Gastrointestinal Physiology

Regulation of Stomach Emptying

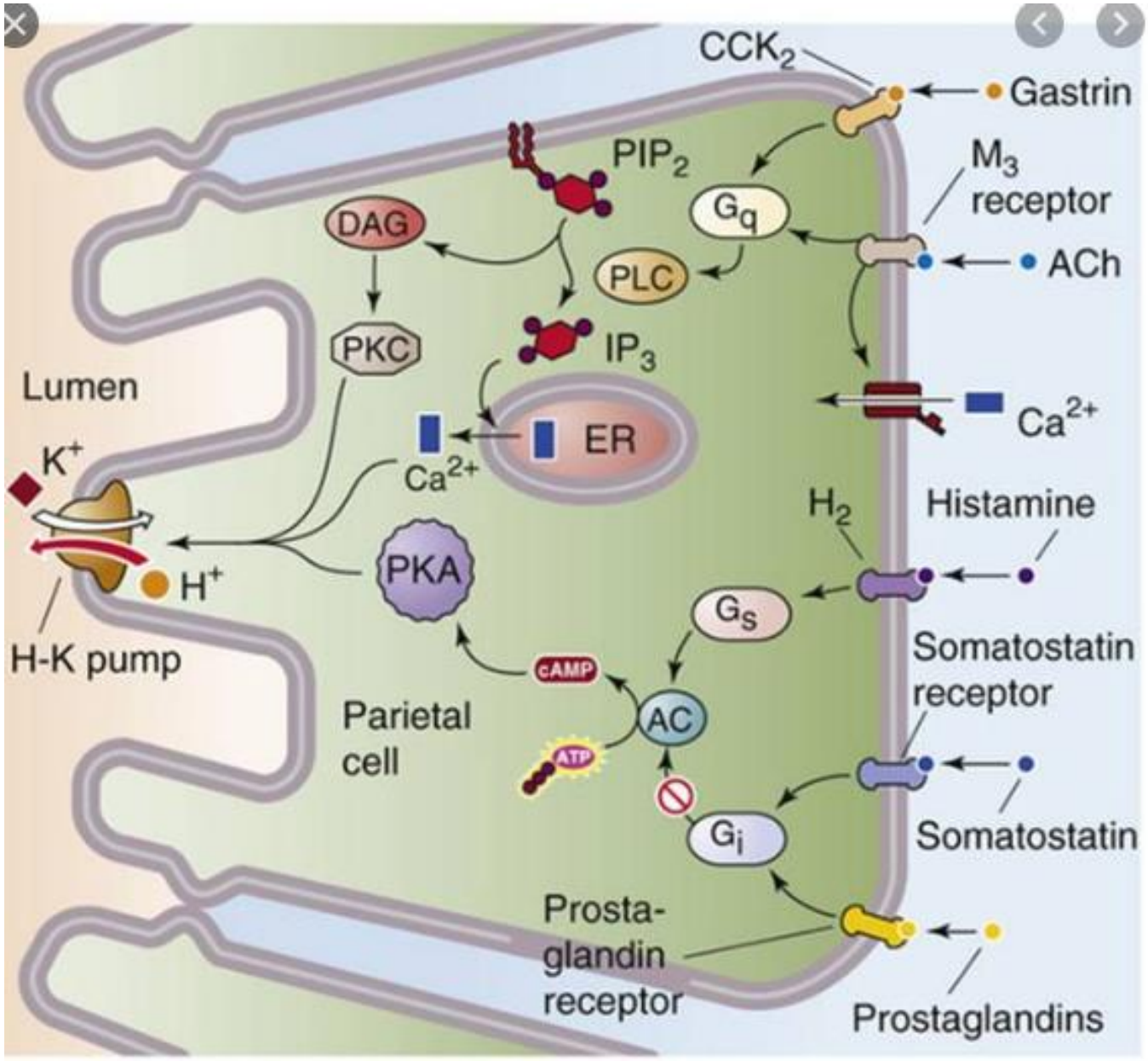
Stomach emptying is promoted by intense peristaltic contractions in the stomach antrum (act as pyloric pump pushing chyme through Pylorus) & Opposed by pyloric sphincter.

The rate at which the stomach empties is regulated by signals from both the stomach and the duodenum (more potent signals).

Gastric Factors promote emptying:

Gastric volume: Increased food volume causes stretching of the stomach wall eliciting local myenteric reflexes in the wall that greatly accentuate activity of the pyloric pump and at the same time inhibit the pylorus.

Gastrin Hormone: stomach wall stretch and the presence of certain types of foods like digestive products of meat—elicit release of *gastrin from the antral mucosa. Which* causes secretion of highly acidic gastric juice by the stomach glands, mild to moderate stimulatory effects on motor functions of stomach & enhance the activity of the pyloric pump.


CCK2
Gastrin
PIP2
M3 receptor
Gq
DAG
PLC
ACh
PKC
IP3
Lumen
Ca2+
ER
K+
Ca2+
H2
Histamine
PKA
H+
Gs
H-K pump
Somatostatin receptor
cAMP
Parietal cell
AC
ATP
Gi
Somatostatin
Prosta-glandin receptor
Prostaglandins

Powerful Duodenal Factors, Inhibiting Emptying

Enterogastric Nervous Reflexes: All 3 type of reflexes 1. Within ENS,

2. Prevertebral ganglia and back, 3. Brain stem.

Strongly inhibits the “pyloric pump” propulsive contractions, and increase the tone of the pyloric sphincter.

Factors that are continually monitored in the duodenum and that can initiate enterogastric inhibitory reflexes include the following:

1. The degree of distention of the duodenum
2. The presence of any degree of irritation of the duodenal mucosa
3. The degree of acidity of the duodenal chyme
4. The degree of osmolality of the chyme
5. The presence of certain breakdown products in the chyme, especially breakdown products of proteins and perhaps to a lesser extent of fats

Hormonal Feedback

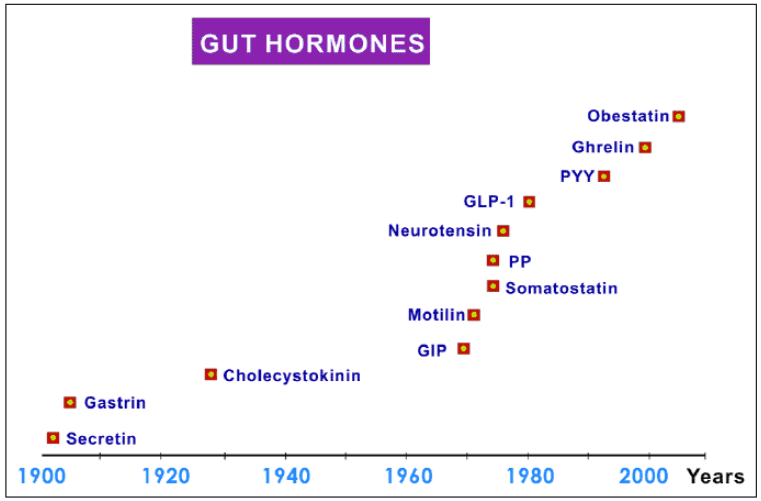
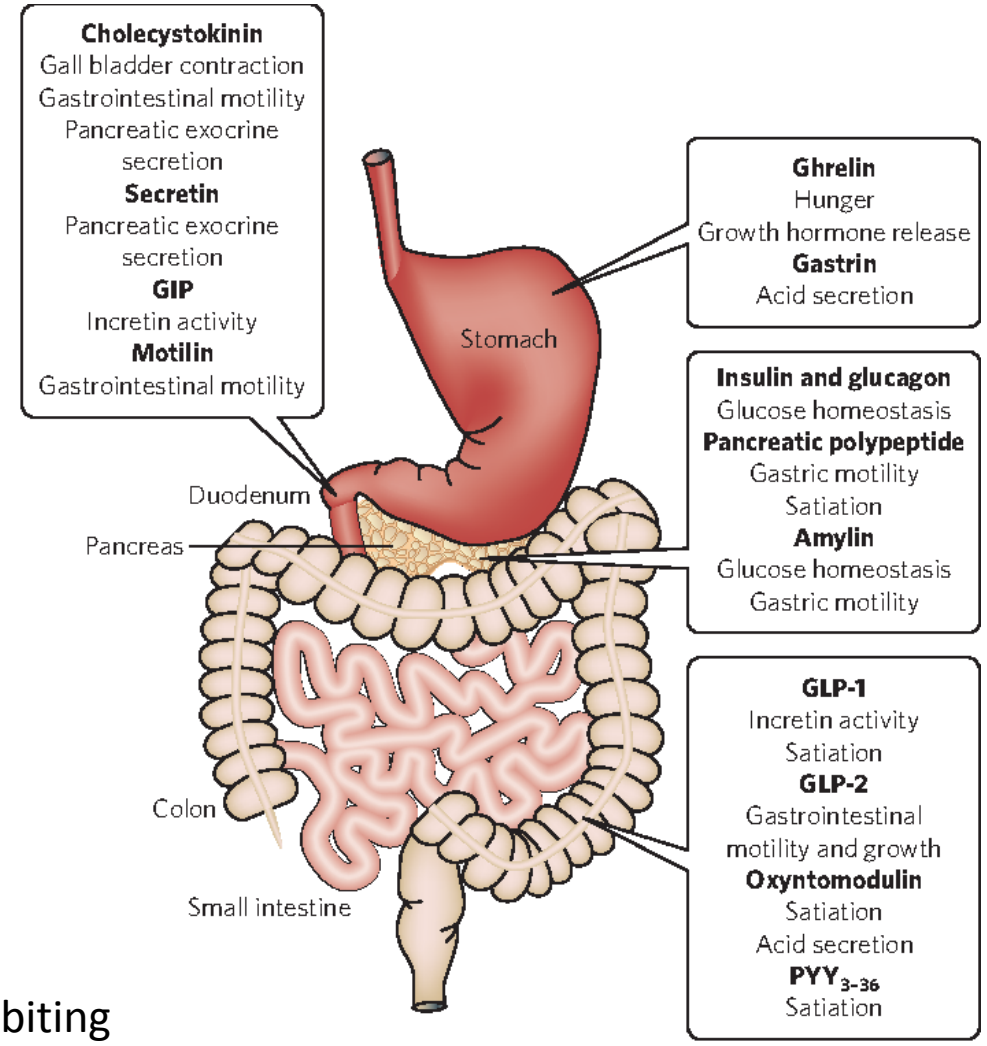


Fig. 1. The discovery of gastrointestinal hormones.



–**Incretins:** lowers glucose levels

by stimulating insulin release and inhibiting

Glucagon release

Hormonal Feedback

Hormones released from the upper intestine most potent cholecystokinin (CCK) , secretin, gastrointestinal peptide (GIP).

- The stimulus for releasing these inhibitory hormones is mainly fats entering the duodenum, other foods to a lesser degree.
- The fats extract several different hormones from the duodenal and jejunal epithelium, either by binding with “receptors” on the epithelial cells or in some other way.

–**CCK** is released from the mucosa of the jejunum in response to fats & acts as an inhibitor to block increased stomach motility caused by gastrin.

–**Secretin** is released mainly from the duodenal mucosa in response to gastric acid passed from the stomach through the pylorus.

–**GIP** is released from the upper small intestine in response mainly to fat in the chyme, but to a lesser extent to carbohydrates as well. GIP inhibit gastric motility to lesser extent but more potent in stimulate secretion of insulin by the pancreas.

Movements of the Small Intestine : mixing contractions and propulsive contractions.

–Mixing Contractions (Segmentation Contractions)

–Stretching of the intestinal wall elicits localized concentric contractions spaced at intervals along the intestine and lasting a fraction of a minute. The contractions cause "segmentation" of the small intestine,.

–As one set of segmentation contractions relaxes, a new set often begins, but the contractions this time occur mainly at new points between the previous contractions., chopping the chyme and mixing it with secretions of the small intestine.

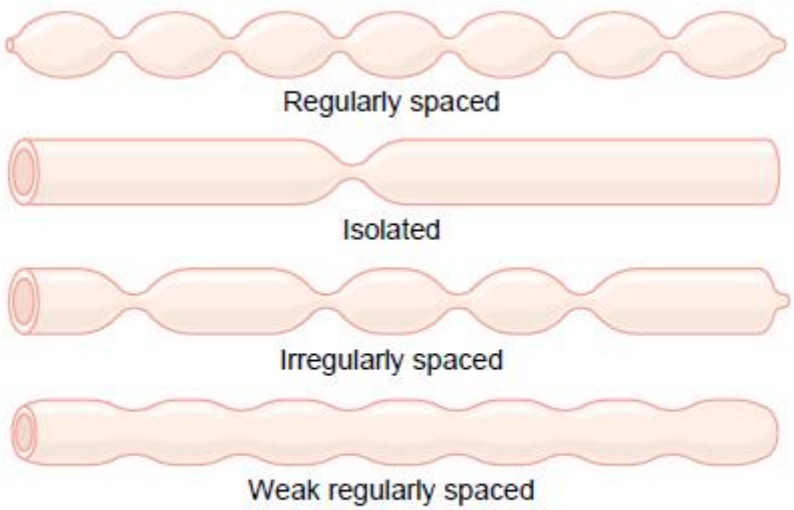


Figure 63–3

Segmentation movements of the small intestine.

–Electrical activity slow waves regulated by Myenteric plexus

Propulsive Movements

–By peristaltic waves of velocity of 0.5 to 2.0 cm/sec, faster in the proximal intestine and slower in the terminal intestine. 3 to 5 hr are required for passage of chyme from the pylorus to the ileocecal valve.

–Peristaltic waves not only cause progression of chyme toward the ileocecal valve but also spread out the chyme along the intestinal mucosa (absorption).

–Chyme movement blocked by ileoceacal valve until *gastroileal reflex* intensifies peristalsis in the ileum and forces the remaining chyme through the ileocecal valve into the cecum of the large intestine.

Control of Peristalsis by Nervous and Hormonal Signals.

–Peristaltic activity of the small intestine is greatly increased after a meal caused by stretching signal as well as ***gastroenteric reflex*** that is initiated by distention of the stomach and conducted principally through the **myenteric plexus** from the stomach down along the wall of the small intestine.

–***Gastrin, CCK, insulin, motilin, and serotonin,*** *enhance* intestinal motility and are secreted during various phases of food processing.

–***Secretin and glucagon*** *inhibit small intestinal motility.*

Peristaltic Rush.

- **P**eristalsis in the small intestine is normally weak, intense irritation of the intestinal mucosa, such as in infectious diarrhea, can cause both powerful and rapid peristalsis, called the *peristaltic rush.*

- Initiated partly by nervous reflexes that involve the ANS and brain stem and partly by intrinsic enhancement of the myenteric plexus reflexes within the gut wall itself.

- The powerful peristaltic contractions travel long distances in the small intestine within minutes, sweeping the contents of the intestine into the colon and thereby relieving the small intestine of irritative chyme and excessive distention.

Ileocecal Valve

➢Prevents backflow of fecal contents from the colon into the small intestine. 1.5 to 2 L of chyme empty into the cecum each day.

➢Degree of contraction of the ileocecal sphincter and the intensity of peristalsis in the terminal ileum are controlled significantly by reflexes from the cecum.

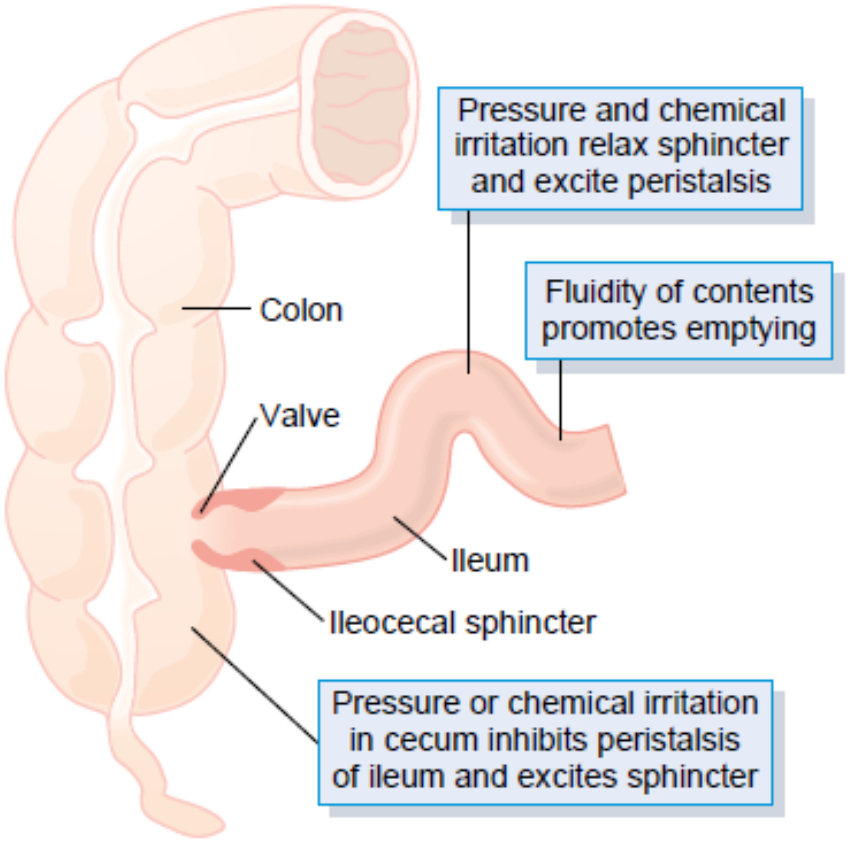


Figure 63–4

Emptying at the ileocecal valve.

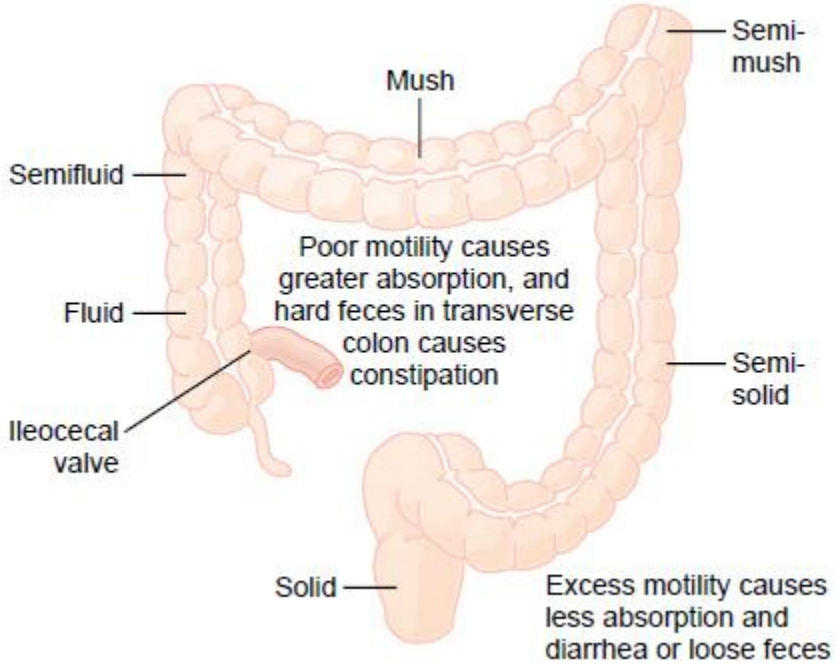
➢The reflexes from the cecum to the ileocecal sphincter and ileum are mediated both by way of the myenteric plexus in the gut wall itself and of the extrinsic autonomic nerves, especially by way of the prevertebral sympathetic ganglia.

Movements of the Colon

Principal functions

(1) absorption of water and electrolytes from the chyme to form solid feces (Proximal half)

(2) storage of fecal matter until it can be expelled (distal half).



Movements of the colon are normally very sluggish (mixing & propulsive).

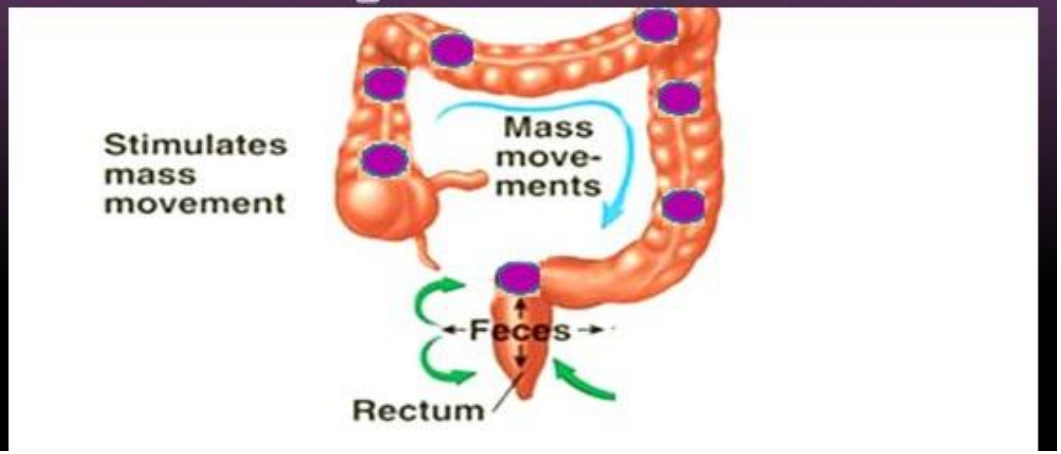
Mixing Movements—"Haustrations."

–Segmentation movements with large circular constrictions forming baglike sacs called *haustrations.*

–Fecal material is gradually exposed to the mucosal surface of the large intestine, and fluid and dissolved substances are absorbed until only 80 to 200 mL of feces are expelled each day.

Propulsive Movements—"Mass Movements."

- Modified type of Peristaltic movement.
- Transverse colon-Sigmoid colon.
- Slow, persistent haustral contraction propelling Chyme through Transverse colon.
- Chyme becomes fecal in nature e.g. Semi solid form from semi liquid form.



Initiation of Mass Movements by Gastrocolic and Duodenocolic Reflexes.

–These reflexes result from distention of the stomach and duodenum after meals. Reflexes are transmitted by way of the autonomic nervous system.

–Irritation in the colon can also initiate intense mass movements. Person with *ulcerative colitis* frequently has mass movements that persist almost all the time.

Defecation

➢Most of the time, the rectum is empty of feces, partly due to a weak functional anal sphincters between rectum and anus. Sharp angulation contributes additional resistance to filling of the rectum.

➢When a mass movement forces feces into the rectum, the desire for defecation occurs immediately, including reflex contraction of the rectum and relaxation of the anal sphincters.

Continual dribble of fecal matter through the anus is prevented by tonic constriction of

(1) **an *internal anal sphincter,***

a several-centimeters-long thickening

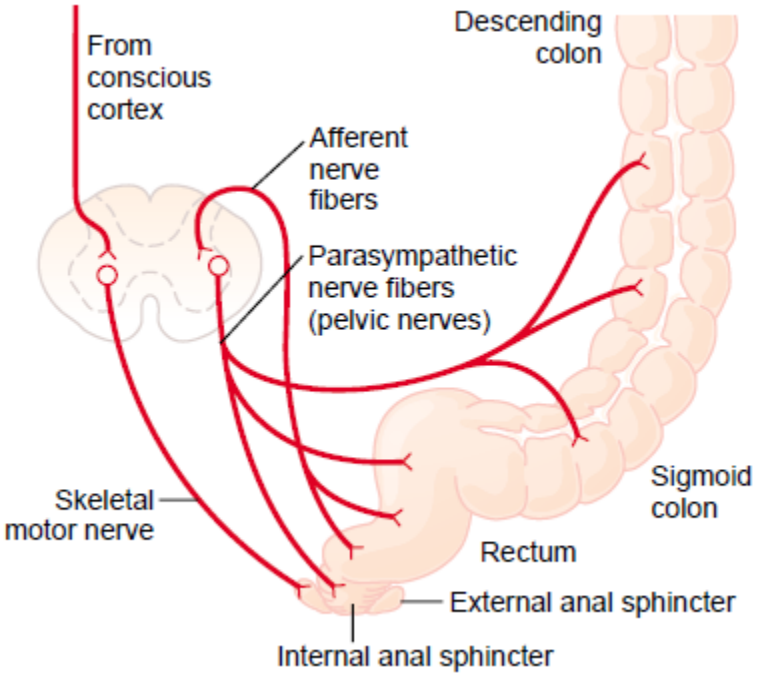
of the circular smooth muscle that lies

Immediately inside the anus

(2) **an *external anal sphincter,*** *composed*

of striated voluntary muscle that both surrounds

the internal sphincter and extends distal to it.



The external sphincter is controlled by nerve fibers in the *pudendal nerve, which is part of the somatic nervous* system and therefore is under *voluntary, conscious*

or at least *subconscious control.*