

The Digestive System

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The Digestive System

消化系統

Processes of digestion and absorption:

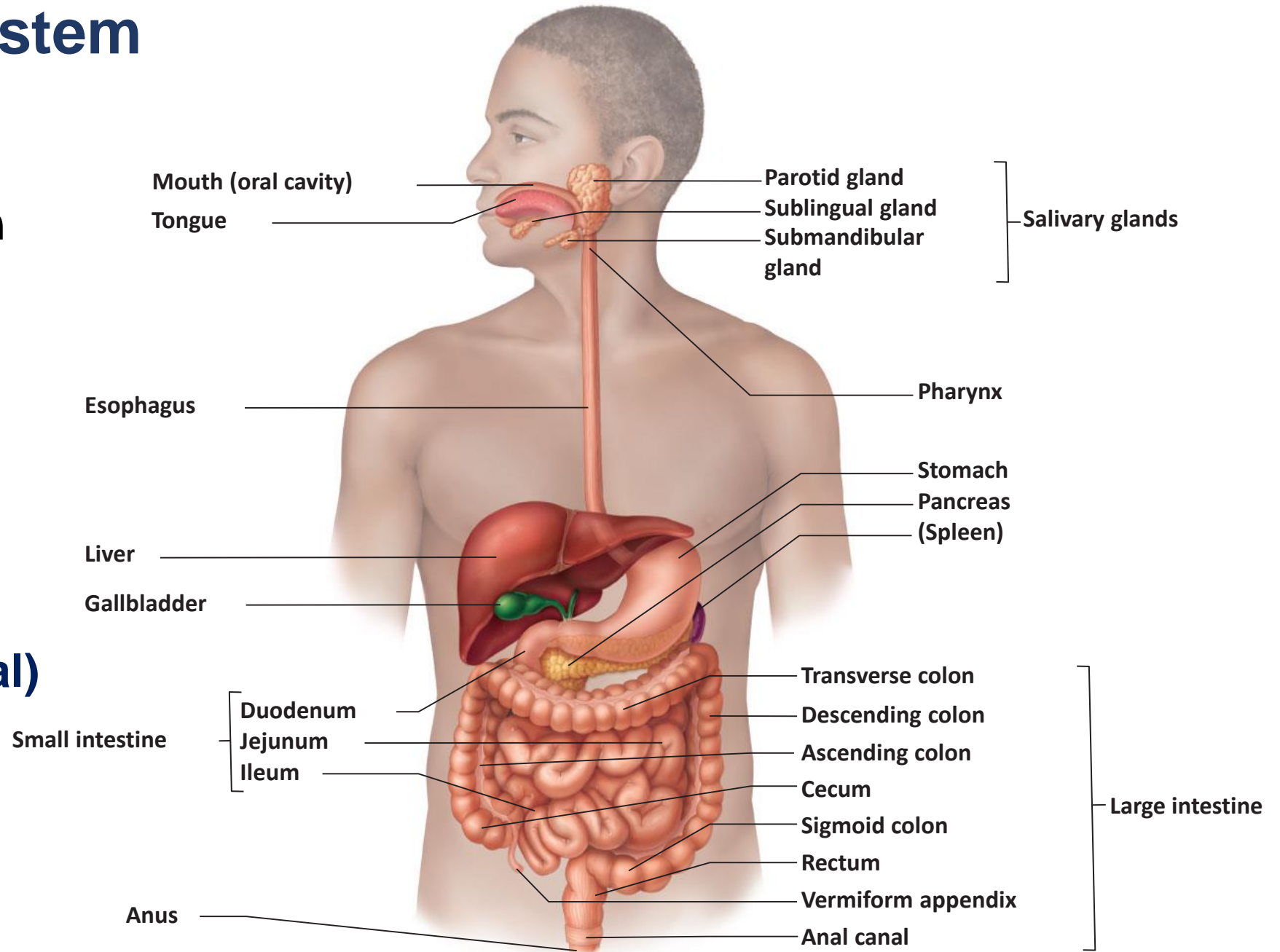
1. Ingestion 攝取

2. Peristalsis 蠕動

3. Digestion 消化
(mechanical & chemical)

4. Absorption 吸收

5. Defecation 排便



• **Digestive tract 消化管**

(alimentary canal):

Mouth 口腔, pharynx 咽

Esophagus 食道

stomach 胃

small intestine 小腸 (6 m)

large intestine 大腸

Rectum 直腸

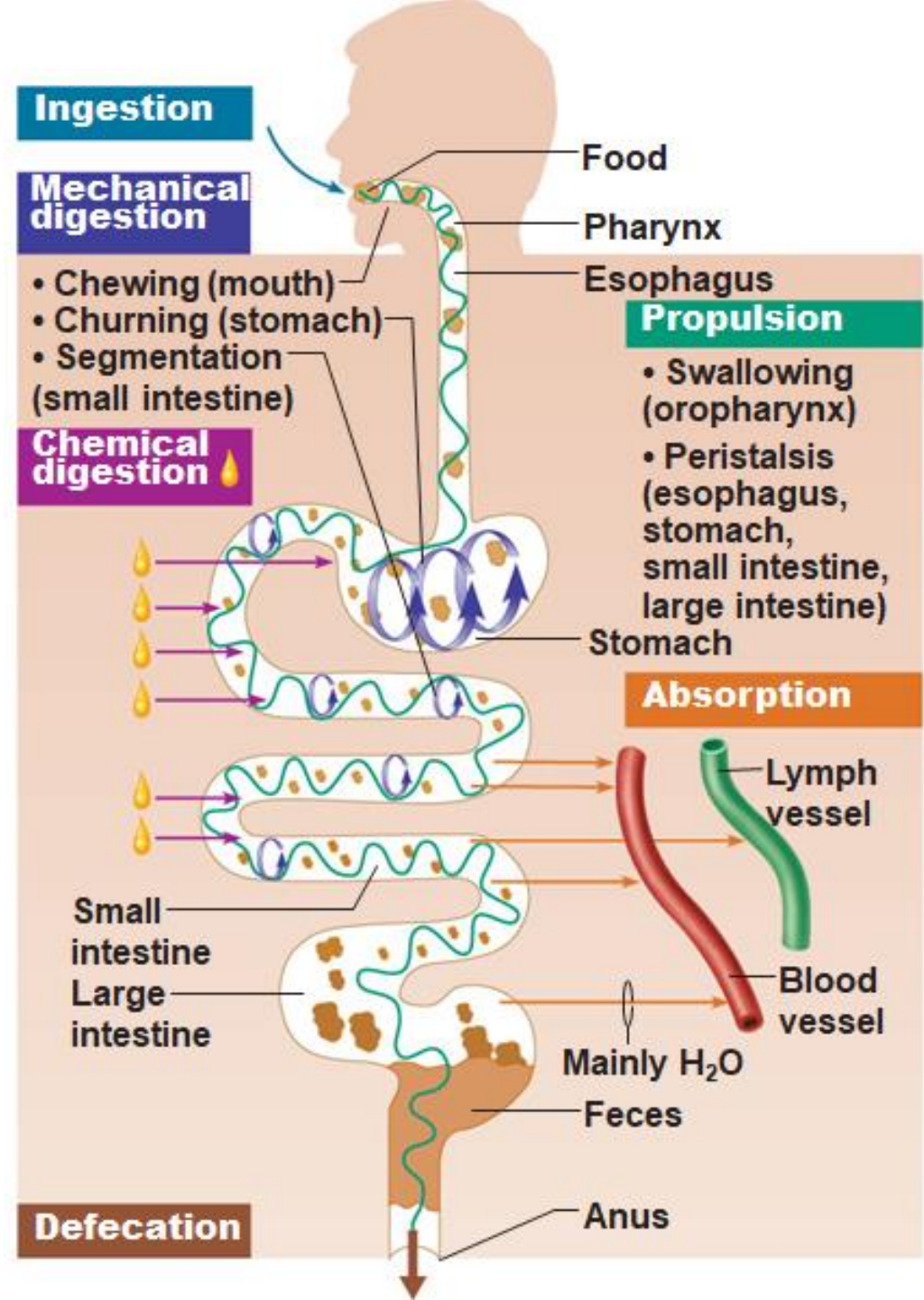
anal canal 肛管, anus 肛門

-- 9 m long.

• **Gastrointestinal (GI) tract: 胃腸道**

stomach, small intestine, large

intestine, rectum, anal canal, anus.



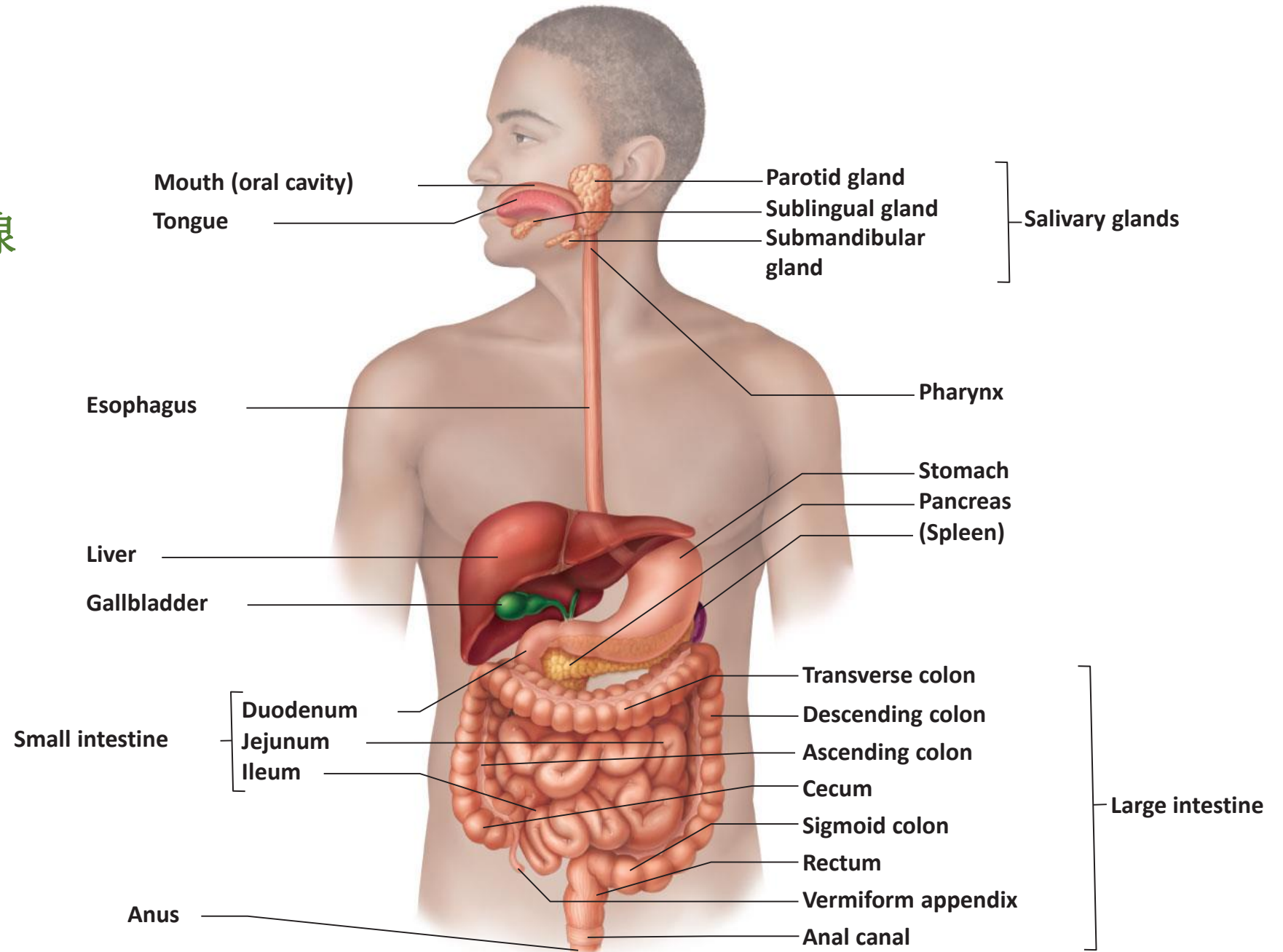
消化腺

Salivary glands 唾液腺

Pancreas 胰臟

Liver 肝臟

Gallbladder 膽囊



Tissue structure of digestive tract:

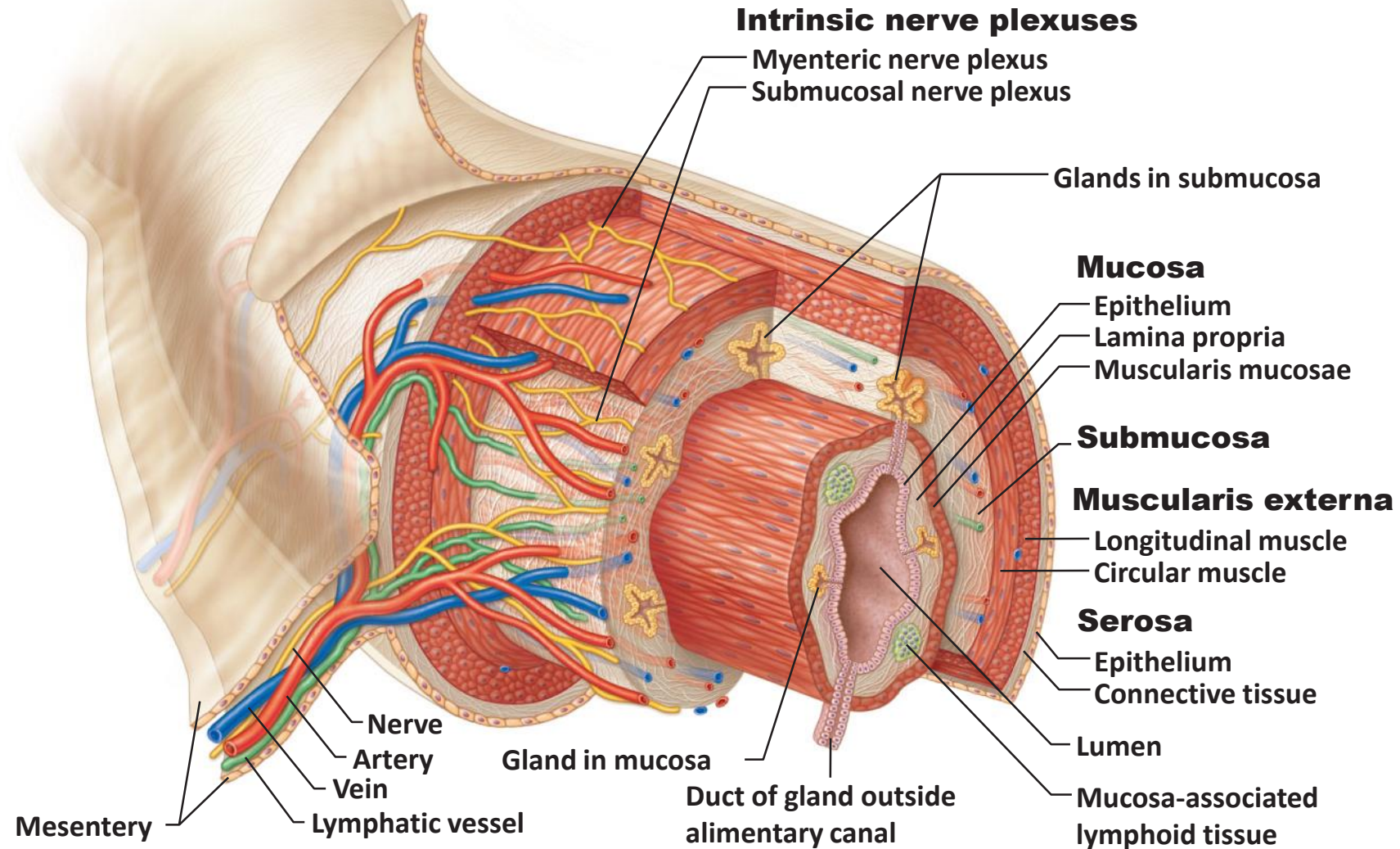
4 main layers :

Mucosa 黏膜層;

Submucosa 黏膜下層

Muscularis externa
肌肉外層

Serosa 漿膜層



(a) Longitudinal and cross-sectional views through the small intestine

Tissue structure of digestive tract:

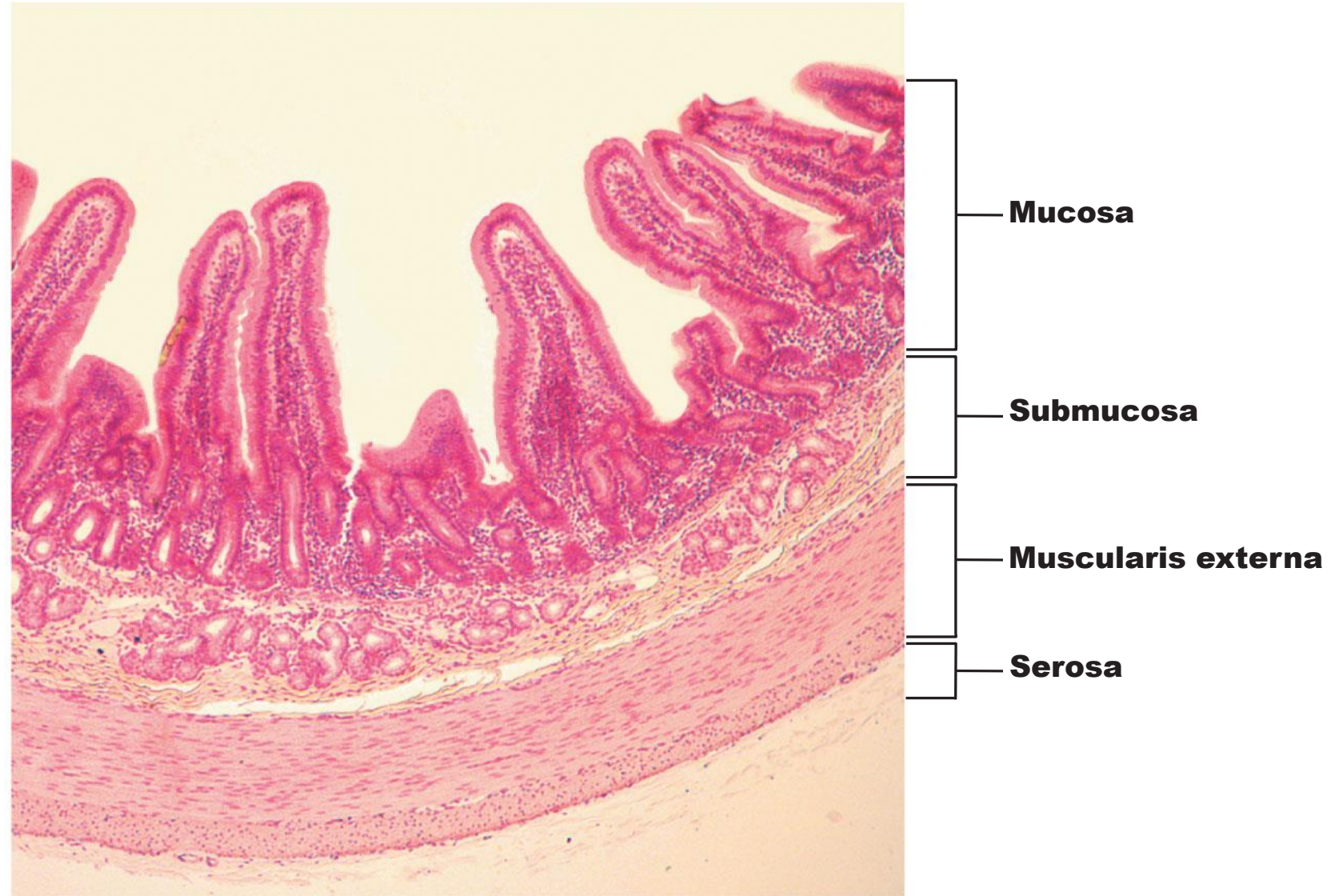
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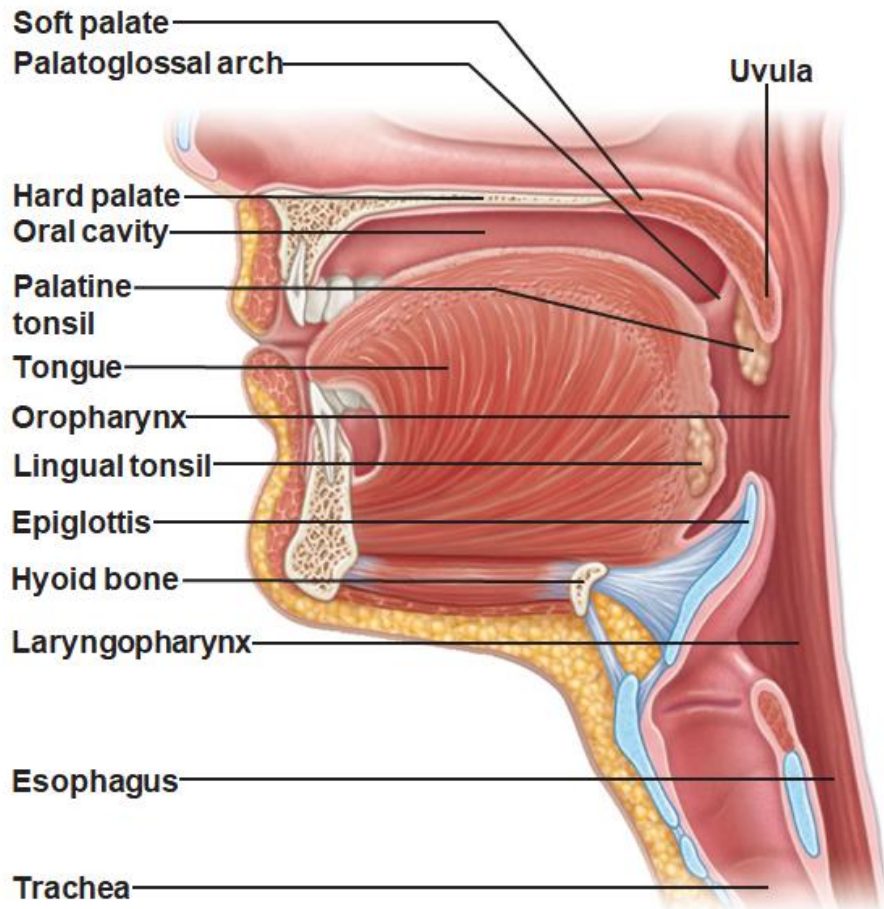


(b) Light micrograph cross section through the small intestine (30×)

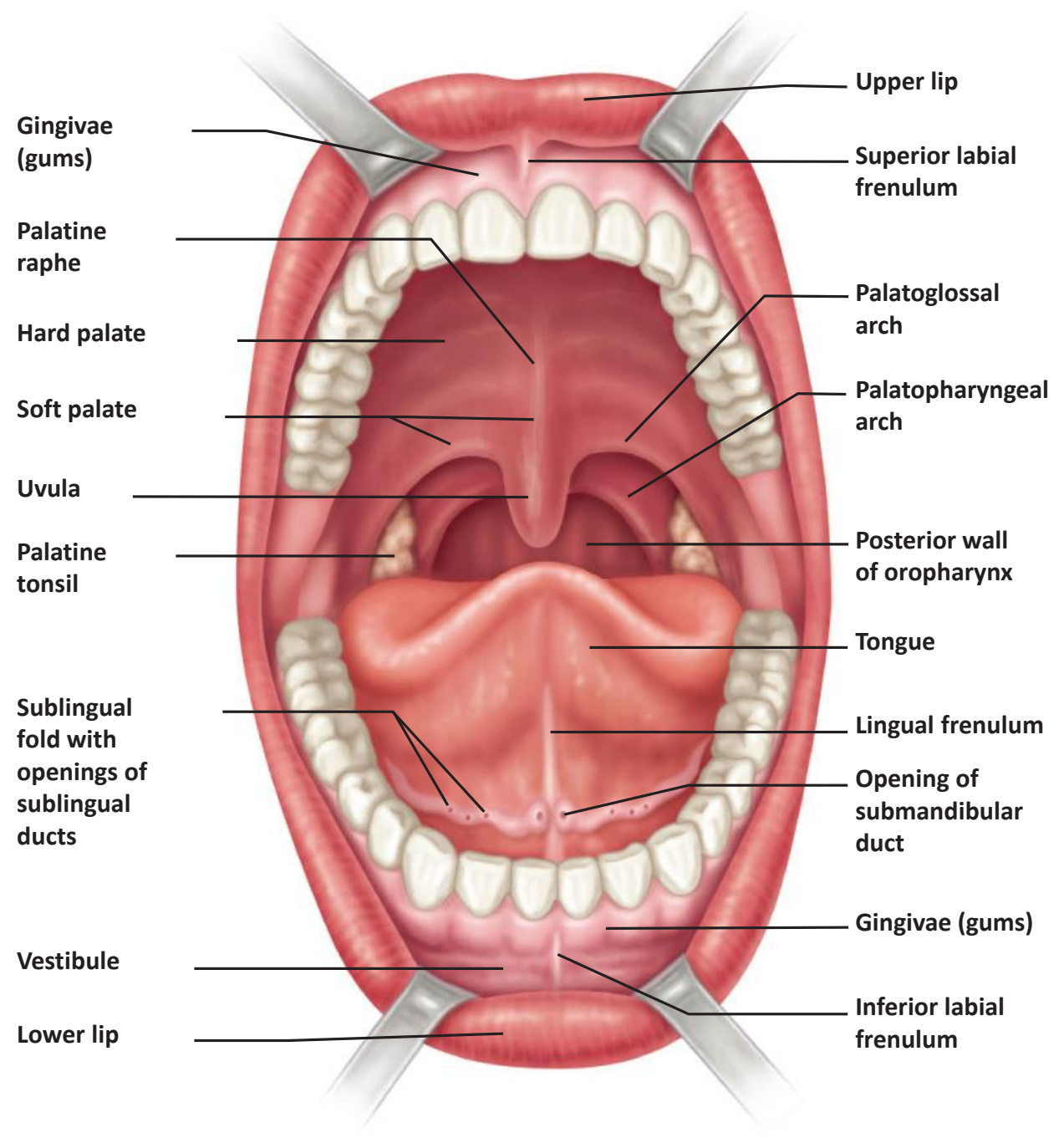
Mouth (oral cavity):

1. vestibule 前庭 or buccal cavity 頰腔

2. oral cavity proper



(a) Sagittal section of the oral cavity and pharynx



(b) Anterior view

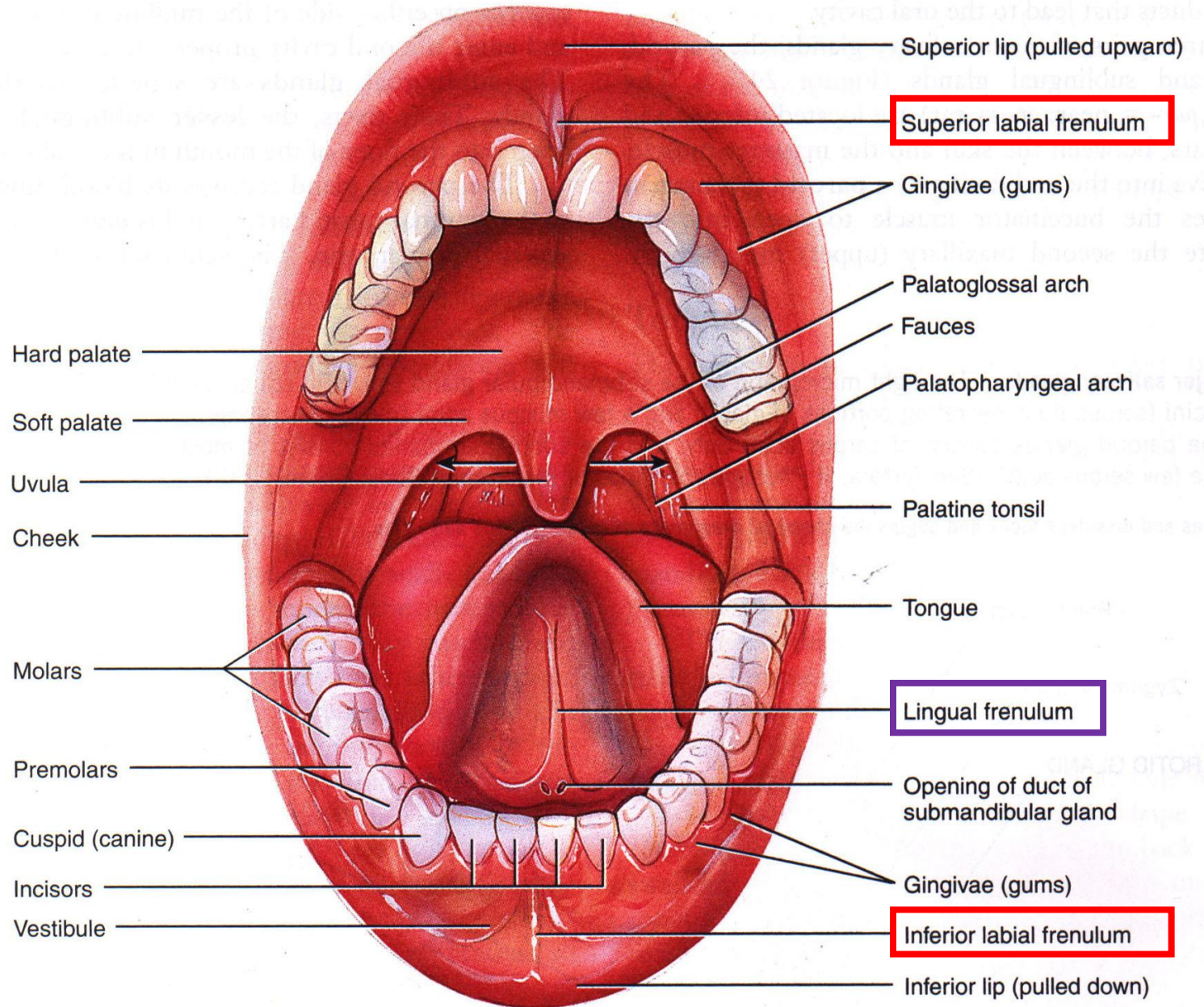
Lips and Cheeks:

help to hold food

labial frenulum 唇繫帶

lingual frenulum 舌繫帶

- nonkeratinized stratified squamous epi.



Anterior view

Teeth牙齒 and Gums牙齦

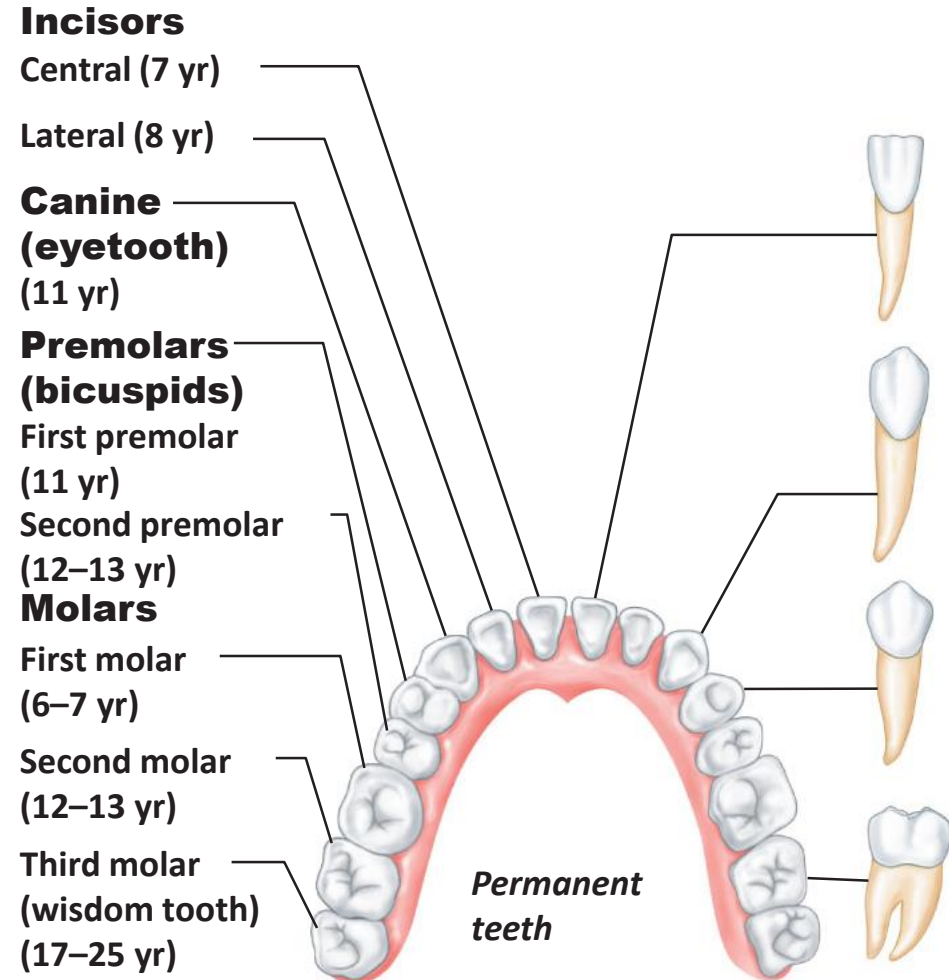
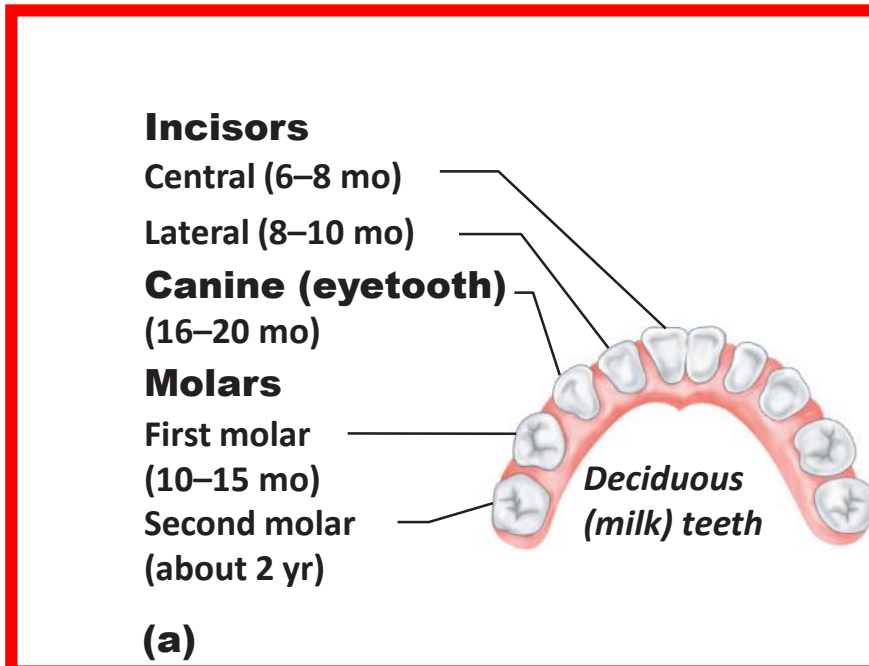
20 deciduous teeth (milk teeth)乳齒: [212-212]

each jaw: 4 **incisors** (for cutting)門牙

2 **canines** (for tearing)犬齒

4 **premolar** (for grinding)前臼齒

20 deciduous teeth (milk teeth)乳齒:



Teeth 牙齒 and Gums 牙齦

32 permanent teeth:
[3212-2123]

each jaw:

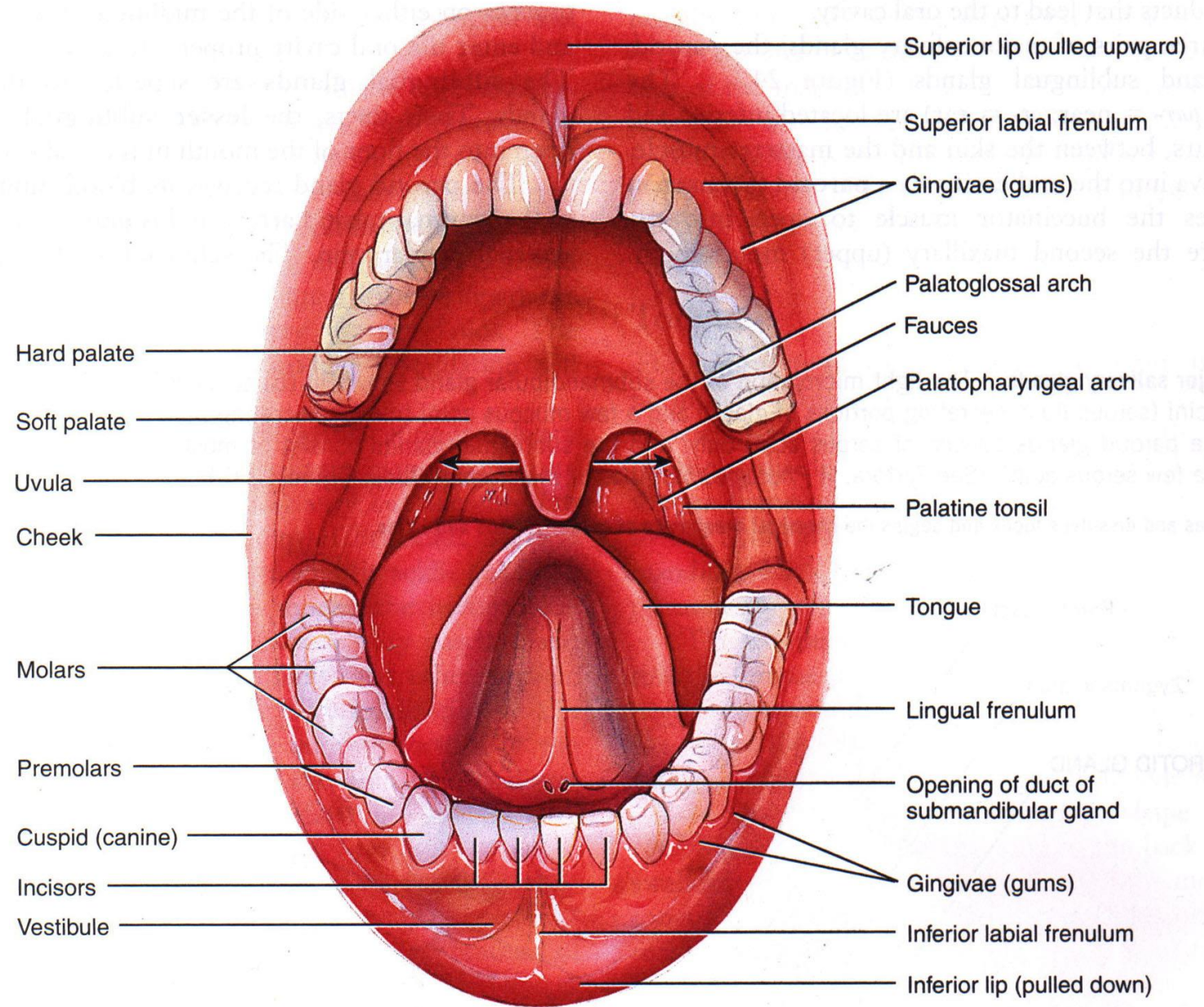
4 **incisors** (cutting teeth) 門牙

2 **canines** (cuspid) 犬齒

4 **premolar** (bicuspid) 前臼齒

6 **molars** (millstone teeth) 臼齒

*third molars = **wisdom teeth** 智齒



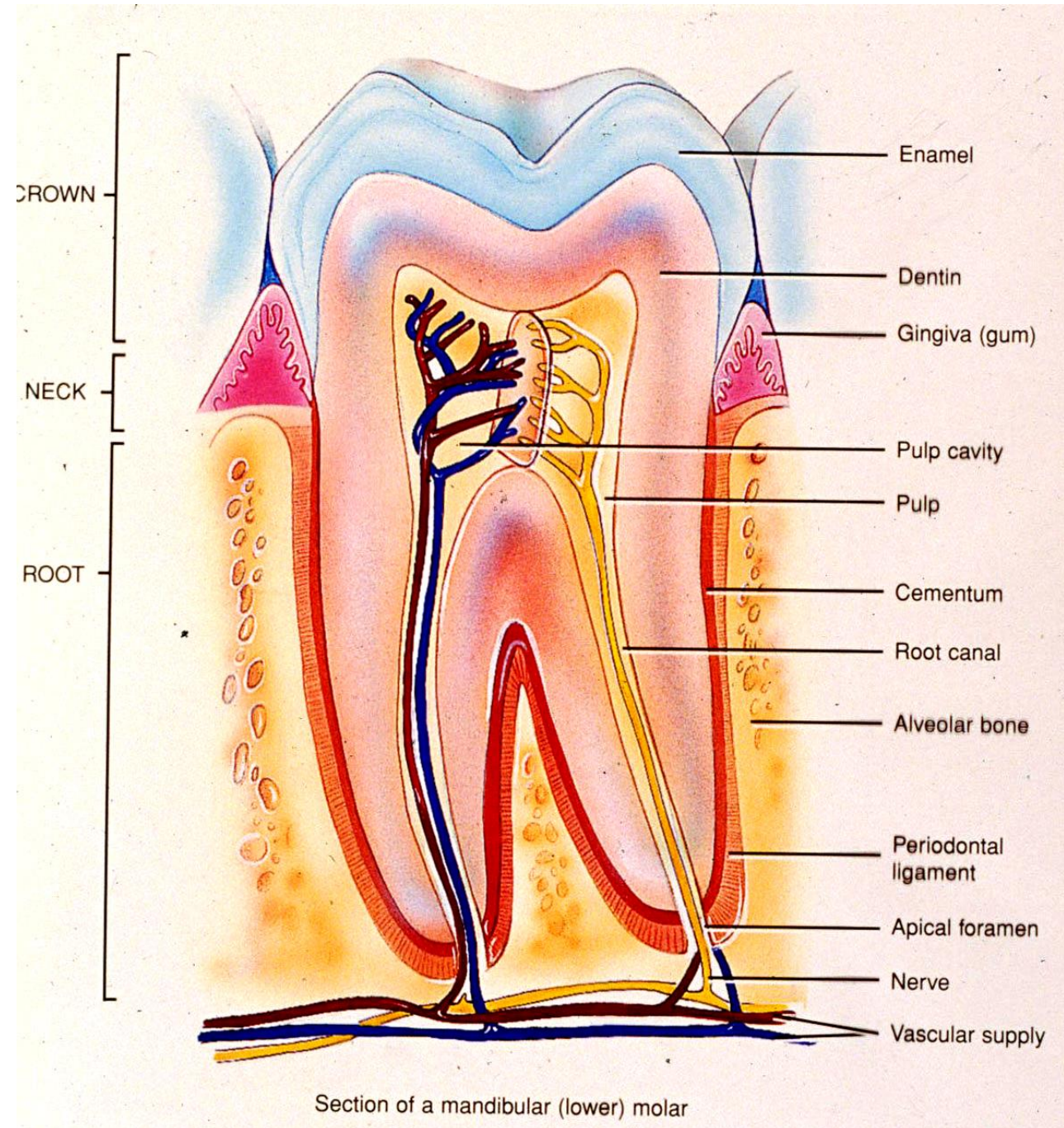
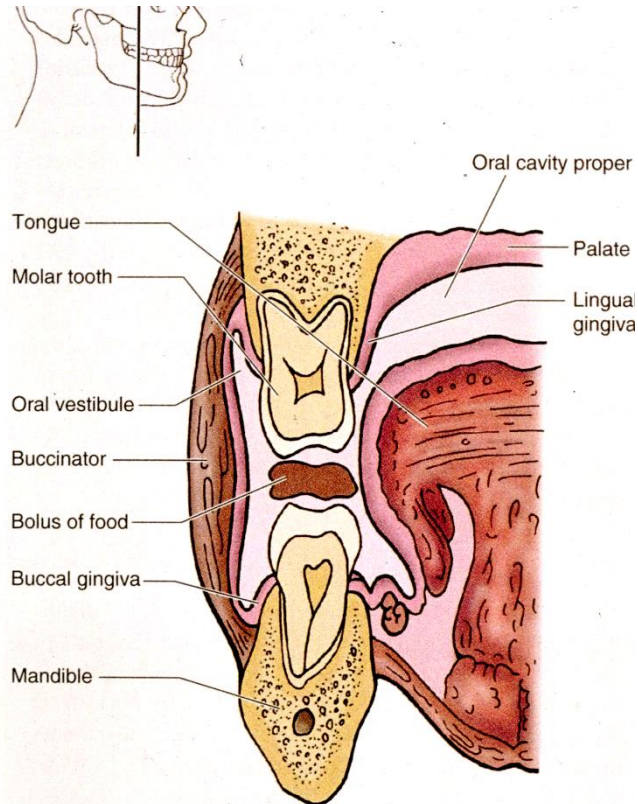
Anterior view

Parts of a tooth:

1. **Root** 牙根;
2. **Crown** 牙冠;
3. **Neck** 牙頸

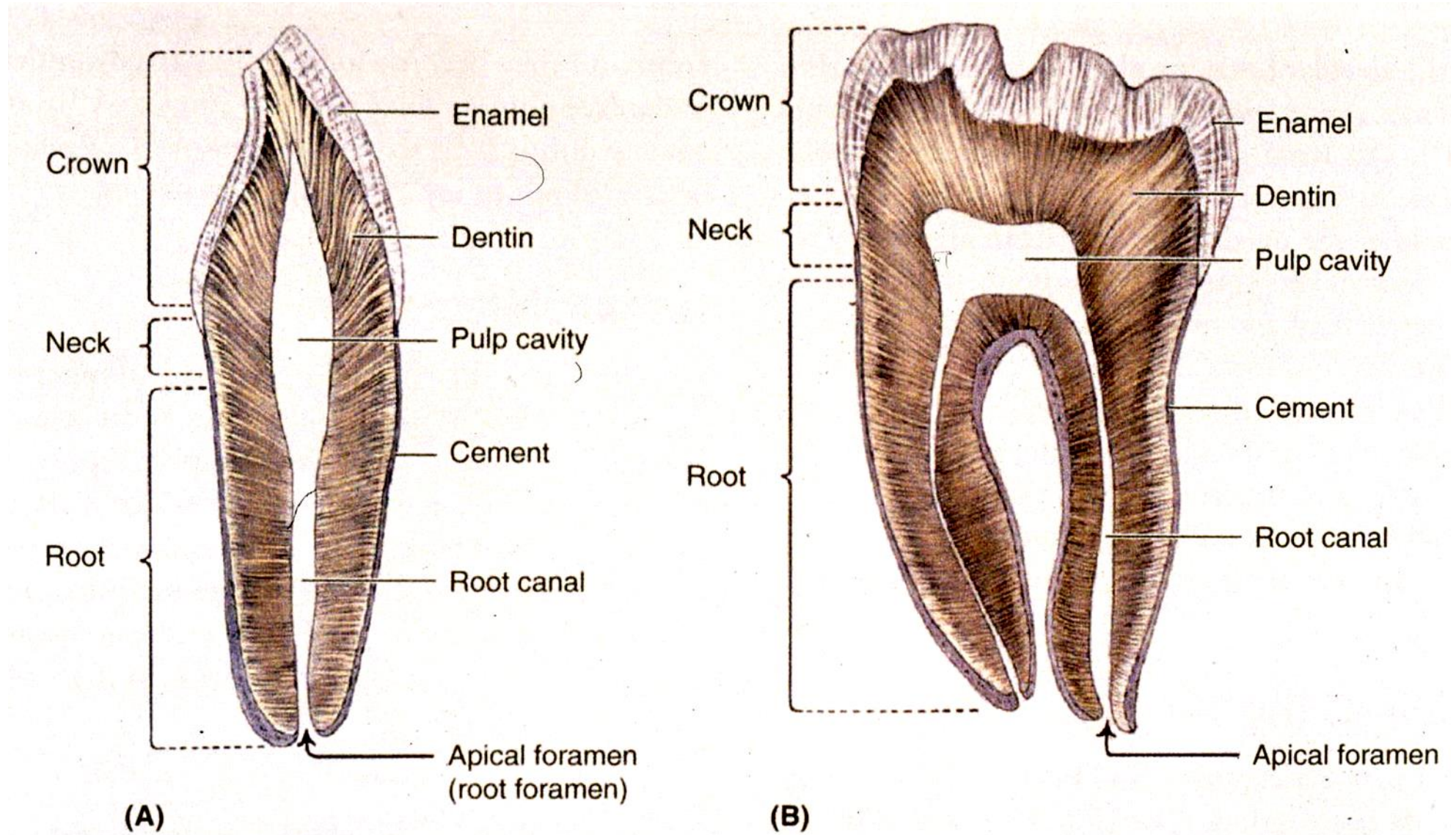
Gum (gingiva) 牙齦

-- stratified squamous epi.



* Composition of teeth:

Dentine 牙本質, enamel 琺瑯質, cement 齒骨質, pulp 牙髓腔



Tongue 舌

Terminal Sulcus 界溝

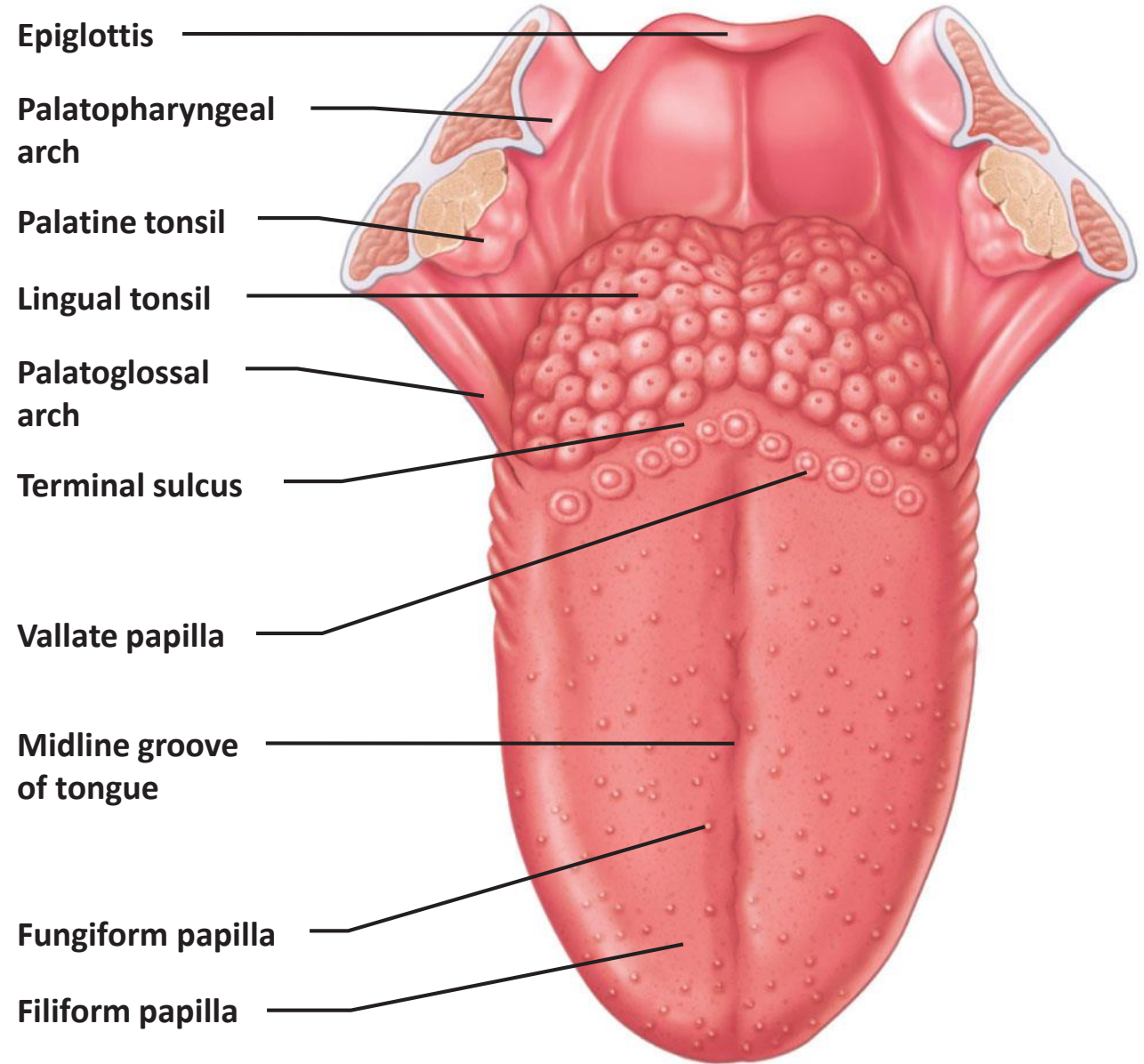
(V-shape) divides 2 parts:

1. oral part (anterior 2/3)

口腔部

2. pharyngeal part

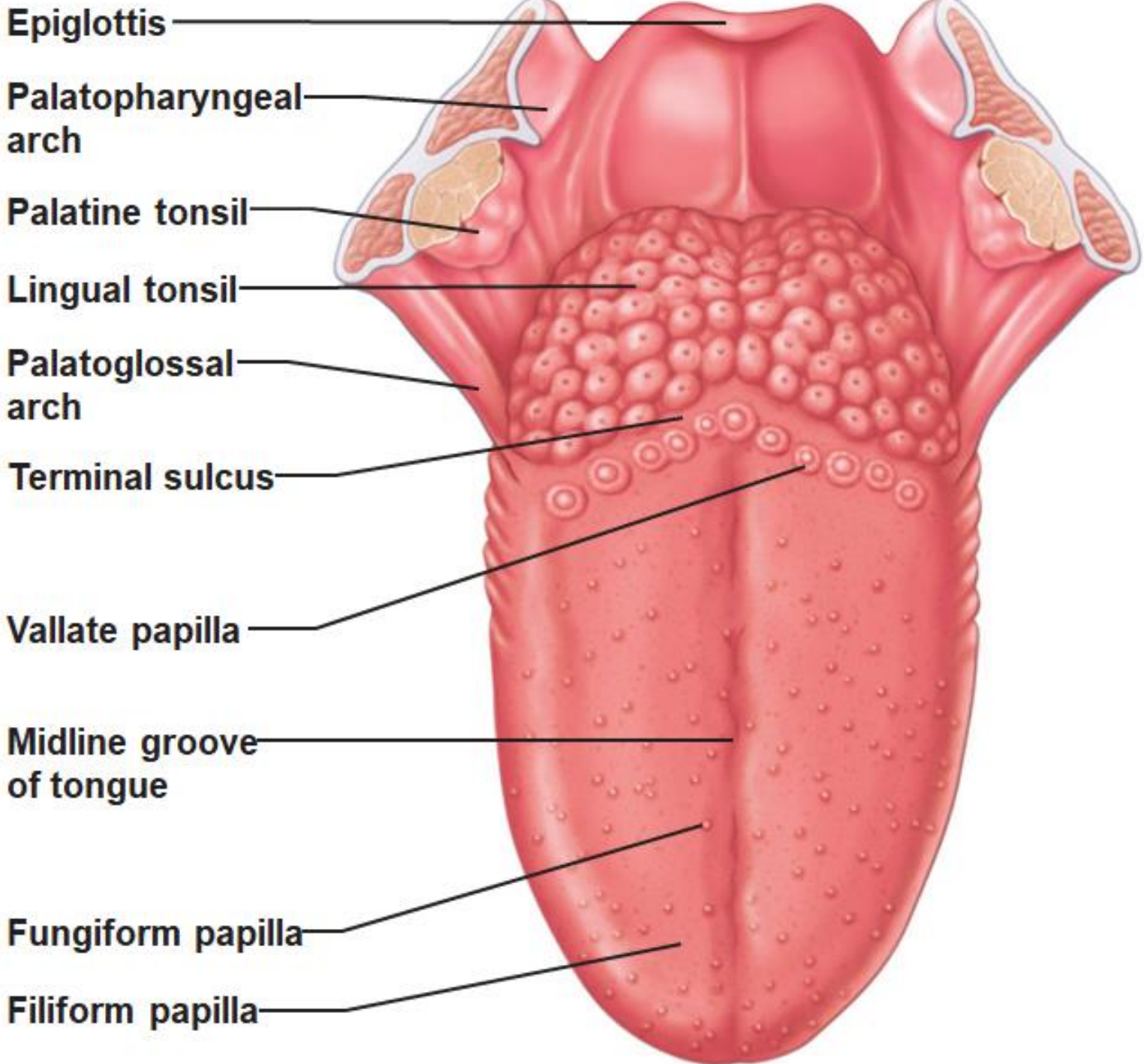
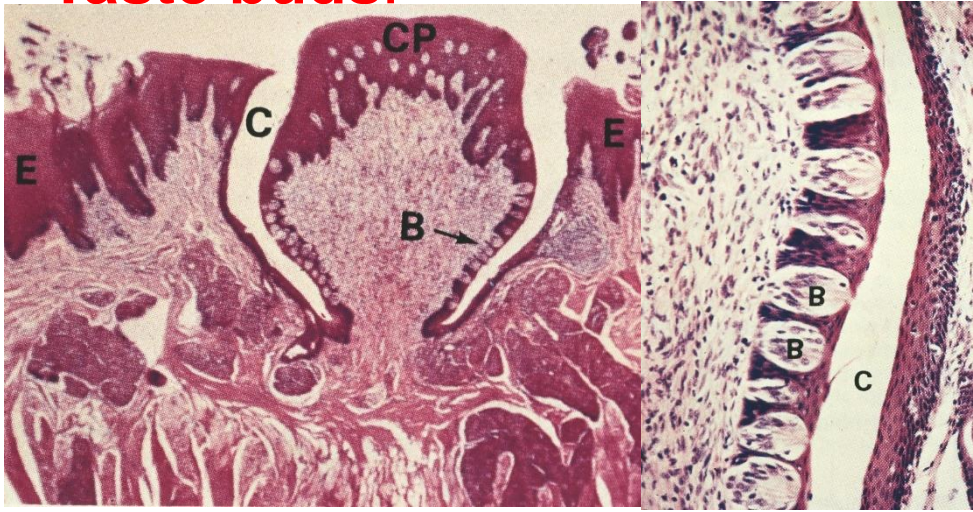
(posterior 1/3) 咽部



Lingual papillae 乳突:

1. vallate papillae 輪狀
2. foliate papillae 葉狀
3. filiform papillae 絲狀
4. fungiform papillae 蕈狀

*Taste buds:



Nerve supply to tongue:

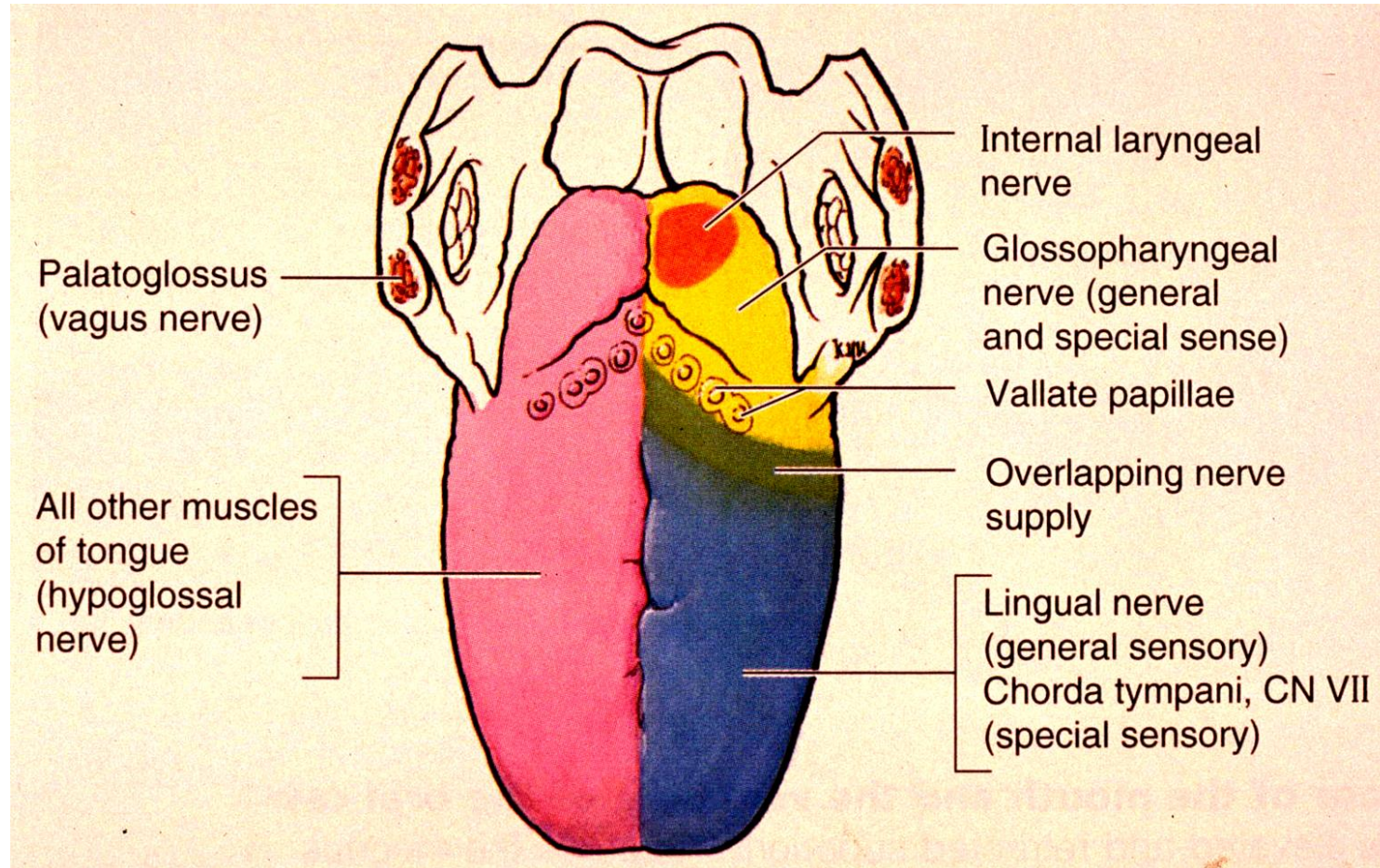
motor: hypoglossal n. (CN XII) 舌下神經

sensory:

anterior 2/3: general--lingual n. (CN V三叉神經) 觸痛覺、溫覺

special--chorda tympani (CN VII顏面神經) 味覺

posterior 1/3: general & special (味覺)-- glossopharyngeal n. (CN IX) 舌咽神經



Sensory:

Anterior 2/3:

General--lingual n. (CN V三叉神經)

觸痛覺、溫覺

Special--chorda tympani (CN VII顏面神經) 味覺

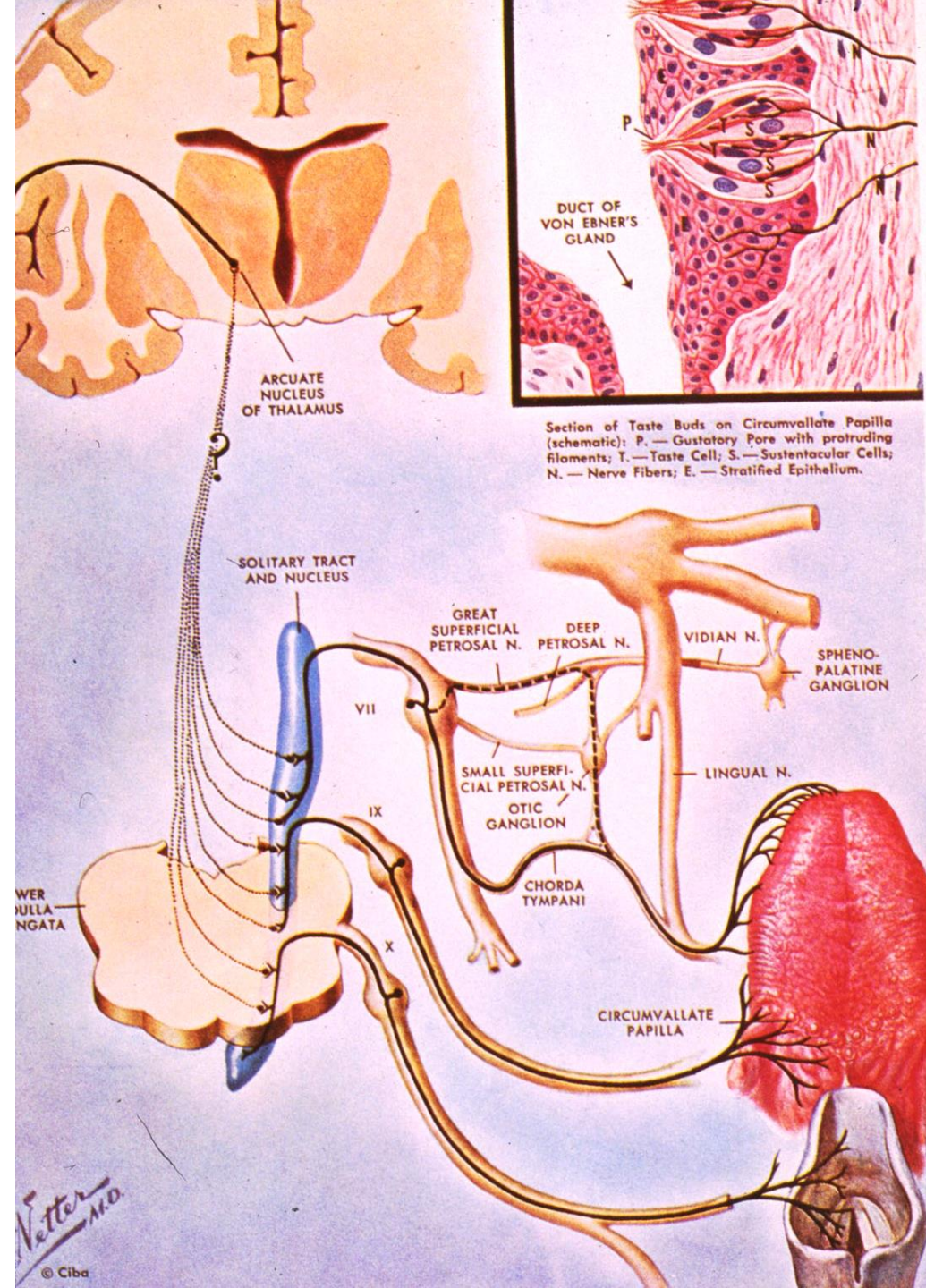
Posterior 1/3:

General: glossopharyngeal n. (CN IX)

舌咽神經 觸痛覺、溫覺

Special -- glossopharyngeal n. (CN IX)
舌咽神經 (味覺)

Larynx: vagus nerve (CN X) (味覺)

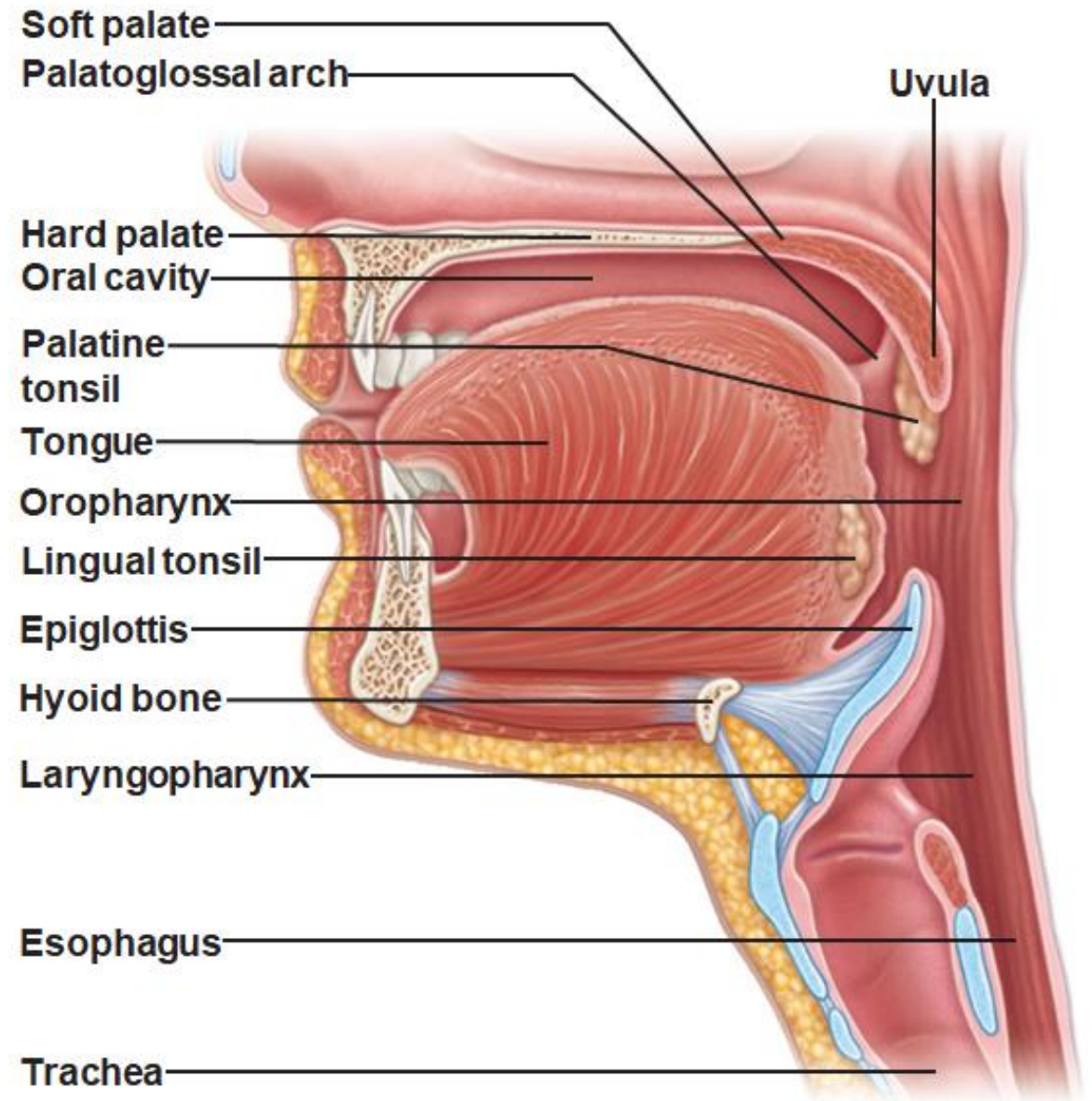
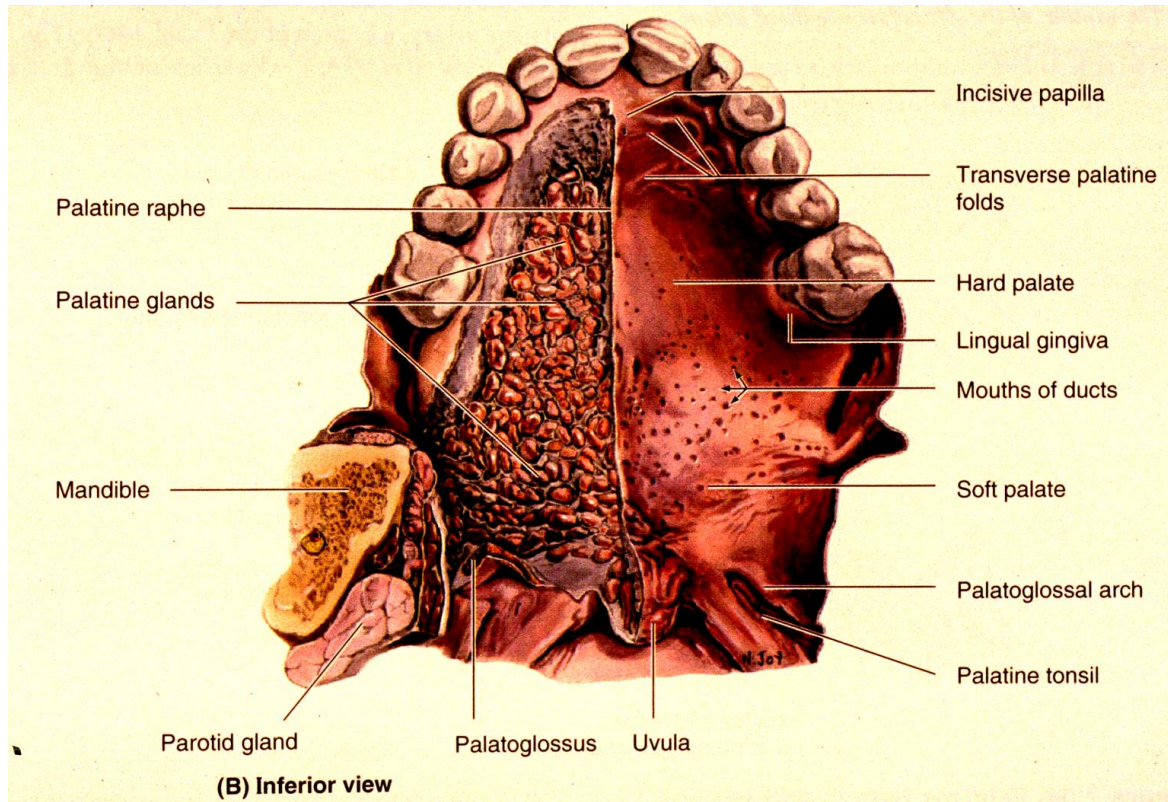


Palate 腭

1. **hard palate** 硬腭

2. **soft palate** 軟腭

keep food from entering the nasal passages during swallowing.



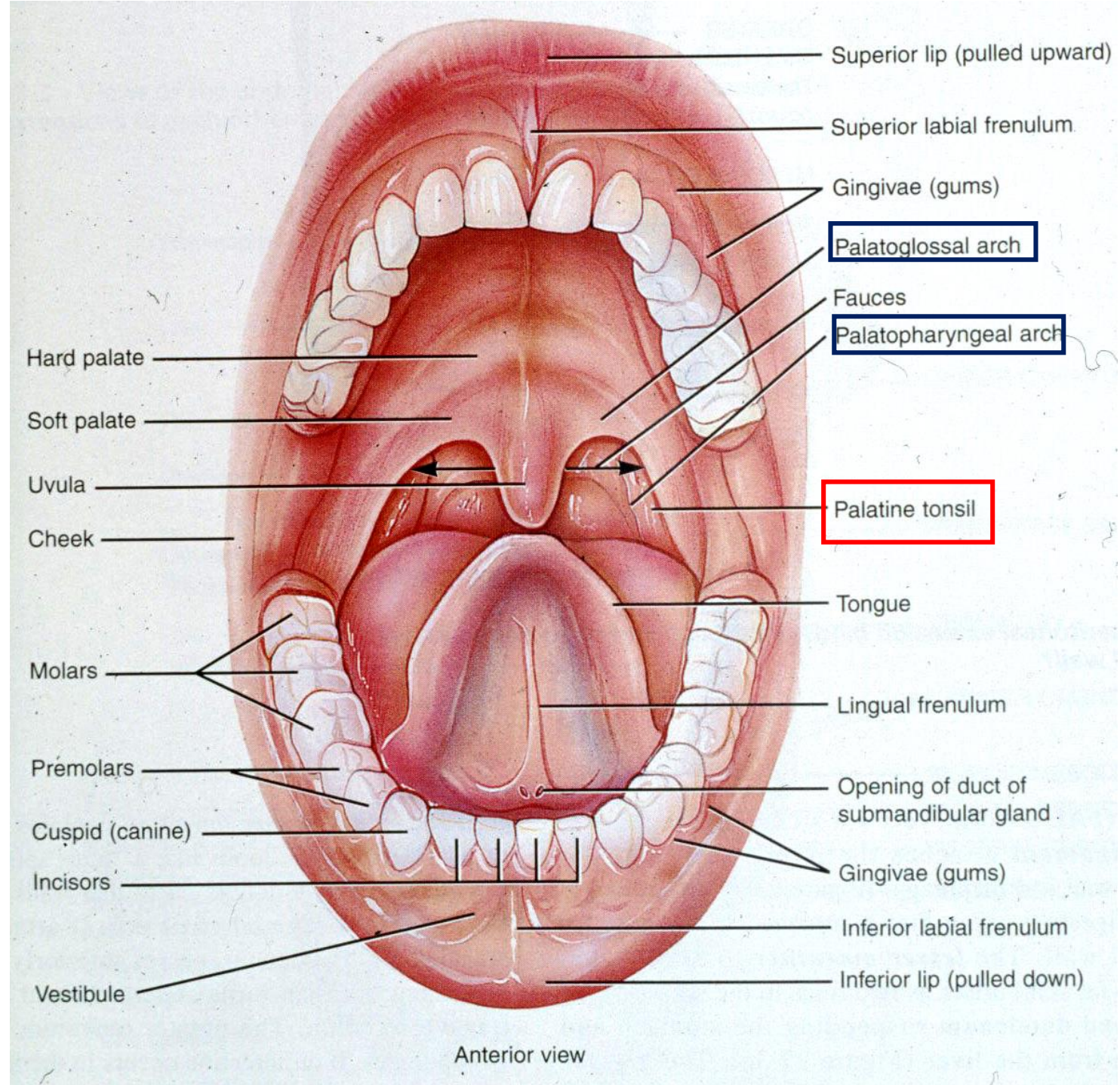
(a) Sagittal section of the oral cavity and pharynx

Uvula 懸壅垂
“Small grape”

palatoglossal arch
腭舌弓

palatine tonsil
腭扁桃腺

palatopharyngeal arch
腭咽弓



Salivary Glands 唾液腺

1) Parotid gland 耳下腺: largest

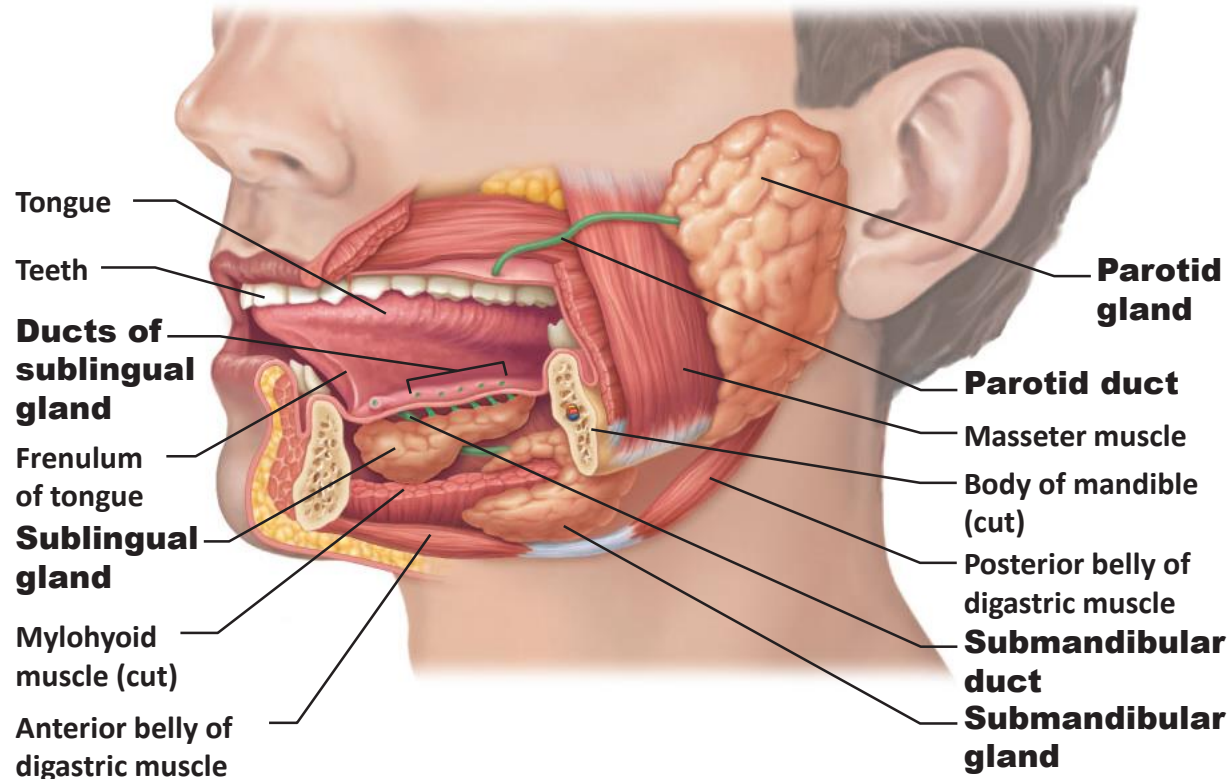
- parotid duct -----> second upper molar tooth

2) Submandibular gland 頷下腺:

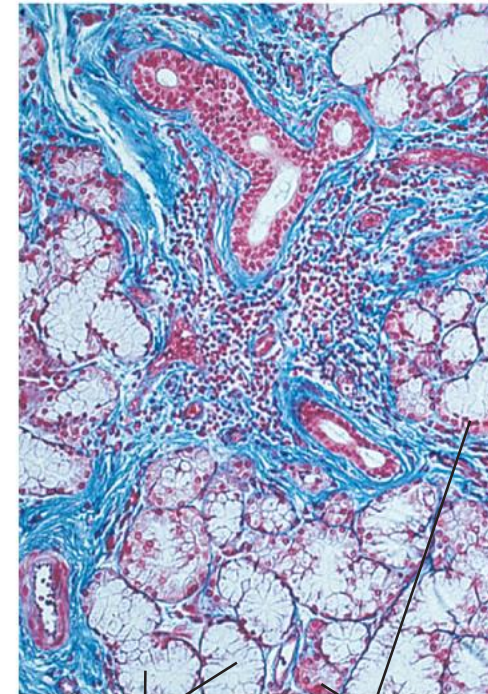
- submandibular duct -----> beside lingual frenulum

3) Sublingual gland 舌下腺: smallest

- small ducts -----> sublingual fold



(a)



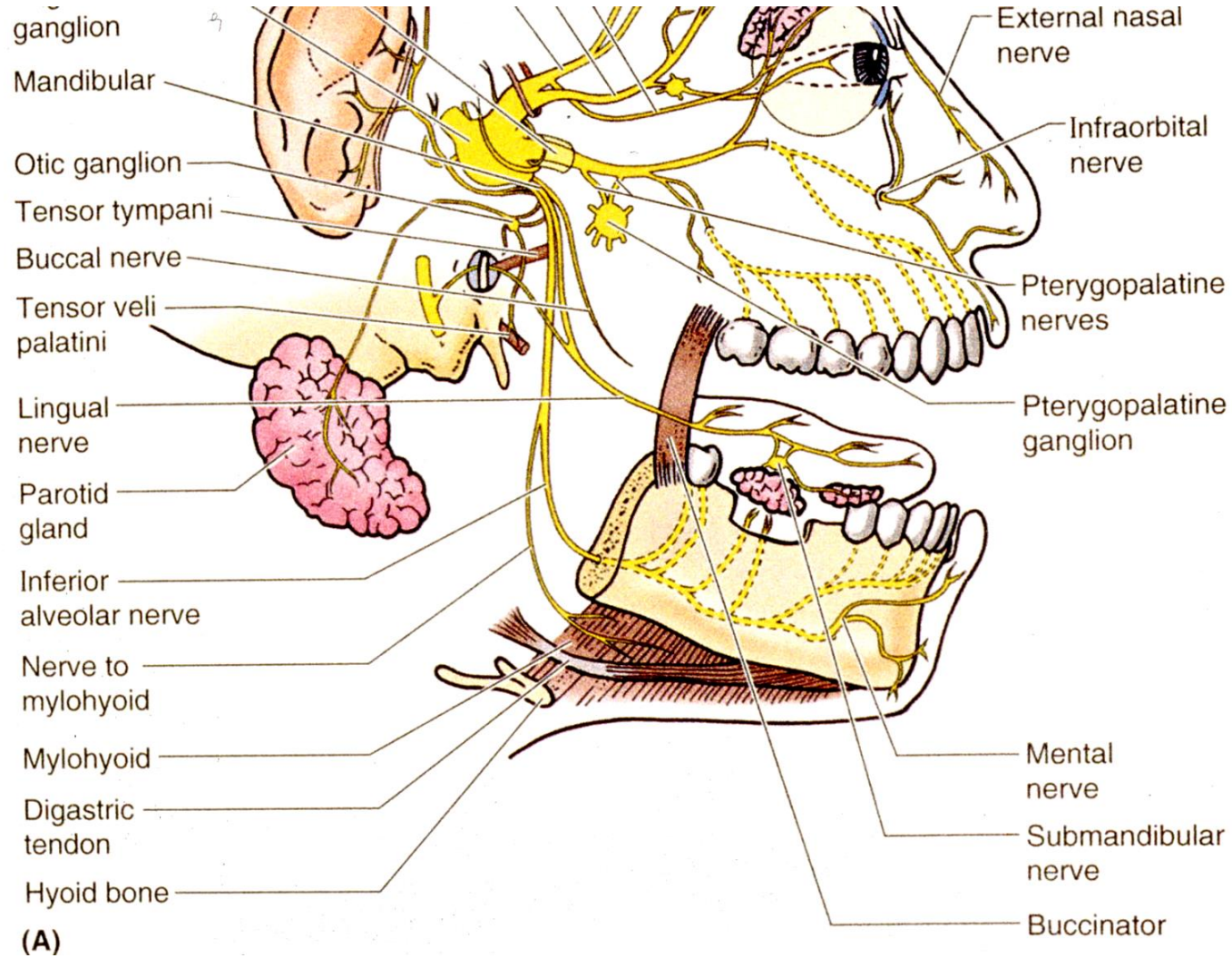
(b)

Mucous cells
Serous cells forming demilunes

Salivary Glands

Saliva 唾液--watery, tasteless, contain mucin, salivary amylase 澱粉酶.

* Control of salivary secretion: autonomic nervous system (副交感神經)



(A)

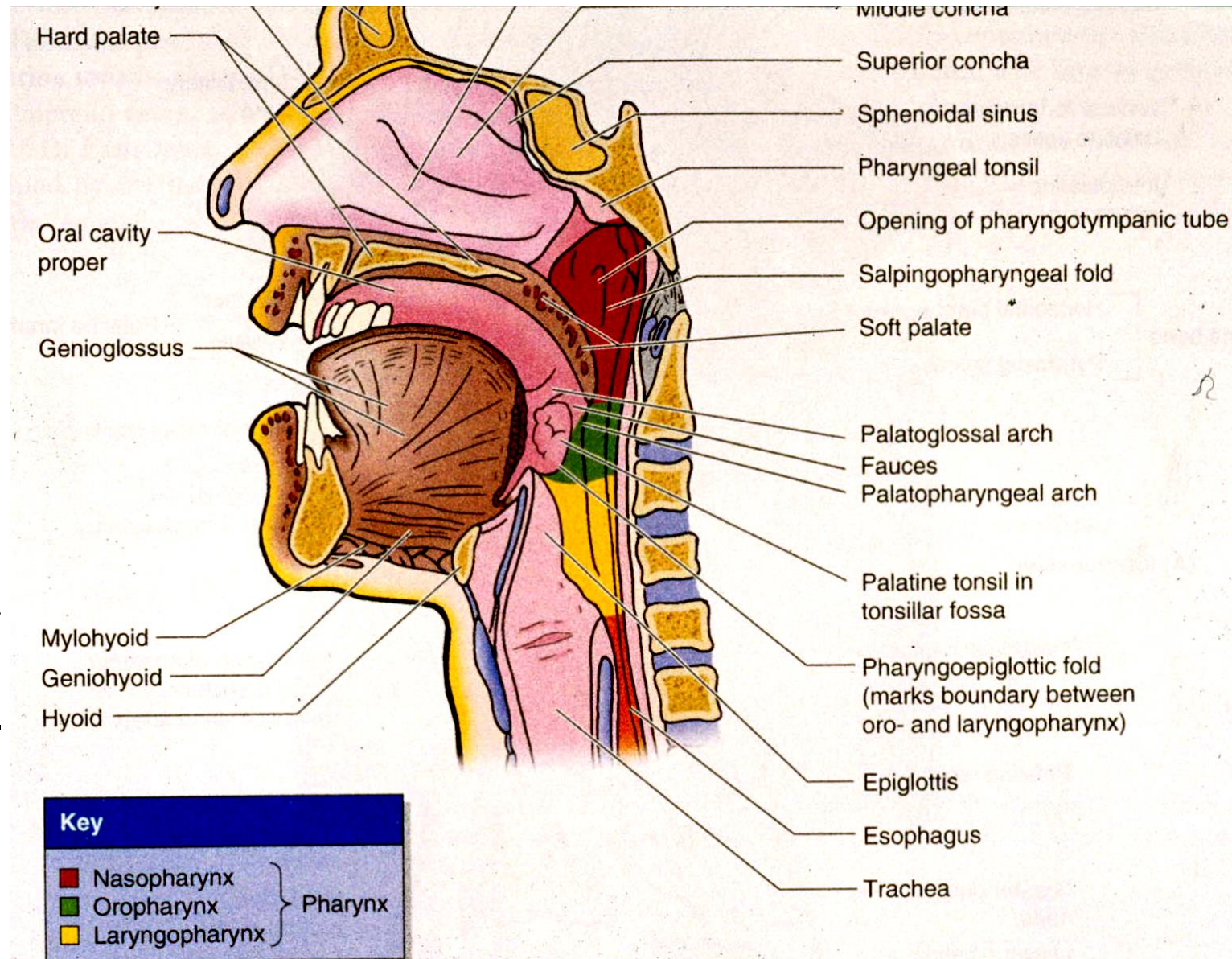


Pharynx:

an air passage during breathing & a food passage during swallowing

1. **Nasopharynx** 鼻咽
2. **Oropharynx** 口咽
3. **Laryngopharynx** 喉咽

• **Pharyngeal constrictors** 收縮肌
(skeletal m.)
--automatic, not autonomic nerve control.



Esophagus 食道

(about 25 cm long)

Mucosa

nonkeratinized stratified squamous epi.
longitudinal folds, mucous glands

Submucosa

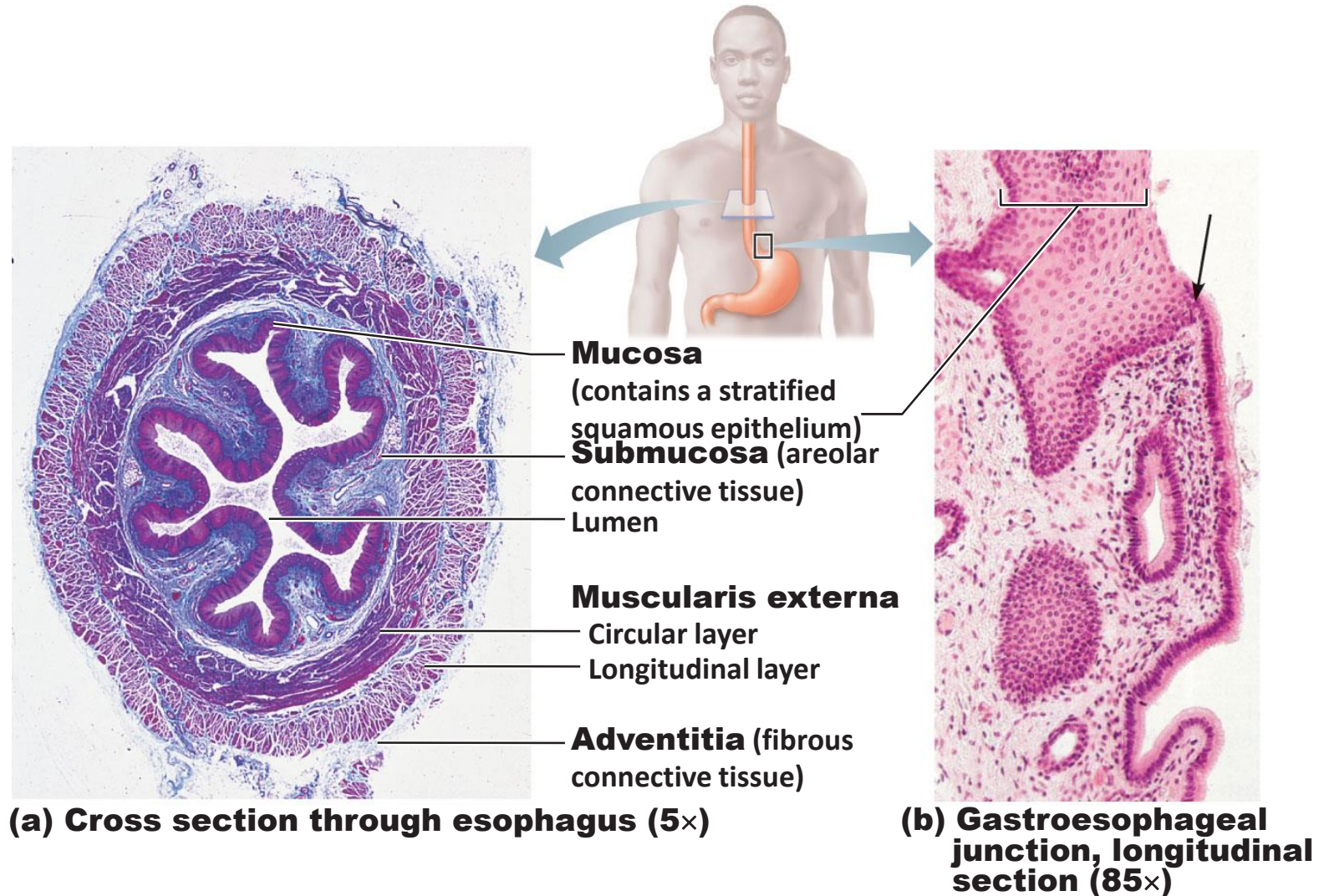
mucous glands, blood vessels

Muscularis externa

upper 1/3 = skeletal m. 骨骼肌
middle 1/3 = mixed 骨骼肌與平滑肌
lower 1/3 = smooth m. 平滑肌

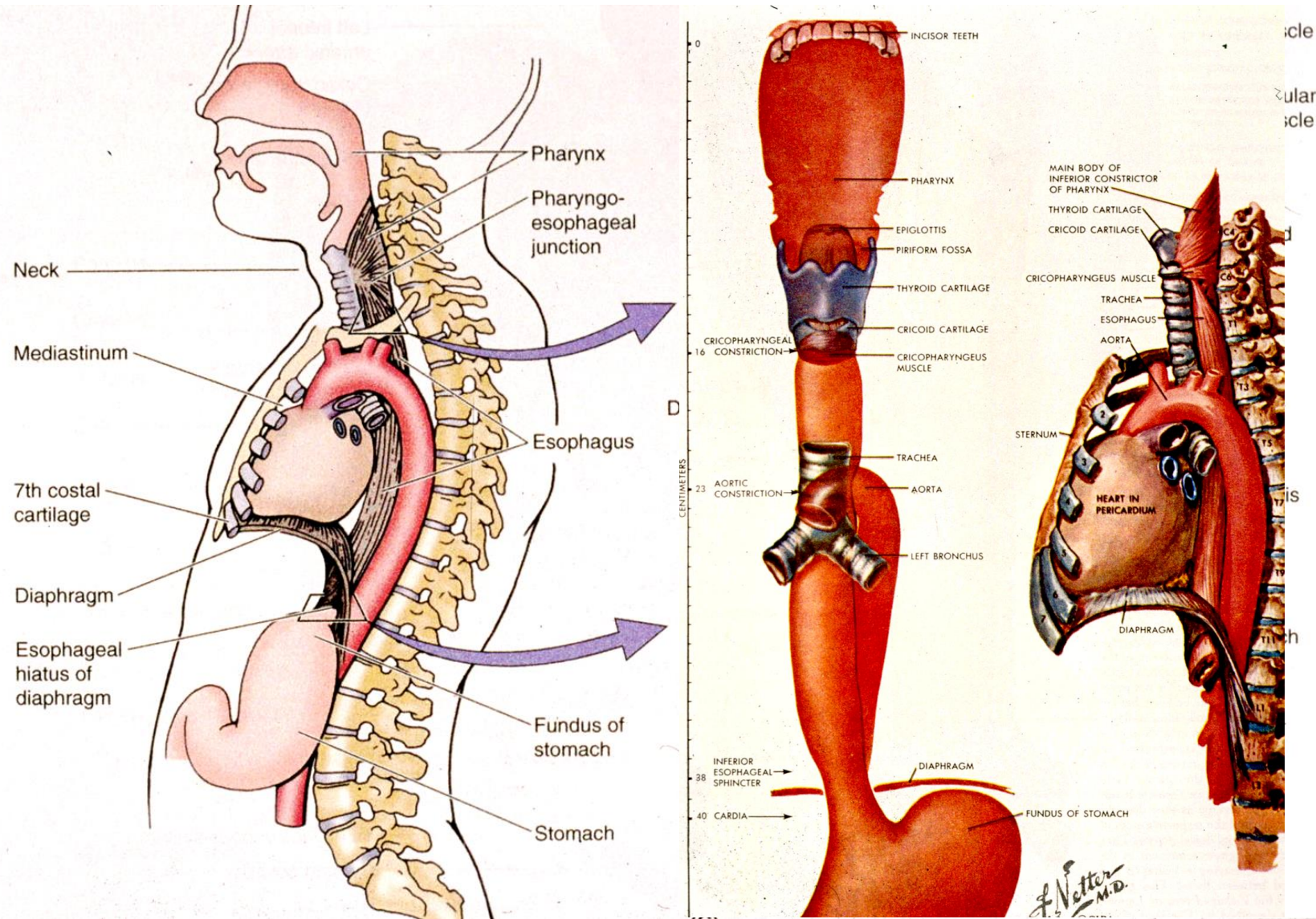
Adventitia

lack an epithelial layer 外膜層



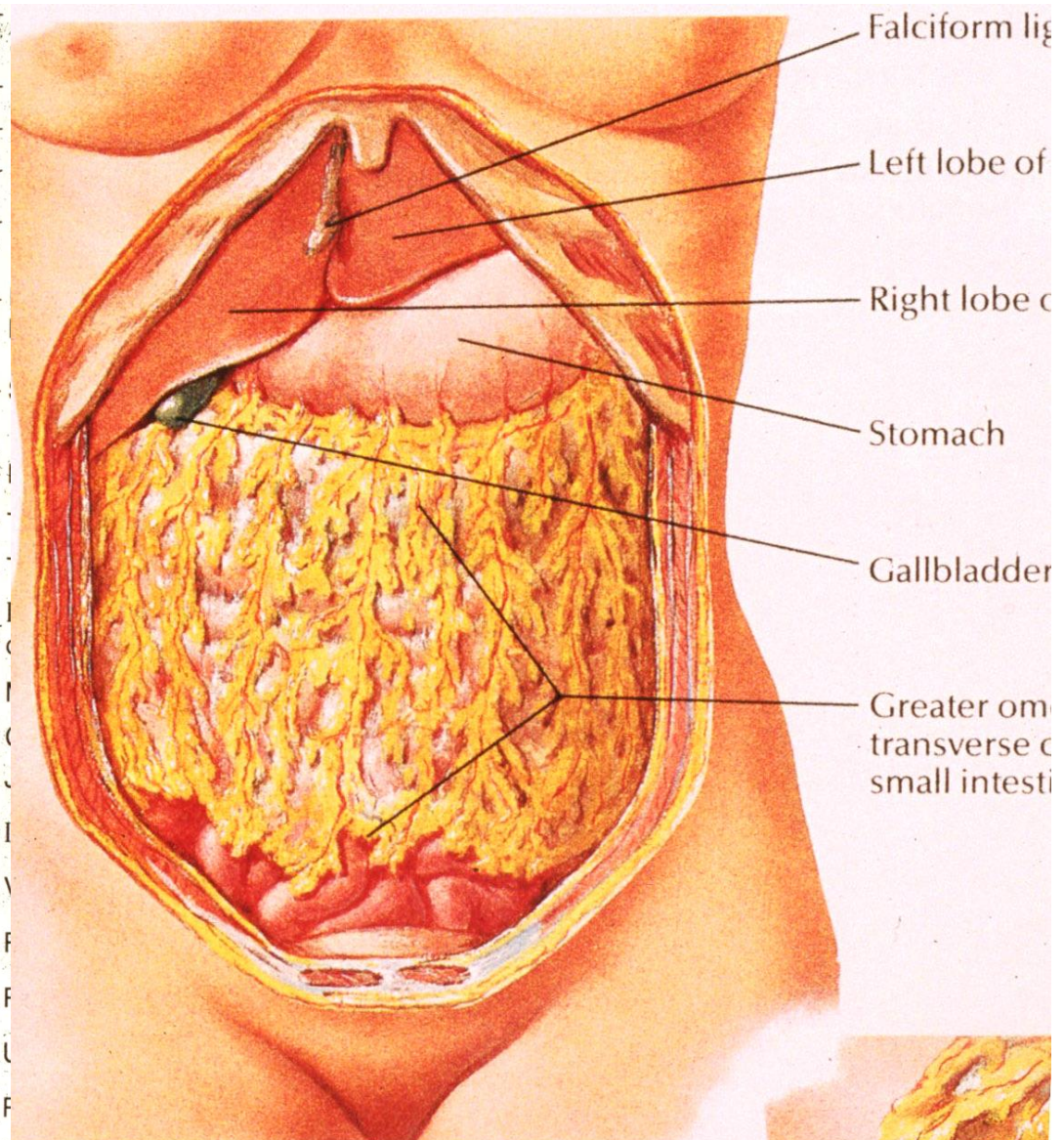
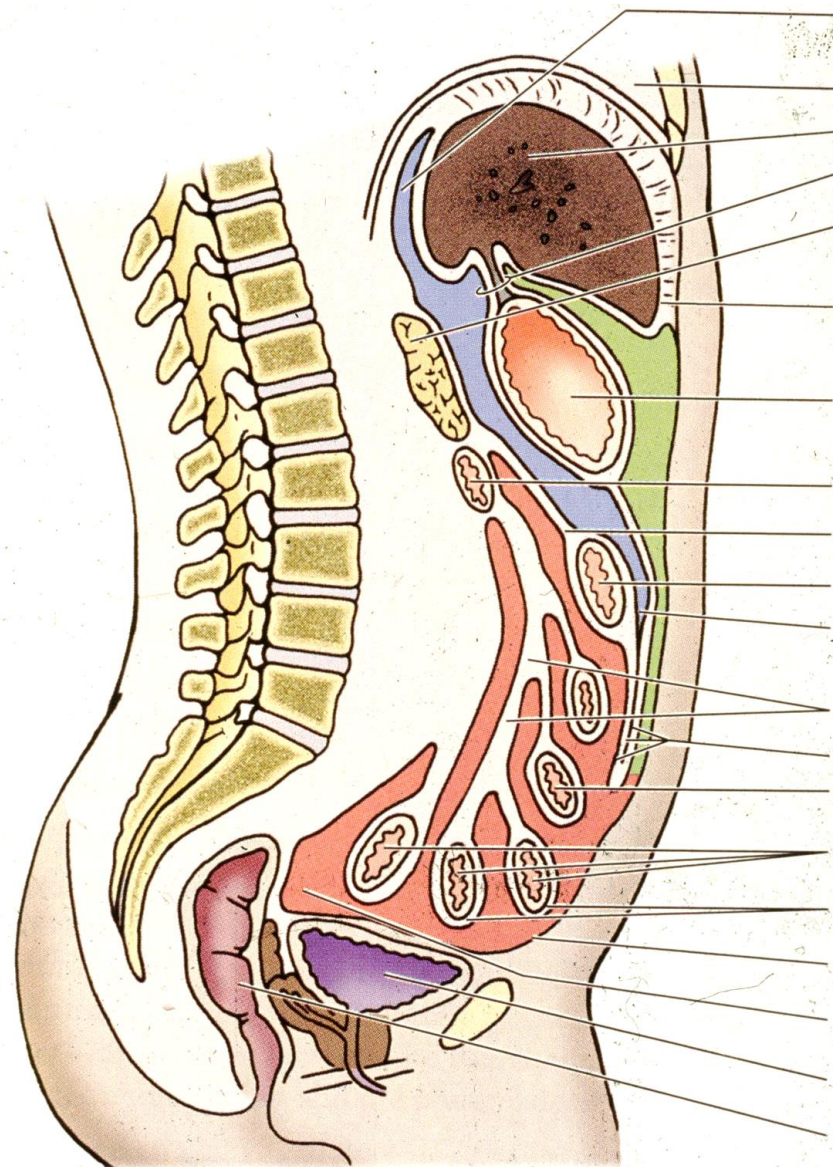
Esophagus Location: in front of the vertebral column and behind the trachea

- Superior esophageal sphincter 括約肌 ← laryngopharynx
- Lower esophageal sphincter → Stomach



ABDOMINAL CAVITY

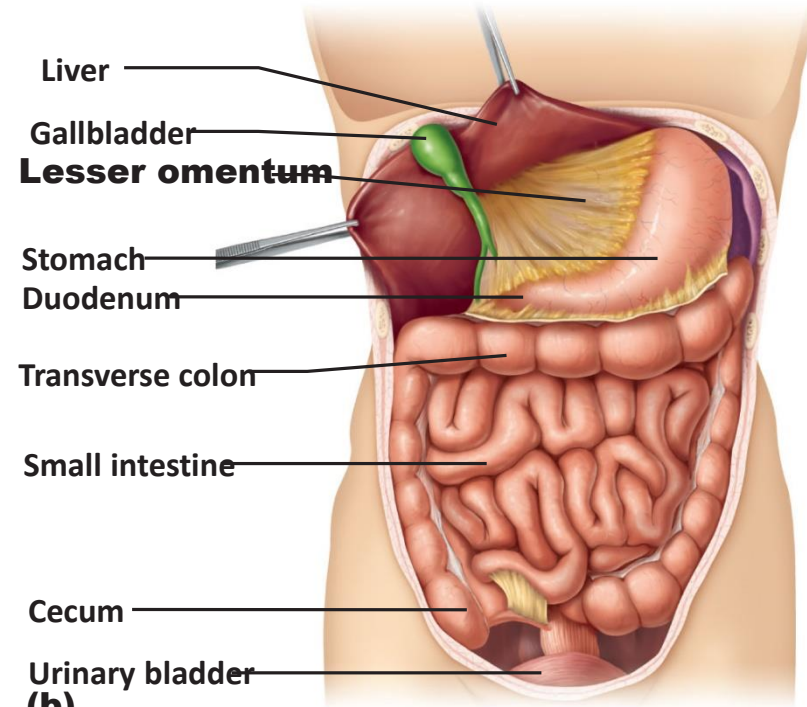
Between parietal and visceral peritoneum = **peritoneal cavity**



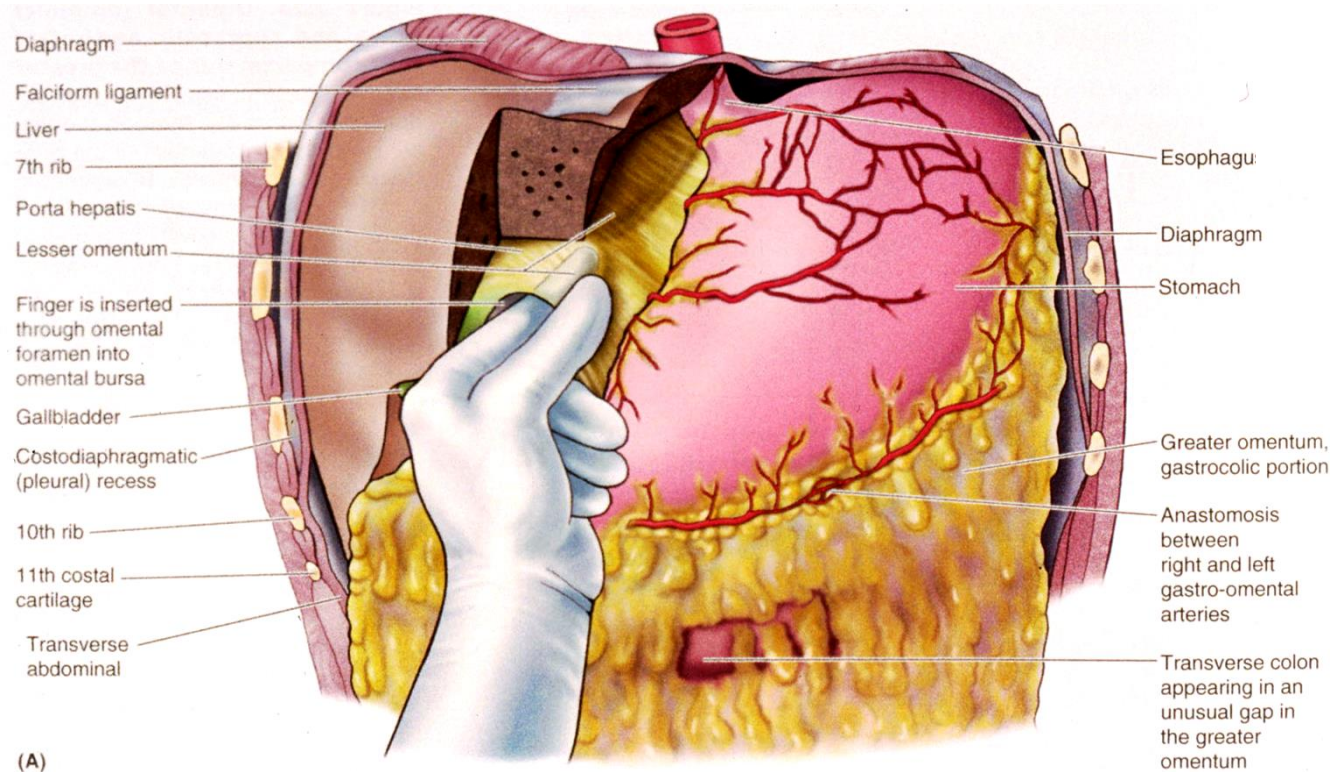
ABDOMINAL CAVITY & PERITONEUM 腹膜

- **Mesentery 腸繫膜:** with arteries, veins, lymphatic vessels, nerves

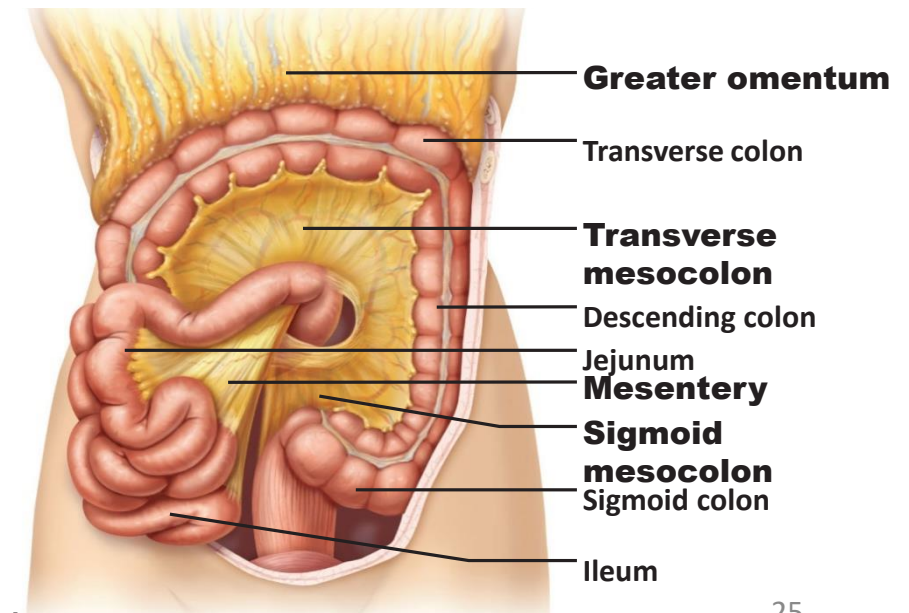
- * **Greater omentum 大網膜**
- * **Lesser omentum 小網膜**



(b)



(A)

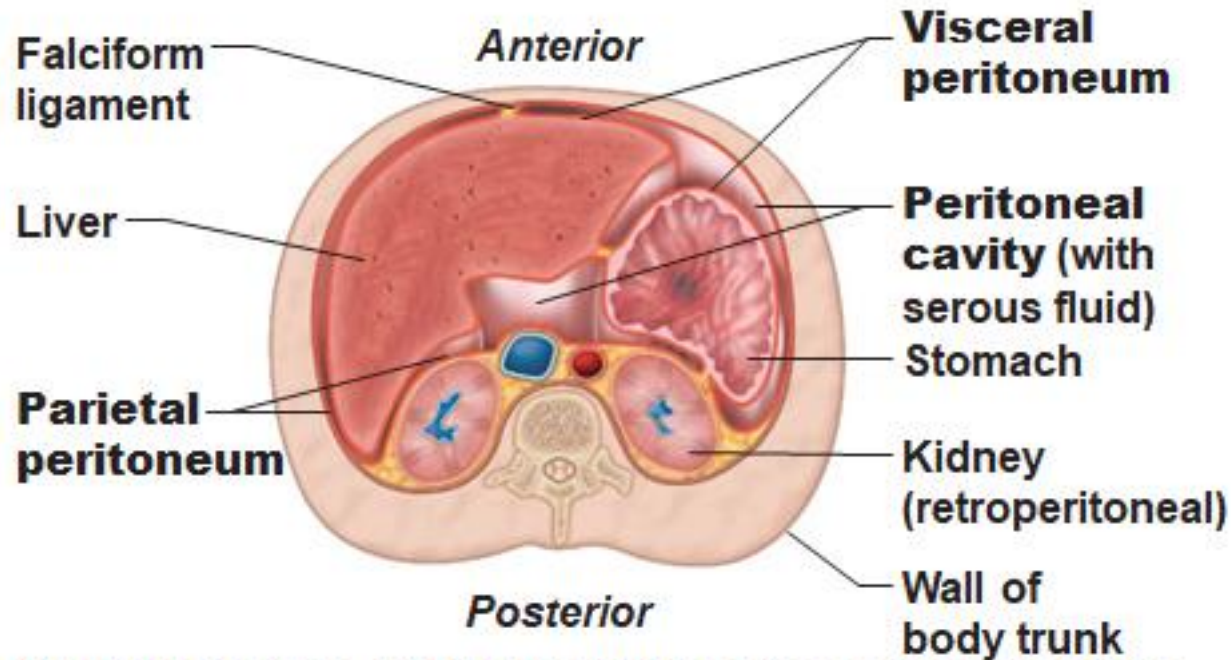


(c)

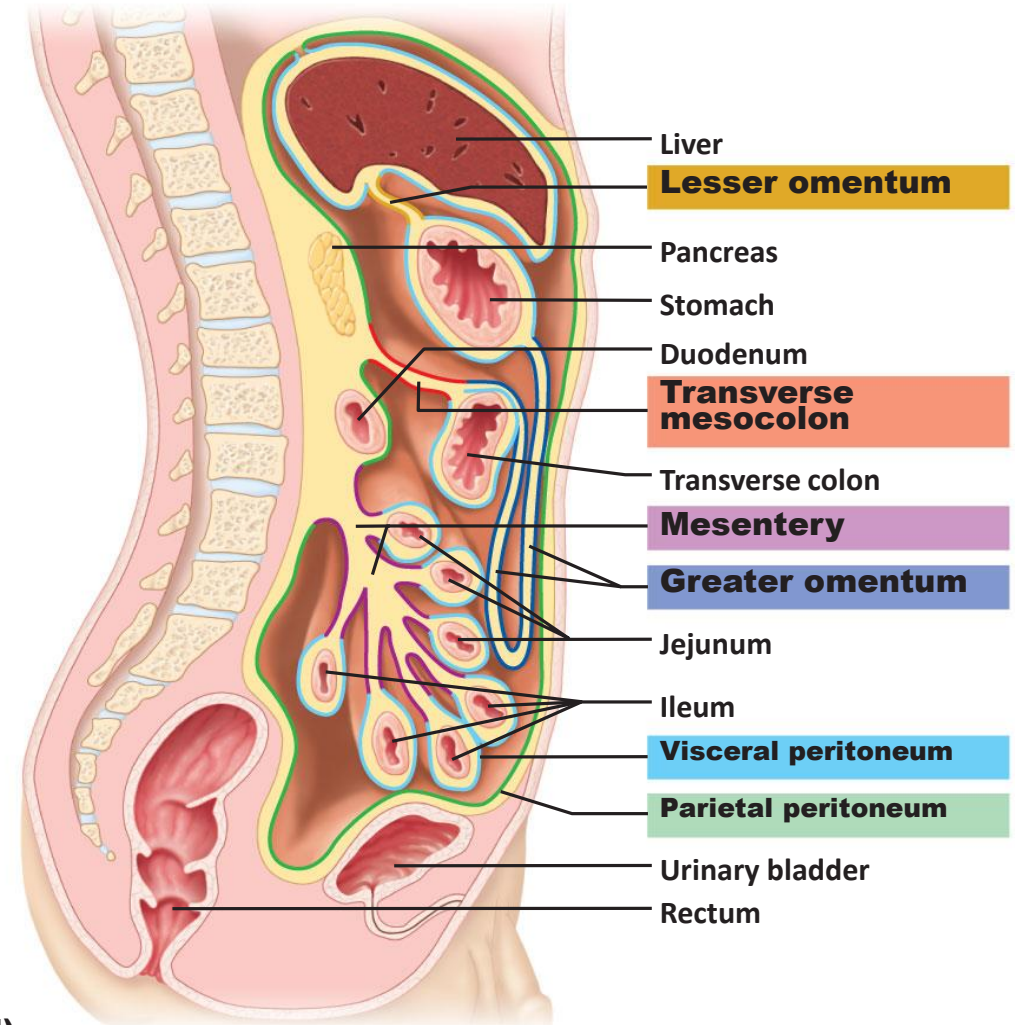
ABDOMINAL CAVITY & PERITONEUM 腹膜

* **Retroperitoneal 後腹膜**: pancreas, most of duodenum, ascending and descending colons, rectum, abdominal aorta, inferior vena cava, kidney

* **Intraperitoneal 腹膜腔內**: liver, stomach, spleen, most of small intestine, cecum, appendix, transverse colon, sigmoid colon



(b) Illustration of the peritonea in a cross section through the superior abdomen, inferior view



(d)

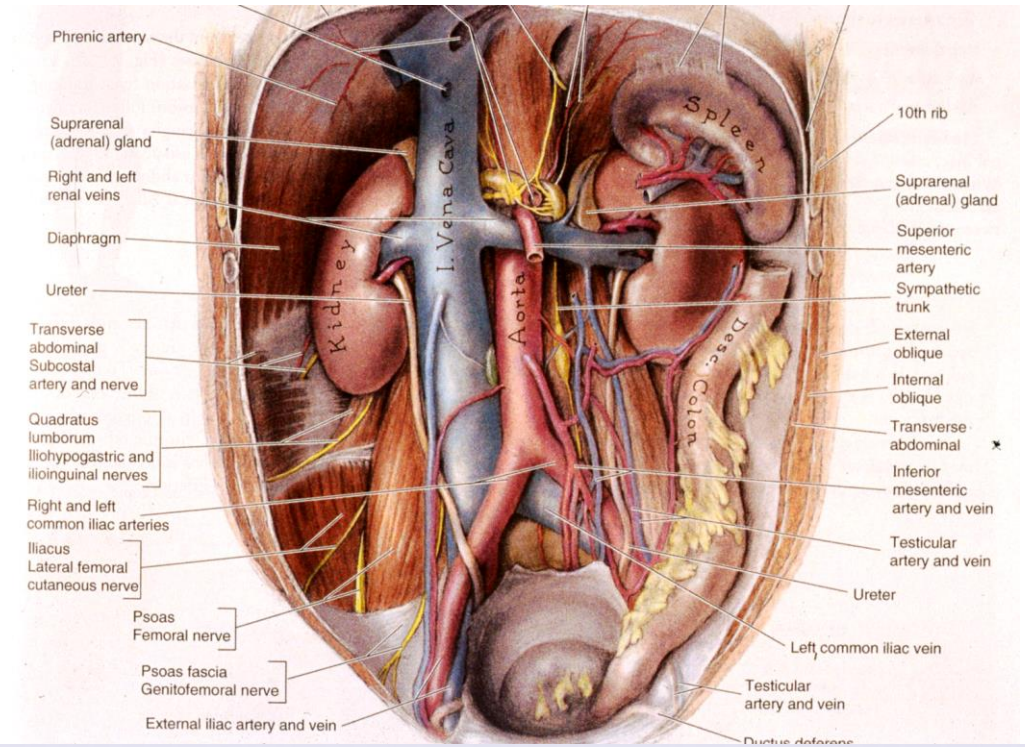
- **Retroperitoneal 後腹膜:**

pancreas, most of duodenum, ascending and descending colons, rectum, abdominal aorta, inferior vena cava, kidney

Secondarily Retroperitoneal Organs :

Initially formed within peritoneum

Become retroperitoneal / Fuse to posterior abdominal wall



Intraperitoneal Organs (and Their Mesenteries)

- Liver (falciform ligament and lesser omentum)
- Stomach (greater and lesser omentum)
- Ileum and jejunum (mesentery proper)
- Transverse colon (transverse mesocolon)
- Sigmoid colon (sigmoid mesocolon)

Secondarily Retroperitoneal Organs (Lack Mesenteries)

- Duodenum (almost all of it)
- Ascending colon
- Descending colon
- Rectum
- Pancreas

STOMACH 胃

- J-shaped sac
- **greater curvature** 大彎 and **lesser curvature** 小彎
- **cardiac orifice** 噴門 and **pyloric orifice** 幽門 (both with sphincter)

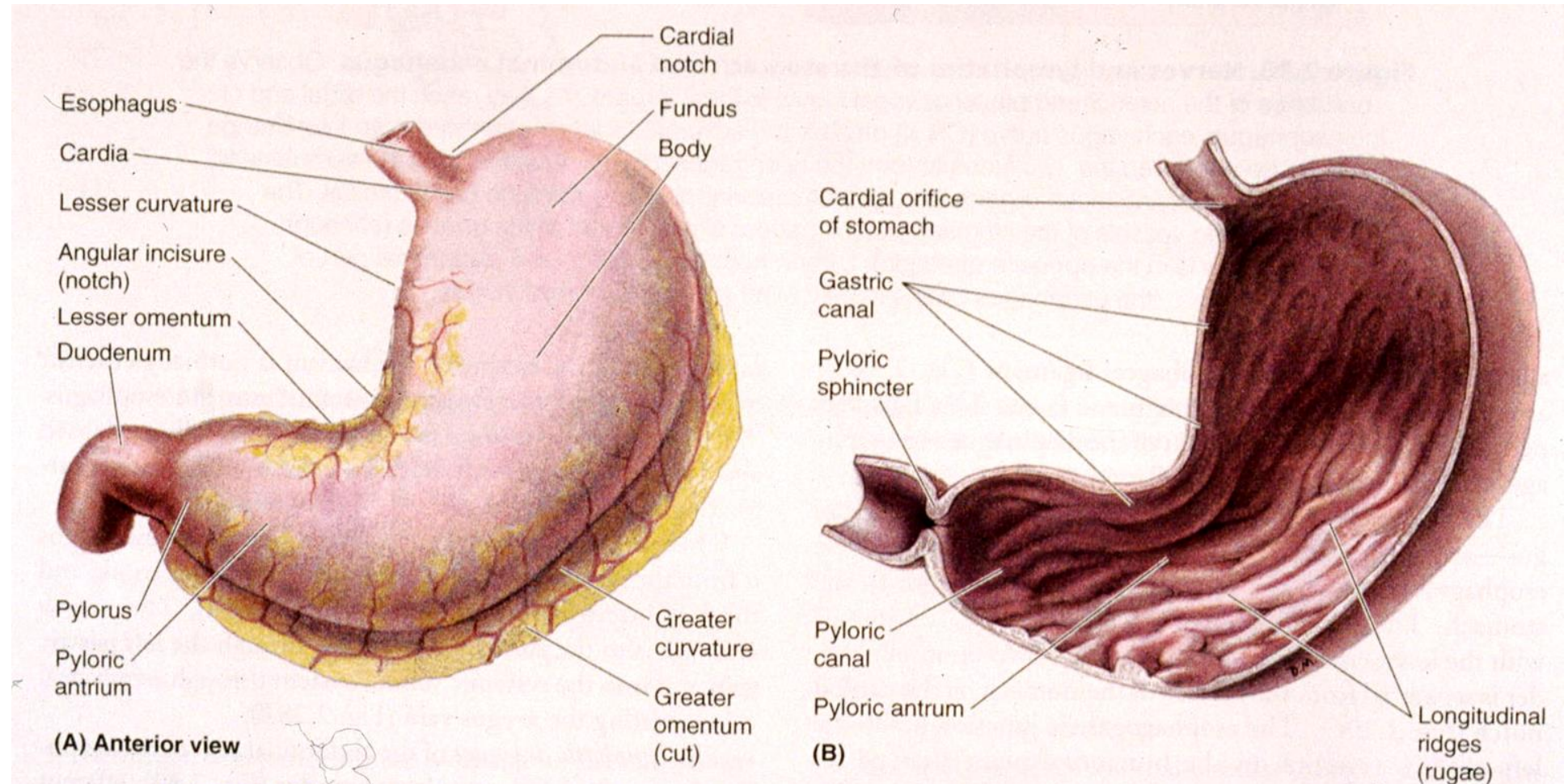


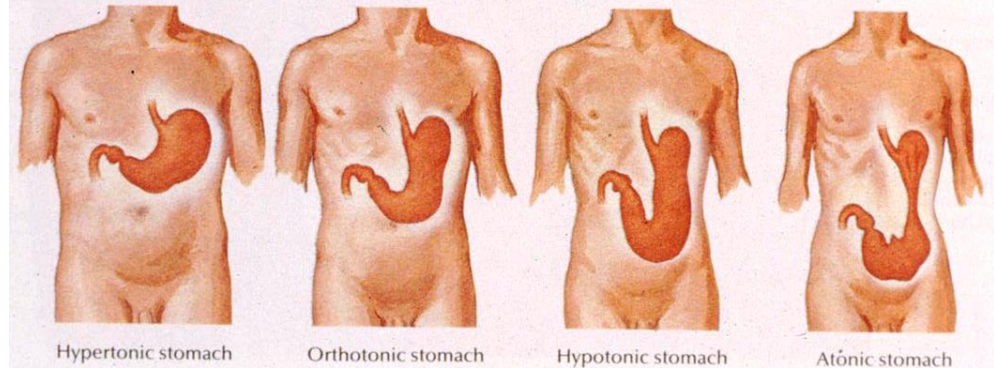
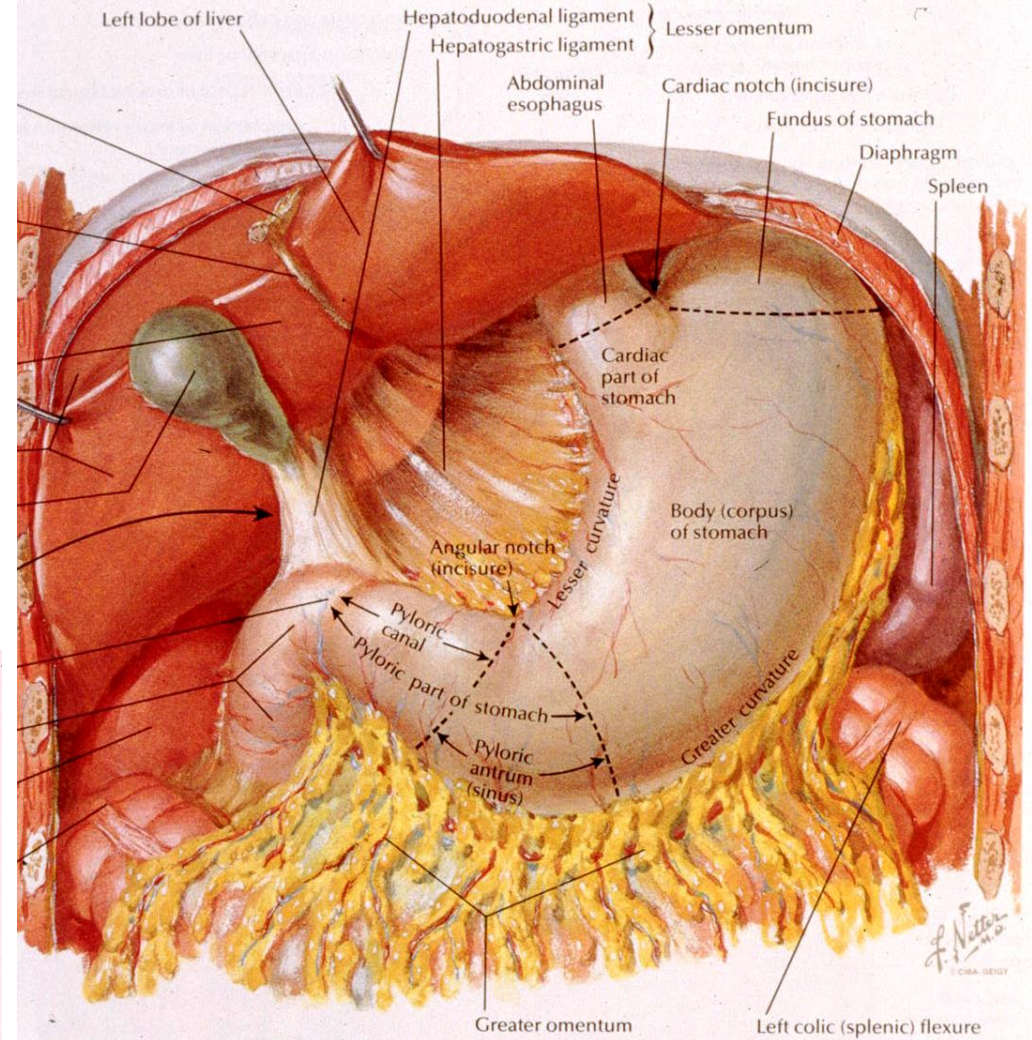
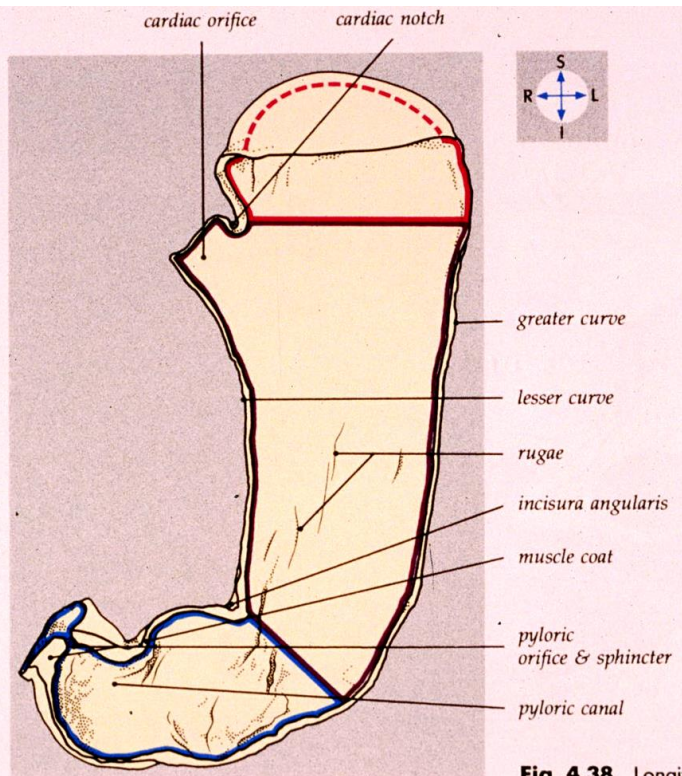
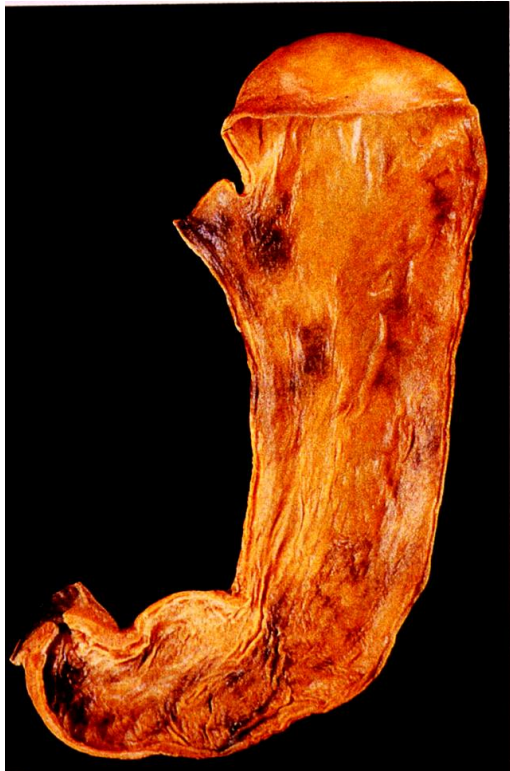
Figure 2.31. Abdominal part of the esophagus, stomach, and proximal part of the duodenum.

A. Lateral view of the external surface. Observe the arteries in the omenta that supply the stomach. **B.** Internal surface (mucous membrane). Observe the longitudinal gastric folds, or rugae. Along the lesser curvature, observe the pyloric canal, the pyloric antrum, and the pyloric sphincter.

STOMACH 胃

* 4 regions:

1. cardiac region 贛門部
2. Fundus 底部 (在上方)
3. Body 體部
4. pyloric canal (antrum) 幽門部



Histological view:

1. serosa

2. muscularis externa inner oblique layer

內斜肌層

middle circular layer

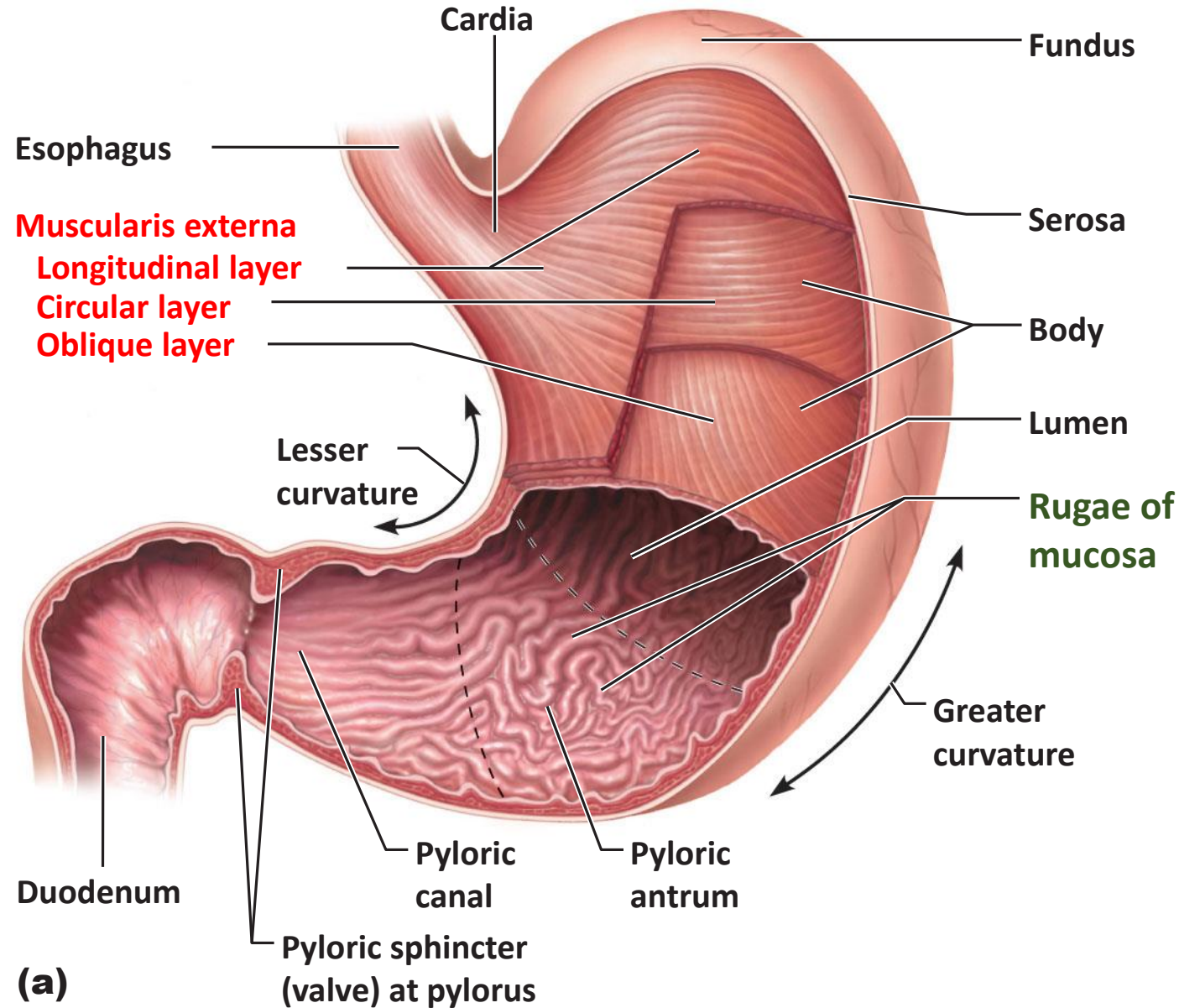
中環肌層

outer longitudinal layer

外縱肌層

3. Mucosa

rugae 皺襞



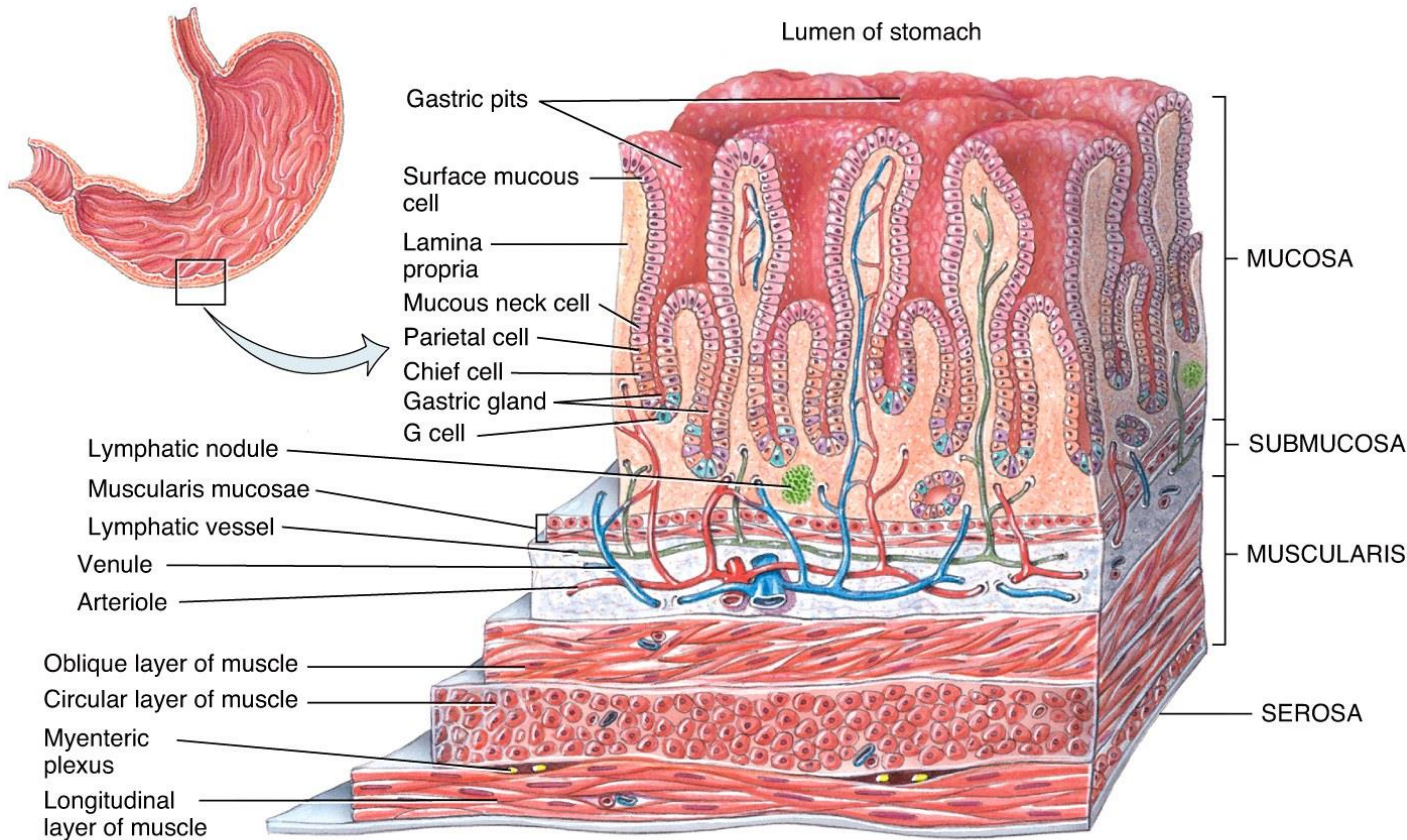
mucosa—rugae 皺襞

gastric pits 胃小窩

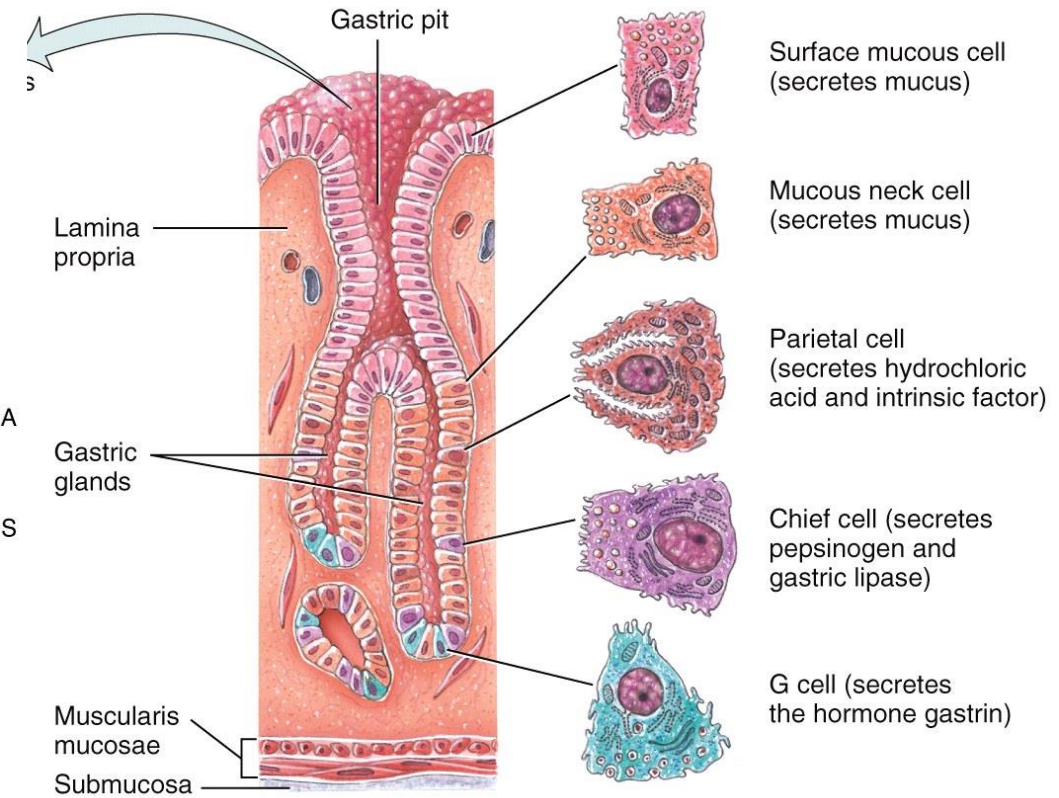
gastric glands: cardiac gland; fundic (gastric) gland, most numerous; pyloric gland

chief (zymogenic) cell 胃蛋白酶

parietal cell: HCl & intrinsic factor [vit B12]



(a) Three-dimensional view of layers of the stomach

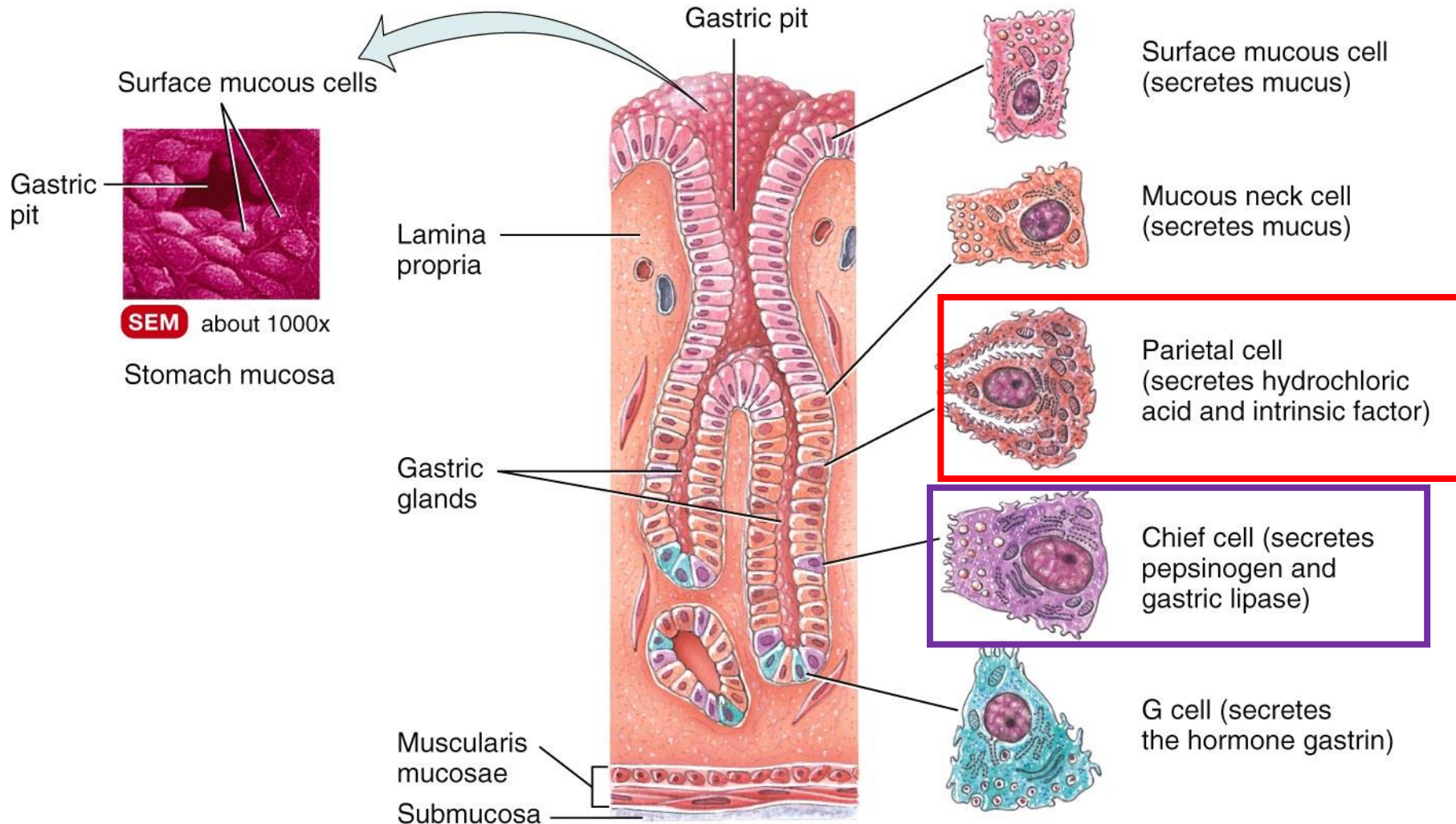


(b) Sectional view of the stomach mucosa showing gastric glands and cell types

Mucosa

chief (zymogenic) cell 胃蛋白酶

parietal cell: HCl & intrinsic factor [vit B12]



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

* Functions:

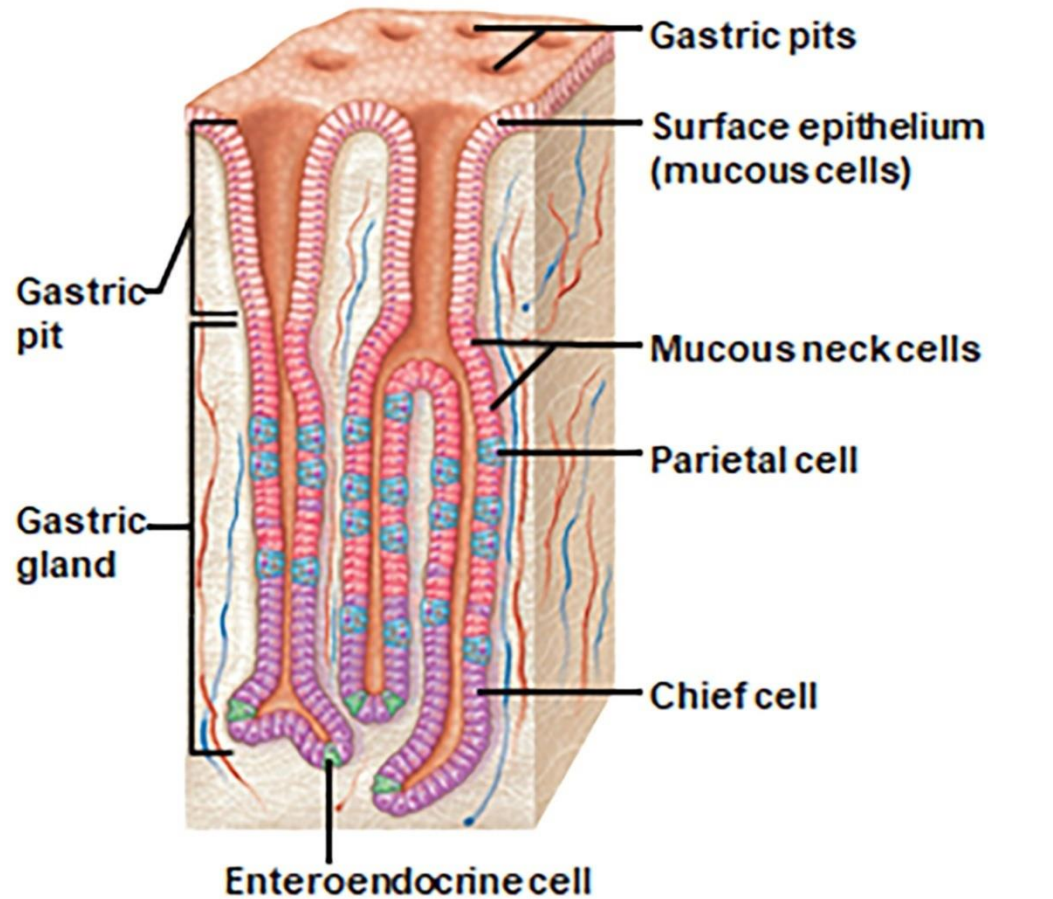
1. store: up to 4 liters

2. churns 攪拌 → chyme 食糜

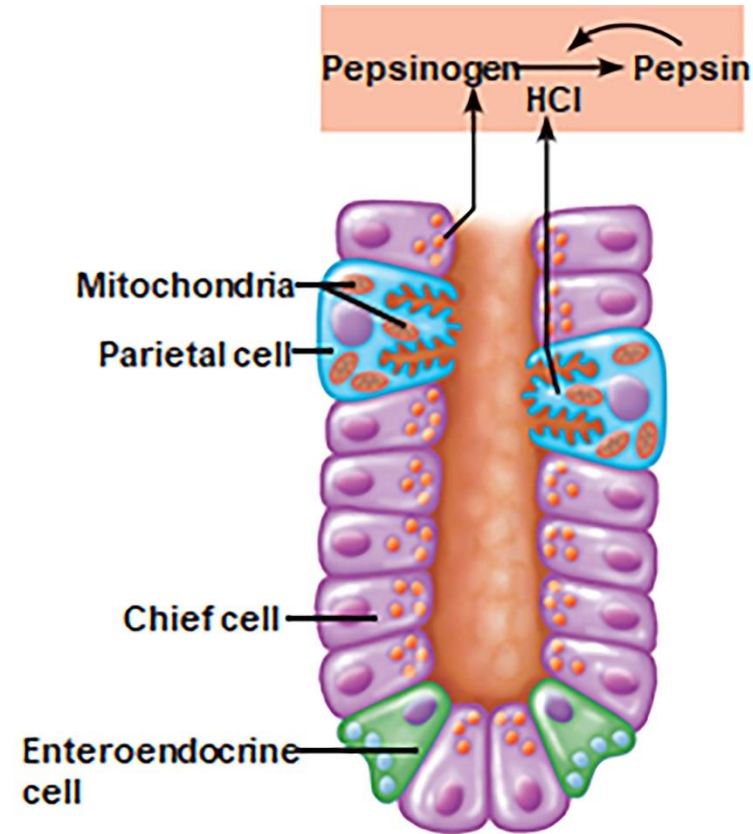
3. HCl + enzyme (digest protein): **Pepsinogen + HCl → Pepsin**

• A protective coat of mucus--secreted by surface and neck mucous cells

Gastric ulcer 胃潰瘍

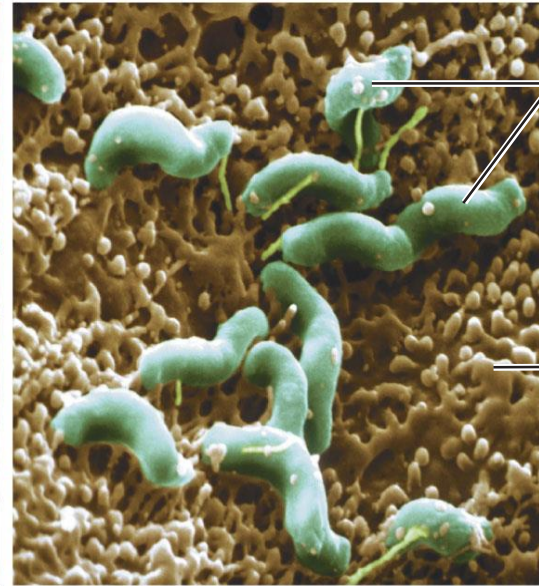
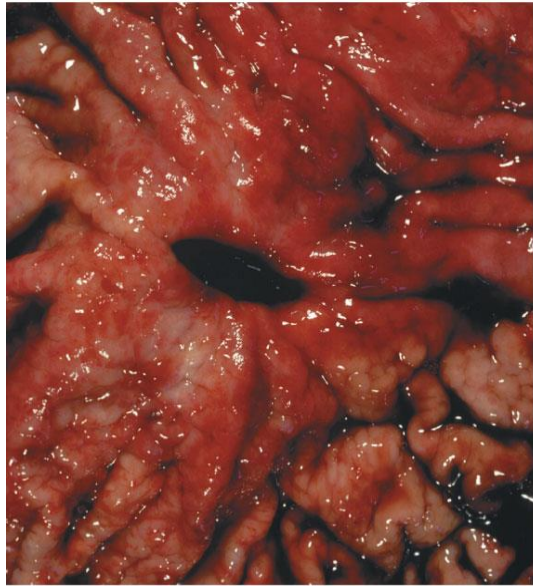


(b) Enlarged view of gastric pits and gastric glands



(c) Location of the HCl-producing parietal cells and pepsin-secreting chief cells in a gastric gland

Gastric Ulcers 胃潰瘍



Bacteria

Mucosa layer of stomach

(a) A gastric ulcer lesion

(b) *H. Pylori* bacteria 幽門桿菌

The Nobel Prize in
Physiology or Medicine
2005

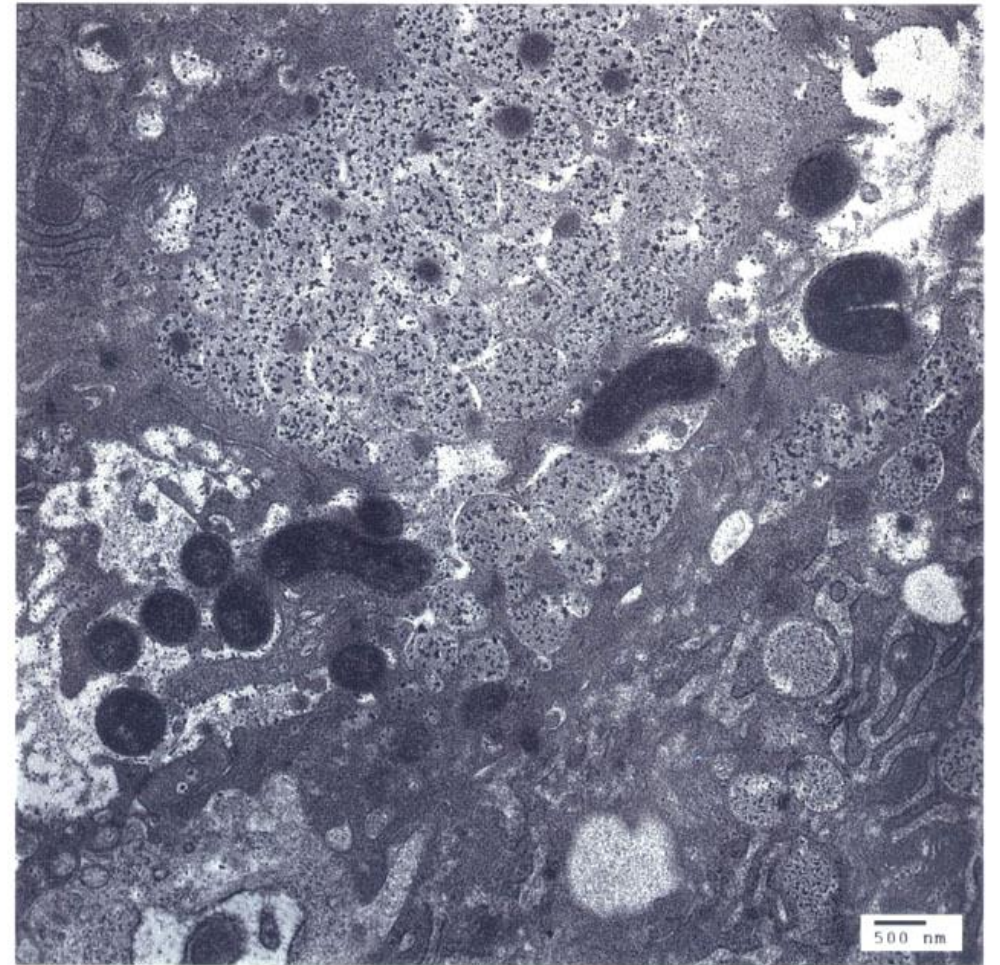


Photo: C. Northcott
Barry J. Marshall



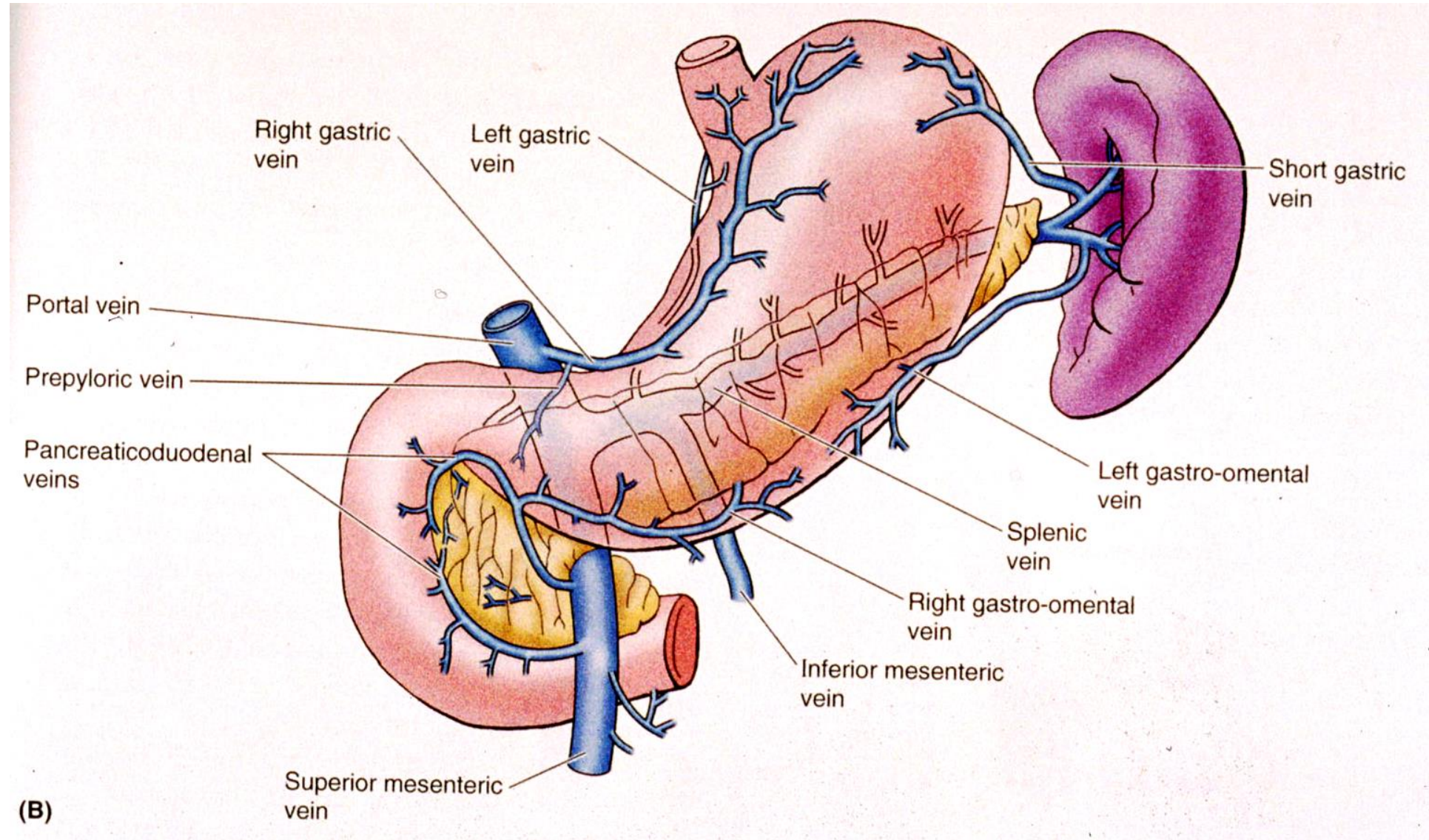
Photo: U. Montan
J. Robin Warren

H. pylori between epithelial cells.



Barry Marshall Nobel Laureate

Alcohol is only absorbed by stomach → Portal system → Liver



SMALL INTESTINE (6 m)

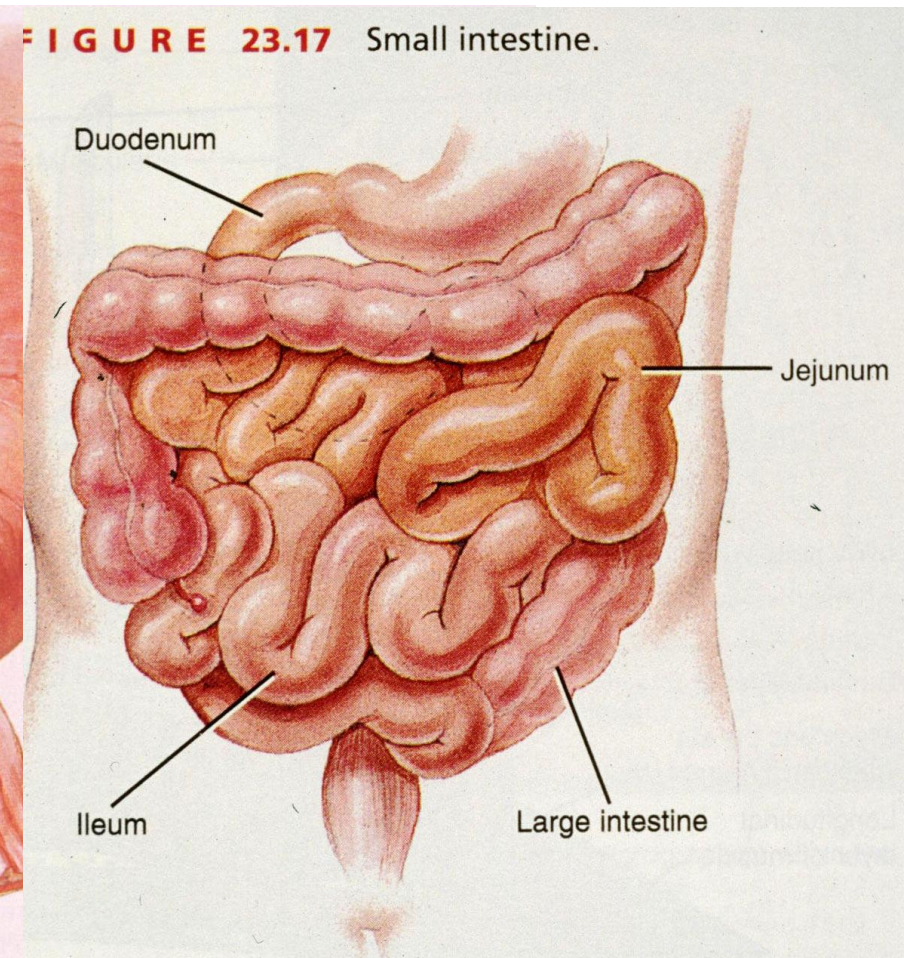
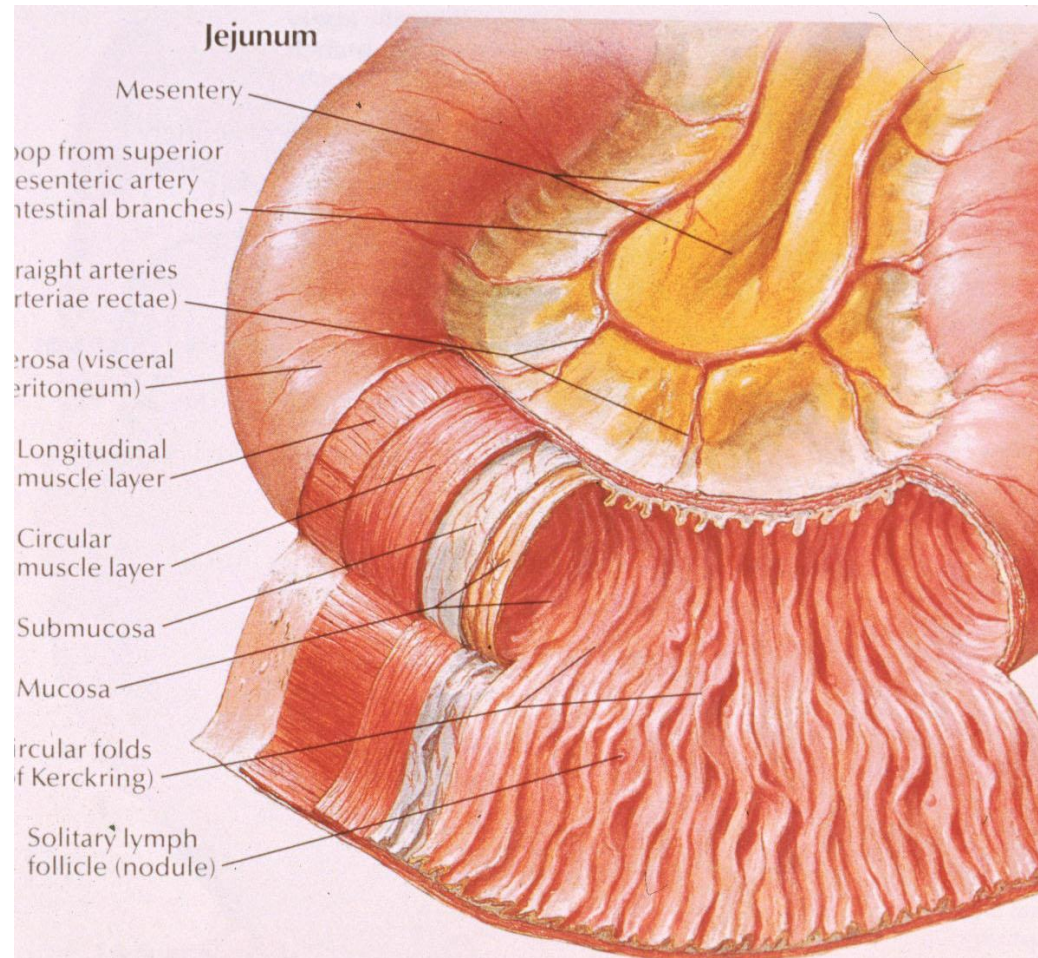
1) **Duodenum** 十二指腸: C shape, about 25 cm.

2) **Jejunum** 空腸: 2.5 m, with mesentery.

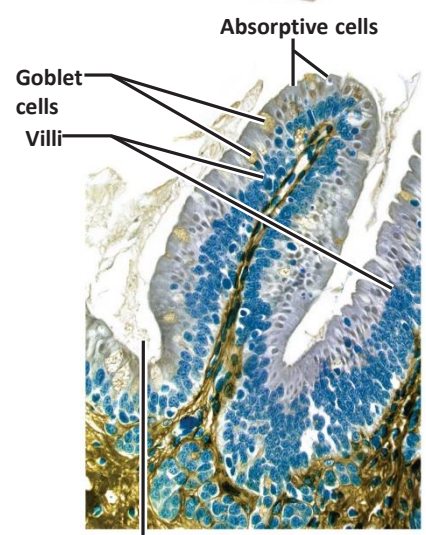
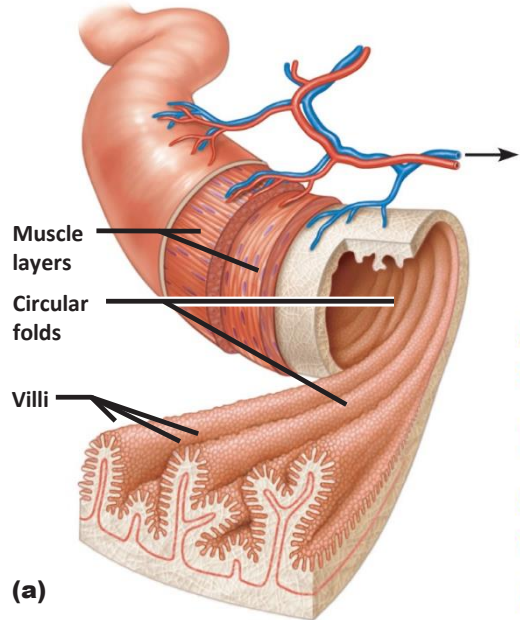
3) **Ileum** 迴腸: 3.5 m, with mesentery,

* **Plicae circulares** 環狀皺襞, **villi** 絨毛, **microvilli** 微絨毛

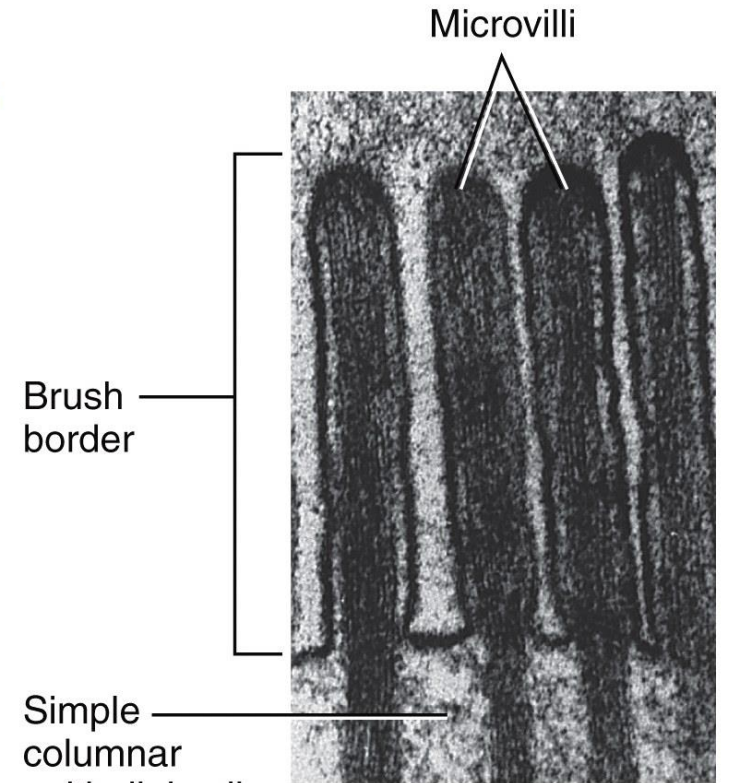
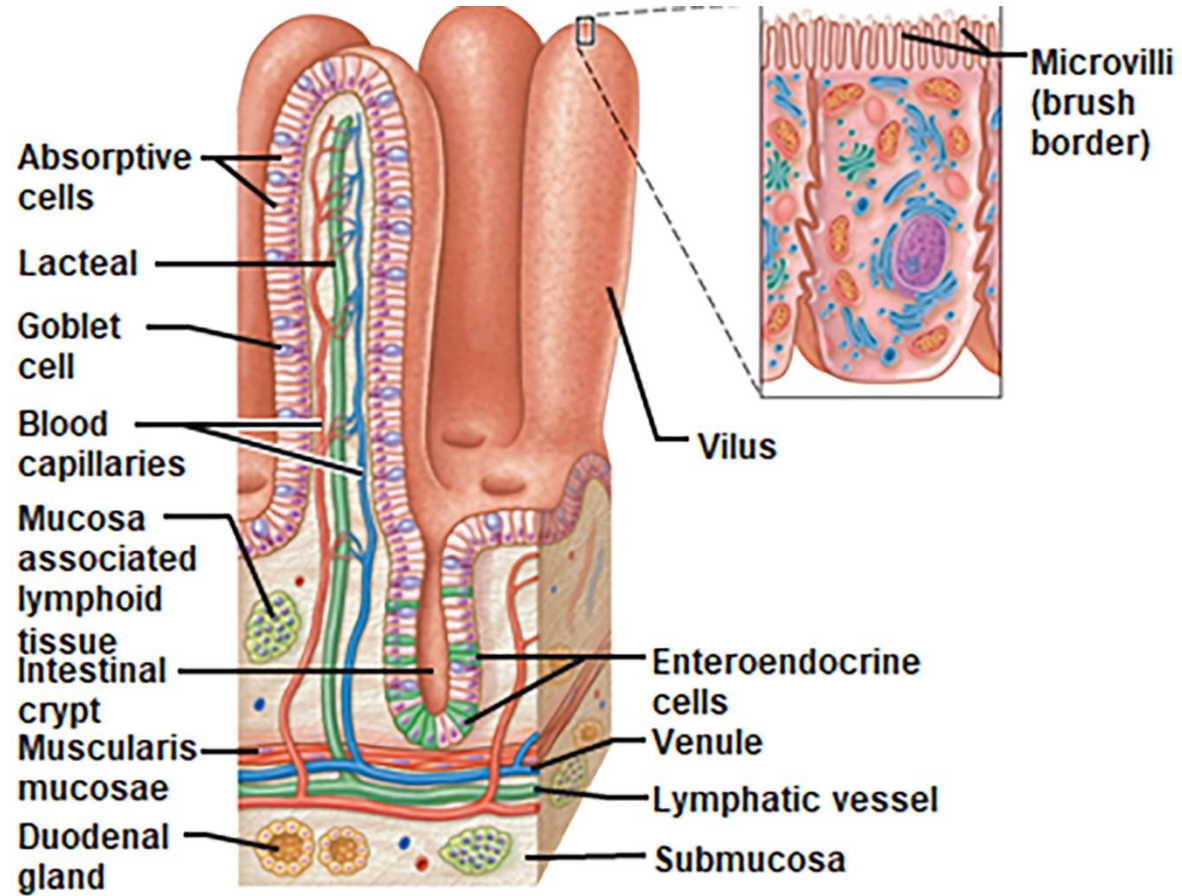
→ increase absorptive surface (600x)



Plicae circulares (Circular folds) 環狀皺襞, villi 絨毛, microvilli 微絨毛 → increase absorptive surface (600x)



(c) Intestinal crypt

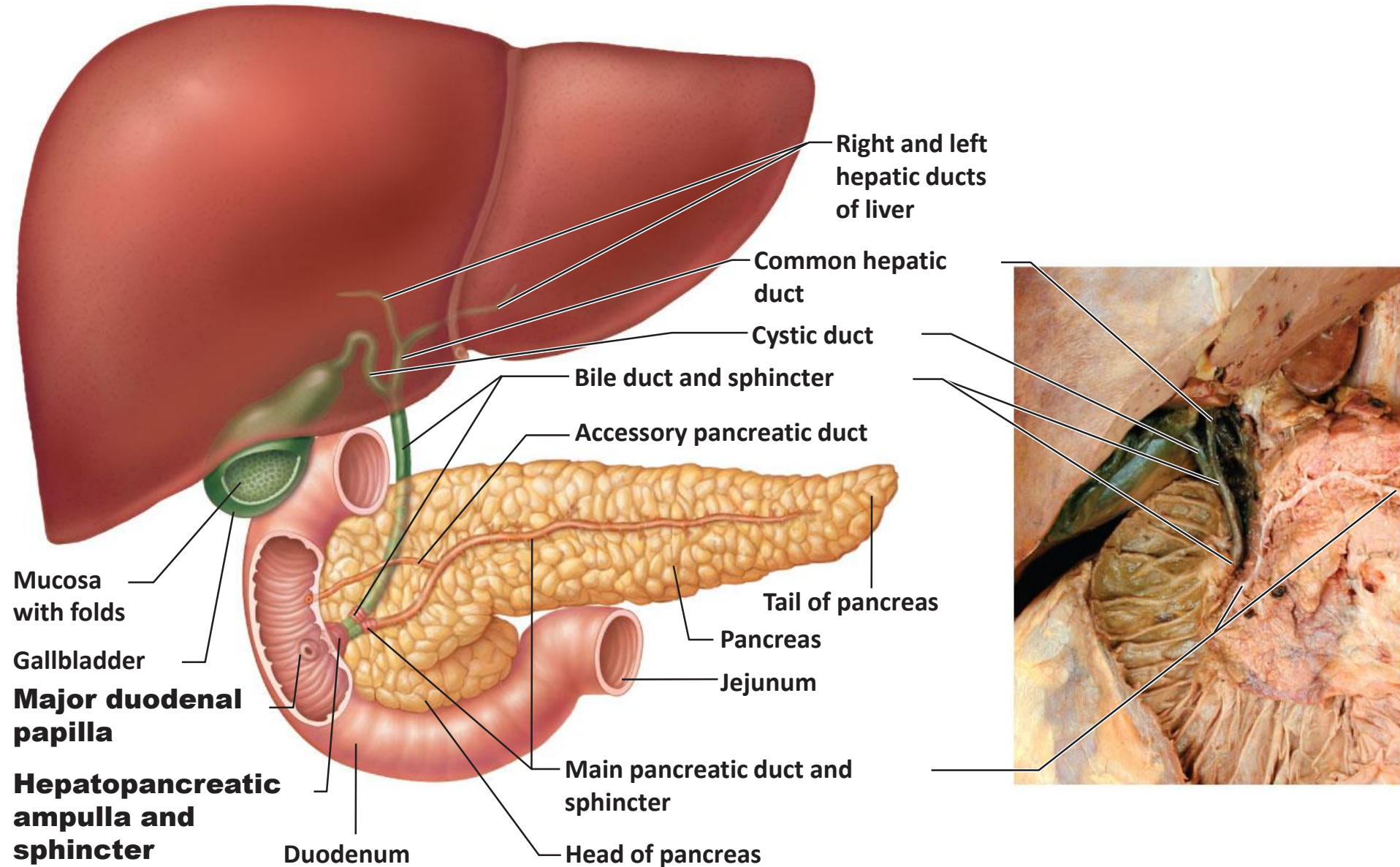


TEM 46,800x

(d) Several microvilli from the duodenum

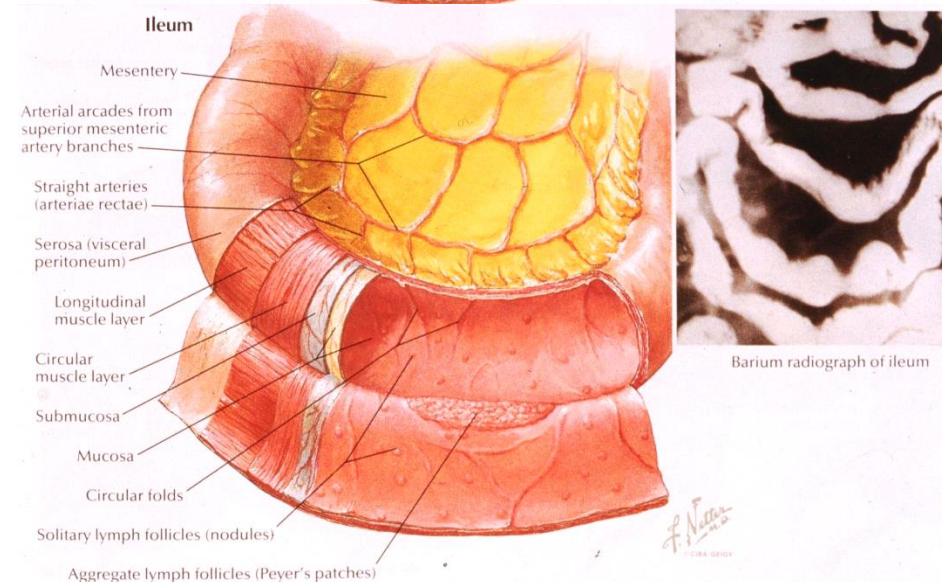
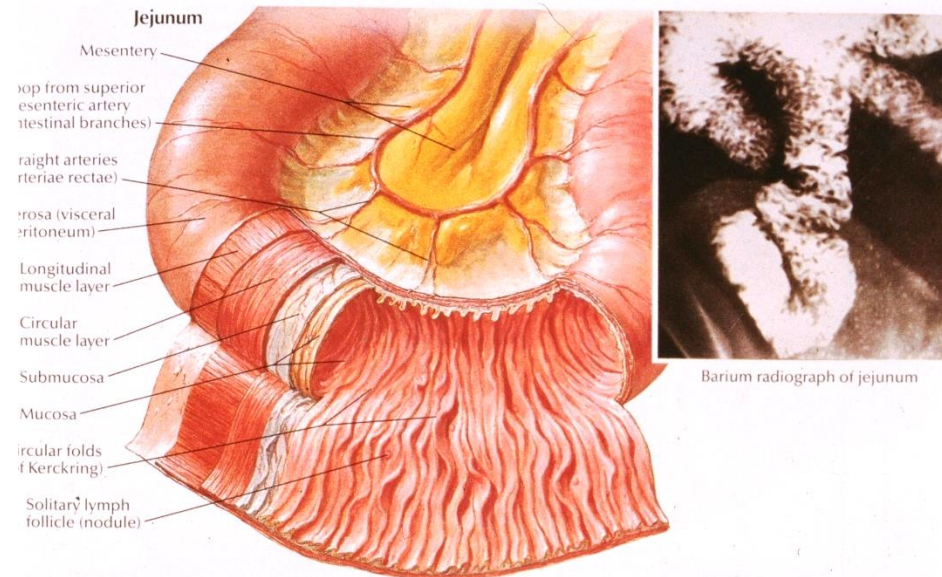
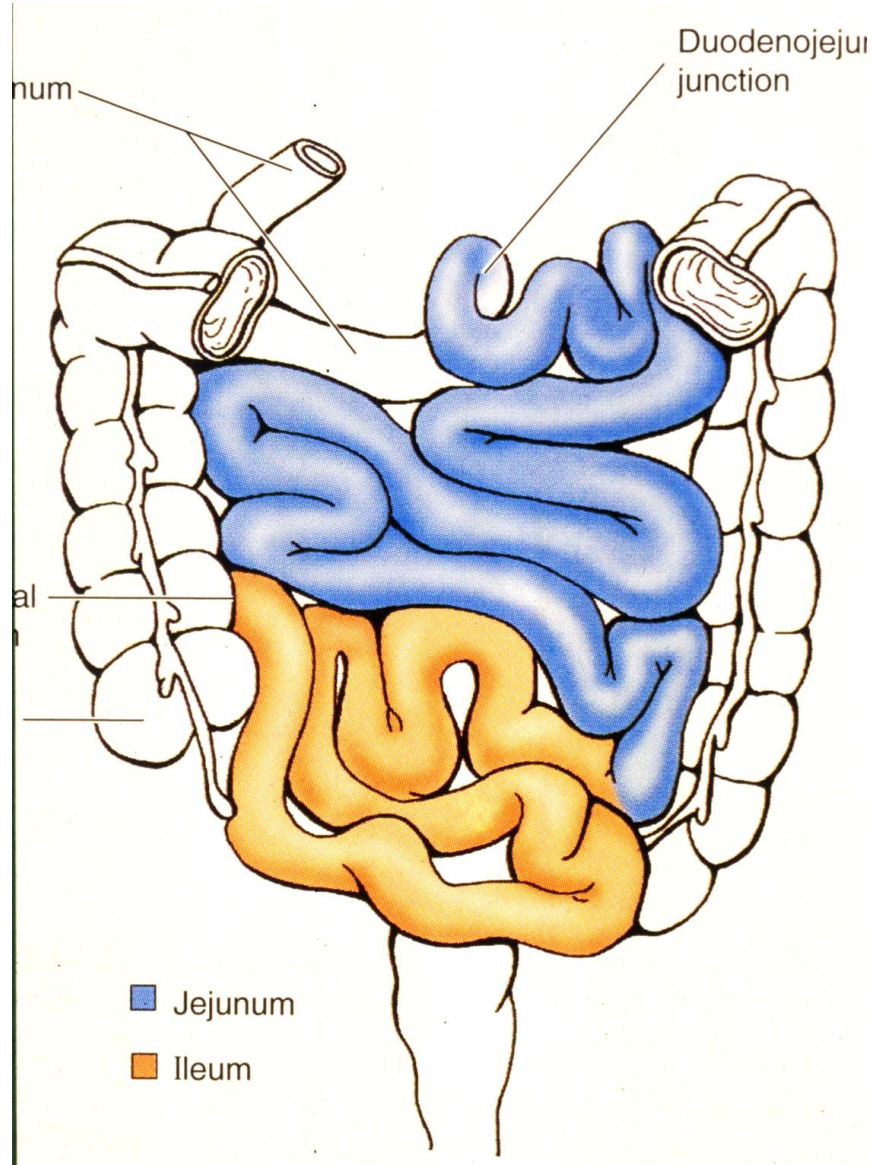
Courtesy Michael Ross, University of Florida

1) Duodenum 十二指腸: C shape, about 25 cm.

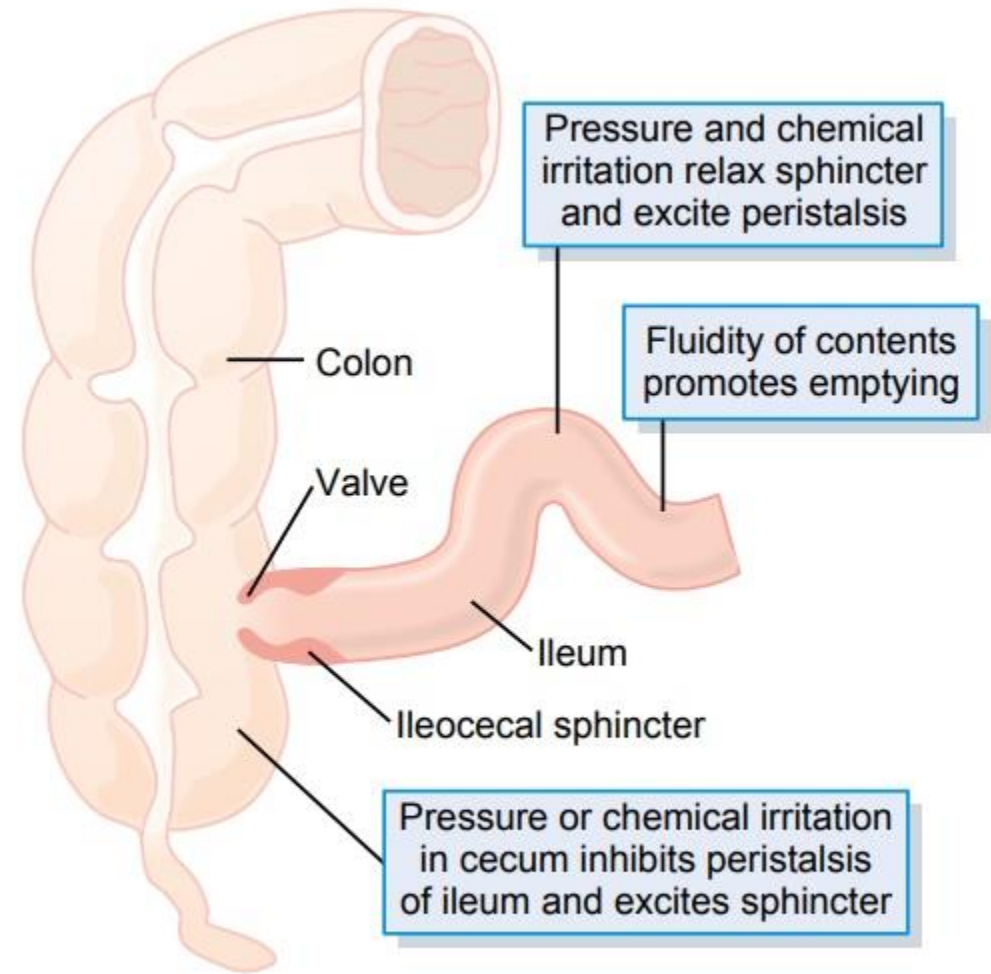
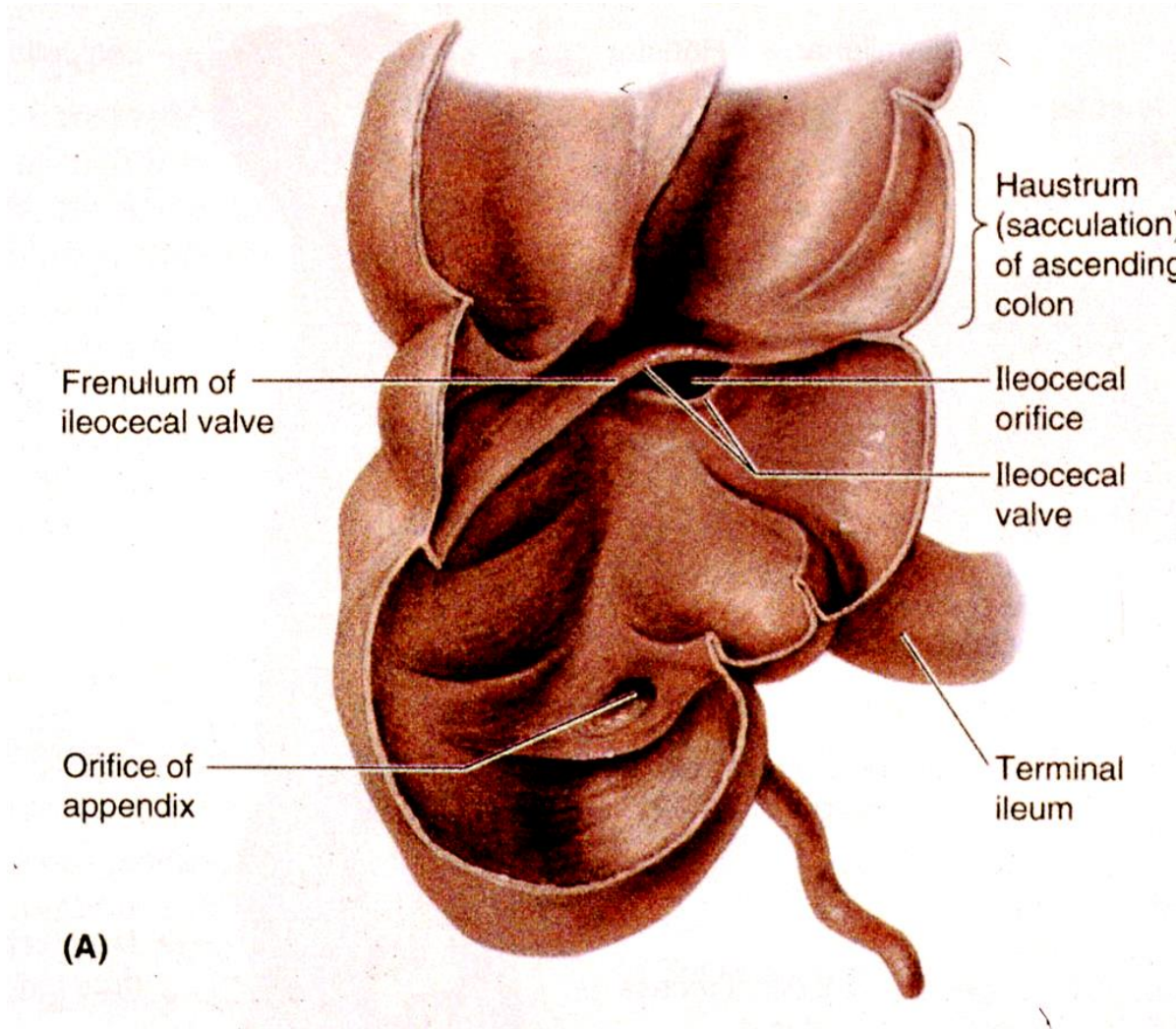


2) **Jejunum** 空腸: 2.5 m, with mesentery.

3) **Ileum** 迴腸: 3.5 m, with mesentery, **ileocecval valve** 迴盲瓣.

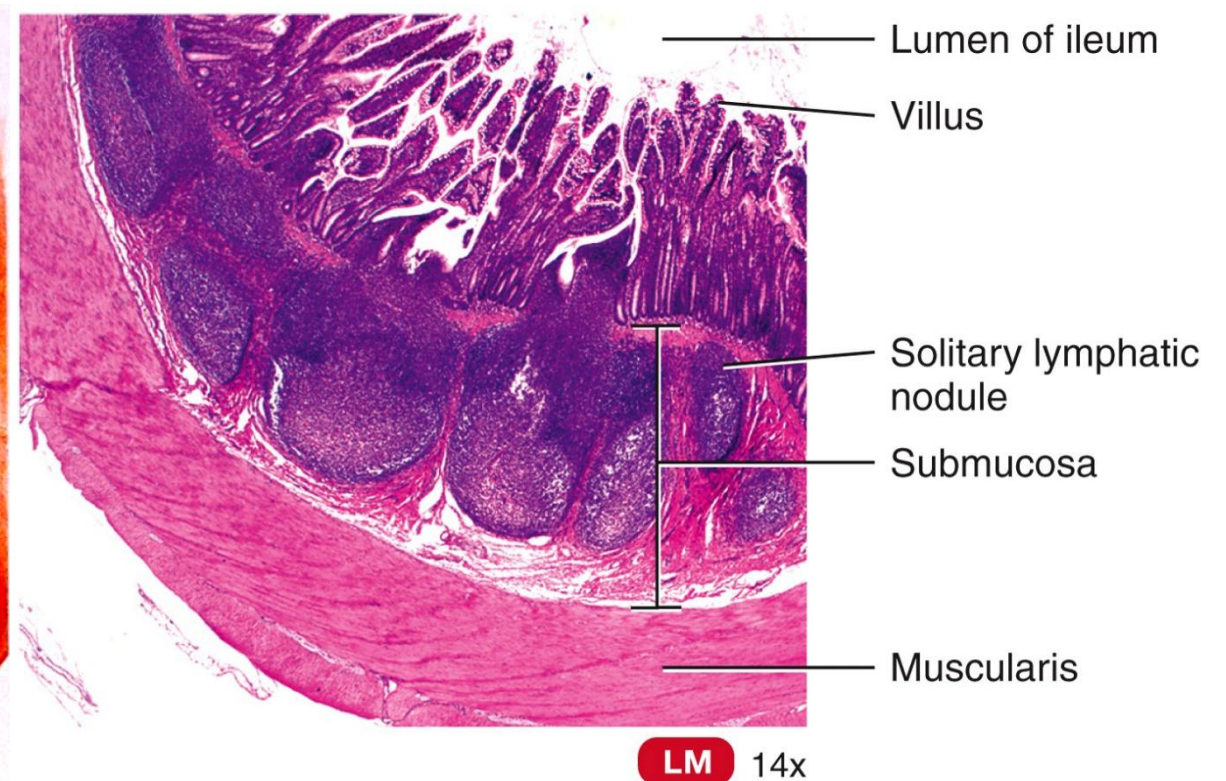
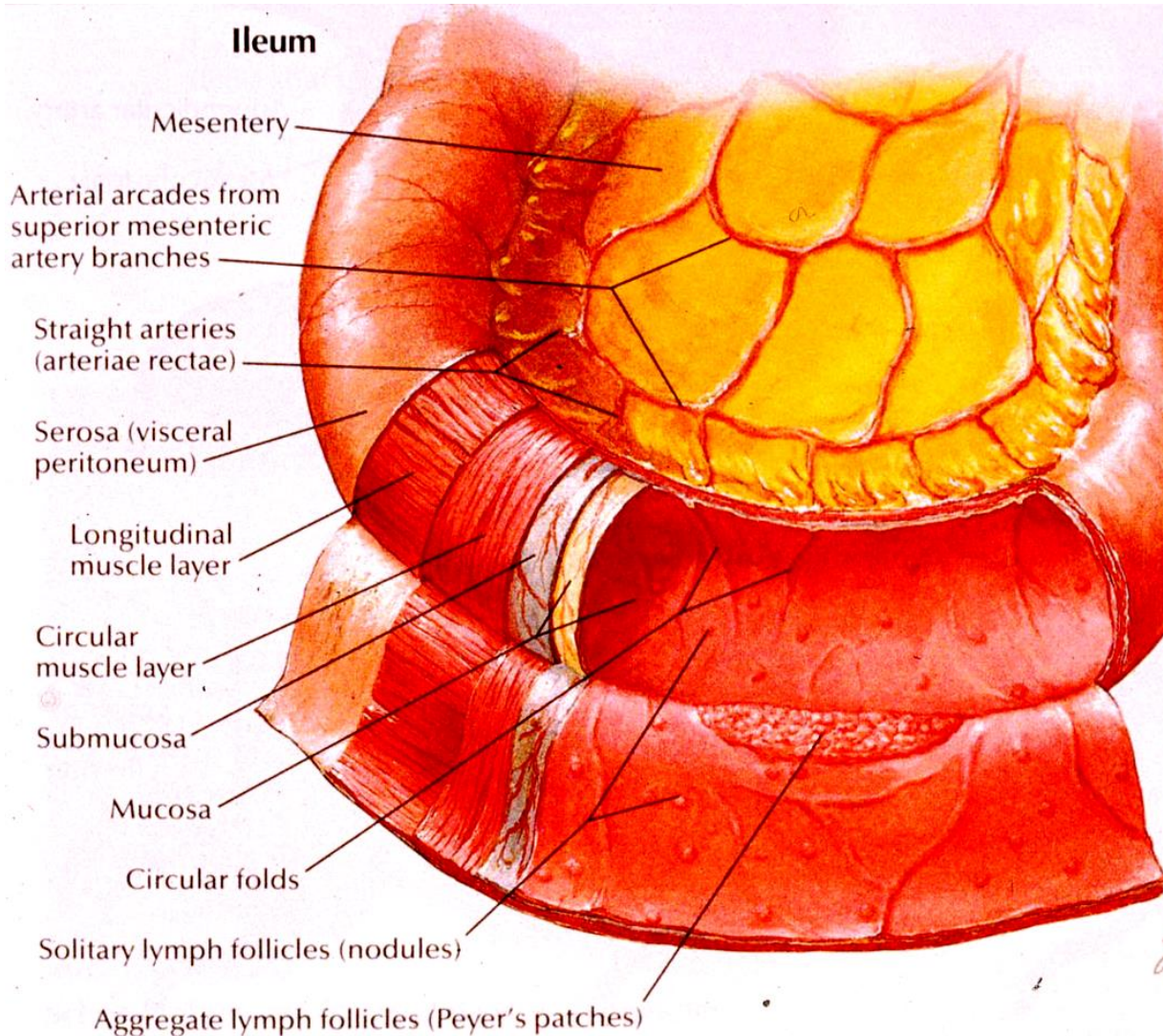


3) Ileum 迴腸: 3.5 m, with mesentery, **ileocecal valve** 迴盲瓣.



Emptying at the ileocecal valve.

- Aggregated **lymph nodules** 淋巴小結: destroy microorganisms
Especially in the ileum: Peyer's patches



(c) Lymphatic nodules in the ileum

Courtesy Michael Ross, University of Florida

F. Netter M.D.
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Cell Types:

小腸細胞類型

1. columnar absorptive cells

柱狀細胞

2. mucous goblet cells

杯狀細胞

3. enteroendocrine cells

腸內分泌細胞

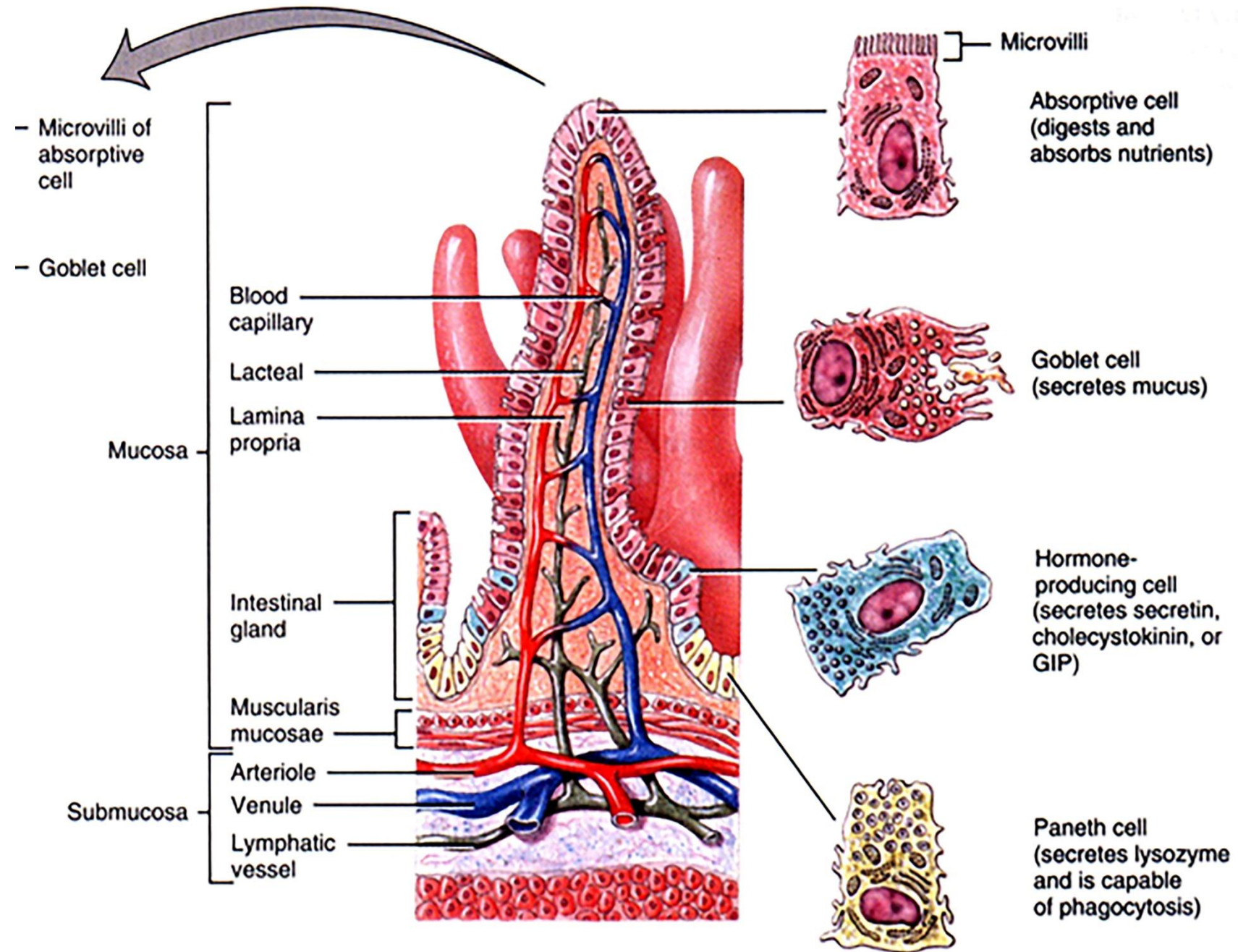
4. Paneth cells

(secrete enzymes: **lysozyme**

溶菌酶 → antibacterial)

5. undifferentiated cells

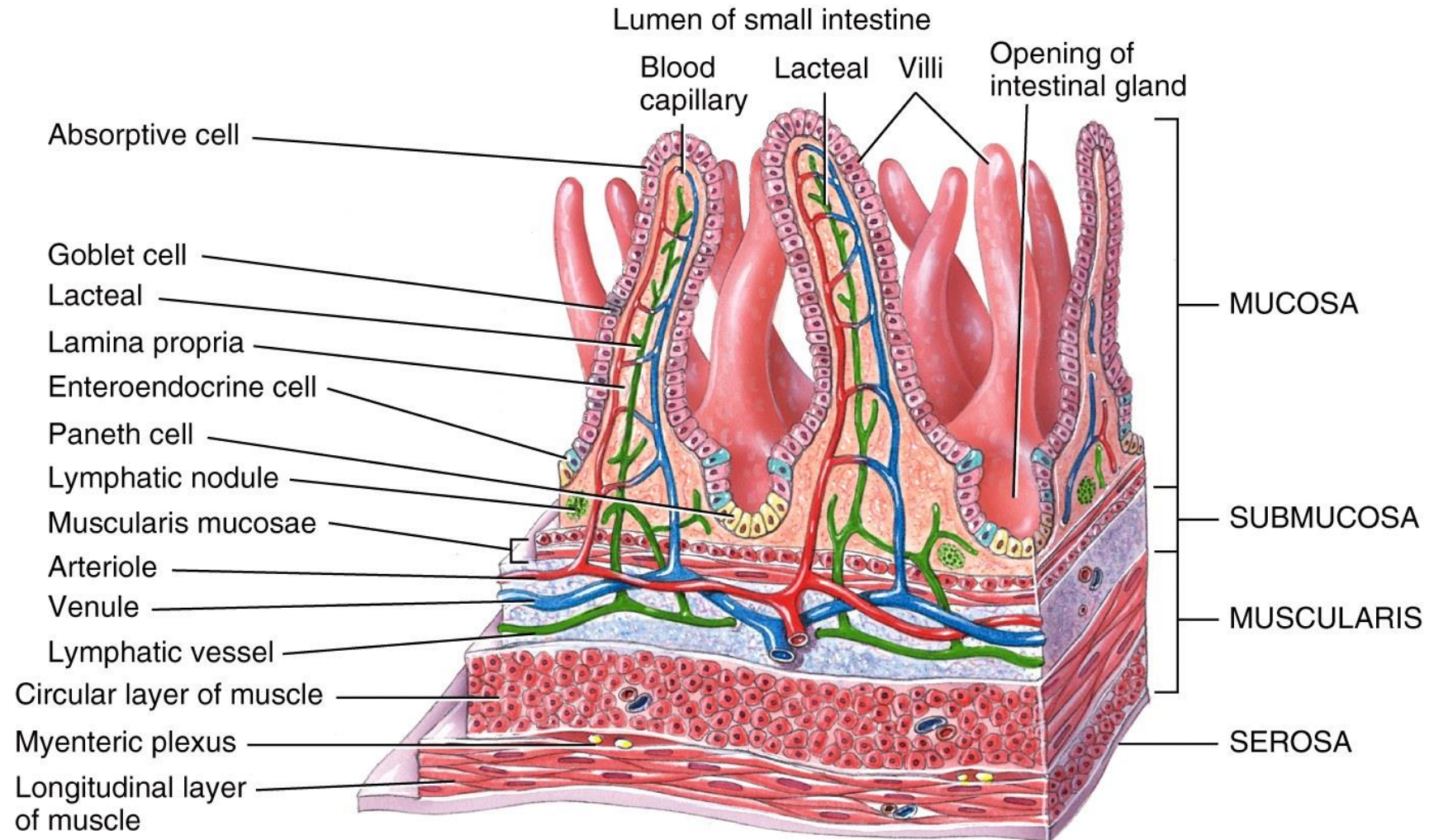
未分化細胞



(b) Enlarged villus showing lacteal, capillaries, and intestinal glands

Functions:

- * Digestion of carbohydrates and proteins is completed → bloodstream
- * Digestion of most fats → **lacteal (chylomicrons)** 乳糜管 → lymphatic system

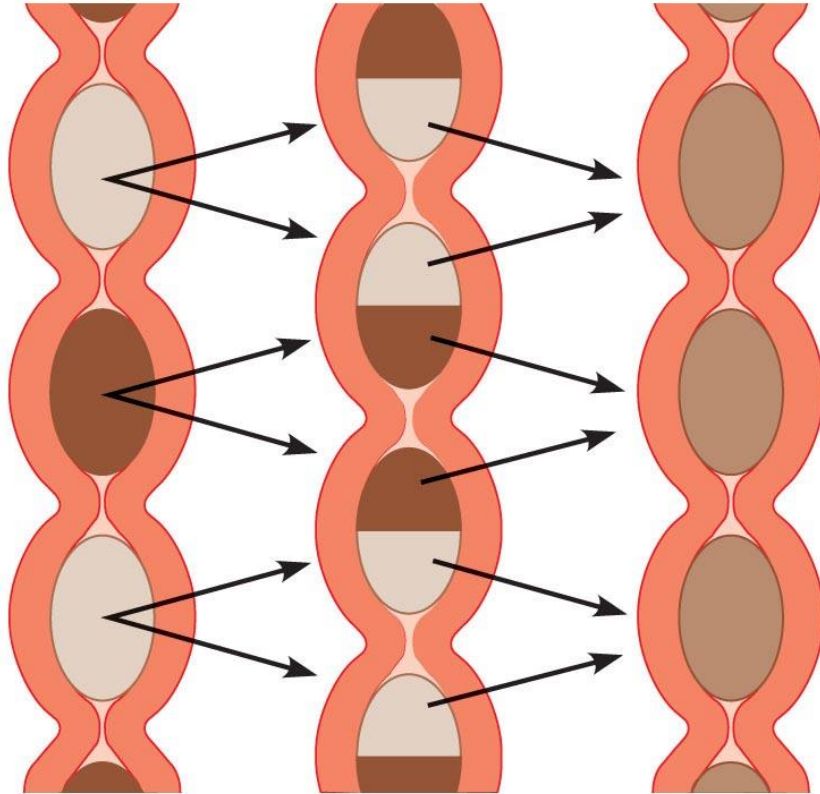


(b) Three-dimensional view of layers of the small intestine showing villi

Segmenting contractions 分節收縮

Rhythmic local contractions of the intestine

Mixes food with digestive juices

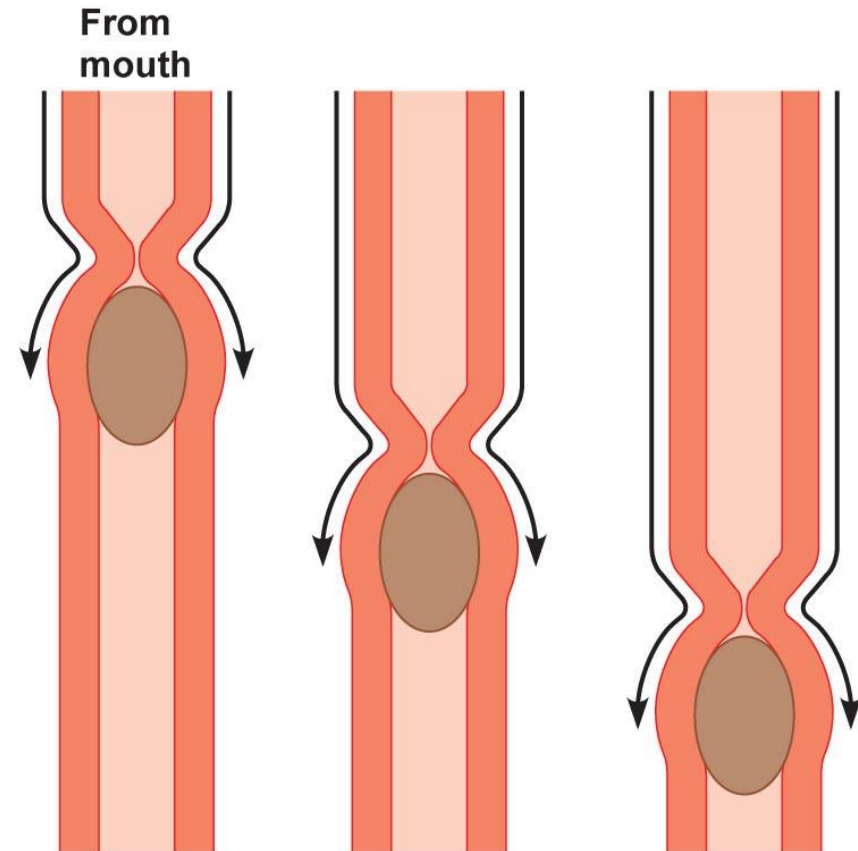


(b) Segmentation: Nonadjacent segments of alimentary tract organs alternately contract and relax, moving the food forward then backward. Food is mixed and slowly propelled.

Peristaltic contractions 蠕動收縮

Major means of propulsion

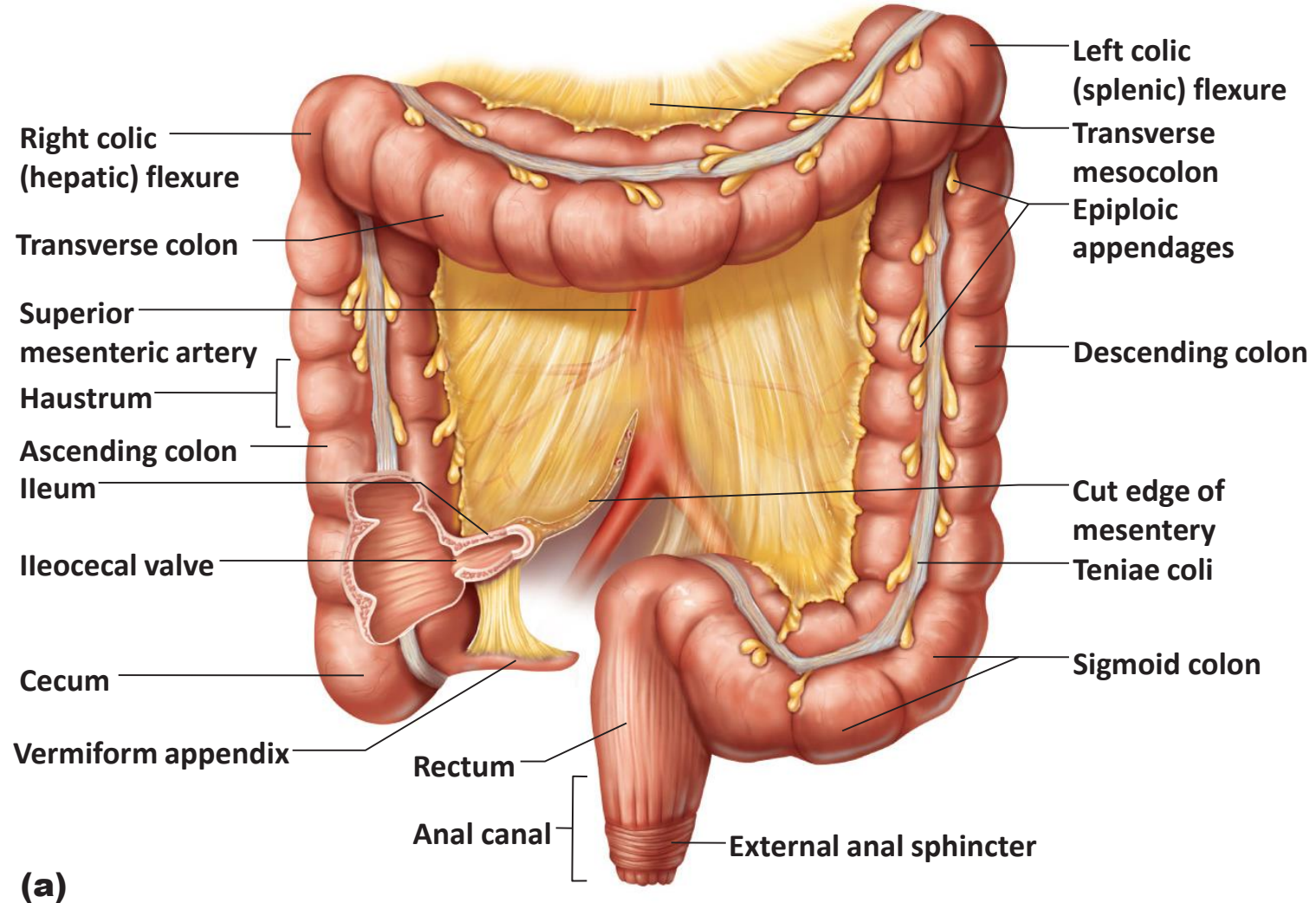
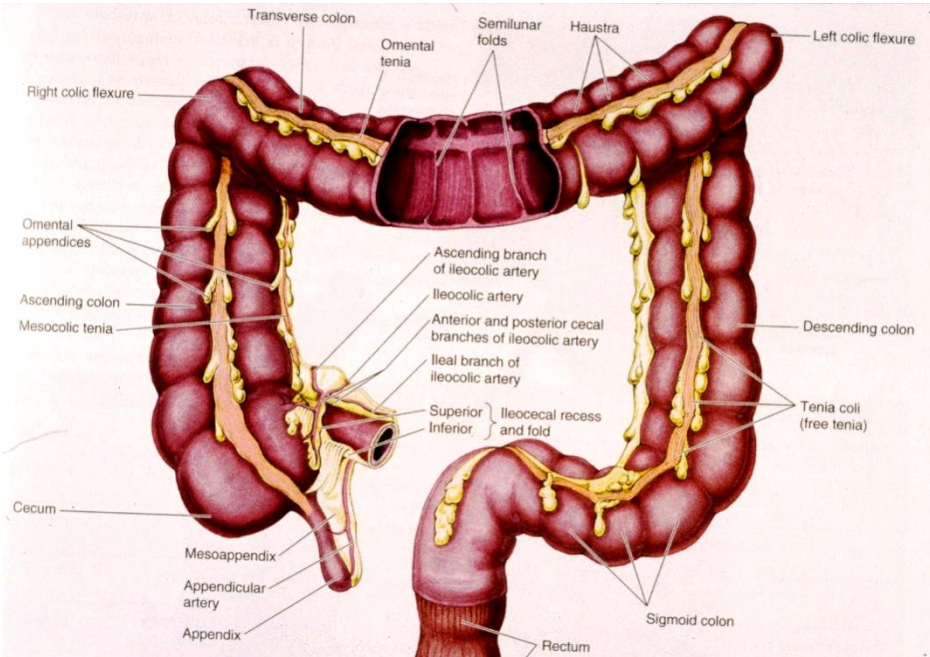
Adjacent segments of the alimentary canal relax and contract



(a) Peristalsis: Adjacent segments of alimentary tract organs alternately contract and relax, moving food along the tract distally.

LARGE INTESTINE 大腸

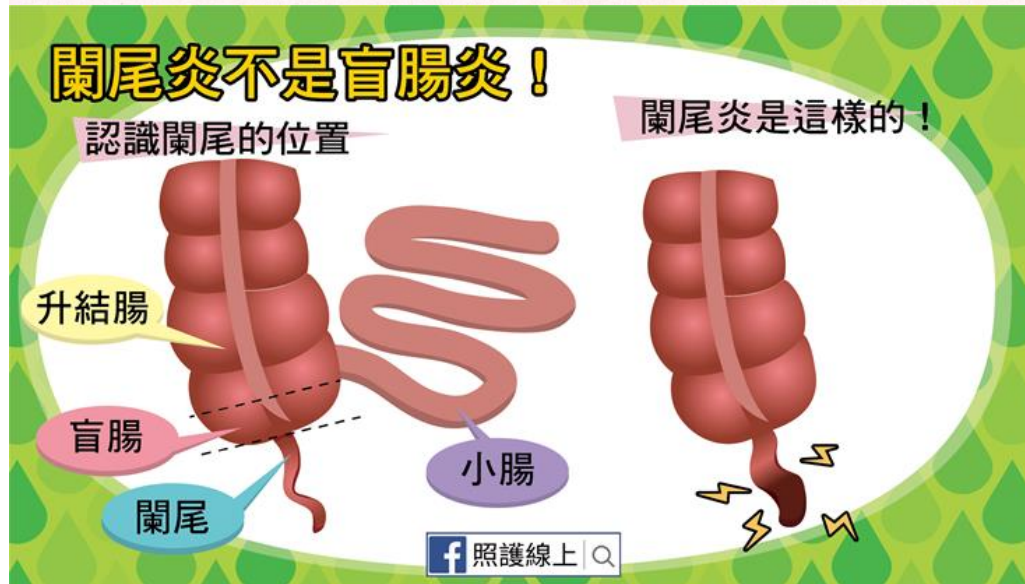
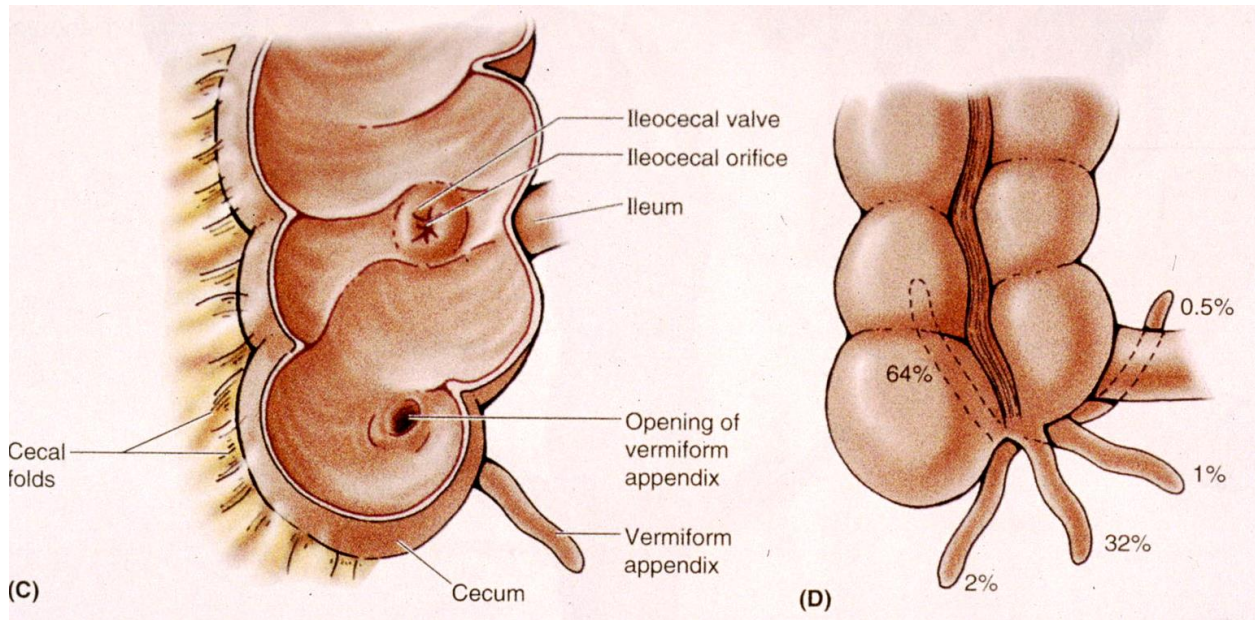
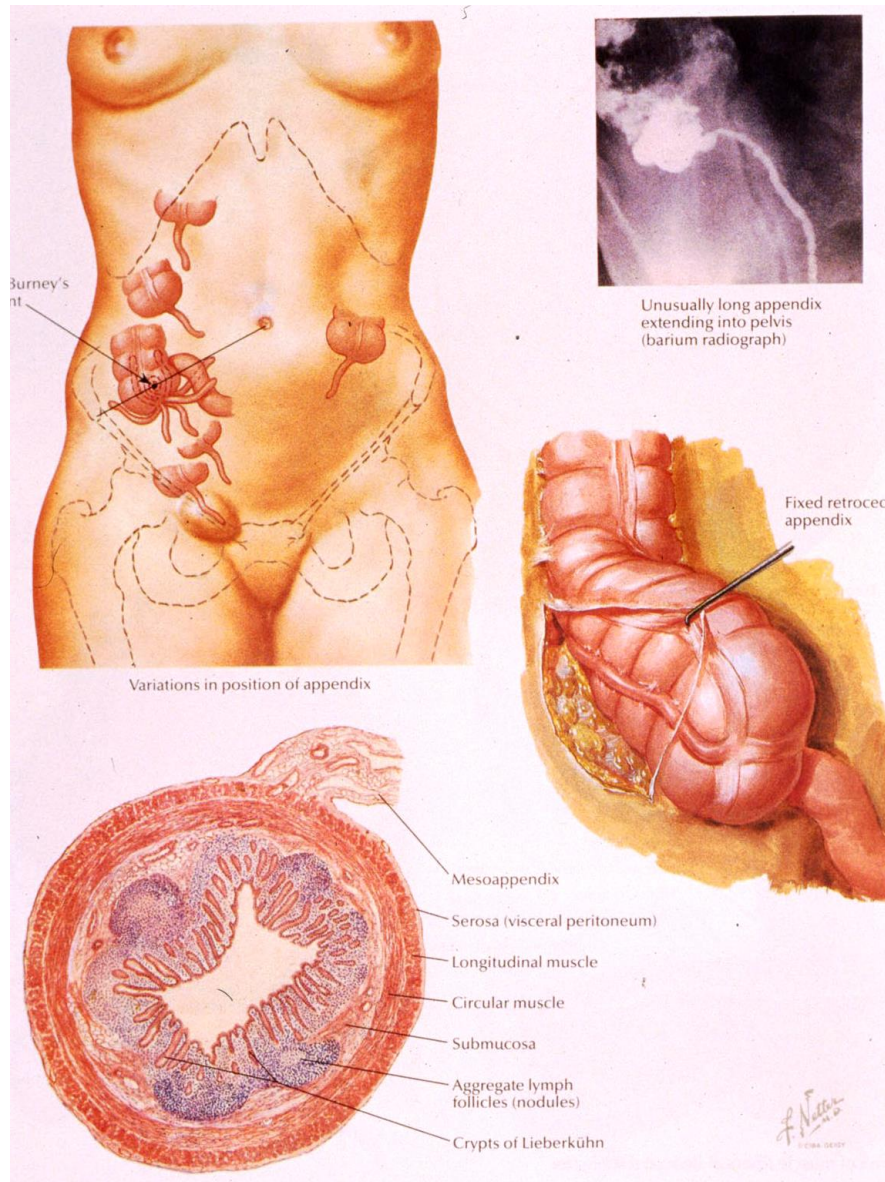
1. cecum 盲腸
2. (vermiform) appendix 闌尾 ;
3. ascending colon 升結腸
4. transverse colon 橫結腸
5. descending colon 降結腸
6. sigmoid colon (S-shape) 乙狀結腸
7. rectum 直腸



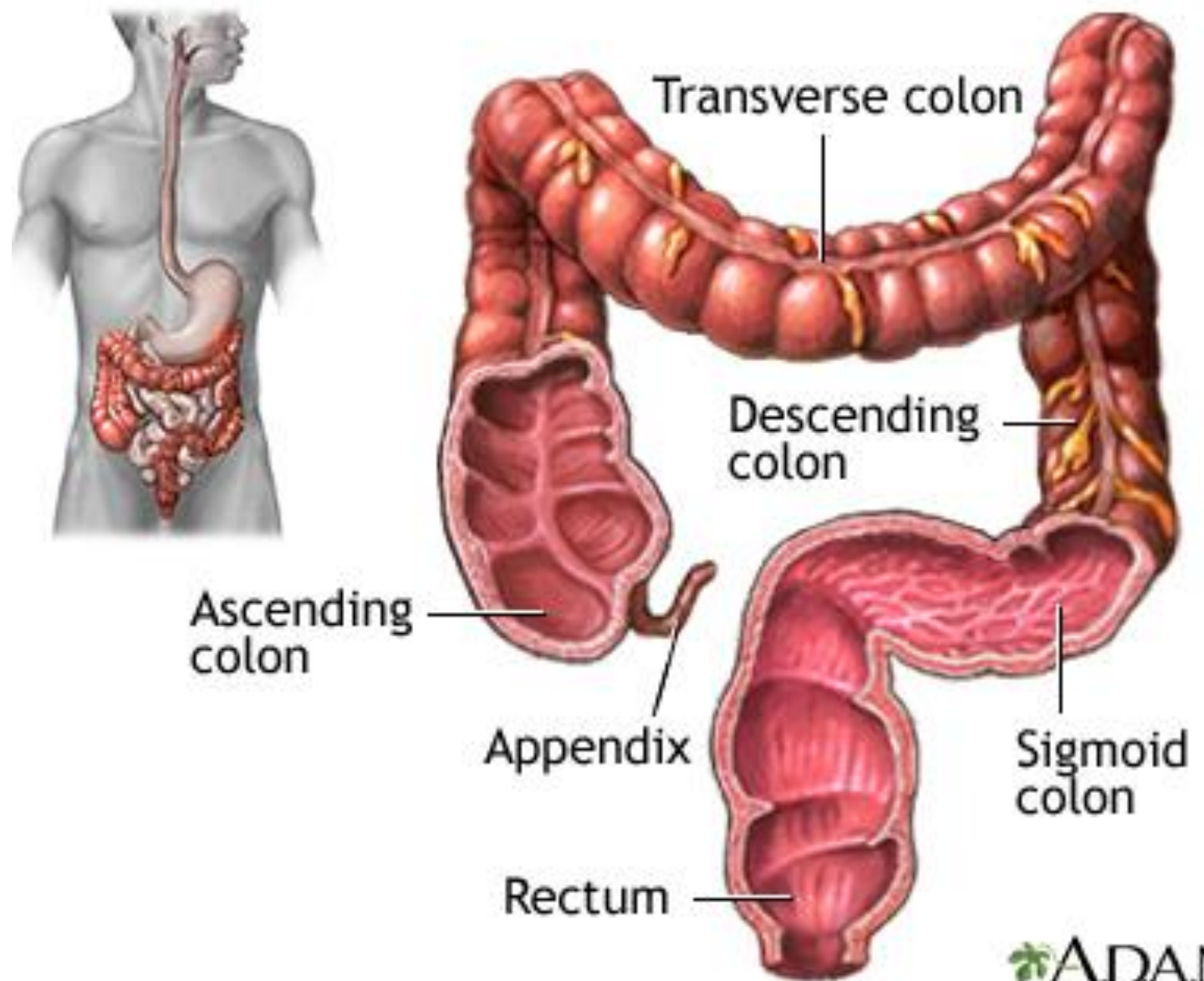
(a)

1. cecum盲腸

2. (vermiform) appendix 闌尾； appendicitis闌尾炎 (appendectomy闌尾切除)



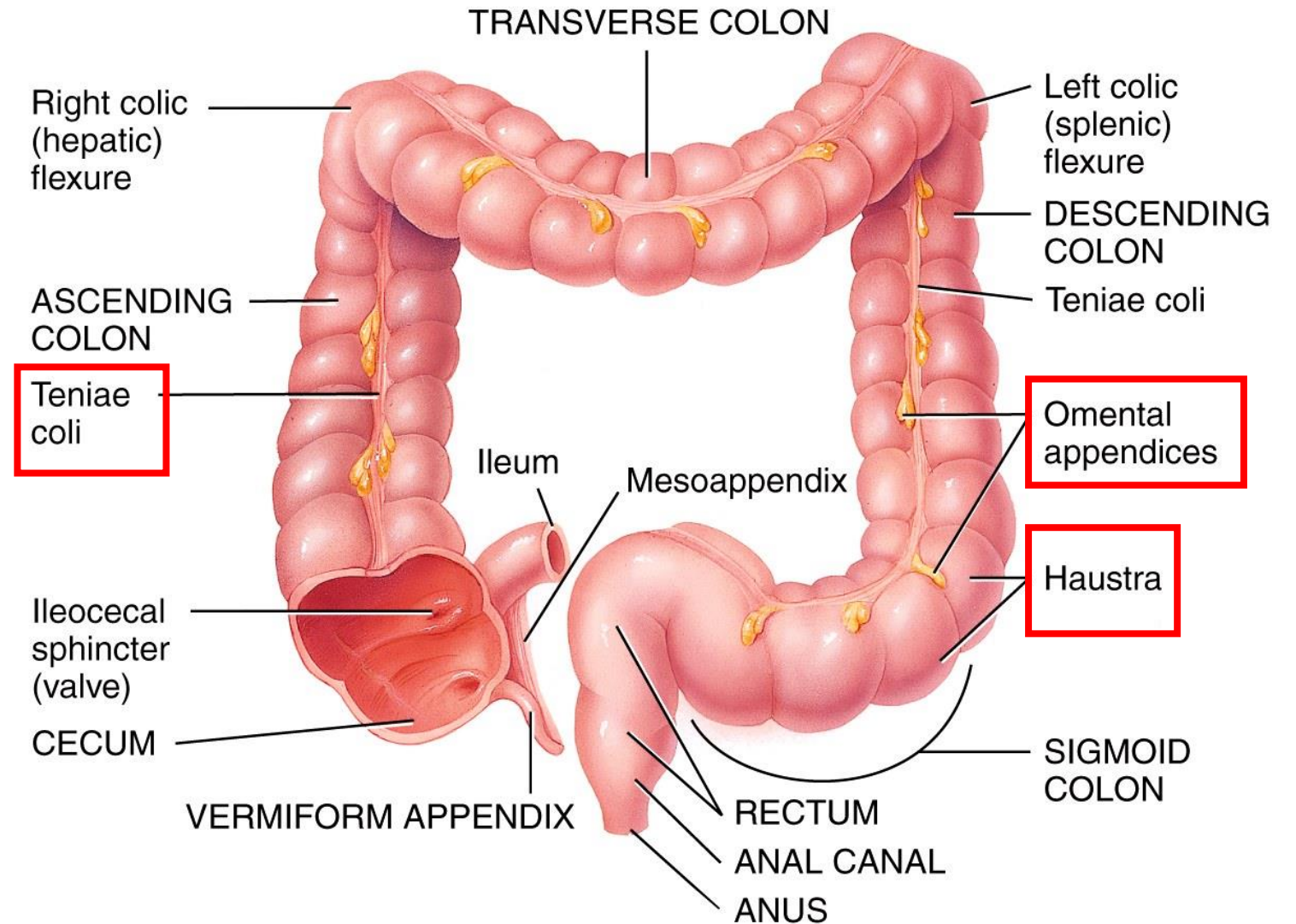
3. **ascending colon**升結腸
4. **transverse colon**橫結腸
5. **descending colon**降結腸
6. **sigmoid colon** (S-shape)
乙狀結腸
7. **rectum**直腸



LARGE INTESTINE

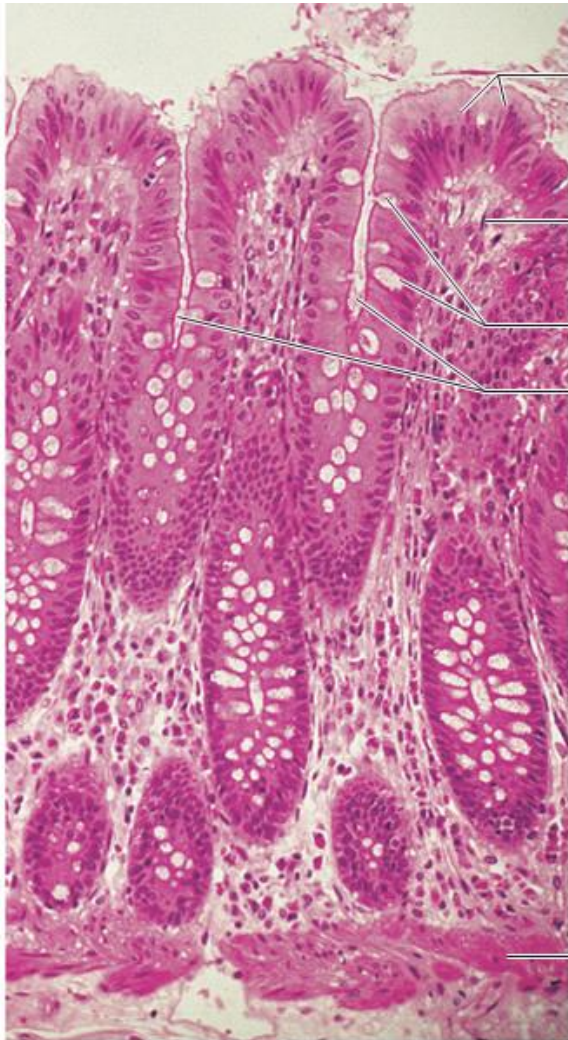
結腸三大特殊結構

1. **taeniae coli** 結腸帶 (from outer longitudinal muscle)
2. **haustra** 結腸袋
3. **epiploic appendages (Omental appendices)** 腸脂垂



(a) Anterior view of large intestine showing major regions

Large intestinal gland



Absorptive cells

Lamina propria

Goblet cells

Intestinal crypts

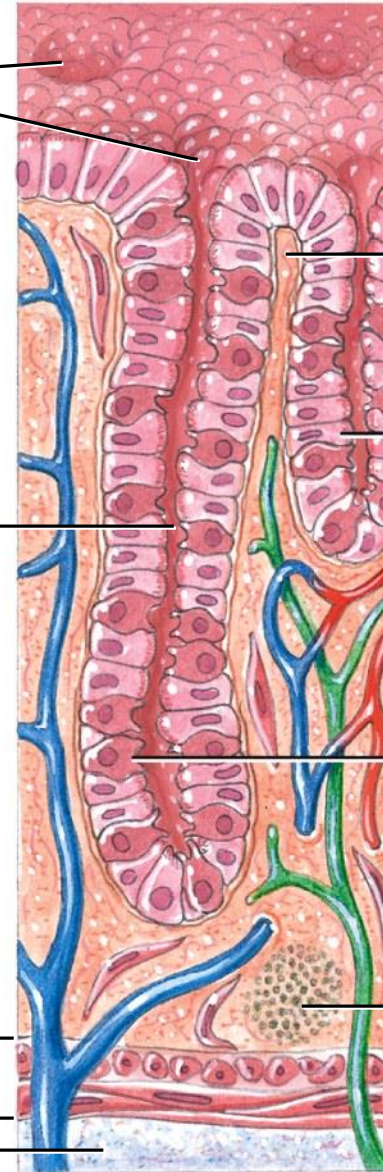
Muscularis mucosae

Openings of intestinal glands

Intestinal gland

Muscularis mucosae

Submucosa



Lamina propria

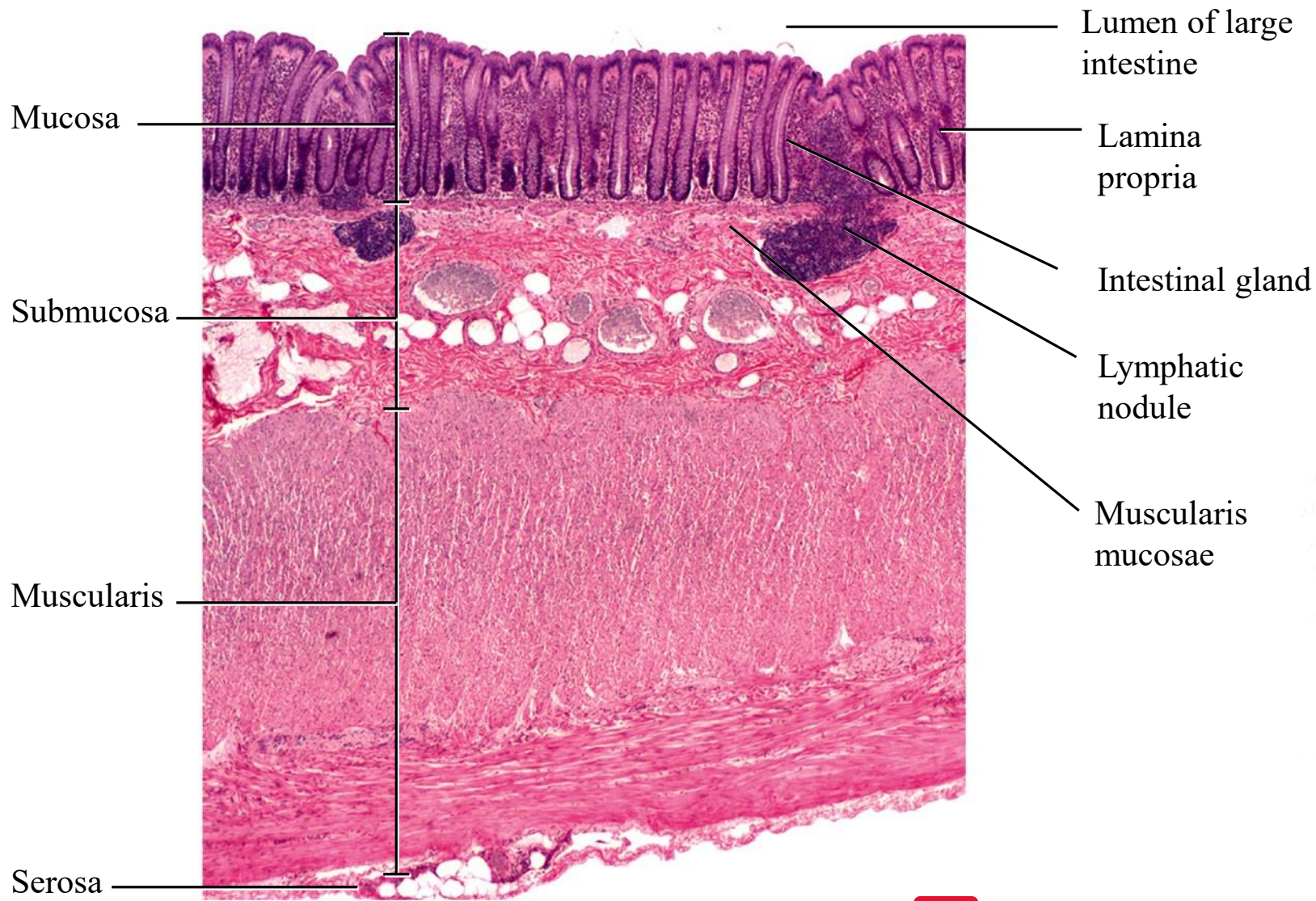
Microvilli

Absorptive cell (absorbs water)

Goblet cell (secretes mucus)

Lymphatic nodule

(b) Sectional view of intestinal glands and cell types

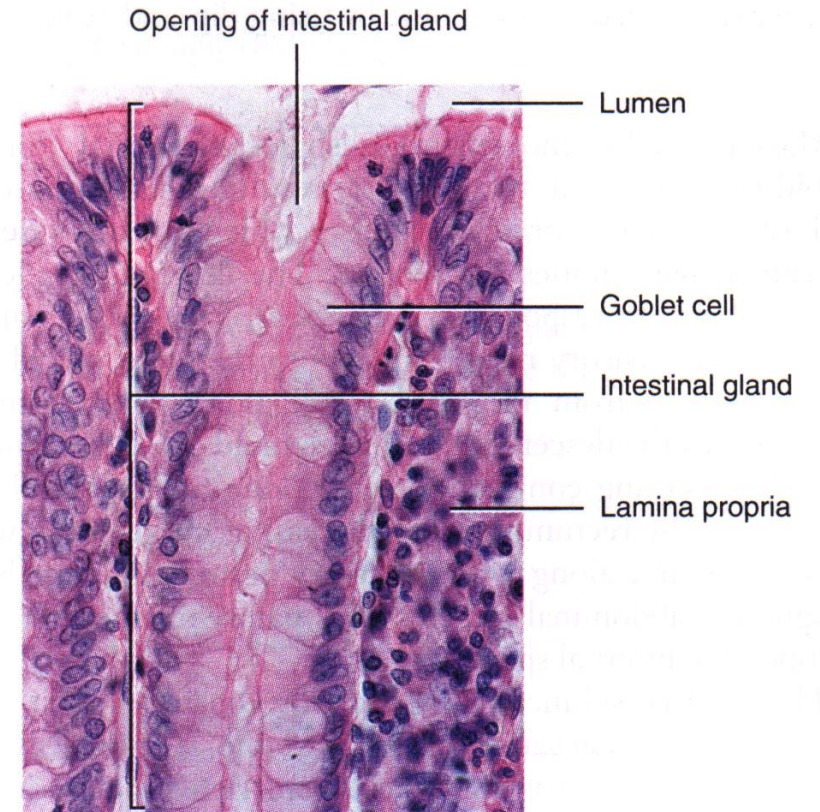


LM 315x

(c) Portion of the wall of the large intestine

- no villi, plicaeulares
 numerous goblet cells, many lymphoid nodules

* Functions: reabsorption of more water, salts and vitamins.



LM 300x

(d) Details of mucosa of large intestine

Rectum 直腸 Anal Canal 肛管 & Anus 肛門

• Rectum: retroperitoneal

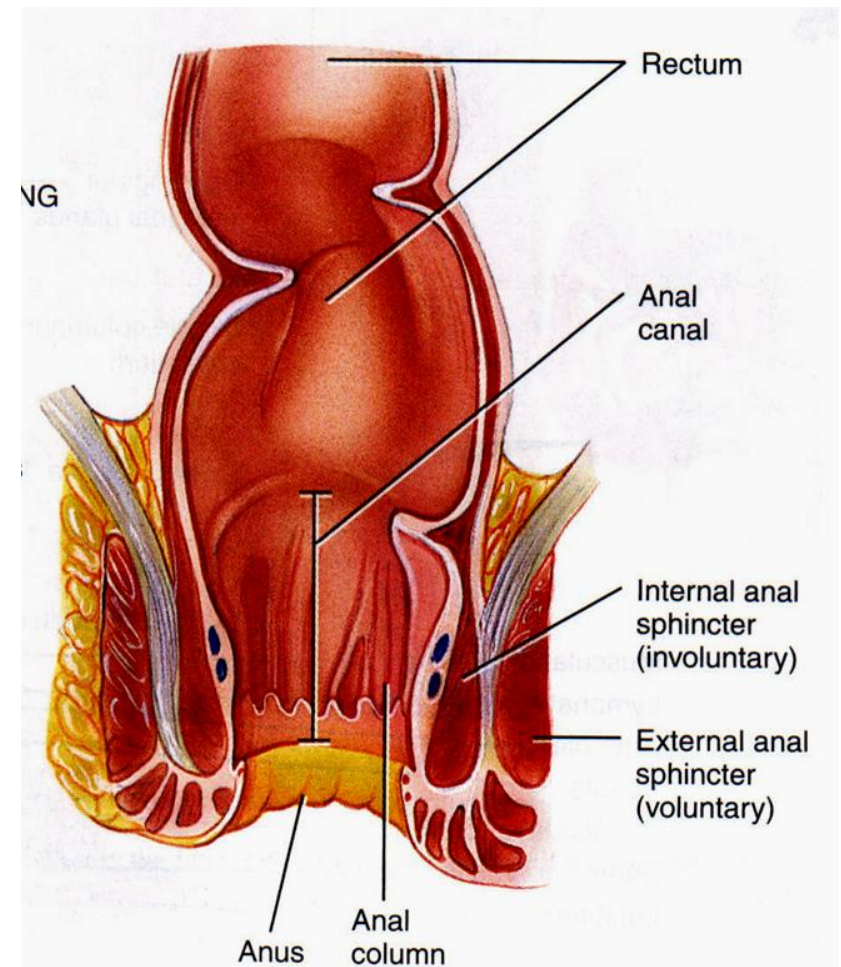
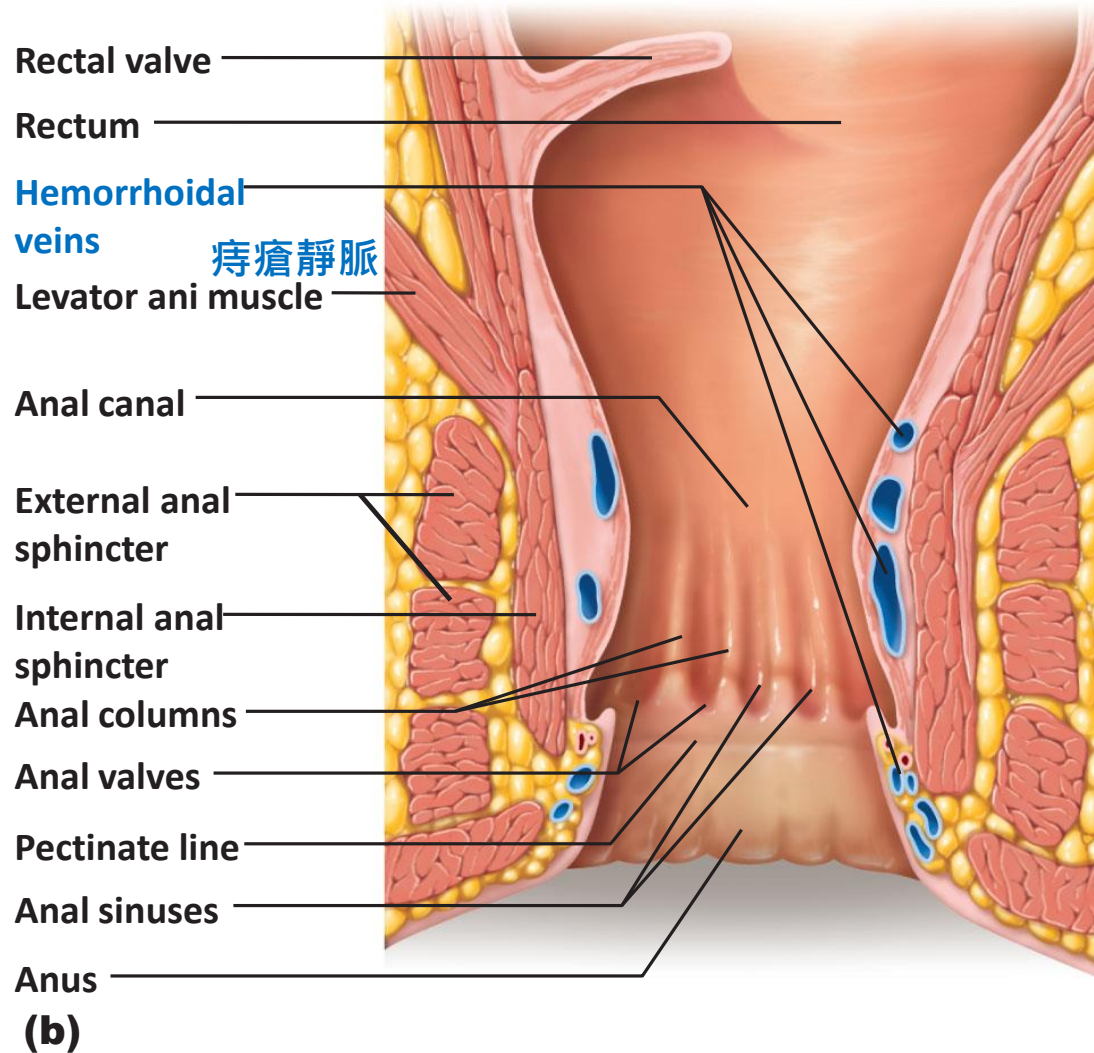
* **Internal anal sphincter** (circular smooth m.)

* **External anal sphincter** (skeletal m.)

* **Hemorrhoidal veins** 痔瘡靜脈

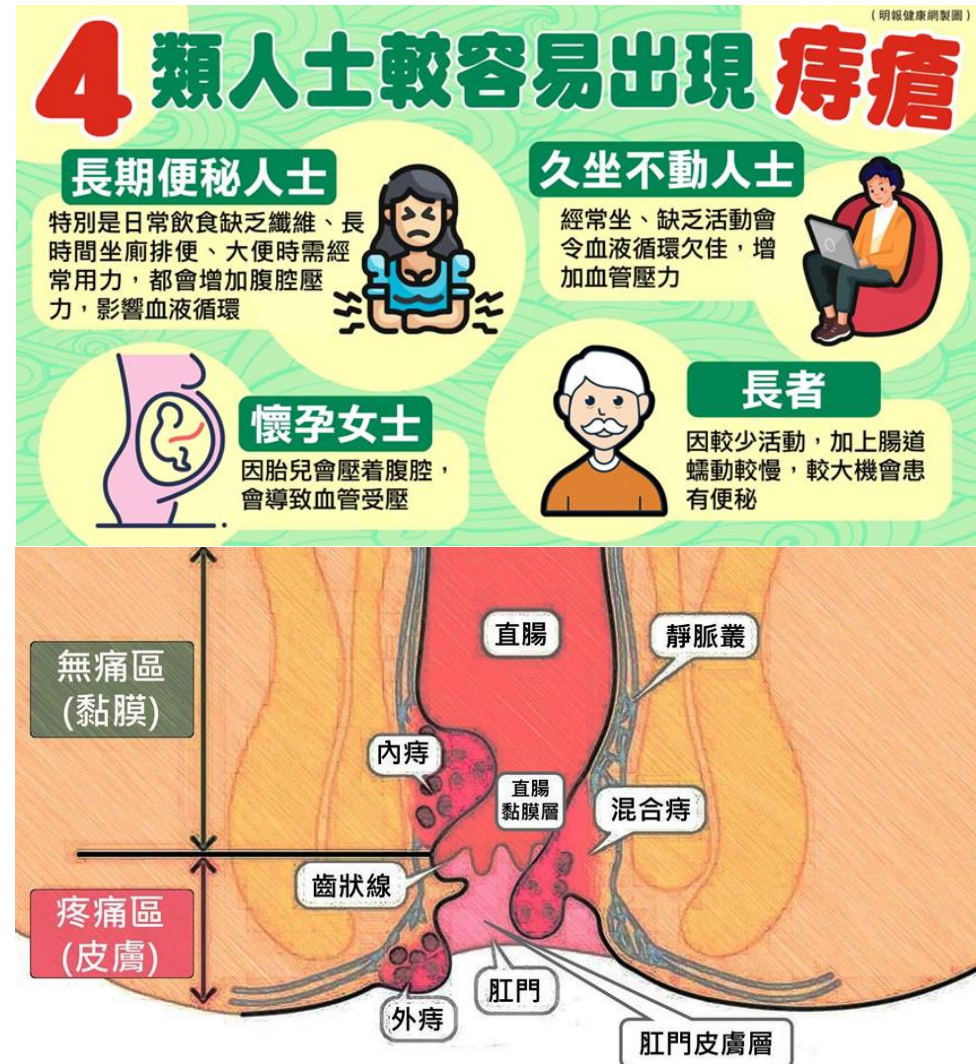
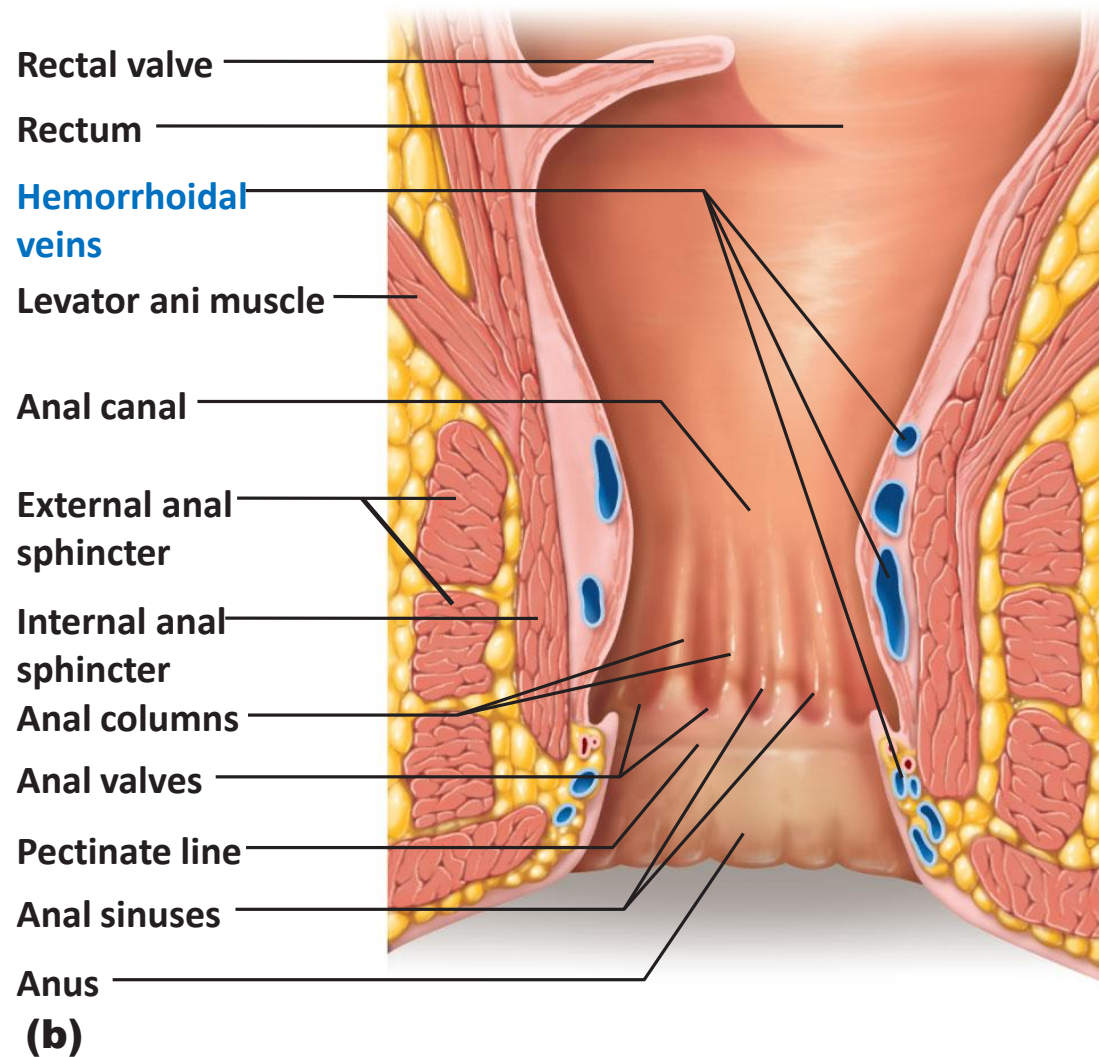
Anal columns; anal valves (simple columnar epi.)

* **Anus** (**keratinized stratified squamous epi.**)



(b) Frontal section of anal canal

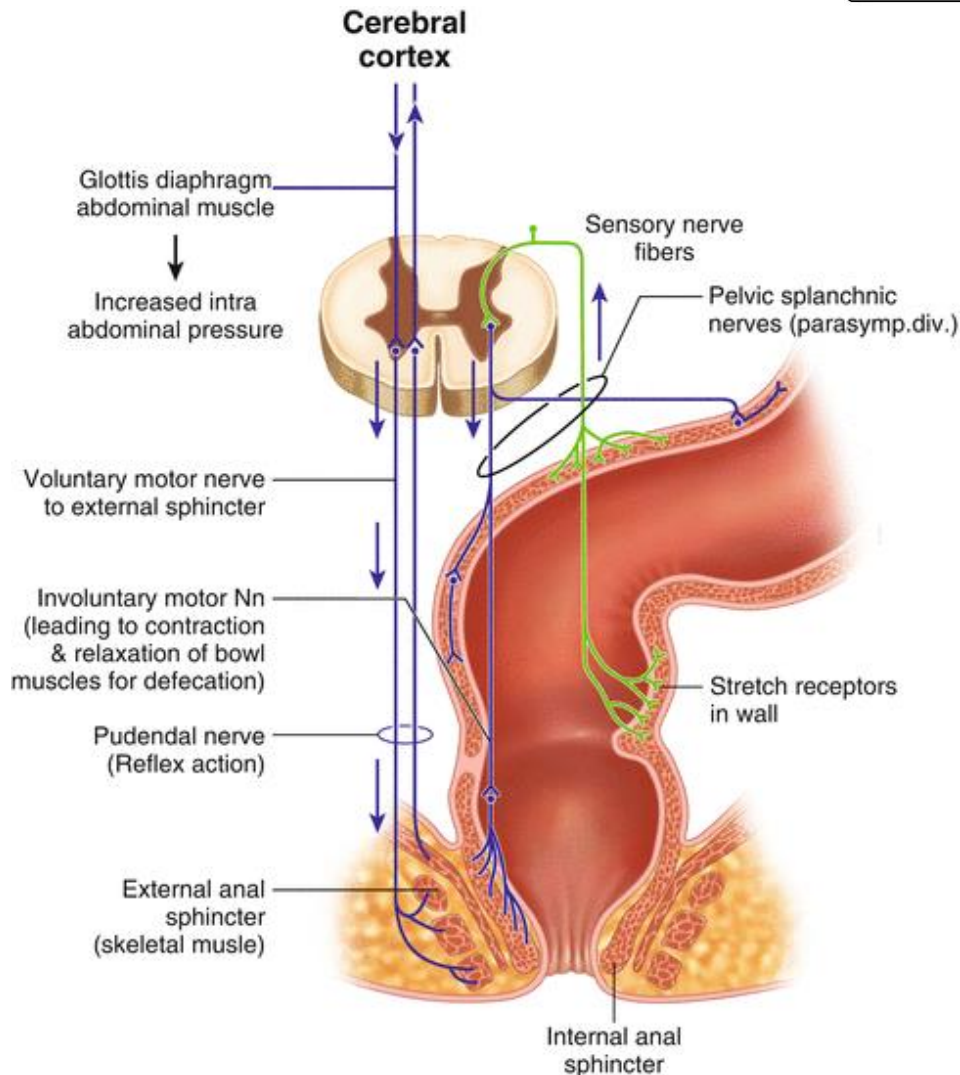
痔瘡 Hemorrhoid 是肛管或直腸下段黏膜下的靜脈叢，發生充血或淤血並擴張腫大，形成柔軟靜脈團的疾病；主要臨床表現可能有出血、疼痛、肛門瘙癢、脫垂等。痔瘡的症狀依其發生位置及種類而定。內痔通常無痛，但在**排便**時會產生鮮紅色的**便血**。外痔則通常會造成肛門周圍疼痛或腫脹，且通常顏色較深。



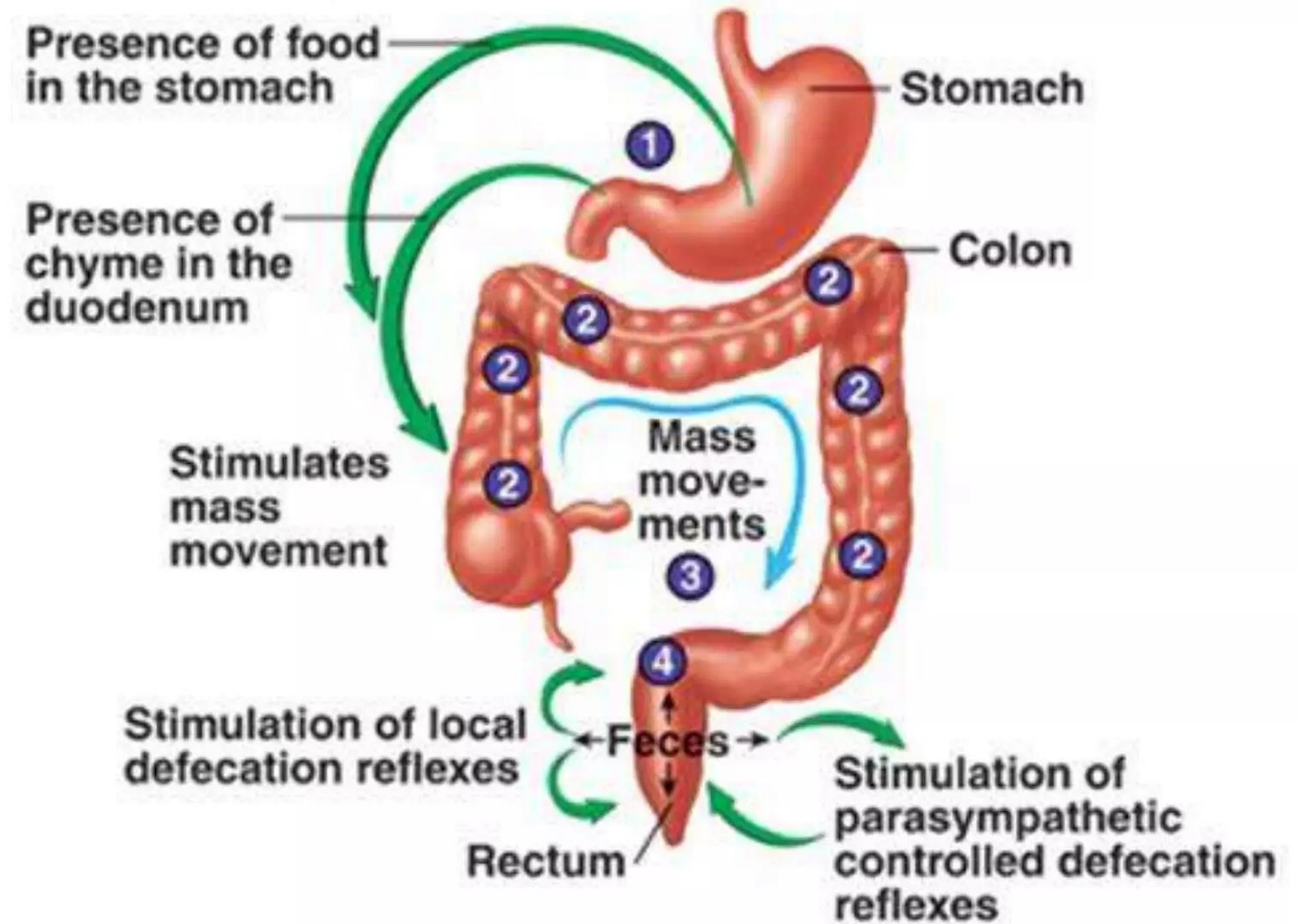
Defecation Reflex

* Mass movement: 3-4 times/ day (following meals)

DEFECATION – INTEGRATED REFLEXES



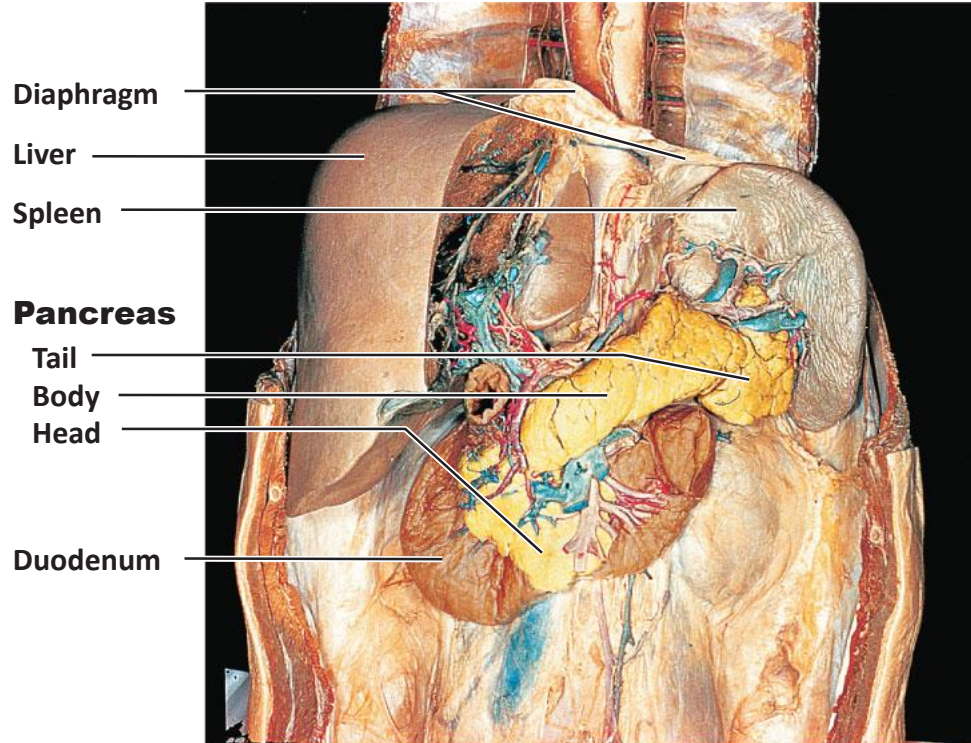
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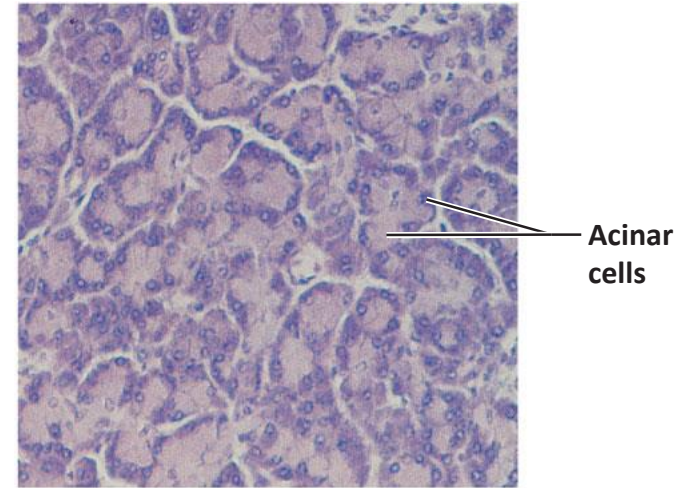
PANCREAS 胰臟: lies transversely, behind stomach, **retroperitoneal** 後腹膜器官

- 3 parts: **head, body, tail**

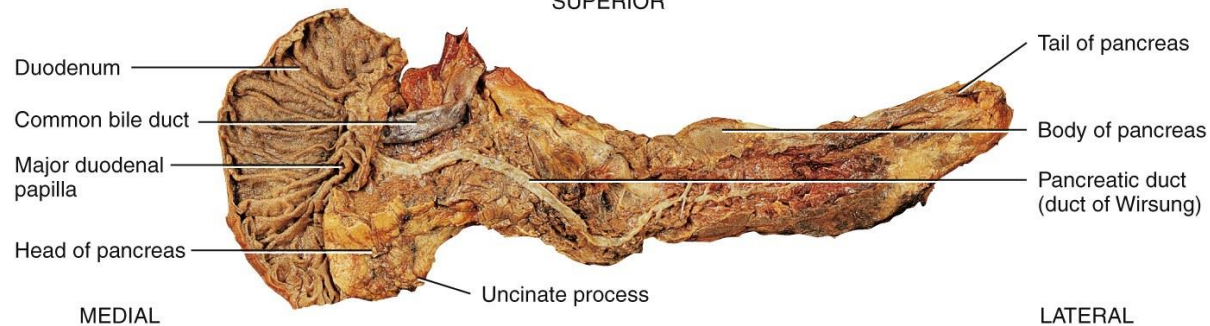
• Exocrine: **acini** 腺泡 → **main or accessory pancreatic duct** → duodenum



SUPERIOR



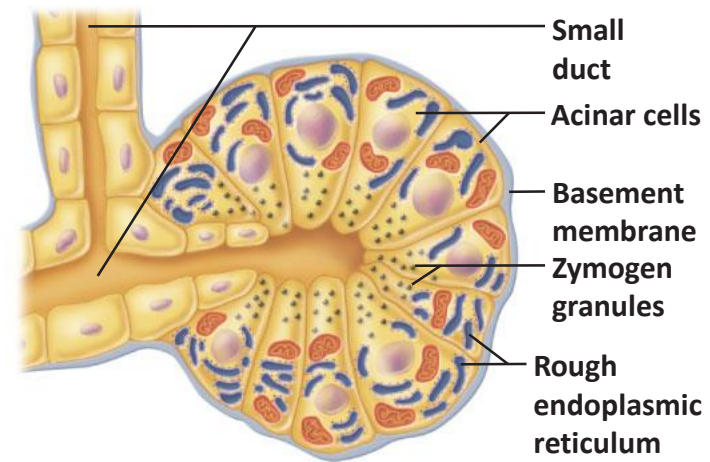
(b) Photomicrograph of the exocrine acinar cells of the pancreas (160x)



MEDIAL

LATERAL

(e) Anterior view



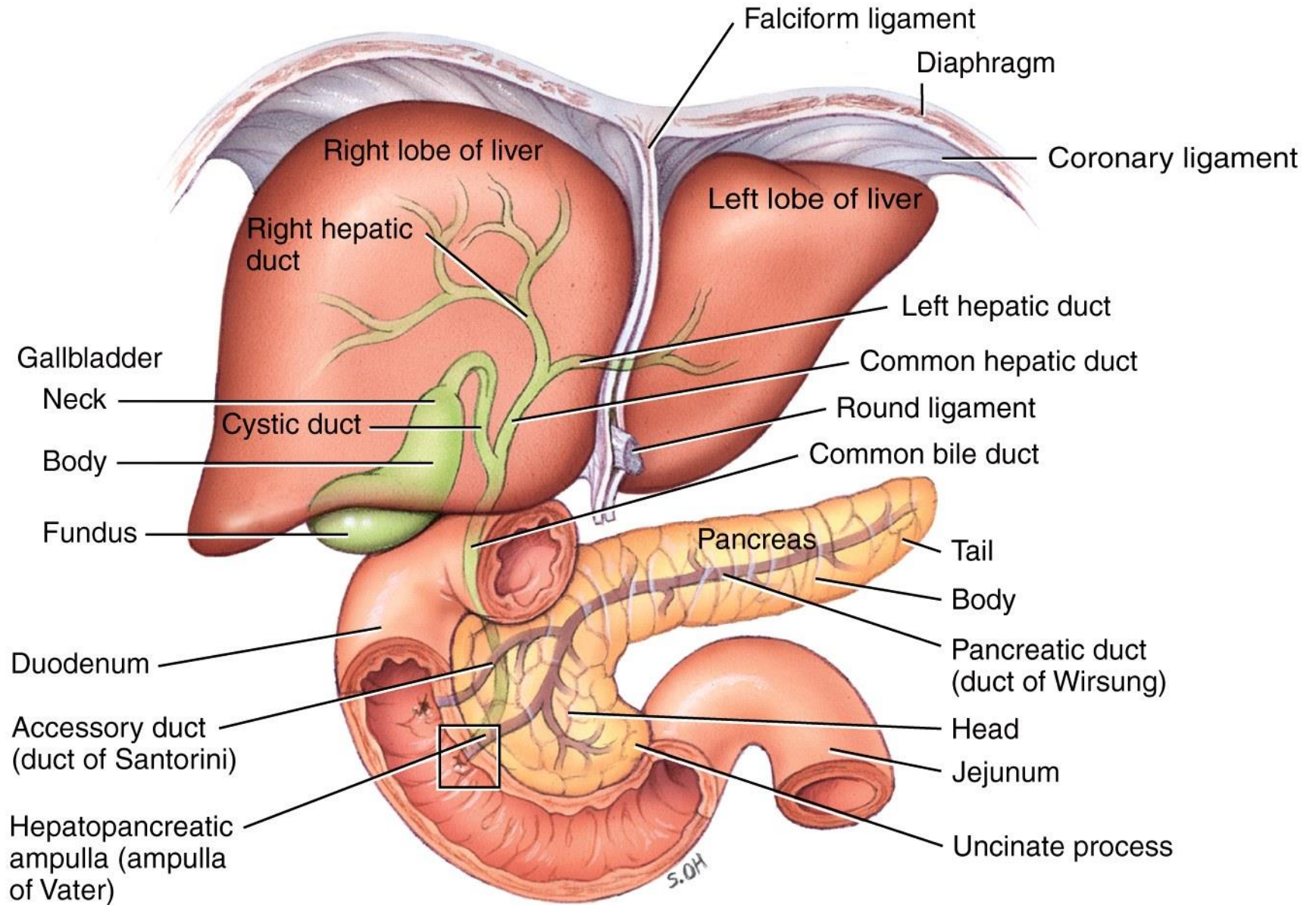
(c) Illustration of the pancreatic acinar cells

PANCREAS 胰臟

•Exocrine:
pancreatic enzymes
acini 腺泡 → **main or accessory pancreatic duct**
→ duodenum

•Endocrine:
islet of Langerhans
藍氏小島
→ Fenestrated capillaries
→ bloodstream

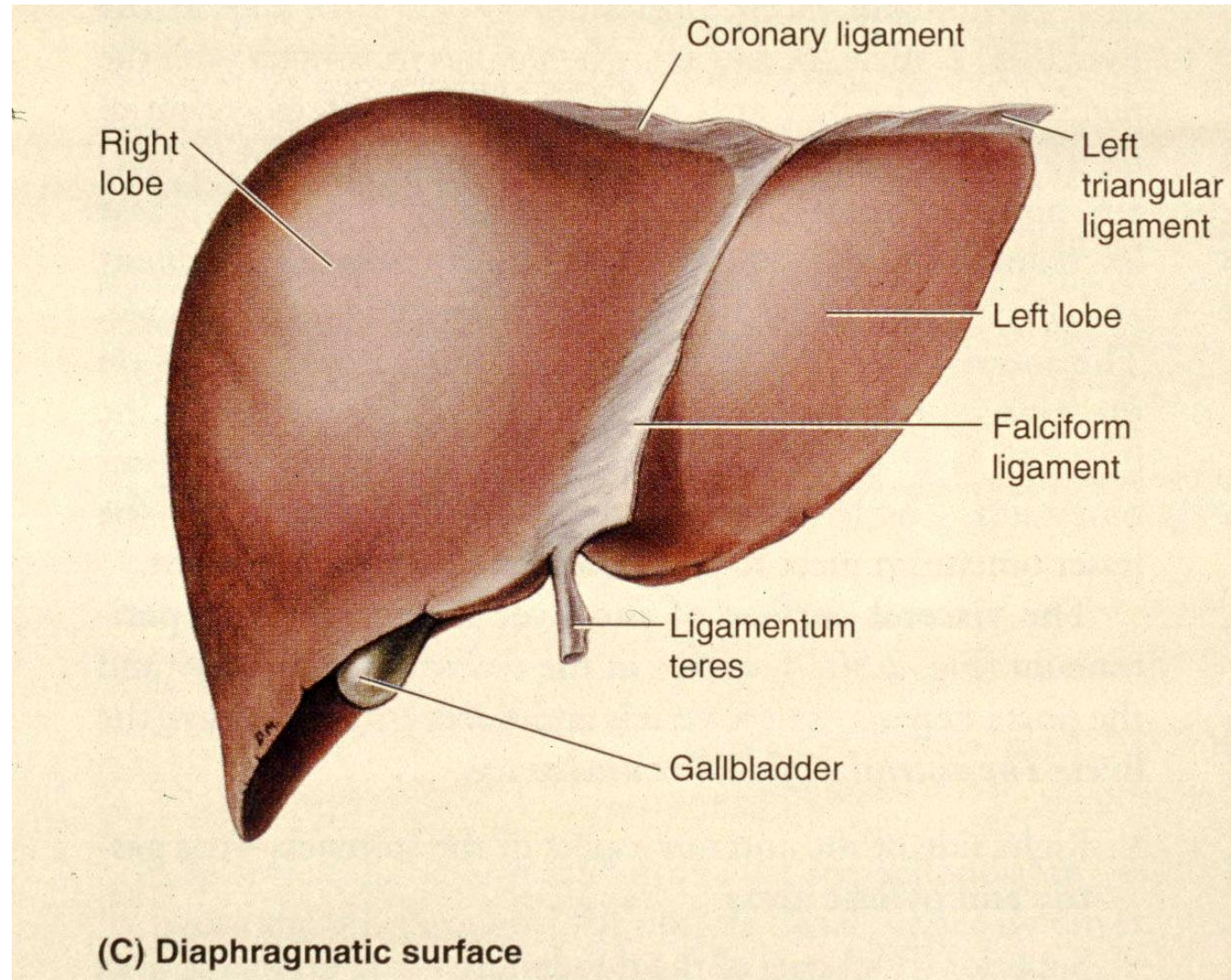
Glucagon (alpha cell)
Insulin (beta cell)
Somatostatin (Delta cell)



(a) Anterior view

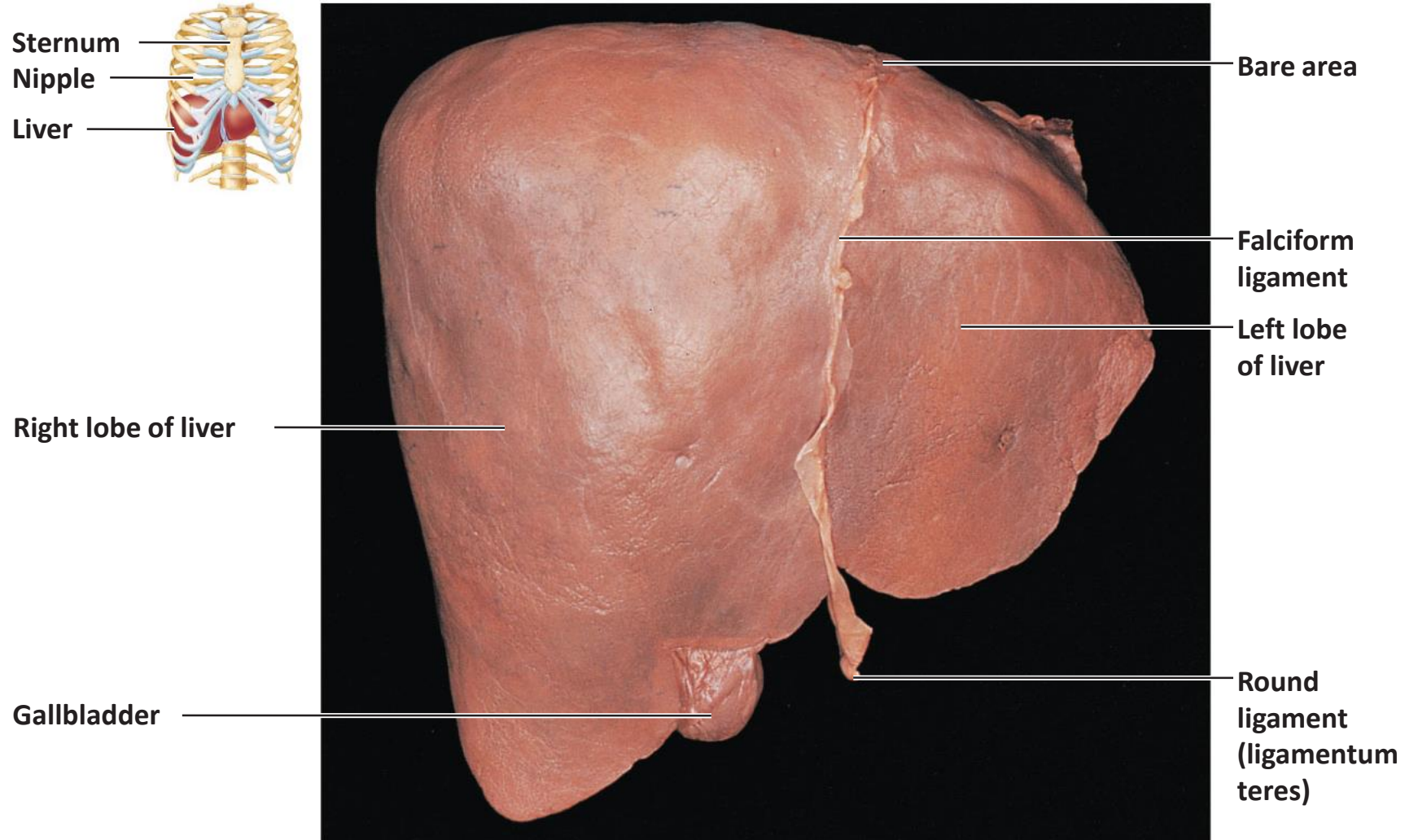
LIVER 肝臟

* **Left lobe** 左葉 <= **falciform lig.** 鎌狀韌帶 => **right lobe** 右葉
quadrate lobe 方葉 & **caudate lobe** 尾葉



LIVER 肝臟

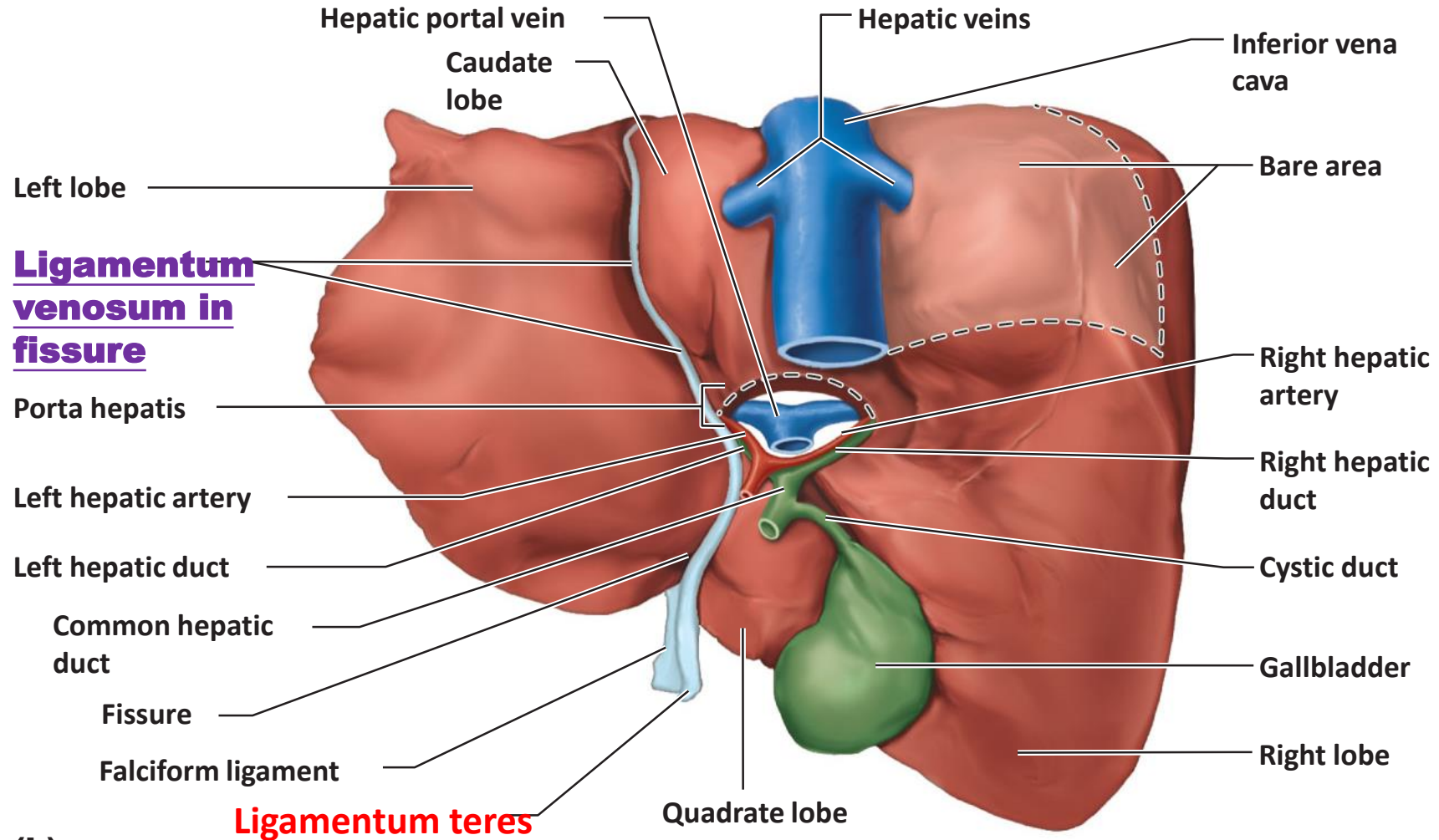
* Left lobe 左葉 <= falciform lig. 鎌狀韌帶 => right lobe 右葉
quadrate lobe 方葉 & caudate lobe 尾葉



Visceral Surface of the Liver

* **Ligamentum teres (round ligament)** 圓韌帶 = **left fetal umbilical vein**

* **Ligamentum venosus** 靜脈韌帶 = **fetal ductus venosus** 靜脈管



(b)

1. **Hepatic a.** (Oxygen-rich) 肝動脈

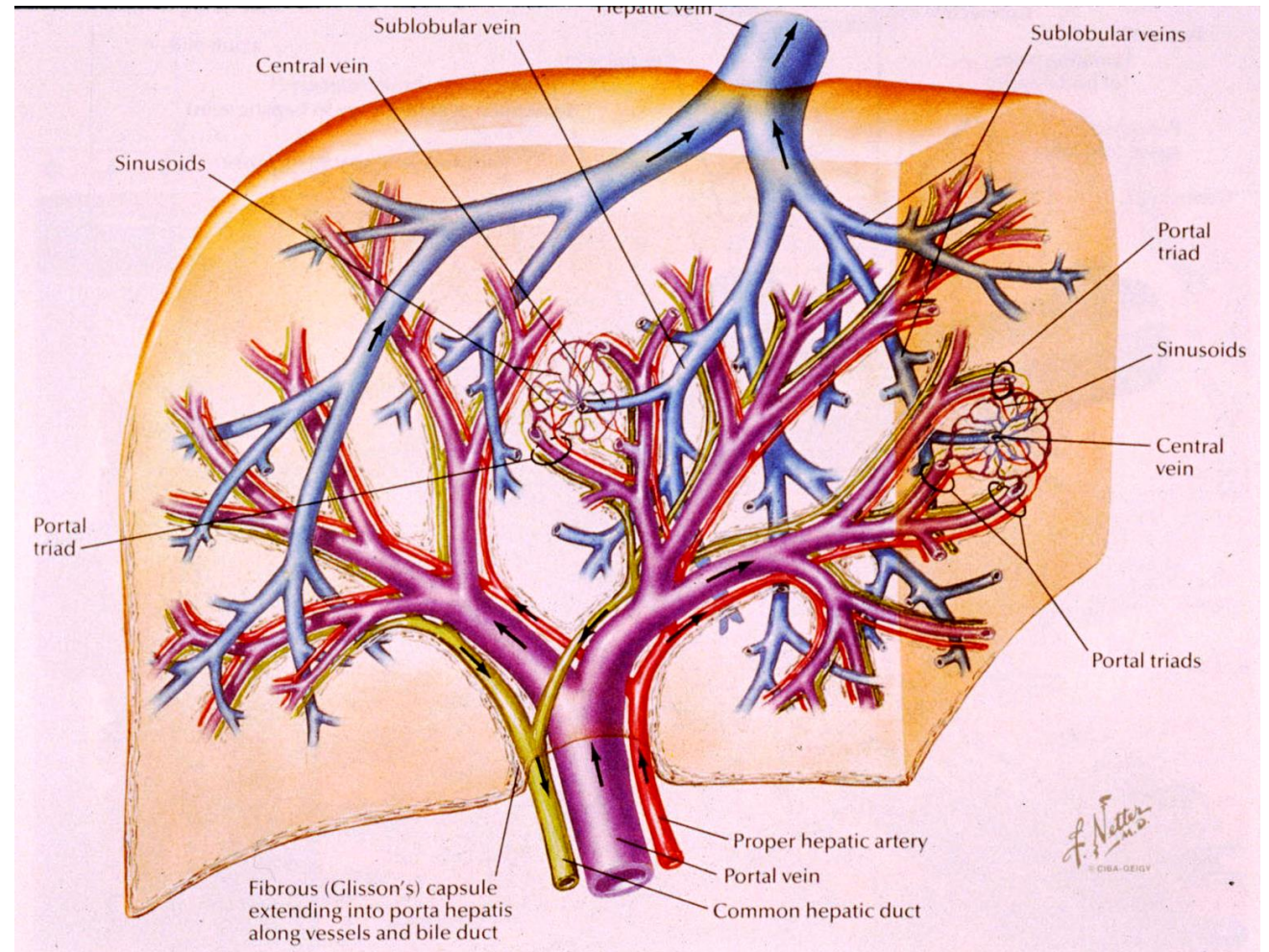
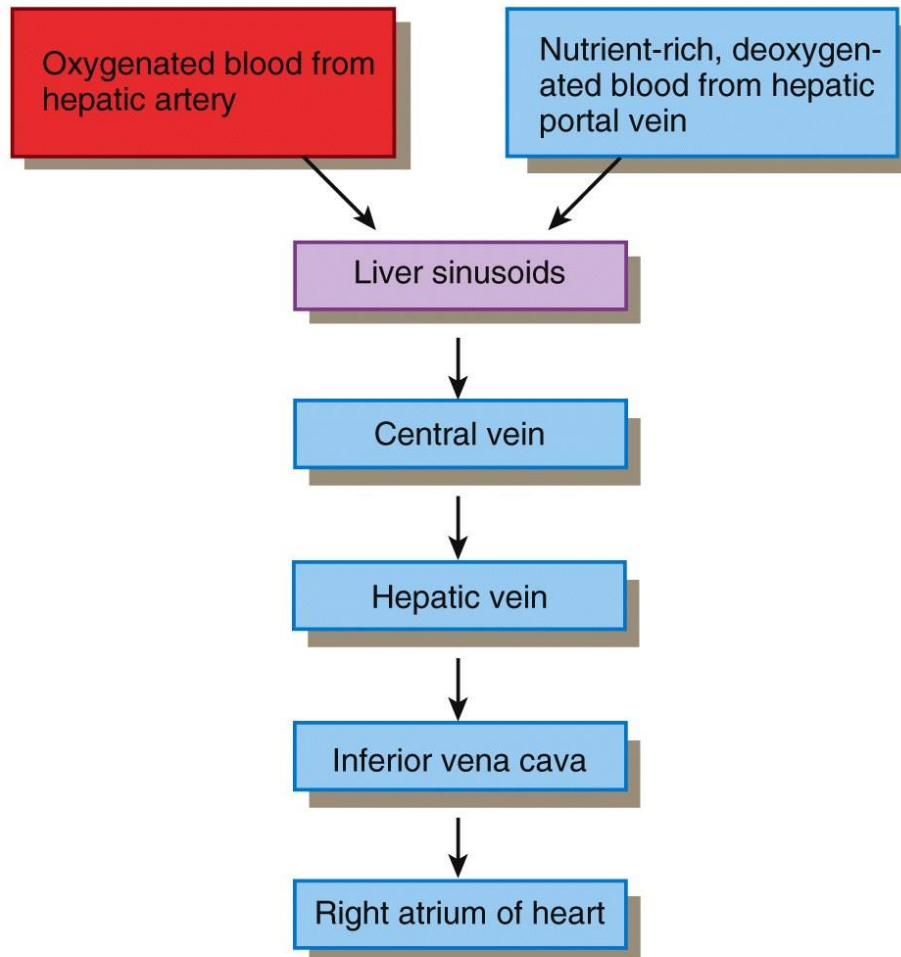
2. **Portal v.** (food-rich) 門脈

1+2 → sinusoids 血竇 → central v. 中央靜脈 → hepatic v. 肝靜脈

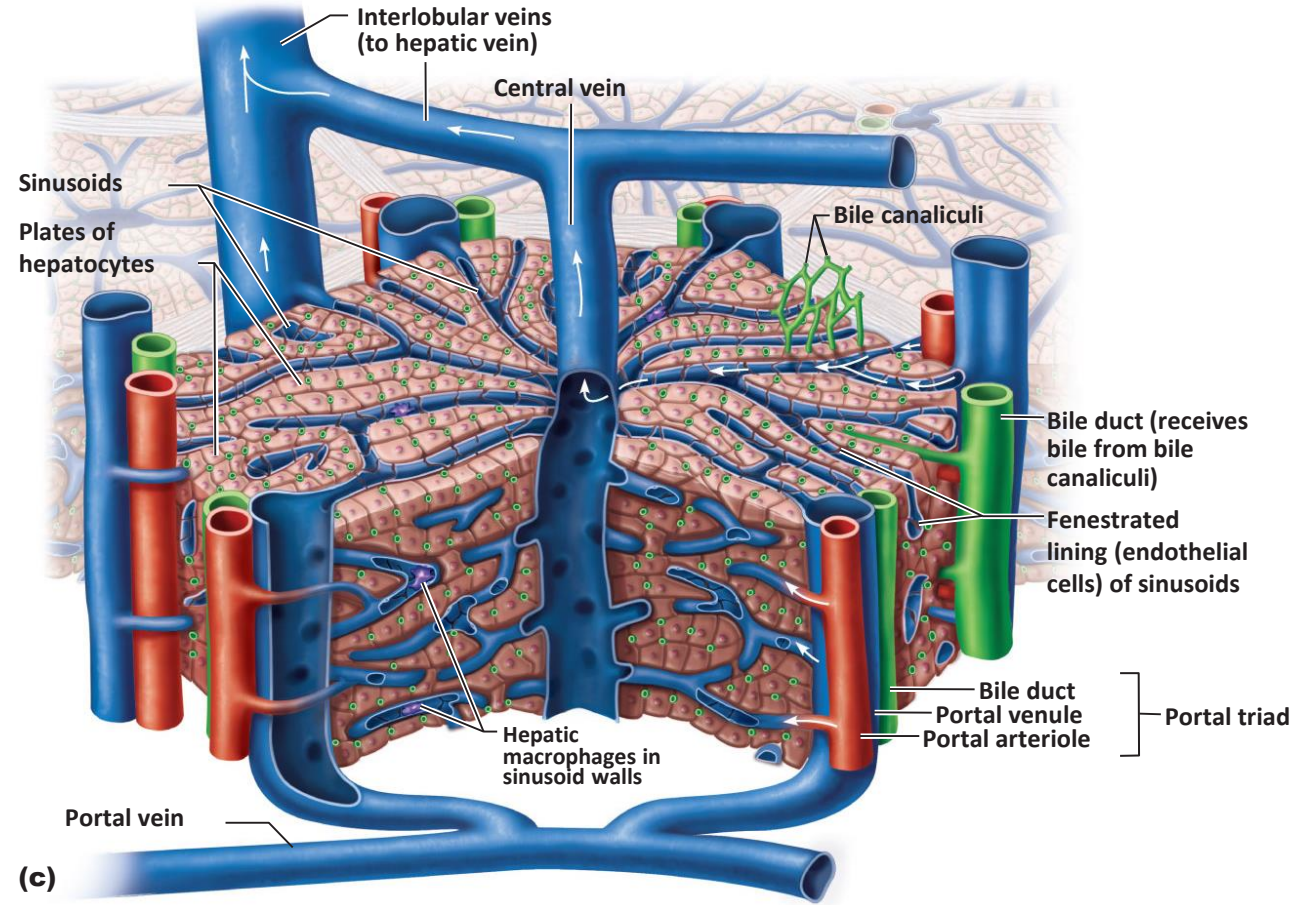
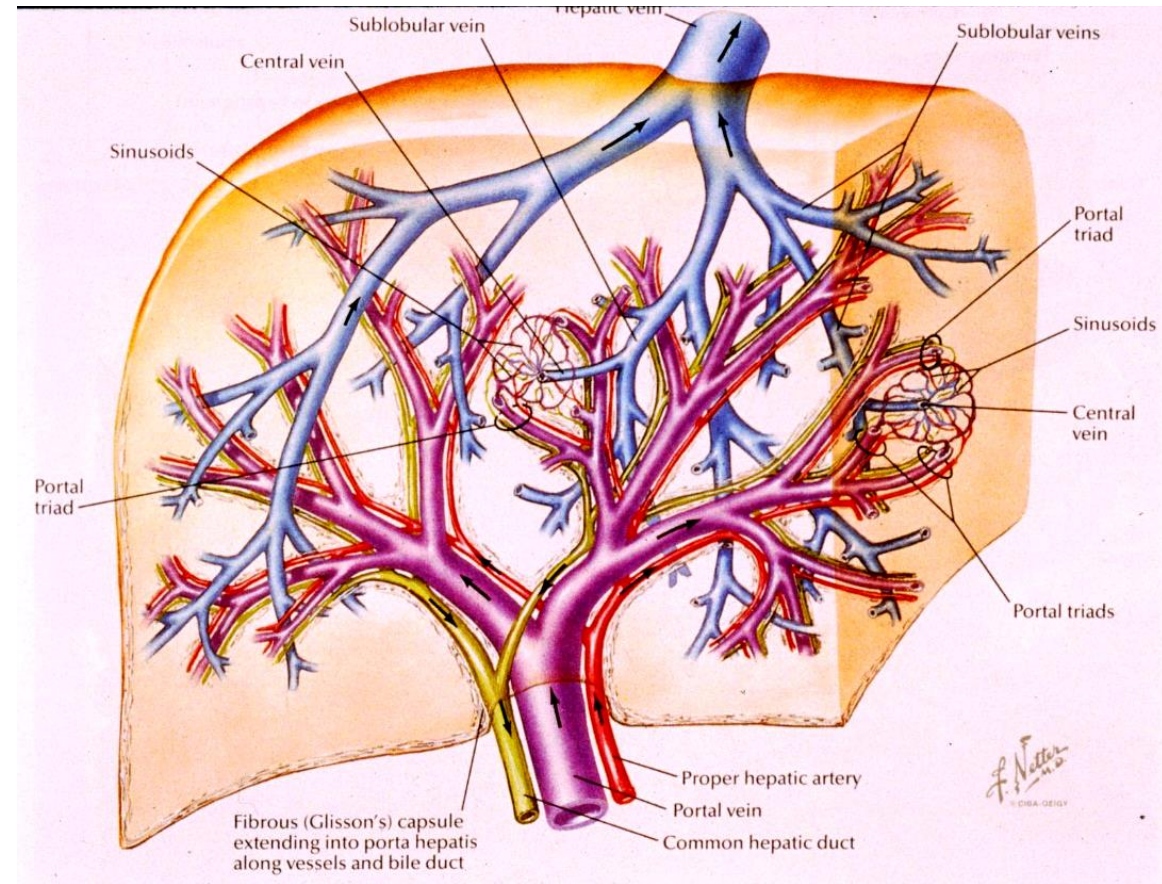
→ inferior vena cava 下腔靜脈

* **Bile** 膽汁 → **bile canaliculi** 膽小管 → **bile duct** 膽管 → **hepatic duct** 肝管

* **Portal area = portal v. + hepatic a. + bile duct + lymphatic + nerve**



- * **Bile 膽汁** → **bile canaliculi 膽小管** → **bile duct 膽管** → **hepatic duct 肝管**
- * **Portal area = portal v. + hepatic a. + bile duct + lymphatic + nerve**

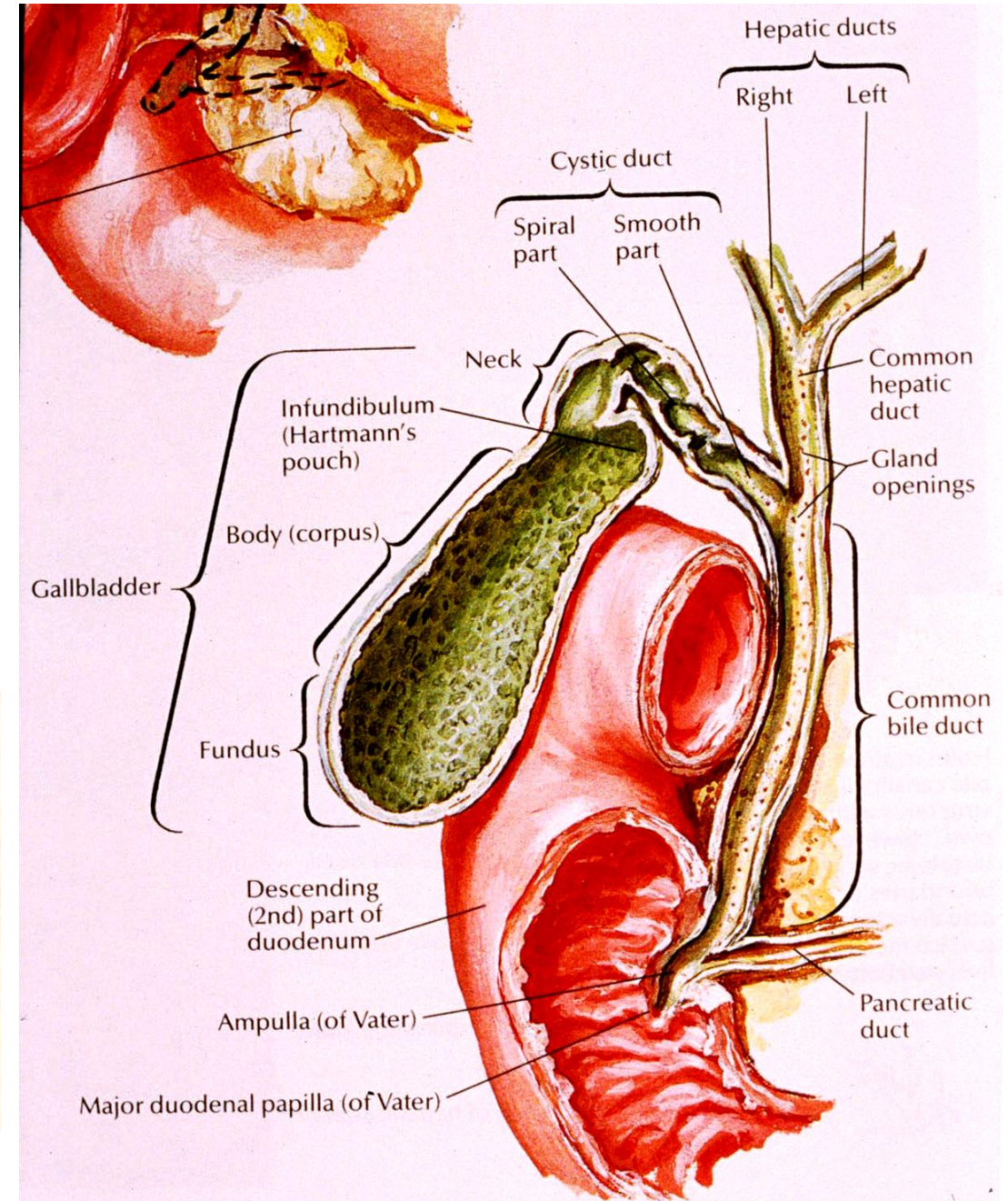
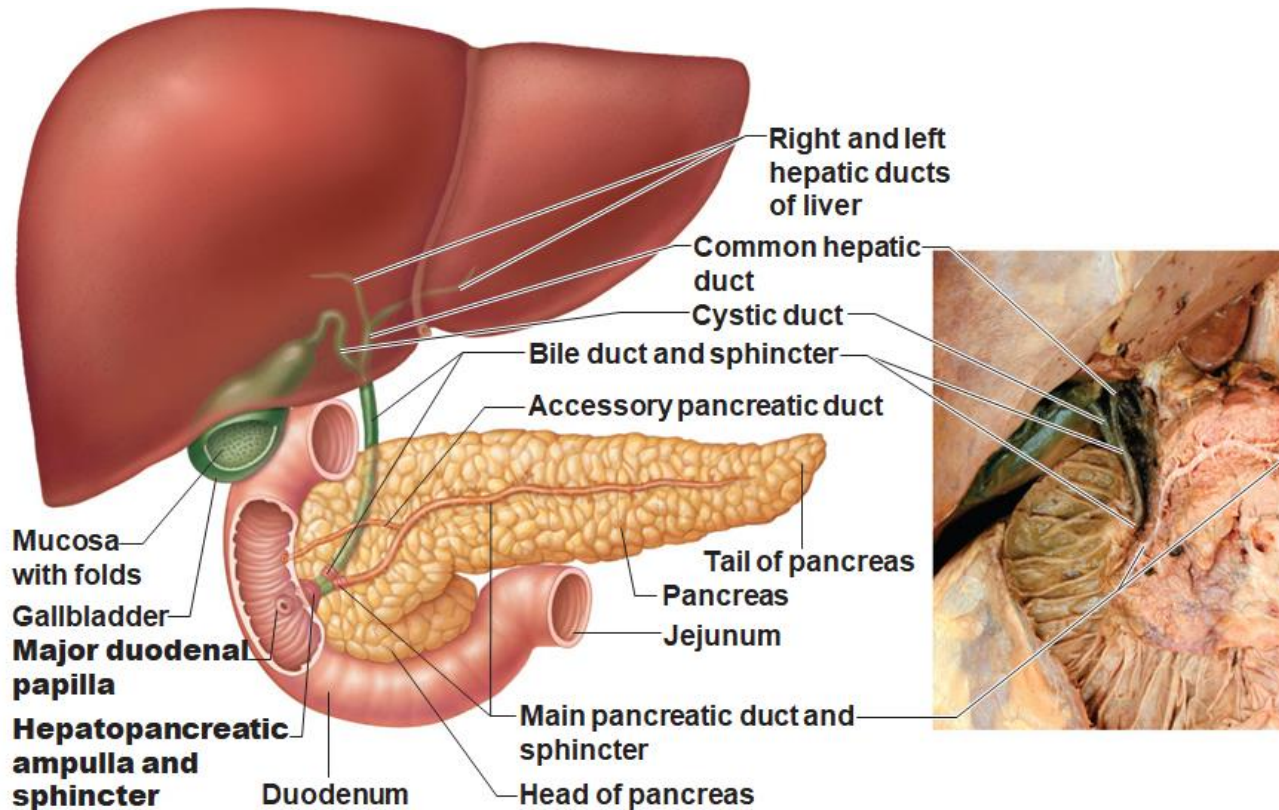


GALLBLADDER 膽囊

- storage of bile, pear-shape

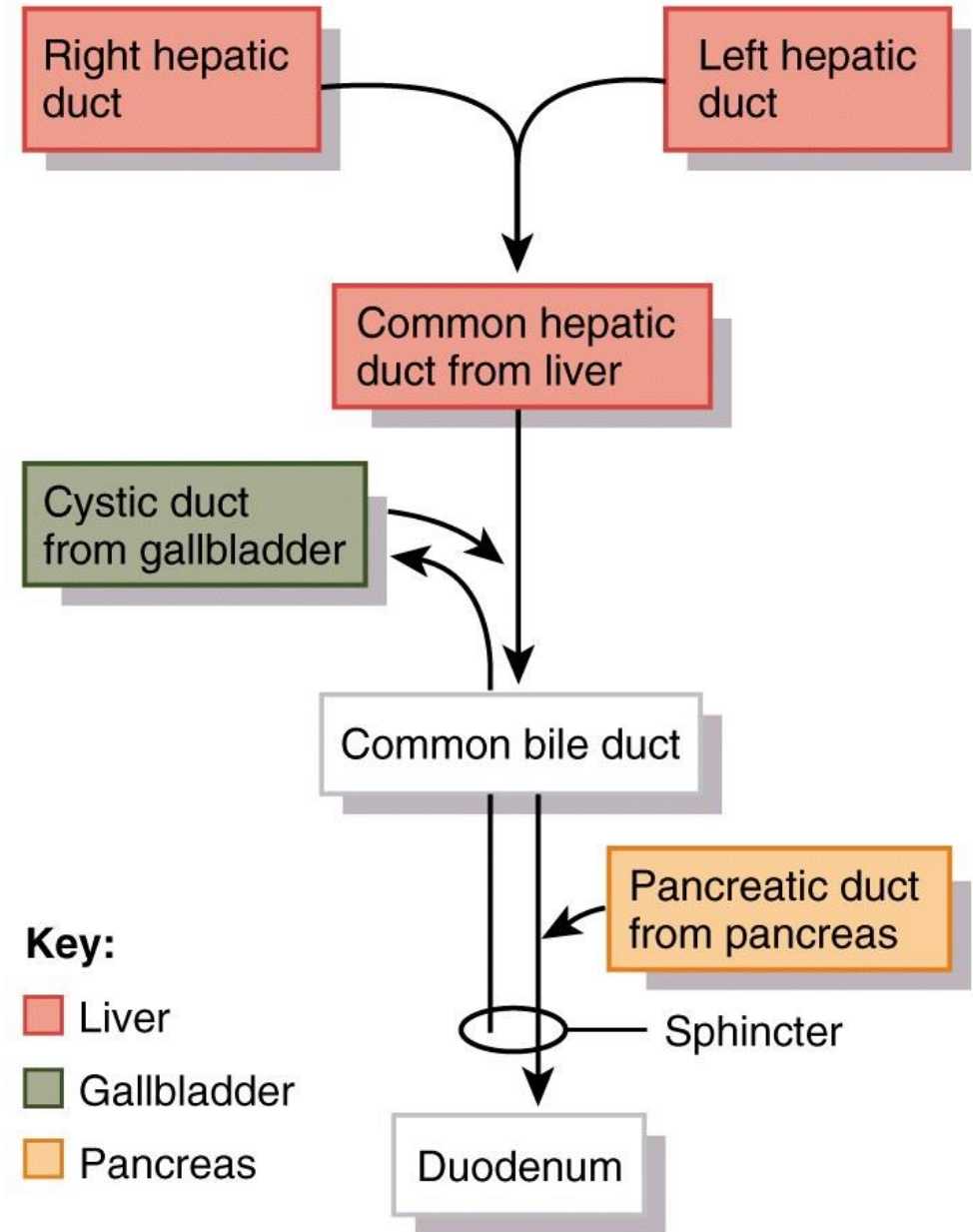
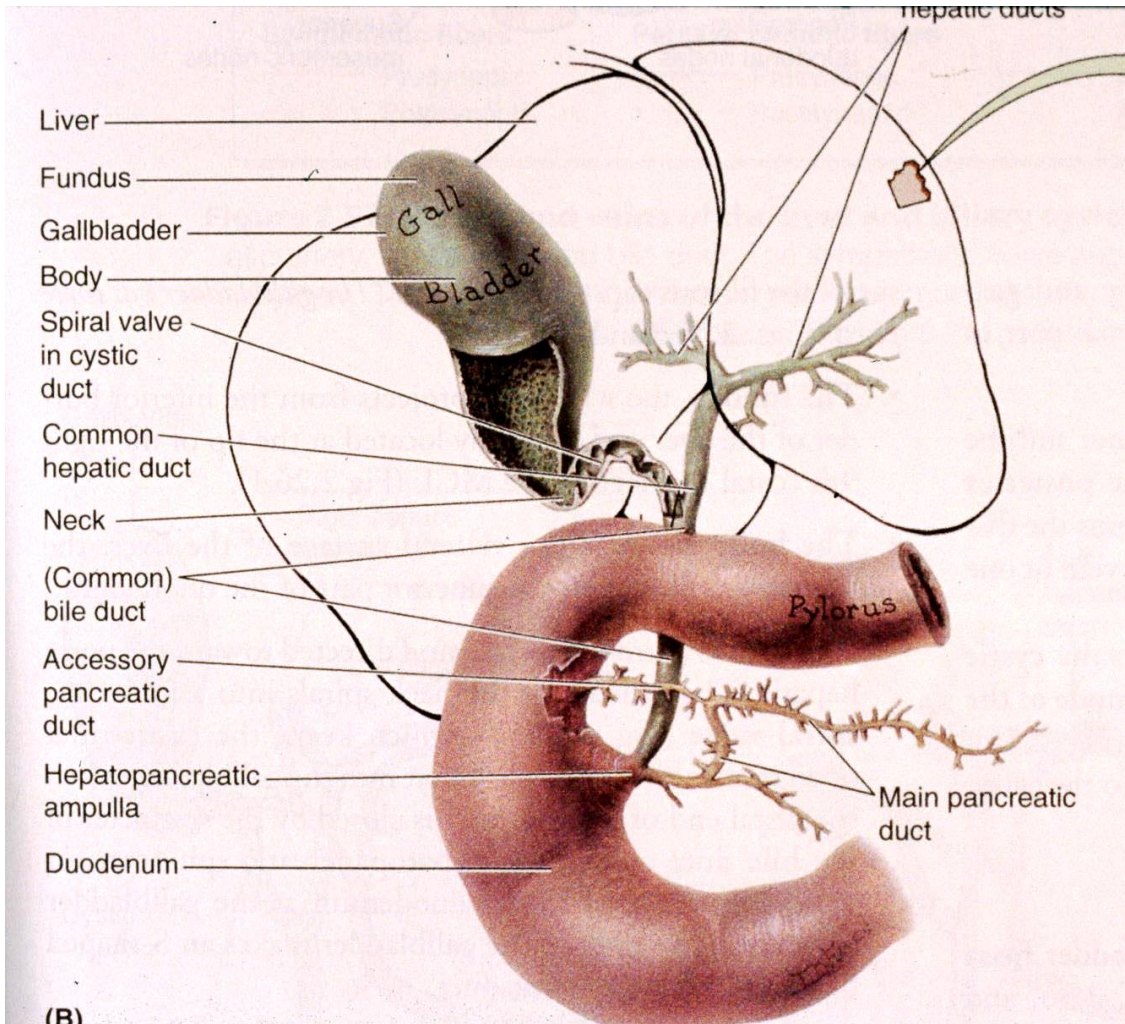
* Biliary system:

1. **Gallbladder** 膽囊
2. **left and right hepatic ducts**
左右肝管
3. **cystic duct** 囊管
4. **common bile duct** 總膽管



Bile flow: gallbladder (storage) \leftrightarrow cystic duct
 left and right hepatic ducts \rightarrow common hepatic duct
 \rightarrow common bile duct

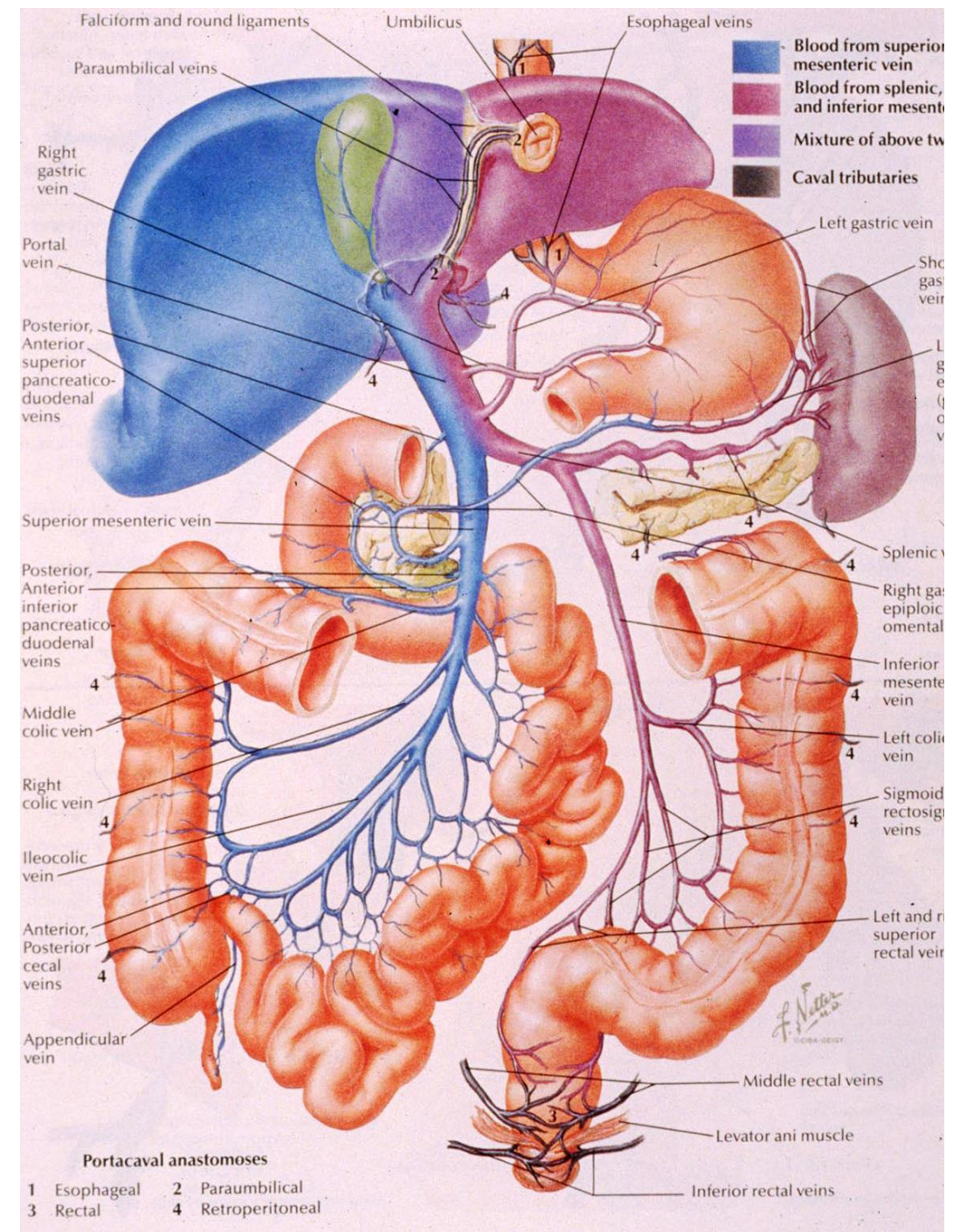
* **Sphincter of common bile duct & sphincter of hepatopancreatic ampulla 壺部 (sphincter of Oddi)**



(c) Ducts carrying bile from liver and gallbladder and pancreatic juice from pancreas to the duodenum

Liver Metabolic functions:

1. Formation of urea from amino acids.
2. Manufacture of blood (plasma) proteins.
3. Formation of erythrocytes during fetal life.
4. Synthesis of the blood-clotting agent fibrinogen.
5. Detoxification of many poisons.
6. Synthesis of bile salts.



Overview of the Functions of the Gastrointestinal Organs

Organ

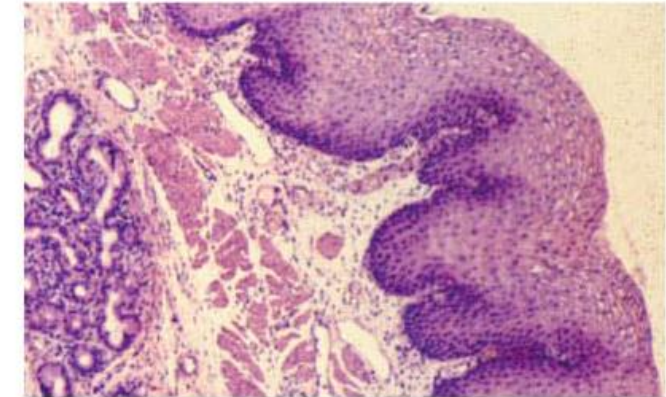
Major Functions*

Histology of the Mucosa

Mouth and associated accessory organs



- Ingestion: food is voluntarily placed into oral cavity.
- Propulsion: swallowing initiated by tongue; propels food into pharynx.
- Mechanical digestion: mastication (chewing) by teeth and mixing movements by tongue.
- Chemical digestion: chemical breakdown of starch is begun by salivary amylase present in saliva produced by salivary glands.
- Propulsion: peristaltic waves move food bolus to stomach.



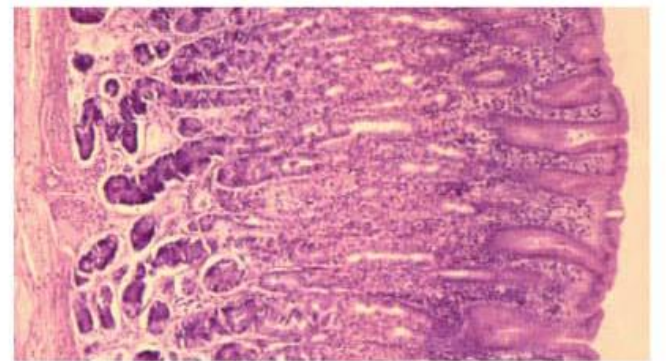
Mucosal epithelium composed of stratified squamous cells (21×).

Pharynx and esophagus

Stomach



- Mechanical digestion and propulsion: peristaltic waves mix food with gastric juice and propel it into the duodenum.
- Chemical digestion: digestion of proteins begun by pepsin.
- Absorption: absorbs a few fat-soluble substances (aspirin, alcohol, some drugs).



Gastric glands in the mucosa of simple columnar epithelium secrete mucus, hydrochloric acid, and enzymes (21×).

Organ

Small intestine and associated accessory organs (liver, gallbladder, pancreas)



Major Functions*

- Mechanical digestion and propulsion: segmentation by smooth muscle of the small intestine mixes contents with digestive juices, and peristalsis moves food along tract and through ileocecal valve at a slow rate.
- Chemical digestion: digestive enzymes conveyed in from pancreas and brush border enzymes attached to microvilli membranes complete digestion of all classes of foods.
- Absorption: breakdown products of carbohydrate, protein, fat, and nucleic acid digestion, plus vitamins, electrolytes, and water, are absorbed by active and passive mechanisms.

Histology of the Mucosa

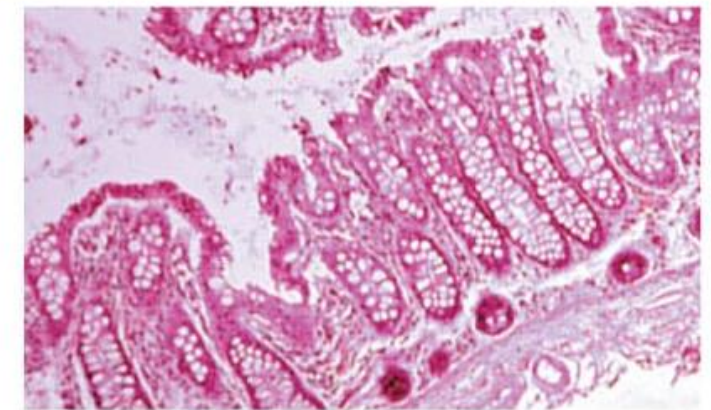


Villi, projections of the mucosa, and microvilli on the absorptive cells increase the surface area for digestion and absorption (21 ×).

Large intestine



- Chemical digestion: some remaining food residues are digested by enteric bacteria (which also produce vitamin K and some B vitamins).
- Absorption: absorbs most remaining water, electrolytes (largely NaCl), and vitamins produced by bacteria.
- Propulsion: propels feces toward rectum by peristalsis, haustral churning, and mass movements.
- Defecation: reflex triggered by rectal distension; eliminates feces from body.



Large numbers of goblet cells secrete mucus to aid the passage of feces (21 ×).