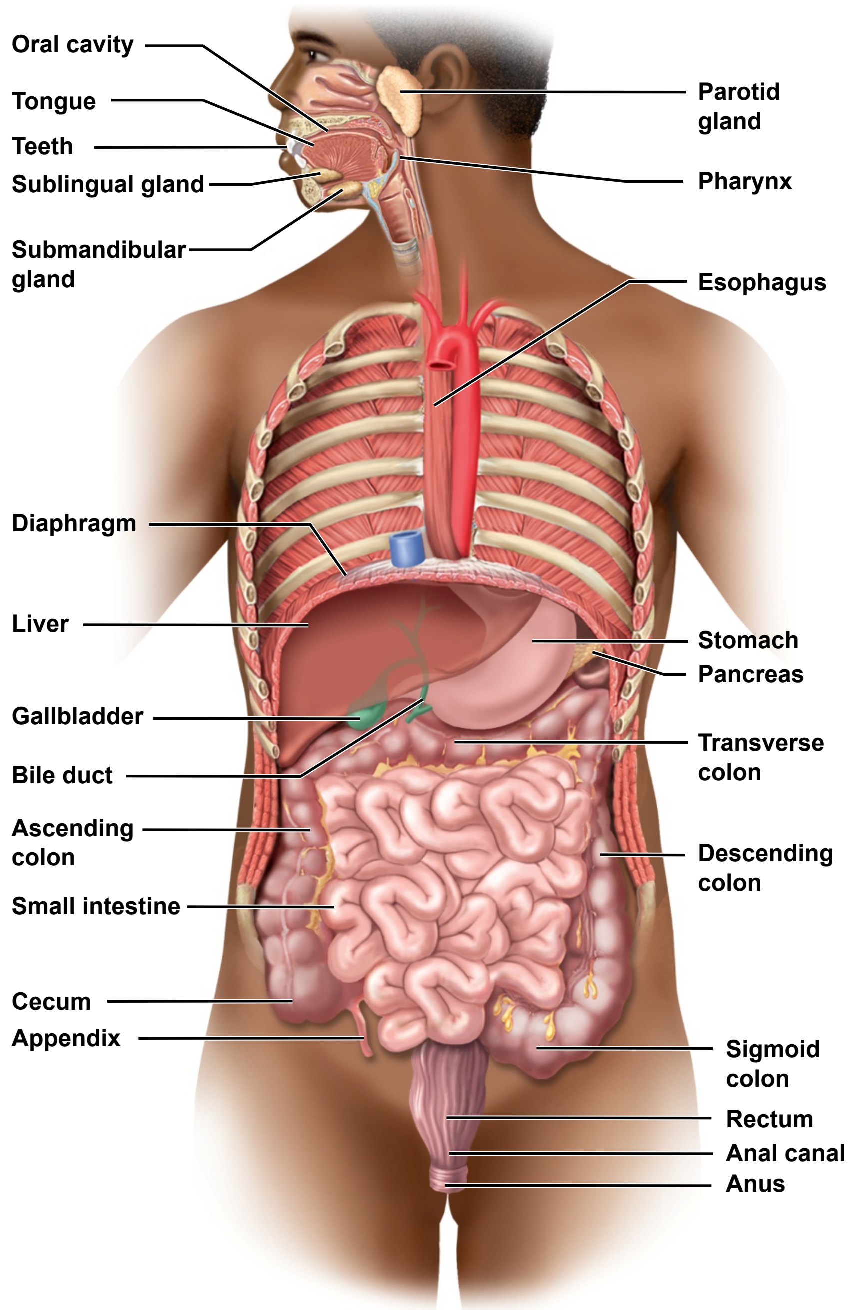
Fig. 25.1



Oral cavity
Tongue
Teeth
Sublingual gland
Submandibular gland
Diaphragm
Liver
Gallbladder
Bile duct
Ascending colon
Small intestine
Cecum
Appendix
Parotid gland
Pharynx
Esophagus
Stomach
Pancreas
Transverse colon
Descending colon
Sigmoid colon
Rectum
Anal canal
Anus

Fig. 25.2

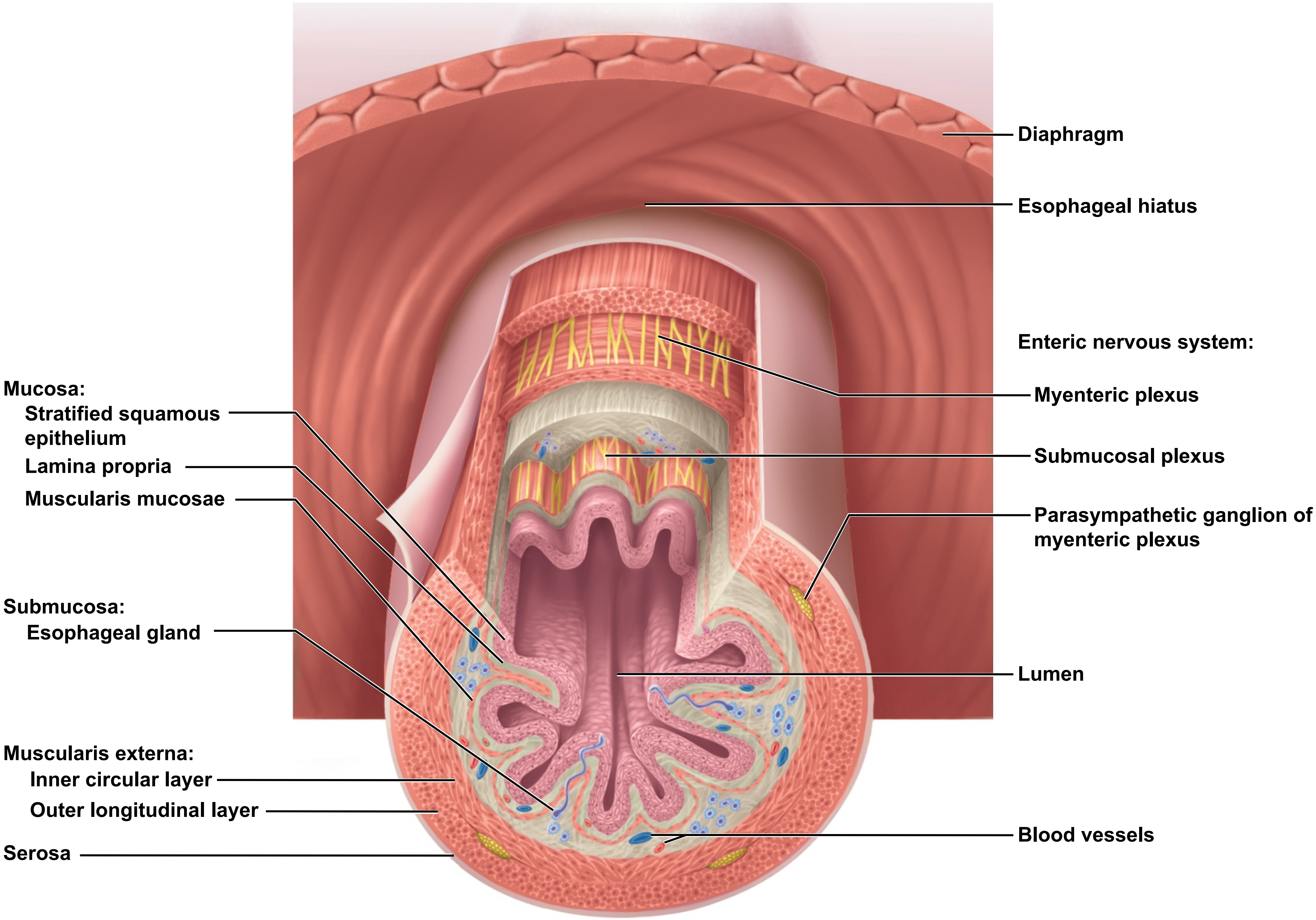
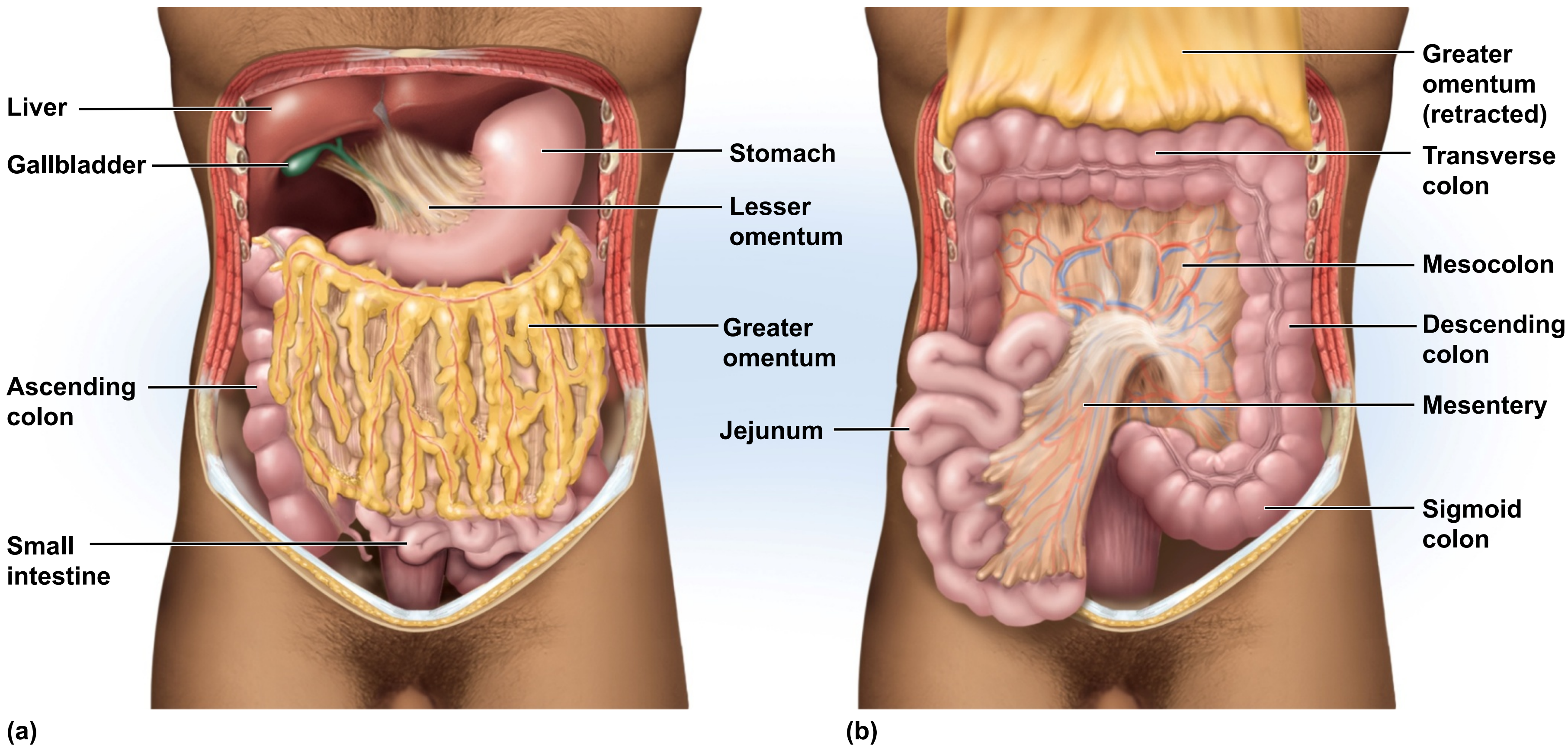
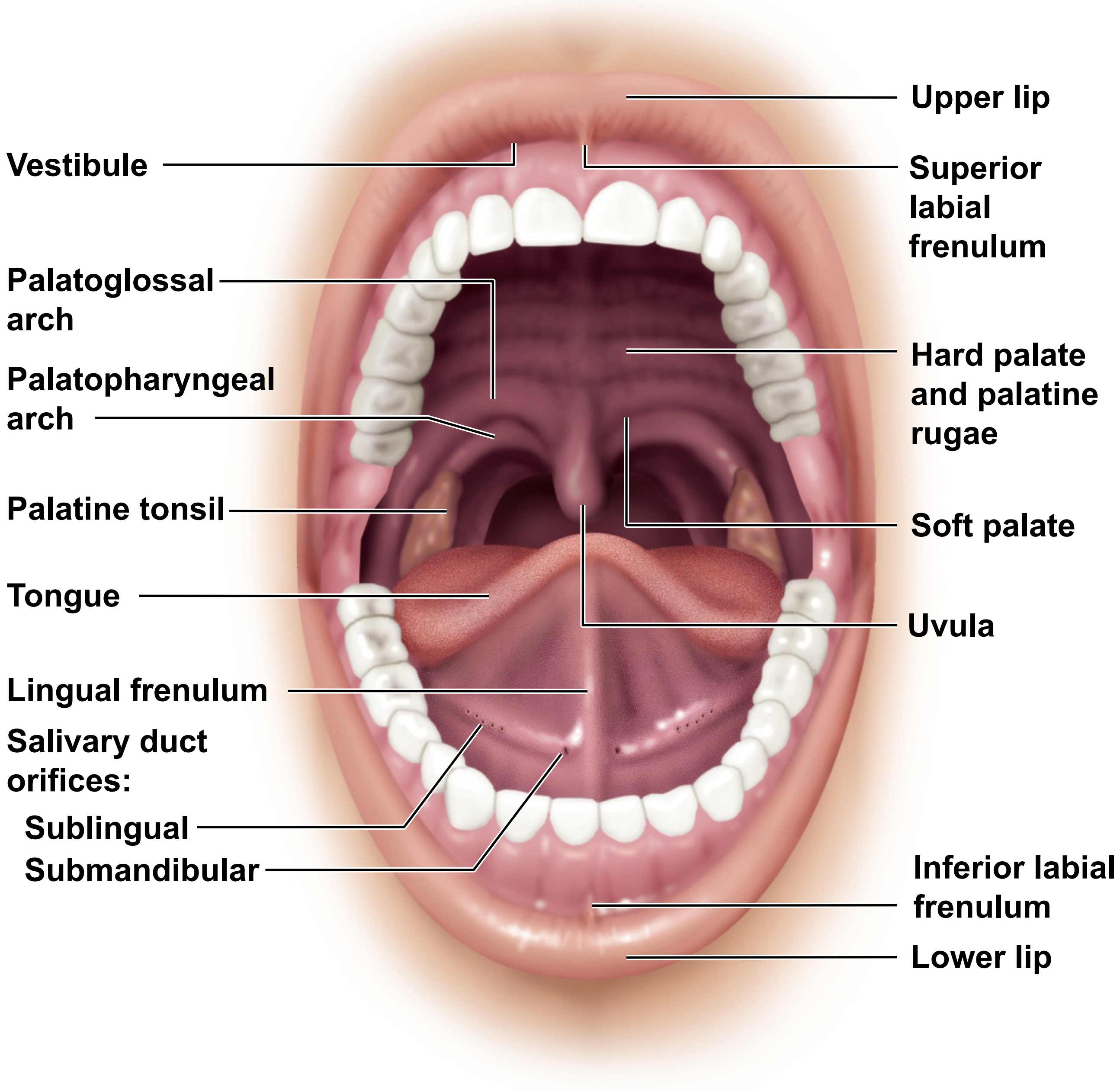

Diaphragm
Esophageal hiatus
Enteric nervous system:
Myenteric plexus
Submucosal plexus
Parasympathetic ganglion of myenteric plexus
Lumen
Blood vessels
Mucosa:
Stratified squamous epithelium
Lamina propria
Muscularis mucosae
Submucosa:
Esophageal gland
Muscularis externa:
Inner circular layer
Outer longitudinal layer
Serosa

Fig. 25.3



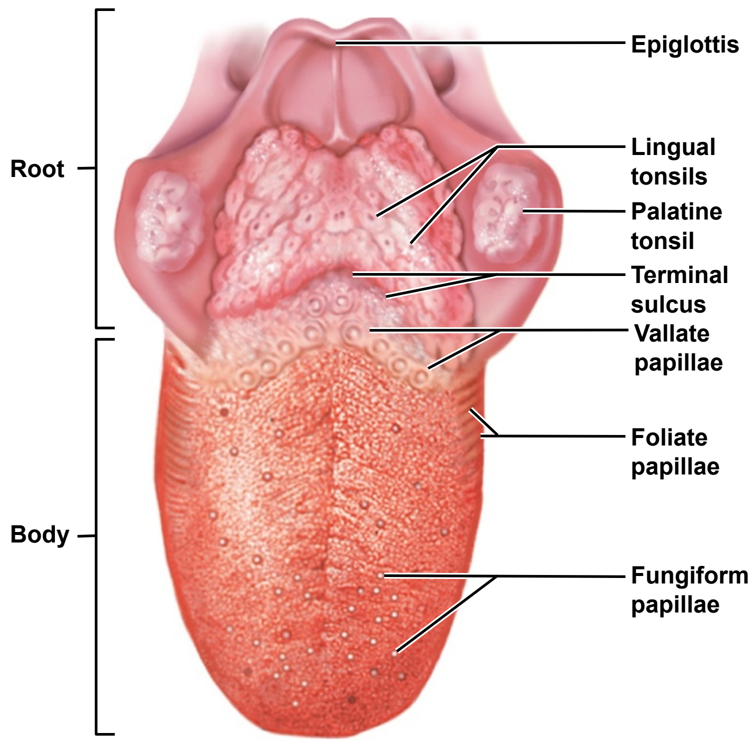
Liver
Gallbladder
Stomach
Lesser omentum
Greater omentum
Ascending colon
Small intestine
(a)
Greater omentum (retracted)
Transverse colon
Mesocolon
Descending colon
Mesentery
Jejunum
Sigmoid colon
(b)

Fig. 25.4

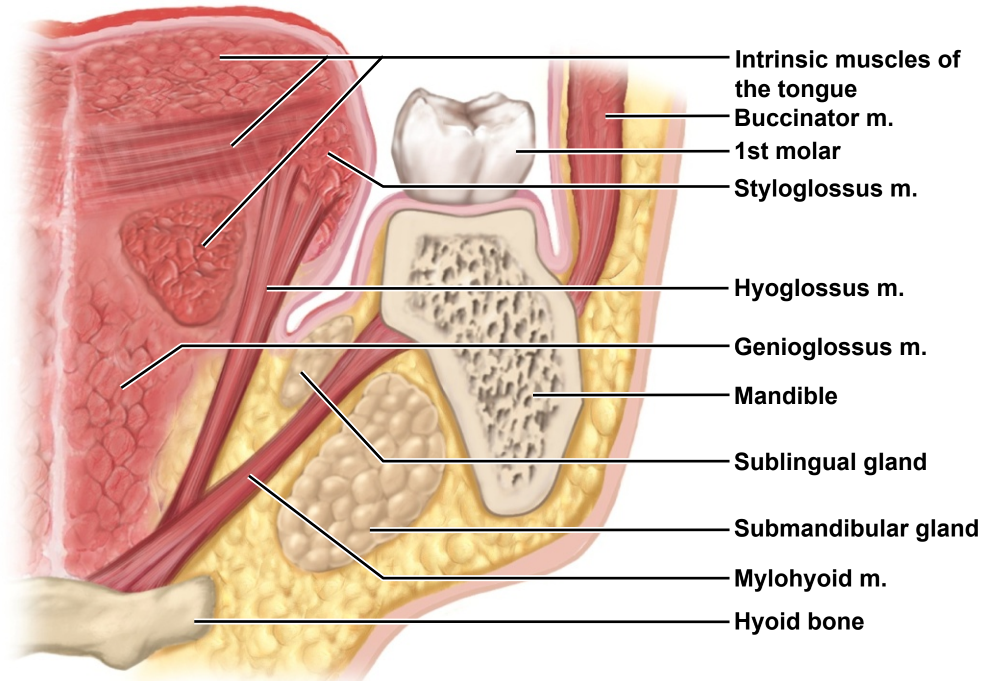


Upper lip
Vestibule
Superior labial frenulum
Palatoglossal arch
Palatopharyngeal arch
Hard palate and palatine rugae
Palatine tonsil
Soft palate
Tongue
Uvula
Lingual frenulum
Salivary duct orifices:
Sublingual
Submandibular
Inferior labial frenulum
Lower lip

Fig. 25.5



(a) Superior view



(b) Frontal section, anterior view

Fig. 25.6

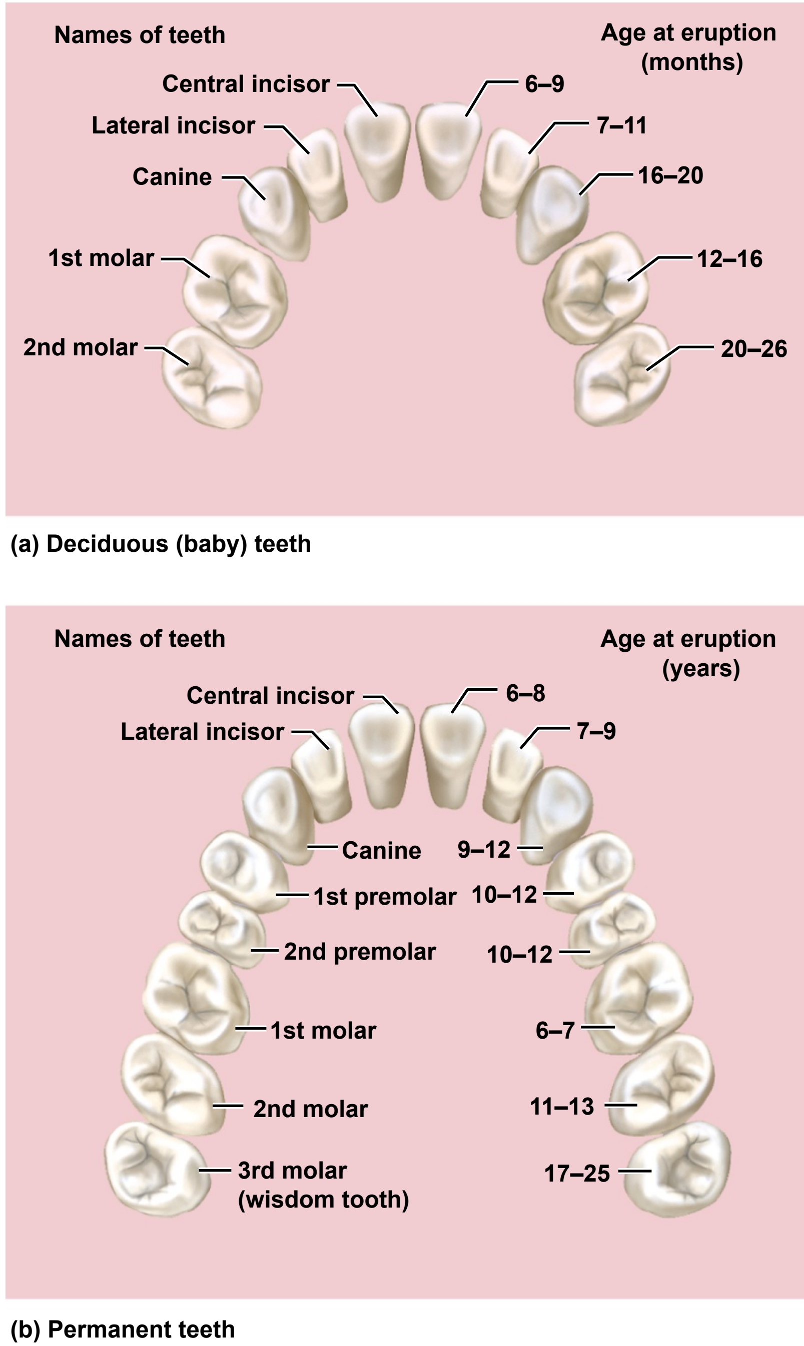
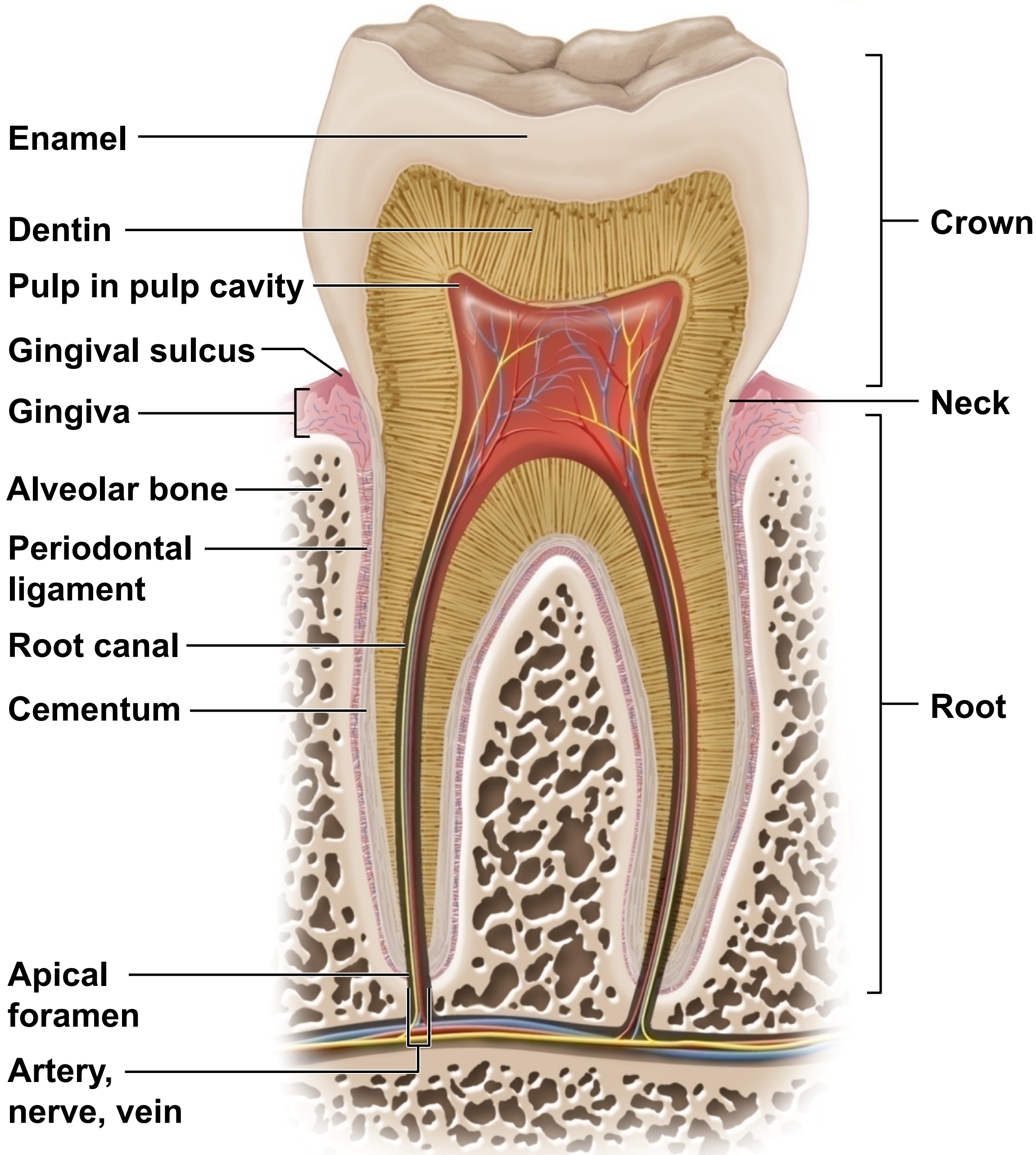
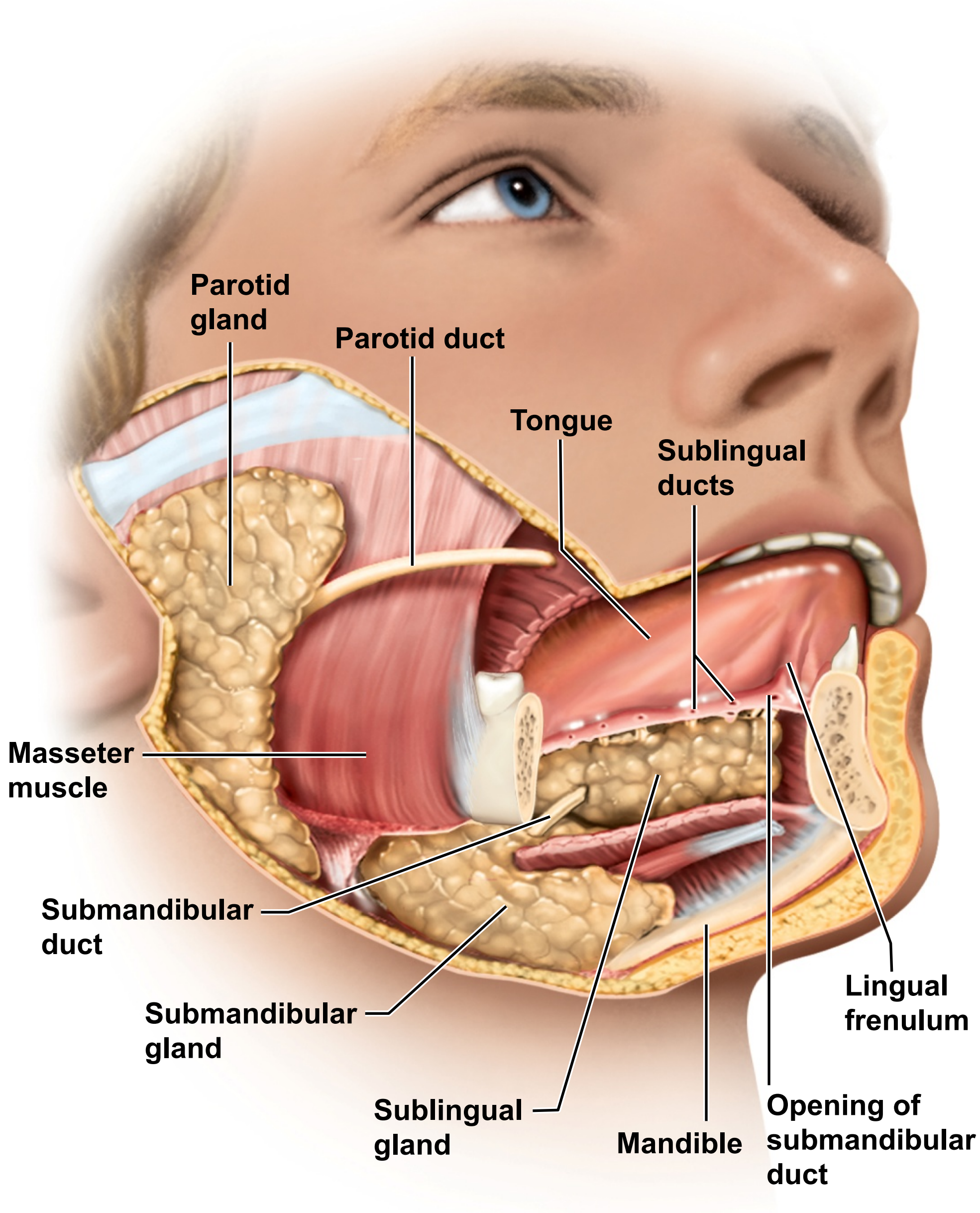

Names of teeth
Age at eruption (months)
Central incisor
Lateral incisor
Canine
1st molar
2nd molar
6–9
7–11
16–20
12–16
20–26
(a) Deciduous (baby) teeth
Names of teeth
Age at eruption (years)
Central incisor
Lateral incisor
Canine
1st premolar
2nd premolar
1st molar
2nd molar
3rd molar (wisdom tooth)
6–8
7–9
9–12
10–12
10–12
6–7
11–13
17–25
(b) Permanent teeth

Fig. 25.7



Enamel
Dentin
Pulp in pulp cavity
Gingival sulcus
Gingiva
Alveolar bone
Periodontal ligament
Root canal
Cementum
Apical foramen
Artery, nerve, vein
Crown
Neck
Root

Fig. 25.9



Parotid gland
Parotid duct
Tongue
Sublingual ducts
Masseter muscle
Submandibular duct
Submandibular gland
Sublingual gland
Mandible
Opening of submandibular duct
Lingual frenulum

Fig. 25.10

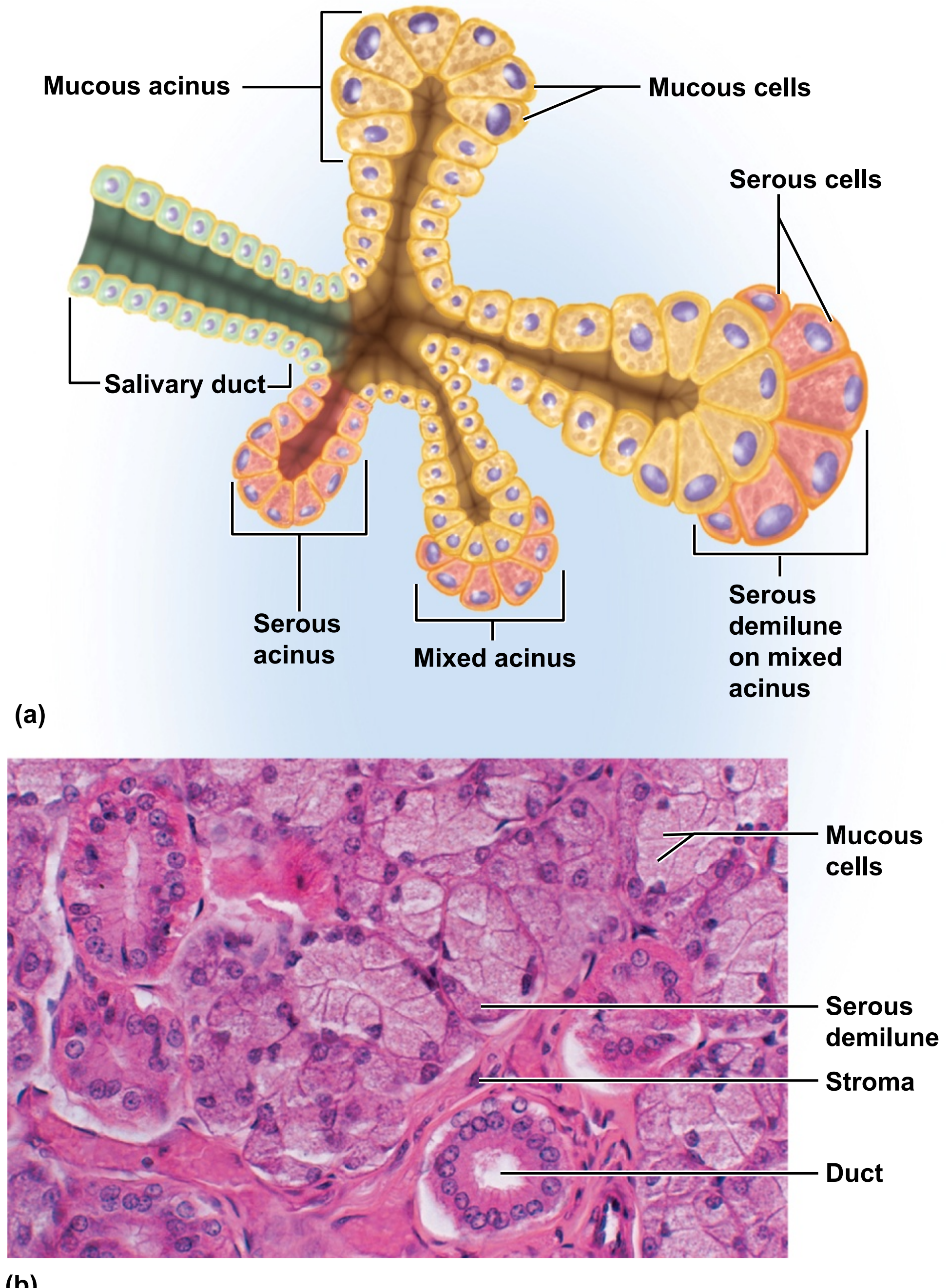
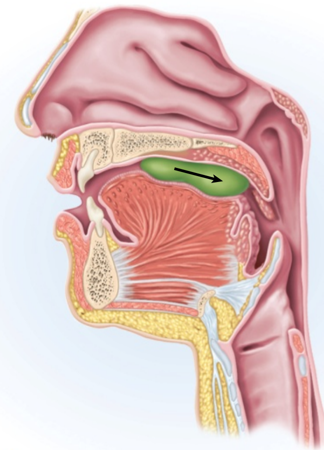
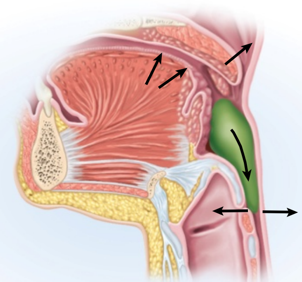

Mucous acinus
Mucous cells
Serous cells
Salivary duct
Serous acinus
Mixed acinus
Serous demilune on mixed acinus
(a)
Mucous cells
Serous demilune
Stroma
Duct
(b)

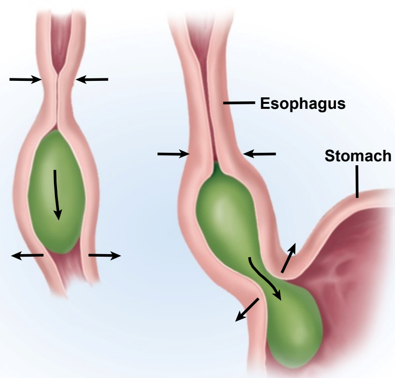
Fig. 25.11



1 Oral phase. The tongue forms a food bolus and pushes it into the laryngopharynx.



2 Pharyngeal phase. The palate, tongue, vocal cords, and epiglottis block the oral and nasal cavities and airway while pharyngeal constrictors push the bolus into the esophagus.



3 Esophageal phase. Peristalsis drives the bolus downward, and relaxation of the lower esophageal sphincter admits it into the stomach.

Fig. 25.12

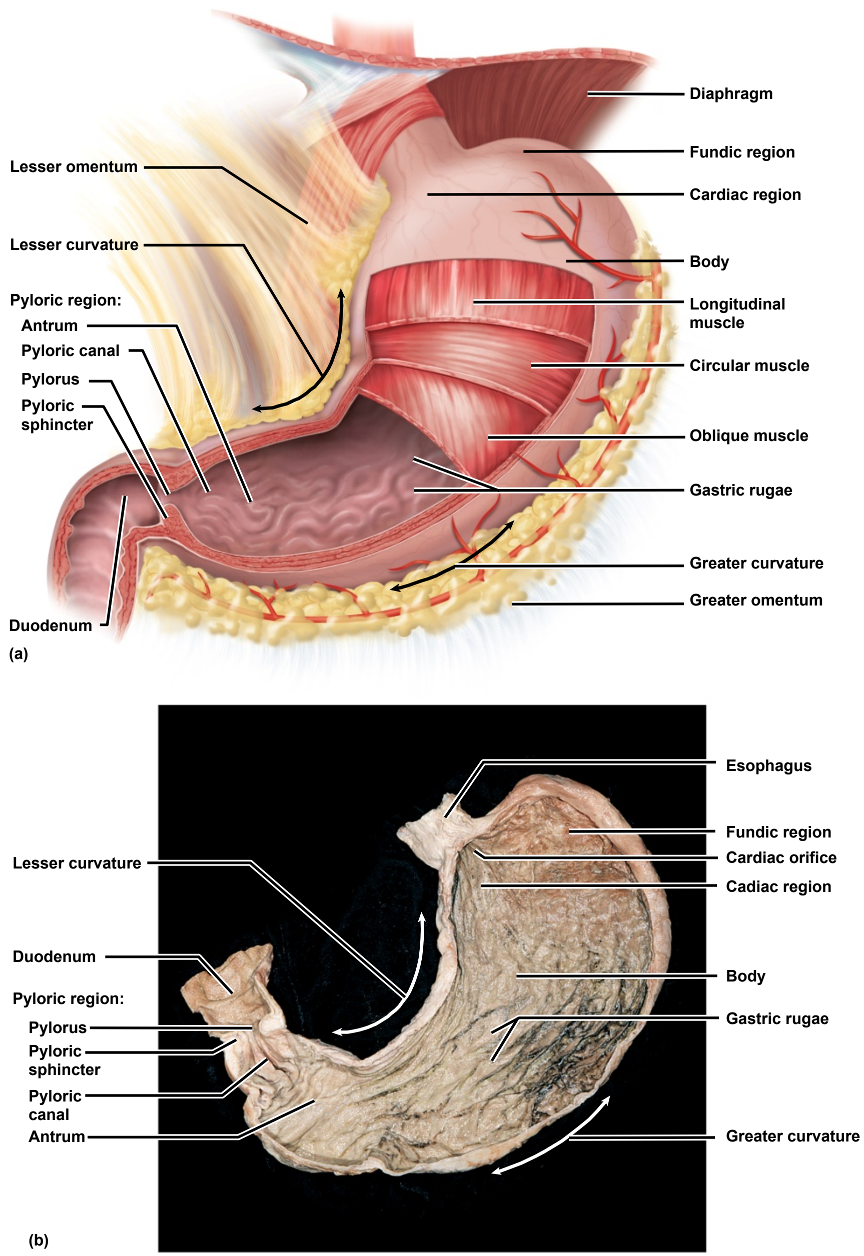
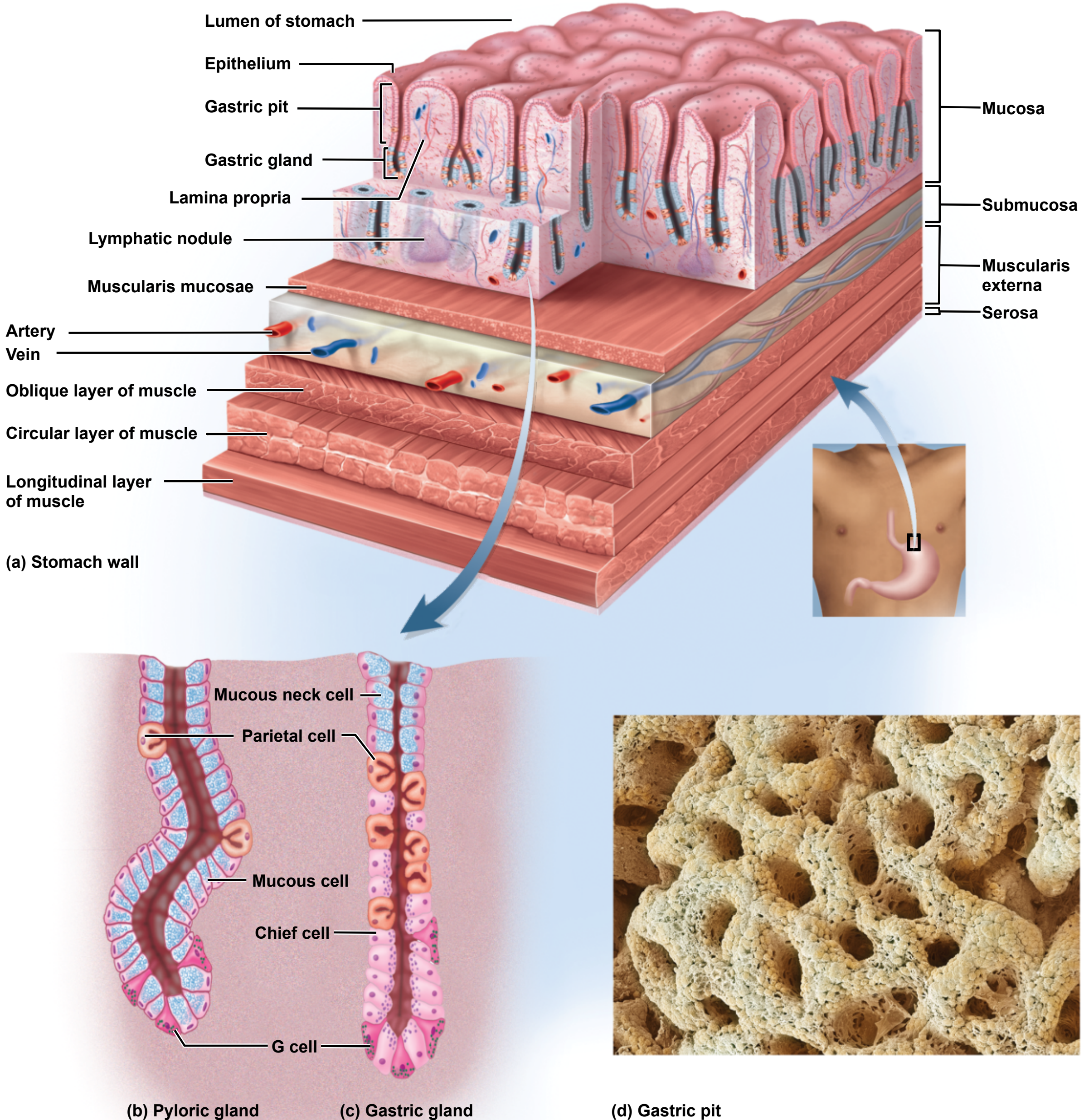
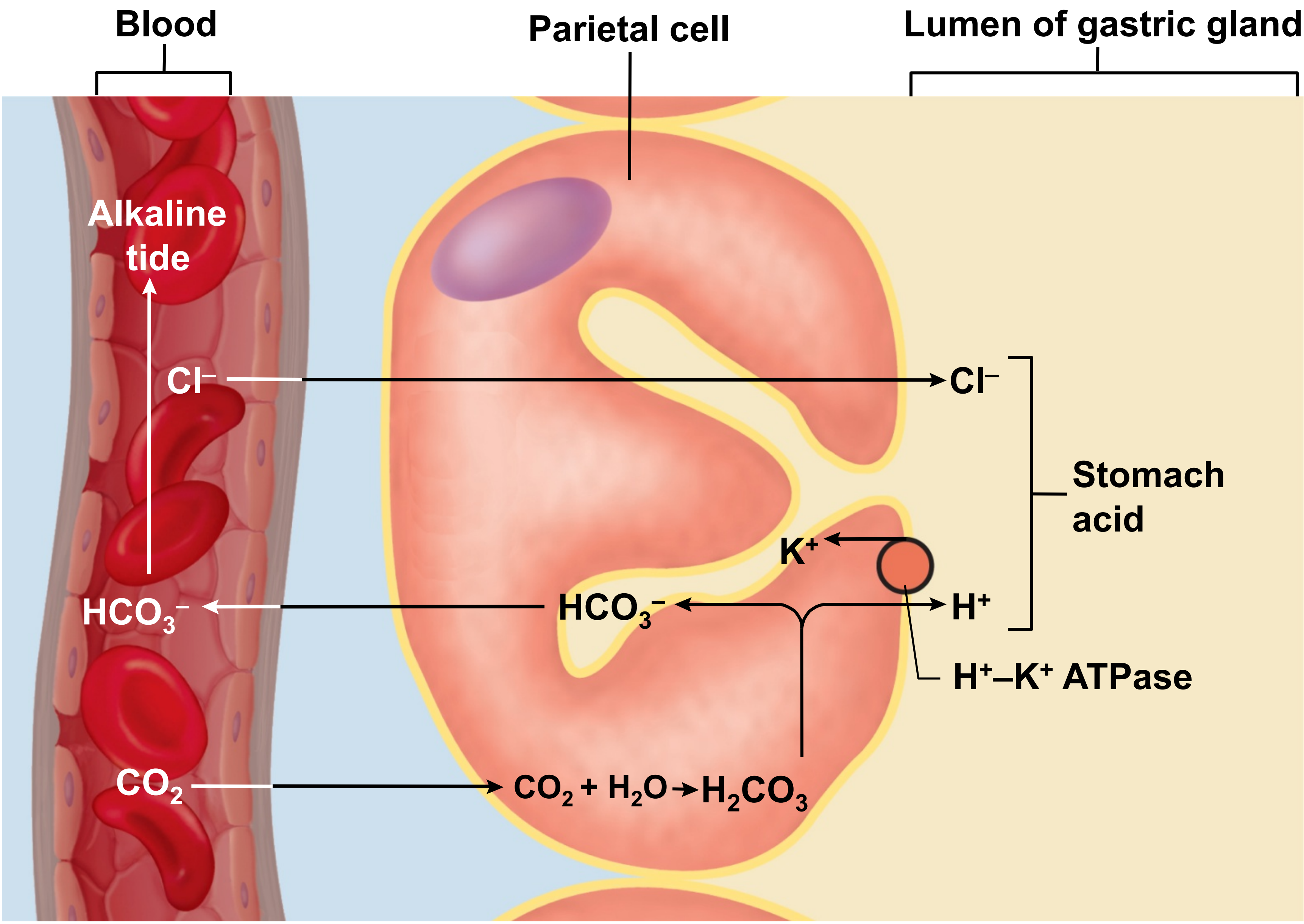

Diaphragm
Fundic region
Cardiac region
Body
Longitudinal muscle
Circular muscle
Oblique muscle
Gastric rugae
Greater curvature
Greater omentum
Lesser omentum
Lesser curvature
Pyloric region:
Antrum
Pyloric canal
Pylorus
Pyloric sphincter
Duodenum
(a)
Esophagus
Fundic region
Cardiac orifice
Cadiac region
Body
Gastric rugae
Greater curvature
Lesser curvature
Duodenum
Pyloric region:
Pylorus
Pyloric sphincter
Pyloric canal
Antrum
(b)

Fig. 25.13



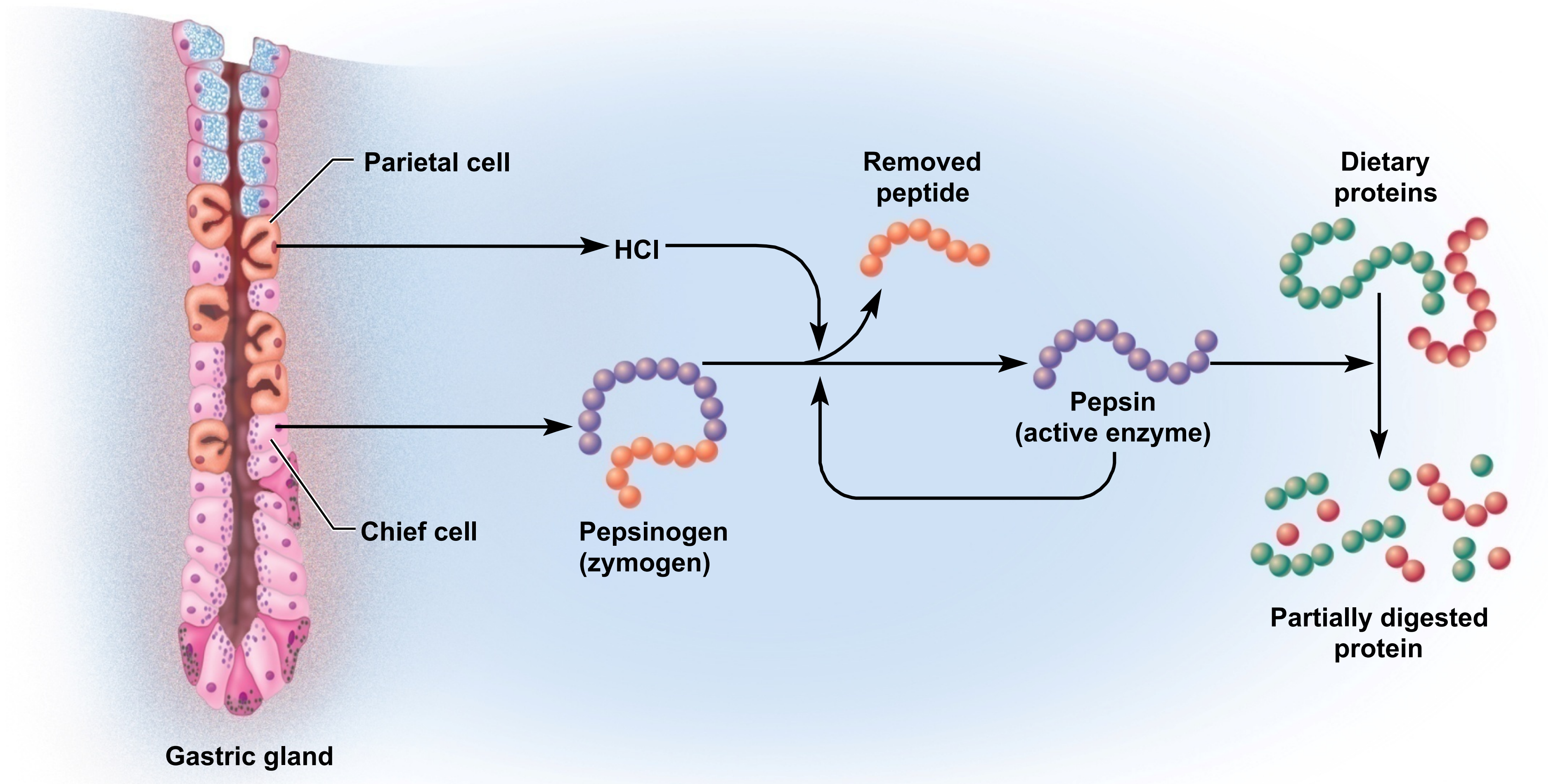
Lumen of stomach
Epithelium
Gastric pit
Gastric gland
Lamina propria
Lymphatic nodule
Muscularis mucosae
Artery
Vein
Oblique layer of muscle
Circular layer of muscle
Longitudinal layer of muscle
Mucosa
Submucosa
Muscularis externa
Serosa
(a) Stomach wall
Mucous neck cell
Parietal cell
Mucous cell
Chief cell
G cell
(b) Pyloric gland
(c) Gastric gland
(d) Gastric pit

Fig. 25.14



Blood
Parietal cell
Lumen of gastric gland
Alkaline tide
Cl^-
Cl^-
Stomach acid
K^+
HCO_3^-
HCO_3^-
H^+
H^+–K^+ ATPase
CO_2
$CO_2 + H_2O \rightarrow H_2CO_3$

Fig. 25.15

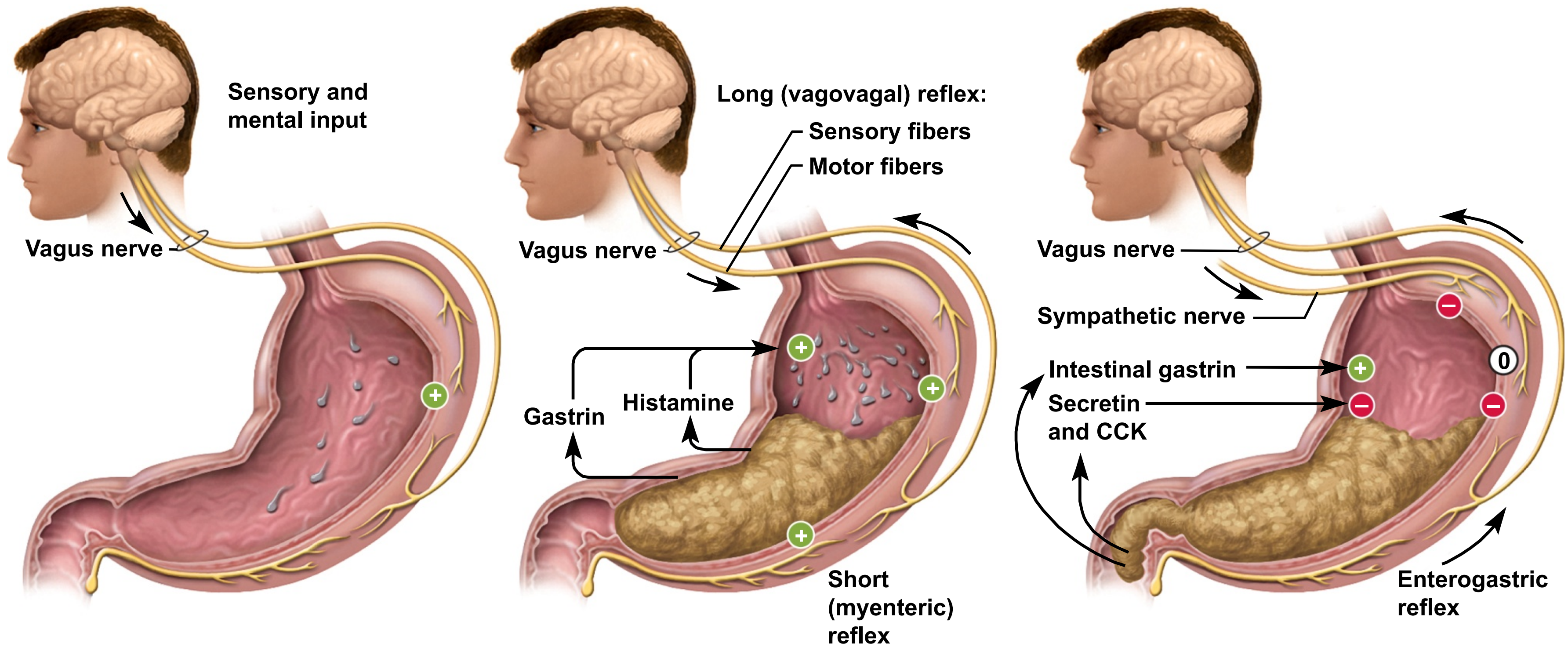


Parietal cell
HCl
Removed peptide
Dietary proteins
Pepsin (active enzyme)
Chief cell
Pepsinogen (zymogen)
Partially digested protein
Gastric gland

Table 25.1

TABLE 25.1	Major Secretions of the Gastric Glands	
Secretory Cells	**Secretion**	**Function**
Mucous neck cells	Mucus	Protects mucosa from HCl and enzymes
Parietal cells	Hydrochloric acid	Activates pepsin and lingual lipase; helps liquefy food; reduces dietary iron to usable form (Fe^{2+}); destroys ingested pathogens
	Intrinsic factor	Enables small intestine to absorb vitamin B_{12}
Chief cells	Pepsinogen	Converted to pepsin, which digests protein
	Gastric lipase	Digests fat
Enteroendocrine cells	Gastrin	Stimulates gastric glands to secrete HCl and enzymes; stimulates intestinal motility; relaxes ileocecal valve
	Serotonin	Stimulates gastric motility
	Histamine	Stimulates HCl secretion
	Somatostatin	Inhibits gastric secretion and motility; delays emptying of stomach; inhibits secretion by pancreas; inhibits gallbladder contraction and bile secretion; reduces blood circulation and nutrient absorption in small intestine
	Gut–brain peptides	Various roles in short- and long-term appetite regulation and energy balance

Fig. 25.17



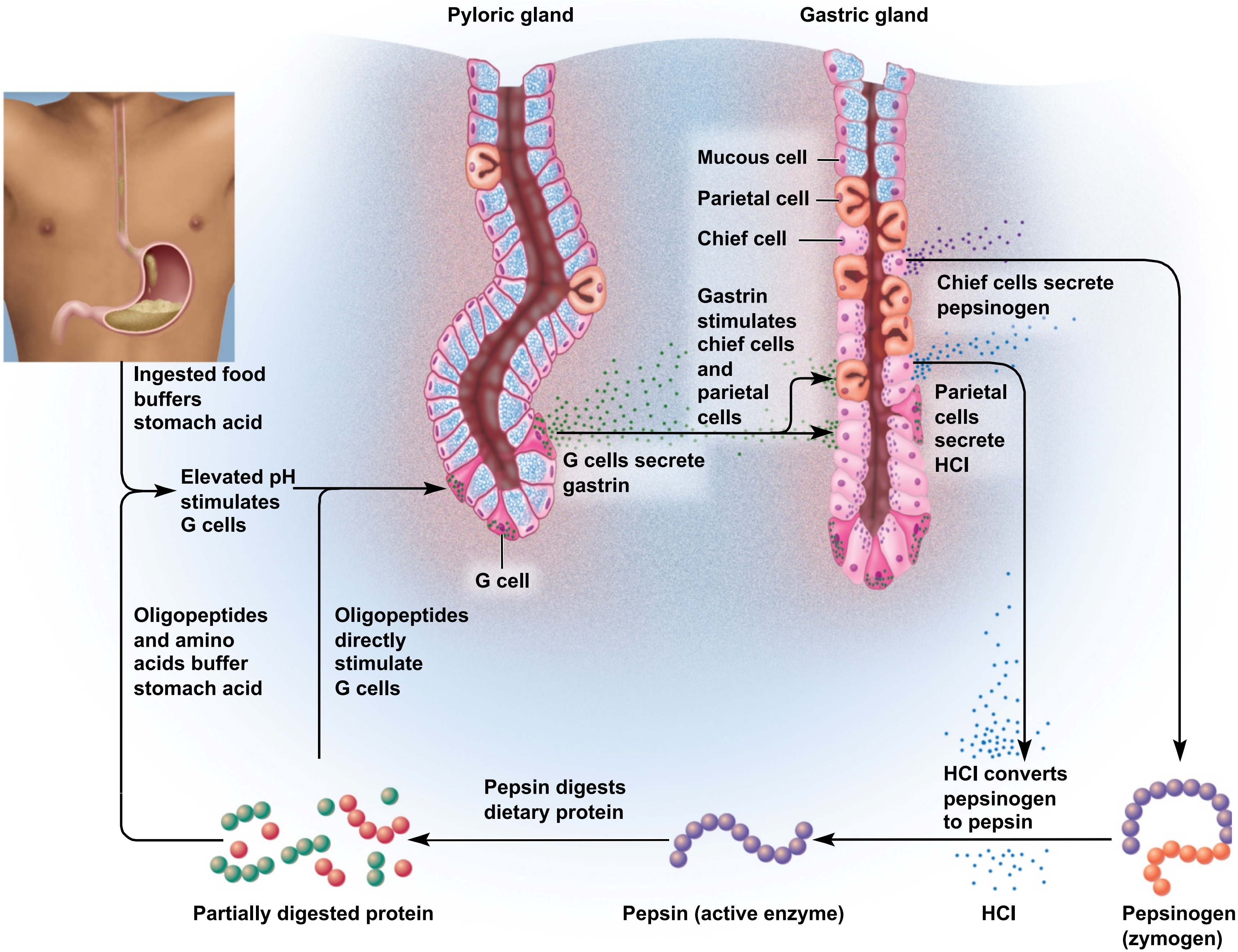
1 **Cephalic phase**
Vagus nerve stimulates gastric secretion even before food is swallowed.

2 **Gastric phase**
Food stretches the stomach and activates myenteric and vagovagal reflexes. These reflexes stimulate gastric secretion. Histamine and gastrin also stimulate acid and enzyme secretion.

3 **Intestinal phase**
Intestinal gastrin briefly stimulates the stomach, but then secretin, CCK, and the enterogastric reflex inhibit gastric secretion and motility while the duodenum processes the chyme already in it. Sympathetic nerve fibers suppress gastric activity, while vagal (parasympathetic) stimulation of the stomach is now inhibited.

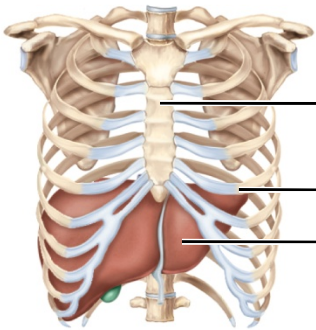
Key
- + Stimulation
- − Inhibition
- 0 Reduced or no effect

Fig. 25.18

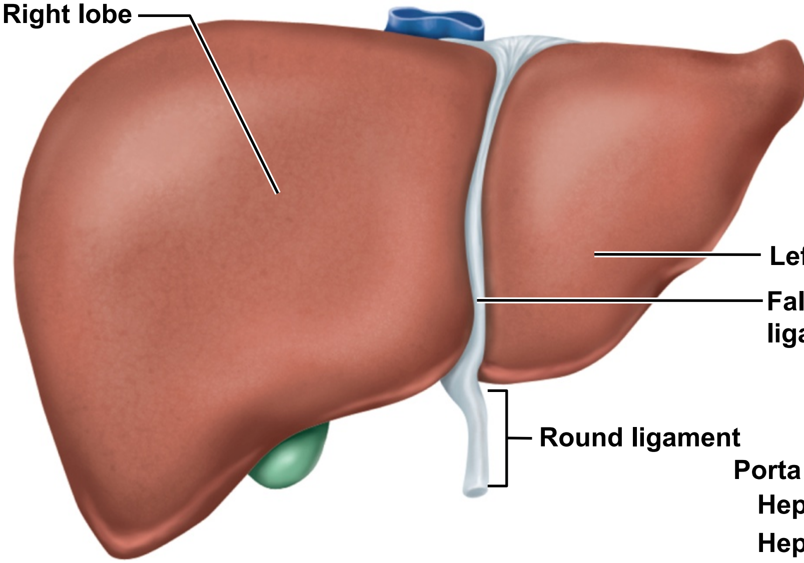


Pyloric gland
Gastric gland
Mucous cell
Parietal cell
Chief cell
Chief cells secrete pepsinogen
Gastrin stimulates chief cells and parietal cells
Parietal cells secrete HCl
G cells secrete gastrin
Ingested food buffers stomach acid
Elevated pH stimulates G cells
G cell
Oligopeptides and amino acids buffer stomach acid
Oligopeptides directly stimulate G cells
Pepsin digests dietary protein
HCl converts pepsinogen to pepsin
Partially digested protein
Pepsin (active enzyme)
HCl
Pepsinogen (zymogen)

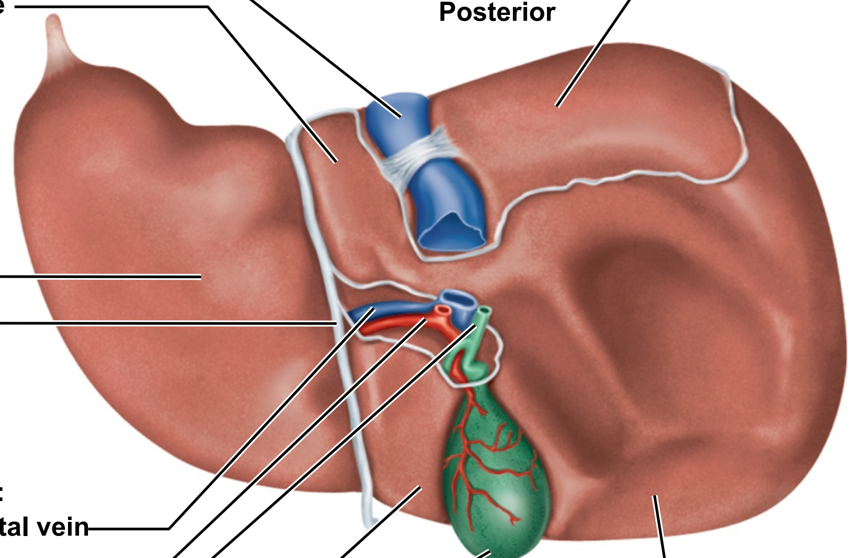
Fig. 25.19



(a) Location



(b) Anterior view



(c) Inferior view

Fig. 25.20

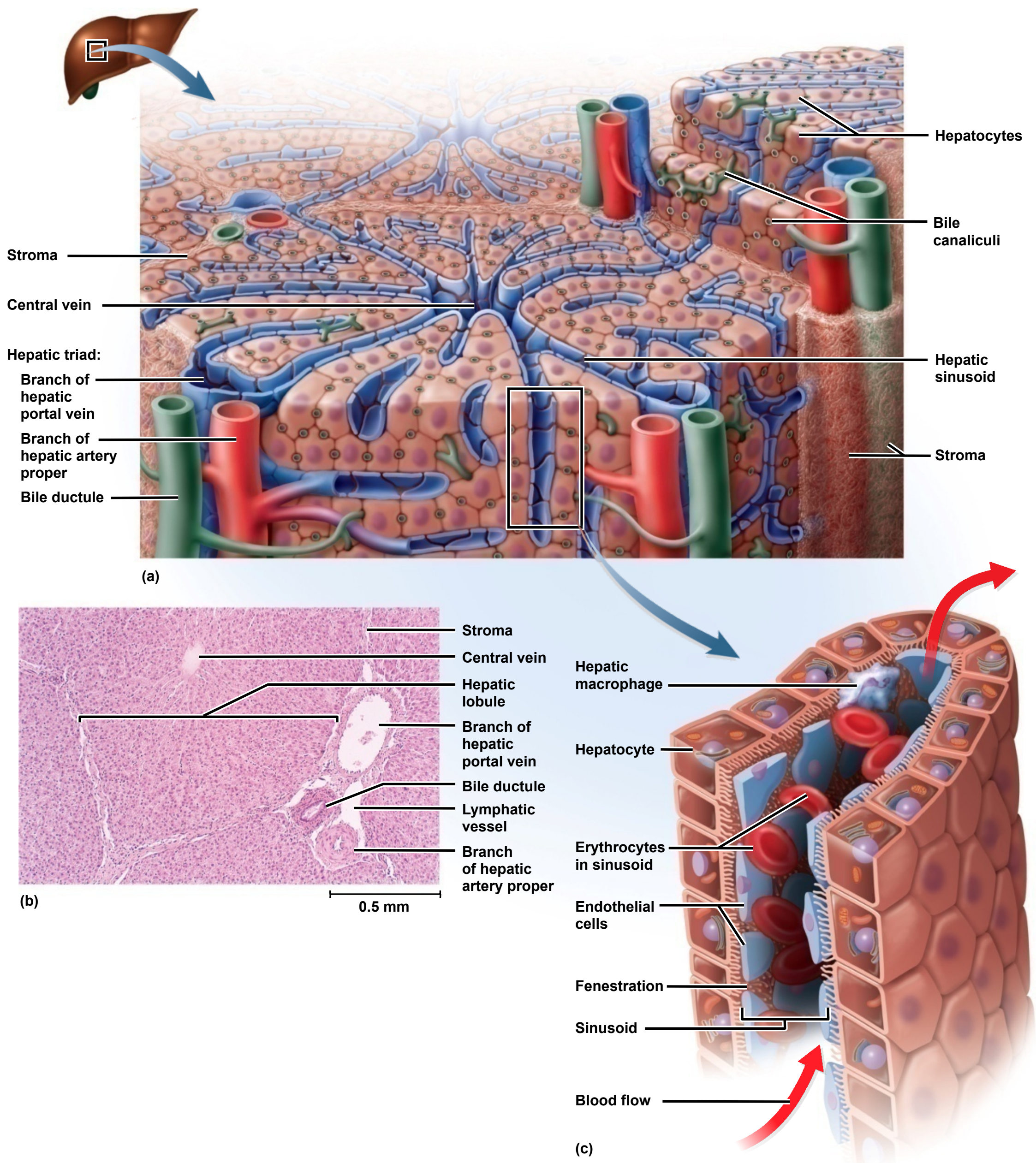

Hepatocytes
Bile canaliculi
Stroma
Central vein
Hepatic triad:
Branch of hepatic portal vein
Branch of hepatic artery proper
Bile ductule
Hepatic sinusoid
Stroma
(a)
Stroma
Central vein
Hepatic lobule
Branch of hepatic portal vein
Bile ductule
Lymphatic vessel
Branch of hepatic artery proper
(b)
0.5 mm
Hepatic macrophage
Hepatocyte
Erythrocytes in sinusoid
Endothelial cells
Fenestration
Sinusoid
Blood flow
(c)

Fig. 25.21

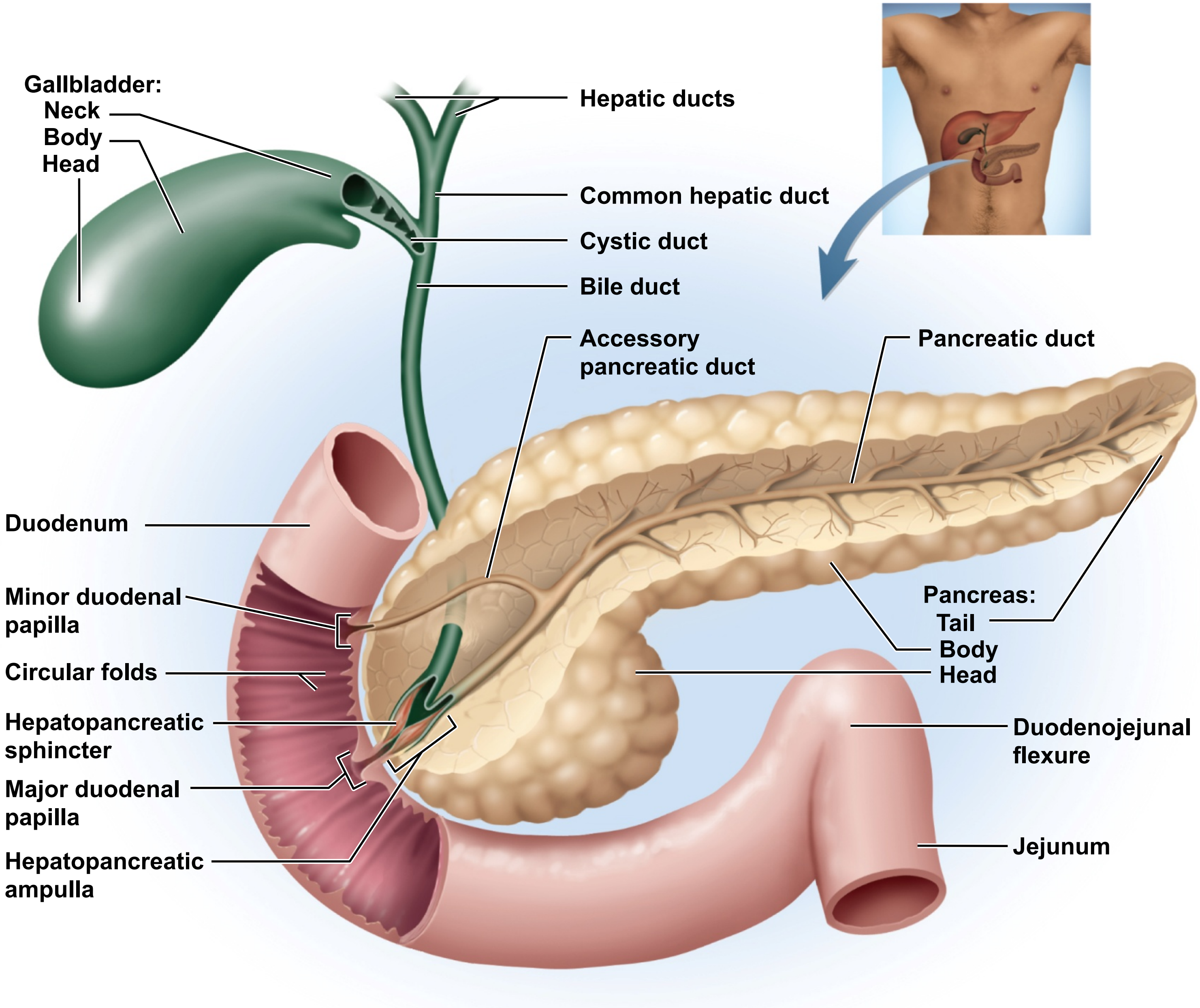
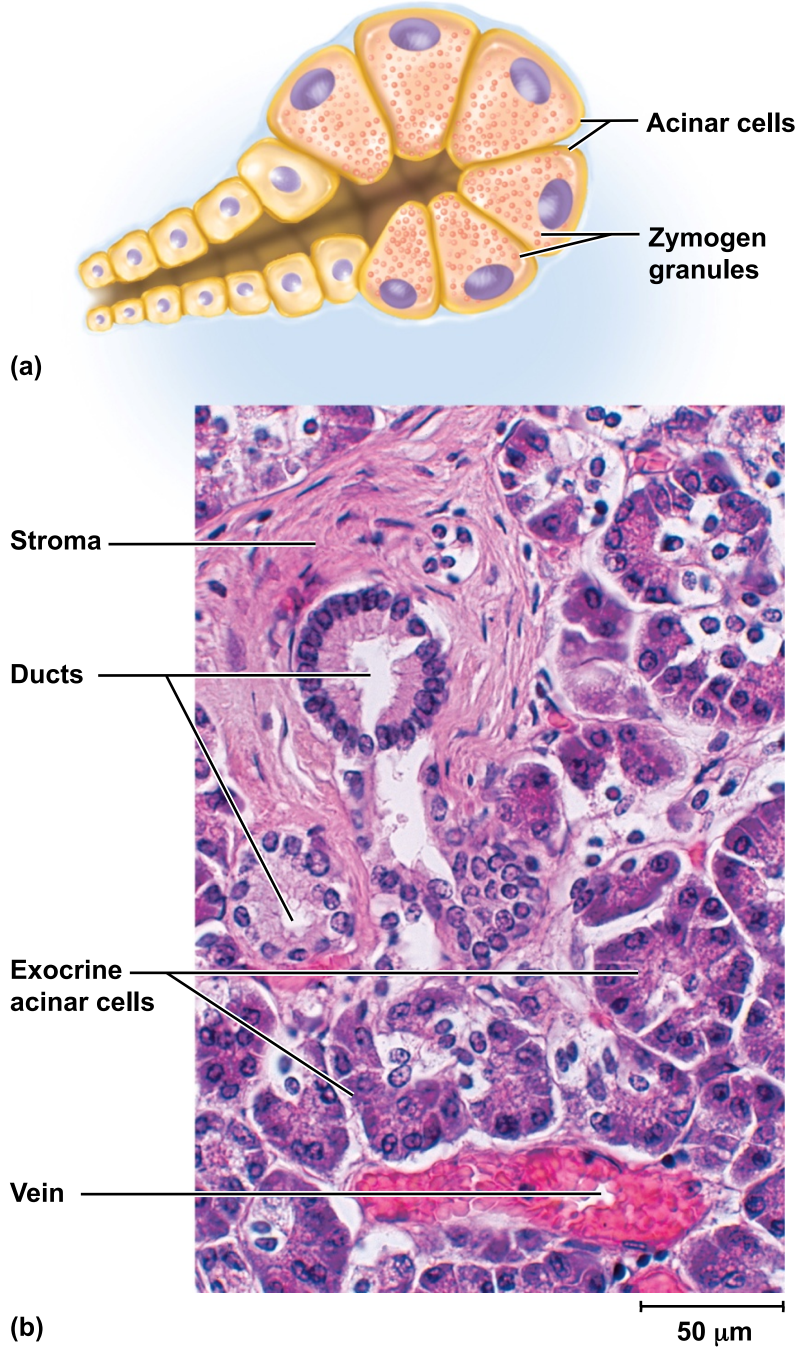

Gallbladder:
Neck
Body
Head
Hepatic ducts
Common hepatic duct
Cystic duct
Bile duct
Accessory pancreatic duct
Pancreatic duct
Duodenum
Minor duodenal papilla
Circular folds
Hepatopancreatic sphincter
Major duodenal papilla
Hepatopancreatic ampulla
Pancreas:
Tail
Body
Head
Duodenojejunal flexure
Jejunum

Fig. 25.22



b: ©McGraw-Hill Education/Dennis Strete

Fig. 25.23

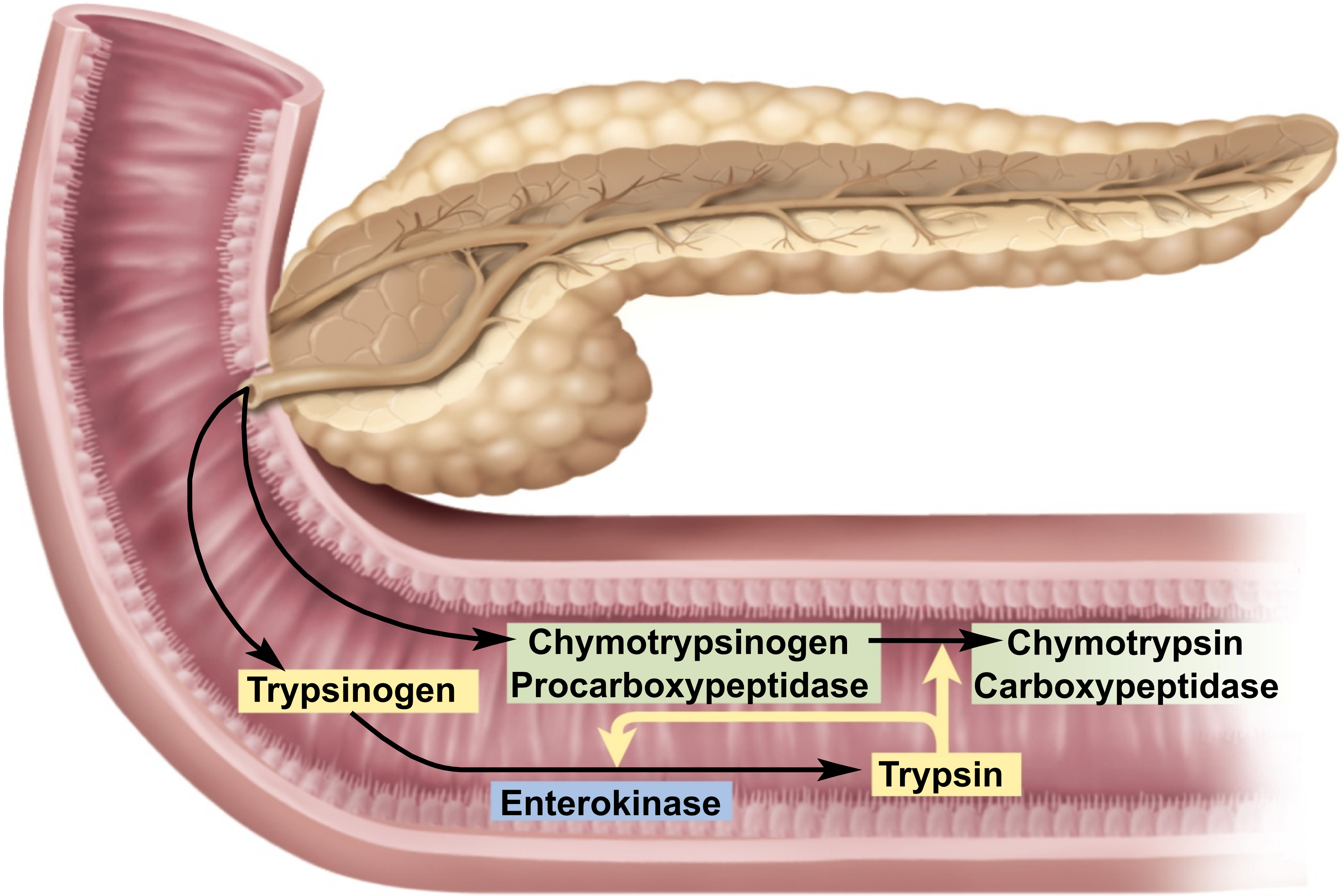

Chymotrypsinogen
Procarboxypeptidase
Chymotrypsin
Carboxypeptidase
Trypsinogen
Trypsin
Enterokinase

Table 25.2

TABLE 25.2	Exocrine Secretions of the Pancreas
Secretion	**Function**
Sodium bicarbonate	Neutralizes HCl
Zymogens	Converted to active digestive enzymes after secretion
Trypsinogen	Becomes trypsin, which digests protein
Chymotrypsinogen	Becomes chymotrypsin, which digests protein
Procarboxypeptidase	Becomes carboxypeptidase, which hydrolyzes the terminal amino acid from the carboxyl (–COOH) end of small peptides
Enzymes	
Pancreatic amylase	Digests starch
Pancreatic lipase	Digests fat
Ribonuclease	Digests RNA
Deoxyribonuclease	Digests DNA

Fig. 25.24

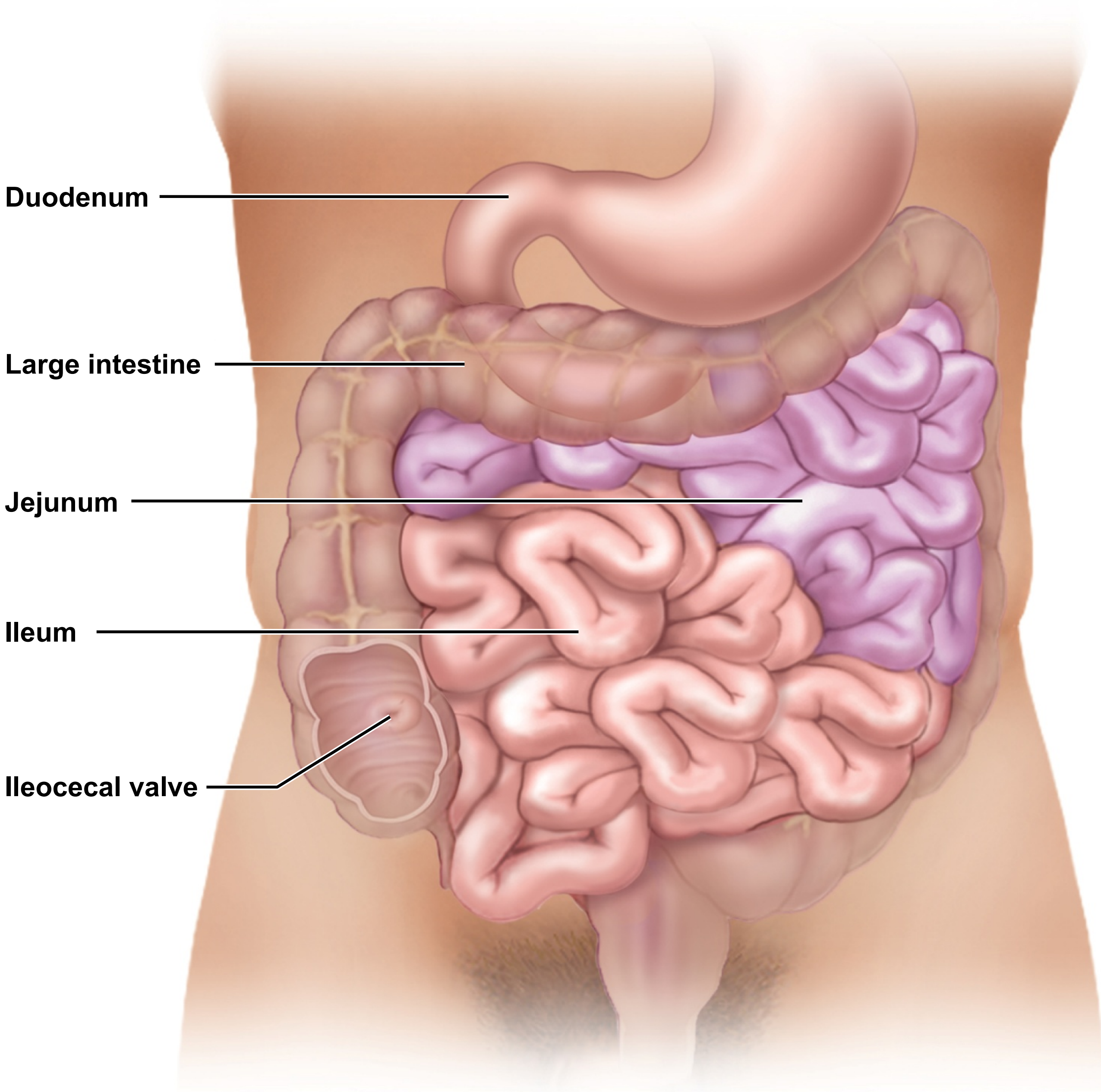


Fig. 25.25

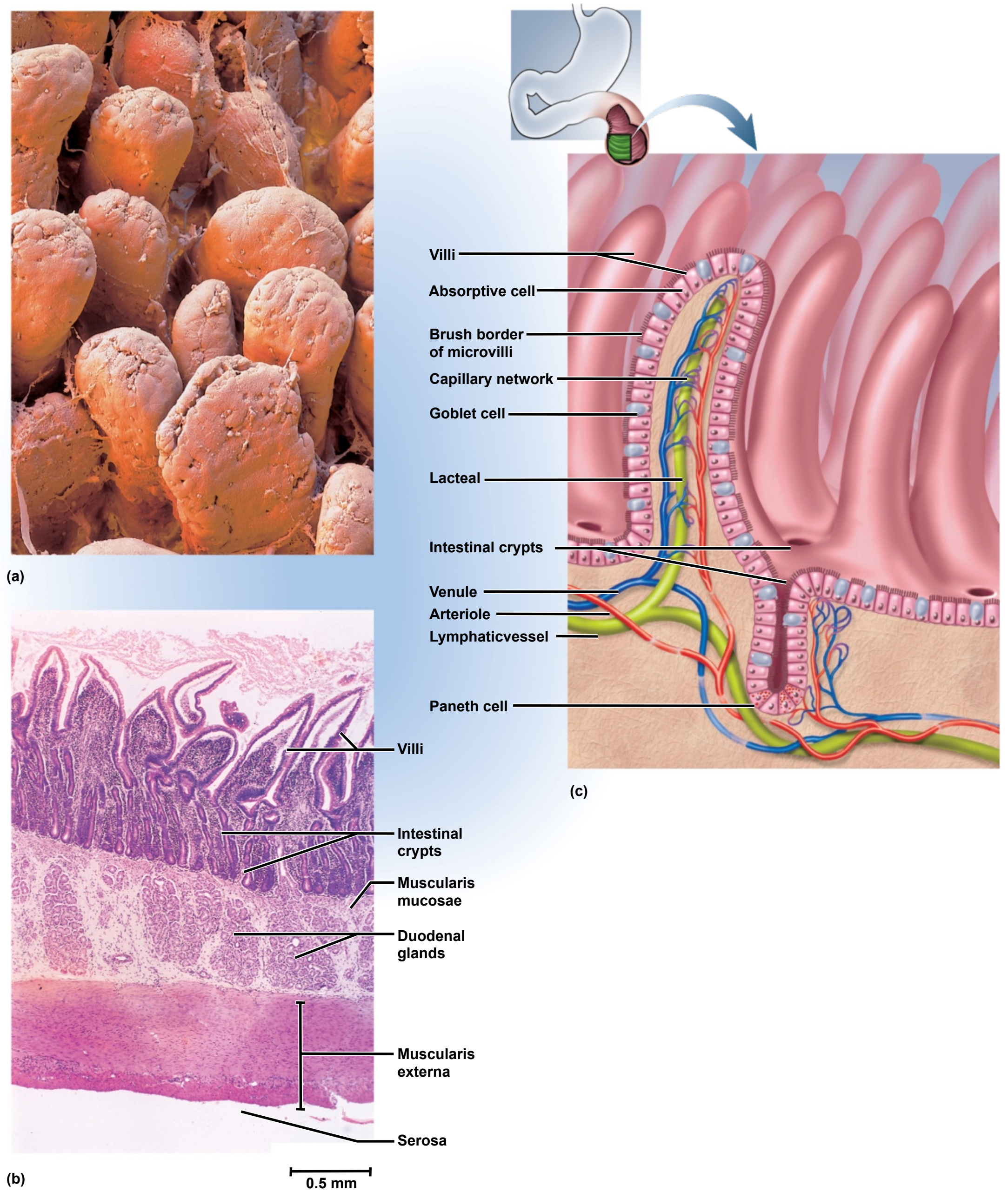
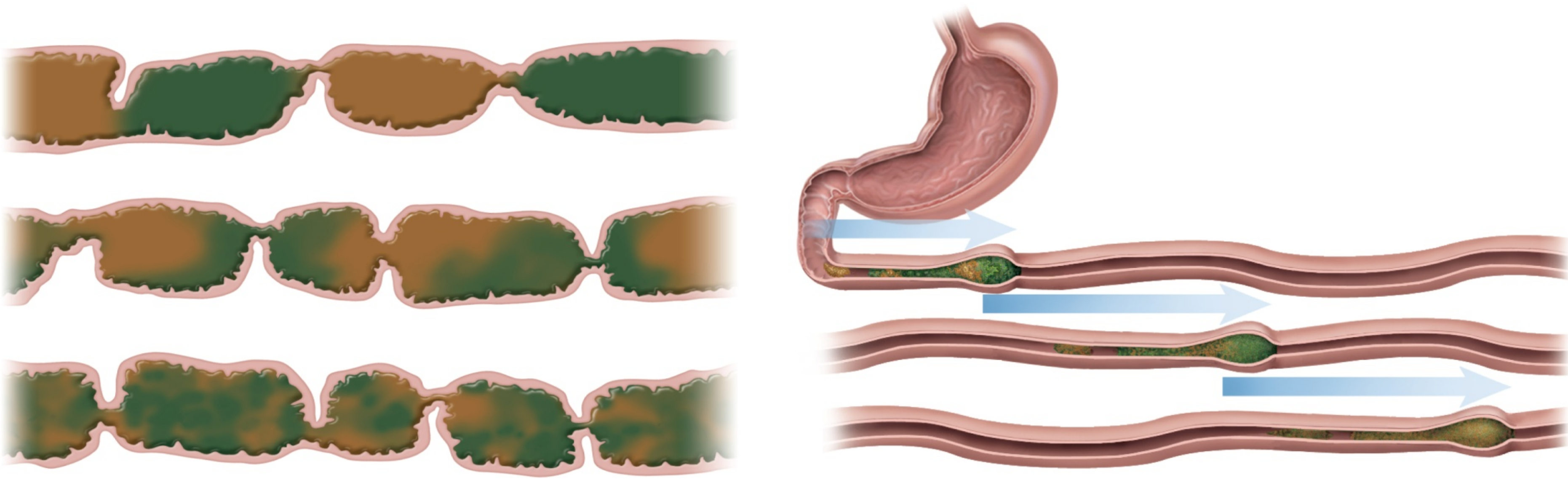

(a)
Villi
Intestinal crypts
Muscularis mucosae
Duodenal glands
Muscularis externa
Serosa
(b)
0.5 mm
Villi
Absorptive cell
Brush border of microvilli
Capillary network
Goblet cell
Lacteal
Intestinal crypts
Venule
Arteriole
Lymphaticvessel
Paneth cell
(c)

Fig. 25.26



(a) Segmentation

(b) Peristalsis

Fig. 25.27

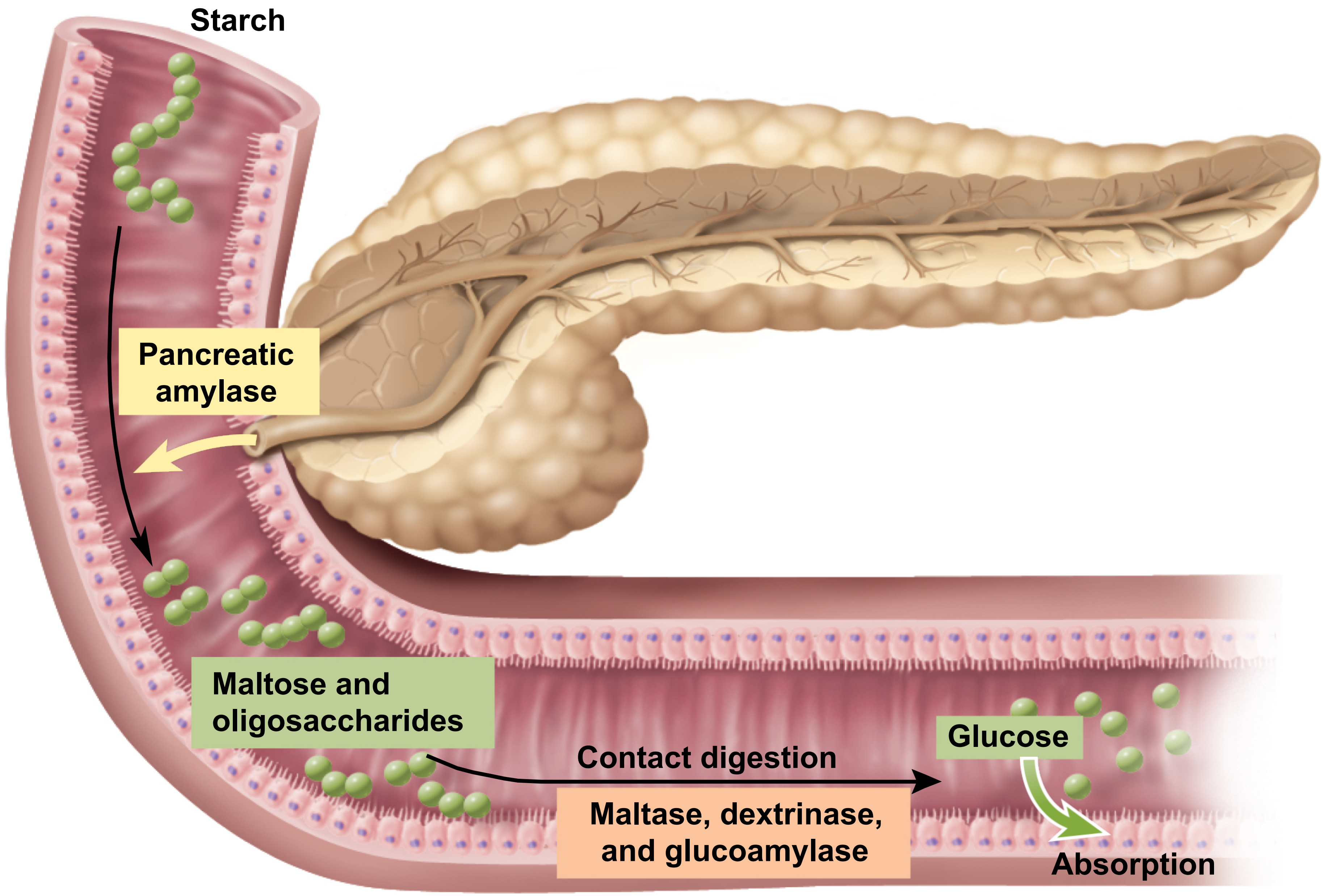

Starch
Pancreatic amylase
Maltose and oligosaccharides
Contact digestion
Maltase, dextrinase, and glucoamylase
Glucose
Absorption

Fig. 25.28

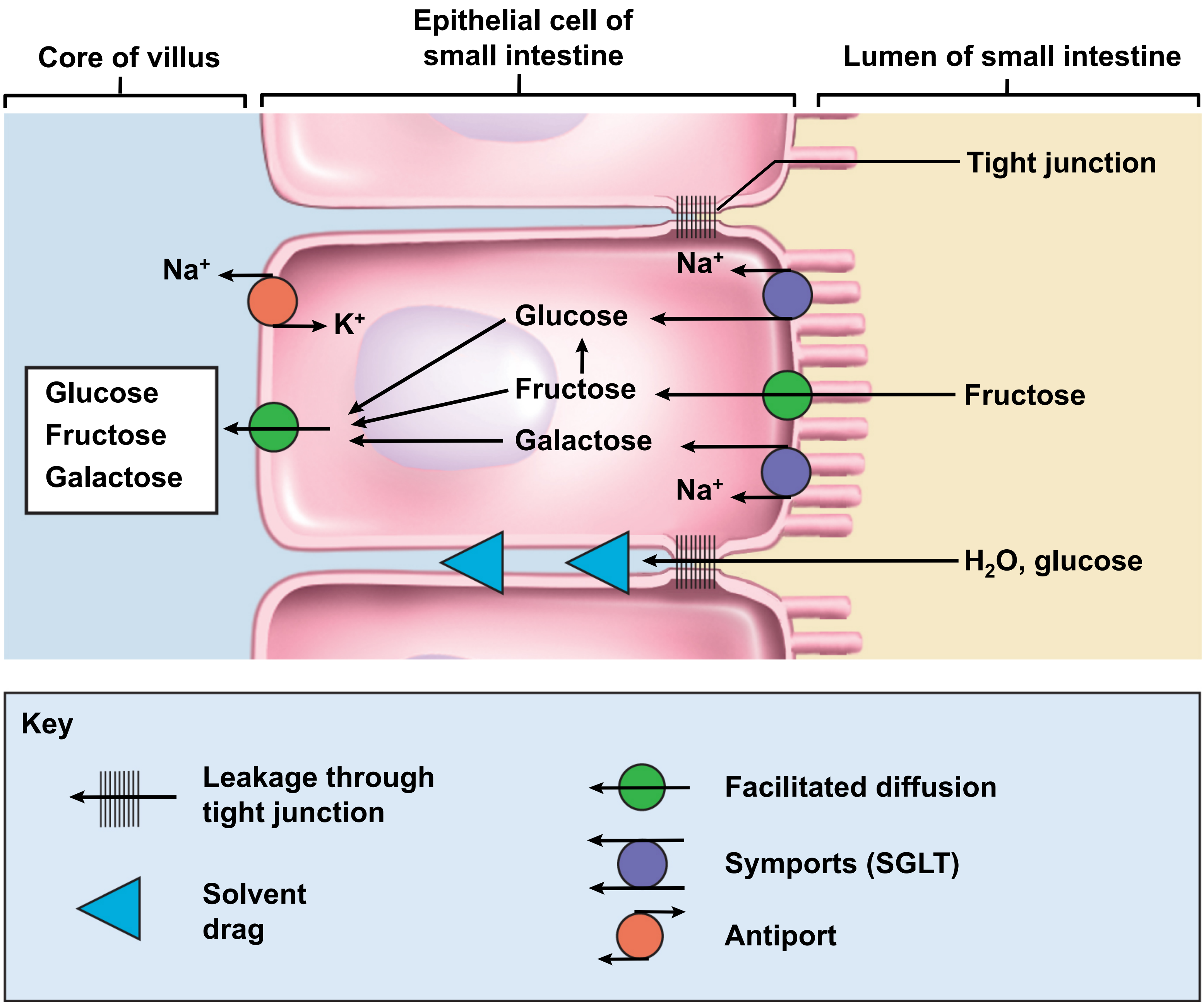

Core of villus
Epithelial cell of small intestine
Lumen of small intestine
Tight junction
Na^+
K^+
Na^+
Glucose
Fructose
Galactose
Glucose
Fructose
Galactose
Fructose
Na^+
H_2O, glucose
Key
Leakage through tight junction
Solvent drag
Facilitated diffusion
Symports (SGLT)
Antiport

Fig. 25.29

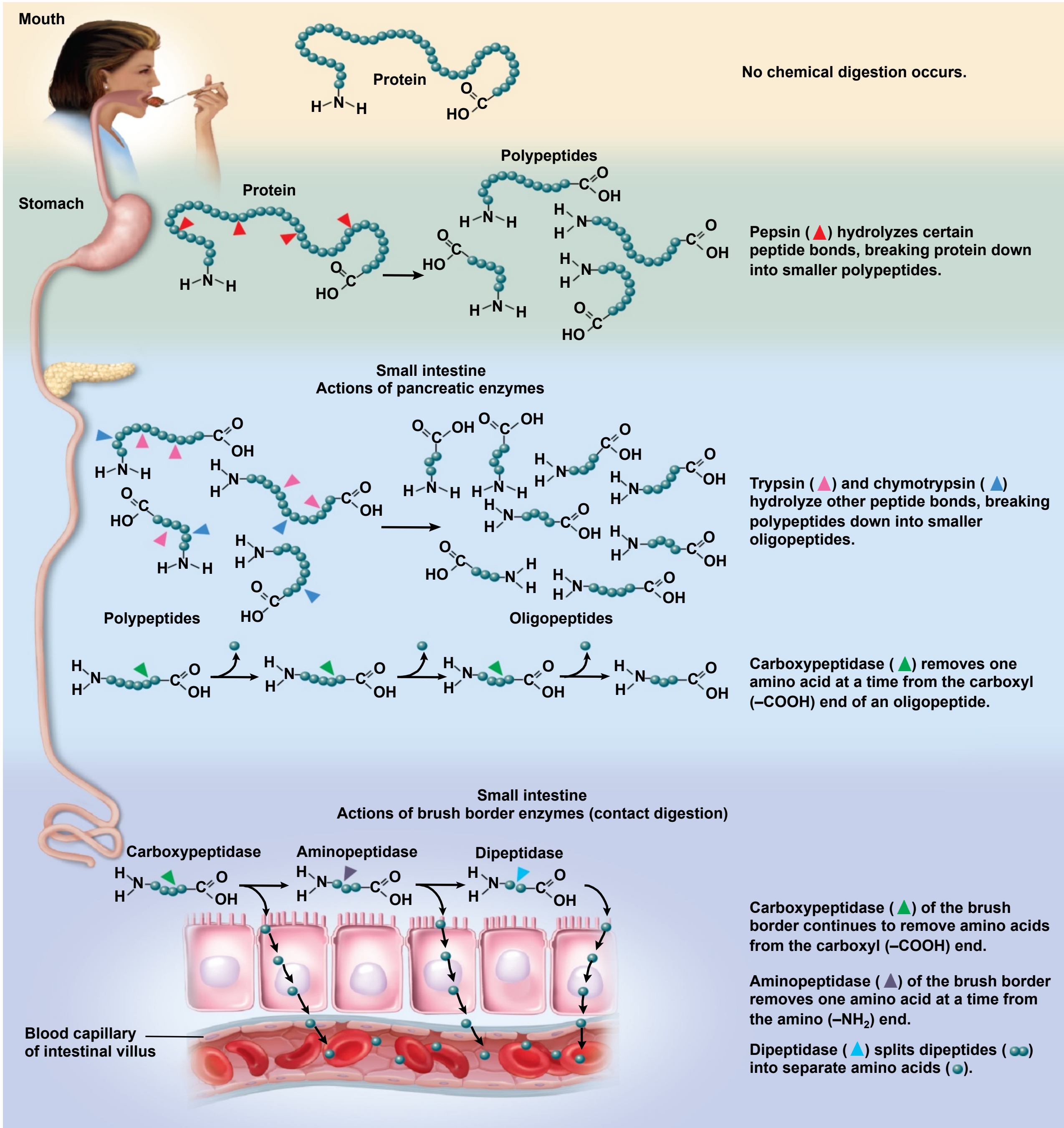

Mouth
Protein
No chemical digestion occurs.
Stomach
Protein
Polypeptides
Pepsin ( ) hydrolyzes certain peptide bonds, breaking protein down into smaller polypeptides.
Small intestine
Actions of pancreatic enzymes
Polypeptides
Oligopeptides
Trypsin ( ) and chymotrypsin ( ) hydrolyze other peptide bonds, breaking polypeptides down into smaller oligopeptides.
Carboxypeptidase ( ) removes one amino acid at a time from the carboxyl (–COOH) end of an oligopeptide.
Small intestine
Actions of brush border enzymes (contact digestion)
Carboxypeptidase
Aminopeptidase
Dipeptidase
Blood capillary of intestinal villus
Carboxypeptidase ( ) of the brush border continues to remove amino acids from the carboxyl (–COOH) end.
Aminopeptidase ( ) of the brush border removes one amino acid at a time from the amino (–NH$_2$) end.
Dipeptidase ( ) splits dipeptides ( ) into separate amino acids ( ).

Fig. 25.30

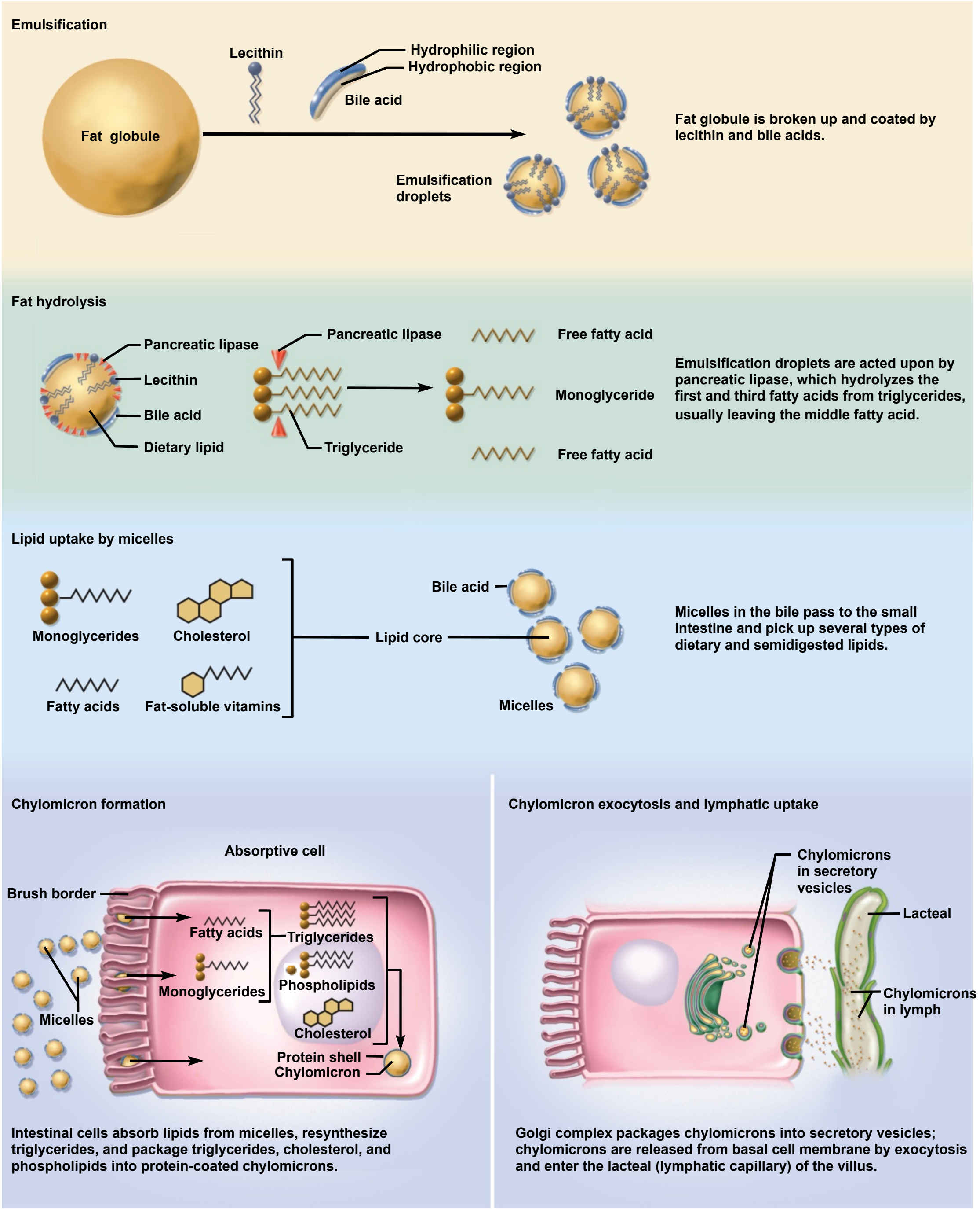
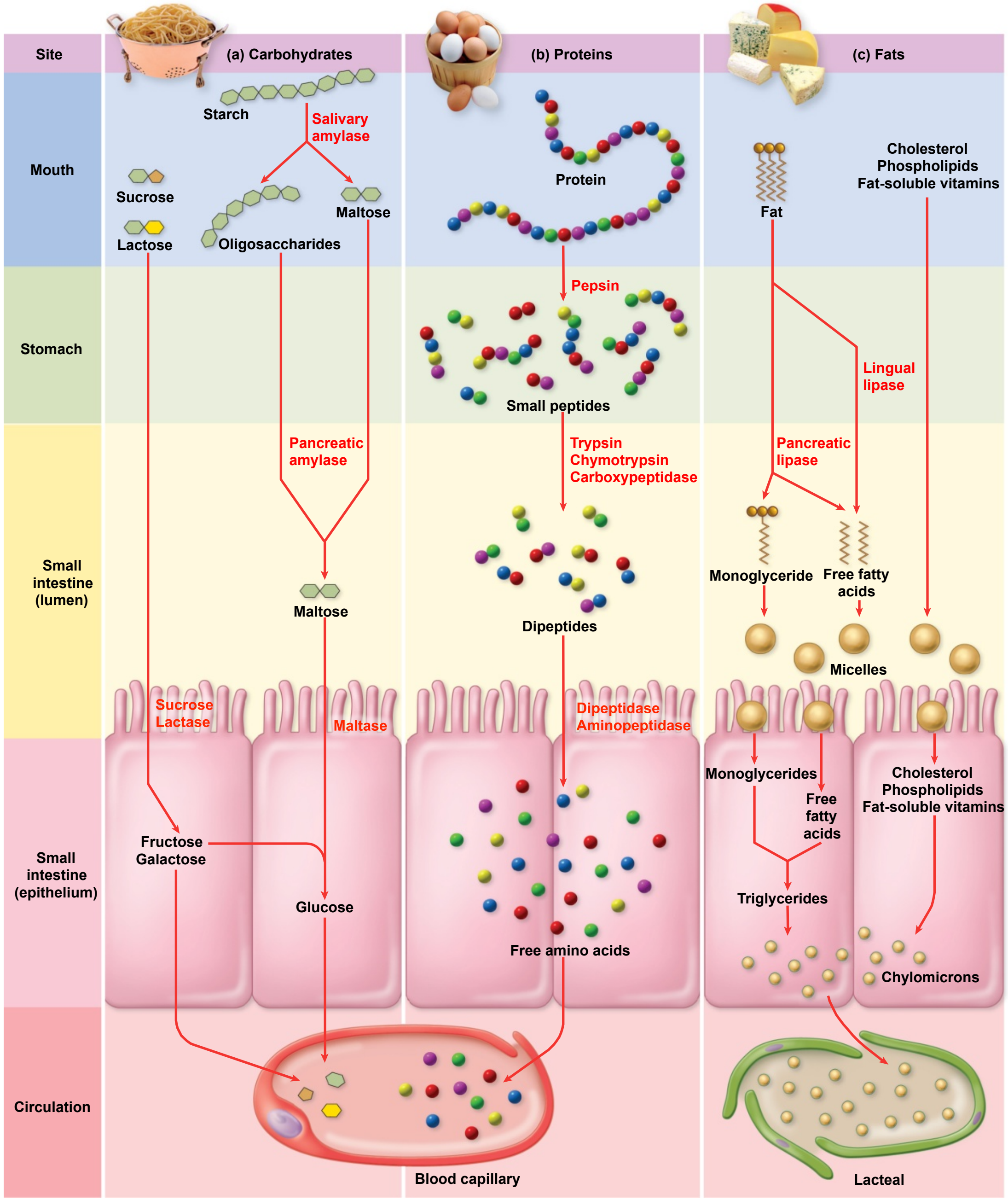
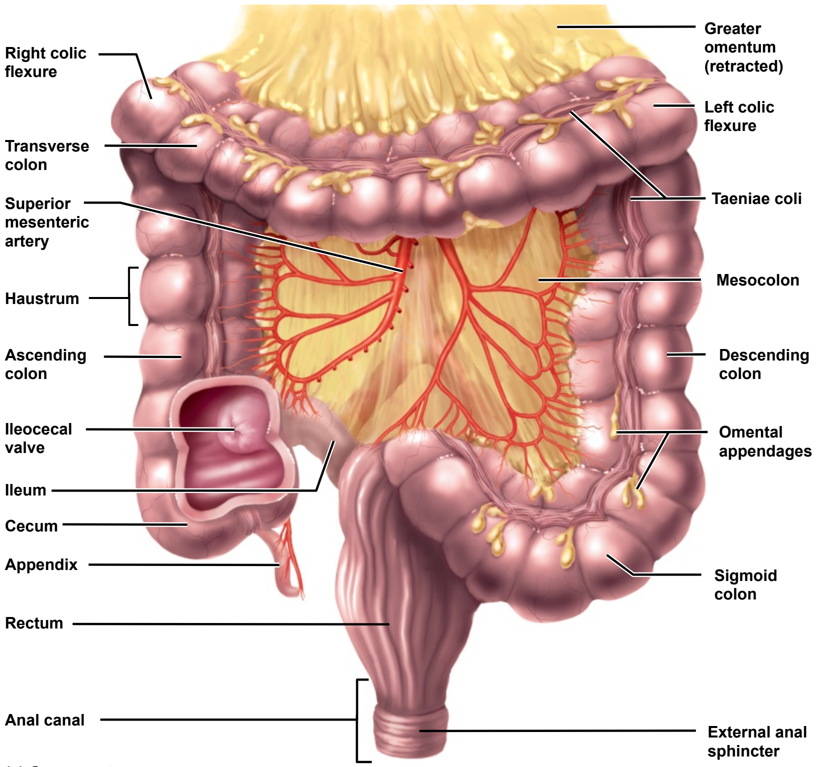

Emulsification
Lecithin
Hydrophilic region
Hydrophobic region
Bile acid
Fat globule
Emulsification droplets
Fat globule is broken up and coated by lecithin and bile acids.
Fat hydrolysis
Pancreatic lipase
Lecithin
Bile acid
Dietary lipid
Pancreatic lipase
Triglyceride
Free fatty acid
Monoglyceride
Free fatty acid
Emulsification droplets are acted upon by pancreatic lipase, which hydrolyzes the first and third fatty acids from triglycerides, usually leaving the middle fatty acid.
Lipid uptake by micelles
Monoglycerides
Cholesterol
Fatty acids
Fat-soluble vitamins
Lipid core
Bile acid
Micelles
Micelles in the bile pass to the small intestine and pick up several types of dietary and semidigested lipids.
Chylomicron formation
Absorptive cell
Brush border
Micelles
Fatty acids
Monoglycerides
Triglycerides
Phospholipids
Cholesterol
Protein shell
Chylomicron
Intestinal cells absorb lipids from micelles, resynthesize triglycerides, and package triglycerides, cholesterol, and phospholipids into protein-coated chylomicrons.
Chylomicron exocytosis and lymphatic uptake
Chylomicrons in secretory vesicles
Lacteal
Chylomicrons in lymph
Golgi complex packages chylomicrons into secretory vesicles; chylomicrons are released from basal cell membrane by exocytosis and enter the lacteal (lymphatic capillary) of the villus.

Fig. 25.31

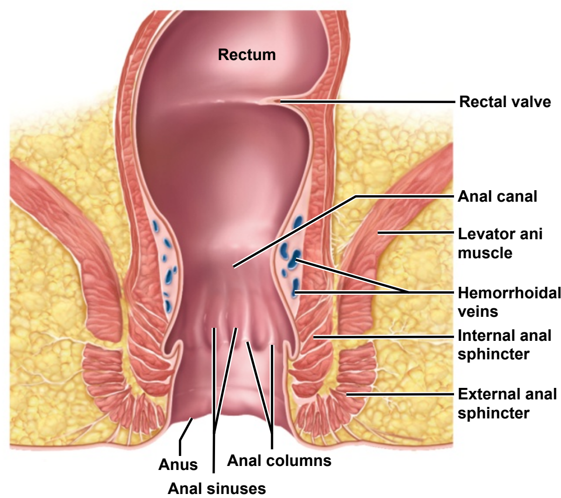


Site
(a) Carbohydrates
(b) Proteins
(c) Fats
Mouth
Stomach
Small intestine (lumen)
Small intestine (epithelium)
Circulation
Starch
Salivary amylase
Sucrose
Lactose
Oligosaccharides
Maltose
Pancreatic amylase
Maltose
Sucrose Lactase
Maltase
Fructose Galactose
Glucose
Protein
Pepsin
Small peptides
Trypsin Chymotrypsin Carboxypeptidase
Dipeptides
Dipeptidase Aminopeptidase
Free amino acids
Blood capillary
Fat
Cholesterol Phospholipids Fat-soluble vitamins
Lingual lipase
Pancreatic lipase
Monoglyceride
Free fatty acids
Micelles
Monoglycerides
Free fatty acids
Cholesterol Phospholipids Fat-soluble vitamins
Triglycerides
Chylomicrons
Lacteal

Fig. 25.32

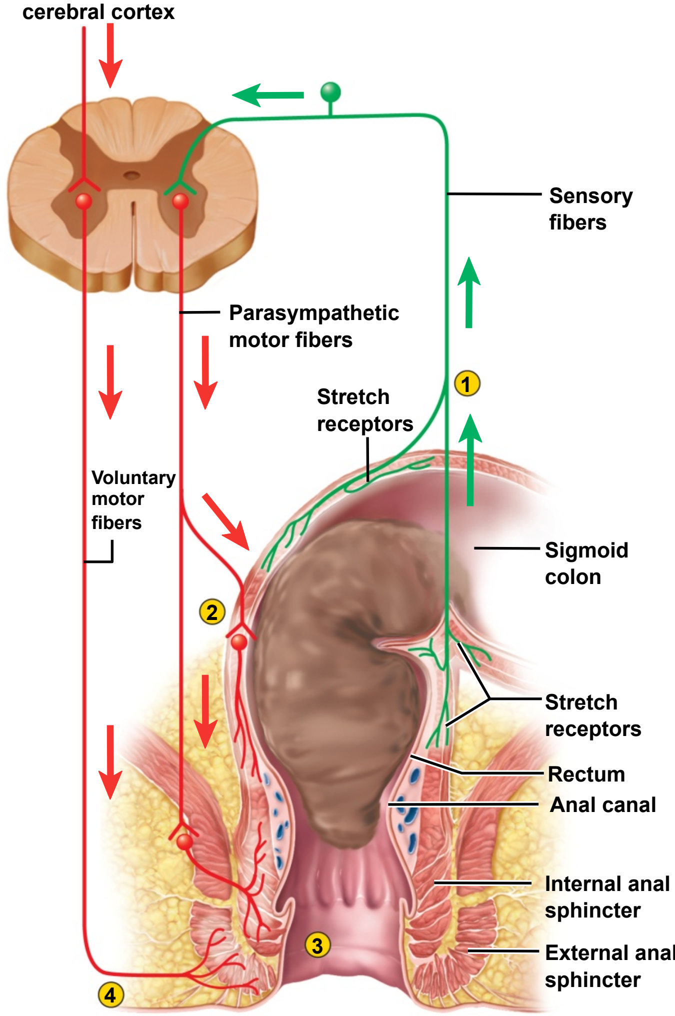


(a) Gross anatomy



(b) Anal canal

Fig. 25.33



1. Feces stretch the rectum and stimulate stretch receptors, which transmit signals to the spinal cord.
2. A spinal reflex stimulates contraction of the rectum.
3. The spinal reflex also relaxes the internal anal sphincter.
4. Impulses from the brain prevent untimely defecation by keeping the external anal sphincter contracted. Defecation occurs only if this sphincter also relaxes.