Lecture series
Gastrointestinal tract

Professor Shraddha Singh,
Department of Physiology,
KGMU, Lucknow

INNERVATION OF GIT

- *1.Intrinsic innervation*-1.Myenteric/Auerbach plexus
  or
  Local
  2.Submucosal/Meissners plexus

2.Extrinsic innervation-1.Parasympathetic
-2.Sympathetic
or
Higher centre

Enteric Nervous System

- Lies **in the wall** of the gut, beginning in the esophagus and
- extending all the way to the anus

- controlling gastrointestinal **movements and secretion**.

- (1) an **outer plexus** lying between the longitudinal and circular muscle layers, called the ***myenteric plexus or Auerbach's plexus,***
- controls mainly the gastrointestinal ***movements***

- (2) an **inner plexus**, called the ***submucosal plexus or Meissner's plexus***, that lies in the submucosa.
- controls mainly gastrointestinal ***secretion*** and ***local blood flow***

Enteric Nervous System

- The **myenteric plexus** consists mostly of a linear chain of many interconnecting neurons that extends the ***entire length of the GIT***

- When this plexus is stimulated, its principal effects are
- (1) increased **tonic contraction, or "tone,"** of the gut wall,
- (2) increased **intensity of the rhythmical contractions**,
- (3) slightly increased **rate of the rhythmical contraction**,
- (4) increased **velocity of conduction** of excitatory waves along the gut wall, causing **more rapid movement of the gut peristaltic waves.**

- **Inhibitory** transmitter - vasoactive intestinal polypeptide ***(VIP)*** - pyloric ***sphincter, sphincter*** of the ileocecal valve

Enteric Nervous System

- The **submucosal plexus** is mainly concerned with controlling function ***within the inner wall***

- **local** intestinal secretion, **local** absorption, and **local** contraction of the submucosal muscle

- Neurotransmitters:
- (1) Ach (7) substance P
- (2) NE (8) VIP
- (3)ATP (9) somatostatin
- (4) 5 – HT (10) bombesin
- (5) dopamine (11) metenkephalin
- (6) cholecystokinin (12) leuenkephalin

Higher centre innervation

- the **extrinsic sympathetic and parasympathetic** fibers that connect to both the myenteric and submucosal plexuses.

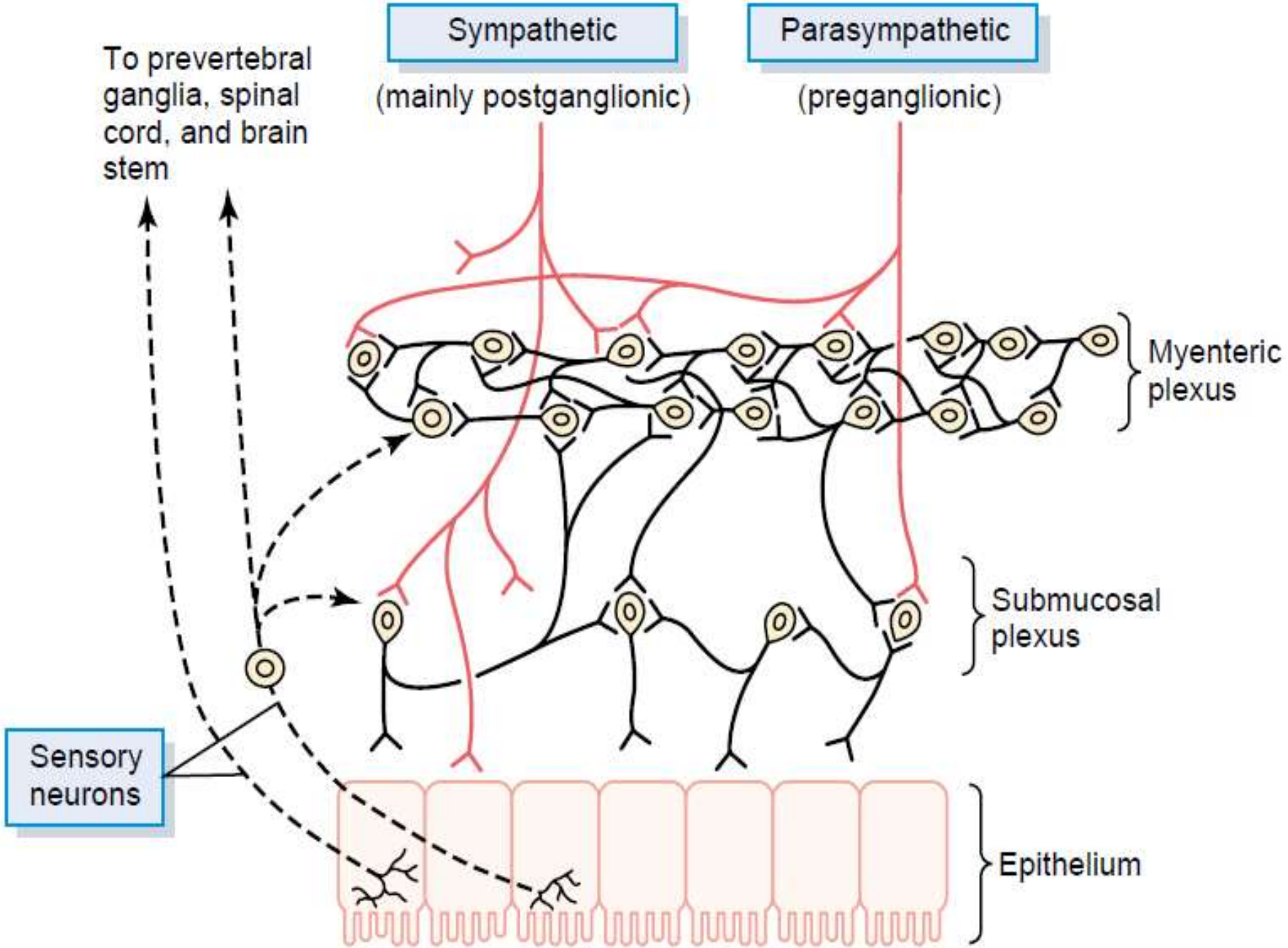
- the **enteric nervous system** can function on its own, independently of these extrinsic nerves,

- **stimulation by the parasympathetic and sympathetic** systems can greatly enhance or inhibit gastrointestinal functions

- **sensory nerve endings** that originate in the gastrointestinal epithelium or gut wall and send **afferent fibers to both plexuses** of the enteric system,

- as well as (1) to the **prevertebral ganglia** of the sympathetic nervous system, (2) to the **spinal cord**, and (3) in the vagus nerves all the way to the **brain stem**.

- These sensory nerves can elicit ***local reflexes*** within the gut wall


Sympathetic
(mainly postganglionic)
Parasympathetic
(preganglionic)
To prevertebral ganglia, spinal cord, and brain stem
Myenteric plexus
Submucosal plexus
Sensory neurons
Epithelium

Autonomic Control

- **Parasympathetic**
- the ***cranial*** parasympathetic nerve fibers - mouth and pharyngeal regions of the alimentary tract, esophagus, stomach, and pancreas and somewhat less to the intestines down through the **first half of the large intestine**.

- The ***sacral*** parasympathetics originate in the 2^{nd}, 3^{rd} & 4^{th} sacral segments of the spinal cord and pass through the **pelvic nerves to the distal half of the large intestine and all the way to the anus**.

- **The sigmoidal, rectal, and anal regions** are considerably better supplied with parasympathetic fibers than are the other intestinal areas - defecation reflexes

Sympathetic Innervation

- spinal cord between segments **T-5 and L-2**.

- Pre ganglionic - sympathetic **chains -** celiac **ganglion** and various mesenteric **ganglia –** post ganglionic

- innervate essentially **all of the gastrointestinal tract** – ***inhibitory***

- (1) to a slight extent by ***direct*** effect of secreted NE to inhibit intestinal tract smooth muscle

- (2) to a major extent by an inhibitory effect of NE on the neurons of the entire enteric nervous system

Afferent Sensory Nerve Fibers

- sensory nerves can be stimulated by

(1) **irritation** of the gut mucosa,

(2) excessive **distention** of the gut,

(3) presence of specific **chemical substances** in the gut.

Higher centre innervation

- the **extrinsic sympathetic and parasympathetic** fibers that connect to both the myenteric and submucosal plexuses.

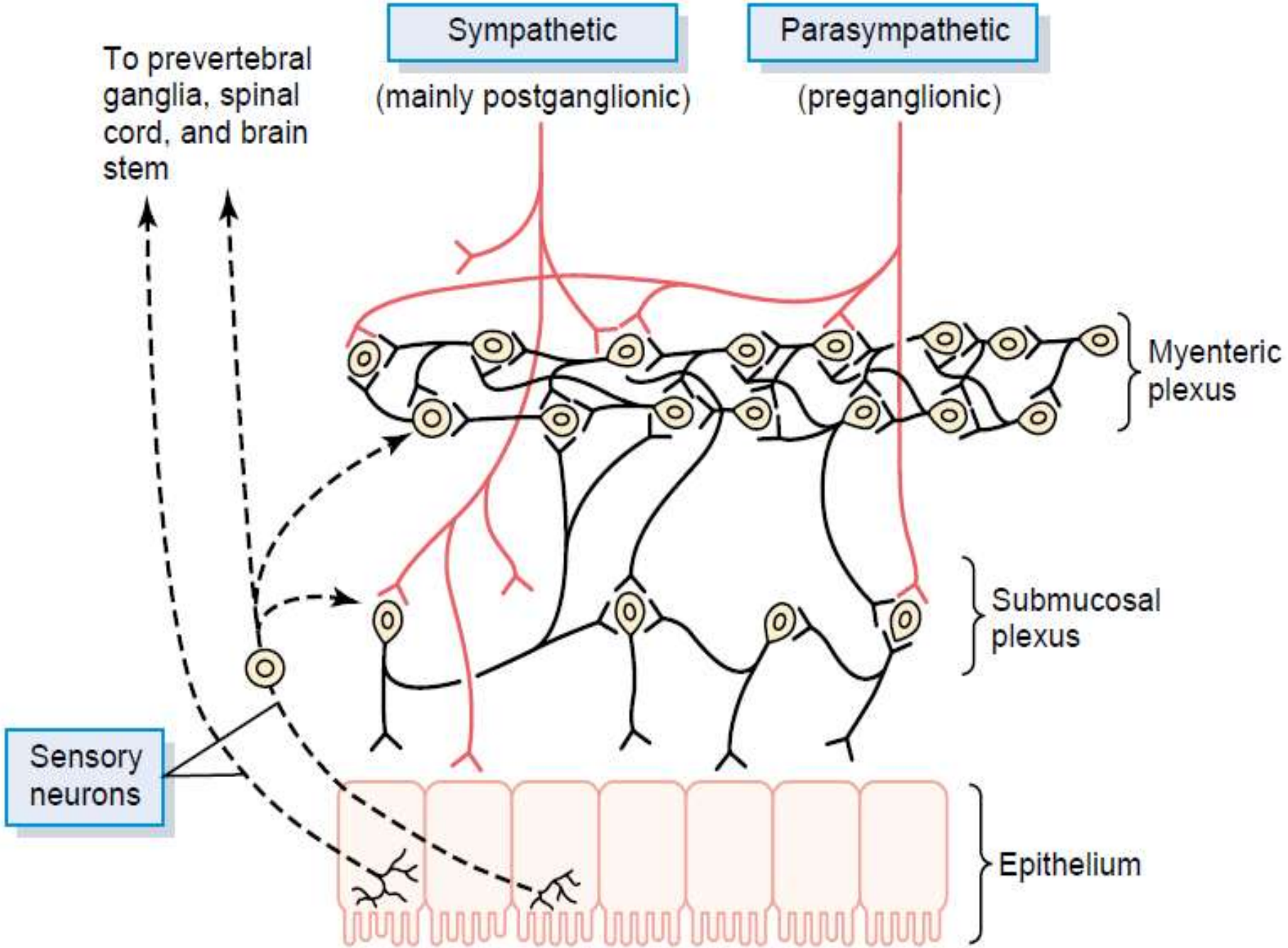
- the **enteric nervous system** can function on its own, independently of these extrinsic nerves,

- **stimulation by the parasympathetic and sympathetic** systems can greatly enhance or inhibit gastrointestinal functions

- **sensory nerve endings** that originate in the gastrointestinal epithelium or gut wall and send **afferent fibers to both plexuses** of the enteric system,

- as well as (1) to the **prevertebral ganglia** of the sympathetic nervous system, (2) to the **spinal cord**, and (3) in the vagus nerves all the way to the **brain stem**.

- These sensory nerves can elicit ***local reflexes*** within the gut wall


Sympathetic
(mainly postganglionic)
Parasympathetic
(preganglionic)
To prevertebral ganglia, spinal cord, and brain stem
Myenteric plexus
Submucosal plexus
Sensory neurons
Epithelium

Autonomic Control

- **Parasympathetic**
- the ***cranial*** parasympathetic nerve fibers - mouth and pharyngeal regions of the alimentary tract, esophagus, stomach, and pancreas and somewhat less to the intestines down through the **first half of the large intestine**.

- The ***sacral*** parasympathetics originate in the 2^{nd}, 3^{rd} & 4^{th} sacral segments of the spinal cord and pass through the **pelvic nerves to the distal half of the large intestine and all the way to the anus**.

- **The sigmoidal, rectal, and anal regions** are considerably better supplied with parasympathetic fibers than are the other intestinal areas - defecation reflexes

Sympathetic Innervation

- spinal cord between segments **T-5 and L-2**.

- Pre ganglionic - sympathetic **chains -** celiac **ganglion** and various mesenteric **ganglia –** post ganglionic

- innervate essentially **all of the gastrointestinal tract** – ***inhibitory***

- (1) to a slight extent by ***direct*** effect of secreted NE to inhibit intestinal tract smooth muscle

- (2) to a major extent by an inhibitory effect of NE on the neurons of the entire enteric nervous system

Afferent Sensory Nerve Fibers

- sensory nerves can be stimulated by

(1) **irritation** of the gut mucosa,

(2) excessive **distention** of the gut,

(3) presence of specific **chemical substances** in the gut.

Gastrointestinal Reflexes

1. *Reflexes that are integrated entirely* ***within the gut wall enteric nervous system*** – secretion, peristalsis, mixing contractions, *local* inhibitory effects

2. *Reflexes from the gut to the* ***prevertebral*** *sympathetic ganglia and then back to the GIT*

- signals from the stomach to cause evacuation of the colon (the **gastrocolic** reflex),
- signals from the colon and small intestine to inhibit stomach motility and stomach secretion (the **enterogastric** reflexes),
- reflexes from the colon to inhibit emptying of ileal contents into the colon (the **colonoileal** reflex).

Gastrointestinal Reflexes

*3. Reflexes from the gut **to the spinal cord or brain stem** and then back to the GIT.*

- (1) reflexes from the stomach and duodenum to the brain stem and back to the stomach — by way of the **vagus** nerves — to control **gastric motor and secretory activity**;

- (2) **pain reflexes** that cause general inhibition of the entire GIT;

- (3) **defecation reflexes** that travel from the colon and rectum to the spinal cord and back again to produce the powerful colonic, rectal, and abdominal contractions required for defecation

GIT Hormones

- ***1.GASTRIN*** is secreted by the "G" cells of the antrum of the **stomach** in response to stimuli associated with ingestion of a meal
- G –cell is neural in origin,also called APUD cells,as it is amine precursor uptake and decarboxylation
- -It occurs in 3 forms-G34,G17,G14
- .G-17(MW-2000) is the principal form.
- It is also found in pituitary gland,hypothalamus,medulla,vagal &sciatic nerves
- Gastrin is secreted as progastrin which get activated to gastrin by HCL

function-1.stimulate gastric acid &pepsin secretion

2.stimulate growth of mucosa of git

3.stimulate gastric motility

4stimulate insulin &glucagon secret

- ***2.cholecystokinin*** is secreted by "I" cells in the mucosa of the
- **duodenum and jejunum** mainly in response to digestive products
- of fat, fatty acids, and monoglycerides in the intestinal contents.

- This hormone strongly ***contracts the gallbladder***, expelling bile into
- the small intestine where the bile in turn plays important roles in
- **emulsifying fatty substances, allowing them to be digested and absorbed**.

- Cholecystokinin also **inhibits stomach contraction moderately** –
- give adequate time for digestion of the fats in the upper intestinal tract.

- ***3.Secretin*** is secreted by the "S" cells in the mucosa of the **duodenum** in response to acidic gastric juice emptying into the duodenum from the pylorus of the stomach.

- Secretin has a **mild effect on motility** of the GIT and acts to promote **pancreatic secretion of bicarbonate** which in turn helps to neutralize the acid in the small intestine

- ***4.Gastric inhibitory peptide*** is secreted by the mucosa of the upper **small intestine**, mainly in response to fatty acids and amino acids but to a lesser extent in response to carbohydrate.

- It has a mild effect in **decreasing motor activity of the stomach** and therefore **slows emptying of gastric contents** into the duodenum when the upper small intestine is already overloaded with food products.

Higher centre innervation

- the **extrinsic sympathetic and parasympathetic** fibers that connect to both the myenteric and submucosal plexuses.

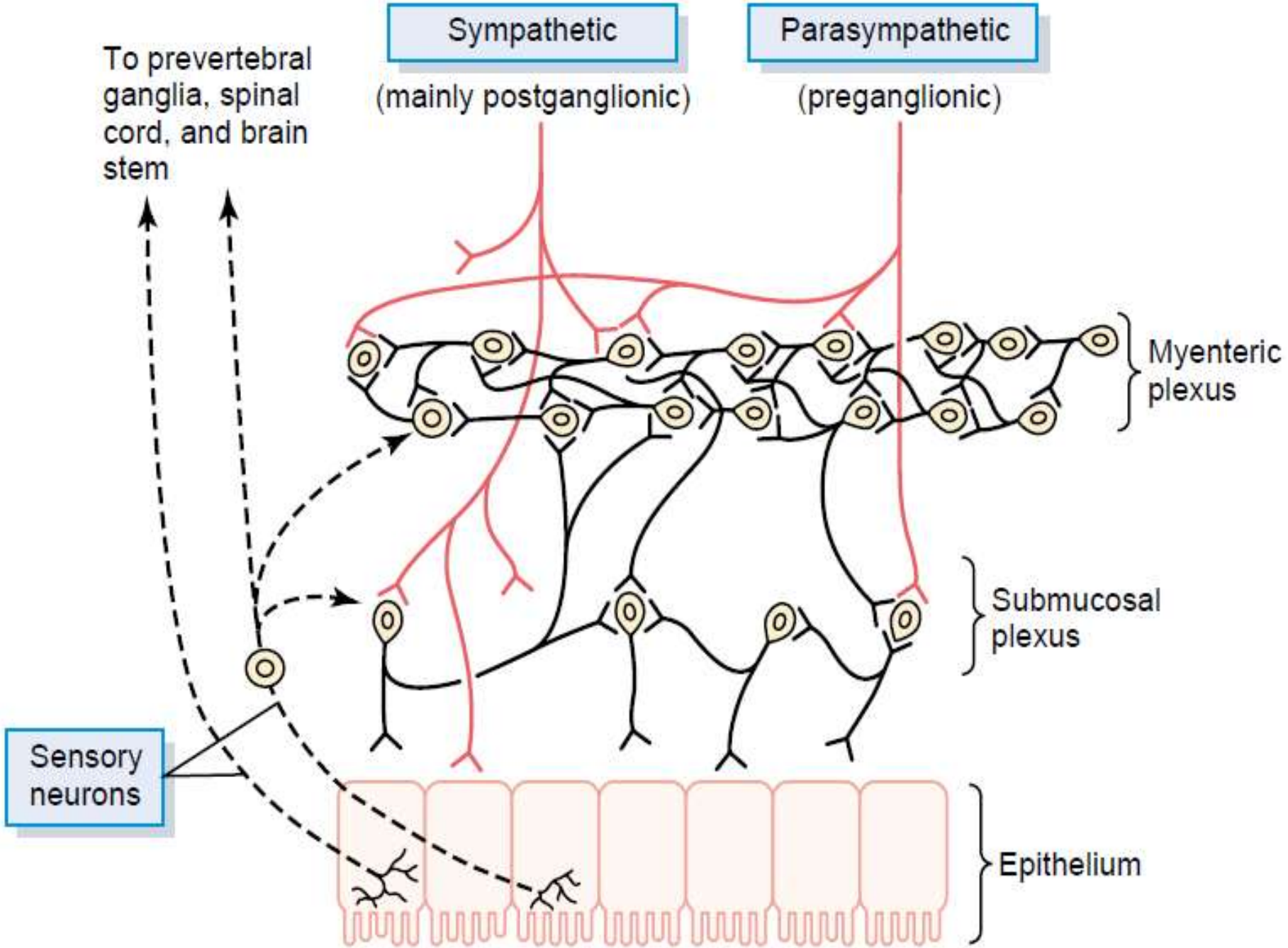
- the **enteric nervous system** can function on its own, independently of these extrinsic nerves,

- **stimulation by the parasympathetic and sympathetic** systems can greatly enhance or inhibit gastrointestinal functions

- **sensory nerve endings** that originate in the gastrointestinal epithelium or gut wall and send **afferent fibers to both plexuses** of the enteric system,

- as well as (1) to the **prevertebral ganglia** of the sympathetic nervous system, (2) to the **spinal cord**, and (3) in the vagus nerves all the way to the **brain stem**.

- These sensory nerves can elicit ***local reflexes*** within the gut wall


Sympathetic
(mainly postganglionic)
Parasympathetic
(preganglionic)
To prevertebral ganglia, spinal cord, and brain stem
Myenteric plexus
Submucosal plexus
Sensory neurons
Epithelium

Autonomic Control

- **Parasympathetic**
- the ***cranial*** parasympathetic nerve fibers - mouth and pharyngeal regions of the alimentary tract, esophagus, stomach, and pancreas and somewhat less to the intestines down through the **first half of the large intestine**.

- The ***sacral*** parasympathetics originate in the 2^{nd}, 3^{rd} & 4^{th} sacral segments of the spinal cord and pass through the **pelvic nerves to the distal half of the large intestine and all the way to the anus**.

- **The sigmoidal, rectal, and anal regions** are considerably better supplied with parasympathetic fibers than are the other intestinal areas - defecation reflexes

Sympathetic Innervation

- spinal cord between segments **T-5 and L-2**.

- Pre ganglionic - sympathetic **chains -** celiac **ganglion** and various mesenteric **ganglia –** post ganglionic

- innervate essentially **all of the gastrointestinal tract** – ***inhibitory***

- (1) to a slight extent by ***direct*** effect of secreted NE to inhibit intestinal tract smooth muscle

- (2) to a major extent by an inhibitory effect of NE on the neurons of the entire enteric nervous system

Afferent Sensory Nerve Fibers

- sensory nerves can be stimulated by

(1) **irritation** of the gut mucosa,

(2) excessive **distention** of the gut,

(3) presence of specific **chemical substances** in the gut.

Gastrointestinal Reflexes

1. *Reflexes that are integrated entirely* ***within the gut wall enteric nervous system*** – secretion, peristalsis, mixing contractions, *local* inhibitory effects

2. *Reflexes from the gut to the* ***prevertebral*** *sympathetic ganglia and then back to the GIT*

- signals from the stomach to cause evacuation of the colon (the **gastrocolic** reflex),
- signals from the colon and small intestine to inhibit stomach motility and stomach secretion (the **enterogastric** reflexes),
- reflexes from the colon to inhibit emptying of ileal contents into the colon (the **colonoileal** reflex).

Gastrointestinal Reflexes

*3. Reflexes from the gut **to the spinal cord or brain stem** and then back to the GIT.*

- (1) reflexes from the stomach and duodenum to the brain stem and back to the stomach — by way of the **vagus** nerves — to control **gastric motor and secretory activity**;

- (2) **pain reflexes** that cause general inhibition of the entire GIT;

- (3) **defecation reflexes** that travel from the colon and rectum to the spinal cord and back again to produce the powerful colonic, rectal, and abdominal contractions required for defecation

GIT Hormones

- ***1.GASTRIN*** is secreted by the "G" cells of the antrum of the **stomach** in response to stimuli associated with ingestion of a meal
- G –cell is neural in origin,also called APUD cells,as it is amine precursor uptake and decarboxylation
- -It occurs in 3 forms-G34,G17,G14
- .G-17(MW-2000) is the principal form.
- It is also found in pituitary gland,hypothalamus,medulla,vagal &sciatic nerves
- Gastrin is secreted as progastrin which get activated to gastrin by HCL

function-1.stimulate gastric acid &pepsin secretion

2.stimulate growth of mucosa of git

3.stimulate gastric motility

4stimulate insulin &glucagon secret

- ***2.cholecystokinin*** is secreted by "I" cells in the mucosa of the
- **duodenum and jejunum** mainly in response to digestive products
- of fat, fatty acids, and monoglycerides in the intestinal contents.

- This hormone strongly ***contracts the gallbladder***, expelling bile into
- the small intestine where the bile in turn plays important roles in
- **emulsifying fatty substances, allowing them to be digested and absorbed**.

- Cholecystokinin also **inhibits stomach contraction moderately** –
- give adequate time for digestion of the fats in the upper intestinal tract.

- ***3.Secretin*** is secreted by the "S" cells in the mucosa of the **duodenum** in response to acidic gastric juice emptying into the duodenum from the pylorus of the stomach.

- Secretin has a **mild effect on motility** of the GIT and acts to promote **pancreatic secretion of bicarbonate** which in turn helps to neutralize the acid in the small intestine

- ***4.Gastric inhibitory peptide*** is secreted by the mucosa of the upper **small intestine**, mainly in response to fatty acids and amino acids but to a lesser extent in response to carbohydrate.

- It has a mild effect in **decreasing motor activity of the stomach** and therefore **slows emptying of gastric contents** into the duodenum when the upper small intestine is already overloaded with food products.

- ***5.Motilin*** is secreted by the **upper duodenum** during fasting, and the only known function of this hormone is to *increase gastrointestinal motility.*

- Motilin is released **cyclically** and stimulates waves of gastrointestinal motility called **interdigestive myoelectric complexes;**

- that move through the stomach and small intestine **every 90 minutes in a fasted person.**

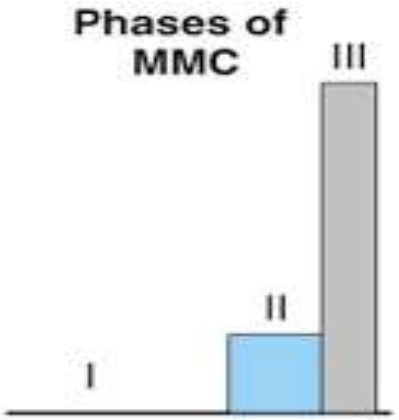
MIGRATING MOTOR COMPLEX

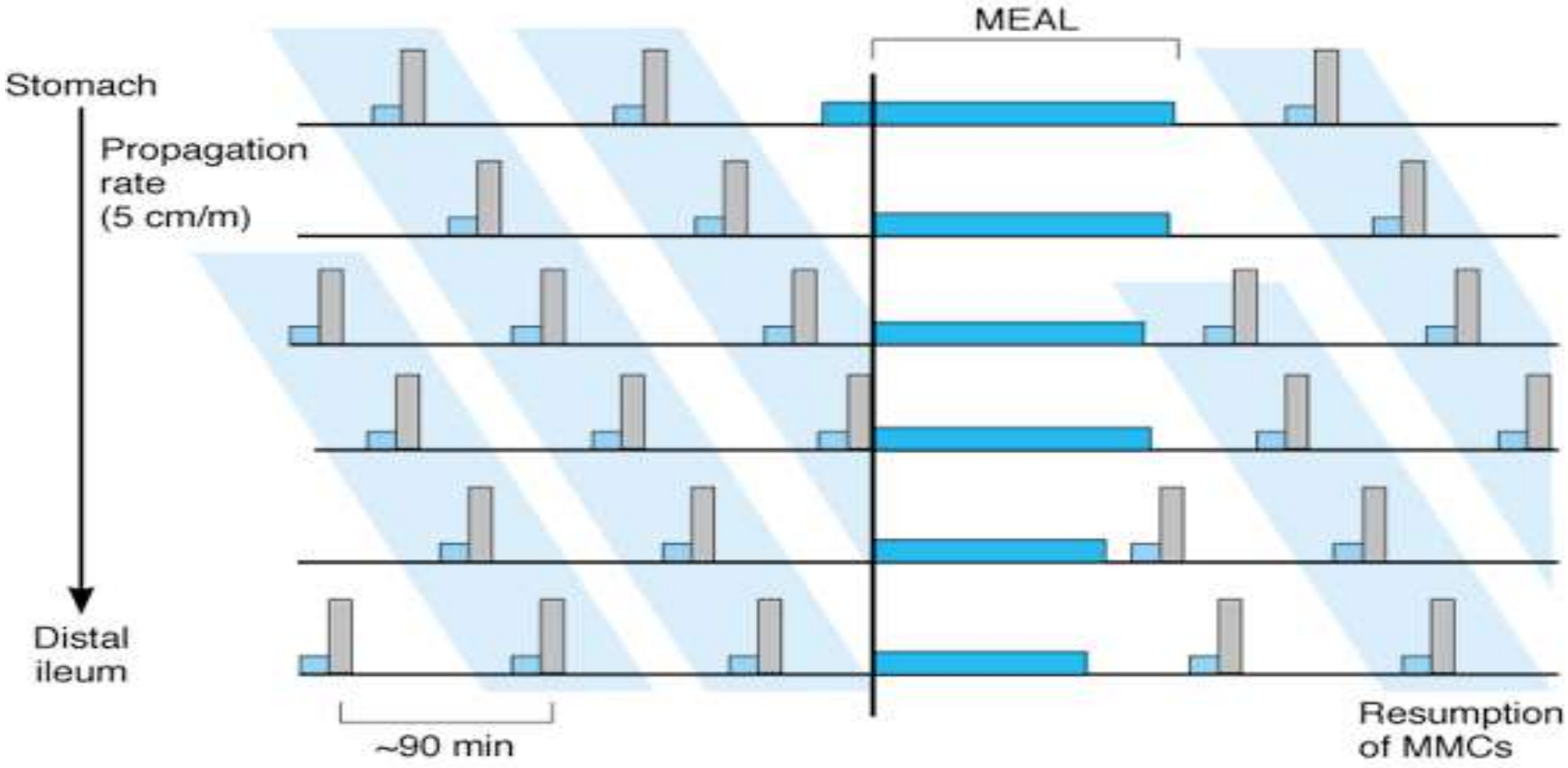
- Electrical and motor activity in gut smooth muscles during interdigestive stage
- Duration : 90-100 min in each cycle
- Rate of movement is 5cm/min from oral to aboral site
- Phase 1-Quescent period with no activity
- Phase 2-Period of irregular activity
- Phase 3-Period of regular activity
- Initiated by motilin
- Gastic secretion,bile flow,pancreatic secretion increases MMC
- Food abolish MMC by inhibiting motilin

Phase I - No spike potentials, no contractions

Phase II - Irregular spike potentials and contractions

Phase III - Regular spike potentials and contractions





References

- Lippincott’s Illustrated Reviews: Physiology (2013)
- Medical Physiology, Updated second edition (walter F. Boron, MD, phd)
- Berne & levy, physiology, sixth edition, updated edition
- Ganong’s Review of Medical Physiology, 26 t h e d i t i o n