Fellow
G-ECHO

Anatomy and Physiology of the Large Bowel

Presented by

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Outlines

- Introduction
- Macroscopic Features
- Microscopic Features
- Developmental Anomalies
- Colonic Motor and Sensory Function
- Intestinal Electrolytes Absorption and Secretion
- Digestion and Absorption of Carbs , Proteins and Fats

- The colon is a tubular structure about 30 to 40 cm in length at birth and measuring some 150 cm in the adult, or about one quarter the length of the small intestine

- The colon begins at the IC valve and ends distally at the anal verge. It consists of 4 segments: cecum and vermiform appendix, colon (ascending, transverse, and descending portions), rectum, and anal canal

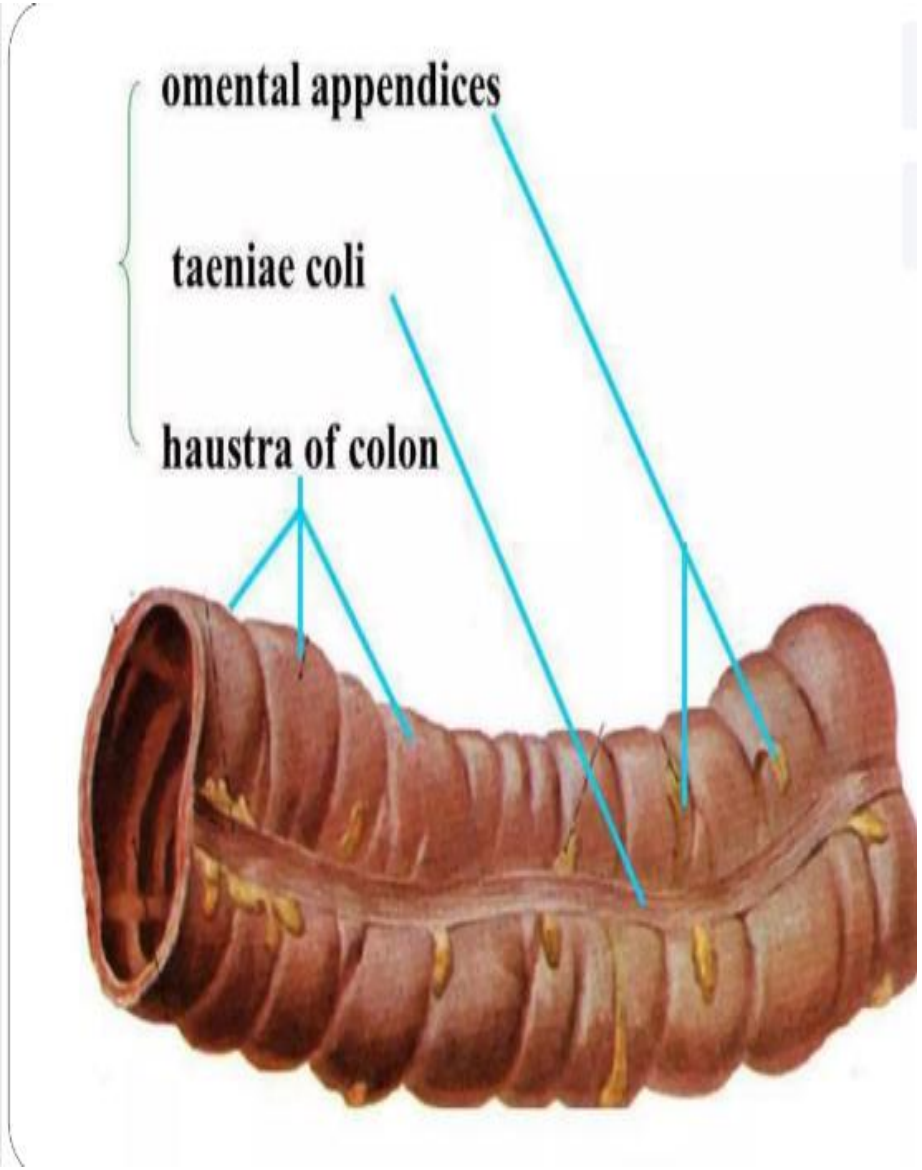
- The diameter of the colon is greatest in the cecum (7.5 cm) and narrowest in the sigmoid (2.5 cm) until it balloons out in the rectum just proximal to the anal canal

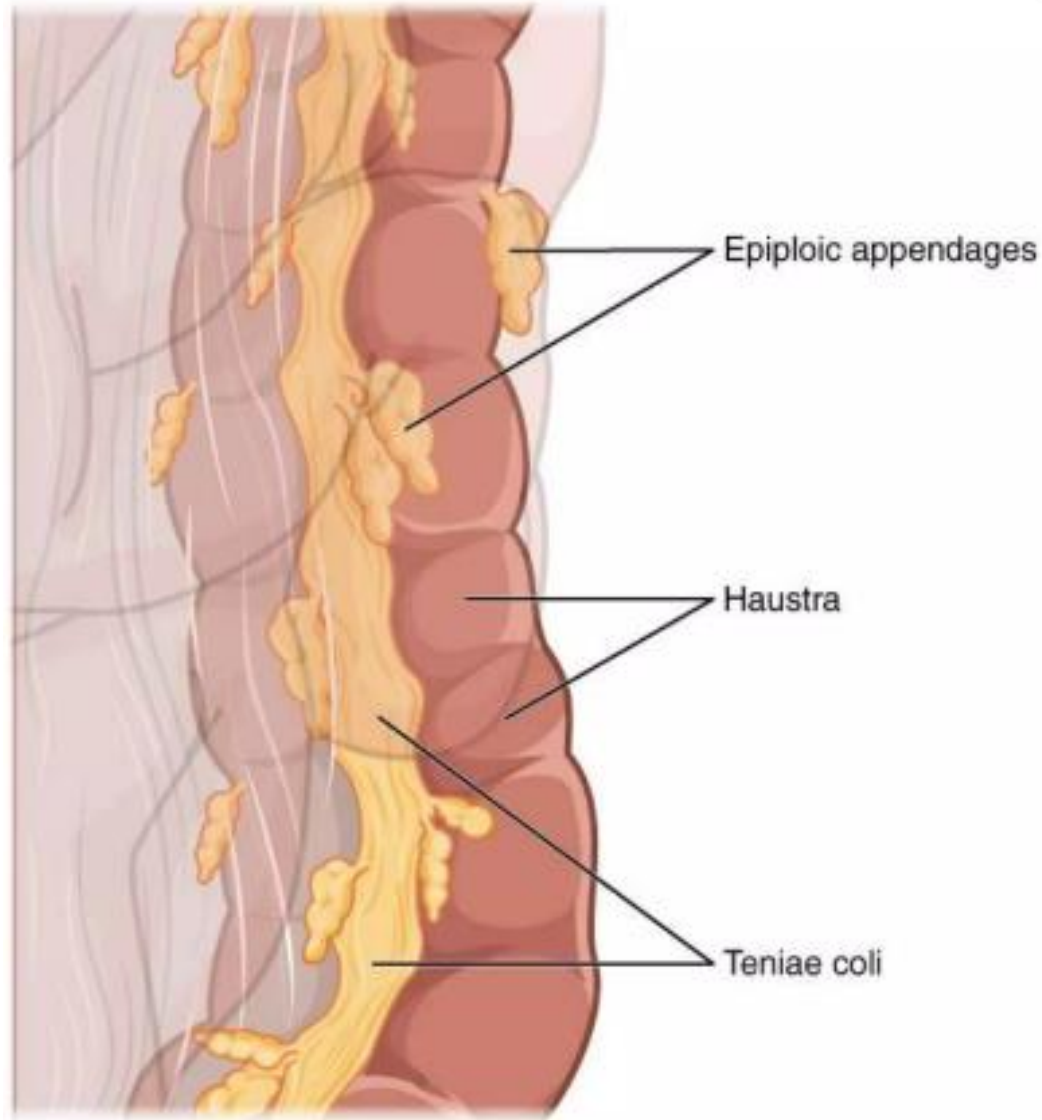
- The colon is distinguished from the small intestine by several features

1. Outer longitudinal muscle Fibers that coalesce into 3 discrete bands called taeniae: the taenia liberis (free tenia), taenia omentalis (omental tenia), and taenia mesocolica (mesenteric tenia)

2. Outpouchings, or haustra, occur between the taeniae, and their mucosal surface is sectioned by semilunar folds to give the serosa a sacculated and puckered appearance

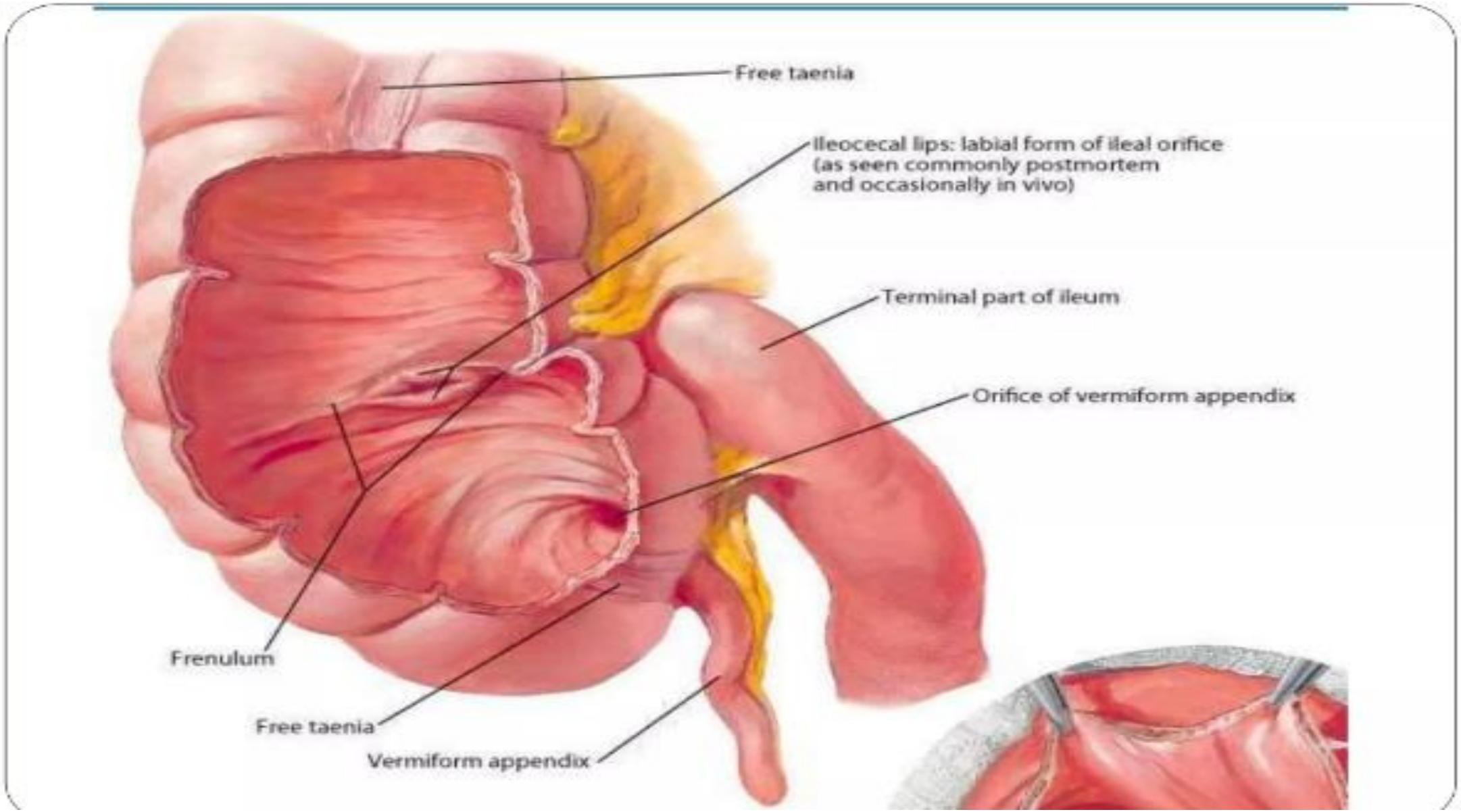
3. Small sacs of peritoneum filled with adipose tissue, the appendices epiploicae, are found on the external surface of the colon


omental appendices
taeniae coli
haustra of colon


Epiploic appendages
Haustra
Teniae coli

Caecum

- The cecum is the most proximal portion of the colon projecting downward as a blind pouch below the entrance of the ileum
- Length 6 – 8 cm
- Width 7.5 cm
- Has two openings
- The IC valve passes perpendicularly through the posteromedial wall of the cecum
- The appendiceal orifice is roughly 2.5 cm inferior to the IC valve, and the vermiform appendix is a blind outpouching extending from the cecum


Free taenia
Ileocecal lips: labial form of ileal orifice
(as seen commonly postmortem
and occasionally in vivo)
Terminal part of ileum
Orifice of vermiform appendix
Frenulum
Free taenia
Vermiform appendix

Ascending Colon

- The ascending colon is narrower than the cecum and extends about 12 to 20 cm from the level of the IC valve to the inferior surface of the posterior lobe of the liver, where it angulates left and forward, forming the hepatic flexure

- The ascending colon is covered with peritoneum in about 75% of individuals and thus is usually considered to reside in the retroperitoneum

Transverse Colon

- At the hepatic flexure, the colon turns medially and anteriorly to emerge into the peritoneal cavity as the transverse colon, fully enveloped in mesentery.

- The transverse is the longest (40 to 50 cm) and most mobile segment of the colon. It lies between the hepatic and splenic flexures and drapes itself across the anterior abdomen and anterior to the stomach

Descending and Sigmoid Colon

- The descending colon is about 25 to 45 cm in length and travels posteriorly and then inferiorly in the retroperitoneal compartment to the pelvic brim.

- It emerges from the retroperitoneum into the peritoneal cavity as the sigmoid colon, an S-shaped redundant segment of variable length, tortuosity, and mobility.

Rectum

- The rectum is 10 to 12 cm in length and begins at the peritoneal reflection, follows the curve of the sacrum passing down and posteriorly, and ends at the anal canal. The rectum narrows at its junction with the sigmoid, expanding proximal to the anus

- The anorectal junction is 2 to 3 cm anterior to the tip of the coccyx. The rectum does not have sacculation, appendices epiploicae, or mesentery

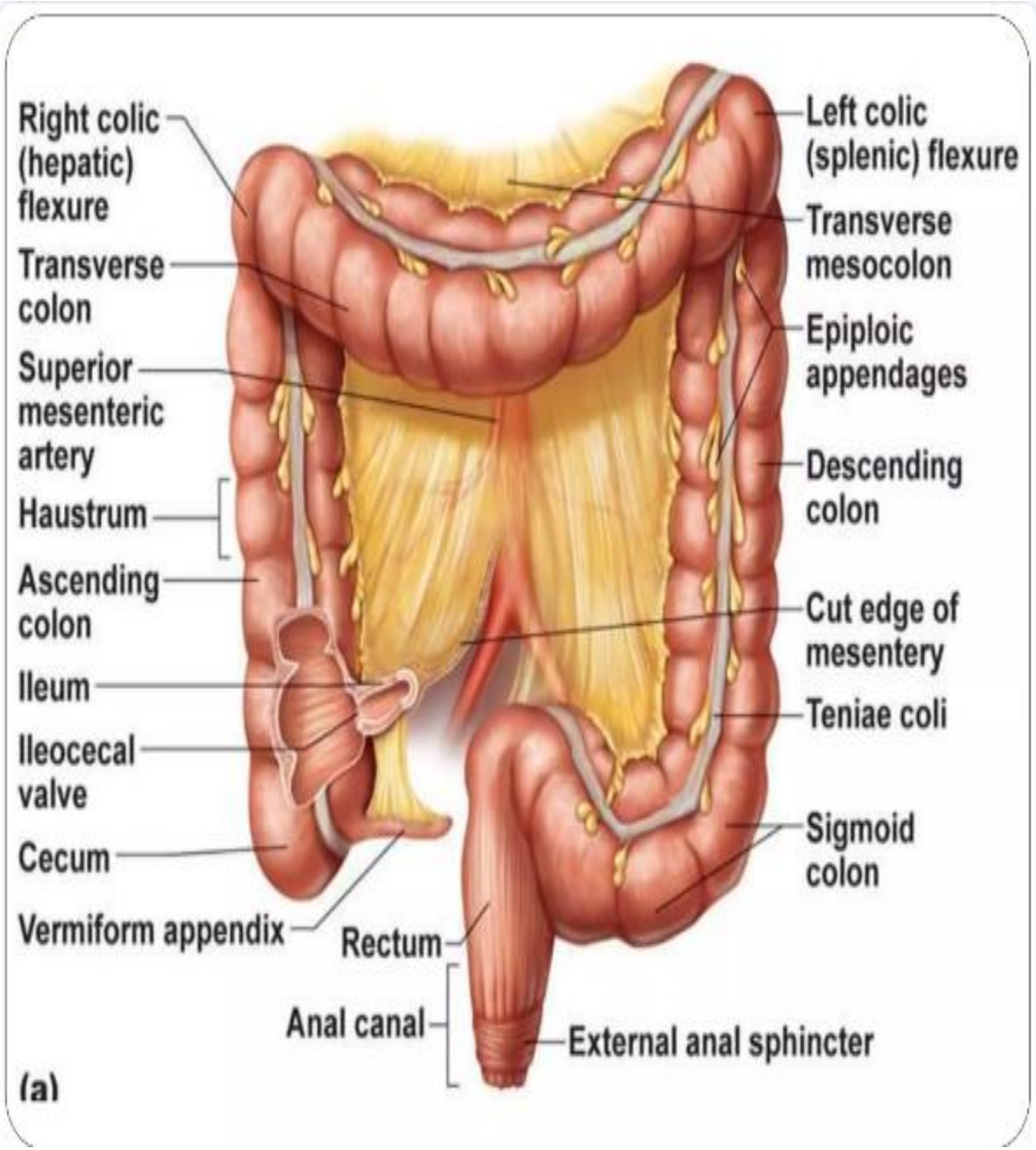
- The luminal surface of the rectum has 3 transverse folds called the valves of Houston

Anal Canal

- It’s 4.5 to 5 cm long in the adult which occupies the ischiorectal fossa, passing inferiorly and outward toward the anal opening

- The anorectal junction is situated within the pelvic diaphragm and made up of the levator ani, coccygeus, and puborectalis muscles which encircle it; contraction of these muscles allows the anorectum to retain stool, and relaxation allows for defecation
- The internal anal sphincter is made up of the circular smooth muscular layer of the intestine, which surrounds the upper three quarters of the canal

- The external sphincter is made up of striated muscle which surrounds the anal canal, and its fibers blend with those of the levator ani muscle to attach posteriorly to the coccyx and anteriorly to the perineal body



GROSS FEATURES

CECUM	ASCEN. COLON	TRANS. COLON	DESC. COLON	SIGMOID COLON
6cm	20cm	38 cm	25 cm	25-38 cm
Intra peritoneal	retroperitoneal	Intra peritoneal	retroperitoneal	intraperitoneal
No mesentry	Short mesentry	Has mesentry	Short mesentry	Largest mesentry

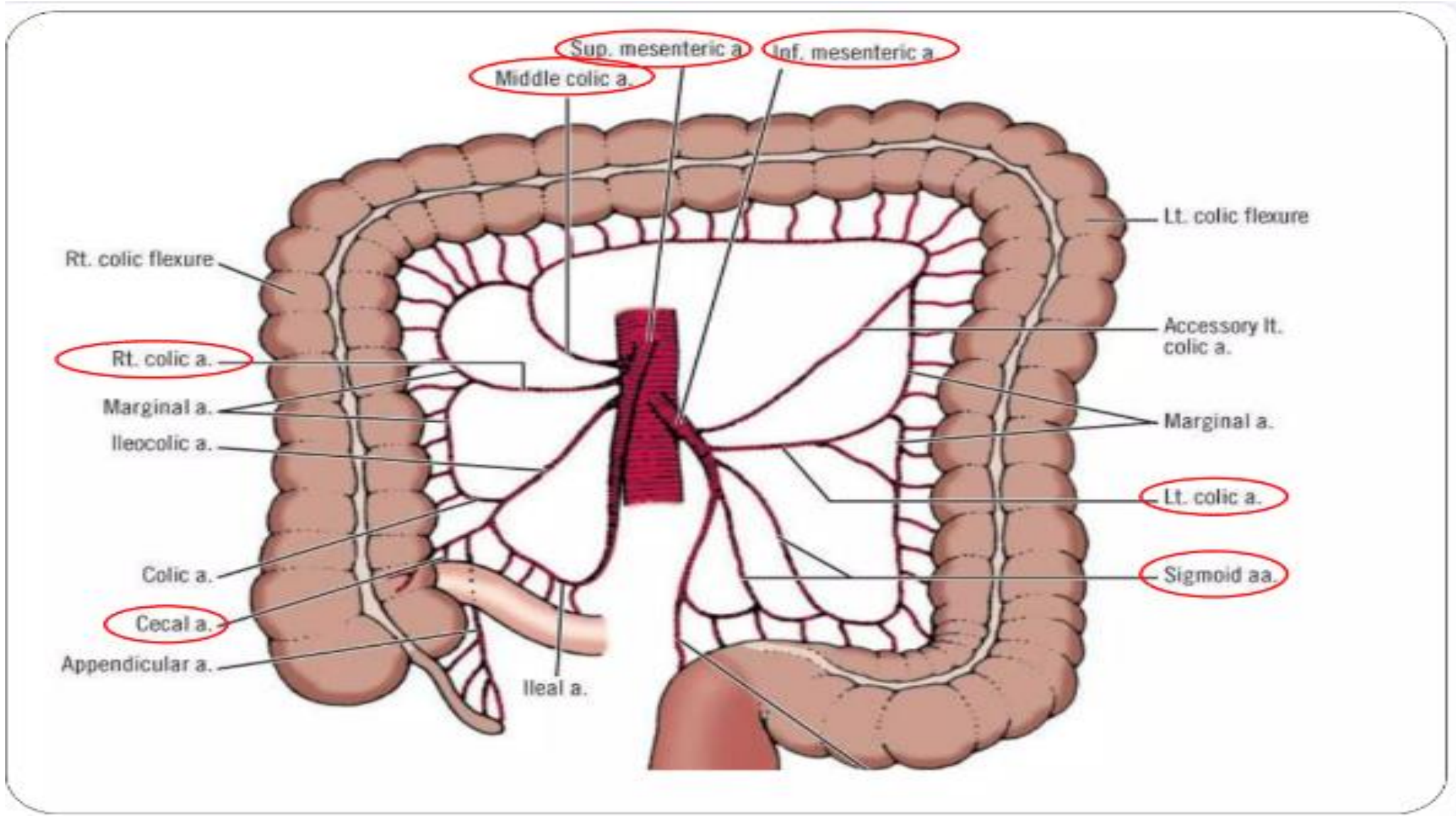
Vasculature

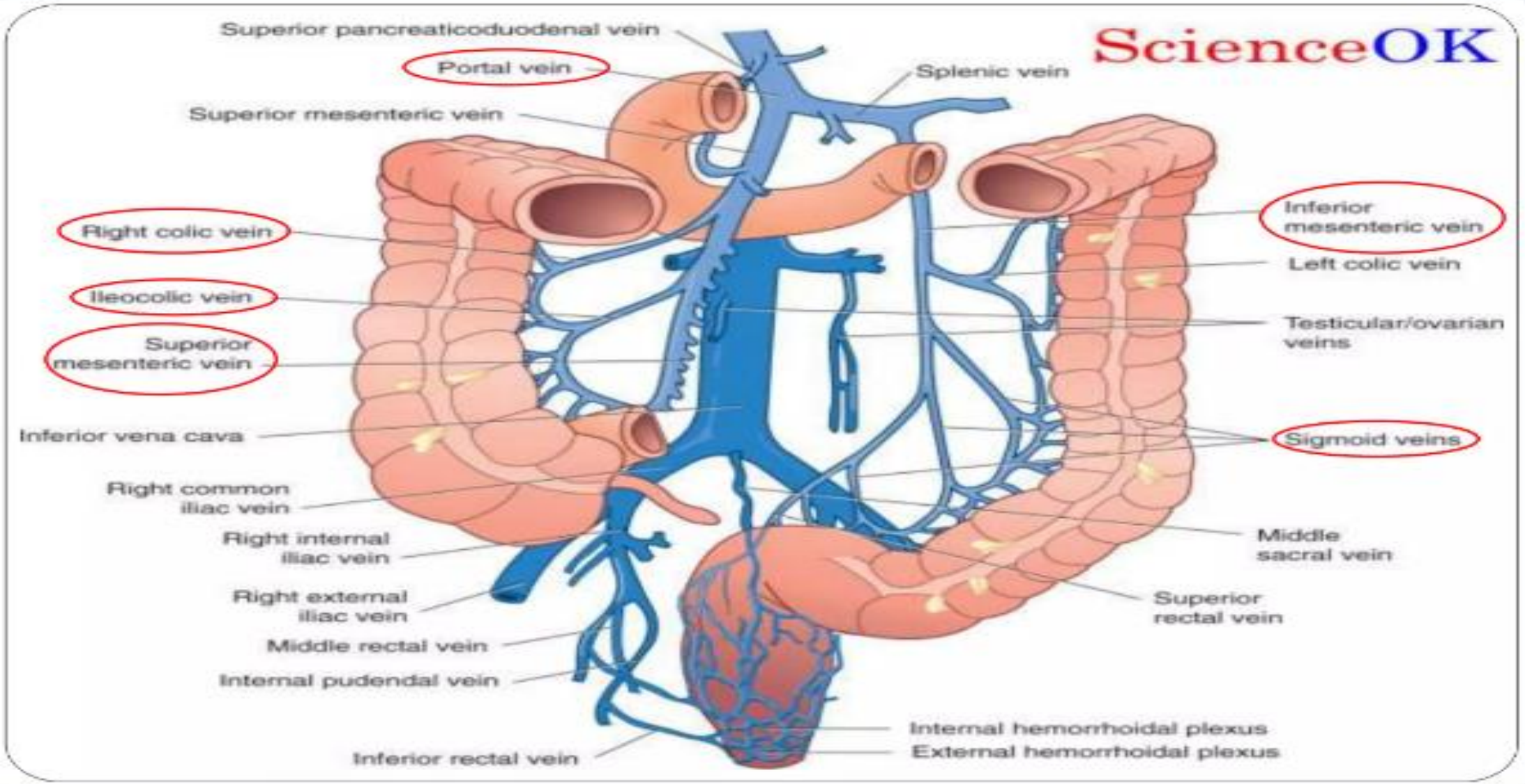
- The SMA delivers oxygenated blood to the distal duodenum, jejunum and ileum, ascending colon, and proximal two thirds of the transverse colon

- Branches of the inferior mesenteric artery supply the remainder of the colon

- The arterial supply of the anal area is from the superior, middle, and inferior hemorrhoidal arteries, which are branches of the inferior mesenteric, hypogastric, and internal pudendal arteries, respectively

- Venous drainage of the anus is by both the systemic and portal systems. The internal hemorrhoidal plexus drains into the superior rectal veins and then into the inferior mesenteric vein, which, with the SMV, joins the splenic vein to form the portal vein


Sup. mesenteric a.
Inf. mesenteric a.
Middle colic a.
Lt. colic flexure
Rt. colic flexure
Accessory lt. colic a.
Rt. colic a.
Marginal a.
Marginal a.
Ileocolic a.
Lt. colic a.
Colic a.
Sigmoid aa.
Cecal a.
Appendicular a.
Ileal a.


ScienceOK
Superior pancreaticoduodenal vein
Portal vein
Splenic vein
Superior mesenteric vein
Right colic vein
Ileocolic vein
Superior mesenteric vein
Inferior vena cava
Right common iliac vein
Right internal iliac vein
Right external iliac vein
Middle rectal vein
Internal pudendal vein
Inferior rectal vein
Inferior mesenteric vein
Left colic vein
Testicular/ovarian veins
Sigmoid veins
Middle sacral vein
Superior rectal vein
Internal hemorrhoidal plexus
External hemorrhoidal plexus

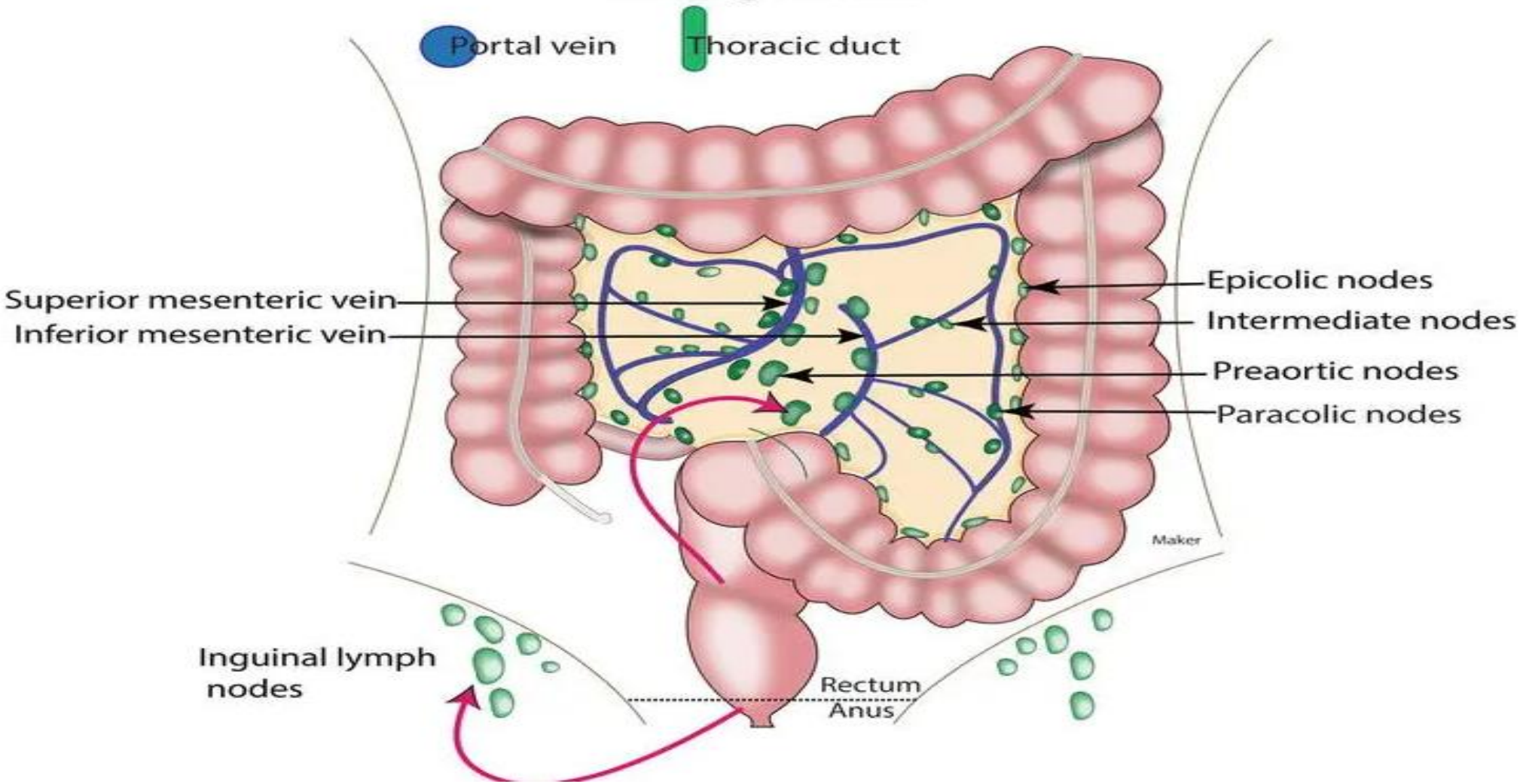
Lymphatic Drainage

- The lymphatic drainage of both the small intestine and colon follows their respective blood supplies to lymph nodes in the celiac, superior preaortic, and inferior preaortic regions. Lymphatic drainage proceeds to the cisterna chyli and then via the thoracic duct into the left subclavian vein

- Proximal to the dentate line, lymphatic drainage is to the inferior mesenteric and periaortic nodes, whereas distal to the dentate line it flows to the inguinal lymph nodes

Lymphatic Drainage of Lower GI Tract

The Big Picture



Microscopic Features

- The histological structure of the gut shows several features that are common to all its part , but it differs in that :

- Has no Villi

- Has no plicae circulares

- Has a smooth interior Surface

- The wall of the colon is composed of 4 layers: mucosa (or mucous membrane), submucosa, muscularis (or muscularis propria), and serosa

The Mucosa

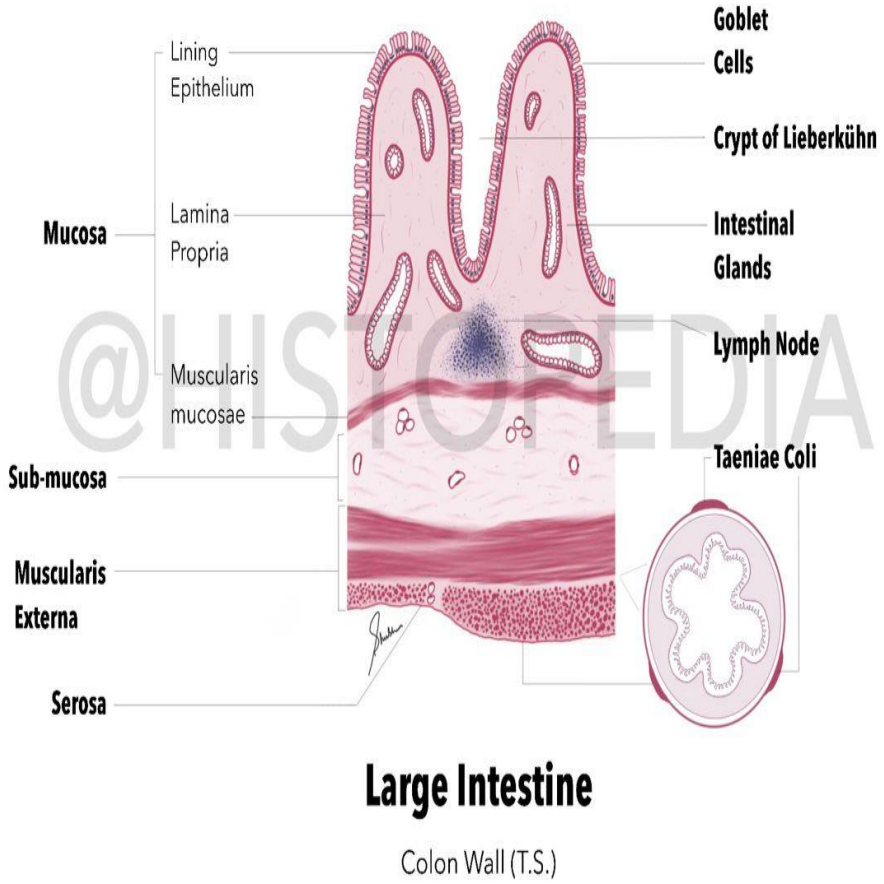
- Consists of :

1. Epithelium – simple columnar

2. Intestinal gland – penetrated in the mucosa is tubular –shaped lined by goblet cells ,absorptive cells (enterocytes)

3. Lamina propria – layer of CT underlying the epithelium rich in MALT

4. Muscularis propria – thin layer of smooth muscle separate LP from submucosa



The Submucosa

- The submucosa supports the mucosa in specialized functions of nutrient, fluid, and electrolyte absorption by conveying a rich network of blood vessel

- The submucosa is a fibrous connective tissue layer that lies between the muscularis mucosae and the muscularis propria

- It contains lymphocytes, fibroblasts, mast cells, blood and lymphatic vessels, and a nerve Fibers plexus—**Meissner plexus**— composed of non-myelinated postganglionic sympathetic Fibers and parasympathetic ganglion cells

The Muscularis Propria

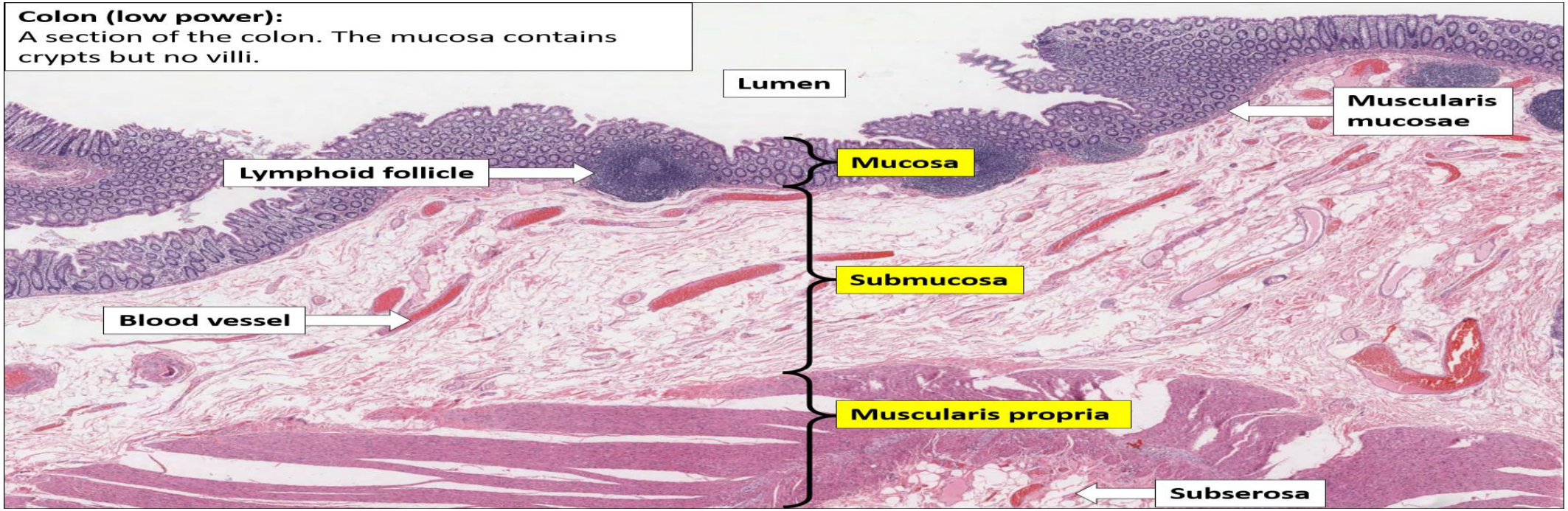
- The muscularis propria is mainly responsible for contractility and peristaltic movement of luminal contents through the GI tract

- It consists of 2 layers of smooth muscle: an inner circular coat and an outer longitudinal coat arranged in a helicoidal pattern

- A prominent nerve fiber plexus called the **myenteric or Auerbach plexus** is located in the plane between these 2 muscle layers

The Serosa

- The serosa is the outermost layer of the intestinal wall and is composed of a thin layer of mesothelial cells, representing an extension of the visceral peritoneum and mesentery as it envelops the intestine



Developmental Anomalies

1. Body wall

Omphalocele – Gastroschisis

2. Omphalomesenteric (Vitelline) Duct Abnormalities

Meckel Diverticulum - Omphalomesenteric (Vitelline) Cyst

3. Malrotations

4. Intestinal Atresia and Stenosis

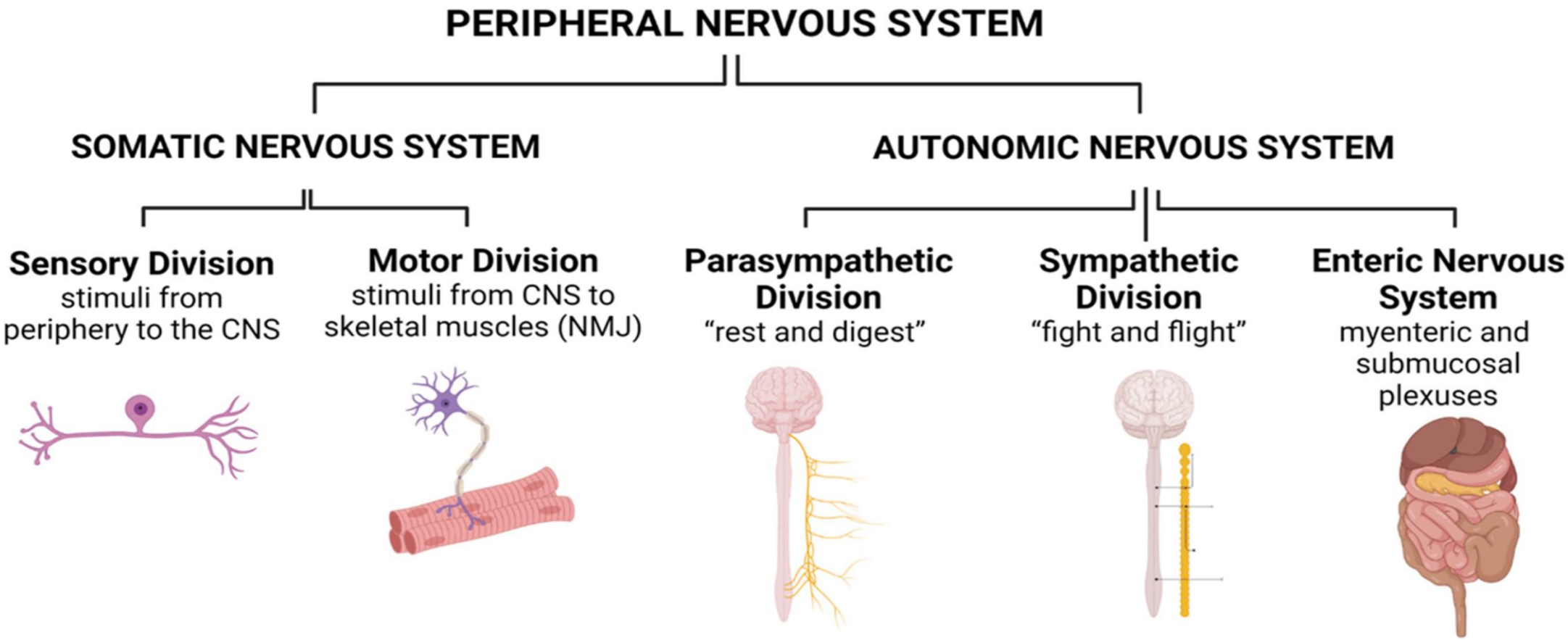
5. Anorectal Malformations

Ano cutaneous Fistula - Rectourethral Fistula - Anorectal Agenesis - Rectal Agenesis (Atresia) - Anal Stenosis - Persistent Cloaca

6. Enteric Nervous System

Hirschsprung Disease - Intestinal Neuronal Dysplasia - Chronic Intestinal Pseudo-Obstruction

PNS


PERIPHERAL NERVOUS SYSTEM
SOMATIC NERVOUS SYSTEM
AUTONOMIC NERVOUS SYSTEM
Sensory Division
stimuli from periphery to the CNS
Motor Division
stimuli from CNS to skeletal muscles (NMJ)
Parasympathetic Division
"rest and digest"
Sympathetic Division
"fight and flight"
Enteric Nervous System
myenteric and submucosal plexuses

Enteric Nervous System – ENS

- **Myenteric plexus – Auerbach's**

Located btw the outer longitudinal and the inner circular layer of the smooth muscles = extend from the upper oesophagus to the anus

Multipolar – motor function

Controls GIT movement

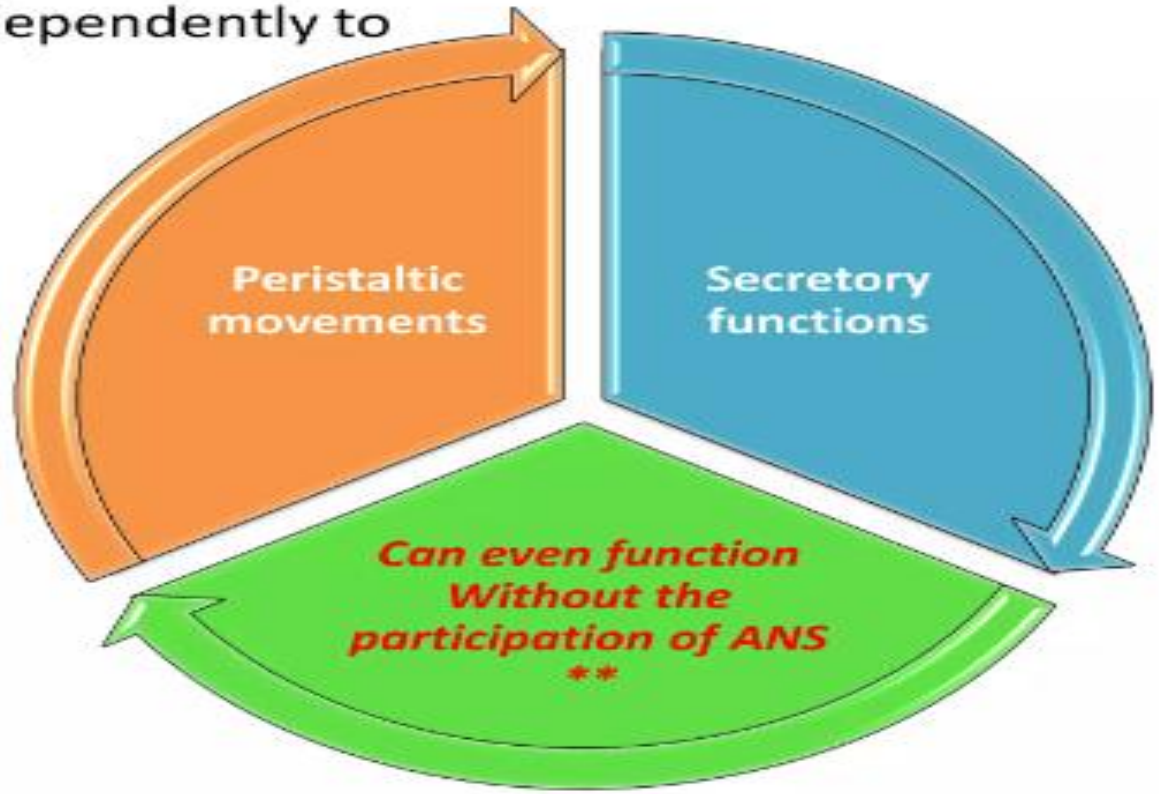
- **Submucosal – Meissner's plexus**

Located btw the inner circular layer of the smooth muscles and the muscularis mucosa = extend from the stomach to the anus

Bipolar / multipolar – sensory function

Controls GIT secretions and local blood flow

ENS works independently to maintain



Three Types of Functional Neurons

- **Sensory neurons** which is activated by distension of the gut wall-stretch receptor

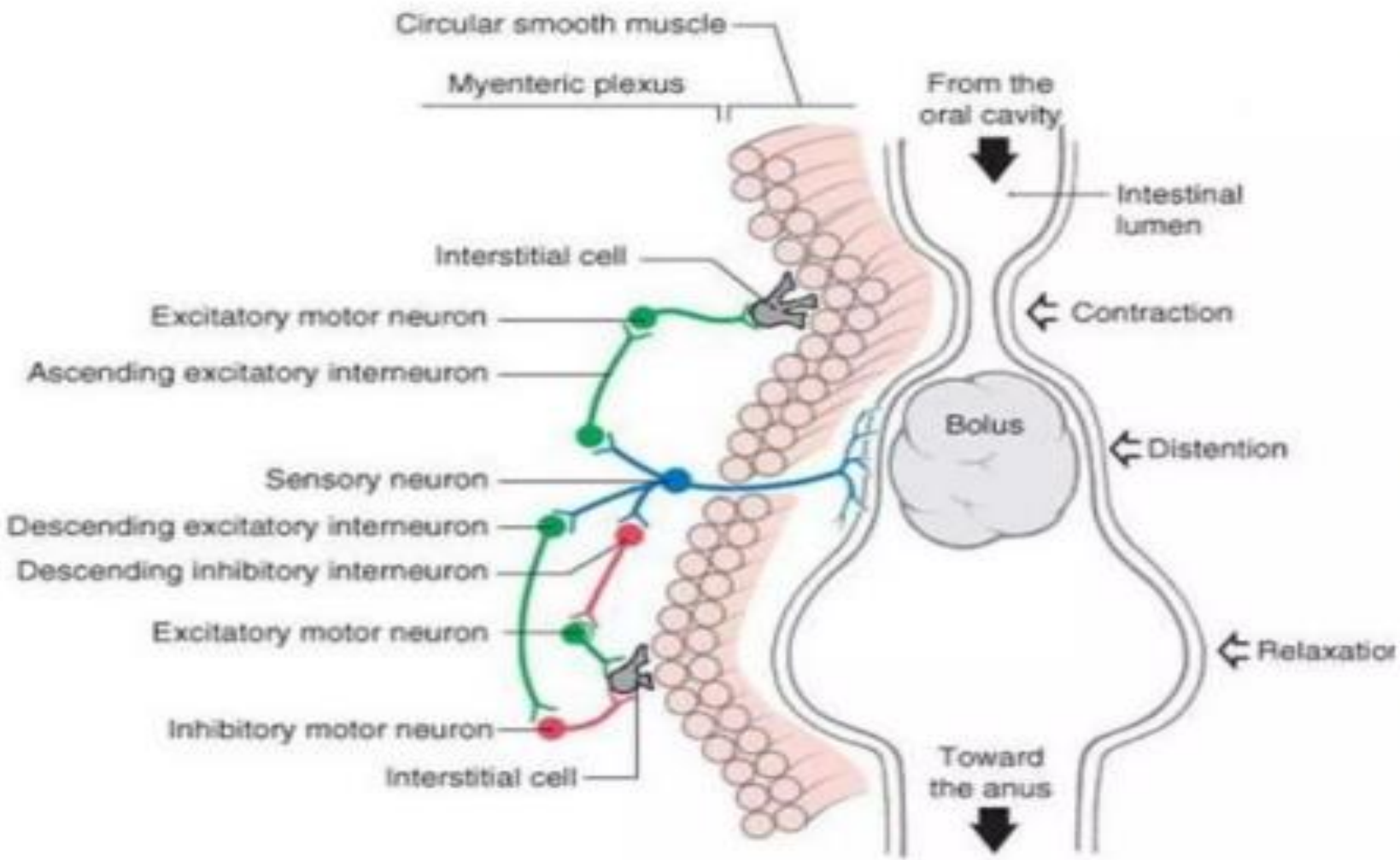
  Receive chemical stimulation from mucosa – chemical receptor

  Axon synapse with interneurons located close to the circular muscles layer

- **Interneurons** their axons are projected longitudinally up & down to a series of motor neurons which are located mostly in the myenteric plexus & some in submucosal plexus

- **Motor neurons –** excitatory (Ach) , inhibitory (ATP , VIP & NO)

GIT RP



Gastro-intestinal reflex pathway

Movement of the Colon

- **Mixing movement – haustrations**

Proximal half – large circular contraction of the circular muscle and longitudinal muscle

Unstimulated area bulge = haustrations

< 2 mins

- **Propulsive movement – mass movement**

Distal half – longer and occurs 1-3 times per day

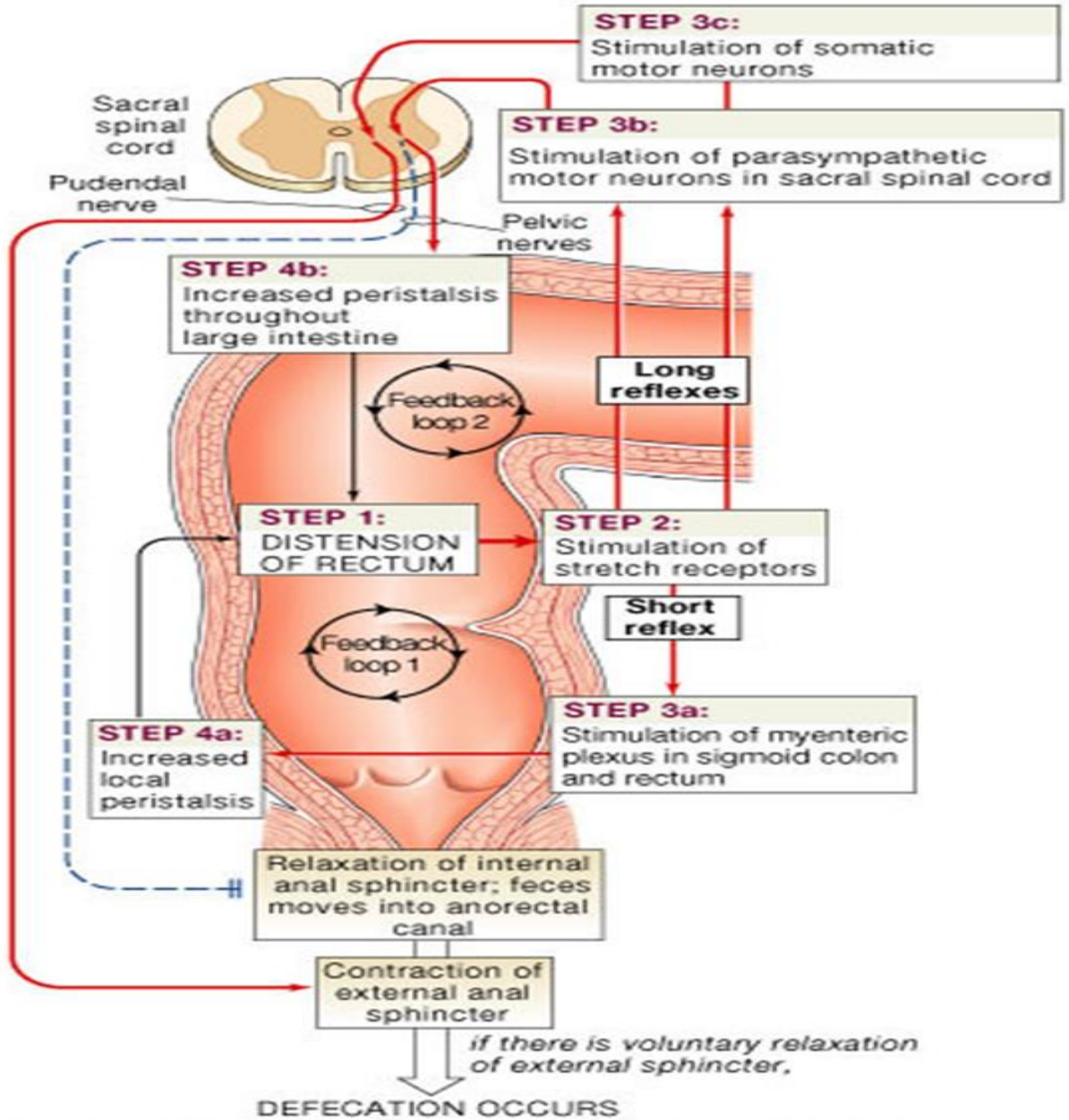
Defecation Reflex

- **Defecation** is the act of eliminating solid or semisolid waste materials from the digestive tract , which is controlled by two types of reflexes:

- **Intrinsic myenteric reflex** = faces in rectum = rectal wall distension = initiate afferent signal through myenteric plexus = peristalsis and internal – external anal sphincter relaxation then faces toward the anus

- **Parasympathetic reflex** = nerve ending in the rectum = signal to the spinal cord = reflex parasympathetic signal in the pelvic nerve = intensify peristalsis and internal – external sphincter relaxation

- **Urge of defecation** is associated with rectal pressure of about 18 mmhg , when the pressure rise about 55 mmhg internal and external sphincter relax and defecation occurs


STEP 3c:
Stimulation of somatic motor neurons
Sacral spinal cord
STEP 3b:
Stimulation of parasympathetic motor neurons in sacral spinal cord
Pudendal nerve
Pelvic nerves
STEP 4b:
Increased peristalsis throughout large intestine
Long reflexes
Feedback loop 2
STEP 1:
DISTENSION OF RECTUM
STEP 2:
Stimulation of stretch receptors
Short reflex
Feedback loop 1
STEP 4a:
Increased local peristalsis
STEP 3a:
Stimulation of myenteric plexus in sigmoid colon and rectum
Relaxation of internal anal sphincter; feces moves into anorectal canal
Contraction of external anal sphincter
if there is voluntary relaxation of external sphincter,
DEFECATION OCCURS

Role of the Ileocecal Junction

- The ileocecal junction regulates colonic filling and prevents colo-ileal reflux, thereby largely preventing contamination of the small bowel with colonic bacteria. In the fasting state, cecal filling is slow and erratic, and chyme is retained in the distal ileum for prolonged periods

Intestinal Electrolytes Absorption and Secretion

- Most of the nutrient transport occurs in the small intestine, whereas the colon is primarily responsible for water and electrolyte transport.

- The GI tract is responsible for handling approximately 8–10 L of fluid containing approximately 800 mmol of sodium (Na^+), 700 mmol of chloride (Cl^-), and 100 mmol of potassium (K^+) that passes through the intestinal lumen every day.

- The bulk of the transport of these fluids and electrolytes occurs through the small intestine, leaving approximately 1.5 L for the colon to absorb and leaving approximately 100 mL that is lost through the stools every day.

Absorption of Ions – Sodium

- Sodium is actively transported through the intestinal membrane

- 20 – 30 g of Na is secreted in the intestinal secretion each day. Therefore , to prevent net loss of Na into the faeces , the intestine must absorb 25 – 35 g each day

- Sodium is also co transported through several specific carrier proteins , including

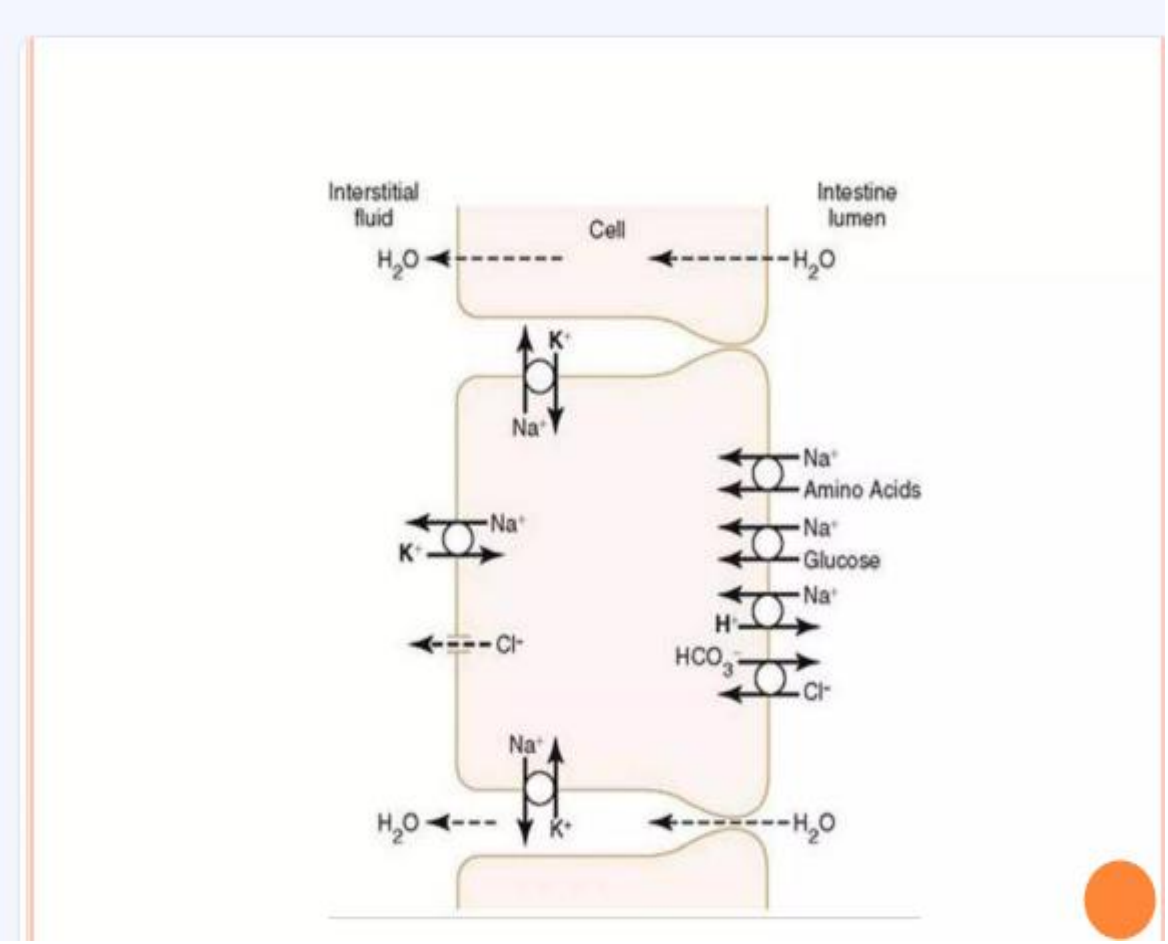
1. Sodium – glucose co transporter 1 (SGLT1)
2. Sodium amino acid co transporters
3. Sodium –hydrogen exchanger

At the same time, they also provide secondary active absorption of glucose and amino acids , powered by the active NA+K+ATPase on the basolateral membrane

There are two stages in the transport of Na+ through the intestinal membrane :

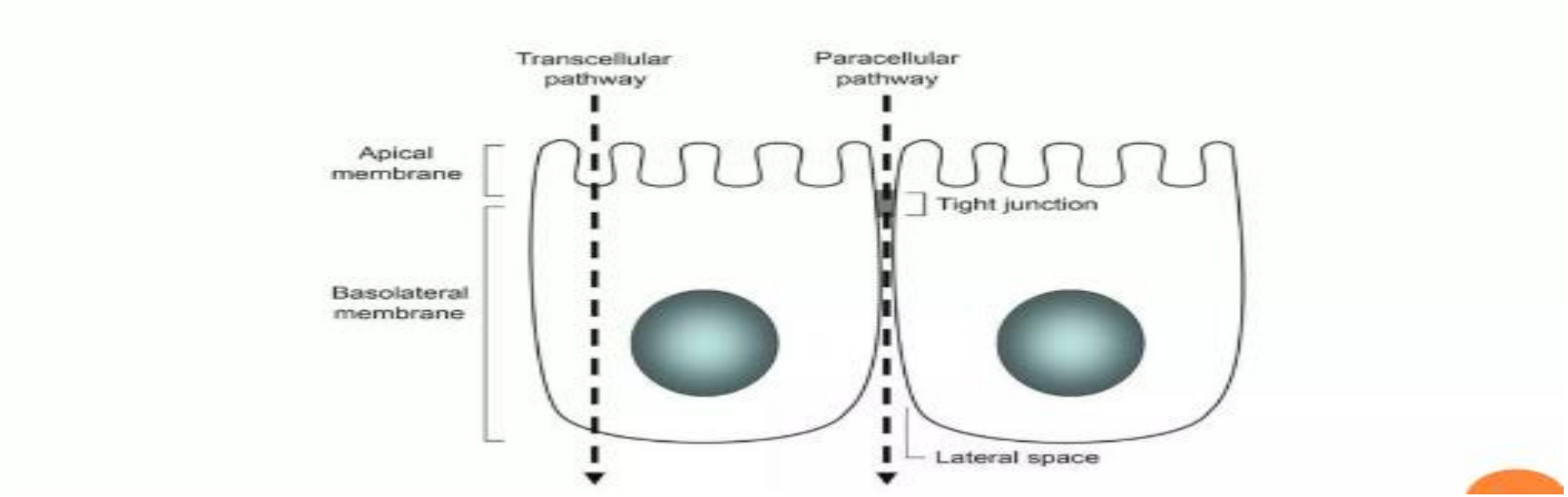
First is **active transport of sodium ions through the basolateral membrane of the intestinal epithelia cells** into the blood ,thereby depleting sodium inside the cells

Second , **decrease of sodium inside the cells causes moving of Na + from the intestinal lumen through the brush border of the epithelial cells** to the cell's interiors by secondary active transport



Osmosis of Water

- The next step in the transport is osmosis of water by transcellular and paracellular pathways
- Much of this osmosis occurs through the tight junctions btw the apical borders of the epithelial cells (paracellular pathway)



Aldosterone greatly enhances Na Absorption

- When a person becomes dehydrated , large amounts of aldosterone almost always are secreted by the cortices of the adrenal glands which leads to activation of the transport mechanism and all aspect of Na absorption by the intestinal epithelium

Absorption of Chloride Ion

- The chloride ion moves along this electrical gradient to follow the sodium ions
- Chloride is also absorbed across the brush border membrane of parts of ileum and large intestine membrane chloride bicarbonate exchanger
- Chloride exits the cell on the basolateral membrane through chloride channels

Absorption of Bicarbonate Ion

- When Na ions are absorbed , moderate amounts of H+ ions are secreted into the lumen of the gut in exchange for some of the Na+
- These H+ in turn combine with the bicarbonate ions to form carbonic acid (H_2CO_3) ,which then dissociates to form water and carbon dioxide
- The water remains as part of the chyme in the intestine ,but the carbon dioxide is readily absorbed into the blood and subsequently expired through the lungs
- The epithelial cells on the surface of the large intestine has a capability of secreting bicarbonate ions in exchange for absorption of chloride ions ,which is important because it provides alkaline neutralization of acid products formed by bacteria in the large intestine

Iron , Potassium , Magnesium and Phosphate

- The all Iron is absorbed by the small intestine , leaving only 1 – 5 mEq each of Na + and chloride ions to be lost in faeces
- Calcium ions are actively absorbed into blood ,especially from duodenum and is regulated by parathyroid hormone and Vit D
- K+ , Mg and Po4 are actively absorbed through intestinal mucosa
- In general , the monovalent ions are absorbed in great quantities. Conversely , bivalent ions are absorbed in small amount

Absorption of Carbohydrates

- Essentially all the carbs in the food are absorbed in the form of monosaccharides , only a small fraction is absorbed as disaccharides and almost none as larger carbohydrate compounds

- By far the most abundant of the absorbed monosaccharides is glucose ,usually accounting for more than 80 percent of absorbed carbs

- The remaining 20 percent of absorbed monosaccharides is composed entirely of galactose and fructose

- Glucose is transported by a sodium co-transport mechanism

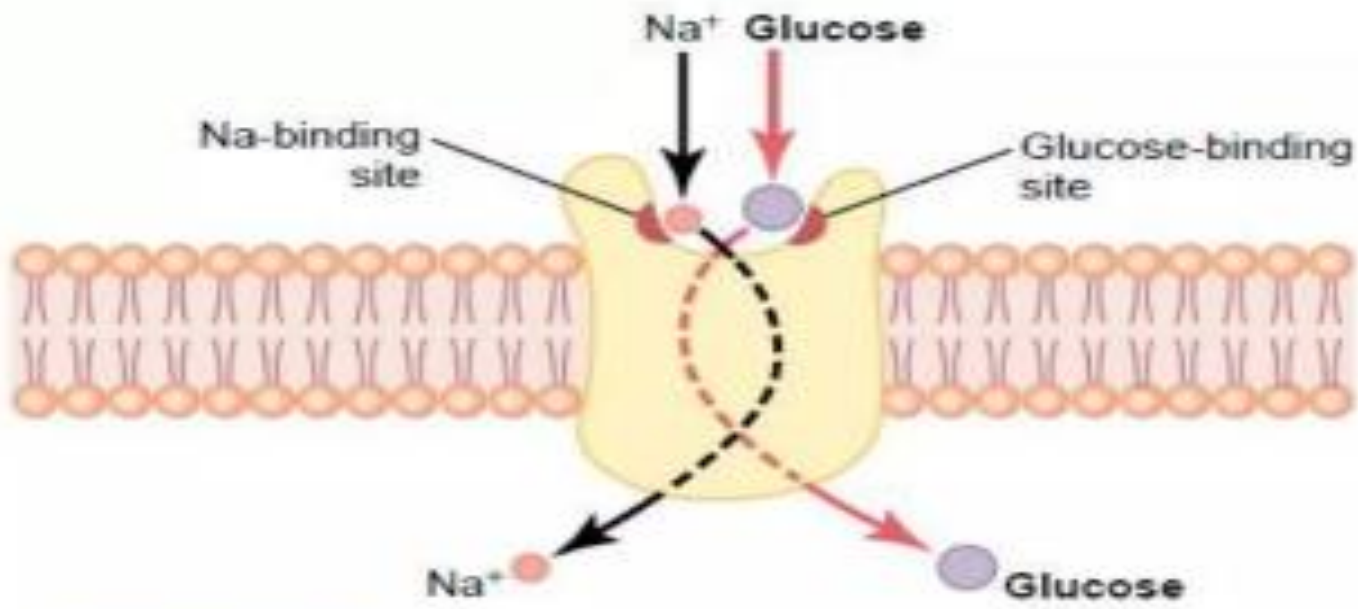


Figure 4–12

Postulated mechanism for sodium co-transport of glucose.

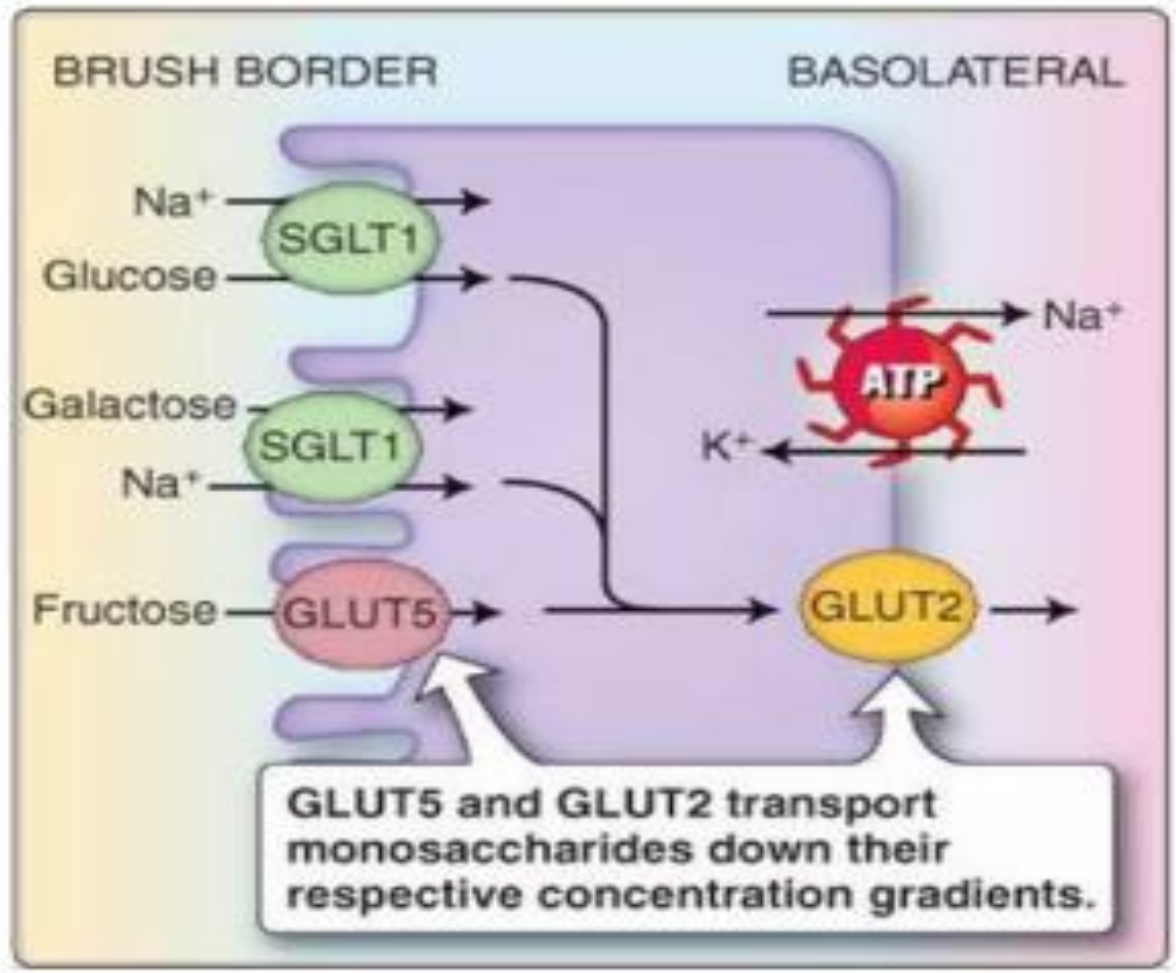
- Sodium ion combines with a transport protein , SGLT1,which will not transport sodium to the cell interior until SGLT1 also combines with glucose

- Once inside the epithelial cell , another transport protein ,glucose transporter GLUT2 facilitates diffusion of the glucose through the cell basolateral membrane into the paracellular space and from there into blood

- Galactose is transported by almost the same mechanism as glucose using SGL1 and SGLT2 transporter

- Fructose is transported by facilitated diffusion from the intestinal lumen to the cell interior by GLUT5 and exit from the cell to the paracellular space by GLUT2

- On entering the cell , becomes phosphorylated ,then converted to glucose and finally transported in the form of glucose the rest of the way into blood


BRUSH BORDER
BASOLATERAL
Na+
SGLT1
Glucose
Galactose
SGLT1
Na+
Fructose
GLUT5
ATP
Na+
K+
GLUT2
GLUT5 and GLUT2 transport monosaccharides down their respective concentration gradients.

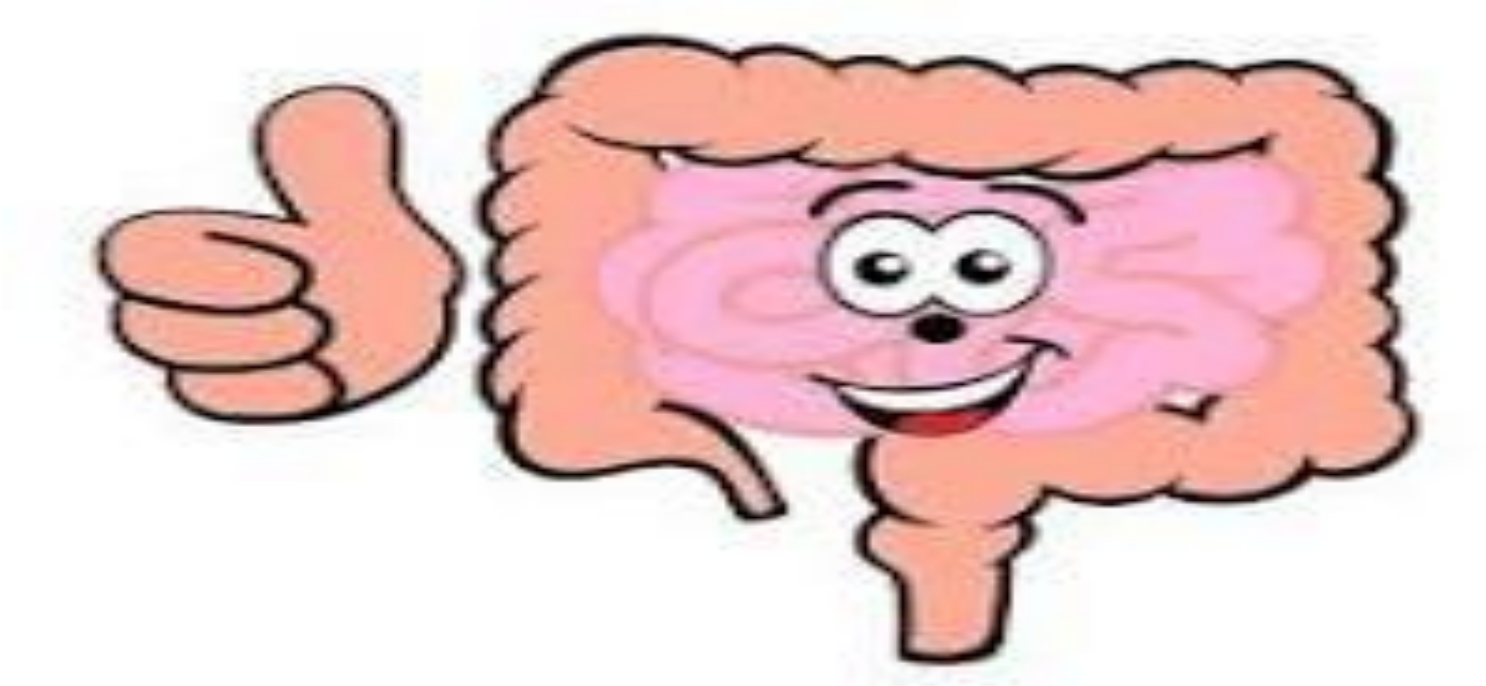
Absorption of Proteins as Dipeptides, Tripeptides or Amino Acids

- Most of the peptides and the amino acids molecules bind in the cell's microvilli membrane with a specific transport protein that requires sodium binding before transport can occur

- After binding, the sodium ion moves down its electrochemical gradient to the interior of the cell and pulls the amino acid or peptide along with it

- This is called co-transport (secondary active transport) of the amino acid and peptides

- At least 10 different types of transport proteins for amino acids and peptides have been found in the luminal membrane of the intestinal epithelial cells



Thank you