

ANATOMY

GASTROINTESTINAL SYSTEM

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GASTROINTESTINAL SYSTEM

- Two groups of organs compose the digestive system
 - ❑ The gastrointestinal (GI) tract
 - ❑ The accessory digestive organs.
- **The gastrointestinal (GI) tract** or alimentary canal is a continuous tube that extends from the mouth to the anus through the **thoracic and abdominopelvic cavities**.
- 9 meter long
- Organs of the gastrointestinal tract include the mouth, most of the pharynx, esophagus, stomach, small intestine, and large intestine.
- **The accessory organs** are not part of the GI tube, but often develop as outgrowths from and are connected to the GI tract. The accessory digestive organs assist the GI tract in the digestion of material.
- Accessory digestive organs include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas.

Histology of gastrointestinal tract

- G.I tract walls are made up of four layers:
 - i. Mucosa
 - ii. Submucosa
 - iii. Muscularis
 - iv. Serosa/ Adventitia

Mucosa

- The innermost layer, mucous membrane
- It is made up by three layers
 - ❑ Epithelium
 - ❑ Lamina propria- layer of connective tissue
 - ❑ Muscularis mucosa- layer of smooth muscles
- Epithelium:
 - Lines the lumen
 - Varies in different region of tract depending on the function
 - In conductive areas (esophagus) it is stratified squamous, performing the protective role
 - In absorptive areas it is columnar, performing the function of absorption and secretion
 - The epithelium rapidly slough off and cells are renewed every 5 to 7 days
 - In between the epithelial cells are both endocrine and exocrine cells. The endocrine release hormones while the exocrine release mucous and fluids to the lumen

- Lamina propria
 - Layer of areolar connective tissue
 - Supports the epithelium attaches it to the muscularis mucosa
 - Extensive capillary network (specially in small intestine), food is absorbed and transported via these capillaries into blood
 - With in the lamina propria are lacteals (blind ended lymphatic tissue which carry out nutrients and white blood cells)
 - contain Gut- associated lymphoid tissue (responsible for IgA production)
- Muscularis mucosae
 - Thin smooth muscle layer
 - Confers ability of motility to the mucosa and facilitate the discharge of secretions from glands

Submucosa

- Made up of areolar connective tissue
- Binds mucosa to the muscularis layer
- Contain extensive network of blood vessels and lymphatics to absorb food
- Have extensive network of neurons called as submusocal plexus

Muscularis

- Made up of muscles
- In the upper portion of GI tract (mouth, pharynx and upper one third of esophagus) muscularis is made up of skeletal muscles to facilitate quick swallowing
- The external anal sphincter also contain skeletal muscles for voluntary control of defecation
- In the rest of the GIT the muscularis is made up of smooth muscles that are arranged in two sheets:
 - Inner circular
 - Outer longitudinal
- The involuntary contraction of smooth muscles facilitates mixing and break down of the food contents
- Between the layers of smooth muscles is second plexus of neurons called myenteric plexus
-

Serosa / Adventitia

- The outer layer of GIT may be serosa or adventitia
- Adventitia is made up of areolar connective tissue with dispersed collagen and elastic fibers. It covers the esophagus and retroperitoneal organs
- The serosa is serous membrane made up of areolar connective tissue and simple squamous epithelium (mesothelium). It covers the intraperitoneal organs like stomach. It is also known as visceral peritoneum

Mucosa

- Epithelium
- Lamina propria
- Muscularis mucosae

Submucosa

- Submucosal gland
- Blood vessel
- Submucosal nerve plexus

Muscularis

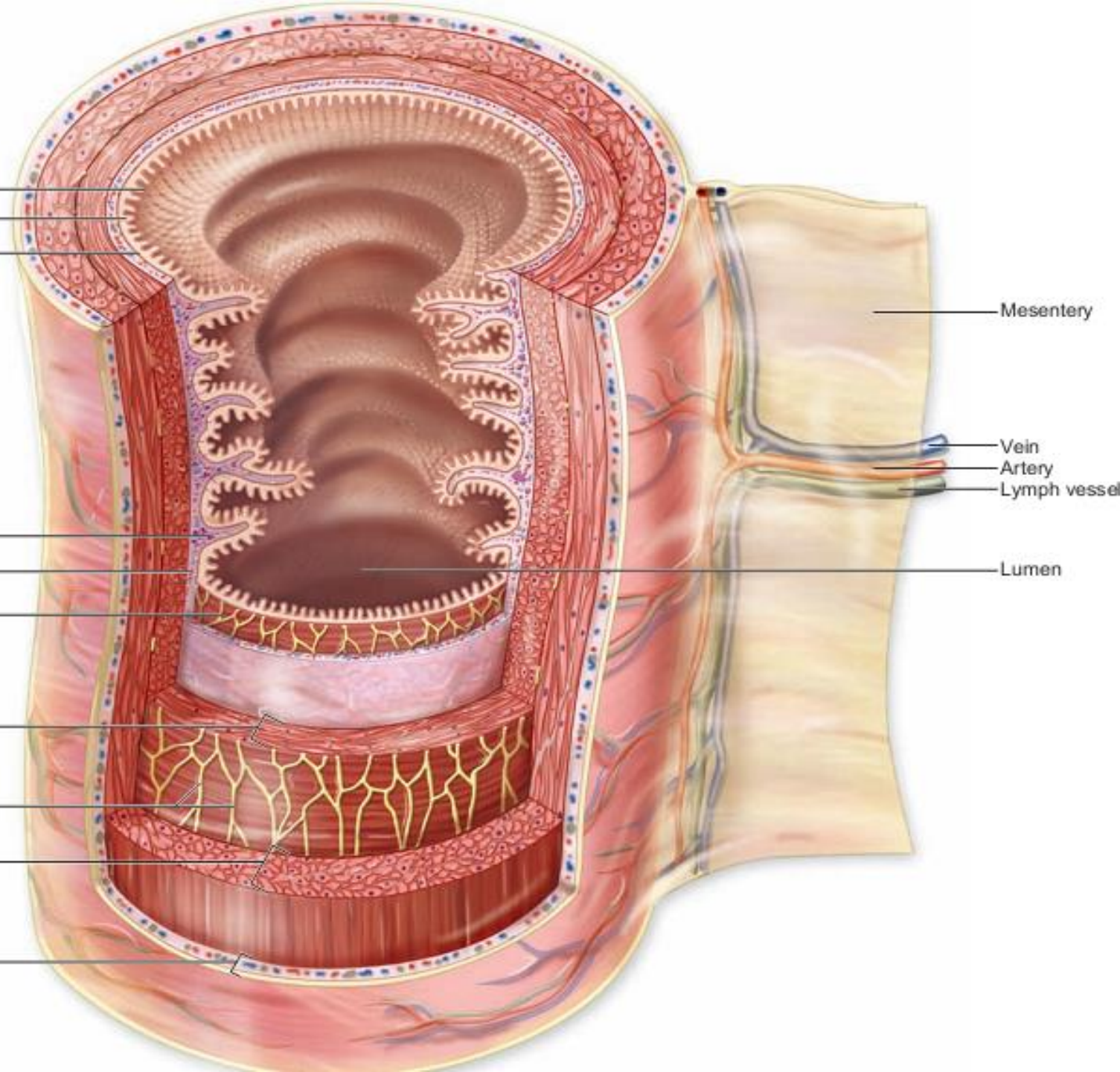
- Inner circular layer
- Myenteric nerve plexus
- Outer longitudinal layer

Serosa

Mesentery

- Vein
- Artery
- Lymph vessel

Lumen



Peritoneum

- Serous membrane lining the abdominopelvic cavity
- It has two layers :
 - Parietal peritoneum: covering the abdominal wall
 - Visceral peritoneum: covering the surface of internal organs (viscera)
 - In between the two layers is a potential space called peritoneal cavity
 - Peritoneal cavity contain fluid to facilitate the frictionless movement of organs
- Some of the abdominal organs are completely covered by visceral peritoneum- **intrapertoneal organs**. They include the stomach, part of the duodenum, the jejunum, the ileum, the cecum, the appendix, the transverse and sigmoid colon.
- Some of the organs lies posterior to the peritoneum and are called- **retroperitoneal organs**. They include most of the duodenum, the pancreas, the ascending and descending colon of the large intestine, and the rectum.
- They have their anterolateral portions covered by peritoneum while posteriorly they lie directly against posterior abdominal wall

Mesenteries

- Mesenteries are the double layered peritoneum present in the posterior abdominal cavity
- Mesentery perform the following functions
 - ❑ The mesentery supports the GIT by binding organs together and with abdominal wall
 - ❑ It provides passage for the nerves and vessels of the GIT
 - ❑ Enables the free peristaltic movement of the intestine
- There are several different types of mesenteries.
 - ❑ **The greater omentum** extends inferiorly like an apron from the greater curvature of the stomach and covers most of the abdominal organs. It often accumulates large amounts of adipose connective tissue.
 - ❑ **The lesser omentum** connects the lesser curvature of the stomach and the proximal end of the duodenum to the liver.
 - ❑ **The mesentery proper** is a fan-shaped fold of peritoneum that suspends most of the small intestine from the internal surface of the posterior abdominal wall.
 - ❑ **Mesocolon** is the peritoneal fold that attaches parts of the large intestine to the internal surface of the posterior abdominal

Liver
Falciform ligament
Round ligament
of the liver
Lesser omentum
Stomach

Greater omentum

(a) Omenta

Greater omentum
(reflected)

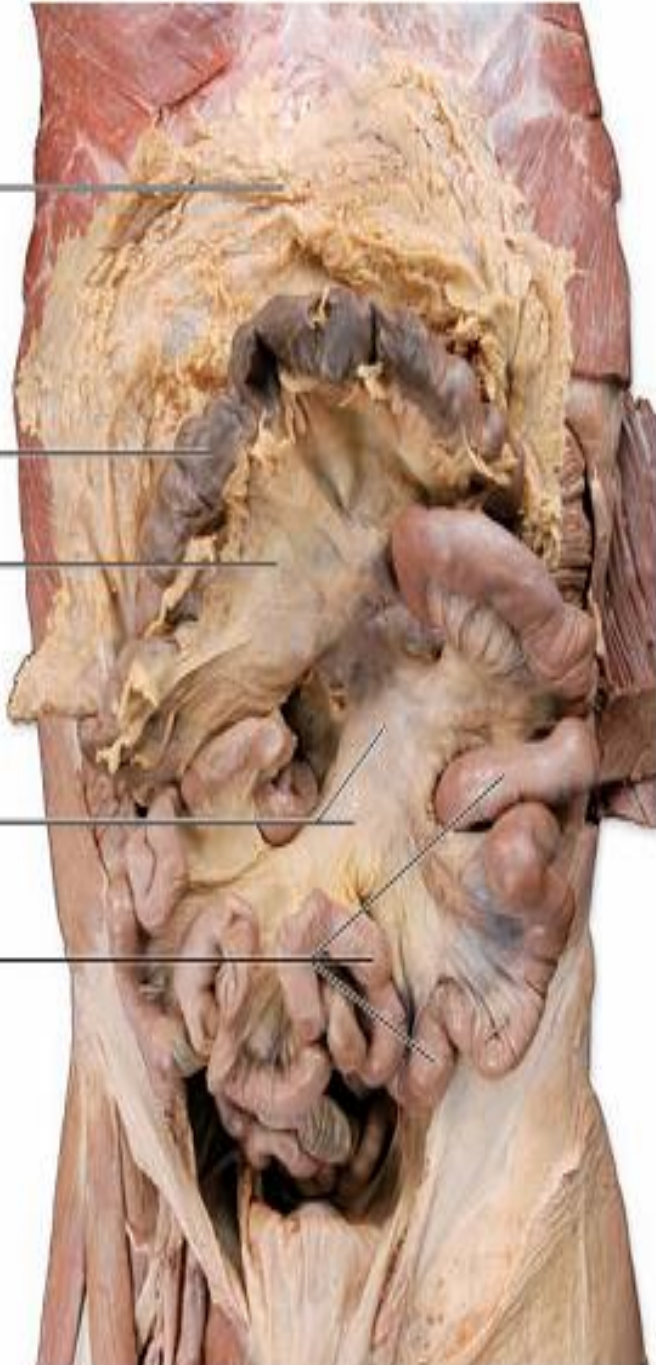
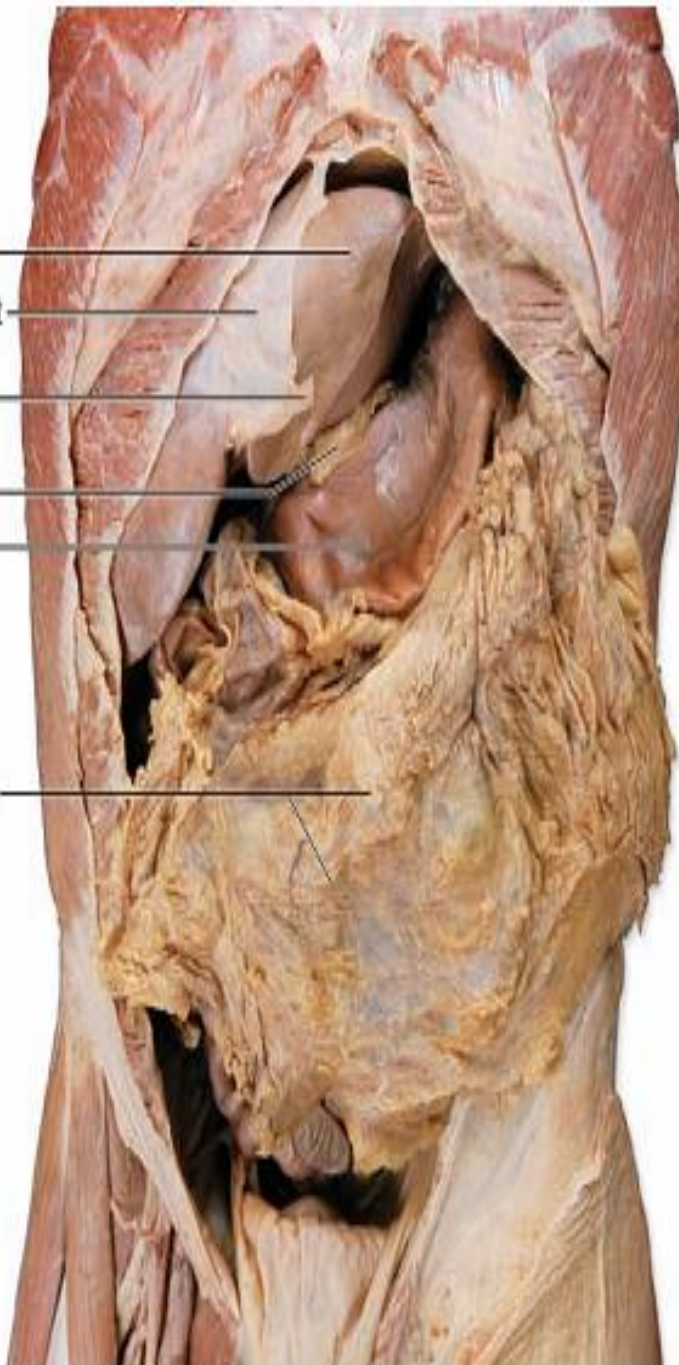
Transverse colon

Transverse
mesocolon

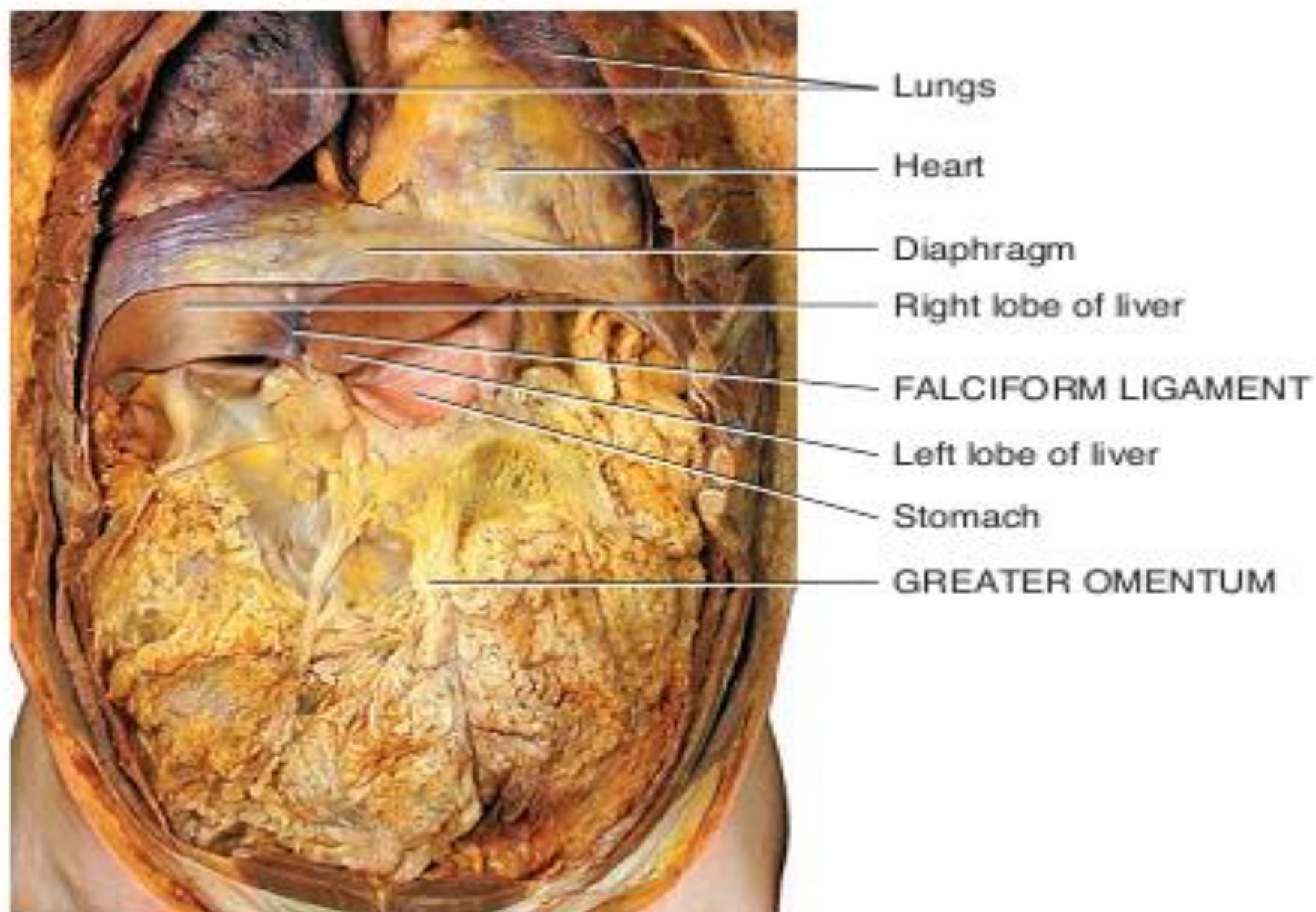
Mesentery proper

Small intestine

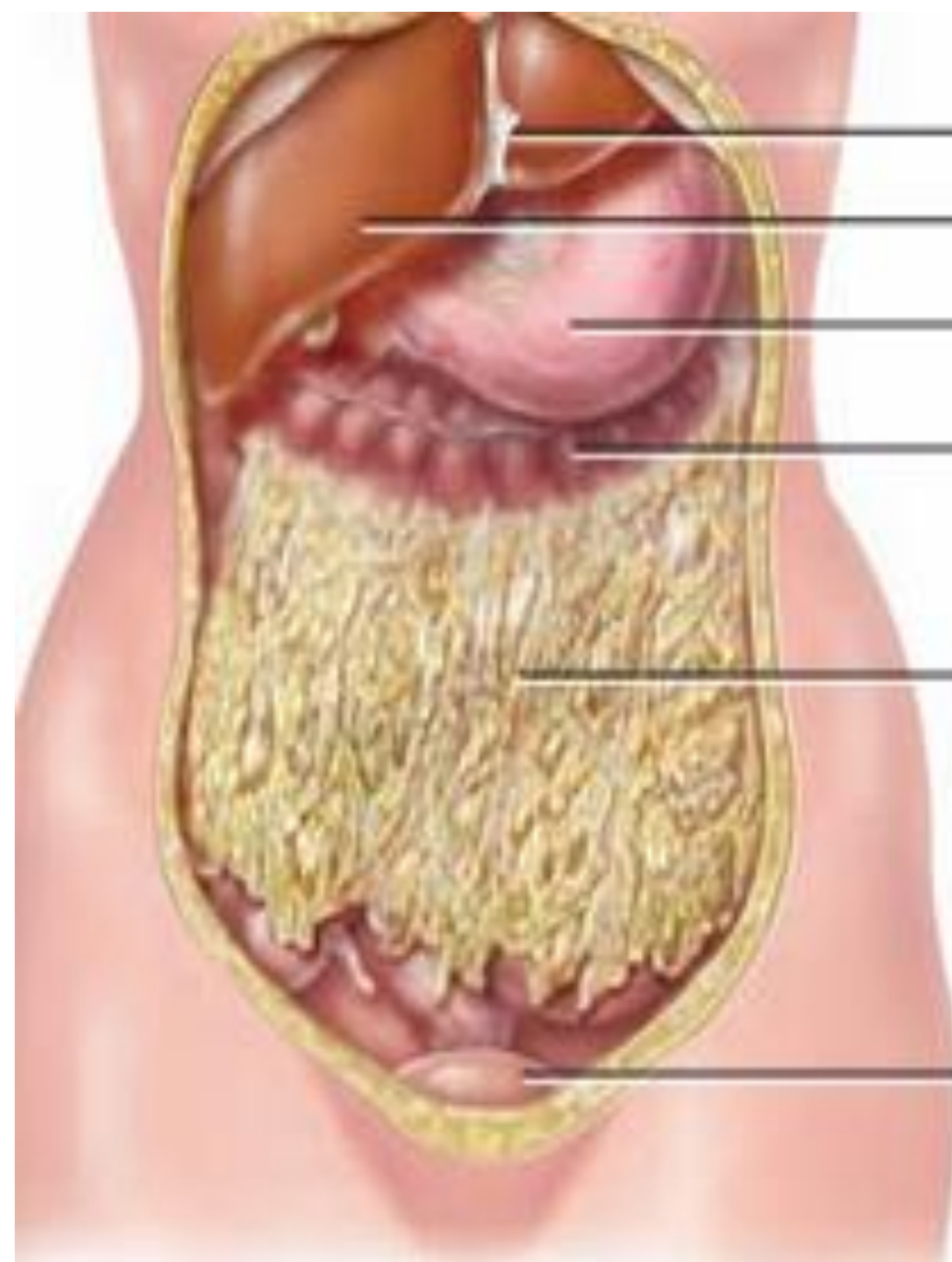
(b) Mesentery proper and mesocolon



SUPERIOR



(e) Anterior view



FALCIFORM LIGAMENT

Liver

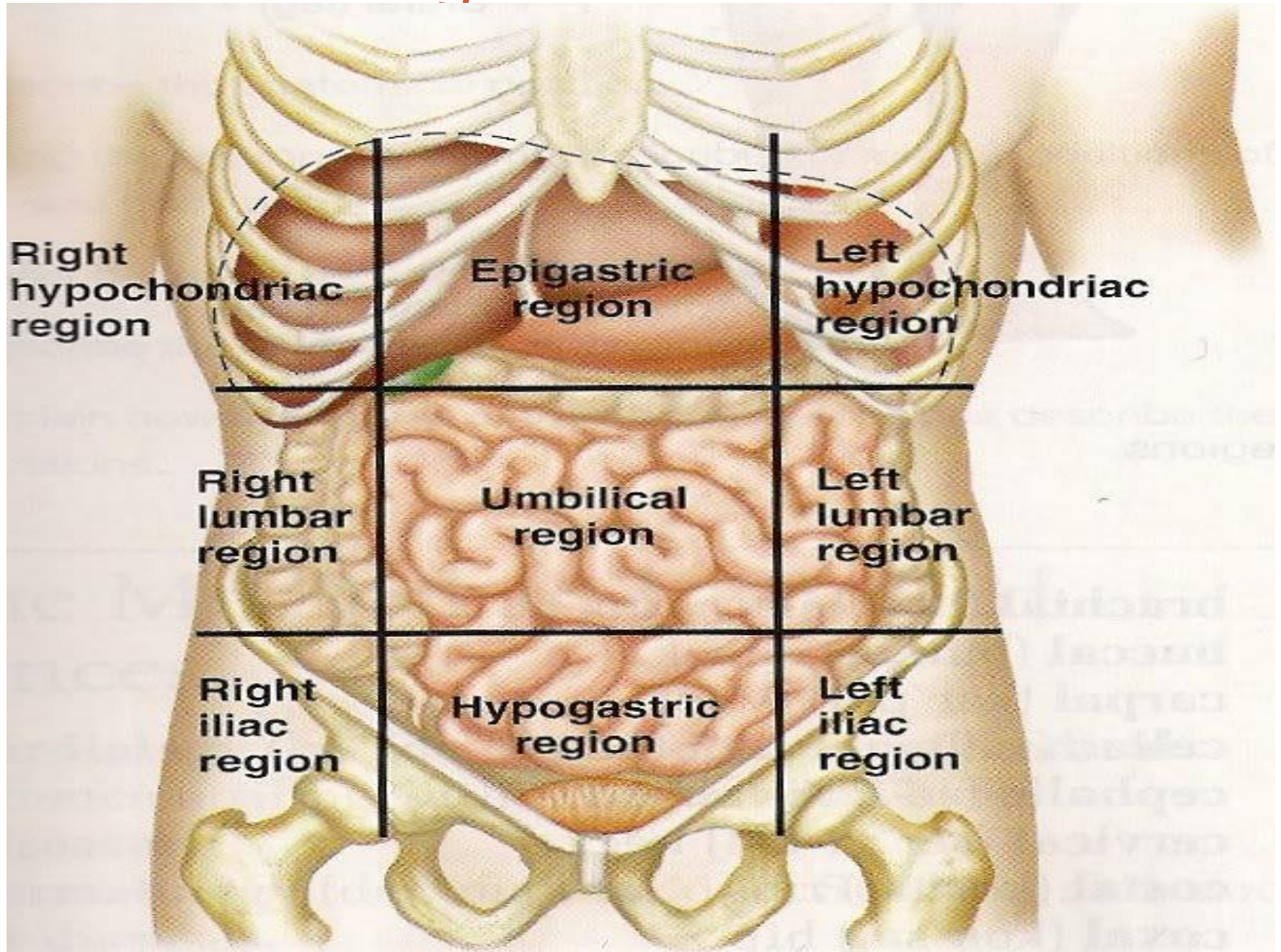
Stomach

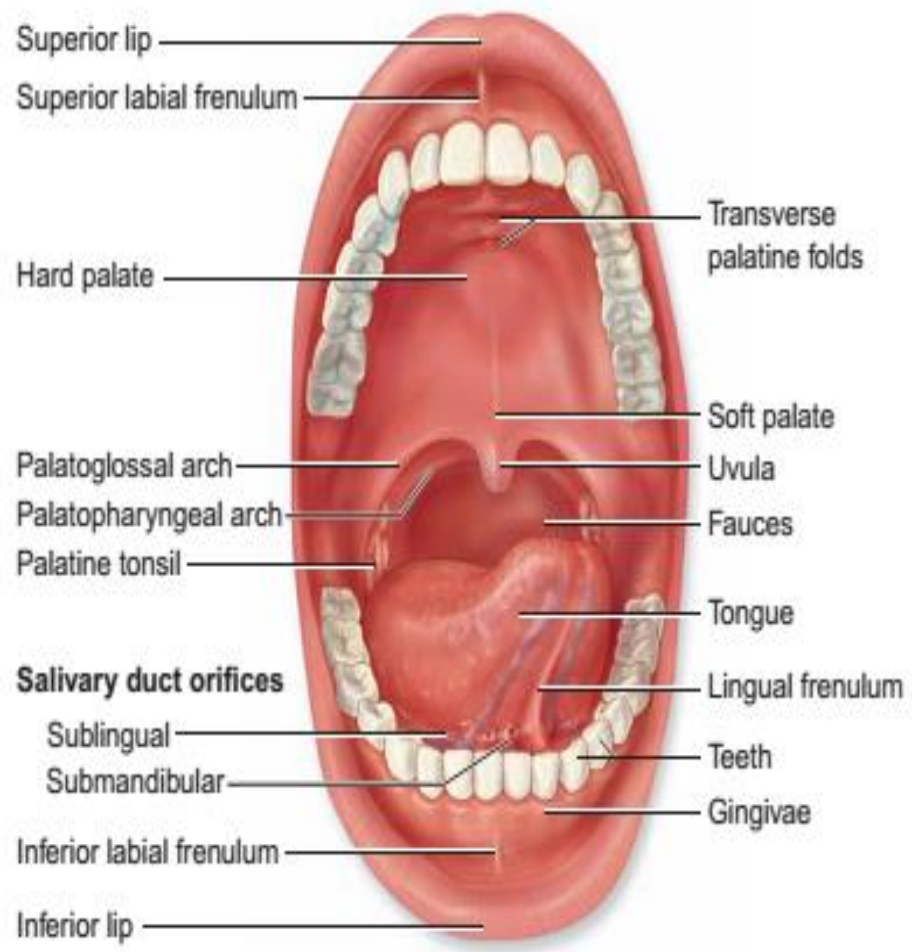
Transverse colon

**GREATER
OMENTUM**

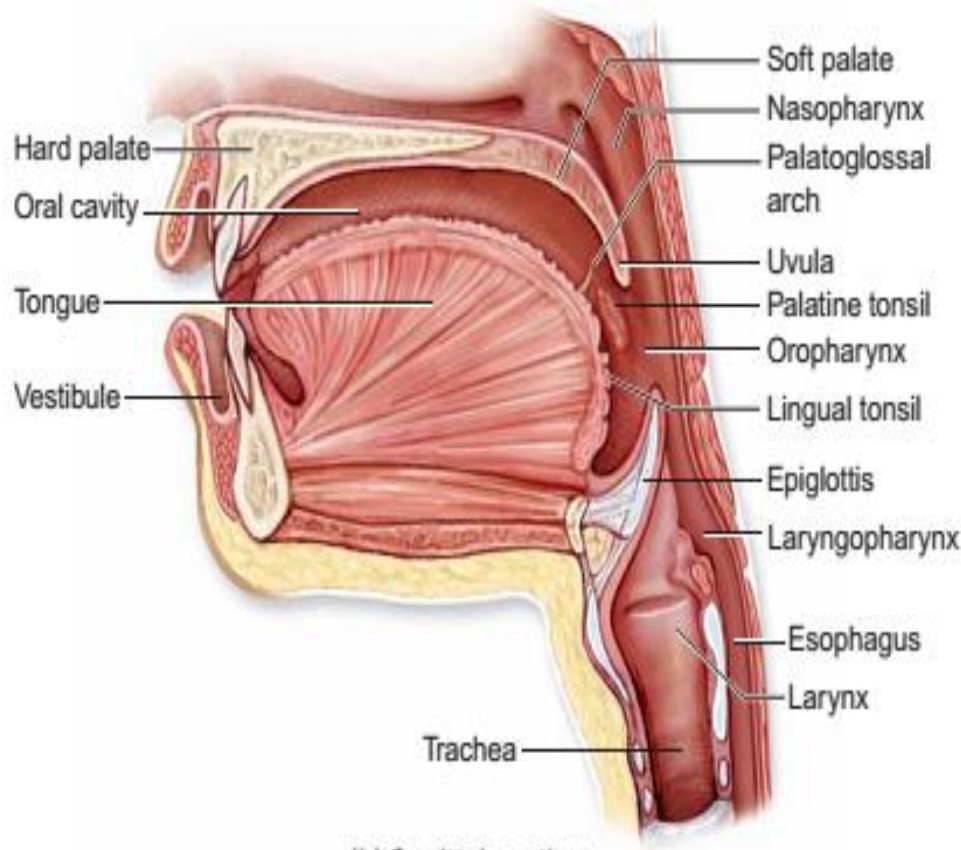
Urinary bladder

Regions of abdomen





(a) Oral cavity, anterior view



(b) Sagittal section

Parotid salivary gland

Parotid duct

Masseter muscle

Mucosa (cut)

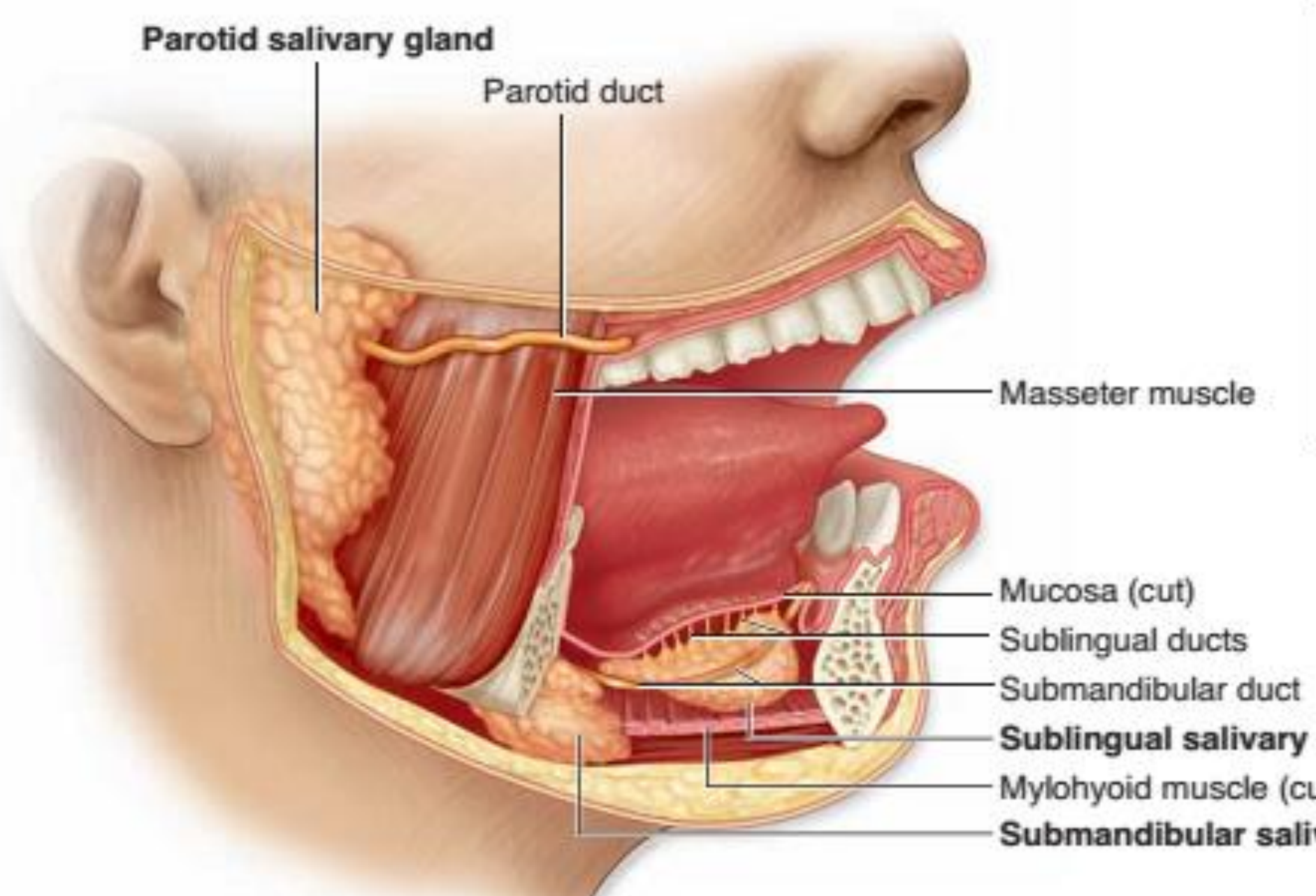
Sublingual ducts

Submandibular duct

Sublingual salivary gland

Mylohyoid muscle (cut)

Submandibular salivary gland



ESOPHAGUS

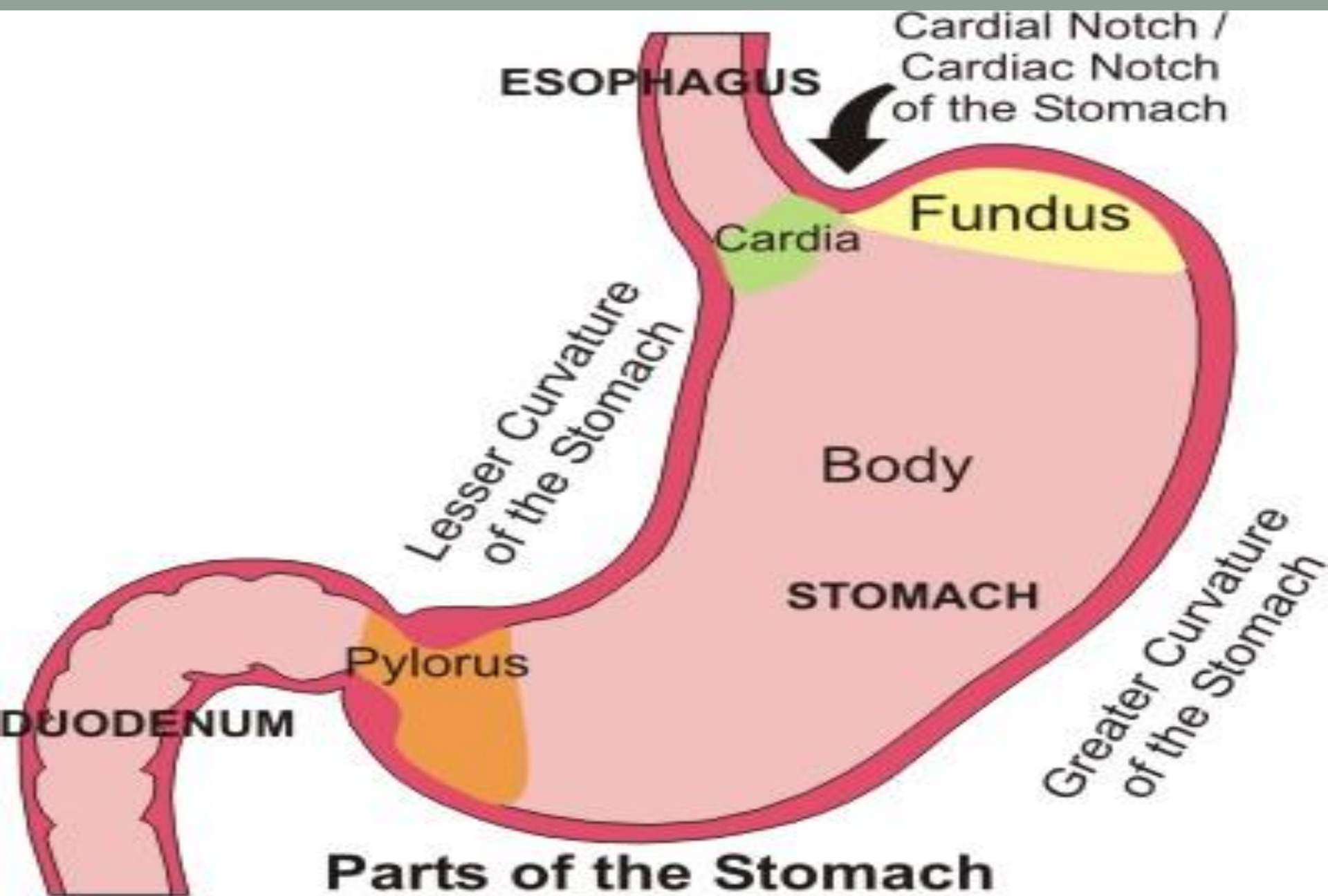
- The esophagus is a collapsible muscular tube, about 25 cm (10 in.) long, that lies posterior to the trachea
- Connects pharynx to stomach
- begins at the inferior end of the laryngopharynx, passes through the inferior aspect of the neck, enters the mediastinum anterior to the vertebral column. Then it pierces the diaphragm through an opening called the esophageal hiatus
- Histology- made up of four tunics (mucosa, submucosa, muscularis, adventitia)
- The muscularis is different from other portions of GIT as the first one third of esophagus is made up of smooth muscles, the middle one third is made up of both smooth and skeletal muscles while the last one third is made up of smooth muscles
- At both ends the muscularis become more prominent making two sphincters – The upper esophageal sphincter made up of skeletal muscles and lower esophageal sphincter made up of smooth muscles

STOMACH

- J shaped muscular structure
- Holding organ of GIT
- Most distendable portion of GIT

Parts of stomach

- Divided into four regions
- **Cardia**: cranial end of stomach
 - Narrow upper region immediately below esophageal sphincter
 - Has prominent notch called as cardiac notch
- **Fundus**: dome shaped elevated portion to the left .
 - In direct contact with diaphragm
- **Body**: large central portion
 - Has two borders: lesser curvature (medial, concave portion to the right)
 - Greater curvature (lateral, convex portion to the left)
- **Pylorus**: Funnel shaped terminal portion
- Has three parts : **antrum**; 1st portion has a downward depression, inferior most portion of stomach. Antrum is followed by **pyloric canal** which leads to the pylorus. **Pylorus** connects stomach and duodenum. The junction is guarded by pyloric sphincter



Parts of the Stomach

Health Hype

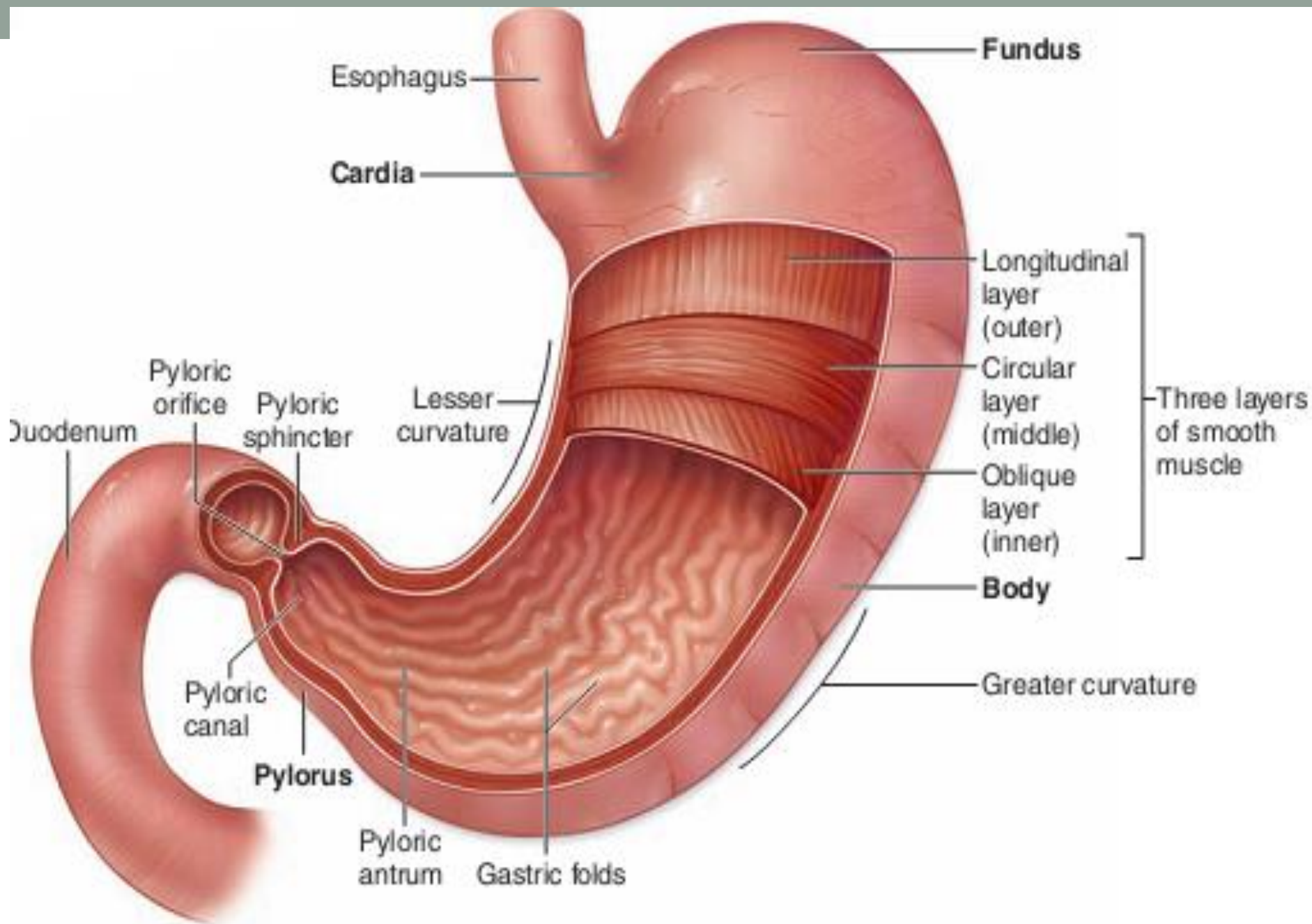
www.healthhype.com

Position of stomach

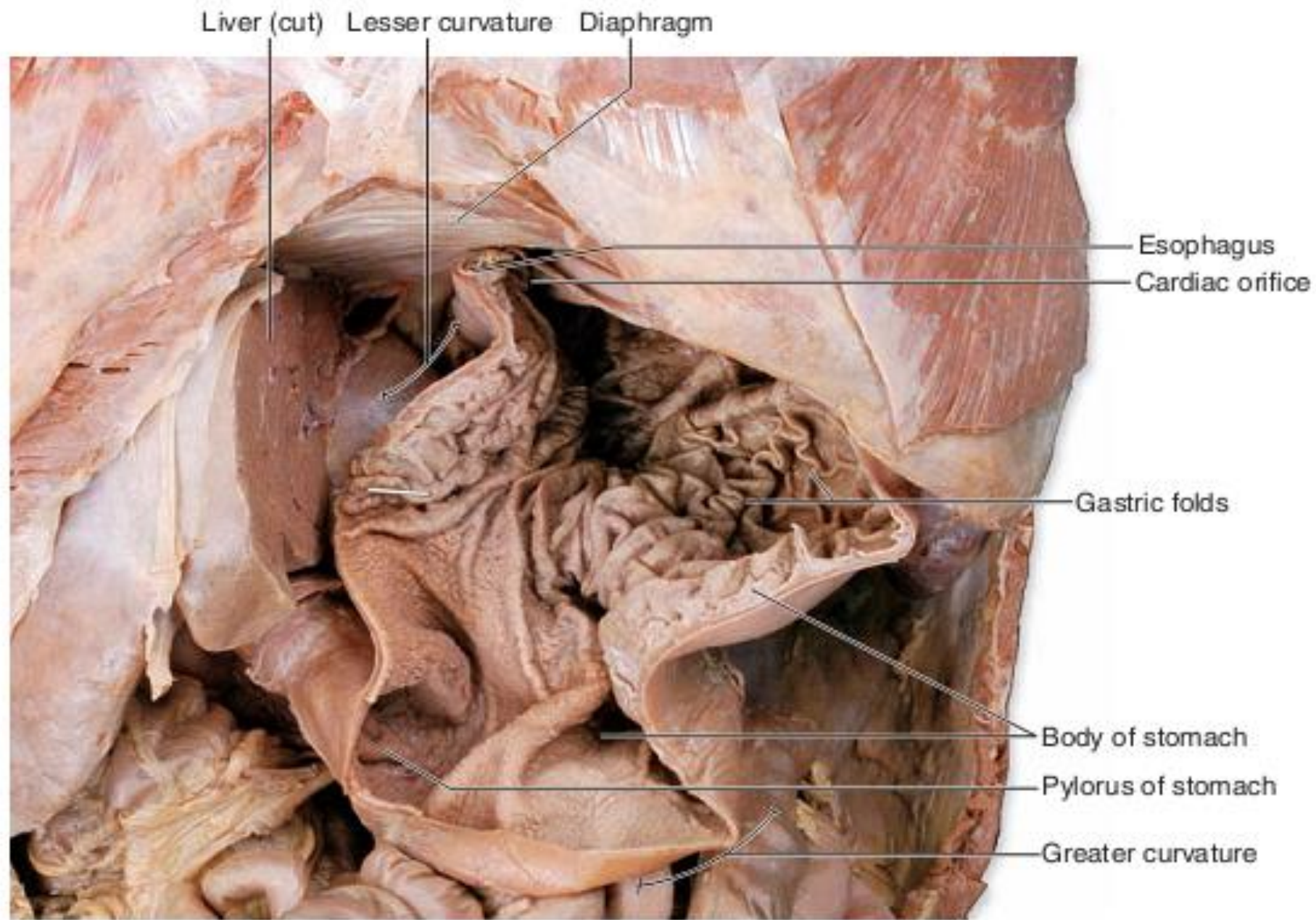
- varies depending on amount of food, stage of digestion and body position
- cardia is situated left to the midline (2.5 cm), beneath 7th costal cartilage
- Pylorus is situated right to midline (1cm) beneath the 1st lumbar vertebrae (at fed state it may go down to 2nd or 3rd vertebrae)
- Anterio- superiorly it is in touch with diaphragm (fundus)
- On right side is liver
- On left is spleen

Histology of stomach

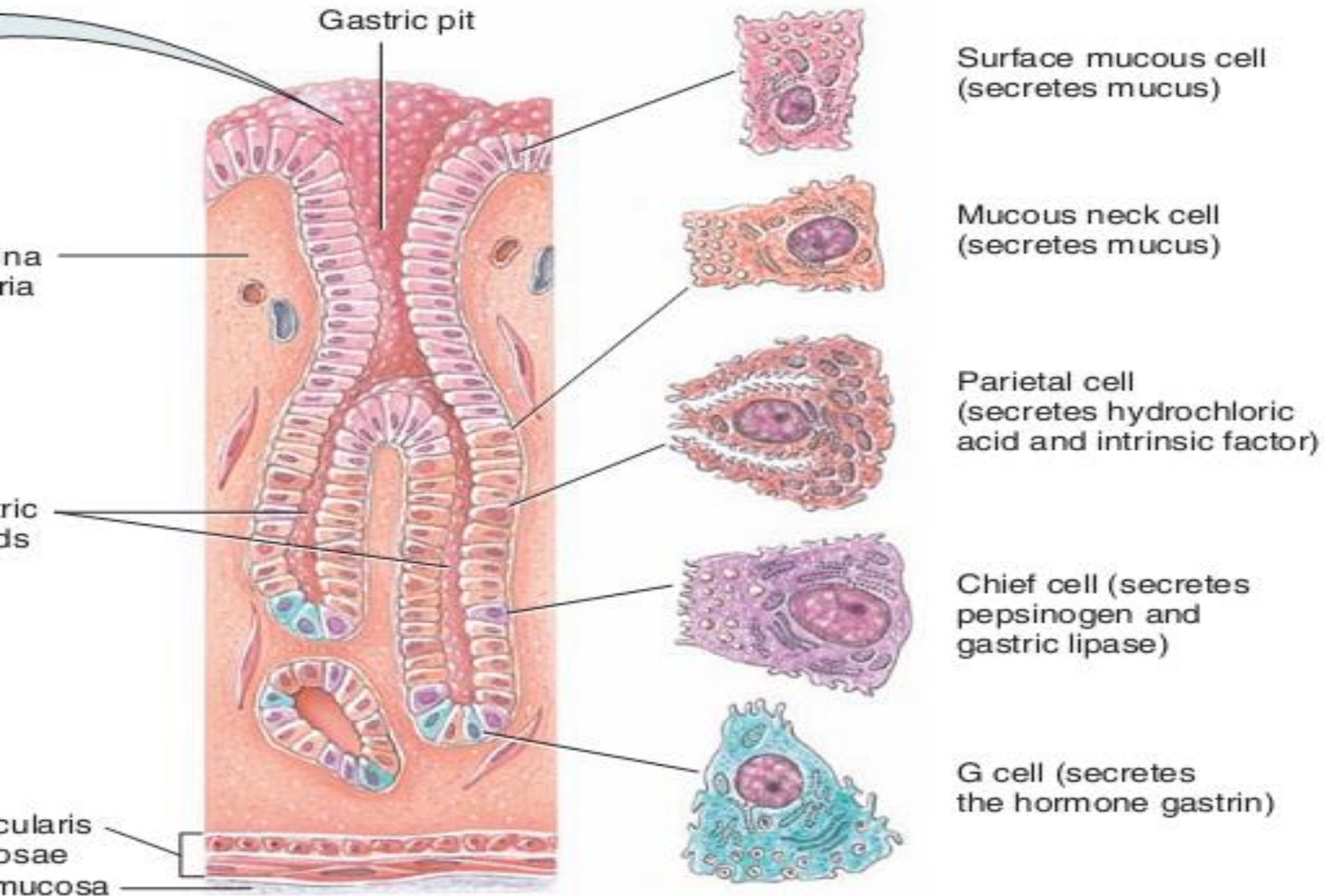
- Stomach has four layers just like the rest of GIT with few differences:
 - ❑ Mucosa contain surface mucous cells which secrete mucous to protect stomach from acid damage
 - ❑ Mucosa has longitudinal folds called rugae which permits stomach distention
 - ❑ The epithelial cells of stomach extends downwards into lamina propria making columns of secretory cells called gastric glands
 - ❑ Gastric glands open into bottom of these narrow channels called gastric pits from which secretions then flow out into lumen of stomach
 - ❑ Gastric glands has three type of exocrine cells:
 - Mucus neck cells – secretes mucous
 - Chief cells – secretes pepsinogen
 - Parietal cells – secretes HCL and intrinsic factor
 - ❑ It also contain G cells which are enteroendocrine cells and secretes gastrin
 - ❑ The muscularis of stomach contain oblique muscles (in addition to circular and longitudinal muscles) which facilitate churning of food



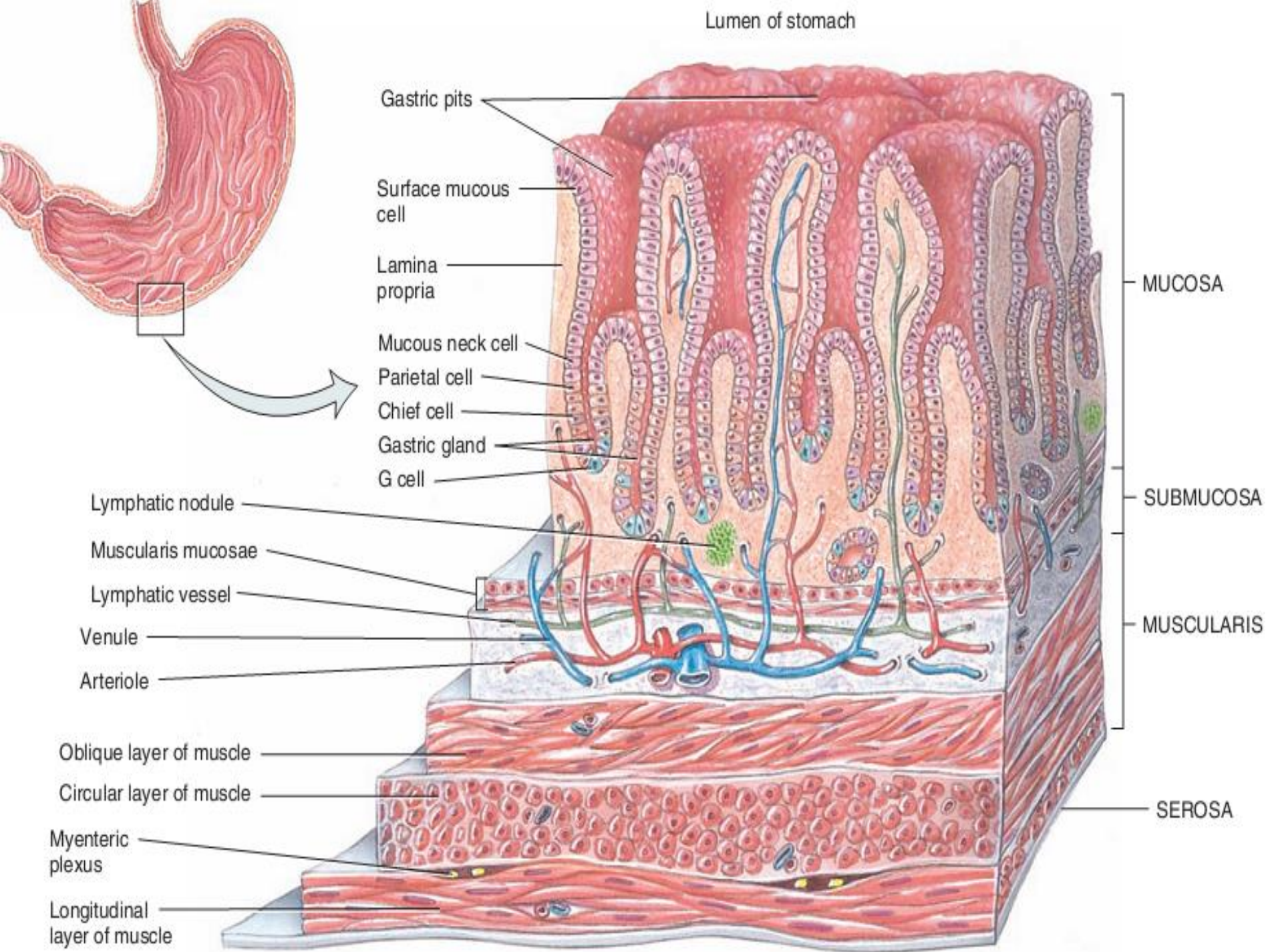
(a) Stomach regions, anterior view



(b) Gross anatomy of stomach (cut open)



(b) Sectional view of stomach mucosa showing gastric glands and cell types



Small intestine

- The small intestine is the portion of the GI tract **between the pyloric sphincter of the stomach and the ileocecal valve** that opens into the large intestine
- Called small intestine because of its small diameter as compared to large intestine
- Main organ of digestion and absorption of food – offers large surface area
- It is positioned in the central and lower portions of the abdominal cavity below stomach and liver in form of convoluted mass and is supported by the mesentery proper (except duodenum)
- The small intestine is approximately 3 m (12 ft) long and 2.4 cm (1 in.) wide in a living person. length approximately doubles in dead person because of muscle relaxation

Duodenum

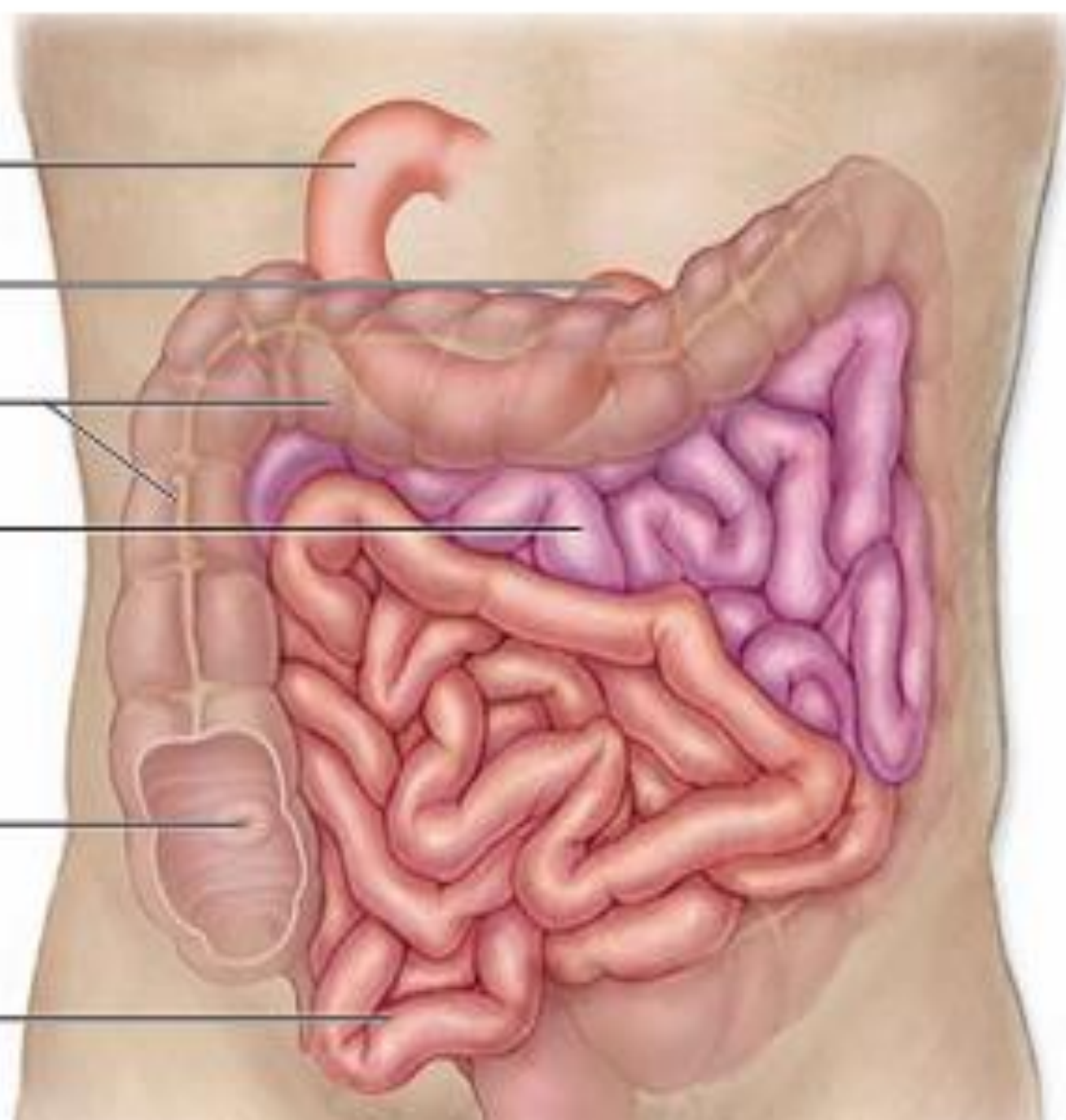
**Duodenojejunal
flexure**

Large intestine

Jejunum

Ileocecal valve

Ileum



Regions of small intestine

- Divided into three regions
 - ❑ Duodenum
 - ❑ Jejunum
 - ❑ Ileum
- **Duodenum**
- C-shaped tubular organ measuring about 25cm
- begins at the pyloric valve, arcs around the head of the pancreas and passes to the left, and ends at a sharp bend called the duodenojejunal flexure
- Except short portion near the stomach, the duodenum is retroperitoneal
- The duodenum receives the stomach contents, pancreatic juice, and bile.
- .

- Duodenum is subdivided into four parts
 - **First/ superior part:** begins at pylorus, passes backwards and upwards to the right- 5cm long
 - **2nd/ descending part:** 8cm long descends downwards
 - **3rd/ horizontal part:** 10 cm long, passes from right to left crossing the midline
 - **4th / ascending part:** 2cm long, runs upward to the left ends by joining jejunum
- Half-way along the second portion enters common opening of the common bile duct and main pancreatic duct(of Wirsung) into the duodenum. The common opening is called the **hepatopancreatic ampulla(ampulla of Vater)**, which pierces the duodenal wall and drains into the duodenum from an elevation called the duodenal papilla. The duodenal papilla can be opened or closed by the action of the **sphincter of ampulla (of Oddi)**. The subsidiary pancreatic duct (of Santorini) opens into the duodenum a little above the papilla

Duodenum

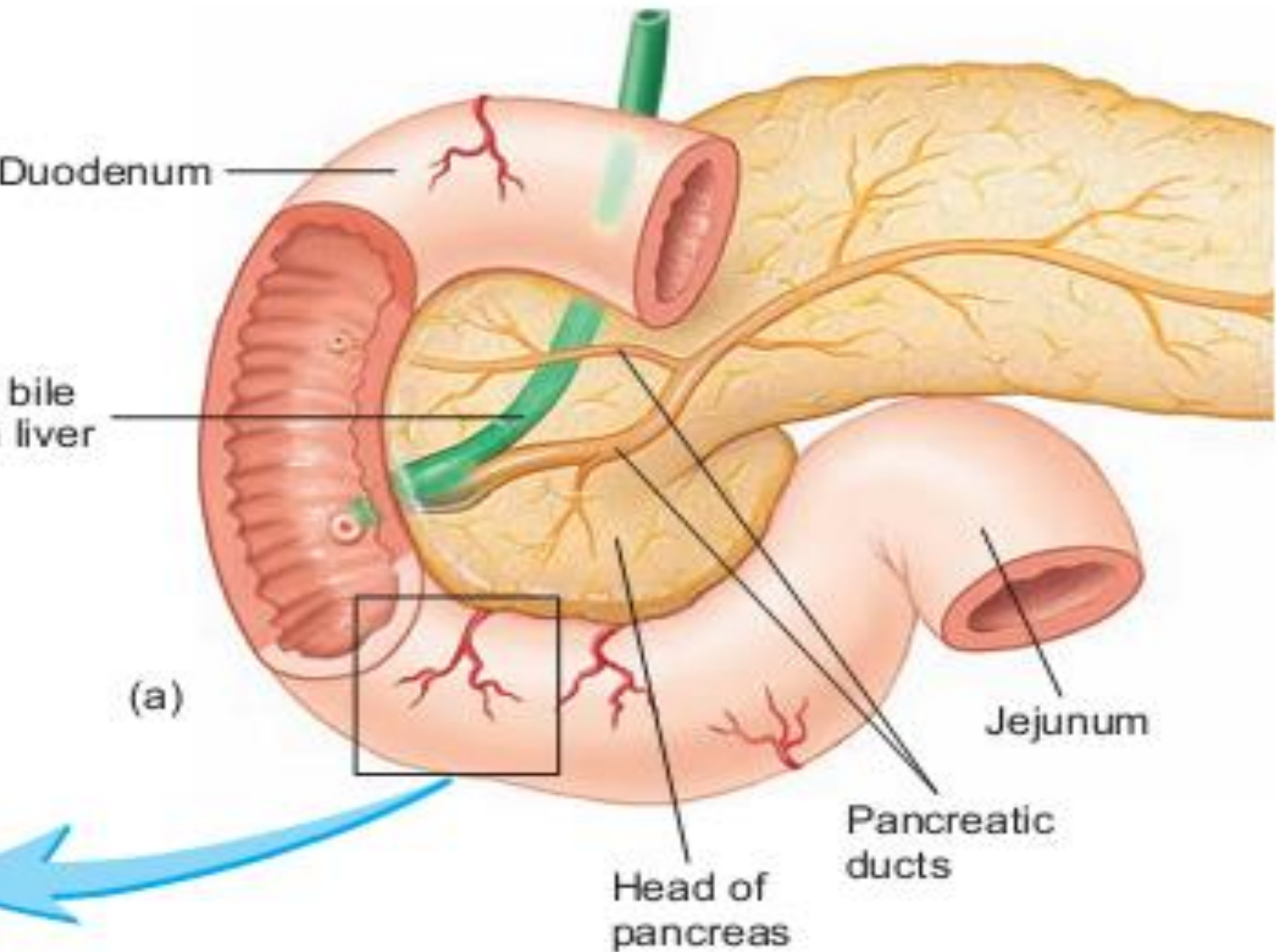
bile
liver

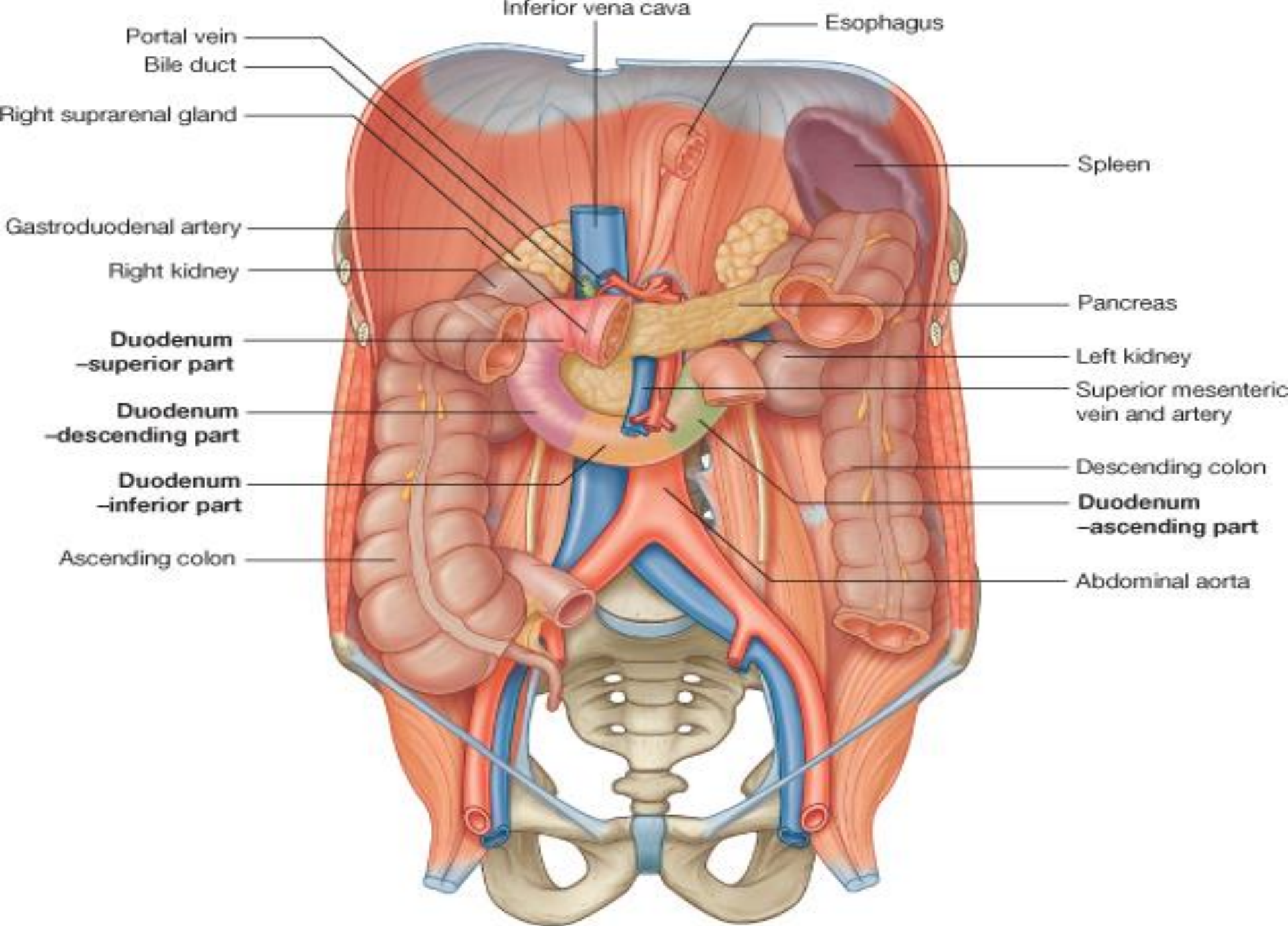
(a)

Jejunum

Pancreatic
ducts

Head of
pancreas





• **Jejunum**

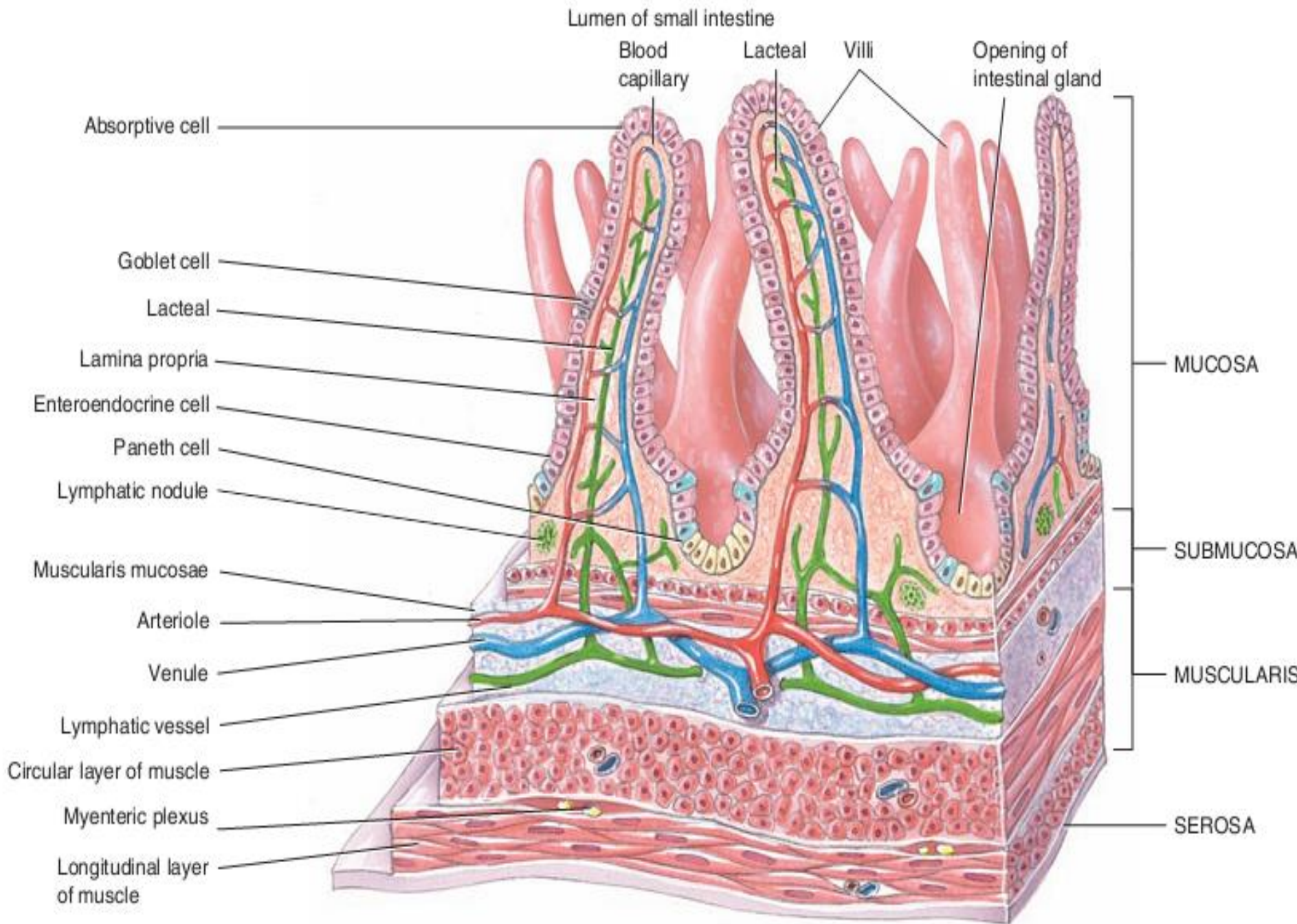
- Middle portion of small intestine
- About 2.5m long
- Primary site of small intestine involved in digestion
- Present intraperitoneal, suspended by mesentery proper
- Jejunum ends at ileum. There is no well defined anatomic separation between jejunum and ileum

• **Ileum**

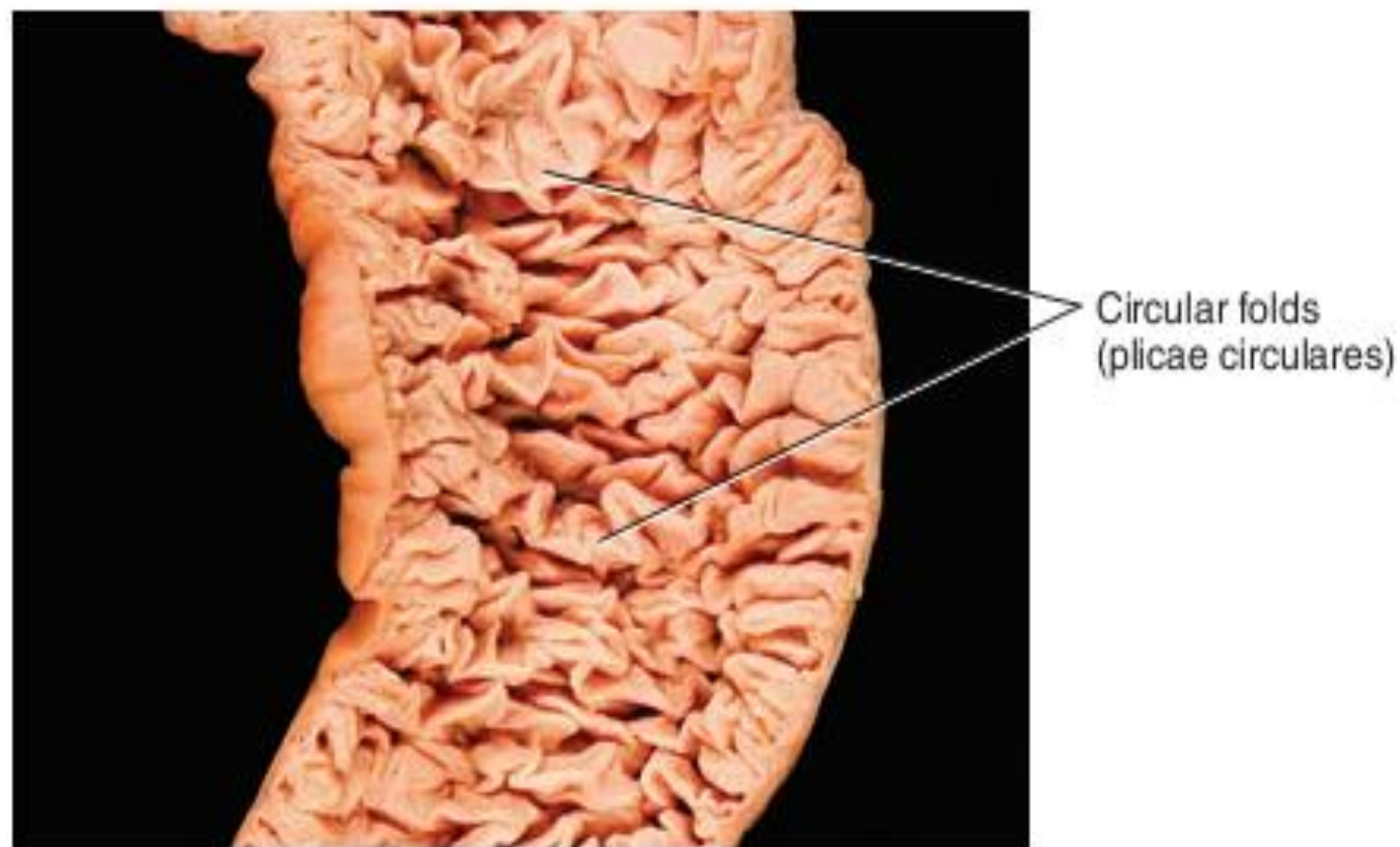
- Last region of small intestine
- 3.5 meter long
- Present intraperitoneal, suspended by mesentery proper
- Ends at ileocecal valve which control passage of material from small intestine into large intestine
- The jejunum tends to lie at the umbilical region, the ileum in the supra-pubic region and pelvis

Histology of small intestine

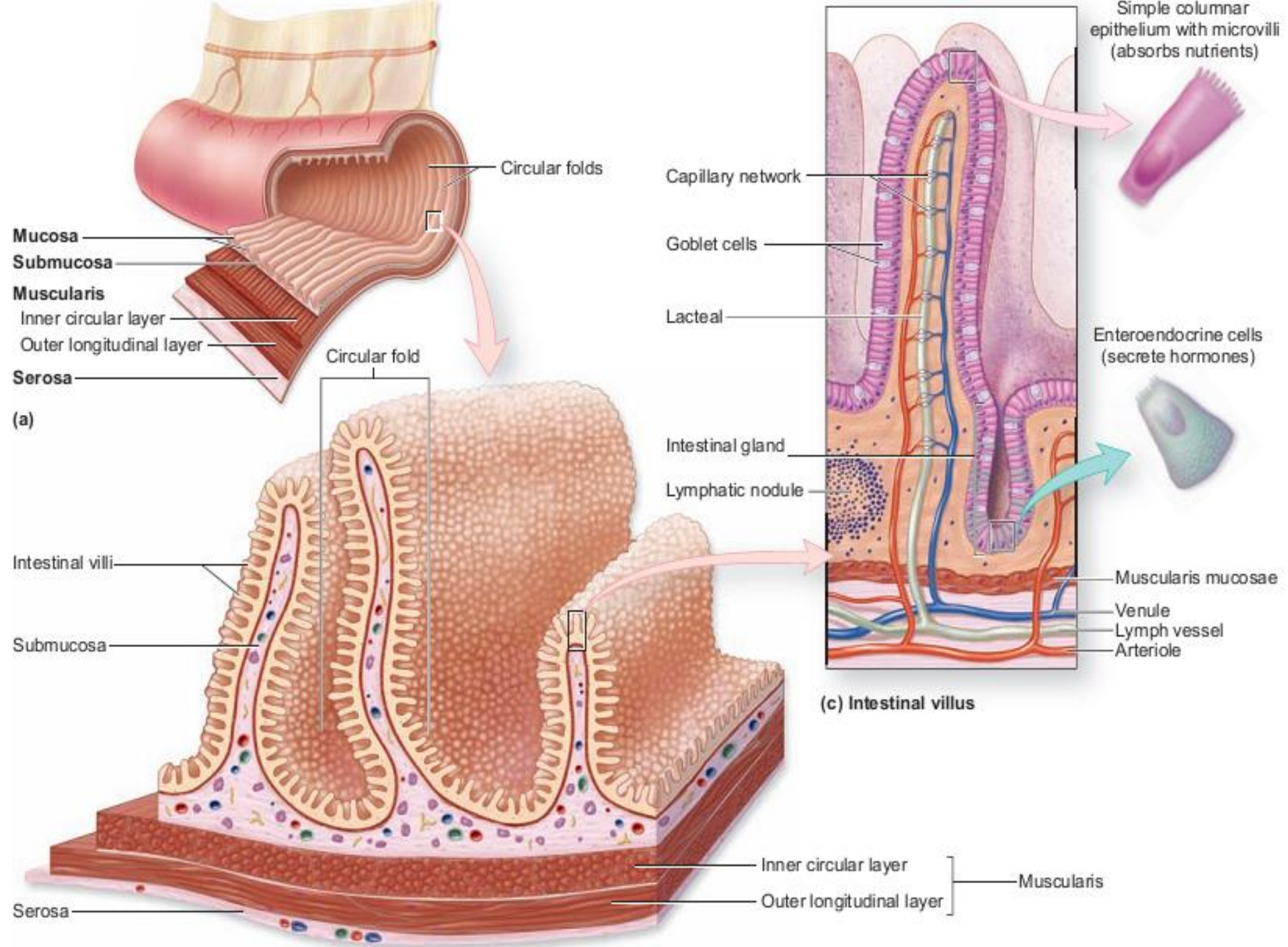
- Made up of same four basic layers of GIT (mucosa, submucosa, muscularis, serosa) with some modifications to facilitate digestion and absorption
- The additional structural features in small intestine which are not observed in rest of GIT are:
 - ❑ Plicae circularis (circular folds) – permanent circular ridges of mucosa and submucosa, about 10mm long, starts at duodenum extends till start of ileum, facilitate digestion and absorption by increasing surface area and decreasing speed of food transit
 - ❑ Villi – fingerlike projection of mucosa, about 0.5-1mm long each villus is covered by epithelium and has a core of lamina propria, embedded in the connective tissue of the lamina propria are an arteriole, a venule, a blood capillary network, and a lacteal
 - ❑ Microvilli – extension of free membrane of absorptive cells, about 1 micrometer long, under microscope microvilli appear as a fuzzy line called brush border



(b) Three-dimensional view of layers of the small intestine showing villi



(b) Internal anatomy of jejunum



- Other than these structural modifications the small intestine have specialized cells which facilitate the process of digestion and absorption. These are:
 - ❑ Absorptive cells – specialized epithelial cells which absorb nutrients
 - ❑ Goblet cells – epithelial cells secreting mucus
 - ❑ Intestinal glands/ crypts of Lieberkühn – these are downward invagination of epithelial cells at the base of villi forming narrow pouches which opens into intestinal lumen through small openings. The intestinal glands contain following cells:
 - Absorptive cells
 - Goblet cells
 - Paneth cells- secretes lysozymes
 - Enteroendocrine cells- which may be S cells, CCK cells, and K cells, which secrete the hormones secretin, cholecystokinin and glucose-dependent insulinotropic peptide or GIP, respectively

- Other distinctive features of small intestine are:
 - ❑ The abundance of MALT in the lamina propria
 - ❑ Peyer's patches – These are oval or round lymphatic nodules or aggregated lymphoid follicles present in ileum. Peyer's patches are the exclusive feature of ileum and used to distinguish ileum and jejunum
 - ❑ Brunner's glands - The submucosa of duodenum contains duodenal glands, also known as Brunner's glands which secrete mucus

Large intestine

- The large intestine forms a three-sided perimeter in the abdominal cavity around the centrally located small intestine
- Starts at the ileocecal junction and has length of approx. 1.5m and diameter of 6.5 cm
- The functions of large intestine is completion of absorption and formation and expulsion of feces
- It is partly located intraperitoneal while partly it is retroperitoneal.
- Large intestine is suspended by specialized mesentery called mesocolon

Parts of large intestine

- Structurally divided into four regions
 - ❑ Cecum
 - ❑ Colon
 - ❑ Rectum
 - ❑ Anal canal
- Cecum is the first portion of large intestine, present in the form of a small blind pouch about 6 cm long
- It is present in right lower quadrant of abdomen and extends inferiorly from **ileocecal valve** (*ileocecal valve is a fold of mucous membrane at the junction of the small intestine and large intestine that prohibits the backflow of chyme*)
- From the posteromedial region of cecum is attached a thin twisted tube measuring 8cm called vermiform appendix
- Appendix is lined with lymphatic nodules
- Appendix has no digestive function and is considered as remnant of an organ that was functional in our ancestors

• **Colon**

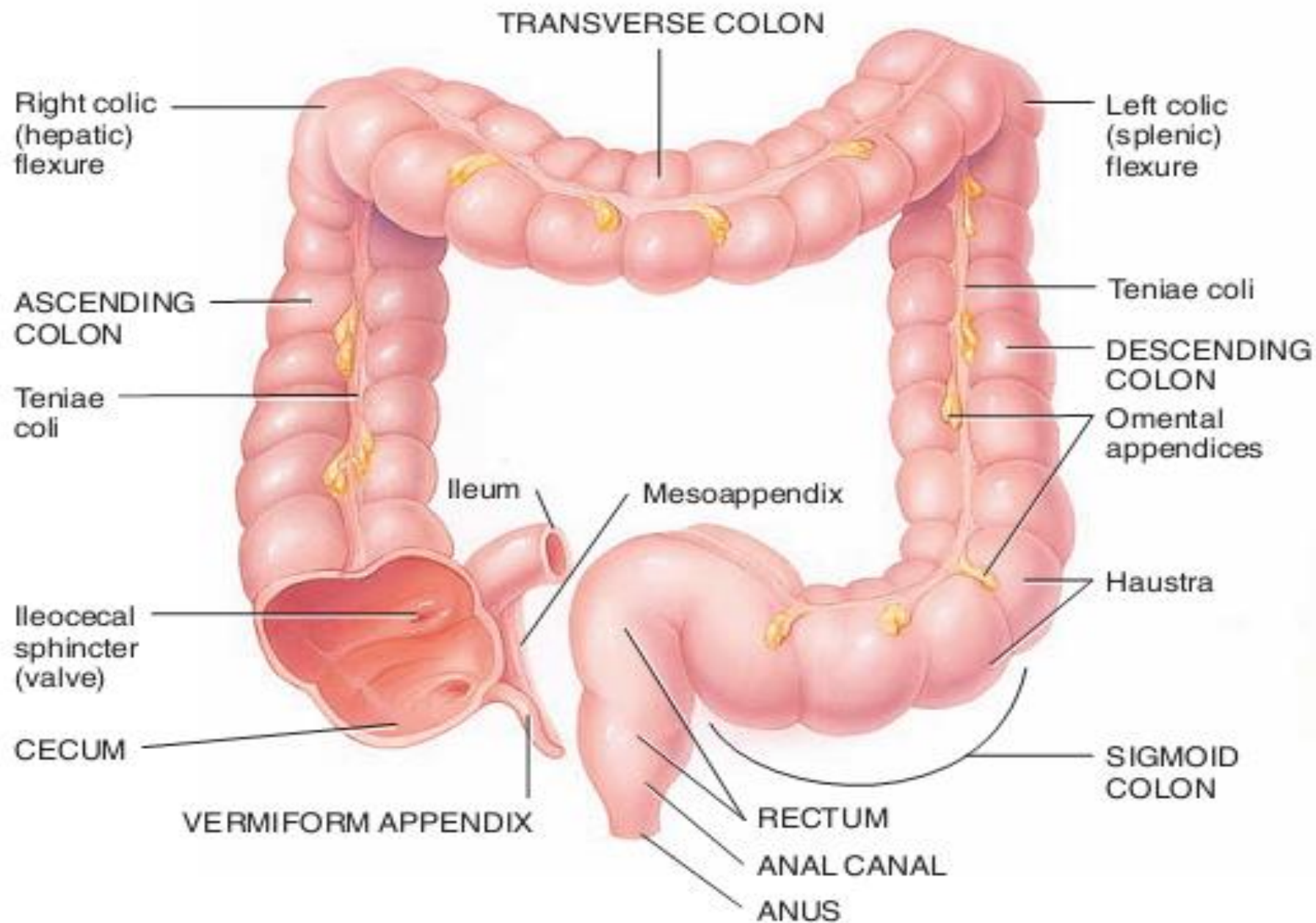
- Starts at the level of ileocecal valve and make a U shaped arch
- It is divided into four segment:
 - ❑ **Ascending colon:** The ascending colon extends superiorly from the cecum along the right abdominal wall to the inferior surface of the liver
 - From there it abruptly turns left forming hepatic flexure or right colic flexure
 - **Transverse colon:** The transverse colon originates at the right colic flexure continues across the abdomen to the left
 - At left upper quadrant beneath the spleen it take sharp bend inferiorly. The bend is called as splenic flexure or left colic flexure

- ❑ **Descending colon:** Originates from left colic flexure and present on the left side of the abdominal cavity
 - It reaches the pelvic region and ends at sigmoid colon

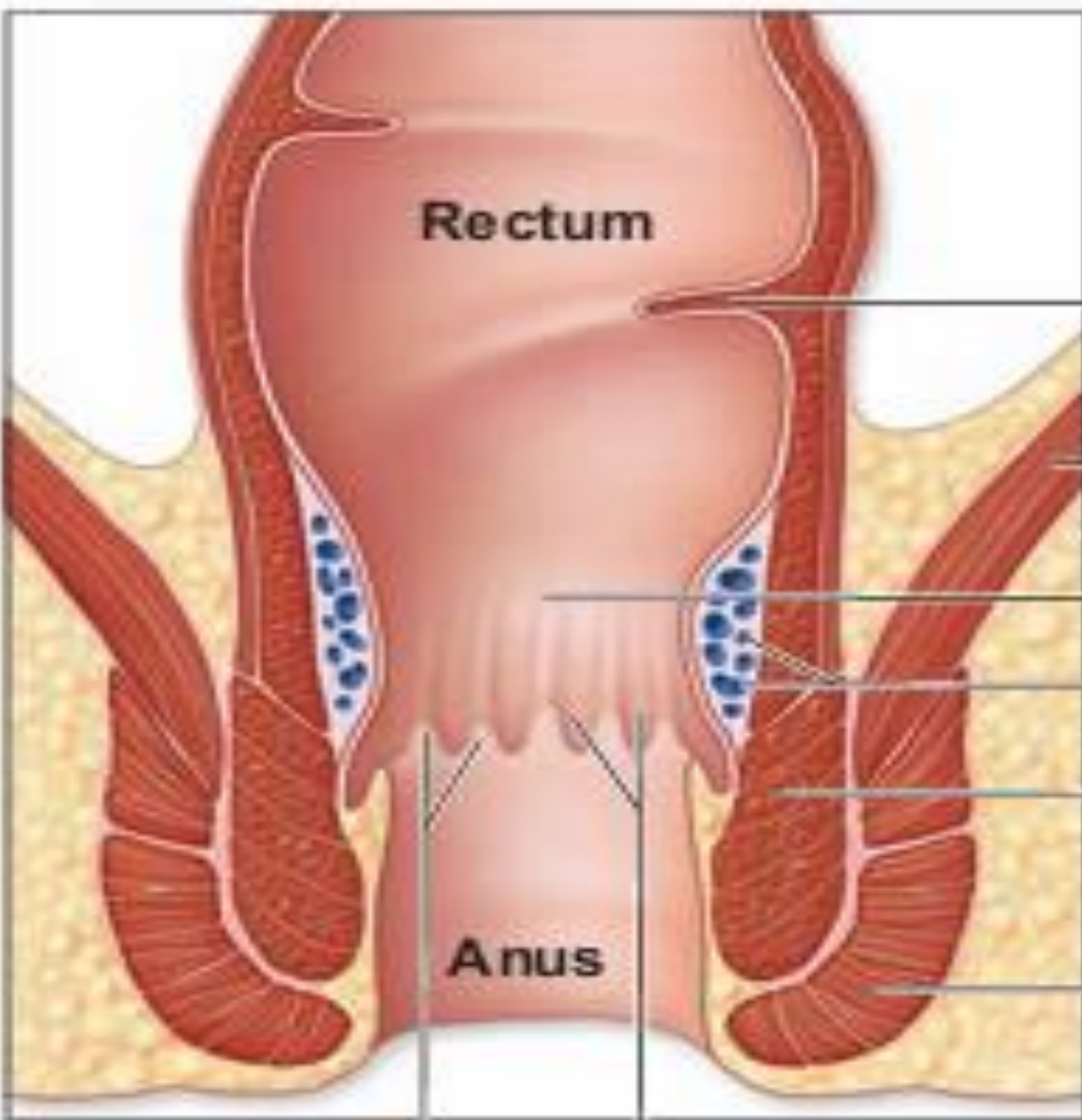
- ❑ **Sigmoid colon :** Sigmoid colon is an S shaped structure, starts with sigmoid flexure where the sigmoid colon takes inferiomedial curve into the pelvic cavity
 - The ascending and descending portion of colon are retroperitoneal while transverse colon and sigmoid colon are intraperitoneal

- **Rectum :**
 - The sigmoid colon ends at rectum at the level of 3rd sacral vertebrae
 - Rectum is 20 cm long and present in front of sacrum and coccyx

- **Anal canal :**
 - The terminal 2-3 cm of rectum is anal canal
 - The anal canal contain anal columns which are longitudinal folds of mucus membrane containing arteries and veins. Between the anal columns are anal sinuses which are small depressions from where mucus is released
 - The anal canal open to exterior by anus which is the guarded by an internal anal sphincter (smooth muscles) and external anal sphincter (skeletal muscles)



(a) Anterior view of large intestine showing major regions



Rectum

Rectal valve

Levator ani muscle

Anal canal

Veins

Internal anal sphincter

External anal sphincter

Anus

Anal columns

Anal sinuses

Histology of large intestine

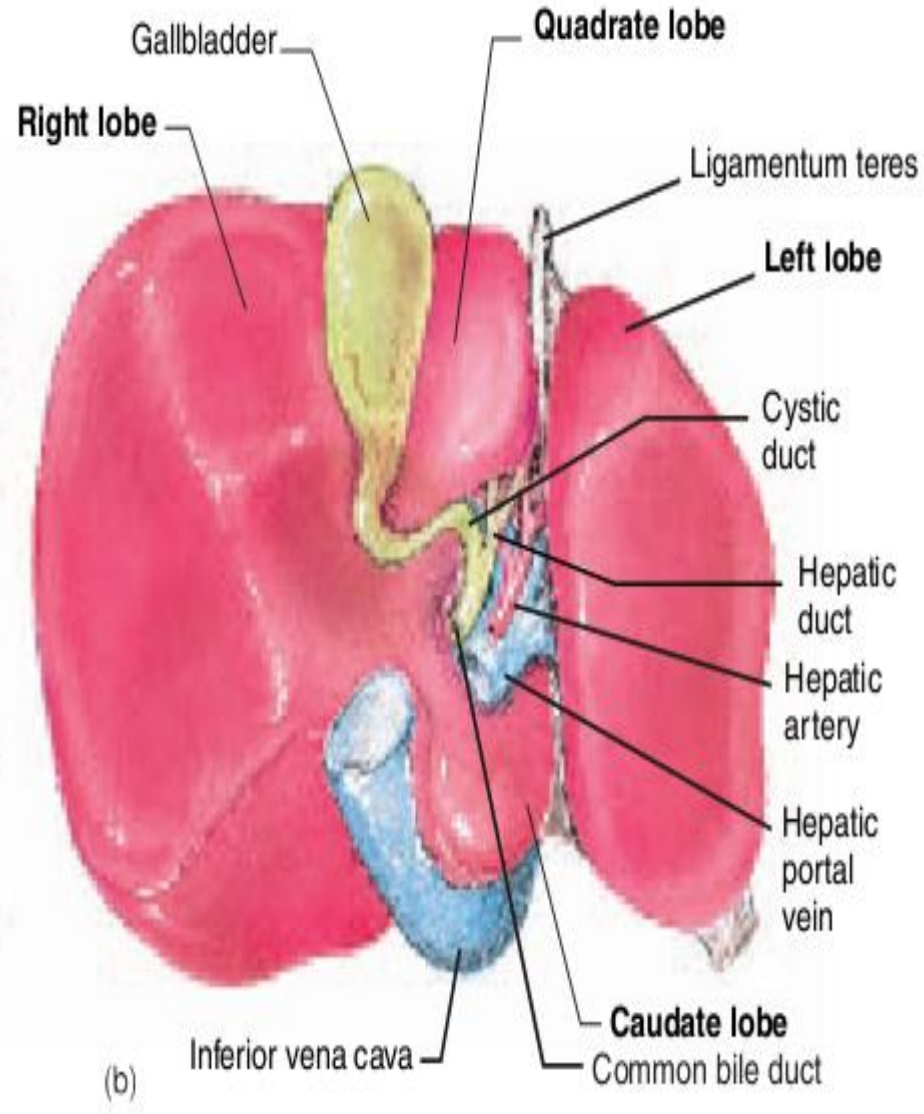
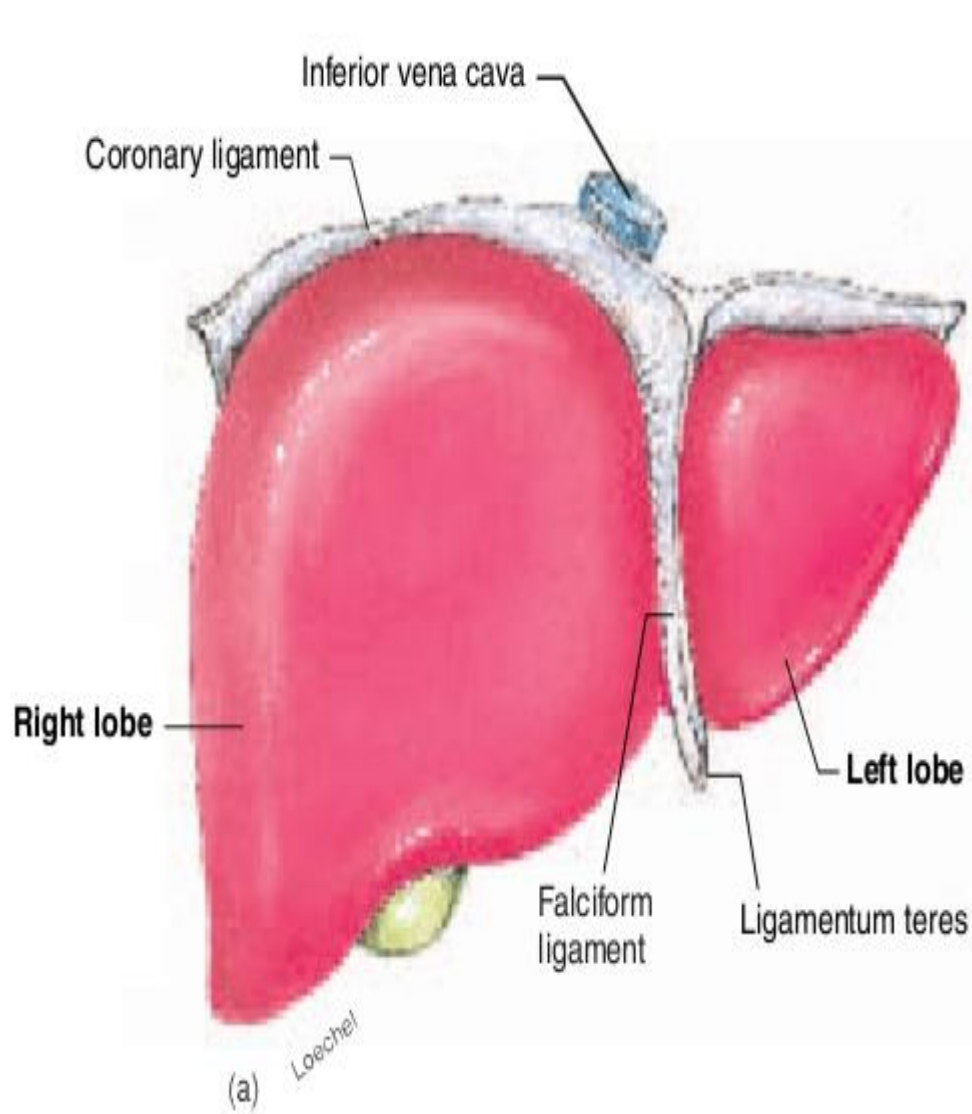
- Wall of large intestine contain four layers just like rest of GIT with some modification:
 - ❑ The mucosa of large intestine is not designed to absorb nutrients so the structure of small intestine which were there to offer large surface area (Plicae circularis, villi) are not present in large intestine, except microvilli.
 - ❑ The mucosa contain absorptive cells and goblet cells. The absorptive cells absorb mostly water while goblet cell secretes mucus. The absorptive cell has brush borders or microvilli. The absorptive and goblet cells are present in the intestinal glands (crypts of Lieberkühn).
 - ❑ The muscularis of large intestine has two layers: inner circular and outer longitudinal. The outer longitudinal muscles are concentrated and thickened in three distinct columns called teniae coli. The teniae coli are separated by portions of the wall with less or no longitudinal muscle. Tonic contractions of the bands gather the colon into a series of pouches called haustra
 - ❑ Small pouches of visceral peritoneum filled with fat are attached to teniae coli and are called omental (fatty) appendices

Liver

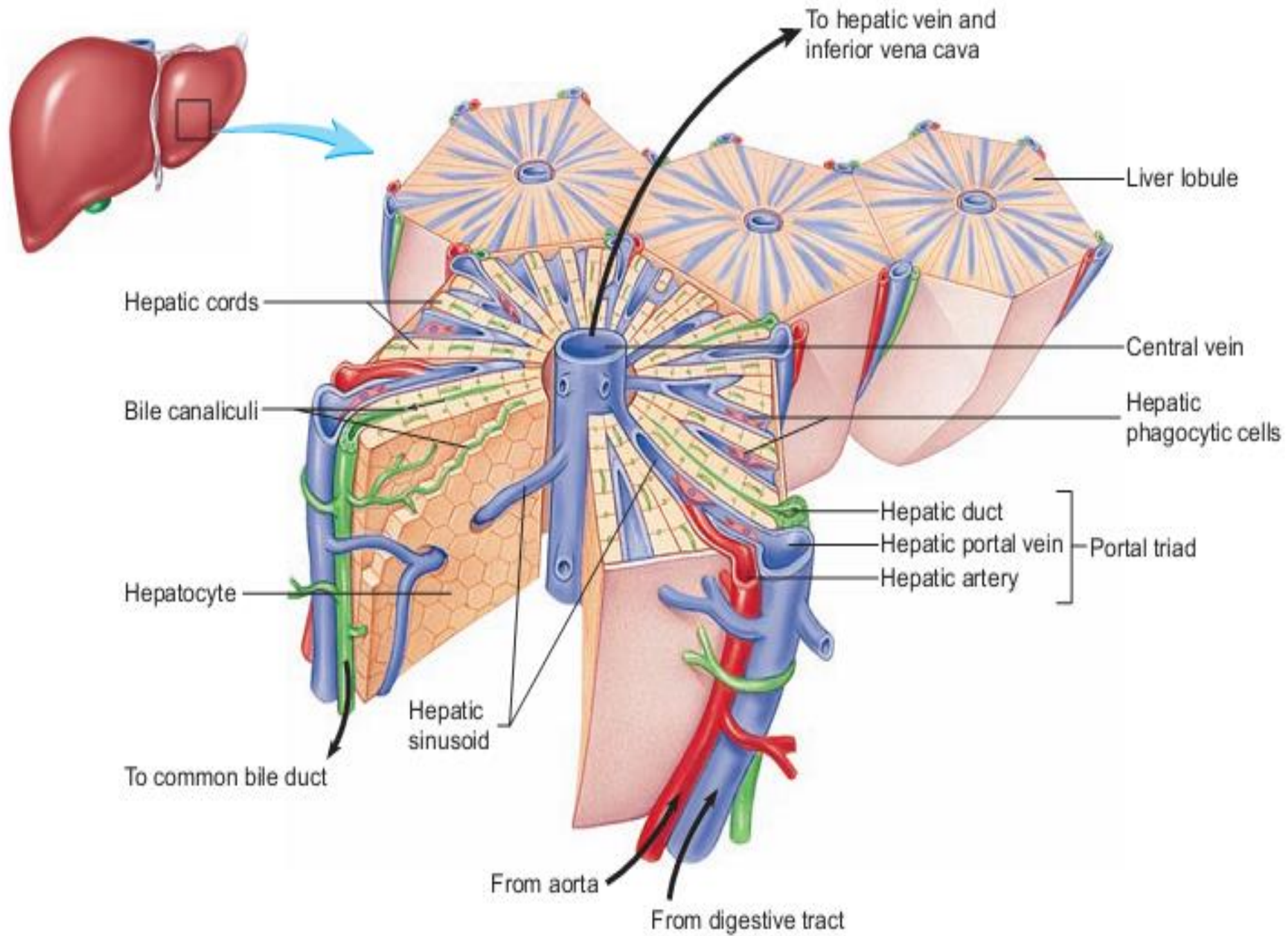
- Liver is the largest and heaviest organ of the body weighing about 1.4 kg
- The liver is inferior to the diaphragm and occupies most of the right hypochondriac and part of the epigastric regions of the abdominopelvic cavity

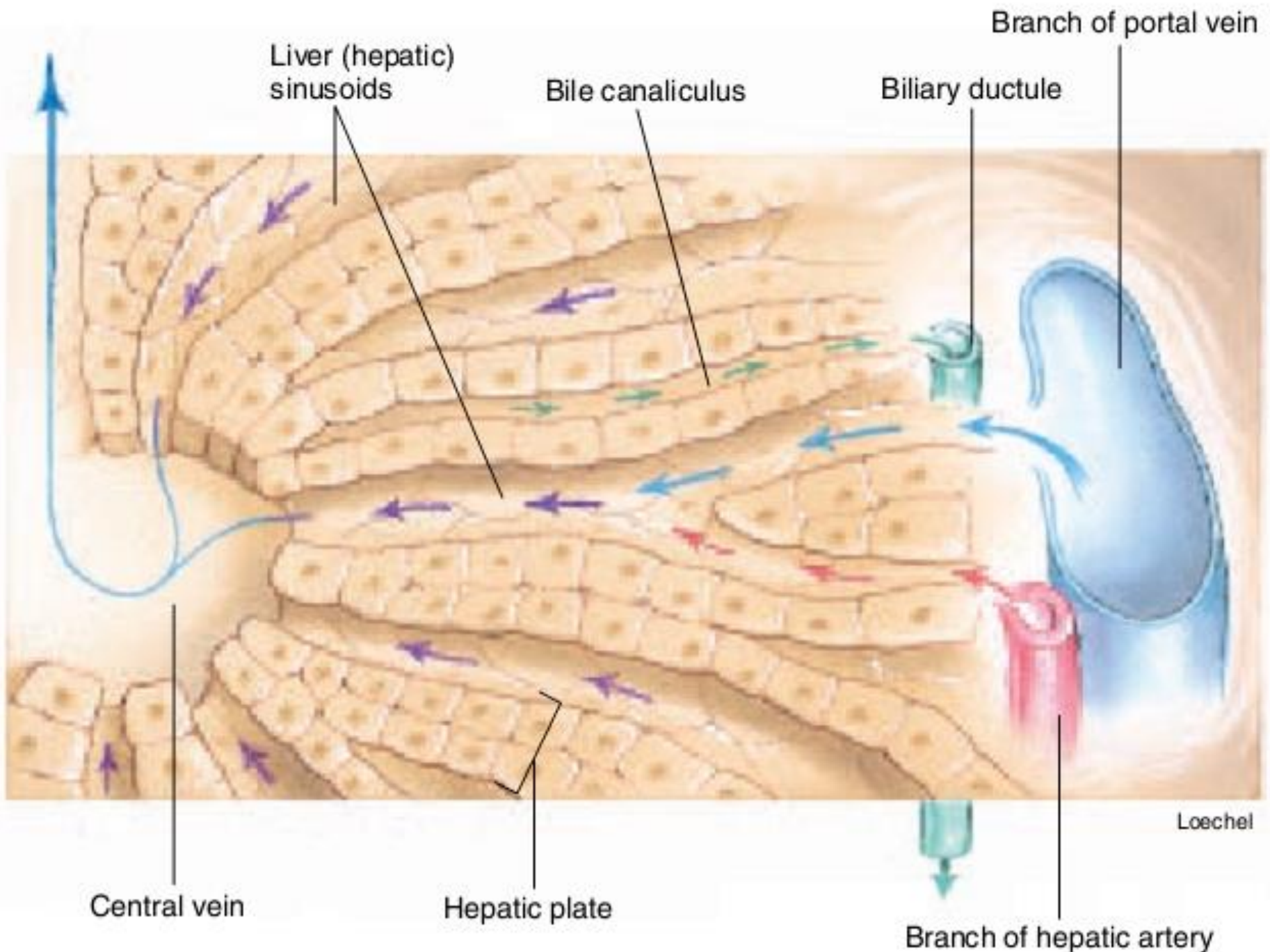
Gross anatomy of liver

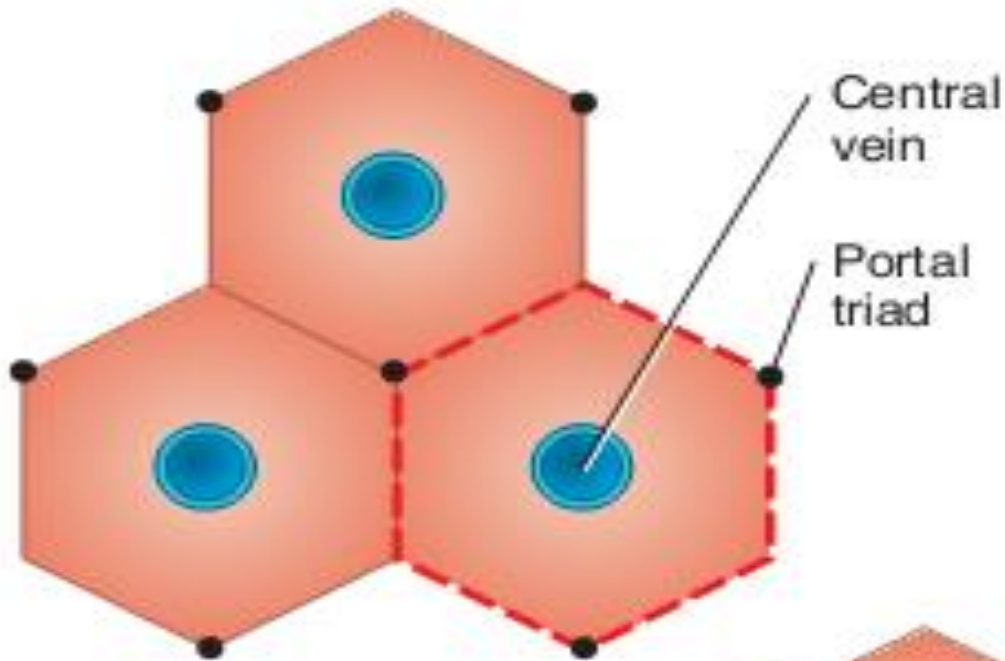
- Liver is covered by two layers
 - ❑ A layer of visceral peritoneum
 - ❑ A layer of dense connective tissue (deep to peritoneal layer)
- It is made up of four incompletely separated lobes:
 - ❑ Right lobe (the larger one) and Left lobe (the smaller one) are major lobes separated from each other anteriorly by falciform ligament (a fold of peritoneum that attach liver to anterior abdominal wall) and posteriorly by vertical groove.
 - ❑ Caudate lobe and quadrate lobes are minor lobes which are subdivision of right lobe. The caudate lobe is present adjacent to inferior venacava on superior right side of vertical groove and quadrate lobe is present adjacent to gallbladder on inferior right of vertical groove.
- The falciform ligament is attached to the diaphragm. Its free border extends inferiorly to the umbilicus.
- To the inferior free border of falciform ligament is attached ligamentam teres (the round ligament) which is remnant of fetal of umbilical vein.
- The ligamentam teres crosses from inferior to posterior side of liver and goes up in the vertical groove where it becomes continuous with ligamentam venosum which is remnant of fetal ductus venosus.
- On the posterior side adjacent to the vertical groove is present porta hepatis where blood vessels, lymphatics and bile ducts enter and leave liver.



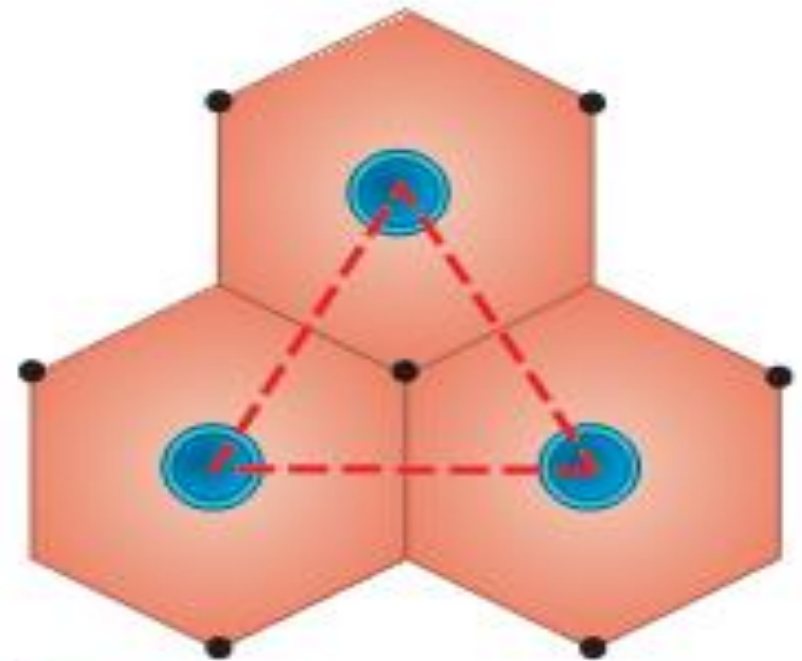
Histology of liver



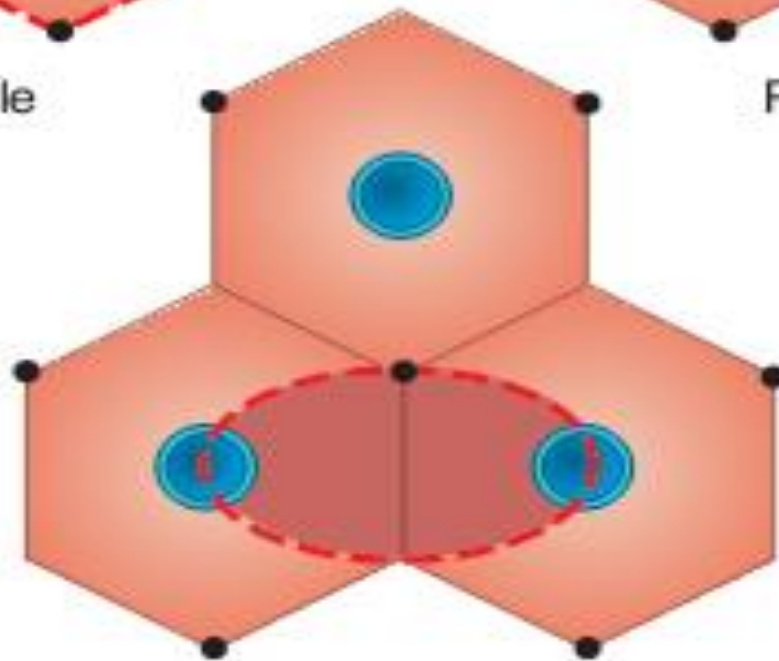




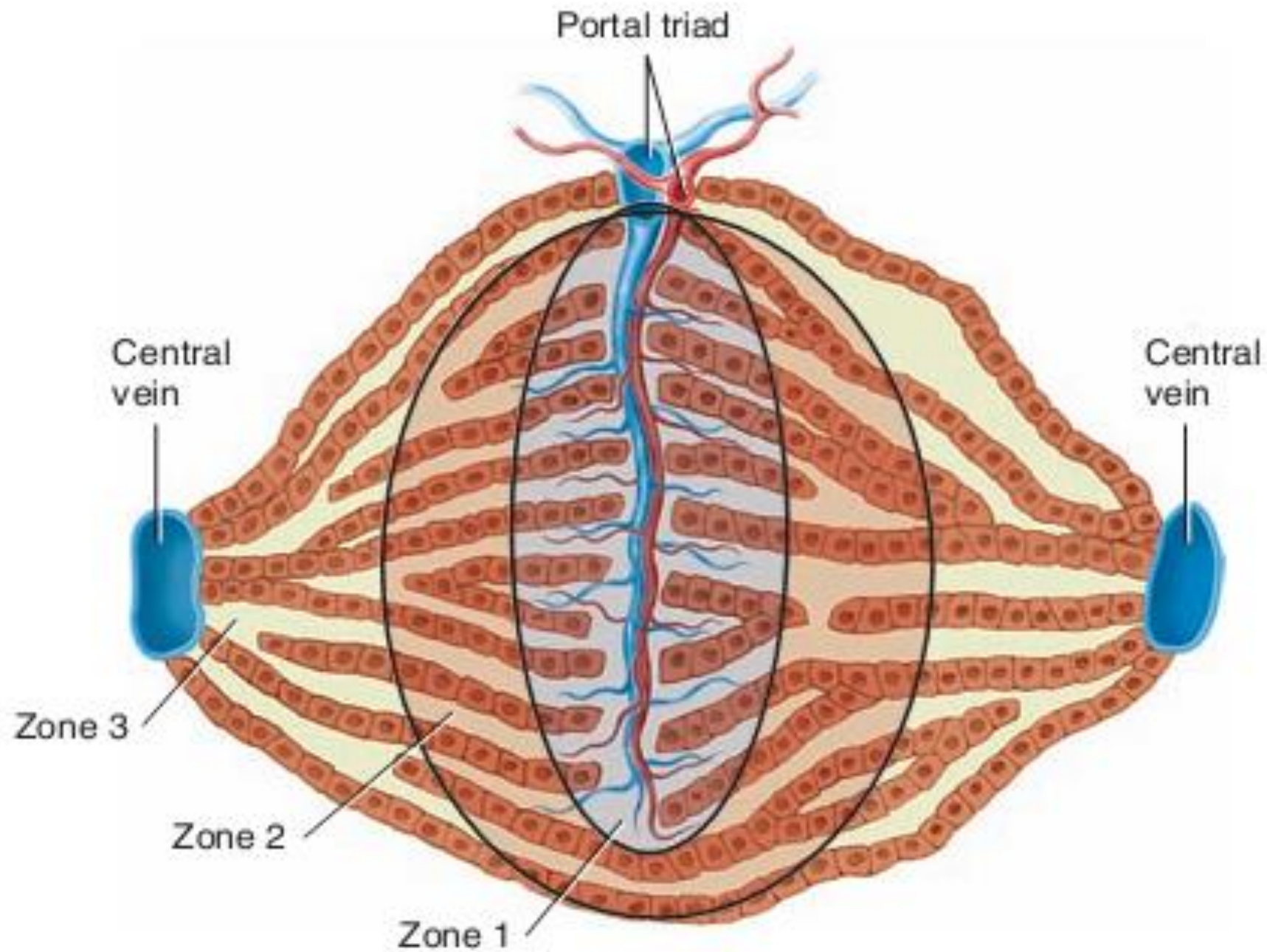
Hepatic lobule



Portal lobule



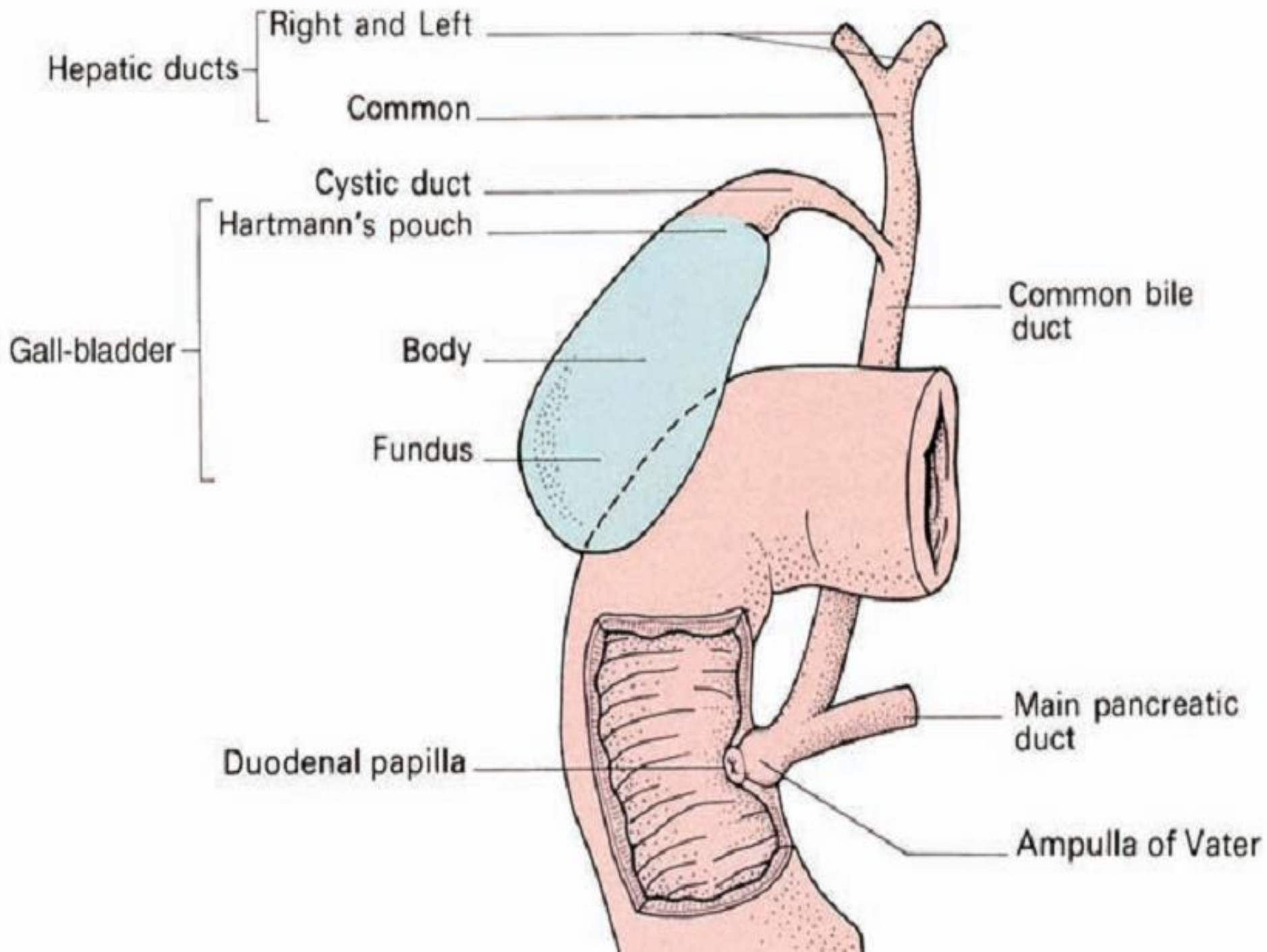
Hepatic acinus

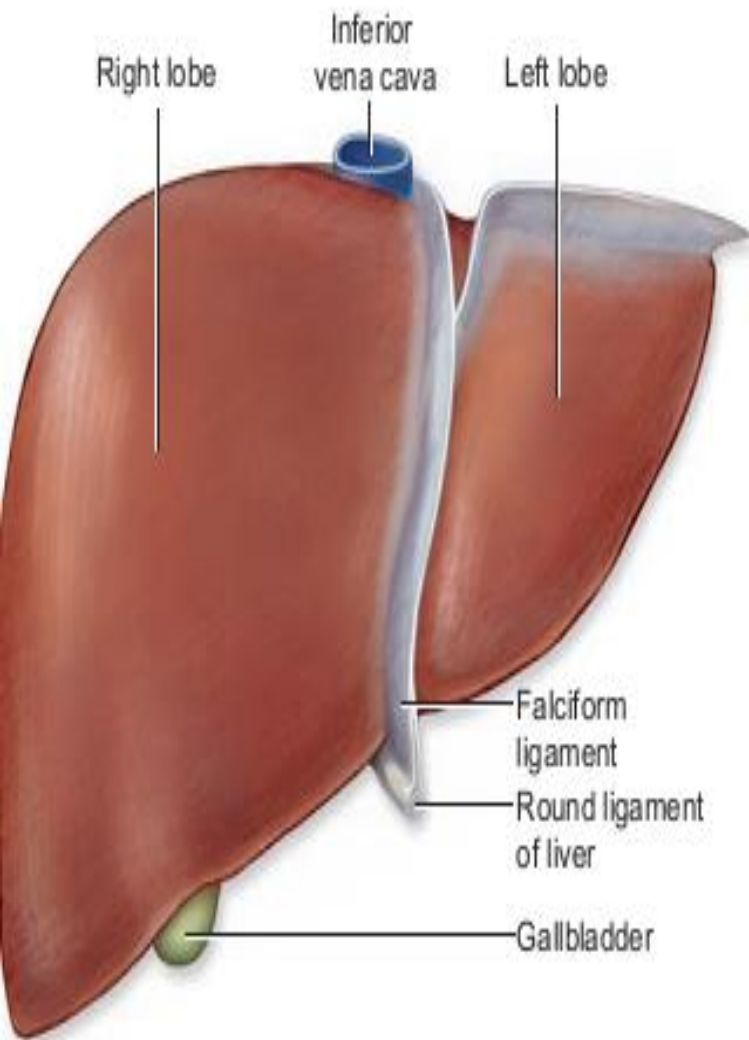


(e) Details of hepatic acinus

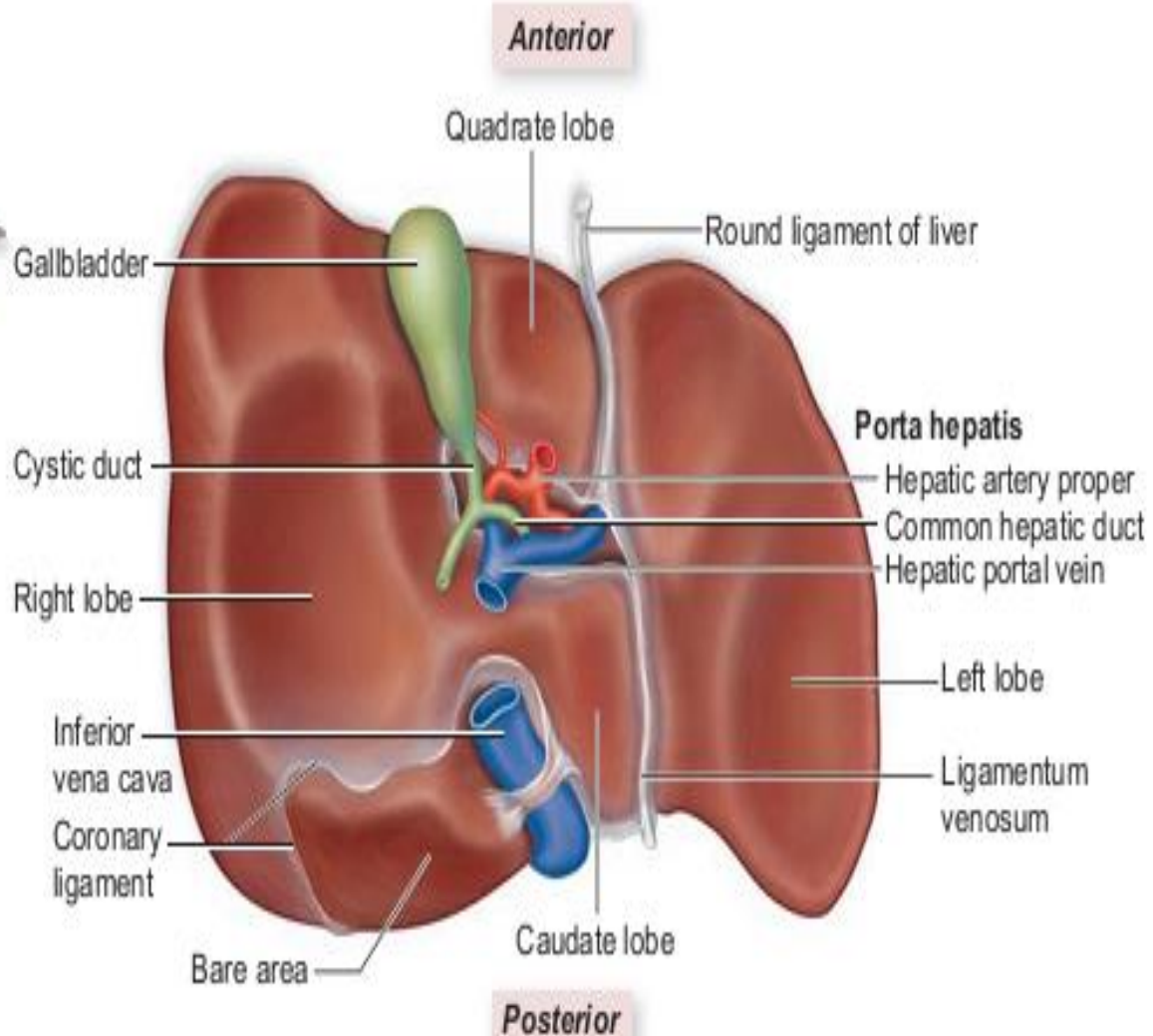
Gallbladder

- The gallbladder is a saclike organ attached to the inferior surface of the liver about 8cm long and 4cm wide
- In dilated form it achieves the size of a pear
- stores and concentrates bile
- Has capacity of 35-50 ml
- The gallbladder wall has three tunics
 - ❑ an inner mucosa folded into rugae that allow the gallbladder to expand
 - ❑ a muscularis, which is a layer of smooth muscle that allows the gallbladder to contract
 - ❑ an outer covering of serosa
- The gallbladder has three regions: the neck, body, and fundus At the neck of the gallbladder, a sphincter valve controls the flow of bile into Common hepatic duct
- In dilated and pathological gall-bladders there is frequently a pouch present on the ventral aspect just proximal to the neck termed Hartmann's pouch in which gallstones may become lodged





(a) Anterior view



(b) Posteroinferior view

Pancreas

- Pancreas is known as a mixed gland as it has both exocrine and endocrine functions
- The pancreas is located retroperitoneal, posterior to the greater curvature of stomach in the inferior part of the left-upper quadrant
- It extends from medial edge of duodenum to the left side of abdominal cavity touching the spleen
- It is about 12–15 cm (5–6 in.) long and 2.5 cm (1 in.) thick
- Pancreas consists of three portions:
 - ❑ **Head**- the expanded portion lying inside the C portion of duodenum
 - ❑ **Body** – the central portion present superior and left to head
 - ❑ **Tail** – the tapering portion that extends to spleen

Diaphragm

Pancreas

Duodenum

Jejunum

Ileum

Rectum

Liver

Lesser omentum

Stomach

Mesocolon

Transverse colon

Greater omentum

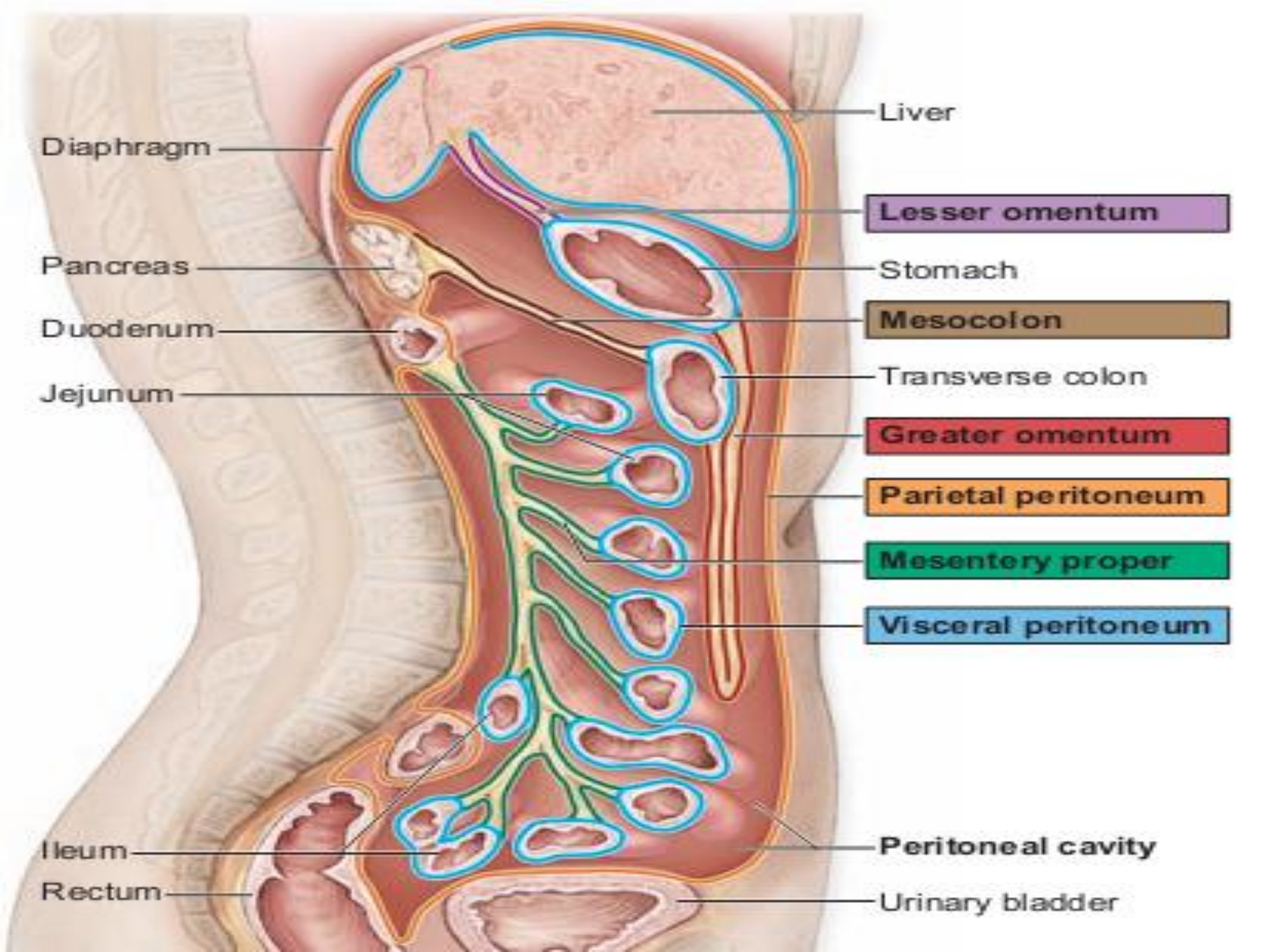
Parietal peritoneum

Mesentery proper

Visceral peritoneum

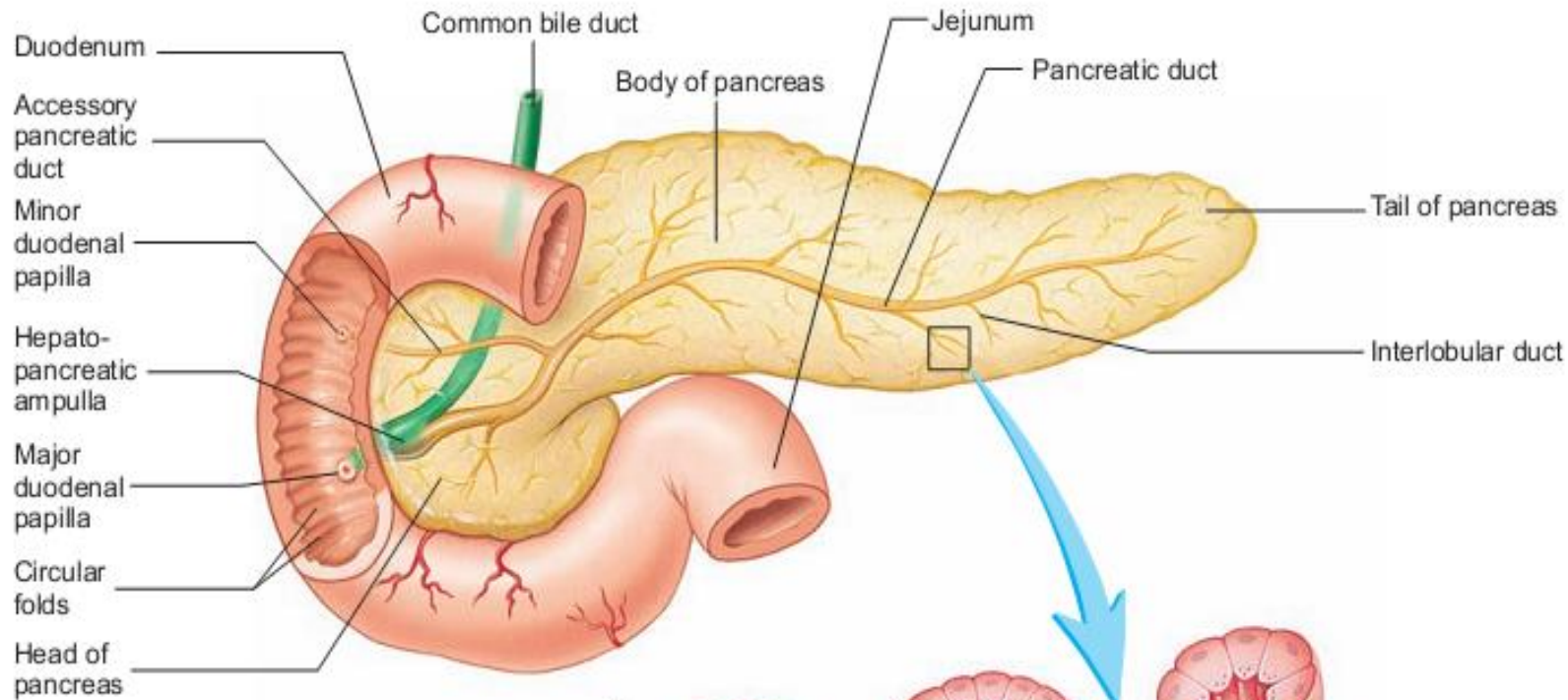
Peritoneal cavity

Urinary bladder



Histology of pancreas

- The pancreas is divided into lobules by connective tissue septae. Lobules are composed largely of grape-like clusters of exocrine cells called acini, which secrete digestive enzymes
- The acini is made up of glandular epithelial cells called acinar cells have exocrine function.
- Acini are drained by small ducts which make larger ducts called interlobular ducts, which join to form large pancreatic duct. The large pancreatic duct join with common bile duct and opens at the major duodenal papilla.
- There is an accessory pancreatic duct which is minor one and drains into duodenum and minor duodenal papilla
- Embedded within the pancreatic exocrine tissue are Islets of Langerhans, the endocrine component of the pancreas. Islets contain several cell types and are richly vascularized.



(a) Anterior view

