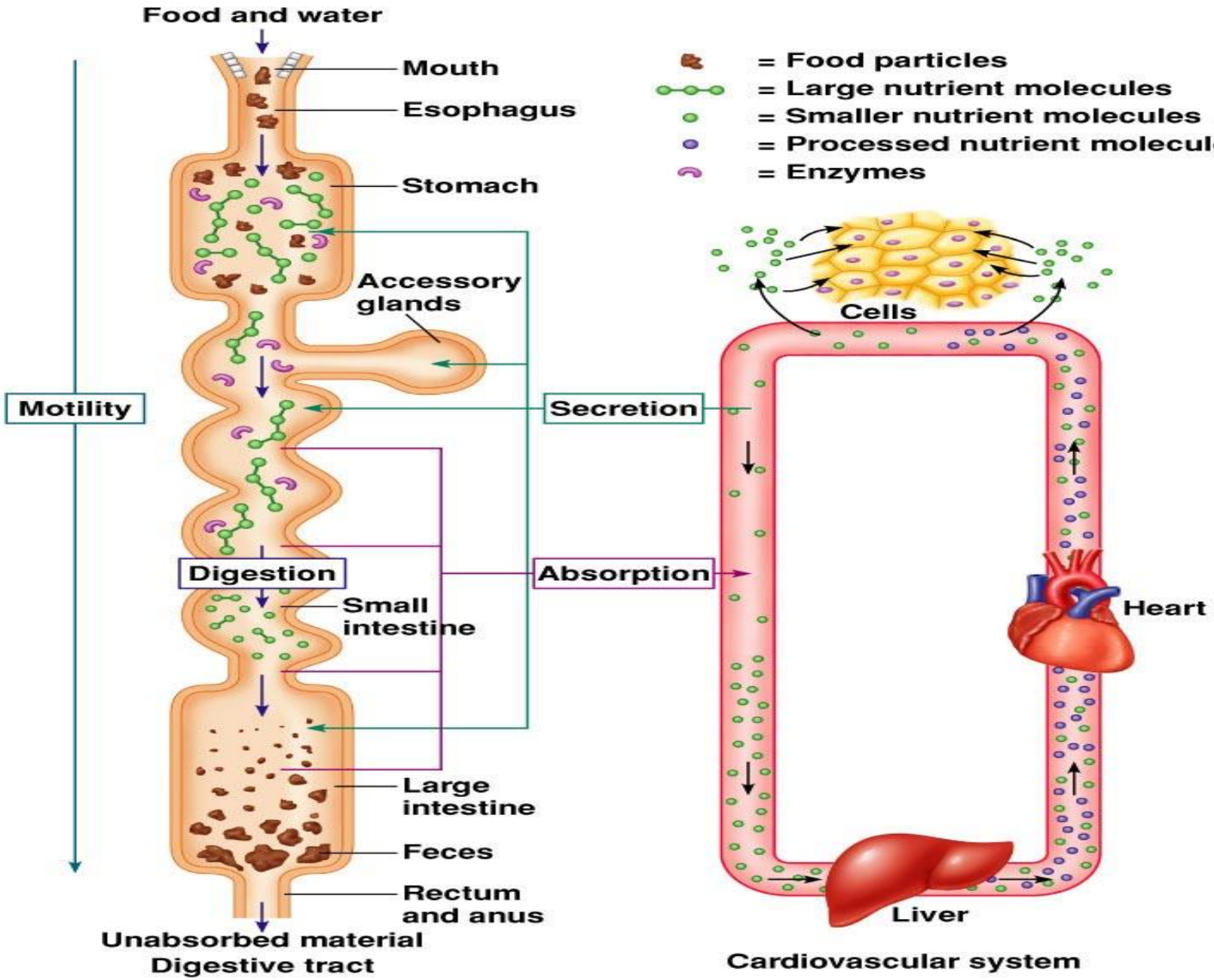
Immense Surface Area

- The small intestine's surface area is about 250 square meters. That is the surface area of a tennis court!
  - This allows for maximum chemical digestion and absorption.

Functions Of the GI Tract

Functions of the digestive system

1. Ingestion of food
2. Secretion of water, acid, buffers, and enzymes into lumen
3. Mixing and propulsion
4. Digestion
   - Mechanical digestion churns food
   - Chemical digestion – hydrolysis
5. Absorption – passing into blood or lymph
6. Defecation – elimination of feces



input → output

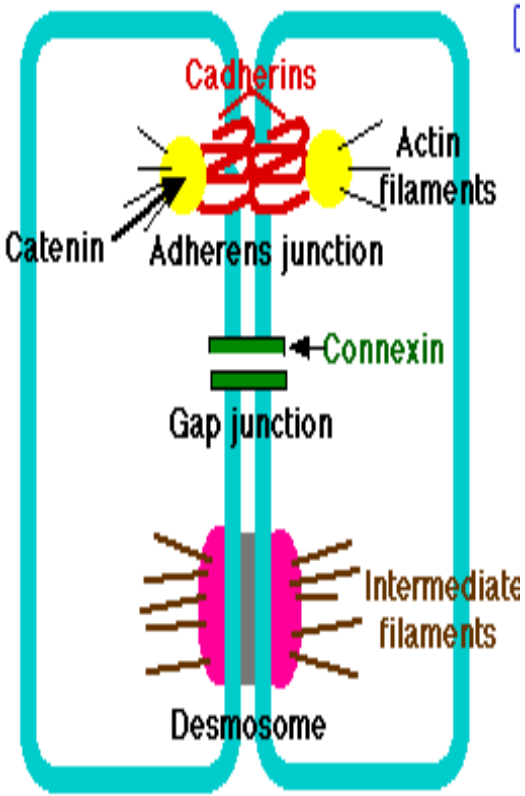
Function of the GIT Muscles and Nerves

Function of Smooth Muscles of the GIT

Length 200-500 um and 2-10 um in diameter, Arranged in parallel bundles.

Muscle fibers are interconnected through 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.



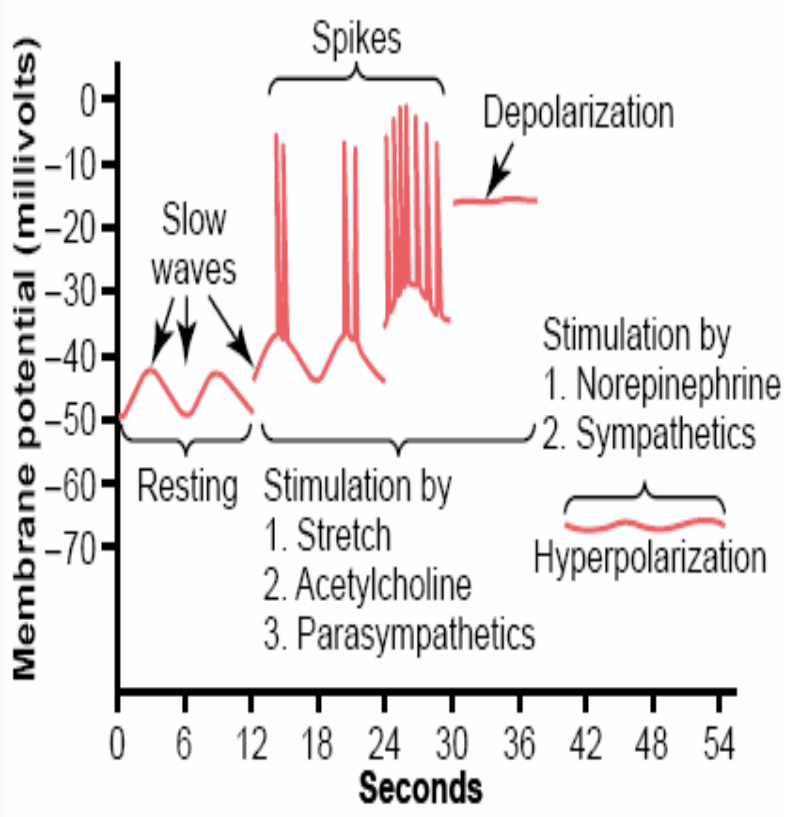
Electrical Activity of Gastrointestinal Smooth Muscle

- The excitability of smooth muscle cells are brought about by two different types of waves.
  (1) Slow waves
  (2) Spikes

- Both perform important role in controlling motor activity of the GIT.

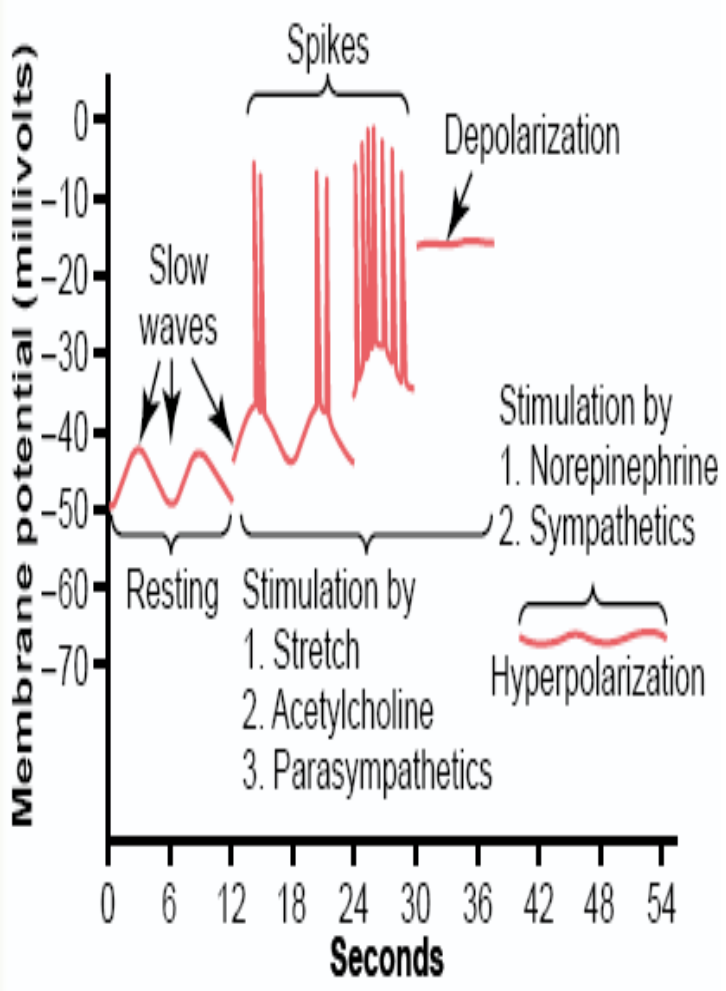
Slow Waves

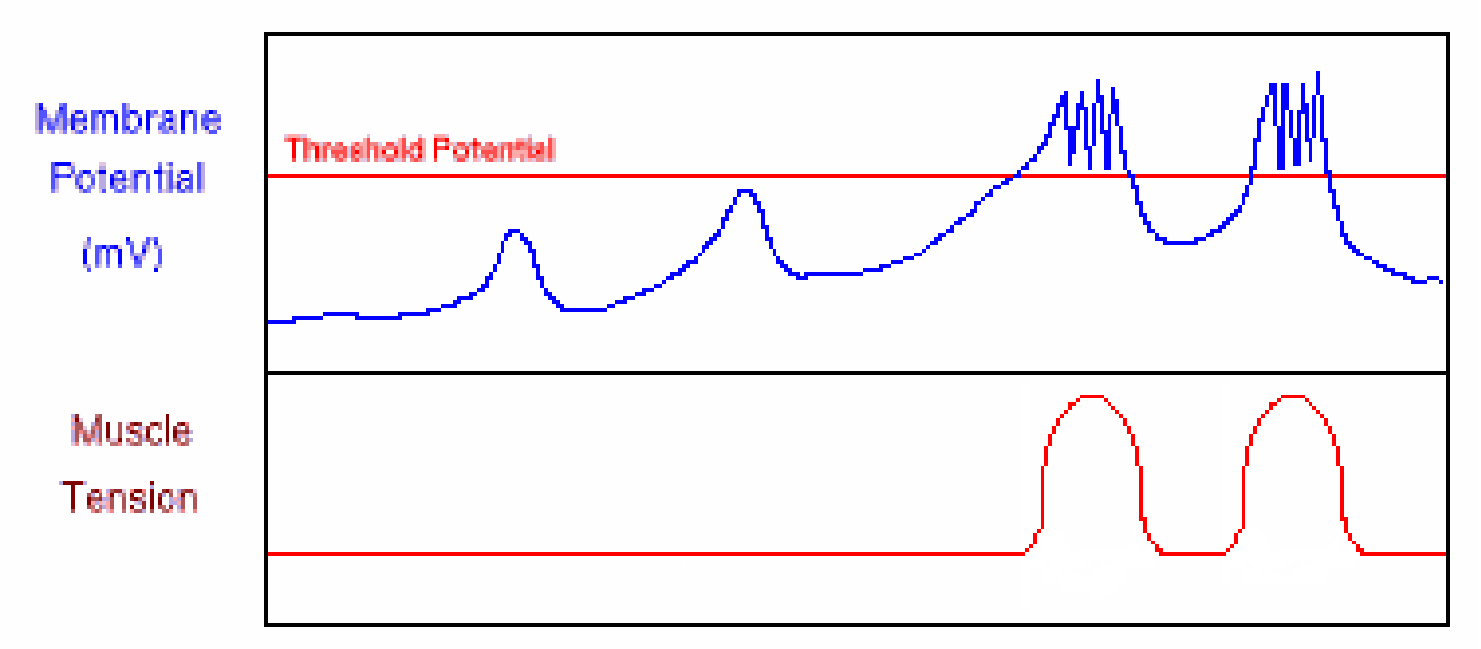
- A slow, undulating changes in resting membrane potential of smooth muscle
- Their intensity usually varies between 5 and 15 millivolts
- Their frequency ranges in different parts of the human gastrointestinal tract from 3 to 12 per/min
- Stomach = 3 Duodenum = 12 Illeum = 8-9



Spike Potentials

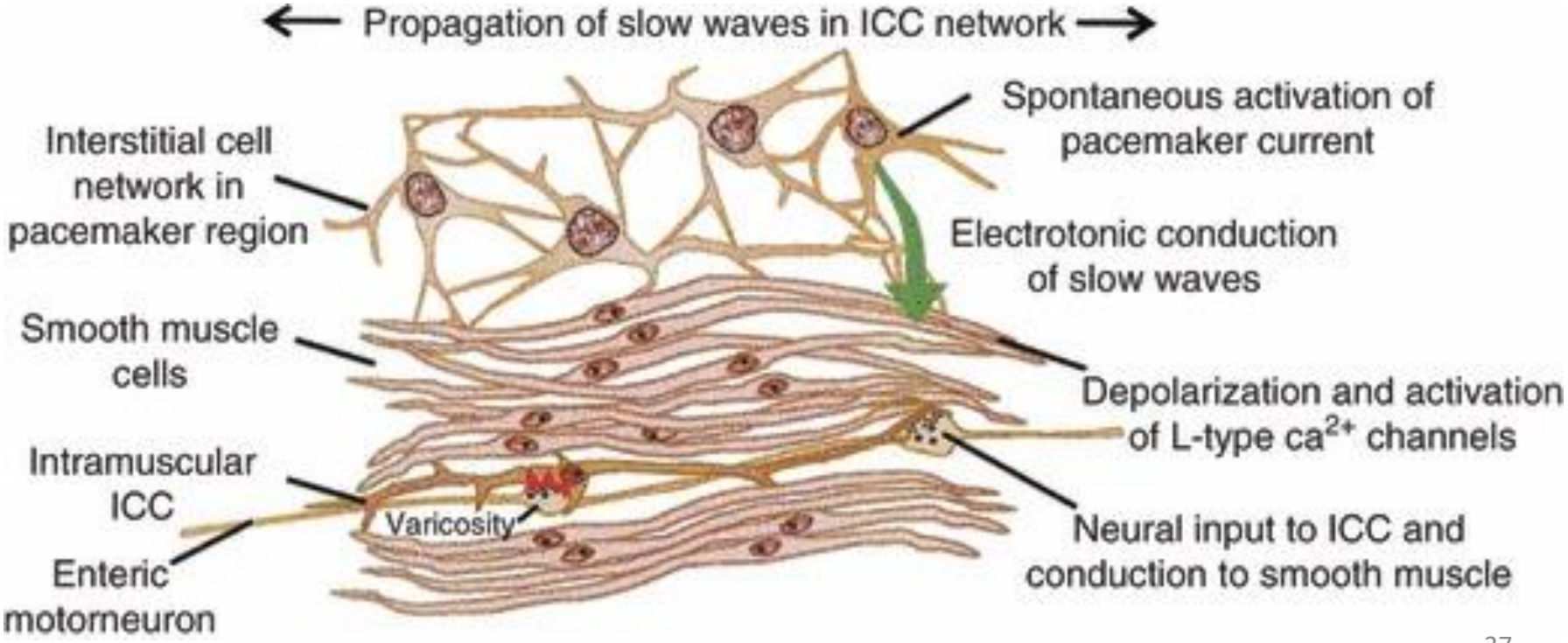
- The true action potentials.
- Occur automatically when the resting membrane potential of the gastrointestinal smooth muscle becomes more positive than about -40 mV (normal gut potential is from -50 to -60 mV).

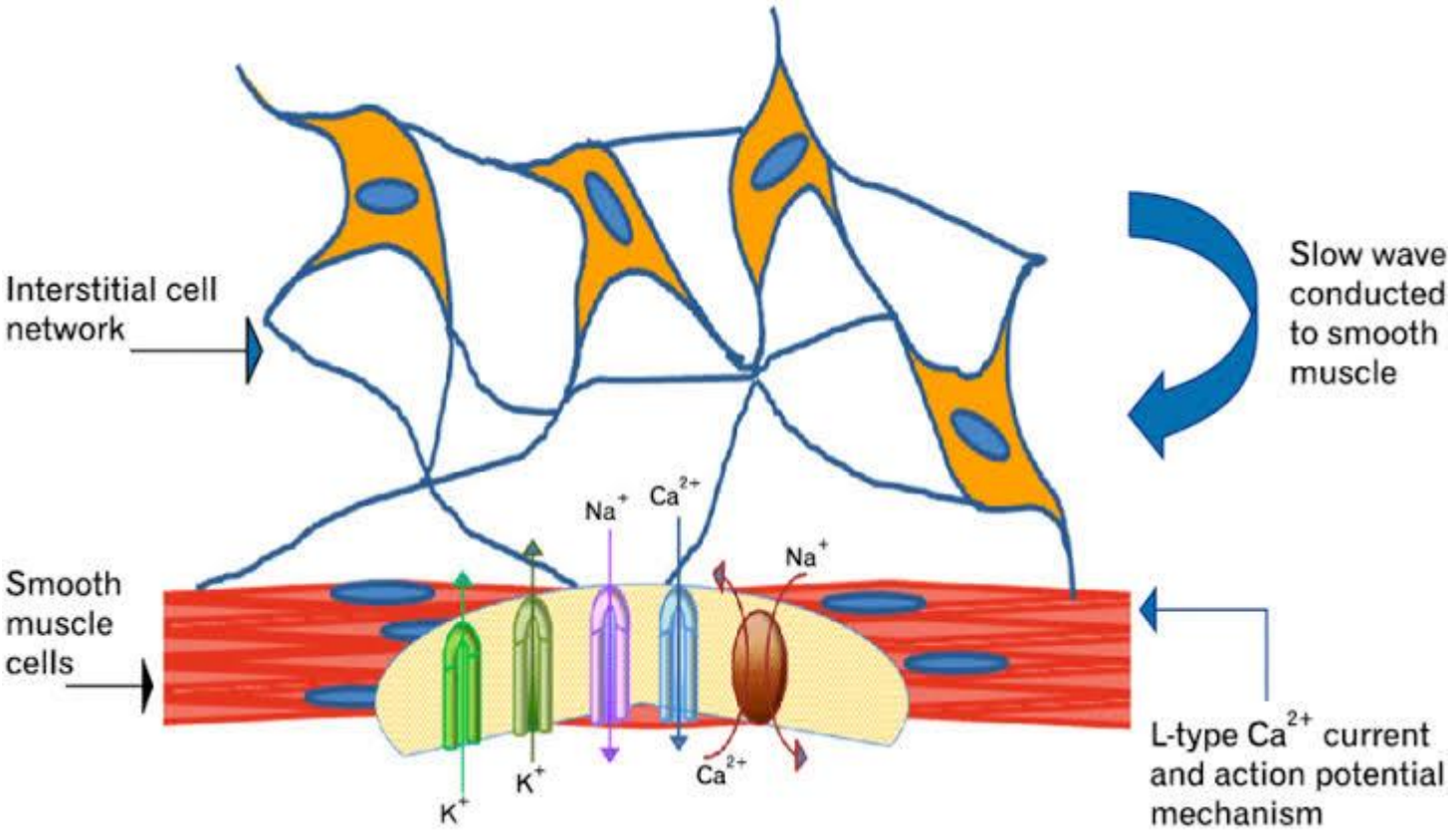



Membrane
Potential
(mV)
Threshold Potential
Muscle
Tension

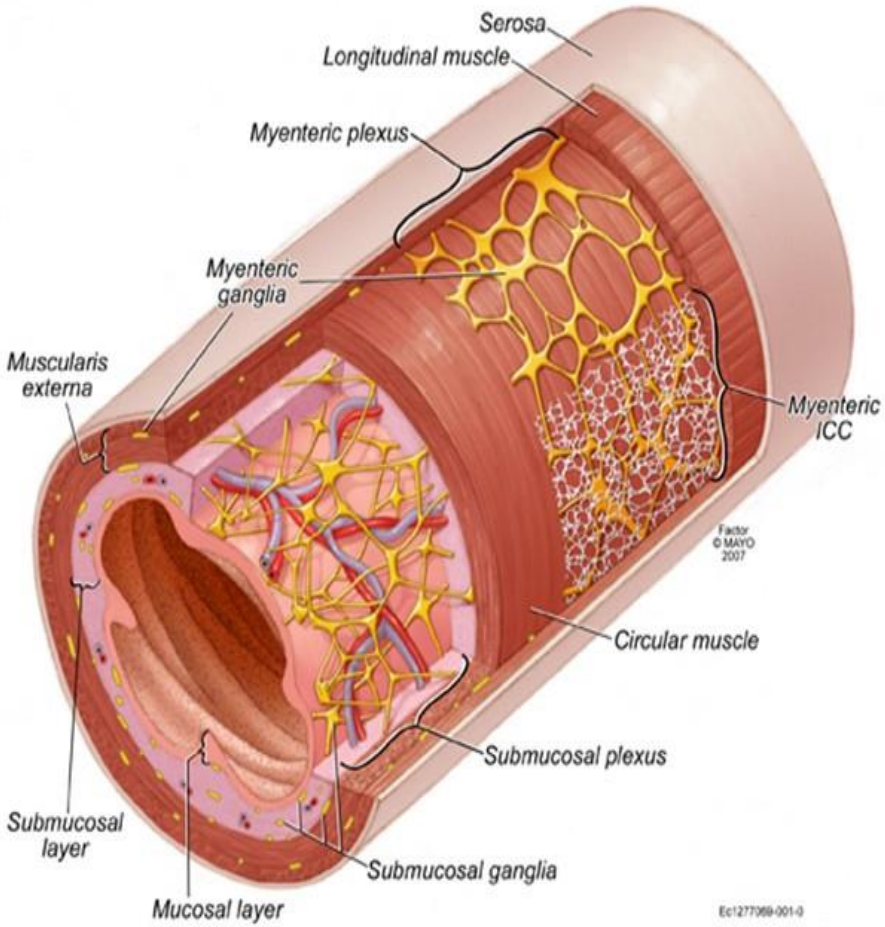
Mechanism of contraction

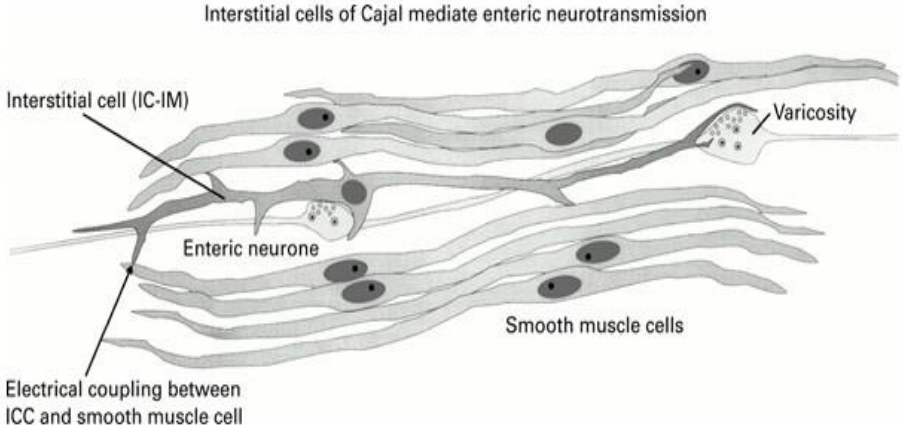
- Contraction of the body wall is caused by complex interactions between smooth muscle cells and specialized cells known as the Interstitial Cells of Cajal (ICC).




Interstitial cell network
Slow wave conducted to smooth muscle
Smooth muscle cells
Na+
Ca2+
Na+
K+
K+
Ca2+
L-type Ca2+ current and action potential mechanism

Elements of the Gut Wall



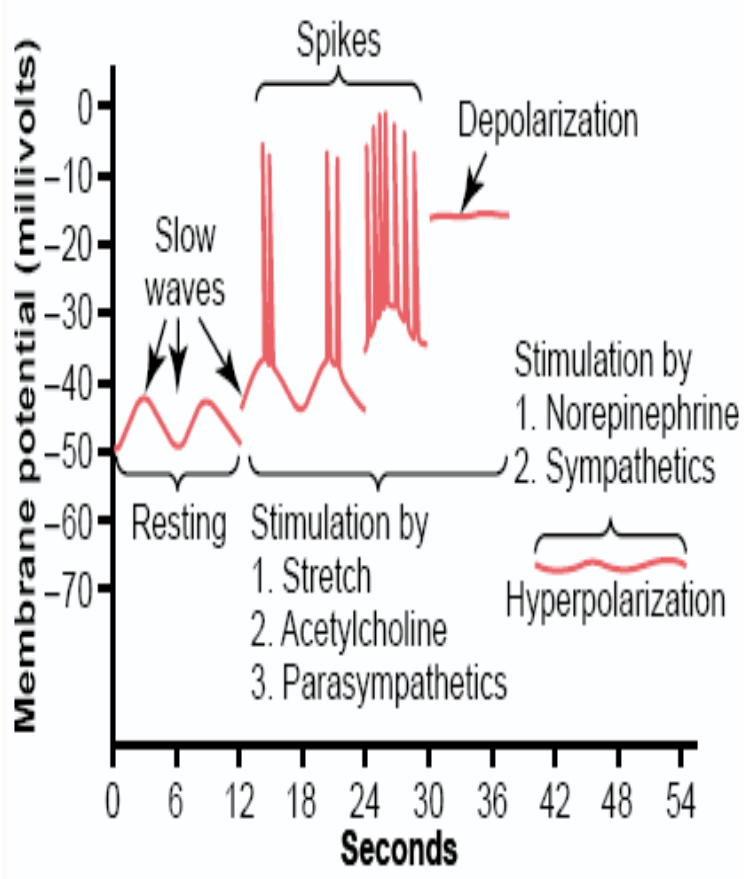


Mechanism of Action

- The Channels called the Calcium-Sodium channels are responsible for the action potential in GI smooth muscle fibers.
- They open and close slowly to enter large number of calcium along with smaller numbers of sodium ions.
- The slow movement of these channels accounts for the long duration of the action potentials.
- Also, the movement of large amounts of calcium ions to the interior of the muscle fiber during the action potential plays a special role in causing the intestinal muscle fibers to contract.

Changes in Voltage of the Resting Membrane Potential

- The resting membrane potential of smooth muscles averages about -56 mV.
- In depolarized state the potential becomes less negative, which is called *depolarization of the membrane, the* muscle fibers become more excitable.

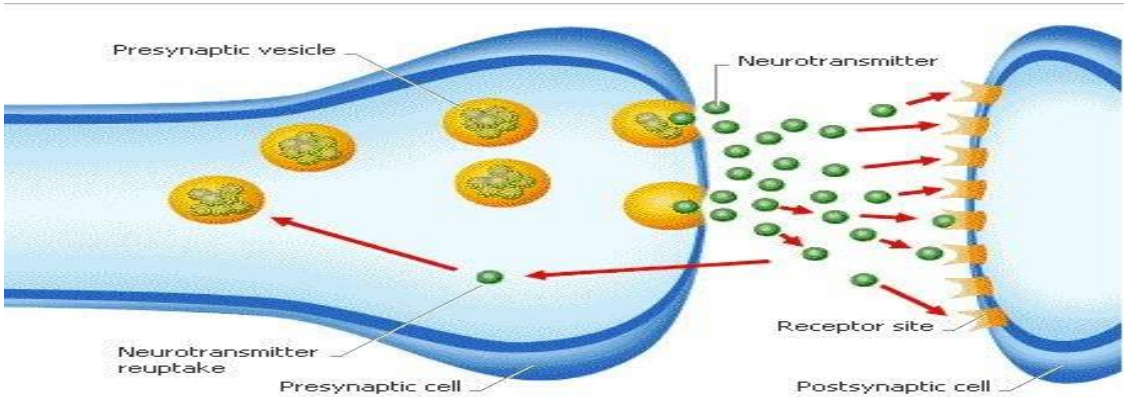


Factors that Depolarize the Membrane

(1) Stretching of the muscle

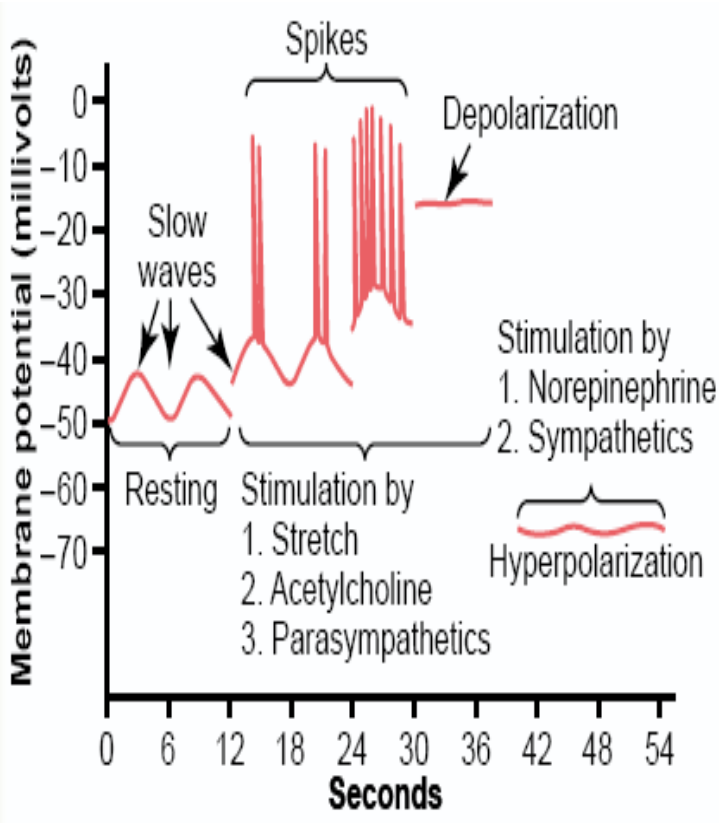
(2) Stimulation by parasympathetic nerves that secrete acetylcholine at their endings

(3) Stimulation by several specific gastrointestinal hormones.



Changes in Voltage of the Resting Membrane Potential

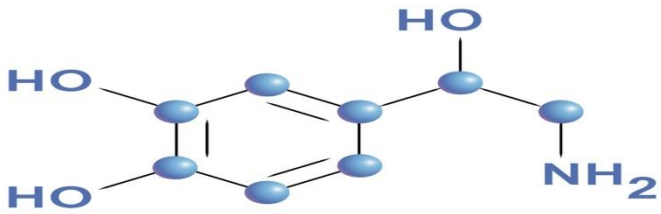
- When the potential becomes more negative, which is called *hyperpolarization*, the fibers become less excitable.



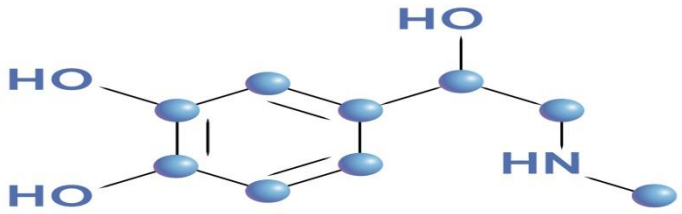
Factors that hyperpolarize the membrane

(1) The effect of norepinephrine or epinephrine on the fiber membrane.

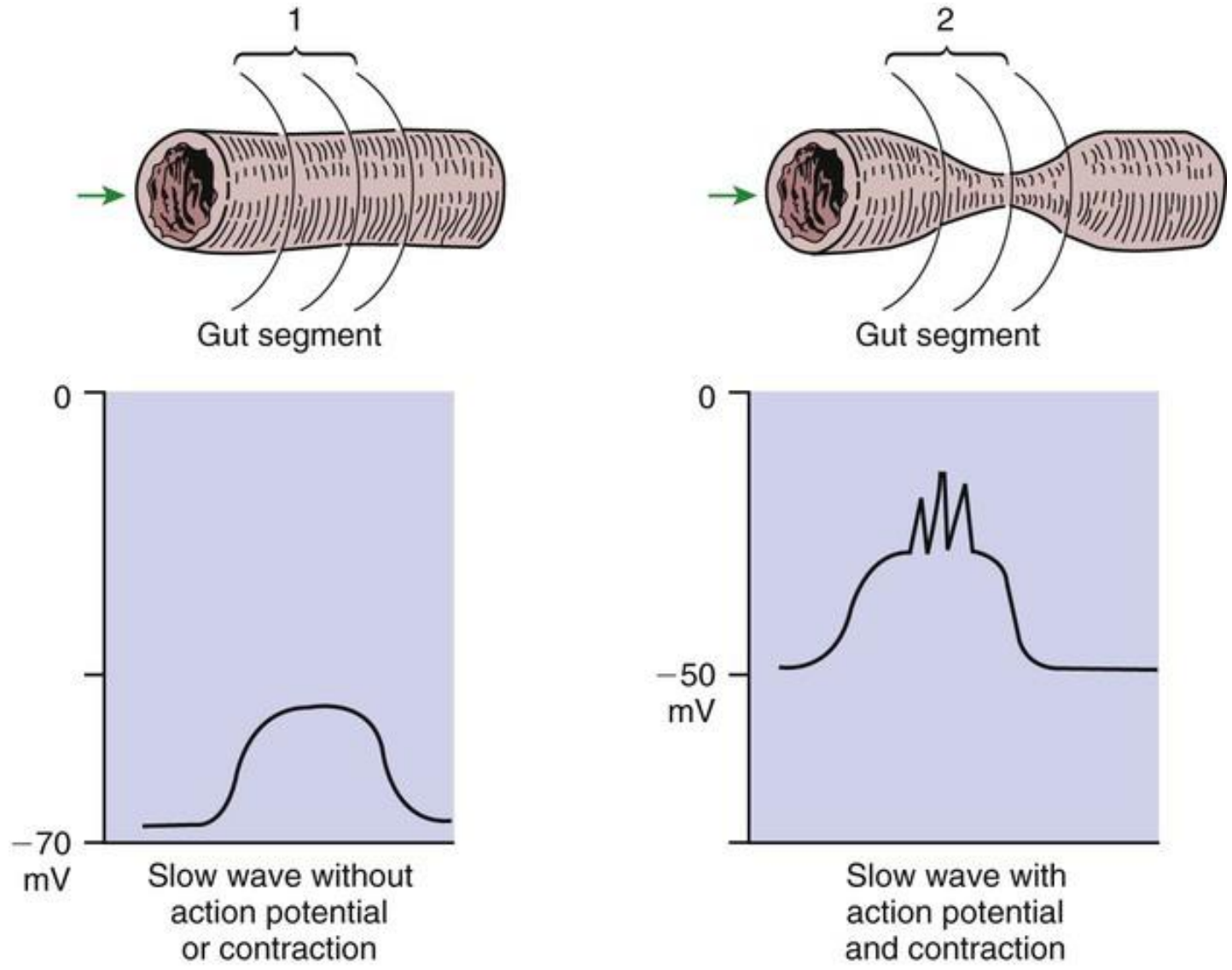
(2) Stimulation of the sympathetic nerves that secrete mainly norepinephrine at their endings.



Norepinephrine

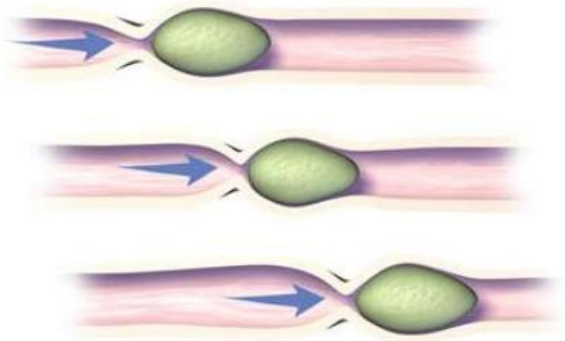


Epinephrine


1
Gut segment
0
−70
mV
Slow wave without
action potential
or contraction
2
Gut segment
0
−50
mV
Slow wave with
action potential
and contraction

LAW OF INTESTINES

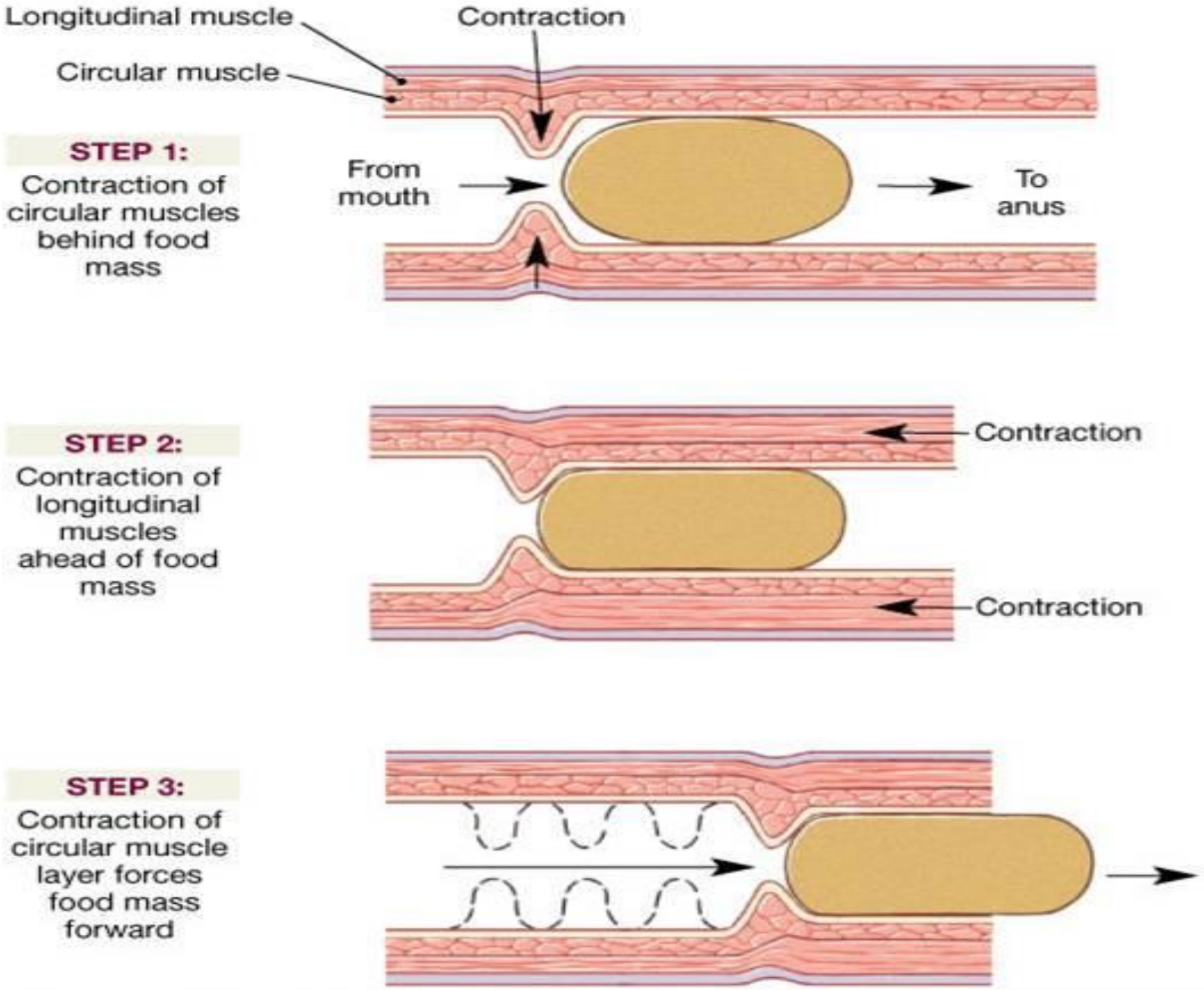
- When a bolus is placed in the small intestine, the portion behind the bolus contracts and portion ahead of it relaxes. This propels the bolus from oral to aboral direction

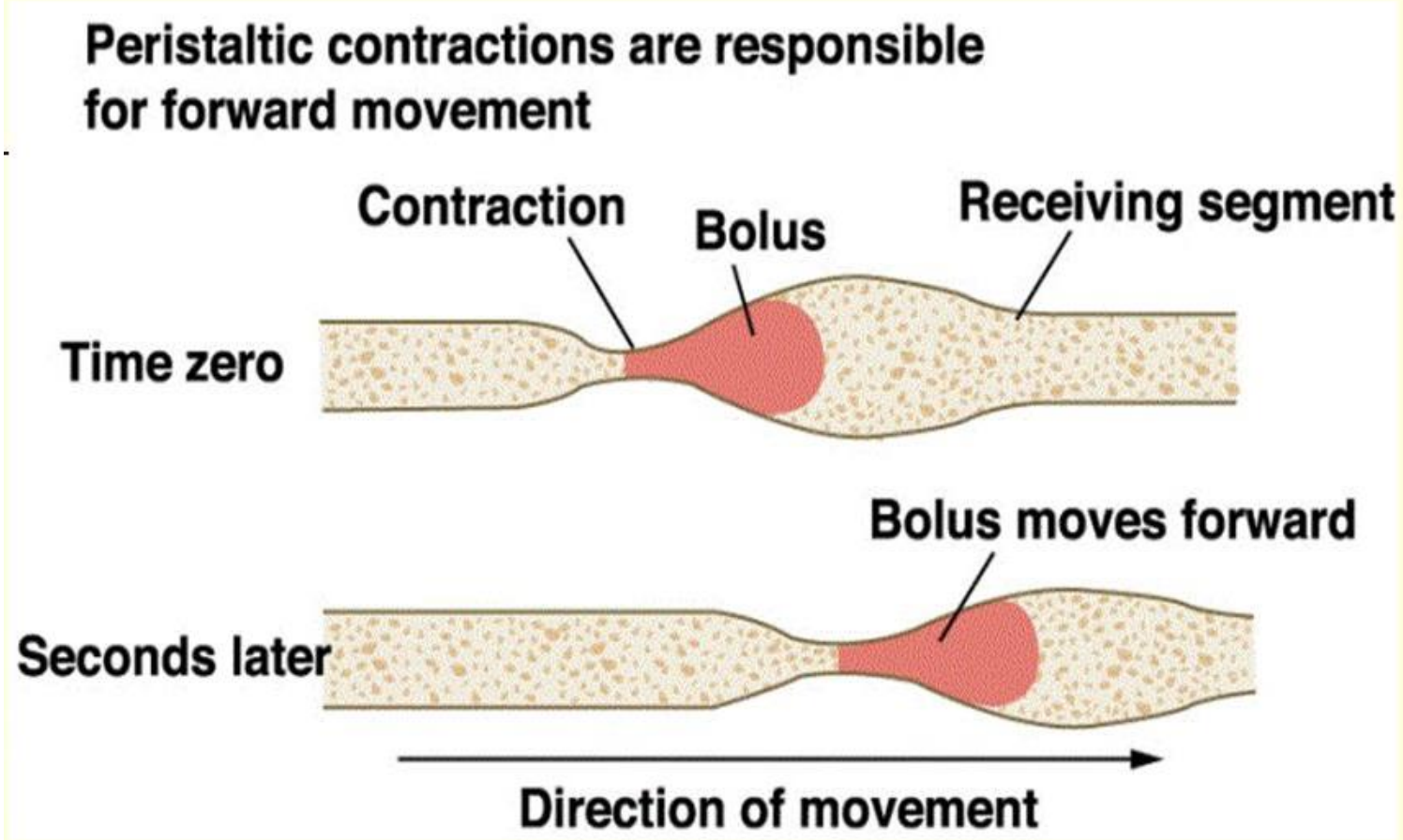


Peristalsis – law of intestine

- Bolus of food →Mechanical distension and mucosal irritation → stimulates afferent enteric neurons → 2 effects

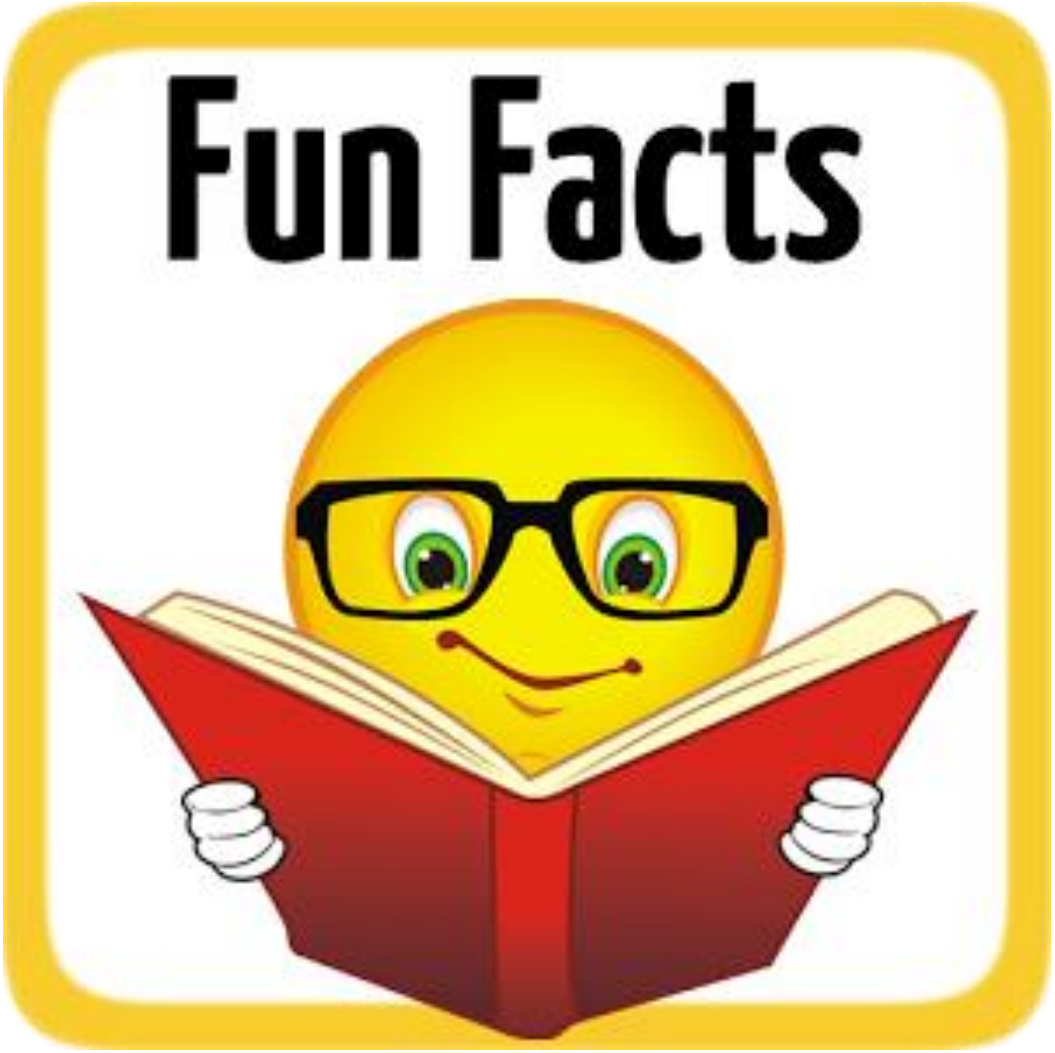
1. Excitatory motor neurons above the bolus activated → **contraction of smooth muscle above the bolus**
   - Via Ach, substance P
2. Inhibitory motor neurons → **stimulate relaxation of smooth muscle below the bolus**
   - Via nitric oxide, vasoactive intestinal peptide and ATP


Longitudinal muscle
Circular muscle
Contraction
STEP 1:
Contraction of circular muscles behind food mass
From mouth
To anus
STEP 2:
Contraction of longitudinal muscles ahead of food mass
Contraction
Contraction
STEP 3:
Contraction of circular muscle layer forces food mass forward

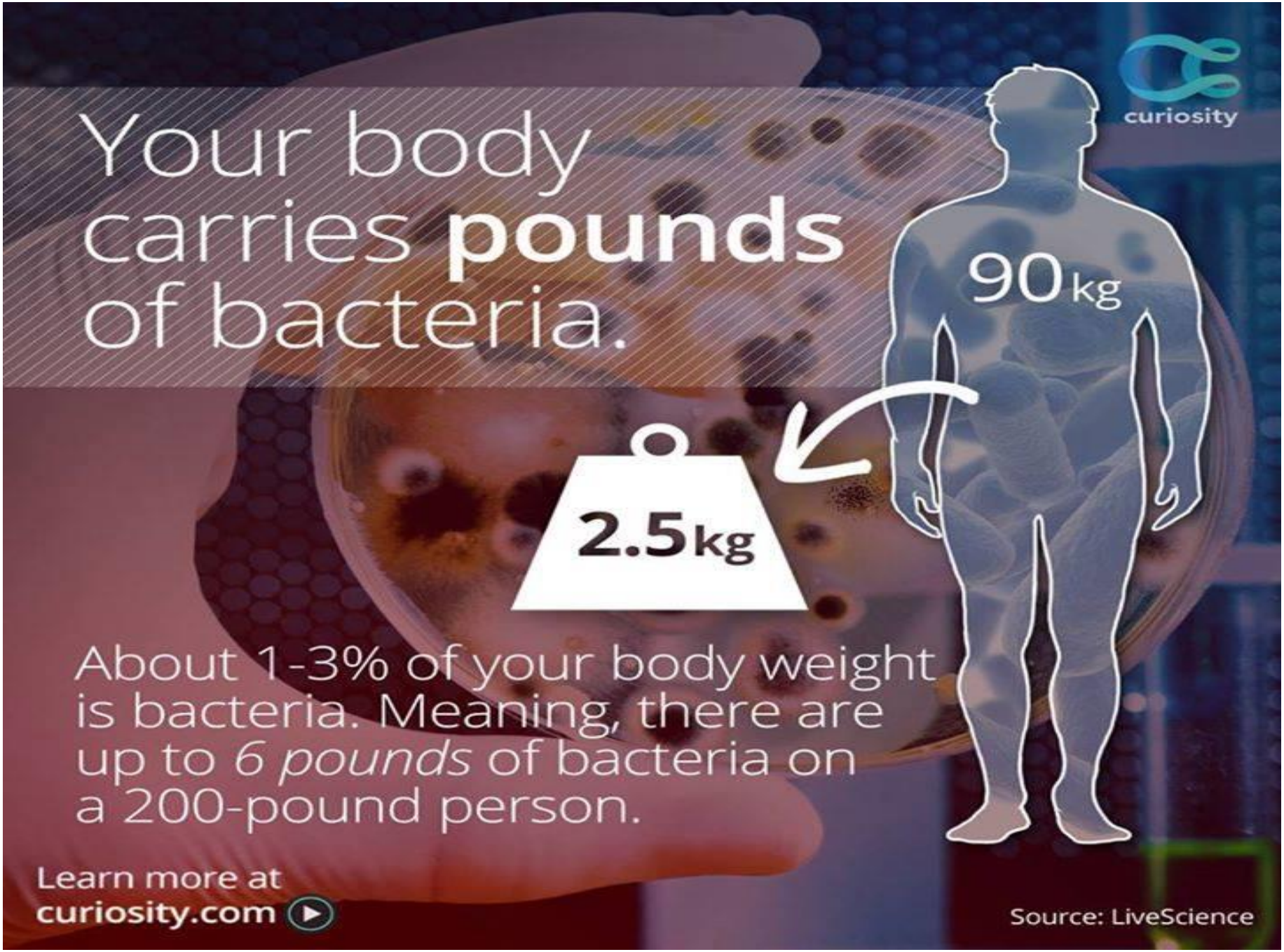

Peristaltic contractions are responsible for forward movement
Contraction
Bolus
Receiving segment
Time zero
Bolus moves forward
Seconds later
Direction of movement

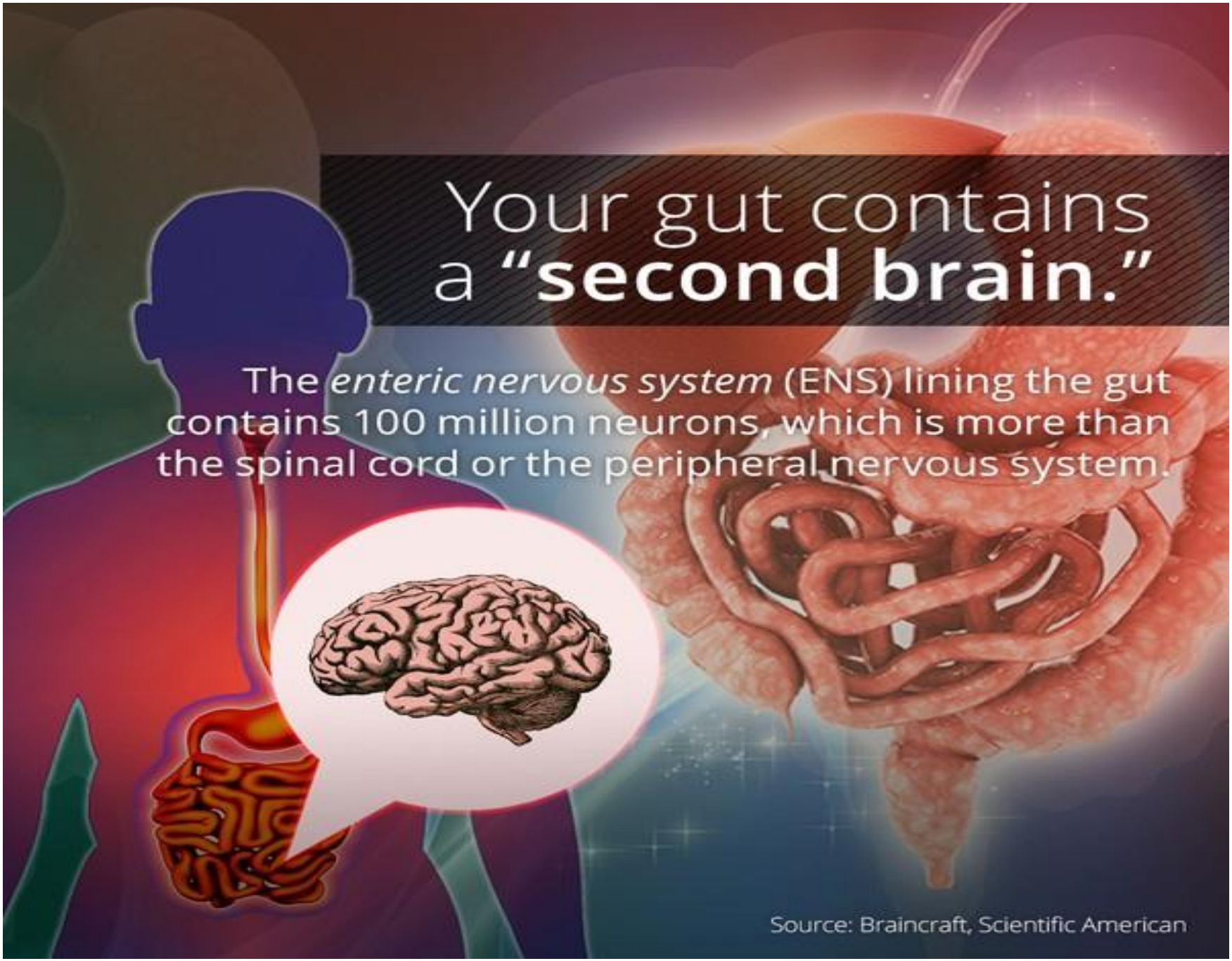
Recap…

- What is the GIT?
- What are the accessory organs?
- How many layers of the GIT?
- How the surface area of the GIT has been increased for digestion n absorbtion ?
- What are the functions of the GIT?
- How the GIT is regulated?


Fun Facts


DID YOU KNOW?
The average person eats about 60,000 pounds of food in their lifetime. That's 6 elephants, if you were wondering!
La Superior


curiosity
Your body carries pounds of bacteria.
90kg
2.5kg
About 1-3% of your body weight is bacteria. Meaning, there are up to *6 pounds* of bacteria on a 200-pound person.
Learn more at curiosity.com
Source: LiveScience


Your gut contains a "second brain."
The *enteric nervous system* (ENS) lining the gut contains 100 million neurons, which is more than the spinal cord or the peripheral nervous system.
Source: Braincraft, Scientific American


TAKE
A BREAK