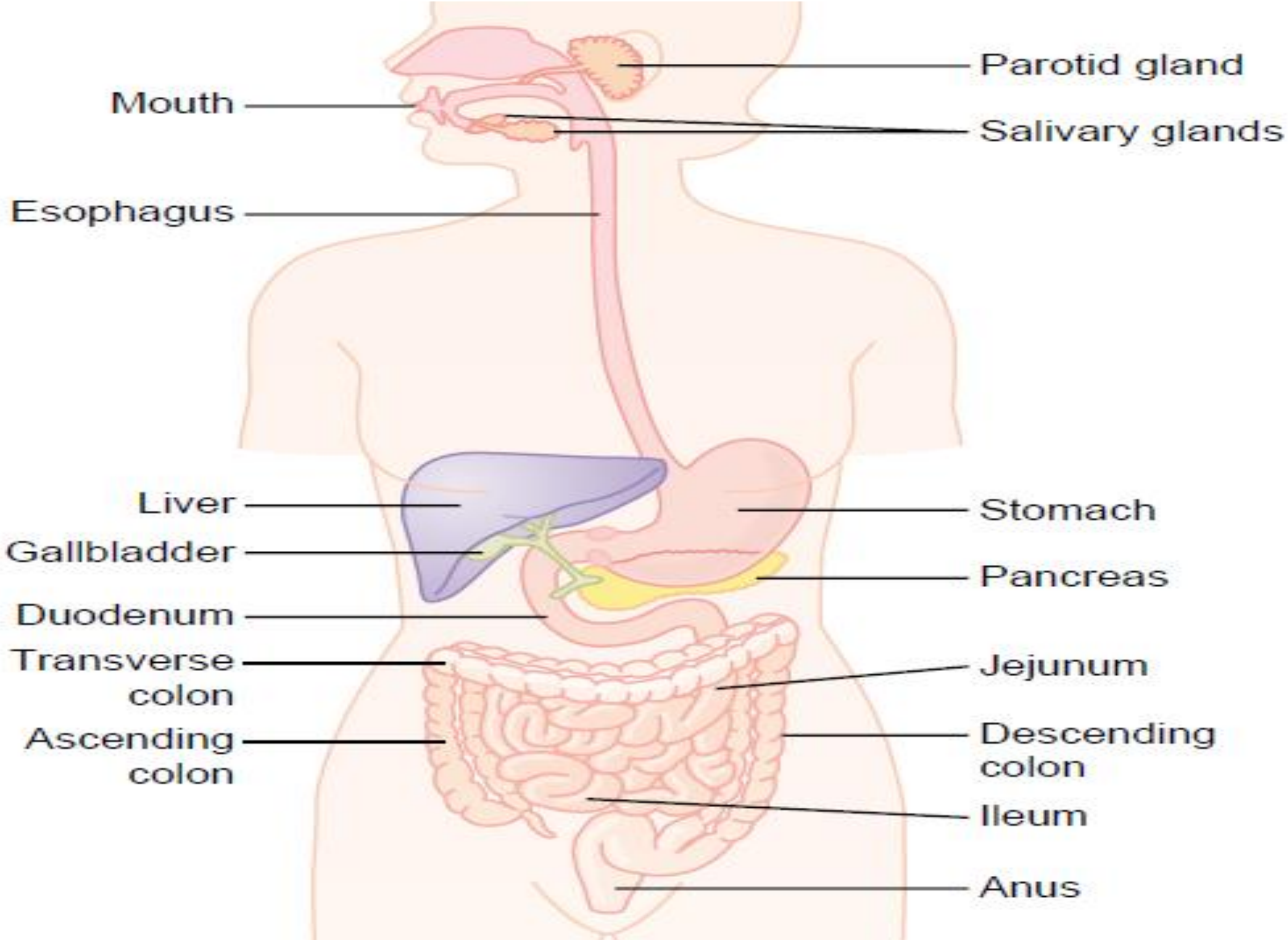
Learning objectives

GASTROINTESTINAL TRACTS

- Introduction of GIT
- Neural innervation of GIT
- Salivary glands-secretion,regulation &function
- Gastric secretion and applied
- Pancreatic secretion-composition,function
- & its applied
- Liver,Gallbladder &its applied
- Carbohydrates & its applied
- Protein & its applied
- Fats & its applied
- Large intestine & its applied
- GI motility I
- GI motility II

Gastrointestinal physiology



INTRODUCTION:-

- gastrointestinal (GI) tract, also known as the alimentary canal, commences at the buccal cavity of the mouth and terminates at the anus.

- It can be divided into an

upper GI tract

- mouth,
- pharynx,
- esophagus
- stomach

lower GI tract

- small instines
- large intestines

General Principles

The **alimentary tract** provides the body with a **continual supply** of water, electrolytes, and nutrients

Functions of alimentary tract:

(1) **movement of food** through the alimentary tract;

(2) secretion of digestive juices and **digestion** of the food;

(3) **absorption** of water, various electrolytes, and digestive products;

(4) **circulation of blood** through the gastrointestinal organs to carry away the absorbed substances;

(5) **control** of all these functions by local, nervous, and hormonal systems

Physiologic Anatomy

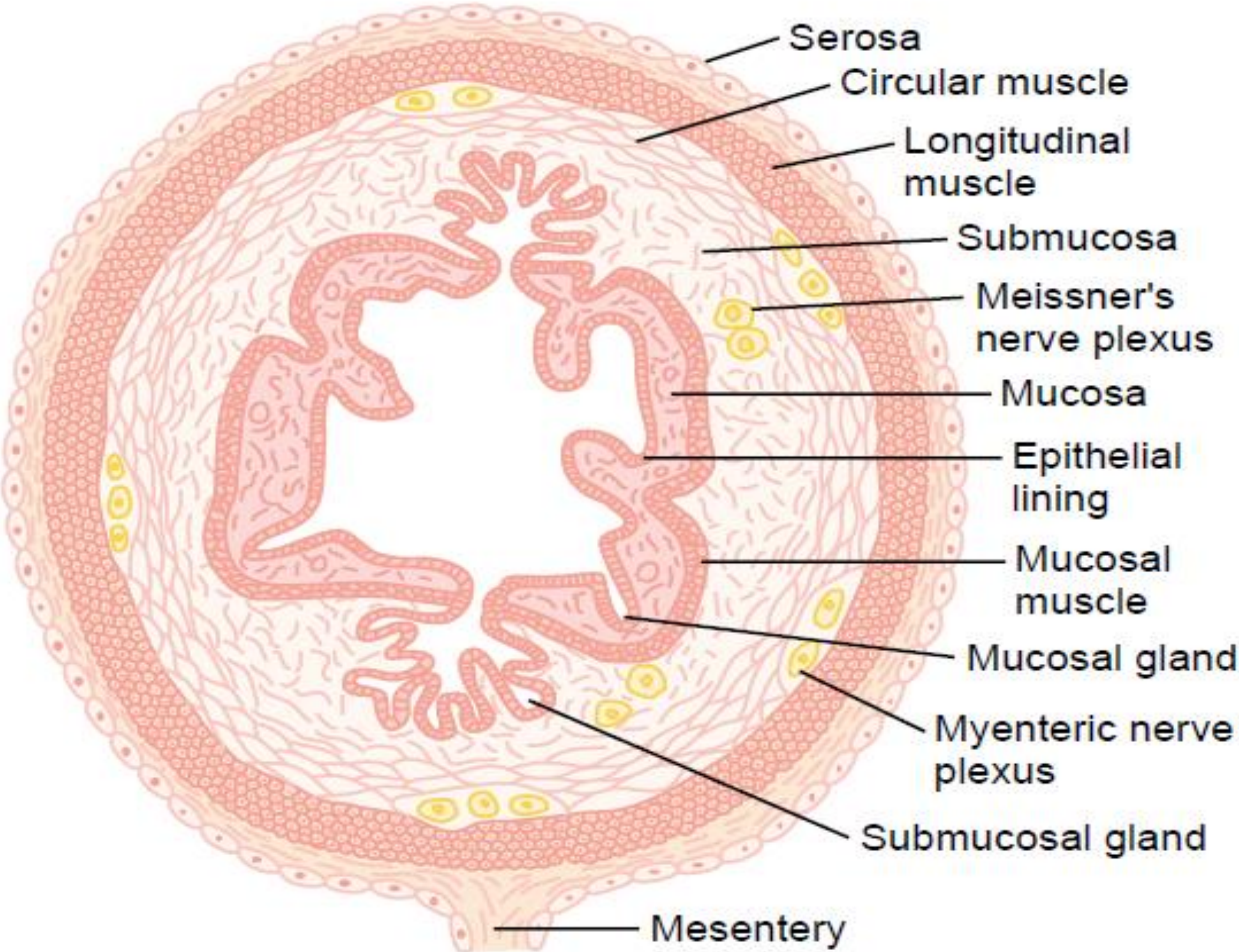
- typical **cross section** of the intestinal wall - layers from outer surface inward:

(1) the **serosa**,
(2) outer longitudinal **muscle** layer,
(3) inner circular **muscle** layer,
(4) the **submucosa**,
(5) the **mucosa**

- The **motor functions of the gut** are performed by the different layers of smooth muscle

- 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.

- each muscle layer functions as a **syncytium**



Serosa
Circular muscle
Longitudinal muscle
Submucosa
Meissner's nerve plexus
Mucosa
Epithelial lining
Mucosal muscle
Mucosal gland
Myenteric nerve plexus
Submucosal gland
Mesentery

Electrical Activity

- an **action potential** is elicited anywhere within the muscle mass, it generally travels in all directions in the muscle

- smooth muscle of the gastrointestinal tract is excited by almost **continual slow, intrinsic electrical activity**

  (1) slow waves and

  (2) spikes

- Most gastrointestinal contractions occur **rhythmically**, and this rhythm is determined mainly by the frequency of so called "slow waves" of smooth muscle membrane potential - ***not action potentials***

- **slow, rising and falling changes in the RMP** - *intensity* usually varies between ***5 and 15 millivolts***

Electrical Activity

- ***frequency ranges*** in different parts of the human GIT from 3 to 12 per minute

- the **rhythm of contraction** of the
- **body of the stomach** usually is about 3 per minute,
- of **the duodenum** about 12 per minute,
- of **the ileum** about 8 to 9 per minute

- ***interstitial cells of Cajal*** **-** electrical pacemakers for smooth muscle cells

- These cells form a network with each other and are interposed between the smooth muscle layers, with **synaptic like contacts to smooth muscle cells**.

Electrical Activity

- The interstitial cells of Cajal undergo **cyclic changes in membrane potential due to unique ion channels that periodically open** and produce inward (pacemaker) currents that may generate slow wave activity

- The slow waves usually do ***not*** by themselves cause muscle contraction in most parts of the gastrointestinal tract, **except in the stomach**.

- Instead, they mainly **excite the appearance of intermittent *spike potentials***, and the spike potentials in turn actually excite the muscle contraction.

Spike Potentials

- ***true*** action potentials

- They occur automatically when the RMP of the GIT smooth muscle becomes **more positive than about -40 millivolts**

- the normal RMP in the smooth muscle fibers of the gut is between **-50 and -60 millivolts**

- each time the peaks of the **slow waves** temporarily become more positive than -40 millivolts, **spike potentials** appear on these peaks

- The **higher** the slow wave potential rises, the **greater** the frequency of the spike potentials - ranging between **1 and 10 spikes / second.**

Spike Potentials

- The spike potentials last **10 to 40 times as long** in GIT muscle as that in large nerve fibers, each spike lasting as long as **10 to 20 milliseconds**

- ***Influx*** of large numbers of Ca ions to enter along with smaller numbers of Na ions and therefore are called ***Ca-Na channels***

- ***slower to open and close – remained open for long time***

- **long duration of the action potentials**

- baseline voltage level (about -56 millivolts) of the smooth muscle RMP **can change.**

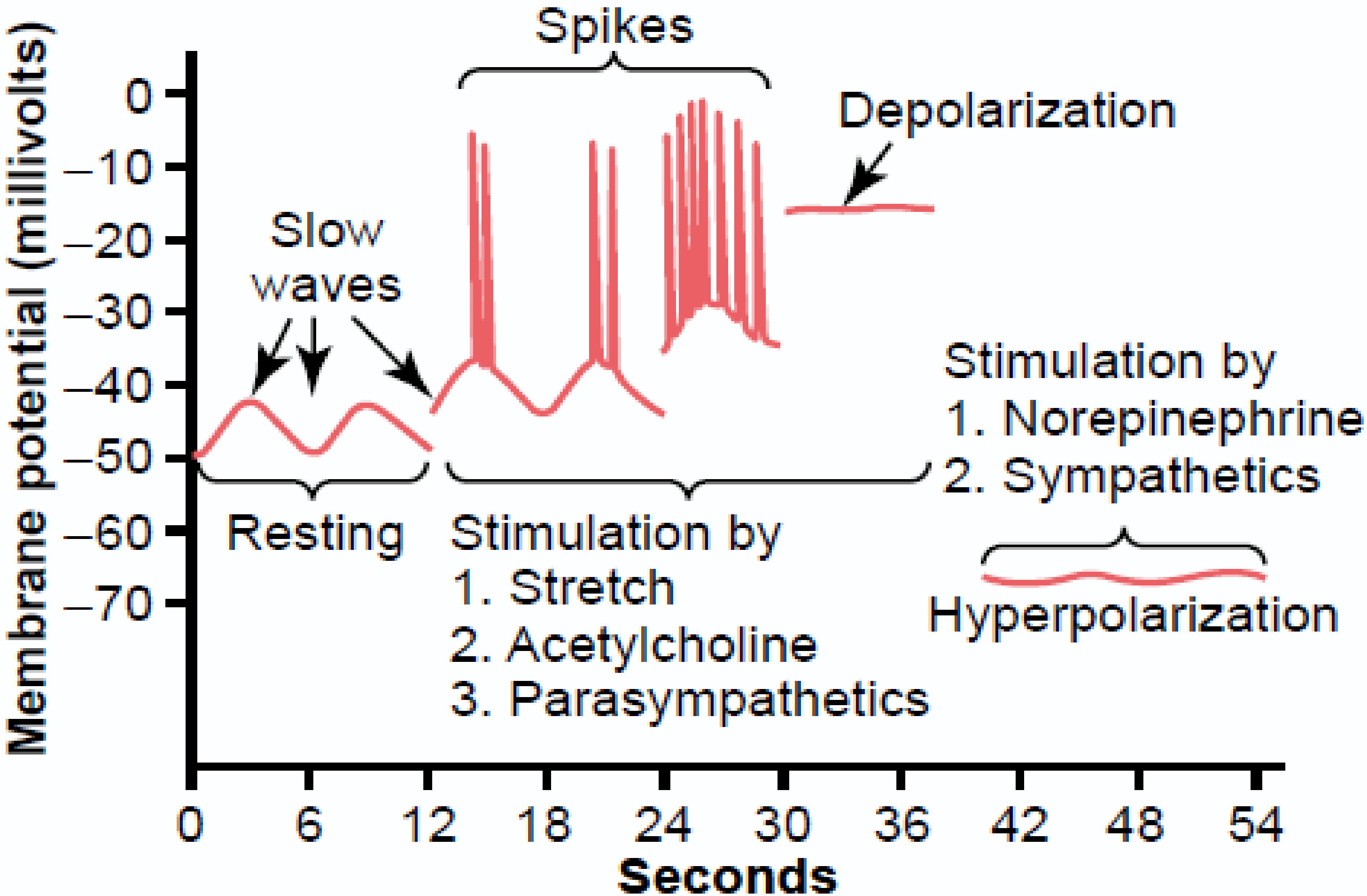
Spike Potentials

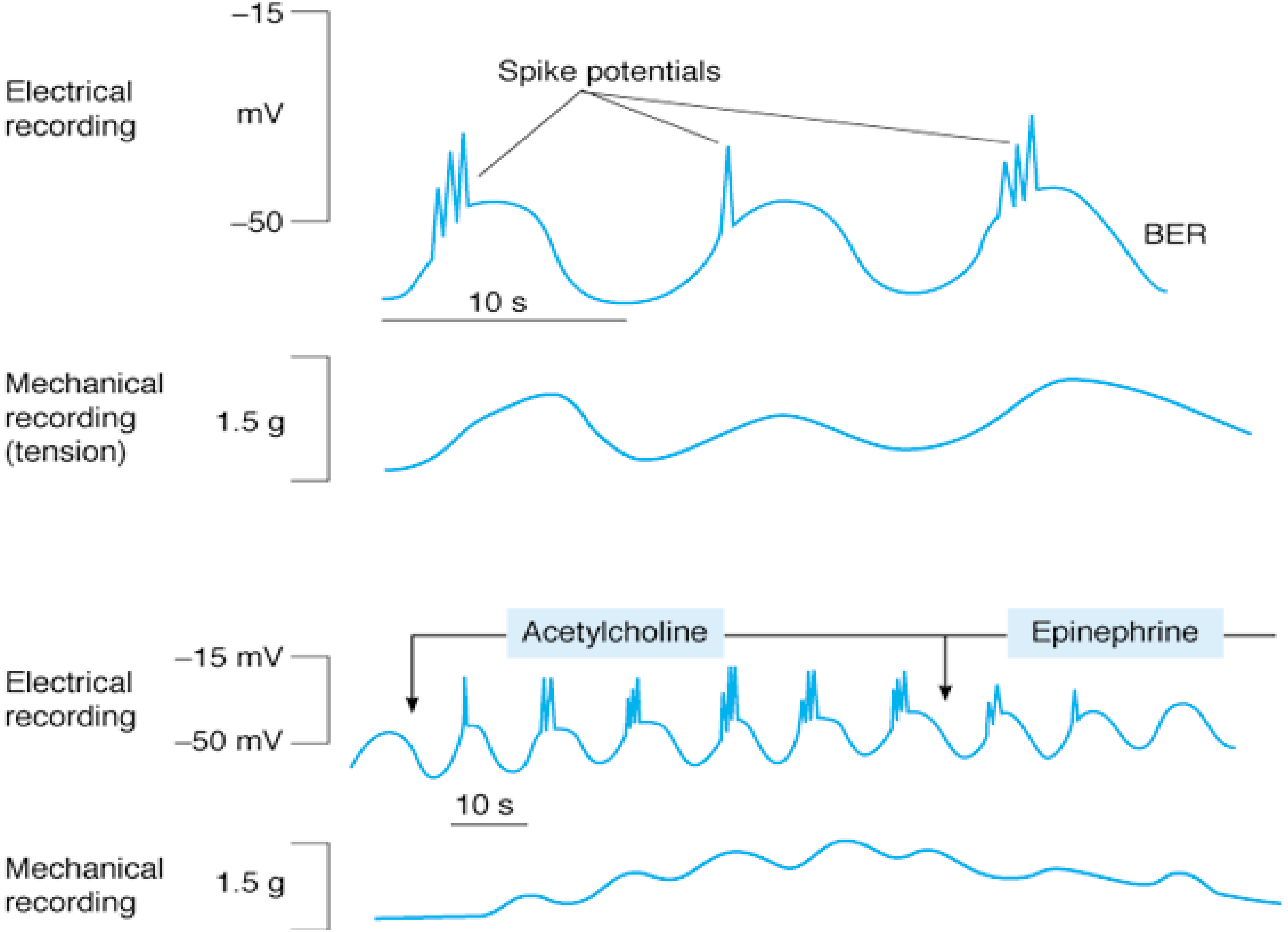
- When the potential becomes **less negative - depolarization** of the membrane, the muscle fibers become **more excitable.**

- When the potential becomes **more negative - hyperpolarization**, the fibers become **less excitable**

- Factors that depolarize the membrane
- (1) **stretching** of the muscle,
- (2) stimulation by **acetylcholine**,
- (3) stimulation by **parasympathetic nerves** that secrete acetylcholine at their endings,
- (4) stimulation by several specific **gastrointestinal hormones**.

- Important 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.


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



Electrical recording
mV
–15
–50
Spike potentials
BER
10 s
Mechanical recording (tension)
1.5 g
Acetylcholine
Epinephrine
Electrical recording
–15 mV
–50 mV
10 s
Mechanical recording
1.5 g

Muscle Contraction

- Ca influx during **spike potential** – Ca **Calmodulin** – MLCK – Contraction

- The **slow waves do not cause** calcium ions to enter the smooth muscle fiber (only sodium ions) - ***no*** muscle contraction

- during the ***spike potentials*** – significant quantities of calcium ions enter the fibers and cause ***most of the contraction***

- ***Tonic contraction*** is continuous - lasting several minutes or even hours - increases or decreases in intensity but continues.

TONIC Contraction

- Continuous repetitive spike potentials—the greater the **frequency**, the greater the **degree of contraction**.

- Hormones or other factors that bring about **continuous partial depolarization** of the smooth muscle membrane **without causing action potentials.**

- **continuous entry of calcium** ions into the interior of the cell

References

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- Medical Physiology, Updated second edition (walter F. Boron, MD, phd)
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- Ganong's Review of Medical Physiology, 26 t h e d i t i o n