Physiology Undergraduate League of Students

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set #8

lecture #:	date:	professor:
21	Monday, March 5th	Dr. Martinez

announcements:

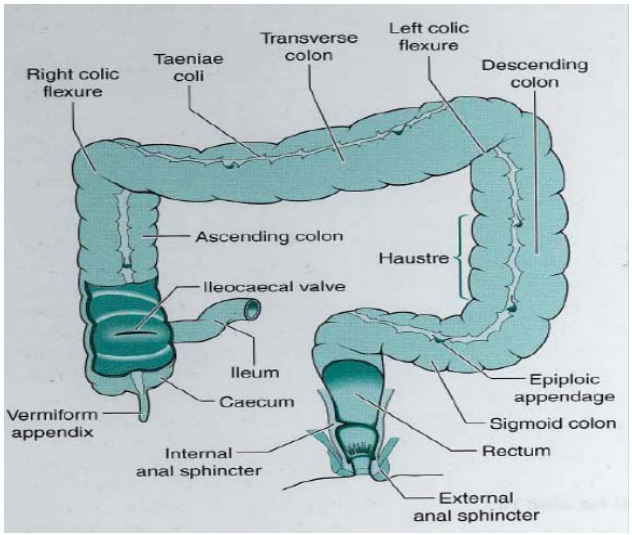
- ***International Phood Phest****: This Friday - March 9 from 2:30 until 4:30 in Shatner Ballroom presented to you by PULS and the Health Science Councils: MBSU, BUGS, MACSS – don't forget to bring your McGill ID card*
- ***ANAT vs PHGY Hockey Game****: March 14th starting at 10am, to sign up to play, email Zach at puls@sus.mcgill.ca or come and cheer on your Physiology team!*
- ***New Discount****: All McGill Physiology students get 20% off Kaplan Test Prep (MCAT, GRE) - for more information: http://www.kaptest.com/puls*

The Gastro test will be held on Monday March 12 at 6:30pm-8:00pm in the Palmer Howard, Room 522. Students who also have the Chemistry 150 exam at the same time will have to sign up at the General office in order to be allowed to write the Gastro test from 5:00pm-6:30pm in another location TBA (you cannot leave the room before 6:30pm).

GOOD LUCK ON THE MIDTERM!!!

THE COLON

Anatomy of the colon



- The **colon** is also known as the large intestine
- The **ileocaecal valve** is a sphincter muscle of about 4 cm that controls transit of chyme from the small intestine to the large intestine
- The **appendix** is a finger-like structure of unknown function in humans. However, it has a lot of lymphatic tissue and so it gets swollen when invaded by bacteria.
- Some studies show that removal of the appendix in humans has very little side-effects, while others say that it causes an increased incidence of cancer and other illnesses
- The appendix has a muscle layer that milks the contents and allows them to leave
- The **caecum** is shaped like a bag and is where the chyme is deposited when it enters the colon.
- The chyme is propelled up the ascending colon by movements of the muscle called **haustration**.
- The **ascending colon** starts at the ileocaecal valve and ends at the **right colic flexure**, which separates it from the **transverse colon**
- Between the transverse and **descending colon** is the **left colic flexure**
- Following the descending colon is the **sigmoid colon**, named so because of its sigmoidal "S" shape
- The **rectum** has a slightly different structure than the rest of the colon because its main function is motility
- The **anus** communicates with the external environment

Layers of the colon

- The colon has the same layers as the small intestine:
  - The mucosa and submucosa
  - The muscle layers (circular and longitudinal)
  - The serosa (layer that covers the intestine)

Taeniae coli

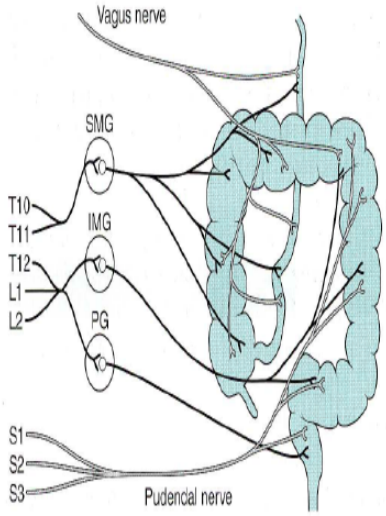
- Aside: Taeniae look like long worms (1.5m) that are found in tropical countries
- The taeniae coli in humans is a condensation of the longitudinal muscle layer that form the three parts of the colon and plays a role in motility
- We do have a longitudinal layer of muscle in the colon, but it is very thin

More anatomy of the colon

- The colon is 1.5m long (much shorter than the small intestine) and 6cm in diameter
- It also **lacks microvilli** because it doesn't need to increase the surface area for absorption as much as the small intestine (it absorbs water and electrolytes, not nutrients)

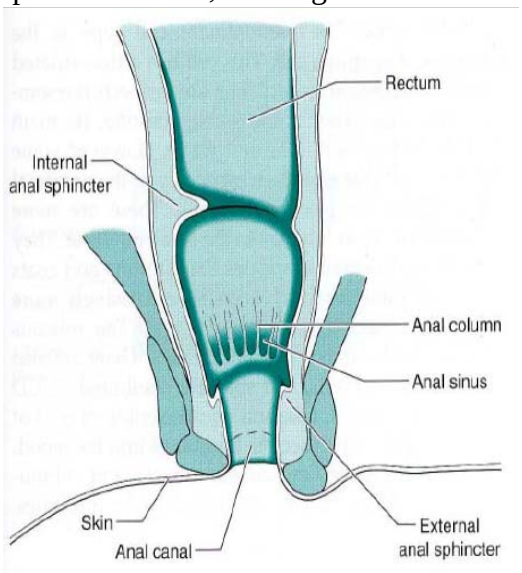
Functions of the colon

- The main function of the colon is storage of fecal material to be released to the external environment
- The transit of material in the stomach and small intestine is from 8 to 10 hours, and up to a week in the colon
- After 3 to 4 days, 80% of the material you ingested has gone down through the colon
- Water and electrolytes are absorbed mostly in the proximal part of the colon
    - Absorption of water is important because every time we drink water, we use energy, so we optimize energy expenditure by absorbing the water in the colon
- Production of mucus
    - Makes condense material slippery so that passage through the colon is facilitated and defecation is easier
- Provides an environment that is favorable for bacteria that produce vitamins
    - Some vitamins are not produced by the body and are hard to find in the diet (e.g. Vitamin K)
    - Experiments on rats that had diseases like AIDS (no immunological system) that had to be kept in a sterile environment. The rats died of hemorrhage because they did not have bacteria to provide them with vitamin K for blood clotting



Innervation of the colon

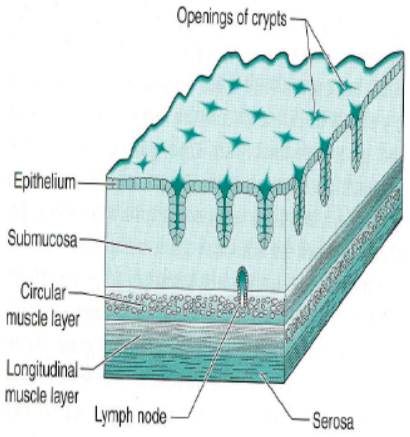
- Provided by the parasympathetic and sympathetic nervous system
- Parasympathetic innervations provided by the vagus nerve: on the **ascending and transverse colon**
- The distal portion of the colon is innervated by the parasympathetic fibers of the sacral nerve (**pudendal nerve**) on the *descending, sigmoid colon, and the rectum*
- **Voluntary/somatic** is part of the pudendal nerve, which gives off fibers that control the external anal sphincter
- The external anal sphincter is under voluntary control: the pudendal nerve allows you to contract the sphincter and prevent defecation



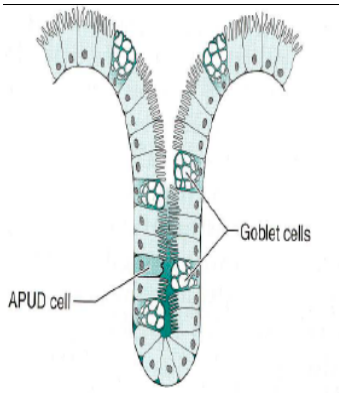
The Rectum

- **Internal anal sphincter**: non-voluntary control
- **External anal sphincter**: voluntary control
- There are also veins running parallel to the rectum, where the portal circulation (portal vein) anastomoses with the systemic circulation (inferior vena cava)
- These veins can dilate and produce **hemorrhoids**
- The portal circulation has low pressure while the systemic circulation has high pressure, causing a weak point where hemorrhoids develop
    - Could also happen because we are standing

Colon Wall Structure



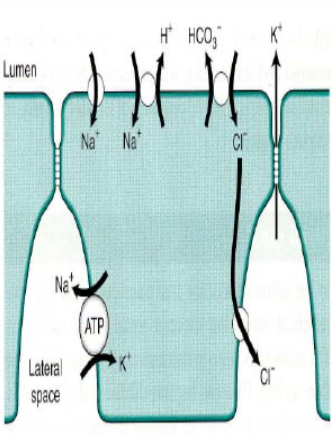
- There is the epithelium, mucosa and the submucosa
- Glandular structures for the production of mucus
- Lymph nodes that go through the submucosa and the muscle layer
- Circular muscle layer
- Longitudinal muscle layer
- Serosa
- *Pretty much the same layers as the small intestine, except that the longitudinal muscle layer is thinner because we have the taeniae coli*



Cell Types

- Absorptive (secretory) cell with microvilli
- Goblet cells
- APUD cells that produce hormones

Absorption and Secretion of Electrolytes



- Absorption of sodium and chloride in the colon, which creates an osmotic gradient, thus forcing the water to follow
- Secretions in the colon are rich in bicarbonate and potassium
    - Bicarbonate is exchanged with chloride
    - Potassium goes through the intracellular space in favor of the electrical gradient
- There is a sodium pump that interchanges sodium with hydrogen
    - When a lot of sodium enters the cell, the outside of the cell becomes negative
    - Potassium, because it is a positive ion, follows the negative charge and exits the cell down the electrical gradient

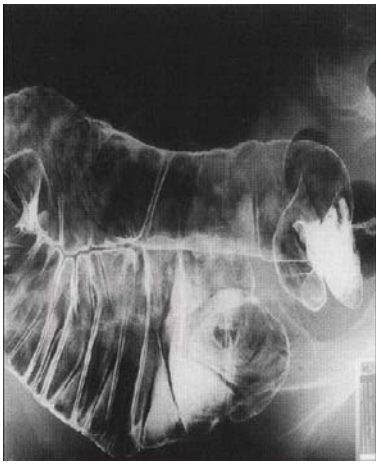
- A sodium-potassium ATPase pump keeps the sodium concentration in the cell low
- There also seems to be some reabsorption of potassium in the descending colon
- The secretion in the column is predominantly reaching bicarbonate and potassium
- ACh and VIP (parasympathetic) stimulate secretion
- Adrenaline and somatostatin (sympathetic) inhibit secretion
- Aldosterone, produced by the adrenal glands, stimulates sodium and water absorption

Bacteria

- There are 10^{14} cells in the human body, only 10% are human cells (the rest are bacterial)
- The bacteria are mostly in the colon, because the other parts of the GI system are sterile
- Bacteria in the colon are anaerobic (do not require oxygen)
- The actions of bacteria produce vitamins
    - Vitamin B12 produced by the bacteria could get absorbed in the colon, (we know that it is absorbed in the terminal ileum) however, it is not 100% sure how it is absorbed
    - Vitamin K is also synthesized, but considering it is **lipid-soluble**, it has no problem going through the lipid bilayer
- It converts primary bile acids to secondary bile acids, and also converts bilirubin to urobilinogen or sterobilinogen (gives color to the feces)

CASE STUDY: HIRSCHSPRUNG'S DISEASE (MEGACOLON)

A newborn infant has a distended abdomen and has not passed meconium (feces) since it was born 2 days ago. After a few days, the baby began to vomit excessively and the obstruction was still present. A biopsy of the rectum was performed and Hirschprung's disease was diagnosed. Surgery was performed to remove the distal colon and suture the remaining colon to the rectum. The child made a full recovery.



1. Why is the child's abdomen distended and why had he passed nomeconium since he was born?

- Lumen of the colon is narrowed because of tonic contraction of the muscle
- Material accumulates proximal to the narrowed region and therefore becomes distended
- The relaxation of the internal anal sphincter (a reflex) is impaired

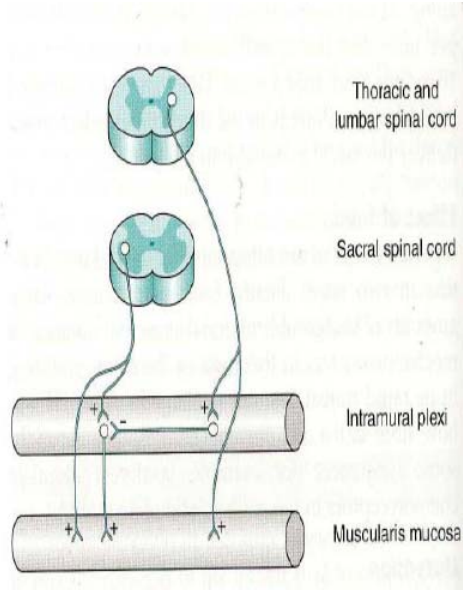
1 in 5000 children born have megacolon, and it is more frequent in children with Downe's Syndrome.

2. What is the defect in Hirschprung's disease? What did the biopsy reveal? Expand on the innervation of the intestine and the function of the enteric nervous system.

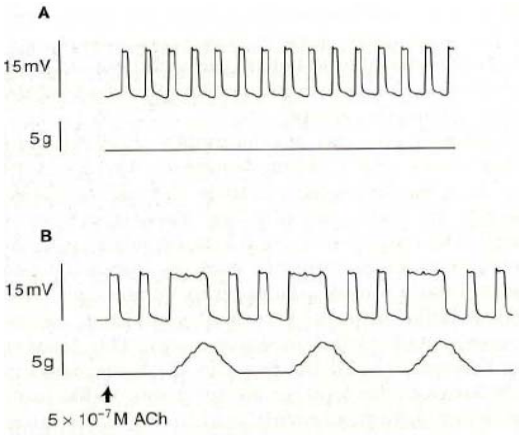
- There is a loss of ganglion cells in the myenteric plexi, leading to tonic contraction of the muscle and inhibition of motility

- Innervation to the myenteric and submucosal plexi is absent, so excitatory and inhibitory stimuli are not present
- We have already talked about innervation of the colon
    - Sympathetic: superior mesenteric, inferior mesenteric, pelvic ganglion
    - Parasympathetic: vagus and pudendal nerves

Motility of the Colon



- Intrinsic innervation which is lost in Hirschsprung's Disease
- Extrinsic innervation
- A neuron in the intramural plexus senses distension of the colon and it will contract the muscle in that area.
- This same neuron also sends an inhibitory signal to the neuron downstream, creating a relaxation of the muscle.
- This allows movement of material down the colon
- There is also innervation at the spinal cord and brainstem level
- Mixing movement called haustration
- Propulsion (peristalsis) is sequential haustration
    - It is much more intense in the rectum than the rest of the colon
    - At rest, it moves material between 5 and 10 cm per hour
    - When you eat, propulsion is stimulated and you feel the need to defecate
- Ingestion of fiber causes distension and stimulation of movement in the colon, but it also absorbs water and therefore makes feces more fluid
    - Fiber is recommended to people who have constipation
- Laxatives bind to chemo-receptors in the colon and stimulate motility
- Emotions also affect motility
    - Depression causes a decrease in motility
    - Anger causes an increase in motility



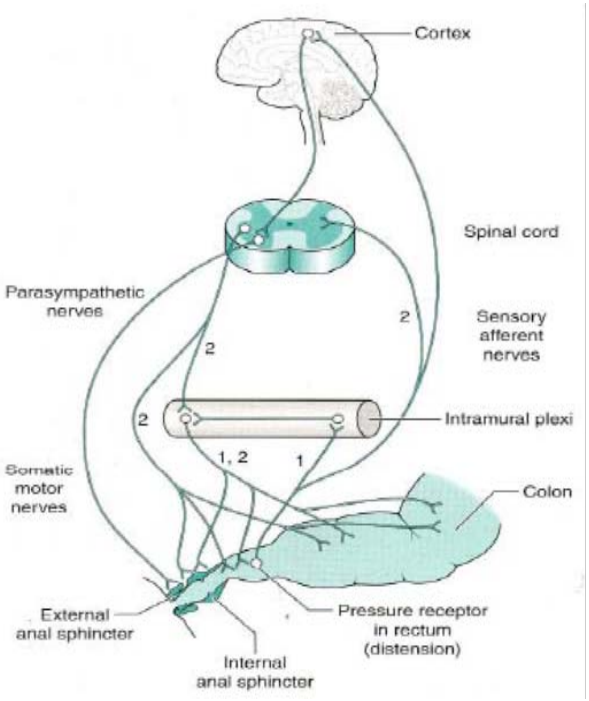
- In the figure, the top oscillation in A shows the electrical potential of a slow wave. We see that there is no contraction during a slow wave
- In B, we see that when there is an increase in duration of the slow wave by injection of ACh (parasympathetic). By prolonging the wave, threshold would be achieved and contraction will occur. This is the mechanical activity

The Defecation Reflex

- If you have a large amount of chyme in the sigmoid colon, distension occurs
- This produces distension of the rectum which allows the chyme to pass
- The rectum then contracts after the chyme has passed it, allowing chyme to pass into the anus, and the internal anal sphincter relaxes
- Relaxation of the external anal sphincter is voluntary, so the person controls when they defecate

Control of the Defecation Reflex

- The number 1 in the figure indicates the essential components of the defecation reflex
- A pressure receptor in the colon detects distension and sends a message to a neuron in the intramural plexi, which causes contraction of the muscle and relaxation of the internal anal sphincter
- Cortical mechanisms are involved in relaxation of the external anal sphincter
- Even if you section the spinal cord, the reflex is still there and so the person will not spontaneously defecate



3. Why was it necessary to remove a segment of the large intestine?

- You must remove the segment of colon that is damaged in order to allow the function of the colon to return to normal
- The muscle in the damaged segment remains tonically contracted because there is no innervation to it, causing distension of the colon proximal to this region
- Distension in the colon is alleviated when you remove the aganglionic segment