

Gastrointestinal Physiology

Prof. N. M. Devanarayana

2018

Objectives

- Describe the
 - electrical properties of intestinal smooth muscle
 - regulation of gastrointestinal motility by
 - myogenic
 - neurologic – ENS, autonomic NS and CNS
 - humoral mechanisms

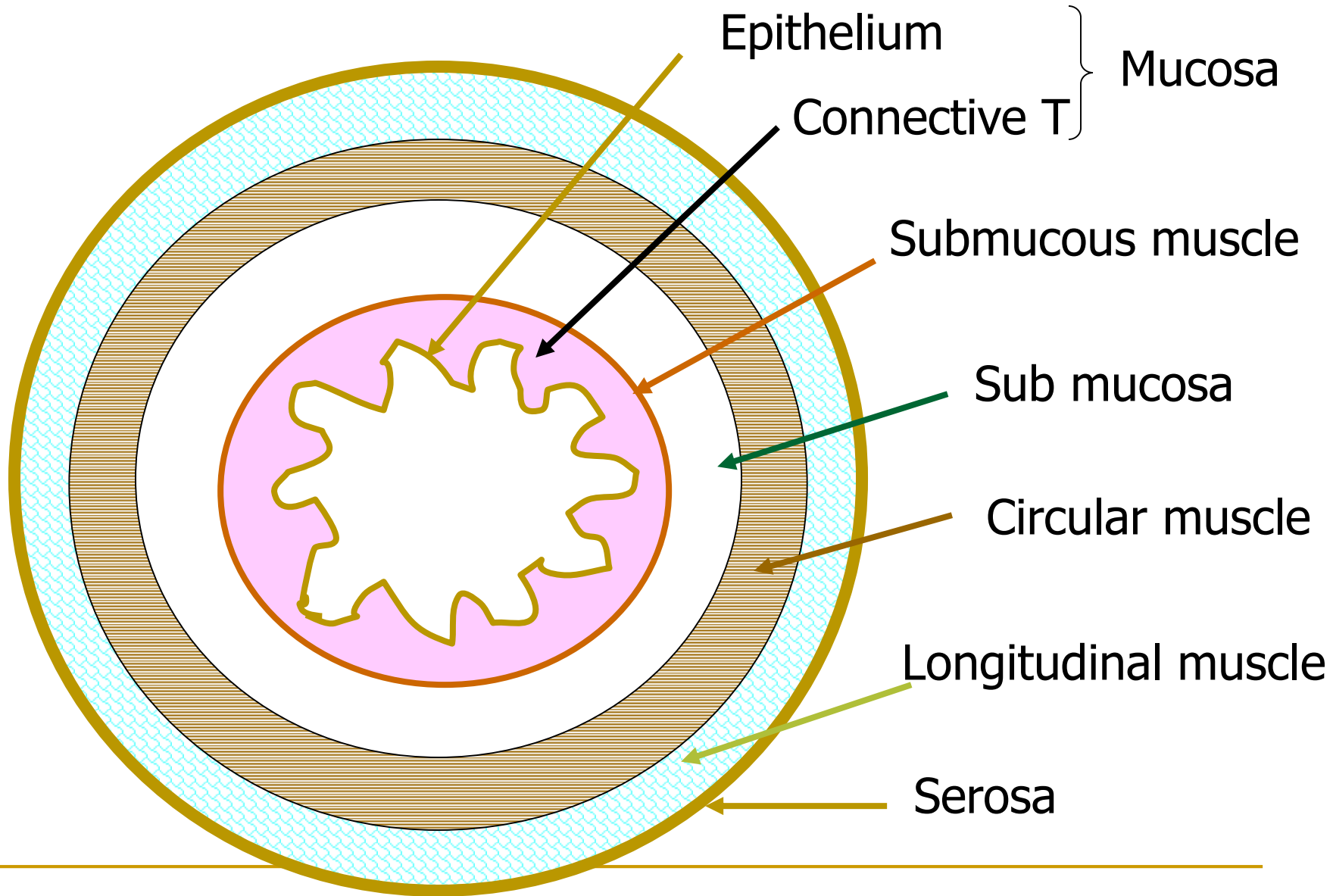
Main functions of GIT

- **Supply the body with water, nutrients & electrolytes**

To achieve this, body requires

1. to move food along the gut
2. to secrete digestive juices and digest food
3. to absorb water, electrolytes and digestive products
4. to circulate the blood and lymph to carry away the absorbed substances
5. a system to control and integrate these functions (neural, hormonal and local)

Basic structure of GIT



Regulation of gastrointestinal motility

Gastrointestinal motility patterns

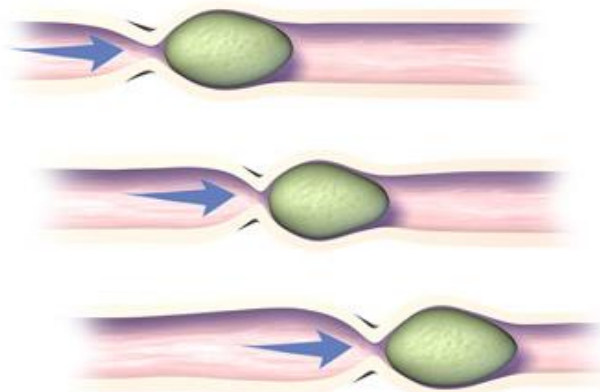
- **Meal/Post prandial period-**

- **peristaltic contractions**- in the oesophagus, stomach & intestines
- **segmental contractions**- seen in the small and large intestines

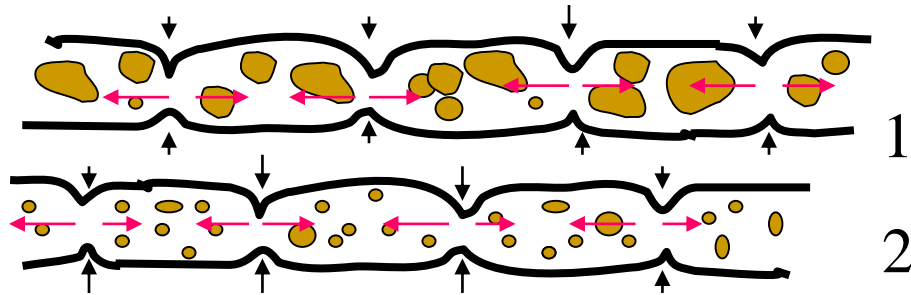
- **Fasting period-**

- **Migrating motor complexes (MMCs)**- seen in the ?lower oesophagus, stomach & intestines

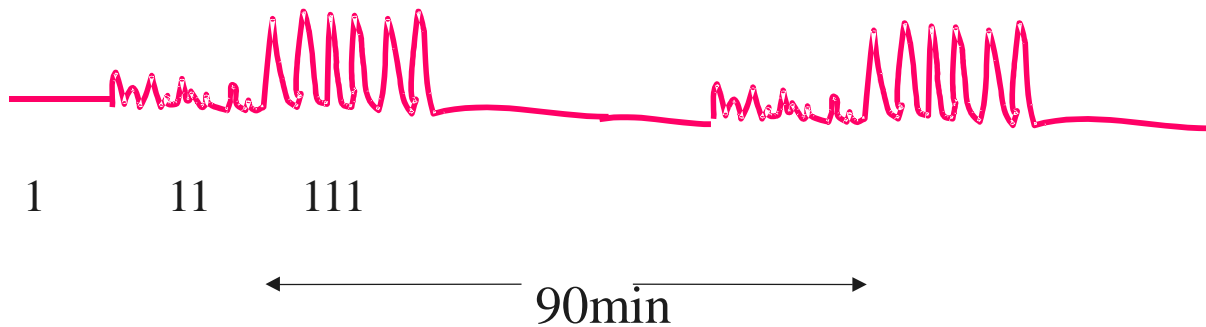
■ Peristalsis-



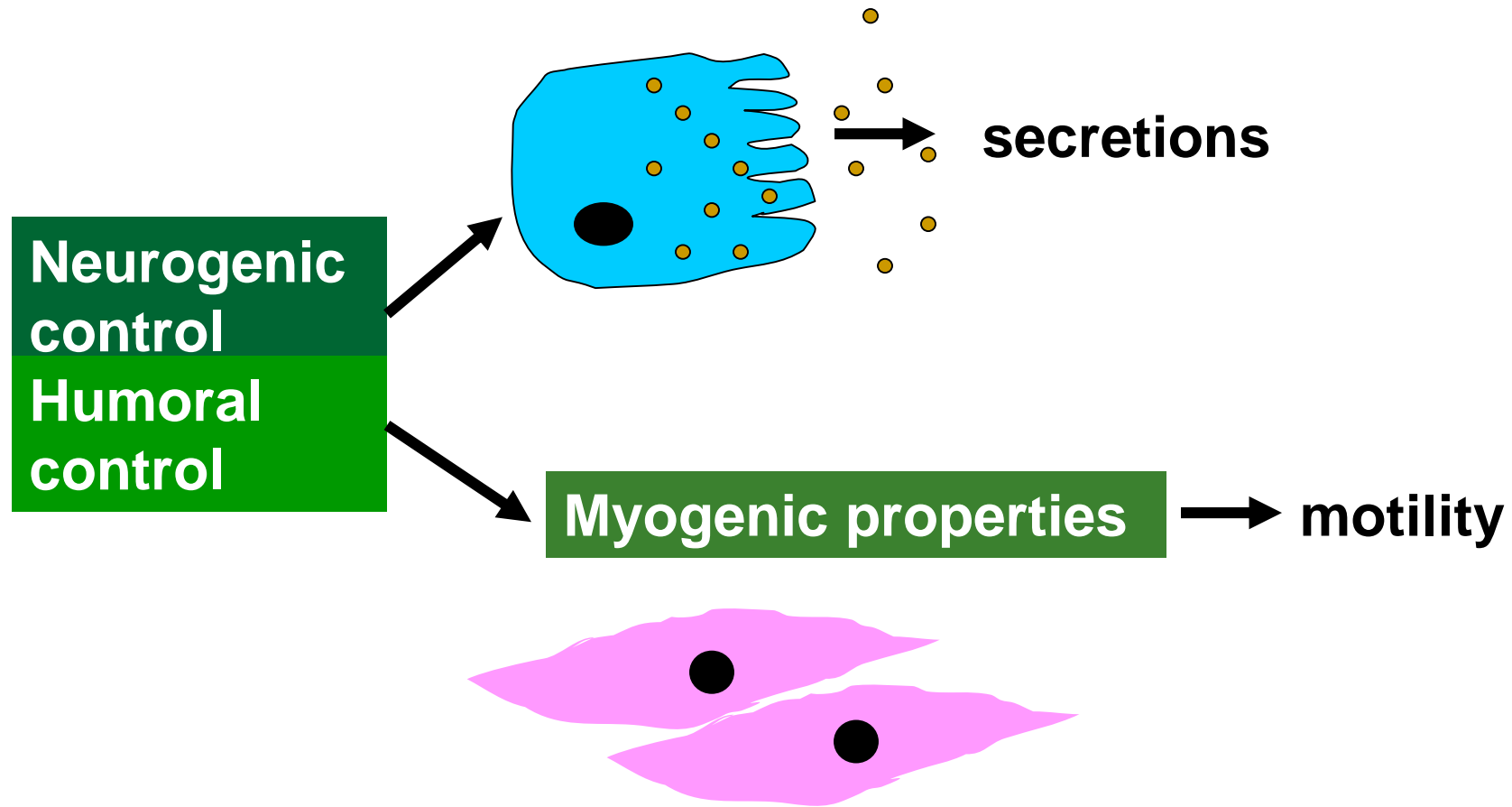
■ Segmentation-



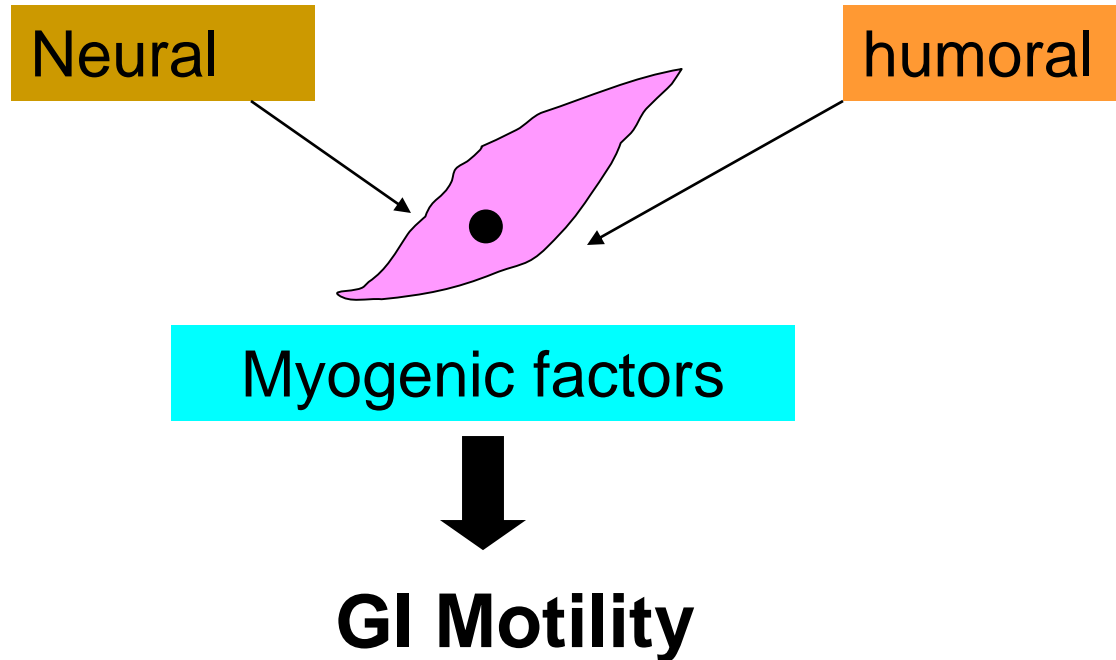
■ MMC-



Regulation of gastrointestinal tract functions



Regulation of gastrointestinal motility



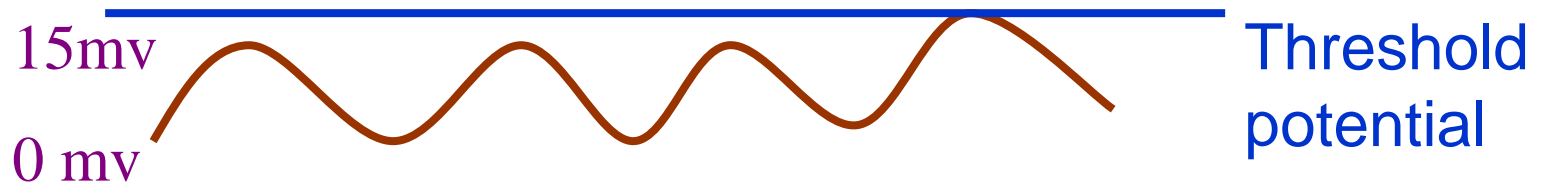
- Neural, humoral and mechanical factors (e.g. stretching) affect the myogenic properties of the smooth muscle cells.

Gastrointestinal smooth muscle

- Visceral smooth muscle
 - Arrange in bundles – in two main layers
 - Longitudinal and circular
 - Layers are separated by loose connective tissue
 - Act as a syncytium –
 - AP spread along the bundles
 - AP can even spread from circular to longitudinal muscle layer
-

Myogenic factors-

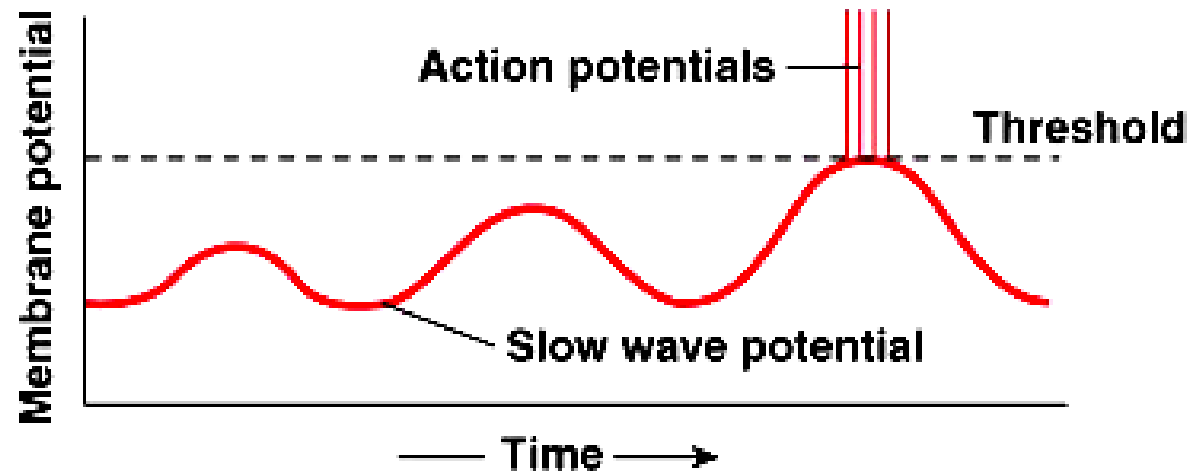
- Smooth muscles of the gastrointestinal tract has spontaneous rhythmic fluctuations in the membrane potential.
- These fluctuations are called **slow waves** or the **basic electrical rhythm(B.E.R)**
- slow waves are generated - by specialized interstitial cells which make gap junctions with adjacent smooth muscle cells



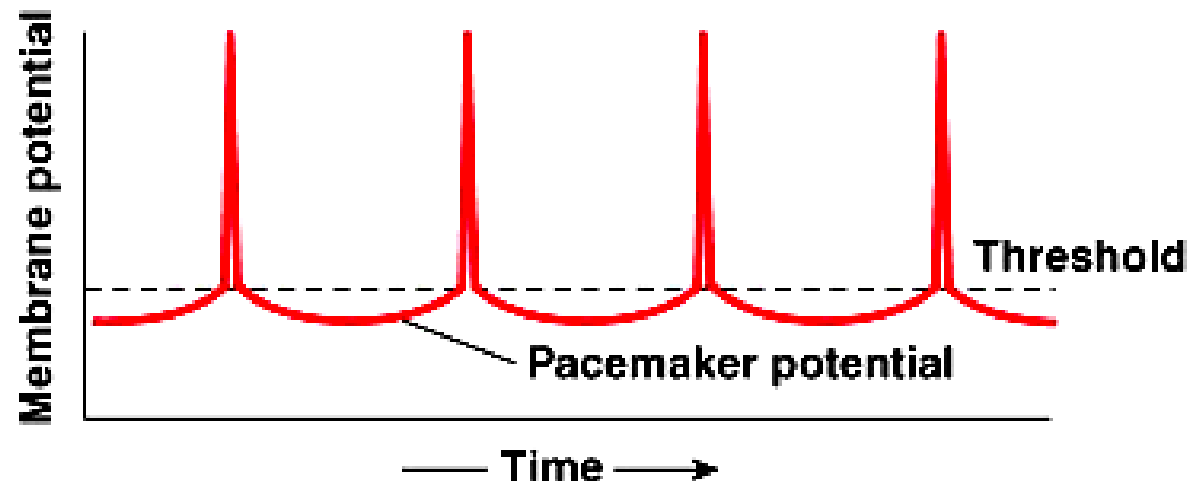
Electrical activity of gastrointestinal smooth muscle

Intrinsic electrical activity originate in the pace maker cells

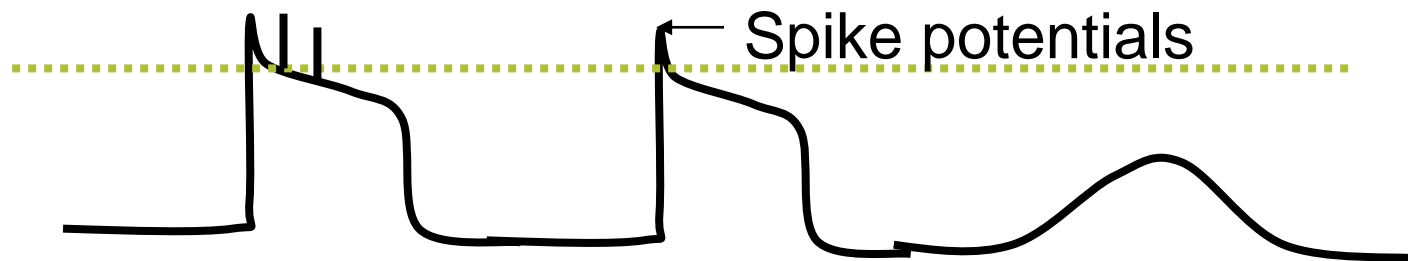
(a) Slow wave potentials fire action potentials when they reach threshold.



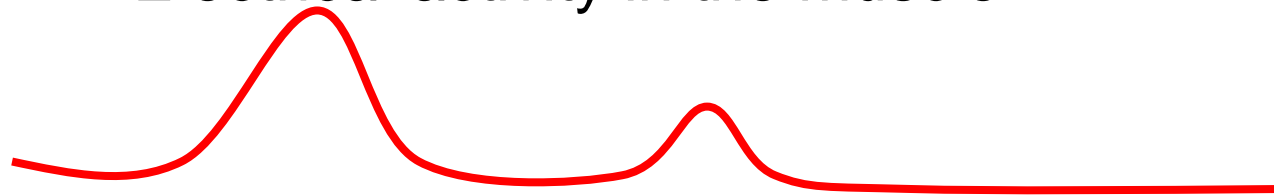
(b) Pacemaker potentials always depolarize to threshold.



- ❑ Frequency of the slow wave (or the BER) - 3 -15cpm in various regions of the GIT
- ❑ slow waves alone - no mechanical activity
- ❑ spikes potentials (action potentials) on top of slow waves- produce muscle contractions.
- ❑ Maximum frequency of muscle contraction = frequency of the slow wave in that region

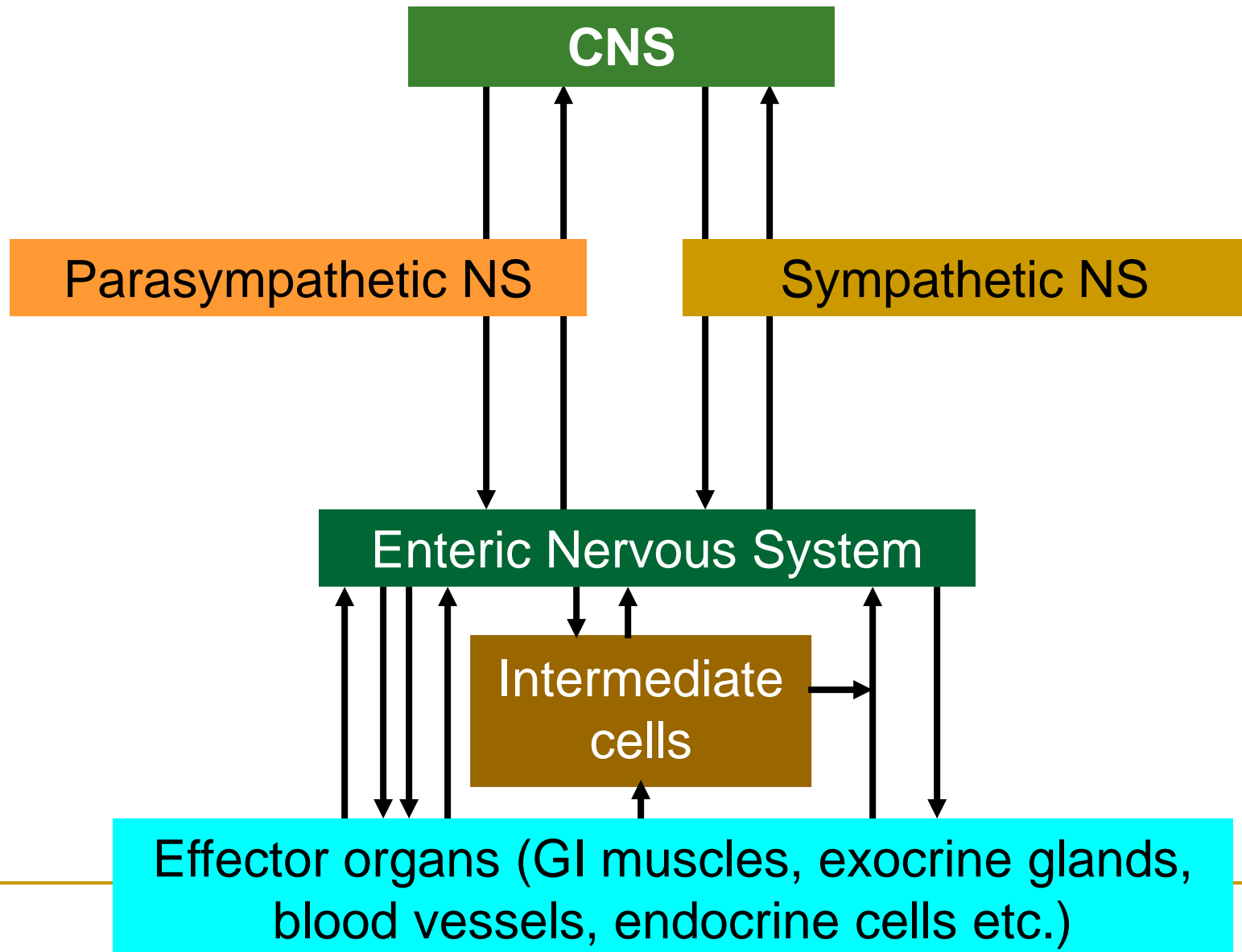


Electrical activity in the muscle



Mechanical activity in the muscle

Neural control of the GIT



Neural regulation of the GI tract

1. Extrinsic innervation

■ Somatic motor nerves-

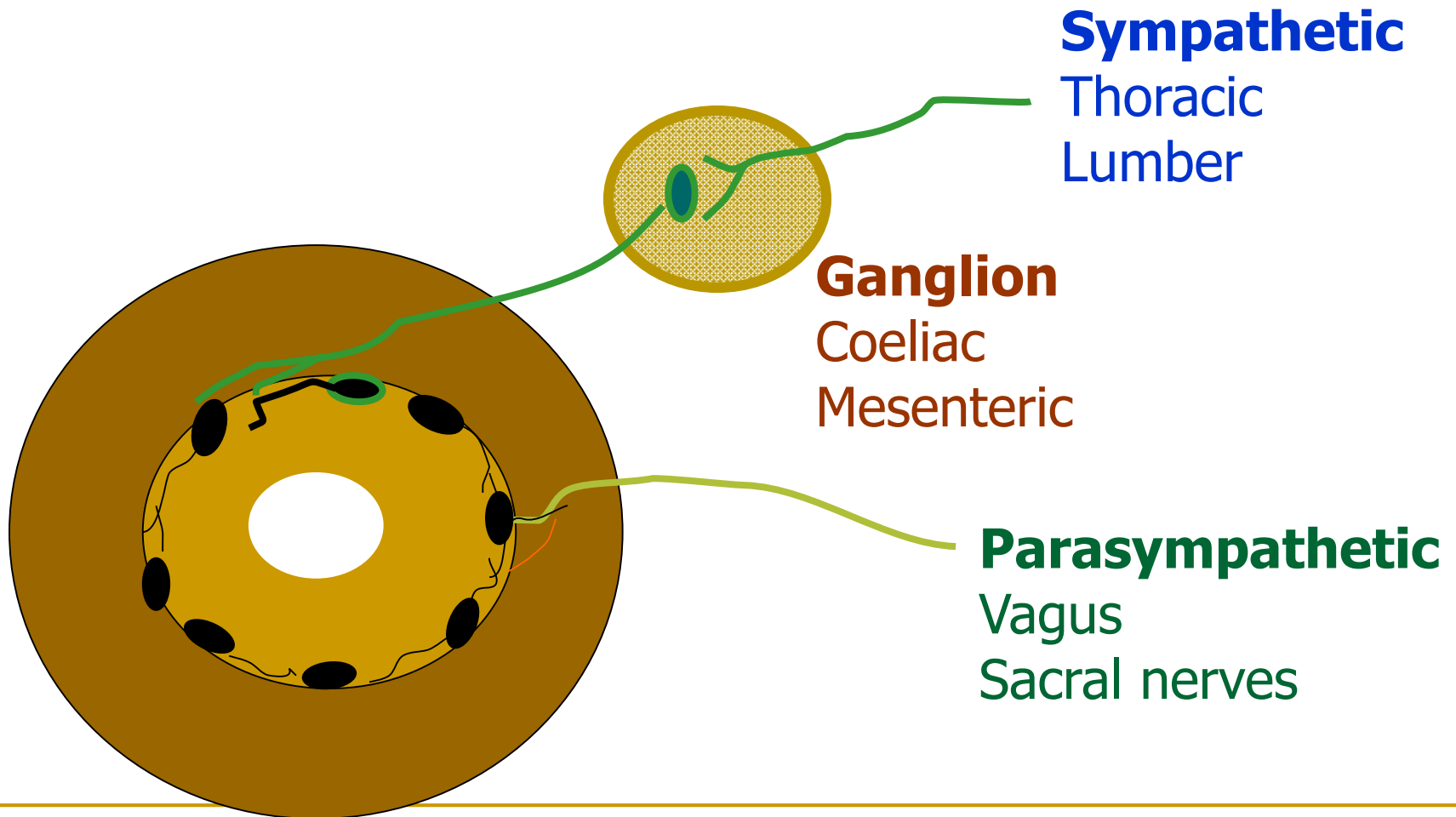
- to striated muscles of the pharynx, upper oesophageal sphincter, proximal oesophagus, external anal sphincter

■ Postganglionic autonomic nerves - Main

- Sympathetic
- Parasympathetic

2. Intrinsic innervation – enteric nervous system

Autonomic nerve supply



Effects of autonomic nervous system

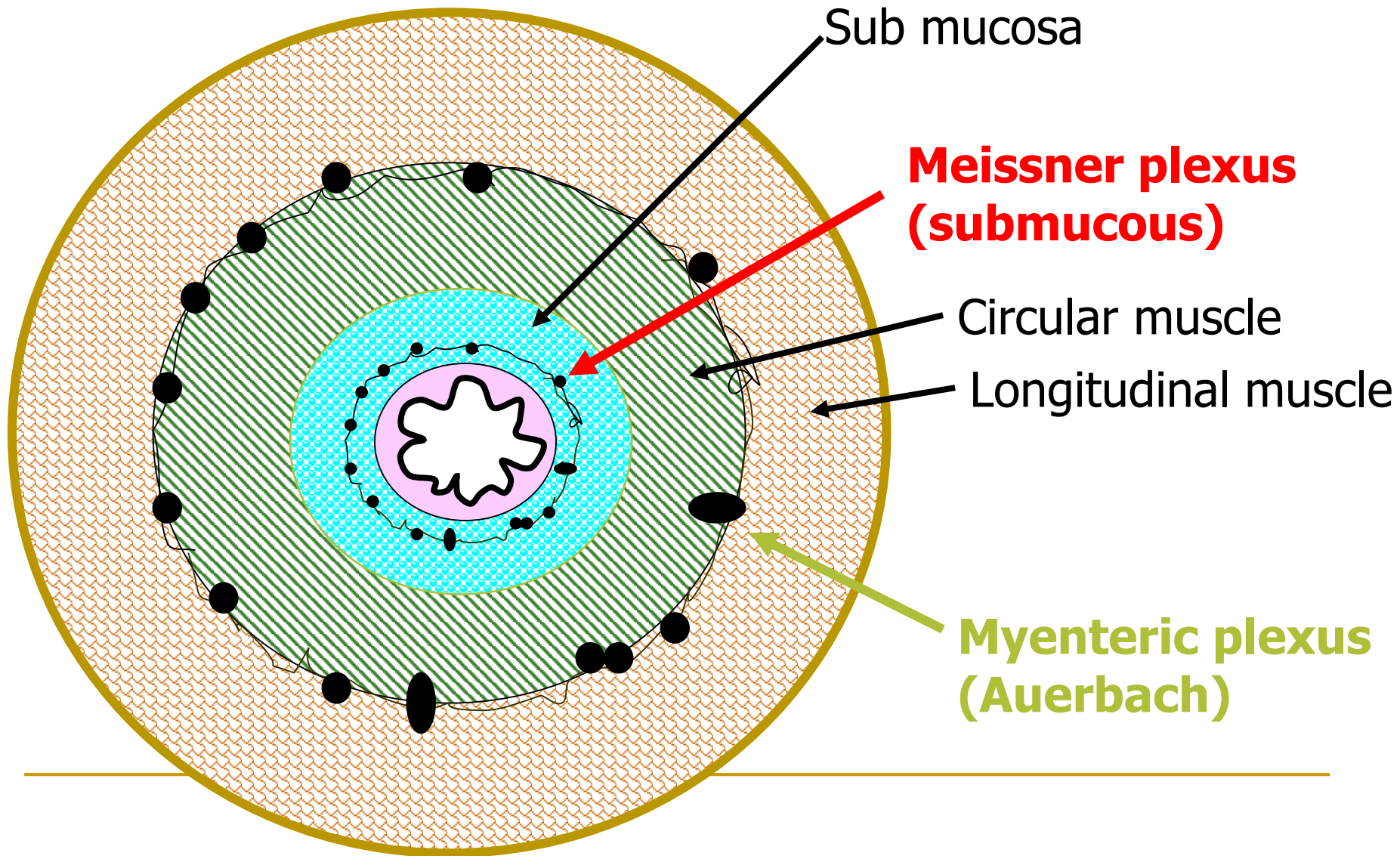
■ Sympathetic

- ❑ Post ganglionic, noradrenergic
- ❑ Decrease activity of smooth muscle
- ❑ Close sphincters
- ❑ Decrease secretion

■ Parasympathetic

- ❑ Pre-ganglionic
 - ❑ Increase activity of intestinal smooth muscle
 - ❑ Open sphincters
 - ❑ Increase secretion
-

The Enteric nervous system



Enteric nervous system

- Two networks of nerve fibers
- Contain sensory neurons, interneurons and motor neurons
- Myenteric plexus –
 - Innervate circular and longitudinal muscle
 - Motor control
- Submucous plexus –
 - Innervate glands, endocrine cells, submucous blood vessels
 - Regulate intestinal secretion
- Neurotransmitters
 - Ach, noradrenaline, serotonin, GABA, purine ATP, NO, CO etc

Humoral control

- The chemical control of the GIT occurs via endogenous substances synthesised in the nerves and endocrine paracrine cells.
- **Endogenous substances-**
 - cholinergics, amines, peptides and fatty acid derivatives
 - Released by chemicals found in food, neural activity or physical distension
- Some are **excitatory** and some have **inhibitory** effects on GI motility and secretions.

Hormonal control of GI functions

Hormone	Location	Stimulus	Action
Gastrin	"G" cells of antrum of stomach	Ingestion of meal (stomach distention, products of protein)	Stimulation of gastric acid secretion and growth of gastric mucosa; promotes stomach emptying
Cholecystokinin	"I" cells in mucosa of duodenum and jejunum	Digestive products of fat, fatty acids, and monoglycerides in intestinal contents	contracts gallbladder, expelling bile to small intestine (Strong); inhibits stomach contractions, slow emptying of food from stomach (moderate); pancreatic enzyme secretion; trophic to exocrine pancreas;

Hormone	Location	Stimulus	Action
Secretin	"S" cells in mucosa of duodenum	Acidic gastric juice emptying into duodenum from pylorus of stomach	Slows motility of GIT (mild); promotes pancreatic and biliary secretion of bicarbonate to neutralize acid; ↓ stomach acid secretion Trophic to exocrine pancreas
Gastric inhibitory peptide (GIP) [glucose-dependent insulinotropic peptide]	Mucosa of upper small intestine (K cells)	Fatty acids and amino acids, carbohydrate (less)	↓ stomach motor activity (mild), slowing gastric emptying when upper small intestines overloaded); ↓ gastric acid secretion; stimulates secretion of insulin by pancreas
Motilin	Upper duodenum	during fasting; inhibited by food ingestion	↑ GI motility; Regulate MMC

-
- Vasoactive intestinal polypeptide (VIP)
 - Causes relaxation of the lower oesophageal sphincter, proximal stomach and gallbladder
-