Anatomy & Physiology of the Upper, Mid and Lower Gut

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Gecho Fellows Lecture

Outline- Luminal anatomy and physiology

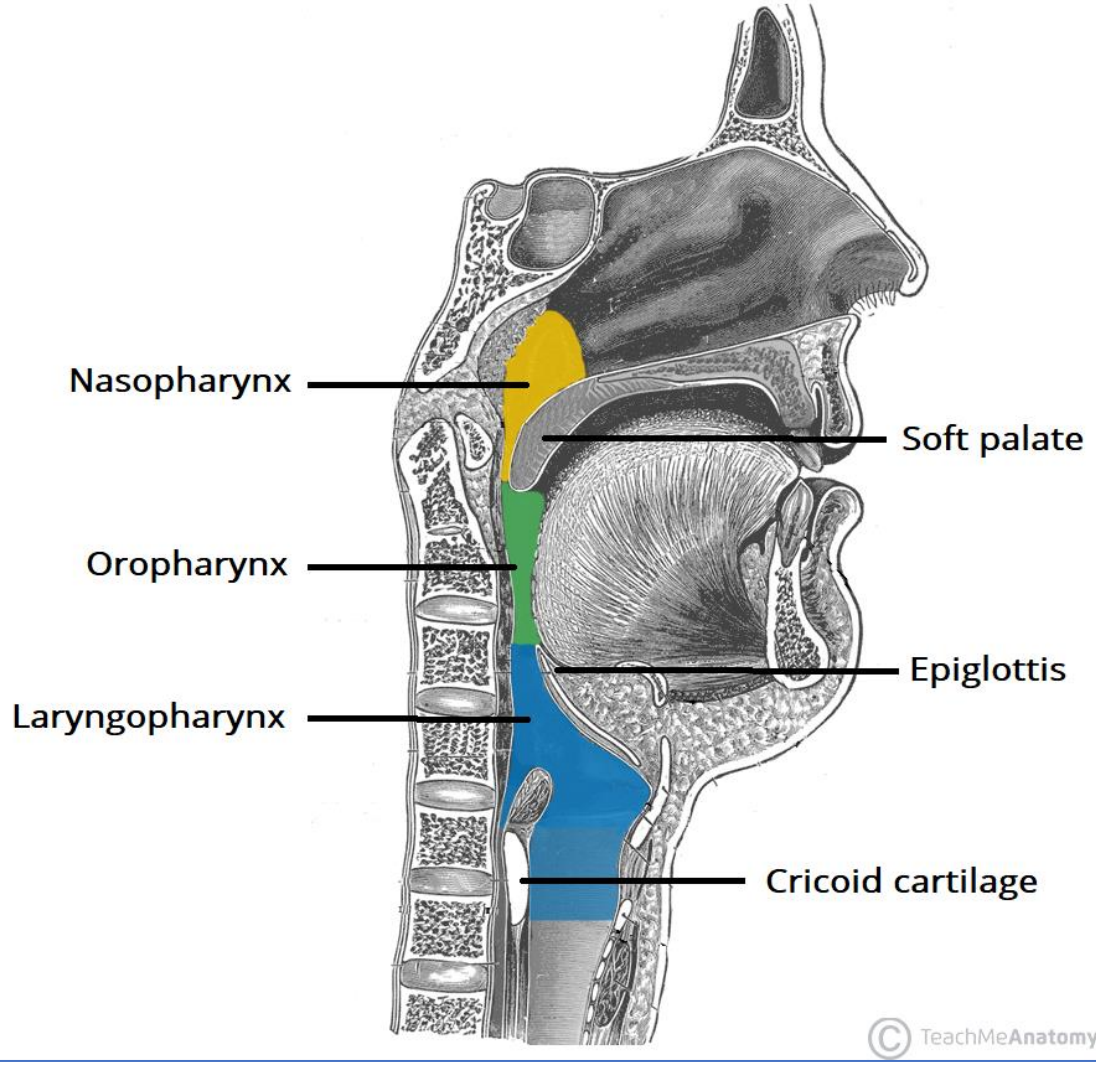
- **UPPER GUT**
  - Oral cavity and pharynx
  - Oesophagus
  - Gastric
- **MID GUT**
  - Small bowel
- **LOWER GUT**
  - Colon and rectum

Oral cavity – Salivary glands

- Salivary secretion:
  - **parotid, submandibular, sublingual glands**
  - Moistens mouth and facilitates speech, taste.
  - Xerostomia→ dental caries. Clean & antibacterial component
  - Buffer- ph 7. reflux

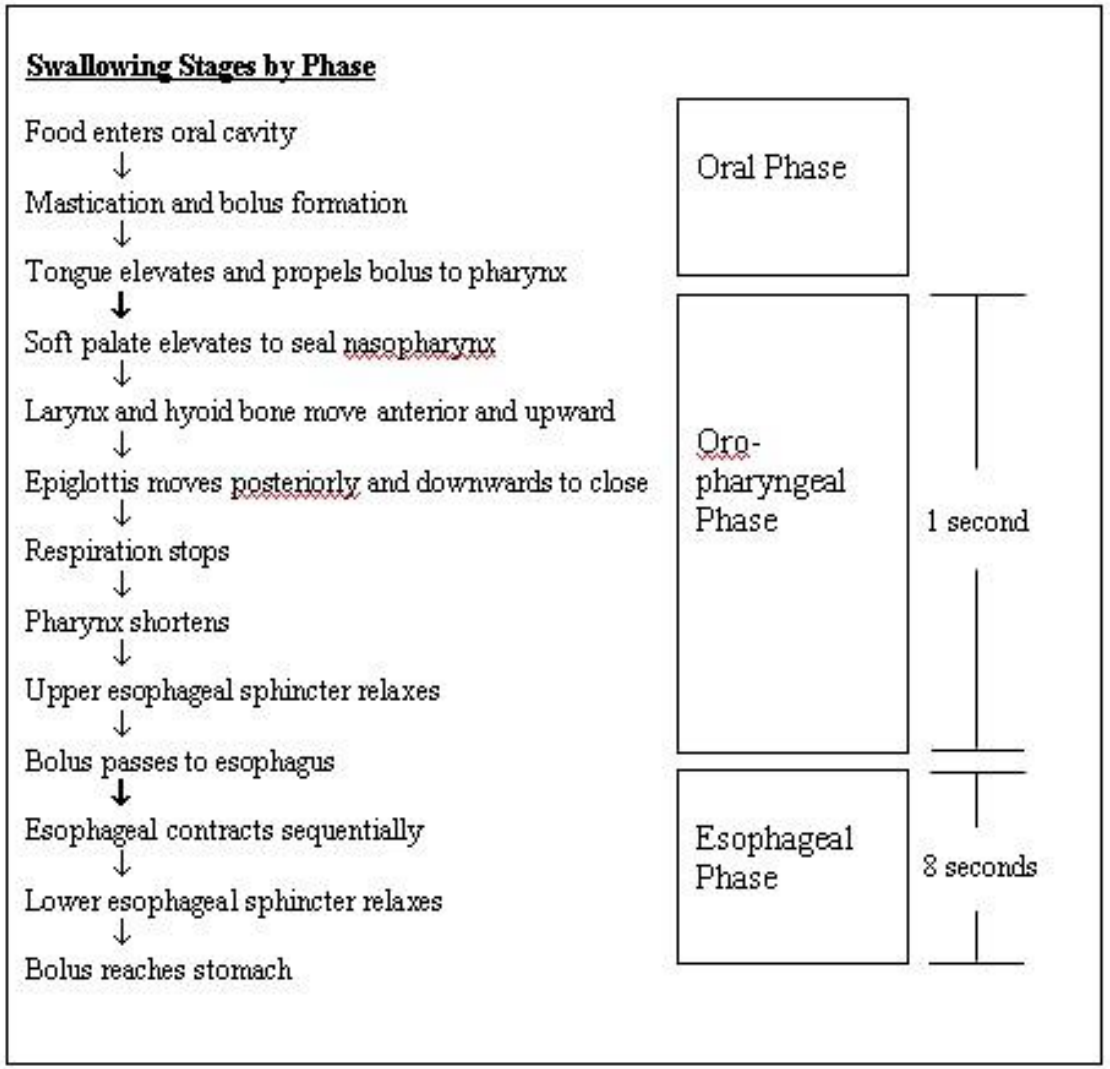
- **Amylase**
- **Immunoglobulin A & lysozyme**
- **Proteinaeous or mucinous**
- Hypotonic
- 1-1.5l produced a day
- Parasympathetic and sympathetic innervation (increa. Proteinaceous content)
- Triggered by reflexes- food- senses.chewing/ inhibited- fear during sleep

Oral Cavity and pharynx



- **Tongue**:
  - Hyoglossus, Genioglossus, Styloglossus (CN XII) and palatoglossus (CN X); Mylohyoid (CN V3)
- **Mastication muscles**:
  - Masseter (CN V3); Temporalis (CN V3); Lateral and medial pterygoid (CN V3)
- **Pharynx:**
  - Tensor palitini (CN V3); levator palitini (pharyngeal plexus CN IX, X); Suprahyoid muscles.
  - Digastric (CN V3 & CN VII); Stylohyoid (CN VII); Geniohyoid (CN XII); Mylohyoid (mylohyoid nerve - a branch of CN V3); Infrahyoid muscles.
  - Sternohyoid and sternothyroid (ansa cervicalis); Thyrohyoid (CN XII); Omohyoid (ansa cervicalis); Longitudinal pharyngeal muscles. Stylopharyngeus (CN IX); Salpingopharyngeus (CN X); Palatopharyngeus (CN X)
  - Superior, middle, and inferior pharyngeal constrictor muscles (CN X) Cricopharyngeus muscle (recurrent laryngeal nerve)
- **Larynx:**
  - Posterior cricoarytenoid, lateral cricoarytenoids, oblique and transverse arytenoids (recurrent laryngeal nerve)
  - Aryepiglotticus (inferior laryngeal nerve)

Physiology of swallowing



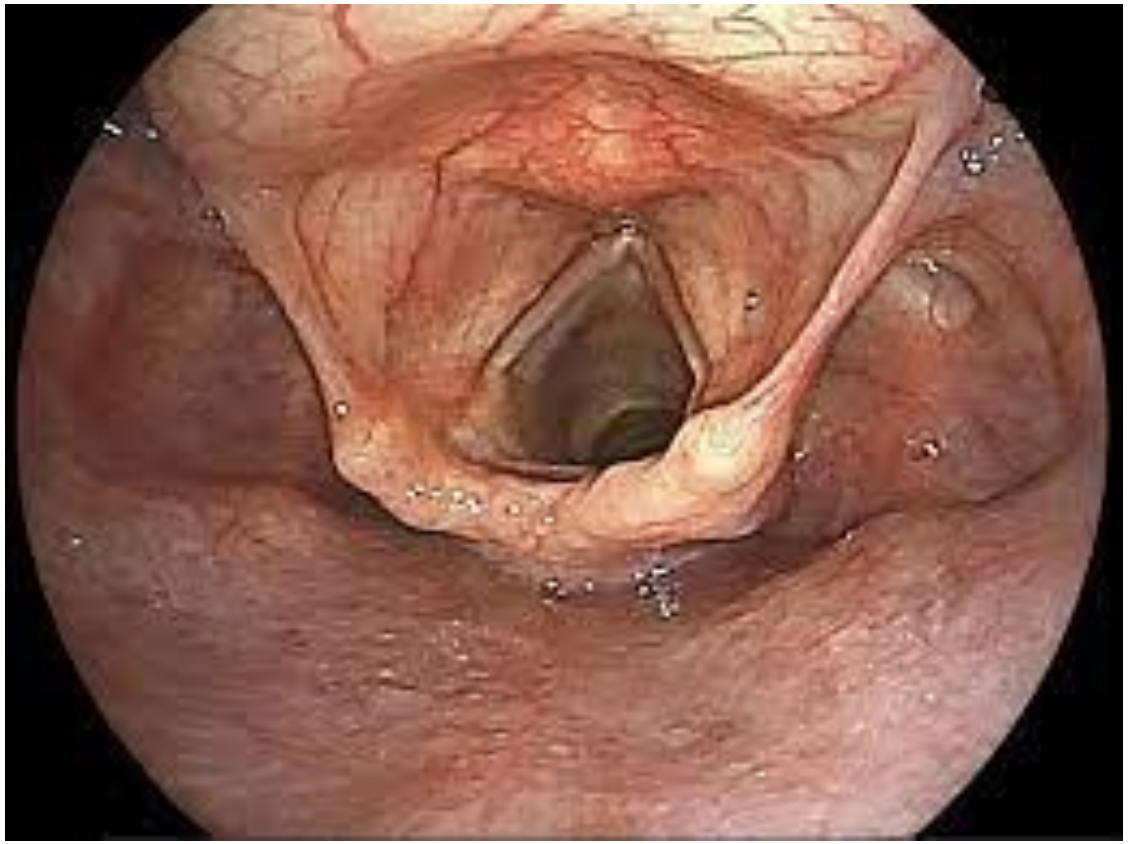
- **ORAL**: liquids- sealed in oral cavity. Tongue and hard palate. Solids mastication and manipulation
- Preparatory and propulsion, voluntary

- **PHARYNGEAL:**
- Nasopharynx – soft palate elevates to seal- **tensor palatini + levator palatini mm**
- **Swallow apnoea** 0.5-1.5seconds
- **Vocal cords-** closure. Posterior cricoarytenoid, lateral cricoartenoid- adduct. Oblique and transverse arytenoids. Glottic closure

Physiology of swallowing

- 1st irreversible step. **Palatoglossal arch.**
- Afferent sensory n –sends impulse to **solitary tract nucleus-brainstem**
- Efferent muscle fibers- larynx, pharynx, oesophagus- coordinated reflex
- Superior, middle & inferior pharyngeal constrictor mm. →wave of pressure to the UES
- Transit through the UES: Cricopharygeus relax.
- **OESOPHAGEAL PHASE:**
  - Wave of peristalsis to LES:

Anatomy of intubation– gastroscopy



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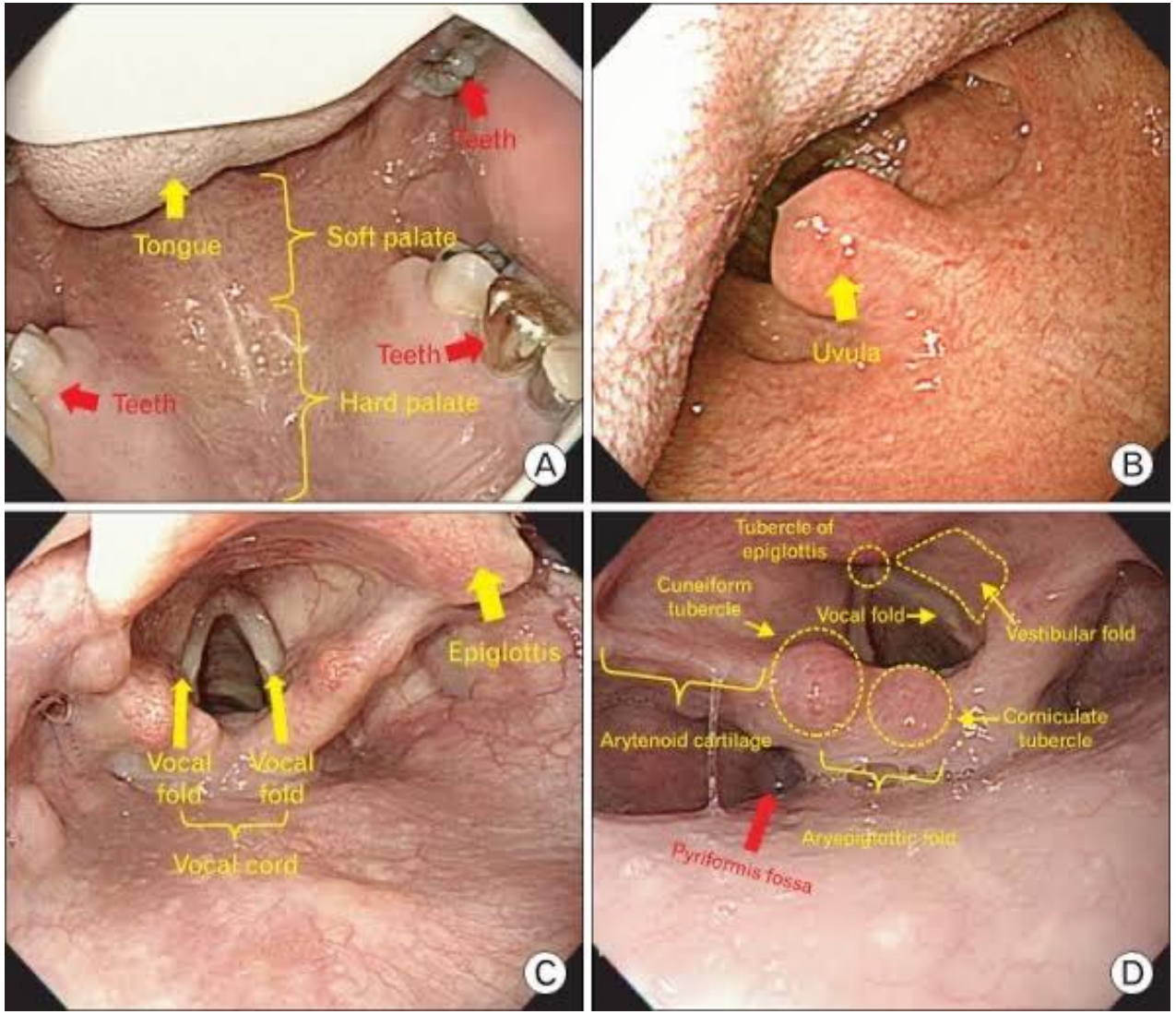


Researchgate- dongryul LEe

Gross anatomy: Oesophagus

Hollow muscular tube,

18-26cm

Stratified squamous epithelium

Expansion, AP 2cm/

3cm laterally

Musculature:

- upper 5-33% → skeletal.
- Distal 50%→ smooth m
- In between mixture.

UES:

- Inferior pharyngeal constrictor, cricopharyngeus.skeletal.
- Inner circular and outer longitudinal

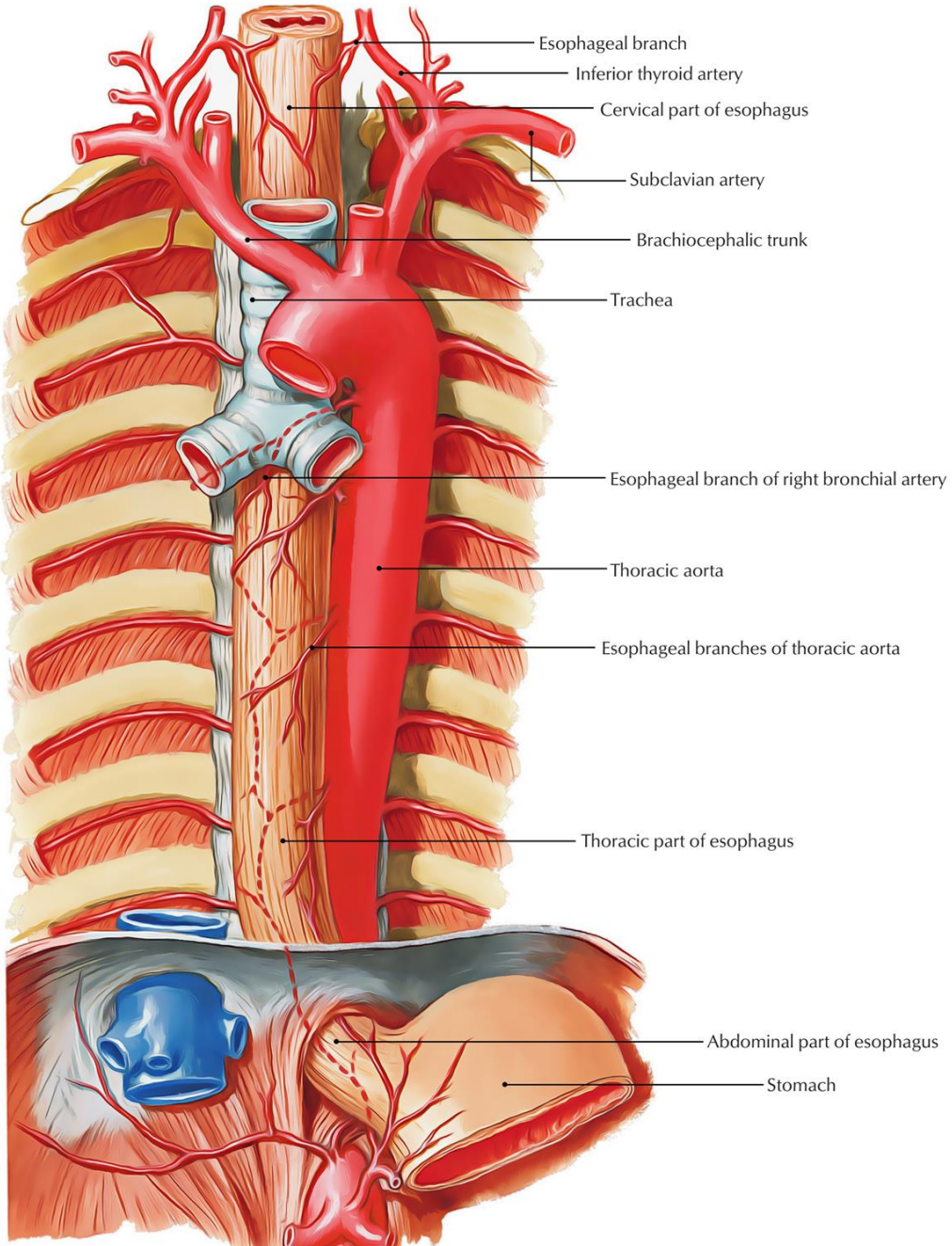
LES:

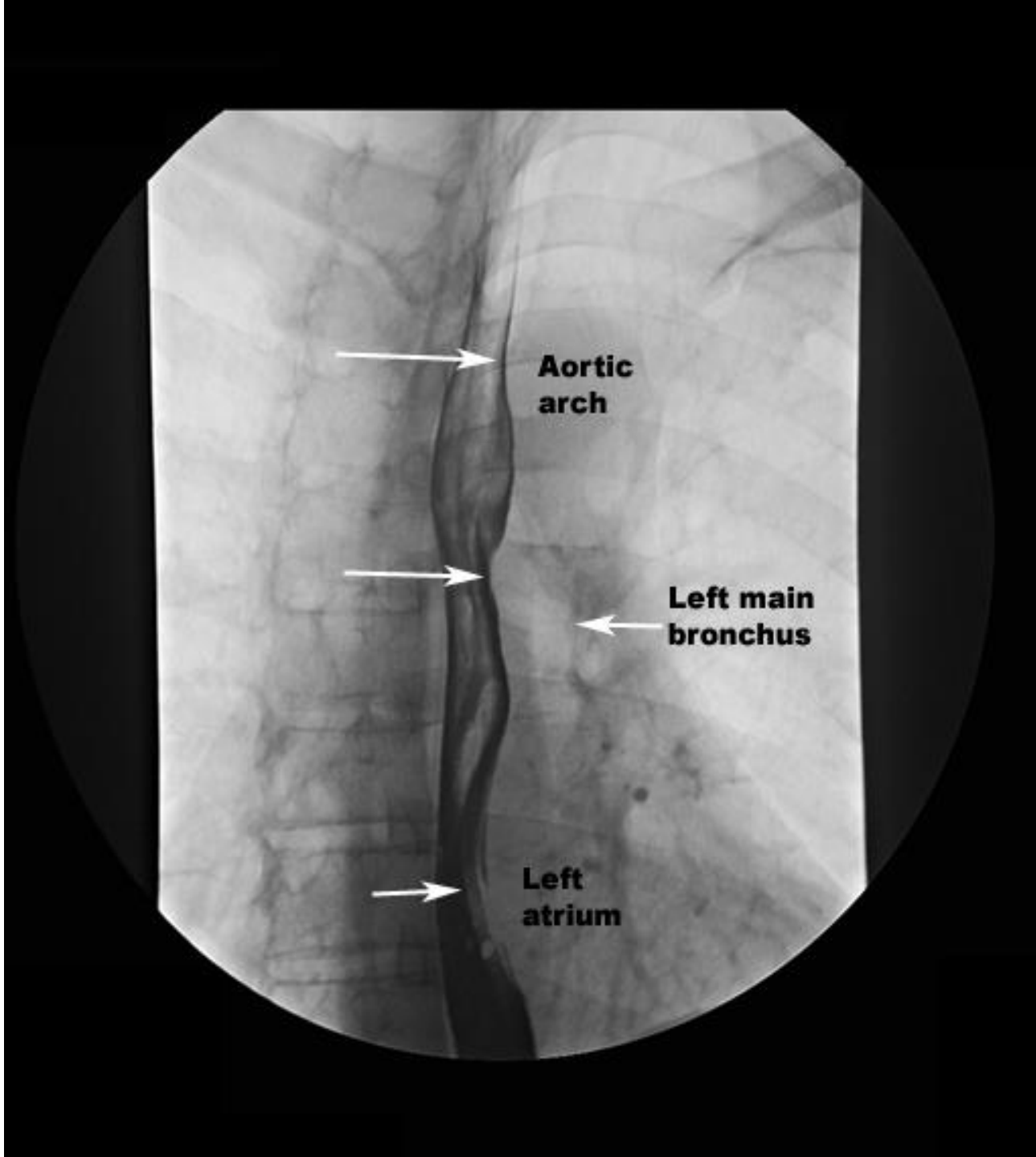
- 2-4cm. Asymmetrical thickens smooth m.
- Phreno-oesophageal ligament → fixation

Body:

- posterior mediastinum behind the trachea and left main bronchus.
- Swings left pass behind the heart, in front of aorta
- T10→ leaves thorax→ right crus of diaphragm

Surrounding structures of the Oesophagus:





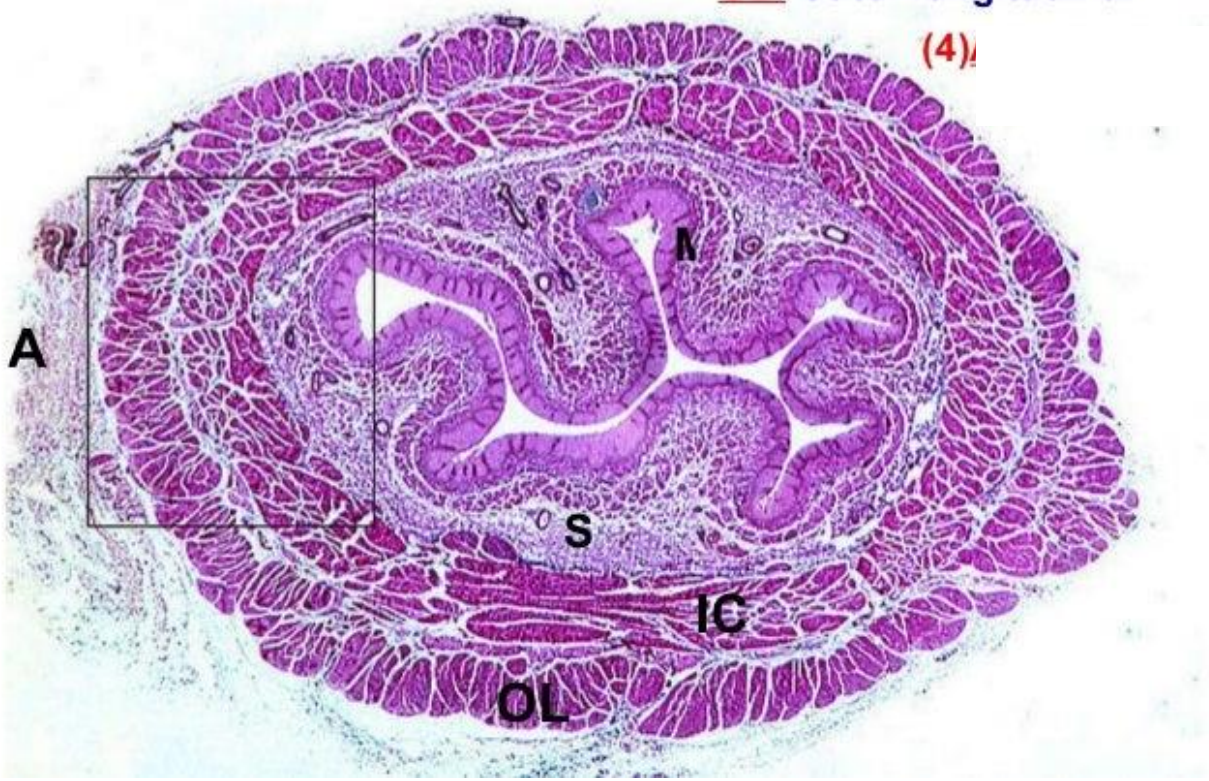
Histology

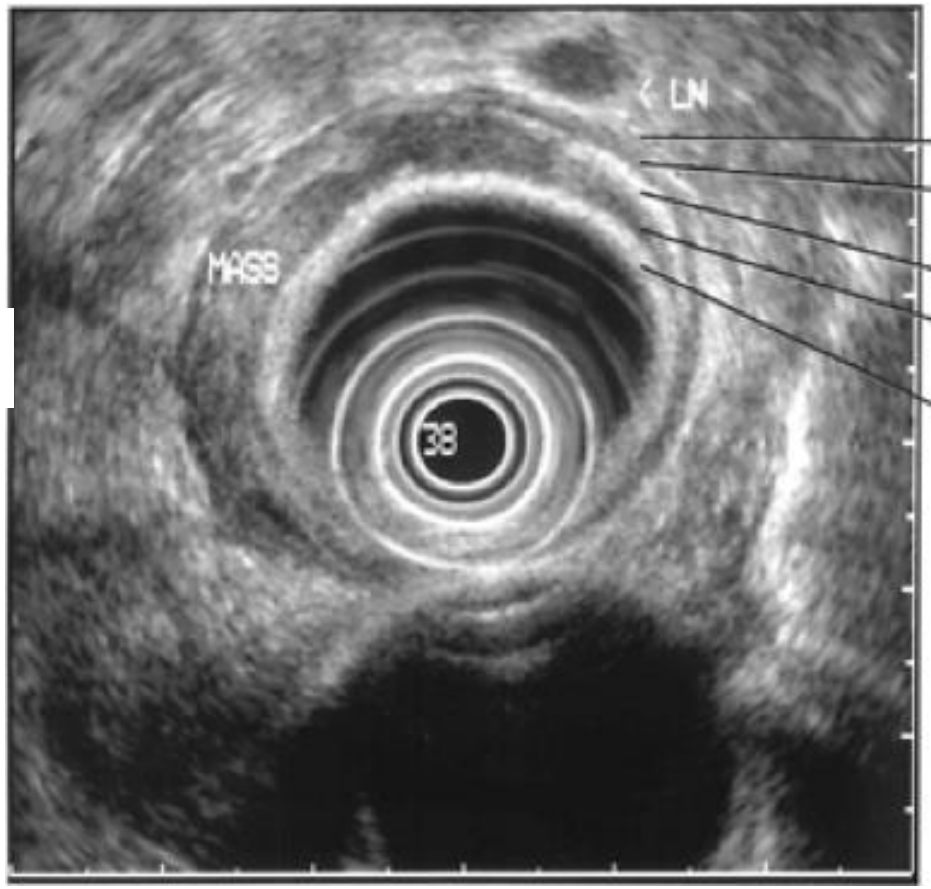
(1)M: Mucosa:
Epithelium
Lamina Propria
Muscularis Mucosa

(2) S: Submucosa

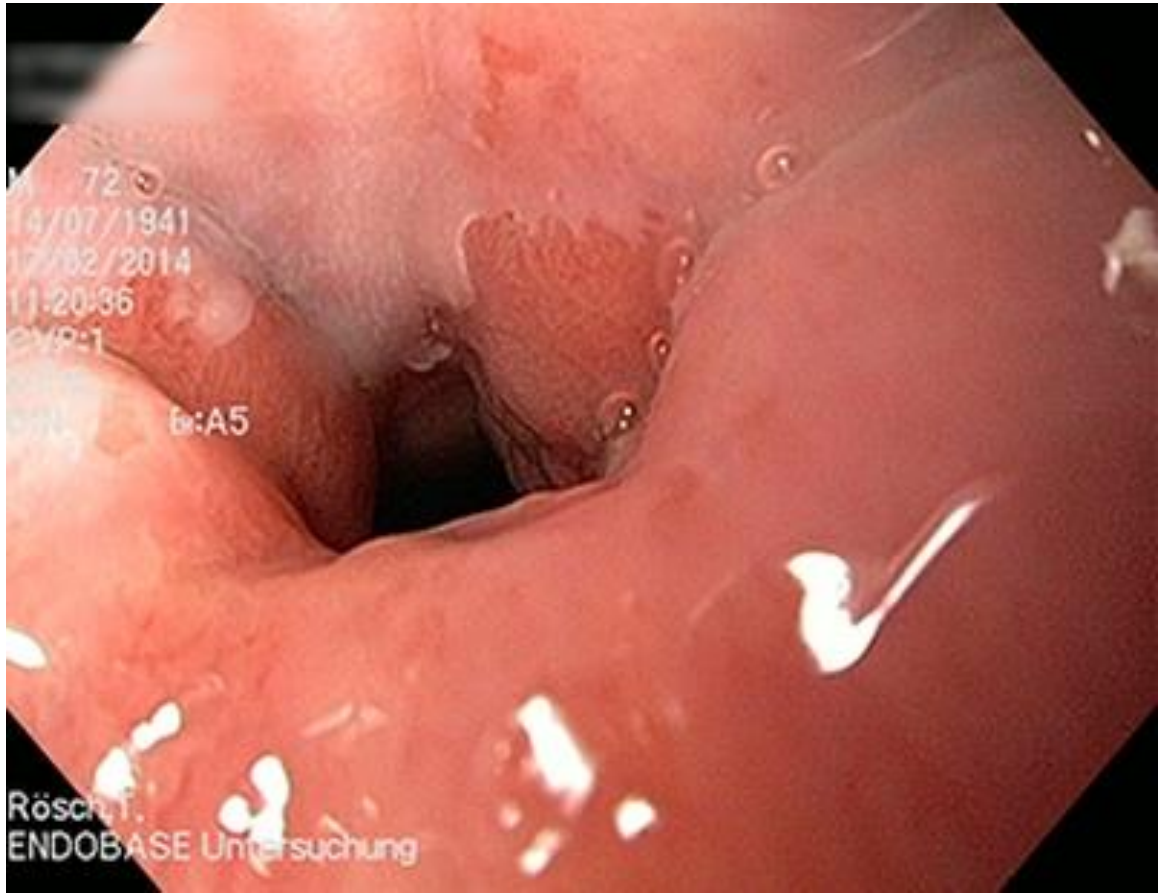
(3) MUSCULOSA
IC: Inner circular
OL: Outer longitudinal

(4)





Oesophagus- mucosa



Epithelium: 3 functional parts

- Stratum corneum
- Stratum spinosum

- Stratum germinativum
- Basal layers cuboidal cells.10-15% of the epithelium thickness
- > 15% basal cell hyperplasia-GORD

The **Z line** → gastro-oesophageal junction that demarcates the squamo-columnar junction

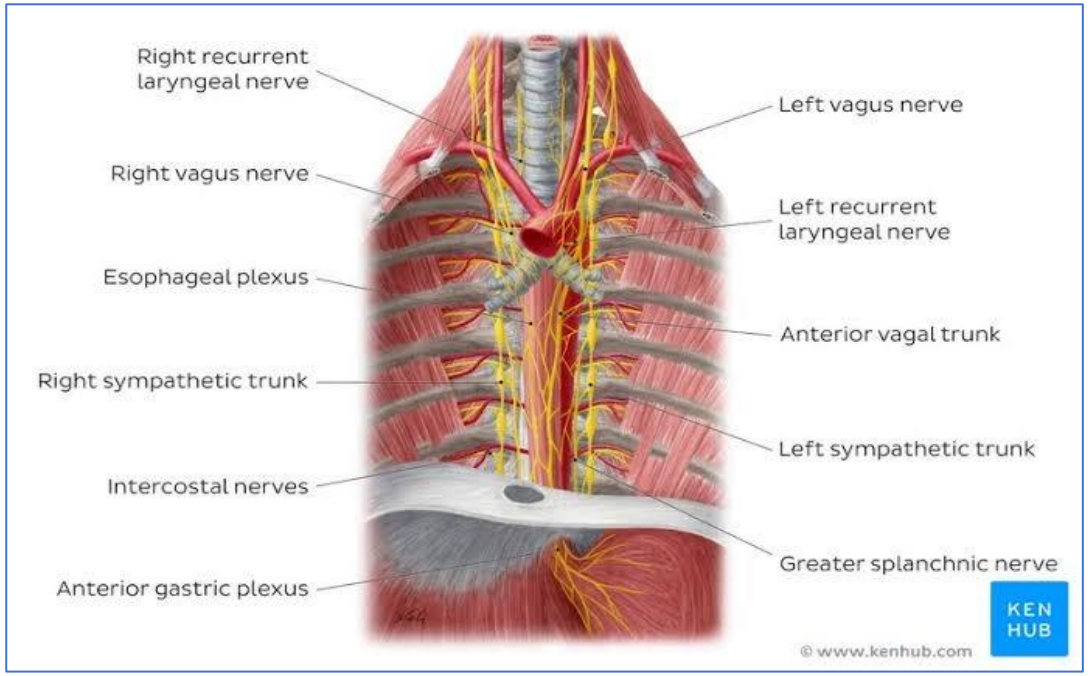
Lighter oesophagus, redder gastric mucosa

Barrett's

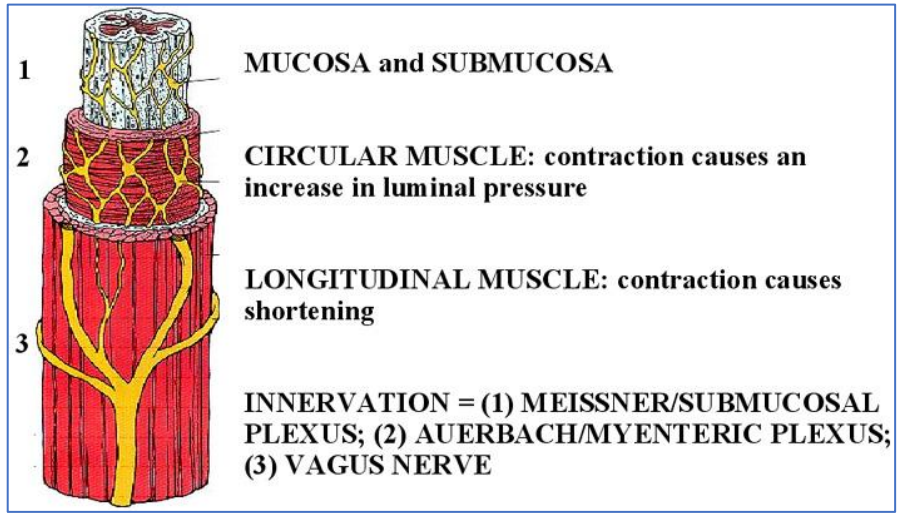
Innervation: Oesophagus

Parasympathetic:

- Regulates peristalsis → **Vagus nn**
- Brainstem- Medulla
  - nucleus ambiguus to control skeletal m.
  - Dorsal motor nucleus – smooth m.
- Medullary vagal post ganglionic efferent → motor end plate of skeletal upper oesophagus



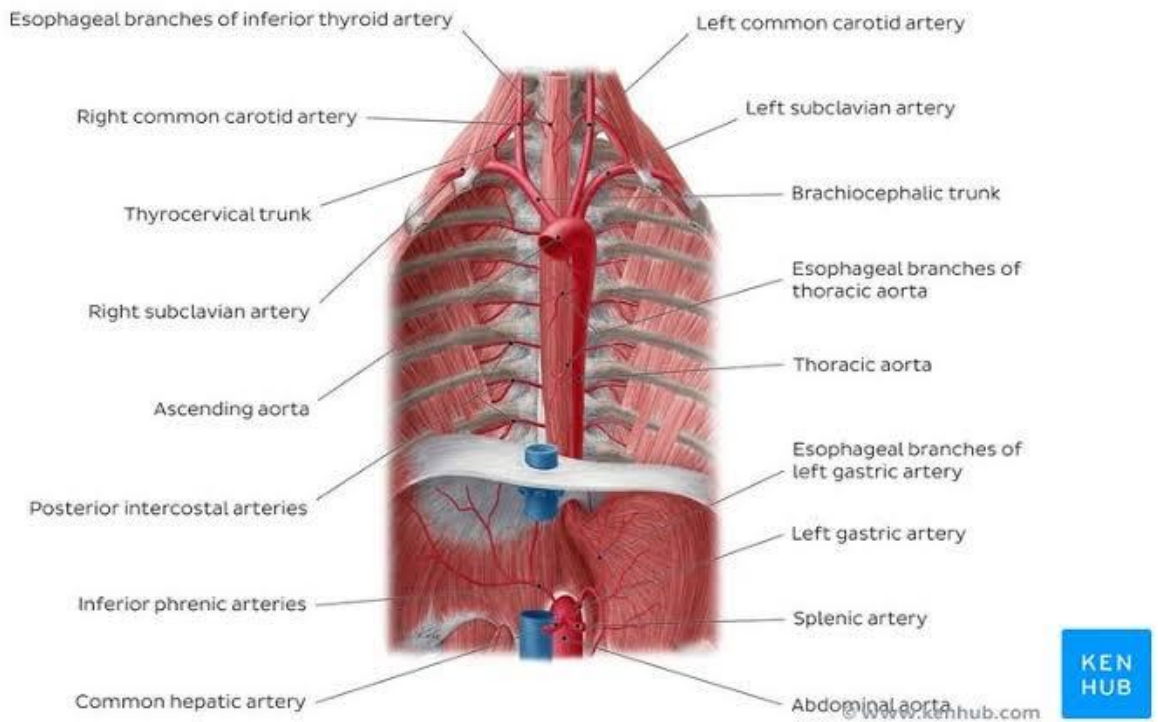
- **Vagal preganglionic efferent:**
  - Smooth m in distal oesophagus→ **myenteric/ auberbach plexus**. Between circular and longitudinal mm
  - **Meissner plexus- submucosa-** afferents, transmitted to cns via vagus parasympathetic and thoracic sympathetic and sympathetic nerves



Innervation of the Oesophagus

- **Sensory** via vagal afferents
  - nucleus tractus solitarius in brainstem
- **Pain sensation**
  - chemo &/or mechanoreceptor
  - **Spinothalamic and spino-reticular, thoracic nerve route**→ thalamus and reticular nuclei→ somatosensory cortex for pain perception and limbic system(pain modulation)
- Overlap, embryonic→ chest pain syndrome

Circulation: Oesophagus



Cervical:

- Branches of the superior & Inferior thyroid artery

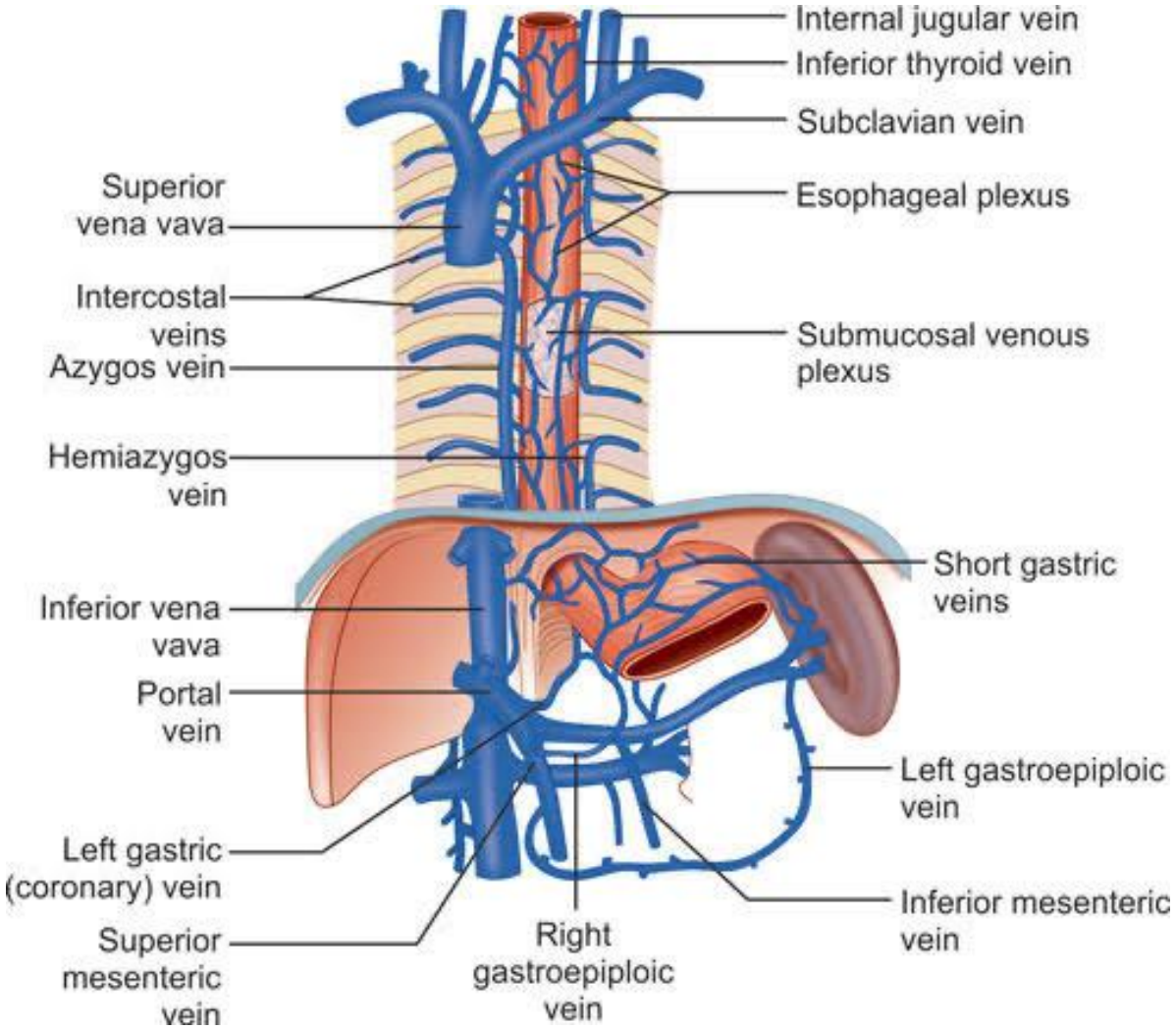
Thoracic:

- Branches of bronchial artery
- Right intercostal
- Descending aorta branches

Abdominal:

- Left gastric aa
- Left inferior phrenic
- Splenic aa

Circulation: venous



Cervical:

- SVC

Thoracic

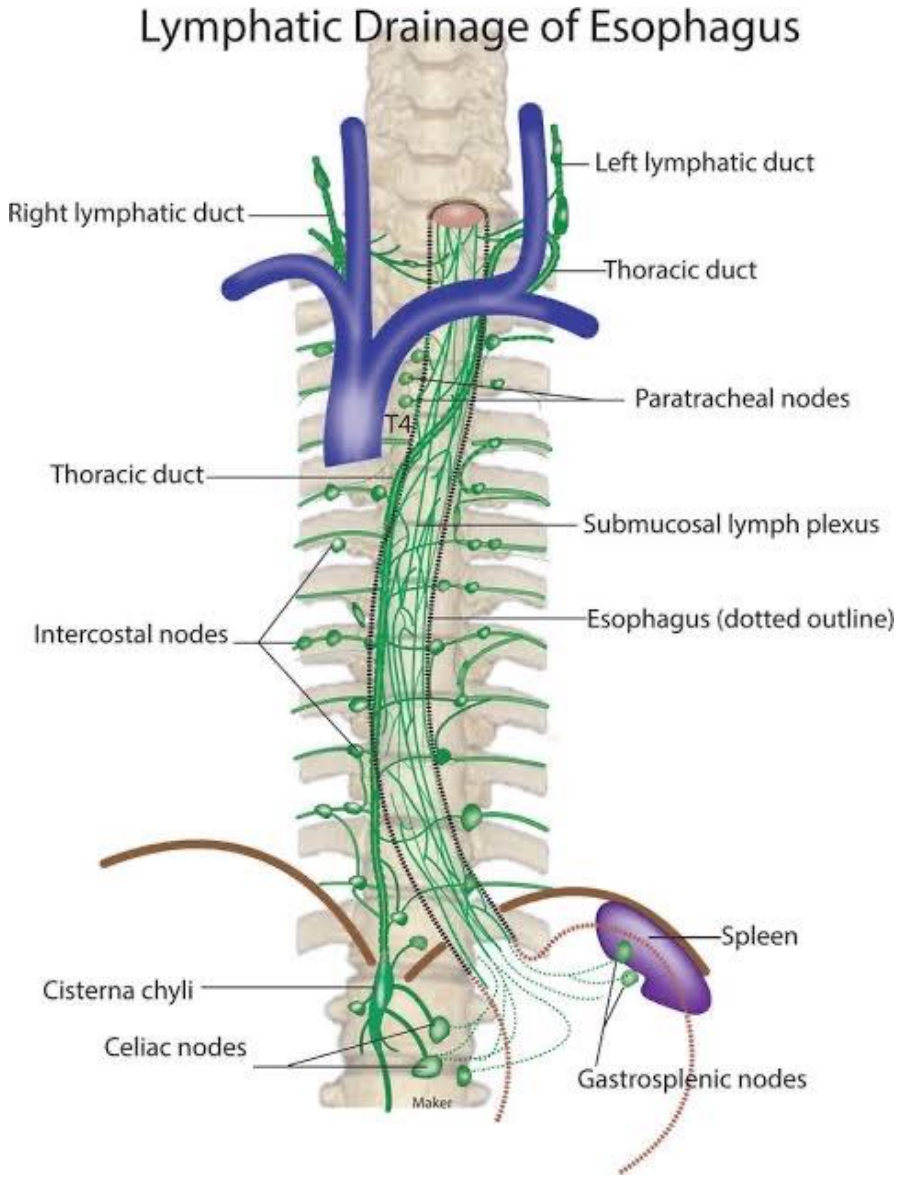
- Branches of the Azygous veins
- Inferior thyroid vein
- Intercostal and bronchial veins

Abdominal

- Portal circulation via Left and short gastric veins
- Systemic- azygous vein
- Porto-systemic anastomoses. Submucosal.

Jaypee digital

Circulation: lymphatics



Rich mucosal and submucosal systems

Cervical– deep cervical LN. Paraoesophageal, supraclavicular

Thoracic- posterior mediastinum

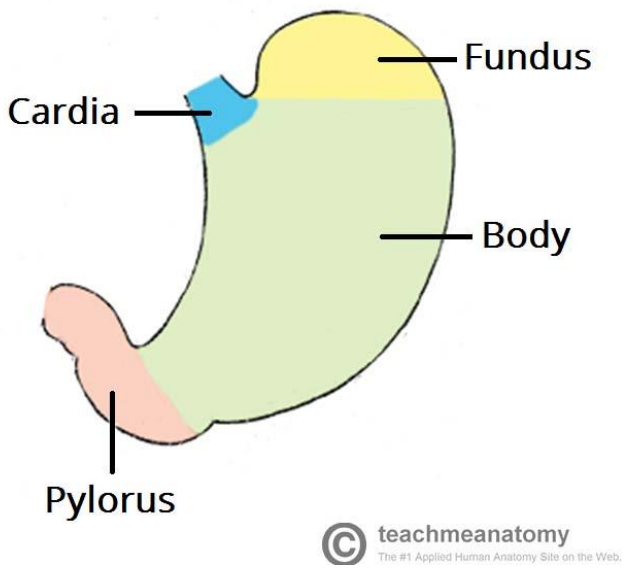
Abdomen- celiac and gastric LN

++interconnected. Spread of cancer

- Basicmedical key

Anatomy Gastric

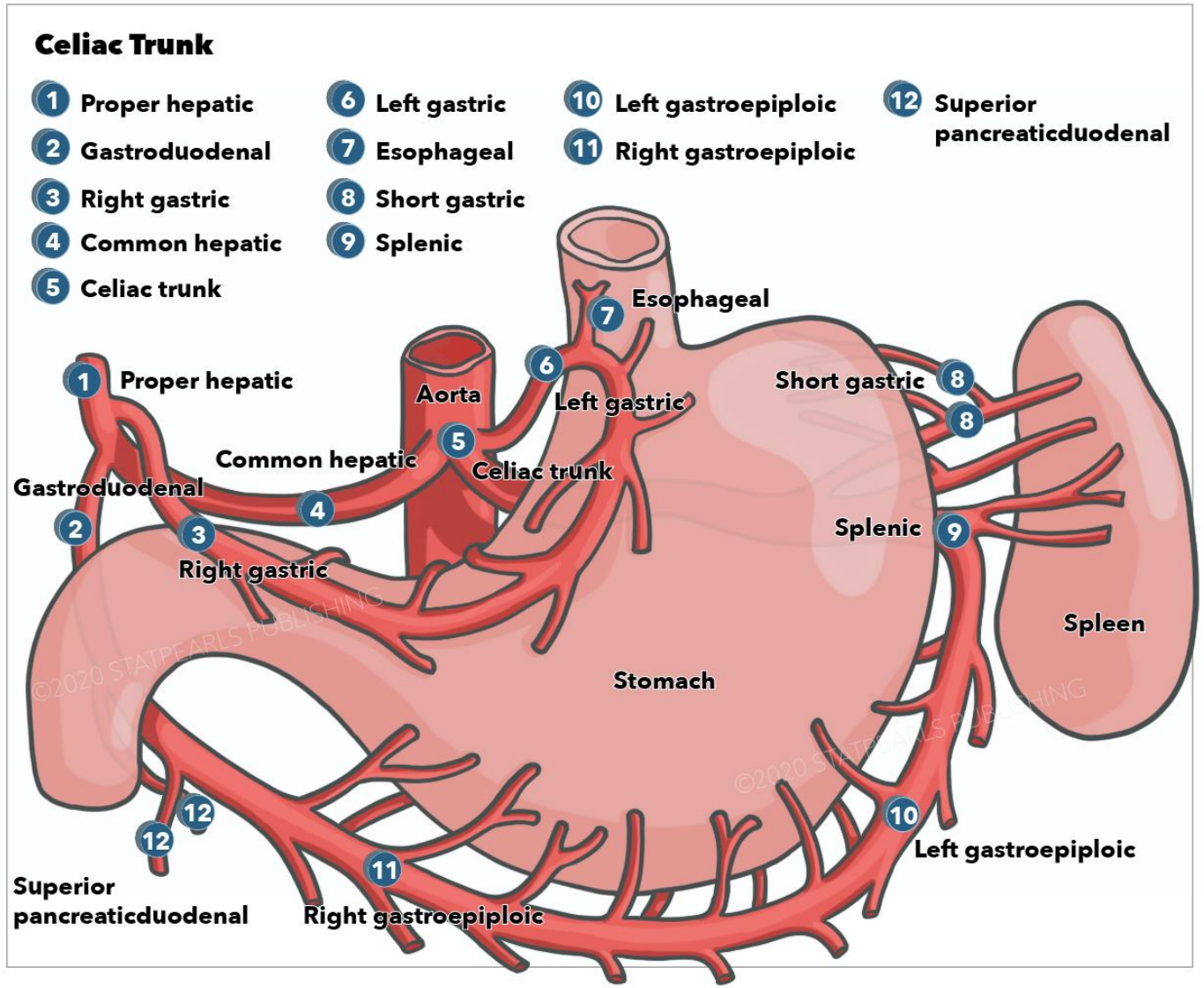
- J-shaped dilatation, reservoir to store large quantities of ingested food
- 1,5-2 liters
- 4 regions – anatomic or histological landmarks



- **Cardia**: small ill-defined area adjacent to oesophagus
- **Fundus**: projects upwards, above cardia and OGJ. Dome shaped. Most superior- adjacent to left hemidiaphragm and spleen
- **Body/ Corpus**: largest, immediately below and continuous to fundus.
- **Incisura angularis**: fixed, sharp indentation
- **Antrum**: body→junction of the pylorus

- **Pylorus**
  - (pyloric channel)
  - tubular structure joining stomach to the duodenum
- Palpable circular m, sphincter
- Mobile
  - enclosed between peritoneum of greater and lesser omenta.
  - 2cm to right of midline at L1

Gastric: Arterial supply



Branches of the **celiac a**a- common hepatic, left gastric and splenic aa

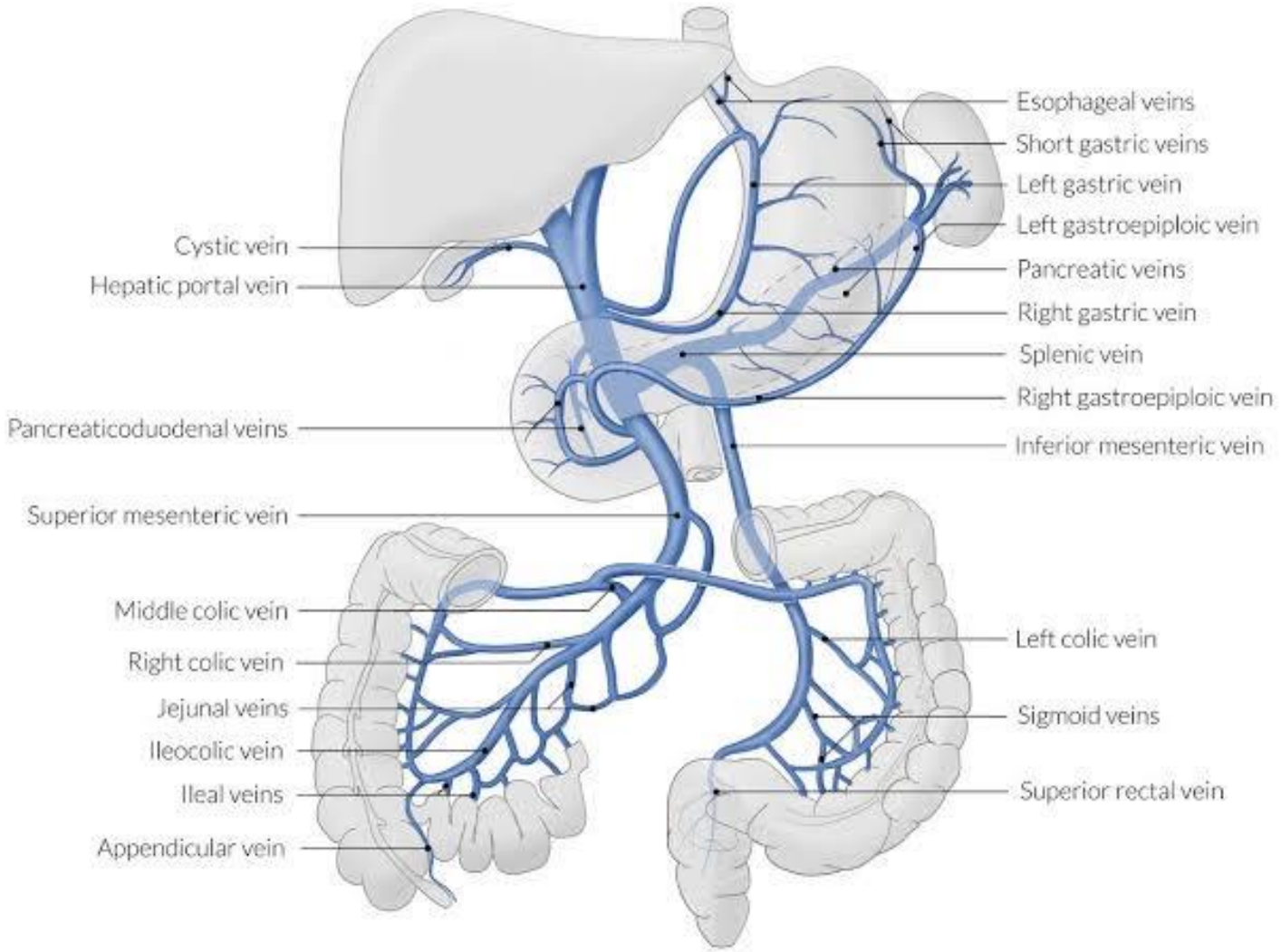
2 arterial arcades – along the lesser curvature of the stomach
+ lower 2/3 of the greater curvature

Lesser curvature: Left gastric aa
Righ gastric aa→ branches off common hepatic or gastroduodenal aa

Greater curvature: below fundus- Left gastroepiploic aa- branch of the splenic
Below from the right epiploic a- branch of gastroduodenal aa
-r+l anastomosis
Gastric fundus- short gastric a- splenic a

https://www.statpearls.com/pictures/getimagecontent//15055

Gastric Venous Supply



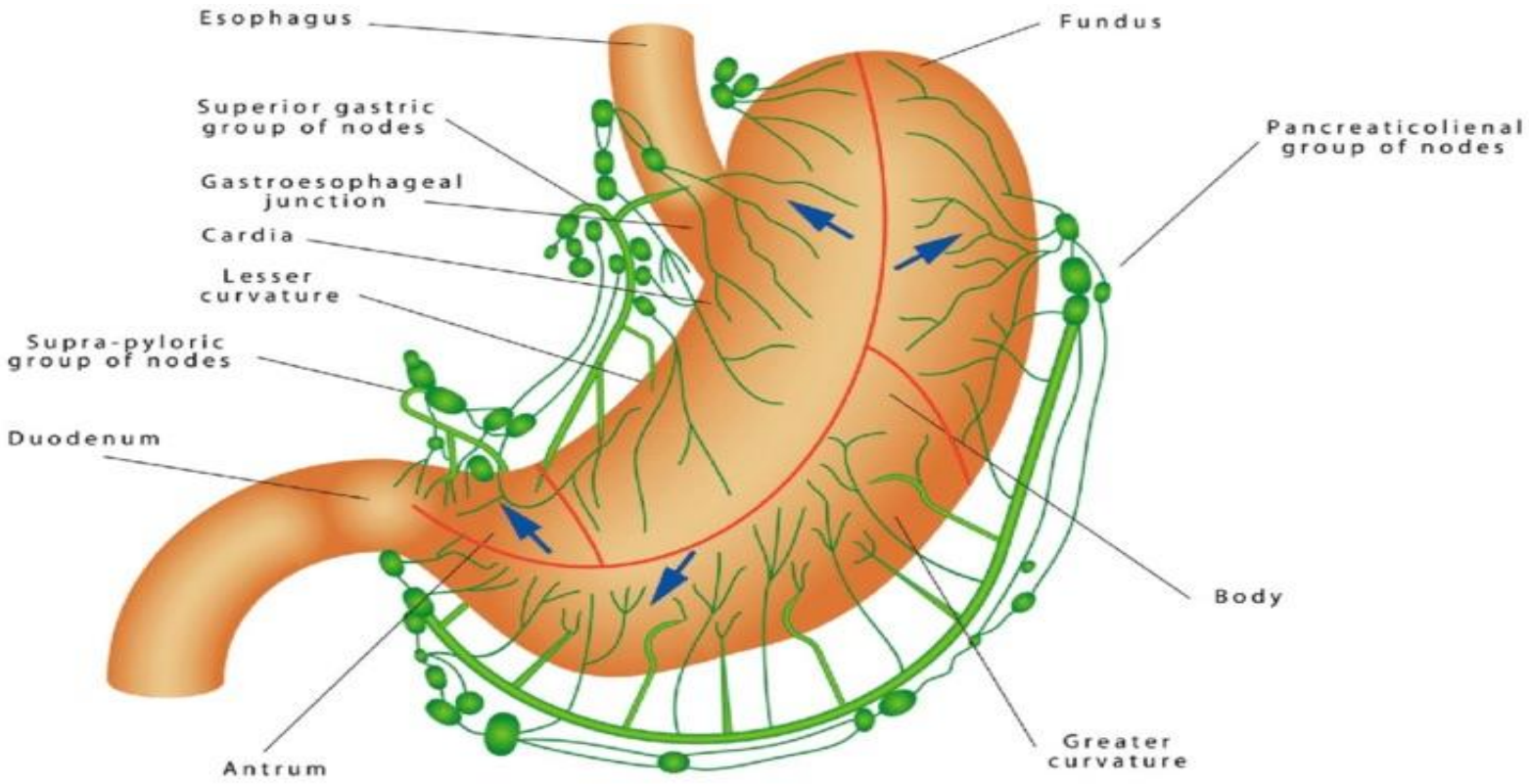
Accompany the arteries
-empty into portal vein or one of the branches
Splenic or superior mesenteric veins

Lesser curvature:
Left and right gastric veins

Inferior and Greater curvature: Right and left gastroepiploic vein drain inferior stomach

https://www.amboss.com/us/knowledge/Stomach/

Gastric: Lymphatics



STOMACH LYMPHATIC DRAINAGE

Celiac nodes
1 of 4 groups
Inferior gastric region- subpyloric and mental nodes

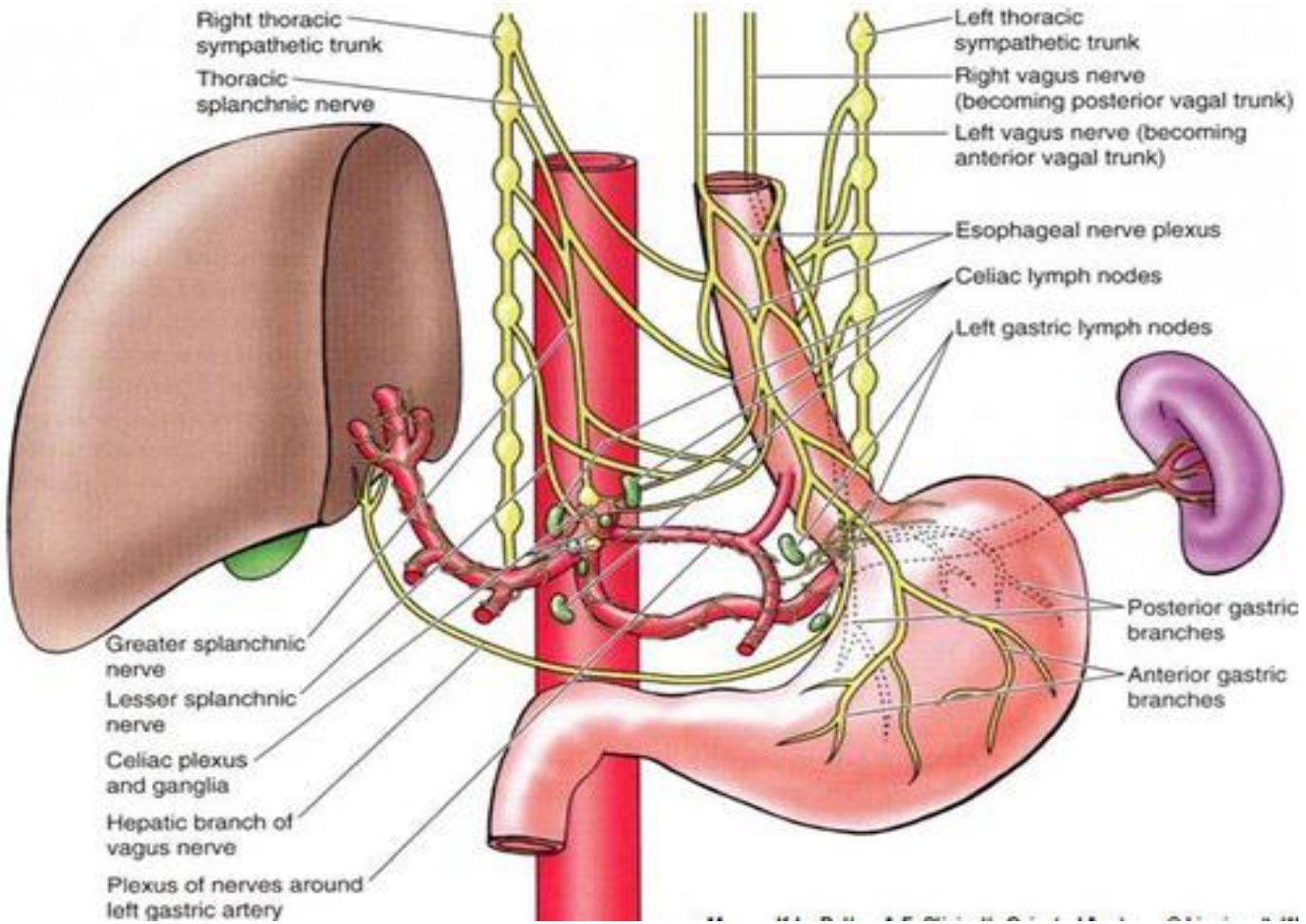
Hepatic nodes

Splenic or superior pancreatocosplenic nodes

Suprapyloric nodes

https://www.canstockphoto.com/lymphatic-drainage-of-the-stomach-85365488.html

Gastric: Innervation



ANS

Sympathetic: preganglionic T6-T8 that synapse bilaterally celiac ganglia→ post ganglionic celiac plexus

Parasympathetic: right and left vagus n, distal oesophageal plexus
Posterior and anterior vagal trunks near gastric cardia

Anterior and posterior nerve of Latarjet

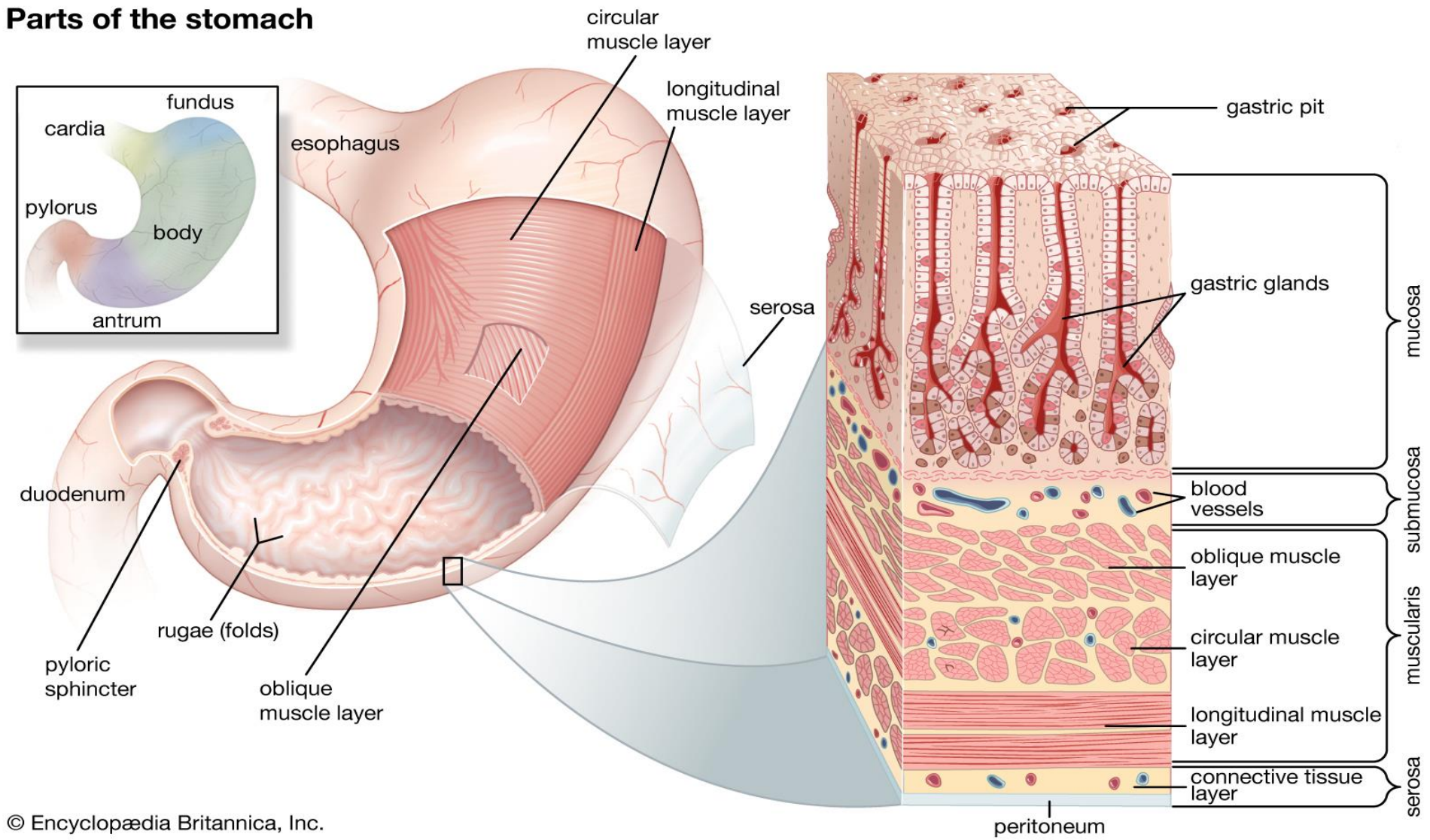
Synapse with ganglion cells in Meissners and Auerbach plexuses
→The distributed to glands and smooth mm

- https://o.quizlet.com/3rHz3sAHCJFE-tYz5VDjHQ.jpg

Tissue layers of the Stomach

- **MUCOSA**:
  - Smooth, velvety.
  - Cardia, antrum, pylorus> paler than the fundus and body→ functional secretory elements
  - Epithelium, lamina propria, muscularis mucosae
- **SUBMUCOSA:**
  - Dense connective tissue skeleton. Collagen and elastin.
  - Contains lymphocytes, plasma cells/Arterioles and venules, lymphatics/ submucosal **neuro plexus**
- **MUSCULARIS PROPRIA:**
  - Inner-oblique/ middle-circular and outer-longitudinal
  - Oblique- courses over the gastric fundus and covers anterior and posterior wall
  - Circular- encircles stomach, thickens distally to form the pyloric sphincter
  - Longitudinal- primarily along greater and lesser curvatures
- **SEROSA:**
  - Transparent/ in continuation with visceral peritoneum

Gastric: Tissue layers



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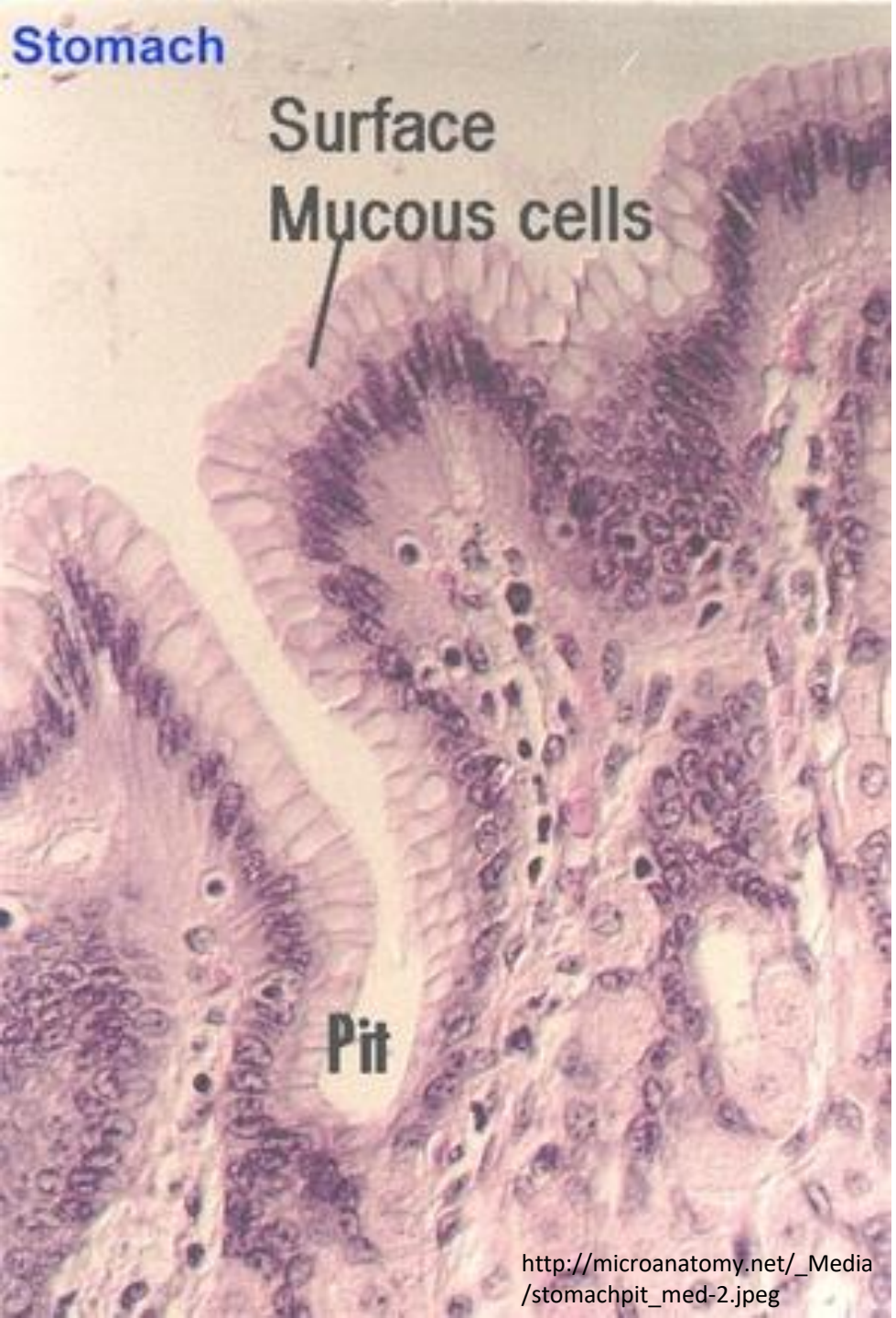


http://microanatomy.net/_Media/stomachpit_med-2.jpeg

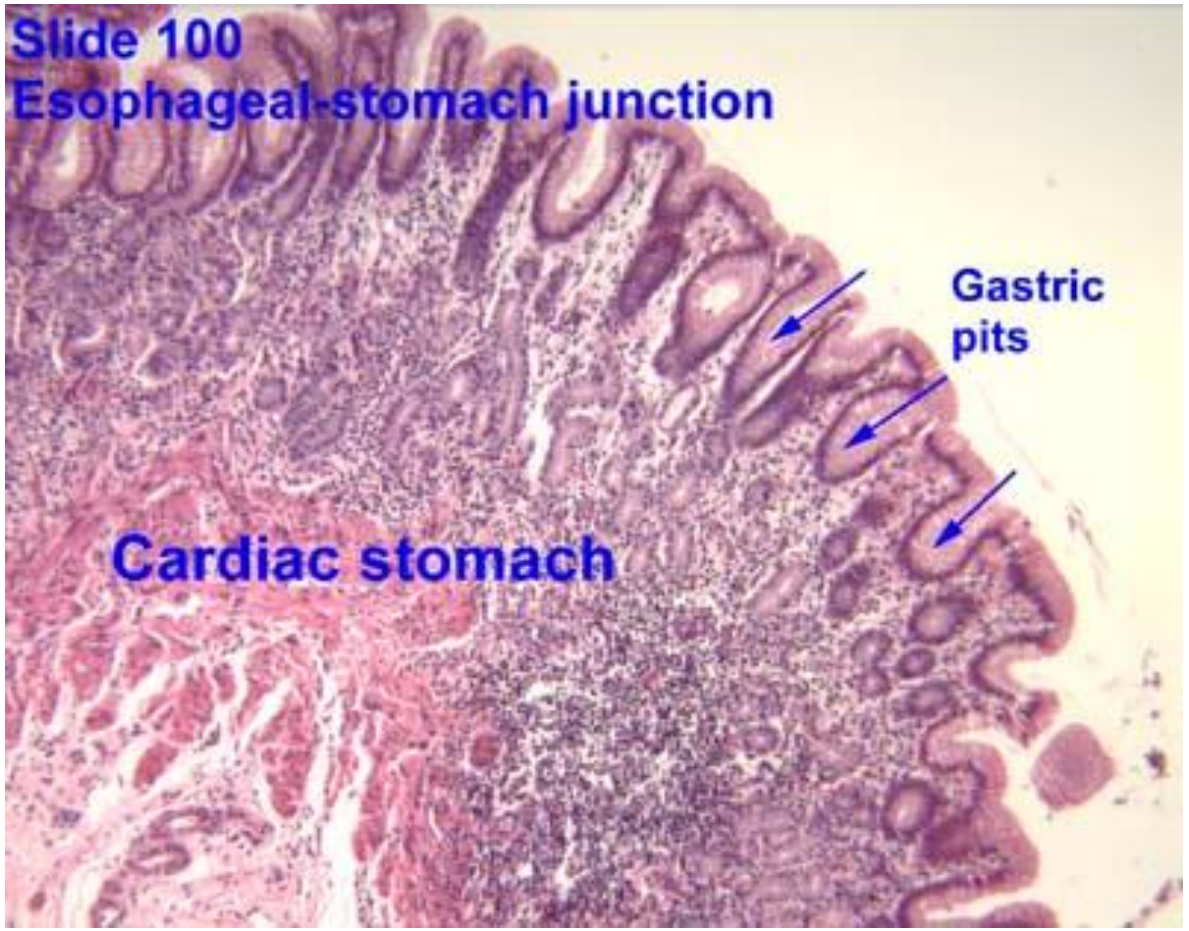
Histology

- **MUCOSAL SURFACE:**
  - **Simple columnar epithelium**. 20-40um in height
  - **SURFACE MUCOUS CELLS**
    - similar throughout the stomach.
    - Basally located nuclei, prominent golgi stacks and dense cytoplasm. Apically located mucin containing membrane bound granules.
    - Secrete mucous in granules → exocytosis. Apical expulsion and cell exfoliation
  - Mucous+ Bicarbonate = cyto-protection
  - Against acid, pepsin, ingested substances and pathogens
  - Cellular renewal time→ 3 days

Histology

- **Gastric pits or foveolae→**
  - Invagination of surface epithelial lining
  - Glands access to the gastric lumen→ Ratio 1 pit :4/5 gastric glands
  - Gastric glands are different in different anatomical regions→ specialized epithelial cells. **Differentiation of regions according to glands**.

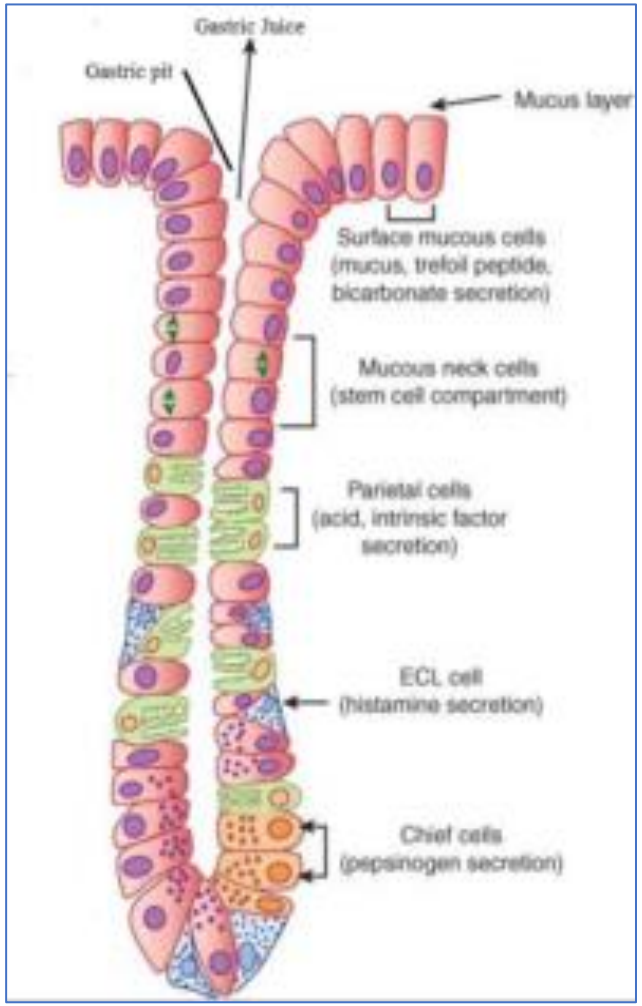
  - **CARDIA:**
    - Small transitional zone stratified sq epithelium→columnar
    - Glands: branched/tortuous and populated with **mucous, endocrine including G-cells and undifferentiated cells.**



https://www.ouhsc.edu/histology/Glass%20slides/100_03.jpg

Histology

- 2nd region→ gradual transition→ **ACID SECRETING SEGMENT OF THE STOMACH: Gastric fundus & body.**
  - **OXYNTIC GLANDS**: Parietal, chief, endocrine, mucous neck & undifferentiated cells
    - Most numerous and distinct gastric glands
    - Acid secretion/ IF /gastric enzymes
    - Straight and simple tubular glands
    - **Subdivided into 3 regions**
    - **Isthmus**: surface mucous cells> / **Neck**: parietal, mucous neck cells/ **Base**: chief cells. Some parietal and mucous neck cells
    - Endocrine cells: Somatostatin-containing **D cell**. Histamine secreting enterochromaffin-like (**ECL)cells**.



https://thefactfactor.com/wp-content/uploads/2020/03/Salivary-Glands-02.png

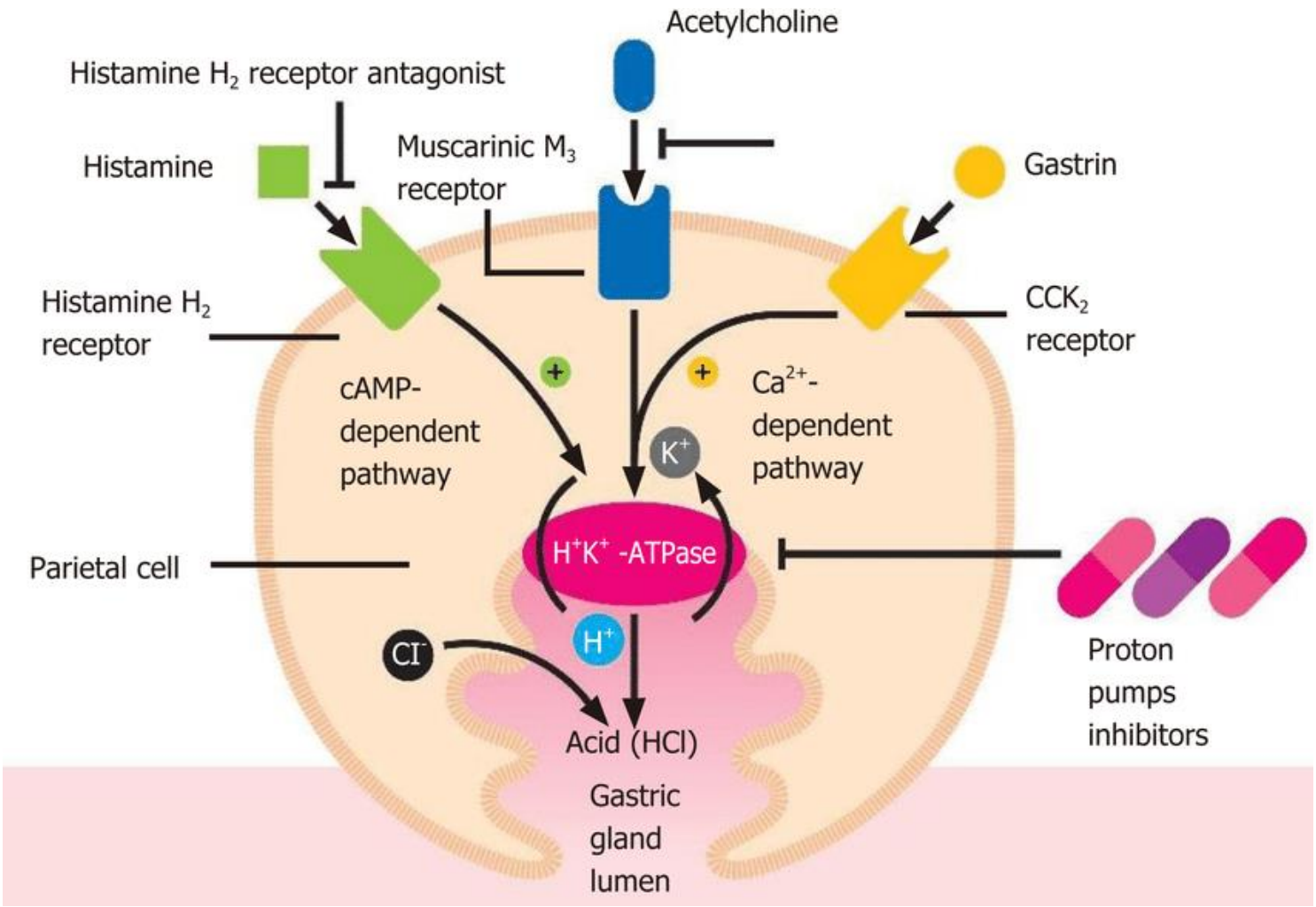
- **PARIETAL CELL:**
- Principle cell of oxyntic gland. 3X 10^4 hydrogen ions per second→ final hydrochloric acid conc 150 mmol.
- Large mitochondria, microvilli lacking glycocalyx. Cytoplasmic canaliculi system in contact with the lumen

- **NON-SECRETING:** cytoplasmic tubulovesicular system> short microvilli line the apical canaliculus.

- **SECRETING:** tubulovesicular system disappears, leaves an extensive system of intracellular canaliculi → containing long microvilli

- Mitochondria 40% of cell vol→ energy acid secretion across apical microvilli
- Proton pump: H+,K+ ATPase→proton translocator; in apical microvillous membrane and carbonic anhydrase
- Acid secretion begins 5-10mins after stimulation
- Intrinsic factor via membrane associated vesicle transport (B12)

Parietal cell proton pump



https://thefactfactor.com/wp-content/uploads/2020/03/Salivary-Glands-02.png

Mucous neck cells	Mucous surface cells
• **Neck/ isthmus** • **Singly or in groups of 2/3 near parietal cells** • **Synthesis of mucous acidic and sulphated** • **Basal nuclei and larger mucous granules around the nucleus** • **FUNCTION: stem cell precursor for surface mucous, parietal, chief and endocrine cells**	• Surface • Neutral mucous • Apical located granules • FUNCTION: cyto-protective

CHIEF CELLS:

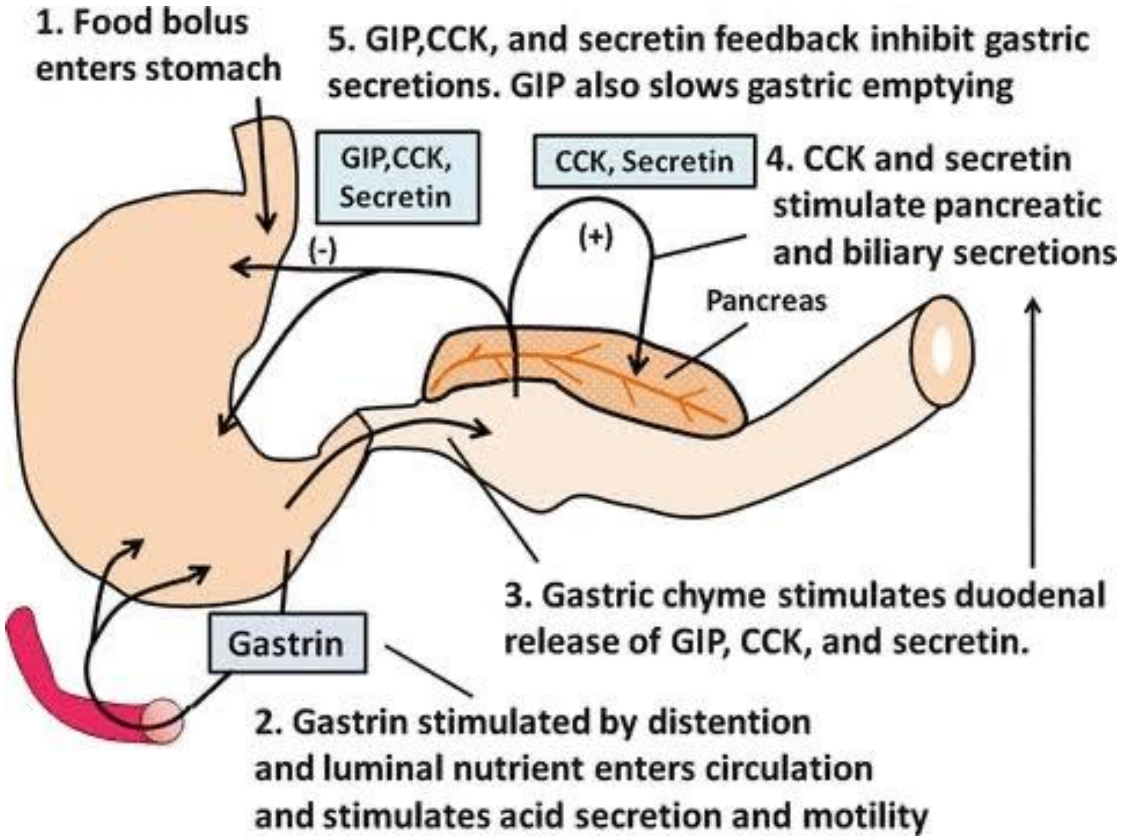
- Zymogen cells→ predominate in deeper layers of oxyntic gland
- Pyramid shaped cells
- Pepsinogens I and II – synthesis and secretion
- Cytoplasm basophilic- ++ ribosomes. Zymogen granules- apical.
- Lumen pepsinogens→ pepsin

ENDOCRINE:

- **D cell**, somatostatin

ENTEROENDOCRINE:

- **Enterochromaffin (EC)** cells- most serotonin
- **ECL-** histamine



Gastric secretion
CEPHALIC PHASE:
Vagal input
GASTRIC PHASE:
Quantitatively most significant
INTESTINAL PHASE

Gcells- gastrin-antrum
Gastrin releasing peptide (GRP) in response to oligopeptides in lumen

To oxyntic gland→ parietal, chief (ach from enteric nerve endings) and enterochromaffin like cells- histamine-h2 receptors.

GIP: K cells duodenum, gastric- absorption of gluc and fat
Large quantiy- inhibit gastric secretion & motility
CCK+ secretin- pancreas. D1 stimulates pancreatic enzyme secretion

Small Bowel: Duodenal Anatomy

Small intestine- 600-800cm

Duodenum:

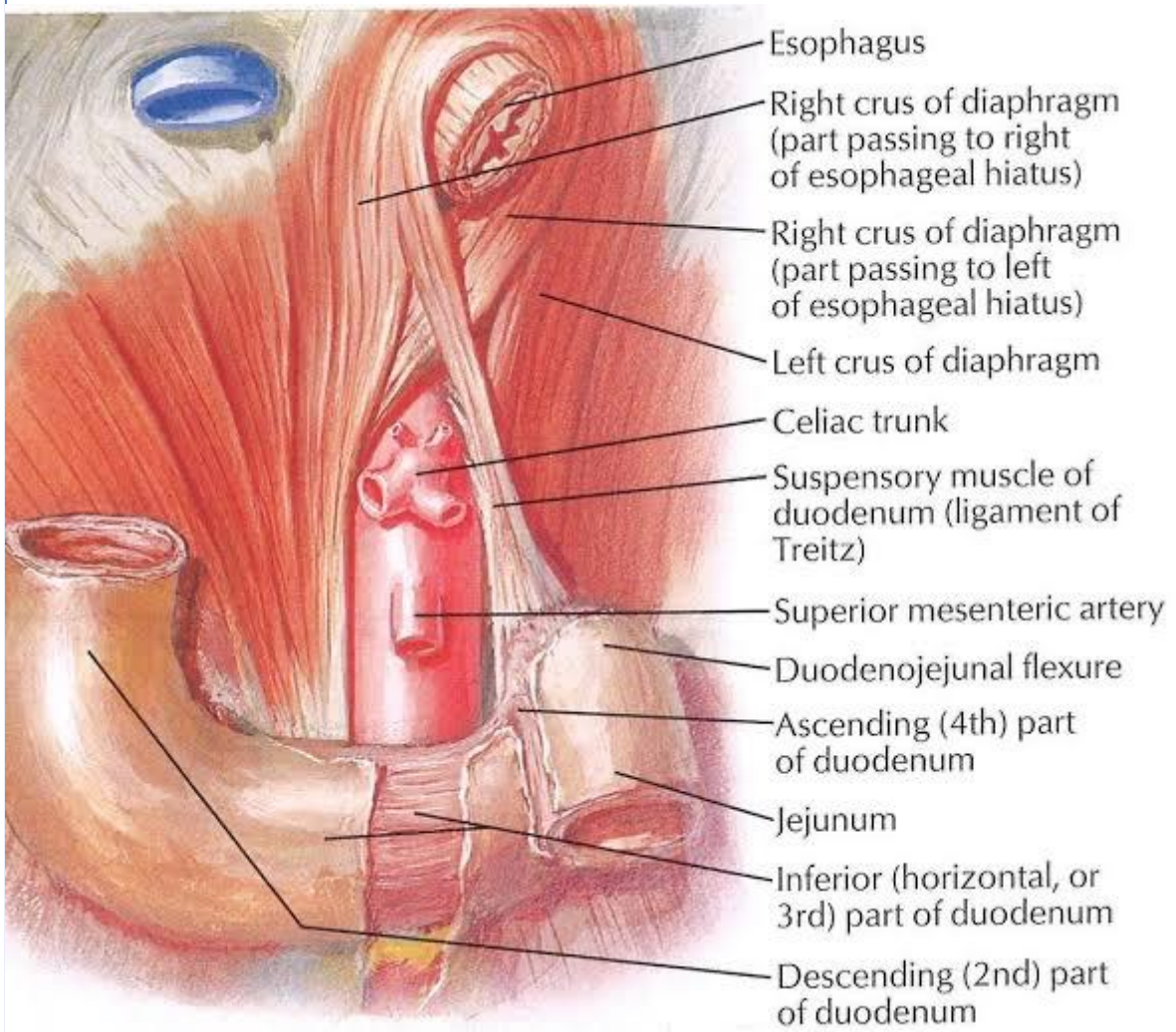
- Caliber decreases prox→ distal; 4x decrease in surface area from distal duodenum to TI

  - Most proximal. Pylorus to the jejunum
  - C-shaped loop around the head of the pancreas
  - 30cm long
  - D1/2/3/4

  D1:

  - **Duodenal bulb or ca**p: 5cm→ rightward, up and backward.
  - Retroperitonal → returns to peritoneum at **ligament of Treitz**

  - Loosely attached to the liver→ hepatoduodenal portion of the lesser omentum
  - Moves in relation to movement of pylorus
  - **Posterior** to D1: gastroduodenal artery, bile duct and portal vein
  - **Anterior**: gallbladder



Small bowel: Duodenal Anatomy

D2:

- 7-10cm. Downward and parallel and in front of the right kidney (hilum)
- Right side: head of pancreas
- With D2 → posterior medial wall, major papilla, ampulla of Vater→ nipple like projection
- Minor duodenal papilla→ accessory pancreatic duct (duct of Santorini). 1-2cm proximal to vater.

D3:

- 10cm, transverse from right to left across midline.
- Posterior to D3 →IVC. Spine and aorta
- Anterior to D3→ superior mesenteric artery & vein

D4:

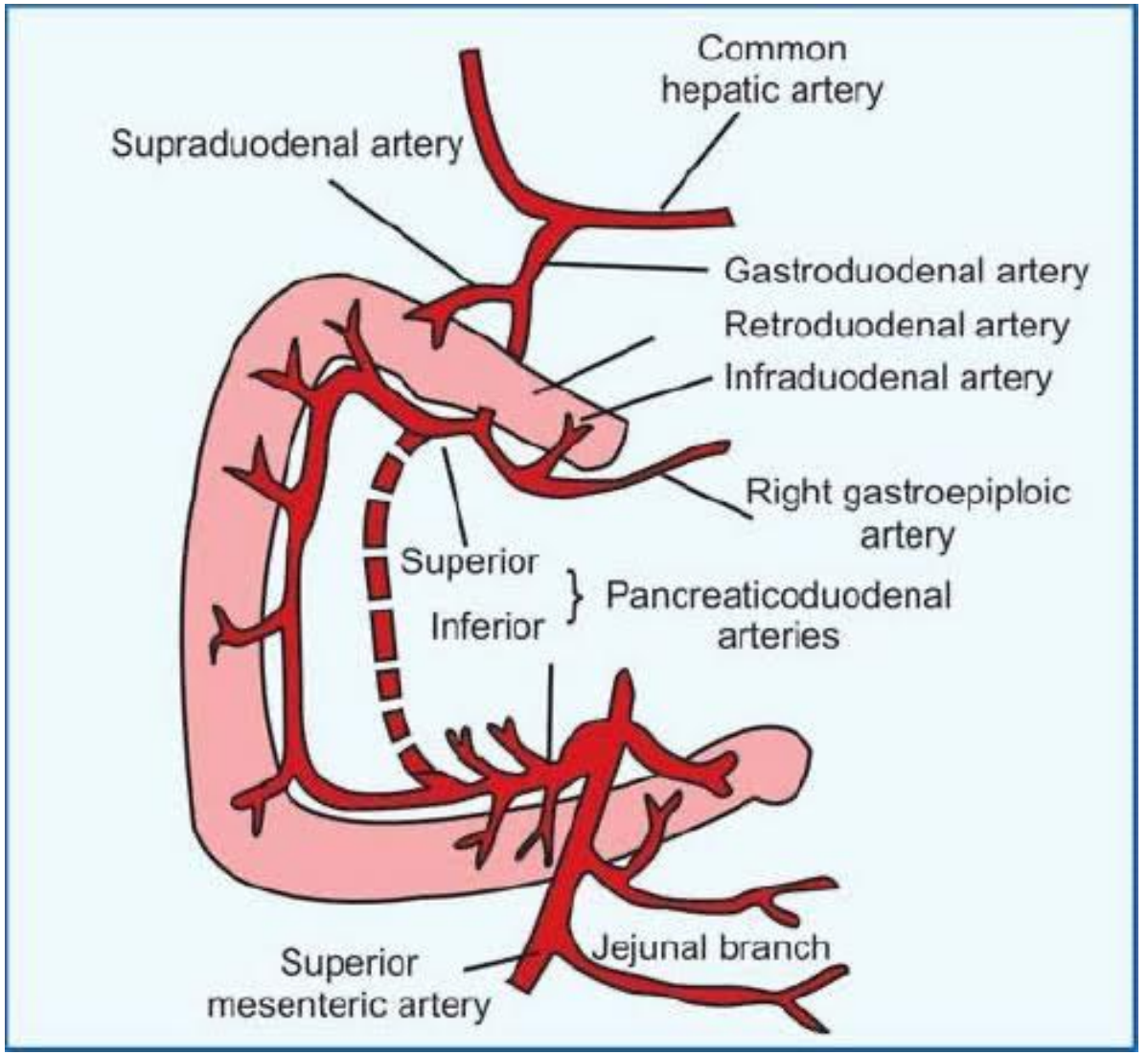
- 5cm → up and to the left of the aorta, reaches inferior border of the pancreas
- Duodeno-jejunal flexure → fixed point→ **ligament of Treitz**

Proximal duodenum: right gastric a, supra-duodenal a, right epiploic a & superior and inferior pancreoduodenal a

Distal duodenum/jejunum, ileum, ascending colon and proximal 2/3 transverse colon: SMA

Remainder of colon: Inferior mesenteric a

Duodenum: Arterial supply



https://www.jaypeedigital.com/book/9788180617348/chapter/ch134

Duodenum: Venous Supply

- Corresponds with arterial supply
- Superior pancreaticoduodenal veins→ transverse duodenum and HOP→ portal vein
- Inferior pancreaticoduodenal vein→ jejunal or SMV

Duodenum: Lymphatics

- Small anterior & posterior duodenal lymph channels
- Pancreaticoduodenal lymph nodes
- Superior hepatic LN
- Inferior SMN

Small bowel: anatomy

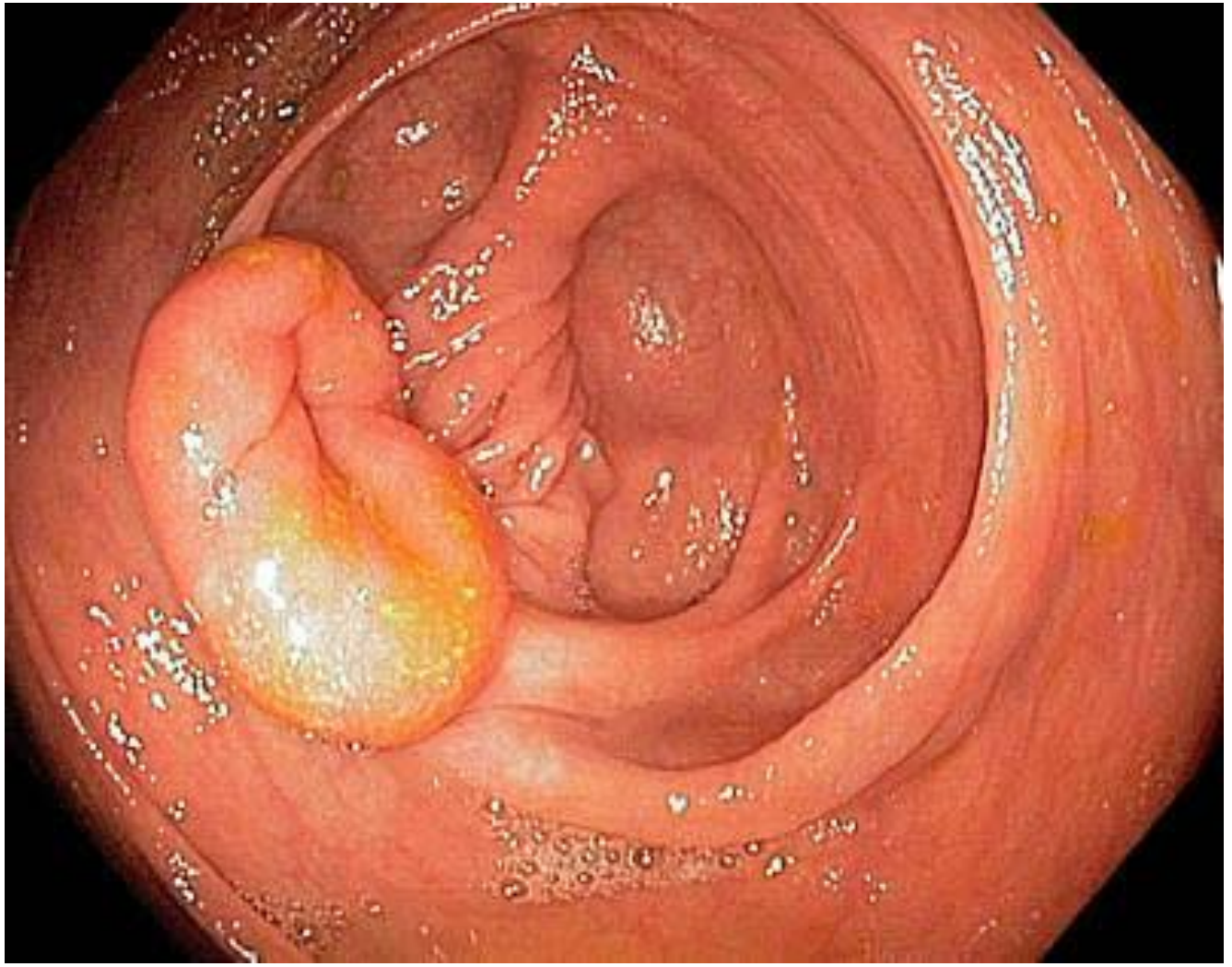
Jejunum (40% of freely mobile small bowel) **and ileum** (60%)

- Within the peritoneum, suspended by **mesentery**
  - Thin, broad based, fan shaped. Anterior reflection of the posterior peritoneum—attached to the abdominal wall.. Extends from L→R sacroiliac joint. Allows free movement but tethered.
- Jejunum →thicker, more vascular, greater diameter
- **Pilcae circularis**
  - Folds; Prominent proximally- jejunum and decrease distally. Nil in TI
- Lymphoid aggregates→ microscopic: scattered
- **GI associated lymphoid tissue (GALT)**
- Macro: **Peyers patches**. Ileum, extent through serosa. ++infancy and childhood

Small bowel: anatomy

Ileo-caecal valve

- 2 semi-lunar lips→ flutter valve
- Anterograde flow. Opens with peristaltic wave
- Prevents retrograde reflux of colonic content into TI
- Angulation→ ileum and caecum→ supported by **Superior &inferior IC ligaments**. NB for function of the valve
- Contracts with distention of caecum
- Colonoscopy NB
- Distal terminal ileum→ **retroperitoneal**



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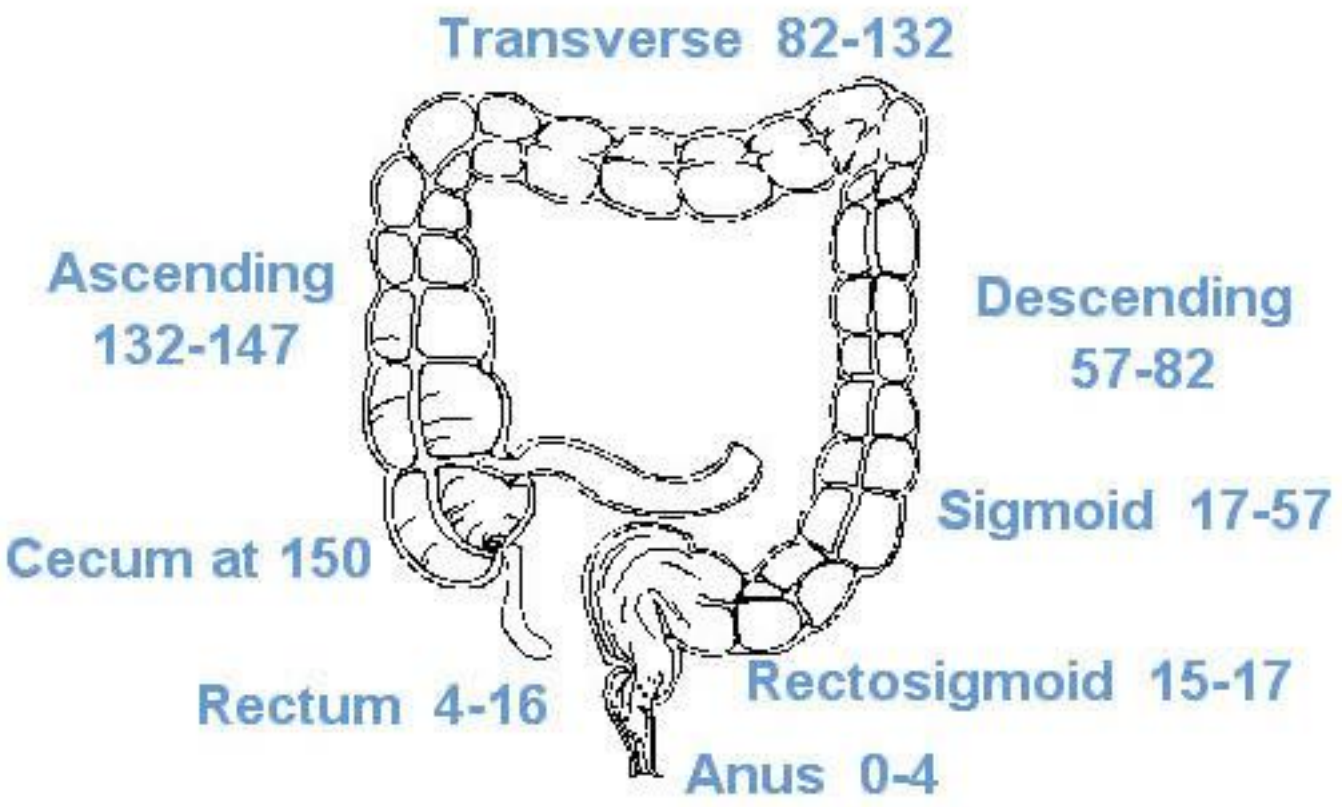
Colon: anatomy

- 150cm length in adults
- Begins at IC valve to the anal verge
- **4 segments: cecum/ verimiform appendix/ colon/rectum & anal verge**
- Diameter greatest at the cecum 7.5cm & narrowest at sigmoid 2.5cm. Then balloons into rectum.

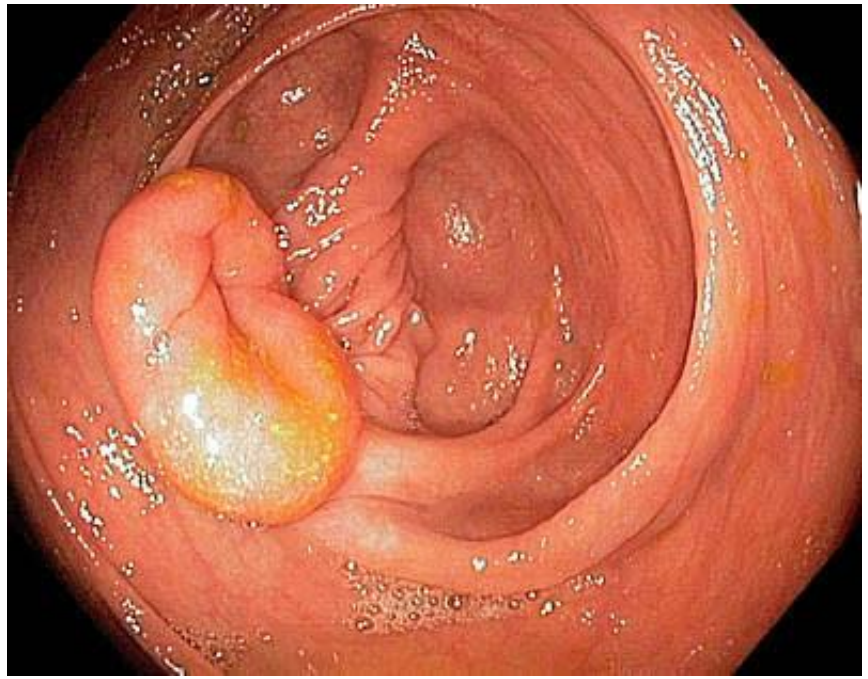


Seer training:colonoscopy.

Colon defining features	
Large **caliber**	Small sacs of peritoneum filled with adipose tissue → **appendices epiploc**ae→ found on external surface
Mostly fixed **position**	**Mesentery** fully suspends: TV colon and sigmoid colon Remainder → only mesentery on free anterior surface
Outer longitudinal muscle fibers – coalesce in 3 discrete bands→ **Taeniae coli** **Width-**6-12mm. Thickeness increases from caecum to sigmoid. • Taeniae liberis (free) • Taeniae omentalis (omental) • Taeniae mesocolica (mesenteric) • 120 degree intervals→ extend from cecum to proximal rectum	Appendix→ short mesentery. **mesoappendix**
Haustra or outpouchings → between the taeniae -mucosal surface→ semilunar folds → serosa a sacculated and puckered appearance	

Colon anatomy: Caecum

- Most proximal→ 6-8cm length and breadth
- RIF, projecting down, blind ended pouch below entrance of the ileum
- **Large diameter**, susceptible to perforation due to distal obstruction
- Mass can grow to substantial size with no obstructive symptoms
- **Nonmobile→fixed** in position by the small mesocecum
- **IC valve**→ perpendicular, posteromedial wall. Superior and inferior fold→ elliptical at the orifice
- **Appendiceal orifi**ce 2,5cm inferior to IC valve
- Vermiform appendix, blind outpouching



Colon Anatomy:

Ascending colon:

- 12-20cm from level of IC valve to inferior surface of posterior lobe of liver
- Hepatic flexure: angulates to the left.
- Covered in peritoneum, retroperitoneal → in 75% of the population

Transverse colon:

- Longest part of colon at 40-50cm
- fully enveloped in mesentery, most mobile segment of the colon
- Phrenocolic ligament anchors the colon at the splenic flexure
- Upright position → dip down in pelvis
- Previous abdominal and pelvic surgery- adhesion. cscope

Colon Anatomy:

Descending Colon:

- 25-45cm, travels posteriorly and inferiorly in the retroperitoneal compartment to pelvic brim
- Emerges from retroperitoneal to peritoneal cavity

- **Sigmoid colon:**
  - S-shaped redundant segment, variable length, tortuosity and mobility
  - Mobile- volvulus- narrowest
  - Mass→ obstructive symptoms

Rectum:

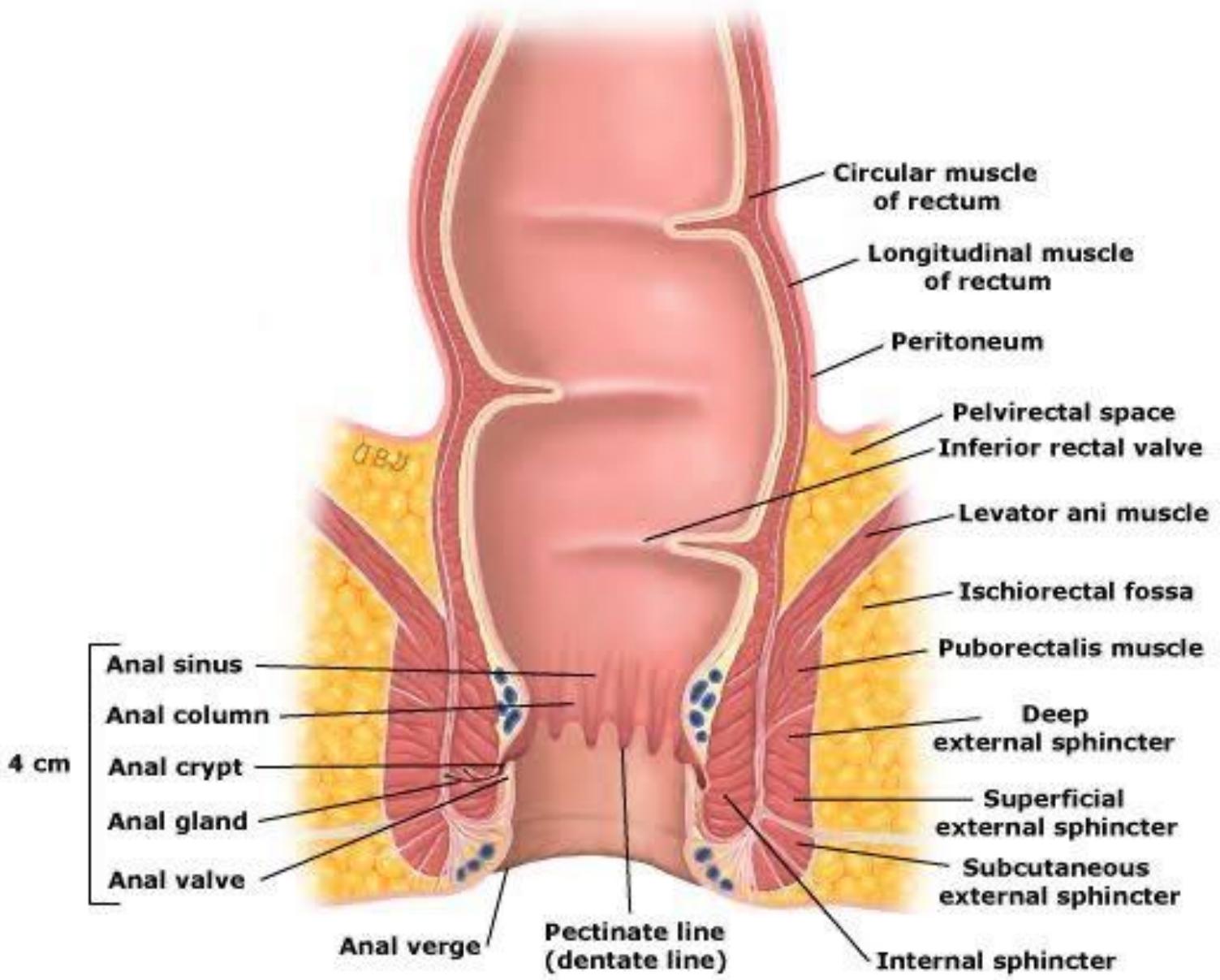
- 10-12cm-→ begins at peritoneal reflection, follows curve of sacrum passing down posteriorly and ends in the anal canal
- no sacculation, appendices or mesentery
- Outer wall→ progressively thickened. Prominent anterior bands of muscle. Luminal - 3 transvers folds called valves of Houston
- Recto-sigmoid junction→ narrows
- Expands at the anus

Anal Canal:

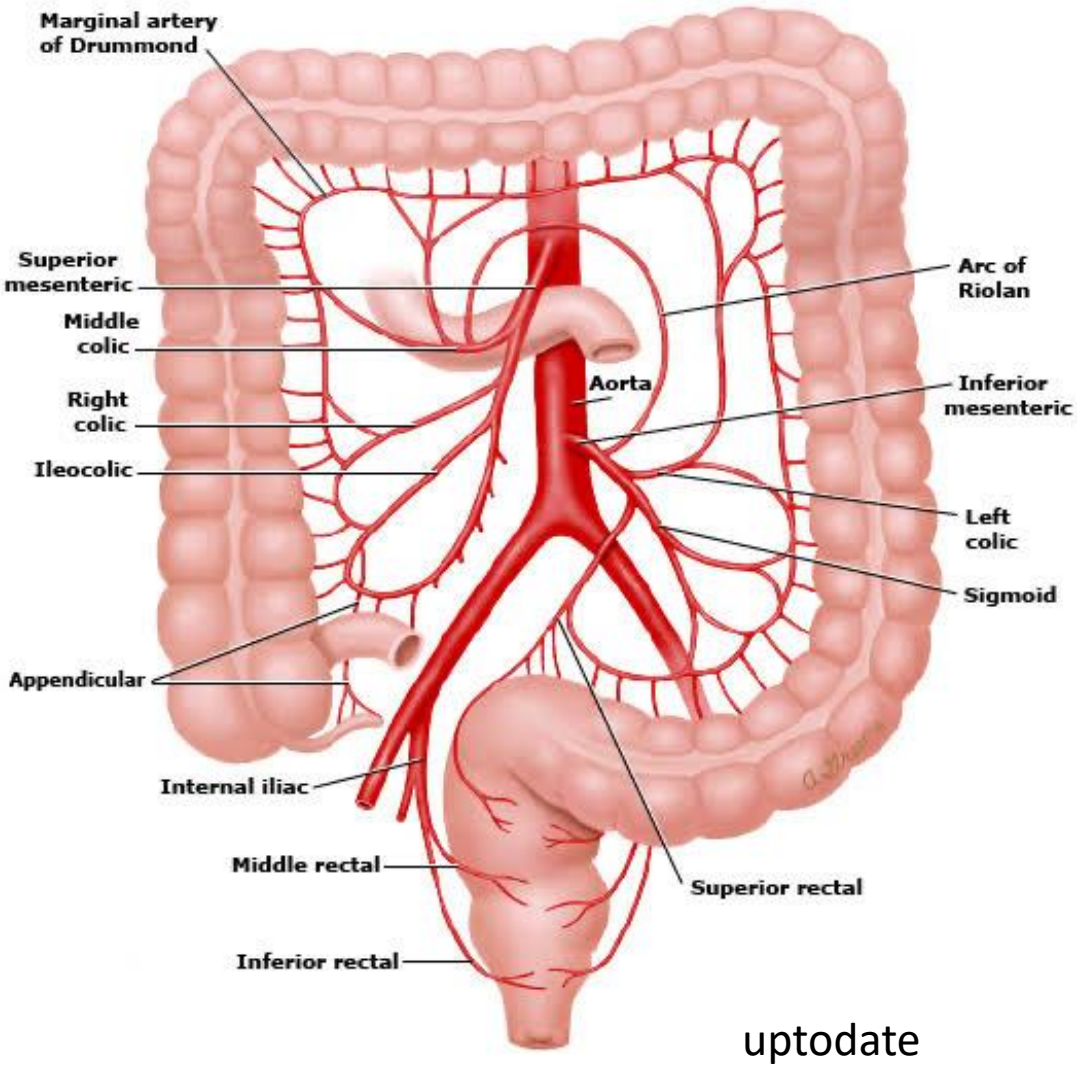
- 4,5cm. **Ischiorectal foss**a- inferior & outward toward the anal opening
- Anorectal junction- 2-3cm anterior to coccyx
- Pelvic diaphragm**. Levator ani, coccygeus and puborectalis muscles**
- **Internal sphincter:** circular smooth mm. upper ¾ of canal
- **External sphincter**: striated muscle. Anal canal. Fibers blend with levator ani and attach posteriorly at the coccyx and perineal body

Anal Canal:

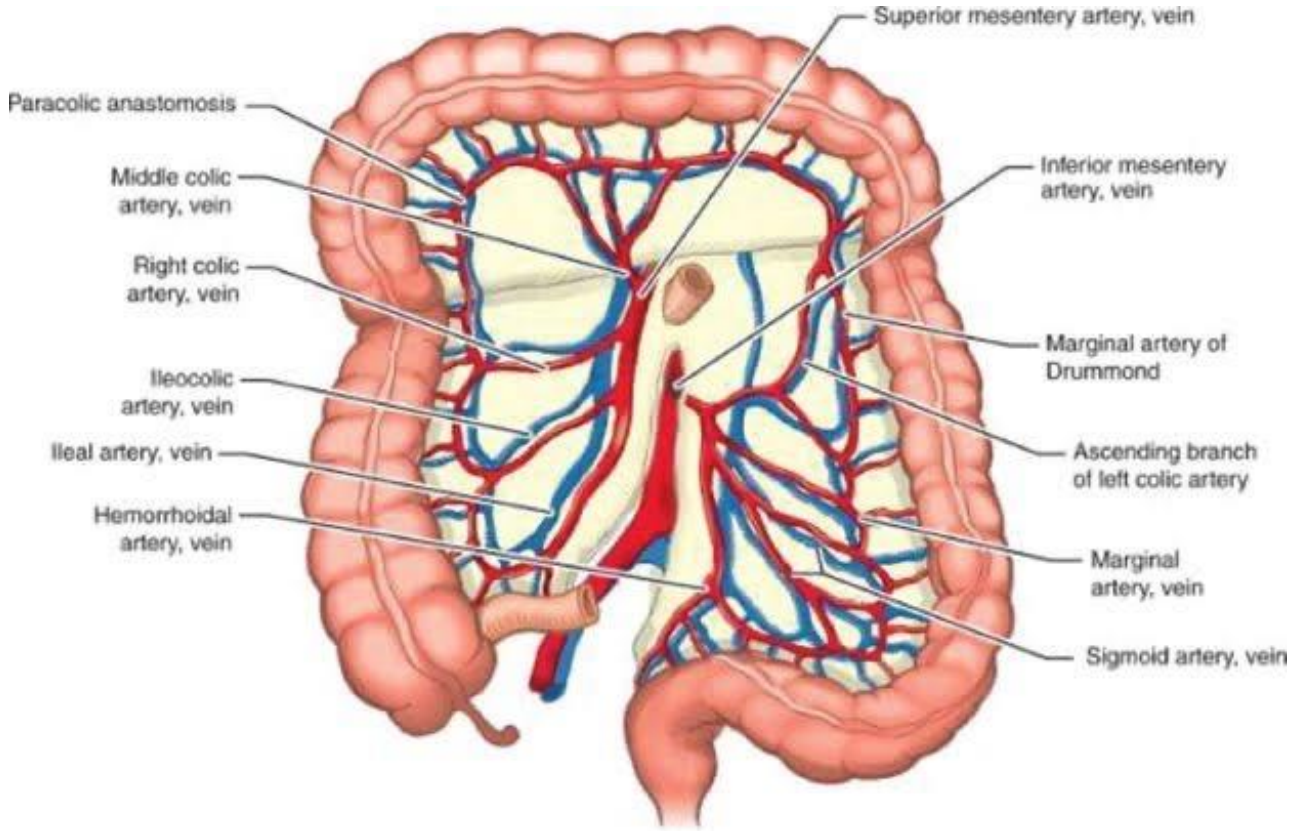
- Distal: **anal verge→ anoderm** to true skin
- Mucosa distal 3cm rectum + anal canal→6-12 redundant longitudinal folds→ **columns of Morgagni. Terminates in the anal papillae**
- Columns joined together by mucosal folds→ **anal valves→** situated at the **dentate line**



Colon: vascular supply



uptodate



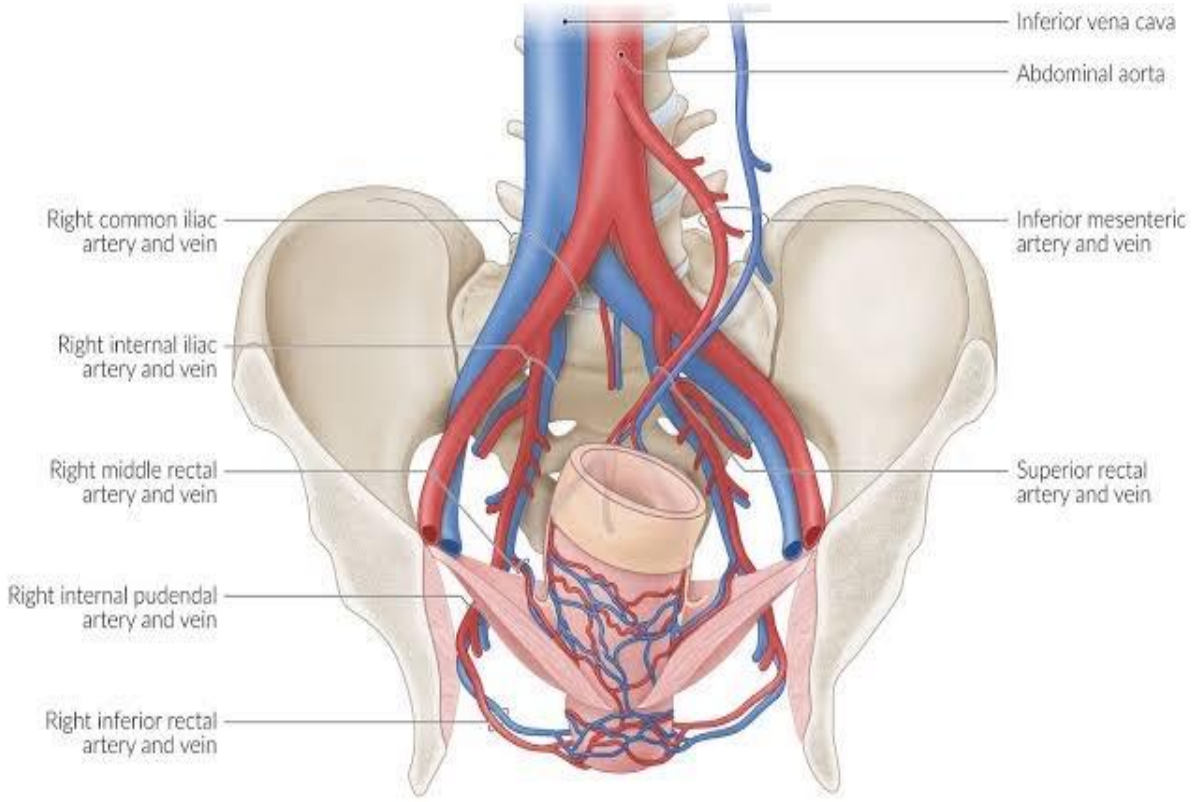
- SMA- distal duodenum, jejunum and ileum, ascending colon and proximal 2/3rd of the TV colon
- Branches if the inferior mesenteric artery →the remainder of the colon

Colon: anal vascular supply

- **<u>Arterial</u>**: Branches of the inferior mesenteric artery, hypogastric and internal pudendal aa. **superior, middle and inferior hemorrhoidal/rectal arteries**

- **<u>Venous</u>**: both systemic and portal systems
- **Internal hemorrhoidal plexus** drains into **superior rectal vein**s→ then into inferior mesenteric vein +SMV→ join splenic to form the portal vein

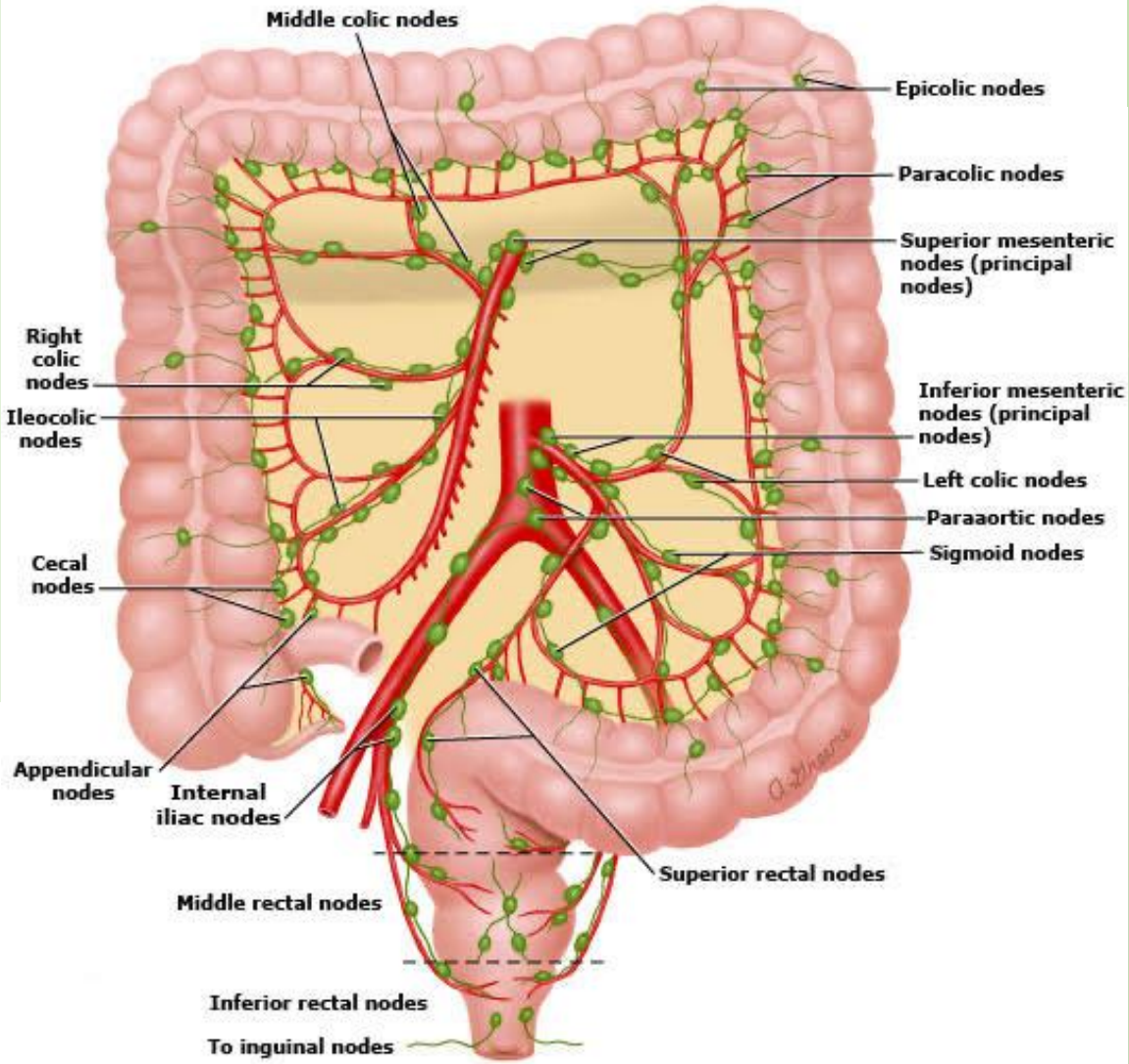
- **Distal anus**: drained by **external hemorrhoidal plexus**, through middle rectal and pudendal veins into internal iliac vein



Amboss

Colon : lymphatic drainage

- Follow blood supply
- **Celiac, preaortic and inferior aortic regions→ cisterna chyli and via thoracic duct into left subclavian vein**
- **Proximal** – dentate→ inferior mesenteric and periaortic nodes
- **Distal**– inguinal LN



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The colic lymphatic vessels are accompanying the arteries.

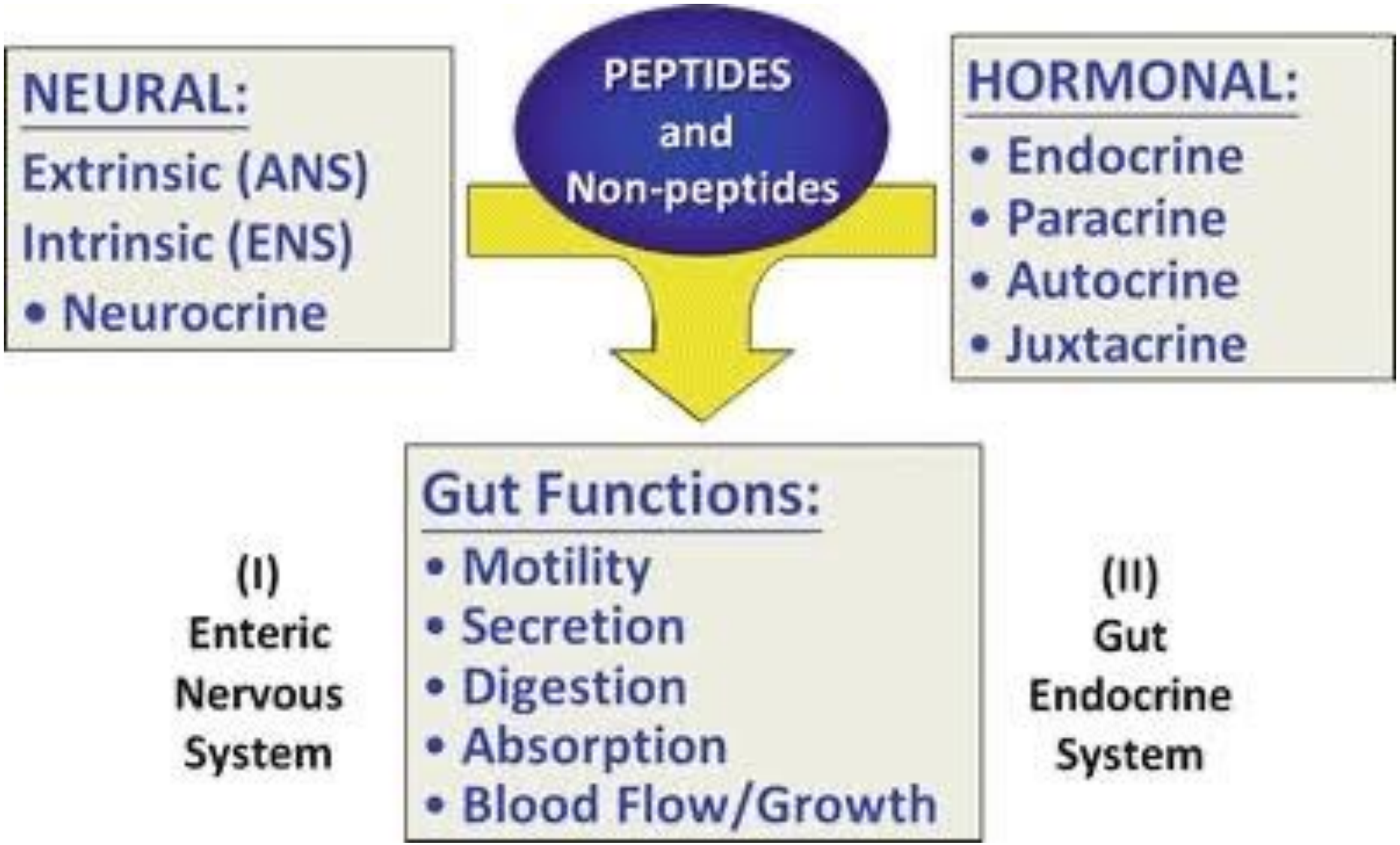
Lymph form cecum, ascending and transverse colon drained toward right and middle colic lymph nodes, then to the ***superior mesenteric lymph nodes***.

Lymph from the descending colon drained toward left colic lymph nodes, then to the ***inferior mesenteric lymph nodes***.

Lymph from the sigmoid colon drained toward the sigmoid lymph nodes, then to the ***inferior mesenteric lymph nodes***.

Lymp from upper third of the rectum drained toward the ***inferior mesenteric lymph nodes***, from inferior two thirds drained toward the ***internal and external iliac lymph nodes***.

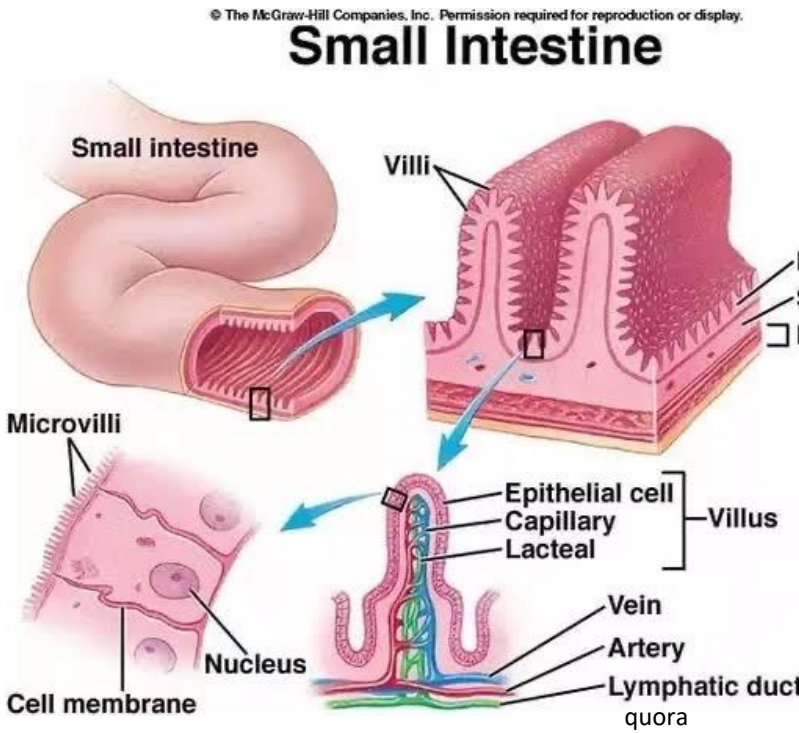
Colon innervation

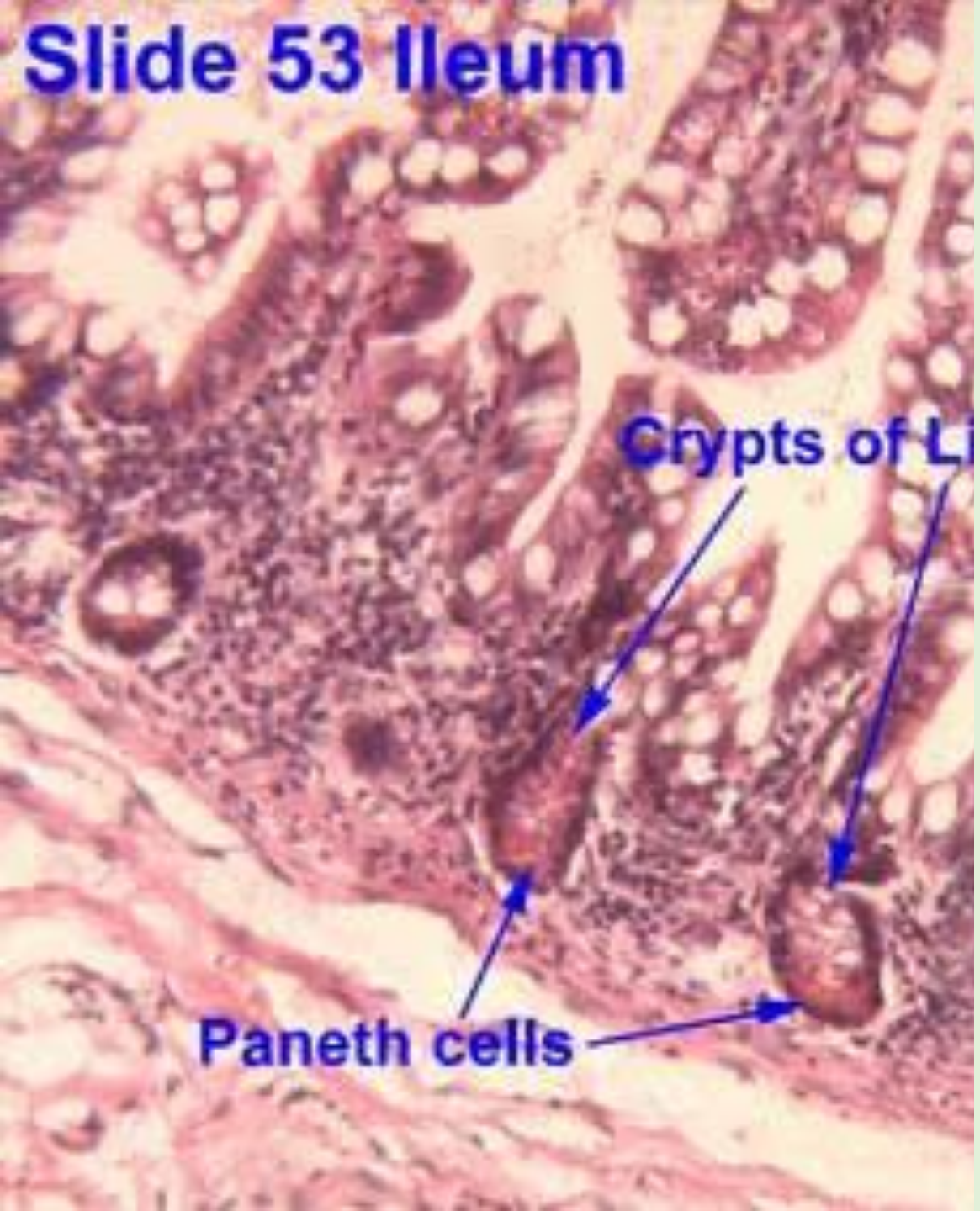


Microscopic Features -Small and large intestine

Mucosa:

- Glandular epithelium, lamina propria, muscularis mucosae
- Thick/highly vascularized
- Concentric fold- plicae circulares
- **Villous projections**→ 400-500 x increase in surface area
- Project 0.5-1.5mm into the lumen. Height decrease as move proximal to distal small intestine.
- Villi wider, leaf like in D1/proximal→ become finger like from jejunum
- **Villi** are covered in mature absorbing enterocytes, interspersed with goblet cells.
- Each villous contains: artery, vein, central lacteal, nerve fibers, plasma cells, macrophages, eosinophils and fibroblasts. Capillary be forms along the epithelium
- Allowing → absorption. Fenestrated cap walls.





- Villi are surrounded by cylindrical **crypts of Lieberkuhn**
- Extend into the lamina propria and muscularis mucosae
- Lined with immature epithelium-secretory primarily.

CELLS:

- **Absorptive**- high columnar cells. Oval base nuclei. Eosinophilic cytoplasm. Brush border- microvilli. 14-40 fold increase in luminal surface area.

- **Secretory**- goblet cells. Mucin. distal ileum and large intestine. Oval or round with flattened basal nuclei.

- **Stem cells- base of crypts.**
  - Mitotic activity- all types of cells. Turnover 5-7days
  - Upper third → mature cell

- **Paneth cells:** only cells that don't migrate.
  - Flask shape with eosinophilic granular cytoplasm and broad base.
  - Exclusively in crypt.
  - Secrete alpha-defensin, antimicrobial proteins, lysozyme and phospholipase A. enteric homeostasis

- **Undifferentiated cells**, tuft cells, cuplike cells ?function.

Neuroendocrine cells:

- 11 different types. Tall columnar, secretory granules.
- Neurosecretory granules- dark. Chromogranin enables identification of large dense core vesicles and synaptophysin target small synaptic like macrovesicles

- **Hormone products**→ discharged into basal and basolateral surface→ **paracrine-** absorption, secretion, motility , mucosal cell proliferation and immune barrier control. Some **endocrine** or systemic effects.

- **Preferred designation according to stored peptide:**
  - Serotonin producing enterochromaffin cell
  - Vasoactive intestinal polypeptide cells
  - Somatostatin D cells
  - Gastrin, ghrelin, GIP, secretin, CCK-stomach and proximal small intestine
  - Peptide YY, GLP-1 and GLP 2 and neurotensin- ileum

Table 2 | **Major hormones released during feeding/digestion known to have gastrointestinal activity***

Hormone	Release from the gut	Functions
Released from the stomach and/or duodenum		
Gastrin	Released from upper gut in response to food in lumen	• Primarily serves to stimulate gastric acid secretion by CCK_2 receptors on parietal cells • Other functions include an ability to reduce lower oesophageal sphincter pressure[152] and gastric emptying[61]
Cholesystokinin (CCK)	Released in response to fat and protein intake[61]	• Signals by CCK_1 receptors on vagal mechanoreceptive nerve terminals[61,153] to reduce feeding and gastric emptying • Signals by CCK_2 receptors in the area postrema (AP) can slow gastric emptying of liquid meals[60], and reduce feeding[61] and illness behaviours[62]
Leptin	Released from adipose tissues but also produced in the stomach[64]; during fasting, gastric leptin synthesis is reduced but it is rapidly released in response to food intake, vagal-nerve stimulation, CCK and secretin[66]	• Circulating leptin is transported across the blood–brain barrier and reduces food intake and body weight[65] • Can modulate the ability of CCK to activate vagal-nerve afferents from the upper gut and thereby influence meal size and satiation[67]
Enterostatin	Released in response to ingested fat[63]	• Decreases food intake when given peripherally or centrally[63]
Released from the small intestine and/or colon		
Peptide YY (PYY)	Released postprandially; plasma levels peak in the second hour after a meal; the major form of PYY in the gut and in the circulation is the N-terminally truncated PYY(3–36)[154]	• Acts as an 'ileal break' by reducing food intake • Slows gastric emptying, intestinal fluid and electrolyte secretion and intestinal meal transport[63,155]
Apolipoprotein A-IV	Synthesized mainly by enterocytes in the small intestine and released in response to long-chain triglyceride absorption[70]	• In rats, it stimulates the release of endogenous CCK to activate CCK_1 receptors on vagal afferents to initiate feedback inhibition of gastric motility and possibly food intake[70]
Glucagon-like peptide 1 (GLP1)	Released into the circulation after a meal containing fat or carbohydrate[133]	• Thought to act as part of an ileal break, at least partly via the vagus nerve to reduce gastric emptying and small-intestinal transit • Shown to reduce food intake in humans and to stimulate insulin release[126,133,156]
Glicentin	Released after feeding, possibly from myenteric neurons[157]	• Can inhibit gastric acid secretion and gastroinstestinal motility[158]

Somatostatin: Growth hormone inhibitory hormone. Originally found in the hypothalamus
Dcells- paracrine. Pancreatic ducts.
Gastrointestinal mucosa
INHIBITS: VIP/GIP/Sectretin/motilin

VIP: nerves in Git. Increase intestinal secretion of electrolytes and water.
Relaxes smooth mm including sphincters

Dipeptidyl-peptidase IV (DPP-4) degrade incretins: glucagon-like peptide-1 (GLP-1) and

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M cells

- specialized **overlying the lymphoid follicles and Peyers patches** → small intestine and colon
- Luminal antigen sampling, immune processing, tolerance. Host defense and homeostasis.

Interstitial cells Cajal (ICC)

- Both small intestine and colon
- **Myenteric plexuses** within muscularis propria and submucosa
- NB regulate peristalsis and pacemaker cells
- Smooth mm contraction, amplify neuronal signals and mediate neurotransmitters, membrane potential gradient
- Spindle shaped; long ramified process→ **express c-kit. CD117- tyrosine kinase** receptor critical for their survival

Micro: Small and Large intestine

Submucosa:

Meissner plexus- nonmyelinated postganglionic sympathetic fibers & parasympathetic ganglion cells

- Supports specialized nutrient, fluid and electrolyte absorption

Brunners glands:

- D1 and decrease in size distally, children in jejunum
- Secrete bicarbonate rich alkaline → neutralize chyme
- Secretions drain into the base of duodenal crypts and increase luminal pH→ promote pancreatic secretion and gallbladder contraction
- Glycoprotein class III mucin glycoproteins

Muscularis Propria

- 2 layers of smooth mm- inner circular and outer longitudinal
- Myenteric or Auerbach plexus – in plane of the 2 muscles

Serosa

- Thin layer of mesothelial cells, extension of mesentery→ envelops the intestine

Anal Canal

3 zones -Proximal, intermediate and distal or anal skin

PROXIMAL: Stratified cuboidal epithelium
ANORECTAL histologic junction: transition with the rectal mucosa- high columnar mucous producing cells
INTERMEDIATE or PECTINATE ZONE: stratified squamous epithelium, anoderm. No adnexae
DENTATE LINE: proximal margin in contact with the
PECTINATE LINE: Distal margin in contact with anal skin
Anal skin: squamous stratified epithelium, hair and sebaceous glands

Microscopy

LYMPHATICS

- Small intestine :Lacteals become filled with milky white lymph called chyle after eating.
- Each villous has 1 – except in duodenum where 2 or more
- Endothelial cells
- Anastomose at base with lymphatic capillaries→ plexus
- Lymphatic vessel absent in **colonic** mucosa but present in remaining layers

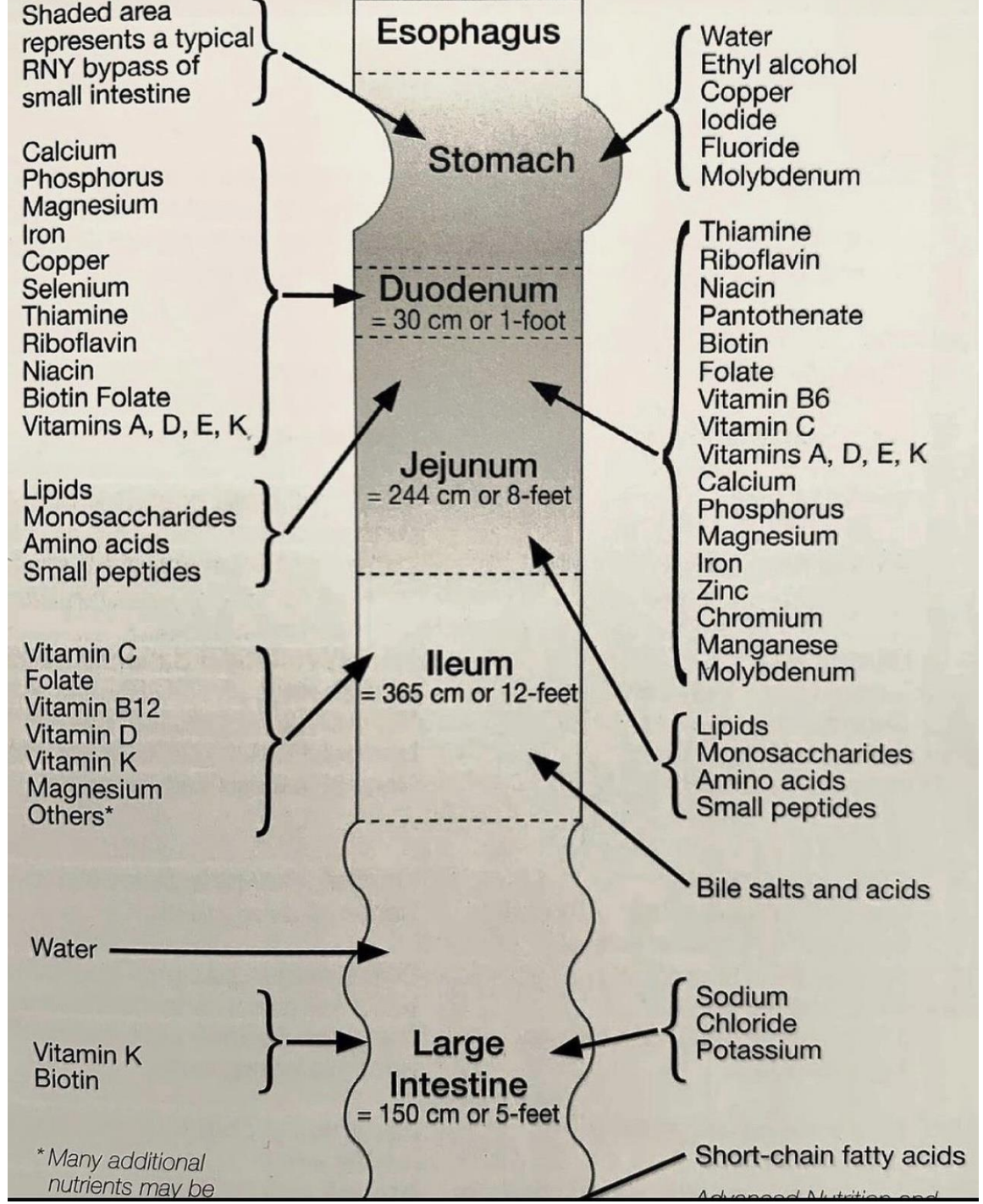
NERVES

ENS

Subserosal

Muscular and

submucosal plexuses


Shaded area represents a typical RNY bypass of small intestine
Esophagus
Water
Ethyl alcohol
Copper
Iodide
Fluoride
Molybdenum
Stomach
Calcium
Phosphorus
Magnesium
Iron
Copper
Selenium
Thiamine
Riboflavin
Niacin
Biotin Folate
Vitamins A, D, E, K
Duodenum
= 30 cm or 1-foot
Thiamine
Riboflavin
Niacin
Pantothenate
Biotin
Folate
Vitamin B6
Vitamin C
Vitamins A, D, E, K
Calcium
Phosphorus
Magnesium
Iron
Zinc
Chromium
Manganese
Molybdenum
Jejunum
= 244 cm or 8-feet
Lipids
Monosaccharides
Amino acids
Small peptides
Vitamin C
Folate
Vitamin B12
Vitamin D
Vitamin K
Magnesium
Others*
Ileum
= 365 cm or 12-feet
Lipids
Monosaccharides
Amino acids
Small peptides
Bile salts and acids
Water
Sodium
Chloride
Potassium
Vitamin K
Biotin
Large Intestine
= 150 cm or 5-feet
*Many additional nutrients may be
Short-chain fatty acids

References

- Sleisenger and Fordtran's Gastrointestinal and Liver disease
- Ganongs Medical physiology
- Harrisons Principles of internal medicine
- Multiple internet sources for graphics, labelled

Thank you!