



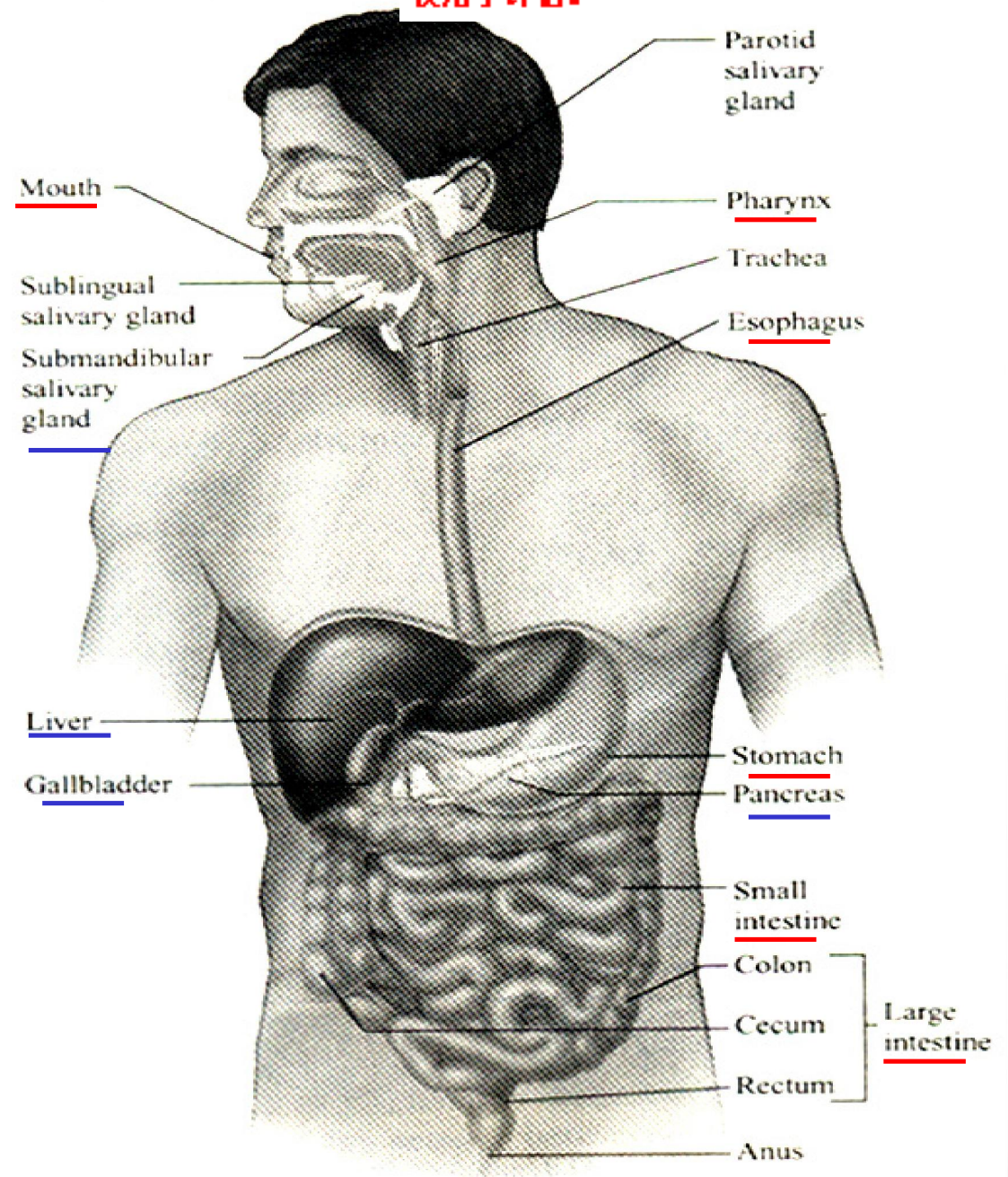
Chapter 6

Function of Gastrointestinal System: Digestion and Absorption

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Gastrointestinal system

- GI tract (gut)
- Accessory organs

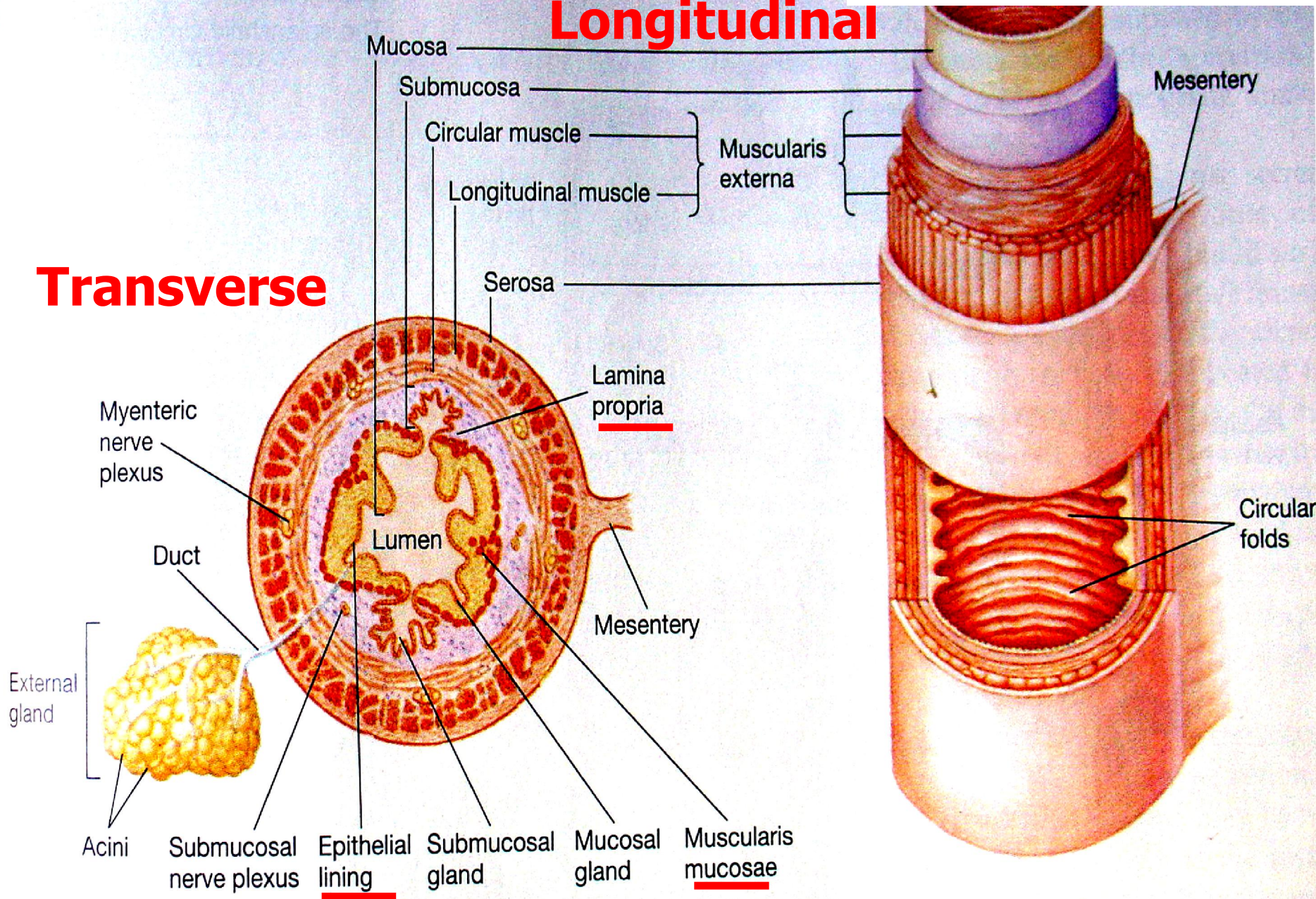


Histological structure of Gut

- **Mucosa** {
 - epithelium**
 - lamina propria**
 - muscularis mucosa**
- **Submucosa**
- **Muscularis externa**
 - circular muscle, longitudinal muscle**
- **Serosa**

Longitudinal

Transverse





Digestion

The macromolecules are dissolved and broken down into small molecules.

- Chemical digestion by digestive enzymes

Starch → maltose

fat → monoglyceride + fatty acid

Protein → amino acid

- Mechanical digestion by gut motility
(mix, propel)



Absorption

The small molecules (digested products, water, minerals, vitamins) move from the gut lumen across the intestinal epithelium, then enter the **blood or **lymph****



Section 1

Overview of the GI System

- Gut smooth muscle
- Nerve innervation
- Gut hormones



1. Gut Smooth Muscle

- **Except for mouth, pharynx, proximal esophagus and external anal sphincter (skeletal muscles), the musculature of the GI tract is smooth muscle**

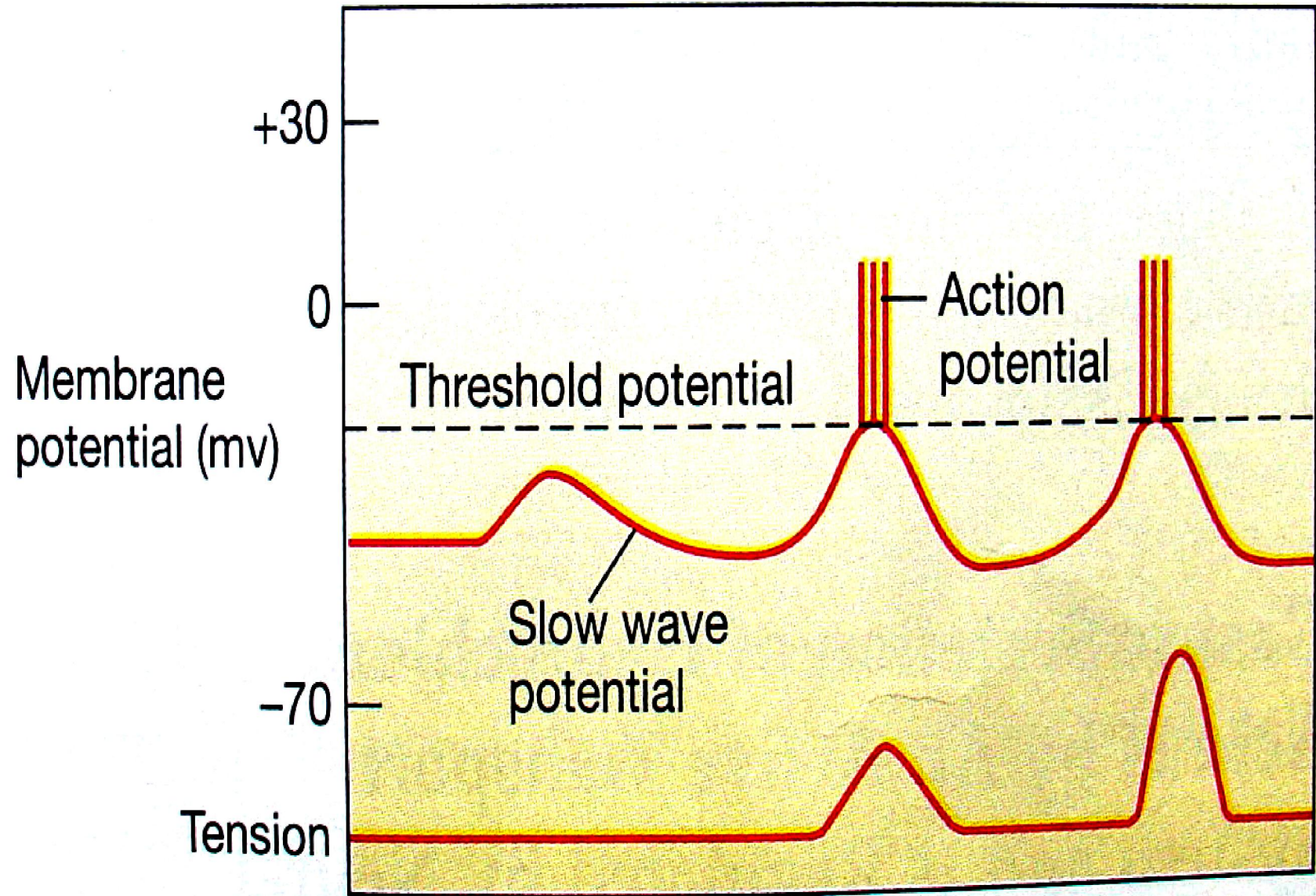
General characteristics of gut smooth muscle

- **Low excitability**
- **Slow contraction**
- **Bigger extensibility (50mL \longrightarrow 1.5L)**
- **Autorhythmicity**
- **Tonic contraction**
(a weak and continual contraction)
- **Sensitive to stretch & chemical stimuli**
but not to electrical stimulus

Electrical activity of smooth muscle

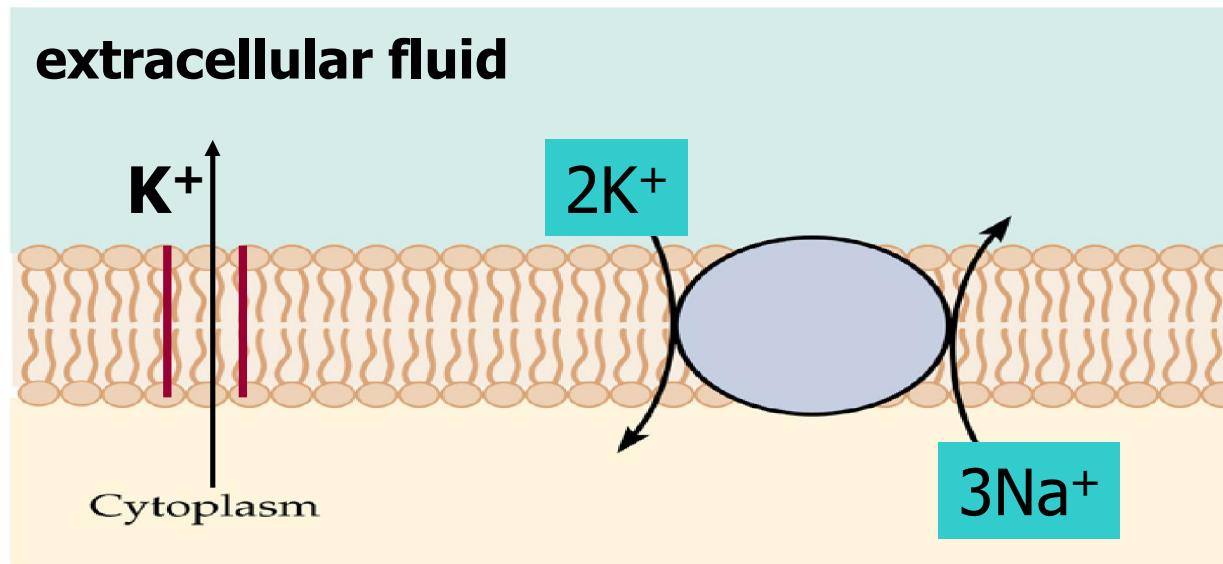


- **Resting potential**
- **Slow wave potential**
(Basic electrical rhythm, BER)
- **Action potential**



(1) Resting potential

- -50 mV ~ -60 mV
- Induced by **K⁺** (kalium ion) **outflow** and **sodium pump activity**

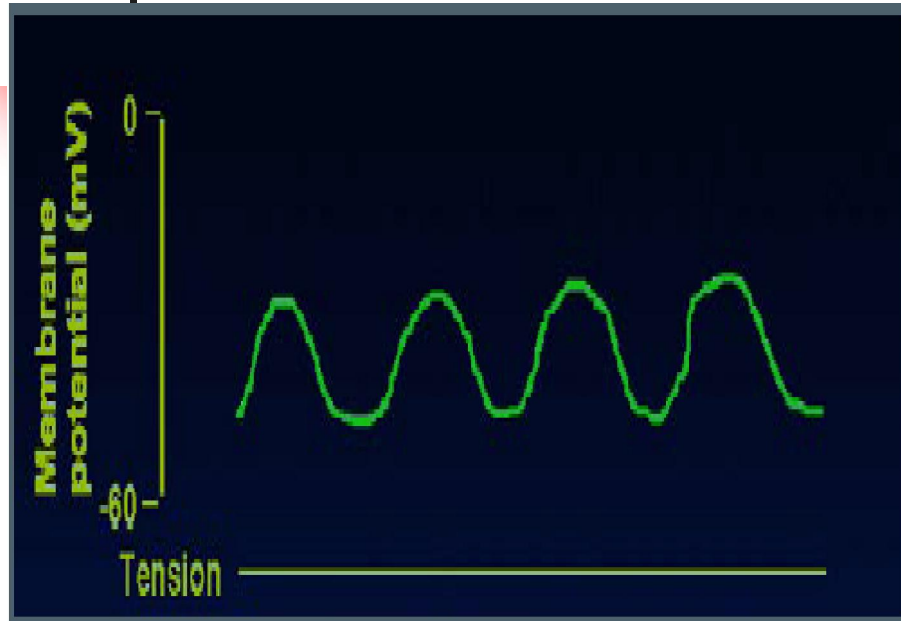




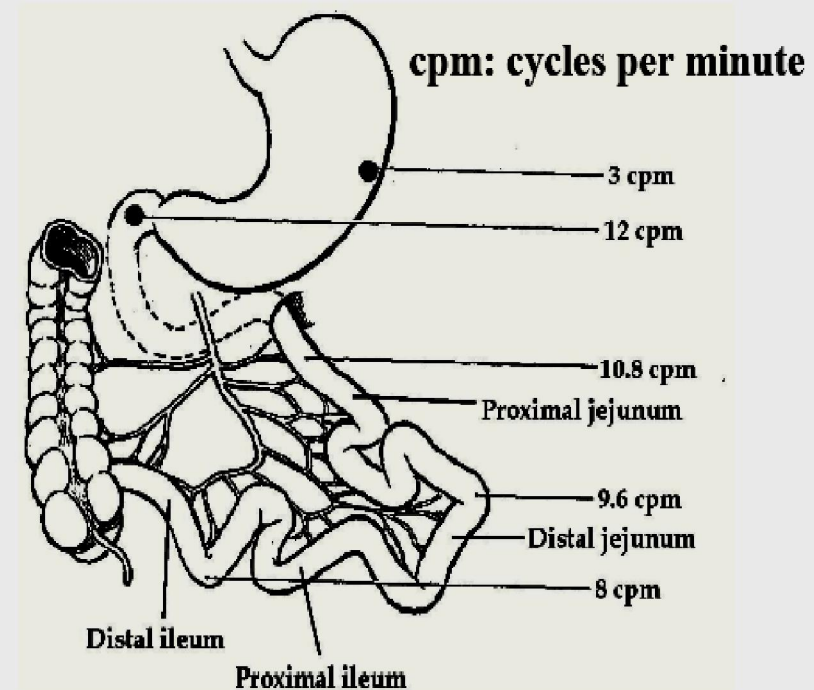
(2) Slow wave potential or Basic electrical rhythm

**A kind of spontaneous, slow and recurring
depolarization wave based on resting
membrane potential
(too small to cause any contractions)**

2. Slow wave /BER

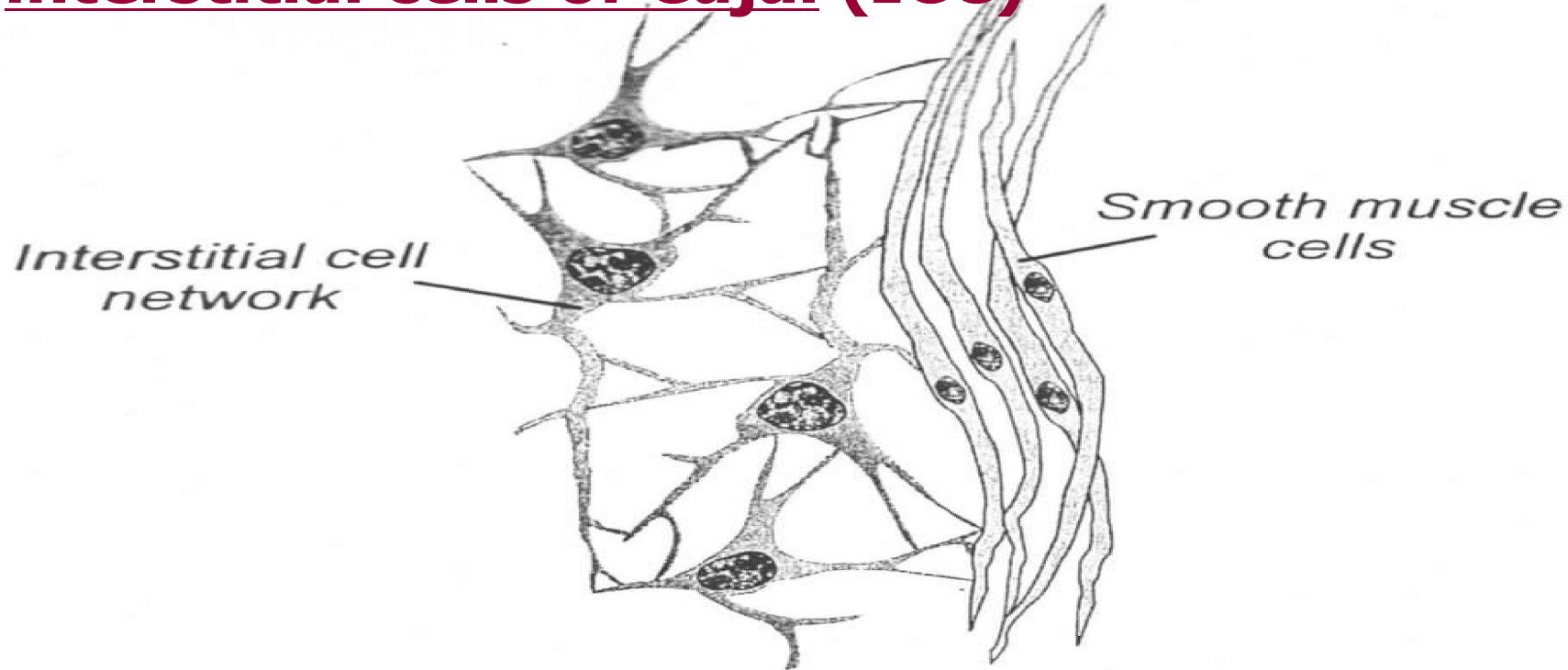


• Frequency:

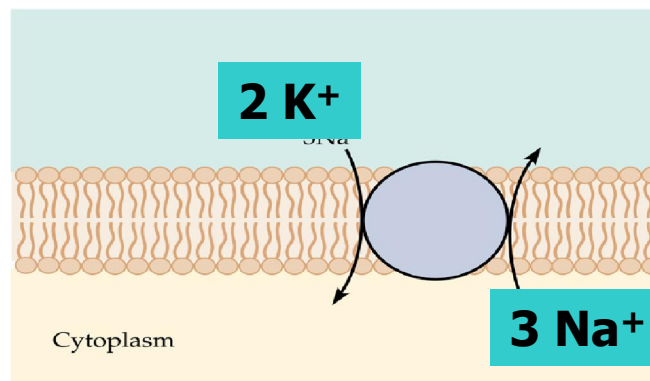


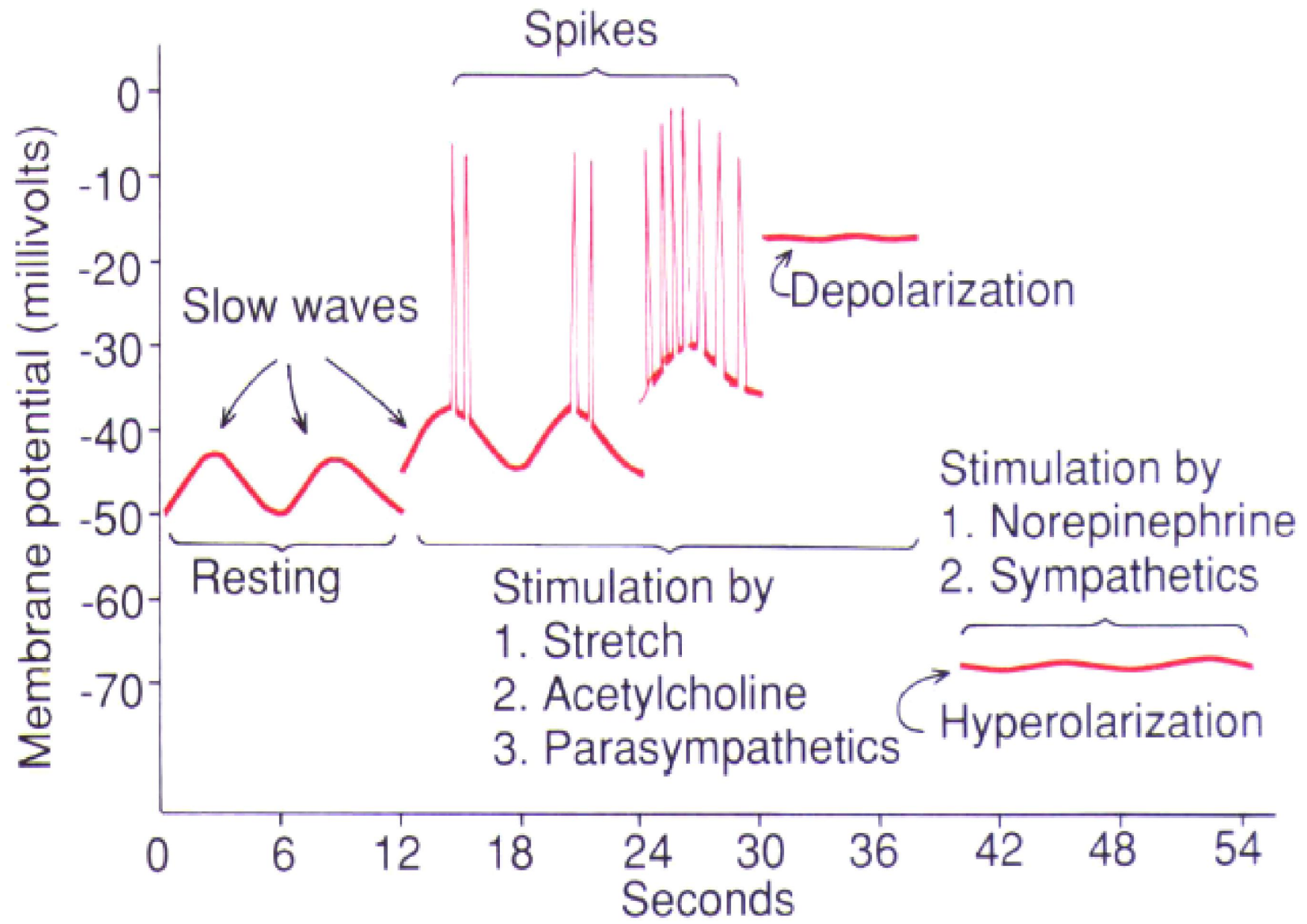
- Spontaneous, rhythmic, subthreshold depolarizations of the cell membrane of GI tract
- Intensity: 5~15mV.
- Frequency: 3~12 cpm
- Initiated in the interstitial cells of Cajal (ICC)

interstitial cells of Cajal (ICC)

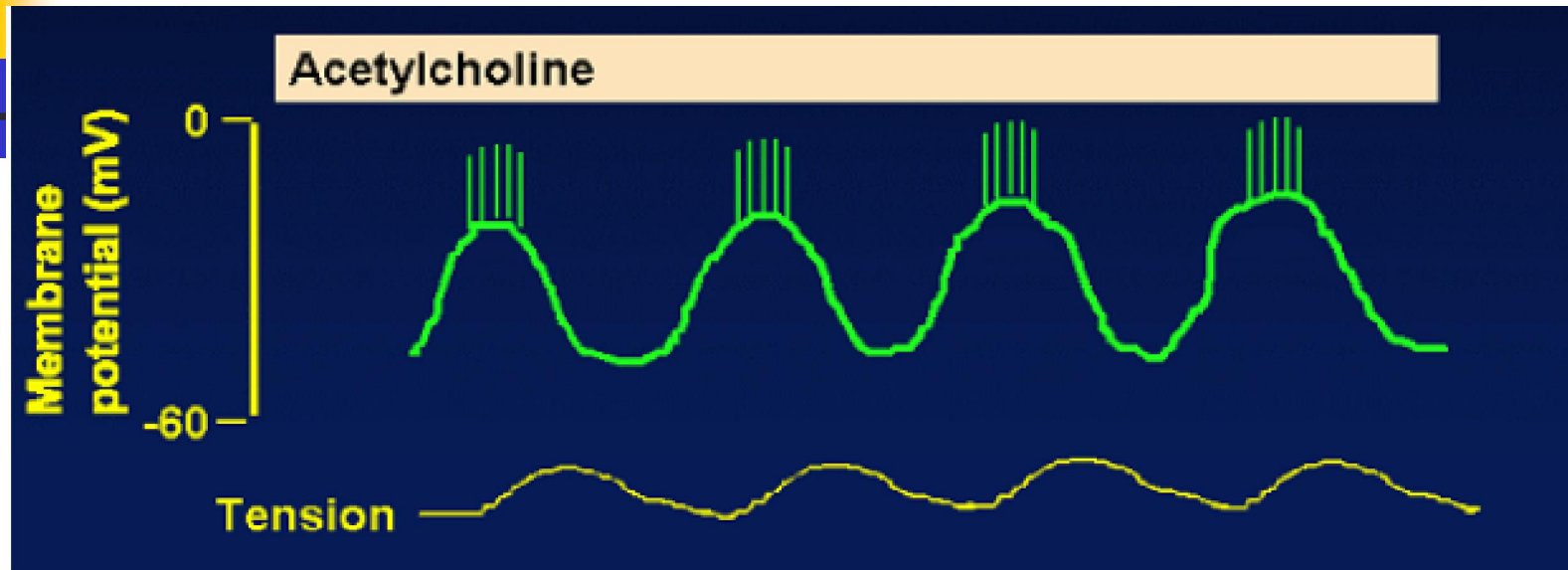


Slow wave of ICC is induced by periodic enhanced and inhibited activity of sodium pump.





3. 动作电位 (Spike potentials)



- Only at the peaks of slow waves
- Threshold: -40 mV; Duration: $10\sim 20$ ms
Frequency: $1\sim 10$ c/s
- **Depolarization phase** is induced by the inflow of Ca^{2+} and **repolarization** by K^{+} outflow
- AP increase muscle tension

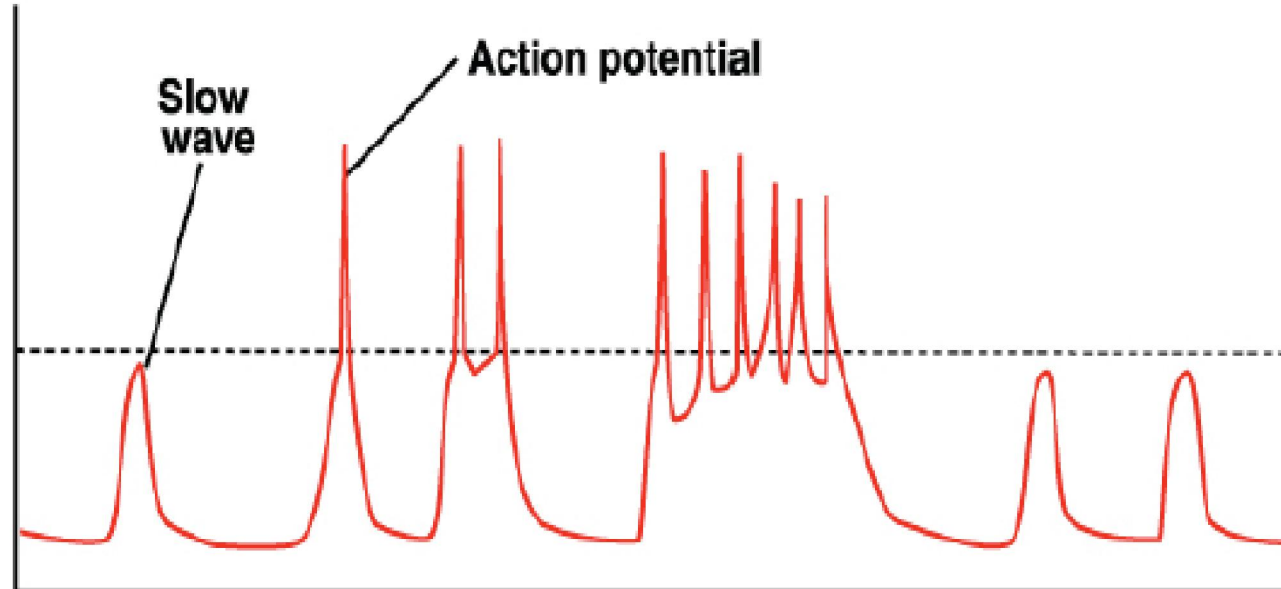
Membrane potential (mV)

Electrical

Threshold

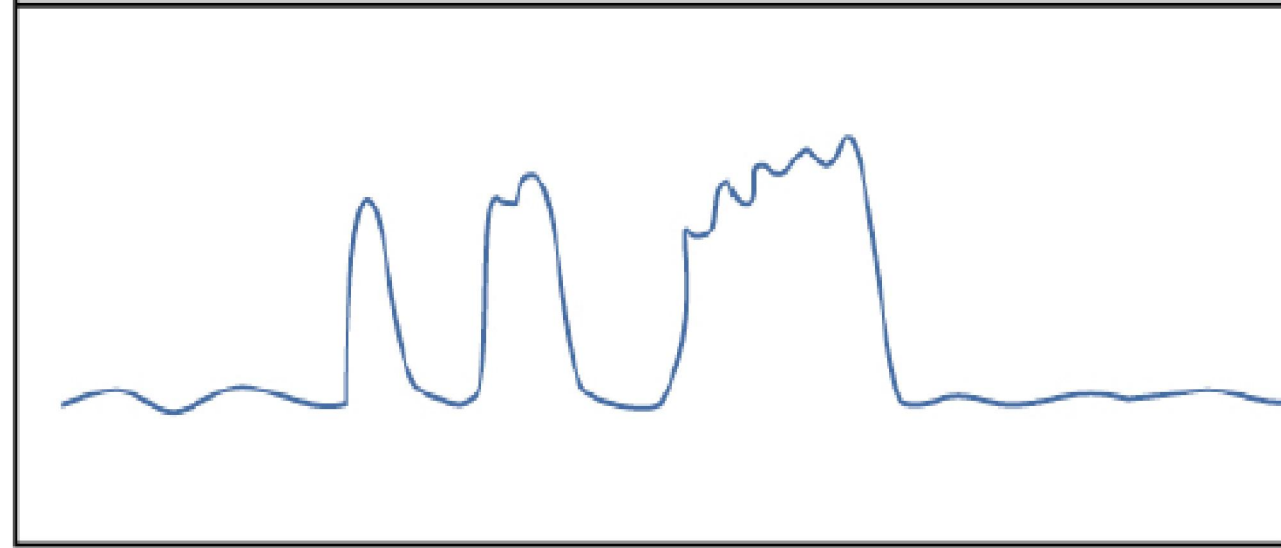
Slow wave

Action potential



Mechanical

Force of muscle contraction



Time →

Factors affecting BER & AP of gut smooth muscles

- **Stimulating factors**

- Ach, +parasympathetic nerve
- stretch
- gut hormones: gastrin, motilin

- **Inhibiting factors**

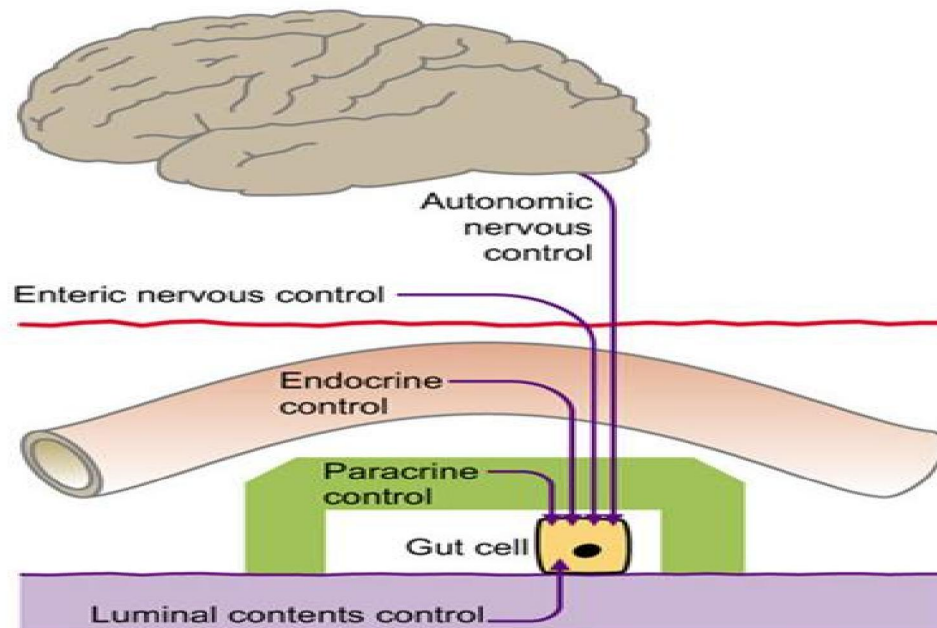
Norepinephrine (NE)

+ sympathetic nerve

gut hormones : secretin, GIP

2. Dual Innervation of Gut

- Intrinsic (enteric) nervous system
- Extrinsic (automatic) nervous system





(1) Enteric nervous system

- **Submucosal plexus** in submucosa
- **Myenteric plexus** between the
circular and longitudinal muscle layers

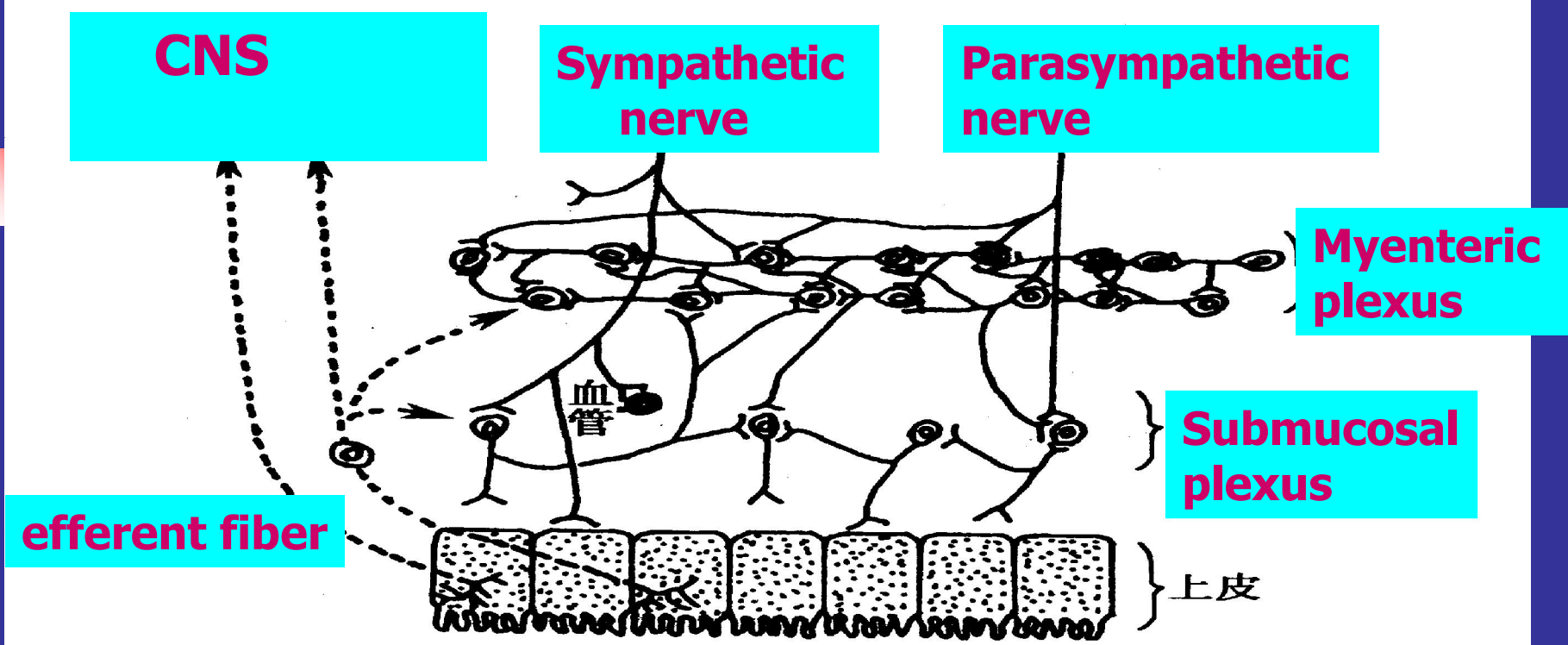


图 6-2 胃肠壁内的神经丛

The stimuli (distension, chyme osmolarity and acidity, digested products) act on receptors located in the wall of GI tract and trigger reflex that influences the gut motility and secretion.

The neural reflexes are completed within the wall of GI tract (**short reflexes**)



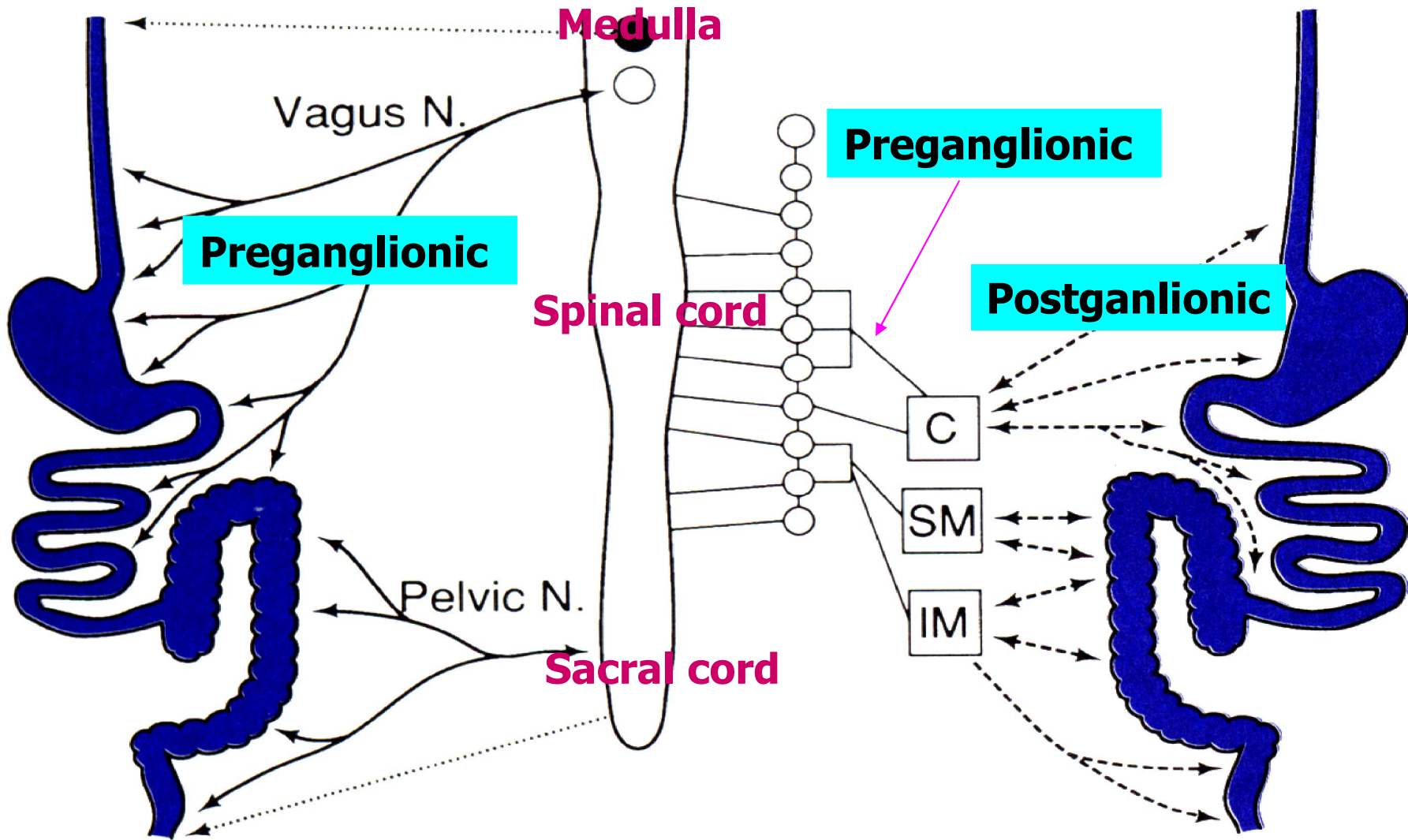
Enteric nervous system

- **Submucosal plexus** influence secretory activity of glands.
- **Myenteric plexus** regulate the movement of GI tract
- Enteric nervous system controls the gut motility and secretion of exocrine glands by **short reflex.**

Automatic nervous system

A Parasympathetic

B Sympathetic



(1) Sympathetic nerve

- Most of postganglionic fibers end on **cholinergic** neurons of enteric nervous system(ENS) , or directly on smooth muscle and blood vessels.
- Postganglionic fibers release **norepinephrine**
- NE **inhibit** gut motility and secretion

(2) Parasympathetic nerve

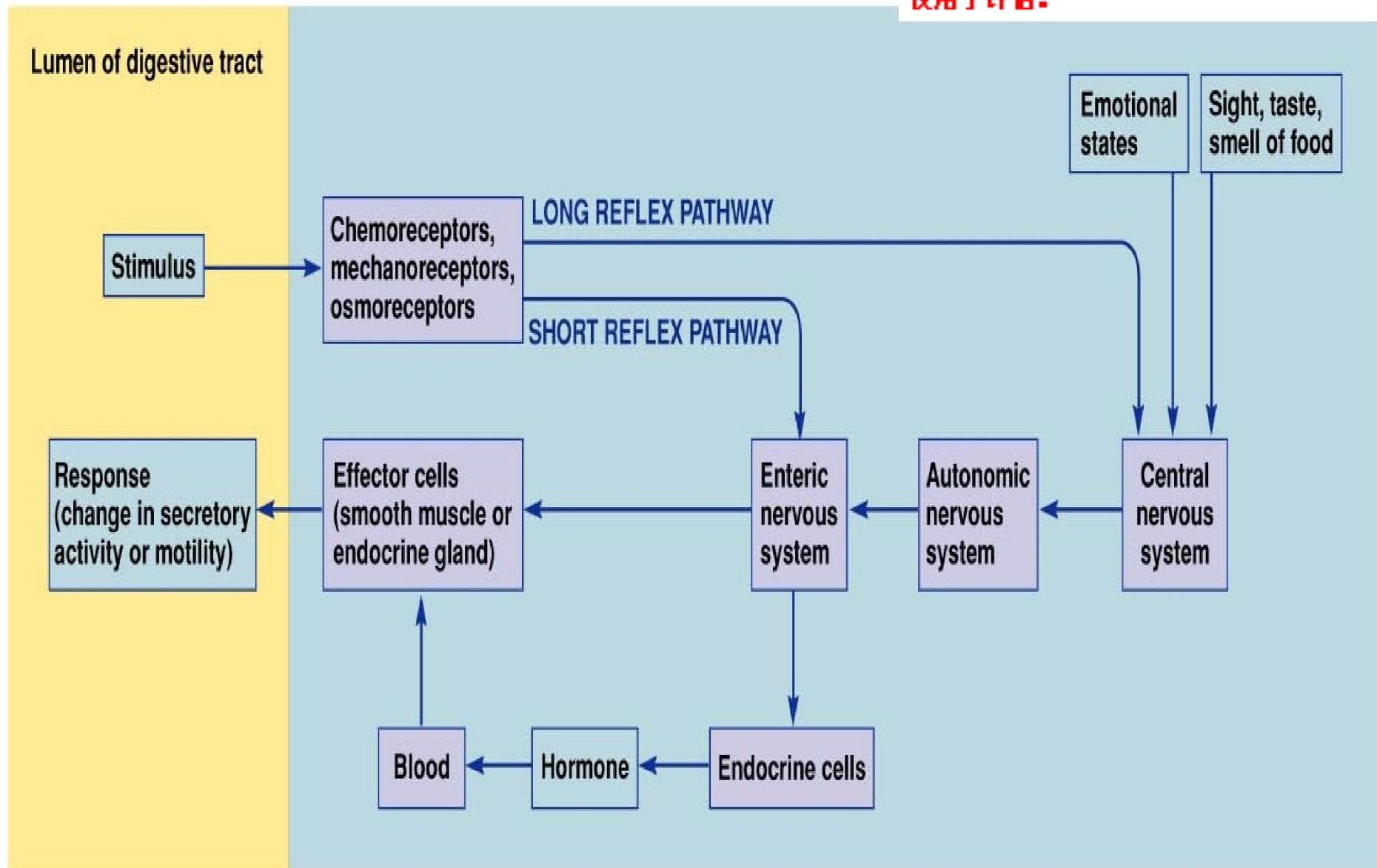
- Preganglionic fibers end on cholinergic neurons of enteric nervous system
- Ach stimulate gut motility and secretion



Enteric nervous system: short reflex

■ **Extrinsic nervous system:**

Long reflex from receptors in the GI tract
to the CNS by the way of afferent nerves
and back to the nerve plexuses and
effector cells

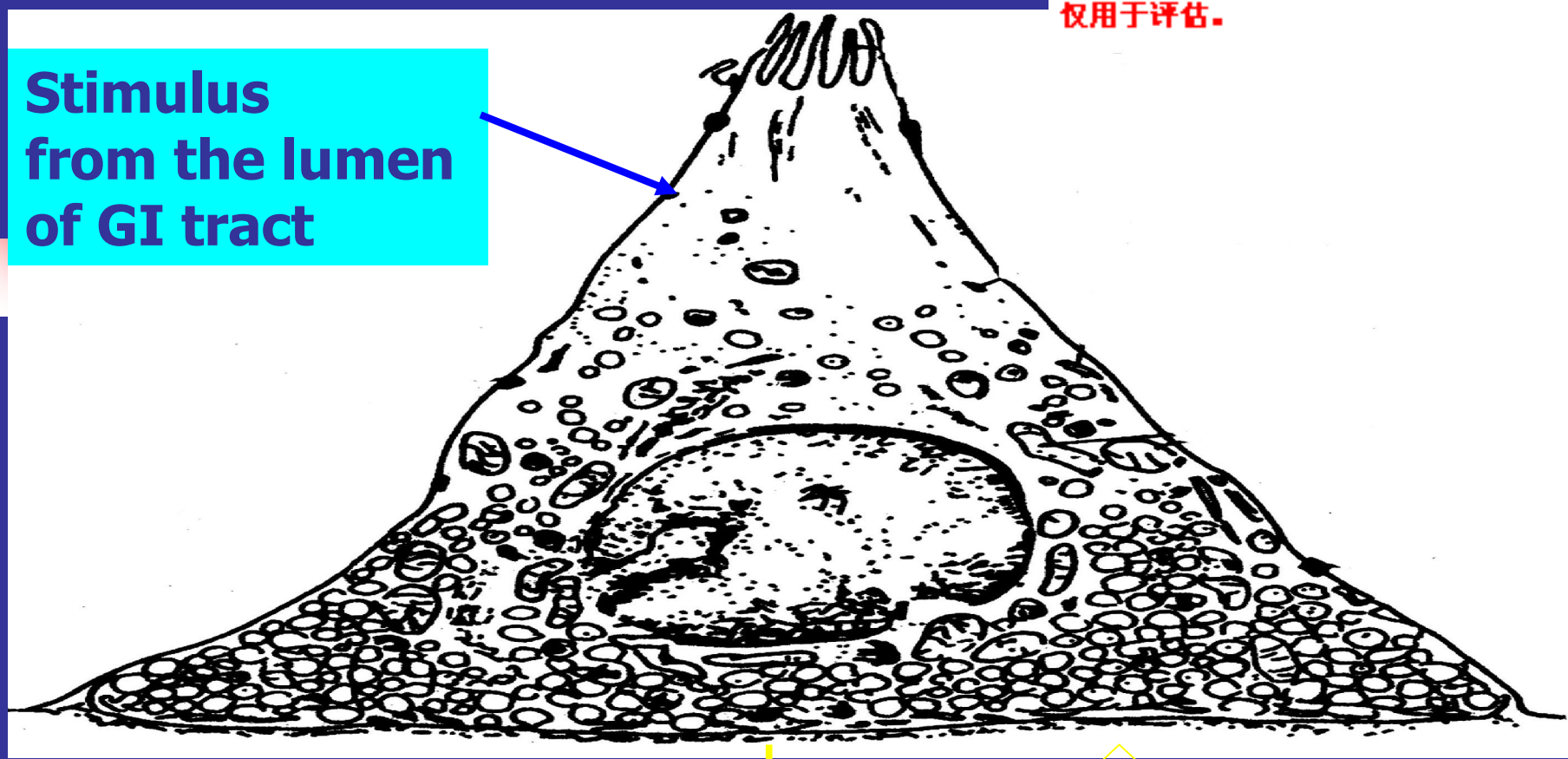




3. Gastrointestinal hormones

- **Source of gut hormones**
 - **secreted from endocrine cells of gut mucosa & pancreas**
 - **secreted from nerve ending of the enteric nervous system**

**Stimulus
from the lumen
of GI tract**

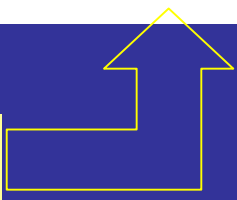


endocrine

Gut hormones

paracrine

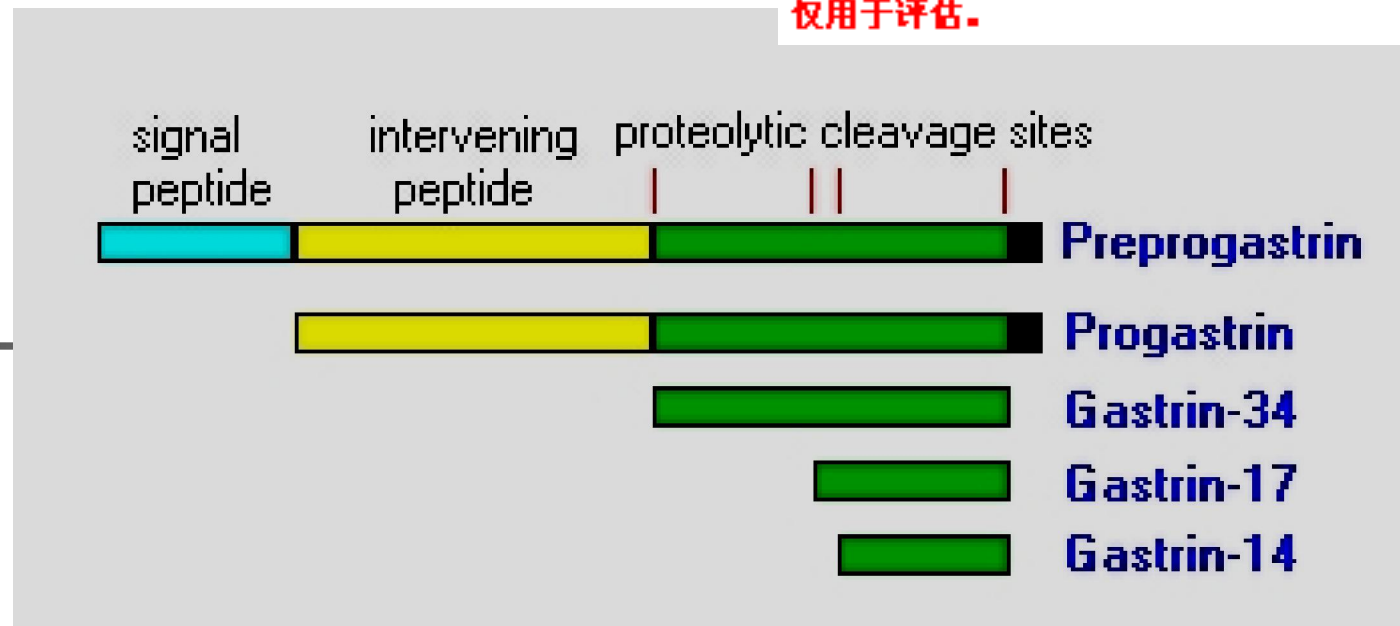
Blood circulation





Main gut hormones

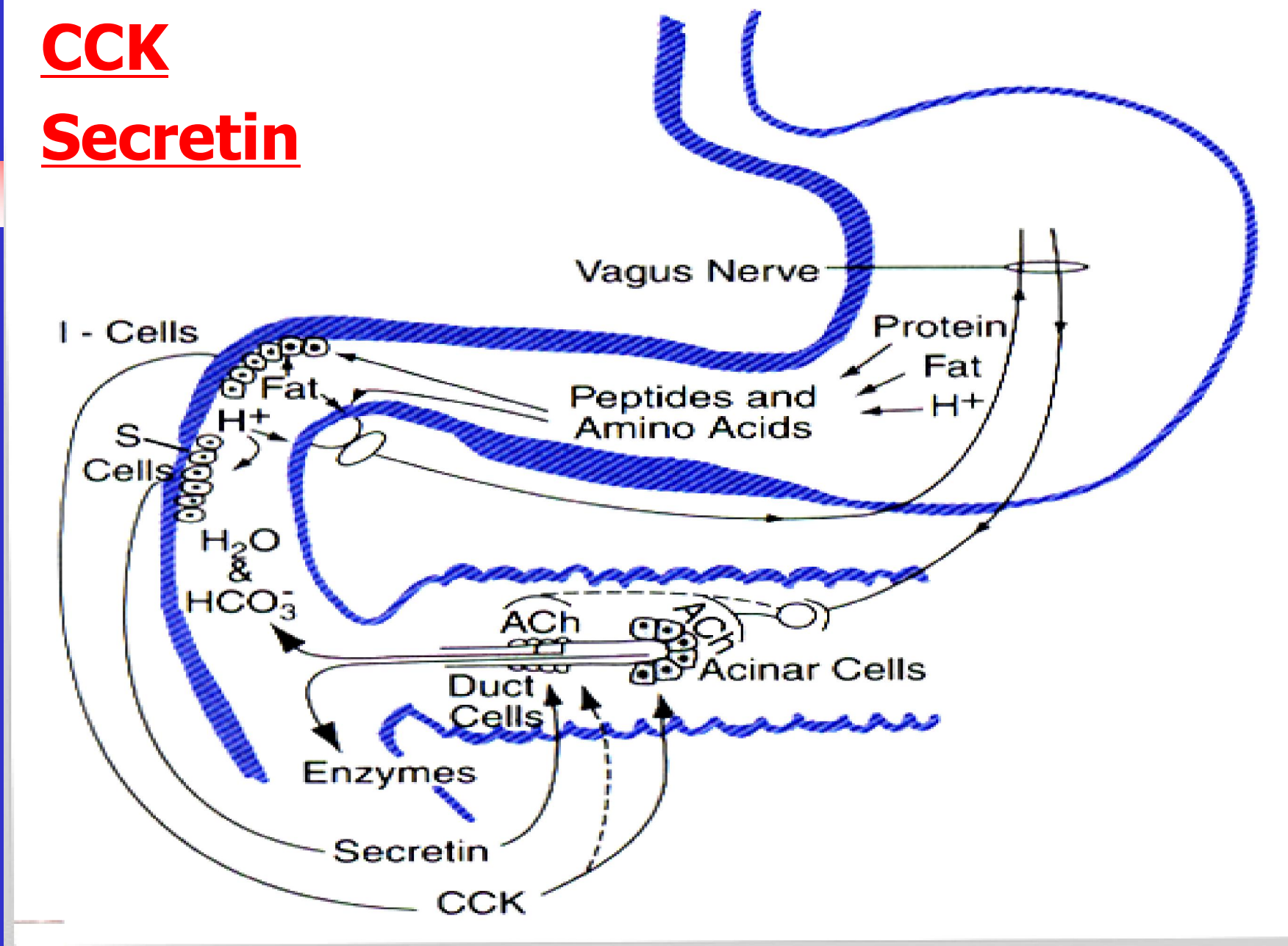
- **Gastrin family:** Gastrin, cholecystokinin(CCK)
- **Secretin family:** Secretin, **Glucogan**,
VIP (vasoactive intestinal peptide),
GIP (gastric inhibitory peptide)
- **Other hormones**
Peptide YY, Ghrelin, Motilin, Somatostatin
Endothelin, Enkephalin



- **Source:** G cells in antrum & duodenum
- **G-34, G-17, and G-14** amino acid residues. All have the same carboxyl terminal configuration.
- **G 17** is the principal form for acid secretion.
- The **carboxyl terminal tetrapeptide** has all the activities of gastrin but only 10% of the strength of G 17.

CCK

Secretin





Gastrin

- **Stimuli:** protein/amino acid , distension
parasympathetic nerve, Ach
- **Functions:**
 - **Stimulates secretion of HCl**
 - **Enhances gastric motility**
 - **Stimulates the growth of the mucosa of the stomach and the small intestine**
(trophic action)



CCK (cholecystokinin)

- **Source:** I cells in duodenum & jejunum
- **Stimulus:** digested products of protein and fat
- **Functions:**
 - **Induce contraction of gallbladder and relaxation of the sphincter of Oddi**
 - **Stimulate pancreatic enzyme secretion**
 - **Is trophic to the exocrine pancreas**
 - **Inhibits gastric emptying and secretion**
 - **Enhance the motility of the small intestine and colon**



Secretin

- **Source:** S cells in duodenum & jejunum
- **Stimulus:** acid, protein
- **Functions:**
 - **Stimulate pancreatic and bile secretion with ample bicarbonate salts**
 - **Inhibit gastric secretion/motility**



GIP (gastric inhibitory peptide)

- **Source:** K cells in duodenum & jejunum
- **Stimulus:** glucose and fat in the duodenum
- **Functions:**
 - **GIP in large doses inhibit gastric secretion and motility**
 - **Stimulate insulin secretion**



Gut-brain peptide

- **Many hormones such as gastrin, CCK, somatostatin, substance P, distribute dually in the GI tract and the brain.**

These hormones are called gut-brain peptide.