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

- Mouth
- Parotid gland
- Salivary glands
- Esophagus
- Liver
- Gallbladder
- Duodenum
- Transverse colon
- Jejunum
- Descending colon
- Ileum
- Ascending colon
- Stomach
- Pancreas
- Anus
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 intestines
  • 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**
- 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
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.
The diagram illustrates the changes in membrane potential (millivolts) over time (seconds) in response to various stimuli.

- **Resting** state is represented by the baseline membrane potential.
- **Spikes** occur with increased depolarization.
- **Slow waves** indicate a gradual change in potential.

Stimulation by:
1. Norepinephrine
2. Sympathetics
3. Stretch
4. Acetylcholine
5. Parasympathetics

The graph shows:
- **Depolarization** up to 30 seconds,
- **Hyperpolarization** after 30 seconds.
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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